BTO Research Report No. 325

2002-03 Pilot Winter Gull Roost Survey (including preliminary details of 2003-04 Full Winter Gull Roost Survey)

Authors

G.E. Austin, M.J.S. Armitage, N.H.K. Burton, R.A. Fuller, S.J. Holloway, A.J. Musgrove, M.M. Rehfisch and S.G. Willis

Report of work carried out by the British Trust for Ornithology funded by English Nature, The Department for the Environment (Northern Ireland), the Joint Nature Conservation Committee, Northumbrian Water Ltd and Scottish Natural Heritage

August 2003

The National Centre for Ornithology, The Nunnery, Thetford, Norfolk IP24 2PU
Registered Charity No. 216652

British Trust for Ornithology

2002-03 Pilot Winter Gull Roost Survey (including preliminary details of 2003-04 Full Winter Gull Roost Survey)

BTO Research Report No. 325

G.E. Austin, M.J.S. Armitage, N.H.K. Burton, R.A. Fuller,
S.J. Holloway, A.J. Musgrove, M.M. Rehfisch and S.G. Willis

Published in August 2003 by the British Trust for Ornithology
The Nunnery, Thetford, Norfolk, IP24 2PU, UK

ISBN 1-902576-75-6

CONTENTS

Page No.

LIST OF TABLES

Page No.

LIST OF FIGURES

Page No.

EXECUTIVE SUMMARY

1. This report summarises the results of pilot work investigating methods for a full Winter Gull Roost Survey (WinGS) planned for the winter of 2003/04. The full WinGS (incorporating the first three components detailed in 4 below) will provide population estimates (with confidence limits) for five species: Black-headed Gull, Common Gull, Lesser Black-backed Gull, Herring Gull and Great Black-backed Gull and provide new 1% thresholds for identifying sites of national importance for wintering gulls. A survey that only covers Key Sites (see below) will only allow population change to be determined.

2. The first objective of the pilot work was to investigate what proportions of gulls arrive at roosts after dark and whether this varies according to site. Twelve surveys were undertaken at nine sites during December and January in order to determine the timing of arrival of gulls at night-time roosts. Counts of gulls arriving at roosts were undertaken from at least one hour prior to darkness, using binoculars and a telescope, and continued after dark using night-viewing equipment: a thermal imager and an image intensifier. The results obtained using the image-enhancing night-vision equipment proved to be slightly disappointing. They did not allow the observer to be fully confident of detecting all gulls arriving at a site after dark. However, it was thought that very few gulls joined the roost after dark, and only at some of the sites surveyed. Counts of gulls arriving during each five-minute period prior to and after dark also suggested that very few birds join the roosts after dark. The arrival rate appeared to be highest during the 60-90 minutes before dark. There was evidence that this rate slowed considerably or stopped shortly before darkness fell. Based on these results, we have concluded that it would be difficult and probably unnecessary to calculate a correction factor to allow for gulls arriving at roosts after dark and the cessation of counts.

3. The second objective of the pilot work was to investigate how much of the coastline away from Key Sites needed to be surveyed to provide reliable estimates, with minimal confidence limits, of the numbers of gulls roosting on inshore waters, and how best to collect these data. The first study area of 54 tetrads along the East Anglian coast was surveyed during January and February 2003 and the second study area of 32 tetrads along the coast in north-east England was surveyed during March 2003. Approximately 18,000 gulls were counted along the East Anglian coastline and 44,000 gulls along the coast of north-east England. Black-headed Gull was the most common species in both areas. The results suggest with less than 20% coverage of the UK coastline, the data collected would not be sufficient to produce estimates of the overall coastal populations of all five target species. However, estimates for Black-headed Gull and Herring Gull may be reasonably accurate if 15% or more of the coast were to be covered. The results also suggest that at 20% coverage a survey of inshore waters is likely to produce confidence limits in the region of +/- 50% of the estimate for the most numerous species, Black-headed Gull and Common Gull, and +/- 60% for Herring Gull. Due to the small number of count stretches on which Lesser Black-backed and Great Black-backed Gulls were recorded it is difficult to draw conclusions for these species. Due to the difficulties of visualising tetrad boundaries, it was also suggested that inshore waters should be surveyed at regularly spaced stretches of coast, with gulls on the landward side included as part of a broad scale survey of inland roosts.

4. Four components are proposed for the forthcoming Winter Gull Roost Survey (WinGS):

   A "Key Site Survey" (KSS) – a survey of pre-selected sites identified from previous surveys as major gull roosts (in excess of 1,000 birds).

   A "Broad Scale Survey" (BSS) – a randomised stratified survey of gulls roosting on inland areas away from Key Sites.

An "Inshore Waters Survey" (IWS) – a randomised stratified survey of gulls roosting on inshore waters away from Key Sites.

"Through the Winter Counts" (TWCs) – for a subset of the Key Sites, observers will be encouraged to make more frequent visits (weekly, fortnightly or monthly) between September and March.

5. It is proposed that the KSS should take place in January 2004, with volunteer counts supplemented by professional coverage. Volunteers will also be encouraged to submit counts for Key Sites from other months (TWCs) and also to count Key Sites in January 2005 and January 2006, so as to investigate between winter variations. This information will be used to help interpret the IWS counts.

6. The BSS will aim to estimate the numbers of gulls roosting on small sites not targeted by the KSS and those larger sites for which observer cover could not be arranged. A total of 600 tetrads will be targeted in January 2004.

7. The IWS will supplement KSS counts of coastal roosts. A total of 400 coastal stretches should be targeted over the next three winters to give an overall sample of 1,200, which would approximate to 20% of the UK coast not being covered by the KSS.

INTRODUCTION

The Pilot Winter Gull Roost Survey (pWinGS) was required to test methods for a full Winter Gull Roost Survey (WinGS) planned for the winter of 2003/04. The WinGS will provide population estimates (with confidence limits) for five species: Black-headed Gull, Common Gull, Lesser Black-backed Gull, Herring Gull and Great Black-backed Gull and provide new 1% thresholds for identifying sites of national importance for wintering gulls.

The previous surveys (1953, 1963, 1973, 1983 and 1993) have targeted known gull roosts and consequently had covered an unquantified, although presumed large, proportion of the UK population of each species. Counts were made as the gulls arrived at roost sites, where they are more concentrated than when foraging during the day. The last survey took place in January 1993, during which a total of 2,594,491 gulls were counted in Great Britain (Burton *et al.* in press). This total included an estimated 1,682,385 Black-headed Gulls *Larus ridibundus*, 429,331 Common Gulls *L. canus*, 60,830 Lesser Black-backed Gulls *L. fuscus*, 376,775 Herring Gulls *L. argentatus*, 43,108 Great Black-backed Gulls *L. marinus* and 2,062 gulls of other species (mostly Kittiwakes). A further 19,030 gulls were counted in Northern Ireland, 3,853 in the Isle of Man and 8,477 in the Channel Islands. These are only minimum population estimates, because not all potential roost sites were covered during these previous surveys. To compound matters further, an unknown proportion of gulls arrive at roosts after dark. A revised approach to data collection and analytical methodology is therefore needed to provide more reliable estimates with confidence limits.

The forthcoming WinGS survey, that is planned to take place during the winter of 2003/04, will increase our knowledge of the UK Gull populations by also sampling the wider countryside and inshore waters away from these "Key Sites". The populations of gulls in the UK vary considerably outwith the breeding season. Lesser Black-backed Gull numbers, for example, peak in September or October, as birds move south on passage. In contrast, numbers of Black-headed, Common, Herring and Great Black-backed Gull tend to peak in mid-winter (when past surveys have taken place) or early spring. It is hoped that WinGS will be able to quantify these seasonal patterns by encouraging the collection of additional counts at regular intervals throughout the period September to March at a subset of Key Sites. The latter would be particularly useful for directing appropriate species specific timing of any follow-up surveys, for example further work which might be necessary for site designation. Also it will usefully determine for each species how representative of peak numbers are the standard January counts.

Consequently there will be four aspects to WinGS:

1) "Key Site Survey" (KSS) – a survey of pre-selected sites identified from previous surveys as major gull roosts (in excess of 1,000 birds).

2) "Broad Scale Survey" (BSS) – a randomised stratified survey of gulls roosting on inland areas away from Key Sites to be surveyed under (1) above. This aspect of the survey will provide an estimate of gulls roosting in the wider countryside including roosts for which volunteer counter coverage is not possible.

3) "Inshore Waters Survey" (IWS) – a randomised stratified survey of gulls roosting on inshore waters away from Key Sites to be surveyed under (1) above.

4) "Through the Winter Counts" (TWCs) – for a subset of the Key Sites, observers will be encouraged to make more frequent visits (weekly, fortnightly or monthly) between September and March.

This document is divided into two parts. Part one reports the results of the pWinGS work carried out during January to March 2003. Part two gives details of the intended sampling strategy to be adopted for WinGS.

PART 1: PILOT WINTER GULL SURVEY

The pilot Winter Gull Roost Survey (pWinGS) was designed to test new methodology for a full Winter Gull Roost Survey (WinGS), planned for the winter of 2003/04.

The main objectives of the pilot study were:

1) To determine what proportion of gulls arrive at roosts after dark and whether this varies according to site.

2) To determine what proportion of the UK coastline needs to be sampled to provide an accurate estimate of the numbers of gulls roosting on inshore waters away from major roosts, and how best to collect these data.

1.1 Objective 1: After Dark Surveys

Objective one aimed to determine what proportion of gulls arrive at roosts after dark and whether this varies according to site. Such information could be used to provide correction factors for the full Winter Gull Roost Survey when observers will not have access to night viewing equipment.

1.1.1 After dark survey methods

Twelve surveys were undertaken at nine sites during December and January (Table 1.1.1.1) to determine the timing of arrival of gulls at night-time roosts. The three sites surveyed twice were Lackford Pits, Redgrave Lake and Weybread Pits. Counts of gulls were undertaken from at least one hour prior to darkness, using binoculars and a telescope, and continued after dark using night-viewing equipment: a thermal imager[1] and an image intensifier[2].

During the first three surveys, at Lackford Pits, Redgrave Lake and Loch of Skene, the efficacy of the thermal imager was tested. This was done by comparing visual counts (of birds at the roost and those flying in) made using binoculars immediately followed by counts made with the thermal imager. After dark, the image-enhancing equipment was further tested by observing birds at the roost and assessing the number of gulls arriving at the roost. Data collected during this initial trial period were largely unsuitable for more detailed analysis of arrival patterns.

After the initial trial period, the following methodology was devised. On arrival at a site, the numbers of gulls of each species already present on the water were counted using binoculars and/or a telescope. Following this initial count, the rate of arrival of gulls prior to dark was determined by counting the number of gulls of each species arriving at the roost (or estimated when necessary) during each five-minute period until it became too dark to continue using binoculars. In some cases, it was possible to record all gulls arriving at a site, although in most circumstances, the numbers of gulls arriving on one flight line were recorded. During these counts, the thermal imager was set up and adjusted to give the optimum settings for detecting gulls arriving (on a single flight-line). After dark, observations were made with the thermal imager, again recording the number of birds seen arriving at the roost during each five-minute period, until one hour after the last birds had been detected arriving. Species of gulls could not be identified using the thermal imager, but it was possible to distinguish between gulls and other groups of birds, such as ducks, geese and crows. The image intensifier was trialled during the first three surveys, but was not considered very good for detecting the arrival of gulls at a site after dark, due to its limited magnification and field of view, and the limited distance illuminated by the infra-red spotlight. Also, the image-intensifier was completely unsuitable when it was raining or misty.

[1] LITE direct view thermal imager (manufactured by Pilkington Thorn Optronics Ltd, Glasgow), a model designed for medium-weight weapons targeting applications. This model can resolve temperature differences of less than 0.1°C and has an image magnification of 9× and 6° × 3° field of view.

[2] Infra-red image intensifier (manufactured by Omega Nightvision Systems), with 50 mm and 300 mm lenses together with a Nightforce SL170 spotlight.

Table 1.1.1.1 Sites covered to determine the timing of arrival of gulls at night-time roosts.

