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The Effect of the Cardiff Bay Barrage on Waterfowl Populations 10. Distribution and Movement Studies August 1998-May 1999

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CONTENTS

LIST OF TABLES

Page No.

LIST OF FIGURES

Page No.

Page No.

EXECUTIVE SUMMARY

1. This report presents the results of the tenth 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 1998/99. Results from autumn (August-October 1998) and spring (April-May 1999) have been analysed, but are not presented here in this short report. The programme of monitoring closely followed that used for the previous nine years, allowing direct comparisons to be made between results from each year.

2. Following the expected completion of the amenity barrage in November 1999, 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 north-west Severn from Cardiff Bay to the Usk Estuary revealed only minor changes in the number and distribution of birds since 1997/98.

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. These species avoided mudflats close to the mouth of the bay (particularly mudflats 2, 5 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 10 years.

5. With three years of intensive study of colour-ringed Redshank it has been possible to use more robust methods than previously in the calculation of survival estimates. These methods have indicated that 91% and 100% of colour-ringed adult Redshank survived the winters of 1996/97 and 1997/98 respectively. Return rates of 89% and 83% were estimated over the two following summers, indicating site-fidelity between winters. Annual survival rates, calculated as the product of the winter survival and over-summer return rates, were 81% and 83%. These results will help to determine whether the loss of the bay results in increased mortality in the population.

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 1998 and May 1999 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 continued to connect the two sides of the barrage and to allow lorries to cross.

- On the eastern side of the bay, where there was continued earth deposition at the edge of mudflat 18.

- 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 the building of a hotel was completed 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, had previously resulted in the loss of approximately 1 ha each to mudflats 3 and 7. There was some siltation at the mouth of the bay, although no appreciable change in mudflat areas.

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 north-west 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, 1998).

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 summarises the results of the 10th 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 nine years' monitoring of the wader and wildfowl populations of Cardiff Bay and nearby areas were given by Evans *et al*. (1990), Donald and Clark (1991b), Toomer and Clark (1992a), Toomer *et al*. (1993, 1994, 1995) and Burton *et al*. (1997a, 1997b, 1998).

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 1998/99. 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 1997/98 winter (Cranswick *et al*. 1999).

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 1998 and May 1999. The findings are compared with results from the previous nine years (Evans *et al*. 1990; Donald & Clark 1991a; Toomer & Clark 1992b; Toomer *et al*. 1993, 1994; Burton *et al*. 1997a, 1997b, 1998).

With 10 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-March) when bird populations tended to be at their greatest and when they were also most stable. Results from the autumn (August-October) and spring (April-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 tenth year of study were similar to those in the nine 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). The sizes of the mudflats at Taff/Ely were similar to those in the previous year. At Rhymney, building work also caused some disturbance to birds on mudflats 2, 3 and 17.

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 - October 1998), winter (November 1998 - March 1999) and spring (April - May 1999). 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 1991a; 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:

$$\sum_{A=+5}^{A=-6}(B \times C)$$

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 north-west 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 nine years of study were reported in Evans *et al*. (1990), Donald & Clark (1991b), Toomer & Clark (1992a), Toomer & Clark (1993), Toomer *et al*. (1994) and Toomer *et al*. (1995) and Burton *et al*. (1997a, 1997b, 1998). 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 nine.

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*. 1999; Table 2.3.1). Accounts concentrate on the winter of 1998/99. 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 (1995/96, 1996/97 and 1997/98). The results are considered in relation to the changes that have occurred to the sites during the nine 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 with a peak WeBS count of 74,000 in 1997/98 (Cranswick *et al*. 1999). 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 north-west 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 north-west 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. Shelduck continued to use mudflats close to the mouth of the bay at a low level, in spite of the continuing building work there.

Groups of up to 53 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, all areas but mudflat 1 were 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 307 Shelduck was recorded at Taff/Ely on 26 January. 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 were higher than in the previous two years. A peak of 1,309 was recorded there on 16 December.

There has been no clear trend in the summed usage of the three sites over the 10 winters of study (r_s = 0.188, n = 10, not significant (ns); Figure 3.1.5). Similarly, there has been no trend in the usage of Cardiff Bay alone (r_s = 0.115, n = 10, ns). No trend in wintering numbers has been seen in Britain as a whole over the same period (Cranswick *et al*. 1999). The mean feeding usage density of Shelduck at Cardiff Bay was slightly lower than that at Rhymney (7.7 bird hours per tidal cycle per hectare, compared with 9.5).

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. The peak count of Dunlin recorded by WeBS in Great Britain was 460,000 in 1997/98 (Cranswick *et al*. 1999). The Severn Estuary holds internationally important numbers of Dunlin during the winter.

Large numbers of feeding Dunlin were recorded along the north-west Severn during low tide counts (Figure 3.2.1). Birds were present on almost all mudflats, with the highest concentrations at St. Brides. 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 (Figure 3.2.2). The distribution of feeding Dunlin was similar to those seen in previous winters, although numbers were at their lowest since work began.

A maximum of 55 Dunlin were seen at Orchard Ledges on 7 January, 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 1-6 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 786 Dunlin was recorded also on 7 January. At Rhymney, Dunlin numbers were relatively stable over the low tide period (Figure 3.2.4c). Numbers were lower than in the previous winter, with a peak of 3,395 on 25 November.

There has been no trend in the summed usage of the three sites over the nine year study period ($r_s = -0.321$, $n = 10$, ns; Figure 3.2.5), although there has been a decline in the usage of Cardiff Bay alone ($r_s = -0.721$, $n = 10$, $P < 0.05$). The usage of Rhymney also fell sharply between 1997/98 and 1998/99. In contrast, there has been no trend in wintering numbers in Britain as a whole (Cranswick *et al*. 1999). The mean feeding usage density of Dunlin at Cardiff Bay remained low in comparison to that at Rhymney (3.6 bird hours per tidal cycle per hectare, compared with 11.7).

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). The peak count of Curlew recorded by WeBS in Great Britain was 91,000 in 1997/98 (Cranswick *et al*. 1999), an increase on the previous year. The Severn Estuary currently holds nationally important numbers of Curlew during winter, although was formerly of international importance for the species.

Low tide counts of feeding Curlew showed that they were very widespread along the north-west Severn (Figure 3.3.1). The highest concentrations were found at the mouth of the River Usk and at Peterstone. 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 distribution of feeding Curlew was similar to that seen in the three previous winters, although levels of usage fell on mudflats 2 and 5, probably due to barrage work.

Curlew numbers at Orchard Ledges in the winter of 1998/99 were similar to those in the previous year. At Rhymney, an increasing number was seen on mudflat 4 but elsewhere numbers were lower (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). At Rhymney numbers peaked one hour after low tide (Figure 3.3.4c). Curlew numbers peaked at 161 at Taff/Ely in the autumn, when the local population was supplemented by passage birds. Peaks of 76 and 106 were recorded during winter at Orchard Ledges and Rhymney respectively. Numbers were similar to those in the previous winter at all three sites.

The summed usage of the three sites was lower than in 1997/98, but has shown no clear trend over the study period ($r_s = -0.188$, $n = 10$, ns; Figure 3.3.5). There has also been no overall trend in the usage of Cardiff Bay alone ($r_s = -0.515$, $n = 10$, ns). No trend in wintering numbers has been seen in Britain as a whole over the same period (Cranswick *et al*. 1999). In 1998/99, the mean feeding usage density of Curlew at Cardiff Bay was greater than that at either Orchard Ledges or Rhymney (1.1 bird hours per tidal cycle per hectare, compared with 0.9 and 0.4 respectively).

