British Trust for Ornithology

BTO Research Report No. 146

THE EFFECT OF THE CARDIFF BAY BARRAGE ON WATERFOWL POPULATIONS 5. DISTRIBUTION AND MOVEMENT STUDIES AUGUST 1993 - MAY 1994

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

Authors

D.K. Toomer, S.J. Browne & N.A. Clark

October 1994

The National Centre for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU
Registered Charity No. 216652

CONTENTS

Page No.

LIST OF TABLES

Page No.

LIST OF FIGURES

Page No.

Page No.

Page No.

Page No.

Page No.

Page No.

Page No.

EXECUTIVE SUMMARY

1.This report represents the results of the fifth season of intensive monitoring of the wildfowl and waders using the intertidal areas in Cardiff Bay and adjacent areas. More extensive monitoring at low tide also covered the intertidal areas between the Taff/Ely Estuary and the mouth of the River Usk. The results presented in this report were derived from data collected between August 1993 and May 1994. The programme of monitoring closely followed that used for the previous three years. By using similar methods, a direct comparison between the five years of study was possible.

2.The intertidal mudflats of the Taff and Ely estuaries (known as Cardiff Bay) will be inundated by fresh water by the beginning of 1998 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 over a number of years will make it possible to determine the fate of these populations 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. There have been increases in the numbers of Mallard and Teal at the east part of this area and smaller increases in the numbers of Pintail, Oystercatcher and Dunlin on some sections.

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

5.The Peripheral Distributor Road (PDR) crossing the River Taff was nearing completion by the end of the current year's study. A further small area of saltmarsh was used as a landfill area as part of the Phase 2 reclamation work. Several species had previously shown a tendency to feed away from the areas with high levels of disturbance. Although the disturbance has been reduced, these species have not returned to their original feeding areas. Mudflats near to the work areas were only used by low numbers of Shelduck, Mallard, Teal, Dunlin and Redshank although these species had been present in greater numbers before the commencement of the work. Very few Redshank were found feeding on mudflats alongside the River Taff, north of the PDR, during the autumn or winter.

6.Redshank that had been caught and colour-ringed in January 1991 were still present in the population of birds that returned during the autumn of 1993, showing a marked level of site-fidelity.

7.A sample of Redshank was caught, colour-marked and colour-ringed at the Taff/Ely site in October 1994 to continue studies of movement patterns around Cardiff Bay. Following some initial movement away from this site to the Rhymney site, there appeared to be little further movement of birds between these sites until the birds left in the spring.

GENERAL INTRODUCTION

With Royal Assent having been given to the Bill for the building of the amenity barrage across the mouth of Cardiff Bay, barrage construction commenced in May 1994. Initially this will involve extension to the raised shore on the dock side of the bay and some construction near the shore on the Penarth side of the mouth of the bay. More significantly, dredging is scheduled to start along the line of the barrage and across mudflats to produce channels to redirect the River Taff and also allow access to the Cardiff Bay Yacht Club. Monitoring of the waterfowl populations of Cardiff Bay and nearby areas since November 1989 and the current winter will produce data that can take account of year-to-year variation. If no other changes were to take place prior to completion of the barrage and flooding of the bay, this alone would provide a good base-line against which to measure changes in distribution of the Cardiff Bay birds. However, during construction, there will be changes within the bay and disturbance that will inevitably affect the birds and may result in some birds leaving the bay prior to closure. Many natural factors, such as severe weather (Clark, 1982) and birds of prey (Cresswell & Whitfield, 1994), are known to have adverse and often striking effects on wader populations during the winter months, when pressures are already high. This complicates the assessment of the effects that any change to the feeding habitat would have on bird populations already under stress. The integrated programme of counting and colour-marking studies are designed to maximise the information that can be gained about the impact of the building of the Cardiff Bay Barrage on bird populations.

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

A number of changes within the bay have already affected the feeding distribution and roosting behaviour of some of the waders and wildfowl. The Peripheral Distributor Road (PDR) construction is nearing completion, but work continues beneath it which causes some disturbance. Part of the mudflats has been reclaimed using waste from the early PDR work and these areas have been unavailable as feeding areas for three winters. The effects of this in the previous winters have been discussed in the reports for those years (Toomer & Clark, 1992a; Toomer & Clark, 1993a). Most of the work of the Phase 1 and Phase 2 land reclamation was completed before the current study period, but a further area of saltmarsh at the west end of Windsor Esplanade was reclaimed during the study period. The direct effect of the landfill has been the loss of parts of the saltmarsh that have been used in earlier years as roost areas by some of the birds remaining in the bay over the high tide period. Further potential roosting area had been lost with the building of the PDR. The continued effects of the changes to the available roost sites during the autumn and winter of 1993/94 have been studied and reported (Toomer & Clark, 1994).

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

The results of the first four years' monitoring of waders and wildfowl populations found during the autumn, winter and spring in Cardiff Bay and nearby areas were given by Evans *et al.* (1990), Donald & Clark (1991a) and Toomer & Clark (1992a and 1993a). This present

report summarizes a fourth autumn and a fifth winter and spring monitoring of waders and wildfowl.

The Birds of Estuaries Enquiry (BoEE) had monitored the populations of birds on all British estuaries since 1969. In October 1993, the BoEE scheme was amalgamated with the National Waterfowl Counts, to form a new scheme, the Wetland Bird Survey (WeBS). This change-over has meant that 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 were 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 1992/93 winter (Waters & Cranswick, 1993).

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 1993 and May 1994. The findings have been compared with the results of the previous four years. The previous studies were described by Evans *et al.* (1990), Donald & Clark (1991a) and Toomer & Clark (1992a; 1993a). The distribution of roosting birds on the Taff/Ely site was studied in the 1990/91, 1991/92 and 1992/93 winters (Donald & Clark, 1991b; Toomer & Clark, 1992b and 1993b). This study was repeated in the winter of 1993/94 to monitor the effects of further development at the northern end of the bay on the roosting pattern of the waterfowl and has been reported in Toomer & Clark (1994).

With five 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 was varied for the first three studies (for the reasons, see Toomer & Clark, 1993a). For this, the fourth autumn of the study, observations were made for the three months of the autumn period, August, September and October, allowing direct comparisons with any of the three 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 Phase 1 and 2 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. With five years of data, it has been possible to assess any change in feeding usage of these areas.

2. METHODS

For this fifth year of study, methods were kept the same as those used in the four 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 five-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 Phase 2a landfill was completed during the winter and produced a bank to the west of Windsor Esplanade, covering a relatively small area of saltmarsh. The PDR, which was nearing completion by the end of the study period, has cut across two count areas. These two areas, sector 7 and sector 10 (Figure 2.1.1) were still counted for the 1991/92 and 1992/93 studies and have continued to be counted during the 1993/94 winter although they continued to be affected by disturbance from the PDR work. The four observation points that had been used in the 1991/92 and 1992/93 studies were used again. As in 1992/93, extra observations were made from the jetty area of the Cardiff Bay Yacht Club if feeding flocks were observed to be using the inner harbour area.

No changes in the Orchard Ledges and Rhymney sites were observed over the five seasons of monitoring and counts were made from the same observation points. The re-landscaping of the raised tip to the west of the observation points at the Rhymney site did not affect the fore-shore or the area from which the counts were made.

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

Counts were divided into three seasons: autumn (August - October 1993), winter (November 1993 - March 1994) and spring (April - May 1994). 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. Waders and wildfowl roosting in areas of saltmarsh were not counted, as accurate counts are also very difficult in this habitat. Observations on the roosting behaviour of birds in Cardiff Bay have been covered in separate reports (Donald & Clark, 1991b; Toomer & Clark, 1992b; Toomer & Clark, 1993; Toomer & Clark, 1994).

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

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

All day usage was calculated using:

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

A = hours from low tide
B = average number of birds feeding at time A when the area was exposed
C = 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 four years of study were reported in Evans *et al.* (1990), Donald & Clark (1991a), Toomer & Clark (1992a) and Toomer & Clark (1993a). This report should be read in conjunction with these four reports as figures for the previous four years' findings are not reproduced here.

Work on the PDR has continued. The Phase 1, Phase 2 and Phase 2a reclamation was completed during the current study period. The most significant effects of this work have been on the saltmarsh areas at the north end of the bay. One of the main effects has been on the roosting behaviour of the birds in the bay and this has been covered in a separate report (Toomer and Clark, 1994). In discussing the results, particular attention will be given to species whose feeding behaviour may have been affected by the continuing PDR work and the Phase 1, Phase 2 and Phase 2a work.

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

Low tide counts were used to produce maps showing the average number of each species present feeding during the winter months. The maps are included in the species accounts that follow. Each species account is divided into three parts, the autumn 1993, winter 1993/94 and spring 1994, the winter 1993/94 part includes the low tide count studies. In each of these, comparisons are made with the four previous seasons, 1989/90, 1990/91, 1991/92 and 1992/93 if appropriate. The results are considered in relation to the changes that have occurred to the sites during the five years of study, as well as with factors such as feeding ecology, behaviour and migration patterns.

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

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, inland sites are being used (Gibbons *et al.*, 1993). Following breeding, most adult Shelduck move to moulting grounds mainly 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 showed a steady increase from 1988/89 to 1991/92 with a reduction to just over 70,000 in 1992/93 (Waters & Cranswick, 1993). In 1992/93, the Severn Estuary was the ninth most important British site for wintering Shelduck and was of international importance.

Autumn 1993

At the beginning of the autumn observations, some Shelduck were present at the Taff/Ely and Rhymney sites. In August, five immature birds were present at the Taff/Ely site, one adult and four immature birds were seen at the Rhymney site. The number of Shelduck increased by the end of the autumn period at the Rhymney site as birds moved from their moulting grounds to their wintering areas. At the Taff/Ely site, the number of birds remained low throughout the autumn.

There was, therefore, a low level of usage at the Taff/Ely site with the few birds feeding on three sectors only during the tidal cycle (Figure 3.1.1). At the Rhymney site, the usage increased as Shelduck returned, with most of the feeding birds being found to the east of the River Rhymney (Figure 3.1.2).

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

The peak mean number of Shelduck at the Rhymney site was almost 100 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.

There were fewer Shelduck at the Taff/Ely site than in autumn 1992, but the numbers were too low for this to be of any significance. At the Rhymney site, the number of birds and their pattern of feeding distribution were both similar to those of 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 five years of study.

Winter 1993/94

Low tide counts showed feeding Shelduck to be present along the whole of the northwest Severn during the winter 1993/94 (Figure 3.1.4). Apart from the stony Orchard Ledges, concentrations of feeding birds were found on all sectors that extended to the lower shore.

Feeding Shelduck were widely distributed at the Taff/Ely site with an even pattern of usage on most of the mudflats (Figure 3.1.5), however there were lower levels of usage on sectors in the northwest of the study site. Few feeding birds were observed on sectors near to the PDR and further up the River Taff.

Small groups of Shelduck were observed feeding at the Orchard Ledges site (Figure 3.1.6). The feeding birds were found on muddy areas between the predominantly stony shore of sector 2 and at the muddier eastern end. At the Rhymney site, feeding Shelduck were observed on all sectors at some time during the tidal cycle (Figure 3.1.6). The highest levels of usage were found on sectors that extended down the lower shore where feeding birds were usually concentrated near the water's edge. Higher numbers of feeding birds occurred on sectors east of the River Rhymney, this being partly responsible for the higher levels of usage there.

The number of Shelduck at the Taff/Ely site fluctuated during the tidal cycle (Figure 3.1.7a). As the receding tide exposed areas of mud, the Shelduck moved from their roost positions and started feeding. With a further fall in the level of the water, birds moved back onto the open water. Some Shelduck also moved out of the study site at this time. This resulted in a fall in the number of birds present on the mudflat sectors over the period of low tide. The peak number of birds at the Orchard Ledges site was less than five birds. At the Rhymney site, Shelduck moved onto the sectors to feed as soon as these areas became uncovered. The number of birds rose sharply, with the peak mean being about 700 (Figure 3.1.7c). The majority of the birds were feeding during the period three hours before and after low tide.