Date surveyed	Site	Grid Reference
10/12/02	Lackford Pits (visit 1)	TL798708
12/12/02	Redgrave Lake (visit 1)	TM055766
18/12/02	Loch of Skene	NJ784074
08/01/03	Weybread Pits (visit 1)	TM250817
09/01/03	Redgrave Lake (visit 2)	TM055766
10/01/03	Weybread Pits (visit 2)	TM250817
13/01/03	Lackford Pits (visit 2)	TL798708
14/01/03	Filby Broad	TG458133
15/01/03	Breydon Water	TG502079
16/01/03	Ranworth Broad	TG354154
17/01/03	Oulton Broad	TM515926
18/01/03	Gosfield Lake	TL774292

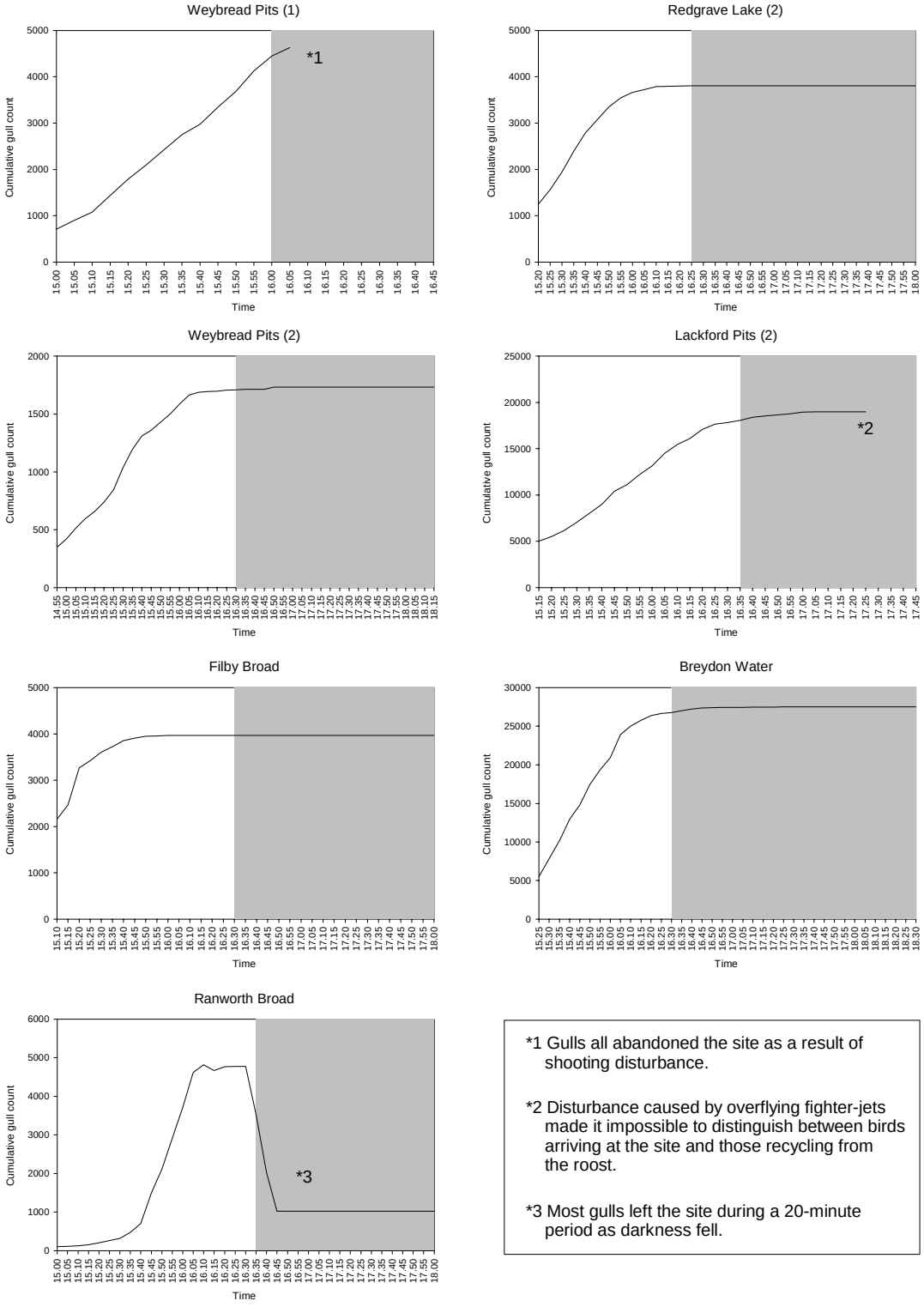
1.1.2 Results of after dark surveys

The results obtained using the thermal imaging equipment proved to be slightly disappointing. As with the image intensifier, the thermal imager lacked the magnification, field of view and depth of field for the observer to be fully confident of detecting all gulls arriving at a site after dark, even on just one flight line. Observations were also confounded by the "recycling" of gulls from the roost. Birds were observed flying up from the water and wheeling around in the air, often over a considerable amount of time and distance. This occurred sometimes as a result of disturbance (by low-flying aircraft or shooting, for example), as well as natural social behaviour. Birds flying around above the roost could number several hundred and it was then not possible to distinguish if any new birds were arriving at the site. It did not prove possible to count birds on the water when they were too close together, and beyond approximately 500 m, it was not possible to resolve individual birds in the flock. Because it was not possible to distinguish between gull species no species specific arrival behaviour could be recorded.

It was possible to record the rate of arrival of gulls for each five-minute period during seven of the latter nine surveys (Figure 1.1.2.1). At all of these sites, the arrival rate of gulls at the roosts appeared to be highest during the 60-90 minutes before dark. There was clear evidence that this rate slowed considerably or even stopped shortly before darkness fell. On three sites visits (Weybread Pits (visit 2), Lackford Pits (visit 2) and Breydon Water), a small proportion of the final numbers of gulls present at the roost were detected arriving after dark, *i.e.* when they could not be detected visually. These birds arrived within the period one hour after darkness fell, and none were detected any later. At Redgrave Lake (visit 2) and Filby Broad, no gulls were detected arriving after dark. At Ranworth Broad, most of the 5,000 gulls that had arrived at the site left during a 20-minute period as darkness fell. At Weybread Pits (visit 1), all gulls left the site shortly after dark as a result of shooting disturbance and at Lackford Pits (visit 2), disturbance caused by over flying fighter-jets made it impossible to distinguish between birds arriving at the site and those flying up from the roost.

It was not possible to record the rate of arrival of gulls for each five minute period during two of the latter nine surveys: at Oulton Broad and Gosfield Lake. At Oulton Broad, a maximum of 200 gulls arrived at the site 90 minutes before dark, but remained unsettled. All gulls had left by dark, although up to 25 birds were detected flying to the site 30 minutes after dark. At Gosfield Lake, no gull roost formed.

Figure 1.1.2.1 Cumulative number of gulls arriving at roost from at least one hour before dark until one hour had elapsed after dark without any new arrivals having been detected. (The after dark period is indicated by the shaded area).



1.1.3 Conclusions from dark surveys

Observations suggested that some gulls did arrive at the roost sites after dark, but it is thought that this represented only a very small proportion of the total number of gulls at the roost. The counts made in five-minute intervals leading up to darkness showed that the rate of arrival slowed considerably in the dwindling light, also suggesting that comparatively few gulls arrived at these sites after dark. Previous observations by Shedden (1983) also suggest that there may by few movements to or from roosts after dark.

There appeared to be some variation in the rate of arrival of gulls between the sites, and based on the results of this aspect of the pilot survey, it would be difficult and probably not necessary to calculate a correction factor that could be applied to the roost counts that will be made by observers for the KSS.

There remains some concern that gulls sometimes left the site just as it got dark. In all but one case this had been due to disturbance or had occurred on water bodies not previously identified as roosts but sufficiently close to those that had been to be surveyed at the same time. Presumably, had these disturbance events not occurred the gulls would have remained at the site. If such events were to be widespread or sites believed to hold gull roosts are in fact pre-roost gatherings the importance of these observations will depend upon the use to which the survey data are put. Where the data are being used to estimate country-wide gull populations, this would only be a problem for subsequent analysis if counting were to continue after dark or if a correction factor were to be applied to allow for after-dark arrivals. In both cases this would effectively lead to double-counting of individuals. Indeed these observations support the argument for not applying a correction factor based on after-dark arrivals. This behaviour may prove more problematic when considering whether an individual site has held sufficient numbers of gulls upon which to build a case for statutory designation if it is considered that this should be based upon roosting numbers. However, it could be argued that pre-roost gathering sites, in addition to feeding and roosting sites, are also important to the conservation of a species.

1.2 Objective 2: Inshore Waters Survey

Objective two aimed to determine what proportion of the UK coastline needs to be sampled to provide an accurate and reasonably precise estimate of the numbers of gulls roosting on inshore waters away from major roosts, and how best to collect these data.

1.2.1 Inshore Waters Survey methods

In order to tackle the second objective, two near-continuous sets of tetrads (2-km by 2-km) were surveyed during January to March 2003. The first study area of 54 tetrads along the East Anglian coast was surveyed during January and February 2003 and the second study area of 32 tetrads along the coast in north-east England was surveyed during March 2003. These tetrads exclude areas identified as Key Sites in previous surveys by virtue of holding over 1,000 gulls. While the choice of these two study areas was largely dictated by practical and budgetary considerations it was assumed that they would differ substantially in character in terms of variation in gull number. However, it is not possible with existing data to say how close they are to the extremes. Each tetrad was surveyed by an observer who either walked along the beach or cliff-top, or accessed the shoreline at various places during the period two hours before dark. The number of gulls of each species roosting on the beach and on the sea was recorded for the area within the assigned tetrad. Birds were also recorded in the area further out to sea beyond the limit of the tetrad and an estimate of the distance of each flock from the shoreline was noted. Wherever possible, gulls roosting within the landward area of the tetrad were also recorded (*e.g.* on buildings or flooded marshes), although this was frequently not possible due to the nature of the terrain.

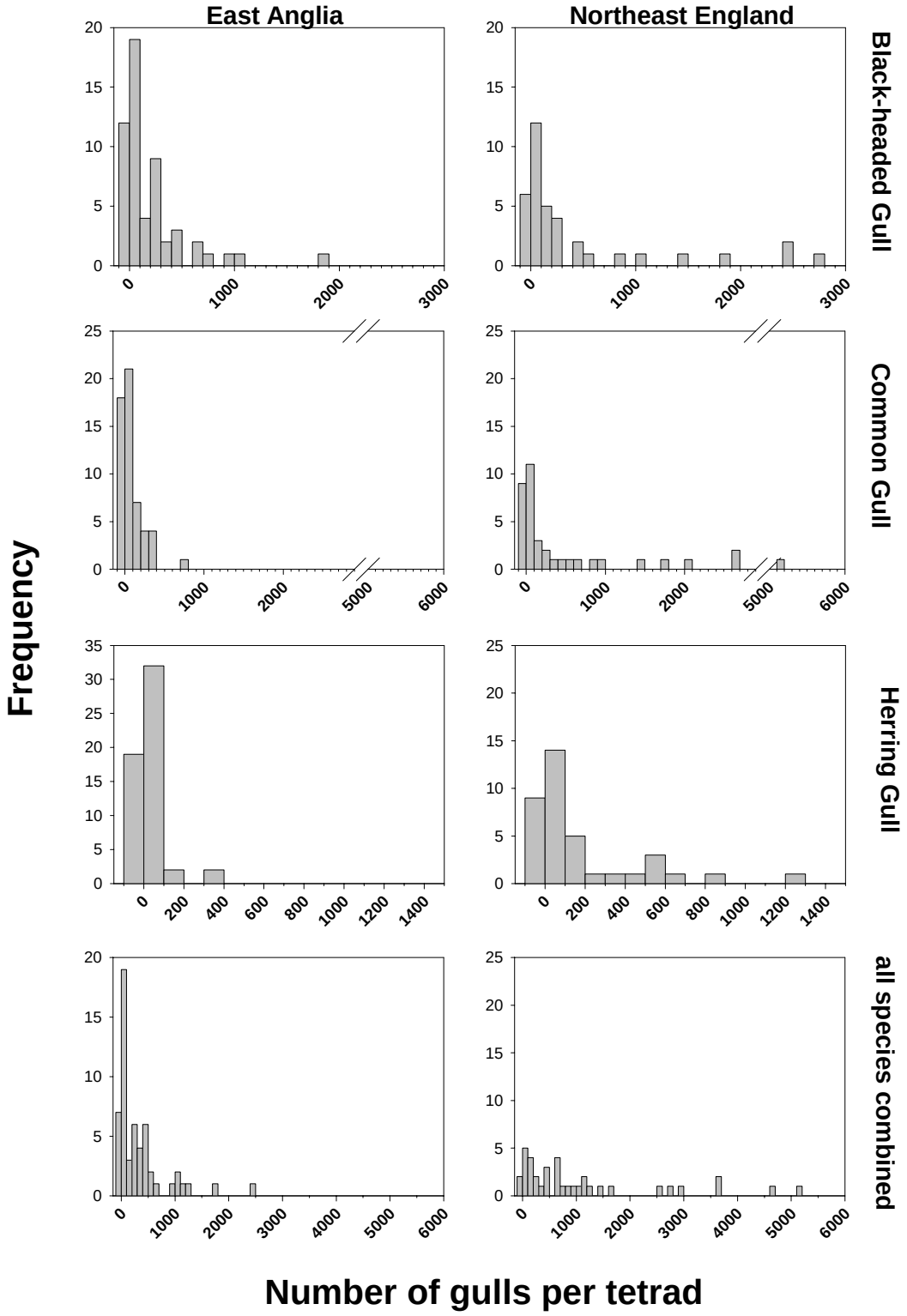
1.2.2 Inshore Waters Survey results

1.2.2.1 Number of gulls observed and arrival patterns

Approximately 18,000 gulls were counted along the East Anglian coastline, with Black-headed Gull being the most abundant accounting for 63% of the total. Common Gull accounted for another 27%, and Herring Gull another 8%. Approximately 44,000 gulls were counted along the coast of north-east England. Here, Common Gull was the most numerous species accounting for 47% of the total, Black-headed Gull another 37% and Herring Gull another 15%. Lesser Black-backed and Great Black-backed Gulls were recorded in comparatively small numbers in both regions. None of the observers reported any obvious habitat associations that might determine whether high or low numbers could be expected. In general, roosting flocks would begin to build up from about an hour before dusk, with most birds arriving from land or from other areas offshore during the hour before dusk. Towards dusk, there was a significant decline in the number of birds arriving, and it is therefore thought that comparatively few birds arrived after dark. It should be noted, however, that the results of this survey are limited to two areas of the UK coastline and distribution patterns and arrival behaviour may by different in other regions.