3.4 Redshank *Tringa totanus*

A total of 30,000-34,000 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). The peak count of Redshank recorded by WeBS in Great Britain was 84,000 in 1997/98 (Cranswick *et al*. 1999). The Severn Estuary is internationally important for Redshank in winter.

The majority of feeding Redshank observed on the north-west 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).

At the Taff/Ely the majority of feeding Redshank found at the north of the site (Figure 3.4.2). Those mudflats adjacent to the River Taff held the highest numbers. The overall levels of usage were similar to those in the three previous winters. However, no Redshank fed on mudflats 2 and 5 and few on mudflats 17 and 18, close to the barrage work.

No Redshank were seen at Orchard Ledges in winter. At Rhymney, Redshank were found on

almost all mudflats with the highest level of usage occurring to the east of the Cardiff Eastern Sewer (Figure 3.4.3). The distribution of Redshank at Rhymney was similar to previous winters, although numbers were slightly higher than in 1997/98. In that winter 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 344 Redshank was observed at Taff/Ely on 12 September when the local population was supplemented by passage birds. Two peaks in numbers also occurred at Rhymney, two 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. A peak of 625 Redshank was observed on 25 November, an increase on the previous winter.

The usage of both sites has declined significantly since 1989/90 (for Taff/Ely: $r_s = -0.794$, $n = 10$, $P < 0.01$; for Rhymney: $r_s = -0.818$, $n = 10$, $P < 0.01$; for both sites combined: $r_s = -0.867$, $n = 10$, $P < 0.01$; Figure 3.4.5). In Britain as a whole, however, numbers have remained stable over this period (Cranswick *et al*. 1999). 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 2.9), 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 127 at the former site on 15 December and at 83 at the latter on 15 August. Only occasional Mallard were observed at Orchard Ledges. Further large concentrations were present at low tide at St. Brides. Numbers were slightly lower than those recorded in 1997/98.

3.5.2 Teal

Teal numbers were greatest at Taff/Ely, where numbers peaked at 121 on 12 January. Although only a maximum of nine 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 slightly higher than in the 1997/98 winter, peaking at 370 on 17 December. Large concentrations also occurred at low tide at Peterstone and St. Brides.

3.5.4 Pochard

Numbers of Pochard have risen at Rhymney in recent years and in 1998/99 a peak of 173 was recorded in January. Up to 48 were also present at Taff/Ely, an increase from 1997/98, and five

were recorded in February at Orchard Ledges. Small numbers were also present at Peterstone and St. Brides at low tide.

3.5.5 Oystercatcher

Oystercatcher numbers in 1998/99 were similar to those at Rhymney in the previous winter, peaking at 467 on 8 September. Peaks at Taff/Ely (121 on 9 March) and Orchard Ledges (246 on 5 February) were higher than 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 at Taff/Ely and Orchard Ledges were similar to those in the previous year, peaking at 45 on 13 October and at 20 the preceding day respectively. Fewer were observed at Rhymney where there was a peak count of 15. Taff/Ely was primarily used as a high tide roosting site, birds moving in from Orchard Ledges and other areas as the tide rose. Occasional Ringed Plover were also observed at low tide at St. Brides, but none were recorded at Peterstone.

3.5.7 Grey Plover

Numbers of Grey Plover have declined sharply at both Taff/Ely and Rhymney in recent years and in the 1998/99 winter only occasional single birds were observed at the former site and three at the latter. Occasional large concentrations were found at low tide at Peterstone and St. Brides, however, numbers peaked at 137 on 19 December.

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 73 at the former site on 27 November and at 96 at the latter on 9 January. 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 although 240 were seen on 25 November at Rhymney, only occasional birds were seen at Taff/Ely and Orchard Ledges. A flock of 300 Knot was recorded at low tide at St. Brides in January, but otherwise numbers were low both there and at Peterstone.

3.5.10 Turnstone

Turnstone were present at all three main sites throughout the autumn, winter and spring. Numbers peaked at 12 at Taff/Ely on 27 November, at 135 at Orchard Ledges on 13 October and at 12 at Rhymney on 25 November. Numbers at these sites were slightly lower than those recorded in 1997/98. A single flock of 18 Turnstone was recorded at St. Brides at low tide on 31

January.

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 70 Black-tailed Godwit *Limosa limosa* which were present at Rhymney in April 1999.

4. DISCUSSION AND CONCLUSIONS (DISTRIBUTION STUDIES)

The continued monitoring of the wader and wildfowl populations of Cardiff Bay and the north-west 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, partly in response to disturbance from work in the bay. Populations also change annually as survival and recruitment rates vary. The long-term monitoring programme has provided 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 continue to monitor changes to the populations of waders and wildfowl after closure of the Cardiff Bay barrage to determine the effect of the barrage on bird populations.

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

Shelduck (slight disturbance effect)

The numbers of Shelduck at Taff/Ely during winter 1998/99 were similar to those in 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. As in other recent winters, only low numbers used mudflat 1, adjacent to the work on the coffer dam and lock system.

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 1998/99 levels of usage were at their lowest since the study began. Numbers were low throughout the bay, though particularly near the barrage on mudflats 1, 2, 5 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 fluctuations in the Dunlin numbers wintering on the Severn.

Curlew (likely disturbance effect)

In comparison to previous winters at Taff/Ely, many fewer Curlew used mudflats 2 and 5 close to the work on the coffer dam and lock system. Mudflat 6, perhaps in consequence, had increased levels of usage during this winter. Levels of usage at both Orchard Ledges and Rhymney during winter were similar to those in the previous winter.

The level of usage of Cardiff Bay was at its lowest since 1991/92. In that winter, low numbers were perhaps a result of 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 10 years of study. At Taff/Ely in 1998/99, Redshank avoided mudflats 1, 2, 4, 5, 6 and 17 close to the barrage. Numbers increased, however, on mudflats 15, 16 and 18 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 numbers were slightly higher than in the previous year.

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 1998/99 at Rhymney.

Oystercatcher numbers increased slightly at Taff/Ely in 1998/99. In contrast, Grey Plover and Knot have both declined considerably at the all-day sites and were rarely recorded in the 1998/99 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, Curlew and Redshank. Continued monitoring in 1999/2000 will help to determine the immediate movements of waterfowl from the bay following its flooding in November. Future monitoring will be needed to determine whether adjacent areas have been able to accommodate those birds displaced from the bay.

PART 2: STUDIES OF THE WINTERING ECOLOGY OF REDSHANK

5. INTRODUCTION

The impact of habitat loss on local bird populations is largely dependent upon the availability of suitable habitat elsewhere and how close these alternative sites are to their carrying capacity (Goss-Custard 1985). The effects may also vary between species due to their site-faithfulness. Wader species, such as Sanderling *Calidris alba,* which regularly move between sites to exploit varying food resources (Evans 1981, Myers 1984, Roberts 1991), may be less affected by the loss of any one site. However, more site-faithful species, such as Turnstone and Purple Sandpiper *C. maritima* (Metcalfe & Furness 1985, Burton & Evans 1997) could be at greater risk. A previous study (McClusky *et al*. 1992) suggested that the effects of habitat loss on a local Redshank population were initially delayed, as birds remained faithful to neighbouring (though formerly less favoured) areas. In the longer term, such a population would be greatly threatened, unless these alternative sites were below their carrying capacity for the species and thus were able to support additional birds.

