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THE EFFECT OF THE CARDIFF BAY BARRAGE ON WATERFOWL POPULATIONS 4. DISTRIBUTION AND MOVEMENT STUDIES AUGUST 1992-MAY 1993

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EXECUTIVE SUMMARY

1.This report represents the results of the fourth season of intensive monitoring of the wildfowl and waders using the intertidal areas in Cardiff Bay and adjacent areas. More extensive monitoring at low tide also covered the intertidal areas between the Taff/Ely Estuary and the mouth of the River Usk. The results presented in this report were derived from data collected between August 1992 and May 1993. The programme of monitoring closely followed that used for the previous three years. By using similar methods, a direct comparison between the four years of study was possible.

2.The intertidal mudflats of the Taff and Ely estuaries (known as Cardiff Bay) will be inundated by fresh water when the amenity barrage is completed. The gathering of information on the distribution and movement of the populations of waders and wildfowl over a number of years will make it possible to determine the fate of these populations when the barrage has been built.

3.Monitoring of the populations of waders and wildfowl on the northwest Severn from Cardiff Bay to the Usk Estuary has revealed only minor changes in the number and distribution of birds. Shelduck and Dunlin showed a decrease in numbers on some parts of this area compared with the previous year but there has been no major change over the four years.

4.The detailed data collected for the Taff/Ely, Orchard Ledges and Rhymney study areas were used to obtain estimates of the size and distribution of wader and wildfowl populations at each site. Only minor changes were detected.

5.The continuing work on the Peripheral Distributor Road (PDR) crossing of the River Taff and the Phase 1 and 2 reclamation work have had further effects on the feeding and roosting areas in the northwest part of Cardiff Bay. Teal and Lapwing have shown a continued tendency to feed away from areas with high levels of disturbance. Redshank have moved away from the area near the PDR work on the west bank of the River Taff which was previously extensively used by feeding birds. The remaining area north of the PDR work was used by large numbers of feeding Redshank during the autumn but by smaller numbers during the winter.

6.The four years of data were analysed to assess the levels of variation of usage of different parts of each study site for the most important species (Shelduck, Dunlin, Curlew and Redshank). All four species showed higher levels of variation in the usage of areas if those areas supported low densities of feeding birds. Redshank showed high variation over the four years on areas adjacent to the PDR work. Mudflats higher up the shore with longer exposure times showed low levels of variation in Redshank usage.

7.Samples of Redshank and Dunlin were caught and colour-marked near the Rhymney in November and February to continue studies of movement patterns around Cardiff Bay. During the winter there was very limited movement of Redshank from the Rhymney site to the Taff/Ely site. When Redshank moved away from the

Rhymney site in March, the number of colour-marked birds in Cardiff bay increased.

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

GENERAL INTRODUCTION

The Bill for the building of the amenity barrage across the mouth of Cardiff Bay has passed through its parliamentary stages and is awaiting Royal Assent. The building itself is likely to start within the next twelve months. In order to see if birds displaced by the development of the freshwater lagoon can be taken up in nearby areas, it is essential to have a detailed and long-term assessment of the bird populations. There is inevitably a limited amount of variation in the numbers and distribution of birds between years. Only by monitoring the populations over a long period can such between-year variation be taken into consideration when determining the overall numbers and distribution of the species of waders and wildfowl. This is the fourth year of detailed monitoring of the birds of Cardiff Bay and adjacent areas. It is now possible to start to assess the level of any variation in the populations of birds that winter in Cardiff Bay.

Many of the theoretical aspects of the behaviour of waders and wildfowl overwintering on such estuaries have been covered in the previous reports and will not be repeated here.

Already there have been changes in the bay that could affect the birds that are present during the autumn, winter and spring. The work associated with the Peripheral Distributor Road (PDR) and with the Phase 1 and Phase 2 land reclamation has affected some feeding and roosting areas at the north end of the bay. Saltmarsh areas have been covered partly or completely and this has also encroached upon some of the mudflats. Other areas have been subjected to disturbance from the adjacent work sites although they have not actually been physically altered. The effects of these changes on the roosting behaviour of the waders and wildfowl in the bay during the autumn and winter of 1992/93 have been studied and reported (Toomer & Clark, 1993).

This report covers the distribution and movement of the birds in Cardiff Bay. The report is in two sections. The first part summarizes the results of the fourth year of monitoring waterfowl populations in the vicinity of Cardiff Bay. The second section analyses the results of waterfowl movements based on observations of colour-marked birds.

The results of the first three years monitoring of waders and wildfowl populations found during the autumn, winter and spring in Cardiff Bay and nearby areas were given by Evans *et al.* (1990), Donald & Clark (1991a) and Toomer & Clark (1992a). This present report summarises a third autumn and a fourth winter and spring monitoring of waders and wildfowl. With four years of data, it is now possible to carry out analyses to show the level of variation of use of specific mudflats by the overwintering birds as well as any larger changes in numbers and distribution.

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

The Severn Estuary is the eighth most important site in Britain for waders in terms of overall numbers (Cranswick *et al.*, 1992). It is currently internationally important for Shelduck, Redshank and Dunlin and falls just below international importance for Curlew (Table 1.2). At a national level, it is additionally important for Ringed Plover, Grey Plover, Curlew and Knot and falls just below national importance for Turnstone. Some parts of a large estuary such as the Severn Estuary may be more important than others as they may hold disproportionately large numbers of birds. As has been quoted before, the Taff/Ely and adjacent areas of the Rhymney Estuary support one of the largest concentrations of birds anywhere on the Severn (Clark, 1990). The Taff/Ely Estuary is currently nationally important for Dunlin and holds almost 0.7% of the British Redshank population (Table 1.1).

PART 1: DISTRIBUTION STUDIES

1. INTRODUCTION

This first part of the report discusses the results of the studies on the feeding distributions of the waterfowl using the Taff/Ely, Orchard Ledges and Rhymney study areas between August 1992 and May 1993. The findings have been compared with the results of the previous three years. The previous studies were described by Evans *et al.* (1990), Donald & Clark (1991a) and Toomer & Clark (1992a). The distribution of roosting birds on the Taff/Ely site was studied in the 1990/91 and 1991/92 winters (Donald & Clark, 1991b; Toomer & Clark, 1992b). This study was repeated in the winter of 1992/93 to monitor the effects of the further development at the north end of the bay on the roosting pattern of the waterfowl and has been recently reported in Toomer & Clark (1993).

With four years data it has been possible to carry out more detailed statistical analyses. These analyses have only been carried out on the distribution of feeding birds during the winter as the previous studies have shown that the sites are of greater importance for waterfowl during this period. The analyses attempt to show how much variation there has been in the usage of individual mudflats by feeding birds throughout the study area. The effects of changes so far within the bay on the waders and wildfowl can then be estimated and predictions made of the effects of continued changes on specific areas. At the same time, areas showing stability of usage can be identified, as year-to-year variation rather than longer term change becomes apparent.

The timing of the autumn fieldwork has been varied during the first three studies. As the project did not start until November of the first year, autumn counts were not included in the first report. Observations made during August and September of 1991 showed that the study area was only used by small numbers of birds passing through on migration. The following year it was therefore decided to monitor the birds during the later part of the autumn period, during September and October. For this fourth year of the study, observations were made for the three months of the autumn period, August, September and October, so that direct comparisons could be made with either of the previous autumn studies.

The winter and spring fieldwork has been carried out for the same periods (November-March and April-May respectively) and the results are therefore directly comparable.

In this report, special attention is given to the areas that have been affected by the changes at the north end of the Taff/Ely study site. The PDR work and the Phase 1 and 2 reclamation work have resulted in the loss of some saltmarsh adjacent to the River Taff but there has been no major loss of mudflat habitat. The main effect on the feeding birds therefore resulted from disturbance associated with the development work in the bay. With four years data, it has been possible to assess the change in feeding bird usage of these areas.

2. METHODS

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

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

2.1 All Day Counts

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

Developments that are taking place at the northern end of the Taff/Ely site have affected some of the count areas. The continuing work on the PDR has cut across two count areas. These two areas, sector 7 and sector 10 (Figure 2.1.1) were considered as *'intact areas'* for the 1991/92 study and counted as such. Although these two sectors have continued to be affected by the PDR work, they were still counted as *'intact areas'* in the current study for direct comparison with previous years. The four observation points that had been used in the 1991/92 study were used again. On sector 19, occasionally some of the feeding flock moved further into the inner harbour area. On such occasions extra observations were made from the jetty area of the Cardiff Bay Yacht Club.

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

The pitted area between Orchard Ledges and the Rhymney sites holds small populations of Turnstone, Curlew, Dunlin and Oystercatcher at low tide. The nature of the broken surface made it very difficult to count birds accurately from either the Orchard Ledges or Rhymney observation points. As with the previous studies, this area was not included in the counting areas.

Counts were divided into three seasons: autumn (August - October 1992), winter (November 1992 - March 1993) and spring (April - May 1993). Each site was counted at least twice a month with one count on a spring tide and one on a neap tide where possible. All count areas of each site were counted once every hour from six hours before to five hours after low tide. Counts were made throughout the hours of daylight or for 12 hours (whichever was the shorter). This procedure enabled the assessment of changes in the usage of different sites throughout the tidal cycle. Feeding and roosting birds were counted separately and factors such as disturbance to the site or impaired visibility were noted. All birds present on the exposed mudflats were counted. Wildfowl feeding in the shallow water offshore, which were clearly feeding on invertebrates in the substrate were included in the counts. However, wildfowl roosting offshore on the open water were not included in the counts as the study is primarily concerned with feeding birds and because such birds are

extremely difficult to count. Waders and wildfowl roosting in areas of saltmarsh were not counted, as accurate counts are also very difficult in this habitat. Observations on the roosting behaviour of birds in Cardiff Bay have been covered in separate reports (Donald & Clark, 1991b; Toomer & Clark, 1992b; Toomer & Clark, 1993).

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

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

All day usage was calculated using:

$$\text{Usage} = \sum_{A=+5}^{A=\_6} (BxC)1$$

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

In addition, further analyses have been carried out on the data for the four winters. These analyses were carried out on the key species (Curlew, Dunlin, Redshank and Shelduck). The lower numbers of the other species meant that statistical analyses were of limited value in interpreting the findings of the four years. Similar analyses were not carried out for autumn and spring as bird numbers show the three sites to be of lesser importance at these times.

Using the mean feeding usage values from each sector at each of the study sites for each of the four winters, the following values were calculated for each sector:

a) overall mean feeding usage, _

$$= \frac{1}{n} \sum_{Yr=1}^{Yr=n} \overline{U}\ 2$$

where Yr = winter period
n = number of winters
_ = mean feeding usage value during a winter

b) overall mean feeding usage density (mean feeding usage corrected for area)

$$= \frac{\overline{U}}{a} 3$$

where a = sector area (*ha*).

c) coefficient of variation of the four winters mean feeding usage values, CV

$$= \frac{100 \times \text{Standard Deviation of } \overline{U}}{\overline{U}} 4$$

In addition, the mean exposure time was calculated for each of the sectors over the four winters.

2.2 Low Tide Counts

The low tide distribution of waterfowl in the northwest Severn was monitored using counts made of all the areas two hours either side of low tide. Counts were made at two-weekly intervals during the winter period by British Trust for Ornithology (BTO) volunteers. As for the previous studies, only areas along the north Severn shore, west of the River Usk were counted as it was considered that changes in Cardiff Bay were most likely to affect the distribution of birds in this area (Figure 2.2.1). As with the all day counts, the whole area was broken down into smaller count areas. These were larger on average than the all day count areas. The average number of feeding birds present on each of the count areas is shown for each species.

2.3 Presentation of Results

The previous three years of study were reported in Evans *et al.* (1990), Donald & Clark (1991a), and Toomer & Clark (1992a). This report should be read in conjunction with these three reports as figures for the previous three years' findings are not reproduced here.

Work on the PDR and the Phase 1 and Phase 2 reclamation has continued. The most significant effects of this work have been on the saltmarsh areas at the north end of the bay. So far, the main effect has been on the roosting behaviour of the birds in the bay and this has been covered in a separate report (Toomer and Clark, 1993). In discussing the results, particular attention will be given to species whose feeding behaviour may have been affected by the continuing PDR and Phase 1 and Phase 2 work.

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

Low tide counts were used to produce maps showing the average number of each species present feeding during the winter months. The maps are included in the species accounts that follow. Each species account is divided into three parts, the autumn 1992, winter 1992/93 and spring 1993 results of all day and low tide counts. In each of these, comparisons are made with the three previous seasons, 1989/90, 1990/91 and 1991/92 if appropriate. The results are considered in relation to the changes that have occurred to the sites during the four years of study, as well as with factors such as feeding ecology and

behaviour and migration patterns. For the more important species, Shelduck, Dunlin, Curlew and Redshank, a fourth part compares the four years statistically.

Presentation of the results of the all day counts follows Evans *et al.* (1990). Graphs showing the number of birds and the proportion feeding through the tidal cycle only give the percentage feeding if a total of 50 birds or more were present at any one tidal hour as such values would carry little meaning if based on smaller samples.

The analyses of the four winters results have been presented in several ways for the key species. The coefficient of variation of the mean usage values (CV) is shown on maps of the three study sites as areas of increasing darkness for higher CV values, (e.g. Figure 3.1.8a). Low CVs reflect little variation in usage over the four years. As the level of variation is more likely to be high on sectors supporting low numbers of feeding birds the mean feeding usage density for each species is shown on maps of the study sites with areas of increasing darkness representing higher usage densities, (e.g. Figure 3.1.8b).

For each of these key species, graphs are produced showing mean feeding usage densities for the four years plotted against mean exposure times for each sector, (e.g. Figure 3.1.10a). Graphs are also produced of the coefficients of variation of the mean feeding usage plotted against the mean feeding usage for the four years, (e.g. Figure 3.1.10b).

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

3. RESULTS AND SPECIES ACCOUNTS

3.1 Shelduck

Over 60,000 Shelduck winter in Britain, their distribution being mainly coastal (Lack, 1986). This is almost half of the western European population. The Severn Estuary holds over 3,000 wintering birds and is of international importance. It is the eighth most important site for wintering Shelduck (Cranswick *et al.*, 1992) and is also an important breeding site in Britain (Delany, 1992).

Autumn 1992

Shelduck were present at the Taff/Ely and Rhymney sites during the autumn of 1992. There was a low level of usage at the Taff/Ely site with feeding occurring on several widespread sectors (Figure 3.1.1). There was a higher level of usage at the Rhymney site, especially on sectors east of the River Rhymney (Figure 3.1.2). Their habit of following the falling tide line produced an even pattern of usage on these sectors.

There were no feeding Shelduck at the Orchard Ledges site during the autumn.

