BTO Research Report No. 69

THE EFFECT OF THE CARDIFF BAY BARRAGE ON WATERFOWL POPULATIONS

1. DISTRIBUTION AND MOVEMENT STUDIES

NOVEMBER 1989 - MAY 1990

A report from the
British Trust for Ornithology
to
Cardiff Bay
Development Corporation
in respect of work
done under contract

by

J. Evans, N.A. Clark & P.F. Donald

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The effect of the Cardiff Bay Barrage on waterfowl populations 1. Distribution and movement studies November 1989 – May 1990.

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EXECUTIVE SUMMARY

This report details progress to date of a study aimed to monitor what effects a barrage across Cardiff Bay (Taff/Ely estuary) will have on the waterfowl populations which use the area during the non-breeding season.

The main objectives of this report were:

1. To consider briefly the importance of the Taff/Ely estuary, both as part of the Severn and in national and international terms, using data collected as part of the Birds of the Estauries Enquiry (BoEE).

2. To consider the results of the winter 1989/90 low tide counts with particular reference to the Welsh Severn. To assess from these results whether any major numerical or distributional changes of waterfowl wintering on the Welsh shore of the Severn have taken place by direct comparison with data collected using similar methodology in the two previous winters.

3. To evaluate patterns of usage of the intertidal areas of the Taff/Ely estuary and two adjacent sites, Orchard Ledges and Rhymney, by waders and wildfowl throughout the tidal cycle and to assess their importance.

4. To consider in detail the movement of different species between and within study sites.

The Severn estuary is both nationally and internationally important for waders and wildfowl, notably Shelduck, Dunlin and Redshank, and the Taff/Ely estuary is an integral part of this intertidal complex. Whilst the latter regularly holds neither nationally nor internationally important populations of waders and wildfowl in the non-breeding season, numbers of Dunlin and Redshank recorded within the bay occasionally achieve national importance. However, although the total intertidal area of the bay available to the wintering waterfowl is less than 1% of the total intertidal area of the whole Severn, it supports more than 5% of Knot, Ringed Plover, Redshank and Turnstone and more than 10% of Oystercatcher, Grey Plover and Dunlin that winter there.

Low tide counts carried out during the 1989/90 winter revealed no evidence for any large-scale changes in numbers or distribution of waterfowl species wintering on the Welsh shore of the Severn in comparison to previous years. Of the key species, Shelduck and Redshank showed particularly consistent patterns of distribution. The highest numbers of Shelduck on the Welsh shore were at Rhymney, while Redshank concentrated around river mouths, including the Taff, Ely and Rhymney. Dunlin showed some local distributional change but the pattern throughout the Severn remained broadly similar. At Caldicot and Magor, low numbers of Dunlin were again recorded, supporting the suggestion from the previous winter's counts that there has been a decline in numbers wintering in these sections.

All day counts revealed the differences in usage within and between study sites by different species at different stages of the tidal cycle. In particular, these concentrated on Shelduck, Dunlin and Redshank, which are present in both nationally and internationally important numbers on the Severn and in large numbers on the Taff/Ely estuary in the winter.

With the exception of Dunlin, most species that fed within the Taff/Ely estuary remained there for as much of the tidal cycle as possible, although some small-scale movement was thought to occur between Orchard Ledges and Rhymney as well as other nearby sites.

Shelduck both at Rhymney and in the Taff/Ely estuary made extensive use of the available intertidal areas but showed little movement between these two study sites.

All day counts showed that Dunlin were feeding in the Taff/Ely estuary on the incoming and outgoing tides and moving to Rhymney for the low tide period in between. At Rhymney, they were joined by large numbers of Dunlin from other areas on the Severn, for example St. Brides and Clevedon (the latter being on the south shore of the Severn). Extensive use was made of the intertidal areas of both Rhymney and Taff/Ely.

Considerable numbers of Redshank made extensive use of all intertidal areas in the Taff/Ely estuary and at Rhymney but there was little evidence of movement between study sites.

1. GENERAL INTRODUCTION

This report covers the first winter and spring of a study aimed at determining the implications of construction of a barrage across Cardiff Bay on the intertidal bird populations which use the area. The work concentrated on Shelduck, Dunlin and Redshank, which were considered to be key species since they occur in internationally important numbers on the Severn and in large numbers in Cardiff Bay (henceforth referred to as the Taff/Ely estuary). Other species of wildfowl occur in nationally and internationally important numbers on the Severn, but are concentrated at Bridgwater Bay or Slimbridge. Additional, relatively common species occurring in the area are considered in less detail. Distributional data were collected in a rigorously standardized way so that implications of a barrage on bird populations could be tested statistically. In addition, the movements of each species within and between different areas were recorded, providing a firm basis for future ringing studies.

The birds which are dependent in winter on the intertidal flats of the Severn breed in areas as far apart as northern Canada and the Taimyr Peninsula in the northern Soviet Union. They come to Britain in autumn to feed on the abundant invertebrates which live in intertidal mud. The Birds of Estuaries Enquiry (BoEE) has been monitoring these bird populations on a monthly basis since 1969, allowing population estimates to be produced for all species wintering on British estuaries (e.g. Prater 1981). In mid-winter 1984 and 1985, the non-estuarine coasts of Britain were also surveyed, permitting production of estimates of the numbers and distribution patterns of waders wintering along the entire British coastline (Moser 1987, Moser and Summers 1987).

The BoEE has shown that the Severn is numerically the ninth most important estuary for waders in Britain (Salmon et al. 1989) with internationally important wintering populations of three species, Dunlin, Redshank and Curlew, and nationally important populations of a further two, Grey Plover and Ringed Plover (Table 1.1). In addition, an internationally important population of Shelduck, which feed intertidally, is present on the Severn both in late summer/autumn, when birds are concentrated in moulting flocks in Bridgwater Bay, and in winter.

The Taff/Ely estuary does not in its own right regularly support nationally or internationally important populations of waders or wildfowl (Table 1.2), although numbers of Dunlin and Redshank approach, and occasionally achieve, national importance. However, expression of its populations as proportions of those on the Severn, of which the Taff/Ely is an integral part, more clearly reveals its true significance.

The Taff/Ely estuary regularly holds over 10% of the Ringed Plover, Knot, Redshank and Turnstone wintering on the Severn and more than 5% of Dunlin, Oystercatcher and Grey Plover (Table 1.3), although the total area of intertidal mudflats available to birds within the Taff/Ely is less than 1% of the total area available within the whole Severn. The construction of a barrage across the mouth of the Taff/Ely estuary (Cardiff Bay) would result in the complete inundation of this area of mudflats. Since most waders species tend to be site faithful to their winter quarters from year to year (Goss-Custard et al. 1982, Clark 1983), the birds displaced by the construction of such a barrage would have to find alternative feeding grounds in the vicinity.

2. DISTRIBUTION STUDIES

2.1 INTRODUCTION

The length of time that waders and wildfowl need to feed per tidal cycle varies according to the time of year and the species involved (Goss-Custard et al. 1977). Smaller species of wader, e.g. Dunlin, need to feed for longer periods during each tidal cycle than larger species, e.g. Curlew. During very harsh weather it becomes critical for birds to feed at every available opportunity in order to survive (e.g. Goss-Custard 1977a). Not only do the birds have to increase their food intake but feeding successfully becomes more difficult: daylight hours are short, invertebrate activity is depressed (Pienkowski 1983a) and adverse weather conditions, e.g. heavy rain and strong winds, will hinder feeding (Davidson 1981). Conversely, during very mild weather feeding effort will be reduced. Consequently, this study paid particular attention to feeding birds. Patterns of distribution, usage and movement were determined for the wader and wildfowl species within the area stretching from the Taff/Ely estuary eastwards beyond the mouth of the river Rhymney.

2.2 METHODS

2.2.1 Low tide counts

For the purposes of this report, the study site was chosen to incorporate the Welsh shore of the Severn and so lay between the Taff/Ely estuary in the west and the river Wye to the east (Figure 2.1). For the 1989/90 winter, the study site was divided into nine counting sections, each covered by a single observer or small team. These sections were divided into smaller intertidal areas most of which were counted during the winter.

Counts were conducted during spring tides on seven dates throughout the winter period (Table 2. 1). The counts were spaced at fortnightly intervals. Count methodology was identical to that used in the 1987/88 and 1988/89 winter (Clark 1989, 1990).

2.2.2 All day counts

Fieldwork was undertaken in two parts: winter (November -March) and spring (April & May).

The area of study was divided into three study units on which all day observations were carried out:

Taff/Ely (Cardiff Bay) : - the intertidal areas of the Taff and Ely estuaries;

Orchard Ledges : - the area of foreshore adjacent to the docks between Taff/Ely and the Heliport;

Rhymney : - the area of foreshore between the Heliport and the groyne just east of the Ystradyfodwg/Pontypridd sewer, including the mouth of the river Rhymney.

The three sites were in turn divided into intertidal areas for ease of counting. These were distinguished by easily recognizable geographical features, e.g. rock outcrops, or they were divided by obvious sight lines on the horizon, e.g. pylons. Thus, Taff/Ely was divided into 19 intertidal areas, Orchard Ledges into 2 and Rhymney into 17. Each study site was observed on one day on a spring tide and one day on a neap tide each month from November 1989 to May 1990 (Table 2.1). Each intertidal area was counted once an hour throughout the period of daylight or for 12 hours, whichever was shorter, giving information throughout the tidal cycle. Roosting and feeding birds were recorded separately. Information was also gathered on the length of time each intertidal area was exposed for on each tidal cycle so that the average exposure time could be calculated. In mid-winter it was not possible to obtain counts for a whole tidal cycle within one day of daylight. In addition, count days were constrained by the gales and torrential rain, which coincided mainly with spring tides in early 1990. This was especially true at Rhymney due to the exposed nature of the observation points and the distance across the mouth of the river. On Orchard Ledges the substrate mixture of mud and shingle meant that birds tended to be very well camouflaged, a problem exacerbated by the low density of birds at this site. Hence, on all but those days with very good visibility, counts would have been affected by poorer weather, whereas the Taff/Ely site could be counted reliably on most days. Consequently there are less data in January and February on spring tides between one hour and four hours after low tide than for other times.

All observations were made from two or more observation points to ensure that each area was covered thoroughly. However, some creeks and channels remained 'blind spots', especially at low water, and may have accounted for the 'disappearance' of some birds. Consequently during the gale periods the numbers of birds counted were lower than expected, particularly in the Taff/Ely area, as in such conditions they sought these more sheltered places to feed.

Figures 2.2 & 2.3 provide maps of each study site giving the average exposure times over the study period for each intertidal area counted within the survey and visual assessments of the substrate type.

2.3 ANALYSIS

2.3.1 Low Tide Counts

In a previous study of the distribution of birds on the Severn estuary, using similar methodology (Clark 1989), it was possible to fill in missing counts by producing an index of numbers of birds present on the estuary and using this index to fill in the missing counts. In this study, a much lower percentage of all possible counting areas were counted on each low tide count date than in previous years. In general, missed counts came from the sites that had small numbers of birds present on them, although on occasions important areas were missed. There were two reasons for missed counts; firstly, the poor weather conditions in January and February which made counting on all areas very difficult, and secondly, counters being unable to make a count due to other commitments. Where possible, BTO staff counted important areas that were missed, however, this was not always possible. Consequently, there were insufficient counts for any index calculated to be reliable. For these reasons, the best measure of usage of each intertidal area within each section by each species was considered to be the average number of birds using that area for all counts actually made during the winter. This was considered valid since wader and wildfowl populations are most stable from November to February, the period during which these counts were carried out. Any counts missed were taken into account in discussion of the distribution patterns for each species.

Distribution maps for feeding birds were given for the north shore of the Severn up to Mathern (the Welsh shore) as this was considered most relevant for this report.

2.3.2 All Day Counts

Data were analysed for the each species on each site at which an average peak of 5 or more birds occurred at any time interval.

As the length for which each intertidal area was exposed varied between counting days, an average exposure time was calculated for each area. These average exposure times vary slightly between seasons, although the relative exposure time of each intertidal area within each site remains constant. Two points must be borne in mind when using these exposure times:

1. As each intertidal area was sampled once an hour and each sampling period could last up to 3/4 hour the exposure time could be up to one hour longer or shorter than calculated. However this was not thought to be a major problem as there were several counting days with different tidal heights (and therefore exposure times) on each site.

2. Average exposure time of the highest part of each intertidal area was based on assessments made during each count visit. Thus, exposure times give relative rather than absolute heights for each intertidal area.

For each species the all day usage was calculated for each area using the following equation:

$$\text{All day usage} = \sum_{A=-6 \text{ to } +5} (B \times C)$$

A = hours from low tide

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

C = proportion of area exposed at time A

2.4 RESULTS

The results of each low tide count carried out through the winter are given in Tables 2.2 - 2.8, showing the total numbers of each species recorded on each count on the Welsh shore. In addition, distribution maps are given for each species showing the mean number of birds present over the seven counts on each counting area during the winter period (November - March).

The results of the all day counts are discussed species by species, with the key species presented first, followed by other species, each in standard scientific order. Winter and spring are dealt with separately in each species account and, where there are sufficient data, they are presented in three ways:-

1. For each species at each study site, graphs are plotted of numbers present and the percentage feeding at each hour throughout the tidal cycle ($\pm$ one standard error). The latter was only

plotted if an average of more than 50 birds were counted at any time interval through the winter. The parts of the tidal cycle which are important for birds feeding within the study area can be thus identified.

2. Distribution maps are given for each species at each study site showing the mean total number of bird-hours feeding per day for each intertidal area (area usage). This gives an indication of the relative importance of each intertidal area for each species.

3. A graph is plotted of hours feeding per hectare versus exposure time, showing all three study sites on the same axes. This indicates, for all species, the height of intertidal area on which most feeding took place within each study site.

2.4 Key Species

Shelduck

The Shelduck population of the Severn is concentrated into two areas in winter, Rhymney and Bridgwater Bay (Clark 1989). Rhymney is thus the most important site for Shelduck on the Welsh shore, although small numbers occur regularly at all other sites. Patterns of distribution were very similar to those recorded in previous years, although some movement away from St. Brides occurred between the 1988/89 and 1989/90 winters (Figure 2.4). Numbers at low tide at Rhymney continued the increase shown over the previous two winters.

Most birds observed during the all day counts were feeding. At Rhymney birds could be seen moving into the vicinity as the tide turned, waiting for the first intertidal areas to be exposed. Thereafter, numbers feeding increased sharply as the birds moved onto the newly exposed mud, continuing to rise as the tide receded and dropping again as the tide advanced (Figure 2.5). The main concentration of birds was east of the river (Figure 2.6). Over the high tide period, Shelduck either remained in the area roosting on the water or moved away to roost at Peterstone.

In the Taff/Ely estuary, the pattern of feeding was similar. Birds that fed within the bay almost always roosted there as well, either on the water or in and around the saltmarsh. As the tide receded they started to move out of the roost to feed, spreading over the whole of the intertidal area as this became exposed (Figure 2.5). As at Rhymney, some birds followed the tide edge down the shore on the receding tide and up the shore on the incoming tide, while others remained feeding on the higher areas, giving an even pattern of feeding distribution throughout the bay (Figure 2.7) with no clear preference for either low or high mudflats (Figure 2.8). Peak numbers occurred four hours before low tide as the birds collected to feed on the areas first exposed (Figure 2.5), declining as some birds moved out of the bay, the rest remaining feeding up to low tide. One hour after low tide, numbers of Shelduck present began to decline. This was probably a result of the birds on the water not being counted, since no substantial movement out of the bay was observed at this time. The decline in numbers counted towards high tide (Figure 2.5) may also have been due to birds moving out of sight into the saltmarsh to roost (Figure 2.7). Very few Shelduck were observed using Orchard Ledges (Figure 2.5), except at the western end where some birds from the Taff/Ely spread onto its muddy periphery (Figure 2.6).

By April, numbers at Rhymney had decreased considerably. The patterns of feeding (Figure 2.9) and distribution (Figure 2.10) remained similar, although a higher proportion of birds concentrated on the upper areas. Shelduck present in the Taff/Ely estuary showed less tendency to leave the bay at any time during the exposed period in spring than in winter and had begun to segregate into pairs. Numbers increased up to three hours before low tide as birds moved out of the saltmarsh or off the water and began to feed, they then remained stable until four hours after low tide, after which the numbers declined as the feeding areas were covered (Figure 2.9). Patterns of distribution remained similar to those found in winter (Figure 2.11), although, as at Rhymney, Shelduck showed an increased preference for the higher areas. They spent some time in courtship displays throughout the tidal cycle. Very few Shelduck were observed using Orchard Ledges (Figure 2.10)

Dunlin

Virtually all Dunlin wintering on the Severn are of the alpina race which breeed in northern Fennoscandia and northern U.S.S.R. (Clark 1983). Migrant schinzii, which breed in northern Britain and Iceland, and arctica, which breed in east Greenland, pass through the Severn in spring and autumn, leaving by October and returning in April. The main concentration of Dunlin on the Welsh shore of the Severn at low tide was from Rhymney to Nash as found in previous winters (Clark 1989, 1990). Numbers at Caldicot remained broadly similar to those recorded during winter 1988/89 (Figure 2.12) supporting the suggestion that there has been a decline in numbers wintering at this site (Clark 1989) compared with previous years (e.g. Ferns 1980).

Most Dunlin were found to be feeding on both low tide and all day counts. All day counts reveal differing patterns of area usage between study sites. Numbers present at Rhymney rose to a peak two hours before low tide, then began to decline again (Figure 2.13). Some moved up the shore on rising tide and down on the falling tide giving a relatively even pattern of distribution of feeding effort (Figure 2.14).

Peak numbers occurred in the Taff/Ely estuary four hours before low tide as birds took advantage of the first exposed areas and two hours after low tide (Figure 2.13). A significant proportion of these birds moved up the shore on the rising tide and down on the falling tide giving a fairly even pattern of usage over all the intertidal areas (Figure 2.15). Only small numbers of Dunlin were recorded at Orchard Ledges between four hours before low tide and low tide itself (Figure 2.13). Most Dunlin at Rhymney fed on the lower tidal levels at low water, whereas at Taff/Ely most feeding took place at the mid-tide level (Figure 2.16).

By April, the alpina Dunlin wintering on the study sites had departed. The spring passage of the schinzii and arctica races rarely starts before April (Clark 1983). Very few Dunlin were seen in April and May and these were probably birds on migration. Hence, no useful conclusions can be drawn regarding their preference for any one intertidal area.

Redshank

The pattern of distribution of Redshank along the Welsh shore of the Severn at low tide in winter 1989/90 (Figure 2.17) was very similar to that found in the winter 1988/89 low tide counts (Clark 1989, 1990). Slightly fewer birds were observed everywhere except Taff/Ely, possibly because Redshank are particularly difficult to observe at low tide in adverse weather conditions when they tend to feed in creeks where they can shelter from the wind. The Rhymney and the Taff/Ely estuaries are not only two of the most important areas for Redshank on the Welsh shore of the Severn, but also two of the most important sites for Redshank on the Severn as a whole. Five hundred birds were regularly observed during the all day counts both at Taff/Ely and at Rhymney.

Fluctuations in numbers counted were most likely to have been due to birds moving in and out of creeks and channels rather than to any significant changes in numbers present within a study site.(Figures 2.18). Redshank were observed feeding on almost all occasions (Figure 2.18), and patterns of distribution indicate that they make considerable use of those areas adjacent to the river at Rhymney (Figure 2.19) and all intertidal areas in the

Taff/Ely estuary (Figure 2.20). Peak numbers were observed three hours before high tide when birds were forced onto the open flats as the channels and creeks filled with water (Figure 2.18). This increased visibility biases the results towards the higher areas. However, Redshank make use of all available intertidal areas (Figure 2.21).

The majority of Redshank feeding in the Taff/Ely estuary remained throughout the tidal cycle, roosting in the mouth of the overflow channel of the South Glamorgan Canal or at the edges of the saltmarsh. On spring tides, which inundate these areas, Redshank used to roost on disused jetties. These were removed in early November 1989 and Redshank are now forced to leave the bay, possibly roosting in the docks. Redshank feeding at Rhymney roosted on the banks of the river near its mouth.

In spring, numbers of Redshank had dropped considerably. Those that remained in the Taff/Ely estuary spent a lower proportion of the time feeding (Figure 2.22) and tended to remain on the banks of the Taff in the area near the South Glamorgan canal (Figure 2.23). At Rhymney birds also fed in a limited area on the banks of the river and closer to their usual roosting area.

2.5 Additional species

Wigeon

The very few Wigeon were recorded on the Welsh shore of the Severn during the winter 1989/90. Only two sites were used, Nash and Redwick (Figure 2.24)

Mallard

The 1989/90 winter low tide counts showed that Mallard tend to occur on the outer portion of the Severn estuary (Figure 2.25). Lack of birds at St. Brides may, however, have been due to incomplete coverage; those counts that did take place here were in adverse weather conditions when birds are harder to locate.

At Rhymney, all day counts showed that numbers were lowest around high tide but increased throughout the low tide period, reaching a peak three hours before low tide before dropping again as the tide covered the area. However, the percentage feeding peaked two hours before low tide and decreased subsequently, suggesting that some birds moved into the area on the rising tide to roost (Figure 2.26). Most Mallard were recorded feeding and roosting on or near the banks of the river (Figure 2.27). All day observations in the Taff/Ely estuary revealed a pattern of alternate feeding and roosting bouts (Figure 2.26), mainly on the banks of the river Taff (Figure 2.28). Numbers feeding decreased around high tide as the birds began to roost on the water or moved out of sight into the saltmarsh and hence were not counted.

There was no clear relationship between the numbers feeding per hectare and exposure time for either Rhymney or Taff/Ely (Figure 2.29). Very few Mallard were observed using Orchard Ledges.

The few Mallard that remained in spring were recorded at Taff/Ely (Figure 2.30). These birds remained near the South Glamorgan canal, feeding on the lower areas and roosting on the river banks or near the saltmarsh (Figure 2.31).

Teal

Teal were recorded at only three sites on the Welsh shore of the Severn during the winter 1989/90 low tide counts. Most were observed at Taff/Ely (Figure 2.32), although in previous years St. Brides has held the most birds (Clark 1989, 1990). This lack of birds recorded may have been due to incomplete coverage and adverse weather conditions during the counts that did take place.

All day observations revealed a pattern of alternate roosting and feeding bouts, similar to that found for Mallard at Taff/Ely and account for the variability in the percentage of birds feeding throughout the tidal cycle (Figure 2.33). However, Teal did not move as far from the river banks as Mallard, tending to remain closer to the water's edge (Figure 2.34 & 2.35). At Taff/Ely, most feeding took place on the lowest and the highest areas (Figure 2.36). Birds moved down to the water's edge from the river banks during the low tide period and fed on the highest areas when all other areas were inundated. No clear pattern emerges at Rhymney (Figure 2.36).

Numbers dropped considerably after mid-March. Those birds remaining were observed at Taff/Ely in April (Figure 2.37). No birds were observed in May.

Pintail

The only significant numbers of Pintail using the Severn estuary are those around the mouth of the Rhymney (Figure 2.38), where a flock of up to 500 birds has been present in winters prior to 1989/90. Up to 250 Pintail were regularly observed at Rhymney in winter 1989/90, exceeding the 100-150 observed in the 1988/89 winter (Clark 1990). All day counts show that the first birds often arrived prior to the first areas being exposed, with the result that the number of Pintail counted increased sharply as they moved onto these areas to feed. Numbers decreased slightly towards low water as some birds moved out of the counting area, but increased again three hours after low tide as they were forced back towards the mouth of the river by the incoming tide. Meanwhile the percentage of birds feeding reached a plateau throughout the low water period. Numbers of Pintail declined again and this is accompanied by a sharp decrease in the number of birds feeding as the returning birds begin to roost on the water or out of sight on the shore (Figure 2.39). The main concentration of birds was around the river itself, and most birds feeding were within 50 metres of the tide's edge, although birds tended to be present on the higher areas on the rising and falling tides (Figure 2.40). Consequently, no clear pattern emerges when hours feeding per hectare is plotted against exposure time (Figure 2. 41). All Pintail had left the study sites by the end of March.

Pochard

No Pochard were recorded during the 1989/90 low tide counts, but were observed regularly throughout the winter during the all day counts (Figure 2.42). Small numbers fed around the mouth of the river Rhymney and flocks of up to 100 were observed roosting on the water in this area during the high tide period. Feeding birds concentrated on two intertidal areas (6 and 11). Numbers present subsequently decreased rapidly towards low tide and the few present one hour after low tide soon moved away or roosted on the water at the tide edge (Figure 2.42).

No Pochard were located in spring. This is to be expected since most will have dispersed to their breeding grounds by April.

Oystercatcher

When compared with the results of winter low tide counts in past years (Clark 1989, 1990), the results of the winter 1989/90 low tide counts suggest that there has been a slight decline in numbers of Oystercatchers wintering on the north shore of he Severn (Figure 2.43), although Oystercatcher populations on the Severn and nationally are increasing (Salmon et al. 1989, BoEE unpubl.). This may reflect the movement of birds away from areas where storm-induced erosion had taken place during the latter half of the winter.

At Rhymney, there was a sharp increase in Oystercatchers present four hours before low tide as the first areas of mud became exposed, followed by a substantial decrease as birds moved out of the area. Those remaining spent the majority of their time feeding near the tide edge. At low tide birds began moving back into the area, numbers present increasing steadily until three hours before low tide after which most areas became covered and they moved off to roost (Figure 2.44) Numbers feeding at Rhymney were well distributed over all the intertidal areas, but highest concentrations were observed in the Ystradyfodwg/Pontypridd sewer area (Figure 2.45).

At Orchard Ledges birds arrived rapidly as soon as the area began to uncover three hours before low tide. Numbers then declined steadily, until two hours after low water when no birds remained. Oystercatchers used Orchard Ledges only for feeding (Figure 2. 44).

A very small population in the Taff/Ely estuary was present throughout the tidal cycle, decreasing slightly around low tide as some individuals ranged further afield and increasing again as the tide forced them back into the bay (Figure 2.44). Birds tended to feed on the lower intertidal areas (e.g. 2, 12, 17), moving onto the higher areas (e.g. 11 & 14) to roost (Figure 2.46). On neap tides these birds would remain roosting in the saltmarsh at high tide while on spring tides they would leave the bay. In winter, Oystercatchers made use of all heights of available intertidal area (Figure 2.47).

In spring, very few individuals remained, the only significant numbers being at Rhymney on the incoming and outgoing tides (Figure 2.48). Oystercatchers at Rhymney seemed to concentrate less on the lower areas wihin the study site at this time of year (Figure 2.49). This may be due to a seasonal change in prey distribution or availablity. However, the birds were also starting to roost earlier, suggesting that Oystercatchers did not need to spend as much time feeding in order to survive in the milder spring weather.

The main concentrations of Oystercatchers within the three study sites were either in an area including the east end of Orchard Ledges and the west end of Rhymney or around the Ystradyfodwg/Pontypridd sewer (Figure 2.49). A very small number of Oystercatchers remained within the Taff/Ely estuary. These birds, like those at Rhymney, fed on the intertidal areas further up the shore (Figure 2.50).

Ringed Plover

Low tide counts in winter 1989/90 showed a similar distribution for Ringed Plover as found for previous winters. For the most part, discrepancies in detail probably reflect difficulty in locating individuals of this small, cryptic species (Spearpoint et al. 1988) rather than a significant change in numbers. However, one of the most important areas during the 1988/89 winter was Redwick, whereas very few were found there in winter 1989/90 (Figure 2.51).

Most of the few feeding birds observed during the all day counts were observed at Rhymney (Figure 2.52). These were observed as the first areas were exposing and just before the last areas were covered, when they were near the shore and easier to locate. This is reflected in the patterns of feeding distribution in Figures 2.53 and 2.54. Few were seen at the other sites, but in particular at Orchard Ledges, some may have been present but unlocated. Other observers recorded flocks of up to forty in the Taff/Ely estuary in November and flocks of up to 120 were seen on separate occasions at Rhymney and Orchard Ledges. Adverse weather conditions causing poor visibility and the extremely cryptic nature of the plumage and behaviour of this species were almost certainly to blame for lack of birds recorded. No clear pattern emerges when hours feeding per hectare is plotted against exposure time (Figure 2.55).

Very few Ringed Plover were observed in spring. Those still present on the study sites were almost certainly part of the small local breeding population.

Grey Plover

Few Grey Plover were recorded during the winter 1989/90 low tide counts (Figure 2.56), reflecting a poorer breeding season for this species in 1989.

The majority of the Grey Plover seen within the three study sites were observed feeding in the Taff/Ely estuary in November and

December (Figure 2.57) and roosted with the other waders. As the tide receded, numbers present declined rapidly, probably moving out of the area to feed. In general, Grey Plover are thought to prefer feeding on more extensive areas of firm mud within the Severn which occur on the mid- to upper shore (Clark 1989).

No Grey Plover were seen in spring.

Lapwing

Most Lapwing feed on farmland around the estuary, but use the estuary when roosting. When feeding conditions are good, Lapwing roost from late morning till dusk. Around new moon or in poor weather, however, they may continue feeding throughout the day. Lapwing were present in winter 1989/90 at all sites on which they had been recorded in winter 1988/89 except Rhymney (Figure 2.58), but in smaller numbers at all but Redwick.

A flock of Lapwing was recorded regularly at Taff/Ely during the all day counts throughout the winter period (Figure 2.59). These birds remained in the areas adjacent to the South Glamorgan Canal throughout the intertidal period (Figure 2.60). As the tide receded, the percentage feeding rose, whilst overall numbers present declined, as some birds began roosting or left the area altogether. Two hours after low tide there was a significant influx of birds, of which some began roosting and others began feeding. The majority of the birds present remained feeding until all areas were covered. Very few birds were seen at the other study sites (Figure 2.59).

From the end of February onwards only single individuals were observed in the Taff/Ely estuary, these being birds that stayed to breed locally, e.g. in the docks.

Knot

During the 1989/90 winter low tide counts no Knot were recorded on the Welsh shore.

During the course of the all day counts Knot were observed on only a single occasion in the Taff/Ely estuary: 750 Knot were seen joining the roost in the South Glamorgan canal overflow on 19 December 1989, some of which had fed in the bay immediately prior to this. No Knot were observed at either Rhymney or Orchard Ledges. Earlier studies (Mudge 1979, Ferns 1980) have found considerable numbers of Knot feeding on the Welsh Grounds (mainly 118 and 120), and Clark (1989) found Knot feeding at Peterstone, Redwick and Caldicot during the 1988/89 winter low tide counts. None of these areas was apparently used in the 1989/90 winter when the only regular concentration of Knot on the Severn was at Bridgwater Bay.

Bar-tailed Godwit

Numbers wintering in the Severn estuary were lower in 1989/90 than in 1988/89. Redwick was the only area on the Welsh shore on which Bar-tailed Godwit were observed.

Curlew

Distribution of Curlew along the Welsh shore of the Severn was broadly similar to that in previous winters (Figure 2.61), although fewer were recorded at Redwick and Peterstone. However, the ubiquity of this species means its precise distribution can only be identified by comprehensive coverage of intertidal areas.

Curlew at Rhymney began to feed as the intertidal flats started to become exposed. Numbers continued to increase towards low water, dropping off more sharply on the rising tide (Figure 2.62), giving a fairly even pattern of distribution of feeding effort (Figure 2.63).

Curlew fed on Orchard Ledges throughout the period for which it was exposed, with peak numbers occurring as the first areas were uncovered, four hours before low tide, and again one hour after low tide (Figure 2.62). A large flock of Curlew was regularly observed roosting in the Taff/Ely estuary on neap tides. As the tide receded, they gradually moved out of the roost and onto the intertidal areas to feed. At this time there is a small increase in the numbers observed (Figure 2.62). Curlew at Taff/Ely were observed feeding on most of the available intertidal areas (Figure 2.64). However, a larger number of Curlew were observed feeding at and below mid-tide level than above it, although at lower densities. Consequently, when hours feeding per hectare is plotted against exposure time, the results for the Taff/Ely are biased in favour of the higher areas (Figure 2.65). As the tide advanced, Curlew moved back into the bay with numbers present reaching a peak three hours after low tide. At the same time the percentage feeding dropped sharply as birds formed a pre-roost on the lower intertidal areas (Figure 2.62), gradually moving into the saltmarsh where they spent the high tide period. On spring tides, when the roost area was flooded, Curlew were forced to leave the bay when the roost area was flooded.

In spring, there were fewer Curlew present on all study sites (Figure 2.66) but these birds showed a similar pattern of distribution to that in winter (Figures 2.67 & 2.68). This similarity is confirmed by comparing the winter and spring graphs of hours feeding per hectare versus exposure time (Figure 2.65).

Turnstone

The distribution of Turnstone recorded during the 1989/90 winter low tide counts on the Welsh shore was very similar to that recorded in previous winters. The only site on which they were located was Rhymney, reflecting the distribution of rock and gravel: Orchard Ledges, an area of extensive shingle and rocky habitat, holds one of the two main concentrations of Turnstone on the Severn (Figure 2.69). During the all day counts, birds were located at all three study sites. At Orchard Ledges numbers counted dropped to almost zero one hour before low tide (Figure 2.70), but this was thought to be due to a failure to locate this small, cryptic species rather than a lack of birds present at this time). The majority of those at Rhymney and Taff/Ely were observed when Orchard Ledges was covered. On these sites they used the few available stony areas high up the shore for feeding (Figures 2.71

& 2.72) and, in some cases, roosting. Consequently, when hours feeding per hectare is plotted against exposure time, it appears that birds at both Rhymney and Taff/Ely clearly favour the higher areas (Figure 2.73).

In spring, the only significant numbers of Turnstone were observed feeding on Orchard Ledges. None were found feeding at Rhymney, some were located on the Taff/Ely as they dispersed from the roost

2.5 DISCUSSION

Numbers of birds wintering on the Severn estuary tend to reflect the success of the preceding breeding season. Consequently, numbers and distribution of the three key species (Shelduck, Redshank and Dunlin) were extremely consistent between years, whereas very few high arctic breeding waders such as Knot or Grey Plover were recorded during the 1989/90 low tide counts in comparison to 1988/89. This was because 1988 was an exceptionally good breeding season throughout the arctic and 1989 rather poor. Bar-tailed Godwit, with their wider breeding distribution, also had a poor breeding season in 1989 compared to 1988 and were present in considerably lower numbers than in the previous years' counts. Most other species showed little variation in low tide distribution and were present in similar numbers to previous years (Clark 1989, 1990). In particular, the numbers and distribution of the three key species were extremely consistent between the three years.

Rhymney remained the most important site for Shelduck both on the Welsh shore and in the study area, with nationally importantnumbers counted here throughout the winter and peak numbers exceeding those counted in previous winters (Clark 1990).

Both Shelduck and Redshank were observed feeding throughout the period for which the intertidal mud was exposed, although Shelduck tended to spend a higher proportion of time roosting. Large numbers of Redshank were recorded at both Rhymney and Taff/Ely, reflecting their dependence on the areas around river mouths as shown in previous studies (Clark 1989, 1990).

The Dunlin recorded within the study area were similar in number to those observed in previous years (Clark 1989, 1990). The importance of each study site for this species varied through the tidal cycle. Peak numbers occurred on the Taff/Ely estuary on the incoming and outgoing tides; peak numbers at Rhymney occurred around low tide. It was clear that, whereas Redshank and Shelduck largely remained within a particular study site through the tidal cycle, Dunlin used two or more sites and tended to remain near the tide edge or on newly exposed areas (within approximately 100m of the tide edge). Shelduck and Redshank ranged widely within each study site. However, the main concentrations of Shelduck were observed feeding near the Ystradyfodwg/Pontypridd sewer within 100 metres of the tide edge, while Redshank tended to prefer the river banks.

Pintail was the only other species of waterfowl present within the study area in nationally significant numbers and these were observed at Rhymney. Large numbers of Curlew were regularly observed both at Rhymney and at Taff/Ely but were not present in nationally significant numbers. Both Curlew and Oystercatcher spent a smaller proportion of their time feeding than either Redshank or Dunlin. The Curlew in particular roosted for long periods of time. However, it should be remembered that during the 1989/90 winter, fieldwork was conducted in very mild weather in which invertebrate activity would not have been depressed by low temperatures (Goss-Custard 1977). In periods of cold weather, waders need to feed for longer to obtain their daily food requirements because their food intake rate is depressed (Goss-Custard 1979, Pienkowski 1983). The smaller waders, which already feed throughout the tidal cycle, would have few means of increasing the time which they are able to spend feeding, and therefore of increasing their daily food intake, to maintain condition and to ensure survival. In very severe weather, this reduction in food intake rate combined with the increase in the amount of food required can result in large scale mortality (Dobinson & Richards 1964, Pilcher et al. 1974, Clark 1982). Redshank are documented as being particularly vulnerable to harsh weather conditions (e.g. Clark 1982). The larger wader species, for example Curlew, whilst being able to increase their daily food intake by feeding for longer, may be forced to feed in higher densities on the upper mudflats. Hence, their food intake rate would be likely to decline through interference (Goss-Custard 1970). At the same time, birds normally feeding on the upper flats might be forced to move to the lower mudflats near low water as the upper flats, exposed to the cold air for longest, cool down and invertebrate activity is reduced (Clark 1983).

The Taff/Ely estuary holds areas of intertidal mud which are the first to be uncovered and the last to be covered by the tide. On neap tides, some of these areas remain exposed throughout the tidal cycle. This means that the importance of this area for waterfowl increases in cold weather. The value of a study of this nature, carried out during a mild winter, is that birds choose areas where they can achieve a high food intake rate. In this way, the preferred areas within an estuary or estuarine complex can be identified for different species. However, more than one year's study is required to assess how the relative importance of each study site for waterfowl changes in severe weather conditions. Investigation of the species using the area under a range of different coditions is vital to ensure a meaningful comparison before and after closure of the proposed barrage.

3. MOVEMENT STUDIES

3.1 INTRODUCTION

This section of the report considers the extent of the movements between study sites revealed by the all day counts.

Previous studies on intra-estuarine movements have highlighted the need for systematic catching, ringing and individual colour-marking of birds in order to elucidate maximum information (e.g. Clark 1983). However, due to the rapid start-up of this study and unfamiliarity with the site, it was considered more profitable to first investigate in detail the movements of birds using the site and identify catching areas of target species. In this way, a coherent colour-marking strategy could be implemented that would enable objective assessment of movements between the Taff/Ely estuary and the surrounding areas

The work carried out to date has covered the winter and spring periods of the 1989/90 non-breeding season. However, this report concentrates particularly on the winter period, since only a small-scale passage of migrant waders appeared to take place through Cardiff Bay in the spring. In addition, those species for which no movement was observed between study sites (i.e. they were found exclusively on one particular study site) are not dealt with in this section of the report.

3.2 METHODS

During the all day counts, that were carried out as part of the distribution studies, the movements of birds into and out of each study site were recorded. This included noting the point in the tidal cycle at which such movements occurred and the numbers of birds involved.

3.3 ANALYSIS

Data collected during the all day counts were analysed to produce a graph for each species, showing mean number present at each study site and the cumulative total mean number present at each hour of the tidal cycle for all study sites. In this way significant movements into and out of the study area can be detected by changes in the cumulative total through the tidal cycle.

3. 4 RESULTS

3. 4. 1 KEY SPECIES

Shelduck

The cumulative total present in the study area through the tidal cycle largely reflects the movements into and out of the Rhymney study site. The biggest movement into the latter occurred four hours before low tide as the first intertidal areas became exposed and birds moved onto them from the large roost at Peterstone, with birds continuing to arrive from other roost sites until low tide (Figure 3.1).

Maximum numbers in the Taff/Ely estuary also occurred as the first areas of mud were exposed although overall numbers were low. A general decrease took place through the tidal cycle reaching lowest numbers at high tide. There was some movement by Shelduck into and out of the bay, but part of the decrease in numbers recorded was due to birds moving onto the water, where they were not counted (Figure 3.1).

In spring, patterns of movement at Rhymney and at Taff/Ely were very similar until two hours after low tide, when numbers of Shelduck increased at Taff/Ely but decreased at Rhymney, presumably leaving to roost at Peterstone.

Dunlin

During the 1987/88 winter, Worrall (1988) studied wader and wildfowl movements within the Rhymney area and considered that Dunlin feeding at Rhymney near low tide roosted on the Peterstone shore. However, Clark (1989) found that BoEE counts for this area were too low for this to be the complete answer and from his own observations concluded that some birds feeding at Rhymney roosted at Clevedon on the south shore of the Severn. This is supported by observations, during this study, of Dunlin flying across the estuary during the course of the all day counts. Other birds arrived from Taff/Ely, via Orchard Ledges, where they had been feeding on the falling tide. The Taff/Ely contains the first mudflats in the study area to be exposed. An initial peak in Dunlin numbers occurred here as birds that had been roosting on

Sully Island (approximately 5km south-west of the Taff/Ely estuary) moved onto these areas to feed. This was followed by a decline in numbers during the next two hours until all but a few individuals had left the bay. Meanwhile, at Rhymney, Dunlin also arrived as the first areas were exposed. However, unlike at the Taff/Ely, numbers continued to increase for the next two hours at which point they accounted for all the Dunlin present in the study area (Figure 3.2). It seems probable that all the birds that had initially fed in the Taff/Ely estuary moved to Rhymney as the tide receded, although it does not entirely account for the increased numbers at Rhymney. This suggests that birds from outside the area, for example Clevedon, moved into it during the same two hour period. In the two hours before low tide, Dunlin numbers at Rhymney declined, with no corresponding increase at any of the other study sites. Hence, a substantial number of birds moved out of the study area at this stage leaving total numbers present very similar to those recorded when the intertidal areas were first exposed. The two hours following low tide saw a further drop in numbers present at Rhymney with a corresponding increase in numbers occurring at Taff/Ely, suggesting that at this point substantial numbers of Dunlin moved from Rhymney back to the Taff/Ely estuary. Numbers at Rhymney continued to decline but there was no further increase in numbers at Taff/Ely, indeed a decrease began here as well (Figure 3.2). In both cases birds had begun to move away in small groups to roost, only remaining to do so on the lowest of the neap tides.

Very few Dunlin were observed in spring. These few stayed for very short periods of time and were considered to be birds on migration.

Redshank

Fluctuations in the cumulative total are almost certainly due to variation in the numbers visible (as discussed in section 1) rather than significant movements into or out of the study area: peak numbers occurred on the incoming tide, three hours after low tide, when birds were forced out of the creeks and channels. Over the high tide period numbers in both areas dropped: At Rhymney, numbers recorded dropped to zero as birds moved out of sight of the observation point (but not out of the study site) to roost (Figure 3.3). Redshank roosted within the Taff/Ely estuary on neap tides and on spring tides they remained for as long as there were areas available before flying to a nearby site, e. g. the docks, to roost.

In spring, the cumulative total shows two large peaks three hours before and three hours after low tide (Figure 3.3). This is mainly attributable to changes in numbers observed at Taff/Ely and the drop in numbers around low tide is almost certainly due to the vastly reduced numbers of birds being harder to locate rather than any significant movements out of the area. Very few Redshank were observed at Rhymney and Orchard Ledges, suggesting that the Taff/Ely estuary is the most important study site for this species in spring.

3.4.2 ADDITIONAL SPECIES

Mallard

Similar numbers of Mallard were observed at Rhymney as at Taff/Ely throughout the tidal cycle. At both sites, numbers increased as the intertidal areas became exposed and similar changes in numbers were recorded as the tide receded. During the low tide period, there was no movement into or out of the study area as a whole. However, numbers at Rhymney doubled in this time while those at Taff/Ely showed an equivalent decrease (Figure 3.4). This suggests that some movement between the two study sites had occurred. One hour after low tide, there was an influx of Mallard into the study area, initially at both Rhymney and Taff/Ely (Figure 3.4). Numbers decreased from four hours after low tide as birds either left the area or moved on to the water where they remained uncounted. Very few birds were seen on Orchard Ledges.

Very few Mallard were observed at any of the study sites in spring. Those that were recorded would almost certainly be part of the local breeding population.

Oystercatcher

There were considerable fluctuations in the numbers of Oystercatchers in the study area through the tidal cycle. The greatest number of Oystercatchers was observed at Rhymney. Initial movement into the area occurred as the first intertidal areas were exposed, but within an hour many birds had either moved west to Orchard Ledges or east to the Peterstone shore.

Thereafter numbers at both Rhymney and Orchard Ledges declined, as did the total number of birds present in the study area (Figure 3.5). This can be explained by movement of birds out of the area, although a small number of birds moving onto the uncounted area of shingle between Orchard Ledges and Rhymney may have accounted for part of this decline. A few birds remained feeding on Orchard Ledges until low tide, gradually moving back towards Rhymney, where numbers experienced a gradual increase on the incoming tide (Figure 3.5). Once again, this implies an influx of birds from other areas. Concentrations of birds were often observed east of the Ystradyfodwg/Pontypridd sewer and these could account for the increase in numbers towards high tide as they were forced back towards the mouth of the river. Birds moved out of the study area to high tide roost sites.

Comparatively few Oystercatchers were present on the Taff/Ely but numbers remained relatively constant throughout the tidal cycle with only single birds moving out of the study site. On neap tides these birds roosted in or around the saltmarsh; on spring tides they were forced out of the bay to roost, possibly at Sully Island (Worrall 1988).

