British Trust for Ornithology

BTO Research Report No. 205

The Effect of the Cardiff Bay Barrage on Waterfowl Populations 9. Distribution and Movement Studies August 1997-May 1998

Authors

N.H.K. Burton, M.M. Rehfisch & N.A. Clark

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

September 1998

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

CONTENTS

Page No.

Page No.

LIST OF TABLES

Page No.

LIST OF FIGURES

Page No.

Page No.

EXECUTIVE SUMMARY

1. This report presents the results of the ninth season of intensive monitoring of the wildfowl and waders of the intertidal areas in Cardiff Bay and adjacent sites. More extensive monitoring at low tide also covered the intertidal areas between Cardiff Bay and the mouth of the River Usk. The report concentrates upon results from the winter of 1997/98. Results from autumn (August to October 1997) and spring (April to May 1998) have been analysed, but are not presented here in this short report. The programme of monitoring closely followed that used for the previous eight years, allowing direct comparisons to be made between results from each year.

2. Following the completion of the amenity barrage in December 1998, the intertidal mudflats of the Taff and Ely estuaries (i.e. Cardiff Bay) will be inundated with fresh water. Monitoring the distributions and movements of waders and wildfowl both before and after barrage completion will enable the effect of the barrage on their populations to be ascertained.

3. Monitoring of the populations of waders and wildfowl at low tide on the northwest Severn from Cardiff Bay to the Usk Estuary revealed only minor changes in the number and distribution of birds since 1996/97.

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 two of the four main species: Dunlin and Redshank. Both species avoided mudflats close to the mouth of the bay (particularly mudflats 2 and 17), probably due to disturbance from the building of the barrage. Feeding numbers of Dunlin were at their lowest level at Cardiff Bay since the study began, whilst those of Redshank have declined significantly at both Cardiff Bay and Rhymney over the nine years.

5. Continuing colour-ringing studies have indicated that a high proportion of the Redshank population of Cardiff Bay is faithful to it throughout the winter. Only 14% of individuals seen at Cardiff Bay during the winter and known to be alive throughout that period were seen at Rhymney. Ninety-six percent of individuals survived the winter. A knowledge of their site-fidelity will be important in determining their behaviour after the bay is inundated.

6. Redshank are also faithful to the bay between winters: 90% of colour-ringed adults seen at the end of winter 1996/97 returned after summer 1997 (1 February to 30 September). An annual survival rate of 86% was determined from these observations, a slightly higher figure than that found the previous year and in other studies.

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 1997 and May 1998 were as follows (see Figure 2.1.1):

> On the western (Penarth) side of the bay, by mudflats 1 and 2, 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.
>
> On the eastern side of the bay, where earth was deposited at the edge of mudflat 18 from April 1998 onwards.
>
> On the western edge of the bay, adjacent to the Peripheral Distributor Road (PDR), where preparations were made for building work at the edge of mudflats 3, 4 and 7.
>
> On the northern edge of the bay, where work continued on the building of a hotel adjacent to mudflats 15 and 19.

In each of these cases, work caused some disturbance to birds on the mentioned mudflats. The work adjacent to the PDR, however, also resulted in the loss of approximately 1 ha each to mudflats 3 and 7. In contrast, at the mouth of the bay, the building of the barrage resulted in some siltation and in consequence, mudflats 17 and 18 had increased in size by approximately 4 and 3 ha respectively by the start of the year. After the winter period, mudflat 18 was reduced in size by approximately 1 ha, due to earth deposition.

Several previous changes have affected the feeding and roosting behaviour of birds in the bay. In particular, 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 closeby (Burton *et al.* 1997a, 1997b).

This report looks at the distribution and movement of the birds in Cardiff Bay and nearby areas, and is in two sections. The first part summarizes the results of the ninth year of monitoring of the waterfowl populations in the Cardiff Bay area. The second reports the continuing study of the site-fidelity and survival of Redshank *Tringa totanus*. The results of the first eight years' monitoring of the wader and wildfowl populations of Cardiff Bay and nearby areas were given by Evans *et al*. (1990), Donald and Clark (1991a), Toomer and Clark (1992a), Toomer *et al*. (1993, 1994, 1995) and Burton *et al*. (1997a, 1997b).

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 1997/98. 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*. 1997).

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 1997 and May 1998. The findings are compared with results from the previous eight years (Burton *et al*. 1997a, 1997b; Evans *et al*. 1990; Donald & Clark 1991a; Toomer & Clark 1992a; Toomer *et al*. 1993, 1994).

With nine 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.

This report concentrates upon the winter period (November to March) when bird populations tended to be at their greatest and when they were also most stable. Results from the autumn (August to October) and spring (April to May) have been analysed in full, but are not presented here in this short report.

Special attention is again 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 large areas of mudflat, feeding birds could have been affected by the disturbance associated with this work.

2. METHODS

The methods used in this ninth year of study were similar to those in the eight previous studies and therefore are described only briefly. 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). Changes in the sizes of some of the mudflats at Taff/Ely due to building work and siltation are described in the general introduction above. At Rhymney, the building of a pipeline across mudflats 2, 5 and 8, between April and November 1997, also caused some disturbance to birds.

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 makes 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 to October 1997), winter (November 1997 to March 1998) and spring (April to May 1998). Each site was counted twice a month (with the exception of April, when only a single count took place) 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 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, 1993, 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 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 FROM {A=+5} TO {A=-6} (B TIMES C)

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 twice a month 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 most likely to affect the distribution of birds in this area (Figure 2.2.1). As with the all day counts, the whole area was broken down into smaller count areas. 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 eight years of study were reported in Evans *et al*. (1990), Donald and Clark (1991a), Toomer and Clark (1992a), Toomer and Clark (1993), Toomer *et al*. (1994), Toomer *et al*. (1995) and Burton *et al*. (1997a, 1997b). 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 eight.

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, species which occur on the Severn estuary in internationally important numbers (Cranswick *et al*. 1997; Table 2.3.1). Accounts concentrate on the winter of 1997/98. For each of these four main species, maps of the 'all day usage' of the mudflat count areas of each site are presented, together with graphs showing the average number of birds and the proportion feeding at each hour through the tidal cycle. Comparison maps are given for the three previous years (1994/95, 1995/96 and 1996/97). 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.

