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INDICES FOR WATERBIRD POPULATIONS

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Summary

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1. This report reviews methods in use to estimate bird population indices.
2. The major problem with generating indices is the fact that, due to missing observations, the total population size is unknown.
3. The paper suggests a model-based method for imputing missing values so that the total population size at a set of estuaries may be estimated and used to produce an index of the population size. The proposed model is multiplicative: each observation is modelled by the product of three factors, a year factor (the "index"), a site factor and a month factor. The model assumes that the three factors are independent.
4. Bootstrap methods which enable approximate confidence intervals for the indices are devised.
5. The methodology is illustrated by application to winter surveys conducted by the Birds of Estuaries Enquiry of the British Trust for Ornithology. Three species were chosen to illustrate the methods: Grey Plover *Pluvialis squatarola*, Dunlin *Calidris alpina* and Curlew *Numenius arquata.*
6. The results show that indices based on a single count per year cannot be considered as representative of the winter as a whole.
7. More reliable indices are obtained by basing the index on an appropriate group of months. Because fewer BoEE surveys are conducted at the beginning and end of winter, a balance has to struck between an index that integrates bird numbers over an extended period, and imputing a large proportion of missing observations.
9. By-products of the indexing methodology are site factors and month factors, which can be used to produce politically defensible estimates of the relative importance of an estuary over extended periods, and to discuss migration phenology. The month factors may also be used to aid the decision as to which months to include in the index for a particular species.
10. The results suggest that the assumption of independence made in the model is tenable. Departures from this assumption can be examined by analysing patterns in the residuals.
11. Even though missing observations can be imputed, every attempt should continue to be made to encourage observers to complete surveys on as many of the BoEE monthly count dates as possible. The motivation for doing so is strengthened by the knowledge that all winter surveys, not only the January survey, can be used in computing the annual indices.
12. The indices reported in this paper are for purposes of illustrating the methodology only. Extensive rechecking of the data base will be undertaken before a new series of wader indices is published.

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INTRODUCTION

In the context of bird populations, an index number may be defined as a measure of the population size in one year, the arbitrarily chosen (or reference) base year, relative to the population size in another year. This is the ideal. However, there are very few situations where a total census of a bird population can be achieved. Instead, sample counts are made from which one can derive an index of the population size which, one hopes, is directly related to the total population. Changes in these indices then tell us the pattern of population change. Fortunately, because waterbirds (waders, ducks, geese, swans, flamingos, pelicans, etc) are generally confined to a finite number of fairly discrete sites, the problems of estimating total population sizes for these species are less difficult than for, say, most passerine species.

The Birds of Estuaries Enquiry (BoEE) of the British Trust for Ornithology (BTO) and the National Wildfowl Counts of the Wildfowl and Wetlands Trust coordinate surveys of waterbirds in the United Kingdom (UK), mostly by amateur ornithologists, and have produced annual indices of numbers of waders wintering in the UK dating back to 1970/71 and of ducks and geese dating back to 1960/61, respectively (see, for example, Prater (1979b), Owen *et al.* (1986), Salmon *et al.* (1988)). The International Waterfowl and Wetlands Research Bureau (IWRB) has computed trend indices for swans, ducks and Coot *Fulica atra* wintering in the western Palaeartic and west Africa (Rüger *et al.* 1986; Monval & Pirot 1989). These indices have been calculated using a method developed by Ogilvie (1967) for Mute Swans *Cygnus olor*. Although the spirit of Ogilvie's method is to produce an index number in the sense defined above, it has several shortcomings which will be discussed later.

The emphasis in this paper is on the development of a new set of indices which makes efficient use of waterbird survey data. The index proposed in this paper may be interpreted in exactly the same way as Ogilvie's index. The examples in the paper use data sets drawn from the BoEE wader surveys. The new indices are suitable for counts of waterbirds at both national and international levels.

REVIEW OF RELATED METHODS

There is an extensive literature on methods for monitoring trends in bird populations and some of the associated issues. Those papers which deal with indices for either waterbird populations or other BTO projects are briefly reviewed here. Also mentioned are papers which show some of the uses to which these indices have been put.

The need for such monitoring methods was discussed by Hinds (1984): the primary motivation is the detection of long-term, often slow-paced and, possibly, subtle changes in ecosystems. He considered that one of the major difficulties in detecting such changes, in the statistical sense, was the large amount of sampling effort required on account of the small signal-to-noise ratio in most ecological data sets.

Geissler & Noon (1981) pointed out some inadequacies of the methods being used at that time to compute population change from surveys conducted for the North American Breeding Birds Survey. These methods were very similar to Ogilvie's index. They introduced several methods of computing index numbers for bird populations. These methods of been further developed in Geissler (1984) and Geissler & Link (1988). Howe, Geissler & Harrington (1989) applied the methods of Geissler & Noon (1981) to censuses conducted by the International Shorebird Survey in order to obtain estimates of population trends in North American passage waders.

The index for the BTO Common Birds Census (CBC) (Marchant 1983) is also computed using Ogilvie's method. Since near its inception the CBC has reported 95% confidence limits for its indices, i.e. upper and lower bounds which cover the true value of the index with 95% probability (Taylor 1965; Bailey 1967; Marchant & Whittington 1989). Upton & Lampitt (1981) showed that the cluster sampling method for computing these confidence limits (Bailey 1967, Appendix (iv)) is incorrect, and suggested an alternative method. North (1977, 1979, 1983) has developed methods for estimating numbers of bird territories on CBC plots. Similarly, Ogilvie's method is used to compute an index for the BTO Constant Effort Sites (CES) scheme (Baillie *et al.* 1986) by considering ratios of adults trapped in successive years. Baillie *et al.* (1986) have developed confidence limits for the CES indices using the ratio sampling method (Cochran 1963). This method for computing confidence intervals is also more appropriate to the CBC than Bailey's (1967) method. No attempt has been made to find confidence limits for the indices for waterbirds covered in the BoEE and the National Wildfowl Counts.

Hinds (1984) emphasized the importance of considering the sampling variability of the data collected by a monitoring programme. No estimates have been made of the precision of BoEE censuses, in the sense of obtaining replications of the censuses. However, some work has been done on comparing the BoEE censuses, which are conducted at spring high tides, with low tide surveys of feeding birds on the same estuaries. A variety of studies have shown that, for waders at least, there is in general good agreement between counts made by BoEE observers at high tide and counts, often made by professional ornithologists, while waders are feeding at low tide (e.g. Goss-Custard 1981; Clark 1989).

Hale (1974) compared counts made by observers on the ground with counts made from a simultaneous aerial photograph: experienced obsevers underestimated flock sizes by about 5%, but larger underestimates were made by less experienced observers. Matthews (1960) and Prater (1979a), in experiments in which observers were asked to estimate the number of birds on a photograph in 30 seconds, both found that flocks of between 100 and 1000 were underestimated by, on average, 8%. It is questionable whether Matthews' and Prater's experiments are relevant to field conditions: although observers do have to make snapshot estimates of the species and numbers of birds in flying flocks, most of the counting is of roosting flocks where deliberate and careful counts may be made and checked, either by recounting or with a co-observer. In the Netherlands, Rappoldt *et al.* (1985) also found that observers tended to underestimate flock sizes, but in their study this was not statistically significant. In their study, several observers counted flying and sitting flocks of waders. The accurate flock sizes were then obtained for flying flocks by photography and for sitting flocks by afterwards counting birds leaving the high tide roost in small groups that could be accurately counted. They estimated that the coefficient of variation for counts of single flocks of flying shorebirds was 17%, and for single flocks of sitting shorebirds was 37%.

An issue addressed by Matthews (1960) was that of the reliability of a monthly count (made on a predetermined date) in comparison with a series of more frequent counts. For seven species of waterfowl at Durleigh Reservoir, Somerset, he found that, on average, the monthly count deviated from the mean of the counts made within the month by between 25% and 50%. For Wigeon *Anas penelope*, the mean of the coefficients of variation within months was 88% at Durleigh Reservoir, whereas for Mute Swan it was 24%. Short term instability of population sizes therefore varied considerably between species, although Matthews warned that results from one site need not be typical of all. However, this apparent unrepresentiveness of monthly counts is a potentially serious problem, and, as pointed out by Matthews (1960) and O'Connor (1989), requires further investigation.

Rappoldt *et al.* (1985) examined the variability in large-scale counts of waterbirds, in which the counts of many flocks are added to form a total for a region. They found that the coefficient of variation of the total was much less than that of individual flocks, so that, for the more abundant species, the coefficient of variation for wader counts over the Dutch Wadden Sea was between 5% and 10%. Similar results are likely to hold for surveys conducted by the BoEE, IWRB and the Wildfowl and Wetlands Trust.

However, Rappoldt *et al.* (1985) failed to address one serious problem which, if it occurs, consistently leads to counts of waders being underestimates. That is the problem of flocks being overlooked completely (Prater 1981; Prater & Lloyd 1987). This may be due to many factors: a flock that normally roosts within an estuary may occasionally roost outside it (in a field or on the open shore); a flock might be disturbed and fly off the estuary without the observer being aware of this; an inexperienced observer may not find all the roosts in an estuary; an experienced observer may consider that he/she knows all potential roost sites and hence does not cover the entire area, thus missing flocks that roost in unusual situations. In large wetlands, such as the Wadden Sea, the location of roosts depends on water levels reached at high tide and weather conditions may prevent observers reaching some of the roosts (Smit 1984). The converse problem of double-counting flocks is one that observers are very aware of and studiously avoid, although there can be no doubt that double-counting does, on occasions, occur. The general consensus regarding counts of waders at estuaries is that they tend to underestimate actual population sizes, but that the relative error is probably less then about 10%, on average. It is therefore probably safest to treat a count as a minimum estimate of the number of birds present during the survey. Moser (1988) and Goss-Custard & Moser (1988) took this approach to its logical conclusion and used the maximum count at an estuary during a given winter to assess the size of the population at the estuary for the winter. However, they pointed out their use of the maximum count put them at risk to errors caused by short-term influxes of birds. The approach taken in this paper is to use the information in all the counts; however, the algorithm described in this paper tends to down-weight the importance of small counts at estuaries, and to give somewhat greater importance to the large counts.

Matthews (1960), Summers *et al.* (1984) and Spearpoint *et al.* (1988) showed that some waterbird species can be counted more accurately than others. In particular, conspicuous, large and boldly marked species are more precisely counted than more cryptic species. The most unreliable counts are those of species that occur as minorities dispersed through mixed-species flocks. This supports the BoEE practise of producing indices only for the more common species.

In the context of the BTO CBC, Mountford (1982, 1985) developed a model for territory occupancy by a species, and from it derived an annual index. Mountford had to overcome a problem which is crucial to the CBC, but less relevant to estuary surveys. The turnover of CBC sites results in few being surveyed for more than several years in succession. In contrast, essentially the same set of estuaries have been surveyed for the BoEE since its inception, so that turnover of survey sites is not a consideration. However, estuaries are sometimes drastically altered by land claim, major pollution incidents, floods and other causes.

Mountford also considered that the high degree of site fidelity to nesting territories, and the relative constancy of the territories themselves, meant that the serial correlations between successive annual surveys needed to be modelled. The way in which the indices for the CBC have continued to be calculated does not take possible serial correlation into account. It is well known that wintering waders also tend to be site faithful (e.g. Symonds *et al.* 1984; Symonds & Langslow 1986; Evans & Townshend 1988). However, although many return to the same estuary each year, there are many records of movements between estuaries both between years and within a single winter. Waders are clearly not tied to a particular estuary in the same way as a breeding bird is to its territory and can readily move in response to disturbance, weather conditions and food availability. In addition, there are varying proportions of juveniles in the population each year seeking wintering grounds. It is thought that these birds show mobility between sites during winter (Hale 1980). Serial correlation is probably a second order effect in comparison with errors of counting and the short term variability in numbers produced by movements of birds (as described by Matthews (1960) for waterfowl). Serial correlation is therefore unlikely to be a serious problem in monthly surveys of waterbirds: however, further research on this matter is required.

BoEE indices have recently been used as input data to papers in population ecology (Goss-Custard & Moser 1988; Moser 1988). Goss-Custard & Moser (1988) related the change in the index for Dunlin *Calidris alpina* in Britain to the spread of cord grass *Spartina anglica*. Moser (1988) considered the three-fold increase in the Grey Plover *Pluvialis squatarola* index between 1970 and 1986, relating it to the numbers of Grey Plovers at individual estuaries. Those estuaries at which the numbers of Grey Plovers remained approximately constant were adjudged to be approaching carrying capacity.

METHODS

Definition of an index number

Let x_{ijk} be the count of the number of birds at locality i in year j and month k, where $i = 1, 2, \ldots, I$, the number of localities, $j = 1, 2, \ldots, J$, the number of years and $k = 1, 2, \ldots, K$, the number of months for which data are available. Suppose we designate year b as the base year, $1 \leq b \leq J$, and select a subset of N months $\{k_1, k_2, \ldots, k_N\}$. Then we define the population index number for year j relative to base year b, using months $k_1, k_2, \ldots, k_N$, to be

$$P_j^{(b)(k_1,k_2,\ldots,k_N)} = \frac{\sum_{i=1}^{I}\sum_{n=1}^{N} x_{ijk_n}}{\sum_{i=1}^{I}\sum_{n=1}^{N} x_{ibk_n}} .$$

For the purpose of this paper, the base year was chosen to be $b = 1972/73$, the base year traditionally used by the BoEE. The indices computed will use selections of the six late autumn and winter months, October (1), November (2), December (3), January (4), February (5) and March (6), assigning to each month the number in parentheses. To illustrate the methods, indices will be computed for each of the months separately ($N = 1$), for the midwinter months (December–February) ($N = 3$),and for the five winter months (November–March) ($N = 5$). To avoid the double subscript notation in development of the algebra, we will assume that $K = N$ and the notation for the index number for year j will be P_j. This will cause no ambiguity because, for each series of index numbers computed in this paper, the number of months N and the selected months k_1, k_2, $\ldots$, k_N will be clear from the context.

Difficulties with the definition

In relation to the BoEE data, there are, however, three problems with the above definition of an index number.

Firstly, the BoEE surveys waders only at estuaries in the UK, and not throughout their entire wintering range. Waders in other habitats are not accounted for, e.g. Oystercatchers, Redshanks and Curlews in fields, and Purple Sandpipers on the open shoreline (Moser 1987; Prater & Lloyd 1987). During cold weather, waders of some species may leave estuaries, moving either inland or to estuaries further south in Europe; likewise, other waders may move to UK estuaries in response to weather conditions in continental northwestern Europe. Thus the size of the population that can be indexed by the BoEE surveys is not the total size of the population of the species, but that part of it that is present on British estuaries during the N months selected for the index computations.

Secondly, not all estuaries are surveyed in each of the winter months and some are not surveyed at all during a given winter. Therefore the total population size at any one time is unknown. Smit (1984) showed that comparison of totals of available counts can give a misleading or distorted impression of the true changes in the size of a population. A way to overcome this problem is to impute missing counts from the available counts, using some suitable model. The method used in this paper for imputing missing values is based on that of Greenacre (1984, sections 8.5 and 8.8.3). It makes use of the principle underpinning the E-M (expectation-maximization) algorithm (Dempster, Laird & Rubin 1977) and is closely related to the iterative proportional fitting algorithm (Bishop *et al.* 1975, sections 3.5, 5.2.5; Fienberg 1971). The idea of imputing missing counts in the production of bird population indices is not new. Geissler & Noon (1981) adopted this strategy for indices for the North American Breeding Bird Survey, so that the omission of sites in a particular year does not bias the annual indices. O'Connor (1989), reviewing Owen *et al.* (1986), also suggested that missing counts should be estimated using a statistical model.

Thirdly, not all surveys are complete. An incomplete survey may be the result of one or more subsections of the estuary not being covered, of poor visibility, or of disturbance to flocks of roosting waders by people, animals, vehicles or boats. Even though a survey as a whole may be classified as incomplete, the count totals for some species may be good estimates of the number of birds present, and may, on occasions, be the maximum count obtained during the winter (R.P. Prŷs-Jones pers. comm.). Although such incomplete surveys constitute only a small percentage of the BoEE database, it is therefore important to consider how information in this category of count may be used.

