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The Role of Birds as a Potential Source of Bacterial Contamination Along Blackpool Shoreline

Authors

S. J. Holloway, M.J.S. Armitage, G. E. Austin
H J. Mellan & M.M.R. Rehfisch

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

Page No.

Page No.

List of Tables

Page No.

List of Figures

Page No.

List of Appendices

Page No.

EXECUTIVE SUMMARY

Background

Concern that designated bathing waters at Blackpool on the Fylde coast have frequently failed to comply with imperative microbiological standards, and evidence to suggest that birds may be a possible source of the contaminants involved, resulted in the Environmental Agency commissioning a study by the British Trust for Ornithology (BTO) to investigate this issue further during 2001.

Key points

- The results of these analyses were consistent with the hypothesis that birds may be a source of microbiological contaminants in Blackpool's designated bathing waters. Gulls, in particular, were potentially implicated and also, possibly, Starlings.

- Continued monitoring of the numbers of waterbirds, particularly gulls, and Starlings is recommended in order to determine whether or not the relationships identified during 2001 persist in future years.

- It is recommended that if action is taken to alleviate the problem of contamination by implementing measures to dissuade birds from using the area, these should be undertaken within an experimental framework in conjunction with continued monitoring.

- Recommendations are made as to how future bird monitoring could be modified to maximise the collection of necessary data while minimising the cost and effort required.

Details

Surveys of waterbirds using the intertidal areas of the Blackpool sea front between Bispham and South Pier and of Starlings and Feral Pigeons roosting and living around the three piers were conducted between May and October inclusive. Intertidal birds were surveyed by mapping flock locations at high, ebb, low and flood tides. Starlings were monitored by counts made at the roosts. Visits to collect these data were timed to coincide with water compliance sampling undertaken by the Environment Agency, which supplied recorded values of faecal coliforms, faecal *streptococci* and total coliforms. Physical environmental data for factors known to affect observed levels of microbiological contaminants (wind speed and direction, rainfall, sunshine and UVB radiation) were supplied by the Environmental Agency and the Meteorological Office.

The numbers of intertidal birds were quantified by summing separately numbers of gulls and waders, counted across the whole study area, over four stages of the tidal cycle, having first applied a species-specific weighting based on basal metabolic rates to give Gull, Intertidal-Bird and All-Bird "**BMR indices**".

The numbers and distributions of intertidal birds were quantified by digitally capturing maps of flock locations. These were processed within a Geographic Information System to derive Gull, Wader, Pigeon and Intertidal-Bird (gulls + waders + pigeon) "**proximity indices**" (the proximity index for a given location being a distance weighted measure, based on Kriging, of bird numbers, weighted by species basal metabolic rate, in the local area).

Feral Pigeons inhabiting the piers could not be reliably quantified. Starling numbers were quantified by counts made as the birds flew into the roosts. Visits to the three piers along the seafront were made separately on consecutive nights.

Generalized linear models were used to explore possible relationships between each of the microbiological contaminants and bird numbers having controlled for the physical aspects of the environment. Exploratory models that restricted analyses to certain sub-sets of the overall suite of variables were used to investigate specific relationships and to determine which variables should be considered in the all-factor models.

Of the physical variables considered both the north vector of the wind (NVW, wind-speed multiplied by the cosine of the direction) and rain significantly accounted for variation in microbiological contaminants. NVW explained 42% of the variation in faecal coliforms, 40% of the variation in faecal *streptococci* and 40% of the variation in total coliforms. We speculate that this may be due to the influence of wind on the direction of water movement across the site in general or to its local influence on the efficiency with which the tides flush the semi-stagnant pools beneath the piers where faecal contaminants may otherwise accumulate. Rain explained 18% of the variation in faecal coliforms, 64% of the variation in faecal *streptococci* and 20% of the variation in total coliforms. Rain may be bringing contaminants into the system from outside but it may also be washing faeces that have accumulated on the pier structure into the sea water. Additionally UVB explained some variation in both faecal coliforms and total coliforms but, because it was only available for the last 12 visits, was not included in the all-factor models.

Having controlled for the affects of wind and rain the Gull BMR Index significantly improved the model fit for faecal coliforms, explaining a further 9% of the variation. This relationship was consistent across the three piers but not for Bispham.

Having controlled for the affects of wind the number of Starlings on North Pier significantly improved the model fit for faecal streptococci, explaining a further 15% of the variation. This relationship was consistent across all three compliance sampling locations plus Bispham. However, when Rain was included in the model both wind and Starling numbers were displaced.

Having controlled for the affects of wind and rain, none of the bird variables significantly improved the model fit for total coliforms.

It would therefore appear that gulls and possibly Starlings may be contributing significantly to the microbiological contaminant load in bathing waters along the Blackpool seafront.

Given the results of these analyses, which were consistent with the hypothesis that birds may be at least one source of microbiological contaminants, further monitoring of the situation is recommended. Furthermore, we would recommend that if steps are taken to discourage either the gulls within the proximity of the piers, or the Starlings roosting on them then this should be undertaken in conjunction with continued monitoring and ideally within an experimental framework.

Based on the results of our analysis we have been able to suggest ways in which future bird monitoring could be modified to maximise the collection of necessary data while minimising the cost and effort required. It must be stressed that any attempt to reduce the amount of data, or to simplify the data collected, might result in weaker models.

1. INTRODUCTION

Beaches at Blackpool and on the Fylde Coast are designated as Bathing Waters under European Community directive 76/160/EEC (The 'Bathing Waters Directive'). Despite considerable investment in new sewerage and sewage treatment facilities, these bathing waters have frequently failed to comply with the imperative microbiological standards set out in the directive. There is an immediate need to ensure the imperative microbiological standards are met, whilst, in the longer term, the target is to meet the more stringent guidelines standards necessary to allow a beach to qualify for the prestigious blue flag award. The Bathing Waters Directive (and its proposed revision COM (94) 0036-94/00006SYN) (Anon. 1976) aims to reduce the pollution of bathing water and to protect such water against further deterioration (bathing water is defined as all running or still fresh waters or parts thereof and seawater in which bathing is authorised or not prohibited and traditionally practised). The Directive requires Member States to identify bathing areas, to monitor them during the bathing season and to report the results of the monitoring to the Commission. As a part of this monitoring procedure, water quality sampling is regularly undertaken along the shoreline at Blackpool. Amongst the data collected, the spatial and temporal variations in faecal coliforms have been quantified, and on most days the counts are below the standard of 2,000/100 ml. However, on occasions the count reaches 10,000/100 ml in the intertidal zone between the three piers, and particularly between the South and Central Piers (Environment Agency 1999). These peak counts for faecal organisms have been made in the months of July and August, with a considerable degree of variation outwith these two months. These data suggest a significant source of faecal contamination present within the inter-tidal zone between the three Blackpool piers.

Evidence from an 18-month study carried out by Brighton University suggests that birds may be a possible source for these contaminants found off the Blackpool coastline, adding to the load from the other candidates such as sewage, or droppings from Donkeys on the beaches (Environment Agency pers. comm.). Studies such as that by MacDonald and Brown (1974) have indicated that the faecal deposits from feeding and roosting birds could contribute to high levels of bacterial loading. In particular, gulls are known to be carriers of faecal contaminants, and are present in large numbers both within the intertidal area and along the promenade at Blackpool throughout the summer and autumn. Various studies have looked at the possible human health risk that may result from gulls feeding at waste-water outfalls and refuse tips (*e.g.* MacDonald & Brown 1974, Fenlon 1981, 1983, Butterfield *et al.*1983, Ferns & Mudge 2000, Fricker 1984, Monaghan *et al.* 1985). In particular, there is concern that gulls may act as carriers of *Salmonella* between these sources and the inland water reservoirs on which they roost at night. Gulls and other coastal waterbirds, which feed at waste-water outfalls, may also excrete large numbers of faecal coliforms and *streptococci* and thus affect the quality of bathing waters in a much larger area (Jones & Obiri-Danso 1999).

Similarly, Feral Pigeons (*Columba livia*) have also been found to carry coliforms, and at Blackpool, pigeons are plentiful, breeding and roosting under the piers, and feeding along the promenade, often in considerable numbers.

Another species that was suspected as a possible source of the contamination was the Starling (*Sturnus vulgaris*). Anecdotal information suggested that “tens of thousands” roosted on the piers at Blackpool in the late summer and early autumn, thereby generating considerable amounts of faecal material. Large, regular Starling roosts are known to damage plantation trees by either breaking small branches by the sheer weight of the roosting birds and/or smothering all the surfaces with a thick coating of uric acid, which can also kill the tree (Feare 1984). Large roosts on buildings can cause pitting of lime-containing stonework, as the calcium carbonate content is dissolved by the acidic nature of the faeces.

The objectives of the project were:

- To monitor the birds making use of the Blackpool seafront (including the piers) during the main holiday period (May to November).

- To relate the spatial and temporal distribution of birds to changes occurring in the local water quality.

2. METHODS

2.1 Study Area

The survey area comprised an 8.5 km stretch of the Blackpool seafront (Figure 2.1.1), which encompassed most of the weekly sampling locations of the Environment Agency. This survey area included a 5 km stretch of coast between Bispham to the north and South Pier to the south and so incorporated the main Environment Agency study area which contains all three of Blackpool's piers. The extent of the study area was defined so as to encompass areas of high and low levels of faecal coliforms and *streptococci* and expected to contain high and low densities of intertidal birds. The inclusion of the Bispham area ensured that compliance measurements and intertidal bird distributions were available for a location other than those in close proximity to a Starling roost.

2.2 Bird Observations

To ensure adequate temporal coverage 24 weekly surveys, each lasting two days and covering the four stages of the tidal cycle - high, ebb, low and flood tides, were conducted weekly on the site between early May and late October. Each of these surveys was conducted within the 48 hour period prior to the corresponding Environment Agency's water sampling date. Additionally, to determine whether there were any differences in the distribution and numbers of birds present between weekdays and weekends, (possibly as a result of increased disturbance to and/or feeding of the birds by the public at weekends), the project also included two intensive four-day monitoring periods, one in May and the other in September. These intensive periods included a Saturday and Sunday as well as two weekdays.

During the weekly bird surveys the entire 8.5 km of coastline was covered, mainly on foot, and all bird species within the intertidal area were counted and mapped on 1:10 000 scale maps. One set of maps was used for each of the four stages of the tidal cycle during each visit. All observations were made using 8x binoculars. Although Feral Pigeons were often encountered as they fed on the beaches in the vicinity of the piers, these data were reinforced by additional weekly counts of the Pigeons breeding and roosting on the three piers. These counts were gathered as a part of the low tide intertidal counts, as access to the underside of the piers was essential in order to maximise the chances of seeing birds and nests.

Anecdotal information suggested that very large numbers of Starlings roosted on the piers from late summer (August onwards), to late winter (Environment Agency *pers. comm.*), but as data were lacking on the exact numbers of birds involved and the development and duration of the roosts observations at the piers were carried out weekly. It was apparent that even from the beginning of May, Starlings regularly roosted on each of Blackpool's three piers. As the three piers are widely spaced along the seafront, it was not possible to accurately count roosting Starlings on more than one pier at a time. Thus, from the start of the project up to the end of June, a different pier roost was counted each week on a regular rota, with each of the three piers covered every third week. Thereafter, each of the piers was counted on successive nights until the end of October. Observations commenced well before the first birds began to arrive and continued to dusk, thus minimising the possibility of missing birds. The observation times were adjusted on a daily basis to allow for the changing of the seasons as well as the weather. The first Starlings began to arrive at roost earlier if the weather was poor (*i.e.* overcast and/or wet) and flights into the roosts finished earlier during very dull conditions.

2.3 Literature Search

To place the numbers of birds recorded at Blackpool into a national context, a literature search was undertaken, based primarily on published county avifauna and annual county bird reports. Particular emphasis was given on finding information pertaining to Cleethorpes, Southsea, Brighton and Southend. The Environment Agency have expressed particular interest in these coastal resorts as they appear superficially similar to Blackpool, each possessing at least one pier, but none have failed any EA water quality sampling tests, despite the presence of birds on or close to the piers.

2.4 Statistical Modelling

Possible relationships between microbiological data from compliance sampling and the bird and environmental data were explored using generalized linear models (GLMs: McCullagh and Nelder 1989, SAS Institute Inc 2001). A summary of the abbreviations used and variables described below is given in Table 2.4.1.

2.4.1 Microbiological Data

Microbiological data from the compliance sampling were collected and supplied by the Environment Agency. Three different measurements were supplied for the analysis, these being faecal coliforms (CFU/100ml), total coliforms (CFU/100ml) and faecal *streptococci* (CFU/100ml). Values of microbiological contaminant measurements were $\log_{10}$ transformed and averaged, using geometric means, across all samples within each compliance sampling period. These averages were either calculated separately for each sampling location (Bispham, North Pier, Central Pier and South Pier), across all piers or across-locations as appropriate for each analysis. Each sampling event collected data over a three day period for various heights of the tide. Although reasonably consistent, there was some variation in the composition of samples for each sampling period in terms of numbers of measurements obtained for each stage of the tide.

2.4.2 Physical Environmental Data

In addition to the numbers and distributions of birds, which may have been related to values of faecal contaminants, a number of other factors are known to affect observed values of water compliance measurements, and it was important that these were taken into consideration during the modelling process. Sunlight, and in particular ultra-violet (UVB) radiation are known to kill the bacteria. Rain would lead to increased quantities of land surface runoff which could bring contaminants in to the site from outside. Wind speed and direction are largely responsible for wave action and long-shore currents.

Data obtained from Squires Gate Airport, Blackpool (SD 31670 31602) were supplied by the Environment Agency. These included Environment Agency 15-minute data for UVB radiation ($W\ m^{-2}$) and rainfall (mm), and Meteorological Office data for wind speed (knots) and direction (degrees) in hourly increments and sunshine hours in daily increments. The UVB measuring device was not commissioned until late June and so were not available prior to visit 10 of the 24 main visits.

For each water compliance measurement visit, hours of sunshine, UVB and rainfall were each summed over a three day period coincident with collection of compliance data and bird counts.

Because the Blackpool shoreline has a north to south alignment, the east vector of the wind (EVW) would quantify the strength of the onshore / offshore component of the wind and the north vector of the wind (NVW) would quantify its long-shore component. The onshore/offshore component of the wind has particular relevance to wave strength and tide height and long-shore wind to long-shore surface currents. For the Blackpool shoreline, an onshore wind would have a positive EVW and an offshore wind a negative EVW component. A wind from the south would have a positive NVW and one from the north a negative NVW. The east vector and north vectors of the wind were calculated according to the following equations and then averaged for the same three day periods over which calculations of other physical variables were based.

EVW=WindSpeed × SIN(Direction in Radians);

NVW=WindSpeed × COS(Direction in Radians);

2.4.3 Intertidal Bird Distributions

The statistical approach adopted sought to relate bird numbers and distribution to measured levels of faecal contaminants. The bird data collected on the intertidal habitat could be considered using several options. Models could be derived based on the total bird numbers across the entire study area. Summing together birds of different species can be simplistic because the amount of faecal material an individual bird can be expected to produce will be related to its energy requirements, which in turn will be largely dependent on its size and also its taxonomic group (for example the metabolic rate of the Starling, a passerine, is higher than that of the much larger Knot, a wader. Faecal output can therefore differ markedly between species. This was addressed by deriving indices based not on numbers but on energy requirements as described below (2.4.3.1). The other option, the proximity indices, also described below (2.4.3.2), takes this further by considering not only numbers but also the distribution of birds. These indices were generated for groups of related species, all birds on the intertidal zone and where appropriate all birds (intertidal zone plus Starling roosts). Group indices are readily justifiable from a biological perspective being comprised of species with similar ecology. The all bird indices may be more difficult to defend biologically. Group indices would also, if significantly related to microbiological contaminants, more clearly determine those species responsible for that contamination.

2.4.3.1 BMR indices

A bird's output of faecal material is related to its food intake, which in turn is related to its metabolic rate. The latter will differ on average between species and also with changes in environmental conditions but the metabolic rate of a bird of a particular species would be expected to be closely related to its Basal Metabolic Rate (BMR; Table 2.4.3.1). By weighting numbers of each species by BMR numbers of different species were quantified on a common scale of measurement that facilitated summing by species group and across all species. This was done for gulls and waders to give **group BMR indices** (not necessary for pigeons or Starlings as only one species was involved in each case), across all species other than Starlings to give an **Intertidal-Bird BMR Index** and across all species (including Starlings) to give an **All-Bird BMR Index**.

The BMR indices are therefore bird numbers, weighted by species basal metabolic rates and summed across the entire study area.

2.4.3.2 Proximity Indices

While the BMR indices can be readily incorporated into statistical models, they fail to capture information regarding the distribution of birds within the site, and thus the way in which concentrations of birds may be related spatially to observed values of water compliance measurements. Consequently, if there were consistent differences between values for water compliance measurements between the sampling areas, the use of BMR indices in the statistical models would have failed to capture these important differences. This was addressed by modelling the bird distributions within a Geographic Information System (GIS). Digital base maps of the study area, provided by the Environment Agency, were incorporated into ArcView GIS (v8.1, ESRI 2001). The bird numbers and distribution data were digitally captured and incorporated into the GIS as geo-referenced polygons with boundaries corresponding to the limits of flocks recorded on the field maps and with associated attributes detailing the number of individuals of each species comprising each flock.

In this 'raw' form these data still do not lend themselves to statistical modelling. In particular it would be expected that faecal contamination by these flocks would have effects spreading beyond the limits of the flocks, both spatially and temporally. Also the recorded limits of the flocks represent one point in time and flocks would be expected to move in response to the tidal cycle although probably remaining in the same general area. Data for each visit were resampled within the GIS by overlaying a regular grid representing 100 m x 100 m on the ground. For each species the numbers contained within each flock were re-allocated to overlapping grid cells in proportion to the area of overlap (between the grid cell and the flock polygon), and then, the values within each grid cell summed over the four surveys representing the complete tidal cycle. The values were then multiplied by the BMR of the species concerned (Table 2.4.3.1). Because bird values were thus represented on a common scale, this facilitated summing them across species whilst allowing for size differentials to give a measure of the overall bird distribution across the grid matrix. This was calculated separately for gulls and waders.

At this stage of the processing each 100 m x 100 m grid cell had associated with it a single value for each of gulls, wader and Feral Pigeon BMR Indices. The main advantage that could be obtained by matching these values spatially against measured water compliance data would have been that it controlled for flock densities. However, this still did not capture the aspect of faecal contaminant input from the birds extending beyond the flock limits due both to being spread out from source by the water and flocks movement. The first aspect was partially addressed by recording flocks through a complete tidal cycle but further processing enabled more account to be taken of both aspects. In areas where no flocks had been recorded it would be expected that levels of faecal contaminants would be related to their proximity to areas where birds had been recorded. Geostatistical interpolation (ESRI 2001) was used to derive **group Proximity Indices** for gulls, waders, and Feral Pigeons and an **Intertidal Proximity Index** for all species combined. It was not appropriate to use the same interpolative approach for Starlings for which data were collected as point counts. This process, known as Kriging, (a feature of most GIS software), uses statistical models that include autocorrelation (the statistical relationship between the measured points) to interpolate a smoothed surface between the measured points. Kriging weights the surrounding measured values to derive a prediction for an unmeasured location. The smoothed surface was derived on a 10 m x 10 m grid (Figures 2.4.3.2.1 – gulls, 2.4.3.2.2 – waders, 2.4.3.2.3 – Feral pigeons excluding piers, 2.4.3.2.4 – all intertidal birds). These were the values that were spatially matched to water compliance sampling locations provided by the Environment Agency, to provide inputs into the statistical modelling that followed.

The proximity indices for a given location are therefore distance-weighted measures, based on Kriging, of bird numbers, weighted by species basal metabolic rate, in the local area.

2.4.4 Modelling Protocol

Statistical models were constructed using a "bottom-up" approach whereby relationships between water compliance data and each of the avian and environmental measures described below were considered first using separate exploratory models and then combined using stepwise methods into the all-factor models. For each water compliance measurement, "across all sampling locations", "across all piers" models and location specific models were considered. Where the location factor did not significantly add to the model fit, the subsequent model development used geometric means of microbiological contaminant data across all four sampling locations ("across-locations" models). Where the location factor did add significantly to the model fit only when Bispham data were included subsequent model development used geometric means of microbiological contaminant data across all three piers ("across-piers" models) and separately for Bispham. Location specific models were developed only where the location factor significantly added to the across-piers model.

2.4.4.1 Exploratory models based on physical variables

GLM analyses were first used to consider potential relationships between microbiological contaminants (MC) - faecal coliforms (FC), faecal *streptococci* (FS) or total coliforms (TC) - and the physical aspects of the environment. Values for microbiological contaminants were $\log_{10}$ transformed. The geometric means of each microbiological contaminant for each sampling site were modelled in response to sunshine, UVB, rainfall and the wind vectors EVW and NVW, with sampling location - Bispham, North Pier, Central Pier or South Pier - included as a class variable represented by the estimable factor location_i:

Thus, the least parsimonious GLM possible for each microbiological contaminant would be:

$$MC_i = \text{intercept} + \text{location}_i + \alpha(\text{sunshine}) + \beta(\text{UVB}) + \gamma(\text{rainfall}) + \delta(\text{EVW}) + \varepsilon(\text{NVW})$$

from which only those variables that significantly improved the model fit to the data would have been included. As UVB data were not available until the end of June (visit 10) separate models were constructed for May to October inclusive and for July to October inclusive.

2.4.4.2 Exploratory models based on Starlings

GLM analyses were next used to consider potential relationships between microbiological contaminants and Starling numbers, with sampling location included as a class variable - again represented by the estimable factor location_i:

Thus, the least parsimonious GLM possible for each microbiological contaminant would be:

$$MC_i = \text{intercept} + \text{location}_i + \alpha(\text{Starlings})$$

from which only those variables that significantly improved the model would have been included. Starling numbers were incorporated into the model structure using two alternative methods - the overall sum of Starlings across the three piers and the count on the pier adjacent to each compliance sampling area. Models relating microbiological contaminants to the overall Starling numbers were restricted by availability of data as counts were only made for all piers on the 12 visits from July onwards. Alternative models that used counts from North Pier, the largest of the three roosts as a surrogate for the overall numbers increased the sample size to 19 visits. Models relating microbiological contaminants to Starling numbers on the adjacent pier to the sampling location spanned May to October (24 visits) but excluded Bispham where there was no Starling roost. Although the time that the Starlings spend at roost will vary throughout the year depending on sunset and sunrise times they would be expected to produce most of their nightly faecal output in the first one or two hours after arrival at the roost (Chris Feare pers. comm.) and so no seasonal adjustment of Starling numbers to represent "Starling hours" was used.

2.4.4.3 Exploratory models based on Intertidal Bird Numbers and Distribution

GLM analyses were next used to consider potential relationships between microbiological contaminants and the number and distribution of birds on the intertidal areas. Unlike gulls, the numbers of waders and pigeons recorded on the intertidal areas were insufficient to implicate either as the sole source of the microbiological contamination and so it was inappropriate to consider them separately in the models. However, while the numbers of gulls recorded was sufficiently high to warrant their inclusion alone in the models, it was also possible that the small numbers of waders and pigeons, although too small to justify being modelled separately in any meaningful manner, may have added measurably to the overall microbiological contamination. Consequently, each microbiological contaminant was modelled separately either in relation to gulls alone or in relation to all birds recorded on the intertidal area. Values were summed across the entire tidal cycle, with the sampling location included as a class variable – again represented by the estimable factor $location_i$:

Thus, the least parsimonious GLM possible for each microbiological contaminant would be:

$$MC_i = \text{intercept} + location_i + \alpha(\text{intertidal birds})$$

from which only those variables that significantly improved the model would have been included. Numbers and distributions of intertidal birds were modelled separately. Intertidal bird numbers were incorporated into the models as BMR indices for either gulls alone or for all intertidal species combined. Because BMR indices were obtained by summing across the entire study area they are best suited to modelling situations where compliance values between piers were similar and / or varied in parallel. Distributions were incorporated in the models as the proximity indices again for either gulls alone or for all intertidal species combined. Because values are matched to each compliance sample locations Proximity indices are better suited to modelling situations where compliance values for the different sampling sites varied independently.

2.4.4.4 Exploratory models based on Overall Numbers

GLM analyses were next used to consider potential relationships between microbiological contaminants and the overall number of birds across the entire study area. This analysis was restricted to using BMR indices because proximity indices were not derived for Starlings. Each microbiological contaminant was modelled in relation to overall bird numbers with the sampling location included as a class variable represented by the estimable factor $location_i$.

Thus, the least parsimonious GLM possible for each microbiological contaminant would be:

$$MC_i = \text{intercept} + location_i + \alpha(\text{birds})$$

from which only those variables that significantly improved the model would have been included.

In the context of this analysis, quantifying bird numbers by adding together numbers from different groups assumes that individuals in the different groups are equally susceptible to contamination by the microbiological organisms. This is unlikely to be the case. Waders are restricted largely to the intertidal zone throughout the day and night, gulls typically roost in large numbers, particularly in inland waters and are attracted in large concentrations to forage repeatedly at sites such as refuse tips while the large roosting flocks of starlings disband into smaller flocks during the day to forage widely over grassland. Consequently, because of the markedly different ecology between bird groups this is the least biologically defensible method of quantifying bird numbers used.

2.4.4.5 All-factor (combined) Models

As already stated, the ultimate models aimed to describe possible relationships between microbiological contaminants and bird numbers and distribution, having first controlled for the physical aspects of the environment that may influence the measured values. This was achieved by seeking the most parsimonious set of predictor variables from the suite of physical environmental variables and then seeking to explain residual variation by the inclusion of avian factors. The ultimate models for microbiological contaminants therefore included physical aspects of the environment, intertidal bird variables and Starling numbers (or the latter combined) as explanatory variables from which only those variables that significantly improved the model would have been included. Because of the markedly different ecology between different bird groups, those variables based on individual species or groups of related species provide a more biologically defensible method of quantifying bird numbers than do variables based on combinations of species across groups. The latter would therefore only be used where they added considerably to the explained variation in microbiological contaminants compared to the former.

3. RESULTS

3.1 Bird Observations

The distributions of birds found on Blackpool seafront between May and October inclusive during 2001 are depicted in terms of proximity indices for gulls (Figure 2.4.3.2.1), waders (Figure 2.4.3.2.2) Feral Pigeons (Figure 2.4.3.2.3) and, together with Starling numbers, for all intertidal birds combined (Figure 2.4.3.2.4).

3.1.1 Gull observations

Five species of gull were commonly recorded during the survey period feeding and roosting within the intertidal area. The commonest of these throughout was Herring Gull (*Larus argentatus*), with a peak count of 2,000 individuals present in mid-August (Figure 3.1.1.1). Lesser Black-backed Gulls (*L. fuscus*) were also present throughout, but in much smaller numbers than the previous species, with the highest count of 220 birds in mid-June (Figure 3.1.1.2). Great Black-backed Gull (*L. marinus*) numbers showed a small increase from the late summer, but counts were always less than 35 individuals, and usually in single figures (Figure 3.1.1.3). Common Gull (*L. canus*) and Black-headed Gull (*L. ridibundus*) were also regularly recorded. Although often absent from counts during May and June, numbers of Black-headed Gulls increased considerably during July and August, which coincides with the post-breeding dispersal of adults and juveniles (Figure 3.1.1.4). By the end of August, more than 700 individuals were present, generally distributed along the entire survey area. Common Gulls were the least frequently recorded of the five species, effectively absent throughout the summer months, with small numbers present in early May, and again from September onwards (Figure 3.1.1.5). The only other species of gull identified on the intertidal area was Western Yellow-legged Gull (*L. (cachinnans) michahellis*), with three sightings during the autumn. Overall gull numbers, corrected for BMR to allow counts of different species to be combined, show a peak in late August (Figure 3.1.1.6).

The majority of the gulls present at Blackpool during the summer were non-breeding, sub-adults (mostly first and second year birds). The larger species, such as Great Black-backed, Herring and Lesser Black-backed Gulls take four or five years to reach full adult breeding condition. In the early years, these birds tend to be less mobile than the adults, often remaining at a suitable feeding site for extended periods (months and even years). The numbers of gulls on the Blackpool beaches increased from July onwards, with the arrival of further adults accompanied by juveniles. It would be expected that many would choose to remain in the area, assuming suitable conditions, for the entire winter period, with the adults returning to their breeding areas the following spring. Some species, such as Lesser Black-backed Gull and Common Gull tend to migrate further south, and many post-breeding birds are likely to pass along the Lancashire coastline during the course of the autumn/early winter, heading north again the following spring.

The temporal distribution of gulls along the study area revealed a gradual build up of numbers around the three piers from the middle of May onwards (Figure 2.4.3.2.1). By the middle of July, the numbers also began to increase between the piers and also off Bispham at the northern end of the site. This trend continued throughout August and into early September. Thereafter, the numbers began to show some decrease, but with concentrations around the three piers and in the northern part of the site. However, over the 9th/10th October, the greatest numbers were to be found just to the south of the South Pier, with relatively few gulls actually around the piers (Figure 2.4.3.2.1).

The intensive four-day surveys carried out in May and September, spanning both weekdays and weekends, did not show any obvious differences in either the numbers of gulls or their distribution within the inter-tidal area (Figures 2.4.3.2.1 & 3.1.1.7) between weekdays and weekends, although the quantity of data were insufficient to allow statistical comparisons to be made.

3.1.2 Wader Observations

Waders were virtually absent for most of the summer months, with the exception of small numbers of Oystercatchers (*Haematopus ostralegus*) (Figure 3.1.2.1), which were breeding nearby, and occasionally fed in the intertidal area. However, by late August, the numbers and variety of waders began to increase, as post breeding adults and young birds began to disperse from their natal areas further to the north. Oystercatcher and Redshank (*Tringa totanus*) (Figure 3.1.2.2) were the most abundant, with the latter mostly found in the areas most distant from the piers, and the former generally distributed along the entire 8.5 km of shoreline. Overall wader numbers increased from early August (Figure 3.1.2.3), with a particular concentration around the three piers (Figure 2.4.3.2.2). However, wader numbers and distribution showed considerable variation between weeks during the remainder of August, with the greatest concentrations to be found at the southern end of the survey area by early September (Figure 2.4.3.2.2). By October, the greatest selection of species was to be found between South Pier and Squires Gate. However, even at the "peak" migration periods, the number of waders present along the intertidal area was relatively small compared to the numbers of gulls within the same area.

The intensive four-day surveys carried out in May and September, spanning both weekdays and weekends, did not show any large differences in either the numbers of waders or their distribution within the inter-tidal area. Too few waders were present in May to allow meaningful comparisons, but a greater number and range of species were present in September (Figures 2.4.3.2.2 & 3.1.2.4).

3.1.3 Feral Pigeons Observations

Feral Pigeons were present in varying numbers along the entire survey area, with the fewest in the northern sector (Bispham), and the greatest concentrations along the coastal stretch encompassing the three piers. Pigeons breed underneath all of the piers, and the concentration of visitors to this part of the shoreline ensures that there are plenty of food scraps to sustain the population. The pigeons were commonly seen feeding on the beach itself adjacent to the piers, particularly on the areas of freshly raked sand (a daily process carried out by Blackpool Council in order to remove most of the accumulated rubbish). During the day, there were always pigeons roosting on top of the piers in addition to breeding and loafing birds present on the undersides of the piers. Fewer than 50 birds were present in general on the intertidal substrate, although more than 400 were counted on or under the three piers on several occasions. During the busiest holiday period (July to September), pigeons were commonly fed along the promenade, and flocks of between 40 and 50 birds were not unusual. Many pigeons were noted flying further inland (and therefore out of sight), presumably to additional feeding areas. Towards dusk, pigeons were recorded flying from inland to roost on the three piers. It is unclear as to whether some of these individuals comprised a part of the breeding populations on the piers, or whether they were additional birds using the structures as a safe roosting site. More than 50 birds were counted on many nights, flying in with the Starlings, and eventually mostly disappearing beneath the piers where the matrix of girders, pipes and other supporting structures afforded the most shelter.

Accurately assessing the numbers of breeding Feral Pigeons on the piers was extremely difficult, as the under-pier structures ensured that many nests and roosting birds were hidden from view on top of the girders, and a few other nests were similarly hidden under the roofs of the buildings on the piers. However, from a combination of calling squabs, individuals flushed from the ledges and counts of the visible nests, estimates were obtained on a regular basis. All three of the piers showed large concentrations of droppings on the supporting girders and pipe work, mostly several centimetres thick. North Pier appeared to have the most pigeons (with more than 50 recorded flying out as a result of a distress flare igniting in June). Fewest pigeons were noted on South Pier, with the greatest concentrations of birds at the distal and proximal ends of the piers. Feral pigeons are known to be capable of breeding for much of the year, and young birds were seen and heard throughout the survey period (May to October), indicating that this was the case at Blackpool.

3.1.4 Starlings Observations

Anecdotal information suggested that up to 250,000 Starlings roosted on the piers at Blackpool (Feare 2001). However, this was an estimate made by a local pest control contractor, who worked for Blackpool Council on bird deterrent measures on the piers and its accuracy is not known. The timing and duration of the roosts were unclear, but it was presumed that the roosts would begin at the end of the breeding season (probably during August), and gradually build up during the autumn and early winter, as continental birds, principally from North-west Europe, arrive in the country and join with our resident post-breeding birds. By late March, most roosts are in decline as the migrant individuals begin to head back to Europe and the British birds begin to seek out breeding territories. With this established pattern in mind, it was a surprise to find that there were varying numbers of Starlings roosting on all three of the piers throughout the survey period (Figures 2.4.3.2.4 & 3.1.4.1).

The actual numbers changed with the seasons, with the expected post-breeding build up from July onwards, with an apparent peak during the last week of August (Figure 3.1.4.1). By far the largest numbers were recorded on North Pier, where the roost was an estimated 25,208 birds at its height. The largest count on Central Pier was of 9,193 birds at the end of August, and that on South Pier, 2,601 birds at the beginning of September. Collectively, the largest number of Starlings was counted on the piers during the period 29th August to 1st September, when the grand total recorded on the three piers amounted to approximately 37,000 individuals.

Whenever possible, the ratio of juveniles to adults was recorded as the birds flew in to roost. Juvenile birds can be distinguished from the adults for several weeks after fledging by virtue of their plain brown plumage (as opposed to the rich purples and greens of the adults). However, the juveniles rapidly moult into adult winter plumage by late summer/early autumn, and are then impossible to tell apart from adults in the field. During the fieldwork at Blackpool, the first juveniles were noted at the roosts on June 28th, with around 10% of the roosting flocks estimated as juveniles. This proportion continued to build up through July and August, with up to 60% of the roosting flocks comprised of juveniles by the second week of August. After the middle of August, it became increasingly difficult to identify the juveniles as many had already moulted into adult plumage, and the size of the roosting flocks had begun to dramatically increase in size, making counting that much more difficult.

From the observations of the roosts, it was not possible to ascertain whether there was regular interchange between the three roosting sites by the birds. Even allowing for counter variation, there was some suggestion that this might have taken place on at least some occasions, as counts showed a marked decline at one site coupled with a similar gain at another, all within the space of a few days.