Less than ten birds were present on average at the Taff/Ely site (Figure 3.1.3a). At the Orchard Ledges site, there was a peak of less than five birds. At Rhymney, the mean peak number was just below 100 birds (Figure 3.1.3c) with most birds moving onto the mudflats to feed shortly after high tide, the numbers slowly decreased through the tidal cycle. The majority of the birds were feeding when they were on the sectors and the decline in the number of birds arose as the Shelduck moved onto the open water to roost, especially at high tide.

In August, all of the Shelduck were juveniles. Adult birds appeared soon after this and their numbers increased through the autumn period. At Rhymney, over forty percent of the birds were adults by September. One of the known post-breeding moulting sites for Shelduck is not far away at Bridgwater Bay on the south side of the Severn Estuary (Eltringham & Boyd, 1963) although large numbers of the British breeding population move to moulting grounds on the Wadden Sea.

There were fewer Shelduck and these birds had a more restricted distribution at the Taff/Ely site in the autumn of 1992 than during the previous autumn, but the numbers were too low to be of any great significance. The pattern of usage and the number of birds at the Rhymney site was very similar to the autumn of 1991. Apart from these minor variations there has been very little overall change in the number of birds and their feeding pattern during the three autumns of the study.

Winter 1992/93

Feeding Shelduck were present throughout the northwest Severn in the winter of 1992/93 (Figure 3.1.4). The highest concentrations were in the vicinity of the River Rhymney and the St Brides section.

Nearly all sectors of the Taff/Ely site were used by feeding Shelduck with greater usage of the extensive mudflats between Ferry Road and the southwest side of the River Taff (Figure 3.1.5). These particular mudflats are only slightly sloping and were found to support feeding birds for long periods during the tidal cycle.

Small groups of Shelduck occasionally fed on the Orchard Ledges site and they were observed on many muddy areas between stony patches (Figure 3.1.6). All sectors at the Rhymney site except for the innermost (sector 17) were used by feeding Shelduck (Figure 3.1.6). On sectors west of the river, average usage was very even. A greater usage was made of the areas to the east of the river, especially sectors 13 and 14. A large proportion of the birds remained near the water's edge throughout the tidal cycle and this partly accounts for the high usage of those sectors that extended a long way down the shore.

The number of Shelduck on the sectors at the Taff/Ely site remained relatively stable throughout the tidal cycle with only a small decrease around low tide (Figure 3.1.7a). This was partly a result of birds moving to areas beyond the counting site as the water level dropped. A small proportion of the birds were roosting at any one time but at times, larger numbers were on the open water where they were not included in the counts. Between 250-350 birds were present at the site at high tide for most of the winter period (Toomer & Clark, 1993).

The relatively small number of Shelduck present at Orchard Ledges were feeding (Figure 3.1.7b). The areas that were more suitable for feeding became uncovered at low tide and at this time, small numbers of up to nearly forty birds moved onto the mud, having moved in from outside the Orchard Ledges site. These birds frequently remained for a short time only, often moving off before the suitable feeding area was covered.

At Rhymney, Shelduck started to move onto the mudflats to feed as soon as they became exposed by the falling tide (Figure 3.1.7c). Very few birds were on the water with the majority of birds feeding throughout most of the tidal cycle on the mudflats close to the tide edge. As the tide rose, Shelduck moved onto the water, or moved to areas further along the Severn Estuary to roost.

The number of Shelduck feeding on the northwest Severn showed a decrease in some areas compared with the findings of 1991/92 but that year had itself shown a rise in numbers and the overall pattern has been fairly similar for the four years of the study.

There has been a limited shift in the pattern of feeding at the Taff/Ely site compared with the winter of 1991/92. There was an increase in usage of sectors 2-5 with a corresponding decrease on sectors north of the PDR work and adjacent to the PDR work on the east side of the River Taff. The number of birds was very similar to the previous winter but a greater proportion of these remained on the study site at low tide. The pattern of usage at Orchard Ledges was similar to 1991/92, although no large flocks were observed throughout the study period. At the Rhymney site, the distribution and number of birds was comparable with that observed the previous winter with a small decrease in the usage of some of the easternmost sectors.

A Comparison of the Four Winters

Since the winter of the first study in 1989/90, the main changes have been an increase in the number of birds at the Taff/Ely site with a higher usage of the south-western sectors. The use of Orchard Ledges as a feeding site, which was first noted in 1990/91 has continued but has shown no marked increase. There has been no major change in distribution or number of birds at the Rhymney site over the four winters.

At the Taff/Ely site, there has been a high level of variation in the feeding usage on sectors adjacent to the PDR and along the River Taff at the northwest part of the bay (Figure 3.1.8a). Although all these sectors hold feeding birds during the winter, the usage density is low (Figure 3.1.8b) and therefore this high variation is not necessarily significant. The areas of highest feeding usage density (sectors 3, 5, 18) show only low to moderate variation over the four winters.

At Orchard Ledges and on those sectors west of the Cardiff eastern sewer at the Rhymney site, the usage density is again low (Figure 3.1.9b) and the variation over the four years is fairly high on some sectors (Figure 3.1.9a). The areas east of the Cardiff eastern sewer have had the highest usage density (in particular sectors 12 and 13) and show relatively low to moderate variation.

The usage density of Shelduck on the sectors of the three sites was not related to their exposure time (R^2=0.010, n=38, P=0.542 - not significant) (see Figure 3.1.10a). The areas with the highest level of usage density are sectors 12 and 13 at Rhymney and these have the shortest and one of the highest exposure times respectively. This is in part because of the tendency for many of the Shelduck to aggregate along the receding edge of the water line to feed. The coefficient of variation of Shelduck usage was not related to mean usage (R^2=0.065, n=36, P=0.134 - not significant) (see Figure 3.1.10b); some of the sectors with the lowest and highest levels of usage showing little variation, although high levels of variation only occur at low usage levels. Generally, most sectors have shown only moderate variation in feeding usage over the four years of the study.

Spring 1993

In spring, Shelduck continued to feed on most sectors of the Taff/Ely site with a similar distribution to that observed in the winter period (Figure 3.1.11). No feeding birds were observed at the Orchard Ledges site during spring (Figure 3.1.12) although between two and four birds were observed to roost on various parts of both sectors for short periods. Feeding Shelduck at the Rhymney site were mainly restricted to the upper mudflats on sectors fifteen and sixteen and beyond the Ystradyfodwg/Pontypridd sewer (Figure 3.1.12).

The number of birds remaining at the Taff/Ely site was about half the number found in the winter with a reduction in the proportion of birds feeding at low tide (Figure 3.1.13a). At Rhymney, only about one quarter of the winter number of birds remained (Figure 3.1.13c).

The pattern of feeding distribution and the number of birds present at the three study sites was similar to the spring of 1992. Over the four study years there have been minor changes in distribution at the Taff/Ely site but at the Rhymney site there has been an increase in the usage of the innermost sectors of the site, resulting partly from an increase in the number of birds remaining in spring.

3.2 Wigeon

Only very low numbers of Wigeon were observed along the northwest Severn during low tide winter counts. A single bird was observed at the Taff/Ely site in November and five birds were seen for a short time at Rhymney in September.

3.3 Mallard

Mallard is the most numerous duck in Britain, with a winter peak of approximately half a million (Lack, 1986). Over 170,000 winter on estuaries (Cranswick *et al.*, 1992).

Autumn 1992

A small number of Mallard were present at the Taff/Ely site from early autumn feeding mainly on the mudflats of sectors adjacent to the River Taff in the middle of the bay (Figure 3.3.1). The birds fed mostly along the shallow edge of the river water. No birds were present on Orchard Ledges during the autumn. At Rhymney, Mallard feeding activity was confined to sectors east of the River Rhymney (Figure 3.3.2) with birds again restricting themselves mainly to the edge of the river.

The number of Mallard at the Taff/Ely site showed two clear peaks of birds on the mudflats (Figure 3.3.3a). Birds moved onto the edge of the mudflats as the tide level dropped, returned to the open water over the low tide period and moved back onto the mudflats as the tide rose. Of the mean peak of over sixty birds, only a small proportion were feeding at any one time. The overall pattern was similar at the Rhymney site but with fewer birds moving onto the water at low tide and with a higher proportion of birds feeding on the falling and rising tide (Figure 3.3.3c).

The small population of Mallard at the Taff/Ely site showed a similar feeding distribution to the 1991 autumn with only minor differences in the amount of usage of some of the sectors. At Rhymney, there was less usage of the area between the Cardiff eastern sewer and the River Rhymney and of the lower part of the shore (sector 12) than for the previous autumn. There was an increase in the number of Mallard on the mudflats of the Taff/Ely site in the 1992 autumn and the proportion feeding on the falling tide was much lower. The number of birds at Rhymney remained the same for the two autumns but the pattern of feeding was very different with more birds feeding before and after low tide during the 1992 autumn compared with 1991.

Winter 1992/93

Very few Mallard were observed on the western half of the northwest Severn during the low tide counts but the eastern sections, in particular St Brides, had relatively high numbers (Figure 3.3.4).

Feeding Mallard were widely distributed at the Taff/Ely site but were not found on those sectors adjacent to the River Taff north of the PDR (Figure 3.3.5). Most feeding birds were along the water channel that runs into the bay from the inner harbour (sectors 16, 17, 18). At the Rhymney site, feeding birds were restricted to those sectors east of the Cardiff eastern sewer that abut onto the river, including the western end of sector 12 (Figure 3.3.6). No birds were observed on the Orchard Ledges site.

The number of Mallard found at the study sites in winter (Figure 3.3.7) was similar to that observed in autumn. At the Taff/Ely site (Figure 3.3.7a), the number of birds on the mudflats was highest soon after high tide and then again before the following high tide, with low numbers at low tide. Less than fifty percent of these were feeding at any one time. The pattern of feeding and roosting at the Rhymney site (Figure 3.3.7c) was very similar to the situation described in the autumn but with a higher percentage of birds feeding at low tide.

The low tide distribution of feeding Mallard on the northwest Severn in 1991/92 showed there to be few birds overall. The situation in the winter of 1992/93 was different, with feeding flocks present on the St Brides section.

There has been an increase in usage of the sectors adjacent to the channel running from the inner harbour at the Taff/Ely site in 1992/93 compared with 1991/92, although the number of birds present and their pattern of feeding during parts of the tidal cycle were very similar. The distribution and number of birds at the Rhymney site was also very similar for the two winters.

Other than the changes already noted between the winters of 1991/92 and 1992/93, there have only been minor changes in the distribution and numbers of Mallard at the Taff/Ely site during the four years of the study. Although there were very few feeding Mallard present in 1990/91, the number of birds has remained very similar. Only minor changes in the distribution and numbers of Mallard have occurred at the Rhymney site since 1989/90.

Spring 1993

Only a few Mallard remained at the study areas during spring. At the Taff/Ely site groups of two to three birds were observed feeding on the mudflats (Figure 3.3.8). No Mallard were observed at the Orchard Ledges and Rhymney sites.

This situation is comparable with that observed during the previous spring study periods.

3.4 Teal

Several thousand pairs of Teal breed in Britain and Ireland and this number rises to well over 100,000 birds in winter as migrants arrive from other breeding grounds (Lack, 1986; Marchant *et al.*, 1990). The Severn Estuary is nationally important for wintering Teal.

Autumn 1992

Although small numbers of Teal were present at the Taff/Ely site during the autumn, few birds were observed feeding during the study period and therefore a feeding distribution map was not produced. At the Rhymney site, only a few birds were feeding on the sectors, in all cases along the edges of the River Rhymney (Figure 3.4.1). No birds were present on the Orchard Ledges site.

The mean peak count for the Taff/Ely site was of over sixty birds (Figure 3.4.2a). As the tide receded, the Teal left their high tide roost sites (usually in the creeks in the saltmarsh) and moved onto the study sectors. Here they spent most of the tidal cycle roosting. The apparent fall in numbers at low tide was not the result of birds leaving the bay but was caused by birds moving onto the open water or quite frequently moving down the bank of the River Taff (sector 13) as the water level dropped and therefore out of sight. This pattern of behaviour has also been noted for Teal on the Mersey (Rehfisch *et al.*, 1991; Holloway *et al.*, 1992).

The observations for the 1992 autumn show a number of differences compared with 1991. In 1991 Teal moved onto the study sectors with the falling tide and a high proportion of them fed until one to two hours after low tide. This maintained the numbers observed over the low tide period. More birds were present at the Rhymney site in the autumn of 1991 although the actual number was still small.

The pattern for the three autumns studied has been similar, with only minor fluctuations occurring.

Winter 1992/93

The low tide winter distribution of feeding Teal on the northwest Severn showed there to be low concentrations of birds associated with the River Taff and the River Rhymney and greater numbers on the St Brides section, near the River Usk (Figure 3.4.3).

Feeding Teal were widely distributed at the Taff/Ely site particularly on the sectors adjacent to the River Taff and Ely as well as the channel running from the inner harbour (Figure 3.4.4). Almost no feeding occurred on sectors further up the River Taff, north of the PDR. At the Rhymney site, feeding Teal were also associated with the sectors adjacent to the river (Figure 3.4.5) and were absent from all other sectors.

The mean peak of Teal at the Taff/Ely site was of over 100 with the number of birds showing a decrease around the hours of low tide (Figure 3.4.6a). For most of the tidal cycle, fifty percent or less of the birds were feeding. Frequently, the number of Teal in the bay was greater than that shown by the data referred to above but many of the birds remained on the water during the tidal cycle and so were not included in the counts. Other observations at the site showed the number to often vary between 200 and 400 birds. Smaller numbers were observed at the Rhymney site, again a with variable proportion feeding during the tidal cycle (Figure 3.4.6c).

The low tide counts showed little change in the distribution and numbers of feeding Teal on the northwest Severn during the four study winters.

The feeding distribution of Teal at the Taff/Ely site in the 1991/92 winter shows several differences compared with 1992/93. There was a higher amount of usage of the sectors adjacent to the River Taff north of the PDR in 1991/92. In 1992/93 very few feeding birds were observed on these sectors but there was a corresponding increase in usage of other sectors adjacent to the river or the channel running from the inner harbour. The number of birds present on the study site was very similar for the two winters. At the Rhymney site, there were minor variations in the amount of usage of those sectors east of the Cardiff eastern sewer but the population stayed the same for the two winters.

During the four years of the study, there has been a shift in the areas that were used by feeding Teal at the Taff/Ely site from sectors at the northwest part of the study site, to sectors further south and east within the bay. The sectors with a reduction in usage were those adjacent to the PDR and the Phase 1 and 2 land reclamation work. There has been a two-fold increase in the number of Teal at the Taff/Ely site since the first year of the study.

Spring 1993

Almost all of the Teal had left the Taff/Ely site by April (Figures 3.4.7 and 3.4.8), the remaining small groups feeding on the sectors at the south of the study site. No birds were observed at the Orchard Ledges or Rhymney sites. This is comparable with the previous years' findings.

3.5 Pintail

Britain has a very small breeding population of Pintail. The birds that are found wintering on the estuaries around the coast are from breeding areas in western Siberia, Scandinavia and Iceland. The current wintering population in Britain numbers over 25,000 (Lack, 1986).

