British Trust for Ornithology

BTO Research Report No. 122

Temporal and Spatial Variation in Low Tide Counts of Wildfowl and Waders on Selected Estuaries in Great Britain

by

J. Evans

August 1993

BTO, The National Centre for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU

BTO Research Report No. 122
August 1993

LIST OF CONTENTS

Page No.

Contents 1

List of Tables 3

List of Figures 5

1. Executive Summary 7

2. General Introduction 9

3. Validation of Counting Procedure 11

- **3.1 Background** 11
- **3.2 Methods** 12
- **3.3 Results** 12
- **3.4 Discussion** 12

4. Validation of Sampling Procedure 15

- **4.1 Background** 15
- **4.2 Methods** 16
- **4.3 Results** 16
- **4.4 Discussion** 17

Acknowledgements 19

References 21

Tables 23

Figures 39

Appendices 49

Appendix A Instructions for the 1992/93 National Low Tide Count Scheme 49

Appendix B The reverse of the recording form used by counters participating in the National Low Tide Count Scheme in 1992/93 51

LIST OF TABLES

Page No.

Table 4.1 **Spearman correlation coefficients (r_s) between the numbers of all species combined in four monthly counts of mudflats within each of five estuaries during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).. 23**

Table 4.2 **Spearman correlation coefficients (r_s) between the densities of all species combined in four monthly counts of mudflats within each of five estuaries during the 1992/93 winter (*=p<0.05, **=<0.01, ***=p<0.001).. 24**

Table 4.3 **Spearman correlation coefficients (r_s) between the numbers of all species combined in the two early winter counts (November & December) and the two late winter counts (January & February) within each of five estuaries during the 1992/93 winter (*=p<0.05, **=<0.01, ***=p<0.001).. 25**

Table 4.4 **Spearman correlation coefficients (r_s) between the density of all species combined in the two early winter counts (November & December) and the two late winter counts (January & February) within each of five estuaries during the 1992/93 winter (*=p<0.05, **=<0.01, ***=p<0.001).. 26**

Table 4.5 **Spearman correlation coefficients (r_s) between the numbers of all species combined in each monthly count and those in all monthly counts combined for each of the five estuaries during the 1992/93 winter (*=p<0.05, **=<0.01, ***=p<0.001).. 27**

Table 4.6 **Spearman correlation coefficients (r_s) between the densities of all species combined in each monthly cont and those in all monthly counts combined for each of the five estuaries during the 1992/934 winter (*=p<0.05, **=<0.01, ***=p<0.001) 28**

Table 4.7 **The percentage of significant results obtained for the spearman rank correlations for each combination of months.............................. 29**

Table 4.8 **Spearman correlation coefficients (r_s) between the density of each species in four monthly counts of mudflats within the Inner Forth during the 1992/93 winter (*=p<0.05, **=<0.01, ***=p<0.001).. 30**

Table 4.9 **Spearman correlation coefficients (r_s) between the density of each species in four monthly counts for mudflats within the Outer Forth North during the 1992/93 winter (*=p<0.05, **=<0.01, ***=p<0.001).. 31**

Page No.

Table 4.10 **Spearman correlation coefficients (r_s) between the density of each species in four monthly counts for mudflats within the Outer Forth South during the 1992/93 winter (*=p<0.05, **=<0.01, ***=p<0.001)** **32**

Table 4.11 **Spearman correlation coefficients (r_s) between the density of each species in four monthly counts for mudflats within the NW Solent during the 1992/93 winter (*=p<0.05, **=<0.01, ***=p<0.001)** **33**

Table 4.12 **Spearman correlation coefficients (r_s) between the density of each species in four monthly counts for mudflats within the Portsmouth Harbour during the 1992/93 winter (*=p<0.05, **=<0.01, ***=p<0.001)** **34**

Table 4.13 **Spearman correlation coefficients (r_s) between the density of each species in four monthly counts for mudflats within the Swale during the 1992/93 winter (*=p<0.05, **=<0.01, ***=p<0.001)** **35**

Table 4.14 **Spearman correlation coefficients (r_s) between the density of each species in four monthly counts for mudflats within the Wigtown Bay during the 1992/93 winter (*=p<0.05, **=<0.01, ***=p<0.001)** **36**

Table 4.15 **The percentage of significant results obtained for the spearman rank correlations for each species** **37**

LIST OF FIGURES

Page No.

Figure 3.1 **The location of the thirteen estuaries included in the National Low Tide Count Scheme 1992/93... 39**

Figure 3.2 **The proportion of mudflats of different sizes on The Inner Forth..... 40**

Figure 3.3 **The proportion of mudflats of different sizes on The NW Solent 41**

Figure 3.4 **The proportion of mudflats of different sizes on Portsmouth Harbour.. 42**

Figure 3.5 **The proportion of mudflats of different sizes on The Swale.............. 43**

Figure 3.6 **The proportion of mudflats of different sizes on Wigtown Bay 44**

Figure 4.1 **Scatterplot matrix (SPLOM) showing the relationship between Shelduck density on each mudflats in each of the four monthly counts on The Swale.. 45**

Figure 4.2 **Scatterplot matrix (SPLOM) showing the relationship between Oystercatcher density on each mudflats in each of the four monthly counts on The Swale.. 46**

Figure 4.3 **Scatterplot matrix (SPLOM) showing the relationship between Dunlin density on each mudflats in each of the four monthly counts on The Swale.. 47**

Figure 4.4 **Scatterplot matrix (SPLOM) showing the relationship between Curlew density on each mudflats in each of the four monthly counts on The Swale.. 48**

1 EXECUTIVE SUMMARY

The objectives of this report are two-fold:

1. **To describe temporal changes in the low water distribution of waterfowl on selected estuaries in Britain based on counts taken during four months (November-February) of 1992/93.**

2. **To define a practical count methodology which minimises bias and maximises the precision of low water count data.**

Long-term monitoring schemes are a compromise between a statistical ideal and what is practical, possible and cost-effective. To achieve the objectives outlined above, it has been necessary to evaluate all aspects of the Low Tide Count methodology. There are therefore two sections to the report. The first discusses sources of error within the counting procedure. The way in which counters are asked to define their counting units is identified as an area where increased standardisation might improve count precision and repeatability. The second section discusses the sampling procedure in relation to the number of counts required per winter. The results of the analyses carried out suggest that there is higher stochastic variability in the distribution of some species than in others. The aim of the Low Tide Count Scheme is to monitor the low tide distribution of all species of wader and wildfowl using intertidal areas of estuaries. The frequency of counts should therefore be high enough to be representative of the most variable species. The question of whether more than four counts should be carried out in a particular winter could be addressed by analysing the long-term datasets collected by the BTO as part of their studies of bird distribution in relation to tidal power.