There have been minor changes in the distribution of feeding birds at all three sites and along the northwest Severn compared with the previous winter. At the Taff/Ely site, the number of birds was similar to the 1992/93 winter and showed a similar pattern over the tidal cycle. Very few Shelduck were seen at Orchard Ledges. The usage and the number of birds had shown an increase up to winter 1991/92, although the size of the flocks observed was smaller during the winter 1992/93. No such flocks were seen during the current study. There has been an increase in the number of Shelduck at the Rhymney site compared with the winter 1992/93, the number being similar to the peak mean observed during the winter 1991/92.

Spring 1994

Shelduck is one of the few birds that are still present in relatively high numbers in the spring. At the Taff/Ely site, feeding birds were distributed throughout the study site with more birds being found along the edge of the River Taff in the middle and outer parts of the bay. This produced a higher level of usage on the sectors in these areas (Figure 3.1.8). Between two and four birds were observed feeding on several muddy areas at the Orchard Ledges site (Figure 3.1.9). At the Rhymney site, most of the feeding Shelduck were located on sector 13 (Figure 3.1.9). All sectors east of the Cardiff Eastern Sewer were used by some feeding birds, but there were only low levels of usage of sectors west of this.

The number of birds remaining at the Taff/Ely site was about half that found in the winter, with a higher proportion continuing to feed over the low tide period (Figure 3.1.10a).

At the Rhymney site, the spring population had declined to less than a third of the wintering population (Figure 3.1.10c).

The pattern of feeding distribution and the number of birds present at the Taff/Ely site were similar to those of the spring of 1993 and have remained fairly stable over the five years of study. The limited usage that has been observed at the Orchard Ledges site has not shown a consistent pattern. At the Rhymney site, there has been a shift in the sectors used by feeding Shelduck in the spring compared with spring 1993. Only relatively low levels of usage of sectors 15 and 16 were observed with a corresponding increase on sector 13.

3.2 Wigeon

No Wigeon were seen along the northwest Severn during low tide winter counts. The only Wigeon observed at the study sites were present at the Rhymney site. Five feeding birds were seen in November and a maximum count of 31 was obtained in December. The birds were feeding on sectors 15 and 16.

3.3 Mallard

The number of Mallard wintering on British estuaries has shown a steady decline over the last five winters, but the population is still very high (Waters & Cranswick, 1993). 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.

Autumn 1993

A small number of Mallard were present at the Taff/Ely site from early autumn. Almost all sectors were used by feeding birds, but the highest levels of usage occurred on the edge of those sectors adjacent to the channel running down the east side of the bay (Figure 3.3.1). No birds were observed at the Orchard Ledges site. At the Rhymney site, almost all feeding birds were found along the edge of the River Rhymney producing relatively high usage values for those sectors that abutted on to the river (Figure 3.3.2).

At the Taff/Ely site, Mallard moved onto the mudflats from their roost sites as the tide receded (Figure 3.3.3a). With a further fall of the tide, some birds moved onto the open water before the low tide period. As the tide rose, covering the feeding areas, Mallard left the water, moving onto the edge of the mudflats before moving to their roost sites. The peak mean number of birds was approximately 45 and occurred three hours after low tide. The highest proportion of birds feeding occurred soon after mudflats were exposed by the falling tide. This pattern of behaviour was similar at the Rhymney site, but with a higher proportion of the birds remaining on the sectors throughout the tidal cycle (Figure 3.3.3c).

Apart from a shift in the sectors used at the Taff/Ely site, the pattern of feeding distribution and numbers of birds at the three sites was similar to autumn 1992.

Winter 1993/94

The low tide distribution of feeding Mallard along the northwest Severn was very uneven, with far higher populations being found at the eastern end of this area (Figure 3.3.4). The feeding birds were observed along the tide line of the lower shore in contrast with the Taff/Ely and Rhymney distribution where they were mainly associated with the river banks.

At the Taff/Ely site the small numbers of feeding birds were found mainly in the eastern half of the study site on the edge of mudflats adjoining the fresh water channels (Figure 3.3.5). Feeding Mallard were similarly associated with fresh water at the Rhymney site, with birds occurring anywhere along the banks of the River Rhymney from where it enters the study site (sector 16) to where the river meets the sea at sector 12 (Figure 3.3.6). No birds were observed at the Orchard Ledges site.

The number of birds observed on the sectors of the Taff/Ely site and their pattern of behaviour through the tidal cycle was very similar to that found in the autumn (Figure 3.3.7a). The Rhymney population was lower than that found in the autumn, but again the pattern of behaviour was similar (Figure 3.3.7c).

The low tide feeding distribution of Mallard along the northwest Severn was similar to that found during the previous winter but with even higher numbers of birds on the St. Brides sector. This was a continuation of the increase that had been noted in winter 1992/93.

The distribution of feeding Mallard at the Taff/Ely and Rhymney sites was similar to that of the 1992/93 winter with minor differences in the level of usage. There were only minor changes in the number of birds and their pattern of behaviour through the tidal cycle compared with the previous winter.

Spring 1994

Very few Mallard remained at the Taff/Ely site until spring (Figures 3.3.8 and 3.3.9a). No Mallard were present at the Orchard Ledges and Rhymney sites during the spring.

This situation is comparable with the findings for the previous spring study periods.

3.4 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). In contrast, the wintering population has shown a general increase over the last 25 seasons, although there has been a slight decrease from 1989/90 to 1992/93 (Waters & Cranswick, 1993).

Autumn 1993

Small numbers of Teal were observed feeding along the channel in the east of the Taff/Ely site and on the edge of sectors adjoining the River Taff (Figure 3.4.1). The few

feeding birds that were observed at the Rhymney site during the autumn were in the corner of the bay on the edge of sector 17 (Figure 3.4.2). No birds were present on the Orchard Ledges site.

The peak mean number of birds at the Taff/Ely site was approximately 40, with most of them roosting (Figure 3.4.3a). Most of the Teal moved onto the water as low tide approached or were out of view at the bottom of the bank of the River Taff on the edge of sector 13. With the rising tide, some of the Teal moved onto the mudflats to feed and later moved to roost areas when the tide covered the feeding areas.

There was a higher level of usage of the sectors in the east part of the Taff/Ely site than had been noted during previous autumns. In particular, the edge of the water channels running into sector 19 were used for a large part of the tidal cycle by a group of feeding Teal. Although feeding Teal were more widespread at the Rhymney site during the 1992 autumn, the low number of birds involved mean that any differences are not important.

Winter 1992/93

Low tide counts of the northwest Severn showed the main concentrations of feeding Teal to be at the eastern end of this area (Figure 3.4.4). The highest densities of birds were found along the edge of the tide on the St Brides section.

At the Taff/Ely site, feeding Teal were found on almost all sectors that were adjoining either the River Taff or the channel running from the inner harbour (Figure 3.4.5). The higher levels of usage were found on sectors 18 and 19. Feeding birds were found only on sectors to the east of the Cardiff Eastern Sewer at the Rhymney site (Figure 3.4.6). No Teal were observed at the Orchard Ledges site.

The peak mean number of Teal at the Taff/Ely site was almost 150 with the number of birds on the sectors showing a decrease over the low tide period (Figure 3.4.7a). The reasons for this have been explained above. The number of birds on the mudflat sectors at any one time reflects only part of the true number of birds within the bay. Other work at the study site showed the winter population to number approximately 350 birds (Toomer & Clark, 1994). Up to two thirds of the Teal seen on the mudflats were roosting. At the Rhymney site, between 10 and 20 birds were present during the tidal cycle, with the peak number being observed on the rising tide (Figure 3.4.7c). A higher percentage was feeding than had been observed at the Taff/Ely site, with less feeding occurring over the low tide period.

The majority of the Teal wintering at the two sites arrived after the autumn study period and remained until March.

The low tide distribution of feeding Teal on the northwest Severn showed a marked increase in the number of birds at the St Brides section compared with the previous winter.

The feeding distribution of Teal at the Taff/Ely site was similar to the winter 1992/93, but with a relatively greater usage of sectors 18 and 19. There were only very minor

changes in the number of birds and the pattern of behaviour during the tidal cycle. Fewer feeding birds were seen along the banks of the River Rhymney where it crosses sectors 10, 11 and 14 resulting in lower levels of usage of this part of the Rhymney site compared with the winter 1992/93. The mean number of birds also showed a reduction at this site.

Spring 1994

Almost all of the Teal had left the Taff/Ely and Rhymney sites before the spring study period. This is comparable with the previous spring study periods.

3.5 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 at least since 1973 the British and Irish breeding population has been relatively stable (Fox & Meek, 1993). Breeding birds from northwest Europe move south in autumn, with over 20,000 being regularly found wintering in Britain, mainly on estuaries (Waters & Cranswick, 1993).

Autumn 1993

No Pintail were recorded at the Taff/Ely and Orchard Ledges sites during the autumn. The first two Pintail were observed at the Rhymney site in September and the number of birds present gradually increased through the autumn. The feeding birds were distributed on the sectors to the east of the Cardiff Eastern Sewer (Figure 3.5.1). Feeding birds followed the edge of the falling and rising tide and therefore used most of the mudflat sectors between the two sewer pipelines.

The number of Pintail at the Rhymney site increased rapidly as the tide receded and birds moved to their feeding areas (Figure 3.5.2c). While they were present at the site, almost all of the Pintail were feeding. Numbers declined further through the tidal cycle as some birds moved onto the open water.

The distribution of feeding birds at the Rhymney site was very similar to autumn 1992. There was a minor change in the pattern of activity through the tidal cycle, there having been more birds after the low tide period in 1992.

Winter 1993/94

Low tide counts of feeding Pintail on the northwest Severn showed the main concentration of birds to be around the Rhymney Estuary with smaller populations distributed along the Peterstone and St Brides sections (Figure 3.5.3).

No Pintail were observed at the Orchard Ledges site during winter. At the Taff/Ely site, single birds were seen for a short time in November and February. At the Rhymney site, the main usage occurred on sectors to the east of the Cardiff Eastern Sewer although feeding Pintail were seen on almost all other sectors (Figure 3.5.4). The high levels of usage on sectors 10, 11, 12 and 14 resulted from feeding activity along the water's edge when the tide was low. Sector 12 was only exposed by the tide for

relatively short periods, but most of the feeding Pintail were concentrated on this area at that time, producing the high level of usage.

The peak mean number of Pintail at the Rhymney site was approximately 150 although the actual number of birds in the vicinity was higher, with part of the population remaining on the open water at any one time (Figure 3.5.5c). Pintail increased in number as the tide receded until an hour after low tide when some of the birds started to move back onto the open water.

There was an increase in the low tide number of feeding Pintail along the northwest Severn compared with the 1992/93 winter with higher numbers of birds being seen on the Peterstone and St Brides sections in particular.

At the Rhymney site, there was an increase in the number of birds observed, producing a higher level of usage on many of the sectors compared with the 1992/93 winter.

Spring 1994

No Pintail were observed at any of the study sites during the spring.

This is comparable with the previous springs.

3.6 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 over 36,000 birds wintered on the sites surveyed in 1992/93 (Waters & Cranswick, 1993). Over 2,000 Pochard winter on the Severn Estuary but, because of their feeding behaviour, few of them occur on the count areas of the study sites.

No Pochard were observed at any of the three study sites during the autumn or in spring.

Winter 1993/94

Feeding Pochard were only observed in very small numbers at the Rhymney section during low tide counts along the northwest Severn.

A group of between 20 and 30 Pochard were present at the Taff/Ely site for part of the tidal cycle during most of the winter months. These birds spent most of the time roosting on the open water and no feeding birds were observed on the sectors during the all day counts. No birds were observed at the Orchard Ledges site. At the Rhymney site several hundred Pochard were visible offshore during the middle of the winter. Part of this flock moved into the mouth of the River Rhymney as the tide receded and variable numbers moved onto the lower edge of sector 10 to feed (Figure 3.6.1). Feeding birds were observed on a number of other sectors as a few individuals continued to feed on the waters edge on the rising tide.

The number of Pochard on the sectors at the Rhymney site increased as the tide receded, peaking two hours after low tide and then falling sharply as birds moved out onto the open water of the Severn Estuary (Figure 3.6.2c). The peak mean was less than 80 birds, but over 110 birds were seen on some days. Many more birds remained further offshore.