A model for the counts

The fundamental assumption which will be used in imputing missing values is that the number of birds of any species at an estuary in a particular year and month can, apart from a random deviation, be modelled by the product of three factors, a site factor, a year factor and a month factor. Further, we assume that the site factors do not change over time, and that the month and year factors are the same for all sites. These are strong assumptions, and will be considered further in the Discussion. However, it needs to be kept in mind that they are only being used for imputing missing counts which constitute a small part of the total number of counts.

Algebraically, the assumption of multiplicity may be expressed by writing the expected value of x_{ijk} as

$$\mathrm{Exp}(x_{ijk}) = s_i \times y_j \times m_k,$$

where $i = 1, 2, \ldots, I$, $j = 1, 2, \ldots, J$ and $k = 1, 2, \ldots, K$. In this multiplicative model, s_i is the factor for locality i, y_j is the factor for year j, and m_k is the factor for month k. In order to determine s_i, y_j and m_k uniquely, it is necessary to place two constraints on these parameters (otherwise for any constants α and β, the product of $\alpha\beta s_1$, y_j/α and m_k/β would also equal $\mathrm{Exp}(x_{ijk})$). These constraints may be chosen fairly arbitrarily: for the sake of continuity with the previous BoEE index, we choose 1972/73 as the base year and January as the base month, i.e. $y_b = y_{1972/73} = 1$ and $m_4 = m_{\mathrm{January}} = 1$. Then s_i may conveniently be interpreted as the expected count in the base year and month at locality i. The expected count at locality i in January of year j is then simply $s_i y_j$.

Because the x_{ijk} are counts, they are likely to have, at least approximately, a Poisson-like distribution. Because of the nonrandom spatial distribution of waders on an estuary, overdispersion (McCullagh & Nelder 1983) seems a certainty: i.e. the variance of the counts is likely to be much larger than the mean (rather than equal to it, as is the case with the Poisson distribution). We assume that the overdispersion factor is a constant multiple D of the mean, so that

$$\mathrm{Var}(x_{ijk}) = D\mathrm{Exp}(x_{ijk}) = Ds_i y_j m_k.$$

The overdispersion parameter plays no role in the method of imputing missing values, and can be estimated separately (see McCullagh & Nelder 1983, 6.2.3).

Estimation of the parameters by both the method of maximum likelihood and by weighted least squares is asymptotically equivalent. McCullagh & Nelder (1983, 6.2.1) show that (1) is an approximation of the Poisson log likelihood function. Suppose, firstly, that there are no missing values. The estimates of s_i, y_j and m_k are those that minimize

$$E = \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K} \frac{(x_{ijk} - s_i y_j m_k)^2}{Ds_i y_j m_k}. \qquad (1)$$

Each term in this sum is the square of the standardized difference between the observed census and the expected value: the formula for the standardized difference being

$$\frac{\text{observed census} - \text{modelled value}}{\sqrt{\text{variance}}}.$$

There is a close analogy with the calculation of the chi-squared test statistic. It is straightforward to show that the maximum likelihood estimates of s_i, y_j and m_k which minimize E, subject to the two constraints, are

$$s_i = \frac{x_{i++}x_{+b+}x_{++4}}{x_{+++}^2}$$
$$y_j = \frac{x_{+j+}}{x_{+b+}}$$
$$m_k = \frac{x_{++k}}{x_{++4}},$$

where the plus notation is used to denote summation over the subscripts replaced by the plus signs, e.g. $x_{i++} = \sum_{j=1}^{J}\sum_{k=1}^{K} x_{ijk}$. Note that, as a result of the choice of constraints, $y_j = P_j$, the index for year j, as defined above. The expressions for y_j and m_k are intuitively obvious. The expression for s_i needs to be thought of as the total number of birds observed at site i (x_{i++}), multiplied by the proportion of the grand total observed in the base year, 1972/73, ($\frac{x_{+b+}}{x_{+++}}$) and multiplied by the proportion of the grand total observed in month 4, January, ($\frac{x_{++4}}{x_{+++}}$). Then s_i may be interpreted as the proportion of the total number of birds counted at site i that ought to have been present in January of the base year, assuming the multiplicative model to be correct.

Imputing missing values and using values obtained during incomplete counts

Now suppose that we have missing counts and counts from incomplete surveys. The procedure for finding the "best" values to impute is an iterative algorithm (several steps are performed repeatedly until there is no further change in the imputed values and the algorithm is said to have converged). Based on the above discussion of incomplete surveys, and the fact that even nominally complete surveys tend to underestimate population sizes, the criterion for using a count for a species made during an incomplete survey is that it should exceed the value that would be imputed if the count were missing. At each iteration of the algorithm, each incomplete count is compared with the associated imputed value, and the larger of these two values is used. This rule introduces an upward bias into the estimates of population size, because some of the incomplete counts with values smaller than the imputed value are in fact correct. However, the bias introduced in this way is small for two reasons: incomplete counts are relatively few in number, and, assuming the imputed values to be unbiased, the error of replacing a correct small count by a larger imputed value will occur on average in less than half of the incomplete counts.

The step-by-step procedure for imputing missing values and dealing with incomplete counts is as follows:

1 For each missing count, insert an arbitrary number. If these inserted values are fairly close to the "best" value, fewer iterations of the algorithm will be needed to achieve convergence. It is suggested that each missing value is replaced by the mean of all available counts at the estuary.

2 Estimate the values of the parameters s_i, y_j and m_k, as described above.

3 Impute new values for each of the missing counts

$$x_{ijk} = s_i y_j m_k.$$

4 For each of the counts from incomplete surveys, compare the count with the imputed value and let x_{ijk} be the larger of these two values.

5 Iterate steps 3 to 5 until the successive imputed values of x_{ijk} are practically the same. Steps 2 and 3 are respectively the maximization and expectation steps of the EM algorithm.

Table 1 contains an example, for one estuary, of how the algorithm iteratively imputes missing values.

Once convergence has been achieved, the final value of y_j is the required index P_j. It is a ratio, the numerator being the grand total of the numbers of birds actually counted plus the imputed counts at all estuaries in the chosen months, and the denominator being the similar total for the winter 1972/73.

Application of bootstrap methods

Approximate confidence intervals for the indices may be found by bootstrapping (Efron 1979, 1982). Bootstrap procedures have proved themselves extremely powerful in generating confidence intervals in many situations when the conventional asymptotic theory of normality breaks down. This method has already been used for deriving confidence intervals for waders by Howe *et al.* (1989): the procedure described here is similar to that used by Howe *et al*; their description is too succinct to determine if the methods are identical. The bootstrap confidence intervals may be computed as follows:

1. Draw, *with replacement*, a random sample (a bootstrap sample) of I estuaries from the population of I estuaries that have been used to compute the index. Suppose that the random sample consists of the estuaries i_n, $n = 1, 2, \ldots, I$. If you think in terms of rolling an I-sided die I times, the i_nth estuary is selected by the nth roll of the die. Sampling with replacement means that the bootstrap sample may include some estuaries more than once and others not at all. Each element of the random sample consists of a series of J values $x_{i_n j+}$, $j = 1, 2, \ldots, J$, the number of birds at the i_nth estuary summed over the K months for which the index has been computed.

2. Compute the proportions of birds in the bootstrap sample for each year: call these values p_j, $j = 1, 2, \ldots, J$:

$$p_j = \frac{\sum_{n=1}^{I} x_{i_n j+}}{\sum_{n=1}^{I} \sum_{j=1}^{J} x_{i_n j+}}.$$

3. Repeat steps 1 and 2 are large number of times, say, M times, producing proportions p_{jm}, $j = 1, 2, \ldots, J$, $m = 1, 2, \ldots, M$.

4. Sort the p_{jm}'s belonging to each year j from smallest to largest.

5. It is now easy to compute the percentiles of the sorted p_{jm}'s, for each year. For, say, 90% confidence intervals, the lower and upper 5% percentiles are required: call these values $p_j(l)$ and $p_j(u)$, $j = 1, 2, \ldots, J$.

6. Divide the lower and upper percentiles by $p_b = \frac{x_{+b+}}{x_{+++}}$ to convert them to confidence limits relative to the chosen base year. The conversion to the base year needs to done at this stage, otherwise there is no confidence interval for the base year.

The pseudo-random number generator used to produce the bootstrap samples is that described by Wichmann & Hill (1982): this generator has been chosen because it is machine independent; i.e. given the same random "seeds", it will produce the same series of random numbers on any computer. For the examples described in this paper, $M = 1\,000$, that is, $1\,000$ bootstrap samples were taken.

Imputed values conform to the multiplicative model and contain no random deviations from that model. Therefore, if the procedure is used on data sets that include large numbers of imputed values, the confidence limits computed by this algorithm will tend to be optimistic, that is, the confidence interval will be shorter than its true value. Thus the confidence limits for a particular year need to be interpreted in relation to the proportion of birds imputed in that year: if the proportion exceeds, say 20%, the confidence limits may be misleading. Extensive simulation studies are necessary before firmer guidelines for interpreting the bootstrapped confidence limits can be given.

There are philosophical difficulties over the bootstrap procedure (S.T. Buckland *in litt.*). The method described above effectively assumes that estuaries included in the index form a random sample from an infinite set of estuaries, and is in fact more appropriate for producing bootstrap confidence intervals for CBC, where the selected sites may be considered a random sample from an infinite set of sites. The direction of the bias in the above procedure is to overestimate the length of the confidence intervals (S.T. Buckland *in litt.*). A more correct approach is to condition on the set of estuaries and to bootstrap the residuals (the difference between the observed counts and the modelled values). This is done by adding the bootstrapped residuals to the modelled values for the set of estuaries. However, this approach assumes constant error variance. Although this problem can be overcome by having a model structure for the residuals, it is not obvious what model structure would be a realistic choice. Further research in this area is required.

There are also philosophical difficulties with the concept of attaching confidence limits to a total that amounts to a census. The justification for computing confidence intervals is that they reflect the extent of the uncertainty about the true population sizes. The bootstrap procedure produces confidence intervals which may be interpreted as measuring the consistency of the change of population levels across all the estuaries included in the index computations.

Following the lead taken by Hinds (1984), 90% confidence limits have been computed. Hinds discussed the balance that needs to be struck between Type I and Type II errors and considered that, because of the inherent variability of most ecological data, the probabilities of making these errors should be set at 10% (or even higher) for ecological monitoring purposes. In this context, a Type I error is to decide that the population of a species at British estuaries has declined (or increased) when in reality it has not, and a Type II error is to decide that the population has not changed when, in reality, it has decreased or increased. Setting the probability of a Type I error at the more traditional values of 1% or 5% increases the probability of a Type II error, so that only massive changes are detected.

While the bootstrap algorithm is in progress, it is easy to count the number of bootstrap samples (out of M) for which the total number of birds for year j_1 exceeds that of year j_2 . This count, divided by M , gives the relative frequency, in the bootstrap samples, with which the population in year j_1 exceeded that in year j_2 . Whether this relative frequency may strictly be interpreted as a probability is a moot point, but it does provide a quantity analogous to a P -value for testing the null hypothesis that there has been no change in the number of birds of a species between any pair of years.

Some implications of the methodology

The terms $\frac{(x_{ijk} - s_i y_j m_k)^2}{D s_i y_j m_k}$ in the sum

$$E = \sum_{i=1}^{I} \sum_{j=1}^{J} \sum_{k=1}^{K} \frac{(x_{ijk} - s_i y_j m_k)^2}{D s_i y_j m_k}$$

can be used to investigate which of the census counts are possible outliers: counts which are so exceptionally large or small that they draw attention to themselves as unlikely values. A rule can be set up to decide which counts are sufficiently unusual to be worth following up with the observer to see if there is a possibility of error.

It is at this point that it becomes clear that the procedure described above attaches greater weight to large counts than to small counts at an estuary in a given month. This is because each of the squared residuals in the sum is divided by the modelled value (rather than by the observed count, or the average of these quantities). Suppose the observed count differs from the modelled value by some fixed amount: if the observed value is less than the modelled value, the contribution to the sum is smaller than if the observed value is greater than the modelled value. For example, suppose an observed count of 200 is associated with a modelled value of 300; the contribution to the sum $(200 - 300)^2/300 = 33.3$, less than the contribution of 50 if the observed count is 300 and the modelled count is 200.

Although the main thrust of this paper has been the use of the year factors to index the trend in the population size, the site and month factors also provide useful insights. The month factors may be used to describe the overall pattern of seasonal change. The site factors provide information on the long-term relative importance of the estuaries. The bootstrap methods described above to produce confidence intervals for the year factors can be adapted to provide confidence intervals for the site and month factors. The factors can also be combined in useful ways. For example, a product of the three factors can be used to give an estimate of the current number of birds of a species at an estuary in a particular month. Currently, such estimates are based on averages of maximum counts, and may be criticised on the grounds of being based on freak and atypical concentrations of waders at an estuary. The model provides an objective, politically defensible, method of arriving at such estimates, making use of all available data: if the current year is year J , then

$$x_{iJ4} = s_i \, y_J \, m_4$$

is an estimate of the January population in the current year. These estimates may be used for determining if the estuary qualifies as a wetland of national or international importance (Salmon *et al.* 1988). If it is considered undesirable that these estimates should include early counts, they may be recomputed using only, say, the most recent five years data.

The month factors provide a measure of the long-term pattern of arrival and departure of the migrants at the estuaries. These may be also used in an exploratory analysis to determine which group of months is the most appropriate for the index for each species. Clearly, one wishes to base a winter index on the group of months in which the population may be considered stable (Spearpoint *et al.* 1988).

One of the consequences of the proposed algorithm for computing indices is that all previous indices are recomputed each year and consequently may change. The reason for this is that each extra year's data has an influence on the imputation of missing values in all previous years. The changes to past indices should be relatively small: a large change would indicate a breakdown of the underlying multiplicative model.

Results

Imputing missing values

The working of the iterative algorithm to impute the missing values is illustrated in Table 1. Of the 57 possible mid-winter surveys for December, January and February between 1969–70 and 1988–89, there were 13 missing counts for Dunlin at The Wash (Table 1). Initially, these 13 values were replaced by the mean of all the remaining counts, which was 30200. The imputed values after four iterations of the algorithms are shown: they are close to the final values obtained after eight iterations, after which no further change took place (Table 1). Those counts which are unexpectedly high or low, in comparison with the modelled value, have +, ++ or − signs to their right in Table 1. The criterion for flagging counts + or − is that their contribution to the sum in equation (1) exceeds 40; counts flagged ++ contributed more than 80 to the sum. These counts may need to be scrutinized further.

Outline of results

Tables 2–7 give a variety of indices and associated results for Grey Plover, Tables 8–12 results for Dunlin and Tables 13–17 results for Curlew *Numenius arquata.* Tables 18–20 give relative frequencies, in the bootstrap samples, with which the population in one year was greater than that in another year, for these three species respectively. Table 21 gives a set of month factors for these species. These three species were chosen to illustrate the method because they are known to represent a species which has increased greatly in abundance at British estuaries (Grey Plover (Moser 1988)), a species that has declined (Dunlin (Goss-Custard & Moser 1988)) and a species with a BoEE index that has shown relatively moderate variability (Curlew). These species also represent different dispersion patterns across the estuaries (Moser 1987, Fig. 3): the Grey Plover population is concentrated at fewer estuaries than that of Dunlin, whereas Curlews are more evenly dispersed over a large number of estuaries.

The index numbers (also referred to as the year factors) in all the tables are printed in boldface type. To the right of the index number, in parentheses, the percentage of birds imputed by the iterative algorithm for that index number is given. Below the index number are given the lower and upper limits for a 90% confidence interval.

Indices based on one count per year

Separate, single month indices for Grey Plover for each month between October and March for the periods 1969/70 to 1988/89 and 1970/71–1988/89 are given in Tables 2 and 3, respectively. The indices based on a single month show considerable variability for each year. For example, in Table 2, if the choice of a single midwinter month on which to base the index had been December, the Grey Plover index would have reached 540.7 (90% confidence limits 447.6 to 627.6) in 1988/89, whereas with a choice of January, it would have reached 408.2 (90% limits 340.7 to 461.8). The indices in Table 2 are based on differing numbers of sites: the criterion for a site being included in the index for a particular month is that it had to have counts in at least 50% of the years, i.e. in 10 of the 20 years 1969/70 to 1988/89. The number of sites included varied between 74 (for October) and 94 (for January) (Table 2).