This chapter investigates the survival rates of Redshank at Cardiff Bay. After three years of study it has been possible to reanalyse data from the winters of 1996/97 and 1997/98 (Burton *et al*. 1998) using more robust methods. The results presented will help to determine whether the loss of the bay results in increased mortality in the population. Previous studies have shown that annual survival in Redshank 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).

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 from November 1994 to March 1999. Each bird was aged according to its plumage characteristics (Prater *et al*. 1977) as either adult or first-year. The majority of adults caught at Cardiff Bay and those originally metal-ringed at Cardiff Bay and subsequently retrapped at Rhymney were then given unique combinations of Darvic plastic colour-rings for subsequent field identification. 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). Subsequent analysis revealed that birds of the first scheme were identified less frequently, as rings on the tarsus were often covered with mud or water (Burton in press). To avoid any bias, it was decided that these individuals should not be used in the following study.

Dates of all colour-ringing at Cardiff Bay and Rhymney in the autumn of 1998 and the winter of 1998/99 are shown in Table 6.1.1. Approximately 40% of the Redshank present at Cardiff Bay in the winter of 1998/99 were individually colour-ringed (Table 6.1.2), 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.

6.2 Site-Fidelity between Winters and Survival

Estimates of survival and return rates of adult Redshank were calculated using mark-recapture methods. Cardiff Bay and Rhymney were searched extensively for colour-ringed Redshank (originally caught and ringed in the bay) twice a year, in February and October, from February 1996 to February 1999. With three years of data it has been possible to use more robust methods in the calculation of survival estimates. A Cormack-Jolly-Seber (CJS) model (Seber 1982; Lebreton *et al*. 1992) was used to estimate local winter survival (ϕ_{wt}) (1 October to 31 January) and the over-summer return rate to the study site (ϕ_{st}) (1 February to 30 September, covering migrations from and back to the study area and the breeding season), as well as resighting probabilities (p_t) in each survey period 't'. Annual survival was calculated as the product of ϕ_{wt} and ϕ_{st} in each of two years (1996/97 and 1997/98). ϕ_{st} may underestimate actual survival as some individuals may move to different wintering areas after the breeding season. The product of ϕ_{wt} and the subsequent ϕ_{st} may thus underestimate annual survival.

7. RESULTS

7.1 Site-Fidelity between Winters and Survival

A total of 119 adult Redshank (originally colour-ringed at Cardiff Bay) was used in the survival analysis. The number of colour-ringed birds seen increased from 26 in February 1996 to 124 in February 1999 (the latter including 40 previously 'unseen' birds which could not be used in the analysis). The validity of the CJS model depends upon the equal catchability (or in this case 'sightability') of each marked individual. Leslie's Test (Seber 1982) indicated that there was no significant difference in the frequency of sighting of those Redshank known to be alive over the period from October 1996 to October 1998, *i.e.* that for which survival estimates are presented ($\chi^2 = 24.26$, df = 17, ns).

CJS estimates of over-summer return and survival rates (ϕ_t) and resighting probabilities (p_t) are shown in Table 7.1.1. Resighting probabilities increased after February 1997 and thereafter *c.* 90% of the colour-marked population was seen in each survey period. Over 82% of adults returned to Cardiff in each of the two years. Adult winter mortality was estimated at 9% in the first year and was negligible in the second. Resultant estimates of annual survival were thus over 80% in each of the two years.

7.2 Controls and Recoveries of Colour-Ringed Redshank

Six Redshank colour-metal-ringed at Cardiff were reported from elsewhere in Britain during the study period (Table 7.2.1), most sightings probably involving breeding birds. In addition, three Redshank originally colour-ringed in the Outer Hebrides during the breeding season were sighted several times at Cardiff during the winter (Table 7.2.2).

8. DISCUSSION (REDSHANK STUDIES)

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 (Furness & Galbraith 1980; Moss 1985; Cresswell & Whitfield 1994; Rehfisch *et al*. 1996). 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 89% of adult Redshank returned to Cardiff after an eight month period in 1997 and 83% in 1998. These figures may underestimate survival over the period as a small proportion of individuals may change their wintering grounds between years (*e.g.* Spencer & Hudson 1982). No Redshank from Cardiff have yet been known to do so, however. One adult moved from Rhymney to Devon within the winter of 1991/92, but it is not known if this move was permanent.

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 31-57% of Redshank (both adult and first-year) were taken by raptors between September and March at their study site in Scotland, but did not calculate overall winter mortality rates (see also Whitfield 1985; Whitfield *et al.* 1999). 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 increased energy demands (Davidson 1981, 1982; Dugan *et al*. 1981; Davidson & Evans 1982; Clark *et al*. 1993). 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, 1985; Norman & Coffey 1994).

At Cardiff, there was only 0-9% mortality in the marked adult Redshank population over the four month winter period (1 October to 31 January). Similar estimates have been found previously for other waders that winter on the coasts of northern Europe (*e.g.* Metcalfe & Furness 1985; Burton & Evans 1997; Dierschke 1998). In comparison to Cresswell and Whitfield's (1994) study of Redshank, predators were probably more scarce at Cardiff. 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 were seen hunting Redshank at Cardiff, however, albeit unsuccessfully (see also Rehfisch *et al*. 1996). 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 as with Merlins have only occasionally been known to attempt to kill full-grown Redshank (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.

Although there were two weeks of cold weather at the start of 1997, both that and the 1997/98 winter were generally mild and this probably aided survival. In previous episodes of severe weather, Redshank mortality has been greater on eastern coasts (Davidson 1982; Davidson & Clark 1985; Clark *et al*. 1993; 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. Their study, based on winter catches of Redshank on the

Moray Firth, calculated that average annual survival rose from just 43% for Redshank between their first and second winters, to 67% for those between their second and third winters and to 74% for older birds. Similar rates have been reported for adult Redshank in several other previous studies (Groβkopf 1959, 1964; Boyd 1962; Moss 1985; Thompson & Hale 1993). At Cardiff, annual survival rates for adult Redshank were 81% in 1996/97 and 83% in 1997/98. Mortality is predicted to increase after the bay's loss, however, partly due to the species' fidelity to the site and reliance upon its food resources.

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Species	Level for International Importance	Level for National Importance	Importance of Severn Estuary (winter 1997/98)	Maximum WeBS count at Cardiff Bay (winter 1998/99)
Shelduck *Tadorna tadorna*	2500	750	International	177
Teal *Anas crecca*	4000	1400	National	70
Mallard *Anas platyrhynchos*	20000	5000	-	155
Pintail *Anas acuta*	700	280	International	0
Pochard *Aythya ferina*	3500	440	National	33
Oystercatcher *Haematopus ostralegus*	9000	3600	-	60
Ringed Plover *Charadrius hiaticula*	500	290	-	58
Grey Plover *Pluvialis squatarola*	1500	430	National	0
Lapwing *Vanellus vanellus*	20000	20000	National	17
Knot *Calidris canutus*	3500	2900	-	21
Dunlin *Calidris alpina*	14000	5300	International	4500
Curlew *Numenius arquata*	3500	1200	National	137
Redshank *Tringa totanus*	1500	1100	International	429
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*, Tufted Duck *Aythya fuligula* and Black-tailed Godwit *Limosa limosa* (Cranswick *et al.* 1999).

