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Statistical comparisons of waterbird site trends with regional and national trends for incorporation within the WeBS Alerts system

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EXECUTIVE SUMMARY

1. A method of comparing numeric site trends of waterbirds with those at a regional and national level is desired for WeBS Alerts reporting, with the objective being to develop techniques of graphical and statistical representation.

2. Plotting annual changes by way of calculating percentage change between yearly counts may not be practical without data transformation, as, although scale issues are rectified, problems arise in certain comparison scenarios.

3. Simple correlations between site counts and regional counts allow visual inspection of relationships between variables, but are poor at coping with precision, error and sensitivity. Year effects are also lost.

4. Logistic models offer a more sophisticated method, are straightforward to run using the SAS system, and produce intuitive visual displays of proportionate site level change as a function of the regional or national totals.

5. It is recommended that logistic modelling procedures be adopted in future WeBS Alerts reports, with proportionate plots being included alongside the site and regional trends.

6. Further topics for potential WeBS development, including the use of Generalized Linear Models, are outlined.

1. INTRODUCTION

In the analysis of WeBS data, there is a frequent need to make informed comment regarding differences between numeric trends assessed at different spatial scales, for example when comparing national and regional indices or investigating WeBS Alerts (Austin *et al*. 2004). Where these trends are non-linear, as is usually the case, a straightforward comparison of regression lines is not an appropriate option. Generally, trends have been compared by direct visual comparison of adjacent plots, description of the differences in percentage changes between smoothed indices (as used in WeBS Site Alerts) and comment based on "expert opinion".

The aim is now to improve on these methods, by producing standardised presentational and statistical methods that are capable of focusing attention on periods where site-specific waterbird trends differ from the wider regional or national trends.

Such methods could form the basis of a useful tool for comparing trends, but before they are applied there is the necessity to explore their development properly. Specifically, the statistical implications of comparing non-linear trends need to be understood, whilst the quantification of differences between site trends and wider trends is a related issue. If statistically reliable methods can be developed, they are likely to have immediate representational and interpretational benefits, particularly for the WeBS Alerts system.

1.1 Aims

1. To produce a method leading to a graphical tool for visual comparison of site and regional or national trends.

2. To develop an approach allowing the statistical comparison of changes in site trends and regional or national trends.

2. DEVELOPING COMPARISON STRATEGIES

2.1 Graphical Comparison

Current WeBS Alerts reporting (*e.g.* Austin *et al.* 2004) presents species trends for individual sites, adjacent to the regional and national trends for the same species (excluding data from the site in question). The regional trends are based on Environment Agency (EA) regions for England and Wales, and on Scottish Environment Protection Agency (SEPA) regions in Scotland. National trends are based on trends for the whole of Britain. Northern Ireland is treated as a region in its own right. Interpretation requires subjective visual comparison of graphs, and implies the need for a presentational method that is both intuitively more visually immediate and statistically more sophisticated.

As site trends and wider trends often refer to grossly different absolute numbers of birds, the first step is logically to convert year-on-year changes from absolute (or indexed) values to percentage changes, thus allowing valid comparison between trends. The equation

$$((Yi - Y) / Y) * 100$$

calculates the percentage change from one year to the next, where Y = the smoothed index value in a given year, and Yi = the smoothed index value for the following year.

The method relies on using data from identical time periods for the site under review, and from the corresponding region (or country). Direct comparisons can then be made between winters. The percentage change between year Y and year Yi for the region is subtracted from the percentage change for the equivalent pair of years at the site, and repeated for all the years that data exist at both spatial scales. These calculated values are then plotted as a trend line. If trends at the site level match those at the regional level, the resultant trend line should remain very close to zero. However, if site trends show proportionally less decline than regionally, the new trend should be above the zero line; conversely, if the birds using the site have declined proportionally more than at a regional level, values below zero will be plotted.

2.1.1 Divergent Site And Regional Trends

Appendix 1 and Figure 2.1.1 present some worked examples of the method, to illustrate the scenario where site and regional trends do not appear to match. Shelduck *Tadorna tadorna* recorded on the Teesmouth and Cleveland Coast SPA are presented as an example, as site and regional trends seem very different over the period 1974/75-2000/01 (Figure 2.1.2). Appendix 1 shows smoothed site and regional index values, year-by-year percentage changes and the difference between values over the two spatial scales.

From this table, the trend of the right-hand column, the difference between percentage changes, can be plotted (Figure 2.1.1).

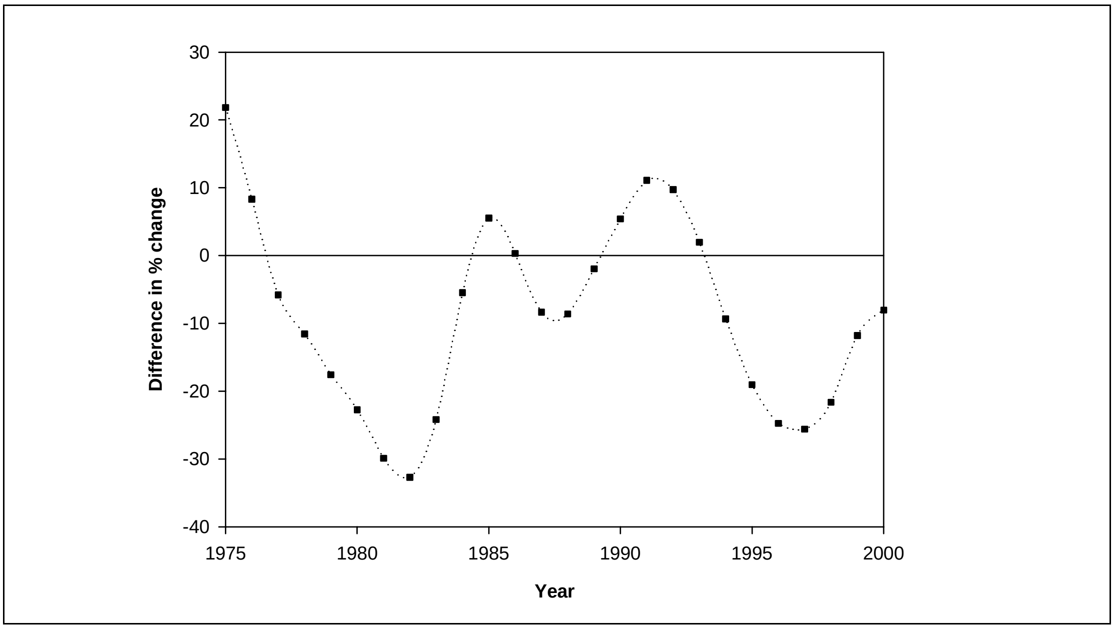

Figure 2.1.1 Plot of year-by-year percentage changes for site and regional trends of Shelduck on the Teesmouth and Cleveland Coast SPA. 1975= change from 1974/75 to 1975/76, and so on. Note: regional trends exclude data from the site in question.

The site and regional trends show clear differences (Figure 2.1.2). At the site level, numbers declined steadily from the mid-1970s until 2000/01, with a slight plateau between 1983/84 and 1994/95. Regional trends have been largely upward, the only notable decline occurring in the early 1990s.

