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THE EFFECT OF THE CARDIFF BAY BARRAGE ON WATERFOWL POPULATIONS 6. DISTRIBUTION AND MOVEMENT STUDIES AUGUST 1994 - MAY 1995

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EXECUTIVE SUMMARY

1.This report represents the results of the sixth season of intensive monitoring of the wildfowl and waders using the intertidal areas in Cardiff Bay and its environs. 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 1994 and May 1995. The programme of monitoring closely followed that used for the previous five years, allowing direct comparisons to be made between the six years of study.

2.By early 1998, the intertidal mudflats of the Taff and Ely estuaries (known as Cardiff Bay) will be inundated by fresh water when the bay is flooded prior to the completion of the amenity barrage. The gathering of information on the distribution and movement of the populations of waders and wildfowl both before and after barrage completion will make it possible to determine their fate when the barrage has been built.

3.Monitoring 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 compared with 1993/94.

4.The detailed data collected for Taff/Ely, Orchard Ledges and Rhymney were used to obtain estimates of the size and distribution of wader and wildfowl populations at each site. There was evidence of changes in feeding distribution of three of the four main species, Dunlin, Curlew and Redshank. Dunlin had been virtually absent from some of the sectors affected during the building of the Peripheral Distributor Road (PDR) and the associated landfill at Taff/Ely. With the cessation of work, there was renewed use of these sectors by feeding Dunlin. Areas that had been used by feeding Curlew in previous winters were used less for feeding when affected by various barrage building activities. Redshank, like Dunlin, showed clear signs of returning to feed on sectors that had been used less while PDR and landfill work continued.

5.Data for the six winters were analysed to determine whether sediment type, distance from land and work disturbance affected waterfowl communities present on the sectors. The three variables examined were all significant.

Only two gross sediment types were considered, stone and mud. Only Orchard Ledges had sectors with stony surfaces which led to distinctive waterfowl communities. These were dominated by Turnstone, Curlew and Oystercatcher with only small numbers of other species.

Waterfowl communities were also affected by the distance from land of a mudflat over all three study sites. Although this variable did not change over the six winters, factors associated with it, such as bait digging near to shore, could change.

The levels of disturbance that mudflats were subjected to from the PDR, landfill and early barrage work at Taff/Ely were estimated. The areas of the study site, Orchard Ledges and Rhymney, that were not affected by these works acted as controls. The level of mudflat disturbance was shown to have a significant effect on waterfowl communities. There was evidence that communities on disturbed mudflats reverted to those pre-disturbance once disturbance ceased. Hierarchical classification made it possible to demonstrate that disturbed mudflats could be classified into similar groups based on their waterfowl communities. Movements of mudflat communities between groups in different years suggested that the waterfowl community changed between years. Some of the mudflats

that were disturbed early in the study changed groups during the period of disturbance. These mudflats reverted to their earlier groups after disturbance ceased.

6. Continuing colour-ringing studies showed that a higher proportion of the Redshank colour-ringed at Taff/Ely, were consistently present at Taff/Ely than at Rhymney. This indicates a degree of site-fidelity.

7. A sample of Redshank was caught and individually colour-ringed at Taff/Ely in February 1995 to continue studies of movement patterns around Cardiff Bay. This group contained birds that had been caught and colour-ringed previously at Taff/Ely: 16% ringed in January 1991, some had been ringed there in 1993. This again demonstrates the site-fidelity of Redshank.

8. Observation of the individually colour-ringed Redshank in the autumn and winter of 1995/96 will give further information on their movements. Counts will be made of scheme and individually colour-ringed birds during the early and late winter, to determine the proportions of these birds at both Taff/Ely and Rhymney. This will allow Redshank survival rates to be estimated at these sites. Observations of the individually colour-ringed birds will increase our knowledge of movements of this species between the two study sites.

GENERAL INTRODUCTION

Work on the amenity barrage across the mouth of Cardiff Bay started in 1994 and as the year progressed, the intensity of this work increased. Dredging of some of the mudflat areas started in late autumn and was continuing throughout the current study period which ran from August 1994 to May 1995. The major areas where work was progressing were as follows. (See Figure 2.1.1).

- A temporary jetty was constructed along the dock side of the bay to the north of the Queen Alexandra Dock entrance, to allow craft to ferry construction materials to the Penarth side of the bay. This resulted in some of the mudflat sediments being removed. Between this jetty and the dock entrance, there was further removal of mudflat as preparations were made for the beginning of the construction of the eastern end of the barrage. Through the winter and spring, there was deposition of rubble and stone onto this area, gradually extending westwards into the bay. This involved many lorry journeys to tip the huge boulders onto the site and the use of large diggers to position the material. As well as directly affecting the mudflat on which this was occurring, this work involved considerable movement of vehicles near to mudflats and much noise.

- Work on the Penarth side of the bay had started by August and continued throughout the current study period. Dredging along the edge of the shore at the mouth of the bay was at first just beyond the limits of the study count area, but this soon progressed northwards into the bay. Shortly after, piling started close to the Penarth shore. This activity involved removal of mudflat sediment, the presence of dredging and piling craft near the mouth of the bay, the movement of barges and tugs and considerable noise from the piling activities. This work continued and more extensive areas of mudflat were removed towards the middle of the southern part of the bay. Further piling and rubble deposition also occurred there.

- A channel to link the yacht club at the northeastern part of the inner harbour with the River Taff in the centre of the bay only commenced in September 1995.

The above represents considerable change to some of the feeding areas of the bay and large amounts of disturbance at the mouth of the bay, where birds moving in and out of Cardiff Bay have to pass.

The intensive monitoring of waders and wildfowl during the study period from 1989/90 to 1993/94 has yielded results that have given a good picture of the wintering birds of the area. It is important to continue this level of monitoring, as the changes within the bay, may affect the behaviour of the birds wintering in the area. The effect of the barrage closure on the local bird population will only be accurately determined if an accurate assessment of their status is known immediately prior to closure.

Theoretical aspects of the behaviour of waders and wildfowl overwintering on estuaries have been covered in previous reports and need not be repeated here.

Some changes had previously affected the feeding and roosting behaviour of birds in the bay. The building of the Peripheral Distributor Road (PDR) resulted in the loss of some mudflat areas, the filling in of an old canal and much disturbance in the northwest part of the bay. The effects that this had on the waders and wildfowl that used this part of the study site have been covered in previous reports (Toomer & Clark, 1992a, 1992b, 1993b, 1994b; Toomer *et al.*, 1993a, 1994a). The PDR was completed at the end of the 1993/94 study period and although the loss of mudflat area and saltmarsh was permanent, the heavy disturbance from the work ceased. The effects of this are discussed in this report. Associated with this road development was the use of some areas of saltmarsh as landfill sites at the north end of the bay affecting birds roosting in the area at high tide. This has been covered in the reports cited above. Although much of this work had also been

completed between autumn 1993 and spring 1994, one area between the east end of the PDR and Windsor Esplanade continued to be used, with waste material from the old graving docks being poured onto the landfill site. Not only did this cover a further area of saltmarsh, raising its level considerably, but material deposited at this site flowed over the bund that had been built and formed a wide tongue of new mud extending down to the existing mudflat. This work was completed at the end of spring 1995. It was therefore not possible to assess the effects of the change to that area of saltmarsh once the disturbance had ceased as the majority of wintering birds had already moved away to their breeding grounds.

This report covers the distribution and movement of the birds in Cardiff Bay and nearby areas and is in three sections. The first part summarizes the results of the sixth year of monitoring waterfowl populations in the vicinity of Cardiff Bay. The second part analyses the data from the six winters to try to determine what environmental factors are responsible for the composition of the waterfowl communities on the mudflats of the three study sites. Particular attention is given to possible role that the effects of the works described above may have in shaping these bird communities. The third section looks at the results of colour-ringing studies in assessing wader movements.

The results of the first five years' monitoring of the 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), Toomer & Clark (1992a) and Toomer *et al.* (1993a and 1994a). This report summarizes the fifth autumn and the sixth winter and spring of wader and wildfowl monitoring.

The transition from the Birds of Estuaries Enquiry (BoEE) monitoring scheme to its replacement, the Wetland Bird Survey (WeBS), led to a delay in data inputting. The data for the mean peak winter counts 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 for winter 1994/95 were thus not available at the time of writing this report. The importance of the Severn Estuary will be referred to in the species accounts using data for the 1993/94 winter (Cranswick *et al.*, 1995).

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 1994 and May 1995. The findings have been compared with the results of the previous four years (Evans *et al.*, 1990; Donald & Clark, 1991a; Toomer & Clark, 1992a; Toomer *et al.*, 1993a and 1994a). The distribution of roosting birds on the Taff/Ely site was studied in the 1990/91, 1991/92, 1992/93 and 1993/94 winters (Donald & Clark, 1991b; Toomer & Clark, 1992b; 1993b and 1994b).

With six years of data it is possible to assess year-to-year variation in bird numbers and their feeding distribution. Changes that have occurred to the bird populations or to their behaviour during this time are examined in the species accounts and discussed in the 'discussion and conclusions' section.

The timing of the autumn fieldwork has varied for the first three studies (see Toomer *et al.*, 1993a). For this, the fifth autumn of the study, observations were made for the three months of the autumn period, August, September and October, allowing direct comparisons to be made with any of the four 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, as with the previous reports, 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 several phases of reclamation work have resulted in the loss of small areas of mudflat and of some saltmarsh adjacent to the River Taff. The effect on the feeding birds, therefore, mainly resulted from disturbance associated with the development work in the bay.

2. METHODS

For this sixth year of study, the same methods were used as the five previous studies. The methods are therefore only briefly described below. Using the same methods allows direct comparisons to be made between seasons and years for the six-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 continued at the northern end of the Taff/Ely site during the current study. The landfill near the west end of Windsor Esplanade, which had ceased during 1994, was started again, with material being deposited to the south and west of the Windsor Esplanade. This continued for a large part of the winter and spring and a further area of saltmarsh became covered by rubble and mud. Much of this was retained by a stone bund, but some of the softer material formed a 'tongue' that flowed down to the edge of the saltmarsh. The PDR was completed and opened by early spring 1995. Two of the count areas, sector 7 and sector 10 (Figure 2.1.1) had been cut in two by the

rubble mounds used in the construction of the elevated road, reducing their areas of mudflat by 8% and 20% respectively. These divided sectors were counted as intact areas from 1991/92 to 1993/94 and have continued to be counted as such during the 1994/95 study period. Disturbance from the PDR work reduced during the year as the road came near to being opened. The four observation points that had been used in the previous three years of study were used again. Extra observations were made from the jetty area of the Cardiff Bay Yacht Club and from the Leisure Centre opposite sector 8 if feeding flocks were seen to be using nearby areas.

No changes in the Orchard Ledges and Rhymney sites were observed over the previous five 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 counted.

Counts were divided into three seasons: autumn (August - October 1993), winter (November 1993 - March 1994) and spring (April - May 1994). With the exception of early spring, April, 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 or plants on or 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. Also, birds roosting on open water may not be making any use of the area and roosts on water are not confined to the bay. 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, 1993b; Toomer & Clark, 1994b).

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

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 as:

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

where A is the hours from low tide (0 hours being low tide and +5/-6 high tide, B is the average number of birds feeding at time A when the area was exposed and C is the proportion of counts when the area was exposed at time A.

2.2 Low Tide Counts

The low tide distribution of waterfowl in the northwest Severn was monitored using counts made of all the areas during the period two hours either side of low tide. Counts were made at two-weekly intervals during the winter period. 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 five years of study were reported in Evans *et al.* (1990), Donald & Clark (1991a), Toomer & Clark (1992a), Toomer & Clark (1993a) and Toomer *et al.* (1994a). This report should be read in conjunction with these five reports as figures for the previous four years' findings are not reproduced here.

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.

