BTO Research Report No. 104

THE EFFECT OF THE CARDIFF BAY BARRAGE ON WATERFOWL POPULATIONS 3. DISTRIBUTION AND MOVEMENT STUDIES SEPTEMBER 1991-MAY 1992

Report of work carried out by
The British Trust for Ornithology
under contract to
Cardiff Bay Development Corporation

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November 1992

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EXECUTIVE SUMMARY

1. This report represents the results of the third season of intensive monitoring of the wildfowl and waders using the intertidal areas in Cardiff Bay and adjacent areas. More extensive monitoring also covered the intertidal areas between the Taff/Ely estuary and the mouth of the River Usk. The results presented in this report are derived from data collected between September 1991 and May 1992. The programme of monitoring closely followed that used for the previous two years. By using similar methods, a direct comparison between the three years of study is possible.

2. Building of an amenity barrage would result in the loss of the intertidal mudflats of the Taff and Ely estuaries, often called Cardiff Bay. The continued gathering of information on the distribution and movements of the populations of waders and wildfowl will allow the effects of the building of the barrage to be assessed.

3. Monitoring of the populations of waders and wildfowl on the northwest Severn from Cardiff Bay to the Severn Bridge has revealed no major changes. There has been an overall increase in the number of Pintail and there were larger numbers of Oystercatchers near the Rhymney compared with previous years.

4. The data collected for the Taff/Ely, Orchard Ledges and Rhymney study areas were used to obtain estimates of the size and distribution of wader and wildfowl populations. Statistical analysis to compare the results of the three year's study showed that there had been few significant changes.

5. Building of the Peripheral Distributor Road and the Phase I reclamation work have had an effect on the feeding and roosting areas at the northern part of Cardiff Bay. Teal and Lapwing moved away from areas adjacent to the work to feed and roost elsewhere in the bay. Redshank were sensitive to the heavy disturbance of some feeding areas during the autumn, but returned as the disturbance lessened.

6. Samples of Redshank and Dunlin were caught and colour-marked near the Rhymney in December and January, to continue studies of movement patterns around Cardiff Bay. There was a limited movement of Redshank from the Rhymney area into the Taff/Ely estuary at the end of December, although there appears to be little movement of birds caught in late January. The presence of colour-marked Dunlin feeding in the Taff/Ely estuary also confirmed at least some interchange between this site and the Rhymney estuary.

7. Observations of a small number of colour-marked birds elsewhere showed that there is at least some limited movement away from the northwest Severn. Notably, one Redshank was observed in northwest Devon shortly after being colour-marked.

8. Redshank that had been colour-ringed during the winter of 1990/91 were seen in Cardiff Bay during the present study. The proportion of colour-ringed birds suggested a high degree of site-faithfulness.

GENERAL INTRODUCTION

The building of an amenity barrage across the mouth of Cardiff Bay will produce a freshwater lagoon, covering the existing tidal mudflats. Waders and wildfowl that feed on the mudflats within the bay will inevitably be displaced and will have to find alternative feeding grounds. Because of this, the wader and wildfowl populations need to be monitored throughout the Phase 2 reclamation and following its completion, so that its effects can be alleviated. Developments have already taken place within the Taff/Ely site that have resulted in loss or alteration of areas of habitats. As this is now the third year of monitoring within the Cardiff Bay area it has been possible to assess the effects of the alteration of the feeding areas and loss of some roosting habitat on the waterfowl of the study sites.

This report is in two sections. The first section summarises the results of the third year of monitoring waterfowl populations in the vicinity of Cardiff Bay. The second section analyses the results of waterfowl movement studies based upon observations of colour-marked birds.

The results of the first two years monitoring of wader and wildfowl populations that are found in the vicinity of Cardiff Bay were given by Evans *et al.* (1990) and Donald & Clark (1991a). The present report summarises the findings of a second autumn monitoring and a third winter and spring monitoring of the waterfowl. A detailed picture of the birds that use the estuaries, their types, numbers and behaviour is being built up. This will allow the effects of the building of the amenity barrage across the mouth of the Taff/Ely estuaries on the waterfowl that use the intertidal mudflats to be assessed.

Such birds will inevitably be displaced when the barrage is built. The adjacent feeding areas on the north shore of the Severn estuary at Orchard Ledges and Rhymney estuary already support populations of feeding birds. It is not immediately obvious whether such areas could absorb increased numbers of birds. Some species such as Shelduck are known to restrict themselves to the areas that hold the greatest concentrations of their prey items (Buxton, 1981) and many waders are known to fill up the most preferred feeding sites in estuaries first (Evans and Dugan, 1984). Thus areas that appear under-used may or may not be able to support more birds. Furthermore, even where an increase in numbers is possible, it may result in loss of feeding time through aggressive behaviour, stealing of food from one bird by another, or disturbance of the prey items (Goss-Custard, 1977; Smith, 1975). None of these reductions in feeding rate is as a result of depletion of the food supply in the substrate but may reduce the number of birds that an area can support below the level that would be expected from the size of the available food supply.

Some species of waders, such as Knot, readily use different estuaries from one year to the next, or even within the same winter, to exploit abundant prey wherever it occurs (Dugan, 1981). Others, such as Grey Plover and Turnstone are 'site-faithful', returning to the same wintering grounds in successive winters (Townshend, 1982; Clark, 1983; Whitfield, 1985). Clearly, the loss of feeding grounds will affect these species in different ways and the results are not easy to predict.

Waterfowl may be affected by disturbance even if large areas of feeding habitat are not destroyed. Many waders use areas for feeding close to their roost sites (Nairn & Farrelly, in prep.) and if roost areas are lost the birds may use alternative feeding sites. This could put extra pressure on the birds already at other sites. Waterfowl are also sensitive to the

disturbance that may result during and after developments such as those taking place in the bay.

The Birds of Estuaries Enquiry (BoEE) has continued to monitor bird populations on all British estuaries since 1969. The counts obtained are used to determine the importance of estuaries, both at a national and international level, as well as to monitor population trends. Tables 1.1 and 1.2 give the mean peak winter count of waterfowl for the Taff/Ely estuary and the Severn estuary as a whole, together with the percentages of the British and European populations. (If an estuary holds 1% or more of the national population of a species, it is deemed to be nationally important for that species; if an estuary regularly holds 1% or more of a distinct geographical international population it is considered to be of international importance.)

The Severn estuary is the eighth most important site in Britain for waders in terms of overall numbers (Kirby *et al.*, 1991). It is currently internationally important for Shelduck, Redshank and Dunlin and falls just below international importance for Curlew (Table 1.2). At a national level, it is additionally important for Ringed Plover, Grey Plover, Curlew and Knot and falls just below national importance for Turnstone. As estuaries are not uniform, some sections may be more important than others. Clark (1990) found that the Taff/Ely estuary and the adjacent areas of the Rhymney estuary support one of the largest concentrations of birds anywhere on the Severn. The Taff/Ely estuary is currently nationally important for Dunlin and holds almost 0.8% of the British Redshank population (Table 1.1).

PART 1: DISTRIBUTION STUDIES

1. INTRODUCTION

This first part of the report discusses the feeding distributions of the waterfowl using the Taff/Ely, Orchard Ledges and Rhymney study areas between September 1991 and May 1992. As this is now the third year of intensive study, it has been possible to compare the three year's findings. The previous studies were described by Evans *et al.* (1990) and by Donald & Clark (1991a). The distribution of roosting birds on the Taff/Ely site was studied in winter 1990/91 (Donald & Clark, 1991b). This study was repeated during the winter of 1991/92 to examine the effects of the development at the north end of the bay on the roosting pattern of the waterfowl and has been recently discussed in Toomer & Clark (1992).

With three year's data, it has been possible to carry out statistical analyses to see if there have been any significant changes in the bird populations, or their patterns of distribution, at the three study sites. Bird populations vary from year to year, but this does not necessarily reflect long term trends. Only with the continuation of this study over several years, will long-term changes will be detected.

Although the winter and spring fieldwork has been carried at the same time for each of the three years of the study, (November-March and April-May respectively) the timing of the autumn fieldwork has been varied. In 1989, autumn counts were not made as the study did not begin until November. It was decided to carry out counts during August and September in 1990 to determine the level of use of the study site by waders passing through on migration. The results from this preliminary autumn study made it clear that the study sites were not used a great deal by waders during the early part of the migration period. For 1991 counts were therefore carried out to cover the later stages of the migration period in September and October. The time of the autumn movement of waders and wildfowl varies for different species. Counts made in August/September may be lower for some species than in September/October as more migrant birds may have arrived at the later count time. Care must therefore be taken when interpreting the autumn differences for some species. This is referred to in the species accounts where possible.

Between-year variability can have various causes. These have been reviewed by Donald & Clark (1991a) and will not be discussed further here. In this report, we focus on changes that may be a result of the development that has already taken place within the bay. So far, the main developments have resulted in the loss of part of the saltmarsh at the northwest part of the bay (Phase I reclamation) and loss of some small areas of mudflats on the side of the River Taff (Peripheral Distributor Road [PDR] work). Such developments inevitably produce disturbance to a larger area, at least in the short term. With the extensive amount of data collected so far, it is now becoming possible to assess the effects of this on the birds that are found within the whole area.

2. METHODS

For this third year of study, methods were kept as similar as possible to those used in the two previous studies. The methods are therefore only briefly described below. Using similar methods to the previous studies allows direct comparison between seasons and years for the three year period.

Two types of counts were carried out, all day counts and low tide counts.

2.1 All Day Counts

The study area consisted of three sites: the Taff/Ely (Figure 2.1.1), Orchard Ledges and Rhymney (Figure 2.1.2). As before, each site was divided into several count areas to increase count accuracy and allow detailed analysis of results. The Taff/Ely site was divided into 19 count areas, Orchard Ledges into two count areas and the Rhymney into 17 count areas. The boundaries of the count areas were those laid down in the first year of monitoring (Evans *et al.*, 1990).

Developments that are taking place at the northern end of the Taff/Ely site have affected some of the count areas. The continuing work on the Peripheral Distributor Road (PDR) has cut across two count areas. These two areas, sector 7 and sector 10 (Figure 2.1.1) were still considered as 'intact areas' and counted as such. The formation of the PDR banks and the raising of the ground level in two areas as part of the Phase 1 Development work for Cardiff Bay Development Corporation (CBDC) considerably reduced the effectiveness of the observation point at Windsor Esplanade. It was also found that observations made from the point near the Pierhead building, adjacent to sector 19, could be effectively covered from the northern most observation point in the Docks area, adjacent to sector 18. Thus for the present study observation points for the Taff/Ely site were reduced from six to four. This reduced the logistic problems of covering the site for hourly counts without reducing their accuracy.

No differences in the Orchard Ledges and Rhymney sites were observed over the three seasons of monitoring and counts were made from the same observation points.

The pitted area between Orchard Ledges and the Rhymney sites holds small populations of Turnstone, Curlew, Dunlin and Oystercatcher at low tide (P.F. Donald, pers. comm.). The nature of the broken surface made it very difficult to count birds accurately from either the Orchard Ledges or Rhymney observation points. As the numbers of birds present were small compared with the populations on the Rhymney site, this area was not included in the counts.

Counts were divided into three seasons: autumn (September-October 1991), winter (November 1991-March 1992) and spring (April-May 1992). Each site was counted at least twice a month with one count on a spring tide and one on a neap tide where possible. All count areas of each site were counted once every hour for six hours before and after low tide. Counts were made throughout the hours of daylight or for 12 hours (whichever was the shorter). This procedure enabled the assessment of changes in the usage of different sites throughout the tidal cycle. Feeding and roosting birds were counted separately and factors such as disturbance to the site or impaired visibility were noted. All birds present on the exposed mudflats were counted. Wildfowl feeding in the shallow water offshore, which were clearly feeding on invertebrates in the substrate were included in the counts. However,

wildfowl roosting offshore on the open water were not included in the counts as the study is primarily concerned with feeding birds and because such birds are extremely difficult to count. Waders and wildfowl roosting in areas of saltmarsh were not counted, as accurate counts are also very difficult in this habitat. Observations on the roosting behaviour of birds in Cardiff Bay have been covered in separate reports (Donald & Clark, 1991b; Toomer & Clark, 1992).

For each season, all day counts were used to calculate the following, following Evans *et al.* (1990):

1. the average exposure time per tidal cycle of each count area;
2. the average number of feeding bird hours per tidal cycle ('all day usage' - the term 'usage' will be used throughout the report);
3. the average number of birds present on each of the three sites at each hour of the tidal cycle and the proportion feeding.

All day usage was calculated using:

$$\text{Usage} = \sum_{A=+5}^{A=-6} (B \times C)$$

A = hours from low tide
B = average number of birds feeding at time A when area was exposed
C = proportion of counts when area was exposed at time A

In addition, further analyses have been carried out on the data for the three winters. Similar analyses have not be carried out for autumn and spring as bird numbers show the three sites to be of lesser importance at these times and such analyses would be less meaningful. For winter counts of the most important species of waterfowl in the Taff/Ely and Rhymney sites, graphs are given showing a comparison of all day usage between the current season and the two previous seasons *ie* 1989/90 compared to 1991/92 and 1990/91 compared to 1991/92.

Correlation coefficients are calculated for these comparisons between years, for each species at each of the two sites, and for all sites combined. If there is a low correlation coefficient (a value close to 0), then one year's counts are a poor prediction of the other year's counts. If on the other hand there is a high correlation coefficient (a value close to 1, or -1 in the case of a negative correlation), then one year's counts are a good prediction of the other year's counts.

The level of significance gives an indication of the confidence that we can place in the correlation, with lower correlation coefficients being less significant.

2.2 Low Tide Counts

The low tide distribution of waterfowl in the northwest Severn was monitored by the use of low tide counts. Counts were made at two-weekly intervals by BTO volunteers who were experienced in counting their own allocated areas. As for 1990/91, only areas along the

north Severn shore, west of the River Usk were counted as it was considered that changes in Cardiff Bay were most likely to affect the distribution of birds in this area (Figure 2.2.1). As with the all day counts, the whole area was broken down into smaller count areas. These were larger on average than the all day count areas. The average number of birds present on each of the count areas is shown for each species. Low tide counts were only made during winter months.

2.3 Presentation of results

The previous two years of study were reported in Evans *et al.* (1990) and Donald & Clark (1991a). This report should be read in conjunction with these two reports as figures for the previous two years findings are not reproduced here.

There have been a number of changes to habitats within Cardiff Bay as a result of work on the PDR and the Phase I reclamation. In discussing the results, particular attention will be given to species that may have been affected by any changes.

All species observed at the three sites during the period of study will be discussed, but most emphasis will be given to the species for which these areas are most important. These species are Redshank, Dunlin, Shelduck and Curlew.

Low tide counts were used to produce maps showing the average number of each species present during the winter months. These are included in the species accounts that follow. Each species account consists of three parts. Results of all day and low tide counts are presented in sections relating to autumn 1991, winter 1991/92 and spring 1992. In each of these, comparisons are made with the two previous seasons, 1989/90 and 1990/91 if appropriate. The results are considered in relation to the changes that have occurred to the sites during the three years of study, as well as with factors such as feeding ecology and behaviour and migration patterns. For several of the more important species, (Shelduck, Teal, Pintail, Oystercatcher, Dunlin, Curlew and Redshank) a fourth part examines the statistical comparison of the three years.

Important points are summarised for species at the end of each species account.

Presentation of the results of the all day counts follows Evans *et al.* (1990). Graphs showing the number of birds and the proportion feeding through the tidal cycle only give the percentage feeding if there was a total of more than 50 birds. This is because such values would carry very little meaning with smaller populations. Graphs are also given comparing the usage of count areas during the winter period of 1991/92 with 1989/90 and 1990/91. Usage values are plotted on logged scales and increased by one to allow zero usage values to be included. Further analyses are carried out to obtain correlation coefficients for this usage data.

The order of the species accounts follows Voous (1973).

3. RESULTS

3.1 Shelduck

Autumn 1991

Shelduck breed and winter in Britain (Owen *et al.*, 1986) with the Severn estuary being the eighth most important site for wintering birds (Kirby *et al.*, 1991).

Both the Taff/Ely and Rhymney sites were used by feeding Shelduck during the autumn of 1991 (Figures 3.1.1 and 3.1.2) with the small numbers present at the Taff/Ely site widely distributed throughout the bay. At the Rhymney site, feeding Shelduck were widely distributed with a greater usage of the mudflats east of the River Rhymney. Feeding birds followed the line of the falling tide and were therefore found on most sectors, although small numbers remained scattered over the exposed mud throughout the low tide period. Donald & Clark (1991a) also reported that most feeding occurred on the falling tide although other workers have found a differing pattern of feeding behaviour (Bryant & Leng, 1975; Thompson, 1981).

Few Shelduck were found at Orchard Ledges during the autumn.

The majority of the birds at all sites in autumn were juveniles. It has long been known that adult Shelduck move away to specific moulting areas at the end of the breeding season. Large numbers of British birds migrate in early July to mudflats of the Grosser Knechsand in the German Wadden Sea to complete their moult (Coombes, 1950; Goethe, 1961) and several thousand birds congregate during late July and August to moult in Bridgwater Bay on the other side of the Severn (Eltringham and Boyd, 1963). Having completed their moult, adults start to return to their wintering grounds in October.

The small number of birds present on the Taff/Ely showed a peak following high tide when most birds were feeding, with numbers remaining fairly constant throughout the rest of the tidal cycle (Figure 3.1.3). As birds ceased feeding on the rising tide, some roosted on the open water. As these were not included in the counts, the number of birds counted on the site fell.

The distribution of feeding Shelduck and the numbers present at the Taff/Ely and Orchard Ledges sites was similar to the previous autumn. The sectors of the Rhymney site showed an increased use compared with 1990 with more of the sectors to the west of the River Rhymney being used by feeding birds throughout the tidal cycle (Figure 3.1.2). There was a higher use of sectors to the east of the river by feeding Shelduck than was found in the previous autumn.

Greater numbers were present on the Rhymney site than in 1990, with a higher proportion of birds feeding throughout most of the tidal cycle.

Winter 1991/92

The low tide counts for the 1991/92 winter show that feeding Shelduck are widely distributed along the shore of the northwest Severn with larger numbers of birds found on the areas from the Rhymney to St. Brides sections (Figure 3.1.4).

The all day pattern of usage in the Taff/Ely site showed that almost all parts of the bay were used by feeding birds with no clear preference for any particular sectors (Figure 3.1.5).

Shelduck were found on the Orchard Ledges site on several counts (Figure 3.1.6). There was no regular pattern to their use of this area for feeding and the numbers of birds found on the mudflats at low tide during the 1991/92 winter varied considerably on different days. Commonly there were five or fewer birds feeding on the exposed mud. Two counts had high numbers of birds with over 60 birds recorded one day and over 240 on a separate day. At the Rhymney site, almost all sectors were used by feeding Shelduck with greater usage of areas east of the river (Figure 3.1.6).

At the Taff/Ely site higher numbers were present on the falling and rising tide than around the period of low tide (Figure 3.1.7a). At low tide, more birds were present roosting on the open water, particularly on the River Taff along the side of sector 17 and were therefore not included in the counts. The majority of birds were feeding throughout the tidal cycle. Donald & Clark (1991a) noted that the Shelduck on the mudflats spent most of their time feeding.

Figure 3.1.7b shows that almost all the birds present on Orchard Ledges were feeding when they were present. Shelduck arrived on the mud exposed at the west end of sector 1 one to two hours before low tide and remained feeding until these muddy areas were covered by the rising tide. Shelduck were observed to come from the direction of the Taff/Ely site. On one occasion about 60 Shelduck were observed to feed on a stonier section of sector 1 adjacent to the Severn instead of the more usual area near the point where the rivers Taff and Ely leave Cardiff Bay.

At the Rhymney site, most birds were feeding near the tide edge during the period three to four hours either side of low tide (Figure 3.1.7). High numbers were seen on sector 13, beyond the Ystradyfodwg Pontypridd sewer and many of these birds roosted on the upper reaches of the shore as the tide rose.

1991/92 low tide counts show that the distribution of Shelduck feeding on the northwest Severn was similar to that for the previous winter (Figure 3.1.4). The increase in feeding birds on the St. Brides and Peterstone sections noted in 1990/91 was maintained, with an increase on the eastern sector of the Rhymney site. However, there was a decrease in the number of feeding birds, as shown by the low tide counts for some of the Taff/Ely low tide count areas during this winter. All day counts did not show this decline, suggesting that it was a result of the birds moving to areas where they were not counted, such as the mouth of the bay or on to the open water at low tide.

The all day pattern of usage in the Taff/Ely for the 1991/92 winter was similar to that of the two previous seasons with a slightly higher usage of some of the sectors in the

northern part of the bay. This was the main area where habitats have been affected by developments within the bay.

The increase in the numbers of birds feeding at the Rhymney shown by the low tide counts agrees with the increase found during the all day counts (Figure 3.1.6). In particular, there was an increase in usage of all sectors east of the Rhymney river with sectors 11, 12, 13, 14 showing the greatest increase. This pattern of usage is closer to that found in 1989, after the decrease noted in 1990.

The irregular use of the Orchard Ledges site during 1991/92 produces an average figure for usage similar to that for 1990/91, although the actual number of birds was low for most present counts. It was noted in 1990 (Donald & Clark, 1991a) that Shelduck had started to make use of the mudflats exposed at the west end of the count area from January onwards, in contrast to the situation found in 1989/90 (Evans *et al.*, 1990).

Almost twice as many Shelduck were present on the Rhymney site in winter 1991/92 as there were in the previous season (Figure 3.1.7c). Clark (1989) considered the Rhymney section to be the second most important site on the Severn for this species and the current study shows this still to be true. The high numbers on sector 13 contributed to the increase between years. Large numbers of Shelduck were located on sections east of this part of the Rhymney site. Thus only a small change in feeding or roosting behaviour of these birds could result in increased numbers within the Rhymney bay area.

A Comparison of the Three Winters

Figure 3.1.8a and b compares the feeding usage at the Taff/Ely site and the Rhymney site for the current season with 1989/90 and with 1990/91. At both sites in both comparisons there is clearly a close correlation. This indicates that there has been no major change in the overall feeding pattern for each site during the three years of the survey. Any changes that may have occurred have only affected the distribution within a site to a limited extent as is shown by the higher usage values for the Rhymney site. Tables 3.1, 3.2 and 3.3 show the correlation coefficients obtained by analysing the between year usage. There has been a very close correlation between the results for the three seasons at the Taff/Ely sites and the Rhymney sites. This very high correlation confirms the absence of any major shift in feeding distribution during the past three winters.

Spring 1992

As in winter, the feeding Shelduck were distributed throughout the Taff/Ely site with no apparent preference for particular mudflats (Figure 3.1.9). At the Rhymney site, there was a preference for the mudflats of those sectors east of the river Rhymney, a similar pattern to that observed in winter (Figure 3.1.10). No Shelduck were found at the Orchard Ledges site in the spring.

A large proportion of the wintering population of Shelduck remained at both the Taff/Ely site into the spring period but the number of birds present at the Rhymney site at this time had fallen to about a third of the winter total (Figure 3.1.11). Birds

left their roost areas as soon as the mudflats started to become exposed and the majority then continued to feed until the rising tide again covered these areas.

The pattern of feeding distribution at the Taff/Ely site was very similar to the findings of the two previous springs. Only minor changes in were apparent, the developments at the north end of the bay having had no marked effect. The feeding usage on the Orchard Ledges and Rhymney sites was very similar to that for the previous two seasons, with a only a slight increase on the sectors east of the Rhymney river.

The numbers of birds at the Taff/Ely site (Figure 3.1.11a) were also similar over the three seasons, with over 100 birds remaining on the mudflats for most of the tidal cycle at this time of the year. Numbers at the Rhymney site (Figure 3.1.11c) were about twice as high as for the two previous seasons, but with a similar proportion of the birds feeding throughout the tidal cycle. This parallels the results found for the winter counts, although the actual numbers were much lower.

In summary, compared with findings for the previous year, there had been an increase in the number of Shelduck at the Rhymney site, especially on eastern sectors. There were no major changes at the Taff/Ely site. Orchard Ledges continued to support occasional feeding flocks of Shelduck at the extreme western end.

3.2 Wigeon

No Wigeon were seen during the autumn, winter and spring study periods. This species had only been observed in very low numbers on the northwest Severn during the two previous winters.

3.3 Mallard

Autumn 1991

Mallard are ubiquitous in the British Isles. Only part of the resident population winters on estuaries. Small numbers fed on the mudflats at the Taff/Ely site, (Figure 3.3.1) with feeding birds being restricted mainly to the shallow water along the edges of sectors adjacent to the rivers. No birds were present on Orchard Ledges during the autumn. At the Rhymney site (Figure 3.3.2), most feeding activity occurred on sectors east of the Cardiff Eastern Sewer and this activity was again mainly along the shallow edges of the river or of the sea.

The number of Mallard using the mudflats of the Taff/Ely site was low (Figure 3.3.3a). Birds that did not remain on the water resumed feeding for a short time soon after high tide, with only small numbers remaining on the mudflats for the rest of the tidal cycle. At Rhymney (Figure 3.3.3c) there was a different pattern. Higher numbers of Mallard left the open water and either fed or roosted through the tidal cycle with numbers remaining high until the mudflats were again covered by the tide. A higher proportion of the population was roosting at any one time compared with the Taff/Ely population.

Mallard at the Taff/Ely site showed a slight increase in usage compared with 1990. There was an increase in usage at the Rhymney site in 1991, especially on sectors east of the Rhymney river.

The number of birds at the Taff/Ely site was similar to 1990, but with a higher proportion feeding. There was an increased number of birds at the Rhymney site but with a similar pattern of feeding and roosting on the sectors used. As has been previously noted, (1990/91), many birds remain roosting on the open water throughout the tidal cycle and are therefore not included in the counts.

Winter 1991/92

The low tide distribution of Mallard on the northwest Severn showed relatively small numbers feeding at Taff/Ely, Rhymney and Peterstone sections (Figure 3.3.4).

At the Taff/Ely site, only small numbers fed on a number of sectors throughout the bay with the majority of birds that were present remaining on the open water for a greater part of the tidal cycle (Figure 3.3.5). At the Rhymney site, (Figure 3.3.6) feeding birds were confined to the sectors east of the Cardiff Eastern Sewer pipe, a similar distribution to that described for autumn. No birds were observed on the Orchard Ledges site.

The numbers of birds on the mudflats of the three sites was low (Figure 3.3.7a, b and c). A higher proportion of the birds at the Taff/Ely site were roosting during the tidal cycle compared with the situation described for autumn. As in the autumn, many birds remained on the open water and were therefore not included in the totals.

In 1990/91 there was a virtual absence of feeding Mallard at the Taff/Ely site, in contrast with the 1989/90 winter. Although numbers of feeding Mallard were low during the winter of the present study, the pattern is closer to that of 1989/90 with a similar feeding distribution. This pattern over the three winters was paralleled at the Rhymney site. However, the numbers of Mallard present on the mudflats through the tidal cycle was similar for the three years of the study.

Figure 3.3.8a and b shows the correlation for feeding usage between the three years of study. The results for 1991/92 and 1989/90 show a close similarity, the scatter of points on the graph mainly reflecting a different use of sectors within each site. Figure 3.3.8b, comparing 1991/92 with 1990/91 confirms the observation already made, that there was a reduction in the number of feeding birds during the winter of 1990/91.

Spring 1992

Almost all Mallard had left the area by spring. One very small group (less than five birds) was observed feeding on sector 8 of the Taff/Ely site on two occasions.

In summary, compared with findings for the previous year, there had been a decrease in the feeding usage at the Taff/Ely site, although the numbers involved were low. There had also been an small increase in usage at Rhymney.

3.4 Teal

Teal are mainly surface feeding ducks, obtaining food by dabbling in shallow water, collecting floating seeds form the surface or up-ending in slightly deeper water. Nocturnal feeding may form the large part of food intake (Clark *et al.*, 1990). When this is the case, much of the day is spent roosting in channels, on saltmarsh or on the open water. Because of this pattern of behaviour, all day counts of activity on mudflats often do not reflect the true size of the population in a particular area.

Autumn 1991

At the Taff/Ely site only low numbers of birds were feeding on the sectors (Figure 3.4.1). No birds were observed at Orchard Ledges during the autumn. Feeding was mainly confined to the sectors east of the Cardiff Eastern Sewer at the Rhymney site, where the birds fed along the edge of the river (Figure 3.4.2).

The actual numbers of birds at the Taff/Ely and the Rhymney site were low (Figure 3.4.3). Of the birds seen on the sectors at both sites, a high percentage were feeding, but as already been stated, this does not represent the whole population in each area.

The distribution of the birds within the bay was different from that found in 1990, when the sectors used most for feeding were 10 and 13. Sector 10 was subject to considerable disturbance from the PDR development during the autumn of 1991 and birds were not found there at all. Sector 13 was found to be used primarily by roosting birds in 1991, rather than for feeding.

Feeding Teal were present at the Rhymney site in 1991 although no feeding was seen in the previous two autumns. These birds may have included some displaced from the Taff/Ely by the disturbance from the PDR work at the north end of the site. They were confined mainly to the edges of water-filled channels on sectors adjacent to the River Rhymney.

Although the number of birds at the Rhymney site was low, it was greater than in the previous two autumns.

Winter 1991/92

Figure 3.4.4 shows the low tide distribution of feeding Teal on the northwest Severn. The highest concentration of feeding birds was found on the St. Brides section with smaller numbers present at the Rhymney and Taff/Ely sections.

At the Taff/Ely site, although many sectors were used by feeding birds, highest activity was on those sectors around the periphery of the bay (Figure 3.4.5). Feeding Teal restricted themselves to the edge of the river at the Rhymney site (Figure 3.4.6) and were therefore found only on those sectors that bordered the river. No Teal were present at the Orchard Ledges site.

At the Taff/Ely site, the number of Teal increased as the high tide receded, as birds left their roosts either in the saltmarsh or on the open water (Figure 3.4.7a). With the approach of low tide, more birds took to the open water, again reducing the

number of birds counted. One other factor that was likely to affect the counts was that Teal were observed to roost on the east bank of the River Taff, on sector 13. As the river level dropped, birds could move out of view as they moved down the bank into the deep channel. Although this was not apparent as the tide fell, it was noted on several occasions that Teal appeared on sector 13 as the rising water level pushed them higher up the bank into view. A similar overall pattern existed at the Rhymney site (Figure 3.4.7c) although here, a much higher proportion of the birds were included in the counts as fewer birds remained on the open water.

The low tide distribution of feeding Teal along the northwest Severn was similar to that in the winter in 1989/90 and 1990/91 but with a reduction in numbers at the Taff/Ely section.

There has been a clear shift in the pattern of feeding behaviour at the Taff/Ely site, (Figure 3.4.5). The highest concentration of feeding birds throughout the tidal cycle was found on sectors 10, 11 and 13 in 1989/90 and 1990/91. In 1991/92, very few feeding birds were present on sectors 10 and 11 and there was a reduction in usage of sector 13. Sectors 10 and 11 were adjacent to the PDR work and its inevitable disturbance. There was a notable increase in the usage on sectors at the eastern side (sectors 18 and 19) and southern end (sectors 1, 2 and 5) of the bay, the areas farthest away from the disturbance. An increase was also noted on sectors 7 and 8, further up the River Taff. Although sector 7 has been affected by disturbance from the PDR work, the Teal feeding there were located at the northern part of the sector, away from the PDR work.

No birds were found on the Orchard Ledges site during the winter period. The pattern of feeding at the Rhymney site was very similar to that found in 1989/90, although almost no feeding birds were recorded in 1990/91. The actual usage was, however low for both years when they were recorded.

There has been an increase in the number of birds recorded on the sectors of the Taff/Ely site since the first study in 1989/90. Counts of Teal numbers made as part of an observation of roosting behaviour (Toomer & Clark, 1992) found the total population of this species in the bay to be approximately 150-200. This was less than the figure quoted in the previous report where up to 500 birds were counted on the open water in the middle of the winter period. This large number of Teal was, however, exceptional and may have been the result of the adverse weather during the winter of 1990/91.

The number of birds recorded at the Rhymney site (Figure 3.4.7c) was similar to that found in 1990/91. If the disturbance at the Taff/Ely site was causing the Teal to move elsewhere, an increase in the number of birds might have been expected at the Rhymney site. This had not occurred. However, as the birds counted on the mudflats were only a part of the whole population within the area, care must be taken in any interpretation. The proportion of feeding Teal at the Rhymney site has increased since the previous winter.

A Comparison of the Three Winters

There has been a change in the feeding pattern of Teal at the Taff/Ely and Rhymney sites over the three winters of the study. The usage for each sector at the Taff/Ely site in 1991/92 shows a lack of correlation with either of the two previous winters (Figure 3.4.8a and b; Table 3.1), with the differences between 1991/92 and 1989/90 being more marked. The data for 1990/91 and 1989/90 show a strong correlation. This suggests a shift in the feeding distribution at this site, particularly in 1991/92. The main change is a reduced use of the sectors at the north end of the bay, near the development work, during the current winter. It must be stressed that the birds feeding at any one time are only a small part of the whole population of Teal at the Taff/Ely site.

Comparisons for the Rhymney site show significant correlations for the usage values of each sector between 1991/92 and the two previous winters (Figure 3.4.8a and b; Table 3.2). The strongest correlation was between 1991/92 and 1989/90, suggesting that feeding distribution changes that had occurred between the first two winters may have only been a temporary shift. The sectors showing most variation were those with lower usage values and the changes are not therefore of major importance to the Teal population.

Spring 1992

Teal were found in very small numbers at the Taff/Ely site (mean count less than 3 birds). No birds were found at the Orchard Ledges site or the Rhymney site during the spring.

In summary, compared with findings for the previous year, there was a reduction in the feeding activity near to the PDR work at the Taff/Ely site, although the numbers feeding were already low. There was an increase in the feeding and roosting on the mudflats of the whole Taff/Ely site but, again, the numbers involved were low. Very little change was observed at Rhymney.

3.5 Pintail

Post-breeding male Pintail form moulting groups in mid summer and then migrate to their wintering grounds. They begin to arrive in Britain in early September. As the numbers increase, they continue to disperse to their wintering grounds. On estuaries, they feed by dabbling in the shallow water of rising or falling tide, and obtaining food items from the mud beneath.

Autumn 1991

No birds were recorded at the Taff/Ely site or Orchard Ledges site in autumn. Small numbers of birds were present at the Rhymney site (Figure 3.5.1), feeding by following the edge of the falling tide, which is characteristic for this species. Relatively little feeding occurred on the upper sectors, with most activity being confined to the sectors uncovered lower down the shore. Feeding then continued as the tide rose, with the birds following the River Rhymney onto the sectors higher up

the shore. The area west of the Cardiff Eastern Sewer was not used by Pintail during the autumn.

Numbers of birds at the Rhymney site were low during the autumn (Figure 3.5.2) with the majority of birds feeding for two hours either side of low tide.

Neither the Taff/Ely or the Orchard Ledges sites have been used by Pintail during the three autumns of this study.

There has been an increase in the number of Pintail at the Rhymney site compared with 1990 when very few birds were noted.

Winter 1991/92

Low tide counts on the northwest Severn (Figure 3.5.3) show that the Rhymney section supports a sizeable winter population, with very few birds being found on other sections.

No Pintail were recorded at the Taff/Ely or Orchard Ledges sites in autumn.

Pintail mainly feed in the shallow water at the tide edge rather than on the exposed mudflats. The Rhymney site had a large population of Pintail during the winter and many of the birds fed on a large number of sectors as the tide rose and fell (Figure 3.5.4). The majority of birds fed on the lower shore as the tide fell, with lines of birds in the shallow water of sections 9, 10, 11, 14 and 12 when these areas were exposed. Little feeding occurred over the main part of the foreshore, and feeding activity on sectors 15, and 16 was mainly confined to areas adjacent to the river Rhymney on the rising tide.

The number of feeding birds increased as the tide receded (Figure 3.5.5). Nearly all the Pintail that were included in the counts were feeding. The actual number of birds on this part of the Severn estuary was not accurately reflected by such all day counts, as at any one time a large part of the population of birds is to be found roosting offshore on open water, far enough from shore to be excluded from the counts.

Low tides counts on the northwest Severn have shown a considerable increase in feeding Pintail since 1989/90, although the increase since the previous winter counts is not so marked.

As with the present study, no birds were found on the Taff/Ely or Orchard Ledges sites in the two previous years. Although the stone-covered shore at Orchard Ledges does not seem suitable for dabbling Pintail to obtain food, it is not so clear why Pintail are never found at the Taff/Ely site. Certainly, birds feeding on similar prey items are supported in reasonable numbers, *eg* Shelduck feeding on *Hydrobia ulvae*, their main prey (Olney, 1965) although it is known that Shelduck also eat a range of other food items (Patterson, 1982).

The pattern of feeding activity of Pintail at the Rhymney site in 1991/92 was more similar to that found in 1989/90 than 1990/91, little feeding activity having been recorded in 1990/91.

More birds were present at the Rhymney site in 1991/92 than in the previous winter, and feeding continued over a larger part of the tidal cycle.

Comparison of the Three Winters

The usage for each sector at the Rhymney site for 1991/92 shows a close correlation with the two previous winters (Figure 3.5.6a and b; Table 3.2). A number of sectors were used by feeding birds in 1991/92 that were not used in either 1989/90 or 1990/91, but many of these had low usage values and therefore, this does not reflect a major change in feeding behaviour.

Spring 1992

No Pintail were found at any of the sites in spring. The majority of Pintail leave the estuaries where they overwinter by April.

In summary, compared with findings for the previous year, there had been an increase in the number of Pintail on the northwest Severn and the Rhymney site. At Rhymney, feeding occurred for longer periods through the tidal cycle.

3.6 Other Wildfowl Species

Several other species of duck were observed, but only in small numbers. During the winter, a group of Pochard (10-16 birds) roosted on the water at the north end of the bay at the Taff/Ely site. They were not observed to feed and did not go onto the mudflats of any sector. One pair of Gadwall and several Goldeneye were seen very briefly on the River Taff at the northwest corner of the bay and a single Mute Swan near the saltmarsh on one occasion.

At the Rhymney site, in the mouth of the bay, the number of Pochard increased during the winter through to February. By the middle of February, over 350 birds were roosting on the open water on some days. Only on one occasion did any of these birds feed on the edge of any of the sectors and so were normally excluded from the counts. Four Shoveler, two Goldeneye, three Scaup and several Tufted Duck were also observed within the bay during the winter, but all were on the open water.

3.7 Oystercatcher

Oystercatcher start to return to estuaries from their breeding grounds during late July and early August. Birds that winter on the estuaries in the west of Britain are those that have bred in Scotland, the Faeroes and Iceland (Dare, 1970). In areas where they are feeding on cockles and mussels, they are unlikely to be in competition with other waders as these prey items are unavailable to birds with less powerful bills. On soft substrates they also feed on polychaetes and other worms that are found in sandy and muddy substrates. At the Orchard Ledges site, both types of prey items may be taken. At the lower shore of the Rhymney site, near to the Cardiff Eastern Sewer, stony islands are exposed at low water, where there are

mussel beds and areas where the large polychaete *Nereis virens* occurs. Oystercatchers feed here, but are also found over much of the area where there is only sand and mud.

Autumn 1991

Small numbers of Oystercatchers fed on the mudflats of the Taff/Ely site (Figure 3.7.1) with most feeding occurring on sectors to the north and centre of the study site. However, the Orchard Ledges and Rhymney sites are far more important for Oystercatchers. Figure 3.7.2 shows the feeding distribution of birds at these two sites. Almost all sectors at these sites are used by feeding birds, with those sectors exposed at low tide being the most important at the Rhymney site.

There was a very distinctive pattern of use of the Taff/Ely site by Oystercatchers (Figure 3.7.3a). Birds moved into the bay approximately two hours after low tide. This coincided with nearby areas, where oystercatchers were found, becoming covered by the rising tide. Some of these birds remained in the bay to roost and did not leave until two to three hours after the high tide. Figure 3.7.3b and c show the number of birds at the Orchard Ledges and Rhymney site. At the Orchard Ledges site, Oystercatchers arrived as the tide receded and fed scattered over the two sectors, although there was a preference for the lower reaches of the shore and the sandy area at the west end of sector 1. This latter area was also used for the formation of pre-roosts before the birds left as the tide rose. Numbers remained high at the Rhymney site as the tide rose (Figure 3.7.3c). This was partly accounted for by the most easterly sector (13) holding large numbers of roosting birds near to high tide while the upper areas remained uncovered.

There have been minor changes in feeding use of sectors of the Taff/Ely site during the autumn periods of the study. The areas near the saltmarsh (sectors 11, 14) and adjacent to the River Taff within the bay (sectors 6, 12 and 17) have been used more by feeding Oystercatcher in 1991 than in 1990.

There has been an increase in feeding usage at the Orchard Ledges site compared with 1989, but this was much less than the increase found at the Rhymney site. Here, all sectors showed an increase in feeding activity, but it was greatest for the sectors lower down the shore, west of the Cardiff Eastern Sewer (sectors 5-9) and the sector at the top end of the bay by the River Rhymney (sector 16).

The number of birds at the Taff/Ely site showed an overall increase compared with 1990 while at the Orchard Ledges site the numbers were very similar to the previous autumn. There has been a clear increase in the number of birds at the Rhymney site compared with 1990. Almost twice as many were present throughout most of the tidal cycle, with more birds remaining to roost.

Winter 1991/92

Low tide counts (Figure 3.7.4) showed that the Rhymney section was the most important area for feeding Oystercatcher along the northwest Severn in 1991/92.

The Taff/Ely site (Figure 3.7.5) was used less by feeding birds during the winter period than it was in the autumn with small numbers scattered over the sectors in the

central part of the bay. There was high feeding usage at both the Orchard Ledges and Rhymney sites (Figure 3.7.6) with increased feeding on sectors west of the Cardiff Eastern Sewer at the latter site compared with autumn.

The numbers of Oystercatcher at the three sites and their pattern of feeding behaviour through the tidal cycle was very similar to that described for the autumn period (Figure 3.7.7a, b and c) with the majority of birds feeding throughout the tidal cycle.

Low tide counts on the northwest Severn during the three winters of the study show that there has been an increase in the use of the Rhymney section by feeding Oystercatchers since 1989/90.

The usage and distribution of Oystercatchers at the Taff/Ely site were similar to the previous two winters. Orchard Ledges also showed a similar pattern of usage over the three years of study. However, there had been an increased use of the Rhymney site in 1991/92 compared with the previous two years. In particular more of the sectors west of the Cardiff Eastern Sewer (sectors 1-9) were used by feeding birds as the mudflats became uncovered by the falling tide.

Figure 3.7.7a, b and c confirms that the increased usage discussed above is the result of an increase in the numbers of birds at the Rhymney site. Numbers at The Taff/Ely site and at the Orchard Ledges site have remained fairly stable over the three winters but there has been almost a three-fold increase At Rhymney.

A Comparison of the Three Winters

There has been a change in the usage by Oystercatchers at both the Taff/Ely and Rhymney sites (Figure 3.7.8a and b; Table 3.1, 3.2 and 3.3). At the Taff/Ely site, the data for 1991/92 shows a close correlation with 1990/91, but not with 1989/90. The usage values for all sectors, however, was low and the change in feeding behaviour at this site is therefore not significant when considering the whole Oystercatcher population of the three sites. The usage values for each sector at the Rhymney site for 1991/92 show a significant, but weak correlation with the values for 1989/90. There has been an increase in the use of many sectors over the three winters, with the largest change occurring between 1989/90 and 1990/91 (Table 3.2). The next year's results will show if this is a distinct trend of increased numbers of feeding birds at the Rhymney site.

Spring 1992

Most adult, breeding Oystercatcher leave their wintering grounds between late February and early April. By late April, birds remaining on the overwintering sites are non-breeding adults or juvenile birds (Prater, 1981).

Only a very small number of Oystercatcher were feeding at the Taff/Ely site in spring (Figure 3.7.9). There were almost no birds at the Orchard Ledges site in 1992 (Figure 3.7.10) while feeding Oystercatchers were widely distributed at the Rhymney site.

The population of birds remaining at the Rhymney site in spring was relatively small (Figure 3.7.11c).

The reduction in the number of birds at the Taff/Ely site was comparable with earlier findings. However, the low numbers at Orchard Ledges was in contrast with spring 1991 when usage was almost half as high as the winter values. The Rhymney site showed a slightly different pattern of usage of sectors in 1992.

The actual number of birds had increased slightly compared with the previous springs but as the number of birds was low at this time of year, it is not an important change.

In summary, compared with findings for the previous year, there was little change at the Taff/Ely site. At Rhymney, there was an overall increase in numbers and feeding usage with a greater use of sectors at the west part of the area. There were more Oystercatchers at the Orchard Ledges site during autumn and winter, but fewer during spring.

3.8 Ringed Plover

Ringed Plovers breed in Britain. The wintering population is comprised of the British breeding birds and some from northern continental Europe. During the autumn migration, birds move down the west of Britain and Ireland before becoming dispersed on their wintering grounds. Although large numbers move through the Severn estuary during autumn migration, many are on route to Africa and far fewer birds stay through the winter (Prater, 1981).

Autumn 1991

Small numbers of feeding birds were found at the Taff/Ely, Orchard Ledges and Rhymney sites in the autumn (Figures 3.8.1 and 3.8.2). At the Rhymney site, birds were only observed on sectors at the top of the shore.

The numbers of birds at each site were low (Figure 3.8.3a, b and c) and their appearance at a site during the tidal cycle was somewhat erratic.

The usage for the Taff/Ely site was comparable with the two previous autumns but there has been an increase in feeding usage at the other two sites. Counts at the Orchard Ledges site showed there to have been a marked increase on sector 1 since 1989. However, any quantitative estimates of this species have to be treated with care as the cryptic coloration of its plumage make it very difficult to observe, even on flat sand (Spearpoint *et al.*, 1988). The stony nature of the substrate of the foreshore at Orchard Ledges make accurate counts difficult unless the birds are close or moving. Even when feeding, birds stand and look for signs of invertebrate activity at the surface and then either catch a food item or move to a new observation point (Pienkowski, 1982).

Winter 1991/92

Low tide counts of feeding Ringed Plover on the northwest Severn (Figure 3.8.4) show that very few were recorded during the winter period. Only one sector at St. Brides had any feeding birds.

Few feeding birds were seen at the Taff/Ely site or the Orchard Ledges site, but at the Rhymney site, feeding Ringed Plover were seen at the uppermost part of the shore on sectors 10 and 17 on several occasions (Figure 3.8.5). The average number of birds (Figure 3.8.6c) showed as two peaks in the tidal cycle. Birds appeared on the upper reaches of sector 17 and 10 as the tide rose. They were not apparent at high tide, when the mudflats of the sectors were covered, but re-appeared as the same areas became exposed again. Almost certainly, some birds moved onto the stony beach to roost, where they would be virtually undetectable form the observation points. Such areas are outside of the counting sectors.

The low tide feeding distribution of Ringed Plover along the northwest Severn in winter 1991/92 was very similar to 1990/91 but showed a reduction compared with the winter of 1989/90 when feeding birds were recorded at the Rhymney section.

The distribution and numbers at the study sites was comparable with the previous observations in 1989/90 and 1990/91.

Spring 1992

British wintering Ringed Plovers return to their breeding territories during the second half of March and April. Migrants also pass through British estuaries during spring on their way to breeding grounds in Iceland and Greenland. Only two groups of Ringed Plover were observed during spring, a group of six birds at the Taff/Ely site and a group of ten at the Rhymney site. Both groups were seen only briefly during the tidal cycle and were not relocated.

In summary, compared with findings for the previous year, there was an increase in the number of Ringed Plover at Orchard Ledges and Rhymney in the autumn but similar numbers in the winter.

3.9 Golden Plover

These birds have not been seen at any of the sites during the previous two years study. One group flew in to roost on the central mudflats of the Taff/Ely site on one day in December. There was a thick fog covering the Severn estuary and the Golden Plover group arrived with several hundred Knot (see below). The Golden Plover flock remained for about two hours before flying off.

3.10 Grey Plover

Grey Plover return from their breeding grounds to winter in Britain from mid-August onwards. The adult breeding birds may be preceded by non-breeding adults and then followed by the current year's juveniles.

Autumn 1991

No grey plover were found at the three sites in the autumn.

Winter 1991/92

The increase in the number of feeding Grey Plover on the northwest Severn, noted in the previous report does not appear to have been maintained, (Figure 3.10.1). Compared with 1990/91, there has been a reduction in the sectors on which feeding birds were found and a reduction in the number of feeding birds, although the findings for the 1991/92 winter are still higher than 1989/90.

Too few birds were recorded at the Taff/Ely site to allow any meaningful discussion of distribution or behaviour through the tidal cycle. Two to four birds were observed on several occasions, usually located on the upper sectors of the bay, near the saltmarsh. This was a reduction on the numbers found in 1990/91, when maxima of 25 and 50 were found on different days, with an average through the tidal cycle of two to fourteen birds. Grey Plover have shown a preference for parts of the mudflats higher up the shore, near to the saltmarsh (Donald & Clark, 1991a). As it was these areas that have been subjected to most disturbance, it was possible that some of them moved to less disturbed sites.

Spring 1992

No birds were observed during the spring period.

3.11 Lapwing

Britain has a large breeding population of Lapwing, estimated as in excess of 200,000 pairs (Marchant *et al.*, 1990) From June onwards there is a partial summer migration to the west of the country with more adults than juveniles being involved, followed by a continued increase in numbers through to October as birds arrive from continental Europe and USSR. A large proportion of Lapwing overwinter inland. Even the birds found on estuaries may move inland to feed during the tidal cycle.

Autumn 1991

Lapwing were confined to the northwest sectors of the Taff/Ely site, alongside the River Taff (Figure 3.11.1). Sector 8 was the main area within this study site to be used by lapwings. No birds were found on the Orchard Ledges site (Figure 3.11.2), but a small number of feeding birds was observed on sector 16 of the Rhymney site, on the uppermost mudflats near to the east bank of the River Rhymney.

Birds were present throughout most of the tidal cycle at the Taff/Ely site (Figure 3.11.3a). Sector 8, where most birds were found in 1991, was partly a very stony area and although some birds did feed on this sector, (Figure 3.11.1) a large proportion of the flock did not.

At the Rhymney site, Lapwing arrived on the rising tide and the majority then roosted on the upper levels of the shore (Figure 3.11.3c).

Overall feeding usage at the Taff/Ely site was comparable with that found for 1990, but in the present year of study, birds were located almost entirely on the most northerly mudflat of sector 8. Sectors 7 and 10, which held many of the feeding

birds in the previous autumn, was little used. These two sectors have involved the main change to habitat and disturbance continued to be high through the autumn. The average number of Lapwing showed a slight increase over the figure for 1990 but a far smaller proportion were feeding than was observed in the previous autumn.

Winter 1991/92

The low tide distribution of feeding Lapwing on the northwest Severn (Figure 3.11.4) shows only small numbers of birds at Peterstone and Taff/Ely.

The distribution of feeding birds within the Taff/Ely site (Figure 3.11.5) was restricted to the same area as in the autumn period. Feeding birds were absent from the Orchard Ledges and Rhymney site.

At the Taff/Ely site birds arrived on the sectors at the northwest of the bay as the tide level fell and remained until the areas were again covered (Figure 3.11.6a). The birds usually flew off inland at high tide, but they have been observed to roost on the newly raised bank adjacent to the Hamadryad Hospital on a number of occasions (Toomer & Clark, 1992). A very small proportion of the flock was feeding at any one time.

There has been a marked reduction in the number of feeding Lapwing on the Severn compared with 1990/91 with no birds on St. Brides which held the largest numbers the previous year.

At the Taff/Ely site, apart from less use of sector 7, the distribution was very similar to 1990/91, but showed a reduction compared with the winter of 1989/90. The number of birds was similar to the previous winter. Lapwing no longer roosted in the saltmarsh at the north of the bay as they had in the previous winter.

Spring 1992

No Lapwing were recorded at any of the sites in the spring.

In summary, compared with findings for the previous year, there had been a change in the distribution of Lapwing at the Taff/Ely site. The birds had moved from areas that had been subjected to change or disturbance to nearby alternative areas.

3.12 Knot

The Taff/Ely site has held reasonably high numbers of Knot in past years, with average peak winter counts of 2,000 being recorded between 1980-1984 (BoEE counts). During the three years of the present study, Knot have been observed only infrequently at this site.

Autumn 1991

No birds were recorded during the autumn period.

Winter 1991/92

The whole Severn estuary holds nationally important numbers of Knot (Table 1.2). The low tide distribution of feeding Knot on the northwest Severn (Figure 3.12.1) shows only limited numbers. These groups were found on the Peterstone and St. Brides sections. Numbers were comparable with 1990/91.

The Taff/Ely estuary has held fewer birds in recent years and the mean peak winter count given in Table 1.1 results from large numbers in 1987, no birds having been recorded by the BoEE counts in the following years. The average feeding usage at the Taff/Ely sector (Figure 3.12.2) was the result of one flock of 320 birds that arrived on the central sections one day and remained for several hours. It is known that Knot are very mobile and readily move between estuaries to exploit local and temporary food reserves (Stanley, 1971; Dugan, 1981). Only single birds were observed at the Rhymney site on several occasions. No birds were observed at the Orchard Ledges site.

Spring 1992

No birds were observed during the spring at any of the sites.

3.13 Dunlin

The Dunlin that winter in Britain are mostly of the race *alpina*, which breed in northern Scandinavia and Russia. The other two races that are found in Britain, *schinzii* and *arctica*, winter chiefly in north and west Africa, may be found in reasonable numbers during autumn and spring migration. A few birds of both these races are known to winter with the large numbers of the *alpina* race on the Severn (Clark, 1983). Estuaries in the southwest of Britain may receive their main influx of wintering birds in November, after they have completed their moult at the Wash and the Wadden Sea.

Autumn 1991

At the Taff/Ely site Dunlin used most of the sectors within the bay, as they followed the line of the falling tide to feed at the water's edge (Figure 3.13.1). They were absent from the innermost sectors of the bay, sectors 7-9 and 15 and 19. Small numbers of birds fed on the sandier/muddier areas of the Orchard Ledges site (Figure 3.13.2). At the Rhymney site, all sectors east of the River Rhymney were used extensively by feeding birds.

Most Dunlin were feeding throughout the tidal cycle at the Taff/Ely site (Figure 3.13.3a). Numbers increased as the tide fell, as birds left their roost within Cardiff Bay or flew in from roosts elsewhere. They followed the receding tide line and then left the bay to feed at other sites at low water. At the Rhymney site (Figure 3.13.3.c), birds increased in number as the tide fell, peaking before the time of low tide and remaining high until the tide started to rise again.

The distribution of feeding Dunlin at the Taff/Ely site was similar to the previous autumn. At the Rhymney site, however, comparison with 1990 suggests a very marked change in the feeding behaviour at this site. The main reason for this,

however, was the timing of the autumn counts (see methods for explanation). In 1990, the counts were carried out in August and September. The main birds at each site would be passage migrants. In the current study, counts were made in September and October, where the later counts would be increased by some returning wintering birds.

The numbers of birds at each site (Figures 3.13.3a, b and c) reinforce this, with approximately ten times as many birds at the Rhymney site in 1991 compared with 1990.

Winter 1991/92

Figure 3.13.4 shows the distribution of feeding Dunlin obtained from low tide counts on the northwest Severn. High numbers of feeding birds were found from St. Brides along to Rhymney with lower numbers at the Taff/Ely section.

The feeding usage at the Taff/Ely site (Figure 3.13.5) shows that birds were distributed throughout the area feeding on almost all sectors. The PDR work and the Phase I development at the north of the bay do not appear to have had a noticeable effect on the feeding distribution of the Dunlin within the bay. This may be because of their habit of following the receding tide as they feed and therefore not remaining on any one sector for long.

Small numbers of feeding birds were found on both sectors of the Orchard Ledges site (Figure 3.13.6). On sector 1, the main feeding activity was at the extreme west end, where soft sand and mud was exposed during the period of low tide. On sector 2, the Dunlin were found at the eastern end near the upper shore, where again, soft sand/mud was present. At the Rhymney site, feeding Dunlin were found over most of the area. Very large flocks were present at times. These were very mobile, forming large groups on the water's edge and then flying parallel to the shore, east and/or west as the receding tide uncovered different areas of mud. Over the period of the winter months, the distribution was fairly even, although the daily pattern of feeding on the different sectors varied.

The pattern of occurrence of Dunlin through the tidal cycle in winter was similar to that found in autumn (Figure 3.13.7a, b and c). There were two peaks in numbers at the Taff/Ely site, about two hours before and two hours after high tide. The birds left their roost (within or outside of the bay) and fed on the mudflats as the water uncovered them. At both high tide and low tide, large numbers of the birds may leave the bay. At low tide they moved to alternative feeding areas and have been observed to fly eastwards out of the bay, towards Orchard Ledges and Rhymney. The behaviour of the Dunlin, although establishing a definite pattern around the tidal cycle and over the winter, was often unpredictable. On some days, large numbers of birds (2,500-3,000 birds) roosted within the bay and fed on the mudflats whilst on other days there were almost no birds within the bay.

At Orchard Ledges, peak numbers occurred at low tide and the birds then left as they were pushed off of the shore by the rising water at about three hours after low tide. At the Rhymney site Dunlin flew from their roosts, from the east and the west, onto the mud as it became uncovered and then continued feeding throughout most of the

tidal cycle. The behaviour and movements within these two sites followed an established pattern, unlike the situation at the Taff/Ely site.

The low tide feeding distribution of Dunlin along the northwest Severn was very similar to the two previous years.

The distribution of feeding birds at the Taff/Ely site was very similar to that found in 1990/91 with only minor variations. There appears to have been a more noticeable change from 1989/90 to 1990/91, when there was a reduction in the feeding usage within the bay. At the Orchard Ledges and Rhymney sites, the level of usage was comparable with 1990/91.

There has been an increase in the number of Dunlin at all three sites over the three year period of study.

A Comparison of the Three Winters

The average number of bird hours per tidal cycle for each sector in 1991/92 was closely correlated to that for the previous winter (Figure 3.13.8b; Table 3.1 and 3.2), but there was a much weaker, though still significant correlation with data for the 1989/90 winter (Figure 3.13.8a; Table 3.1 and 3.2). This strongly suggests that there was a shift in the usage by Dunlin of many sectors between the first and the last two winters of study. These shifts were most pronounced on the areas that had lower usage values and thus these changes are unlikely to have a major effect on the distribution of Dunlin as a whole.

Spring 1992

Dunlin wintering in western Britain start to leave their wintering grounds for spring staging posts as early as late February. The spring counts were carried out in late April and early May. Most birds seen on estuaries at this time are likely to be migrants of the races *schinzii* or *arctica* returning from their wintering grounds in Africa to breeding grounds in Britain, Iceland and Greenland. All of the Dunlin observed at this time were in fresh breeding plumage.

Few feeding Dunlin were observed at the Taff/Ely site in spring (Figure 3.13.9). These were observed at the north end of the site near to the saltmarsh on sector 11 on rising tides. Small flocks of feeding birds were also observed at the Rhymney site, but were absent from the Orchard Ledges site during spring (Figure 3.13.10). At Rhymney, the birds followed the rising or falling tide, mainly on the sectors east of the Cardiff Eastern Sewer. Figure 3.13.11 shows that the number of birds involved at both sites was small. At the Taff/Ely site, birds present on the falling tide were roosting, but any flocks that returned with the rising tide fed on the mudflats.

These results were comparable with the findings for the two previous years.

In summary, compared with findings for the previous year, there had been little change in distribution or numbers of Dunlin at the three sites.

3.14 Bar-tailed Godwit

Low tide counts of feeding birds on the northwest Severn (Figure 3.14.1) found a few birds at Rhymney and St. Brides only.

During the all day counts, Bar-tailed Godwit were seen during autumn and winter at the Taff/Ely sites. The feeding usage for the Taff/ely site is shown in Figure 3.14.2. The small number of birds were found feeding over a large area of the bay. At the Rhymney site, (Figure 3.14.3) feeding birds were found east and west of the River Rhymney, with the highest number occurring on sector 1. The actual number of birds was low, (Figure 3.14.4a, b and c) with the maximum flock at the Taff/Ely site on any one sector being 14 and at Rhymney on any one sector being 16 birds.

No birds were observed during the spring.

3.15 Curlew

Large numbers of Curlew breed in Britain. They start to move to their wintering grounds in late June and July.

Autumn 1991

The distribution of feeding Curlew at the Taff/Ely site (Figure 3.15.1) shows that birds were widely distributed over the central and eastern sectors of the site with the largest concentration of birds in the centre of the bay. The distribution of feeding Curlew at the Orchard Ledges site and the Rhymney site (Figure 3.15.2) shows that the birds are widely dispersed throughout these areas. At Rhymney, more feeding activity occurred along the lower reaches of the shore.

At the Taff/Ely site the numbers of Curlew decreased as the tide fell and birds left the site to feed on adjacent areas, and then increased again as the tide rose to cover the feeding areas outside of the site (Figure 3.15.3a). Returning birds formed pre-roosts as the rising tide pushed them further up the shore. The numbers on the mudflats peaked at three hours after low tide and then decreased as the birds moved onto the saltmarsh at the north of the bay, where they were not counted. The peak average count was approximately 150 birds. Curlew moved to the Orchard Ledges site (Figure 3.15.3b) as the falling tide uncovered the shore. Almost all birds were feeding throughout the time that they remained on this area. At the Rhymney site (Figure 3.15.3c) Curlew were present through the tidal cycle, with no clear peaks in numbers. Feeding continued for three hours either side of high tide.

The feeding distribution at the Taff/Ely and Orchard Ledges sites was very similar to that found in 1990 but all day counts at the Rhymney site showed a changed pattern (Figure 3.15.2). All sectors other than those highest up the shore showed an increase in use by the feeding Curlew, this being particularly noticeable on sectors 7, 8 and 9.

At the Taff/Ely site, the pattern of feeding through the tidal cycle was similar to that found in the previous year but with increased numbers.

The number of Curlew at the Orchard Ledges site was comparable with that found in the previous year. The overall pattern of feeding and roosting of Curlew through the tidal cycle at the Rhymney site was similar to that in 1990. The actual numbers of birds were approximately twice as high as found in 1990 with most birds feeding two to three hours either side of low tide. This produces the higher usage values described earlier.

Winter 1991/92

The low tide counts on the northwest Severn (Figure 3.15.4) showed that feeding Curlew were widely distributed with Rhymney and the eastern end of the Peterstone section holding the highest concentrations.

All day counts for the Taff/Ely site (Figure 3.15.5) showed a similar distribution to that described for autumn, with birds favouring the central areas. Figure 3.15.6 shows high usage of the western sectors of both the Orchard Ledges and Rhymney sites, a shift in distribution at the latter site compared with autumn.

The number of Curlew at the Taff/Ely site (Figure 3.15.7a) was lower than in the autumn although the pattern of behaviour through the tidal cycle was very similar. The formation of a safe high tide roost island and its effect on the roosting behaviour of Curlew has been described by Toomer and Clark (1992). It was found that on high spring tides, when birds would have previously left the bay to roost, they remained to roost on the high tide roost island. The overall effect that this has on the numbers feeding and roosting throughout the range of tide heights on the mudflats will be discussed below. The pattern of feeding and roosting behaviour of the Curlew at the other two study sites was very similar to that already described for autumn (Figure 3.15.7b and c) but with fewer birds present at the Orchard Ledges site.

The low tide distribution of feeding Curlew on the northwest Severn showed an increase in the numbers of feeding birds on the sectors west of the river Rhymney, but a decrease on some sectors of the Taff/Ely area and the western-most sector of the Rhymney area compared with the previous years.

At the Taff/Ely site, all day counts showed a similar distribution of feeding birds to that found in the previous two winters. At the Rhymney site there was a higher usage of the sectors west of the River Rhymney than the previous winter. Comparison with the first report shows that usage has increased considerably since 1989/90.

The number of Curlew at the Taff/Ely site has remained fairly constant for the three years of study. There was a reduction in the numbers of birds at the Orchard Ledges site compared with 1990/91, with the peak mean reduced from over 60 to under 35 birds. The number of Curlew at the Rhymney site (Figure 3.15.7c) showed an increase since the 1990/91 study, but this was not as pronounced as the autumn increase.

A Comparison of the Three Winters

The usage for all the sectors at the Taff/Ely site in the three years of study shows a high correlation (Figures 3.15.8a and b; Table 3.1). This lack of variability between years has been observed on other estuaries (Clark *et al.*, 1990).