For other species, the main feeding areas are described, any trends in numbers noted and the peak numbers present during the year also given. Those species recorded on the study sites only infrequently or in very small numbers are detailed in a table. 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 relatively steady in recent winters and was estimated at 77,000 in 1995/96 (Cranswick *et al*. 1997). The Severn Estuary is of international importance for Shelduck in winter.

Low tide counts showed feeding Shelduck to be present along the whole of the northwest Severn during the winter of 1997/98 (Figure 3.1.1). The main concentrations were found at Peterstone and Rhymney.

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 3.1.2). The numbers of feeding birds and their distribution in the bay were similar to those in the three previous winters. With the exception of mudflat 1, Shelduck continued to use mudflats close to the mouth of the bay, in spite of the continuing building work there.

Groups of up to nine Shelduck were observed feeding at Orchard Ledges (Figure 3.1.3). These birds mainly used the muddy bank at the eastern end of mudflat 2, 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 3.1.3). Feeding birds were usually concentrated near the water's edge and 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.

There were two peaks in Shelduck numbers at Taff/Ely during the tidal cycle (Figure 3.1.4a). 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. A peak of 320 Shelduck was recorded at Taff/Ely on 12 February. At Rhymney, Shelduck numbers rose sharply after high tide, as birds flew in from roost areas to the east (Figure 3.1.4c). The majority of birds fed while the lower mudflats were exposed. Numbers of Shelduck at Rhymney have declined since 1995/96. A peak of 892 was recorded there on 10 December.

There has been no clear trend in the summed usage of the three sites over the nine winters of study (r_s = 0.017, n = 9, not significant (ns); Figure 3.1.5). Similarly, there has been no trend in the usage of Cardiff Bay alone (r_s = 0.050, n = 9, ns). No trend in wintering numbers has been seen in Britain as a whole over the same period (Cranswick *et al*. 1997). The mean feeding usage density of Shelduck at Cardiff Bay was slightly lower than that at Rhymney (5.8 bird hours per tidal cycle per hectare, compared with 6.6).

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). In winter, these birds move south to Africa, whilst others that have bred in Scandinavia and Siberia, migrate to Britain. A total of 475,000 Dunlin wintered in Britain in 1995/96 (Cranswick *et al*. 1997). The Severn Estuary holds internationally important numbers of Dunlin during the winter.

Large numbers of feeding Dunlin were recorded along the northwest Severn during low tide counts (Figure 3.2.1). 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 flocks were observed on mudflats adjacent to the River Taff at the north of the bay, although almost all mudflats were used by some feeding birds (Figure 3.2.2). The distribution of feeding Dunlin was similar to those seen in previous winters, although numbers were lower.

A maximum of 130 Dunlin were seen at Orchard Ledges on 17 February, an increase on the previous winter. Birds fed on both mudflats, but were usually there for one to two hours only (Figure 3.2.3). At Rhymney, the highest numbers of feeding Dunlin were recorded to the east of the Cardiff Eastern Sewer (Figure 3.2.3). 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, held higher numbers of Dunlin than mudflats 1 to 6 higher up.

At Taff/Ely, Dunlin numbers peaked shortly before and shortly after high tide (Figure 3.2.4a). 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. A peak of 1,384 Dunlin was recorded on 12 November. At Rhymney, Dunlin numbers were greatest on the falling tide (Figure 3.2.4c). Numbers were lower than in the previous winter, with a peak of 7,100 on 13 December.

There has been no trend in the summed usage of the three sites over the nine year study period (r_s = -0.067, n = 9, ns; Figure 3.2.5), although there is evidence of a decline in the usage of Cardiff Bay alone (r_s = -0.642, n = 9, $P < 0.10$). The usage of Rhymney also fell sharply between 1996/97 and 1997/98. In contrast, there has been no trend in wintering numbers in Britain as a whole (Cranswick *et al*. 1997). The mean feeding usage density of Dunlin at Cardiff Bay remained low in comparison to that at Rhymney (3.8 bird hours per tidal cycle per hectare, compared with 24.21).

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 to 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 total of 59,000 wintered

on the estuaries and shores of Britain in 1995/96 (Cranswick *et al*. 1997), a decrease on the previous year (Waters *et al*. 1996). The Severn Estuary holds internationally important numbers of Curlew during winter.

Low tide counts of feeding Curlew showed that they were very widespread along the northwest Severn (Figure 3.3.1). The highest concentrations were found at the mouth of the River Usk, at Peterstone, and on the western mudflats of Rhymney (i.e. the Orchard Ledges all day count site). Numbers were similar to those recorded in the previous winter on nearly all mudflats.

At Taff/Ely the majority of feeding birds were found on mudflats near the mouth of the bay and in its centre, adjacent to the River Taff (Figure 3.3.2). The number and distribution of feeding Curlew were similar to those seen in the three previous winters. Levels of usage fell on mudflats 1 and 18, probably due to barrage work, but increased on mudflat 17.

Curlew numbers at Orchard Ledges in the winter of 1997/98 were similar to those in the previous year. At Rhymney, increasing numbers were found on mudflats 1, 4 and 5 in spite of nearby building work, whilst fewer birds were found on mudflats 15 and 16 (Figure 3.3.3).

At Taff/Ely, Curlew numbers were highest shortly before and shortly after high tide, as birds moved between their feeding and roosting sites (Figure 3.3.4a). Many of the birds that left the bay at low tide flew to feed at Orchard Ledges (Figure 3.3.4b). Other Curlew that fed at this site moved off to Rhymney as the tide came in, numbers peaking there three hours after low tide (Figure 3.3.4c). Curlew numbers peaked at 165 at Taff/Ely and at 107 at Orchard Ledges in the autumn, when the local population was supplemented by passage birds. At Rhymney, a peak of 174 was recorded on 19 February. Numbers were similar to those in the previous winter at all three sites.

The summed usage of the three sites has risen since 1995/96, having declined over the three previous winters (r_s = 0.067, n = 9, ns; Figure 3.3.5). There has also been no overall trend in the usage of Cardiff Bay alone (r_s = -0.450, n = 9, ns). No trend in wintering numbers has been seen in Britain as a whole over the same period (Cranswick *et al*. 1997). In 1997/98, 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 1.1 and 0.6 respectively).