2 GENERAL INTRODUCTION

Waterfowl which overwinter in Britain occupy different habitats both within and between estuaries. Food is the critical determinant of habitat selection within estuaries and differences in prey density account for a large proportion of the variation in bird density at low water (Goss-Custard *et al*. 1993). Numerous studies have shown that waders forage efficiently by feeding in the best places and selecting the most profitable sizes of prey (Goss-Custard *et al*. 1977). As a result, waterfowl tend to concentrate where prey density and availability are relatively high and hence energy expenditure is low. The distribution of their invertebrate prey species is in turn affected by other physical characteristics of the estuary, the most important of which are salinity and several inter-related sediment static variables such as grain size and organic content. Habitat use therefore influences how species distribute themselves both between and within estuaries with species varying in their degree of preference for specific habitat features. Species segregation is determined by differences in inter-specific morphological, dietary and behavioural differences, but can also be shaped by various random or stochastic environmental events which influence prey availability.

As overall numbers of birds on an estuary increase, densities tend to reach a maximum on the most preferred areas. Resources are always limited, however, and an upper threshold density must exist. The point at which this density is reached has been defined as the carrying capacity of an area. Sutherland and Goss-Custard's (1991) definition of the term rests on the assumption that various forms of feedback from bird density to the rate at which individuals can feed (interference, prey depletion) will cause an increasing number to fail to achieve adequate intake rates as the local bird density increases. Eventually, density will reach a level at which the addition of one further bird would result in another either starving or leaving that locality to seek a better area. However, changes in feeding conditions or, in some cases, the social system, could allow even higher bird numbers to be present in a particular locality. Distinguishing between the maximum density seen in this locality and the maximum density that is possible is a fundamentally important issue when considering the effects of changes in habitat on estuarine bird populations. Detecting levels of spatial distribution and identifying causal factors is therefore an important objective of estuarine research. In addition, baseline data on the distribution of waterfowl is of practical, conservation importance. Obtaining data on a large scale requires the development of a suitable monitoring scheme.

In designing such a scheme, a distinction must be made between census methods and sampling procedure (Blondel 1985). When considering the former, one of the most important objectives must be the precision of the counts. Lack of precision may be caused by failings in the inherent experimental design, by observer variability (since most monitoring schemes rely on large numbers of volunteers) or by differences in the way the data could be interpreted. Sampling procedure, on the other hand, is largely a question of scale. Bird populations are inherently variable. The number of plots sampled and the frequency and timing of the counts must therefore be chosen to give results that are representative of the behaviour of those populations.

Britain's estuary birds have been counted since 1969 as part of the Birds of Estuaries Enquiry (BoEE). The main function of the BoEE is to monitor the absolute numbers of waterfowl present on individual estuaries. On most estuaries this involves counting the birds in roosting flocks during the two hours either side of high water, as this is the only

time that they are concentrated onto a few, relatively accessible sites. These data enable the number of each species wintering on estuaries in Britain to be calculated and changes in population levels to be monitored.

Roosts often form at considerable distances from feeding areas (Symonds *et al*. 1984) and do not necessarily, therefore, provide information on the relative importance of different parts of individual estuaries as feeding areas for intertidal waterfowl. The increasing number of threats to estuaries has highlighted the need for information relevant to understanding their potential impact, particularly when they affect only a proportion of an estuary. Such information has, in the past, often been gathered at short notice in response to knowledge of immediate threats, with little attention paid to any standardised, comparable methods of procedure.

The aim of the National Low Tide Count Scheme, initiated in 1992, is to obtain and update regularly, information on the feeding distributions of intertidal waterfowl on all the main UK estuaries. It is therefore vital to determine the optimum procedure for achieving this aim at an early stage. This report uses the results of the first winter's low tide counts to review the current methods used and, if necessary, to recommend changes in those methods for future years' monitoring.

3 VALIDATION OF COUNTING PROCEDURE

3.1 BACKGROUND

Recording feeding distributions of intertidal estuarine birds on a nationwide basis requires a project design that is both labour-intensive and time-consuming. When organising such a project, the BTO has the advantage of a large volunteer-observer network. However, because several nationwide surveys, including the BoEE, rely on these volunteers, many of them are likely already to be involved with BoEE high tide counting. Several important constraints were considered when deciding on appropriate methods for the new National Low Tide Count Scheme. The first was the total amount of time any individual could be expected to devote to recording feeding distributions and the necessity for co-ordinating any such additional recording with their BoEE commitments. A second consideration involved the difficulties of identifying at least some species of wader over long distances and of finding birds which are foraging in creeks. Walking out over mudflats at low tide is potentially dangerous and in some circumstances impossible; recommending it to volunteers was inadvisable for safety reasons, regardless of any recording problems caused by disturbance to the birds. Observer 'quality' was therefore likely to be an even more important variable than is the case for the BoEE. Reduced visibility due to snow, mist, high winds and poor light occurs regularly in winter. An appropriate level of redundancy in the counting regime adopted was therefore required. The final consideration was the timing of the tidal cycle on particular estuaries in relation to the hours of daylight available on short winter days. In almost all circumstances, counting would be restricted to weekends, limiting the possibilities for counting at some stages of the lunar cycle.
The field approach suggested for the National Low Tide Count Scheme was based on methods devised and used in earlier short-term projects carried out by the BTO and included the following six points:

1. To count the main UK estuaries on a five-year rotating basis, using volunteer labour as far as possible.

2. To focus on the winter (November - February), with one simultaneous complete count per estuary being planned for each of the four months.