Feeding Pochard had been recorded by low tide counts on the northwest Severn during the previous winter, but not during the three winters before.

Although the Pochard at the Taff/Ely site were not seen feeding or roosting on the sectors during the all day counts, there was an increase in the number of birds seen on the open water compared with the previous winter. At the Rhymney site, the number of Pochard on the sectors has increased compared with the 1992/93 winter.

3.7 Other Wildfowl Species

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

At the Taff/Ely site, a single Brent Goose was present for a short time in December. A single male Gadwall was seen near the saltmarsh in May for one day. In November, two male Shoveler were seen near the inner harbour and a further four males were seen in early December. A single female Eider was seen for a short time in the east half of the study site in November and a single male Common Scoter was seen on one day in both January and May. Single female Goosanders were seen during several months, each time for one day; on two days in January, one day in February, one day in April and two days in May. Apart from the Eider, all of these species have been seen at the Taff/Ely site during the previous winters.

At the Rhymney site, four Scaup (two male and two female) were seen near the inner part of sector 10 in October and a single Goldeneye was present briefly in December.

3.8 Oystercatcher

Tens of thousands of pairs of Oystercatcher breed throughout the British Isles, occupying inland and coastal sites (Gibbons *et al.*, 1993). There has been a significant increase in the number of pairs of breeding birds in wet, lowland grassland during the 1980s as Oystercatchers have expanded their range of nesting sites (O'Brien & Smith, 1992). In autumn and winter, this number increases with the influx of birds from northern Europe and the wintering population was estimated at over 290,000 in 1992/93 (Waters & Cranswick, 1993). The Severn Estuary is not an important wintering site.

Autumn 1993

Oystercatchers were present at the Taff/Ely site from early autumn onwards. Feeding birds were found on most sectors, other than the northwest and northeast parts of the study site (Figure 3.8.1). Only low levels of usage were recorded.

Both sectors of the Orchard Ledges site had feeding birds in autumn (Figure 3.8.2). The small number of birds were well distributed, feeding amongst the stones, but the highest concentration occurred at the eastern end of the study site on the soft muddy areas. At the Rhymney site, all sectors other than sectors 16 and 17 were used by feeding Oystercatchers in autumn. The highest usage occurred on sectors 12, 13 and 14 where feeding birds were found close to the edge of the water on the falling and rising tide. Most sectors to the west of this area were used by feeding birds as they followed the water's edge.

At the Taff/Ely site, as the tide fell, 15 to 20 Oystercatchers flew into the bay and fed on the mudflats until the rising tide covered the feeding areas (Figure 3.8.3a). There was some reduction around the low tide period, possibly as birds moved to nearby feeding sites that were only available at this time during the tidal cycle. At the Orchard Ledges site, 10-15 birds arrived as the tide uncovered the stony shore, approximately two hours after high tide (Figure 3.8.3b). The number of birds then declined until low tide and then increased on the rising tide. At the Rhymney site, there were many more birds than at either the Taff/Ely or Orchard Ledges sites. The number of birds increased steadily through the tidal cycle until three hours after low tide and then declined sharply as birds moved away from the area to roost (Figure 3.8.3c). The peak mean number was almost 150 birds. The majority of Oystercatchers fed throughout the first half of the tidal cycle with the proportion of feeding birds falling on the rising tide.

The distribution of feeding Oystercatcher at the Taff/Ely site was very similar to that of the 1992 autumn. There was a lower level of usage of both sectors at the Orchard Ledges site and the sectors to the west of the Cardiff Eastern Sewer at the Rhymney site compared with autumn 1992.

The pattern of behaviour of Oystercatchers during the tidal cycle at the three sites was similar to the previous autumn, but there were slightly less birds at all three sites. There has been a shift in the feeding distribution of Oystercatchers at the three sites during autumn since 1991. In particular, there has been a continued reduction in usage at the Orchard Ledges site and the western sectors at the Rhymney site with an increase in usage of the other areas of the Rhymney site. This has been mainly as a result of the change in use of certain sectors and only to a lesser extent as a result of the change in the number of birds.

Winter 1993/94

Feeding Oystercatchers were widely distributed along the northwest Severn at low tide (Figure 3.8.4) with all sections holding feeding populations. The highest concentrations were near the River Rhymney.

Small numbers of Oystercatchers were found feeding on most sectors at the Taff/Ely site, other than the sectors in the northeast and northwest of the site (Figure 3.8.5). Usage levels were low and the distribution and levels of usage were very similar to those found in the autumn.

Both sectors at the Orchard Ledges site were used by feeding Oystercatchers and had similar levels of usage (Figure 3.8.6). At the Rhymney site, Oystercatchers moved onto the feeding areas as they became uncovered by the receding tide and followed the waterline with the result that all sectors were used by feeding birds. As in the autumn, highest levels of usage were on sectors 12 and 13.

The number of Oystercatchers and their pattern of behaviour through the tidal cycle was similar to that observed during the autumn for the three study sites (Figure 3.8.7). At the Taff/Ely site, the pattern of movement was more pronounced than during the autumn with birds arriving on the feeding areas as the tide receded, many moving to other feeding areas over the low tide period before returning on the rising tide (Figure 3.8.7a). The number of birds present after the low tide period was about double the peak number present before low tide. At the Orchard Ledges site, the number of Oystercatchers increased sharply as the feeding areas were uncovered by the tide, arriving from other feeding sites to the east and west (Figure 3.8.7b). The number of birds then decreased through the tidal cycle until the area became covered. At the Rhymney site the number of Oystercatcher rose rapidly as the tide fell and remained high throughout the tidal cycle, with all birds feeding until three hours after low tide (Figure 3.8.7c).

There were small increases in the number of feeding Oystercatchers at low tide on some of the sectors of the northwest Severn compared with the previous winter.

The levels of usage and distribution of feeding birds at the Taff/Ely and Orchard Ledges site were very similar to those observed during the 1992/93 winter. At the Rhymney site, there has been a reduction in the level of usage of sectors to the west of the Cardiff Eastern Sewer compared with 1992/93 winter, which had already shown a reduction in usage from the 1991/92 winter. The number of birds at the site has remained similar and the reduction in usage of the areas mentioned has resulted mainly from a shift to sectors at the eastern part of the study site.

Spring 1994

By early spring, the number of Oystercatchers at the study sites was much lower. At the Taff/Ely site between one and 12 birds were seen feeding on the mudflats of the sectors adjacent to the River Taff in the southern part of the site (Figure 3.8.8).

Small numbers of feeding Oystercatchers were observed on both sectors of the Orchard Ledges site and on most sectors of the Rhymney site (Figure 3.8.9). At the Rhymney site, the sectors that had the highest levels of usage were scattered over the whole study site, a much less clear pattern than had been observed in autumn or winter.

The pattern of behaviour of Oystercatchers through the tidal cycle at the Taff/Ely and Orchard Ledges sites was similar to that observed during the winter period, but with half the number of birds (Figure 3.8.10a and b). At the Rhymney site, the pattern of behaviour through the tidal cycle was not consistent (Figure 3.8.10c). The feeding population was present at times on the lower shore line and almost entirely absent at

other times with the peak mean number of birds being only slightly lower than that observed during winter.

The number of birds and the level of usage at all three sites was higher than the 1993 spring and showed an increase over the springs of the early years of the study.

3.9 Ringed Plover

The British and Irish breeding population of Ringed Plover is almost 10,000 pairs, with the majority being found on coastal sites, but increasingly more breeding birds are being found on suitable inland areas (Gibbons *et al.*, 1993). Many of these birds winter around the estuaries and coast of Britain with the 1992/93 winter estimated population being over 10,000 (Waters & Cranswick, 1993). The British wintering population has remained very stable for several years.

Autumn 1993

No Ringed Plover were observed at the Taff/Ely site during the autumn. At the Orchard Ledges site, small numbers of feeding birds were observed on both sectors (Figure 3.9.1). At the Rhymney site feeding Ringed Plover were observed close in to the shore on sector 17 and the west end of sector 15 (Figure 3.9.1). Some birds were seen on some study days roosting over the high tide period on the shingle shore above sector 17 and then moving onto the runneled mud as it became uncovered.

The peak mean number of Ringed Plover at the Orchard Ledges and Rhymney sites was less than ten birds (Figure 3.9.2b and c). At the Orchard Ledges site, the birds were most evident when they were near the upper shore on the falling and rising tide. Although the birds were almost certainly present at other times during the tidal cycle, the nature of the substrate and their cryptic colouration made them very difficult to locate. At the Rhymney site, the Ringed Plover became apparent as they moved onto the mud as the tide receded and then they left the site or moved to areas where they could not be detected. This produced the peak in the number of birds three hours after high tide.

The number of birds and therefore the usage were lower than in autumn 1992 although because of the low numbers involved this is not important. The pattern of behaviour during the tidal cycle was similar to the previous autumns.

Winter 1993/94

Ringed Plover were only observed on the upper sector of the St. Brides section of the northwest Severn during low tides counts (Figure 3.9.3). Because of the difficulty in seeing this species on many substrates it could have been overlooked on some of the other sections.

Two groups of feeding Ringed Plover were seen at the Taff/Ely site during the winter, feeding on sector 4, close to the southern-most observation point (Figure 3.9.4). At the Orchard Ledges site, feeding Ringed Plover were only observed on sector 1 (Figure 3.9.5) although non-feeding birds were observed at other times on both sectors. At the Rhymney site the feeding Ringed Plover were located in the same area as in the autumn, on sectors 15 and 17, but with a higher usage of sector 15 during the winter.

At the Taff/Ely site, although the peak mean number of birds was less than five, the largest group seen was of 17 feeding birds. For both the Orchard Ledges and Rhymney

sites, the pattern of behaviour through the tidal cycle was very similar to that observed in the autumn (Figure 3.9.6b and c). At the Orchard Ledges site, the maximum number observed at any one time was of 35 birds with the peak mean number of 25 being observed on the rising tide. At the Rhymney site, the peak mean number of birds was also seen on the rising tide. The maximum number of birds seen was a group of 65 feeding birds on sector 15 for a short time, although the peak mean was ten birds.

Small numbers of feeding Ringed Plover have been recorded during low tide counts on the St. Brides section of the northwest Severn in some previous years.

The feeding distribution and the number of birds involved were similar to those of the 1992/93 winter for the three study sites. Although there has been an increase in the number of observations of flocks of the size indicated above, the difficulty in finding this species in certain habitats means that it is not possible to say how significant this might be.

Spring 1994

No Ringed Plover were seen at any of the three study sites during the spring. In previous springs, only very low numbers (up to three birds) have been seen.

3.10 Golden Plover

Although large numbers of Golden Plover winter in lowland Britain, very few birds have been seen during the five years of the study. No birds were seen during the current year of study. Only one flock has been seen during the years of the study.

3.11 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 1992/93 at over 38,000, showed a marked increase compared with the previous winter (Waters & Cranswick, 1993).

Autumn 1993

No birds were seen at the Taff/Ely and Orchard Ledges sites during the autumn. At the Rhymney site, small numbers of Grey Plover were seen during each autumn. month. Two birds in summer plumage were seen in August, with a further six birds in September and seven in October, all for short times.

Winter 1993/94

Grey Plover were present on the Peterstone and St. Brides section of the northwest Severn during low tide counts (Figure 3.11.1)

Very few birds were seen at the study areas during the winter. Grey Plover were seen for short periods at the Taff/Ely site in November, December and February, with the

largest group being of four birds. No Grey Plover were seen at the Orchard Ledges or Rhymney sites during the winter.

The low tide distribution of Grey Plover on the northwest Severn was comparable with previous winters.

Since the 1990/91 winter very few Grey Plover have been seen at any of the study sites.

Spring 1993

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

3.12 Lapwing

Almost a quarter of a million pairs of Lapwing breed in the British Isles. Although there has been a significant decline in the number of breeding birds on wet, lowland grasslands of England and Wales during the 1980s, it is still the commonest occurring breeding wader in such habitats (O'Brien & Smith, 1992). The wintering number of birds is even higher 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, but the Severn Estuary is not nationally important.

