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Disturbance studies on Swansea Bay and the Burry Inlet in relation to bird populations

by

J. Evans & N.A. Clark

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The National Centre for Ornithology, The Nunnery, Thetford, Norfolk. IP24 2PU

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EXECUTIVE SUMMARY

Lower numbers of bait-diggers were observed in Swansea Bay than expected, possibly because of the time of year that this study took place. Bird distributions were similar those seen in winter 1991/92.

The beaches between Marina and Mumbles are heavily disturbed, particularly between Marina and Blackpill. The location of the high tide roosts appears to be a response to this disturbance. No waders were seen feeding at the tideline on any of the beaches over the high tide period.

The study area at Weobley, on the Burry Inlet, provides the first and last opportunities for waders to feed on the south shore of this estuary. Large numbers of birds were observed feeding and roosting there, particularly Oystercatchers, when all the other areas on the south shore were covered. Cocklers were observed using the proposed new exit track as a regular access route to Llanrhidian Sands. This allowed them earlier access to the cockle beds at a time when birds had limited opportunities for feeding. Disturbance to feeding and roosting birds, notably Oystercatchers and Curlew, was recorded as a result.

1.GENERAL INTRODUCTION

Disturbance to estuary birds is of increasing concern but difficult to investigate in any systematic way. Approaches differ according to the source of disturbance under investigation. Definitions include 'any situation in which a bird behaves differently from its preferred behaviour' (Boere 1975) and 'any situation in which human activities cause a bird to behave differently from the behaviour it would exhibit without the presence of that activity' (Oranjewoud 1982). There is, however, a distinction between an effect of disturbance, which might cause a change in activity or behaviour and an impact, which has a consequence on the population size through its effect on survival and breeding productivity of individual birds (Bell & Owen 1991). Cayford (1993) summarises the possible effects of disturbance which may impact on the population as a whole as a result of a change in feeding behaviour. Waders forage efficiently by feeding in the best areas and selecting the most profitable size-classes of prey (*e.g.* Cayford & Goss-Custard 1990). As a result, they generally concentrate in areas of high prey density and availability where their intake rate is therefore relatively high and where energy expenditure as a result of, for example, search effort is relatively low (Goss-Custard & Charman 1976). In order to meet its daily energy requirements, a wader must achieve a certain minimum prey intake rate below which it will starve. Cayford (1993) therefore argues that if its intake rate in a particular feeding area falls below this critical threshold, through disturbance, then it must move to a different feeding area. If forced to move, the question arises as to whether alternative feeding areas can accommodate displaced individuals and what effect increased bird density will have on intake rates, body condition and, ultimately, the fitness of both those birds forced to move and the birds into whose feeding areas they are moving. Goss-Custard (1980) showed that, for some species, average intake rate declines as bird density increases. This is a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. If the population is limited by the quality and availability of feeding areas, then disturbance may cause increasing mortality or decreasing recruitment. Such impacts of disturbance on populations are more difficult to demonstrate than its effects which have been demonstrated in a variety of studies. There is still no conclusive evidence that populations suffer as a result of disturbance (Owen 1993).

This project investigates three estuarine activities: beach-cleaning, bait-digging and cockle-fishing. In each case these activities may have two effects: removal of a food source and physical disturbance from feeding and/or roosting areas. It is the latter that is concentrated on here.

2.BAIT-DIGGING STUDIES

2.1Introduction

Swansea Bay SSSI is used by large numbers of bait-diggers, although few records have been kept of the numbers and frequency of digging (Jones 1992). Angling has increased in popularity, particularly during the last three years. At the same time there has been a reduction in the number of anglers digging for their own worms (Cadman 1989). This, in conjunction with an increase in the number of people out of work in South Wales, has led to many more people obtaining a living or at least some income from bait-digging. The effect on the birds is likely to be two-fold. The presence of diggers can keep birds from potential feeding areas and there may be a reduction of the invertebrates themselves (Prater 1981).

The most widely used bait for sea-fishing in South Wales are the two forms of the lugworm, *Arenicola marina*, referred to by the anglers as blow lug (or occasionally red lug) and black lug. Adult black lug, the preferred variety, are reported as being found only on the lower tidal levels. Adult blow lug, the typical *A. marina* described extensively by Newell (1948) and others are found at the mid- to low tidal levels (Cadman 1989).