In spite of the fact that over 80% of the birds were imputed for each month of 1969/70, the indices in Tables 2 and 3 are very similar. The largest discrepancy is in the index based on February counts: including the 1969/70 counts, the index was 385.9 in 1988/89 (Table 2), but excluding this start-up year, the index was 365.6 in 1988/89 (Table 3), a relative difference of 6%. However, the indices based on November and December counts are nearly identical (Tables 2, 3). In a year in which few censuses were made, such as 1969/70, and a large number of missing values have to be imputed, those few counts which have been made play a key role in imputing the missing values for the year. Because of the iterative nature of the algorithm, this small number of counts has a disproportionate influence on imputing missing values in all years. Thus a few exceptional counts in a year with few counts can have a considerable impact on all the indices. For this reason, the 1969/70 counts have been omitted from all subsequent index calculations.

Tables 8 and 13 show the single-month indices for Dunlin and Curlew, respectively. If the Dunlin index had been based on December counts alone, rather than January counts, peak Dunlin numbers would have been reported in winter 1974/75 rather than in 1972/73. Of the 18 comparisons that can be made between successive years, the December and January indices moved in the same direction 11 times and in opposite directions seven times (Table 8). For the three midwinter months, December, January and February, the indices for Curlew show a generally similar pattern (Table 13).

Tables 2, 3, 8 and 13 should **not** be used to compare relative abundance within a year. For example, in Table 3,the drop in the Grey Plover index from 214.0 in December 1977 to 95.6 in January 1978 does not necessarily indicate that the population decreased by 55% over the month. This interpretation is incorrect because both the December index and the January index have been set to 100 for winter 1972/73, and thus do not take into account differences in the population sizes between months in the base year.

Overall, the message of Tables 3, 8 and 13 is that indices based on counts in a single winter month cannot be considered to be representative of the winter as a whole. Indices based on a group of months are likely to be more reliable because they are based on several counts at each site during the winter. They are less likely to influenced by unusual counts caused either be severe weather (which would tend to influence many counts) or an exceptional influx or egress of birds at a site (which may influence only a single count).

Indices based on groups of months

Table 4 shows the effects, for Grey Plovers, of combining the winter months in various ways. The shortest confidence limits for all years except 1980/81 are obtained with either the November–March index (13 times) or the December–February index (5 times). Comparison of Tables 3 and 4 shows that, although the indices have been based on differing numbers of localities, and are not strictly comparable as discussed above, the index obtained when months are grouped (Table 3) is, in almost all cases, close to the average of the single months in the group (Table 3). For example, the average of the five single month indices from November to March in Table 3 for Grey Plover in 1988/89 is 468.3, close to the November–March index of 457.1 (Table 4). Similarly, for 1988/89 the average of the three single month indices from December to February is 435.4, compared to the December–February index of 434.4 (Tables 3, 4).

Tables 9 and 14 give analogous results for Dunlin and Curlew, respectively. For Dunlin, the November–March index is very similar to the December–February index, but both differ substantially from the January index (Table 9). For Curlew, all three indices tend to agree closely (Table 14). Table 10 shows the modelled number of Dunlin in January 1989 at selected estuaries for the indices of Table 9. Regardless of the number of months over which the index is computed, the modelled number of Dunlin at each estuary is similar. The exception is the larger value for the Wash for the index based on surveys for the whole winter period November–March (Table 10). It is likely that this is related to the fact that Dunlin populations cannot be considered stable in March (Table 21).

BoEE observers have tended to regard the survey in January as being of the utmost importance, both because it has been the one upon which the BoEE index has traditionally been based, and because it corresponds to the time of the major international count effort. The midwinter months, December to February, have been promoted as priority months (e.g. Marchant 1982), and at most estuaries surveys are made in these months. Fewer estuaries are regularly surveyed in November and March. As a consequence of the way BoEE surveys have been conducted, the overall percentage of imputed birds increases as one goes from the January index to the midwinter index (December–February) to the winter index (November–March) (Tables 4, 9, 14). A compromise has to be struck between an index which is more reliable because it integrates bird numbers over the longest possible period, and the fact that fewer surveys are conducted near the beginning and end of winter and, consequently, a large proportion of birds need to be imputed. In the circumstances, the best decision is probably to base indices on the three midwinter months. Omission of March would also appear recommendable on biological grounds, as a number of species of wintering waders are moving away from UK estuaries back to their breeding grounds at this time. For example, the March index for Dunlin is only 54% of the January index (Table 21). However, there is no reason why the same group of months needs to be chosen for all species; Table 21 also shows that the wintering populations of Grey Plover and Curlew remain stable into March.

BoEE observers should be encouraged to complete as many of the surveys on the dates set down annually as possible. Although this paper is recommending indices in which up to 50% of the counts at a site are being imputed, observers should not take the view that only half the surveys therefore need to be completed. The ability to impute counts should be communicated to the observers as a stop-gap measure, resorted to only in an emergency. The ideal remains to achieve complete coverage of all estuaries in each month of the year. This would enable monthly indices (as in Table 21) to be extended to all 12 months, and facilitate discussion of migration phenology.

Robustness of indices in relation to sites and years

Tables 5, 11 and 15 explore the effect of varying the criterion for a site to be included in the indices in terms of the average number of complete counts per year. These indices are all based on counts in the five winter months (November to March) over the 19 year period 1970/71–1988/89, so the possible total number of counts is 95. If only 19 complete counts are required (an average of one per year) 144 sites are included in the index computations, decreasing to 35 if 76 complete counts are required (an average of four per year) (Tables 5, 11, 15). As the proportion of complete counts required is increased, the overall percentage of imputed birds decreases. For Grey Plovers, this decrease is from 24.5% to 9.2% (Table 5, last line). Similarly, the percentage of imputed birds generally decreases in each individual year as the proportion of complete counts required is increased. Clearly, these two factors are in tension: it is desirable to include as many sites as possible in the computation of the indices; at the same time, one would prefer to keep the number of imputed birds to a minimum.

Table 6 lists the sites that make the largest contributions to each of the indices of Table 5 along with the modelled numbers of Grey Plovers at these sites in January 1989. As the proportion of complete counts required is increased, some of the sites which support the largest numbers of Grey Plovers have insufficient counts to be included in the index (Table 6). For example, at the most important site in Britain for wintering Grey Plovers, The Wash, 60 complete counts (3.2 per year) have been made. The Wash is therefore not included in the indices in the final column of Table 6 which required at least 76 count to have been made. Table 6 shows that if more than 50% complete counts are required for a site to be included in the index, unacceptably many of the important sites for Grey Plover are excluded from the index. Examining the row of totals in Table 6 shows that the modelled number of Grey Plovers at the sites included in the index decreases slowly from 36 266 for the one-count per year index to 32 415 for the 2.5-counts per year index, and then decreases rapidly to 11 966 for the four-counts per year index. The 2.5-counts per year index is based on 86 sites, 58 sites fewer than the one-count per year index. However, these 58 sites only supported *c.* 4000 Grey Plovers. It therefore seems that a sensible compromise between including as many sites as possible in the index and minimizing the number of imputed birds is to use the 2.5-counts per year index, i.e. include all sites for which at least 50% complete counts are available, as was done in Tables 2 and 3.

Tables 7, 12 and 16 demonstrate how indices change as annual data are included or deleted. The columns of Table 7 show series of indices for Grey Plovers as they would have been computed at various stages of the BoEE. The first column shows the indices after the 1979/80 counts were available, the second column shows the indices five years later after the 1984/85 counts, the third column shows the indices after 1987/88 and the fourth column after 1988/89. The final two columns of Table 7 (and Tables 12 and 16) show the indices that would be obtained if only counts made in the last ten years 1979/80–1988/89 and last five years 1984/85–1988/89 are considered, respectively. The 1979/80–1988/89 series of indices have been adjusted to base year 1972/73 to facilitate comparison with the other columns of the table. (The adjustments have been made for the 1979/80–1988/89 indices by letting the 1980/81 index be equal to the average of the other three indices for 1980/81 and for the 1984/85–1988/89 indices by letting the 1984/85 index be equal to the average of the other four indices for 1984/85). Note that these series of indices have not necessarily been based on identical choices of sites: the criterion for the selection of sites for inclusion in the index computation was, in each case, more than 50% complete counts over the period for which each series of indices was computed. Examining the rows of Table 7, the differences between indices for Grey Plovers computed over varying sets of years (and sites) are mostly small, the largest relative difference in the table being 16% between the 1979/80 indices for the period 1970/71–1979/80 and and for the period 1979/80–1988/89. The indices for Dunlin (Table 12) and Curlew (Table 16) show little dependence on the group of years chosen for the index. Table 17 shows the modelled numbers of Curlews at selected estuaries in January 1989. In general, the modelled numbers are similar, regardless of the period of years on which the indices are based. However, it is apparent that numbers of Curlew on the South Solway (Inner) have decreased over time, whereas at the Severn (Gloucester) they appear to have increased (Table 17).

Aids in decision making

Tables 18, 19 and 20 provide aids to help determine whether there has been a significant increase or decrease in a population between years. For example, 86% of the bootstrapped samples for 1971/72 had a larger total population than for 1970/71 (Table 18). As discussed under Methods, these relative frequencies cannot simply be interpreted as P-values in a test of the null hypothesis that the population sizes are equal in two specified years. However, they should provide an objective and politically defensible guide upon which conservation arguments can be based and management decisions can be taken.

Discussion

Ogilvie's index

Ogilvie's (1967) index O_j for year j is based on only one of the winter surveys (by convention, the BoEE index has used the January ($k = 4$) count. Only those sites with complete surveys in consecutive years are used. Algebraically, it may be written as follows. Let

$$Y_j = \sum_{i=1}^{I} x_{ij4}\delta^i_{j-1,j} \quad \text{and} \quad Z_j = \sum_{i=1}^{I} x_{ij4}\delta^i_{j,j+1},$$

and $\delta^i_{j-1,j} = 0$ unless complete January surveys were made in both years $j-1$ and j, in which case it is set equal to one. Y_j is the sum of the number of birds counted at localities in year j for which there are also counts in the previous year, and Z_j the sum of the number counted at localities with comparable counts the following year. The index for the base year is set equal to 100: $O_b = 100$. Then, for years after the base year,

$$O_j = O_{j-1} \frac{Y_j}{Z_{j-1}} \quad \text{for } b < j \leq J$$

and, for years before the base year,

$$O_{j-1} = O_j \frac{Z_{j-1}}{Y_j} \quad \text{for } 1 \leq j < b.$$

Ogilvie's index thus takes no account of the information available from comparisons of counts more than a year apart; if there is a break of one year in the January survey at an estuary, this estuary cannot be used in the calculation of Ogilvie's index for two successive years (as it has to be excluded from both Y_j and Z_{j-1}). Geissler & Noon (1981, Fig. 1) demonstrated in a simulation study that an index which is based only on paired counts in successive years can behave as a random walk, and can show realistic looking trends when none are present. The chief problem with this type of index is that sampling errors tend to accumulate, largely because each index is based only on counts in adjacent years, no account being taken of the information in counts two or more years apart.

Problems with indices based on geometric means

An obvious and attractive alternative to the index proposed here is to take logarithms and convert the multiplicative model into an additive one:

$$log x_{ijk} = \log s_i + \log y_j + \log m_k = S_i + Y_j + M_k.$$

the estimates of the parameters S_i, Y_j and M_k which minimize the sum of squares

$$F = \sum_{i=1}^{I} \sum_{j=1}^{J} \sum_{k=1}^{K} \left(\log x_{ijk} - (S_i + Y_j + M_k) \right)^2$$

are simply the means of the $\log x_{ijk}$ summed over the appropriate subscripts. For example, assuming no missing data, and imposing suitable constraints,

$$Y_j = \frac{1}{IK} \sum_{i=1}^{I} \sum_{k=1}^{K} \log x_{ijk}.$$

Then it might be expected that the exponents (antilogarithms) of the numbers Y_j divided by $\exp Y_b$ (i.e. $P_j^* = \exp(Y_j)/\exp(Y_b)$) would provide a satisfactory set of index numbers. However, these numbers do not satisfy the above definition of an index number because the numerator (and denominator) are not the sum of all the counts. For example, suppose $I = 2$ and $K = 1$, and that we have counts of 700 and 3 000 at the two sites in year j and counts of 100 and 2 000 in the base year. The total population has clearly increased by more than 50% but has not doubled. Then $P_j = (700 + 3\,000)/(100 + 2\,000) = 1.76$, but $P_j^* = \exp(\frac{1}{2}(\log 700 + \log 3\,000) - \frac{1}{2}(\log 100 + \log 2\,000)) = 3.24$. Suppose now that the two sites have 150 and 14 000 birds, respectively, in year j. Clearly, there are now nearly seven times more birds than in the base year. Then $P_j = 6.74$, but $P_j^* = 3.24$, once again! P_j^* is clearly meaningless as an index, suggesting in both cases that the population has more than trebled in size! The fault lies in the fact that it has averaged the information that at one site the population has increased by 600% and at the other site by 50%. Indices based on this concept of converting to additivity by taking logarithms (or equivalently, of finding geometric means) are not only misleading but dangerous if conservation decisions are based on them. Some of the indices developed by Geissler & Noon (1981), and applied in Howe *et al.* (1989), have this problem.

However, there are situations in which geometric means are useful. For example, in the CBC, it might be desirable to give each site equal importance, regardless of the size of the area surveyed. In such a case, the result described in the example would be exactly what is required.

Consideration of assumptions

We now consider the assumptions made in imputing missing counts. These assumptions were that the site factors were the same in all months and years, that the year factors were the same at all sites and in all months, and that the month factors were the same at all sites and in all years. Effectively, these are the assumptions of statistical independence between these three factors. There is little hard evidence, backed up by rigorous statistical analyses, either in favour or against these assumptions. For example, Evans (1976) produced a series of graphs showing that the annual pattern of overall numbers of several species of waders in Britain was consistent over a three year period, supporting in qualitative terms the assumption that month factors are the same in all years. Tables 7, 12 and 16, which showed indices based on differing series of years to be very similar also provide evidence that the assumptions are approximately satisfied. Moser (1988) considered that Grey Plovers had shown different rates of increase at different estuaries. The fact that the series of indices for Grey Plovers over varying time periods are similar (Table 7) tends to confirm that such different rates of increase in numbers of Grey Plovers at different estuaries are second order effects in comparison with the assumptions of independence.

These assumptions are the most parsimonious in that they result in the smallest possible number of parameters in the model. Each assumption can be examined by considering the residuals between observed and modelled values. There are at least two possible avenues for doing this. The first is the formal hypothesis testing approach using chi-squared tests (in much the same way as the early analyses of CBC data by Taylor (1965) and Bailey (1967)). Secondly, the most important features of the residuals may be displayed graphically by techniques such as correspondence analysis (Greenacre 1984). If the assumptions are formally rejected, the graphical displays will help to reveal any underlying patterns. For example, the displays might suggest that sites should be grouped regionally (*cf.* Fuller *et al.* 1985), or classified according to size; they might suggest periods of years over which the assumption of constant site factors holds, at least approximately. If it does prove necessary, for some, or all, species, to produce a series of sub-indices, for each of which the parsimonious assumptions hold, a weighted sum of these can be formed to produce a national index.