3. To base data collection for each estuary on pre-established subdivisions of the intertidal area.

4. To use count units averaging in the range 100-250 ha intertidal area in size.

5. To conduct counts during daylight around low tide on average tides (*i.e.* neither springs nor neaps).

6. To record birds separately according to whether they were feeding or roosting.

3.2 METHODS

Thirteen estuaries were covered (Fig. 3.1). Each estuary was divided into a number of sections with one person counting each section. The boundaries of each section were chosen so that, if necessary, comparisons could be made with information collected at high tide. Initially, therefore, the BoEE boundaries for each section were used. In most cases, however, these sections were too large for only one person to count and sub-divisions were necessary within the existing BoEE sectors. Once a section had been allocated to a counter, the counter was asked to further sub-divide it into areas that were termed 'mudflats' and was provided with detailed written instructions on how to do so (Appendix A). Sections were usually split into between 1 and 10 mudflats, depending on their intertidal areas, using easily recognisable features such as the change in substrate or a permanent landmark on the mud, for example a channel marker. The need for permanence of features indicating boundaries, in order to be able to repeat counts in future years, was emphasised. There were two reasons for dividing the estuary in this manner: Firstly, the sections were easier to count if they were split into mudflats and secondly, the level of detail in the data obtained for each species was that much greater.

Counts were carried out once a month on pre-determined dates from November to February inclusive. Wherever possible, all the counts on a particular estuary took place on the same day, but on a small number of occasions this was not possible. In these situations, counters were asked to count on a date as near as possible to the one originally decided. Counts were conducted during daylight, during the period between two hours before and two hours after low tide. For each mudflat, birds were recorded separately according to whether they were feeding or roosting and an accuracy code was assigned to the count. These data, along with information on visibility, disturbance level and disturbance type were entered on specially designed forms. Detailed instructions are printed on the reverse of the form (Appendix B).

3.3 RESULTS

The results of the 1992-93 National Low Tide Counts are presented in Evans (1993) in which they are summarised on a number of distribution maps and tables. For each estuary, the following measurements were calculated and presented for each mudflat:

1. Area of mudflat (ha)
2. Peak number of birds counted (all months' data combined for each species)
3. Mean number of birds counted each month (all species)
4. Density of each species (all months' data combined).

For the purposes of this report an assessment was made of the counting procedure, both in practical and scientific terms, and is discussed below.

3.4 DISCUSSION

There are two main sources of error associated with the counting procedure: experimental design and observer variability. The latter has been the subject of considerable discussion (*e.g.* Prater 1981) and will not be discussed further here. The former involves the decision to base data collection for each estuary on pre-established sub-divisions of the intertidal area. This approach has a number of advantages. Firstly, by use of standard forms, it

facilitates rapid collection and processing of information on bird numbers and eliminates analyst variability. Secondly, where appropriate, boundaries to units can reflect changes in habitat structure. Thirdly, regardless of whether unit boundaries are based on habitat structure or lines-of-sight topographical features, etc. they can be designed to be simply and unequivocally recognisable, ensuring standardisation between counts. However, the count units defined on this basis will inevitably be variable in size. The most common alternative approach in the recording of low tide bird distributions involves use of large-scale maps to plot the positions of individual birds and flocks. These maps can then be overlain with grids of standardised size or with outlines of habitat distribution, to which birds can be assigned. This has the potential advantage of considerable flexibility in interpretation, but also has severe practical disadvantages. These include the cumbersome and time consuming nature of the operation for the counter, including post-observation map interpretation and difficulties in the field assessment of distance and direction in order to pin-point flock or bird positions on the map. For cooperative work involving counters, the simplicity of the method used in the National Low Tide Count Scheme seem the preferred approach. If mudflat size distribution is plotted for a number of estuaries (Figs. 3.2 - 3.6). Fitting a curve to the distribution makes it clear that there are two aspects to this variability - mudflats are on average smaller on smaller estuaries and there is a bias towards smaller mudflat size. Given the instructions provided, these results are not surprising, but they indicate a possibility for greater standardisation within the counting procedure. Delimitation of the optimal, average size of a recording unit necessarily involves the sort of compromise chosen for the first winter's fieldwork. Subdivision into a large number of small areas potentially gives the greatest flexibility in considering the likely impact of, for example, habitat loss. This is counterbalanced both by declining precision of usage estimates, caused by stochastic variability in bird numbers, and by potential problems of accurately delimiting numerous small count areas on intertidal flats. However, by asking counters to carry out the subdivisions of the intertidal area there is at least the possibility that they are using features that most people would find easily recognisable. Limiting mudflat size to between 100 and 250 ha would have two practical problems. Firstly, if the counter is asked to do it, there are difficulties for the counter of estimating mudflat size and deciding mudflat boundary features. Secondly, the job would be extremely time-consuming for a single person should complete standardisation be required. It may be possible, however, to give greater guidance without either of these problems occurring.

4 VALIDATION OF SAMPLING PROCEDURE

4.1 BACKGROUND

Bibby *et al*. (1992) summarised the need for distribution studies in five points:

1. The distribution can be related to land-use.
2. Many of the conservation needs of a particular species or community can be identified by investigating habitat preferences which may manifest themselves through patterns of distribution.
3. The relative value of sites of conservation importance and vulnerability can be assessed with respect to their bird fauna.
4. Information valuable to environmental impact assessments is provided.
5. Baseline information is generated against which future changes can be assessed.

The sampling procedures employed in any such study must therefore be sufficiently rigorous to fulfil these aims.

Waterfowl distribution within estuaries varies within and between years and during the tidal cycle (Clark *et al*. 1993). In addition there is variability between species in the extent to which distribution and numbers are likely to change with time both within and between sites. In devising a field approach for the National Low Tide Count Scheme, a balance was struck between the scientific ideal and what it was practical to achieve using a volunteer workforce. In doing so, certain basic assumptions were made which have direct bearing on the sampling procedure. These were:

1. One winter's coverage in five is the minimum required for detecting changes in distribution taking place between years.
2. November to February is the period of the year over which numbers of birds present tend both to be highest and to remain most consistent over an extended period.
3. Three good quality counts per winter is the minimum dataset on which to assess distribution patterns. The inclusion of four counts in the programme therefore provides a level of redundancy to take into account problems with weather conditions or coverage.

Low tide counts have been carried out successfully using a volunteer workforce at more frequent intervals than those carried out as part of the National Low Tide Count Scheme. In these cases the counts were maintained for up to five consecutive years (*e.g.* Clark *et al*. 1993). However, the time investment required in achieving and maintaining this level of coverage on the 59 main British estuaries would probably prove prohibitive. Counters found the compromise of a five year repeat time appealing and the number of counts they were expected to carry out acceptable. However, their reaction may have proved similar if, for example four monthly counts every three years had been proposed. In addition, there is no dataset containing more than five years of low tide counts with which to assess the validity of this first assumption. Leaving aside the question of the value of collecting data during passage periods, the aim of this section of the report is to assess the validity of carrying out four monthly counts on each estuary taking part in the National Low Tide Count Scheme.