There is increasing concern amongst local naturalists that there has been a decline in the numbers of certain species of bird using the bay, particularly the Bar-tailed Godwit and Curlew. Analysis of BoEE trends show that Bar-tailed Godwit numbers were highest and most stable in the 1970s, since when they have generally been lower and more variable (Warbrick *et al.* 1992). The most recent five years show peak numbers occurring in autumn, whereas in the years prior to this, particularly in the 1970s, the peaks occurred in mid-winter. Curlew numbers present have shown no significant decrease over the years, although the monthly counts averaged over the most recent four years are generally lower than those averaged over both 1969-71 and 1972-74 (Warbrick *et al.* 1992).

In the winter, Bar-tailed Godwit feed mainly on lugworm (Smith 1975) and is therefore in direct competition with the bait-diggers. Local birdwatchers therefore believe that bait-digging is the main cause of the decline in this species in Swansea Bay and that the birds may be acting as an indicator of other changes happening in the food chain which are yet to be detected, for example, Swansea Bay is an important breeding ground for several species of fish (Jones 1992).

The recorded efficiency of digging for bait varies according to the technique employed, the estuary being dug and the target species (van den Heiligenberg 1987). Studies on Whitley Bay (Blake 1979) and Budle Bay, Northumberland (Shahid 1982) concluded that the level of bait-digging on those estuaries was insufficient to threaten spawning stocks of lugworms, but the potentially damaging effects of commercial exploitation have been illustrated at Pevensey on the south coast of England where the intertidal area was virtually 'dug out' to below Mean Low Water of neap tides (Cadman 1989). In addition, Olive (1986) described how Northumbrian bait-diggers almost eliminated a population within a few weeks during November so that full recovery was not achieved till the following September.

As well as having potentially damaging effects on the populations of *Arenicola* through removal, bait-digging could have harmful effects on other invertebrate species. The turning over of the mud could cause damage by burying them (Jackson & James 1979) and by exposing them to temperature-stress, desiccation and predation (Ferns 1993).

There are two ways in which lugworms are harvested. Mechanical bait-digging, which takes place at high tide and does not therefore pose a disturbance threat to feeding birds, and hand digging, which takes place when the intertidal areas are exposed and the visual signs of invertebrate activity are therefore visible. Hand diggers on some estuaries start work a few hours before low tide and walk to their areas when the sediment is still inundated. Their presence may disturb most of the feeding birds in many thousands of m^2 (van den Heiligenberg 1987). Zwarts (1974) estimated an area of 50,000 m^2 to 200,000 m^2 around one bait-digger or walker to be unsuitable for feeding.

Clearly, further work is required on the inter-relationship between bait-diggers, birds and invertebrates. A first step towards achieving this is to monitor the level of bait-digging in the areas where competition for invertebrates is most likely to occur between bait-diggers and birds. The first part of this project quantifies the level of bait-digging in Swansea Bay over a limited period in February 1993.

2.2Methods

During the fieldwork carried out as part of the study by Warbrick *et al.* (1992) in winter 1991/92, Swansea Bay was divided into four study sites (Figs. 2.1 & 2.2). These were subdivided, for ease of counting, using easily recognisable features such as a change in substrate, wooden posts and outfall pipes or by obvious sight lines, for example, permanent buoys or breakwaters. Three of these study sites, Mumbles, Blackpill and Marina, and their count areas, were adopted for this study. At an early stage, it was clear that the bulk of the digging took place on the Blackpill study site and fieldwork therefore concentrated on this area (Fig. 2.3). On each visit, each intertidal count unit was counted once an hour whenever the sandflats were exposed. The majority of the visits were timed to coincide with the period between three hours before and three hours after low tide when, of necessity, the bulk of the bait-digging took place. Weekends were believed to be the days when the greatest intensity of digging occurred, with much lower levels during the week, particularly in the first half (Jones 1992). A total of eight days were spent in observation, including both weekdays and weekends, to give a representative overall picture of bait-digging within the Bay.

The birds using the study site were recorded as well as the number of people on each count unit and their activity. No time was lost during the fieldwork due to heavy rain or very strong winds but separating Dunlin and Sanderling, two very similar species which regularly fed together at the tide edge, was occasionally impossible when the light quality was very poor in overcast and/or misty conditions.

