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DISTRIBUTION STUDIES OF WADERS AND SHELDUCK ON THE SEVERN ESTUARY WITH REFERENCE TO SEDIMENT MOBILITY.

Report to the Severn Tidal Power Group
under contract to Balfour Beatty Ltd.

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EXECUTIVE SUMMARY

There were three main objectives to this study. Firstly, to obtain fourth successive winter's intensive survey of the low tide distribution of waders and Shelduck on the Severn. Secondly, to look in detail at the sediment on one site, Clevedon, and examine the relationship between sediment mobility and bird distribution. And thirdly, to assess the variability in habitat use through the tidal cycle at selected sites around the estuary.

The Severn is known to hold internationally important wintering populations of Dunlin, Redshank and Curlew as well as nationally important numbers of Grey Plover and Ringed Plover. In addition, there are internationally important numbers of Shelduck wintering on the estuary.

Dunlin was the only one of these species to be recorded in increased numbers at low tide during the 1990/91 winter, compared to numbers recorded in previous survey years. Curlew, Redshank, Shelduck and Ringed Plover were all present in lower numbers in 1990/91 compared to previous years. Numbers of Grey Plover were similar to 1988/89 but higher than 1987/88.

The waders and Shelduck on the Severn estuary were monitored at low tide, with virtually all intertidal areas regularly counted throughout the winter, as in the two winters of intensive survey

(1987/88 and 1988/89). The overall distribution was very similar from year to year with the most important areas in all years, remaining between the Rhymney and Nash sites on the north shore and in the Bridgwater Bay area on the south shore.

There were however distinct changes within the actual count areas used during the 1990/91 winter. In particular, there was a dramatic difference at one site, Clevedon, with the numbers of Dunlin on this site very much lower than in previous years. There was an increase in the importance of the Peterstone site in 1990/91 compared to past survey years. All day counts revealed that Dunlin in particular were shifting on to this site at low tide from adjacent areas. The lower count areas of Weston Bay steadily increased in importance through all three survey years.

The proportion of the estuary which held 50% of all waders and Shelduck remained very constant, only ranging between 11% and 14% in all survey years. Although the exact count areas which made up this percentage varied between years, they did remain within similar locations on the estuary. During the 1990/91 winter half of the total intertidal area held 90% of the waders and Shelduck at low tide.

Sediment studies at Clevedon revealed that virtually all the soft surface mud had been removed prior to the start of the 1990/91 winter. With its removal, there was also a reduction in the available prey organisms which inhabit this soft mud, and on which the majority of wader species and Shelduck feed. It is almost certainly due to the erosion of this sediment that the numbers of Dunlin on this site were reduced in the 1990/91 winter.

Although the sediment was examined in less detail on the other all day sites, there did not appear to be any obvious change in the depth or extent of soft mud on these sites between years. In contrast to Clevedon, there did not appear to be any changes in the numbers of birds present on these sites which were not experienced by the whole estuary.

This study has shown that there is a link between the accretion and deposition of sediments, and the distribution of birds within the Severn. This is of particular relevance in the context of tidal power barrages since changes to sediments will accompany the construction of a barrage. The precise nature and associated impacts of these changes on birds are not fully understood. It is recommended that a fifth and final year of monitoring the bird populations is carried out, in conjunction with more extensive and detailed studies of the sediment accretion and deposition around the Severn. All the count data obtained since 1987 should be reanalysed to assess the degree of within and between year variability in bird populations.

1 GENERAL INTRODUCTION

The importance of the Severn estuary as a wintering area for waders and Shelduck is widely recognized (Prater 1981). The BTO Birds of Estuaries Enquiry (BoEE) has been monitoring these bird populations on a monthly basis since 1969 and has shown that the Severn estuary is numerically the ninth most important estuary for waders in Britain (Kirby et al. 1990). The Severn holds internationally important wintering populations of Dunlin, Redshank and Curlew as well as nationally important numbers of Grey Plover and Ringed Plover. In addition there are internationally important populations of Shelduck which moult and winter on the Severn (Table 1.1).

There have been many studies of the distribution of waders and Shelduck wintering on the Severn estuary over the past 15 years, especially since the Bondi studies on the Severn tidal barrage in the late 1970s (eg Mudge 1979, Ferns 1980). Previous studies of the feeding ecology of intertidal birds on the Severn have either been restricted to one species such as Dunlin (Worrall 1981, Clark 1983) or, when several species were studied, restricted to short periods of the winter (Mudge 1979, Ferns 1980). The work carried out by the BTO in the winter of 1987/88 was the first comprehensive study on the Severn of low tide feeding by all the wader species and Shelduck throughout the intertidal area of the Severn (Clark 1989, ETSU 4055). This survey was repeated in a comparable fashion in the winters of 1988/89 (Clark 1990) and 1990/91. Low tide distribution studies were carried out in the 1989/90 winter but have not yet been analysed and will not be referred to in this report. In 1988/89 an additional survey was set up to examine the use each species made of selected study sites throughout the tidal cycle. This survey was repeated in the 1990/91 winter.

Between-year variability in the distribution and numbers of each species are likely to be due to some combination of the following natural factors, which are often interlinked. Firstly, biological factors such as a good breeding season will affect the number of birds arriving on British estuaries. Climatic factors over the winter will affect the population and distribution of birds on Britain's estuaries. For example, in the 1990/91 winter an estimated 70% of the 4,400 Redshank wintering on the Wash died during the severe cold weather there in late January. Physical changes in the environment can also affect bird species. For instance, storm erosion or accretion of the soft mud on which many species feed, may alter the distribution of the invertebrate food supply and thus modify the birds' distribution. Also variations in the breeding success of the invertebrate prey will influence the number and distribution of their dependent avian predators. Thus it requires several years of comparable surveys to build up a reliable picture of the distribution of feeding waders and Shelduck on an estuary. Then, areas which are regularly used can be distinguished from areas which are used only occasionally.

It is only when the effect of these natural factors on the populations of waders and Shelduck are understood, and the degree of between-year variability identified, that accurate predictions can be made of the direct impacts of a barrage on the birds.

The first part of this report describes the numbers of waders and Shelduck on the estuary, the proportion of the estuary used and the percentage of birds feeding at low tide on each count through the 1990/91 winter. The average low tide distribution of waders and Shelduck over the 1990/91 winter is also presented.

The second part of the report describes the detailed use by waders and Shelduck of four sites around the estuary, which were studied throughout the tidal cycle. On one of these sites (Clevedon) detailed sediment studies were also carried out and related to bird distribution.

It was not within the scope of this project to undertake a detailed variability analysis, however some variability observed between years has been highlighted. Therefore, it is advised that for the comparison of figures, this report is read in conjunction with the two previous reports (Clark 1989, Clark 1990).

LOW TIDE DISTRIBUTIONS

2 BACKGROUND

The aim of the low tide survey was to evaluate the distribution of feeding waders and Shelduck over the entire intertidal area of the estuary throughout the 1990/91 winter. The first such survey was carried out in the 1987/88 winter, and this was repeated, using the same methodology in 1988/89 and 1990/91 winters. Information gained from these surveys can be used to identify the areas of major importance to feeding waders and Shelduck on the Severn in each year and how this varies between years. Once these areas and the variability in their importance have been identified, the proportion of each species' low tide feeding area that will be lost under the predicted post-barrage tidal regime can be assessed. This does not necessarily mean that the birds feeding on these areas will actually be displaced from the estuary as they may not be dependant on these lower level mudflats for their survival. There may also be beneficial post-barrage changes, which may enable birds to be accommodated at higher densities (Kirby 1988).

3 METHODS

3.1 Data Collection

The estuary was divided into 28 counting sites for the 1990/91 winter, each covered by a single observer or a small team. In 1988/89 and 1990/91 the Portbury site was not counted due to the difficulty in obtaining access from the Royal Portbury Dock Authority.

The sites covered contained 151 count areas (Figure 3.1.1), intertidal areas which were not observed at all during the 1990/91 winter are shaded.

Counts were conducted on seven weekends, when low tide occurred during daylight hours, spaced between mid-November and early March (Table 3.1.2). Count methodology was identical to that used in the 1987/88 winter (Clark 1989).

3.2 Data analysis

Data was used from all seven counts. In previous years, missing counts were estimated by creating an index of the population on the Severn and interpolating missing counts. This was not considered appropriate for the 1990/91 winter as coverage was incomplete on the first count in November, due to the short run-up period before the start of fieldwork. In particular, two sites (Burnham and Berrow) on the south shore of the Severn were not counted, where large numbers of birds are often located at this time of year. Thus an index would underestimate the importance of these sites in November. However, after the first count the key areas of the Severn for internationally important species were covered on each count. If the local counters were unable to carry out a count BTO staff stood in for them. Generally, the numbers counted gave an accurate representation of those birds present; any discrepancies are noted in the individual species account.

As in previous surveys, the usage of each count area by each species was calculated, giving the average number of birds present throughout the mid-winter. Usage values for the 1988/89 winter covered the period from 19 November to 25 February and for the 1990/91 winter covered a similar period from 17 November to 03 March, whereas the 1987/88 winter covered a more extended period from 4 October to 26 March. The latter covers much of the autumn arrival and spring departure periods and therefore results in lower usage values than those found in 1988/89 and 1990/91, when the coverage coincided closely with the period when the peak numbers of birds were on the estuary. As a result, the average number of birds on each count area given in N.A. Clark (1989) should not be used in conjunction with those in N.A. Clark (1990) or this report to make direct between-winter comparisons of the importance of any particular count area at low tide. However, direct comparisons of the importance of count areas can be made between 1988/89 and 1990/91, and comparisons of the distribution of birds and relative importance of count areas can be made between all three years.

For each count through the winter, values were calculated for the total number of each species recorded on the estuary at low tide; the percentage of those which were feeding (if over 50 birds were counted); and the percentage of the count areas counted which had birds present on them.

4 RESULTS

The numbers of birds recorded feeding and roosting at low tide on each count are given in Tables 4.1 - 4.7.

4.1 Shelduck

Numbers of Shelduck ranged from 1551 to 2147, with the lowest count in mid-November, after which numbers remained very stable at a higher level for the rest of the winter (Figure 4.1.1). Normally, Shelduck numbers peak on southwest estuaries in January/February. By this time most birds have returned to Britain from moulting grounds on the Wadden Sea (Prater 1981). Some birds moult in Britain and Shelduck had already dispersed to approximately 30% of the intertidal areas from their moulting concentrations in Bridgwater Bay by the first count in mid/late-November (Figure 4.1.1). There was a tendency for Shelduck to occupy an increasing proportion of mudflats as the winter progressed. This dispersal may be due to many Shelduck moving into their breeding sites on the Severn by late winter, resulting in their distribution becoming more closely related to breeding site than food availability.

Most birds were recorded feeding (Figure 4.1.1) at low tide; roosting birds which were swimming offshore were not counted. The main concentrations of Shelduck were around Bridgwater Bay on the south shore and between the Taff/Ely and Nash sites on the north shore (Figure 4.1.2).

Between-year variability

Numbers of SheldUck were substantially lower than those found in the 1988/89 winter but slightly higher and more consistent than in the 1987/88 winter. In contrast to past years, when numbers rose to a peak in February, the population in 1990/91 remained stable from December through to March. The proportions of mudflats used over the 1990/91 winter suggests an earlier dispersal than in 1987/88 but similar to 1988/89. The overall distribution pattern of Shelduck in 1990/91 was very similar to past years. The main differences in 1990/91 were a relative increase in the importance of Taff/Ely, Nash, Caldicot and especially Weston Bay sites, and a shift in the feeding areas to the west on Bridgwater Bay compared to 1987/88 and 1988/89.

4.2 Oystercatcher

Numbers of Oystercatchers ranged from 199 to 855 (Figure 4.2.1). The first count in mid-November was remarkably high due to 300 birds spread over the count areas at Slimbridge, a site which had no Oystercatchers present on it throughout the rest of the winter. Oystercatchers do not use the surrounding fields on the upper Severn. Therefore it is likely that these were migrant birds passing through the estuary from their moulting grounds to winter elsewhere.

Brean Beach is the most important site on the estuary for Oystercatchers, with an average count of 170 throughout the 1990/91 winter. This site was not counted in early December, resulting in a low overall count. Adjustments to account for these two anomalous counts results in a very stable population throughout the winter (Figure 4.2.1).

The proportion of count areas that held birds was similar in each count (20% - 26%), with the exception of the December count which was low due to Brean Beach not being counted. Virtually all birds were feeding at low tide throughout the winter (Figure 4.2.1).

Oystercatchers were evenly spread over the Rhymney, Peterstone and west St Brides sites on the north shore and from the Bridgwater Bay to Weston Bay sites on the south shore (Figure 4.2.2). The concentration at Slimbridge was due to the large migrant flock recorded on the first count.

Between-year variability

Numbers and the proportion of count areas used were similar to that found in past winters. The high percentage of birds feeding at low tide throughout the 1990/91 winter was similar to 1987/88 but contrasts with 1988/89 when the proportion of birds feeding tended to decline throughout the winter. This was probably a result of the birds not needing to feed for so long in the extremely mild weather conditions in the late 1987/88 winter.

The overall low tide distribution pattern in 1990/91 was very similar to that found in the 1987/88 and 1988/89 winters. However, in 1990/91 there was a slight dispersal in the distribution of Oystercatchers eastwards along the north shore compared to previous years when most birds were concentrated at the Rhymney site. No migrant Oystercatchers have been recorded before at Slimbridge in either the 1987/88 or 1988/89 winters, indeed Oystercatchers are considered rare upstream of the Severn Bridge.

4.3 Ringed Plover

Numbers of Ringed Plover were highest on the first count in mid-November (231), this was a result of an large flock (110) being recorded at the Mathern site which was not present on any other count and the origin of which is unknown. Numbers fell steadily through the rest of the winter. By early March only 39 birds were recorded (Figure 4.3.1). Ringed Plovers normally leave estuaries around this time to return to display at their breeding territories. Low tide counts in previous years have shown numbers to be somewhat erratic, probably a reflection of the difficulty in locating this small, cryptic species (Spearpoint et al. 1988).

All birds were recorded feeding at low tide (Figure 4.3.1). Ringed Plover used less than 10% of the mudflats on the estuary at low tide and the only count areas with an average of more than 10 birds present on them through the winter, were on the St Brides, Redwick, Mathern and Brean sites (Figure 4.3.2).

Between-year variability

Numbers of Ringed Plover were overall very much lower than those found in the 1987/88 and 1988/89 winters which, although erratic, were generally above 200. A similar proportion of the mudflats was used in all three survey years. The distribution pattern was different in all three years. In 1987/88 birds were mainly found on the Rhymney and Brean Beach sites, but in 1988/89 birds were dispersed over a greater number of sites (Rhymney, St Brides, Redwick, Portishead and Berrow). In contrast to previous years, no Ringed Plover were recorded at Rhymney in 1990/91 on the low tide counts although Ringed Plover were often present on this site (P.F. Donald pers. obs.); in contrast to 1988/89 numbers were lower at Redwick and Portishead, and birds had shifted from the Berrow to Brean Beach sites in 1990/91.

4.4 Grey Plover

Numbers of Grey Plover were low in the mid-November count (only 95 birds) as four sites which are important for Grey Plover, (St Brides, Nash, Caldicot and Berrow) were not counted (Figure 4.4.1). The second count in early-December was the peak count of the winter, with 696 birds observed feeding on the estuary. The majority of these were in a large flock (580) on Bridgwater Bay and numbers may have been boosted by transient birds, as have occurred on the Severn in past winters (Clark 1989) and on the Humber (Goodall 1988). Numbers were more stable between mid-December and mid-February, ranging from 320 to 470. In early March numbers dropped to 195, probably as a result of departure by some birds for the Wadden Sea to fatten (Prater 1981), before migrating to breeding grounds between the White Sea and the Taimyr Peninsula (Branson and Minton 1976).

Between 10% and 20% of the count areas were used throughout the winter, with the higher percentages recorded in the latter half of the winter. A high proportion of birds were feeding at low tide throughout the winter (Figure 4.4.1).

Grey Plover were not evenly distributed over the estuary but concentrated on the muddier Peterstone, St Brides, Nash and Caldicot sites on the north shore and the Bridgwater Bay and Berrow sites on the south shore (Figure 4.4.2).

Between-year variability

Except for the first two counts, numbers of Grey Plover on the Severn in 1990/91 were very similar to those in the 1988/89 winter, but were in general higher than in 1987/88. The variability in the population on the Severn over the first two years' surveys also occurred on a national scale. The

National BoEE counts showed that between the 1987/88 and 1988/89 winters there was a increase in the January index of 29% (Salmon et al. 1989). This increase in the resident population has been partly attributed to the exceptionally good breeding season in arctic Russia (Clark 1990). As the 1990/91 BoEE counts are not yet available it cannot be shown here whether the national populations were similar in 1988/89 and 1990/91 as was found for the Severn populations.

In the 1988/89 winter there were similar numbers of birds to 1990/91, but far fewer count areas were used (6% - 9% in 1988/89 and 10% - 20% in 1990/91). This may be a result of the birds being more mobile or feeding in less dense flocks or even singly in 1990/91. Thus Grey Plover are now occupying a greater proportion of the estuary than was the case when the population was lower. The reason for this is unclear.

Although a greater proportion of mudflats was being used in 1990/91 the distribution of Grey Plover was similar to that of 1988/89 and 1987/88 in that St Brides, Nash, Caldicot and Bridgwater Bay were important sites and regularly used in all years. On three out of the five counts at Berrow in 1990/91, Grey Plover were present on the outer mudflat. Grey Plover have not used this area in any of the previous surveys and their presence in 1990/91 may be due to a change in sediment type on this site.

4.5 Lapwing

Numbers were variable through the winter but peaked in late January, which is typical for southwest estuaries (Prater 1981), and dropped quickly in February with birds leaving on spring migration to breeding grounds throughout Britain, continental Europe or Russia (Figure 4.5.1). Lapwing were only present on a small number of count areas and a low percentage of birds were observed feeding at low tide (Figure 4.5.1).

Estuary counts of Lapwing are by nature likely to be variable as many birds frequent inland fields and are not dependent on the intertidal mudflats for feeding. Lapwing use the higher mudflats to roost and occasionally feed on at any time of day. Low tide counts of this species are therefore likely to be variable. Any estuary count of Lapwing will show the general pattern of occurrence but will not provide a comprehensive total.

Birds were dispersed over many of the count areas above the Severn Bridge but concentrated on fewer count areas on the main estuary, namely St Brides and Nash on the north shore and Bridgwater Bay and the River Parrett on the south shore (Figure 4.5.2).

Between-year variability

Numbers of Lapwing were similar to those found in 1988/89 and over most of 1987/88, but did not reach the exceptionally high peaks found in 1987/88. The overall distribution of Lapwing was similar between all survey years.

4.6 Knot

Numbers of Knot on the estuary were highly variable between counts in 1990/91. Very few birds (ca. 300 or less) or no birds were recorded in November, December and late January. Over 2,000 birds were recorded on the mid-January count but the highest counts were in mid-February (8,303) and early March (4,880) (Figure 4.6.1).

This sudden increase in late-February does not agree with the trend shown by the average monthly Knot totals on the Severn for 1982/83 to 1986/87, when numbers regularly increased on the estuary during December, January and February and fell substantially in March (Talbot 1988).

Substantial winter movements of Knot between estuaries, are however well known (Stanley 1971). It is possible that Knot are moving between estuaries in the area during the winter, and this would account for the variability between counts.

Recoveries of Knot, ringed during autumn on the Wash, show movements north and west during late autumn and winter (Stanley 1971). The trend of increasing numbers during late winter on the Severn, may therefore be part of this general winter dispersal (reaching a peak in February) rather than a more directed northward movement of spring migrants (Talbot 1988).

The decrease in numbers of Knot in March coincides with a large influx of birds at a few early spring staging points, particularly Morecambe Bay (Prater and Wilson 1972), the Wash and the Wadden Sea (Uttley et al. 1987). The choice of these gathering sites is not determined by the particular wintering site (Davidson et al. 1986), so for example, birds from the Severn may disperse to any one of these areas (Talbot 1988).

Even when numbers were high on the last two counts, Knot were observed on less than 5% of the count areas. Knot were found in three areas: on the Peterstone and St Brides sites, on the Slimbridge site and on the Bridgwater Bay and Berrow sites (Figure 4.6.2).

Between-year variability

Low tide counts of Knot were variable in all three survey years, but the 1990/91 peak (8,303) was almost ten times higher than previous low tide counts. As in past years Knot were observed on a very small percentage of count areas and were virtually all feeding at low tide. In all three years Knot were found on the Bridgwater Bay and Peterstone sites. However, in 1990/91 no birds were seen at Caldicot and Magor, sites where Knot were found on occasions in both 1987/88 and 1988/89 and occurred regularly in 1978/79 (Mudge 1979). In mid-February 1990/91 a large flock of 1,500 birds occurred at Slimbridge, which was not a site used in either 1987/88 or 1988/89.

4.7 <u>Sanderling</u>

Very few birds were recorded, with a flock of 18 at Brean on the first count and a flock of 14 at Berrow on the last count (Figure 4.7.1). These occurrences may reflect post-moult dispersal and early spring passage, respectively (Cooper 1988).

Between-year variability

The low numbers on the estuary in 1990/91 were however an increase on the previous years; 1987/88 no Sanderling were counted between mid-November and March and in 1988/89 there was one count of six birds on the Berrow site in early December.

4.8 Dunlin

Numbers of Dunlin in 1990/91 rose from around 20,000 on the first count in mid-November to a peak of nearly 60,000 at the end of January, after which numbers fell to around 28,000 by the beginning of March (Figure 4.8.1).

The percentage of the estuary's intertidal area used through the early winter was between 30% and 40%, with an increase to around 50% coinciding with the peak number of birds in late winter (Figure 4.8.1).

Throughout the winter, the majority of Dunlin were found between the Rhymney and Nash sites on the north side and from Bridgwater Bay to Weston Bay on the south side (Figure 4.8.2). Figures 4.8.3 - 4.8.9 show changes in the use of the count areas in successive counts over the winter months. Numbers were low for the initial three counts in November and December. During this period the distribution and concentration of Dunlin around the estuary was broadly similar (Figures 4.8.3 - 4.8.5) with no large concentrations away from the Weston Bay to Berrow sites. By count 4 in mid-January, numbers of Dunlin on the estuary had increased from around 30,000 to over 40,000 and there was an associated increase in the concentration of birds on the Peterstone, St Brides and Caldicot sites (Figure 4.8.6). Numbers continued to increase to a peak in late

January. The majority of birds on the north side of the estuary were then concentrated on the Peterstone site but the only change on the south side was a slight increase on the Burnham and Berrow sites (Figure 4.8.7). Numbers declined after count 6 and, although there remained a high concentration of birds at Peterstone, birds had dispersed along the Peterstone and St Brides sites by the time of the last count in March (Figure 4.8.9). There was a similar number of birds on the intertidal mudflat between Bridgwater Bay and Weston Bay on all the counts but the observed distribution of birds across these sites varied from count to count (Figures 4.8.3 - 4.8.9).

Between-year variability

The 1990/91 winter peak count was higher (by approximately 10,000 birds) than in either 1987/88 or 1988/89. The trend in numbers over the winter months varied in all three years. Whereas in 1990/91 numbers peaked in late January, in 1988/89 numbers rose to their highest level in mid-February with no distinct winter peak, and in 1987/88 numbers were high (over 30,000) from mid-December to early March.

The Dunlin were dispersed over a greater percentage of count areas throughout 1990/91 compared to previous years. As in 1990/91 the proportion of intertidal mudflat used in 1987/88 increased with an increase in the number of birds.

In contrast to this, as the number of birds increased during the 1988/89 winter fewer count areas were used; this was possibly due to the mild conditions late in the 1988/89 winter. It has been suggested that birds disperse over a greater area when numbers increase, to minimise interference between feeding individuals (Zwarts 1978). In mild weather, invertebrates are more active in the surface layer and are therefore more accessible to birds (Reading and McGrorty 1978). This may lead to an increased encounter rate of prey by feeding birds which can therefore satisfy their feeding requirements in a smaller area without interference (Goss-Custard 1976 & 1977a).

The overall distribution was similar to that found in 1987/88 and 1988/89 but there were some distinct differences on a local scale. The Peterstone site was of relatively greater importance in the 1990/91 winter than it had been in either 1987/88 or 1988/89. But the most noticeable change in the 1990/91 winter was the paucity of Dunlin at Clevedon, a site which was used by a winter average of over 4,000 birds throughout 1988/89. An obvious difference in the quality of the site had occurred between 1988/89 and 1990/91, with the erosion and removal of the soft mud which was covering the feeding area. This resulted in either a reduction in the invertebrate food supply or the invertebrates became unavailable in the underlying clay. Changes in the sediments on this site will be discussed in further detail in Section 8.

4.9Bar-tailed Godwit

Peak numbers (18 in January - Figure 4.9.1) of Bar-tailed Godwit present on the Severn were, as in previous years, minute compared to the UK total (33,400 in 1989/90 BoEE counts). Birds were observed on the Bridgwater Bay and the River Parrett sites on the south shore and on the Rhymney, Peterstone, St Brides and Caldicot sites on the north shore (Figure 4.9.2).

4.10 Curlew

The peak count of the winter was in November (2,153) but throughout the rest of the winter low tide counts only recorded between 900 and 1,600 birds (Figure 4.10.1). No count was carried out in late January at Oldbury. This is the most important site for feeding Curlew on the Severn, holding an average of 580 birds over the 1990/91 winter, and the lack of this count led to a low total for the estuary. The low count in February may have been due to birds moving out of the estuary as a result of the cold weather.

Curlew were catholic in their use of the estuary with birds present on around 50% of the count areas on any count

(Figure 4.10.1). Curlew, with their long bill, have a choice of a wide range of prey items and therefore their distribution on an estuary is not solely restricted by the presence of a particular prey species. They do, however, often feed on large prey items but as these occur at low density this also leads to a wide distribution of Curlew. The proportion of birds feeding at low tide ranged from approximately 65% - 90% (Figure 4.10.1).

The main concentrations of Curlew were on the central count areas above the Severn Bridge, at the Oldbury site (Figure 4.10.2). Bridgwater Bay was the next most important site, but good numbers occurred on many other sites around the estuary.

Between-year variability

Numbers of Curlew on the Severn were on the whole lower than those found in 1987/88 and 1988/89 when levels were stable around 2,000 birds. The high proportion of count areas holding Curlew and their wide distribution was very similar to that found in 1987/88 and 1988/89.

4.11 Redshank

The highest numbers of Redshank were observed between November and mid-January (approximately 1,000 birds), after which numbers generally declined (Figure 4.11.1). Small variations between counts were expected for this species as many Redshank feed spaced out in gullies and river channels in the mudflats and are therefore difficult to observe. Averaged over four winters (1982/83 - 1986/87), peak numbers on the Severn occurred during October, November and December (Talbot 1988). The exact timing of these peaks will vary between years and was slightly later in 1990/91, with numbers still high in January. Two subspecies of Redshank winter on the Severn, Tringa totanus totanus breeding in Britain and Europe, and Tringa totanus robusta breeding in Iceland and the Faeroe islands. Icelandic birds start arriving in November and from December to April make up nearly 20% of the population (Talbot 1988). Since some British birds occupy breeding territories from late-February, it is likely that the drop in numbers in late winter is due to some of the birds leaving the estuary as part of a general movement back to the breeding areas.

Virtually all birds were feeding at low tide (Figure 4.11.1). The proportion of count areas used varied from 25% - 42% over the winter. As the majority of Redshank remained concentrated on two sites, the variation in the proportion of counts areas used is probably due to movements by the small number of birds spread over count areas elsewhere.

As noted by Clark (1989, 1990), the distribution of Redshank on the Severn is concentrated around sub-estuarine river mouths, with the Taff/Ely and Rhymney river mouths being the most important sites for Redshank on the estuary. There were smaller concentrations at Clevedon, Weston Bay and around the River Parrett (Figure 4.11.2).

Between-year variability

Numbers of Redshank recorded in 1990/91 were lower than those found in 1988/89 and 1987/88 when peak counts within the same period were 1662 and 2408 respectively. The distribution pattern was very similar to that found in past years, with the only differences being that in 1990/91 the St Brides and Weston Bay sites were of relatively greater importance than in past years.

4.12 Turnstone

The peak count of the winter was of a flock of 200 birds on the Rhymney site in mid-November, after which numbers ranged from 36 to 123 (Figure 4.12.1). Turnstone are very well camouflaged when feeding on their preferred sites of seaweed covered rocks, which makes them extremely difficult to find at low tide and may be the reason for the variability in counts from December to March. It is thought that Turnstone often concentrate in large flocks on arrival and departure from the Severn, but disperse over the estuary in mid-winter (N.A. Clark pers. obs.). This may account for the lower numbers of this cryptic species in mid-winter, as Turnstone are more difficult to locate at a lower density.

All birds were recorded as feeding at low tide but on a very small proportion of count areas (Figure 4.12.1). The highest numbers of birds were recorded on the rocky areas of the Rhymney site, (Figure 4.12.2). Turnstone were also found in small numbers on the Severn Beach, Clevedon and Bridgwater Bay sites, and on several count areas above the Severn Bridge.

Between-year variability

Low tide counts of Turnstone in 1990/91 were lower than in 1988/89 and 1987/88. The reason for this is unclear. Rhymney was also a preferred site in past winters. Although birds were present at Severn Beach in 1990/91 it was relatively less important than it had been in 1988/89 and 1987/88. It may be that in 1990/91 Turnstone were feeding on the outer reaches of this uneven rocky outcrop, which extends to approximately 2.5 km from the shore, and were too far away to be discerned from the seaweed and algae cover. Turnstone had been recorded above the Severn Bridge before, during all day counts at Oldbury in 1988/89, but had always been feeding too far out to be observed at low tide. In both previous years, Turnstone were recorded on the Clevedon site but 1990/91 was the first year they were seen at Bridgwater Bay.

4.13 The overall low tide distribution of waders and Shelduck on the Severn in mid-winter 1990/91

The distribution of low tide usage of count areas by all species combined is given in Figure 4.13.1. All count sites were used, to varying degrees, at some point during the winter. The most important intertidal areas were on the Caldicot site, between the Rhymney and Nash sites on the north shore and between the Bridgwater Bay and Weston Bay sites on the south shore. At low tide, these sites held 70% of the overwintering waders on 24% of the Severn's intertidal mudflats. On average, 50% of all overwintering waders and Shelduck on the Severn were concentrated at low tide on count areas which amounted to just 11% of the whole intertidal mudflats of the Severn (Figure 4.13.2).

On the Berrow, Weston Bay and St Brides sites, where count areas distinguished between the lower and upper intertidal areas, it was the lower intertidal areas which were of greater importance at low tide. From personal observations, the same can be said for the Rhymney, Peterstone and Nash sites. Several of the count areas above the Severn Bridge and on the Severn Beach site were also used by many birds over the winter. 90% of the overwintering population of waders and Shelduck were observed at low tide on 51% of the intertidal areas (Figure 4.13.2). **Between-year variability**

There was a similar overall distribution in the 1988/89 and

1987/88 winters to that observed in 1990/91. Several intertidal areas have become of relatively greater importance since 1987/88. The most noticeable of these are from the mouth of the Rhymney east to Nash, especially the Peterstone site. In 1990/91 there was a corresponding decline in the numbers of birds using the Rhymney section, probably due to birds shifting east onto the Peterstone site. The Sharpness and Slimbridge sites above the Severn Bridge, and the Weston Bay and Berrow sites have also become of relatively greater importance.

There was a noticeable decrease in the average number of all waders and Shelduck found on the Clevedon site in 1990/91 compared to 1988/89 and in it's relative importance compared to 1987/88. This is almost certainly due to sediment changes which have occurred at this site prior to the 1990/91 survey and will be discussed in further detail in Section 7.

The Caldicot site was of greater importance than it had been in 1988/89, but was not as important as in 1987/88.

Similar numbers of birds used the count areas from Bridgwater Bay to Brean Beach in 1990/91 compared to 1988/89. There had been an increase in the relative importance of the Brean Beach and Weston Bay sites between 1987/88 and 1988/89 and a greater number of birds were using the lower mudflat at Weston Bay in 1990/91 compared to 1988/89.

In all three years of survey, the percentage of count areas holding 50% of waders and Shelduck at low tide was very similar, between 11% and 14% (Table 4.13.1). The percentage holding 90% of the birds was lower in 1988/89 (37%), than 1987/88 and 1990/91 (47% and 51% respectively). The 1988/89 winter was milder than the other two winters and birds may have been able to feed at higher densities without their feeding success declining through interference.

ALL DAY DISTRIBUTIONS AND SEDIMENT MOBILITY

5BACKGROUND

During the 1987/88 winter, studies of the feeding distributions of waders and Shelduck on the Severn concentrated on the low tide period. However, the length of time that waders need to feed per tidal cycle varies according to the time of year and species involved (Goss-Custard et al. 1977b). Therefore, in the second year's survey, 1988/89, studies were also carried out throughout the tidal cycle at five sites around the estuary. One of the main aims of this was to assess how long each species needed to feed for and which count areas within each site were used the most. These studies throughout the tidal cycle were repeated in 1990/91 to obtain a second winter's data and to allow sediment mobility at one of these sites to be related to bird distribution.

The Severn has one of the highest tidal ranges of any estuary in the world and this has a major effect on the distribution and mobility of unconsolidated sediments. There is an exaggerated separation of the mobile sediments in the estuary: mobile sand, which is largely confined to the outer banks, and fine sediment which occurs either as settled mud (and is regarded as being part of the sea bed), or as suspensions (mobile, static or temporarily resident).

The Severn carries the highest suspended load of any estuary in the UK. The construction of a barrage would reduce the tidal range and so have a major effect on the present sediment mobility (Kirby and Parker 1980). It is therefore important to know to what degree the distribution of birds on the Severn is influenced by sediment mobility. With this aim in mind, transects had been carried out in the 1988/89 survey on one of the all day study sites, to monitor the sediments and invertebrates over the winter. These transects were repeated through the 1990/91 winter and the results are examined in Section 7.

In Section 8, results obtained in 1990/91 on the distribution and total feeding effort of waders and Shelduck throughout the tidal cycle are examined to assess changes in site use over the tidal cycle. Year-to-year variability in the use of the intertidal count areas on these sites and any relation to weather conditions and sediment mobility is highlighted. As before, the study concentrated on the four internationally important species.

6 METHODS

6.1 Data Collection - Feeding distribution in relation to the tidal cycle

All day observations were conducted on the four best study sites which were covered in 1988/89 (Rhymney, St Brides, Caldicot and Clevedon). The four all day study sites are shown in Figures 6.1.1 - 6.1.4.

The criteria for selecting these study sites is outlined in N.A. Clark 1989. The observation point on the Rhymney site was changed in 1990/91 to obtain a better view of the Rhymney river channel. In order to concentrate on areas which could be divided easily by height up the shore, count area 14 on the Clevedon site was not counted in 1990/91.

The study sites at Rhymney, St Brides and Caldicot were counted once a month. Clevedon was counted every two weeks. All counts were carried out between mid-November and early March. Where possible, all observations were made when high tide was at or near dawn or dusk, so that counts covered as much of the low tide period as possible. Each count area on a site was counted at hourly intervals throughout the tidal cycle. It was not thought necessary to count every half hour, as in 1988/89.

In addition to the key species (Dunlin, Curlew, Shelduck and Redshank) data was also obtained on other species present.

6.2 Data Collection - Sediment mobility

At the Clevedon site it was possible to walk a transect down to the tide edge and this was done five times spaced over the mid-winter period. No sediment samples were taken, but visual inspections of the invertebrates present in the surface sediment and estimates of the depth of soft sediment were carried out.

Figure 6.2.1 shows in detail the central area of the all day study site at Clevedon, its access, the observation point from which counts were taken and the position of the sediment transect. The site was divided into four sections parallel to the shore and these were further divided by a line of sight from the observation point to the shore and along the channel of the River Yeo. The sections parallel to the shore depended largely on changes in the angle of the shore slope as illustrated by the profile of the line of transect which crossed count areas 2, 5, 8 and 12 (Figure 6.2.2). Count area 2 consisted of scattered Spartina clumps and raised Spartina marsh. In 1988/89 count area 5 was initially distinguished by a cover of very fine liquid mud, overlying soft mud on top of the basal consolidated clay. This was eroded as the 1988/89 winter progressed and in 1990/91 could only be distinguished from count area 8 by estimating it's width. The shore profile on count areas 5 and 8 was very flat (note vertical exaggeration on shore profile Figure 6.1.2) and were uncovered quickly by the tide. The lowest count area (12) was below a distinct change in slope.

6.3 Data Analysis - feeding distribution in relation to the tidal cycle

For each species, the all day usage value was calculated for each count area using the following equation.

$$\text{All day usage} = \sum_{A=+5}^{A=-5} (B \times C)$$

where:

A =hours from low tide

B =Average number of birds feeding at time A when area exposed

C =Proportion of counts when count area is exposed at time A

The percentage of the total usage value for the site (the sum of the usage values for each count area within the site) was calculated and plotted for each count area on all day site maps.

The 1990/91 data on the average number of bird hours per tidal cycle on each mudflat was compared to that of 1988/89 for one site on each shore of the estuary. The Clevedon and St Brides sites were chosen as these both have similar open shore profiles.

The average number of birds present and the percentage feeding were plotted for each hour through the tidal cycle for the main species at all four sites.

7 SEDIMENT STUDIES

Many shorebirds are known to concentrate their feeding effort in areas which have the highest densities of prey (Wolff 1969, Goss-Custard 1970, 1977c, 1981, Bryant 1979, Goss-Custard _et al_. 1981). In habitats where the physical characteristics of the prey patches are similar, an efficient forager would concentrate on areas where the prey density or biomass is greatest. However, many feeding areas are physically heterogenous and these differences in physical characteristics of the sediment can influence the efficiency with which birds can detect and/or capture their prey. Studies carried out on a small area of the Wash with a heterogenous substrate showed that patch selection was not based simply on prey density (Kelsey and Hassal 1989). Although there were almost twice as many Oligochaetes in an area of firm mud, the penetrability of an area of soft mud was almost three times greater. If that meant that three times as much sediment could be foraged per unit time, the encounter rate of prey items could be 1.5 times greater in the soft mud. Kelsey and Hassal (1989) found that more Dunlin were observed foraging on soft, wet substrates where prey were more accessible than on the firm mud where there was a higher density of prey. The accessibility of prey can therefore determine a predator's perception of prey density.

From these studies it can be seen that in a physically heterogenous environment, birds choose the type of substrate to forage on. It has therefore been suggested that the distribution of birds on the Severn estuary may be influenced by the mobility of the sediments affecting substrate type. Because of the large area of intertidal flats on the Severn and the limited manpower available it was felt that a survey on one site, for which there was also data on the birds from an all day survey, and which could be repeated in another winter would be more feasible than an extensive survey. This would also answer the basic question of whether sediment mobility on the Severn influenced the distribution of birds.

Figure 7.1 shows the findings of the 1990/91 transects. There was a shallow layer of soft surface mud, 2 - 4 cm thick, during December and January 1990/91. Over this time there was a decline in the abundance of visible Nereis, Hydrobia and Macoma. By the first week in February, there had been a deposition of 7 - 16 centimetres of fine mud covered by a thin surface layer of brown algae. Approximately 5 - 10 centimetres of this had been removed by the following week.

During the first week of February, Britain was struck by very cold weather from the north. Birds on the east coast were the worst affected by this, with heavy casualties on the Wash. Although this cold weather lasted for several days on the Severn, it was not so severe. The lower flats were exposed for the shortest period, and therefore only a thin layer of ice had time to form on these areas before they were covered again by the tide. Up to 2 cm of frozen mud was recorded on the surface of the upper mudflats and ice accumulated in a ridge along the high tide line, pushed up by the tide from the lower flats. There were no noticeable wader mortalities on the Severn from this cold weather.

Not surprisingly, although there was a deeper layer of soft mud covering the area in February, there was not an accompanying increase in the abundance of visible invertebrates on the surface. During cold weather, some invertebrate species are less available to feeding birds. This is either because they are less active or they remain deeper in the mud and are thus less accessible to birds (Goss-Custard et al. 1977b).

The general changes in the relative depth of soft mud between years are shown diagrammatically in Figure 7.2. The transects showed a noticeable decrease in the thickness of the fine soft surface mud in 1990/91 compared to 1988/89. In 87/88, the thickness of fine surface mud was very variable at Clevedon. The mud was removed twice by storm erosion in December and January and redeposited after each storm. The stability of the slope profile is such that in all years the depth of sediment usually increased towards the shore. A similar paucity of invertebrate species was found on this site by Warwick et al. in October 1987

(Warwick et al. 1989). The only species they found in any abundance were Nereis diversicolor, Hydrobia ulvae and Macoma balthica.

The absence of suspension feeding invertebrates from the Severn is almost certainly due to the high turbidity. The species which are present in the Severn are all relatively robust (e.g. Macoma) and/or mobile (e.g. Hydrobia, Bathyporeia, Nephtys) and so would be capable of withstanding the rigours of mobile sediment. It has been predicted that with the reduced post-barrage tidal range there would be a decrease in the relative importance of the above species, which are associated with large dynamic hypertidal estuaries, and an increase in the abundance and biomass of those species associated with smaller, less dynamic estuaries, e.g. Corophium volutator, Cyathura carinata, Scrobicularia plana, Cerastoderma edule and tubuficid and nereid worms amongst others (Warwick et al. 1991).

As already shown, there was a noticeable decline in the number of birds using the Clevedon site at low tide between the 1988/89 and 1990/91 winters. This decline is almost certainly due to the loss of soft mud from the site between these years and thus the distribution of birds on the Severn can be said to be affected by sediment mobility.

8 RESULTS

8.1 <u>Shelduck</u>

Peak numbers of Shelduck over the tidal cycle were about 50 at Caldicot and Clevedon, whereas St Brides held approximately 80, and Rhymney as many as 230. On three sites, Rhymney, St Brides and Caldicot, birds started to arrive just after high tide, numbers then rose to a peak just after low tide and quickly fell thereafter, with birds leaving the sites as the mudflats were covered by the incoming tide (Figure 8.1.1). Numbers at Clevedon rose steadily, from about 20 just after high tide to a peak at low tide and fell more slowly than the other sites on the incoming tide (Figure 8.1.1).

The distribution of birds within the Rhymney site shows that the Shelduck used all levels of count areas as they follow the receding and advancing tide, but spent more time foraging on the count areas to the east of the river channel (Figure 8.1.2).

The distribution of Shelduck at Caldicot is strongly related to the changes in substrate over the site (Figure 8.1.3). The outer, sandy or stony count areas 11 - 13 were hardly ever used, whereas the higher, inner count areas, and especially the most northeasterly count area 15, which were covered in soft mud, were favoured.

Shelduck fed over the entire length of the Clevedon site but spent a greater percentage of time on the middle and upper count areas (Figure 8.1.4). In contrast to this, Shelduck on the St Brides site spent a greater proportion of time feeding on the lower count areas (Figure 8.1.5).

Most birds observed during the all day counts were feeding (Figure 8.1.1). No Shelduck roosted on the intertidal flats on these sites; therefore the smaller numbers apparent near high tide were the result either of birds roosting on the water, where they were not counted, or roosting outside the count site altogether. These patterns agree with observations of birds moving into the vicinity of the sites as the tide turned and waiting for the first intertidal areas to be exposed. Thereafter numbers increased as the birds moved onto the newly exposed mud, continuing to rise as the tide receded and dropping again as the tide advanced. The Caldicot site was slightly different as the birds did not follow the tide edge to feed on the outer reaches which are very sandy and stony.

Between-year variability

In the 1990/91 winter, numbers of Shelduck were very much lower at Rhymney, Clevedon and St Brides than in 1988/89, but similar at Caldicot, which had held the fewest birds in 1988/89. Low tide counts recorded lower numbers of Shelduck on the estuary as a whole in 1990/91; this decline was not therefore local to these sites. The timing of arrivals and departures over the tidal cycle in 1990/91 were broadly similar on all sites to those found in 1988/89. In 1990/91 the low tide peaks were more prominent, but this may be a result of the lower numbers making the arrival or departure of a few birds at low tide, more noticeable than they would have been with the greater numbers in 1988/89.

In 1990/91, due to the change in the observation point on the Rhymney site, a few birds which remained on the upper count areas until high tide were visible. This accounts for the longer time period in which birds were recorded on this site in 1990/91.

In 1990/91 the overall distribution of Shelduck was broadly similar to 1988/89 on all sites. There were however a few changes in the relative importance of count areas between years, except on the Rhymney site which remained very similar.

On the Caldicot site there was an increase in the relative importance of the upper count areas (1 - 5) in 1990/91, and more especially count area 9 which was hardly used in 1988/89. In contrast count area 7, which was comparatively well used in 1988/89 was not used at all in 1990/91.

There has been an increase in the feeding range of Shelduck over the Clevedon site since 1988/89. In the 1990/91 winter birds were more evenly distributed over the entire length of the site, whereas in 1988/89 Shelduck spent most of their time feeding in the north and south ends of the site. This more even dispersal is reflected in Figure 8.1.6a, which shows that even though there were fewer Shelduck on the Clevedon site in 1990/91 the average number of bird hours spent on virtually all count areas increased in 1990/91 compared to 1988/89. There was a substantial increase in the relative importance of the upper count area 6. Although there may have been the same number of birds feeding on this count area in 1990/91 as in 1988/89, with the reduced number of Shelduck on the site as a whole, it has increased in importance relative to other count areas.

On the St Brides site although the average number of hours Shelduck spent on each count area in 1990/91 was similar to 1988/89 (Figure 8.1.6b), there was a substantial increase in the relative importance of the outer count areas to Shelduck. As there was a corresponding decrease in the percentage of time birds were feeding on the middle count area 6, birds may have shifted from the middle to outer count areas in 1990/91.

