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The Effect of the Cardiff Bay Barrage on Waterfowl Populations
8. Distribution and Movement Studies August 1996-May 1997

Authors

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CONTENTS

Page No.

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 presents the results of the eighth season of intensive monitoring of the wildfowl and waders of the intertidal areas in Cardiff Bay and its environs. More extensive monitoring at low tide also covered the intertidal areas between Cardiff Bay and the mouth of the River Usk. The results presented in this report were derived from data collected between August 1996 and May 1997. The programme of monitoring closely followed that used for the previous seven years, allowing direct comparisons to be made between results from each year.

2. Following the completion of the amenity barrage, the intertidal mudflats of the Taff and Ely estuaries (i.e. Cardiff Bay) will be inundated with fresh water. The gathering of information on the distribution and movement of the populations of waders and wildfowl both before and after barrage completion will help make it possible to assess their fate once the bay has been flooded.

3. Monitoring of the populations of waders and wildfowl on the northwest Severn from Cardiff Bay to the Usk Estuary has revealed only minor changes in the number and distribution of birds since 1995/96.

4. The detailed data collected for Taff/Ely, Orchard Ledges and Rhymney were used to determine the size and distribution of wader and wildfowl populations at each site. There was evidence of changes in the feeding distributions of three of the four main species: Dunlin, Curlew and Redshank. Dunlin numbers were especially low at Taff/Ely. All three species avoided mudflats close to the mouth of the bay (particularly mudflat 2), probably due to disturbance from the building of the barrage.

5. Data for the eight years were analysed to determine whether substrate type, distance from land and work disturbance affected the waterfowl communities present on mudflats. The three variables examined all helped to explain the species mix found on mudflats.

Only two substrate types were considered: mud and stone. Only Orchard Ledges had mudflats with stony surfaces, and these held distinctive communities, dominated by Oystercatcher and Curlew. Waterfowl communities were also related to the distance from land of a mudflat. Those mudflats furthest from land were the least likely to be disturbed by man.

The level of disturbance to a mudflat also had a significant effect on waterfowl communities. The communities of mudflats affected by the construction of the Peripheral Distributor Road (PDR) or barrage changed during the years of work. There was evidence, however, that mudflat communities returned to their former composition after disturbance from work ceased.

6. Continuing colour-ringing studies have indicated that a high proportion of the Redshank population of Cardiff Bay are faithful to it throughout the winter. Only a small number of the birds observed in the bay (9%) were also observed at Rhymney. A knowledge of their site-fidelity will be important in determining their behaviour after the bay is inundated.

7. **Redshank are also faithful to the bay between winters: 81% of colour-ringed adults seen at the end of winter 1995/96 returned after summer 1996 (1 February to 30 September). An annual survival rate (from 1 February 1996 to 31 January 1997) of 70% was determined from these observations, a similar figure to that found in other studies.**

8. **Catches of Redshank at Cardiff Bay and at Rhymney allowed analysis of the species mass changes through winter. Birds were heaviest in December and January, prior to the worst winter weather.**

GENERAL INTRODUCTION

Work on the amenity barrage across the mouth of Cardiff Bay started in 1994 and is still continuing at present. The major areas where work took place between August 1996 and May 1997 were as follows (see Figure 2.1.1):

- **On the western (Penarth) side of the bay, where work continued on the coffer dam and lock system within the western arm of the barrage. A bascule bridge built the previous winter continued to connect the two sides of the barrage and to allow lorries to cross.**

- **Along the River Taff, where housing was being constructed close to mudflat 7.**

- **On the western edge of the bay, adjacent to the Peripheral Distributor Road (PDR), where earth was deposited on saltmarsh and the edge of the mudflats during spring, prior to building work in the area.**

- **On the northern edge of the bay, where earth was deposited on saltmarsh and around the 'roost island' adjacent to mudflats 15 and 19 during late spring, prior to summer building work.**

None of these developments changed the size of the mudflat feeding areas in the bay. However, there has been considerable disturbance at the mouth of the bay, where birds pass on their way to and from the estuary and other feeding areas.

The intensive monitoring of waders and wildfowl from 1989/90 to 1996/97 has given a good picture of their numbers and distribution in the area. It is important to continue this level of monitoring as the changes within the bay may affect the behaviour of the birds wintering in the area. The effect of the barrage closure on the local bird populations will only be accurately determined if their status is known immediately prior to closure.

Some changes had previously affected the feeding and roosting behaviour of birds in the bay. The building of the PDR resulted in the loss of some mudflat areas, the filling in of an old canal and much disturbance in the northwest part of the bay. Many species of waders and wildfowl moved away from this part of the study site during building work, but have since returned (Toomer & Clark, 1992a, 1992b, 1993, 1994; Toomer *et al*., 1993, 1994, 1995). The building of the barrage has similarly displaced birds of some species from mudflats close by (Burton *et al.*, 1997).

This report looks at the distribution and movement of the birds in Cardiff Bay and nearby areas and is in three sections. The first part summarizes the results of the eighth year of monitoring of the waterfowl populations in the Cardiff Bay area. The second analyses the data from the eight winters to determine which environmental factors are responsible for the composition of waterfowl communities on the mudflats of the three study sites. Particular attention is given to the possible role that building work, such as that described above, may have in shaping bird communities. The third reports a study of the site-fidelity and survival of Redshank.

The results of the first seven years' monitoring of the wader and wildfowl populations of Cardiff Bay and nearby areas were given by Evans *et al*. (1990), Donald & Clark (1991a),

Toomer & Clark (1992a), Toomer *et al*. (1993, 1994, 1995) and Burton *et al*. (1997). This report summarizes the seventh autumn and the eighth winter and spring of wader and wildfowl monitoring.

Data from the Wetland Bird Survey (WeBS) are used to show the importance of Cardiff Bay and the Severn Estuary for waterfowl in a British and a European context. Data for Cardiff Bay are from winter 1996/97. As information concerning the Severn Estuary was not available for this winter at the time of writing, its importance will be referred to using data from the 1995/96 winter (Cranswick *et al*., in press).

PART 1: DISTRIBUTION STUDIES

1. INTRODUCTION

This first part of the report discusses the results of studies on the feeding distributions of waterfowl using the Taff/Ely (i.e. Cardiff Bay), Orchard Ledges and Rhymney study areas between August 1996 and May 1997. The findings are compared with results from the previous seven years (Burton *et al*., 1997; Evans *et al*., 1990; Donald & Clark, 1991a; Toomer & Clark, 1992a; Toomer *et al*., 1993 and 1994). The distribution of roosting birds on the Taff/Ely site was studied in the 1990/91, 1991/92, 1992/93 and 1993/94 winters (Donald & Clark, 1991b; Toomer & Clark, 1992b; 1993 and 1994).

With eight 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 later.

The timing of autumn fieldwork varied for the first three studies (see Toomer *et al*., 1993). For this, the seventh autumn of study, observations were made during August, September and October, which allowed direct comparisons to be made with the results from the preceding three autumns.

Winter and spring fieldwork were carried out over the same periods as previous years (November-March and April-May respectively) and the results are therefore directly comparable.

In this report special attention is given to the development at the mouth of Cardiff Bay. Although the continued work on the barrage has not resulted in the loss of any further areas of mudflat, feeding birds would have been affected by the disturbance associated with this work.

2. METHODS

The methods used in this eighth year of study were similar to those in the seven previous studies and therefore are described only briefly below. Using the same methodology allows direct comparisons to be made between seasons and years.

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: Taff/Ely (Figure 2.1.1), Orchard Ledges and Rhymney (Figure 2.1.2). Each site was divided into several mudflat count areas to allow detailed analyses. The Taff/Ely site was divided into 19 count areas, Orchard Ledges into two count areas and 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 mouth of the Taff/Ely estuary during the current study. Mudflats 1, 2, 17 and 18 were subject to disturbance for much of the winter. The deposition of earth at the western side of the bay marginally reduced the area of mudflats 3, 4 and 7 from April 1997 and covered an adjacent area of saltmarsh. Similar work affected the western margins of mudflats 15 and 19 from May 1997. Disturbance from the work affected birds in both areas during spring. The four observation points that had been used in the previous years of study were used again. Extra observations were made from the jetty area of the yacht club and from the leisure centre opposite sector 8 if feeding flocks were seen to be using nearby areas.

No changes were observed in the Orchard Ledges study site and counts were made from the same observation points as previous years. At Rhymney, a pipeline was being built across mudflats 2 and 5 in April and May 1997 and this caused some disturbance to birds in these areas. Counts were made from the same observation points as previous years.

The pitted area between Orchard Ledges and the Rhymney sites holds small populations of Oystercatcher *Haematopus ostralegus,* Dunlin *Calidris alpina,* Curlew *Numenius arquata* and Turnstone *Arenaria interpres* at low tide. The nature of the broken surface made it very difficult to count birds accurately from either the Orchard Ledges or Rhymney observation points. As with the previous studies, this area was not counted.

Fieldwork was divided into three seasons: autumn (August-October 1996), winter (November 1996-March 1997) and spring (April-May 1997). Each site was counted twice a month (with the exception of April) with one count on a spring tide and one on a neap tide where possible. All count areas at 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). Using this methodology it is possible to assess changes in the usage of different mudflats through the tidal cycle. Feeding and roosting birds were counted separately and any disturbance to count areas 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 difficult to count accurately. Birds roosting on open

water are also not directly associated with adjacent mudflats. 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).

Following Evans *et al*. (1990) and Toomer *et al*. (1993), for each season, all day counts were used to calculate the following:

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

All day usage was calculated as:

$$\sum_{A=+5}^{A=-6} (BxC)$$

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

2.2 Low Tide Counts

The distribution of waterfowl on the wider northwest Severn was monitored by counts made during the low tide period (i.e. from two hours before to two hours after low tide). Counts were made at approximately 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 the changes in Cardiff Bay are only 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. 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 seven years of study were reported in Evans *et al*. (1990), Donald & Clark (1991a), Toomer & Clark (1992a), Toomer & Clark (1993), Toomer *et al*. (1994) and Toomer *et al*. (1995) and Burton *et al*. (1997). Some figures from the latter three reports are reproduced here for comparison with this year's results. As not all previous results are reproduced, however, the present report should be read in conjunction with the previous seven.

All species observed at the three sites during the period of study are discussed, but most emphasis is given to Shelduck *Tadorna tadorna*, Dunlin, Curlew and Redshank *Tringa*

***totanus*, species which occur on the Severn estuary in internationally important numbers (Cranswick *et al*., in press; Table 2.3.1). For these four main species, accounts are divided into three sections: autumn 1996, winter 1996/97 and spring 1997. For other species, discussion concentrates on the winter period. In each section, maps of the 'all day usage' of the mudflat count areas are presented. Comparison maps are given for the three previous years (1993/94, 1994/95 and 1995/96). In addition, for Shelduck, Dunlin, Curlew and Redshank, maps of mean feeding usage density are presented in the winter accounts. The results are considered in relation to the changes that have occurred to the sites during the eight years of study, as well as the feeding ecology, behaviour and migration patterns of the waterfowl.**

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

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

3. RESULTS AND SPECIES ACCOUNTS

3.1 Shelduck *Tadorna tadorna*

Shelduck breed in Britain at many coastal locations, but increasingly, at inland sites (Gibbons *et al*., 1993). Following breeding, most adult Shelduck move to moulting grounds on the German Wadden Sea and start to return to their wintering areas from September onwards. There is a small but important moulting population at Bridgewater Bay on the south side of the Severn. The British wintering population has remained steady in recent winters and was estimated at 65,000 in 1994/95 (Waters *et al*., 1996). The Severn Estuary is of international importance for Shelduck in winter.

Autumn 1996

During the autumn few Shelduck were present on any of the three study sites. Only a very few were present at Taff/Ely, feeding on the central mudflats along the River Taff (Figure 3.1.1). No Shelduck were observed at Orchard Ledges. Numbers were also low at Rhymney, although almost all mudflats were used (Figure 3.1.2). Feeding numbers at Rhymney were similar to the previous autumn.

Shelduck used the Rhymney mudflats throughout the low water period and there was a peak mean number of over 90 birds (Figure 3.1.3c). The majority of Shelduck fed whilst mudflats were uncovered.