Autumn 1992

No Pintail were recorded on the Taff/Ely or Orchard Ledges sites during the autumn. Small numbers of birds started to be observed early in autumn at the Rhymney site (Figure 3.5.1). The majority of these birds fed along the edge of the tide mainly on the lower reaches of the shore. On the rising tide, the birds followed the course of the river, feeding along its edge on sectors 10, 11, 14 and 15. All of the feeding birds were located on sectors east of the Cardiff eastern sewer.

The number of birds at the Rhymney site increased as the tide receded peaking around low tide with birds moving from adjacent areas to feed on the lower shore (Figure 3.5.2c), although the actual numbers were low in autumn.

The number of birds and their feeding distribution was very similar to that observed in the 1990 and 1991 autumns.

Winter 1992/93

Low tide counts of feeding Pintail on the northwest Severn showed the main concentrations to be around the Rhymney Estuary (Figure 3.5.3) with a few birds on the St Brides section.

No Pintail were observed at the Taff/Ely or Orchards Ledges sites during the winter. At the Rhymney site the number of feeding birds increased through the autumn and continued to rise during the first part of the winter (Figure 3.5.4). The highest usage was on the sectors east of the River Rhymney (other than sector 13) where birds were mainly present on the water's edge on the lower parts of the shore. Small numbers of feeding birds were observed on some of the sectors west of the river. Only occasionally did birds leave the shallow water and feed on the wet areas of mud.

Birds moved in from other areas and moved onto the edge of the water as the tide dropped, numbers increasing for three hours after high tide (Figure 3.5.5c). At this time the lower reaches of the shore were exposed, the preferred feeding area of the Pintail. As the tide rose, birds moved away from the edge and were no longer included in counts. Only part of the Pintail population fed at the water's edge at any one time, with larger numbers just offshore. The actual number of Pintail was therefore higher than the counts show, in excess of 250 birds being seen on some days in winter.

The low tide distribution of feeding Pintail on the northwest Severn in the 1992/93 winter was very similar to that of the previous winter. The pattern of numbers and distribution at low tide has been comparable in the winter period for three of the four years of the study, numbers having been lower during the 1990/91 winter.

At the Rhymney site, feeding Pintail were less widespread than in the winter of 1991/92. In that winter, higher numbers of feeding Pintail were found on sector 10 and some of the other sectors to the west of the Cardiff eastern sewer. In the present study very few Pintail were observed on the lower reaches of sector 10, a preferred feeding area in the previous winter. The number of birds has not varied greatly between the two winters.

The four winters of the study have shown several changes in the numbers and distribution of Pintail. The biggest variation was in the winter of 1990/91 when there was a marked decrease in the number of Pintail at the Rhymney site. The following year, numbers had returned to the level observed in 1989/90, which was comparable with that found in the current study. The other changes in the feeding pattern have already been discussed.

Spring 1993

No Pintail were observed at the Taff/Ely or Orchard Ledges site during the spring. At the Rhymney site almost all of the Pintail had left by the spring and only two to three birds were recorded during the spring counts.

This is comparable with the previous springs.

3.6 Pochard

Pochard breed in Britain where they are found on lakes, reservoirs and gravel pits. A large proportion of this population is found in similar habitats in winter but the wintering numbers are increased by an influx of thousands of migrants from central Europe and the former USSR. The wintering population in Britain numbers about 50,000 birds (Lack, 1986). Many of these birds overwinter on estuaries, the Severn Estuary being the fifth most important wintering site in Britain in 1991/92 (Cranswick *et al.*, 1992). As Pochard feed by diving, they prefer water between one and four metres deep and therefore will not usually be included as feeding birds on the study sectors.

No Pochard were observed at any of the three study sites during the autumn nor in spring.

Winter 1992/93

Feeding Pochard were present on the Rhymney and Peterstone sections of the northwest Severn during the low tide observations but only in small numbers (Figure 3.6.1).

A small group of Pochard was observed at the Taff/Ely site during the winter. The group, numbering between eight and sixteen birds, spent most of the time roosting on the open water with only the occasional movement onto one of the sectors. Feeding birds were only observed on sector 18 (Figure 3.6.2). No birds were observed at the Orchard Ledges site. At the Rhymney site flocks of several hundred Pochard were visible offshore during the middle of the winter. Smaller numbers of these moved into the study area on many of the study days, but most usually remained on the open water and were not included in the counts. Some of these were observed feeding on the edge of the water on sectors adjacent to the mouth of the River Rhymney (Figure 3.6.3).

The mean peak number of birds on the study sectors at the Taff/Ely site was less than five but at the Rhymney site between twenty and thirty birds were observed during the low tide period (Figure 3.6.4c). Here the birds moved onto the study sectors near the mouth of the River Rhymney as the tide fell with the number of birds and the proportion feeding increasing up until low tide.

No feeding Pochard were recorded on the northwest Severn during the previous three winters by low tide counts.

The same number of Pochard had been noted at the Taff/Ely and Rhymney site in the winter of 1991/92 but no birds had moved onto the study sectors. These results were comparable with the findings for the 1989/90 winter.

3.7 Other Wildfowl Species

Several other species of wildfowl were observed at the Taff/Ely and Rhymney site but in numbers too small to be included in the separate species accounts.

At the Taff/Ely site, three Goldeneye were seen in January on the River Taff for a short time. A single female Goosander was seen for several months from January to May but as it was usually only present for a day at a time, it is not known if it was the same individual. Both of these species overwinter on the southwest coasts of Great Britain and are also commonly found on inland sites. Two unusual observations for the Taff/Ely site were of a single Brent Goose present on one day in early January and a male Common Scoter for several days in May. Both of these species prefer more open coastal areas in winter and the preferred wintering grounds for the Brent Goose are further east.

At the Rhymney site in November, one Red-breasted Merganser was seen briefly on sector 15 and one Tufted Duck on the edge of sector 10.

3.8 Oystercatcher

Thousands of Oystercatchers breed in the British Isles. These birds move to the coast to winter where their numbers are boosted to hundreds of thousands by birds migrating from breeding grounds in other countries (Prater, 1981). The population wintering on the west coast of Britain return from breeding grounds in Scotland, the Faeroes, Iceland and Norway. Although Oystercatchers can adapt to a variety of substrates to obtain a range of food items, it is the abundance of shellfish such as cockles and mussels that determines the main distribution of wintering birds. Many of the areas of the Severn Estuary do not support these food items (Ferns, 1977) and the estuary does not hold nationally important numbers of Oystercatchers.

Autumn 1992

Oystercatchers were present at the Taff/Ely site from early autumn onwards. Feeding birds were found on most sectors of the site other than those northwest of the PDR (Figure 3.8.1). The highest recorded usage was on sectors 17, 12, 14, and 2, four sectors with very different features.

Both sectors of the Orchard Ledges site had feeding birds in autumn (Figure 3.8.2). Small numbers of birds fed amongst the stones and on the softer muddy areas mainly at the eastern and western ends of the site. At the Rhymney site, all sectors were used by feeding Oystercatchers in autumn. Sectors east of the River Rhymney had the highest usage, in particular, those with mudflats extending down to the edge of the water at low tide. Most feeding birds were located close to the receding or rising water's edge. Relatively large numbers of Oystercatchers moved along the shore from sector 13 onto sector 14 or 12.

Between fifteen and twenty-five Oystercatchers flew into the bay at the Taff/Ely site from their roost areas as the tide uncovered the mudflats (Figure 3.8.3a). These birds then

remained feeding on the mud until the tide again covered these areas. At the Orchard Ledges site, fifteen to twenty Oystercatchers (mean peak of approximately fourteen birds) arrived as the tide uncovered the stony shore (Figure 3.8.3b). The number of birds was highest initially, falling off through the tidal cycle until the area was again covered. The birds fed continuously while they were on this site. At the Rhymney site there were many more Oystercatchers with the mean peak in excess of 150 birds. The number of birds increased on the lower shore as the tide approached low water and then decreased again as the tide rose (Figure 3.8.3c). The majority of birds fed throughout most of the tidal cycle, a small proportion of the birds starting to roost two hours after low tide. Most of the Oystercatchers moved elsewhere to roost upon ceasing to feed.

The distribution of feeding Oystercatchers at the Taff/Ely site was very similar to that of the 1991 autumn although no feeding birds were observed on sector 11, near to the PDR work. There was a lower level of usage at the Orchard Ledges site and of many of the western sectors at the Rhymney site with a proportionally higher usage of some of the sectors near to the Cardiff eastern sewer and the lowest part of the shore, sector 12.

The number of birds and the pattern of behaviour during the tidal cycle was similar in 1991 at the Orchard Ledges and Rhymney sites, but not at the Taff/Ely site. There, the peak number of Oystercatchers occurred one to two hours before high tide during the previous autumn as birds left their feeding grounds elsewhere and moved into the bay. This produced two peaks in the number of birds in contrast to the situation observed in the 1992 autumn.

Although the number of birds at this time of the year is low, there has been a notable shift in the distribution of feeding birds at the Taff/Ely site over the three autumns of the study. In the autumn of 1990 the majority of feeding Oystercatchers were found on the sectors to the south and west of the River Taff in contrast to the autumns of 1991 and 1992, where feeding birds were mainly on sectors to the north and east of the river. At Rhymney there was a much lower level of usage of the sectors to the west of the Cardiff eastern sewer in 1990 than in 1991. The number of birds at the three sites was comparable for the three years and the differences in behaviour over the tidal cycle have already been described.

Winter 1992/93

Feeding Oystercatchers were widely distributed along the northwest Severn at low tide (Figure 3.8.4) with all sections holding feeding populations.

Feeding Oystercatchers were found on a number of sectors at the Taff/Ely site primarily in the central and southwestern part of the study site (Figure 3.8.5). Usage levels were low and were similar to those found in the autumn although the distribution showed some variation.

At the Orchard Ledges and Rhymney sites, the distribution of feeding Oystercatchers was even across most sectors (Figure 3.8.6). At Rhymney, Oystercatchers arrived as

sectors became uncovered and followed the receding water along the whole of the water front, thus feeding on all sectors.

The number of birds at the three sites was very similar to that observed in the autumn (Figure 3.8.7). The pattern of behaviour noted through the tidal cycle at the Taff/Ely site in the autumn was not evident in the winter period. During the winter, Oystercatcher numbers started to drop three to four hours before low tide as the birds left the area to feed on adjacent sites that had become uncovered by the falling tide (Figure 3.8.7a). Birds were then observed flying into the bay from the direction of Orchard Ledges as the tide rose. At the Orchard Ledges and Rhymney sites, numbers were highest one to two hours before and after low tide as birds moved to other sites along the shore to feed at other times (Figures 3.8.7b and c).

Low tide counts along the northwest Severn have shown relatively minor changes in the numbers and distribution of feeding birds over the four years of the study.

The low level of usage and the distribution of the feeding birds at the Taff/Ely site was very similar to that observed during the winter of 1991. There were only very minor changes in the levels of usage at the Orchard Ledges and Rhymney sites compared to the previous winter. The numbers and behaviour pattern during the tidal cycle at the three study sites also showed very little variation.

There have been some changes in the distribution of the relatively small number of Oystercatchers feeding at the Taff/Ely site during the four years of the study but with no clear pattern evolving. Similarly, the distribution of feeding birds at the other two sites, whilst showing variation, has not revealed any consistent change. There does appear to have been a reduction in the level of usage at Orchard Ledges since 1990/91. The number of birds at the three sites has been steady over the study period after the 1989/90 winter when populations were about half those found in subsequent years.

Spring 1993

Although most Oystercatchers had left the area by early spring, small numbers of birds were found on the three sites and were still present in mid-May. At the Taff/Ely site, between one and seven birds were observed feeding on the mudflats of the sectors near to the mouth of the River Taff (Figure 3.8.8).

Feeding Oystercatchers were only observed on sector 2 at the Orchard Ledges site (Figure 3.8.9). At the Rhymney site, small numbers of birds were observed feeding on most of the sectors, with the higher usage on sectors east of the River Rhymney.

The mean peak of Oystercatchers at Orchard Ledges was less than ten and these birds were only observed on the falling tide (Figure 3.8.10b). At Rhymney, the highest number of birds was observed soon after high tide, with a mean peak number of between forty and fifty birds (Figure 3.8.10c). The number of birds decreased markedly as the tide fell with very few birds remaining after low tide, a similar situation to that observed at Orchard Ledges.

The feeding distribution at the Taff/Ely and Orchard Ledges sites was very similar to that of the 1992 spring. At the Rhymney site, in spring 1992 there was greater usage of many sectors including several sectors west of the Cardiff eastern sewer. The number of birds and pattern of behaviour during the tidal cycle at both the Taff/Ely and Orchard Ledges sites was comparable with the previous autumn but although the number of birds was very similar at the Rhymney site, their behaviour was not. In 1992 the number of birds was low shortly after high tide and rose continuously to peak about one hour before the next high tide in contrast with the findings for the current spring.

The four years study has shown only minor changes in feeding distribution during the spring period. In 1991 there was a greater level of usage at both Orchard Ledges sectors. The main concentrations of feeding birds at the Rhymney site were on different sectors compared with subsequent years. In the first year of the study, 1990, there were fewer Oystercatchers remaining in the spring than in the following springs but otherwise, with the exceptions already referred to above, numbers and behaviour during the tidal cycle have been very similar.

3.9 Ringed Plover

Ringed Plovers breed in Britain with an estimated population of 8,600 pairs (Prater, 1989). Some of these move south to the continent to overwinter, while those remaining move to coastal areas. Here the numbers are added to by birds that arrive from other areas of the continent (Lack, 1986).

Autumn 1992

Small groups of Ringed Plover were seen at the Taff/Ely site early in the autumn. Feeding birds were located on sector 5, close to Ferry Road (Figure 3.9.1). Non-feeding birds were also observed elsewhere in the bay. At Orchard Ledges, feeding Ringed Plover were observed in small numbers on both sectors with greater numbers invariably on sector 1 and hence the higher usage (Figure 3.9.2). At the Rhymney site feeding Ringed Plover were nearly always close into the west corner of the bay by sector 17 (Figure 3.9.2). In this area, there are numerous runnels in which the birds feed. Because of their specific method of feeding by standing still and looking, then making short runs to obtain food items, individuals could remain out of sight for a large proportion of the time spent on the mud. Together with the fact that these birds are well camouflaged on most substrates, this species is certain to have been under-recorded. On some observations, birds were seen feeding on the mud towards the River Rhymney on sectors 15 and 16.

The number of birds at all sites was low, with a mean peak of less than fifteen at Orchard Ledges and less than twenty at Rhymney (Figures 3.9.3b and c). The two peaks in numbers, either side of low tide, at Orchard Ledges is likely to be partly because of the difficulty in observing this species. Ringed Plover are most visible as the shore becomes exposed by the falling tide and they move onto the area to feed, and again as the rising tide pushes them further up the shore towards the observation points. At low tide, the birds could well be undercounted. Although the number of birds here

was low at this time of the year, these explanations apply to the observations during the winter period when a similar pattern existed.