In spring, the main concentration of Oystercatchers was at the Rhymney. Peak numbers occurred on the incoming and outgoing tide and declined sharply to their lowest point at low tide (Figure 3.5). This supports observations that birds roosting outside the study site arrived in the area to feed as the first areas of mud were exposed, moved elsewhere during the low tide period, and returned on the incoming tide before finally moving out of the study site to roost. In spring, birds moved away, presumably to roost, much earlier than in winter; numbers declined to near zero well before all the intertidal areas were covered by the tide.

Fewer birds used Orchard Ledges in spring than in winter but their pattern of movement remained very similar. Very few birds were observed on the Taff/Ely in spring.

Curlew

At Rhymney, most of the Curlew arrived after high tide, soon after the first intertidal areas were exposed and small numbers continued to arrive until two hours before low tide. Thereafter, numbers present decreased as birds flew away singly and in small groups to roost at Peterstone (Figure 3.6). The Curlew observed in the Taff/Ely estuary either roosted in the saltmarsh within the bay or, if this area became inundated, joined the roost at Peterstone. As the tide receded, birds moved onto the intertidal mud to feed. The adjacent intertidal areas at Orchard Ledges were the last to be exposed and some Curlew from the Taff/Ely moved on to these intertidal areas at the first opportunity. They remained there feeding until forced to leave by the advancing tide, at which point they moved back into the Taff/Ely estuary. By three hours after low tide a large roost had usually formed on the higher areas of mud within the bay (Figure 3.6). These birds were gradually forced onto the saltmarsh as the mud became inundated. Thereafter, many birds were hidden from view and accurate counting was impossible.

Turnstone

Turnstone were observed roosting both at Rhymney and at Taff/Ely on the few stony shores that are available at these study sites. As the tide receded, birds began to feed on these areas. However, all these birds were subsequently observed to fly towards Orchard Ledges where they fed during the entire period for which it was exposed. The drop in numbers recorded around low tide is probably due to under-recording of this small, cryptic species rather than a significant movement out of the area. However, the birds observed on Orchard Ledges did not account for the maximum number of birds observed within the study area (Figure 3.7) and this may therefore indicate that some Turnstone were using alternative feeding areas outside the three study sites. Very few Turnstone were observed at either Taff/Ely or Rhymney during the low tide period (Figure 3.7) but returned as the flood tide covered their intertidal feeding areas.

3.5 DISCUSSION

Waterfowl populations have been monitored for more than twenty years by counts in their non-breeding range. In particular, mid-winter counts over the whole of western Europe have given a good indication of year-to-year fluctuations in several wader species. Systematic counting of waders and wildfowl has been carried out on the estuaries of Great Britain since the inception of the Birds of Estuaries Enquiry in 1969. These counts provide essential baseline data for monitoring bird populations and the importance of the sites used, but give no indication of either turnover through a site or of movement within it.

Some of the most important wintering areas for waders and wildfowl are large estuaries or complexes of adjacent smaller ones (Symonds et al. 1984). At these sites individuals may be faithful to particular locations (see Minton 1975) or move around the whole area. The Taff/Ely estuary is a part of a much larger estuary, the Severn, which holds nationally and internationally important populations of waders and wildfowl during the non-breeding season. It is necessary to have a full understanding of the movement patterns in and around Cardiff Bay in order to assess its importance, both as part of the Severn and as an individual site. Only then can a realistic appraisal be made of the likely implications for waterfowl in the event of barrage construction.

During this first season of work at Cardiff Bay, a good insight into movements within the study area was gained. This enabled a strategy for colour marking to be devised to answer the most important questions about the significance of Cardiif Bay for the key species. Different species present during the winter were found to use the estuary in different ways; this is clear when studying their movement between the intertidal areas of the Taff/Ely estuary, Orchard Ledges and the Rhymney estuary.

Of the three key species, the Shelduck and Redshank populations at Rhymney and in the Taff/Ely appeared to remain essentially separate, although some Shelduck that fed in both areas were thought to roost together in rafts on the water. Past work has shown Redshank to be highly site faithful (Minton 1975, Furness & Galbraith 1980, Symonds et al. 1984). Symonds and Langslow (1986) found that Redshank ranged widely within a particular area, but that only a small amount of interchange occurred between this and other areas throughout the winter. These conclusions are supported by data collected during the present study.

There has been some disagreement in the past over the degree of movement undertaken by Dunlin within an estuarine complex. Symonds et al. (1984) considered Dunlin to be an 'itinerant' species which frequently flew large distances (18km) between a roost site and a feeding area. In addition, they observed interchange between feeding areas, although the frequency of these movements was not consistent for all sites. By contrast, Minton (1975) found that interchange between feeding areas occurred infrequently. Symonds and Langslow (1986) suggested that Dunlin were mostly sedentary; although some local movement occurred between feeding areas, other movements could be explained by factors such as the distance between the feeding ground and the roost site. Thus, availability of suitable roosts may be important in determining the extent of mobility by this species. Dunlin using Cardiff Bay moved freely between here and other feeding areas and the movement observed followed a consistent pattern; during a complete tidal cycle, the intertidal mud within the Taff/Ely estuary was both the first and the last available feeding area for a large number of Dunlin and an intrinsic part of their feeding pattern. Most movement was local, between the three study sites and the Sully Island roost site, but some birds entered the study area to feed from other areas within the Severn estuary, such as Clevedon (on the south shore) and St. Brides.

Significant movements of other wader species between feeding areas usually involved moving to and from Orchard Ledges. Most movements of Oystercatchers observed during the present study were from Rhymney and the Taff/Ely to Orchard Ledges and back. Some birds moved east from Rhymney and west from the Taff/Ely where they were not counted, but these were not long distance movements. These results are similar to those of Symonds and Langslow (1986) who found that this species usually remained loyal to selected feeding areas, although a few individuals changed sites at various times during the winter. By contrast, Minton (1975) found that Oystercatchers showed a high degree of movement between feeding areas. Reasons for these differences in behaviour might either be an inter-estuarine difference in the prey type available or a difference in the definitions of 'local' movement.

Symonds and Langslow (1986) found that wintering Curlew remained loyal to selected feeding areas. This seemed to be the case with the Curlew observed during the course of this study. A very large number roosted at Peterstone, most of which moved onto the intertidal areas of Peterstone and Rhymney to feed. Some of these birds moved from Rhymney to Orchard Ledges before returning to roost. Birds roosting within the Taff/Ely either remained within the estuary to feed or moved to Orchard Ledges to do so. On spring tides, all the Curlew within the study area roosted at Peterstone but despite the longer round trip, a similar number returned to the Taff/Ely to feed. Hence, Curlew appeared to be highly site faithful to their feeding areas in Cardiff Bay.

Of the additional species studied, Turnstone appeared to move most extensively between study sites. Turnstone prefer rocky shores to intertidal mud and this is thought to be the reason for their loyalty to specific feeding areas during the winter (Pienkowski 1979). The habitat available to Turnstone within the study area was extremely localized. Small areas of shingle beach, high up the shore, were available at Rhymney and Taff/Ely; an extensive, but lower-lying, area of rock and shingle was available at Orchard Ledges. Hence, movement occurred between the stony shores of Rhymney and Taff/Ely and the more extensive area of rock and shingle at Orchard Ledges. Birds fed at Orchard Ledges throughout the period for which it was exposed, moving to the areas at Rhymney and Taff/Ely only when Orchard Ledges was covered by the tide. Movement by Turnstone was therefore local.

Few conclusions can be drawn concerning movements of wildfowl within the study area. It appeared that little interchange occurred between the study sites.

From the results obtained it is clear that there can be both inter-specific and intra-specific variation in the movements of waterfowl. In addition, there are several types of movement that waterfowl undertake and several factors that affect these movements. Adverse weather conditions further east in mainland

Europe may cause birds to move west into Britain (e.g. Pienkowski 1981, Dugan 1981, Evans 1981, Townshend 1982) but, on a local scale, may also cause differences in prey availability and hence be the reason for movements from one part of an estuary to another. For many species, the effects of temperature, precipitation and wind force on the availability of prey (Evans 1976, 1979, Pienkowski 1981, 1982, 1983a,b) lead to much wider fluctuations in availability of prey from day to day during the winter than do changes in the density of birds. This means that bird feeding rates fluctuate from day to day chiefly as a result of weather factors. Davidson (1981) summarized the weather conditions under which different species of shorebirds draw upon their fat reserves (and usually their muscles also) to avoid death from inadequate rates of food intake. He divided the species into four major groups:

1. Species that normally feed inland but which move to the shore when feeding grounds become frozen (e.g. Lapwing);

2. Long-legged and/or visual-feeding estuarine species that have difficulty foraging on open mudflats during gales (e.g. Redshank);

3. Short-legged, tactile feeding estuarine species that can only feed on the tide edge or on exposed mud and which are chiefly affected by freezing (e.g. Dunlin);

4. Open coastal species affected by increasing wind strength causing increasing wave action which leads to interference with feeding and removes sediments and prey (e.g. Turnstone) - (see also Evans 1981).

Some species require a wide choice of feeding areas, perhaps because prey availabilty and distribution are variable. Such birds may move frequently between sites selecting the most favourable feeding areas in terms of prey availability and shelter, under conditions prevailing over a short period of time (Symonds et al. 1984). Symonds & Langslow (1986) suggested that the reason for inter-species differences in mobility lay in their differing choice of prey. Invertebrates in soft sediments vary their activity and depth both seasonally and in response to weather conditions (Pienkowski 1981) whereas surface living prey (e.g. Mytilus edulis) are less likely to vary. Species that are apparently site faithful may be able to meet their requirements only at such sites. Conversely, the use of many sites by individuals may imply not so much that the bird has a choice of sites but that its requirements are met in a changeable or sequential manner such that a wide choice must be available.

Other factors affecting apparent mobility of a species include whether or not the birds are disturbed, whether they are displaced by the incoming tide, and the position of the roost in relation to the feeding grounds.

Hence, loss or damage to intertidal sites will impose different problems on different species. This may involve loss of part of a network of sites and will present the greatest problems during harsh weather, when the need to feed to survive is increased. The smaller species, for example Dunlin, may be particularly badly affected. The Taff/Ely, which is both the first be uncovered and the last to be covered by the tide, may thus become of vital importance to these birds as a feeding area when all the surrounding areas are unavailable for feeding.

Cardiff Bay and the surrounding areas form a network of intertidal sites between which waders and wildfowl move to a varying extent. This first year's study has yielded valuable information about these movements. Future colour-marking studies will allow a fuller understanding of the dependence on Cardiff Bay of waders and wildfowl using the Welsh shore.

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Table 1.1 The national and international importance of the Severn for wintering Shelduck and waders, 1984/85 - 1988/89.

	Average Peak Count (Nov - Mar)	% of British Population	% of European Population
Shelduck	2586	3.50	1.00
Oystercatcher	599	0.21	0.07
Ringed Plover	251	1.09	0.50
Grey Plover	443	2.11	0.30
Lapwing	4532	0.45	0.23
Knot	1965	0.89	0.56
Dunlin	44445	10.34	3.17
Bar-tailed Godwit	71	0.12	0.07
Curlew	3641	4.00	1.04
Redshank	2956	3.94	1.97
Turnstone	360	0.80	0.51

Table 1.2 The national and international importance of the Taff/Ely for wintering Shelduck and waders, 1984/85 - 1988/89.

	Average Peak Count (Nov - Mar)	% of British Population	% of European Population
Shelduck	333	0.45	0.13
Oystercatcher	45	0.02	0.00
Ringed Plover	53	0.23	0.11
Grey Plover	28	0.13	0.02
Lapwing	125	0.01	0.01
Knot	341	0.15	0.10
Dunlin	3793	0.88	0.27
Bar-tailed Godwit	1	0.00	0.00
Curlew	94	0.10	0.03
Redshank	549	0.73	0.37
Turnstone	51	0.11	0.07

Table 1.3 1984/85-88/89 BoEE count data for the Taff/Ely and the Severn summarized to show the importance of the Taff/Ely estuary for roosting Shelduck and waders relative to the Severn as a whole.

	1984/85-1988/89		
	MEAN PEAK		Taff/Ely as %
	Taff/Ely	Severn	Severn
Shelduck	333	2586	12.9
Oystercatcher	45	599	7.5
Ringed Plover	53	251	21.1
Grey Plover	28	443	6.3
Lapwing	125	4532	2.8
Knot	341	1965	17.4
Dunlin	3793	44445	8.5
Bar-tailed Godwit	1	71	1.4
Curlew	94	3641	2.6
Redshank	549	2956	18.6
Turnstone	51	360	14.2

Table 2.1 Count dates for the 1989/90 winter.

Low tide counts	All day counts
	6 - 10 November 1989
	13 - 15 November 1989
	20 - 22 November 1989
26/27 November 1989	24 - 27 November 1989
9/10 December 1989	13 - 15 December 1989
	19 - 21 December 1989
23/24 December 1989	
6/7 January 1990	
	24 - 26 January 1990
27/28 January 1990	31 January - 2 February 1990
	5 - 8 February 1990
10/11 February 1990	
	12 - 14 February 1990
24/25 February 1990	
	6 - 8 March 1990
	12 - 14 March 1990
	3 - 5 April 1990
	11 - 17 April 1990
	14 - 16 May 1990
	21 - 23 May 1990

Table 2.2 Number of birds recorded during Count 1, 26/27 November 1989

NUMBER OF INTERTIDAL AREAS COUNTED:27

Species	FEEDING No. Birds	FEEDING No.of Areas with Birds	ROOSTING No. Birds	ROOSTING No.of Areas with Birds	Total No.of Areas with Birds
SHELDUCK	783	14	184	1	14
WIGEON	6	1	0	0	1
TEAL	28	2	68	2	3
MALLARD	84	3	169	4	6
PINTAIL	201	2	12	1	2
POCHARD	0	0	0	0	0
OYSTERCATCHER	68	5	0	0	5
RINGED PLOVER	74	3	0	0	3
GREY PLOVER	5	2	0	0	2
LAPWING	0	0	5	1	1
KNOT	0	0	0	0	0
DUNLIN	2655	5	0	0	5
BAR-TAILED GODWIT	11	2	0	0	2
CURLEW	144	11	47	2	12
REDSHANK	336	9	250	1	9
TURNSTONE	259	1	0	0	1

Table 2.3 Number of birds recorded during Count 2, 9/10 December 1989.

NUMBER OF INTERTIDAL AREAS COUNTED:34

Species	FEEDING No. Birds	FEEDING No.of Areas with Birds	ROOSTING No. Birds	ROOSTING No.of Areas with Birds	Total No.of Areas with Birds
SHELDUCK	300	12	800	1	13
WIGEON	25	3	4	1	4
TEAL	0	0	44	4	41
MALLARD	116	4	69	3	7
PINTAIL	10	1	0	0	1
OYSTERCATCHER	115	3	0	0	3
RINGED PLOVER	0	0	0	0	0
GREY PLOVER	18	1	0	0	1
LAPWING	7	1	22	2	3
KNOT	0	0	0	0	0
DUNLIN	4810	4	0	0	4
BAR-TAILED GODWIT	0	0	0	0	0
CURLEW	131	13	115	3	14
REDSHANK	209	6	0	0	6
TURNSTONE	0	0	0	0	0

Table 2.4 Number of birds recorded during Count 3, 23/24 December 1989.

NUMBER OF INTERTIDAL AREAS COUNTED:8

Species	FEEDING No. Birds	FEEDING No.of Areas with Birds	ROOSTING No. Birds	ROOSTING No.of Areas with Birds	Total No.of Areas with Birds
SHELDUCK	85	4	0	0	4
WIGEON	7	1	0	0	1
TEAL	0	0	54	1	1
MALLARD	0	52	2	2	0
PINTAIL	0	0	0	0	0
POCHARD	0	0	0	0	0
OYSTERCATCHER	1	1	0	0	1
RINGED PLOVER	0	0	0	0	0
GREY PLOVER	18	1	0	0	1
LAPWING	0	0	215	2	2
KNOT	0	0	0	0	0
DUNLIN	7067	2	0	0	2
BAR-TAILED GODWIT	0	0	0	0	0
CURLEW	176	5	1	1	5
REDSHANK	292	5	1	1	5
TURNSTONE	0	0	0	0	0

Table 2.5 Number of birds recorded during Count 4, 6/7 January 1990.

NUMBER OF INTERTIDAL AREAS COUNTED:38

	FEEDING		ROOSTING		Total
Species	No. Birds	No.of Areas with Birds	No. Birds	No.of Areas with Birds	No.of Areas with Birds
SHELDUCK	670	15	0	0	15
WIGEON	23	1	0	0	1
TEAL	2	1	119	3	4
MALLARD	9	2	99	4	6
PINTAIL	0	0	0	0	0
POCHARD	0	0	0	0	0
OYSTERCATCHER	116	6	0	0	6
RINGED PLOVER	0	0	0	0	0
GREY PLOVER	65	4	0	0	4
LAPWING	0	0	122	2	2
KNOT	0	0	0	0	0
DUNLIN	4709	7	0	0	7
BAR-TAILED GODWIT	0	0	0	0	0
CURLEW	296	18	38	1	19
REDSHANK	427	7	0	0	7
TURNSTONE	0	0	0	0	0

Table 2.6 Number of birds recorded during Count 5, 27/28 January 1990.

NUMBER OF INTERTIDAL AREAS COUNTED:24

Species	FEEDING No. Birds	FEEDING No.of Areas with Birds	ROOSTING No. Birds	ROOSTING No.of Areas with Birds	Total No.of Areas with Birds
SHELDUCK	223	13	0	0	13
WIGEON	0	0	0	0	0
TEAL	0	0	29	2	2
MALLARD	0	0	173	2	2
PINTAIL	0	0	0	0	0
POCHARD	0	0	0	0	0
OYSTERCATCHER	1	1	0	0	1
RINGED PLOVER	100	1	0	0	1
GREY PLOVER	15	1	0	0	1
LAPWING	2	1	1	1	2
KNOT	0	0	0	0	0
DUNLIN	8650	7	0	0	7
BAR-TAILED GODWIT	0	0	0	0	0
CURLEW	106	9	0	0	9
REDSHANK	302	6	0	0	6
TURNSTONE	6	1	0	0	1

Table 2.7 Number of birds recorded during Count 6, 10/11 February 1990.

NUMBER OF INTERTIDAL AREAS COUNTED:40

	FEEDING		ROOSTING		Total
Species	No. Birds	No.of Areas with Birds	No. Birds	No.of Areas with Birds	No.of Areas with Birds
SHELDUCK	477	18	36	2	18
WIGEON	0	0	0	0	0
TEAL	0	0	45	1	1
MALLARD	74	4	12	1	5
PINTAIL	1	1	0	0	1
POCHARD	0	0	0	0	0
OYSTERCATCHER	42	5	0	0	5
RINGED PLOVER	45	2	0	0	2
GREY PLOVER	0	0	0	0	0
LAPWING	0	0	0	0	0
KNOT	0	0	0	0	0
DUNLIN	10756	6	0	0	6
BAR-TAILED GODWIT	0	0	0	0	0
CURLEW	136	9	4	2	10
REDSHANK	51	6	0	0	6
TURNSTONE	30	1	0	0	1

Table 2.8 Number of birds recorded during Count 7, 24/25 February 1990.

NUMBER OF INTERTIDAL AREAS COUNTED:47

	FEEDING		ROOSTING		Total
Species	No. Birds	No.of Areas with Birds	No. Birds	No.of Areas with Birds	No.of Areas with Birds
SHELDUCK	1857	26	12	4	27
WIGEON	0	0	0	0	0
TEAL	0	0	12	2	2
MALLARD	10	2	83	2	4
PINTAIL	100	1	0	0	1
POCHARD	0	0	0	0	0
OYSTERCATCHER	110	7	40	1	8
RINGED PLOVER	18	1	25	1	2
GREY PLOVER	20	2	0	0	2
LAPWING	197	3	0	0	3
KNOT	0	0	0	0	0
DUNLIN	4160	5	10000	1	6
BAR-TAILED GODWIT	0	0	0	0	0
CURLEW	195	16	39	3	16
REDSHANK	665	7	0	0	7
TURNSTONE	5	1	0	0	1

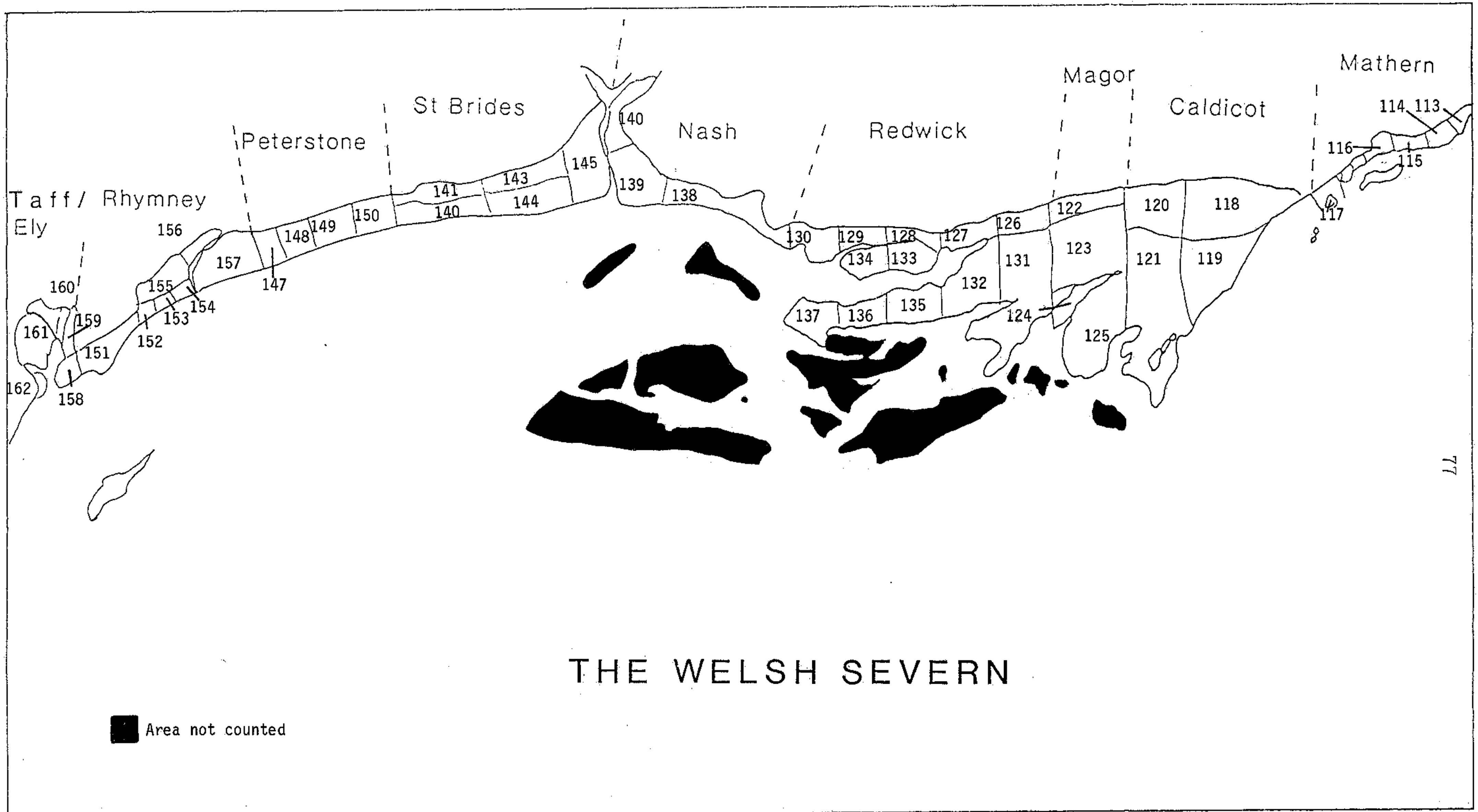


Figure 2.1 The distribution of low tide count areas on the Welsh Severn.

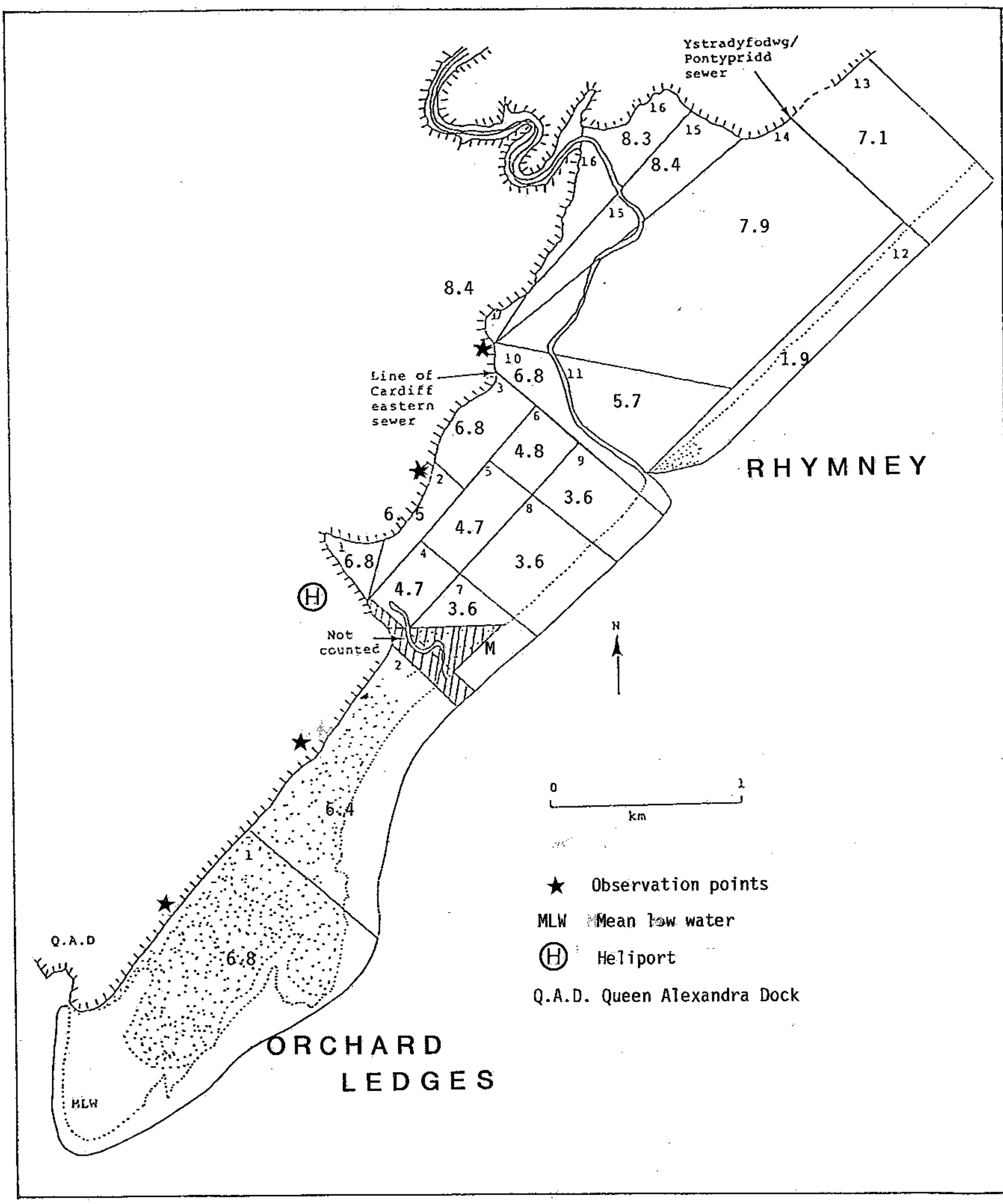
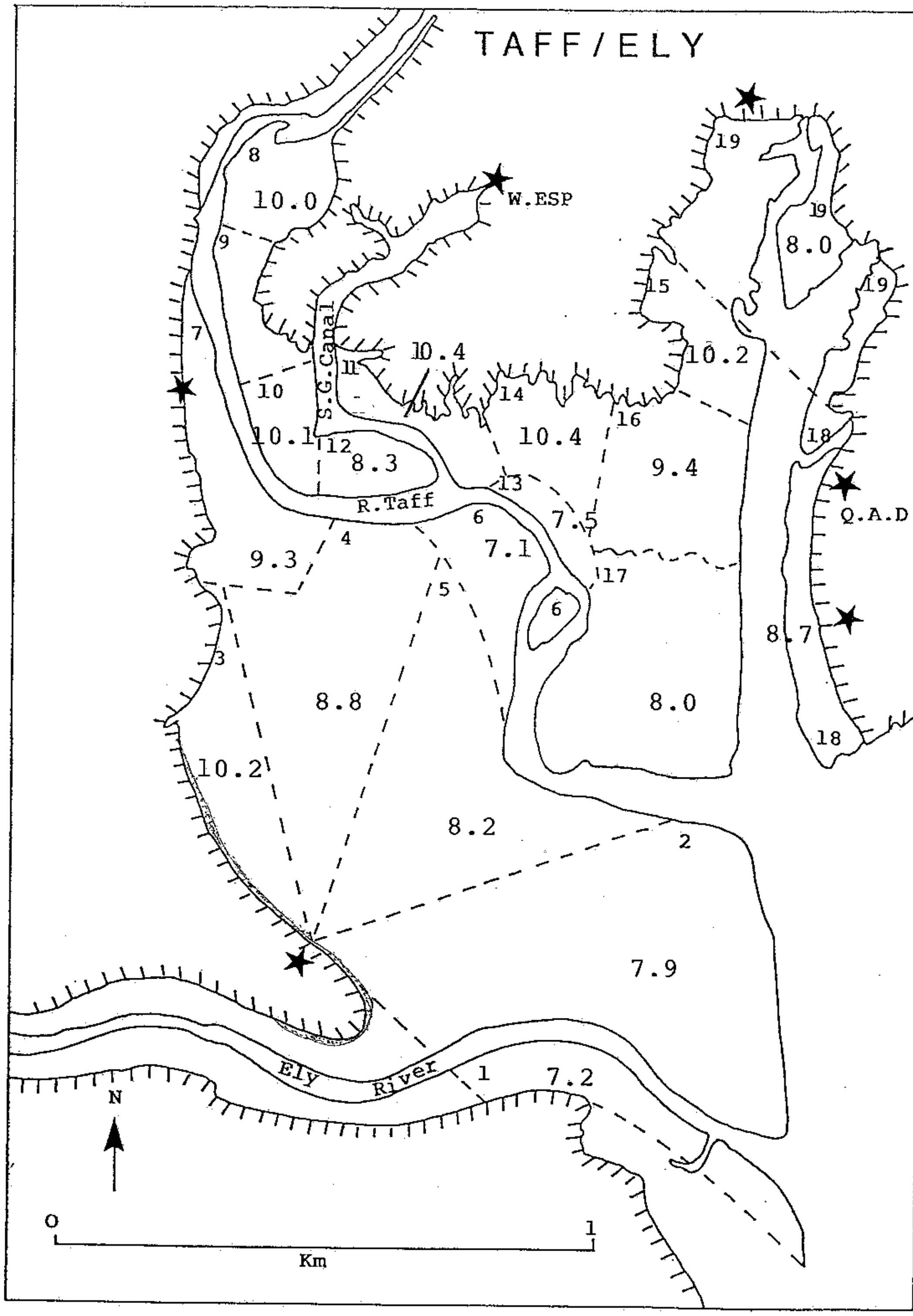


Figure 2.2 All day count areas at Rhymney and Orchard Ledges, showing average exposure times for each area.



S.G. Canal = South Glamorgan Canal
W. Espanade = Windsor Esplanade
Q.A.D. = Queen Alexandra Dock

mud

stones

Observation point

Figure 2.3 All day count areas in Cardiff Bay, showing average exposure times for each area.

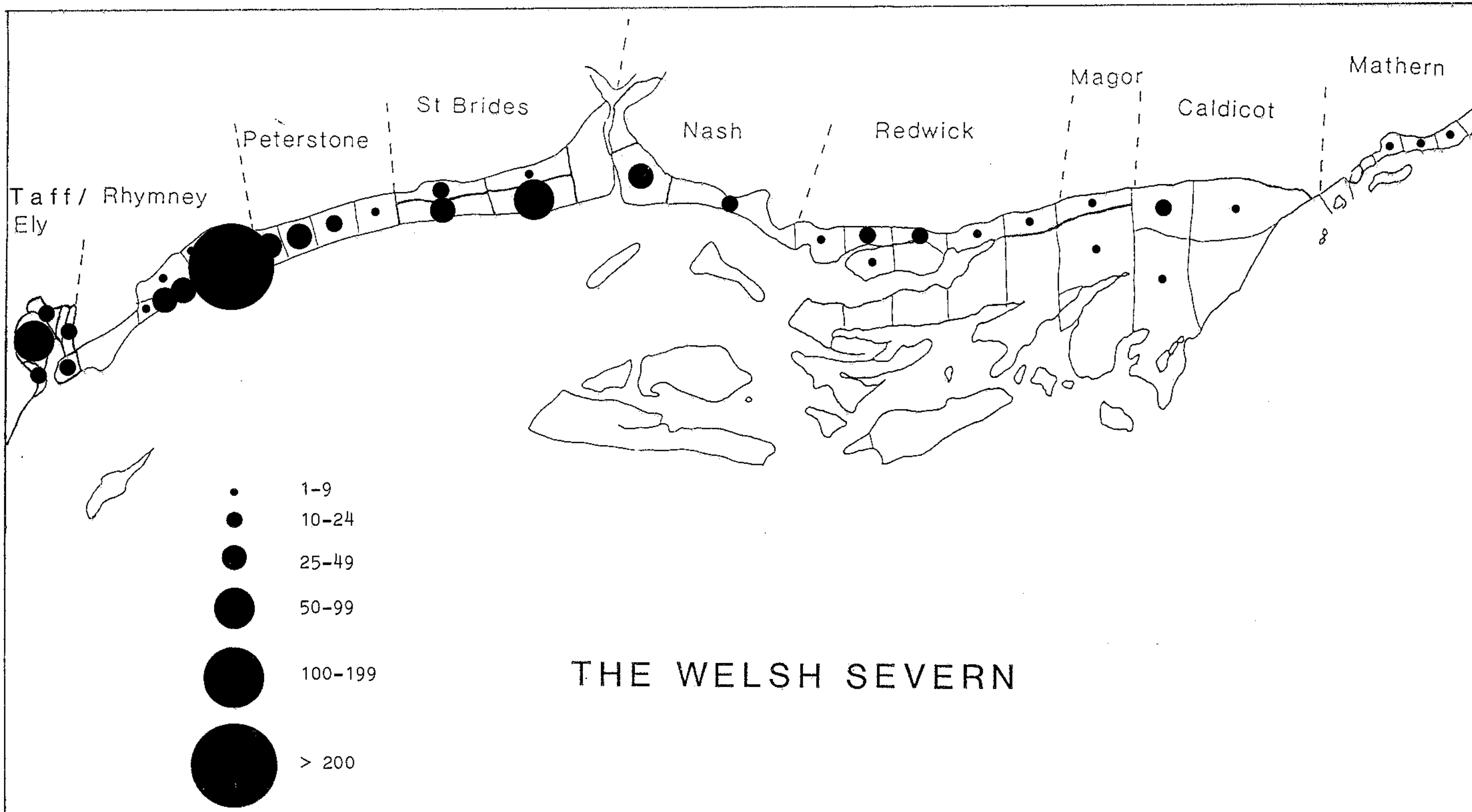


Fig 2.4 The distribution of feeding Shelduck at low tide on the Welsh Severn during Winter 1989/90.

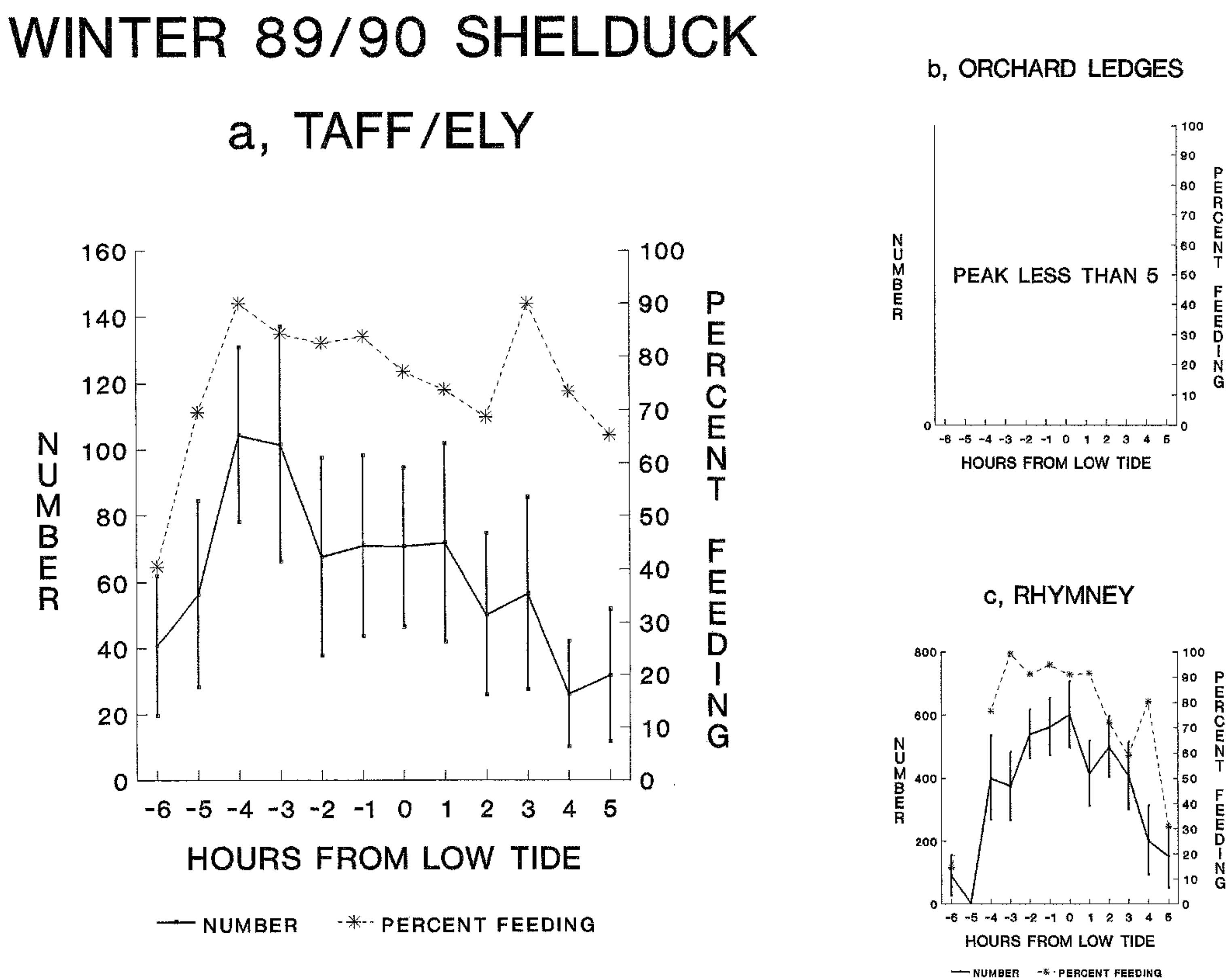


Fig 2.5 The total number of Shelduck present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

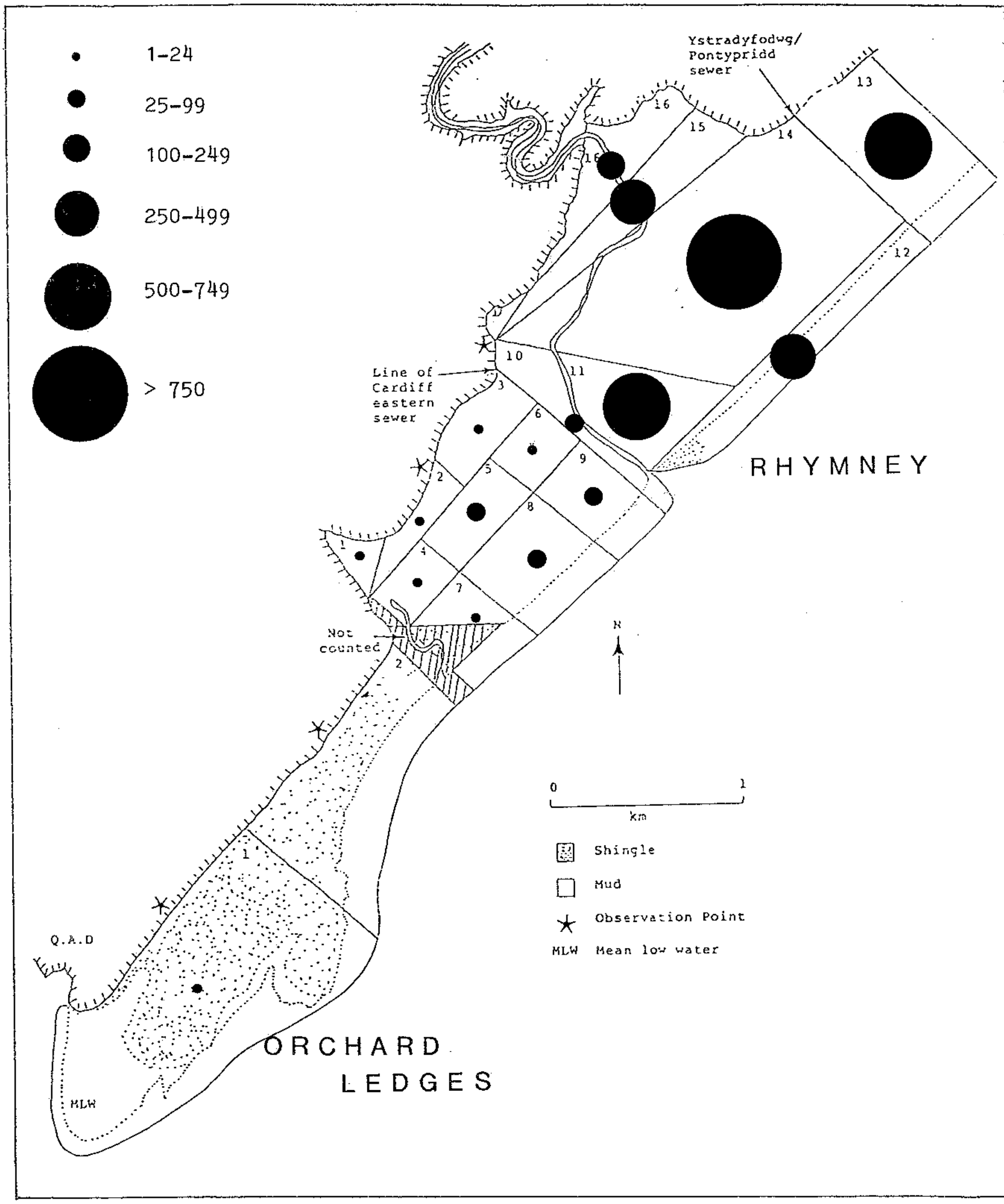


Fig 2.6 The distribution of feeding Shelduck at the Rhymney and Orchard Ledges all day sites during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

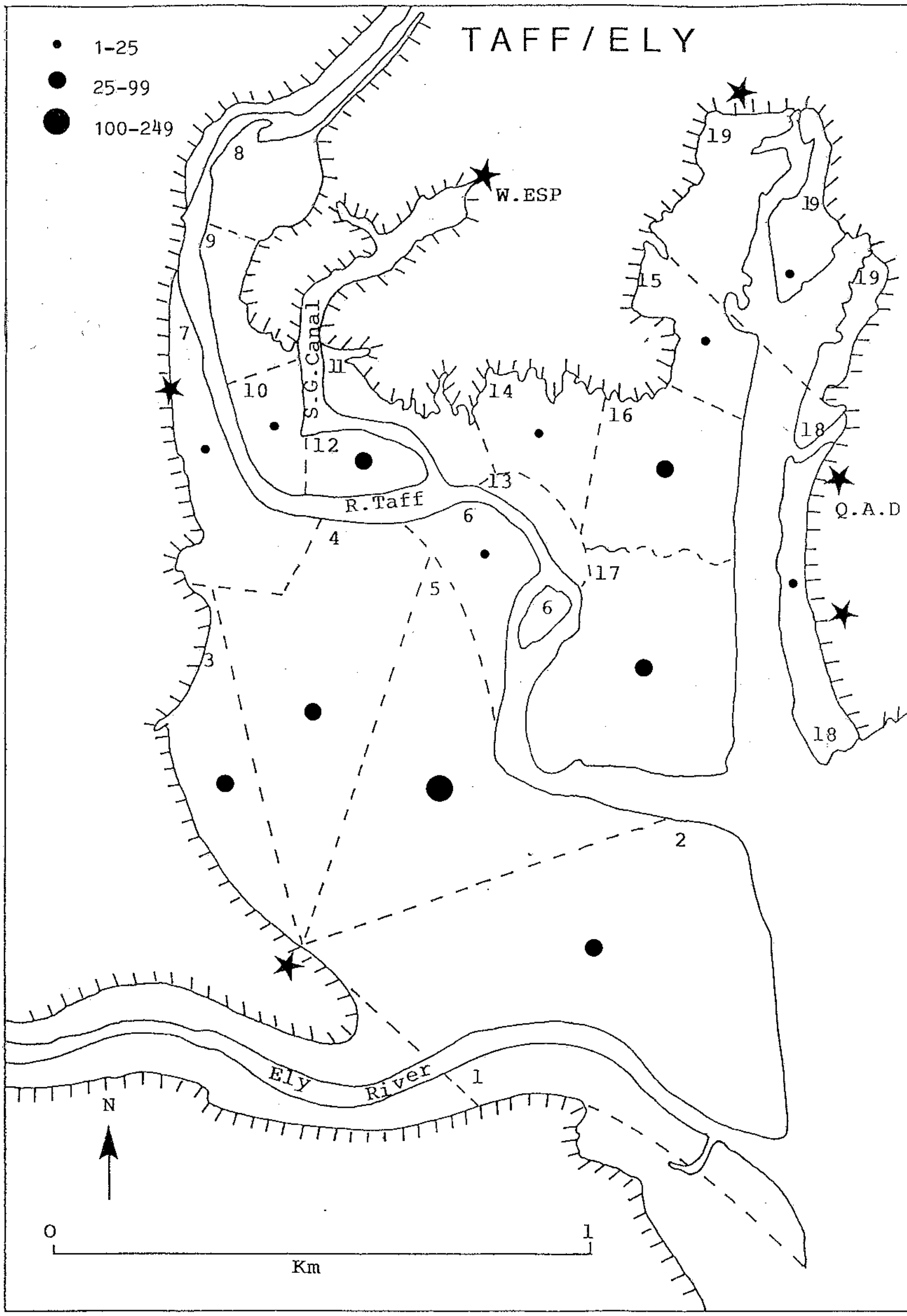
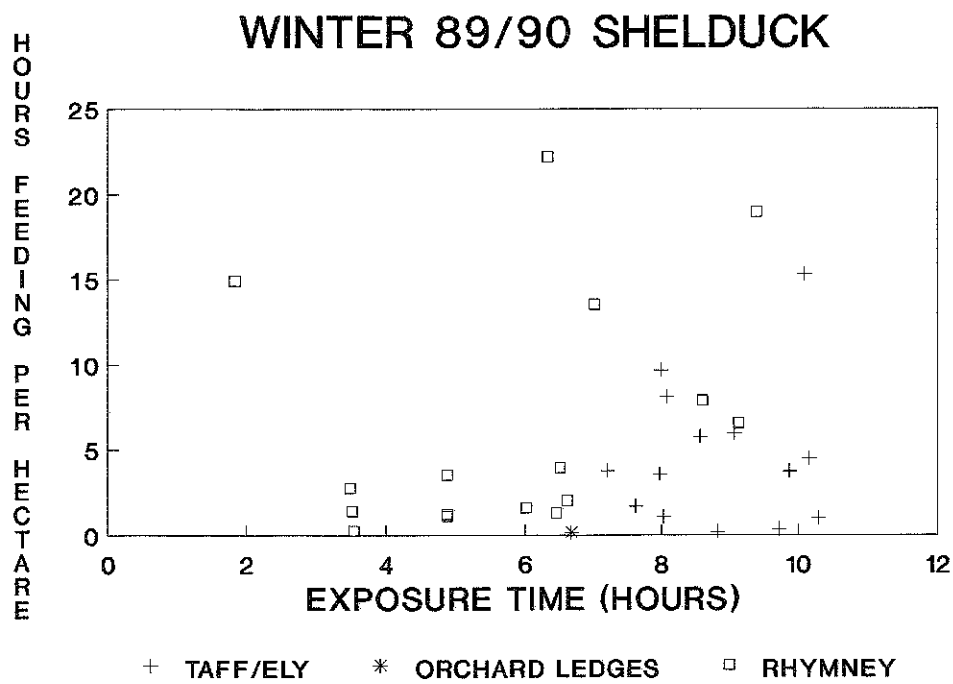


Fig 2.7 The distribution of feeding Shelduck in Cardiff Bay during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.