Shelduck summary

Tidal Cycle: Shelduck were present on all sites while the intertidal flats were uncovered. This pattern was broadly similar from year to year.

Distribution: Shelduck were present on virtually all count areas at Rhymney, St Brides and Clevedon, but mainly on middle and upper count areas at Caldicot, this distribution was broadly similar between years.

8.2 Dunlin

The numbers and patterns of occurrence of Dunlin varied considerably between sites.

Peak numbers of Dunlin over the tidal cycle were about 1,750 and 1,300 at Rhymney and St Brides, whereas Caldicot and Clevedon only held about 700 and 250 respectively (Figure 8.2.1).

Numbers of Dunlin on the Rhymney rose as the tide receded and remained high throughout the low tide period before falling off again as soon as birds were displaced by the rising tide. Virtually all birds were recorded as feeding throughout the tidal cycle.

On the Clevedon site numbers also rose on the receding tide and remained high throughout the low tide period, following a similar pattern to that found on the Rhymney. But at Clevedon ca. 100 birds remained on the site until high tide. Just prior to high tide, many of these roosted on the higher mudflat for a short period, until this too was covered and the Dunlin left to roost outside the count site on Blackstone rocks, at the north end of the bay.

Numbers at St Brides peaked shortly after high tide and steadily declined up to the following high tide. During the period when most birds were present they were virtually all feeding. Dunlin may use the whole Peterstone/St Brides shore as one feeding site, concentrating at St Brides on the falling tide and Peterstone at low tide. Many birds were observed leaving the site in the direction of the low tide Peterstone site, which as already discussed was very important for Dunlin at low tide (Section 4.8).

In contrast to the feeding patterns found at all the other sites, which showed a peak in numbers at some point over the tidal cycle, numbers at Caldicot were remarkably stable, at around 500, throughout the tidal cycle. Birds were feeding throughout the tidal cycle as the site seldom becomes totally covered by the tide.

The distribution map of the Rhymney site (Figure 8.2.2) shows that Dunlin used the lower count areas to the west of the river channel but preferred the count areas to the east of the river, especially the lower count areas.

As with Shelduck, Dunlin at Caldicot spent most time feeding on the soft mud on the middle and upper shore, and avoided the sandy and stony outer count areas (Figure 8.2.3).

The most important count areas for Dunlin at Clevedon were the middle and lower count areas (7 and 12), with a fairly even distribution over the remaining middle and upper shore (Figure 8.2.4). The middle and lower count areas at Clevedon held the most soft mud and therefore had the most accessible invertebrate prey.

On the St Brides site, Dunlin spent virtually all their feeding time distributed evenly between the middle and lower count areas 6 - 10 (Figure 8.2.5).

Between-year variability

Numbers of Dunlin in 1990/91 were very much lower than 1988/89 on three sites (Rhymney, St Brides and Clevedon) but similar at Caldicot. Numbers had dropped to approximately 56% at Rhymney, 28% at St Brides and 3% at Clevedon of the numbers found in 1988/89.

The pattern over the tidal cycle was similar in both years at the Rhymney and St Brides sites, with peaks over the low tide period. But on the Caldicot site the pattern was distinctly different between years; in 1988/89 numbers peaked just after high tide and declined thereafter, whereas numbers in 1990/91 were stable throughout the tidal cycle. With the significant drop in numbers at Clevedon it is hardly surprising that the pattern is different between years. In 1988/89 numbers increased throughout the tidal cycle, however, in 1990/91 numbers peaked over the low tide period and then fell.

The count areas east of the river channel on the Rhymney site have increased in relative importance between years.

On the Caldicot site birds were concentrated in both years on areas of soft mud in the northeast and the upper levels of the site. There has however been an increase in the relative importance of these upper count areas between years, the most noticeable being count area 6 which was relatively unimportant in 1988/89.

Although the distribution of Dunlin on the Clevedon site was similar between years there have been some changes in the relative importance of count areas. However, these changes have not shown any particular trend either towards the upper or lower count areas, but there have been shifts between adjacent count areas. Figure 8.2.6a shows a drop in the relative importance of all count areas at Clevedon in 1990/91 compared to 1988/89. This is a result of the drastic fall in numbers between years.

The distribution of Dunlin on the St Brides site was very similar between years but there has been an increase in the relative importance of the lower mudflats (Figure 8.2.6b).

Dunlin summary

Tidal cycle: Numbers and patterns over the tidal cycle varied considerably between sites and between years.

Distribution: Dunlin were present on all count areas except for three upper count areas at Rhymney.

8.3 Curlew

Numbers of Curlew varied between sites; at Rhymney and Clevedon the peak counts over the tidal cycle were 35 and 25 respectively; Caldicot held 80 birds and St Brides only held about 9 birds.

The patterns of site use over the tidal cycle were similar on the Rhymney and St Brides sites. Curlew arrived as the intertidal flats started to become exposed, numbers were high over the low tide period but dropped off sharply on the rising tide (Figure 8.3.1).

On the Caldicot and Clevedon sites, Curlew again arrived as the tide receded and exposed the intertidal flats but, in contrast to Rhymney and St Brides, numbers continued to rise throughout the tidal cycle. The fall in the percentage of birds feeding after low tide coincides with the increase in numbers, as birds arrive on these sites to roost. (Figure 8.3.1).

Curlew were dispersed over virtually all count areas on the Rhymney site. The middle and upper count areas to the west of the river channel were relatively less important than the rest of the count areas, which were fairly equal in importance, with no apparent preference for feeding on higher or lower count areas (Figure 8.3.2).

Curlew were present on virtually all count areas on the Caldicot site. A noticeable exception to this was count area 15, which was of relatively greater importance than other count areas to Shelduck and Dunlin but was not used at all by Curlew. The middle count areas 9 and 10 were of greatest importance to Curlew on this site, followed by count areas of equal importance on the upper, middle and lower shore (Figure 8.3.3).

Curlew were also feeding on all heights of mudflat at Clevedon, although the upper count area 10 was of greatest importance (Figure 8.3.4).

Only the middle and lower count areas were used by Curlew on the St Brides site, but count area 7 was the most important to the few Curlew which fed on this site (Figure 8.3.5).

Between-year variability

The numbers of Curlew recorded on three of the all day sites in 1990/91 were very much lower than those found in 1988/89; ca. 50% lower on the Rhymney and Clevedon sites and ca. 25% lower on the Caldicot site. St Brides only held ca. 9 birds in both years.

The pattern of use over the tidal cycle was very similar between years on the Rhymney, St Brides and Caldicot sites. The only slight difference between years was at Caldicot, where in 1990/91, instead of roosting on the upper mudflats at Caldicot for the first three hours of the falling tide, as occurred in 1988/89, Curlew roosted on the adjacent saltmarsh where they were not counted. Clevedon did not show such a marked increase in numbers towards high tide in 1988/89 as there was in 1990/91.

As with Dunlin, there has been a shift eastward on the Rhymney site in the distribution of feeding Curlew and the relative importance of count areas compared to 1988/89. The distribution of Curlew at Caldicot was similar in 1990/91 to 1988/89, but there was an increase in the relative importance of the middle count area 9 between years. There was little similarity between years on the Clevedon site, in either the distribution or the relative importance of count areas (Figure 8.3.6a). In 1988/89 the middle and upper count areas were of greater importance, whereas in 1990/91 there were count areas of equal importance on the upper, middle and lower shore. The most important count areas in 1990/91, the upper and lower count areas 10 and 12, were not used at all in 1988/89. Curlew were distributed over a greater number of count areas on the St Brides site in 1990/91 compared to 1988/89 but count area 7 was again the most important (Figure 8.3.6b).

Curlew summary

Tidal cycle: The Rhymney and St Brides sites showed a similar pattern of peaking over the low tide period, and the Caldicot and Clevedon sites a similar pattern of numbers increasing towards high tide with birds arriving to roost.

Distribution: Curlew were present on all heights of count area on all sites.

8.4 Redshank

The Rhymney is one of the most important sites on the Severn for Redshank. The Rhymney site held approximately 230 Redshank in the 1990/91 winter and the Clevedon site ca. 14 Redshank. Redshank started feeding on the intertidal areas on both sites as soon they were uncovered by the receding tide (Figure 8.4.1). On the Rhymney site numbers increased up to low tide and then steadily decreased as birds were pushed out of channels and creeks by the incoming tide. Fluctuations in numbers counted, especially from the more distant observation point used in 1988/89, were most likely to have been due to birds moving in and out of creeks and channels rather than to any significant changes in numbers present within a study site. Numbers on the Clevedon site peaked before low tide, but birds may have been missed in the saltmarsh. The Redshank feeding on the Rhymney site roosted on the banks of the river near its mouth. Redshank were observed feeding on almost all occasions and patterns of distribution indicate that they make considerable use of all heights of the count areas adjacent to the river at Rhymney (Figure 8.4.2). Redshank were only recorded feeding on the middle and upper count areas on the Clevedon site, with the upper count areas of relatively greater importance (Figure 8.4.3).

Between-year variability

Numbers of Redshank on the Rhymney appeared to have increased from ca. 150 in 1988/89 to ca. 230 in 1990/91, but numbers in the 1988/89 winter were low due to many birds feeding in the Rhymney river channel where they were missed from the observation point used in that year. Both distribution patterns and numbers over the tidal cycle were similar between the two years of study.

Redshank summary

Tidal cycle: On the Rhymney site numbers peaked over the low tide period. Numbers peaked before low tide on the Clevedon site, but there were only very few Redshank present there anyway. There were similar patterns between years.

Distribution: Redshank were present on the Rhymney site on all count areas adjacent to the river channel, but only present on the middle and upper count areas on the Clevedon site. Similar patterns were found between years.

Additional Species

8.5 Mallard

Numbers of Mallard on the Rhymney site in 1990/91 increased after low tide, as birds arrived to roost (Figure 8.5.1). This contrasts with 1988/89, when the highest numbers of Mallard were present at low tide, with 50% of the birds feeding, and very few birds present on the rising tide.

At St Brides, numbers of Mallard were very much lower than recorded in 1988/89, and in contrast to 1988/89 a high percentage of those present were feeding over low tide (Figure 8.5.1). The lower count areas were of relatively greater importance, as most birds remained near the tide edge and no birds fed at any stage on the highest count areas (Figure 8.5.2). This distribution is very similar to that found in 1988/89.

8.6 <u>Teal</u>

Although numbers of Teal were lower than those recorded at St Brides in 1988/89, the distribution and tidal cycle patterns were similar between years. Birds started to arrive on the site two hours after high tide, when the lower areas were exposed and left soon after low tide before they were completely covered again (Figure 8.6.1). The lower count areas were of relatively greater importance (Figure 8.6.2).

8.7 <u>Pintail</u>

Winter average numbers of Pintail recorded on the Rhymney site in 1990/91 only reached 30, compared to the 100 - 150 regularly seen in 1988/89. Pintail started to arrive as soon as the tide exposed the upper flats, and birds continued to arrive up to two hours after low water, but started leaving thereafter (Figure 8.7.1). The highest percentage of birds were feeding over the low water period. By three hours after low water, the few remaining Pintail were roosting on the flats. This pattern is similar to that found in 1988/89. Pintail only used the count areas adjacent to or east of the river channel (Figure 8.7.2). The middle and lower count areas east of the river channel are, as occurred in 1988/89, the most important on the site but the middle and upper count areas have increased in relative importance since 1988/89.

8.8Oystercatcher

Oystercatchers arrived on the Rhymney site as soon as the upper count areas started to become exposed. Their numbers peaked at nearly 50 over the low tide period but fell soon after (Figure 8.8.1). Virtually all birds fed for the whole time that they were within the study site. Numbers were higher in 1988/89, with 70 or 80 birds feeding at low water, although the pattern of usage over the tidal cycle was very similar between years. In 1990/91 Oystercatchers were well dispersed over the site, but the most important count areas were east of the river (Figure 8.8.2). This contrasts with 1988/89 when the count areas to the west of the river channel were of relatively greatest importance.

8.9Ringed Plover

There were fewer Ringed Plover at St Brides in 1990/91, compared to 1988/89. Only seven birds were seen regularly there, as opposed to twenty in the earlier winter (Figure 8.9.1). Birds began to arrive as soon as the upper areas were exposed; most left soon after low tide, but a few birds remained on the site until the area was covered. As in

1988/89, Ringed Plover spent all their time on the higher mudflats (Figure 8.9.2).

Small numbers of Ringed Plover were also recorded on the upper mudflats at Rhymney after low tide (Figures 8.9.1 and 8.9.3).

8.10 Grey Plover

Grey Plovers were present on three sites (St. Brides, Caldicot and Clevedon), which each showed differing patterns of usage. Each site held between 10 and 20 birds over the tidal cycle, which was lower than 1988/89 at Clevedon but similar on the other two sites. The timing of the peak numbers of birds over the tidal cycle varied between sites (Figure 8.10.1). These patterns were only similar to 1988/89 on the St Brides site; patterns at Clevedon and Caldicot changed between the two years of study. Virtually all birds were feeding on each site while numbers were highest.

On the Caldicot site, birds were dispersed over a greater number of count areas in 1990/91 than 1988/89. There was a considerable increase in the relative importance of the upper count area 5 in 1990/91 (Figure 8.10.2).

Grey Plover were also using a greater number of count areas on the Clevedon site in 1990/91 compared to 1988/89. In both years the middle and upper count areas were of greater importance than the lower count areas (Figure 8.10.3). As shown by Figure 8.10.4a there was very little similarity between the two years in the distribution of feeding Grey Plovers over the site or of the importance of each count area.

The distribution of Grey Plover on the St Brides site varied considerably between years and the lack of similarity between years is shown in Figure 8.10.4b. The two most important count areas in 1990/91 (middle count areas 6 and 7) (Figure 8.10.5) had not been used at all in 1988/89.

9 DISCUSSION AND CONCLUSIONS

Most animal communities show considerable variability between years or generations. Estuarine bird populations are known to vary considerably between years (Clark 1989, Kirby et al. 1990) depending on factors such as breeding success and severe weather. It is therefore not surprising that numbers of most species on the Severn have varied over the three years of intensive study. These increases or decreases in numbers have not been consistent for all species between years.

Dunlin was the only species that was present in higher numbers in 1990/91 than in both previous years, but several species were present in lower numbers in 1990/91 compared to both previous years, i.e. Curlew, Redshank, Ringed Plover and Turnstone. These variations in population sizes exemplify the need for several years' survey before fluctuations between years can be identified as an occasional or regular occurrence. For a few species, such as Shelduck, Oystercatcher, Lapwing, Grey Plover and Bar-tailed Godwit, the Severn held similar populations in two or three of the study years. However, three years is not long enough to identify stable and variable species with certainty.

The period of cold weather which hit Britain in late January and early February was milder on the west coast and seemed to have little effect on wader populations on the Severn.

Low tide studies have shown a very similar distribution of waders and Shelduck on the Severn from year-to-year. In all survey years the most important areas of the estuary remained between the Rhymney and Nash sites on the north shore and the Bridgwater Bay and Weston Bay area on the south shore.

As Dunlin occur in the highest numbers of any species on the Severn, changes in this species' distribution are the most noticeable, but many other species also underwent similar changes in distribution on the north shore, during the 1990/91 winter compared to previous years. In particular, for several species there was an increase in the low tide importance of the Peterstone site; the St Brides and Nash sites to the east also became more important. All day studies at Rhymney and St Brides showed that Dunlin concentrated their feeding on these sites on the falling tide, but at low tide numbers dropped as birds moved off to feed at Peterstone.

There were very few Dunlin present on the Clevedon site in 1990/91, a site which had held an average of over 4,000 birds in 1988/89. Other species which occur in lower numbers on the Clevedon site also showed a decline in 1990/91, although this was not as marked as it was for Dunlin. Sediment studies on this site have shown that virtually all the soft surface sediment, which held easily accessible invertebrates, had been removed before the 1990/91 winter. In consequence, Dunlin moved to feed on sites with more suitable surface sediments, such as Peterstone or Weston Bay. Even though there was some deposition of soft mud at Clevedon as the winter progressed, there was no associated increase in the numbers of Dunlin. This may have been because, in this instance, the quality of the site on which they were feeding was still high, and there was apparently no necessity for Dunlin to move to Clevedon in late winter.

There was little change observed between years in the depth or extent of sediments on the other all day study sites (albeit that they were not examined in as much detail as at Clevedon). In contrast to Clevedon, there did not appear to be any changes in the numbers of birds present on these sites which were not experienced by the whole estuary.

Although the numbers of birds present on all day sites sometimes changed between years, many species showed a similar use of count areas on all day sites. Grey Plover was a notable exception to this, with variations in patterns over the tidal cycle between sites, as well as between years.

For the majority of species, the number of birds and the percentage feeding were highest over the low tide period, when most of the intertidal mudflat was exposed and available to feed on. Exceptions to this could be found on sites which were used for roosting by Curlew and numbers were highest on these sites before high tide. The smaller wader species, such as Dunlin and Redshank needed to feed for a longer period over the tidal cycle than the larger wader species, for example Curlew and Oystercatcher, in order to satisfy their food requirements. A similar pattern to this was found on the Wash (Goss-Custard et al. 1977b).

On three of the all day sites (Rhymney, St Brides and Clevedon), all heights of mudflat were important to one or more of the internationally important species. On the Caldicot site, which was the only site with sandy and gravelly outer substrates, the middle and upper muddy areas were of greater importance to these key species than the outer areas.

The exact count areas which have held 50% of the waders and Shelduck on the Severn at low tide has varied between years. However, they were within similar locations, that is the Caldicot site, and between the Rhymney and Nash sites on the north shore, and between Bridgwater Bay and Weston Bay on the south shore. Between 11% and 14% of the Severn's intertidal area has held 50% of birds present on the estuary in each year and therefore the region in which this small percentage of mudflat occurs is of great importance to a large percentage of the waders and Shelduck on the Severn estuary.

Any development on the estuary which will change the area of mudflat available to feeding waders and Shelduck will have a direct impact on the distribution and numbers of birds. From the studies presented here, it is clear that there would be a larger number of birds whose feeding area would be lost if the core areas were affected, i.e. between the Rhymney and Nash sites on the north shore and around Bridgwater Bay on the south shore, rather than the areas within the estuary which hold a lower density of birds. Any reduction of the available feeding time on core feeding areas, will have a greater impact on smaller species (e.g. Dunlin and Redshank) than on larger species (e.g. Curlew and Oystercatcher). From sediment studies, it can also be seen that developments, such as a barrage, which could reduce the sediment mobility, may also have a beneficial effect on the distribution and populations of waders and Shelduck on the Severn.

When projections are made by sedimentologists of the post-barrage substrate types of the estuary it will be possible to predict the likely changes in the distribution and numbers of waders and Shelduck. Key factors that will need to be considered are the likely time that the new sediment regime will take to develop and the geographic variations in sediment stability around the estuary resulting from the new wave and tidal current conditions. In order to make such projections there are several gaps in our knowledge that need to be understood. These include the between and within-year variability in distribution and whether there is evidence for long term shifts in distribution patterns around the estuary. It is unclear to what extent these changes in bird populations are affected by changes in sediment accretion and deposition in the Severn. This relationship needs to be investigated further.

RECOMMENDATIONS FOR FURTHER WORK

1.Within and between-year variability in distribution patterns.

The three years of intensive study so far analysed have shown considerable consistency in the distribution patterns of many species. However, there have been considerable local changes for all species and a few species have shown very large shifts in distribution. A 5th year's monitoring should be carried out and then all the data obtained over the last five years should be reanalysed by methods specifically designed to assess the differences within and between years in the distribution patterns of waders and Shelduck on the Severn. This should give considerable information on small scale shifts within the estuary over a five year period and any large scale shifts which have occurred within this period.

2.Large scale variations in the distribution of waders and Shelduck over the past 21 years.

Birds of Estuaries Enquiry counts monitor the distribution of birds at high tide around the Severn. These should be analysed in order to assess large scale shifts in the distribution patterns of waders and Shelduck over a 20 year period. Waders and Shelduck are known to move between feeding and roosting sites. However, the Severn is so large that it can be split into units in which there will be little movement between feeding and roosting areas. This information can then be used to put the results of Recommendation 1 into context.

3.The effect of accretion and deposition of sediments on bird populations.

This study has shown that there is a link between the amount of erosion and accretion around the Severn and the numbers of birds using individual areas. However, responses of birds are not always immediate and when sediment returns to an area birds do not always return with it. This may well be because there are large areas of suitable feeding elsewhere within the estuary hence there is no need for birds to move. A study is therefore required to assess the erosion and accretion around the Severn concentrating on the important areas for bird feeding. This study would need to match bed level measurements against bird numbers over the winter in a paired manner. It should then be possible to assess in greater detail the role of erosion and deposition in determining bird distribution within the estuary. This has considerable relevance to tidal power as it is still unclear exactly what the new environment of the intertidal flats will be post barrage. If the estuary becomes a wave dominated erosional regime, there might be severe reductions in the bird populations unless engineering methods are used to protect certain areas from wave attack.

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	Av. Peak Winter Count (Nov.-Mar.)	% of British population	% of European population
SHELDUCK Tadorna tadorna	2833	3.8	1.1
OYSTERCATCHER Haematopus ostralegus	692	0.3	0.1
RINGED PLOVER Charadrius hiaticula	265	1.2	0.5
GOLDEN PLOVER Pluvialis apricaria	19	0.0	0.0
GREY PLOVER Pluvialis squatarola	1039	5.0	0.7
LAPWING Vanellus vanellus	2904	0.3	0.2
KNOT Calidris canutus	3188	1.5	0.9
SANDERLING Calidris alba	10	0.1	0.0
DUNLIN Calidris alpina	49198	11.4	3.5
RUFF Philomachus pugnax	7	*	0.0
SNIPE Gallinago gallinago	98	*	0.0
BLACK-TAILED GODWIT Limosa limosa	21	*	0.0
BAR-TAILED GODWIT Limosa lapponica	55	0.1	0.1
CURLEW Numenius arquata	3300	3.6	0.9
REDSHANK Tringa totanus	2693	3.6	1.8
TURNSTONE Arenaria interpres	421	0.9	0.6

* No population estimate available.

An additional seven species (Jack Snipe, Green Sandpiper, Common Sandpiper, Spotted Redshank, Greenshank, Avocet and Purple Sandpiper) had average peak counts of less than ten birds.

Table 1.1 The National and International Importance of the Severn for wintering waders and Shelduck, 1986/87-1990/91 (Shelduck figures are subject to slight modification if additional data becomes available).

LOW TIDE COUNT DATES

Count 1	17/18	November	1990
Count 2	01/02	December	1990
Count 3	15/16	December	1990
Count 4	12/13	January	1991
Count 5	26/27	January	1991
Count 6	16/17	February	1991
Count 7	02/03	March	1991

Table 3.1.2 Count dates for the 1990/91 winter.

NUMBER OF MUDFLATS COUNTED: 99

Species	FEEDING No. Birds	FEEDING No. Mudflats with Birds	ROOSTING No. Birds	ROOSTING No. Mudflats with Birds	% Mudflats with Birds
SHELDUCK	1452	26	99	6	29
OYSTERCATCHER	785	24	70	2	25
RINGED PLOVER	231	6	0	0	6
GREY PLOVER	93	14	2	1	15
LAPWING	452	5	1145	6	11
KNOT	320	2	20	1	3
SANDERLING	18	1	0	0	1
DUNLIN	15459	31	4750	2	32
BAR-TAILED GODWIT	2	2	0	0	2
CURLEW	1968	49	185	5	52
REDSHANK	890	24	177	3	26
TURNSTONE	200	7	0	0	7

Table 4.1Number of birds recorded during Count 1, 17/18 November 1990.

NUMBER OF MUDFLATS COUNTED: 105

Species	FEEDING No. Birds	FEEDING No. Mudflats with Birds	ROOSTING No. Birds	ROOSTING No. Mudflats with Birds	% Mudflats with Birds
SHELDUCK	2041	33	106	4	34
OYSTERCATCHER	513	26	0	0	25
RINGED PLOVER	118	10	0	0	10
GREY PLOVER	696	11	0	0	10
LAPWING	998	4	2002	12	15
KNOT	15	1	0	0	1
SANDERLING	0	0	0	0	0
DUNLIN	30153	42	200	1	41
BAR-TAILED GODWIT	3	2	0	0	2
CURLEW	1426	48	221	6	49
REDSHANK	912	33	20	1	31
TURNSTONE	36	2	0	0	2

Table 4.2Number of birds recorded during Count 2, 01/02 December 1990.

NUMBER OF MUDFLATS COUNTED: 112

Species	FEEDING No. Birds	FEEDING No. Mudflats with Birds	ROOSTING No. Birds	ROOSTING No. Mudflats with Birds	% Mudflats with Birds
SHELDUCK	1970	41	36	5	38
OYSTERCATCHER	197	15	2	1	13
RINGED PLOVER	98	10	0	0	9
GREY PLOVER	467	11	0	0	10
LAPWING	138	6	683	4	9
KNOT	0	0	0	0	0
SANDERLING	0	0	0	0	0
DUNLIN	25768	46	0	0	41
BAR-TAILED GODWIT	0	0	0	0	0
CURLEW	920	59	43	4	55
REDSHANK	916	40	5	1	37
TURNSTONE	76	4	0	0	4

Table 4.3Number of birds recorded during Count 3, 15/16 December 1990.

NUMBER OF MUDFLATS COUNTED: 131

Species	FEEDING No. Birds	FEEDING No. Mudflats with Birds	ROOSTING No. Birds	ROOSTING No. Mudflats with Birds	% Mudflats with Birds
SHELDUCK	1780	49	24	5	38
OYSTERCATCHER	413	28	55	1	22
RINGED PLOVER	88	5	0	0	4
GREY PLOVER	321	17	0	0	13
LAPWING	639	6	1671	12	13
KNOT	1880	1	240	1	1
SANDERLING	0	0	0	0	0
DUNLIN	41869	48	155	2	36
BAR-TAILED GODWIT	11	4	0	0	3
CURLEW	1276	57	437	12	47
REDSHANK	1054	42	40	1	32
TURNSTONE	123	3	0	0	2

Table 4.4Number of birds recorded during Count 4, 12/13 January 1991.

NUMBER OF MUDFLATS COUNTED: 106

	FEEDING		ROOSTING		
Species	**No. Birds**	**No. Mudflats with Birds**	**No. Birds**	**No. Mudflats with Birds**	**% Mudflats with Birds**
SHELDUCK	1972	46	123	6	46
OYSTERCATCHER	440	26	75	2	26
RINGED PLOVER	17	2	0	0	2
GREY PLOVER	440	21	7	1	20
LAPWING	611	9	3216	11	19
KNOT	305	2	0	0	2
SANDERLING	0	0	0	0	0
DUNLIN	59273	53	0	0	50
BAR-TAILED GODWIT	18	4	0	0	4
CURLEW	735	55	311	6	54
REDSHANK	657	44	80	1	42
TURNSTONE	70	2	0	0	2

Table 4.5Number of birds recorded during Count 5, 26/27 January 1991.

NUMBER OF MUDFLATS COUNTED: 117

Species	FEEDING No. Birds	FEEDING No. Mudflats with Birds	ROOSTING No. Birds	ROOSTING No. Mudflats with Birds	% Mudflats with Birds
SHELDUCK	1812	41	61	6	37
OYSTERCATCHER	486	27	6	1	23
RINGED PLOVER	54	8	0	0	7
GREY PLOVER	371	21	0	0	18
LAPWING	2	1	29	2	3
KNOT	8303	6	0	0	5
SANDERLING	0	0	0	0	0
DUNLIN	43312	55	40	1	48
BAR-TAILED GODWIT	13	5	0	0	4
CURLEW	645	57	122	6	51
REDSHANK	866	40	7	1	34
TURNSTONE	83	4	0	0	3

Table 4.6Number of birds recorded during Count 6, 16/17 February 1991.

NUMBER OF MUDFLATS COUNTED: 109

	FEEDING		ROOSTING		
Species	**No. Birds**	**No. Mudflats with Birds**	**No. Birds**	**No. Mudflats with Birds**	**% Mudflats with Birds**
SHELDUCK	1766	56	137	11	55
OYSTERCATCHER	382	21	46	5	22
RINGED PLOVER	39	2	0	0	2
GREY PLOVER	181	14	14	1	14
LAPWING	66	6	51	3	7
KNOT	4880	4	0	0	4
SANDERLING	14	2	0	0	2
DUNLIN	27844	32	670	2	29
BAR-TAILED GODWIT	0	0	0	0	0
CURLEW	1326	48	239	12	47
REDSHANK	613	27	21	2	25
TURNSTONE	38	2	0	0	2

Table 4.7Number of birds recorded during Count 7, 02/03 March 1991.

Year	**% mudflats holding 50% of birds**	**% mudflats holding 90% of birds**
1987/88	12	47
1988/89	14	37
1990/91	11	51

Table 4.13.1The percentage of the intertidal mudflat area which at low tide held both 50% and 90% of all waders and Shelduck present on the Severn during mid-winter in different years.

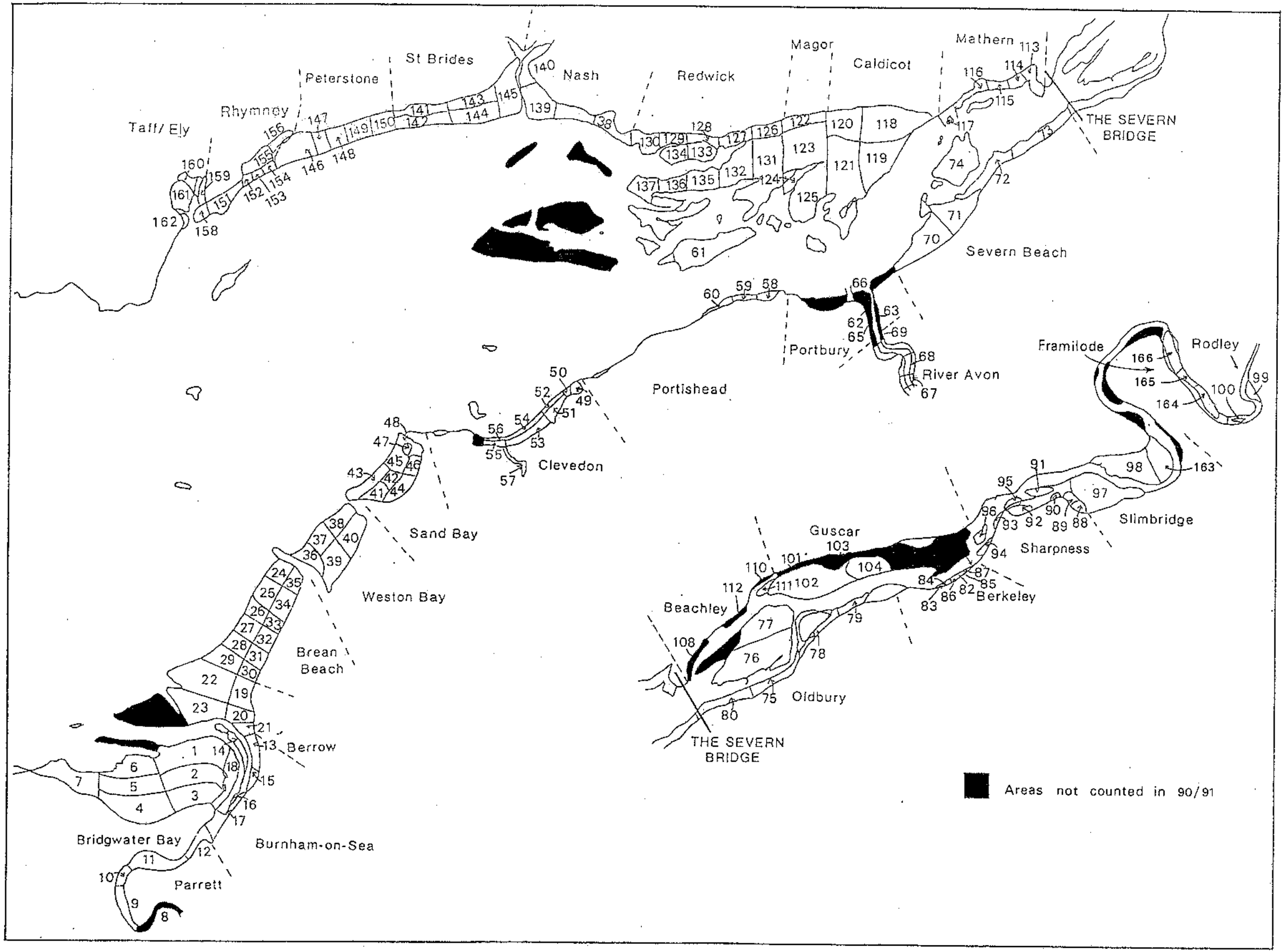


Figure 3.1.1 The locations of the 151 count areas regularly surveyed during mid-winter 1990/91

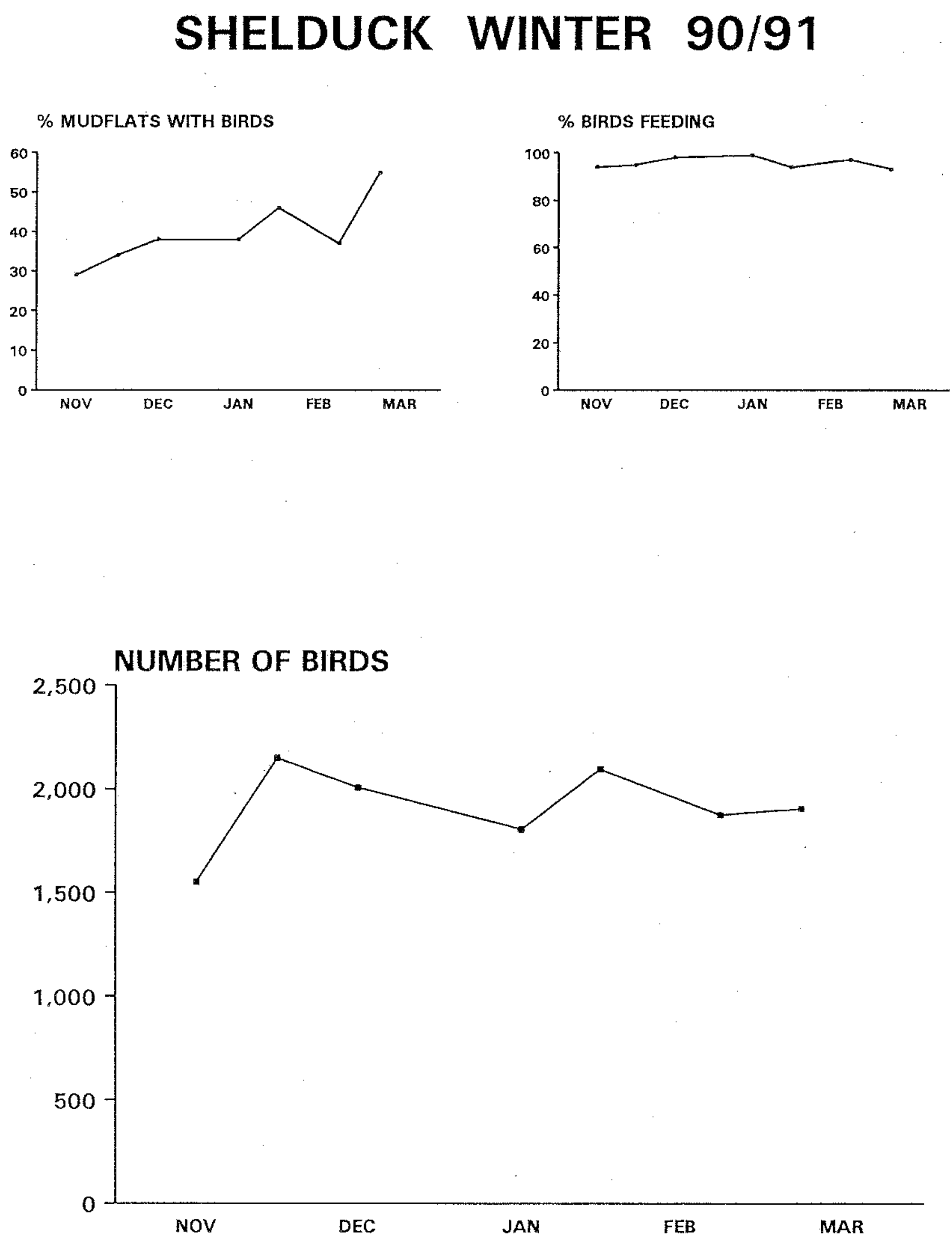


Figure 4.1.1 Graphical summary of information on Shelduck obtained on each count during mid-winter 1990/91

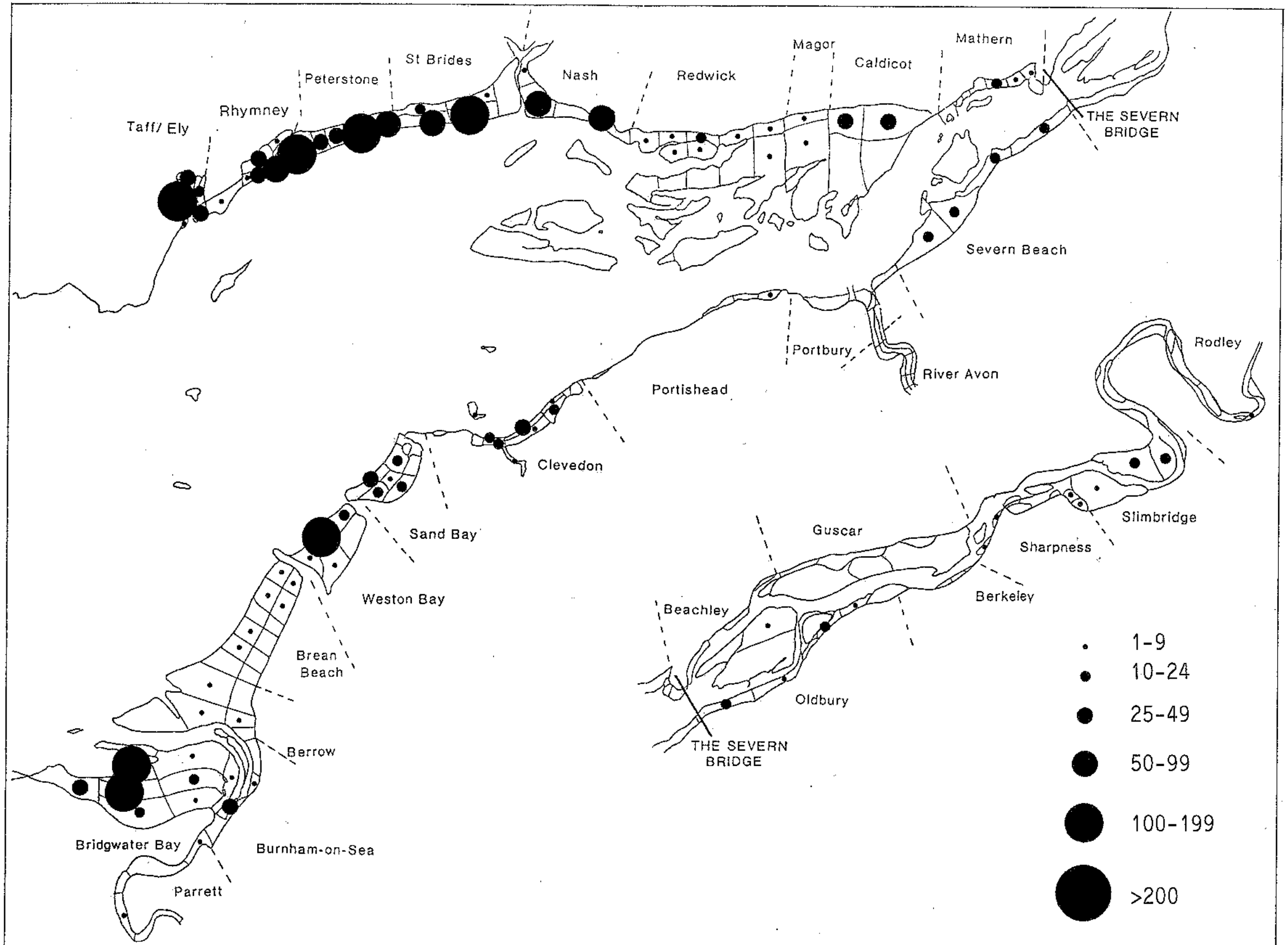


Figure 4.1.2 The average number of Shelduck present on each count area at low tide during winter 1990/91.

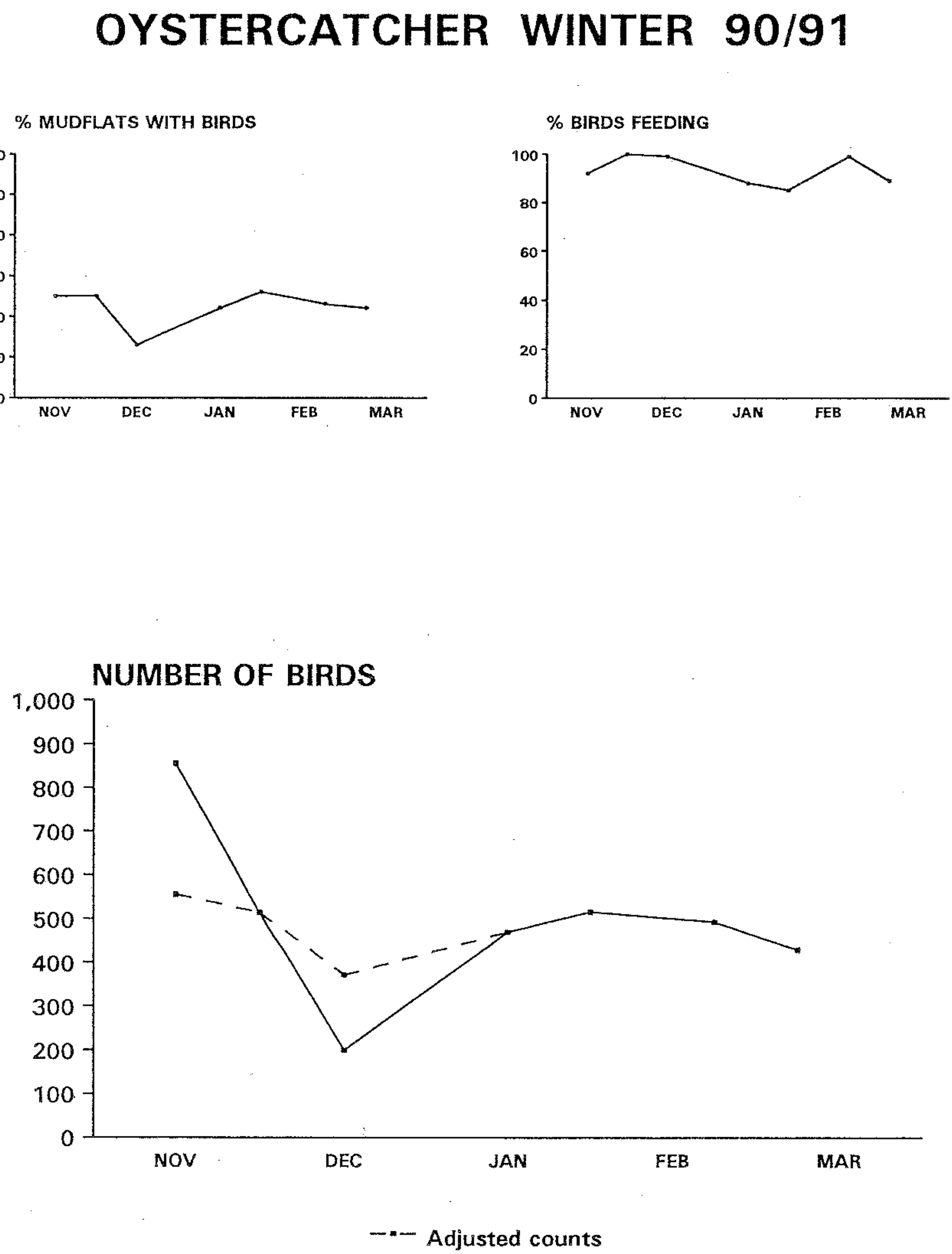


Figure 4.2.1 Graphical summary of information on Oystercatcher obtained on each count during mid-winter 1990/91

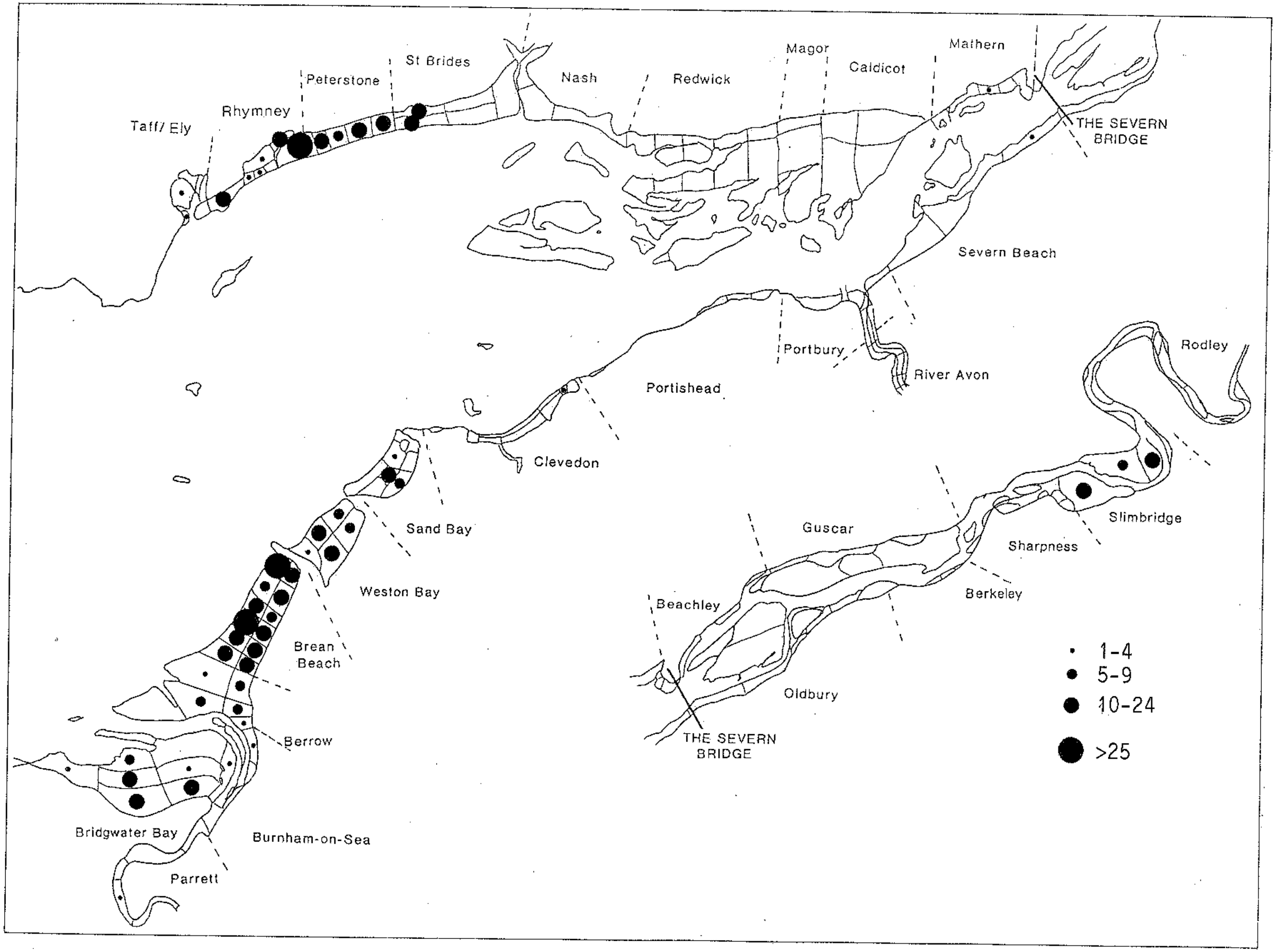


Figure 4.2.2 The average number of Oystercatcher present on each count area at low tide during mid-winter 1990/91.