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TABLES

Table 1. *Counted, imputed and modelled numbers of Dunlin at The Wash, for the midwinter months, December, January and February. Imputed values are shown in boldface. In the first of the four columns for each month, the counts and initial imputed values (the mean of all complete counts) are shown; in the second column, the imputed values after four iterations of the imputing algorithm; in the third column, the modelled values (in italics) and the final imputed values, obtained after eight iterations; in the fourth column, the plus or minus signs indicate a count which is much greater or smaller, respectively, than the modelled value*

	December				January				February			
	Counted & initial values	Imputed values after iteration 4	Modelled imputed values	+–	Counted & initial values	Imputed values after iteration 4	Modelled imputed values	+–	Counted & initial values	Imputed values after iteration 4	Modelled imputed values	+–
1970/71	**30200**	**22159**	**22078**		32348		*22669*	+	19990		*21072*	
1971/72	21649		*29468*	–	46758		*30256*	++	31521		*28125*	
1972/73	22740		*42702*	–	29118		*43844*	–	26630		*40756*	–
1973/74	41765		*39782*		50286		*40846*	+	43855		*37969*	
1974/75	**30200**	**37909**	**37928**		39807		*38942*		29409		*36199*	
1975/76	19823		*38567*	–	22400		*39598*	–	20132		*36809*	–
1976/77	29923		*39050*	–	30971		*40094*	–	30596		*37270*	
1977/78	18046		*27304*	–	22991		*28034*		20731		*26060*	
1978/79	11651		*29919*	–	23748		*30719*		**30200**	**28536**	**28555**	
1979/80	36983		*29177*	+	35209		*29957*		**30200**	**27833**	**27847**	
1980/81	**30200**	**28675**	**28696**		25016		*29464*		30193		*27388*	
1981/82	**30200**	**25179**	**25189**		**30200**	**25860**	**25863**		27572		*24041*	
1982/83	25300		*25377*		29082		*26056*		21424		*24221*	
1983/84	**30200**	**25669**	**25667**		**30200**	**26364**	**26353**		27044		*24497*	
1984/85	**30200**	**23268**	**23266**		**30200**	**23897**	**23888**		20101		*22206*	
1985/86	41105		*24839*	++	32356		*25503*	+	**30200**	**23720**	**23707**	
1986/87	23481		*21687*		22571		*22267*		37257		*20699*	++
1987/88	**30200**	**22147**	**22127**		29200		*22719*	+	46239		*21119*	++
1988/89	35092		*27325*	+	45610		*28055*	++	51061		*26079*	++

Table 2. *Indices for Grey Plover, 1969/70 to 1988/89 shown in bold, for each of the winter months. Only sites with at least 50% complete counts (i.e. 10) have been used. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

	October	November	December	January	February	March
No. of sites	74	82	87	94	91	77
1969/70	**59.9** (81.2%)	**65.2** (80.9%)	**89.1** (80.9%)	**57.6** (81.5%)	**40.7** (80.8%)	**97.3** (82.8%)
	(54.0–66.3)	(62.2–68.1)	(85.8–92.4)	(54.9–59.9)	(38.3–43.1)	(90.5–104.4)
1970/71	**94.9** (54.2%)	**87.9** (32.4%)	**82.8** (49.9%)	**80.0** (35.4%)	**52.9** (30.8%)	**84.7** (30.5%)
	(77.2–112.8)	(68.2–113.9)	(67.4–98.5)	(67.7–90.8)	(43.6–63.0)	(70.8–104.1)
1971/72	**36.7** (31.4%)	**65.0** (24.1%)	**97.5** (19.9%)	**78.5** (20.5%)	**76.2** (20.8%)	**82.4** (23.2%)
	(27.5–46.6)	(56.8–76.6)	(77.5–122.8)	(62.5–95.0)	(62.4–92.4)	(63.5–97.6)
1972/73	**100.0** (26.1%)	**100.0** (19.8%)	**100.0** (11.7%)	**100.0** (16.2%)	**100.0** (16.7%)	**100.0** (16.1%)
	(78.3–122.6)	(91.5–111.7)	(79.1–125.9)	(84.4–116.1)	(82.2–122.0)	(78.0–129.0)
1973/74	**136.8** (5.5%)	**150.5** (2.8%)	**192.0** (2.5%)	**137.4** (2.8%)	**124.1** (2.9%)	**159.2** (8.8%)
	(97.0–180.5)	(128.4–170.0)	(151.3–227.5)	(118.7–159.2)	(97.0–156.6)	(134.1–190.5)
1974/75	**123.3** (3.1%)	**169.0** (4.5%)	**213.0** (19.0%)	**160.7** (2.7%)	**115.3** (9.4%)	**158.8** (2.4%)
	(96.2–157.1)	(148.9–194.2)	(187.8–239.3)	(121.5–194.1)	(90.8–135.1)	(118.0–198.6)
1975/76	**128.7** (30.4%)	**127.8** (49.2%)	**187.4** (6.1%)	**159.5** (8.9%)	**110.7** (14.2%)	**188.0** (51.2%)
	(109.7–147.1)	(114.9–141.2)	(138.5–227.1)	(129.4–194.9)	(93.9–130.8)	(154.4–232.7)
1976/77	**202.8** (20.4%)	**190.4** (43.3%)	**195.1** (11.0%)	**179.7** (8.0%)	**142.6** (15.9%)	**206.1** (46.2%)
	(163.6–252.4)	(166.3–216.6)	(150.1–260.5)	(152.3–214.3)	(119.7–174.0)	(185.7–225.7)
1977/78	**137.4** (51.8%)	**223.0** (65.0%)	**213.9** (32.1%)	**97.5** (22.2%)	**81.4** (26.7%)	**250.6** (53.1%)
	(125.6–147.6)	(207.3–237.1)	(178.3–258.9)	(77.2–124.7)	(71.5–91.7)	(219.5–286.3)
1978/79	**185.8** (53.6%)	**183.5** (57.0%)	**242.7** (20.6%)	**133.6** (16.8%)	**135.4** (38.9%)	**234.9** (55.2%)
	(137.6–239.9)	(168.2–199.0)	(210.8–287.1)	(121.2–149.6)	(120.4–149.6)	(209.6–265.9)
1979/80	**210.6** (55.7%)	**314.3** (56.5%)	**235.2** (23.7%)	**185.6** (13.7%)	**152.6** (34.9%)	**231.7** (63.9%)
	(191.0–228.9)	(286.5–341.5)	(206.2–272.4)	(153.9–230.7)	(133.6–173.3)	(212.5–247.5)
1980/81	**199.6** (26.9%)	**207.8** (28.1%)	**341.8** (22.1%)	**168.8** (3.8%)	**216.1** (6.2%)	**298.8** (23.8%)
	(166.1–226.4)	(180.7–238.5)	(293.4–393.8)	(146.2–194.1)	(141.5–277.8)	(236.4–375.9)
1981/82	**238.6** (10.5%)	**360.1** (8.4%)	**244.5** (18.3%)	**153.1** (27.7%)	**172.7** (11.6%)	**235.5** (30.8%)
	(207.0–270.1)	(286.6–417.1)	(211.7–277.3)	(130.9–177.6)	(137.2–219.6)	(204.2–265.5)
1982/83	**253.9** (14.8%)	**281.0** (32.0%)	**326.8** (15.6%)	**201.7** (1.0%)	**136.3** (4.0%)	**323.2** (27.4%)
	(180.5–333.1)	(234.5–329.5)	(278.1–376.3)	(179.9–223.3)	(118.3–156.0)	(277.2–366.6)
1983/84	**210.6** (9.8%)	**331.5** (31.5%)	**292.8** (21.1%)	**208.2** (25.6%)	**192.4** (2.9%)	**284.3** (27.6%)
	(166.6–260.3)	(280.8–392.0)	(261.0–325.7)	(184.7–234.5)	(166.7–228.7)	(254.9–314.3)
1984/85	**189.2** (8.1%)	**284.1** (7.2%)	**420.7** (16.7%)	**217.1** (17.4%)	**188.6** (10.5%)	**373.5** (4.7%)
	(162.2–218.9)	(247.8–332.4)	(342.1–498.6)	(188.2–252.8)	(160.0–218.4)	(312.5–422.0)

1985/86	**206.7** (1.3%)	**241.6** (24.8%)	**398.8** (12.9%)	**247.0** (12.1%)	**227.7** (33.4%)	**368.5** (7.5%)
	(170.7–240.9)	(215.2–269.6)	(350.5–445.4)	(219.1–278.9)	(195.9–263.9)	(316.1–424.1)
1986/87	**314.9** (24.6%)	**368.2** (35.1%)	**386.5** (13.8%)	**247.6** (19.7%)	**277.8** (11.7%)	**383.6** (6.8%)
	(267.4–352.6)	(323.0–407.4)	(342.0–430.9)	(202.1–307.6)	(240.9–317.8)	(302.7–490.4)
1987/88	**239.9** (22.0%)	**348.5** (12.7%)	**548.6** (20.1%)	**437.3** (25.5%)	**311.3** (25.9%)	**472.7** (21.3%)
	(208.1–275.1)	(316.0–391.7)	(485.5–592.8)	(368.5–494.1)	(259.2–351.5)	(380.6–563.5)
1988/89	**240.0** (3.6%)	**440.0** (8.1%)	**540.7** (12.8%)	**408.2** (10.1%)	**385.9** (15.8%)	**602.2** (10.9%)
	(182.7–320.0)	(393.7–509.0)	(447.6–627.6)	(340.7–461.8)	(317.1–483.7)	(512.3–664.5)

Table 3. *Indices for Grey Plover, 1970/71 to 1988/89 shown in bold, for each of the winter months. Only sites with at least 50% complete counts (i.e. 10 or more) have been used. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

	October	November	December	January	February	March
No. of sites	71	78	85	90	89	72
1970/71	**95.0** (55.2%)	**87.9** (32.4%)	**82.8** (49.9%)	**80.1** (37.1%)	**49.2** (33.0%)	**76.1** (31.9%)
	(77.7–113.7)	(69.5–115.8)	(68.6–100.2)	(66.9–90.8)	(39.4–58.8)	(65.0–92.6)
1971/72	**37.2** (32.1%)	**65.2** (24.1%)	**97.4** (19.9%)	**71.4** (21.4%)	**68.8** (22.3%)	**76.6** (24.1%)
	(28.0–47.7)	(56.9–76.5)	(78.5–122.1)	(56.7–86.2)	(55.3–83.4)	(55.9–91.3)
1972/73	**100.0** (26.6%)	**100.0** (19.9%)	**100.0** (11.7%)	**100.0** (16.9%)	**100.0** (17.9%)	**100.0** (16.9%)
	(78.4–123.8)	(91.8–111.4)	(81.2–125.6)	(84.3–115.8)	(82.7–120.7)	(77.6–131.2)
1973/74	**136.8** (5.7%)	**150.8** (2.7%)	**192.0** (2.5%)	**132.9** (2.9%)	**120.0** (3.1%)	**152.6** (9.0%)
	(97.2–177.2)	(127.0–169.2)	(147.6–227.6)	(112.7–153.3)	(91.1–152.5)	(127.6–186.0)
1974/75	**122.5** (3.2%)	**169.6** (4.5%)	**213.0** (19.0%)	**159.7** (2.8%)	**112.9** (10.2%)	**162.8** (2.5%)
	(96.4–153.5)	(148.5–195.6)	(190.8–237.0)	(120.4–192.8)	(88.9–132.1)	(119.3–198.6)
1975/76	**127.2** (29.2%)	**128.4** (49.3%)	**187.3** (6.1%)	**156.4** (4.4%)	**104.9** (8.0%)	**186.2** (49.0%)
	(109.3–145.7)	(115.9–141.1)	(136.4–225.8)	(125.3–189.8)	(88.0–124.9)	(151.9–230.1)
1976/77	**200.3** (19.0%)	**190.8** (43.3%)	**195.1** (11.0%)	**176.1** (3.5%)	**135.2** (9.8%)	**204.3** (43.6%)
	(157.6–245.2)	(165.9–217.7)	(153.2–259.2)	(147.9–211.3)	(111.6–168.6)	(183.0–224.9)
1977/78	**135.4** (50.8%)	**223.6** (64.9%)	**214.0** (32.1%)	**95.6** (18.5%)	**77.2** (21.4%)	**247.9** (50.8%)
	(123.9–145.8)	(210.8–237.4)	(180.0–259.2)	(74.2–122.2)	(66.8–87.8)	(213.7–283.1)
1978/79	**183.4** (52.9%)	**184.0** (57.0%)	**242.7** (20.6%)	**130.8** (12.8%)	**128.2** (34.4%)	**232.5** (53.2%)
	(138.9–236.7)	(168.9–198.9)	(208.5–288.0)	(116.5–147.7)	(112.7–143.4)	(205.6–261.3)
1979/80	**207.5** (54.8%)	**315.1** (56.5%)	**235.2** (23.7%)	**181.9** (9.6%)	**144.6** (30.2%)	**229.6** (62.2%)
	(187.9–225.8)	(288.9–343.2)	(205.7–274.0)	(147.6–226.0)	(125.0–165.3)	(211.5–246.8)
1980/81	**197.0** (25.5%)	**208.3** (28.0%)	**341.7** (22.0%)	**162.6** (4.0%)	**195.6** (6.6%)	**295.5** (20.1%)
	(165.5–223.9)	(179.9–238.5)	(292.2–389.6)	(143.0–188.7)	(123.1–261.7)	(231.4–377.9)
1981/82	**235.8** (8.9%)	**360.8** (8.2%)	**244.5** (18.3%)	**154.7** (29.2%)	**169.1** (12.5%)	**246.6** (32.6%)
	(202.3–268.1)	(288.1–418.6)	(211.9–277.7)	(131.2–177.8)	(131.8–220.4)	(213.8–280.1)
1982/83	**251.0** (13.4%)	**281.7** (32.0%)	**326.9** (15.6%)	**193.1** (1.0%)	**129.4** (4.3%)	**303.1** (28.8%)
	(179.9–327.4)	(238.7–329.4)	(272.0–375.8)	(171.9–212.3)	(111.3–153.8)	(260.2–345.4)
1983/84	**212.5** (10.3%)	**332.5** (31.6%)	**292.7** (21.1%)	**211.5** (27.0%)	**180.0** (3.0%)	**282.3** (28.9%)
	(169.0–260.0)	(279.2–386.1)	(261.0–327.3)	(186.4–234.8)	(154.2–217.8)	(249.7–315.1)
1984/85	**186.8** (6.7%)	**284.7** (7.2%)	**420.6** (16.7%)	**214.7** (18.5%)	**178.8** (7.7%)	**379.4** (4.9%)
	(162.6–214.6)	(249.1–333.6)	(337.1–495.1)	(186.2–246.9)	(149.9–208.0)	(318.9–430.3)
1985/86	**204.3** (0.5%)	**241.6** (24.8%)	**398.8** (13.0%)	**242.2** (7.9%)	**215.6** (28.6%)	**363.9** (3.0%)
	(168.1–240.0)	(215.3–271.5)	(355.8–445.4)	(215.6–277.0)	(185.1–253.0)	(311.4–430.3)

1986/87	**303.5** (24.7%)	**369.1** (35.1%)	**386.7** (13.9%)	**242.8** (15.8%)	**263.2** (5.4%)	**379.1** (2.4%)
	(256.7–343.9)	(324.8–409.5)	(342.4–431.9)	(199.1–303.4)	(225.5–302.6)	(299.9–501.7)
1987/88	**236.3** (22.3%)	**349.2** (12.6%)	**548.7** (20.1%)	**428.7** (21.9%)	**295.0** (20.5%)	**467.4** (17.5%)
	(204.7–271.9)	(313.6–393.4)	(486.5–595.2)	(357.5–486.5)	(239.5–334.7)	(363.1–559.1)
1988/89	**234.2** (3.4%)	**440.4** (8.0%)	**540.5** (12.9%)	**400.1** (5.8%)	**365.6** (9.7%)	**595.0** (6.4%)
	(176.4–315.1)	(389.5–503.6)	(446.2–635.6)	(335.9–455.5)	(297.7–473.1)	(501.8–659.3)
Imputed	21.5%	27.3%	17.4%	13.0%	13.9%	22.4%

Table 4. *Indices for Grey Plover, 1970/71 to 1988/89 shown in bold, for groups of winter months. Only sites with at least 50% complete counts have been used. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

	November–March	December–February	January
No. of sites	86	89	90
1970/71	**76.4** (35.8%)	**74.0** (38.1%)	**80.1** (37.1%)
	(66.6–87.1)	(62.6–84.6)	(66.9–90.8)
1971/72	**77.2** (21.6%)	**82.1** (20.5%)	**71.4** (21.4%)
	(67.1–87.1)	(70.6–96.6)	(56.7–86.2)
1972/73	**100.0** (16.3%)	**100.0** (14.8%)	**100.0** (16.9%)
	(89.3–113.4)	(88.7–114.0)	(84.3–115.8)
1973/74	**147.4** (3.6%)	**144.5** (2.7%)	**132.9** (2.9%)
	(129.9–164.3)	(123.9–163.8)	(112.7–153.3)
1974/75	**157.6** (9.1%)	**156.9** (10.5%)	**159.7** (2.8%)
	(134.1–178.2)	(130.8–178.2)	(120.4–192.8)
1975/76	**146.4** (26.1%)	**145.5** (10.2%)	**156.4** (4.4%)
	(128.1–167.5)	(124.4–165.4)	(125.3–189.8)
1976/77	**173.7** (25.8%)	**168.9** (13.0%)	**176.1** (3.5%)
	(155.3–201.7)	(144.4–200.6)	(147.9–211.3)
1977/78	**140.2** (39.5%)	**115.3** (27.0%)	**95.6** (18.5%)
	(125.1–160.1)	(100.9–134.3)	(74.2–122.2)
1978/79	**165.7** (35.4%)	**156.7** (24.1%)	**130.8** (12.8%)
	(155.0–181.4)	(143.9–174.4)	(116.5–147.7)
1979/80	**194.8** (37.6%)	**174.1** (23.5%)	**181.9** (9.6%)
	(180.3–210.4)	(160.5–190.5)	(147.6–226.0)
1980/81	**237.3** (19.6%)	**230.7** (11.4%)	**162.6** (4.0%)
	(205.3–262.7)	(186.6–264.7)	(143.0–188.7)
1981/82	**229.2** (22.4%)	**186.8** (20.4%)	**154.7** (29.2%)
	(202.0–249.4)	(166.6–211.4)	(131.2–177.8)
1982/83	**225.8** (14.6%)	**203.3** (7.9%)	**193.1** (1.0%)
	(206.5–248.4)	(186.2–222.8)	(171.9–212.3)
1983/84	**242.6** (20.0%)	**223.6** (16.1%)	**211.5** (27.0%)
	(226.2–262.0)	(206.6–245.2)	(186.4–234.8)
1984/85	**281.0** (13.2%)	**254.4** (16.3%)	**214.7** (18.5%)
	(250.0–307.9)	(220.8–289.2)	(186.2–246.9)