Winter 1996/97

Low tide counts showed feeding Shelduck to be present along the whole of the northwest Severn during the winter of 1996/97 (Figure 3.1.4). The main concentrations were found at Peterstone and St. Brides.

At Taff/Ely, feeding Shelduck were widely distributed over the mudflats, with fewest birds being found on the northwest part of the study site (Figure 3.1.5). The numbers of feeding birds and their distribution in the bay were similar to the three previous winters. Shelduck continued to use mudflats close to the mouth of the bay, in spite of the building work there. Densities of Shelduck in each of the four winters were highest in the centre of the bay, along the River Taff, and along the eastern channel to the yacht club (Figure 3.1.6).

Groups of up to four Shelduck were observed feeding at Orchard Ledges (Figure 3.1.7). These birds mainly used the muddy bank at the extreme western end of mudflat 1, which was only exposed for a short period around low tide. At Rhymney, every mudflat was used by feeding Shelduck at some time during the tidal cycle (Figure 3.1.7). Feeding Shelduck were usually concentrated near the water's edge. Levels of usage were greatest to the east of the mouth of the River Rhymney. The distribution of Shelduck was similar to those seen in the previous three winters. Densities of Shelduck in each of the four winters were highest on mudflats 12 and 13 in the lower intertidal zone, but were comparatively low on mudflat 14, due to its large area (Figure 3.1.8).
There were two peaks in Shelduck numbers at Taff/Ely during the tidal cycle (Figure 3.1.9a). Shelduck that had been roosting in the saltmarsh or on the open

water, moved onto the mudflats to feed as the tide receded. Towards low tide some birds moved back onto the open water, while others left the study site to feed elsewhere. Numbers rose again on the flood tide, before birds returned to their roost sites. At Rhymney, Shelduck numbers rose sharply after high tide, as birds flew in from roost areas to the east. A peak mean of about 490 birds was recorded, in comparison to 800 the previous winter (Figure 3.1.9c). The majority of the birds fed while the lower mudflats were exposed.

There has been no clear trend in the usage of the three sites over the eight winters of study (r_s = 0.262, *n* = 8, ns; Figure 3.1.10). Similarly, there has been no trend in the usage of Cardiff Bay alone (r_s = 0.310, *n* = 8, ns). The mean feeding usage density of Shelduck at Cardiff Bay was slightly higher than that at Rhymney (7.4 bird hours per tidal cycle per hectare, compared with 6.0).

Spring 1997

Relatively high numbers of Shelduck usually remain into spring. At Taff/Ely, some feeding birds were found on all mudflats, but the highest levels of usage were in the middle of the bay (Figure 3.1.11). No Shelduck were observed feeding at Orchard Ledges. At Rhymney, most Shelduck fed on mudflats 13-16 to the east of the Rhymney river (Figure 3.1.12). The numbers and distribution of Shelduck at each site were similar to those seen in the springs of 1995 and 1996. Numbers, particularly at Rhymney, were lower than those recorded in spring 1994, however.

The spring population of Shelduck at Taff/Ely was about half that found in the winter. Most birds stayed in the bay over the low tide period (Figure 3.1.13a). At Rhymney, the spring population was about one sixth of that found in the winter (Figure 3.1.13c).

3.2 Dunlin *Calidris alpina*

Almost 10,000 pairs of Dunlin breed in Britain (Reed, 1985; Stone *et al*., 1997), mainly in the flows of northern Scotland and on peaty bogs in the English and Scottish uplands (Stroud *et al*., 1987), but these leave Britain to winter in Africa. A British wintering population of 530,000 birds was estimated from WeBS data in 1994/95 (Waters *et al*., 1996) and comes from nearby areas in north Fennoscandia and the former USSR. The Severn Estuary holds internationally important numbers of Dunlin during the winter.

Autumn 1996

Dunlin present in early autumn are likely to be birds on passage to their wintering grounds in Africa. Only relatively small numbers of these birds have been found to stop over at the study sites. In contrast to previous years, no Dunlin were seen at Taff/Ely during autumn (Figure 3.2.1). In addition, no Dunlin were seen at Orchard Ledges (Figure 3.2.2). At Rhymney, however, up to 170 birds were recorded. These were mainly observed feeding on mudflats to the east of the River Rhymney (Figure 3.2.2). The distribution of Dunlin was similar to that seen in the previous three autumns, although numbers were low.

At Rhymney most Dunlin were present on the falling tide, feeding on the newly exposed mudflats (Figure 3.2.3c).

Winter 1996/97

Large numbers of feeding Dunlin were recorded along the northwest Severn during low tide counts (Figure 3.2.4). Birds were present on almost all mudflats, with the highest concentrations at St. Brides and Peterstone. Numbers in all areas were similar to the previous winter.

At Taff/Ely, most feeding flocks were observed on mudflats adjacent to the River Taff in the centre of the bay, with mudflats 4, 11, 12 and 17 having the highest levels of usage (Figure 3.2.5). Almost all mudflats were used by some feeding birds. The numbers of feeding Dunlin in the bay were lower than in previous winters, although the birds' distribution was similar. Densities of Dunlin in each winter tended to be highest on central mudflats adjacent to the River Taff (Figure 3.2.6).

A maximum of 50 Dunlin were seen at Orchard Ledges, many fewer than in previous winters (Figure 3.2.7). Birds fed on both mudflats, but were usually there for one to two hours only. At Rhymney, the highest numbers of feeding Dunlin were recorded to the east of the Cardiff Eastern Sewer (Figure 3.2.7). Dunlin arrived at the site on the falling tide, most moving along the shore from the east. The shore to the west of the Cardiff Eastern Sewer was usually occupied last, when most of the intertidal zone had become exposed. Mudflats 7, 8 and 9, therefore, were used in preference to mudflats 1-6 higher up. More Dunlin fed at Rhymney than in the previous winter, however, notably on mudflats 1-9. Densities of Dunlin in each of the four winters were highest along the River Rhymney and on mudflats along the lower intertidal (Figure 3.2.8). Although mudflat 14 held high numbers, densities were low due to its large area.

At Taff/Ely, there were peaks in Dunlin numbers shortly before and shortly after high tide (Figure 3.2.9a). Many of these birds roosted in the saltmarsh whilst mudflats were covered. Nearly all Dunlin left the bay over the low water period to feed elsewhere. The peak mean number of 240 Dunlin was only half that of the 1995/96 winter and only an eighth of that of the 1993/94 winter. At Rhymney the peak mean number of 5000 birds occurred at low tide (Figure 3.2.9c). This figure was 40% greater than that for the previous winter.

There has been no trend in the total usage of the three sites over the eight year study period ($r_s = 0.333$, $n = 8$, ns; Figure 3.2.10). Similarly, there has been no trend in the usage of Cardiff Bay alone ($r_s = -0.452$, $n = 8$, ns). The mean feeding usage density of Dunlin at Cardiff Bay was less than a tenth of that at Rhymney (5.3 bird hours per tidal cycle per hectare, compared with 68.5).

Spring 1997

The number of Dunlin decreased after the February counts, and very few were present at the three study sites after the end of March. Dunlin seen during spring

were likely to be on passage north from wintering areas in Africa. At Taff/Ely small groups of up to 42 birds were seen feeding in May (Figure 3.2.11). A maximum of 20 Dunlin were seen at Orchard Ledges in spring. At Rhymney, groups of up to 30 birds were present during May (Figure 3.2.12). Numbers of Dunlin at Taff/Ely peaked both before and after low tide (Figure 3.2.13a). Very few Dunlin have been seen during previous springs.

3.3 Curlew *Numenius arquata*

The Curlew characteristically breeds on damp upland moorlands, but this century has colonised many lowland regions, including agricultural habitats (Gibbons *et al*., 1993). The breeding population of Britain has been estimated at 33,000-38,000 pairs (Reed, 1985). Some of this population winters in France, but many other Curlew from continental Europe, notably Scandinavia, migrate to Britain to winter (Prater, 1981). A population of 88,000 wintered on the estuaries and shores of Britain in 1994/95 (Waters *et al*., 1996), an increase on the previous year (Cranswick *et al*., 1995). The Severn Estuary holds internationally important numbers of Curlew during winter.

Autumn 1996

Curlew usually return early to their wintering grounds and by the beginning of autumn they were present at all three study sites. At Taff/Ely, Curlew moved from their roost sites in the saltmarsh onto neighbouring mudflats as the tide receded. Most birds did not feed immediately, but continued to roost. When the tide was low enough to uncover adjacent feeding sites, many birds left the bay. Fewer Curlew fed in the bay than in the three previous autumns, particularly on mudflat 2 close to the mouth of the bay (Figure 3.3.1). This mudflat had been reduced in size by the building of the barrage in winter 1995/96 and was disturbed by continuing work. Many of the Curlew that left Taff/Ely on the falling tide moved onto Orchard Ledges to feed, where both mudflats had high levels of usage (Figure 3.3.2). At Rhymney, Curlew used mudflats to the east of the River Rhymney, notably mudflats 14 and 15 (Figure 3.3.2).

The pattern in the numbers of Curlew recorded at Taff/Ely was consistent with the observations described above. There were two clear peaks, three hours either side of low tide (Figure 3.3.3a). These peaks were mainly of non-feeding birds. With the approach of low tide many Curlew left the bay. Most of those remaining fed during the low tide period. At Orchard Ledges, most Curlew fed for the entire exposure period, approximately three hours before to three hours after low tide. There was a peak mean of over 60 birds, a similar figure than in the previous autumn (Figure 3.3.3b). Curlew numbers at Rhymney peaked at low water (Figure 3.3.3c). Curlew roosted away from the site, but moved onto eastern mudflats as the tide ebbed. The peak mean number of Curlew at Rhymney was similar to those in the three previous autumns.

Winter 1996/97

Low tide counts of feeding Curlew showed that they were very widespread along the northwest Severn (Figure 3.3.4). The highest concentrations were found on the

western mudflat of Peterstone and on the eastern mudflat of St Brides. Numbers were similar to those recorded in the previous winter on nearly all mudflats.

Previous observations have not shown any major differences in the sizes of the autumn and winter populations of Curlew at the study sites. Birds return to the study area by early autumn and appear to remain faithful to feeding sites through winter. At Taff/Ely feeding birds were present on many sectors, but the highest levels of usage were found on mudflats near the mouth of the bay and in its centre, adjacent to the River Taff (Figure 3.3.5). The number and distribution of feeding Curlew were similar to those seen in the three previous winters. Mudflat 2, which had been avoided in autumn, probably due to barrage work, had a lower level of usage than in the previous winter. Densities of feeding Curlew in each of the four winters were highest on central mudflats, adjacent to the River Taff, and along the channel to the east of the bay (Figure 3.3.6).

Curlew numbers at Orchard Ledges were greater than in winter 1995/96, though similar to the two preceding winters (Figure 3.3.7). At Rhymney, many more Curlew used mudflats 13, 14 and 15 to the east of the Cardiff Eastern Sewer than in the three previous winters. Densities of Curlew in 1996/97 were highest on mudflats 13 and 15 at Rhymney and on mudflat 2 at Orchard Ledges (Figure 3.3.8). In the winters of 1993/94 and 1994/95, Orchard Ledges and neighbouring mudflats of Rhymney had held the highest densities.

Peak numbers of Curlew at Taff/Ely occurred three hours before and four hours after low tide, following the pattern observed in autumn (Figure 3.3.9a). The winter peak mean was similar to that seen in the previous winter. Peak mean numbers at the other two study sites were higher than those seen in the previous winter, however (Figure 3.3.9b and c).

The total usage of the three sites has risen since 1995/96, having declined over the three previous winters ($r_s = -0.333$, $n = 8$, ns; Figure 3.3.10). There has been no overall trend in the usage of Cardiff Bay alone, however ($r_s = -0.452$, $n = 8$, ns). In 1996/97, the mean feeding usage density of Curlew at Cardiff Bay was greater than that at either Orchard Ledges or Rhymney (1.4 bird hours per tidal cycle per hectare, compared with 0.9 and 0.6 respectively).