At the Rhymney site, there were also two peaks of bird observations during the tidal cycle (Figure 3.9.3c). As the upper shore was uncovered by the falling tide, Ringed Plover moved onto the mud of sector 17. Ringed Plover were observed to roost on the shingle in this corner of the bay on some occasions but on other occasions birds flew into the bay from roosts elsewhere. Two to three hours before low tide, birds would leave the area presumably to fly to feeding grounds outside of this study site. Some birds returned to feed in the same area three hours after low tide.

There was lower usage of sectors at the Taff/Ely site compared with 1991 although this is probably not important as the number of birds involved was low. The difference in usage at the Orchard Ledges site between these autumns was greater, although this could easily occur from one or two larger flocks having been observed for a short time. At Rhymney, although the distribution of feeding birds appears to have changed, this resulted from the Ringed Plover feeding in the same corner of the bay but marginally closer to the upper shore thus putting them into a different sector.

The number of birds at each of the study sites was similar for the two autumns but the pattern of behaviour during the tidal cycle described above was less pronounced in 1991.

The pattern of feeding distribution, number of birds and behaviour during the tidal cycle has been fairly stable for the three autumns of the study.

Winter 1992/93

No Ringed Plover were recorded during low tide observations on the northwest Severn on any of the sections during the winter of 1992/93.

Very few feeding birds were present at the Taff/Ely site in winter (Figure 3.9.4). Groups of two to three birds were seen on the western part of sectors 3 and 5. At the Orchard Ledges and Rhymney sites the feeding distribution was similar to that observed in the autumn but with lower levels of usage at both sites (Figure 3.9.5).

The mean peak number of birds at Orchard Ledges was over thirty birds but as their observed presence was erratic, this does not give an indication of the maximum flock size seen (Figure 3.9.6b). On several occasions flocks of over a hundred birds were seen although only for brief periods. When first observed, these flocks landed on the smooth muddier areas between the stony patches where they proceeded to feed. The pattern of behaviour during the tidal cycle was very similar to that already described for the autumn period. At Rhymney, the mean peak was ten birds but as with Orchard ledges, the maximum number of birds was higher, with flocks between thirty and fifty birds being seen (Figure 3.9.6c). At both sites, Ringed Plover were seen roosting on the shingle beach above the high water mark over the high tide period.

Small numbers of feeding Ringed Plover had been recorded on the St Brides section of the northwest Severn during low tide counts in the previous winter. This section had feeding birds present at low tide during the first three years of the study but none were found during the winter of this study.

The feeding distribution of Ringed Plover was similar to that observed for the 1991/92 winter at the three study sites but the number of birds was higher at the Orchard Ledges site. The large flocks referred to above were not observed during the previous winter. The pattern of behaviour during the tidal cycle was the same at the Rhymney site for the two winters.

The main difference in distribution of Ringed Plover at the three sites for the four years of the study was an increase in the number of birds observed at the Orchard Ledges site. Because of the unpredictable behaviour and the difficulty in seeing this species on certain substrates, it is not clear how significant this is.

Spring 1993

By early spring, most Ringed Plover had left the study sites and moved to their breeding grounds. Very few birds were seen during the spring observations. Other than a single bird seen at Orchard Ledges, the only other sighting was of a group of three at the Taff/Ely site for one count only. These could have been migrants passing through the estuary or overwintering birds that had not yet moved to their breeding grounds.

These findings are comparable with the other three years of the study.

3.10 Golden Plover

Although large numbers of Golden Plover winter in lowland Britain, very few birds have been seen during the four years of the study. No birds were seen during the autumn, winter and spring of the current study. Only one flock has been seen in the years of the study and that only for a short time.

3.11 Grey Plover

The winter distribution of Grey Plover is almost entirely coastal with highest concentrations being in the southeast of Britain. The Severn Estuary is not of national importance for this species although parts of the estuary hold wintering populations.

Autumn 1992

No birds were seen at the study sites during the autumn.

Winter 1992/93

The northwest Severn has wintering populations of Grey Plover but all the birds observed during low tide counts were located at the eastern end of this area on the end of the Peterstone section and on the St Brides section (Figure 3.11.1).

Very few birds were seen at the study areas during the winter. Single birds were observed on central areas of the Taff/Ely site on several days during the winter with the largest flock of nine birds being seen on sector 14 for one count only. No Grey Plover were seen at the Orchard Ledges or Rhymney sites during the winter period.

In the winter of 1991/92, feeding Grey Plover were observed only on one sector of the St Brides section of the northwest Severn during low tide counts. This species was more widespread in the 1990/91 and 1992/93 winters.

Very few Grey Plover were observed on the study sites in 1991/92, the numbers being comparable with the current study. It was noted in the previous report that the low numbers were a decrease on the findings of 1990/91, although even then the peak counts were only of twenty five birds at Taff/Ely.

Spring 1993

No birds were seen at the three study sites in the spring.

3.12 Lapwing

The wintering distribution of Lapwing shows that this species is not strictly a coastal wintering bird (Lack, 1986). The birds avoid the higher ground of north and west Britain but are otherwise very widespread. The wintering population of Lapwing is large with a peak of over two million birds, a high proportion of which is of Scandinavian, Danish, Dutch and north German origin.

Autumn 1992

Lapwing feeding at the Taff/Ely site were all found on the inner part of the Taff Estuary on sector 8 (Figure 3.12.1). Feeding birds did not spread from this area although a few individuals were observed roosting on sector 7 at times. No Lapwing were observed at the Orchard Ledges or Rhymney sites during the autumn.

The number of birds increased on sector 8 at the Taff/Ely site as the tide level dropped reaching a peak two hours before low tide (Figure 3.12.2a). The Lapwing numbers then decreased up to low tide as the birds dispersed to other nearby areas before returning to the sector as the tide level rose again. Only a small percentage were observed to be feeding at any one time and the majority of birds were roosting.

The usage of sector 8 was considerably less in autumn 1991 compared with 1992. The number of birds was similar, the difference in usage being produced by a higher proportion of feeding birds.

Feeding Lapwing were more widespread in autumn 1990 with birds on sectors 7, 8, 9 and 10. This was before the PDR work was affecting the mudflats of these sectors.

Winter 1992/93

Few feeding Lapwing were observed on the northwest Severn during low tide counts other than on the eastern end of the St Brides section, on the Usk Estuary (Figure 3.12.3).

At the Taff/Ely site, feeding Lapwing were found only on sector 8 (Figure 3.12.4). Lapwing were nearly always present in this area while it remained uncovered by the tide. In particular, they were scattered amongst stones of a rough part of the lower shore. The usage level was low. No birds were found on the Orchard Ledges site. Small numbers of feeding birds were present on some occasions at the Rhymney site (Figure 3.12.5). When present, these were usually to be found on a rough muddy part of sector 16 between the west bank of the River Rhymney and the upper shore.

The mean peak number of Lapwing at the Taff/Ely site was less than fifty with only a small proportion of these feeding for most of the tidal cycle (Figure 3.12.6a). At high tide, when the area used by the Lapwing became covered, the birds moved elsewhere to roost, or spent a lot of the time on the wing. The area further up the shore from the feeding area had been built up by the Phase 2 Landfill and was not used very often by roosting Lapwing in the 1992/93 winter (Toomer & Clark, 1993). The Lapwing present at the Rhymney site were only ever seen in low numbers with the majority of them roosting (Figure 3.12.6c). The birds arrived on the upper shore as it became uncovered and moved to other areas by low tide.

The low tide distribution of feeding Lapwing on the northwest Severn in 1991/92 was similar to the current findings, except for the occurrence of feeding birds at the mouth of the river Usk. Low tide counts over the four years of the study have not shown any particular pattern of change in feeding behaviour with small groups scattered along the four sections.

In winter 1991/92, feeding Lapwing were also located in the inner estuary of the River Taff with more birds on sector 9. At Rhymney no feeding Lapwing were recorded during that winter. The number of birds at the Taff/Ely site was similar for the two years.

The results from the four winters of study show that there has been a decrease in the number of feeding Lapwing at the Taff/Ely site overall since the 1989/90 winter. The extent of the area used for feeding has become reduced, with feeding birds being found on fewer sectors of the inner Taff Estuary. The number of birds has not shown a major change in this time, however, with the mean peak number being between thirty and sixty.

Spring 1993

By April, all the Lapwing had left the study sites to move to their breeding grounds and no birds were seen at any of the three sites.

3.13 Knot

Knot breed in the high Arctic and winter in large numbers on Britain's estuaries (Lack, 1986). Over 200,000 birds winter around the coast and the Severn Estuary is nationally important for this species (Cranswick *et al.*, 1992).

Moderate flocks of feeding Knot were observed during the low tide counts on the northwest Severn (Figure 3.13.1). These were restricted to the eastern part of this area, in particular the eastern-most sector of the Peterstone section and the St Brides section.

There were very few sightings of Knot at the three study sites. A single juvenile bird was seen at the Taff/Ely site in September 1992 and two adult birds were seen in January. At the Rhymney site, four birds were seen in January. No other birds were seen during the study period.

In the previous two winters, flocks of Knot were present on the northwest Severn but as with this current year, they were found on the eastern sections. Although Knot have been known to winter in moderate numbers in the past at the Taff/Ely site, the detailed studies over the four years have not located many birds.

3.14 Dunlin

The Severn Estuary is internationally important for Dunlin with over 40,000 birds wintering there (Cranswick *et al.*, 1992). Small numbers of birds are also found at inland sites, but the vast majority are found on estuaries around the shores of Britain. Over half a million birds, mainly of the *alpina* race, winter in Britain while Dunlin of two other races may be present during migration.

Autumn 1992

The Dunlin observed during the early part of autumn are likely to be birds on migration to north and west Africa. Very few birds were seen at the Taff/Ely site of which only a small proportion were feeding (Figure 3.14.1). These were located on the mudflat adjacent to the creeks that emerged from the saltmarsh, sector 11. Small numbers of feeding birds were present at both the Orchard Ledges and the Rhymney sites (Figure 3.14.2). At the Orchard Ledges site, a few Dunlin were observed feeding on the muddier areas between the stony patches of both sectors. At the Rhymney site, the feeding Dunlin were all found on sectors to the east of the Cardiff eastern sewer from August through to October.

The number of Dunlin at the Taff/Ely site was low, with a mean peak of less than twenty five birds (Figure 3.14.3a). Some birds arrived on the mudflats near to the time of low tide with the main flocks present three hours after low tide. The largest flock observed was of thirty five birds roosting over the high tide period outside of the counting areas. Larger numbers of Dunlin were present at the Rhymney site (Figure 3.14.3c). The birds were present throughout the tidal cycle over the autumn period with all birds on the study areas feeding. Larger flocks of Dunlin were seen to be roosting on the shingle beach outside of the counting areas over the high tide period. The largest number of birds observed was a group of 140 roosting in the corner of the bay near to sector 17.

Although the number of Dunlin at the Taff/Ely site in the autumn of 1991 was also low, there was a higher level of usage than in 1992, with feeding birds widely distributed in the central and southern part of the bay. At the Rhymney site, there was considerably higher usage of all sectors to the east of the River Rhymney and low levels of usage on many sectors to the west of this area in the previous autumn. The number of birds at all three sites was higher, particularly at the Rhymney site. This could well have resulted from an earlier return of wintering birds that year rather than much higher numbers of passage migrants.

Winter 1992/93

Low tide counts of feeding Dunlin on the northwest Severn during the winter showed that this species was present on all sections (Figure 3.14.4). The highest concentrations of the feeding flocks were on the Peterstone and St Brides sections.

During the winter, large flocks of Dunlin entered the bay at the Taff/Ely site and fed on the mudflats for part of the tidal cycle. The feeding birds were widely distributed over the sectors of this site with the main feeding groups being located on the sectors to the south and west of the River Taff (Figure 3.14.5). Only much lower numbers of feeding birds were found in the inner harbour area (sectors 15, 16, 18 and 19) and the inner estuary, north of the PDR work (sectors 7, 8, 9 and 10). Small numbers of Dunlin were observed feeding at the Orchard Ledges site (Figure 3.14.6) with the sandier areas at the eastern end of sector 2 being the preferred feeding areas. At the Rhymney site, feeding Dunlin followed the tide line and were therefore widely distributed over a period of time. This pattern of behaviour produced an even level of usage of the sectors to the east of the Cardiff eastern sewer. Most sectors of this site were used by feeding birds with the other concentration of feeding activity being sectors 4 and 7, at the western end of the study area.

The mean peak number of Dunlin at the Taff/Ely site was over 1,000 birds (Figure 3.14.7a). The use of this site by Dunlin was not predictable and on some days almost no birds were seen. On the days that Dunlin were present, large flocks, sometimes of several thousand entered the bay after high tide and spread out as feeding flocks on the central and southwestern sectors. Several hundred to more than 1,000 birds roosted in the bay on some days. These would move onto the mudflats adjacent to the saltmarsh initially as the tide receded before spreading onto more central areas. As the water level dropped, the feeding birds moved to sectors nearer the mouth of the bay before flying off to alternative feeding grounds. Frequently, large flocks would return to the mudflats as the tide was rising, again feeding mainly on sectors 2-5. Flocks of 2,000-4,000 were observed in the bay on some days.

The presence of Dunlin at the Orchard Ledges site was much less predictable. On many observation days, no Dunlin were seen. Flocks of twenty to thirty birds were frequently seen but on some days larger numbers were present (Figure 3.14.7b).

These birds flew in as the falling tide uncovered suitable feeding areas, mainly at the extreme east and west of the site, but they usually remained there for only short periods of time. At Rhymney, there were larger flocks of Dunlin (Figure 3.14.7c). These birds arrived from roost sites outside of the study area, with numbers increasing as the extensive mudflats became uncovered and peaking three hours before low tide. The number of birds then steadily declined during the rest of the tidal cycle. The mean peak number of birds was almost 2,500.

At all three sites, nearly all the Dunlin were observed to be feeding for the whole time that they were on the study areas.

The distribution of feeding Dunlin on the northwest Severn was very similar to that of the previous winter but there was a reduction in the numbers on the Rhymney section and the western half of the Peterstone section in the current study. The results of the first three years of the study were comparable and this decline has only been evident in the current year.

The distribution of feeding Dunlin at the Taff/Ely site was very similar to that observed in 1991/92 although there was a higher level of usage on sectors 4-6. At the Orchard Ledges and Rhymney sites, almost all sectors showed a reduction in the level of usage compared with the previous winter. These differences appear to be partly the result of changes in the sizes of the Dunlin populations at the three sites. The mean peak number of birds at the Taff/Ely site was about 25% higher in the current study. At Orchard Ledges there were more Dunlin staying on the study area for longer in the 1991/92 winter. Even more noticeable was the decrease in the number of Dunlin at the Rhymney site in 1992/93 compared with 1991/92. The pattern of behaviour during the tidal cycle was very similar but the mean peak number of birds at the site was 2,500 compared with almost 4,000 in 1991/92.