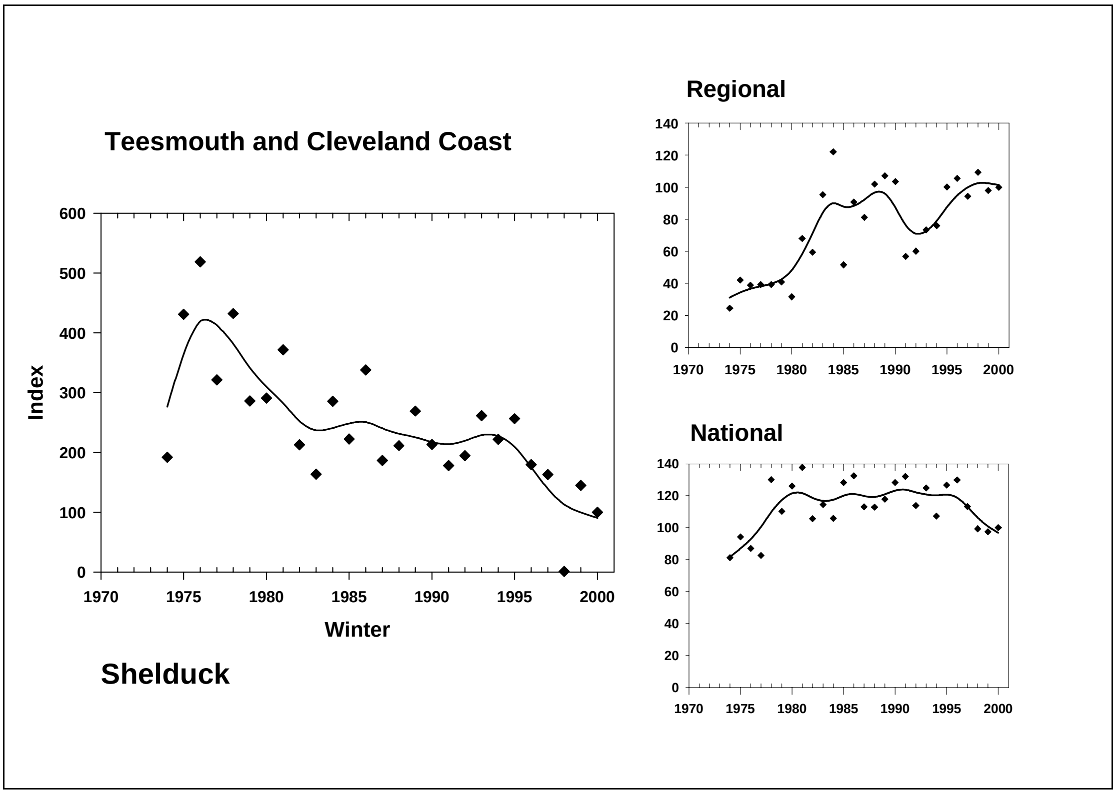

Figure 2.1.2 Plots of site (Teesmouth & Cleveland Coast SPA), regional (EA Northeast) and national (Britain) trends for Shelduck. 1975= change from 1974/75 to 1975/76, and so on. Note: regional trends exclude data from the site in question.

Figure 2.1.1 demonstrates these patterns reasonably effectively. The trend is below zero, indicating a rate of decline exceeding that at a regional level, for all years but eight (two of these extremely close to the zero line). During the period between 1990/91 and 1994/95, when regional trends indicated declines whilst site trends were reasonably stable, values rise clearly above the zero line.

2.1.2 Similar Site And Regional Trends

The example of Grey Plover *Pluvialis squatarola* on the Stour & Orwell Estuaries SPA was chosen to demonstrate a species with similar direction in site and regional trends. Appendix 2 and Figure 2.1.3 again demonstrate the working of the method and the graphical output. Figure 2.1.4 shows the site, regional and national trends for the species.

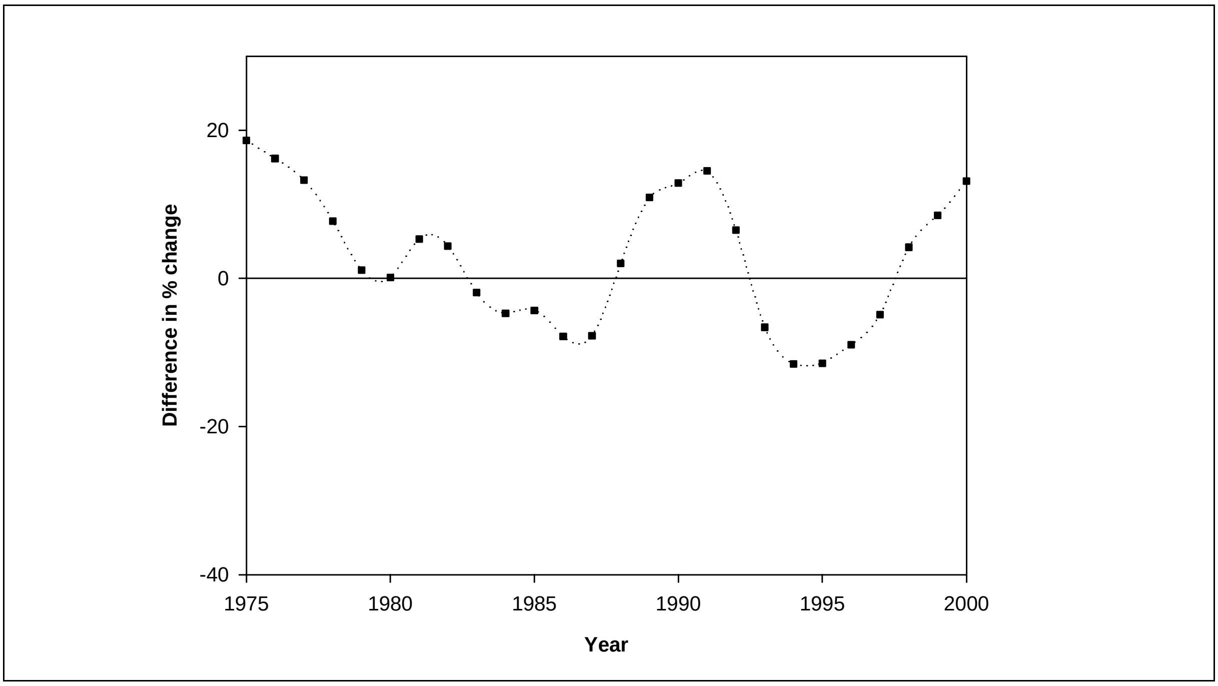

Figure 2.1.3 Plot of year-by-year percentage changes for site and regional trends of Grey Plover on the Stour & Orwell Estuaries SPA. 1975= change from 1974/75 to 1975/76, and so on. Note: data used to calculate regional trends exclude data from the site in question.

Fig. 2.1.3 suggests that for most of the period, Grey Plover were increasing proportionally more on the Stour & Orwell Estuaries SPA than at the regional level. This agrees with a careful examination of Figure 2.1.4; the species was increasing more rapidly at the site than across the region, as the index values increase more steeply.

However, the trend-line in Figure 2.1.3 does not intuitively suggest that the two trends are of a similar direction, which is the ultimate aim of these displays. The same general point can be applied to the previous example (Figure 2.1.1), although note that the magnitude of change is smaller in Figure 2.1.3. There are no departures greater than 20% from the zero line in the case of Grey Plover on the Stour & Orwell Estuaries SPA, whereas the trend for Shelduck on the Teesmouth & Cleveland Coasts SPA exceeds 20% both positively and negatively.