Spring 1997

Very few Curlew remained at the study sites into spring. At Taff/Ely feeding birds were concentrated at the mouth of the bay (Figure 3.3.11). Curlew were also recorded feeding at Orchard Ledges and there was a large concentration on mudflat 13 at Rhymney (Figure 3.3.12).

A peak mean of 10 Curlew was recorded at Taff/Ely, four hours before low tide (Figure 3.3.13a). A similar peak number was recorded at Orchard Ledges (Figure 3.3.13b). Numbers at Rhymney were higher than in the previous spring (Figure 3.3.13c).

3.4 Redshank *Tringa totanus*

An estimated 30,000-34,000 pairs of Redshank breed in Britain, mainly on wet grasslands and on coastal saltmarshes (Reed, 1985; Gibbons *et al*., 1993; Stone *et al*., 1997). The British wintering population is formed of birds from both Britain and Ireland, and Iceland (Prater, 1981). An population of 83,000 wintered on Britain's estuaries and shores in 1994/95 (Waters *et al*., 1996). The Severn Estuary is internationally important for Redshank in winter.

Autumn 1996

At Taff/Ely, over 200 Redshank were present through the autumn and were seen feeding on most mudflats (Figure 3.4.1). The main areas of usage were adjacent to the River Taff in the centre and north of the study site. In the autumns of 1993 and 1994, Redshank had been more concentrated along the upper mudflats of the River Taff and on those adjacent to the yacht club. No Redshanks were seen at Orchard Ledges. At Rhymney, up to 250 Redshank were present in autumn and feeding activity was observed on most mudflats to the east of the Cardiff Eastern Sewer (Figure 3.4.2). Most birds fed on the banks of the River Rhymney along mudflats 14-16. The distribution of Redshank was similar to that in the previous autumn, although numbers were somewhat lower. The majority of the Redshank observed in autumn are likely to remain at Cardiff for the winter. A small proportion, however, are likely to be birds on passage to other wintering areas.

At Taff/Ely, as the tide ebbed, Redshank moved from their roosting areas in the saltmarsh onto the nearest mudflats. Initially feeding flocks were large and visible, but by low tide, many birds had moved out of sight, feeding in small numbers along creeks or on river banks. Most birds came back into view as the rising tide pushed them onto higher mudflats. There was a peak mean of over 210 birds at this time, a slightly higher figure than in the previous autumn (Figure 3.4.3a). Two peaks in numbers also occurred at Rhymney, two hours before and three hours after low tide (Figure 3.4.3c). The birds were not seen to leave the site, and the apparent fall in numbers occurred when Redshank moved onto lower areas of the river banks and out of sight from the observation points.

Winter 1996/97

The majority of feeding Redshank observed on the northwest Severn during low tide counts were located at Taff/Ely and Rhymney, with just a few feeding birds being observed at St Brides (Figure 3.4.4).

Feeding Redshank were widely distributed at Taff/Ely and used almost all mudflats (Figure 3.4.5). Those adjacent to the River Taff held the highest numbers. The overall levels of usage were similar to those in autumn and the two previous winters. However, fewer Redshank fed on mudflats 2 and 5, close to the barrage work, than in winter 1995/96. In terms of density, mudflats 8, 9, 10 and 12 on the upper River Taff were most important for Redshank. Densities on the eastern channel to the yacht club were lower than in the three previous winters (Figure 3.4.6). Larger mudflats close to the barrage, such as 2 and 5, held the lowest densities.

No Redshank were seen at Orchard Ledges in winter. At Rhymney, Redshank were found on all mudflats to the east of the Cardiff Eastern Sewer with the highest level

of usage occurring on mudflat 14 (Figure 3.4.7). As in the autumn, the main feeding areas were adjacent to the river. The distribution of Redshank at Rhymney was similar to previous winters, although numbers were lower. Towards the end of winter many Redshank stayed up the Rhymney river throughout the tidal cycle and did not appear on the study site. Densities of Redshank were particularly low on the large mudflat 14, but high on mudflat 16 along the river (Figure 3.4.8).

The numbers of Redshank observed at Taff/Ely through the tidal cycle were similar to those described for the autumn period (Figure 3.4.9a), although birds fed for longer periods. The number of Redshank at Rhymney was higher than in autumn and the peak mean of 315 birds occurred two hours before low tide (Figure 3.4.9c). This figure was 15% lower than that for the previous winter. As in the autumn, many Redshank at both sites were out of sight at low tide in creeks and along river banks.

The total usage of the three sites has declined since 1989/90 ($r_s = -0.810$, $n = 8$, $P < 0.05$), although not significantly within sites (for Taff/Ely: $r_s = -0.667$, $P < 0.10$; for Rhymney: $r_s = -0.714$, $P < 0.10$; Figure 3.4.10). The mean feeding usage density of Redshank at Cardiff Bay was twice that at Rhymney (6.7 bird hours per tidal cycle per hectare, compared with 2.8), perhaps because the mudflats at Cardiff Bay are dissected by more creeks and rivers, where birds are able to feed.

Spring 1997

Redshank numbers declined during the late winter and by the beginning of spring, almost all birds had left for their breeding grounds. A maximum of 55 Redshank was seen at Taff/Ely in April, most of which were confined to the upper mudflats of the River Taff, but none were observed at the other two sites. Only one Redshank was observed in Cardiff Bay in May.

These observations are comparable to the findings of previous springs.

3.5 Other Species

3.5.1 Mallard *Anas platyrhynchos*

The Mallard is the most abundant wildfowl in Britain, but may have recently shown a decline in its wintering population (Waters *et al*., 1996; Cranswick *et al*., in press). Large numbers of birds are found on inland sites and the population is boosted annually by the release of hand-reared birds for shooting.

Winter 1996/97

The majority of feeding Mallard observed on the northwest Severn during low tide counts was located at the east of the study area, at St Brides (Figure 3.5.1.1).

At Taff/Ely feeding Mallard were concentrated in the centre of the bay along the River Taff, notably on mudflats 6 and 17 (Figure 3.5.1.2). Numbers of Mallard in the bay were higher than in the three previous winters.

Only one feeding Mallard was observed at Orchard Ledges. At Rhymney, feeding birds were concentrated along the edge of the river (Figure 3.5.1.3).

There were peak means of 65 and 39 Mallard at Taff/Ely and Rhymney respectively (Figures 3.5.1.4a and c). At both sites the majority of Mallard fed during the low water period.

The distribution of Mallard in winter was very similar to that seen in autumn. In spring, up to 15 Mallard were seen at Taff/Ely, none at Orchard Ledges and five at Rhymney.

3.5.2 Teal *Anas crecca*

The British breeding population of Teal is thinly distributed in areas throughout England, Scotland and Wales, but there has been a marked contraction in its range over the last 20 years (Gibbons *et al*., 1993). The wintering population, in contrast, has shown a general increase over the last 25 years (Cranswick *et al*., in press). The Severn Estuary holds nationally important numbers of Teal in winter.

<u>Winter 1996/97</u>

At low tide the majority of feeding Teal observed on the northwest Severn were at the east of the study area, at St Brides. Smaller numbers occurred at Taff/Ely (Figure 3.5.2.1).

Feeding Teal at Taff/Ely were concentrated on central mudflats along the River Taff and along the eastern channel to the yacht club. In the previous winter, bird numbers were greater on the upper River Taff (Figure 3.5.2.2). Overall, however, there has been little change in the feeding distribution of Teal at Taff/Ely since 1991/92. In that winter, high levels of usage occurred on mudflats 1 and 2, near the mouth of the study site.

At Rhymney, Teal were confined to the banks of the river (Figure 3.5.2.3). Numbers were lower than in previous winters as many Teal stayed on the Rhymney river throughout the tidal cycle and did not appear on the study site. No Teal were seen at Orchard Ledges.

The peak mean numbers of Teal at Taff/Ely and Rhymney were 66 and 6 respectively (Figures 3.5.2.4a and c). The figure for Rhymney was only 25% of that for the previous winter.

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

3.5.3 Pintail *Anas acuta*

The Pintail is a rare and local breeding bird in Britain (Gibbons *et al*., 1993). The species colonised Britain in the late nineteenth century and since 1973, at least, the British and Irish breeding population has been relatively stable (Fox & Meek, 1993). Breeding birds from northwest Europe move south in autumn and a population of 22,000 wintered in Britain in 1994/95 (Waters *et al*., 1996). The Severn Estuary holds nationally important numbers of Pintail in winter.

Winter 1996/97

The highest numbers of feeding Pintail observed during low tide counts on the northwest Severn were on mudflats near to the River Rhymney and at St. Brides (Figure 3.5.3.1). Few birds were seen elsewhere. Over 100 Pintail were seen on each of two mudflats at St. Brides, where none were seen the previous winter.

No Pintail were seen at Taff/Ely or Orchard Ledges during the winter period. At Rhymney, Pintail fed along the tide line, both to the east and west of the Cardiff Eastern Sewer (Figure 3.5.3.2). Birds were observed to move onto the study area from the east as the tide ebbed and remained at the water's edge to feed. Pintail moved onto mudflats higher up the intertidal zone as the tide flooded. Levels of usage on mudflats to the west of the Cardiff Eastern Sewer have increased over the last four winters.

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

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

3.5.4 Pochard *Aythya ferina*

Pochard have bred in Britain since the last century, but are still only present in low numbers (Gibbons *et al*., 1993). The wintering population has shown a decline since the late 1980s and was estimated at 39,000 birds in 1994/95 (Waters *et al*., 1996). The Severn Estuary holds nationally important numbers of wintering Pochard.

Winter 1996/97

Only occasional Pochard were observed during low tide counts of the northwest Severn and their distribution, therefore, is not mapped.

At Taff/Ely Pochard were concentrated along the central River Taff and the eastern channel to the yacht club (Fig. 3.5.4.1). More Pochard used the bay than in the three previous winters. At Rhymney, Pochard were concentrated near the mouth of the river on mudflats 8 to 11 (Figure 3.5.4.2). An increasing number of Pochard has fed on the River Rhymney since 1991/92.

At Taff/Ely, Pochard numbers peaked two hours before and four hours after low tide (Fig. 3.5.4.3a). The peak mean of 34 Pochard observed at Rhymney at low tide was twice that recorded in 1995/96 (Figure 3.5.4.3c).

Pochard were only present during the winter.

3.5.5 Oystercatcher *Haematopus ostralegus*

A population of 33,000-43,000 pairs of Oystercatcher breed in Britain, occupying both inland and coastal sites (Piersma, 1986; Gibbons *et al*., 1993). In autumn and winter, the number of birds increases with an influx of migrants from northern Europe and Iceland. A population of 237,000 wintered on the estuaries and coasts of Britain in 1994/95 (Waters *et al*., 1996). The Severn Estuary is not an nationally important wintering site.

Winter 1996/97

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

At Taff/Ely, feeding Oystercatcher were concentrated on mudflats 4 to 6 to the south and west of the River Taff. Numbers were higher than in the three previous winters (Figure 3.5.5.2). Oystercatcher moved onto mudflats from their roosts in the bay shortly after high tide, but moved away over low water to Orchard Ledges.

Much larger numbers of feeding Oystercatcher were present at Orchard Ledges and Rhymney (Figure 3.5.5.3). Birds moved onto the Orchard Ledges mudflats from their high tide roosts, to the east of Rhymney and in Cardiff Bay, as soon as the shore became uncovered. Numbers here were similar to the previous winter. At Rhymney, all mudflats were used by feeding Oystercatcher. Large numbers of birds moved to the lower shore as the tide ebbed and continued to feed as new mudflats were exposed. The highest numbers of feeding birds were found on mudflats 12, 13 and 14. Numbers here were lower than in the previous winter.

Numbers of Oystercatcher at Taff/Ely peaked before they had moved to Orchard Ledges, four hours before low tide and peaked again on their return four hours after low tide (Figure 3.5.5.4a). Not all of these birds remained to roost in the bay, however. At Orchard Ledges numbers peaked shortly before and shortly after low tide (Figure 3.5.5.4b). At Rhymney numbers peaked three hours before and one hour after low tide (Figure 3.5.5.4c).