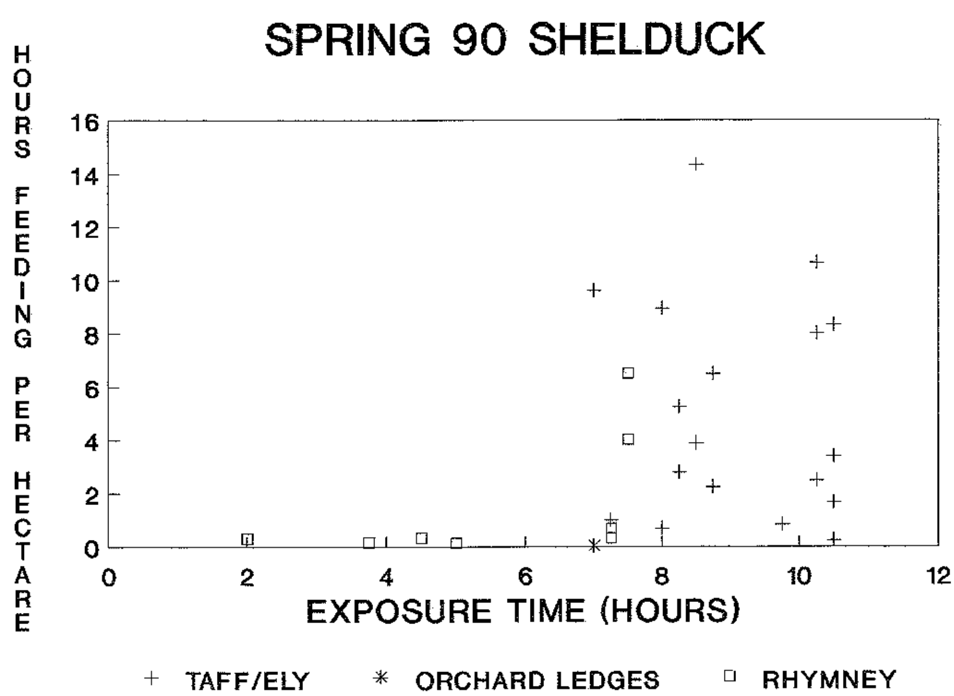


Figure 2.8 A comparison of feeding density with exposure time for Shelduck at all day sites, Winter 1989/90 and Spring 1990.

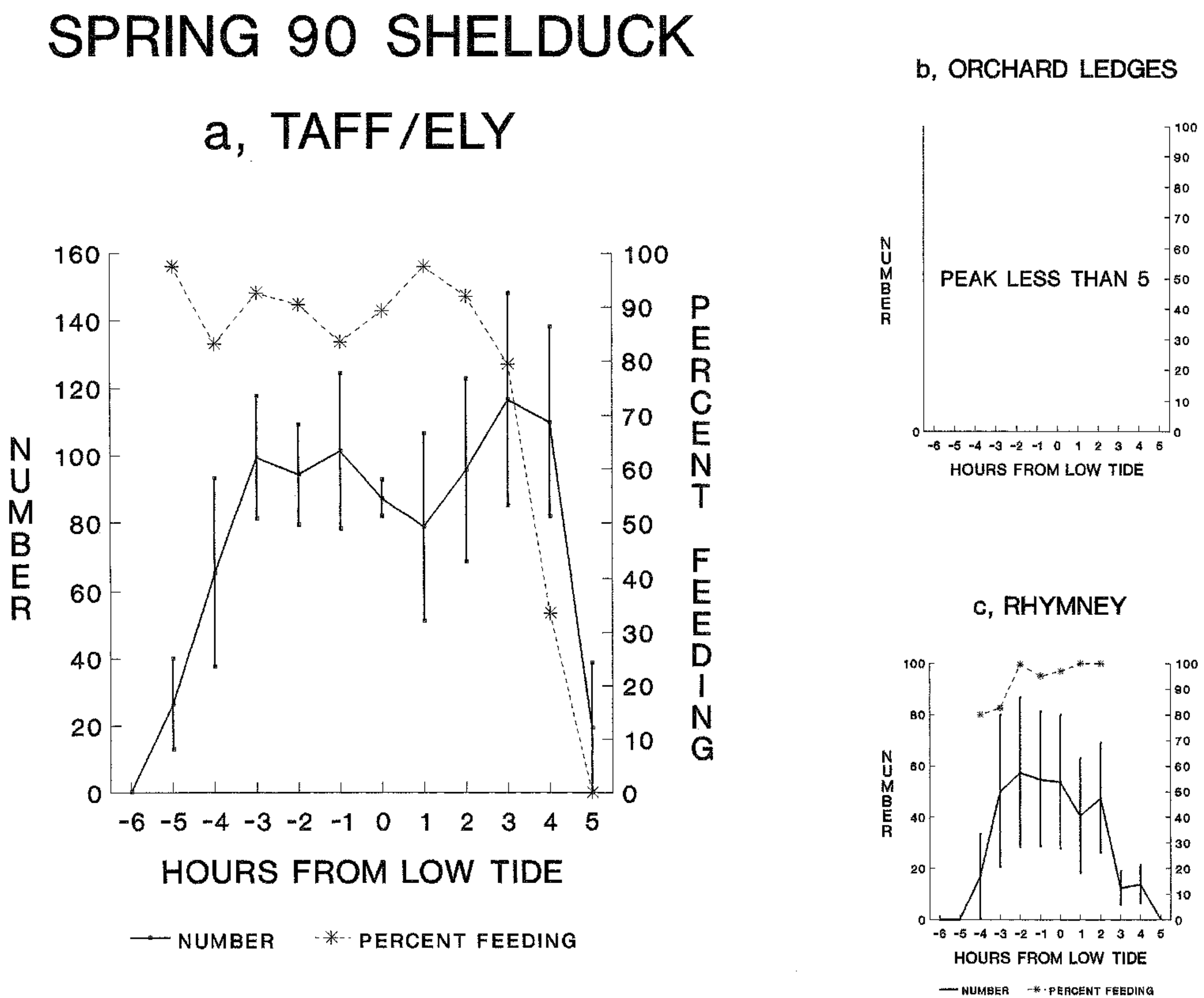


Fig 2.9 The total number of Shelduck present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Spring 1990.

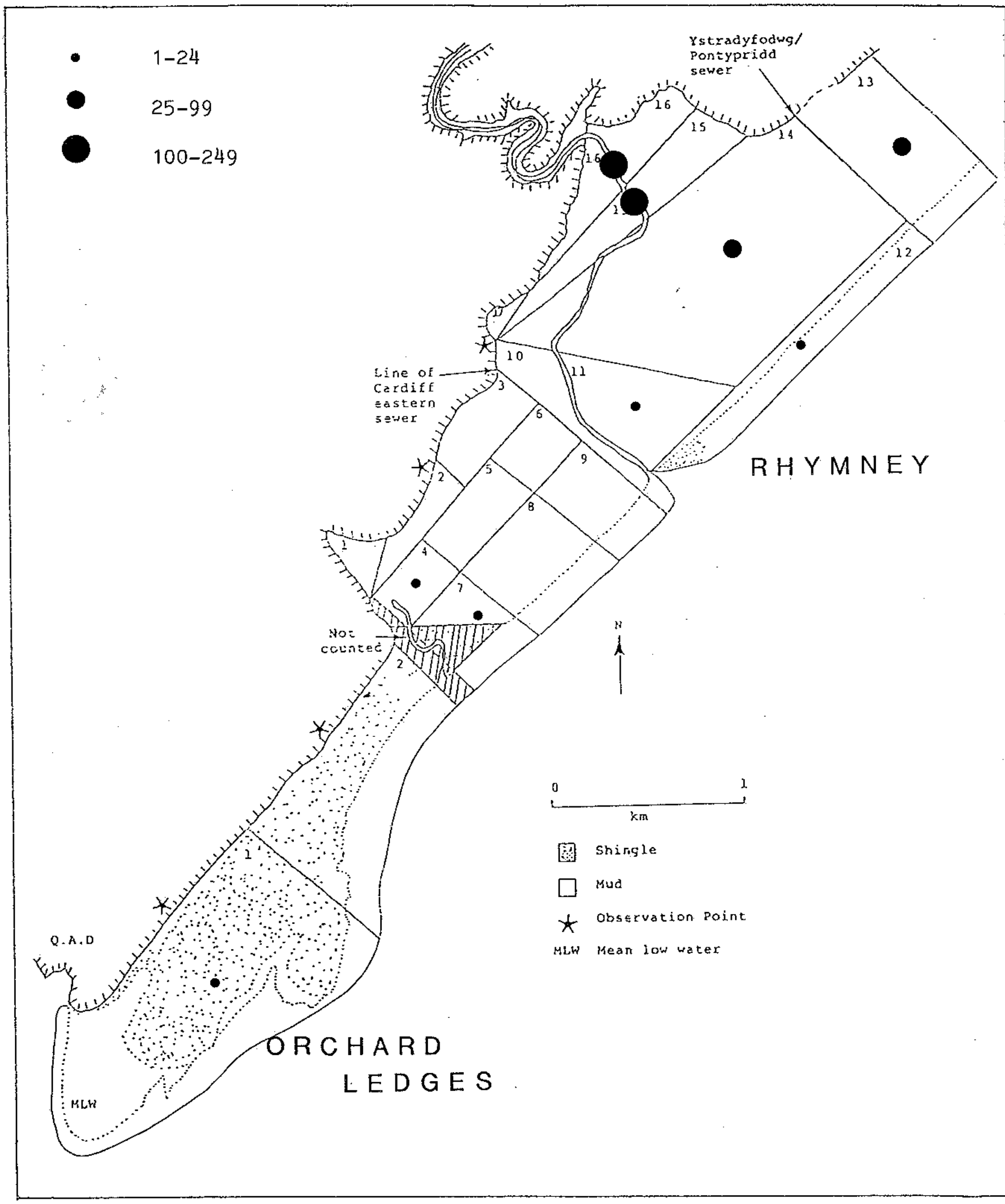


Fig 2.10 The distribution of feeding Shelduck at the Rhymney and Orchard Ledges all day sites during Spring 1989/90. The average number of bird hours per tidal cycle is depicted.

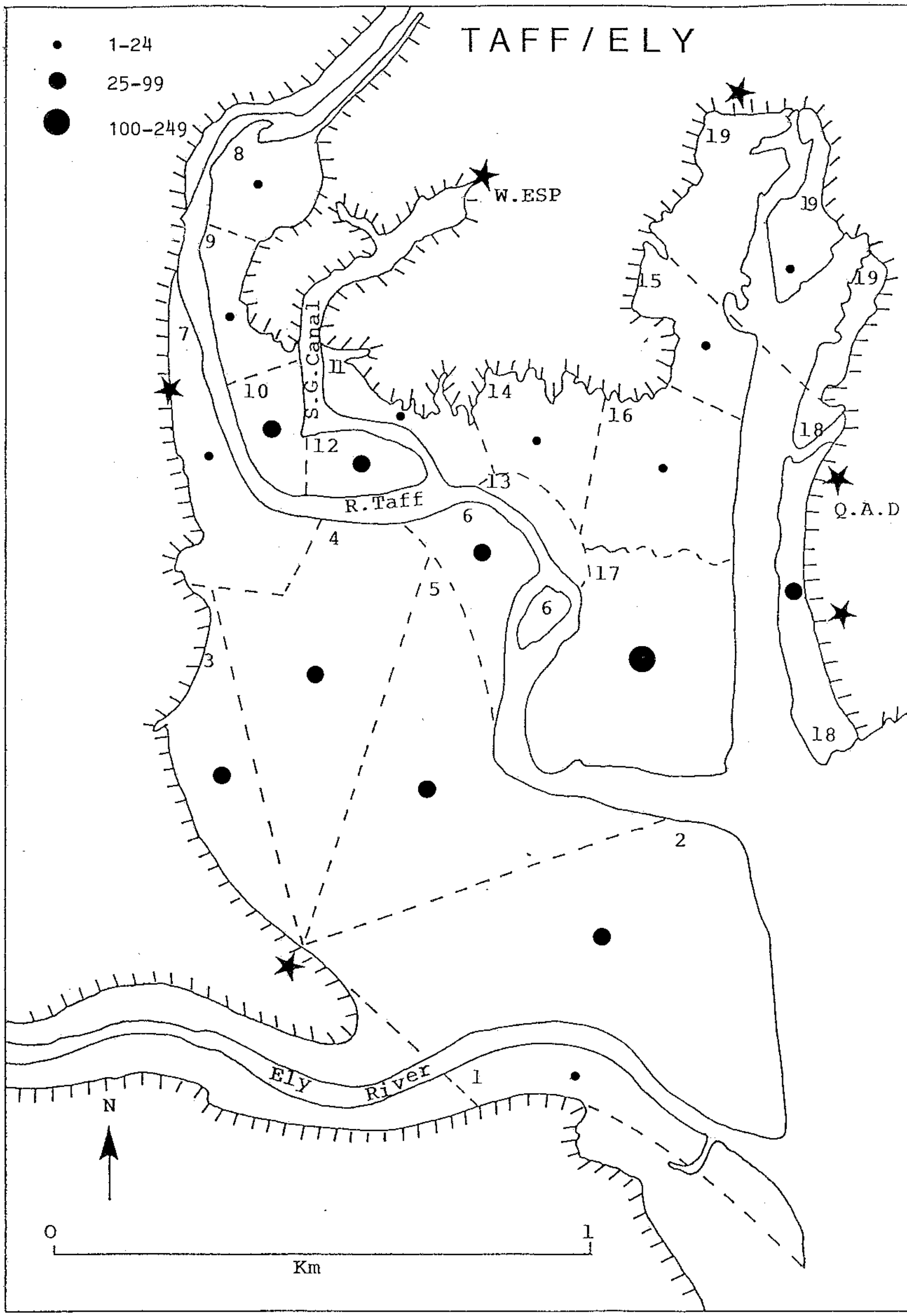


Fig 2.11 The distribution of feeding Shelduck in Cardiff Bay during Spring 1990. The average number of bird hours per tidal cycle is depicted.

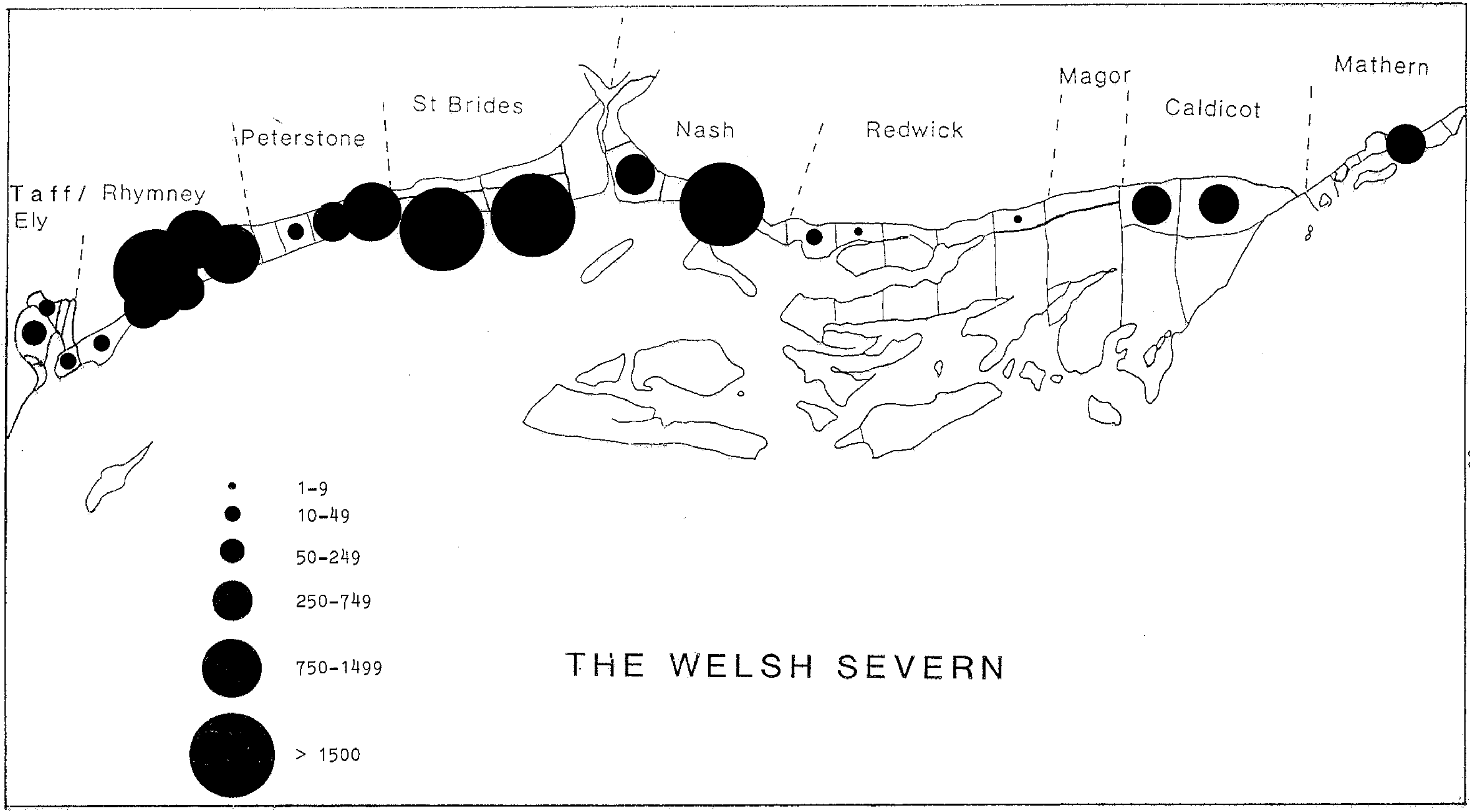


Fig 2.12 The distribution of feeding Dunlin at low tide on the Welsh Severn during Winter 1989/90.

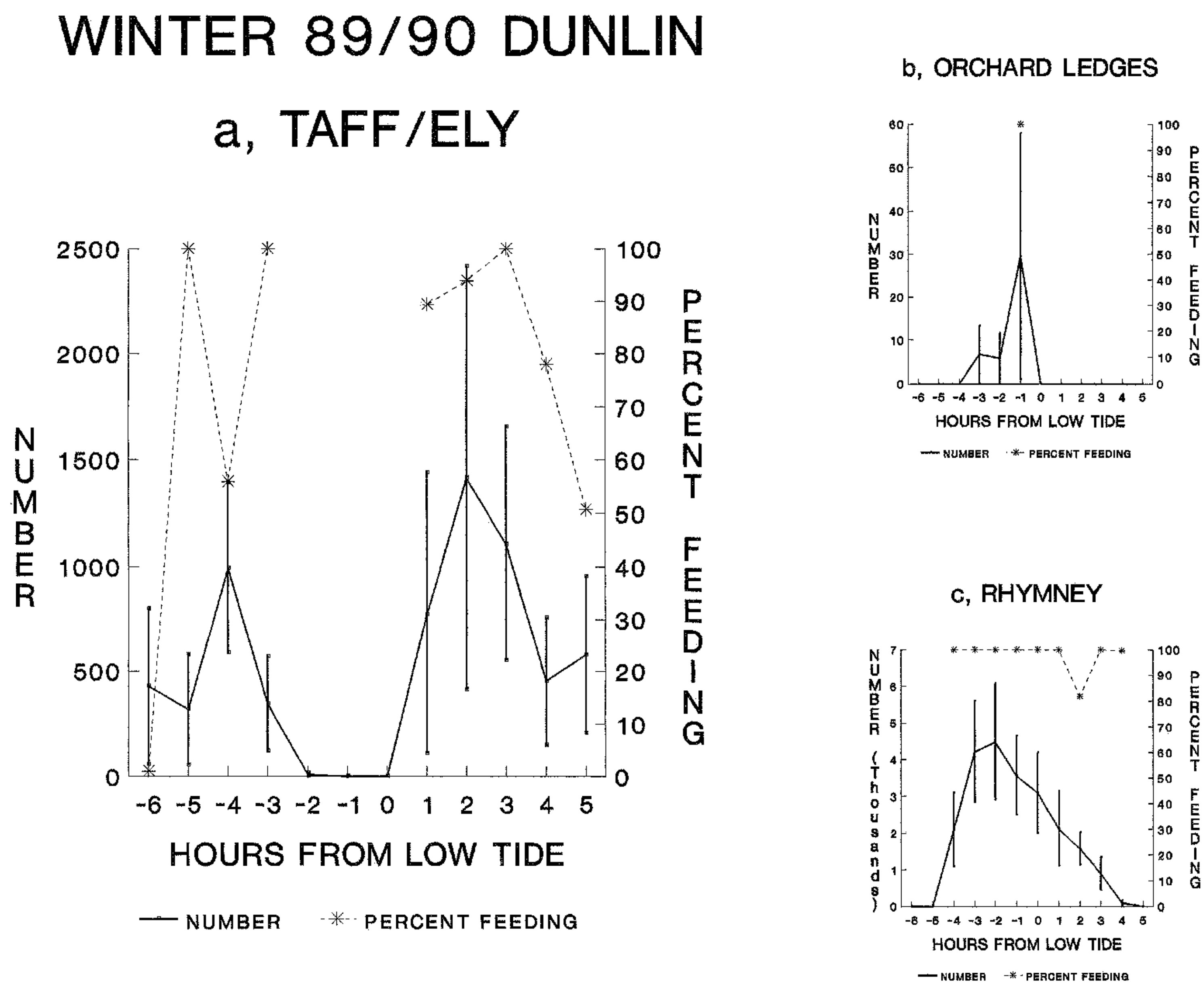


Fig 2.13 The total number of Dunlin present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

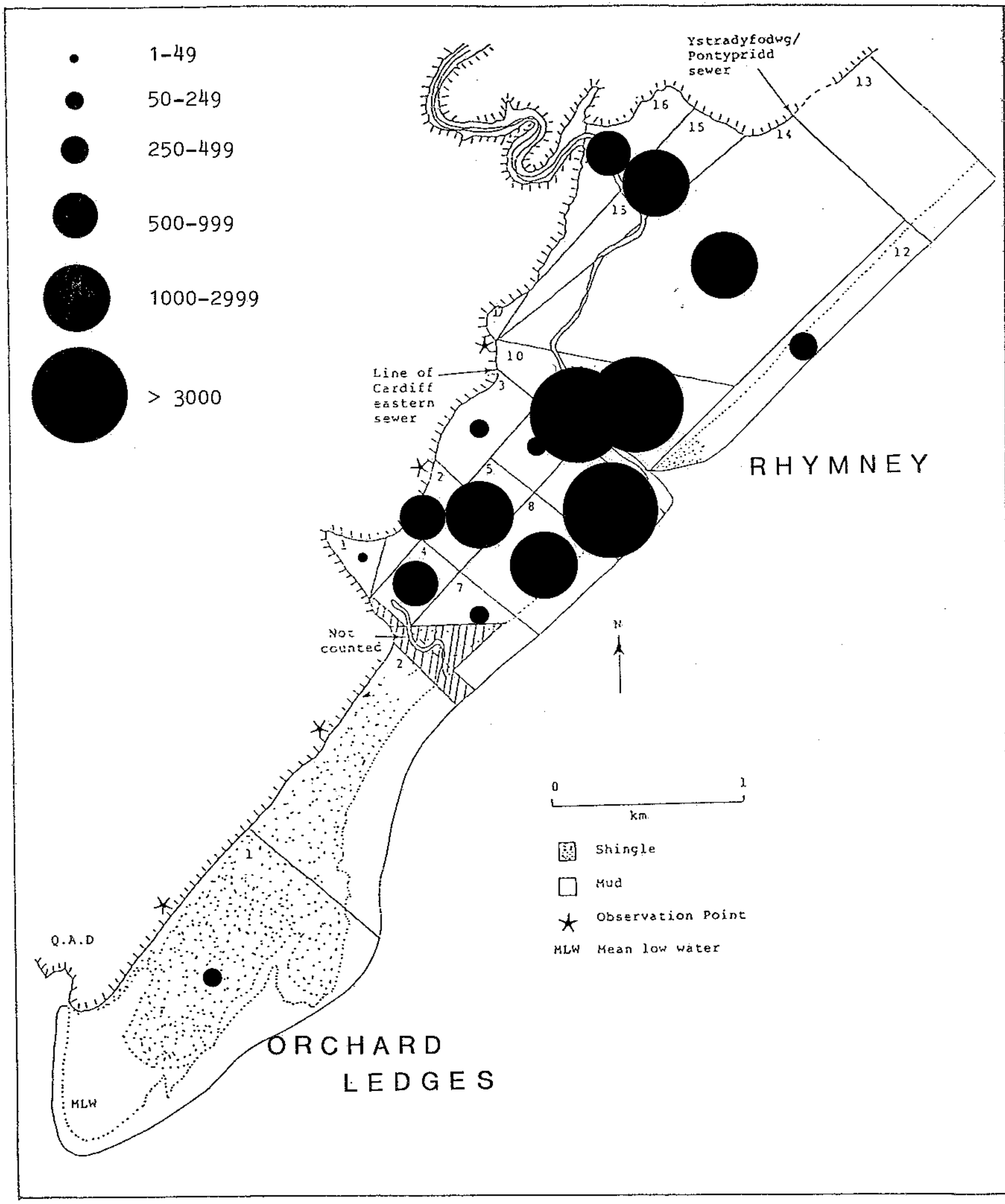


Fig 2.14 The distribution of feeding Dunlin at the Rhymney and Orchard Ledges all day sites during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

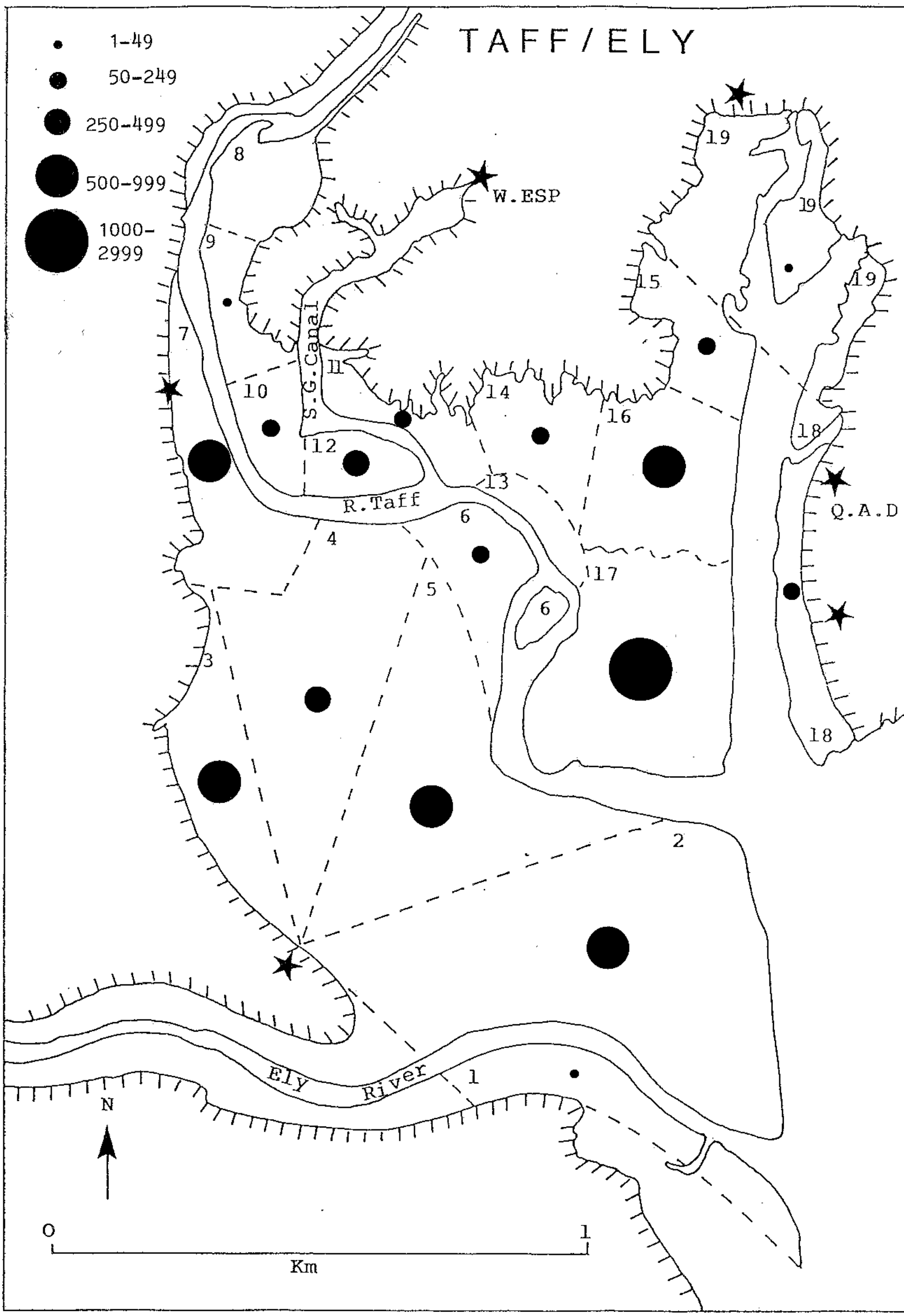


Fig 2.15 The distribution of feeding Dunlin in Cardiff Bay during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

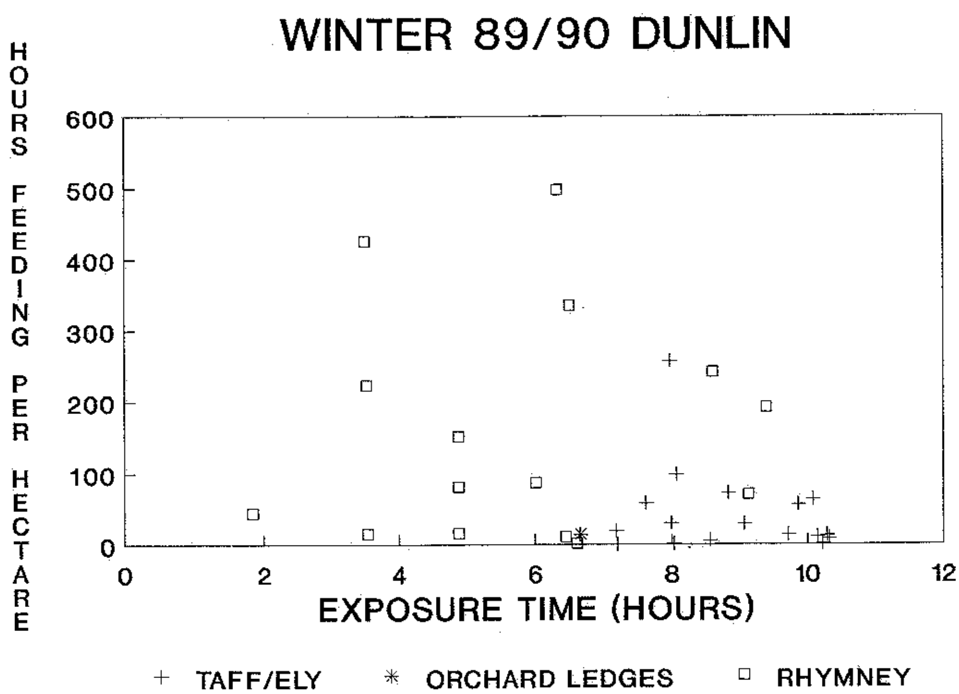


Fig 2.16 A comparison of feeding density with exposure time for Dunlin at all day sites, Winter 1989/90.

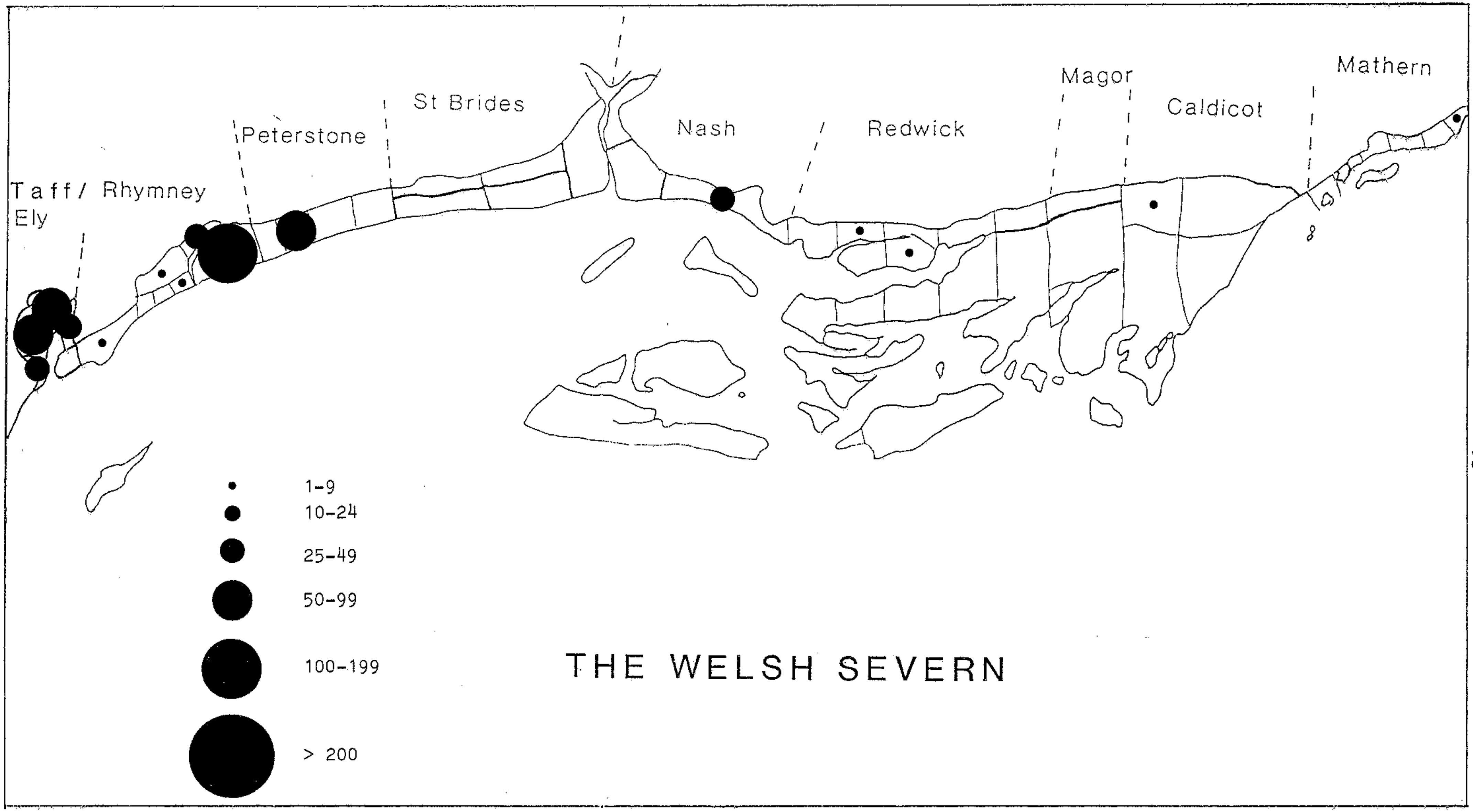


Figure 2.17 The distribution of feeding Redshank at low tide on the Welsh Severn during Winter 1989/90.

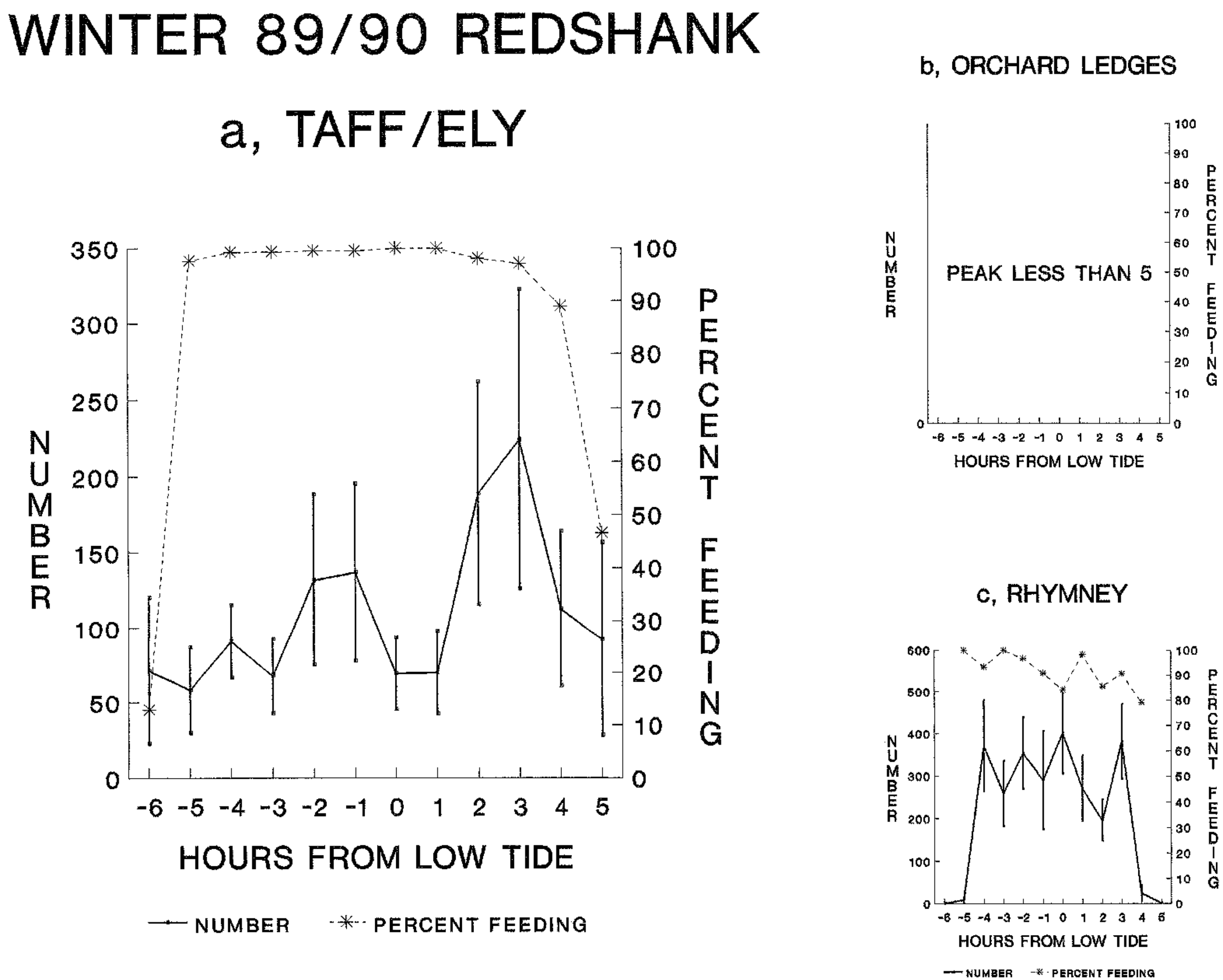


Fig 2.18 The total number of Redshank present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

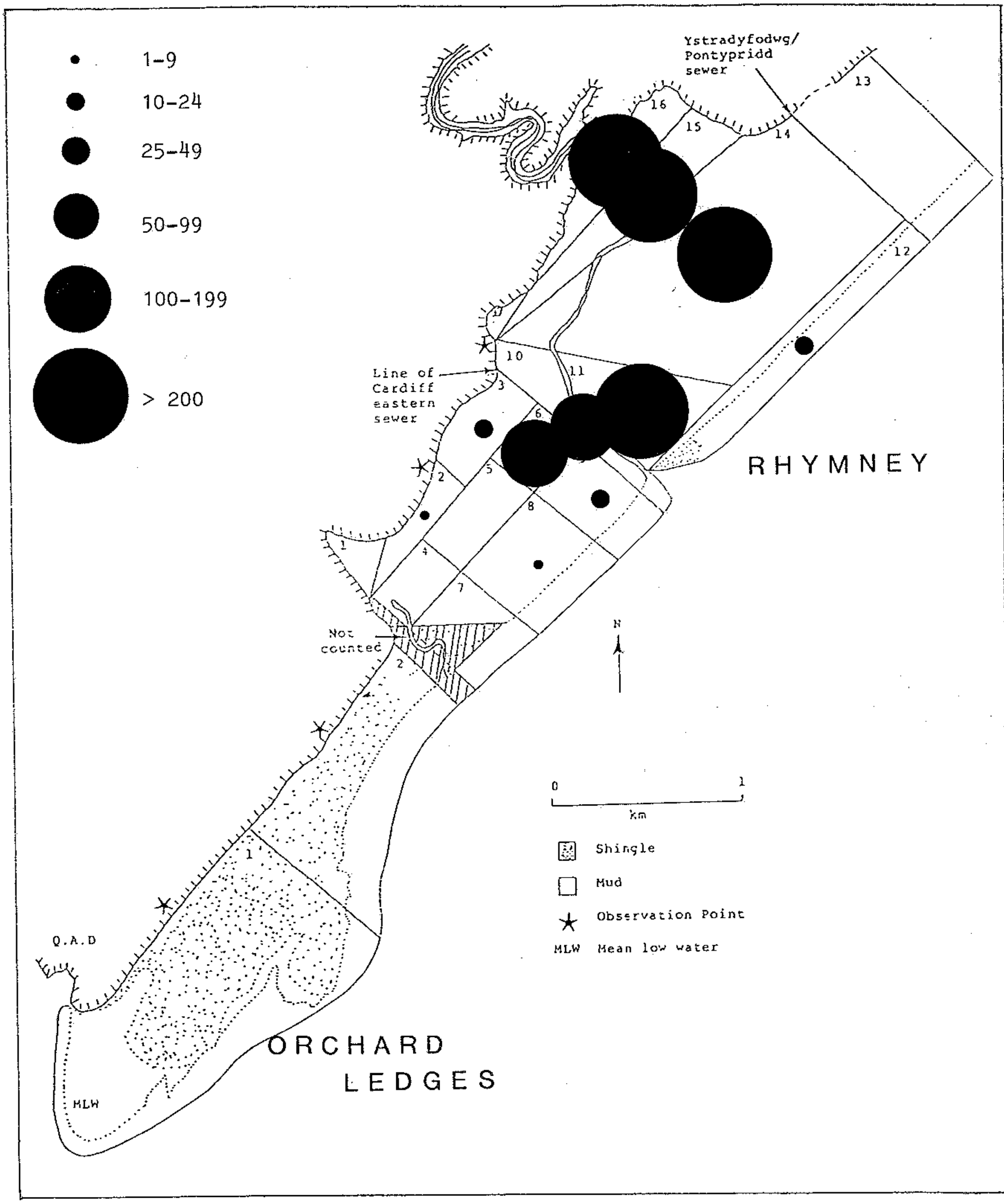


Fig 2.19 The distribution of feeding Redshank at the Rhymney and Orchard Ledges all day sites during Winter 1989/90.
The average number of bird hours per tidal cycle is depicted.