The Rhymney site, however, indicates that there has been some change in use by feeding Curlew. Figure 3.15.8a and b shows some increase in use of a number of sectors between 1990/91 and 1991/92. Comparing 1989/90 with 1991/92, there has been a greater increase in use of many sectors. There is a lack of correlation of the all day usage of all sectors at the Rhymney site between the winter 1989/90 and the following two winters (Table 3.2). Variation between the 1990/91 and 1991/92 winters is less pronounced and shows a weak, but significant correlation.

As part of the mitigation for changes to the saltmarsh at the northern part of Cardiff Bay by recent developments, a secure high tide roost was constructed during 1991. This provided an area free from disturbance and uncovered at the highest spring tides. It was found that Curlew made use of this as a roost on spring tides when the saltmarsh at the northern end of the bay was covered (Toomer & Clark, 1992). A study of roosting behaviour during the 1990/91 winter (Donald & Clark, 1991b) had found that prior to the construction of the high tide roost, Curlew flew out of the bay to roost when the tide was high enough to cover the normal roost area of the saltmarsh. As this was a significant change in the habits of the Curlew, the data for the numbers of birds feeding and roosting in Cardiff Bay was compared to see if the high tide roosting behaviour has had any effect on the numbers of birds in the bay at other parts of the tidal cycle. Figure 3.15.9 compares feeding numbers and roosting numbers for the three years of study. It is clear that there has been no major change in the number of birds feeding or roosting on the mudflats during the tidal cycle since 1989/91, and the changes are confined to the roosting behaviour on high spring tides. Curlew are known to be long-lived and site-faithful (Evans, 1988) and it could take time for numbers to change significantly.

Spring 1992

Curlew start to return to their breeding grounds from the middle of February onwards. Birds remaining on estuaries in late spring are likely to be first-year birds as most birds age two years or over return to the vicinity of their natal grounds to breed. No Curlew were observed at the Taff/Ely site during the spring of 1992. Small numbers of Curlew were found at the Orchard Ledges site and the Rhymney site (Figure 3.15.10). Feeding birds were mainly confined to the sectors at the Rhymney site west of the river Rhymney. This is in contrast with 1991 when birds remaining during spring were located on the Orchard Ledges site. However, the overall numbers of birds present in the springs of 1991 and 1992 were similar (Figure 3.15.11).

In summary, compared with findings for the previous year, Curlew have changed their pattern of roosting behaviour on high spring tides at the Taff/Ely site. They stayed in the bay area and utilised a newly formed roost area. At Rhymney, there were more birds with a preference for areas at the west of the study site.

3.16 Redshank

The Severn estuary is internationally important for wintering Redshank. Large numbers breed throughout Britain. Those that breed in northern parts of the country move southwards to coastal areas to winter, starting their migration in early July. Many British breeding birds winter relatively near to their breeding grounds. The British wintering population is swelled by the arrival of migrants of the Icelandic breeding population. Donald & Clark (1991a) found that the population of Redshank wintering on the study site was made up of two thirds British breeding birds and one third Icelandic breeders.

Autumn 1991

All sectors at the Taff/Ely site were used by the feeding Redshank with very little obvious preference for any part of the bay (Figure 3.16.1). Redshank were virtually absent from the Orchard Ledges site (Figure 3.16.2). At the Rhymney site feeding birds were mainly present on sectors between the two sewer pipe-lines.

At both the Taff/Ely and Rhymney sites the majority of the birds were feeding for four to five hours before and after low tide (Figure 3.16.3a and c). The population at both sites remains in the same area to roost at high tide. There were relatively high numbers of birds at both the Taff/Ely and Rhymney sites during the early autumn. This is characteristic of many estuaries as the birds present may represent the whole of the British breeding population and a large part of the Icelandic breeding population (Prater, 1981).

At the Taff/Ely site, the general level of usage was comparable with the previous year's study. More specifically, sectors 7-10 show a reduction in usage. This area was most affected by the development work. Nearby sectors, 11 and 12, appear to be unaffected and there has possibly been an increase in use by feeding birds.

A similar pattern to the previous autumn of usage by feeding birds was found at the Rhymney site. In 1990 and 1991 most feeding birds were found on sectors 14, 15 and 16 and to a lesser extent sectors 10 and 11, where the birds fed along the edge of the river.

There has been a slight increase in the number of birds at both the Taff/Ely and Rhymney sites compared with 1990.

Winter 1991/92

The low tide feeding counts on the northwest Severn (Figure 3.16.4) show the largest concentrations of birds to be on the Rhymney and Taff/Ely sectors.

All day counts at the Taff/Ely site (Figure 3.16.5) showed a widespread use of areas throughout the bay. Almost all sectors were used by feeding birds during the tidal cycle. As the birds left their roost to feed, they spread out over the mudflats within the bay, giving the even pattern of usage for most sectors. This pattern of behaviour of spreading out over suitable habitat and then feeding singly or in small dispersed flocks is characteristic of Redshank (Goss-Custard, 1970). No birds were found at the Orchard Ledges site during the winter period. There was a widespread use of the

mudflats of all sectors at the Rhymney site (Figure 3.16.6). Sectors at the western end of this site were all found to be used by feeding birds at some time. The greatest use by feeding birds was of sector 14. Redshank would frequently return to this area after having spread out over the whole site as the tide fell. The raised mud close to the River Rhymney and near the border of sector 11 was a favoured area.

At the Taff/Ely site the population of Redshank observed at roost was frequently larger than the total number of birds counted in the bay during the tidal cycle (Figure 3.16.7a). This reflects the difficulty in counting birds on such mudflats. The numerous small gullies can hide feeding birds. This probably also accounts for the fall in numbers around low tide, as the Redshank do not leave the bay. At the Rhymney site (Figure 3.16.7c), as the tide fell, there was a rapid increase in the number of Redshank on the mudflats which was then maintained until the birds resumed roosting over the high tide period. The formation of pre-roosts was observed on a number of occasions. Preferred areas were on the west bank of the River Rhymney on the edge of sector 10 and 16, where the birds were out of sight from the observation points. The majority of the birds were feeding throughout the tidal cycle.

The low tide distribution of Redshank on the northwest Severn showed a similar distribution to the previous two winters, although there has been a reduction in the number of birds found.

The feeding distribution at the Taff/Ely site was similar to the previous two winters and there appears to have been little if any reduction in the use of those sectors most affected by the development work (sectors 7, 10 and 11). At the Rhymney site there was a more extensive use by feeding Redshank than was observed in the previous winters.

The number of Redshank at the Taff/Ely site has been fairly consistent for the three winters. In contrast, there has been an increase in the population of birds at the Rhymney site compared with the two previous winters.

A Comparison of the Three Winters

There is a close correlation between the three winters for feeding usage at the Taff/Ely site (Figure 3.16.8a and b), showing that the sectors used and the number of birds has remained steady. The correlation coefficients obtained by comparing the three years (Table 3.1) confirms this. The comparison of the results for the Rhymney site shows that there has been a changed pattern of feeding distribution over the three years, with different sectors becoming more, or less, important for feeding birds. The overall correlation between the years, however, is still significant (Table 3.2 - where $P < 0.001$ for all three comparisons).

Spring 1992

Redshank may start to leave for their breeding grounds as early as late January. By April, most of the British breeding birds will be at their breeding sites.

All day counts found few Redshank during the spring. Small numbers were observed feeding on sectors at the north of the bay at the Taff/Ely site (Figures 3.16.9 and 3.16.10). No birds were observed at the Orchard Ledges site or the Rhymney site.

In summary, compared with findings for the previous year, Redshank altered their feeding behaviour in the autumn at the Taff/Ely site. Sectors near to the PDR work were used less. This change was not continued into the winter. At the Rhymney site, there was a slight increase in numbers and a more extensive use of the sectors.

3.17 Turnstone

Turnstone do not breed in Britain. The wintering population breed in Canada and Greenland. Some first year birds may remain through the summer after the breeding adults have left.

Autumn 1991

The largest population of Turnstone at the three sites was found on the stony shore of the Orchard Ledges site where the terrain is most suitable for feeding, but there were small populations at the other two sites at various times. At this time of the year, the Turnstone populations may be swelled by migrants on route to their wintering grounds in West Africa (Branson *et al.*, 1978). All day counts for the Taff/Ely site (Figure 3.17.1) show that Turnstone were only found feeding at sector 3, where there is a rocky edge to the road at shore level. At the Orchard Ledges site (Figure 3.17.2) feeding birds were present on both sectors. A small number of feeding birds were found on the higher parts of the shore at the Rhymney site, on sector 16.

The Turnstone at the Taff/Ely site either fed or roosted from high tide up to about three hours before low tide, when they left the bay (Figure 3.17.3a). Observations at Orchard Ledges as the tide receded showed that Turnstone frequently arrived from a westward direction, including flocks flying out of Cardiff Bay. Birds were also observed to return there when the shore of the Orchard ledges site became covered by the rising tide. The number of birds at the Orchard Ledges site is shown in Figure 3.17.3. Birds arrived on the upper shore as it began to be uncovered by the falling tide and then spread out over the exposed stony areas, feeding all the time. The numbers of Turnstone at the Rhymney site were low during the 1991 autumn. Birds were observed on the upper reaches of the shore immediately after high tide and again before the next high tide, being absent at other times.

At the Taff/Ely site, sector 3 has held feeding birds during the three autumn periods of the study. Sector 7, which had feeding birds in 1990, has been subjected to considerable change and no feeding birds were found in 1991.

There has been a slight shift in the pattern of usage at the Orchard Ledges site in 1991, with more feeding birds on sector 2 than on sector 1, the reverse of the situation found in 1990.

The number of Turnstone at the Taff/Ely site was slightly lower than the previous autumn, but the pattern of behaviour remains the same. At the Orchard Ledges site, the number of Turnstone was comparable with that for 1990.

The pattern of behaviour of Turnstone at the Rhymney site was a marked contrast to that found the previous autumn. In 1990, Turnstone were present two to three hours either side of low tide unlike the situation observed in 1991 when birds were only present for about two hours either side of high tide.

Winter 1991/92

Feeding Turnstone were only found in two areas on the northwest Severn during low tide feeding counts (Figure 3.17.4). Both of these areas were part of the Rhymney section and the distribution is most likely directly related to the limited availability of suitable feeding habitat.

At the Taff/Ely site, (Figure 3.17.5) feeding Turnstone were present on two sectors. Turnstone were not observed very frequently, occasionally roosting groups were located higher up on the sloping concrete edge of the road by sector 3 where they were not included in counts. The usage of sector 18 was mainly due to the observation of one group. The feeding usage at the Orchard Ledges and Rhymney sites (Figure 3.17.6) was very similar to that described for autumn. At the Rhymney site, the most significant difference during the winter periods compared with autumn was that feeding Turnstone were found on the extreme upper reaches of sector 17 and 15 as well as 16. The main concentration of feeding Turnstone was around the stony area adjacent to the disused wooden jetty.

The Taff/Ely site held very few birds during the current winter (Figure 3.17.7a). Turnstone that entered the bay often did so to roost and were then located higher up on the concrete edge of sector 3 where they were not included in the counts. The pattern of behaviour through the tidal cycle at Orchard Ledges and Rhymney was similar to that found in the autumn but with an increase in numbers (Figures 3.17.7b and c).

The low tide feeding distribution of Turnstone on the northwest Severn in 1991/92 was similar to the previous two winters.

At the Taff/Ely site the usage showed a reduction compared with 1990/91 unlike the other two sites where the usage is comparable to the previous two winters. The change at the Taff/Ely site was reflected in the low number of birds observed. The numbers for the other two sites were similar to those for 1990/91. There were apparently fewer birds at the Orchard Ledges site in 1989. The difficulty in counting this cryptic species at stony sites such as Orchard Ledges means that too much significance should not be attached to the variation.

Spring 1992

No observations were made of Turnstone at the Taff/Ely or Rhymney sites during the spring. Feeding birds were present on sector 1 only at the Orchard Ledges site (Figure 3.17.8). The average number of approximately 20 birds (Figure 3.17.9b) is similar to that found in 1991. Most of these birds are non-breeding birds that have not migrated.

In summary, compared with findings the previous year, there was a changed feeding pattern at Rhymney, with Turnstone feeding shortly before and after high tide only. There were only minor changes at the other sites.

3.18 Other Wader Species

Snipe had previously been observed in the saltmarsh at the north end of the Taff/Ely site (Toomer & Clark, 1992). On one occasion, when the small section of saltmarsh at the north corner of sector 3 was being observed as it became completely covered by the rising tide, 28 Snipe were observed to fly out. (Two Water Rail were seen at the same time.) Although Snipe were clearly present in the bay, they were never seen on any of the sectors as they are confined to the saltmarsh within the Taff/Ely site.

Black-tailed Godwit winter in Britain and Ireland, with a winter population of over 10,000 birds. Only small numbers winter on the northwest Severn. No birds were seen during the autumn or spring observations at any site. During the winter, a maximum of five birds were seen at the Rhymney site and two birds were seen on one occasion at the Taff/Ely site.

Whimbrel do not winter in Britain, but pass through in quite large numbers during autumn and spring migration. No birds were seen during the autumn, but up to six birds were present at the Taff/Ely site in late April and early May. One bird was seen at the Rhymney site in May.

4. DISCUSSION AND CONCLUSIONS

This is now the third year of intensive monitoring of the waterfowl populations of the northwest Severn in relation to the proposed Cardiff Bay Barrage. An overall picture has emerged of the status of the bird populations. The developments that have so far taken place within Cardiff Bay as a result of PDR work and Phase I Development work, although relatively minor compared with the longer term plans for the bay, have had some effect on the bird populations.

The effects of the development work on the species of birds that are found within the Taff/Ely estuary and adjacent areas are discussed below with emphasis given to the most important species.

There has been an increase in the number of Shelduck at the Rhymney site compared with 1990/91. Clark (1989) judged the Rhymney site to be the second most important area on the Severn for Shelduck. In both autumn and winter, more birds were present, especially on areas east of the River Rhymney. This area was used by feeding Shelduck, with large numbers also roosting on the eastern most part of the area. Large numbers of birds are found each winter on areas just east of the study site and the increase on the Rhymney site could have resulted from a minor change in feeding and roosting behaviour.

The Rhymney site clearly supports this increased number of birds at present but it is not possible to determine what effect a further increase would have on the competition for food. Birds that would be displaced from Cardiff Bay with the building of the barrage may move to nearby sites initially and the extra competition could put pressure on the existing populations at those sites. Although the wintering densities of many coastal birds have been shown to be directly related to prey density (Goss-Custard *et al.*, 1977), it is not easy to determine how many birds an area could support simply by measuring the abundance of food present, as the relationships over a winter period are complex (Goss-Custard & Charman, 1976). It is not known if areas such as the Rhymney site could accommodate a further influx of birds.

The Shelduck population at the Taff/Ely site has remained fairly stable for the three years. Numbers of birds and their feeding behaviour have shown only a slight shift, with areas at the north end of the bay being used more by feeding birds. This area, adjacent to the saltmarsh, is not very far away from the current disturbance but so far this has had limited effect on the Shelduck population.

Areas just outside of Cardiff Bay, at the Orchard Ledges site, have begun to be used by feeding Shelduck during the last two winters. This is a recent change, with very few birds using this area prior to 1990 (Clark 1989; 1990; Evans *et al.*, 1990). The area concerned is on the east side of the Rivers Taff and Ely where they emerge from the bay. This area is different from most of the rest of the Orchard Ledges site in having a muddy substrate. It only becomes available to feeding birds at low tide and so is not available for most of the tidal cycle. Its value, after the building of the barrage, is therefore not certain.

Only a small part of the Mallard population within the Taff/Ely site actively use the mudflats for feeding or roosting, most birds being found on the open water. There has been some change in the feeding behaviour over the study period, with a decrease in 1991/92 but the number of birds involved is low. There has been an increased use of the Rhymney site by

feeding Mallard, but again the numbers of birds are low. This is probably one of the few birds at the three study sites that could remain unaffected by the building of a barrage, because of its tolerance of a wide range of environmental conditions and its wide range of feeding methods and food items. Also, this is the most numerous duck in Britain and Ireland (Lack, 1986), so any reduction in population at this site would have little national impact.

The population of Teal found at the Taff/Ely site remain there from autumn until their departure in early spring. Much of their daytime is spent roosting on the water, with only small numbers feeding. This underestimates the importance of the area, as much of the Teal's activity is nocturnal (Clark *et al.*, 1990). There has been a reduction in the use of those mudflats that are immediately adjacent to the work on the PDR and the Phase I development at the northwest corner of the study area, with a corresponding increase in the number of birds found in other parts of the bay. There has been an increase in the number of birds roosting and feeding on the mudflats within the bay, but this still only represents a small part of the total population that is found there. Because of this, it is difficult to assess the effects of further disturbance from the PDR work or the Phase II development work.

There has been little change in the numbers of Teal or their behaviour at the Rhymney site, with only small numbers of birds using the mudflats.

Although there has been an increase in the number of Pintail on the northwest Severn including the Rhymney study site, this species has not moved into the Taff/Ely site. The Rhymney area has been the main area used by wintering Pintail on the Severn (Clark, 1990). Any changes within the bay at the present time are therefore unlikely to affect this species directly.

The Oystercatcher population on the Severn estuary is small in national terms. Of the three study sites, the Taff/Ely site is used the least. Feeding birds were found scattered over the Orchard Ledges and Rhymney sites. The numbers at the latter site were quite variable, with a sizeable population being present at times during the winter. Oystercatchers have been shown to fill up the most preferred sites first with food availability being one of the most important factors (Evans & Dugan, 1984) and it must be assumed that the distribution of this species within the three areas is related to this habitat quality. There has been an increase in use of the Rhymney site for feeding during the autumn and winter periods since the first year of study. Only small numbers of birds are usually found at the Taff/Ely site and there has been little change in the size of this population or in its behaviour during the study period.

There has been an increase in the numbers of Ringed Plover at both the Orchard Ledges and Rhymney site for the autumn and winter periods since 1989. The Severn estuary is nationally important for this species (Kirby *et al.*, 1991). Although this species is probably under-recorded at the Orchard Ledges and Rhymney sites because of its cryptic colouration and behaviour (Spearpoint *et al.*, 1988) the numbers found there represent approximately 7% of the Severn population. Few birds were found within Cardiff Bay, and then only sporadically.

The Lapwing that use the Taff/Ely site have altered their behaviour in response to the changes at the northwest part of the bay. During the autumn and winter 1991/92 they were found to have moved from their usual area, where there had been considerable environmental change (PDR bank work), to nearby areas with less disturbance. The substrate of the new

areas was much stonier and the birds were observed to feed less. In the previous two years, Lapwing feeding in the bay roosted in the saltmarsh at high tide when the mudflats were covered. Their preferred area of saltmarsh has been subject to disturbance and change and during the current year of study the Lapwing usually flew northwards inland to roost outside the study area.

The Severn estuary holds internationally important populations of Dunlin (Table 1.2), with about one third of these being found on the northwest Severn. All three sites have shown some increase in numbers since 1989. The BoEE counts, which includes roosting birds, show that the Taff/Ely site holds nationally important numbers of Dunlin in winter (Table 1.1). Flocks of well over 2,500 Dunlin may feed on the mudflats of the Taff/Ely site for limited periods of time, although the mean winter number of feeding birds found was approximately 700. The distribution of these birds within the bay has shown little change during the three year period. The development work at the northwest of the bay has not had a major effect on the numbers of birds or on their feeding behaviour. What effect further work in this area will have on the Dunlin in the future is difficult to assess, as their feeding behaviour means that they do not remain near to the high water areas, but move lower down the shore with the falling tide. On occasions when Dunlin roost in the bay they may use the saltmarsh areas near to the continuing development work and further reduction of these areas will affect their roosting behaviour. This has been more fully discussed elsewhere (Toomer & Clark, 1992).

The Dunlin populations at the other two sites have been fairly stable over the three years, with only minor changes of the feeding pattern within each study area.

Nationally important numbers of Curlew are found in the Severn estuary during the winter period. Only a small proportion of these is found at the Taff/Ely site. These birds, however, are extremely site-faithful (Evans, 1988) and feed and roost within the bay when possible. The result of building a secure high tide roost island at the northeast of the bay has already been discussed in this report and elsewhere (Toomer & Clark, 1992). This island has resulted in the biggest change in the behaviour of the Curlew. The changes to the habitat at the northwest of the bay have had little noticeable effect on the Curlew population. The bulk of the population feed on central and eastern parts of the bay and it is only when roosting that the birds may be pushed towards disturbed areas. Over the last three years, the birds have preferred more northeasterly areas in which to form pre-roosts and eventually roosts. With the provision of the high tide roost island, Curlew are unlikely to be effected much by the continued work on the PDR or the Phase II development in the immediate future.

There have been statistically significant changes in the feeding distribution of the Curlew population at the Rhymney site since 1989, the largest changes having occurred between 1989/90 and 1990/91. Overall, there are more birds feeding on the mudflats, with an increased preference for the areas of the west part of the study site. It is not known if this is a long or short term change.

The Severn estuary is internationally important for wintering Redshank. The three years study has shown that the Redshank population at the Taff/Ely site is stable. Colour ringing and colour marking of birds during the winter of 1990/91 (Donald & Clark, 1991a) showed the birds that are found in the bay during the winter period are site faithful, feeding and roosting within the same site. Similar studies for the winter of 1991/92 are described and

discussed in the second part of this report. It confirms that there is only limited movement between the Taff/Ely and other feeding or roosting sites. Because of this, the Taff/Ely site assumes a greater importance for this species. Within the bay, areas near to the major work that was taking place were used less for feeding during the autumn than in previous years. Daytime work on the PDR and the Phase I Reclamation was producing considerable disturbance. This effect was not apparent for the winter period, although there had been a change to some of the areas used by Redshank. The nature of the disturbance had changed, and the birds again used parts of these mudflats for feeding.

This species has also benefited from the provision of the secure high tide roost island. Areas of saltmarsh that were important for roosting on high spring tides have been destroyed or altered. The population within the bay roost on the artificial island when other available areas of saltmarsh are covered by the high tide (Toomer & Clark, 1992).

The population of Redshank at the Rhymney site showed a more extensive use of some of the areas of mudflats with a slightly increased winter population.

The Taff/Ely site is used primarily as a pre-roost site by some Turnstone when they are pushed off of their favoured feeding grounds at Orchard Ledges. The population has shown minor fluctuations during the three years of study. A limited amount of feeding takes place on suitable areas within the bay, but it is the Orchard Ledges site that is used most by the large proportion of birds in the area. On some days, Turnstone did not roost or feed on the edge of their usual area within the bay and it would appear that it is not an essential area. Alternative higher tide feeding and roosting areas are obviously used and some known possible sites are not part of the count area.

To summarize, so far the changes to the roosting and feeding habitats that have occurred in the Cardiff Bay area have resulted in limited change in the size and behaviour of bird populations. Habitat destruction and disturbance from the continuing PDR and Phase I development work have caused some birds to move to alternative parts of the bay where they have been able to continue to feed or roost. There has been no loss of species or pronounced reduction in the size of populations during the three years of study. Provision of the high tide roost island has compensated for the loss of saltmarsh that had been used by some roosting birds.

This third year of monitoring of the bird populations in Cardiff Bay will help us to impartially assess the effect the building of the barrage.

PART 2 : MOVEMENT STUDIES

5. INTRODUCTION

All day counts give valuable information on the number of birds of different species that are present in an estuary throughout the tidal cycle. They cannot give information about the total number of birds that are using an area, however, as the birds seen at anyone one time may not be the same as those seen earlier or later. There may or may not be significant turnover of the population of birds using a site: if there is, then the site will be important for more birds than the all day counts would suggest. Certainly waders may move on and off particular feeding areas during a tidal cycle (*eg* Evans *et al.*, 1990).

Donald & Clark (1991) carried out observations on colour-marked Redshank that had been caught at the Taff/Ely site. A review of findings by other workers is given in their report together with reasons for choosing this species and they will not be repeated here. The observations made showed that the Taff/Ely population of Redshank was a fairly discrete group that remained at the site to feed and roost, with very few birds moving out of the area to adjacent sites.

As these birds were also marked with a coloured ring, they would be identifiable in following years and could give information on site-faithfulness.

In the 1991/92 winter, a further sample of Redshanks were caught and colour-marked, this time at the Rhymney site. Observations were subsequently made at the three study sites to see if there was any movement away from the Rhymney area at any time throughout the tidal cycle or over a longer period of time.

The Taff/Ely site is important also for Dunlin during the winter. Flocks of this species appear to be far more mobile than Redshank, with birds moving in and out of the Taff/Ely site throughout the tidal cycle. The Dunlin that feed at the Rhymney site can be seen to move along the shore to different areas as the tide rises and falls. To investigate this movement further, Dunlin were caught and colour-marked at the Rhymney site and observations made over a period of two months at the three study sites.

Presence of colour-marked birds in a flock at any one site would confirm movement of birds of that species and any changes in the ratio of colour-marked birds within a population would give information about the turnover rate at that site.

6. METHODS

Early in 1991, 151 Redshank were caught at the Taff/Ely site and colour-ringed and colour-marked. Movements of these birds were described in the previous report (Donald & Clark, 1991). Although the dye would have faded within three or four months, the colour rings are permanent and could be visible if any of these birds returned to the Taff/Ely or Rhymney sites in subsequent winters.

Throughout the autumn, winter and spring of 1991/92, whenever flocks of feeding Redshank were close enough to observe carefully at either the Taff/Ely or the Rhymney site, colour-ringed birds were looked for. As colour rings are difficult to see, especially on birds that wade in soft mud, the areas where this was most practical were on the west edge of sectors 2,3,4 and 5 at the Taff/Ely site and on the west edge of sector 10 at the Rhymney site (see Figure 2.1.1). If any ringed birds were observed, the largest number of Redshank that could be seen to be with or without rings was counted and the proportion with rings calculated.

Groups of Redshank and Dunlin were caught at the end of December 1991 and at the end of January 1992. Observations of the high tide roosts of these species at the Rhymney site showed that the birds regularly moved onto areas of grass above the high tide water line near Maerdy Farm and onto a raised area east of the Ystradyfodwg Pontypridd sewer. Cannon nets were used to catch Redshank and Dunlin. On December 28th and 29th, a total of 94 Redshank, 12 of which were first-year birds, and 14 Dunlin, all of which were first-year birds, were caught for colour-marking. On January 25th and 26th a further 105 Redshank, of which 15 were first-year birds, and 225 Dunlin, of which 102 were first-year birds, were caught for colour-marking.

All of the caught birds were aged, weighed and measured and fitted with a metal ring embossed with a unique letter and a number code to allow individual identification in the event of the bird being re-caught. The birds were dye-marked with an application of Rhodamine B dye dissolved in isopropyl alcohol. Birds identified as adults were colour-marked on the breast and those identified as first-year birds were marked on the rump and undertail.

This dye produces a purple colour on the pale feathering when first applied gradually fading to a pink colour after several weeks. A well-marked bird may remain identifiable for several months. Colour marking has no adverse effect on the behaviour of the birds, or the behaviour of other birds towards them.

Unlike the situation in the previous winter when Redshank were caught in Cardiff Bay at the Taff/Ely site, it was not possible to accurately assess the total population of birds of which the colour-marked birds formed a part. The Redshank that are found within the bay area at the Rhymney site do not form such a discrete population as the Redshank at the Taff/Ely site, with the total number of birds being more variable. The size of the Dunlin population of which the colour-marked birds formed part was even more difficult to assess, as the total population that feeds along the tide edge may number several thousands on some days, but is very mobile.

For these reasons, observations made at the site within a few days of the colour-marking were used to determine the proportion of dyed and un-dyed birds that were present at the start of the study. These initial observations were made from the east side of the Rhymney

estuary, near to the place where the birds had been caught. As the water receded after high tide, the Redshank and Dunlin that have roosted in the area moved onto the exposed mud to feed. At this time they were visible from the shore and the proportion of colour-marked birds could be counted.

After each sample had been colour-marked and initial observations made, further observations were carried out regularly at both the Rhymney and Taff/Ely sites whenever flocks of birds were on sectors that made detailed observation possible. Several visits were made to the east side of the Rhymney site near to the original capture site, specifically to count marked birds that could be viewed with relative ease as they fed on mud exposed by the falling tide. On many occasions the colour-marked birds were clearly visible at a distance from the observation points, although the intensity and direction of the sun could make it impossible to detect any colour at some other times. Counts were only made of groups of birds where it was possible to see the presence and absence of colour. The number of adult and first-year marked birds and unmarked birds was noted. Several counts were made and the largest total count was used to calculate the proportion of colour-marked birds. If groups of birds were counted at more than one sector on a site or at different times of day, the highest total counts at each sector or during each period of observation were summed and the proportion of colour-marked birds calculated.

The proportion of colour-marked birds observed at the Rhymney site on each count date was compared with the proportion of colour-marked birds observed shortly after capture. This would give an indication of whether the birds were moving around the estuaries during winter. Observations of colour-marked birds at other sites, in particular, the Taff/Ely site where detailed observations were being made would give an indication of movements of these birds. If the proportion did not remain constant over a period of time at the Taff/Ely site, this would suggest more complex movements between sites.

Local observers were given details of the presence of colour-marked Redshank and Dunlin and asked to submit details of any sightings. Birdwatchers further afield also sent in useful, isolated observations.

No analysis of the racial composition of the captured birds was made this year. This had been carried out on the Redshank caught in January 1991 and the proportion of different races is reported in Donald & Clark (1991). The racial composition of the Dunlin that winter on the Severn estuary has been examined before (Clark, 1983).

7. RESULTS AND DISCUSSION

The results of the observations carried out to assess the proportion of colour-marked Redshank and Dunlin at the Taff/Ely and Rhymney sites are given in Tables 7.1 - 7.4 and Figure 7.1.

Part of the Redshank population at the Taff/Ely site was observed closely on a number of occasions from September 1991 to January 1992 and colour-rings were clearly visible on some of the birds (Table 7.1). These birds form part of the group that was caught and colour-ringed in January 1991 (Donald & Clark, 1991), when 133 adult birds were colour-ringed out of an estimated Taff/Ely population of 370 (35.9%). The observations during autumn and winter 1991/92 showed that the proportion of colour-ringed Redshank varied from 11% in September 1991 to 50% in December 1991, although the flock observed on this latter occasion was small. The mean percentage of colour-ringed birds observed was 18.5%. During January and February of 1991, shortly after the colour-ringing had taken place, the proportion observed at the Taff/Ely site varied from 27% to 39%. While this is higher than the ratios obtained the following autumn and winter, it can be seen that a large proportion of the Redshank have returned to winter at the same site. The ratio of ringed to un-ringed birds remained reasonably stable throughout the period of observation through the autumn and winter of 1991/92 reflecting little, if any, turnover of Redshank on the Taff/Ely. This was also the case in the previous year.

Two Redshank colour-ringed as part of the January/February 1991 study were among the birds caught for colour-marking at the Rhymney site at the end of December. Although a further 105 more birds were caught at the end of January, these were the only two Redshank to have been previously caught in Cardiff Bay. Together with the observations of these birds at the Taff/Ely site, this suggests that the majority of this group of Redshank are remaining site-faithful from one year to the next.

The observations of Redshank colour-marked at the Rhymney site at the end of December 1991 are given in Table 7.1. The proportion of colour-marked birds seen at this site varied from 2% to 7% (adults and first-year birds combined) during January with a maximum of 35 colour-marked birds in a flock of 770 Redshank. This flock size was near to the maximum seen at the Rhymney site but it contained only just over one third of the total of colour-marked birds. Therefore, some turnover of Redshank must have taken place shortly after colour-marking.

Redshank from this first group of colour-marked birds were observed at the Taff/Ely site early in January (Table 7.1), with between one and five being seen during the month (1-3%). They were observed on many of the sectors, showing no clear preference for any one area. Figure 7.1 shows that there was not a major difference in the proportion of colour-marked Redshank at the Rhymney and Taff/Ely sites after the first group of birds were marked. There had been movement of birds from their place of marking to the Taff/Ely site, after which time, the ratio of marked to unmarked birds remained steady. It is likely that this was because of little further interchange of the Redshank populations but this cannot be confirmed from this study.

Following the colour-marking of the second group of Redshank, the proportion of marked birds observed at the Rhymney site increased and remained fairly stable (Figure 7.1). The proportion varied from 5-13% with a maximum of 29 colour-marked Redshank being seen

(Table 7.2). This group of marked birds was from a total of 199 Redshank that were colour-marked in the two months. The proportion of marked birds at the Taff/Ely site did not increase after the second group of birds were colour-marked (Table 7.2; Figure 7.1). There appears to have been little or no further interchange between the population of Redshank at the Rhymney site and the population at the Taff/Ely site.

Although there was some initial movement of Redshank from the Rhymney site to the Taff/Ely site, the majority of birds remained in their own specific feeding areas. This agrees with the findings of other workers at other estuaries (Minton, 1975; Mackie, 1976; Symonds *et al.*, 1984).

Observation in January of Dunlin marked at the end of December produced very few sightings of colour-marked birds (Table 7.3). As has already been stated, the Dunlin population within the area near to the Rhymney site numbers several thousand birds during the winter and the original proportion of colour-marked birds was inevitably very low. With only part of this large group ever being close enough to examine carefully and only 14 birds marked initially, any sightings would seem unlikely. On two occasions two colour-marked birds were observed at the Rhymney site. One colour-marked bird was also seen in a group of 750 Dunlin at the Taff/Ely site confirming that at least some of the flocks of birds at this site are found at other times at different feeding sites.

Following the marking of a second group of Dunlin, bringing the total number of marked birds to 239, there was very little overall increase in the proportion of marked birds observed at the Rhymney site (Table 7.3). The exception was at the end of January when a total of six marked birds were seen in a group of 49 Dunlin (12%). The highest number of colour-marked birds seen was seven. After the earlier January observations, no more marked Dunlin were located at the Taff/Ely site until the second week of February, but it would have been easy to overlook such birds among the flocks on the mudflats in the centre of the site. A number of observations were then made on different days, with a maximum of four colour-marked birds being seen, once as part of a flock of 630 and once in 2480 birds. Although the numbers of marked birds are low, they compare well with the ratios observed at the Rhymney site. The Dunlin that move into the Taff/Ely site to feed must include, at least in part, birds that are found at the Rhymney site. As Dunlin frequently leave the Taff/Ely site at high tide, the later observations of increased numbers of marked birds must result from a continued interchange of birds. Other workers have also observed limited movement of Dunlin between sites when working with colour-marked birds (Pienkowski & Clark, 1979; Clark, 1983).

A number of sightings of colour-marked birds were made by other observers outside of the study sites. These are shown in Table 7.4. Dunlin were observed in flocks further east on the north shore of the Severn on several separate occasions. One bird was sighted on the southern shore of the Severn at New Passage, Avon. Clark (1990) has already shown by careful observation that flocks of Dunlin seen to leave a roost at Clevedon on the southern shore flew across the Severn estuary towards Rhymney. Further observations suggested that some Dunlin that feed at Rhymney fly across the Severn to roost.

A colour-marked Redshank was also sighted on the southern shore of the Severn at the Yeo estuary, Clevedon suggesting that there was some movement of Redshank across the Severn. A more striking observation was of a colour-marked Redshank at the River Caen in Devon, a distance of over 50 miles from the ringing area. One other sighting was in March, of a

bird at Masham, North Yorkshire. This bird had left its wintering grounds and was moving north probably to its breeding grounds.

Further observations of colour-marked Dunlin and Redshank were not attempted at the study sites in March or spring. At this time, waterfowl are starting to move to their breeding sites, reducing the numbers remaining at the estuaries. Also, the intensity of the colour-marking becomes reduced, making any quantitative estimations less valuable.

To summarize, the presence of colour rings (placed there in January, 1991) on Redshank at the Taff/Ely site during the autumn and early winter of 1991 reflects a high degree of site-fidelity. Observations of Redshank colour-marked at the end of December, 1991 show that there was some dispersion away from the site of capture. Only a small proportion of these colour-marked birds was seen at the Rhymney site and the occurrence of colour-marked birds at the Taff/Ely site confirmed that there was at least some one-way movement of birds between sites. Following the second capture and colour-marking of Redshank at the end of January, there appears to have been less dispersion of the birds, with no further increase in the number of marked birds at the Taff/Ely site. Observations of Redshank colour-marked in late January 1991 also found little evidence of movement. The movement of the December marked Redshank may well be the result of the continued spreading out of the wintering population onto their final feeding grounds.

Because of the large number of Dunlin present in the vicinity of Cardiff Bay and the relatively low numbers of birds that were caught and colour-marked, it is more difficult to draw firm conclusions. The finding of colour-marked birds at the Taff/Ely site confirms some interchange of feeding Dunlin between this and the Rhymney site. Further study of this kind is necessary to give a fuller picture of any movements of Dunlin as they feed throughout the tidal cycle.

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Species	Mean Peak Winter Count	% British Population	% European Population
Shelduck	310	0.41	0.12
Oystercatcher	34	0.01	<0.01
Lapwing	114	0.01	0.01
Ringed Plover	49	0.21	0.10
Grey Plover	16	0.08	0.01
Turnstone	67	0.15	0.10
Curlew	97	0.11	0.03
Redshank	585	0.78	0.39
Knot	201	0.09	0.06
Dunlin	4740	1.10	0.34

Table 1.1 The national and international importance of the Taff/Ely estuary for waders and Shelduck, 1987/88 to 1991/92.

Species	Mean Peak Winter Count	% British Population	% European Population
Shelduck	3149	4.19	1.25
Oystercatcher	692	0.25	0.08
Lapwing	3115	0.31	0.16
Ringed Plover	284	1.23	0.57
Grey Plover	842	4.01	0.56
Turnstone	421	0.94	0.60
Curlew	3277	3.60	0.94
Black-tailed Godwit	28	<0.01	<0.01
Bar-tailed Godwit	54	0.09	0.05
Redshank	2730	3.64	1.82
Knot	2564	1.17	0.73
Dunlin	49198	11.44	3.51

Table 1.2 The national and international importance of the Severn estuary for waders and Shelduck, 1987/88 to 1991/92.

CORRELATIONS OF BETWEEN YEAR USAGE

Taff/Ely Site

SPECIES	1989/90 v. 1990/91	1990/91 v. 1991/92	1989/90 v.1991/92
	CORRELATION COEFFICIENT	CORRELATION COEFFICIENT	CORRELATION COEFFICIENT
SHELDUCK	0.851 ***	0.853 ***	0.719 ***
TEAL	0.467 ***	0.220	-0.153
OYSTERCATCHER	-0.192	0.898 ***	-0.092
DUNLIN	0.788 ***	0.621 **	0.562 *
CURLEW	0.699 ***	0.839 ***	0.847 ***
REDSHANK	0.771 ***	0.797 ***	0.688 **

LEVEL OF SIGNIFICANCE:

*** = P<0.001
** = P<0.01
* = P<0.05

Table 3.1 Correlation values of between year usage of the Taff/Ely site by waders and wildfowl.

CORRELATIONS OF BETWEEN YEAR USAGE

Rhymney Site

SPECIES	1989/90 v. 1990/91	1990/91 v. 1991/92	1989/90 v. 1991/92
	CORRELATION COEFFICIENT	CORRELATION COEFFICIENT	CORRELATION COEFFICIENT
SHELDUCK	0.812 ***	0.938 ***	0.907 ***
TEAL	0.580 *	0.691 **	0.955 ***
PINTAIL	0.625 **	0.752 ***	0.837 ***
OYSTERCATCHER	0.572 *	0.676 **	0.490 *
DUNLIN	0.416	0.864 ***	0.348
CURLEW	0.397	0.572 *	0.106
REDSHANK	0.832 ***	0.919 ***	0.802 ***

LEVEL OF SIGNIFICANCE:

*** = P<0.001
** = P<0.01
* = P<0.05

Table 3.2 Correlation values of between year usage of the Rhymney site by waders and wildfowl.

CORRELATIONS OF BETWEEN YEAR USAGE

Taff/Ely and Rhymney Sites Combined

SPECIES	1989/90 v. 1990/91	1990/91 v. 1991/92	1989/90 v.1991/92
	CORRELATION COEFFICIENT	CORRELATION COEFFICIENT	CORRELATION COEFFICIENT
SHELDUCK	0.847 ***	0.906 ***	0.835 ***
TEAL	0.490 **	0.421 **	0.340 *
OYSTERCATCHER	0.637 ***	0.825 ***	0.617 ***
DUNLIN	0.522 ***	0.738 ***	0.419 ***
CURLEW	0.536 ***	0.767 ***	0.432 **
REDSHANK	0.846 ***	0.901 ***	0.776 ***

LEVEL OF SIGNIFICANCE:

*** = P<0.001
** = P<0.01
* = P<0.05

Table 3.3 Correlation values of between year usage of the Taff/Ely and Rhymney sites combined, by waders and wildfowl.

Date	Site	Total Birds	Numbers Colour-ringed (%)
19/9/91	Taff/Ely	91	10 (10.9)
12/11/91	Taff/Ely	19	3 (15.8)
18/11/91	Taff/Ely	21	6 (28.6)
16/12/91	Taff/Ely	10	5 (50)
19/12/91	Taff/Ely	16	4 (25)
29/1/92	Taff/Ely	54	11 (20.3)
*29/12/91	Rhymney	90	2 (2.2)

Mean percentage of colour-ringed Redshank at Taff/Ely = 18.5%

* - This group of Redshank was caught at Maerdy Farm, Rhymney as part of the colour-marking of birds for the 1991/92 observations.

Table 7.1 Numbers and proportion of Redshank colour-ringed in January 1991 and observed during Autumn and Winter 1991/92.

Date	Site	Total Birds	Numbers Marked (%)	
			Adults	First-yrs
7/1/92	Rhymney	465	26 (5.6)	2 (<1.0)
8/1/92	Rhymney	770	35 (4.6)	0
10/1/92	Taff/Ely	117	3 (2.6)	0
13/1/92	Taff/Ely	180	5 (2.8)	0
15/1/92	Rhymney	430	8 (1.8)	0
16/1/92	Rhymney	520	26 (5.0)	1 (<1.0)
17/1/92	Taff/Ely	75	1 (1.3)	0
18/1/92	Rhymney	85	4 (4.7)	2 (2.4)
19/1/92	Rhymney	385	8 (2.1)	2 (<1.0)
20/1/92	Rhymney	270	5 (1.9)	0
21/1/92	Rhymney	230	9 (3.9)	1 (<1.0)
21/1/92	Taff/Ely	49	2 (4.1)	0
29/1/92	Rhymney	75	9 (12.0)	1 (1.3)
29/1/92	Taff/Ely	188	4 (2.1)	0
30/1/92	Taff/Ely	77	1 (1.3)	0
30/1/92	Rhymney	220	29 (13.2)	2 (<1.0)
10/2/92	Taff/Ely	96	1 (1.0)	0
11/2/92	Taff/Ely	150	3 (2.0)	0
12/2/92	Taff/Ely	60	2 (3.3)	0
13/2/92	Rhymney	110	12 (10.9)	0
14/2/92	Taff/Ely	202	4 (2.0)	0
17/2/92	Rhymney	330	22 (6.7)	0
18/2/92	Rhymney	460	25 (5.4)	0
20/2/92	Rhymney	100	5 (5.0)	1 (1.0)
21/2/92	Taff/Ely	98	2 (2.0)	1 (1.0)
24/2/92	Rhymney	25	2 (8.0)	1 (4.0)

Shaded Zone = Second group of Redshank colour-marked.

Table 7.2 Numbers and proportions of colour-marked Redshank in January and February 1992.

Date	Site	Total Birds	Numbers Marked (%)	
			Adults	First-yrs
7/1/92	Rhymney	850	0	2 (<1.0)
8/1/92	Rhymney	70	0	0
9/1/92	Taff/Ely	750	0	1 (<1.0)
17/1/92	Taff/Ely	450	0	0
18/1/92	Rhymney	85	0	2 (2.4)
21/1/92	Rhymney	400	0	0
29/1/92	Rhymney	650	5 (<1.0)	2 (<1.0)
29/1/92	Taff/Ely	120	0	0
30/1/92	Taff/Ely	125	0	0
30/1/92	Rhymney	49	3 (6.1)	3 (6.1)
11/2/92	Taff/Ely	700	1 (<1.0)	0
12/2/92	Taff/Ely	720	1 (<1.0)	0
14/2/92	Taff/Ely	630	4 (<1.0)	0
17/2/92	Rhymney	1100	3 (<1.0)	1 (<1.0)
17/2/92	Taff/Ely	2480	4 (<1.0)	0

Shaded Zone = Second group of Dunlin colour-marked.

Table 7.3 Numbers and proportions of colour-marked Dunlin in January and February 1992.

Date	Species	Location	Total Birds	Numbers Marked
1/1/92	Dunlin	Cardiff Heliport.	6	1
6/2/92	Dunlin	Goldcliffe Pill, Gwent.	6000	2
13/2/92	Dunlin	St.Brides, S.Glamorgan.	4300	4
22/2/92	Dunlin	New Passage, Avon	-	1
14/1/92	Redshank	River Caen, Devon.	-	1
16/2/92	Redshank	Peterstone, S.Glamorgan.	50	6
16/2/92	Redshank	River Rhymney, Rhymney.	35	6
20/2/92	Redshank	Yeo Estuary, Clevedon, Avon	-	1
2/3/92	Redshank	Masham, North Yorks.	2	1

Table 7.4 Further sightings of colour-marked Redshank and Dunlin in 1992.

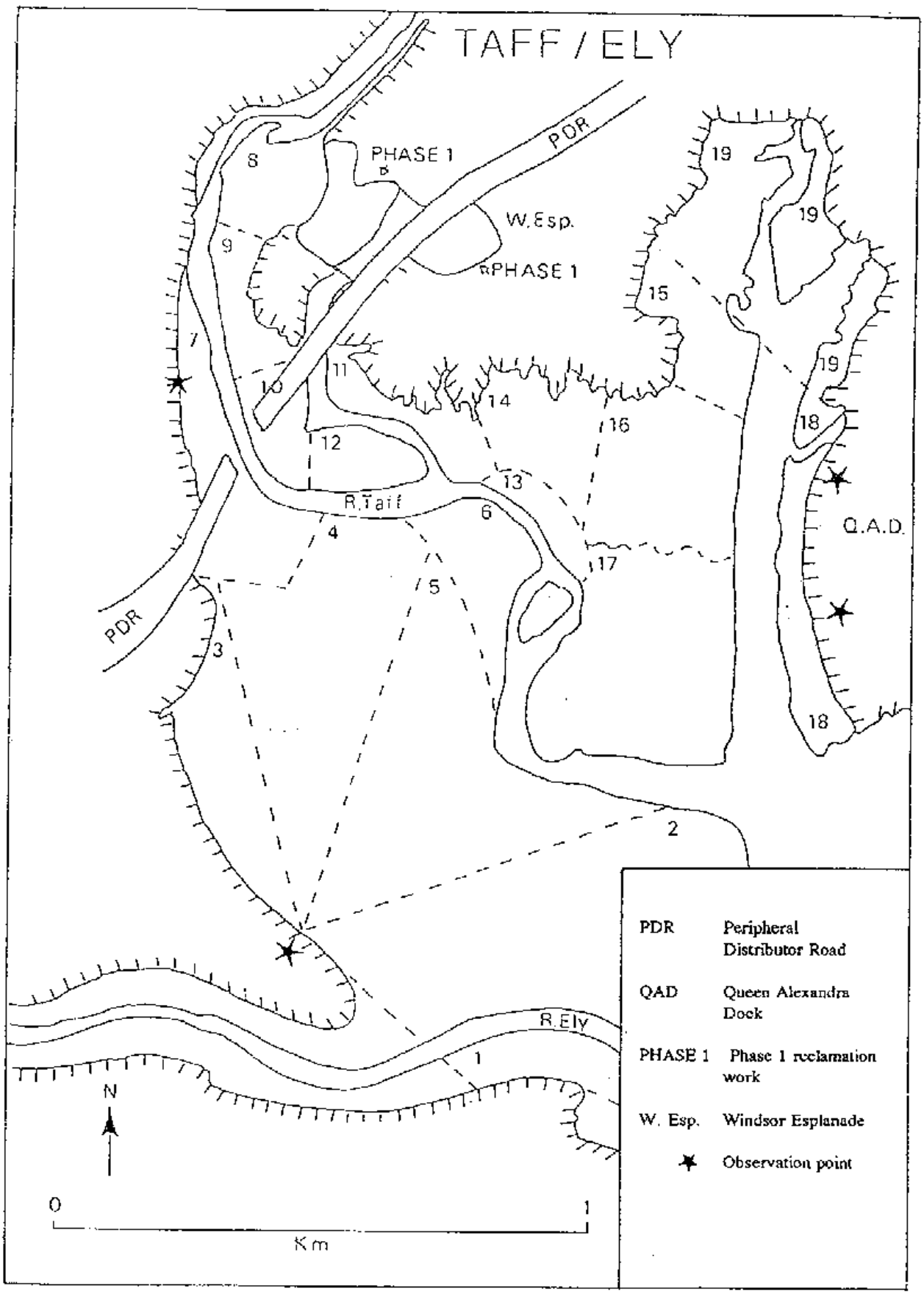


Figure 2.1.1 The Taff/Ely study site showing the intertidal count areas numbered. Observation points are marked with an asterisk.

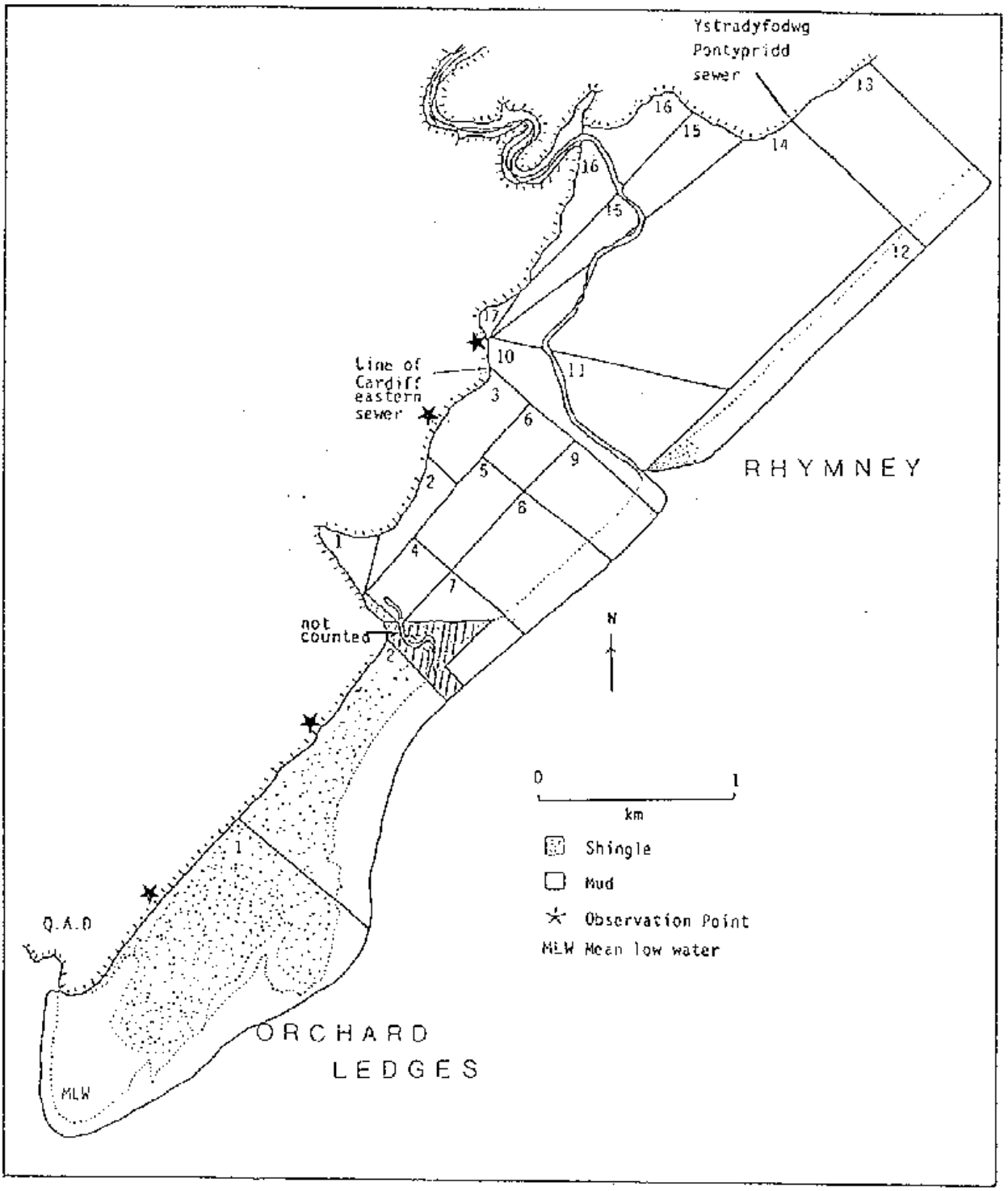


Figure 2.1.2 The Rhymney and Orchard Ledges study site showing the intertidal count areas numbered. Observation points are marked with an asterisk.

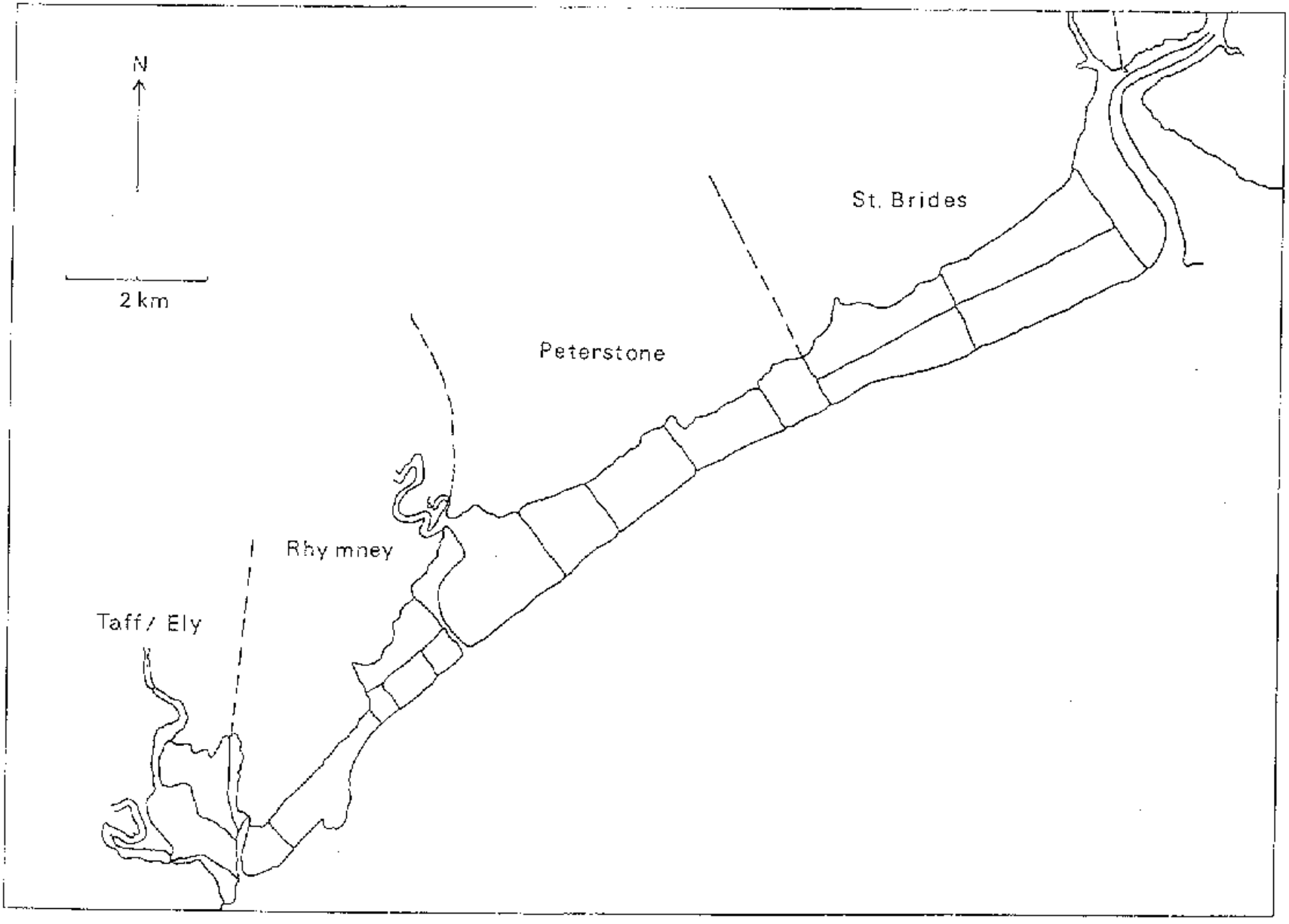


Figure 2.2.1 The breakdown of low tide count areas on the northwest Severn.

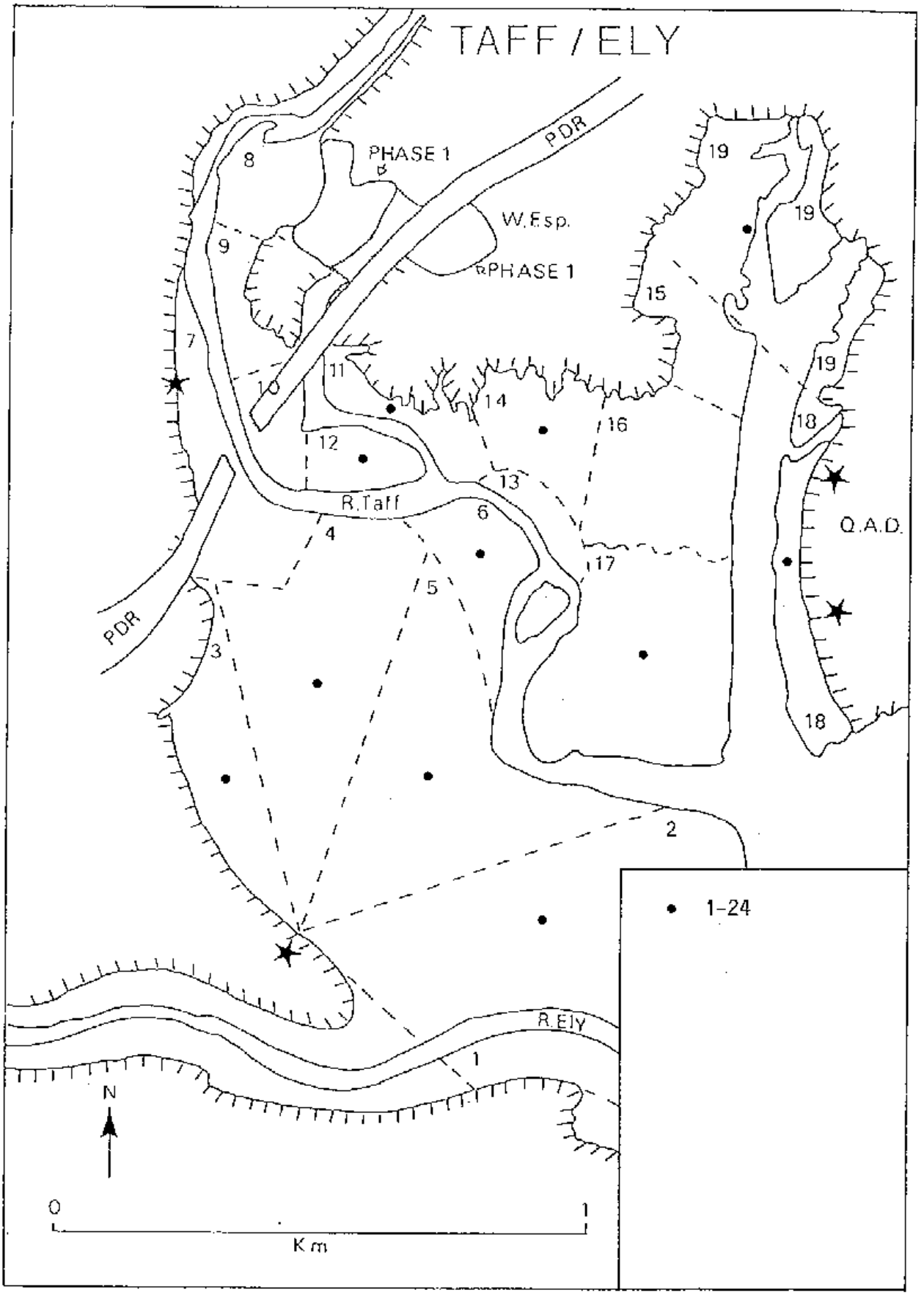


Figure 3.1.1 The distribution of feeding Shelduck on the Taff/Ely all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

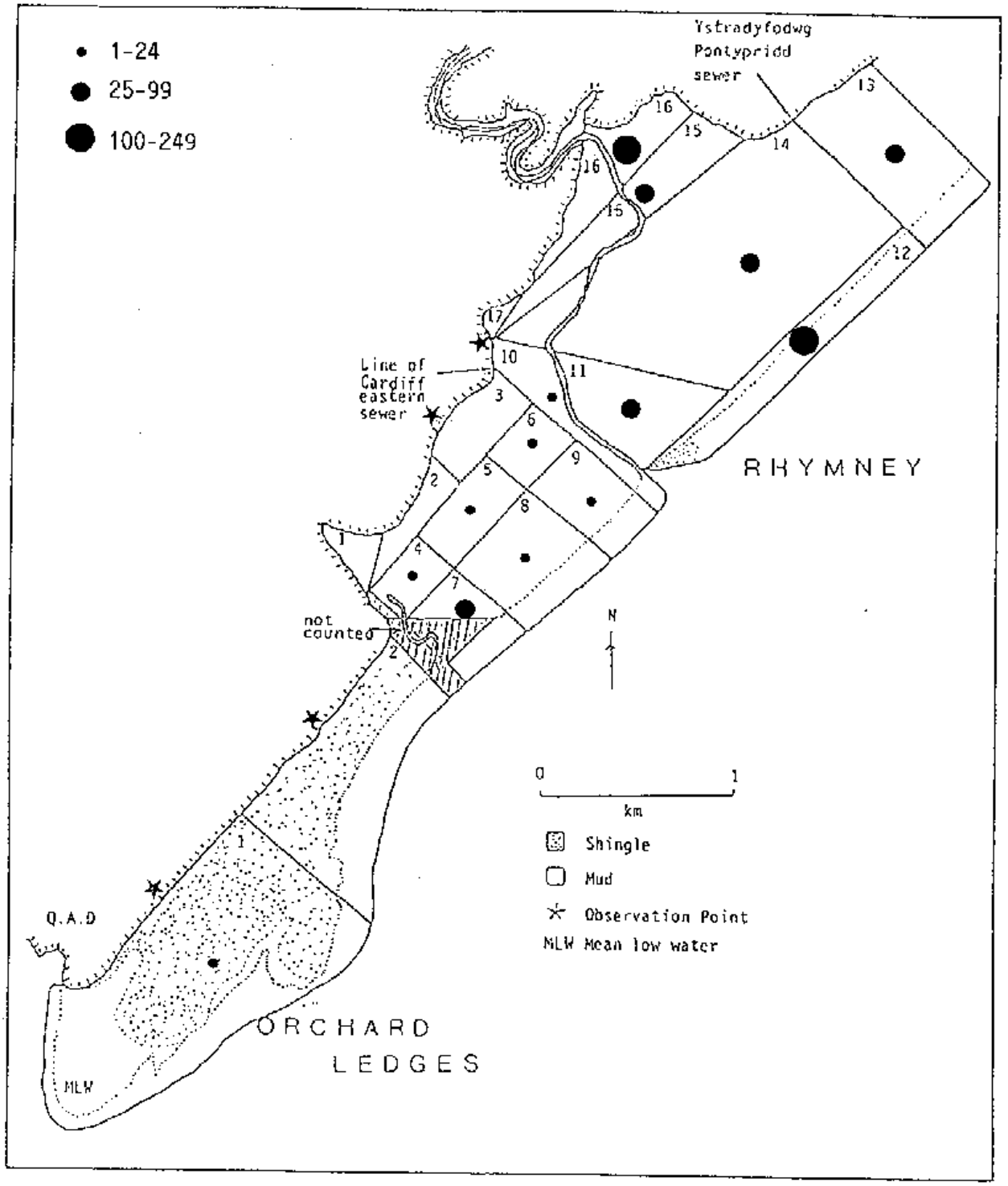


Figure 3.1.2 The distribution of feeding Shelduck on the Rhymney and Orchard Ledges all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

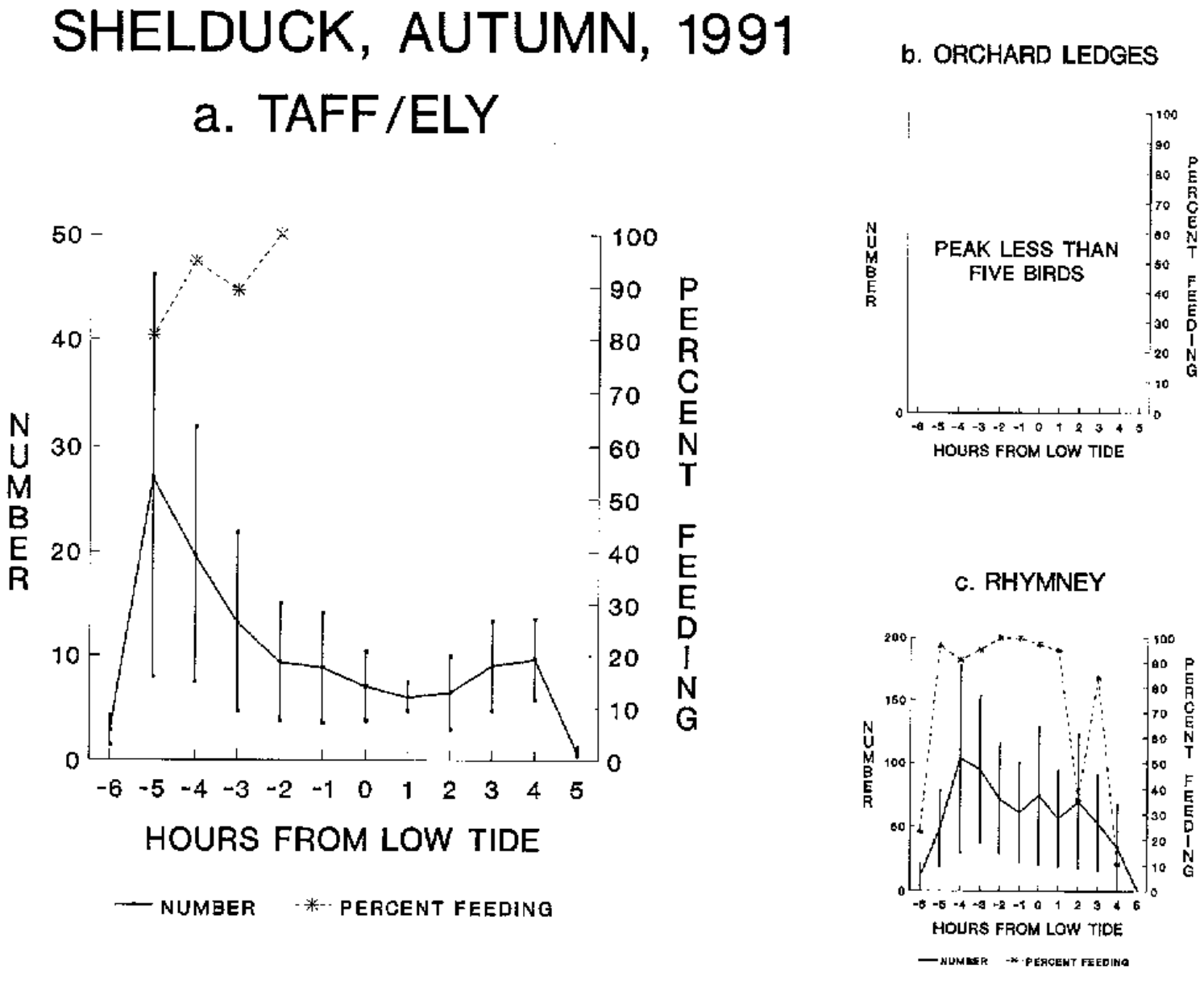


Figure 3.1.3 The total number of Shelduck present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during autumn 1991.