Autumn 1993

At the Taff/Ely site, feeding Lapwing were present on the inner part of the River Taff, mainly on sector 8 (Figure 3.12.1). Most of the flock of Lapwing restricted themselves to the stony area exposed by the lower tide, with a few birds moving to adjacent areas. No Lapwing were observed at the Orchard Ledges site during the autumn. A small group of Lapwing was present at the Rhymney site on sector 16 near the west bank of the River Rhymney (Figure 3.12.2). Only one or two of these birds were feeding at any time.

As the tide receded at the Taff/Ely site, Lapwing left their roost sites and moved onto the east side of the River Taff, with the number of birds rising irregularly until after low tide (Figure 3.12.3a). There was no clear pattern of the number of birds feeding through the tidal cycle. At the Rhymney site, the peak number of birds was less than five birds.

The usage of sector 8 has increased since the 1991 autumn but their numbers are small and they have an irregular pattern of feeding.

Winter 1993/94

Few feeding Lapwing were seen during low tide counts on the northwest Severn (Figure 3.12.4). The small number of birds present were near the rivers of this area, on the sectors adjacent to the River Taff, Rhymney and Usk.

At the Taff/Ely site, most of the feeding Lapwing were present on sectors 8 and 9 (Figure 3.12.5). During the winter, small flocks of Lapwing were present for short periods of time on other sectors, producing the low usage values shown. No feeding Lapwing were seen at the Orchard Ledges site. A group of birds was frequently present at the Rhymney site (Figure 3.12.6). Although the commonest place for the feeding flock was on the rough muddy part of sector 16, near the west bank of the River Rhymney, feeding birds were seen for shorter periods on sectors 13, 14 and 15.

The peak mean number of Lapwing at the Taff/Ely site was almost 60 birds with a small percentage feeding at any one time (Figure 3.12.7a). Two peaks of numbers were produced during the tidal cycle, with the number of birds being lowest near the low tide period. Because the nature of the adjacent areas had been changed by the Phase 1 and 2 landfill work, the Lapwing flock did not roost very regularly on the land above the mudflats, but frequently spent much of the time over the high tide period on the wing. The peak mean number of Lapwing at the Rhymney site was over 40 birds four hours after high tide, with the number declining sharply over the low tide period (Figure 3.12.7c).

The low tide counts of Lapwing on the northwest Severn did not show any notable overall increase compared with winter 1993/94, although there were some minor changes in distribution.

The 1993/94 winter showed an increase in the number of feeding Lapwing and an increase in the sectors used for the Taff/Ely and Rhymney sites compared with the previous winter. This increase, both in feeding numbers and areas used is the first increase during the five years of the study, Lapwing having shown a reduction in the areas used until this winter.

Spring 1994

No Lapwing were present at any of the three sites during spring.

3.13 Knot

Knot that winter in Britain and Ireland arrive from breeding areas in northern Greenland and northeastern Canada. The wintering total represents about 65% of the European and northwest African population (Prater, 1981). The winter maximum for Great Britain was over 300,000 in 1992/93, but the Severn Estuary is not a nationally important wintering site (Waters & Cranswick, 1993).

No Knot were seen during the autumn or spring at any of the three study sites.

Winter 1993/94

Feeding Knot were seen during low tide counts of the northwest Severn on the Rhymney and St Brides sections (Figure 3.13.1). Their occurrence was irregular and the concentration at the eastern end of the St. Brides section was the result of one large flock.

A small number of Knot were seen at the Rhymney site early in the winter. In January, a larger flock was present in the area and was observed feeding at the study sites. At the Taff/Ely site, Knot were first seen at the end of January, and a flock of up to 800 birds was present on and off for the remaining part of the winter, with numbers declining sharply in March. The feeding birds used a number of sectors in the central part of the bay (Figure 3.13.2). The highest density of feeding birds was found on sectors 4 and 6, where the Knot were usually associated with Dunlin present in the bay. At the Orchard Leges site, a flock of 100 Knot was present at the eastern end of sector 2 for a short time on one tide in February (Figure 3.13.3). At the Rhymney site, a flock of 20 Knot was seen as early as November, but the main numbers of Knot arrived in January. Many sectors were used by feeding birds, especially those extending to the lower shore (Figure 3.13.3), although Knot were also observed to gather with Dunlin on the inner part of the study area (sector 16) as high tide approached.

Two peaks of bird numbers occurred at the Taff/Ely site with Knot being absent from the study site for more than four hours over the low tide period (Figure 3.13.4a). On some tides, Knot remained in the bay over the high tide period and moved onto the sectors as they became uncovered. At other times, Knot were seen to fly into the bay as soon as the central mudflats were exposed. Having left the bay over the low tide period, on some tides, Knot returned as some of the lower sectors were becoming covered, to feed for the last two hours of the tidal cycle. At the Orchard Ledges site, the flock of Knot moved onto the exposed eastern end of sector 2 and remained until low tide (Figure 3.13.4b). There was no clear pattern to the number of birds present through the tidal cycle at the Rhymney site (Figure 3.13.4c) with flocks of varying size arriving at any time that the sectors were uncovered. Although the peak mean number of birds was approximately 200, the largest number of birds counted was 1,200 in February.

Knot have been present in moderate numbers on the northwest Severn in previous years, but this is the first year of the study that large feeding flocks have been seen at the three sites. Prior to the five years of this study, Knot were known to winter in moderate numbers at the Taff/Ely site.

3.14 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). Estimates of the wintering population in 1992/93 showed there to be almost 450,000 birds around the estuaries and shores of Britain (Waters & Cranswick, 1993). The Severn Estuary holds internationally important numbers of Dunlin during winter.

Autumn 1993

Dunlin present in early autumn are likely to be of the *schinzii* race migrating to their wintering grounds in north and west Africa and only those arriving later being from the *alpina* race winter in Britain. At the Taff/Ely site very few Dunlin were seen in August and September, but by late autumn, several hundred were feeding in the bay on some tides. Most feeding birds were present on sectors 3 and 4 (Figure 3.14.1).

No Dunlin were present on the Orchard Ledges site during autumn. The return of Dunlin to the Rhymney site was similar to that described for the Taff/Ely site. The main area of feeding was the sectors between the Cardiff Eastern and the Ystradyfodwg/Pontypridd Sewers, in particular those sectors running down to the lower shore line (Figure 3.14.2).

The peak mean number of Dunlin at the Taff/Ely site was over 60 birds, these being present on the sectors two hours after low tide (Figure 3.14.3a). The largest flocks, numbering up to 250 birds, were present at the end of October. At the Rhymney site the peak mean of over 250 birds occurred one hour after low tide (Figure 3.14.3c). Dunlin moved from adjacent areas onto the newly exposed sectors and fed there briefly. By late October, flocks of up to 1,200 Dunlin were present on some tides.

The level of usage and the number of birds present were higher at both the Taff/Ely and Rhymney sites during the current autumn compared with the 1992/93 autumn. This is probably due to some of the wintering birds arriving at the end of October.

Winter 1993/94

Low tide counts along the northwest Severn showed feeding Dunlin to be numerous and widespread (Figure 3.14.4). All sections had feeding birds present, with the highest concentrations being on Peterstone and St. Brides.

Large flocks of Dunlin were observed to enter the bay at the Taff/Ely site and feed on the exposed mudflats (Figure 3.14.5). The main sectors used by feeding birds were sectors 3, 4 and 5, with moderate levels of usage on sectors 6 and 17. Many sectors were used by some feeding birds, but feeding Dunlin were not observed on sectors north of the PDR. A few Dunlin moved onto the muddy areas of sector 1 of the Orchard Leges site on some tides (Figure 3.14.6). The muddy east end of sector 2 of this site attracted more feeding birds and these spread towards the west, amongst the stony substrate, as they continued feeding. The Rhymney site had the highest level of usage of the three sites (Figure 3.14.6). Large flocks of Dunlin moved along the shore from the east or flew in from roost areas to the west, usually arriving as the lower sectors became uncovered. These birds fed mainly along the water line and moved up the shore on the rising tide, producing the high usage values on sectors 10-16. On the sectors west of the Cardiff Eastern Sewer, most of the feeding Dunlin flew to other areas as the rising tide covered the lower sectors.

The peak mean number of Dunlin at the Taff/Ely site was over 2,000 birds and occurred three hours after low tide (Figure 3.14.7a). On some tides in the middle of the winter period, up to 6,000 birds entered the bay to feed on the rising tide before leaving the bay to roost elsewhere. 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 of the study site. As low tide approached, the Dunlin left the site to feed elsewhere but on the rising tide large numbers returned to feed.

The Dunlin at Orchard Ledges arrived as muddy areas became exposed and continued to feed until these lower areas became covered again (Figure 3.14.7b). The presence of

Dunlin at this site was not so predictable and although the peak mean was approximately 300 birds, Dunlin were absent on some tides. At the Rhymney site the peak mean number of birds was over 6,000 (Figure 3.14.7c). As the tide receded, Dunlin continued to arrive from outside of the study area and the number of birds increased sharply until two hours before low tide. After this time, the number of Dunlin declined steadily as birds moved to areas outside the study site to continue feeding or to roost.

The low tide distribution of feeding Dunlin on the northwest Severn was similar to the 1992/93 winter although there was an increase in the number of feeding birds on the Rhymney section.

The distribution of feeding Dunlin at the Taff/Ely site was similar to the 1992/93 winter with minor variations in the level of usage on some of the sectors. The level of usage at the Rhymney site was markedly higher on all sectors used by feeding birds compared with the 1992/93 winter. This increase in usage was mainly due to an increase in the number of Dunlin at all three sites during the current winter. At both the Taff/Ely and Orchard Ledges sites there was a two-fold increase in the peak mean number of birds, with an even greater increase at the Rhymney site. This was the highest mean number of Dunlin seen at the three study sites since the 1989/90 winter.

Spring 1994

The number of Dunlin present at the three sites decreased towards the end of the winter period and very few remained in March. No Dunlin were seen during April at the three study 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 the Taff/Ely site small groups of less than 100 birds were seen feeding on the central sectors on several tides towards the end of May (Figure 3.14.8). No Dunlin were seen at the Orchard Ledges site in spring. At the Rhymney site, groups of up to 60 birds were present during May, feeding mainly on the sectors to the east of the Cardiff Eastern Sewer (Figure 3.14.9). At both sites where Dunlin were observed, most birds were present during the second half of the tidal cycle (Figure 3.14.10a and 10c). Very few birds have been seen during the previous springs.

3.15 Curlew

Curlew characteristically breed on damp upland and northern moorlands but this century they have colonised many lowland regions, especially agricultural habitats (Gibbons *et al.*, 1993). There is some evidence that changes in land use, resulting in decreased grassland and increased habitat fragmentation have resulted in decreased breeding and foraging possibilities (Berg, 1992). The breeding population of Britain and Ireland has been estimated as 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 to be over 85,000 in 1992/93, the highest value since estuarine counts began (Waters & Cranswick, 1993).

Autumn 1993

Curlew were present at the three sites at the beginning of autumn. At the Taff/Ely site, Curlew that had roosted in the bay, and others from areas outside of the study site, moved mainly onto sectors adjacent to the mouths of the Rivers Taff and Ely (Figure 3.15.1). The southeastern corner of sector 2 frequently had the highest population of feeding Curlew on it. Both sectors of the Orchard Ledges site had high levels of usage, with feeding birds being scattered widely over the stony site (Figure 3.15.2). At the Rhymney site, although Curlew were observed to roost in moderate numbers at the top of sector 13 and further east, most of the birds spread out to feed on other areas. The usage at this site was low on most sectors, but feeding birds were widespread (Figure 3.15.2).

At the Taff/Ely site, two peaks of numbers of birds occurred (Figure 3.15.3a). Most of the birds leaving their roost sites in the bay moved onto the sectors, initially to continue roosting. The proportion of birds feeding increased as the tide receded. Many birds left the bay to feed on other sites for the period two hours either side of low tide with approximately 40 birds remaining at this site to feed. Adjacent feeding areas became covered three hours after low tide, at which time the Curlew that moved out of the bay returned and roosted on the sectors near to their eventual high tide roost site. Over 150 Curlew were present at this time on some tides, the number reducing as birds moved onto the saltmarsh to roost.