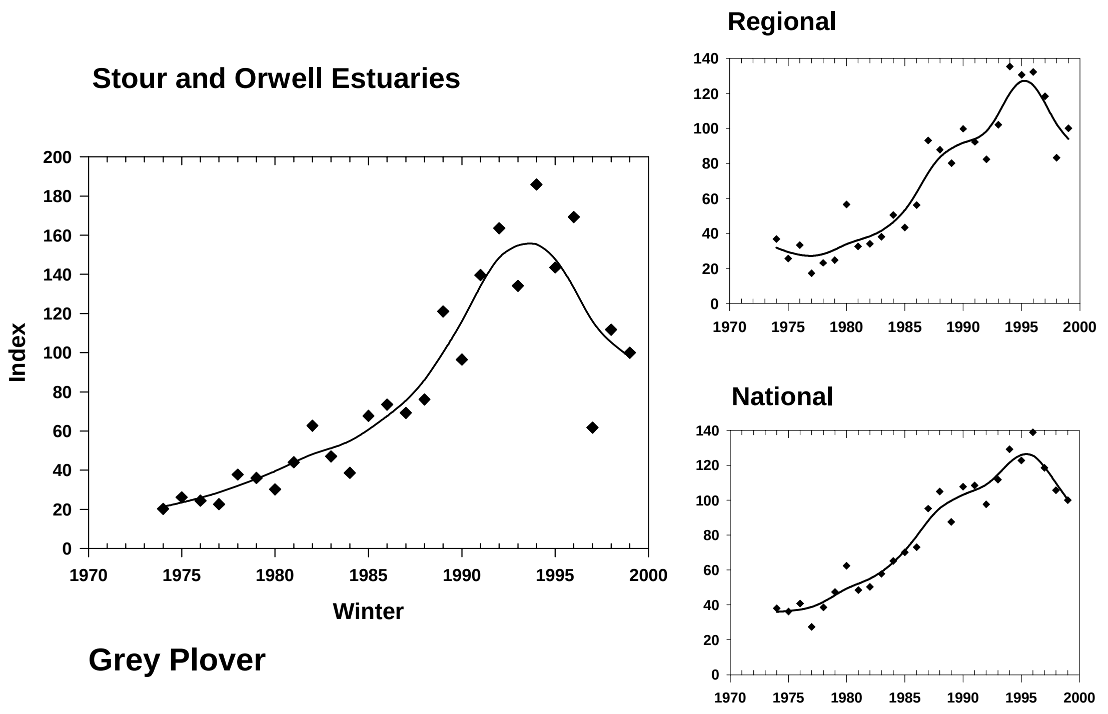

Figure 2.1.4 Plots of site (Stour & Orwell Estuaries SPA) and regional (EA Anglian) trends for Grey Plover.

2.1.3 Evaluation

Although this method produces trends that are readily accessible and interpretable, it is worth considering whether the outputs are optimal at answering questions demanded by WeBS, namely whether site trends reflect wider species trends. There are three immediate drawbacks with the underlying data, which may contribute to the efficacy of the method.

Inequality of change

As the scales upon which the various site, regional and national trends are plotted differ, it is necessary to convert yearly changes to percentage values. However, as a consequence, change is not represented accurately, as absolute change and percentage change are unequal.

As an example, consider a site upon which the count increases from 40 birds to 60 birds. By the equation $((Yi – Y) / Y) * 100$, this would be a 50% increase. However, consider another species at the same site, where the numbers have decreased from 60 birds to 40 between years. Using the same equation, this represents a 33% decrease. Clearly, although the absolute change in numbers was identical, the percentage change was not. Therefore it is arguably unjustified to base comparisons on data including this discrepancy. Calculating changes in index values is subject to the same issue, and it is for this reason that the WeBS Alerts system weighs 25% and 50% decreases against 33% and 100% increases.

Disproportionate change

A related problem exists when comparing species trends over varying spatial scales that climb from very small starting points. For example, the smoothed index used for WeBS Alerts for Avocet *Recurvirostra avosetta* at Foulness (Austin *et al.* 2004), increased from 3.76 to 8.49 between the years 1990/91 and 1991/92 (Figure 2.1.5). This translates to a 126% increase. However, during the same time period, the national smoothed index showed an increase from 33.87 to 39.76, a rise of 5.89 points (fig. 2.1.5). This increase represented a 17% percentage gain, so that subtracting the national percentage change from the site-level percentage change for Avocet produces a figure of 109%. Attributing such a high rate of increase to the site, which at that time likley supported very few birds, seems foolhardy, particularly when, as in this case, the national trend is subjectively similar, at least in direction.

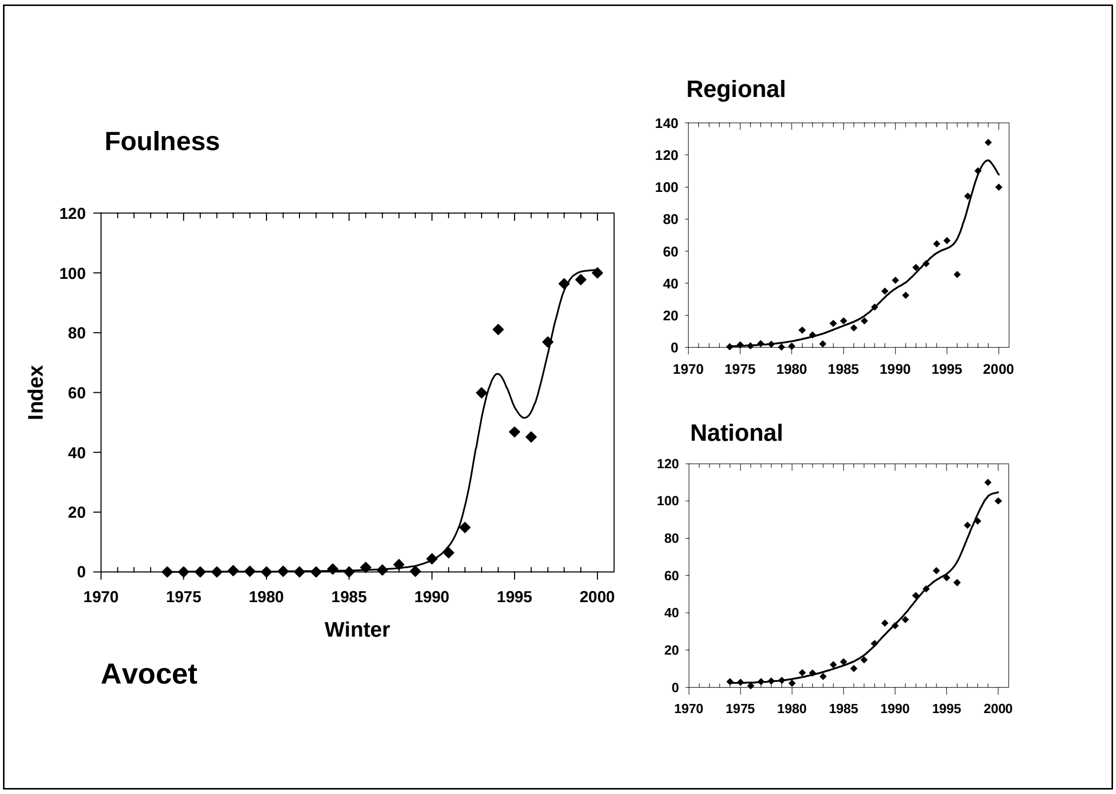

Figure 2.1.5 Site (Foulness SPA), regional (EA Anglian) and national (Britain) trends for Avocet.

Temporal variation

Although the smoothed GAM serves to eliminate much fluctuation from the trends on which WeBS Alerts are based (Leech *et al*. 2002), some residual variation is inevitably retained. Therefore there is an argument that comparing year-by-year changes can be misleading. For instance, if a particular species declines by between 25% and 50% at both the site and regional levels over five, 10 or 25 years, Medium Alerts will be fired. It could be contested that the rate of change over the time period involved is consistent at both spatial scales. However, if the regional trend was for a slow, shallow decline, and the site trend was for a series of large increases followed by an even larger decrease, then obtaining the percentage change figure between the spatial scales could present a misleading picture. The resulting plot would closely resemble the site plot, as the yearly change at the regional level would be small. One might therefore correctly conclude that site and regional trends were not related, based on the annual rate of change, when over the longer time period the total decline was identical.