The average numbers of each species recorded feeding during the winter months' low tide counts are represented in map format. For the four main species, Shelduck, Dunlin, Curlew and Redshank, the accounts are divided into three sections, autumn 1994, winter 1994/95 and spring 1995. The low tide count studies are included in the winter 1994/95 section. In each section, comparisons are made with the five previous seasons, 1989/90, 1990/91, 1991/92, 1992/93 and 1993/94 whenever appropriate. For the other species, the main discussion will concentrate on the winter period. The results are considered in relation to the changes that have occurred to the sites during the five years of study, as well as the feeding ecology, behaviour and migration patterns of the waterfowl.

Presentation of the results of the all day counts follows Evans *et al.* (1990). Graphs showing the number of birds and the proportions feeding through the tidal cycle only give the percentage feeding if a total of 50 birds or more was present during any one tidal hour.

As there have been major development works in part of the bay already and the barrage works have commenced, it is important to try to determine if physical changes and their associated disturbance have been responsible for any changes in the waterfowl communities. A further section analyses some factors that may have affected the waterfowl communities.

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

3. RESULTS AND SPECIES ACCOUNTS

3.1 Shelduck

Shelduck breed in Britain and Ireland at many coastal locations, but increasingly, in inland sites (Gibbons *et al.*, 1993). Following breeding, most adult Shelduck move to moulting grounds on the German Wadden Sea and start to return to their winter areas from September onwards. There is a small but important moulting population at Bridgwater Bay on the south side of the Severn. The British wintering population has remained steady in recent winters with the wintering population

was estimated at 75,000 in 1993/94 (Cranswick *et al.*, 1995). In 1993/94 the Severn Estuary was the 9th most important British site for wintering Shelduck and was of international importance.

Autumn 1994

During the early part of autumn, very few Shelduck were present on the three study sites. One to two juveniles were present at Taff/Ely, feeding only on mudflat 6 (Figure 3.1.1). Adult birds did not return to this site until the beginning of the winter period. No Shelduck were observed at Orchard Ledges during the autumn. No juvenile Shelduck were seen at Rhymney, but moderate numbers of adult birds returned during the late autumn (Figure 3.1.2). These birds fed mainly near the falling tide line, with higher levels of usage occurring on mudflats to the east of the Cardiff Eastern Sewer.

The peak mean number of Shelduck at Rhymney was over 80 birds (Figure 3.1.3c). As the tide receded, birds moved onto the mudflats to feed. The feeding pattern of the birds was somewhat erratic, with large numbers ceasing to feed for short periods although the majority of birds continued to feed throughout the tidal cycle.

Very few Shelduck were present at Taff/Ely in autumn 1993 and, as with the 1994 birds, they were mainly juveniles. At Rhymney the number of birds and their pattern of feeding distribution was similar to the previous autumn. There have been only minor changes in the number and feeding distribution of Shelduck at the three study sites during the autumn period of the six years of study.

Winter 1994/95

Low tide counts showed feeding Shelduck to be present along the whole of the northwest Severn during the winter 1994/95 (Figure 3.1.4). No Shelduck were recorded at Orchard Ledges during low tide counts. The main concentration of feeding birds on the other sections of the northwest Severn was found at Peterstone, but all sectors that extended to the lower shore supported populations of feeding Shelduck.

At Taff/Ely, feeding Shelduck were widely distributed over the mudflats, with fewest birds being found on the northwest part of the study site (Figure 3.1.5).

Groups of up to 20 Shelduck were observed feeding on sector 1 at Orchard Ledges (Figure 3.1.6). The main area used by feeding birds was the muddy bank at the extreme western end of sector 1, which was only exposed for a short period around low tide. At Rhymney, all sectors were used by feeding Shelduck at some time during the tidal cycle (Figure 3.1.6). Feeding Shelduck were usually concentrated near the water's edge, especially to the east of the mouth of the River Rhymney where the highest levels of usage were observed.

There were two peaks of Shelduck numbers at Taff/Ely during the tidal cycle (Figure 3.1.7a). Shelduck that had been roosting in the saltmarsh or on the open water, moved onto the mudflats to feed as the tide receded. With a further fall in the water level, some birds moved back onto the open water, while others left the study site to feed elsewhere. The low numbers of Shelduck at Orchard Ledges were present during the four hour period around low tide, when suitable feeding substrate was exposed (Figure 3.1.7b). At Rhymney, most Shelduck flew from roost areas to the east and fed on the recently uncovered mudflats. The number of birds rose sharply, with the peak mean being about 700 (Figure 3.1.7c). The majority of the birds continued to feed while the lower levels of the mudflats were exposed.

Compared with the previous winter there have been only minor changes in the distribution of feeding birds at all three sites and along the northwest Severn. At Taff/Ely the number of birds was similar to the 1993/94 winter and showed a similar pattern over the tidal cycle. The number of Shelduck seen at Orchard Ledges was greater than in 1993/94, but the overall number of Shelduck using this site was small. The usage and the number of birds had shown an increase up to winter 1991/92, but this was not maintained during the winter 1992/93. The number of Shelduck and their feeding distribution at Rhymney was very similar to that of the winter 1993/94, the rise that had occurred in that year had not continued in the current season.

Spring 1995

Relatively high numbers of Shelduck usually remain into spring. At Taff/Ely, some feeding birds were found on all sectors, but the highest levels of usage were on sectors 3 and 4, and some of the sectors in the middle of the study site (Figure 3.1.8). Two Shelduck were observed feeding several times on muddy areas of both sectors at Orchard Ledges. Almost no feeding birds were seen on areas to the west of the Cardiff Eastern Sewer at Rhymney, most of the feeding Shelduck being present on sector 13-16 (Figure 3.1.9).

The spring population of Shelduck at Taff/Ely was about half that found in the winter, with most of the birds staying at the study site over the low tide period (Figure 3.1.10a). At Rhymney, the spring population had declined to about a tenth of the wintering population (Figure 3.1.10c).

Although the spring population of Shelduck at both the Taff/Ely and Rhymney sites was lower than that observed during the 1994 spring, there has not been a pattern of reduction and such change probably reflects year-to-year variation. Limited usage observed previously at the Orchard Ledges continued, but the increase in usage that occurred three seasons ago has not been maintained. At Rhymney, there has been a shift in the sectors used by feeding Shelduck in the spring compared with spring 1994, with a more even usage of sectors east of the Cardiff Eastern Sewer.

3.2 Dunlin

Almost 10,000 pairs of Dunlin breed in Britain, mainly on the flows of northern Scotland and on high peaty bogs of the English and Scottish mountains (Gibbons *et al.*, 1993). The wintering population is boosted by the arrival of large numbers of migrant birds from the north. Estimates of the wintering population in 1993/94 showed there to be over 450,000 birds around the estuaries and shores of Britain (Cranswick *et al.*, 1995). The Severn Estuary holds internationally important numbers of Dunlin during the winter and is the 2nd most important estuary for this species in Great Britain.

Autumn 1994

Dunlin present in early autumn are likely to be birds on passage to their wintering grounds in Africa. Only relatively small numbers of these birds have been found to stop over at the study sites. Few Dunlin were seen during autumn at Taff/Ely, with a maximum number of 21 being present for a short time in September. Feeding birds were present on several sectors (Figure 3.2.1). No Dunlin were present on Orchard Ledges during the autumn. At Rhymney, the largest flocks of up to 220 birds were seen during the autumn. These were mainly observed feeding on the mudflats just to the west of the Cardiff Eastern Sewer and along the lower shore east of the River Rhymney (Figure 3.2.2).

The peak mean number of Dunlin at Taff/Ely was less than 10 birds, but with the low numbers involved, there was no clear pattern throughout the tidal cycle (Figure 3.2.3a). At Rhymney most Dunlin were present on the falling tide, feeding on the newly exposed mud surfaces, producing a peak of activity before low tide (Figure 3.2.3c). Dunlin moved from adjacent roost areas onto the newly exposed sectors to feed.

The number of Dunlin and the level of usage was lower at both the Taff/Ely and Rhymney sites compared with the 1994 autumn, although that autumn held higher numbers than had been observed previously in that season.

Winter 1994/95

Large numbers of feeding Dunlin were seen along the northwest Severn during low tide counts (Figure 3.2.4). Almost all sections had feeding birds present, with the highest concentrations on St. Brides and the west part of Peterstone.

At Taff/Ely, large flocks of Dunlin entered the bay as the tide receded and fed on the exposed mudflats (Figure 3.2.5). Most feeding flocks were observed on the part of sectors adjacent to the River Taff in the centre of the study site, with sectors 4, 6 and 14 having the highest levels of usage. Almost all sectors were used by some feeding birds. Flocks of up to 2,700 Dunlin were seen on sector 2 of Orchard Ledges (Figure 3.2.6). These were mainly present on the exposed muddy areas at the east end of the sector and were usually there for one to two hours only. At Rhymney, the sectors west of the Cardiff Eastern Sewer that did not extend to the lower shore had lower levels of usage than the other parts of the site (Figure 3.2.6). Dunlin arrived at the site on the falling tide, flying in from roost areas to the west or moving along the shore from the east. Sectors to the west of the Cardiff Eastern Sewer were usually occupied later in the tidal cycle than sectors 11, 12 and 14, and these birds therefore used 7-9 in preference to 1-6.

At Taff/Ely, there was a small peak in numbers of Dunlin on the falling tide, but the high peak mean number of Dunlin occurred three to four hours after low tide with (Figure 3.2.7a). The largest flock of 4,000 Dunlin was seen in November, flying into the bay on the rising tide and feeding until high tide covered their feeding areas. Generally feeding flocks were much smaller than this. On occasions, some of the Dunlin remained in the bay over the high tide period and moved onto the sectors to feed as the tide receded, being joined by birds arriving from outside the study site. As low tide approached, nearly all Dunlin left the site to feed elsewhere but on the rising tide large numbers returned to feed.

The large flocks of Dunlin, seen feeding mainly on the muddier east end of sector 2 at Orchard Ledges, were only present during the three hour period around low tide (Figure 3.2.7.b). At Rhymney the mean, peak number of 5,000 birds occurred three hours before low tide (Figure 3.2.7c). The number gradually declined during the rest of the tidal cycle, all birds feeding during this time.

There were minor changes in the distribution of the main feeding flocks of Dunlin along the northwest Severn compared with the winter 1993/94. Higher numbers of feeding birds were present on the eastern end of the Peterstone section.

There was a noticeable change in the number and distribution of feeding Dunlin at Taff/Ely compared with previous winters. The highest levels of usage were found on sectors 4, 6, 12, 14 and 17, with only low levels of usage on sectors 3 and 5. Feeding activity also increased on sector 7 south of the PDR and on sector 11. During previous winters, sectors 2-6 and 17 supported most feeding activity. Sector 7 had been used by feeding Dunlin prior to the

start of the PDR work, but they had been absent since 1991/92. The highest levels of feeding activity during the winter 1994/95 were observed along the waters edge, as the rising tide filled the river. The number of Dunlin at Taff/Ely was markedly lower than that recorded during the 1993/94 winter with the mean peak of over 800 birds being less than half that for that year. However, the 1994/95 numbers were similar to those of earlier years with the exception 1993/94. There were only minor changes in the feeding distribution and number of birds at the Rhymney and Orchard Ledges sites.

Spring 1995

The number of Dunlin decreased after the February counts, and very few were present at the three study sites by the end of March. No Dunlin were seen during April at the three sites, but in May birds that were likely to be migrating north from their wintering areas in Africa were present for a short while. At Taff/Ely small groups of less than 10 birds were seen feeding on sector 12 on several tides in May (Figure 3.2.8). Only two Dunlin were seen at Orchard Ledges in spring. At Rhymney, groups of up to 50 birds were present during May (Figure 3.2.9). At Rhymney, the small number of birds occurred in two peaks, before and after low tide (Figure 3.2.10c). Very few birds have been seen during the previous springs.