A Comparison of the Four Winters

Since the 1989/90 winter, there has been a shift in the pattern of areas used by feeding Dunlin at the Taff/Ely site. Four winters ago, usage by Dunlin was more even throughout the site with relatively higher levels of feeding occurring on sectors 7, 10, 12 and 16 than was found in the current study. The number of birds was higher during that winter than in the following two years but the current study has shown an increase to nearer the former level. There has been little change in the usage at the Orchard Ledges site since 1989/90 although the number of birds has shown some limited fluctuation. At the Rhymney site, however, there have been changes in the distribution and number of Dunlin since the first year of the study. There has been a reduction in usage of sectors to the west of the River Rhymney and a corresponding increase on those sectors east of the river. The peak number of birds has fluctuated between 2,500 and over 4,000 over the four winters.

At the Taff/Ely site, there has been high variation in the feeding usage of many of the sectors (Figure 3.14.8a). Some of the sectors showing the highest variation are in the northwest part of the study site. Most of these have only a low usage density (Figure 3.14.8b). Although large numbers of Dunlin enter the bay to feed at times, they are usually only present for part of the tidal cycle and therefore usage and usage density of birds is relatively low throughout the study site. Sectors 3 and 17 have the highest usage density but these have still shown moderate to high variation over the four winters.

At Orchard Ledges, variation in feeding usage has been high over the four years, but this site is used by relatively small numbers of birds and therefore the usage density is low (Figures 3.14.9a and b). The sectors of the Rhymney site hold the highest concentrations of Dunlin during the tidal cycle for the three study areas. In particular, the sectors lower down the shore support large numbers of feeding birds around the low tide period and these have therefore the highest usage density. These sectors have shown moderate levels of variation in usage, the lowest variation being found on those sectors east of the Cardiff eastern sewer that have lower levels of usage density.

The usage density of Dunlin on the sectors of the three sites was not related to their exposure time (R^2=0.101, n=38, P=0.051 - not significant) (see Figure 3.14.10a). Flocks of Dunlin feed mostly on areas of mud recently uncovered by the tide and hence follow the receding water down the shore, moving from sector to sector. On the other hand the coefficient of variation of Dunlin usage was strongly correlated with mean usage (R^2=0.184, n=38, P=0.0073) (see Figure 3.14.10b); in other words, if an area is 'preferred' or used by large numbers of Dunlin in one year it is very likely to be also used by high numbers of Dunlin the following year.

Spring 1993

The number of overwintering Dunlin was showing a marked decrease during March and by April almost all the birds had left for their breeding grounds. No Dunlin were seen at the Orchard Ledges or Rhymney sites during spring. At the Taff/Ely site, one group of five birds was seen briefly in April and a further group of four birds in summer plumage was seen on sector 17 in May. One further group of about thirty five birds was observed flying around and then out of the bay.

The above observations were comparable with the findings from the previous three years.

3.15 Curlew

The preferred wintering habitat for Curlew in Britain is large estuarine mudflats. Part of the British breeding population moves south to the continent to overwinter while the British wintering population is enlarged by birds migrating from Scandinavia (Lack, 1986). The Severn Estuary was the seventh most important wintering site in the United Kingdom in 1991/92 and although the numbers were of national importance, they fell just below the level for international importance (Cranswick *et al.*, 1992). The British and Irish wintering population is about 200,000 birds.

Autumn 1992

By early autumn there were already moderate numbers of Curlew at all three sites. At the Taff/Ely site the highest concentration of feeding birds was on the mudflats adjacent to the mouth of the estuary, sector 2 (Figure 3.15.1). Feeding Curlew were also present on several other sectors in the centre and east of the bay but were not found north of the PDR or in the inner harbour (sectors 15 and 19). Both sectors of the Orchard Ledges site supported feeding Curlew (Figure 3.15.2). At the Rhymney site feeding birds were found on almost all sectors but highest levels of usage occurred on the sectors that were lower down the shore on both sides of the River Rhymney.

At the Taff/Ely site, Curlew roosted over the high tide period in the saltmarsh at the north east part of the bay. As the tide receded, the birds left the roost site and moved onto the mudflats in front of the saltmarsh. Initially, only about fifty percent of the Curlew were feeding (Figure 3.15.3a). As the tide fell further, the birds started to leave the site reducing the number of birds to about 25% of its maximum. This part of the tidal cycle coincides with nearby known feeding areas (including Orchard Ledges) becoming uncovered by the falling tide. The birds that remained at the Taff/Ely site were feeding throughout the low tide period. As the tide level rose, the Curlew returned to the Taff/Ely site and by three hours after low tide all the birds present were roosting.

The number of Curlew increased sharply as the shore at Orchard Ledges became uncovered by the falling tide (Figure 3.15.3b). Many of these birds could be seen to arrive from the Taff/Ely site. The birds then fed throughout the low tide period before leaving the site as the tide level started to rise. At Rhymney, the pattern of behaviour during the tidal cycle was less well defined. Curlew arrived from roosts outside of the study site and started feeding on the sectors as they became uncovered by the falling tide (Figure 3.15.3c). There was a decrease in the number of birds at the site during the low tide period but this was not as clear cut as at the Taff/Ely site. The number of birds again increased as the tide level started to rise and the proportion of birds feeding fell sharply.

The pattern of usage at the Taff/Ely and Orchard Ledges sites was similar to that found during the previous autumn. The 1990 observations at the Rhymney site compared with autumn 1991 had shown a marked increase in usage of most sectors, especially those lower down the shore west of the Cardiff eastern sewer. The usage values obtained for the current study show a reduction on these sectors, but they were still higher than in 1990. The number of birds, and their behaviour during the tidal cycle, has been very similar at the three sites for the three autumns observed, other than an increase in the number of Curlew at the Rhymney site between 1990 and 1991.

Winter 1992/93

Feeding Curlew were widely distributed along the northwest Severn at low tide (Figure 3.15.4). The concentration of birds was not high on any of the sections.

The highest level of usage at the Taff/Ely site was on the sectors adjacent to the river mouth (sectors 2, 5 and 17) but with moderate levels of usage of some other sectors (Figure 3.15.5). As in the autumn, feeding birds were not found on the western-most sectors, north of the PDR work or in the inner harbour area (sectors 15 and 19). Both sectors of the Orchard Ledges site had higher levels of usage than sectors in the Taff/Ely study area (Figure 3.15.6). At the Rhymney site, almost all sectors were used by feeding Curlew (Figure 3.15.6). Usage was much more even over this site than in autumn but was not very high.

The numbers of birds, and the pattern of behaviour during the tidal cycle for the three study sites, was very similar to that described for the autumn period and need only be covered briefly (Figure 3.15.7). The pattern of behaviour at the Taff/Ely site was again very clear, with Curlew leaving their roost areas, post-roosting on the mud, leaving the area as the tide fell or staying within this study site to feed until two to three hours after low tide (Figure 3.15.7a). At the Orchard Ledges site, the number of birds increased as the site became uncovered by the falling tide, but the number of birds was lower than in the autumn (Figure 3.15.7b). The number of Curlew at the Rhymney site was also lower than the autumn total (Figure 3.15.7c). The number of birds increased as the tide receded and, unlike in autumn, the highest number of birds present was over the low tide period. Almost all the birds were feeding for about three hours before and after high tide. The number of birds was reduced as the tide rose again, with birds leaving the area to roost elsewhere.

The distribution of feeding Curlew along the northwest Severn was very similar to that observed the previous winter. Other than minor variations in the number of birds on some sectors, the pattern of distribution has shown no major change during the four years of study.

The distribution of feeding Curlew at the Taff/Ely site was similar to the 1991/92 winter but there was a higher level of usage on almost all the sectors that had feeding birds. At the Orchard Ledges site, in 1991/92 there was a higher level of usage of sector 1 than of sector 2 but the usage was very similar for the two sectors during the current winter. Usage at the Rhymney site showed a number of changes compared with the previous winter. The usage of the different sectors in the current winter was very even but in 1991/92 there was much higher usage of sectors to the west of the Cardiff eastern sewer especially at lower tide levels on sector 8. East of the sewer there were also differences, with the areas higher up the shore having increased usage during the 1992/93 winter compared with the previous winter.

The number of birds at the three sites showed some variation compared with the previous winter. At the Taff/Ely site, the number of birds increased by about 25% but the pattern of behaviour during the tidal cycle remained very similar. Compared with the winter of 1991/92, Curlew numbers increased quicker as the tide fell at the Orchard Ledges site and more birds remained at the site until forced to leave by the rising tide. The change in usage at the Rhymney site already referred to was associated with a 25% decrease in the number of Curlew at the site since 1991/92.

A Comparison of the Four Winters

Over the four years there does not appear to have been a consistent change in the feeding behaviour of Curlew at the Taff/Ely site. This is true, also, of the Orchard Ledges and Rhymney sites. Although there have been between-year variations there has not been a clear shift in the pattern of usage. The number of birds at the Taff/Ely site has not shown a consistent increase and the number of birds observed during the present winter's study was comparable with that found during the first of the four winters. The number of Curlew at the Orchard Ledges site has fluctuated over the four years with low numbers in 1989/90 being followed in the next winter by the highest numbers observed during the whole study. The number of birds observed at the Rhymney site showed a noticeable increase in the winter of 1991/92 before falling again in 1992/93 although the numbers were still higher than the first two winters. The pattern of behaviour during the tidal cycle for each study site remained very similar.

A large part of the Taff/Ely site shows high levels of variation in feeding usage over the four winters (Figure 3.15.8a). Almost all of these areas are sectors with low feeding usage density and such variation is not therefore of importance (Figure 3.15.8b). The sectors that were used most regularly by Curlew and had the higher usage densities showed relatively low levels of variation. This is especially true of sector 17, the area with the highest usage density and the lowest level of variation. This confirms the observations made during the routine counts. Curlew followed a fairly rigid pattern, spreading out onto sector 17 as the tide fell, feeding and then possibly flying to areas outside of the bay, then returning to feed and pre-roost before moving up the shore with the rising tide.

There has been little variation in the feeding usage over the four winters at Orchard Ledges (Figure 3.15.9a). The usage density of this area is relatively low (Figure 3.15.9b), with this large area supporting only a moderate number of birds but their feeding behaviour has been consistent over the whole study period. At the Rhymney site, the large sector number 14 had a relatively high usage density and the pattern of usage was similar over the four winters (Figures 3.15.9a and b). Higher variation was found on the sectors with lower usage.

The usage density of Curlew on the sectors of the three sites was not related to their exposure time (R^2=0.102, n=38, P=0.050 - not significant) (see Figure 3.15.10a) with some areas uncovered for longer periods sometimes supporting few Curlew for short periods and others having a relatively high feeding usage density. On the other hand, the coefficient of variation of Curlew usage was strongly correlated with mean usage (R^2=0.244, n=32, P=0.0041) (see Figure 3.15.10b); in other words if an area is 'preferred' or used by large numbers of Curlew in one year it is very likely to be also used by high numbers of Curlew the following year.

Spring 1993

The majority of Curlew had left the study sites by early spring, moving to their breeding grounds.

Small numbers of feeding Curlew were present at the Taff/Ely site throughout the spring study period (Figure 3.15.11). Their distribution was very similar to that observed

during the winter, with birds feeding on the central and southern sectors of the bay. Only single birds were observed feeding at the Orchard Ledges site on several occasions. At Rhymney, small numbers of birds were feeding on sectors throughout the study area (Figure 3.15.12).

The number of birds was low at all sites (Figure 3.15.13). The mean peak number of birds at the Taff/Ely site was ten birds. Their behaviour during the tidal cycle followed the same pattern as that observed during the winter with two peaks of numbers either side of the low tide period. At the Rhymney site, the mean peak number of birds was six and, as in the winter period, this occurred near to the time of low tide.

The feeding distribution of Curlew at the Taff/Ely site has shown some variation during the four years of the study. There was a moderate level of usage of sector 2 in spring 1990 but in the following two springs usage was too low to be recorded. The number of birds has, however, remained low in spring over the whole study period. There has been a decline in the usage of the sectors at the Orchard Ledges site over the four years of the study. There was a moderate level of usage of both sectors in spring 1990 but this reduced over the next three springs to almost none. There has been no consistent change at the Rhymney site over the four years with no feeding distribution recorded in spring 1991 but different patterns of feeding of the low number of birds during the other years.

3.16 Redshank

Large numbers of Redshank breed in Britain. The majority of these move to coastal areas to winter where their numbers are increased by migrants mainly from Iceland (Lack, 1986). The wintering population probably exceeds 100,000 birds. The Severn estuary is internationally important for Redshank (Cranswick *et al.*, 1992). Because Redshank are known to be site-faithful to their wintering grounds (Hale, 1986; Donald & Clark, 1991a; Toomer & Clark, 1992a), even sites that hold populations below the level of national importance can be important for such a species.

Autumn 1992

Redshank were already present at the Taff/Ely site in early autumn. Feeding birds were widely distributed throughout the study site but with most birds on sectors north of the River Taff (Figure 3.16.1). The highest usage was on sectors 8 and 9, north of the PDR work and sector 19 in the inner harbour. No Redshank were present at the Orchard Ledges site. At the Rhymney site, almost all of the feeding Redshank were found on the sectors adjacent to the east side of the River Rhymney (Figure 3.16.2). Here, the birds could be seen to spend much of the time that the areas were uncovered feeding within a short distance of the river bank. On sectors 15 and 16, Redshank would move down the side of the bank as the water level fell in the river and remain out of site for considerable lengths of time during some observations. The usage of these areas was inevitably under-recorded.

The autumn population of Redshank at the Taff/Ely site was high from August onwards. At high tide roost, the number of birds was estimated to be over 460 on one day at the end of August. As the tide receded, the Redshank spread out onto the sectors to

feed and the numbers increased on the counting areas through the tidal cycle, reaching a maximum three hours after low tide (Figure 3.16.3a). A large proportion of these, especially the birds on the side of the inner estuary (sectors 8, 9 and 10), were observed to roost for long periods during the tidal cycle. The mean number of birds observed on the counting sectors at the Rhymney site during the all day counts ranged from fifty to over 150 birds but with no clear pattern of peaks (Figure 3.16.3c). Most of these were feeding throughout the tidal cycle from high tide through to two hours after low tide. Because of the habit of these birds of moving onto the steep banks of the River Rhymney in the far part of the site and not being visible at times, the population estimated by the all day counts is lower than the number of birds actually present. The number of birds present on one day in October for example was in excess of 490, but a large part of this population was out of sight for some of the counts.