The behaviour of the Starlings prior to going to roost and actually at the roosting sites also changed during the course of the season. During the observations made between early May to early July, the birds flew directly to the piers from either directly inland or from further along the coast. Sometimes, they would go straight to their roosting ledges below the pier, but often they would first land on the roofs of pier buildings, or on the railings around the pier, and gradually drop down to their roosting area over a period of a few minutes. In very windy conditions the birds tended to fly straight to their roost site under the pier. However, as the numbers of roosting birds increased from July onwards, it was very noticeable that the Starlings formed pre-roost gatherings on seafront buildings before flying on to the piers. This made the counting more difficult, as instead of relatively small flocks arriving in a fairly regular stream, very large flocks comprising up to 6,000 individuals would descend on the pier, many going straight to their roosting ledges. By September and October, the behaviour of the Starlings changed once again, as large flocks arriving at the piers engaged in spectacular display flights, flying round and round the structures, often being joined by additional in-coming parties. On many occasions, these wheeling flocks would then head back inland again, picking up and shedding satellite flocks en-route, before eventually once again returning to the piers. Getting accurate counts proved to be a real challenge confronted with this type of behaviour.

Throughout the season, it was noticeable that there was always a small contingent of the Starlings on the piers in the evenings that arrived and mixed with a flock, but after sitting on the buildings for a while or flying around the piers, would head off inland, presumably to another roosting site. By the late summer, several hundred birds exhibited this type of behaviour, by flying inland from North Pier. It is thought that these large pre-roost gatherings by communal species such as Starlings act as "information centres" for food finding (Ward & Zahavi 1973).

On each of the three piers, the Starlings chose specific parts of the structures for roosting. On the North Pier, the majority of the birds used the seaward (distal) end, with small numbers also present at the landward (proximal) end, mostly from August onwards. On the Central Pier, the birds preferred the central and distal sections, with netting at the landward end deterring the birds. On South Pier, the roost was concentrated towards the centre of the structure.

3.1.5 The Numbers of Birds Recorded at Blackpool in a National Context

Overall, the numbers of waders recorded along the intertidal area was not exceptionally high, particularly when compared with nearby Morcambe Bay and Ribble Estuary that attract vast numbers. It is likely that the regular human disturbance reduces wader numbers along the Blackpool seafront, particularly the intertidal areas between the three piers. The gull population at Blackpool was also unexceptional within national terms. Indeed, it is perhaps surprising that larger numbers were not regularly recorded given the readily available food supply along the seafront. It is possible that many gulls made regular feeding trips to the large municipal rubbish tip at Fleetwood, so the actual numbers visiting the seafront during the summer months may have been substantially larger than a series of counts can indicate.

There are many coastal areas around the British Isles where hundreds of sub-adult gulls regularly occur throughout the summer months, well away from rubbish tips and large holiday resorts *e.g.* parts of the North Norfolk coast. Although flocks of gulls are almost certain to occur on the intertidal areas of Cleethorpes, Southend, Brighton and Southsea, there are no specific data pertaining to actual numbers in the literature consulted. Similarly, there was relatively little literature pertaining to Starlings in the four towns. However, the relevant county avifauna and Bird Reports (Lincolnshire, Essex, Sussex and Hampshire) all report a marked decline in the populations of breeding, migrant and wintering Starlings over the last decade. In the late 1980's, up to 3,000,000 birds were estimated at a single inland roost in Essex, but the highest recent count for that area barely exceeded 10,000 individuals. Similarly, it is reported that as many as 100,000 Starlings roosted in "the Portsmouth area" during the early 1980's, which may have included Southsea Pier, but the highest count anywhere in Hants during 2001 was a mere 5,000 birds (on Farlington Marshes during the summer.) Brighton West Pier is still regularly used by between 10,000 – 20,000 Starlings during mid-winter. Eastbourne Pier also currently holds a similar sized roost during the winter period, but with the exception of these two sites, no flocks above 5,000 birds are regularly recorded. No large flocks have been recorded in Lincolnshire in recent years. Thus, the number of Starlings using the three pier roosts at Blackpool, (reaching an estimated 37,000 individuals in late August/early September), is considerably higher than at the four resorts discussed above.

3.2 Statistical Modelling

Ultimately, the aim of this analysis was to model possible relationships between microbiological contaminants and a set of avian factors having first controlled for physical aspects of the environment. Thus, models based on physical environmental variables, Starling roost counts and intertidal bird numbers and distributions were first explored separately and then combined for the all-factor analysis. By first considering separate models, either derived using physical variables only or particular methods for quantifying bird numbers and distribution, it is possible to gain insight that may be obscured in the ultimate models. However, those exploratory models that were based on avian factors alone, should not themselves be used to assess the likelihood that levels of microbiological contaminants are related to bird numbers. That assessment should be reserved for the ultimate models in which the physical environmental factors have first been controlled for. Site-specific models were also examined where it was considered that these might provide additional insight into any relationships that were identified.

3.2.1 Exploratory models based on physical variables

The location factor significantly added to the model fit for faecal coliforms (and "nearly so" to the model for total coliforms) using data from all sampling locations but not when data from Bispham were excluded. Consequently across-piers and Bispham only models were required for faecal coliforms and so also developed for the other microbiological contaminants for reasons of consistency. In the across-piers models NVW added significantly to model fit for all three microbiological contaminant measures, while Rain significantly added to the model fit for faecal coliforms and total coliforms models (Model A, Table 3.2.1). NVW explained 42% of the variation in FC, 40% of the variation in FS and 40% of the variation in TC while Rain accounted for a further 18% of the variation in FC and 22% of the variation in TC. The models for Bispham were similar with respect to NWV but Rain did not significantly improve the model fit for any of the microbiological contaminants. In all cases a negative parameter estimate for NVW indicated that levels of faecal contaminants decreased as the northward component of the wind increased (i.e. microbiological contaminant levels were lowest with strong southerly winds). In both cases where it significantly added to the model fit a positive parameter estimate for Rain indicated that levels of faecal contaminants increased with increasing rain fall.

When the models were based on data from July to October – May and June being excluded by the inclusion of UVB data - the location factor again significantly added to the model fit for both faecal coliforms and total coliforms when these were based on all sampling locations, but not when data from Bispham were excluded. Consequently, across-piers and Bispham only models were required for both faecal coliforms and total coliforms and so were also developed for faecal *streptococci* for reasons of consistency. Rain significantly improved the model fit for all three measures of microbiological contaminants. Positive parameter estimates for Rain for all three models indicated that levels of faecal contaminants increased with increasing rainfall. Additionally UVB levels significantly improved the model fit for faecal coliforms and total coliforms (Model B, Table 3.2.1). A negative parameter estimate in both cases indicated that measured values of the microbiological contaminants decreased as UVB levels increased. Unfortunately, because UVB data were only available from the end of June (12 visits), its inclusion in the all-factor models would have reduced the observation to variable ratio to an unacceptable degree (Tabachnick & Fidell 1989) .

3.2.2 Exploratory models based on Starlings numbers

Overall Starling numbers did not significantly improve the fit of the models for any of the microbiological contaminants, regardless of whether considering across-locations or location specific models (Model C, Table 3.2.2). When Starling counts from North Pier were substituted for overall Starling numbers, thus increasing the sample size (from 14 to 19 visits), the inclusion of sampling location did not significantly improve the fit of the models for any of the microbiological contaminants. Consequently across-locations models were appropriate. The number of Starlings roosting on North Pier significantly improved the fit of the models for all of the microbiological contaminants, explaining 30%, 33% and 27% of the variation in faecal coliforms, faecal *streptococci* and total coliforms respectively (Model D, Table 3.2.2). When the alternative approach of using Starling numbers matched to sampling location was used, sampling location significantly improved the fit of the models of all three microbiological contaminants. Consequently, separate models for each pier were appropriate for each of the microbiological contaminants. Only in the case of North Pier did matched Starling numbers significantly improve model fit, doing so for all three microbiological contaminants (Model E, Table 3.2.2). Thus for North Pier, Starling numbers explained 30%, 42% and 34% of the variation in faecal coliforms, faecal streptococci and total coliforms respectively. A positive parameter estimate for all three models indicated that microbiological contamination increased with increasing Starling numbers. These results should not be used in isolation to assess the likelihood that levels of microbiological contaminants are related to Starling numbers because no other factors were considered by these exploratory models. However, these results suggested that Starling numbers should be considered during the development of the ultimate models.

3.2.3 Exploratory models based on Intertidal Bird Numbers and distributions

3.2.3.1 Proximity indices

The location factor did not significantly improve the fit of the models for any of the microbiological contaminants regardless of whether gulls alone or summed intertidal birds were used in the modelling. Thus, models based on data from all locations, rather than location-specific models, were appropriate. Gull Proximity Index significantly added to the fit of the model for faecal coliforms, explaining 7% of the variation, but not to those for the other microbiological contaminant measurements (Model F, Table 3.2.3.1). A similar result was obtained when using Intertidal Proximity Index, which explained 8% of the variation in faecal coliforms (Model G, Table 3.2.3.1), a result reflecting the numerical dominance of gulls, especially when measured in terms of basal metabolic rate, in the intertidal bird community.

3.2.3.2 BMR indices

The location factor did not significantly improve the fit of the models for any of the microbiological contaminants regardless of whether it was gulls alone or summed intertidal birds were included in the modelling. Thus across-location models were appropriate. Gull BMR Index significantly improved model fit for both faecal coliforms and faecal *streptococci* explaining 25% and 23% of the variation in each respectively (Model H, Table 3.2.3.1). In the alternative models based on Intertidal Bird Index that variable significantly added to the model fit for all microbiological contaminant measurements, explaining 26%, 25% and 18% of the variation in faecal coliforms, faecal *streptococci* and total coliforms respectively (Model I, Table 3.2.3.2).

As emphasised for Starlings, these results should not be used in isolation to assess the likelihood that levels of microbiological contaminants are related to gull or intertidal bird numbers because no other factors were considered by these exploratory models. However, these results suggested that either gull BMR index or Intertidal Bird BMR Index should be considered during the development of the ultimate models. There is little to choose between these two options because of the numerical dominance of gulls in the intertidal avian community. Consequently, Gull BMR Index would be preferred because interpretation of the results would be less ambiguous especially as the numbers of the other species were too small in themselves to have contributed appreciably to microbiological contamination.

3.2.4 Exploratory models based on All-Birds BMR indices

The All-Bird BMR Index did not significantly improve the fit of the models for any of the microbiological contaminants, regardless of whether considering across-locations or location specific models (Model J, Table 3.2.3.1). It is, therefore, unlikely that this variable would be useful in the all-factor models. Also, if the group-specific bird variables were to be included in the all-factor models rather than the All-Bird index, and these significantly added to the fit of the models, the results would be less ambiguous as to which birds were the likely cause.

3.2.5 All-factor (combined) Models

3.2.5.1 Faecal Coliforms

The results from the exploratory modelling suggested that having controlled for NVW and rain it would be particularly worthwhile to consider adding North Pier Starling numbers and either Gull BMR Index or Intertidal Bird Index for inclusion in the ultimate model for faecal coliforms. Additionally, the All-Bird BMR Index was considered. Ideally UVB would have also been included as a control factor in the all-factor models but, because UVB data were only available from the end of June, the numbers of visits from which data could be included would have been insufficient to support the number of explanatory variables being considered (Tabachnick & Fidell 1989). In all alternatives explored during the modelling process, the location factor significantly added to the model fit for all combinations of the other variables when considered across-locations but not when data from Bispham was excluded. Consequently, separately all piers combined and Bispham only models were appropriate.

Having first controlled for NVW and Rain, whereas neither Starling numbers nor All-Bird BMR Index significantly improved the fit of the model, Gull BMR Index (or alternatively Intertidal BMR Index) did (Model K.a, Table 3.2.5). However the latter was only the case when the model was based on all 24 visits rather than the subset of 19 visits for which Starling numbers were available. Consequently, the ultimate model for faecal coliforms included NVW, Rain and Gull BMR Index these together explaining 70% of the variation in faecal coliforms of which Gull BMR Index explained 9%.

3.2.5.2 Faecal *Streptococci*

The results from the exploratory modelling suggested that having controlled for NVW it would be particularly worthwhile to consider adding North Pier Starling numbers and either Gull BMR Index or Intertidal Bird Index for inclusion in the ultimate model for faecal *streptococci*. Additionally, the All-Bird BMR Index was also considered. In all alternatives explored during the modelling process, the location factor did not significantly improve the model fit. Consequently, across-location models were appropriate.

Having first controlled for NVW, both Starling numbers and Gull BMR Index (or alternatively Intertidal BMR Index) significantly improved the fit of the model when entered separately but when both were considered together, Gull BMR Index was displaced (Model K.b, Table 3.2.5). Consequently, the ultimate model for faecal coliforms included NVW and North Pier Starling numbers, these together explaining 55% of the variation in faecal *streptococci* of which Starling numbers explained 15%.

Although the exploratory models had not suggested that rain could usefully be incorporated in the all-factor model for faecal *streptococci*, because the above model incorporated North Pier Starling numbers it had necessarily used a subset of visits not previously explored in relation to the physical variables. It was, therefore, appropriate to reassess rain in that model. Rain significantly improved model fit and when included displaced all other variables explaining 64% of the variation in faecal *streptococci*.

3.2.5.3 Total Coliforms

The results from the exploratory modelling suggested that having controlled for NVW and Rain it would be worthwhile to consider Intertidal Bird Index for inclusion in the ultimate model for total coliforms. However, North Pier Starling numbers, Gull BMR Index and All-Bird BMR Index were also considered. In all alternatives explored during the modelling process, the location factor did not significantly improve the model fit. Consequently across-location models were appropriate. Having first controlled for NVW and Rain, none of the bird variables considered significantly improved the fit of the model (Model K.c, Table 3.2.5).

4. DISCUSSION

The principal aim of this report was to investigate whether levels of microbiological contaminants in the designated bathing areas off the Blackpool seafront could be related to the spatial and temporal distribution of birds given that the contaminants involved have implicated birds as a potential source. Observed levels of microbiological contaminants off the Blackpool seafront arise from what is undoubtedly a complex system of environmental factors that affect the persistence and redistribution of the contaminants. Despite this complexity, the analyses have detected relationships between birds and observed levels of faecal coliforms and faecal *streptococci*, having first controlled for physical factors known to affect the observed levels of these contaminants, including wind and rain. The variables that came through most strongly were rain and the north vector of the wind. Additionally, gulls on the intertidal areas explained some of the variation in faecal coliform levels and the number of roosting Starlings explained some of the variation in faecal *streptococci*. These relationships were consistent with, but do not prove, the hypothesis that gulls on the intertidal areas along the Blackpool shoreline and Starlings roosting on the piers were the source of the microbiological faecal contaminants.

4.1 Physical Environment

The prevalence of the north vector of wind in the models suggests that long-shore movement of surface currents caused by the wind influences the observed values of microbiological contaminants. As the north vector component of the wind increased, the observed values of microbiological contaminants decreased. A number of hypotheses could be drawn from this relationship. Firstly, it may be that when the wind has a strong southerly (positive north vector) component, surface currents from the south are strengthened and either the arrival of cleaner waters from the south increases, or the arrival of contaminated waters from the north decreases. The former would decrease microbiological contamination if the source was at Blackpool itself, and the latter if it arose from further north along the Fylde coast. Secondly, it may be that as the southerly component of the wind increases this affects local surface currents in a manner that flushes microbiological contaminants that have accumulated in the relatively stagnant pools that can be found beneath the piers (Feare 2001). These possibilities would be worthy of further investigation by the Environment Agency. In particular, if the flushing of pools beneath the piers does reduce the levels of microbiological contaminants, then it may be possible to devise methods to enhance this.

Rain was also an important variable in the models for both faecal coliforms and total coliforms. Additionally, although rain did not significantly improve model fit for faecal *streptococci* when data from all visits were included, when using a reduced sample (to allow North Pier Starling counts to be considered) rain alone gave the best model fit, explaining 64% of the variation in faecal streptococci. No other variables significantly improved model fit beyond this. It was to be expected that rain would significantly improve the fit of the microbiological contaminant models because high rainfall is invariably associated with failure under the compliance sampling (Environment Agency pers. comm.). This may be due to contaminants in the run-off either from local sources or possibly from further along the coast, the latter being carried to Blackpool by long-shore currents. There has, however, been considerable investment in new sewerage and sewage treatment facilities, which would have been expected to reduce run-off as a source of contamination locally. It may, therefore, be that the contamination associated with high rainfall has a much more immediate source the prime candidate being bird faeces washed off the pier structure during heavy rain. It may be possible to determine whether run-off from the piers does contain high microbiological contaminant loads by collecting rain run-off from the piers before it has entered the sea. Additionally, frequent (e.g. 30 minute time intervals) monitoring at regular (e.g. 100 m intervals) points along the seafront with the onset of heavy rain might be expected to show spacio-temporal pattern of contamination spreading out from the piers.

4.2 Intertidal Birds

It is known that gull faeces can contain organisms that are pathogenic to man (Girdwood *et al*. 1985, Klauber 1996, Levesque *et al*. 1993) and they have been suspected of contaminating domestic water supplies (Jones *et al*. 1978, Sachs *et al*. 1986, Levesque *et al*. 1993) and other static waterbodies (Lee *et al*. 1982). There are, however, no comparable studies that can be drawn upon which would help determine whether or not the numbers of gulls frequenting an open system, such as the Blackpool shoreline, could excrete sufficient quantities of these organisms to affect measured levels of faecal contaminants. Although the information is scant and largely anecdotal, the number of gulls on the Blackpool seafront would not be considered to be exceptionally high compared to other resorts.

Although gulls were generally distributed along the intertidal area, there was a tendency for them to cluster close to the three piers, particularly as numbers built up through the season. Thus, although during the April visit by Chris Feare (Feare 2001) and during the earlier visits made by the BTO, the distribution of gulls had suggested that they were unlikely to have been the source of contamination, this analysis based on data recorded through the whole season suggest otherwise. In the across-piers models the number of gulls explained a reasonable proportion of the variation in faecal coliforms whereas this was not the case for the Bispham site, where fewer gulls were recorded. This suggests that contamination from gulls in the proximity of the piers while being redistributed throughout that area, consistent with strong currents cause mixing but not water movement in and out of the system at Blackpool (Andrew Wither pers. comm.), was not reaching Bispham. This would explain why the BMR indices compared favourably with the proximity indices in explaining the variation in microbiological contaminants (the former based on bird numbers and the latter on bird distribution in relation to individual compliance points). This would not be expected for a site in which water movement in and out of the site occurred without mixing within the site. In such a situation the BMR indices would be expected to show relatively weak relationships with microbiological contaminants compared with those of the proximity indices.

Compared to the numbers of gulls, only small numbers of waders and pigeons were observed on the intertidal zone. When all birds on the intertidal area were combined into Intertidal indices the resulting models corresponded closely with those based on Gull Indices. This reflects the dominance of gulls in the intertidal bird community especially when measured in terms of BMR. Unlike the other species discussed in this report, there is little in the published literature to suggest that waders could be a possible source of contaminants (although this may simply be due to a lack of research in this area).

4.3 Starlings

Both numbers of resident and wintering Starlings have undergone declines over much of the United Kingdom within the last decade, with several coastal resorts previously recording tens of thousands of roosting birds now only supporting a few thousand birds. Within this context, it would appear that the Blackpool Piers support a larger than average numbers of roosting birds at the time of the peak counts. However, within a local context, several other inland sites within Lancashire regularly support roosts upwards of 20,000 birds, with Marton Mere at Blackpool peaking at 50,000 individuals in October 1999. It was strongly suspected that many of these birds originated from the North Pier roost, driven inland by bad weather. The numbers of Starlings roosting on North Pier (used as a surrogate for numbers roosting across all piers to increase sample size) contributed significantly to the model for faecal *streptococci*. The results for Starlings must be interpreted with caution because there was a marked build-up of numbers from August onwards which coincided with the majority of the higher values of faecal *streptococci* measured during the compliance sampling. Had Starlings been the cause of the latter, then consistently high measurements might have been expected from August onwards rather than just occasionally.

4.4 Feral Pigeons

Although Feral Pigeons were included in the Intertidal Indices the numbers on the intertidal areas were small. Accurately assessing the numbers of breeding Feral Pigeons on the piers proved to be extremely difficult and sufficiently robust data for these were not obtained. Consequently Feral Pigeons should not be ruled out as a possible, additional, source of contamination based on the results of these analyses.

4.5 Future Monitoring

Given the results of these analyses, which were consistent with the hypothesis that birds may be a source of microbiological contaminants, further monitoring of the situation is recommended. Furthermore, we would recommend that any future decision to take steps to reduce the number of gulls within the proximity of the piers, or Starlings on the piers should be undertaken in conjunction with continued monitoring and ideally within an experimental framework. Furthermore, an analysis of faecal samples from the birds in question would be recommended to determine whether or not they actually contain the microbiological contaminants of concern and, if so, to quantify average production of these by the birds. This information could be used to determine whether or not the numbers of birds present could conceivably produce the level of contamination that has been recorded. If there were to be a significant shortfall then further sources of contamination would need to be considered. Additionally, the persistence of the microbiological organisms in samples of sea water could be investigated with a view to building models that would control for the accumulation of contaminants under different conditions of wind, rain and UVB. If any approach were to be adopted that aimed to construct more complex models it would be necessary to increase the frequency of sampling of both microbiological contaminants and bird numbers in order to increase the sample size above that obtained for 2001.

Comparisons between the various models presented in this report suggest ways in which monitoring could be modified to maximise relevant data while minimising costs and effort. The models did not detect any significant differences in the levels of microbiological contaminants between the compliance sampling locations associated with the three piers during 2001. If this is known to have been generally true of other years, then it may not be necessary to map the distribution of intertidal waterbirds during future sampling, numbers of each species occurring over the entire study area being sufficient. It would still be desirable to record species separately in order that numbers of each could be weighted by BMR to produce BMR indices. However, if sampling were to be restricted to the proximity of the three piers (thus excluding Bispham), our models suggest that, of the species occurring on intertidal areas, only gulls need to be recorded. Were future bird monitoring to be undertaken by non-specialist personnel, this exclusion of waders may be advantageous. For the same reason it would probably be reasonable to categorise gulls into large (Herring Gull and Lesser and Great Black-backed Gulls) and smaller species (Black-headed and Common Gulls), given that within each group BMRs are similar enough to be averaged. Because BMR indices relate to numbers rather than distributions it would also be reasonable to make a single count for each tidal cycle, ideally at low tide when numbers on the site would be expected to be at their highest.

It must be stressed that any attempt to reduce the amount of data, or to simplify the data collected, might result in weaker models. Consequently, before initiating any further monitoring that might seek to modify data collection along these lines, it would be desirable to undertake further analyses, using those detailed data collected in 2001, to simulate the various options suggested above.

Monitoring Starling numbers during 2001 presented problems, because only one roost could be monitored on any one evening. The results suggest that it would have been reasonable to monitor the numbers roosting on North Pier only. Again caution should be exercised before adopting this approach, as in future years, Starlings may favour one of the other piers. If so it would be more appropriate to monitor that roost instead, but the time-series of counts on that pier would be incomplete. Ideally all three roosts should be monitored, preferably using simultaneous counts, rather than separate counts over three evenings. The latter would be particularly important if future monitoring took place in conjunction with measures designed to dissuade roosting birds, which may result in large numbers shifting between roosts on subsequent nights.

4.6 Conclusions

The results of this study were consistent with the hypothesis that birds may be one source of microbiological contamination in the waters of the Blackpool shoreline. Both gulls on the intertidal areas and possibly roosting Starlings could be involved. In a national context, the numbers of gulls recorded within the intertidal area was not exceptional, with far larger gatherings often to found elsewhere. From the scant evidence available it would appear that, currently, the piers at Blackpool do support a larger than average roosting Starling numbers during the time of the peak counts. These numbers are, however, small compared to numbers found elsewhere before the recent decline in both resident and wintering Starling populations of the United Kingdom. The results certainly suggest that continued monitoring is necessary in order to determine whether or not the relationships identified for 2001 persist over a longer time-series. Furthermore, if it were to be decided to take steps to reduce numbers of birds in close proximity to, or using the piers, we would recommend that this be undertaken in conjunction with continued monitoring and ideally be conducted within an experimental framework. The BTO would be delighted to help design the experimental framework.

Acknowledgements

We would like to thank Ian Dunhill (for supplying EA and Meteorological Office data) and Andrew Wither and John Greaves (for EA funding).

References

Anon. 1976 Council Directive concerning the quality of bathing water. (76/160/EEC). *Official Journal of the European Communities*, **L31**, 1-7.

Butterfield, J., Coulson, J.C., Kearsey, S.V., Monaghan, P., McCoy, J.H. & Spain, G.E. (1983) The Herring Gull *Larus argentatus* as a carrier of salmonella. *Journal of Hygiene, Cambridge*, **91**, 429-436.

Environment Agency. (1999). *Fylde Coast Summer Bathing Water Surveys* 1999. EA report MSP-00-05.

ESRI (2001) Environmental Systems Research Institute, Inc. USA.

Feare, C. (1984). *The Starling.* Oxford University Press, Oxford.

Feare, C. (2001). *Birds as a potential source of bacterial contamination on the Fylde coast*. Unpublished report to EA.

Fenlon, D.R. (1981) Seagulls (*Larus* spp.) as vectors of salmonellae: an investigation into the range of serotypes and numbers of salmonellae in gull faeces. *Journal of Hygiene, Cambridge*, **86**,195-202.

Fenlon, D.R. (1983) A comparison of salmonella serotypes found in the faeces of gulls feeding at a sewage works with serotypes present in the sewage. *Journal of Hygiene, Cambridge*, **91**, 47-52.

Ferns, P.N. & Mudge, G.P. (2000). Abundance, diet and *Salmonella* contamination of gulls feeding sewage outfalls. *Water Research*, **34,** 2653-2660.

Fricker, C.R. (1984). A note on salmonella excretion in the Black-headed Gull (*Larus ridibundus*) feeding at sewage treatment works. *Journal of Applied Bacteriology*, **56**, 499-502.

Girdwood, R.W.A., Fricker, C.R., Munro, D., Shedden, C.B. & Monaghan, P. (1985) The incidence and significance of salmonella carriage by gulls (*Larus sp.*) in Scotland. *Journal of Hygiene, Cambridge,* **95**, 229-241.

Jones, K. & Obiri-Danso, K. (1999). Non-compliance of beaches with the EU Directives of bathing water quality: evidence of non-point sources of pollution in Morecambe Bay. *Journal of Applied Microbiology Symposium Supplement*, **86,** 101S-107S.

Jones, F., Smith, P. & Watson, D.P. (1978) Pollution of a water supply catchment by breeding gulls and the potential environmental health implications. *Journal of the Institute of Water Engineering Science,* **32**, 469-482.

Klauber, B. (1996) Gulls as vectors of *Salmonella enteritidis* in the Lower Mohawk valley region of New York. *Kingbird,* **46**, 117-122.

Lee, J.V., Bashford, T.J., Donovan, A.L., Furniss, A.L. & West, P.A. (1982) The incidence of *Vibrio cholerae* in water, animals and birds in Kent, England. *Journal of Applied Bacteriology,* **52**, 281-291.

Levelsque, B., Broussear, P., Simard, P., Dewailly, E., Miesels, M., Ramsay, D. & Joly, J. (1993) Impact of the ring-billed gull (*Larus delawarensis*) on the microbiological quality of recreational water. *Applied Environmental Microbiology,* **59**, 1228-1230.

MacDonald, J.W. & Brown, P.D. (1974). Salmonella infection in wild birds in Britain. *Veterinary Record*, **94,** 321-322.

McCullagh, P. & Nelder, J.A. (1989). *Generalized Linear Models*. Second edition. Chapman & Hall, London.

Monaghan, P., Shedden, C.B., Ensor, K., Fricker, C.R. & Girdwood, R.W.A. (1985). Salmonella carriage by Herring Gulls in the Clyde area of Scotland in relation to their feeding ecology. *Journal of Applied Ecology*, **22,** 669-680.

Sachs, J.J., Lieb, S., Baldry, L.M., Barta, S., Patton, C.M., White, M.C., Wigler, W.J. & Witte, J.M. (1986). Epidemic campylobacteriosis associated with a community water supply. *American Journal of Public Health*, **76**, 424-428.

SAS (2001). The SAS Institute Inc. Cary, NC, USA.

Tabachnick, B.G. & Fidell, L.S. (1989). *Using Multivariate Statistics (2nd Edition)*. Harper & Row, New York, USA.

Ward, P. & Zahavi, A. (1973). The importance of certain assemblages as "information centres" for food finding. *Ibis*, **115,** 517-534.

Variable / Term	Description
EVW	Variable name used for the east vector of the wind, calculated as EVW=WindSpeed × SIN($Direction_{Radians}$)
NVW	Variable name used for the North vector of the wind, calculated as NVW=WindSpeed × COS($Direction_{Radians}$)
MC	Variable name used for microbiological contaminants in statistical models
FC	Variable name used for faecal coliforms in statistical models
FS	Variable name used for faecal *streptococci* in statistical models
TC	Variable name used for total coliforms in statistical models
BMR Indices	Term used for the bird numbers, weighted by species specific basal metabolic rate and summed across the entire study area, that is representative of the bird faecal input of the whole study area
Gull BMR Index	*BMR Index based on all gull species*
Wader BMR Index	*BMR Index based on all wader species*
Pigeon BMR Index	*BMR Index based on all Feral Pigeon*
Intertidal BMR Index	*BMR Index based on all birds on the intertidal area*
All-bird BMR Index	*BMR Index based on all birds (including Starlings)*
Proximity Indices	Term used for the distance weighted interpolation of bird numbers, weighted by species specific basal metabolic rate, based on Kriging, that is representative of the bird faecal input in the region of any specific geographic location.
Gull Proximity Index	*Proximity Index based on all gull species*
Wader Proximity Index	*Proximity Index based on all wader species*
Pigeon Proximity Index	*Proximity Index based on Feral Pigeon*
Intertidal Proximity Index	*Proximity Index based on all birds on the intertidal area*

Table 2.4.1 Variables and Terms used in descriptions of statistical models.

Species	**BMR (Kcal/day)**
Oystercatcher	46
Ringed Plover	9
Knot	18
Sanderling	9
Dunlin	8
Curlew	64
Redshank	17
Turnstone	15
Black-headed Gull	29
Common Gull	41
Lesser Black-backed Gull	67
Herring Gull	79
Yellow-legged Gull	79
Great Black-backed Gull	116
Feral Pigeon	38
Starling	19

Table 2.4.3.1 Basal metabolic rates (Kcal/day) of birds recorded during surveys of Blackpool.

Model	Applicability	a Faecal coliforms		b Faecal *streptococci*		c Total coliforms	
A) Microbiological contaminants vs. Physical variables (excluding UVB)	Across all piers (n=24)	NVW Rain	42% – – – 18% + +	NVW	40% – –	NVW Rain	40% – – 22% + +
	Bispham (n=24)	NVW	46% – – –	NVW	38% – –	NVW	41% – –
B) Microbiological contaminants vs. Physical variables (including UVB)	Across all piers (n=12)	Rain	61% + +	Rain	58% + +	Rain UVB	57% + + 18% – –
	Bispham (n=12)	UVB Rain	59% – – 16% +	Rain	51% + +	UVB	57% – –

Table 3.2.1 Summary of results of exploratory models relating microbiological contaminants to physical aspects of the environment. Explanatory variables considered included rainfall (Rain), sunshine hours (Sun) and north and east vectors or the wind (NVW & EVW). Models were considered both A) with and B) without the inclusion of UVB radiation (UVB) as UVB was not available for May and June visits. For complete statistical output see Appendix 1.

– and + indicate the direction of the association where
– /+ P<0.05; – – / + + P<0.01; – – – / + + + P<0.001; – – – – / + + + + P<0.0001

Model	Applicability	a Faecal coliforms	b Faecal *streptococci*	c Total coliforms
C) Microbiological contaminants vs. Starlings - overall numbers	Across all locations (n=13)	none	none	none
D) Microbiological contaminants vs. North Pier Starlings	Across all locations (n=19)	Starlings 30% +	Starlings 33% +	Starlings 27% +
E) Microbiological contaminants vs. Starlings - matched to pier	Central Pier (n=13)	none	none	none
	North Pier (n=19)	Starlings 30% +	Starlings 42% + +	Starlings 34 ++
	South Pier (n=13)	none	none	none

Table 3.2.2.1 Summary of results of exploratory models relating microbiological contaminants to numbers of Starlings roosting on Blackpool's piers. Explanatory variables considered included C) Starlings summed across all piers for visits where counts for all three piers had been obtained, D) North Pier Starling numbers (used as a surrogate for the preceding to increase sample size) and E) Starling numbers matched to pier. For complete statistical output see Appendix 1.

– and + indicate the direction of the association where
– /+ P<0.05; – – / + + P<0.01; – – – / + + + P<0.001; – – – – / + + + + P<0.0001

Model	Applicability	**a** Faecal coliforms		**b** Faecal *streptococci*	**c** Total coliforms
F) Microbiological contaminants vs. gull proximity index	Across all locations (n=92)	Gulls	7% + +	none	none
G) Microbiological contaminants vs. intertidal bird proximity index	Across all locations (n=92)	Int-Birds	8% + +	none	none

Table 3.2.3.1 Summary of results of exploratory models relating microbiological contaminants to proximity indices of birds on the intertidal area. Explanatory variables considered included F) Gull proximity index and G) Intertidal-bird proximity index (based on gulls + waders + Feral Pigeons). For complete statistical output see Appendix 1.

– and + indicate the direction of the association where
– /+ P<0.05; – – / + + P<0.01; – – – / + + + P<0.001; – – – – / + + + + P<0.0001

Model	Applicability	a Faecal coliforms		b Faecal *streptococci*		c Total coliforms	
H) Microbiological contaminants vs. gull BMR index	Across all locations (n=23)	Gulls	25% +	Gulls	23% +	none	
I) Microbiological contaminants vs. intertidal bird BMR index	Across all locations (n=23)	Int-Birds	26% +	Int-Birds	25% +	Int-Birds	18% +
J) Microbiological contaminants vs. all-bird (intertidal + Starlings) BMR index	Across all locations (n=13)	none		none		none	

Table 3.2.4.1 Summary of results of exploratory models relating microbiological contaminants to BMR indices of birds. Explanatory variables considered included H) Gull BMR index, I) Intertidal-bird proximity index (based on gulls + waders + Feral Pigeons) and J) All-bird BMR Index (based on gulls + waders + Feral Pigeons + Starlings). For complete statistical output see Appendix 1.

– and + indicate the direction of the association where
– /+ P<0.05; – – / + + P<0.01; – – – / + + + P<0.001; – – – – / + + + + P<0.0001

Model	Applicability	a Faecal coliforms	b Faecal *streptococci*	c Total coliforms
K) Microbiological contaminants vs. Physical and bird	Across all piers (n=23)	NVW 42% – – – Rain 18% + + Gulls[1] 9% +	not applicable	not applicable
	Bispham (n=23)	NVW 46% – – –	not applicable	not applicable
	Across all piers (n=23)	not applicable	NVW 40% – – Starlings[2] 15% + OR (for n=19) Rain 64% – –	NVW 40% – – Rain 22% + +

Table 3.2.5 Summary of results of all-factor models relating microbiological contaminants to both physical environmental factors and birds numbers and distribution on the Blackpool shoreline and piers. Explanatory variables considered included all those considered in exploratory models. For complete statistical output see Appendix 1.