3.3 Curlew

Curlew characteristically breed on damp upland and northern moorlands but this century it has colonised many lowland regions, especially agricultural habitats (Gibbons *et al.*, 1993). The breeding population of Britain and Ireland has been estimated at almost 50,000 pairs. Some of the birds that breed in southern Britain winter in France, but at the same time, Curlew from continental Europe, especially Scandinavia migrate to Britain to winter (Prater, 1981). The British wintering population of Curlew was estimated at over 76,000 in 1993/94, a decrease from the high 1992/93 value (Cranswick *et al.*, 1995).

Autumn 1994

Curlew usually return early to their wintering grounds and by the beginning of autumn they were present at all three sites. At Taff/Ely, Curlew moved from their roosting position in the saltmarsh onto the mudflats as the tide receded. Most birds did not feed immediately, but continued to roost. When the tide was low enough to uncover adjacent feeding sites, some birds left Taff/Ely while others remained to feed on sectors near to the mouth of the bay (Figure 3.3.1). Many of the Curlew that left Taff/Ely on the falling tide moved onto Orchard Ledges to feed, where both sectors had high levels of usage (Figure 3.3.2). At Rhymney, apart from sector 1, the sectors nearest the land had low levels of usage (Figure 3.3.2). Feeding birds were mainly confined to areas near the tide line, especially at low tide.

The pattern of the numbers of Curlew at Taff/Ely was consistent with the observations described above. There were two clear peaks, three hours either side of low tide (Figure 3.3.3a). These peaks were mainly of non-feeding birds. With the approach of low tide, many Curlew left the bay. Those remaining were seen to be feeding for the two hours before and after low tide. At Orchard Ledges, Curlew fed for the whole of the time that the area was uncovered, approximately three hours before and after low tide, with a mean peak of over 70 birds (Figure 3.3.3b). The pattern of Curlew numbers through the tidal cycle at Rhymney, like that at Taff/Ely, showed two peaks (Figure 3.3.3c). All the Curlew roosted away from the site and as the water level dropped they moved onto the eastern sectors. Some birds left the site to feed elsewhere, while the birds remaining at Rhymney spread out to feed.

The autumn pattern of feeding distribution at Taff/Ely has shown a number of changes. There has been an overall reduction in feeding usage compared with the previous autumns of the study. The main areas of feeding activity have also shown a shift, with eastern and southern sectors, especially sector 2, becoming relatively more important. With the beginning of work on the barrage, the loss of mudflat area in sectors 2 and 18 and the associated disturbance, it will be interesting to see the response of this species. The number of Curlew and their behaviour during the tidal cycle at this site has remained similar since 1990. Levels of usage at Orchard Ledges are similar to the previous autumn study. In contrast, Rhymney has shown a decline in feeding usage by Curlew since the first autumn of the study in 1990. The distribution of feeding birds has remained similar, but the level of usage of nearly all sectors has fallen. The 1994/95 autumn was, however, similar to autumn 1993/94. This reduction in usage is accounted for partly by a smaller number of birds feeding at the site, but also by a changed pattern of behaviour, with only part of the population remaining for the major part of the tidal cycle.

Winter 1994/95

Low tides counts of feeding Curlew showed that they were very widespread along the northwest Severn (Figure 3.3.4). The highest concentration of birds was found on the west part of Rhymney, the east part of Peterstone, and on St Brides.

Previous observations have not shown major changes between autumn and winter populations of Curlew at the study sites. Birds appear to have returned by early autumn and occupied their wintering territory. At Taff/Ely feeding birds were present on many sectors, but the highest levels of usage were found on areas in the centre of the study site, adjacent to the River Taff (Figure 3.3.5). The levels of usage at Orchard Ledges were similar to those found during the autumn (Figure 3.3.6). At Rhymney, there were higher levels of usage on the sectors west of the Cardiff Eastern Sewer compared with sectors at the east end of the study site (Figure 3.3.6). This was a shift of feeding activity compared with that observed in autumn.

Two mean peak numbers of over 60 Curlew were present at Taff/Ely, following the pattern observed in autumn (Figure 3.3.7a). The winter mean peaks were lower than the autumn numbers, but this was similar to that observed during the previous study winters. At the other two study sites, the mean peak number of birds was slightly lower than the autumn values, but otherwise the pattern of presence during the tidal cycle was very similar (Figure 3.3.7b and c).

There has been a reduction of feeding usage at Taff/Ely during the 1995/96 winter compared with the previous winters, in particular on sectors 2, 5, 6 and 17. These sectors are those that are directly affected by, or are close to, dredging and barrage construction work. Although there have been changes in the usage of the other two sites, with an increase in feeding activity on part of Rhymney, the increase has only been small compared to other changes in earlier winters. The number of birds at the three sites during the winter period, was comparable to that found in previous winters.

Spring 1995

Very small numbers of Curlew remained at the study sites into spring. At Taff/Ely, one to two birds were observed feeding on several sectors (Figure 3.3.8). Single birds were present briefly at the Orchard Ledges and Rhymney sites.

A maximum of 10 birds was observed at Taff/Ely, with the majority continuing to roost on the mudflats after the high tide period (Figure 3.3.9a).

During previous spring periods, some Curlew have remained and usage at the Orchard Ledges and Rhymney sites has been higher than 1995 spring, but the number of birds has always been very low.

3.4 Redshank

Redshank breed on wet grasslands and on coastal saltmarshes in Britain and Ireland where the estimated population is over 38,000 (Gibbons *et al.*, 1993). Some of these breeding birds form part of the British wintering population together with Redshank from the Icelandic population (Prater, 1981). The wintering population in 1993/94 was estimated at over 74,000 (Cranswick *et al.*, 1995). The Severn Estuary holds internationally important numbers of wintering Redshank and was the 13th most important estuary in Great Britain in 1993/94.

Autumn 1994/95

Many Redshank return from their breeding grounds and are present at estuarine sites by mid to late summer. Although some of these birds may not have settled on a wintering site at this time, many remain into the autumn period. At Taff/Ely, several hundred Redshank were present through the autumn and were seen feeding on most of the sectors (Figure 3.4.1). The main areas of usage were adjacent to the River Taff in the central part of the study site. No Redshank were seen at Orchard Ledges. At Rhymney, several hundred birds were present and feeding activity was observed on a number of sectors to the east of the Cardiff Eastern Sewer (Figure 3.4.2). Most feeding birds were present on the banks of the River Rhymney on sectors 14-16.

As the tide receded at Taff/Ely, Redshank moved from their roosting areas onto the mudflats. Many birds were out of sight, feeding in small runnels or on parts of the river banks for the early part of the tidal cycle. The bulk of the population at this site came into view as the rising tide pushed them onto higher mudflats. The mean peak population was of over 200 birds (Figure 3.4.3a). During the autumn, many of the birds were present only part of the time that the mudflats were uncovered. Two clear peaks of Redshank numbers occurred at Rhymney, two to three hours before and after low tide (Figure 3.4.3c). The birds have not been seen leaving the site, and the apparent fall in numbers occurred when Redshank moved onto lower areas of the river banks and out of sight from the observation points.

The autumn distribution of feeding Redshank at Taff/Ely has changed compared with previous autumns. During the autumn 1994, there were lower levels of usage on sectors 15-19 in the east of the study site, compared with 1993. There were also lower levels of usage on sectors 8 and 9, north of the PDR work. The distribution of feeding birds at Rhymney was similar to that found during previous autumns, but the levels of usage on the sectors were lower. The number of Redshank at Taff/Ely was comparable with the autumns 1992 and 1993, all of which were lower than 1991. The number of Redshank observed during the all day counts at Rhymney was lower than the three previous autumns, but as has been explained, the specific behaviour of the birds can affect the number seen on such counts.

Winter 1994/95

Low tide counts of feeding Redshank on the northwest Severn showed that the main areas occupied were at the Taff/Ely and Rhymney areas, with a few feeding birds being located on Peterstone and St Brides (Figure 3.4.4).

Feeding Redshank were widely distributed at Taff/Ely with almost all sectors being used (Figure 3.4.5). Many birds were located on areas adjacent to the river or to fresh water channels. The overall levels of usage were similar to the autumn observations, but some sectors showed a noticeable change. Sectors 2 and 5, which were closest to the barrage work, had very few Redshank feeding on them. No Redshank were seen at Orchard Ledges. At Rhymney, Redshank were found on all sectors to the east of the Cardiff Eastern Sewer with the highest levels of usage occurring on sectors 14, 15 and 16 (Figure 3.4.6). As in the autumn, the main feeding areas were confined to the areas adjacent to the river on these sectors.

The numbers of Redshank observed at Taff/Ely and their behaviour during the tidal cycle was similar to that described for the autumn period (Figure 3.4.7a), although a higher proportion of the birds fed for longer periods. The number of birds at Rhymney was higher than in autumn and the mean peak occurred three hours before low tide (Figure 3.4.7c). As during the autumn, Redshank did not leave the site until late in the tidal cycle, but moved to positions where they were less visible.

The feeding distribution of Redshank at Taff/Ely has shown a number of changes since the 1991/92 winter. Feeding birds were then present on sectors 7, 10, 11 and 12 and the levels of usage were comparable with many other sectors. Levels of usage on these sectors declined during the following two winters, as work proceeded on the PDR. During the current winter 1994/95, feeding Redshank were again seen more frequently on these sectors. The observed levels of usage at Rhymney were lower than the previous three winters although this may in part be because of the behaviour of the birds, referred to above. The number of birds and their pattern of behaviour during the tidal cycle at the three study sites was very similar to the previous winters of the study.

Spring 1995

Redshank numbers declined during the late winter and by the beginning of spring, almost all the birds had left for their breeding grounds. A maximum of three birds was seen at Taff/Ely but no birds were observed at the other two sites.

These observations are comparable to the findings of previous springs.

3.5 Other Species

3.5.1 Mallard

Although Mallard is the most abundant wildfowl in Britain, the numbers wintering on British estuaries have continued to decline (Cranswick *et al.*, 1995). Large numbers of birds are also found on inland sites and the population is boosted annually by the release of hand-reared birds for shooting. The Severn Estuary holds nationally important numbers of Mallard and is the 5th most important estuary in Great Britain for this species.

Winter 1994/95

The majority of the feeding Mallard observed on the northwest Severn during low tide counts were located at the east end of this area, mainly on the east of Peterstone and on the lower sectors of St Brides (Figure 3.5.1.1). These birds fed along the tide edge.

Taff/Ely supported small numbers of feeding Mallard. These were mainly found along the sectors bordering freshwater channels and the River Taff, especially in the centre of the study site (Figure 3.5.1.2). Because of the nature of the substrate, no feeding Mallard were found at Orchard Ledges. At Rhymney, feeding birds were again found mainly along the edge of the river and only sectors bordering this freshwater were used at all (Figure 3.5.1.3).

There were few Mallard at both Taff/Ely and Rhymney, with peak means of 25-35 birds (Figures 3.5.1.4a and c). Only part of the population fed at any one time at either site. At Taff/Ely the majority of observed birds roosted through the tidal cycle.

The winter observations were very similar to those found during the autumn period at both sites where Mallard were present. In spring, only one or two birds remained at Taff/Ely and no birds were seen at Rhymney.

The number and feeding distribution of Mallard at all three study sites has shown only minor changes during the period from 1991-1995. The only sector near any of the works where Mallard were found in earlier winters was sector 12. No feeding birds were present on this area during the winter 1993/94, but low levels of usage were found during the current winter 1994/95.

3.5.2 Teal

Teal breed in Britain, thinly distributed in areas throughout England, Scotland, Wales and Ireland. There has been a marked contraction in range over the last twenty years (Gibbons *et al.*, 1993). The wintering population, although showing a general increase over the last 25 seasons, has fluctuated between the 1989/90 to 1993/94 winters (Cranswick *et al.*, 1995). The Severn Estuary holds nationally important populations of Teal.

Winter 1994/95

The main population of feeding Teal seen at low tide on the northwest Severn was at the east end of this area on St Brides section, with smaller numbers occurring near the rivers Taff and Rhymney (Figure 3.5.2.1).