Oystercatcher return from their breeding grounds early and were present at all three study sites during the autumn. Their numbers and feeding distribution were similar to those described for the winter. By spring, there were few Oystercatcher at Taff/Ely, and the Orchard Ledges and Rhymney populations were reduced to about a third of their winter values.

3.5.6 Ringed Plover *Charadrius hiaticula*

The majority of the British and Irish breeding population of almost 10,000 pairs of Ringed Plover is found on coastal sites, but increasingly breeding birds are found on suitable inland areas (Prater, 1989; Gibbons *et al*., 1993). Many of these birds winter around the estuaries and coast of Britain, particularly on the west coast, and there is an estimated population of 28,600 (Cayford & Waters, 1996). There is evidence for a decline in the numbers of Ringed Plover on non-estuarine sites in winter (Browne *et al*., 1996). The Severn Estuary does not hold nationally important numbers of this species.

<u>Winter 1996/97</u>

Only occasional Ringed Plover were observed during low tide counts of the northwest Severn and their distribution, therefore, is not mapped.

Similarly, only a few feeding Ringed Plover were present at Taff/Ely on all day counts and therefore their distribution there is also not mapped. At Orchard Ledges, Ringed Plover were very difficult to detect, unless they were near to the shore and actively feeding, because of the nature of the substrate. Feeding birds were only observed on mudflat 1. Small numbers of Ringed Plover sometimes roosted over the high tide period on the shingle shore near mudflat 17 at Rhymney. These moved onto the mudflat to feed as the tide receded, fed elsewhere for most of the tidal cycle and returned to feed briefly just before the area was again covered (Figure 3.5.6.1). Smaller numbers were present than in the three previous winters.

Small groups of Ringed Plover were seen at all three study sites during the autumn, but by spring, the species was only seen occasionally at Cardiff Bay and Orchard Ledges.

3.5.7 Grey Plover *Pluvialis squatarola*

The British wintering population of Grey Plover originates mainly from breeding areas between the White Sea and the Taimyr Peninsula in Russia (Prater, 1981). There has been a steady increase in numbers over recent winters and there was an estimated population of 49,000 in 1994/95 (Waters *et al*., 1996). The Severn Estuary holds nationally important numbers of wintering Grey Plover.

<u>Winter 1996/97</u>

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

Occasional small flocks of feeding Grey Plovers were seen at Taff/Ely, but their presence was irregular and they usually only remained for one to two hours. No birds were seen at either of the other two study sites during the winter period.

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

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

3.5.8 Lapwing *Vanellus vanellus*

A population of 205,000-260,000 pairs of Lapwing breed in the British Isles (Gibbons *et al*., 1993). In winter, numbers in Britain and Ireland are increased by arrivals from Scandinavia and eastern Europe (Prater, 1981). Large numbers of wintering Lapwing are located on both estuaries and inland sites (Waters *et al*., 1996) and the Severn Estuary holds nationally important numbers of this species.

<u>Winter 1996/97</u>

Although large flocks of Lapwing are present in the area, the majority of birds remain inland to feed and roost. Groups of feeding Lapwing were observed on low water counts of the northwest Severn at Rhymney and at Taff/Ely (Figure 3.5.8.1).

At Taff/Ely feeding Lapwing were present on mudflats 7, 8, 9, 10 and 12 along the upper River Taff (Figure 3.5.8.2). This distribution was similar to those of the three previous winters. Lapwing only spent a small proportion of their time feeding while on these mudflats. No Lapwing were seen at Orchard Ledges. At Rhymney feeding Lapwing were confined to mudflats 15 and 16 (Figure 3.5.8.3).

The number of Lapwing at these sites is small compared with the size of many inland wintering flocks. At Taff/Ely, there was a peak mean of over 40 birds three hours after low tide (Figure 3.5.8.4a). At Rhymney, Lapwing numbers peaked at low tide (Figure 3.5.8.4c). At both sites, spells of feeding activity were interspersed with long spells of inactivity.

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

3.5.9 Knot *Calidris canutus*

The British wintering population of Knot originate from breeding areas in northern Greenland and north-eastern Canada (Prater, 1981). A population of 246,000 Knot wintered in Britain in 1994/95 (Waters *et al*., 1996). The Severn Estuary is not a nationally important wintering site.

<u>Winter 1996/97</u>

Knot are less site-faithful than many other waders and may change their wintering sites regularly (Pienkowski & Clark, 1979; Dugan, 1981). In consequence of this, the numbers of Knot seen in the study area have varied considerably over the eight

year study period. No Knot were recorded on low water counts of the northwest Severn in winter 1996/97 and their distribution, therefore, is not mapped.

Flocks of feeding Knot, however, were recorded on all day counts at Rhymney, mainly on mudflats 12 and 14 (Figure 3.5.9.1). Numbers at Rhymney have declined considerably over the last four winters. Knot usually arrived at Rhymney towards low tide and were often associated with Dunlin (Figure 3.5.9.2c).

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

3.5.10 Turnstone *Arenaria interpres*

The British wintering population of Turnstone originates from breeding areas in Greenland and Canada (Prater, 1981). The majority winter on open coasts, particularly on rocky shores, where their numbers have been estimated to have declined by 44% between 1984/85 and 1994/95 (Browne *et al*. 1996). The British wintering population has been estimated at 64,400 birds (Cayford & Waters, 1996). The Severn Estuary is not a nationally important site.

<u>Winter 1996/97</u>

At low water on the northwest Severn, feeding Turnstone were found mainly at the western end of Rhymney, i.e. the stony area of Orchard Ledges (Figure 3.5.10.1). Apart from a few other very small areas, most of the northwest Severn mudflats are unsuitable for feeding Turnstone.

Feeding Turnstone were recorded occasionally at Taff/Ely, but only along the stony edge of mudflat 3 (Figure 3.5.10.2). Turnstone typically arrived in this area three hours after low tide as Orchard Ledges was covered by the rising tide. Orchard Ledges supported many more feeding birds (Figure 3.5.10.3). Small numbers of Turnstone were also found at Rhymney mainly on mudflat 12. Fewer Turnstone were recorded at both these sites than in the three previous winters.

At Orchard Ledges, the peak mean of almost 60 Turnstone occurred two hours before low tide (Figure 3.5.10.4b). At Rhymney, a peak mean of 13 birds occurred one hour after low tide (Figure 3.5.10.4c).

Small numbers of Turnstone were present at all three sites during autumn. By spring, almost all Turnstone had left the study area.

3.6 Other Wildfowl and Wader Sightings

Several other species of waterfowl were observed at the Taff/Ely, Orchard Ledges and Rhymney study sites but in numbers too small to be included in the separate species accounts. These are shown in Table 3.6.1. Of particular note are the Scaup *Aythya marila* which were present at Rhymney from January to March 1997.

4. DISCUSSION AND CONCLUSIONS

The continued monitoring of the wader and wildfowl populations of Cardiff Bay and the northwest Severn has revealed much of the distributions and movements of the major species which winter in the area. The distribution of many species has changed from year to year, either in response to disturbance from work in the bay or to changing food supplies. Populations also change annually as survival and recruitment rates vary. The long-term monitoring programme will provide an understanding of the 'natural' population and distributional changes of the waterfowl and thus allow the future impact of the inundation of the bay to be more fully determined.

Construction work began at the mouth of the bay in 1994 and by spring 1996, the eastern and western sides of the barrage had been built and connected with a bridge. Work on the barrage, particularly at Penarth, is continuing to affect the distributions and numbers of birds using the bay as a wintering area. If the effect of the Cardiff Bay barrage on waders and wildfowl is to be assessed, it will be essential to monitor any such changes to their populations during this phase.

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

Shelduck (no obvious disturbance effect)

The small population of Shelduck present at Rhymney during autumn 1996 was similar in size to those seen in the previous three autumns and was similarly distributed. Likewise, numbers at this site and at Taff/Ely during winter 1996/97 were similar to those from the previous three winters. The distribution of wintering Shelduck at Taff/Ely seems unaffected by the building of the barrage, having remained unchanged since before construction work began. Similar numbers of Shelduck remained into spring as in previous years.

Dunlin (likely disturbance effect)

Few Dunlin were present on the study site during autumn. Numbers at Rhymney during autumn 1996, however, were similar to those in the previous autumn. Although numbers of Dunlin at Rhymney were greater in winter 1996/97 than in the previous year, the sharp decline in numbers at Taff/Ely continued. Numbers were low throughout the bay, though particularly near the barrage on mudflats 2 and 5, possibly due to disturbance there.

Curlew (likely disturbance effect)

In comparison to previous autumns and winters at Taff/Ely, few Curlew used mudflat 2 close to the mouth of the bay, possibly due to disturbance from work on the barrage near Penarth. Mudflats 5 and 17, perhaps in consequence, had increased levels of usage in winter. Levels of usage at both Orchard Ledges and Rhymney during winter were greater than in the previous winter.

The level of usage of Cardiff Bay was at its lowest in 1991/92. This was perhaps due to disturbance from the construction of the PDR and in that winter the use of Orchard Ledges declined sharply too. At Rhymney, however, site usage was high, suggesting that birds had

moved there from the other two sites and that this site was not at its carrying capacity in previous or, indeed, subsequent winters.

Redshank (likely disturbance effect)

The total usage of the three sites by Redshank has declined significantly over the eight years of study. At Taff/Ely during the winter, Redshank avoided mudflats 2 and 5 close to the barrage. Numbers were higher, however, on the upper River Taff, particularly on mudflats 7, 9 and 12. In contrast to the previous year, therefore, it seems likely that Redshank were displaced by disturbance from building work. At rhymney, Redshank often stayed up the river throughout the tidal cycle and numbers on the study site were thus comparatively low.

Other species

Numbers of Mallard at Taff/Ely during winter 1996/97 were higher than in the previous three winters. Their feeding distribution has not changed significantly, however, and the species was not thought to have been affected by the building of the barrage.

Pochard numbers increased sharply at Taff/Ely in winter 1996/97. The species was concentrated on central mudflats along the River Taff away from the barrage work.

The numbers of two species of wader have also changed: Oystercatcher have increased at Taff/Ely and Rhymney, whilst Knot have continued to decline at Rhymney. Only small changes were seen in the numbers and distribution of Pintail, Ringed Plover, Grey Plover, Lapwing and Turnstone.

To summarize, the work on the barrage at the mouth of the bay has had some effect on the numbers and distribution of, in particular, Curlew and Redshank. This displacement effect was noticeable both in autumn and in winter. Continued monitoring in 1997/98 will determine if the work has continued to cause disturbance and will enable us to further assess the recovery rate of waterfowl communities after disturbance events.

PART 2: WATERFOWL COMMUNITIES AND FACTORS AFFECTING THEIR COMPOSITION

5. INTRODUCTION

The waterfowl that winter at Cardiff Bay, Orchard Ledges and Rhymney occur in varied communities, i.e. the species mix varies from site to site. The community composition may be related to food. Oystercatcher, for example, are associated with areas of musselbeds, Teal with muddy creeks. Hill *et al*. (1993) found that a number of other factors influenced the composition of wader communities on British estuaries, notably estuary size, climatic factors (rainfall and temperature) and factors relating to water chemistry. Holloway *et al*. (1996), likewise found that the waterfowl communities of 27 British estuaries were related to estuary shape, longitude and sediment type. Man may also have a direct influence on communities, through disturbance, particularly at a local scale, as the tolerance of species is very variable (Kirby *et al*., 1993; Smit & Visser, 1993; Burton *et al*., 1996).

Since the beginning of the long-term study of the waders and wildfowl of Cardiff Bay and nearby areas, there have been a number of changes within the bay itself. The first of these was the construction between 1990 and 1994 of the PDR across the northwest corner of the bay. The obvious changes associated with this that could have affected the bird communities were: the direct loss of areas of mudflat that had been used for feeding; changes to areas immediately adjacent to mudflats and disturbance from the work itself. During autumn 1994, work started on the barrage and this has also resulted in the loss of mudflat area and in disturbance to nearby areas. The effects of these changes on individual species have been referred to in sections three and four. This chapter assesses the effect of this disturbance on the waterfowl communities of individual mudflats. Communities on mudflats outside the bay, at Orchard Ledges and Rhymney, were not directly affected by building work, but may have been affected by other physical factors or by an influx of birds displaced from the bay.