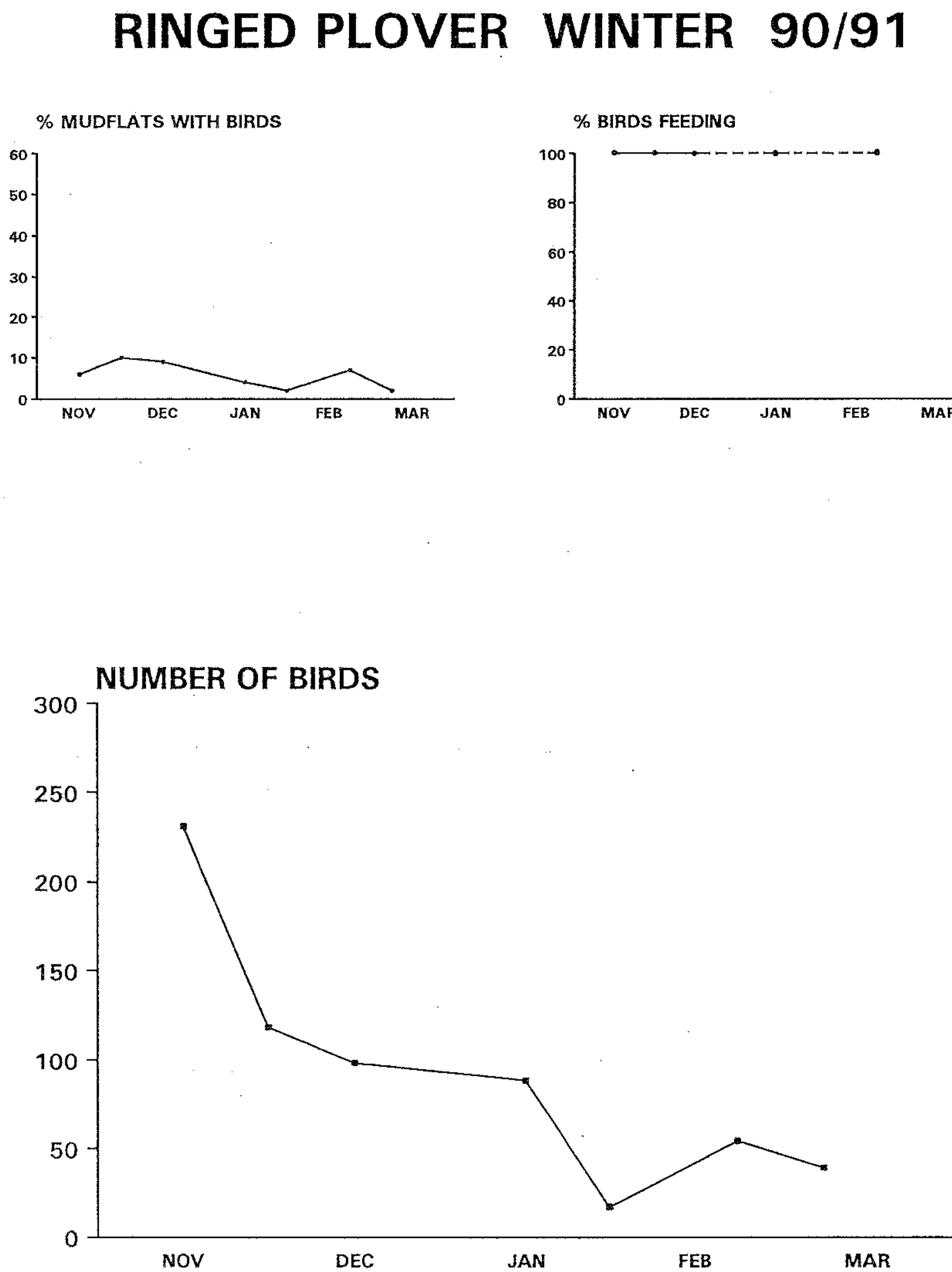


Figure 4.3.1 Graphical summary of information on Ringed Plover obtained on each count area during mid-winter 1990/91

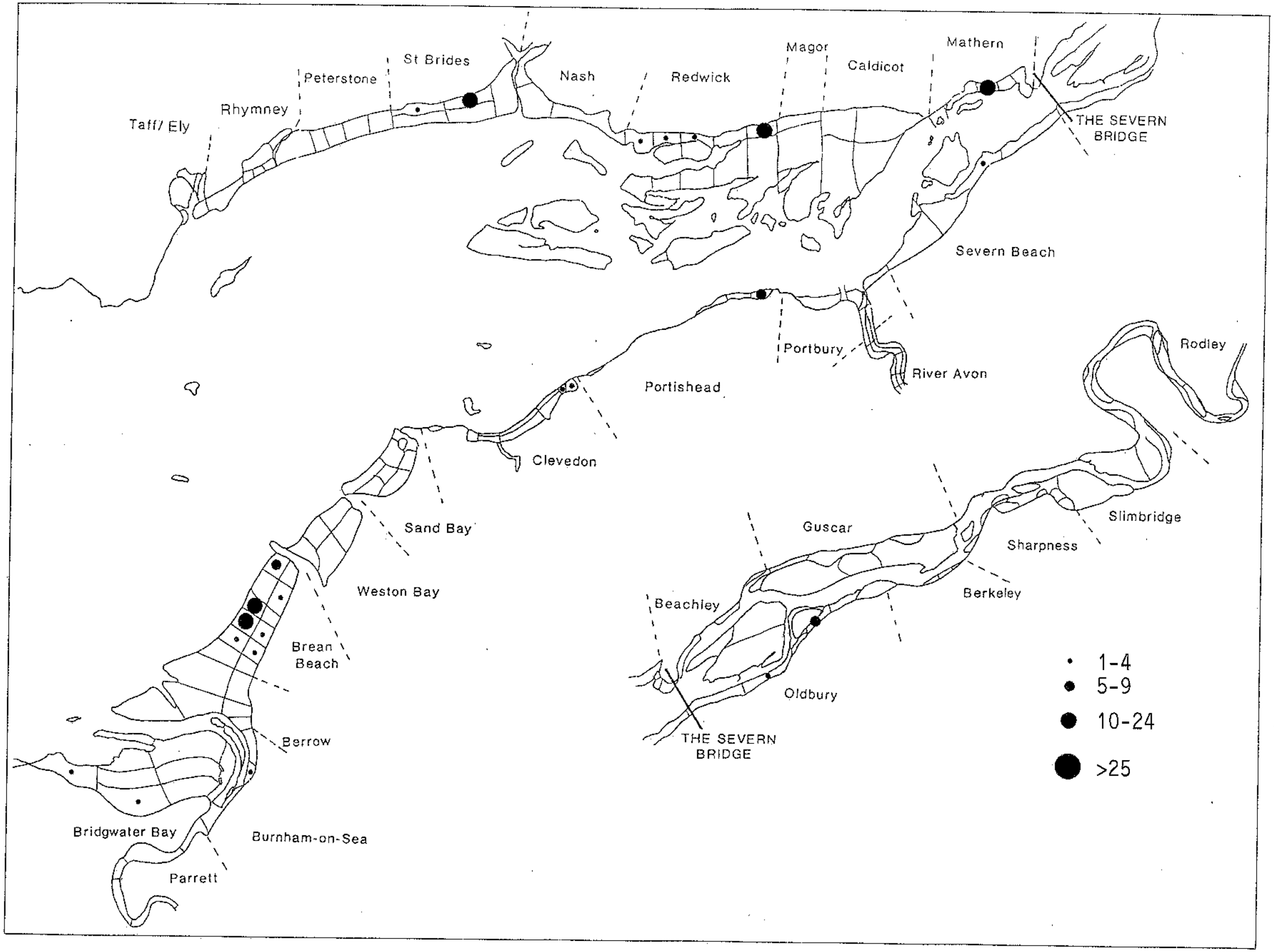


Figure 4.3.2 The average number of Ringed Plover present on each count area at low tide during mid-winter 1990/91.

GREY PLOVER WINTER 90/91

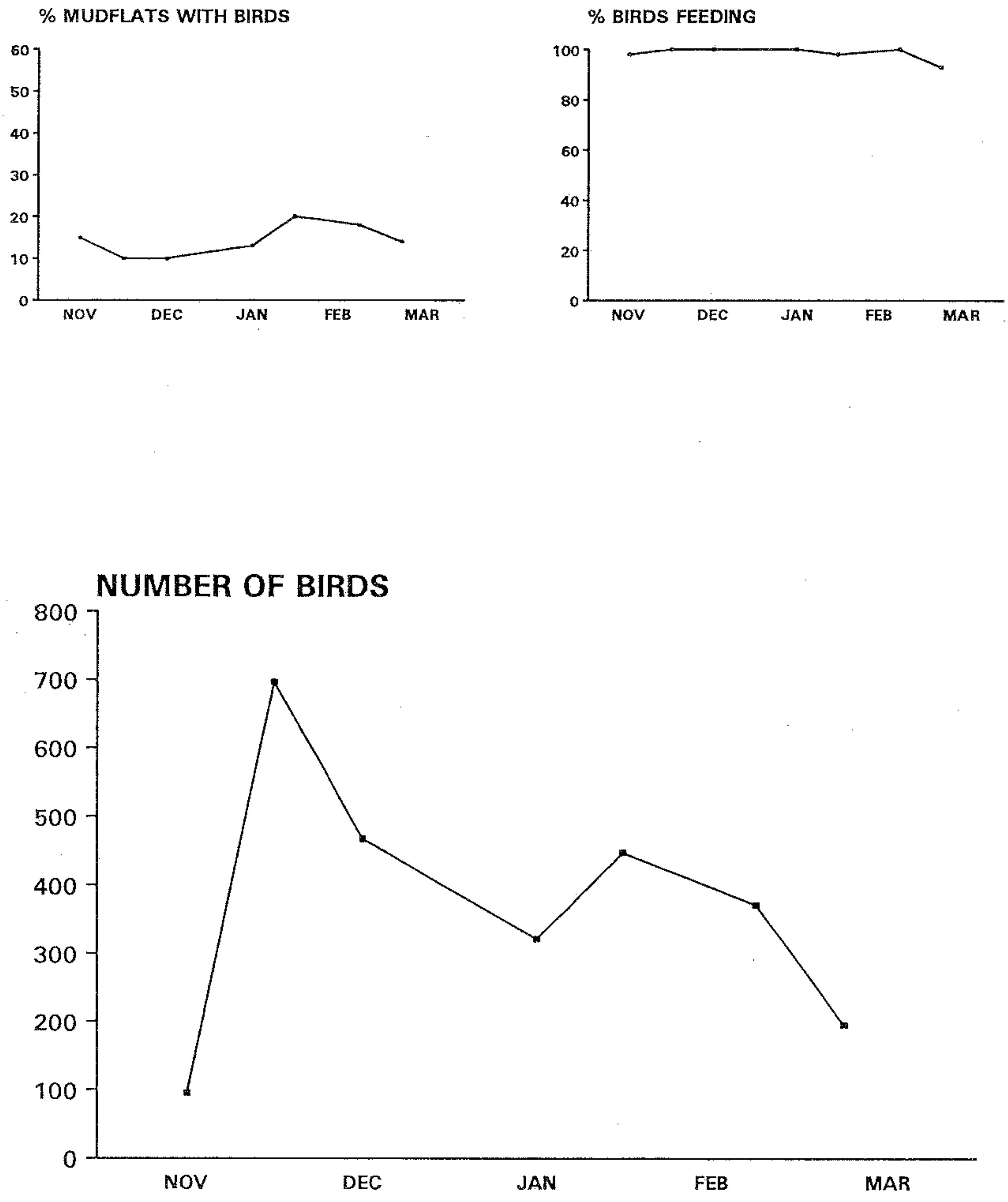


Figure 4.4.1 Graphical summary of information on Grey Plover obtained on each count during mid-winter 1990/91

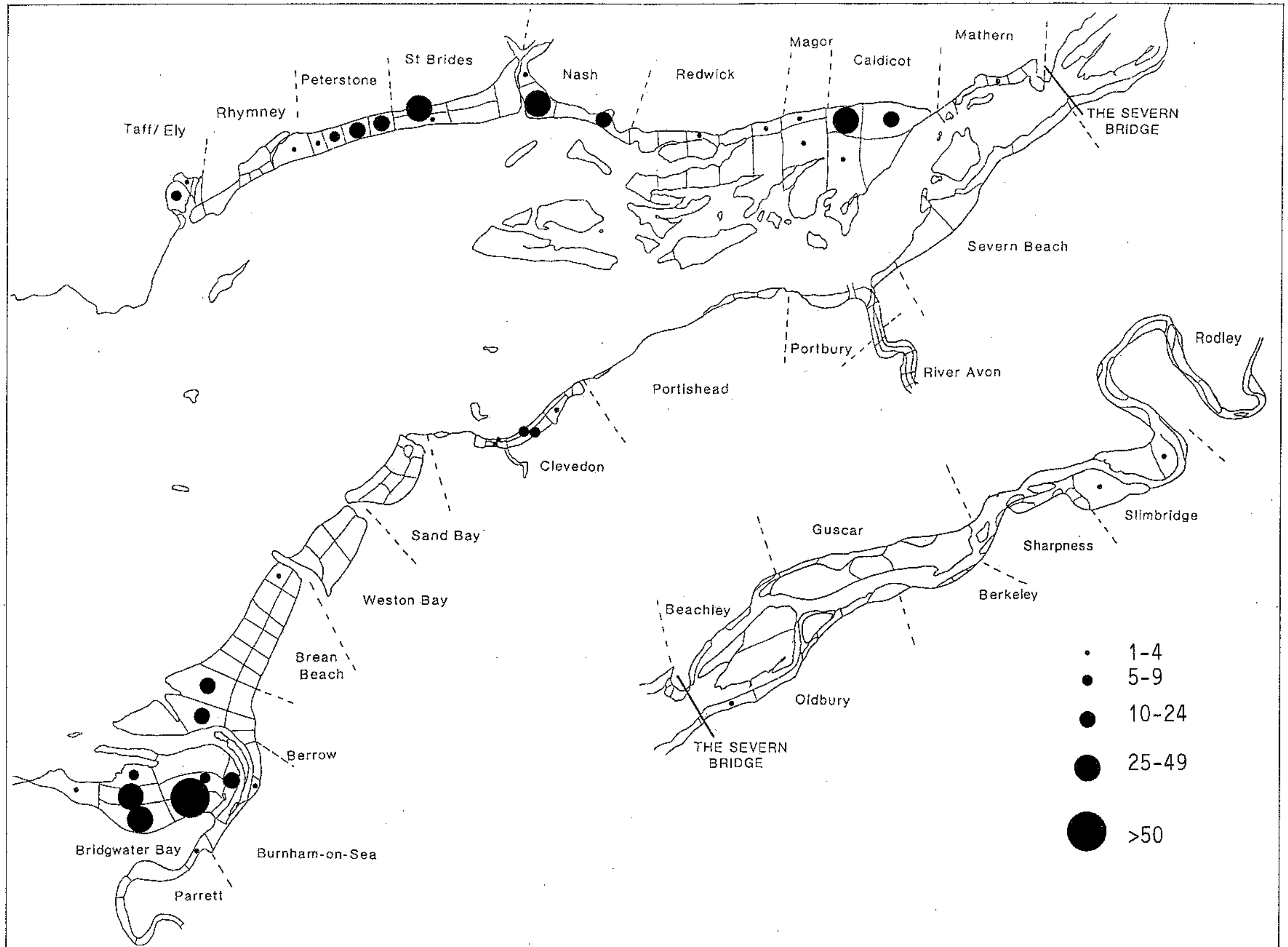


Figure 4.4.2 The average number of Grey Plover present on each count area at low tide during mid-winter 1990/91.

LAPWING WINTER 90/91

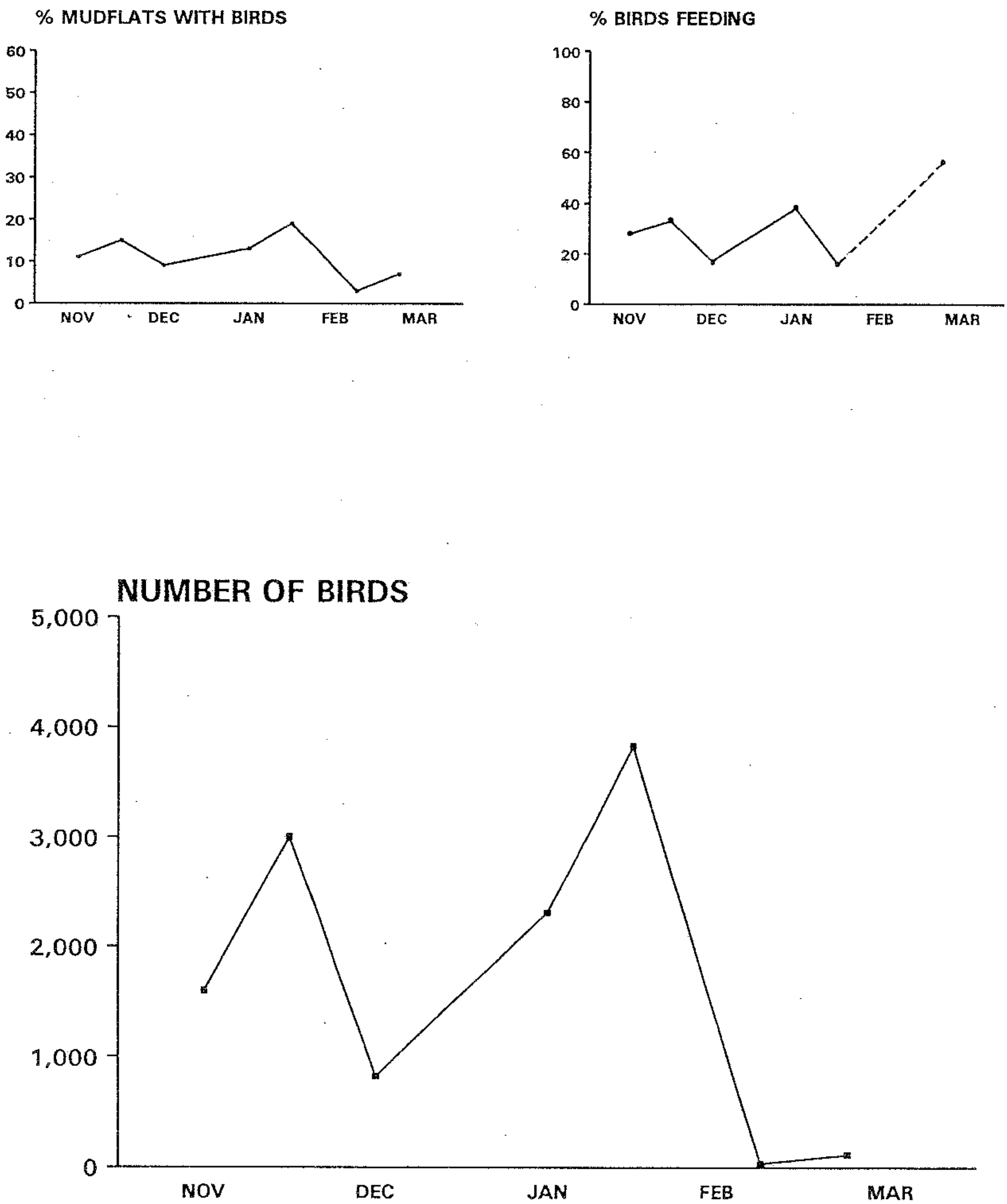


Figure 4.5.1 Graphical summary of information on Lapwing obtained on each count during mid-winter 1990/91

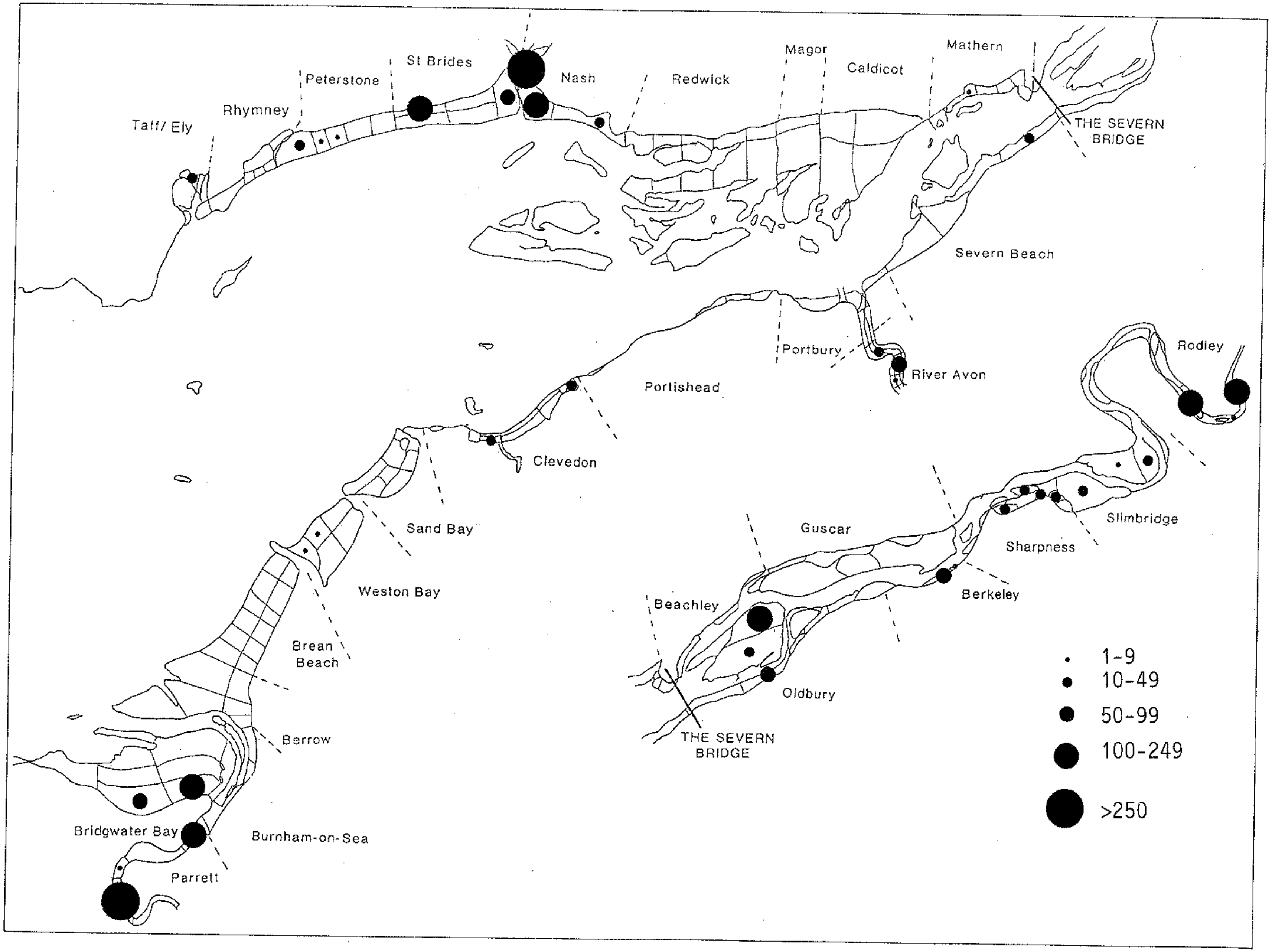


Figure 4.5.2 The average number of Lapwing present on each count area at low tide during mid-winter 1990/91.

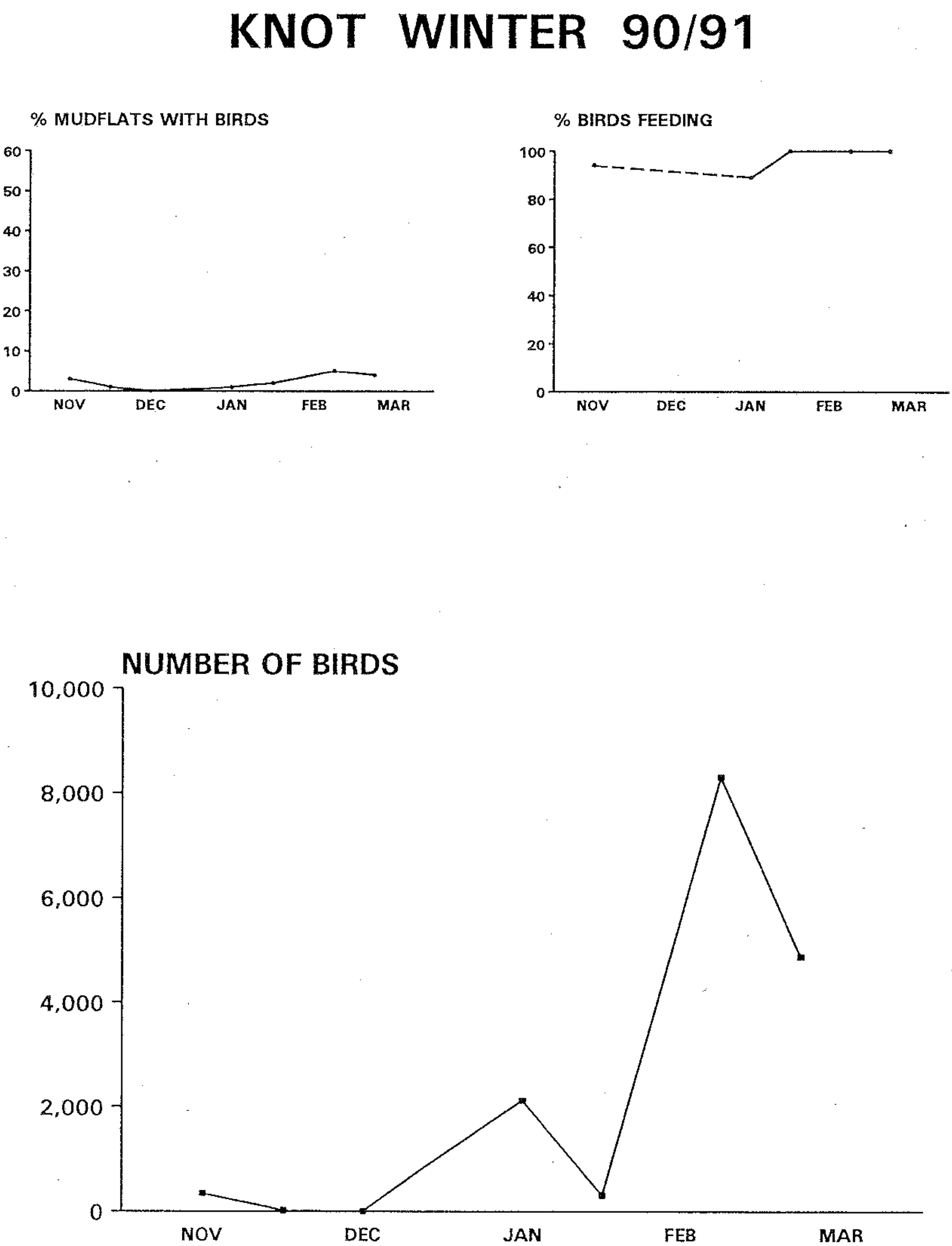


Figure 4.6.1 Graphical summary of information on Knot obtained on each count during mid-winter 1990/91

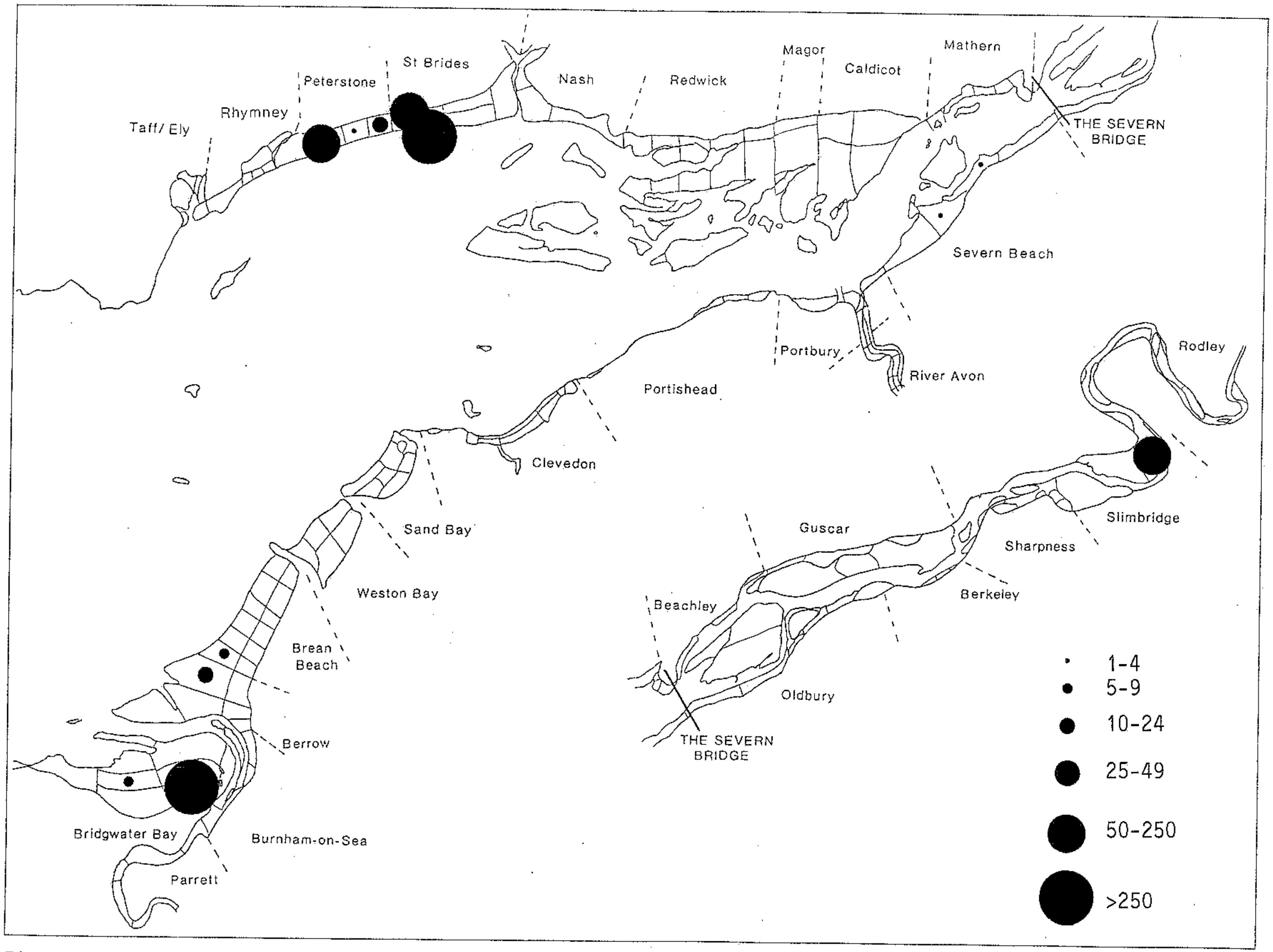


Figure 4.6.2 The average number of Knot present on each count area at low tide during mid-winter 1990/91.

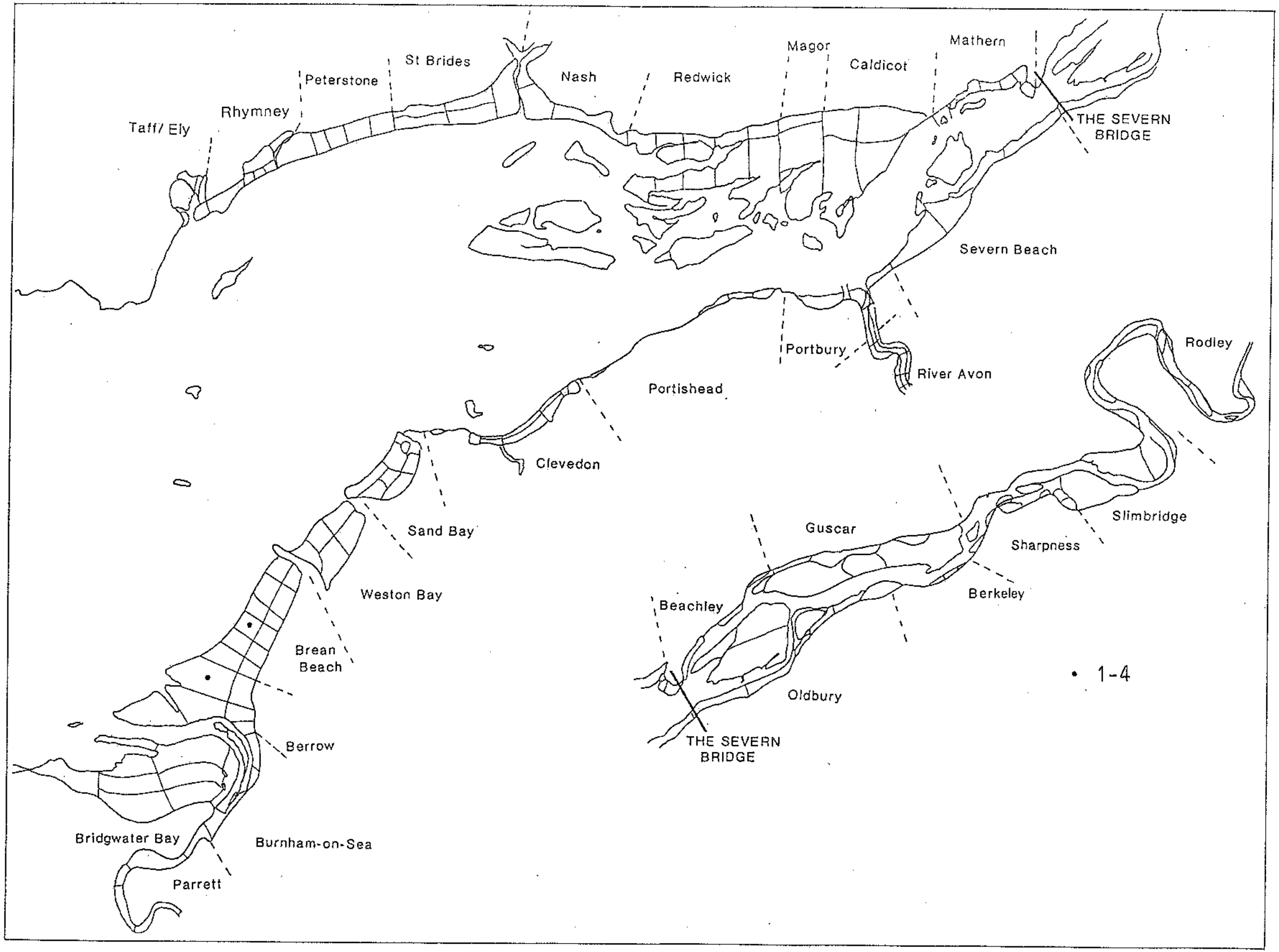


Figure 4.7.1 The average number of Sanderling present on each count area at low tide during mid-winter 1990/91.

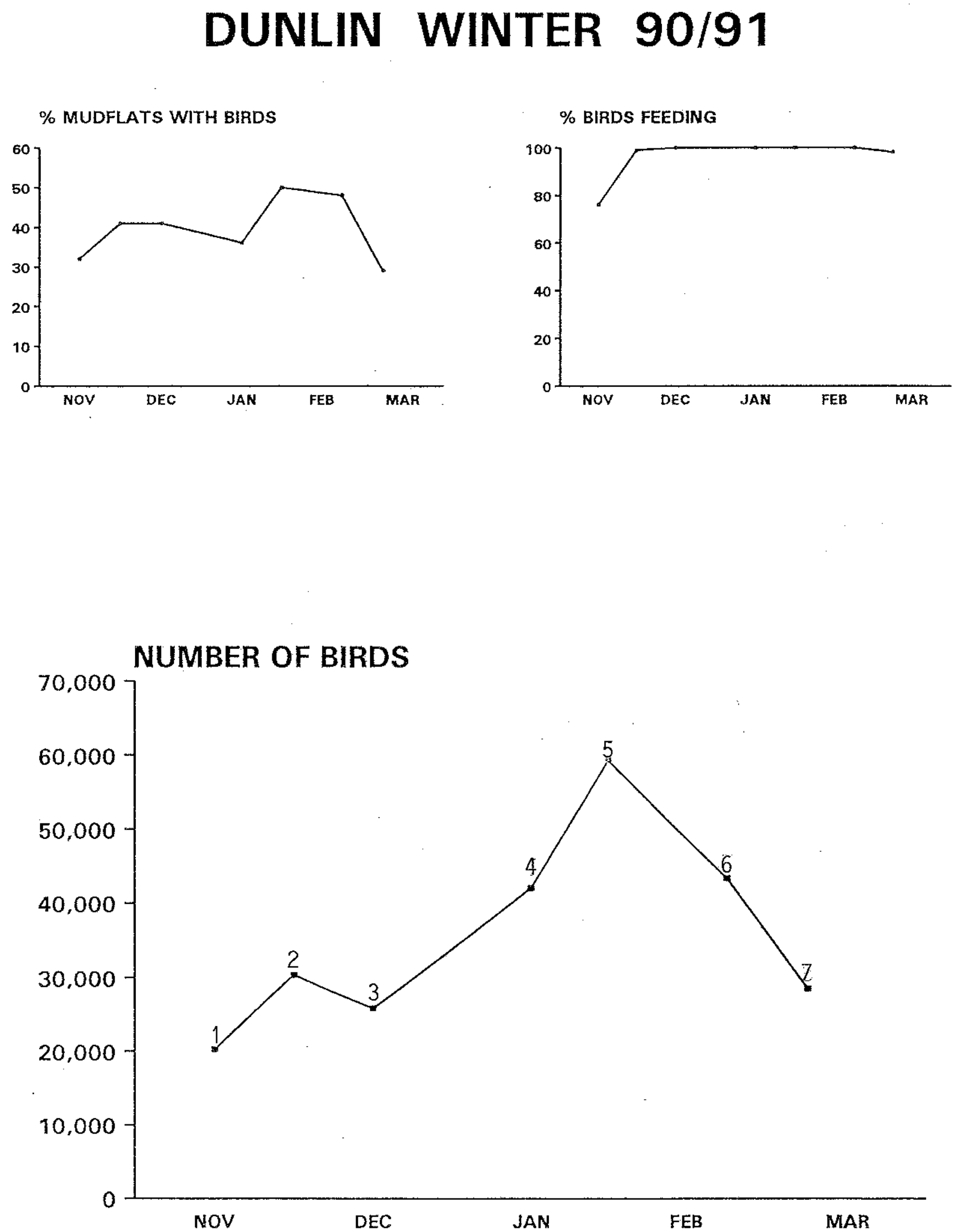


Figure 4.8.1 Graphical summary of information on Dunlin obtained on each count during mid-winter 1990/91

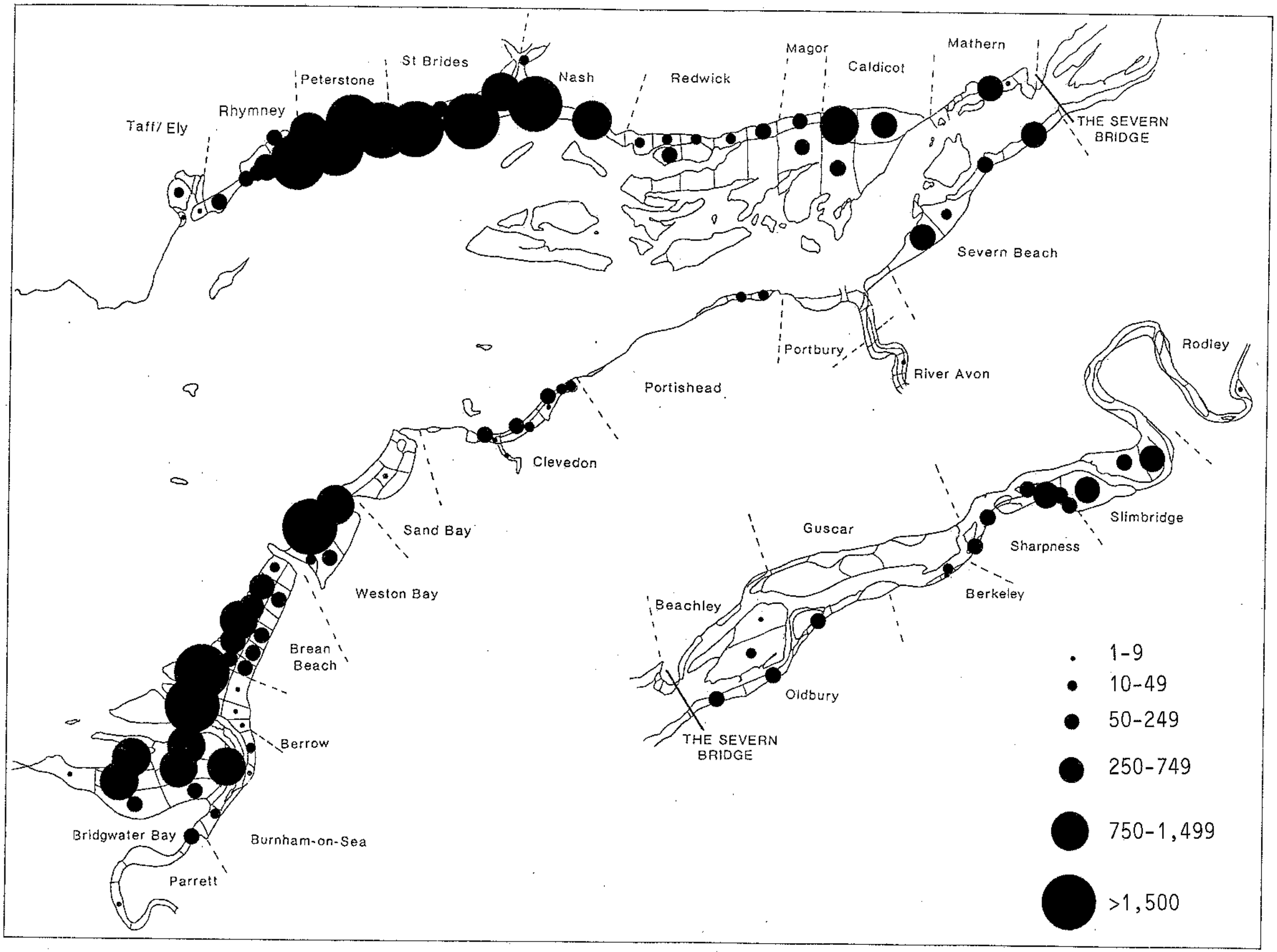


Figure 4.8.2 The average number of Dunlin present on each count area at low tide during mid-winter 1990/91.