There were three main areas of feeding Teal at Taff/Ely. Teal feed mainly in shallow water and sector 18 adjacent to the freshwater channel, had the highest level of usage (Figure 3.5.2.2). The other feeding groups were located along the line of the old South Glamorgan Canal between sectors 11 and 12, and on the north edge of sector 8. Lower levels of usage were found at Rhymney, with the Teal confining themselves to the banks of the River Rhymney, east of the Cardiff Eastern Sewer (Figure 3.5.2.3). No Teal were seen at Orchard Ledges.

The peak mean number of Teal at Taff/Ely and Rhymney was less than 100 birds (Figure 3.5.2.4a and c). There was no clear pattern of feeding or presence on the mudflats and many birds were not included in counts as they spent a lot of time on the open water.

Only small numbers of Teal had returned to Taff/Ely during the autumn, and no birds were recorded at the other two sites during this period. By the end of the winter period, all of the Teal had moved away from the study area.

There has been a change in the feeding distribution of Teal at Taff/Ely since the winter 1991/92. High levels of usage occurred on sectors 1 and 2, near the mouth of the study site, in that winter. During the following winters, feeding Teal have made more use of the sectors to the north and east of the River Taff. During the current winter 1994/95, almost no feeding

birds were found on sectors 1-7. Although sectors 1 and 2 have had considerable disturbance during the current winter this cannot explain the shift away from the area that occurred during the previous winters. Only much smaller changes have occurred in the feeding distribution of Teal at Rhymney. The number of birds present at these study sites has not shown a marked change during this same time period.

3.5.3 Pintail

Pintail is a rare and local breeding bird in Britain (Gibbons *et al.*, 1993). This species colonised Britain in the late nineteenth century and since 1973 at least the British and Irish breeding population has been relatively stable (Fox & Meek, 1993). Breeding birds from northwest Europe move south in autumn, with over 19,000 being found wintering on British estuaries in 1993/94 (Cranswick *et al.*, 1995). The wintering population declined a number of years go and remains low. The Severn Estuary holds nationally important numbers of Pintail.

Winter 1994/95

The highest densities of feeding Pintail observed during low tide counts on the northwest Severn were on sectors near to the River Rhymney at Peterstone and Rhymney (Figure 3.5.3.1). Smaller numbers of birds were also present, feeding along the tide line, at the east end of this whole study area. This pattern is consistent with that observed during previous winters.

No Pintail were seen at Taff/Ely or Orchard Ledges during the winter period. At Rhymney, feeding Pintail were present along the tide line, mainly to the east of the Cardiff Eastern Sewer (Figure 3.5.3.2). The birds were observed to move from further east, on to the study area as the tide receded, remaining on the waters edge to feed. As the tide turned, feeding birds moved onto sectors higher up the shore, producing the pattern of usage shown in the diagram. Lower levels of usage were found on sectors to the west of the Cardiff Eastern Sewer, apart from sector 9, where feeding birds were present at the east end of this sector around the low tide period.

Most of the birds at Rhymney arrived three hours before low tide, when the lower shore became exposed, remaining there until these areas again became covered on the rising tide (Figure 3.5.3.3c). The majority of Pintail fed at this time.

By late autumn, small numbers of Pintail had returned to Rhymney, but all had left before the spring study period.

Apart from minor changes in the feeding distribution at Rhymney, the pattern of usage and the numbers of birds has shown little change during the study winters.

3.5.4 Pochard

Pochard have bred in Britain since the last century, but are still only present in low numbers (Gibbons *et al.*, 1993). The wintering population, as estimated by the Wetland Bird Survey, has shown a decline since the late 1980s, but the 1993/94 counts showed an increase. Over 37,000 birds wintered on estuarine sites in that year (Cranswick *et al.*, 1995). The Severn Estuary holds nationally important numbers of wintering Pochard and is the fourth most important estuary in Great Britain.

Small numbers of feeding Pochard were present on the northwest Severn during low tide counts, near the Rivers Taff and Rhymney (Figure 3.5.4.1). Larger numbers of Pochard were

present at times near to the mouth of the River Rhymney, but usually these birds remained on the open water where they fed by diving.

At Taff/Ely, up to three birds were observed feeding on sectors to the west of the River Taff. Up to 40 birds were present within the bay on many count days, but these birds usually roosted on the open water. At Rhymney, Pochard moved into the channel of the mouth of the river as the tide receded and some of these birds fed on the edge of the adjacent sectors (Figure 3.5.4.2). Less commonly, some Pochard moved to the west of the Cardiff Eastern Sewer and fed along the tideline.

A peak mean of over 50 birds was recorded after the low tide period at Rhymney (Figure 3.5.4.3c). Many of these moved onto the edge of the sectors forming the river banks and roosted, with only a small part of this population feeding at any one time.

Pochard were only present during the winter part of the study period.

Since winter 1991/92, at Rhymney, there has been an increased tendency for Pochard to move to the River Rhymney to feed, or more commonly, roost for short periods. This only involves a minor change in behaviour, as large numbers of this species have been present in the vicinity of this study site each year.

3.5.5 Oystercatcher

Tens of thousands of pairs of Oystercatcher breed throughout the British Isles, occupying inland and coastal sites (Gibbons *et al.*, 1993). In autumn and winter, the number of birds increases with the influx of migrants from northern Europe. The wintering population was estimated at over 237,000 in 1993/94 (Cranswick *et al.*, 1995). The Severn Estuary is not an important wintering site.

Winter 1994/95

Feeding Oystercatchers were found on most parts of the northwest Severn during low tide counts, the largest numbers being present at Rhymney and the east end of Peterstone (Figure 3.5.5.1).

Small numbers of feeding Oystercatcher were present at Taff/Ely, mainly on sectors to the south and west of the River Taff (Figure 3.5.5.2). On some tides, Oystercatcher remained in the bay over the high tide period and moved onto the sectors to feed for a short time as these areas became uncovered. Much larger populations of feeding Oystercatcher were present at Orchard Ledges and Rhymney (Figure 3.5.5.3). At Orchard Ledges, the birds moved from their high tide roost sites, mainly to the east of Rhymney, onto the stony shore as soon as it started to become uncovered. At Rhymney, all sectors were used by feeding Oystercatcher. Large numbers of birds moved along the lower shore as the tide receded and continued to feed while areas were exposed, producing the pattern of usage shown in Figure 3.5.5.3. The highest densities of feeding birds were found on sector 13 and the east end of sector 14, giving these sectors their high usage values.

A very distinctive pattern of Oystercatcher presence was found at Taff/Ely during the tidal cycle (Figure 3.5.5.4a). Almost all of the birds moved out of the bay two hours before low tide, and returned two to three hours after low tide. These birds were observed flying to the adjacent Orchard Ledges when it became uncovered and returning when it was later covered by the tide. The peak mean number of birds was high after the low tide period, but not all of these birds remained to roost in the bay. Oystercatcher arrived at Orchard Ledges as it became exposed by the falling tide and remained feeding until it was again covered,

producing a broad peak of about 25 birds around low tide (Figure 3.5.5.4b). The peak mean number of 170 Oystercatcher at Rhymney occurred shortly after the eastern part of the study site became uncovered and this number dropped as birds moved to other areas to feed nearer the low tide period (Figure 3.5.5.4c).

Oystercatcher had returned from their breeding grounds and were present at the three study sites during the autumn period. Their numbers and feeding distribution were similar to that described for winter. By spring, there were almost no Oystercatcher at Taff/Ely, and the Orchard Ledges and Rhymney populations were reduced to about a third of their winter values.

The numbers of Oystercatcher and their feeding distribution at all three study sites has remained stable since the 1989/90 winter.

3.5.6 Ringed Plover

The majority of the British and Irish breeding population of almost 10,000 pairs of Ringed Plover is found on coastal sites, but increasingly breeding birds are found on suitable inland areas (Gibbons *et al.*, 1993). Many of these birds winter around the estuaries and coast of Britain with the 1993/94 winter estimated population at over 9,000 (Cranswick *et al.*, 1995). Ringed Plover wintering numbers may be decreasing (Browne *et al.*, in press). The Severn Estuary does not hold nationally important numbers of this species.

Winter 1994/95

No Ringed Plover were observed during low tide counts of the northwest Severn.

Feeding Ringed Plover were present at Taff/Ely on a number of count days, but their occurrence was not consistent. Small groups of birds were seen for short periods of time feeding on the mudflats in the middle of the study site (Figure 3.5.6.1). Occasionally a group of Ringed Plover was seen to fly into the bay to roost over the high tide period. At Orchard Ledges, Ringed Plover were very difficult to detect, unless they were near to the shore and actively feeding, because of the nature of the substrate. Feeding birds were only observed on sector 1 (Figure 3.5.6.2). Small numbers of Ringed Plover sometimes roosted over the high tide period on the shingle shore near sector 17 at Rhymney. These moved onto the mudflat to feed as the tide receded, fed elsewhere for most of the tidal cycle and returned to feed briefly just before the area was again covered (Figure 3.5.6.2).

The number of Ringed Plover at any of the study sites was small. At Orchard Ledges, birds arrived just as the site became uncovered, moved elsewhere or out of site for most of the period near low tide and then again reappeared just before sector 1 became covered (Figure 3.5.6.3b). This similar pattern has already been described for Rhymney and produced two peak means of less than 10 birds.

Small groups of Ringed Plover were seen at the three study sites during the autumn period, but by spring, only one small group was noted at Rhymney.

These findings are similar to those reported during the previous study years.

3.5.7 Grey Plover

Grey Plover do not breed in the British Isles. The wintering birds originate mainly from breeding areas between the White Sea and the Taimyr Peninsula. The British wintering population,

estimated in 1993/94 at over 46,000, showed a continued increase compared with the previous winters (Cranswick *et al*., 1995). The Severn Estuary holds nationally important numbers of wintering Grey Plover.

Winter 1994/95

Feeding Grey Plover were found on several sections during low tide counts on the northwest Severn (Figure 3.5.7.1). The main groups were on St Brides.

Several small groups of feeding Grey Plover were seen at Taff/Ely, with a maximum count of 11 birds. Their presence was irregular and they usually only remained for one to two hours. No birds were seen at either of the other two study sites during the winter period.

Grey Plover were not present at the study sites during autumn and spring.

This species has been regularly recorded at Taff/Ely, and during the earlier winters larger numbers were observed. The population of wintering Grey Plover has always been too small to be important.

3.5.8 Lapwing

Almost a quarter of a million pairs of Lapwing breed in the British Isles. Even more birds winter, as Lapwing from Scandinavia and other parts of Europe move southwest, although at the same time, some of the British breeding birds move to the continent to winter (Prater, 1981). Large numbers of wintering Lapwing are located on both estuaries and inland sites, and the Severn Estuary holds nationally important numbers of this species.

Winter 1994/95

Although large flocks of Lapwing are present in the area, the majority of birds remain inland to feed and roost. Groups of feeding Lapwing were observed on several sections of the northwest Severn during low tide counts (Figure 3.5.8.1). St Brides supported the largest feeding groups with other birds being present on Rhymney and Taff/Ely.

Feeding Lapwing were present on the northwest part of Taff/Ely (Figure 3.5.8.2). The highest levels of usage were recorded from sector 12 and the sectors north of the PDR bridge, 8, 9 and 10. The Lapwing only spent part of the time feeding while they were on these sectors. No Lapwing were seen at Orchard Ledges. At Rhymney, the main group of feeding Lapwing were close to the shore on sector 16, with smaller numbers of birds moving along the east edge of sectors 14, 15 and 16 at times (Figure 3.5.8.3).

The number of Lapwing at these sites is small compared with the size of many inland wintering flocks. At Taff/Ely, there were two peaks of less than 50 birds during the tidal cycle, fewer birds remaining at the study site during the low tide period (Figure 3.5.8.4a). At Rhymney, the number of Lapwing increased during the tidal cycle with the peak mean of about 50 birds occurring just before the tide covered the mudflats (Figure 3.5.8.4c). At both sites, spells of feeding activity were interspersed with long spells of inactivity.