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May
Taff/Ely										
Mute Swan *Cygnus olor*										2
Goosander *Mergus merganser*	3	1	3	3	4	12	3	7	3	2
Shoveler *Anas clypeata*					2					
Curlew Sandpiper *Calidris ferruginea*		9								
Ruff *Philomachus pugnax*		1								
Snipe *Gallinago gallinago*				1						
Black-tailed Godwit *Limosa limosa*	5									
Whimbrel *Numenius phaeopus*	1									6
Greenshank *Tringa nebularia*		1								
Common Sandpiper *Actitis hypoleucos*	1	1								
Orchard Ledges										
Whimbrel										3
Rhymney										
Swan Goose *Anser cygnoides*					1					
Wigeon *Anas penelope*						4				
Shoveler				6	6		6			
Tufted Duck *Aythya fuligula*				1	50					
Little Stint *Calidris minuta*			1							
Black-tailed Godwit								14	70	
Bar-tailed Godwit *Limosa lapponica*					7					2
Whimbrel										3
Spotted Redshank *Tringa erythropus*			1							

Table 3.6.1 The maximum numbers of wildfowl and waders seen only occasionally at Cardiff during allday counts, 1998/99, and not included in the separate species accounts.

Date	Site	Number colour-ringed
17.9.98	Cardiff Bay	19
13.10.98	Cardiff Bay	15
10.11.98	Cardiff Bay	5
25.11.98	Cardiff Bay	9
2.12.98	Rhymney	72
5.12.98	Cardiff Bay	18
10.1.99	Cardiff Bay	4
20.1.99	Rhymney	11
2.2.99	Cardiff Bay	7
3.2.99	Cardiff Bay	15
6.3.99	Cardiff Bay	36

Table 6.1.1 Dates of Redshank colour-ringing at Cardiff Bay and at Rhymney during winter 1998/99.

Date	Site	Percentage scheme-marked (*n*)	Percentage individually colour-ringed (*n*)	Sample size
14.8.98	Cardiff Bay	1.3 (1)	24.0 (18)	75
10.9.98	Cardiff Bay	3.3 (1)	30.0 (9)	30
10.10.98	Cardiff Bay	2.4 (2)	42.7 (35)	82
12.10.98	Cardiff Bay	0	25.9 (15)	58
13.10.98	Cardiff Bay	0	31.3 (10)	32
14.10.98	Cardiff Bay	3.3 (1)	40.0 (12)	30
25.11.98	Cardiff Bay	0	29.2 (7)	24
26.11.98	Cardiff Bay	3.8 (2)	45.3 (24)	53
27.11.98	Cardiff Bay	0	39.0 (32)	82
28.11.98	Cardiff Bay	5.4 (2)	40.6 (15)	37
29.11.98	Cardiff Bay	1.9 (1)	51.9 (28)	54
2.12.98	Cardiff Bay	3.6 (1)	42.9 (12)	28
7.1.99	Cardiff Bay	0	40.0 (18)	45
5.2.99	Cardiff Bay	4.1 (3)	45.3 (33)	70
6.2.99	Cardiff Bay	2.3 (1)	38.6 (17)	44
7.3.99	Cardiff Bay	4.7 (3)	42.2 (27)	64
9.3.99	Cardiff Bay	5.0 (1)	40.0 (8)	20
7.4.99	Cardiff Bay	0	20.0 (15)	75
10.10.98	Rhymney	2.8 (2)	2.8 (2)	72
11.10.98	Rhymney	2.9 (2)	2.9 (2)	70
12.10.98	Rhymney	2.5 (3)	3.3 (4)	120
24.11.98	Rhymney	2.0 (2)	7.1 (7)	98
25.11.98	Rhymney	0	9.1 (3)	33
29.11.98	Rhymney	3.2 (1)	9.7 (3)	31
16.12.98	Rhymney	5.7 (7)	5.7 (7)	123
8.1.99	Rhymney	1.8 (1)	3.6 (2)	56
9.1.99	Rhymney	1.1 (1)	3.2 (3)	94
6.2.99	Rhymney	0	5.0 (3)	60
7.2.99	Rhymney	0	6.7 (2)	30
9.2.99	Rhymney	2.4 (2)	7.1 (6)	84
3.3.99	Rhymney	0	2.7 (1)	37
7.4.99	Rhymney	0	0	19
26.11.98	Peterstone	0	0	14
18.12.98	Peterstone	0	0	22
8.2.99	St. Brides	0	0	9
18.12.98	R. Usk, Newport	0	0	13
8.2.99	R. Usk, Newport	0	0	41
6.3.99	R. Usk, Newport	0	0	25

Table 6.1.2 Estimates of the percentages of colour-ringed birds in the Redshank populations at Cardiff Bay, Rhymney, Peterstone, St. Brides and the River Usk at Newport from August 1998 to April 1999.

		ϕ_t	p_t
1996/97	Over-winter survival rate	0.913 (0.074)	0.639
1997	Over-summer return rate	0.886 (0.049)	0.871
	Annual survival rate	0.809 (0.069)	
1997/98	Over-winter survival rate	1.000 (0.018)	0.911
1998	Over-summer return rate	0.831 (0.045)	0.872
	Annual survival rate	0.831 (0.043)	

Table 7.1.1 Return and survival rates (ϕ_t) and resighting probabilities (p_t) for adult Redshank wintering at Cardiff. ϕ_t estimates are given with standard errors in parentheses. p_t values indicate resighting probabilities at the end of each period.

Metal-ringed or individually or scheme colour-ringed	Ring number	Date ringed	Date observed / recovered	Location
Individual	Unknown		19.6.97	Marshside, Lancashire
Individual	Unknown		2.5.98	Jedburgh, Borders
Individual	Unknown		6.8.98	Llanelli, Dyfed
Individual	DK76748	17.1.97	9.8.98	Seaforth, Merseyside
Individual	DN54912	14.2.96	14.3.99	Near Cricklade, Wiltshire
Individual	DK10667	21.9.94	17.3.99	Frampton, Gloucestershire
Individual	DK76625	2.2.99	27.3.99	Peterstone
Individual	Unknown		18.4.99	Peterstone
Individual	DK76046	17.9.98	24.4 & 14.5.99	Tiree, Strathclyde
Individual	DK76634	3.2.99	6.5.99	Tiree, Strathclyde
Individual	DR96455	21.9.94	6.5.99	Kjarlaksvellir Saurbaer, Dala ICELAND
Individual	DN54732	17.1.97	15.5.99	Peterstone
Individual	DR96370	20.1.91	20.5.99	Druridge Bay, Northumberland
Individual	DN54994	20.1.99	2.6.99	Stokkseyri, Skipar ICELAND
Individual	DK76566	19.2.95	27.6.99	Llanelli, Dyfed
Individual	DR96467	21.9.94	15.7.99	Carnforth, Lancashire

Table 7.2.1 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
DN83751	17.5.86	South Uist, Western Isles	13.8.98, 15.8.98, 16.8.98, 17.8.98, 11.9.98, 12.9.98, 14.10.98, 6.2.99, 9.2.99 & 10.2.99	Cardiff Bay
			25.11.98 & 17.12.98	Rhymney
Unknown	8.6.96	South Uist, Western Isles	12.10.98, 6.2.99, 7.2.99 & 8.2.99	Rhymney
Unknown		South Uist, Western Isles	10.10.98, 11.10.98 & 14.10.98	Rhymney

Table 7.2.2 Sightings at Cardiff of Redshank colour-ringed elsewhere.