1985/86	**280.3** (19.0%)	**273.2** (18.5%)	**242.2** (7.9%)
	(255.0–304.9)	(249.1–303.3)	(215.6–277.0)
1986/87	**314.1** (16.0%)	**297.3** (14.7%)	**242.8** (15.8%)
	(278.6–358.4)	(268.0–337.0)	(199.1–303.4)
1987/88	**407.0** (23.2%)	**416.4** (24.1%)	**428.7** (21.9%)
	(368.2–442.0)	(367.8–451.9)	(357.5–486.5)
1988/89	**457.1** (13.9%)	**434.4** (13.6%)	**400.1** (5.8%)
	(416.6–499.2)	(382.9–491.3)	(335.9–455.5)
Imputed	20.4%	16.6%	13.0%

Table 5. *Indices for Grey Plover, 1970/71 to 1988/89 shown in bold, for November to March, with different numbers of complete counts for each site. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

Complete counts	19	38	48	57	76
Average no. of counts per year	1	2	2.5	3	4
No. of sites	144	102	86	71	35
1970/71	**76.3** (41.6%)	**76.6** (36.3%)	**76.4** (35.8%)	**78.5** (39.9%)	**58.4** (30.2%)
	(67.2–86.3)	(67.2–87.4)	(66.6–87.1)	(67.8–90.2)	(44.7–72.1)
1971/72	**76.8** (29.3%)	**77.1** (22.4%)	**77.2** (21.6%)	**77.8** (23.9%)	**68.2** (8.8%)
	(68.0–85.9)	(68.4–87.1)	(67.1–87.1)	(68.7–87.9)	(52.2–89.1)
1972/73	**100.0** (24.5%)	**100.0** (17.1%)	**100.0** (16.3%)	**100.0** (17.8%)	**100.0** (2.0%)
	(90.1–111.7)	(89.5–112.8)	(89.3–113.4)	(89.5–114.2)	(82.9–120.3)
1973/74	**148.8** (11.1%)	**148.1** (4.3%)	**147.4** (3.6%)	**139.5** (3.6%)	**129.3** (2.6%)
	(134.3–163.4)	(132.3–164.2)	(129.9–164.3)	(122.5–155.5)	(102.1–155.4)
1974/75	**157.7** (16.4%)	**157.3** (10.1%)	**157.6** (9.1%)	**159.4** (8.9%)	**128.6** (1.3%)
	(135.3–177.1)	(133.8–177.9)	(134.1–178.2)	(135.4–181.0)	(104.5–162.6)
1975/76	**149.0** (33.2%)	**146.9** (27.0%)	**146.4** (26.1%)	**141.9** (20.5%)	**126.0** (10.9%)
	(131.4–167.0)	(127.4–166.7)	(128.1–167.5)	(120.8–165.7)	(101.7–145.6)
1976/77	**174.9** (32.5%)	**173.2** (26.1%)	**173.7** (25.8%)	**173.4** (19.7%)	**150.9** (12.4%)
	(157.7–195.4)	(154.6–197.2)	(155.3–201.7)	(152.9–202.4)	(121.6–184.2)
1977/78	**140.6** (45.5%)	**140.8** (40.0%)	**140.2** (39.5%)	**145.3** (35.2%)	**161.3** (33.0%)
	(125.1–158.0)	(125.0–159.9)	(125.1–160.1)	(128.1–168.4)	(144.0–177.4)
1978/79	**171.4** (41.3%)	**166.3** (36.0%)	**165.7** (35.4%)	**169.6** (32.9%)	**166.5** (27.6%)
	(160.7–185.7)	(155.4–181.1)	(155.0–181.4)	(158.3–187.9)	(151.6–183.4)
1979/80	**205.8** (43.1%)	**194.9** (38.4%)	**194.8** (37.6%)	**194.3** (30.0%)	**186.5** (21.0%)
	(190.0–225.5)	(181.4–210.4)	(180.3–210.4)	(179.4–212.8)	(166.5–202.6)
1980/81	**235.8** (23.4%)	**236.6** (20.1%)	**237.3** (19.6%)	**229.6** (16.0%)	**193.8** (11.5%)
	(208.0–260.1)	(202.7–262.0)	(205.3–262.7)	(196.2–256.0)	(152.6–230.6)
1981/82	**228.4** (25.7%)	**228.3** (22.4%)	**229.2** (22.4%)	**237.6** (19.4%)	**199.6** (1.2%)
	(206.3–247.4)	(202.4–248.9)	(202.0–249.4)	(211.4–259.4)	(170.6–227.2)
1982/83	**224.8** (18.1%)	**225.4** (14.9%)	**225.8** (14.6%)	**224.5** (14.5%)	**215.2** (1.3%)
	(206.4–245.1)	(205.4–246.8)	(206.5–248.4)	(203.4–249.7)	(180.1–241.2)
1983/84	**243.2** (21.4%)	**242.6** (20.2%)	**242.6** (20.0%)	**244.4** (21.9%)	**201.6** (3.6%)
	(226.9–261.4)	(226.0–262.2)	(226.2–262.0)	(225.3–266.3)	(173.8–227.4)

1984/85	**277.2** (13.9%)	**280.2** (13.6%)	**281.0** (13.2%)	**271.2** (12.3%)	**210.7** (1.1%)
	(252.3–301.9)	(251.4–306.0)	(250.0–307.9)	(237.8–300.2)	(180.5–234.0)
1985/86	**281.7** (22.5%)	**279.5** (19.3%)	**280.3** (19.0%)	**273.8** (9.5%)	**257.1** (1.9%)
	(260.7–304.7)	(255.8–304.0)	(255.0–304.9)	(246.4–303.1)	(223.9–299.1)
1986/87	**312.0** (19.5%)	**315.3** (16.0%)	**314.1** (16.0%)	**313.6** (10.4%)	**272.6** (1.6%)
	(281.7–351.1)	(279.0–360.9)	(278.6–358.4)	(274.4–362.8)	(222.7–340.7)
1987/88	**391.1** (25.2%)	**405.2** (23.0%)	**407.0** (23.2%)	**411.0** (16.8%)	**304.4** (23.5%)
	(353.8–424.4)	(362.0–443.4)	(368.2–442.0)	(362.7–448.5)	(263.9–332.4)
1988/89	**455.1** (15.9%)	**458.5** (13.9%)	**457.1** (13.9%)	**454.3** (3.5%)	**358.1** (0.8%)
	(416.1–494.6)	(417.6–500.0)	(416.6–499.2)	(405.8–502.4)	(304.7–416.7)
Imputed	24.5%	20.8%	20.4%	16.4%	9.2%

Table 6. *Modelled numbers of Grey Plovers at selected sites in January 1989 using the indices computed in Table 5, i.e. based on data from November to March, 1970/71 to 1988/89, and varying numbers of complete counts. The figures in parentheses denote the ranks of the sites (in terms of modelled numbers of Grey Plovers) for each of the indices of Table 5. The totals refer to the modelled total number of Grey Plovers at all sites included in the index*

Complete counts	19	38	48	57	76
Average number of counts per year	1	2	2.5	3	4
No. of sites	144	102	86	71	35
The Wash	6339	6347	6317	6310	—
Chichester Harbour	2276	2293	2283	2280	2050
Ribble	1935	1940	1930	1927	1791
Swale	1826	1827	1816	—	—
Foulness	1585	1593	1585	1581	—
Medway	1485	1496	1489	—	—
Dee (England)	1351	1353	1346	1346	1257
Langstone Harbour	1266	1272	1266	1260	1159
Hamford Water	1217	1229	1223	1223	—
Stour	1137	1140	1135	1131	1042
Blackwater	1058	1065	1061	—	—
Leigh/Canvey	1039	1044	1039	1036	—
Lindisfarne	932	936	932	930	847
Blackwater North	765	—	—	—	—
Pagham Harbour	802	804	801	798	731
Dengie Flats	626	628	625	624	577
Southampton Water	611	615	612	611	555
Exe	559	562	559	558	511
Totals	36266	33020	32415	28518	11966

Table 7. *Indices for Grey Plover shown in bold, for December to February, for groups of years. Only sites with at least 50% complete counts have been used. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

Years	70/71–79/80	70-71–84/85	70/71–87/88	70/71–88/89	79/80–88/89	84/85–88/89
Complete counts	15	23	27	29	15	8
No. of sites	81	85	88	89	109	128
1970/71	**77.5** (41.2%)	**75.8** (39.3%)	**74.2** (38.0%)	**74.0** (38.1%)		
	(65.7–88.4)	(64.3–86.5)	(62.4–84.4)	(62.6–84.6)		
1971/72	**81.8** (20.8%)	**82.0** (19.7%)	**82.2** (20.2%)	**82.1** (20.5%)		
	(69.4–93.7)	(70.6–94.7)	(71.0–95.1)	(70.6–96.6)		
1972/73	**100.0** (15.3%)	**100.0** (14.1%)	**100.0** (14.4%)	**100.0** (14.8%)		
	(92.1–107.5)	(89.2–111.8)	(88.7–113.3)	(88.7–114.0)		
1973/74	**143.4** (1.9%)	**146.3** (3.0%)	**145.2** (2.7%)	**144.5** (2.7%)		
	(126.5–158.0)	(126.7–163.4)	(124.2–163.6)	(123.9–163.8)		
1974/75	**153.7** (9.8%)	**158.9** (10.8%)	**157.9** (10.7%)	**156.9** (10.5%)		
	(131.6–173.9)	(133.1–178.5)	(132.9–179.0)	(130.8–178.2)		
1975/76	**143.6** (9.8%)	**147.7** (10.7%)	**146.4** (10.4%)	**145.5** (10.2%)		
	(123.7–159.8)	(127.5–165.7)	(126.0–165.9)	(124.4–165.4)		
1976/77	**164.3** (11.8%)	**170.8** (13.1%)	**169.8** (13.0%)	**168.9** (13.0%)		
	(146.7–184.4)	(148.1–197.6)	(147.9–199.0)	(144.4–200.6)		
1977/78	**112.6** (25.2%)	**117.2** (27.5%)	**115.6** (26.8%)	**115.3** (27.0%)		
	(100.3–126.2)	(103.2–135.0)	(100.8–135.2)	(100.9–134.3)		
1978/79	**149.9** (20.7%)	**157.7** (23.9%)	**157.5** (24.1%)	**156.7** (24.1%)		
	(135.9–168.4)	(143.6–177.1)	(143.9–175.0)	(143.9–174.4)		
1979/80	**168.6** (21.8%)	**176.0** (23.9%)	**174.7** (23.4%)	**174.1** (23.5%)	**195.1** (19.5%)	
	(153.9–187.3)	(163.5–191.3)	(162.3–190.3)	(160.5–190.5)	(172.1–228.6)	
1980/81		**232.3** (11.1%)	**232.0** (11.4%)	**230.7** (11.4%)	**231.7** (14.6%)	
		(190.6–267.8)	(192.5–265.7)	(186.6–264.7)	(97.4–135.2)	
1981/82		**188.7** (20.7%)	**188.5** (20.7%)	**186.8** (20.4%)	**201.6** (21.1%)	
		(171.0–210.3)	(170.8–208.0)	(166.6–211.4)	(181.0–228.4)	
1982/83		**203.8** (7.4%)	**203.9** (7.8%)	**203.3** (7.9%)	**211.8** (8.8%)	
		(187.8–222.1)	(188.6–221.7)	(186.2–222.8)	(192.7–234.3)	
1983/84		**225.2** (16.1%)	**225.4** (16.4%)	**223.6** (16.1%)	**237.7** (18.6%)	
		(208.6–244.0)	(207.9–245.3)	(206.6–245.2)	(218.7–280.5)	

1984/85		**255.1** (16.3%)	**256.5** (16.7%)	**254.4** (16.3%)	**247.7** (15.6%)	**253.4** (15.4%)
		(220.6–292.6)	(224.2–290.7)	(220.8–289.2)	(218.7–280.5)	(221.5–286.1)
1985/86			**274.5** (18.5%)	**273.2** (18.5%)	**283.8** (10.2%)	**288.3** (9.0%)
			(248.5–303.2)	(249.1–303.3)	(263.0–310.0)	(262.8–322.6)
1986/87			**299.0** (14.8%)	**297.3** (14.7%)	**303.3** (8.7%)	**296.8** (7.1%)
			(266.2–342.3)	(268.0–337.0)	(273.9–343.0)	(273.7–331.0)
1987/88			**422.9** (24.9%)	**416.4** (24.1%)	**407.8** (14.5%)	**384.6** (10.9%)
			(375.9–459.8)	(367.8–451.9)	(356.6–442.6)	(335.5–420.4)
1988/89				**434.4** (13.6%)	**437.2** (2.3%)	**445.2** (2.5%)
				(382.9–491.3)	(387.4–494.1)	(409.8–487.8)
Imputed	16.3%	16.0%	17.2%	16.6%	12.4%	8.3%

Table 8. *Indices for Dunlin, 1970/71 to 1988/89 shown in bold, for each of the winter months. Only sites with at least 50% complete counts (i.e. 10 or more) have been used. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