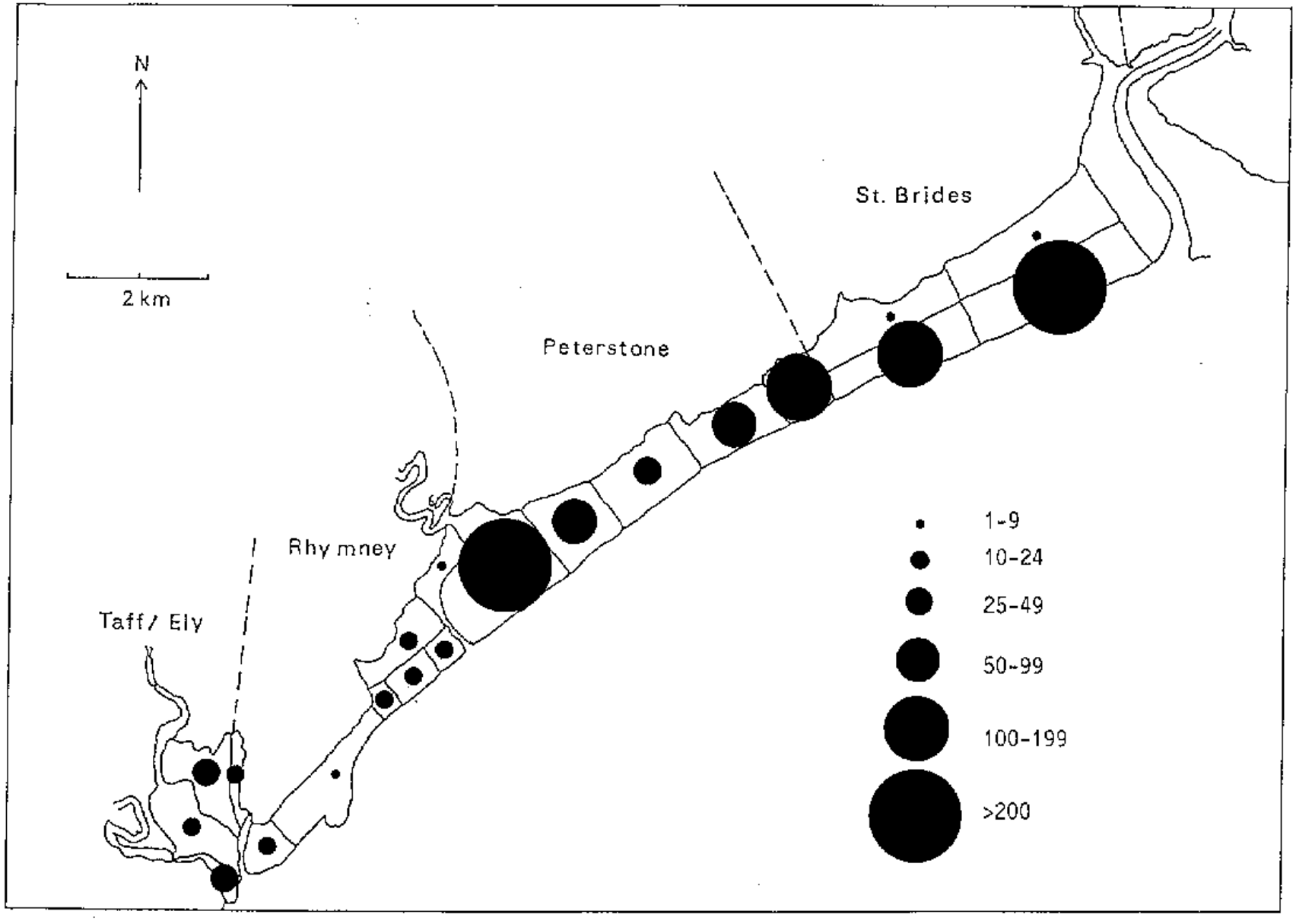


Figure 3.1.4 The low tide distribution of feeding Shelduck on the northwest Severn during winter 1991/92.

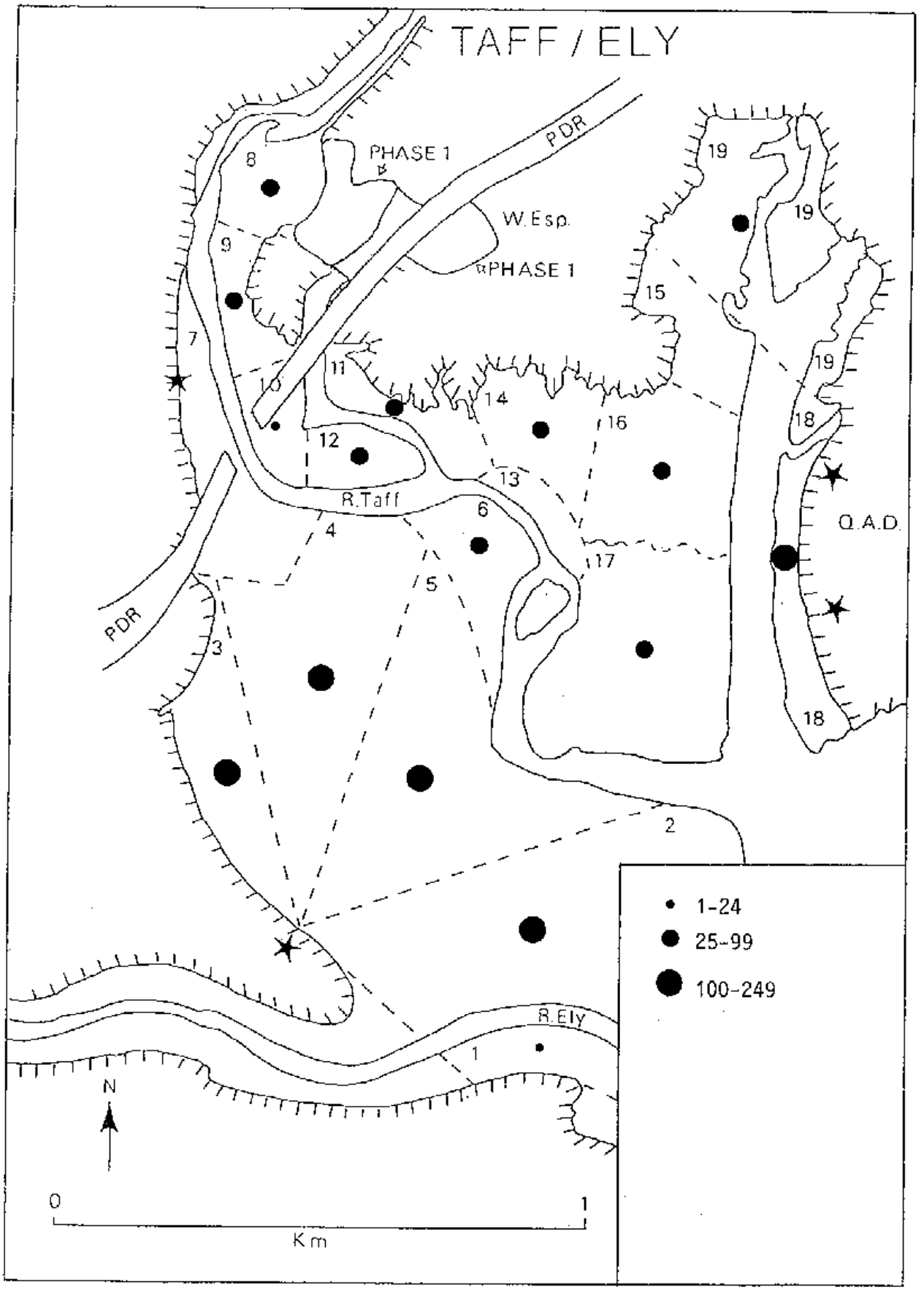


Figure 3.1.5 The distribution of feeding Shelduck on the Taff/Ely all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

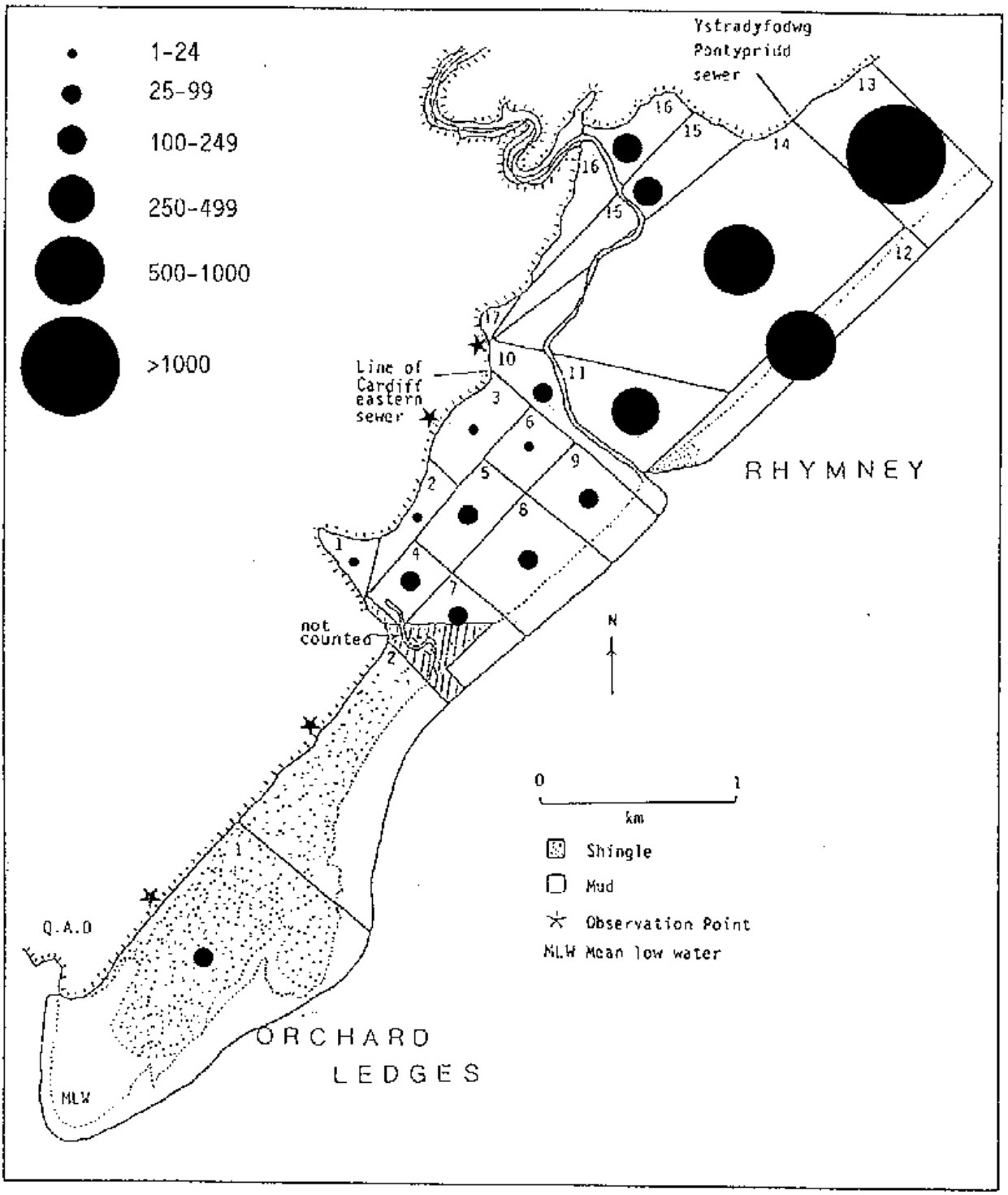


Figure 3.1.6 The distribution of feeding Shelduck on the Rhymney and Orchard Ledges all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

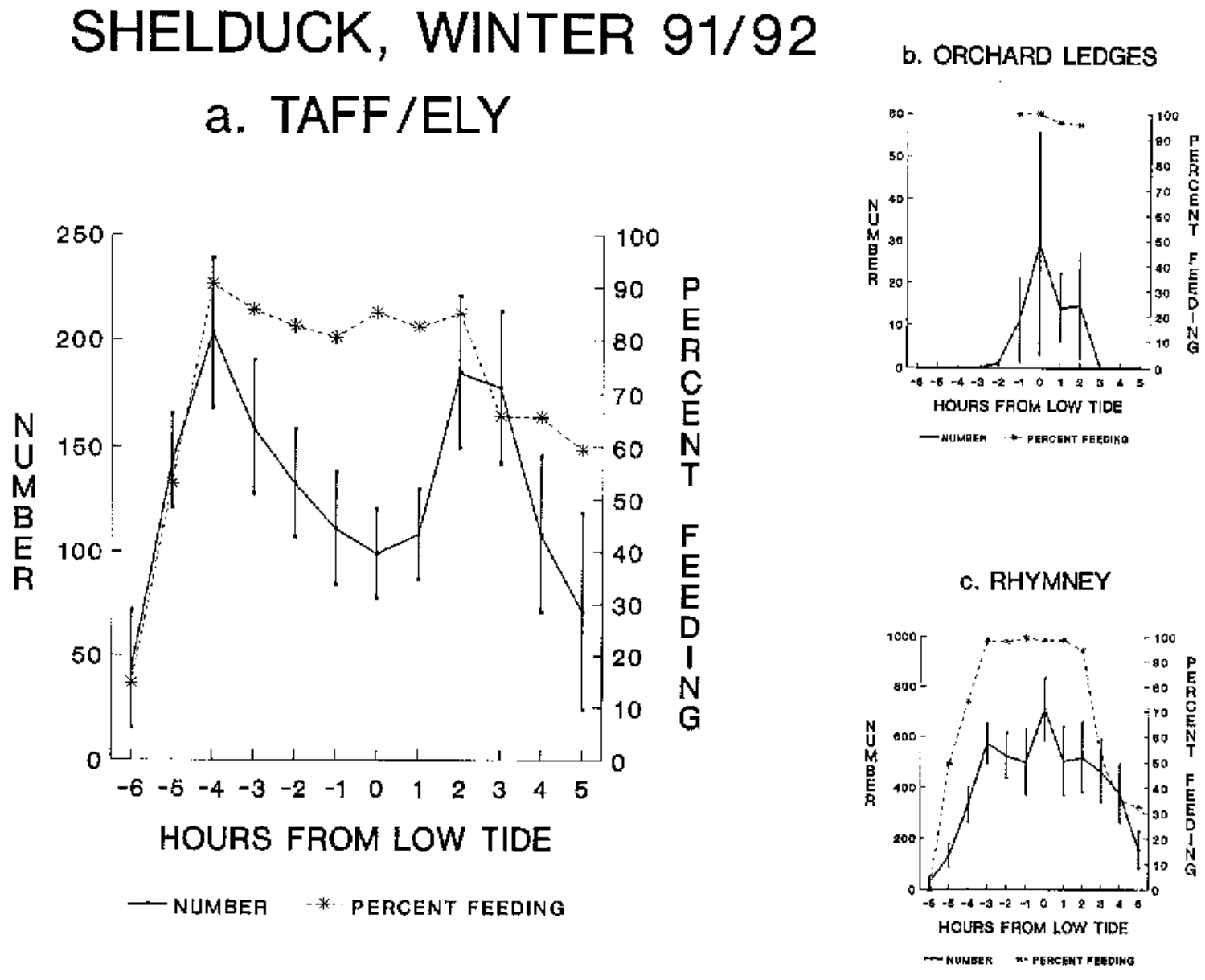
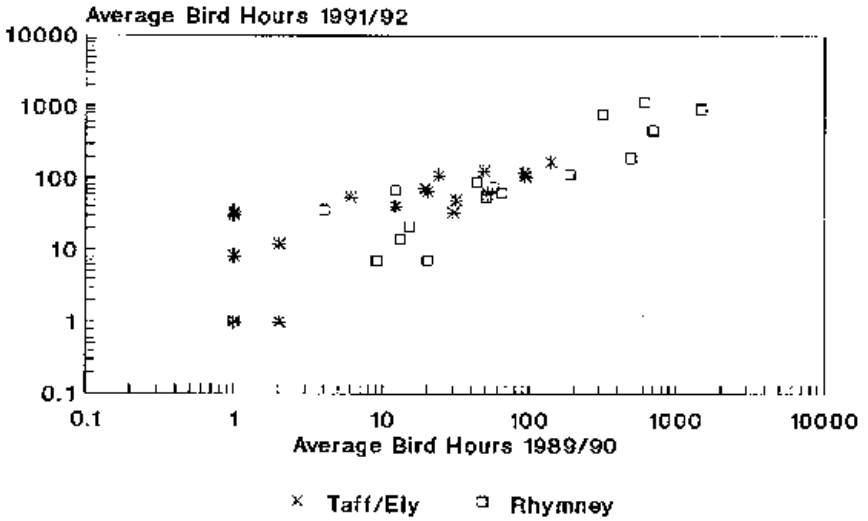


Figure 3.1.7 The total number of Shelduck present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during winter 1991/92.

SHELDUCK, WINTER

a. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1989/90 and 1991/92.



b. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1990/91 and 1991/92.

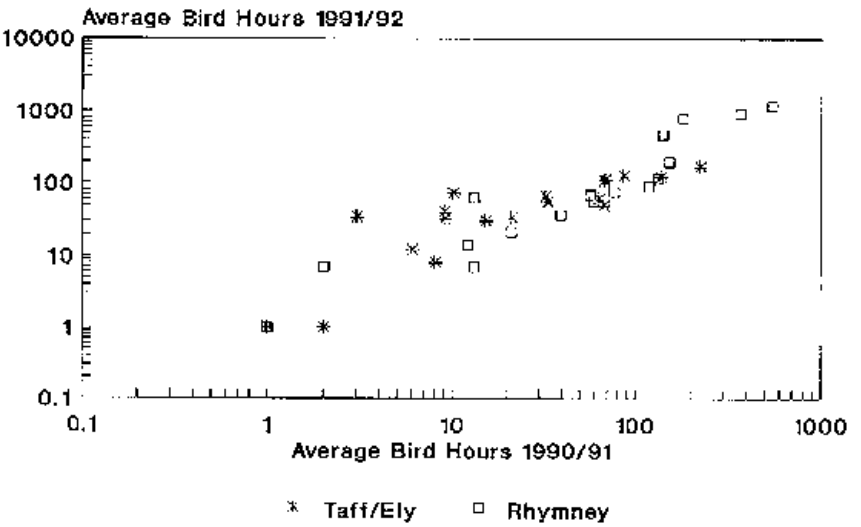


Figure 3.1.8 A comparison of usage values for Shelduck between winter 1989/90 and winter 1991/92 and between winter 1990/91 and winter 1991/92.

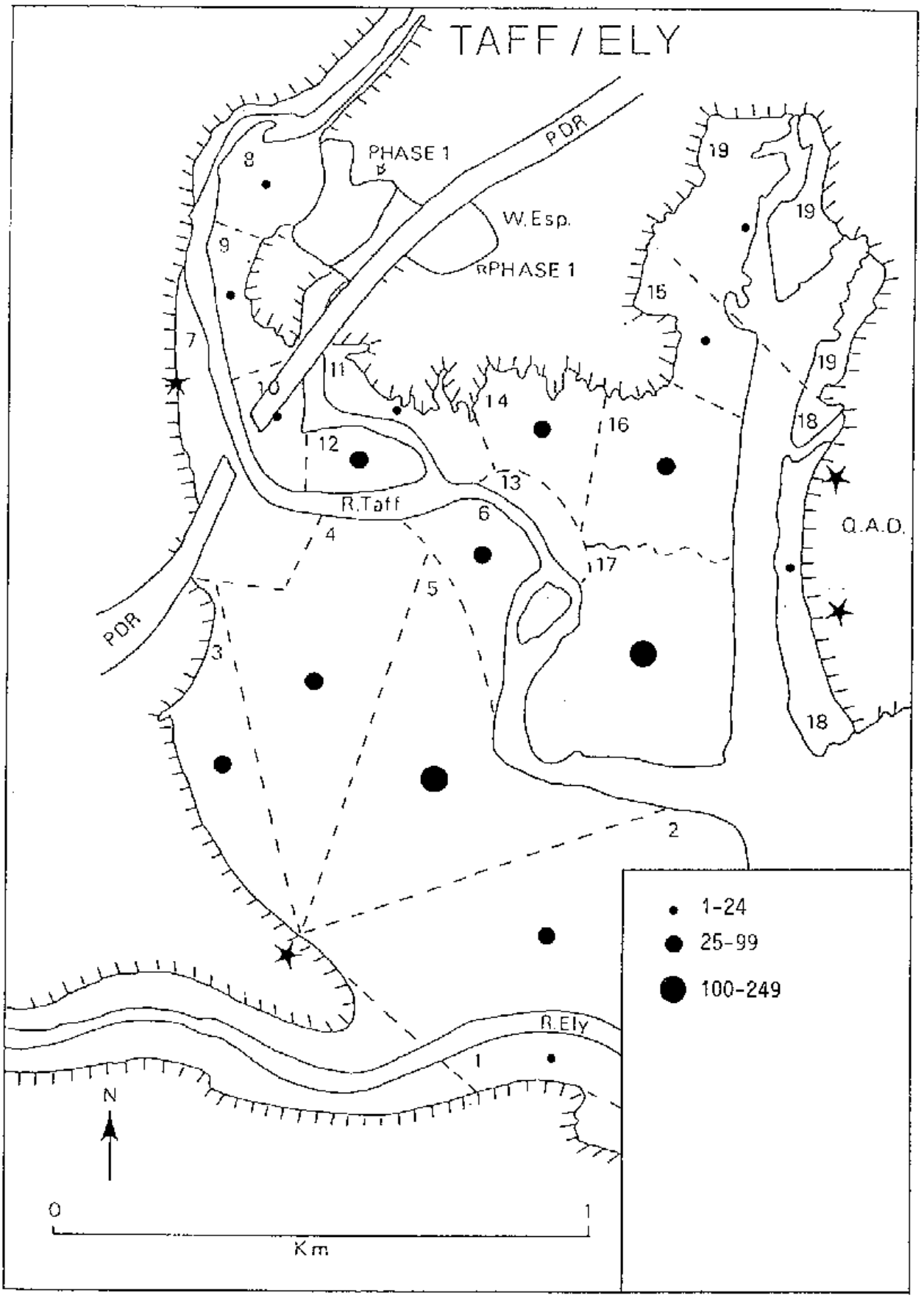


Figure 3.1.9 The distribution of feeding Shelduck on the Taff/Ely all day site during the spring 1992. The average number of bird hours per tidal cycle is depicted.

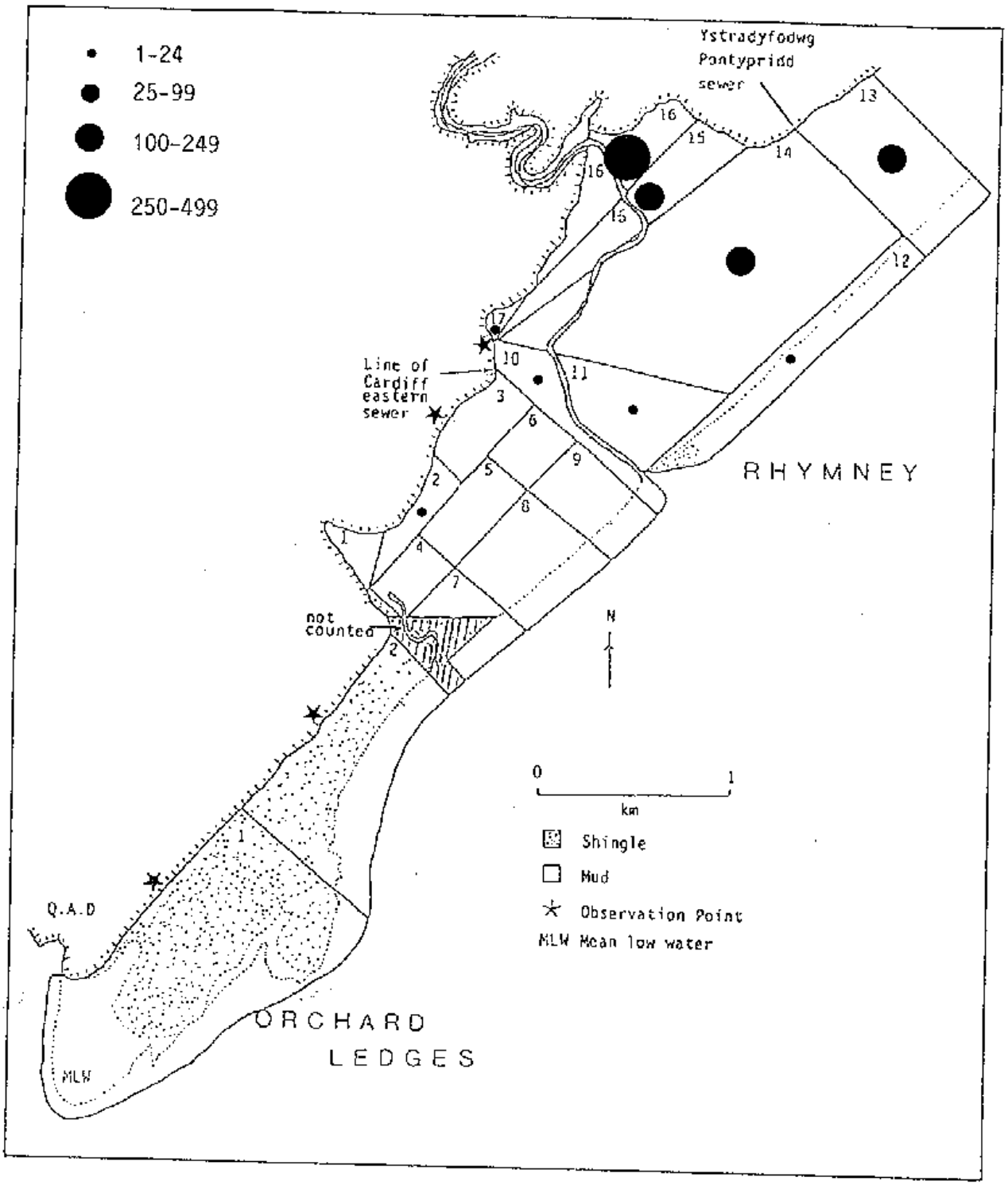


Figure 3.1.10 The distribution of feeding Shelduck on the Rhymney and Orchard Ledges all day site during the spring 1992. The average number of bird hours per tidal cycle is depicted.

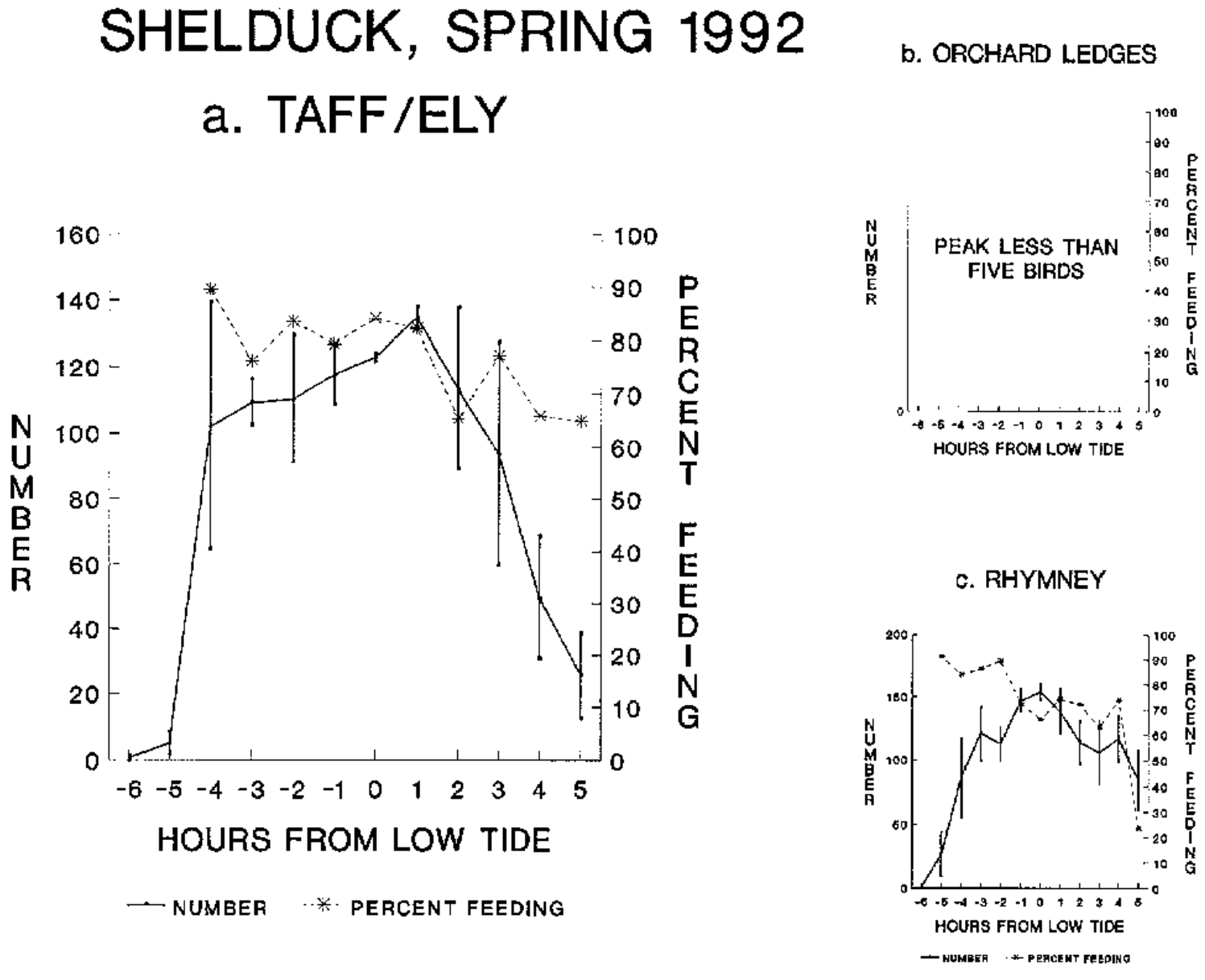


Figure 3.1.11 The total number of Shelduck present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during spring 1992.

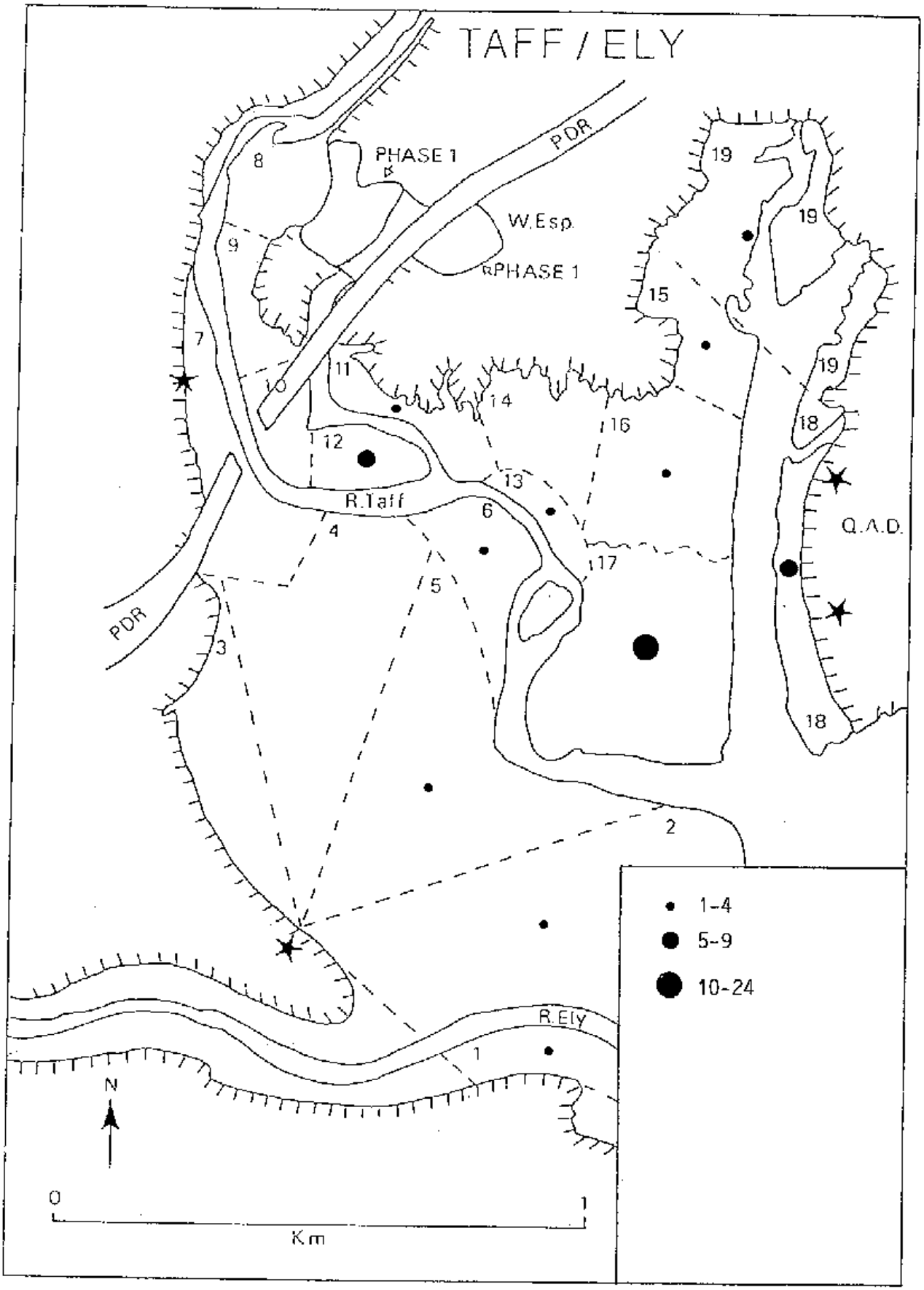


Figure 3.3.1 The distribution of feeding Mallard on the Taff/Ely all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

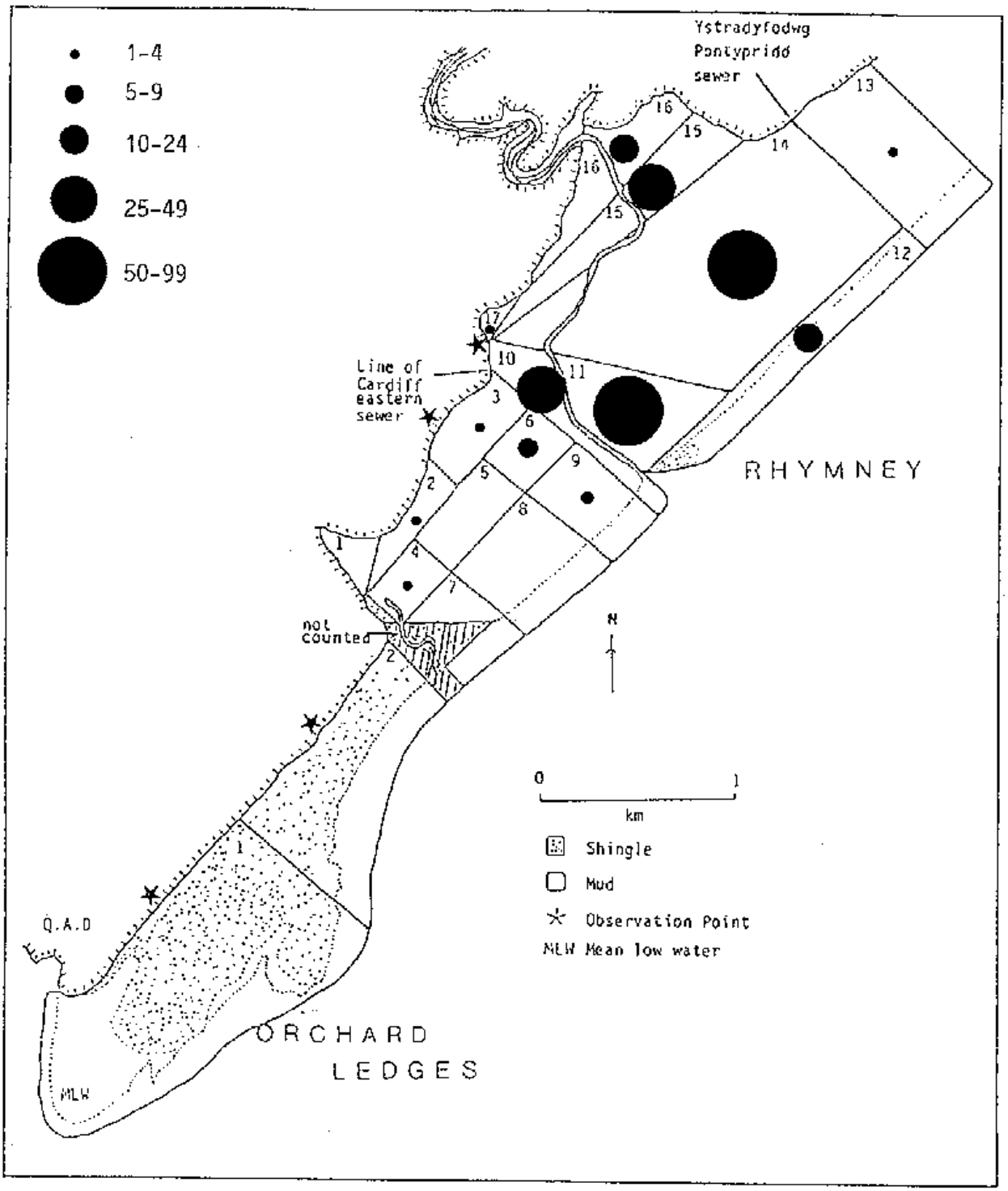


Figure 3.3.2 The distribution of feeding Mallard on the Rhymney and Orchard Ledges all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

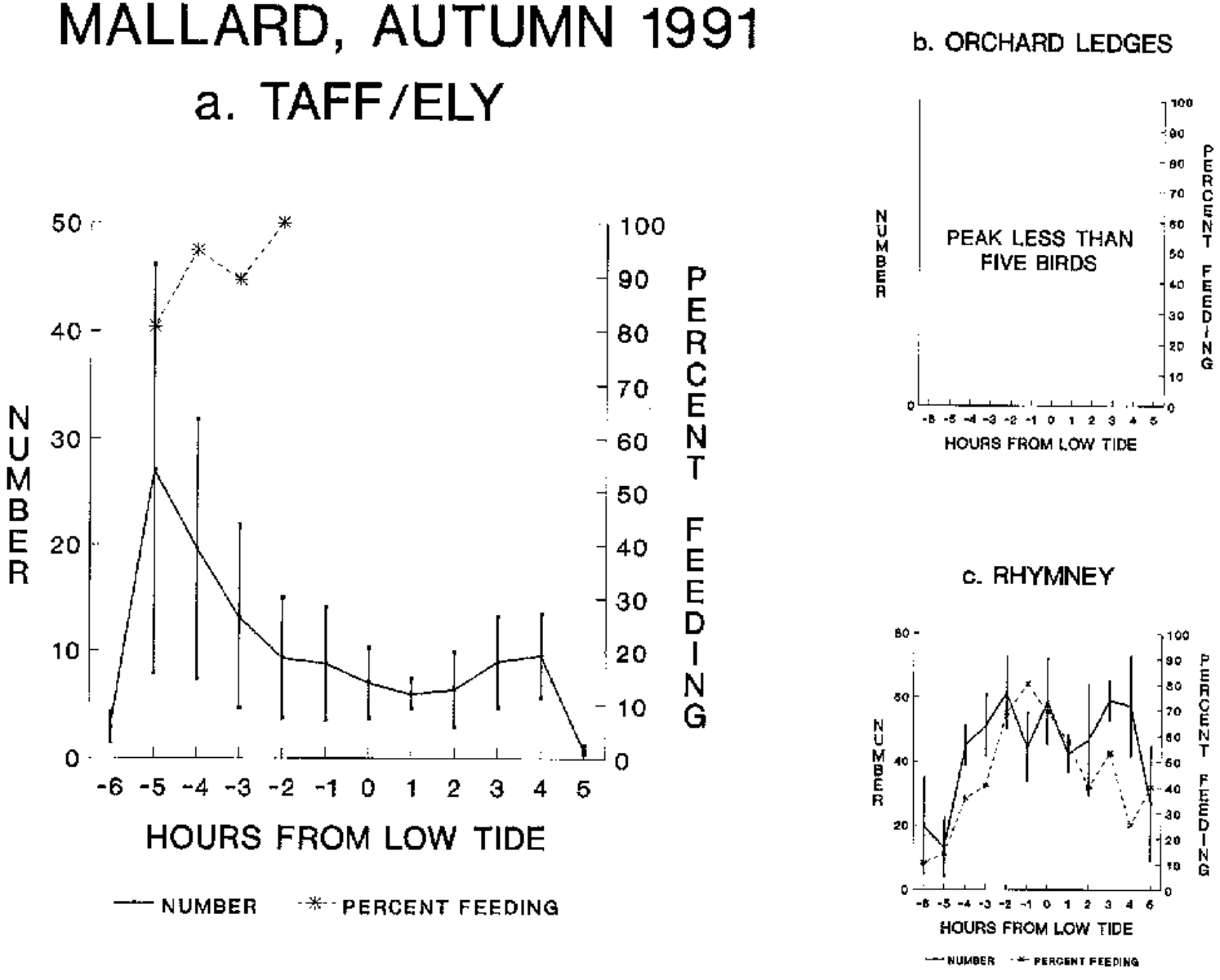


Figure 3.3.3 The total number of Mallard present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during autumn 1991.

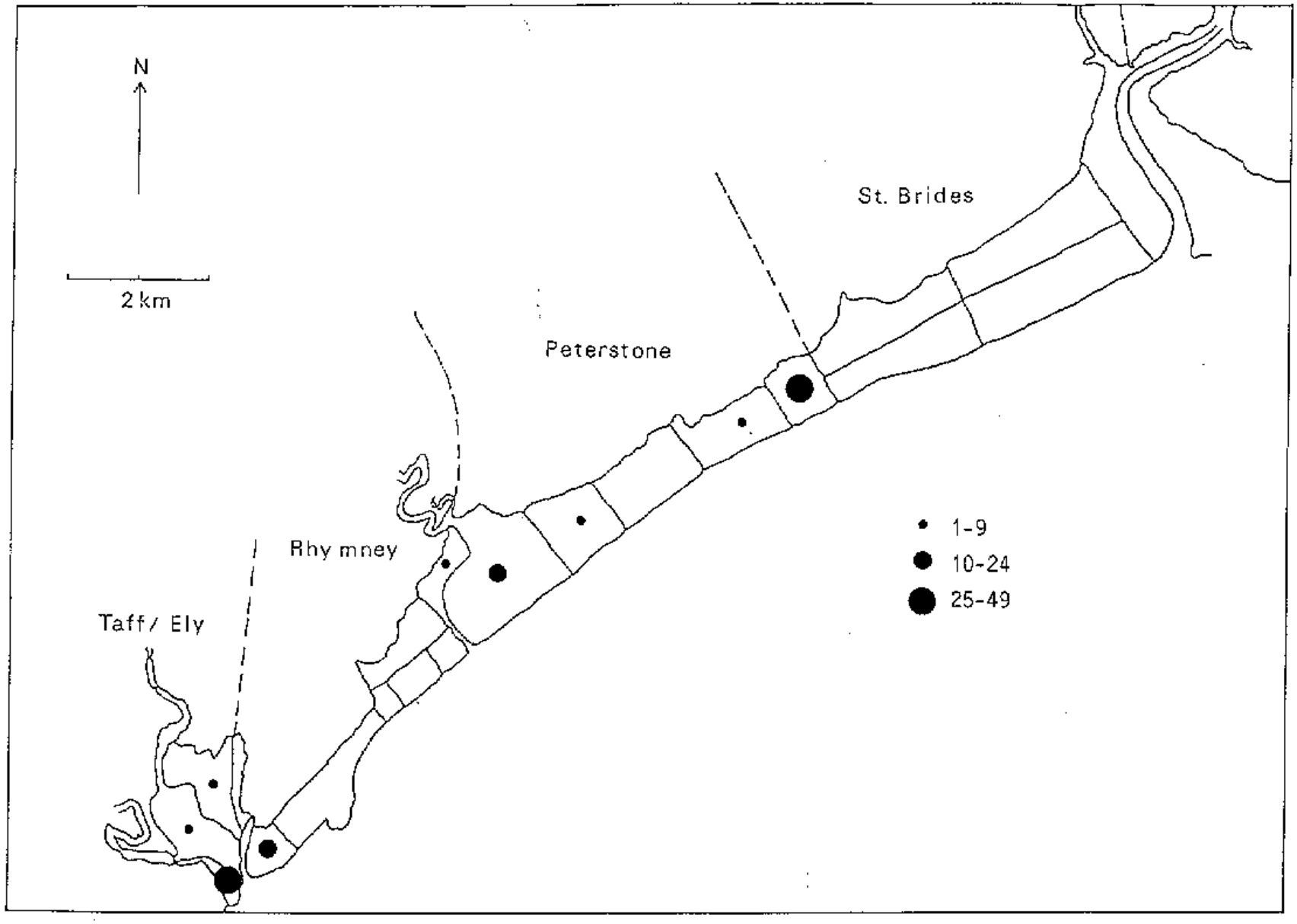


Figure 3.3.4 The low tide distribution of feeding Mallard on the northwest Severn during winter 1991/92.

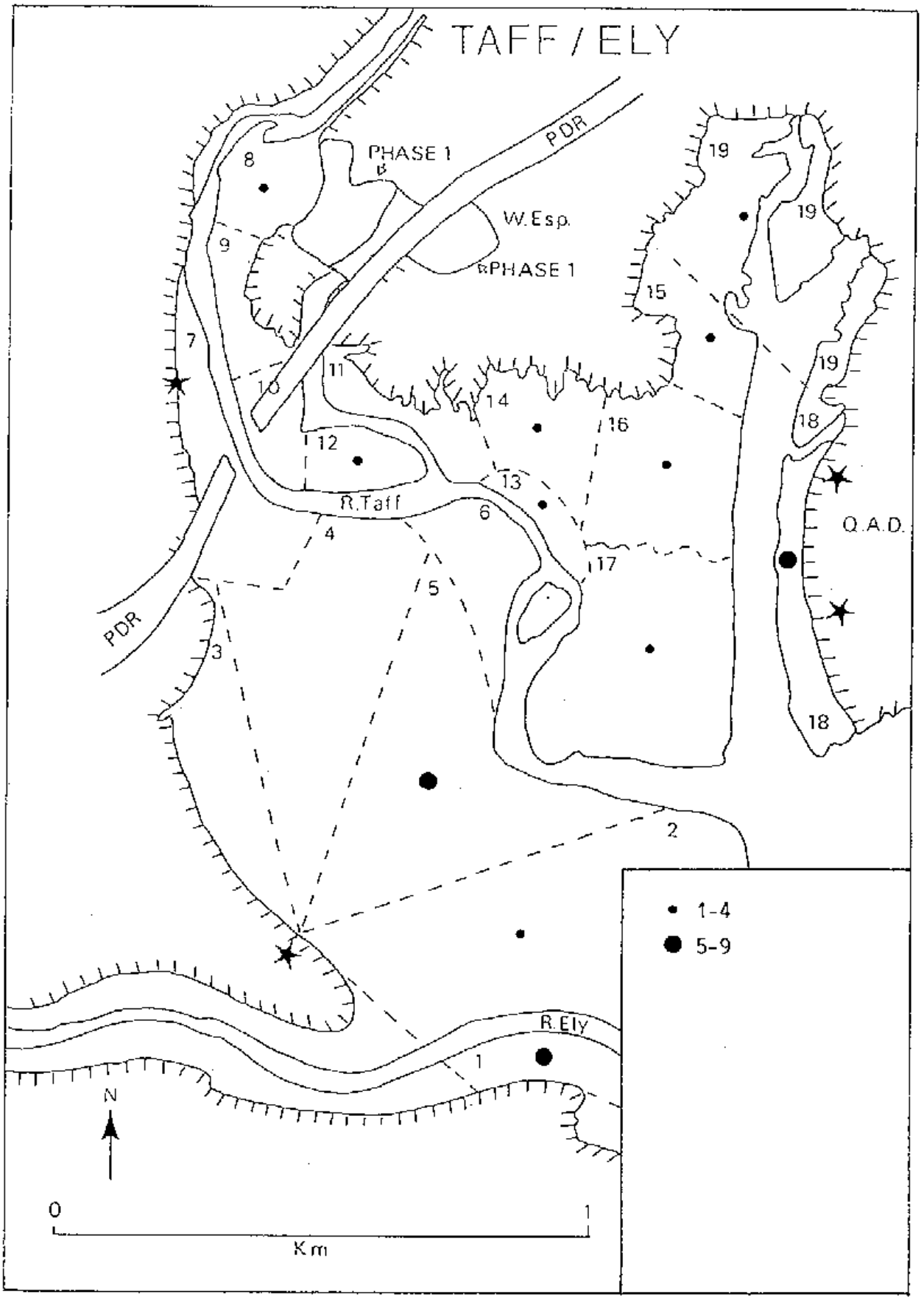


Figure 3.3.5 The distribution of feeding Mallard on the Taff/Ely all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

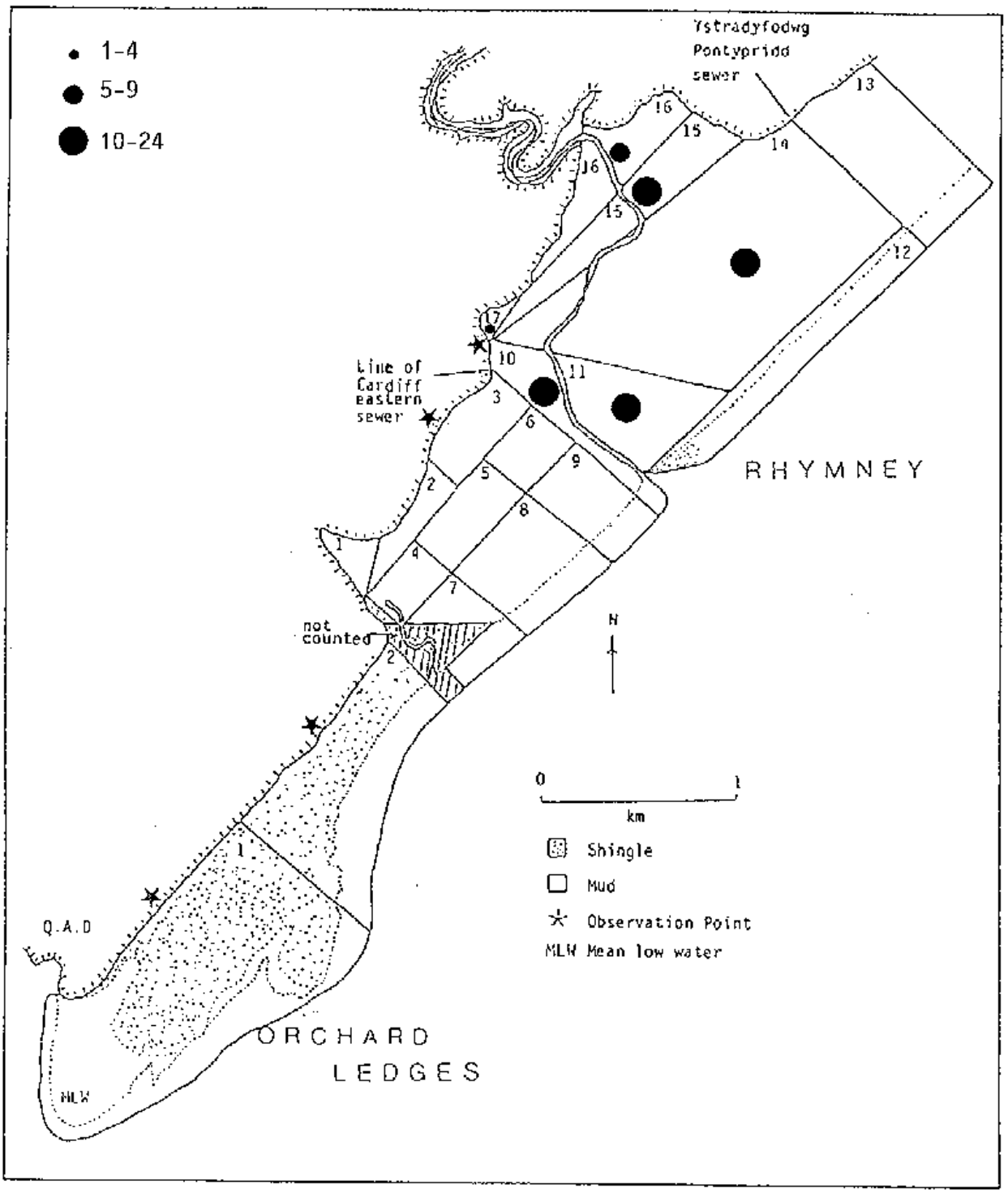


Figure 3.3.6 The distribution of feeding Mallard on the Rhymney and Orchard Ledges all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

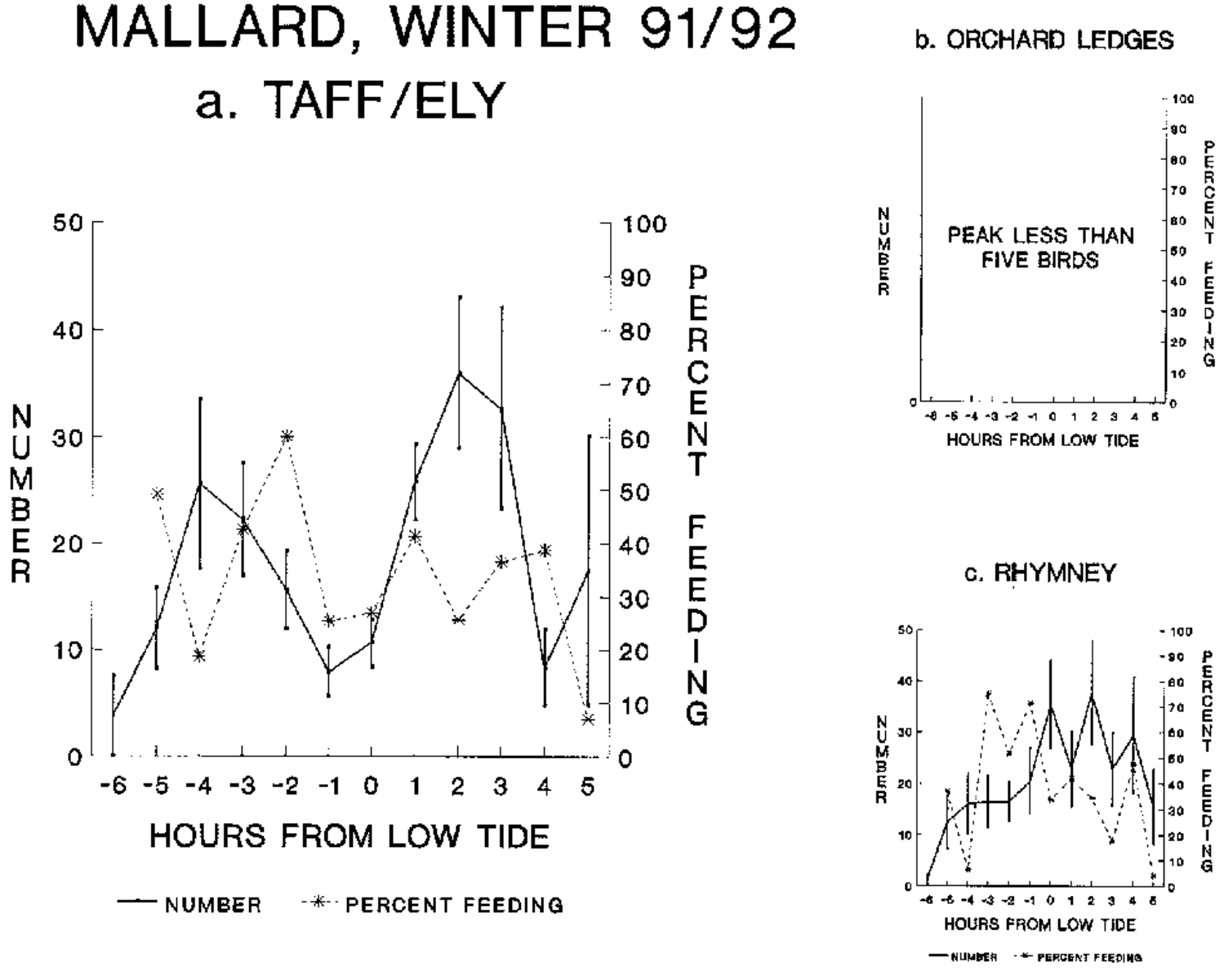
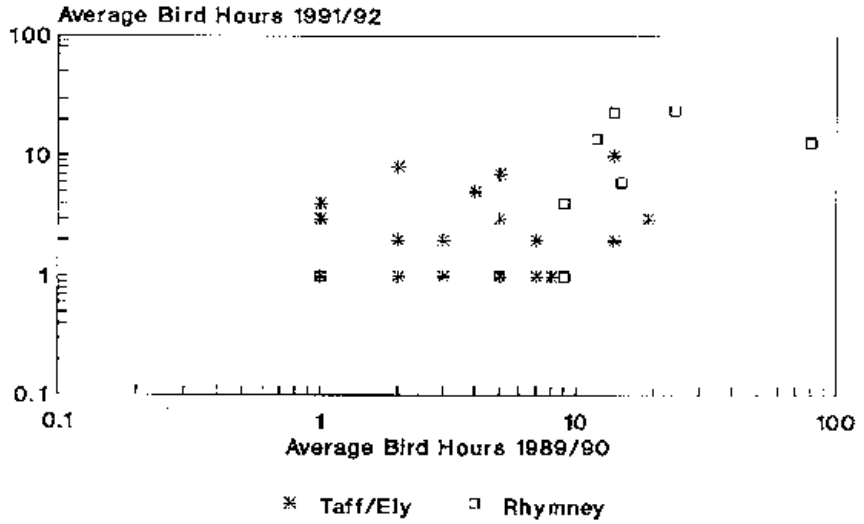


Figure 3.3.7 The total number of Mallard present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during winter 1991/92.

MALLARD, WINTER

a. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1989/90 and 1991/92.



b. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1990/91 and 1991/92.

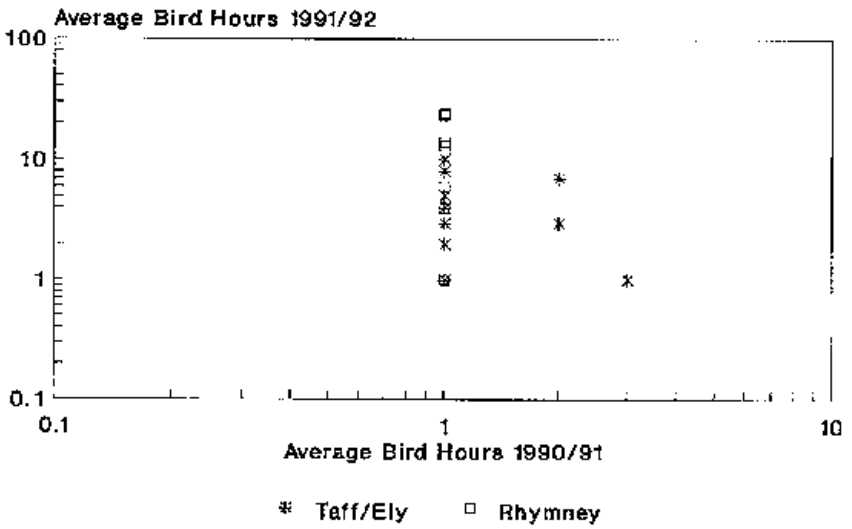


Figure 3.3.8 A comparison of usage values for Mallard between winter 1989/90 and winter 1991/92 and between winter 1990/91 and winter 1991/92.