– and + indicate the direction of the association where
– /+ P<0.05; – – / + + P<0.01; – – – / + + + P<0.001; – – – – / + + + + P<0.0001

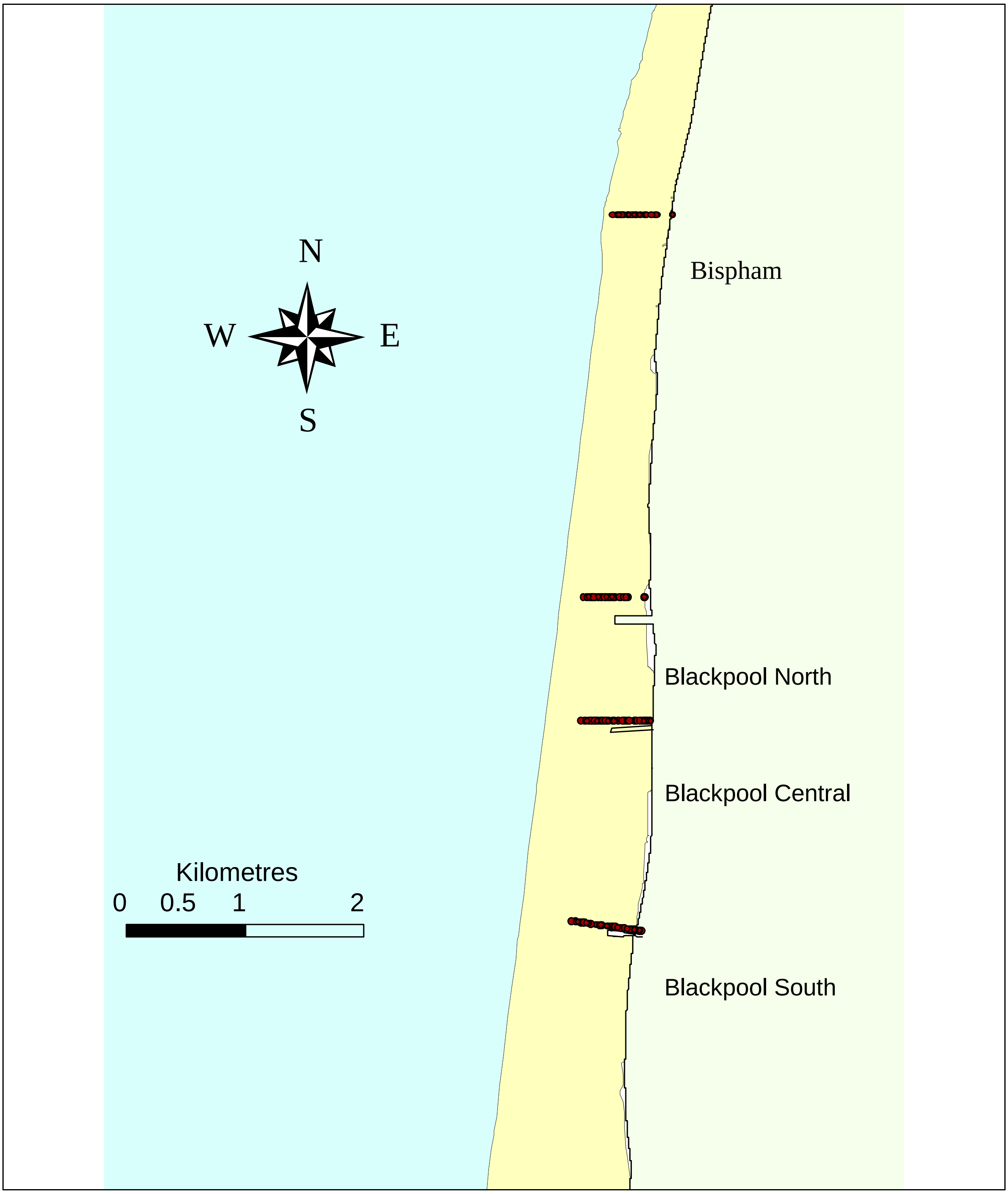

Figure 2.1.1 Blackpool beach and piers study area.

●●● = water sample points

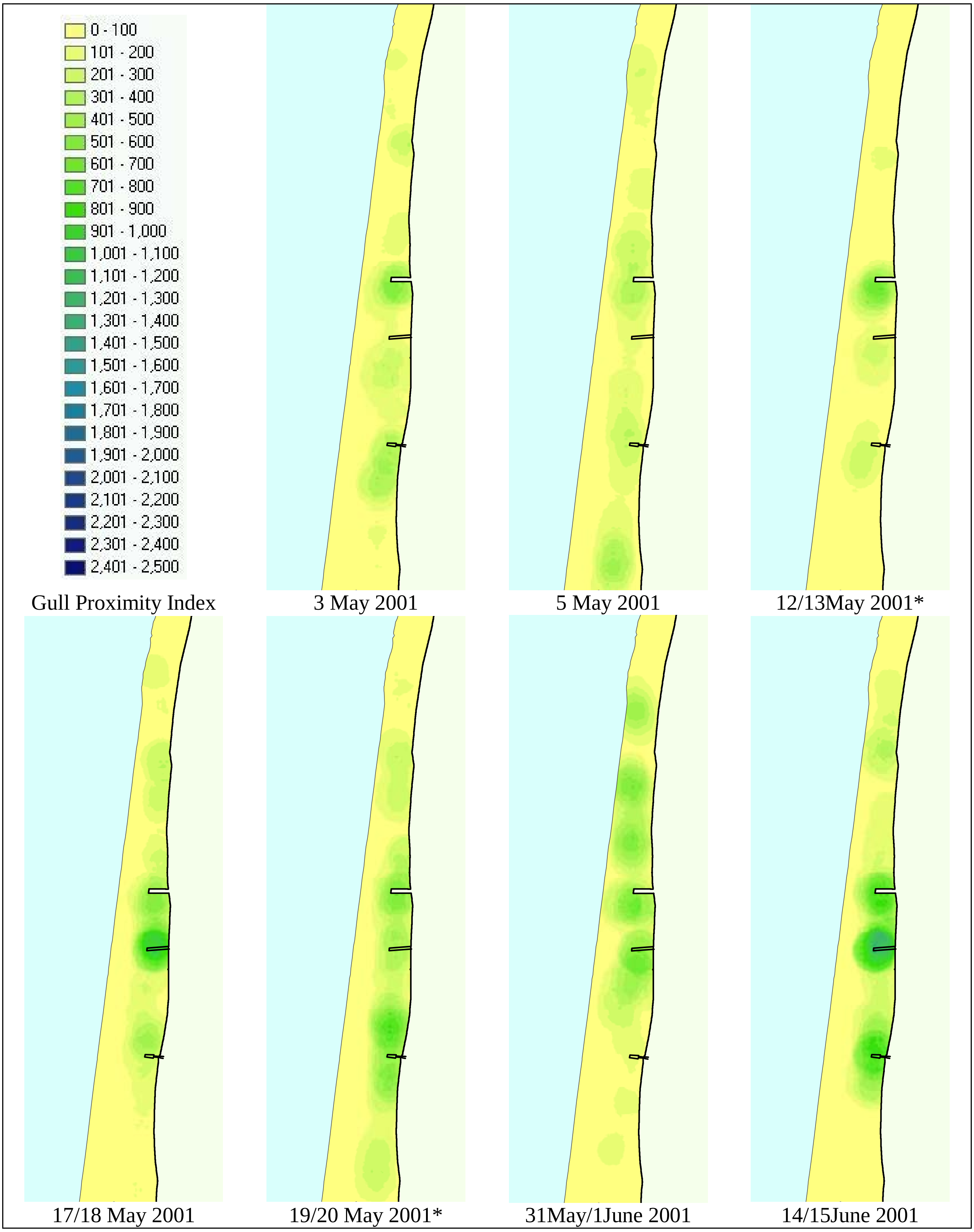

Figure 2.4.3.2.1 Distribution of gulls observed on the Blackpool shoreline during 2001 depicted using the gull proximity index.

* Weekend Visits ** count based upon only three tides *** count based upon low tide

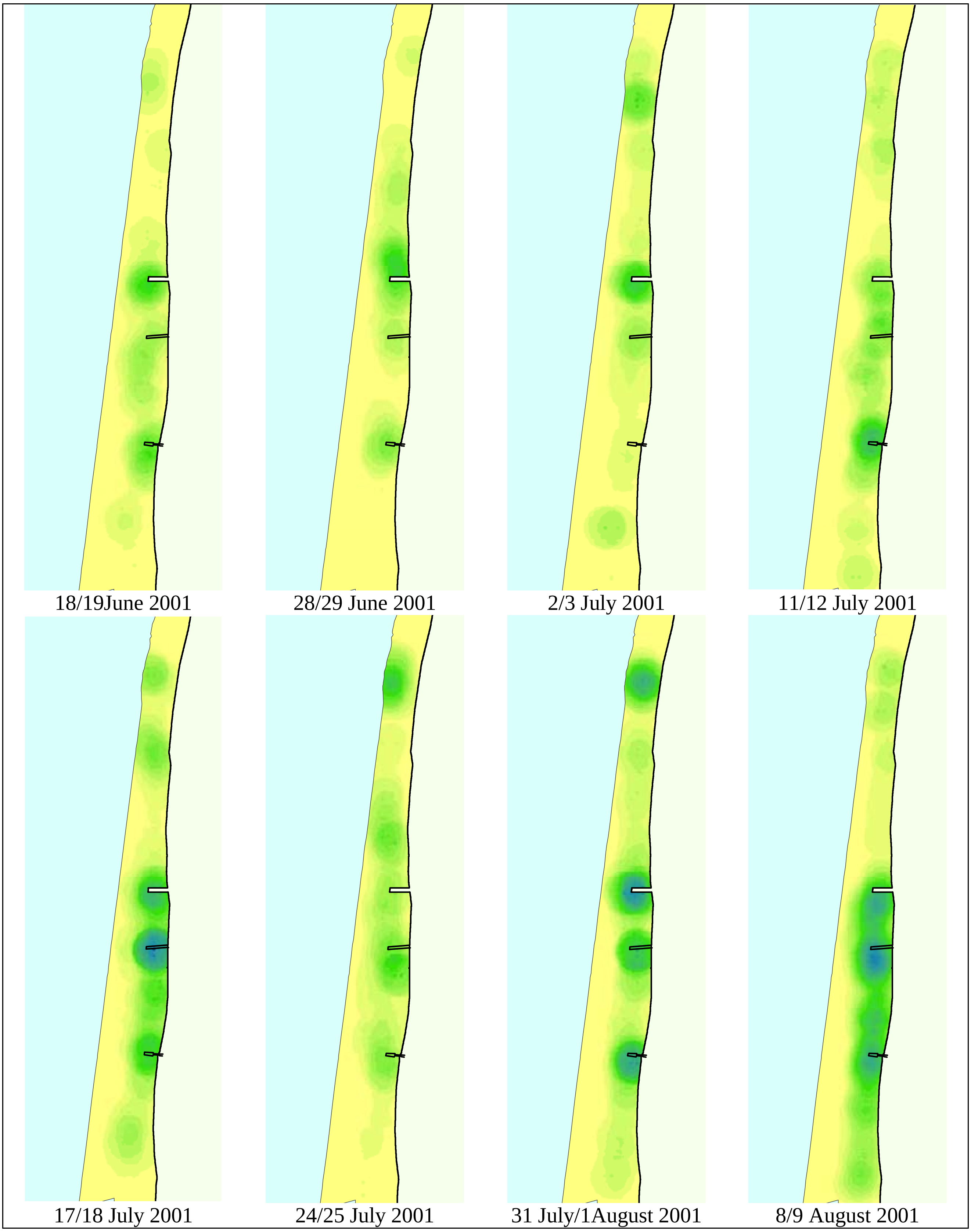

Figure 2.4.3.2.1 Continued.

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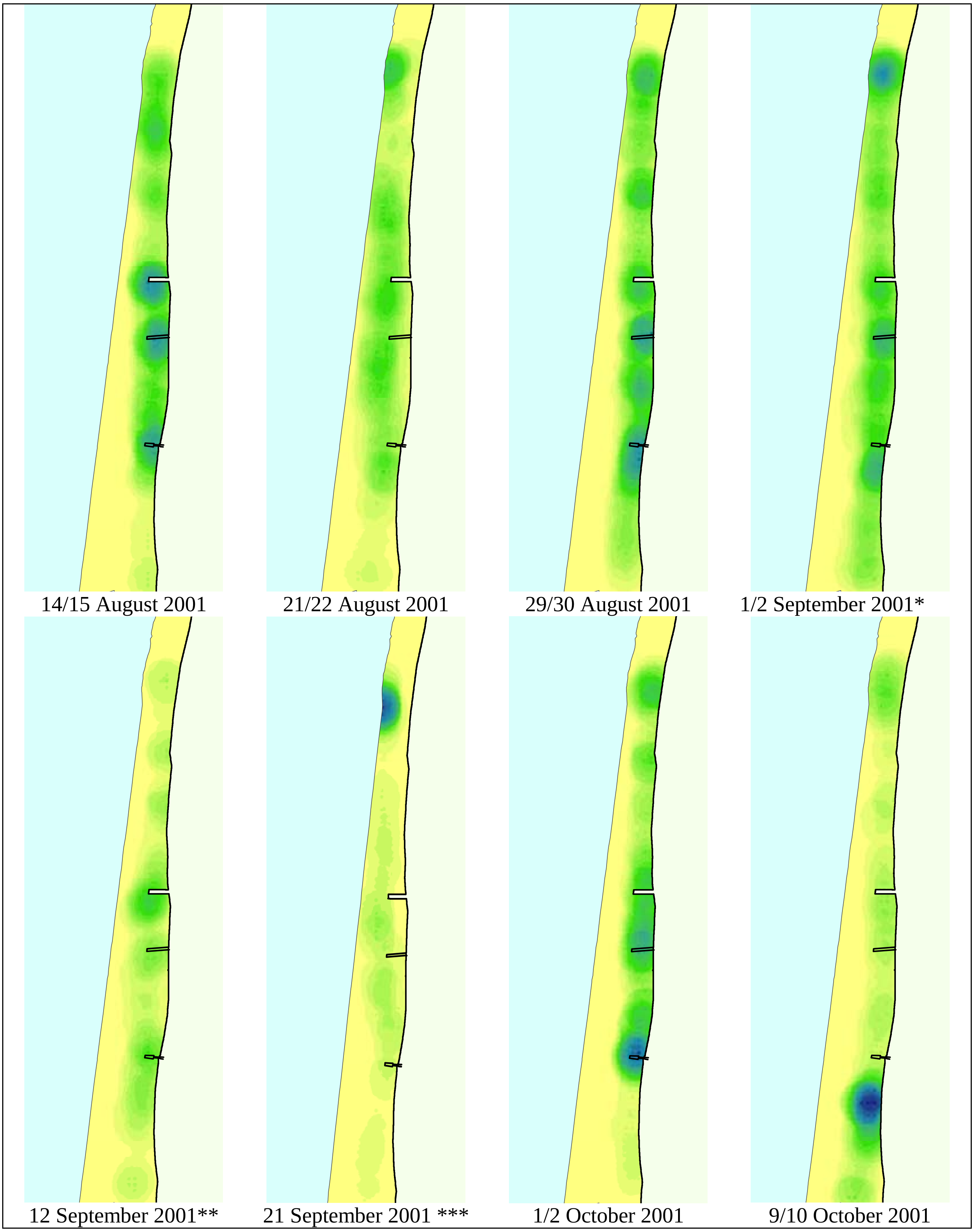
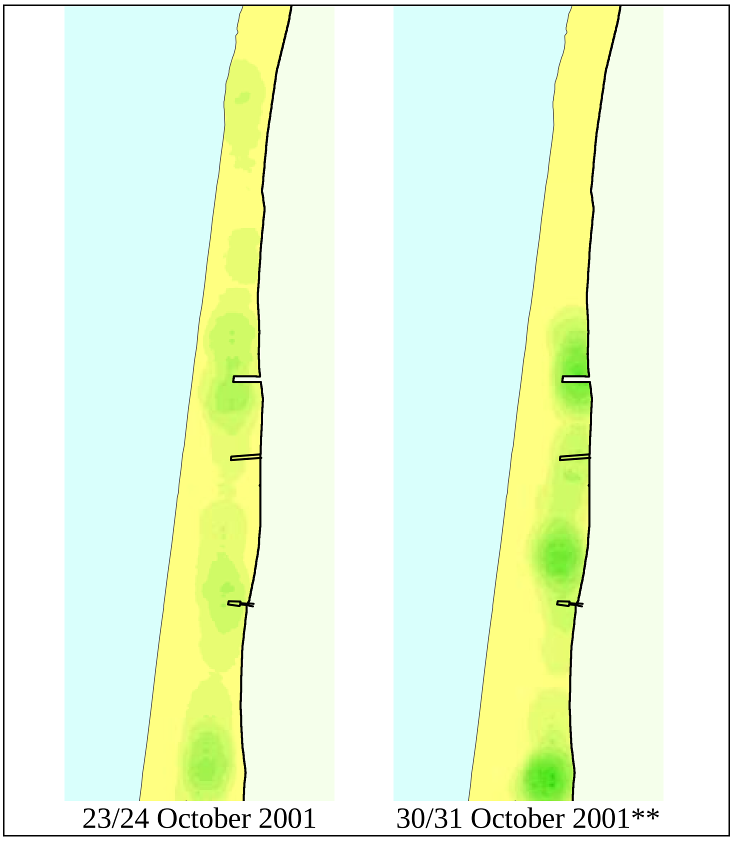


Figure 2.4.3.2.1 Continued.

* Weekend Visits ** count based upon only three tides *** count based upon low tide



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* Weekend Visits ** count based upon only three tides *** count based upon low tide

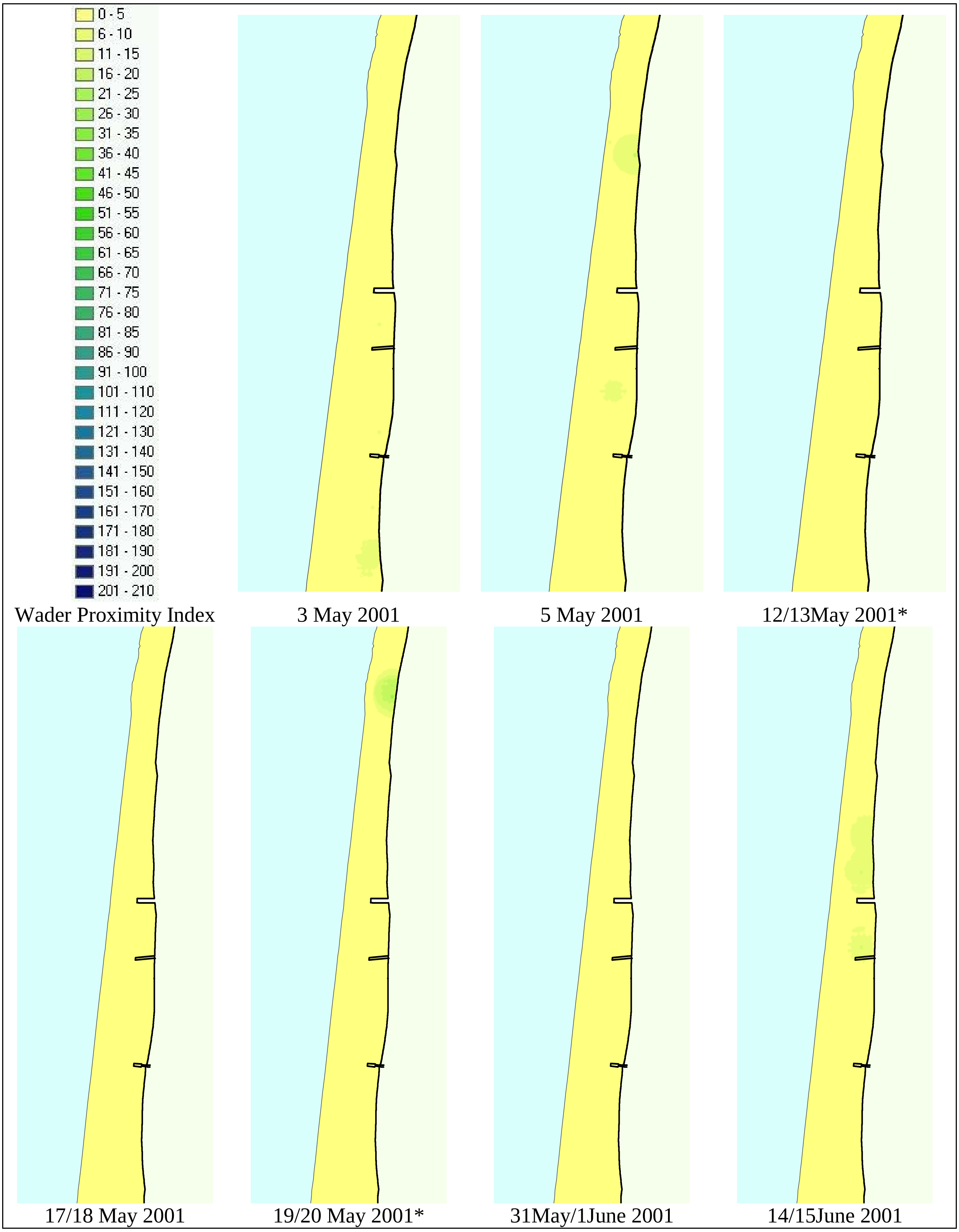

Figure 2.4.3.2.2 Distribution of waders observed on the Blackpool shoreline during 2001 depicted using the wader proximity index.

* Weekend Visits ** count based upon only three tides *** count based upon low tide

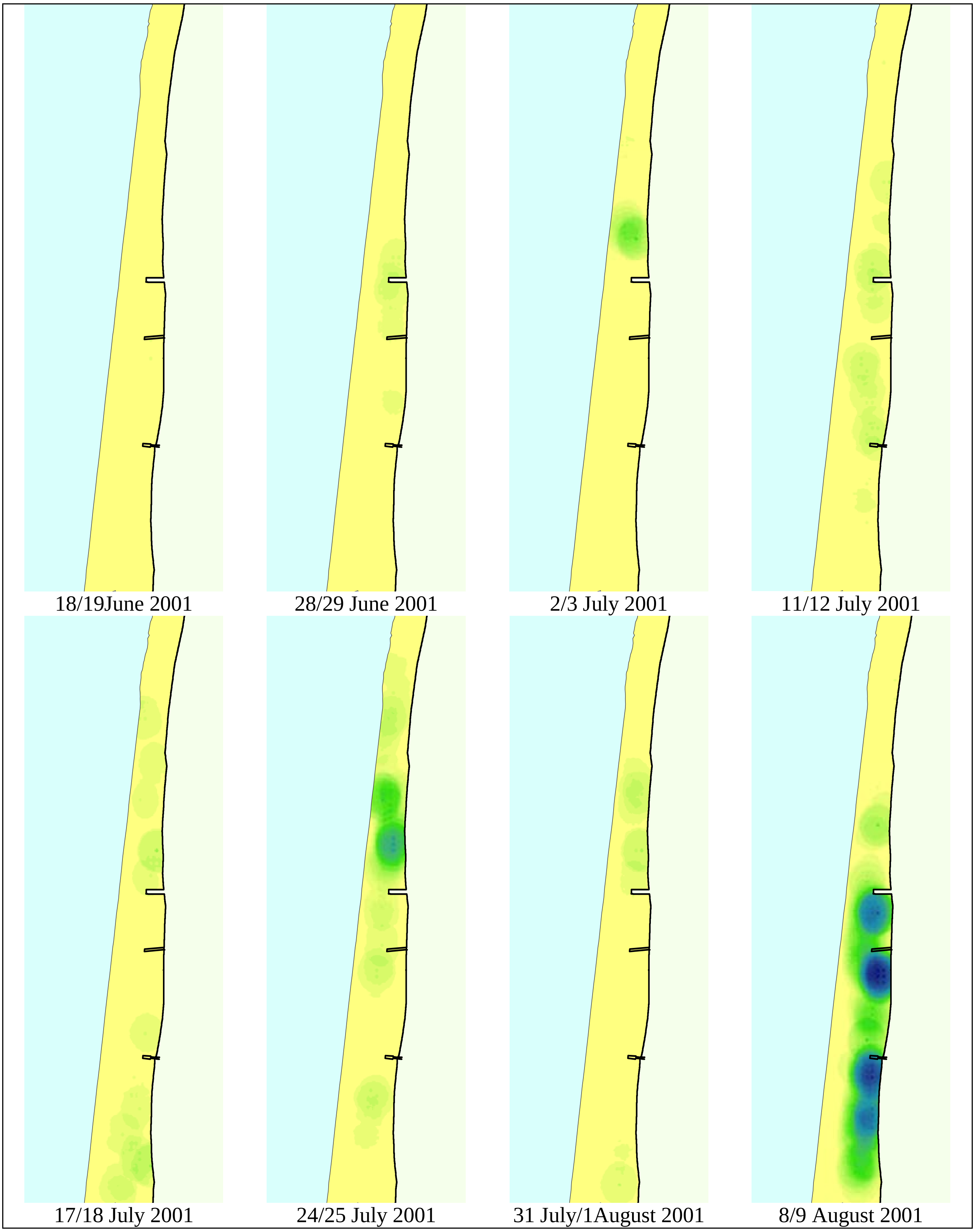

Figure 2.4.3.2.2 Continued.

* Weekend Visits ** count based upon only three tides *** count based upon low tide

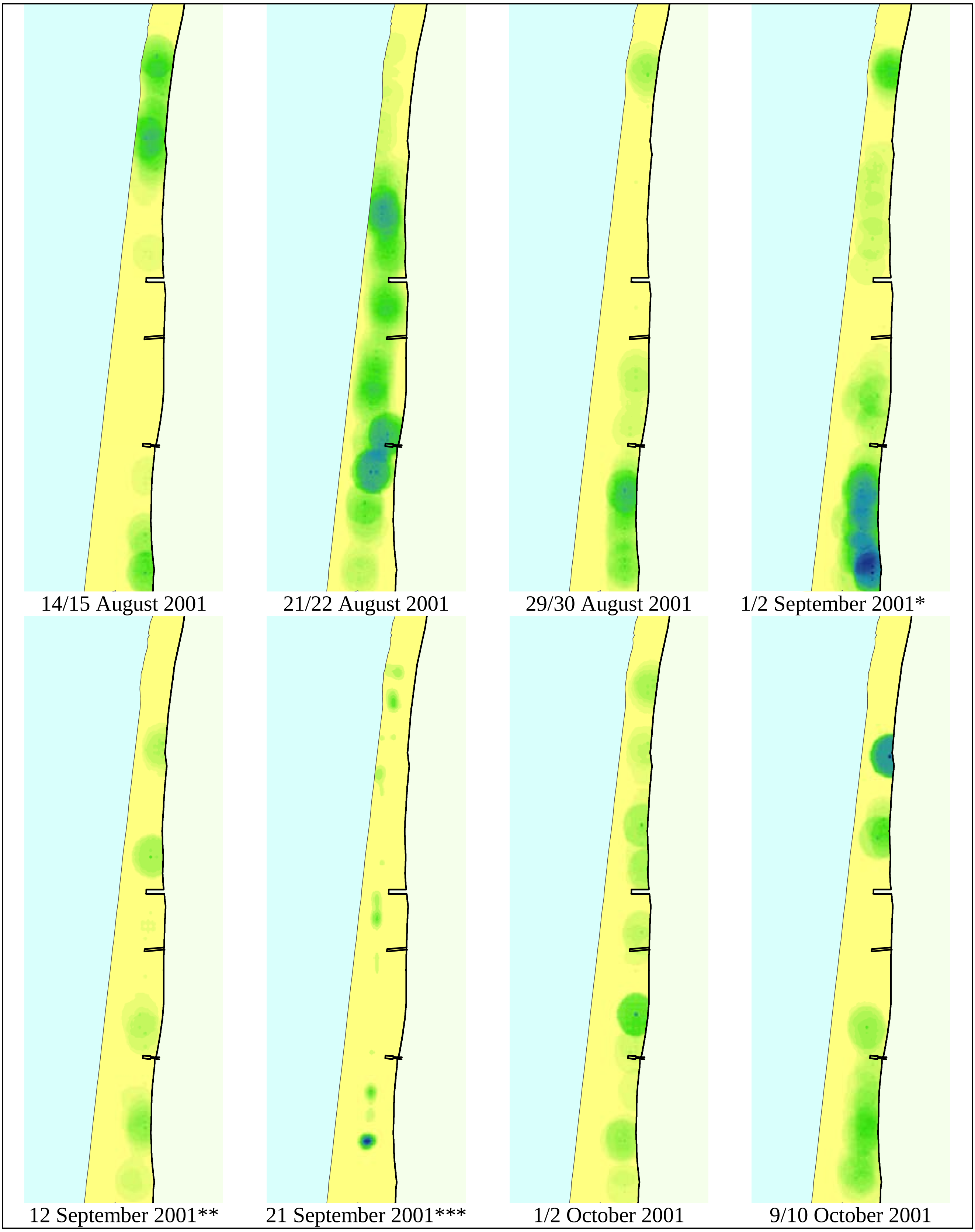

Figure 2.4.3.2.2 Continued.

* Weekend Visits ** count based upon only three tides *** count based upon low tide

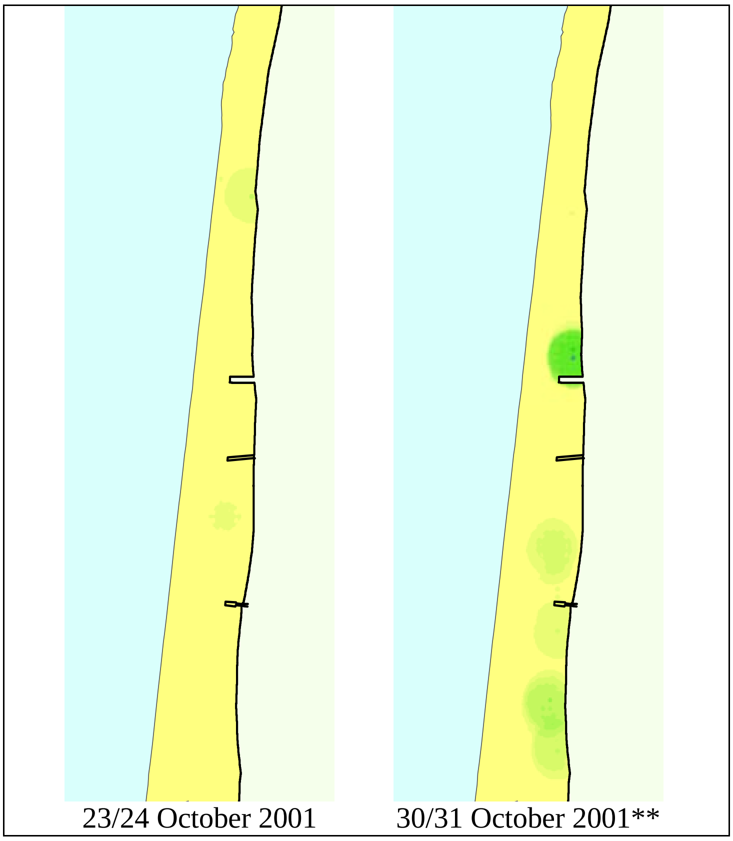

Figure 2.4.3.2.2 Continued.

* Weekend Visits ** count based upon only three tides *** count based upon low tide

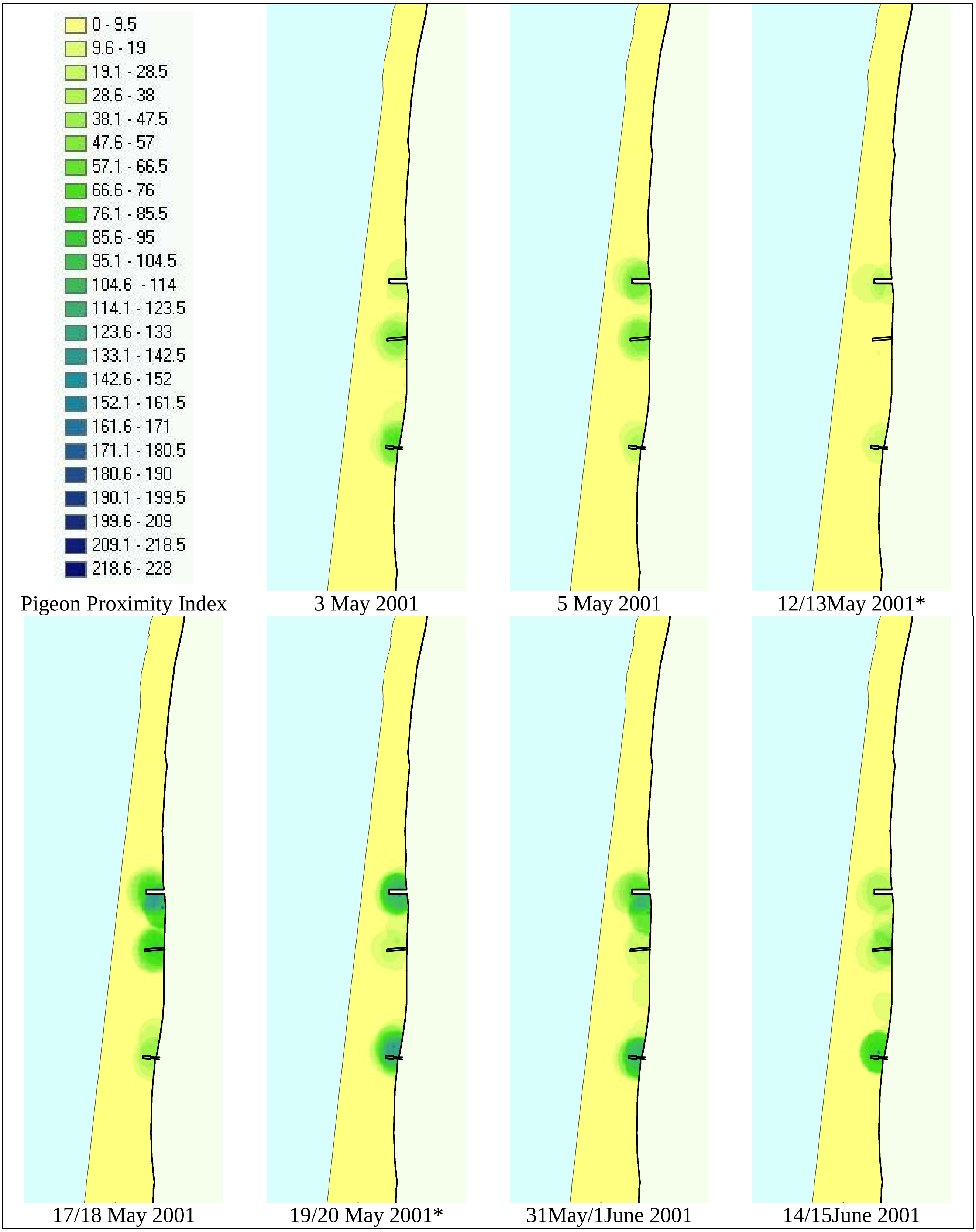

Figure 2.4.3.2.3 Distribution of Pigeons observed on the Blackpool shoreline during 2001 depicted using the Pigeon proximity index.