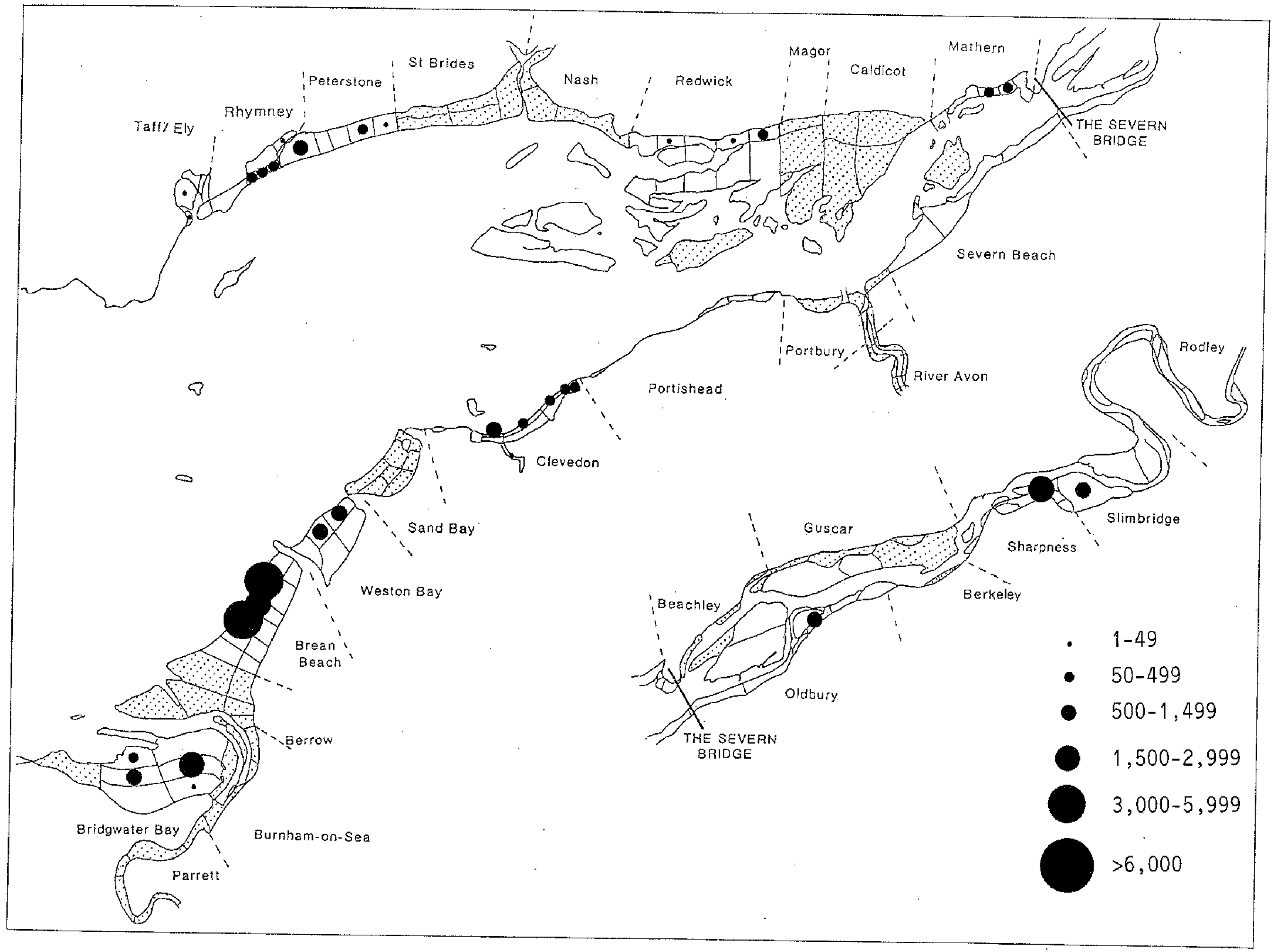


Figure 4.8.3 The distribution of Dunlin on Count 1 (17/18 November 1990). Shaded areas were not covered on this count.

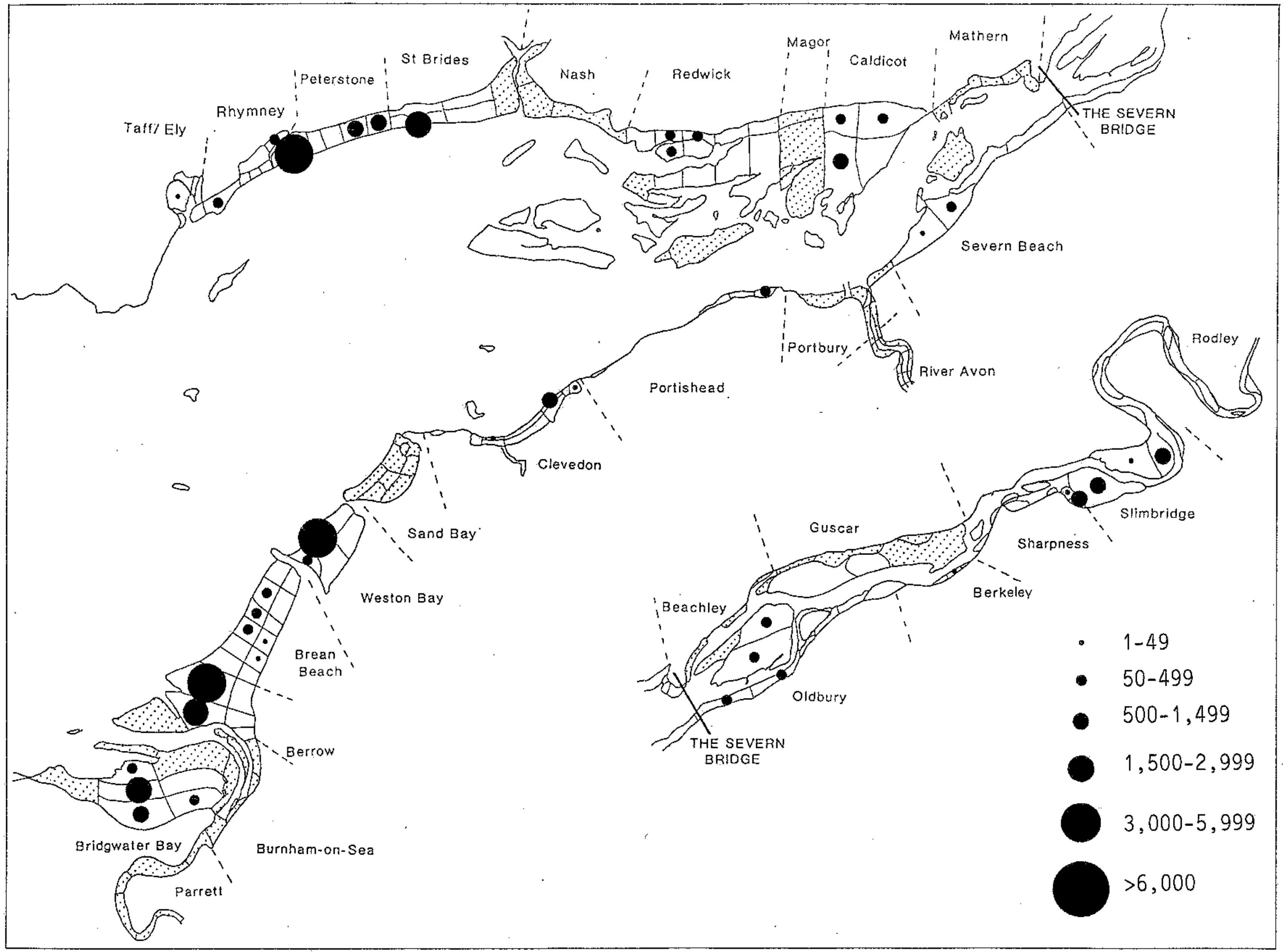


Figure 4.8.4 The distribution of Dunlin on Count 2 (01/02 December 1990). Shaded areas were not covered on this count.

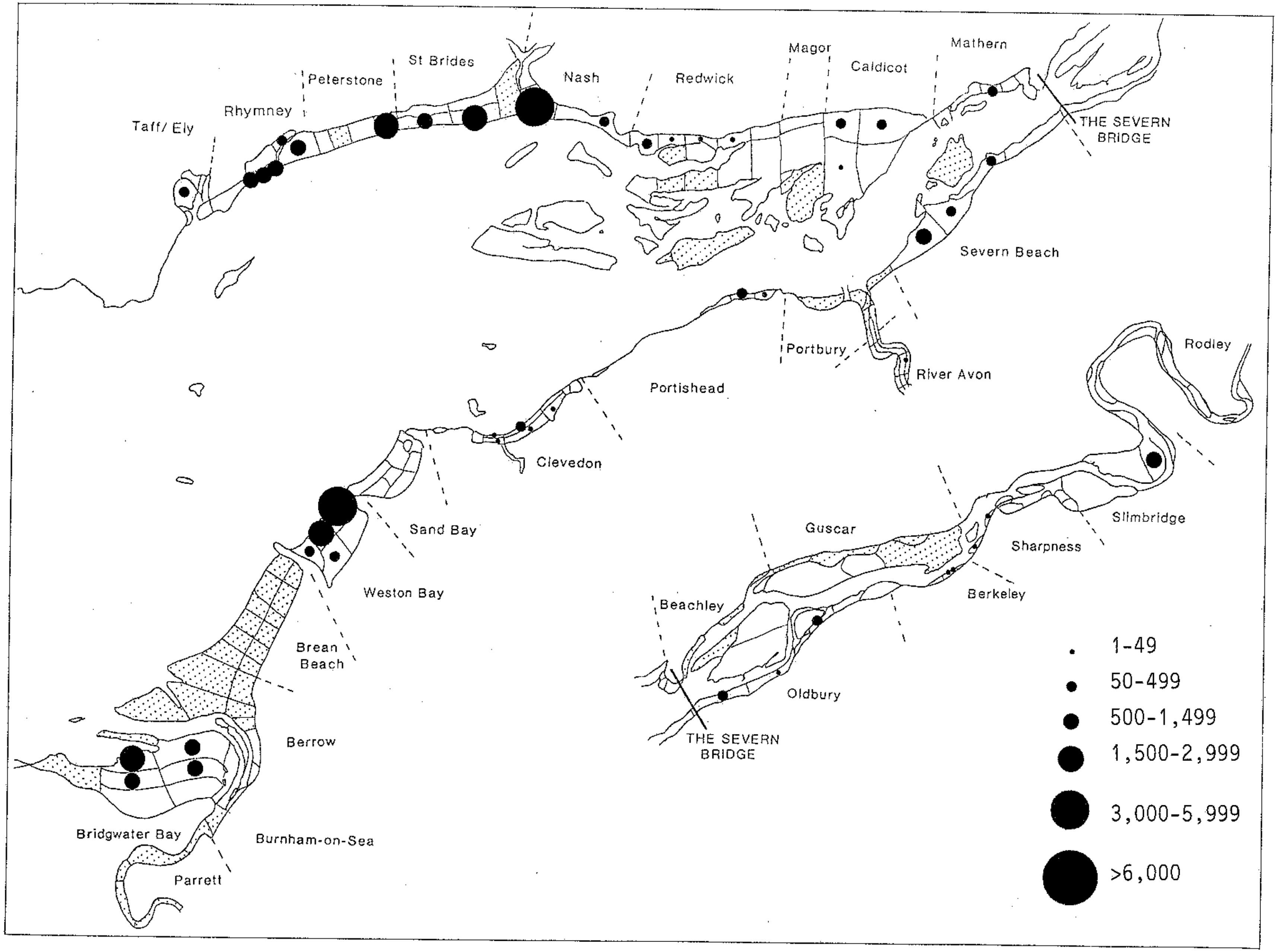


Figure 4.8.5 The distribution of Dunlin on Count 3 (15/16 December 1990). Shaded areas were not covered on this count.

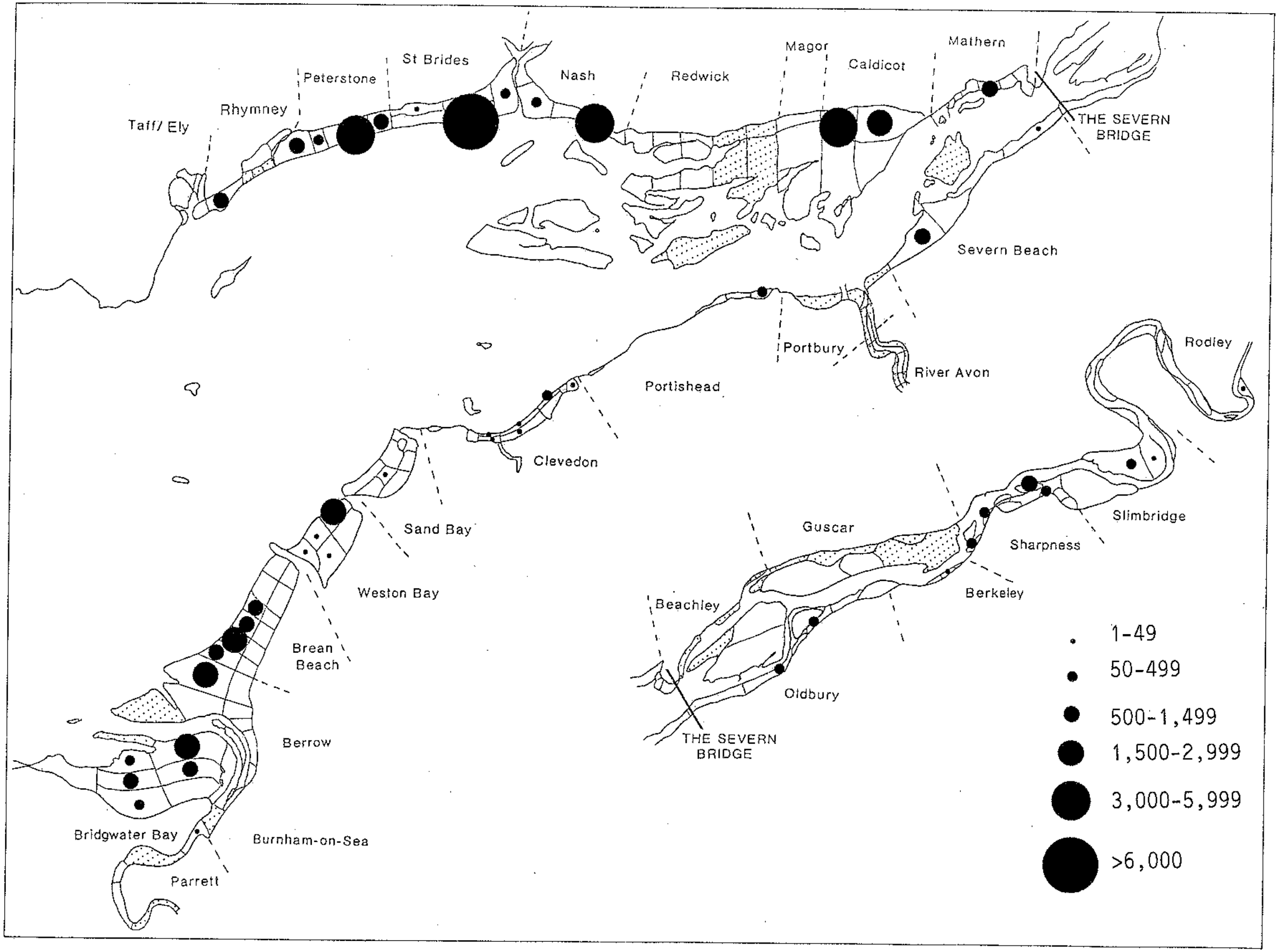


Figure 4.8.6 The distribution of Dunlin on Count 4 (12/13 January 1991). Shaded areas were not covered on this count.

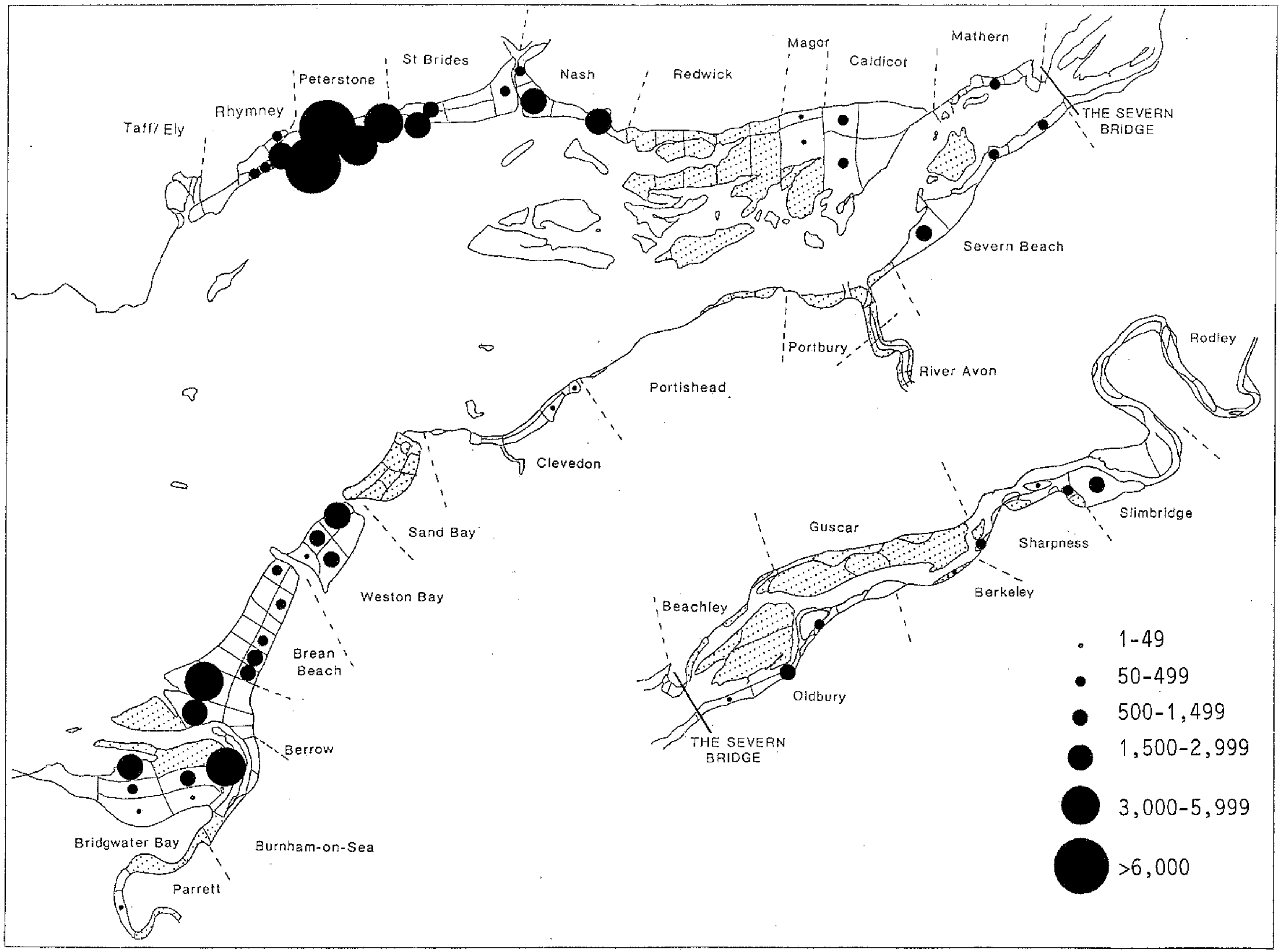


Figure 4.8.7 The distribution of Dunlin on Count 5 (26/27 January 1991). Shaded areas were not covered on this count.

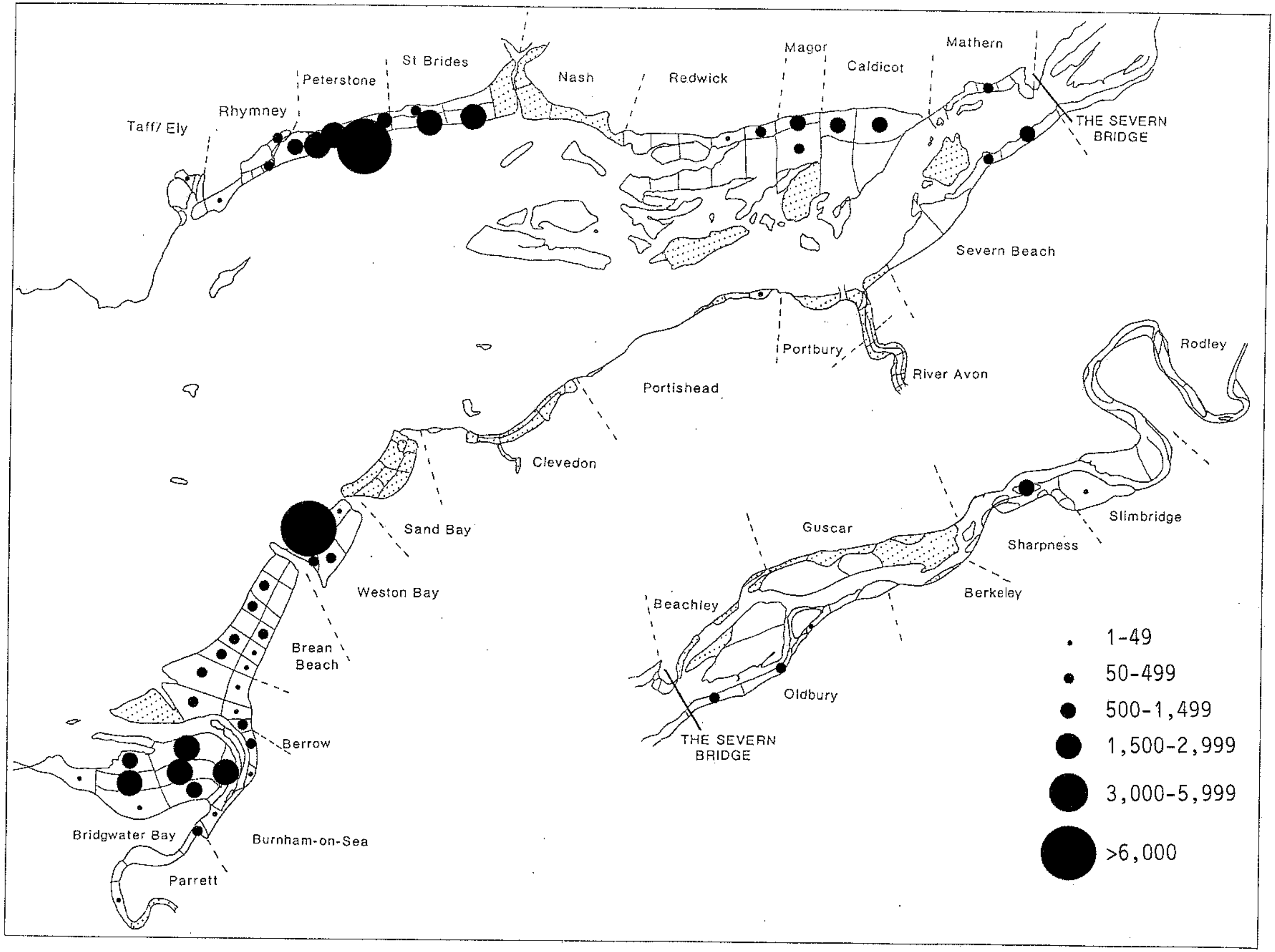


Figure 4.8.8 The distribution of Dunlin on Count 6 (16/17 February 1991). Shaded areas were not covered on this count.

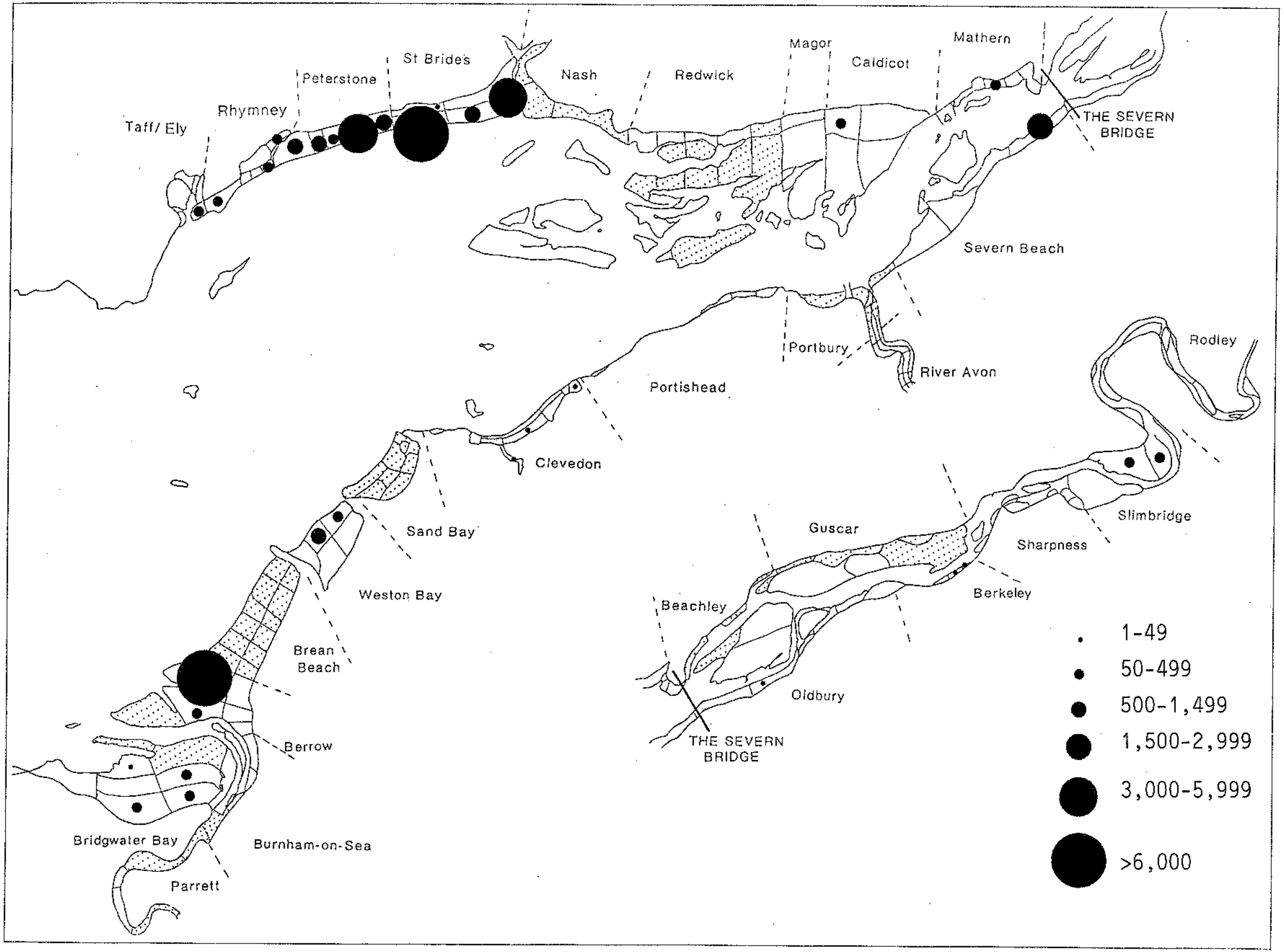


Figure 4.8.9 The distribution of Dunlin on Count 7 (02/03 March 1991). Shaded areas were not covered on this count.

BAR-TAILED GODWIT WINTER 90/91

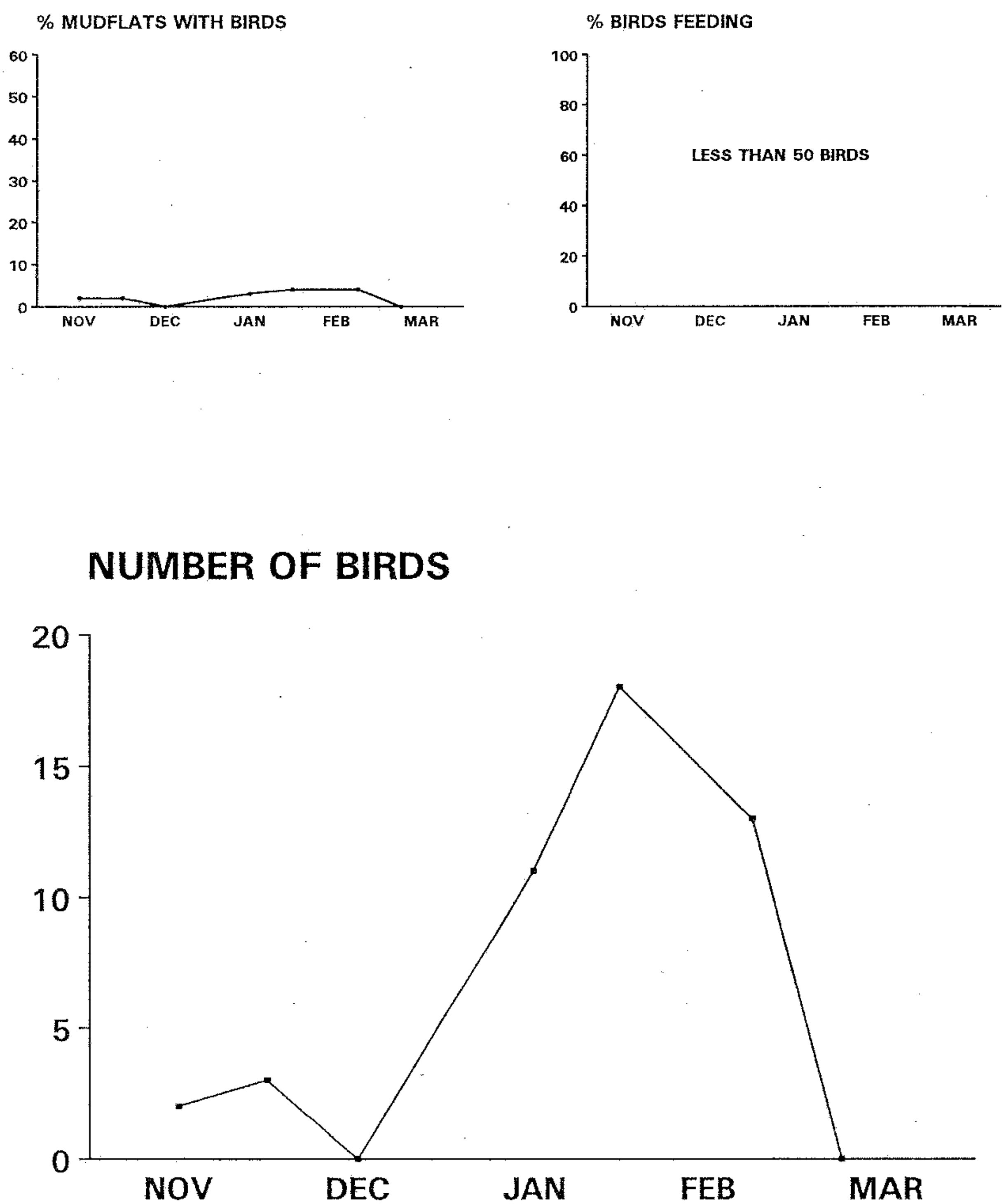


Figure 4.9.1 Graphical summary of information on Bar-tailed Godwit obtained on each count during mid-winter 1990/91

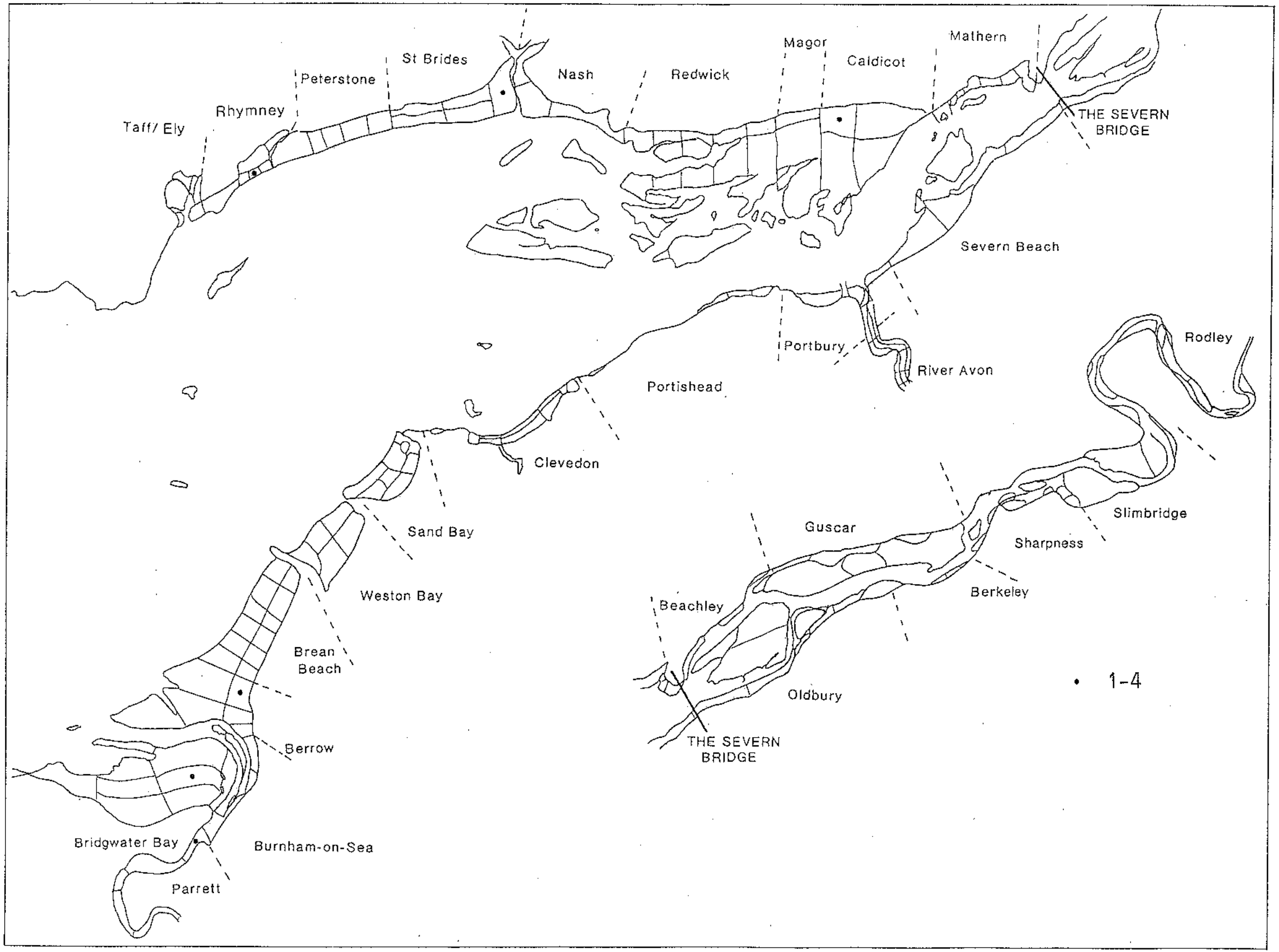


Figure 4.9.2 The average number of Bar-tailed Godwit present on each count area at low tide during mid-winter 1990/91.

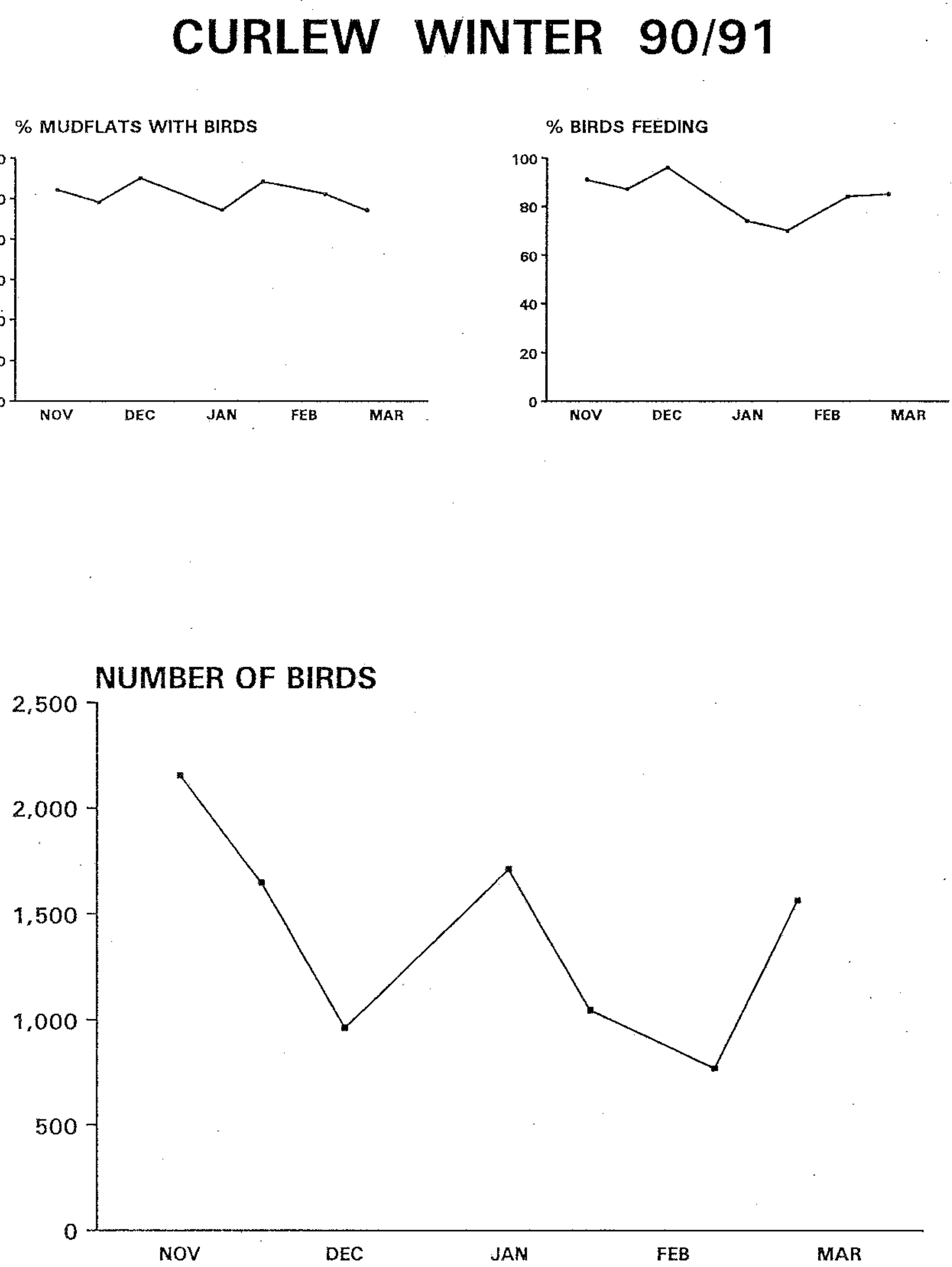


Figure 4.10.1 Graphical summary of information on Curlew obtained on each count during mid-winter 1990/91

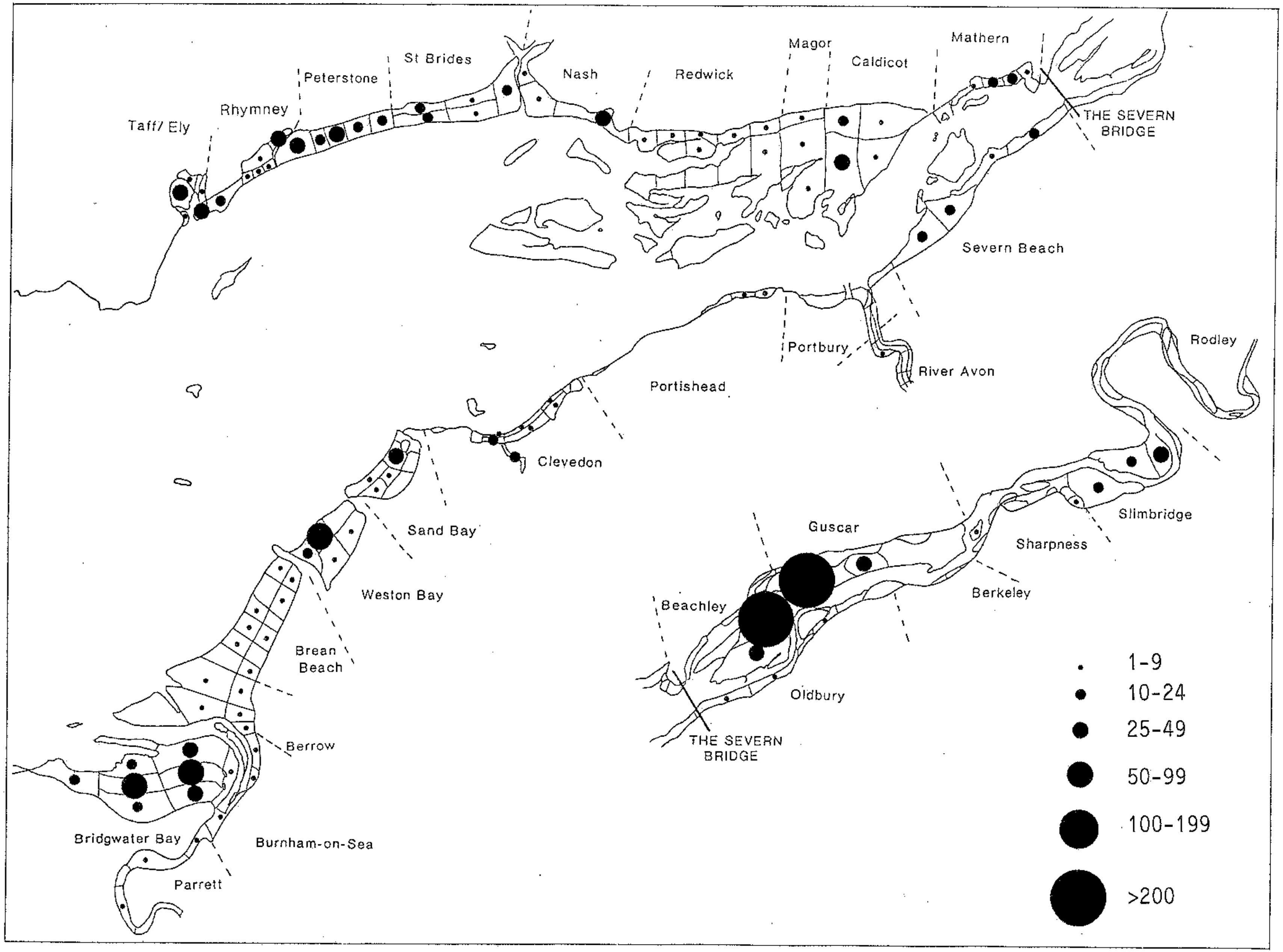


Figure 4.10.2 The average number of Curlew present on each count area at low tide during mid-winter 1990/91.