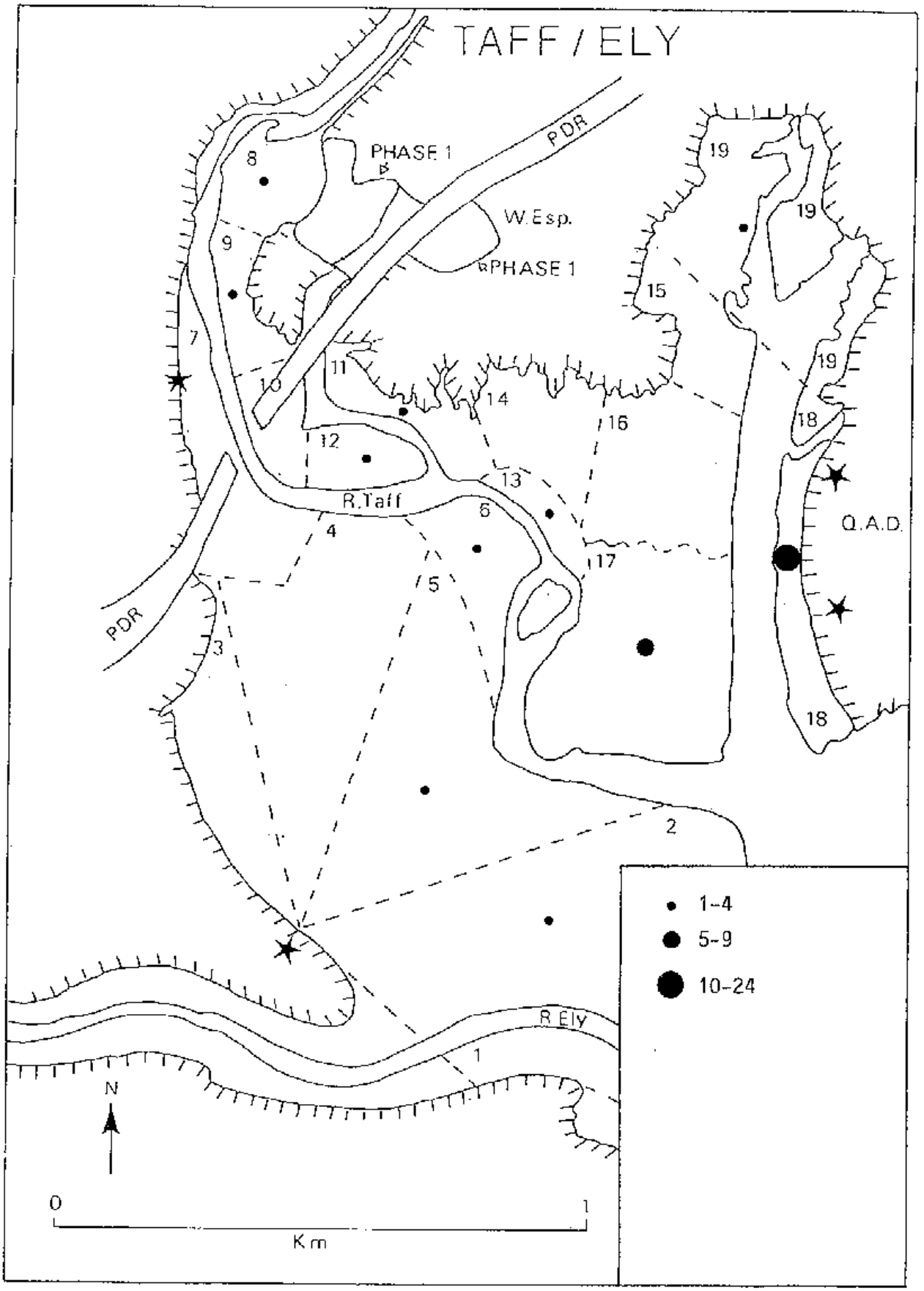


Figure 3.4.1 The distribution of feeding Teal on the Taff/Ely all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

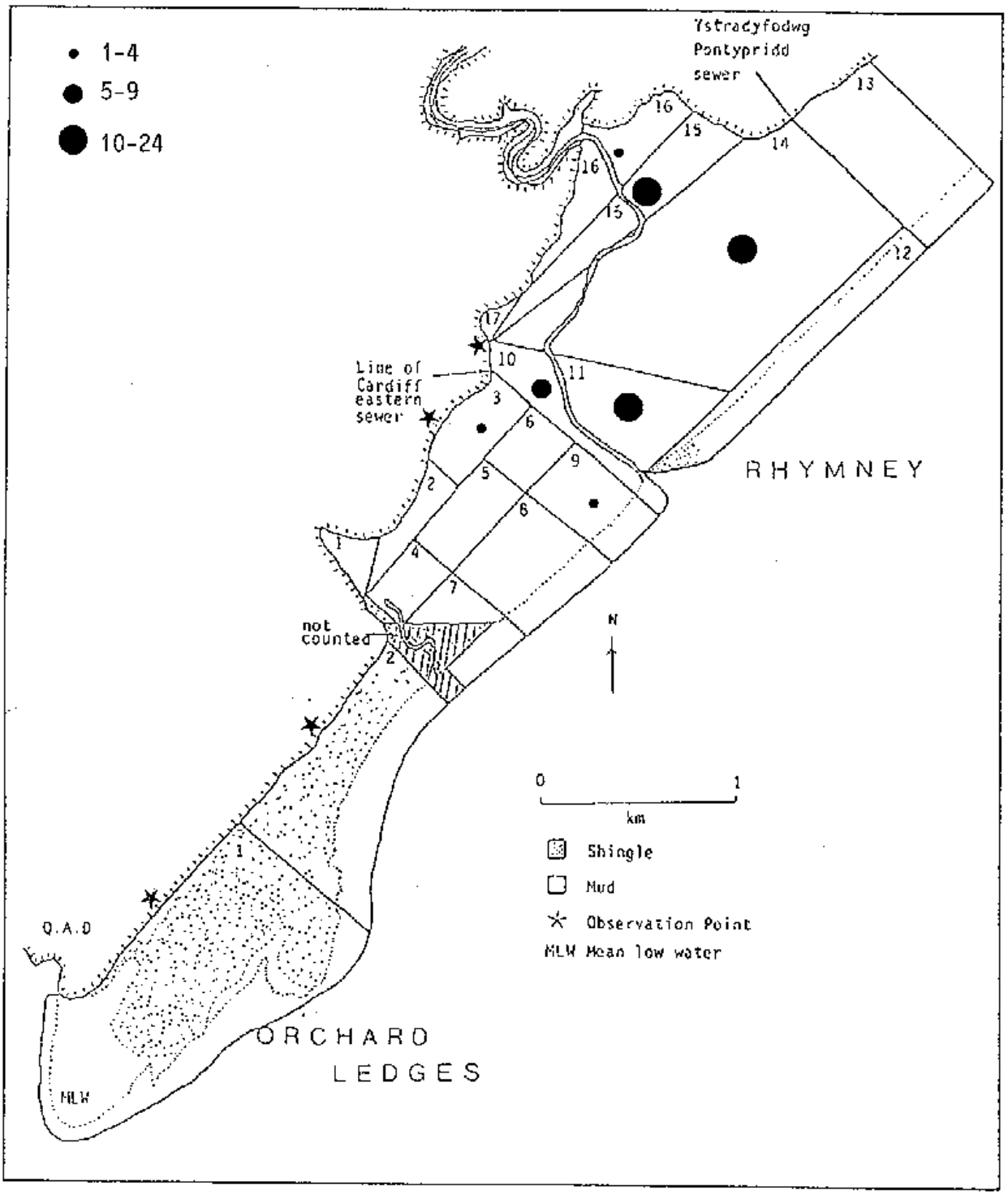


Figure 3.4.2 The distribution of feeding Teal on the Rhymney and Orchard Ledges all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

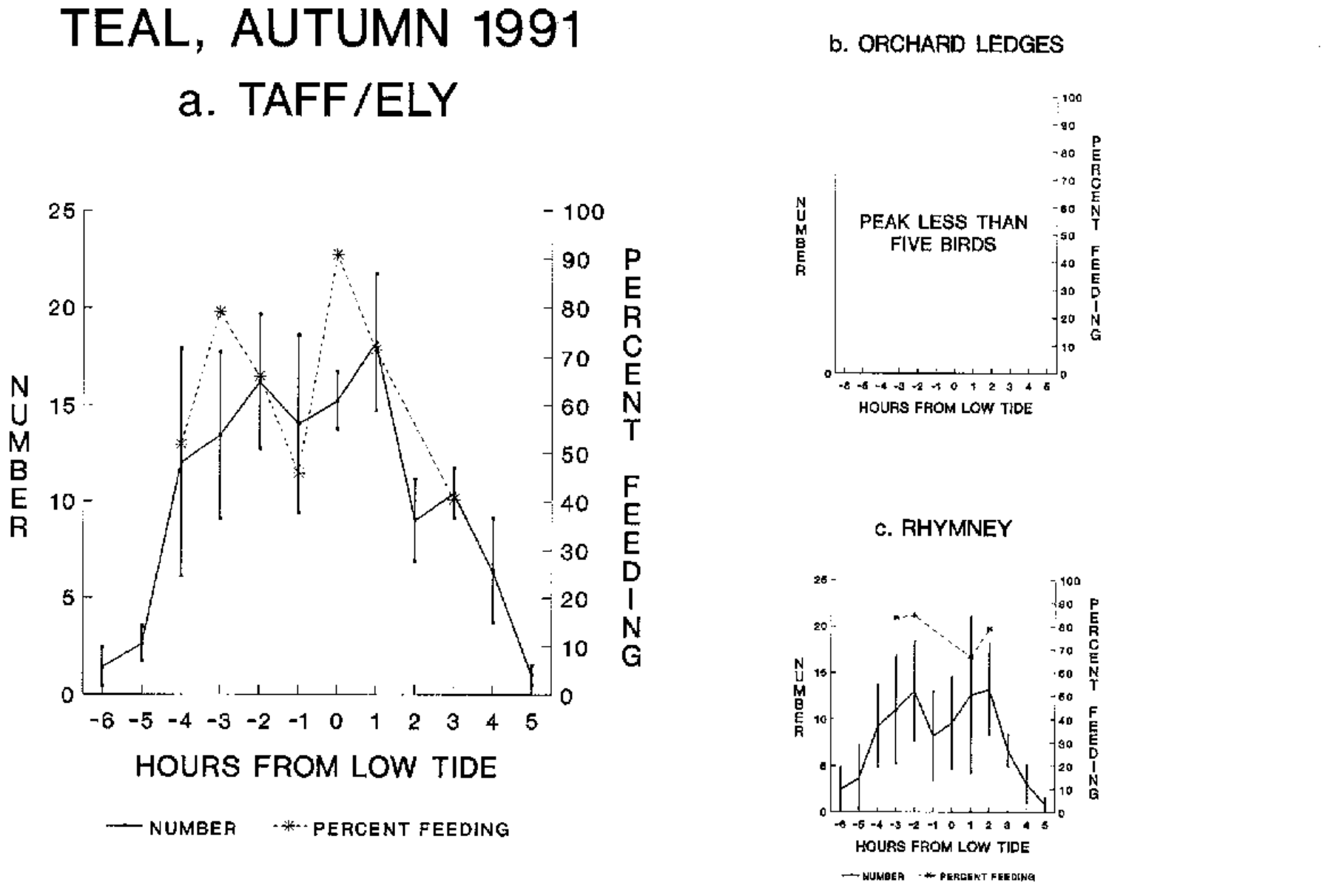


Figure 3.4.3 The total number of Teal present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during autumn 1991.

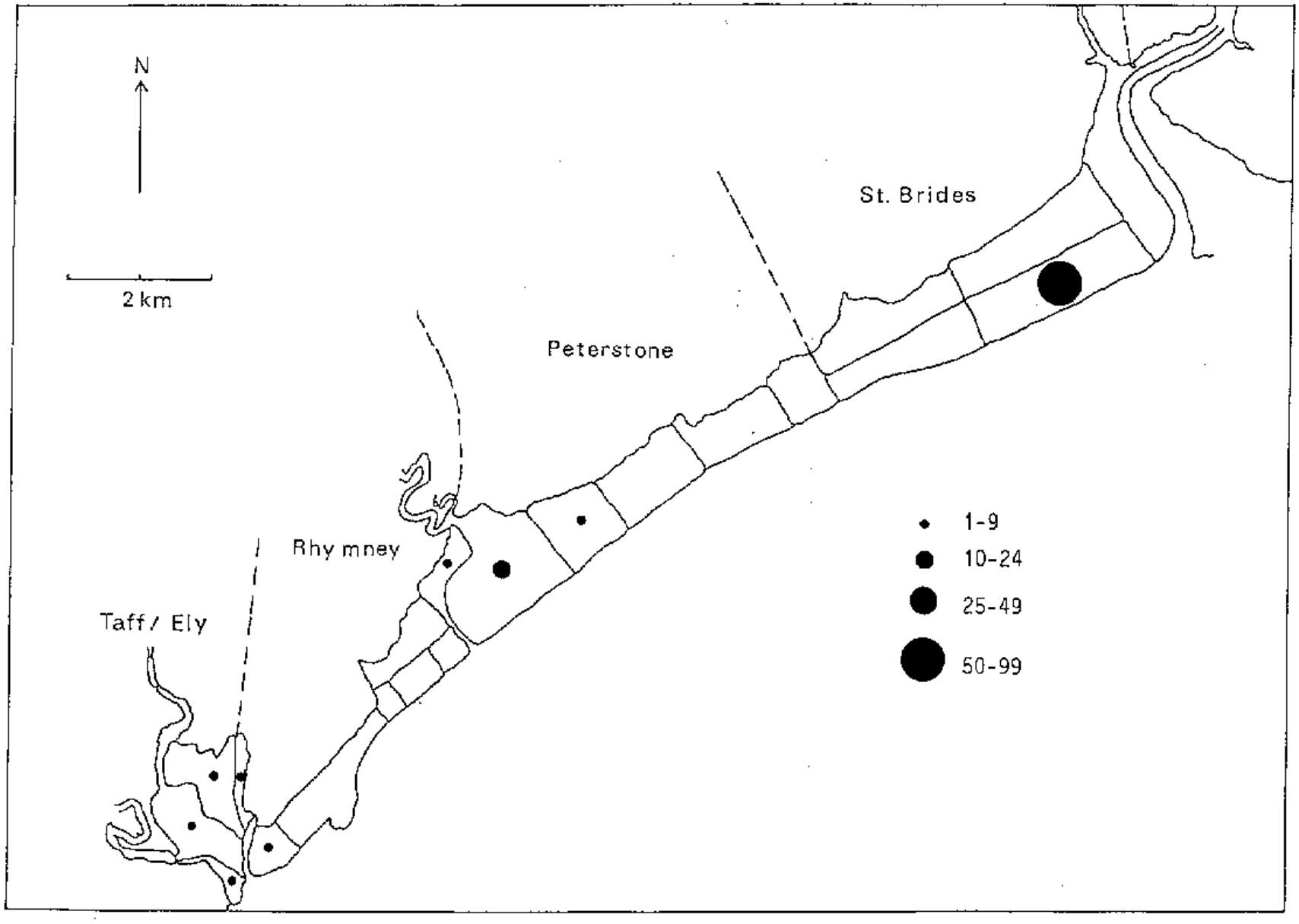


Figure 3.4.4 The low tide distribution of feeding Teal on the northwest Severn during winter 1991/92.

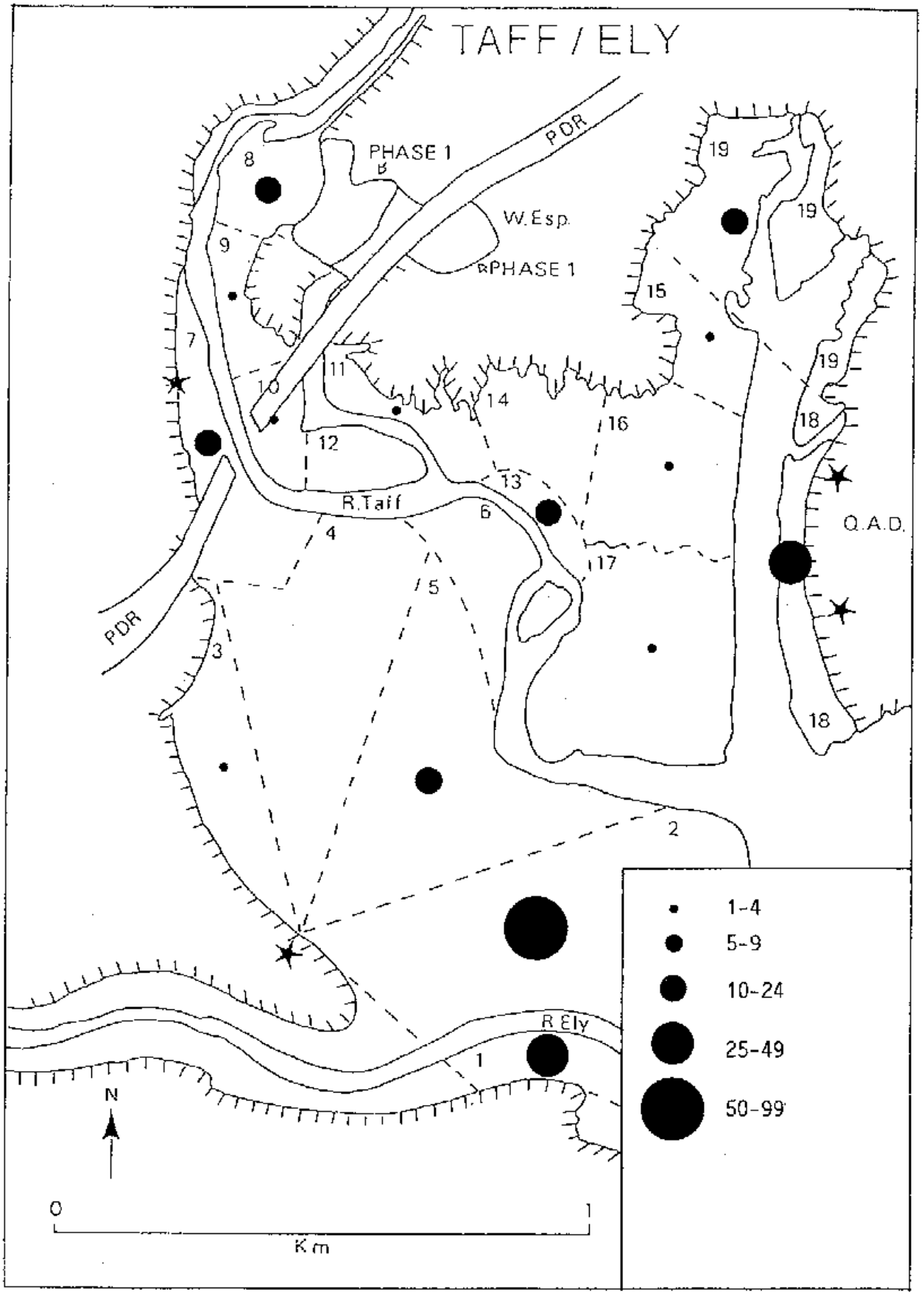


Figure 3.4.5 The distribution of feeding Teal on the Taff/Ely all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

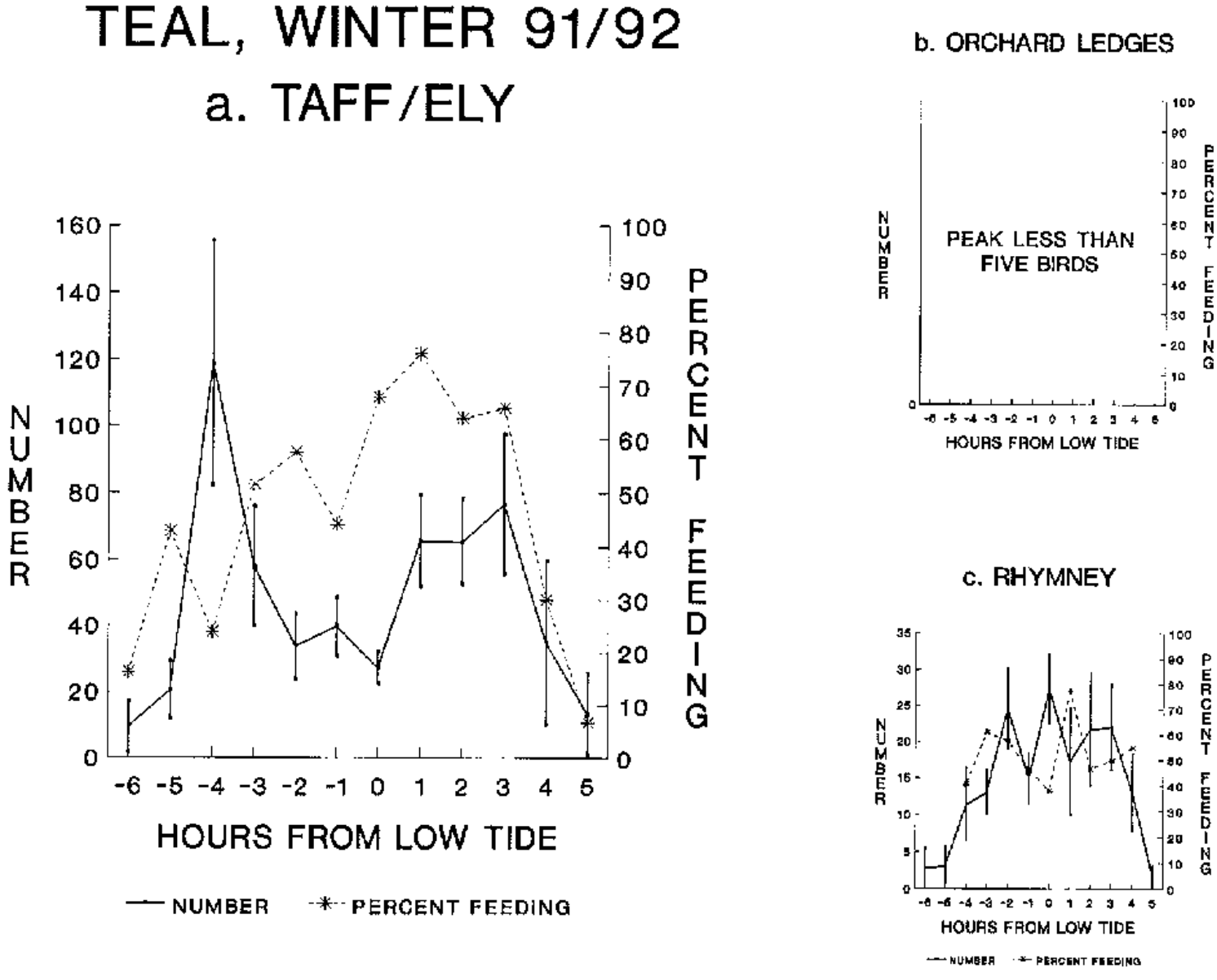
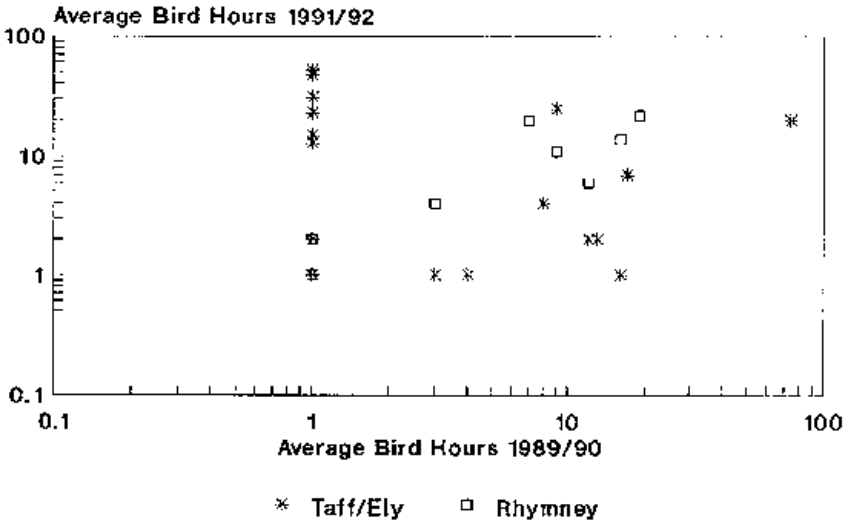


Figure 3.4.7 The total number of Teal present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during winter 1991/92.

TEAL, WINTER

a. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1989/90 and 1991/92.



b. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1990/91 and 1991/92.

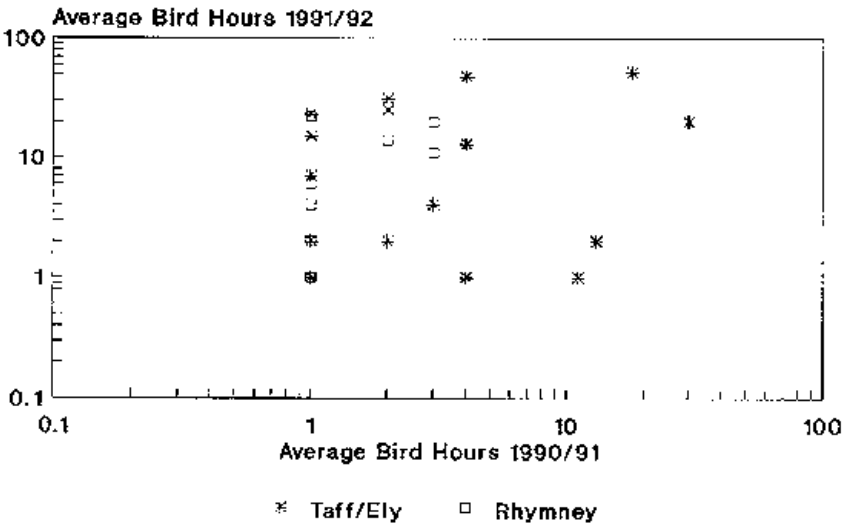


Figure 3.4.8 A comparison of usage values for Teal between winter 1989/90 and winter 1991/92 and between winter 1990/91 and winter 1991/92.

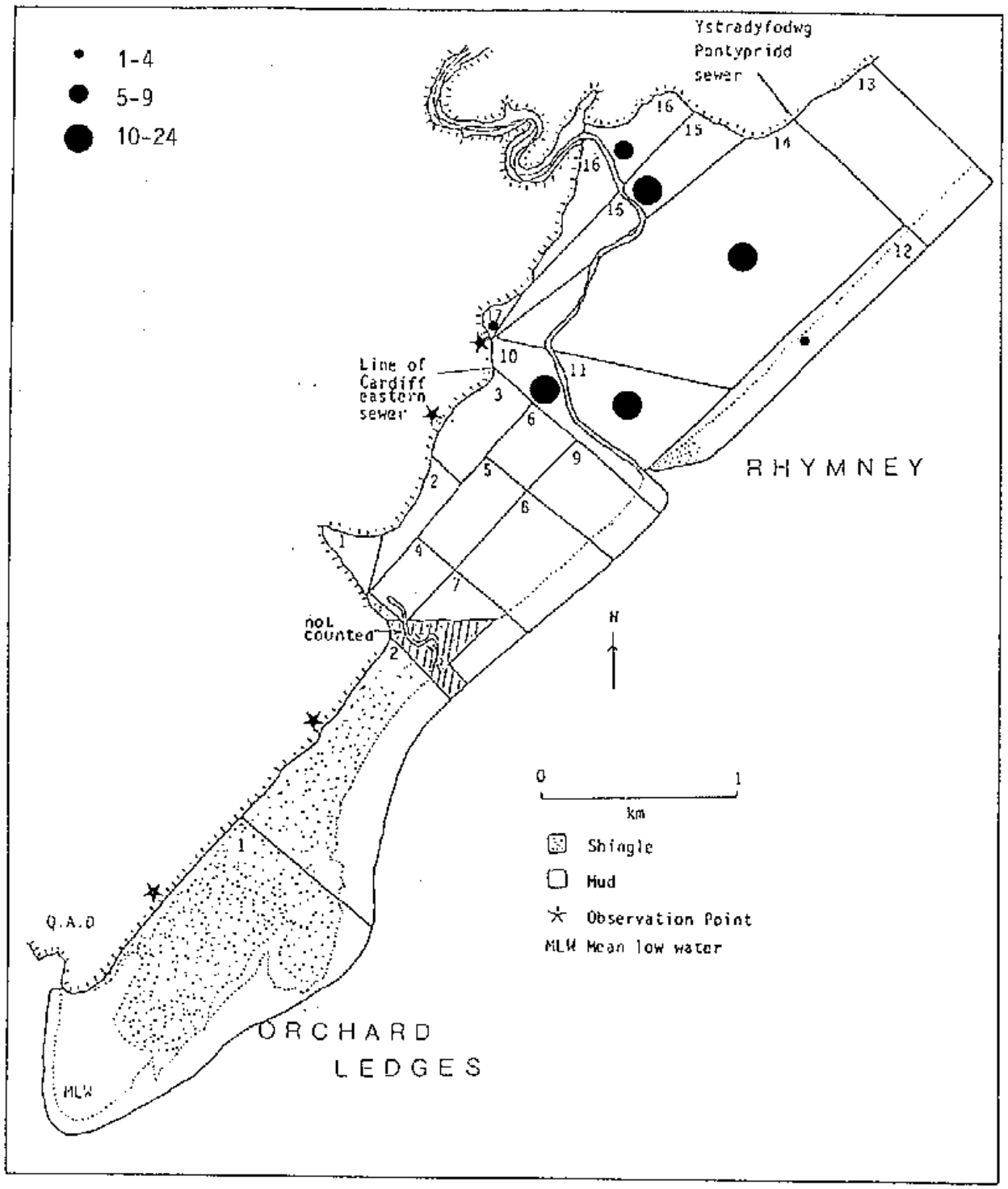


Figure 3.4.6 The distribution of feeding Teal on the Rhymney and Orchard Ledges all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

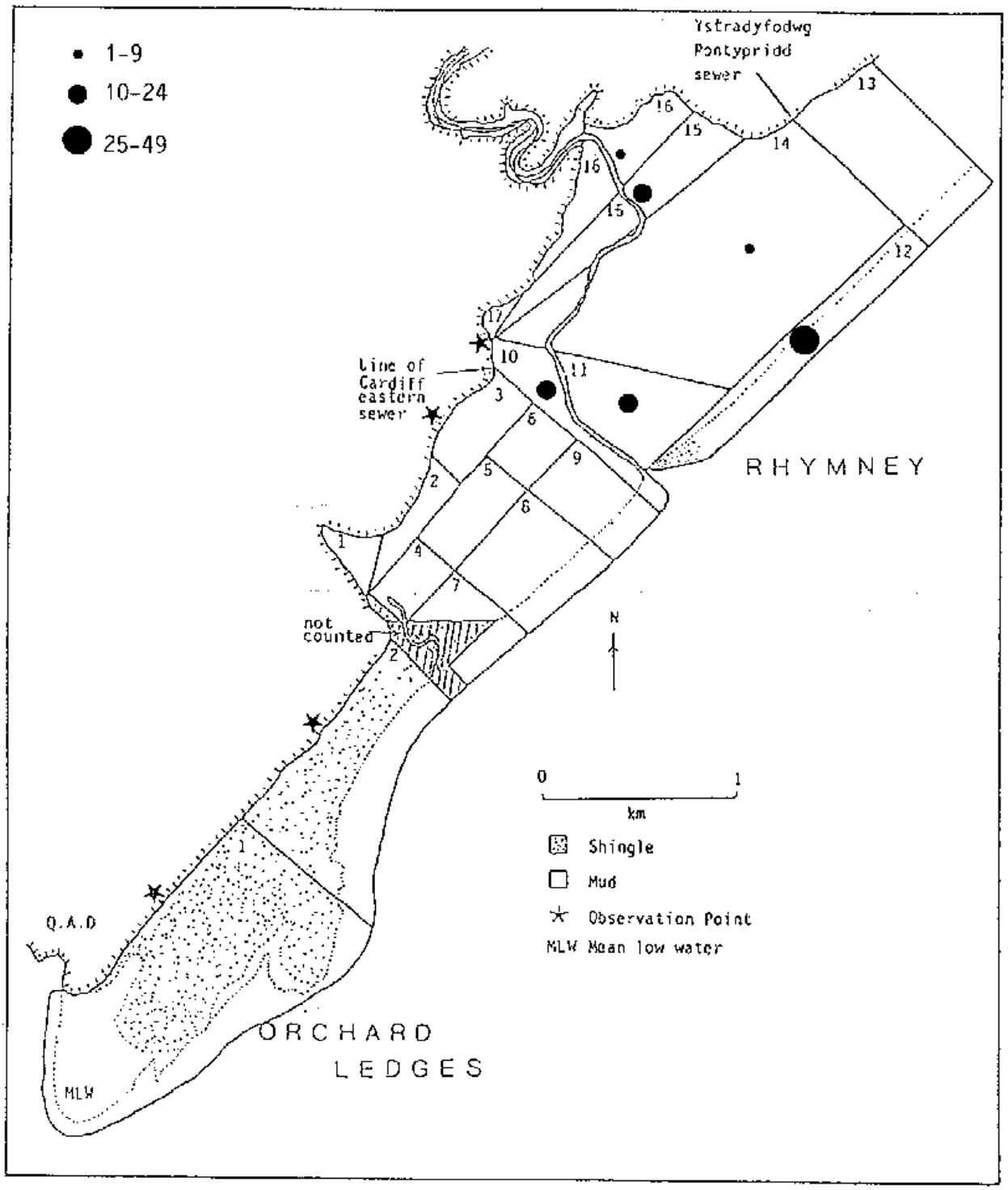


Figure 3.5.1 The distribution of feeding Pintail on the Rhymney and Orchard Ledges all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted..

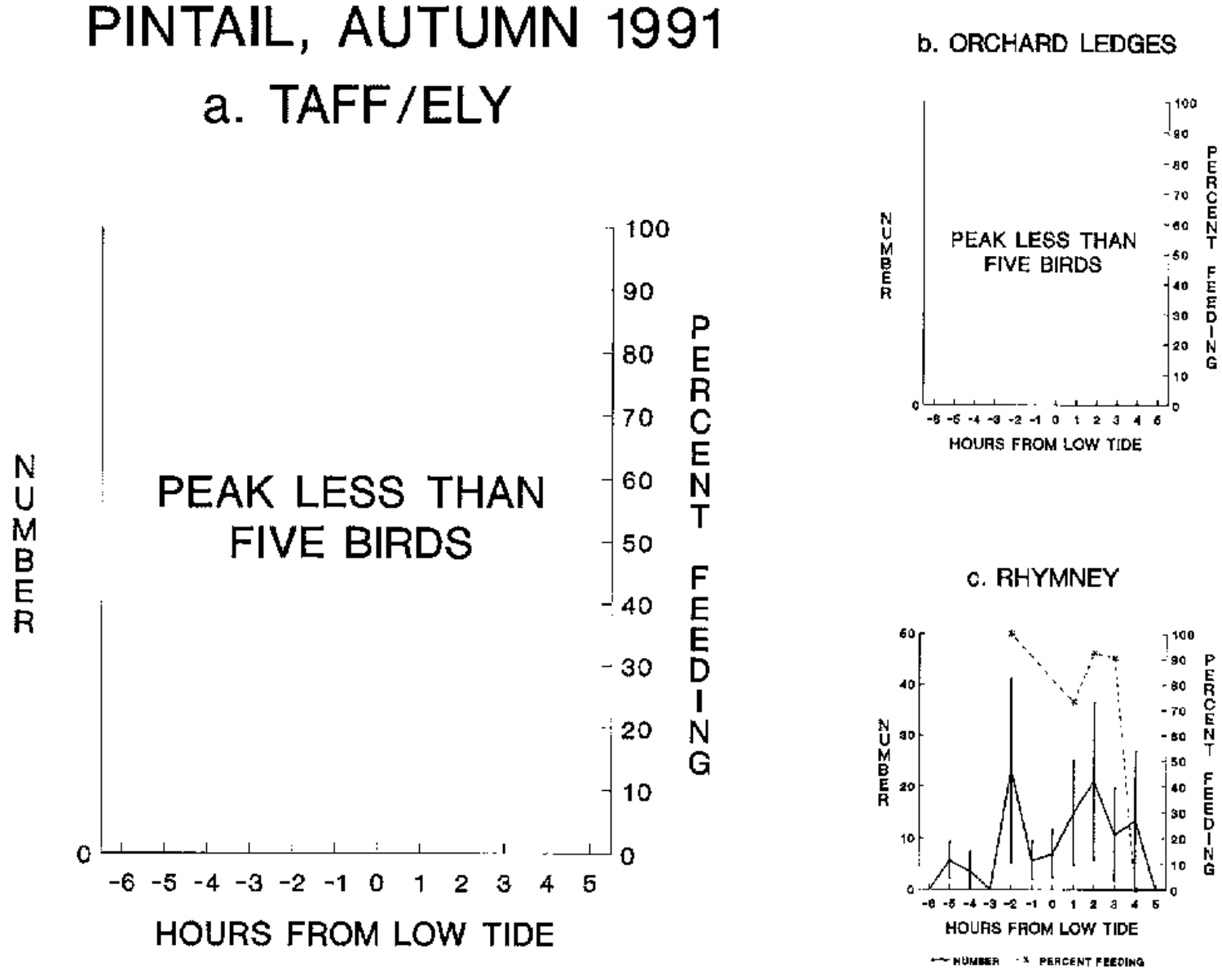


Figure 3.5.2 The total number of Pintail present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during autumn 1991.

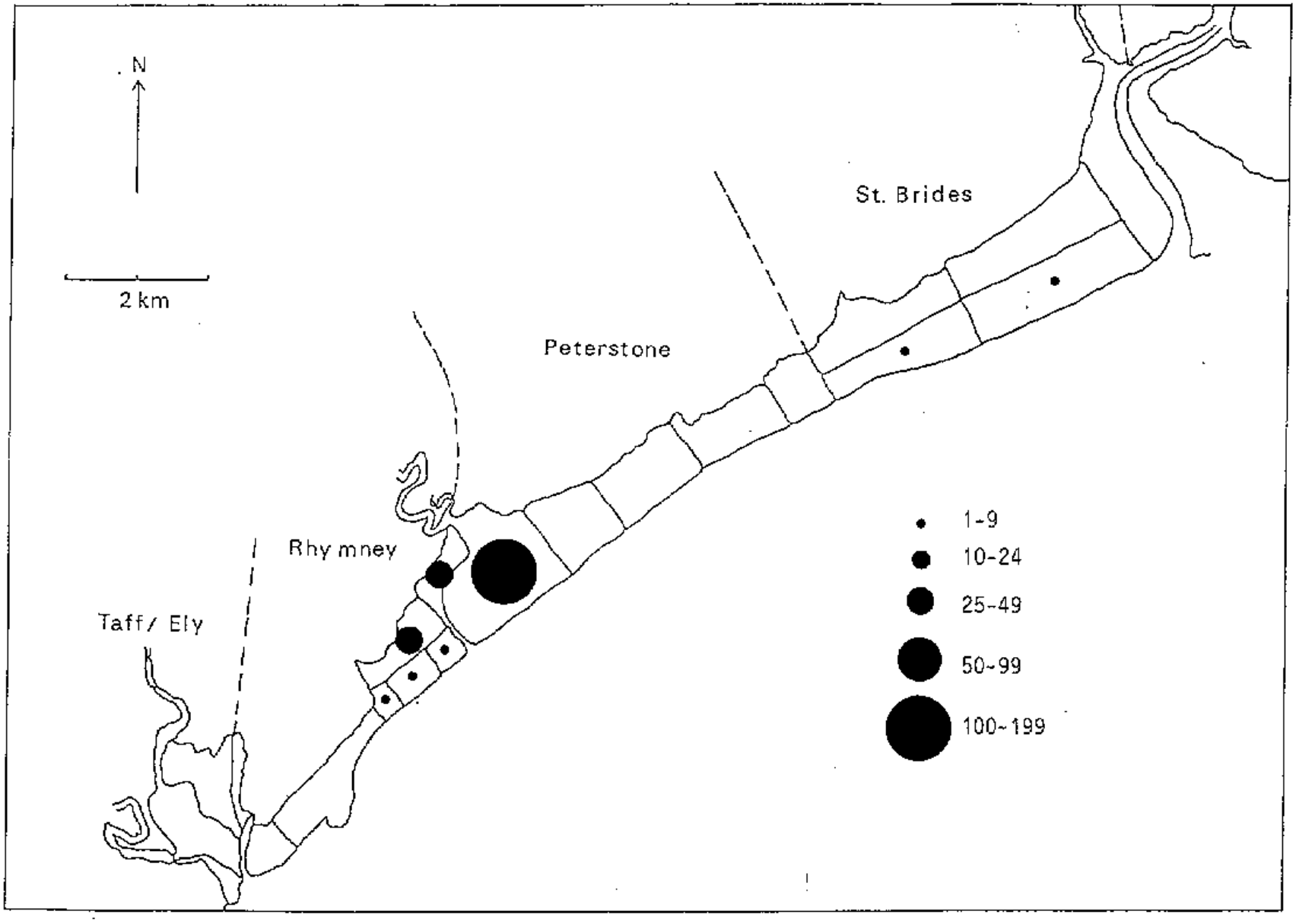


Figure 3.5.3 The low tide distribution of feeding Pintail on the northwest Severn during winter 1991/92.

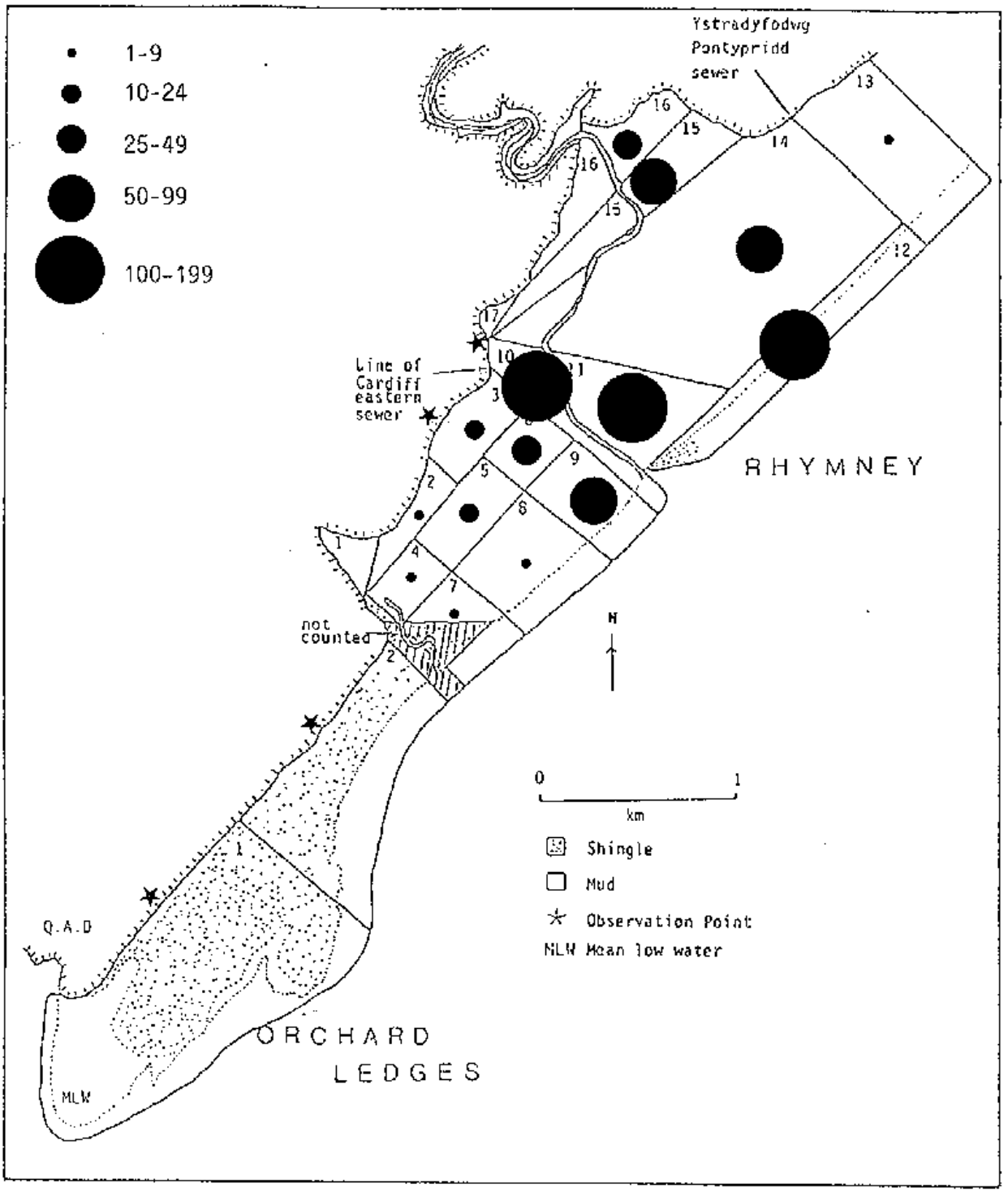


Figure 3.5.4 The distribution of feeding Pintail on the Rhymney and Orchard Ledges all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

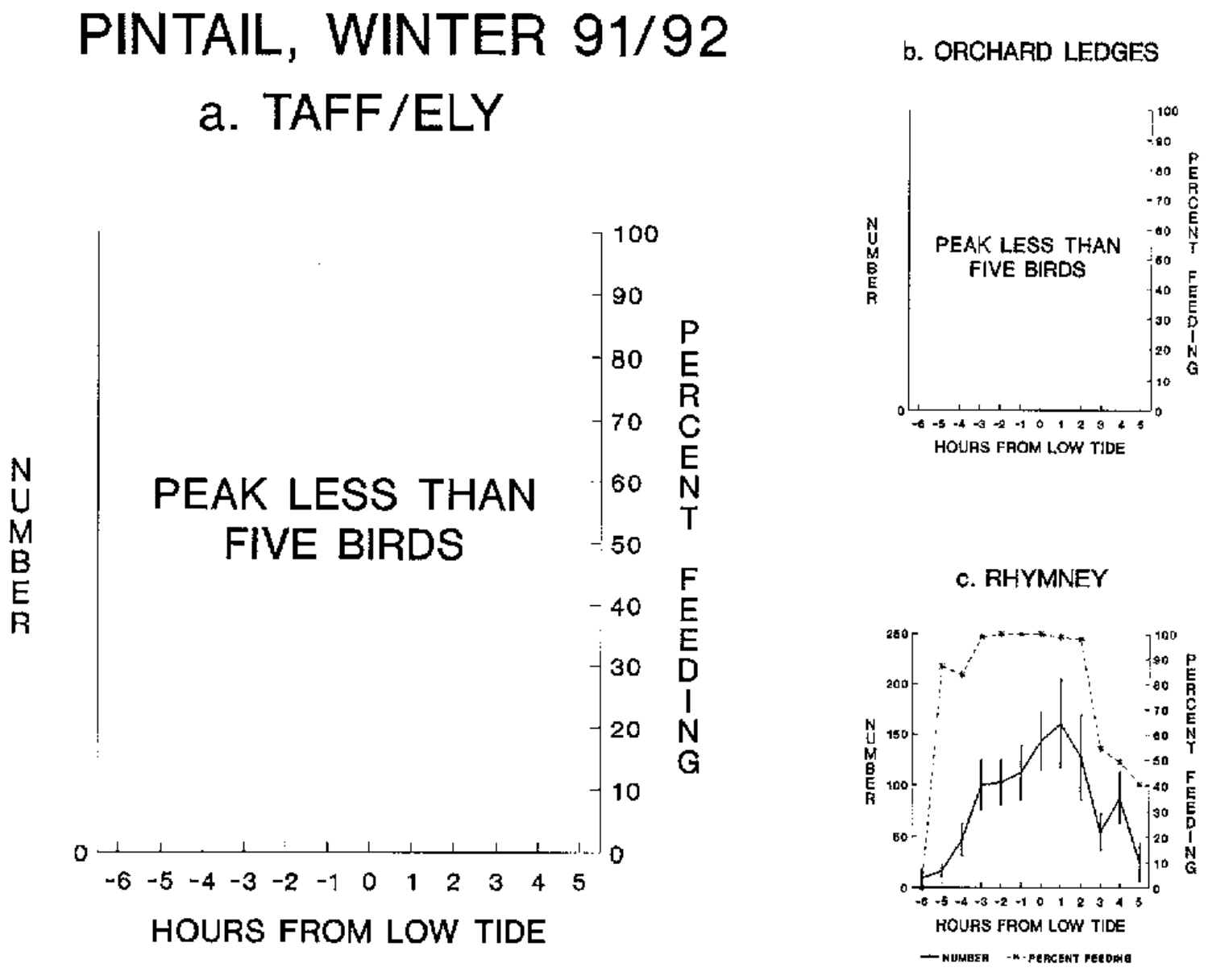
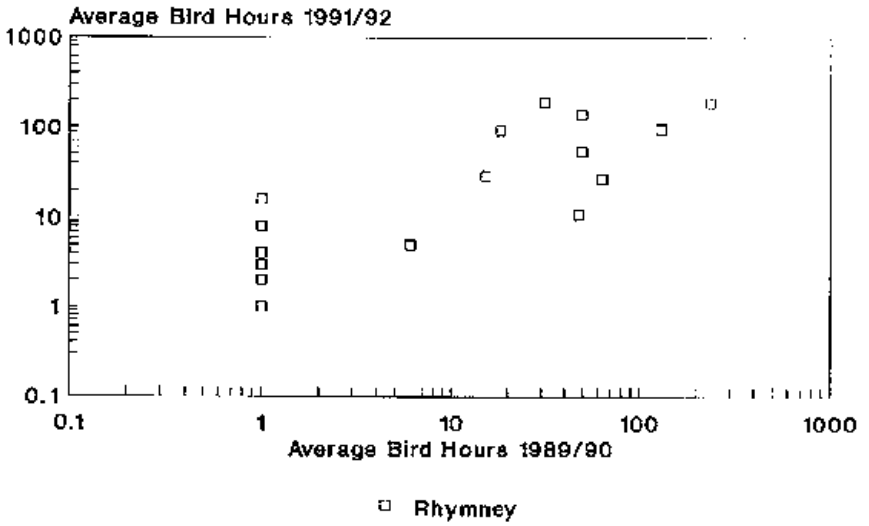


Figure 3.5.5 The total number of Pintail present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during winter 1991/92.

PINTAIL, WINTER

a. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1989/90 and 1991/92.



b. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1990/91 and 1991/92.

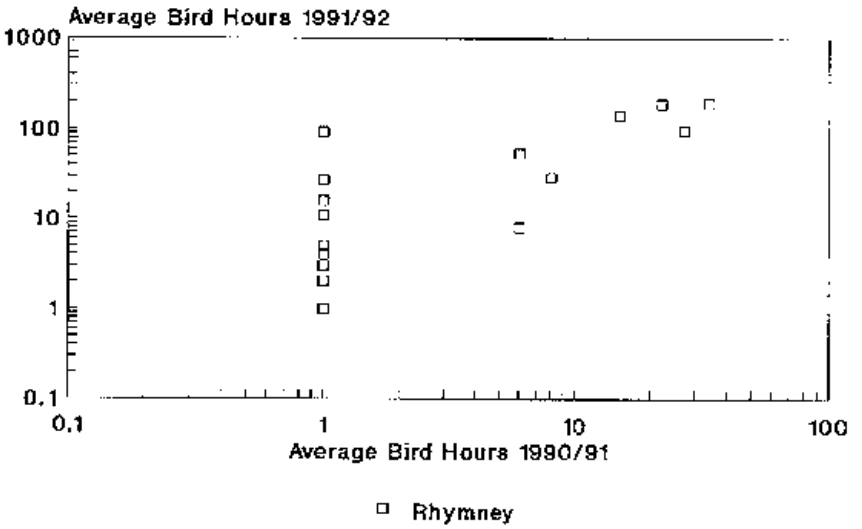


Figure 3.5.6 A comparison of usage values for Pintail between winter 1989/90 and winter 1991/92 and between winter 1990/91 and winter 1991/92.

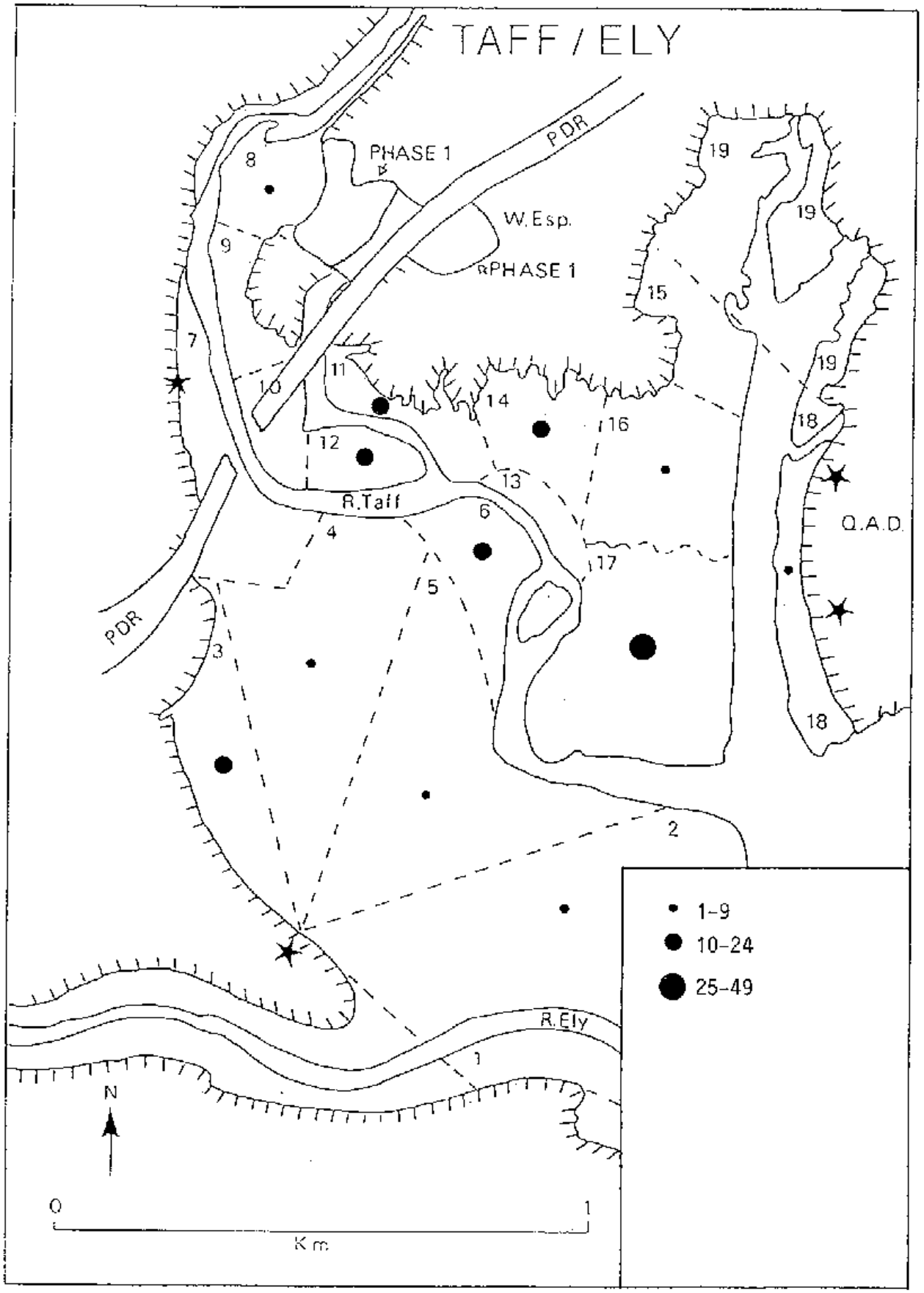


Figure 3.7.1 The distribution of feeding Oystercatcher on the Taff/Ely all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

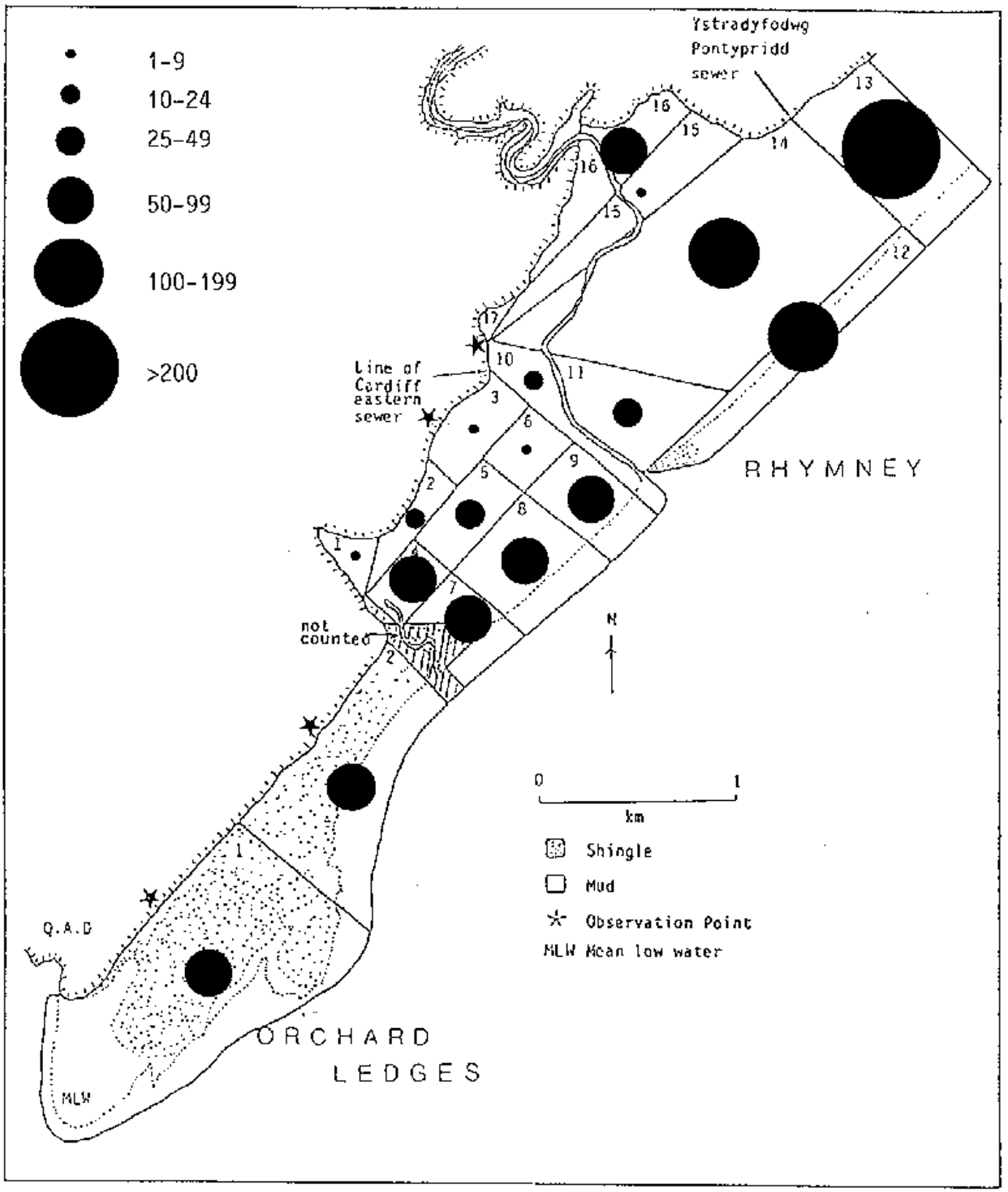


Figure 3.7.2 The distribution of feeding Oystercatcher on the Rhymney and Orchard Ledges all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

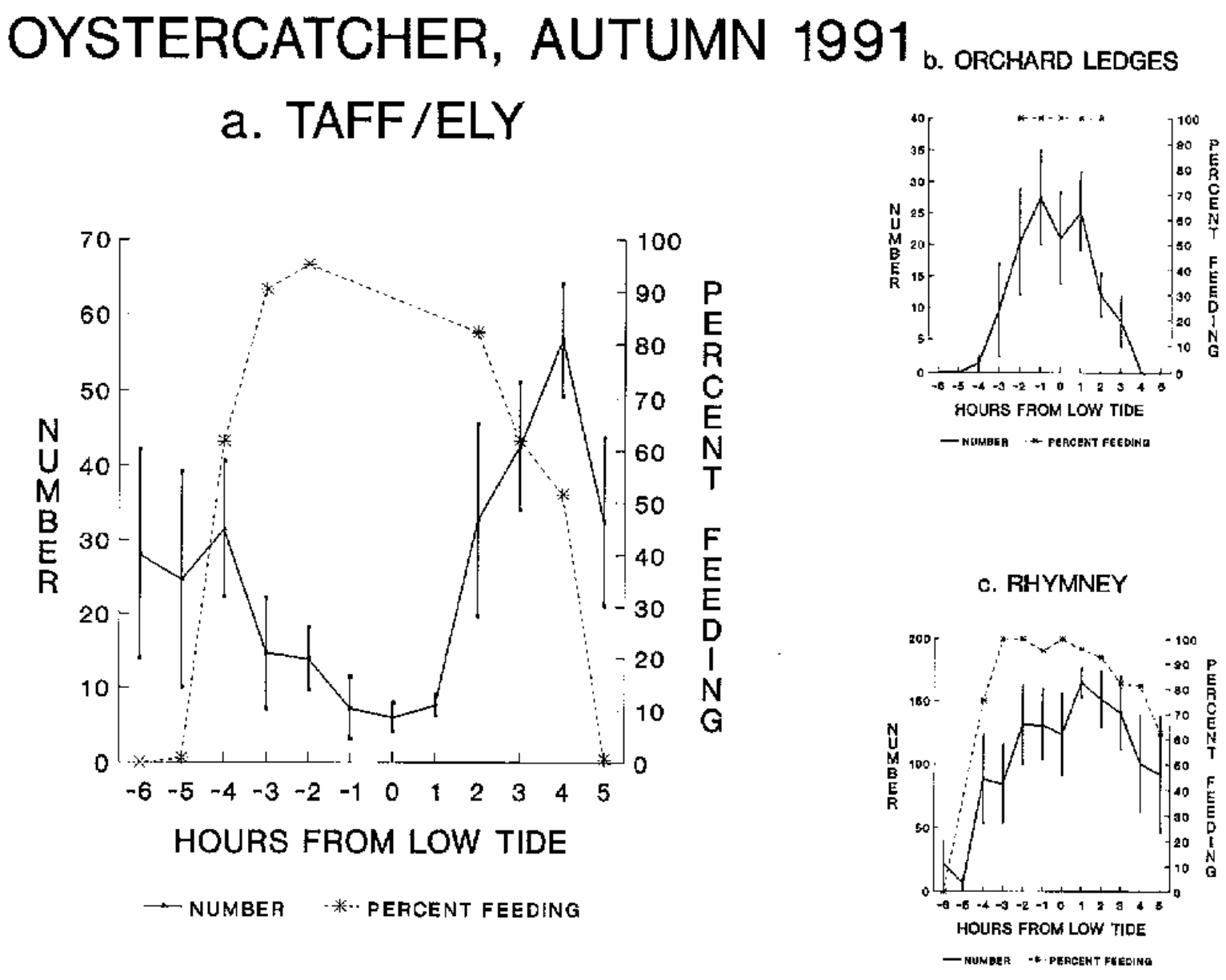


Figure 3.7.3 The total number of Oystercatcher present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during autumn 1991.

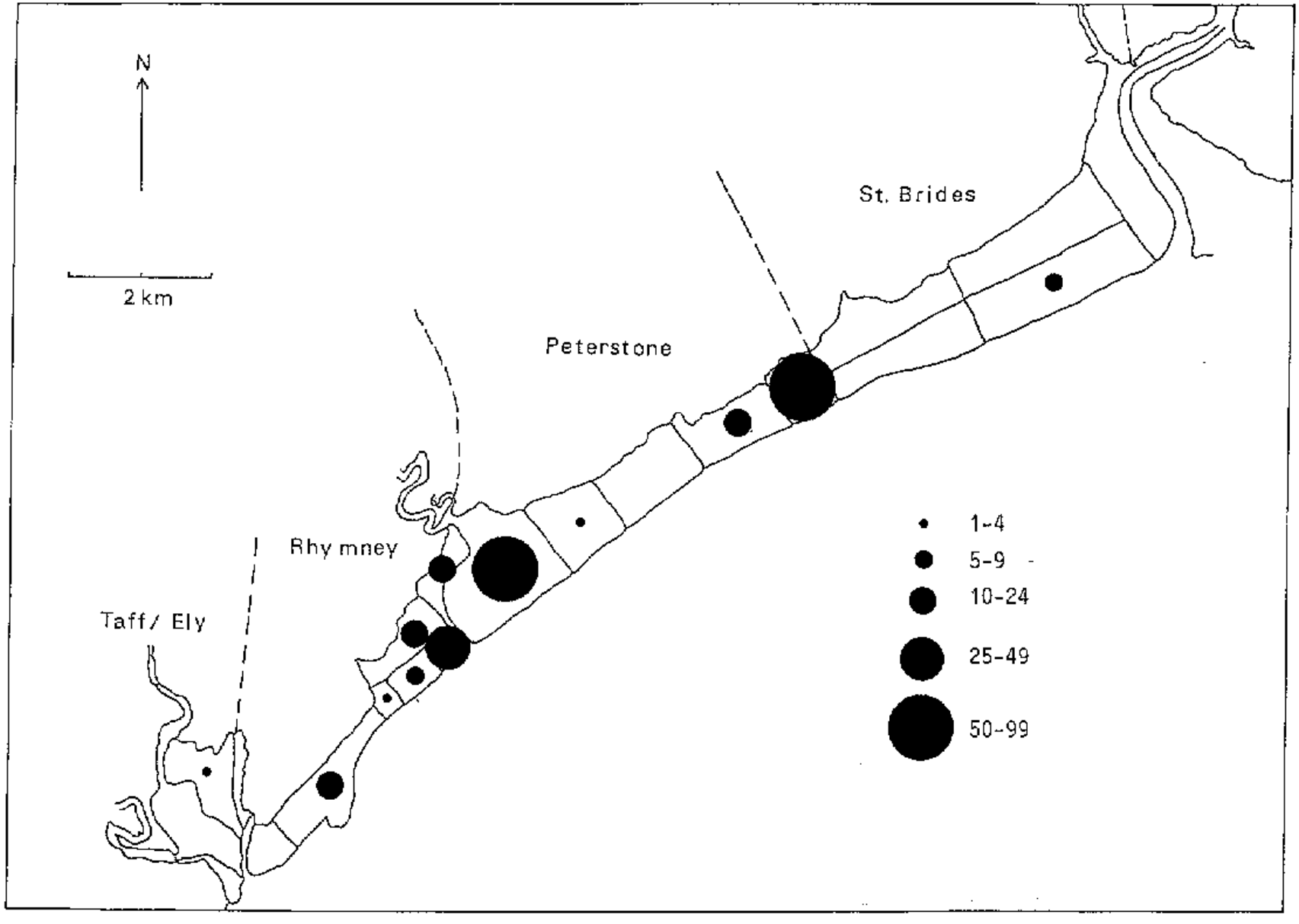


Figure 3.7.4 The low tide distribution of feeding Oystercatcher on the northwest Severn during winter 1991/92.