In the autumn of 1991 feeding Redshank were widely distributed on the mudflats of the Taff/Ely site sectors. Far more of the birds were feeding on sectors in the central and southern part of the bay with lower usage of the sectors north of the PDR than was found in 1992. At the Rhymney site, the distribution of feeding birds was almost the same in 1991 as was observed during the current study. However, there was a much lower level of usage of sectors 14, 15, and 16 during the 1992 autumn. The mean peak number of birds at the Taff/Ely site was higher in 1992 than in 1991 and the pattern of behaviour during the tidal cycle showed a number of differences. In 1991 the number of birds fluctuated much less during the tidal cycle, with a decrease over the low tide period. Then, most of the birds were feeding for a large part of the time that the mudflats were uncovered. This is in contrast with what has been described for 1992. At Rhymney, the number of birds was higher in 1991, ranging from 250-600 during the tidal cycle. As has already been explained, the true number of Redshank at the Rhymney site in 1992 was much higher than that shown in Figure 3.16.3c and was near to that of the previous autumn.

The usage values for the Taff/Ely site in 1990 were higher than those for the two following autumns with an even distribution throughout the study site. The number of birds was markedly lower in 1990, especially compared with 1992, and the higher usage values were as a result of a higher proportion of birds feeding throughout the tidal cycle. The number of birds recorded on the sectors at the Rhymney site in 1992 was the lowest for the three autumns studied but, as has been explained, is partly a result of a change in behaviour rather than just a reduction in the number of birds.

Winter 1992/93

The low tide counts on the northwest Severn showed feeding Redshank to be mainly associated with the side estuaries of the Severn (Figure 3.16.4). The main concentrations of birds were at the Taff/Ely, Rhymney and Usk estuaries with very few feeding birds elsewhere along this part of the Severn Estuary.

Feeding Redshank at the Taff/Ely site were very widely distributed in the winter period with all sectors being used to some extent (Figure 3.16.5). The higher levels of usage occurred on the sectors adjacent to the water channels running from the inner harbour (sectors 15, 16, 18 and 19) and at the west part of the site (sectors 3 and 4).

The sectors on the side of the River Taff, north of the PDR work, which had been the main feeding areas in autumn had only average levels of usage compared with the rest of the site at this time of year. No Redshank were present on Orchard Ledges during the winter. At the Rhymney site, feeding Redshank were located almost entirely to the east of the Cardiff eastern sewer (Figure 3.16.6). Usage of sectors 15 and 16 was similar to that in autumn but there was a higher level of usage of sectors 10 and 14 and feeding birds were also found on sectors 1, 11, 12 and 17 during the winter.

The number of Redshank at the Taff/Ely site varied from 150-250 for most of the tidal cycle with a noticeable increase after the low tide period (Figure 3.16.7a). Approximately 80% of the birds were feeding for most of the tidal cycle. Redshank feed in runnels and small creeks and some of the population on the sectors may be out of sight at any one time. The number of Redshank at high tide roosts counted in mid-winter at the Taff/Ely site as a part of other fieldwork ranged from 350-410 birds. This value is noticeably higher and, as Redshank were not observed to move in or out of the bay, it is probably a truer estimate of the maximum number of birds at the site. The number of Redshank at the Rhymney site showed two clear peaks during the tidal cycle (Figure 3.16.7c). Redshank were not observed leaving the area at the low tide period and the dip in the number of birds must be accounted for by some of the feeding population being out of sight on the banks of the river. Feeding continued with most of the birds until four hours after low tide when most of the birds started to pre-roost. On a number of observations, Redshank flew onto the west bank of the river on the eastern edge of sector 10. In this position the birds were out of sight until the rising level of water moved them higher up the bank and into view. This in part accounted for the drop in numbers between three and four hours after low tide.

The low tide distribution of feeding Redshank on the northwest Severn was very similar to the results for the 1991/92 winter. Other than minor changes in the number of birds on the main sectors, and the presence of low numbers on a variety of other sectors, the situation has been relatively stable for the four years of the study.

The feeding distribution of Redshank at the Taff/Ely site in 1991/92 was comparable with that for the winter of the current study with only minor changes in usage of some of the sectors. This was true also for the Rhymney site, although there were almost no feeding Redshanks seen west of the Cardiff eastern sewer.

The number of Redshank observed during the tidal cycle at the Taff/Ely site was similar for the current and previous winter. There had been a slight shift in behaviour, with a larger peak of numbers being countable after low tide and a lower proportion observed feeding for a large part of the tidal cycle. There had been a reduction in the number of birds at the Rhymney site since the 1991/92 winter together with a shift in the pattern of behaviour. In 1991/92 the number of Redshank observed at the site increased as the tide receded until low tide and then decreased again on the rising tide. This is in contrast with the situation observed during the current winter's study when the number of Redshank seen was lower either side of the low tide period. The probable reason for this has already been discussed above.

A Comparison of the Four Winters

There have been no major changes in the distribution of feeding Redshank at the Taff/Ely site during the four winters of the study. All sectors of the site have been used by feeding birds with an even spread of usage. Sector 7 is one sector where there has been a consistent change. Very few feeding Redshank were observed on this area during the 1991/92 and 1992/93 winters. This sector is the one that has been subjected to the largest change as a result of the PDR development. The pattern of usage at the Rhymney site has also shown little major change during the four winters. The main noticeable difference has been in the reduction in usage of the sectors to the west of the Cardiff eastern sewer especially on those sectors immediately adjacent to it.

The number of Redshank at both the Taff/Ely and Rhymney sites has shown some fluctuation over the four year study period but with no obvious long-term increase or decrease. Similarly, the pattern of behaviour during the tidal cycle has shown some variation but with no sign of a consistent shift to a new pattern.

There has been very little variation in the level of feeding usage on much of the Taff/Ely site during the four years of study (Figure 3.16.8a). The areas that support the highest levels of feeding usage per hectare (e.g. sectors 3, 9 and 15) have been very stable over the four winters (Figure 3.16.8b). Sector 7 has shown a large amount of variation and this was one of the areas most affected by early developments of the PDR. This sector now supports fewer feeding birds. The other area showing high variation, sector 13, has a very low feeding usage density. The other areas near to the PDR and Phase 1 and 2 development work (sectors 8, 10, 11 and 12) have shown moderate levels of variation.

At the Rhymney site, those sectors that are regularly used by feeding Redshank (sectors 10, 11, 15 and 16) show little variation over the four winters, in contrast with the less well used areas where variation was moderate to very high (Figure 3.16.9a and b).

The usage density of Redshank on the sectors of the three sites was strongly correlated with their exposure time (R^2=0.010, n=38, P=0.0001) (see Figure 3.16.10a) with sectors which remained uncovered for longer periods having a higher usage density. The coefficient of variation of Redshank usage was also strongly correlated with mean usage (R^2=0.210, n=36, P=0.0049) (see Figure 3.16.10b); in other words if an area is 'preferred' or used by large numbers of Redshank in one year it is very likely to be also used by high numbers of Redshank the following year.

Spring 1993

Almost all of the Redshank that overwinter at the study sites had left for their breeding grounds by early spring and only low numbers remained.

At the Taff/Ely site, small groups of feeding Redshank were found on the east side of the River Taff north of the PDR crossing (sectors 8 and 9) and on sector 4 (Figure 3.16.11). A maximum of eleven birds was seen on one count but the few groups seen were usually less than this. No birds were observed any further east than this and by

May no further Redshank were seen at the site. No Redshank were seen at the Orchard Ledges or Rhymney sites in spring.

Very few Redshank have been seen at the Taff/Ely site in spring during the long-term study so far. In all years, when present, the birds have been restricted to the western part of the site. Usage of these sectors has shown some fluctuation and sector 7 has not had feeding Redshank present for the last two springs. No Redshank have been seen at the other two sites during the four springs.

3.17 Turnstone

Turnstone are present around the coast of Britain throughout the year. The birds that are present during the summer are first-year birds that have remained after migrating to Britain to overwinter. Adults of the Canadian/Greenland breeding population return to Britain to overwinter, arriving from July onwards. Scandinavian breeding birds also pass through Britain on migration to Africa (Lack, 1986). Turnstone are site-faithful during the overwintering period and from one winter to another (Metcalfe & Furness, 1985).

Autumn 1992

Almost the only area used by Turnstone at the Taff/Ely site is along the side of Ferry Road, on the rocky area of the upper shore (Figure 3.17.1). On some tides the birds fed on the weed-covered stones although more frequently they were inactive and roosting. The Orchard Ledges site was well-used by feeding Turnstone during the year. Some birds were present in August but the numbers increased through the autumn period with moderate usage of both sectors (Figure 3.17.2). It is likely that this species is under-recorded at low tide times because of the nature of the broken rock surface and the cryptic coloration of the birds. At the Rhymney site, feeding Turnstone were present in low numbers in autumn (Figure 3.17.2). The feeding birds were nearly always located in the corner of the bay by sector 17 occasionally moving onto the west end of sector 15.

The number of birds at the Taff/Ely site showed two peaks either side of low tide (Figure 3.17.3a). Turnstone were more commonly present on the rising tide when alternative feeding areas were becoming covered. At the Orchard Ledges site, Turnstone were observed to fly in from other areas about three hours before low tide and to start feeding on both sectors (Figure 3.17.3b). As the tide fell, the feeding birds moved down the shore near the water's edge where they were very difficult to see. By the end of the autumn period, flocks of over eighty birds were seen on some occasions. The number of birds at the Rhymney site was low with more birds being seen on the rising tide, a very similar pattern to that described for the Taff/Ely site (Figure 3.17.3c). Some of the Turnstone that were observed to feed at this site were seen to roost on the shingle shore above sector 17 at high tide on some occasions.

The autumn usage at the Taff/Ely and Orchard Ledges followed the same pattern of distribution in 1991 but was higher on all the sectors involved. The usage at the Rhymney site, although not very high in 1992, was noticeably lower in 1991. More birds were present at the Taff/Ely site in 1991 with the mean peak following low tide

being almost four times the 1992 peak. The pattern of feeding in 1991 was somewhat erratic. At Orchard Ledges, more birds were recorded during most of the tidal cycle in the autumn of 1991 and the reduction in numbers over the low tide period was not noted. The numbers and pattern of behaviour during the tidal cycle at the Rhymney site was similar for both autumns.

In the earlier autumn of the study, in 1990, Turnstone were feeding near to Ferry Road but were also observed on sector 7. No birds were seen on this latter area in the following two autumns and, as has already been stated, this is the sector that has been subjected to most change. Although the usage at the Orchard Ledges site was higher in 1991 than 1992, this does not appear to be a consistent change as only moderate usage was recorded in 1990.

There has been no major change in the number of Turnstone or in the pattern of behaviour during the tidal cycle at any of the study sites in the three autumns of the study.

Winter 1992/93

Low tide counts of waders and wildfowl on the northwest Severn reveal that Turnstone were only found on the Rhymney section (the Orchard Ledges site of the all day counts) (Figure 3.17.4).

Turnstone were located on sector 3 at the Taff/Ely site and the level of usage was similar to that in the autumn period (Figure 3.17.5). Feeding birds were not observed in other areas of the site. Both sectors of the Orchard Ledges site had higher levels of usage than in the winter period (Figure 3.17.6). The distribution of feeding birds and the level of usage at the Rhymney site was very similar to that described for the autumn period.

Flocks of up to fifty Turnstone roosted over high tide on the stones adjacent to Ferry Road at the Taff/Ely site. Some of these fed along the lower stones as the tide fell and more returned to feed on the rising tide (Figure 3.17.7a). At Orchard Ledges, the population of Turnstone was much higher with a maximum of over 150 birds being seen at the site. Two peaks of numbers of birds was recorded with a marked dip over the low tide period (Figure 3.17.7b). While suitable areas were uncovered, all the Turnstone were observed to feed throughout the tidal cycle. At the Rhymney site the Turnstone were again only present up until two to three hours before low tide and one to two hours afterwards (Figure 3.17.7c). The mean peak number of birds was ten.

At low tide on the northwest Severn, Turnstone were found on the Rhymney section during both the current and the previous winter. Counts for the first two years of the study confirms this to have been the situation for the whole study period.

In the winter of 1991/92 a group of Turnstone was observed feeding on sector 18, otherwise the feeding birds were restricted to sector 3. The feeding distribution and level of usage at the other two sites was also very similar in the winter of 1991/92.

The number of Turnstone, and their pattern of behaviour during the tidal cycle at the Orchard Ledges and Rhymney sites, was comparable for the winters of 1991/92 and 1992/93. More birds were recorded on the Taff/Ely site in 1992/93 than in the previous winter. This may, in part, be because the Turnstone on sector 3 were found further up the shore on some occasions in 1991/92 and were outside of the counting area.

The main variations in feeding distribution and level of usage at the three sites over the four years of the study have been minor and the presence of Turnstone at the study sites has been very consistent. The largest change was in the number of Turnstone observed at the Orchard Ledges site during the first year of the study which was appreciably lower than the subsequent years.

Spring 1993

No Turnstone were seen at the Taff/Ely or Rhymney sites during the spring of 1993. At the Orchard Ledges site birds were still present in April on both sectors (Figure 3.17.8). Flocks of up to forty eight were seen to fly in as the tide receded on sector 1 and to spread out over both sectors (Figure 3.17.9b). The birds were not located after the low tide period. No Turnstone were seen in May at this site.

These findings are comparable with the observations in the spring periods of the previous three years.

3.18 Other Wader Species

Waders frequently stop on route when migrating to their wintering grounds. This may a brief stop to feed or can be a longer stop for partial moult. There is always the potential at suitable habitats for migrating birds to stop-over regularly. The extra observations of waders at the study sites includes such passage migrants as well as overwintering birds but none is present in large numbers.

At the Taff/Ely site, single Black-tailed Godwit were seen in September, December and May and three birds were present briefly in January. This wader overwinters in Britain mainly at other estuaries and also breeds in small numbers in the south and east of Britain. In August, three Bar-tailed Godwit were seen on one day. This wader winters on other estuaries around the coast of Britain. Snipe are resident waders and there are certainly some that spend the winter at the Taff/Ely site. Very occasional sightings were had of birds flitting up and down in the saltmarsh area as it became inundated by the rising tide at the edge of the bay. Because of their habit of remaining in the saltmarsh to feed and roost Snipe are not easily seen. Whimbrel are primarily passage migrants, only stopping around the coasts of Britain as they migrate to and from their breeding grounds. Two to three Whimbrel were present at the Taff/Ely site during the study period in April and May feeding and roosting near the edge of the saltmarsh adjacent to Ferry Road.

At the Orchard Ledges site, the only additional wader observation was of a single Bar-tailed Godwit in May.

4. DISCUSSION AND CONCLUSIONS

This is now the fourth year of intensive monitoring of the waders and wildfowl populations of the northwest Severn in relation to the proposed Cardiff Bay Barrage. With several years data it is becoming possible to obtain a picture of the status of the bird populations excluding normal between-year variations. This will be essential if the fate of the birds displaced by building of the barrage is to be determined. The developments that have had an effect on the habitats within Cardiff Bay so far are relatively minor compared to those of the final barrage. These changes have resulted from the work on the PDR and the Phase 1 and 2 land reclamations and have had some effects on the bird populations.

These effects are discussed below, with particular emphasis being given to the most important species.