4.2 METHODS

Data from five estuaries, NW Silent, Portsmouth Harbour, Swale, Forth and Wigtown Bay were used in the analysis. These were estuaries that were both well-spread geographically and on which complete coverage had been achieved.

Initially a community approach was adopted. The following comparisons were made using Spearman rank correlations:

1 A between-month comparison of overall bird numbers (all species combined) and overall bird density on each mudflat.
2. A comparison of early winter (November and December combined) and late winter counts (January and February combined).
3. A comparison of each count with all counts combined using both numbers and density.

It is, however, known that there is variability between species in the extent to which low tide distribution and numbers are likely to change with time within sites. A second, species-specific approach was therefore adopted which investigated this variability. A between-month comparison of the density of each species on each mudflat was made using Spearman rank correlation. In addition the percentage of significant results obtained for each species was calculated, in order to provide some measure of the differences in the predictability of different species' distribution within estuaries. The percentage of significant results obtained for each between-month comparison was calculated to give a measure of the comparability of each combination of counts.

Scatterplot matrices (SPLOMs) were plotted using the densities of four widespread species (Shelduck, Oystercatcher, Dunlin, Curlew) on one estuary, the Swale, to illustrate differences in their relative distribution. If similar densities of birds were present on each mudflat then plotting the results of one count against another should have a gradient close to 1.

4.3 RESULTS

The results of the analyses carried out for all species combined are presented in Tables 4.1 - 4.7. The relative importance of each mudflat was similar between consecutive and non-consecutive counts both when absolute numbers and when density were considered (Tables 4.1 & 4.2). Similarly, the relative importance of the mudflats did not change significantly between early and late winter counts on any of the estuaries considered (Tables 4.3 & 4.4). In addition, when the results of any single count were correlated with those of all counts combined the results were significant (Tables 4.5 & 4.6). Interestingly, the percentage of significant results obtained for each correlation between counts was similar for all combinations (Table 4.7).

The results of the analyses carried out for each species separately are presented in Tables 4.8 - 4.14. The percentage of significant results obtained varied between species (Table 4.15). The highest percentage was achieved for Grey Plover, the lowest for Curlew.

Scatterplot matrices are presented for Shelduck, Dunlin, Oystercatcher and Curlew on the Swale (Figs. 4.1 - 4.4). In all four cases, adjacent counts tended to have a gradient closer to one than counts two or three months apart. This suggests that there are changes in the numbers and distribution of these four species over the period from November to

February.

4.4 DISCUSSION

The purpose of low tide counts is to provide a standardised and reliable estimate of the relative importance of different parts of individual estuaries to waterfowl. Counting them at low tide provides a measure of the distribution of each species. Repeat counts provide a measure of the temporal variation in distribution and numbers.

A considerable number of variables can influence the numbers of intertidally feeding birds present on an estuary and the manner in which they distribute themselves. The effects of some of the more predictable environmental variables have been minimised by standardisation of the counting procedure. Two other sources of variability, however, will influence the choice of sampling procedure. Firstly, episodic events can suddenly and unpredictably affect bird feeding distribution in the dynamic estuarine environment. It has, for example, been demonstrated that large-scale changes in bird distribution occur after gales which cause soft sediment removal from exposed mudflats (Clark 1989). Secondly, even when sources of environmental variability have been controlled for, the distribution of foraging intertidal birds will vary stochastically with time. The relative importance of this source of variability in affecting estimates of feeding distribution derived from sample observations is likely to vary between species, being less important for those in which individuals tend towards being relatively solitary and sedentary, *e.g.* Redshank, than for those which tend to be more mobile and aggregated, *e.g.* Knot. These factors are evident in the results of the analysis of the first winter's National Low Tide Count data.

If there is high stochastic variability then, regardless of accuracy of counting, assessment of spatial usage patterns will be imprecise, *i.e.* have poor repeatability. This problem can be counteracted either by increasing the frequency of recording or by increasing the areas of the recording sectors into which the estuary is divided. The first section of this report considered mudflat size. It was clear that the average mudflat size chosen by counters was smaller than the recommended 100 - 250 ha. Future instructions to counters should therefore include more guidance in this respect. This second section of the report demonstrated the differing levels of variability in distribution between species. Since the aim of the Low Tide Count Scheme is to record the distribution of all species of wader and wildfowl using the intertidal area, it is logical to adopt the number of counts required to give the most accurate representation of the distribution of the largest number of species possible. In this respect, given the practical considerations discussed in this report, the number of counts adopted for the first winter's fieldwork seems likely to be the minimum required. The need for more frequent counts is a question that could be addressed by carrying out further analyses on the longer-term datasets that the BTO has collected during its studies of bird distribution in relation to tidal power.

ACKNOWLEDGEMENTS

Many thanks are due to all the people who took part in this winter's fieldwork, without whom a scheme of this nature would not be possible. Their enthusiasm and dedication are second to none.

The work was funded (under contract number 21/7200/1172) as a joint project by the Royal Society for the Protection of Birds and the BTO.

I am grateful to the many members of staff at the BTO who have helped me throughout this first year of the project. I am particularly grateful to Nigel Clark and Rowena Langston for their help with all aspects of the work and to Ray Waters for valuable assistance with co-ordinating the Low Tide and BoEE schemes. Carol Powley assisted with the day-to-day running of the scheme. John Cayford supervised the production of this report and assisted with the analysis. This and the previous report would not have been possible without the considerable secretarial skills of Sophie Foulger and Tracey Brookes.

REFERENCES

Bibby, C.J., Burgess, N.D. & Hill, D.A. (eds.) 1992. *Bird Census Techniques*. Academic Press Ltd.

Blondel, J. 1985. Bird distribution and abundance: some technical and theoretical comments. In *Bird Census and Atlas Studies*. K.Taylor, R.J. Fuller & P.C. Lack (eds.)

Clark, N.A. 1989. *Wader migration and distribution in south-west estuaries*. Report to UK Department of Energy's Renewable Energy Research and Development Programme (ETSU TID 4055), 277pp.