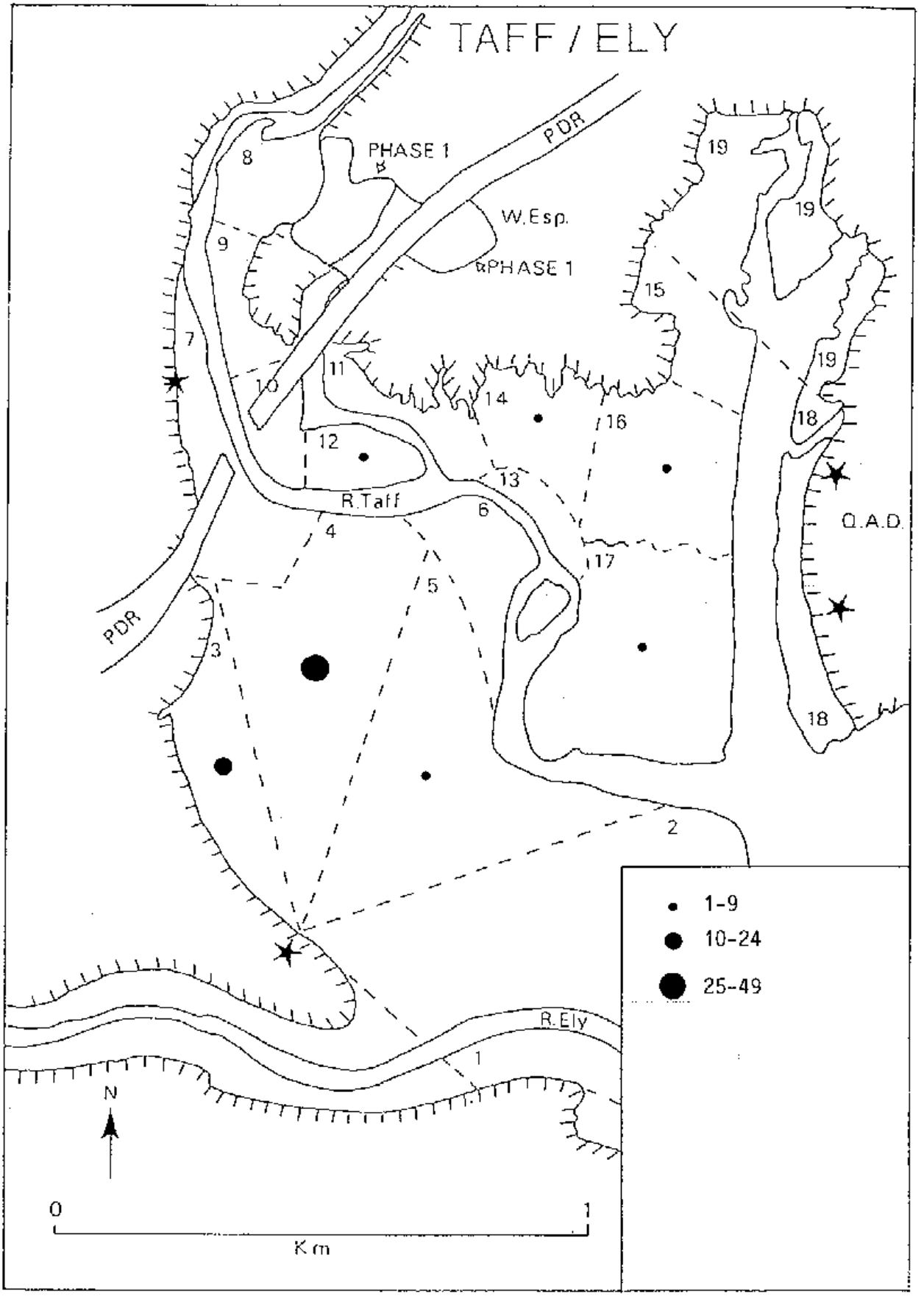


Figure 3.7.5 The distribution of feeding Oystercatcher on the Taff/Ely all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

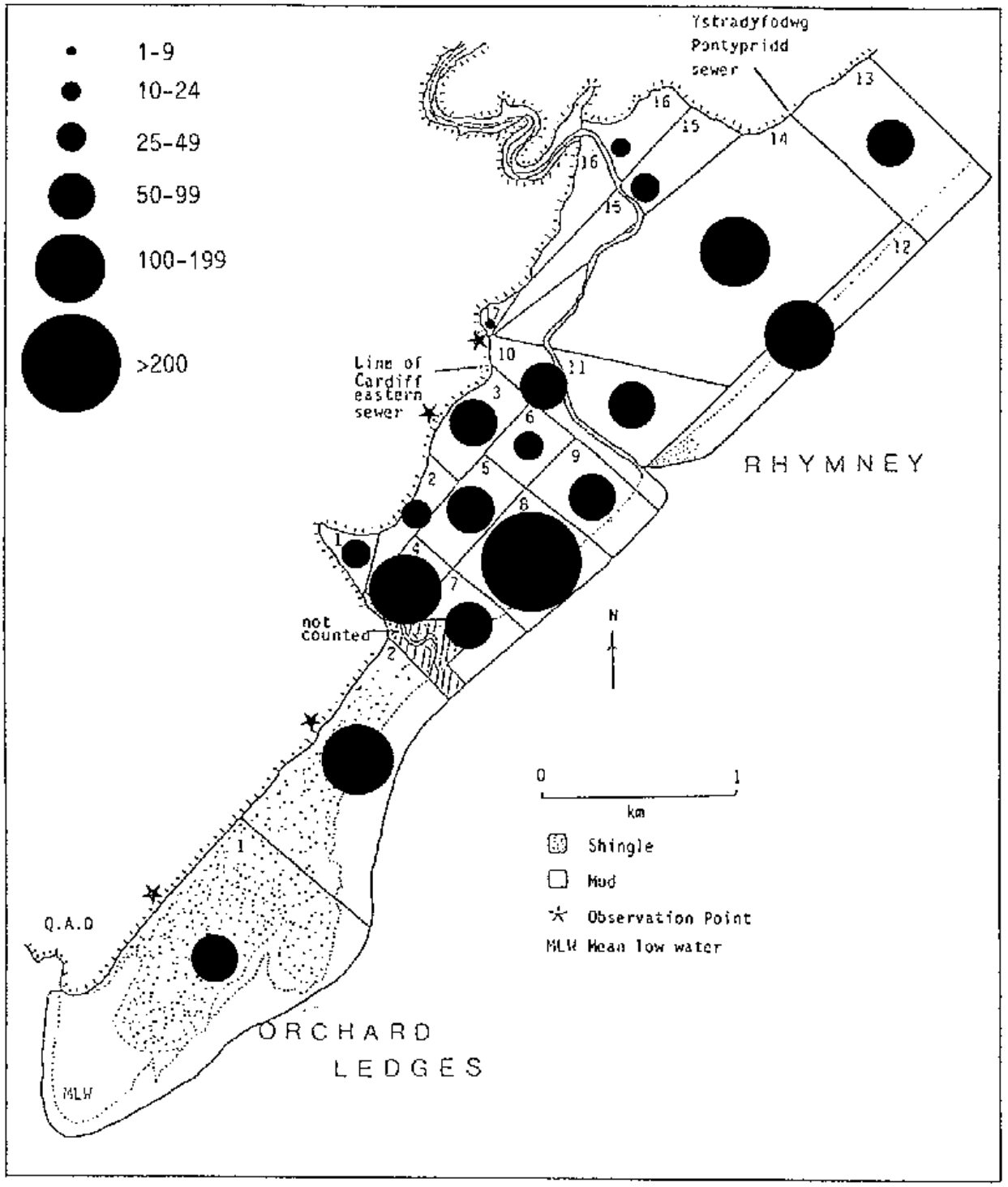


Figure 3.7.6 The distribution of feeding Oystercatcher on the Rhymney and Orchard Ledges all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

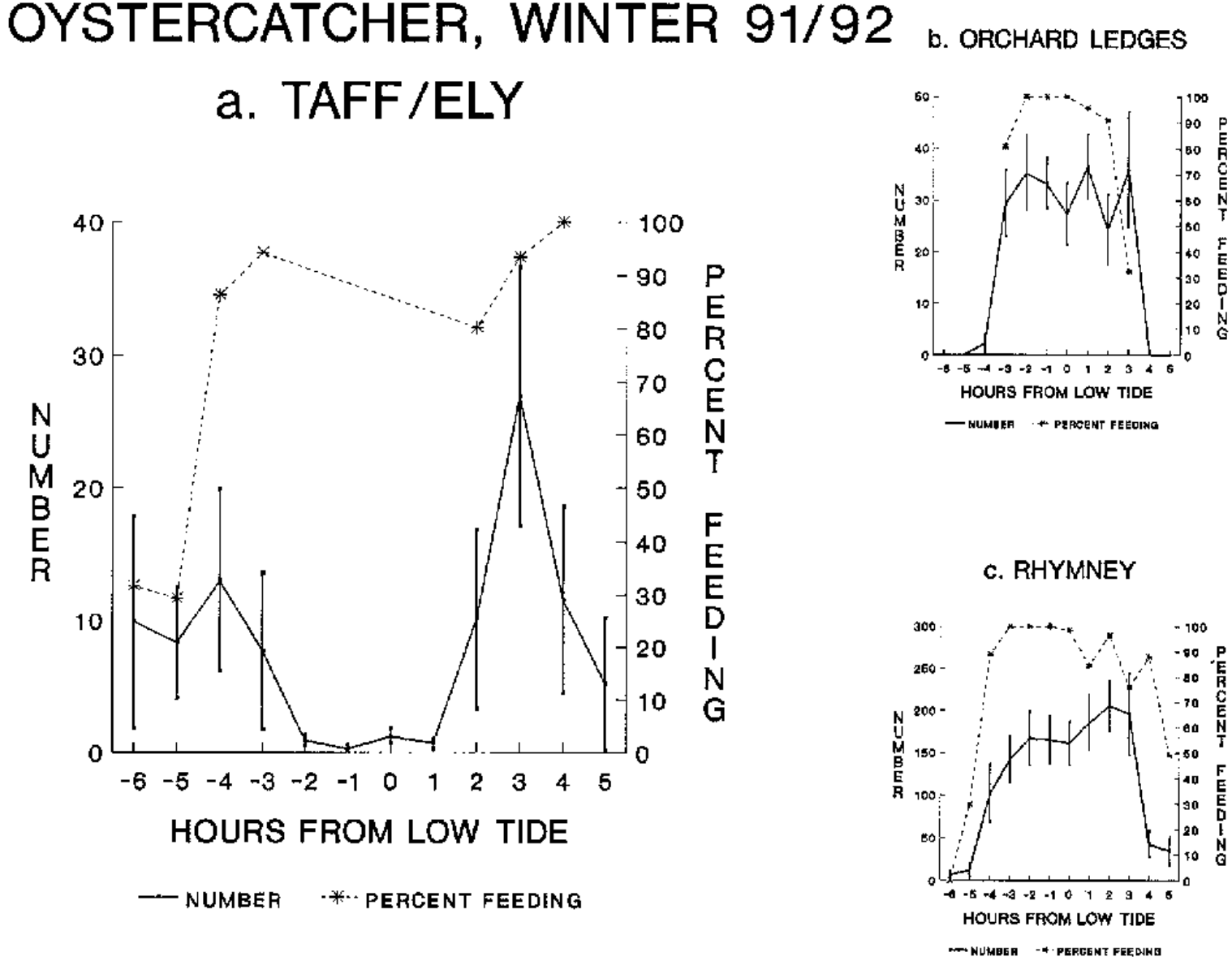
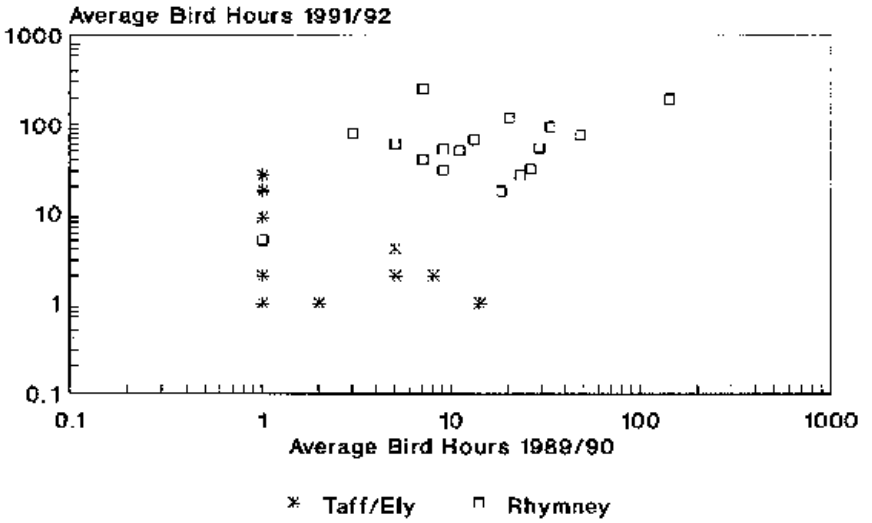


Figure 3.7.7 The total number of Oystercatcher present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during winter 1991/92.

OYSTERCATCHER, WINTER

a. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1989/90 and 1991/92.



b. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1990/91 and 1991/92.

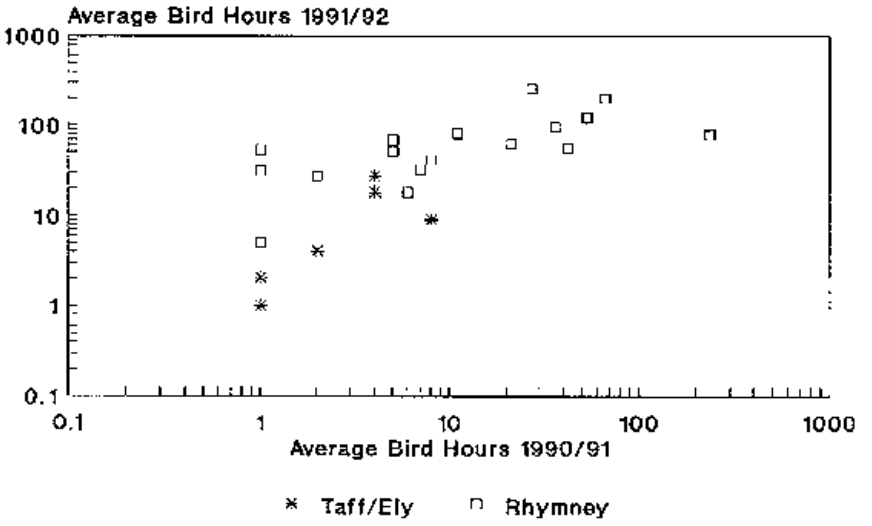


Figure 3.7.8 A comparison of usage values for Oystercatcher between winter 1989/90 and winter 1991/92 and between winter 1990/91 and winter 1991/92.

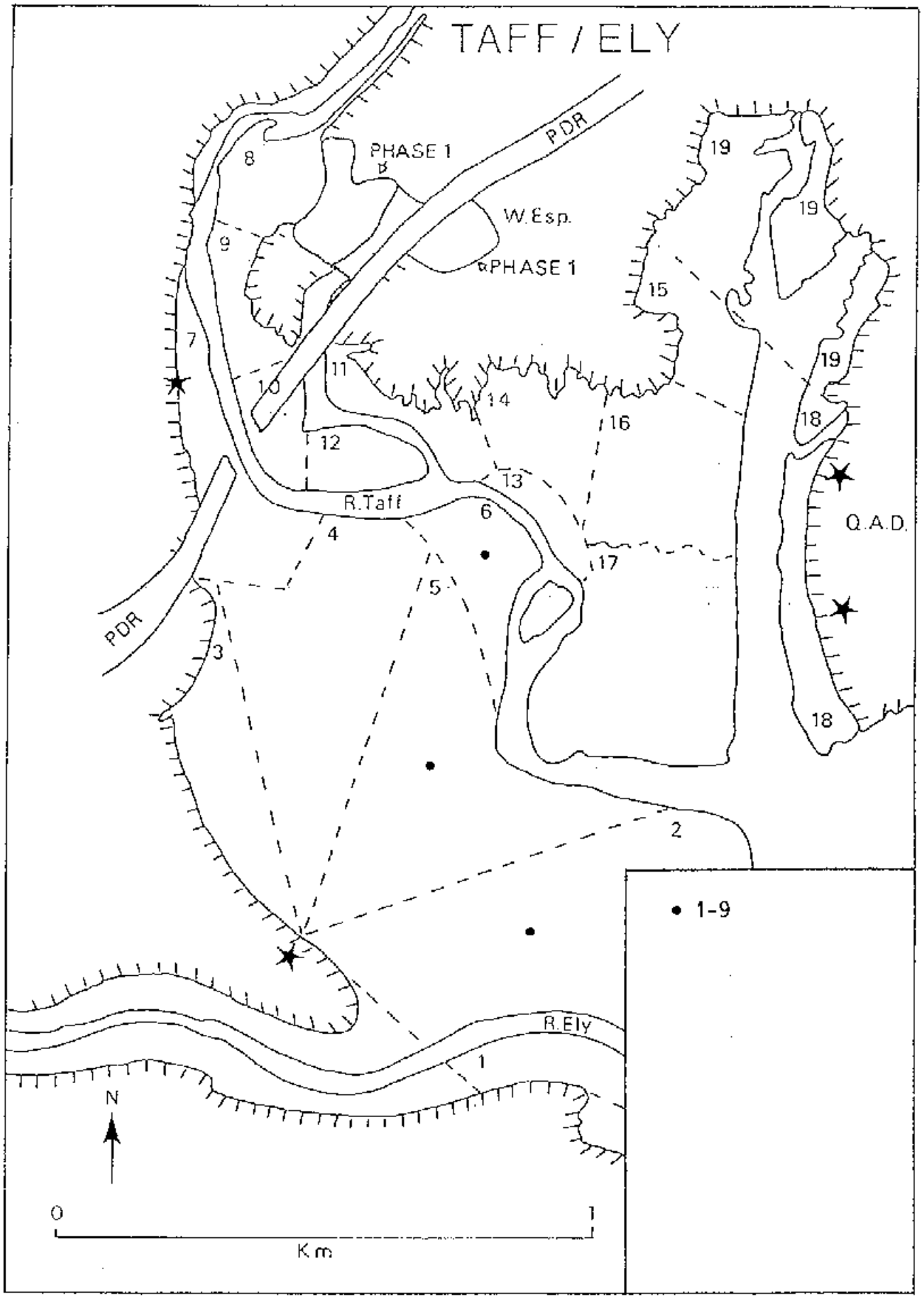


Figure 3.7.9 The distribution of feeding Oystercatcher on the Taff/Ely all day site during the spring 1992. The average number of bird hours per tidal cycle is depicted.

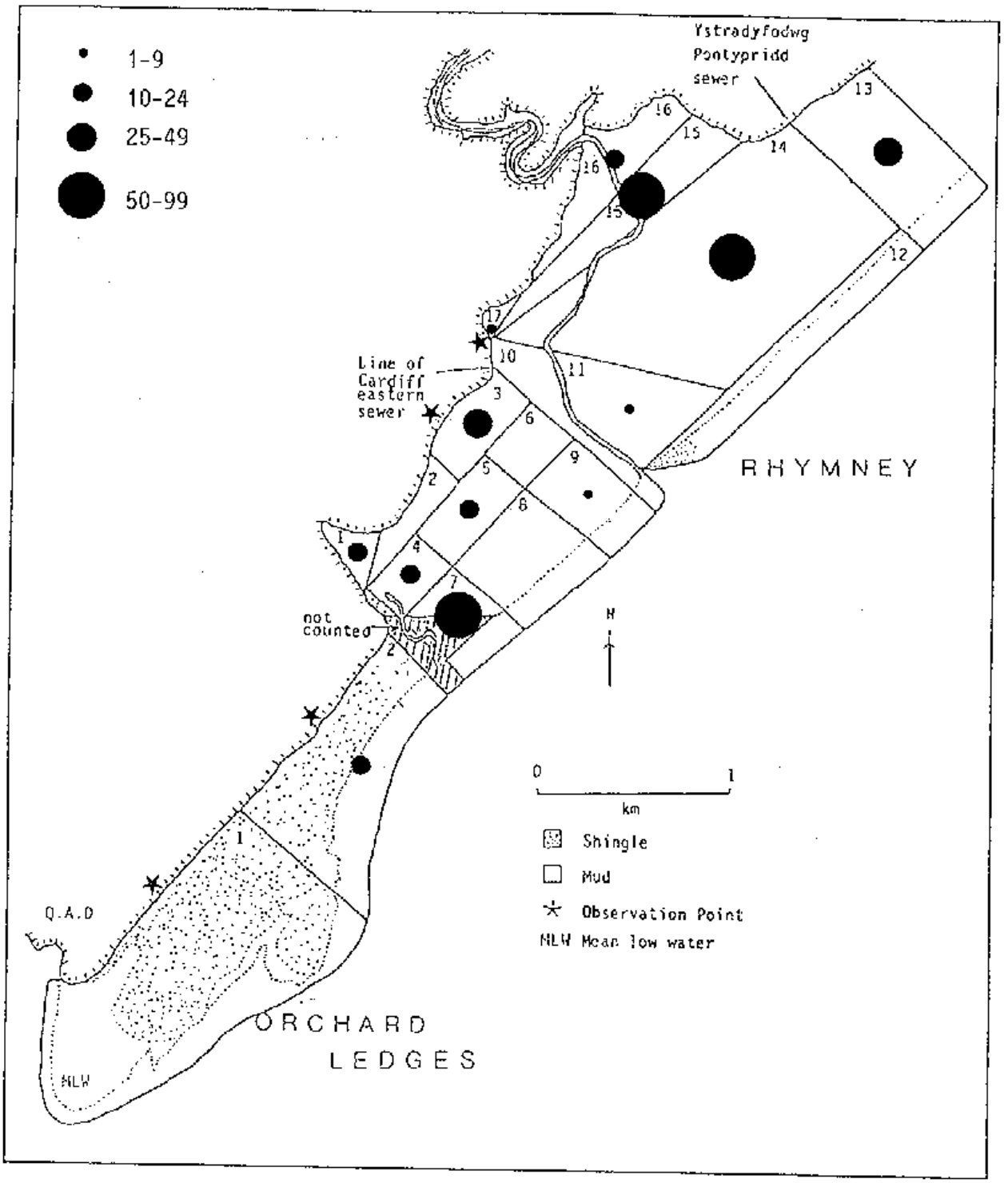


Figure 3.7.10 The distribution of feeding Oystercatcher on the Rhymney and Orchard Ledges all day site during the spring 1992. The average number of bird hours per tidal cycle is depicted.

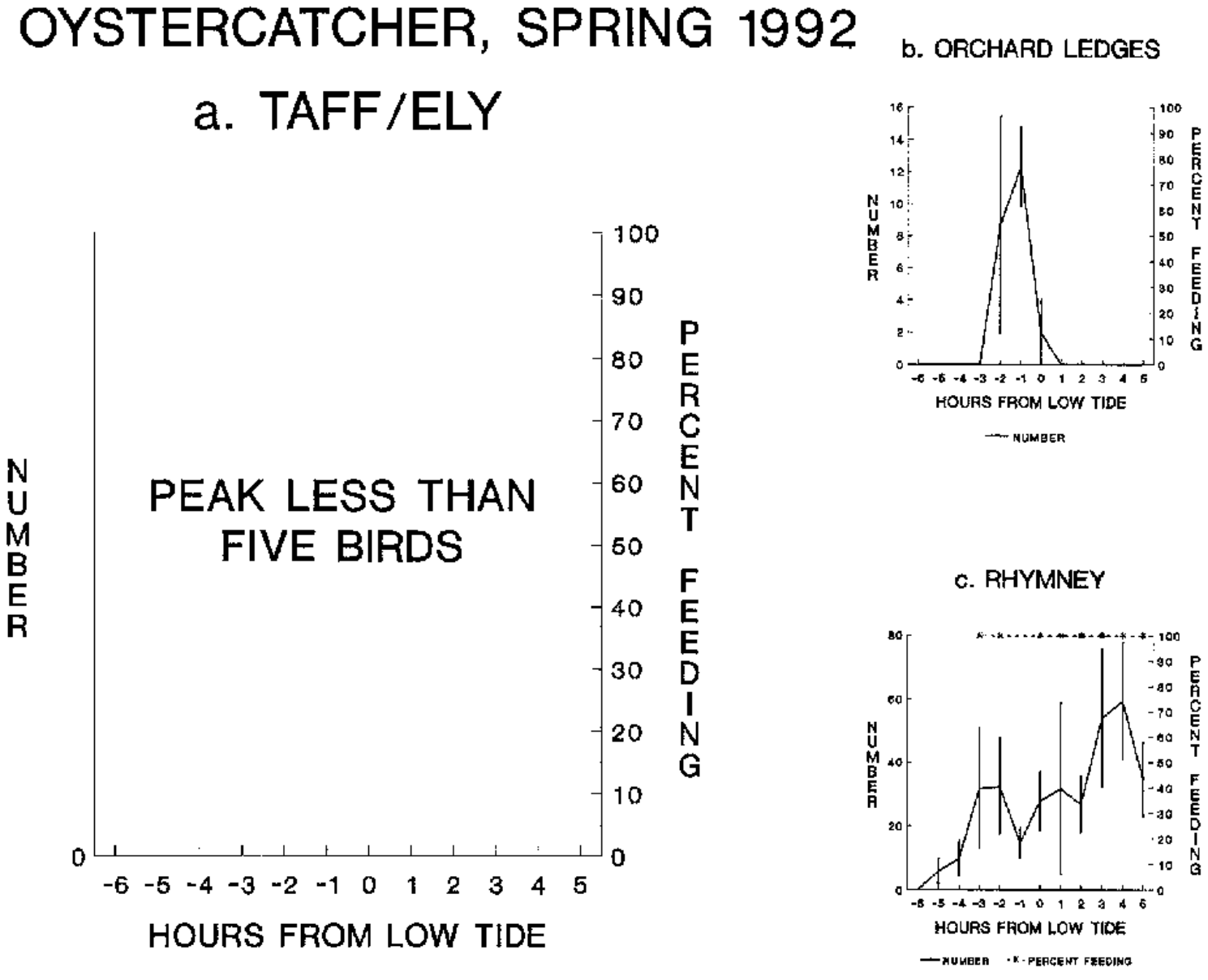


Figure 3.7.11 The total number of Oystercatcher present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during spring 1992.

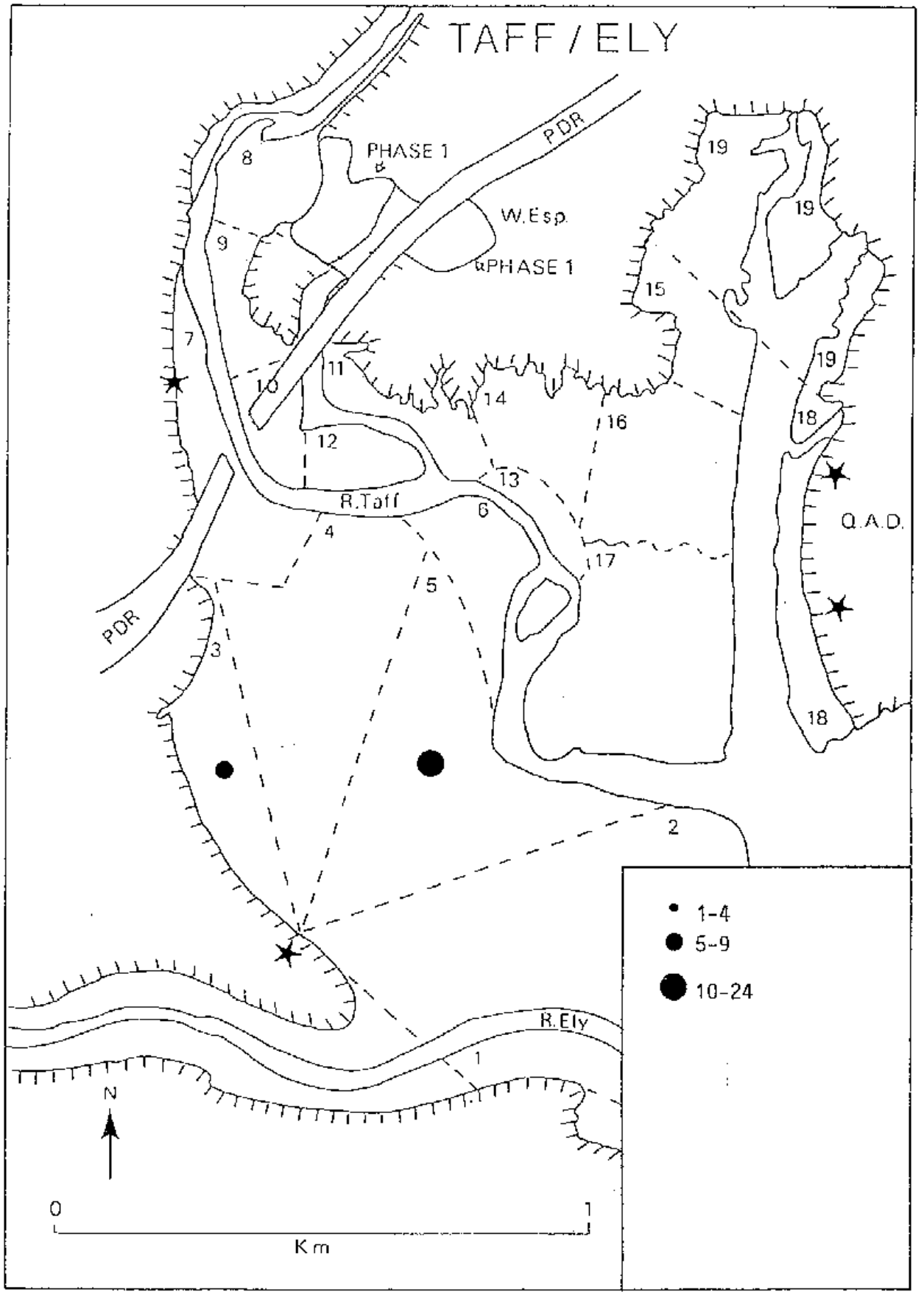


Figure 3.8.1 The distribution of feeding Ringed Plover on the Taff/Ely all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

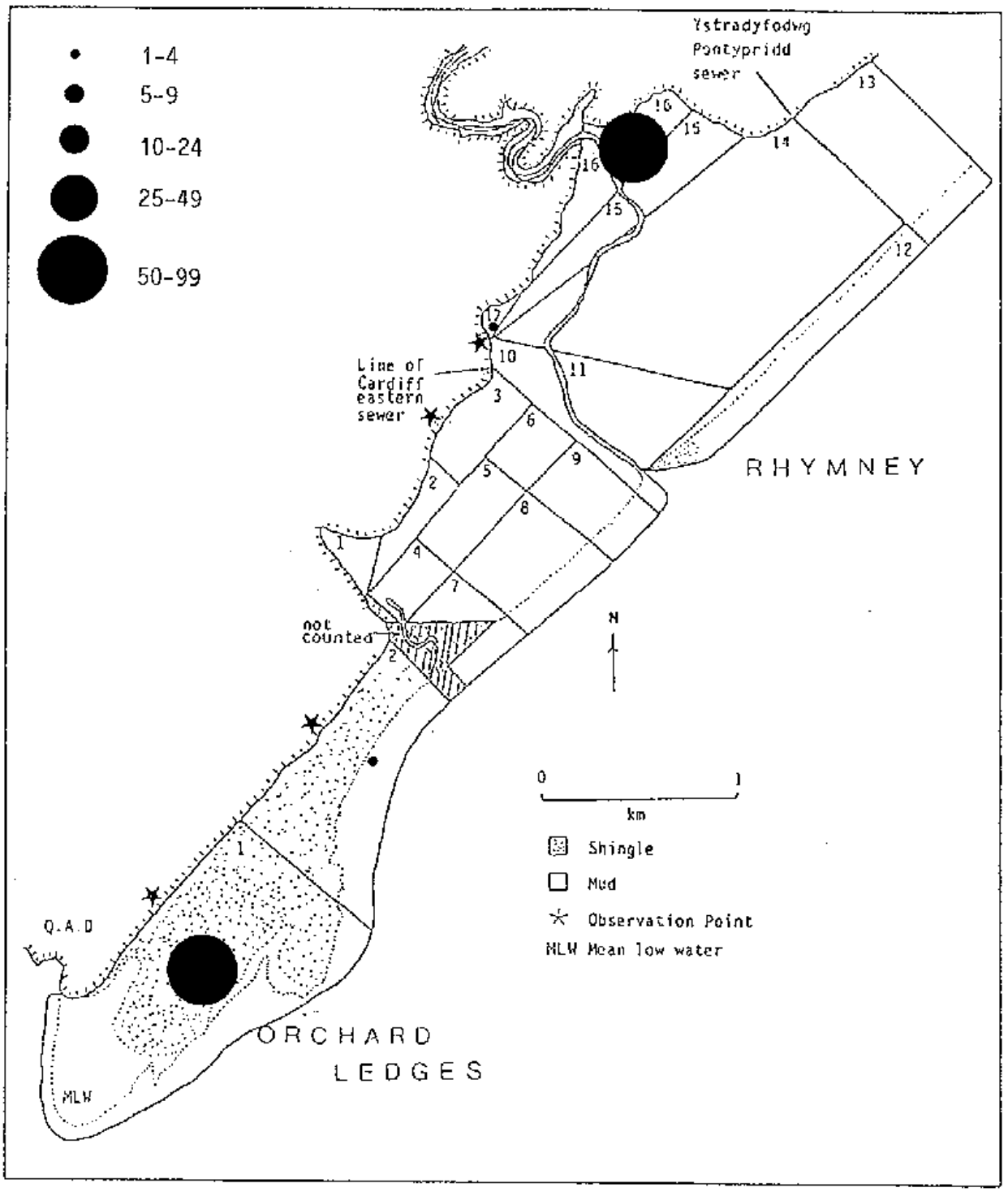


Figure 3.8.2 The distribution of feeding Ringed Plover on the Rhymneyand Orchard Ledges all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

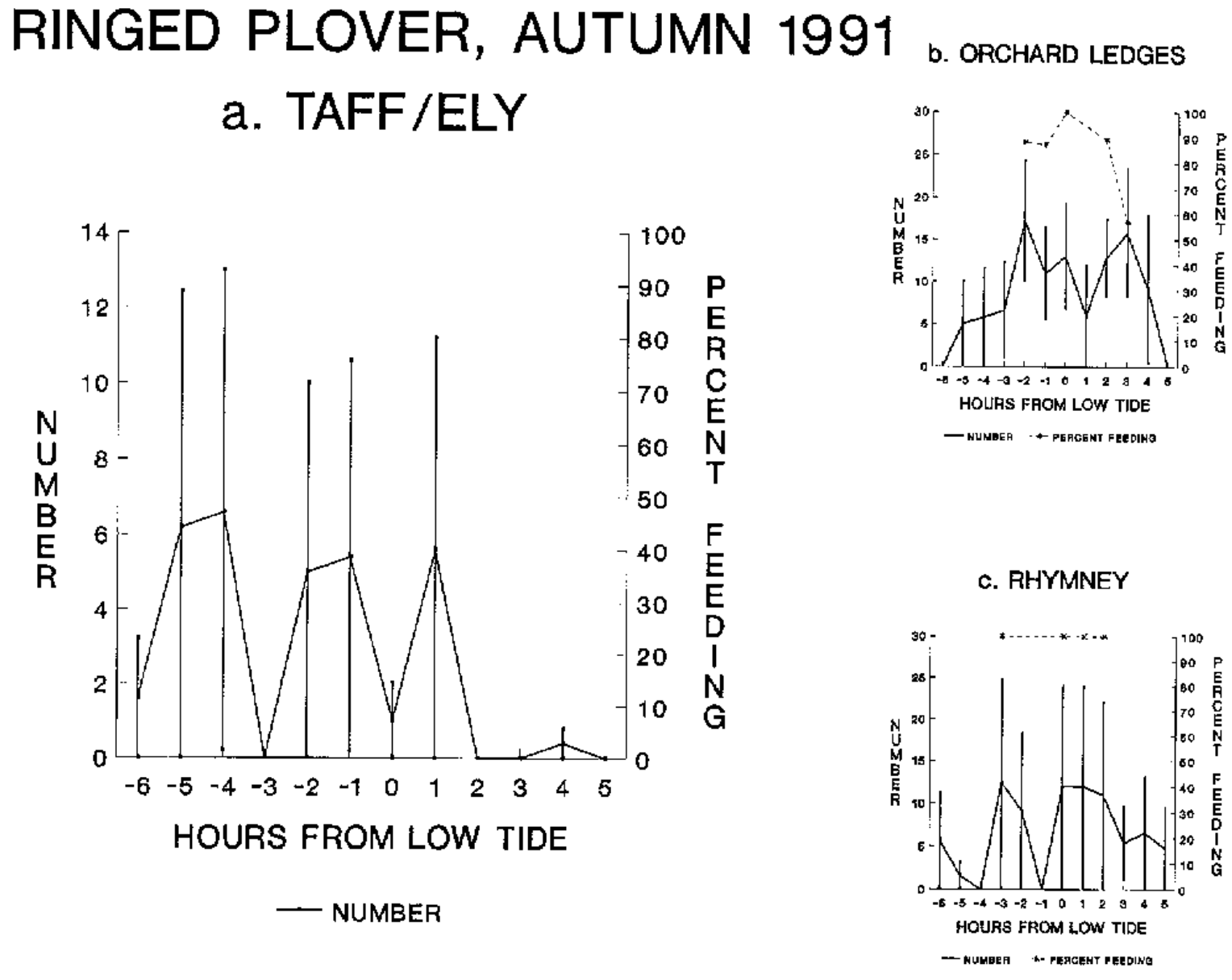


Figure 3.8.3 The total number of Ringed Plover present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during autumn 1991.

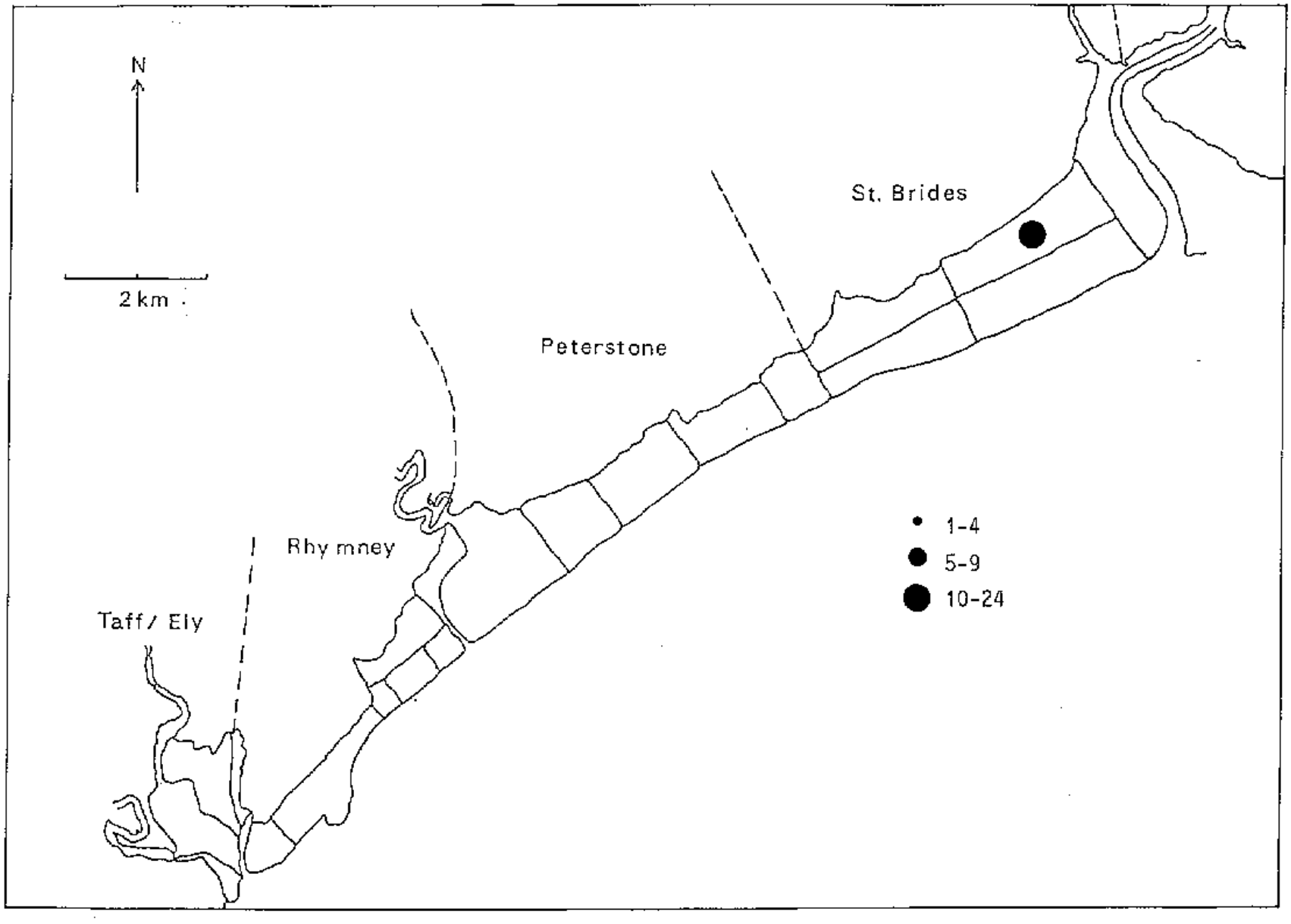


Figure 3.8.4 The low tide distribution of feeding Ringed Plover on the northwest Severn during winter 1991/92.

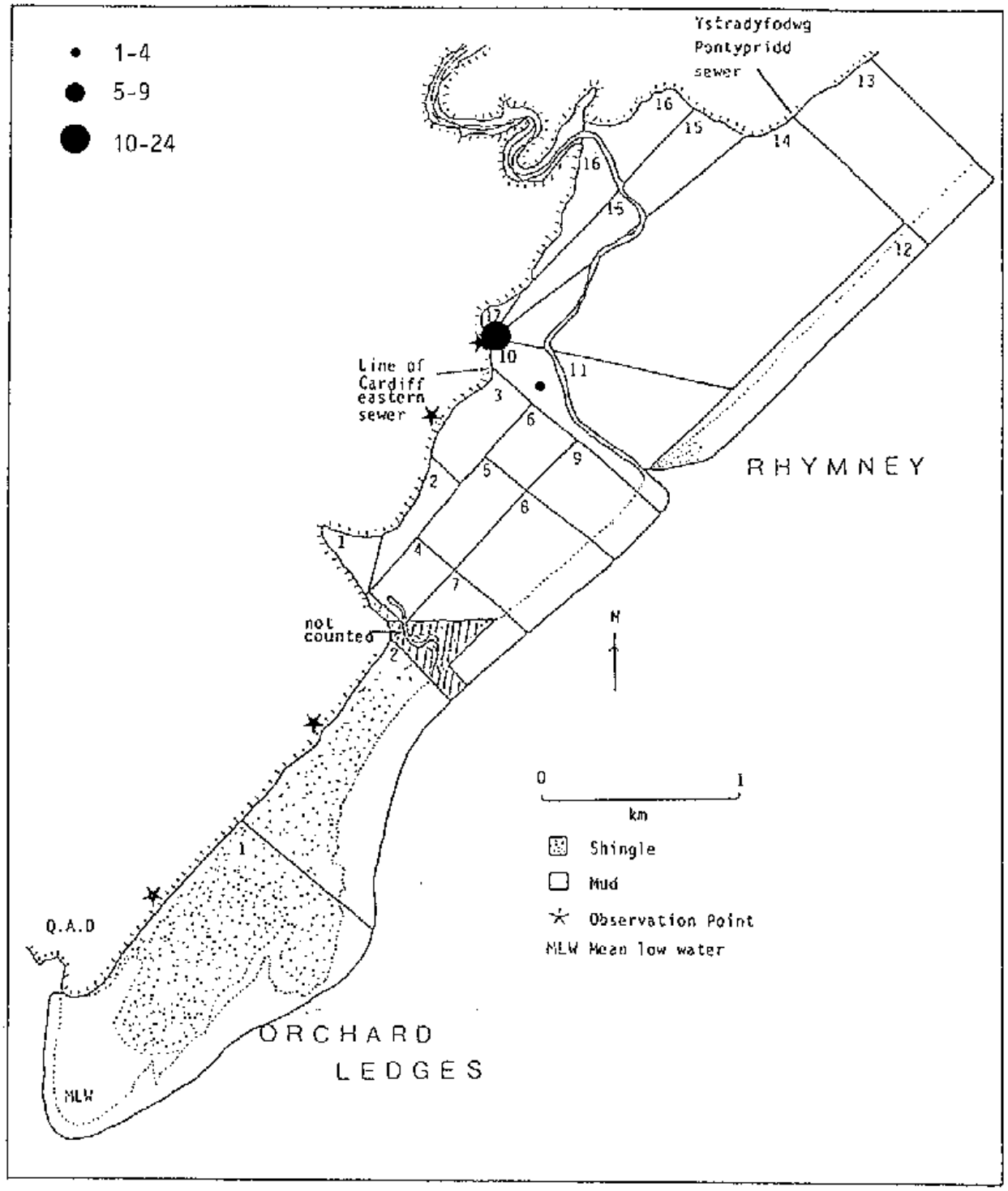


Figure 3.8.5 The distribution of feeding Ringed Plover on the Rhymneyand Orchard Ledges all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

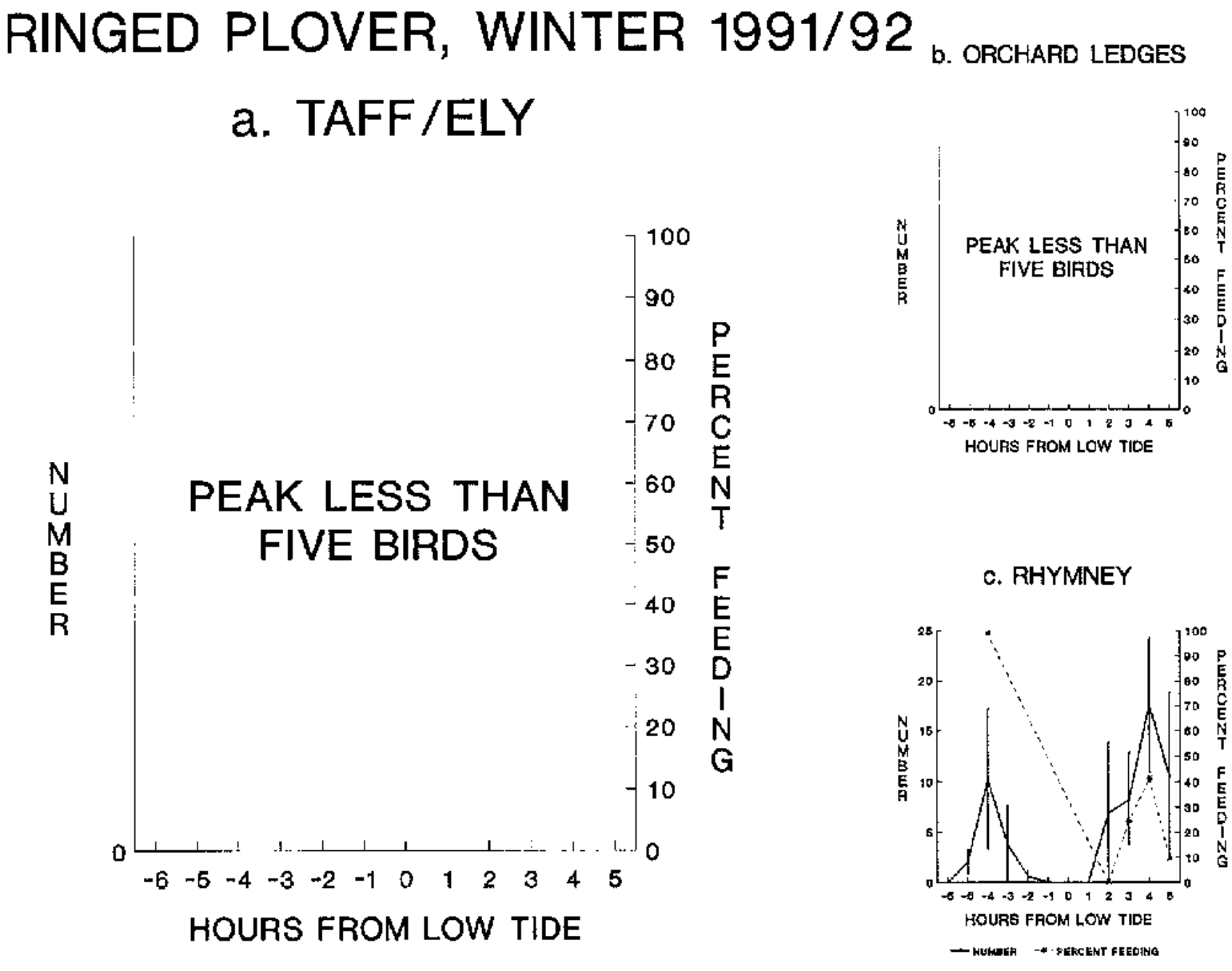


Figure 3.8.6 The total number of Ringed Plover present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during winter 1991/92.

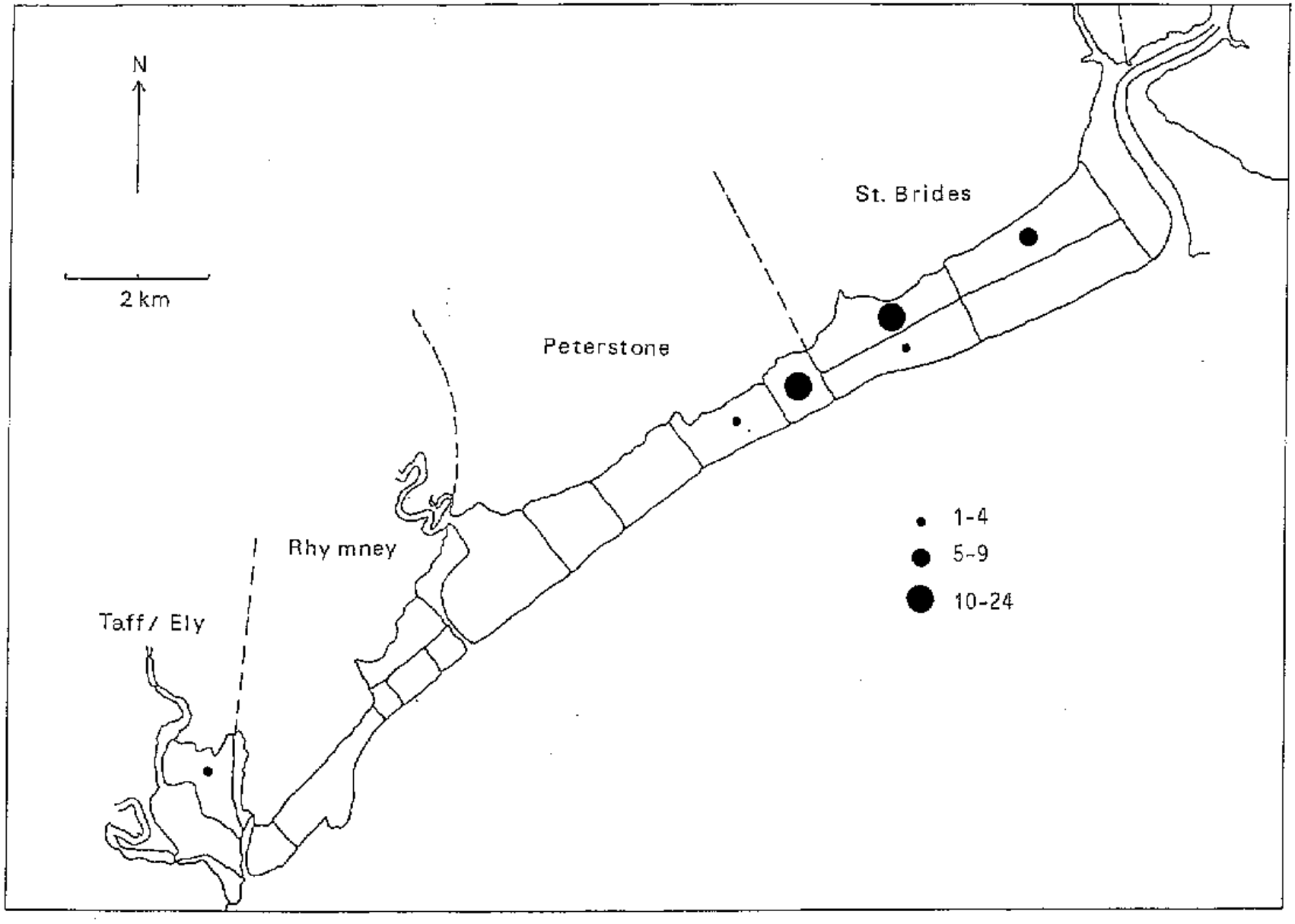


Figure 3.10.1 The low tide distribution of feeding Grey Plover on the northwest Severn during winter 1991/92.

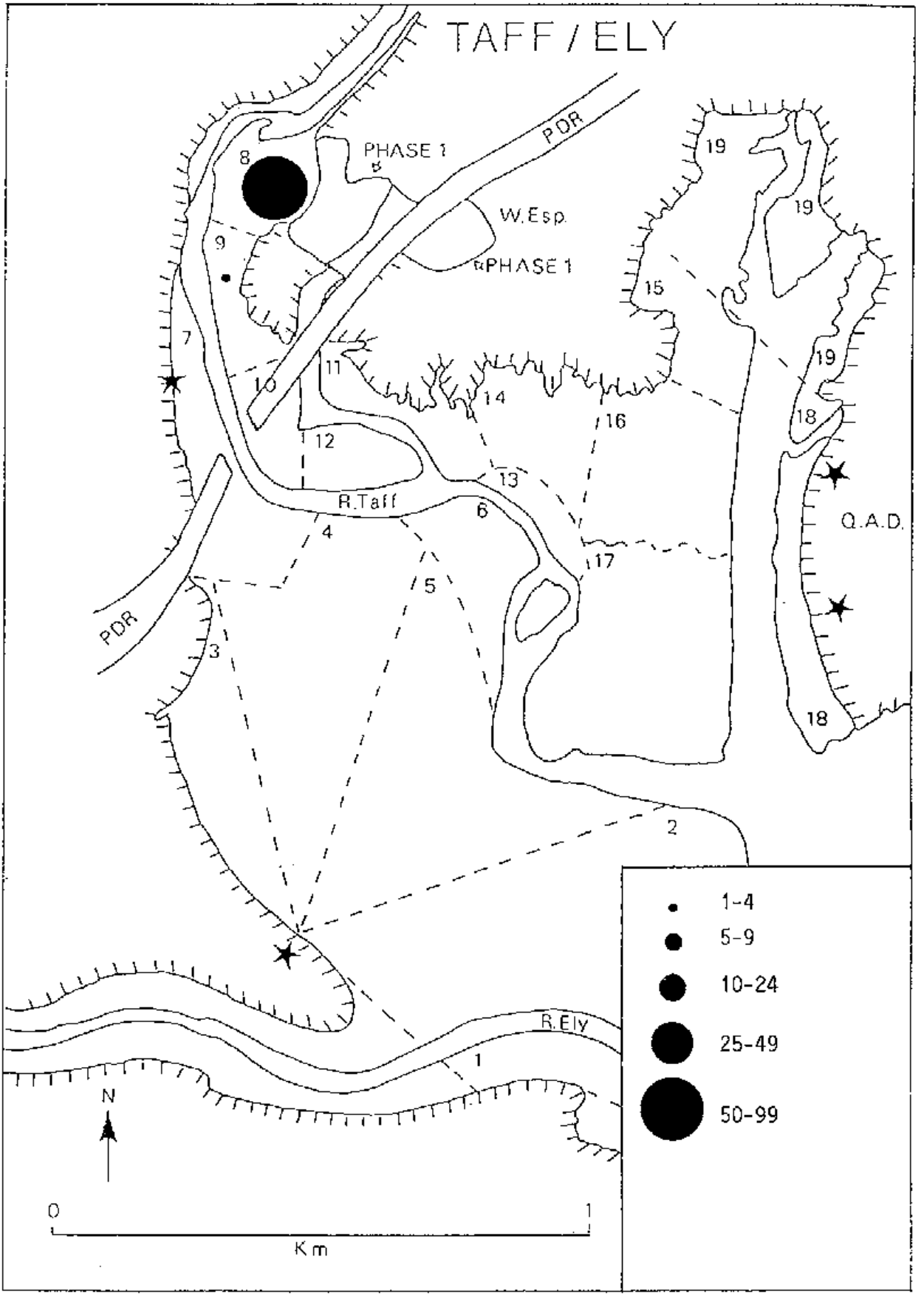


Figure 3.11.1 The distribution of feeding Lapwing on the Taff/Ely all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

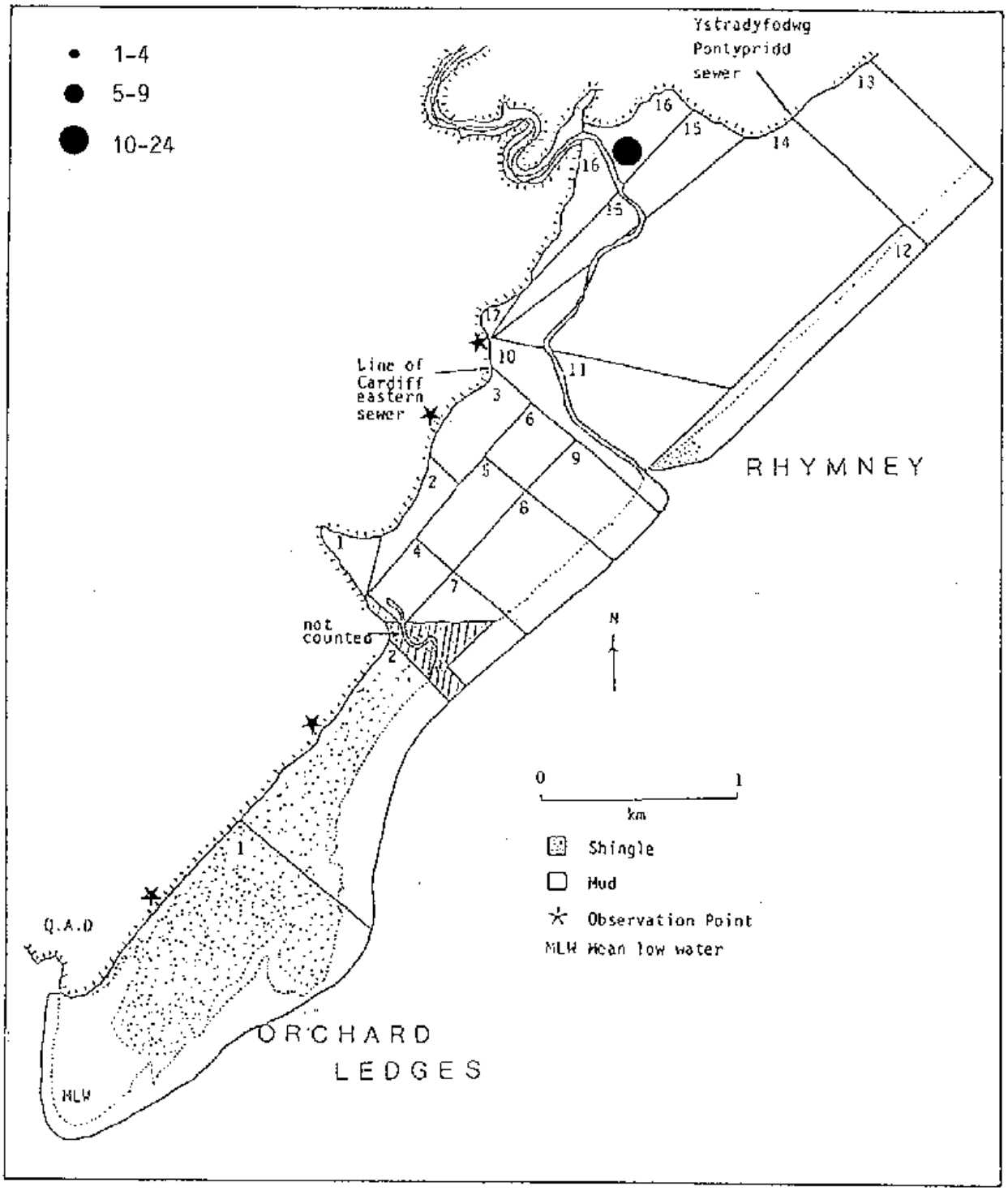


Figure 3.11.2 The distribution of feeding Lapwing on the Rhymney and Orchard Ledges all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

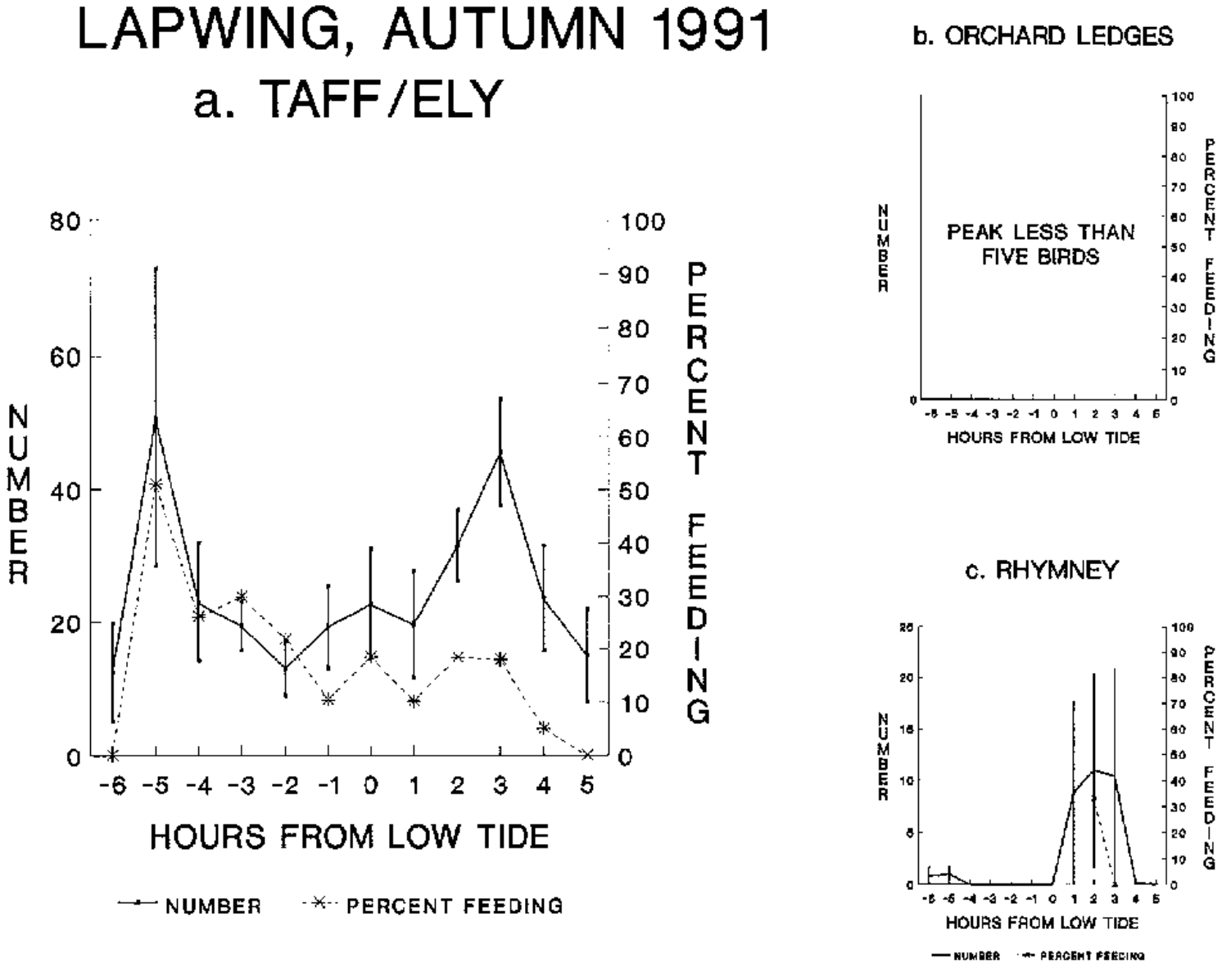


Figure 3.11.3 The total number of Lapwing present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during autumn 1991.