2.1.4 Data Transformation

One possible solution to the above-mentioned problems, particularly the issue regarding unequal change, is to transform the data prior to treatment. For instance, the Wider Countryside Report (Baillie *et al.* 2002) follows log transformation methods, which serve to recognise a doubling in numbers as the inverse of a halving. Another effectively analogous method may be to investigate procedures used in the production of wild bird indicators (e.g. Gregory *et al*. 1999), where geometric means are derived from individual species trends to provide a truer calculation. Using the geometric mean ensures that a doubling in the size of one species is equivalent to a halving in another.

Either of these methods is potentially applicable to overcome the situation presented here, and future WeBS research could pursue this theme.

2.2 Statistical Comparison

A potential method of avoiding the pitfalls outlined in the previous section is to generate graphics from the output of statistical models. This approach has the associated advantage of giving significance values useful in objective comparison of trends. Additionally, these methods rely on data from raw counts of birds (or averages across selected months) as opposed to smoothed indices. Therefore a high count will be proportionally large regardless of spatial scale, although the benefits of smoothing are lost. At this stage at least, there is an element of non-independence as some missing counts are imputed. It may be preferable to avoid these issues by using input-level data in future.

2.2.1 Simple Correlation

An initial step is to investigate the relationship between site level trends and those at wider scales through basic correlation techniques. Correlations are perhaps preferable to regressions in this case, as there is no obligation to assign a predictor variable.

X-Y scatterplots of site counts against regional or national counts generate visual impressions of relationships between the variables. Associated Pearson's ρ statistics indicate the significance of such relationships. For this study, site counts are averages of the monthly site totals for the months that the species in question is indexed by WeBS (see Pollitt *et al.* 2003 for details). These data were run through the Underhill Indexing Program (Underhill & Prŷs-Jones 1994) to estimate missing counts for absent site-month combinations (except where no data were recorded at a site in a given year). Regional counts are the average numbers of birds (including imputed values) counted on all sites in the appropriate Environment Agency region (excluding the site under review), for the corresponding species indexing months.

Examples of such correlations are given below. One dot on the graph indicates one year.

2.2.1.1 Positive correlation

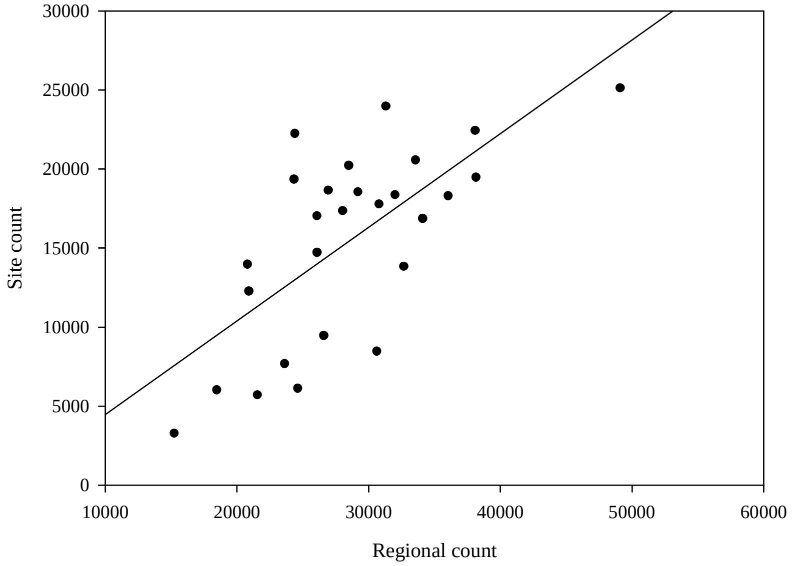

Figure 2.2.1 Correlation between regional and site counts of Dark-bellied Brent Geese on The Wash SPA.

Figure 2.2.1 shows the correlation between site and regional counts of Dark-bellied Brent Geese *Branta bernicla bernicla* at The Wash SPA. Counts at the site and regional levels are significantly positively correlated, suggesting that site trends may be related to the trends of Dark-bellied Brent Geese at the regional (Anglia) level ($\rho = 0.687$, $n = 27$, $P < 0.0001$). One other interpretation is that regional trends could be partially explained by those at The Wash, although this seems less likely despite the large population of Dark-bellied Brent geese held.

2.2.1.2 Negative correlation

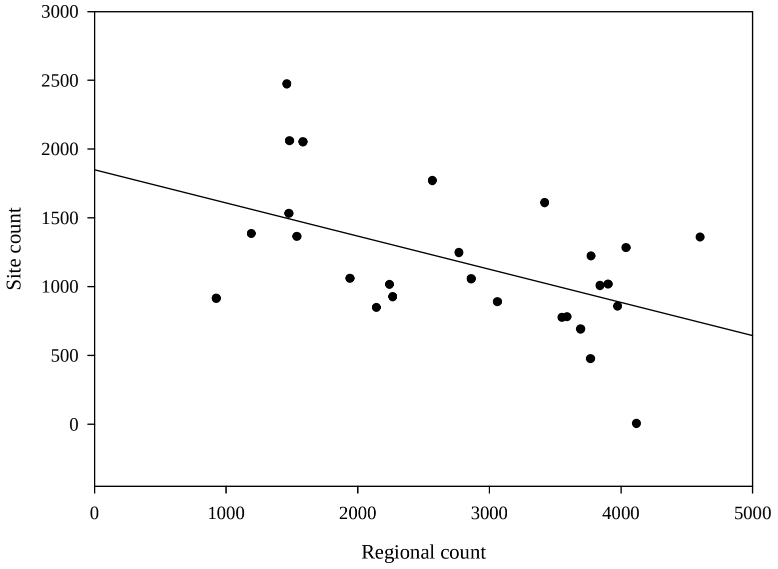

Figure 2.2.2 Correlation between regional and site counts of Shelduck on the Teesmouth & Cleveland Coast SPA.

Figure 2.2.2 shows the correlation between site and regional counts of Shelduck on the Teesmouth & Cleveland Coast SPA. The negative relationship between the regional count and that at the site is prominent. Pearson's *ρ* correlation coefficient is calculated as ρ = -0.507, n = 27, *P* = 0.007. There thus is a significant inverse relationship between counts made at the site level and those at the regional level:- when site counts are high, regional counts are low, and vice versa.