	October	November	December	January	February	March
No. of sites	71	78	85	90	89	72
1970/71	**66.4** (49.3%)	**85.6** (38.0%)	**65.4** (36.8%)	**48.9** (35.3%)	**46.0** (31.5%)	**42.7** (26.8%)
	(57.7–75.5)	(71.9–104.3)	(58.0–74.2)	(41.9–55.7)	(41.0–51.7)	(37.4–49.8)
1971/72	**59.7** (31.0%)	**82.2** (25.7%)	**92.3** (19.6%)	**69.1** (19.9%)	**55.9** (21.4%)	**56.0** (19.4%)
	(47.2–73.3)	(71.9–91.6)	(79.0–105.7)	(59.3–77.5)	(48.7–62.7)	(45.1–68.0)
1972/73	**100.0** (24.1%)	**100.0** (16.5%)	**100.0** (14.2%)	**100.0** (12.1%)	**100.0** (12.4%)	**100.0** (9.2%)
	(81.0–123.3)	(83.4–119.6)	(87.9–111.6)	(72.4–138.6)	(73.8–137.9)	(69.8–139.7)
1973/74	**134.3** (3.0%)	**155.5** (7.8%)	**133.8** (7.5%)	**92.5** (6.1%)	**74.4** (6.0%)	**83.5** (5.8%)
	(116.0–152.9)	(136.8–176.8)	(121.0–145.2)	(83.1–101.7)	(67.1–82.5)	(72.8–98.0)
1974/75	**124.1** (1.9%)	**142.9** (2.8%)	**147.5** (11.2%)	**76.8** (2.5%)	**64.7** (8.3%)	**62.9** (2.1%)
	(102.4–148.0)	(118.7–168.3)	(121.1–180.1)	(68.7–85.1)	(59.0–71.6)	(52.1–75.4)
1975/76	**116.2** (26.0%)	**146.4** (38.0%)	**134.1** (4.3%)	**81.7** (9.3%)	**73.1** (9.0%)	**76.1** (42.9%)
	(106.8–126.4)	(134.8–158.0)	(116.4–151.3)	(72.6–91.0)	(64.3–82.6)	(69.5–82.6)
1976/77	**111.1** (19.0%)	**147.2** (28.9%)	**125.2** (6.4%)	**78.3** (7.6%)	**82.6** (12.9%)	**61.3** (40.7%)
	(99.1–123.1)	(136.0–158.5)	(107.7–143.5)	(68.5–88.6)	(71.3–93.7)	(47.9–75.5)
1977/78	**119.0** (45.5%)	**100.8** (51.5%)	**114.1** (28.6%)	**57.4** (24.7%)	**42.5** (23.3%)	**58.5** (47.6%)
	(101.7–137.0)	(89.4–113.3)	(100.5–127.4)	(51.3–63.3)	(36.6–48.7)	(53.3–64.1)
1978/79	**97.2** (43.9%)	**127.3** (46.7%)	**104.0** (17.3%)	**65.1** (19.9%)	**55.8** (26.0%)	**39.3** (59.1%)
	(87.7–107.4)	(115.4–138.3)	(91.5–117.5)	(59.6–70.7)	(51.4–60.7)	(36.9–41.8)
1979/80	**78.1** (49.1%)	**102.9** (47.6%)	**95.5** (18.9%)	**63.5** (12.6%)	**59.2** (23.7%)	**39.1** (55.8%)
	(62.2–93.7)	(92.9–112.0)	(83.6–107.8)	(57.7–68.9)	(52.7–65.0)	(35.5–43.0)
1980/81	**69.8** (26.8%)	**105.7** (33.9%)	**96.9** (19.0%)	**63.7** (11.8%)	**53.2** (10.6%)	**39.1** (30.1%)
	(59.0–79.5)	(94.5–117.5)	(81.6–112.6)	(58.5–68.6)	(46.5–59.3)	(27.1–48.8)
1981/82	**64.2** (7.9%)	**113.2** (8.5%)	**88.3** (20.3%)	**59.4** (21.1%)	**42.8** (10.6%)	**24.6** (23.2%)
	(52.8–76.5)	(99.7–126.6)	(75.5–99.2)	(52.1–67.8)	(36.3–48.7)	(20.6–28.6)
1982/83	**51.7** (15.4%)	**90.5** (23.0%)	**95.6** (17.4%)	**56.8** (7.1%)	**40.1** (7.7%)	**28.3** (25.8%)
	(45.3–58.1)	(77.8–102.6)	(85.8–105.1)	(50.9–63.3)	(36.0–44.7)	(24.0–32.4)
1983/84	**35.0** (9.3%)	**91.8** (18.3%)	**84.3** (11.1%)	**49.9** (20.1%)	**54.1** (5.3%)	**52.1** (23.3%)
	(25.9–44.8)	(79.8–105.2)	(73.3–96.2)	(44.5–55.4)	(44.7–65.0)	(43.8–59.4)
1984/85	**34.4** (6.4%)	**78.2** (9.7%)	**91.6** (10.3%)	**49.7** (8.8%)	**37.3** (6.1%)	**41.7** (6.8%)
	(26.6–42.9)	(66.8–92.0)	(74.7–107.6)	(40.8–59.4)	(32.4–42.3)	(33.8–48.2)
1985/86	**34.8** (2.2%)	**73.6** (16.2%)	**86.5** (5.7%)	**54.9** (7.0%)	**43.6** (13.7%)	**46.8** (2.8%)
	(28.2–41.7)	(62.1–84.9)	(70.6–101.8)	(47.5–62.9)	(38.0–50.1)	(40.6–55.6)

1986/87	**67.3** (22.3%)	**68.5** (17.3%)	**74.1** (10.6%)	**42.8** (13.1%)	**45.7** (4.7%)	**44.0** (2.3%)
	(47.0–86.9)	(56.9–80.7)	(62.9–86.1)	(37.8–47.9)	(37.5–54.5)	(33.4–58.1)
1987/88	**44.0** (14.5%)	**73.6** (9.0%)	**73.2** (15.4%)	**49.5** (14.3%)	**46.5** (19.3%)	**33.4** (20.3%)
	(28.8–63.6)	(61.7–86.6)	(60.1–88.1)	(42.3–57.5)	(37.6–55.0)	(22.6–43.4)
1988/89	**39.5** (2.0%)	**97.3** (5.9%)	**81.5** (7.3%)	**55.9** (4.9%)	**59.0** (9.5%)	**45.1** (5.1%)
	(29.2–51.4)	(75.8–119.7)	(70.0–94.2)	(48.2–64.3)	(48.6–69.6)	(31.1–55.8)
Imputed	22.7%	23.8%	14.2%	12.9%	13.5%	22.5%

Table 9. *Indices for Dunlin, 1970/71 to 1988/89 shown in bold, for groups of winter months. Only sites with at least 50% complete counts have been used. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

Months	November–March	December–February	January
No. of sites	86	89	90
1970/71	**54.7** (32.7%)	**51.7** (33.1%)	**48.9** (35.3%)
	(49.0–60.9)	(46.2–57.4)	(41.9–55.7)
1971/72	**69.5** (20.4%)	**69.0** (20.2%)	**69.1** (19.9%)
	(62.4–76.5)	(60.8–76.8)	(59.3–77.5)
1972/73	**100.0** (12.7%)	**100.0** (12.6%)	**100.0** (12.1%)
	(79.9–125.6)	(78.8–127.8)	(72.4–138.6)
1973/74	**99.7** (6.1%)	**93.2** (7.3%)	**92.5** (6.1%)
	(92.3–108.4)	(85.1–100.1)	(83.1–101.7)
1974/75	**91.0** (5.8%)	**88.8** (8.1%)	**76.8** (2.5%)
	(81.0–103.7)	(79.1–99.5)	(68.7–85.1)
1975/76	**93.4** (19.3%)	**90.3** (8.9%)	**81.7** (9.3%)
	(85.6–102.3)	(81.3–99.7)	(72.6–91.0)
1976/77	**92.8** (19.3%)	**91.4** (12.0%)	**78.3** (7.6%)
	(84.7–100.8)	(82.9–99.6)	(68.5–88.6)
1977/78	**65.6** (34.6%)	**63.9** (26.6%)	**57.4** (24.7%)
	(59.5–71.2)	(57.8–70.0)	(51.3–63.3)
1978/79	**72.3** (30.3%)	**70.1** (20.9%)	**65.1** (19.9%)
	(67.5–77.1)	(64.8–75.4)	(59.6–70.7)
1979/80	**67.7** (29.7%)	**68.3** (20.0%)	**63.5** (12.6%)
	(62.5–72.3)	(61.6–73.7)	(57.7–68.9)
1980/81	**67.8** (20.5%)	**67.2** (14.6%)	**63.7** (11.8%)
	(61.3–74.0)	(61.2–73.3)	(58.5–68.6)
1981/82	**61.1** (18.1%)	**59.0** (18.4%)	**59.4** (21.1%)
	(55.9–66.0)	(53.8–64.4)	(52.1–67.8)
1982/83	**58.4** (15.6%)	**59.4** (11.7%)	**56.8** (7.1%)
	(54.9–62.5)	(55.5–63.3)	(50.9–63.3)
1983/84	**63.5** (14.0%)	**60.1** (11.5%)	**49.9** (20.1%)
	(57.6–71.2)	(53.0–67.2)	(44.5–55.4)
1984/85	**56.6** (12.0%)	**54.5** (10.6%)	**49.7** (8.8%)
	(49.1–64.0)	(46.6–62.3)	(40.8–59.4)

1985/86	**59.0** (11.7%)	**58.2** (8.5%)	**54.9** (7.0%)
	(52.2–65.5)	(51.1–65.4)	(47.5–62.9)
1986/87	**52.3** (11.8%)	**50.8** (9.4%)	**42.8** (13.1%)
	(47.3–59.1)	(44.2–57.8)	(37.8–47.9)
1987/88	**52.0** (17.8%)	**51.8** (16.2%)	**49.5** (14.3%)
	(44.4–59.7)	(44.9–59.4)	(42.3–57.5)
1988/89	**65.4** (10.0%)	**64.0** (8.6%)	**55.9** (4.9%)
	(55.4–76.0)	(55.3–73.4)	(48.2–64.3)
Imputed	17.5%	14.2%	12.9%

Table 10. *Modelled numbers of Dunlin at selected sites in January 1989 using the indices computed in Table 9, i.e. based on data from November to March, December to February, and January. The totals refer to the modelled total number of Dunlin at all sites included in the index*

Months	November–March	December–February	January
Complete counts	48	28	10
No. of sites	86	89	90
The Wash	32855	28055	27353
Ribble	22788	21794	17225
Lindisfarne	19225	19139	20024
Mersey	19114	20109	18984
Dee, England	19564	19339	18574
Langstone Harbour	18416	18665	17732
Chichester Harbour	17056	17587	16215
Humber (North)	14700	14999	15942
Bridgewater Bay	9818	10349	10204
Severn (Avon)	9331	9818	9399
Stour	9565	9744	9538
Blackwater	9943	9608	8920
Total	338595	349873	336612

Table 11. *Indices for Dunlin, 1970/71 to 1988/89 shown in bold, for November to March, with different numbers of complete counts for each site. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

Complete counts	19	38	48	57	76
Average no. of counts per year	1	2	2.5	3	4
No. of sites	144	102	86	71	35
1970/71	**54.9** (45.8%)	**55.1** (34.6%)	**54.7** (32.7%)	**54.7** (35.2%)	**45.7** (25.3%)
	(50.0–60.0)	(49.5–61.3)	(49.0–60.9)	(48.2–61.0)	(37.8–55.6)
1971/72	**69.1** (36.1%)	**69.6** (23.0%)	**69.5** (20.4%)	**68.7** (21.3%)	**59.7** (15.7%)
	(63.0–74.9)	(63.0–76.7)	(62.4–76.5)	(60.9–75.9)	(49.6–71.1)
1972/73	**100.0** (29.5%)	**100.0** (15.3%)	**100.0** (12.7%)	**100.0** (12.0%)	**100.0** (9.3%)
	(84.6–120.1)	(81.2–124.8)	(79.9–125.6)	(78.8–129.0)	(70.6–134.3)
1973/74	**100.5** (21.0%)	**100.3** (8.6%)	**99.7** (6.1%)	**98.6** (5.0%)	**87.6** (3.8%)
	(94.7–107.4)	(93.0–107.8)	(92.3–108.4)	(91.3–106.5)	(77.0–98.3)
1974/75	**91.3** (20.8%)	**92.1** (8.3%)	**91.0** (5.8%)	**90.3** (5.3%)	**82.1** (1.7%)
	(83.3–101.4)	(82.7–103.1)	(81.0–103.7)	(80.1–102.2)	(67.9–99.7)
1975/76	**94.6** (34.5%)	**94.3** (21.6%)	**93.4** (19.3%)	**90.4** (14.3%)	**84.9** (6.4%)
	(88.1–101.4)	(86.6–102.1)	(85.6–102.3)	(81.6–99.3)	(76.2–93.0)
1976/77	**93.8** (34.7%)	**94.0** (21.6%)	**92.8** (19.3%)	**86.7** (14.0%)	**83.9** (7.7%)
	(87.5–100.3)	(86.2–102.2)	(84.7–100.8)	(78.3–94.8)	(73.3–93.8)
1977/78	**67.0** (47.9%)	**66.9** (36.5%)	**65.6** (34.6%)	**62.5** (31.4%)	**59.4** (25.7%)
	(62.3–71.6)	(61.1–72.4)	(59.5–71.2)	(56.7–68.5)	(52.0–66.4)
1978/79	**73.5** (43.4%)	**73.0** (32.6%)	**72.3** (30.3%)	**68.6** (27.7%)	**63.9** (20.0%)
	(69.6–77.3)	(68.7–77.8)	(67.5–77.1)	(63.6–73.8)	(58.5–69.2)
1979/80	**69.3** (42.9%)	**68.4** (32.3%)	**67.7** (29.7%)	**66.2** (24.1%)	**60.2** (11.7%)
	(65.1–73.6)	(63.4–73.0)	(62.5–72.3)	(60.3–71.7)	(52.0–66.5)
1980/81	**69.3** (31.9%)	**68.5** (23.3%)	**67.8** (20.5%)	**64.5** (16.9%)	**58.1** (8.9%)
	(64.1–74.6)	(62.0–73.9)	(61.3–74.0)	(57.5–71.2)	(48.4–66.4)
1981/82	**63.8** (28.0%)	**62.0** (19.3%)	**61.1** (18.1%)	**57.8** (13.2%)	**49.5** (1.1%)
	(59.5–68.2)	(57.3–67.1)	(55.9–66.0)	(53.0–62.9)	(44.0–56.8)
1982/83	**58.0** (25.6%)	**58.2** (16.2%)	**58.4** (15.6%)	**55.1** (14.2%)	**51.4** (7.4%)
	(54.9–61.5)	(54.8–62.1)	(54.9–62.5)	(51.8–58.9)	(47.0–56.2)
1983/84	**64.9** (17.0%)	**64.2** (14.6%)	**63.5** (14.0%)	**59.1** (14.4%)	**53.1** (4.7%)
	(60.0–70.7)	(58.1–71.1)	(57.6–71.2)	(53.2–65.3)	(45.9–61.3)

1984/85	**57.9** (12.9%)	**56.8** (12.9%)	**56.6** (12.0%)	**51.7** (9.5%)	**44.2** (0.4%)
	(51.9–63.6)	(49.6–63.3)	(49.1–64.0)	(44.6–59.2)	(35.8–53.8)
1985/86	**59.4** (17.9%)	**59.3** (12.6%)	**59.0** (11.7%)	**56.5** (6.3%)	**49.7** (2.7%)
	(53.7–64.8)	(52.5–65.4)	(52.2–65.5)	(49.3–64.0)	(41.2–59.8)
1986/87	**53.9** (17.4%)	**52.8** (12.2%)	**52.3** (11.8%)	**49.0** (8.2%)	**42.1** (1.5%)
	(48.8–59.0)	(47.2–59.4)	(47.3–59.1)	(42.8–56.2)	(35.8–50.8)
1987/88	**52.4** (20.6%)	**52.3** (18.0%)	**52.0** (17.8%)	**51.6** (15.2%)	**42.7** (14.2%)
	(46.6–58.4)	(44.5–59.3)	(44.4–59.7)	(43.3–59.9)	(35.1–52.9)
1988/89	**66.1** (14.4%)	**66.7** (10.9%)	**65.4** (10.0%)	**63.1** (3.5%)	**49.0** (0.6%)
	(57.9–75.1)	(55.7–76.5)	(55.4–76.0)	(51.7–74.2)	(40.4–59.9)
Inputed	28.9%	19.4%	17.5%	14.9%	8.8%

Table 12. *Indices for Dunlin shown in bold, for December to February, for groups of years. Only sites with at least 50% complete counts have been used. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