3.4 Redshank *Tringa totanus*

An total of 30,000 to 34,000 pairs of Redshank was estimated to breed in Britain in the mid-1980s, 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 Iceland (Summers *et al*. 1988). An total of 77,000 wintered on Britain's estuaries and shores in 1995/96 (Cranswick *et al*. 1997). The Severn Estuary is internationally important for Redshank in winter.

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 being observed at St. Brides (Figure 3.4.1).

Feeding Redshank were widely distributed at Taff/Ely and used almost all mudflats (Figure 3.4.2). Those adjacent to the River Taff held the highest numbers. The overall levels of usage were similar to those in the three previous winters. However, fewer Redshank fed on mudflats 17 and 18, close to some of the barrage work, than in winter 1996/97.

No Redshank were seen at Orchard Ledges in winter. At Rhymney, Redshank were found on almost all mudflats to the east of the Cardiff Eastern Sewer with the highest level of usage occurring on mudflat 16 (Figure 3.4.3). The distribution of Redshank at Rhymney was similar to previous winters, although numbers were lower. Many Redshank stayed up the Rhymney river throughout the tidal cycle and did not appear on the study site.

At Taff/Ely, as the tide ebbed, Redshank initially formed large feeding flocks as they moved from their saltmarsh roosting areas. However, by low tide, these flocks had dispersed and many birds fed out of sight, along small creeks or on the river banks. Birds came back into view as the rising tide pushed them onto higher mudflats (Figure 3.4.4a). A peak of 397 Redshank was observed at Taff/Ely on 8 September when the local population was supplemented by passage birds. Two peaks in numbers also occurred at Rhymney, four hours before and three hours after low tide (Figure 3.4.4c). Birds were not seen to leave the site, the apparent fall in numbers occurring when Redshank moved out of sight onto lower areas of the river banks. Although overall usage levels were lower at Rhymney than in previous winters, a peak of 491 Redshank was observed on 28 January. It is probable that much of the population at Rhymney frequented the upper tidal stretches of the Rhymney river and thus did not appear on the study site.

The usage of both sites has declined significantly since 1989/90 (for Taff/Ely: $r_s = -0.750$, $n = 9$, $P < 0.05$; for Rhymney: $r_s = -0.800$, $n = 9$, $P < 0.05$; for both sites combined: $r_s = -0.867$, $n = 9$, $P < 0.01$; Figure 3.4.5). In Britain as a whole, however, numbers have remained stable over this period (Cranswick *et al*. 1997). The mean feeding usage density of Redshank at Cardiff Bay was much greater than that at Rhymney (7.4 bird hours per tidal cycle per hectare, compared with 1.6), perhaps because the mudflats at Cardiff Bay are dissected by more creeks and rivers, where birds are able to feed.

3.5 Other Species

3.5.1 Mallard

Mallard were present at both Taff/Ely and Rhymney throughout the autumn, winter and spring. Numbers peaked at 154 at the former site on 12 September and at 97 at the latter on the same day. Only occasional Mallard were observed at Orchard Ledges. Further large concentrations were present at low tide at St. Brides. Numbers were similar to those recorded in recent years.

3.5.2 Teal

Teal numbers were greatest at Taff/Ely, where numbers peaked at 103 on 16 February. Although only a maximum of eight were observed at Rhymney, many more used the upper tidal stretches of the Rhymney river and thus did not appear on the study site. Further concentrations of Teal were present at low tide at St. Brides. Numbers were similar to those recorded in recent years.

3.5.3 Pintail

As in previous years no Pintail were recorded at either Taff/Ely or Orchard Ledges. Numbers at Rhymney were higher than in the 1996/97 winter, peaking at 339 on 12 December. Large concentrations also occurred at low tide at Peterstone and St. Brides.

3.5.4 Pochard

The number of Pochard using the Rhymney river during winter has continued its recent rise (see Burton *et al*. 1997b), numbers peaking in the 1997/98 winter at 212 on 23 January. Up to 24 were also present at Taff/Ely, although none were recorded at Orchard Ledges. Small numbers were also present at Peterstone and St. Brides at low tide.

3.5.5 Oystercatcher

Oystercatcher numbers were higher at Rhymney than in the previous winter, peaking at 506 on 13 February. Peaks at Taff/Ely (83 on 17 February) and Orchard Ledges (174 on 19 February) were similar to those in the previous winter, however. Few Oystercatchers were present at Taff/Ely at low tide. Those that did use the bay moved in from Orchard Ledges as the tide rose. As in previous years, further concentrations of Oystercatchers occurred at low tide at Peterstone and St. Brides.

3.5.6 Ringed Plover

Numbers of Ringed Plover were greater at all three sites than in the previous year, peaking at 57 on 24 August at Taff/Ely, at 15 the following day at Orchard Ledges and at 47 at Rhymney on 7 October. Taff/Ely was primarily used as a high tide roosting site, birds moving in from Orchard Ledges and other areas as the tide rose. No Ringed Plover were observed at low tide at either Peterstone or St. Brides.

3.5.7 Grey Plover

Numbers of Grey Plover have declined sharply at both Taff/Ely and Rhymney in recent years and in the 1997/98 winter only one bird was observed at Rhymney. Occasional large concentrations were found at low tide at Peterstone and St. Brides, however, numbers peaking at 170 on 28 January.

3.5.8 Lapwing

Lapwing were present at both Taff/Ely and Rhymney in the autumn and winter. Numbers were similar to those in previous years, peaking at 115 at the former site on 24 January and at 52 at the latter on 10 December. Small numbers of Lapwing were also present at St. Brides at low tide, although these were primarily roosting.

3.5.9 Knot

Knot numbers have declined at all sites in recent years and only occasional birds were seen at Taff/Ely and Orchard Ledges in the 1997/98 winter. Only occasional flocks were seen at

Rhymney too, numbers peaking at 140 birds on 19 February. A single flock of 21 Knot was recorded at low tide at St. Brides on 10 March.

3.5.10 Turnstone

Turnstone were present at all three main sites throughout the autumn, winter and spring. Numbers peaked at 26 at Taff/Ely on 11 October, at 181 at Orchard Ledges on 20 November and at 64 at Rhymney on 10 December. Numbers at these sites were similar to those recorded in recent years. A single flock of 14 Turnstone was recorded at St. Brides at low tide on 19 November.