2.3Analysis

Because the methods and counting areas were identical to those used by Warbrick *et al.* (1992), the data could be analysed in the same way. However, due to the limited time available for fieldwork, data collection concentrated on a core period between three hours before and three hours after low tide, the main feeding period for most species of wader. Thus data were analysed for each species for which an average peak of five or more birds occurred during any time interval in this period. For each species, the core period usage was calculated for each area using the following equation:

$$\text{Core period usage} = \sum_{A=+3}^{A=\_3} (BxC)1$$

where:

A = hours from low tide
B = average number of birds feeding at time A when area is exposed
C = proportion of counts when count area is exposed at time A

Core period usage therefore gives the usage over the seven hour period around low tide.

The average number of bird hours spent feeding on each count area during the core period was calculated separately for each species and plotted on maps of the study site.

2.4Results

Species accounts

2.4.1Oystercatcher

As the tide fell Oystercatchers moved out of the roost at Blackpill and began to feed at the water's edge, following the tide edge as it receded down the shore. Consequently, the majority of feeding birds present were on the lower areas in the period between three hours before and three hours after low tide (Fig. 2.4). The numbers present on the study site during this period declined towards low tide as the mussel beds to the south and north of the study site became exposed and birds moved onto them to feed. Lowest numbers were recorded at low tide when the largest area of mussel bed would have been exposed (Fig. 2.5). These results agree closely with those of Warbrick *et al.* (1992). Blackpill is one of two main roost sites within Swansea Bay, both of which hold up to 1,500 birds. During the high tide period all the birds present at Blackpill were on the upper shore, the lower areas being covered by the tide. The transition from roosting to feeding on the outgoing tide and feeding to roosting on the incoming tide is illustrated by the presence of comparable numbers of birds on upper and lower areas (Fig. 2.6). Numbers of Oystercatchers present at Blackpill were comparable between winters.

2.4.2Ringed Plover

The highest numbers of Ringed Plover present during the low tide period were found on the upper mudflats at the Blackpill end of the study site (Fig. 2.7) reflecting this species' preference for well-drained, sandy substrates on which to feed (Prater 1981). Numbers present on these areas during the period between three hours before and three hours after low tide peaked at low tide (Fig. 2.8). By contrast, Warbrick *et al.*'s (1992) results show that the number of Ringed Plover on the study site remains relatively constant throughout the tidal cycle with no discernible peak at low tide (Fig. 2.9). However, Ringed Plover are very cryptic and can therefore be very difficult to locate at low tide (Spearpoint *et al.* 1988). Both studies showed that the upper shore of Blackpill was the main feeding and roosting site for this species.

2.4.3 Grey Plover

Grey Plover were always observed in the southern half of the study site during the low tide period (Fig. 2.10). Feeding birds that had roosted at Blackpill moved down the shore with the ebbing tide or left the study site to feed elsewhere, returning on the incoming tide. Few birds were recorded between two hours before and one hour after low tide (Fig. 2.11). Only one or two individuals remained and these birds regularly associated with Ringed Plover on the upper shore. During the 1991/92 winter, fewer Grey Plover were recorded on the study site, however, high tide counts were very variable (Warbrick *et al.* 1992) and one might therefore expect low tide counts to be the same. The marked increase in numbers present on the lower areas two hours after high tide reflects an influx of birds to feed as these areas became exposed. Subsequently however, numbers quickly dropped and did not increase again towards high tide (Fig. 2.12). During the February 1993, fieldwork numbers did increase again as birds returned to the site to feed on the rising tide, indicating a difference in roosting behaviour compared with the previous winter.

2.4.4 Sanderling

Compared with the 1991/92 winter, very few Sanderling were observed using the study site between three hours before and three hours after low tide. Those that did so were observed feeding on the lower mudflats at the water's edge (Fig. 2.13). Although not included in the analysis, the results of the high tide observations suggested that there were fewer birds roosting at Blackpill than had been recorded in the past. During the February 1993 fieldwork, no birds were observed in the core period until low tide onwards when some birds were seen associating with Dunlin (Fig. 2.14). Although numbers varied, there were usually more Sanderling present throughout the corresponding period during Warbrick *et al.*'s (1992) study (Fig. 2.15). Another important feeding area for this species is at Crymlyn (Warbrick *et al.* 1992) where most of the birds that roosted at Blackpill went to feed from three hours before low tide. It is possible that the lower numbers at Blackpill during February 1993 were due to a higher proportion of the birds that roosted at Blackpill using Crymlyn as a feeding area. However, numbers recorded at high tide during the study period were also low. This may reflect the lower numbers present on the whole of Swansea Bay or a change in roosting site for this species.