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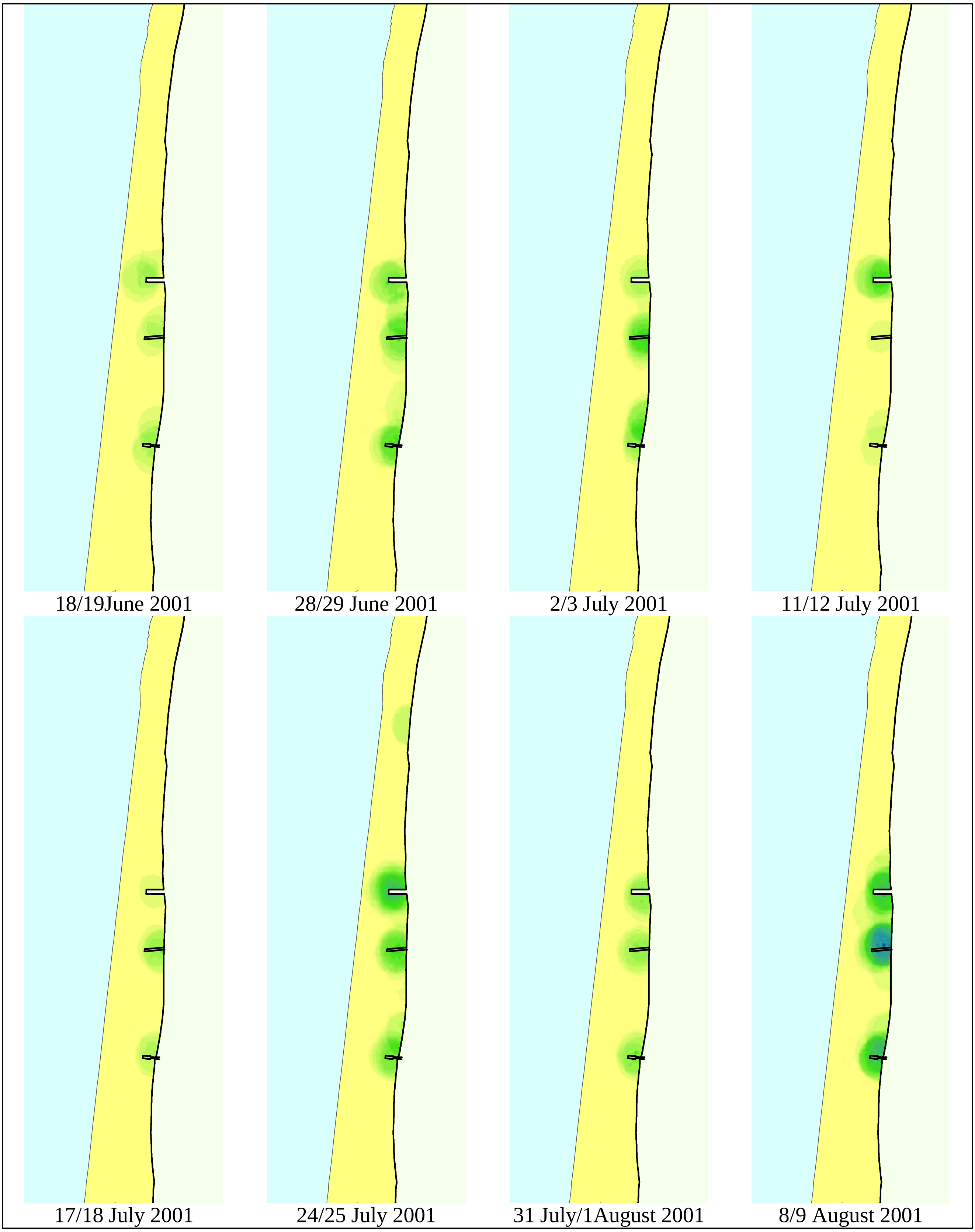

Figure 2.4.3.2.3 Continued.

* Weekend Visits ** count based upon only three tides *** count based upon low tide

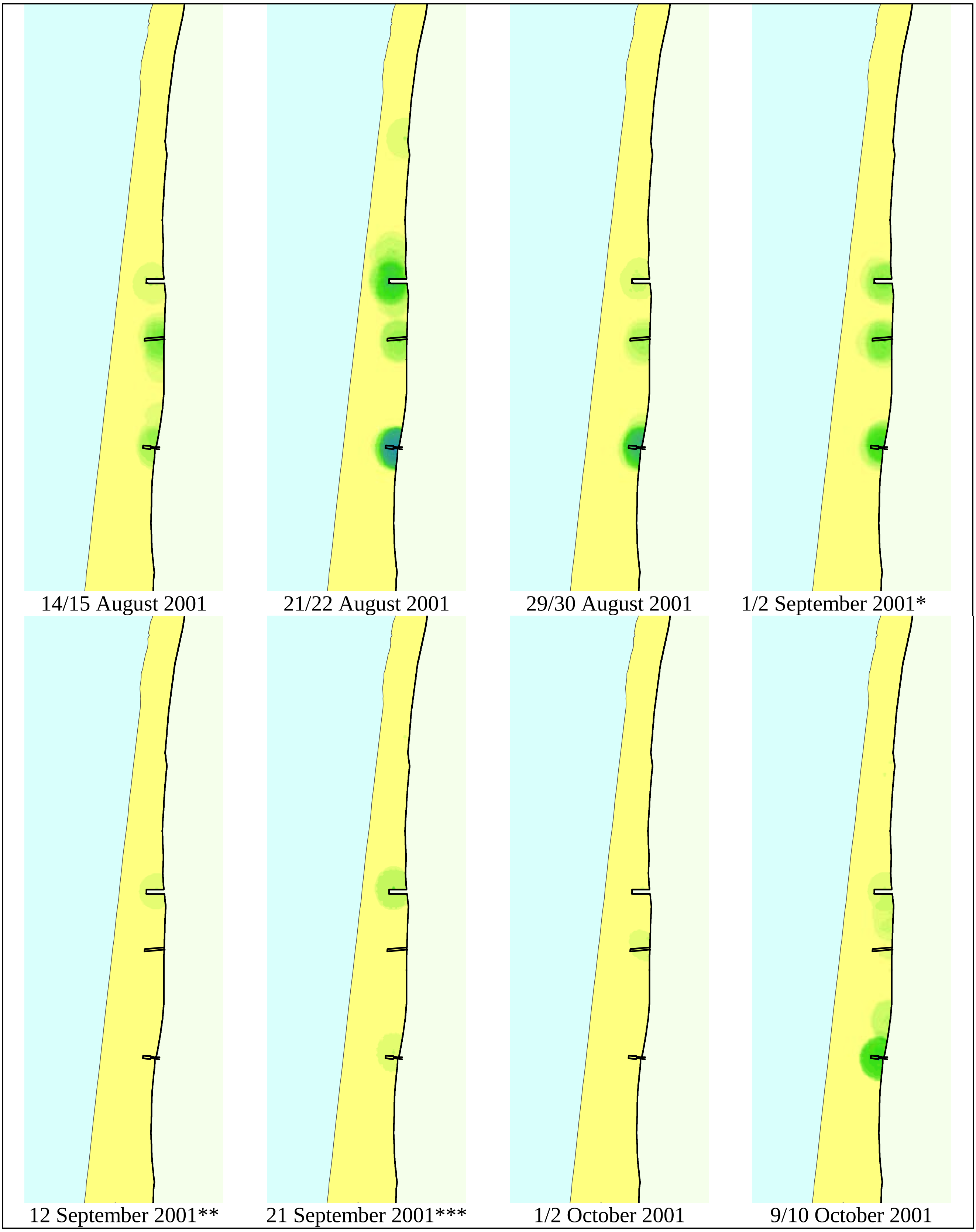

Figure 2.4.3.2.3 Continued.

* Weekend Visits ** count based upon only three tides *** count based upon low tide

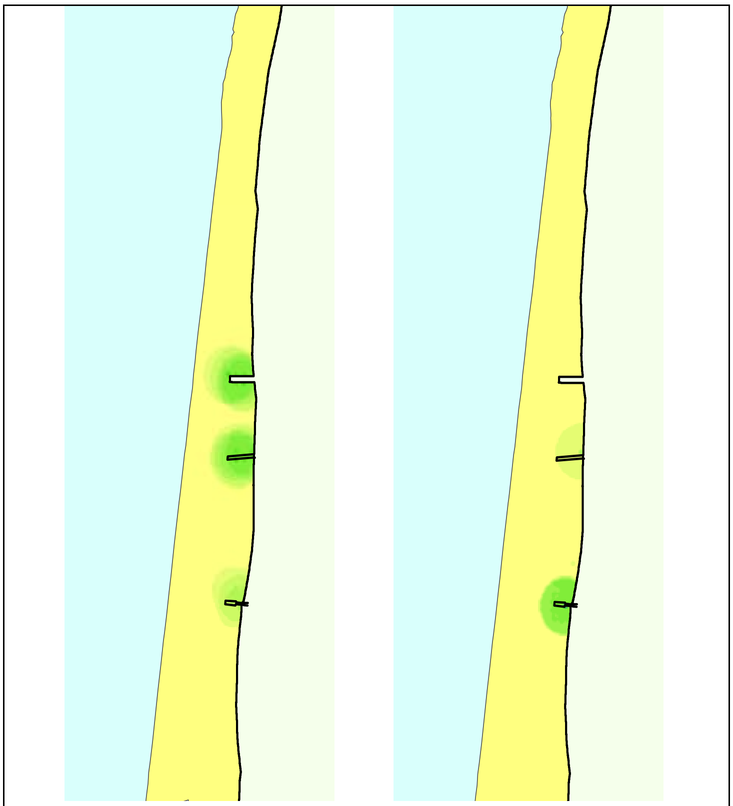

Figure 2.4.3.2.3 Continued.

* Weekend Visits ** count based upon only three tides *** count based upon low tide

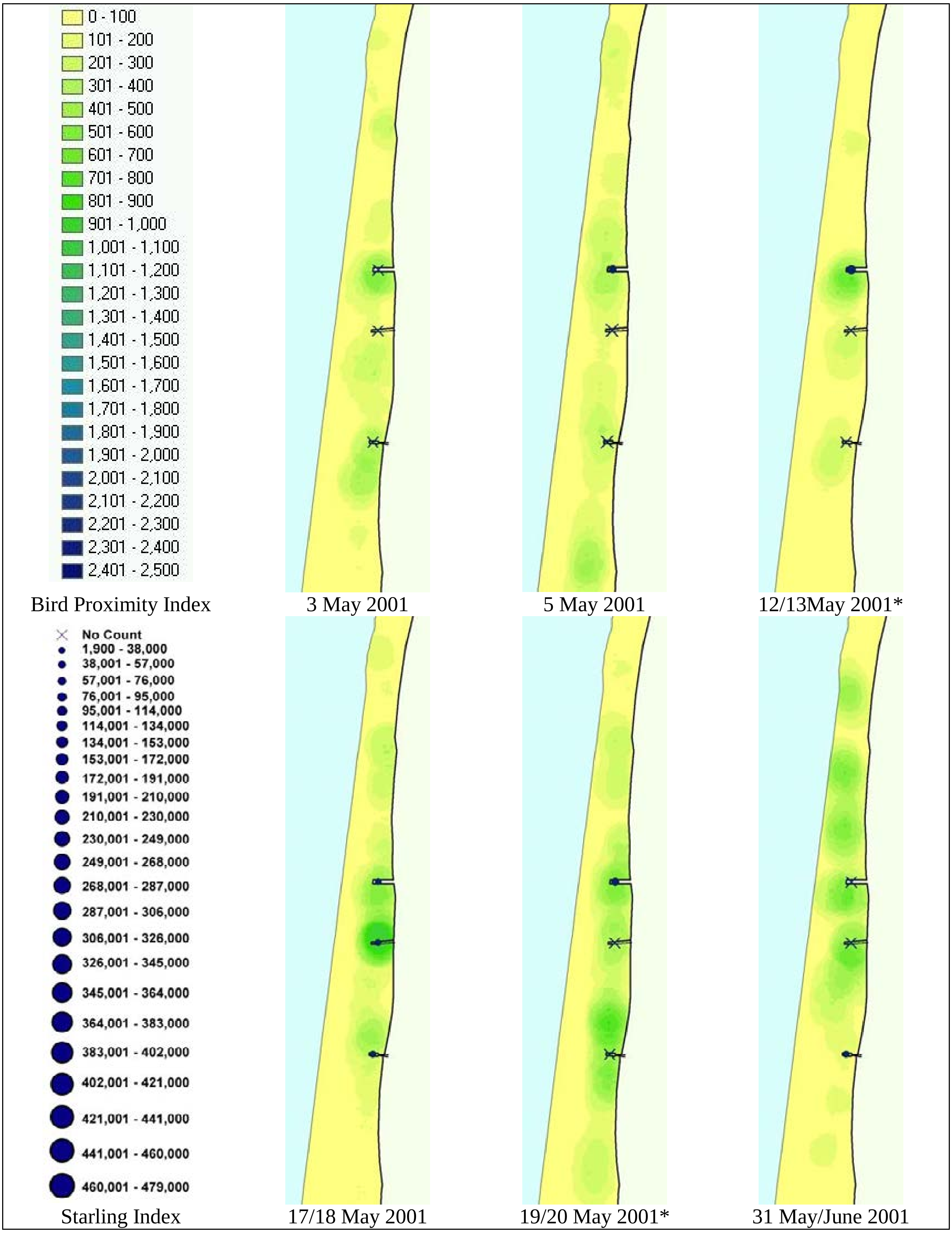

Figure 2.4.3.2.4 Distribution of birds observed on the Blackpool shoreline during 2001 depicted using the intertidal-bird proximity index and Starling roost counts.

* Weekend Visits ** count based upon only three tides *** count based upon low tide

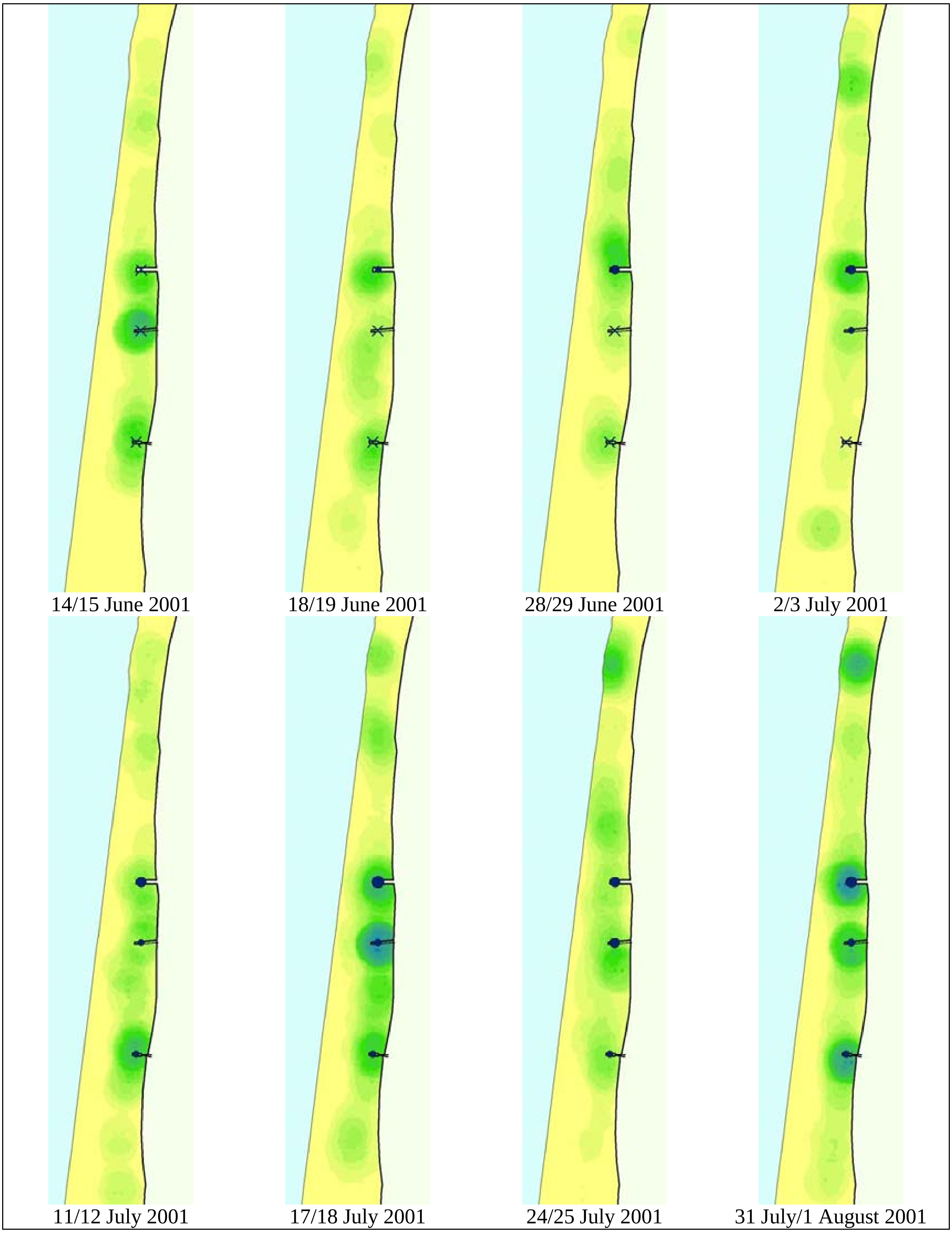

Figure 2.4.3.2.4 Distribution of birds observed on the Blackpool shoreline during 2001 depicted using the intertidal-bird proximity index and Starling roost counts.

* Weekend Visits ** count based upon only three tides *** count based upon low tide

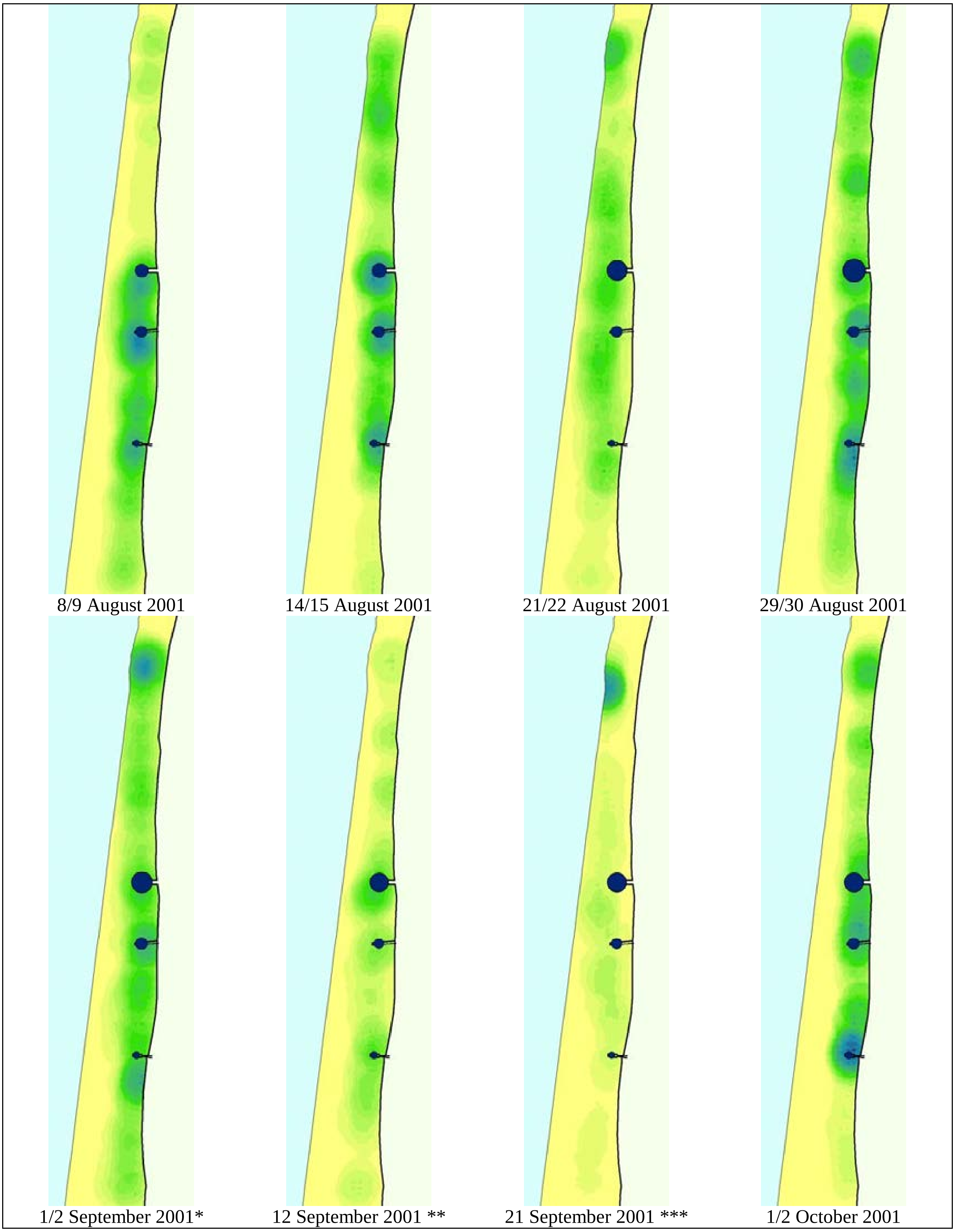

Figure 2.4.3.2.4 Distribution of birds observed on the Blackpool shoreline during 2001 depicted using the intertidal-bird proximity index and Starling roost counts.

* Weekend Visits ** count based upon only three tides *** count based upon low tide

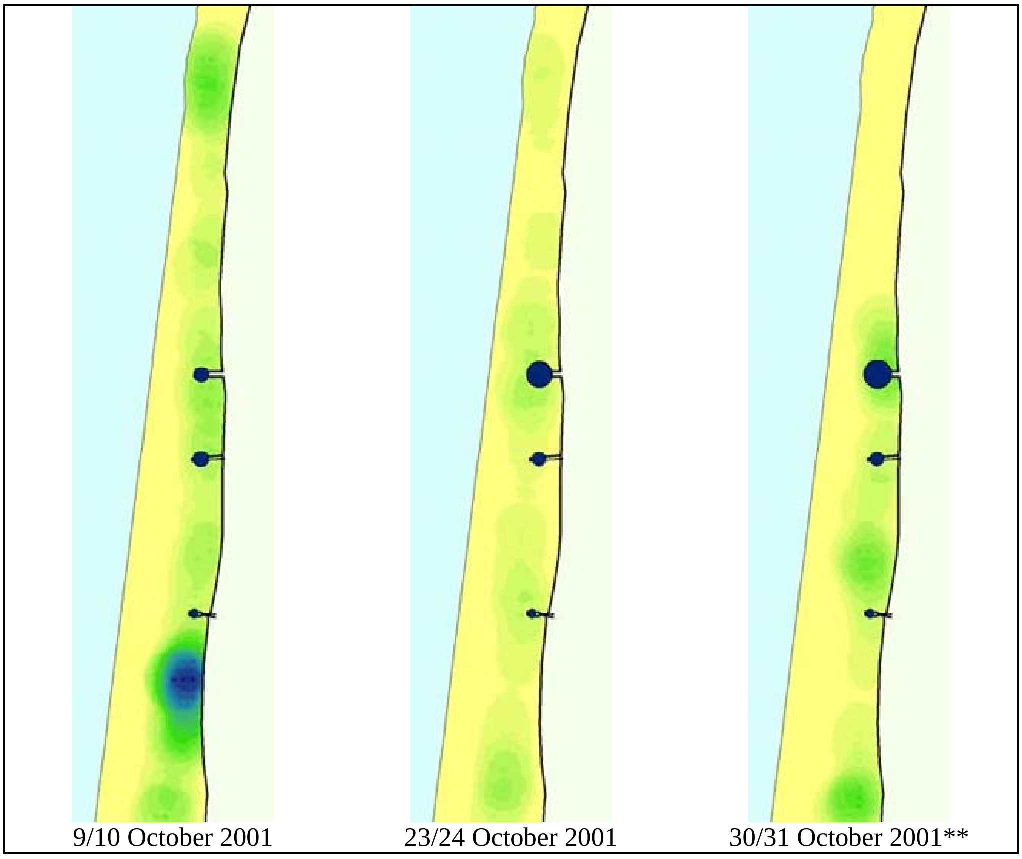

Figure 2.4.3.2.4 Distribution of birds observed on the Blackpool shoreline during 2001 depicted using the intertidal-bird proximity index and Starling roost counts.

* Weekend Visits ** count based upon only three tides *** count based upon low tide

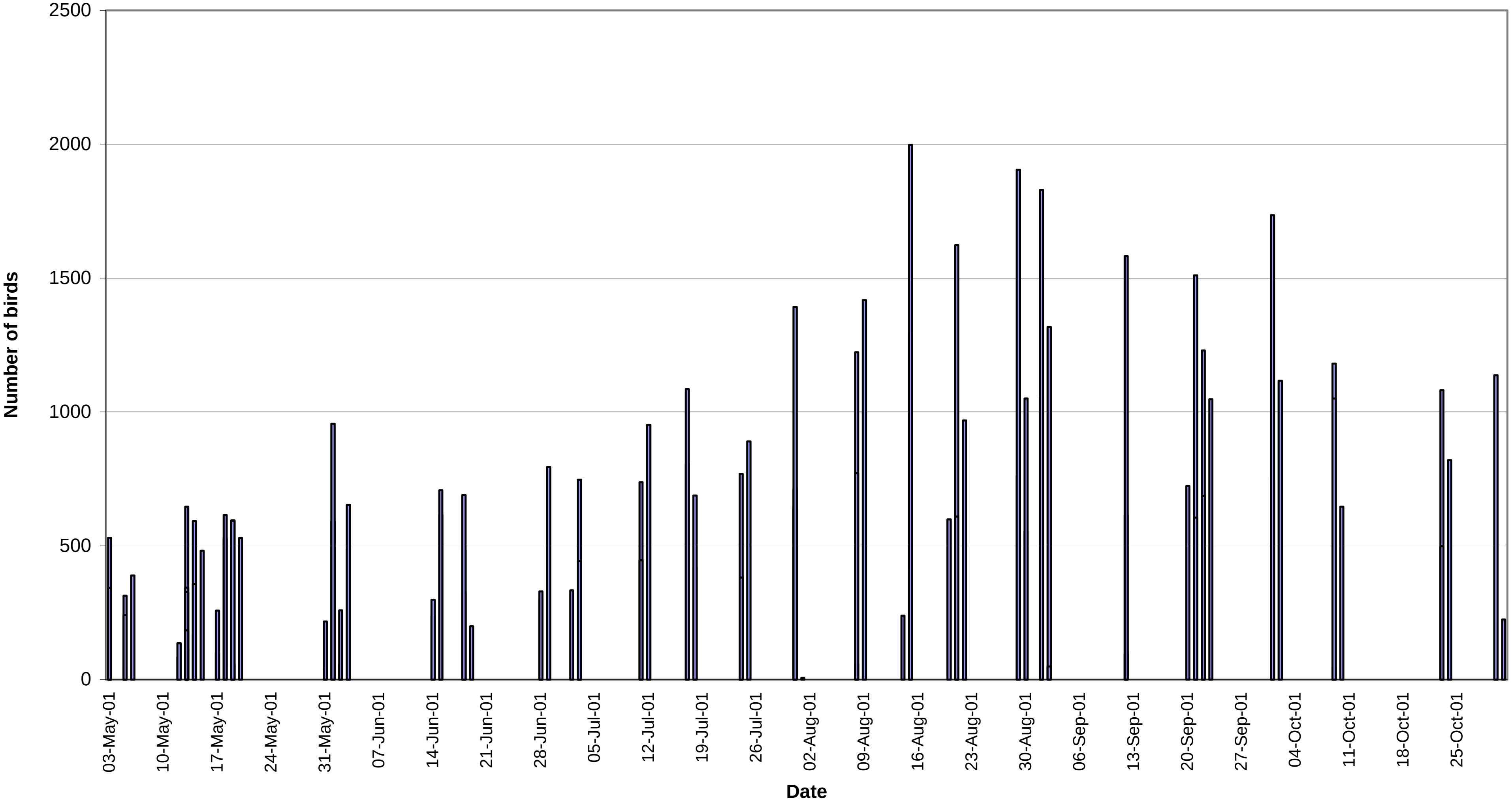

Figure 3.1.1.1 Maximum number of Herring Gulls observed during shoreline surveys at Blackpool.

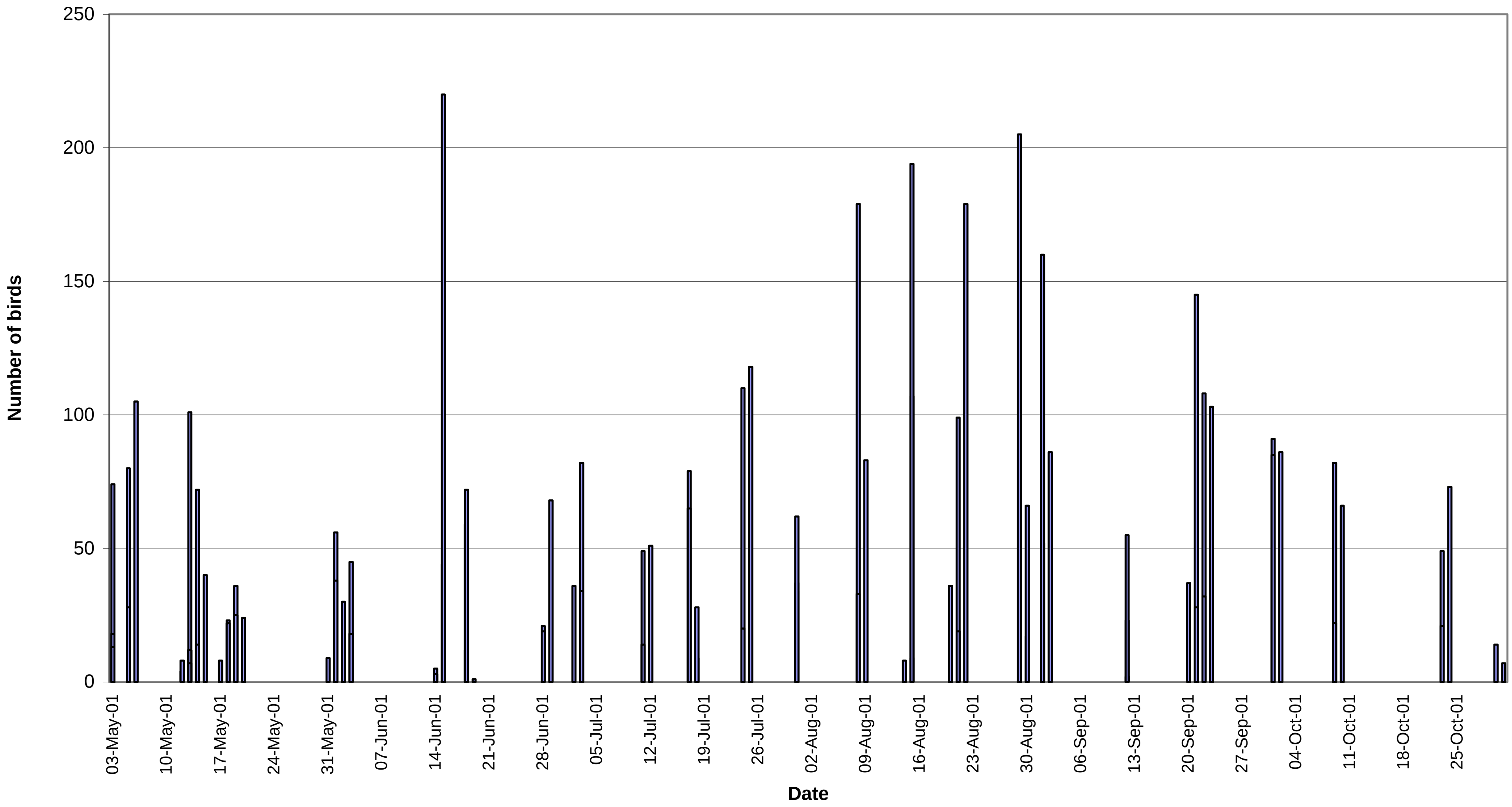

Figure 3.1.1.2 Maximum number of Lesser Black-backed Gulls observed during shoreline surveys at Blackpool.

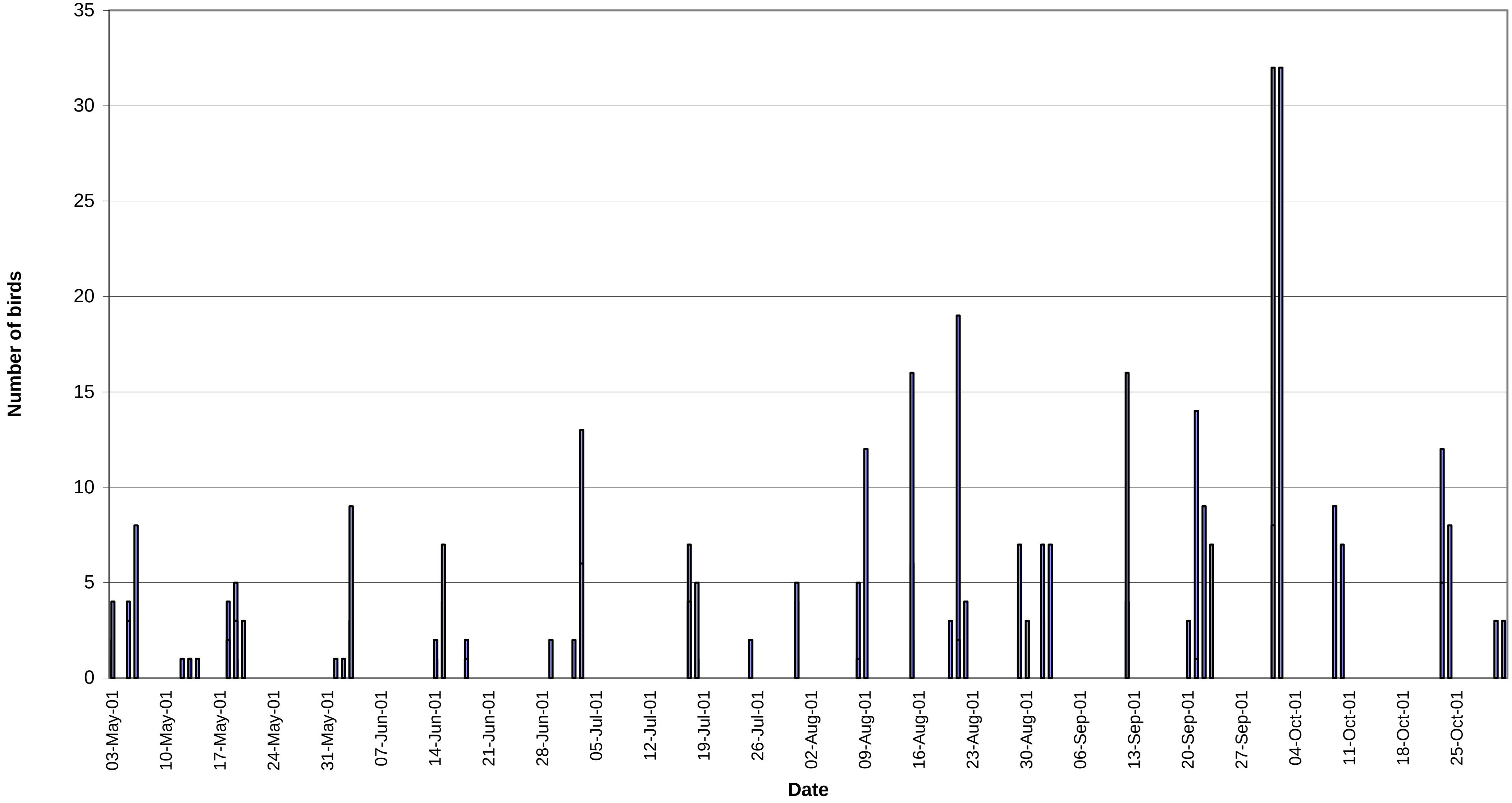

Figure 3.1.1.3 Maximum number of Great Black-backed Gulls observed during shoreline surveys at Blackpool.