3.6 Occasional Species

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 November 1997 to February 1998.

4. DISCUSSION AND CONCLUSIONS (DISTRIBUTION STUDIES)

The continued monitoring of the wader and wildfowl populations of Cardiff Bay and the northwest Severn has revealed much about the distributions and movements of the major species which winter in the area. The distribution of many species has changed from year to year, possibly in response to disturbance from work in the bay or due to other local factors. Populations also change annually as survival and recruitment rates vary. The long-term monitoring programme is providing an understanding of the 'natural' population and distributional changes of the waterfowl and will 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. It is essential to monitor any changes to the populations of waders and wildfowl during the completion of the Cardiff Bay barrage and subsequent flooding to determine what the final impact will be.

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

Shelduck (slight disturbance effect)

The numbers of Shelduck at Taff/Ely during winter 1997/98 were similar to those from the previous three winters. Their distribution seems to have been unaffected by the building of the barrage, having remained unchanged since before construction work began. Only mudflat 1, adjacent to the work on the coffer dam and lock system, was avoided.

Dunlin (likely disturbance effect)

Dunlin numbers have fallen at Taff/Ely since building work on the barrage started in 1994 and in the winter of 1997/98 levels of usage were at their lowest since the study began. Numbers were low throughout the bay, though particularly near the barrage on mudflats 2 and 17, probably due to disturbance from the building work. Numbers also fell sharply at Rhymney, although it is possible that this decline was part of a natural fluctuation in the population.

Curlew (slight disturbance effect)

In comparison to previous winters at Taff/Ely, few Curlew used mudflat 1 adjacent to the work on the coffer dam and lock system and mudflat 18 at the opposite end of the barrage. Mudflat 17, perhaps in consequence, had increased levels of usage in winter. Levels of usage at both Orchard Ledges and Rhymney during winter were marginally 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 levels of usage of both Cardiff Bay and Rhymney have declined significantly over the nine years of study. At Taff/Ely in 1997/98, Redshank avoided mudflats 1, 2, 5, 17 and 18 close to the barrage. Numbers increased, however, on mudflat 19 near the yacht club in the north-east of the bay. As in 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 Pochard have recently increased at Taff/Ely and, in particular, at Rhymney. At Taff/Ely, the species was concentrated on central mudflats along the River Taff away from the barrage work. Pintail numbers also rose in the winter of 1997/98 at Rhymney.

Oystercatcher numbers continued to increase at Rhymney, whilst Ringed Plover numbers increased at all three sites having been low the previous year. Grey Plover and Knot have both declined considerably at the all day sites and were rarely recorded in the 1997/98 winter.

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, Dunlin and Redshank. Continued monitoring in 1998/99 will help to determine the immediate movements of waterfowl from the bay following its permanent flooding in December. Future monitoring will be needed to determine whether adjacent areas have been able to accomodate those birds displaced from the bay.

PART 2: STUDIES OF THE WINTERING ECOLOGY OF REDSHANK

5. INTRODUCTION

Waders vary in their site-fidelity both between and within winters (Symonds *et al*. 1984; Rehfisch *et al*. 1996a). 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 the continuing 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*. 1996a; Insley *et al*. 1997) 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*. 1997), although this may vary between years and sites according to weather conditions and predation pressure (Cresswell & Whitfield 1994; Insley *et al*. 1997). Redshank suffer particularly high mortality in cold winters (Davidson 1982; Insley & Swann 1996).

This study of site-fidelity and survival builds on results obtained previously at Cardiff. These earlier colour-marking studies indicated that there was only limited interchange of Redshank between Cardiff Bay and Rhymney (whilst, in contrast, many Dunlin used both sites). Results from this year's study are discussed with particular reference to those obtained in 1996/97.

6. METHODS

6.1 Colour-Ringing

Redshank were caught by cannon- or mist-netting at high tide roosts at Cardiff Bay and at the Rhymney estuary. Each bird was aged according to its plumage characteristics (Prater *et al*. 1977) as either an adult or a first-winter bird. The majority of adults caught at Cardiff Bay, and those originally metal-ringed at Cardiff Bay and subsequently retrapped at Rhymney, were then given an unique combination of Darvic plastic colour-rings for subsequent identification in the field. On the first colour-ringing scheme used (from November 1994 to February 1995), three colours had to be determined on the left tibia and tarsus for an individual to be identified (two constant scheme colours of yellow over white additionally being placed on the right tibia). In contrast, on the second (used from October 1995), colours only had to be determined on the tibias (the constant scheme colours being placed on the right tarsus). Whilst information from birds ringed in both periods has been useful in determining the extent of Redshank movement between Cardiff Bay and Rhymney, recent analysis revealed that birds of the first scheme were identified comparatively infrequently, as rings on the tarsus were often covered with mud or water (Burton in press). In consequence, it was decided that the data from these individuals should not be used in the following study. In total, from October 1995 to December 1997, 114 adult Redshank had been individually colour-ringed at Cardiff Bay and a further 19 colour-ringed at Rhymney. In addition, four first-winter Redshank were colour-ringed at Cardiff Bay in the winter of 1996/97 and one in August 1997.

Dates of all colour-ringing at Cardiff Bay and Rhymney in the autumn of 1997 and the winter of 1997/98 are shown in Table 6.1.1.

6.2 Site-Fidelity Within Winter

To determine the fidelity of Redshank to Cardiff Bay during winter, both the bay and Rhymney were searched regularly for colour-ringed individuals from August 1997 to March 1998. The proportion of fieldwork days that an individual was sighted at each site over winter (1 October to 31 January) was calculated for those individuals seen at Cardiff Bay between August and October, and again the following February or March and thus known to be alive throughout the winter. These analyses only involved adults. The percentage of colour-ringed birds in samples of the population was also recorded at both Cardiff Bay and Rhymney whenever possible.

The coast to the east of Rhymney to the mouth of the River Usk was surveyed for colour-ringed individuals twice a month from November to March during the low tide period. Additonally, data were available from another study from partial searches of the estuary of the River Usk on 11 days between November 1997 and February 1998.