Curlew arrived at the Orchard Ledges site as soon as the sectors became uncovered, flying in from the direction of the Taff/Ely site and from the east. The number of Curlew increased rapidly and nearly all of this population then remained feeding at the site until the two sectors were again covered by the rising tide (Figure 3.15.3b). The peak in the number of Curlew at the Rhymney site occurred three hours after low tide as extra birds arrived to start roosting on the sectors of the eastern part of the site (Figure 3.15.3c). On the falling tide, approximately 20 Curlew left their nearby roost sites and fed on the sectors until about one hour after low tide when they also started to roost.

The distribution of feeding birds at the three sites was similar to the 1992 autumn, but the levels of usage at the Rhymney site had shown some changes. The usage of nearly all sectors at this site had shown a reduction since 1991, although the values were much nearer those obtained for the autumn 1990. This was partly because of a reduction in the peak number of birds at the site but mainly due to fewer birds remaining at the site to feed during the first half of the tidal cycle.

Winter 1993/94

Low tide counts along the northwest Severn showed feeding Curlew to be very widely distributed (Figure 3.15.4).

The distribution of feeding Curlew and the level of usage on the individual sectors at the Taff/Ely site were very similar to those observed during the autumn (Figure 3.15.5). At the Orchard Ledges and Rhymney sites, the distribution and usage were also

very similar to those of the autumn period apart from some small increases in the usage of some sectors of the west half of the Rhymney site (Figure 3.15.6).

The same pattern of behaviour through the tidal cycle at the Taff/Ely site was observed during the winter as that already described for the autumn (Figure 3.15.7a). Both peaks of numbers of birds, however, were only about 50% of the numbers present during the autumn. At the Orchard Ledges site, the number of birds present was approximately 65% of that during the autumn, but with a very similar pattern of behaviour during the tidal cycle (Figure 3.15.7b). The movement of birds onto the Rhymney site two to three hours after low tide, that had been noted during the autumn period, was not evident during the winter (Figure 3.15.7c). The number of birds increased as the sectors became uncovered by the falling tide and the majority of the birds remained feeding until the sectors started to become covered again, two to three hours after low tide.

The low tide feeding distribution of Curlew on the northwest Severn was similar to that of the 1992/93 winter with minor changes in the numbers on some sectors. There have been no major changes in the low tide distribution of this species during the five winters.

There was a wider usage of the sectors at the Taff/Ely site compared with the 1992/93 winter, but the number of feeding birds using new sectors was low. The level of usage was similar and there have only been minor changes during the five winters of the study. At the other two sites, there was an increase in usage of sector 1 at the Orchard Ledges site, but a moderate decrease in the usage of many of the sectors at the Rhymney site, compared with winter 1992/93.

The number of Curlew and their pattern of behaviour during the tidal cycle at the Taff/Ely site was very similar to the 1992/93 winter and there had been no major change detected since the 1989/90 winter. The number of birds at the Orchard Ledges site has shown less consistency with the peak mean varying from 15 to 70 but not showing any definite trend. At the Rhymney site, the pattern of behaviour through the tidal cycle has been comparable for the five winters, but the number of birds present has shown a reduction since the 1990/91 winter.

Spring 1994

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

One to two Curlew were present feeding on a few sectors during the spring at the Taff/Ely site (Figure 3.15.8). At the Orchard Ledges site a maximum of five birds during April, and nine birds during May, was observed feeding on sectors at the Orchard Ledges site (Figure 3.15.9). No Curlew were seen at the Rhymney site during April, and a maximum of five birds was seen on a sector in May. These feeding birds were confined to sectors 11 and 14.

Although there were very few Curlew at the Taff/Ely site in spring, they followed a similar pattern of behaviour through the tidal cycle as for autumn and winter (Figure

3.15.10a). The main difference was that these low peaks of numbers were mainly of non-feeding birds that were present on one or two tides. At the Orchard Ledges and Rhymney sites the peak was of less than five birds.

There have been few Curlew at the study sites during the springs of the study. The 1993 spring showed there to be a wider usage of sectors at the Taff/Ely and Rhymney sites, but almost no birds were observed at the Orchard Ledges site. The numbers involved, however, were too low to draw any firm conclusions. Over the five spring study periods, there has been most variation in numbers and usage at the Orchard Ledges site, but this has only involved relatively low numbers of Curlew.

3.16 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 estimated wintering population in 1992/93 was over 70,000 (Waters & Cranswick, 1993). The Severn Estuary holds internationally important numbers of wintering Redshank.

Autumn 1993

By early autumn, several hundred Redshank were already present at the Taff/Ely site. Return migration from their breeding grounds starts in July and continues into autumn. In the autumn, feeding Redshank were well distributed throughout the study site, but the highest levels of usage occurred on the sectors in the northern half of this area (Figure 3.16.1). The highest concentrations of feeding birds were near the inner harbour on sectors 15, 18 and 19 and on the inner part of the River Taff on sector 8. No Redshank were seen on the Orchard Ledges site during the autumn. At the Rhymney site, Redshank were restricted to the area east of the Cardiff Eastern Sewer (Figure 3.16.2). In particular, feeding Redshank were located on the sectors adjacent to the eastern banks of the River Rhymney, sectors 11, 14, 15 and 16, feeding within a short distance of the river.

In August, almost 400 Redshank were observed roosting at high tide at the Taff/Ely site and this had risen to over 550 in October. The peak mean number of birds at this site was almost 300 (Figure 3.16.3a). The Redshank moved onto the sectors to feed as the tide receded and some birds were then out of sight to the counter, either in runnels on the mudflats or on steep banks. As the tide rose, many Redshank stopped feeding and moved to areas where they were more visible. This resulted in two peaks of numbers of birds at the site, either side of the low tide period. At the Rhymney site, there were less than 100 birds in August, but this increased to over 300 birds by the end of the autumn period. Redshank left their roost sites and moved onto the sectors to feed as the water level dropped, producing a peak of almost 200 birds three hours before low tide (Figure 3.16.3c). Up to this time, all the Redshank were feeding, but as the number of birds dropped over the rest of the tidal cycle, so did the proportion of feeding birds.

Feeding Redshank were widely distributed at the Taff/Ely site in the autumn of 1992, but the usage of the sectors was more even than in the current autumn. Since the 1991 autumn, there has been a shift in the usage of sectors at this site. Prior to this time, feeding Redshank used all of the sectors evenly over the whole tidal cycle period. Autumn feeding Redshank have gradually made relatively more use of the sectors at the north part of the site in the following autumn periods. At the Rhymney site, the distribution and level of usage were both very similar to those of the 1992 autumn. There has been little variation in the sectors used by feeding birds at this site during the five autumns, but the level of usage has varied between autumns with differing numbers of birds being present during the count period.

Winter 1993/94

Low tide counts on the northwest Severn showed feeding Redshank to be associated with the two side-estuary areas of the Taff/Ely and the Rhymney with only a few birds feeding outside of these sectors (Figure 3.16.4).

Almost all sectors at the Taff/Ely site were used by feeding Redshank during the winter period (Figure 3.16.5). Apart from those sectors near to the PDR, levels of usage were fairly even. Although Orchard Ledges was not used by feeding Redshank, a single bird was present for a short time on sector 1 during one December tide. This is the first recorded observation of a Redshank during the study periods at this site for over three years. One other unusual observation was of a flock of 45 Redshank flying east to west over the Orchard Ledges site and into Cardiff Bay, one hour after low tide in February. Although there is known to be a very limited movement of Redshank between the Taff/Ely and Rhymney sites (see later, and Donald & Clark, 1991a; Toomer & Clark, 1992a; Toomer & Clark, 1993a), no Redshank have been seen flying between the two sites during the whole of the observation periods of at least the last three years. At the Rhymney site, feeding Redshank were more widely distributed than in the autumn study period (Figure 3.16.6). However, there were only low levels of usage on those sectors that had not been used by feeding birds in the autumn. There were higher levels of usage on the sectors that were the main feeding areas than in the autumn period.

The pattern of behaviour through the tidal cycle at the Taff/Ely site showed two peaks in the number of birds seen (Figure 3.16.7a). Birds moved from their roost areas onto the sectors and the number of Redshank increased up to almost 250, three hours before low tide. As these birds spread out to feed, the number remaining visible was reduced over the low tide period. As the tide rose, the number of birds counted increased up to three hours after low tide, at which time the birds started to move off from the count areas to roost elsewhere. The pattern of behaviour and the number of birds were both similar to those observed in autumn. At the Rhymney site, there was only one clear peak in the number of birds counted during the tidal cycle, three hours before low tide (Figure 3.16.7c). The number of Redshank then declined gradually through the rest of the tidal cycle until birds moved off from the sectors to their roost sites.

The low tide distribution of feeding Redshank on the northwest Severn was very similar to the results for the 1992/93 winter. There have been only minor changes in the number and distribution of feeding Redshank observed at low tide on the northwest Severn during the five years of the study.

The feeding distribution of Redshank at the Taff/Ely and Rhymney sites was comparable with that for the 1992/93 winter, with only minor changes in the use of some sectors.

The number of Redshank observed during the tidal cycle at the Taff/Ely site was similar to the 1992/93 winter. The change in the pattern of behaviour through the tidal cycle that had been noted in the 1992/93 winter was not continued into the current winter. The pattern was more comparable with that observed in the first three years of the study with two peaks of numbers of birds, before and after low tide. At the

Rhymney site, the number of Redshank was also similar to the 1992/93 winter, but the main peak in numbers occurred before the low tide.

Spring 1994

The number of Redshank decreased during March and by April very few birds remained.

At the Taff/Ely site, the only feeding birds observed during the spring period were located on sector 8 (Figure 3.16.8). No birds were observed at the Orchard Ledges or Rhymney sites during the spring period.

These findings are consistent with the observations for the previous springs.

3.17 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 1992/93 British wintering population was estimated at almost 16,000 birds from estuarine surveys, a decrease on the estimate for the previous years (Waters & Cranswick, 1993). Because this estimate did not include counts of non-estuarine coasts, it is an under-estimation of the true wintering population which is nearer 64,000.

Autumn 1993

Small groups of Turnstone were observed early in the autumn on the stony shore edge adjacent to Ferry Road on the Taff/Ely site. By mid-autumn, larger groups of more than 50 birds were observed in the same area, but few birds were observed feeding (Figure 3.17.1). At the Orchard Ledges site, Turnstone were present from early autumn, with the number increasing during this period. Both sectors were used by feeding birds, with higher levels of usage being observed on sector 2 (Figure 3.17.2). The possibility of under-recording this species at this site has been referred to before. The cryptic coloration of Turnstone, the broken nature of the substrate and the difficult light conditions all reduce the accuracy of counting at low tide. At the Rhymney site, feeding Turnstone were only observed close in to the upper shore on sector 17 (Figure 3.17.2).

The number of birds at the Taff/Ely site showed two peaks either side of low tide, although the actual number of birds was low (Figure 3.17.3a). The small population that was occasionally present moved from the raised edge of the roadside where they had been roosting, onto the stony edge of the shore. As the tide fell further, the birds left the Taff/Ely site to feed on nearby areas, returning again as the tide rose. At the Orchard Ledges site, some Turnstone arrived on the upper shore just as it was becoming exposed by the falling tide (Figure 3.17.3b). The number of birds continued to increase with a further fall of the tide as they arrived from nearby areas. The apparent decrease in the number of birds over the low tide period may be because of the problems of observing the Turnstone, already referred to above. At the Rhymney site, between 10 and 40 birds sometimes roosted on the shingle above the high tide line near sector 17. As the tide receded and sector 17 became exposed,

the birds moved onto the mud to feed for a short time before flying to other feeding sites (Figure 3.17.3c). On several occasions Turnstone were seen to fly onto the raised stony strip covering the Cardiff Eastern Sewer before leaving the site completely. Shortly before sector 17 became covered on the rising tide, Turnstone returned on some occasions to feed briefly before roosting above the tide line.