Only very small numbers of Lapwing were present at the study sites during autumn, and by spring, all of the birds had left.

3.5.9 Knot

Knot that winter in Britain and Ireland arrive from breeding areas in northern Greenland and north-eastern Canada. The winter maximum for Great Britain was over 250,000 in 1993/94 (Cranswick *et al.*, 1995). The Severn Estuary is not a nationally important wintering site.

Winter 1994/95

Feeding flocks of Knot are less predictable than many other waders, as their behaviour from one year to the next can show considerable variation. The numbers of Knot seen on the northwest Severn during low tide counts over the winter periods of the study have varied a lot. The only notable groups of feeding Knot were found on the east of St Brides, with smaller numbers present at Rhymney (Figure 3.5.9.1).

Very few feeding Knot were present at Taff/Ely during all day counts and these were seen on sector 17 only (Figure 3.5.9.2). Larger flocks of feeding birds were present at Rhymney and these were seen mainly on the parts of sectors 14-16 adjacent to the river (Figure 3.5.9.3). The Knot usually arrived at the site when the sectors concerned had been uncovered for several hours and were often associated with Dunlin or Redshank.

At both the Taff/Ely and Rhymney sites, the Knot arrived after low tide and left before the mudflats were covered by the rising tide (Figure 3.5.9.4a and c).

No Knot were present at the three study sites during the autumn or spring periods.

During previous winters, the numbers of Knot at the study sites have varied considerably. Compared with the winter 1993/94, the numbers of Knot present at the Taff/Ely and Rhymney sites were much lower, but almost no Knot were recorded during the winter before that. This is due to the erratic behaviour of the Knot and is unlikely to have been affected by any changes at the study sites.

3.5.10 Turnstone

Turnstone do not breed in Britain and the wintering population is derived from the Greenland and Canadian breeding populations. They winter around coastal areas, occupying a variety of habitats, including rocky shores where their numbers could be underestimated. The 1993/94 British estuarine wintering population was estimated at 14,600 birds (Cranswick *et al.*, 1995).

Winter 1994/95

Low tides counts of the northwest Severn found feeding Turnstone occurring only on the western end of Rhymney (Figure 3.5.10.1). This is the stony area of Orchard Ledges. Apart from a few other very small areas, most of the northwest Severn has mudflats with substrates unsuitable for feeding Turnstone.

Feeding Turnstone were recorded regularly at Taff/Ely, but only along the stony edge of sector 3 (Figure 3.5.10.2). The birds arrived on this area on many tides, two to three hours after low tide. These birds could be seen flying into the bay from the direction of Orchard Ledges, which would be covered by the rising tide at this time. The Turnstone stayed on the edge of sector 3 on some count days, over the high tide period, and then left the bay on the falling tide. Orchard Ledges supported many more feeding birds on both sectors (Figure 3.5.10.3). Small numbers of Turnstone were found at Rhymney, flying in to feed three to four hours after low tide. They were found on sector 17 and sometimes on the nearby parts of sectors 14 and 15.

At Taff/Ely, flocks of over 20 birds were recorded occasionally, although the number of birds was usually less than this, giving a peak mean count of less than 10 birds (Figure 3.5.10.4a). The peak mean number of almost 60 birds at Orchard Ledges occurred when the falling tide

first exposed the stony shore (Figure 3.5.10.4b). At Rhymney, there were two clear peaks of birds, as has already been explained, both of less than 20 birds (Figure 3.5.10c).

Small numbers of Turnstone were present at the three sites during the autumn, following the pattern of behaviour described for the winter period. By the spring, almost all the Turnstone had left the study area.

There has been some small variation in the numbers of birds present at the three study sites compared with previous winter periods, but the overall pattern of Turnstone distribution has remained very similar.

3.6 Other Wildfowl and Wader Sightings

Several other species of wildfowl and waders were observed at the Taff/Ely and Rhymney sites but in numbers too small to be included in the separate species accounts. These are shown in Table 3.6.1.

4. DISCUSSION AND CONCLUSIONS

This is now the 6th year of intensive monitoring of the waders and wildfowl populations of the northwest Severn in relation to the proposed Cardiff Bay Barrage. The several years of intensive studies have built a picture of the distributions and movements of the main species wintering in the area. Because of year-to-year variation, several years' data are essential if an accurate view of the status of the waterfowl populations is to be obtained before the barrage is built. Without this, it would be very difficult to determine the fate of the birds after the bay is inundated. The current study period, from autumn 1994 to spring 1995, is the first year of the second phase of this study, the 'during construction phase'. Changes that have already taken place in the bay have had an effect on the distribution of birds within the study site. As work progresses with the barrage construction, it already appears that this too will affect the distributions and numbers of birds using the bay as a wintering area. It will be essential to obtain a clear picture of any such changes to these populations during this phase if it is to be possible to assess the effect of the Cardiff Bay barrage on waders and wildfowl.

The recent changes to the distribution and abundance of the waterfowl of the area, as shown by the current all day counts, are discussed below.

Shelduck (no obvious disturbance effect)

The low numbers of Shelduck present during the autumn have not shown any notable change in behaviour or distribution. The winter numbers and distributions of this species have also remained similar to those recorded in the previous year and in the earlier winters of the study. Their distribution at Taff/Ely has meant that they have not been unduly affected by changes and disturbance from the development of the PDR. The number of birds remaining in the spring study period at both the Taff/Ely and Rhymney sites was down on that of spring 1994, but there is no evidence of any longer term trend.

Dunlin (likely disturbance effect)

At both Taff/Ely and Rhymney, the autumn numbers of birds and the levels of usage have shown a reduction compared with the autumn 1993. However, that year had seen larger numbers of Dunlin present on the study sites. There was a shift in the distribution of feeding birds at Taff/Ely during the winter. Sector 3, previously an important feeding area for Dunlin, held fewer feeding birds for less time. Sector 7, however, showed increased levels of usage. This is one of the sectors that was

directly affected by the PDR work and for several years, very few Dunlin were seen to feed. Feeding flocks gathered on the rising tide south of the PDR, especially on the steep river bank. It is likely that this renewed use of sector 7 is in response to the cessation of disturbance close to this feeding area now that work on the PDR has finished.

Curlew (possible disturbance effect)

During the autumn period, there was a reduction in the levels of usage and a shift in the distribution of feeding Curlew at Taff/Ely compared with the previous autumn, although the numbers of birds remained similar. Higher levels of feeding occurred on sectors in the east and south of the study site, especially sector 2. By the beginning of the winter study period, dredging work had commenced on sector 2, with large amounts of mud being removed directly from that sector and considerable accompanying disturbance from the dredging craft. Both sector 2 and the adjacent sector 5 showed a marked reduction in the levels of usage. Far fewer birds were feeding at the site at this time. At Rhymney, there has been a continued decline for several years in the autumn levels of usage although the number of birds and their feeding distribution has remained similar. This would suggest a change in feeding behaviour, with less time being spent actually feeding while the birds are at this site. The winter feeding at Rhymney has not shown these changes. Fewer Curlew were recorded during the 1995 spring at all three sites compared with the previous year.

Redshank (likely disturbance effect)

There was a shift in the feeding distribution of Redshank at Taff/Ely. Two northern areas, sectors 8-9 and 15-19 which had been important during previous autumns, showed a reduction in the levels of usage, but the numbers of birds were similar to the previous autumn, the lower usage of some areas resulting from a change in the pattern of feeding behaviour. During the winter, sectors 11 and 12 showed increased levels of usage compared with previous winters. These areas had been used by many feeding Redshank during the early winters of the study, but with the commencement of the work on the PDR, usage levels declined markedly. With the reduction in disturbance following completion of the PDR work, it appears that Redshank are again returning to these sectors. Lower levels of usage were recorded at Rhymney, but this was attributable to a change in the behaviour of the Redshank. On many observation days, Redshank could be seen to move to the west banks of the River Rhymney as the water level fell and to remain there feeding during much of the tidal cycle. In this position, the birds were out of sight and were not therefore recorded during the counts.

Other species

The most common of these, Mallard, Pintail, Oystercatcher, Ringed Plover, Grey Plover and Turnstone showed changes that were no greater than the usual level of year-to-year variation.

At Taff/Ely, Teal have shown a shift in feeding distribution, with almost no feeding taking place now on sectors 1-7, in contrast with earlier winters. The reduction in feeding on sectors 1 and 2 was not attributable to dredging, as these particular sectors had been used less the previous winter.

There have always been sizeable populations of Pochard on the Severn Estuary, just off the River Rhymney mouth. Since 1991/92, more of these birds have moved into the mouth of the river, with some feeding at the water's edge, producing the highest levels of usage during the current year's study.

Lapwing have shown some changes in distribution at both the Taff/Ely and Rhymney site, although the populations concerned are relatively small. At Taff/Ely, sector 12 was used by feeding

Lapwing during the 1994/95 winter. This sector has become more important for feeding birds of several species during this winter, this possibly being related to the cessation of disturbance from the PDR work.

The number of Knot and their level of usage at Taff/Ely and Rhymney were lower this winter than the previous winter, but as has already been explained, this is not atypical of this species.

To summarize, the work on the PDR and landfill areas in the northwest of Taff/Ely has now finished. This has removed one major source of direct and indirect disturbance. There is some evidence that birds are again making more use of some of the sectors that have been affected by disturbance for several years. At the same time, dredging has commenced in other areas of the bay and the barrage construction is now underway. Several sectors will be directly affected by this work, as well as increasing the general levels of disturbance within the bay. There are early signs that this work is affecting the feeding distribution of some of the species that use the bay.

PART 2: THE EFFECT OF SOME WHOLE ESTUARY ENVIRONMENTAL VARIABLES ON WATERFOWL COMMUNITIES

5.1 INTRODUCTION

Birds usually exist in habitats as communities, e.g. a woodland community may be composed of species of tits, Wood Warbler, Crossbills etc; a farmland community may include Yellowhammer, Whitethroat, etc.. The species involved have some common requirements that are met by the habitat such as food or nest sites. Many estuarine communities rely on food items available on or in the intertidal mud. Waders and wildfowl are the main species that make up such estuarine communities and the exact composition of the community may be determined by specific requirements, e.g. Oystercatchers are associated with mussel-beds; Wigeon are associated with saltmarsh. Many other factors are responsible for determining the exact composition of bird communities in a wintering area. These may include natural physical, biotic and climatic factors, but may also include man-made factors. Disturbance can be an important factor as the tolerance of species is very variable.

Since the beginning of the long-term study of the waders and wildfowl of Cardiff Bay and nearby areas, there have been a number of changes within the bay itself (Taff/Ely site). From 1990-1994, the PDR was built across the northwest corner of the bay. The obvious changes associated with this that could have affected the bird communities were: the direct loss of mudflat area that had been used for feeding substrate; changes to areas immediately adjacent to mudflats; and disturbance from the large scale works. During autumn 1994, work started on the barrage itself and this has also resulted in the loss of mudflat area and of disturbance to nearby areas. The possible effects of these changes have already been referred to in sections 3 and 4. In order to assess if such changes to the habitat are responsible for any changes to the bird communities, or if other factors have been responsible, it is necessary to re-analyse the data from the whole study period using a range of statistical procedures. All areas of the bay (Taff/Ely site) were counted. This includes areas directly affected by the works, indirectly affected and far removed from the works, as well as areas outside the bay (Orchard Ledges and Rhymney sites). The unaffected areas can act as controls.

5.2 METHODS

The composition of the bird communities was calculated from the data obtained from the all day counts for the six year period 1989/90 to 1994/95. Only data relating to the winter periods were used, as several species were only rarely present during the other two seasons. The data for the eight main species, Shelduck, Mallard, Teal, Pintail, Oystercatcher, Dunlin, Curlew, Redshank were used to define the community composition. Usage values (the average number of feeding bird hours per tidal cycle) were available for a total of 38 mudflats or sectors (Taff/Ely 19; Orchard Ledges 2; Rhymney 17) and these were corrected for the area of each mudflat to produce a 'usage density' value. These values were adjusted for the direct loss of 8% and 23% feeding area of sector 7 and 10 respectively from 1991/92 onwards. There was a significant change in the area of sectors 1, 2 and 18 during the 1994/95 winter and this will have to be taken into consideration in future years.