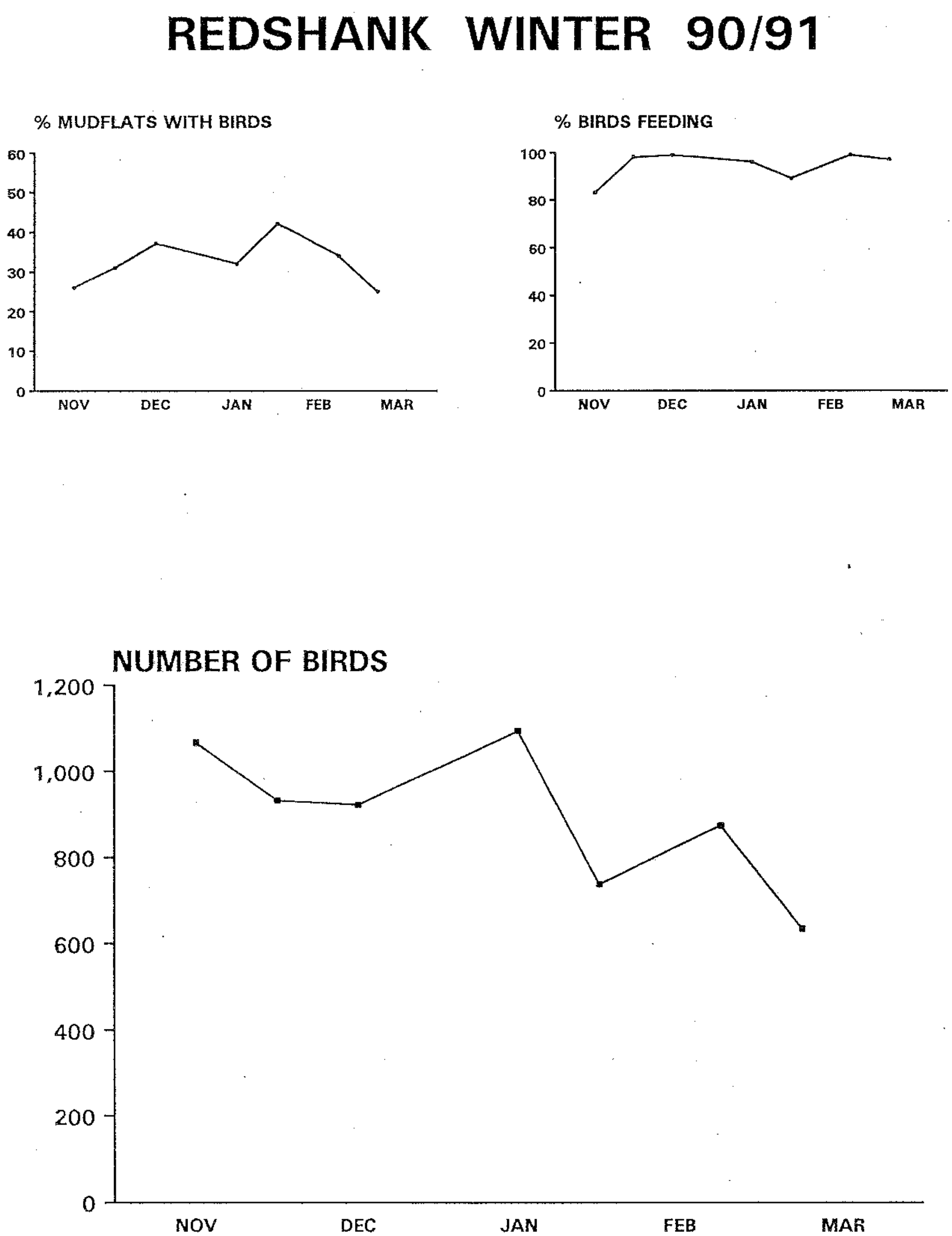


Figure 4.11.1 Graphical summary of information on Redshank obtained on each count during mid-winter 1990/91

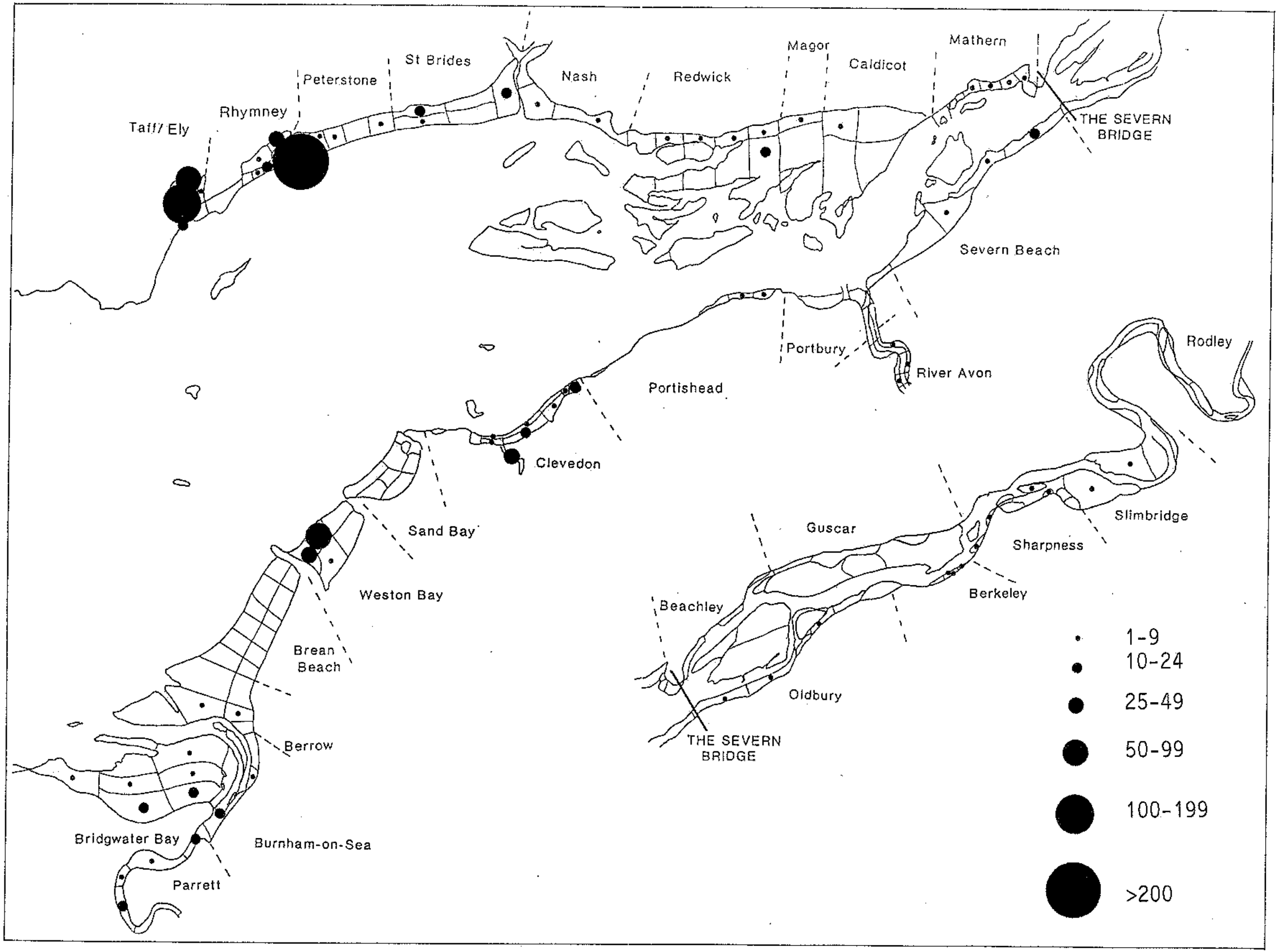


Figure 4.11.2 The average number of Redshank present on each count area at low tide during mid-winter 1990/91.

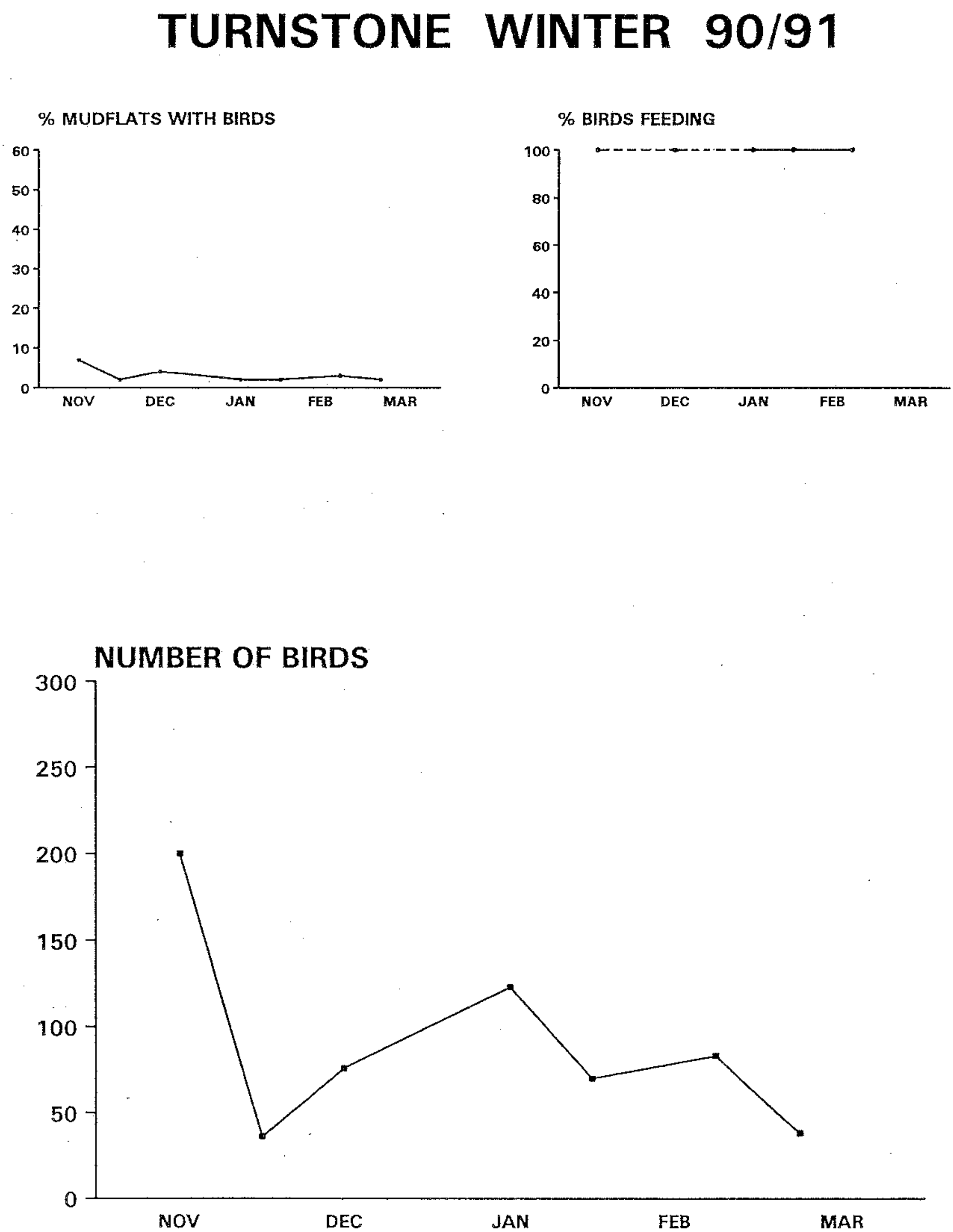


Figure 4.12.1 Graphical summary of information on Turnstone obtained on each count during mid-winter 1990/91

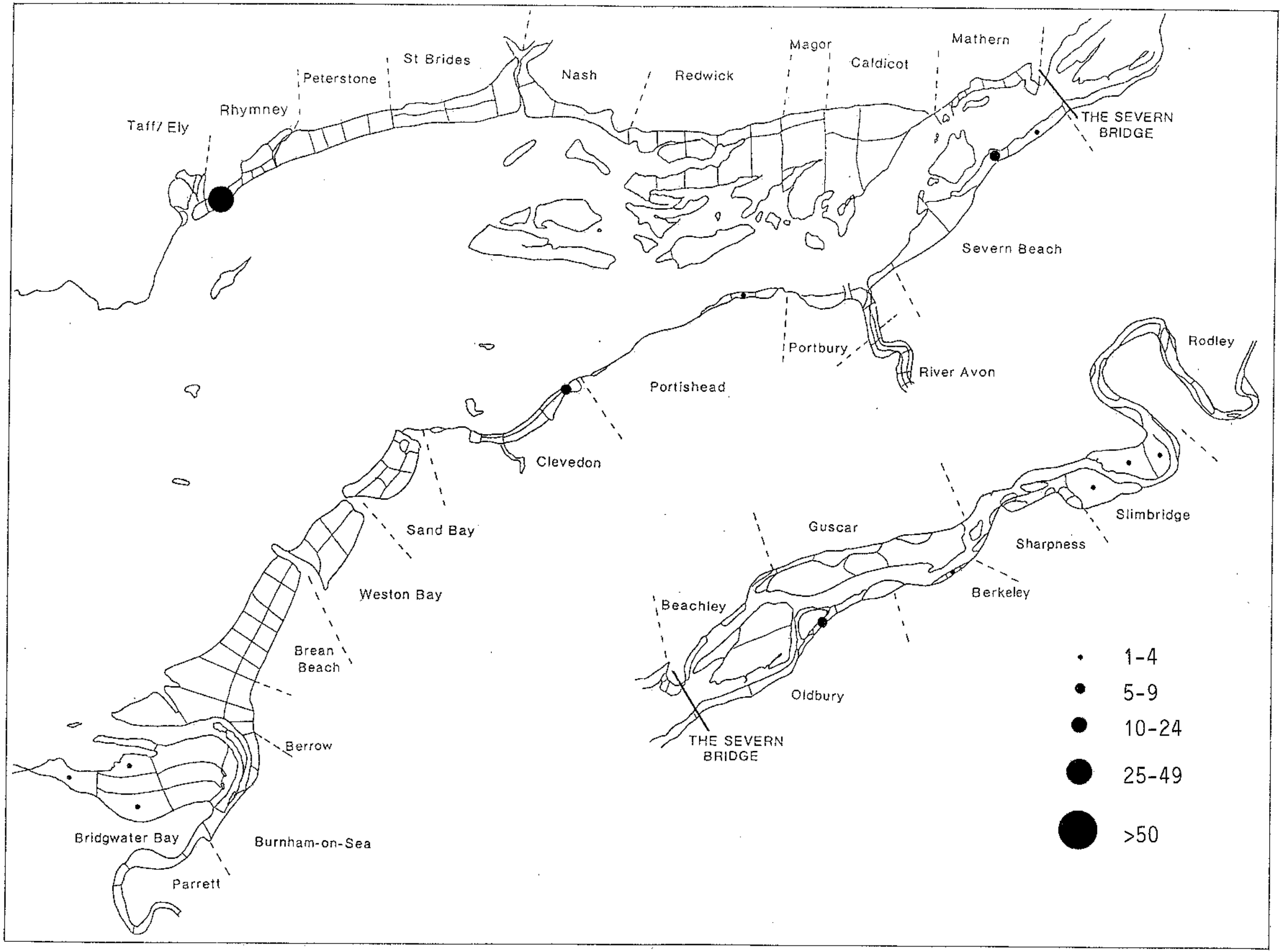


Figure 4.12.2 The average number of Turnstone present on each count area at low tide during mid-winter 1990/91.

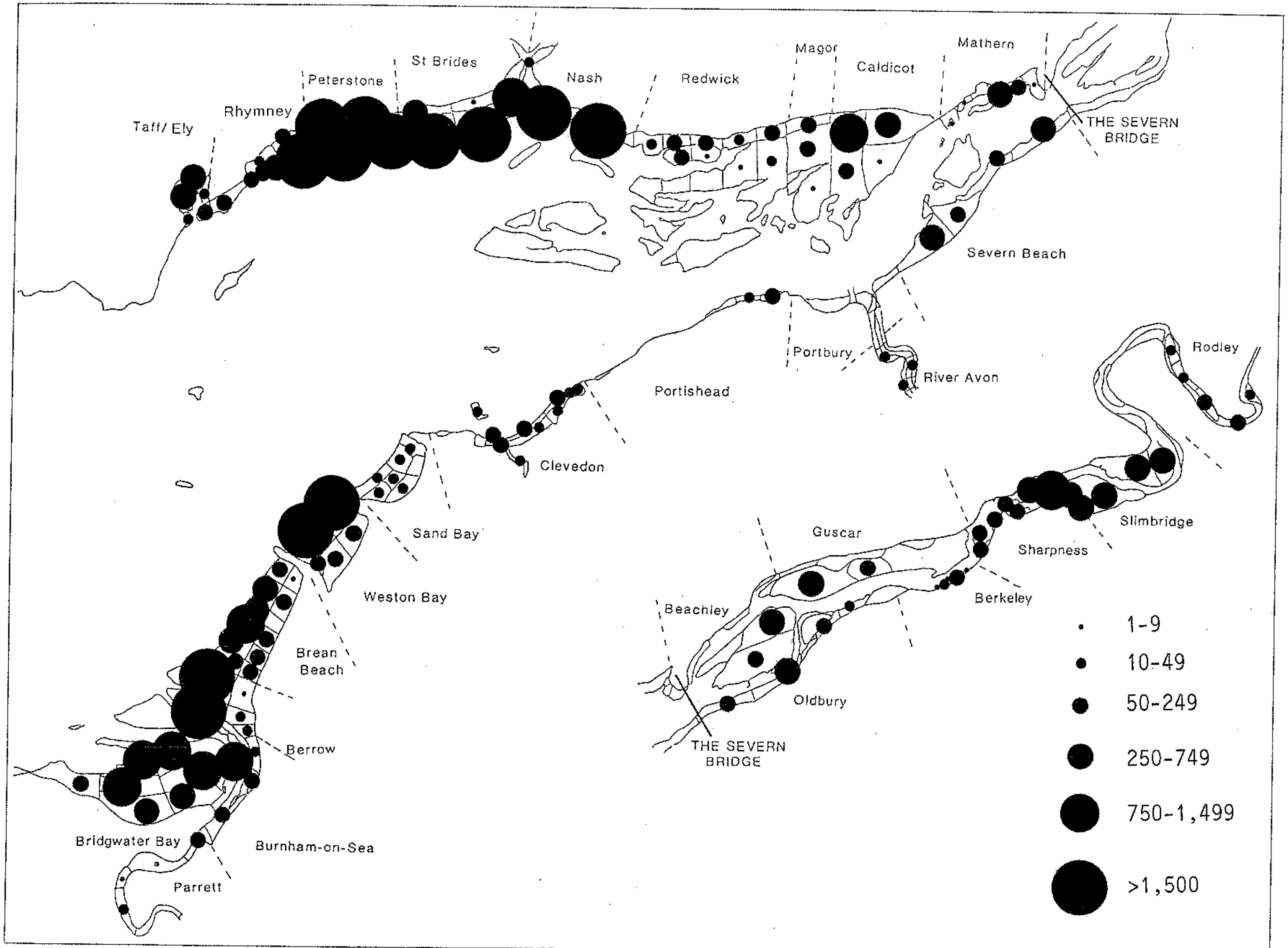


Figure 4.13.1 The average total number of waders and Shelduck present at low tide on each count area during mid-winter 1990/91

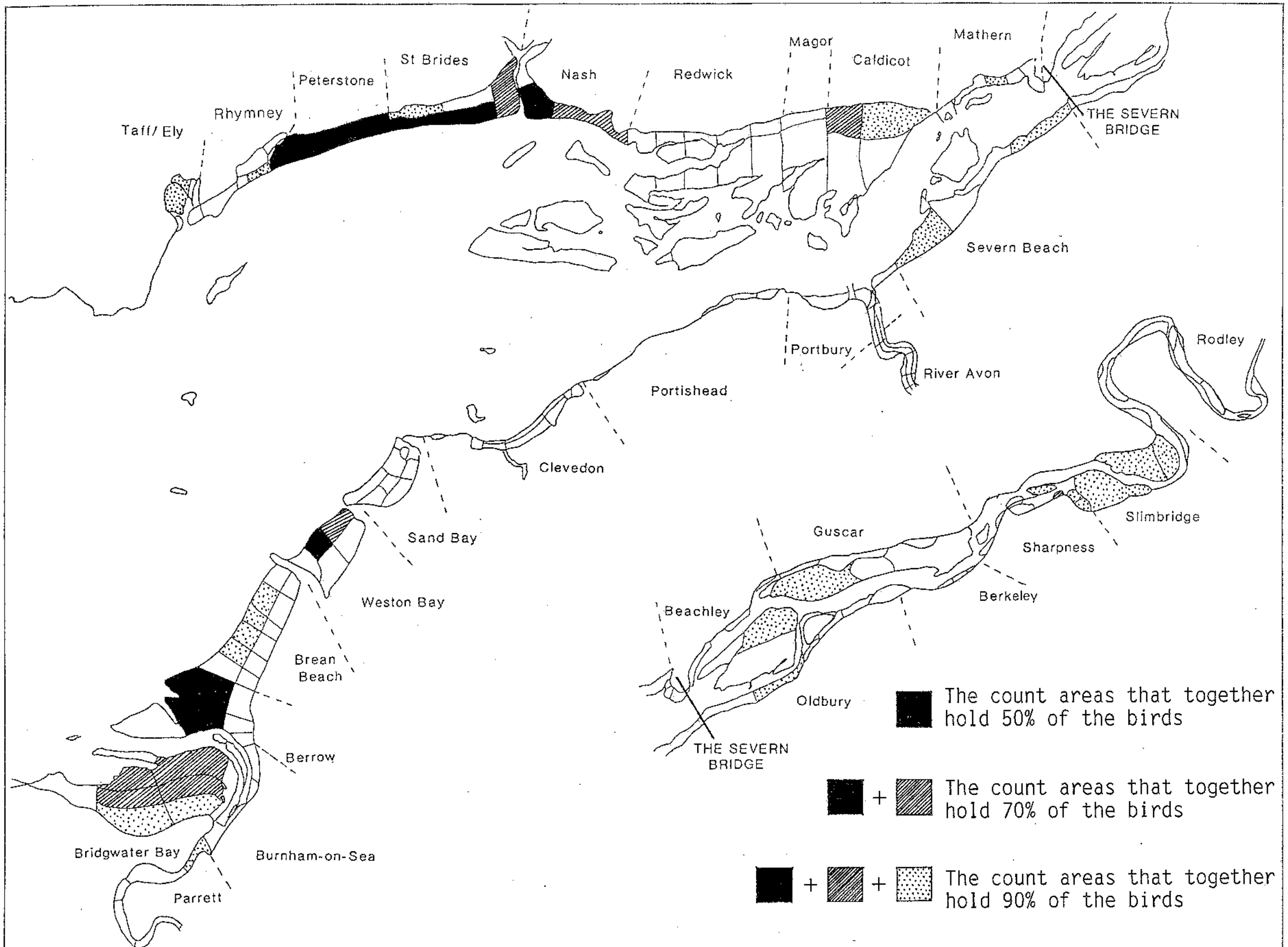


Figure 4.13.2 Areas of the Severn that were important to waders and Shelduck at low tide in the 1990/91 winter.

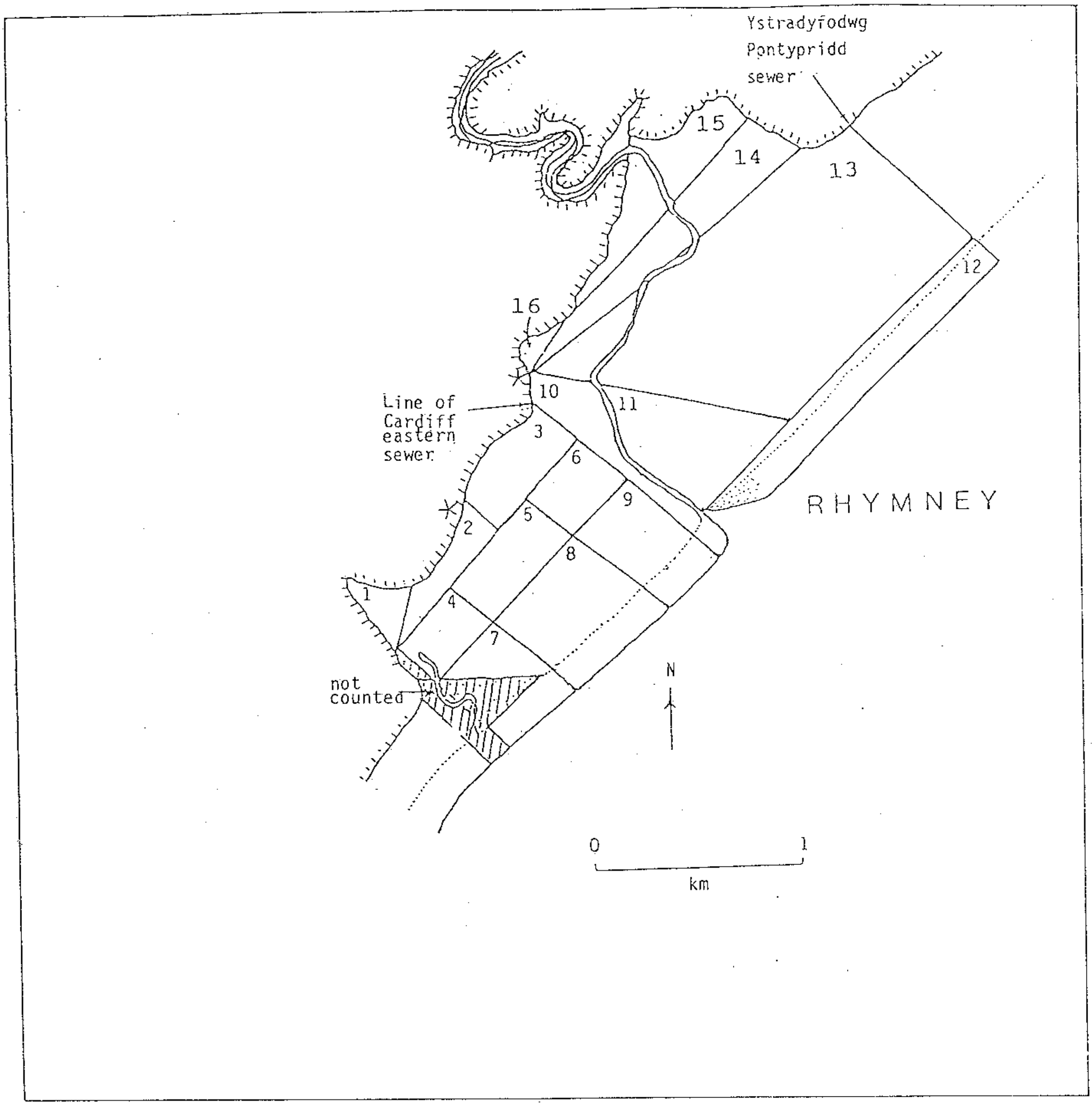


Figure 6.1.1 The Rhymney all day study site.

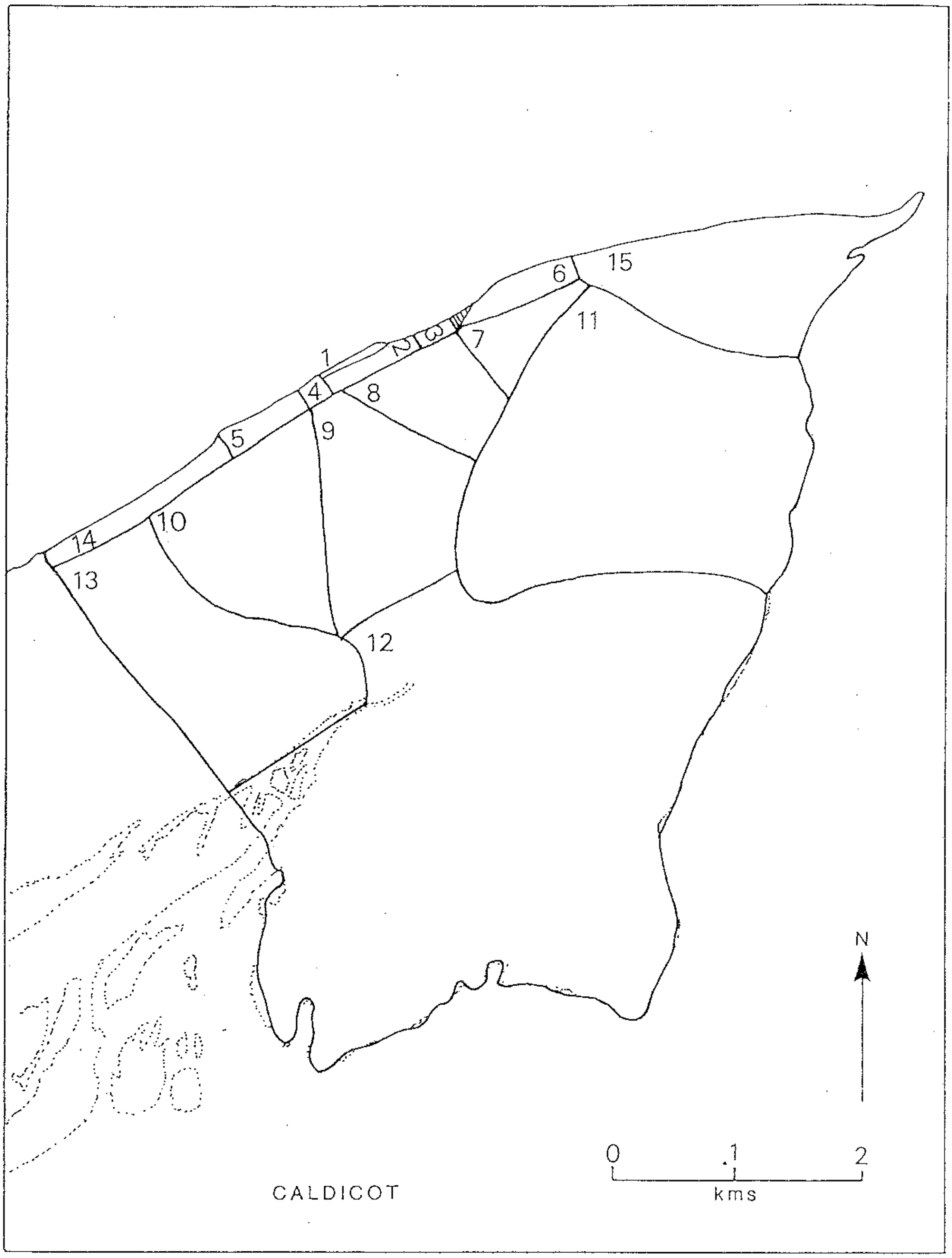


Figure 6.1.2 The Caldicot all day study site.

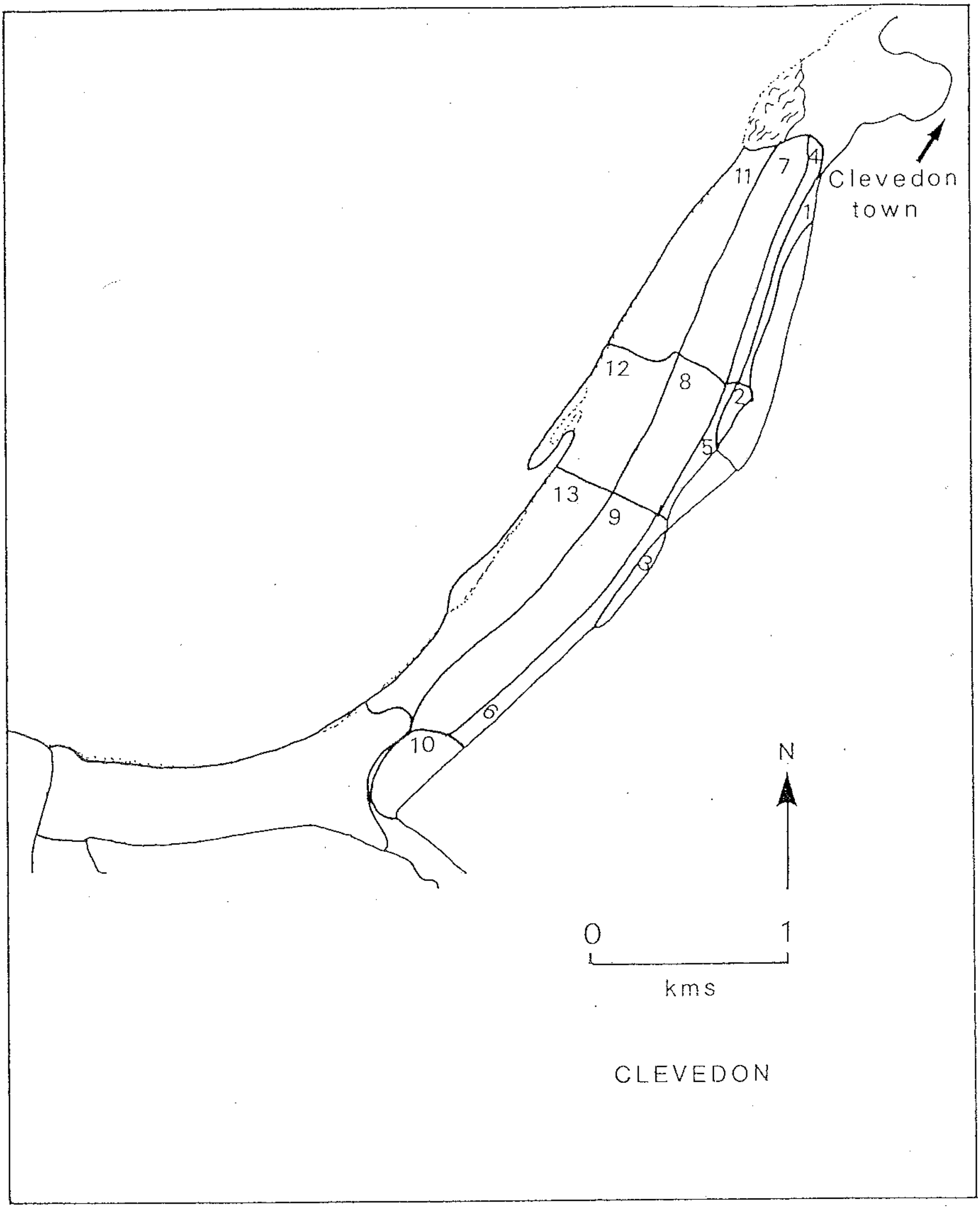


Figure 6.1.3 The Clevedon all day study site.

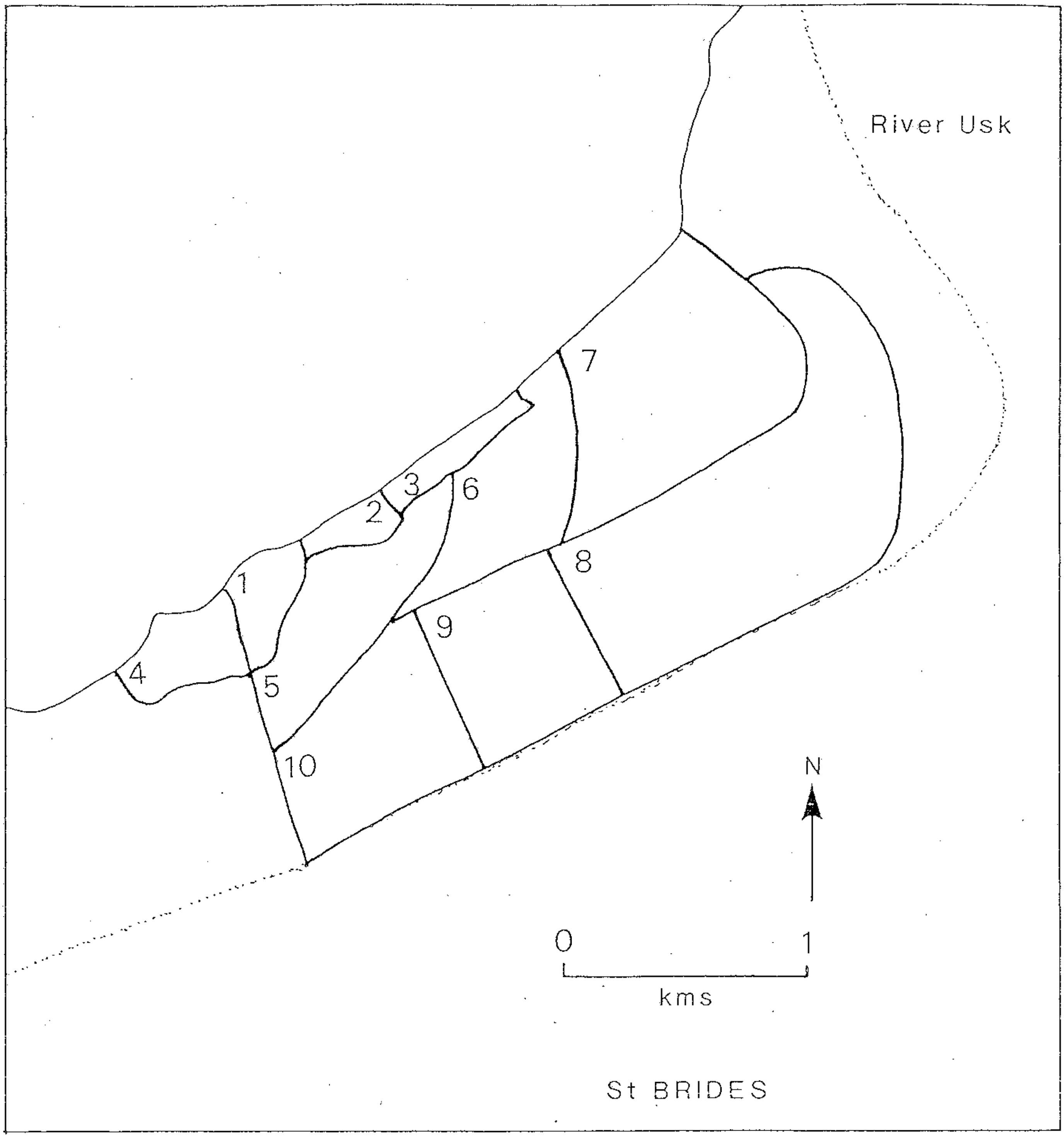


Figure 6.1.4 The St Brides all day study site.

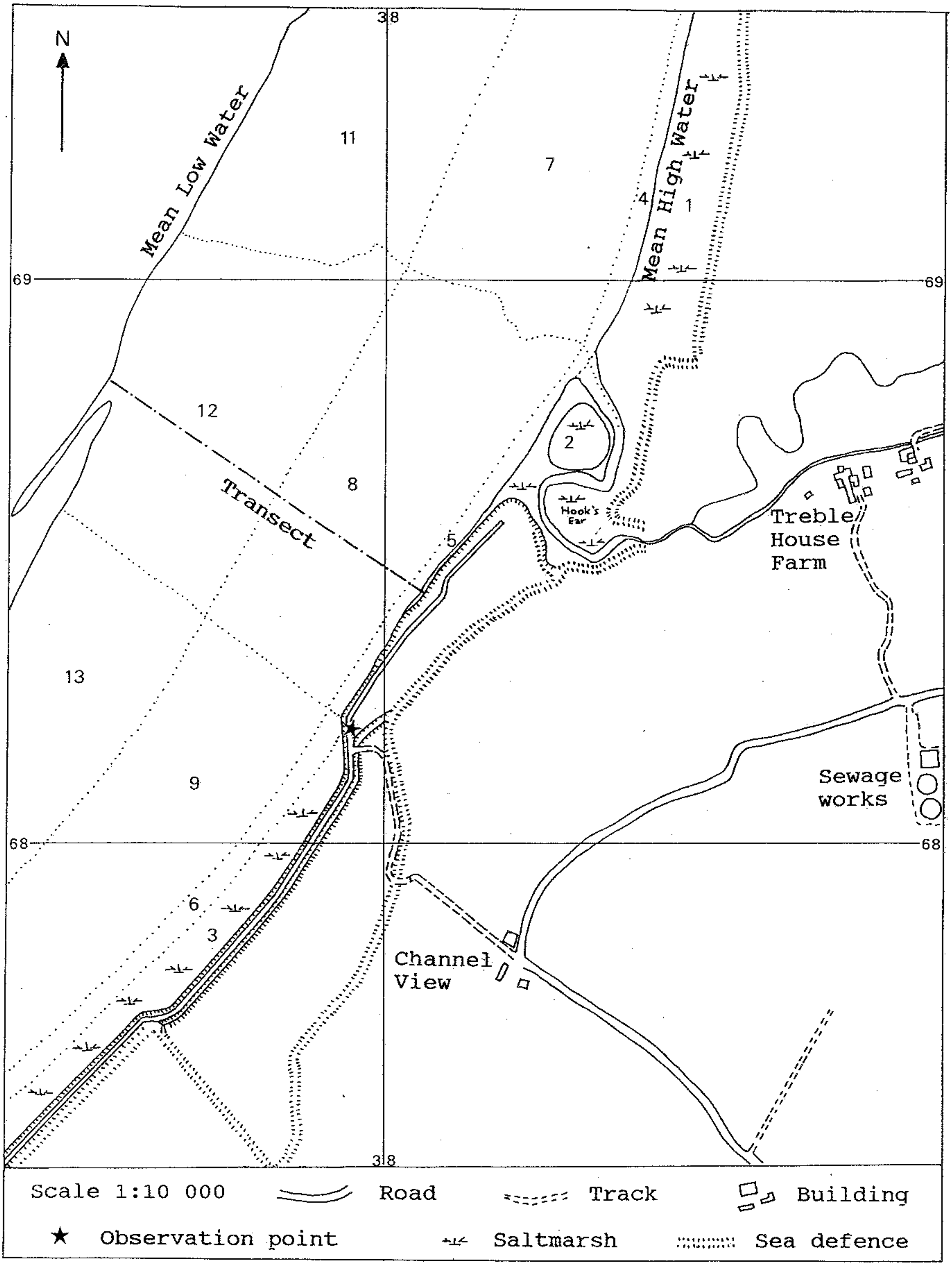
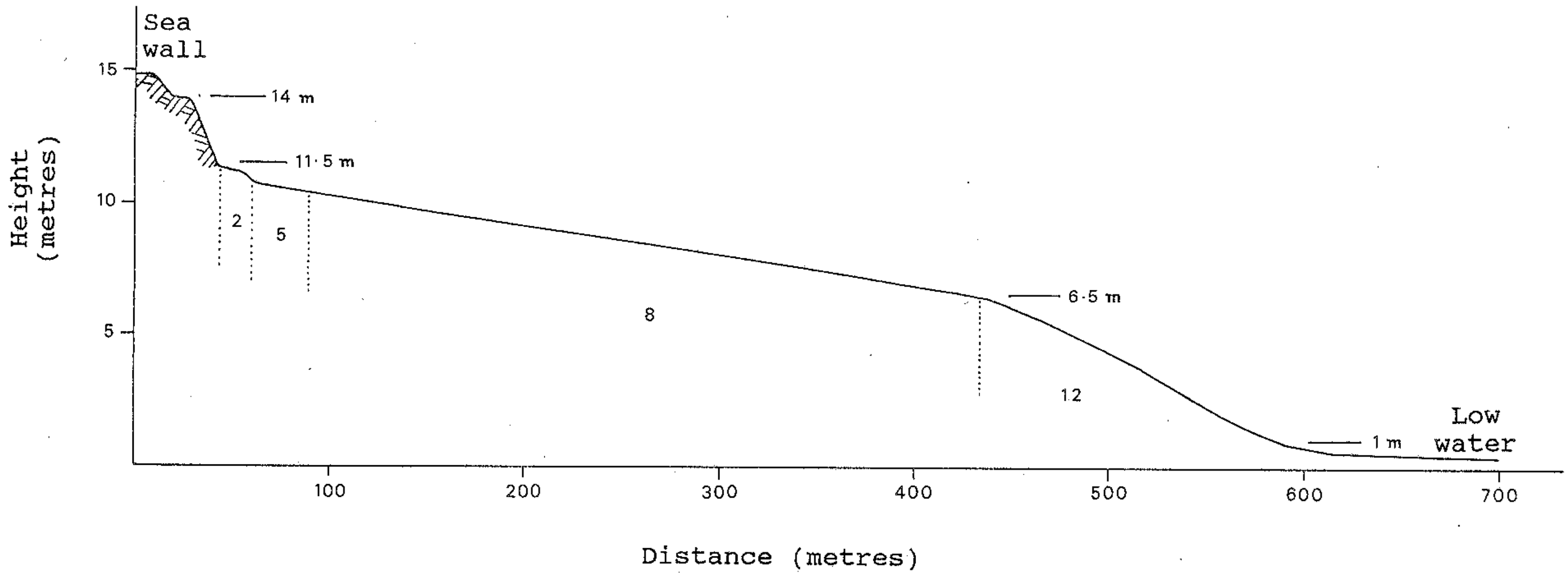


Figure 6.2.1 Position of sediment transect within the Clevedon study site.



Profile heights given are relative to Chart datum (Ordnance datum, Newlyn +6.5m).

Mudflat number appears below the beach profile.

All measurements are approximate.

Figure 6.2.2 Shore profile along the sediment transect on the Clevedon study site.

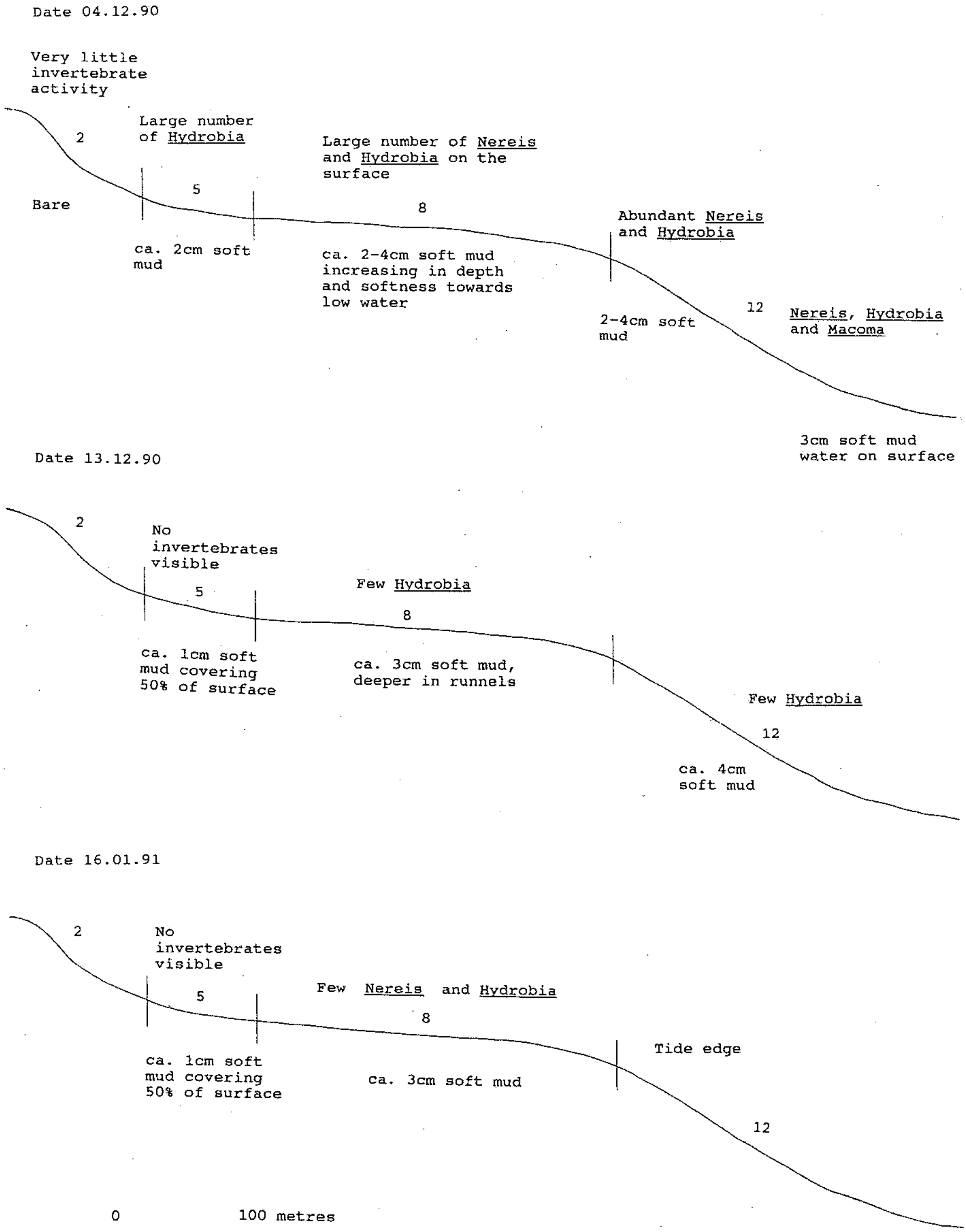


Figure 7.1 Changes in surface sediment and invertebrate activity during the 1990/91 winter.