6.3 Site-Fidelity Between Winters and Survival

A minimum annual survival rate was calculated from 1 February 1997 to 31 January 1998. This was 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 was 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 after the end of that period. Over-summer return rates may underestimate actual survival as some individuals may move to a different wintering area after the breeding season, although few Redshank have been known to do so. The product of the over-summer return rate and the subsequent winter survival rate thus only provides a minimum annual survival estimate (see Metcalfe & Furness 1985; Burton & Evans 1997). As few first-year birds were colour-ringed, survival rates were only calculated for adults.

7. RESULTS

7.1 Site-Fidelity Within Winter

Sixty-four individually colour-ringed adult Redshank were seen at Cardiff Bay between August and October 1997 and again from February to March 1998 and were thus known to be alive throughout the defined winter period (1 October to 31 January). These individuals were seen on a median proportion of 0.185 of fieldwork days at Cardiff Bay (n = 27 days, range = 0-0.481), but significantly less often than at Rhymney (n = 14 days, range = 0-0.643) (Wilcoxon $z = 4.539$, $P < 0.001$). Only 13 (20%) of the 64 individuals were seen at Rhymney during the winter. However, five of these were actually never seen in the bay during this period and were probably resident at Rhymney.

Approximately 30% of Redshank at Cardiff Bay were individually colour-ringed in the winter of 1997/98 (Table 7.1.1), although this percentage varied as new birds were caught and marked. The comparatively low proportion of marked birds in the population at Rhymney emphasises individuals' fidelity to the bay - birds were only colour-ringed when caught at Cardiff Bay or if they had been previously metal-ringed there.

Only two colour-ringed Redshank were recorded during the low water surveys of the coast to the east of Rhymney, both at Peterstone in February and March 1998. One of these was originally colour-ringed in a study on breeding grounds in the Outer Hebrides (D. Jackson, pers. comm.) and was often seen at Rhymney in the winters of 1996/97 and 1997/98, but never at Cardiff Bay. The second, although originally metal-ringed in the bay, was colour-ringed at Rhymney (in December 1997). It too appeared to be resident at Rhymney during winter and was only once seen in the bay. No colour-ringed Redshank were recorded on the occasional surveys of the Usk estuary in the winter of 1997/98 (M. Armitage & S. Holloway, pers. comm.).

7.2 Site-Fidelity Between Winters and 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). Although in this study individual Redshank were seen, on average, only once every five to six fieldwork days during winter, considerably more time was spent each day on colour-ring searches in October and February, in order that all birds present after the end of the preceeding defined periods (summer and winter respectively) were sighted as soon as possible. Of those birds that were known to survive given periods, 85% were seen within a month of the end of those periods (n = 170). The frequent resighting of birds during winter suggests that most, if not all, Redshank used in the calculation of survival rates were local winter residents and not on passage to other wintering areas.

Of 48 adult Redshank observed at Cardiff in February 1997, 90% (95% confidence limits = 81-98%) returned after the defined summer period. Three of the four first-year Redshank that were colour-ringed in winter 1996/97 also returned for a second winter. Of 76 adult Redshank seen at Cardiff in October 1997, 96% (95% confidence limits = 91-100%) survived the winter and were present on the study site after 31 January 1998. The product of these rates gave a minimum annual survival rate of 86% (95% confidence limits = 76-95%). This

was slightly but insignificantly higher than the previous year's rate of 76% (95% confidence limits = 61-91%).

7.3 Controls and Recoveries of Metal- and Colour-Ringed Redshank

Six Redshank colour- or metal-ringed at Cardiff were reported from elsewhere in Britain during the study period (Table 7.3.1), most sightings probably involving breeding birds. In addition, two Redshank originally colour-ringed in the Outer Hebrides during the breeding season were sighted several times at Cardiff during the winter, and two Redshank metal-ringed elsewhere recovered at Rhymney (Table 7.3.2).

8. DISCUSSION (REDSHANK STUDIES)

8.1 Site-Fidelity Within Winter

Individually colour-ringed adult Redshank, present at Cardiff Bay in the autumn and spring, were seen in the bay, on average, once every five to six fieldwork days during winter and most were probably resident on the study site during this period. One individual seen in August and September 1997 and then again the following March, but not between, was probably on passage to and from other wintering grounds.

Only a proportion of each day was spent on these observations (on average 39 min per day over 39 days) and it is probable that these individuals were present in the bay on a far higher percentage of days than the above figure suggests. Most were seen at Rhymney only rarely. Indeed, only 13% (n = 30) were seen at Rhymney in 1996/97 and only 20% (n = 64) in 1997/98. Five individuals which were sighted regularly at Rhymney in the winter of 1997/98 were probably resident there and not in the bay.

No colour-ringed Redshank were seen to the east of Rhymney in the defined winter period, although two were seen at Peterstone in February and March 1998. A single, earlier report from Peterstone in late June 1995 was probably of a bird just returned from breeding grounds and still not settled on its wintering quarters. Other coastal wintering waders have previously been shown to be considerably more mobile in autumn and spring than in winter (Myers 1984; Metcalfe 1986).

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*. 1996a; Insley *et al*. 1997). Insley *et al*. (1997), for example, reported that, within winter, 65% of 3,656 retraps of adult Redshank were made at the same roost site.

8.2 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*. 1996a; Insley *et al*. 1997). Few studies, however, have calculated actual over-summer return rates of Redshank to their wintering quarters. Cresswell and 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 in 1996 and 90% in 1997. These figures only represent minimum survival rates for the period, as occasional individuals may change their wintering grounds between years (e.g. Mackie 1976; Spencer & Hudson 1982). One Redshank from Cardiff moved to Devon within the winter of 1991/92, although it is not known if it subsequently returned.

Winter survival rates too have not been reported before, although there have been a number of studies on the causes of winter mortality. Cresswell and Whitfield (1994) found that an exceptional 31 to 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 (Clark *et al*. 1993; Davidson 1981, 1982; Dugan *et al*. 1981; 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 (Nicoll & Summers 1980; Johnson 1982; Johnson 1985; Norman & Coffey 1994).