The numbers Black-headed Gull, Common Gull, Herring Gull and of all species combined within the sampled tetrads have frequency distributions approximating to Poisson - typical of count data (Figure 1.2.2.1). This suggests that individuals were not overlooked in tetrads containing few gulls. The majority of tetrads contained fewer than 1,000 gulls and the majority of these contained fewer than 500. The most frequent class for all species and all species combined was that of tetrads holding no more than 100 gulls. Few tetrads contained no gulls (seven in East Anglia and two in Northeast England) or more than 1,000 gulls (six in East Anglia and seven in Northeast England).

Figure 1.2.2.1 Frequency distribution of gull numbers found during the Pilot Inshore Waters Survey for sample tetrads in East Anglia (left) and Northeast England (right) for each of (top to bottom) Black-headed Gull, Common Gull, Herring Gull and all species combined. The latter includes these three species, Great Black-backed Gull, Lesser Black-backed Gull, Mediterranean Gull and those not identified to species. The height of each bar represents the number of tetrads falling within each 100-bird incremental class (1-100, 101-200, 201-300 *etc*). The class bar for tetrads containing no birds is plotted below zero.



1.2.2.2 Practical considerations and consequential methodological changes for WinGS

All of the observers involved in the pilot survey agreed that estimating the boundaries of the tetrads was extremely difficult and probably unreliable. It was particularly difficult to visualise the tetrad boundaries out to sea and it was often not possible to view the landward part of the tetrad during the same visit. Observers were also of the opinion that counts of gull flocks at distances greater than 1-km out to sea were unreliable. However, the pilot survey has shown that there were a significant number of gulls roosting along the coast away from the major known roost sites and so it will be important to include an estimate for such birds for the entire coast of the UK for inclusion in the overall UK gull population estimates.

Observers also agreed that it was extremely difficult to record gull arrival while walking along the coast for a number of reasons. Firstly, rechecking some flocks within tetrads indicated the continued arrivals could be easily missed while stretches of inshore waters were unsighted. Secondly, it would often take more than one hour between start and finish of the walk, the observer then being at a distance of more than 2-km from the start of the survey stretch which would then be unsighted. Thus, sampling of different parts of a single coastal stretch would often not be synchronous. Observers suggested that a much better understanding of gull arrival could be achieved from a single well chosen vantage point within the target coastal stretch.

As a result of these considerations, the methodology of pWinGS will be modified for WinGS. Counts will not be made of gulls within tetrad boundaries but rather of gulls visible from a fixed vantage point on the shore. No attempt will be made to include gulls on the landward side. The latter will now be surveyed by the inclusion of a "close proximity to coast" stratum within the Broad Scale Survey. For the inshore waters survey, observers will be issued grid references and asked to select a vantage point along the shore within 1-km of that grid reference and chosen to give good all round visibility of the inshore waters. The designated grid references will be regularly spaced along the coast separated by approximately 20-km "line of sight" distances (to avoid bias towards highly convoluted stretches of coastline). Observers will be asked to count all the gulls that they can detect on the inshore waters within an area that they will define. The boundaries of that area will be defined by the distance out to sea that they believe they have been able to survey accurately (we will recommended 1-km as a guideline) and by limits in either direction that the observers will indicate on a map with straight lines drawn perpendicular to the coast (we will recommend that these lines will cross the coast at a maximum of 1-km in either direction from the vantage point).

1.2.3 Analysis of counts

As the pWinGS data had been collected in such a way that several different methods of data collection could be assessed, it was possible to analyse these data as if they had been collected using the revised methodology. Thus counts obtained for tetrads were treated as if they had come from a stretch of coastline delimited by boundaries defined as above. Although this was not the case, it is reasonable to assume that for a length of coastline defined by the point at which a tetrad boundary crosses the coast, on average the area within that tetrad would be similar to that defined by lines perpendicular to the shore given that gulls beyond the perceived tetrad boundary had also been counted and few birds beyond 1-km had been recorded.

It will not be feasible to get complete coverage of the UK coast for WinGS and consequently a sampling approach will be used. In choosing the sample size two attributes of the resulting population estimate need to be considered. Firstly, the sample size that would be required to give an accurate

estimate and secondly, for a given sample size what precision can be expected. The data collected during the pWinGS were analysed with the aim of answering these questions. These two attributes are largely dependent on the variation in gull numbers found between individual samples, and in general the larger the sample size the greater the accuracy and precision that can be obtained.

1.2.4 Expected accuracy of Inshore Waters Survey with respect to sample size

The pWinGS data were first used to simulate surveys based on random samples of coast from the same areas. Random samples of from 2% to 10% inclusive at 1% increments and from 15% to 95% inclusive at 5% increments were chosen from the complete data. For each of these percentage levels 999 random samples without replacement were drawn. For each of these an estimate of the total number of each gull species along the entire coastline was derived by multiplying the total number of each species in the sample by the inverse of the proportion of the total coastline included in the sample. For a given species, for a given percentage coverage, the 25^{th} and 974^{th} highest values approximate to the extreme population estimates that would be expected from 95% of occasions and the 499^{th} highest value approximates to the median expected value. These values can then be compared with the total number of each species actually recorded for the complete survey, the latter being treated as if it were a real census to give an indication of how accurate we can expect a survey of a given proportional coverage of the coast to be (Figure 1.2.4.i to 1.2.4.v). Note that the sharp fall in the mean estimate for low values of percentage cover (typically <15%) indicates that at these levels the simulations have reached the limit of their reliability because so few coast stretches will be drawn to compile the random sample and the high probability that all of them will contain zero counts. Consequently, no conclusions should be made based on the results of less than 15% simulated coverage. This approach does not give an indication of the magnitude of the confidence interval that can be expected for a given percentage sampling effort (for magnitude of confidence intervals see next section - 1.2.5).

The simulation was run for each of the two regions separately and for the two regions combined. The latter provides an estimate of how the accuracy obtained from a sample covering the whole of the UK may be affected by between region differences in gull densities. However, a greater variation in gull density may be expected when data from other regions are included and thus the realised variation can be expected to be greater. Unfortunately, it was not feasible to collect broader scale data as part of the pWinGS fieldwork because the cost of travel between sites would have been prohibitive.

The results suggest that if we achieve less than about 20% coverage of the UK coastline we cannot be confident that the data collected will be sufficient to produce accurate estimates of the overall coastal populations of all five target species although those for Black-headed Gull and Herring Gull may be reasonably accurate if 15% or more of the coast were to be covered.

Figure 1.2.4.i Predicted accuracy of estimate for Black-headed Gull for a given percentage coastal coverage. The estimate that would have been obtained from a random sample of coastal stretches from those visited for pWinGS would lie within the limits indicated by the vertical bars on 95% of occasions.

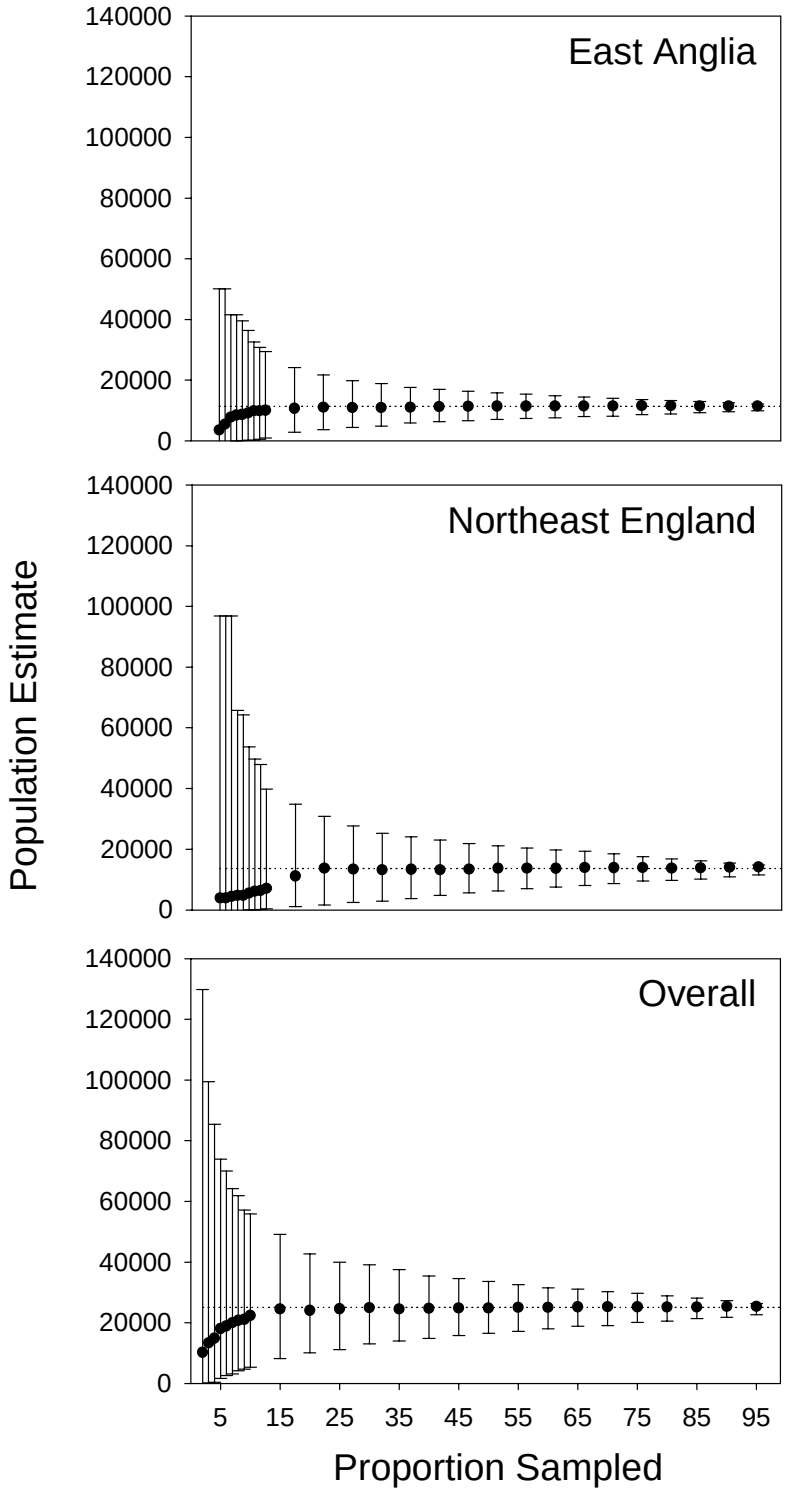


Figure 1.2.4.ii Predicted accuracy of estimate for Common Gull for a given percentage coastal coverage. The estimate that would have been obtained from a random sample of coastal stretches from those visited for pWinGS would lie within the limits indicated by the vertical bars on 95% of occasions.