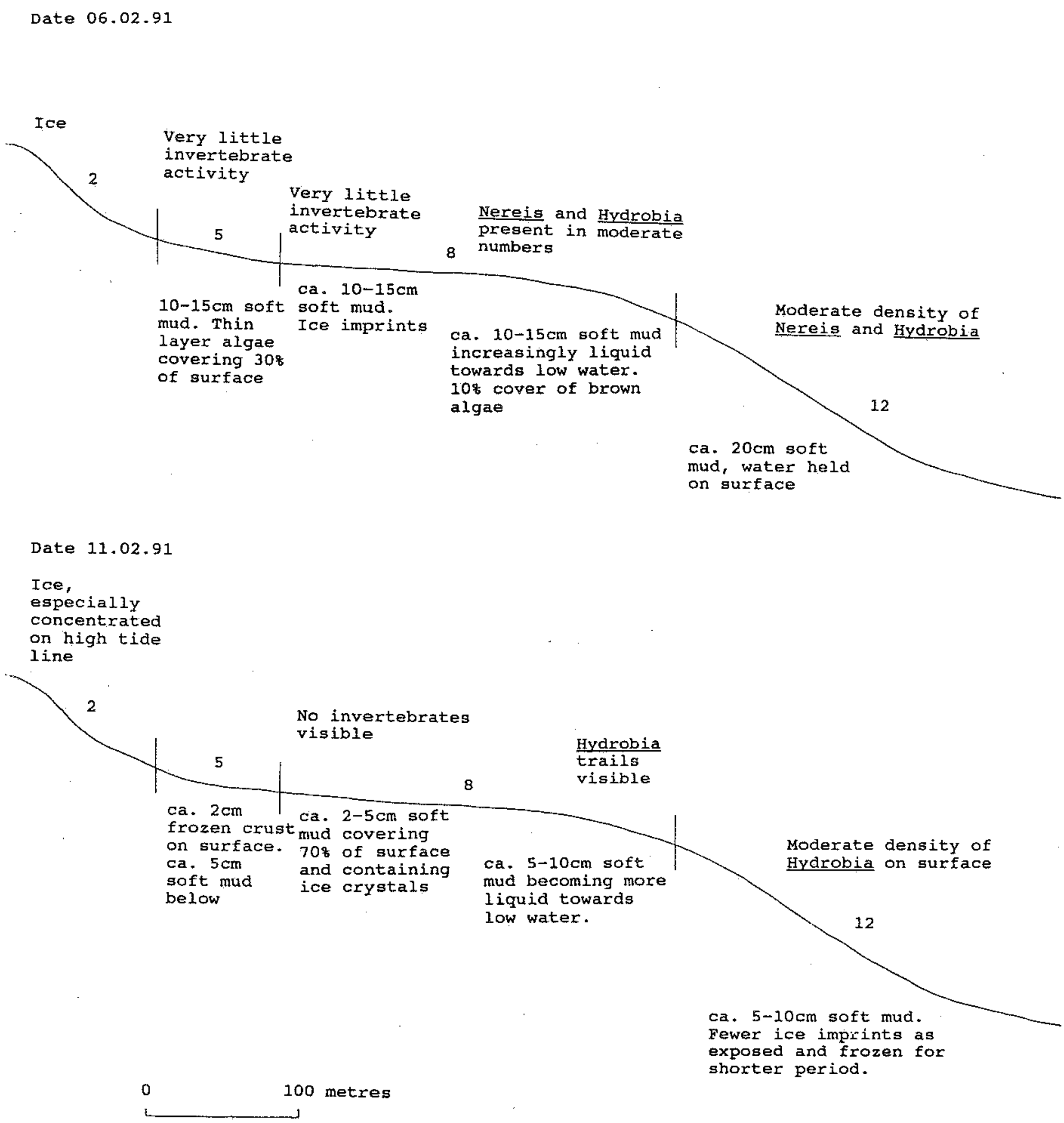


Figure 7.1 (Continued)

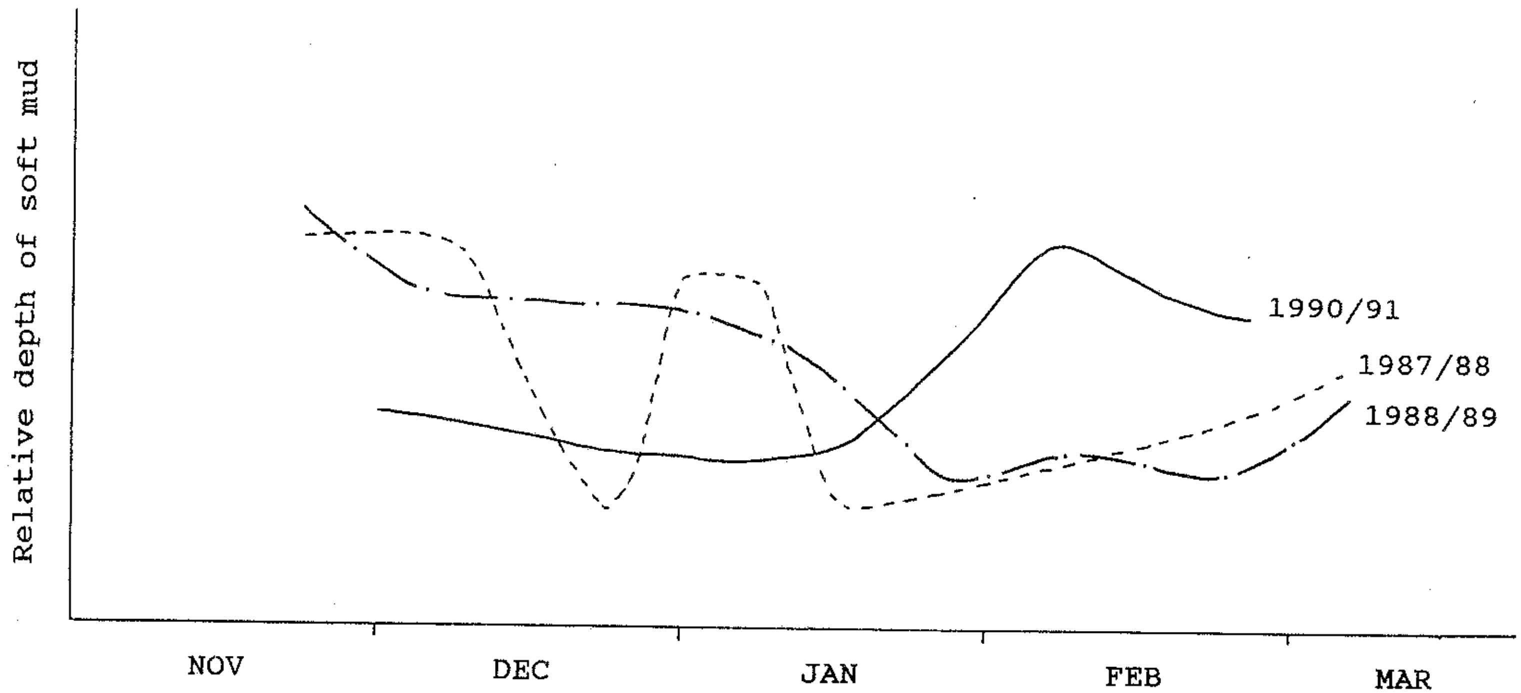


Figure 7.2 Diagrammatic representation of the seasonal changes in the relative depth of soft muds along the transects at Clevedon in different years.

SHELDUCK WINTER 90/91

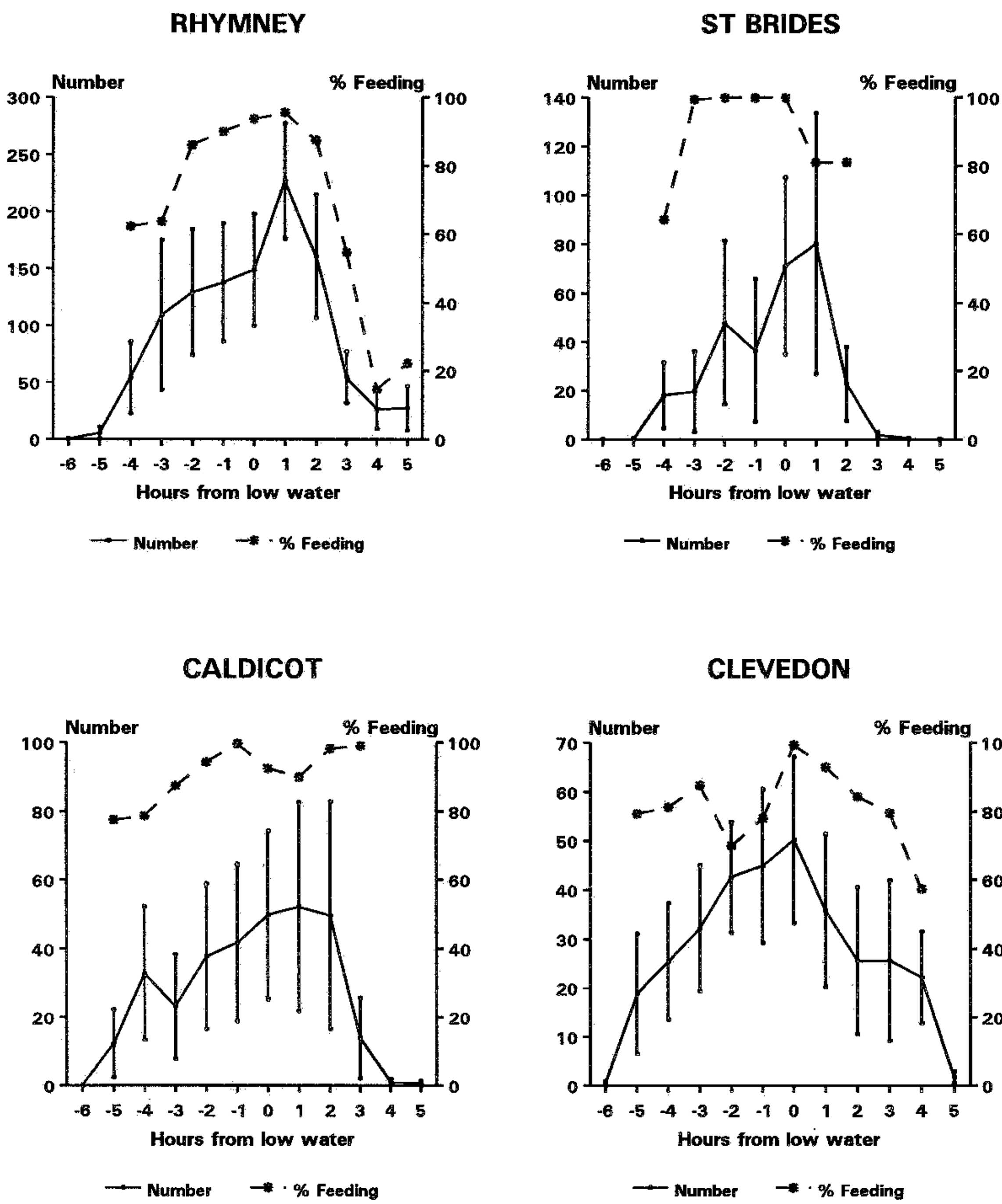


Figure 8.1.1 The average number of Shelduck present and the percentage feeding, in each study site throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

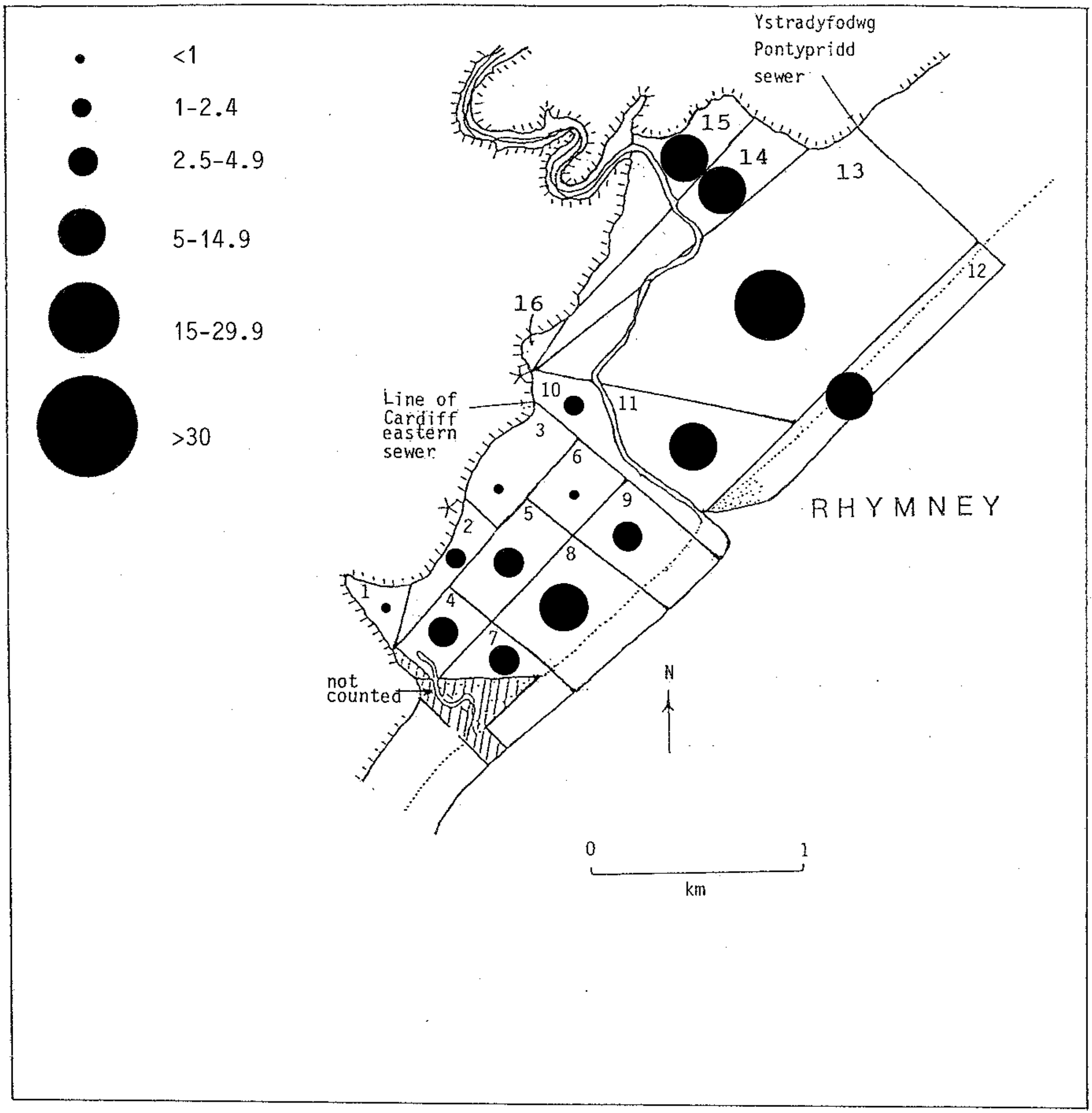


Figure 8.1.2 The distribution of feeding Shelduck at Rhymney during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

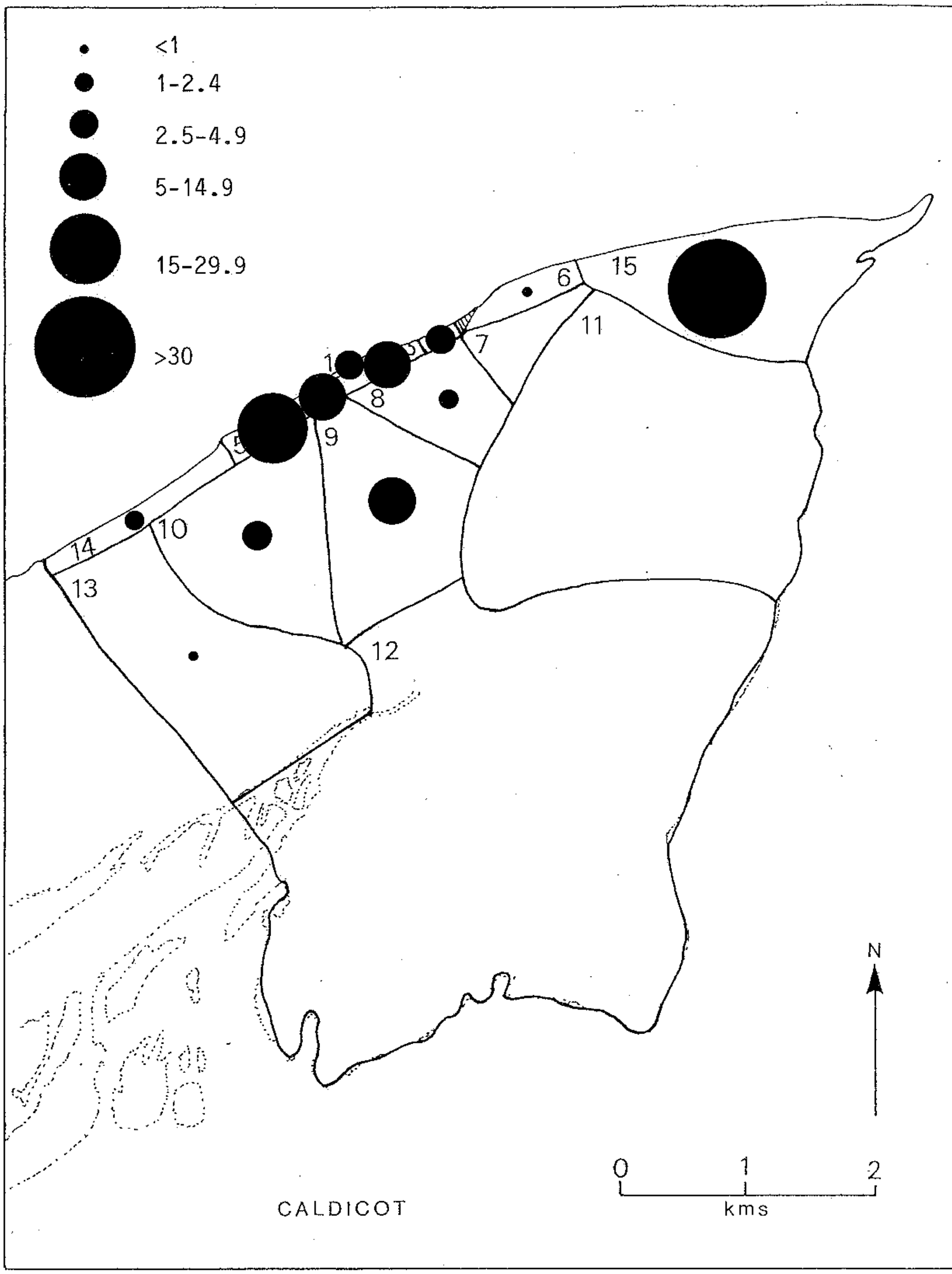


Figure 8.1.3 The distribution of feeding Shelduck at Caldicot during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

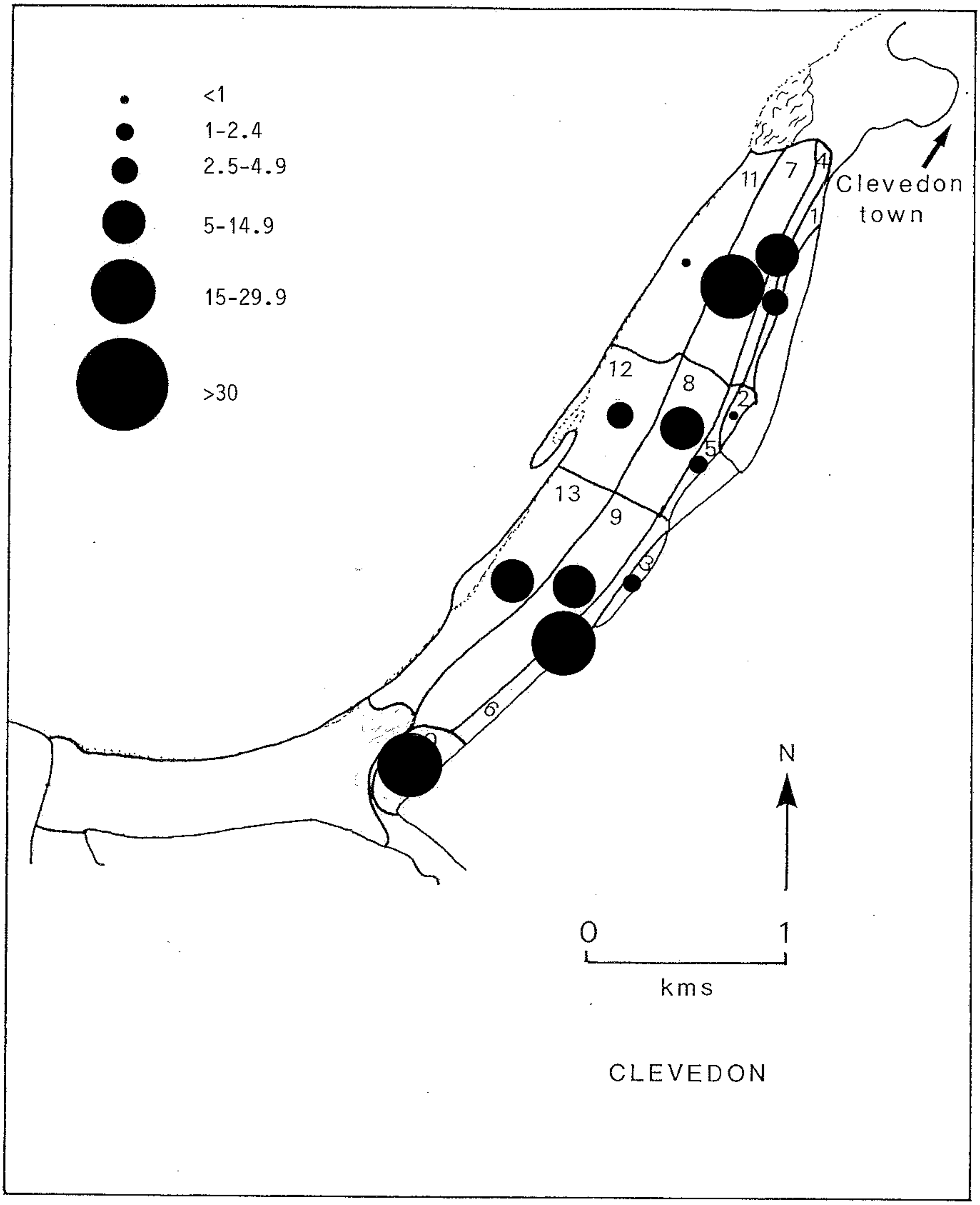


Figure 8.1.4 The distribution of feeding Shelduck at Clevedon during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

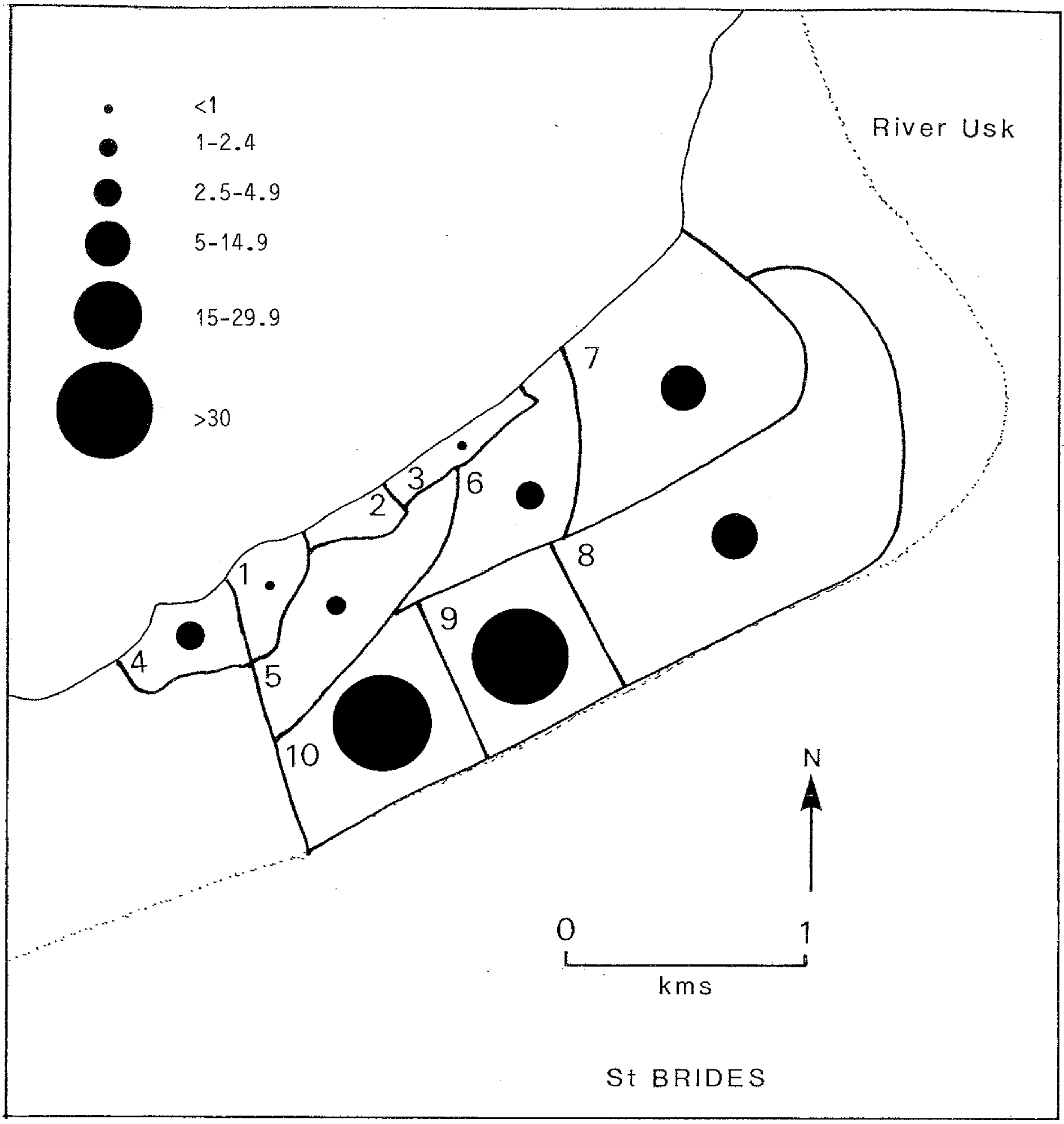
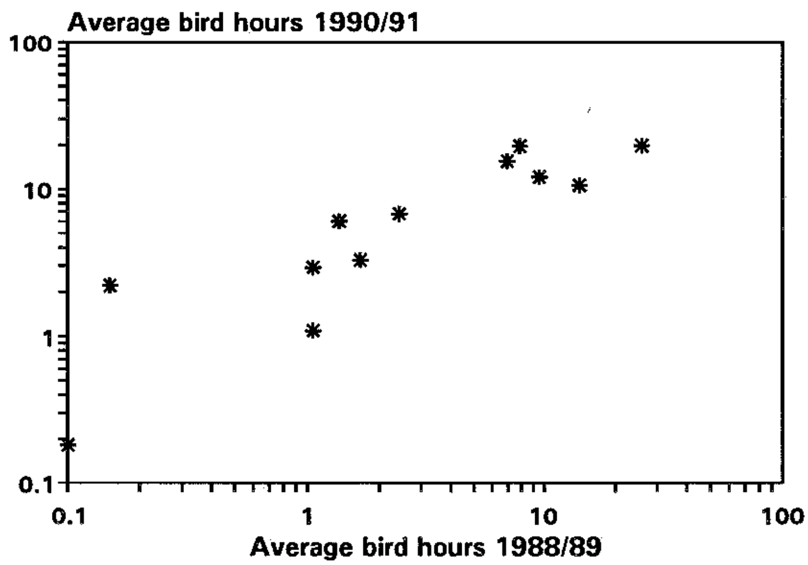


Figure 8.1.5 The distribution of feeding Shelduck at St Brides during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

SHELDUCK

a) CLEVEDON



b) ST BRIDES

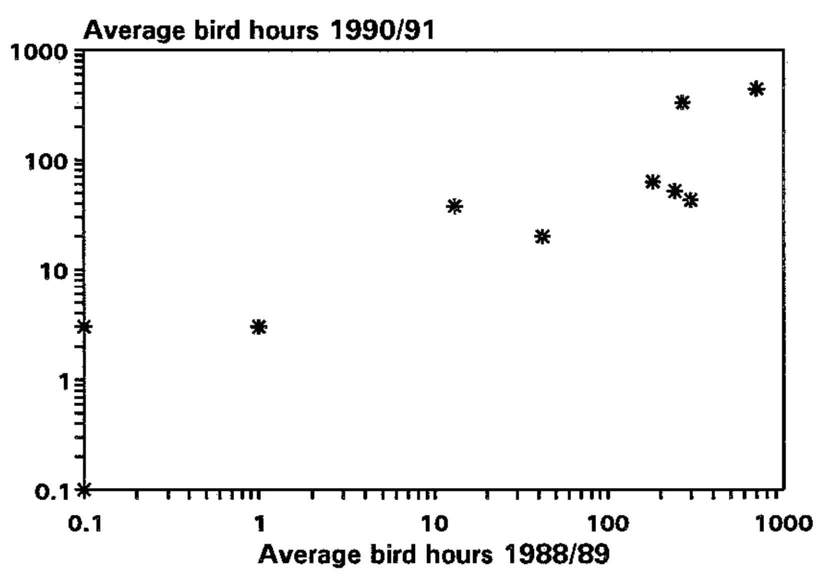


Figure 8.1.6 A comparison of average bird hours for Shelduck on each intertidal count area between the two winters of study

DUNLIN WINTER 90/91

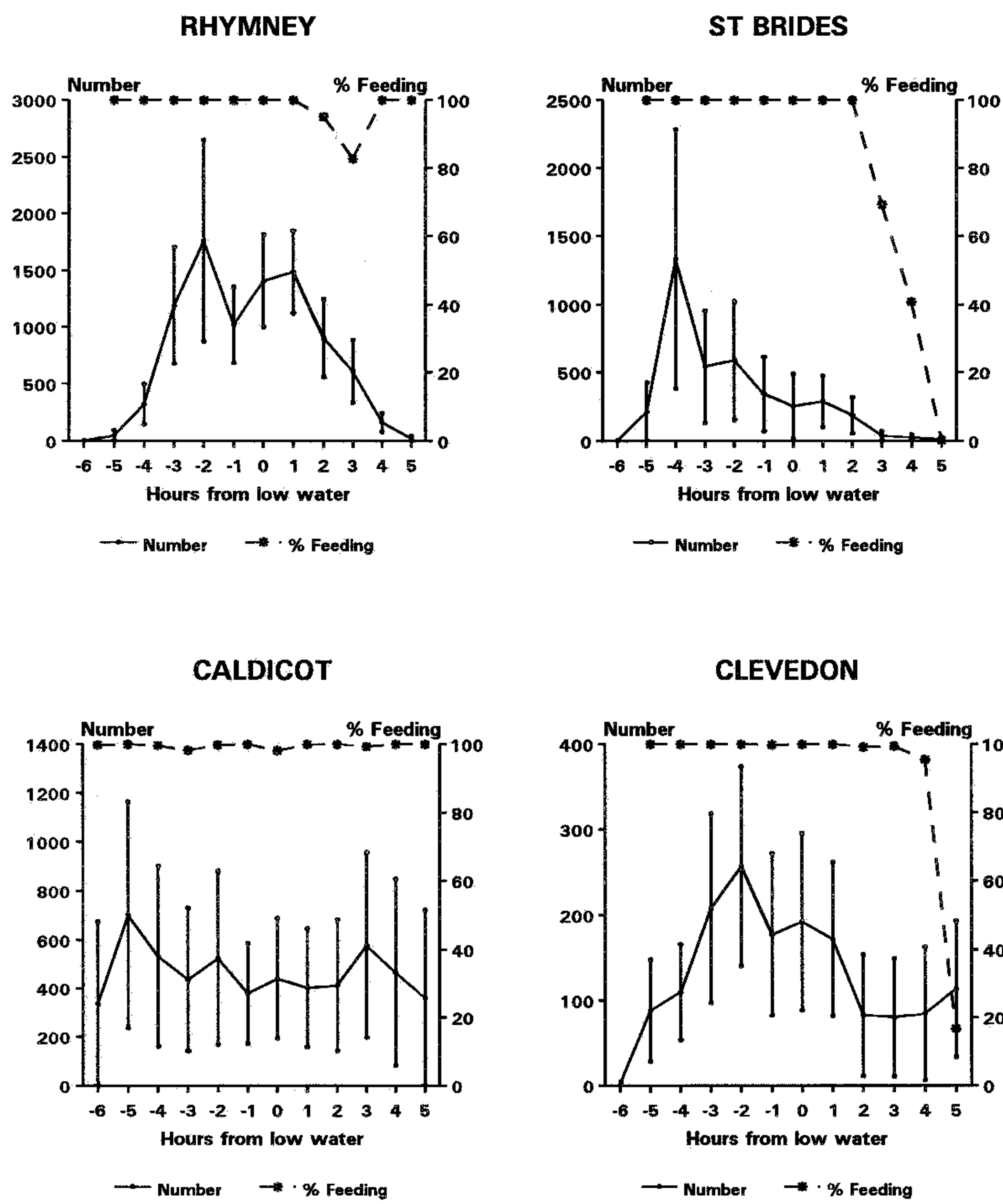


Figure 8.2.1 The average number of Dunlin present and the percentage feeding, in each study site throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

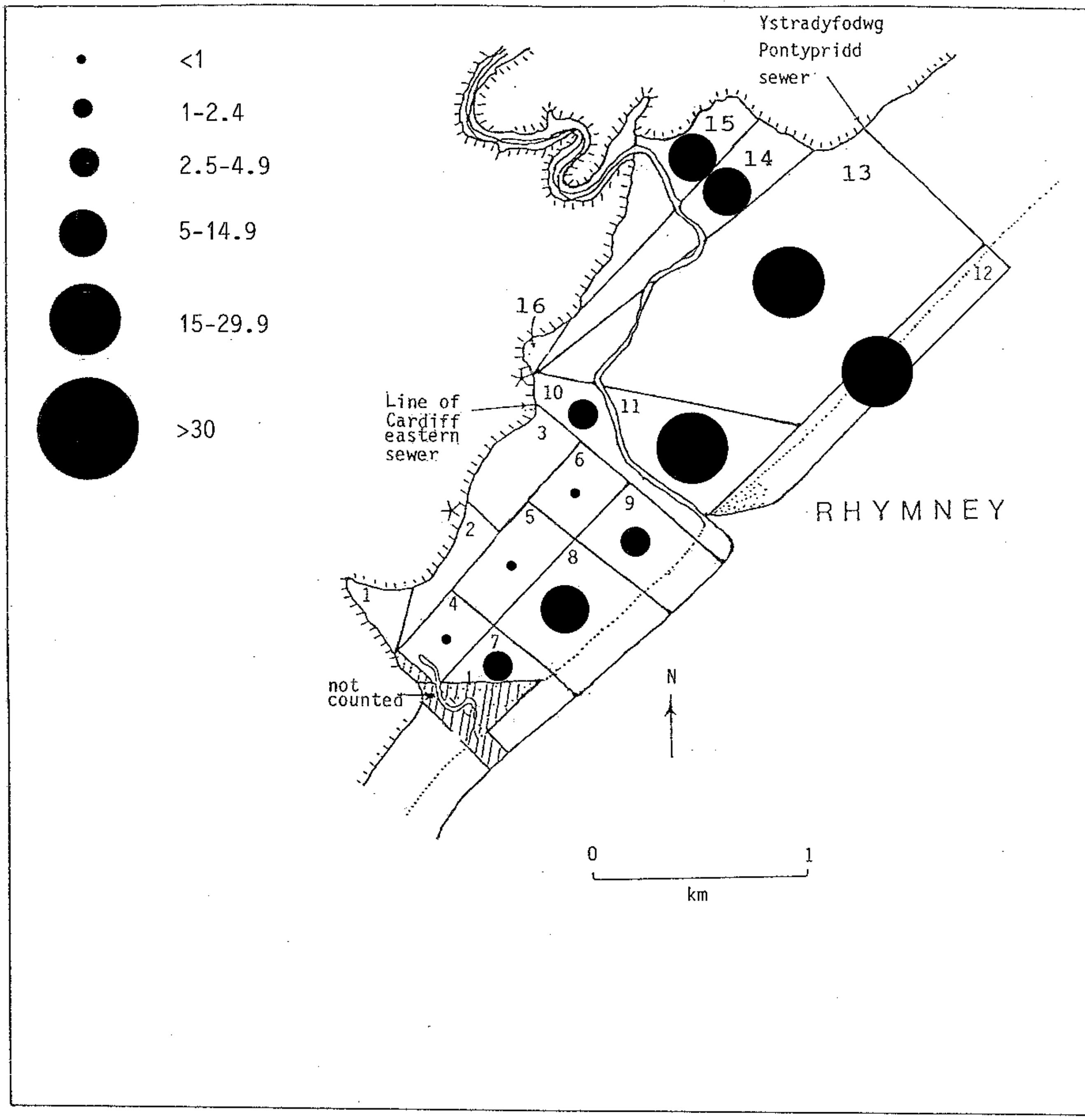


Figure 8.2.2 The distribution of feeding Dunlin at Rhymney during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

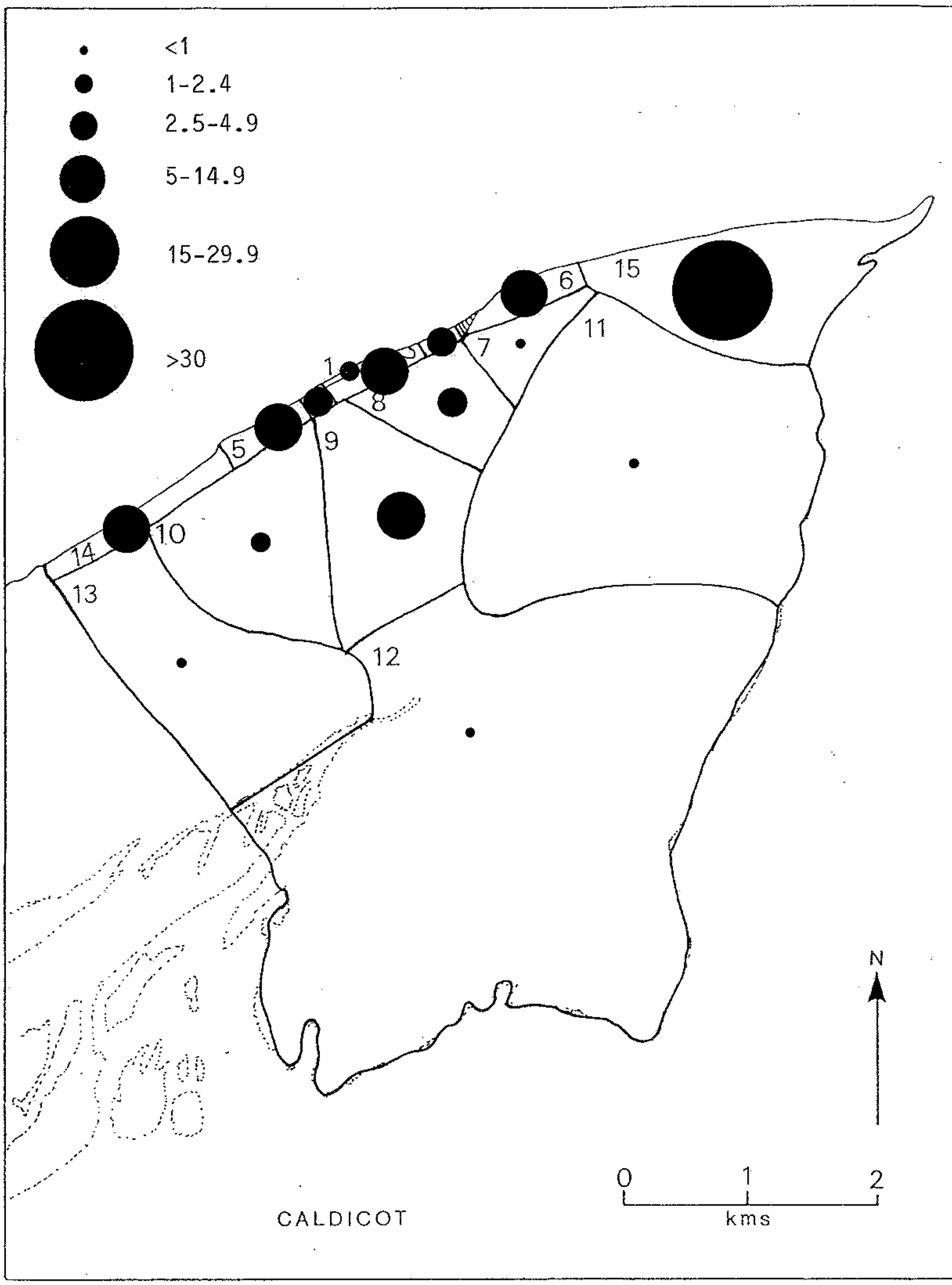


Figure 8.2.3 The distribution of feeding Dunlin at Caldicot during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

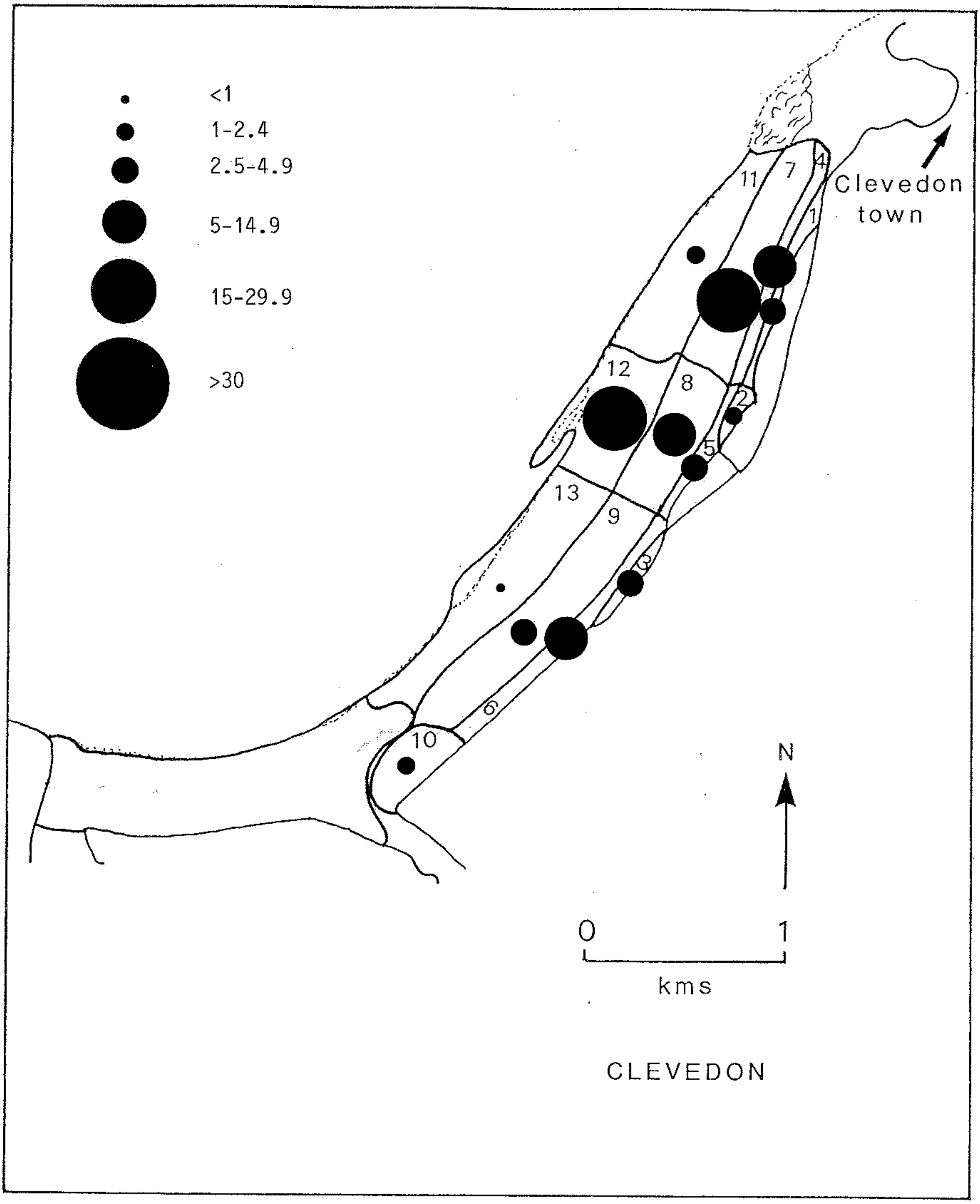


Figure 8.2.4 The distribution of feeding Dunlin at Clevedon during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