At Cardiff, there was only 4 to 7% mortality in adult Redshank over the four month winter period (from 1 October 1996 to 31 January). In comparison to Cresswell and Whitfield's (1994) study, predators were certainly scarce. Only seven 'Peregrine *Falco peregrinus* days' and five 'Sparrowhawk *Accipiter nisus* days' were recorded during 88 site-days of fieldwork over the two winters. Both species have been seen hunting Redshank at Cardiff, however, albeit unsuccesfully (see also Rehfisch *et al*. 1996b). Although Merlins *F. columbarius* were recorded on the coast immediately to the east in winter, they were seen at Cardiff only twice, each time in early spring. Kestrels *F. tinnunculus* were much more numerous, but are only occasionally known to attempt to kill full-grown Redshank (Whitfield 1985; Cresswell & Whitfield 1994) and indeed seldom prey on anything so large (Village 1990). Foxes *Vulpes vulpes*, which were occasionally seen around the bay at night and once near a high tide roost in the daytime, may have been more common predators.

Both the 1996/97 and 1997/98 winters were also relatively mild and were thus unlikely to have caused increased mortality. The cold weather of early January 1997 was perhaps too short to have affected many species of wader, although effects have yet to be documented. In previous such episodes Redshank mortality has been greater on eastern coasts of the UK (Clark *et al*. 1993; Davidson 1982; Davidson & Clark 1985; Norman & Coffey 1994).

The effects of cold winter weather may be seen in the annual survival rates of Redshank. Insley *et al*. (1997) 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*. (1997) 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 and Hale (1993) reported rates of 75% and 72% for males and females respectively and Jackson (1988) similarly reported rates of 77% and 75%. Annual survival rates for adult Redshank at Cardiff were 76% in 1996/97 and 86% in 1997/98.

ACKNOWLEDGEMENTS

Thanks are due to Steve Dodd, Graham Couchman, Peter Ferns and other members of local ringing groups for their help in the catching, ringing and colour-marking of waders. Mike Armitage also gave valuable support whilst on fieldwork.

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

Nicola Read and other secretarial staff gave considerable assistance in the completion of this report.

The continuing study of the waterfowl of Cardiff Bay was funded by Cardiff Bay Development Corporation.

REFERENCES

Bainbridge, I.P. & Minton, C.D.T. (1978) The migration and mortality of the Curlew in Britain and Ireland. *Bird Study*, **25**, 39-50.

Burton, N.H.K. (In press) Variation in sighting frequencies of colour-ringed Redshanks *Tringa totanus*, according to ringing-scheme and ring colour. *Wader Study Group Bulletin*.

Burton, N.H.K. & Evans, P.R. (1997) Survival and winter site-fidelity of Turnstones *Arenaria interpres* and Purple Sandpipers *Calidris maritima* in north-east England. *Bird Study*, **44**, 35-44.

Burton, N.H.K., Toomer, D.K., Balmer, D.E., Rehfisch, M.M. & Clark, N.A. (1997a) *The Effect of the Cardiff Bay Barrage on Waterfowl Populations: 7. Distribution and Movement Studies, August 1995 - May 1996*. BTO Research Report No. 174 to Cardiff Bay Development Corporation.

Burton, N.H.K., Armitage, M.J.S, Rehfisch, M.M. & Clark, N.A. (1997b) *The Effect of the Cardiff Bay Barrage on Waterfowl Populations: 8. Distribution and Movement Studies, August 1996 - May 1997*. BTO Research Report No. 183 to Cardiff Bay Development Corporation.

Clark, J.A., Baillie, S.R., Clark, N.A. & Langston, R.H.W. (1993) *Estuary Wader Capacity following Severe Weather Mortality*. BTO Report No. 103 to the Department of Trade and Industry's Renewable Energy Research and Development Programme (ETSU TID 4113).

Cranswick, P.A., Waters, R.J., Musgrove, A.J. & Pollit, M.S. (1997) *The Wetland Bird Survey 1995-1996: Wildfowl and Wader Counts.* BTO/WWT/RSPB/JNCC.

Cresswell, W. & Whitfield, D.P. (1994) The effects of raptor predation on wintering wader populations at the Tyninghame estuary, southeast Scotland. *Ibis*, **136**, 223-232.

Davidson, N.C. (1981) Survival of shorebirds (Charadrii) during severe weather: the role of nutritional reserves. In: Jones, N.V. & W.J. Wolff (eds.), *Feeding and Survival Strategies of Estuarine Organisms*. Plenum Press, New York.

Davidson, N.C. (1982) Changes in the body condition of Redshanks during mild winters: an inability to regulate reserves? *Ringing & Migration*, **4**, 51-63.

Davidson, N.C. & Clark, N.A. (1985) The effects of severe weather in January and February 1985 on waders in Britain. *Wader Study Group Bulletin*, **44**, 10-16.

Davidson, N.C. & Evans, P.R. (1982) Mortality of Redshank and Oystercatcher from starvation during severe weather. *Bird Study*, **29**, 183-188.

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

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

Dugan, P.J. (1981) Seasonal movements of shorebirds, in relation to spacing behaviour and prey availability. Unpubl. Ph.D. thesis, University of Durham.

Dugan, P.J., Evans, P.R., Goodyer, L.J. & Davidson, N.C. (1981) Winter fat reserves in shorebirds: disturbance of regulated levels by severe weather conditions. *Ibis*, **123**, 359-363.

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

Evans, P.R. (1981) Migration and dispersal of shorebirds as a survival strategy. In: Jones, N.V. & W.J. Wolff (eds.), *Feeding and Survival Strategies of Estuarine Organisms*. Plenum Press, New York.

Furness, R.W. & Galbraith, H. (1980) Numbers, passage and local movements of Redshanks *Tringa totanus* on the Clyde estuary as shown by colour-marking. *Wader Study Group Bulletin*, **29**, 19-22.

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

Goss-Custard, J.D. (1985) Foraging behaviour of wading birds and the carrying capacity of estuaries. In: Sibly, R.M. & R.H. Smith (eds.), *Behavioural Ecology: Ecological Consequences of Adaptive Behaviour*. Blackwell Scientific Publications, Oxford.

Harris, M.P. & Calladine, J. (1993) A check on the efficiency of finding colour-ringed Kittiwakes *Rissa tridactyla*. *Ringing & Migration*, **14**, 113-116.

Insley, H., Peach, W., Swann, B. & Etheridge, B. (1997) Survival rates of Redshank *Tringa totanus* wintering on the Moray Firth. *Bird Study*, **44**, 277-289.