The autumn usage at the Taff/Ely site was slightly lower than the previous autumn, although the birds were present on the same area. At the Orchard Ledges site, usage levels were also similar to the previous autumn, although it was sector 2 that had the higher level of usage during the current autumn. There were only minor differences in the number of birds and the pattern of behaviour through the tidal cycle at the three study sites compared with the 1992 autumn.

Winter 1993/94

Low tide counts of the birds on the northwest Severn showed that feeding Turnstone were restricted to the Orchard Ledges part of the Rhymney section, (Figure 3.17.4).

At the Taff/Ely site, feeding Turnstone were present in small numbers on the stony edge of the upper shore near Ferry Road and on the mud immediately adjacent to it (Figure 3.17.5). This was very similar to the autumn feeding distribution. The levels of usage for both sectors at the Orchard Ledges site were higher than in the autumn period (Figure 3.17.6). As the Turnstone moved onto the sectors to feed at the Rhymney site, they spread out more than in the autumn period, but never moving much more than fifty metres from the shingle shore. This resulted in a slightly wider feeding distribution than in the autumn.

Fewer roosting groups of Turnstone were observed during the winter period than in the autumn at the Taff/Ely site and these usually flew out of the bay without moving onto the counting areas. The peak mean number of Turnstone at the Orchard Ledges site was approximately 90 birds and this peak occurred shortly after the sectors became exposed by the falling tide (Figure 3.17.7b). The apparent number of birds then fell as low tide approached, with a small second peak in numbers shortly before the area was again covered. The peak mean number of birds was higher than in the autumn although the number of birds present for most of the tidal cycle was similar. At the Rhymney site, both the number of Turnstone and their behaviour through the tidal cycle were very similar to those observed during the autumn (Figure 3.17.7c).

There have only been minor changes in the low tide distribution of Turnstone on the northwest Severn and the feeding distribution and number of birds at the three sites compared with the 1992/93 winter.

Spring 1994

Although the number of Turnstone had declined during March, at the Taff/Ely site, the level of usage was higher than during the winter period. Groups of 10-30 birds were present for short periods during April, feeding on the mud of sectors 3 and 5 (Figure 3.17.8). At the Orchard Ledges site, feeding birds were observed on both sectors, but

having much lower levels of usage than during the winter period (Figure 3.17.9). At the Rhymney site, Turnstone were observed roosting on the shingle of the upper shore and in the vicinity of the Cardiff Eastern Sewer, but only a few birds were observed feeding on sector 17 (Figure 3.17.9).

The Turnstone present at the Taff/Ely site arrived as the tide was rising, remaining until the mudflats were covered (Figure 3.17.10a). In contrast, at the Orchard Ledges site, the birds arrived at the site as the falling tide started to uncover the shore, but were not observed from two hours before low tide through the rest of the tidal cycle (Figure 3.17.10b).

Although the level of usage and the number of birds at the Taff/Ely site showed an increase compared with spring 1993, the findings are comparable with some of the previous springs.

3.18 Other Wader Species

Waders frequently stop on route when migrating to or from their wintering grounds. Some areas can be important stop-over points for various groups of birds. Although passage migrants have been observed at the study sites in previous years, they have only occurred in small numbers. The extra observations of waders at the study sites includes birds on migration as well as species rarely recorded within the study sites.

There were few sightings of others waders at the Taff/Ely site during the current study. Two Common Sandpipers were seen on the edge of sector 18 in August and September. One Bar-tailed Godwit was present one study day and one to two Black-tailed Godwits were present for several study days during September. A further sighting of a single Bar-tailed Godwit was made in May. Snipe were observed flying to higher land on rising tides on several occasions. In spring, up to three Whimbrel were observed near the areas of saltmarsh at the west part of the site. One unusual observation at Orchard Ledges was of a Spotted Redshank in summer plumage feeding in a 'freshwater' creek on sector 2 for two hours. A Common Sandpiper was present for a short time one day in August at the Rhymney site and there were observations of one to three Whimbrel near the Cardiff Eastern Sewer during the spring. A maximum of four Black-tailed Godwits were observed during April and up to four Bar-tailed Godwits were present one day in May on the western part of the Rhymney study site.

4. DISCUSSION AND CONCLUSIONS

This is now the fifth 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 distribution and movement 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 can be obtained before the barrage is built. Without this, it will be very difficult to determine the fate of these birds after the bay is inundated. Changes that have already taken place in the bay have had an effect on the distribution of birds within this study site. As work progresses with the barrage construction, it is possible that this too will affect the distribution and number 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.

Changes to the distribution and abundance of the waterfowl of the area over the first five years are discussed below.

Shelduck

Autumn observations of the feeding distribution and numbers of Shelduck show some variation during the four years. This is partly because of the pattern of return of adult birds during the late autumn, where small changes in the timing of this return can alter counts during the finite autumn study period. However, the number of birds concerned was relatively low compared with the winter populations.

At the Taff/Ely site, the size of the population remained very stable apart from an increase in the number of birds after the first winter of the study. The increase in usage of several sectors in 1992/93 was not maintained in the current winter (1993/94). In the last report, it was noted that there had been a reduction in the usage on sectors near to the PDR construction. This has continued during the current winter, with almost no Shelduck being observed on sectors 7 - 12. Although there is inevitably some disturbance from the construction work, this has probably not increased much since 1991, and yet the reduction in feeding in this area has continued.

The Rhymney site has seen minor fluctuations in the level of usage of certain sectors during the five winters, but with no clear trend. The number of birds at this site decreased in 1992/93, the first winter for four years, but this appears to have been a single year dip. The number of birds present in the current study period was comparable with the first three winters. The use of the Orchard Ledges site by feeding Shelduck has not been consistent. At one time it looked as if there was going to be a continued increase in the usage of this site, but this has not been maintained.

Mallard

Because of the size of the national population of Mallard compared with the relatively small number of birds found at the study sites, changes to the number of birds or their behaviour will only be of interest at a local level. As with Shelduck, there has been a change in the distribution of feeding birds at the Taff/Ely site. Almost no feeding Mallard are now found

on sectors 7, 10, 11 and 12, those sectors most affected by the PDR work. As any disturbance to this general area decreases with completion of the road work, it will be interesting to see if there is a return of feeding Mallard or if some other factor has resulted in their changed pattern of behaviour. This is one species that will probably be present after the barrage has been completed. The management of the freshwater lagoon produced will affect the success of wildfowl populations.

Teal

The total number of Teal at the Taff/Ely site is large compared with the number of birds that are observed feeding at any one time during the hours of daylight. Only part of the population is present on the mudflat sectors, with many birds staying on the open water and, of those on the mudflats, only some are seen feeding. Because Teal are known to feed sporadically and continue through the hours of darkness (Rehfisch *et al.*, 1991) the routine all day counts give an under-estimation of the size of the population that is reliant on the Taff/Ely site during the winter. During casual observations, Teal have not been seen to fly away from the site to other areas during the tidal cycle and it is presumed that most remain there all the time. There has been a shift in the areas used for feeding at the Taff/Ely site since 1989/90, from sectors at the northwest part of the study site, near the inner Taff, to sectors further east. This is again a movement from sectors near to the PDR work and landfill sites.

Pintail

This species was again present primarily at the Rhymney site. Only minor changes in the feeding distribution and number of birds have been noted during the five years of study. The Taff/Ely site has not been used by Pintail as a roosting area or a feeding area in previous years, but one to two birds were seen at the site on two occasions. Although this does not suggest that Pintail are about to spread into the Taff/Ely site in large numbers, this is the first evidence of this species at this site for several years. The main relevance of this species is that it could be a possible competitor for food if some of the wildfowl population from the Taff/Ely site move to the Rhymney site after closure of the barrage.

Pochard

Pochard have been observed on the open water near to the Rhymney site during the winters of the study, without making any major use of the site itself. Although this species is a diving duck, and obtains plant and animal food from bottom sediments, it is known to feed on the shoreline. During the current winter, there was a notable increase in the number of birds moving into the study area and feeding on the water's edge. At the Taff/Ely site, a small group of Pochard entered the bay to roost over the high tide period, as they have been observed to in previous winters. No feeding was observed by the birds at this site. This species is therefore unlikely to be affected by changes in Cardiff Bay, other than being a potential competitor for food at the Rhymney site if other displaced wildfowl move there.

Oystercatcher

Oystercatcher feed at all three study sites, although the number of birds involved is low in national terms. The whole of the Severn Estuary falls well below the level for national

importance for this species (Waters & Cranswick, 1993). The population found at each site is part of the larger population, with interchange occurring at least between the study sites. The birds that are seen to feed and roost at the Taff/Ely site can be seen to fly to the Orchard Ledges site when this becomes uncovered by the falling tide. Oystercatcher also fly from the direction of the Rhymney site to feed on the Orchard Ledges site. The largest population of the three sites occurs at the Rhymney site and birds feeding there are seen to fly in from both the east and the west. There has been an increase in the number of birds at the Rhymney site since 1989/90, although the actual numbers remain low.

Ringed Plover

There has been an increase in the number of Ringed Plover feeding at the Orchard Ledges site since 1989/90. The peak mean numbers shown from data analysis do not necessarily reflect the true picture, as this species is so difficult to observe in this habitat. The largest number of Ringed Plover seen at either site was 65 birds. It is not known if the population of Ringed Plover that was seen at the Rhymney site is the same as that seen at the Orchard Ledges site, although birds were only visible at Rhymney when Orchard Ledges was covered by the tide. The Severn Estuary holds nationally important numbers of Ringed Plover, but as the qualifying level is under 300, the population that is present at the Orchard Ledges and Rhymney area may well represent an important part of this total.

Lapwing

Lapwing were mainly confined to the inner part of the River Taff during the first years of the study. The number of feeding birds showed a decrease up until the current year, but this winter has seen higher levels of usage of the areas originally used as well as a wider distribution of feeding birds. The actual population is, however, small and not of importance at a national level.

Knot

Knot have been present in moderate numbers at the area covered by the study sites in earlier years (Ferns, 1977). During the first four years of the study, very few Knot were seen at any of the study sites. During the current winter, a group of Knot numbering up to 1,000 birds was present in the general area and parts of this population were observed at all three study sites. The Severn Estuary holds nationally important numbers of birds during the winter but, as with many other wintering sites, there is a wide fluctuation in numbers from year to year. It is not possible to say how important the Taff/Ely site is to this species because of this variation. Even when there are a large number of birds in the area, their use of this site is irregular.

Dunlin

Large numbers of Dunlin winter around the Estuaries of Britain. The Severn Estuary holds internationally important numbers of birds during the winter and the Taff/Ely site holds nationally important numbers. Unlike some of the other waterfowl, Dunlin are fairly mobile during the tidal cycle and several thousand birds move along the shore to feed, from the Rhymney Estuary eastwards. On some days, several thousand birds enter the Taff/Ely study site and feed, sometimes only for about one hour. Because of the apparently

inconsistent behaviour shown by this species, it is difficult to estimate how important the Taff/Ely site may be as a winter feeding area. It is likely, however, that this site forms a part of a mosaic of feeding areas, all important for the survival of the population that winters in the area.

There have been fluctuations in the number of Dunlin at the study sites during the five winters, but without any long-term increase or decrease. The main changes have been in the distribution of feeding birds, especially at the Taff/Ely site. Here, there has been a move away from sectors near to the PDR work with a corresponding increase in the usage of sectors to the southwest part of the site. The current winter has had some of the largest groups of Dunlin present for several years, but almost no feeding birds have been found on sectors 7-12. The Rhymney site has also had the highest number of Dunlin present since the start of the study. The whole study area has supported this increase in population over the last three years but, at present, it is not possible to say what effect the loss of the Taff/Ely feeding area will have in future years.

Curlew

The Curlew, present in winter at the three study sites, form part of the nationally important Severn Estuary population. Examination of the number of birds at the three study sites and of the pattern of behaviour through the tidal cycle shows a consistent pattern for the five winters. There have been small variations in the feeding distribution, especially at the Rhymney site, but overall this wader has provided the most consistent data over the whole study period of the birds that winter in the area. Although no colour-marking studies have been carried out on this population, Curlew are known to show a high degree of site-fidelity and it is likely that the Taff/Ely population includes birds that return from one year to the next. Clearly these birds will have to change their pattern of behaviour when the barrage is completed.