Clark, N.A., Evans, J., Shepherd, M. & Rehfisch, M.M. 1993. *Variability in waterfowl distribution within hypertidal estuaries in relation to sediments*. Report to UK Department of Energy's Renewable Energy Research and Development Programme (ETSU TID 4114).

Goss-Custard, J.D., Jones, R.E. & Newbery, 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., Warwick, R.M., Kirby, R., McGrorty, S., Clarke, R.T., Pearson, B., Rispin, W.E., le V dit Durell, S.E.A. & 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., Yates, M.G., McGrorty, S., Lakhani, K., le V dit Durell, S.E.A., Clarke, R., Rispin, E., Moy, I., Parsell, R. & Yates, T. 1988. *Wash birds and invertebrates*. ITE report to the UK Department of Environment and NCC.

Evans, J. 1993. *Low tide counts of wildfowl and waders on selected estuaries in Great Britain*. Unpublished report to RSPB.

Prater, A.J. 1981. *Estuary Birds of Britain & Ireland*. T. & A.D. Poyser.

Spearpoint, W.J., Every, B. & Underhill, L.G. 1988. Waders (Charadrii) and other shorebirds at Cape Recife, Algoa Bay, South Africa: Seasonality, trends, conservation and reliability of surveys. *Ostrich* 59(4): 166-177.

Sutherland, W.J. & Goss-Custard, J.D. 1991. Predicting the consequence of habitat loss on shorebird populations. *Proceedings of the International Ornithological Congress* XX: 2199-2207.

Symonds, F.L.D., 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.

SPECIES	COUNT	DEC	JAN	FEB
INNER FORTH	NOV DEC JAN	0.664*** - -	0.602*** 0.614*** -	0.642*** 0.664*** 0.657***
OUTER FORTH SOUTH	NOV DEC JAN	0.725*** - -	0.651*** 0.691*** -	0.647*** 0.686*** 0.696***
OUTER FORTH NORTH	NOV DEC JAN	0.764*** - -	0.718*** 0.699*** -	0.677*** 0.690*** 0.689***
NW SOLENT	NOV DEC JAN	0.582*** - -	0.595*** 0.514*** -	0.573*** 0.629*** 0.580***
PORTSMOUTH HARBOUR	NOV DEC JAN	0.756*** - -	0.663*** 0.774*** -	0.693*** 0.695*** 0.707***
SWALE	NOV DEC JAN	0.707*** - -	0.666*** 0.715*** -	0.663*** 0.691*** 0.700***
WIGTOWN BAY	NOV DEC JAN	0.500*** - -	0.429*** 0.550*** -	0.489*** 0.517*** 0.484***

Table 4.1 **Spearman correlation coefficients (r_s) between the numbers of all species combined in four monthly counts of mudflats within each of five estuaries during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).**

SPECIES	COUNT	DEC	JAN	FEB
INNER FORTH	NOV DEC JAN	0.621** - -	0.451* 0.223 -	0.647*** 0.603** 0.581**
OUTER FORTH SOUTH	NOV DEC JAN	0.840*** - -	0.672*** 0.676*** -	0.690*** 0.792*** 0.601***
OUTER FORTH NORTH	NOV DEC JAN	0.631*** - -	0.648*** 0.677*** -	0.580*** 0.662*** 0.593***
NW SOLENT	NOV DEC JAN	0.593* - -	0.721** 0.615** -	0.536* 0.760*** 0.701**
PORTSMOUTH HARBOUR	NOV DEC JAN	0.600* - -	0.424 0.396 -	0.664* 0.667* 0.464
SWALE	NOV DEC JAN	0.801*** - -	0.414** 0.420** -	0.717*** 0.686*** 0.551***
WIGTOWN BAY	NOV DEC JAN	0.619** - -	0.486* 0.361 -	0.589** 0.343 0.439*

Table 4.2 Spearman correlation coefficients (r_s) between the densities of all species combined in four monthly counts of mudflats within each of five estuaries during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).

ESTUARY	r_s
INNER FORTH	0.669***
OUTER FORTH SOUTH	0.736***
OUTER FORTH NORTH	0.765***
NW SOLENT	0.715***
PORTSMOUTH HARBOUR	0.755***
SWALE	0.748***
WIGTOWN BAY	0.586***

Table 4.3 Spearman correlation coefficients (r_s) between the numbers of all species combined in the two early winter counts (November & December) and the two late winter counts (January & February) within each of five estuaries during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).

ESTUARY	r_s
INNER FORTH	0.583***
OUTER FORTH SOUTH	0.775***
OUTER SOUTH NORTH	0.782***
NW SOLENT	0.761***
PORTSMOUTH HARBOUR	0.567
SWALE	0.728***
WIGTOWN BAY	0.602**

Table 4.4 **Spearman correlation coefficients (r_s) between the density of all species combined in the two early winter counts (November & December) and the two late winter counts (January & February) within each of five estuaries during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).**

ESTUARY	COUNT	NOV + DEC + JAN + FEB
INNER FORTH	NOV	0.752***
	DEC	0.773***
	JAN	0.789***
	FEB	0.753***
OUTER FORTH SOUTH	NOV	0.772***
	DEC	0.789***
	JAN	0.786***
	FEB	0.833***
OUTER FORTH NORTH	NOV	0.802***
	DEC	0.834***
	JAN	0.831***
	FEB	0.806***
NW SOLENT	NOV	0.712***
	DEC	0.686***
	JAN	0.740***
	FEB	0.715***
PORTSMOUTH HARBOUR	NOV	0.873***
	DEC	0.838***
	JAN	0.776***
	FEB	0.791***
SWALE	NOV	0.806***
	DEC	0.782***
	JAN	0.782***
	FEB	0.837***
WIGTOWN BAY	NOV	0.657***
	DEC	0.721***
	JAN	0.692***
	FEB	0.586***

Table 4.5 **Spearman correlation coefficients (r_s) between the numbers of all species combined in each monthly count and those in all monthly counts combined for each of the five estuaries during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).**

ESTUARY	COUNT	NOV + DEC + JAN + FEB
INNER FORTH (n=20)	**NOV DEC JAN FEB**	**0.848*** 0.681** 0.776*** 0.794*** **
OUTER FORTH SOUTH (n=54)	**NOV DEC JAN FEB**	0.910** 0.883*** 0.855** 0.828**
OUTER FORTH NORTH (n=27)	**NOV DEC JAN FEB**	0.723*** 0.903*** 0.847*** 0.626***
NW SOLENT (n=15)	**NOV DEC JAN FEB**	0.814*** 0.836*** 0.857*** 0.896***
PORTSMOUTH HARBOUR (n=9)	**NOV DEC JAN FEB**	0.683* 0.917*** 0.767* 0.800**
SWALE (n=44)	**NOV DEC JAN FEB**	0.847*** 0.851*** 0.696*** 0.875***
WIGTOWN BAY (n=23)	**NOV DEC JAN FEB**	0.878*** 0.683*** 0.668*** 0.751***

Table 4.6 **Spearman correlation coefficients (r_s) between the densities of all species combined in each monthly count and those in all monthly counts combined for each of the five estuaries during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).**

COUNT	DEC	JAN	FEB
NOV	71.3	60.9	61.1
DEC	-	63.9	61.7
JAN	-	-	63.0

Table 4.7 The percentage of significant results obtained for the spearman rank correlations for each combination of months.