2.2.1.3 No significant correlation

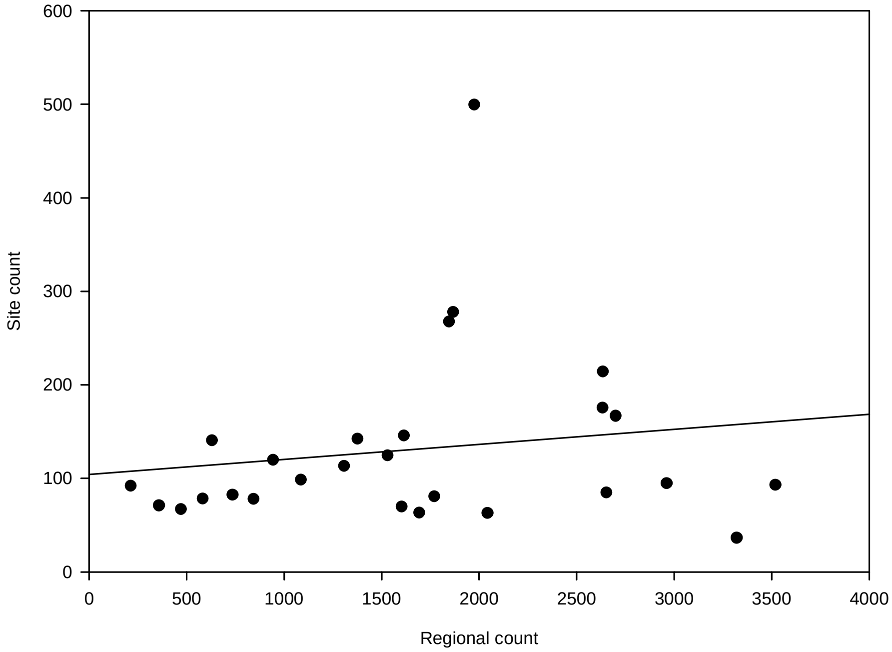

Figure 2.2.3 Correlation between national and site counts of Gadwall on the Abberton Reservoir SPA.

Figure 2.2.3 shows the correlation between site and regional counts of Gadwall *Anas strepera* on the Abberton Reservoir SPA. No relationship exists between the counts of Gadwall on the Abberton Reservoir SPA and the regional (Anglian) trend for the species (ρ = 0.157, n = 27, *P* = 0.435). In this case it is reasonably safe to accept that the species trend at Abberton does not match the large increases elsewhere in the region, possibly because the carrying capacity of the site was reached before expansion into other areas.

2.2.1.4 Evaluation

Using basic correlations to describe relationships between site and regional counts is a straightforward process but suffers somewhat from its simplicity. Graphical outputs are clear, readily understandable and require little post-hoc interpretation. *P* values are routinely generated and bring focus to relationships of interest.

However, this method is considered to be of limited value, as much information is not considered. Also, the procedure is fairly insensitive to subtle changes. For example, missing values cannot be factored in to the process, and imputing data may affect the validity of the correlation. Importantly, no information is retained on year-on-year change, so that the full subtlety of temporal patterns does not emerge.

Correlations should therefore be used in restricted cases, such as where complete raw count data exist and where there is high confidence in the data set. Correlations may prove useful in WeBS Alerts research, but it is not recommended that this technique be routinely adopted for WeBS Alerts reports.

2.2.2 Logistic Models

The proportion, i.e. the number of birds counted at a site per year divided by the total regional number for the year, as counted on all sites within the relevant EA region, was modelled by logistic regression. The models were binomial and specified a logit link function. Count values were again obtained having used the Underhill Indexing Program (Underhill & Prŷs-Jones 1994) to estimate missing counts for absent site-month combinations (except where no data were recorded at a site in any month of a given year in which case the year in question was excluded from the analysis).

As a trial, models were applied to data for all species recorded in the EA Anglian region. Any sites where no counts had been made for the year were excluded from regional total calculation, as the effect of missing years is to introduce temporal inconsistency to the proportional calculations. In practice, this represented very few locations contributing large counts to the regional total, with the North Norfolk Coast the only SPA excluded.

Output plots were generated for each species / site combination. In this way, the proportion of the region's birds occurring at a given site could be calculated across years. The 95% confidence limits obtained represent the confidence in the calculation of the proportion as it varies with the total number of birds in the region (e.g. we can be statistically more confident that a site truly holds 10% of the regional total based on a site count of 100 birds and a regional count of 1000 birds than based on a count of 10 birds on a site and 100 in the region). In the future, proportions would be based on monthly rather than summed winter data in which case the confidence intervals for a given winter would also encapsulate the between-month variation in the average proportion a site holds in a given winter. Three example graphs are produced for interpretation, showing how this relative proportion may change on a temporal scale. As only one region (Anglian) was considered for the purposes of this report, examples do not necessarily correspond to those used for correlation.

2.2.2.1 Proportional site decrease

The first example shows how the proportion of Coot *Fulica atra* in the Anglian region using the Abberton Reservoir SPA has decreased. Figure 2.2.4 shows that from 1982/83 to 2000/01, the proportion of the total number of Coot in the Anglian region predicted to be found at Abberton has seen a general decline, from just above 0.4 to just above 0.2.

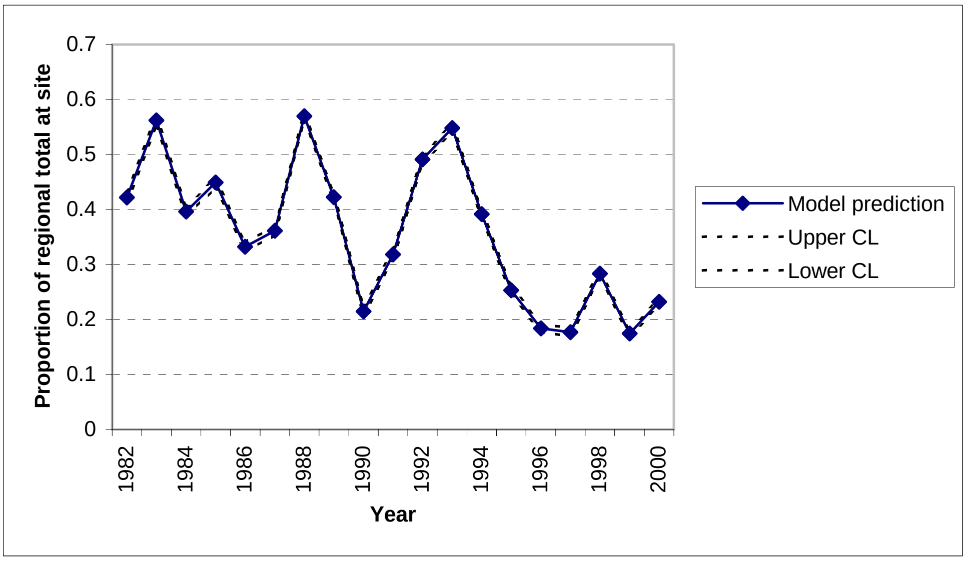

Figure 2.2.4 Logistic model prediction of Coot at the Abberton Reservoir SPA as a proportion of the Anglian Region total. CL = confidence limits. 1982 = winter of 1982/83, and so on.

Three possible scenarios could have resulted in this trend. Consideration of regional and site trends, in conjunction with the proportional trend can determine which applies. Firstly, it is possible that the site trend has shown a decrease while the regional trend has increased or been stable. Thus the proportion at the site becomes smaller as the two trends diverge. Secondly, the site trend could have remained stable whilst the regional trend has increased. Thirdly, both trends may have increased, but with the site trend at a slower rate than the regional trend. If regional counts were formerly low, a particular site may have held a relatively high proportion of the regional total. However, if the species in question expands across the region but remains stable at the site, the relative proportion at the site will be seen to decrease. Where a WeBS Alert has been fired, it may be safe to assume the former explanation is more likely. Figure 2.2.5 shows that for Coot at the Abberton Reservoir SPA, this has indeed been the case. Coot have increased and then declined at Abberton (with particular declines over the past seven years of analysis), whilst the regional trend has shown the opposite, being steadily upwards in recent years.