Shelduck

There has been no major change in the number of Shelduck at the Orchard Ledges and Rhymney study sites during the autumn and winter period compared with the previous years of the study. The most notable changes have been in the increasing numbers of wintering Shelduck at the Taff/Ely site and, to a lesser extent, the increasing numbers of birds at the Rhymney site during the spring. These increases have been associated with some changes in distribution. At the Taff/Ely site the number of Shelduck has increased over the four years of observations. There has not been a corresponding decrease at the adjacent sites and these birds must come from outside of the study area. There has been very little change in the national numbers of Shelduck as revealed by the BoEE counts from 1972 to 1990 (1972-75 = 62,000; 1987-90 = 67,000), although the British population showed a January peak of 84,000 in 1991. Increases at the Taff/Ely site are probably the result of limited redistribution within the Severn Estuary as this apparent national increase was not accompanied by an increase at the Severn Estuary (Cranswick *et al.*, 1992).

Perhaps more pertinent to this study are the changes in distribution within the Taff/Ely study site itself. There was an increase in feeding activity on areas in the southwest of the study site, with a corresponding decrease in usage of sectors adjacent to the main areas of disturbance from engineering contractors in the northwest of the site. Koepff and Dietrich (1986) showed that Shelduck are fairly susceptible to disturbance and flocks on the water were observed to fly away when approached within 300-500m by a small boat. These disturbed areas have shown the highest variation over the four years, but this may not be particularly important as they only hold small numbers of feeding birds. The areas holding the highest density of feeding Shelduck are not subjected to this disturbance and have shown less variation.

The use made of the lower areas of the Orchard Ledges study site by feeding Shelduck has continued, but the rise in usage since 1989/90 noted in the last report has not been maintained. The areas well-used by feeding birds at the Rhymney site have shown only moderate levels of variation over the four years and the pattern of feeding at the site has been fairly stable.

Analyses of the data from the four years has shown no significant relationship between the relative amount of feeding that occurs on the sectors of the study sites during the tidal cycle and the time that the sectors remain uncovered by the tide. The level of the variation of the

feeding usage was not related to the amount of feeding that occurred on the sectors. High and low levels of variation were found over the four years on areas that were either well used or used very little by feeding birds.

Mallard

Although there have been changes in the feeding distribution of Mallard within the Taff/Ely and Rhymney study sites, the size of this population compared with the national population makes such changes insignificant. The changes that have occurred at the Taff/Ely site have shown a shift in distribution away from the edges of the freshwater channels near the PDR and Phase 1 work to areas in the east of the study site. Although Mallard are very familiar birds in areas subjected to high pressure from the public, such populations are only a small part of the national population and the majority of birds are relatively sensitive to disturbance. The changed pattern of Mallard feeding may therefore have been influenced by the development work within the bay.

Teal

The importance of the Taff/Ely and Rhymney study sites for Teal is not necessarily apparent from this study as the birds spend much of the time during the hours of daylight roosting on the open water and use the hours of darkness to feed (Toomer & Clark, 1992). There have been minor changes in the feeding distribution of Teal at the Taff/Ely site since 1991/92. Of the small proportion of the population that were observed feeding, there has been a reduction in the number of birds feeding on areas of the River Taff north of the PDR crossing. The number of birds found in the channels running down the east side of the bay has increased. The latter areas are free from any disturbance when the mudflats are uncovered by the falling tide.

Pintail

Pintail continued to restrict their feeding activity to parts of the Rhymney study site and only minor changes in their distribution on the mudflats have been noted. As this species is not found at the Taff/Ely site, changes in the bay will only affect it indirectly. As the diet of Pintail, which includes *Macoma*, *Neiris diversicolor* and plant seeds, overlaps with Shelduck and several of the wader species, any displacement of birds from the Taff/Ely site could result in increased competition for such food items. Overall, the only detectable changes in the Pintail population have been slight shifts in the preferred feeding areas which could have resulted from changes in the density of prey items in some of the sediments.

Pochard

Pochard can be found in large numbers offshore near the Rhymney site at times during the winter. Although variable numbers have been observed at the study sites during the four winters, only very low numbers have ever been seen feeding at the water's edge or roosting on the count areas.

Oystercatcher

Oystercatchers can adapt to either feed on shellfish such as *Cerastoderma edule* or *Mytilus edulis* which need to be forced open, or else feed by probing substrates for soft-bodied invertebrates such as *Nereis diversicolor*. The three sites have a variety of substrates but only support small populations of Oystercatchers. The Severn Estuary Oystercatcher population falls well below that of national importance (Cranswick *et al.*, 1992). All three sites support feeding Oystercatchers with the highest numbers being found at the Rhymney

site. A reduction in the usage made of the Orchard Ledges site since 1990/91 has been the result of birds spending less time feeding there as the number of birds has not shown a similar decrease. At the Taff/Ely site, the small feeding population of Oystercatchers shows peaks either side of low tide and this population is almost certainly shared with the Orchard Ledges population. The areas used by feeding Oystercatchers at the Taff/Ely site are mainly in the southern half of the bay and have not been affected by the changes that have taken place further north in the bay. Although Oystercatchers are prone to high rates of mortality during severe weather in areas where there has been a reduction in the available feeding grounds (Smit *et al.*, 1987), this may not be a problem at the study sites if they are below their carrying capacity for this species.

Ringed Plover

Ringed Plover have shown a continued increase at the Orchard Ledges site. Although the numbers involved are low compared with some other species of wader, a significant proportion of the Severn population may be present at times during the tidal cycle. The colour and behaviour of this species make it very difficult to observe on most substrates but especially so on the type of stony surface that is found at Orchard Ledges. It is likely that the maximum number of birds present is observed at some time during a tidal cycle, but the level of feeding activity may be considerably under-recorded. At the other sites, Ringed Plover are found in lower numbers.

Lapwing

Changes to the mudflats along the River Taff adjacent to the Phase 1 and 2 land reclamation areas on the northeast side of the PDR crossing may be having some effect on feeding Lapwing at the Taff/Ely site. There has been a decrease in feeding activity in this area although the mean size of the Lapwing population has not shown a major change. Daytime feeding on estuaries may be relatively unimportant for species such as this as they may be able to obtain sufficient food by night-time foraging on inland fields (Milsom, 1984). The Taff/Ely and Rhymney populations are small compared with the total estuarine population or the total British winter population.

Dunlin

Large numbers of Dunlin pass through Britain during autumn and spring migration. Although nationally important numbers are present on the feeding grounds of the Taff/Ely site during the winter, relatively few birds occur during early autumn or late spring. During the winter, the feeding birds are distributed over a large part of the centre of the bay but with relatively low numbers using the mudflats north of the PDR crossing. Sector 7 has been divided in two by the PDR crossing on the west side of the River Taff and now holds no feeding birds during the winter, having declined from being a relatively important feeding area within the bay in 1989/90. This is reflected in the high level of variation recorded over the four years and is true to a lesser extent for the sectors north and south of the eastern half of the PDR crossing over the River Taff. Dunlin have been shown to be susceptible to disturbance, flying away when approached to within 400-500m by small boats (Koepff & Dietrich, 1986). Dunlin must use almost all of the available feeding time during the main winter months (Goss-Custard *et al.*, 1977) making the selection of feeding areas free from disturbance very important.

The number of Dunlin at the Taff/Ely site has increased in the current winter after declines over the two previous winters. The changes at the northwest part of the bay have therefore

had an effect on redistributing the Dunlin that use the bay rather than forcing them onto totally new feeding grounds. At the same time, this current year has seen a noticeable reduction in the number of Dunlin at the Rhymney site compared with the two previous years. The preferred feeding areas at this site (the lower parts of sectors 9, 10, 11 and 12) have shown moderate levels of variation over the four years of the study.

Analyses of the data from the four years has shown no significant relationship between the relative amount of feeding by Dunlin that occurs on the sectors of the study sites during the tidal cycle and the time that the sectors remain uncovered by the tide. The level of variation of the amount of feeding on the sectors of the study sites over the four years was related to the amount of feeding that occurred on those areas. Sectors that were well used by feeding Dunlin showed little variation over the four years.

Curlew

The Severn Estuary as a whole is nationally important for Curlew and falls just below the level required for international importance (Cranswick *et al.*, 1992; Table 1.2). The population of Curlew using the three study sites is a relatively small part of the Severn population but, as Curlew show a high level of site-fidelity, all parts of the whole estuary are of importance.

Although this winter there was an increase in the number of Curlew at the Taff/Ely site and a decrease at the Rhymney site as well as minor changes in the distribution of feeding birds there has been no consistent change. The Taff/Ely population levels have fluctuated but the current population of Curlew is comparable with that of the first of the four years. There have been high levels of variation in the feeding usage on the sectors adjacent to the PDR and Phase 1 and 2 work, but all of these sectors only support small numbers of feeding Curlew.

Analyses of the data for the four years has shown that the amount of feeding that occurs on the sectors is not related to the time that the sectors remain uncovered by the tide. The level of variation of the amount of feeding on the sectors of the study sites over the four years was related to the amount of feeding that occurred on those areas. The areas within the bay that are used most by feeding birds have shown very high levels of consistency over the study period, with the most important feeding area, sector 17, showing very little variation. The preferred feeding areas are well away from the main areas of disturbance at the present time. A similar situation occurs at both of the other sites, where areas of relatively high use show little variation over the study period. It seems likely that Curlew will be little affected by the interim changes occurring in the Taff/Ely bay as they make use of areas away from the current changes, are less prone to disturbance than many other waders (Koepff & Dietrich, 1986) and can usually obtain sufficient food during the winter months without using up all of the available feeding time (Goss-Custard *et al.*, 1977).

Redshank

The Taff/Ely winter population of Redshank appears to behave as a discrete group and shows a high degree of site-fidelity (Donald & Clark, 1991a; Toomer & Clark, 1992a; Toomer & Clark, 1993). In autumn Redshank showed a different feeding pattern to that in winter. A relatively high proportion of the feeding birds were located on sectors 8, 9, 10 and 11, near to the PDR and Phase 1 and 2 work, with relatively few birds on sectors 3, 4 and 5 away from any possible disturbance. Although the birds utilised those sectors prone to high

levels of disturbance, they mainly fed at the water's edge, at a reasonable distance from the engineering work. The winter feeding population showed a stronger preference for the large mudflats between Ferry Road and the River Taff than in the autumn, although feeding birds were also found on the east side of the River Taff, north of the PDR crossing.

The areas most affected by the PDR work so far were sectors 7 and 10. In the 1989/90 winter, before the work commenced, these sectors were amongst the more important areas for feeding Redshank. They were used by very few birds during the 1992/93 winter. Most other areas of the study site, including areas with higher usage, have remained consistent in their use by Redshank over the four winters.

A similar pattern exists at the Rhymney site, where the level of usage and the number of Redshank have remained very similar over the four years.

Analyses of the data from the four years of the study have shown that the amount of feeding that occurs on sectors during the tidal cycle is related to the time that the sectors remain uncovered by the tide. Although this may at first seem to be a likely relationship, it does not occur in all species because of their feeding behaviour. At the Taff/Ely and Rhymney study sites, Redshank can be observed feeding on areas of the upper shore for a large part of the tidal cycle unlike species such as Dunlin that follow the receding tide. The level of variation of the amount of feeding on sectors of the study sites over the four years was strongly correlated with the amount of feeding that occurred there. Sectors that had a high level of feeding in one year were found to have a similar level in subsequent years.

Turnstone

Feeding Turnstone are found mainly on the substrates of the Orchard Ledges site and to a lesser extent the Rhymney site. At the Taff/Ely site, Turnstone move there to roost over the high tide period and a limited amount of feeding occurs at times. The population size and behaviour has been fairly stable at the three study sites apart from an apparent increase in feeding usage at the Orchard Ledges site between 1989/90 and 1990/91.

To summarize, there have been further changes to areas at the northwest part of the Taff/Ely bay that have directly affected the feeding and roosting habitats. There has been a loss of saltmarsh, covered by the Phase 2 reclamation work, and a partial loss and change to mudflats from the PDR banks. The level of disturbance in the vicinity of this ongoing work has also increased. The net effect has been for some birds to move to other areas to feed within the study site, away from the changed or heavily disturbed areas. In most cases this has only led to a minor change in the pattern of feeding distribution and only affected those birds that previously used areas adjacent to the engineering work. No loss of species or marked reduction in the number of birds found wintering in the bay has been detected by the studies carried out over the last four years.

This fourth year of monitoring bird populations in Cardiff Bay and nearby areas has added to the data that will help in predicting the effects of the barrage when it is built.

PART 2: MOVEMENT STUDIES

5. INTRODUCTION

As has been stated in previous reports, in order to completely assess the importance of an area for birds it is necessary not only to gather information on the distribution and numbers of birds but to determine if there is any significant turnover of the population. If birds move around freely between sites, the total population that relies on a site for food and/or to roost could be considerably larger than that suggested by all day counts. At the same time, if birds confine themselves to a specific area to overwinter, that site assumes far more importance for those birds than if they were to move freely between alternative sites. If this behaviour results in a population using specific areas not only within a year, but also from one year to the next, the site becomes critical for the population (Goss-Custard *et al.*, 1982)

Casual observations made during fieldwork at the three study sites give some indication of the movement of certain species during the tidal cycle. At the Taff/Ely site, Turnstone arrive about three hours after low tide, when the adjacent feeding areas at Orchard Ledges become covered by the rising tide. At Orchard Ledges itself, Turnstone arrive from the west as the tide recedes. Later, birds can be observed leaving the feeding grounds and flying west into Cardiff Bay. This species certainly moves between these two sites. Similarly, some of the Curlew that have been roosting at the Taff/Ely site can be seen flying south towards the mouth of the bay and then turning eastwards towards Orchard Ledges. Separate observations at Orchard Ledges confirm that some of the Curlew that feed on the site fly in from the west and, when they are moved off by the rising tide, they are then seen flying westwards and then north into Cardiff Bay. Again, there is no doubt that there is some interchange between the Taff/Ely population of Curlew and those observed feeding at Orchard Ledges. Such casual observations cannot determine, however, if it is the same birds that move between these sites during each tidal cycle or if it is a varying and random sample of the population that is seen in Cardiff Bay.

With other species it is far more difficult to assess any level of interchange of populations. The majority of Dunlin roost outside of the Taff/Ely and Rhymney study sites and fly from both the west and east of these sites to their feeding areas. Redshank are not seen to move from the Taff/Ely site during the all day count observations. The only way to determine how mobile the Dunlin populations might be or if the Taff/Ely Redshank do restrict themselves to the one wintering site, is to identify birds of such populations by marking them.

Donald & Clark (1991a) colour-marked and colour-ringed Redshank at the Taff/Ely site and showed that there was virtually no movement of these birds to other sites during that winter. Observations of ringed birds the following season (Toomer & Clark, 1992a) suggested that a large part of the Taff/Ely Redshank population were birds that had been present the previous season. Further colour-marking of Redshank at the Rhymney site in 1991/92 found that there was a limited amount of movement of birds from that site to the Taff/Ely site during the first half of the winter period and very little further winter movement. Dunlin that had been colour-marked at Rhymney were seen at the Taff/Ely site although the sample size of marked birds was a very small proportion of the total population of birds that were present at the Rhymney site.