SPECIES	COUNT	DEC	JAN	FEB
PINK-FOOTED GOOSE	NOV	-0.050	0.549**	.
	DEC	-	-0.072	.
	JAN	-	-	.
SHELDUCK	NOV	0.766***	0.735***	0.587***
	DEC	-	0.572**	0.758***
	JAN	-	-	0.492*
WIGEON	NOV	0.712***	0.421*	0.583**
	DEC	-	0.635**	0.800***
	JAN	-	-	0.440*
TEAL	NOV	0.356	0.461	0.663***
	DEC	-	0.449*	0.462*
	JAN	-	-	0.672***
MALLARD	NOV	0.366	0.634**	0.340
	DEC	-	0.260	0.384
	JAN	-	-	0.746***
PINTAIL	NOV	0.398	0.723***	0.724***
	DEC	-	0.606**	0.608**
	JAN	-	-	1.000***
OYSTERCATCHER	NOV	0.913***	0.894***	0.564**
	DEC	-	0.863***	0.654**
	JAN	-	-	0.650**
RINGED PLOVER	NOV	.	.	.
	DEC	-	0.725	0.290
	JAN	-	-	0.486*
GOLDEN PLOVER	NOV	-0.196	-0.082	-0.086
	DEC	-	0.539	-0.114
	JAN	-	-	-0.048
GREY PLOVER	NOV	.	.	.
	DEC	-	0.725	.
	JAN	-	-	.
LAPWING	NOV	0.479*	0.489*	0.356
	DEC	-	0.232	0.786***
	JAN	-	-	0.471*
KNOT	NOV	0.669***	-0.119	0.291
	DEC	-	0.493*	0.376
	JAN	-	-	0.411
DUNLIN	NOV	0.504*	0.510*	0.588**
	DEC	-	0.511*	0.545*
	JAN	-	-	0.695***
BLACK-TAILED GODWIT	NOV	0.725***	.	-0.100
	DEC	-	.	-0.076
	JAN	-	-	.
BAR-TAILED GODWIT	NOV	0.523*	0.245***	-0.230
	DEC	-	0.377***	0.157
	JAN	-	-	0.424*
CURLEW	NOV	0.519*	0.656***	-0.207
	DEC	-	0.824***	0.229
	JAN	-	-	0.186
REDSHANK	NOV	0.645**	0.583**	0.638**
	DEC	-	0.718***	0.573**
	JAN	-	-	0.839***
TURNSTONE	NOV	0.179	0.333	0.336
	DEC	-	0.487*	0.455*
	JAN	-	-	0.611**

Table 4.8 Spearman correlation coefficients (r_s) between the density of each species in four monthly counts of mudflats within the Inner Forth during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).

SPECIES	COUNT	DEC	JAN	FEB
SHELDUCK	NOV	.	.	.
	DEC	-	1.000***	1.000***
	JAN	-	-	0.520***
WIGEON	NOV	1.000***	0.718***	0.675***
	DEC	-	0.720***	1.000***
	JAN	-	-	0.472**
TEAL	NOV	.	1.000***	-0.029
	DEC	-	.	.
	JAN	-	-	-0.038
MALLARD	NOV	0.678***	0.676***	0.628***
	DEC	-	0.556**	0.639***
	JAN	-	-	0.719***
OYSTERCATCHER	NOV	0.743***	0.743***	0.650***
	DEC	-	0.717***	0.513**
	JAN	-	-	0.558***
RINGED PLOVER	NOV	0.634***	0.629***	0.641***
	DEC	-	0.379*	0.415*
	JAN	-	-	0.522***
GOLDEN PLOVER	NOV	0.450*	-0.044	-0.030
	DEC	-	0.307	0.232
	JAN	-	-	0.357*
GREY PLOVER	NOV	0.763***	0.515**	0.773***
	DEC	-	0.843***	0.522**
	JAN	-	-	0.493**
LAPWING	NOV	0.467*	0.324	0.016
	DEC	-	0.498**	0.348
	JAN	-	-	0.553***
KNOT	NOV	0.365	0.890***	0.272
	DEC	-	0.558**	0.294
	JAN	-	-	0.644***
SANDERLING	NOV	0.599***	0.595***	0.656***
	DEC	-	1.000***	0.598***
	JAN	-	-	0.593***
PURPLE SANDPIPER	NOV	0.667***	1.000***	0.577***
	DEC	-	0.667***	0.353
	JAN	-	-	0.577***
DUNLIN	NOV	0.928***	0.709***	0.713***
	DEC	-	0.648***	0.480**
	JAN	-	-	0.740***
BAR-TAILED GODWIT	NOV	0.761***	0.814***	0.811***
	DEC	-	0.850***	0.637***
	JAN	-	-	0.589***
CURLEW	NOV	0.459*	0.348*	0.293
	DEC	-	0.219	0.290
	JAN	-	-	0.442**
REDSHANK	NOV	0.707*	0.461**	0.608***
	DEC	-	0.696***	0.630***
	JAN	-	-	0.537***
TURNSTONE	NOV	0.319	0.187	0.251
	DEC	-	0.562**	0.655***
	JAN	-	-	0.510***

Table 4.9 Spearman correlation coefficients (r_s) between the density of each species in four monthly counts for mudflats within the Outer Forth North during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).