6. METHODS

The composition of the bird communities was calculated from data obtained from the all day counts for the eight year period from 1989/90 to 1996/97. Only data relating to the winter period were used, as several species were only rarely present during autumn and spring. Mean feeding usage densities (i.e. the mean number of feeding bird hours per tidal cycle per hectare) for eight species, Shelduck, Mallard, Teal, Pintail, Oystercatcher, Dunlin, Curlew and Redshank, were used to define the community composition for each of the 38 mudflats (Taff/Ely 19; Orchard Ledges 2; Rhymney 17) each year. Density values take into account the direct loss of 8% and 23% of the areas of mudflats 7 and 10 at Cardiff Bay respectively from 1991/92 onwards. Similarly mudflats 2, 5 and 18 at Cardiff Bay lost 60%, 12% and 50% of their areas respectively prior to the 1995/96 winter.

6.1 Environmental Variables

The communities found on the mudflats were related to three environmental variables: distance from land (related to the possible effects of man's activities), substrate and disturbance from road or barrage construction.

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

- Mudflats were broadly categorised into one of two substrate types: mud and stone. All mudflats at Taff/Ely and Rhymney were categorised as mud. Only those at Orchard Ledges were noticeably different, consisting of a surface of broken stones. These values were constant for the whole eight year period.

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

The values for these mudflat variables are given in Tables 6.1.1a and b.

6.2 Analysis of Data

Multivariate analysis of the mean feeding usage densities of each species on each mudflat was used to determine which species tended to be found together on the same mudflat and also which mudflats tended to hold the same species. As this statement implies, this is a two-way analysis of birds by mudflats. The mudflats and species were simultaneously ordered along ordination axes using detrended correspondence analysis (DECORANA) with no down-weighting of less common species (Hill, 1979). Data were analysed using the FORTRAN program CANOCO (ter Braak, 1987-92). Mudflats placed close together on the ordination graph (i.e. with similar axes scores) have similar bird communities and species placed close together tend to occur on the same or similar type of mudflat. Thus mudflats at the two extremes of the axes tend to have most dissimilar bird communities.

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

The mudflat scores on each of the first two ordination axes were plotted against and correlated with the individual environmental variables described earlier to aid interpretation of the axes. General Linear Modelling was then used to select the combination of variables which jointly gave the best predictions of scores on the ordination axes (SAS Institute, 1989).

In a separate analysis, mudflats were classified according to their waterfowl communities using Ward's Cluster Analysis (Ward, 1963; SAS Institute, 1989). Density values were double square rooted to normalize their distribution. The aim was to examine whether the mudflats could be classified into a number of clusters on the basis of the similarity of their bird communities. Of particular interest was the effect of disturbance on mudflat classification.

Nonparametric analyses were used to determine whether distance, sediment and disturbance values varied between mudflats in different clusters. Nonparametric discriminant analysis (SAS Institute, 1989) was then used to determine the effectiveness of environmental variables in predicting the clustering of mudflats.

7. RESULTS

7.1 Contribution of Species to Community Composition

The species scores for DECORANA axes 1 (DCA 1) and 2 (DCA 2) are represented in Figure 7.1.1 and their values on the four ordination axes are tabulated in Table 7.1.1. (Axes scores are in standard deviation units). DCA 1 and DCA 2 explain 61.0% and 20.9% respectively of the variation in the four axes. There were no close associations between the eight species in the ordination space. The wide separation of some species in the ordination space in part reflects their different habitat requirements and dissimilar diets. Mudflats that have communities that include Oystercatcher and Curlew would tend to have fewer Redshank, for example.

7.2 The Community Composition of Mudflats and Correlations of the Ordination Axes with Environmental Factors.

The DCA 1 and DCA 2 scores for the mudflats from the three study sites for the eight winters are shown in Figure 7.2.1. The three study sites are differently aggregated in the ordination space, but do not fall into completely separate groupings, reflecting an overlap in the bird communities on mudflats at these sites. The Orchard Ledges mudflats for the eight winters have high scores on DCA 1 and varying DCA 2 scores. The majority of the Rhymney mudflats for the eight winters also have high DCA 1 scores, although there are a number of outliers. The Cardiff Bay (Taff/Ely) mudflat scores overlap with some Rhymney scores, suggesting a similarity in the bird communities on some of the mudflats during the six winters. However, many Cardiff Bay mudflats have both lower DCA 1 and DCA 2 scores.

Figures 7.2.2 and 7.2.3 show the DCA 1 and DCA 2 ordination scores for two Cardiff Bay mudflats (7 and 10) affected by the building of the PDR and landfill activities (see Figure 2.1.1). The position of these mudflats in the ordination space shifted in 1991/92 when building work began, reflecting a change in their community composition. The communities changed from being dominated by Dunlin, to ones with more Teal and Redshank. After building work on the PDR ceased in 1994, the position of mudflat 7 reverted to that seen previously, suggesting that its bird community had recovered. This does not seem to have been permanent, however. The bird community of mudflat 10, in contrast, has not shown any obvious recovery, possibly as the mudflat has changed as a result of landfilling.

Figures 7.2.4 and 7.2.5 show DCA 1 and DCA 2 scores for two mudflats (2 and 17) affected by the construction of the barrage (see Figure 2.1.1). The communities of both of these mudflats were dominated by Dunlin at the start of the study period, but have both changed since 1995/96 when their areas were reduced and major work disturbance began. Their communities now include Shelduck, Mallard and Curlew.

The DCA 1 and 2 axes scores for each of the mudflats for each of the eight winters were plotted against the distance from land of the mudflat and against the mudflat disturbance value (Figures 7.2.6-7.2.9). There were significant correlations between the DCA 1 scores and distance from land ($r_s = 0.446$, $n = 304$, $P < 0.001$) and disturbance value ($r_s = 0.653$, $n = 304$, $P < 0.001$). Similarly distance from land ($r_s = 0.170$, $n = 304$, $P < 0.01$), disturbance value ($r_s = 0.379$, $n = 304$, $P < 0.001$) and substrate ($r_s = 0.322$, $n = 304$, $P < 0.001$) were all

significantly correlated to the DCA 2 scores. There was also a significant correlation between distance from land and disturbance value (r_s = 0.367, *n* = 304, *P* < 0.001).

Based on a linear model, the natural logarithm of distance to land ($F_{1,299}$ = 135.06, *P* < 0.001) and disturbance ($F_{3,299}$ = 42.93, *P* < 0.001) jointly explained 46.9% of the variation in the first ordination axis scores. Substrate ($F_{1,299}$ = 79.32, *P* < 0.001) and disturbance value ($F_{3,299}$ = 10.01, *P* < 0.001) jointly explained 26.8% of the variation in the second ordination axis scores.

7.3 Ward's Cluster Analysis Classification of Mudflats based on their Waterfowl Communities

The Ward's Cluster Analysis classification of the mudflats is shown in Figure 7.3.1 and the mudflat composition of the clusters shown in Tables 7.3.1a-d. Cluster 4 (*n* = 146) was the largest group and contained central mudflats from Cardiff Bay and from Rhymney. Cluster 6 (*n* = 66) contained peripheral mudflats from Cardiff Bay, e.g. mudflats 1, 8, 9, 10, and 19 and one upper shore mudflat from Rhymney. Cluster 8 (*n* = 54) only contained mudflats from Rhymney. Cluster 9 (*n* = 38) contained all Orchard Ledges mudflats, some adjacent mudflats from Rhymney and a few mudflats from Cardiff Bay which were directly or indirectly disturbed by the building of the barrage from 1994/95. Mudflat 1 at Cardiff Bay, for example, was in cluster 6 from 1989/90 to 1993/94, but joined cluster 9 following the start of the barrage work in 1994/95.

Mudflats from clusters 2 and 3, split at the first division of the Cluster Analysis, differed in disturbance value (Mann-Whitney *z* = 9.410, *P* < 0.001) and substrate (Mann-Whitney *z* = 6.226, *P* < 0.001). Cluster 3 mudflats were less disturbed and the cluster contained all those at Orchard Ledges of a rocky substrate. Nonparametric discriminant analysis using disturbance value alone correctly classified 69.3% of mudflats from cluster 2 into that group and 94.6% of mudflats from cluster 3 into that group. In total, 77.0% of mudflats were correctly classified.

Mudflats from clusters 4 and 6, split at the second division of the Cluster Analysis (see Figure 7.3.1), differed in distance from land (Mann-Whitney *z* = 7.032, *P* < 0.001). Cluster 4 mudflats were further from land than those in cluster 6. Nonparametric discriminant analysis using distance from land alone correctly classified 96.6% of mudflats from cluster 4 into that group and 83.3% of mudflats from cluster 6 into that group. In total, 92.5% of mudflats were correctly classified.

Mudflats from clusters 8 and 9, split at the third division of the Cluster Analysis (see Figure 7.3.1), differed in distance from land (Mann-Whitney *z* = 3.086, *P* < 0.01), substrate (Mann-Whitney *z* = 5.212, *P* < 0.001) and disturbance value (Mann-Whitney *z* = 2.714, *P* < 0.01). Cluster 8 mudflats were further from land than those in cluster 9 and none were disturbed. All the Orchard Ledges mudflats were in cluster 9. Nonparametric discriminant analysis using all three factors correctly classified 96.3% of mudflats from cluster 8 into that group and 65.8% of mudflats from cluster 9 into that group. In total, 83.7% of mudflats were correctly classified.

8. DISCUSSION

Previous analyses of estuarine bird communities in winter (Hill *et al*., 1993; Holloway *et al*., 1996) have been at a nationwide scale and have thus only investigated factors which affect the communities of whole estuaries. The scale of the present study has allowed an analysis of more localised factors, notably disturbance from man.

The waterfowl communities present on mudflats at Cardiff were affected by all three factors investigated: distance to land, disturbance from work and substrate type. Only two substrates were defined: mud and stone. The latter was found only on the two mudflats at Orchard Ledges, and here there were distinctive bird communities, dominated by Oystercatcher and Curlew.

The distance of a mudflat from land was also significant in determining the composition of its bird community. Man's activities are clearly likely to disturb birds on upper shore mudflats, but their effects on community composition depend on the varying susceptibility of species to different disturbance factors (Kirby *et al*., 1993; Smit & Visser, 1993; Burton *et al*., 1996). Curlew, for example, may be more susceptible to disturbance from walkers than Oystercatcher (Smit & Visser, 1993).

The ordination and cluster analyses also showed that disturbance from the construction of the PDR and the barrage has had a significant effect on the bird communities of neighbouring mudflats. The positions in the ordination space of mudflats 7 and 10, by the PDR, for example, moved after construction work began. Both had mixed communities beforehand, of Shelduck, Mallard, Dunlin and Redshank, but during the work, these mudflats were only used by occasional Redshank. Likewise, mudflat 7 and mudflat 1, close to the barrage, both moved into different clusters in periods of building work. Mudflat 1 was only used by occasional Curlew from 1994/95 and was grouped, therefore, with the Curlew and Oystercatcher dominated mudflats of Orchard Ledges. There was also evidence, however, that the bird communities of these mudflats may recover after construction related disturbance ceases.

PART 3: STUDIES OF THE WINTERING ECOLOGY OF REDSHANK

9. INTRODUCTION

Waders vary in their site-fidelity both between and within winters (Symonds *et al*., 1984; Rehfisch *et al*., 1996). Some species, such as Knot, commonly change their wintering grounds between winters (Pienkowski & Clark, 1979; Dugan, 1981), whilst many, for example, Curlew (Bainbridge & Minton, 1978), Green Sandpiper *Tringa ochropus* (Smith *et al*., 1992), Turnstone and Purple Sandpiper *Calidris maritima* (Burton & Evans, 1997), return to the same area each year and stay there throughout winter. The degree of site-fidelity shown by different species is largely a result of the temporal stability and predictability of their food resources (Evans, 1981). Sanderling *Calidris alba*, for example, may move between a number of sites within a winter because of the less predictable nature of their food supplies (Evans, 1981; Myers, 1984; Roberts, 1991).