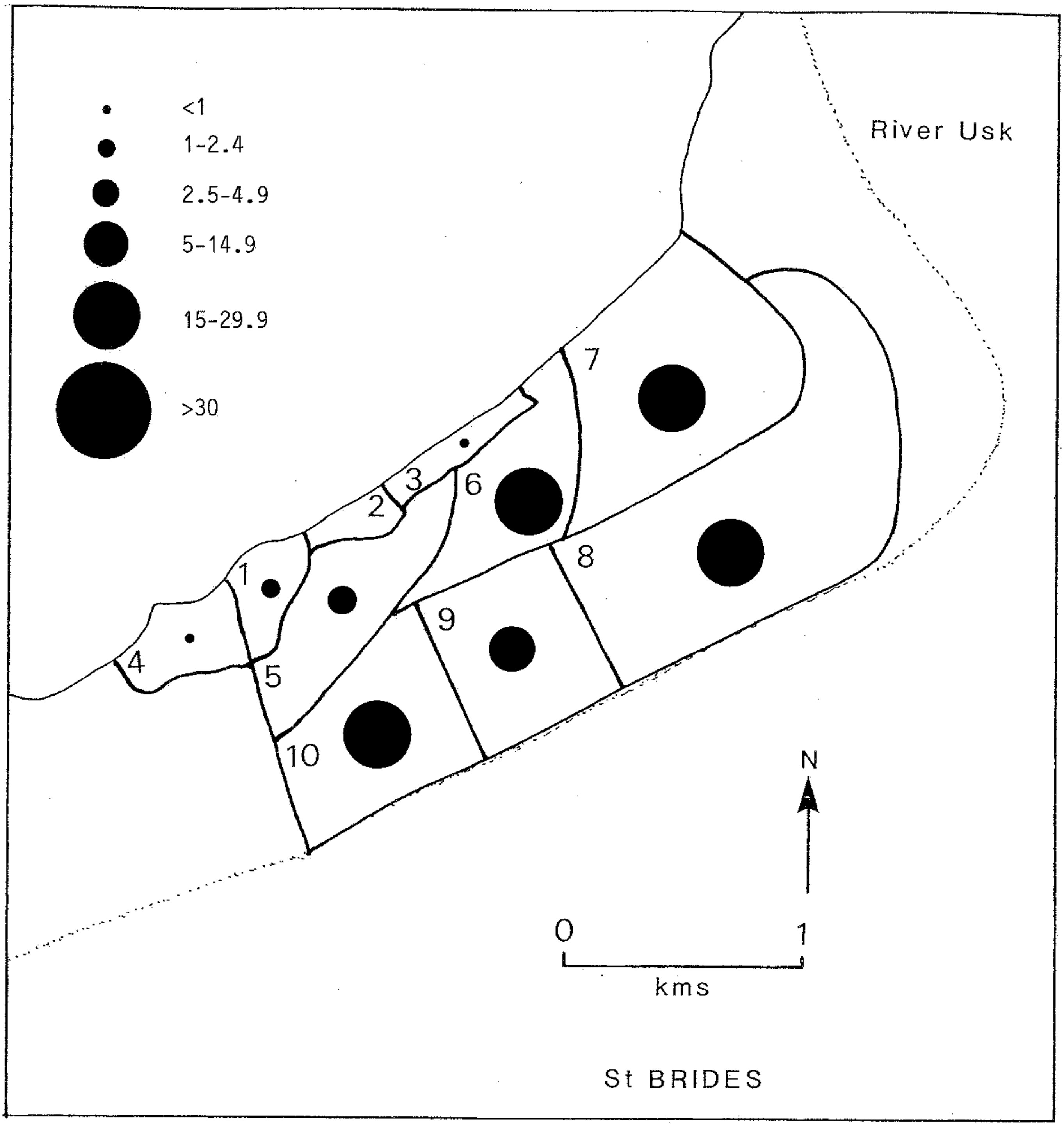
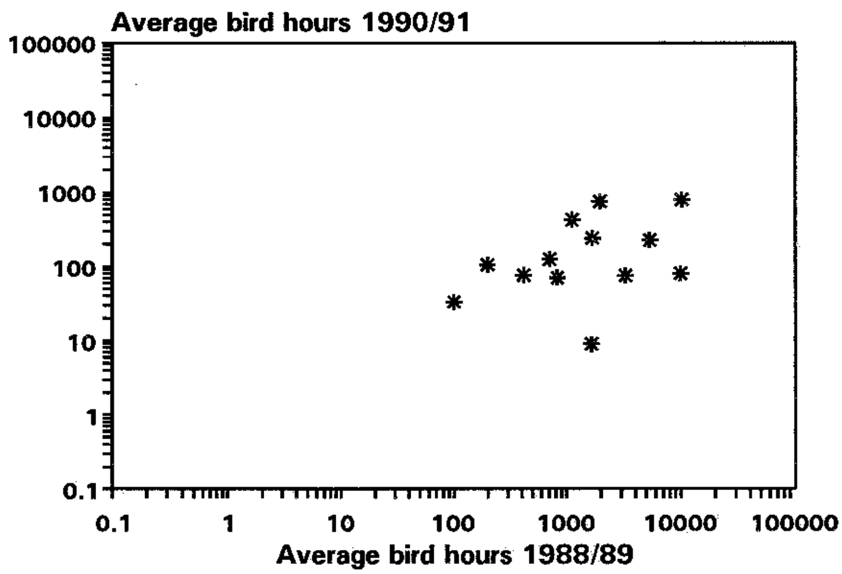


Figure 8.2.5 The distribution of feeding Dunlin at St Brides during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

DUNLIN

a) CLEVEDON



b) ST BRIDES

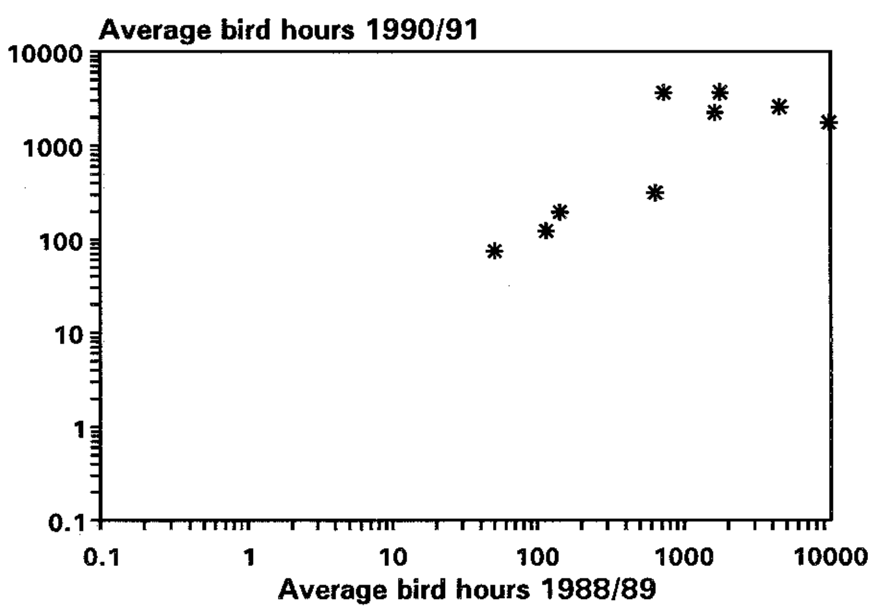


Figure 8.2.6 A Comparison of average bird hours for Dunlin on each intertidal count area between the two winters of study

CURLEW WINTER 90/91

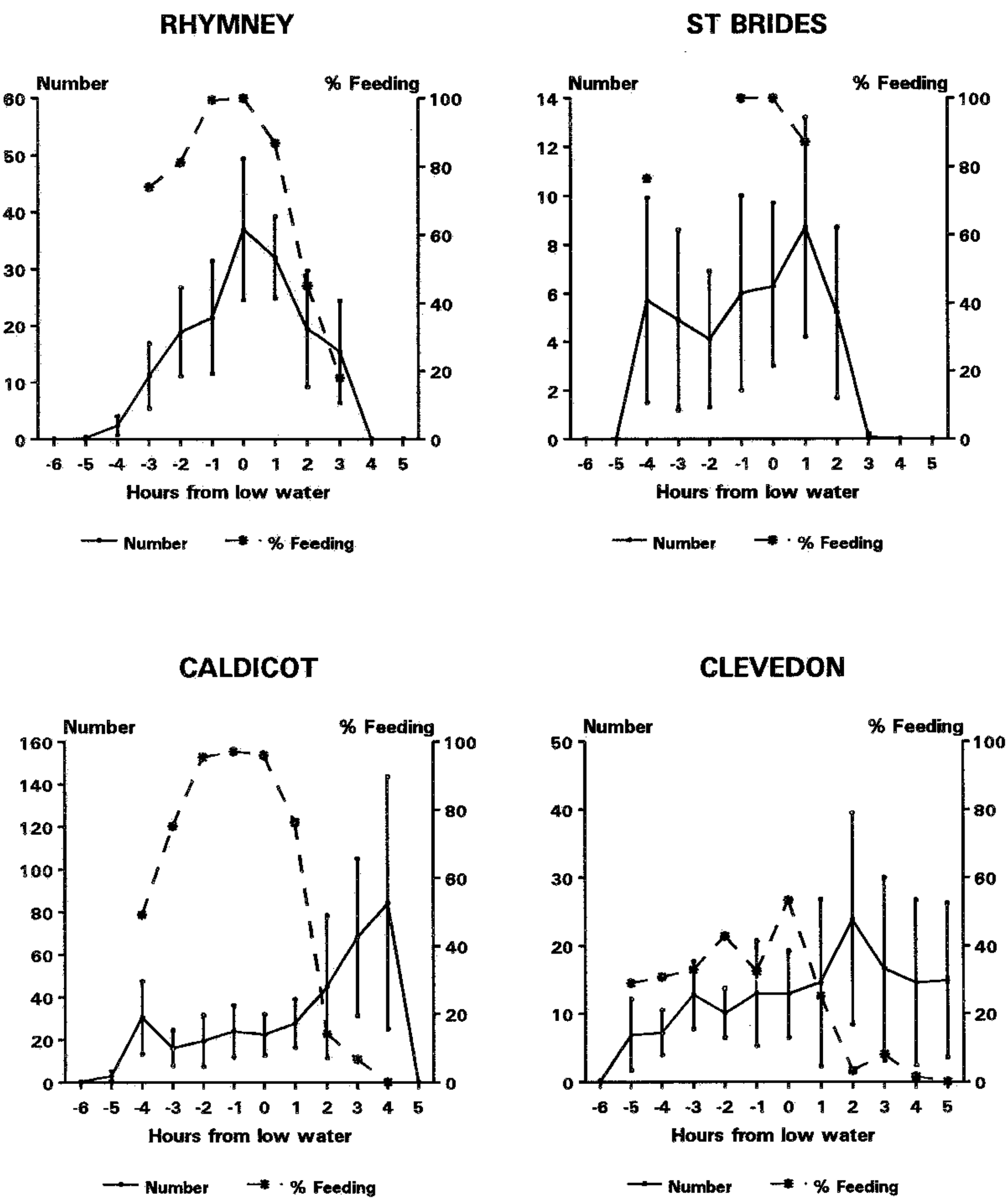


Figure 8.3.1 The average number of Curlew present and the percentage feeding, in each study site throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

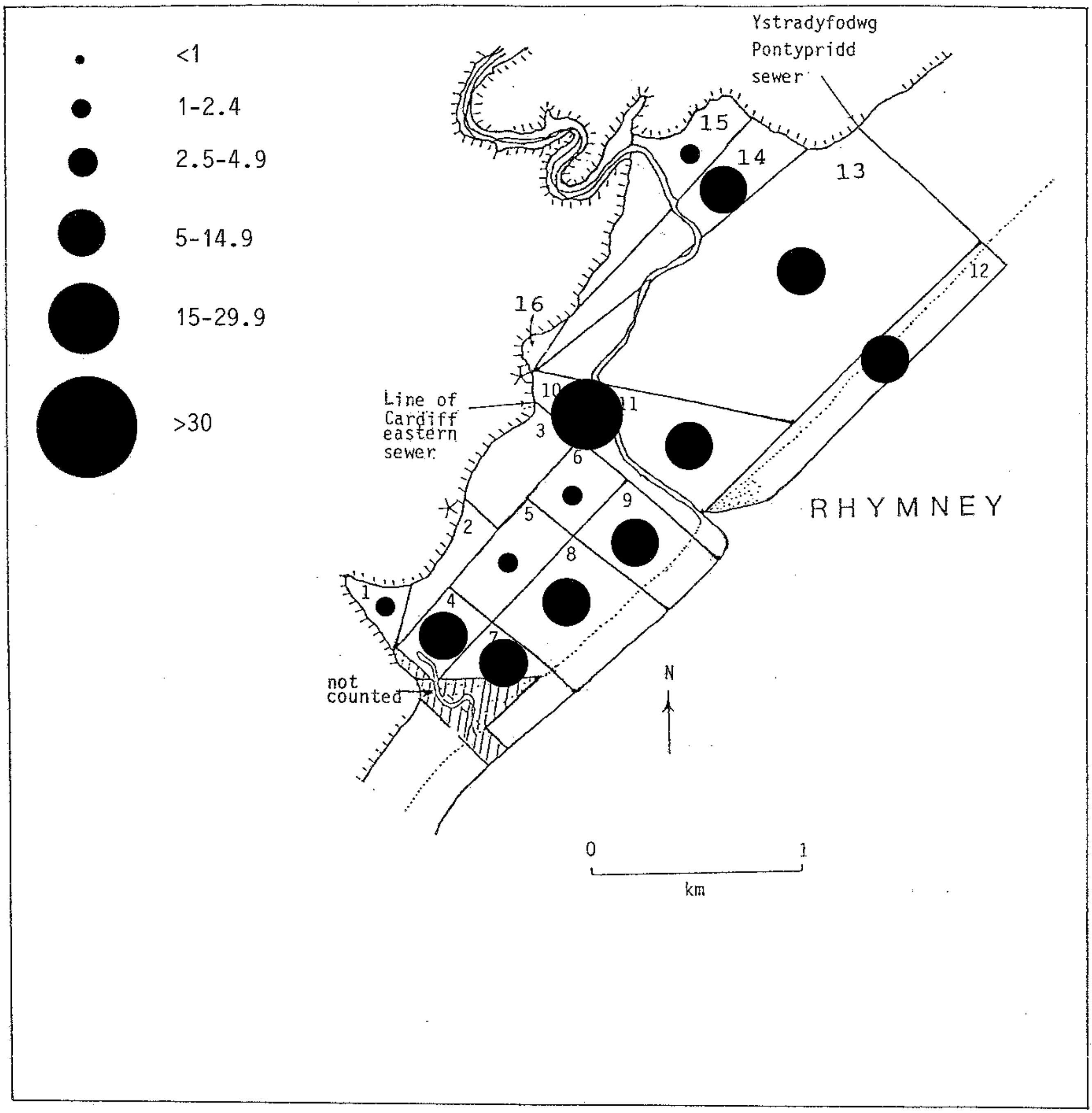


Figure 8.3.2 The distribution of feeding Curlew at Rhymney during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

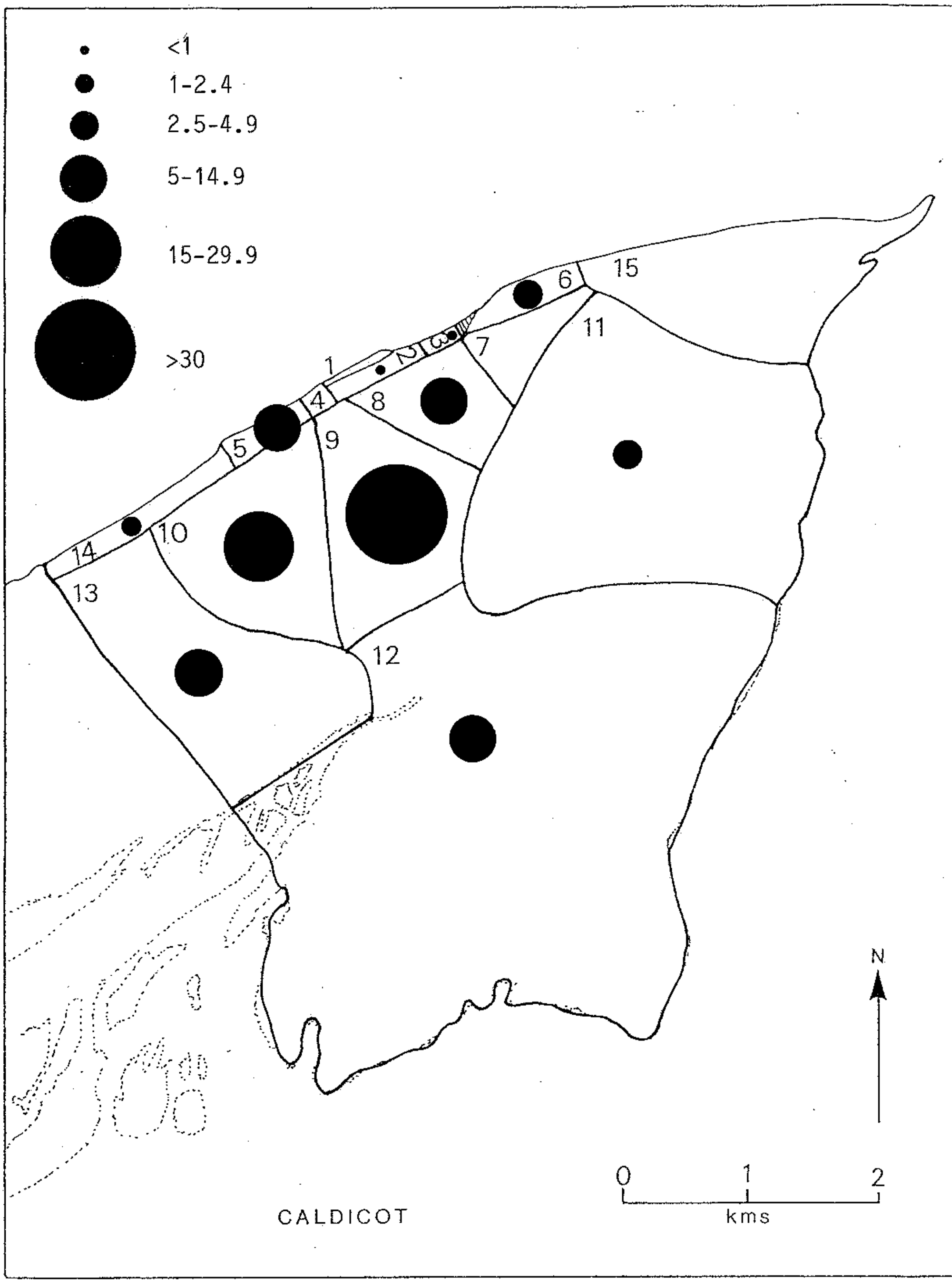


Figure 8.3.3 The distribution of feeding Curlew at Caldicot during the 1990/91 winter assessed from all day observations. The percentage of the site is plotted for each area.

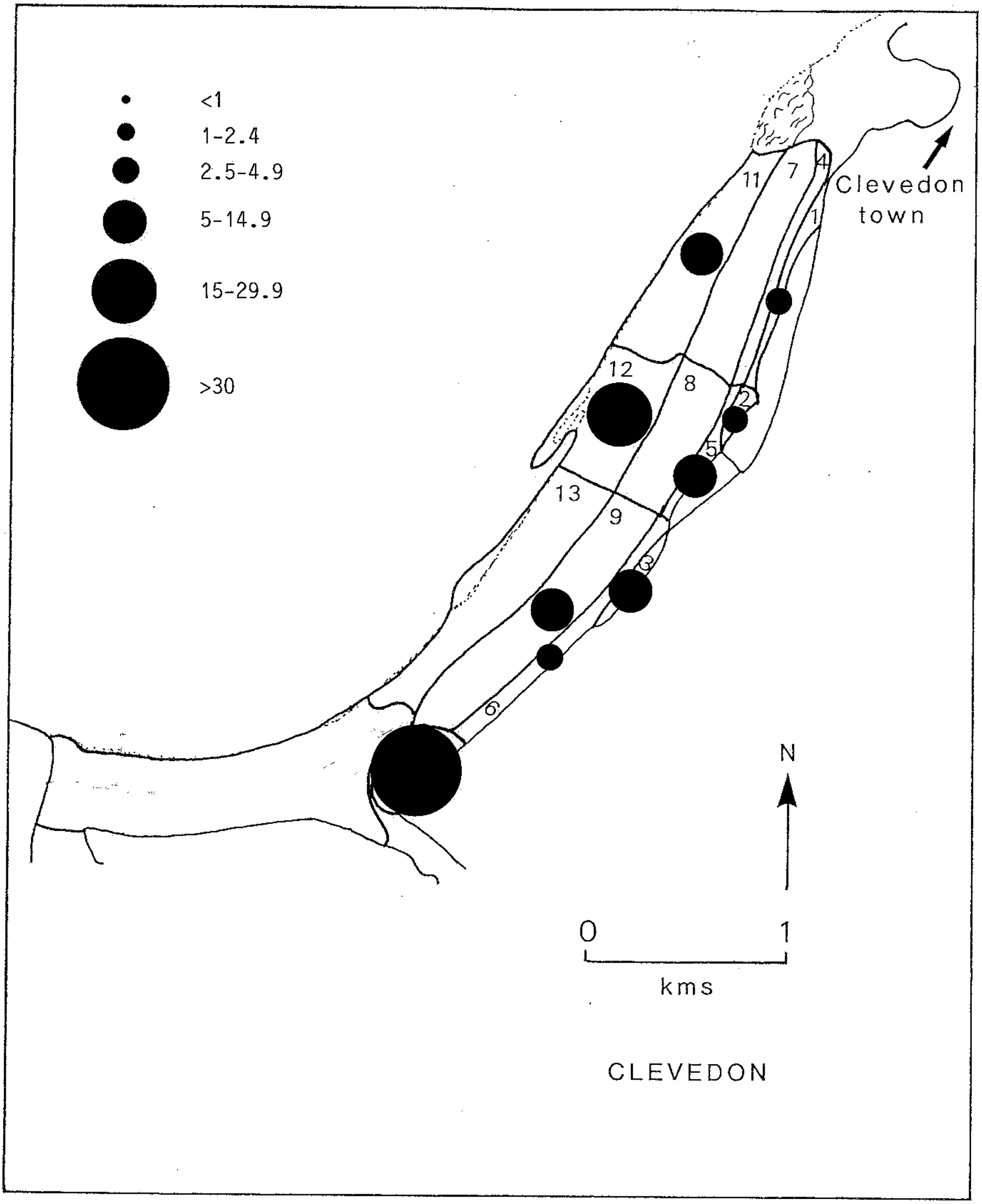


Figure 8.3.4 The distribution of feeding Curlew at Clevedon during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

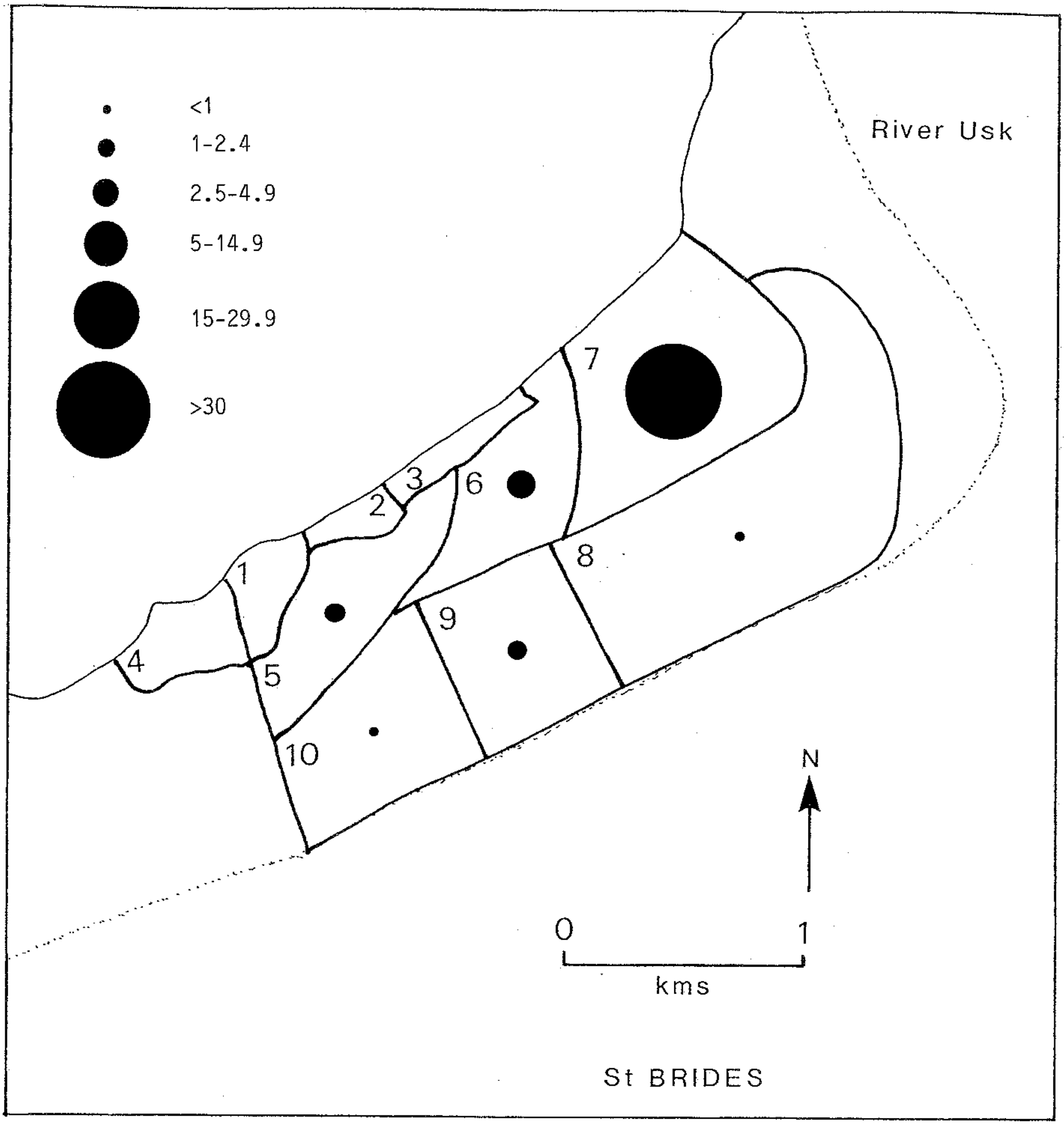
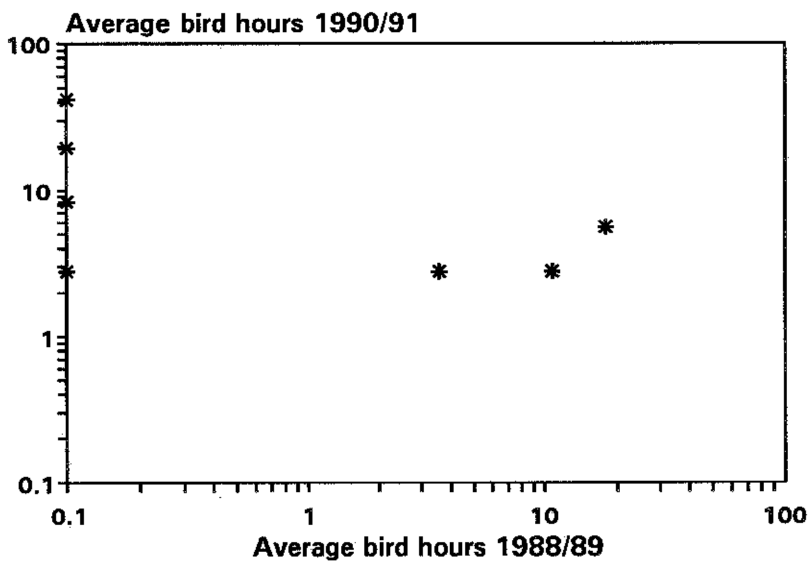


Figure 8.3.5 The distribution of feeding Curlew at St Brides during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

CURLEW

a) CLEVEDON



b) ST BRIDES

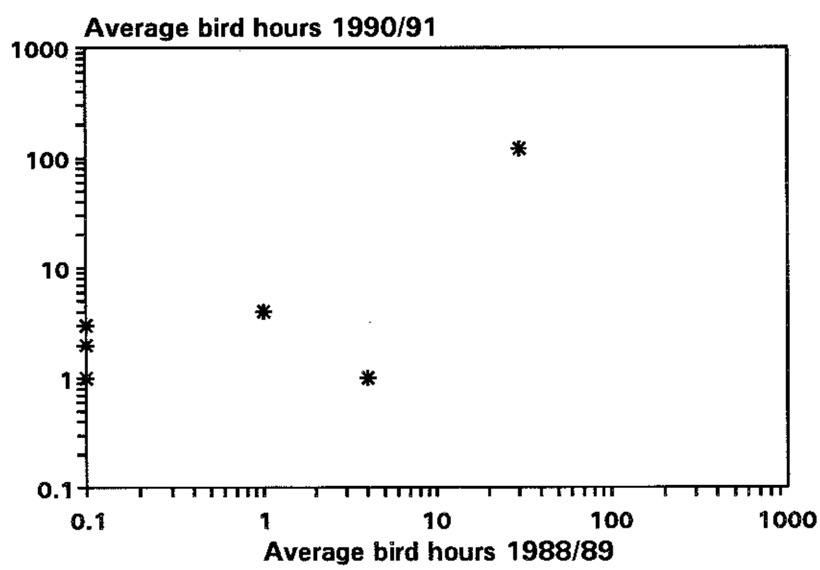
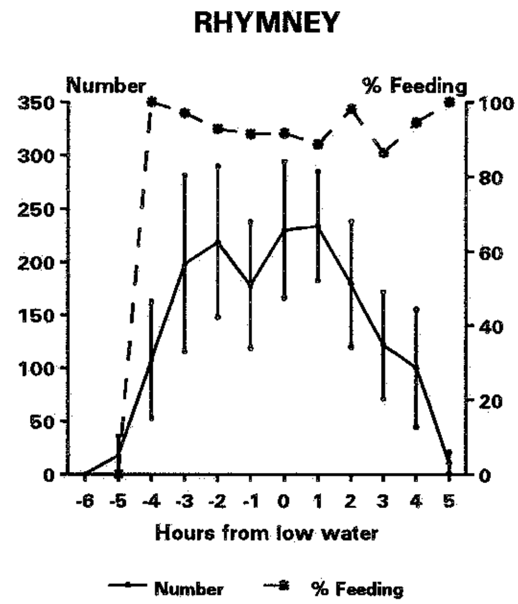


Figure 8.3.6 A comparison of average bird hours for Curlew on each intertidal count area between the two winters of study

REDSHANK WINTER 90/91



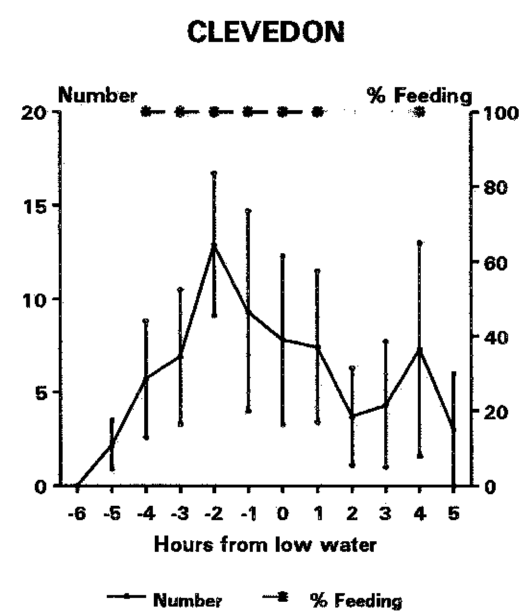


Figure 8.4.1 The average number of Redshank present and the percentage feeding, in each study site throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

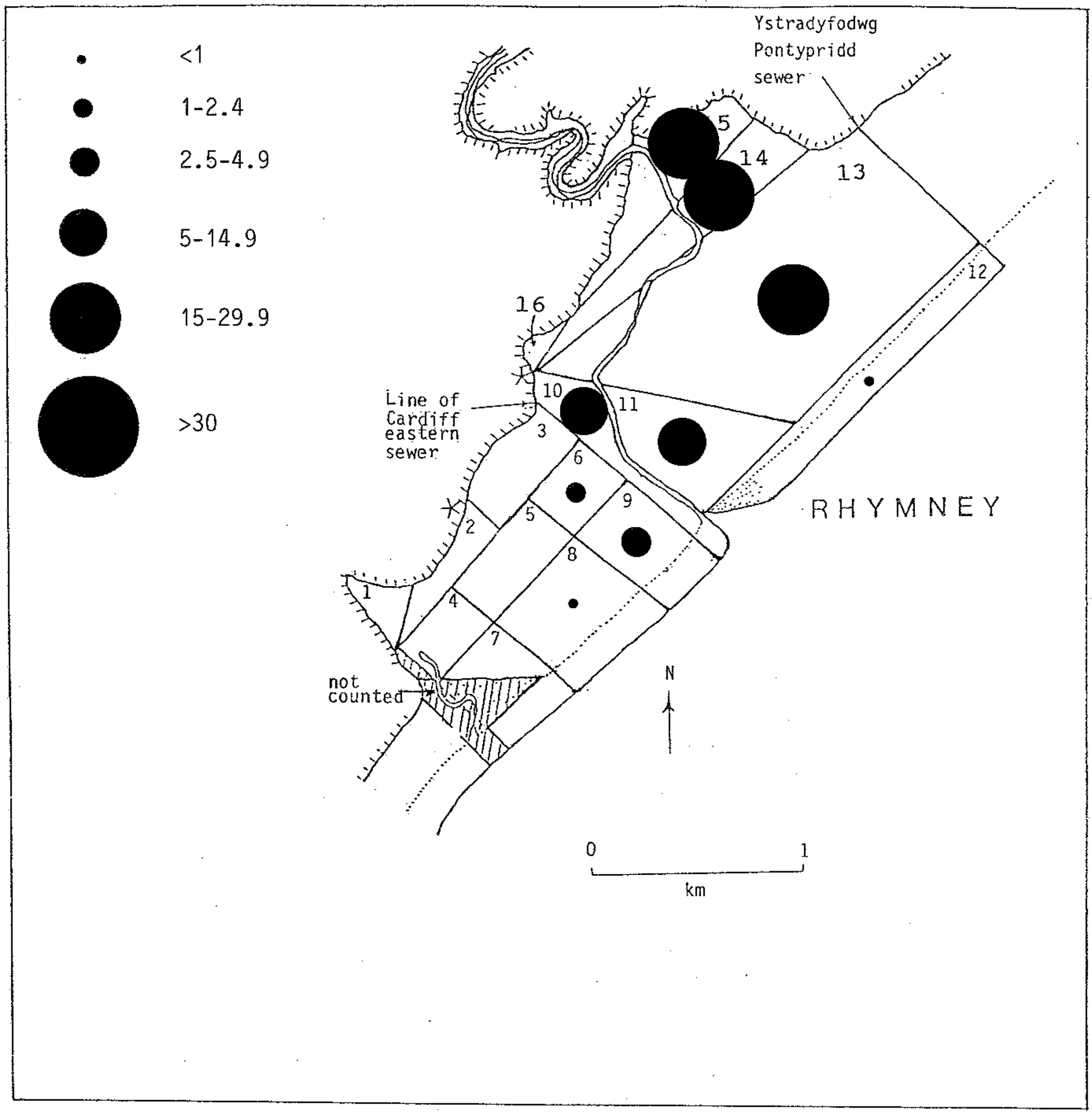


Figure 8.4.2 The distribution of feeding Redshank at Rhymney during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

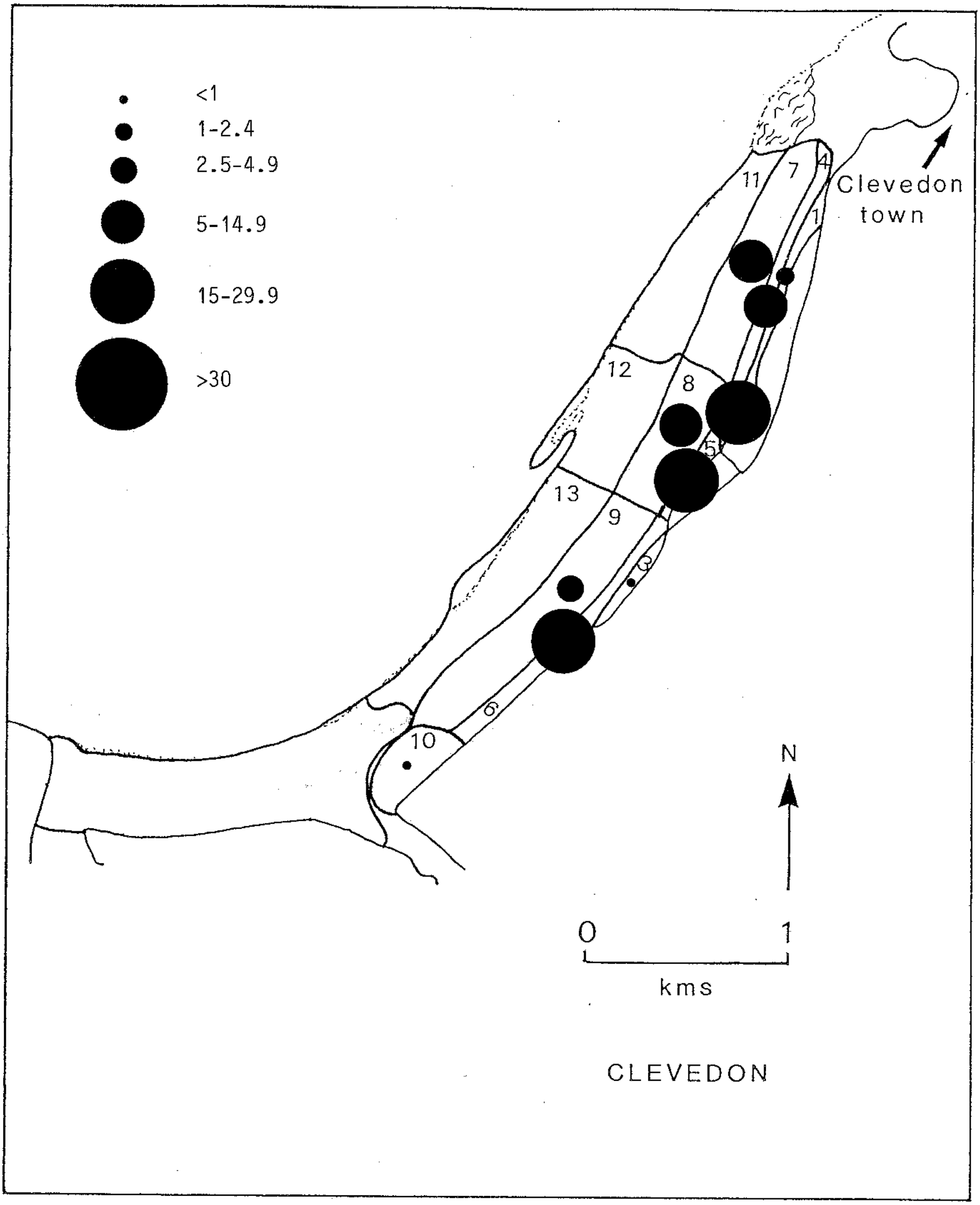
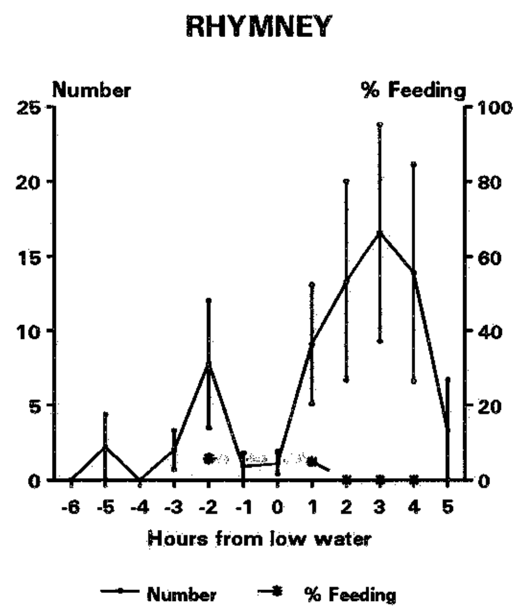


Figure 8.4.3 The distribution of feeding Redshank at Clevedon during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

MALLARD WINTER 90/91



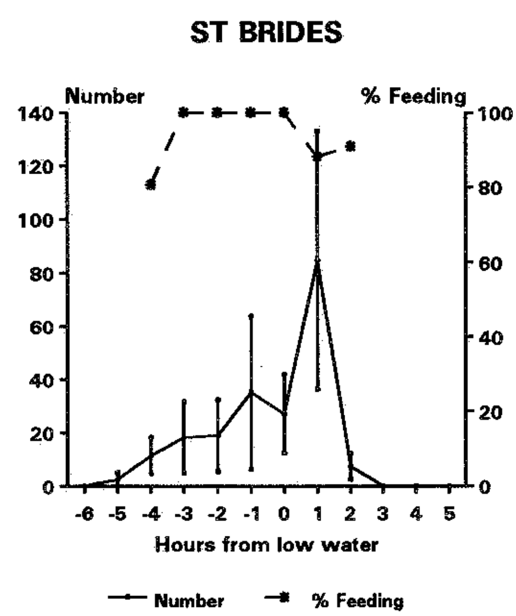


Figure 8.5.1 The average number of Mallard present and the percentage feeding, in each study site throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

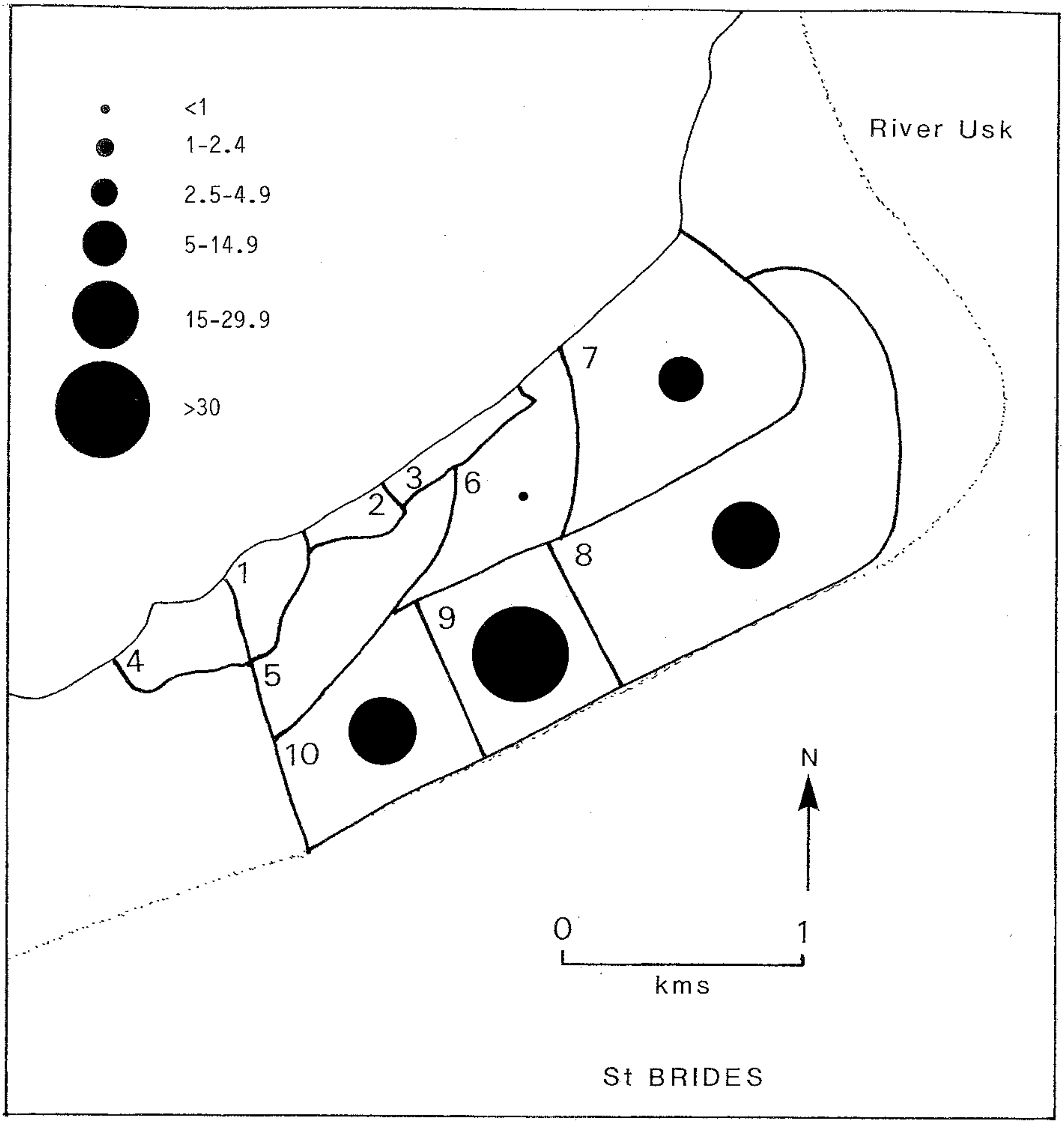


Figure 8.5.2 The distribution of feeding Mallard at St Brides during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