Years	70/71–79/80	70-71–84/85	70/71–87/88	70/71–88/89	79/80–88/89	84/85–88/89
Complete counts	15	23	27	29	15	8
No. of sites	81	85	88	89	109	128
1970/71	**51.0** (30.0%)	**51.1** (31.6%)	**51.7** (32.7%)	**51.7** (33.1%)		
	(45.0–57.4)	(45.0–57.0)	(45.9–57.8)	(46.2–57.4)		
1971/72	**68.4** (18.8%)	**69.1** (18.7%)	**69.1** (19.9%)	**69.0** (20.2%)		
	(59.8–76.7)	(60.9–77.8)	(60.9–77.8)	(60.8–76.8)		
1972/73	**100.0** (12.1%)	**100.0** (11.9%)	**100.0** (12.3%)	**100.0** (12.6%)		
	(81.4–124.7)	(80.3–126.7)	(79.2–126.8)	(78.8–127.8)		
1973/74	**92.9** (4.2%)	**93.6** (6.0%)	**93.2** (6.7%)	**93.2** (7.3%)		
	(84.8–100.4)	(85.7–101.2)	(85.7–100.3)	(85.1–100.1)		
1974/75	**87.9** (6.1%)	**88.6** (6.0%)	**88.5** (7.3%)	**88.8** (8.1%)		
	(77.7–97.9)	(78.8–98.6)	(78.7–99.2)	(79.1–99.5)		
1975/76	**89.0** (5.6%)	**90.8** (7.0%)	**90.3** (8.1%)	**90.3** (8.9%)		
	(80.8–96.7)	(82.9–98.5)	(81.4–100.0)	(81.3–99.7)		
1976/77	**90.6** (8.4%)	**91.6** (9.7%)	**91.6** (11.2%)	**91.4** (12.0%)		
	(82.7–98.2)	(83.9–99.2)	(83.2–100.5)	(82.9–99.6)		
1977/78	**66.1** (27.2%)	**65.1** (26.8%)	**64.0** (26.0%)	**63.9** (26.6%)		
	(61.1–71.1)	(59.8–70.7)	(58.3–69.9)	(57.8–70.0)		
1978/79	**70.1** (18.3%)	**70.6** (19.6%)	**70.1** (20.1%)	**70.1** (20.9%)		
	(64.5–75.9)	(65.4–75.9)	(65.0–75.8)	(64.8–75.4)		
1979/80	**66.4** (16.7%)	**68.0** (18.0%)	**68.2** (18.8%)	**68.3** (20.0%)	**69.3** (27.9%)	
	(60.5–72.2)	(62.4–73.4)	(62.0–73.5)	(61.6–73.7)	(62.5–76.8)	
1980/81		**67.2** (12.3%)	**67.2** (13.7%)	**67.2** (14.6%)	**67.2** (24.5%)	
		(61.2–73.1)	(60.8–73.2)	(61.2–73.3)	(60.7–74.5)	
1981/82		**57.7** (16.7%)	**58.2** (17.9%)	**59.0** (18.4%)	**61.7** (25.7%)	
		(51.5–63.9)	(52.6–64.2)	(53.8–64.4)	(57.0–66.1)	
1982/83		**59.9** (11.4%)	**59.5** (11.5%)	**59.4** (11.7%)	**56.7** (20.3%)	
		(55.3–64.2)	(55.5–63.8)	(55.5–63.3)	(53.5–60.5)	
1983/84		**60.7** (9.9%)	**60.0** (10.8%)	**60.1** (11.5%)	**59.8** (15.8%)	
		(52.8–68.2)	(52.5–67.1)	(53.0–67.2)	(55.7–64.2)	
1984/85		**54.1** (9.7%)	**54.2** (10.1%)	**54.5** (10.6%)	**53.5** (11.1%)	**54.1** (11.7%)
		(45.8–62.9)	(46.4–62.7)	(46.6–62.3)	(49.1–58.3)	(50.2–58.3)

1985/86			**57.9** (8.3%)	**58.2** (8.5%)	**57.3** (8.5%)	**57.2** (5.9%)
			(50.2–65.3)	(51.1–65.4)	(53.5–60.5)	(54.6–59.9)
1986/87			**50.9** (9.4%)	**50.8** (9.4%)	**49.6** (9.8%)	**48.8** (6.8%)
			(44.1–58.4)	(44.2–57.8)	(45.4–53.7)	(45.4–52.5)
1987/88			**52.0** (16.5%)	**51.8** (16.2%)	**52.8** (%13.5)	**50.9** (12.3%)
			(44.8–59.7)	(44.9–59.4)	(47.8–57.0)	(47.5–54.1)
1988/89				**64.0** (8.6%)	**62.6** (3.4%)	**61.8** (4.4%)
				(55.3–73.4)	(56.7–67.9)	(58.3–64.8)
Inputed	13.3%	13.5%	13.9%	14.2%	16.5%	8.1%

Table 13. *Indices for Curlew, 1970/71 to 1988/89 shown in bold, for each of the winter months. Only sites with at least 50% complete counts (i.e. 10 or more) have been used. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

	October	November	December	January	February	March
No. of sites	71	78	85	90	89	72
1970/71	**86.4** (35.2%)	**112.3** (39.2%)	**88.9** (39.4%)	**93.9** (46.1%)	**99.2** (40.5%)	**56.8** (34.1%)
	(73.0–103.6)	(97.4–129.5)	(78.6–98.4)	(83.5–103.9)	(86.9–114.2)	(49.8–64.7)
1971/72	**99.9** (31.3%)	**120.2** (30.5%)	**124.7** (25.4%)	**104.5** (23.0%)	**115.6** (30.1%)	**76.8** (22.7%)
	(90.2–110.2)	(103.7–140.1)	(106.5–144.4)	(91.6–117.4)	(101.5–130.2)	(67.8–86.7)
1972/73	**100.0** (22.3%)	**100.0** (18.0%)	**100.0** (19.4%)	**100.0** (16.2%)	**100.0** (20.8%)	**100.0** (14.8%)
	(88.7–111.8)	(82.0–119.0)	(82.1–122.3)	(87.0–114.5)	(86.7–115.1)	(76.7–135.4)
1973/74	**92.5** (8.3%)	**151.5** (15.8%)	**100.5** (15.7%)	**133.5** (15.2%)	**112.1** (12.3%)	**82.7** (10.6%)
	(79.3–107.9)	(134.3–171.5)	(89.0–113.5)	(120.0–147.0)	(100.7–122.4)	(70.2–94.8)
1974/75	**116.6** (3.2%)	**189.7** (4.9%)	**149.5** (13.5%)	**136.3** (6.2%)	**130.6** (11.8%)	**97.9** (3.7%)
	(101.2–132.3)	(149.9–236.8)	(136.5–164.0)	(123.6–149.4)	(114.7–147.3)	(86.1–111.8)
1975/76	**138.8** (19.0%)	**141.5** (29.9%)	**119.7** (6.3%)	**143.8** (14.1%)	**104.4** (12.9%)	**49.4** (32.4%)
	(118.8–158.6)	(121.2–163.9)	(104.1–136.6)	(127.1–160.9)	(85.0–129.5)	(44.7–55.0)
1976/77	**132.4** (9.2%)	**149.1** (24.2%)	**143.2** (13.2%)	**95.7** (18.6%)	**99.9** (21.4%)	**59.3** (42.6%)
	(99.5–169.1)	(127.0–169.5)	(99.3–198.9)	(83.7–108.7)	(92.3–107.3)	(53.6–65.2)
1977/78	**126.8** (46.9%)	**162.8** (55.4%)	**106.9** (34.3%)	**84.6** (29.0%)	**84.8** (27.8%)	**86.0** (50.9%)
	(119.8–133.7)	(151.4–175.7)	(92.5–123.0)	(77.2–92.0)	(77.3–92.9)	(80.0–91.9)
1978/79	**109.6** (48.1%)	**126.3** (52.8%)	**121.2** (30.9%)	**80.5** (28.9%)	**71.8** (36.8%)	**71.0** (57.3%)
	(101.2–118.0)	(114.2–139.1)	(107.9–135.3)	(73.4–88.0)	(65.8–77.7)	(66.3–75.8)
1979/80	**121.9** (53.1%)	**121.8** (55.6%)	**115.0** (30.9%)	**106.2** (22.4%)	**134.5** (35.8%)	**85.1** (54.9%)
	(111.5–132.8)	(114.2–129.1)	(104.9–124.8)	(97.8–114.0)	(119.4–150.5)	(77.2–93.5)
1980/81	**110.4** (22.6%)	**131.3** (29.0%)	**110.0** (28.8%)	**111.2** (21.4%)	**94.0** (18.8%)	**66.0** (28.0%)
	(95.8–125.0)	(120.6–145.1)	(102.4–117.7)	(103.0–119.8)	(82.7–105.2)	(58.4–73.1)
1981/82	**125.6** (21.5%)	**140.8** (15.5%)	**91.8** (26.1%)	**95.1** (30.9%)	**109.7** (21.8%)	**80.6** (33.7%)
	(109.5–141.5)	(131.5–149.4)	(83.6–100.7)	(85.2–104.6)	(101.1–118.3)	(69.1–91.8)
1982/83	**101.4** (15.7%)	**138.6** (23.1%)	**130.0** (18.3%)	**119.3** (8.5%)	**79.6** (11.2%)	**79.2** (21.7%)
	(93.0–111.2)	(126.6–149.5)	(117.1–141.5)	(107.9–131.5)	(71.6–86.9)	(70.9–87.5)
1983/84	**122.3** (11.1%)	**124.0** (17.3%)	**103.1** (13.8%)	**86.7** (17.5%)	**95.3** (10.5%)	**68.4** (21.9%)
	(111.4–135.3)	(110.2–139.8)	(91.7–114.7)	(75.8–97.5)	(83.1–107.0)	(61.0–76.6)
1984/85	**119.4** (8.0%)	**145.0** (8.8%)	**152.8** (10.4%)	**81.2** (7.5%)	**79.3** (8.0%)	**96.4** (10.6%)
	(103.3–135.3)	(130.4–163.5)	(138.8–168.6)	(73.7–89.2)	(67.9–93.1)	(83.4–108.2)
1985/86	**133.7** (1.4%)	**124.0** (9.4%)	**161.8** (5.6%)	**97.8** (4.2%)	**92.0** (14.5%)	**64.9** (3.2%)
	(112.9–153.0)	(109.5–138.8)	(135.3–185.8)	(86.2–109.7)	(82.3–101.7)	(54.4–75.2)

1986/87	**126.4** (21.3%)	**135.4** (23.0%)	**136.3** (17.0%)	**99.0** (13.0%)	**130.9** (10.4%)	**74.5** (11.3%)
	(113.5–139.7)	(122.1–150.2)	(120.5–154.1)	(87.2–111.8)	(117.9–145.2)	(64.1–85.7)
1987/88	**137.1** (11.2%)	**168.7** (11.9%)	**123.1** (8.6%)	**152.2** (13.2%)	**140.3** (14.1%)	**103.1** (14.2%)
	(119.4–155.6)	(142.3–195.7)	(106.4–141.4)	(135.8–170.1)	(128.0–151.9)	(92.6–112.8)
1988/89	**110.6** (3.5%)	**130.9** (11.4%)	**115.1** (10.2%)	**128.6** (6.2%)	**113.0** (10.7%)	**82.5** (11.1%)
	(96.8–126.0)	(117.0–148.5)	(100.9–129.6)	(117.8–140.9)	(104.5–120.8)	(74.9–90.3)
Imputed	20.3%	24.4%	18.4%	17.2%	19.3%	24.2%

Table 14. *Indices for Curlew, 1970/71 to 1988/89 shown in bold, for groups of winter months. Only sites with at least 50% complete counts have been used. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

	November–March	December–February	January
No. of sites	86	89	90
1970/71	**91.8** (37.1%)	**98.9** (39.9%)	**93.9** (46.1%)
	(83.0–101.5)	(89.1–109.4)	(83.5–103.9)
1971/72	**105.9** (25.2%)	**114.5** (27.0%)	**104.5** (23.0%)
	(94.3–117.5)	(102.4–127.9)	(91.6–117.4)
1972/73	**100.0** (17.4%)	**100.0** (19.7%)	**100.0** (16.2%)
	(86.9–115.5)	(88.3–114.3)	(87.0–114.5)
1973/74	**113.8** (12.7%)	**115.4** (15.2%)	**133.5** (15.2%)
	(106.0–121.0)	(107.1–123.6)	(120.0–147.0)
1974/75	**133.8** (8.1%)	**138.2** (12.0%)	**136.3** (6.2%)
	(122.2–147.0)	(126.9–148.2)	(123.6–149.4)
1975/76	**108.8** (21.0%)	**122.0** (14.4%)	**143.8** (14.1%)
	(100.3–116.6)	(109.5–134.9)	(127.1–160.9)
1976/77	**106.3** (26.6%)	**114.3** (23.2%)	**95.7** (18.6%)
	(95.3–120.4)	(98.6–132.0)	(83.7–108.7)
1977/78	**98.8** (41.6%)	**91.2** (33.1%)	**84.6** (29.0%)
	(93.4–104.6)	(84.9–98.4)	(77.2–92.0)
1978/79	**88.4** (41.6%)	**89.6** (35.0%)	**80.5** (28.9%)
	(84.2–93.2)	(84.1–95.2)	(73.4–88.0)
1979/80	**111.7** (41.4%)	**119.3** (33.3%)	**106.2** (22.4%)
	(104.8–119.2)	(111.0–127.8)	(97.8–114.0)
1980/81	**101.4** (25.1%)	**105.6** (24.3%)	**111.2** (21.4%)
	(94.8–107.6)	(98.6–112.8)	(103.0–119.8)
1981/82	**102.9** (27.5%)	**101.4** (27.4%)	**95.1** (30.9%)
	(97.2–108.2)	(95.9–107.7)	(85.2–104.6)
1982/83	**108.0** (17.5%)	**110.5** (13.5%)	**119.3** (8.5%)
	(100.6–115.5)	(102.5–118.8)	(107.9–131.5)
1983/84	**95.2** (16.1%)	**96.5** (14.2%)	**86.7** (17.5%)
	(88.7–101.3)	(88.7–104.3)	(75.8–97.5)
1984/85	**107.9** (12.4%)	**101.6** (11.3%)	**81.2** (7.5%)
	(102.1–114.4)	(95.3–108.7)	(73.7–89.2)

1985/86	**104.9** (11.6%)	**116.1** (10.3%)	**97.8** (4.2%)
	(96.5–113.3)	(107.4–125.0)	(86.2–109.7)
1986/87	**112.9** (17.5%)	**124.5** (14.1%)	**99.0** (13.0%)
	(104.2–122.1)	(113.1–135.7)	(87.2–111.8)
1987/88	**134.5** (16.3%)	**139.2** (13.6%)	**152.2** (13.2%)
	(125.3–143.6)	(128.6–151.2)	(135.8–170.1)
1988/89	**111.3** (12.9%)	**120.2** (10.2%)	**128.6** (6.2%)
	(103.3–119.0)	(112.7–128.8)	(117.8–140.9)
Imputed	22.2%	20.0%	17.2%

Table 15. *Indices for Curlew, 1970/71 to 1988/89 shown in bold, for November to March, with different numbers of complete counts for each site. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

Complete counts	19	38	48	57	76
Average no. of counts per year	1	2	2.5	3	4
No. of sites	144	102	86	71	35
1970/71	**89.4** (54.4%)	**90.9** (41.1%)	**91.8** (37.1%)	**91.6** (40.4%)	**77.9** (36.7%)
	(83.7–95.7)	(82.9–99.6)	(83.0–101.5)	(82.3–101.0)	(66.6–90.1)
1971/72	**101.6** (46.5%)	**103.3** (29.9%)	**105.9** (25.2%)	**107.8** (27.0%)	**102.0** (27.3%)
	(93.7–109.4)	(93.4–113.7)	(94.3–117.5)	(94.7–120.8)	(88.4–116.4)
1972/73	**100.0** (39.8%)	**100.0** (22.5%)	**100.0** (17.4%)	**100.0** (17.4%)	**100.0** (20.3%)
	(91.2–110.1)	(87.8–113.1)	(86.9–115.5)	(85.1–117.2)	(87.2–119.4)
1973/74	**109.7** (35.3%)	**112.5** (18.6%)	**113.8** (12.7%)	**112.7** (12.3%)	**92.5** (14.3%)
	(104.4–115.3)	(105.8–119.1)	(106.0–121.0)	(104.9–119.7)	(86.3–99.8)
1974/75	**131.3** (31.5%)	**132.5** (14.0%)	**133.8** (8.1%)	**137.4** (8.1%)	**107.3** (3.2%)
	(123.4–140.6)	(122.0–145.1)	(122.2–147.0)	(124.4–151.7)	(99.7–115.5)
1975/76	**109.5** (44.4%)	**109.3** (28.4%)	**108.8** (21.0%)	**110.3** (15.6%)	**96.4** (4.3%)
	(104.1–115.2)	(102.1–116.7)	(100.3–116.6)	(102.3–119.2)	(84.5–108.6)
1976/77	**108.3** (48.2%)	**107.1** (33.3%)	**106.3** (26.6%)	**107.6** (21.2%)	**91.6** (6.5%)
	(100.2–117.1)	(96.8–119.5)	(95.3–120.4)	(94.2–122.5)	(79.8–104.8)
1977/78	**97.0** (58.9%)	**96.6** (46.2%)	**98.8** (41.6%)	**99.6** (37.9%)	**96.2** (21.4%)
	(92.9–100.7)	(91.4–101.7)	(93.4–104.6)	(93.3–106.8)	(89.0–102.0)
1978/79	**89.3** (58.9%)	**88.5** (46.8%)	**88.4** (41.6%)	**89.9** (38.5%)	**79.3** (20.3%)
	(86.3–92.6)	(84.3–92.9)	(84.2–93.2)	(85.3–95.2)	(72.2–87.8)
1979/80	**110.9** (59.5%)	**112.2** (46.9%)	**111.7** (41.4%)	**111.4** (36.3%)	**90.9** (10.8%)
	(106.5–116.2)	(106.3–118.6)	(104.8–119.2)	(104.0–121.6)	(82.2–99.8)
1980/81	**98.8** (47.7%)	**100.6** (33.1%)	**101.4** (25.1%)	**98.3** (20.8%)	**86.0** (7.0%)
	(94.4–103.2)	(94.5–106.0)	(94.8–107.6)	(91.6–105.1)	(80.2–90.9)
1981/82	**104.8** (43.3%)	**103.6** (28.5%)	**102.9** (27.5%)	**104.3** (23.5%)	**95.4** (4.5%)
	(100.9–108.7)	(97.8–108.6)	(97.2–108.2)	(97.5–109.7)	(85.7–102.7)
1982/83	**105.7** (34.5%)	**105.6** (18.3%)	**108.0** (17.5%)	**107.5** (16.3%)	**85.8** (7.4%)
	(100.5–111.1)	(98.6–113.0)	(100.6–115.5)	(99.7–115.2)	(76.2–94.4)
1983/84	**97.3** (21.0%)	**96.1** (17.5%)	**95.2** (16.1%)	**95.3** (15.9%)	**87.0** (6.6%)
	(92.0–102.7)	(89.3–102.5)	(88.7–101.3)	(88.4–102.8)	(78.6–95.8)