2.4.5 Dunlin

The most important feeding areas were on the lower shore, south of the mouth of the river which empties into the bay at Blackpill (Fig. 2.16). During the period between three hours before and three hours after low tide, the numbers of Dunlin present varied from, on average, approximately 100 to 450 birds. Numbers declined towards low tide and increased again on the incoming tide, with lowest numbers being recorded one hour before low tide (Fig. 2.17). A few birds remained on the upper levels feeding with the Ringed Plover. The results from the 1991/92 fieldwork also showed a decline in numbers towards low tide, but the lowest numbers were observed one hour after low tide (Fig. 2.18). Fig. 2.15 clearly shows the movement of the birds that roosted at Blackpill from the upper areas to the newly exposed lower areas - a peak one hour after high tide in the numbers on the upper shore is followed by a sharp drop which coincides with an equivalent rise in numbers present on the lower shore. Similarly, a second peak two hours before high tide on the lower shore is followed by a peak on the upper shore coincidental with a drop in the numbers on the lower shore, indicating the movement of birds up the shore with the incoming tide.

2.4.6 Bar-tailed Godwit

One of the most important feeding areas for Bar-tailed Godwit, during the 1991/92 winter, was along the shoreline of the Blackpill study site (Warbrick *et al.* 1992). During February 1993, this species was observed on only two of the count areas (Fig. 2.19) and these birds were always seen feeding at the water's edge. None were recorded between two hours before and one hour after low tide and fewer than 15 birds were recorded at any other time during the core study period (Fig. 2.20). During the 1991/92 season the only part of the tidal cycle when Bar-tailed Godwit were not recorded was two hours after low tide. Slightly more birds were recorded in the period between three hours before and three hours after low tide and there were always more birds present roosting than feeding (Fig. 2.21).

2.4.7 Curlew

Curlew were always found on the lower mudflats in the period between three hours before and three hours after low tide (Fig. 2.22). In contrast to Oystercatchers, all the Curlew present on the study site had already moved on to the lower mudflats by three hours before low tide. However, numbers decreased steadily towards low tide in a similar manner to Oystercatchers as many individuals moved onto the mussel beds to feed (Fig. 2.23). These results differed from Warbrick *et al.*'s (1992) results which found fewer birds present in the same period during which some birds remained on the upper mudflats (Fig. 2.24). In addition, the changes in bird numbers around low tide did not show the same symmetry as was observed in February 1993.

2.4.8 Bait-diggers

Only three of the ten count areas remained unaffected by bait-digging during the study period. The highest number of bait-diggers occurred on area 8 and generally the digging effort seemed to be concentrated at this end of the study site (Fig. 2.25). The pattern of change in numbers present during the core study period contrasted with those of the birds. As might be expected, peak numbers on the lower shore occurred around low tide. Peak numbers on the upper shore occurred after the tide had turned. With the exception of one hour, there were, on average, more bait-diggers present on the upper shore (Fig. 2.26). Observation showed that the diggers on the lower shore were usually on the upper half of those areas.

2.5 Conclusions

It is clear that a high level of bait-digging takes place on Swansea Bay. During the limited period of this study, the activity was concentrated on the upper shore and at a relatively low intensity. Jones (1992) also observed low levels of bait-digging between January and March. A maximum of 11 bait-diggers were present on the study site, whereas up to 35 and even as many as 50 (pers. comm.) have been recorded there. Peak numbers of diggers occur in late summer/early autumn. It is possible that the areas dug vary according to the number of diggers present and to the seasonal changes in lugworm distribution.

In general, the areas that had the highest numbers of birds were those with fewest bait-diggers in the period between three hours before and three hours after low tide. This can be interpreted in two ways. Either the presence of the bait-diggers is preventing birds from feeding on the upper shore or the birds' preferred feeding area is the lower shore and they are therefore relatively unaffected by the presence of the bait-diggers.