Redshank

Colour-marking of the Taff/Ely population of Redshank, and of Redshank found at the Rhymney site, has shown a high degree of site-fidelity in this species (Donald & Clark, 1991a; Toomer & Clark, 1992a; Toomer & Clark, 1993a; Part 2 of this report). Once Redshank have moved to their wintering area, apart from some early shorter distance movement of birds, they appear to remain at a specific site until spring. The presence of colour-ringed birds that have returned to the Taff/Ely site for several years show has shown that at least part of the population relies specifically on this area for winter feeding and roosting. Redshank are known to show a high degree of site-fidelity to their breeding sites (Thompson & Hale, 1993). This species is also known to be especially susceptible to severe weather (Clark, 1982) and the presence of birds of prey at wintering sites, with over 50% of wintering Redshank falling prey to raptors over a two-year period in some areas (Cresswell & Whitfield, 1994).

The number of birds at the three sites has remained similar over the winters of the study. The main changes have been in the level of usage and distribution of feeding birds at the Taff/Ely site and to a lesser extent at the Rhymney site. As with several other species, the main change at the Taff/Ely site has been a reduction in the usage of sectors near to the PDR work. During the 1989/90 and 1990/91 winters Redshank showed very even usage of

almost all sectors of the site. As PDR developments started to affect the mudflats of sectors 7, 10 and 11 there was a reduction in the level of usage of these feeding areas. Although sector 12 was not affected directly by the PDR mounds, this mudflat also showed a decrease in usage. This reduction continued and increased through the succeeding winters and there has been no evidence of any increase in usage this current winter, even though disturbance has been reduced. Few feeding birds were observed on sectors 7, 10, 11 and 12 in the current winter.

At the Rhymney site, there has been very little disturbance during the study winters and only minor changes in the level of usage of some sectors has been noted.

Turnstone

The Orchard Ledges site remains the main feeding area for Turnstone at the study sites. The number or birds and their feeding distribution have both been similar at all three sites over the study winters. As the Taff/Ely site is only used by relatively few Turnstone, and then mainly for roosting during part of the tidal cycle, permanent flooding of this site is unlikely to have a marked effect on the Turnstone population of the area.

To summarize, the work on the PDR and landfill areas at the northwest part of the Taff/Ely site has continued. The overall level of direct disturbance has reduced, but the species that previously used the adjacent areas have not yet shown any tendency to increase their feeding activity on these sectors. The final phase of landfill will continue into the following study period and this will again increase the disturbance of this area, as well as directly affecting areas used by roosting birds. Dredging of large parts of the sectors in the area of the barrage construction is due to commence in the autumn of 1994. Although this will occur when the areas are covered by the tide and not being used by feeding birds, changes to the substrate may have an effect on the invertebrates and therefore affect the relative feeding area of the site. Direct changes to sectors at the landward end of the barrage will inevitably reduce the potential feeding habitat in these areas.

This fifth year of monitoring of Cardiff Bay and nearby areas added to the data that will allow a clear and accurate assessment of the status of the bird populations before the commencement of any work on the barrage.

PART 2: MOVEMENT STUDIES

5. INTRODUCTION

The importance of determining if there is any turnover in the population of waders or waterfowl at the Taff/Ely site has been stressed in previous reports (Donald & Clark, 1991a; Toomer & Clark, 1992a; Toomer & Clark, 1993a). 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 taken in isolation. 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, some wintering sites may become 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.

Continued behavioural observations at the three study sites made during fieldwork has given some indication of the movement of certain species during the tidal cycle. During the current study period, some Turnstone have been observed flying into the Taff/Ely site from Orchard Ledges as the tide covered the feeding grounds. At other times, Turnstone were seen to fly from the east end of the Orchard Ledges site towards the Rhymney site, from the Rhymney site towards the Orchard Ledges site and also to the west, beyond the Taff/Ely site. Clearly there is interchange between sites of at least some of the Turnstone population. Similarly, further observations of Curlew have shown some of them to move between the Taff/Ely site and Orchard Ledges and from the Rhymney area towards the Orchard Ledges site. 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 it is the same individuals involved each time.

Species such as Dunlin present different problems as the population present at the three sites is far less predictable. Several thousand birds feed in the area and move from roost sites to the west and east to concentrate on the lower shore of the Rhymney site. At times during the tidal cycle, hundreds of Dunlin may be found feeding on suitable parts of the Orchard Ledges site and at other times several thousand birds may fly into the Taff/Ely site to feed. However, Dunlin may be absent from both of these sites on some days. It is not possible to determine just by straightforward observation if there are sub-populations that are specifically involved at a particular site, or if the populations are freely interchangeable. One other observation of interest was of a mixed flock of Dunlin and Knot flying from the west end of the Rhymney site out towards the middle of the Severn Estuary towards Clevedon on the south coast of the Severn. Earlier observations had showed that some Dunlin feeding at the Rhymney area flew across the Severn to roost at Clevedon (Clark, 1990).

During the previous winters of the study, Redshank had not been seen to fly away from the Taff/Ely site nor had any been seen flying past Orchard Ledges. From earlier colour-marking studies (Toomer & Clark, 1992a; Toomer & Clark, 1993a) it was known that there was a very limited interchange of Redshank between the Taff/Ely and Rhymney sites. It was not until the current winter that any Redshank were observed flying between study sites. A flock of 45 birds was seen flying east to west past the Orchard Ledges site and then

turning north to fly into the Taff/Ely site. This occurred in February, shortly after low tide, and was therefore not influenced by birds being moved off of feeding areas by the high tide.

Previous colour-marking of Redshank had been carried out in January, 1991 at Taff/Ely; December, 1991 and January, 1992 at Rhymney; November, 1992 at Rhymney. 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.

Because of the number of birds colour-marked each time and the limitations in observing birds after that time, it was necessary to continue with the colour-marking for this study.

6. METHODS

Early in 1991, 151 Redshank were caught at the Taff/Ely site and 133 adult birds were colour-ringed and colour-marked. Movements of these birds were described in the 1990/91 report (Donald & Clark, 1991a). The colour rings were still visible on some birds during the autumns and winters of 1991/92 and 1992/93 and observations of these birds were reported in Toomer & Clark (1992a) and Toomer & Clark (1993a).

Colour-ringed Redshank from the 1991 study were looked for during the early autumn of the current study. These rings are difficult to see, especially at a distance, in poor light, or if the birds had been wading in soft mud. The celluloid colour rings that were used in 1991 had also faded and discoloured by this time. The largest number of Redshank that could be seen to be with or without rings was counted and the proportion with rings was estimated.

A smaller number of Redshank were caught and colour-marked (not colour-ringed) at the Rhymney site during the 1992/93 winter. The dye that was used did not fade and would only be lost by moulting of the coloured feathers. Such colour-marked birds, that had not completed their moult by early autumn, were also looked for.

In October 1993, attempts were made to catch, colour-mark and colour-ring a large proportion of the Redshank present at the Taff/Ely site. Observations had shown that the bulk of the Redshank population were using the artificial high tide roost island to roost over the high tide period on high spring tides. Cannon nets were used to catch the Redshank. On October 16th, 212 Redshank were caught. This included a number of birds that had been caught and ringed in previous years at the Rhymney area or elsewhere, as well as birds that had been caught and colour-ringed in 1991. Of the newly trapped birds, only adults were colour-ringed and colour-marked as juveniles could moult colour-marked feathers. Colour-rings that were put on Redshank in 1991 were replaced with new, long-lasting Darvic colour-rings. A total of 174 Redshank were colour-marked.

All newly-caught birds were also fitted with a metal ring embossed with a unique letter and number code to allow individual identification in the event of the bird being re-caught. Colour-marking was carried out using an application of picric acid dissolved in alcohol on the breast. The dye initially produces a bright yellow colour on the pale feathering. As the dye binds with the keratin in the feathers themselves, rather than colouring the surface, this dye remains visible as long as the feathers last. The colour of the dye changes and intensifies with age, becoming a deeper orange-yellow. This colour is lost when the feathers are moulted before the breeding season.

As with the previous winters' studies, it was not possible to accurately assess the total population of Redshank of which the colour-ringed and colour-marked birds formed a part. The initial observations made at both the Taff/Ely and Rhymney sites were therefore used to determine the proportion of dyed and undyed birds that were present at the start of the study.

Following the colour-ringing and colour-marking of the birds, regular searches were made at the Taff/Ely and Rhymney sites. Whenever Redshank were in good viewable position at the 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 or colour-rings. The number of marked and unmarked birds were noted. Several counts were made and the largest total count was used to calculate the proportion of colour-marked birds. If groups of birds were counted on more than one sector at a site, or at different times of the day, the highest total counts at each sector or during each period of observation were summed and the proportion of colour-marked birds calculated.

The proportions of colour-marked birds observed at both sites on each count date were compared with the proportions of colour-marked birds observed shortly after capture. Variations in these proportions would indicate that the birds were moving from these sites or other birds were moving into these sites at any time during the winter. An increase in the proportion of colour-marked birds at the Rhymney site and a corresponding decrease at the Taff/Ely site would indicate movement of birds between these sites.

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.

7. RESULTS AND DISCUSSION

The results of the observations carried out to assess the proportion of Redshank colour-ringed in January 1991 at the Taff/Ely site and still present at this site during autumn 1993 are given in Table 7.1. The observations of Redshank colour-ringed and colour-marked in October and then sighted at the Taff/Ely and Rhymney sites during the rest of the study period are given in Table 7.2. and Figure 7.1. No sightings of colour-marked Redshank were reported outside of the study area during the winter period. Observations of colour-ringed Redshank at other areas during the spring and summer are given in Table 7.3.

During searches carried out at the Taff/Ely site in August 1993, colour-ringed birds were seen among the Redshank population that had returned. These birds were part of the group of 133 that had been caught and colour-ringed in January 1991 (Donald & Clark, 1991a). At the time of capture, the proportion of birds colour-ringed was 35.9% and the proportion observed during the remainder of the winter 1990/91 was 32.1%. A mean percentage of 18.5% colour-ringed Redshank was observed at the Taff/Ely site during the 1991/92 winter, and this had decreased to between 3.0%-16.5% during winter 1992/93 (only two counts were possible during this winter). The proportion present at the Taff/Ely site in August 1993 was 11.8% (Table 7.1). This proportion represents the colour-ringed Redshank that are present for the fourth winter, having decreased from 32.1%. Mortality and recruitment to the population during the two and a half years would reduce the proportion of colour-ringed birds in the population. Many Redshank are clearly site-faithful from one year to the next.

During the same observations, two birds showing signs of colour-marking were seen. These were Redshank that had been caught and colour-marked at the Rhymney site during the 1992/93 winter.

Of the 212 Redshank that were caught in October 1993, 34 possessed closed metal rings. Of these, 19 had been caught and colour-ringed at the Taff/Ely site in January 1991 (Table 7.1). These colour-ringed birds represented 9.0% of the Taff/Ely Redshank population in October. Of the 15 other metal-ringed birds, 13 had been caught and ringed at Rhymney in the 1991/92 and 1992/93 winters. One Redshank had been ringed at Llanelli North Dock in 1991, and the remaining bird was ringed as an adult at Chew Valley, Avon in December 1989.

Although it was not easy to determine the size of the Redshank population at the Taff/Ely site, observations in October, prior to the time of capture, showed there to be between 500 and 550 birds present. The proportion of birds that were colour-marked was therefore approximately 32-35%. Estimates of the Taff/Ely population shortly after the capture showed the population to be between 300 and 350 birds. Movement of Redshank colour-marked at the Rhymney site in winter 1991/92 indicated that the Redshank populations of the study sites were still spreading out to their final wintering destinations during December. Movement of some of the Redshank away from the Taff/Ely site following capture was likely to be the result of birds moving to their final wintering area rather than a response to disturbance.