SPECIES	COUNT	DEC	JAN	FEB
SHELDUCK	NOV	0.350**	0.617***	0.703***
	DEC	-	0.411**	0.301*
	JAN	-	-	0.805***
WIGEON	NOV	0.771***	0.496***	0.482***
	DEC	-	0.673***	0.635***
	JAN	-	-	0.396**
TEAL	NOV	.	.	.
	DEC	-	-0.019	-0.027
	JAN	-	-	0.691***
MALLARD	NOV	0.739***	0.515***	0.337**
	DEC	-	0.659***	0.501***
	JAN	-	-	0.485***
OYSTERCATCHER	NOV	0.803***	0.789***	0.708***
	DEC	-	0.742***	0.770***
	JAN	-	-	0.646***
RINGED PLOVER	NOV	0.831***	0.532***	0.555***
	DEC	-	0.581***	0.361**
	JAN	-	-	0.582***
GOLDEN PLOVER	NOV	0.553***	0.310*	0.339**
	DEC	-	0.245	0.645***
	JAN	-	-	-0.075
GREY PLOVER	NOV	0.352**	0.694***	0.638***
	DEC	-	0.420**	0.757***
	JAN	-	-	0.607***
LAPWING	NOV	0.662***	0.570***	0.452***
	DEC	-	0.816***	0.380**
	JAN	-	-	0.504***
KNOT	NOV	0.537***	0.554***	0.487***
	DEC	-	0.370**	0.317*
	JAN	-	-	0.457***
SANDERLING	NOV	-0.019	-0.022	0.298*
	DEC	-	-0.019	0.456***
	JAN	-	-	0.433***
PURPLE SANDPIPER	NOV	0.123	0.142	0.142
	DEC	-	0.749***	0.885***
	JAN	-	-	0.718***
DUNLIN	NOV	0.767***	0.406***	0.553***
	DEC	-	0.393**	0.463***
	JAN	-	-	0.309*
BAR-TAILED GODWIT	NOV	0.789***	0.479***	0.453***
	DEC	-	0.589***	0.376**
	JAN	-	-	0.497***
CURLEW	NOV	0.370**	0.277*	0.262*
	DEC	-	0.309*	0.086
	JAN	-	-	0.252*
REDSHANK	NOV	0.453***	0.498***	0.387**
	DEC	-	0.568***	0.630***
	JAN	-	-	0.433***
TURNSTONE	NOV	0.634***	0.606***	0.582***
	DEC	-	0.715***	0.662***
	JAN	-	-	0.699***

Table 4.10 Spearman correlation coefficients (r_s) between the density of each species in four monthly counts for mudflats within the Outer Forth South during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).

SPECIES	COUNT	DEC	JAN	FEB
BRENT GOOSE	NOV	0.283	0.360	0.361
	DEC	-	0.172	0.328
	JAN	-	-	0.460
SHELDUCK	NOV	0.531*	0.391	0.489
	DEC	-	0.198	0.469
	JAN	-	-	0.626**
WIGEON	NOV	0.619*	0.781***	0.003
	DEC	-	0.655**	0.182
	JAN	-	-	0.434
TEAL	NOV	0.488	0.255	0.382
	DEC	-	-0.200	0.460
	JAN	-	-	0.270
MALLARD	NOV	0.463	0.238	0.879***
	DEC	-	-0.133	0.467
	JAN	-	-	0.249
OYSTERCATCHER	NOV	0.172	0.090	0.500
	DEC	-	0.010	0.000
	JAN	-	-	0.593**
RINGED PLOVER	NOV	0.627*	-0.133	0.556*
	DEC	-	-0.200	0.270
	JAN	-	-	0.604*
GOLDEN PLOVER	NOV	1.000***	1.000***	0.516*
	DEC	-	1.000***	0.507*
	JAN	-	-	0.503*
GREY PLOVER	NOV	0.561*	0.523*	0.588*
	DEC	-	0.537*	0.917***
	JAN	-	-	0.613**
LAPWING	NOV	0.704*	0.799***	0.663**
	DEC	-	0.603*	0.526*
	JAN	-	-	0.697**
KNOT	NOV	.	0.627*	0.619*
	DEC	-	.	.
	JAN	-	-	0.780*
DUNLIN	NOV	0.613*	0.219	0.502
	DEC	-	0.630**	0.661**
	JAN	-	-	0.456
BLACK-TAILED GODWIT	NOV	1.000***	1.000***	0.759***
	DEC	-	1.000***	0.753***
	JAN	-	-	0.750***
BAR-TAILED GODWIT	NOV	.	.	.
	DEC	-	0.480	0.380
	JAN	-	-	0.398
CURLEW	NOV	0.525*	0.195	0.604*
	DEC	-	-0.001	0.336
	JAN	-	-	-0.021
REDSHANK	NOV	0.260	0.579*	0.508
	DEC	-	0.296	0.539*
	JAN	-	-	0.429
TURNSTONE	NOV	0.589*	0.752**	0.553*
	DEC	-	0.447	0.648**
	JAN	-	-	0.156

Table 4.11 Spearman correlation coefficients (r_s) between the density of each species in four monthly counts for mudflats within the NW Solent during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).

SPECIES	COUNT	DEC	JAN	FEB
BRENT GOOSE	NOV	0.528	0.121	-0.136
	DEC	-	0.593**	0.167
	JAN	-	-	0.497
SHELDUCK	NOV	0.734**	0.633**	0.579
	DEC	-	0.658**	0.700*
	JAN	-	-	0.672*
WIGEON	NOV	0.323	.	.
	DEC	-	.	.
	JAN	-	-	.
TEAL	NOV	-0.113	.	.
	DEC	-	.	.
	JAN	-	-	.
MALLARD	NOV	0.754**	0.486	-0.91
	DEC	-	0.170	-0.300
	JAN	-	-	-0.100
OYSTERCATCHER	NOV	0.876***	0.253	0.510
	DEC	-	0.539*	0.729*
	JAN	-	-	0.566
RINGED PLOVER	NOV	0.774**	0.403	.
	DEC	-	0.329	.
	JAN	-	-	.
GREY PLOVER	NOV	0.295	0.492	0.784**
	DEC	-	0.230	0.443
	JAN	-	-	0.371
LAPWING	NOV	0.471	0.592**	0.500
	DEC	-	0.812***	0.750*
	JAN	-	-	0.500
DUNLIN	NOV	0.820***	0.393	0.702*
	DEC	-	0.404	0.409
	JAN	-	-	0.641*
BLACK-TAILED GODWIT	NOV	0.444	0.523*	.
	DEC	-	0.583**	.
	JAN	-	-	.
BAR-TAILED GODWIT	NOV	-0.077	.	-0.100
	DEC	-	-0.050	-0.125
	JAN	-	-	.
CURLEW	NOV	0.593*	0.264	0.564
	DEC	-	0.295	0.745*
	JAN	-	-	0.616*
REDSHANK	NOV	0.815***	0.387	0.545
	DEC	-	0.302	0.783*
	JAN	-	-	0.264
TURNSTONE	NOV	-0.067	0.482	0.259
	DEC	-	0.427	0.380
	JAN	-	-	0.500

Table 4.12 Spearman correlation coefficients (r_s) between the density of each species in four monthly counts for mudflats within the Portsmouth Harbour during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).