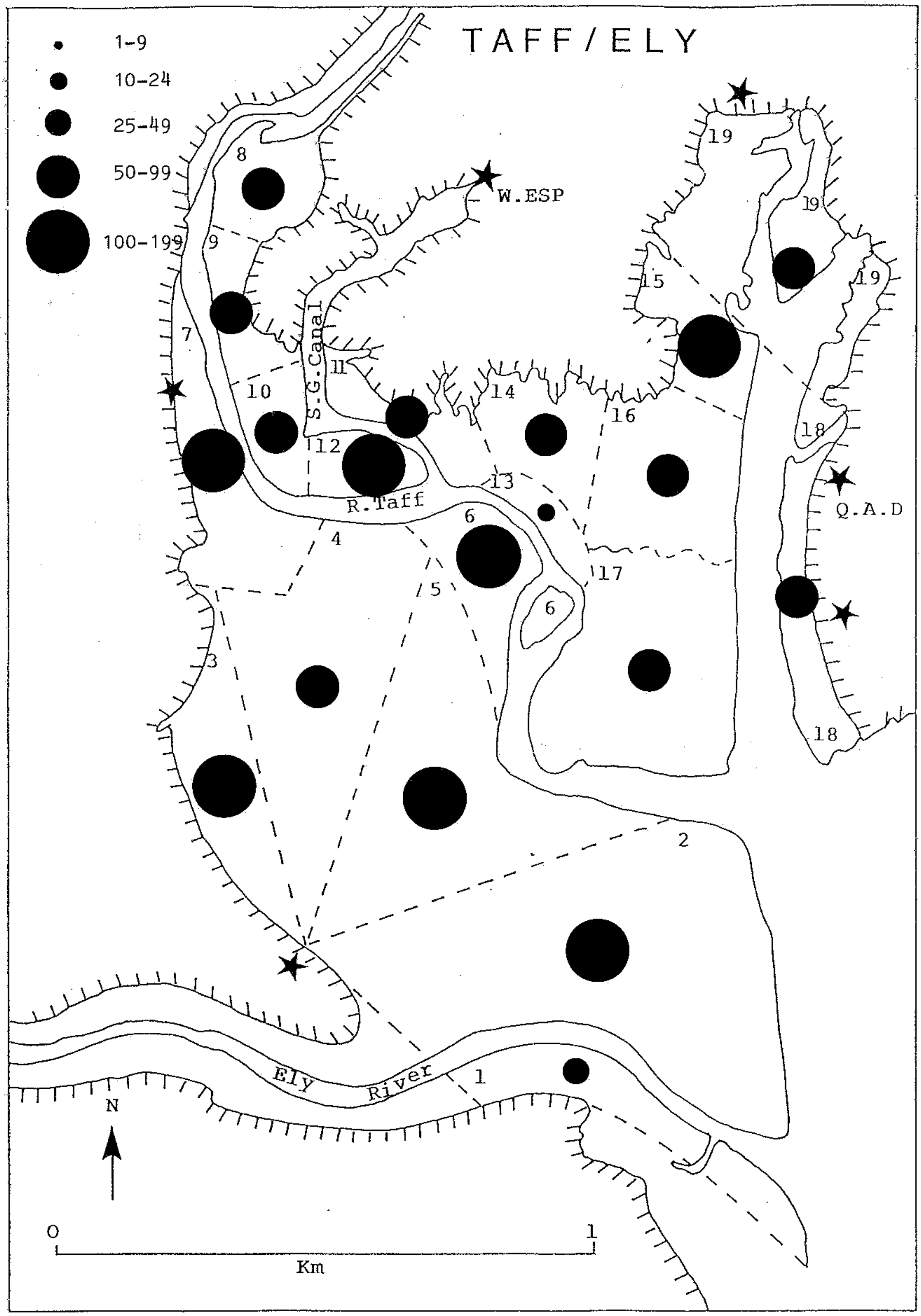
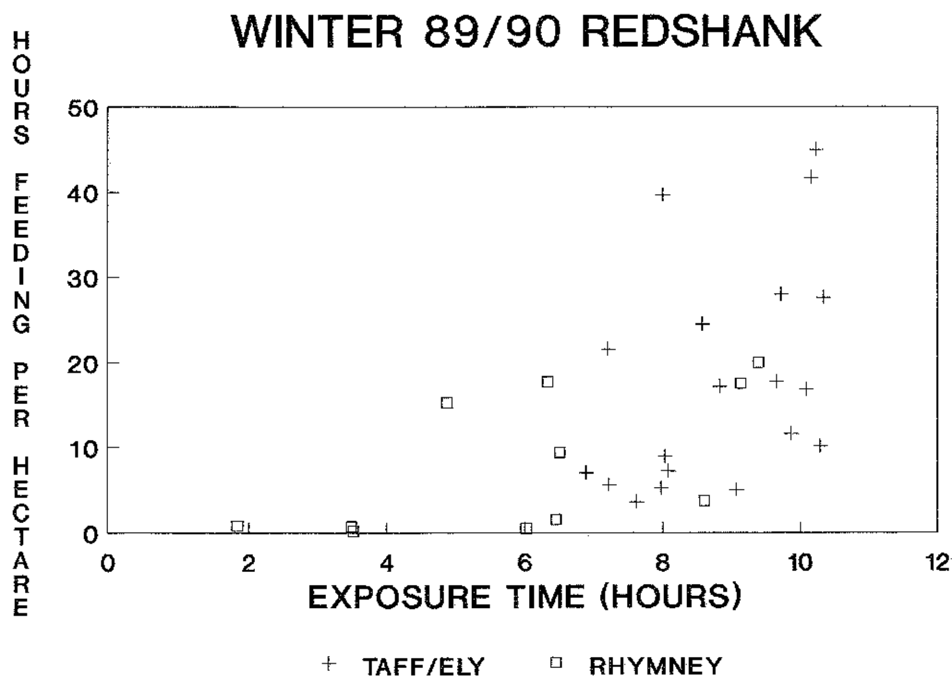


Fig 2.20 The distribution of feeding Redshank in Cardiff Bay during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.



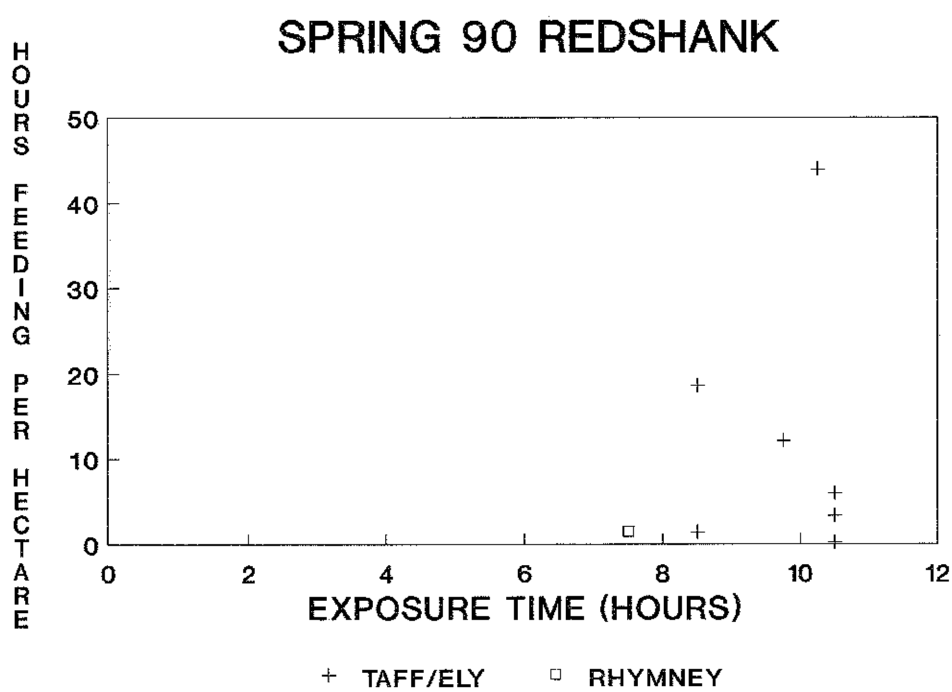


Fig 2.21 A comparison of feeding density with exposure time for Redshank at all day sites, Winter 1989/90 and Spring 1990.

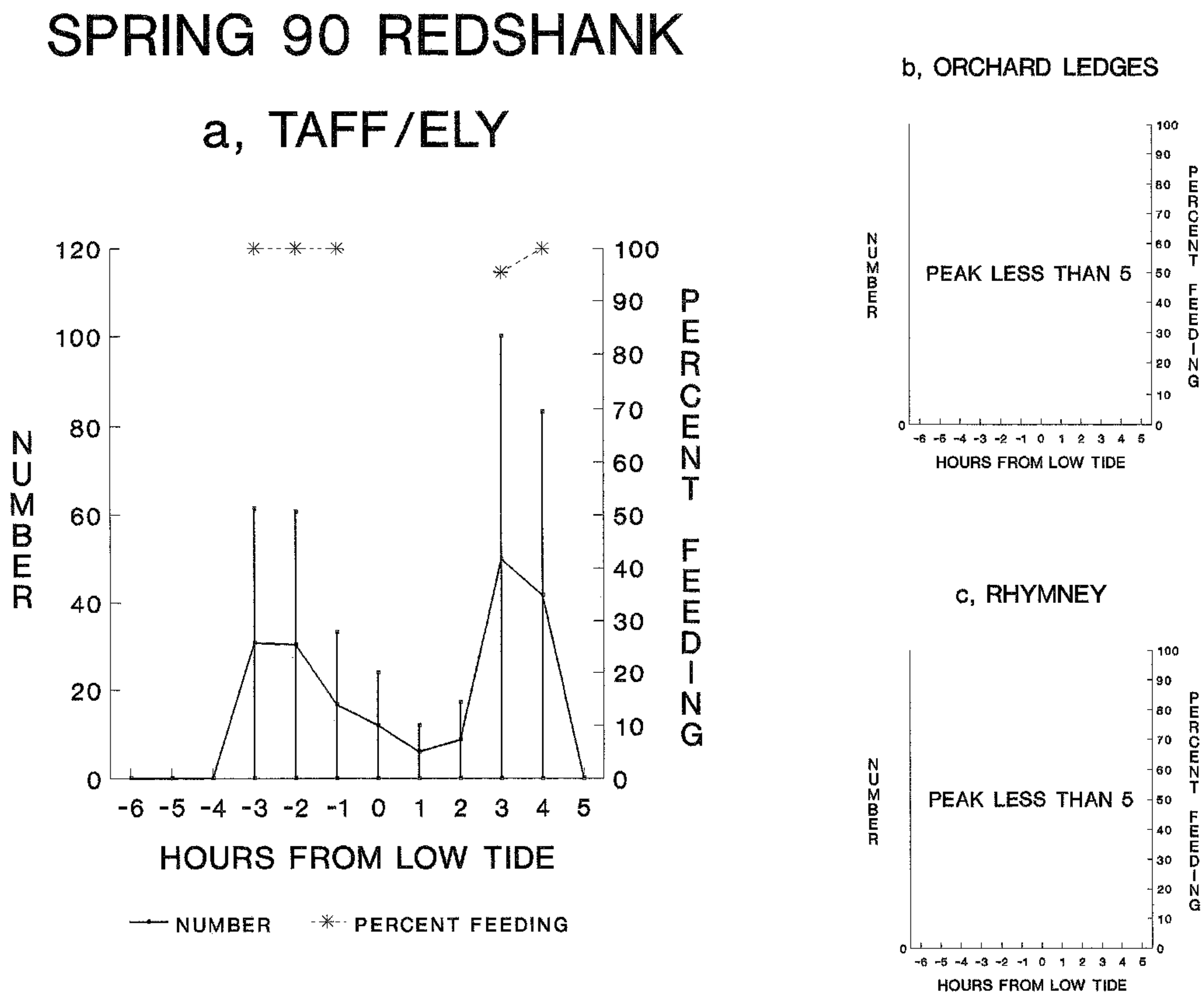


Fig 2.22 The total number of Redshank present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Spring 1990.

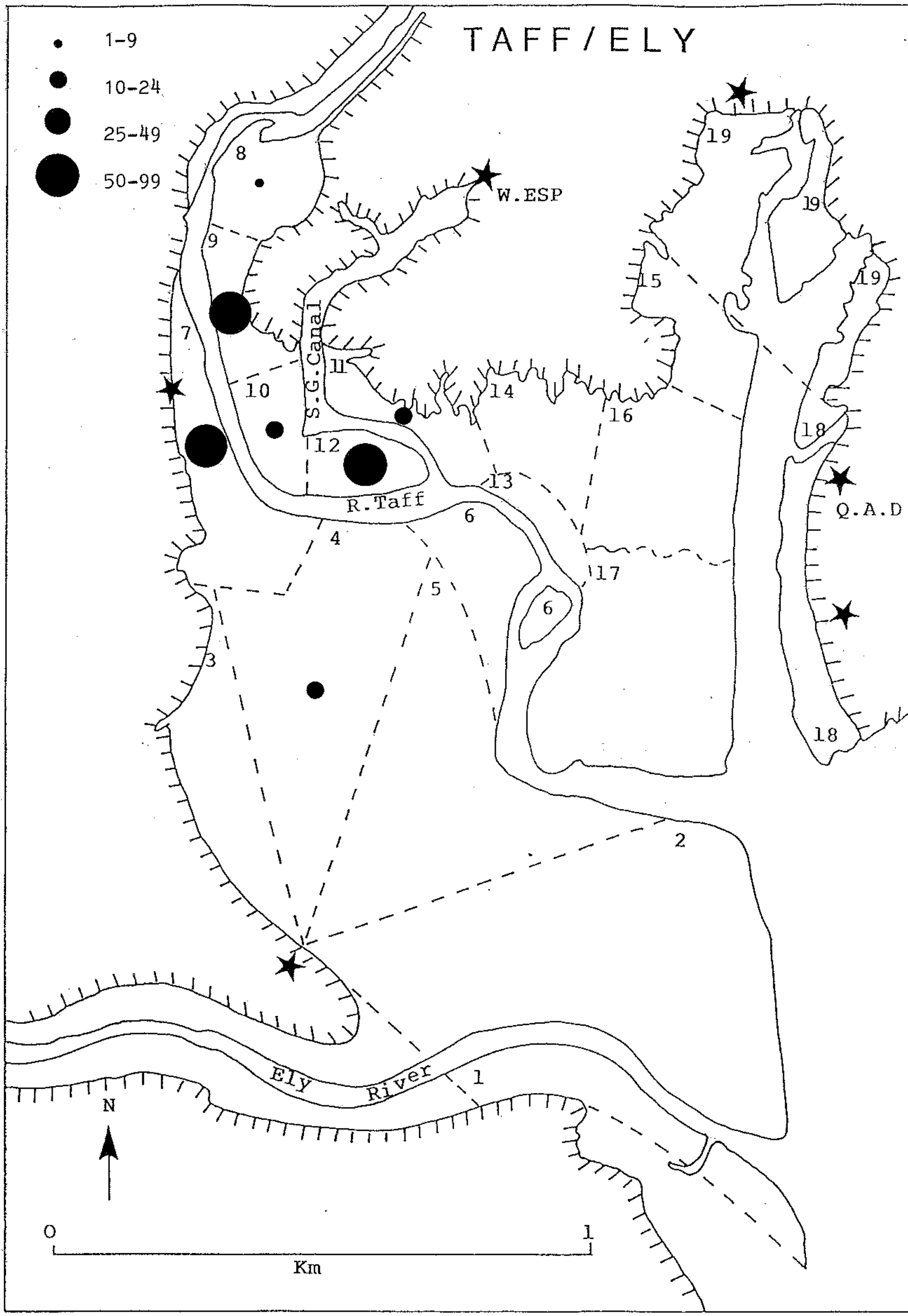


Fig 2.23 The distribution of feeding Redshank in Cardiff Bay during Spring 1990. The average number of bird hours per tidal cycle is depicted.

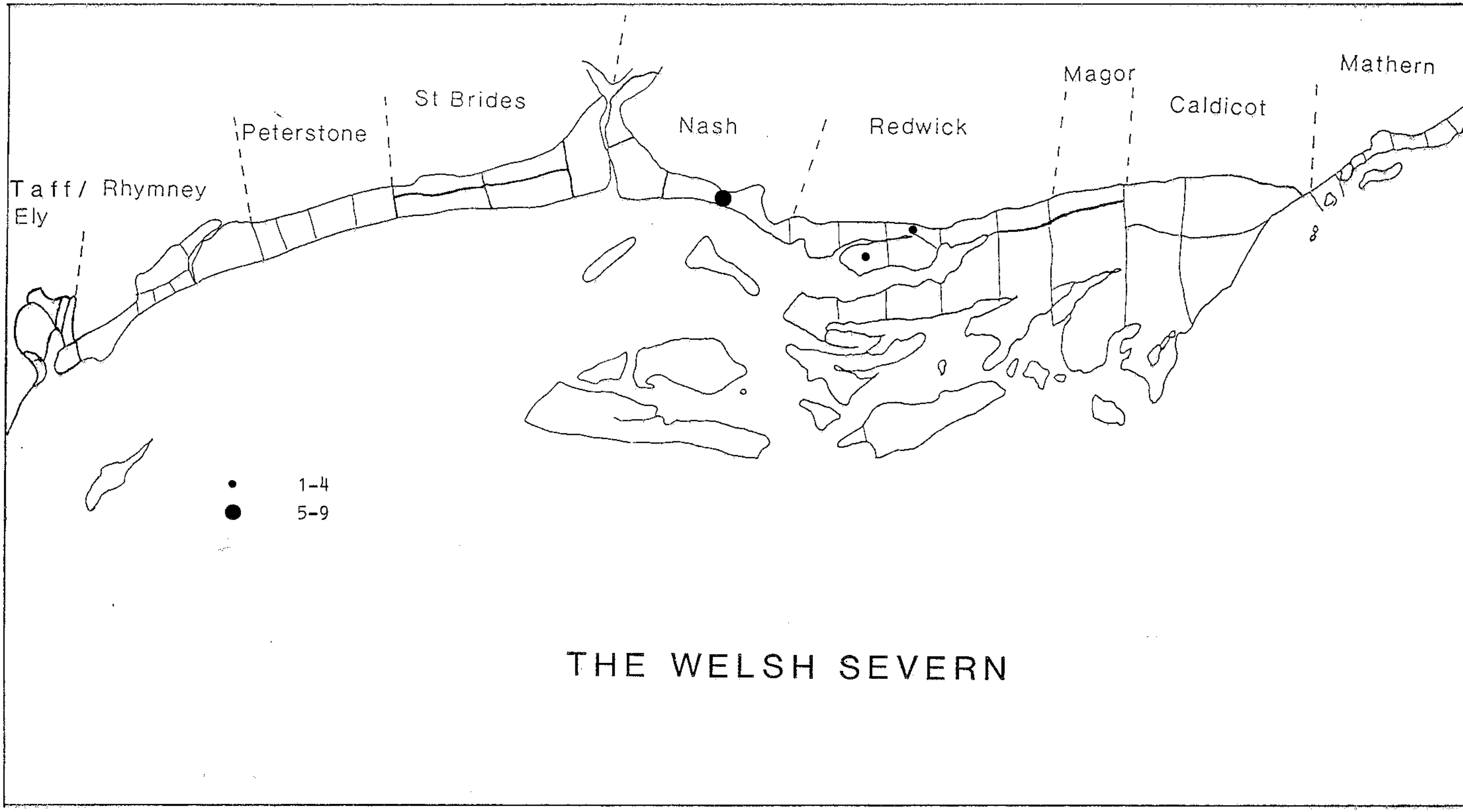


Fig 2.24 The distribution of feeding Wigeon at low tide on the Welsh Severn during Winter 1989/90.

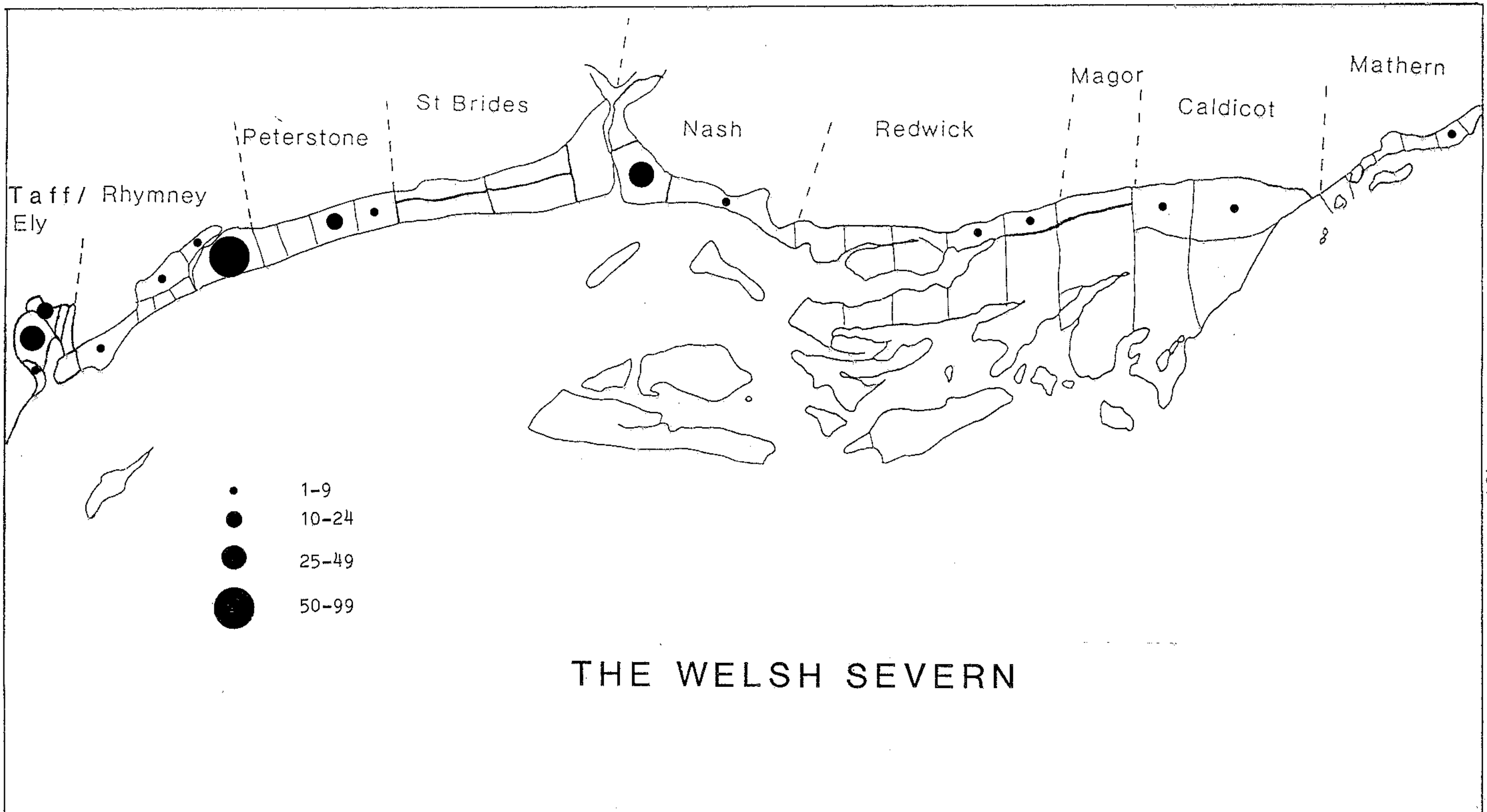


Fig 2.25 The distribution of feeding Mallard at low tide on the Welsh Severn during Winter 1989/90.

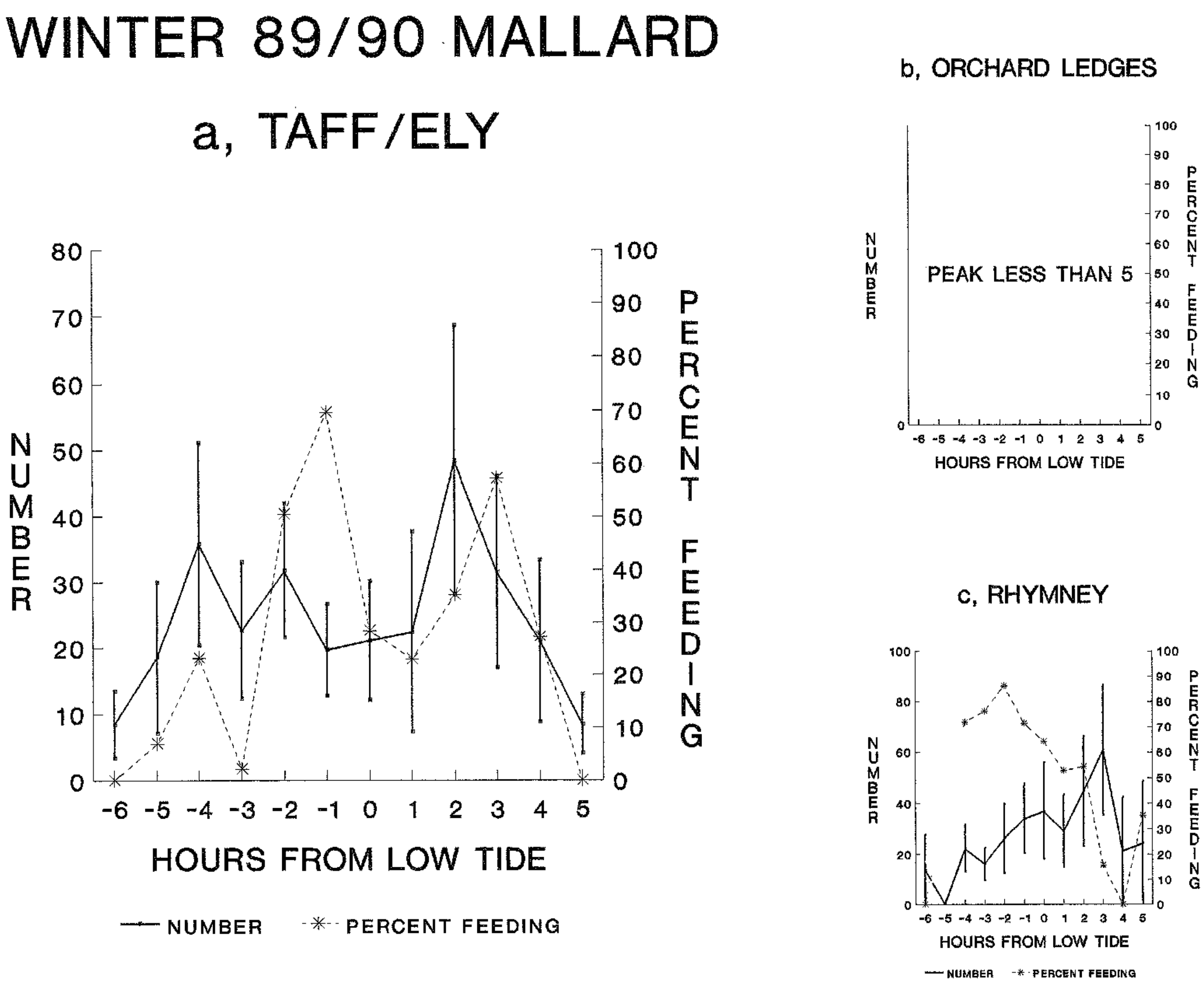


Fig 2.26 The total number of Mallard present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

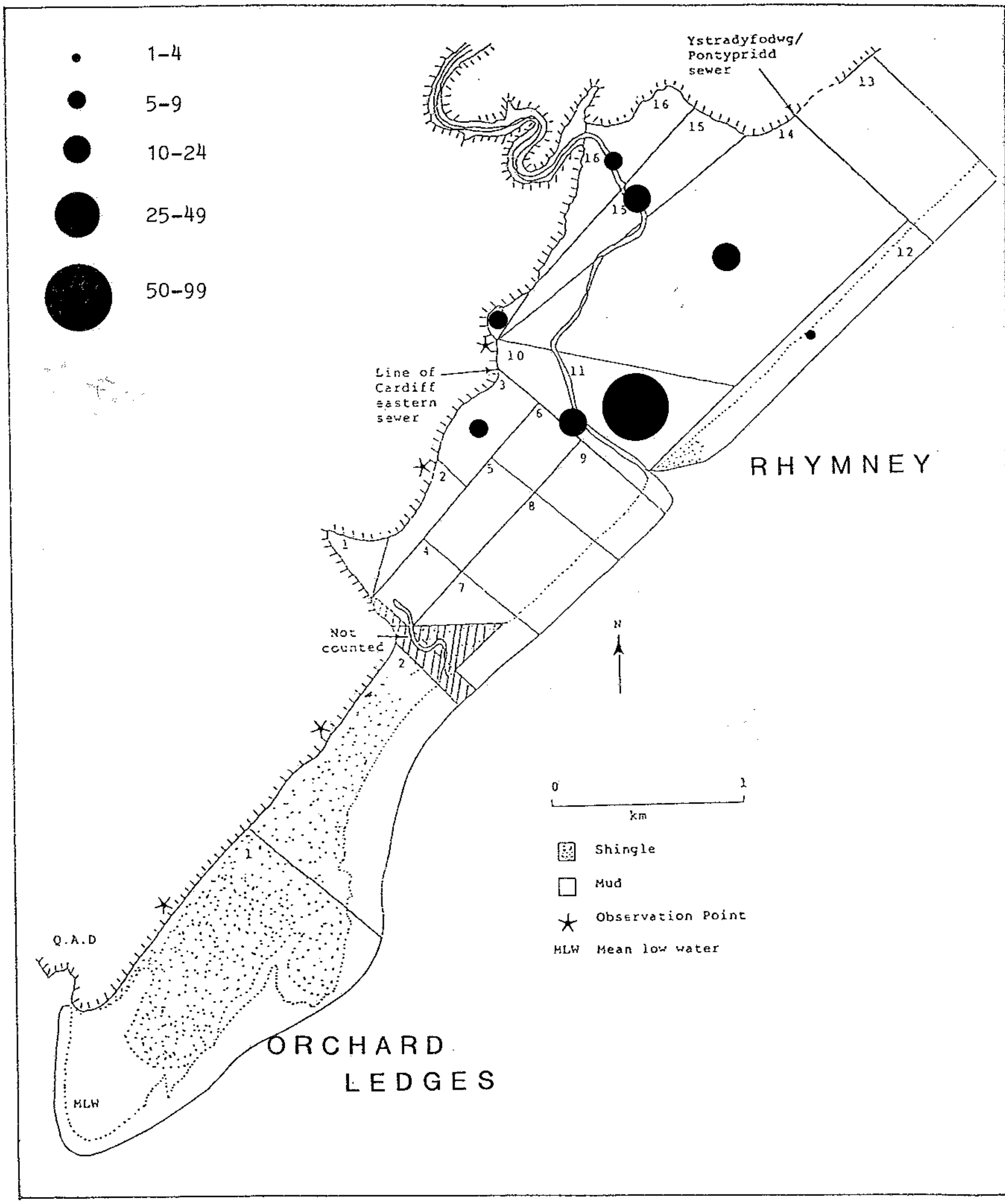


Fig 2.27 The distribution of feeding Mallard at the Rhymney and Orchard Ledges all day sites during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

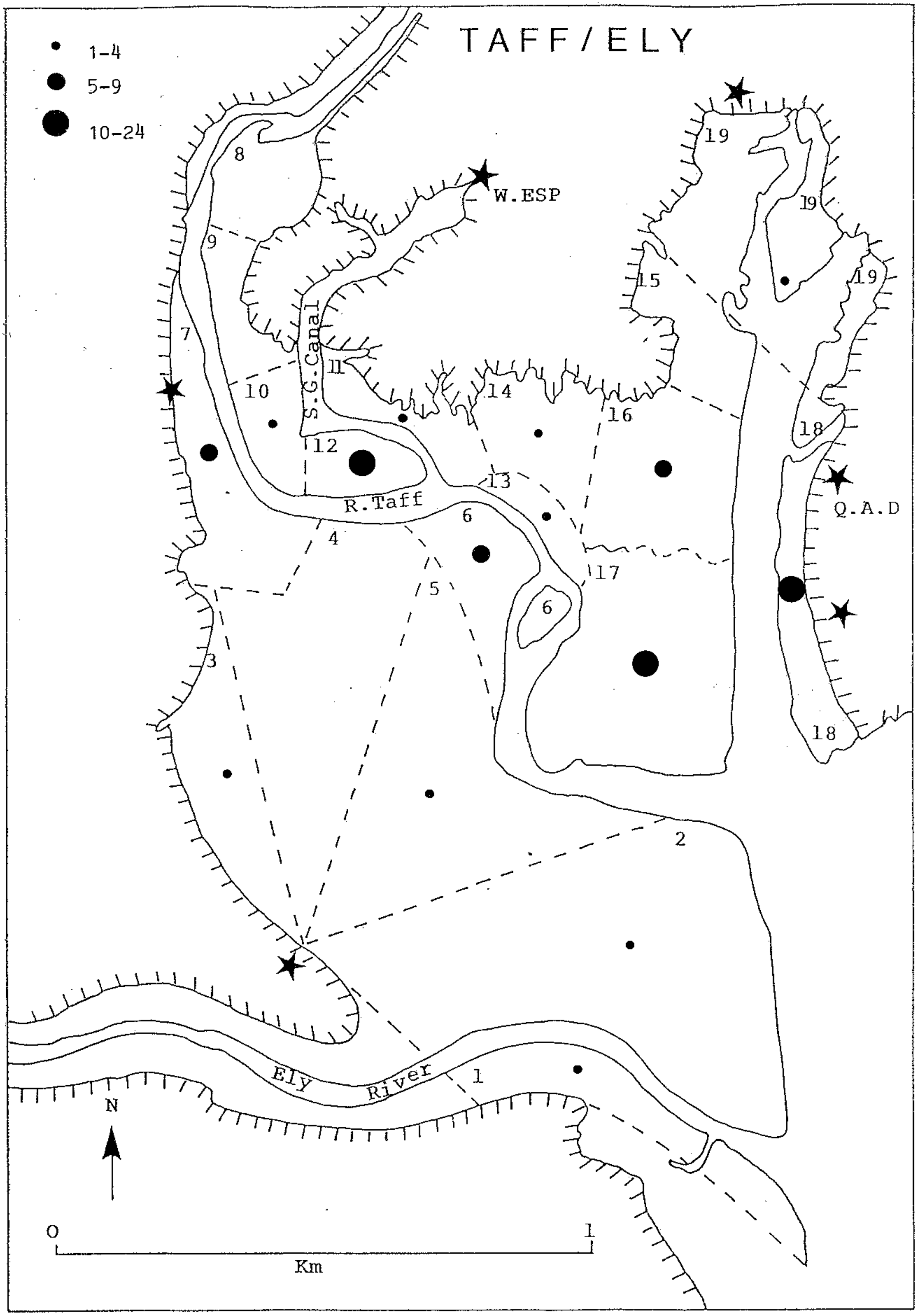


Fig 2.28 The distribution of feeding Mallard in Cardiff Bay during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

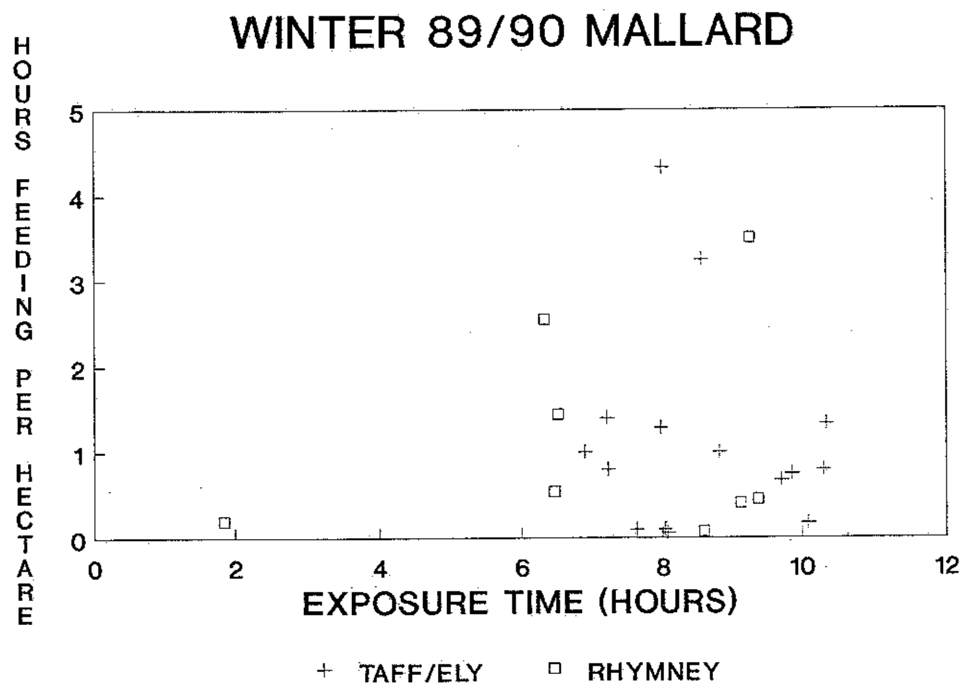


Fig 2.29 A comparison of feeding density with exposure time for Mallard at all day sites, Winter 1989/90.

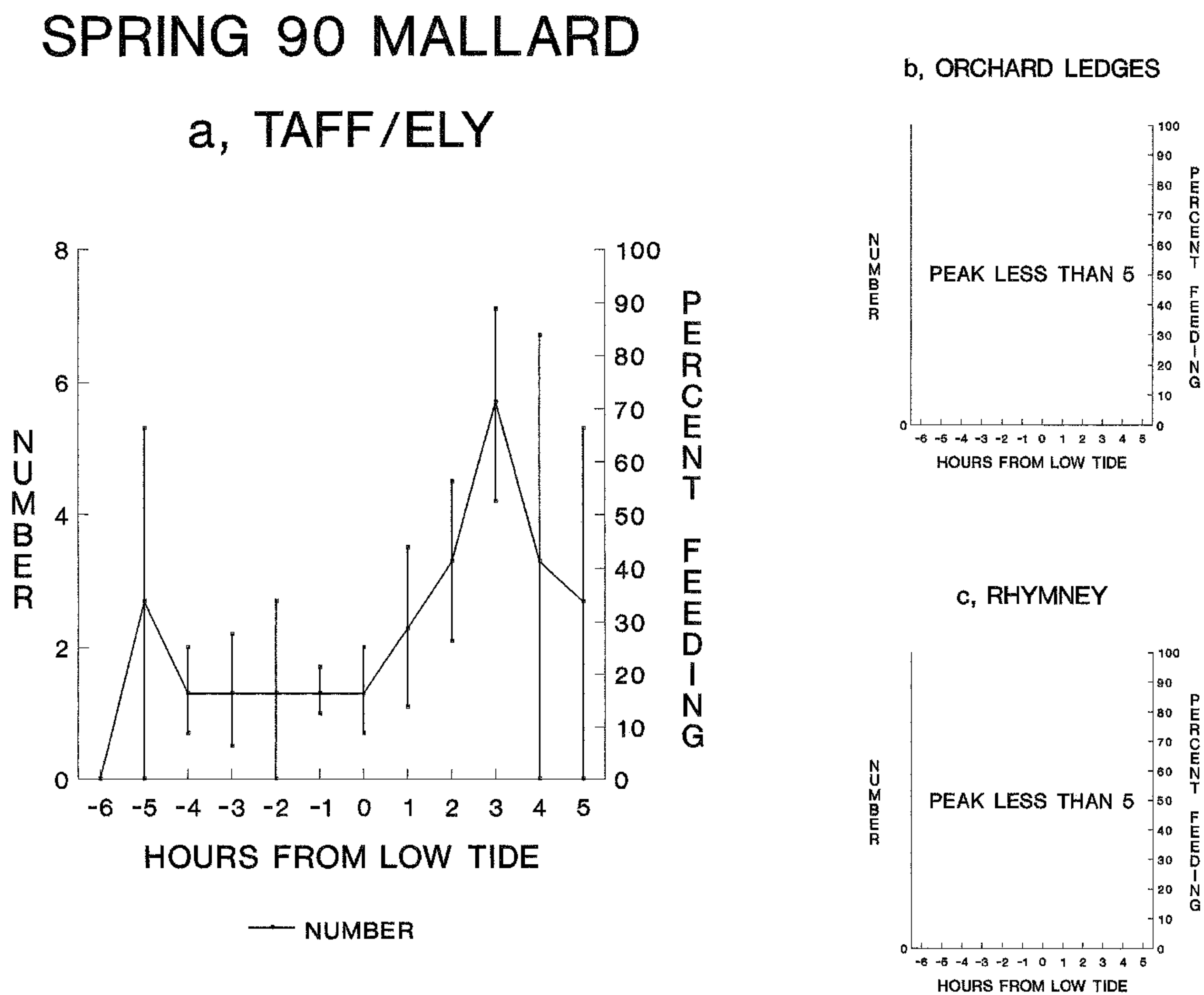


Fig 2.30 The total number of Mallard present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Spring 1990.

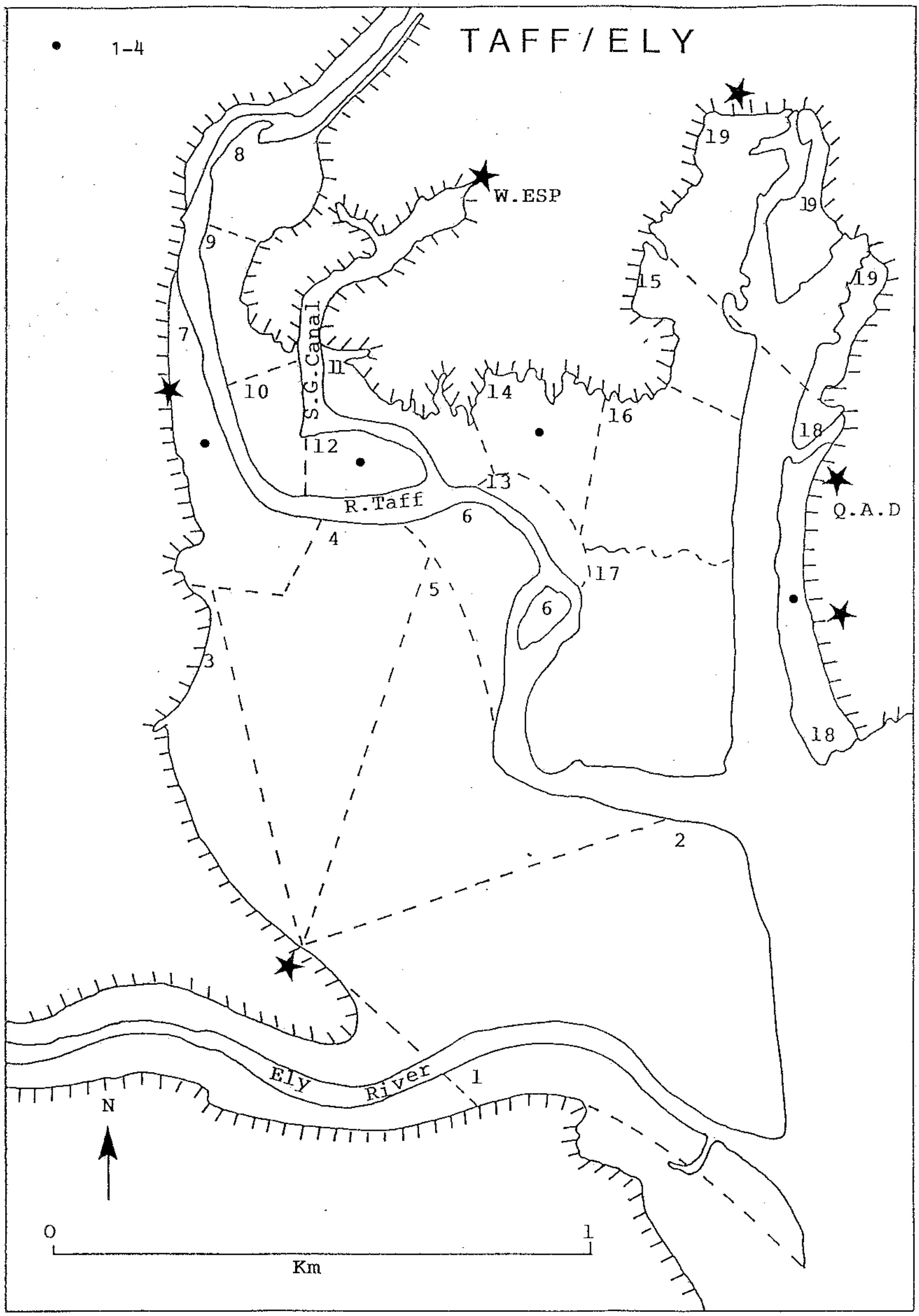


Fig 2.31 The distribution of feeding Mallard in Cardiff Bay during Spring 1990. The average number of bird hours per tidal cycle is depicted.