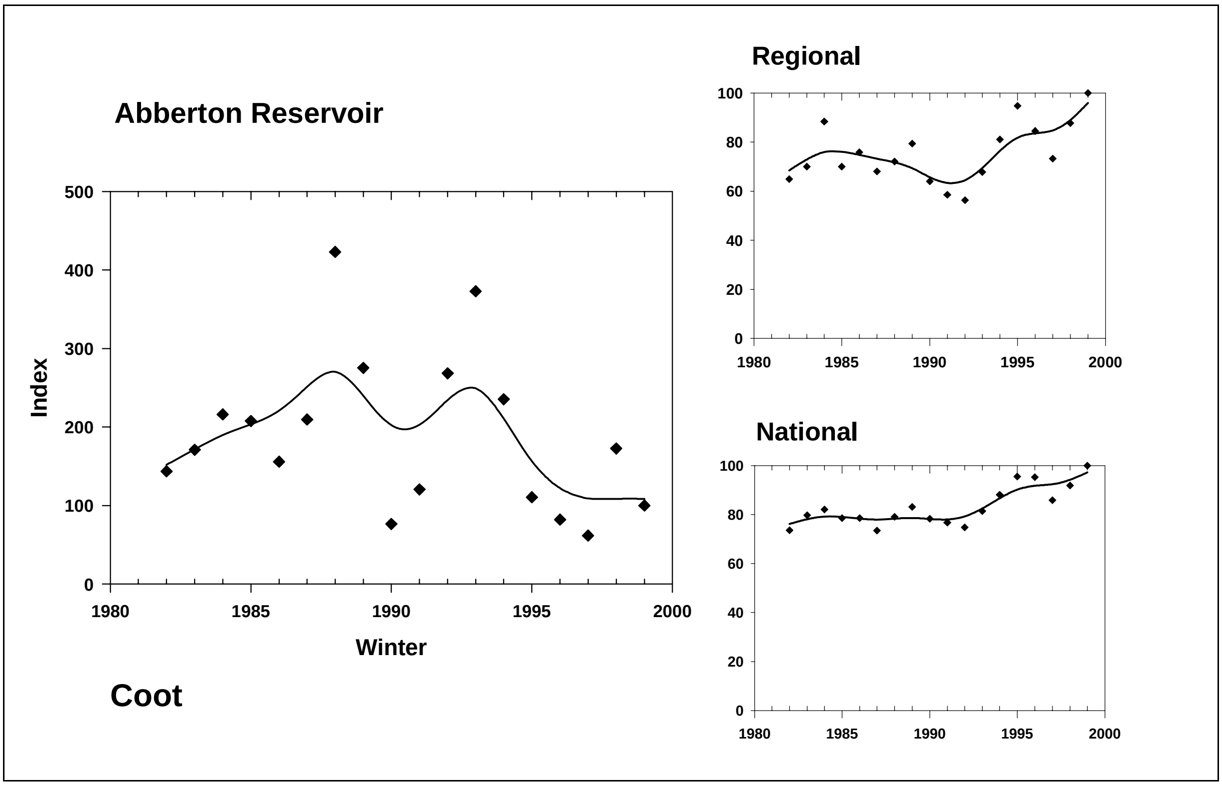

Figure 2.2.5 Plots of site (Abberton Reservoir SPA), regional (EA Anglian) and national (Britain) trends for Coot. 1982 = winter of 1982/83, and so on. Note that the regional and national trends from Austin *et al.* (2004) exclude data from the site under review, which is included in calculations of proportion.

2.2.2.2 Proportional site increase

Where numbers on a site undergo expansion, and regional trends decline or remain stable, a proportional increase is seen at the site under review. As an example, Figure 2.2.6 presents the output from the model for Dark-bellied Brent Geese on The Wash SPA.

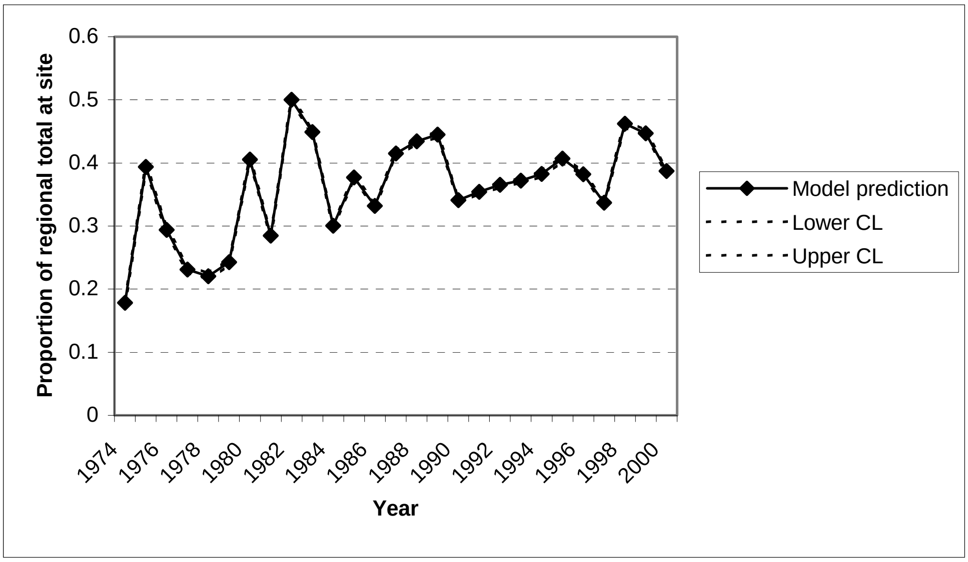

Figure 2.2.6 Logistic model prediction of Dark-bellied Brent Geese on The Wash SPA as a proportion of Anglian Region total. CL = confidence limits. 1974 = winter of 1974/75, and so on.

The overall trend is for an increase in the proportion of Anglian region Brent Geese found on The Wash, from just below 0.2 to just below 0.4. Examining the smoothed indices for site and regional trends (Figure 2.2.7), it is apparent that at a regional level, numbers have declined recently after an increase during the 1970s and 1980s.On The Wash SPA, however, the recorded increase has been much steeper than in the region as a whole, and therefore an upward trend emerges in Figure. 2.2.6.