5.2.1 Estuary Environmental Variables

The variables that were used in an attempt to elucidate the factors that affected the waterfowl communities on each mudflat were: distance from land (related to the possible effects of man's activities), sediment type and disturbance from road or barrage construction.

- The distance value was calculated as the distance from the centre of each mudflat to the nearest point on land. These values were constant for the whole six-year period, even on those mudflats that lost feeding area as such loss ran at right angles to the shore.

- No detailed sediment analyses are available and the mudflats were broadly categorised into two types, muddy or stony. The majority of the mudflats are of mud, looking superficially similar, although the proportion of particles of different sizes would vary. Only those at Orchard Ledges were noticeably different, consisting of a surface of broken stones. These values were constant for the whole six-year period.

- Disturbance values were assessed on a four-point scale. Category 1 included mudflats affected by loss of some of their area as a direct result of road or barrage construction. These mudflats were inevitably heavily disturbed during the construction period. Category 2 included mudflats adjacent to those in category 1, where disturbance from work activity could be high, but the mudflats were not affected directly. Category 3 included all of the mudflats at Taff/Ely that were not put into categories 1 and 2. During the six-year period, some mudflats became less disturbed as the work on the PDR progressed and eventually finished, whilst others became affected by the beginning of the barrage work. Category 4 included all the mudflats at the other two sites, Orchard Ledges and Rhymney. These were unaffected by disturbance from major works for the whole of the six-year period, though they could, of course, be affected by localised disturbance events such as bait-digging, dog walking etc..

No data were available for the invertebrate composition of the various mudflats, the source of food for the wintering birds. The values for these mudflat variables are given in Tables 5.2.1a and b.

5.2.2 Analysis of data

Multivariate analysis of the patterns of species usage densities between the mudflats was used to determine which species tended to found together on the same mudflat and also which mudflats tended to hold the same species. As this statement implies, this is a two-way analysis of birds by mudflats. The mudflats and species were simultaneously ordered along ordination axes using detrended correspondence analysis (DECORANA) with no down-weighting of less common species (Hill, 1979a). Correspondence analysis gives each mudflat and species a score along an ordination axis such that a particular mudflat's score is the average (weighted by the species densities) of the scores of the species which occur on it, while a species' score is the average of the scores of the mudflats on which it was recorded, where the weight given to each mudflat is proportional to the usage density of the species on that mudflat. Mudflats placed close together on the ordination graph have similar bird communities and species placed close together tend to occur on the same or similar type of mudflat. Thus mudflats at the two extremes of the axes tend to have most dissimilar bird communities.

The analysis was based on the overall usage densities of the eight commonest waterfowl species for each of the 38 mudflats.

The mudflat scores for each of the first four ordination axes were plotted against and correlated with the individual environmental variables described earlier to aid interpretation of the axes. Stepwise multiple regression was then used to select the combination of variables which jointly gave the best predictions of the ordination axes (based on PROC STEPWISE procedure of SAS with p=0.05 significance level for each variable entry and removal (SAS Institute, 1989)).

In a separate analysis, the communities of birds were classified using two-way indicator species analysis (TWINSPAN) (Hill, *et al.* 1975; Hill, 1979b; Gauch, 1982). The aim was to examine whether the mudflats could be classified into a number of groups on the basis of their bird communities. Of particular interest was the effect of disturbance on mudflat classification.

The estimated environmental variables on each mudflat were used as descriptive variables in a stepwise linear analysis (James, 1985) using SAS PROC STEPDISC with a P = 0.05 entry and elimination significance level for independent variables (SAS Institute, 1989) in an attempt to identify the factors determining the differences between the mudflat groups identified by TWINSPAN. The effectiveness of different models in describing the data is compared using SAS PROC DISCRIM.

5.3 RESULTS

5.3.1 Contribution of Species to Community Composition

The species scores for DECORANA axes 1 (DCA 1) and 2 (DCA 2) are represented in Figure 5.3.1.1 and their values on the four ordination axes are tabulated in Table 5.3.1.1. DCA 1 explains 64.4% and DCA 2 explains 18.2% of the variation in the four axes. Shelduck and Mallard have similar DCA 2 scores and are loosely positioned in the middle of the ordination space. This indicates that they tend to be found in association, and a waterfowl community that holds Mallard is also likely to include Shelduck. Pintail has a diet that can be dominated by molluscs, unlike other species of dabbling ducks, and the low DCA 1 score suggests that it is unlikely to be associated with other ducks. Widely separated positions on the ordination space may at least in part reflect the different habitat requirements of species with dissimilar diets. Mudflats that have communities that include Oystercatcher and Curlew would tend to have fewer Redshank.

5.3.2 Contribution of The Mudflats to Community Composition and Ordination Axes Interpretation According to Environmental Factors

The DCA 1 and DCA 2 scores for the mudflats from the three study sites for the six winters are given in Figure 5.3.2.1. This includes the periods of work and disturbance at Taff/Ely. The three study sites are differently aggregated in the ordination space, but do not fall into completely separate groupings, reflecting an overlap in the bird communities on mudflats at these sites. The Orchard Ledges mudflats for the six winters are aggregated towards the 'y' axis, with low DCA 1 scores and varying DCA 2 scores. The majority of the Rhymney mudflats for the six winters have moderate DCA 1 and DCA 2 scores, although there are a number of outliers. The Cardiff Bay (Taff/Ely) mudflat scores overlap with some Rhymney scores, suggesting a similarity in the bird communities on some of the mudflats during the six winters. However, many Cardiff Bay mudflats have lower DCA 2 scores and higher DCA 1 scores than the Rhymney mudflats.

Figures 5.3.2.2 and 5.3.2.3 depict these same DCA 1 and DCA 2 scores, but separate them into scores for the 1989/90-1990/91 winters (before the major PDR, landfill or barrage work at Cardiff Bay) and for the 1991/92-1994/95 winters (during much of the major works at Cardiff Bay). There is clearly some change in the communities at all three sites as shown by the differing aggregations in the ordination space, but the scores for Cardiff Bay show a higher degree of movement or change. At Rhymney, most ordination values are similarly aggregated over both time periods. The Cardiff Bay ordination values show some spreading out between these periods, with more mudflats having higher DCA 1 scores for the 1991/92-1994/95 period than compared with the earlier period. This suggests that there has been some change in the bird communities on some of these mudflats.

Figures 5.3.2.4 and 5.3.2.5 show these DCA 1 and DCA 2 ordination scores for the six winters for the Cardiff Bay mudflats only. Figure 5.3.2.4 shows the scores of the mudflats that were affected by the PDR and landfill activities, mudflats 7 and 10 being affected directly and mudflats 8, 9, 11 and 12 being indirectly affected by the disturbance. Figure 5.3.2.5 shows the scores for the remaining mudflats at the Cardiff Bay site which were less likely to be affected by this work. The ordination scores for all of the 'disturbed' mudflats shown in Figure 5.3.2.4 have shifted during the period of the six study winters, but the scores for mudflats 7 and 10 have shown most variation. It is

interesting to note that the 1989/90 score for mudflat 7 is similar to that for 1994/95. This suggests that the bird community changed during the years of disturbance, but by 1994/95 it had recovered and was similar to the first winter of the study. Mudflat 10, on the other hand, had similar waterfowl communities from 1989/90 to 1991/92, which changed considerably before stabilising at a new community type from 1992/93 to 1994/95. The lack of any obvious recovery to the earlier community may be due to the large amount of landfill associated with the PDR which occurred on mudflat 10. Most of the scores of the 'undisturbed' mudflats of Cardiff Bay in Figure 5.3.2.5 are closely aggregated, suggesting that less change occurred in the bird communities during the six winters.

The DCA 1 and 2 axes scores for each of the three study site mudflats for the six winters were plotted against the distance from land and against the disturbance value (Figure 5.3.2.6). There were significant ($P<0.05$) negative correlations between the DCA 1 scores and distance from land, disturbance value and sediment type. There were significant positive correlations between the DCA 2 scores and distance from land, disturbance value and sediment type.

Based on a stepwise multiple regression analysis, distance to land and disturbance (work) jointly explained 41% of the variation in the first ordination axis scores (Table 5.3.2.1). Disturbance (work), distance to land and sediment type explained 34% of the variation in the second ordination axis score.

5.3.3 Hierarchical Classification of Mudflats Based on Their Waterfowl Communities

The TWINSPAN hierarchical classification of the mudflats, taken to six levels, is shown in Figure 5.3.3.1 and the mudflat composition of the 46 groups is shown in Table 5.3.3.1. The first division separated groups 1-25 from 26-46.
The main observations are:

- The disturbed mudflats at the Cardiff Bay site are mostly in groups 1-25. The three exceptions are for years when disturbance had not started to affect the mudflats concerned or after disturbance had ceased.

- The undisturbed mudflat communities tend to be in similar groups e.g. Orchard Ledges; Cardiff Bay 3-4 and 17; Rhymney 15.

- Disturbed mudflat communities move between groups e.g. Cardiff Bay 7 and 10.

- Certain Groups tend to have a higher proportion of disturbed mudflat communities e.g. groups 4, 5, 6, 7, 24 and 25.

The results of stepwise discriminant analysis indicated that all three untransformed variables considered, distance ($F = 54.92$, $P = 0.0001$), work disturbance ($F = 33.13$, $P = 0.0001$) and sediment type ($F = 12.79$, $P = 0.0004$) were significant discriminators between the first division of the 234 mudflat communities into groups 1-25 and 26-46 identified from the TWINSPAN analysis. These variables correctly assigned 77.3% of the mudflat communities from the groups 1-25 into that pooled category, and correctly assigned 65.2% of the mudflat communities from groups 26-46 into that pooled category. In total, 71.4% of the mudflat communities were correctly assigned to their group.

In subsequent reports we will attempt to improve the discrimination of these analyses.

5.4 DISCUSSION

The waterfowl communities present on a mudflat are affected by distance to land, disturbance from work and sediment type. The mudflats at the three study sites could only be divided at a superficial level into two sediment types. The stony surface was found only on the two mudflats at Orchard Ledges, resulting in distinctive bird communities at this site.

The distance of a mudflat from land was significant in determining the composition of its bird community. Although this remains constant for the mudflats concerned, the associated factors that may affect the bird communities, such as the presence of people and their activities on shore, could vary between years.

DECORANA and TWINSPAN analyses showed that the disturbance from the PDR and landfill work have had significant effects on the bird communities of affected mudflats. There is also evidence that the bird communities of these mudflats are recovering now that these aspects of work-related disturbance have ceased. The TWINSPAN groupings of the 234 mudflat communities placed most of the disturbed mudflats into similar groups. Mudflats which were undisturbed acted as controls and these occurred in other groups. The fact that the disturbed mudflats were found in differing groups before, during and after the work disturbance suggested that there were changes in the bird communities during this time. There was also an indication that the changed communities were returning to their former composition.

Similar analyses for data obtained during the next winters will be important to determine the extent of recovery on disturbed mudflats and to investigate the effect of the work associated with barrage construction.

PART 3: MOVEMENT STUDIES

6.1 INTRODUCTION

The importance of determining the turnover in the population of waders or waterfowl at Taff/Ely has been stressed in previous reports (Donald & Clark, 1991a; Toomer & Clark, 1992a; Toomer *et al.*, 1993a; Toomer *et al.*, 1994a). If taken in isolation, the total number of birds present at times during the tidal cycle and the level of usage may not give an accurate estimation of the importance of a site. If there is no turnover of the population, a particular site may assume even greater importance for a species as that species may be dependent on one site for the whole of the wintering period. As many species are known to exhibit year-to-year site-faithfulness (Rehfisch *et al.*, in press; Symonds & Langslow, 1986; Symonds *et al.*, 1984), some wintering sites may be critical for the population (Goss-Custard *et al.*, 1982). The situation may be complicated if there is movement of birds between adjacent sites, as the number of birds dependent on a given area may be far higher than is suggested by the number of birds present at any one time.