SPECIES	COUNT	DEC	JAN	FEB
BRENT GOOSE	NOV	-0.049	-0.093	-0.100
	DEC	-	0.100	0.250
	JAN	-	-	0.491***
SHELDUCK	NOV	0.660***	0.715***	0.752***
	DEC	-	0.898***	0.834***
	JAN	-	-	0.813***
WIGEON	NOV	-0.028	-0.030	-0.047
	DEC	-	0.807***	0.544***
	JAN	-	-	0.672***
TEAL	NOV	-0.028	-0.043	0.433**
	DEC	-	-0.029	0.361*
	JAN	-	-	0.270
MALLARD	NOV	0.527***	0.704***	0.422**
	DEC	-	0.810***	0.604***
	JAN	-	-	0.621***
PINTAIL	NOV	0.480***	-0.030	0.384***
	DEC	-	0.714***	0.825***
	JAN	-	-	0.591***
OYSTERCATCHER	NOV	0.761***	0.656***	0.573***
	DEC	-	0.786***	0.717***
	JAN	-	-	0.649***
AVOCET	NOV	.	-0.021	-0.032
	DEC	-	.	.
	JAN	-	-	0.682***
RINGED PLOVER	NOV	0.376**	0.193	0.106
	DEC	-	0.405**	0.496***
	JAN	-	-	0.114
GOLDEN PLOVER	NOV	-0.081	0.330*	-0.046
	DEC	-	-0.098	0.306*
	JAN	-	-	-0.069
GREY PLOVER	NOV	0.561***	0.770***	0.694***
	DEC	-	0.418**	0.451**
	JAN	-	-	0.744***
LAPWING	NOV	0.510***	0.071	0.291
	DEC	-	0.487***	0.589***
	JAN	-	-	0.428**
KNOT	NOV	0.659***	0.531***	0.405**
	DEC	-	0.594***	0.560***
	JAN	-	-	0.418**
DUNLIN	NOV	0.577***	0.419**	0.598***
	DEC	-	0.619***	0.547***
	JAN	-	-	0.489***
BLACK-TAILED GODWIT	NOV	0.412***	0.474***	0.587***
	DEC	-	0.254	0.353*
	JAN	-	-	0.413*
BAR-TAILED GODWIT	NOV	0.629***	0.501***	0.468**
	DEC	-	0.379**	0.600***
	JAN	-	-	0.321*
CURLEW	NOV	0.440***	0.497***	0.480***
	DEC	-	0.268	0.467***
	JAN	-	-	0.371
REDSHANK	NOV	0.502***	0.570***	0.545***
	DEC	-	0.631***	0.665***
	JAN	-	-	0.656***
TURNSTONE	NOV	0.491***	0.503***	0.420**
	DEC	-	0.624***	0.528***
	JAN	-	-	0.510***

Table 4.13 Spearman correlation coefficients (r_s) between the density of each species in four monthly counts for mudflats within the Swale during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).

SPECIES	COUNT	DEC	JAN	FEB
PINK-FOOTED GOOSE	NOV DEC JAN	. - -	. -0.119 -	. -0.200 0.071
SHELDUCK	NOV DEC JAN	0.207 - -	0.181 0.180 -	0.496* 0.471* 0.202
WIGEON	NOV DEC JAN	0.451* - -	0.650*** 0.207 -	0.262 0.317 0.336
TEAL	NOV DEC JAN	1.000*** - -	0.723*** 0.723*** -	0.722*** 0.723*** 0.500*
MALLARD	NOV DEC JAN	0.300 - -	0.292 0.631** -	1.000*** 0.300 0.292
PINTAIL	NOV DEC JAN	0.657*** - -	0.535** 0.700*** -	1.000*** 0.657*** 0.535**
OYSTERCATCHER	NOV DEC JAN	0.832*** - -	0.807*** 0.890*** -	0.662*** 0.606** 0.612**
RINGED PLOVER	NOV DEC JAN	. - -	-0.066 . -	. . .
GOLDEN PLOVER	NOV DEC JAN	0.450* - -	-0.066 -0.066 -	0.358 0.399 -0.082
LAPWING	NOV DEC JAN	0.357 - -	-0.176 0.263 -	0.079 0.202 -0.295
KNOT	NOV DEC JAN	. - -	. . -	. -0.066 .
DUNLIN	NOV DEC JAN	0.791*** - -	0.125 0.301 -	-0.035 0.117 0.500*
BAR-TAILED GODWIT	NOV DEC JAN	-0.082 - -	-0.082 1.000*** -	0.464* -0.045 -0.045
CURLEW	NOV DEC JAN	0.232 - -	0.399 0.010 -	0.355 0.196 0.275
REDSHANK	NOV DEC JAN	-0.033 - -	0.184 0.507* -	0.487* 0.305 0.307
TURNSTONE	NOV DEC JAN	0.604** - -	0.604** 1.000*** -	. . .

Table 4.14 Spearman correlation coefficients (r_s) between the density of each species in four monthly counts for mudflats within the Wigtown Bay during the 1992/93 winter (*=p<0.05, **=p<0.01, ***=p<0.001).

SPECIES	%
Grey Plover	83.9
Dunlin	83.3
Black-tailed Godwit	77.8
Shelduck	76.9
Oystercatcher	76.2
Redshank	71.4
Bar-tailed Godwit	71.0
Wigeon	70.0
Turnstone	64.1
Lapwing	59.5
Mallard	59.5
Ringed Plover	56.0
Golden Plover	50.0
Teal	47.1
Curlew	45.2

Table 4.15 The percentage of significant results obtained for the spearman rank correlations for each species.

BTO Research Report No. 122
August 1993