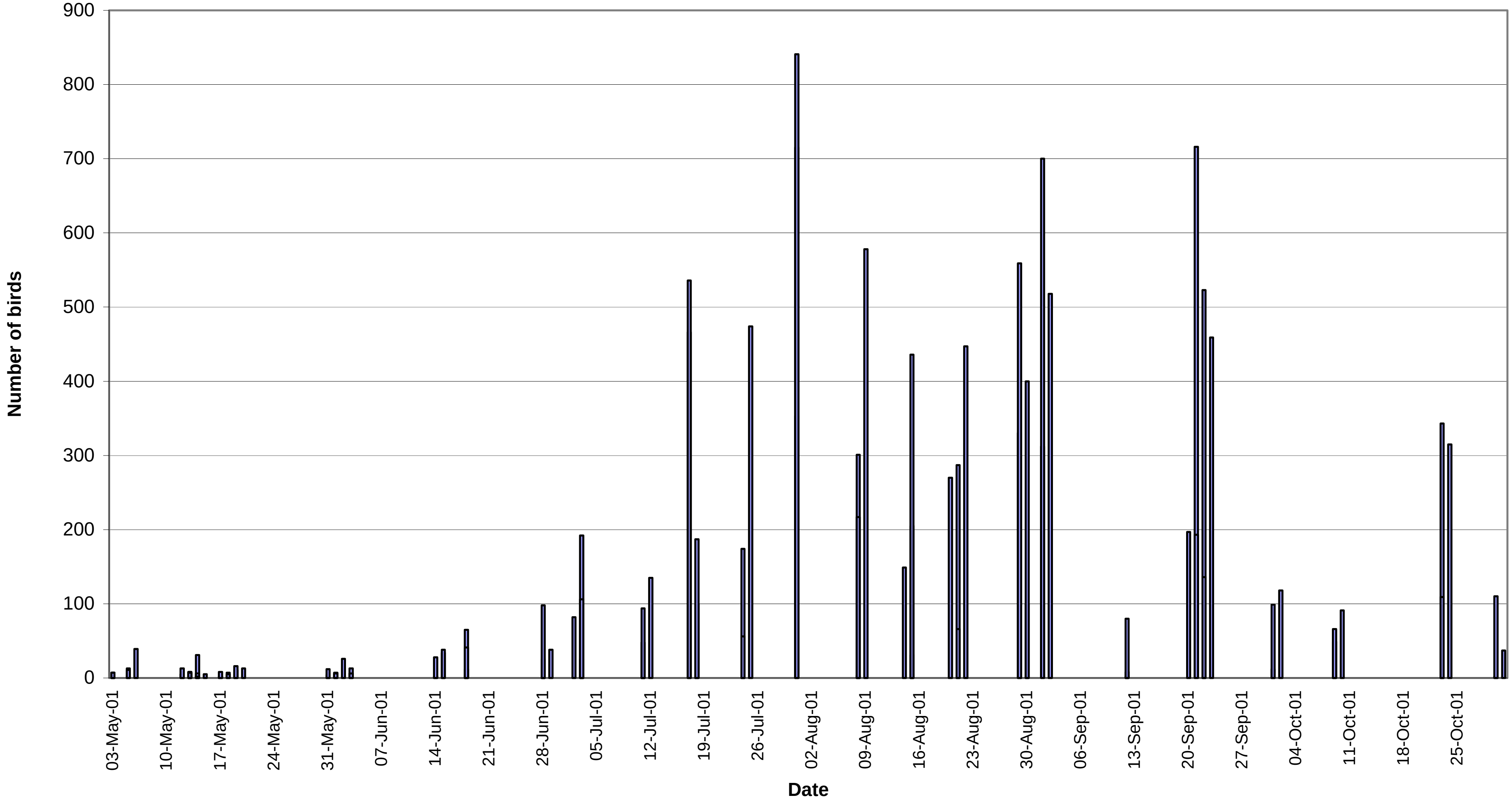

Figure 3.1.1.4 Maximum number of Black-headed Gulls observed during shoreline surveys at Blackpool.

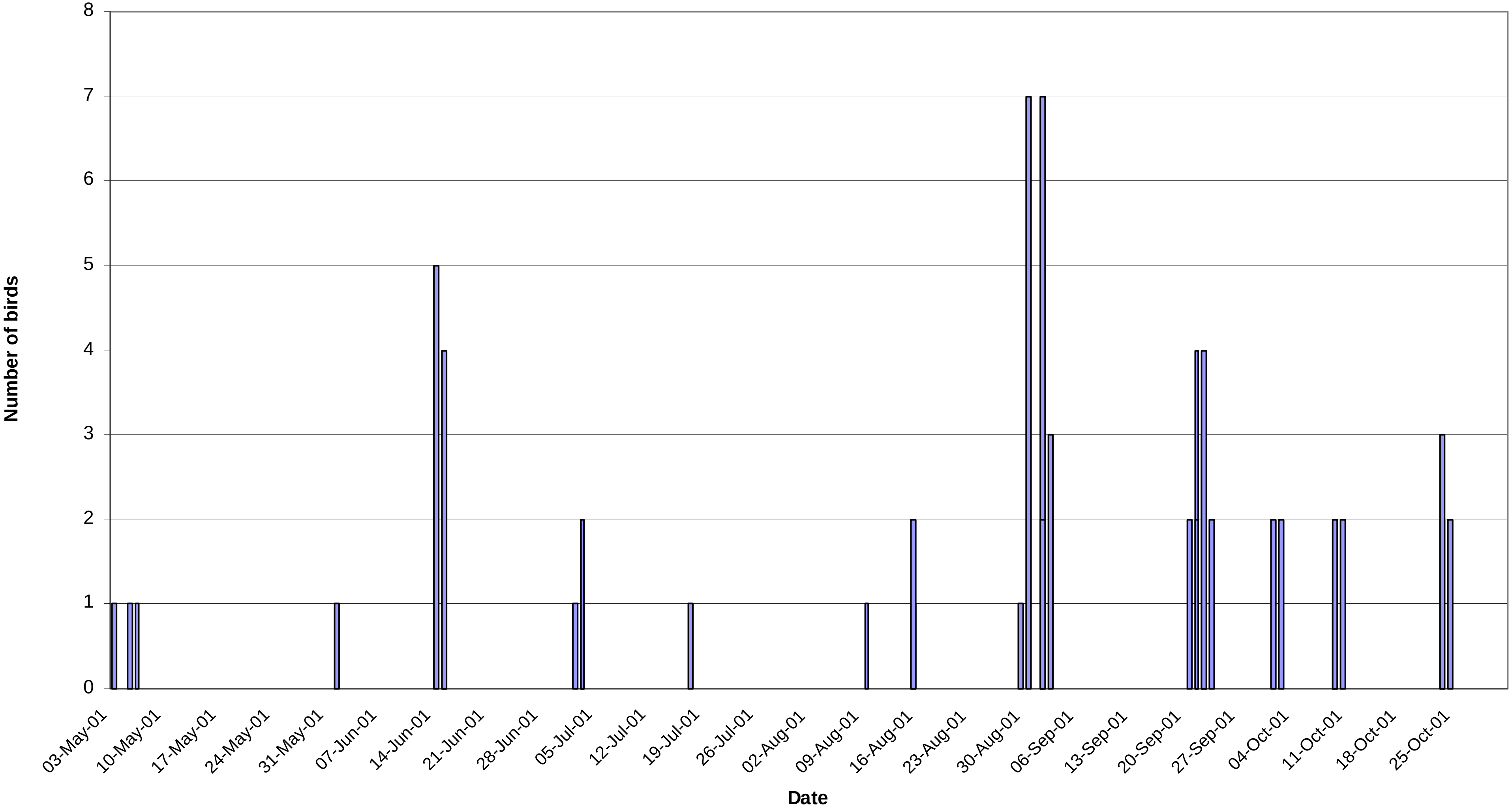

Figure 3.1.1.5 Maximum number of Common Gulls observed during shoreline surveys at Blackpool.

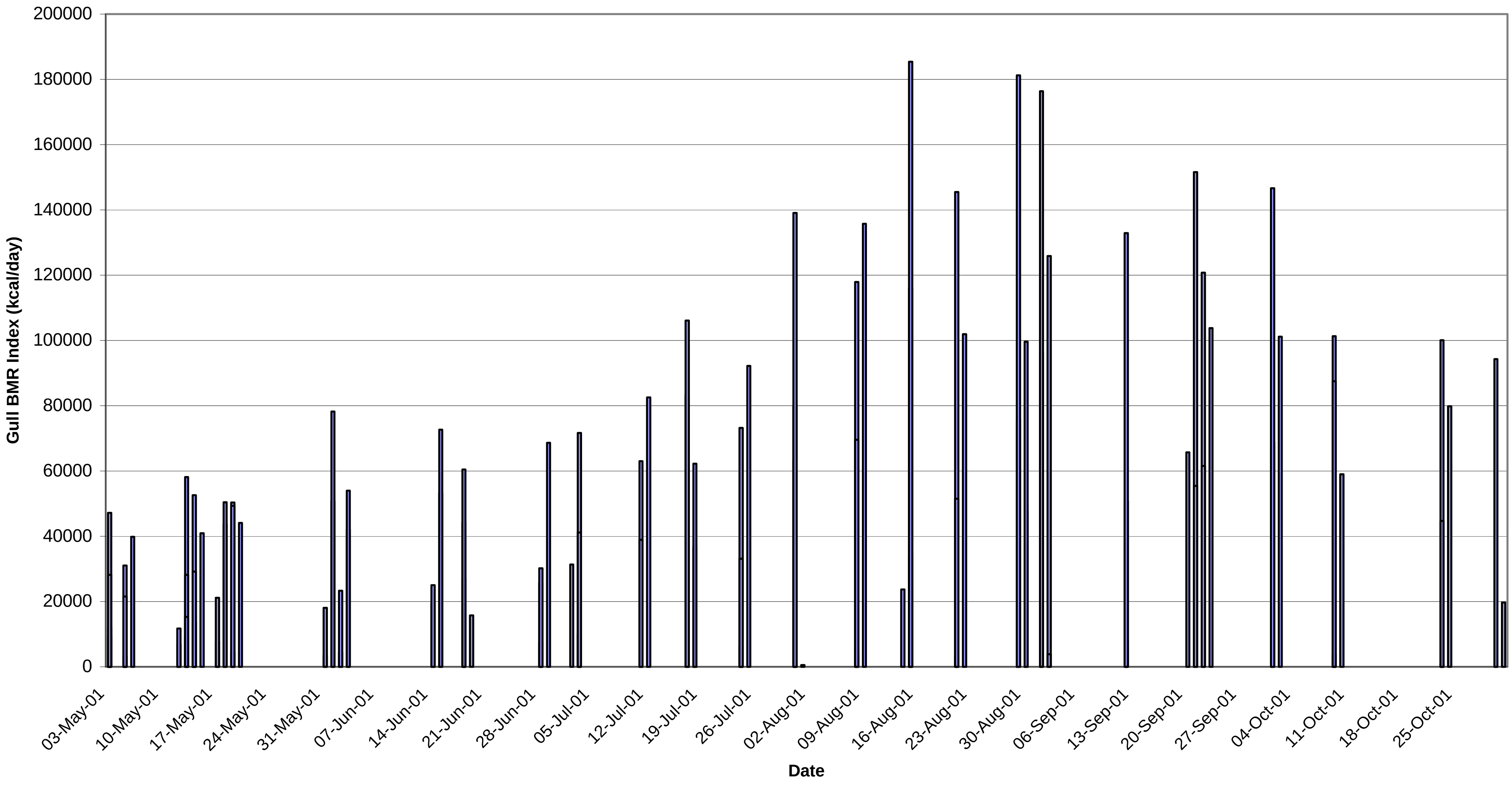

Figure 3.1.1.6 Gull BMR Index for shoreline surveys at Blackpool.

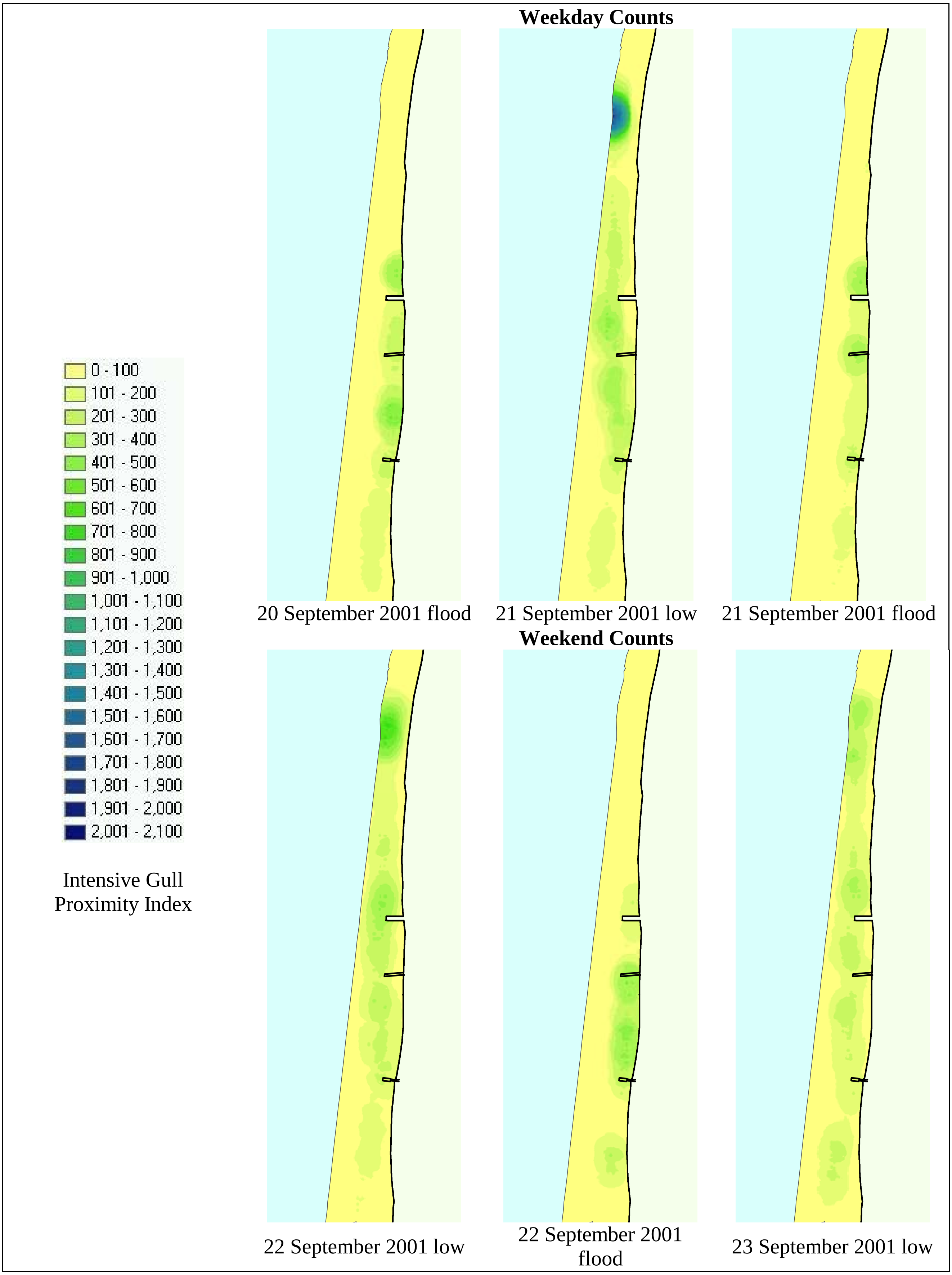

Figure 3.1.1.7 Comparison of weekday and weekend distributions of Gulls on the Blackpool shoreline during Autumn 2001. See also Figure 2.3.3.2.1 for 12/13 May and 17/18 May for similar comparison for Spring 2001.

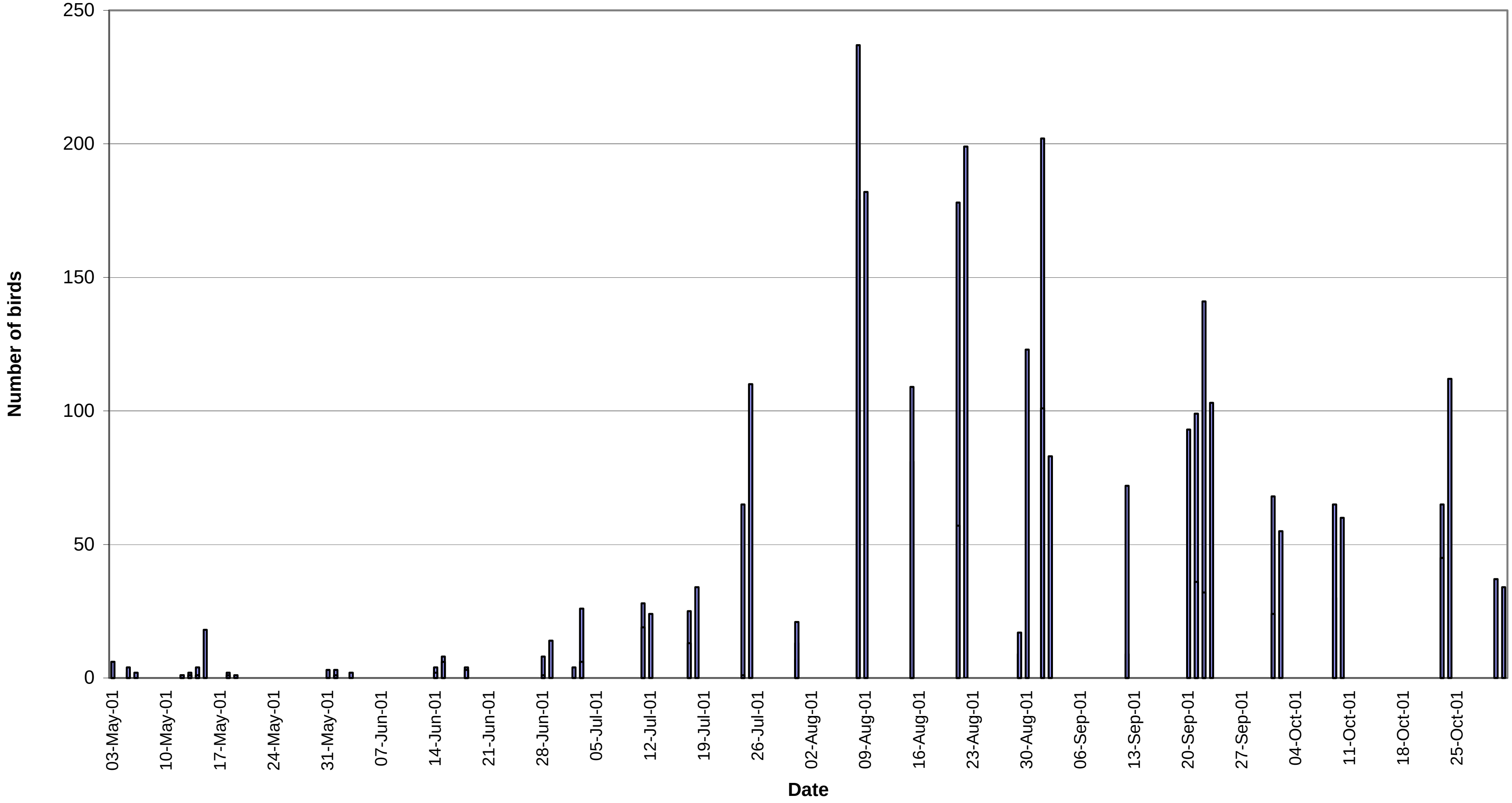

Figure 3.1.2.1 Maximum number of Oystercatchers observed during shoreline surveys at Blackpool.

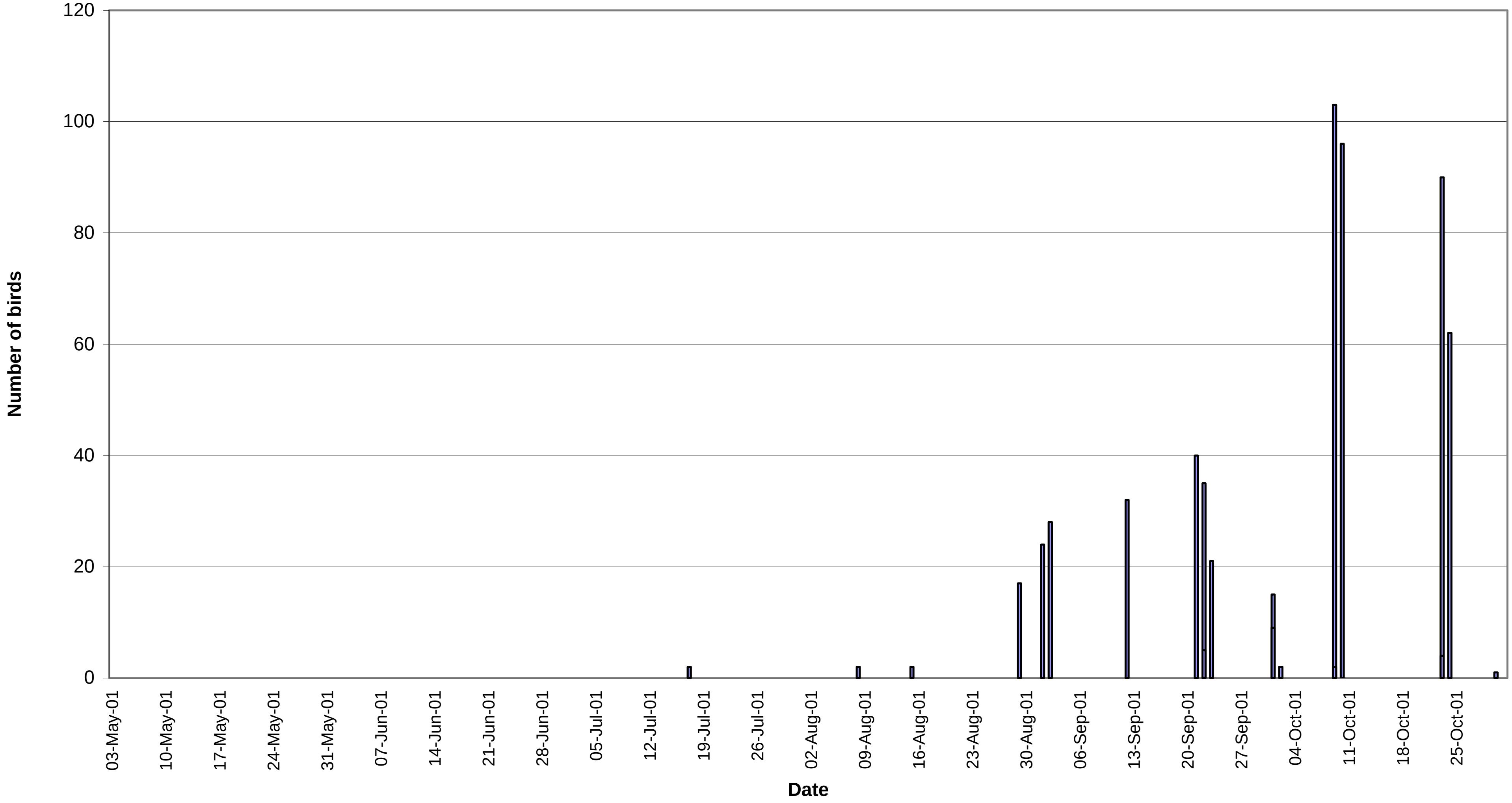

Figure 3.1.2.2 Maximum number of Redshank observed during shoreline surveys at Blackpool.

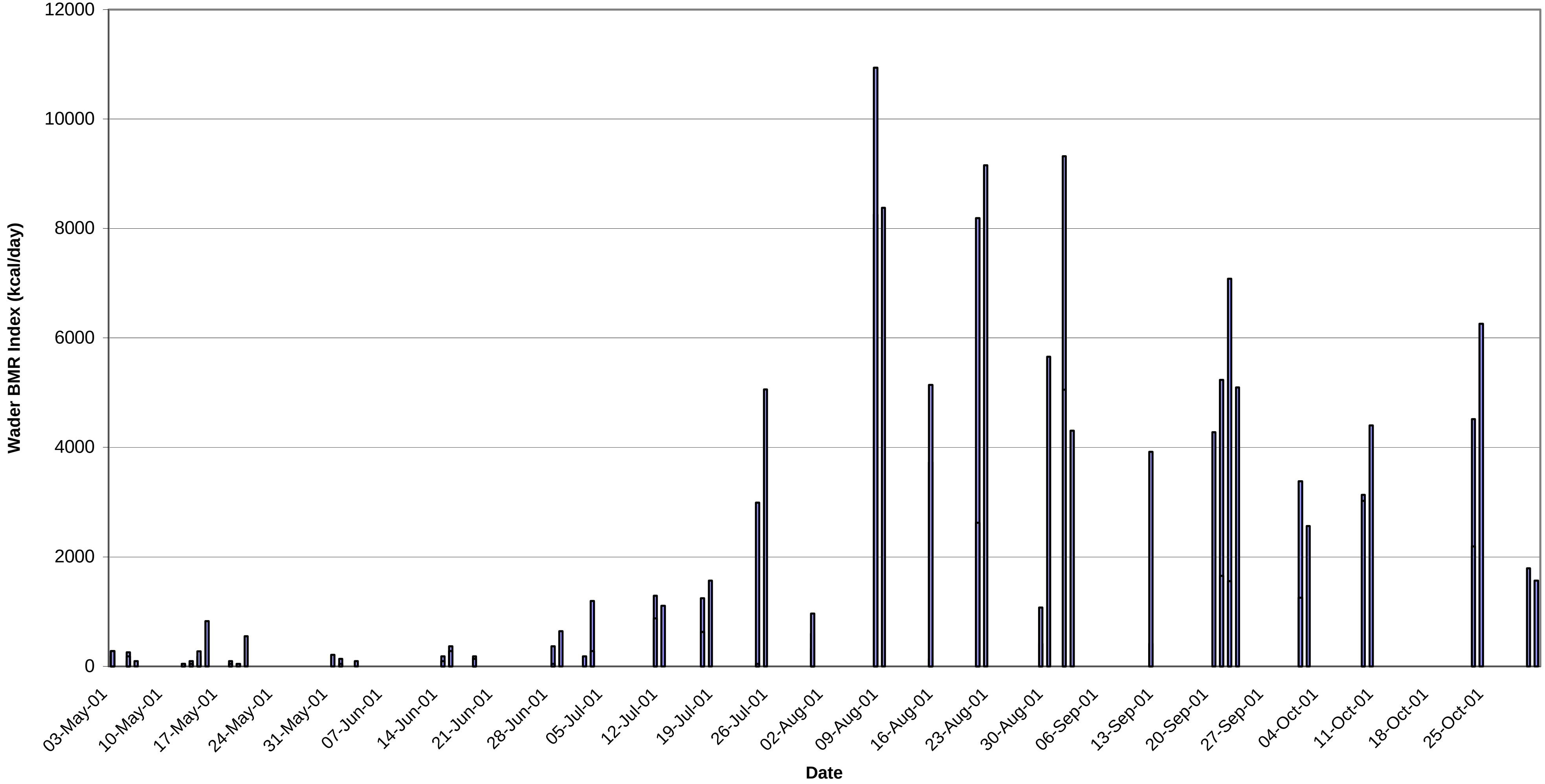

Figure 3.1.2.3 Wader BMR Index.

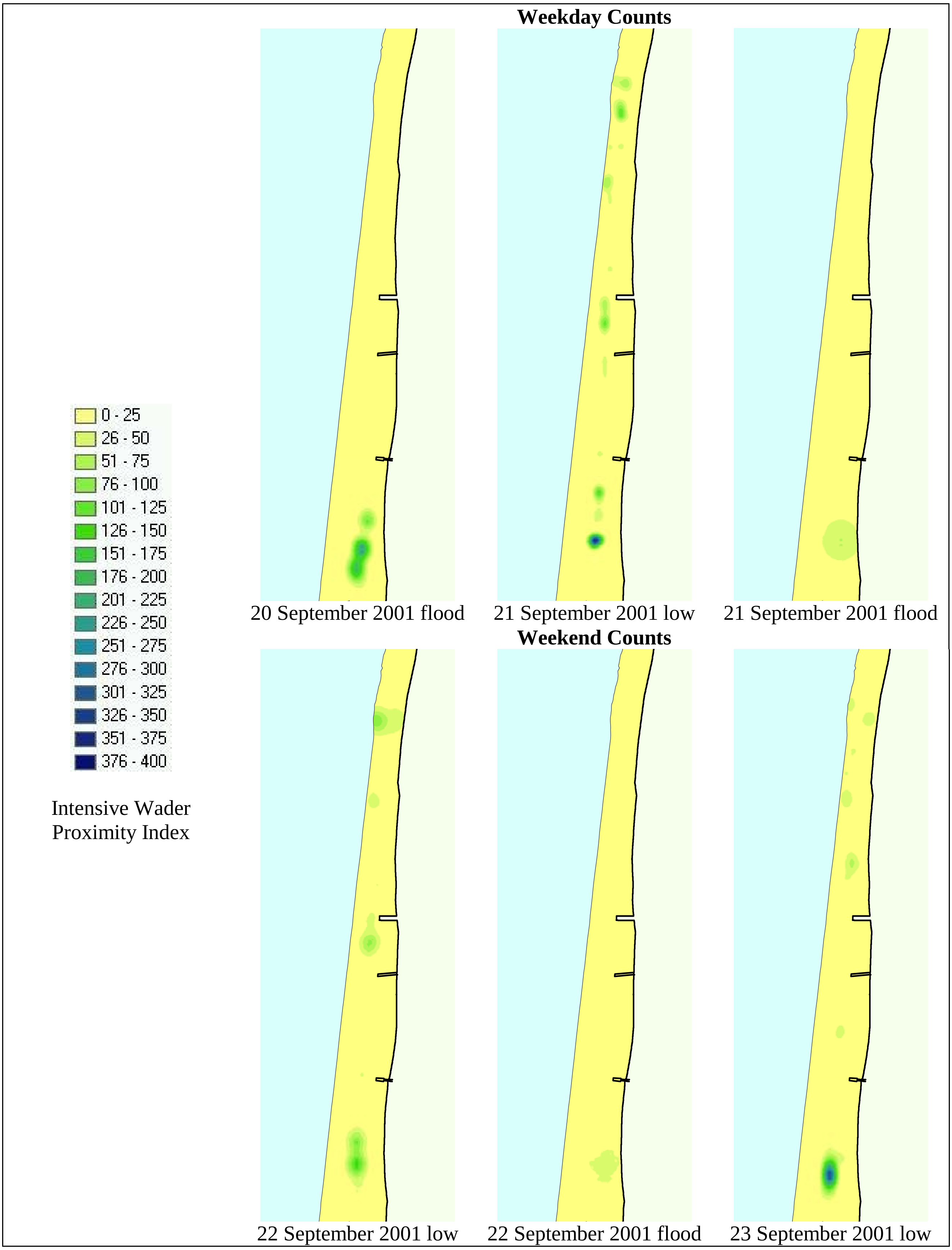

Figure 3.1.2.4 Comparison of weekday and weekend distributions of Waders on the Blackpool shoreline during Autumn 2001. See also Figure 2.3.3.2.1 for 12/13 May and 17/18 May for similar comparison for Spring 2001.

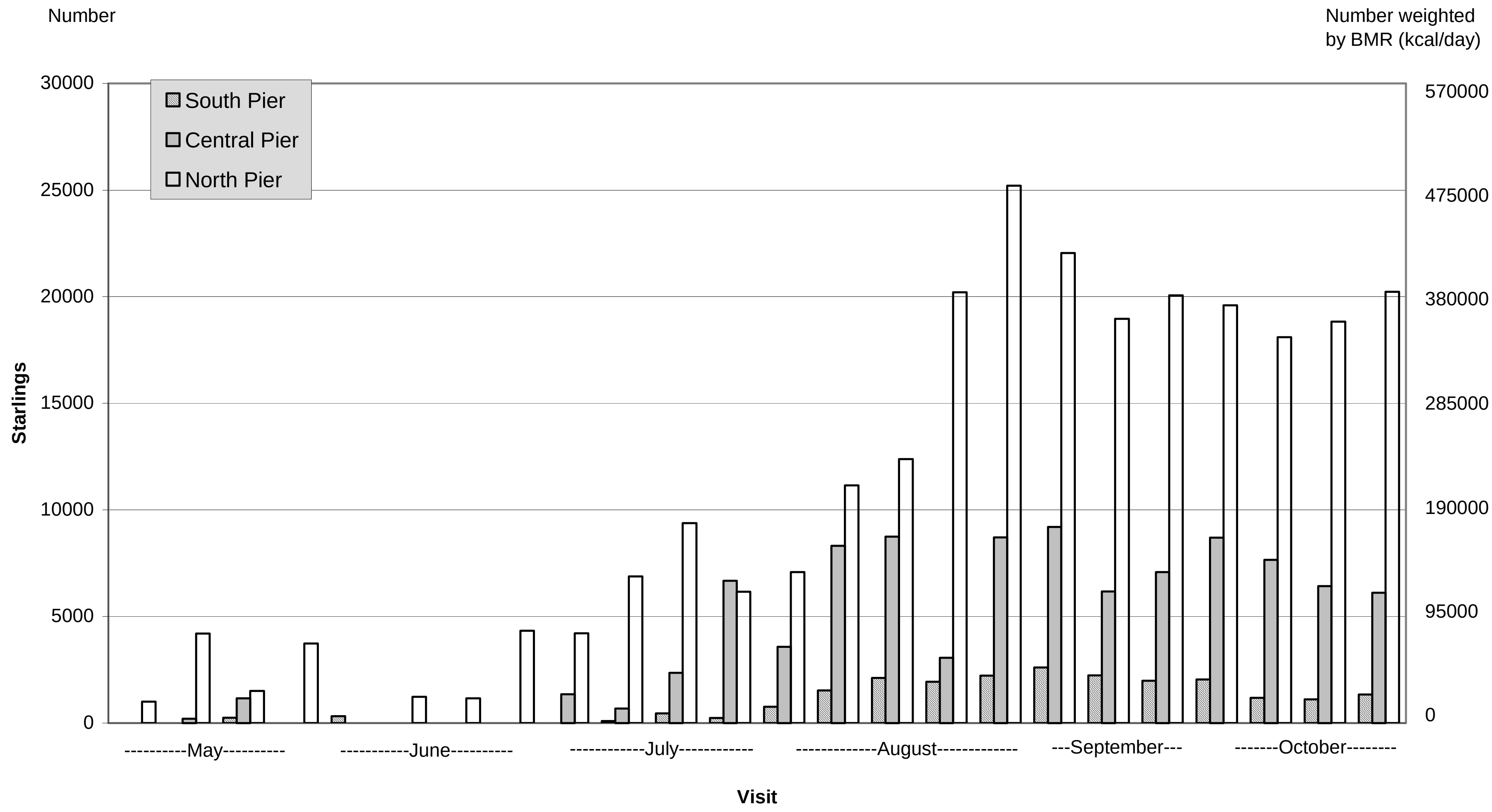

Figure 3.1.4.1 Starling roost counts.