Most waders tend to feed at the tideline where the mud is wettest and their invertebrate prey are closest to the surface and most active. The observed bird distribution during the period between three hours before and three hours after low tide did not, therefore, differ significantly from the expected. Two species, however, habitually feed on the upper shore and it is these species, Ringed Plover and Grey Plover, for which disturbance by bait-diggers may hinder or prevent feeding opportunities. Ringed Plover concentrated at the Blackpill end of the study site whereas the bait-diggers were concentrated at the Mumbles end. Very few Grey Plover remained to feed on the study site during the low tide period but those that did tended to associate with the Ringed Plover. Curlew occur on most intertidal habitats on upper and lower levels of the shore (Clark 1989) but they are also notoriously one of the most sensitive of waders to disturbance. Curlew were not recorded on the upper levels and this may have been due to disturbance or a lack of a suitable food supply. The distribution of the waders in the Bay is, however, similar to that found on other sites in the UK. The limited nature of this study and lack of bird data collected before the rise in popularity of bait-digging on Swansea Bay means that it is not possible to draw any conclusions about the disturbance effect of bait-digging activity on the birds.

3.BEACH CLEANING STUDIES

3.1Introduction

In response to new standards of hygiene for beaches imposed by the EC due to an increased awareness of pollution levels in our coastal waters, the local council implemented a beach cleaning scheme as part of its drive to reach the standards set. Since 1991 the beaches between Marina and Blackpill have been systematically cleared of all stones, litter and debris brought in by the tide on a daily basis. These activities have led to concern that part of the decline in numbers of certain species of wader using these beaches and the numbers in Swansea Bay as a whole is a result of a combination of the removal of potential food sources at the tide edge and disturbance by beach users. The species thought to be most affected are Sanderling and Turnstone. Neither species has shown a significant decline in numbers counted as part of the BoEE, although Sanderling appear to have shown a slight decline since 1985 and the numbers of Turnstone roosting at Blackpill had decreased markedly in the 1991/92 winter (Warbrick *et al.* 1992). This latter decline highlighted the need for careful monitoring over the next few years to see whether more permanent declines are taking place.

3.2Methods

The beaches between Marina and West Cross were observed at or around high tide on eight separate occasions. The numbers of birds, their location and activity were noted as well as any occasion when they were seen to be disturbed by walkers, *etc.*

3.3Results

Two roost sites were located, both of which were at Blackpill (Fig. 3.1). Mudflat 6 was often incompletely covered throughout the high tide period, the area remaining uncovered being dependent on the height of the tide. During neap tides, when a large area remained exposed, any birds observed were found here. The majority of these were roosting although a small proportion, particularly of the smaller species such as Dunlin, continued to feed over the high tide period. On spring tides the beaches were the only areas available for the birds to use. In this situation they split into two flocks, one on the beach above area 6 and one on the beach above area 3.

Both areas were subject to disturbance by people. The roost above area 6 was very close to the footpath/cycleway that runs the length of the Bay thereby passing behind the roost. This footpath experiences a high level of pedestrian and cycle traffic to which the birds were, to an extent, habituated. Inevitably, though, people stopping nearby or moving directly towards them along the beach, particularly with dogs, frequently caused flight. The roost above area 3 was only seen to be used on spring tides. This may be because the nearest point of access by people is further along and they are discouraged from walking in the direction of the birds by the tide cutting off access along the beach to Blackpill. In consequence, the number of people walking near this roost is very much lower than the number walking past the roost above mudflat 6. On neap high tides and at other states of tide, this roost area is more highly disturbed than the area at Blackpill. This is because more people walk along the beach rather than being largely confined to the footpath behind the beach.

No waders were observed feeding on any of the beaches. There were, however, significant numbers of passerines feeding on the tideline, almost all of which were observed in the uncleaned Blackpill area.

3.4 Conclusions

Without historical information on the use made by waders of the beaches in Swansea Bay as feeding areas, it is difficult to draw any firm conclusions about the effect of beach-cleaning on this behaviour. It is clear that, during the course of this study, no waders were feeding regularly on any of the beaches studied. However, the uncleaned beaches at Blackpill were used by significant numbers of passerines. Very few were observed feeding on the cleaned beaches. It therefore seems reasonable to suggest that a richer food supply is available on the uncleaned beaches. The implications of this for waders, however, are less clear. The 1992/93 winter was very mild and therefore most waders would not have experienced any pressure to feed over the high tide period. During severe winters, waders must feed at every available opportunity. Further studies would be required to draw any firm conclusions about the importance of the beaches as feeding areas. In addition, it is desirable that, during these periods of hardship, the birds should remain as undisturbed as possible. The differences in the location of the roost sites on neap tides compared with spring tides suggests that the main factor governing their position is disturbance. Disturbance levels should therefore be taken into consideration in any future study.