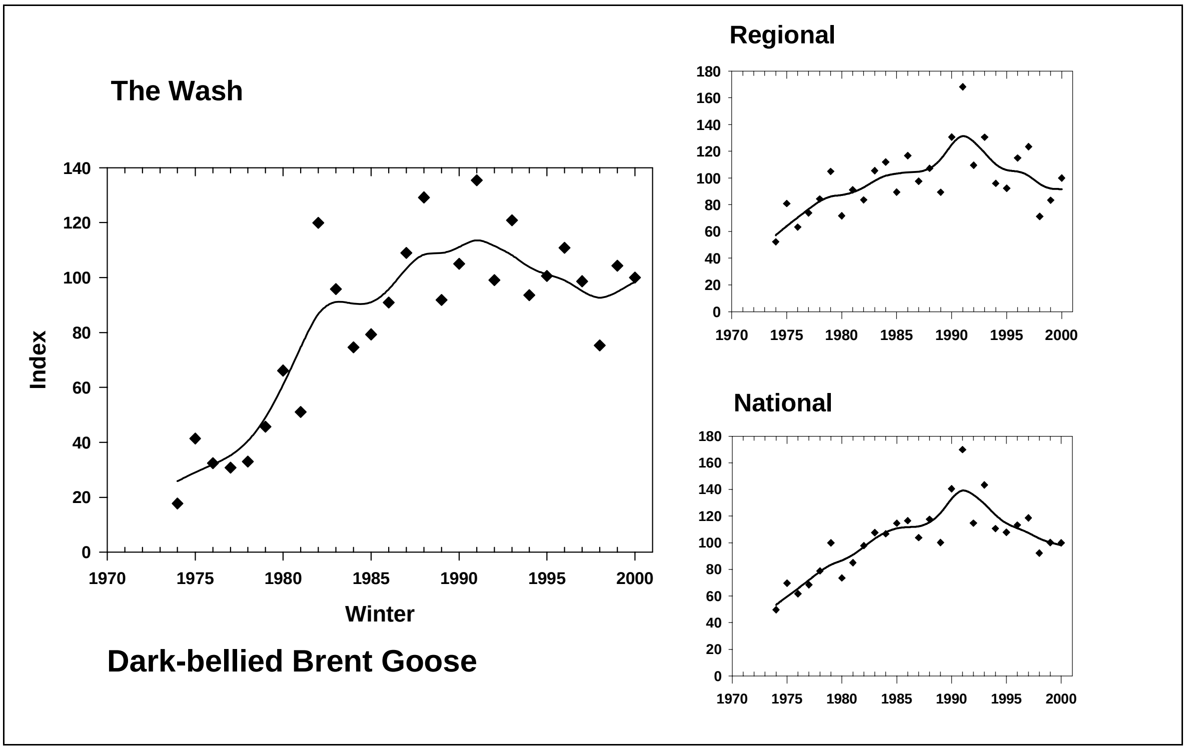

Figure 2.2.7 Plots of site (The Wash SPA) regional (EA Anglian) and national (Britain) trends for Dark-bellied Brent Geese. 1974 = winter of 1974/75, and so on.

2.2.2.3 Proportional stability

Logistic modelling can also produce plots that suggest a species is relatively stable in numbers in comparison to the region. These plots do not signify in which direction the site and regional trends are heading (i.e. increasing, decreasing or stable), merely that they remain consistent to each other. This is perhaps a good example of where wider trends can be used to explain trends at the site level.

Figure 2.1.4 shows the site, regional and national trends of Grey Plover on the Stour & Orwell Estuaries SPA. All appear to be very similar, with consistent increases in the smoothed species indices. Applying the logistic model to the count data, a plot is obtained confirming that the site trend closely tracks the regional trend, as the proportion of Grey Plovers remains reasonably consistent (Figure 2.2.8).

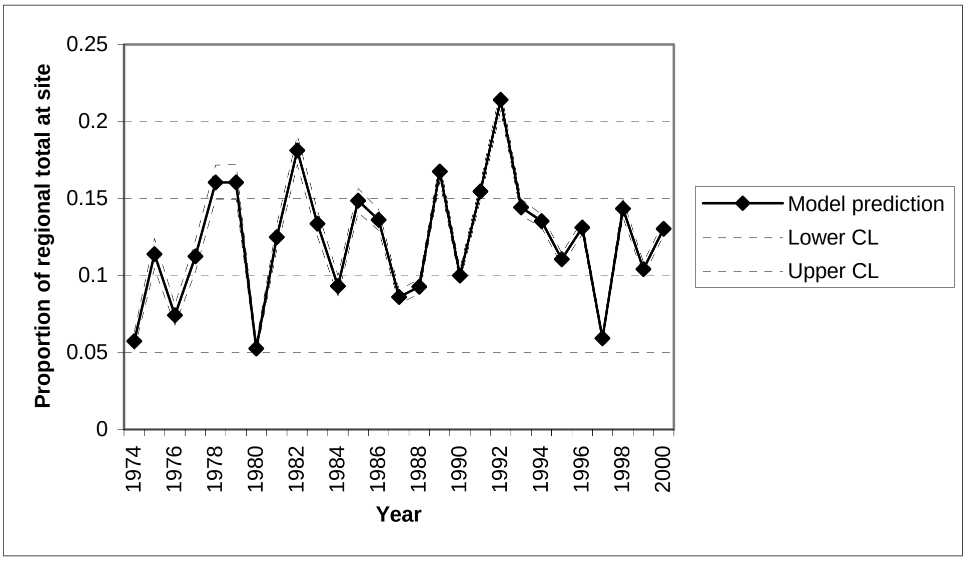

Figure 2.2.8 Logistic model prediction of Grey Plover on the Stour & Orwell Estuaries SPA as a proportion of Anglian Region total. CL = confidence limits. 1974 = winter of 1974/75, and so on.

During the period 1974/75 to 2000/01, the predicted proportion on the Stour & Orwell Estuaries SPA increases by less than 0.1, and in only one year (1992) does it exceed 0.2. This demonstrates that as the site trend has increased, so the regional trend has expressed a similar increase, thus keeping the two trends in similar proportion.

2.2.2.4 Evaluation

This method appears to output clear, intuitive, and easy to comprehend visual displays. These techniques may be developed further to obtain ‘best fit’ lines, and statistics based on, for example, the slope of the line generated. An example is that if the model ran on monthly count data, more instructive confidence limits could be constructed, as at present they tend to be very tight around the predicted values. However, as there are myriad site-species combinations, and therefore many separate tests, it is arguable how instructive significance tests would be, as the risk of Type II error is high.

These illustrative examples have been based on site / region comparisons. A similar approach could also be used to make national comparisons. These would be likely to prove more instructive than correlations between site and national counts, where the former may become ‘swamped’, as the value obtained would always be a proportion.

Current plots used for WeBS Alerts show site trends adjacent to national trends and those for the region excluding the site under review. Using the logistic modelling method, future plots could also include the ‘proportional change’ graph. It would then be more appropriate to include the site under review in the regional plot (rather than exclude it as at present). The national trend (although including the site under review) would be retained. For some large sites it may be appropriate to include national proportional plots where the site in question holds a substantial proportion of the national total (e.g. Knot on the Wash). An incidental advantage of this approach is that regional and national trends would not need to be recalculated for each site: the regional total remains constant, and therefore is calculated only once per region.

Such a method may allow inferences to be made regarding population-level changes in wintering waterbirds, such as the buffer effect (Gill *et al*. 2001). If the best quality sites were filled first, the proportion of the regional total of birds would remain fairly stable at such locations. Concurrently the regional proportion at poorer sites would drop, as these sites buffer good quality habitat from wider species decline.

3. FUTURE WORK

This investigation has raised a number of issues and pointed towards alternative analyses that would warrant further investigation. These could form a basis for future WeBS research.

3.1 Systematic Testing Of Sites Within Regions

Generalized Linear Models (GLMs) could be constructed to factor in effects of year, regional sites and specific site. Average winter counts for all sites would first be log transformed, to compensate for the variability of counts across different scales. A model would then be built including a term for the [specific site*year] interaction. Therefore the influence of the site under review (e.g. The Wash SPA) could be ascertained in the context of the region (e.g. Anglian region).

The model would take the form:

$$\text{Log average count} = S_i + Y_j + (Z_k{*}Y_j)$$

Where S_i = factor for all sites within region, Y_j = year factor, and Z_k = factor for the specific site under review, i.e. $Z = 1$ for a count at the site and 0 otherwise.

A significant [specific site*year] interaction would indicate that counts at the site under review are not reflective of those in the rest of the region, as this interaction term is necessary to explain overall count variance. Non-significant [specific site*year] interactions would suggest that wider trends help to explain specific site trends, as a large part of the variance can be apportioned to the regional trend, and the interaction term explains nothing further; therefore the site trend is likely to resemble the regional species trend.

3.2 Turning Points

Another approach that may be applicable to future WeBS Alerts work- particularly where it is useful to pinpoint temporal changes in species trends with respect to site-specific events- is that of so-called ‘turning points’ in trend lines. Such methods have been developed to examine declines in farmland species, using smoothed Common Bird Census (CBC) trends (Siriwardena *et al.* 1998, Fewster *et al.* 2000). Essentially, turning points are identified as significant changes in the gradient of trend lines, using bootstrap methods to generate confidence limits.