Appendix 1 Complete computer outputs from statistical modelling

Explanation

Relationships between water compliance measurements and a range of physical and biological factors were considered using generalized linear models. **Each of the summary models reported in the body of the report will have resulted from a series of sequential steps (separate models), which are reported fully here**. A two stage approach was adopted. Firstly, exploratory models considered each class of potential explanatory variables in isolation. Classes considered in this manner were physical environment variables, Starling numbers at roosts on the three piers, gulls on the intertidal areas, all species combined on the intertidal areas and all birds on the entire study area. Secondly, all-factor models were developed for each water compliance measure that considered variables from all the variable classes simultaneously. Models from the first stage should not be used in isolation to draw conclusions regarding whether or not birds are contributing to the microbiological contaminants in the Blackpool bathing waters. The principal function of the first stage models is to provide insight into the second stage models and the latter should be used to assess relationship between birds and contaminants.

The physical environment variables considered north vector of wind (NVW), east vector of wind (EVW), rainfall (Rain), sunshine (Sunshine) and Ultra Violet B radiation (UVB), all averaged or summed as appropriate over a three day period. Starling numbers were considered both when summed across all piers (or using North Pier numbers as a surrogate) and matched to piers (pier specific models only). Gulls and intertidal birds numbers and distribution relation to water compliance sampling locations were considered using the Gull proximity and intertidal-bird proximity indices respectively (location specific models only). Gulls, intertidal-birds (gulls + waders + pigeons) and all-birds (gulls + waders + pigeons + Starlings) across the whole area were considered using Gull, Intertidal-bird and All-bird BMR indices respectively.

For each water compliance measure, for each class of model the method adopted followed the same line of development. Two procedures from the SAS statistical software package GLM and REG, were used in conjunction to obtain a description each water compliance measure in terms of the most parsimonious model given the set of explanatory variables being considered. Both procedures develop generalized linear models. The procedure GLM allows class variables (such as location) to be included in the model statement but does not allow automated stepwise selection methods. The procedure REG allows stepwise selection methods to be specified in the model statement and produces more extensive statistical output but does not allow class variables to be included. The procedure GLM was first used to consider a model that included location an exploratory variable and was based on data from all sampling locations. When location added significantly to that model then two separate models, one based on data from Bispham only and one based on data from across all piers combined were considered. When location significantly added to the across all piers model then pier-specific models were considered. Having deduced whether across all sites, across all piers or pier-specific models should would be appropriate (to remove the location factor) the procedure REG, specifying stepwise variable selection used to obtain the ultimate model which only retained variables that significantly added to model fit.

Where possible, analyses were all based on the 23 visits for which complete counts of intertidal birds had been completed (there was one of the 24 main visits for which coverage was not obtained for all states of the tide due to extreme weather conditions). Counts of Starling numbers on all three piers were only obtained on 14 visits but counts for North Pier were obtained on 19 visits. Data on UVB were available for 13 visits. Thus, the sample sizes (number of visits) available to models that considered these variables were reduced accordingly.

Table of Models

Exploratory Models based on Physical Environment Variables only

Deriving Model A (Table 3.2.1).

Model 1: Compliance data VS. Physical variables - Assessing site factor (UVB excluded) - all sites GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 2: Compliance data VS. Physical variables - Assessing site factor (UVB excluded) - excluding Bispham GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 3: Compliance data VS. Physical variables except UVB across piers STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 4c: Compliance data VS. Physical variables except UVB (and sunshine) across piers STEPWISE REGRESSION
Dependent Variable: Total Coliforms

Model 5: Compliance data VS. Physical variables except UVB for Bispham STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Deriving Model B (Table 3.2.1).

Model 6: Compliance data VS. Physical variables - Assessing site factor (UVB included) - all sites GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 7: Compliance data VS. Physical variables - Assessing site factor (UVB included) - excluding Bispham GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 8: Compliance data VS. Physical variables including UVB across piers STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 9: Compliance data VS. Physical variables including UVB for Bispham STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Exploratory Models based on Starling Roost Variables only

Deriving Model C (Table 3.2.2.1).

Model 10: Compliance data VS. Starling roosts (summed piers) - Assessing site factor - all sites GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 11: Compliance data VS. Starling roosts (summed piers) - Assessing site factor - excluding Bispham GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 12: Compliance data VS. Starling roosts (summed piers) across sites STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 13: Compliance data VS. Starling roosts (summed piers) by site STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 14: Compliance data VS. Starling roosts (summed piers) by site STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 15: Compliance data VS. Starling roosts (summed piers) by site STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 16: Compliance data VS. Starling roosts (summed piers) by site STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Deriving Model D (Table 3.2.2.1).

Model 17:Compliance data VS. Starling roosts (matched piers) - Assessing site factor - all piers GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 18: Compliance data VS. Starling roosts (matched piers) by pier STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 19: Compliance data VS. Starling roosts (matched piers) by pier STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 20: Compliance data VS. Starling roosts (matched piers) by pier STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Deriving Model E (Table 3.2.2.1).

Model 21: Compliance data VS. Starling roost (North Pier) - Assessing site factor - all sites GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 22: Compliance data VS. Starling roost (North Pier) - Assessing site factor - excluding Bispham GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 23: Compliance data VS. Starling roost (North Pier) - across sites STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Exploratory Models based on Gull Proximity Index only

Deriving Model F (Table 3.2.3.1).

Model 24: Compliance data VS. Gull Proximity Index - Assessing site factor - all sites GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 25: Compliance data VS. Gull Proximity Index - Assessing site factor - excluding Bispham GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 26: Compliance data VS. Gull Proximity Indices STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 27: Compliance data VS. Gull Proximity Indices by site STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 28: Compliance data VS. Gull Proximity Indices by site STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 29: Compliance data VS. Gull Proximity Indices by site STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 30: Compliance data VS. Gull Proximity Indices by site STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Exploratory Models based on Intertidal-bird Proximity Index only

Deriving Model G (Table 3.2.3.1).

Model 31: Compliance data VS. Intertidal Proximity Index - Assessing site factor - all sites GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 32: Compliance data VS. Intertidal Proximity Index - Assessing site factor - excluding Bispham GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 33: Compliance data VS. Intertidal Proximity Index STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 34: Compliance data VS. Intertidal Proximity Index by site STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 35: Compliance data VS. Intertidal Proximity Index by site STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 36: Compliance data VS. Intertidal Proximity Index by site STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 37: Compliance data VS. Intertidal Proximity Index by site STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Exploratory Models based on Gull BMR Index only

Deriving Model H (Table 3.2.3.2).

Model 38: Compliance data VS. Gull BMR Index - Assessing site factor - all sites GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 39: Compliance data VS. Gull BMR Index - Assessing site factor - excluding Bispham GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 40: Compliance data VS. Gull BMR Index across sites STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Exploratory Models based on Intertidal-bird BMR Index only

Deriving Model I (Table 3.2.3.2).

Model 41: Compliance data VS. Intertidal BMR Index - Assessing site factor - all sites GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 42: Compliance data VS. Intertidal BMR Index - Assessing site factor - excluding Bispham GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 43: Compliance data VS. Intertidal BMR across sites STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Exploratory Models based on All-bird BMR Index only

Deriving Model J (Table 3.2.3.2).

Model 44: Compliance data VS. All-bird BMR Index - Assessing site factor - all sites GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 45: Compliance data VS. All-bird BMR Index - Assessing site factor - excluding Bispham GLM WITH SITE FACTOR
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

Model 46: Compliance data VS. All-bird BMR across sites STEPWISE REGRESSION
a: Dependent Variable: Faecal Coliforms
b: Dependent Variable: Faecal Streptococci
c: Dependent Variable: Total Coliforms

All-factor models for Faecal coliforms

Deriving Model K.a (Table 3.2.5).

Model 47: Faecal Coliforms Vs. North Vector, Rain and N. Pier Starlings using GLM WITH SITE FACTOR

Model 48: Faecal Coliforms Vs. North Vector, Rain and N. Pier Starlings using GLM WITH SITE FACTOR (excluding Bispham)

Model 49: Faecal Coliforms Vs. North Vector, Rain and Intertidal BMR using GLM WITH SITE FACTOR

Model 50: Faecal Coliforms Vs. North Vector, Rain and Intertidal BMR using GLM WITH SITE FACTOR (excluding Bispham)

Model 51: Faecal Coliforms Vs. North Vector, Rain and Gull BMR using GLM WITH SITE FACTOR

Model 52: Faecal Coliforms Vs. North Vector, Rain and Gull BMR using GLM WITH SITE FACTOR (excluding Bispham)

Model 53: Faecal Coliforms Vs. North Vector, Rain and All-bird BMR using GLM WITH SITE FACTOR

Model 54: Faecal Coliforms Vs. North Vector, Rain and All-bird BMR using GLM WITH SITE FACTOR (excluding Bispham)

Model 55: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Intertidal BMR using GLM WITH SITE FACTOR

Model 56: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Intertidal BMR using GLM WITH SITE FACTOR (excluding Bispham)

Model 57: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Gull BMR using GLM WITH SITE FACTOR

Model 58: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Gull BMR using GLM WITH SITE FACTOR (excluding Bispham)

Model 59: Faecal Coliforms Vs. North Vector Rain and Gull BMR using STEPWISE REGRESSION across Piers

Model 60: Faecal Coliforms Vs. North Vector Rain and Gull BMR using STEPWISE REGRESSION Bispham only

Model 61: Faecal Coliforms Vs. North Vector Rain and Intertidal BMR using STEPWISE REGRESSION across Piers

Model 62: Faecal Coliforms Vs. North Vector Rain and Intertidal BMR using STEPWISE REGRESSION Bispham only

Model 63: Faecal Coliforms Vs. North Vector Rain and N. Pier Starlings using STEPWISE REGRESSION across Piers

Model 64: Faecal Coliforms Vs. North Vector Rain and N. Pier Starlings using STEPWISE REGRESSION Bispham only

Model 65: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Gull BMR using STEPWISE REGRESSION across Piers

Model 66: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Gull BMR using STEPWISE REGRESSION Bispham only

Model 67: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Intertidal BMR using STEPWISE REGRESSION across Piers

Model 68: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Intertidal BMR using STEPWISE REGRESSION Bispham only

All-factor models for Faecal *streptococci*

Deriving Model K.b (Table 3.2.5).

Model 69: Faecal Streptococci Vs. North Vector and N. Pier Starlings using GLM WITH SITE FACTOR

Model 70: Faecal Streptococci Vs. North Vector and Intertidal BMR using GLM WITH SITE FACTOR

Model 71: Faecal Streptococci Vs. North Vector and Gull BMR using GLM WITH SITE FACTOR

Model 72: Faecal Streptococci Vs. North Vector and All-bird BMR using GLM WITH SITE FACTOR

Model 73: Faecal Streptococci Vs. North Vector, N. Pier Starlings and Intertidal BMR using GLM WITH SITE FACTOR

Model 74: Faecal Streptococci Vs. North Vector, N. Pier Starlings and Gull BMR using GLM WITH SITE FACTOR

Model 75: Faecal Streptococci Vs. North Vector, N. Pier Starlings and Intertidal BMR using STEPWISE REGRESSION across sites

Model 76: Faecal Streptococci Vs. North Vector, N. Pier Starlings and Gull BMR using STEPWISE REGRESSION across sites
Model 77: Faecal Streptococci Vs. North Vector, N. Pier Starlings, Gull BMR and Rain using STEPWISE REGRESSION across sites

Model 78: Faecal Streptococci Vs. North Vector and Intertidal BMR using STEPWISE REGRESSION across sites

Model 79: Faecal Streptococci Vs. North Vector and Gull BMR using STEPWISE REGRESSION across sites

Model 80: Faecal Streptococci Vs. North Vector, Gull BMR and Rain using STEPWISE REGRESSION across sites

All-factor models for Total coliforms

Deriving Model K.c (Table 3.2.5).

Model 81: Total Coliforms Vs. North Vector Rain and N. Pier Starlings using GLM WITH SITE FACTOR

Model 82: Total Coliforms Vs. North Vector Rain and Gull BMR using GLM WITH SITE FACTOR

Model 83: Total Coliforms Vs. North Vector, Rain and Intertidal BMR using GLM WITH SITE FACTOR

Model 84: Total Coliforms Vs. North Vector, Rain and All Bird BMR using GLM WITH SITE FACTOR

Model 85: Total Coliforms Vs. North Vector, Rain and Gull BMR across sites STEPWISE REGRESSION

Model 86: Total Coliforms Vs. North Vector, Rain and Intertidal BMR across sites STEPWISE REGRESSION

Model 87: Total Coliforms Vs. North Vector, Rain and BMR All Birds across sites STEPWISE REGRESSION

Models

Model 1a: Compliance data VS. Physical variables - Assessing site factor (UVB excluded) - all sites

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	23.83329753	3.40475679	17.73	<.0001
Error	84	16.13447564	0.19207709		
Corrected Total	91	39.96777318			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.596313	22.83868	0.438266	1.918963

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.00118598	0.66706199	3.47	0.0196
East Vector	1	1.81097555	1.81097555	9.43	0.0029
North Vector	1	13.90178334	13.90178334	72.38	<.0001
Rain	1	5.98255983	5.98255983	31.15	<.0001
Sunshine	1	0.13679284	0.13679284	0.71	0.4011

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	2.00118598	0.66706199	3.47	0.0196
East Vector	1	0.35041960	0.35041960	1.82	0.1804
North Vector	1	5.48768279	5.48768279	28.57	<.0001
Rain	1	3.86906612	3.86906612	20.14	<.0001
Sunshine	1	0.13679284	0.13679284	0.71	0.4011

Model 1b: Compliance data VS. Physical variables - Assessing site factor (UVB excluded) - all sites

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	8.03984187	1.14854884	9.49	<.0001
Error	84	10.16576090	0.12102096		
Corrected Total	91	18.20560277			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.441614	23.37069	0.347881	1.488534

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.43925908	0.14641969	1.21	0.3112
East Vector	1	2.01062719	2.01062719	16.61	0.0001
North Vector	1	4.67693308	4.67693308	38.65	<.0001
Rain	1	0.80755346	0.80755346	6.67	0.0115
Sunshine	1	0.10546906	0.10546906	0.87	0.3532

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.43925908	0.14641969	1.21	0.3112
East Vector	1	0.70613693	0.70613693	5.83	0.0179
North Vector	1	2.93810208	2.93810208	24.28	<.0001
Rain	1	0.89135248	0.89135248	7.37	0.0081
Sunshine	1	0.10546906	0.10546906	0.87	0.3532

Model 1c: Compliance data VS. Physical variables - Assessing site factor (UVB excluded) - all sites

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	36.61497095	5.23071014	19.02	<.0001
Error	84	23.09729633	0.27496781		
Corrected Total	91	59.71226728			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.613190	25.00815	0.524374	2.096811

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.06092619	0.68697540	2.50	0.0652
East Vector	1	1.99391140	1.99391140	7.25	0.0086
North Vector	1	19.52769294	19.52769294	71.02	<.0001
Rain	1	11.35112561	11.35112561	41.28	<.0001
Sunshine	1	1.68131480	1.68131480	6.11	0.0154

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	2.06092619	0.68697540	2.50	0.0652
East Vector	1	0.30351268	0.30351268	1.10	0.2964
North Vector	1	5.42877461	5.42877461	19.74	<.0001
Rain	1	5.43367449	5.43367449	19.76	<.0001
Sunshine	1	1.68131480	1.68131480	6.11	0.0154

Model 2a: Compliance data VS. Physical variables - Assessing site factor (UVB excluded) - excluding Bispham

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	17.78834671	2.96472445	15.24	<.0001
Error	62	12.05885293	0.19449763		
Corrected Total	68	29.84719964			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.595980	22.14138	0.441019	1.991831

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.53571998	0.26785999	1.38	0.2599
East Vector	1	1.40020797	1.40020797	7.20	0.0093
North Vector	1	10.32627835	10.32627835	53.09	<.0001
Rain	1	5.45988741	5.45988741	28.07	<.0001
Sunshine	1	0.06625301	0.06625301	0.34	0.5616

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.53571998	0.26785999	1.38	0.2599
East Vector	1	0.36422896	0.36422896	1.87	0.1761
North Vector	1	3.85545175	3.85545175	19.82	<.0001
Rain	1	3.70648070	3.70648070	19.06	<.0001
Sunshine	1	0.06625301	0.06625301	0.34	0.5616

Model 2b: Compliance data VS. Physical variables - Assessing site factor (UVB excluded) - excluding Bispham

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	5.82471034	0.97078506	8.12	<.0001
Error	62	7.41357062	0.11957372		
Corrected Total	68	13.23828096			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.439990	22.76611	0.345794	1.518899

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.18477792	0.09238896	0.77	0.4662
East Vector	1	1.52598651	1.52598651	12.76	0.0007
North Vector	1	3.31402107	3.31402107	27.72	<.0001
Rain	1	0.76014970	0.76014970	6.36	0.0143
Sunshine	1	0.03977514	0.03977514	0.33	0.5662

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.18477792	0.09238896	0.77	0.4662
East Vector	1	0.58745590	0.58745590	4.91	0.0303
North Vector	1	1.90292615	1.90292615	15.91	0.0002
Rain	1	0.74027643	0.74027643	6.19	0.0155
Sunshine	1	0.03977514	0.03977514	0.33	0.5662

Model 2c: Compliance data VS. Physical variables - Assessing site factor (UVB excluded) - excluding Bispham

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	28.49982361	4.74997060	17.55	<.0001
Error	62	16.77586225	0.27057842		
Corrected Total	68	45.27568586			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.629473	23.89212	0.520172	2.177168

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.27874512	0.13937256	0.52	0.6000
East Vector	1	1.80686896	1.80686896	6.68	0.0121
North Vector	1	14.54833198	14.54833198	53.77	<.0001
Rain	1	10.62174529	10.62174529	39.26	<.0001
Sunshine	1	1.24413226	1.24413226	4.60	0.0359

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.27874512	0.13937256	0.52	0.6000
East Vector	1	0.47030541	0.47030541	1.74	0.1922
North Vector	1	3.59255729	3.59255729	13.28	0.0006
Rain	1	5.39009993	5.39009993	19.92	<.0001
Sunshine	1	1.24413226	1.24413226	4.60	0.0359

Model 3a: Compliance data VS. Physical variables except UVB across piers

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4245 and C(p) = 8.5939

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3.90876	3.90876	15.49	0.0008
Error	21	5.29827	0.25230		
Corrected Total	22	9.20703			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.93344	0.10578	84.28677	334.08	<.0001
North Vector	-0.10279	0.02611	3.90876	15.49	0.0008

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable Rain Entered: R-Square = 0.6071 and C(p) = 1.8385

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	5.58987	2.79494	15.45	<.0001
Error	20	3.61715	0.18086		
Corrected Total	22	9.20703			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.74020	0.10972	45.49576	251.56	<.0001
North Vector	-0.08376	0.02297	2.40428	13.29	0.0016
Rain	0.03180	0.01043	1.68111	9.30	0.0063

Bounds on condition number: 1.0796, 4.3186

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4245	0.4245	8.5939	15.49	0.0008
2	Rain		2	0.1826	0.6071	1.8385	9.30	0.0063

Model 3b: Compliance data VS. Physical variables except UVB across piers

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.3952 and C(p) = 2.2574

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.52283	1.52283	13.72	0.0013
Error	21	2.33069	0.11099		
Corrected Total	22	3.85353			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.48245	0.07016	49.55190	446.47	<.0001
North Vector	-0.06416	0.01732	1.52283	13.72	0.0013

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.3952	0.3952	2.2574	13.72	0.0013

Model 3c: Compliance data VS. Physical variables except UVB across piers

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable Sunshine Entered: R-Square = 0.4110 and C(p) = 12.6636

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	5.81231	5.81231	14.65	0.0010
Error	21	8.33029	0.39668		
Corrected Total	22	14.14260			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	3.23901	0.30692	44.18000	111.37	<.0001
Sunshine	-0.05730	0.01497	5.81231	14.65	0.0010

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable North Vector Entered: R-Square = 0.5381 and C(p) = 7.8314

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	7.60978	3.80489	11.65	0.0004
Error	20	6.53282	0.32664		
Corrected Total	22	14.14260			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	2.87017	0.31983	26.30634	80.54	<.0001
North Vector	-0.07949	0.03389	1.79747	5.50	0.0294
Sunshine	-0.03983	0.01549	2.15986	6.61	0.0182

Bounds on condition number: 1.3005, 5.2019

Stepwise Selection: Step 3

Variable Rain Entered: R-Square = 0.6541 and C(p) = 3.5959

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	9.25026	3.08342	11.97	0.0001
Error	19	4.89234	0.25749		
Corrected Total	22	14.14260			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	2.30596	0.36139	10.48396	40.72	<.0001
North Vector	-0.07743	0.03010	1.70415	6.62	0.0186
Rain	0.03547	0.01405	1.64048	6.37	0.0207
Sunshine	-0.02161	0.01553	0.49827	1.94	0.1803

Bounds on condition number: 1.6589, 13.013

Stepwise Selection: Step 4

Variable Sunshine Removed: R-Square = 0.6188 and C(p) = 3.4898

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	8.75199	4.37600	16.24	<.0001
Error	20	5.39061	0.26953		
Corrected Total	22	14.14260			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.83739	0.13394	50.71976	188.18	<.0001
North Vector	-0.09471	0.02805	3.07368	11.40	0.0030
Rain	0.04456	0.01273	3.30207	12.25	0.0023

Bounds on condition number: 1.0796, 4.3186

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Sunshine		1	0.4110	0.4110	12.6636	14.65	0.0010
2	North Vector		2	0.1271	0.5381	7.8314	5.50	0.0294
3	Rain		3	0.1160	0.6541	3.5959	6.37	0.0207
4		Sunshine	2	0.0352	0.6188	3.4898	1.94	0.1803

Model 4c: Compliance data VS. Physical variables except UVB (and sunshine) across piers

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.4015 and C(p) = 12.2257

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	5.67831	5.67831	14.09	0.0012
Error	21	8.46428	0.40306		
Corrected Total	22	14.14260			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.81626	0.16362	49.66824	123.23	<.0001
Rain	0.05624	0.01498	5.67831	14.09	0.0012

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable North Vector Entered: R-Square = 0.6188 and C(p) = 2.8866

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	8.75199	4.37600	16.24	<.0001
Error	20	5.39061	0.26953		
Corrected Total	22	14.14260			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.83739	0.13394	50.71976	188.18	<.0001
North Vector	-0.09471	0.02805	3.07368	11.40	0.0030
Rain	0.04456	0.01273	3.30207	12.25	0.0023

Bounds on condition number: 1.0796, 4.3186

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.4015	0.4015	12.2257	14.09	0.0012
2	North Vector		2	0.2173	0.6188	2.8866	11.40	0.0030

Model 5a: Compliance data VS. Physical variables except UVB for Bispham

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4604 and C(p) = 2.7399

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3.98496	3.98496	17.92	0.0004
Error	21	4.67015	0.22239		
Corrected Total	22	8.65511			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.64140	0.09931	60.74753	273.16	<.0001
North Vector	-0.10378	0.02452	3.98496	17.92	0.0004

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4604	0.4604	2.7399	17.92	0.0004

Model 5b: Compliance data VS. Physical variables except UVB for Bispham

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.3819 and C(p) = 0.5710

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.79987	1.79987	12.98	0.0017
Error	21	2.91297	0.13871		
Corrected Total	22	4.71284			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.35781	0.07843	41.57002	299.68	<.0001
North Vector	-0.06975	0.01936	1.79987	12.98	0.0017

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.3819	0.3819	0.5710	12.98	0.0017

Model 5c: Compliance data VS. Physical variables except UVB for Bispham

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4051 and C(p) = 4.3802

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	5.12644	5.12644	14.30	0.0011
Error	21	7.52796	0.35847		
Corrected Total	22	12.65440			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.78887	0.12609	72.15322	201.28	<.0001
North Vector	-0.11771	0.03113	5.12644	14.30	0.0011

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4051	0.4051	4.3802	14.30	0.0011

Model 6a: Compliance data VS. Physical variables - Assessing site factor (UVB included) - all sites

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: All dependent variables are consistent with respect to the presence or absence of missing values. However only 52 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	15.29328396	1.91166050	17.53	<.0001
Error	43	4.68995067	0.10906862		
Corrected Total	51	19.98323463			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.765306	14.81899	0.330255	2.228595

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.73002026	0.57667342	5.29	0.0034
East Vector	1	0.12820271	0.12820271	1.18	0.2843
North Vector	1	6.68474931	6.68474931	61.29	<.0001
Rain	1	5.37416723	5.37416723	49.27	<.0001
Sunshine	1	0.13334504	0.13334504	1.22	0.2750
UVB	1	1.24279942	1.24279942	11.39	0.0016

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.73002026	0.57667342	5.29	0.0034
East Vector	1	0.02087417	0.02087417	0.19	0.6640
North Vector	1	1.11609526	1.11609526	10.23	0.0026
Rain	1	3.46097380	3.46097380	31.73	<.0001
Sunshine	1	0.27669277	0.27669277	2.54	0.1185
UVB	1	1.24279942	1.24279942	11.39	0.0016

Model 6b: Compliance data VS. Physical variables - Assessing site factor (UVB included) - all sites

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	7.64231878	0.95528985	13.06	<.0001
Error	43	3.14578218	0.07315773		
Corrected Total	51	10.78810096			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.708403	15.82995	0.270477	1.708640

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.47986171	0.15995390	2.19	0.1034
East Vector	1	0.38065748	0.38065748	5.20	0.0276
North Vector	1	2.40908407	2.40908407	32.93	<.0001
Rain	1	3.35828607	3.35828607	45.90	<.0001
Sunshine	1	0.05086744	0.05086744	0.70	0.4090
UVB	1	0.96356202	0.96356202	13.17	0.0008

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.47986171	0.15995390	2.19	0.1034
East Vector	1	0.14932198	0.14932198	2.04	0.1603
North Vector	1	0.24001315	0.24001315	3.28	0.0771
Rain	1	2.15142012	2.15142012	29.41	<.0001
Sunshine	1	0.28229054	0.28229054	3.86	0.0560
UVB	1	0.96356202	0.96356202	13.17	0.0008

Model 6c: Compliance data VS. Physical variables - Assessing site factor (UVB included) - all sites

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	22.48786381	2.81098298	18.13	<.0001
Error	43	6.66727987	0.15505302		
Corrected Total	51	29.15514369			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.771317	16.46958	0.393768	2.390879

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.48400528	0.49466843	3.19	0.0330
East Vector	1	0.05072603	0.05072603	0.33	0.5703
North Vector	1	11.82807930	11.82807930	76.28	<.0001
Rain	1	6.30537503	6.30537503	40.67	<.0001
Sunshine	1	0.31648664	0.31648664	2.04	0.1603
UVB	1	2.50319153	2.50319153	16.14	0.0002

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.48400528	0.49466843	3.19	0.0330
East Vector	1	0.20393221	0.20393221	1.32	0.2578
North Vector	1	2.39849916	2.39849916	15.47	0.0003
Rain	1	3.58848512	3.58848512	23.14	<.0001
Sunshine	1	0.51131341	0.51131341	3.30	0.0764
UVB	1	2.50319153	2.50319153	16.14	0.0002

Model 7a: Compliance data VS. Physical variables - Assessing site factor (UVB included) - excluding Bispham

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

NOTE: All dependent variables are consistent with respect to the presence or absence of missing values. However only 39 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	9.95683185	1.42240455	12.47	<.0001
Error	31	3.53662432	0.11408466		
Corrected Total	38	13.49345617			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.737901	14.60947	0.337764	2.311955

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.64601788	0.32300894	2.83	0.0742
East Vector	1	0.08431389	0.08431389	0.74	0.3966
North Vector	1	4.43898953	4.43898953	38.91	<.0001
Rain	1	4.08732525	4.08732525	35.83	<.0001
Sunshine	1	0.04479571	0.04479571	0.39	0.5355
UVB	1	0.65538958	0.65538958	5.74	0.0228

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.64601788	0.32300894	2.83	0.0742
East Vector	1	0.01789794	0.01789794	0.16	0.6948
North Vector	1	0.74737031	0.74737031	6.55	0.0156
Rain	1	2.83559077	2.83559077	24.86	<.0001
Sunshine	1	0.17638593	0.17638593	1.55	0.2230
UVB	1	0.65538958	0.65538958	5.74	0.0228

Model 7b: Compliance data VS. Physical variables - Assessing site factor (UVB included) - excluding Bispham

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	5.55021557	0.79288794	11.62	<.0001
Error	31	2.11585773	0.06825348		
Corrected Total	38	7.66607330			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.723997	15.04019	0.261254	1.737038

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.35406084	0.17703042	2.59	0.0909
East Vector	1	0.28241252	0.28241252	4.14	0.0506
North Vector	1	1.53635144	1.53635144	22.51	<.0001
Rain	1	2.51116666	2.51116666	36.79	<.0001
Sunshine	1	0.04484015	0.04484015	0.66	0.4238
UVB	1	0.82138396	0.82138396	12.03	0.0016

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.35406084	0.17703042	2.59	0.0909
East Vector	1	0.14938707	0.14938707	2.19	0.1491
North Vector	1	0.11250035	0.11250035	1.65	0.2087
Rain	1	1.56794881	1.56794881	22.97	<.0001
Sunshine	1	0.23819195	0.23819195	3.49	0.0712
UVB	1	0.82138396	0.82138396	12.03	0.0016

Model 7c: Compliance data VS. Physical variables - Assessing site factor (UVB included) - excluding Bispham

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	15.55141661	2.22163094	15.09	<.0001
Error	31	4.56441218	0.14723910		
Corrected Total	38	20.11582879			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.773094	15.51029	0.383717	2.473954

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.40737597	0.20368799	1.38	0.2658
East Vector	1	0.11376020	0.11376020	0.77	0.3862
North Vector	1	8.09618480	8.09618480	54.99	<.0001
Rain	1	5.11343529	5.11343529	34.73	<.0001
Sunshine	1	0.14343015	0.14343015	0.97	0.3313
UVB	1	1.67723020	1.67723020	11.39	0.0020

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.40737597	0.20368799	1.38	0.2658
East Vector	1	0.05360084	0.05360084	0.36	0.5507
North Vector	1	1.61094964	1.61094964	10.94	0.0024
Rain	1	3.11960705	3.11960705	21.19	<.0001
Sunshine	1	0.41392134	0.41392134	2.81	0.1037
UVB	1	1.67723020	1.67723020	11.39	0.0020

Model 8a: Compliance data VS. Physical variables including UVB across piers

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.6124 and C(p) = 3.8649

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.40872	2.40872	17.38	0.0016
Error	11	1.52427	0.13857		
Corrected Total	12	3.93299			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.86633	0.14860	21.85668	157.73	<.0001
Rain	0.06736	0.01616	2.40872	17.38	0.0016

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.6124	0.6124	3.8649	17.38	0.0016

Model 8b: Compliance data VS. Physical variables including UVB across piers

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.5786 and C(p) = 4.4373

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.28409	1.28409	15.11	0.0025
Error	11	0.93509	0.08501		
Corrected Total	12	2.21918			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.41167	0.11639	12.50473	147.10	<.0001
Rain	0.04918	0.01265	1.28409	15.11	0.0025

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.5786	0.5786	4.4373	15.11	0.0025

Model 8c: Compliance data VS. Physical variables including UVB across piers

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.5663 and C(p) = 9.9633

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3.40364	3.40364	14.36	0.0030
Error	11	2.60654	0.23696		
Corrected Total	12	6.01017			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.94423	0.19433	23.71939	100.10	<.0001
Rain	0.08007	0.02113	3.40364	14.36	0.0030

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable UVB Entered: R-Square = 0.7451 and C(p) = 4.1447

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	4.47831	2.23916	14.62	0.0011
Error	10	1.53186	0.15319		
Corrected Total	12	6.01017			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	2.86706	0.38184	8.63627	56.38	<.0001
UVB	-0.01143	0.00431	1.07468	7.02	0.0244
Rain	0.05678	0.01913	1.35001	8.81	0.0141

Bounds on condition number: 1.2679, 5.0716

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.5663	0.5663	9.9633	14.36	0.0030
2	UVB		2	0.1788	0.7451	4.1447	7.02	0.0244

Model 9a: Compliance data VS. Physical variables including UVB for Bispham

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable UVB Entered: R-Square = 0.5898 and C(p) = 7.5125

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3.18816	3.18816	15.81	0.0022
Error	11	2.21762	0.20160		
Corrected Total	12	5.40578			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	3.15444	0.32086	19.48583	96.66	<.0001
UVB	-0.01748	0.00440	3.18816	15.81	0.0022

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable Rain Entered: R-Square = 0.7478 and C(p) = 3.1497

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	4.04267	2.02133	14.83	0.0010
Error	10	1.36311	0.13631		
Corrected Total	12	5.40578			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	2.54047	0.36020	6.78076	49.74	<.0001
UVB	-0.01280	0.00407	1.34744	9.89	0.0104
Rain	0.04518	0.01804	0.85451	6.27	0.0312

Bounds on condition number: 1.2679, 5.0716

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	UVB		1	0.5898	0.5898	7.5125	15.81	0.0022
2	Rain		2	0.1581	0.7478	3.1497	6.27	0.0312

Model 9b: liance data VS. Physical variables including UVB for Bispham

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.5063 and C(p) = 1.6503

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.51687	1.51687	11.28	0.0064
Error	11	1.47936	0.13449		
Corrected Total	12	2.99623			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.26982	0.14640	10.11788	75.23	<.0001
Rain	0.05346	0.01592	1.51687	11.28	0.0064

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.5063	0.5063	1.6503	11.28	0.0064

Model 9c: Compliance data VS. Physical variables including UVB for Bispham

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable UVB Entered: R-Square = 0.5637 and C(p) = 4.1338

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	4.48885	4.48885	14.21	0.0031
Error	11	3.47384	0.31580		
Corrected Total	12	7.96269			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	3.53699	0.40158	24.49852	77.58	<.0001
UVB	-0.02074	0.00550	4.48885	14.21	0.0031

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	UVB		1	0.5637	0.5637	4.1338	14.21	0.0031

Model 10a: Compliance data VS. Starling roosts (summed piers) - Assessing site factor - all sites

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: All dependent variables are consistent with respect to the presence or absence of missing values. However only 48 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	4.27616970	1.06904242	2.88	0.0339
Error	43	15.98494684	0.37174295		
Corrected Total	47	20.26111654			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.211053	27.58880	0.609707	2.209981

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.24996224	0.41665408	1.12	0.3512
SGAll	1	3.02620746	3.02620746	8.14	0.0066

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.24996224	0.41665408	1.12	0.3512
SGAll	1	3.02620746	3.02620746	8.14	0.0066

Model 10b: Compliance data VS. Starling roosts (summed piers) - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	2.62851046	0.65712762	3.12	0.0243
Error	43	9.04685532	0.21039198		
Corrected Total	47	11.67536579			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.225133	27.15906	0.458685	1.688884

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.49200233	0.16400078	0.78	0.5119
SGAll	1	2.13650814	2.13650814	10.15	0.0027