4.COCKLING ACCESS

4.1Introduction

Cockle fishing on estuaries presents three potential problems for estuary birds. Firstly, shellfish are a cash crop and anything feeding on them represents an apparent threat to the fishermen's livelihoods, leading to occasional pressure to cull the competing birds (Prater 1981). Secondly, the techniques for gathering shellfish may be harmful to the other invertebrates in the sand and thirdly, the vehicles and people collecting the cockles may cause disturbance, preventing birds from feeding and/or roosting.

The Burry Inlet has one of the three largest commercial cockle fisheries in Britain. The problem of competition between birds and cocklers here reached a peak in the 1970s and is the subject of a review of the available information by Horwood & Goss-Custard (1977). This and the problem of harm to other invertebrates are not within the scope of this project and will not be dealt with here.

Traditionally, access to the cockle beds on the Burry has been via a track across the saltmarsh from Wernffrwd to the area known as Llanrhidian Sands. Recently, however, the fishermen claim to be finding it more risky for their tractors to use this route to leave the Sands and have sought permission to use a second track across the saltmarsh at Weobley in emergencies. The aim of this part of the project was to assess whether significant numbers of estuary birds would be disturbed by cocklers using the track for this purpose.

4.2Methods

For the purposes of this study, the area observed included the saltmarsh either side of the track in question and the upper sandflats over which the cocklers would need to travel in order to get to it (Fig. 4.1). The study area was divided into three counting areas chosen, after preliminary observations, according to their differing likelihood of disturbance by cocklers. Thus, by drawing a line perpendicular to the shore, from the high tide to the low tide mark, count area 1 included part of the main cockling area and the saltmarsh behind; area 2 included the upper sandflats across which the tractors would travel to reach this area if allowed to use the track and the saltmarsh behind; area 3 included the sandflats and saltmarsh to the west of the track which, from preliminary observations, seemed to be undisturbed. Visits were made at all states of tide but concentrated on the time between high tide and half tide on both the falling and rising tide. This was considered to be both the time when the cocklers would be most likely to need to use the track and the time when birds would have the most limited area in which to feed and therefore would be most likely to be affected by this use.

Counts were made at hourly intervals recording feeding and roosting birds of each species separately. If any cocklers were present, their numbers and position was mapped, any movements were observed and their effect on the birds recorded.

4.3Results

4.3.1Cocklers

In the course of the study, eight cockling vehicles were regularly observed using the proposed new exit route as an access route to Llanrhidian Sands. They arrived when the intertidal flats adjacent to the original track access were still covered by the tide. From the first vehicle starting to travel across the saltmarsh to the last arriving at the cockle beds took 30 to 40 minutes. Most of the vehicles headed in an easterly direction towards the cockle beds when they reached the intertidal flats, but two tractors regularly headed in a westerly direction towards Whiteford and stopped about halfway between the track and the creek known as Great Pill. During this study, the cocklers stayed on the intertidal flats for up to six hours. Figure 4.2 shows that between three hours before and one hour before low tide was the main cockling period - during each observation period tractors were always present at these states of tide. On about a third of these occasions, tractors were present four hours before low tide. These were always tractors that had gained access to the intertidal flats at Weobley. The last tractors to leave were usually those that had arrived via the original route. The tractors were never observed using the track at Weobley as an exit route but the pick-up vehicles that accompanied them occasionally did so.

Species accounts

4.3.2Brent Goose

The maximum number of birds was recorded around high tide when they were seen feeding at the water's edge. No birds were seen in the period between three hours before and three hours after low tide (Fig. 4.3). Pr_s-Jones *et al.* (1989) noted that grazing on the saltmarsh has become increasingly important to this species on the Burry Inlet as the population has increased, but this behaviour was not observed during this study. Most birds were probably feeding on the mussel scars near Whiteford Point which are uncovered during this part of the tidal cycle. Brent Geese are also concentrated around Whiteford Point during the high tide period (Pr_s-Jones *et al.* 1989). The birds seen within the study area moved in from that direction and hence the highest numbers were observed feeding in count area 3 (Fig. 4.4).

A few Brent Geese were occasionally present when the tractors arrived on the upper sandflats. The distance between the birds, which were at the water's edge, and the vehicles was substantial (>500m) and little disturbance occurred.