Observations of the colour-marked Redshank from the time of capture to the end of March 1994 are shown in Table 7.2. and Figure 7.1. Counts of colour-marked birds at the Taff/Ely site the day after capture gave a proportion of 18.4%. Regular counts through the winter

period showed the proportion of colour-marked Redshank at this site to vary from 12.3% to 25.9% in February. This did not reflect a marked increase with time as there were fluctuations in estimates throughout the winter. Figure 7.1 suggests that there was a small but gradual increase in the proportion of colour-marked birds during the winter. As it was not possible to obtain an accurate count of the total number of colour-marked birds present, it is not possible to determine if the change in proportion resulted from an increase in the actual number of colour-marked birds or a decrease in unmarked ones. Estimates of the total population of Redshank at the Taff/Ely site throughout the winter showed that the population remained between 300 and 350 birds. These estimates were not accurate enough to determine which was the underlying cause of the slight increase in the proportion of colour-marked birds at this site. The mean proportion of colour-marked birds during the winter period was 19.0%.

Observations at the Rhymney site two days after the Redshank were caught at the Taff/Ely site showed there to be a number of colour-marked birds present (Table 7.2 and Figure 7.1). These birds had moved from the Taff/Ely site to the next suitable feeding area on the Severn Estuary. This initial movement, within two days of the catch, could have been in response to the disturbance caused. Further observations during the winter at the Rhymney site showed there to be only a slight increase in the proportion of colour-marked birds. The proportion of colour-marked birds at this site varied from 5.2 % two days after capture to 8.7% at the end of November. The mean proportion observed over this period was 7.4%. The highest number of colour-marked birds was 36, three days after they had been caught at the Taff/Ely site. These were counted in two groups of birds totalling 478, a large proportion of the Redshank population at the Rhymney site.

Clearly, there was some movement of Redshank from the Taff/Ely site to the Rhymney site very soon after colour-marking. There is no evidence of further movement between these sites from the proportions of colour-marked birds present during the winter. As both sites show a slight increase in the proportion of colour-marked birds during the winter, it would seem that there was no net movement between the two sites after the initial movement from the Taff/Ely site. The increase in the proportion of colour-marked birds at the two sites is likely to have resulted from movement of non-marked birds away from the these sites. The next population of Redshank on the Severn Estuary is found at the Usk Estuary. Careful observation of almost the whole Redshank population at this site in December found there to be no colour-marked birds present. It seems unlikely that numbers of Redshank would have moved further from the Taff/Ely site than the Usk Estuary without some birds remaining at the latter site.

By late February, Redshank were starting to move away from their wintering sites. The number of birds present at the Rhymney site declined markedly in late February and relatively few birds were present in March. No counts of colour-marked birds were possible at the Rhymney site in March. The increase in the number of colour-marked Redshank at the Taff/Ely site at this time could have been caused by Redshank starting to move away from their wintering sites to sites used during the autumn movement. There was, however, no definite evidence of an increase in the actual number of colour-marked birds at the Taff/Ely site.

There were several sightings of colour-ringed Redshank away from the study area in the spring and one further sighting in the summer (Table 7.3). The two birds in Norfolk were

present at breeding sites. Both birds mated and produced clutches of eggs, although it could not be confirmed if they raised young. The sighting from Clonakilty, Ireland was likely to be a bird migrating to breeding grounds in that country. The sighting in Northern Ireland in August was likely to be of a bird migrating from breeding grounds in Ireland or possibly northern Britain or Iceland.

As the colour-rings applied in October should remain on the birds while they are alive, it should be possible to continue their observation during the following winters.

To summarize, the continued occurrence of Redshank with colour-rings (fitted when trapped in January, 1991) at the Taff/Ely site during the autumn of 1993 show that there is long-term site-fidelity. This the fourth season at the same wintering site for at least 12% of the birds present in October. A number of Redshank present at that time had been trapped previously at the Rhymney site (representing 6.1% of the Taff/Ely population in October) showing that these birds had returned to the same general area, but not to the specific site. Following colour-marking in October, there was some rapid dispersal from the site of capture. There appears to have been very little further movement of Redshank between these two sites.

With the inundation of the Taff/Ely planned to take place within the next four years it will be important to try to colour-mark or colour-ring most of the Taff/Ely population of Redshank prior to that time, so that the fate of these be birds can be determined. More knowledge is needed of the movement of Dunlin between the study sites. This requires catching and colour-marking a large number of Dunlin, which is a more difficult task as they do not routinely roost near the study sites. This work will depend on Dunlin roosting consistently on a suitable catching site.

ACKNOWLEDGEMENTS

Thanks are due to the Wash Wader Ringing Group and the SCAN Ringing Group for the loan of equipment and to the local ringers for assisting in the catching, ringing and colour-marking of waders.

The discussion of parts of this project with other members of the BTO staff was of considerable value.

Sophie Foulger and other secretarial staff gave considerable assistance in the completion of this report.

Funding by Cardiff Bay Development Corporation has allowed the continuing study of the waterfowl of Cardiff Bay.

REFERENCES

Berg, Å. (1992). Habitat Selection by Breeding Curlews *Numenius arquata* on Mosaic Farmland. *Ibis*, 134: 355-360.

Clark, N.A. (1982). The Effects of Severe Weather in December 1981 and January 1982 on Waders in Britain. *Wader Study Group Bulletin*, 34: 5-7.

Clark, N.A. (1990). *Distribution Studies of Waders and Shelduck in the Severn Estuary.* BTO Research Report to Energy Technology Support Unit. Published as ETSU TID 4076.

Cresswell, W. & Whitfield, D.P. (1994). The Effects of Raptor Predation on Wintering Wader Populations at the Tyninghame Estuary, Southeast Scotland. *Ibis*, 136: 223-232.

Donald, P.F., & Clark, N.A. (1991a). *The Effect of the Cardiff Bay Barrage on Waterfowl Populations: 2. Distribution and Movement Studies, August 1990 - May 1991.* BTO Research Report No. 83 to Cardiff Bay Development Corporation. British Trust for Ornithology, Thetford.

Donald, P.F., & Clark, N.A. (1991b). *The Roosting Behaviour of Waders and Wildfowl in Cardiff Bay.* BTO Research Report No. 74 to Cardiff Bay Development Corporation. British Trust for Ornithology, Thetford.

Evans, J., Clark, N.A., & Donald, P.F. (1990). *The Effect of the Cardiff Bay Barrage on Waterfowl Populations: 1. Distribution and Movement Studies, November 1989 - May 1990.* BTO Research Report No. 69 to Cardiff Bay Development Corporation. British Trust for Ornithology, Tring.

Ferns, P.N. (1977). *Wading Birds of the Severn Estuary.* Nature Conservancy Council.

Fox, A.D. & Meek, E.R. (1993). History of the Northern Pintail Breeding in Britain and Ireland. *British Birds*, 86: 151-162.

Gibbons, D.W., Reid, J.B. & Chapman, R.A. (1993). *The New Atlas of Breeding Birds in Britain and Ireland: 1988-1991.* T. & A.D. Poyser, London.

Goss-Custard, J.D. le V. dit Durell, S.E.A., Sitters, H.P. & Swinfen, R. (1982). Age Structure and Survival of a Wintering Population Of Oystercatchers. *Bird Study*, 29: 83-98.

O'Brien, M. & Smith, K. (1992). Changes in the Status of Waders Breeding on Wet Lowland Grasslands in England and Wales between 1982 and 1989. *Bird Study*, 39: 16-176.

Prater, A.J. (1981). *Estuary Birds of Britain and Ireland.* T. & A.D. Poyser, Calton.

Rehfisch, M.M., Sim, I., Clark, N.A., Donald, P.F., & Warbrick, S. (1991). *Waterfowl Distribution and Diet on the Mersey Estuary and Adjacent Areas.* BTO Research Report No. 77. British Trust for Ornithology, Thetford.

Thompson, P.S. & Hale, W.G. (1993). Adult Survival and Numbers in a Coastal Breeding Population of Redshank *Tringa totanus* in Northwest England. *Ibis*, 135: 61-69.

Toomer, D.K., & Clark, N.A. (1992a). *The Effect of the Cardiff Bay Barrage on Waterfowl Populations: 3. Distribution and Movement Studies, September 1991 - May 1992.* BTO Research Report No. 104 to Cardiff Bay Development Corporation. British Trust for Ornithology, Thetford.

Toomer, D.K., & Clark, N.A. (1992b). *The Roosting Behaviour of Waders and Wildfowl in Cardiff Bay.* BTO Research Report No. 89 to Cardiff Bay Development Corporation. British Trust for Ornithology, Thetford.

Toomer, D.K., & Clark, N.A. (1993a). *The Effect of the Cardiff Bay Barrage on Waterfowl Populations: 4. Distribution and Movement Studies, August 1992 - May 1993.* BTO Research Report No. 126 to Cardiff Bay Development Corporation. British Trust for Ornithology, Thetford.

Toomer, D.K., & Clark, N.A. (1993b). *The Roosting Behaviour of Waders and Wildfowl in Cardiff Bay.* BTO Research Report No. 116 to Cardiff Bay Development Corporation. British Trust for Ornithology, Thetford.

Toomer, D.K., & Clark, N.A. (1994). *The Roosting Behaviour of Waders and Wildfowl in Cardiff Bay.* BTO Research Report No. 137 to Cardiff Bay Development Corporation. British Trust for Ornithology, Thetford.

Voous, K.H. (1973). A List of Recent Holarctic Species. Non-passerines. *Ibis*, 115: 612-638.

Waters, R.J. & Cranswick, P.A. (1993). *The Wetland Bird Survey 1992-1993: Wildfowl and Wader Counts.* BTO/WWT/RSPB/JNCC, Slimbridge.

Date	Site	Total Birds Checked	Number Colour-ringed Jan. '91 (%)
17/08/93	Taff/Ely	93	11 (11.8)
16/10/93	Taff/Ely	212*	19 (9.0)

Table 7.1 The numbers and proportion of Redshank colour-ringed in January 1991 which were observed during the autumn 1993.

*This group of Redshank were caught for colour-ringing and colour-marking.

Date	Site	Total Birds	Numbers Marked (%)
16/10/93	**174 Redshank caught and colour-marked at Taff/Ely**		
17/10/93	Taff/Ely	141	26 (18.4)
20/10/93	Taff/Ely	256	39 (15.2)
22/10/93	Taff/Ely	102	17 (16.7)
15/11/93	Taff/Ely	212	26 (12.3)
17/11/93	Taff/Ely	68	13 (19.1)
18/11/93	Taff/Ely	209	44 (21.0)
23/11/93	Taff/Ely	56	10 (17.8)
6/12/93	Taff/Ely	75	10 (13.3)
21/12/93	Taff/Ely	66	11 (16.7)
5/1/94	Taff/Ely	98	16 (16.3)
17/1/94	Taff/Ely	151	34 (22.5)
21/1/94	Taff/Ely	39	8 (20.5)
24/1/94	Taff/Ely	46	10 (21.7)
7/2/94	Taff/Ely	93	14 (15.0)
8/2/94	Taff/Ely	179	40 (22.5)
21/2/94	Taff/Ely	135	35 (25.9)
7/3/94	Taff/Ely	131	28 (21.0)
9/3/94	Taff/Ely	85	22 (25.9)
18/10/93	Rhymney	230	12 (5.2)
19/10/93	Rhymney	478	36 (7.5)
20/10/93	Rhymney	226	14 (6.2)
16/11/93	Rhymney	280	21 (7.5)
24/11/93	Rhymney	242	21 (8.7)
25/11/93	Rhymney	187	14 (7.5)
13/12/93	Rhymney	382	29 (7.6)
7/1/94	Rhymney	176	13 (7.4)
27/1/94	Rhymney	74	6 (8.1)
9/2/94	Rhymney	232	19 (8.2)

Table 7.2 The numbers and proportions of colour-marked Redshank observed at the Taff/Ely and Rhymney sites from October 1993 to March 1994.

Date	Location	Numbers Marked
25/4/94	Burnham Norton, Norfolk	1_
27/4/94	Holkham, Norfolk	1_
2/5/94	Clonakilty, Co. Cork, Ireland	1
early/5/94	Dyfi Estuary, nr. Aberystwyth	1
13/8/94	Millisle, C. Down, N. Ireland	1

Table 7.3 Further sightings of colour-marked Redshank in 1994.