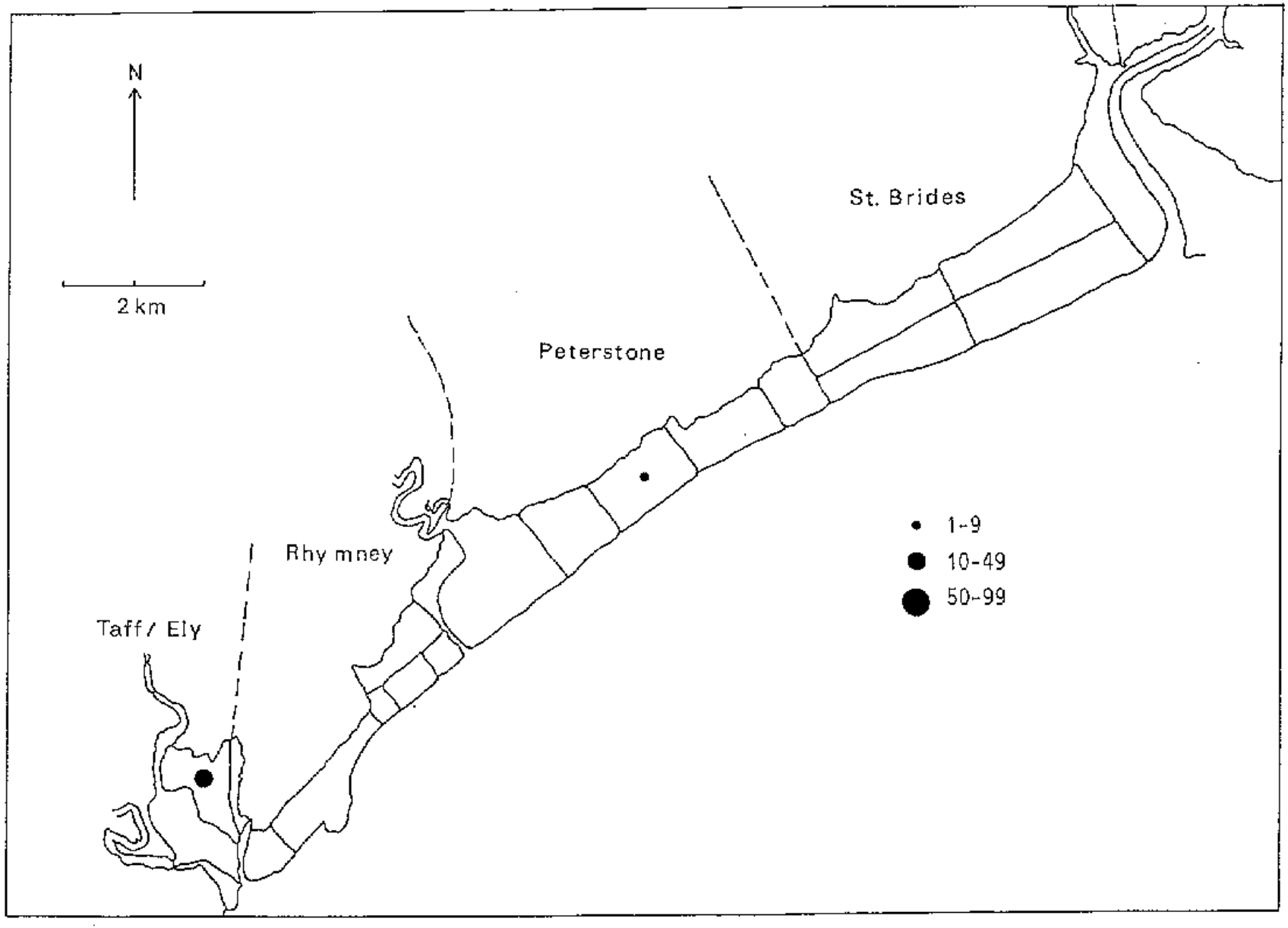


Figure 3.11.4 The low tide distribution of feeding Lapwing on the northwest Severn during winter 1991/92.

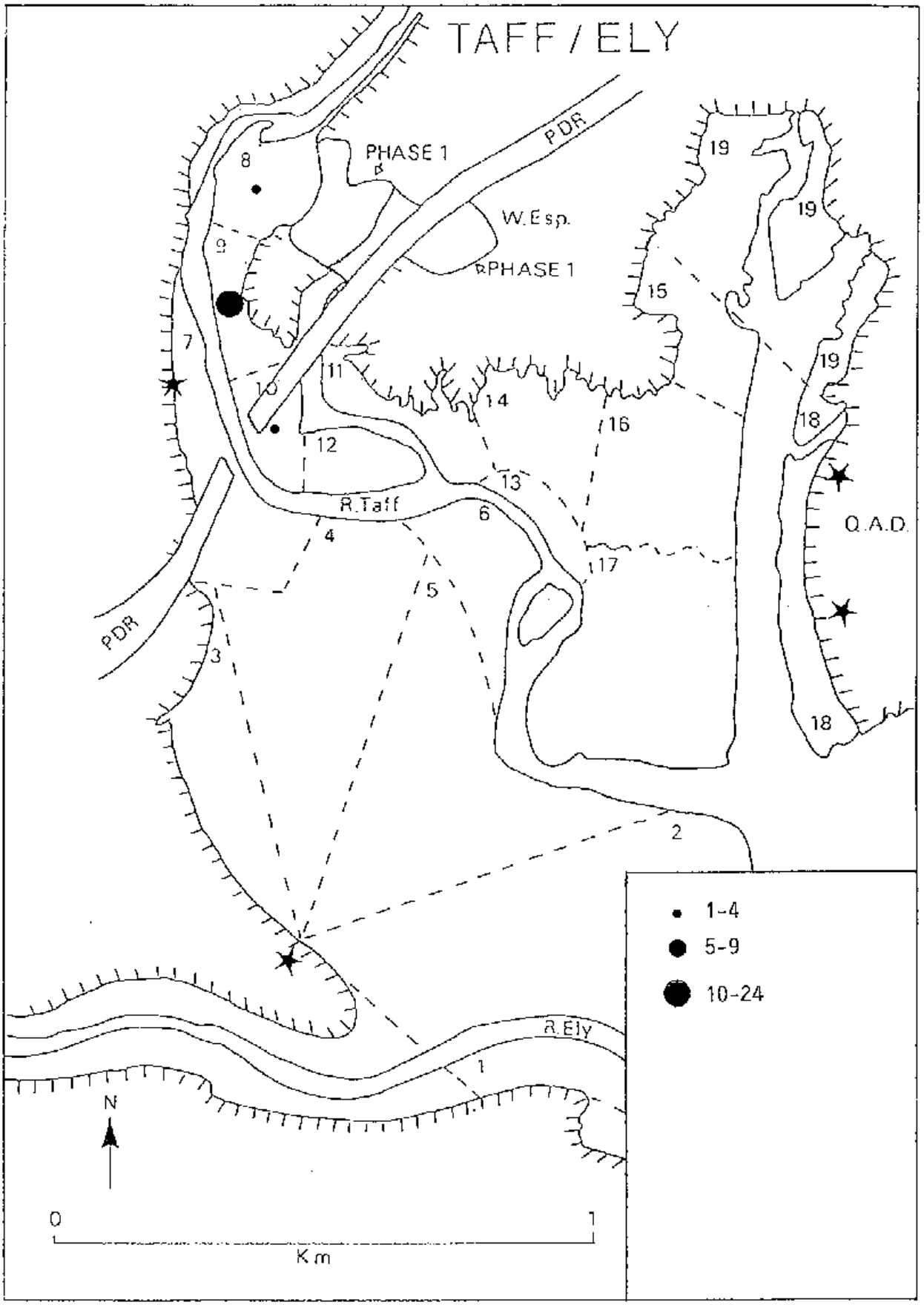


Figure 3.11.5 The distribution of feeding Lapwing on the Taff/Ely all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

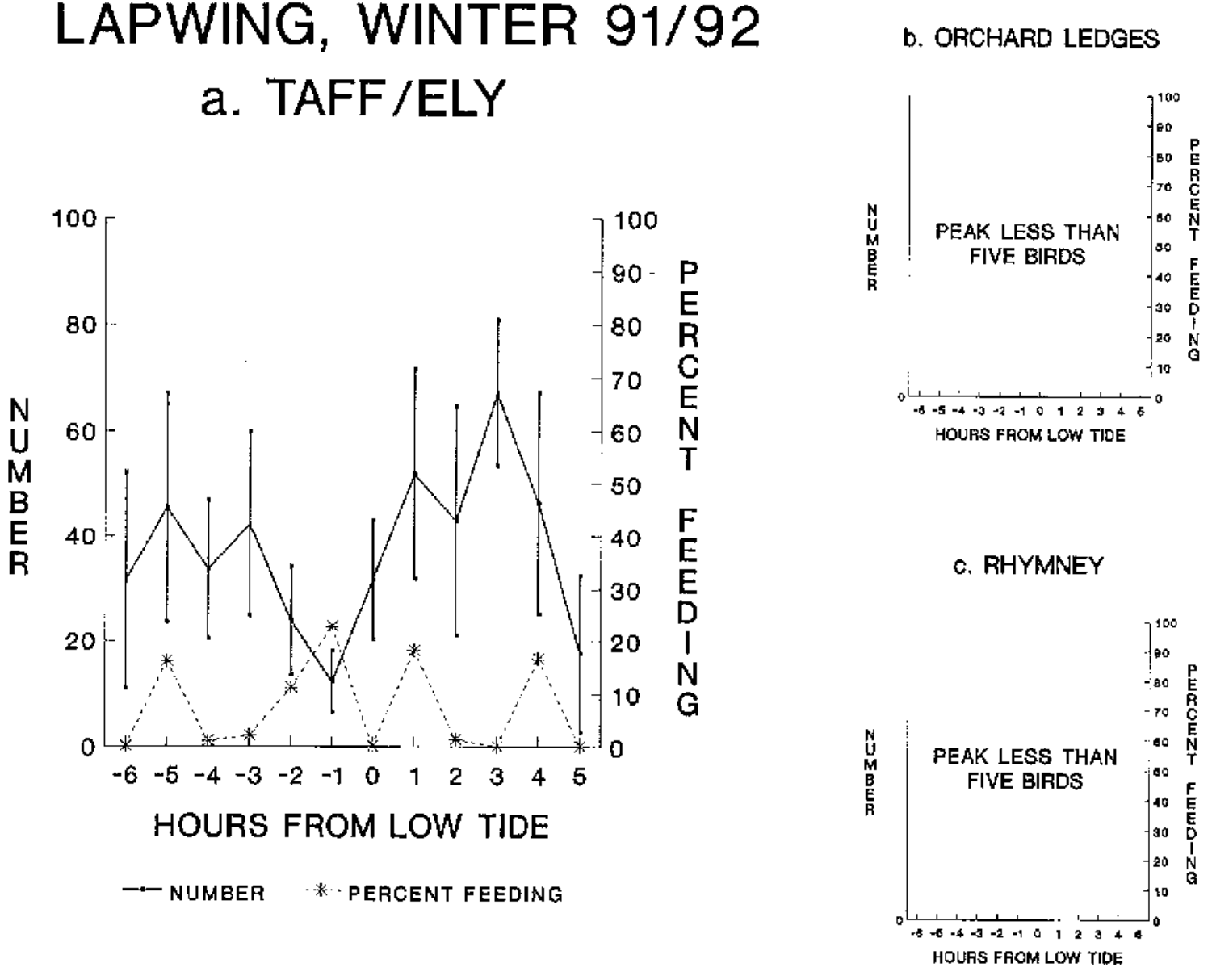


Figure 3.11.6 The total number of Lapwing present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during winter 1991/92.

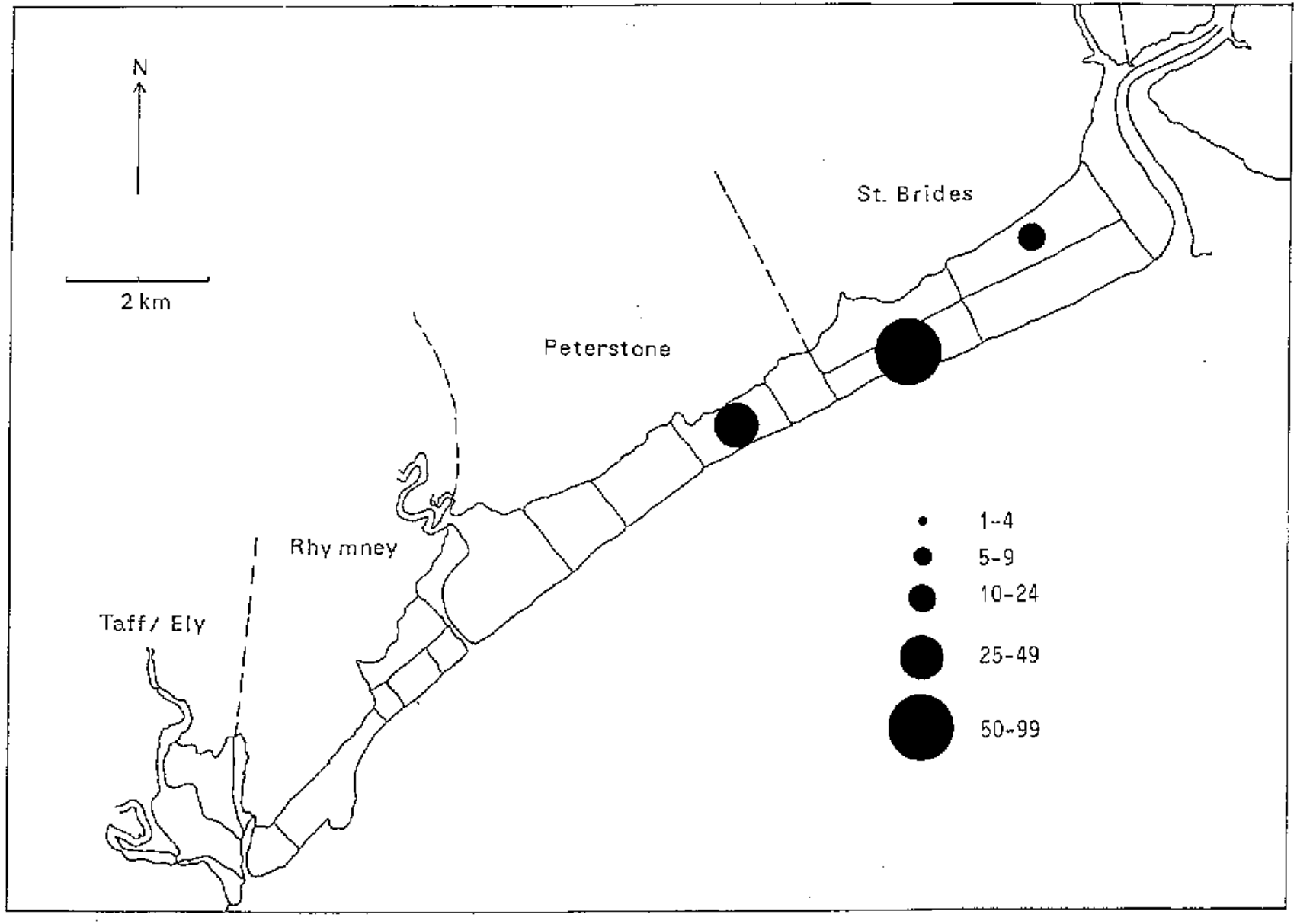


Figure 3.12.1 The low tide distribution of feeding Knot on the northwest Severn during winter 1991/92.

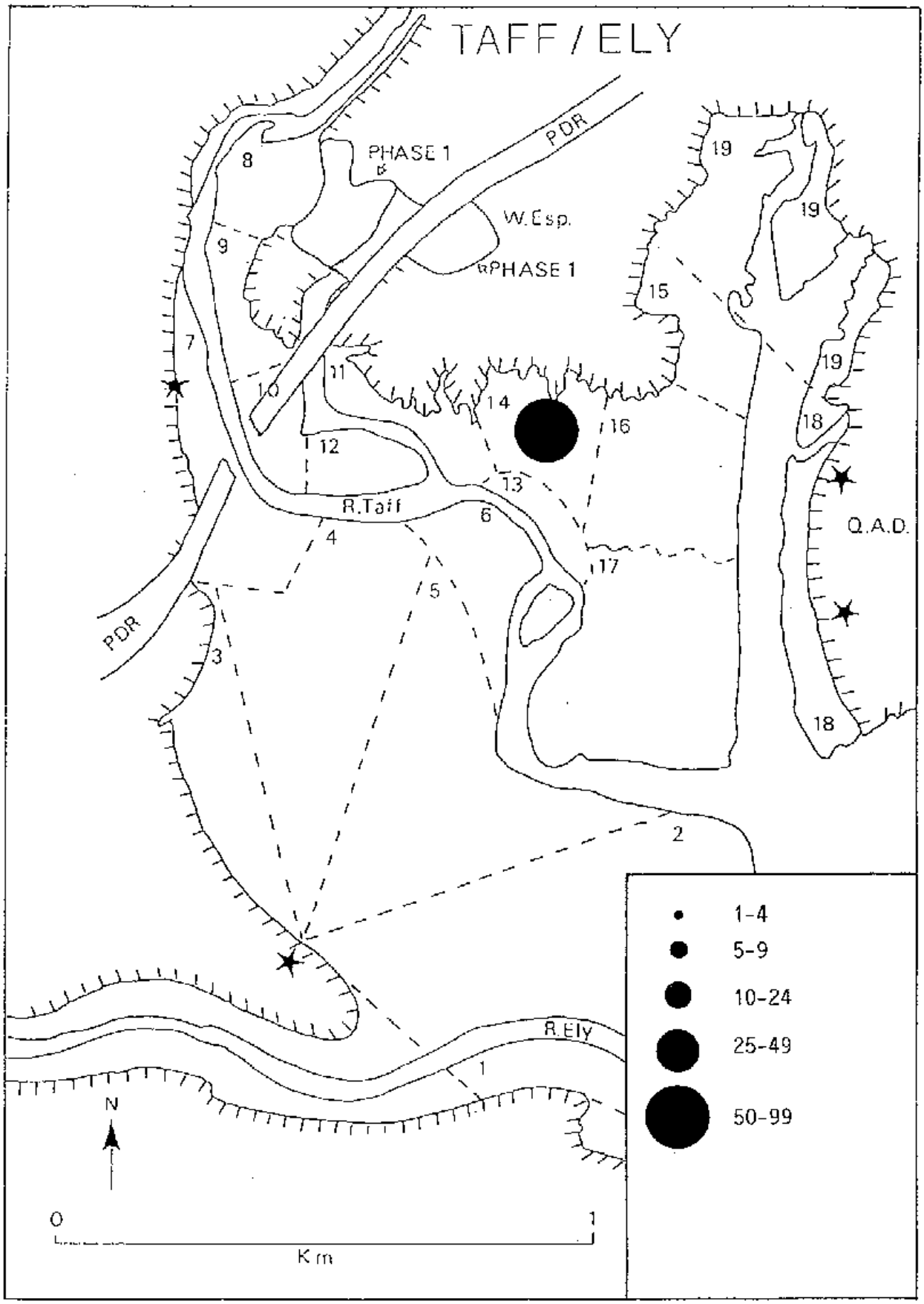


Figure 3.12.2 The distribution of feeding Knot on the Taff/Ely all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

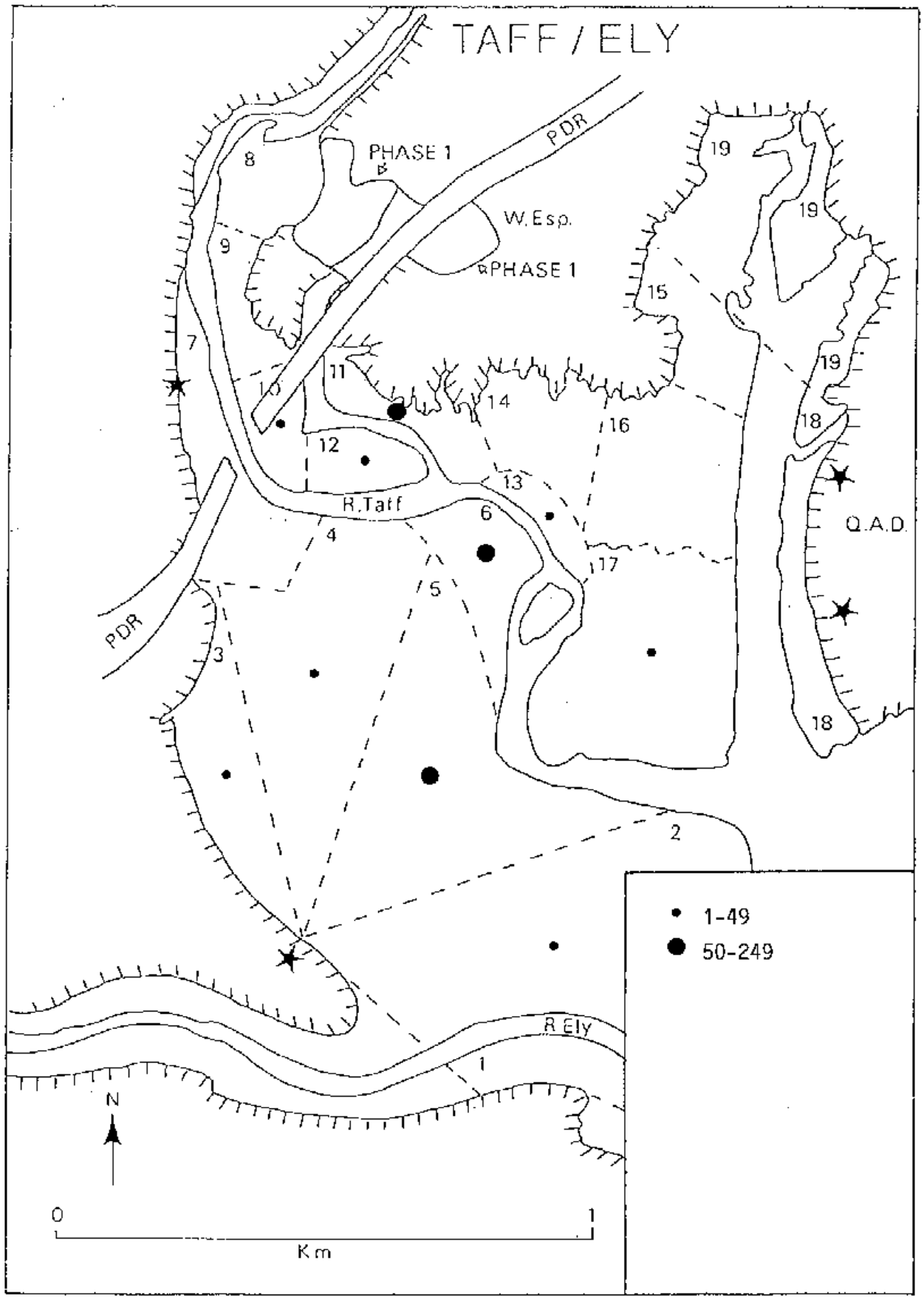


Figure 3.13.1 The distribution of feeding Dunlin on the Taff/Ely all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

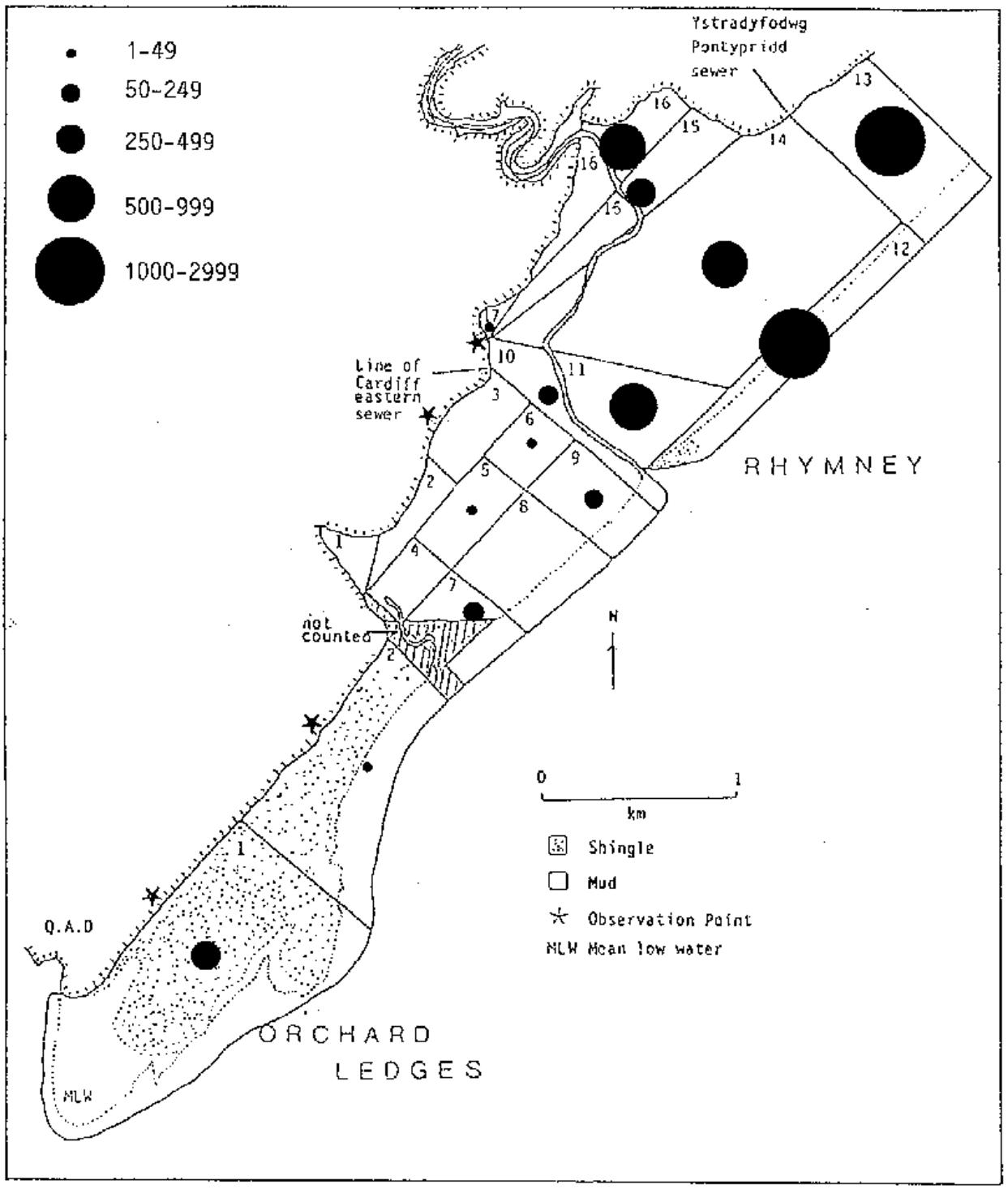


Figure 3.13.2 The distribution of feeding Dunlin on the Rhymney and Orchard Ledges all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

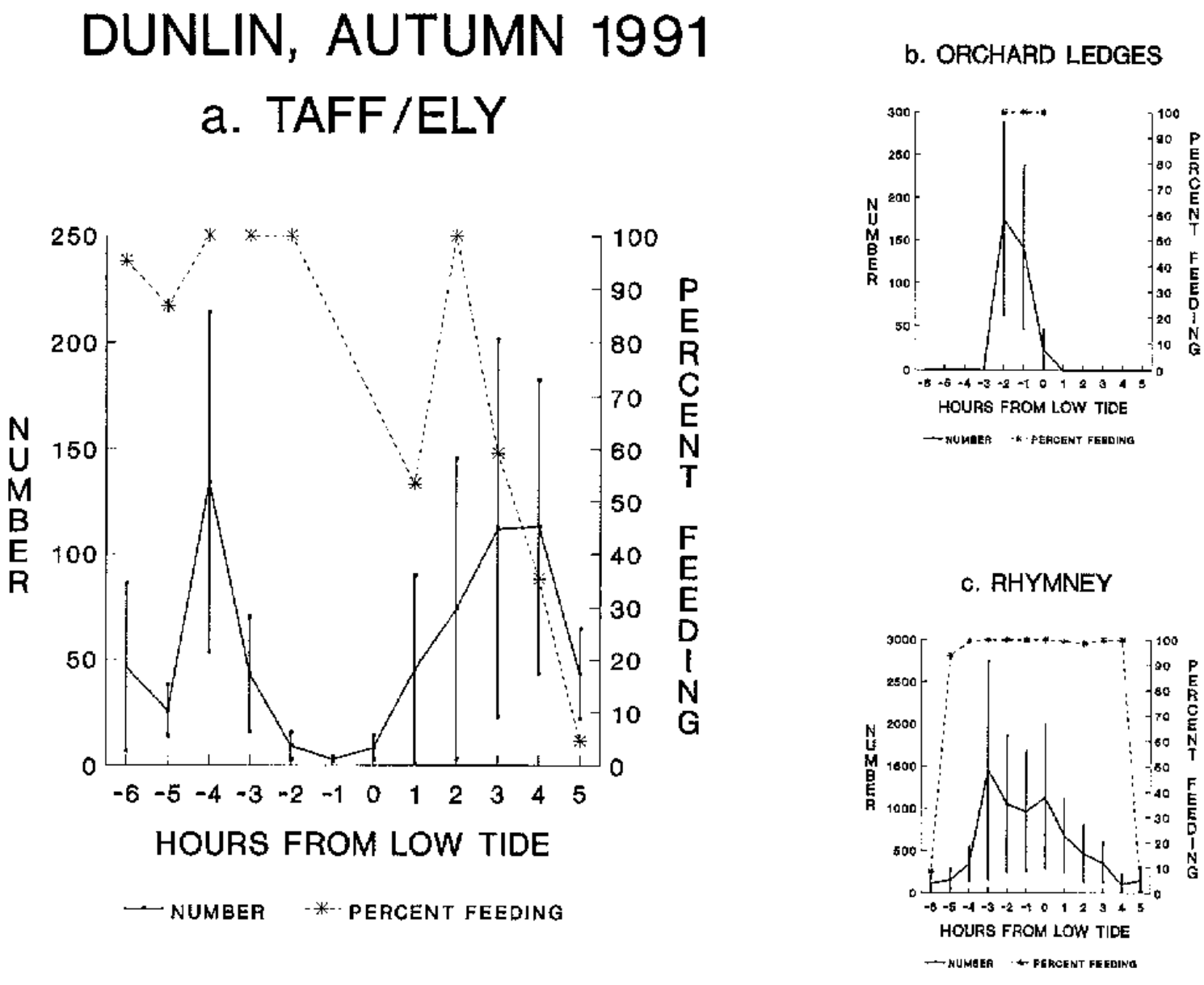


Figure 3.13.3 The total number of Dunlin present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during autumn 1991.

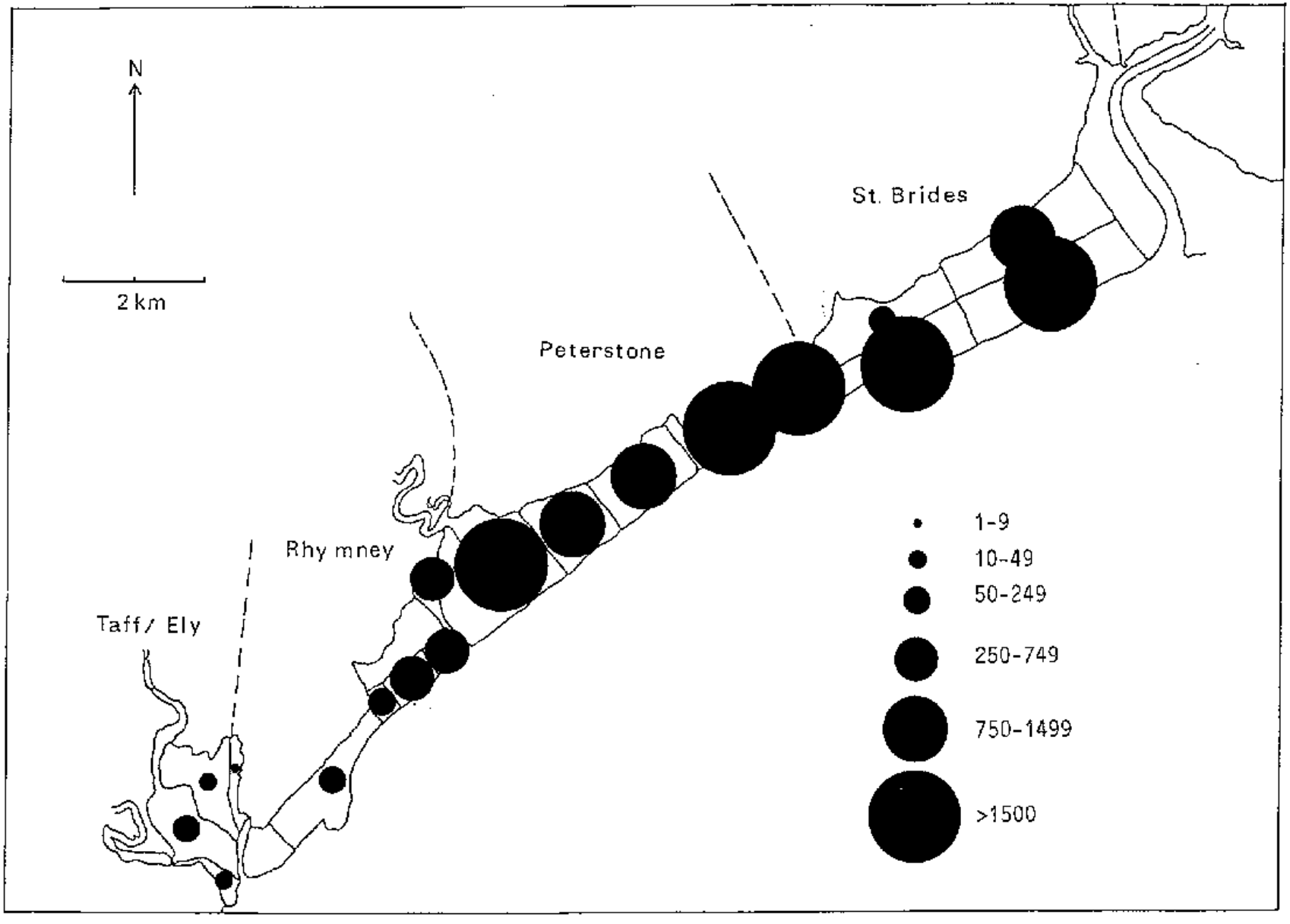


Figure 3.13.4 The low tide distribution of feeding Dunlin on the northwest Severn during winter 1991/92.

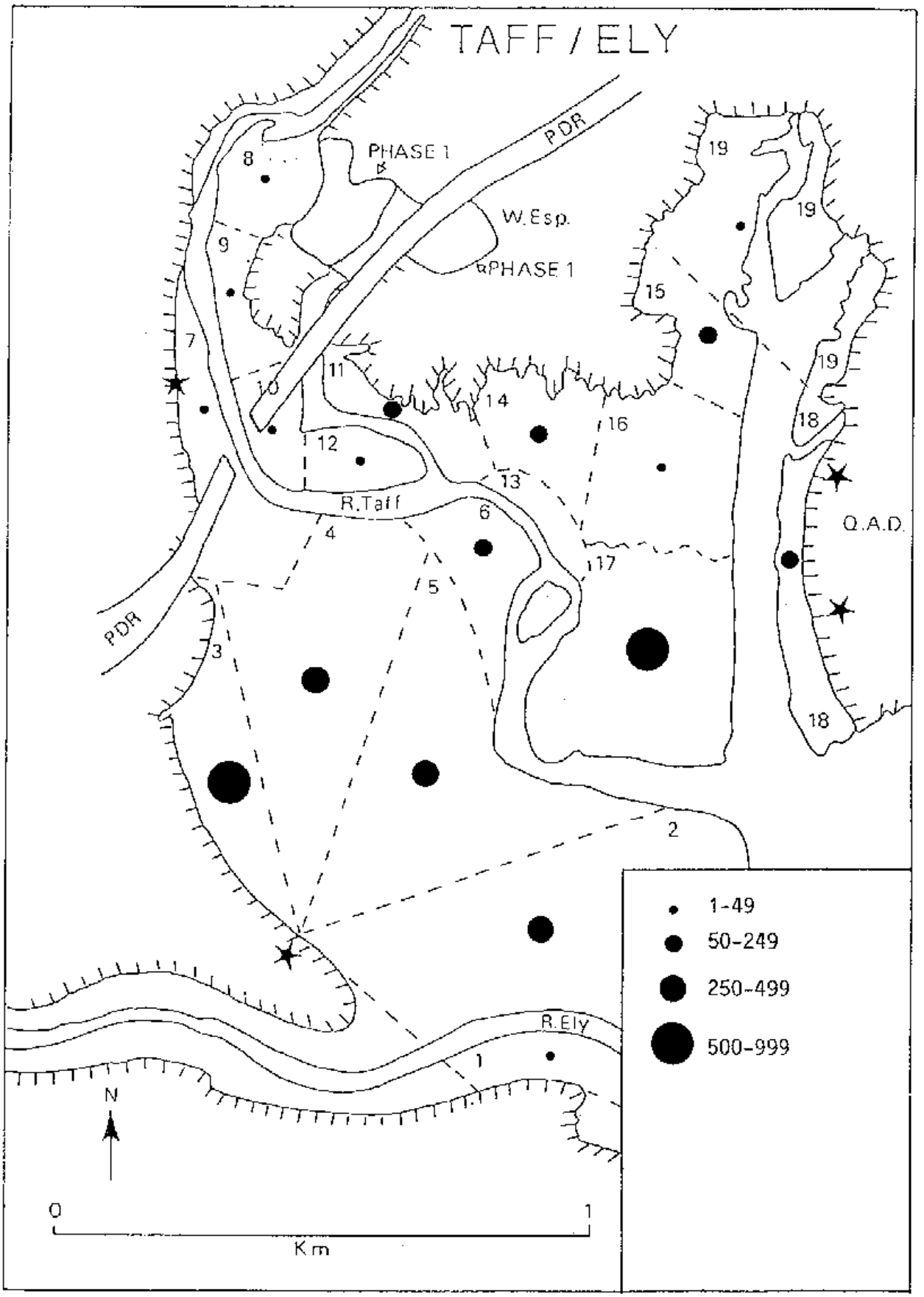


Figure 3.13.5 The distribution of feeding Dunlin on the Taff/Ely all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

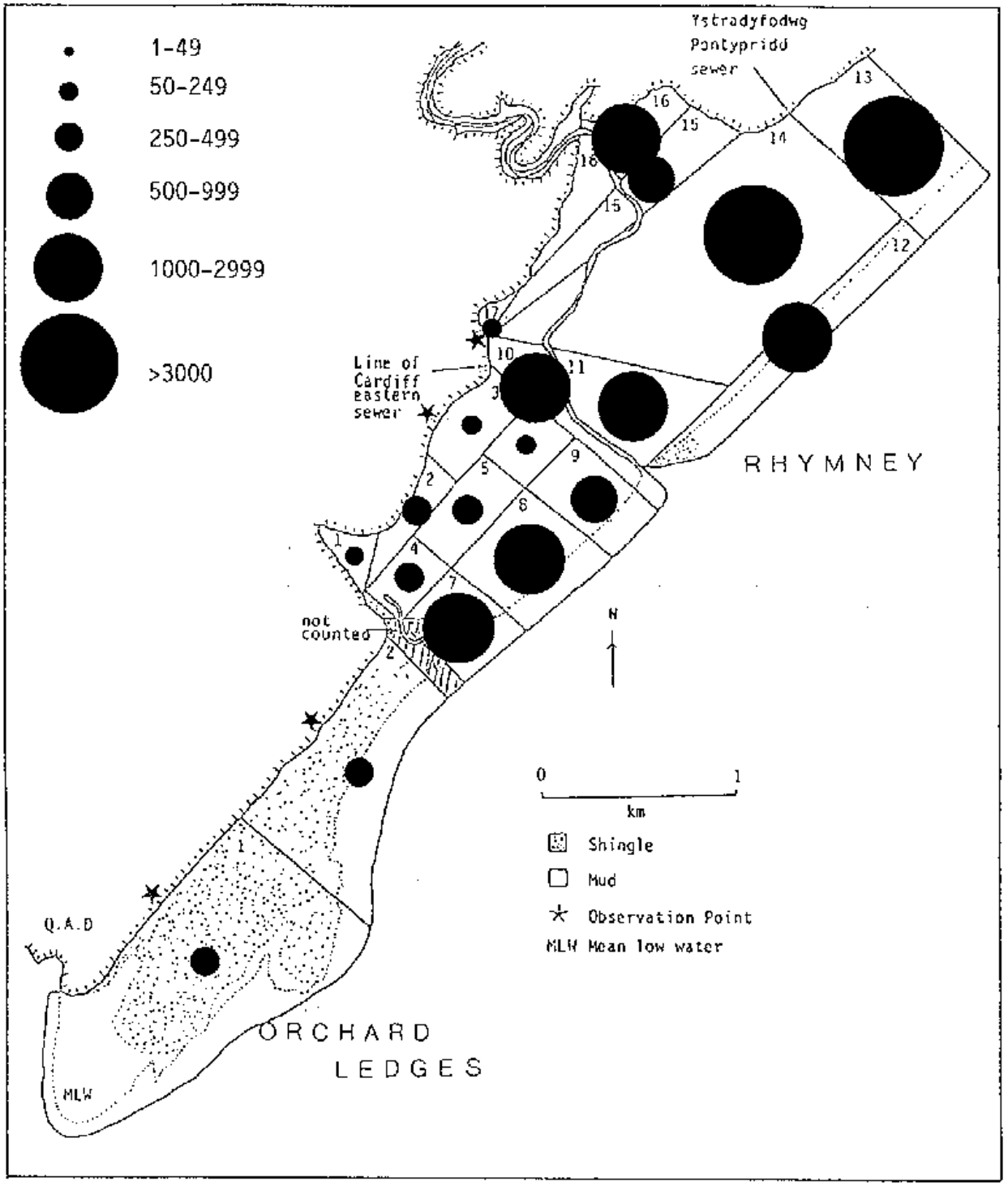


Figure 3.13.6 The distribution of feeding Dunlin on the Rhymney and Orchard Ledges all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

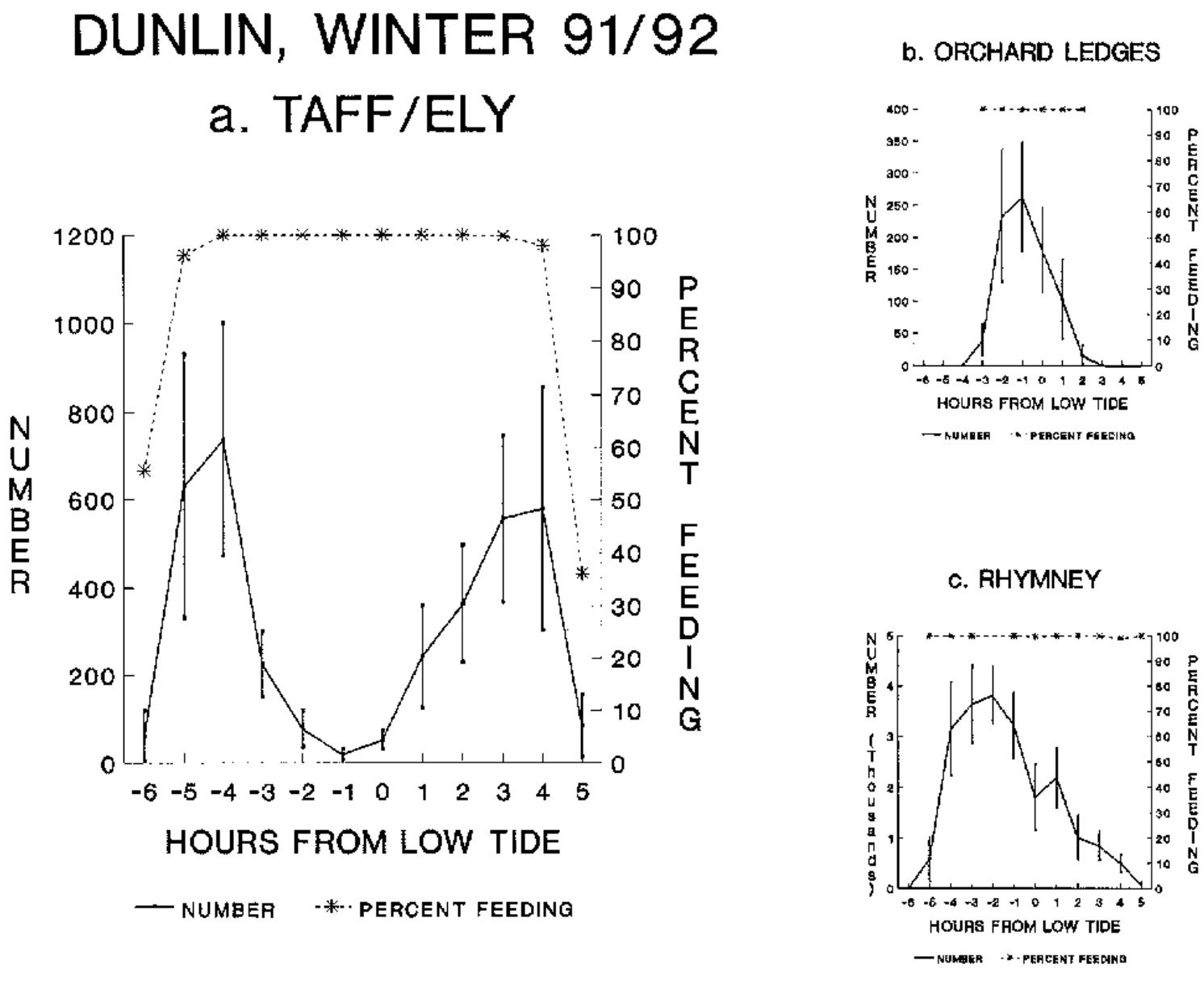
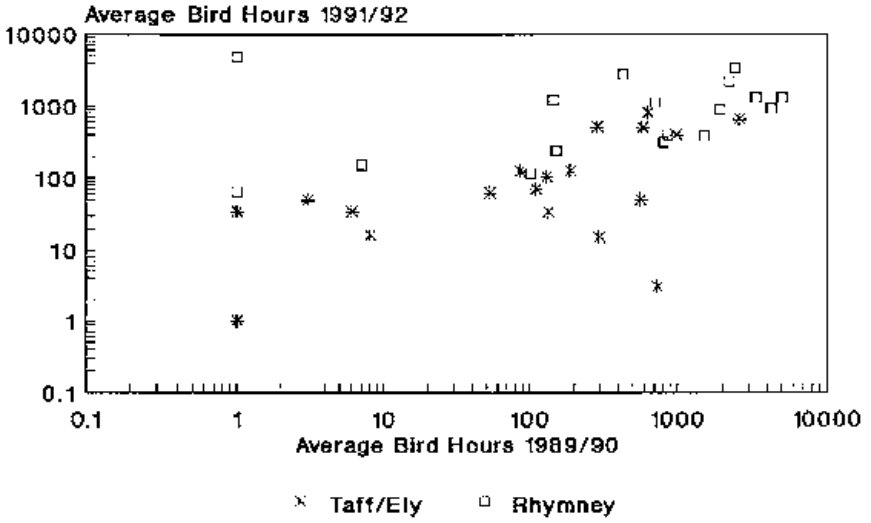


Figure 3.13.7 The total number of Dunlin present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during winter 1991/92.

DUNLIN, WINTER

a. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1989/90 and 1991/92.



b. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1990/91 and 1991/92.

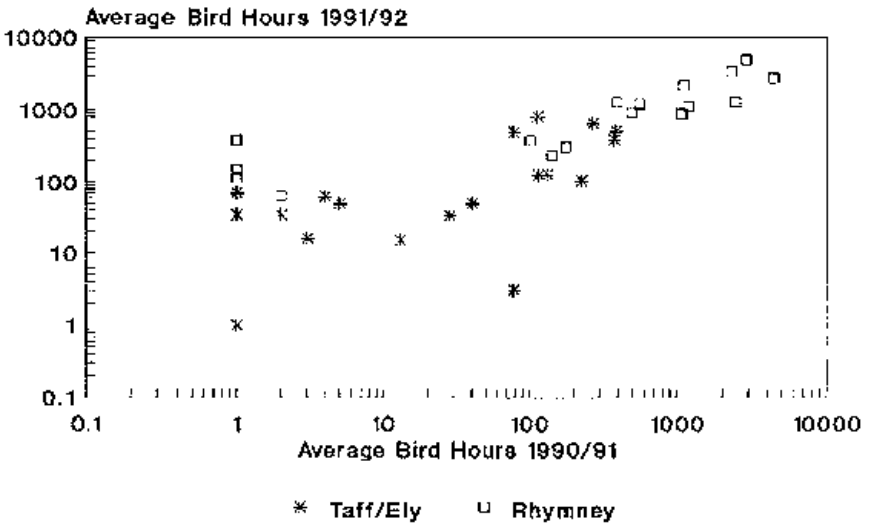


Figure 3.13.8 A comparison of usage values for Dunlin between winter 1989/90 and winter 1991/92 and between winter 1990/91 and winter 1991/92.

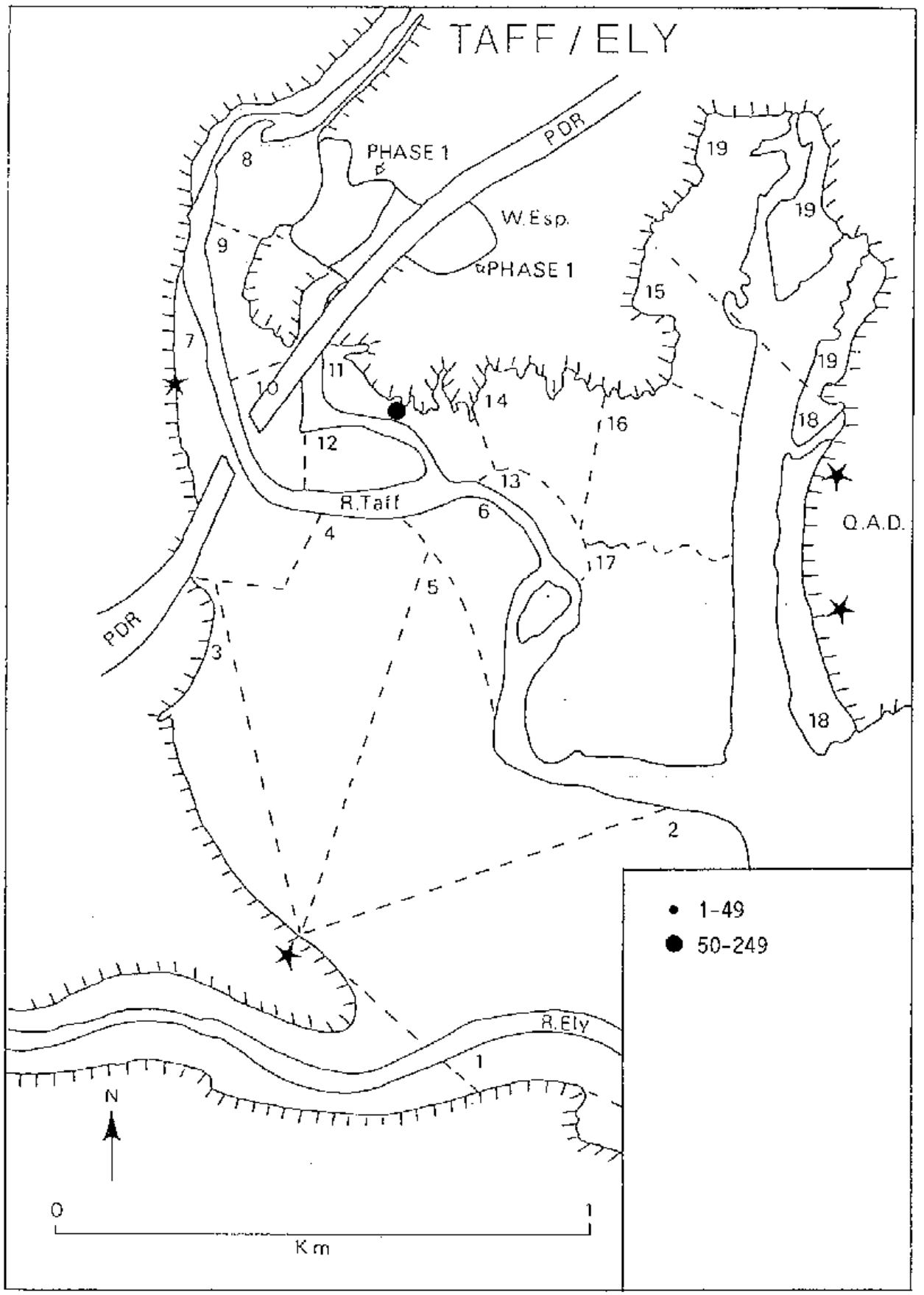


Figure 3.13.9 The distribution of feeding Dunlin on the Taff/Ely all day site during the spring 1992. The average number of bird hours per tidal cycle is depicted.

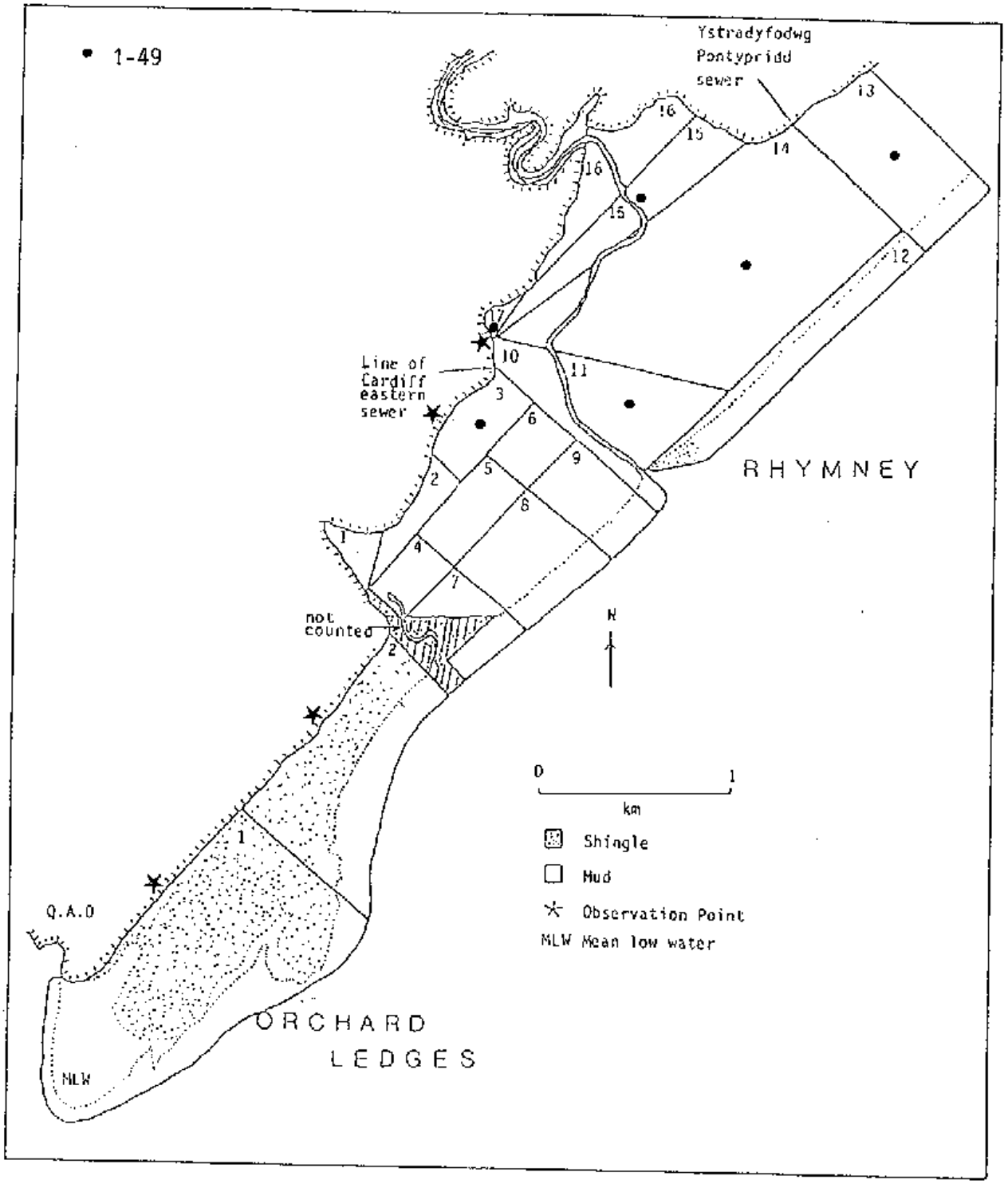


Figure 3.13.10 The distribution of feeding Dunlin on the Rhymney and Orchard Ledges all day site during the spring 1992. The average number of bird hours per tidal cycle is depicted.

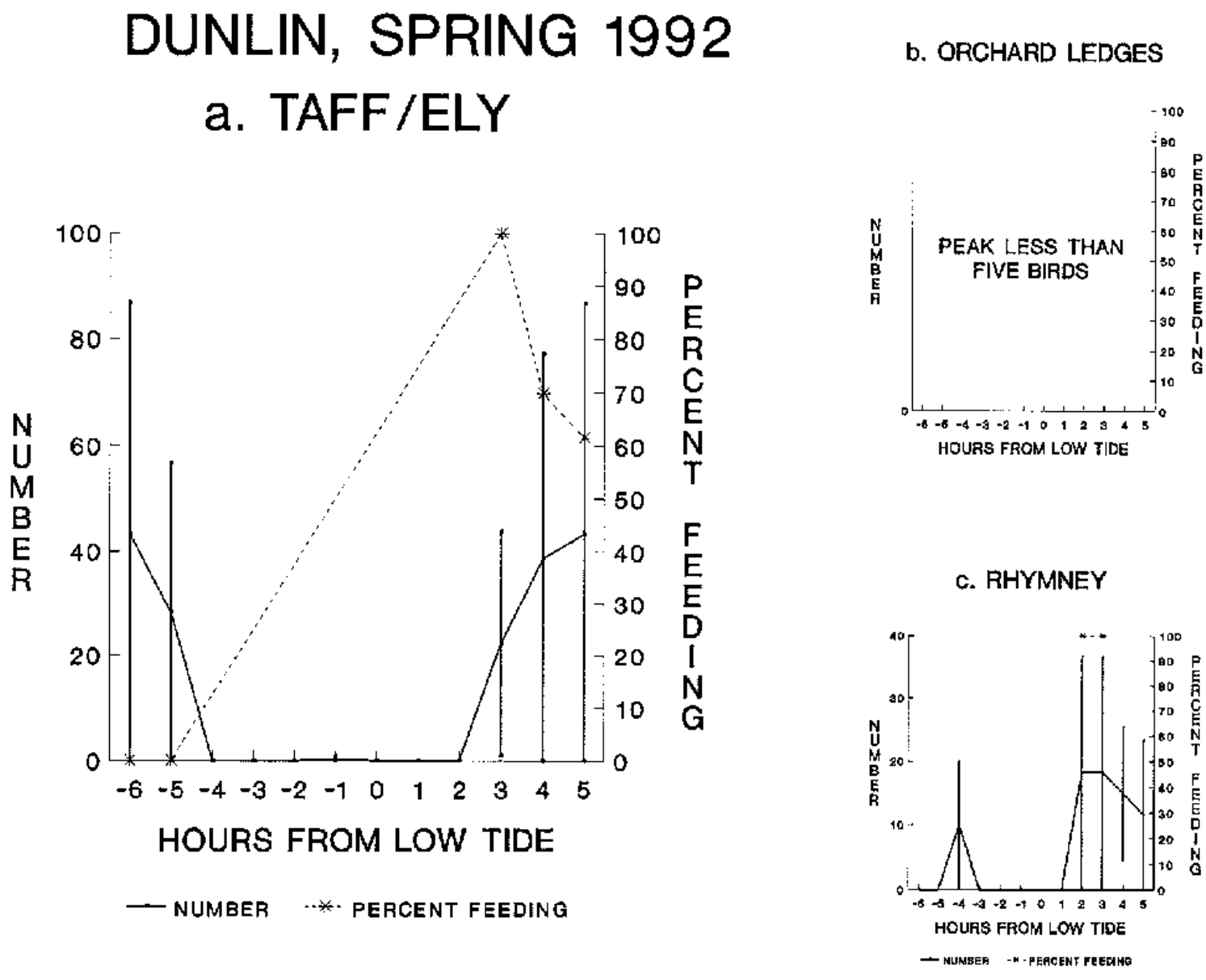


Figure 3.13.11 The total number of Dunlin present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during spring 1992.

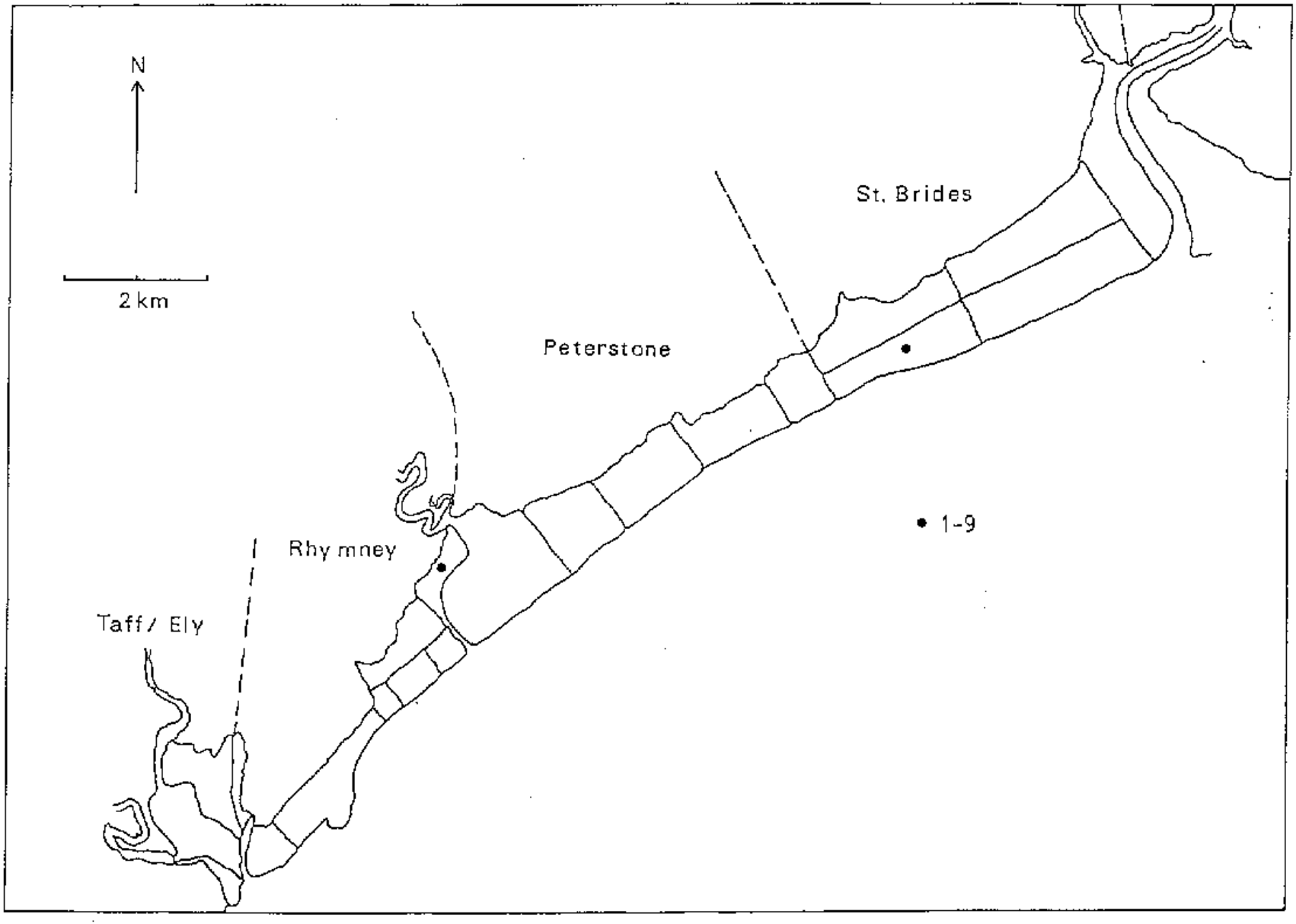


Figure 3.14.1 The low tide distribution of feeding Bar-tailed Godwit on the northwest Severn during winter 1991/92.