Application of the methods to smoothed WeBS data may prove useful. One caveat, however, is that Siriwardena *et al*. (1998) generated confidence limits from 999 bootstraps. As WeBS data frequently includes missing counts that must be imputed, the dataset is rendered non-random, and would not be subject to the same bootstrapping procedures. This problem would need to be circumnavigated should WeBS Alerts adopt similar techniques.

Identifying the temporal component to changes in trends would seemingly be of benefit to WeBS Alerts for a number or reasons. Firstly, it would help to place potentially detrimental (or beneficial) site events in context, as the timing of turning points could be compared to the timing of such events. This could feedback to site management and focus conservation effort. One possible example is investigating the trends of species targeted by habitat compensation; turning points in upward trends would inform developers of likely timescales for species recovery. Secondly, and perhaps most importantly, turning points at site and regional (or national) levels could be directly compared. If turning points were coincidental, this could indicate that trends at differing spatial scales were following similar patterns (although some interpretation of magnitude and direction of change would be necessary). Thirdly, comparing turning points across species at a site or region may serve to identify changes in groups of ecologically similar species, thus highlighting change on the relevant spatial scale.

3.3 National Trend Comparison

This report has focused primarily on comparisons between site trends and regional trends; however, there is also some need to make comparisons between site trends and national trends.

Issues of scale are likely to arise, and data transformation may be necessary. Whether the modelling procedures outlined here can be modified and applied to national trends could be discovered with further research. Logistic modelling suffers in that proportions of national totals are likely to be diminished, as site totals will be relatively low, and therefore relatively large changes in bird numbers could translate to minor changes in national proportion. The GLMs proposed here are also more appropriate at a regional scale for similar reasons. The analysis of turning points mentioned above could prove beneficial, as if site trends do follow national trends, they may be expected to show similar temporal shifts in their species trends.

3.4 Further Logistic Modelling

If logistic binomial modelling proves successful, more sophisticated models could be devised. For instance, at present, one trial within the model predicts that a bird is either present on the target site (p1) or elsewhere (1-p1). Regional data could be considered to represent a multinomial distribution, as the probability of a bird being at site 1 and of being 'elsewhere', is governed by p1 of being at site 1, p2 at site 2, p*k* at site *k* and so forth, all changing over time but always adding up to one. P1, p2, p*k* can be estimated at once, rather than through repeated tests. SAS programs in use for similar applications could be modified for this procedure.

Alternatively, and if data were readily available, other factors could be added to the existing binomial model. One example is to include a weather variable, to see, for instance, whether certain estuaries are disproportionately favoured due to a sheltered aspect, or local 'mild spots' during severe winters.

4. CONCLUSIONS

(i) Graphical display of changes between years may not be practical using the method originally envisaged in the proposal, given the issues outlined with percentage changes. Further research could examine methods of data transformation if this approach is still valid.

(ii) Simple correlations between counts at site and regional levels can serve to illustrate relationships between variables. However, this approach does not take into account count precision, error or year-by-year factors and should be considered of limited application value.

(iii) Logistic regression appears to be a relatively expedient, efficient and illustrative method for examining variation between site and regional trends. It is suggested that this technique be adopted for future WeBS Alerts reports, with plots of regional proportion replacing or complementing those for national trends.

(iv) Future WeBS development research could focus on the issue of GLMs, with the aim of investigating the effects of removing each site in turn on the regional (or national) total. This would allow assessment of the relative 'influence' of each site for each species.

(v) Further suggestions include more sophisticated binomial modelling, factoring in variables such as weather. Examining the applicability of 'turning points' to WeBS Alerts may also be worthwhile.

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Appendix 1 Smoothed index values, year-by-year percentage changes and differences between site and regional trends for Shelduck on the Teesmouth & Cleveland Coast SPA.

	Site		Region		
Year	**Index value**	**% change$_s$**	**Index value**	**% change$_r$**	**% change$_s$-%change$_r$**
1974	276.62		31.22		
1975	364.41	31.73668	34.31	9.897502	21.83918
1976	419.43	15.09838	36.64	6.791023	8.307355
1977	412.75	-1.59264	38.18	4.203057	-5.79569
1978	381.69	-7.52514	39.72	4.033525	-11.5587
1979	341.46	-10.54	42.51	7.024169	-17.5641
1980	309.84	-9.26024	48.23	13.45566	-22.7159
1981	282.22	-8.91428	58.34	20.96206	-29.8763
1982	252.18	-10.6442	71.2	22.0432	-32.6874
1983	237.06	-5.99572	84.13	18.16011	-24.1558
1984	240.8	1.57766	90.05	7.036729	-5.45907
1985	248.41	3.160299	87.91	-2.37646	5.536757
1986	250.71	0.925889	88.45	0.614265	0.311624
1987	240.48	-4.08041	92.22	4.262295	-8.34271
1988	231.41	-3.77162	96.67	4.825417	-8.59704
1989	225.22	-2.67491	95.98	-0.71377	-1.96114
1990	217.4	-3.47216	87.46	-8.87685	5.404689
1991	213.86	-1.62833	76.34	-12.7144	11.08605
1992	219.71	2.735434	71.01	-6.98192	9.717357
1993	228.99	4.223749	72.61	2.253204	1.970546
1994	227.67	-0.57644	78.96	8.745352	-9.3218
1995	209.24	-8.09505	87.59	10.92958	-19.0246
1996	175.17	-16.2827	94.99	8.448453	-24.7312
1997	139.38	-20.4316	99.89	5.158438	-25.59
1998	112.98	-18.941	102.57	2.682951	-21.624
1999	99.55	-11.8871	102.46	-0.10724	-11.7798
2000	90.5	-9.09091	101.39	-1.04431	-8.0466

Appendix 2 Smoothed index values, year-by-year percentage changes and differences between site and regional trends for Grey Plover on the Stour & Orwell Estuaries SPA.

	Site		**Region**		
Year	**Index value**	**% change$_s$**	**Index value**	**% change$_r$**	**% change$_s$-%change$_r$**
1974	13.52		26.96		
1975	14.89	10.13314	24.67	-8.49407	18.6272
1976	16.37	9.939557	23.13	-6.2424	16.18196
1977	18.12	10.69029	22.53	-2.59403	13.28432
1978	20.27	11.86534	23.46	4.12783	7.737513
1979	22.53	11.14948	25.81	10.01705	1.132432
1980	25.03	11.09632	28.64	10.96474	0.131574
1981	27.98	11.78586	30.5	6.494413	5.291444
1982	30.69	9.68549	32.12	5.311475	4.374014
1983	32.47	5.799935	34.6	7.721046	-1.92111
1984	34.66	6.744687	38.56	11.44509	-4.7004
1985	38.42	10.84824	44.41	15.17116	-4.32292
1986	42.82	11.45237	52.98	19.29746	-7.84509
1987	47.64	11.25642	63.05	19.00717	-7.75075
1988	54.22	13.81192	70.48	11.7843	2.027625
1989	63.14	16.45149	74.37	5.519296	10.9322
1990	73.22	15.96452	76.66	3.079199	12.88532
1991	85.18	16.33433	78.07	1.83929	14.49504
1992	94.71	11.18807	81.72	4.675291	6.512781
1993	98.42	3.917221	90.32	10.52374	-6.60652
1994	98.62	0.203211	100.94	11.75819	-11.555
1995	92.89	-5.81018	106.64	5.646919	-11.4571
1996	82.43	-11.2606	104.2	-2.28807	-8.97256
1997	71.71	-13.005	95.74	-8.119	-4.88597
1998	69.17	-3.54204	88.33	-7.73971	4.197667
1999	75.16	8.659824	88.46	0.147175	8.512648
2000	89.88	19.58489	94.18	6.466199	13.11869