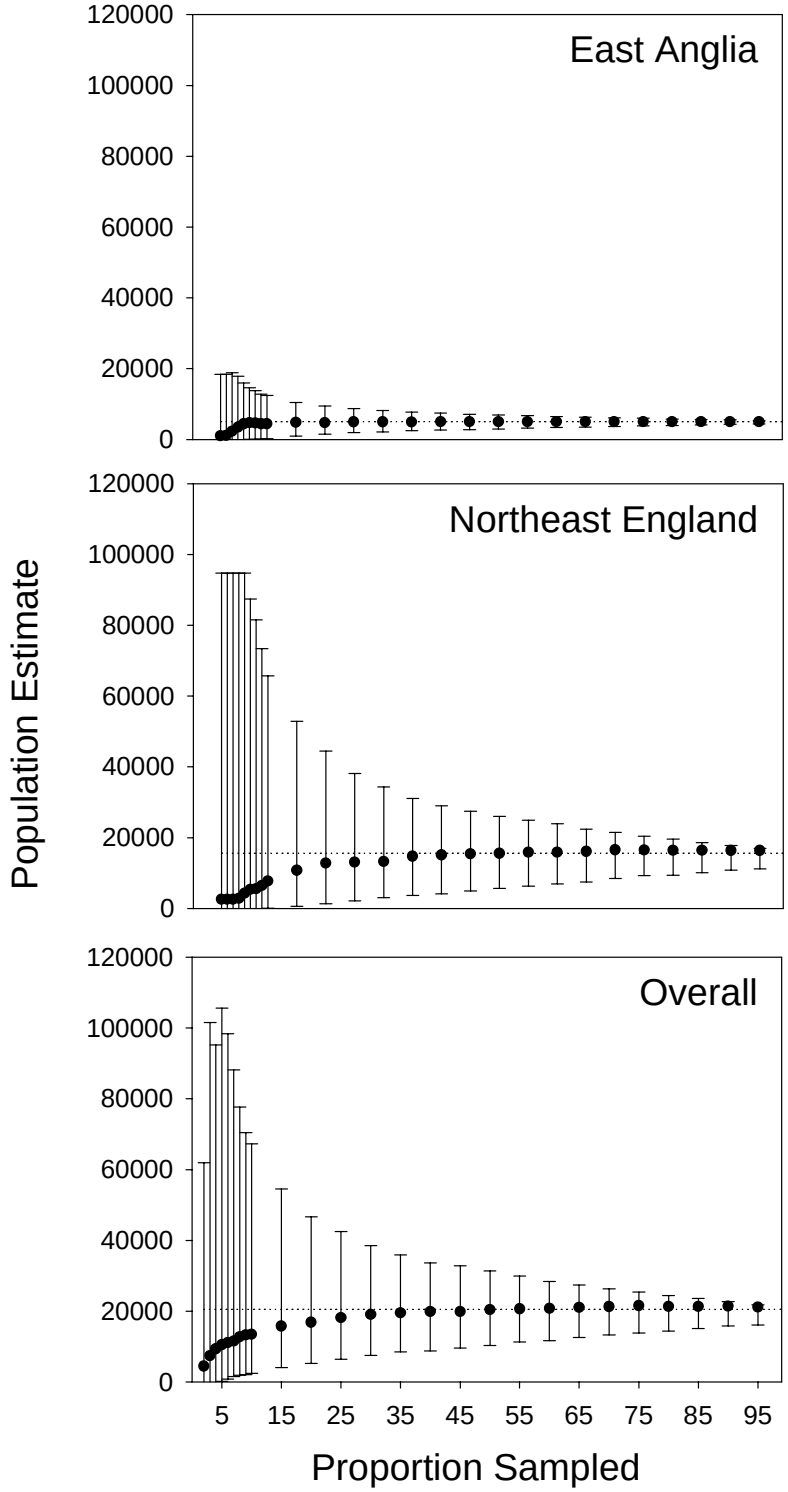


Figure 1.2.4.iii Predicted accuracy of estimate for Lesser Black-backed Gull for a given percentage coastal coverage. The estimate that would have been obtained from a random sample of coastal stretches from those visited for pWinGS would lie within the limits indicated by the vertical bars on 95% of occasions. Estimates for less than 5% were unreliable due to the small number of stretches on which this species was recorded.

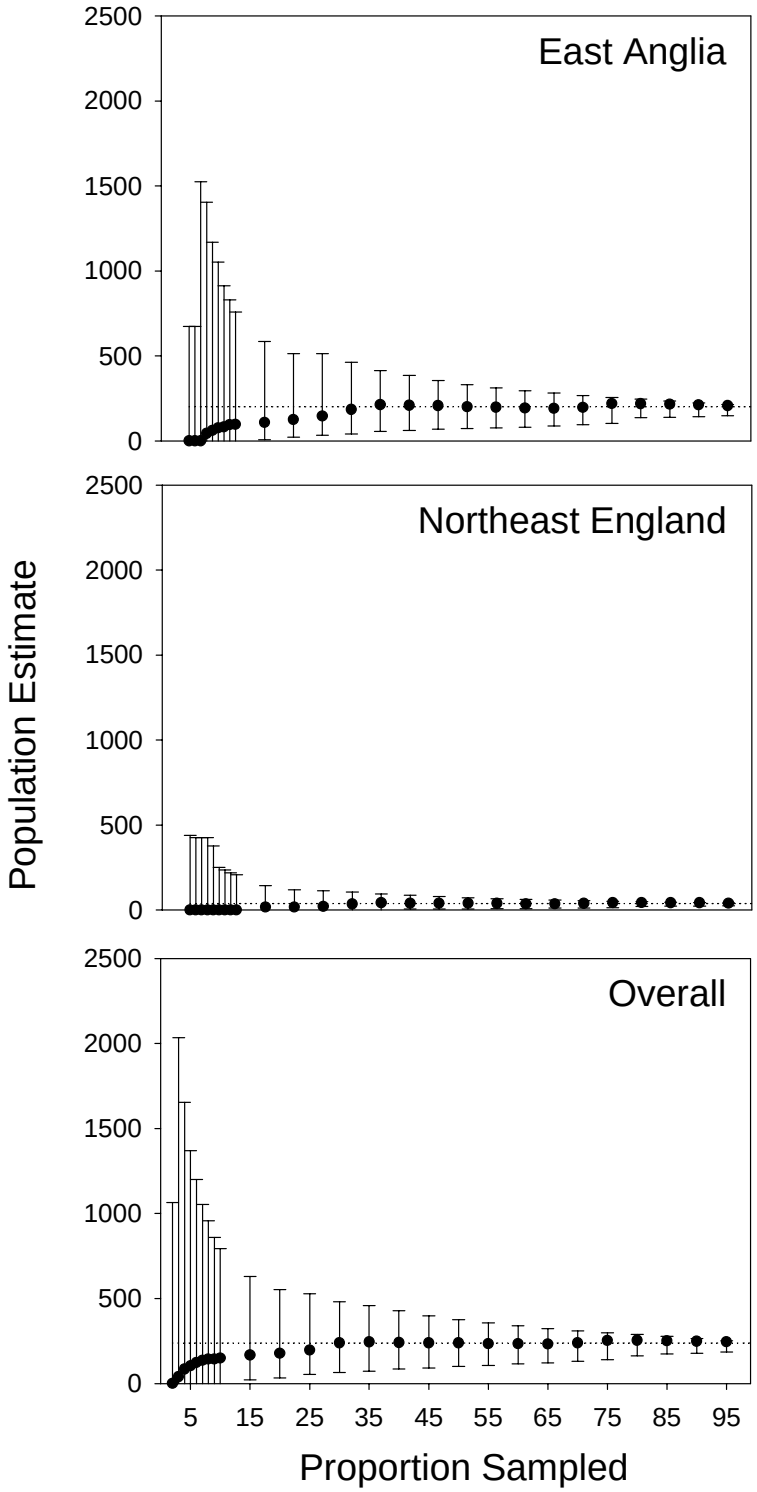


Figure 1.2.4.iv Predicted accuracy of estimate for Herring Gull for a given percentage coastal coverage. The estimate that would have been obtained from a random sample of coastal stretches from those visited for pWinGS would lie within the limits indicated by the vertical bars on 95% of occasions.

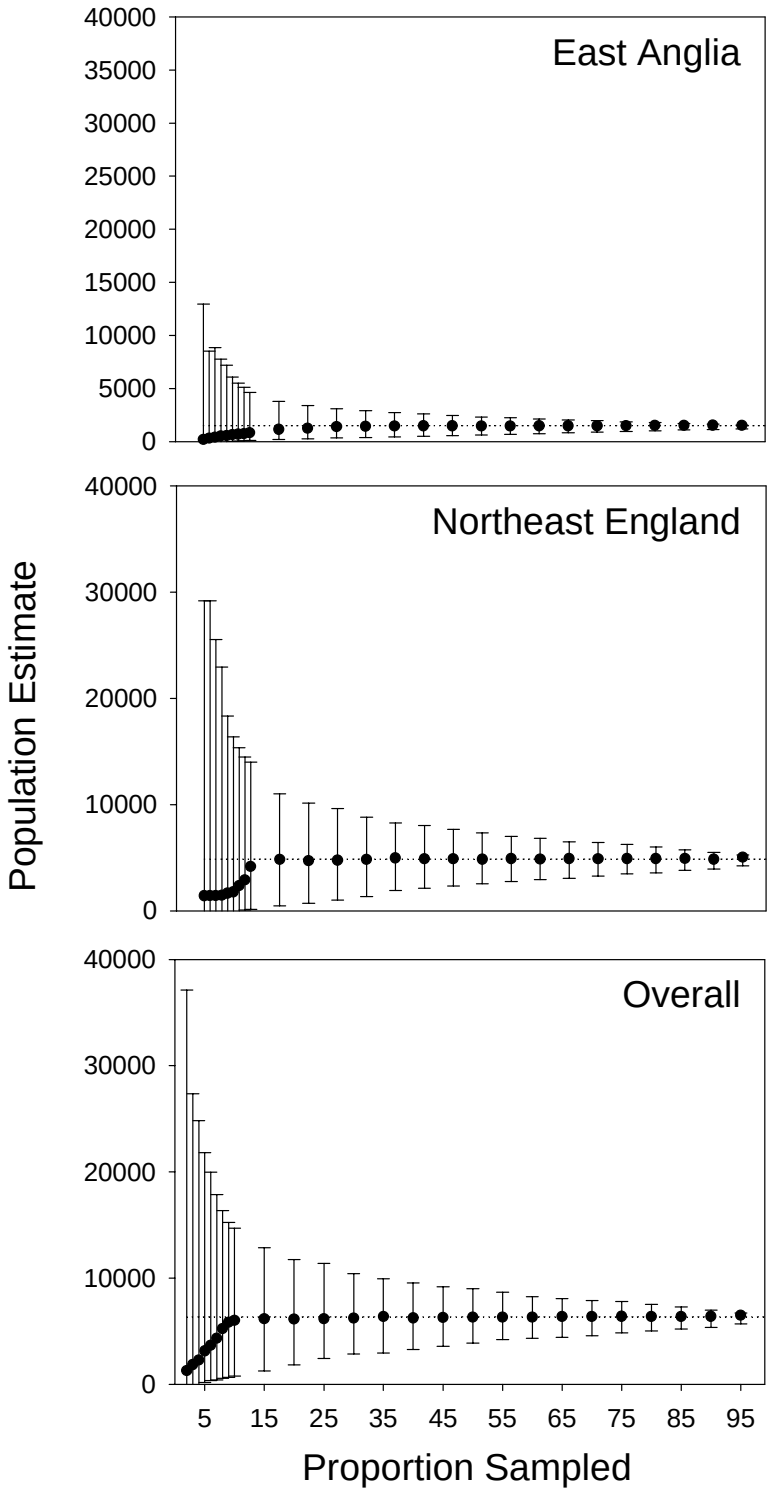
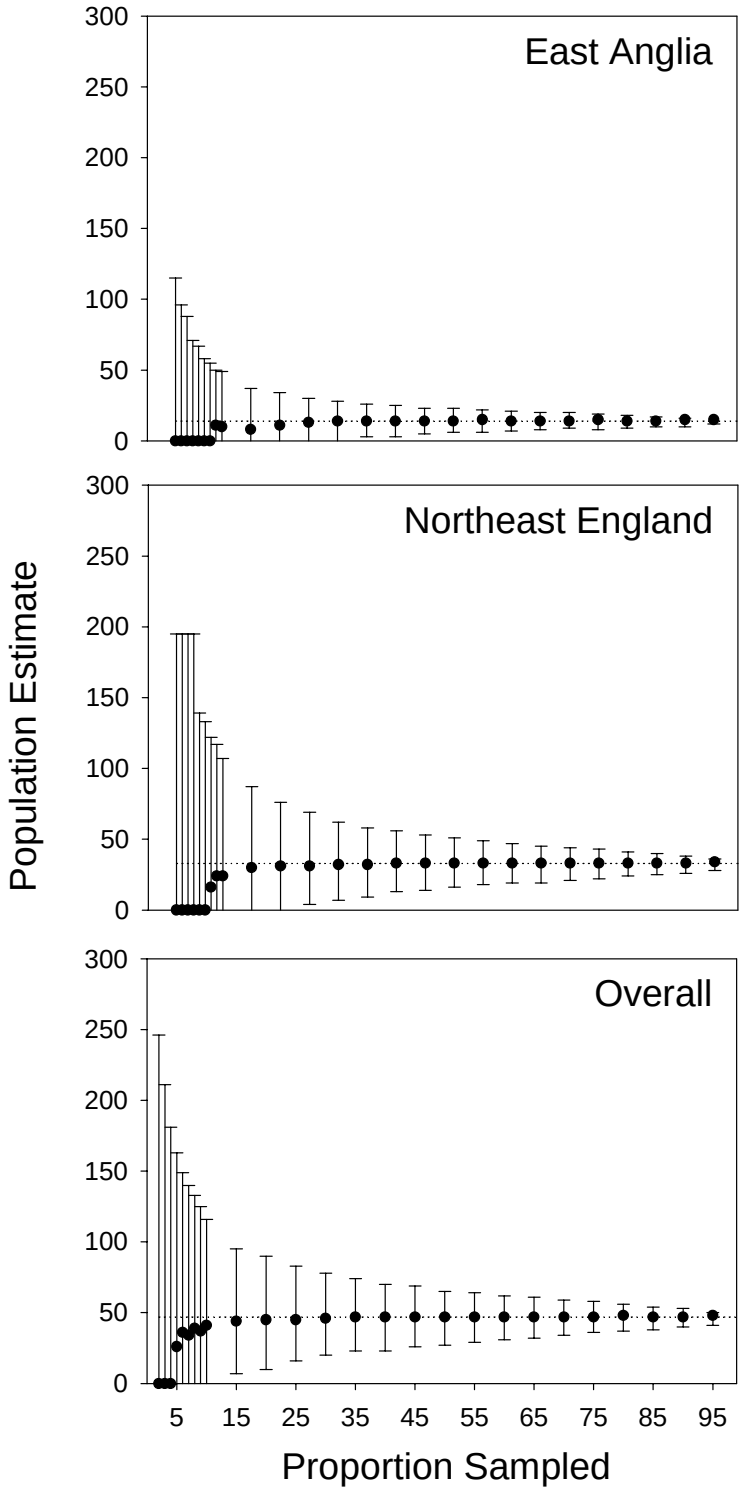


Figure 1.2.4.v Predicted accuracy of estimate for Great Black-backed Gull for a given percentage coastal coverage. The estimate that would have been obtained from a random sample of coastal stretches from those visited for pWinGS would lie within the limits indicated by the vertical bars on 95% of occasions. Estimates for less than 5% were unreliable due to the small number of stretches on which this species was recorded.