Insley, H. & Swann, R. (1996) Moray Firth Redshank crash as Dunlin survive the cold spell. *BTO News*, **203**, 8.

Jackson, D.B. (1988) Habitat selection and breeding ecology of three species of waders in the Western Isles of Scotland. Unpubl. DPhil. thesis, University of Durham.

Jackson, D.B. (1994) Breeding dispersal and site-fidelity in three monogamous wader species in the Western Isles, U.K. *Ibis*, **136**, 463-473.

Johnson, C. (1985). Patterns of seasonal weight variation in waders on the Wash. *Ringing and Migration*, **6**, 19-32.

Johnson, G. (1982) Seasonal variation in wader weights in north Wales. *SCAN Ringing Group Annual Report*, 1981/82, 45-55.

Mackie, P. (1976) A short note on Redshank in the upper Clyde estuary. *Wader Study Group Bulletin*, **17**, 5-10.

Metcalfe, N.B. (1986) Variation in winter flocking associations and dispersal patterns in the Turnstone *Arenaria interpres*. *J. Zool. Lond.*, **209**, 385-403.

Metcalfe, N.B. & Furness, R.W. (1985) Survival, winter population stability and site fidelity of the Turnstone *Arenaria interpres.* *Bird Study*, **32**, 207-214.

Myers, J.P. (1984) Spacing behavior of non-breeding shorebirds. In: Burger, J. & B.L. Olla (eds.), *Behavior of Marine Animals, Vol. 6: Shorebirds: Migration and Foraging Behaviour*. Plenum Press, New York.

Nicoll, M. & Summers, R.W. (1980) A study of Redshanks in eastern Scotland. *Tay Ringing Group Report*, 1978-79, 19-26.

Norman, D. & Coffey, P. (1994) The importance of the Mersey estuary for waders in the cold weather of February 1991. *Ringing and Migration*, **15**, 91-97.

Pienkowski, M.W. & Clark, H. (1979) Preliminary results of winter dye-marking on the Firth of Forth, Scotland. *Wader Study Group Bulletin*, **27**, 16-18.

Pirot, J.Y., Laursen, K., Madsen, J. & Monval, J-Y. (1989) Population estimates of swans, geese, ducks and Eurasian Coot *Fulica altra* in the Western Palaeartic and Sahelian Africa. In: Boyd, H. & J.Y. Pirot (eds.), *Flyways and reserve networks for water birds*. International Waterfowl and Wetlands Research Bureau Special Publication **9**, Slimbridge.

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

Prater, A.J., Marchant, J.H. & Vuorinen, J. (1977) *Guide to the Identification and Ageing of Holarctic Waders*. BTO, Tring.

Reed, T. (1985) Estimates of British breeding wader populations. *Wader Study Group Bulletin*, **45**, 11-12.

Rehfisch, M.M., Clark, N.A., Langston, R.H.W. & Greenwood, J.J.D. (1996a) A guide to the provision of refuges for waders: an analysis of thirty years of ringing data from the Wash, England. *J.Appl.Ecol.*, **33**, 673-687.

Rehfisch, M., Toomer, D. & Browne, S. (1996b) Responses of Common Redshanks to attacks by Peregrine Falcons. *Brit. Birds*, **89**, 315-316.

Roberts, G. (1991) Winter movements of Sanderlings *Calidris alba* between feeding sites. *Acta Oecol.*, **12**, 281-294.

Smit, C.J. & Piersma, T. (1989) Numbers, midwinter distribution and migration of wader populations using the East Atlantic flyway. In: Boyd, H. & J.Y. Pirot (eds.), *Flyways and reserve networks for water birds*. International Waterfowl and Wetlands Research Bureau Special Publication **9**, Slimbridge.

Smith, K.W., Reed, J.M. & Trevis, B.E. (1992) Habitat use and site-fidelity of Green Sandpipers *Tringa ochropus* wintering in Southern England. *Bird Study*, **39**, 155-164.

Spencer, R. & Hudson, R. (1982). Report on bird-ringing for 1981. *Ringing & Migration*, **4**, 65-128.

Stone, B.H., Sears, J., Cranswick, P.A., Gregory, R.D., Gibbons, D.W., Rehfisch, M.M., Aebischer, N.J. and Reid, J.B. (1997) Population estimates of birds in Britain and in the United Kingdom. *British Birds*, **90**, 1-22.

Stroud, D.A., Reed, T.M., Pienkowski, M.W. & Lindsay, R.A. (1987) *Birds, Bogs and Forestry. The Peatlands of Caithness and Sutherland*. NCC, Peterborough.

Summers, R.W., Nicoll, M., Underhill, L.G., & Petersen, A. (1988) Methods for estimating the proportions of Icelandic and British Redshanks *Tringa totanus* in mixed populations wintering on British coasts. *Bird Study*, **35**, 169-180.

Symonds, F.L., Langslow, D. & Pienkowski, M.W. (1984) Movements of wintering shorebirds within the Firth of Forth: species differences in usage of an intertidal complex. *Biological Conservation*, **28**, 187-215.

Thompson, P.S. & Hale, W.G. (1989) Breeding site fidelity and natal philopatry in the Redshank *Tringa totanus*. *Ibis*, **131**, 214-224.

Thompson, P.S. & Hale, W.G. (1993) Adult survival and numbers in a coastal breeding population of Redshank *Tringa totanus* in northwest England. *Ibis*, **135**, 61-69.

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

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

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

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

Toomer, D.K., Browne, S.J. & Clark, N.A. (1994) *The Effect of the Cardiff Bay Barrage on Waterfowl Populations: 5. Distribution and Movement Studies, August 1993 - May 1994*. BTO Research Report No. 146 to Cardiff Bay Development Corporation.

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

Toomer, D.K., Balmer, D.E., Rehfisch, M.M. & Clark, N.A. (1995) *The Effect of the Cardiff Bay Barrage on Waterfowl Populations: 6. Distribution and Movement Studies, August 1994 - May 1995*. BTO Research Report No. 161 to Cardiff Bay Development Corporation.

Village, A. (1990) *The Kestrel*. T & AD Poyser, London.