1984/85	**109.7** (16.2%)	**105.7** (14.5%)	**107.9** (12.4%)	**107.0** (9.6%)	**94.3** (0.9%)
	(104.5–114.7)	(100.6–111.6)	(102.1–114.4)	(100.8–113.8)	(86.0–103.1)
1985/86	**101.8** (16.0%)	**104.4** (13.6%)	**104.9** (11.6%)	**103.5** (5.7%)	**98.2** (1.6%)
	(95.1–109.1)	(97.0–112.1)	(96.5–113.3)	(93.8–112.7)	(87.9–109.4)
1986/87	**114.6** (19.7%)	**115.3** (17.8%)	**112.9** (17.5%)	**109.2** (14.4%)	**99.0** (3.7%)
	(108.0–120.5)	(107.4–123.9)	(104.2–122.1)	(99.1–119.2)	(88.9–109.4)
1987/88	**133.8** (20.6%)	**133.7** (16.9%)	**134.5** (16.3%)	**131.2** (12.7%)	**119.0** (10.4%)
	(126.0–140.4)	(125.4–142.4)	(125.3–143.6)	(121.6–140.4)	(104.7–134.5)
1988/89	**114.8** (18.9%)	**115.0** (14.4%)	**111.3** (12.9%)	**107.2** (7.7%)	**101.4** (2.0%)
	(108.8–121.3)	(107.1–123.4)	(103.3–119.0)	(98.9–115.4)	(91.6–111.0)
Induced	36.9%	25.8%	22.0%	19.5%	10.7%

Table 16. *Indices for Curlew shown in bold, for December to February, for groups of years. Only sites with at least 50% complete counts have been used. The figure in parentheses to the right of each index number is the percentage of birds imputed for that index number. The figures in parentheses below each index number is an approximate 90% confidence interval for the index number. The base year is 1972/73*

Years	70/71–79/80	70-71–84/85	70/71–87/88	70/71–88/89	79/80–88/89	84/85–88/89
Complete counts	15	23	27	29	15	8
No. of sites	81	85	88	89	109	128
1970/71	**107.6** (38.0%) (96.9–119.3)	**100.2** (39.9%) (90.3–111.2)	**99.3** (39.2%) (89.1–110.8)	**98.9** (39.9%) (89.1–109.4)		
1971/72	**121.8** (27.7%) (107.3–135.5)	**116.3** (26.4%) (103.0–129.9)	**115.7** (26.8%) (101.4–129.1)	**114.5** (27.0%) (102.4–127.9)		
1972/73	**100.0** (19.1%) (89.9–110.6)	**100.0** (18.6%) (87.9–113.7)	**100.0** (19.2%) (87.9–114.1)	**100.0** (19.7%) (88.3–114.3)		
1973/74	**124.8** (9.7%) (115.1–134.0)	**117.6** (13.5%) (108.8–126.2)	**115.6** (13.8%) (106.8–124.7)	**115.4** (15.2%) (107.1–123.6)		
1974/75	**146.1** (6.9%) (138.3–154.0)	**139.6** (8.4%) (130.7–149.9)	**138.1** (10.1%) (127.8–148.7)	**138.2** (12.0%) (126.9–148.2)		
1975/76	**129.6** (7.7%) (116.3–141.8)	**122.1** (9.7%) (108.8–135.2)	**121.9** (12.2%) (108.6–136.3)	**122.0** (14.4%) (109.5–134.9)		
1976/77	**125.6** (18.8%) (109.1–144.0)	**113.7** (18.8%) (97.8–133.1)	**113.9** (21.5%) (97.2–134.3)	**114.3** (23.2%) (98.6–132.0)		
1977/78	**99.4** (28.3%) (92.3–107.3)	**92.9** (31.5%) (86.1–99.6)	**91.7** (31.7%) (84.7–98.6)	**91.2** (33.1%) (84.9–98.4)		
1978/79	**95.5** (28.1%) (88.8–102.6)	**89.5** (31.4%) (84.0–94.9)	**89.1** (33.3%) (83.7–94.9)	**89.6** (35.0%) (84.1–95.2)		
1979/80	**129.4** (30.8%) (120.8–139.6)	**120.3** (30.3%) (112.6–129.1)	**119.4** (31.5%) (111.4–128.9)	**119.3** (33.3%) (111.0–127.8)	**119.1** (44.2%) (112.0–128.0)	
1980/81		**104.1** (19.3%) (96.2–112.1)	**105.5** (22.1%) (98.0–113.3)	**105.6** (24.3%) (98.6–112.8)	**105.1** (39.9%) (99.8–110.7)	
1981/82		**100.5** (26.6%) (92.8–107.3)	**100.3** (27.6%) (94.2–106.1)	**101.4** (27.4%) (95.9–107.7)	**107.5** (37.3%) (102.6–112.2)	
1982/83		**111.4** (12.1%) (102.0–120.6)	**111.1** (13.2%) (102.5–120.0)	**110.5** (13.5%) (102.5–118.8)	**107.8** (26.1%) (101.2–114.3)	
1983/84		**96.2** (12.2%) (86.7–105.4)	**96.2** (14.0%) (88.2–104.7)	**96.5** (14.2%) (88.7–104.3)	**101.2** (14.2%) (93.7–109.0)	

1984/85		**99.3** (10.8%)	**100.7** (11.2%)	**101.6** (11.3%)	**103.9** (8.7%)	**101.4** (12.7%)
		(91.4–107.9)	(93.7–108.4)	(95.3–108.7)	(97.8–109.7)	(95.9–106.8)
1985/86			**116.8** (10.3%)	**116.1** (10.3%)	**112.0** (5.5%)	**108.5** (5.6%)
			(107.8–125.7)	(107.4–125.0)	(104.7–119.6)	(100.9–115.8)
1986/87			**124.9** (14.7%)	**124.5** (14.1%)	**122.8** (9.6%)	**118.7** (8.3%)
			(113.3–138.0)	(113.1–135.7)	(114.9–130.5)	(113.1–124.9)
1987/88			**140.1** (14.1%)	**139.2** (13.6%)	**137.4** (9.6%)	**132.4** (7.2%)
			(127.4–153.3)	(128.6–151.2)	(129.0–135.3)	(126.2–138.4)
1988/89				**120.2** (10.2%)	**121.7** (6.0%)	**120.4** (5.6%)
				(112.7–128.8)	(115.9–128.5)	(114.8–126.5)
Imputed	20.7%	20.1%	19.8%	20.0%	19.7%	7.7%

Table 17. *Modelled numbers of Curlew at selected sites in January 1989 using the indices in the last three columns in Table 16, i.e. based on data from November to March, over different periods of years. The totals refer to the modelled total number of Curlew at all sites included in the index*

Years	1970/71–1988/89	1979/80–1988/89	1984/85–1988/89
Complete counts	48	15	8
No. of sites	92	109	128
Morecambe Bay (Walney-Kent)	–	4803	4894
The Wash	2494	2559	2240
Dee (England)	1885	2125	2272
South Solway (Inner)	2446	2054	1763
Foulness	1539	1664	1625
Duddon	–	1449	1313
Lavan Sands	1273	1304	1068
Strangford Lough	1545	1283	1275
Humber (North)	1202	1248	1334
Taw/Torridge	1370	1227	1084
Swale	1091	–	–
South Solway (Outer)	919	1084	1114
Severn (Gloucester)	781	1078	1100
Keer	–	1030	904
North Solway	1084	673	511
Totals	40457	48202	51379

Table 18. *The relative frequency, in the bootstrapped samples, with which the Grey Plover population size between December and February was greater in the year in the row than in the year in the column. The index numbers are reproduced from Table 4. The relative frequencies are expressed as percentages*

Year	70/ 71	71/ 72	72/ 73	73/ 74	74/ 75	75/ 76	76/ 77	77/ 78	78/ 79	79/ 80	80/ 81	81/ 82	82/ 83	83/ 84	84/ 85	85/ 86	86/ 87	87/ 88	88/ 89
Index	**74**	**82**	**100**	**144**	**157**	**146**	**169**	**115**	**157**	**174**	**231**	**187**	**203**	**224**	**254**	**273**	**297**	**416**	**434**
1970/71	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1971/72	86	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972/73	100	97	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
1973/74	100	100	100	0	24	51	6	96	23	2	0	0	0	0	0	0	0	0	0
1974/75	100	100	100	76	0	74	26	97	48	17	0	5	0	0	0	0	0	0	0
1975/76	100	100	100	49	26	0	7	95	25	0	0	0	0	0	0	0	0	0	0
1976/77	100	100	100	94	74	93	0	100	74	36	5	17	5	0	1	0	0	0	0
1977/78	100	100	97	4	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0
1978/79	100	100	100	77	52	75	26	100	0	5	0	1	0	0	0	0	0	0	0
1979/80	100	100	100	98	83	100	64	100	95	0	1	15	0	0	0	0	0	0	0
1980/81	100	100	100	100	100	100	95	100	100	99	0	91	83	56	16	2	1	0	0
1981/82	100	100	100	100	95	100	83	100	99	85	9	0	11	0	0	0	0	0	0
1982/83	100	100	100	100	100	100	95	100	100	100	17	89	0	5	1	0	0	0	0
1983/84	100	100	100	100	100	100	100	100	100	100	44	100	95	0	13	0	0	0	0
1984/85	100	100	100	100	100	100	99	100	100	100	84	100	99	87	0	16	4	0	0
1985/86	100	100	100	100	100	100	100	100	100	100	98	100	100	100	84	0	11	0	0
1986/87	100	100	100	100	100	100	100	100	100	100	99	100	100	100	96	89	0	0	0
1987/88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0	25
1988/89	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	75	0

Table 19. *The relative frequency, in the bootstrapped samples, with which the Dunlin population size between December and February was greater in the year in the row than in the year in the column. The index numbers are reproduced from Table 9. The relative frequencies are expressed as percentages*

Year	70/71	71/72	72/73	73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Index	**52**	**69**	**100**	**93**	**89**	**90**	**91**	**64**	**70**	**68**	**67**	**59**	**59**	**60**	**54**	**58**	**51**	**52**	**64**
1970/71	0	0	0	0	0	0	0	1	0	0	0	7	6	8	35	15	57	50	2
1971/72	100	0	0	0	0	0	0	78	45	57	61	96	94	89	97	92	99	100	74
1972/73	100	100	0	61	69	66	63	100	99	99	99	100	100	100	100	100	100	100	99
1973/74	100	100	39	0	76	66	62	100	99	100	100	100	100	100	100	100	100	100	100
1974/75	100	100	31	24	0	43	37	100	99	99	99	100	100	100	100	100	100	100	100
1975/76	100	100	34	34	57	0	41	100	100	100	100	100	100	100	100	100	100	100	99
1976/77	100	100	37	38	63	59	0	100	100	100	100	100	100	100	100	100	100	100	99
1977/78	99	22	0	0	0	0	0	0	4	19	26	83	81	71	91	79	98	96	51
1978/79	100	55	1	1	1	0	0	96	0	66	74	98	99	96	99	96	99	99	80
1979/80	100	43	1	0	1	0	0	81	34	0	64	93	97	90	98	93	99	99	69
1980/81	100	39	1	0	1	0	0	74	26	36	0	90	96	89	98	94	99	99	67
1981/82	93	4	0	0	0	0	0	17	2	7	10	0	45	39	84	60	98	97	15
1982/83	94	6	0	0	0	0	0	19	1	3	4	55	0	41	90	61	98	96	21
1983/84	92	11	0	0	0	0	0	29	4	10	11	61	59	0	94	68	98	97	23
1984/85	65	3	0	0	0	0	0	9	1	2	2	16	10	6	0	12	79	72	3
1985/86	85	8	0	0	0	0	0	21	4	7	6	40	39	32	88	0	98	98	3
1986/87	43	1	0	0	0	0	0	2	1	1	1	2	2	2	21	2	0	40	0
1987/88	50	0	0	0	0	0	0	4	1	1	1	3	4	3	28	2	60	0	0
1988/89	98	26	1	0	0	1	1	49	20	31	33	85	79	77	97	97	100	100	0

Table 20. *The relative frequency, in the bootstrapped samples, with which the population size of Curlew between December and February was greater in the year in the row than in the year in the column. The index numbers are reproduced from Table 14. The relative frequencies are expressed as percentages*

Year	70/ 71	71/ 72	72/ 73	73/ 74	74/ 75	75/ 76	76/ 77	77/ 78	78/ 79	79/ 80	80/ 81	81/ 82	82/ 83	83/ 84	84/ 85	85/ 86	86/ 87	87/ 88	88/ 89
Index	**99**	**114**	**100**	**115**	**138**	**122**	**114**	**91**	**90**	**119**	**106**	**101**	**110**	**96**	**102**	**116**	**124**	**139**	**120**
1970/71	0	2	47	2	0	1	9	82	88	1	19	37	6	61	35	3	0	0	0
1971/72	98	0	96	45	1	27	52	99	99	30	82	96	66	97	91	42	21	1	23
1972/73	53	4	0	5	0	2	20	83	90	3	27	42	18	63	42	7	2	0	3
1973/74	98	55	95	0	0	27	55	100	100	29	94	98	74	99	96	47	16	0	25
1974/75	100	99	100	100	0	96	98	100	100	100	100	100	99	100	100	98	90	48	96
1975/76	99	73	98	73	4	0	84	100	100	62	95	99	90	99	98	71	42	12	54
1976/77	91	48	80	45	2	16	0	99	100	30	72	85	61	93	83	42	21	7	31
1977/78	18	1	17	0	0	0	1	0	66	0	1	5	0	24	2	0	0	0	0
1978/79	12	1	10	0	0	0	0	34	0	0	0	1	0	14	0	0	0	0	0
1979/80	99	70	97	71	0	38	70	100	100	0	97	99	88	100	99	62	26	0	46
1980/81	81	18	73	6	0	5	28	99	100	3	0	78	21	96	72	5	1	0	0
1981/82	63	4	58	2	0	1	15	95	99	1	22	0	7	83	47	0	0	0	0
1982/83	94	34	82	26	1	10	39	100	100	12	79	93	0	96	92	22	3	0	10
1983/84	39	3	37	1	0	1	7	76	86	0	4	17	4	0	22	0	0	0	0
1984/85	65	9	58	4	0	2	17	98	100	1	28	53	8	78	0	1	0	0	0
1985/86	97	58	93	53	2	29	58	100	100	38	95	100	78	100	99	0	14	0	26
1986/87	100	79	98	84	10	58	79	100	100	74	99	100	97	100	100	86	0	3	70
1987/88	100	99	100	100	52	88	93	100	100	100	100	100	100	100	100	100	97	0	99
1988/89	100	77	97	75	4	46	69	100	100	54	100	100	90	100	100	74	30	1	0

Table 21. *Month indices for Grey Plover, Dunlin and Curlew for November to March, associated with the year indices in the first columns of Tables 4, 9 and 14.*

Species	Grey Plover	Dunlin	Curlew
November	1.017	0.910	0.988
December	0.975	0.979	0.975
January	1.000	1.000	1.000
February	1.092	0.930	1.165
March	0.999	0.541	0.933