1.2.5 Expected precision of Inshore Waters Survey with respect to sample size

The simulation discussed gives an indication of how close to the actual population an estimate, made from a sample of a particular percentage cover of coast, can be expected to be. In the actual survey such an estimate will then have confidence limits attached to it that will be based on a bootstrap analysis of the data. This will be obtained using a similar approach to that used for the previous simulation except that a random sample with replacement will be used (the simulation above was based on a random sample without replacement). For each species, when the resulting 999 estimates are sorted in ascending order, the 499th value will be taken as the estimate and the 25th and 974th values respectively as the lower and upper 95% confidence limits of that estimate.

Thus in order to get an indication of how the magnitude of the confidence limits may change with the percentage of coast coverage achieved a second bootstrap simulation was done for each species using similar percentage coverage increments to those used for the estimation of accuracy. Again 999 random samples without replacement were drawn from the complete data set for each of the percentage cover increments. Each sample was taken to represent a sample of the total coast chosen at random for the forthcoming WinGS survey. However this time, from each of these random samples without replacement, a second random sample with replacement was drawn. For each region, the sample was drawn until the cumulative length of the coastal stretches selected equated to the total coastal length that would not have been covered under the percentage cover increment in question, and then the total number of each species in this sample calculated. This was taken as a single estimate of gull numbers on that part of the coast that was not "visited" and then added to the total number of birds counted on the stretches that were "visited". Thus this approach was not a precise match for the bootstrap analysis that will ultimately be used for the final survey, as that will be based on 999 samples with replacement of a single selection of coastal stretches chosen at random. However, it does give an estimate of how wide the confidence limits of the final estimate might be. For each species at each increment of percentage coverage, the difference between the 25th and the 974th highest values was taken as an indication of the magnitude of the 95% confidence limits that can be expected for a survey of that size (Figure 1.2.5.i to 1.2.5.v).

Again, the simulation was run for each of the two regions separately and for the two regions combined, the latter to provide an estimate of how the precision obtained from a sample covering the whole of the UK may be affected by between region differences in gull densities. Again, this estimate will be conservative.

Due to the practicalities of obtaining volunteer coverage of coastal stretches it was felt that a maximum of 20% coverage of the UK coast would be a reasonable target. The results suggest that at this level of coverage the IWS is likely to produce confidence limits in the region of +/- 50% of the estimate for the most numerous species, Black-headed Gull and Common Gull, and +/- 60% for Herring Gull. Due to the small number of count stretches on which Lesser Black-backed and Great Black-backed Gulls were recorded it is difficult to draw conclusions from the results for these species.

Figure 1.2.5.i Predicted precision of estimate for Black-headed Gull for a given percentage coastal coverage. Confidence intervals will be attached to the point estimate produced from a single random sample of the UK coastline for WinGS. The expected magnitude of these confidence intervals, expressed below as a percentage of the point estimate, were assessed from data collected for pWinGS. Thus for example, the confidence interval on the estimate from the combined East Anglia and Northeast data can be expected to be approximately - 40% to +60% of that estimate given the targeted 20% coverage (indicated by vertical dotted line).

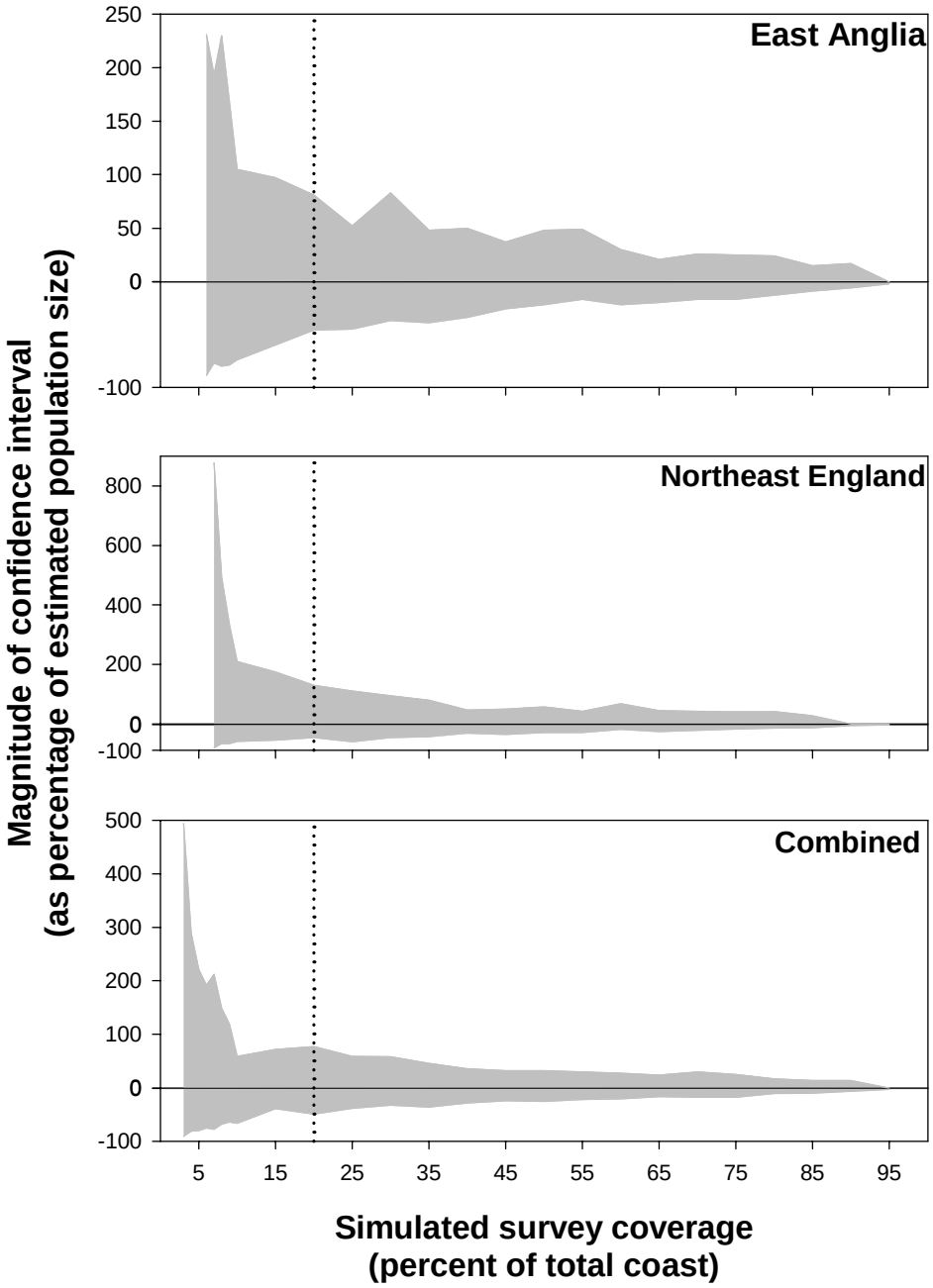


Figure 1.2.5.ii Predicted precision of estimate for Common Gull for a given percentage coastal coverage. Confidence intervals will be attached to the point estimate produced from a single random sample of the UK coastline for WinGS. The expected magnitude of these confidence intervals, expressed below as a percentage of the point estimate, were assessed from data collected for pWinGS. Thus for example, the confidence interval on the estimate from the combined East Anglia and Northeast data can be expected to be approximately - 50% to +120% of that estimate given the targeted 20% coverage (indicated by vertical dotted line).

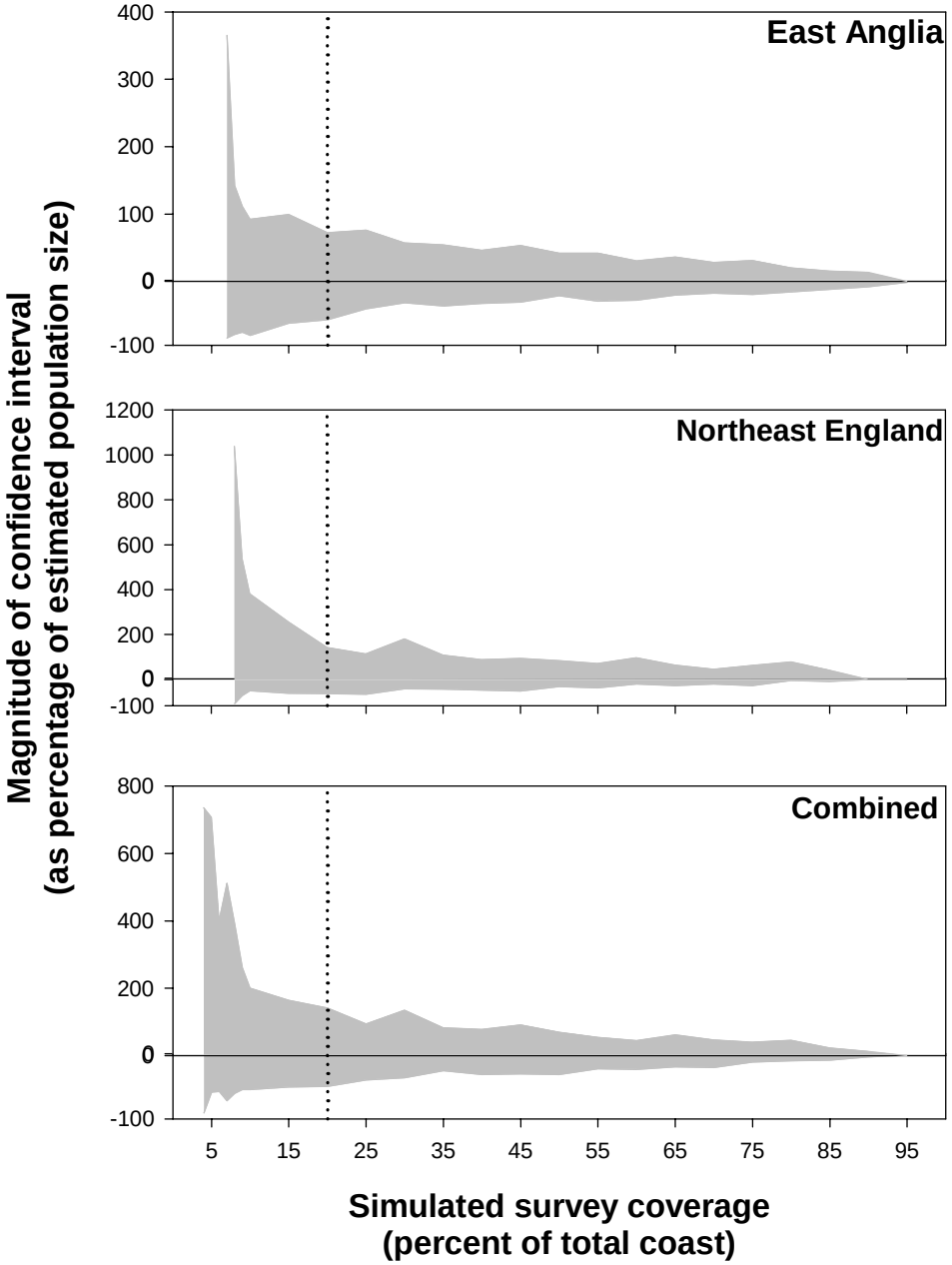


Figure 1.2.5.iii Predicted precision of estimate for Lesser Black-backed Gull for a given percentage coastal coverage. Confidence intervals will be attached to the point estimate produced from a single random sample of the UK coastline for WinGS. The expected magnitude of these confidence intervals, expressed below as a percentage of the point estimate, were assessed from data collected for pWinGS. Given the low encounter rate for this species in the pWinGS data it has not been possible to assess the precision that might be expected for the targeted 20% coverage (indicated by vertical dotted line).