Voous, K.H. (1973) A list of recent Holarctic species. Non-passerines. *Ibis*, **115**, 612-638.

Waters, R.J., Cranswick, P.A., Evans, J. & Pollitt, M.S. (1996) *The Wetland Bird Survey 1994-95: Wildfowl and Wader Counts*. BTO/WWT/RSPB/JNCC.

Whitfield, D.P. (1985) Raptor predation on wintering waders in southeast Scotland. *Ibis*, **127**, 544-558.

Zhmud, M. Ye (1992) Territorial relations and population structure of the Redshank *Tringa totanus* during the nesting period in the south of Ukraine. *Wader Study Group Bulletin*, **64**, 45-46.

Species	Level for International Importance	Level for National Inportance	Importance of Severn Estuary (winter 1995/96)	Maximum WeBS count at Cardiff Bay (winter 1997/98)
Shelduck *Tadorna tadorna*	2500	750	International	191
Teal *Anas crecca*	4000	1400	National	81
Mallard *Anas platyrhynchos*	20000	5000	-	86
Pintail *Anas acuta*	700	280	National	0
Pochard *Aythya ferina*	3500	440	National	20
Oystercatcher *Haematopus ostralegus*	9000	3600	-	108
Ringed Plover *Charadrius hiaticula*	500	290	-	38
Grey Plover *Pluvialis squatarola*	1500	430	National	0
Lapwing *Vanellus vanellus*	20000	20000	National	12
Knot *Calidris canutus*	3500	2900	-	5
Dunlin *Calidris alpina*	14000	5300	International	3000
Curlew *Numenius arquata*	3500	1200	International	114
Redshank *Tringa totanus*	1500	1100	International	250
Turnstone *Arenaria interpres*	700	640	-	48

Table 2.3.1 The importance of the Severn Estuary and Cardiff Bay for waterfowl in a British and international 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*. 1997).

	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Taff/Ely										
Mute Swan *Cygnus olor*			1							
Goosander *Mergus merganser*	1	1		2	5	5	14	7	2	
Ruff *Philomachus pugnax*									1	
Black-tailed Godwit *Limosa limosa*				3						
Whimbrel *Numenius phaeopus*	2								7	
Spotted Redshank *Tringa erythropus*								1		
Greenshank *Tringa nebularia*									1	
Common Sandpiper *Actitis hypoleucos*		2								
Orchard Ledges										
Whimbrel					1				1	
Rhymney										
Canada Goose *Branta canadensis*								5		
Tufted Duck *Aythya fuligula*					125	36	40			
Scaup *Aythya marila*				2	6		2			
Curlew Sandpiper *Calidris ferruginea*			1							
Bar-tailed Godwit *Limosa lapponica*		1	38				1			
Whimbrel									2	
Common Sandpiper	1		1							

Table 3.6.1 The maximum numbers of wildfowl and waders seen only occasionally at Cardiff during all day counts, 1997/98, and not included in the separate species accounts.

Date	Site	Number colour-ringed
28/7/97	Cardiff Bay	21
2/8/97	Rhymney	6
26/8/97	Cardiff Bay	8
6/11/97	Cardiff Bay	3
2/12/97	Rhymney	3
13/12/97	Rhymney	1
20/12/97	Cardiff Bay	5

Table 6.1.1 Dates of Redshank colour-ringing at Cardiff Bay and at Rhymney during winter 1997/98.

Date	Site	Percentage scheme-marked (*n*)	Percentage individually colour-ringed (*n*)	Sample size
25/8/97	Cardiff Bay	8.2 (4)	34.7 (17)	49
8/9/97	Cardiff Bay	15.2 (5)	27.3 (9)	33
15/12/97	Cardiff Bay	7.7 (4)	36.5 (19)	52
22/1/98	Cardiff Bay	15.6 (5)	46.9 (15)	32
17/2/98	Cardiff Bay	1.9 (1)	18.5 (10)	54
19/2/98	Cardiff Bay	1.3 (1)	30.3 (23)	76
7/3/98	Cardiff Bay	6.7 (3)	31.1 (14)	45
25/8/97	Rhymney	2.9 (3)	1.0 (1)	104
28/8/97	Rhymney	2.9 (1)	2.9 (1)	34
11/9/97	Rhymney	3.2 (2)	6.3 (4)	63
14/11/97	Rhymney	3.9 (3)	3.9 (3)	76
10/12/97	Rhymney	2.1 (2)	7.4 (7)	95
13/12/97	Rhymney	0	7.7 (3)	39
25/1/98	Rhymney	8.3 (6)	2.8 (2)	72
5/3/98	Rhymney	2.0 (1)	10.2 (5)	49

Table 7.1.1 Estimates of the percentages of colour-ringed birds in the Redshank populations at Cardiff Bay and Rhymney from August 1997 to March 1998.

Metal-ringed or individually or scheme colour-ringed	Ring number	Date ringed	Date observed / recovered	Location
Metal	DR96370	20/1/91	3/5/97	Druridge Pools, Northumberland
Individual	DN54908	19/12/95	17/9/97	Conwy estuary, Gwynedd
Scheme	Unknown		24-25/5/97	Messingham, Lincolnchire
Individual	Unknown		6/97	Loch Bhasapol, Tiree, Strathclyde
Individual	DK10667	21/9/94	1 & 16/4/98	Frampton, Gloucestershire
Scheme	Unknown		16/4/97	Peterstone

Table 7.3.1 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 / recovered	Location
DN34895	18/4/87	Findhorn Bay, Grampian	11/12/96	Rhymney
DS65868	29/7/95	Ogwen estuary, Gwynedd	29/10/96	Rhymney
DN83751	1986	South Uist, Western Isles	8/9/97, 14/12/97,17/2/98, 19/2/98, 5/3/98 & 11/3/98	Cardiff Bay
			11/9/97, 10/10/97, 13/10/97, 14/11/97 & 23/1/98	Rhymney
Unknown	8/6/96	South Uist, Western Isles	11/9/97, 7/10/97, 10/10/97, 14/11/97, 10/12/97, 12/12/97 & 13/12/97	Rhymney
			18/2/98 & 10/3/98	Peterstone

Table 7.3.2 Sightings at Cardiff of Redshank colour-ringed elsewhere and recoveries of Redshank metal-ringed elsewhere.