In order to gather more information on the movements of these species, catching and colour-marking of birds was repeated for the current study.

6. METHODS

Early in 1991, 151 Redshank were caught at the Taff/Ely site and 133 adult birds were colour-ringed and colour-marked. Movements of these birds were described in the 1990/91 report (Donald & Clark, 1991a). The colour rings were still visible on some birds during the autumn and winter of 1991/92 and observations of these birds were reported in Toomer & Clark (1992a).

Throughout the autumn, winter and spring of 1992/93, colour-ringed Redshank were looked for. These rings are difficult to see, especially at a distance, in poor light or if the birds had been wading in soft mud. In the 1991/92 study, Redshank were commonly observed on the west edge of sectors 2, 3, 4 and 5 (Figure 2.1.1). During 1992/93, flocks of Redshank were not seen on this area in a position close enough to make accurate observations and ringed birds were looked for on other areas. The largest number of Redshank that could be seen to be with or without rings was counted and the proportion with rings was estimated.

Redshank that were caught and colour-marked for the 1991/92 study were marked with a dye that faded within a few months and were not colour-ringed. It was not therefore possible to identify any of these birds during the following season.

During the winter of 1992/93, attempts were made to catch and colour-mark Redshank and, to a lesser extent, Dunlin. Observations of the areas used as high tide roosts in 1991/92 showed that the behaviour of the roosting Redshank was less predictable in the 1992/93 winter. Only relatively small groups of Redshank moved into the corner of the bay near Maerdy Farm at the Rhymney site on some high tides and there was not a single reliable roost area on the raised foreshore east of the Ystradyfodwg Pontypridd sewer although parts of this area was used by roosting birds. One of the preferred roost sites this winter was on grassy areas on the side of the River Rhymney, up-river from its mouth, where catching was not practical. Cannon nets were used to catch the Redshank and Dunlin at Maerdy Farm. On November 14th, thirty adult Redshank were caught for colour-marking. No more birds were caught in 1992. A further successful attempt was made on February 7th when three adult Redshank and twelve Dunlin (seven first year birds and five adults) were caught.

Each trapped bird was aged, weighed, measured and fitted with a metal ring embossed with a unique letter and number code to allow individual identification in the event of the bird being re-caught. The birds were marked with an application of picric acid dissolved in alcohol on the under-tail area.

This dye initially produces a bright yellow colour on the pale feathering. As the dye affects the chemicals of the feathers themselves, rather than colouring the surface, this dye remains visible for longer than the dye used in the previous years. The colour of the dye changes and intensifies with age, becoming a deeper orange-yellow. This colour is lost when the feathers are moulted before the breeding season and has no adverse effect on the behaviour of the birds or other birds towards them.

As with the previous winter's study it was not possible to assess the total population of Redshank of which the colour-marked birds formed a part. The initial observations made at the Rhymney site were therefore used to determine the proportion of dyed and undyed birds that were present at the start of the study. These initial observations were made from

the east side of the Rhymney near to where the birds had been caught. As the high tide receded, Redshank left their roost and spread out over the recently exposed mudflats to feed, at which time they were visible from the shore.

Following the colour-marking of the birds, further observations were carried out at the Taff/Ely and Rhymney sites. Whenever Redshank were in a good viewable position at either site, and the light condition permitted clear observation of the individual birds, counts were made. Several extra visits were made to the far side of the Rhymney specifically to count marked birds. Other observations at this site were possible from the west side of the Rhymney when Redshank pre-roosted on the rising tide on the east and west banks of the river. Counts of birds were only made of groups of birds where it was possible to see the presence and absence of colour. The number of marked and unmarked birds was noted. Several counts were made and the largest total count was used to calculate the proportion of colour-marked birds. If groups of birds were counted on more than one sector at a site or at different times of the day, the highest total counts at each sector or during each period of observation were summed and the proportion of colour-marked birds calculated.

The proportion of colour-marked birds observed at the Rhymney site on each count date was compared with the proportion of colour-marked birds observed shortly after capture. Variation in this proportion would indicate that the birds were moving from this site or other birds were moving into this site at any time during the winter. Observations of colour-marked birds at other sites, in particular the Taff/Ely site would indicate movement of these birds to that site. Any subsequent variation in the proportion of colour-marked birds would indicate movements between sites.

BTO volunteer observers around the Severn Estuary were given details of the presence of colour-marked Redshank and Dunlin and were asked to submit details of any sightings.

The racial composition of the captured birds was analysed in 1991 and the proportion of the different races was reported in Donald & Clark (1991a). This was not repeated this year.

7. RESULTS AND DISCUSSION

The results of the observations carried out to assess the proportion of Redshank colour-ringed in January 1991 at the Taff/Ely site and Redshank and Dunlin colour-marked at both the Taff/Ely and Rhymney sites in 1992/93 are given in Tables 7.1 and 7.2. Further sightings of colour-marked birds is given in Table 7.3.

Only on two days were large enough groups of Redshank clearly visible to allow accurate counts of colour-ringed and non-ringed birds on sector 8 (Table 7.1). The colour-ringed birds were part of the group of 133 Redshank that were caught and colour-ringed in January 1991 (Donald & Clark, 1991a). At the time of capture, the proportion of birds colour-ringed was 35.9%. During the autumn and winter of 1991/92 the proportion of colour-ringed birds observed varied from 11% in September 1992 to 50% in December 1992 with a mean percentage of 18.5%. This is compared with 27-39% colour-ringed birds observed shortly after colour-ringing had taken place. During the autumn and winter of the current study, 3.1% in November and 16.7% in January of the Redshank were colour-ringed. Mortality and recruitment to the population during the two years would reduce the proportion of colour-ringed birds in the population. The presence of colour-ringed birds during the third winter after trapping indicates that many Redshank are site-faithful from one winter to the next.

Of the of thirty-three Redshank captured at Rhymney in November 1992 and February 1993, none possessed colour-rings. Ten of the birds captured in November had metal rings bearing numbers that identified them as Redshank that had been caught at Rhymney as part of the 1991/92 study.

Observations of these birds from the time of capture to the end of the fieldwork in 1992/93 are shown in Table 7.2. From November to the end of January, a maximum of six colour-marked birds was seen at the Rhymney site, giving proportions of colour-marked birds ranging from 2.0-3.1%. Accurate counts of the total Redshank population were not possible at the time of capture but observations suggested a total in the region of 400-550 birds which would have given a proportion of colour-marked birds of 5.5-7.5%. It seems likely that there is at least some temporary moving away from the site.

Following the marking of this first group, the first sighting of a colour-marked bird at the Taff/Ely site was on the 8th of December 1992. No more colour-marked birds were then seen at this site until the 14th of January when another single marked bird was observed. The proportions of colour-marked birds recorded at the Taff/Ely site were less than 1%, although the size of the sample makes this value less significant. By early February, two colour-marked birds were observed at the Taff/Ely site. This gave a proportion of 2.1% of colour-marked birds, similar to the proportions obtained at Rhymney, but being based on a single observation it may not reflect the true balance of marked to un-marked birds. A count of a larger group of Redshank a week later found no marked birds.

Clearly there is some movement of Redshank from the Rhymney site, or maybe between the two sites where Redshank are found. In was almost a month before the first colour-marked bird was observed at the Taff/Ely site although as the highest number of birds that had been clearly seen before that was 179 it is possible that a colour-marked bird or birds could have been present without being seen. There was no increase in the number of

marked birds seen until February, and that was only of one more marked Redshank. Any movement of Redshank from Rhymney to Taff/Ely or between the two sites seems very limited and the Taff/Ely population appears to be a fairly discrete population. This is in agreement with the findings of the two previous colour-marking studies (Donald & Clark, 1991a; Toomer & Clark, 1992a) but the sample size obtained in the current study was unfortunately small and further colour-marking studies of Redshank of the Rhymney and Taff/Ely populations is required to build a complete picture of the movement of this species at the study sites.

In early February the largest number of colour-marked Redshank was observed at the Rhymney site when 13 birds were seen in a total flock of 550 giving a proportion of 2.4% marked birds. This flock of Redshank probably represented a large proportion of the birds that were seen at the Rhymney site at any one time. This proportion of colour-marked birds is within the range obtained from the other observations and as less than 50% of the colour-marked birds were present it suggests that there was some turnover of the Redshank population shortly after colour-marking.

The second capture of birds only succeeded in colour-marking three more Redshank and this was unlikely to affect the proportion of marked birds to any great extent. The observations made in February after the second marking obtained proportions similar to those earlier in the month (Table 7.2).

By the time of the first observations in March, the Redshank had left the Rhymney site and the number of birds seen at the Taff/Ely was much lower. Four colour-marked birds were seen in the inner harbour at the Taff/Ely site amongst a large group of Redshank. This was the highest number of colour-marked individuals seen at the Taff/Ely site and produced the highest proportion of marked birds (2.2%) at this site up to that time (Table 7.2). A further marked individual was seen with a relatively small group of Redshank two days later. No further sightings of marked birds were made and by April there were only a few remaining Redshank at the Taff/Ely site.

As the Redshank had left the Rhymney site by the very early spring, the increase in marked birds at the Taff/Ely site is the direct result of part of the Rhymney population moving to this site. At the same time, the Taff/Ely population of Redshank was starting to move away to their breeding areas, reducing the total number of birds considerably.

No reports were received of sightings of Redshank away from the study area during the autumn, winter or spring period.

Very few Dunlin were successfully colour-marked during the 1992/93 winter and these were not marked until late in the winter period. Any observations would therefore have limited statistical significance. The only sightings of colour-marked Dunlin are shown in Table 7.3. The three sightings were outside of the study area. The observation of a colour-marked bird at the Usk Estuary within five days of their capture was made as part of other fieldwork in that area (Browne *et al.*, 1993). That study found Dunlin to be present in large numbers (5,000-10,000) near the mouth of the river Usk at different stages of the tidal cycle. There must be some interchange of populations along the northwest Severn, at least during late winter. The other sightings of marked birds were at Peterstone, an area on the Severn Estuary, adjacent to the site of capture and does not reflect any distinct movement.

It has still proved difficult to capture and mark a large enough sample of Dunlin to obtain a fuller picture of their movement and further studies of this type are required.

To summarize, the occurrence of Redshank with colour-rings (fitted when trapped in January, 1991) at the Taff/Ely site during the autumn and winter of 1992/93 shows that there is long term site-fidelity. Observations of Redshank colour-marked in November, 1992 showed that there is some dispersion from the site of capture. Only a few colour-marked birds were seen at the Taff/Ely site but this does suggest some limited movement from the Rhymney site, or possibly some limited interchange of birds between these two sites. The small number of colour-marked birds involved makes it difficult to determine if such movement increased at all during the early and mid-winter period. An increase in the number and proportion of colour-marked birds at the Taff/Ely site in March, when Redshank had already moved away from the Rhymney site shows that there was movement to the former site at a time when many of the birds were starting their movement to breeding grounds.

The small number of Dunlin captured and colour-marked make it difficult to add to the knowledge of their movement obtained the during the previous winter's study. The finding of a colour-marked bird as far east as the Usk Estuary suggests that there could be some fairly extensive movements to alternative feeding grounds during the tidal cycle or on different days.

Although these results have added to the knowledge of the movements of birds between the study sites, it will be necessary to obtain further catches of the two species in the future if a fuller picture of their behaviour is to be obtained.

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Species	Mean Peak Winter Count	% British Population	% European Population
Shelduck	306	0.40	0.12
Oystercatcher	40	0.01	<0.01
Lapwing	100	0.01	<0.01
Ringed Plover	33	0.14	0.07
Grey Plover	12	0.06	0.01
Turnstone	64	0.14	0.09
Curlew	106	0.12	0.03
Redshank	520	0.69	0.35
Knot	1	<0.01	<0.01
Dunlin	4800	1.12	0.34

Table 1.1 The national and international importance of the Taff/Ely Estuary for waders and Shelduck, 1988/89 to 1992/93.

Species	Mean Peak Winter Count	% British Population	% European Population
Shelduck	3170	3.77	1.27
Oystercatcher	718	0.26	0.08
Lapwing	3541	0.35	0.18
Ringed Plover	270	1.17	0.54
Grey Plover	855	4.07	0.57
Turnstone	398	0.88	0.57
Curlew	3273	3.60	0.94
Black-tailed Godwit	37	*	0.05
Bar-tailed Godwit	54	0.09	0.05
Redshank	2626	3.50	1.75
Knot	2946	1.34	0.84
Dunlin	48357	11.25	3.45

Table 1.2 The national and international importance of the Severn Estuary for waders and Shelduck, 1988/89 to 1992/93.

* As 1% of the British wintering population is less than 50, this value is not calculated, but 50 birds is used as the qualifying level for national importance.

Date	Site	Total Birds	Numbers Colour-ringed (%)
16/11/92	Taff/Ely	159	5 (3.1)
4/1/93	Taff/Ely	48	8 (16.7)

Table 7.1 The numbers and proportion of Redshank colour-ringed in January 1991 which were observed during the autumn and winter 1992/93.

Date	Site	Total Birds	Numbers Marked (%)
14/11/92	30 Redshank caught and colour-marked at Rhymney		
15/11/92	Rhymney	210	6 (2.9)
15/11/93	Taff/Ely	111	0
16/11/93	Taff/Ely	159	0
17/11/92	Rhymney	305	6 (2.0)
17/11/93	Taff/Ely	179	0
7/12/93	Taff/Ely	104	0
8/12/92	Rhymney	197	6 (3.1)
8/12/92	Taff/Ely	144	1 (0.7)
13/1/93	Rhymney	305	6 (2.0)
14/1/93	Taff/Ely	144	1 (0.7)
1/2/93	Rhymney	140	3 (2.1)
2/2/93	Taff/Ely	134	0
3/2/93	Rhymney	550	13 (2.4)
4/2/93	Taff/Ely	96	2 (2.1)
7/2/93	3 Redshank caught and colour-marked		
10/2/93	Taff/Ely	148	0
11/2/93	Rhymney	320	13 (4.6)
23/2/93	Taff/Ely	110	0
15/3/93	No Redshank remaining at Rhymney		
16/3/93	Taff/Ely	179	4 (2.2)
18/3/93	Taff/Ely	18	1 (5.5)

Table 7.2 The numbers and proportions of colour-marked Redshank observed from November 1992 to March 1993

Date	Species	Location	Total Birds	Numbers Marked
12/2/93	Dunlin	Usk Estuary, Gwent	2000	1
18/2/93	Dunlin	Peterstone	1000	1
28/2/93	Dunlin	Peterstone	?	2

Table 7.3 Further sightings of colour-marked Dunlin outside of the three study sites. (See text for further details.)