In order to understand the impact of the loss of Cardiff Bay to any given species it is important to have a knowledge of the site-fidelity of that species (Goss-Custard, 1985). More mobile species, which are less reliant on the food resources of the bay, may be better able to cope with its loss. This chapter discusses the results of studies on the site-fidelity of Redshank. Over 200 Redshank are found in Cardiff Bay in winter and up to 300 at Rhymney. The species has been found to be particularly site-faithful to wintering grounds in other studies (Furness & Galbraith, 1980; Cresswell & Whitfield, 1994; Rehfisch *et al*., 1996; Insley *et al*., in press) and may, therefore, be at particular risk from the loss of the bay and its intertidal feeding areas.

Studies of the over-summer return rates of Redshank to the study area (i.e. Cardiff Bay, Orchard Ledges and Rhymney) and their winter survival rates will help to determine whether the loss of the bay results in increased mortality in the population. Previous studies have shown that annual survival is high (Jackson, 1988; Thompson & Hale, 1993; Insley *et al*., in press), although this may vary between years and sites according to weather conditions and predation pressure (Cresswell & Whitfield, 1994; Insley *et al*., in press). Redshank suffer particularly high mortality in cold winters (Davidson, 1982; Insley & Swann, 1996). Additional analysis of the pattern of seasonal mass change in Redshank prior to and following the flooding of the bay will help to determine whether their body condition was adversely affected by the loss of the bay and its food resources. Comparison will be made with the pattern of seasonal mass change recorded over the previous seven years.

10. METHODS

10.1 Movement Studies

During winter 1996/97, samples of Redshank were caught by mist-netting at high tide roosts at both Cardiff Bay and Rhymney. Each bird caught was aged according to its plumage characteristics (Prater *et al*., 1977) as either an adult or a first-winter bird and the majority of adults then given an unique combination of Darvic plastic colour-rings for subsequent identification in the field. A total of 34 Redshank (30 adults and four first-years) were colour-ringed at Cardiff Bay during five catches made in January and February (Table 10.1.1). In addition, three adult Redshank controlled at Rhymney, but originally fitted with metal rings at Cardiff Bay, were also colour-ringed (Table 10.1.1). A total of 138 Redshank were given individual combinations of colour-rings in the winters of 1994/95 and 1995/96 (Toomer *et al*., 1995; Burton *et al*., 1997) and many more previously 'scheme-marked' with just yellow and white rings for identification as Cardiff Bay birds.

In order to understand the movements of Redshank during winter, both Cardiff Bay and Rhymney were searched regularly for colour-ringed individuals (Redshank have never been recorded at Orchard Ledges). In addition, the percentage of colour-ringed birds in samples of the population was recorded at both Cardiff Bay and Rhymney whenever possible. Sightings from further afield, made throughout the year, are also reported, together with details of sightings from the study area of Redshank colour-ringed elsewhere.

10.2 Survival

Sightings of colour-ringed Redshank also provide the basis for calculating survival rates for the species (see Metcalfe & Furness, 1985; Burton & Evans, 1997). A minimum annual survival rate is calculated from February 1996 to February 1997 and is subdivided into an over-summer 'return rate' (1 February to 30 September, covering migrations from and back to the study area and the breeding season) and a winter survival rate (1 October to 31 January). The survival or return rate is calculated as the proportion of colour-ringed individuals seen alive at the start of a period that were known to be alive in the study area at the end of that period. (Minimum annual survival is calculated as the product of the over-summer return rate and the subsequent winter survival rate). Actual annual survival will be higher than the figure calculated if some individuals do not return to the study area after the breeding season.

10.3 Mass Changes

The mass of all Redshank caught during the study period was recorded to the nearest 1 g with a Pesola balance. Data were available from 35 catches, from 20 January 1991 to 8 February 1997. Data were from September to March inclusive.

11. RESULTS

11.1 Movement Studies

A total of 961 sightings of individually colour-ringed adult Redshank were made in the study area between August 1996 and March 1997 by NHKB. The majority of these were from Cardiff Bay, only 35 came from Rhymney. In all 136 individuals were identified, 119 exclusively at Cardiff Bay, five exclusively at Rhymney and 12 at both sites. Eleven of those seen at Rhymney were originally colour-ringed at Cardiff Bay (one other was originally ringed in another study in the Outer Hebrides - see Table 11.1.2). Two of the three Redshank colour-ringed at Rhymney were seen at Cardiff Bay.

To further quantify the fidelity of Redshank to the study sites, the resighting rates of colour-ringed individuals through winter are investigated. Sixty-six individually colour-ringed Redshank were seen at Cardiff Bay between August and October 1996 and again from February to March 1997 and were thus known to be alive throughout the defined winter period (1 October to 31 January). These birds came from two different colour-ringing schemes (see Figure 11.1.1). On scheme A birds, the constant scheme colours of yellow over white were on the right tarsus, a colour (red, orange or yellow) above the metal on the left tibia and two other colours on the right tibia. On scheme B birds, the constant scheme colours of yellow over white were on the right tibia, a colour (either lime or white) above the metal ring on the left tibia and two other colours on the left tarsus. Individuals were seen on a mean of 4.409 days (SE = 0.416, n = 66, range = 0-14) at Cardiff Bay on 31 fieldwork days between 1 October and 31 January, though this varied between the two schemes. Individuals of scheme A were seen on a mean of 5.267 days (SE = 0.671, n = 30, range = 0-12) and those of scheme B on a mean of 3.694 days (SE = 0.496, n = 36, range = 0-14), an almost significant difference (t = 1.921, df = 64, P = 0.05). As birds from scheme B were seen less frequently, future analyses will only consider those from scheme A.

Individual Redshank (of scheme A) thus had a mean probability of 0.170 (range 0-0.387) of being seen on any one day at Cardiff Bay. These same birds had a mean probability of 0.010 (range 0-0.294) of being seen on any one day at Rhymney (n = 17 days).

The frequency that individuals were seen may also depend on the colours used. On birds from scheme A, the colour on the left tibia was always one of just three bright colours: red, orange or yellow, and were thus easily read. Eight different colours were used for the two rings on the right tibia, however. Bright colours, such as white and yellow, are likely to be quick to read and birds with these rings may be successfully identified more frequently as a consequence. In contrast, dark coloured-rings: niger, dark blue and dark green may take longer to distinguish and thus birds with these rings may be missed and seen less frequently. Potentially, colours may also be mistaken for one another (white with yellow; niger, dark blue and dark green with one another). To determine whether this was the case, the frequency that birds were seen was compared for individuals with varying colours on the right tibia. Those individuals with a single niger ring were seen on a median of two days (n = 6, range = 0-8), those with a dark blue ring on a median of six days (n = 7, range = 2-12), those with a dark green ring on a median of five days (n = 9, range = 0-11) and others on a median of six days (n = 8, range = 2-12), an insignificant difference (H_c = 3.459, df = 3, ns). Niger, dark blue and dark green were never used together on the right tibia. Those with a single white ring were seen on a median of eight days (n = 15, range = 0-12), more frequently than those with a yellow ring (median = 2.5 days, n = 8, range = 0-10) and all

others (median = 3 days, n = 7, range = 1-7) (H_c = 6.261, df = 2, P < 0.05). White and yellow were never used together on the right tibia.

Estimates of the percentage of colour-ringed Redshank in the population at each site are given in Table 11.1.1. Although more Redshank were colour-ringed during winter, the estimated percentages of colour-ringed birds at Cardiff Bay and at Rhymney did not vary over the study period.

An additional six sightings of Redshank colour-ringed in Cardiff were reported from elsewhere in Britain during the study period (Table 11.1.2), most probably involving breeding birds. Three Redshank metal-ringed at Cardiff were also recovered elsewhere, one from Iceland (Table 11.1.2). Two Redshank originally colour-ringed in the Outer Hebrides during the breeding season were sighted several times at Cardiff during the winter (Table 11.1.3).

11.2 Survival

To determine survival rates from samples of colour-ringed birds it is vital that all individuals that have survived a given period are sighted (Harris & Calladine, 1993). As scheme B Redshank were identified so infrequently during winter it was clearly unreliable to include them in these calculations. Scheme A individuals were seen only once every six days, on average, during the low intensity winter searches and in order that none of these birds were missed at the end of the summer and winter periods, considerably more time was spent on colour-ring searches in October and February.

Thirty-two individually colour-ringed adult Redshank (of scheme A) seen at Cardiff in February 1996 formed a sample from which an over-summer return rate was calculated. Twenty-six were present at Cardiff after 30 September, giving a return rate of 0.81 (95% confidence limits = 0.66-0.97). Of 30 adult Redshank seen at Cardiff in October 1996, 26 were present on the study site after 31 January 1997, giving a winter survival rate of 0.87 (95% confidence limits = 0.73-1.00). The product of these two rates gave a minimum annual survival rate of 0.70 (95% confidence limits = 0.53-0.86).

Forty-eight adult and four first-year Redshank form samples of colour-ringed individuals (all of scheme A) from which over-summer return rates will be calculated for 1997.

11.3 Mass Changes

The masses of adult Redshank in the study area varied significantly over winter ($F_{6,912}$ = 45.31, P < 0.001; Figure 11.3.1). Birds were lightest in September and October and were heaviest in December and January. Birds were lighter again in February, but increased in mass in March prior to migration. The masses of first-winter Redshank also varied across winter, although with a less clear pattern ($F_{6,76}$ = 1.25, ns; Figure 11.3.1). First-winter Redshank were significantly lighter than adults in December (t = 5.206, df = 188, P < 0.001).

12. DISCUSSION

Colour-ringing Schemes for Redshank

Colour-ringing has become a widespread technique for studies of the behaviour of many groups of birds, including waders (Marchant, 1995). By using different combinations of colours within a given ringing scheme, it is possible to identify individuals and thus to study movements and survival (e.g. Metcalfe & Furness, 1985; Roberts, 1991; Smith *et al.*, 1992; Jackson, 1994; Burton & Evans, 1997). To avoid the misidentification of individuals, such studies clearly rely on rings retaining their colour and birds retaining their rings. Previous studies, however, have reported that ring loss may be a problem, even over a single year, either due to wear, removal by the bird or other less obvious factors (Anderson 1980; Reese 1980; Rees *et al*., 1990; Nisbet, 1991; Spendelow *et al*., 1994). Darvic plastic rings have been shown to be preferable to those made of celluloid or 'Scotchlite', due to their colour retention and their low rate of wear and thus loss (Anderson, 1980; Rees *et al*., 1990; Spendelow *et al*., 1994).

There has been little study, however, on the ease with which different colour-ringing schemes or different colours may be read in the field. The present study showed that individual Redshank were seen less frequently if colour rings had to be determined on a tibia and a tarsus, rather than on the two tibias. This was clearly a result of the problem of seeing rings on the tarsus whilst individuals foraged in the water or mud. Scheme B Redshank were seen so infrequently as a result of this problem that it was deemed unreliable to include them in survival calculations. For the study of other long-legged estuarine waders, it would also, therefore, be preferable for the majority of colour-rings to be on the tibias rather than the tarsi. The large number of colour-ringing schemes already active for many species may preclude this, however (Marchant, 1995; S. Browne & H. Mead, pers. comm.).

Up to nine Darvic colours are used in present colour-ringing schemes for waders (Marchant, 1995; S. Browne & H. Mead, pers. comm.), eight of which were used for Redshank at Cardiff. This study has shown that scheme A Redshank bearing a white ring on the right tibia were seen more frequently than other individuals. It is probable that white rings were simply more quickly determined than others and that individuals with a white ring were successfully identified more frequently as a result. It is not thought that yellow rings on the right tibia were mistaken for white, as individuals with a yellow ring in this position would have been seen less often than those with neither yellow or white. Field observations, however, did suggest that if white rings were on the tarsus, they may discolour to yellow over time, possibly as a result of an encrustation. There were no apparent problems in the determination of niger, dark blue or dark green rings in the field (although sample sizes were relatively small).