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.49200233	0.16400078	0.78	0.5119
SGAll	1	2.13650814	2.13650814	10.15	0.0027

Model 10c: Compliance data VS. Starling roosts (summed piers) - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	4.21326949	1.05331737	1.88	0.1313
Error	43	24.09211158	0.56028166		
Corrected Total	47	28.30538107			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.148850	31.04492	0.748520	2.411086

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.17477034	0.39159011	0.70	0.5579
SGAll	1	3.03849915	3.03849915	5.42	0.0246

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.17477034	0.39159011	0.70	0.5579
SGAll	1	3.03849915	3.03849915	5.42	0.0246

Model 11a: Compliance data VS. Starling roosts (summed piers) - Assessing site factor - excluding Bispham

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

NOTE: All dependent variables are consistent with respect to the presence or absence of missing values. However only 36 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2.43264318	0.81088106	2.27	0.0997
Error	32	11.44919256	0.35778727		
Corrected Total	35	13.88183574			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.175239	26.17061	0.598153	2.285592

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.42672259	0.21336129	0.60	0.5568
SGAll	1	2.00592059	2.00592059	5.61	0.0241

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.42672259	0.21336129	0.60	0.5568
SGAll	1	2.00592059	2.00592059	5.61	0.0241

Model 11b: Compliance data VS. Starling roosts (summed piers) - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1.86521576	0.62173859	3.19	0.0367
Error	32	6.23461549	0.19483173		
Corrected Total	35	8.09983125			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.230278	25.50982	0.441397	1.730304

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.24495147	0.12247573	0.63	0.5398
SGAll	1	1.62026429	1.62026429	8.32	0.0070

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.24495147	0.12247573	0.63	0.5398
SGAll	1	1.62026429	1.62026429	8.32	0.0070

Model 11c: Compliance data VS. Starling roosts (summed piers) - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2.25987955	0.75329318	1.41	0.2568
Error	32	17.05242954	0.53288842		
Corrected Total	35	19.31230909			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.117018	29.26037	0.729992	2.494815

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.16526383	0.08263192	0.16	0.8570
SGAll	1	2.09461572	2.09461572	3.93	0.0561

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.16526383	0.08263192	0.16	0.8570
SGAll	1	2.09461572	2.09461572	3.93	0.0561

Model 12a: Compliance data VS. Starling roosts (summed piers) across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 12b: Compliance data VS. Starling roosts (summed piers) across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 12c: Compliance data VS. Starling roosts (summed piers) across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 13a: Compliance data VS. Starling roosts (summed piers) by site

--- Site=Bispham ---

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 13b: Compliance data VS. Starling roosts (summed piers) by site

-- Site=Bispham --

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 13c: Compliance data VS. Starling roosts (summed piers) by site

--- Site=Bispham ---

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 14a: Compliance data VS. Starling roosts (summed piers) by site

```
------------------------------------- Site=Blackpool Central -------------------------------------

                                        The REG Procedure
                                          Model: MODEL1
                                 Dependent Variable: Faecal Coliforms

             No variable met the 0.0500 significance level for entry into the model.
```

Model 14b: Compliance data VS. Starling roosts (summed piers) by site

------------------------------------ Site=Blackpool Central ------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 14c: Compliance data VS. Starling roosts (summed piers) by site

```
------------------------------------ Site=Blackpool Central ------------------------------------

                                        The REG Procedure
                                          Model: MODEL1
                                 Dependent Variable: Total Coliforms

             No variable met the 0.0500 significance level for entry into the model.
```

Model 15a: Compliance data VS. Starling roosts (summed piers) by site

------------------------------------- Site=Blackpool North -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 15b: Compliance data VS. Starling roosts (summed piers) by site

```
------------------------------------- Site=Blackpool North -------------------------------------

                                        The REG Procedure
                                          Model: MODEL1
                                 Dependent Variable: Faecal Streptococci

             No variable met the 0.0500 significance level for entry into the model.
```

Model 15c: Compliance data VS. Starling roosts (summed piers) by site

------------------------------------- Site=Blackpool North -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 16a: Compliance data VS. Starling roosts (summed piers) by site

------------------------------------- Site=Blackpool South -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 16b: Compliance data VS. Starling roosts (summed piers) by site

------------------------------------- Site=Blackpool South -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 16c: Compliance data VS. Starling roosts (summed piers) by site

------------------------------------- Site=Blackpool South -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 17a:Compliance data VS. Starling roosts (matched piers) - Assessing site factor - all piers

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: All dependent variables are consistent with respect to the presence or absence of missing values. However only 45 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	5.47653293	1.82551098	5.48	0.0029
Error	41	13.65010620	0.33292942		
Corrected Total	44	19.12663913			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.286330	26.73100	0.577000	2.158544

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	2.28136913	1.14068457	3.43	0.0421
SG4pier	1	3.19516380	3.19516380	9.60	0.0035

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	4.64493936	2.32246968	6.98	0.0025
SG4pier	1	3.19516380	3.19516380	9.60	0.0035

Model 17b: Compliance data VS. Starling roosts (matched piers) - Assessing site factor - all piers

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2.89207466	0.96402489	5.79	0.0021
Error	41	6.82528774	0.16647043		
Corrected Total	44	9.71736240			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.297619	24.64010	0.408008	1.655869

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.61456236	0.30728118	1.85	0.1708
SG4pier	1	2.27751230	2.27751230	13.68	0.0006

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	1.75464211	0.87732106	5.27	0.0092
SG4pier	1	2.27751230	2.27751230	13.68	0.0006

Model 17c: Compliance data VS. Starling roosts (matched piers) - Assessing site factor - all piers

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	6.82290888	2.27430296	4.68	0.0067
Error	41	19.92134281	0.48588641		
Corrected Total	44	26.74425169			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.255117	29.83511	0.697056	2.336360

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	2.38731730	1.19365865	2.46	0.0982
SG4pier	1	4.43559158	4.43559158	9.13	0.0043

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	5.75626844	2.87813422	5.92	0.0055
SG4pier	1	4.43559158	4.43559158	9.13	0.0043

Model 18a: Compliance data VS. Starling roosts (matched piers) by pier

------------------------------------- Site=Blackpool Central -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 18b: Compliance data VS. Starling roosts (matched piers) by pier

------------------------------------ Site=Blackpool Central ------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 18c: Compliance data VS. Starling roosts (matched piers) by pier

```
------------------------------------ Site=Blackpool Central ------------------------------------

                                        The REG Procedure
                                          Model: MODEL1
                                 Dependent Variable: Total Coliforms

             No variable met the 0.0500 significance level for entry into the model.
```

Model 19a: Compliance data VS. Starling roosts (matched piers) by pier

------------------------------------- Site=Blackpool North -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable SG4pier Entered: R-Square = 0.3031 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.55099	2.55099	7.40	0.0146
Error	17	5.86415	0.34495		
Corrected Total	18	8.41514			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.45672	0.21400	15.98394	46.34	<.0001
SG4pier	0.00004805	0.00001767	2.55099	7.40	0.0146

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	SG4pier		1	0.3031	0.3031	2.0000	7.40	0.0146

Model 19b: Compliance data VS. Starling roosts (matched piers) by pier

------------------------------------- Site=Blackpool North -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable SG4pier Entered: R-Square = 0.4223 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.65695	1.65695	12.43	0.0026
Error	17	2.26698	0.13335		
Corrected Total	18	3.92393			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.18121	0.13306	10.50960	78.81	<.0001
SG4pier	0.00003873	0.00001099	1.65695	12.43	0.0026

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	SG4pier		1	0.4223	0.4223	2.0000	12.43	0.0026

Model 19c: Compliance data VS. Starling roosts (matched piers) by pier

------------------------------------- Site=Blackpool North -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable SG4pier Entered: R-Square = 0.3412 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3.58348	3.58348	8.81	0.0086
Error	17	6.91770	0.40692		
Corrected Total	18	10.50118			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.53173	0.23243	17.67229	43.43	<.0001
SG4pier	0.00005696	0.00001919	3.58348	8.81	0.0086

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	SG4pier		1	0.3412	0.3412	2.0000	8.81	0.0086

Model 20a: Compliance data VS. Starling roosts (matched piers) by pier

------------------------------------- Site=Blackpool South -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 20b: Compliance data VS. Starling roosts (matched piers) by pier

```
------------------------------------- Site=Blackpool South -------------------------------------

                                        The REG Procedure
                                          Model: MODEL1
                                 Dependent Variable: Faecal Streptococci

             No variable met the 0.0500 significance level for entry into the model.
```

Model 20c: Compliance data VS. Starling roosts (matched piers) by pier

------------------------------------- Site=Blackpool South -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 21a: Compliance data VS. Starling roost (North Pier) - Assessing site factor - all sites

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: All dependent variables are consistent with respect to the presence or absence of missing values. However only 76 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	10.56375686	2.64093921	8.07	<.0001
Error	71	23.24009719	0.32732531		
Corrected Total	75	33.80385405			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.312502	29.09800	0.572124	1.966196

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.59388261	0.53129420	1.62	0.1917
SGnorth	1	8.96987424	8.96987424	27.40	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.59388261	0.53129420	1.62	0.1917
SGnorth	1	8.96987424	8.96987424	27.40	<.0001

Model 21b: Compliance data VS. Starling roost (North Pier) - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	4.96821541	1.24205385	8.01	<.0001
Error	71	11.00901830	0.15505660		
Corrected Total	75	15.97723370			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.310956	25.51209	0.393772	1.543473

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.31853581	0.10617860	0.68	0.5643
SGnorth	1	4.64967959	4.64967959	29.99	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.31853581	0.10617860	0.68	0.5643
SGnorth	1	4.64967959	4.64967959	29.99	<.0001

Model 21c: Compliance data VS. Starling roost (North Pier) - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	12.69885128	3.17471282	6.72	0.0001
Error	71	33.53718078	0.47235466		
Corrected Total	75	46.23603206			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.274653	32.42671	0.687281	2.119490

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.58472947	0.52824316	1.12	0.3475
SGnorth	1	11.11412181	11.11412181	23.53	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.58472947	0.52824316	1.12	0.3475
SGnorth	1	11.11412181	11.11412181	23.53	<.0001

Model 22a: Compliance data VS. Starling roost (North Pier) - Assessing site factor - excluding Bispham

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

NOTE: All dependent variables are consistent with respect to the presence or absence of missing values. However only 57 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	7.48322965	2.49440988	7.52	0.0003
Error	53	17.59132489	0.33191179		
Corrected Total	56	25.07455454			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.298439	28.35061	0.576118	2.032118

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.60304369	0.30152184	0.91	0.4093
SGnorth	1	6.88018597	6.88018597	20.73	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.60304369	0.30152184	0.91	0.4093
SGnorth	1	6.88018597	6.88018597	20.73	<.0001

Model 22b: Compliance data VS. Starling roost (North Pier) - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3.91040084	1.30346695	9.06	<.0001
Error	53	7.62415516	0.14385198		
Corrected Total	56	11.53455600			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.339016	24.12995	0.379278	1.571815

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.13539593	0.06769797	0.47	0.6272
SGnorth	1	3.77500491	3.77500491	26.24	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.13539593	0.06769797	0.47	0.6272
SGnorth	1	3.77500491	3.77500491	26.24	<.0001

Model 22c: Compliance data VS. Starling roost (North Pier) - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	9.31374747	3.10458249	6.67	0.0007
Error	53	24.68150141	0.46568871		
Corrected Total	56	33.99524888			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.273972	31.15357	0.682414	2.190484

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.43556131	0.21778065	0.47	0.6290
SGnorth	1	8.87818617	8.87818617	19.06	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.43556131	0.21778065	0.47	0.6290
SGnorth	1	8.87818617	8.87818617	19.06	<.0001

Model 23a: Compliance data VS. Starling roost (North Pier) - across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable SGnorth Entered: R-Square = 0.2979 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.24247	2.24247	7.21	0.0156
Error	17	5.28522	0.31090		
Corrected Total	18	7.52769			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.54230	0.20316	17.91709	57.63	<.0001
SGnorth	0.00004506	0.00001678	2.24247	7.21	0.0156

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	SGnorth		1	0.2979	0.2979	2.0000	7.21	0.0156

Model 23b: Compliance data VS. Starling roost (North Pier) - across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable SGnorth Entered: R-Square = 0.3285 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.16242	1.16242	8.32	0.0103
Error	17	2.37628	0.13978		
Corrected Total	18	3.53870			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.23828	0.13623	11.54959	82.63	<.0001
SGnorth	0.00003244	0.00001125	1.16242	8.32	0.0103

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	SGnorth		1	0.3285	0.3285	2.0000	8.32	0.0103

Model 23c: Compliance data VS. Starling roost (North Pier) - across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable SGnorth Entered: R-Square = 0.2685 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.77853	2.77853	6.24	0.0230
Error	17	7.56812	0.44518		
Corrected Total	18	10.34665			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.64764	0.24311	20.44818	45.93	<.0001
SGnorth	0.00005015	0.00002007	2.77853	6.24	0.0230

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	SGnorth		1	0.2685	0.2685	2.0000	6.24	0.0230

Model 24a: Compliance data VS. Gull Proximity Index - Assessing site factor - all sites

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	4.85496529	1.21374132	3.01	0.0225
Error	87	35.11280788	0.40359549		
Corrected Total	91	39.96777318			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.121472	33.10598	0.635292	1.918963

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.00118598	0.66706199	1.65	0.1831
intgulls	1	2.85377931	2.85377931	7.07	0.0093

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.87908402	0.62636134	1.55	0.2069
intgulls	1	2.85377931	2.85377931	7.07	0.0093

Model 24b: Compliance data VS. Gull Proximity Index - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1.04541141	0.26135285	1.33	0.2671
Error	87	17.16019136	0.19724358		
Corrected Total	91	18.20560277			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.057423	29.83614	0.444121	1.488534

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.43925908	0.14641969	0.74	0.5297
intgulls	1	0.60615233	0.60615233	3.07	0.0831

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.42977116	0.14325705	0.73	0.5390
intgulls	1	0.60615233	0.60615233	3.07	0.0831

Model 24c: Compliance data VS. Gull Proximity Index - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	4.13760089	1.03440022	1.62	0.1766
Error	87	55.57466639	0.63878927		
Corrected Total	91	59.71226728			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.069292	38.11707	0.799243	2.096811

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.06092619	0.68697540	1.08	0.3638
intgulls	1	2.07667470	2.07667470	3.25	0.0748

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.90620844	0.63540281	0.99	0.3993
intgulls	1	2.07667470	2.07667470	3.25	0.0748

Model 25a: Compliance data VS. Gull Proximity Index - Assessing site factor - excluding Bispham

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3.40521936	1.13507312	2.79	0.0474
Error	65	26.44198028	0.40679970		
Corrected Total	68	29.84719964			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.114088	32.02122	0.637809	1.991831

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.53571998	0.26785999	0.66	0.5211
intgulls	1	2.86949938	2.86949938	7.05	0.0099

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.56675510	0.28337755	0.70	0.5020
intgulls	1	2.86949938	2.86949938	7.05	0.0099

Model 25b: Compliance data VS. Gull Proximity Index - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.80148149	0.26716050	1.40	0.2519
Error	65	12.43679947	0.19133538		
Corrected Total	68	13.23828096			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.060543	28.79842	0.437419	1.518899

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.18477792	0.09238896	0.48	0.6192
intgulls	1	0.61670357	0.61670357	3.22	0.0773

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.20700015	0.10350007	0.54	0.5848
intgulls	1	0.61670357	0.61670357	3.22	0.0773

Model 25c: Compliance data VS. Gull Proximity Index - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2.68547668	0.89515889	1.37	0.2610
Error	65	42.59020919	0.65523399		
Corrected Total	68	45.27568586			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.059314	37.17974	0.809465	2.177168

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.27874512	0.13937256	0.21	0.8090
intgulls	1	2.40673155	2.40673155	3.67	0.0597

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.26234323	0.13117162	0.20	0.8191
intgulls	1	2.40673155	2.40673155	3.67	0.0597

Model 26a: Compliance data VS. Gull Proximity Indices

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable intgulls Entered: R-Square = 0.0745 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.97588	2.97588	7.24	0.0085
Error	90	36.99189	0.41102		
Corrected Total	91	39.96777			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.72353	0.09871	125.32090	304.90	<.0001
intgulls	0.00047599	0.00017690	2.97588	7.24	0.0085

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	intgulls		1	0.0745	0.0745	2.0000	7.24	0.0085

Model 26b: Compliance data VS. Gull Proximity Indices

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 26c: Compliance data VS. Gull Proximity Indices

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 27a: Compliance data VS. Gull Proximity Indices by site

--- Site=Bispham ---

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 27b: Compliance data VS. Gull Proximity Indices by site

--- Site=Bispham ---

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 27c: Compliance data VS. Gull Proximity Indices by site

--- Site=Bispham ---

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 28a: Compliance data VS. Gull Proximity Indices by site

------------------------------------ Site=Blackpool Central ------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 28b: Compliance data VS. Gull Proximity Indices by site

------------------------------------ Site=Blackpool Central ------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 28c: Compliance data VS. Gull Proximity Indices by site

------------------------------------ Site=Blackpool Central ------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 29a: Compliance data VS. Gull Proximity Indices by site

------------------------------------- Site=Blackpool North -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 29b: Compliance data VS. Gull Proximity Indices by site

------------------------------------- Site=Blackpool North -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 29c: Compliance data VS. Gull Proximity Indices by site

------------------------------------- Site=Blackpool North -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable intgulls Entered: R-Square = 0.1720 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.29986	2.29986	4.36	0.0491
Error	21	11.07400	0.52733		
Corrected Total	22	13.37385			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.60535	0.27631	17.80001	33.75	<.0001
intgulls	0.00118	0.00056481	2.29986	4.36	0.0491

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	intgulls		1	0.1720	0.1720	2.0000	4.36	0.0491

Model 30a: Compliance data VS. Gull Proximity Indices by site

------------------------------------- Site=Blackpool South -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 30b: Compliance data VS. Gull Proximity Indices by site

------------------------------------- Site=Blackpool South -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 30c: Compliance data VS. Gull Proximity Indices by site

------------------------------------- Site=Blackpool South -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 31a: Compliance data VS. Intertidal Proximity Index - Assessing site factor - all sites

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	4.95208523	1.23802131	3.08	0.0203
Error	87	35.01568795	0.40247917		
Corrected Total	91	39.96777318			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.123902	33.06016	0.634412	1.918963

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.00118598	0.66706199	1.66	0.1821
intsum	1	2.95089925	2.95089925	7.33	0.0082

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.88386050	0.62795350	1.56	0.2048
intsum	1	2.95089925	2.95089925	7.33	0.0082

Model 31b: Compliance data VS. Intertidal Proximity Index - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1.09279005	0.27319751	1.39	0.2445
Error	87	17.11281272	0.19669900		
Corrected Total	91	18.20560277			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.060025	29.79492	0.443508	1.488534

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.43925908	0.14641969	0.74	0.5285
intsum	1	0.65353097	0.65353097	3.32	0.0718

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.43245450	0.14415150	0.73	0.5352
intsum	1	0.65353097	0.65353097	3.32	0.0718

Model 31c: Compliance data VS. Intertidal Proximity Index - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	4.22224653	1.05556163	1.65	0.1678
Error	87	55.49002075	0.63781633		
Corrected Total	91	59.71226728			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.070710	38.08803	0.798634	2.096811

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.06092619	0.68697540	1.08	0.3631
intsum	1	2.16132033	2.16132033	3.39	0.0691

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.90379903	0.63459968	0.99	0.3992
intsum	1	2.16132033	2.16132033	3.39	0.0691

Model 32a: Compliance data VS. Intertidal Proximity Index - Assessing site factor - excluding Bispham

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3.47159443	1.15719814	2.85	0.0440
Error	65	26.37560521	0.40577854		
Corrected Total	68	29.84719964			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.116312	31.98100	0.637007	1.991831

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.53571998	0.26785999	0.66	0.5202
intsum	1	2.93587445	2.93587445	7.24	0.0091

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.57536635	0.28768317	0.71	0.4959
intsum	1	2.93587445	2.93587445	7.24	0.0091

Model 32b: Compliance data VS. Intertidal Proximity Index - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.85607275	0.28535758	1.50	0.2234
Error	65	12.38220821	0.19049551		
Corrected Total	68	13.23828096			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.064666	28.73514	0.436458	1.518899

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.18477792	0.09238896	0.48	0.6179
intsum	1	0.67129482	0.67129482	3.52	0.0650

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.21164055	0.10582027	0.56	0.5765
intsum	1	0.67129482	0.67129482	3.52	0.0650

Model 32c: Compliance data VS. Intertidal Proximity Index - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2.73717855	0.91239285	1.39	0.2525
Error	65	42.53850731	0.65443857		
Corrected Total	68	45.27568586			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.060456	37.15716	0.808974	2.177168

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.27874512	0.13937256	0.21	0.8087
intsum	1	2.45843343	2.45843343	3.76	0.0569

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.26335018	0.13167509	0.20	0.8183
intsum	1	2.45843343	2.45843343	3.76	0.0569

Model 33a: Compliance data VS. Intertidal Proximity Index

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable intsum Entered: R-Square = 0.0768 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3.06822	3.06822	7.48	0.0075
Error	90	36.89955	0.40999		
Corrected Total	91	39.96777			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.72061	0.09856	124.95319	304.77	<.0001
intsum	0.00047557	0.00017384	3.06822	7.48	0.0075

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	intsum		1	0.0768	0.0768	2.0000	7.48	0.0075

Model 33b: Compliance data VS. Intertidal Proximity Index

```
                         The REG Procedure
                          Model: MODEL1
```

Dependent Variable: Faecal Streptococci

```
No variable met the 0.0500 significance level for entry into the model.
```

Model 33c: Compliance data VS. Intertidal Proximity Index

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 34a: Compliance data VS. Intertidal Proximity Index by site

--- Site=Bispham ---

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 34b: Compliance data VS. Intertidal Proximity Index by site

--- Site=Bispham ---

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 34c: Compliance data VS. Intertidal Proximity Index by site

--- Site=Bispham ---

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 35a: Compliance data VS. Intertidal Proximity Index by site

------------------------------------ Site=Blackpool Central ------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 35b: Compliance data VS. Intertidal Proximity Index by site

------------------------------------ Site=Blackpool Central ------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 35c: Compliance data VS. Intertidal Proximity Index by site

------------------------------------ Site=Blackpool Central ------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 36a: Compliance data VS. Intertidal Proximity Index by site

------------------------------------- Site=Blackpool North -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 36b: Compliance data VS. Intertidal Proximity Index by site

------------------------------------- Site=Blackpool North -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 36c: Compliance data VS. Intertidal Proximity Index by site

------------------------------------- Site=Blackpool North -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable intsum Entered: R-Square = 0.1748 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.33759	2.33759	4.45	0.0471
Error	21	11.03626	0.52554		
Corrected Total	22	13.37385			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.59779	0.27728	17.45036	33.20	<.0001
intsum	0.00118	0.00055966	2.33759	4.45	0.0471

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	intsum		1	0.1748	0.1748	2.0000	4.45	0.0471

Model 37a: Compliance data VS. Intertidal Proximity Index by site

------------------------------------- Site=Blackpool South -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 37b: Compliance data VS. Intertidal Proximity Index by site

------------------------------------- Site=Blackpool South -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 37c: Compliance data VS. Intertidal Proximity Index by site

------------------------------------- Site=Blackpool South -------------------------------------

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 38a: Compliance data VS. Gull BMR Index - Assessing site factor - all sites

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	10.76839011	2.69209753	8.02	<.0001
Error	87	29.19938307	0.33562509		
Corrected Total	91	39.96777318			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.269427	30.18982	0.579332	1.918963

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.00118598	0.66706199	1.99	0.1218
GullsBMR	1	8.76720413	8.76720413	26.12	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	2.00118598	0.66706199	1.99	0.1218
GullsBMR	1	8.76720413	8.76720413	26.12	<.0001

Model 38b: Compliance data VS. Gull BMR Index - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	4.07573071	1.01893268	6.27	0.0002
Error	87	14.12987206	0.16241232		
Corrected Total	91	18.20560277			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.223872	27.07389	0.403004	1.488534

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.43925908	0.14641969	0.90	0.4439
GullsBMR	1	3.63647163	3.63647163	22.39	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.43925908	0.14641969	0.90	0.4439
GullsBMR	1	3.63647163	3.63647163	22.39	<.0001

Model 38c: Compliance data VS. Gull BMR Index - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	11.03711373	2.75927843	4.93	0.0012
Error	87	48.67515354	0.55948452		
Corrected Total	91	59.71226728			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.184838	35.67260	0.747987	2.096811

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.06092619	0.68697540	1.23	0.3045
GullsBMR	1	8.97618754	8.97618754	16.04	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	2.06092619	0.68697540	1.23	0.3045
GullsBMR	1	8.97618754	8.97618754	16.04	0.0001

Model 39a: Compliance data VS. Gull BMR Index - Assessing site factor - excluding Bispham

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	7.40993622	2.46997874	7.16	0.0003
Error	65	22.43726341	0.34518867		
Corrected Total	68	29.84719964			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.248262	29.49686	0.587528	1.991831

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.53571998	0.26785999	0.78	0.4645
GullsBMR	1	6.87421625	6.87421625	19.91	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.53571998	0.26785999	0.78	0.4645
GullsBMR	1	6.87421625	6.87421625	19.91	<.0001

Model 39b: Compliance data VS. Gull BMR Index - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3.35773137	1.11924379	7.36	0.0003
Error	65	9.88054959	0.15200846		
Corrected Total	68	13.23828096			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.253638	25.66876	0.389883	1.518899

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.18477792	0.09238896	0.61	0.5476
GullsBMR	1	3.17295345	3.17295345	20.87	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.18477792	0.09238896	0.61	0.5476
GullsBMR	1	3.17295345	3.17295345	20.87	<.0001

Model 39c: Compliance data VS. Gull BMR Index - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	7.25205836	2.41735279	4.13	0.0096
Error	65	38.02362750	0.58497888		
Corrected Total	68	45.27568586			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.160176	35.13000	0.764839	2.177168

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.27874512	0.13937256	0.24	0.7887
GullsBMR	1	6.97331324	6.97331324	11.92	0.0010

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.27874512	0.13937256	0.24	0.7887
GullsBMR	1	6.97331324	6.97331324	11.92	0.0010

Model 40a: Compliance data VS. Gull BMR Index across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable GullsBMR Entered: R-Square = 0.2480 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.19180	2.19180	6.92	0.0156
Error	21	6.64774	0.31656		
Corrected Total	22	8.83955			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.29854	0.26336	7.69620	24.31	<.0001
GullsBMR	0.00000671	0.00000255	2.19180	6.92	0.0156

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	GullsBMR		1	0.2480	0.2480	2.0000	6.92	0.0156

Model 40b: Compliance data VS. Gull BMR Index across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable GullsBMR Entered: R-Square = 0.2310 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.90912	0.90912	6.31	0.0203
Error	21	3.02582	0.14409		
Corrected Total	22	3.93494			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.08896	0.17768	5.41239	37.56	<.0001
GullsBMR	0.00000432	0.00000172	0.90912	6.31	0.0203

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	GullsBMR		1	0.2310	0.2310	2.0000	6.31	0.0203

Model 40c: Compliance data VS. Gull BMR Index across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 41a: Compliance data VS. Intertidal BMR Index - Assessing site factor - all sites

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	11.23272973	2.80818243	8.50	<.0001
Error	87	28.73504345	0.33028786		
Corrected Total	91	39.96777318			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.281045	29.94881	0.574707	1.918963

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.00118598	0.66706199	2.02	0.1171
BMRIntertidal	1	9.23154375	9.23154375	27.95	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	2.00118598	0.66706199	2.02	0.1171
BMRIntertidal	1	9.23154375	9.23154375	27.95	<.0001

Model 41b: Compliance data VS. Intertidal BMR Index - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	4.32237001	1.08059250	6.77	<.0001
Error	87	13.88323276	0.15957739		
Corrected Total	91	18.20560277			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.237420	26.83656	0.399471	1.488534

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.43925908	0.14641969	0.92	0.4359
BMRIntertidal	1	3.88311093	3.88311093	24.33	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.43925908	0.14641969	0.92	0.4359
BMRIntertidal	1	3.88311093	3.88311093	24.33	<.0001

Model 41c: Compliance data VS. Intertidal BMR Index - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	11.74743820	2.93685955	5.33	0.0007
Error	87	47.96482908	0.55131987		
Corrected Total	91	59.71226728			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.196734	35.41135	0.742509	2.096811

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.06092619	0.68697540	1.25	0.2980
BMRIntertidal	1	9.68651201	9.68651201	17.57	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	2.06092619	0.68697540	1.25	0.2980
BMRIntertidal	1	9.68651201	9.68651201	17.57	<.0001

Model 42a: Compliance data VS. Intertidal BMR Index - Assessing site factor - excluding Bispham

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	7.80359413	2.60119804	7.67	0.0002
Error	65	22.04360551	0.33913239		
Corrected Total	68	29.84719964			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.261451	29.23696	0.582351	1.991831

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.53571998	0.26785999	0.79	0.4582
BMRIntertidal	1	7.26787415	7.26787415	21.43	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.53571998	0.26785999	0.79	0.4582
BMRIntertidal	1	7.26787415	7.26787415	21.43	<.0001

Model 42b: Compliance data VS. Intertidal BMR Index - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3.57664800	1.19221600	8.02	0.0001
Error	65	9.66163296	0.14864051		
Corrected Total	68	13.23828096			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.270175	25.38280	0.385539	1.518899

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.18477792	0.09238896	0.62	0.5403
BMRIntertidal	1	3.39187008	3.39187008	22.82	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.18477792	0.09238896	0.62	0.5403
BMRIntertidal	1	3.39187008	3.39187008	22.82	<.0001

Model 42c: Compliance data VS. Intertidal BMR Index - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	7.84875821	2.61625274	4.54	0.0059
Error	65	37.42692765	0.57579889		
Corrected Total	68	45.27568586			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.173355	34.85327	0.758814	2.177168

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.27874512	0.13937256	0.24	0.7857
BMRIntertidal	1	7.57001309	7.57001309	13.15	0.0006

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.27874512	0.13937256	0.24	0.7857
BMRIntertidal	1	7.57001309	7.57001309	13.15	0.0006

Model 43a: Compliance data VS. Intertidal BMR ACROSS SITES

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable BMRIntertidal Entered: R-Square = 0.2611 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.30789	2.30789	7.42	0.0127
Error	21	6.53166	0.31103		
Corrected Total	22	8.83955			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.28018	0.26175	7.43988	23.92	<.0001
BMRIntertidal	0.00000650	0.00000239	2.30789	7.42	0.0127

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	BMRIntertidal		1	0.2611	0.2611	2.0000	7.42	0.0127

Model 43b: Compliance data VS. Intertidal BMR ACROSS SITES

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable BMRIntertidal Entered: R-Square = 0.2467 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.97078	0.97078	6.88	0.0159
Error	21	2.96416	0.14115		
Corrected Total	22	3.93494			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.07424	0.17633	5.23876	37.11	<.0001
BMRIntertidal	0.00000421	0.00000161	0.97078	6.88	0.0159

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	BMRIntertidal		1	0.2467	0.2467	2.0000	6.88	0.0159

Model 43c: Compliance data VS. Intertidal BMR ACROSS SITES

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable BMRIntertidal Entered: R-Square = 0.1812 and C(p) = 2.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.42163	2.42163	4.65	0.0429
Error	21	10.94532	0.52121		
Corrected Total	22	13.36695			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.44248	0.33884	9.44585	18.12	0.0004
BMRIntertidal	0.00000666	0.00000309	2.42163	4.65	0.0429

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	BMRIntertidal		1	0.1812	0.1812	2.0000	4.65	0.0429

Model 44a: Compliance data VS. All-bird BMR Index - Assessing site factor - all sites

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: All dependent variables are consistent with respect to the presence or absence of missing values. However only 48 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	3.83331108	0.95832777	2.51	0.0558
Error	43	16.42780546	0.38204199		
Corrected Total	47	20.26111654			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.189195	27.96836	0.618095	2.209981

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.24996224	0.41665408	1.09	0.3633
BMRAllBirds	1	2.58334884	2.58334884	6.76	0.0127

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.24996224	0.41665408	1.09	0.3633
BMRAllBirds	1	2.58334884	2.58334884	6.76	0.0127

Model 44b: Compliance data VS. All-bird BMR Index - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	2.25466362	0.56366590	2.57	0.0511
Error	43	9.42070217	0.21908610		
Corrected Total	47	11.67536579			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.193113	27.71453	0.468066	1.688884

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.49200233	0.16400078	0.75	0.5292
BMRAllBirds	1	1.76266129	1.76266129	8.05	0.0069

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.49200233	0.16400078	0.75	0.5292
BMRAllBirds	1	1.76266129	1.76266129	8.05	0.0069

Model 44c: Compliance data VS. All-bird BMR Index - Assessing site factor - all sites

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	3.56798228	0.89199557	1.55	0.2048
Error	43	24.73739879	0.57528834		
Corrected Total	47	28.30538107			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.126053	31.45792	0.758478	2.411086

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.17477034	0.39159011	0.68	0.5687
BMRAllBirds	1	2.39321194	2.39321194	4.16	0.0476

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.17477034	0.39159011	0.68	0.5687
BMRAllBirds	1	2.39321194	2.39321194	4.16	0.0476

Model 45a: Compliance data VS. All-bird BMR Index - Assessing site factor - excluding Bispham

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

NOTE: All dependent variables are consistent with respect to the presence or absence of missing values. However only 36 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2.15576477	0.71858826	1.96	0.1397
Error	32	11.72607097	0.36643972		
Corrected Total	35	13.88183574			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.155294	26.48516	0.605343	2.285592

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.42672259	0.21336129	0.58	0.5644
BMRAllBirds	1	1.72904218	1.72904218	4.72	0.0374

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.42672259	0.21336129	0.58	0.5644
BMRAllBirds	1	1.72904218	1.72904218	4.72	0.0374

Model 45b: Compliance data VS. All-bird BMR Index - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1.61625913	0.53875304	2.66	0.0649
Error	32	6.48357212	0.20261163		
Corrected Total	35	8.09983125			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.199542	26.01416	0.450124	1.730304

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.24495147	0.12247573	0.60	0.5525
BMRAllBirds	1	1.37130766	1.37130766	6.77	0.0139

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.24495147	0.12247573	0.60	0.5525
BMRAllBirds	1	1.37130766	1.37130766	6.77	0.0139

Model 45c: Compliance data VS. All-bird BMR Index - Assessing site factor - excluding Bispham

The GLM Procedure

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1.80770504	0.60256835	1.10	0.3628
Error	32	17.50460404	0.54701888		
Corrected Total	35	19.31230909			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.093604	29.64578	0.739607	2.494815

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.16526383	0.08263192	0.15	0.8604
BMRAllBirds	1	1.64244121	1.64244121	3.00	0.0928

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.16526383	0.08263192	0.15	0.8604
BMRAllBirds	1	1.64244121	1.64244121	3.00	0.0928

Model 46a: Compliance data VS. All-bird BMR ACROSS SITES

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 46b: Compliance data VS. All-bird BMR ACROSS SITES

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

No variable met the 0.0500 significance level for entry into the model.

Model 46c: Compliance data VS. All-bird BMR ACROSS SITES

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

No variable met the 0.0500 significance level for entry into the model.