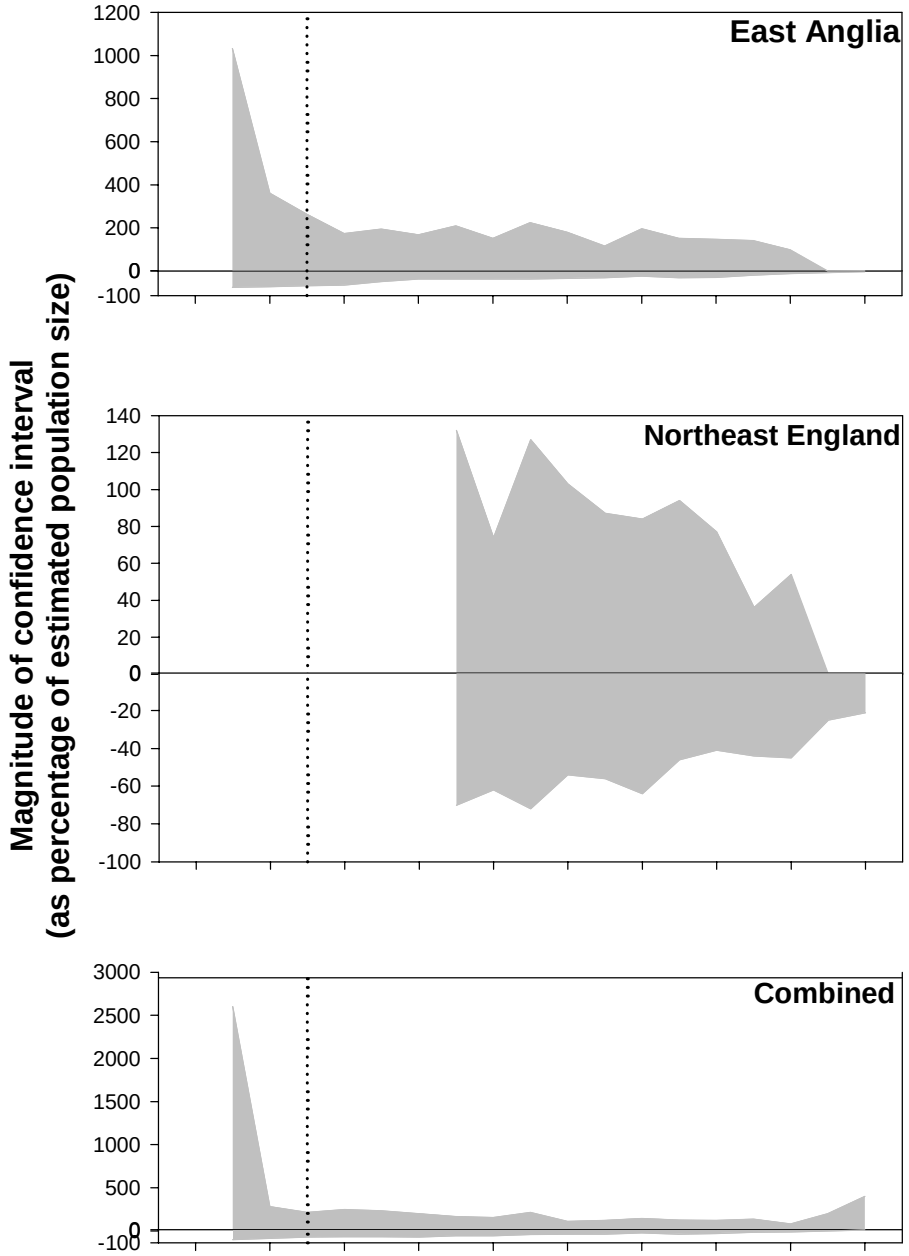


Figure 1.2.5.iv Predicted precision of estimate for Herring Gull for a given percentage coastal coverage. Confidence intervals will be attached to the point estimate produced from a single random sample of the UK coastline for WinGS. The expected magnitude of these confidence intervals, expressed below as a percentage of the point estimate, were assessed from data collected for pWinGS. Thus for example, the confidence interval on the estimate from the combined East Anglia and Northeast data can be expected to be approximately - 50% to +70% of that estimate given the targeted 20% coverage (indicated by vertical dotted line).

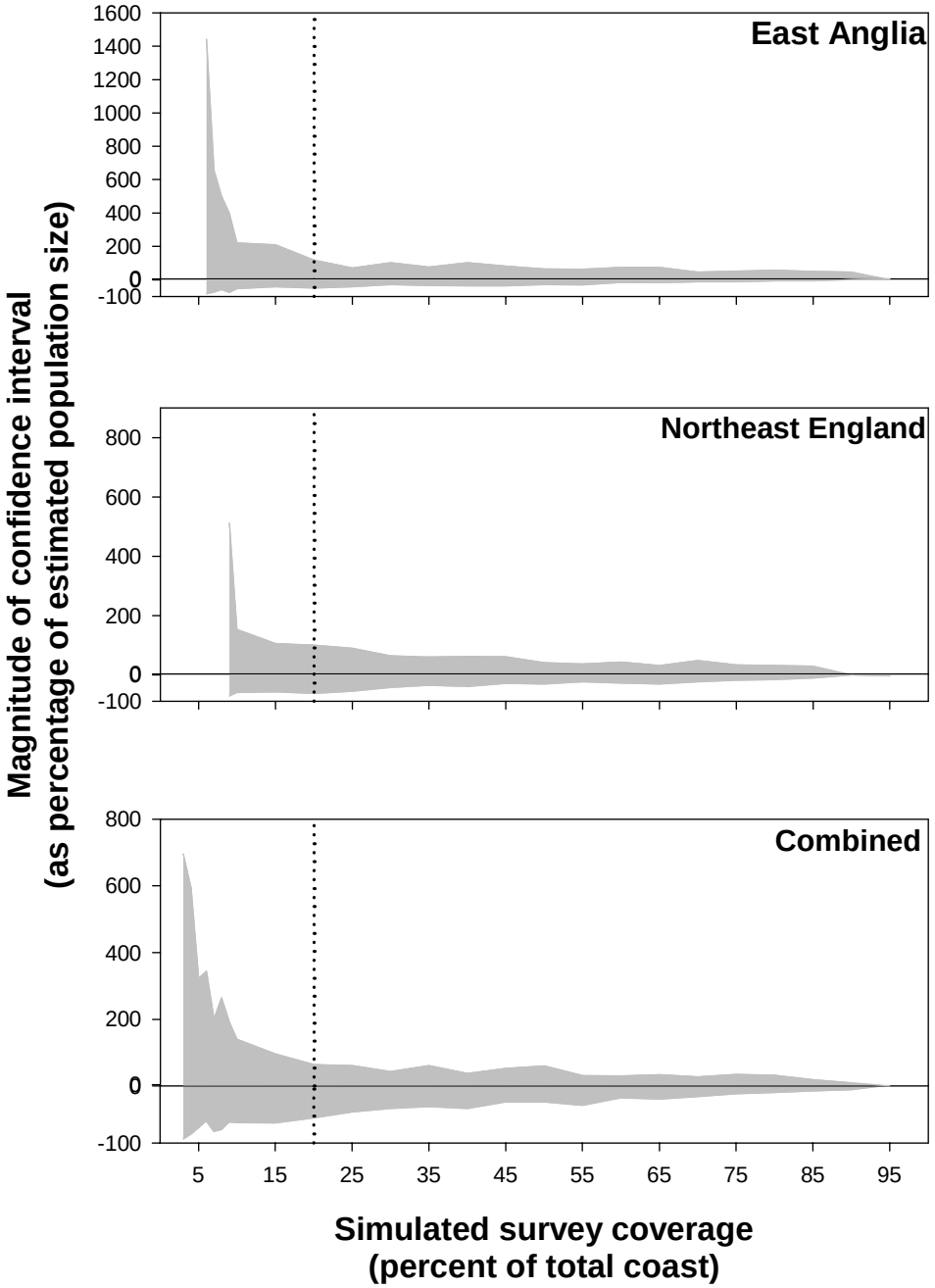
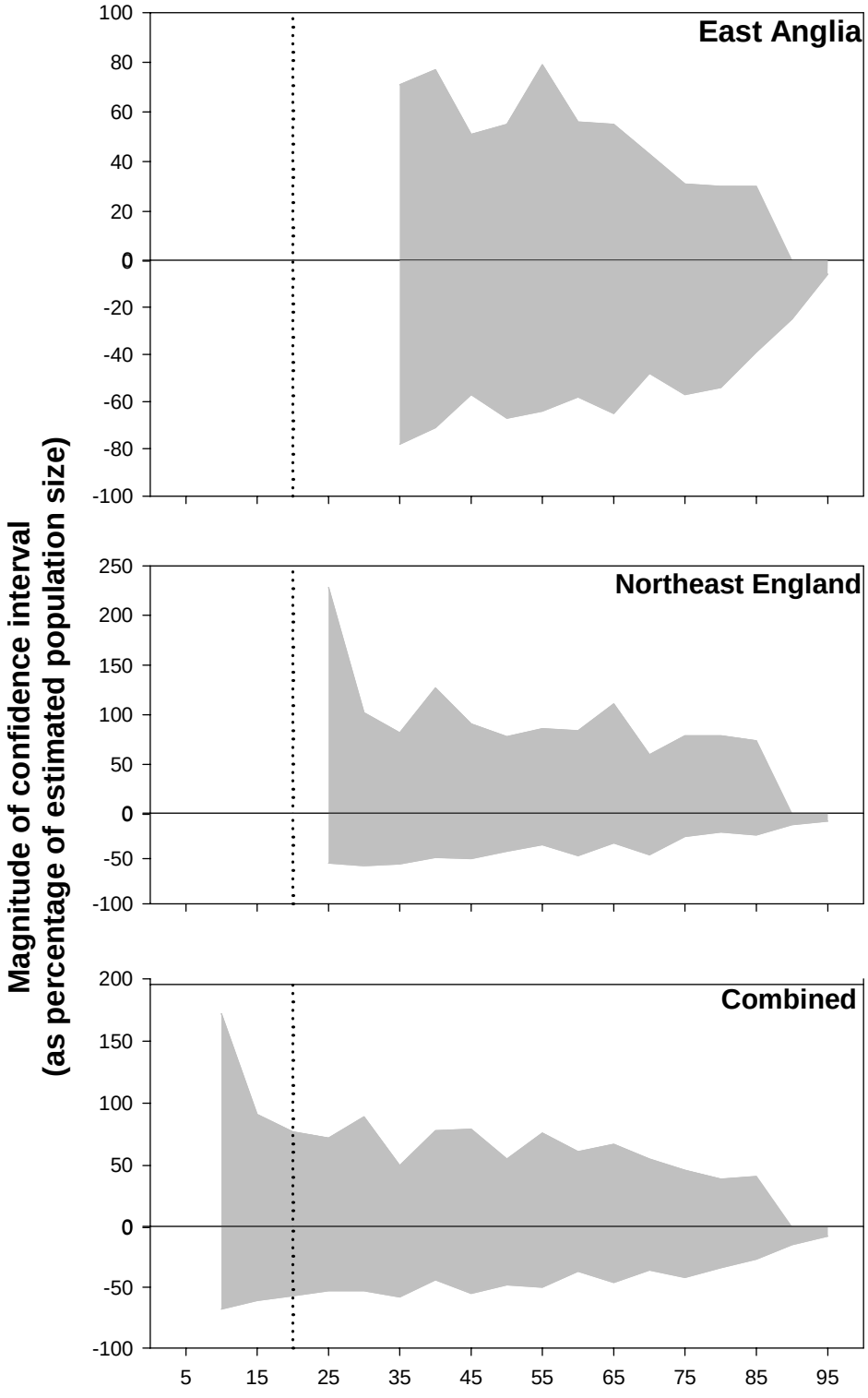


Figure 1.2.5.v Predicted precision of estimate for Great Black-backed Gull for a given percentage coastal coverage. Confidence intervals will be attached to the point estimate produced from a single random sample of the UK coastline for WinGS. The expected magnitude of these confidence intervals, expressed below as a percentage of the point estimate, were assessed from data collected for pWinGS. Given the low encounter rate for this species in the pWinGS data it has not been possible to assess the precision that might be expected for the targeted 20% coverage (indicated by vertical dotted line).