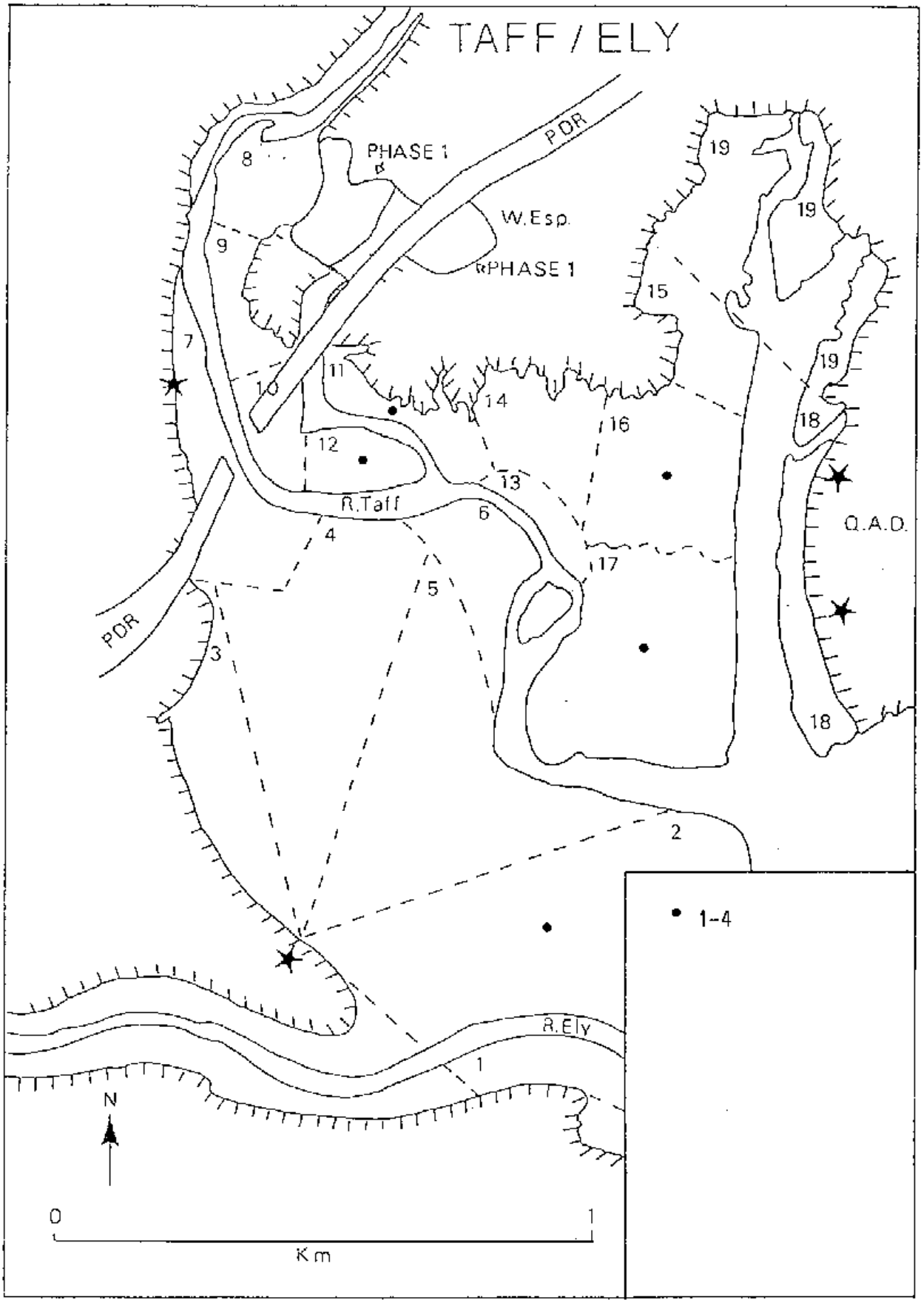


Figure 3.14.2 The distribution of feeding Bar-tailed Godwit on the Taff/Ely all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

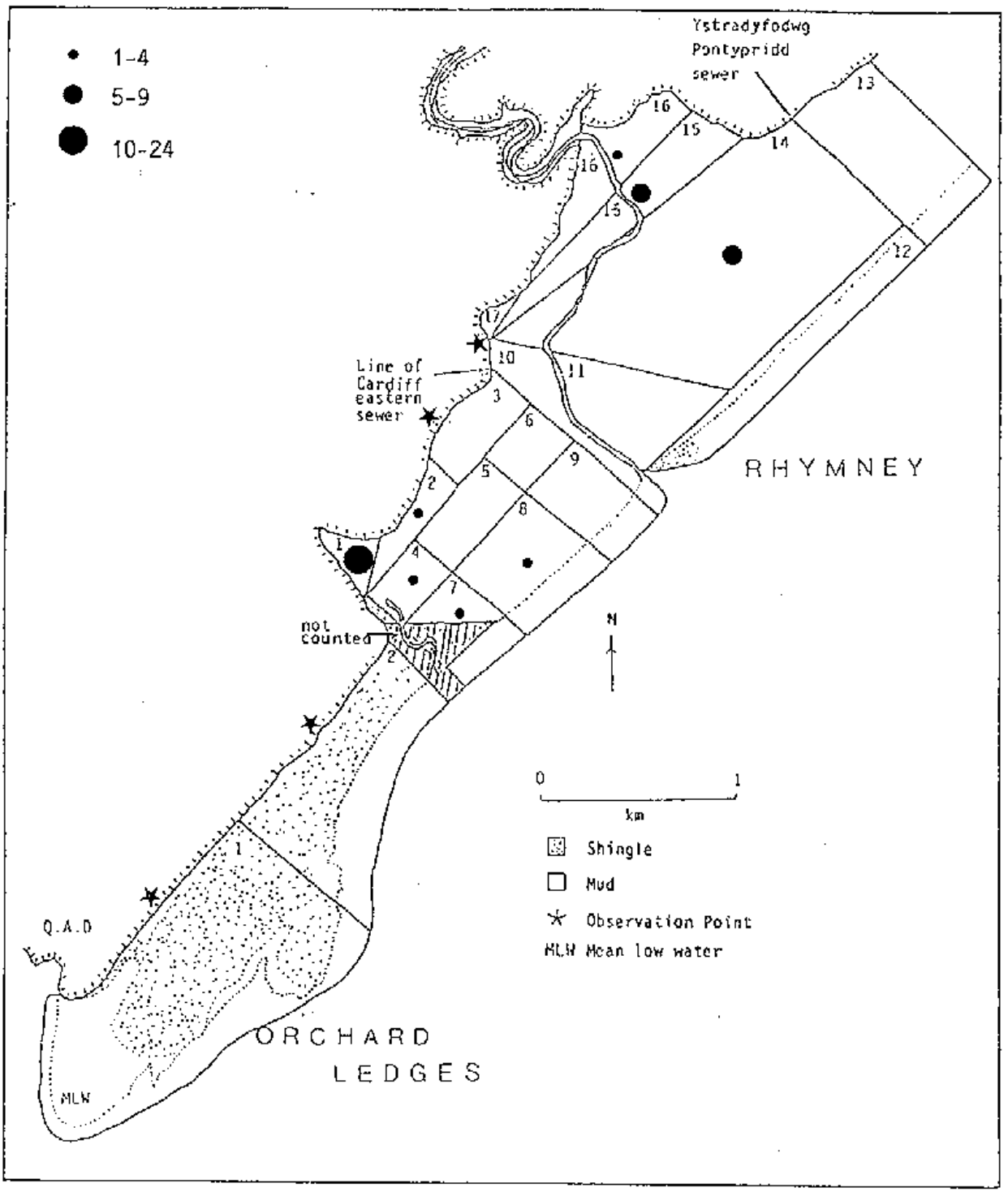


Figure 3.14.3 The distribution of feeding Bar-tailed Godwit on the Rhymney and Orchard Ledges all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

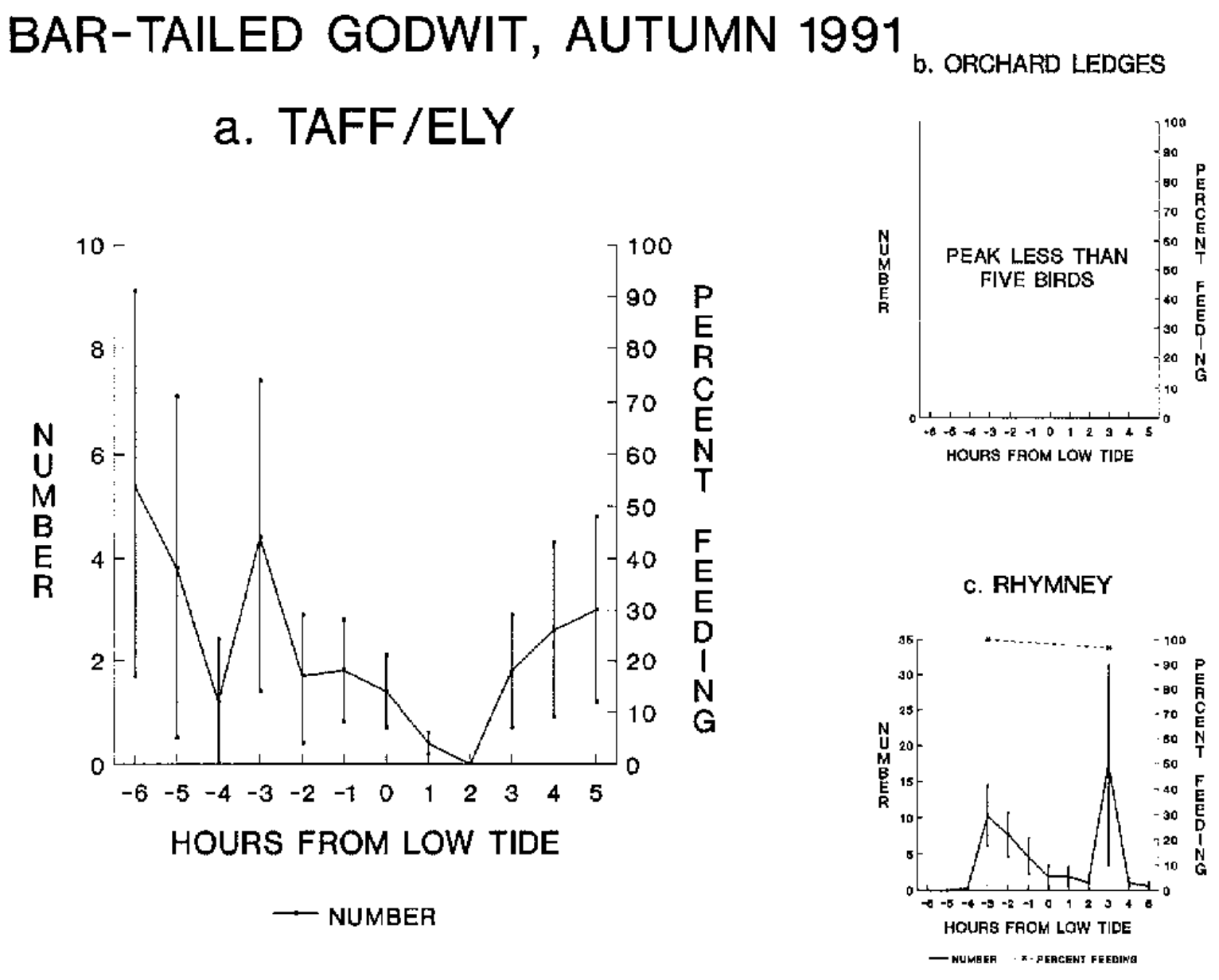


Figure 3.14.4 The total number of Bar-tailed Godwit present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during autumn 1991.

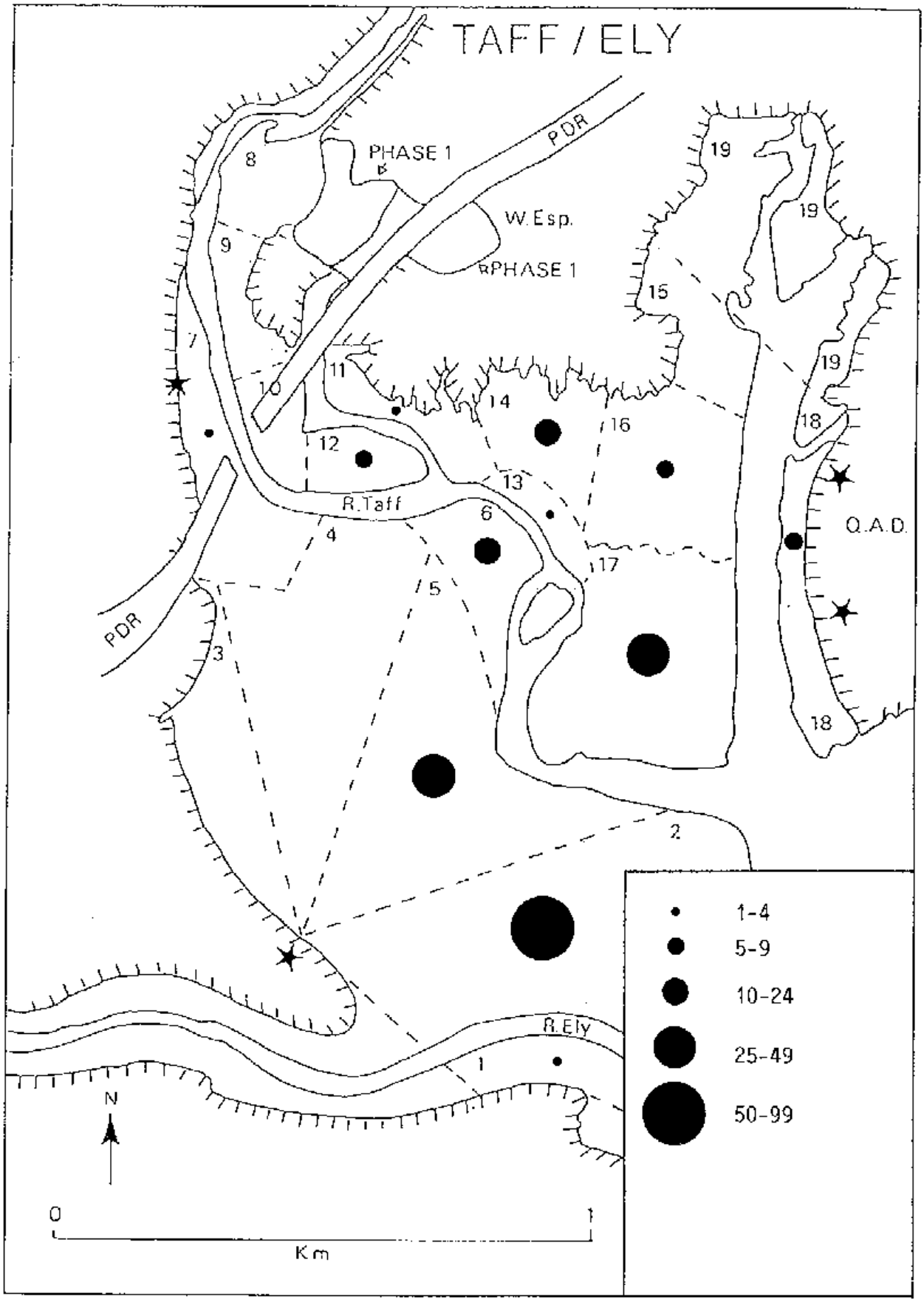


Figure 3.15.1 The distribution of feeding Curlew on the Taff/Ely all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

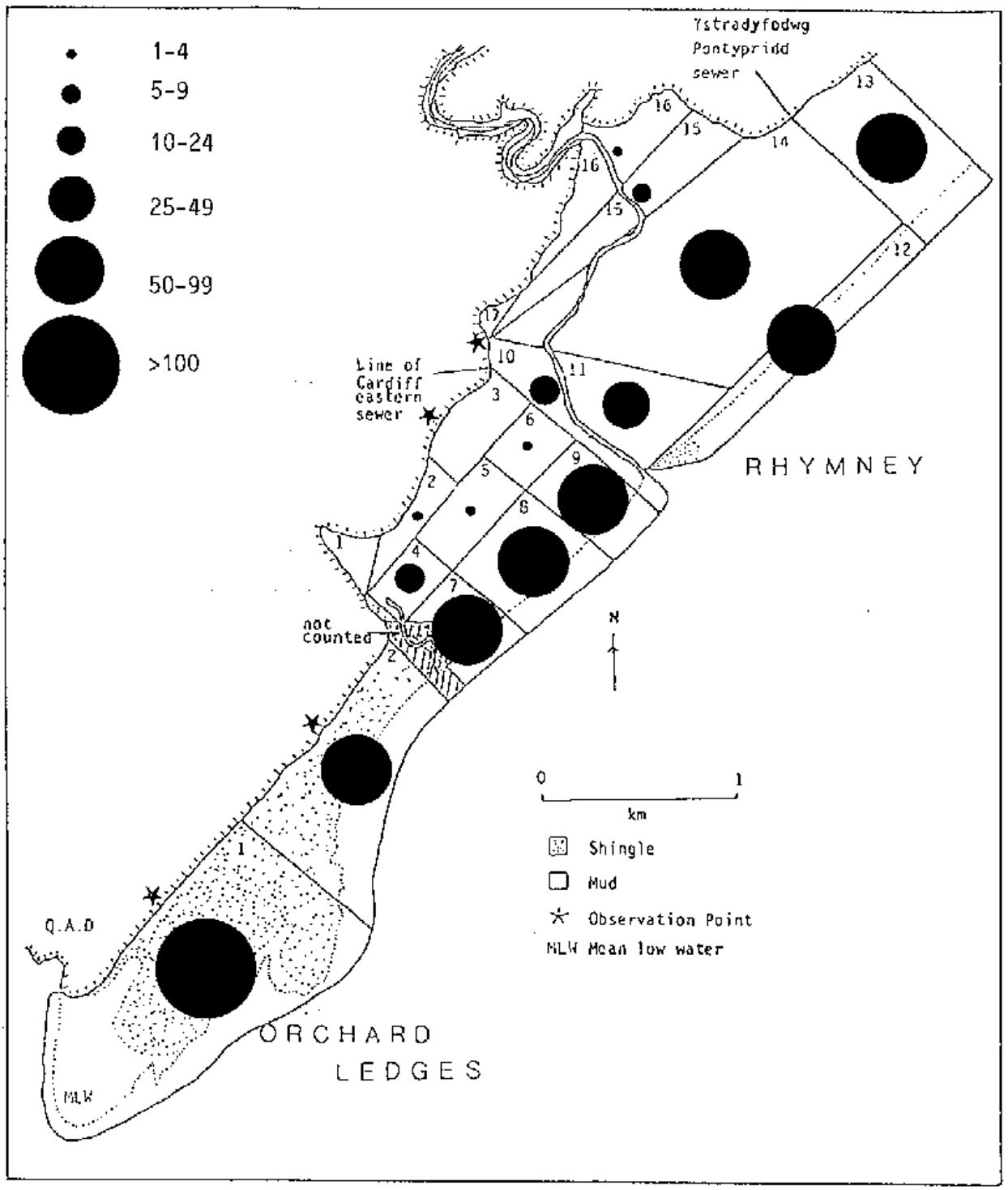


Figure 3.15.2 The distribution of feeding Curlew on the Rhymney and Orchard Ledges all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

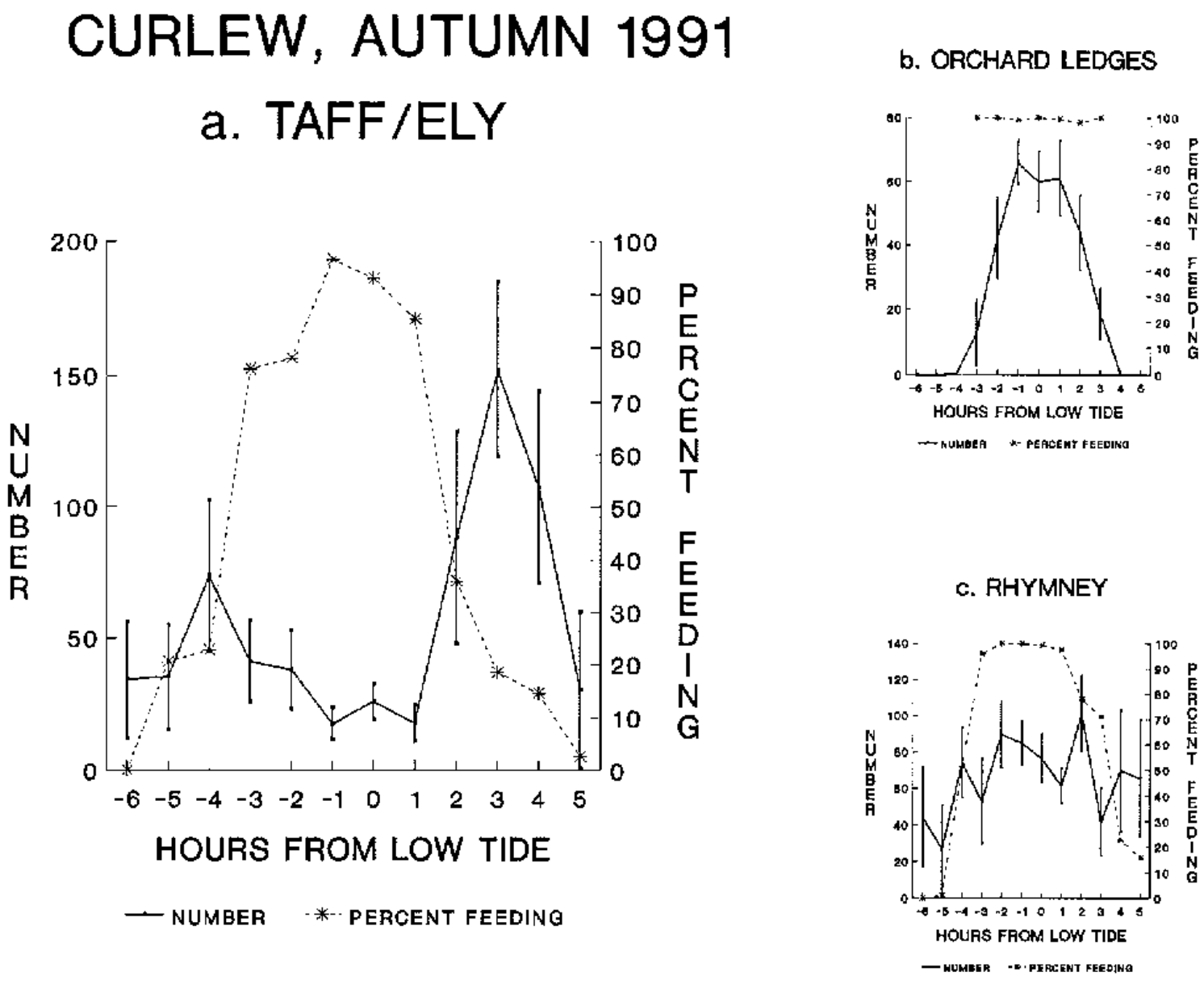


Figure 3.15.3 The total number of Curlew present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during autumn 1991.

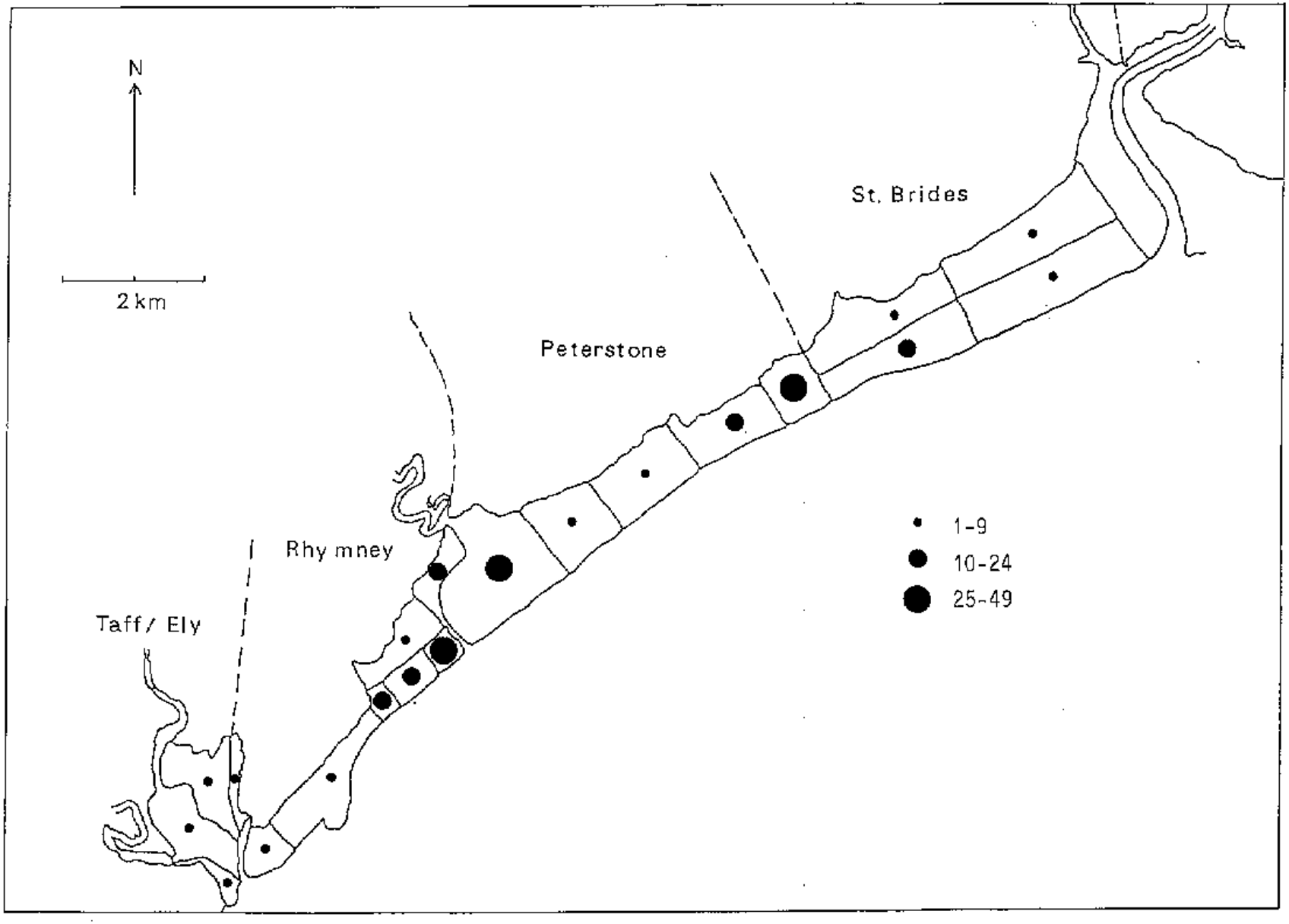


Figure 3.15.4 The low tide distribution of feeding Curlew on the northwest Severn during winter 1991/92.

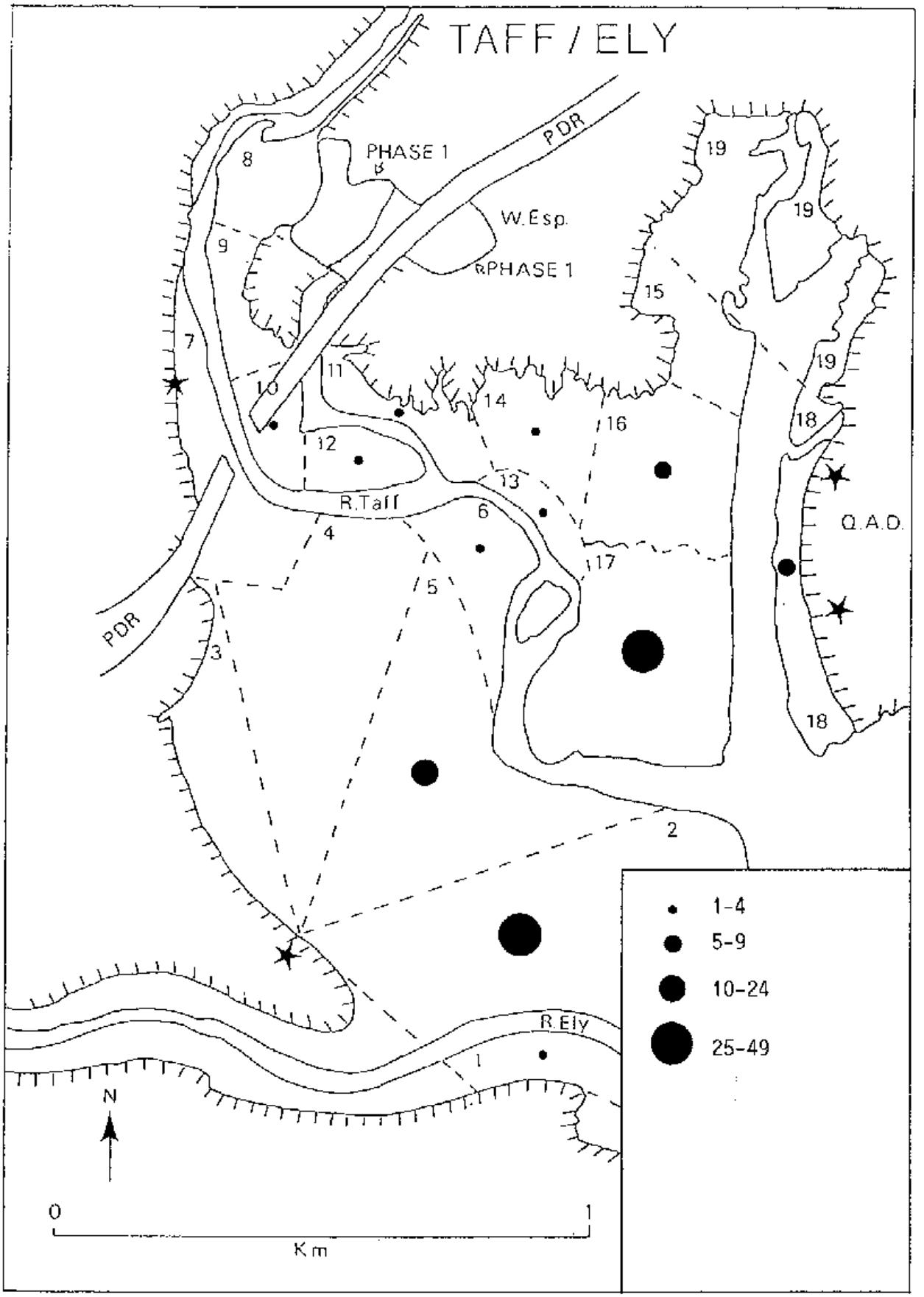


Figure 3.15.5 The distribution of feeding Curlew on the Taff/Ely all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

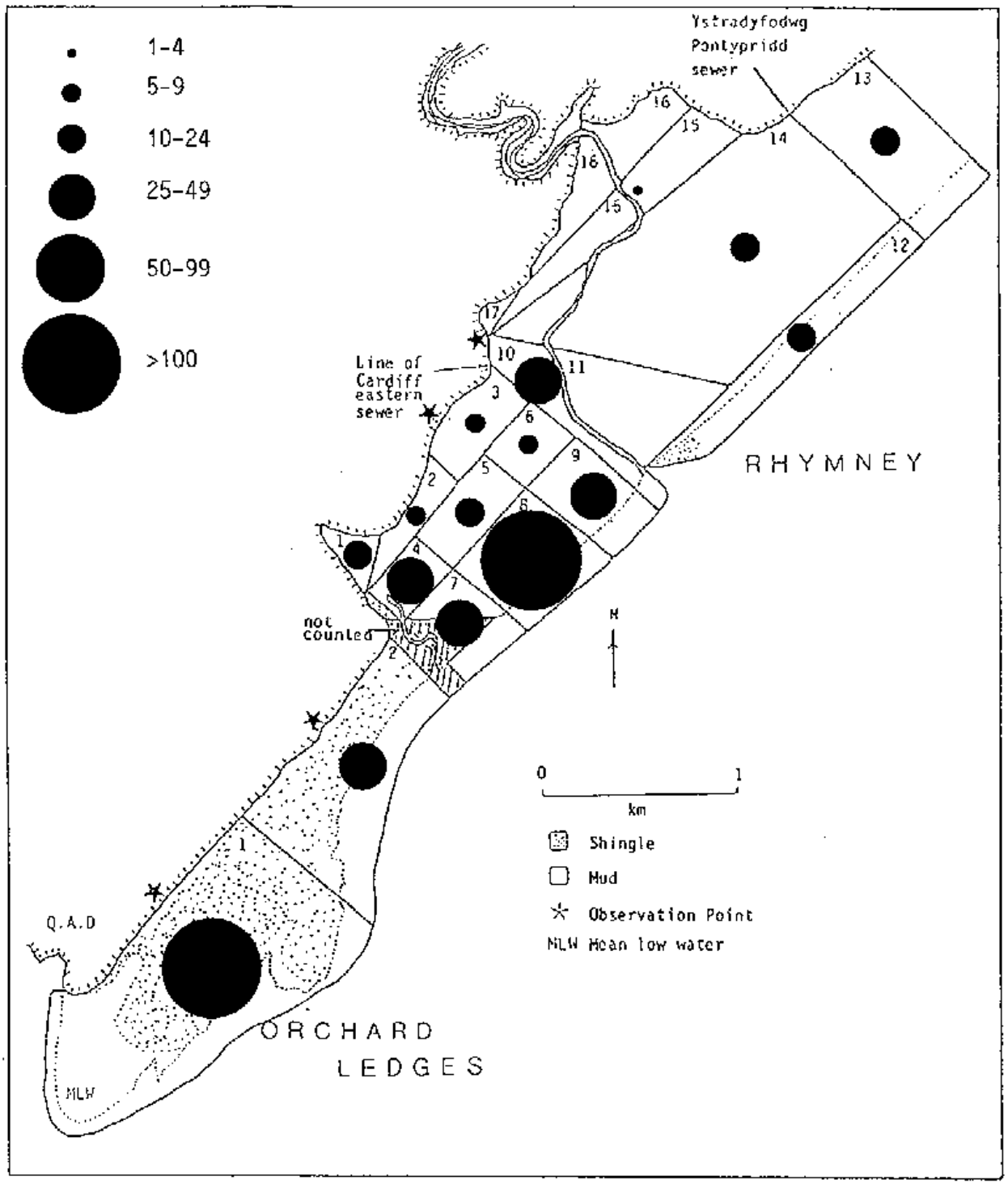


Figure 3.15.6 The distribution of feeding Curlew on the Rhymney and Orchard Ledges all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

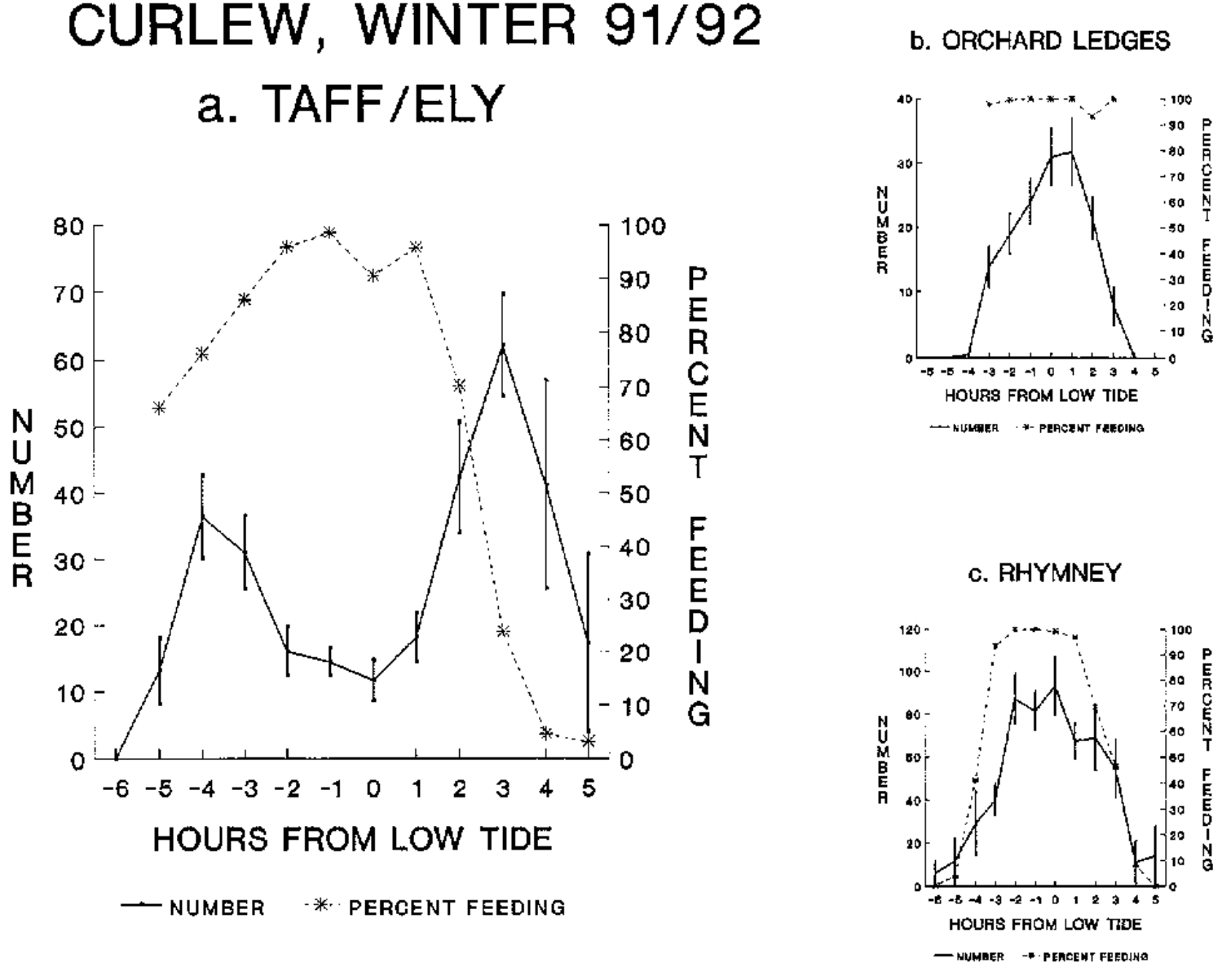
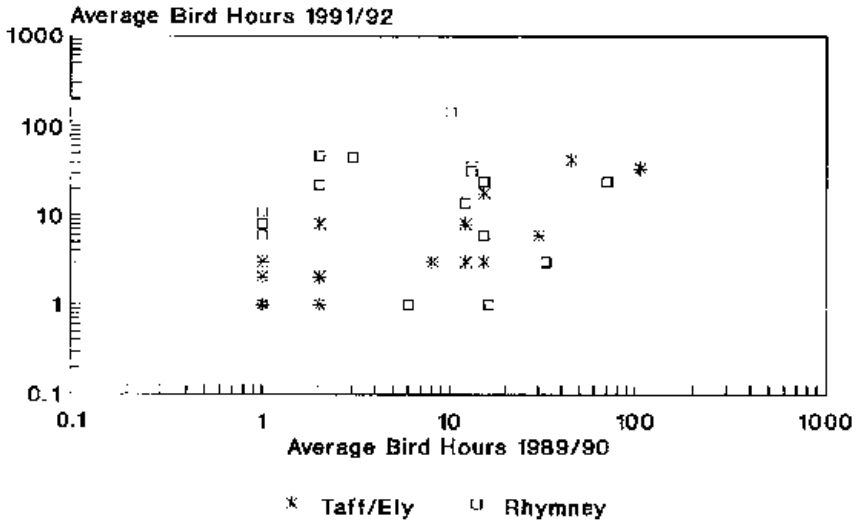


Figure 3.15.7 The total number of Curlew present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during winter 1991/92.

CURLEW, WINTER

a. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1989/90 and 1991/92.



b. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1990/91 and 1991/92.

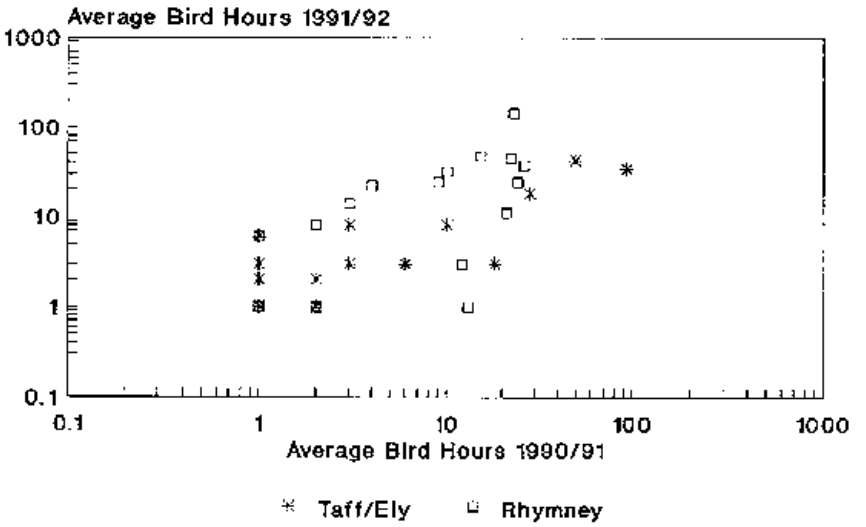
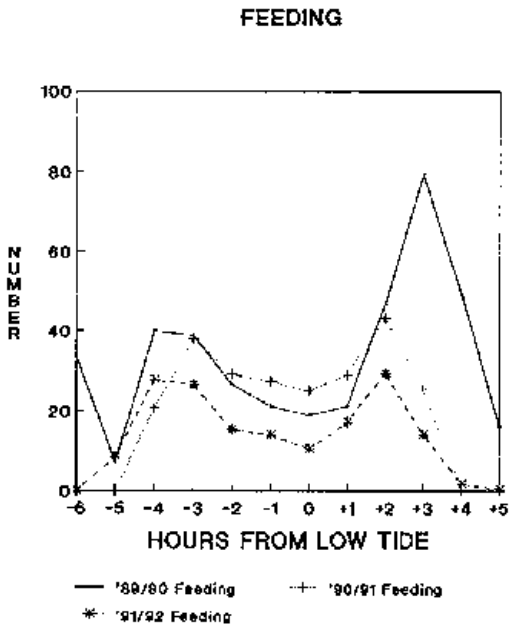


Figure 3.15.8 A comparison of usage values for Curlew between winter 1989/90 and winter 1991/92 and between winter 1990/91 and winter 1991/92.

CURLEW

Comparison of Mean Feeding Numbers, Winter 1989/90, 1990/91 and 1991/92



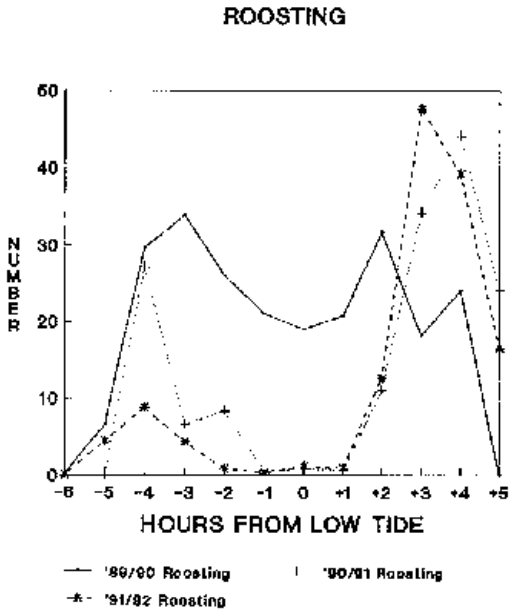


Figure 3.15.9 A comparison of the mean feeding and roosting numbers of Curlew on the Taff/Ely all day site during winters 1989/90, 1990/91 and 1991/92.

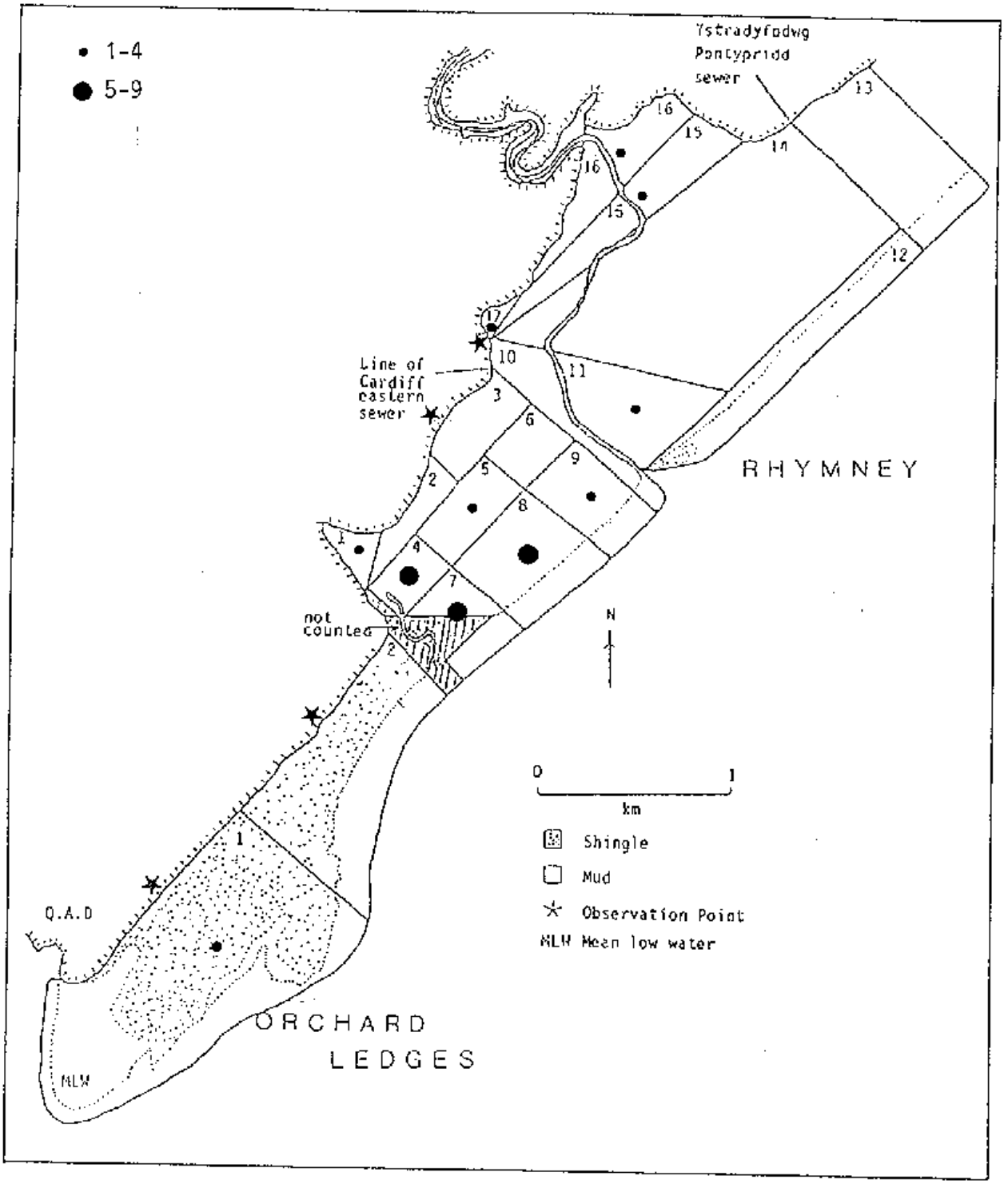


Figure 3.15.10 The distribution of feeding Curlew on the Rhymney and Orchard Ledges all day site during the spring 1992. The average number of bird hours per tidal cycle is depicted.

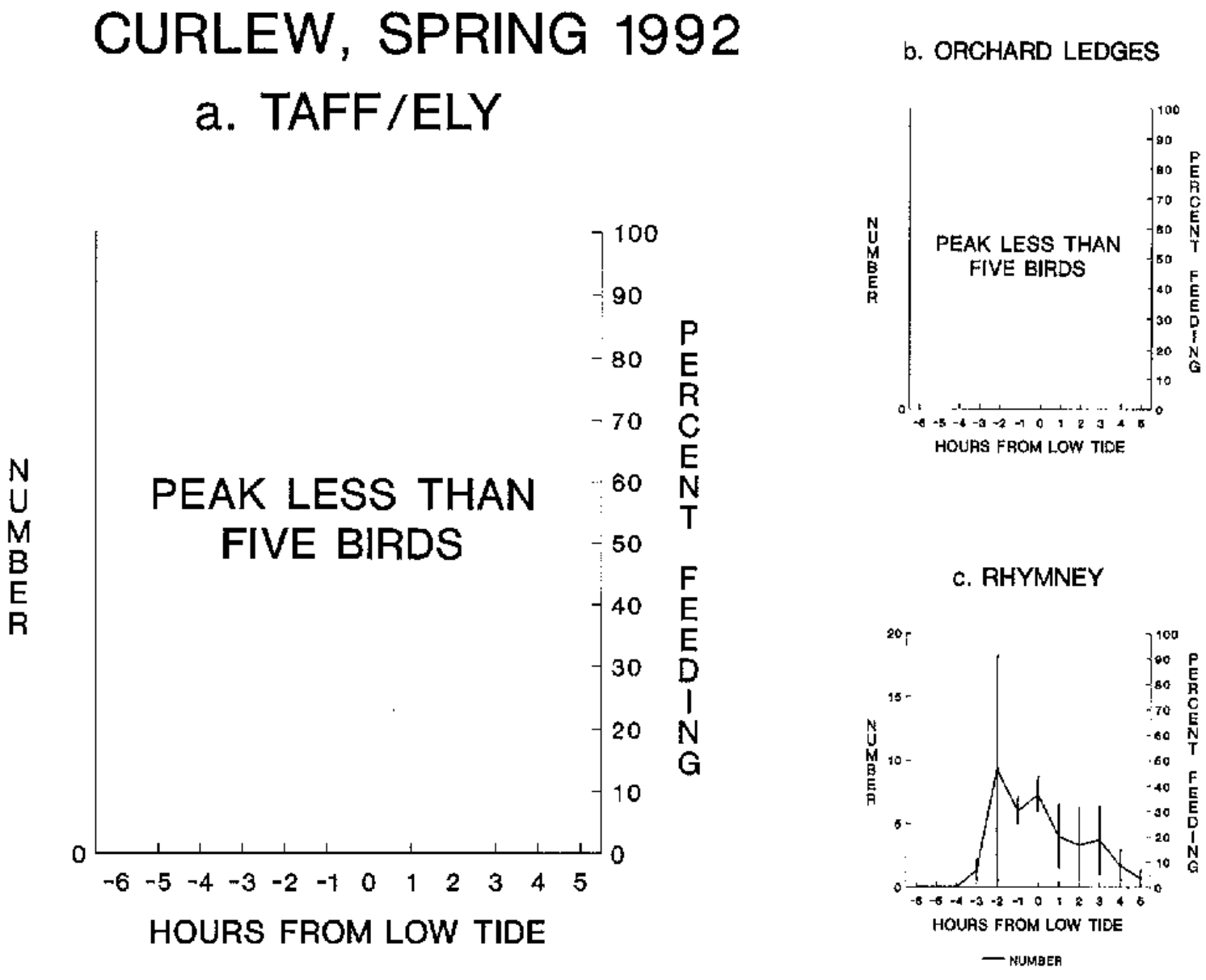


Figure 3.15.11 The total number of Curlew present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during spring 1992.

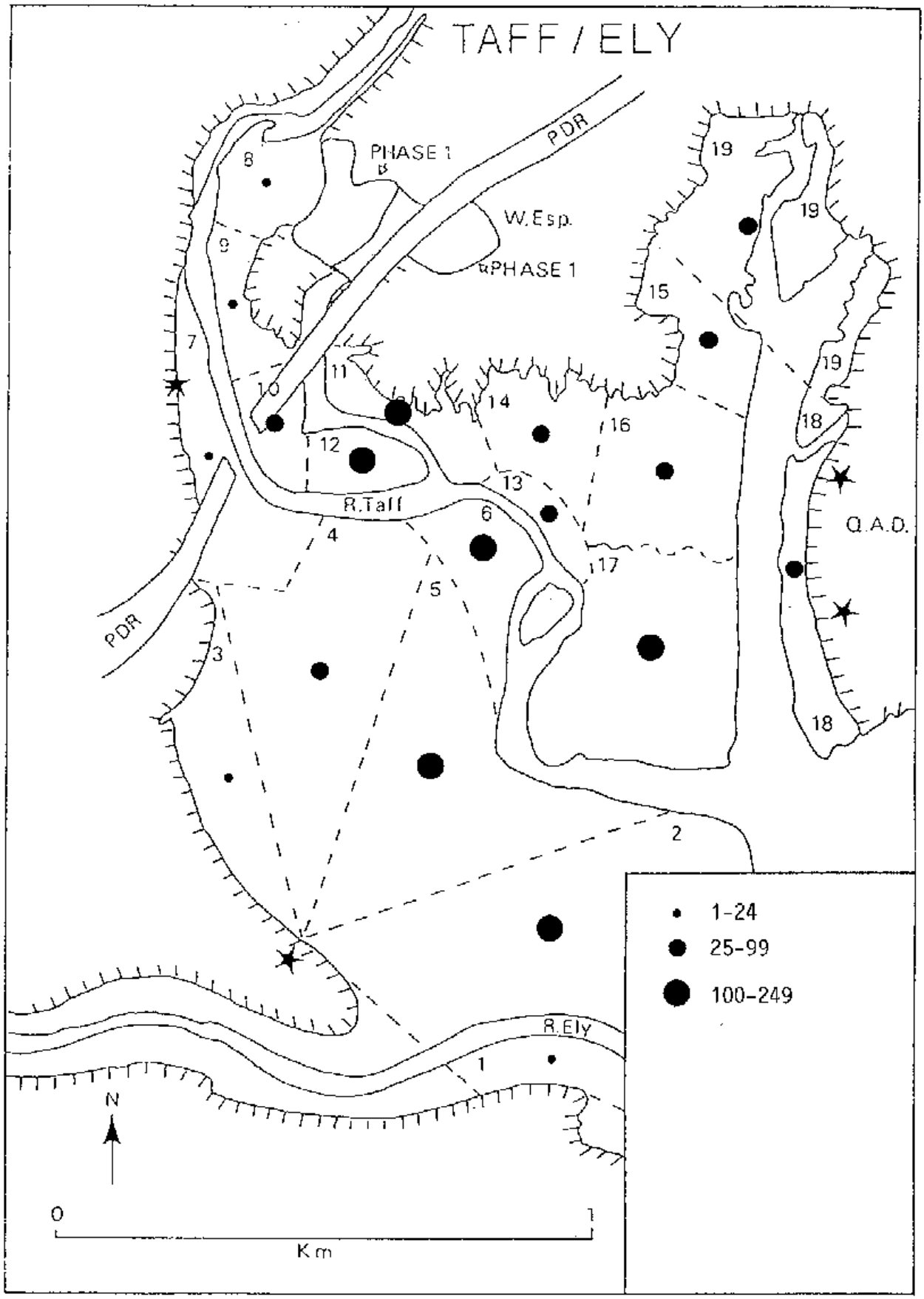


Figure 3.16.1 The distribution of feeding Redshank on the Taff/Ely all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

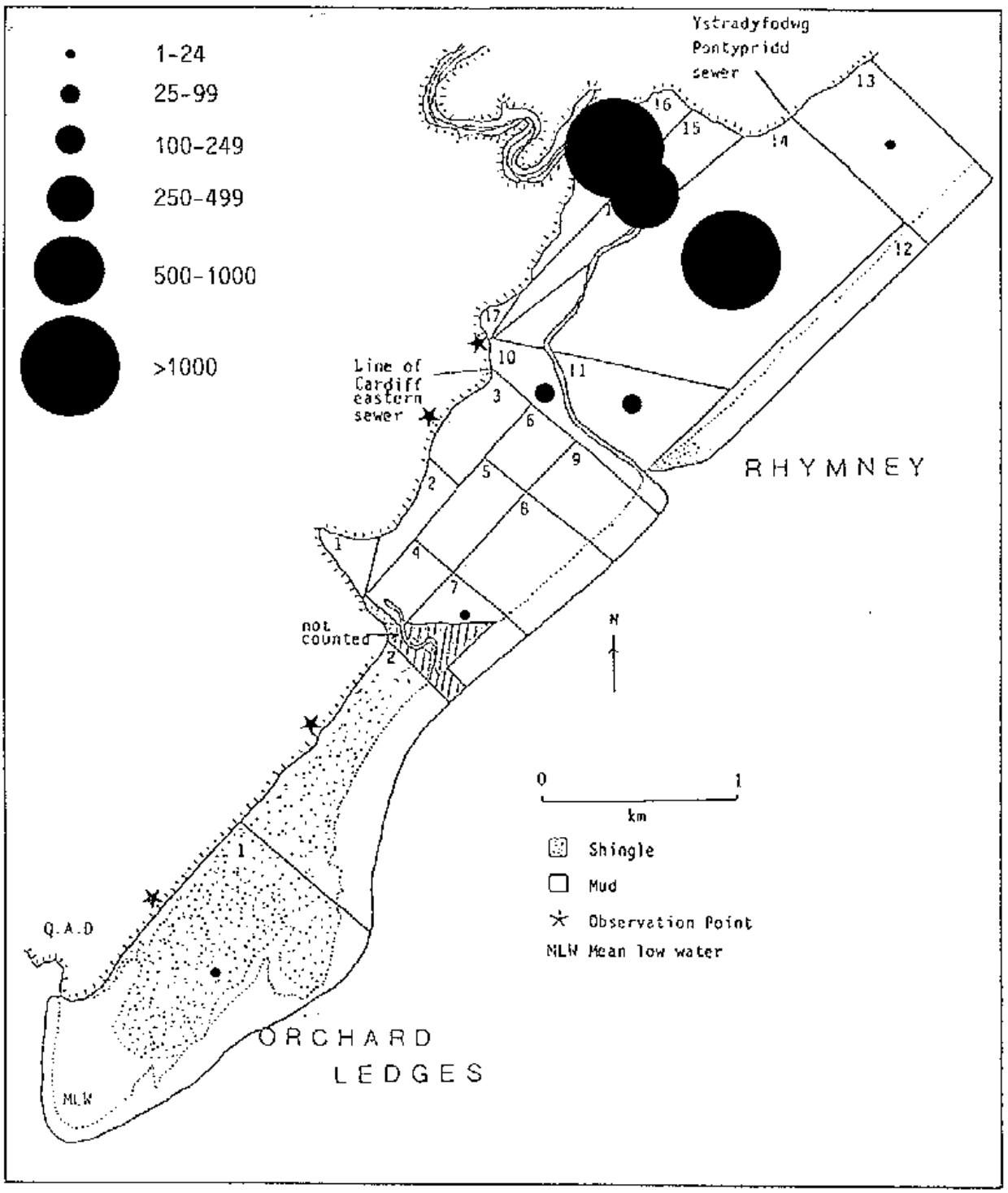


Figure 3.16.2 The distribution of feeding Redshank on the Rhymney and Orchard Ledges all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

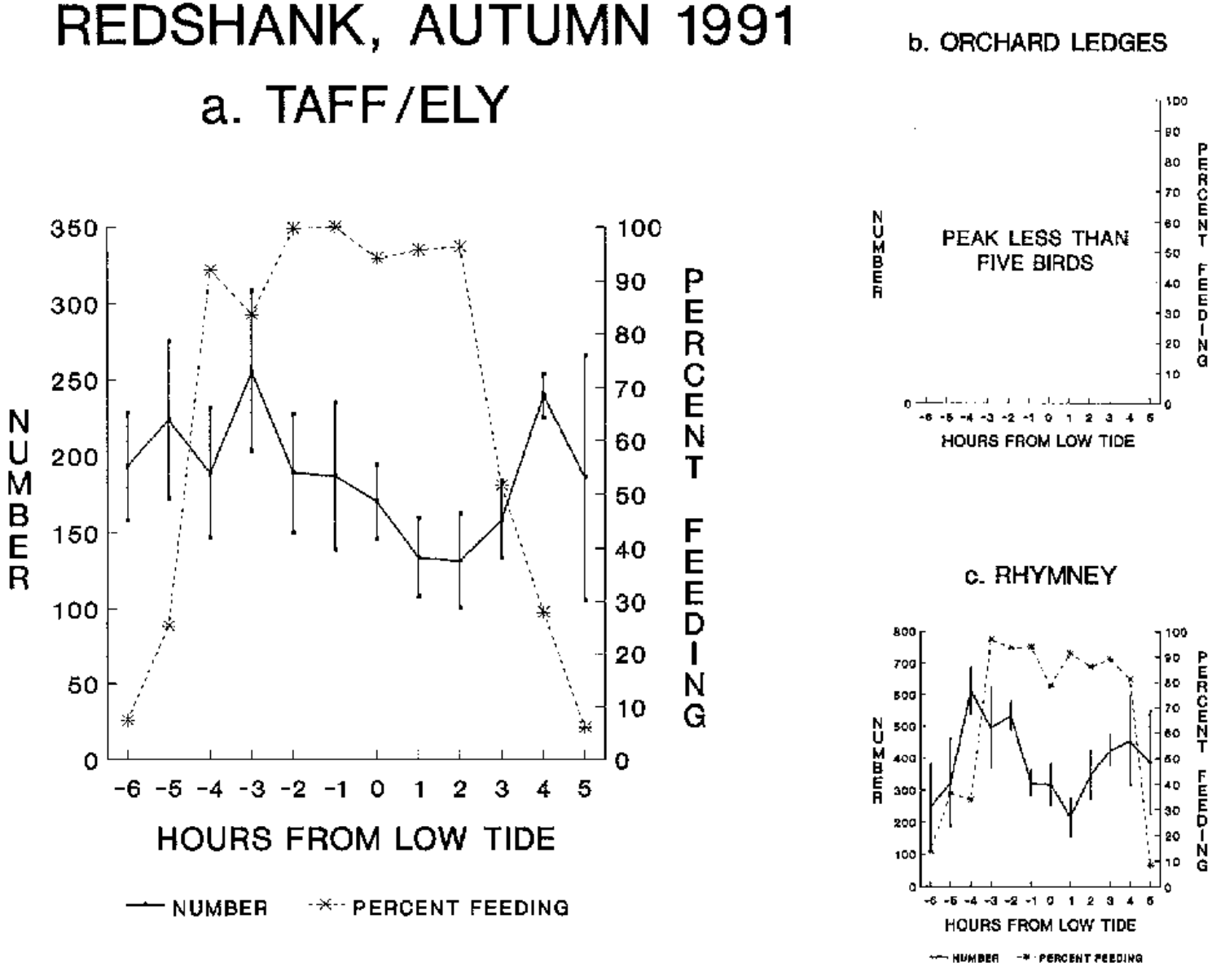


Figure 3.16.3 The total number of Redshank present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during autumn 1991.