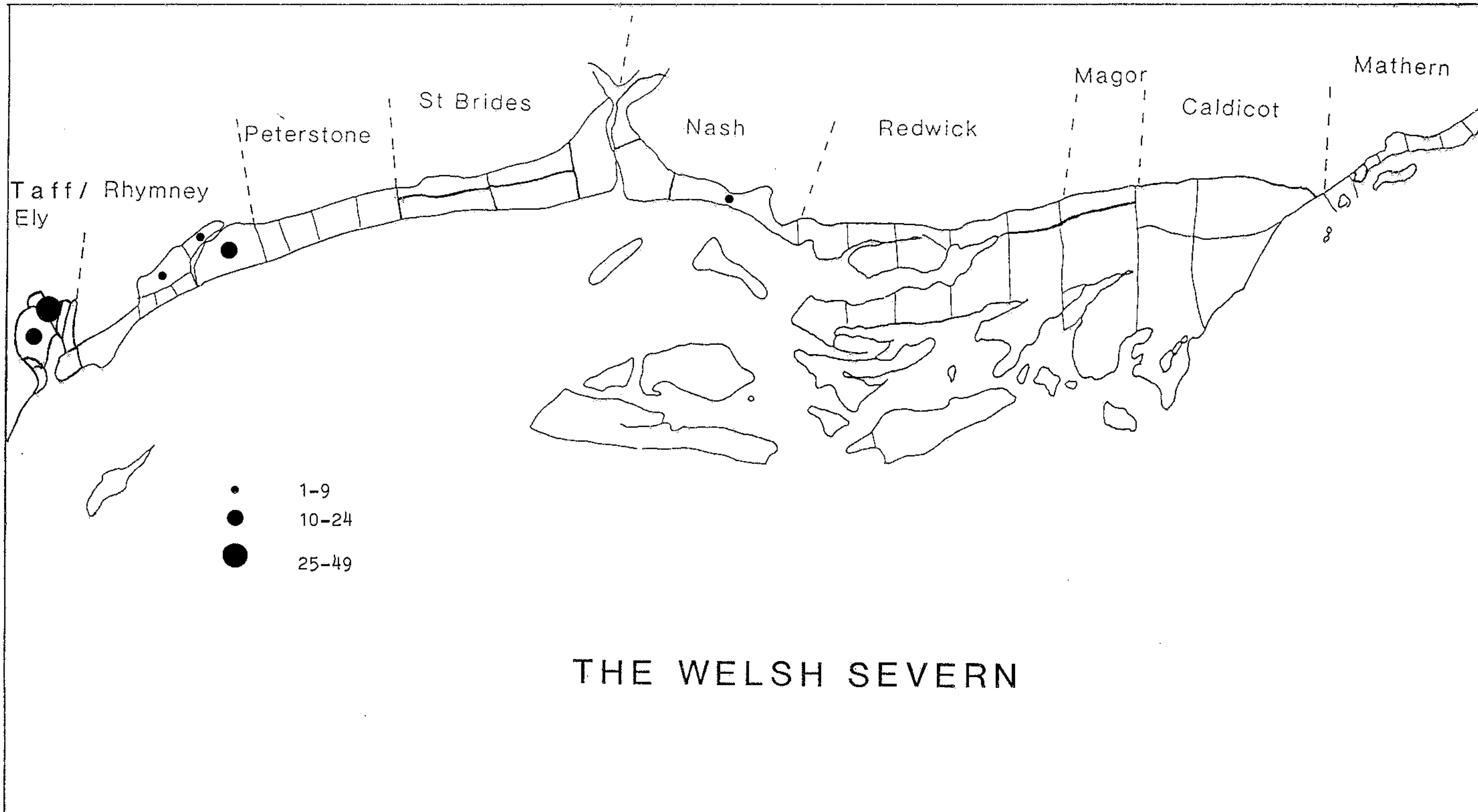


Fig 2.32 The distribution of feeding Teal at low tide on the Welsh Severn during Winter 1989/90.

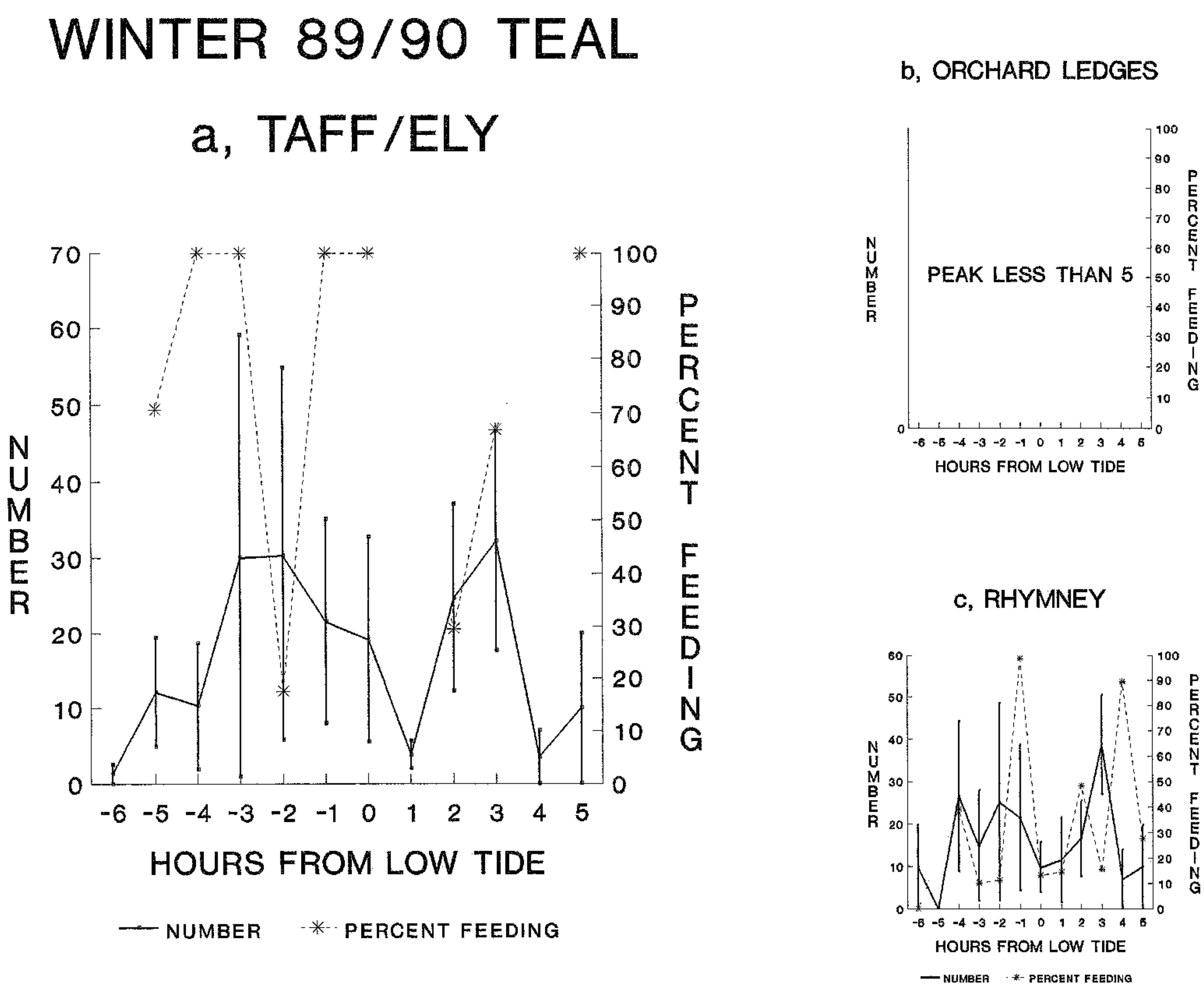


Fig 2.33 The total number of Teal present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

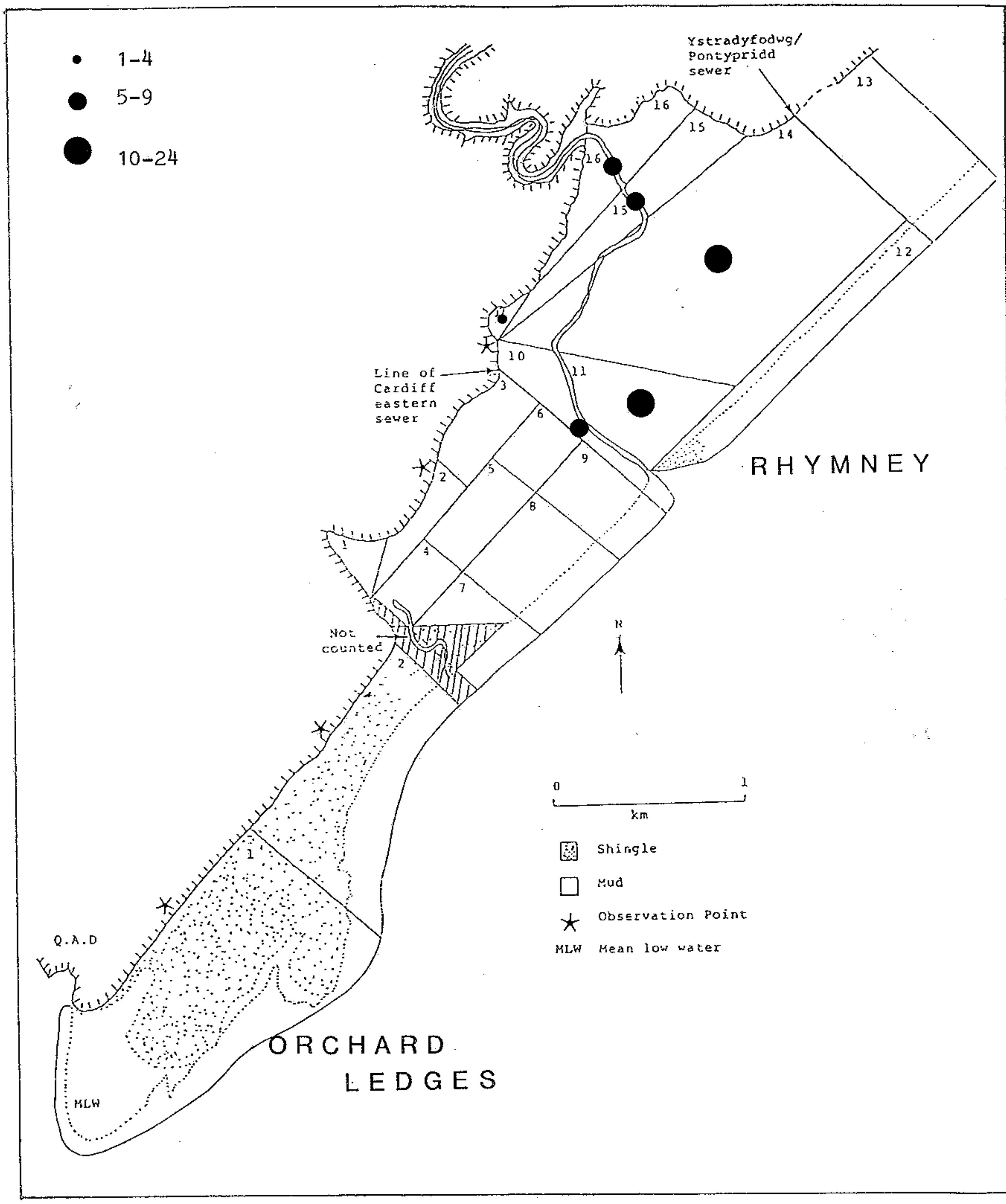


Fig 2.34 The distribution of feeding Teal at the Rhymney and Orchard Ledges all day sites during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

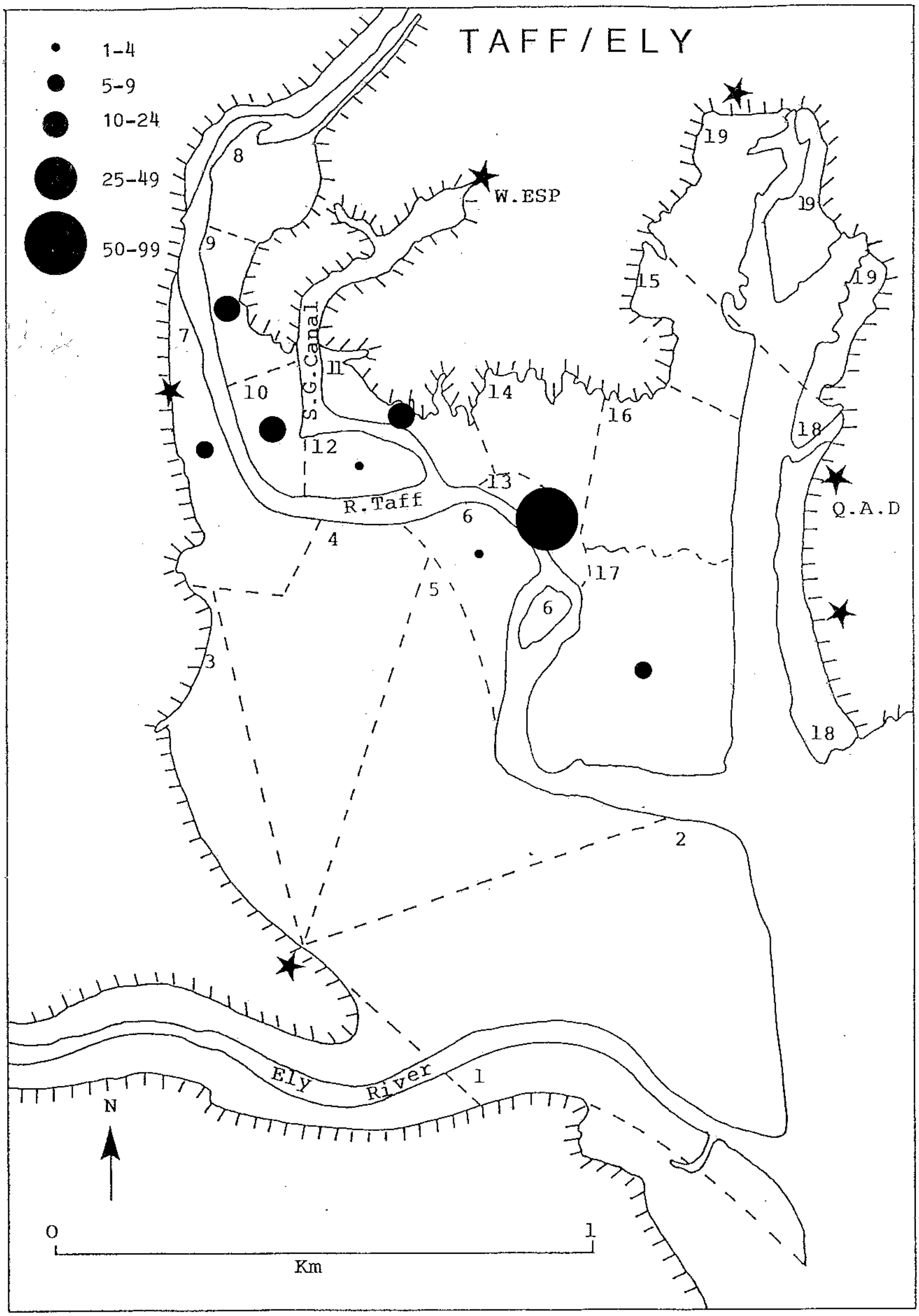


Fig 2.35 The distribution of feeding Teal in Cardiff Bay during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

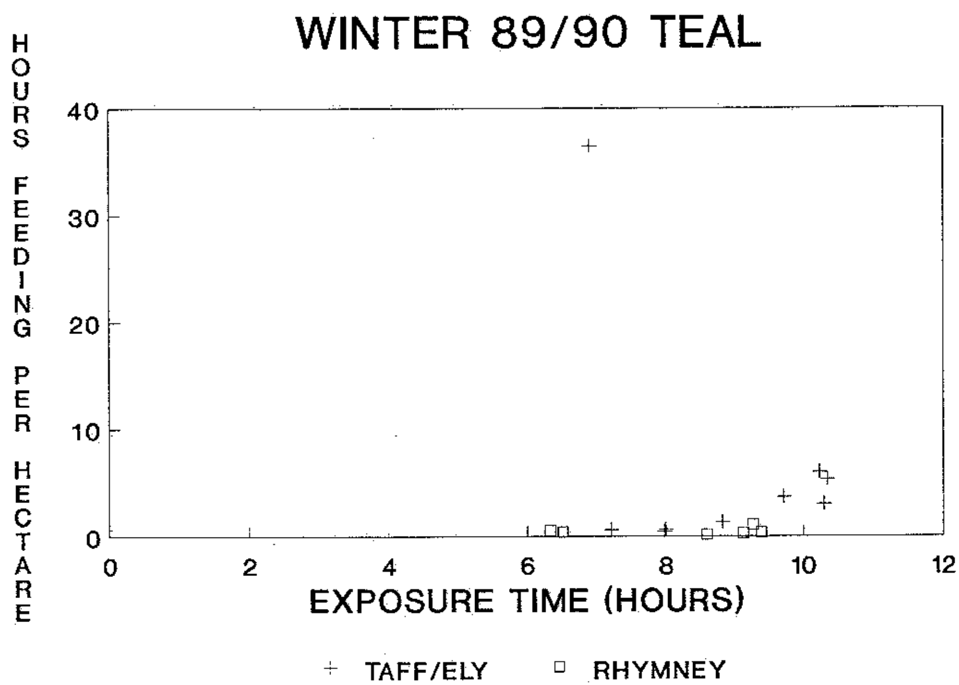


Fig2.36 A comparison of feeding density with exposure time for Teal at all day sites, Winter 1989/90.

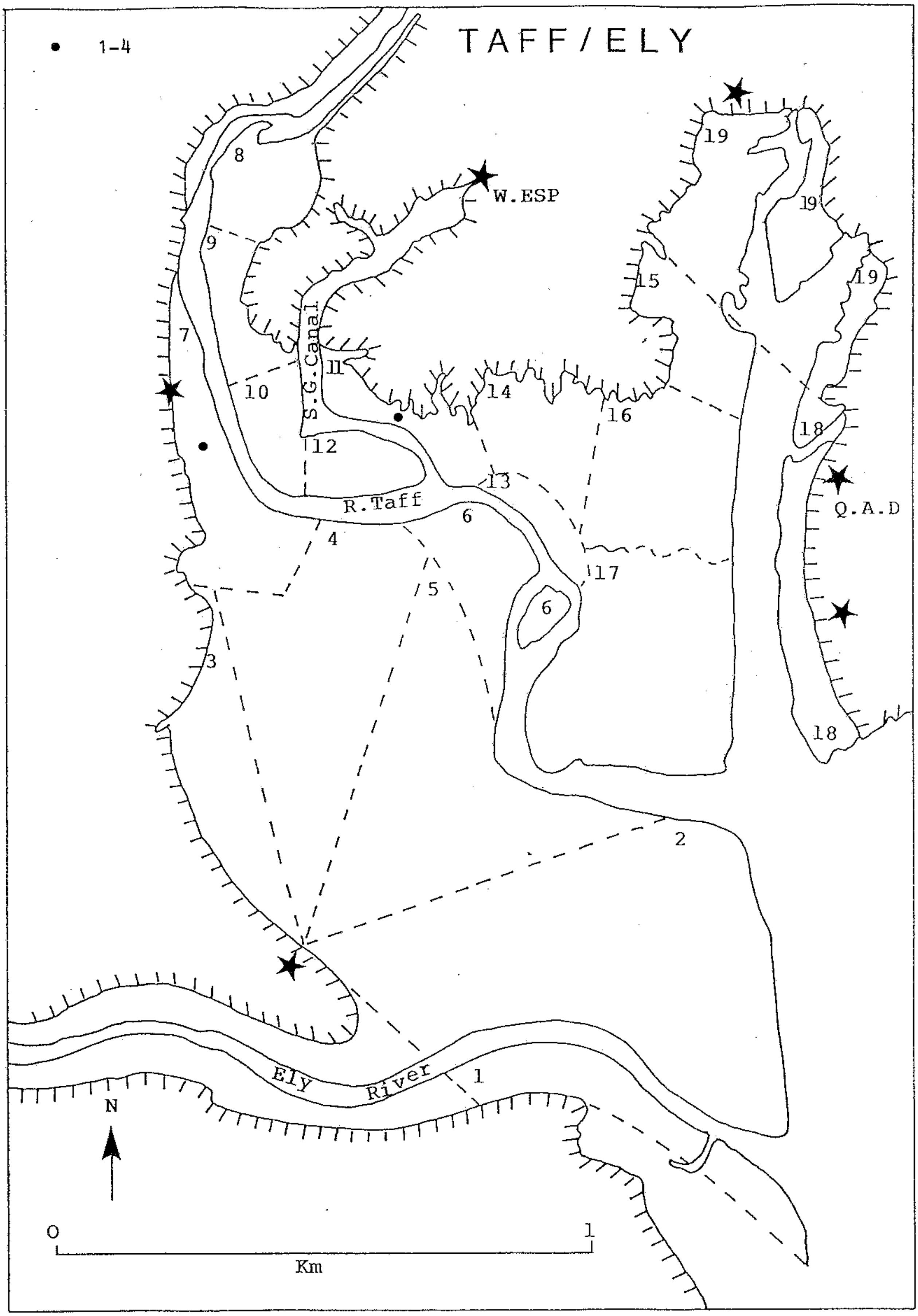


Fig 2.37 The distribution of feeding Teal in Cardiff Bay during Spring 1990. The average number of bird h ours per tidal cycle is depicted.

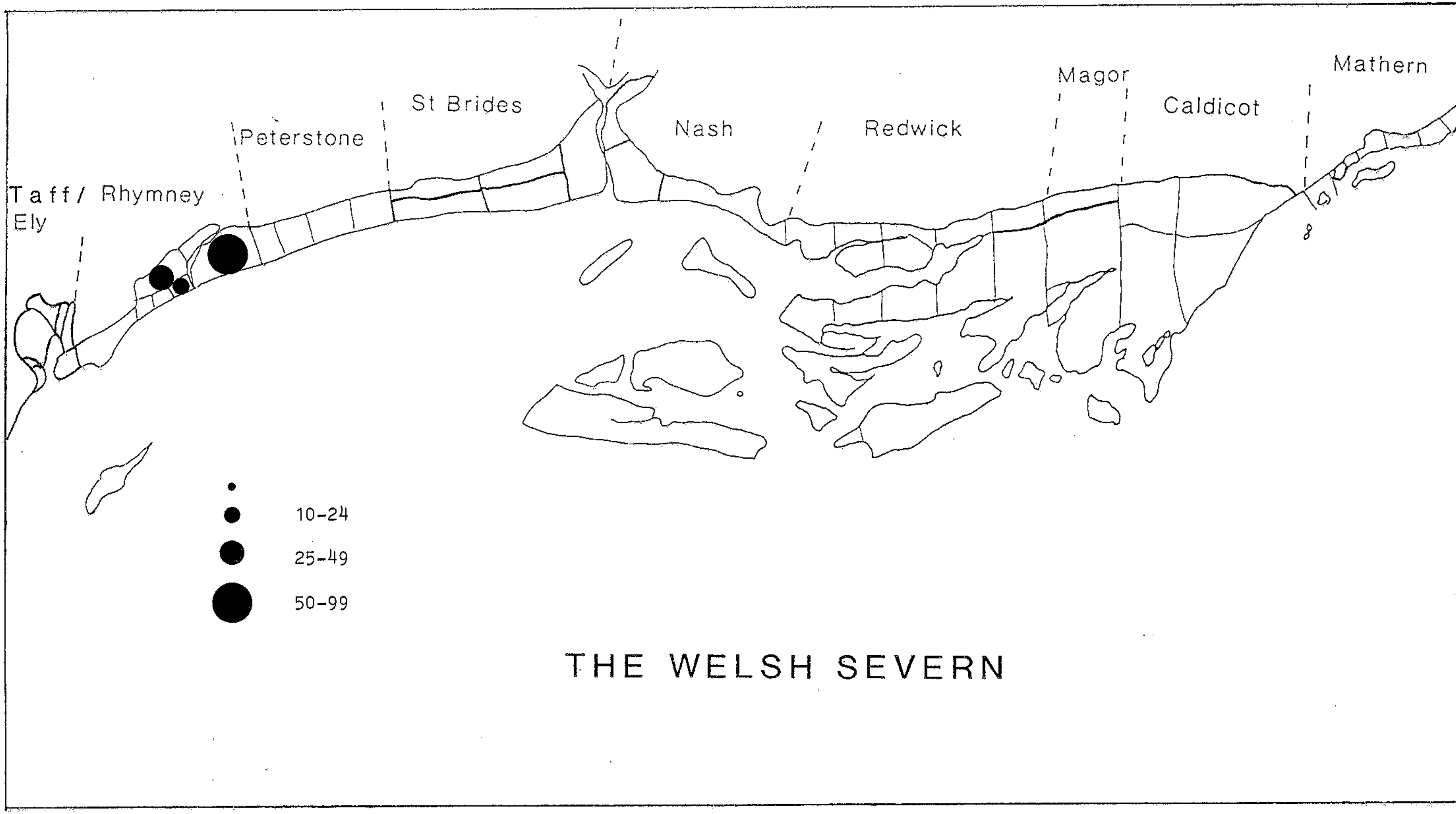


Fig 2.38 The distribution of feeding Pintail at low tide on the Welsh Severn during Winter 1989/90.

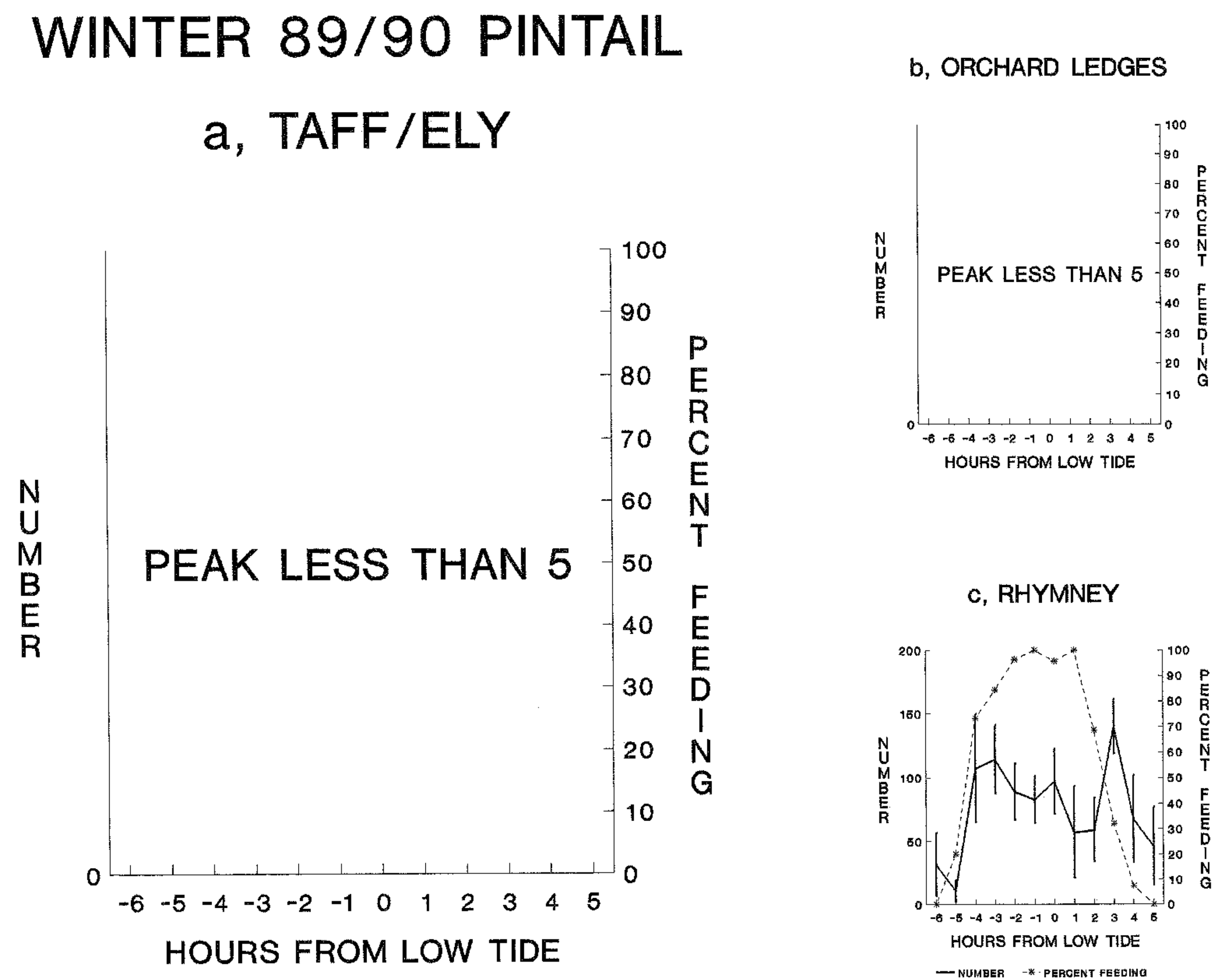


Fig 2.39 The total number of Pintail present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

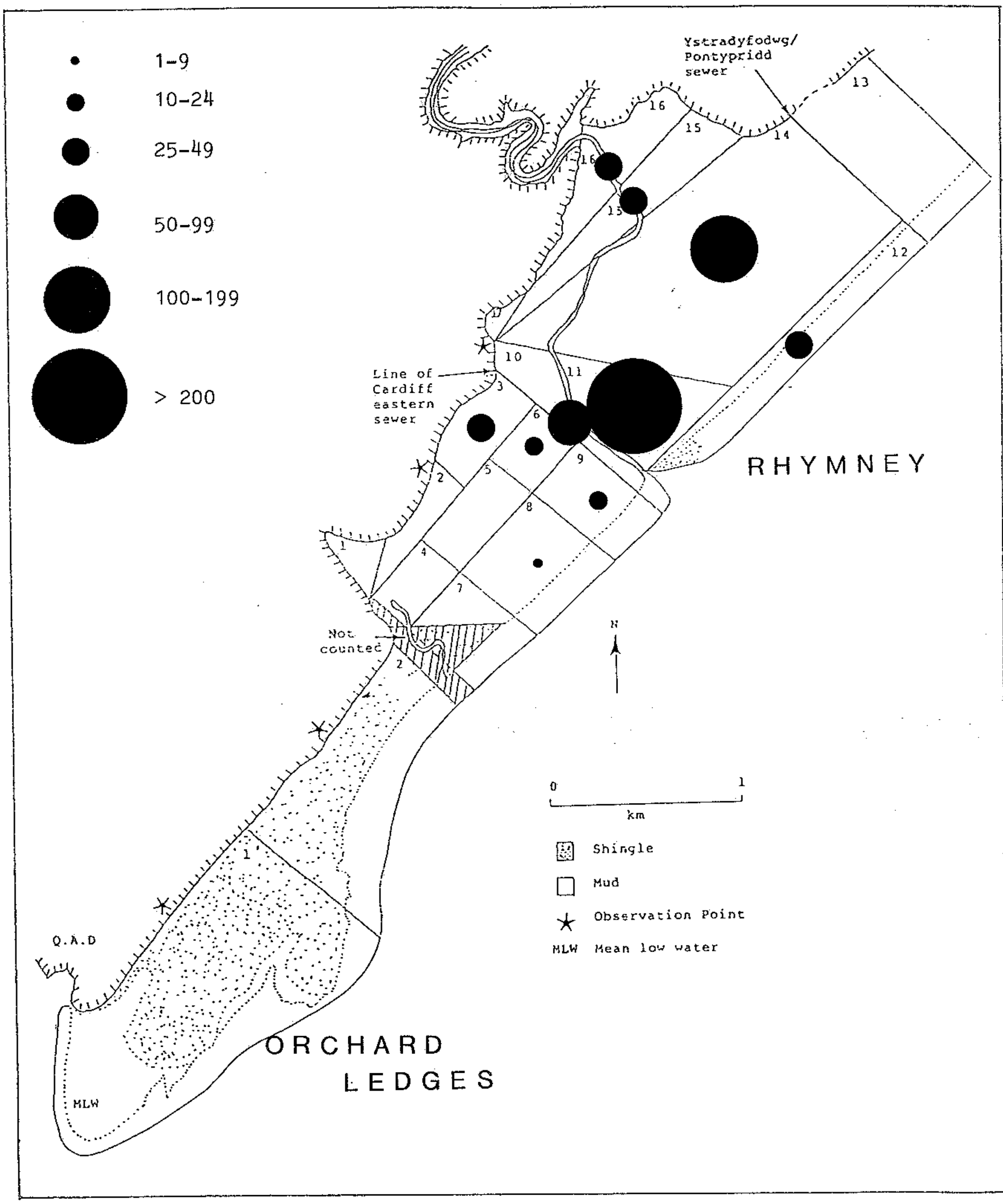


Fig 2.40 The distribution of feeding Pintail at the Rhymney and Orchard Ledges all day sites during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

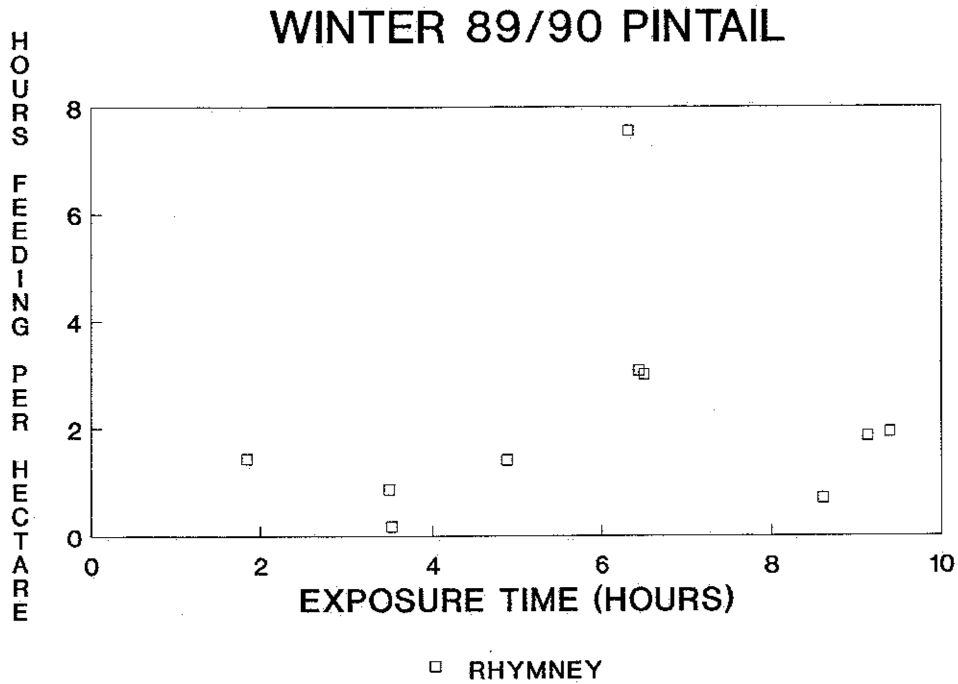


Fig 2.41 A comparison of feeding density with exposure time for Pintail at all day sites, Winter 1989/90.

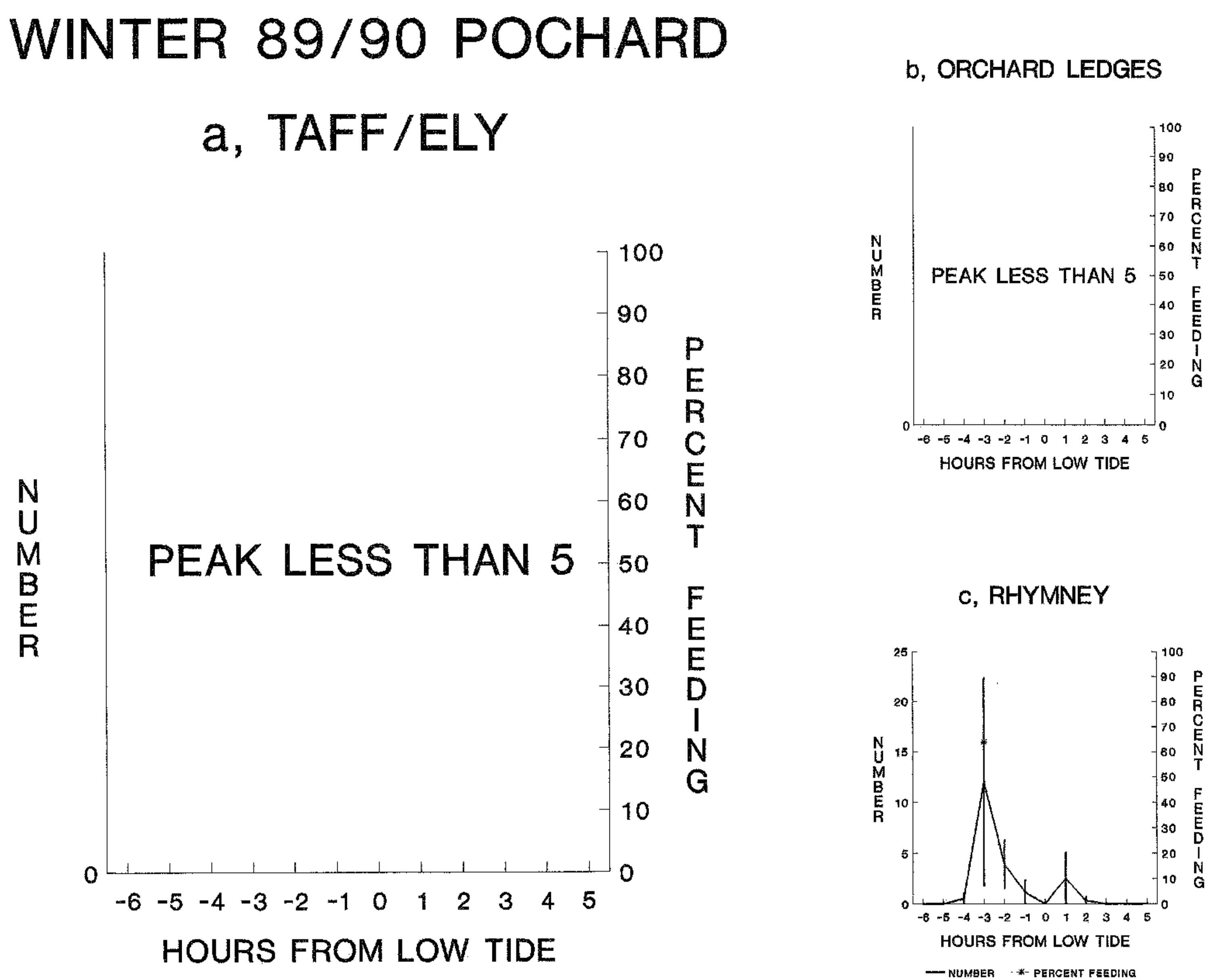


Fig 2.42 The total number of Pochard present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

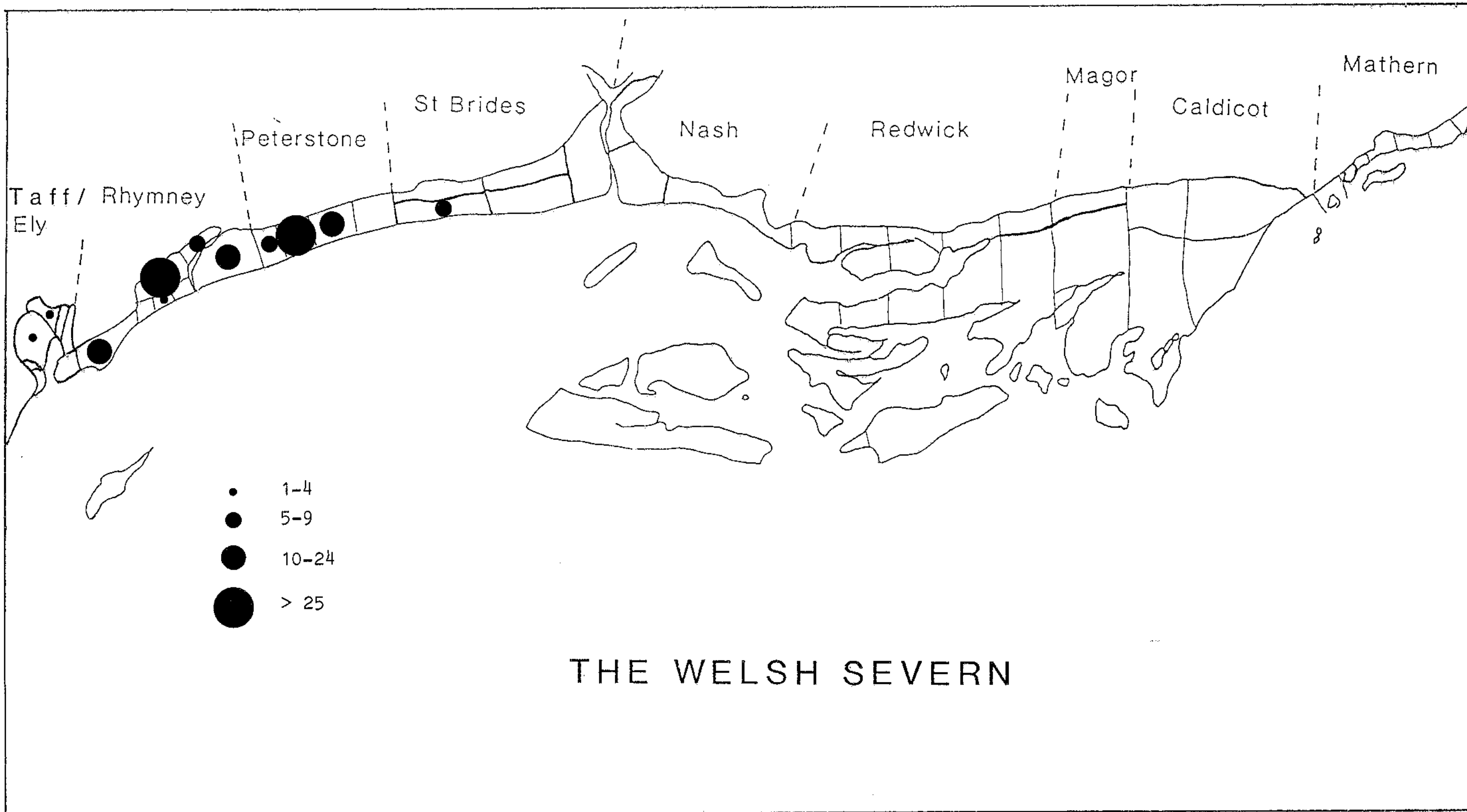


Fig 2.43 The distribution of feeding Oystercatcher at low tide on the Welsh Severn during Winter 1989/90.