Site-fidelity within Winter

Individually colour-ringed adult Redshank (of scheme A) were seen at Cardiff Bay, on average, once every six fieldwork days during winter and most were probably resident on the study site during this period. A few seen in August and/or September 1996 and then again in February and/or March 1997, but not between, may have been birds on passage to and from other wintering grounds. A Redshank originally ringed at Llanelli on 3 February

1991 (and thus possibly wintering there), for example, was subsequently controlled at Cardiff Bay on 21 September 1994.

Due to other fieldwork commitments, only a proportion of each day was spent on these observations and it is probable that individuals were present in the bay on a far higher proportion of days than the above figure suggests. The same individuals were seen at Rhymney, on average, only once every 100 fieldwork days. Although this figure partly reflects the difficulty of observing colour-ringed birds at Rhymney, it is clear that Redshank from Cardiff Bay only occasionally left the site for Rhymney. Only 9.1% (*n* = 131) of those individuals seen in the bay were also seen at Rhymney.

A number of previous studies have also reported the site-fidelity of Redshank within winter, though few have quantified it (Furness & Galbraith, 1980; Cresswell & Whitfield, 1994; Rehfisch *et al*., 1996; Insley *et al*., in press). Insley *et al*. (in press), for example, reported that, within winter, 65% of 3656 retraps of adult Redshank were made at the same roost site.

Site-fidelity between Winters and Survival

It is now well-known that Redshank are highly faithful between years both to their breeding grounds (Thompson & Hale, 1989, 1993; Zhmud, 1992; Jackson, 1994) and to their wintering grounds (Cresswell & Whitfield, 1994; Rehfisch *et al*., 1996; Insley *et al*., in press). Few studies, however, have calculated actual over-summer return rates of Redshank to their wintering quarters. Cresswell & Whitfield (1994) did report that a minimum of 77% of Redshank colour-ringed one winter returned to the same site in Scotland the following winter (though this was over an undefined period). In the present study 81% of adult Redshank returned to Cardiff after the eight month summer period. This figure only represents a minimum survival rate for the period, as some individuals may change their wintering grounds between years (e.g. Mackie, 1976; Spencer & Hudson, 1982). No Redshank from Cardiff have yet been known to do so, however.

Winter survival rates too have not been reported before, although there have been a number of studies on the causes of winter mortality. Cresswell & Whitfield (1994) found that an exceptional 31-57% of Redshank were taken by raptors at their study site in Scotland between September and March, but did not calculate an overall winter mortality rate (see also Whitfield, 1985). Redshank are also known to suffer high mortality during severe winter weather, either because of the exhaustion of body reserves or due to an inability to mobilise these reserves quickly enough to meet the increased energy demands (Davidson, 1981; Dugan *et al*., 1981; Davidson, 1982; Davidson & Evans, 1982; Insley & Swann, 1996). As with other waders, Redshank have been found to increase their mass in midwinter prior to the possibility of such weather (Figure 11.3.1; Nicoll & Summers, 1980; Johnson, 1982; Johnson, 1985; Norman & Coffey, 1994). The cold weather of early January 1997 may have caused high mortality in a number of species of wader, including Redshank, although effects have yet to be documented. In previous such episodes Redshank mortality has been greater on eastern coasts (see Davidson, 1982; Norman & Coffey, 1994). At Cardiff, there was only 13% mortality over the four month winter period (from 1 October 1996 to 31 January 1997), in spite of this cold spell.

The effects of cold winter weather may be seen in the annual survival rates of Redshank. Insley *et al*. (in press) found that the number of snow days in winter explained 10% of the inter-annual variation in adult survival estimates. Annual survival rates for Redshank are

usually high, however, Insley *et al*. (in press) calculating a rate of 67% for Redshank between their second and third winters, though a rate of just 43% for Redshank between their first and second winters. Thompson & Hale (1993) reported rates of 75% and 72% for males and females respectively and Jackson (1988) similarly reported rates of 77% and 75%. There was a survival rate of 70% for adult Redshank at Cardiff between 1 February 1996 and 30 January 1997.

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Species	Level for international importance	Level for national importance	Importance of Severn Estuary (winter 1995/96)	Maximum WeBS count at Cardiff Bay (winter 1996/97)
Shelduck *Tadorna tadorna*	**2500**	**750**	**International**	**221**
Teal *Anas crecca*	**4000**	**1400**	**National**	**134**
Mallard *Anas platyrhynchos*	**20000**	**5000**	**-**	**120**
Pintail *Anas acuta*	**700**	**280**	**National**	**0**
Pochard *Aythya ferina*	**3500**	**440**	**National**	**95**
Oystercatcher *Haematopus ostralegus*	**9000**	**3600**	**-**	**101**
Ringed Plover *Charadrius hiaticula*	**500**	**290**	**-**	**33**
Grey Plover *Pluvialis squatarola*	**1500**	**430**	**National**	**0**
Lapwing *Vanellus vanellus*	**20000**	**20000**	**National**	**70**
Knot *Calidris canutus*	**3500**	**2900**	**-**	**0**
Dunlin *Calidris alpina*	**14000**	**5300**	**International**	**3000**
Curlew *Numenius arquata*	**3500**	**1200**	**International**	**89**
Redshank *Tringa totanus*	**1500**	**1100**	**International**	**300**
Turnstone *Arenaria interpres*	**700**	**640**	**-**	**71**

Table 2.3.1 The importance of the Severn Estuary and Cardiff Bay for waterfowl in a British and European context. A wetland site is considered internationally important for a species if it regularly holds at least 1% of the individuals in a population of that species. Britain's wildfowl belong to the north-west European population (Pirot *et al*. 1989), and the waders to the east Atlantic flyway population (Smit & Piersma, 1989). A wetland site in Britain is considered nationally important for a species if it regularly holds 1% or more of the estimated British population of that species. The Severn Estuary also holds internationally important numbers of Bewick's Swan *Cygnus columbianus bewickii* and nationally important numbers of European White-fronted Goose *Anser albifrons albifrons*, Wigeon *Anas penelope*, Gadwall *Anas strepera*, Shoveler *Anas clypeata* and Tufted Duck *Aythya fuligula* (Cranswick *et al*., in press).

	A	S	O	N	D	J	F	M	A	M
Taff/Ely										
Brent Goose ***Branta bernicla bernicla***		**5**			**1**					
Wigeon ***Anas penelope***				**2**						
Gadwall ***Anas strepera***					**1**					
Shoveler ***Anas clypeata***			**4**	**2**	**2**		**1**			
Tufted Duck ***Aythya fuligula***						**1**				
Red-breasted Merganser ***Mergus serrator***							**1**			
Goosander ***Mergus merganser***	**1**	**1**	**1**	**3**	**4**	**6**	**3**	**4**		**2**
Curlew Sandpiper ***Calidris ferruginea***			**1**							
Ruff ***Philomachus pugnax***								**2**		**1**
Black-tailed Godwit ***Limosa limosa***	**1**	**1**			**2**	**2**			**1**	
Bar-tailed Godwit ***Limosa lapponica***			**1**	**3**						**1**
Whimbrel ***Numenius phaeopus***										**1**
Spotted Redshank ***Tringa erythropus***								**1**		
Orchard Ledges										
Mute Swan ***Cygnus olor***									**2**	
Snipe ***Gallingo gallingo***				**2**						
Whimbrel									**1**	**1**
Rhymney										
Barnacle Goose ***Branta leucopsis***							**1**	**1**	**1**	**1**
Wigeon		**9**								
Shoveler					**5**	**4**				
Tufted Duck							**1**			
Scaup ***Aythya marila***						**23**	**50**	**11**		
Eider		**1**	**1**		**1**					
Black-tailed Godwit						**2**		**1**		
Bar-tailed Godwit						**1**				**1**
Whimbrel									**1**	**1**

Table 3.6.1 The maximum numbers of other wildfowl and waders seen at Cardiff during all day counts, 1996/97.

Mudflat	Substrate	Distance to land (m)	Disturbance value							
			89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97
Taff/Ely 1	0	60	3	3	3	3	3	1	1	2
2	0	250	3	3	3	3	3	1	1	2
3	0	100	3	3	3	3	3	3	3	3
4	0	270	3	3	3	3	3	3	2	3
5	0	340	3	3	3	3	3	2	1	3
6	0	520	3	3	3	3	3	3	2	3
7	0	70	3	3	1	1	1	2	3	2
8	0	60	3	3	2	2	3	3	3	3
9	0	70	3	3	2	2	2	3	3	3
10	0	150	3	2	1	1	1	2	3	3
11	0	300	3	3	2	2	2	2	3	3
12	0	350	3	3	2	2	2	3	3	3
13	0	400	3	3	3	3	3	3	2	3
14	0	340	3	3	3	3	3	3	3	3
15	0	220	3	3	3	3	3	3	3	3
16	0	220	3	3	3	3	3	3	2	3
17	0	270	3	3	3	3	3	2	1	2
18	0	50	3	3	3	3	3	1	1	2
19	0	120	3	3	3	3	3	3	3	3

Table 6.1.1a **The distance to land, substrate (0 = mud, 1 = stone) and disturbance value (see text for definition) of each mudflat at Cardiff Bay.**

Mudflat	Substrate	Distance to land (m)	Disturbance value							
			89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97
Orchard Ledges 1	0	367	4	4	4	4	4	4	4	4
2	0	230	4	4	4	4	4	4	4	4
Rhymney 1	1	133	4	4	4	4	4	4	4	4
2	1	67	4	4	4	4	4	4	4	4
3	0	167	4	4	4	4	4	4	4	4
4	0	233	4	4	4	4	4	4	4	4
5	0	333	4	4	4	4	4	4	4	4
6	0	433	4	4	4	4	4	4	4	4
7	0	400	4	4	4	4	4	4	4	4
8	0	700	4	4	4	4	4	4	4	4
9	0	867	4	4	4	4	4	4	4	4
10	0	233	4	4	4	4	4	4	4	4
11	0	733	4	4	4	4	4	4	4	4
12	0	1067	4	4	4	4	4	4	4	4
13	0	467	4	4	4	4	4	4	4	4
14	0	700	4	4	4	4	4	4	4	4
15	0	367	4	4	4	4	4	4	4	4
16	0	167	4	4	4	4	4	4	4	4
17	0	67	4	4	4	4	4	4	4	4

Table 6.1.1b The distance to land, substrate (0 = mud, 1 = stone) and disturbance value (see text for definition) of each mudflat at Orchard Ledges and Rhymney.

Species	DCA1	DCA2	DCA3	DCA4
Oystercatcher	2.7667	3.0536	3.5065	0.3674
Dunlin	2.9495	0.7094	1.9858	1.5551
Curlew	1.8199	2.2657	1.3521	-0.4038
Redshank	0.9017	0.0000	2.8366	0.8464
Shelduck	1.8620	1.6087	3.1609	2.4352
Mallard	1.1065	2.5031	-0.2699	2.3577
Teal	-0.0628	1.7759	1.0796	2.6116
Pintail	3.3268	1.5300	4.8101	1.3603

Table 7.1.1 The species scores for the four DECORANA axes (DCA 1-4). Axes scores are in standard deviation units.