Model 47: Faecal Coliforms Vs. North Vector, Rain and N. Pier Starlings using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: Due to missing values, only 76 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	24.34981521	4.05830254	29.62	<.0001
Error	69	9.45403884	0.13701506		
Corrected Total	75	33.80385405			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.720327	18.82597	0.370155	1.966196

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.59388261	0.53129420	3.88	0.0127
North Vector	1	14.52053771	14.52053771	105.98	<.0001
Rain	1	7.93386045	7.93386045	57.91	<.0001
SGnorth	1	0.30153443	0.30153443	2.20	0.1425

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.59388261	0.53129420	3.88	0.0127
North Vector	1	3.48196472	3.48196472	25.41	<.0001
Rain	1	4.94517301	4.94517301	36.09	<.0001
SGnorth	1	0.30153443	0.30153443	2.20	0.1425

Model 48: Faecal Coliforms Vs. North Vector, Rain and N. Pier Starlings using GLM WITH SITE FACTOR (excluding Bispham)

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

NOTE: Due to missing values, only 57 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	17.94924971	3.58984994	25.69	<.0001
Error	51	7.12530483	0.13971186		
Corrected Total	56	25.07455454			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.715835	18.39364	0.373780	2.032118

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.60304369	0.30152184	2.16	0.1260
North Vector	1	10.86419590	10.86419590	77.76	<.0001
Rain	1	6.25181065	6.25181065	44.75	<.0001
SGnorth	1	0.23019947	0.23019947	1.65	0.2051

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.60304369	0.30152184	2.16	0.1260
North Vector	1	2.50328131	2.50328131	17.92	<.0001
Rain	1	3.91103872	3.91103872	27.99	<.0001
SGnorth	1	0.23019947	0.23019947	1.65	0.2051

Model 49: Faecal Coliforms Vs. North Vector, Rain and Intertidal BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	26.68269673	4.44711612	28.45	<.0001
Error	85	13.28507644	0.15629502		
Corrected Total	91	39.96777318			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.667605	20.60183	0.395342	1.918963

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.00118598	0.66706199	4.27	0.0074
North Vector	1	15.71095910	15.71095910	100.52	<.0001
Rain	1	5.56226220	5.56226220	35.59	<.0001
BMRIntertidal	1	3.40828945	3.40828945	21.81	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	2.00118598	0.66706199	4.27	0.0074
North Vector	1	6.24806654	6.24806654	39.98	<.0001
Rain	1	5.32027352	5.32027352	34.04	<.0001
BMRIntertidal	1	3.40828945	3.40828945	21.81	<.0001

Model 50: Faecal Coliforms Vs. North Vector, Rain and Intertidal BMR using GLM WITH SITE FACTOR (excluding Bispham)

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	20.07367870	4.01473574	25.88	<.0001
Error	63	9.77352093	0.15513525		
Corrected Total	68	29.84719964			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.672548	19.77438	0.393872	1.991831

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.53571998	0.26785999	1.73	0.1862
North Vector	1	11.72627412	11.72627412	75.59	<.0001
Rain	1	5.04334267	5.04334267	32.51	<.0001
BMRIntertidal	1	2.76834194	2.76834194	17.84	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.53571998	0.26785999	1.73	0.1862
North Vector	1	4.34866088	4.34866088	28.03	<.0001
Rain	1	4.83534922	4.83534922	31.17	<.0001
BMRIntertidal	1	2.76834194	2.76834194	17.84	<.0001

Model 51: Faecal Coliforms Vs. North Vector, Rain and Gull BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	26.46082231	4.41013705	27.75	<.0001
Error	85	13.50695087	0.15890530		
Corrected Total	91	39.96777318			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.662054	20.77316	0.398629	1.918963

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.00118598	0.66706199	4.20	0.0081
North Vector	1	15.71095910	15.71095910	98.87	<.0001
Rain	1	5.56226220	5.56226220	35.00	<.0001
GullsBMR	1	3.18641502	3.18641502	20.05	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	2.00118598	0.66706199	4.20	0.0081
North Vector	1	6.19266103	6.19266103	38.97	<.0001
Rain	1	5.48412025	5.48412025	34.51	<.0001
GullsBMR	1	3.18641502	3.18641502	20.05	<.0001

Model 52: Faecal Coliforms Vs. North Vector, Rain and Gull BMR using GLM WITH SITE FACTOR (excluding Bispham)

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	19.88927926	3.97785585	25.17	<.0001
Error	63	9.95792038	0.15806223		
Corrected Total	68	29.84719964			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.666370	19.96005	0.397570	1.991831

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.53571998	0.26785999	1.69	0.1919
North Vector	1	11.72627412	11.72627412	74.19	<.0001
Rain	1	5.04334267	5.04334267	31.91	<.0001
GullsBMR	1	2.58394249	2.58394249	16.35	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.53571998	0.26785999	1.69	0.1919
North Vector	1	4.31098813	4.31098813	27.27	<.0001
Rain	1	4.97630137	4.97630137	31.48	<.0001
GullsBMR	1	2.58394249	2.58394249	16.35	0.0001

Model 53: Faecal Coliforms Vs. North Vector, Rain and All-bird BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: Due to missing values, only 48 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	15.36741013	2.56123502	21.46	<.0001
Error	41	4.89370641	0.11935869		
Corrected Total	47	20.26111654			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.758468	15.63286	0.345483	2.209981

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.24996224	0.41665408	3.49	0.0240
North Vector	1	9.86317499	9.86317499	82.63	<.0001
Rain	1	4.24615486	4.24615486	35.57	<.0001
BMRAllBirds	1	0.00811804	0.00811804	0.07	0.7956

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.24996224	0.41665408	3.49	0.0240
North Vector	1	1.22928967	1.22928967	10.30	0.0026
Rain	1	3.68692700	3.68692700	30.89	<.0001
BMRAllBirds	1	0.00811804	0.00811804	0.07	0.7956

Model 54: Faecal Coliforms Vs. North Vector, Rain and All-bird BMR using GLM WITH SITE FACTOR (excluding Bispham)

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

NOTE: Due to missing values, only 36 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	10.35585311	2.07117062	17.62	<.0001
Error	30	3.52598263	0.11753275		
Corrected Total	35	13.88183574			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.746000	14.99964	0.342831	2.285592

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.42672259	0.21336129	1.82	0.1802
North Vector	1	6.81007174	6.81007174	57.94	<.0001
Rain	1	3.10455446	3.10455446	26.41	<.0001
BMRAllBirds	1	0.01450433	0.01450433	0.12	0.7278

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.42672259	0.21336129	1.82	0.1802
North Vector	1	0.78872782	0.78872782	6.71	0.0147
Rain	1	2.75376581	2.75376581	23.43	<.0001
BMRAllBirds	1	0.01450433	0.01450433	0.12	0.7278

Model 55: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Intertidal BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: Due to missing values, only 76 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	25.62773348	3.66110478	30.45	<.0001
Error	68	8.17612056	0.12023707		
Corrected Total	75	33.80385405			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.758131	17.63569	0.346752	1.966196

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.59388261	0.53129420	4.42	0.0067
North Vector	1	14.52053771	14.52053771	120.77	<.0001
Rain	1	7.93386045	7.93386045	65.99	<.0001
SGnorth	1	0.30153443	0.30153443	2.51	0.1179
BMRIntertidal	1	1.27791827	1.27791827	10.63	0.0017

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.59388261	0.53129420	4.42	0.0067
North Vector	1	3.01186410	3.01186410	25.05	<.0001
Rain	1	5.85187202	5.85187202	48.67	<.0001
SGnorth	1	0.31193753	0.31193753	2.59	0.1119
BMRIntertidal	1	1.27791827	1.27791827	10.63	0.0017

Model 56: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Intertidal BMR using GLM WITH SITE FACTOR (excluding Bispham)

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

NOTE: Due to missing values, only 57 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	19.20765223	3.20127537	27.28	<.0001
Error	50	5.86690231	0.11733805		
Corrected Total	56	25.07455454			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.766022	16.85662	0.342546	2.032118

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.60304369	0.30152184	2.57	0.0866
North Vector	1	10.86419590	10.86419590	92.59	<.0001
Rain	1	6.25181065	6.25181065	53.28	<.0001
SGnorth	1	0.23019947	0.23019947	1.96	0.1675
BMRIntertidal	1	1.25840252	1.25840252	10.72	0.0019

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.60304369	0.30152184	2.57	0.0866
North Vector	1	2.11460800	2.11460800	18.02	<.0001
Rain	1	4.73989142	4.73989142	40.40	<.0001
SGnorth	1	0.35290928	0.35290928	3.01	0.0890
BMRIntertidal	1	1.25840252	1.25840252	10.72	0.0019

Model 57: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Gull BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: Due to missing values, only 76 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	25.40430265	3.62918609	29.38	<.0001
Error	68	8.39955140	0.12352281		
Corrected Total	75	33.80385405			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.751521	17.87503	0.351458	1.966196

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.59388261	0.53129420	4.30	0.0077
North Vector	1	14.52053771	14.52053771	117.55	<.0001
Rain	1	7.93386045	7.93386045	64.23	<.0001
SGnorth	1	0.30153443	0.30153443	2.44	0.1228
GullsBMR	1	1.05448744	1.05448744	8.54	0.0047

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.59388261	0.53129420	4.30	0.0077
North Vector	1	2.99961293	2.99961293	24.28	<.0001
Rain	1	5.70899605	5.70899605	46.22	<.0001
SGnorth	1	0.20480487	0.20480487	1.66	0.2022
GullsBMR	1	1.05448744	1.05448744	8.54	0.0047

Model 58: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Gull BMR using GLM WITH SITE FACTOR (excluding Bispham)

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	3	Blackpool Central Blackpool North Blackpool South

Number of observations 69

NOTE: Due to missing values, only 57 observations can be used in this analysis.

Dependent Variable: Faecal Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	19.00308912	3.16718152	26.08	<.0001
Error	50	6.07146542	0.12142931		
Corrected Total	56	25.07455454			

R-Square	Coeff Var	Root MSE	Faecal Coliforms Mean
0.757863	17.14797	0.348467	2.032118

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	2	0.60304369	0.30152184	2.48	0.0937
North Vector	1	10.86419590	10.86419590	89.47	<.0001
Rain	1	6.25181065	6.25181065	51.49	<.0001
SGnorth	1	0.23019947	0.23019947	1.90	0.1747
GullsBMR	1	1.05383941	1.05383941	8.68	0.0049

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	0.60304369	0.30152184	2.48	0.0937
North Vector	1	2.10287428	2.10287428	17.32	0.0001
Rain	1	4.61642627	4.61642627	38.02	<.0001
SGnorth	1	0.24595154	0.24595154	2.03	0.1609
GullsBMR	1	1.05383941	1.05383941	8.68	0.0049

Model 59: Faecal Coliforms Vs. North Vector Rain and Gull BMR using STEPWISE across Piers

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4245 and C(p) = 17.5287

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3.90876	3.90876	15.49	0.0008
Error	21	5.29827	0.25230		
Corrected Total	22	9.20703			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.93344	0.10578	84.28677	334.08	<.0001
North Vector	-0.10279	0.02611	3.90876	15.49	0.0008

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable Rain Entered: R-Square = 0.6071 and C(p) = 7.9383

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	5.58987	2.79494	15.45	<.0001
Error	20	3.61715	0.18086		
Corrected Total	22	9.20703			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.74020	0.10972	45.49576	251.56	<.0001
North Vector	-0.08376	0.02297	2.40428	13.29	0.0016
Rain	0.03180	0.01043	1.68111	9.30	0.0063

Bounds on condition number: 1.0796, 4.3186

Stepwise Selection: Step 3

Variable GullsBMR Entered: R-Square = 0.7007 and C(p) = 4.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	6.45119	2.15040	14.83	<.0001
Error	19	2.75584	0.14504		
Corrected Total	22	9.20703			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.34085	0.19108	7.14251	49.24	<.0001
North Vector	-0.06792	0.02158	1.43700	9.91	0.0053
Rain	0.03158	0.00934	1.65877	11.44	0.0031
GullsBMR	0.00000443	0.00000182	0.86131	5.94	0.0248

Bounds on condition number: 1.1875, 10.131

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4245	0.4245	17.5287	15.49	0.0008
2	Rain		2	0.1826	0.6071	7.9383	9.30	0.0063
3	GullsBMR		3	0.0935	0.7007	4.0000	5.94	0.0248

Model 60: Faecal Coliforms Vs. North Vector Rain and Gull BMR using STEPWISE Bispham only

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4604 and C(p) = 7.3433

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3.98496	3.98496	17.92	0.0004
Error	21	4.67015	0.22239		
Corrected Total	22	8.65511			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.64140	0.09931	60.74753	273.16	<.0001
North Vector	-0.10378	0.02452	3.98496	17.92	0.0004

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4604	0.4604	7.3433	17.92	0.0004

Model 61: Faecal Coliforms Vs. North Vector Rain and Intertidal BMR using STEPWISE across Piers

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4245 and C(p) = 18.3620

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3.90876	3.90876	15.49	0.0008
Error	21	5.29827	0.25230		
Corrected Total	22	9.20703			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.93344	0.10578	84.28677	334.08	<.0001
North Vector	-0.10279	0.02611	3.90876	15.49	0.0008

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable Rain Entered: R-Square = 0.6071 and C(p) = 8.5072

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	5.58987	2.79494	15.45	<.0001
Error	20	3.61715	0.18086		
Corrected Total	22	9.20703			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.74020	0.10972	45.49576	251.56	<.0001
North Vector	-0.08376	0.02297	2.40428	13.29	0.0016
Rain	0.03180	0.01043	1.68111	9.30	0.0063

Bounds on condition number: 1.0796, 4.3186

Stepwise Selection: Step 3

Variable BMRIntertidal Entered: R-Square = 0.7074 and C(p) = 4.0000

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	6.51265	2.17088	15.31	<.0001
Error	19	2.69437	0.14181		
Corrected Total	22	9.20703			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.32863	0.18834	7.05741	49.77	<.0001
North Vector	-0.06798	0.02126	1.44955	10.22	0.0047
Rain	0.03114	0.00924	1.61178	11.37	0.0032
BMRIntertidal	0.00000432	0.00000169	0.92278	6.51	0.0195

Bounds on condition number: 1.1795, 10.097

All variables left in the model are significant at the 0.0500 level.

All variables have been entered into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4245	0.4245	18.3620	15.49	0.0008
2	Rain		2	0.1826	0.6071	8.5072	9.30	0.0063
3	BMRIntertidal		3	0.1002	0.7074	4.0000	6.51	0.0195

Model 62: Faecal Coliforms Vs. North Vector Rain and Intertidal BMR using STEPWISE Bispham only

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4604 and C(p) = 7.6537

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3.98496	3.98496	17.92	0.0004
Error	21	4.67015	0.22239		
Corrected Total	22	8.65511			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.64140	0.09931	60.74753	273.16	<.0001
North Vector	-0.10378	0.02452	3.98496	17.92	0.0004

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4604	0.4604	7.6537	17.92	0.0004

Model 63: Faecal Coliforms Vs. North Vector Rain and N. Pier Starlings using STEPWISE across Piers

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.6280 and C(p) = 7.6520

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	4.81796	4.81796	28.70	<.0001
Error	17	2.85404	0.16788		
Corrected Total	18	7.67200			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.63288	0.11996	31.10722	185.29	<.0001
Rain	0.08428	0.01573	4.81796	28.70	<.0001

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable North Vector Entered: R-Square = 0.7437 and C(p) = 2.6090

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	5.70534	2.85267	23.21	<.0001
Error	16	1.96666	0.12292		
Corrected Total	18	7.67200			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.68688	0.10459	31.97296	260.12	<.0001
North Vector	-0.05684	0.02116	0.88738	7.22	0.0162
Rain	0.06374	0.01548	2.08394	16.95	0.0008

Bounds on condition number: 1.3224, 5.2897

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.6280	0.6280	7.6520	28.70	<.0001
2	North Vector		2	0.1157	0.7437	2.6090	7.22	0.0162

Model 64: Faecal Coliforms Vs. North Vector Rain and N. Pier Starlings using STEPWISE Bispham only

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.5575 and C(p) = 7.2023

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	4.31383	4.31383	21.41	0.0002
Error	17	3.42463	0.20145		
Corrected Total	18	7.73846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.39066	0.13140	22.56270	112.00	<.0001
Rain	0.07975	0.01723	4.31383	21.41	0.0002

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable North Vector Entered: R-Square = 0.6918 and C(p) = 2.4629

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	5.35335	2.67667	17.96	<.0001
Error	16	2.38511	0.14907		
Corrected Total	18	7.73846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.44910	0.11518	23.59448	158.28	<.0001
North Vector	-0.06152	0.02330	1.03952	6.97	0.0178
Rain	0.05752	0.01705	1.69694	11.38	0.0039

Bounds on condition number: 1.3224, 5.2897

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.5575	0.5575	7.2023	21.41	0.0002
2	North Vector		2	0.1343	0.6918	2.4629	6.97	0.0178

Model 65: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Gull BMR using STEPWISE across Piers

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.6280 and C(p) = 12.1728

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	4.81796	4.81796	28.70	<.0001
Error	17	2.85404	0.16788		
Corrected Total	18	7.67200			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.63288	0.11996	31.10722	185.29	<.0001
Rain	0.08428	0.01573	4.81796	28.70	<.0001

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable North Vector Entered: R-Square = 0.7437 and C(p) = 5.7242

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	5.70534	2.85267	23.21	<.0001
Error	16	1.96666	0.12292		
Corrected Total	18	7.67200			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.68688	0.10459	31.97296	260.12	<.0001
North Vector	-0.05684	0.02116	0.88738	7.22	0.0162
Rain	0.06374	0.01548	2.08394	16.95	0.0008

Bounds on condition number: 1.3224, 5.2897

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.6280	0.6280	12.1728	28.70	<.0001
2	North Vector		2	0.1157	0.7437	5.7242	7.22	0.0162

Model 66: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Gull BMR using STEPWISE Bispham only

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.5575 and C(p) = 6.6686

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	4.31383	4.31383	21.41	0.0002
Error	17	3.42463	0.20145		
Corrected Total	18	7.73846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.39066	0.13140	22.56270	112.00	<.0001
Rain	0.07975	0.01723	4.31383	21.41	0.0002

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable North Vector Entered: R-Square = 0.6918 and C(p) = 2.0913

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	5.35335	2.67667	17.96	<.0001
Error	16	2.38511	0.14907		
Corrected Total	18	7.73846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.44910	0.11518	23.59448	158.28	<.0001
North Vector	-0.06152	0.02330	1.03952	6.97	0.0178
Rain	0.05752	0.01705	1.69694	11.38	0.0039

Bounds on condition number: 1.3224, 5.2897

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.5575	0.5575	6.6686	21.41	0.0002
2	North Vector		2	0.1343	0.6918	2.0913	6.97	0.0178

Model 67: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Intertidal BMR using STEPWISE across Piers

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.6280 and C(p) = 12.1728

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	4.81796	4.81796	28.70	<.0001
Error	17	2.85404	0.16788		
Corrected Total	18	7.67200			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.63288	0.11996	31.10722	185.29	<.0001
Rain	0.08428	0.01573	4.81796	28.70	<.0001

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable North Vector Entered: R-Square = 0.7437 and C(p) = 5.7242

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	5.70534	2.85267	23.21	<.0001
Error	16	1.96666	0.12292		
Corrected Total	18	7.67200			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.68688	0.10459	31.97296	260.12	<.0001
North Vector	-0.05684	0.02116	0.88738	7.22	0.0162
Rain	0.06374	0.01548	2.08394	16.95	0.0008

Bounds on condition number: 1.3224, 5.2897

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.6280	0.6280	12.1728	28.70	<.0001
2	North Vector		2	0.1157	0.7437	5.7242	7.22	0.0162

Model 68: Faecal Coliforms Vs. North Vector, Rain, N. Pier Starlings and Intertidal BMR using STEPWISE Bispham only

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Coliforms

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.5575 and C(p) = 6.6686

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	4.31383	4.31383	21.41	0.0002
Error	17	3.42463	0.20145		
Corrected Total	18	7.73846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.39066	0.13140	22.56270	112.00	<.0001
Rain	0.07975	0.01723	4.31383	21.41	0.0002

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable North Vector Entered: R-Square = 0.6918 and C(p) = 2.0913

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	5.35335	2.67667	17.96	<.0001
Error	16	2.38511	0.14907		
Corrected Total	18	7.73846			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.44910	0.11518	23.59448	158.28	<.0001
North Vector	-0.06152	0.02330	1.03952	6.97	0.0178
Rain	0.05752	0.01705	1.69694	11.38	0.0039

Bounds on condition number: 1.3224, 5.2897

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.5575	0.5575	6.6686	21.41	0.0002
2	North Vector		2	0.1343	0.6918	2.0913	6.97	0.0178

Model 69: Faecal Streptococci Vs. North Vector and N. Pier Starlings using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: Due to missing values, only 76 observations can be used in this analysis.

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	8.07764379	1.61552876	14.32	<.0001
Error	70	7.89958991	0.11285128		
Corrected Total	75	15.97723370			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.505572	21.76477	0.335933	1.543473

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.31853581	0.10617860	0.94	0.4257
North Vector	1	5.70417084	5.70417084	50.55	<.0001
SGnorth	1	2.05493714	2.05493714	18.21	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.31853581	0.10617860	0.94	0.4257
North Vector	1	3.10942839	3.10942839	27.55	<.0001
SGnorth	1	2.05493714	2.05493714	18.21	<.0001

Model 70: Faecal Streptococci Vs. North Vector and Intertidal BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	8.37383786	1.67476757	14.65	<.0001
Error	86	9.83176491	0.11432285		
Corrected Total	91	18.20560277			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.459959	22.71473	0.338117	1.488534

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.43925908	0.14641969	1.28	0.2862
North Vector	1	6.35968912	6.35968912	55.63	<.0001
BMRIntertidal	1	1.57488966	1.57488966	13.78	0.0004

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.43925908	0.14641969	1.28	0.2862
North Vector	1	4.05146785	4.05146785	35.44	<.0001
BMRIntertidal	1	1.57488966	1.57488966	13.78	0.0004

Model 71: Faecal Streptococci Vs. North Vector and Gull BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	8.17695422	1.63539084	14.02	<.0001
Error	86	10.02864855	0.11661219		
Corrected Total	91	18.20560277			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.449145	22.94104	0.341485	1.488534

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.43925908	0.14641969	1.26	0.2948
North Vector	1	6.35968912	6.35968912	54.54	<.0001
GullsBMR	1	1.37800602	1.37800602	11.82	0.0009

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.43925908	0.14641969	1.26	0.2948
North Vector	1	4.10122351	4.10122351	35.17	<.0001
GullsBMR	1	1.37800602	1.37800602	11.82	0.0009

Model 72: Faecal Streptococci Vs. North Vector and All-bird BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: Due to missing values, only 48 observations can be used in this analysis.

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	5.33163568	1.06632714	7.06	<.0001
Error	42	6.34373010	0.15104119		
Corrected Total	47	11.67536579			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.456657	23.01166	0.388640	1.688884

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.49200233	0.16400078	1.09	0.3656
North Vector	1	4.23146857	4.23146857	28.02	<.0001
BMRAllBirds	1	0.60816478	0.60816478	4.03	0.0513

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.49200233	0.16400078	1.09	0.3656
North Vector	1	3.07697207	3.07697207	20.37	<.0001
BMRAllBirds	1	0.60816478	0.60816478	4.03	0.0513

Model 73: Faecal Streptococci Vs. North Vector, N. Pier Starlings and Intertidal BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: Due to missing values, only 76 observations can be used in this analysis.

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	8.09712297	1.34952050	11.82	<.0001
Error	69	7.88011073	0.11420450		
Corrected Total	75	15.97723370			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.506791	21.89487	0.337942	1.543473

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.31853581	0.10617860	0.93	0.4311
North Vector	1	5.70417084	5.70417084	49.95	<.0001
SGnorth	1	2.05493714	2.05493714	17.99	<.0001
BMRIntertidal	1	0.01947918	0.01947918	0.17	0.6809

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.31853581	0.10617860	0.93	0.4311
North Vector	1	3.11759728	3.11759728	27.30	<.0001
SGnorth	1	0.96025420	0.96025420	8.41	0.0050
BMRIntertidal	1	0.01947918	0.01947918	0.17	0.6809

Model 74: Faecal Streptococci Vs. North Vector, N. Pier Starlings and Gull BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: Due to missing values, only 76 observations can be used in this analysis.

Dependent Variable: Faecal Streptococci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	8.13666376	1.35611063	11.93	<.0001
Error	69	7.84056994	0.11363145		
Corrected Total	75	15.97723370			

R-Square	Coeff Var	Root MSE	Faecal Streptococci Mean
0.509266	21.83987	0.337093	1.543473

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	0.31853581	0.10617860	0.93	0.4289
North Vector	1	5.70417084	5.70417084	50.20	<.0001
SGnorth	1	2.05493714	2.05493714	18.08	<.0001
GullsBMR	1	0.05901997	0.05901997	0.52	0.4735

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	0.31853581	0.10617860	0.93	0.4289
North Vector	1	3.13705226	3.13705226	27.61	<.0001
SGnorth	1	1.17105334	1.17105334	10.31	0.0020
GullsBMR	1	0.05901997	0.05901997	0.52	0.4735

Model 75: Faecal Streptococci Vs. North Vector, N. Pier Starlings and Intertidal BMR using STEPWISE across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4030 and C(p) = 4.8801

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.42604	1.42604	11.47	0.0035
Error	17	2.11266	0.12427		
Corrected Total	18	3.53870			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.49574	0.08209	41.25539	331.97	<.0001
North Vector	-0.06266	0.01850	1.42604	11.47	0.0035

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable SGnorth Entered: R-Square = 0.5482 and C(p) = 2.0458

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	1.93978	0.96989	9.71	0.0017
Error	16	1.59892	0.09993		
Corrected Total	18	3.53870			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.29045	0.11669	12.22102	122.29	<.0001
North Vector	-0.04916	0.01762	0.77736	7.78	0.0131
SGnorth	0.00002291	0.00001011	0.51373	5.14	0.0376

Bounds on condition number: 1.1289, 4.5158

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4030	0.4030	4.8801	11.47	0.0035
2	SGnorth		2	0.1452	0.5482	2.0458	5.14	0.0376

Model 76: Faecal Streptococci Vs. North Vector, N. Pier Starlings and Gull BMR using STEPWISE across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4030 and C(p) = 5.0041

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.42604	1.42604	11.47	0.0035
Error	17	2.11266	0.12427		
Corrected Total	18	3.53870			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.49574	0.08209	41.25539	331.97	<.0001
North Vector	-0.06266	0.01850	1.42604	11.47	0.0035

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable SGnorth Entered: R-Square = 0.5482 and C(p) = 2.1397

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	1.93978	0.96989	9.71	0.0017
Error	16	1.59892	0.09993		
Corrected Total	18	3.53870			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.29045	0.11669	12.22102	122.29	<.0001
North Vector	-0.04916	0.01762	0.77736	7.78	0.0131
SGnorth	0.00002291	0.00001011	0.51373	5.14	0.0376

Bounds on condition number: 1.1289, 4.5158

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4030	0.4030	5.0041	11.47	0.0035
2	SGnorth		2	0.1452	0.5482	2.1397	5.14	0.0376

Model 77: Faecal Streptococci Vs. North Vector, N. Pier Starlings, Gull BMR and Rain using STEPWISE across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.6425 and C(p) = 3.9634

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.27369	2.27369	30.56	<.0001
Error	17	1.26501	0.07441		
Corrected Total	18	3.53870			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.26921	0.07986	18.79404	252.57	<.0001
Rain	0.05790	0.01047	2.27369	30.56	<.0001

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.6425	0.6425	3.9634	30.56	<.0001

Model 78: Faecal Streptococci Vs. North Vector and Intertidal BMR using STEPWISE across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4041 and C(p) = 5.0355

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.58992	1.58992	14.24	0.0011
Error	21	2.34501	0.11167		
Corrected Total	22	3.93494			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.45129	0.07037	47.49076	425.29	<.0001
North Vector	-0.06556	0.01737	1.58992	14.24	0.0011

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4041	0.4041	5.0355	14.24	0.0011

Model 79: Faecal Streptococci Vs. North Vector and Gull BMR using STEPWISE across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4041 and C(p) = 4.4441

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.58992	1.58992	14.24	0.0011
Error	21	2.34501	0.11167		
Corrected Total	22	3.93494			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.45129	0.07037	47.49076	425.29	<.0001
North Vector	-0.06556	0.01737	1.58992	14.24	0.0011

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4041	0.4041	4.4441	14.24	0.0011

Model 80: Faecal Streptococci Vs. North Vector, Gull BMR and Rain using STEPWISE across sites

The REG Procedure
Model: MODEL1
Dependent Variable: Faecal Streptococci

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4041 and C(p) = 4.6793

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.58992	1.58992	14.24	0.0011
Error	21	2.34501	0.11167		
Corrected Total	22	3.93494			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.45129	0.07037	47.49076	425.29	<.0001
North Vector	-0.06556	0.01737	1.58992	14.24	0.0011

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4041	0.4041	4.6793	14.24	0.0011

Model 81: Total Coliforms Vs. North Vector Rain and N. Pier Starlings using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: Due to missing values, only 76 observations can be used in this analysis.

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	31.09511523	5.18251921	23.62	<.0001
Error	69	15.14091683	0.21943358		
Corrected Total	75	46.23603206			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.672530	22.10142	0.468437	2.119490

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.58472947	0.52824316	2.41	0.0746
North Vector	1	20.17157416	20.17157416	91.93	<.0001
Rain	1	9.00002757	9.00002757	41.01	<.0001
SGnorth	1	0.33878404	0.33878404	1.54	0.2182

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.58472947	0.52824316	2.41	0.0746
North Vector	1	5.58125073	5.58125073	25.43	<.0001
Rain	1	5.61598574	5.61598574	25.59	<.0001
SGnorth	1	0.33878404	0.33878404	1.54	0.2182

Model 82: Total Coliforms Vs. North Vector Rain and Gull BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	36.92131772	6.15355295	22.95	<.0001
Error	85	22.79094956	0.26812882		
Corrected Total	91	59.71226728			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.618320	24.69519	0.517812	2.096811

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.06092619	0.68697540	2.56	0.0602
North Vector	1	21.47248321	21.47248321	80.08	<.0001
Rain	1	10.85507744	10.85507744	40.48	<.0001
GullsBMR	1	2.53283087	2.53283087	9.45	0.0028

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	2.06092619	0.68697540	2.56	0.0602
North Vector	1	8.52247973	8.52247973	31.79	<.0001
Rain	1	10.75729232	10.75729232	40.12	<.0001
GullsBMR	1	2.53283087	2.53283087	9.45	0.0028

Model 83: Total Coliforms Vs. North Vector, Rain and Intertidal BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	37.21451887	6.20241981	23.43	<.0001
Error	85	22.49774841	0.26467939		
Corrected Total	91	59.71226728			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.623231	24.53583	0.514470	2.096811

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	2.06092619	0.68697540	2.60	0.0577
North Vector	1	21.47248321	21.47248321	81.13	<.0001
Rain	1	10.85507744	10.85507744	41.01	<.0001
BMRIntertidal	1	2.82603202	2.82603202	10.68	0.0016

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	2.06092619	0.68697540	2.60	0.0577
North Vector	1	8.53452255	8.53452255	32.24	<.0001
Rain	1	10.54321874	10.54321874	39.83	<.0001
BMRIntertidal	1	2.82603202	2.82603202	10.68	0.0016

Model 84: Total Coliforms Vs. North Vector, Rain and All Bird BMR using GLM WITH SITE FACTOR

The GLM Procedure

Class Level Information

Class	Levels	Values
Site	4	Bispham Blackpool Central Blackpool North Blackpool South

Number of observations 92

NOTE: Due to missing values, only 48 observations can be used in this analysis.

Dependent Variable: Total Coliforms

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	20.26759419	3.37793237	17.23	<.0001
Error	41	8.03778688	0.19604358		
Corrected Total	47	28.30538107			

R-Square	Coeff Var	Root MSE	Total Coliforms Mean
0.716033	18.36384	0.442768	2.411086

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Site	3	1.17477034	0.39159011	2.00	0.1294
North Vector	1	13.70404457	13.70404457	69.90	<.0001
Rain	1	5.19833915	5.19833915	26.52	<.0001
BMRAllBirds	1	0.19044013	0.19044013	0.97	0.3301

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	1.17477034	0.39159011	2.00	0.1294
North Vector	1	1.93274735	1.93274735	9.86	0.0031
Rain	1	5.11249093	5.11249093	26.08	<.0001
BMRAllBirds	1	0.19044013	0.19044013	0.97	0.3301

Model 85: Total Coliforms Vs. North Vector, Rain and Gull BMR STEPWISE ACROSS Sites

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4016 and C(p) = 13.6704

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	5.36812	5.36812	14.09	0.0012
Error	21	7.99883	0.38090		
Corrected Total	22	13.36695			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	2.02838	0.12997	92.76788	243.55	<.0001
North Vector	-0.12046	0.03209	5.36812	14.09	0.0012

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable Rain Entered: R-Square = 0.6046 and C(p) = 4.5863

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	8.08189	4.04095	15.29	<.0001
Error	20	5.28506	0.26425		
Corrected Total	22	13.36695			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.78286	0.13262	47.75394	180.71	<.0001
North Vector	-0.09629	0.02777	3.17691	12.02	0.0024
Rain	0.04040	0.01261	2.71377	10.27	0.0044

Bounds on condition number: 1.0796, 4.3186

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4016	0.4016	13.6704	14.09	0.0012
2	Rain		2	0.2030	0.6046	4.5863	10.27	0.0044

Model 86: Total Coliforms Vs. North Vector, Rain and Intertidal BMR using STEPWISE ACROSS Sites

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable North Vector Entered: R-Square = 0.4016 and C(p) = 14.1934

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	5.36812	5.36812	14.09	0.0012
Error	21	7.99883	0.38090		
Corrected Total	22	13.36695			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	2.02838	0.12997	92.76788	243.55	<.0001
North Vector	-0.12046	0.03209	5.36812	14.09	0.0012

Bounds on condition number: 1, 1

Stepwise Selection: Step 2

Variable Rain Entered: R-Square = 0.6046 and C(p) = 4.9319

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	8.08189	4.04095	15.29	<.0001
Error	20	5.28506	0.26425		
Corrected Total	22	13.36695			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.78286	0.13262	47.75394	180.71	<.0001
North Vector	-0.09629	0.02777	3.17691	12.02	0.0024
Rain	0.04040	0.01261	2.71377	10.27	0.0044

Bounds on condition number: 1.0796, 4.3186

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	North Vector		1	0.4016	0.4016	14.1934	14.09	0.0012
2	Rain		2	0.2030	0.6046	4.9319	10.27	0.0044

Model 87: Total Coliforms Vs. North Vector, Rain and BMR All Birds using STEPWISE ACROSS Sites

The REG Procedure
Model: MODEL1
Dependent Variable: Total Coliforms

Stepwise Selection: Step 1

Variable Rain Entered: R-Square = 0.6701 and C(p) = 2.8126

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	4.23134	4.23134	20.31	0.0011
Error	10	2.08311	0.20831		
Corrected Total	11	6.31445			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.84026	0.18276	21.12133	101.39	<.0001
Rain	0.09461	0.02099	4.23134	20.31	0.0011

Bounds on condition number: 1, 1

All variables left in the model are significant at the 0.0500 level.

No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	Rain		1	0.6701	0.6701	2.8126	20.31	0.0011