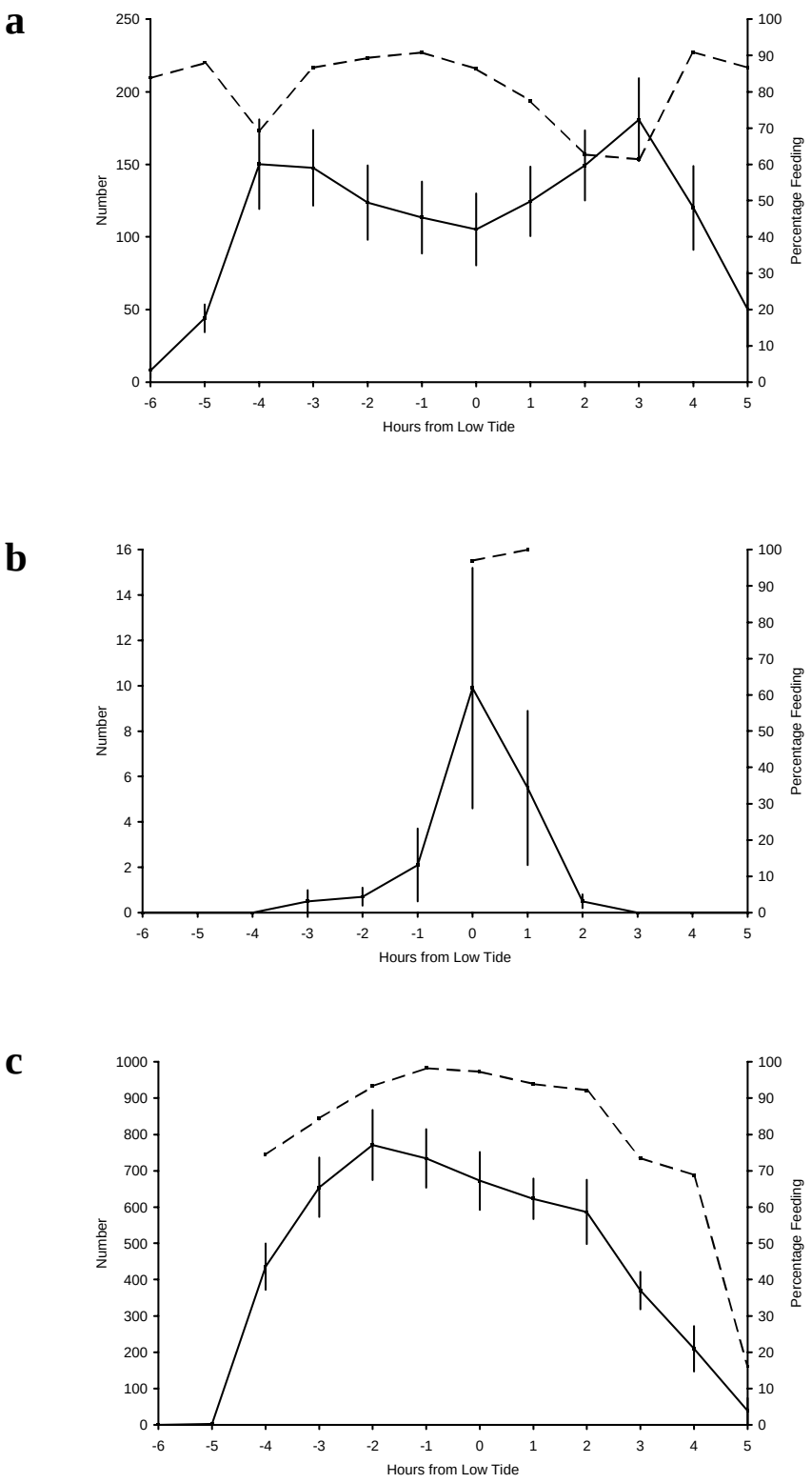


Figure 3.1.4 The total number of Shelduck present (solid line) and the percentage feeding (dashed line) during each hour of the tidal cycle at **a.** Cardiff Bay, **b.** Orchard Ledges and **c.** Rhymney during the winter of 1998/99.

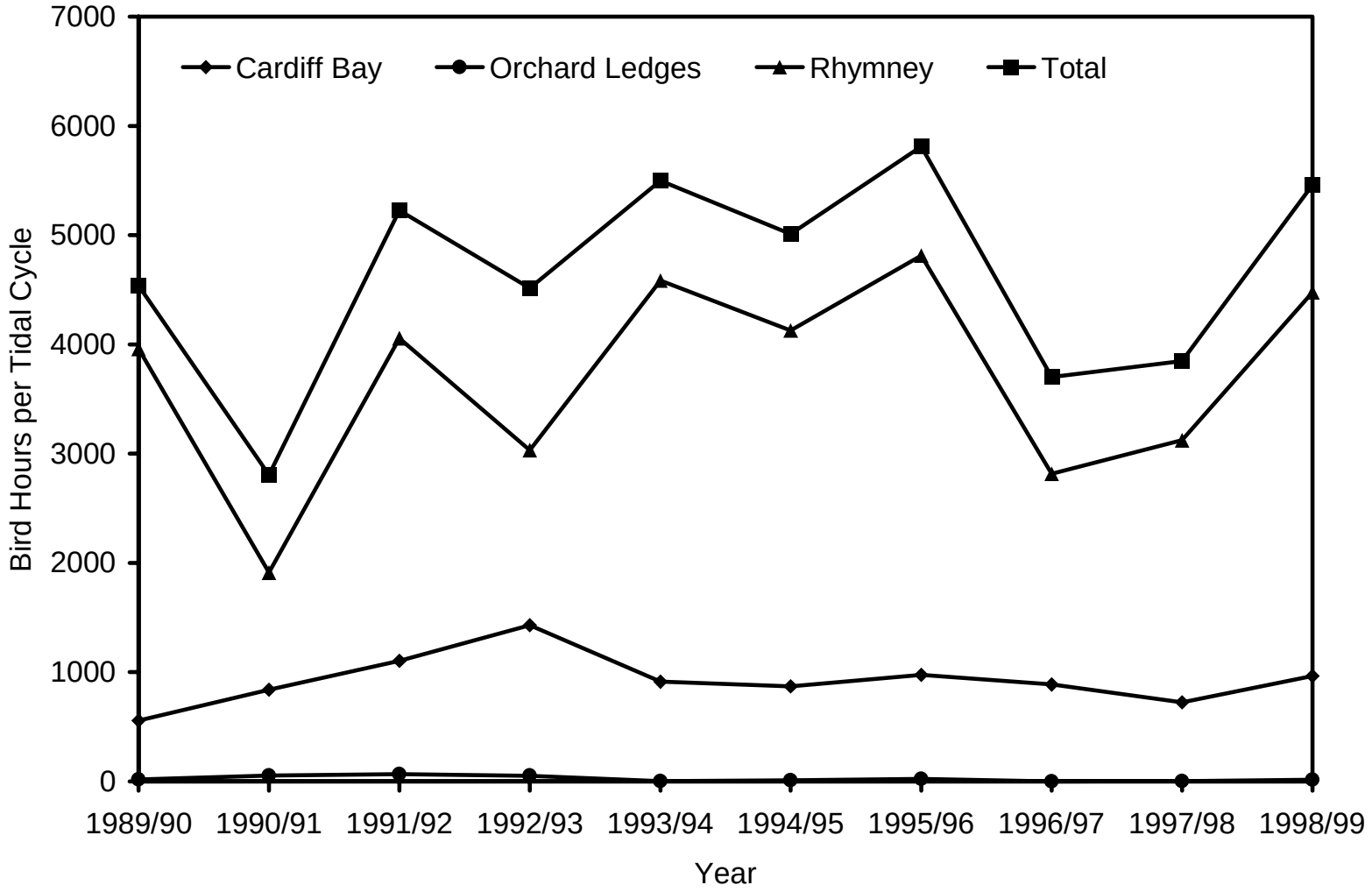
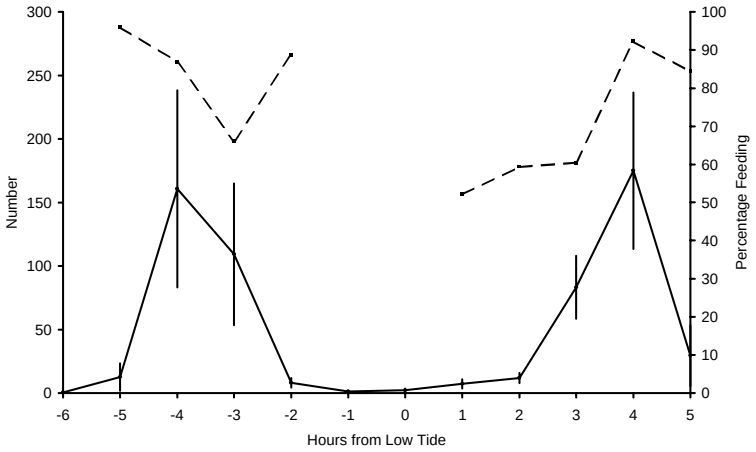
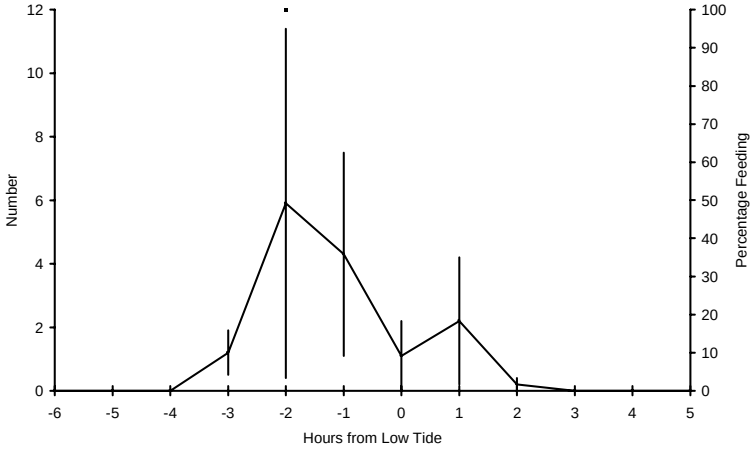