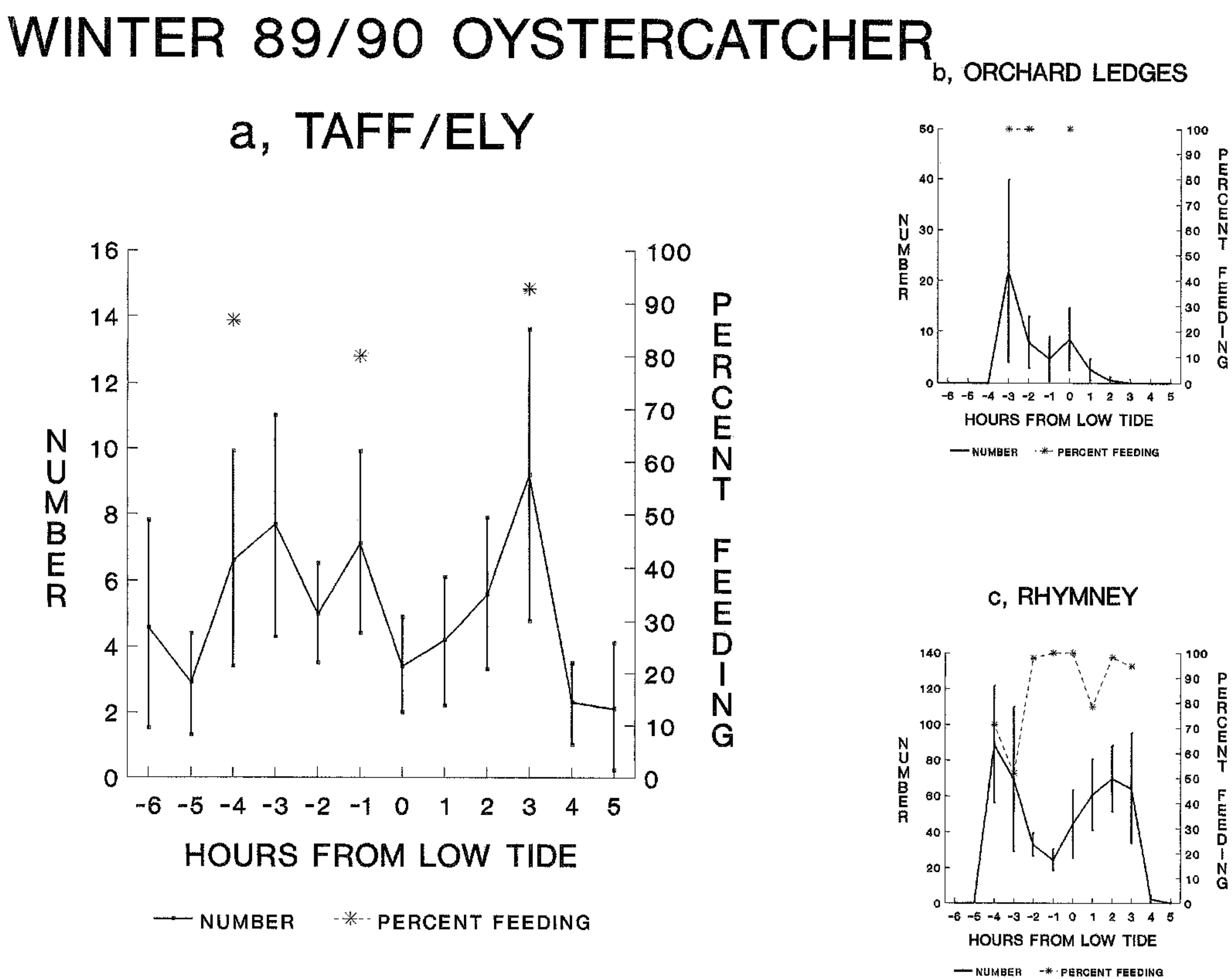


Fig 2.44 The total number of Oystercatcher present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

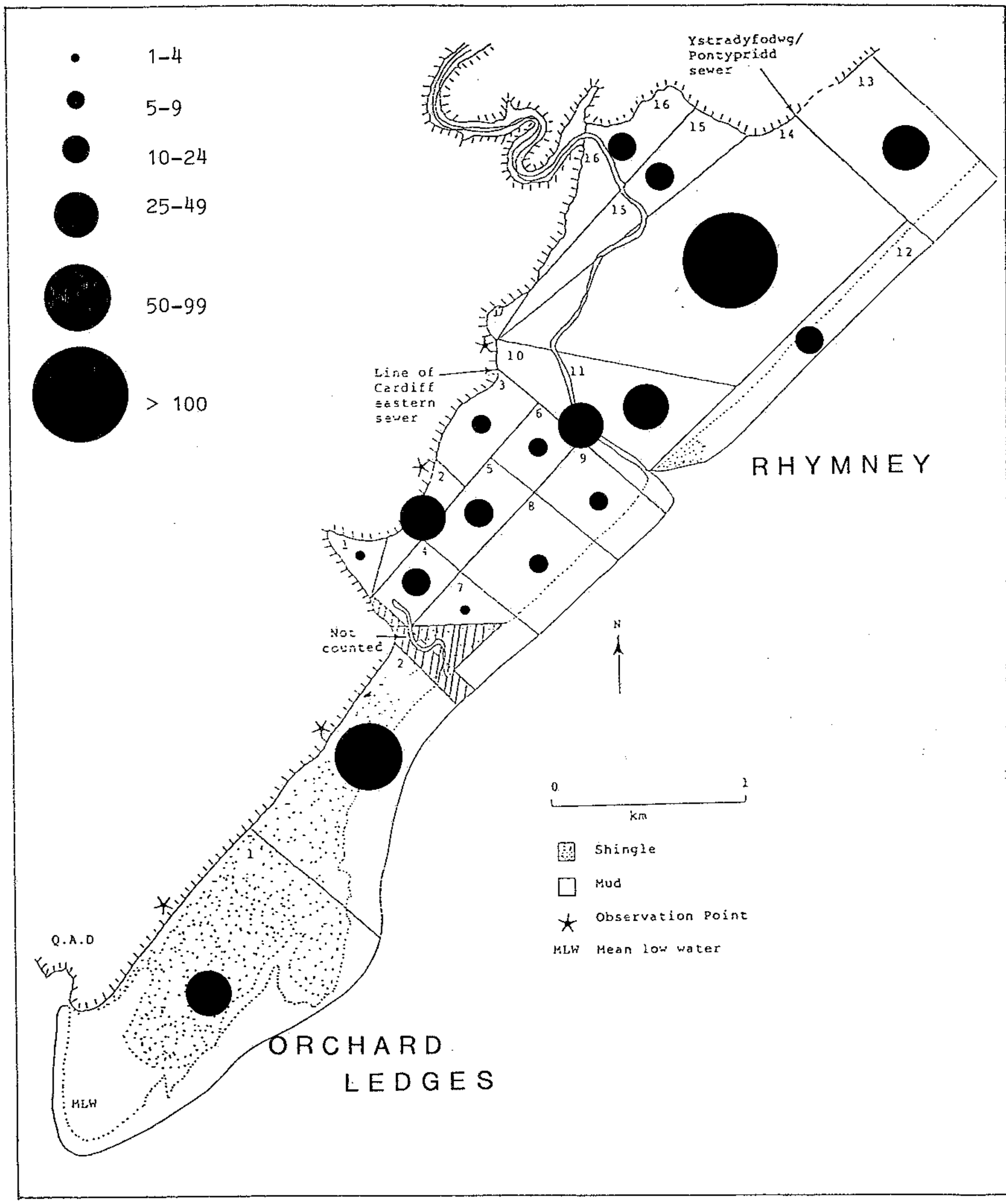


Fig 2.45 The distribution of feeding Oystercatcher at the Rhymney and Orchard Ledges all day sites during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

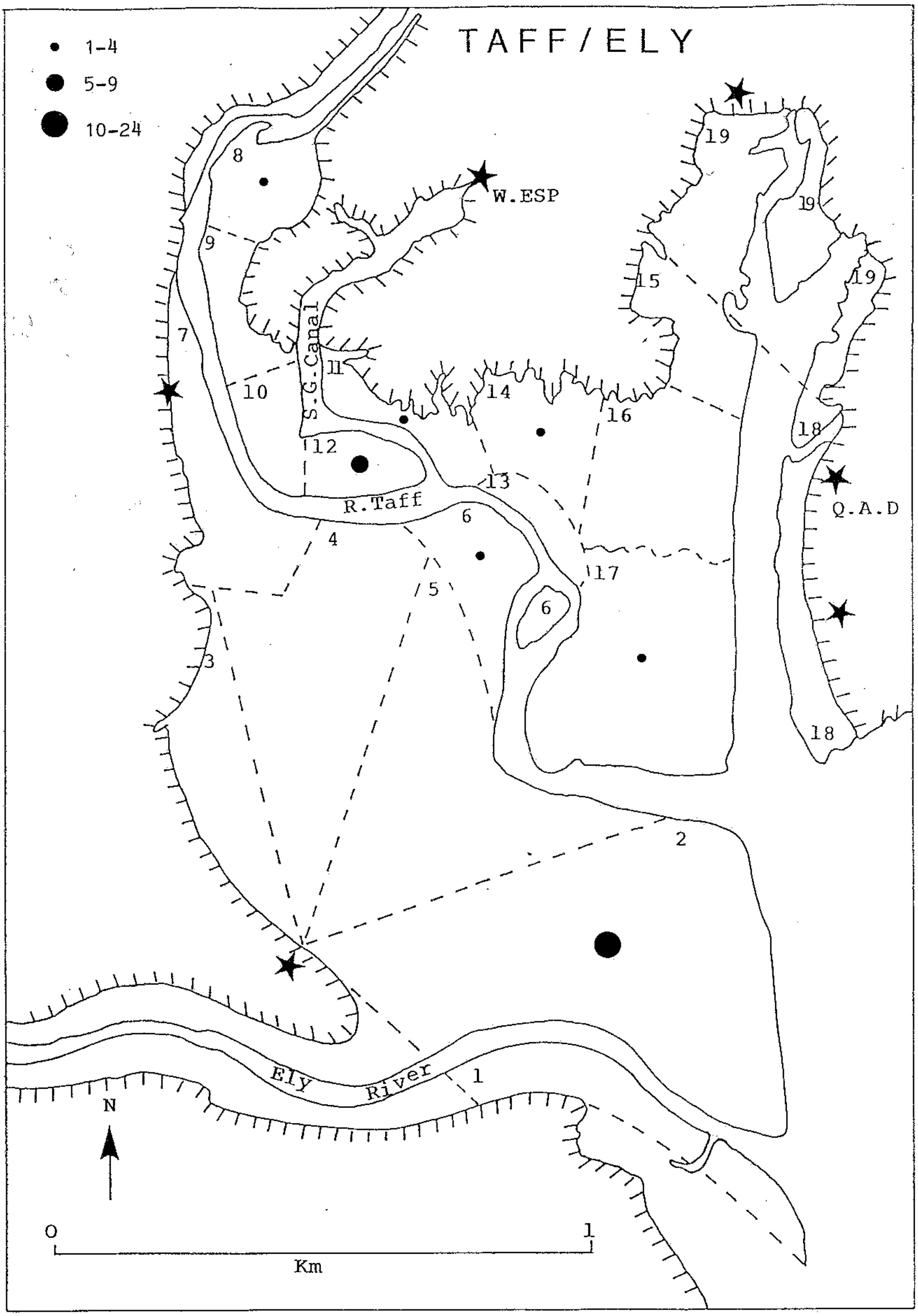


Fig 2.46 The distribution of feeding Oystercatcher in Cardiff Bay during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

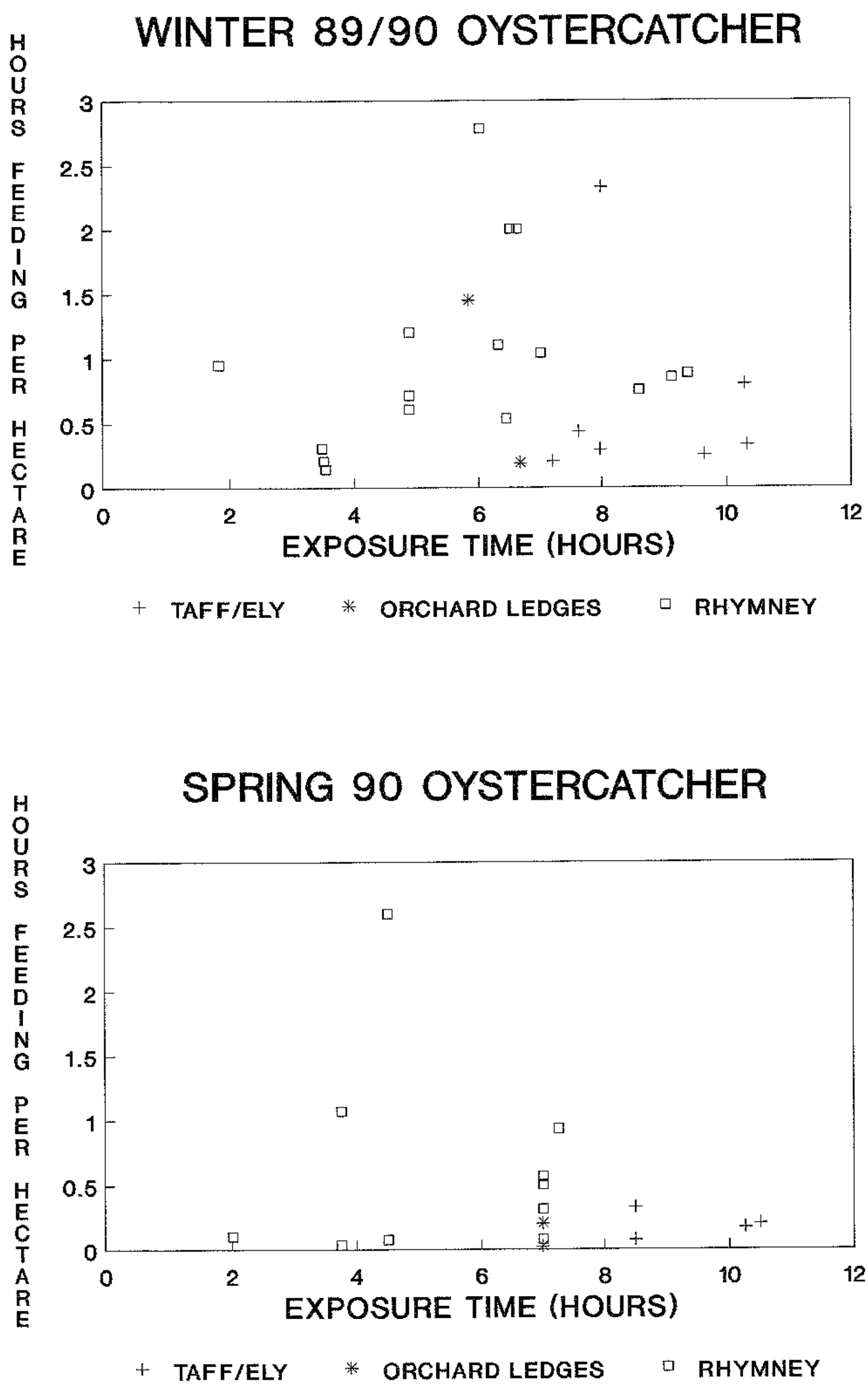


Fig 2.47 A comparison of feeding density with exposure time for Oystercatcher at all day sites, Winter 1989/90 and Spring 1990.

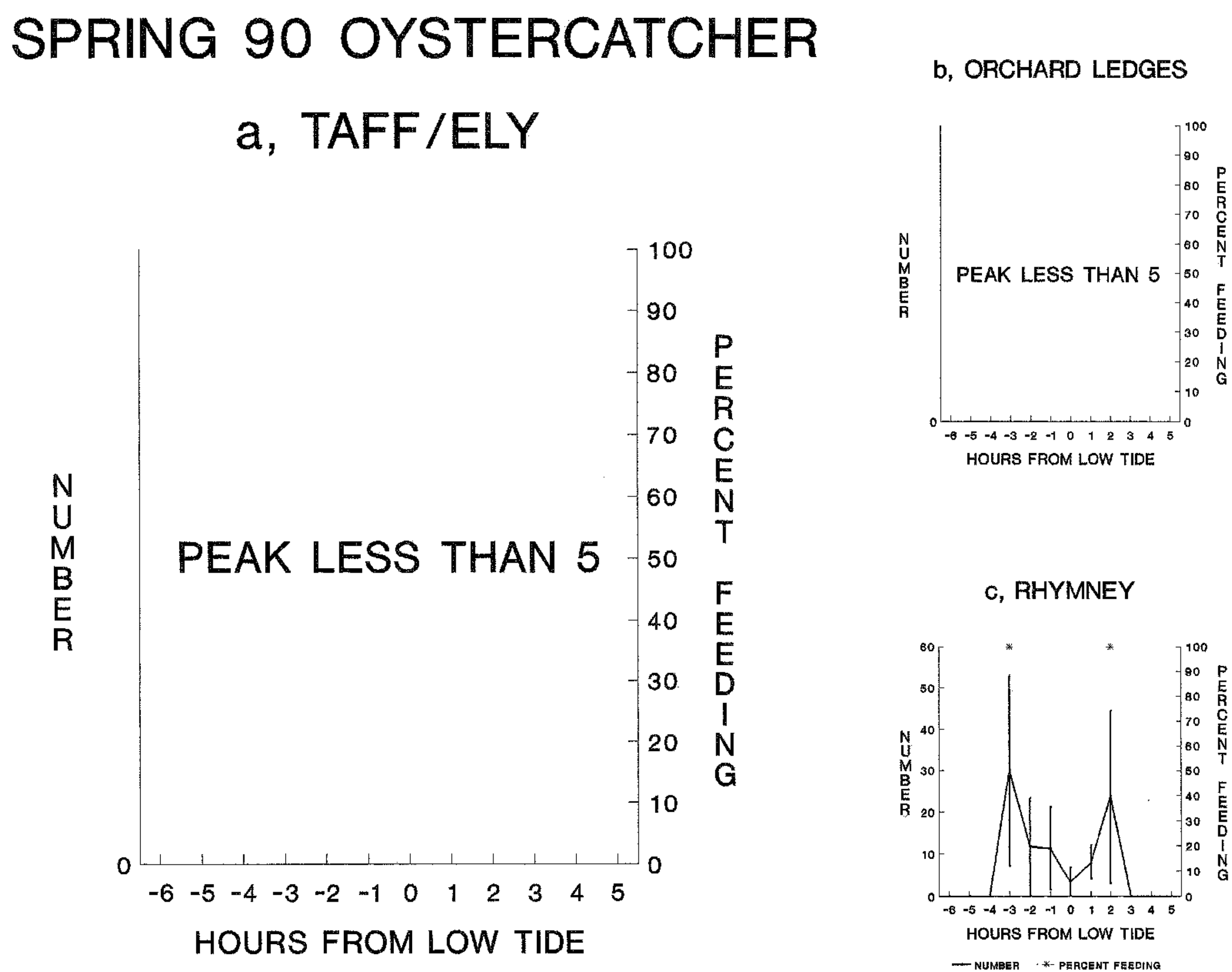


Fig 2.48 The total number of Oystercatcher present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Spring 1990.

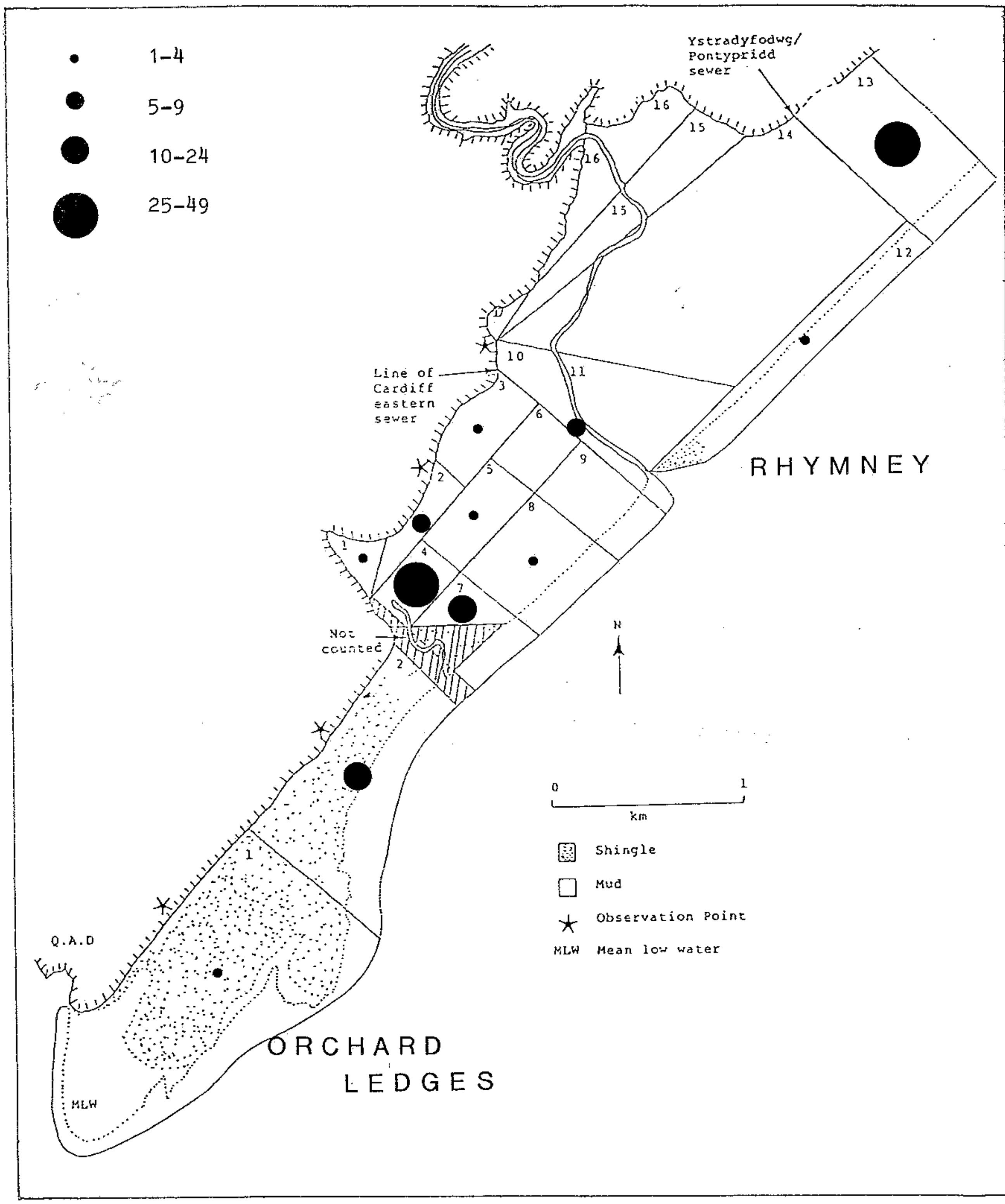


Fig 2.49 The distribution of feeding Oystercatcher at the Rhymney and Orchard Ledges all day sites during Spring 1990. The average number of bird hours per tidal cycle is depicted.

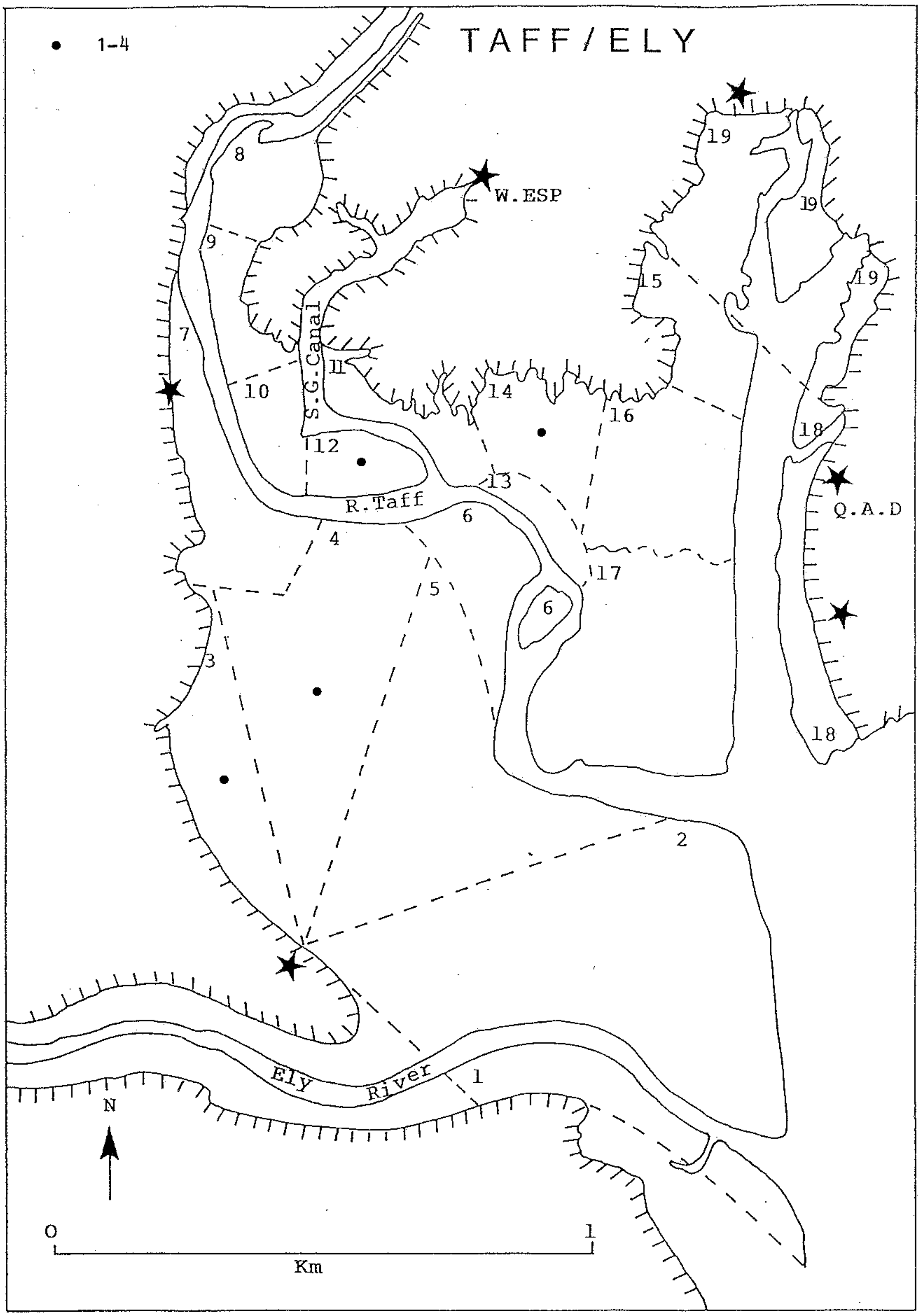


Fig 2.50 The distribution of feeding Oystercatcher in Cardiff Bay during Spring 1990. The average number of bird hours per tidal cycle is depicted.

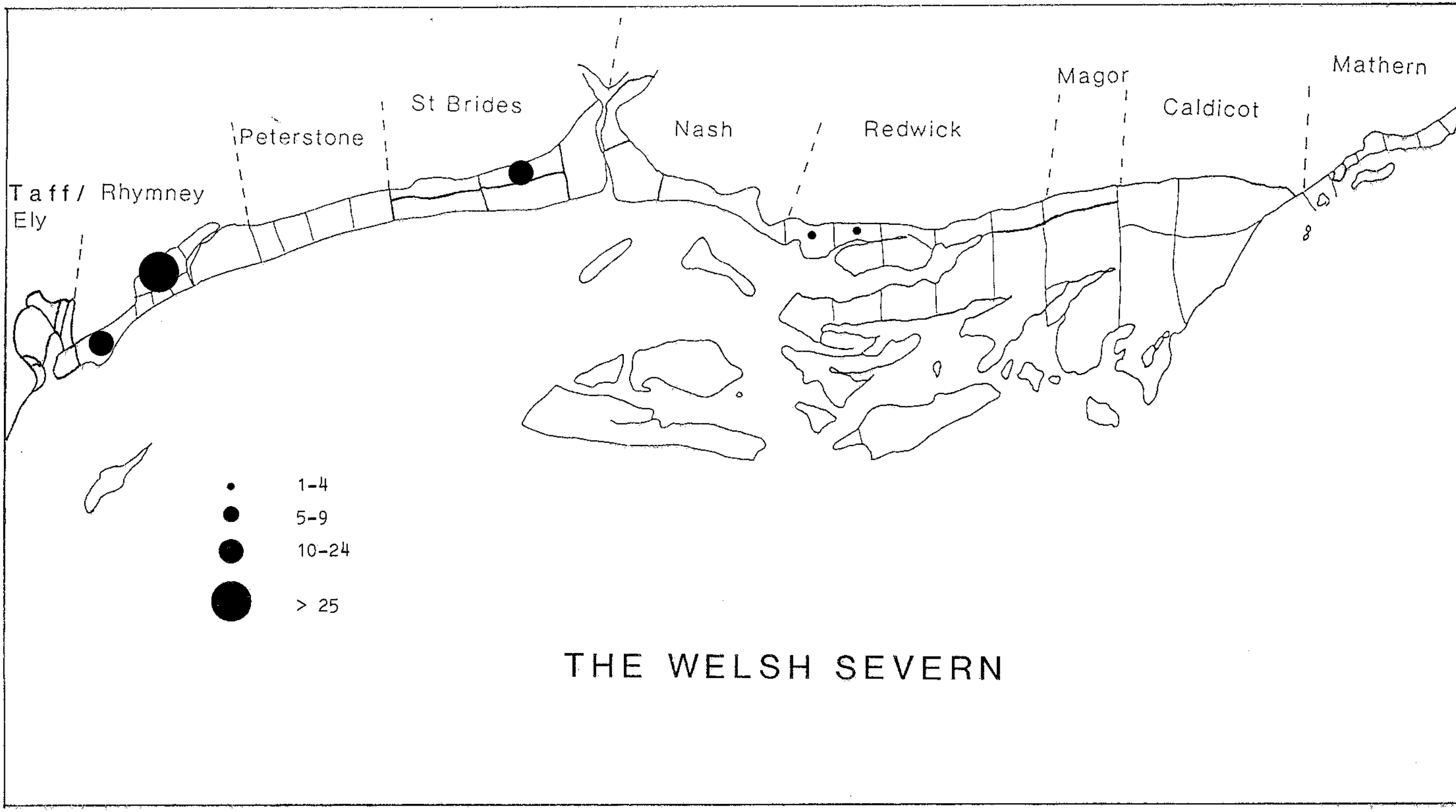


Fig 2.51 The distribution of feeding Ringed Plover at low tide on the Welsh Severn during Winter 1989/90.

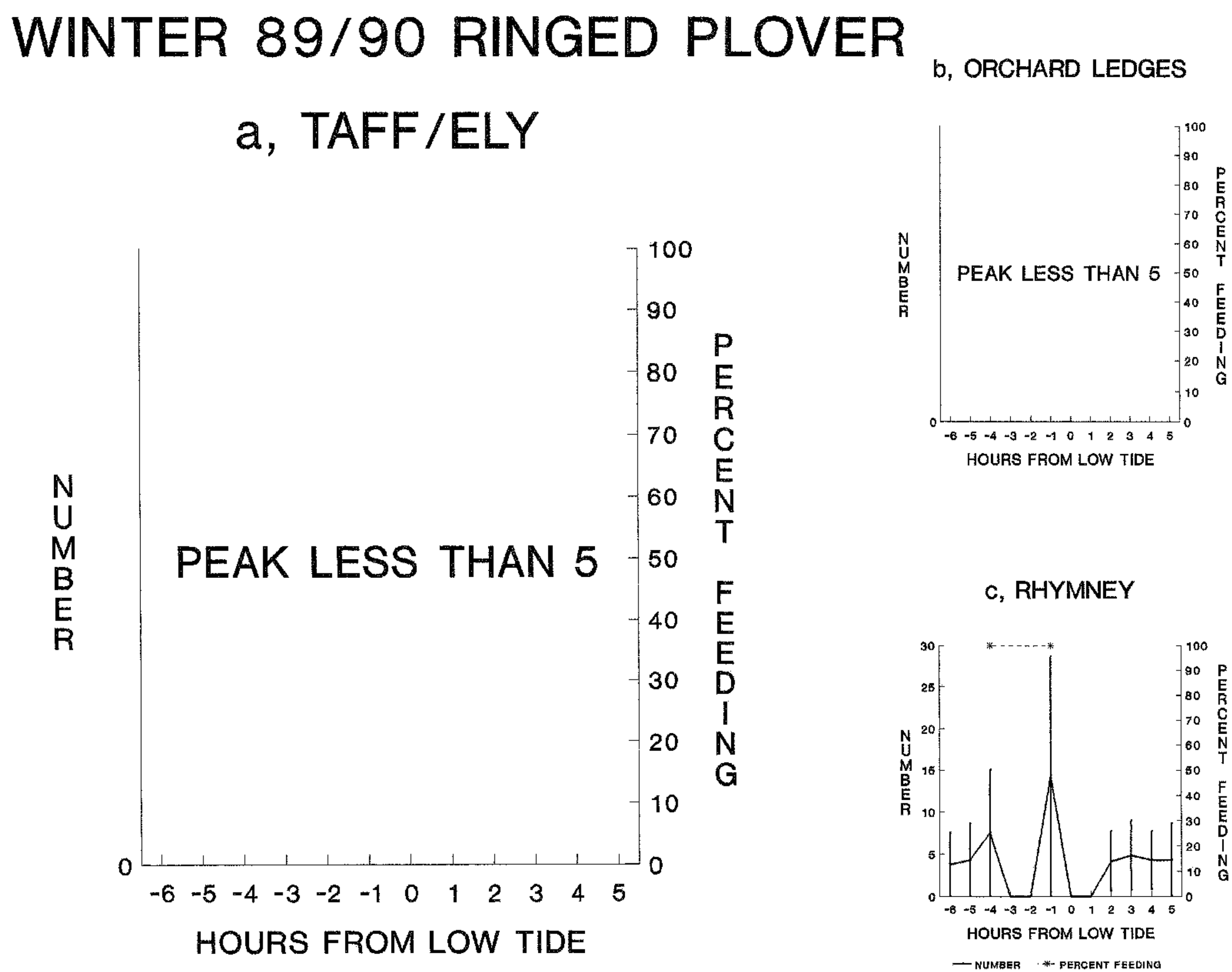


Fig 2.52 The total number of Ringed Plover present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

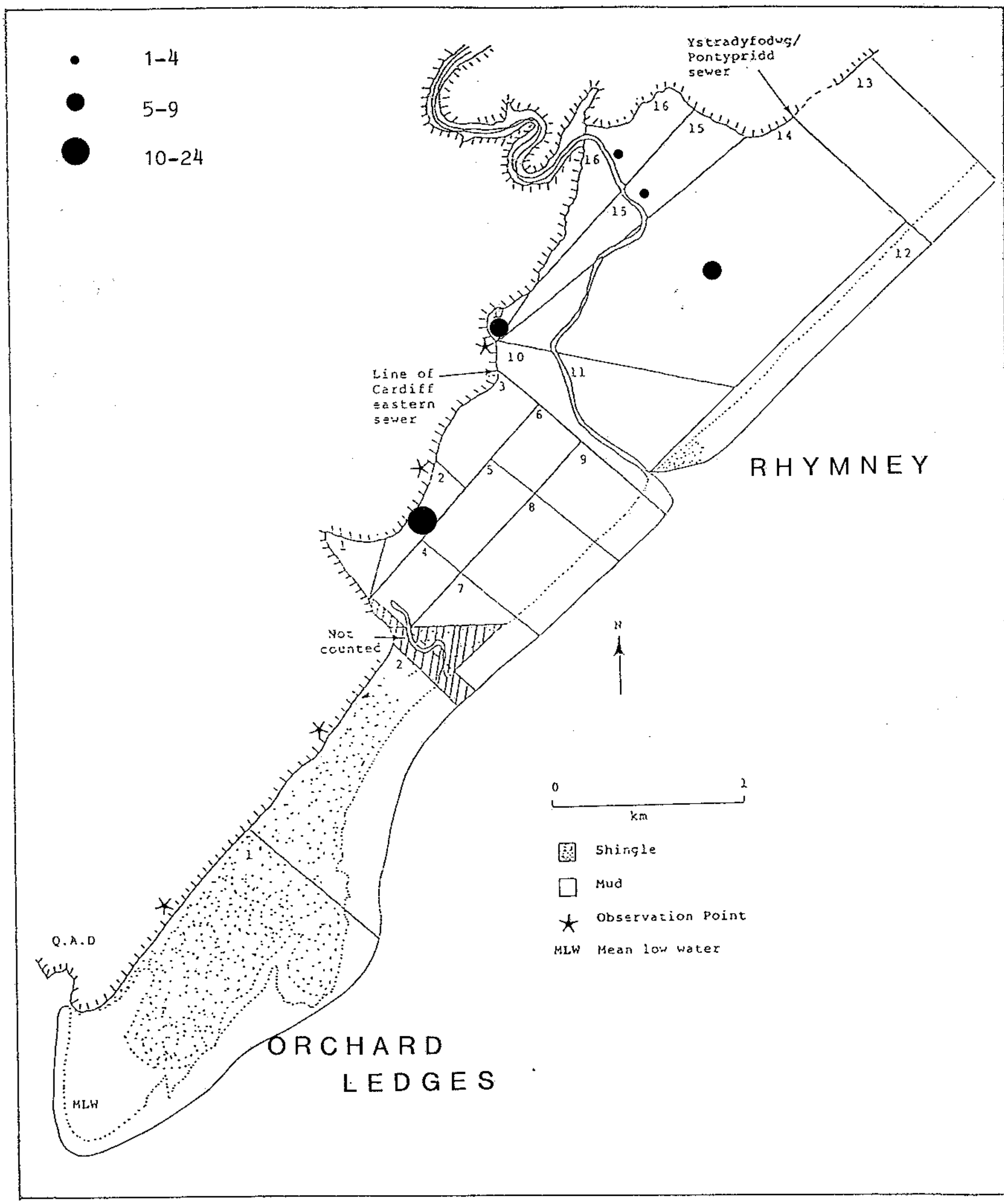


Fig 2.53 The distribution of feeding Ringed Plover at the Rhymney and Orchard Ledges all day sites during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

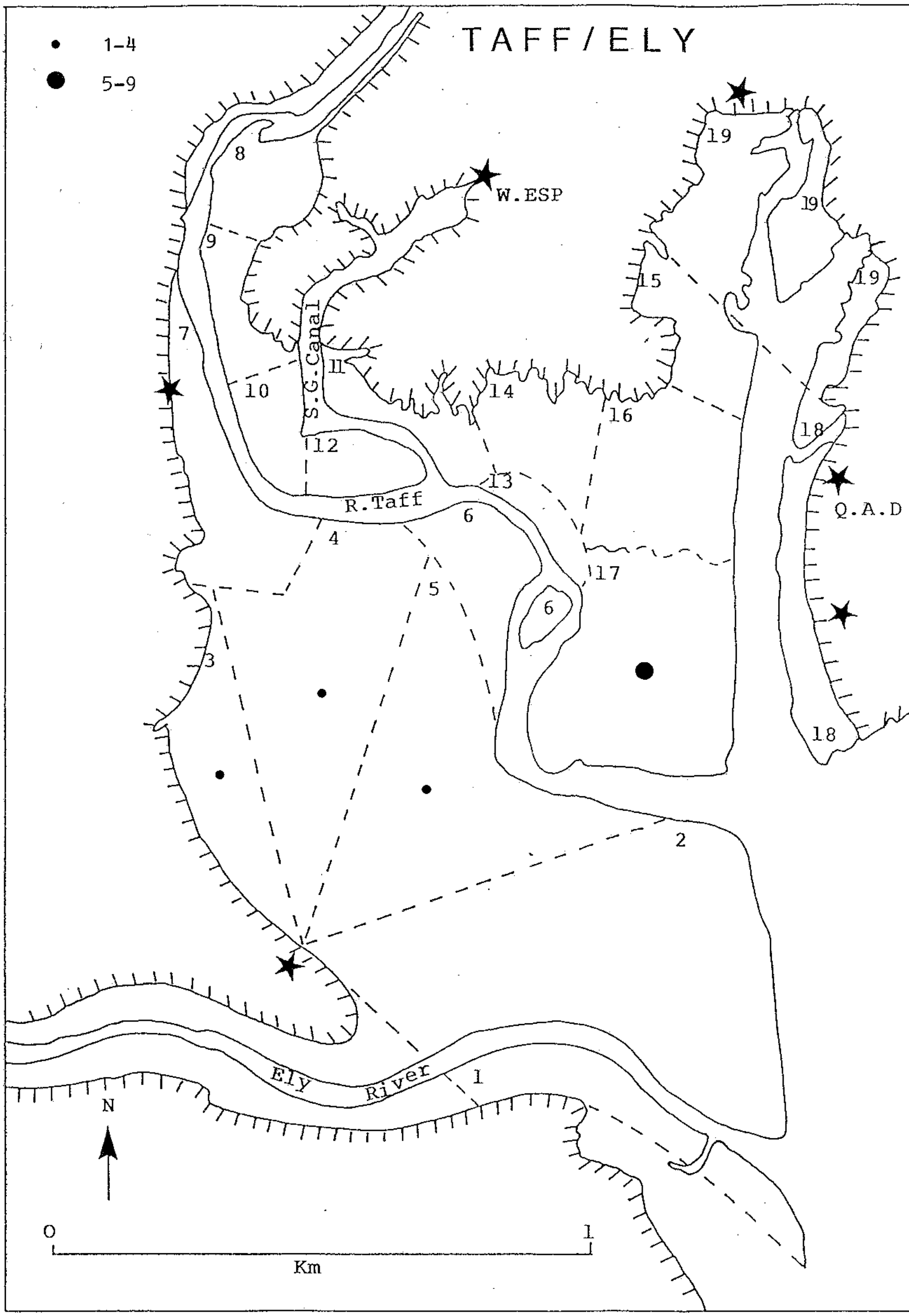


Fig 2.54 The distribution of feeding Ringed Plover in Cardiff Bay during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

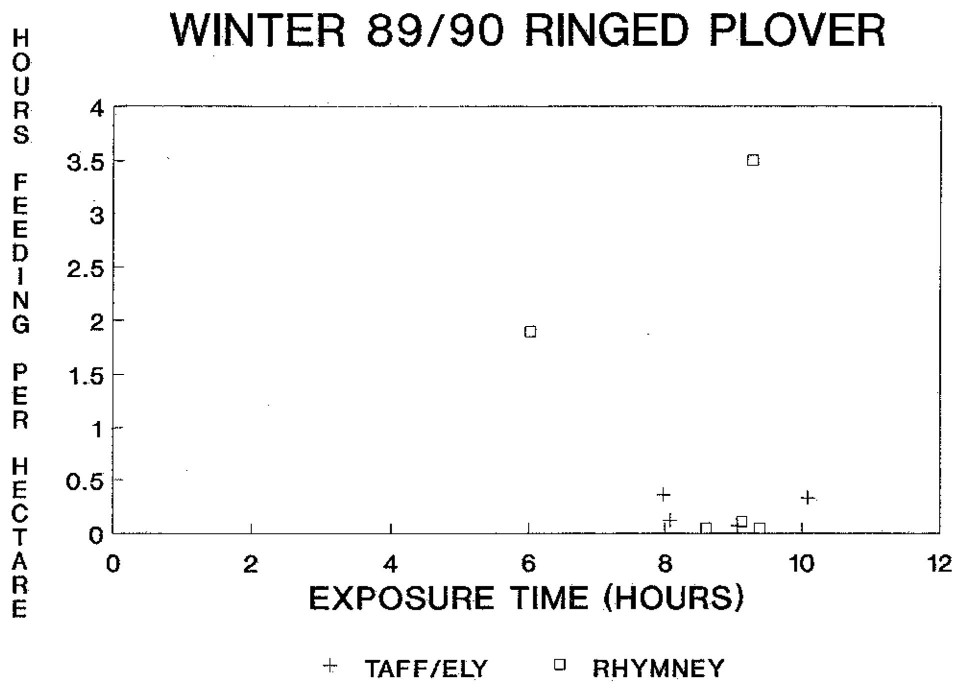


Fig 2.55 A comparison of feeding density with exposure time for Ringed Plover at all day sites, Winter 1989/90.

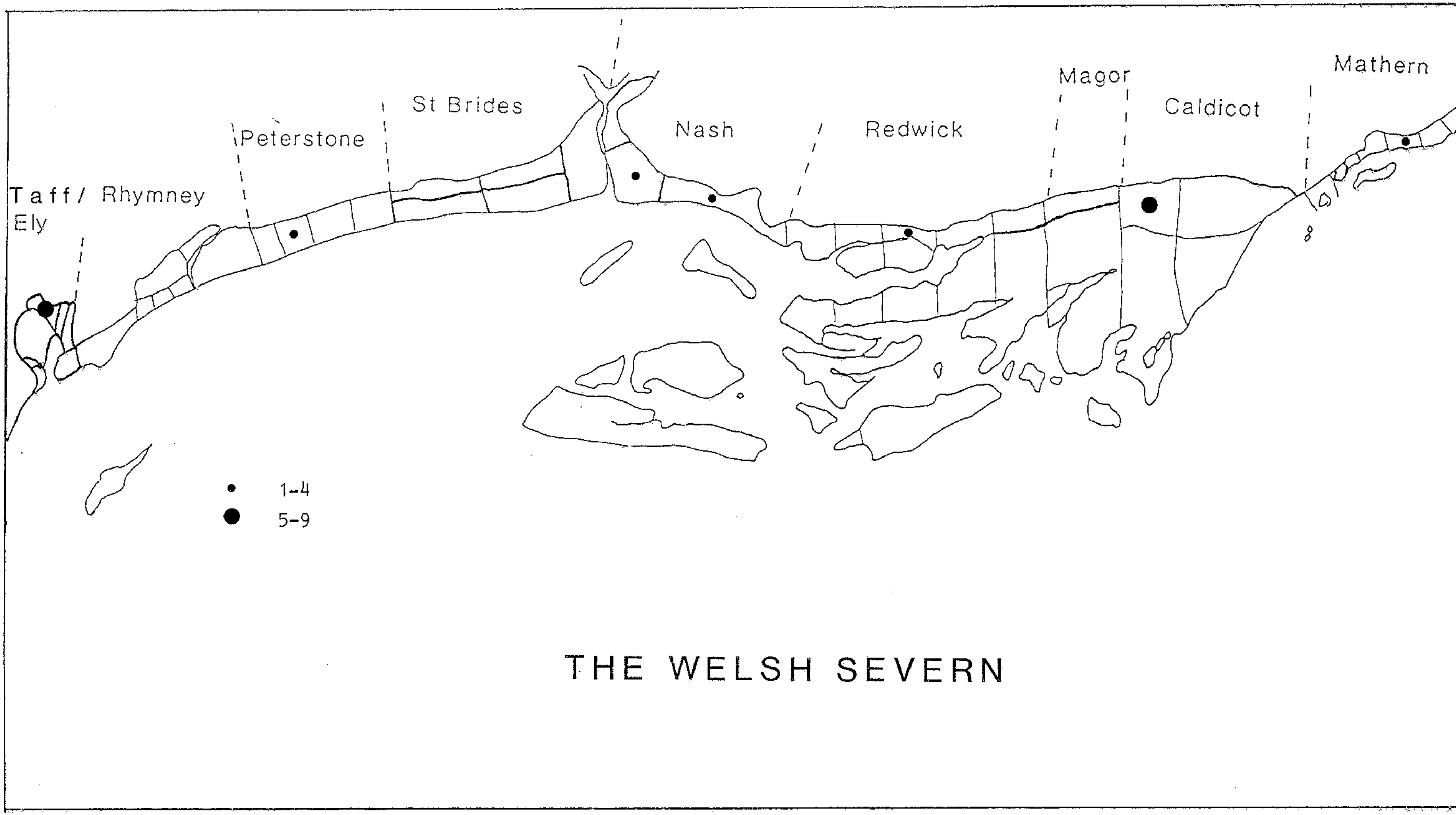


Fig 2.56 The distribution of feeding Grey Plover at low tide on the Welsh Severn during Winter 1989/90.