PART 2: STRATEGY FOR THE WINTER GULL ROOST SURVEY

2.1 Survey Structure

The four components of the WinGS are planned to run in parallel during the winter of 2003/04. The main counts will be scheduled to take place during January with TWCs between September and March at Key Sites. Results of the Key Sites Survey (KSS), the Broad Scale Surveys (BSS) and the Inshore Waters Survey (IWS) will be brought together to produce a single UK population estimate for each species. The plans for the forthcoming WinGS are more ambitious than those for previous winter gull surveys had been but if successful will produce an more complete understanding of gull numbers than has previously been available. However, it is essential to ensure that the KSS, which will be comparable with past surveys and therefore could stand alone, is not compromised as a result of counter resources being spread too thinly in order to target the other components. To avoid this the various components of the overall WinGS will be prioritised.

Highest priority will be given to obtaining cover for the KSS because, even without the results of the other two components, this will allow comparison with previous surveys. The BSS will be given priority over the IWS as this will complete our understanding of inland gull numbers and distribution. However, further funding needs to be sought to allow any shortfall from any of these three components to be addressed by further counts during the winter of 2004/05 and possibly 2005/06. If this approach is taken it will be most defensible if the areas covered in different winters are as distinct and possible. Lowest priority will be given to the Through the Winter Counts (TWCs). While we intend to encourage observers involved in the KSS to make additional counts throughout the winter these will be optional because, although they will increase our understanding of temporal variation in gull numbers, they are not essential for obtaining population estimates.

All components of WinGS will aim to use volunteer observers as in previous winter gull surveys. The survey will be organised within the framework of the BTO Regional Network although we will also be contacting individuals involved in organising the 1993 winter gull survey where these were not the BTO Regional Representative. However, because it has proved difficult to get coverage of all major roosts in previous surveys (Burton *et al.* in press) and because this survey is more ambitious in its scope, funds are being sought to enable professional counters to be employed to supplement the volunteer effort. It is essential that these professional counters are used in the most efficient manner and so the bulk of professional effort will be targeted towards counting at KKS sites for which it has not been possible to recruit sufficient volunteer coverage. Any surplus professional capacity will then be directed towards the BSS tetrads.

2.2 Key Sites Survey

The KSS will survey pre-selected sites identified from previous surveys as major gull roosts. All sites where greater than 1,000 gulls (of all species) were recorded during any one of the previous surveys will be targeted. A single count during January 2004 will be required but observers will be encouraged to supply additional periodic counts between September and March (TWCs). No professional observer effort will be directed towards additional counts outwith January.

Observations of known inland roosts in previous winter gull surveys have typically only recorded numbers of gulls on waterbodies. In order to allow the KSS to be integrated efficiently with the BSS, boundaries will be defined using tetrads around the waterbodies. Separate counts will be recorded for each distinct waterbody and a further count made of any gulls in other parts of the tetrad. This will allow direct comparison with previous surveys as well as effectively providing data for an "adjacent to major roosts" stratum for the BSS. Observers will be supplied with customised data recording sheets which will include a map of the site in question and detailed instructions.

In order to plan the forthcoming survey a geographically referenced database has been partially compiled in the ArcView Geographic Information System (GIS). The WinGS GIS database will be

completed once funding for the forthcoming survey has been confirmed and will be used to store the relationships between the site boundaries defined during previous surveys and those used for the KSS, the locations of the BSS tetrads and IWS coastal stretches. This database will also be used to store the data collected during the forthcoming survey.

2.3 Broad Scale Survey

The BSS will aim to estimate the numbers of gulls roosting on small sites not targeted by the KSS and those larger sites for which observer cover could not be arranged. This estimate will be obtained from gull counts made at a randomised stratified sample of tetrads. The methods employed to count gulls on these tetrads will be identical to those used on the KSS sites i.e. separate counts made for each waterbody and for the remainder of the tetrad. As for the KSS, observers will be supplied with customised data recording forms that include a map of the tetrad.

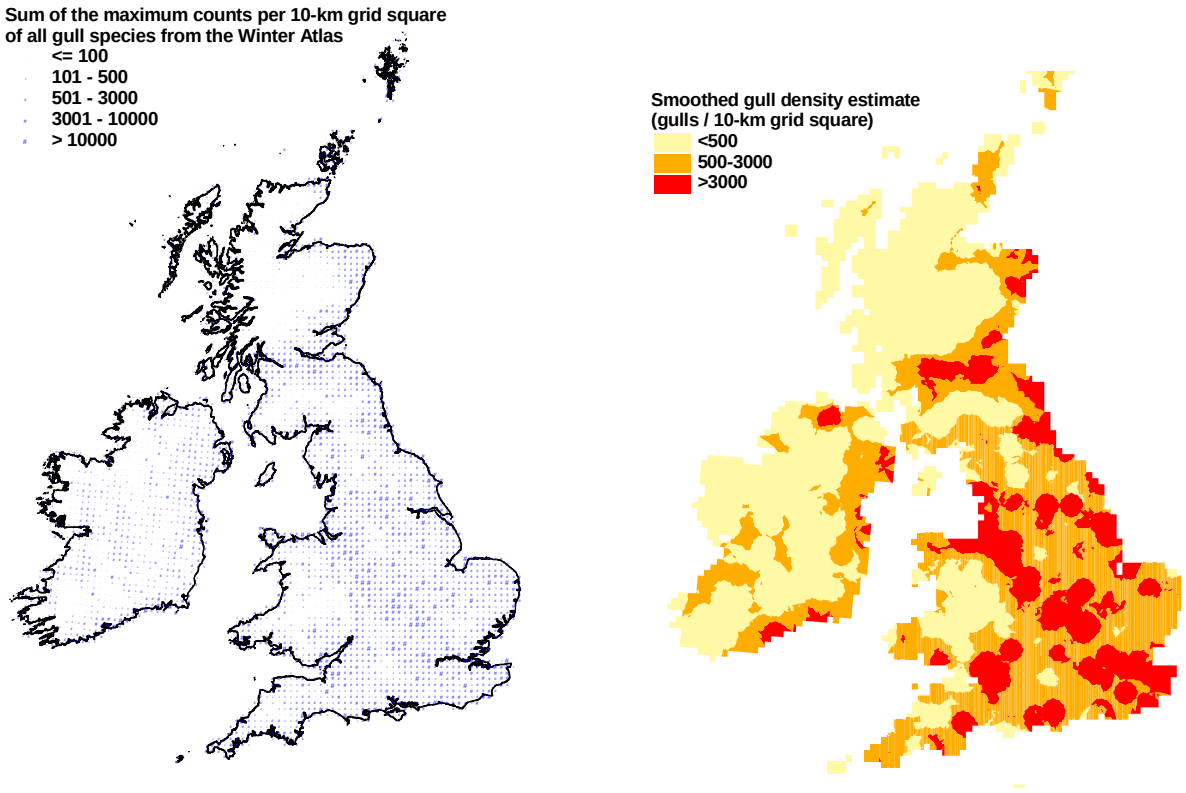
2.3.1 BSS stratification

The stratification to be used has been based on winter gull distribution data derived from The Atlas of Wintering Birds in Britain and Ireland (Lack 1986), hereafter referred to as the Winter Atlas, and freshwater cover data derived from the CEH Landclass 2000 database (Fuller *et al.* 2002). Both of these are factors that might reasonably be expected to have a relationship to the between tetrad variation in the numbers of gulls likely to be counted. Adopting such a stratification should minimise the magnitude of the confidence limits that will be attached to the resulting population estimates while ensuring that the wide spectrum of UK habitats are surveyed.

The Winter Atlas covered the whole of Britain and Ireland at a 10-km resolution. The Winter Atlas maximum count data for gulls were imported into the WinGS GIS and numbers of all gull species summed for each 10-km grid square (Figure 2.3.1.1.a). These data were then smoothed by "Kriging" (a spatially aware data interpolation facility within ArcView GIS: ESRI 2003) and the resulting gull-density surface classified into three categories representing Low (0 – 500 gulls/10-km grid), Medium (501 – 3,000 gulls/10-km grid) and High (>3,000 gulls/10-km grid) gull densities (Figure 2.3.1.1.b). Output resolution of the smoothed gridded output from this process was set to 2-km in order to co-inside with the tetrads defining the boundaries of Key Sites. All tetrads within the UK were then assigned a value representing their class in this classification.

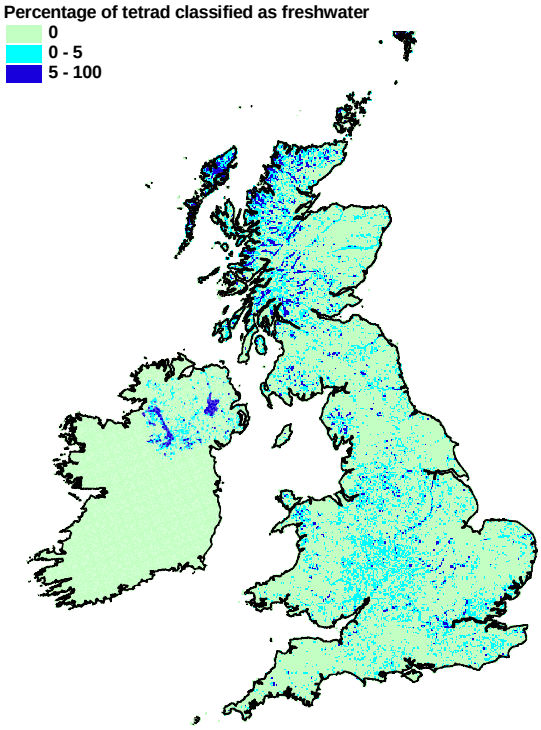
Figure 2.3.1.1 Frequency distribution across the three class gull density classification of UK tetrads. This classification was one of three layers of information used to derive the ultimate stratification of tetrads throughout the UK for the BSS. Winter gull density was classified by assigning each tetrad a value in terms of gulls / 10-km obtained from the smoothed Winter Atlas data. The raw data is included for comparison.

a) b)



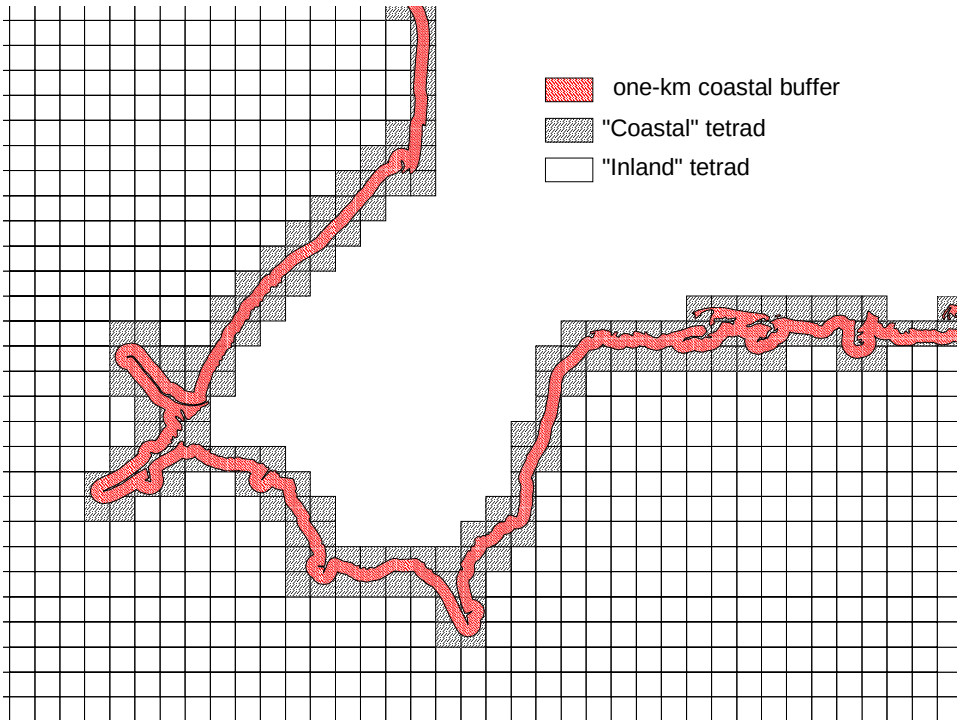
The CEH2000 data cover the whole of the UK at a 1-km resolution. The freshwater cover data were also imported into the WinGS GIS, summarised to a tetrad resolution, and re-classified according to percentage water cover into "No Water", "Low Water" (>0%, <=5%) and "High Water" (>5%) (Figure 2.3.1.2).

Figure 2.3.1.2 Frequency distribution across the three class "percentage freshwater cover" classification of UK tetrads. This classification was one of three layers of information used to derive the ultimate stratification of tetrads throughout the UK for the BSS. Freshwater cover was derived from the CEH2000 Landclass classification.