Figure 3.1.5 The all-day usage of the three study sites by Shelduck between 1989/90 and 1998/99.

a



b



c

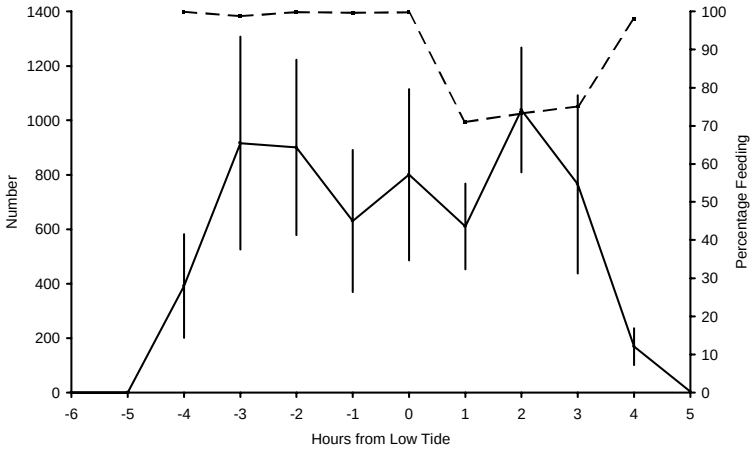


Figure 3.2.4 The total number of Dunlin present (solid line) and the percentage feeding (dashed line) during each hour of the tidal cycle at **a.** Cardiff Bay, **b.** Orchard Ledges and **c.** Rhymney during the winter of 1998/99.

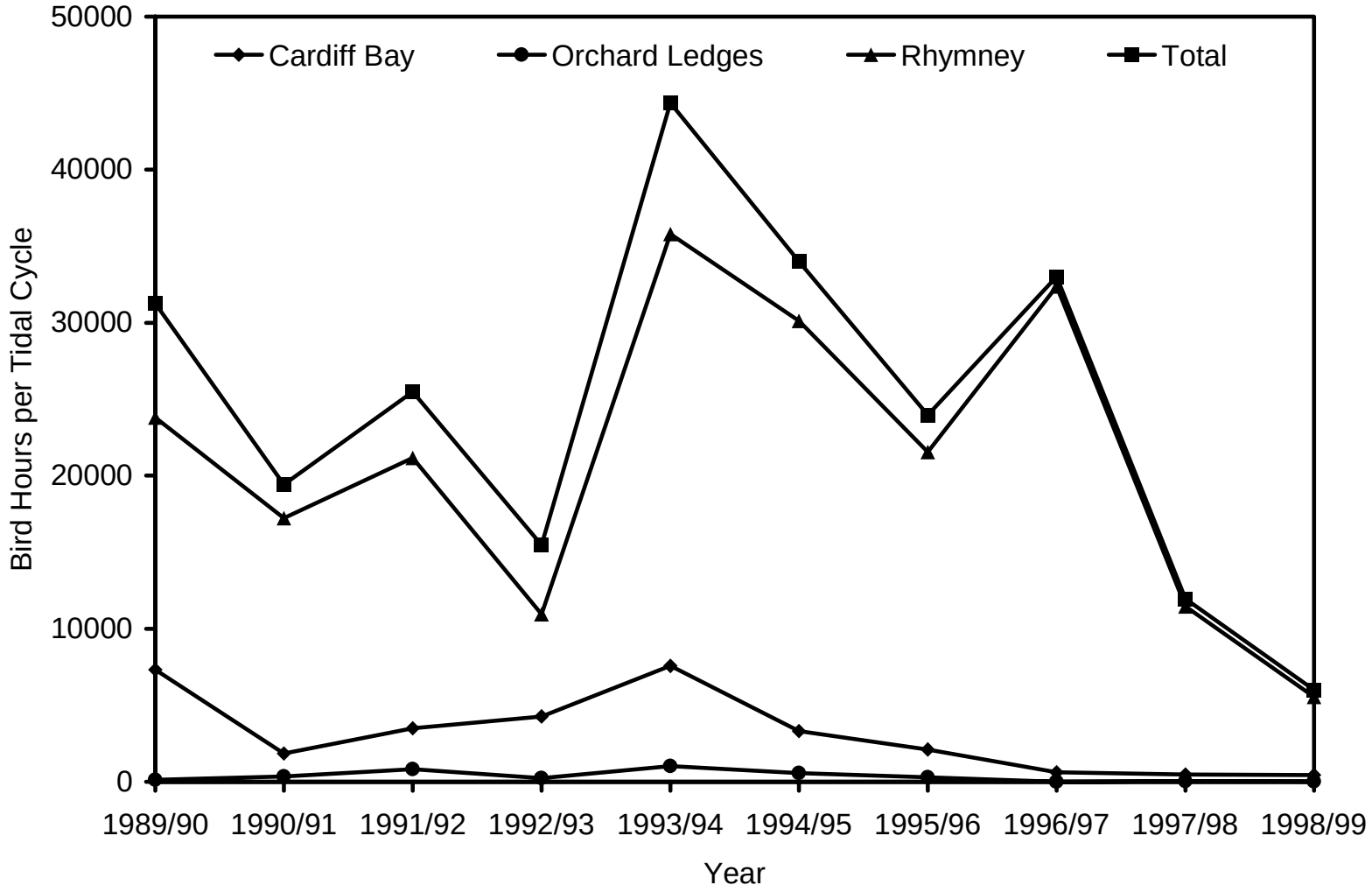
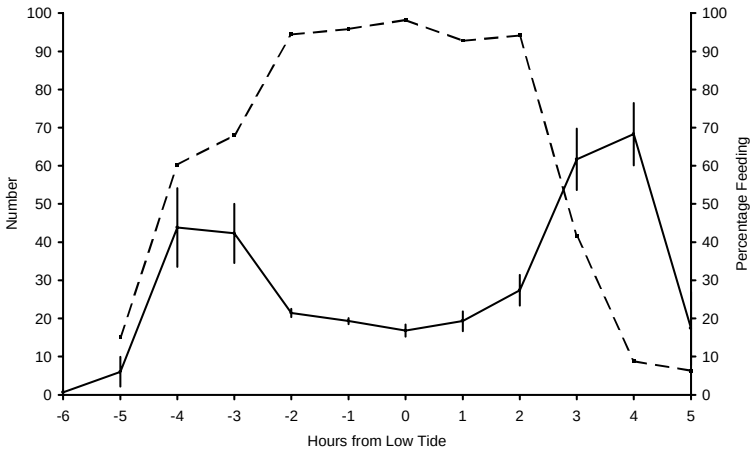
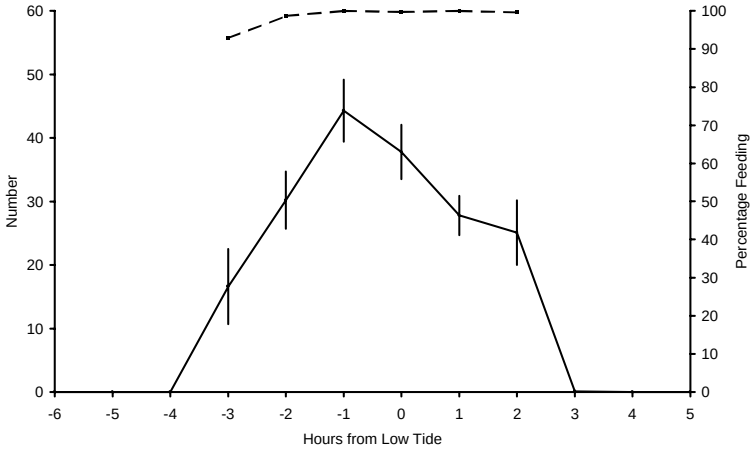