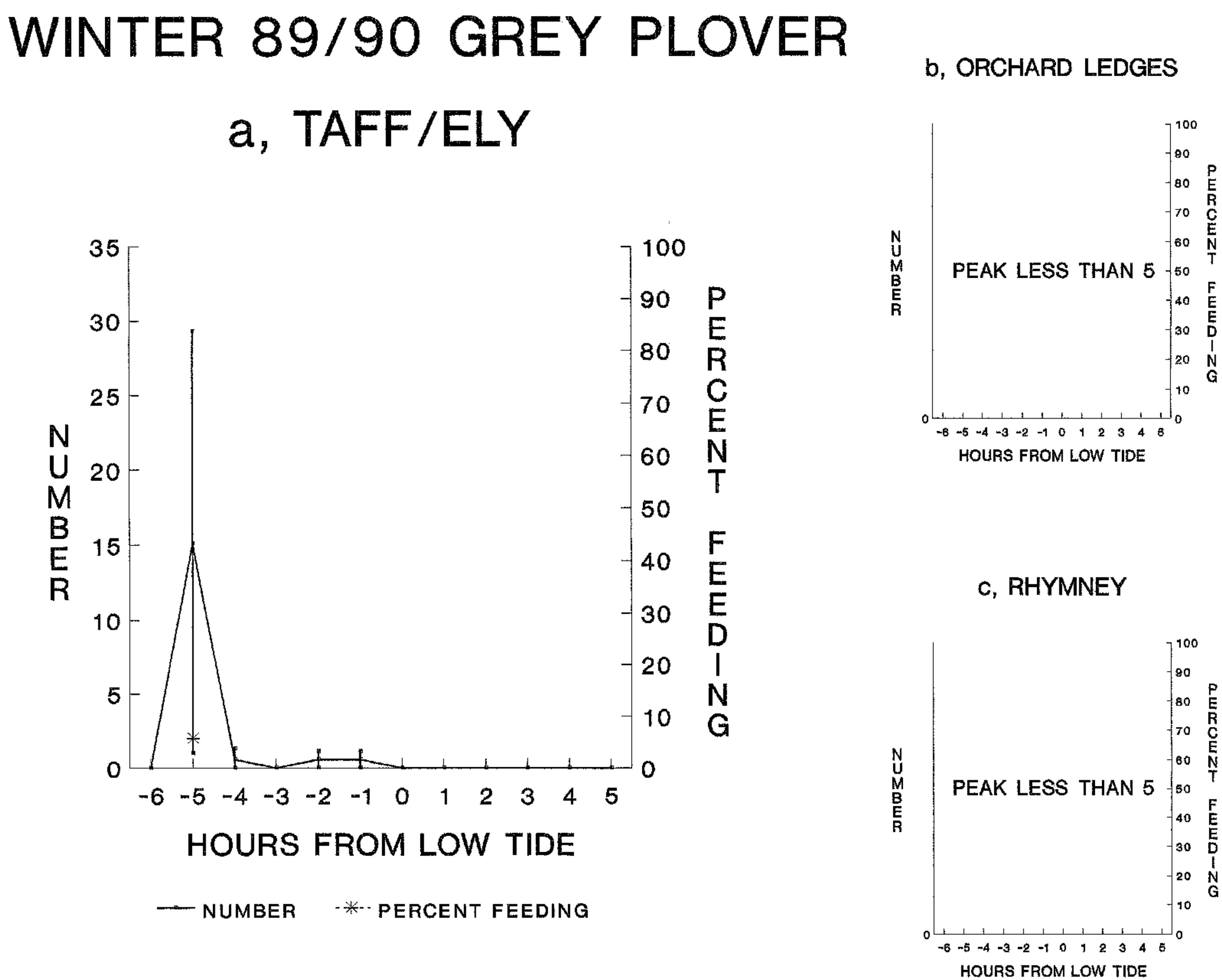


Fig 2.57 The total number of Grey Plover present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

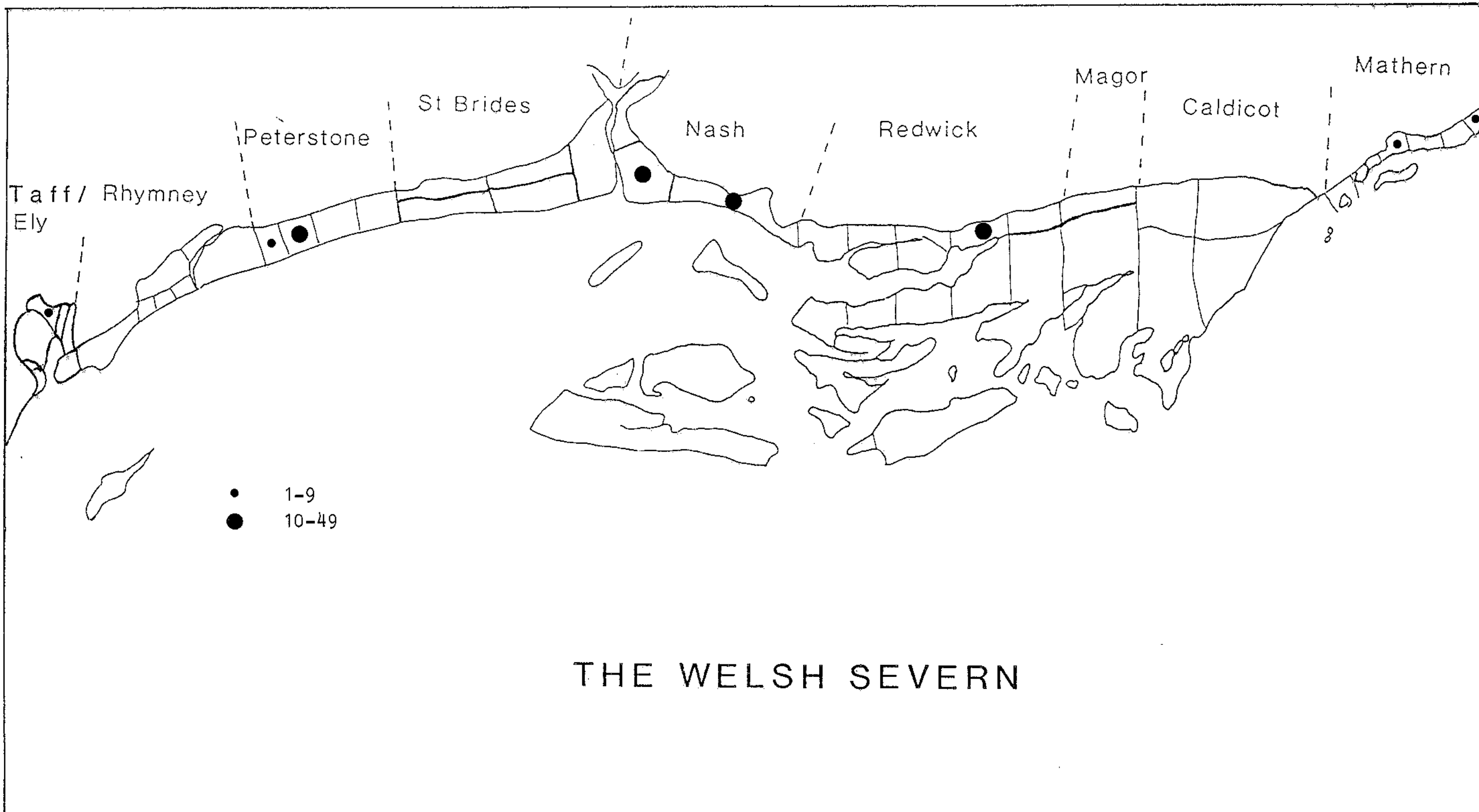


Fig 2.58 The distribution of feeding Lapwing at low tide on the Welsh Severn during Winter 1989/90.

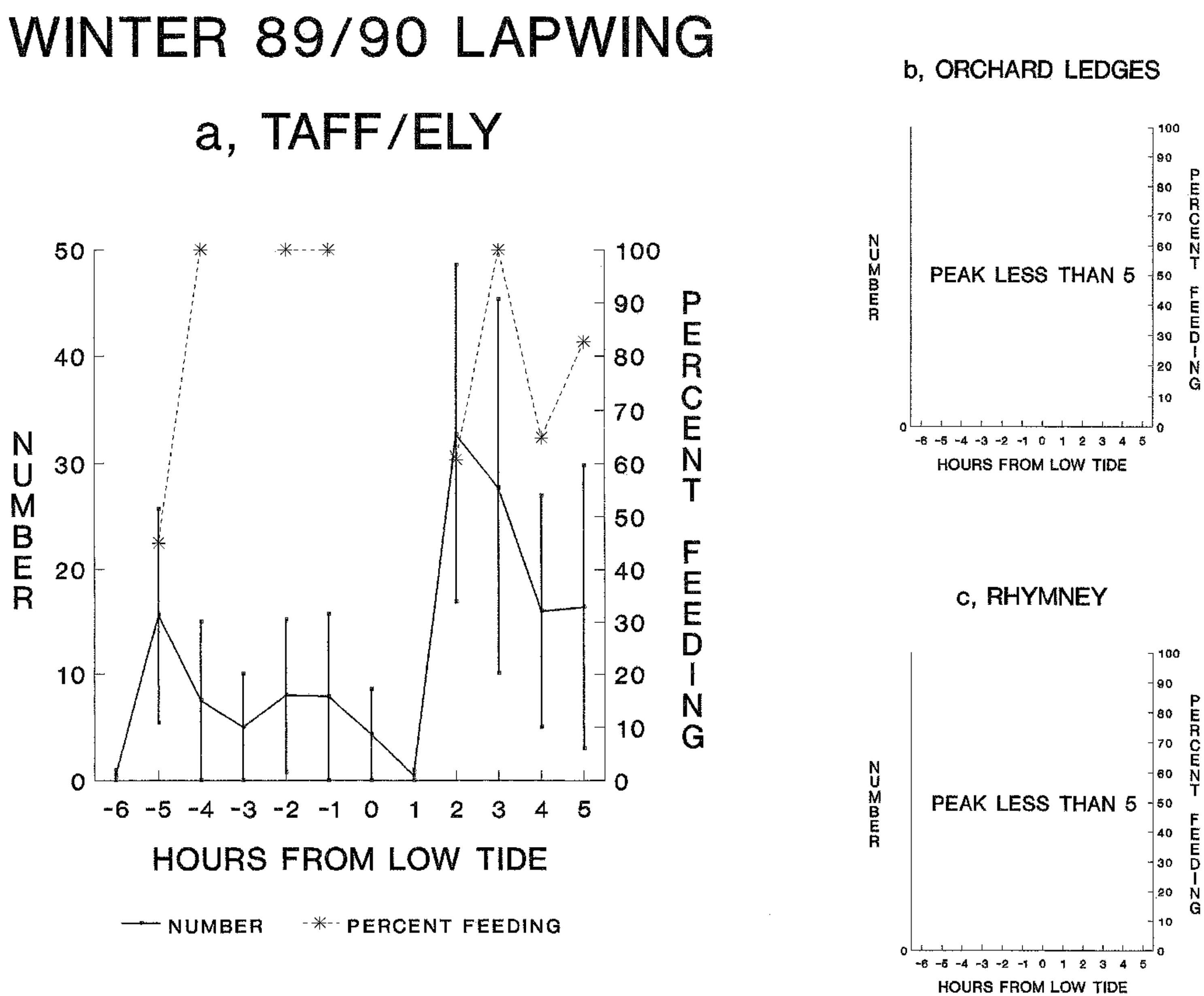


Fig 2.59 The total number of Lapwing present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

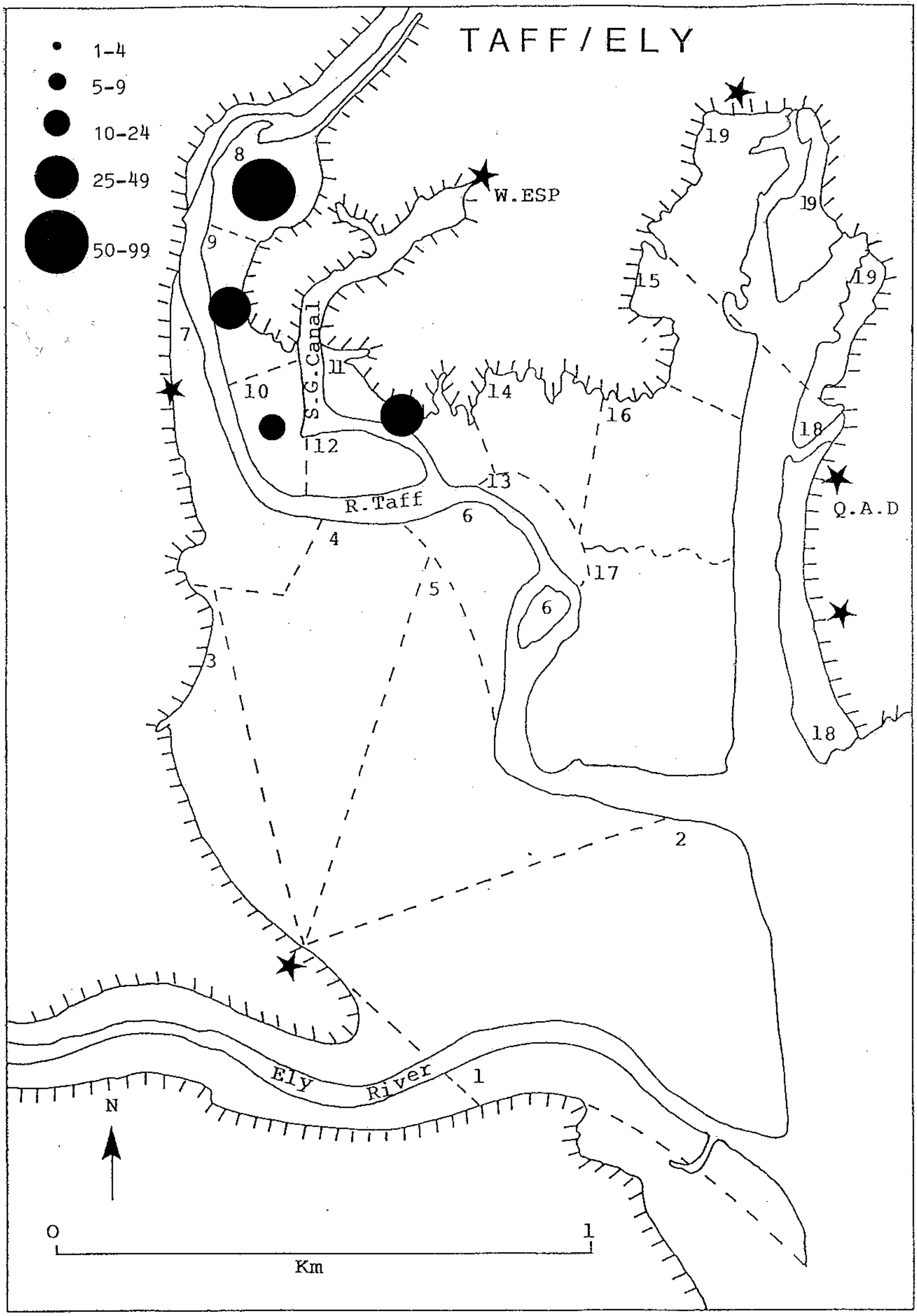


Fig 2.60 The distribution of feeding Lapwing in Cardiff Bay during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

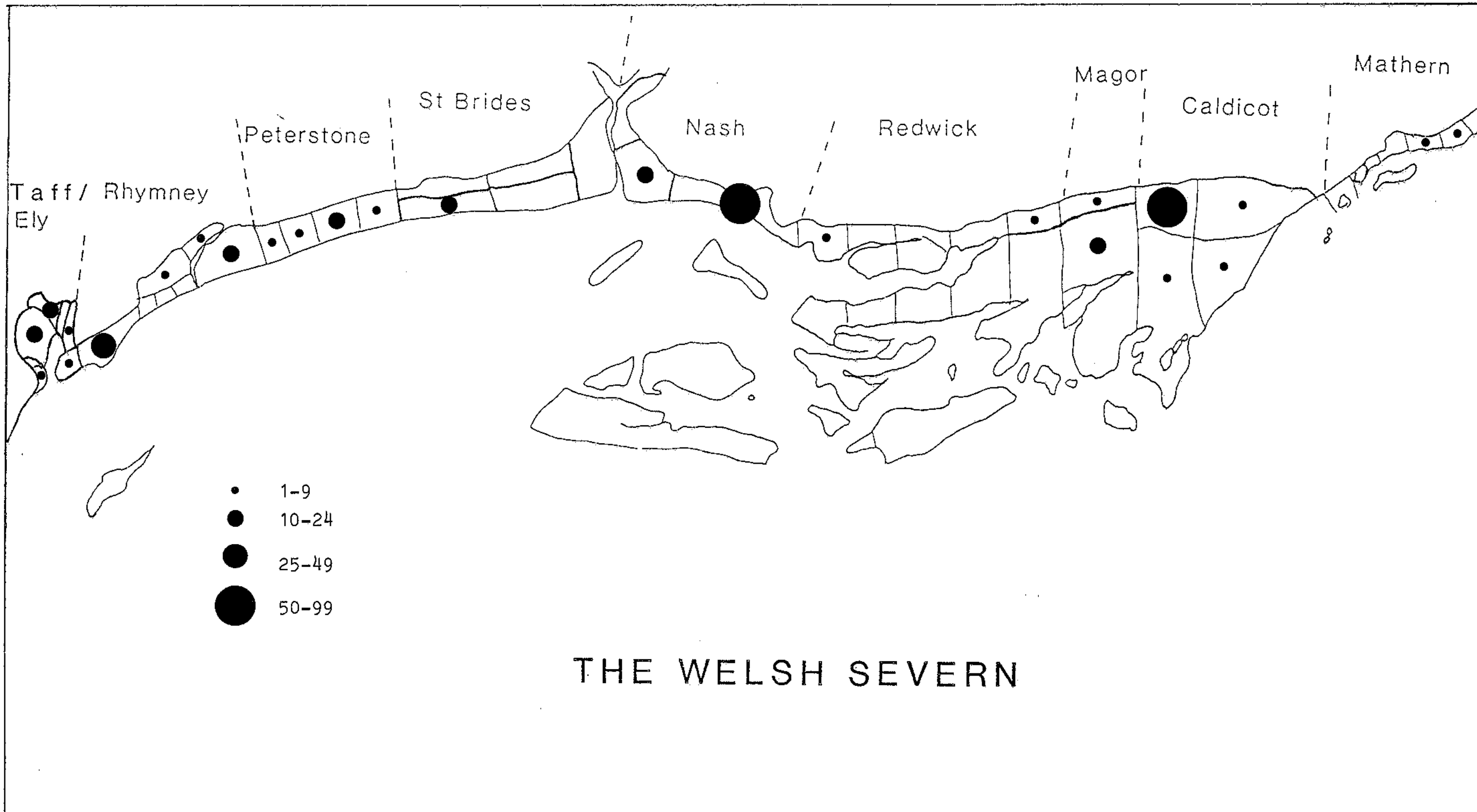


Fig 2.61 The distribution of feeding Curlew at low tide on the Welsh Severn during Winter 1989/90.

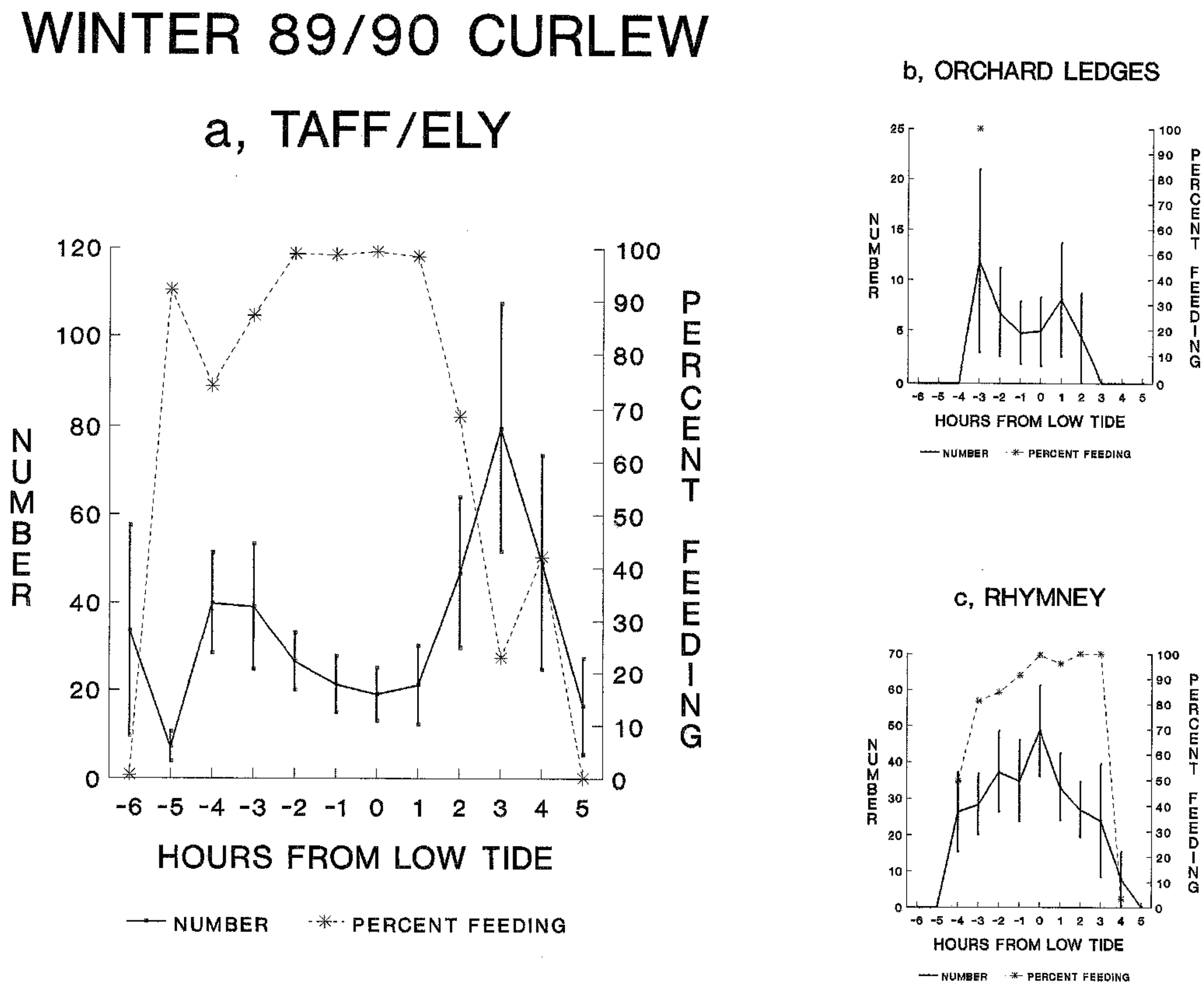


Fig 2.62 The total number of Curlew present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

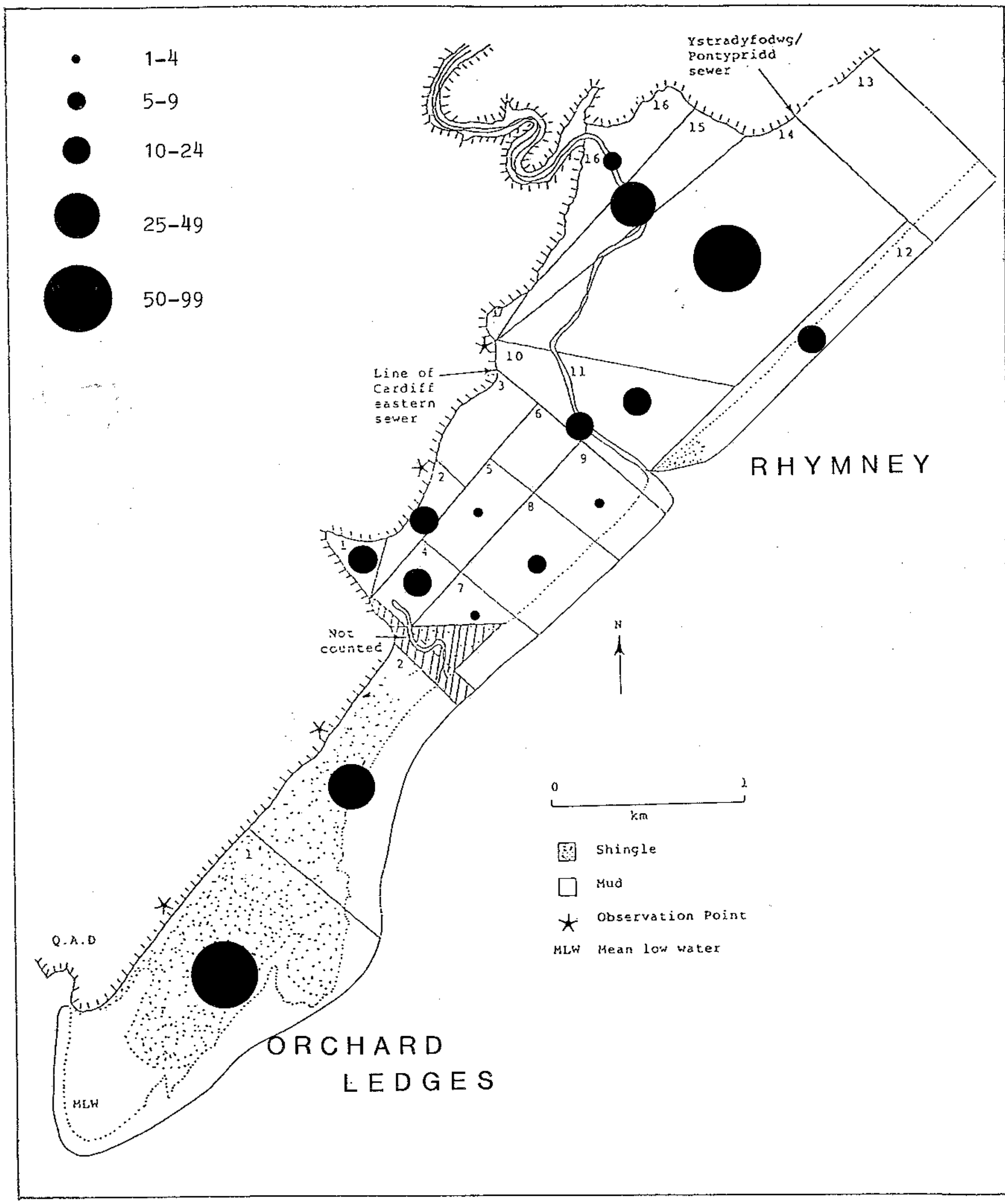


Fig 2.63 The distribution of feeding Curlew at the Rhymney and Orchard Ledges all day sites during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

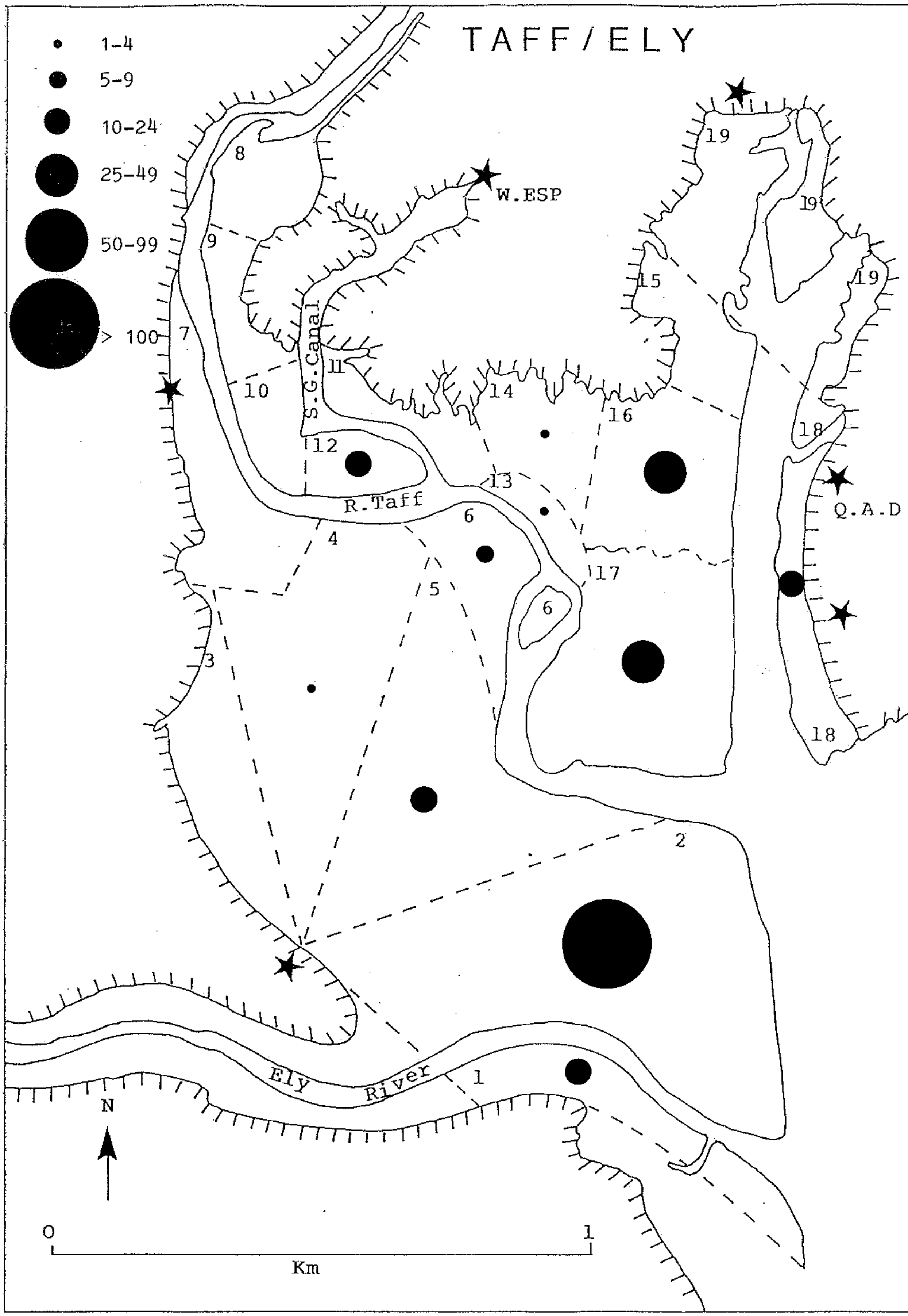
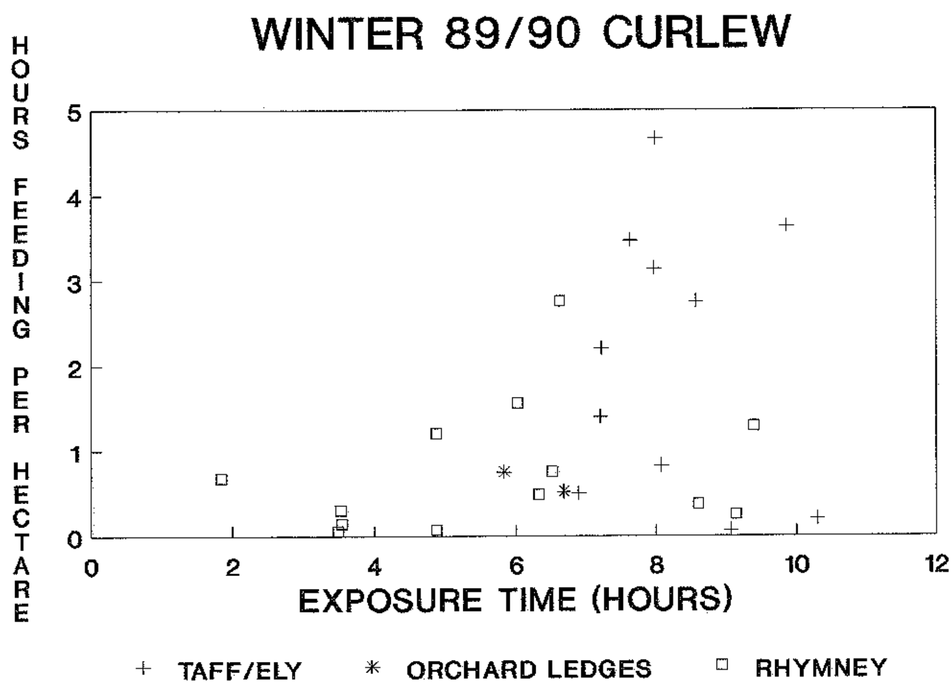


Fig 2.64 The distribution of feeding Curlew in Cardiff Bay during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.



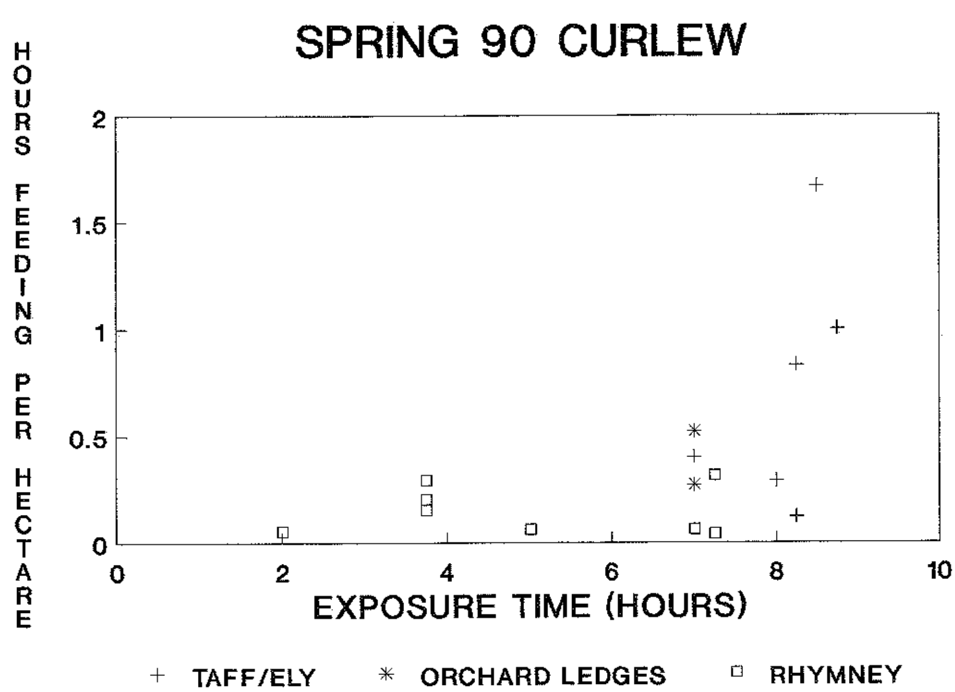


Fig 2.65 A comparison of feeding density with exposure time for Curlew at all day sites, Winter 1989/90 and Spring 1990.

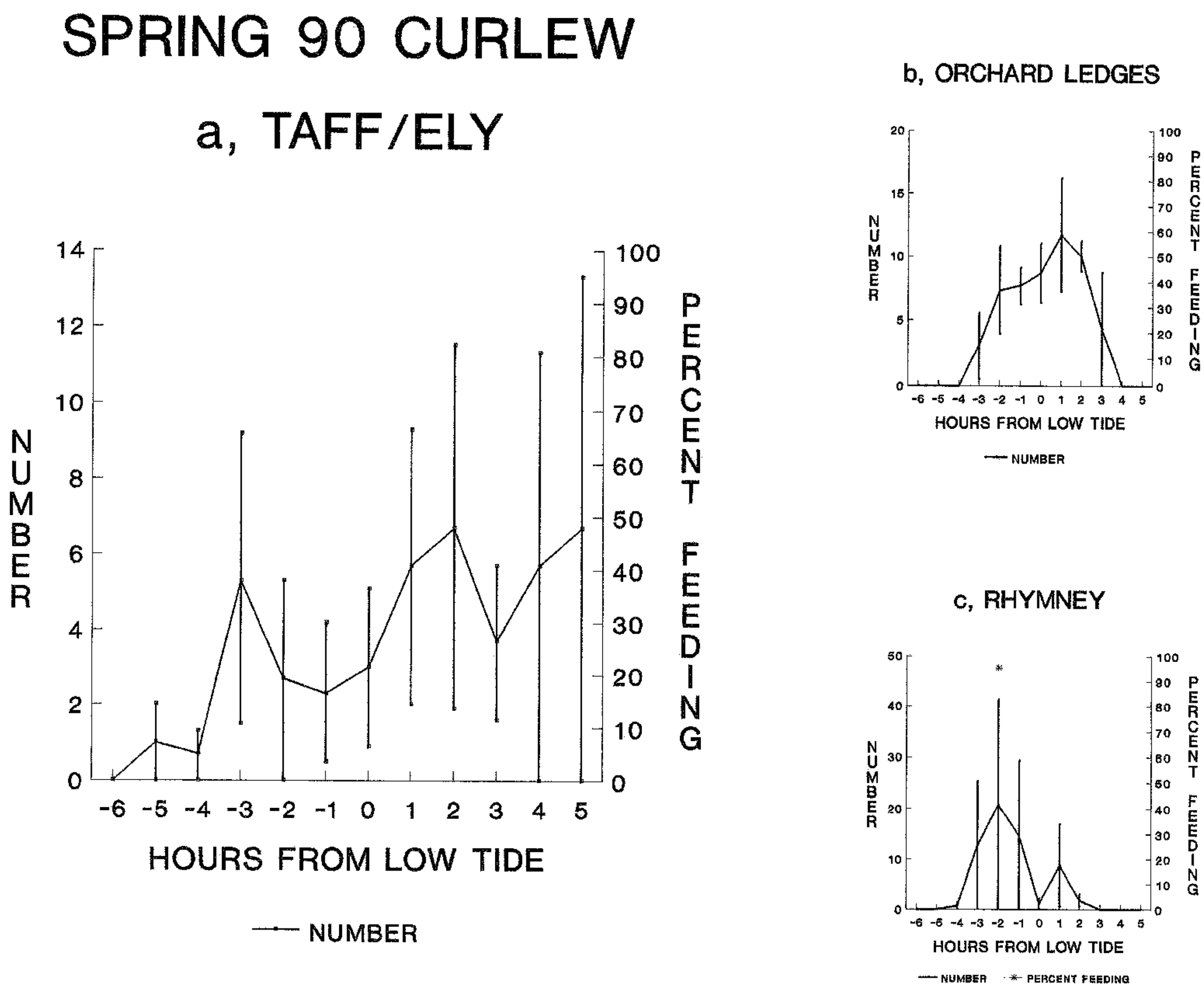


Fig 2.66 The total number of Curlew present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Spring 1990.

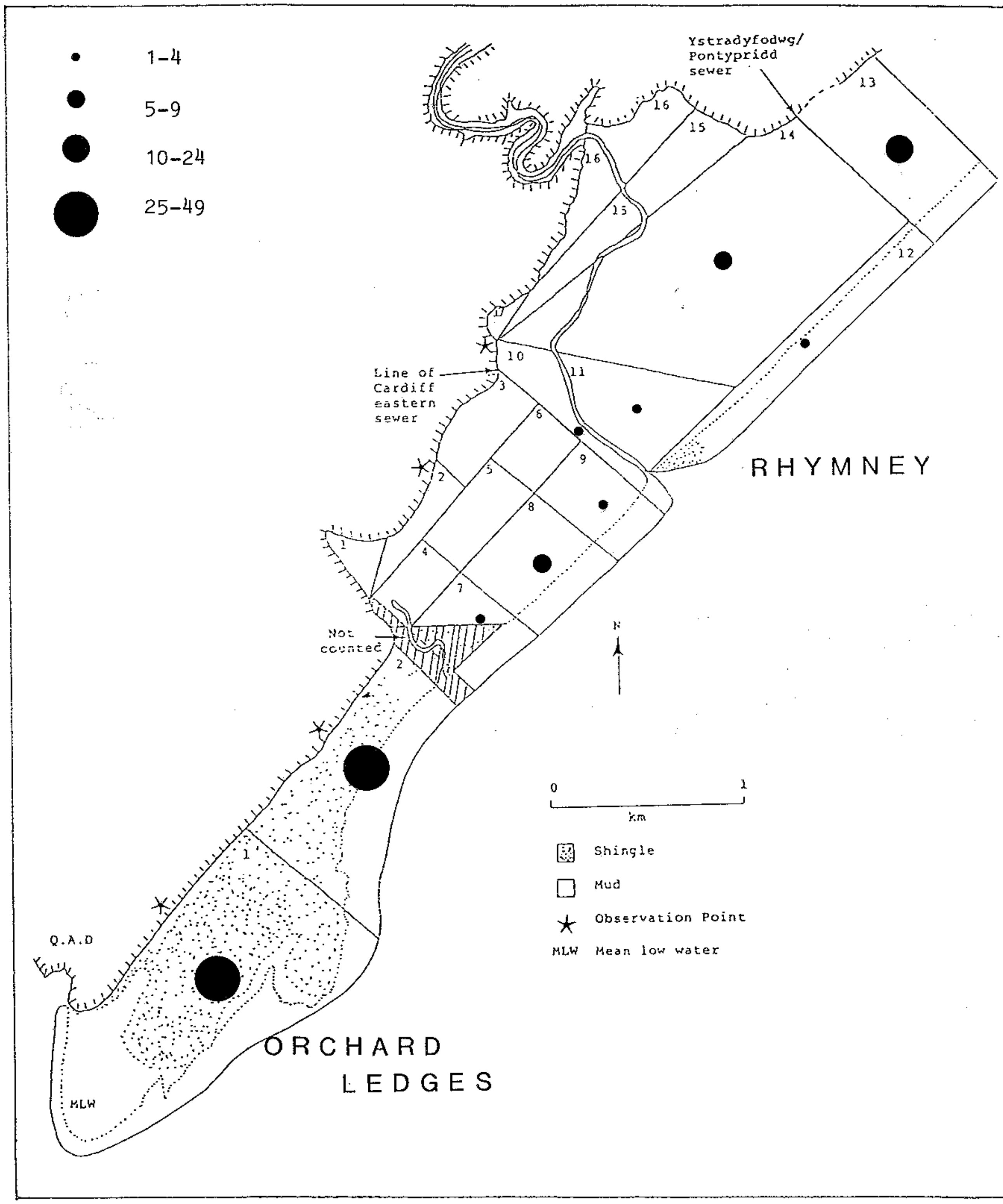


Fig 2.67 The distribution of feeding Curlew at the Rhymney and Orchard Ledges all day sites during Spring 1989/90. The average number of bird hours per tidal cycle is depicted.