Observations made at the three study sites has given some indication of the movement of species during the tidal cycle. There is interchange between Taff/Ely and Orchard Ledges and Rhymney of at least some of the Turnstone population. Observations of Curlew have shown that some of them move between Taff/Ely and Orchard Ledges and from Rhymney towards Orchard Ledges. With both of these species, only part of the population has been observed to move from one site to another and it is not possible to determine if the same individuals are involved each time.

The movements of colour-marked Dunlin are discussed in previous reports. It is likely that individuals of this species feed at both Taff/Ely and Rhymney at different times. Because of the large size of the Dunlin population relative to the number of birds that it is possible to colour-mark, it has been difficult to obtain confirmation of this. Redshank behaviour during all day counts gave no indication of movement between sites during the hours of daylight. No Redshank have been seen flying away from Taff/Ely and only one small group have been seen flying past Orchard Ledges during the last four years of study. Earlier colour-marking studies (Toomer & Clark, 1992a; Toomer *et al.*, 1993a; Toomer *et al.*, 1994a) had indicated that there was only a very limited interchange of Redshank between Taff/Ely and Rhymney.

Previous colour-marking and colour-ringing of Redshank had been carried out in January, 1991 at Taff/Ely; December 1991 and January 1992 at Rhymney; November 1992 at Rhymney; and October 1993 at Taff/Ely. The preliminary findings from these studies suggested that a few Redshank were still spreading out to their final wintering areas in November and December but were much more static by January with almost no apparent movement away from or between study sites.

Relatively few birds were colour-ringed each time and because it is difficult to read the rings, it has proved necessary to continue annual colour-ringing. To be able to identify the individual birds that may be moving between sites, unique colour-ring sequences have to be fitted to each bird.

6.2 METHODS

Samples of waders at both Taff/Ely and Rhymney have been caught for marking with dye and/or plastic colour-rings. Two catching methods have been used, mist-netting and cannon-netting.

- Mist-netting has been used to catch Redshank and Dunlin at Rhymney. The nets were positioned on the raised shore at Rhymney or the adjacent Peterstone wharfs before a late-evening high tide. Catching has to take place at night when the nets will not be seen by the birds,

and catching is not possible if it is windy or wet. This method relies on birds flying into the nets as they move around at high tide.

- Cannon-netting has been used to catch Redshank and Dunlin at Rhymney and Taff/Ely. Nets are fired over groups of waders that are roosting. Nets have to be set up to catch birds near to high tide, early in the day. As birds have to be within a small area before the nets can be fired safely, cannon-netting cannot always be carried out successfully.

Any bird caught was fitted with a metal ring embossed with a unique letter and number code, allowing individual identification if re-captured.

Metal rings cannot be identified in the field, so some other identification is needed. Several methods of colour-marking have been used. Breast feathers have been dyed, using temporary or more permanent feather dyes. These are moulted later in the year. All Redshank caught at Taff/Ely have been fitted with plastic colour-rings. The first group caught and ringed at Taff/Ely were fitted with celluloid plastic rings, as were a group caught by Dr Ferns of Cardiff University in 1994. Apart from these, all Redshank colour-ringed at Taff/Ely since 1993 have been fitted with Darvic rings, a more stable plastic material. Any birds retrapped at Taff/Ely or Rhymney with celluloid plastic rings had them replaced with Darvic rings.

Use of two colour-rings, yellow above white, allows identification of birds originating from Taff/Ely, but does not allow individual identification. During the winter 1994/95, Redshank were trapped at Taff/Ely and fitted with a series of colour-rings that allowed individual identification. Such rings were also fitted on Redshank caught at Rhymney if such birds were identified as having been originally ringed at Taff/Ely.

Marked or colour-ringed birds were looked for after capture at both the Taff/Ely and Rhymney sites. Whenever Redshank were in a good viewable position at either site, and the light conditions permitted clear observation of the individual birds, counts were made. Counts were only made of groups of birds where it was possible to see the presence or absence of colour dye or colour-rings. 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.

Early in 1991, 151 Redshank were caught at Taff/Ely and 133 adult birds were colour-ringed and colour-marked.

In September, Dr Ferns of Cardiff University caught a group of 196 Redshank at Taff/Ely and scheme marked 187 of these birds with plastic, not Darvic, rings.

During winter 1994/95, attempts were made to catch and individually colour-ring Redshank, primarily at Taff/Ely. Two attempts in November 1994 were unsuccessful because of the behaviour of the Redshank in response to disturbance from work around the bay.

It was not until February 1995 that suitable conditions became available and, using cannon nets, a group was caught at the east end of the saltmarsh at Taff/Ely. A total of 181 birds was caught, 130 Redshank and 51 Dunlin. All birds were fitted with an embossed metal ring. A total of 82 Redshank were fitted with individual combinations of colour-rings. As with the previous winters' studies it was not possible to accurately assess the total population of Redshank of which the colour-ringed birds formed a part.

These colour-ringed birds were looked for at the Taff/Ely and Rhymney sites during the rest of the winter 1995 study period. As Redshank leave their wintering grounds during late winter, there was only a limited amount of time to look for colour-ringed birds during the 1994/95 study, but observations of these birds during the following autumn, winter and spring will be very important.

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

6.3 RESULTS AND DISCUSSION

A discussion of the observations of Redshank colour-ringed in 1991 and 1993 can be found in previous reports. 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 autumns and winters of 1991/92 and 1992/93 and observations of these birds were reported in Toomer & Clark (1992a) and Toomer & Clark (1993a).

During 1994/95, colour-ringed Redshank were recorded at both Taff/Ely and Rhymney. The behaviour of the birds and poor visibility resulting from bad weather resulted in fewer estimates of the proportion of colour-ringed birds present than had been possible in previous winters. The proportions of marked birds at Taff/Ely and Rhymney are given in Table 6.3.1 and sightings of Redshank away from the study site in Table 6.3.2 The origins of the previously ringed Redshank caught for colour-ringing in February 1995 are given in Table 6.3.3.

Before the group of Redshank was scheme-marked by Dr Ferns in September 1994, the proportions of colour-ringed birds at Taff/Ely ranged from 10.6-25%, although the latter was estimated from a small sample (Table 6.3.1). Only one group of Redshank was close enough at Rhymney to allow a count of colour-ringed birds. No colour-ringed Redshank were seen in the group of 92 birds.

Prior to the catching of the group of Redshank at Taff/Ely in February 1995, the proportion of colour-ringed Redshank at Taff/Ely ranged from 14.5-23.3% (apart from one small sample count of 13 birds where the proportion ringed was 54%). At Rhymney, the proportion of colour-ringed Redshank varied between 3.8-7.0%. All of the colour-ringed Redshank seen at Rhymney had been originally ringed at Taff/Ely. There was no marked increase in the proportion of colour-ringed Redshank at Rhymney from early November to late February. The presence of fewer colour-ringed birds at Rhymney than Taff/Ely is an indication of the site-faithfulness of Redshank.

Observations of individually colour-ringed Redshank

There were two groups of Redshank individually colour-ringed during 1994/95: six Redshank were colour-ringed at Rhymney in November 1994; 82 Redshank were colour-ringed at Taff/Ely in February 1995.

The six Rhymney colour-ringed Redshank were birds that were originally scheme-marked at Taff/Ely. Within four days, one of these birds was seen at Taff/Ely (Table 6.3.1). A single individually colour-ringed bird was seen on four occasions by the end of December, but only once was it possible to read the colour combinations. It was therefore not possible to determine if more than one bird was involved. In January, two individually colour-ringed Redshank were observed in the same group of birds at Taff/Ely, but again, it was not possible to determine the colour combinations. Clearly, at least two of the Redshank individually ringed at Rhymney had moved later to Taff/Ely. Three counts of groups of up to 244 Redshank were made at Rhymney, and no individually colour-ringed birds were seen.

The group of Redshank caught at Taff/Ely in February 1995 for individual colour-ringing included 46% (60 out of 130) of birds that had been previously caught and colour-ringed at that site. Details of these birds are given in Table 6.3.3. A further two Redshank had been metal-ringed at Rhymney in 1992 and a single bird had been ringed in a breeding area in 1983 (Table 6.3.3). The Redshank retrapped from the 1991 ringed group represents 16.2% (21 out of 130) of the total group caught, compared with the proportion of the Taff/Ely population that was ringed in 1991, which was estimated then at 35.9%. Nineteen (9%) of 212 Redshank caught in October 1993 had been ringed at Taff/Ely in 1991. It is clear that a large proportion of the surviving 1991 colour-ringed Redshank have, therefore, returned again to Taff/Ely.

By March, a maximum 16 Redshank were observed at Rhymney and by April no Redshank remained. At Taff/Ely, Redshank were only clearly visible on one count day in March. The population was present at the site in several groups, all of which were examined. In a total of 84 Redshank, 23 birds (27.4%) were scheme or individually colour-ringed. Six of the ringed birds were individually colour-ringed (7.1%). By spring, almost no Redshank remained at Taff/Ely.

By July, Redshank had started to return from their breeding grounds to Taff/Ely and Rhymney. At this time, Redshank populations may contain juveniles and birds that may eventually winter away from the site. At Taff/Ely, the highest number of Redshank examined for colour-rings was 68, which included seven colour-ringed birds (10.3%), two of which had individual colour-ring combinations (2.9%). At Rhymney the highest number of Redshank examined for colour-rings was 73, which included one scheme marked bird and none with individual colour-ring combinations. Although the returning population included birds that had been scheme ringed in 1994 or earlier, as well as birds caught and individually ringed in February 1994, the sample of ringed birds was too small too allow any conclusions to be made.

The ringing studies and observations from autumn 1994 to spring 1995 have added to our understanding of the movements of Redshank within the area. During 1995/96 we will be carrying out several studies to give a more complete picture of Redshank movements prior to barrage closure. We will be carrying out total counts to determine the number of individually and scheme ringed birds at each site both during the early and later part of winter. From this it will be possible to assess the proportion of birds returning to the study sites and their survival during the winter. Careful observations of the individually colour-ringed birds at the study sites should confirm their local movements within sites and movements, if any, between study sites.

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Site/Species	September	October	November	December	January
Taff/Ely					
Black-tailed Godwit	1				
Bar-tailed Godwit	2				
Greenshank	1				
Goosander	1		2	2	2
Common Sandpiper			1		
Mute Swan				3	
Goldeneye				1	
Avocet					2
Rhymney					
Sanderling	2				
Bar-tailed Godwit	2				
Scaup		1	3		

Table 3.6.1 The maximum numbers of other wildfowl and waders seen at Taff/Ely and Rhymney during all day counts, 1994/95.

Mudflat	Sediment	Distance to land (m)	Disturbance value					
			89/90	90/91	91/92	92/93	93/94	94/95
Taff/Ely 1	0	60	3	3	3	3	3	1
2	0	250	3	3	3	3	3	1
3	0	100	3	3	3	3	3	3
4	0	270	3	3	3	3	3	3
5	0	340	3	3	3	3	3	2
6	0	520	3	3	3	3	3	3
7	0	70	3	3	1	1	1	2
8	0	60	3	3	2	2	3	3
9	0	70	3	3	2	2	2	3
10	0	150	3	2	1	1	1	2
11	0	300	3	3	2	2	2	2
12	0	350	3	3	2	2	2	3
13	0	400	3	3	3	3	3	3
14	0	340	3	3	3	3	3	3
15	0	220	3	3	3	3	3	3
16	0	220	3	3	3	3	3	3
17	0	270	3	3	3	3	3	2
18	0	50	3	3	3	3	3	1
19	0	120	3	3	3	3	3	3

Table 5.2.1a The distance to land, the sediment type (0 = mud, 1 = stone) and the level of disturbance (see text for definition) of each sector (mudflat) at Taff/Ely (Cardiff Bay).