Figure 3.2.5 The all-day usage of the three study sites by Dunlin between 1989/90 and 1998/99.

a



b



c

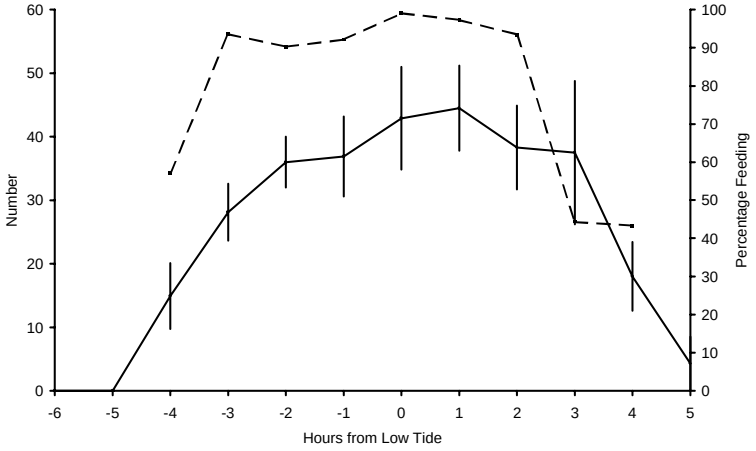


Figure 3.3.4 The total number of Curlew present (solid line) and the percentage feeding (dashed line) during each hour of the tidal cycle at **a.** Cardiff Bay, **b.** Orchard Ledges and **c.** Rhymney during the winter of 1998/99.

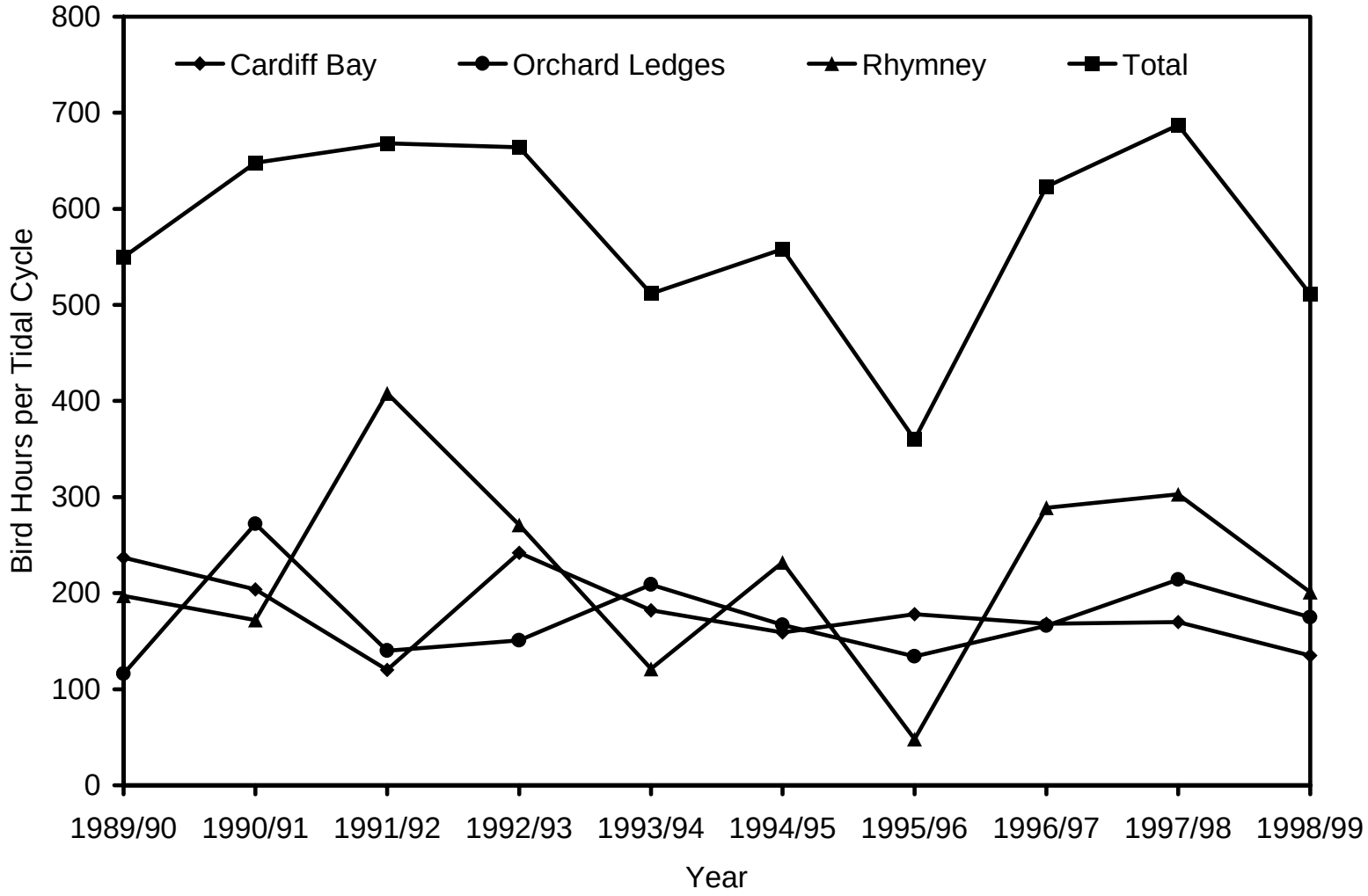
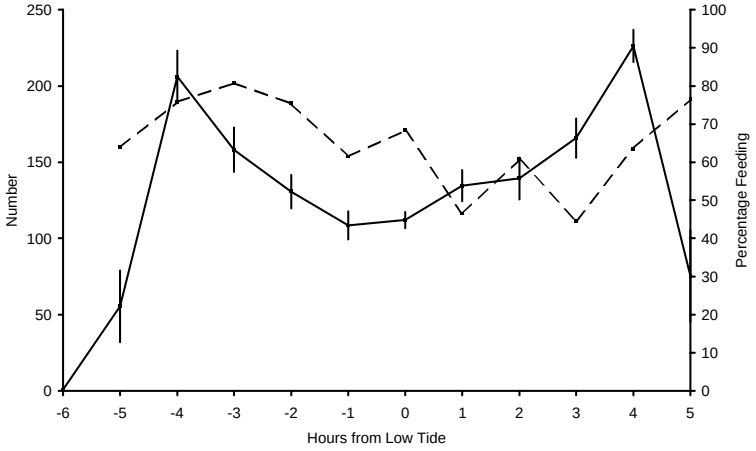