TEAL WINTER 90/91

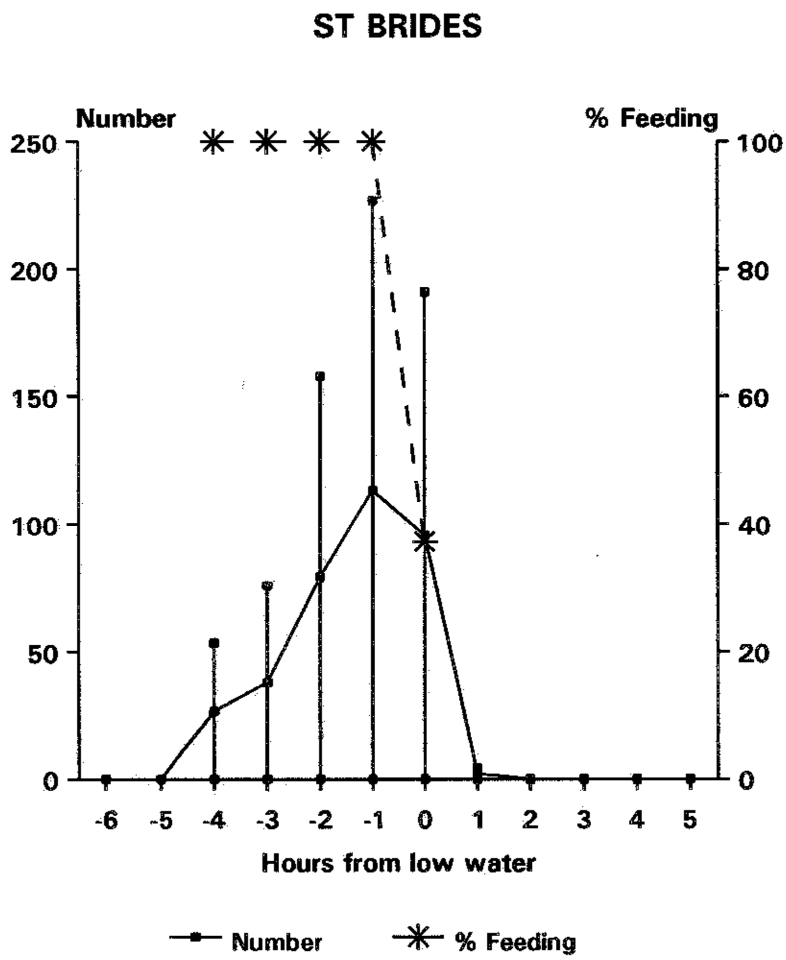


Figure 8.6.1 The average number of Teal present and the percentage feeding, in each study site throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

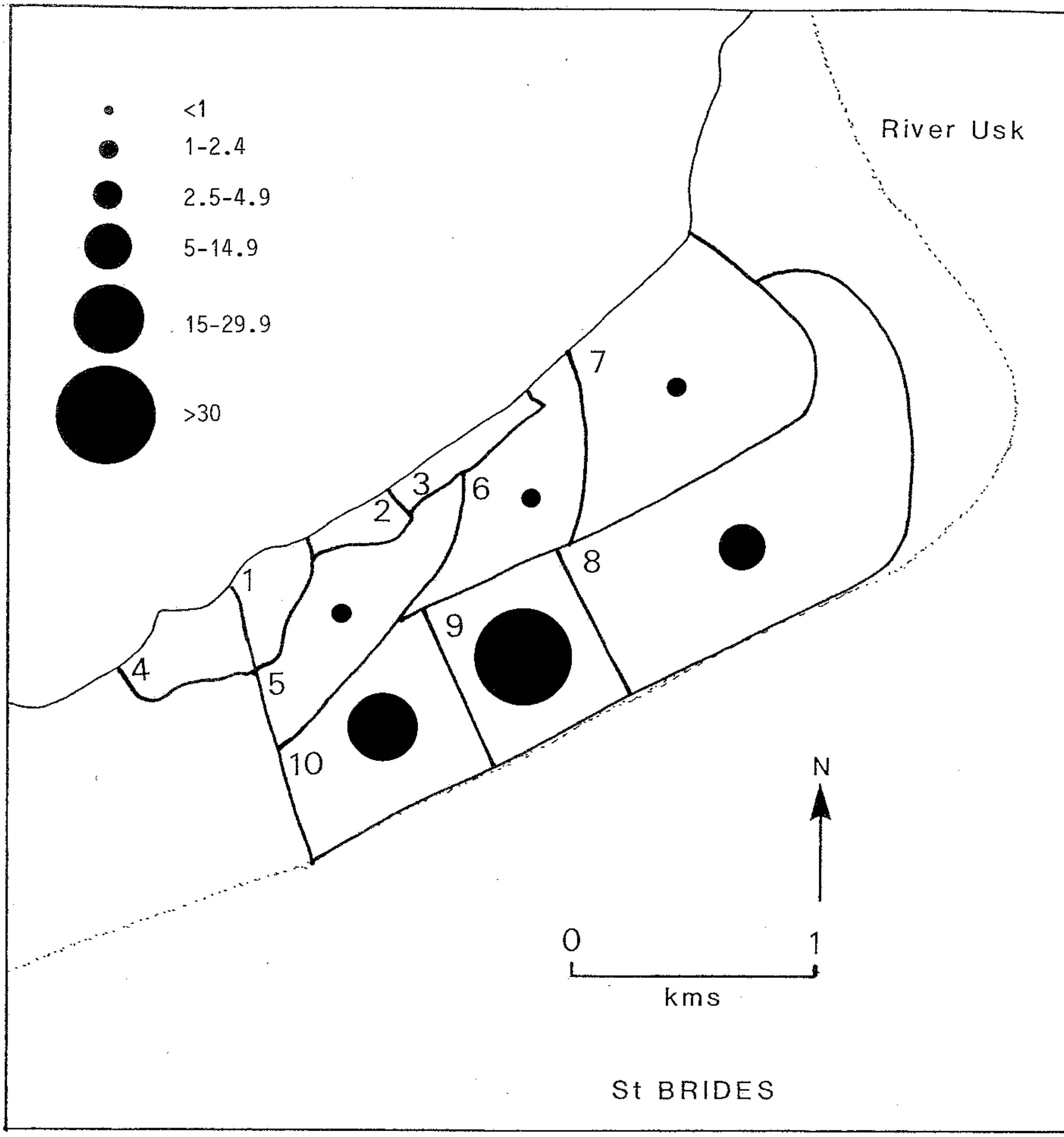


Figure 8.6.2 The distribution of feeding Teal at St Brides during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

PINTAIL WINTER 90/91

RHYMNEY

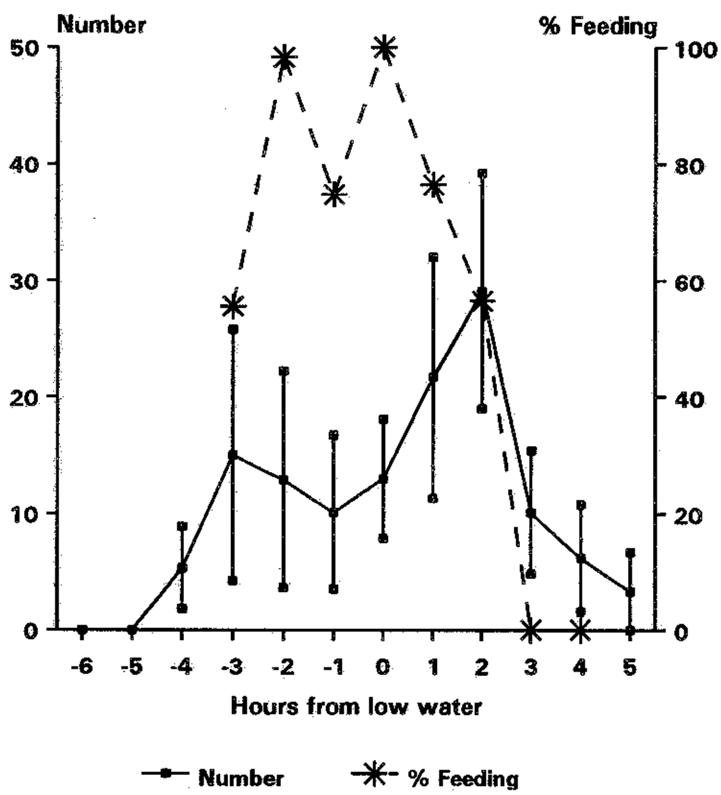


Figure 8.7.1 The average number of Pintail present and the percentage feeding, in each study site throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

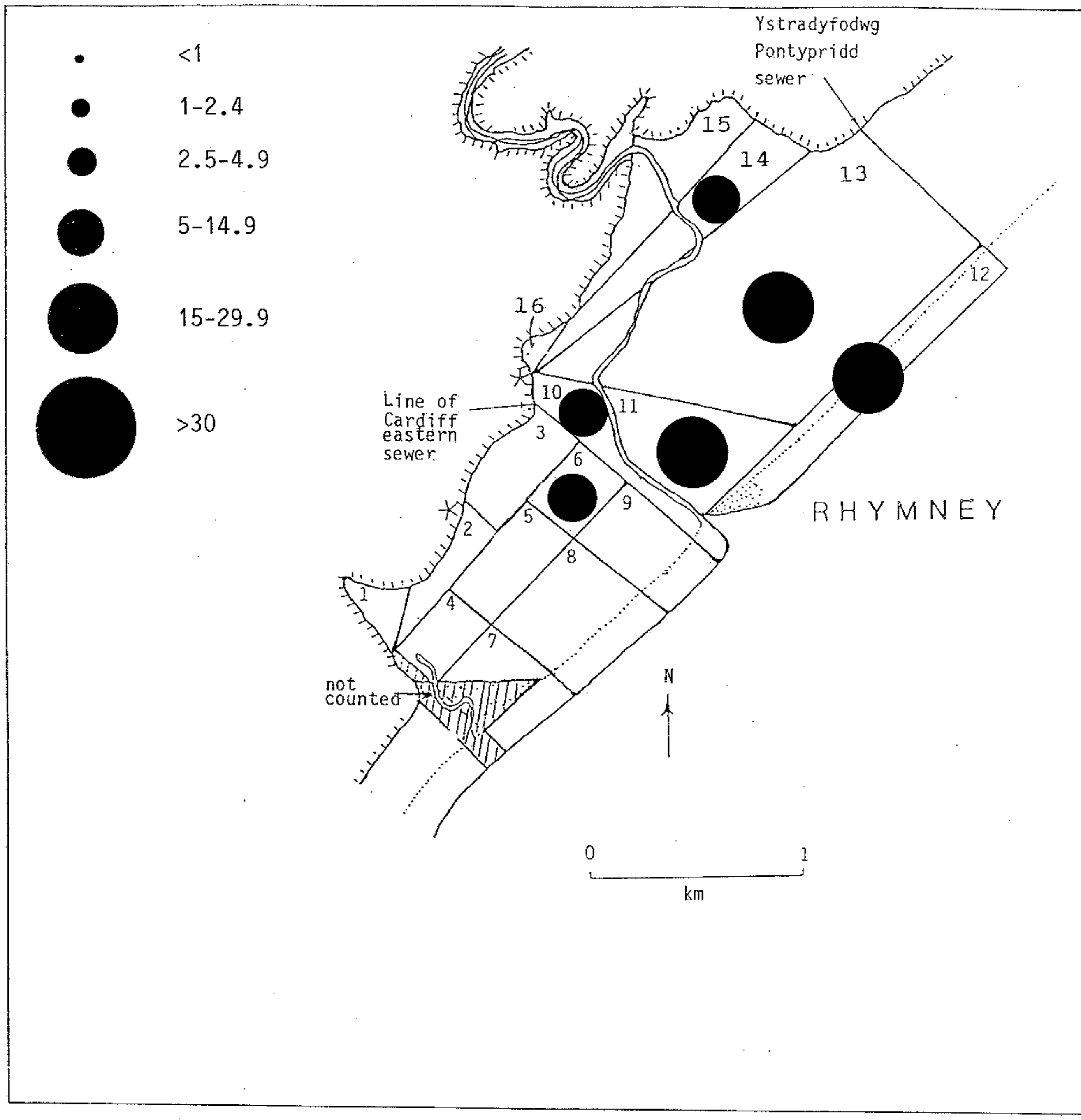


Figure 8.7.2 The distribution of feeding Pintail at Rhymney during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

OYSTERCATCHER WINTER 90/91

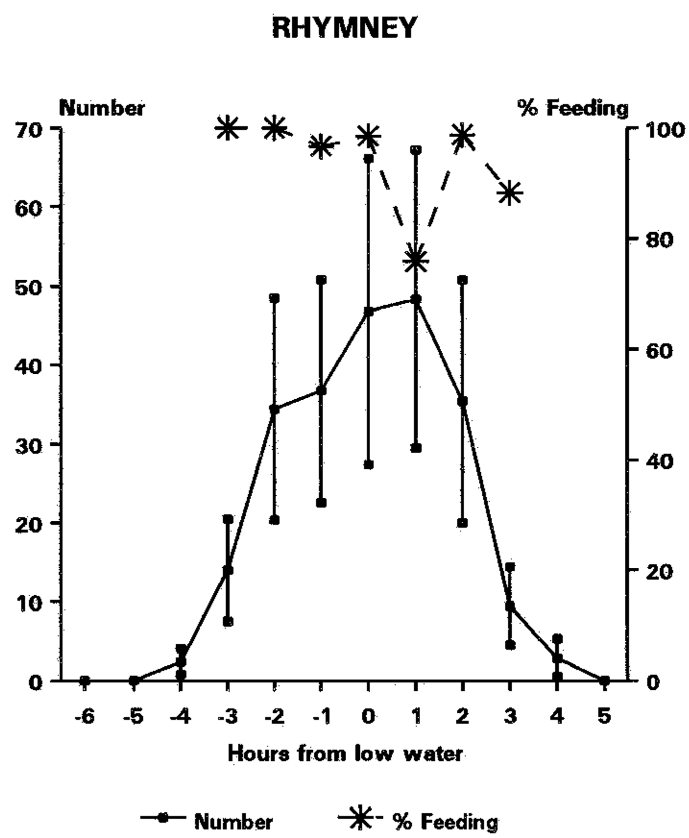


Figure 8.8.1 The average number of Oystercatcher present and the percentage feeding, in each study site throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

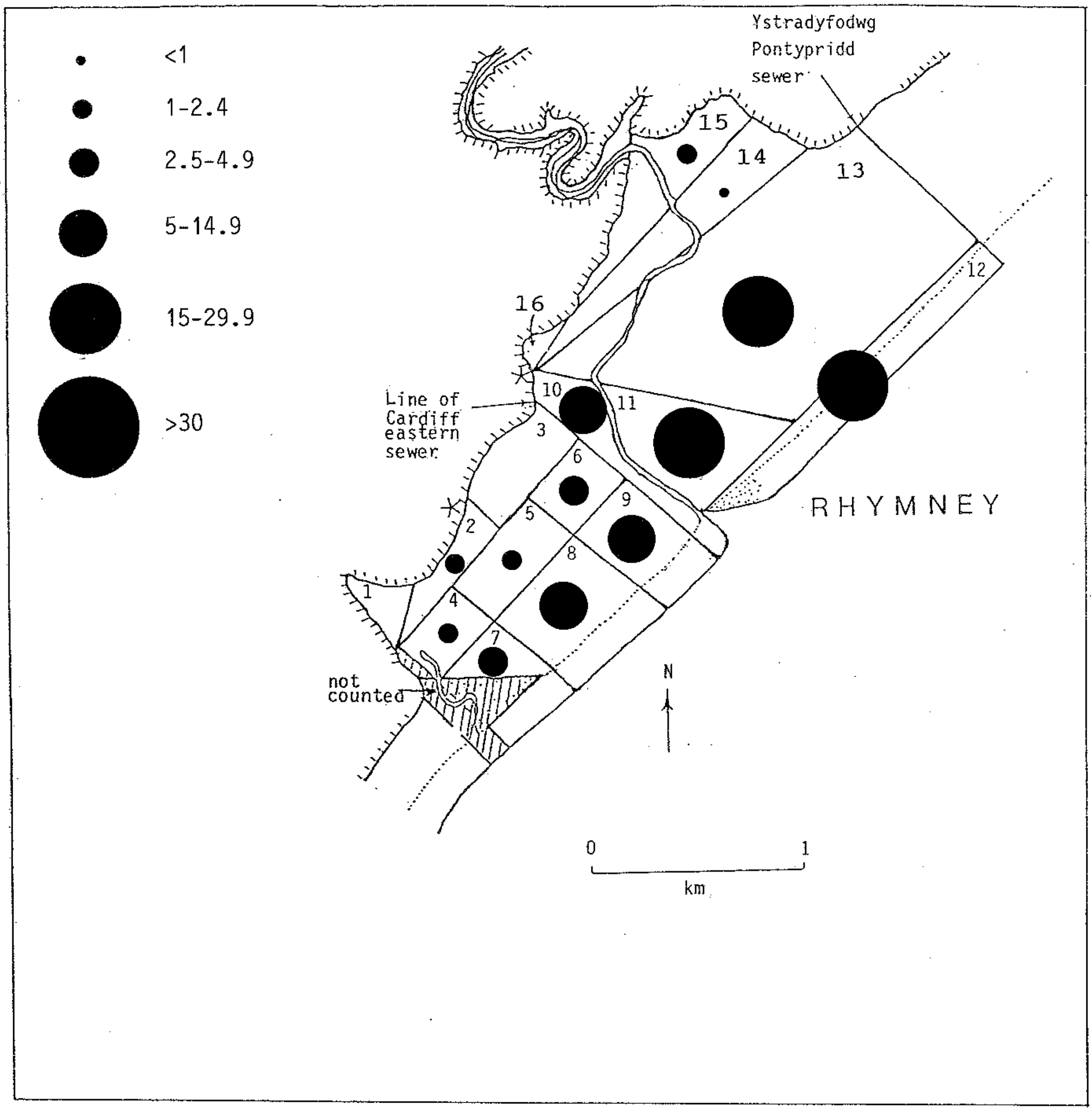
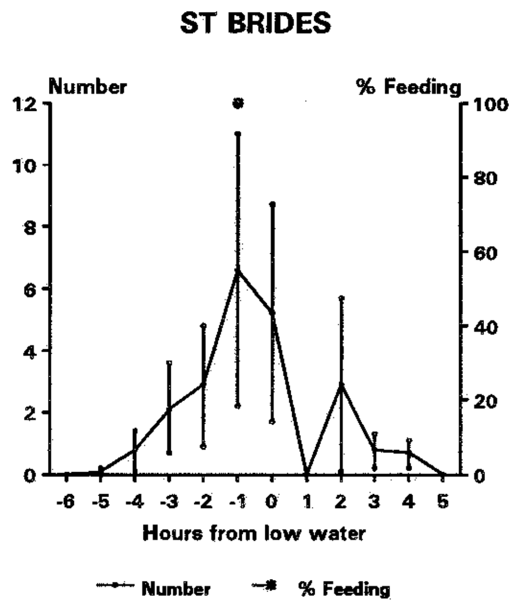


Figure 8.8.2 The distribution of feeding Oystercatcher at Rhymney during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

RINGED PLOVER WINTER 90/91



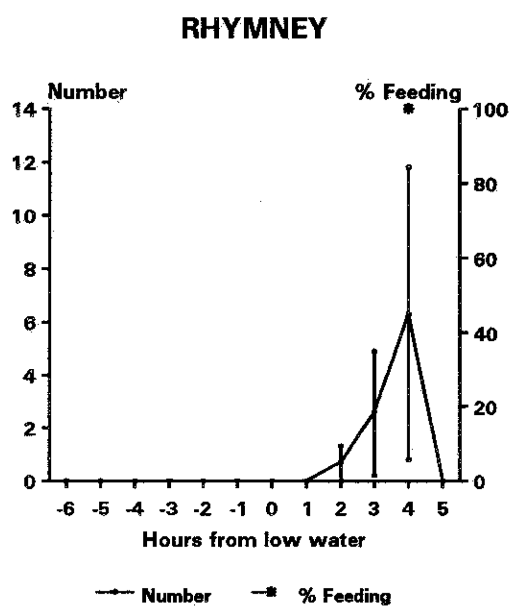


Figure 8.9.1 The average number of Ringed Plover present and the percentage feeding, in each study site throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

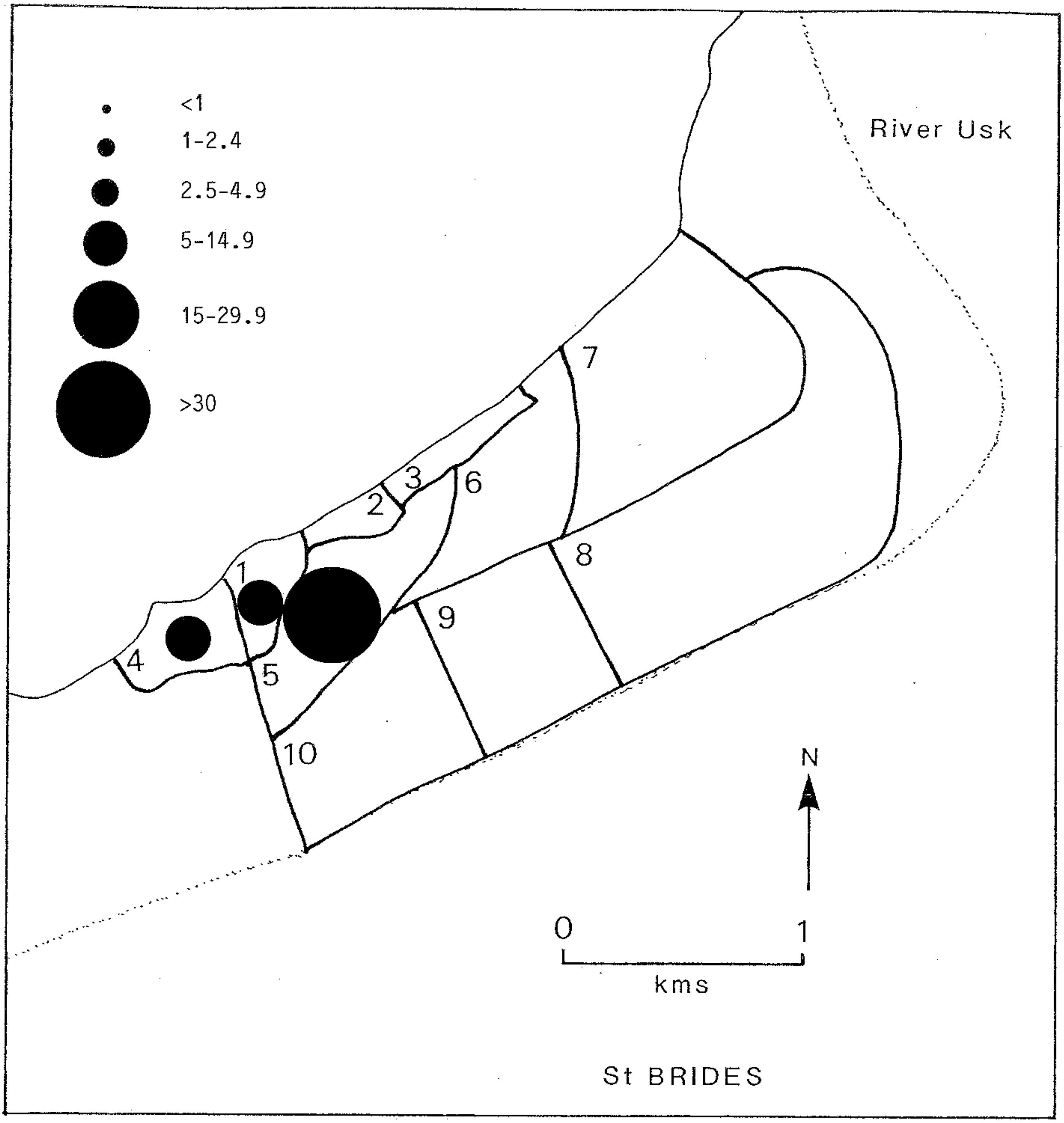


Figure 8.9.2 The distribution of feeding Ringed Plover at St Brides during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

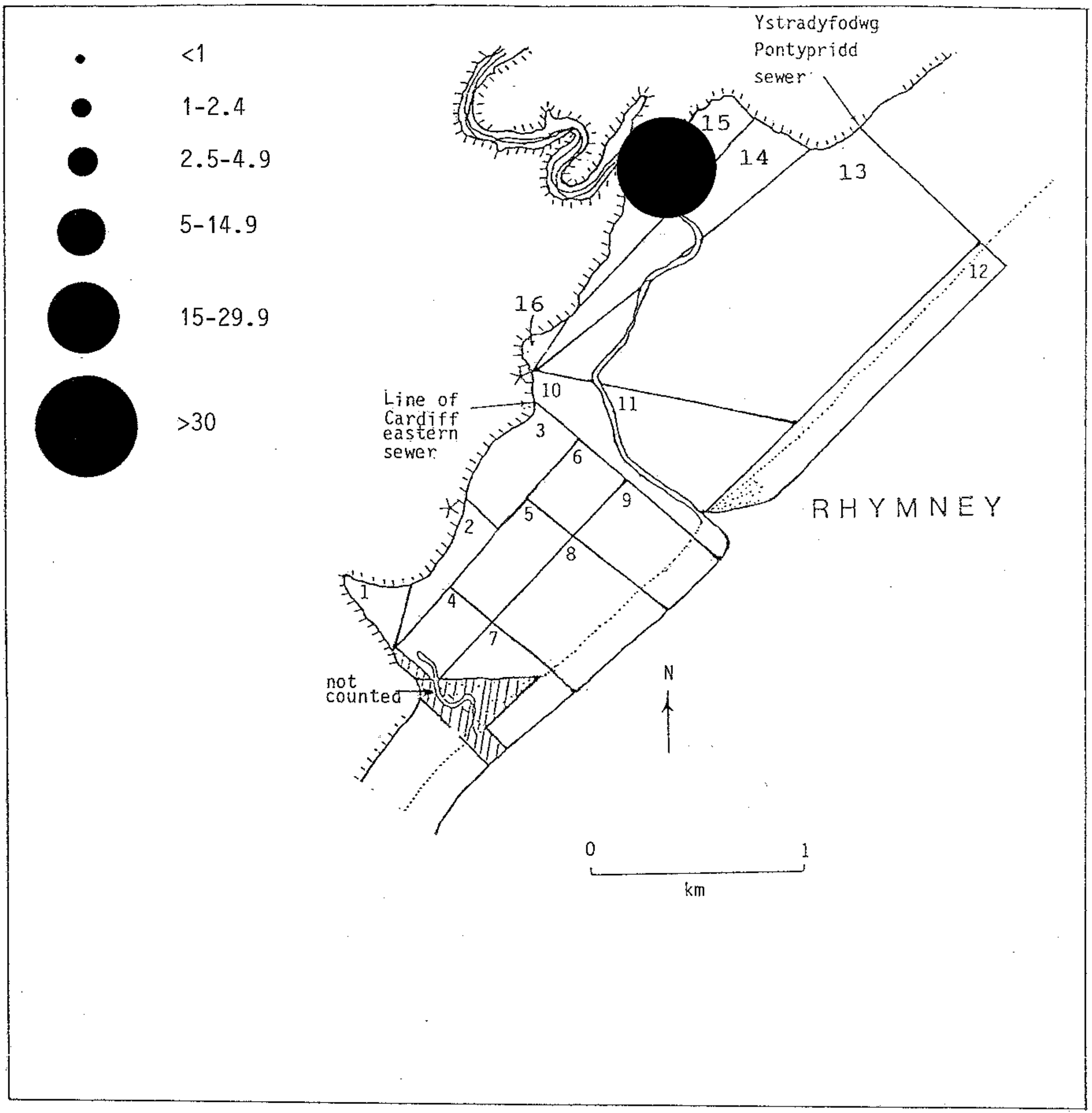


Figure 8.9.3 The distribution of feeding Ringed Plover at Rhymney during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

GREY PLOVER WINTER 90/91

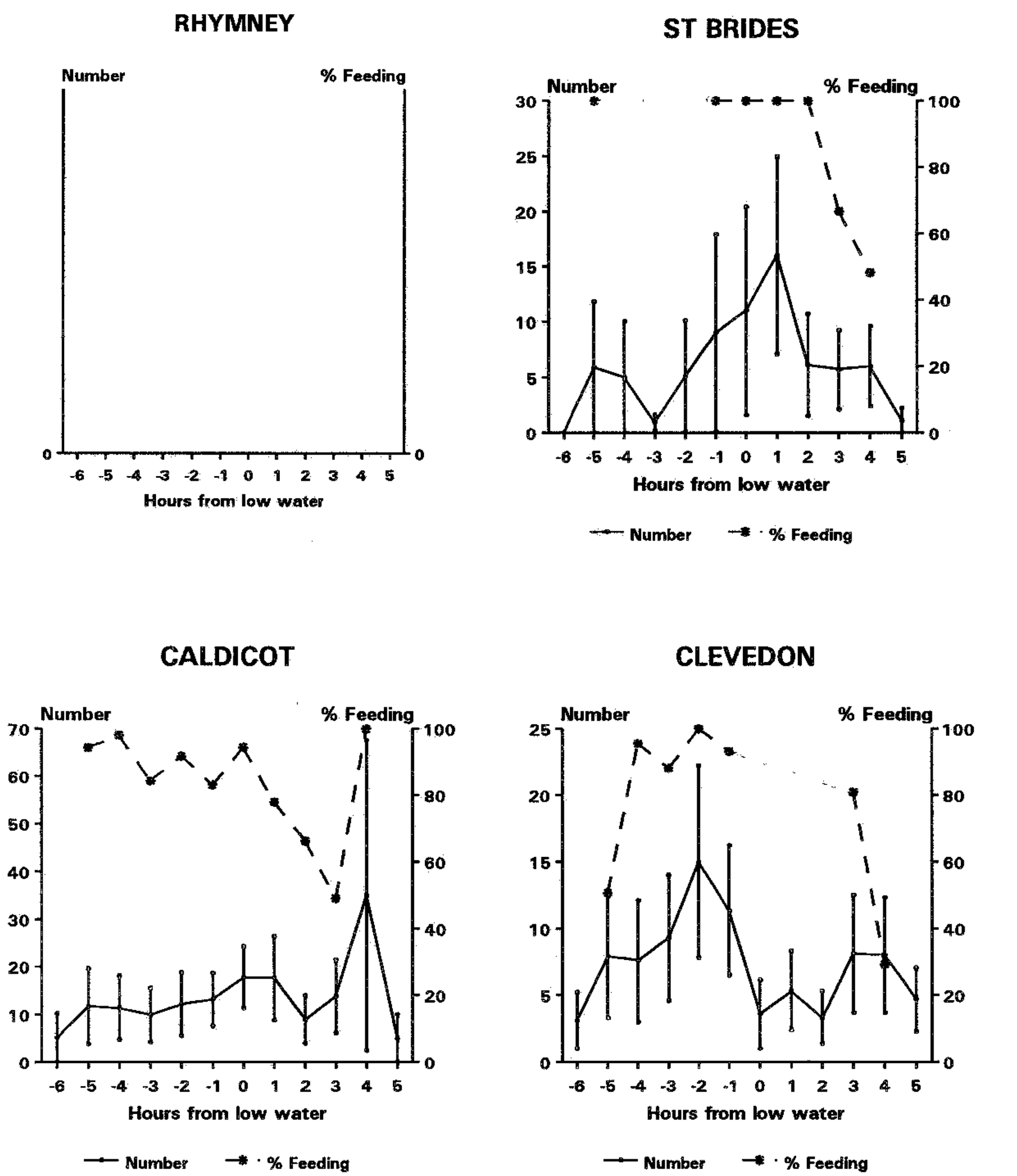


Figure 8.10.1 The average number of Grey Plover present and the percentage feeding, in each study site throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

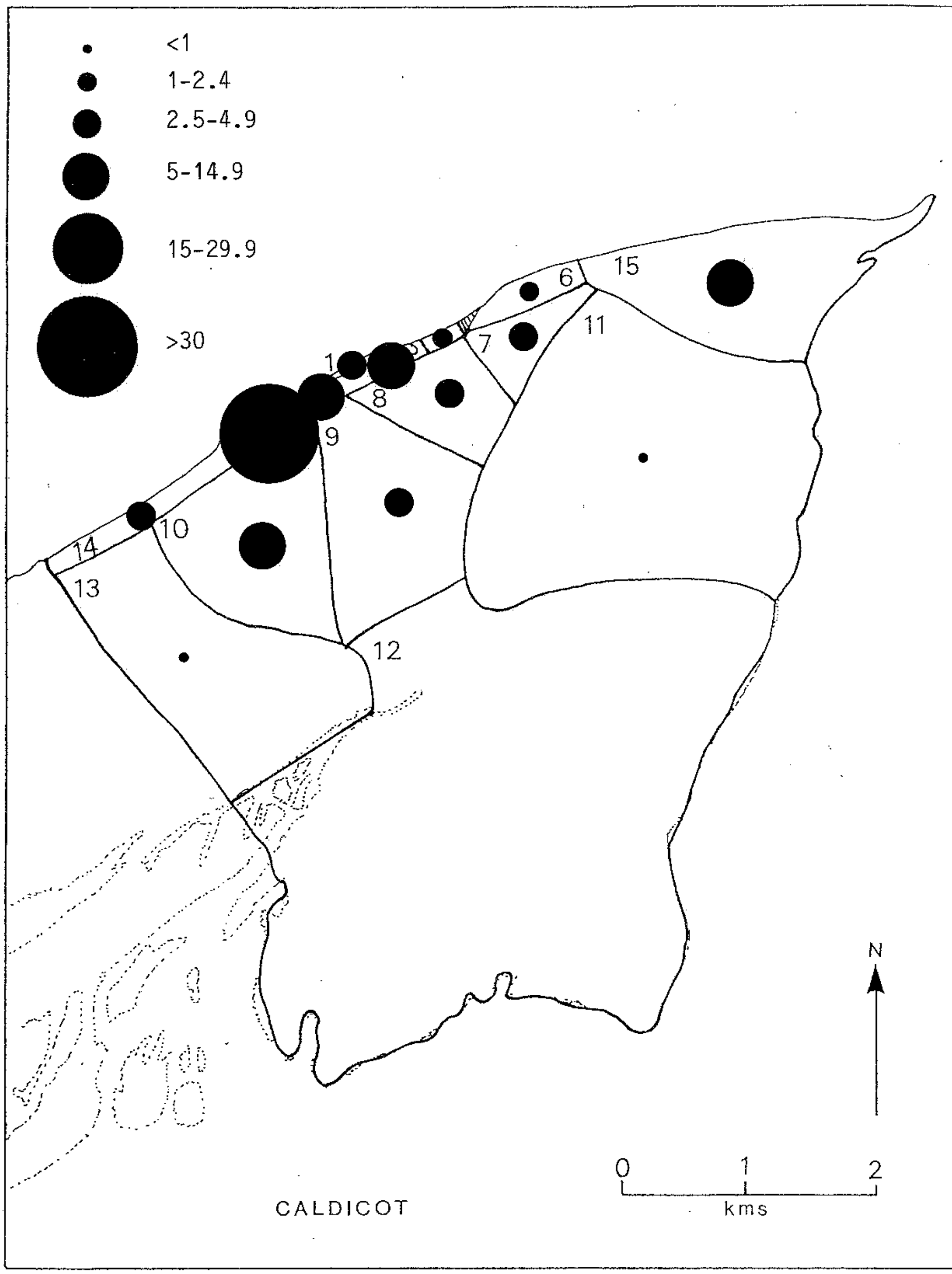


Figure 8.10.2 The distribution of feeding Grey Plover at Caldicot during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

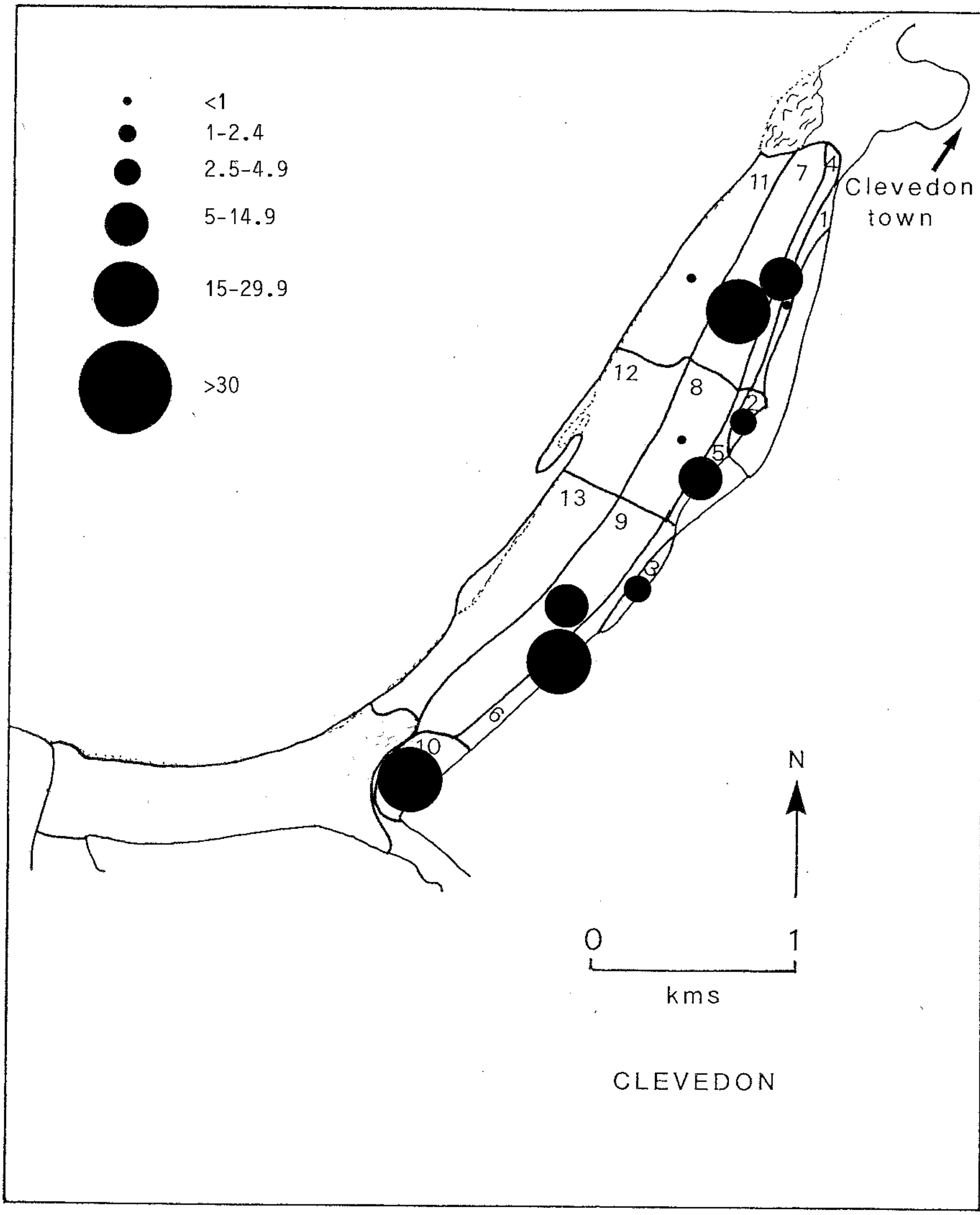
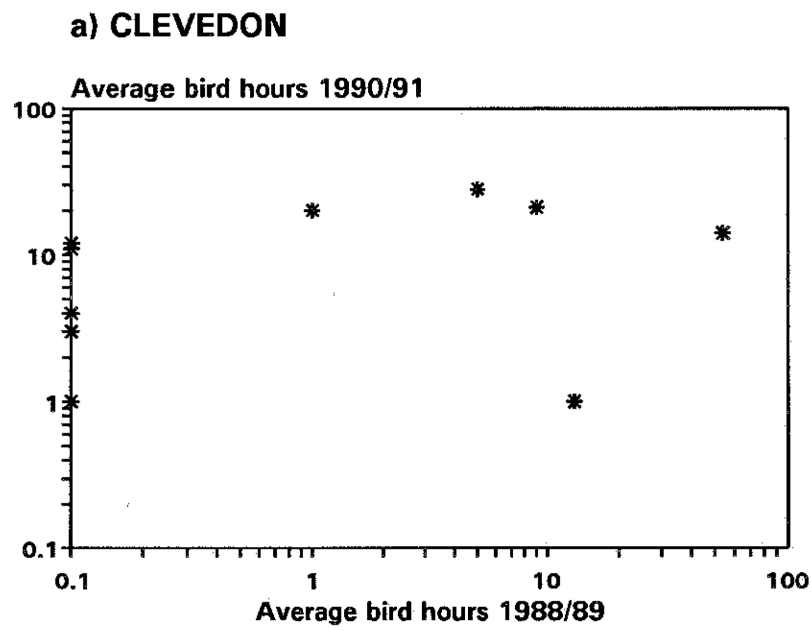


Figure 8.10.3 The distribution of feeding Grey Plover at Clevedon during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.

GREY PLOVER



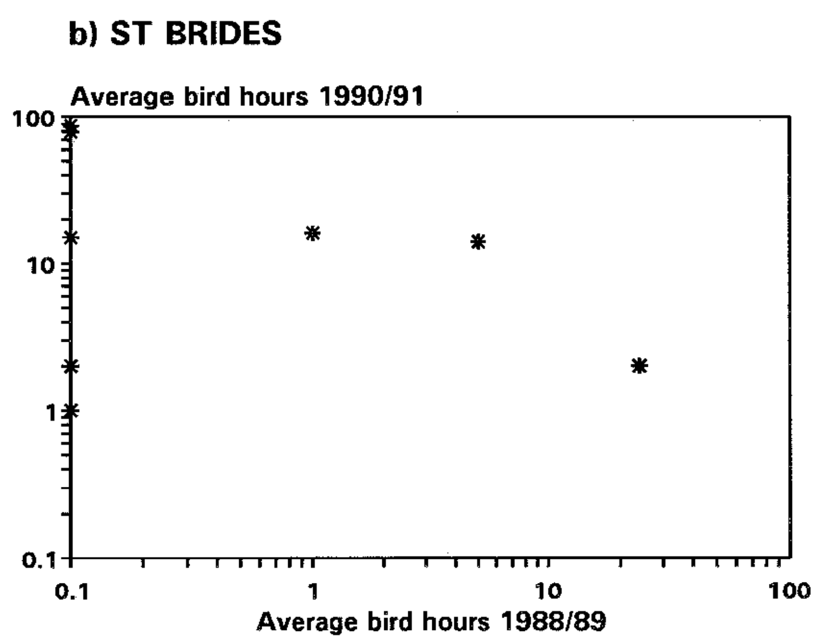


Figure 8.10.4 A comparison of average bird hours for Grey Plover on each intertidal count area between the two winters of study

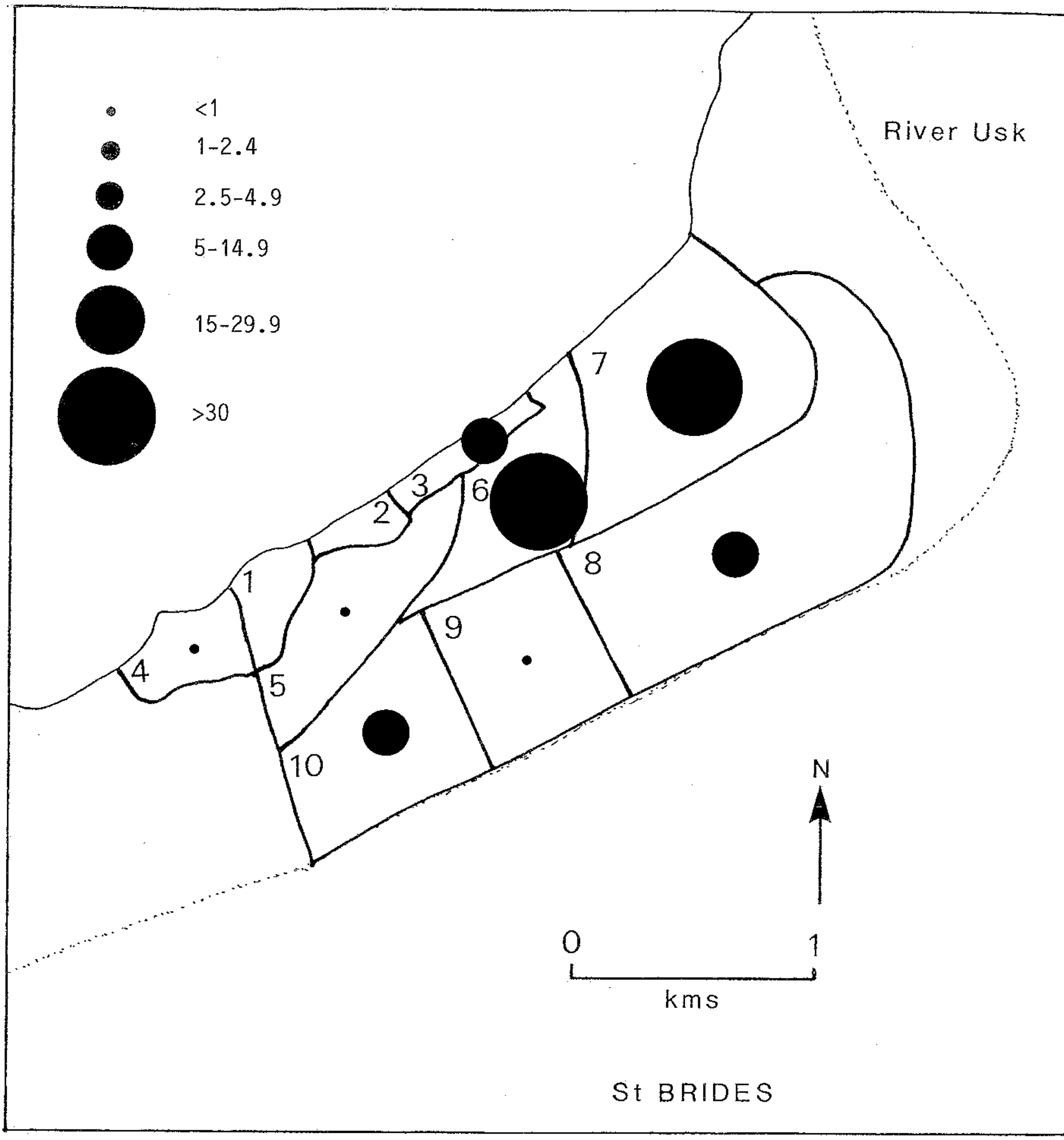


Figure 8.10.5 The distribution of feeding Grey Plover at St Brides during the 1990/91 winter assessed from all day observations. The percentage of the site usage is plotted for each area.