Mudflat	Sediment	Distance to land (m)	Disturbance value					
			89/90	90/91	91/92	92/93	93/94	94/95
Orchard Ledges 1	1	367	4	4	4	4	4	4
2	1	230	4	4	4	4	4	4
Rhymney 1	0	133	4	4	4	4	4	4
2	0	67	4	4	4	4	4	4
3	0	167	4	4	4	4	4	4
4	0	233	4	4	4	4	4	4
5	0	333	4	4	4	4	4	4
6	0	433	4	4	4	4	4	4
7	0	400	4	4	4	4	4	4
8	0	700	4	4	4	4	4	4
9	0	867	4	4	4	4	4	4
10	0	233	4	4	4	4	4	4
11	0	733	4	4	4	4	4	4
12	0	1067	4	4	4	4	4	4
13	0	467	4	4	4	4	4	4
14	0	700	4	4	4	4	4	4
15	0	367	4	4	4	4	4	4
16	0	167	4	4	4	4	4	4
17	0	67	4	4	4	4	4	4

Table 5.2.1b The distance to land, the sediment type (0 = mud, 1 = stone) and the level of disturbance (see text for definition) of each sector (mudflat) at Orchard Ledges and Rhymney.

Species	DCA 1	DCA 2	DCA 3	DCA 4
Oystercatcher	-2	295	160	-11
Dunlin	6	74	152	168
Curlew	107	298	250	23
Redshank	199	0	107	65
Shelduck	112	169	0	207
Mallard	197	145	415	230
Teal	296	162	270	271
Pintail	-16	125	24	82

Table 5.3.1.1 The species scores for the four DECORANA ordination axes (DCA 1-4).

Decorana axis variable	Partial regression coefficients ± SE: Intercept ± SE	Work^2	$\log_{10}$ (Work)	$\log_{10}$ (Distance+1)	Sediment	*n* and overall model significance	Model coefficients of determination adjusted for degrees of freedom R^2
DCA 1	261.71 ± 17.28 ****	-7.86 ± 0.76 ****		-37.56 ± 6.82 ****		233 ****	0.41
DCA 2	151.55 ± 38.14 ****	7.65 ± 1.84 ****	-193.21 ± 90.27 *	-11.89 ± 5.33 *	85.57 ± 12.47 ****	233 ****	0.34

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; **** $P < 0.0001$.

Table 5.3.2.1 The intercepts, partial regression coefficients and coefficients of determination (R^2) of multiple regression equations relating the untransformed DECORANA axis 1 (DCA 1) and axis 2 (DCA 2). The models only include variables found to be significant at P < 0.05 and other variables are excluded from this table.

TWINSPAN Groupings

Group	Site	Mudflat	Year
1	***CB***	***7***	***91/92***
	CB	13	93/94
	CB	13	91/92
	RH	17	93/94
2	CB	13	90/91
	CB	13	92/93
3	**CB**	**8**	**94/95**
	CB	13	89/90
4	**CB**	**9**	**94/95**
5	**CB**	**9**	**90/91**
	CB	**9**	**92/93**
	CB	**9**	**93/94**
	CB	***10***	***94/95***
6	CB	1	89/90
	CB	1	90/91
	CB	***1***	***94/95***
	CB	***7***	***92/93***
	CB	**8**	**90/91**
	CB	**8**	**93/94**
	CB	***10***	***92/93***
	CB	***10***	***93/94***
	CB	19	89/90
	CB	19	90/91
7	**CB**	**8**	**89/90**
	CB	**8**	**92/93**
8	RH	6	92/93
	RH	13	89/90
9	RH	1	90/91
	RH	2	90/91
10	***CB***	***7***	***93/94***
	CB	***2***	***94/95***
	OL	1	89/90
	OL	1	90/91
	OL	1	92/93
	OL	1	93/94
	OL	1	94/95
	OL	2	89/90
	RH	3	90/91
	RH	3	92/93
	RH	10	93/94
	RH	17	89/90
	RH	17	90/91
11	CB	1	93/94
	CB	**12**	**93/94**
12	***CB***	***7***	***90/91***
	OL	2	93/94
	RH	6	90/91
	RH	7	89/90
	RH	14	90/91
13	CB	13	94/95
	OL	1	91/92
	OL	2	91/92
	OL	2	92/93
	OL	2	94/95
	RH	3	89/90
	RH	5	90/91
	RH	17	94/95
14	OL	2	90/91
	RH	1	92/93
	RH	2	92/93
	RH	3	91/92
	RH	3	94/95
15	CB	1	91/92
	RH	17	92/93
16	CB	18	91/92
	CB	18	93/94
	CB	***18***	***94/95***
17	CB	18	90/91
	CB	18	92/93

Table 5.3.3.1 *Continued on next page*

18	CB	5	94/95
	CB	**12**	**91/92**
	CB	16	92/93
19	**CB**	**8**	**91/92**
	CB	**9**	**91/92**
	CB	**12**	**90/91**
	CB	15	92/93
	CB	15	94/95
	CB	16	90/91
	CB	16	91/92
	CB	16	94/95
20	CB	1	92/93
	CB	2	90/91
	CB	**9**	**89/90**
	CB	***10***	***90/91***
	CB	***10***	***91/92***
	CB	**11**	**93/94**
	CB	**12**	**92/93**
	CB	15	90/91
	CB	19	91/92
	CB	19	92/93
	CB	19	93/94
	CB	19	94/95
	RH	6	89/90
	RH	14	92/93
21	CB	6	93/94
	CB	18	89/90
22	**CB**	**11**	**91/92**
	CB	15	91/92
	CB	15	93/94
23	CB	6	89/90
	CB	**11**	**94/95**
	CB	14	90/91
	CB	14	93/94
	CB	15	89/90
	RH	15	90/91
	RH	16	90/91
	RH	16	91/92
24	***CB***	***7***	***89/90***
	CB	***10***	***89/90***
	CB	**11**	**89/90**
	CB	**11**	**92/93**
	CB	14	89/90
25	**CB**	**12**	**94/95**
26	RH	10	91/92
	RH	10	94/95
27	RH	10	93/94
	RH	11	89/90
	RH	11	91/92
	RH	11	93/94
28	CB	3	94/95
	CB	4	89/90
	CB	4	90/91
	CB	4	93/94
	CB	5	89/90
	CB	6	90/91
	CB	14	94/95
	RH	10	89/90
	RH	11	92/93
	RH	11	94/95
	RH	15	91/92
	RH	15	92/93
	RH	15	93/94
	RH	15	94/95
	RH	16	89/90
	RH	16	94/95
29	CB	3	89/90
	CB	3	90/91
	CB	3	91/92
	CB	3	93/94
	CB	4	92/93
	CB	4	94/95
	CB	5	90/91
	CB	16	93/94
	RH	15	89/90
	RH	16	92/93
	RH	16	93/94
30	CB	3	92/93
	CB	5	92/93
	CB	6	94/95
	CB	**12**	**89/90**
31	RH	12	91/92
	RH	12	92/93
	RH	12	93/94
	RH	12	94/95
32	RH	9	94/95
33	RH	6	91/92
	RH	10	90/91
	RH	10	92/93
	RH	17	91/92

Table 5.3.3.1 *Continued on next page*

34	CB	2	89/90
	CB	2	92/93
	CB	6	92/93
	CB	**11**	**90/91**
	CB	16	89/90
	CB	17	89/90
	CB	17	90/91
	CB	17	91/92
	CB	17	92/93
	CB	17	93/94
	CB	17	94/95
	RH	11	90/91
	RH	14	91/92
35	CB	2	91/92
	CB	***7***	***94/95***
	RH	4	89/90
	RH	4	93/94
	RH	5	89/90
	RH	6	93/94
	RH	6	94/95
	RH	7	90/91
	RH	8	89/90
	RH	8	90/91
	RH	9	90/91
	RH	9	89/90
	RH	14	93/94
	RH	14	94/95
36	CB	2	93/94
	RH	14	89/90
37	CB	4	91/92
38	CB	5	91/92
	CB	5	93/94
	CB	6	91/92
	CB	14	91/92
39	RH	1	93/94
	RH	1	94/95
40	RH	1	91/92
	RH	4	91/92
	RH	4	94/95
	RH	7	91/92
	RH	8	91/92
41	CB	14	92/93
	RH	1	89/90
	RH	9	91/92
	RH	7	94/95
42	RH	2	89/90
	RH	2	91/92
	RH	2	93/94
	RH	2	94/95
	RH	5	91/92
	RH	5	92/93
	RH	5	94/95
	RH	7	92/93
	RH	8	92/93
	RH	8	94/95
	RH	9	92/93
43	RH	4	90/91
	RH	5	93/94
	RH	8	93/94
	RH	12	90/91
	RH	13	92/93
44	RH	7	93/94
	RH	12	89/90
	RH	13	91/92
45	RH	13	90/91
	RH	13	94/95
46	RH	4	92/93
	RH	9	93/94
	RH	13	93/94

Table 5.3.3.1 Legend of TWINSPAN groupings of Cardiff Bay (CB), Orchard Ledges (OL) and Rhymney (RH) mudflats. Mudflats in ***bold italics*** are directly affected by PDR or barrage works; mudflats in **bold** are adjacent to those directly affected.

Date	Site	Total Redshank	Numbers colour-ringed (%)
10/8/94	Taff/Ely	12	3 (25)
13/9/94	Taff/Ely	42	5 (11.9)
14/9/94	Taff/Ely	112	12 (10.6)
16/9/94	Rhymney	92	0 (0)
A group of 187 Redshank colour-ringed by Dr Ferns at Taff/Ely in September. Six Redshank were caught at Rhymney and individually colour-ringed in November.			
7/11/94	Rhymney	106	7 (6.6)
9/11/94	Taff/Ely	69	10 (14.5) including 1 individually colour-ringed
29/11/94	Taff/Ely	90	21 (23.3)
30/11/94	Rhymney	244	17 (7.0)
9/12/94	Taff/Ely	79	16 (20.3) including 1 individually colour-ringed
14/12/94	Taff/Ely	80	14 (17.5) including 1 individually colour-ringed
18/1/95	Taff/Ely	31	5 (16.0) including 2 individually colour-ringed
24/1/95	Taff/Ely	13	7 (54.0)
6/2/95	Rhymney	53	2 (3.8)
10/2/95	Rhymney	118	8 (6.7)
82 Redshank individually colour-ringed at Taff/Ely on 19/2/95 - of which 60 had been scheme-marked previously			
14/3/95	Taff/Ely	84	23 (27.4) including 6 individually colour-ringed
IT was not possible to estimate the proportion of colour-ringed birds at Rhymney in March and spring as very few birds remained.			

Table 6.3.1 The numbers and proportions of colour-marked Redshank observed at Taff/Ely and Rhymney from August 1994 to March 1995.

Date	Location	Observation
11/3/95	Suffolk	One bird
22/3/95	North Yorkshire	One bird in breeding area
23/5/95	Co. Durham	Bird attending two chicks
14/5/95	Lancashire	Individually colour-ringed bird caught on nest,

Table 6.3.2 Sightings of Taff/Ely and Rhymney colour-ringed Redshank made away from the study site in 1995.

Site of ringing	Year of ringing	Number and % of retrapped birds
130 Redshank were caught on 19/2/95 at Taff/Ely of which 63 birds had been previously ringed		
Lancashire	1983	1 (1.6%)
Rhymney	1992	2 (3.2%)
Taff/Ely	1991	21 (33.3%)
Taff/Ely	1993	10 (15.9%)
Taff/Ely	1994 (Dr Ferns)	29 (46%)

Table 6.3.3 The origins of previously ringed Redshank caught at Taff/Ely on 19/2/95 for individual colour-ringing.