Figure 3.3.5 The all-day usage of the three study sites by Curlew between 1989/90 and 1998/99.

a



b

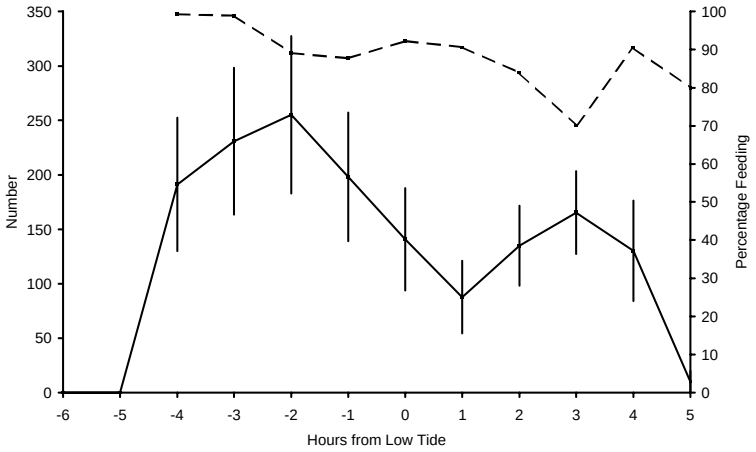


Figure 3.4.4 The total number of Redshank present (solid line) and the percentage feeding (dashed line) during each hour of the tidal cycle at **a.** Cardiff Bay and **b.** Rhymney during the winter of 1998/99. No Redshank were recorded at Orchard Ledges.

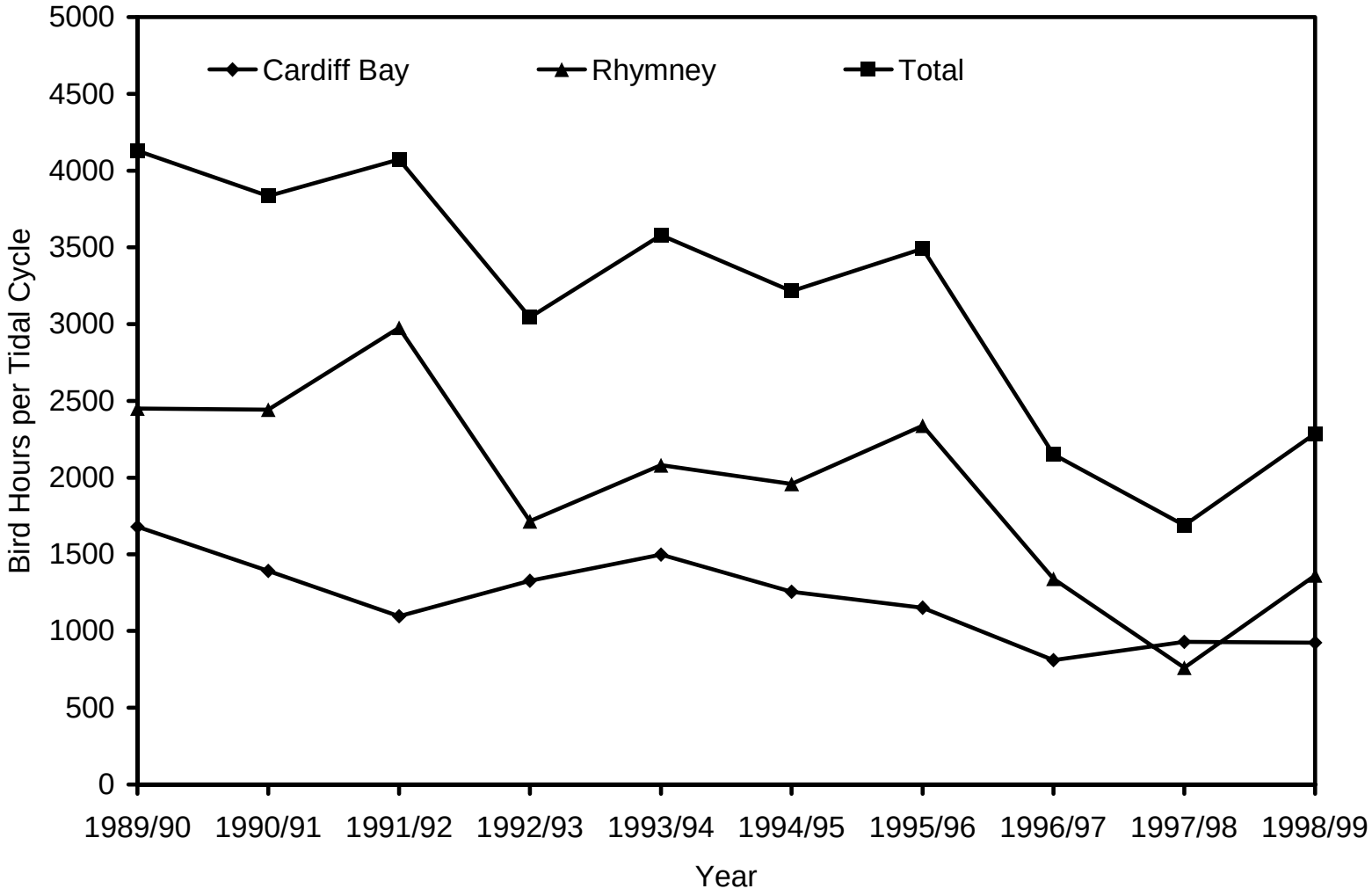


Figure 3.4.5 The all-day usage of the study sites by Redshank between 1989/90 and 1998/99.