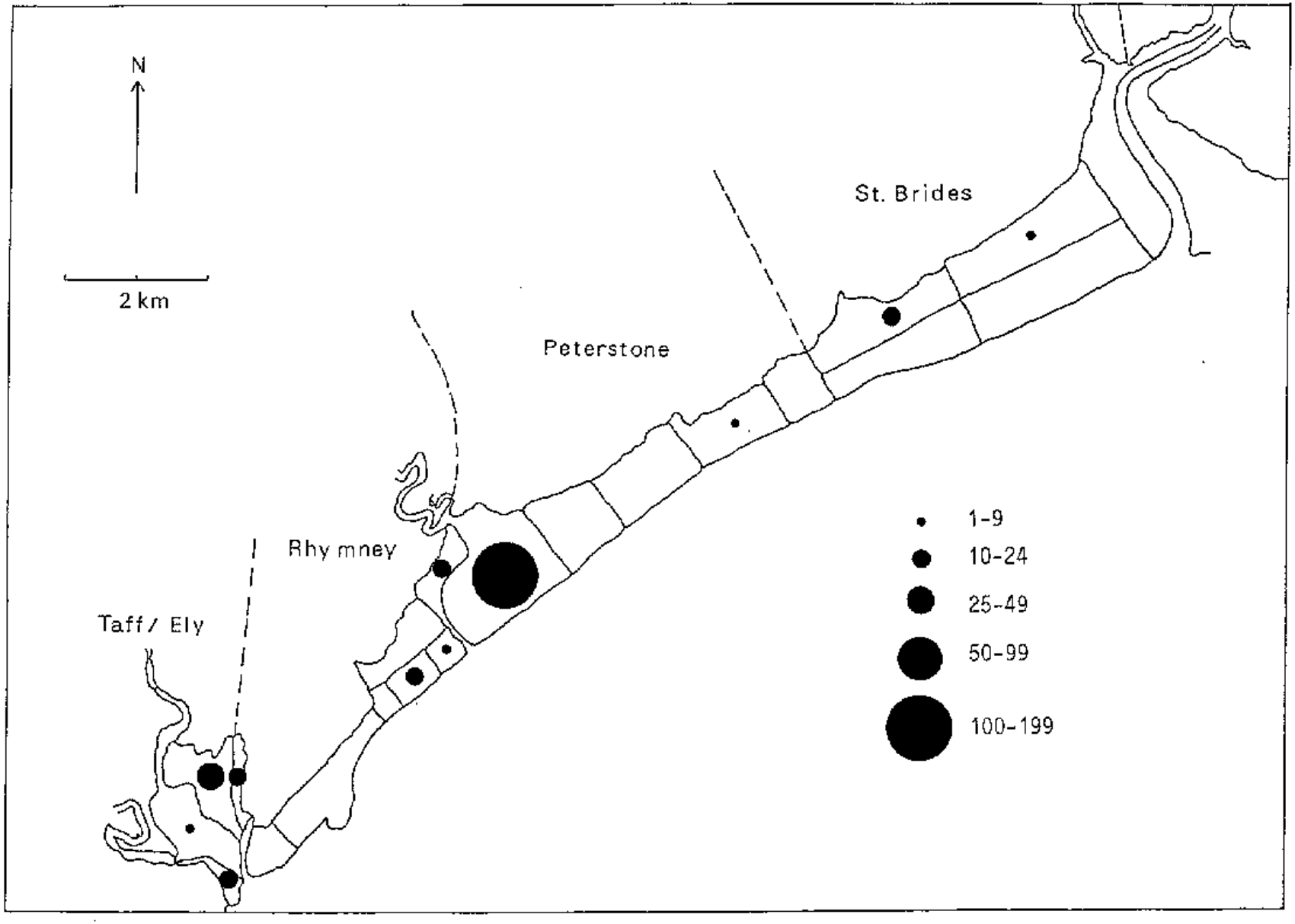


Figure 3.16.4 The low tide distribution of feeding Redshank on the northwest Severn during winter 1991/92.

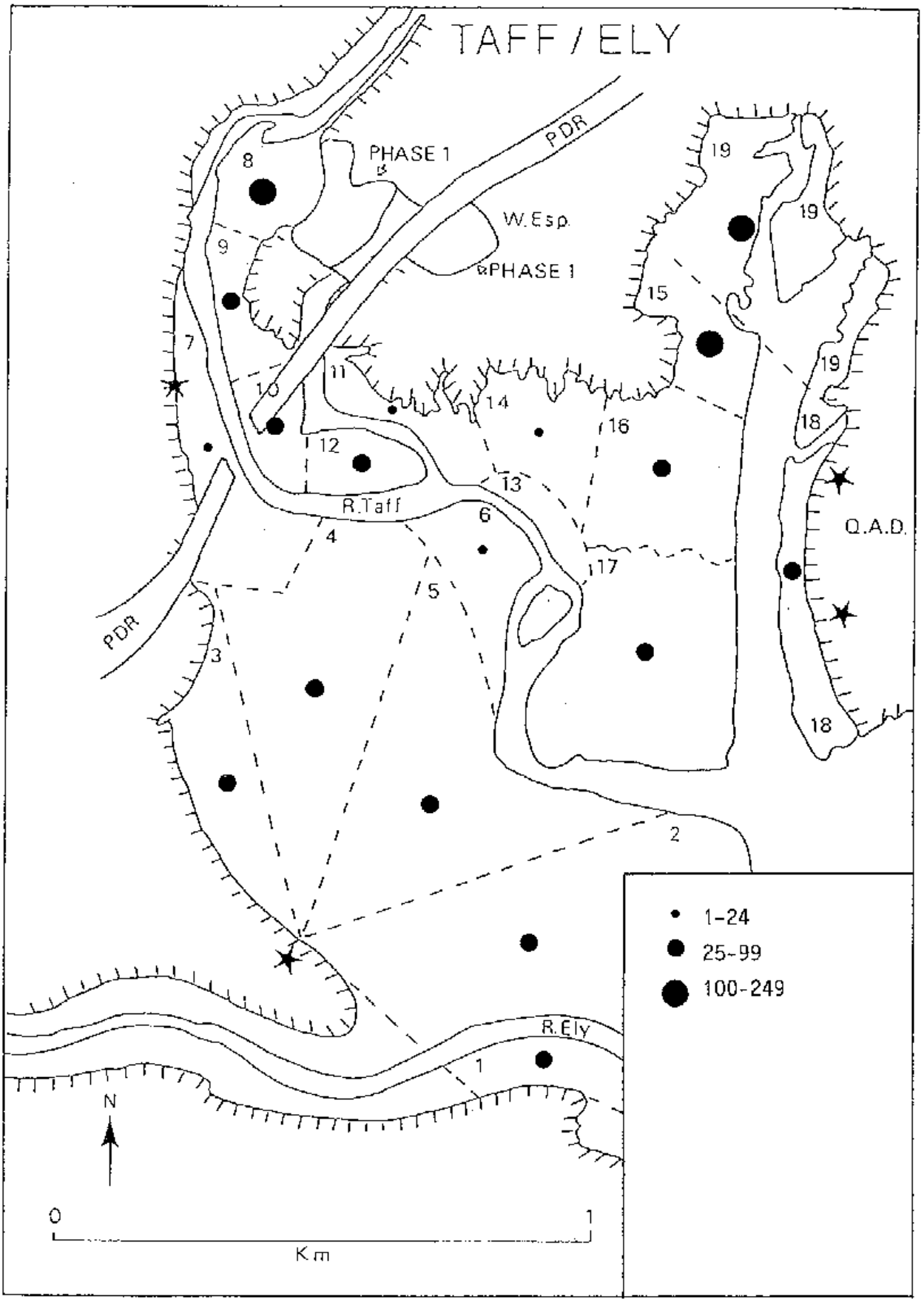


Figure 3.16.5 The distribution of feeding Redshank on the Taff/Ely all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

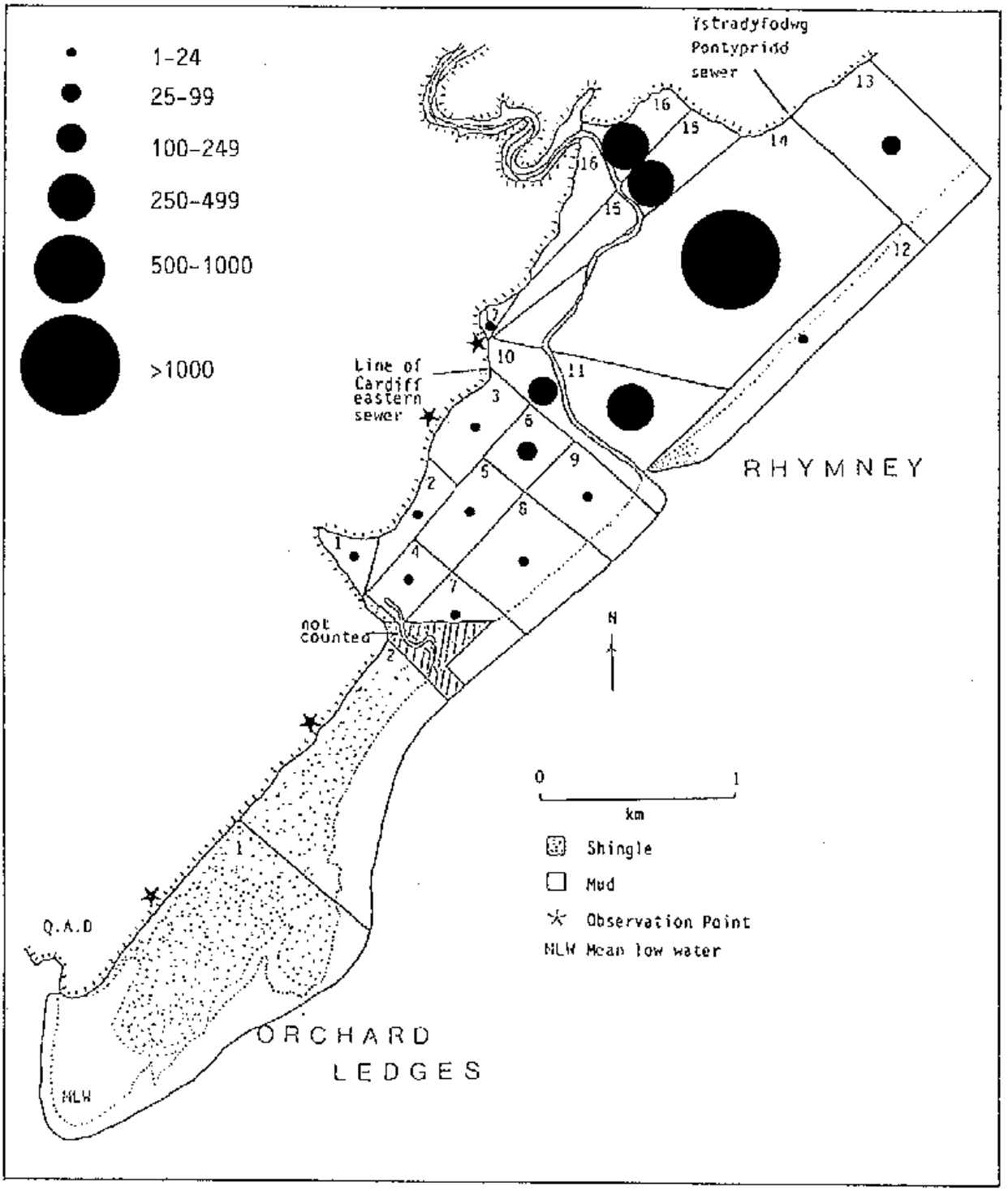


Figure 3.16.6 The distribution of feeding Redshank on the Rhymney and Orchard Ledges all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

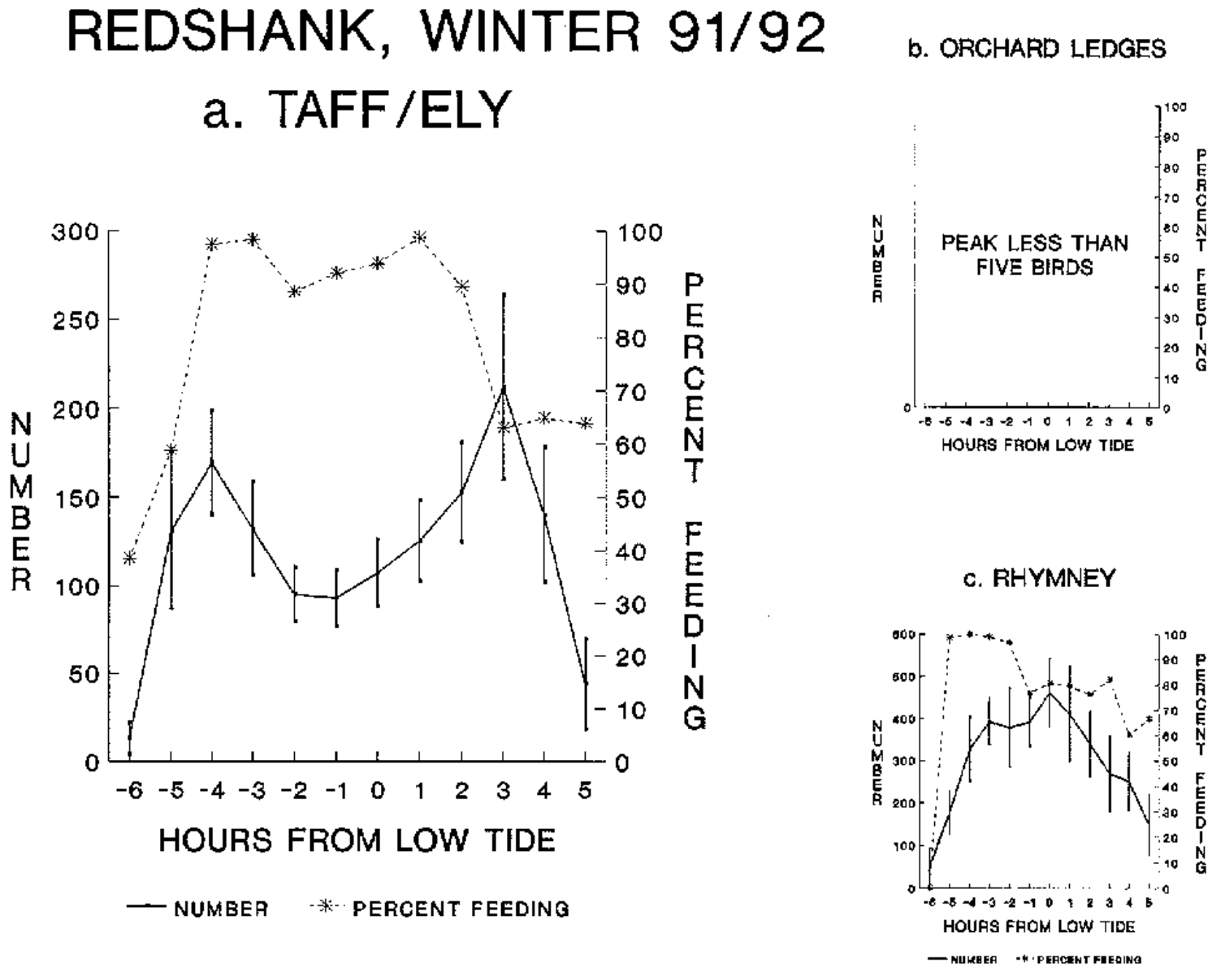
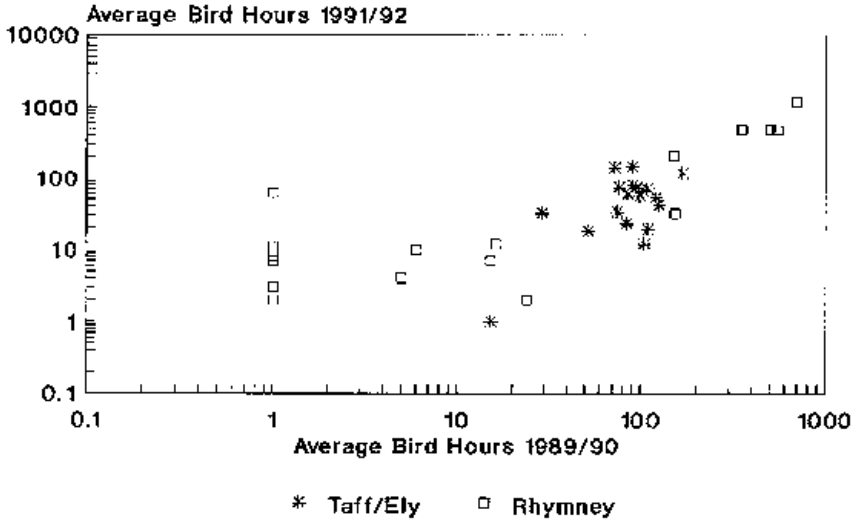


Figure 3.16.7 The total number of Redshank present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during winter 1991/92.

REDSHANK, WINTER

a. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1989/90 and 1991/92.



b. A Comparison of Average Bird Hours per Tidal Cycle between the Winters of 1990/91 and 1991/92.

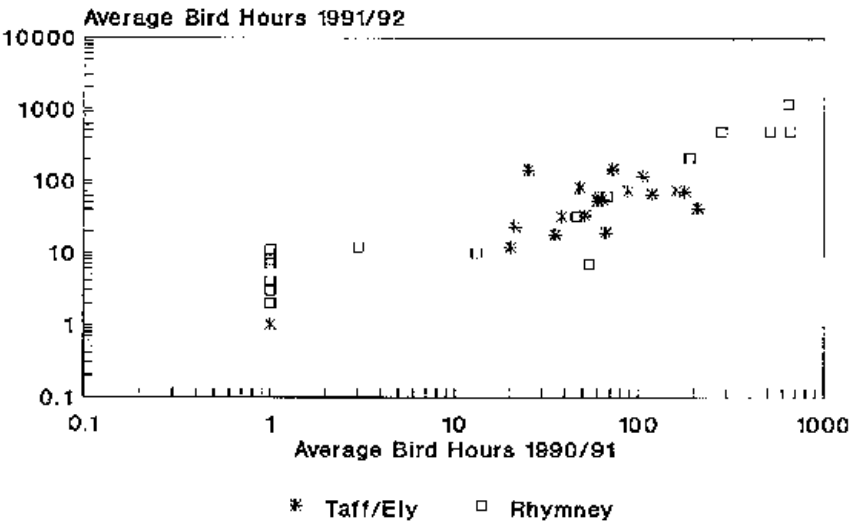


Figure 3.16.8 A comparison of usage values for Redshank between winter 1989/90 and winter 1991/92 and between winter 1990/91 and winter 1991/92.

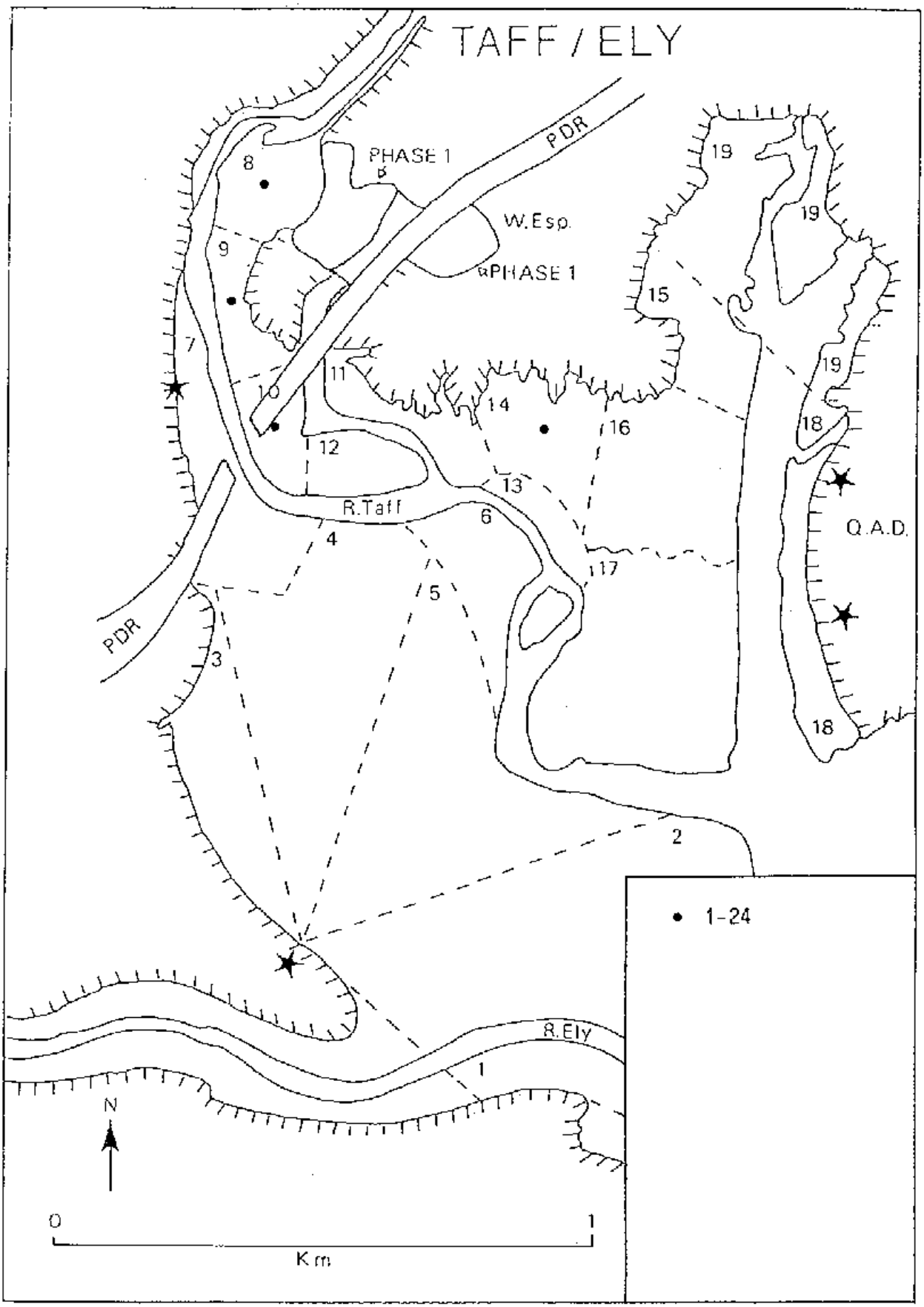


Figure 3.16.9 The distribution of feeding Redshank on the Taff/Ely all day site during the spring 1992. The average number of bird hours per tidal cycle is depicted.

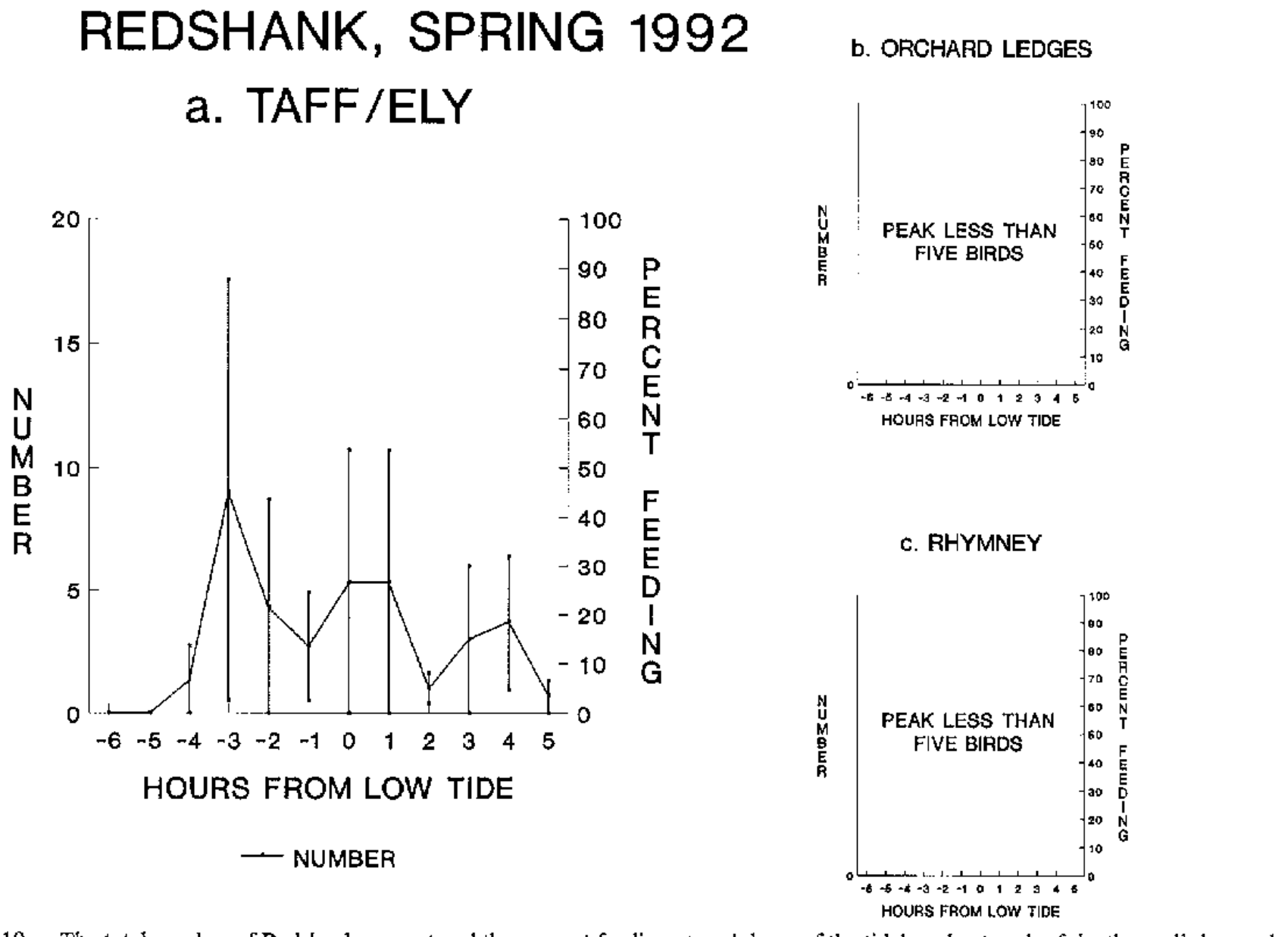


Figure 3.16.10 The total number of Redshank present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during spring 1992.

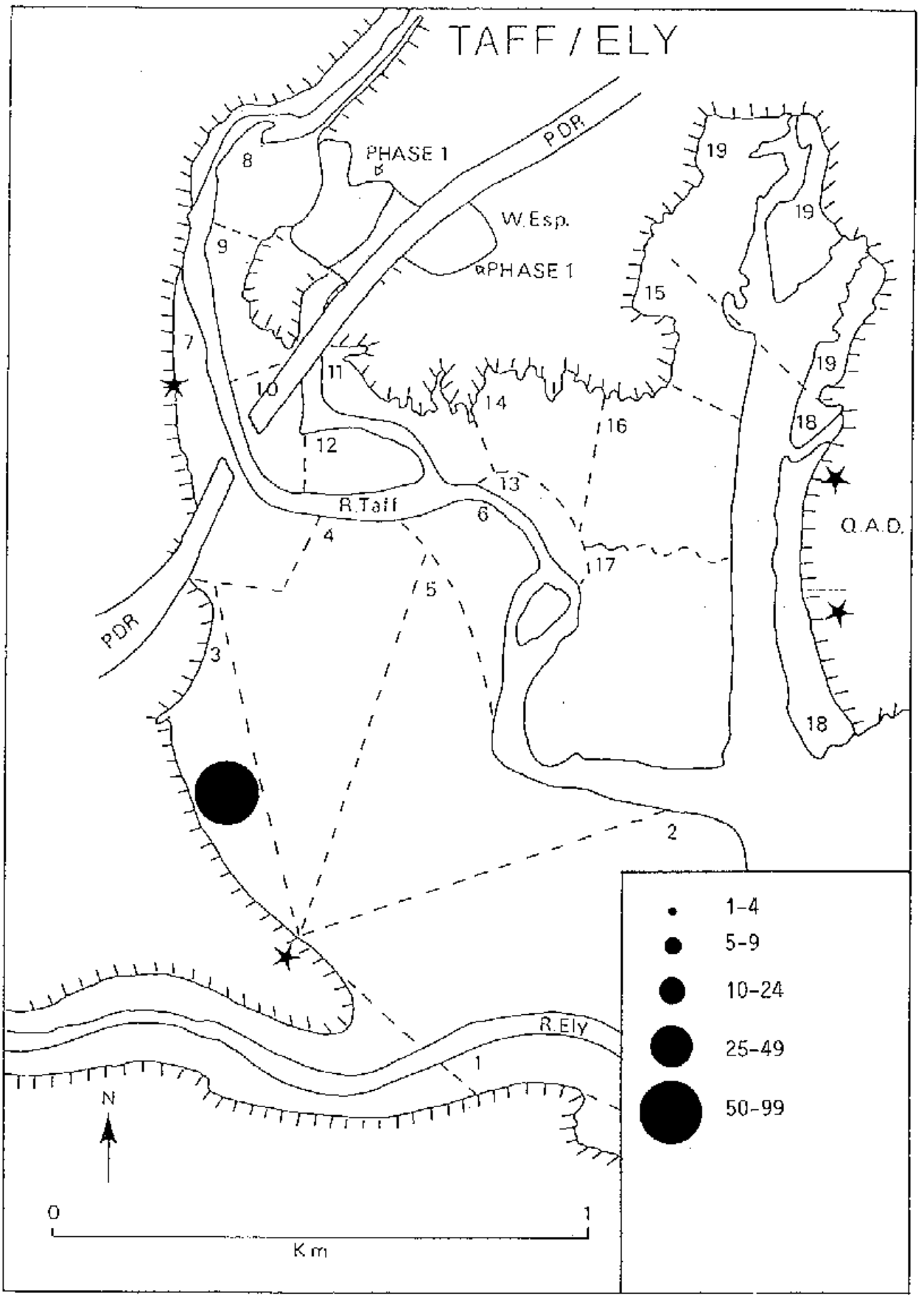


Figure 3.17.1 The distribution of feeding Turnstone on the Taff/Ely all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

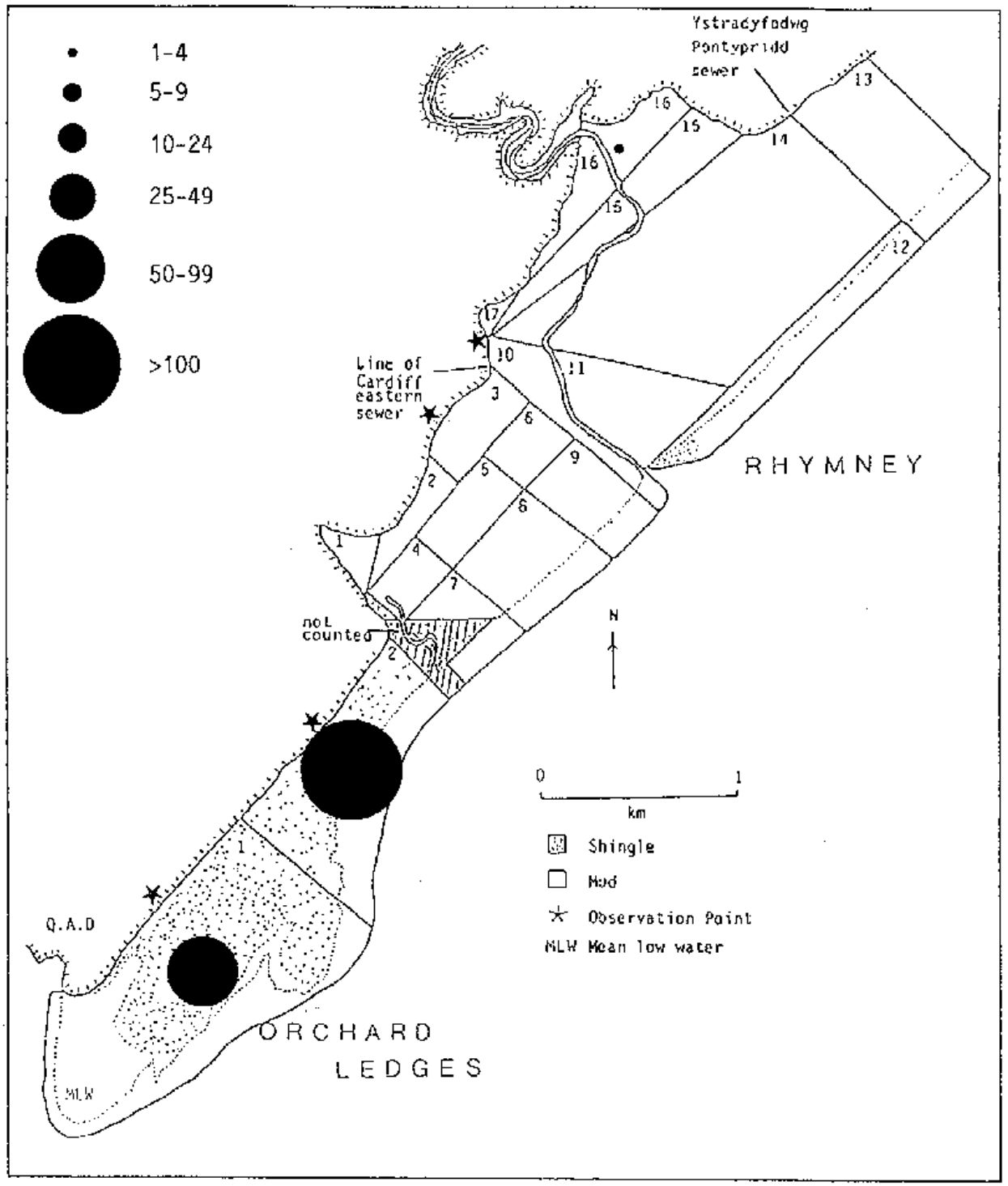


Figure 3.17.2 The distribution of feeding Turnstone on the Rhymney and Orchard Ledges all day site during the autumn 1991. The average number of bird hours per tidal cycle is depicted.

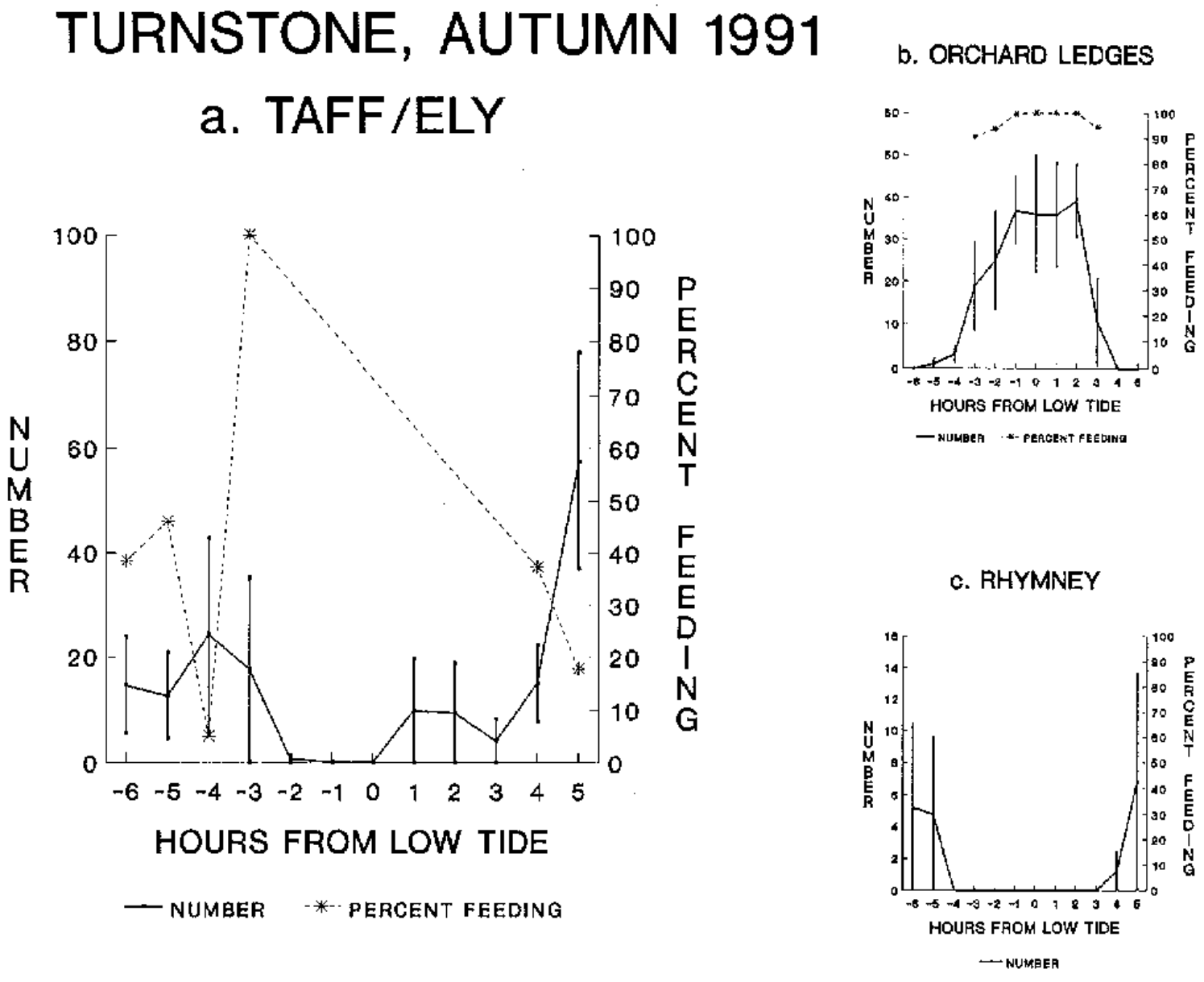


Figure 3.17.3 The total number of Turnstone present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during autumn 1991.

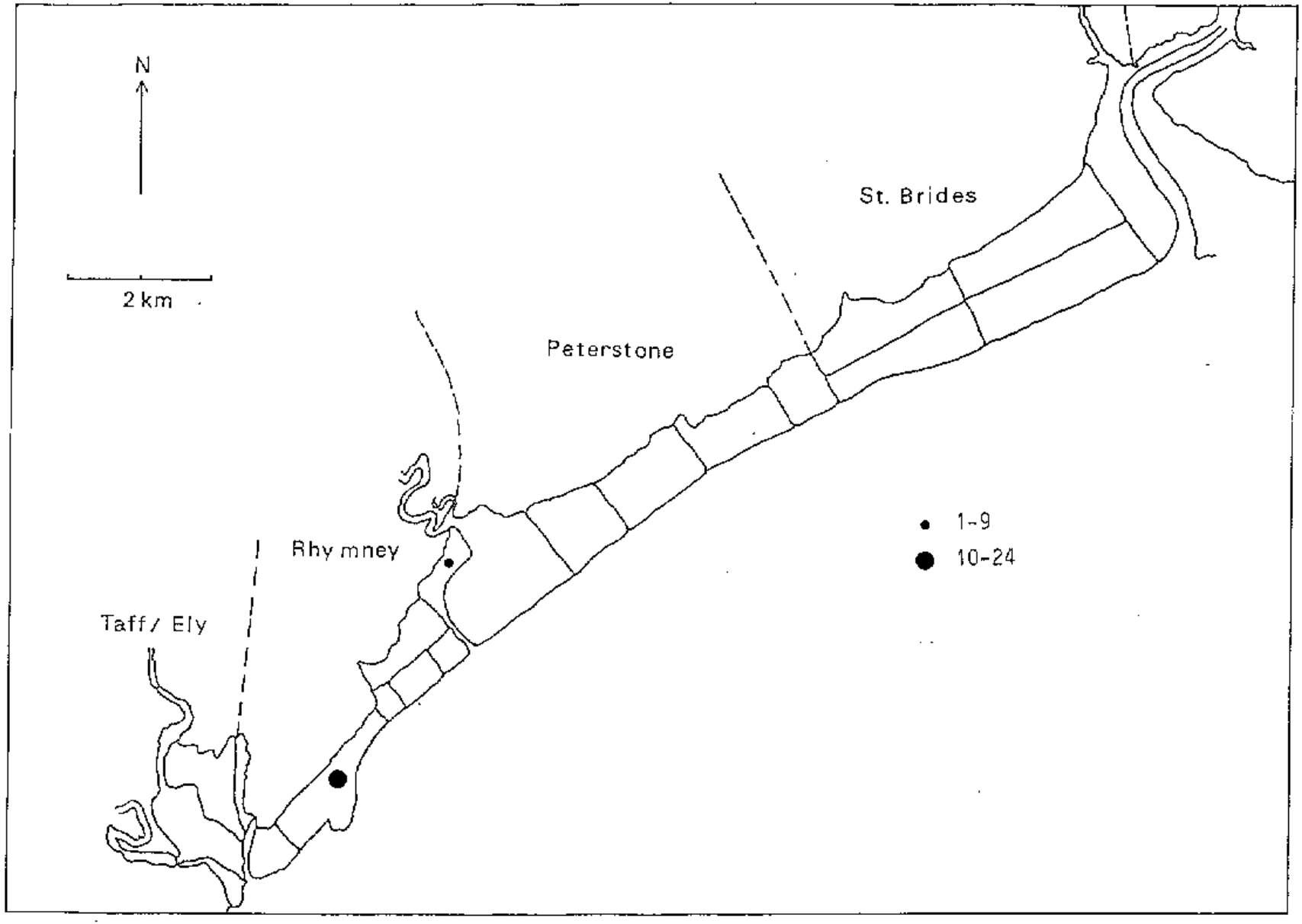


Figure 3.17.4 The low tide distribution of feeding Turnstone on the northwest Severn during winter 1991/92.

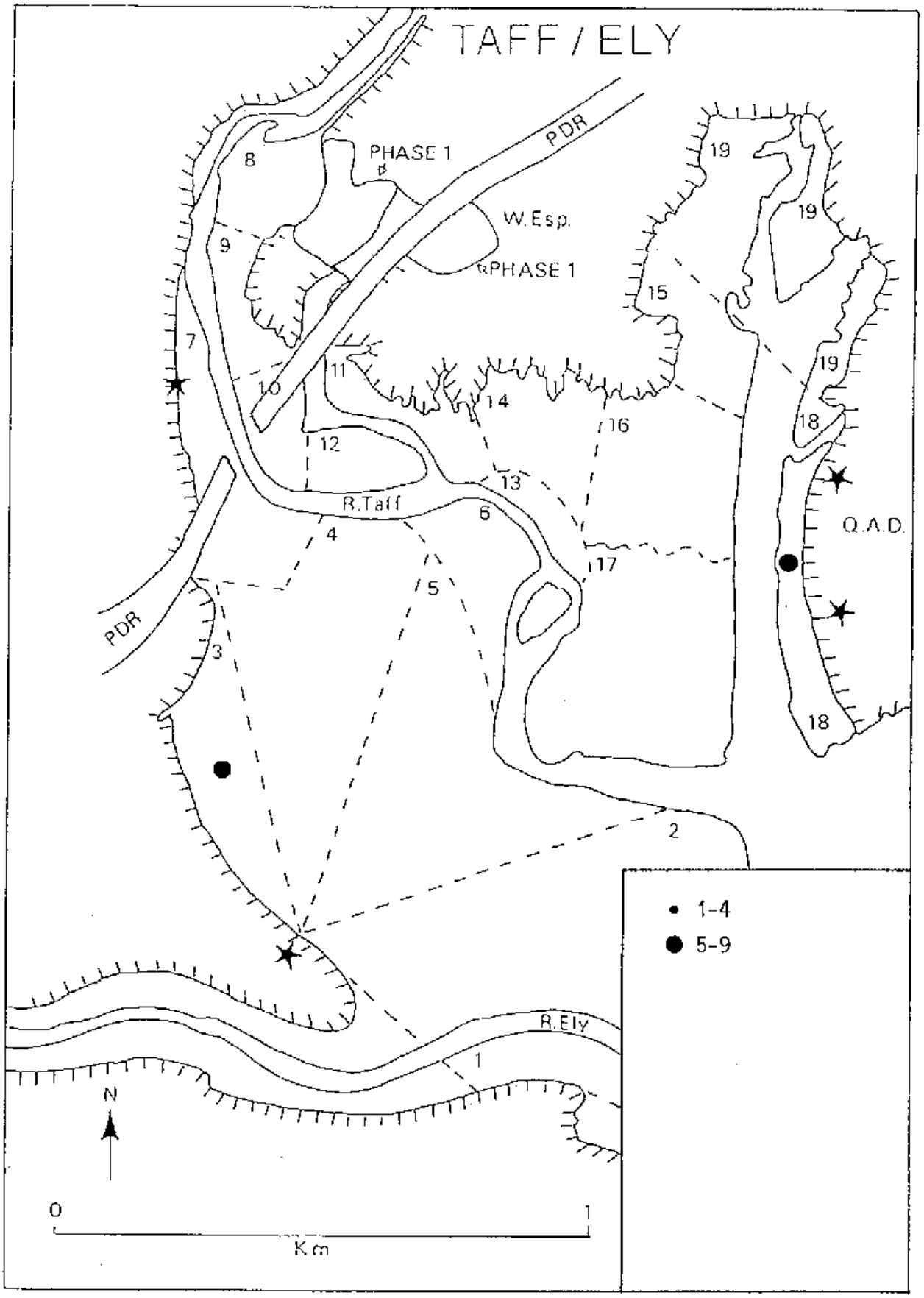


Figure 3.17.5 The distribution of feeding Turnstone on the Taff/Ely all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

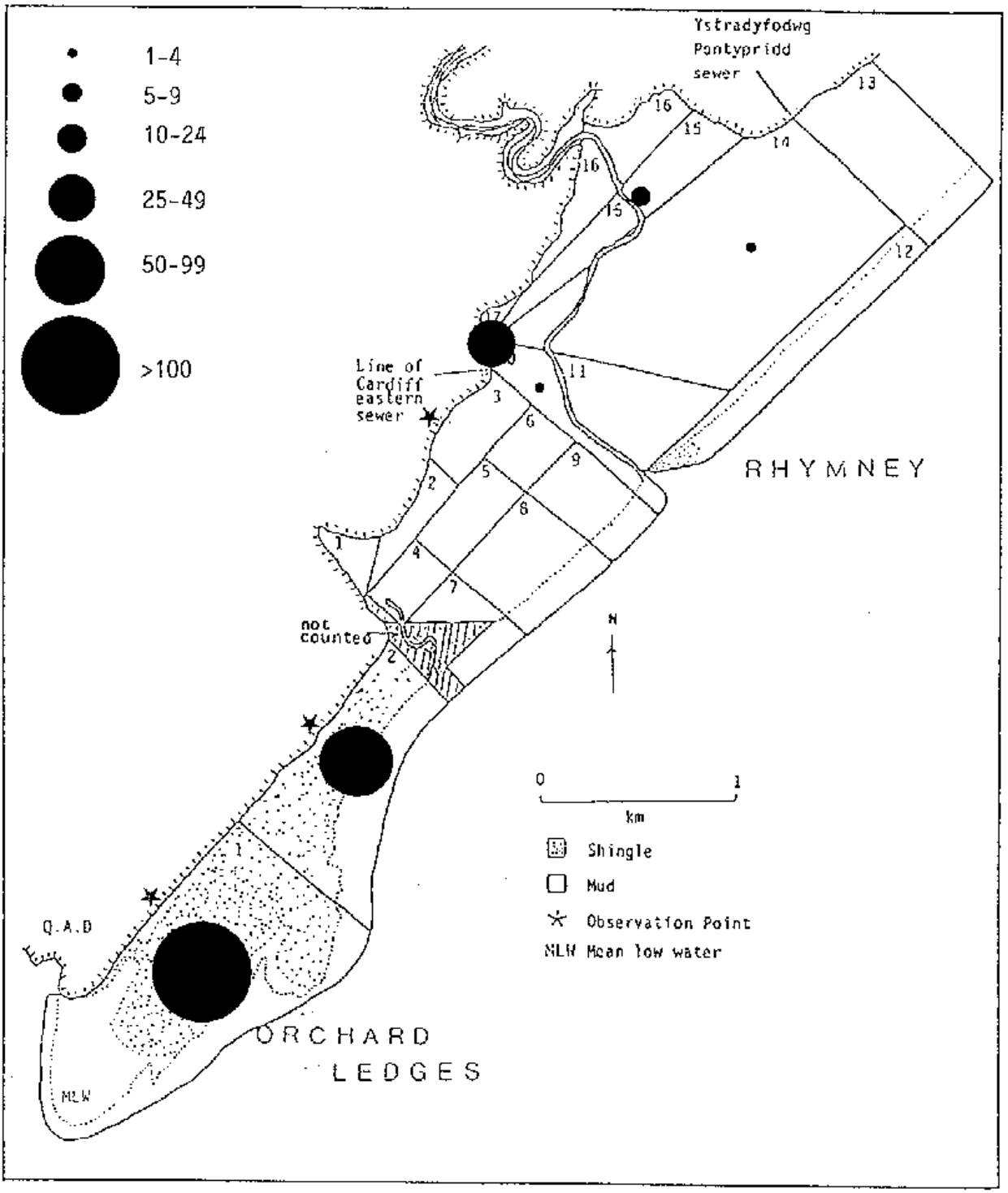


Figure 3.17.6 The distribution of feeding Turnstone on the Rhymney and Orchard Ledges all day site during the winter 1991/92. The average number of bird hours per tidal cycle is depicted.

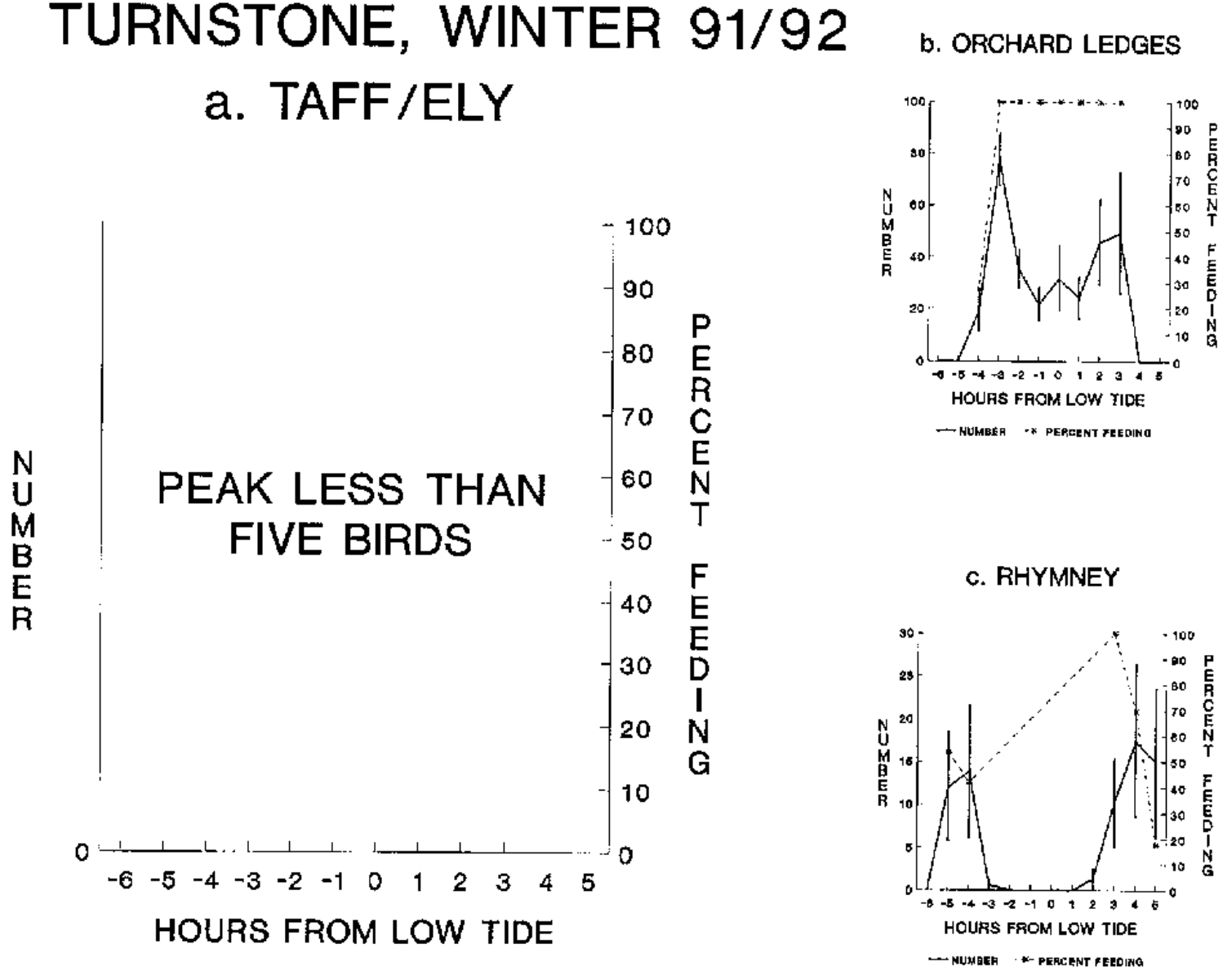


Figure 3.17.7 The total number of Turnstone present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during winter 1991/92.

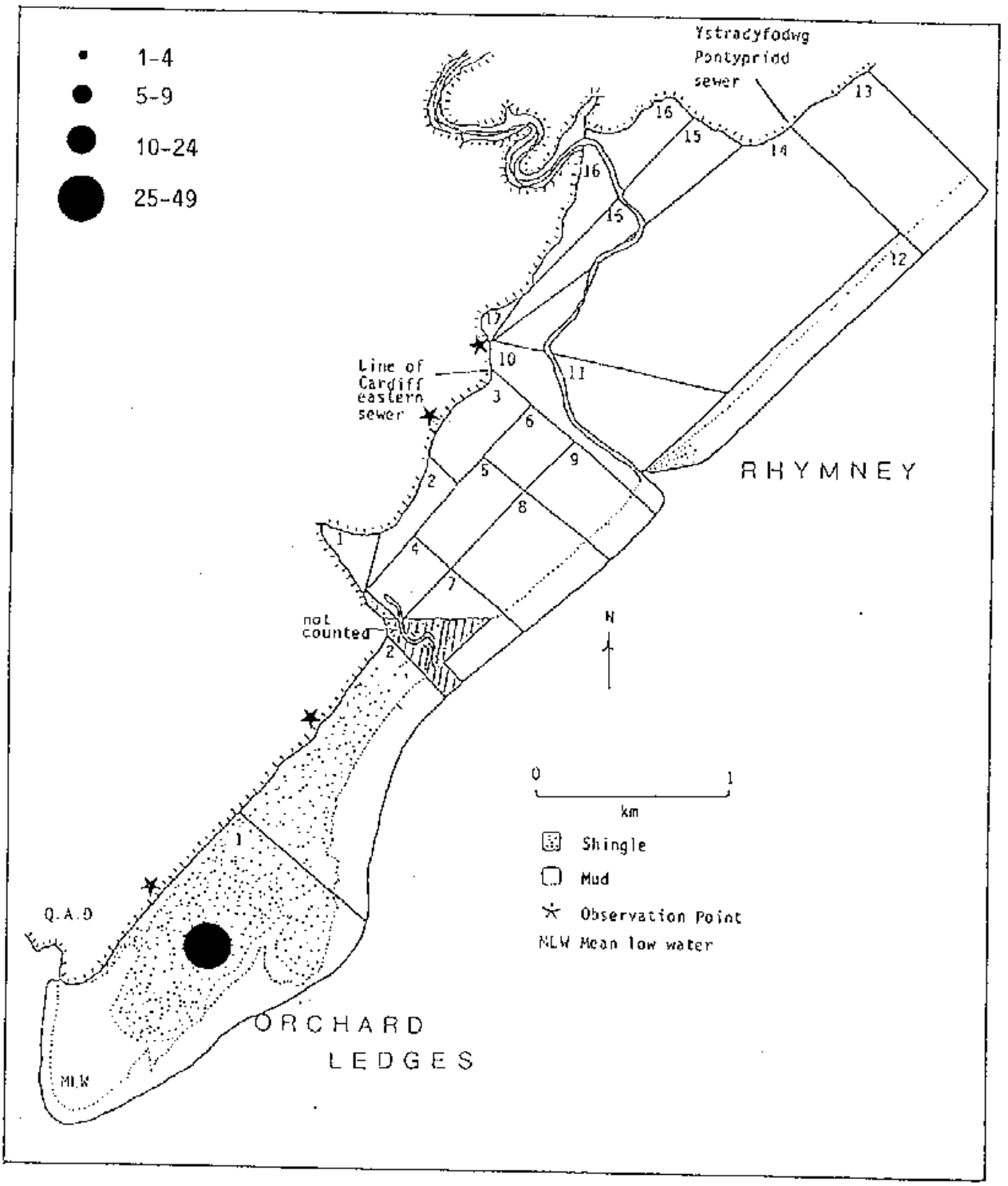


Figure 3.17.8 The distribution of feeding Turnstone on the Rhymney and Orchard Ledges all day site during the spring 1992. The average number of bird hours per tidal cycle is depicted.

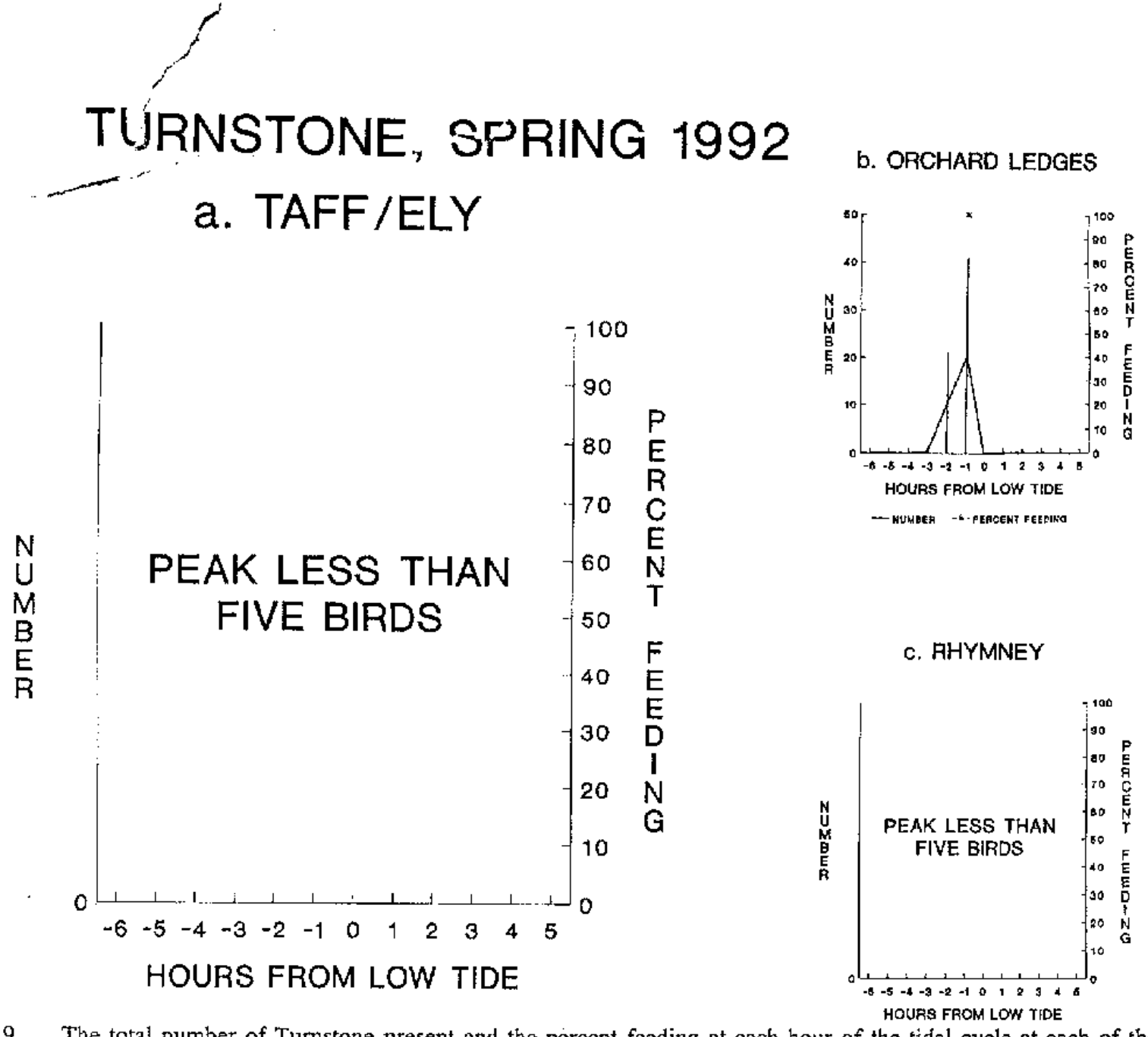


Figure 3.17.9 The total number of Turnstone present and the percent feeding at each hour of the tidal cycle at each of the three all day study sites during spring 1992.

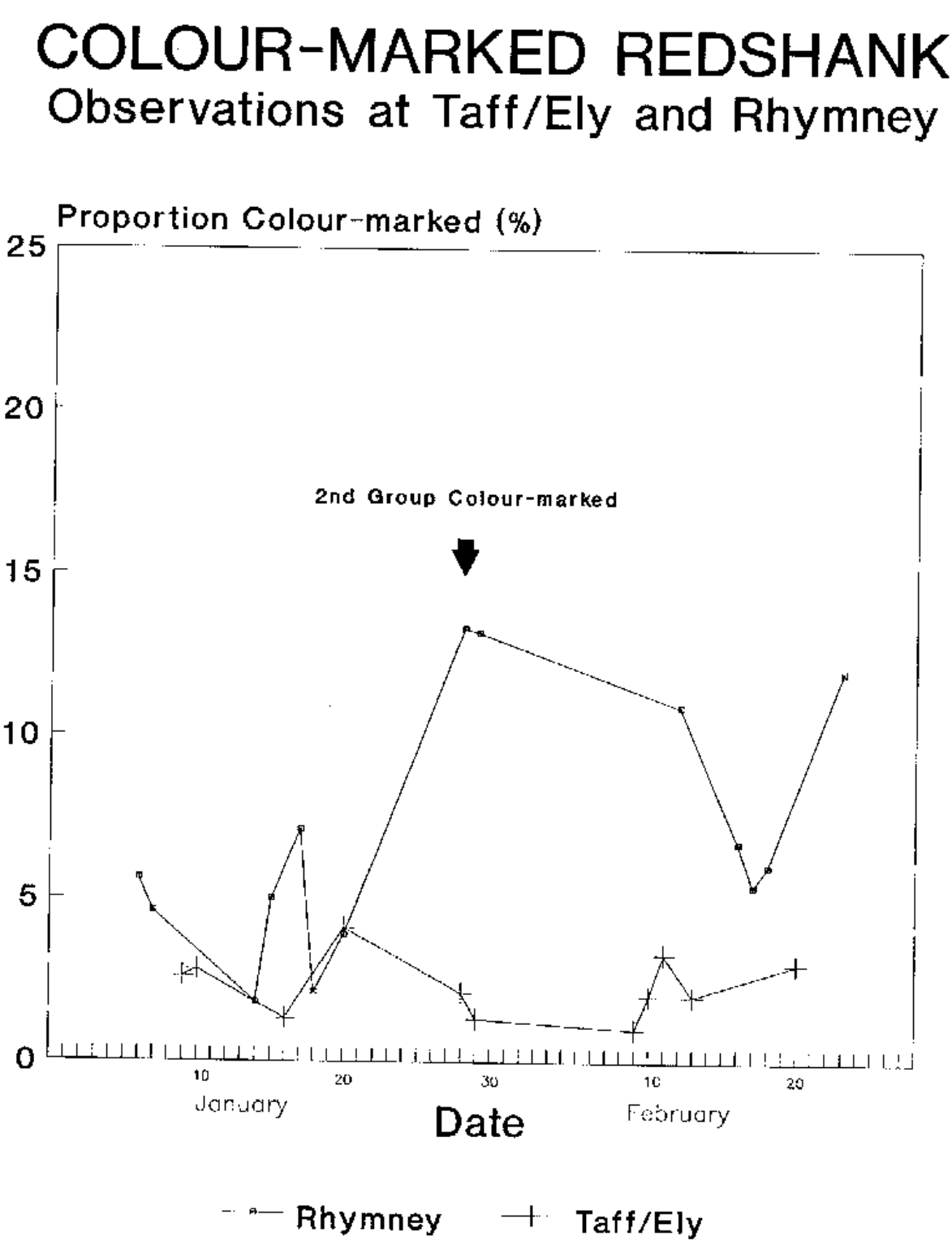


Figure 7.1 The percentage of colour-marked Redshank observed at the Taff/Ely and Rhymney Sites in January and February 1992. Colour-marking was carried out at the end of December and the end of January.