Site	Mudflat	Year
CB	**2**	**1989/90**
CB	**3**	**1989/90**
CB	**4**	**1989/90**
CB	**5**	**1989/90**
CB	**6**	**1989/90**
CB	**7**	**1989/90**
CB	**10**	**1989/90**
CB	**11**	**1989/90**
CB	**12**	**1989/90**
CB	**14**	**1989/90**
CB	**15**	**1989/90**
CB	**16**	**1989/90**
CB	**17**	**1989/90**
CB	**19**	**1989/90**
CB	**3**	**1990/91**
CB	**4**	**1990/91**
CB	**5**	**1990/91**
CB	**6**	**1990/91**
CB	**11**	**1990/91**
CB	**14**	**1990/91**
CB	**17**	**1990/91**
CB	**2**	**1991/92**
CB	**3**	**1991/92**
CB	**4**	**1991/92**
CB	**5**	**1991/92**
CB	**6**	**1991/92**
CB	**11**	**1991/92**
CB	**12**	**1991/92**
CB	**14**	**1991/92**
CB	**16**	**1991/92**
CB	**17**	**1991/92**
CB	**18**	**1991/92**
CB	**2**	**1992/93**
CB	**3**	**1992/93**
CB	**4**	**1992/93**
CB	**5**	**1992/93**
CB	**6**	**1992/93**
CB	**11**	**1992/93**
CB	**14**	**1992/93**
CB	**16**	**1992/93**

Site	Mudflat	Year
CB	**2**	**1993/94**
CB	**3**	**1993/94**
CB	**4**	**1993/94**
CB	**5**	**1993/94**
CB	**6**	**1993/94**
CB	**11**	**1993/94**
CB	**12**	**1993/94**
CB	**14**	**1993/94**
CB	**16**	**1993/94**
CB	**17**	**1993/94**
CB	**18**	**1993/94**
CB	***2***	***1994/95***
CB	**3**	**1994/95**
CB	**4**	**1994/95**
CB	**5**	**1994/95**
CB	**6**	**1994/95**
CB	**11**	**1994/95**
CB	**12**	**1994/95**
CB	**14**	**1994/95**
CB	**17**	**1994/95**
CB	***18***	***1994/95***
CB	***2***	***1995/96***
CB	**3**	**1995/96**
CB	**4**	**1995/96**
CB	***5***	***1995/96***
CB	**6**	**1995/96**
CB	**7**	**1995/96**
CB	**11**	**1995/96**
CB	**12**	**1995/96**
CB	**14**	**1995/96**
CB	**15**	**1995/96**
CB	**16**	**1995/96**
CB	***17***	***1995/96***
CB	***18***	***1995/96***
CB	**3**	**1996/97**
CB	**4**	**1996/97**
CB	**6**	**1996/97**
CB	**7**	**1996/97**
CB	**11**	**1996/97**
CB	**12**	**1996/97**

CB	17	1992/93	CB	14	1996/97
CB	18	1992/93	CB	15	1996/97
CB	16	1996/97	RH	15	1992/93
CB	17	1996/97	RH	16	1992/93
CB	18	1996/97	RH	10	1993/94
RH	3	1989/90	RH	11	1993/94
RH	6	1989/90	RH	12	1993/94
RH	10	1989/90	RH	13	1993/94
RH	11	1989/90	RH	14	1993/94
RH	12	1989/90	RH	15	1993/94
RH	14	1989/90	RH	16	1993/94
RH	15	1989/90	RH	10	1994/95
RH	16	1989/90	RH	11	1994/95
RH	6	1990/91	RH	12	1994/95
RH	8	1990/91	RH	14	1994/95
RH	9	1990/91	RH	15	1994/95
RH	10	1990/91	RH	16	1994/95
RH	11	1990/91	RH	1	1995/96
RH	14	1990/91	RH	6	1995/96
RH	15	1990/91	RH	10	1995/96
RH	16	1990/91	RH	11	1995/96
RH	6	1991/92	RH	12	1995/96
RH	10	1991/92	RH	14	1995/96
RH	11	1991/92	RH	15	1995/96
RH	12	1991/92	RH	16	1995/96
RH	14	1991/92	RH	17	1995/96
RH	15	1991/92	RH	6	1996/97
RH	16	1991/92	RH	10	1996/97
RH	1	1992/93	RH	11	1996/97
RH	10	1992/93	RH	12	1996/97
RH	11	1992/93	RH	14	1996/97
RH	12	1992/93	RH	15	1996/97
RH	14	1992/93	RH	16	1996/97

Table 7.3.1a The composition of cluster 4 (*n* = 146). Mudflats in italics are those directly affected by PDR or barrage works. CB = Cardiff Bay; OL = Orchard Ledges; RH = Rhymney.

Site	Mudflat	Year
CB	1	1989/90
CB	8	1989/90
CB	9	1989/90
CB	13	1989/90
CB	19	1989/90
CB	1	1990/91
CB	2	1990/91
CB	7	1990/91
CB	8	1990/91
CB	9	1990/91
CB	10	1990/91
CB	12	1990/91
CB	13	1990/91
CB	15	1990/91
CB	16	1990/91
CB	18	1990/91
CB	19	1990/91
CB	1	1991/92
CB	*7*	*1991/92*
CB	8	1991/92
CB	9	1991/92
CB	*10*	*1991/92*
CB	13	1991/92
CB	15	1991/92
CB	19	1991/92
CB	1	1992/93
CB	*7*	*1992/93*
CB	8	1992/93
CB	9	1992/93
CB	*10*	*1992/93*
CB	12	1992/93
CB	13	1992/93
CB	15	1992/93
CB	19	1992/93
CB	1	1993/94
CB	*7*	*1993/94*
CB	8	1993/94
CB	9	1993/94
CB	*10*	*1993/94*
CB	13	1993/94
CB	15	1993/94
CB	19	1993/94
CB	7	1994/95
CB	8	1994/95
CB	9	1994/95
CB	10	1994/95
CB	13	1994/95
CB	15	1994/95
CB	16	1994/95
CB	19	1994/95
CB	8	1995/96
CB	9	1995/96
CB	10	1995/96
CB	13	1995/96
CB	19	1995/96
CB	8	1996/97
CB	9	1996/97
CB	10	1996/97
CB	13	1996/97
CB	19	1996/97
RH	17	1989/90
RH	17	1991/92
RH	17	1992/93
RH	17	1993/94
RH	17	1994/95
RH	17	1996/97

Table 7.3.1b The composition of cluster 6 (n = 66). Mudflats in italics are those directly affected by PDR or barrage works. CB = Cardiff Bay; OL = Orchard Ledges; RH = Rhymney.

Site	Mudflat	Year
RH	2	1989/90
RH	4	1989/90
RH	5	1989/90
RH	8	1989/90
RH	9	1989/90
RH	7	1990/91
RH	12	1990/91
RH	13	1990/91
RH	1	1991/92
RH	2	1991/92
RH	3	1991/92
RH	4	1991/92
RH	5	1991/92
RH	7	1991/92
RH	8	1991/92
RH	9	1991/92
RH	13	1991/92
RH	2	1992/93
RH	4	1992/93
RH	7	1992/93
RH	9	1992/93
RH	13	1992/93
RH	2	1993/94
RH	4	1993/94
RH	5	1993/94
RH	6	1993/94
RH	7	1993/94

Site	Mudflat	Year
RH	8	1993/94
RH	9	1993/94
RH	2	1994/95
RH	3	1994/95
RH	5	1994/95
RH	6	1994/95
RH	7	1994/95
RH	8	1994/95
RH	9	1994/95
RH	13	1994/95
RH	2	1995/96
RH	3	1995/96
RH	4	1995/96
RH	5	1995/96
RH	7	1995/96
RH	8	1995/96
RH	9	1995/96
RH	13	1995/96
RH	1	1996/97
RH	2	1996/97
RH	3	1996/97
RH	4	1996/97
RH	5	1996/97
RH	7	1996/97
RH	8	1996/97
RH	9	1996/97
RH	13	1996/97

Table 7.3.1c The composition of cluster 8 (*n* = 54). Mudflats in italics are those directly affected by PDR or barrage works. CB = Cardiff Bay; OL = Orchard Ledges; RH = Rhymney.

Site	Mudflat	Year
CB	*1*	*1994/95*
CB	*1*	*1995/96*
CB	1	1996/97
CB	2	1996/97
CB	5	1996/97
OL	1	1989/90
OL	2	1989/90
OL	1	1990/91
OL	2	1990/91
OL	1	1991/92
OL	2	1991/92
OL	1	1992/93
OL	2	1992/93
OL	1	1993/94
OL	2	1993/94
OL	1	1994/95
OL	2	1994/95
OL	1	1995/96
OL	2	1995/96
OL	1	1996/97
OL	2	1996/97
RH	1	1989/90
RH	7	1989/90
RH	13	1989/90
RH	1	1990/91
RH	2	1990/91
RH	3	1990/91
RH	4	1990/91
RH	5	1990/91
RH	17	1990/91
RH	3	1992/93
RH	5	1992/93
RH	6	1992/93
RH	8	1992/93
RH	1	1993/94
RH	3	1993/94
RH	1	1994/95
RH	4	1994/95

Table 7.3.1d The composition of cluster 9 (*n* = 38). Mudflats in italics are those directly affected by PDR or barrage works. CB = Cardiff Bay; OL = Orchard Ledges; RH = Rhymney.

Date	Site	Number colour-ringed
26/11/96	Rhymney	2
11/12/96	Rhymney	1
2/1/97	Cardiff Bay	1
3/1/97	Cardiff Bay	6
16/1/97	Cardiff Bay	8
30/1/97	Cardiff Bay	4
8/2/97	Cardiff Bay	15

Table 10.1.1 Dates of Redshank colour-ringing at Cardiff Bay and at Rhymney during winter 1996/97.

Date	Site	Percentage scheme-marked (n)	Percentage individually colour-ringed (n)	Sample size
24/8/96	Cardiff Bay	20.3 (12)	23.7 (14)	59
26/8/96	Cardiff Bay	11.1 (9)	37.0 (30)	81
22/9/96	Cardiff Bay	20.5 (23)	24.1 (27)	112
19/10/96	Cardiff Bay	30.3 (23)	28.9 (22)	76
20/11/96	Cardiff Bay	20.8 (10)	29.2 (14)	48
14/12/96	Cardiff Bay	22.6 (12)	26.4 (14)	53
27/1/97	Cardiff Bay	15.6 (5)	28.1 (9)	32
16/2/97	Cardiff Bay	10.2 (6)	37.3 (22)	59
17/2/97	Cardiff Bay	17.1 (6)	25.7 (9)	35
15/3/97	Cardiff Bay	6.9 (2)	17.2 (5)	29
16/3/97	Cardiff Bay	12.3 (14)	28.9 (33)	114
17/3/97	Cardiff Bay	7.1 (2)	28.6 (8)	28
22/8/96	Rhymney	3.2 (3)	2.1 (2)	94
22/9/96	Rhymney	6.7 (3)	2.2 (1)	45
23/9/96	Rhymney	7.3 (3)	0	41
17/10/96	Rhymney	6.8 (11)	1.2 (2)	162
22/11/96	Rhymney	5.0 (6)	2.5 (3)	119
12/12/96	Rhymney	2.3 (1)	2.3 (1)	44
13/12/96	Rhymney	7.1 (10)	2.1 (3)	141
24/1/97	Rhymney	7.5 (11)	2.7 (4)	146
25/1/97	Rhymney	16.7 (6)	2.7 (1)	36
18/2/97	Rhymney	10.7 (3)	0	28
21/2/97	Rhymney	5.0 (2)	2.5 (1)	40
16/3/97	Rhymney	3.5 (2)	1.8 (1)	57

Table 11.1.1 Estimates of the percentages of colour-ringed birds in the Redshank populations at Cardiff Bay and Rhymney from August 1996 to March 1997.

Metal-ringed or individually colour-ringed	Ring number	Date ringed	Date observed	Location
Individual	Unknown		24/6/95	Peterstone Wentlooge, Gwent
Individual	DN54761	16/10/93	27/5/96	Bragar, Lewis, Western Isles
Individual	Unknown		1/6/96	Newton Marsh, Lancashire
Metal	DR96452	21/9/94	4/6/96	Langhus, Fljot, Skagafjorður ICELAND
Individual	Unknown		7/6/96	Newton Marsh, Lancashire
Metal	DN54909	19/12/95	4/7/96	Malham Cove, North Yorkshire
Individual	DR96418	21/9/94	25/3/97	Balephetrish Bay, Tiree, Strathclyde
Individual	DK76738	3/1/97	1/5/97	Heylipol, Tiree, Strathclyde

Table 11.1.2 Sightings of Redshank colour-ringed at Cardiff reported from elsewhere during the study period and recoveries of Redshank metal-ringed at Cardiff.

Ring number	Date ringed	Location	Dates observed	Location
DN83751	1986	South Uist, Western Isles	8/2/96, 14/2/96, 15/2/97, 16/2/97, 19/2/97, 13/3/97, 15/3/97 & 16/3/97	Cardiff Bay
Unknown	8/6/96	South Uist, Western Isles	22/9/96, 17/10/96, 18/10/96, 29/11/96, 21/1/97 & 14/3/97	Rhymney

Table 11.1.3 Sightings at Cardiff of Redshank colour-ringed elsewhere.