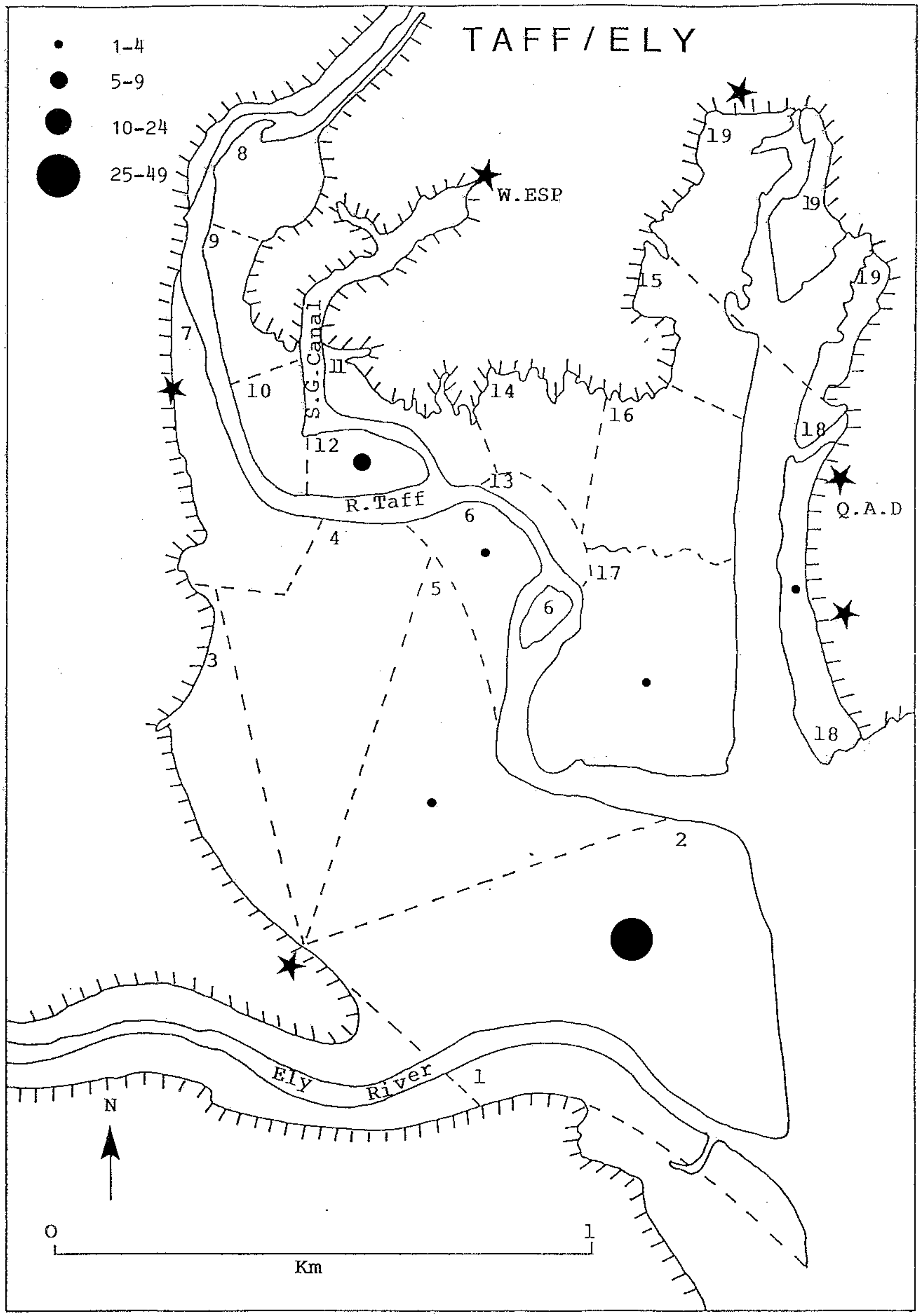


Fig 2.68 The distribution of feeding Curlew in Cardiff Bay during Spring 1990. The average number of bird hours per tidal cycle is depicted.

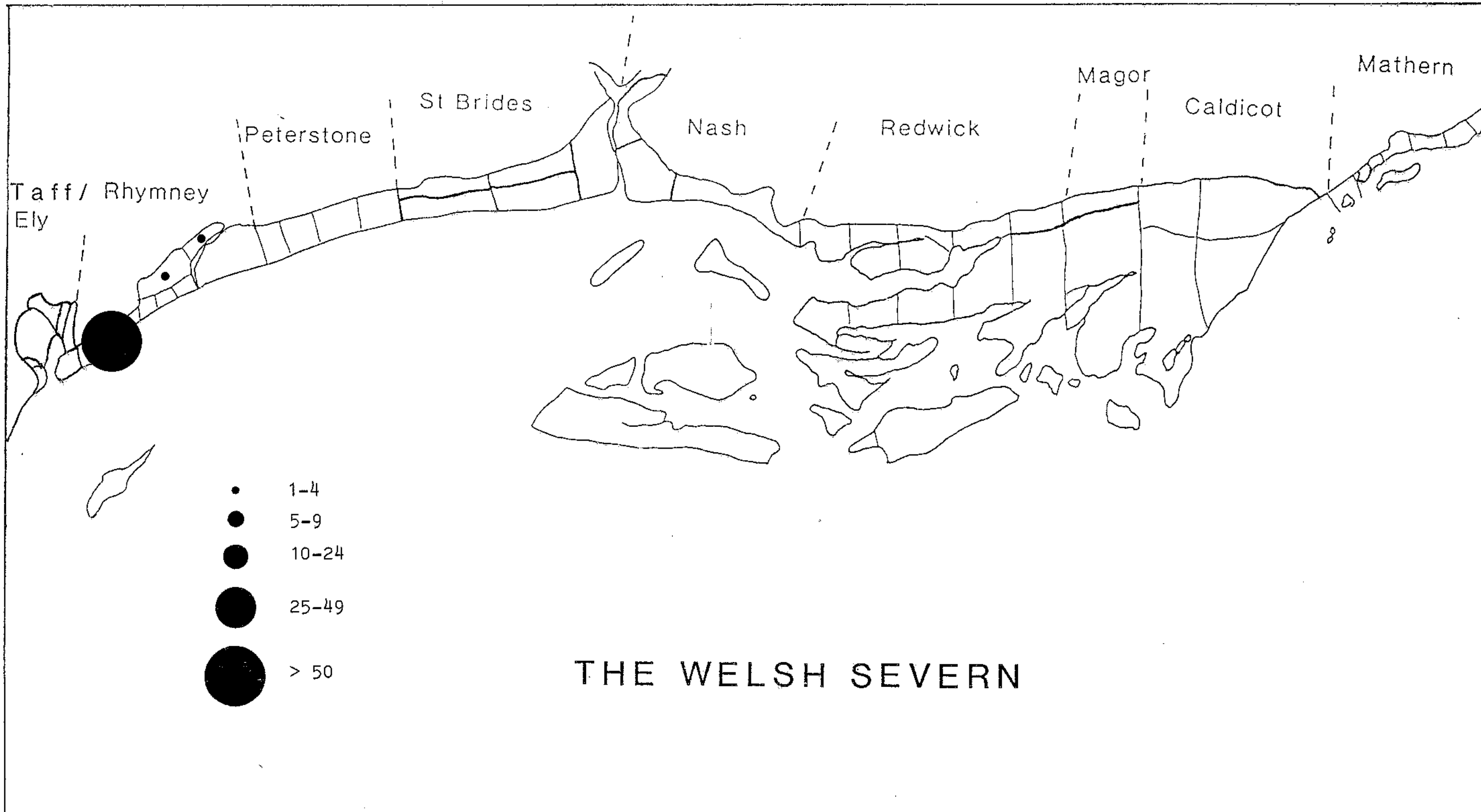


Figure 2.69 The distribution of feeding Turnstone at low tide on the Welsh Severn during Winter 1989/90.

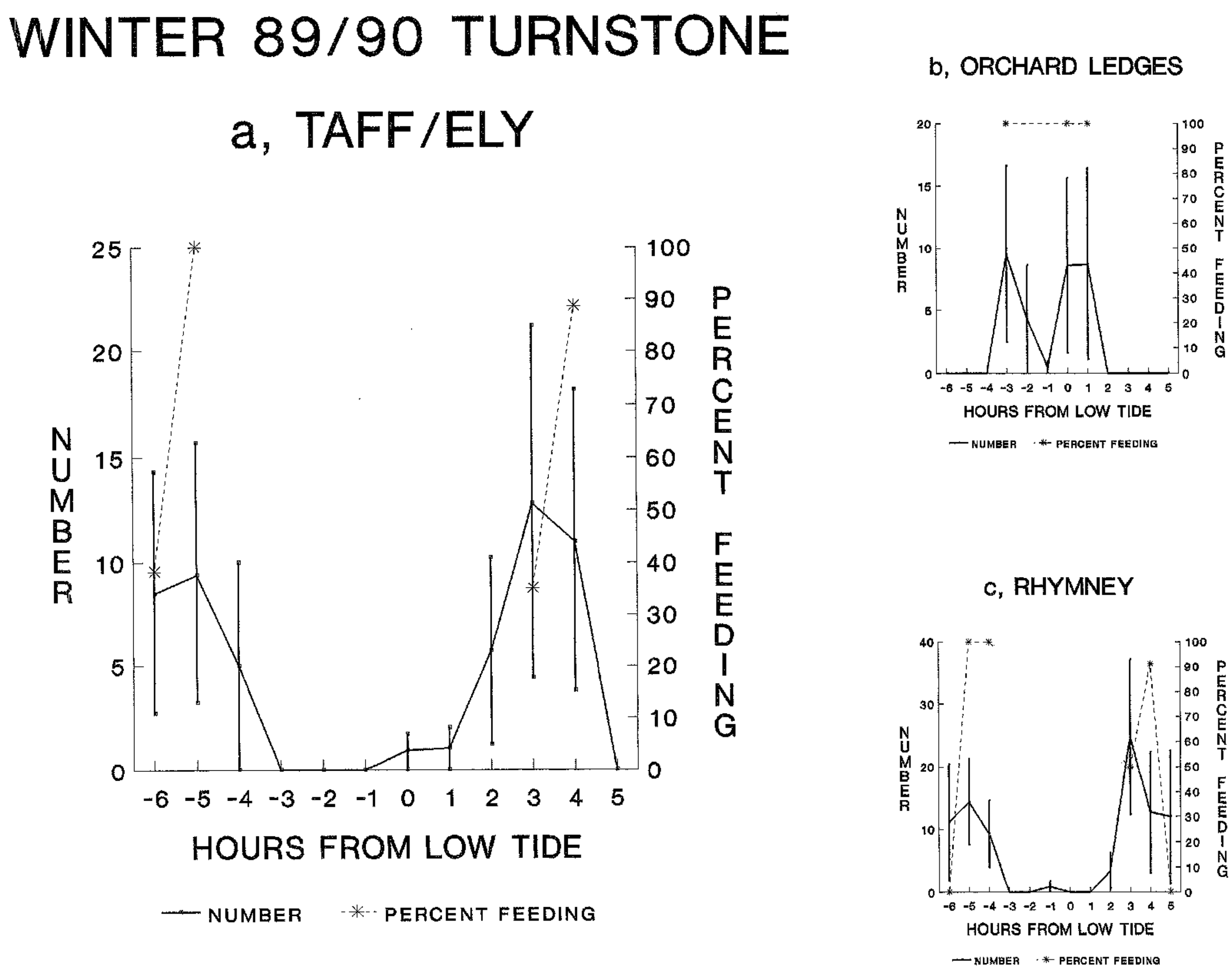


Fig 2.70 The total number of Turnstone present and the percent feeding at each hour of the tidal cycle at the three all day study sites during Winter 1989/90.

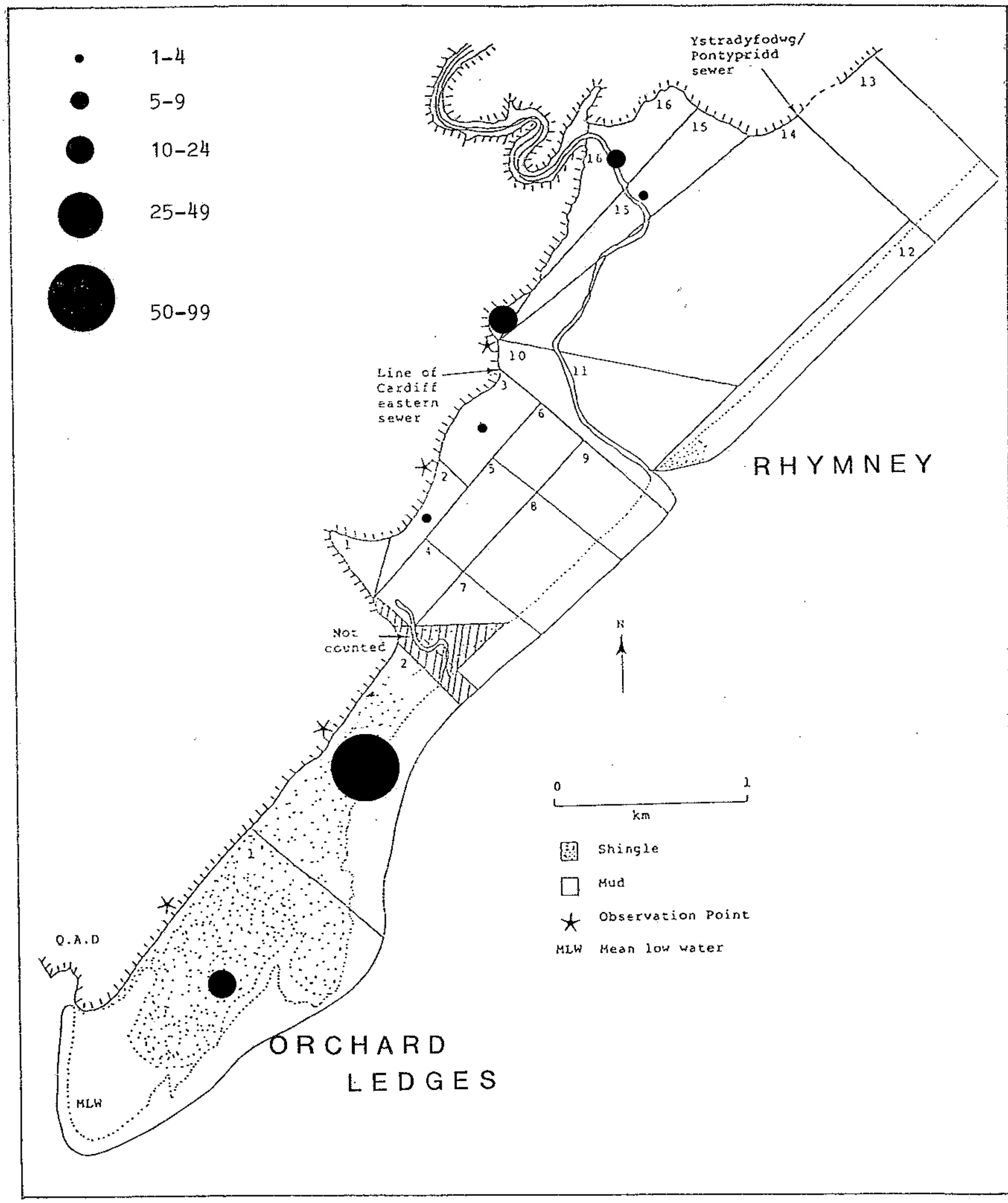


Fig 2.71 The distribution of feeding Turnstone at the Rhymney and Orchard Ledges all day sites during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

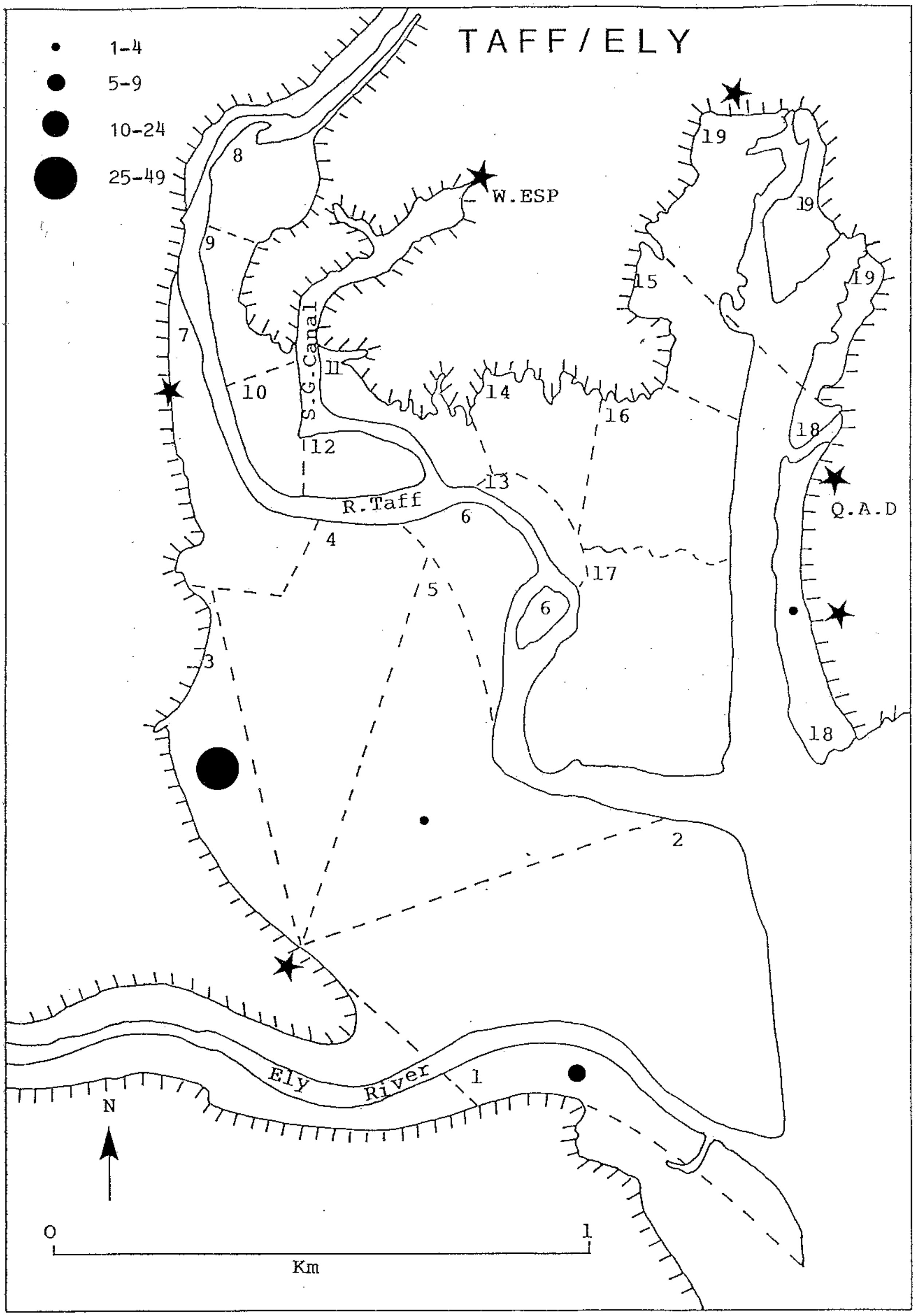


Fig 2.72 The distribution of feeding Turnstone in Cardiff Bay during Winter 1989/90. The average number of bird hours per tidal cycle is depicted.

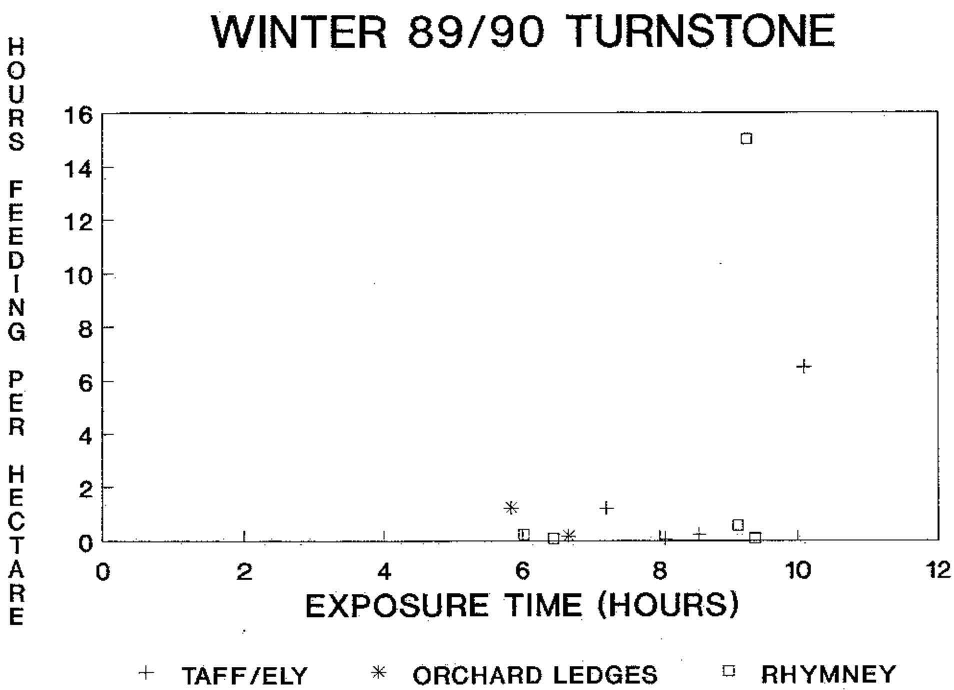
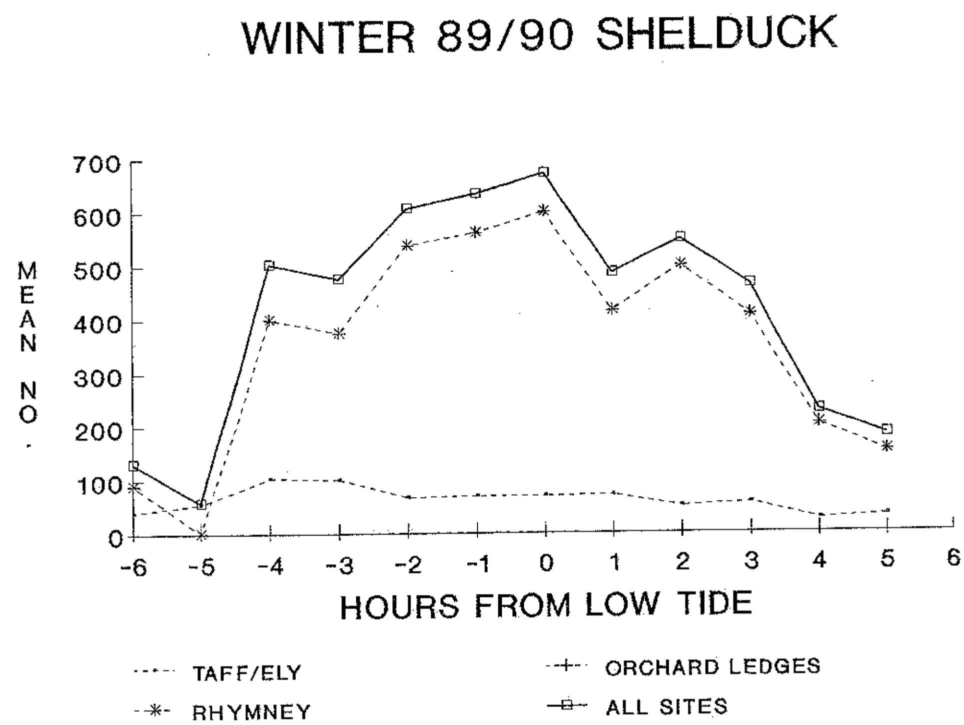


Fig 2.73 A comparison of feeding density with exposure time for Turnstone at all day sites, Winter 1989/90.



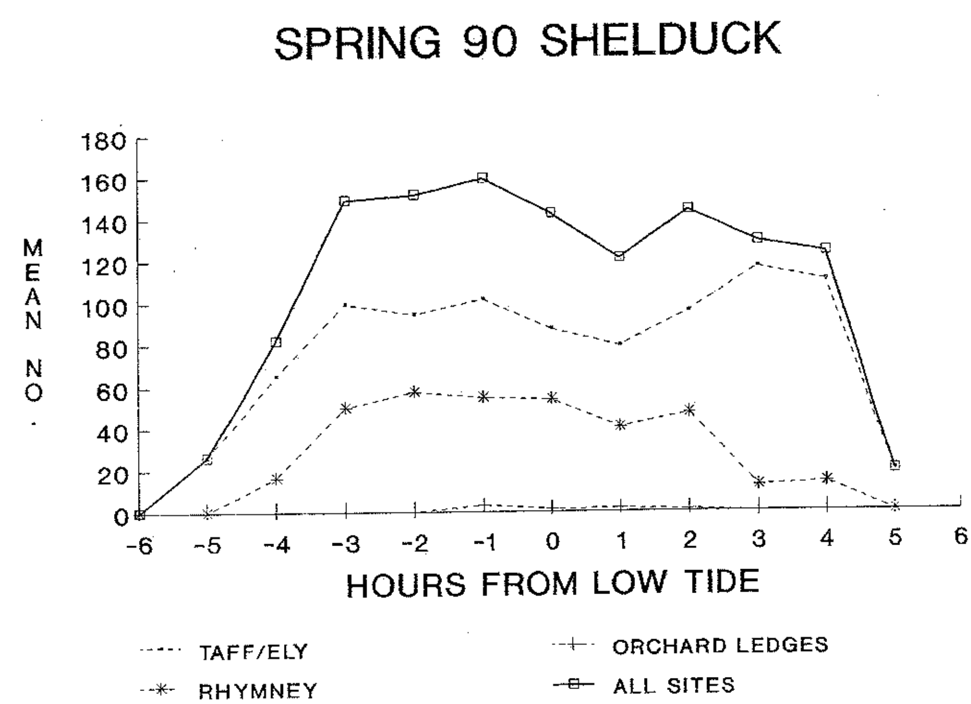


Figure 3.1 The total number of Shelduck within the three study sites and within the whole study area throughout the tidal cycle.

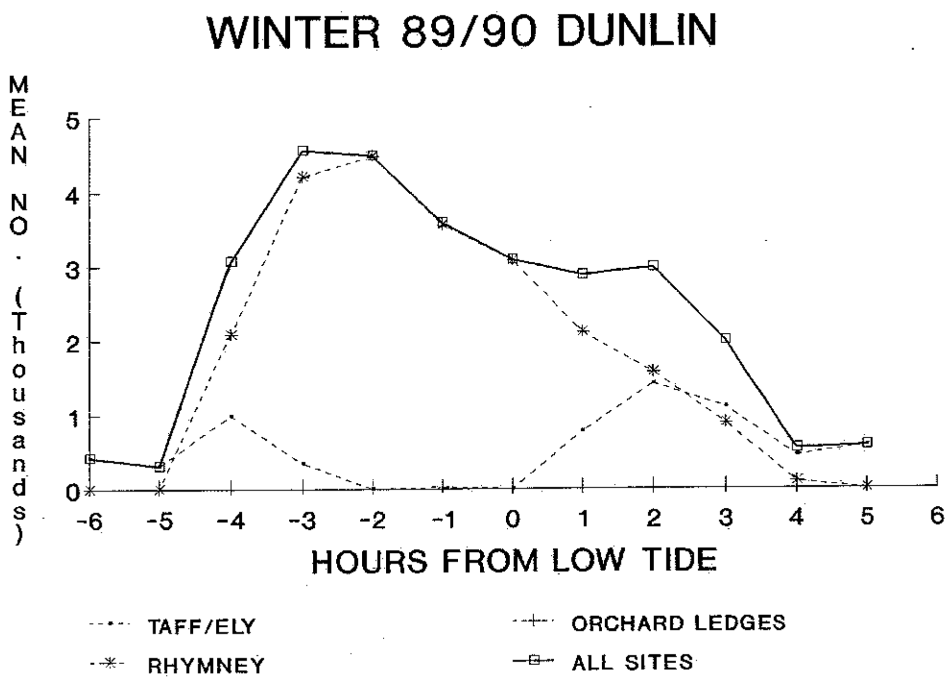
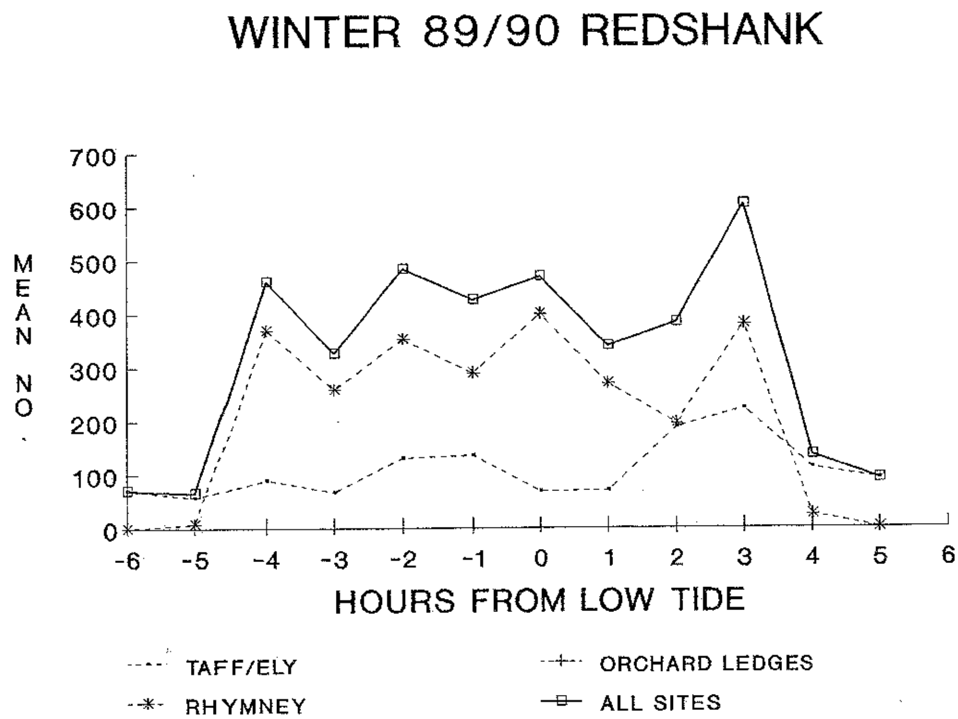


Figure 3.2 The total number of Dunlin within the three study sites and within the whole study area throughout the tidal cycle.



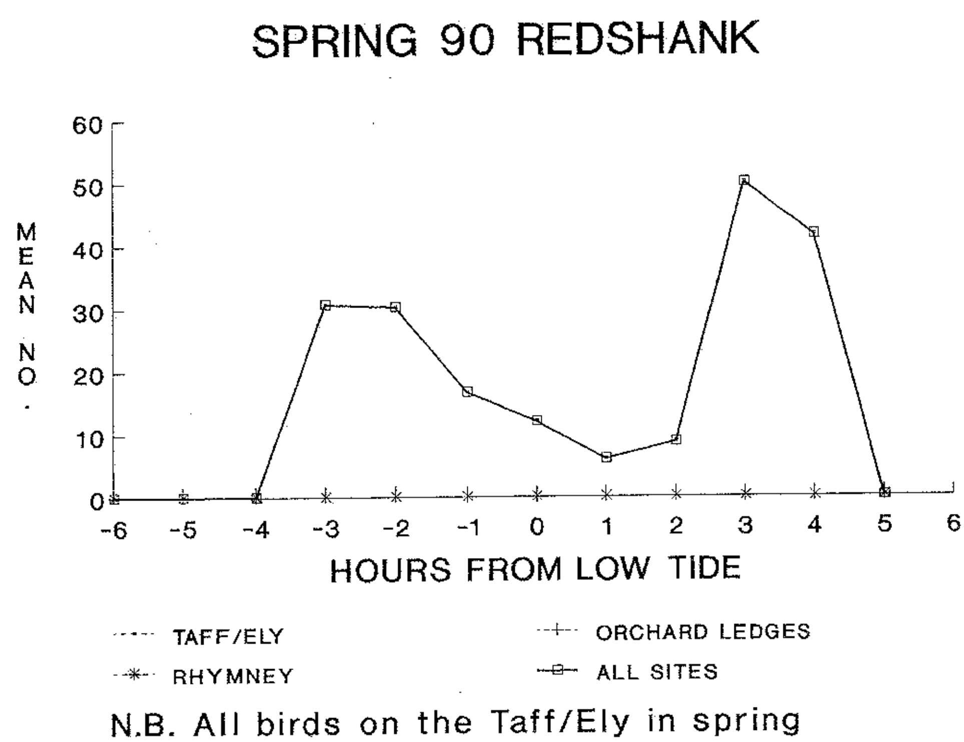


Figure 3.3 The total number of Redshank within the three study sites and within the whole study area throughout the tidal cycle.

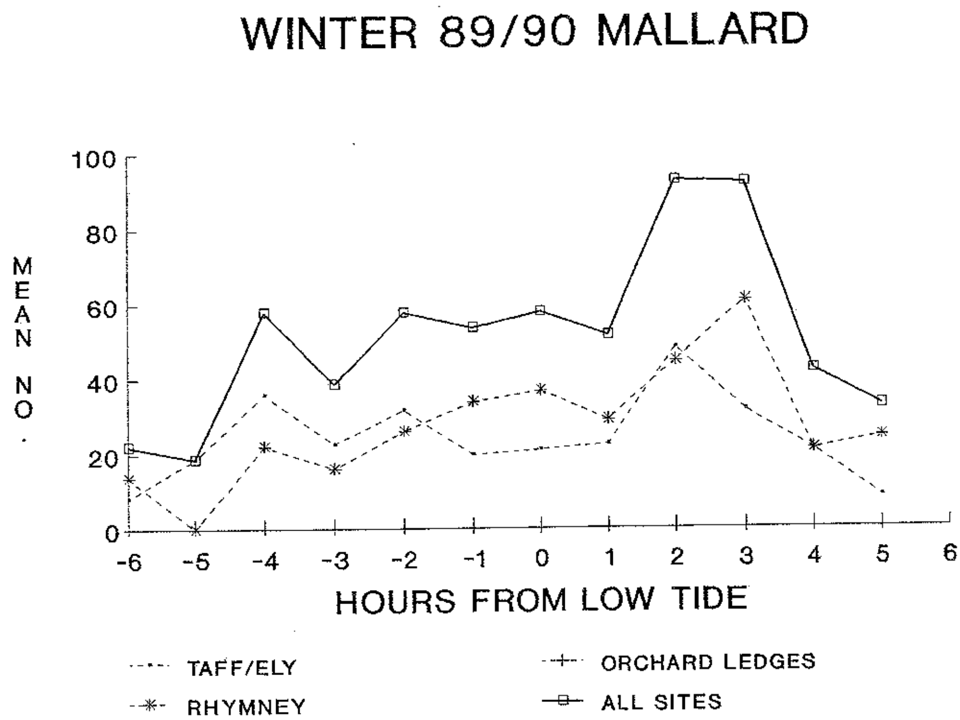
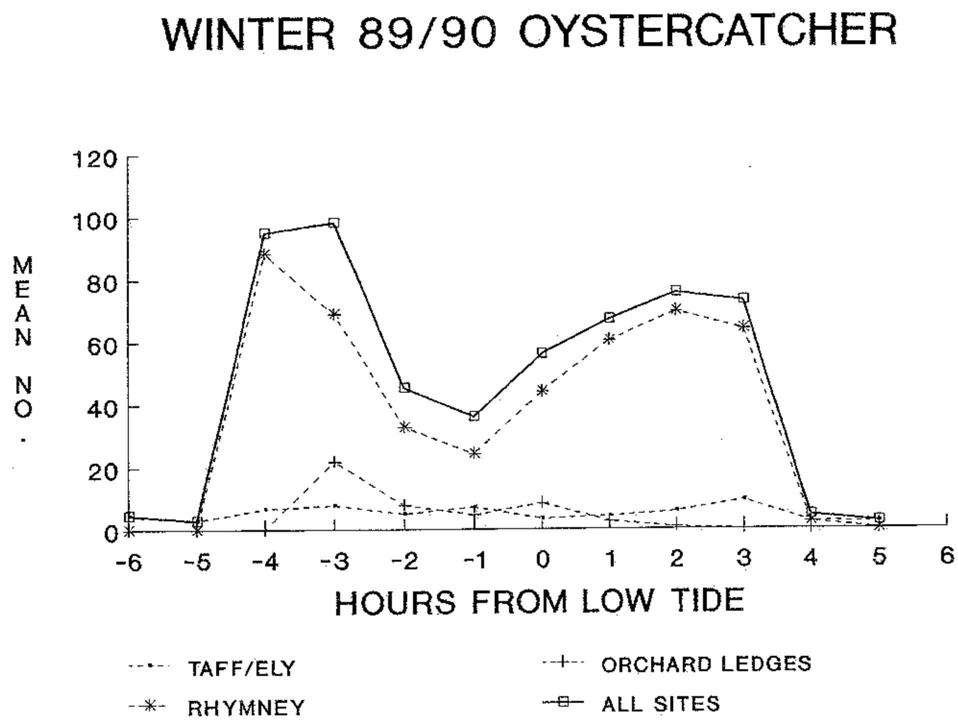


Figure 3.4 The total number of Mallard within the three study sites and within the whole study area throughout the tidal cycle.



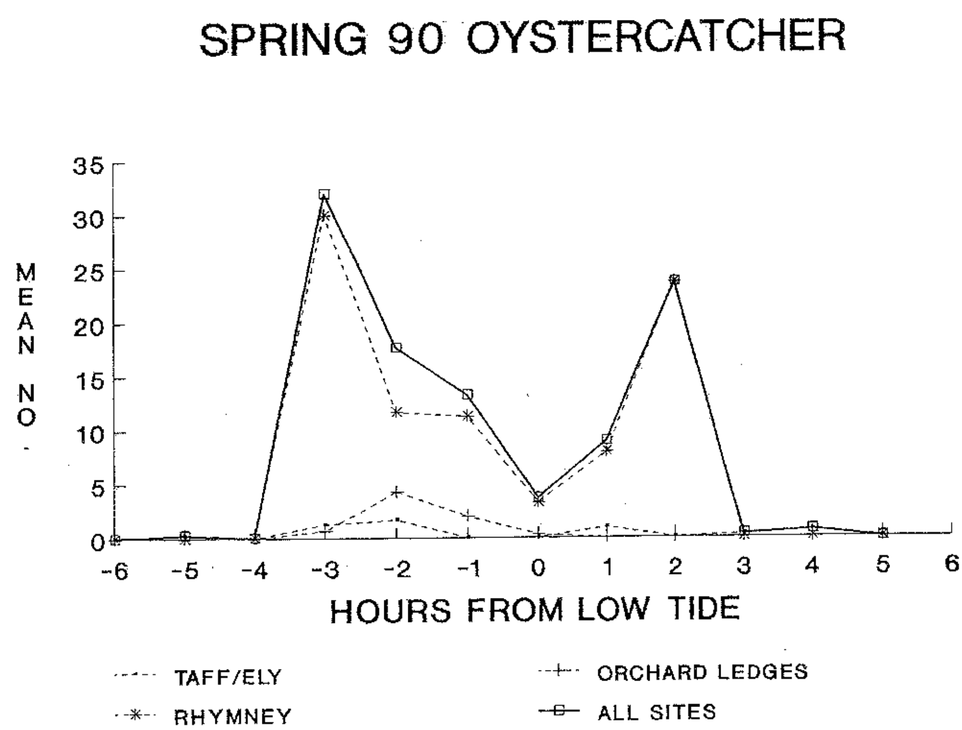
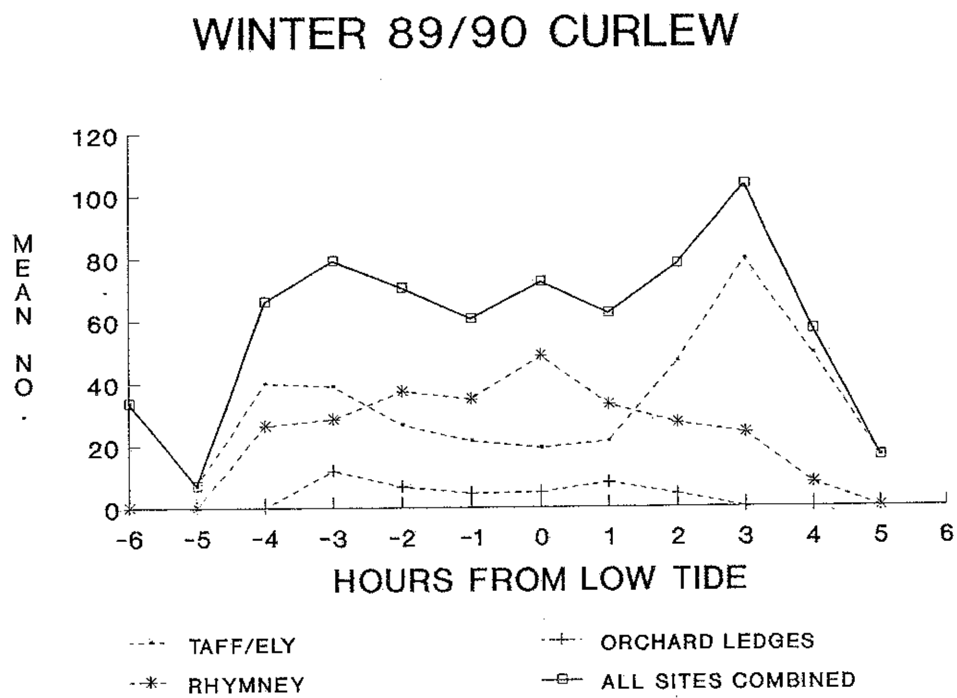


Figure 3.5 The total number of Oystercatcher within the three study sites and within the whole study area throughout the tidal cycle.



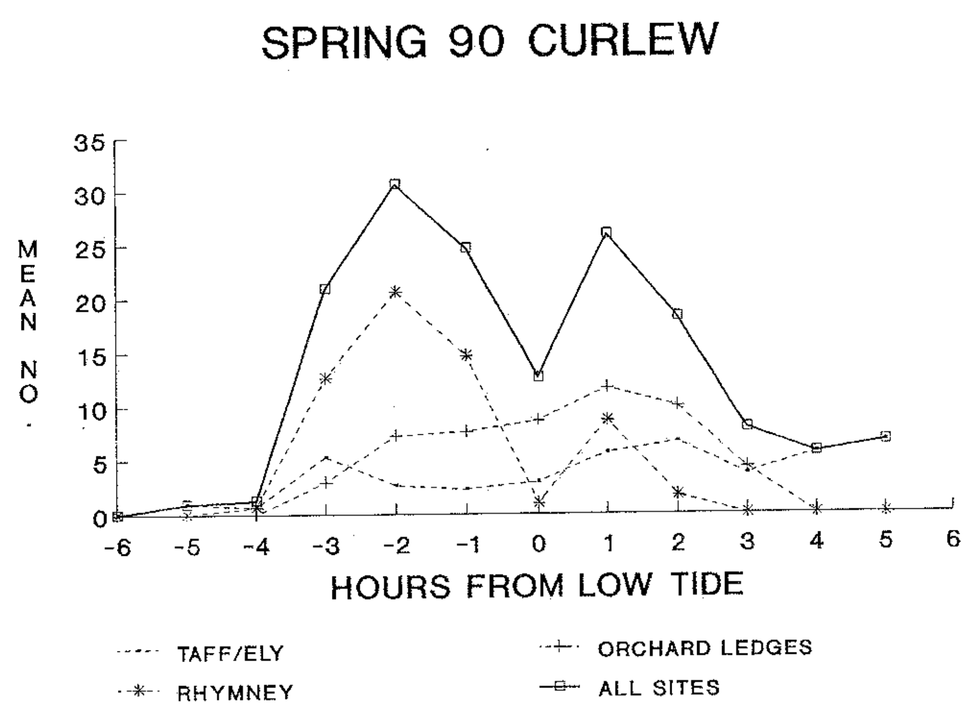


Figure 3.6 The total number of Curlew within the three study sites and within the whole study area throughout the tidal cycle.

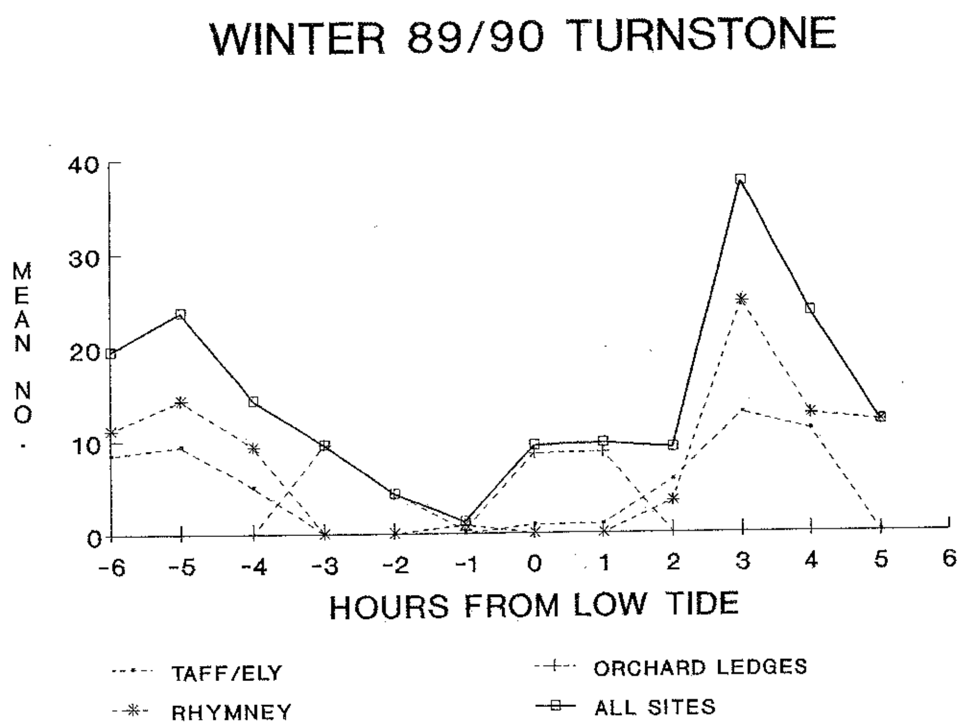


Figure 3.7 The total number of Turnstone within the three study sites and within the whole study area throughout the tidal cycle.