It is possible that the numbers of gulls on tetrads in close proximity to the coast would be consistently different to tetrads further inland. Thus tetrads were further classified by coastal proximity using a 1-km buffer to the landward side of the coast. All tetrads that clipped this buffer were classified as "coastal" while those which did not were classified as "inland" (e.g. Figure 2.3.1.3).

Figure 2.3.1.3 Example of 1-km coastal buffer used to assign UK tetrads as coastal or inland. This classification was one of three layers of information used to derive the ultimate stratification of tetrads throughout the UK for the BSS. All tetrads that clipped the 1-km (in from coast) buffer were assigned to the coastal class the remaining tetrads being assigned to the inland class.



The gull-density classification and the freshwater cover classification were superimposed on tetrads not in close proximity to the coast to give nine "inland" strata and the gull-density classification alone was superimposed on the remaining tetrads to derive a further three "coastal" strata. This gave a 12 strata classification (Figure 2.3.1.4; Table 2.3.1.1) for the purposes of targeting sampling effort to which one further stratum - the "adjacent to major roosts" stratum from the KSS, will be added for analysis purposes.

Figure 2.3.1.4 Distribution across the 12 class stratification of UK tetrads. This stratification was derived by overlaying the three layers of information representing Winter Atlas gull density (Figure 2.3.1.1), freshwater cover (Figure 2.3.1.2) and coastal proximity (Figure 2.3.1.3). The frequency distribution of tetrads across this stratification is tabulated below (Table 2.3.1.1)

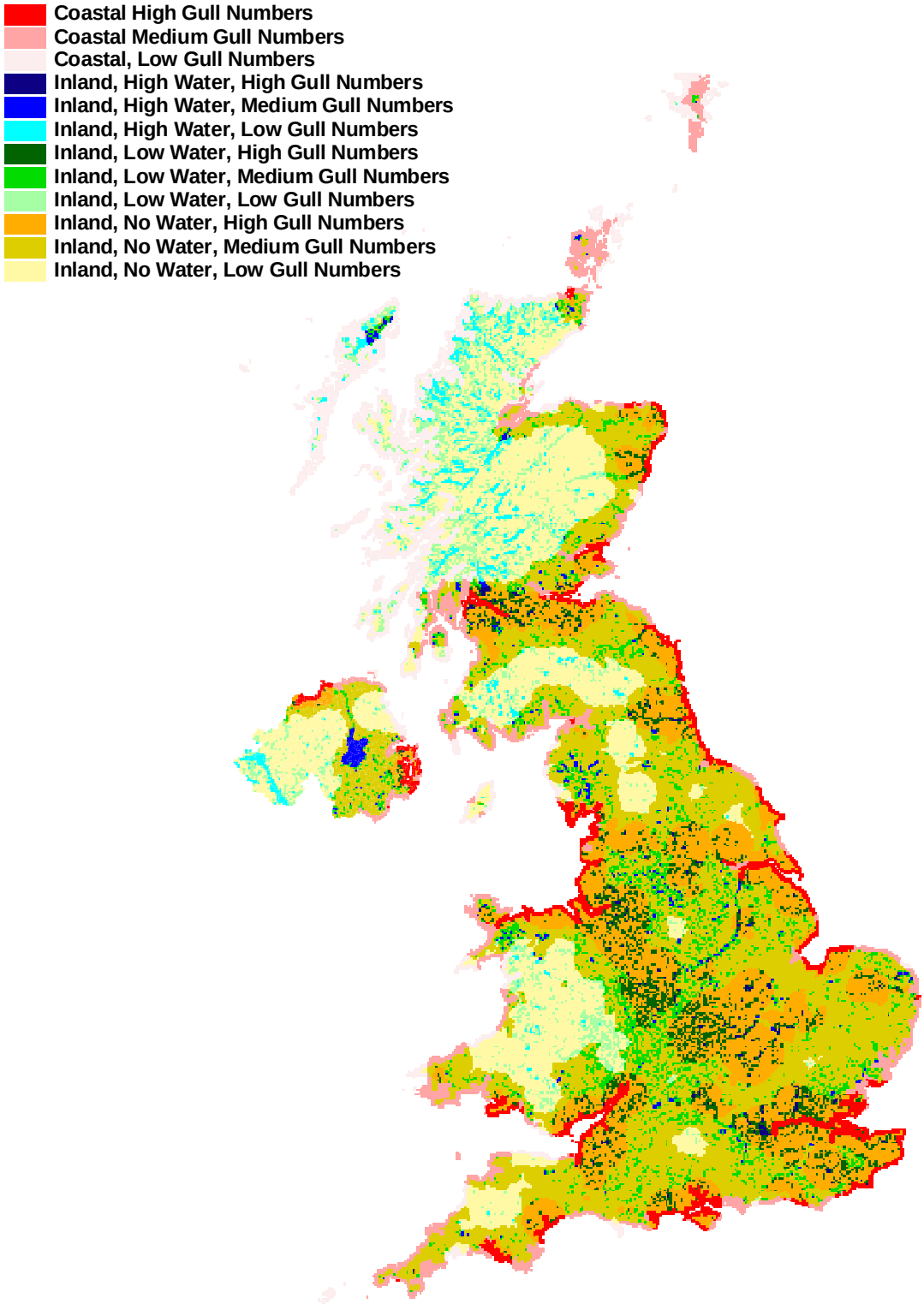


Table 2.3.1.1 Frequency distribution across BSS strata of UK tetrads. Winter gull density is classified in terms of gulls / 10-km obtained from the smoothed Winter Atlas data. Freshwater coverage is classified as None, Low and Medium based on the percentage coverage for the four 1-km grid squares comprising the tetrad as recorded in the CEH2000 Land Classification. Tetrads are defined as Coastal when they clip the boundary of a 1-km buffer in from the coast. CH = Coastal High Gull Numbers; CM = Coastal Medium Gull Numbers; CL = Coastal Low Gull Numbers; IHH = Inland, High Water, High Gull Numbers; IHM = Inland, High Water, Medium Gull Numbers; IHL = Inland, High Water, Low Gull Numbers; ILH = Inland, Low Water, High Gull Numbers; ILM = Inland, Low Water, Medium Gull Numbers; ILL = Inland, Low Water, Low Gull Numbers; INH = Inland, No Water, High Gull Numbers; INM = Inland, No Water, Medium Gull Numbers; INL = Inland, No Water, Low Gull Numbers.

Coastal / Inland (Coastal=tetrad coming to within 1-km of the coast)	**Inland Water Coverage - from CEH2000**	**Gull density - from Winter Atlas (density measured as gulls/10-km sq)**					
		Low <=500 / 10-km		**Medium >500-3000 / 10-km**		**High >3000 / 10-km**	
Inland	None	INL	12053	INM	18789	INH	10298
Inland	Low (<=5%)	ILL	3512	ILM	3996	ILH	2989
Inland	High (>5%)	IHL	1297	IHM	618	IHH	323
Coastal	N/A	CL	5188	CM	3805	CH	2791

Available data does not allow an assessment to be made of the variability in gull counts that can be expected within each stratum. Thus, it is not possible to obtain estimates for the number of tetrads to be sampled within each stratum. Consequently, the overall sample will be distributed equally between all 12 strata. It is felt that during January 2004 a sample of 50 tetrads should be targeted in each stratum. This means that 600 tetrads will need to be visited which is probably the maximum we could hope to achieve given that priority must go to the KSS. In the unlikely event of a surplus capacity of observers then additional tetrads would be targeted in the larger strata. If the sample for a given stratum proves to be inadequate, because a higher than average degree of variation in counts between tetrads leads to unacceptably wide confidence limits, then additional funding may be sought to increase the sample the following winter.

2.4 Inshore Waters Survey

In addition to large inland gull roosts, the KSS will also target large coastal roosts. The latter have only been included in the last two winter gull surveys (1983 and 1993) and have been less thoroughly covered than those inland. As with inland sites, all known major coastal roost sites will be covered by the KSS. The aim of the IWS is to supplement KSS counts of coastal roosts in a similar manner to the way the BSS will aim to supplement KSS count for inland sites. The proposed methodology of data collection for the IWS was described in section 1.2.2.2. We are proposing that 400 coastal stretches should be targeted in each of the next three winters to give a sample of 1,200 which, at approximately 2-km each would approximate to 20% of the UK coast not being covered by the KSS. During January 2004 those coastal stretches in regions with least demand arising from the KSS and BSS may be targeted for the IWS, although the main thrust of this survey will be during January 2005 with a "gap-filling" / supplementary exercise in January 2006.

This will be a major undertaking, covering approximately 2,400-km of coastline, although it is a target that previous BTO organised surveys have surpassed (e.g. the Non-estuarine Waterbird Survey, 1998, achieved 32% coverage of the UK's non-estuarine coast). Because the main thrust for the IWS will be in winter-two, this will allow time to conduct a preliminary analysis of IWS data in order to reassess the expected precision and accuracy based on a much larger and more varied sample than obtained for pWinGS. If necessary, resources could be redirected towards or increased for the IWS in winter-three.

The Low, Medium and High gull-density stratification used for coastal tetrads for the BSS will also be used to stratify coastal stretches for the IWS. At the local scale the strength of the correlations between the size of inland, coastal and inshore roosts may be quite weak, because of the availability of freshwater roosts and movements between feeding and roosting sites. However, at the low resolution of the gull-density stratification, correlations are likely to be stronger. This will enable effort to be targeted towards those coastlines most likely to hold high gull numbers without biasing the resulting estimates (e.g. stratum and sample: High 600; Medium 400; Low 200). The preliminary analysis of winter-two will also allow an assessment of how successful this stratification has been in minimising the effect of variation in counts and, if necessary, effort can be redirected in winter-three.

It is intended that the organisation and data collection for the coastal sites counted under the IWS will be integrated as far as possible with the organisation and data collection of coastal sites being covered for the KSS. The instructions and recording sheets supplied to observers counting the coast will not distinguish between these two components of WinGS but will be flexible enough to allow survey stretches to be extended whenever large concentrations of gulls are encountered. This will allow previously unrecorded high gull concentrations to be treated as part of the KSS data for analysis purposes and not allowing them to inflate the confidence intervals of the estimate of "background" coastal gull numbers obtained from the IWS. This will also be beneficial because comparisons of large inshore roosts between the 1983 and 1993 surveys within the WinGS GIS has shown that the precise location of these roosts has not been consistent between winters. Consequently, if observers were to adhere rigidly to the coordinates that they will be supplied with they may miss the large concentrations of gulls being targeted by the KSS.

2.5 Reporting Schedule

2.5.1 Population change estimate

Assuming similar coverage to previous surveys, the completion of the KSS during the first winter will allow the production of population estimates comparable to those previous surveys i.e. a head count from the larger inland and inshore roosts. More importantly, and even if coverage achieved were to be lower than that for previous surveys, completion of the KSS will allow estimates of population change to be made using paired data. This will be reported during the summer of 2004.

2.5.2 Population estimates

Completion of the BSS and IWS will allow improved population estimates to be made which will include an estimate (with confidence intervals) of gulls using smaller inland roosts, larger roosts that could not be covered for the KSS and gulls dispersed throughout the inshore waters around the UK coast. The BSS should have been completed by the end of the first winter although it will probably be necessary to make up for shortfall in coverage with professional observers during the following winter. The IWS will be completed during the third winter. Following this a complete UK population estimate will be reported during the summer of 2006.

Acknowledgments

We thank English Nature, The Department for the Environment (Northern Ireland), the Joint Nature Conservation Committee, Northumbrian Water Ltd and Scottish Natural Heritage for their help in funding this work. We thank Countryside Council for Wales for their comments. Helen Baker, Andy Brown, Stan Brown, Steve Cook, Andy Douse, Ian Enlander Catherine Gray, Chris Spray, David Stroud and Siân Whitehead gave advice in planning the pilot work and future survey. Heidi Mellan and Nicki Read helped to finalise the report.

References

Burton, N.H.K., Musgrove A.J., Rehfisch, M.M., Sutcliffe, A. & Waters, R. (in press) Numbers of wintering gulls in the United Kingdom: a review of the 1993 and previous Winter Gull Roost Surveys. *British Birds*.

ESRI (2003) Environmental Systems Research Institute, Inc. USA.

Fuller, R.M., Smith, G.M., Sanderson, J.M., Hill, R.A., Thomson, A.G., Cox, R., Brown, N.J., Clarke, R.T., Thothery, P. & Gerard, F.F. (2002) *Countryside Survey 2000 Module 7 Land Cover Map 2000*. Centre for Ecology and Hydrology, UK.

Lack, P.C. (1986) The Atlas of Wintering Birds in Britain and Ireland. T. & A.D. Poyser, Calton.

Shedden, C.B. (1983) *Feeding and Roosting Behaviour of Gulls: Implications for Water Storage.* Unpublished Ph.D. Thesis, University of Glasgow.