4.3.3Shelduck

Shelduck numbers followed the same pattern as Brent Geese numbers. No birds were observed during the period between three hours before and three hours after low tide and those birds present around high tide were feeding at the water's edge (Fig. 4.5). The main concentration of Shelduck occurred in count area 2 where the track leads onto the intertidal flats (Fig. 4.6). Pr_s-Jones *et al.* (1989) noted that the highest high tide concentrations of Shelduck on the south shore were found in this area. At low tide, they moved away from here and the most consistent large concentrations were found on the pills east of Whiteford Point and on the intertidal flats off Tir Morfa and Llanelli on the north shore.

Any Shelduck that were present when the tractors arrived were spread along the water's edge. The vehicles did not cause a sudden change in distribution by causing flight, but the birds did redistribute themselves by swimming west away from the area on which the men were working.

4.3.4 Oystercatcher

Up to between 2,000 and 2,500 Oystercatchers regularly roosted within the study area. As the tide receded, the birds gradually moved out of the roost to feed at the tideline. The numbers present declined towards low tide as the birds moved out of the study area following the water's edge. Shortly after low tide, a pre-roost could be seen forming on the opposite shore and birds arrived in flocks from this direction in the two hours before high tide. A large proportion of these birds continued to feed throughout the high tide period (Fig. 4.7). The majority of birds fed in count areas 1 and 2 (Fig. 4.8) and count area 2 was the most important for roosting (Fig. 4.9). Pr_s-Jones *et al.* (1989) found that the largest concentrations of roosting birds occurred on this part of the southern shore. Previous reviews had implied that the Llanrhidian Sands region of the Burry was the most important feeding site for the species (*e.g.* Prater 1977, Howells 1983) but Pr_s-Jones *et al.*'s (1989) study showed that the largest concentration of feeding birds occurred on the flats to the north of the feeding channel. The results of the present study show that the upper intertidal flats of the Llanrhidian Sands region of the Burry were an important feeding site on the incoming and outgoing tide and at neap high tides.

Every observed occasion on which tractors arrived via the track at Weobley involved disturbance to the large Oystercatcher roost on the upper sandflats. The roost was situated directly between the end of the track and the main cockling area. The progress of the tractors therefore inevitably caused disturbance. In most cases, the birds that were still roosting took flight and landed at the water's edge, joining the large numbers of birds that were feeding there. Feeding birds in the area where the tractors stopped were less affected by the vehicles, simply running out of the way. Once the men left their vehicles, however, all the birds that had been in that area moved away. Between four hours and three hours before low tide, the water level had usually dropped sufficiently to allow all the Oystercatchers to feed on the lower areas, undisturbed by the activity of the cocklers.

4.3.5 Golden Plover

Up to 2,000 Golden Plover were regularly observed on the saltmarsh during the study period. The numbers present at different stages of the tidal cycle were variable. In general there were two peaks, one around high tide and one between one and two hours after low tide, with lower numbers present in between (Fig. 4.10). Feeding birds seemed to concentrate on the saltmarsh to the east of the track, in count area 1 (Fig. 4.11), whereas roosting birds were usually recorded on the saltmarsh to the west of the track in count area 3 (Fig. 4.12). Pr_s-Jones *et al.* (1989) also found the saltmarsh in front of Weobley Castle to be the most important area on the Burry for this species.

On some occasions, Golden Plover appeared to be disturbed by the tractors travelling down the track across the saltmarsh, particularly those birds nearest the track. The disturbance caused by birds of prey, however, was much greater. They appeared to be more tolerant of the presence of the vehicles than they were of people walking across the saltmarsh.

4.3.5Grey Plover

The number of Grey Plover recorded was extremely variable. Relatively small numbers of this species were observed between high tide and two hours before low tide (Fig. 4.13). Feeding birds were seen in count area 3 (Fig. 4.14) while roosting birds occurred at the western edge of the flock of roosting Oystercatchers in count area 3 or at the eastern edge of the Curlew flock in count area 1 (Fig. 4.15). Pr_s-Jones *et al.* (1989) found that Grey Plover roosts were well spread along the southern shore of the Burry at high tide. Largest numbers were observed at Llanrhidian and Whiteford, either side of the study site. They also found that birds were very scattered when feeding.

The small number of birds present made assessing the effects of disturbance by cocklers very difficult.

4.3.7Lapwing

Up to between 300 and 350 Lapwing were observed on the saltmarsh in front of Weobley Castle where they associated with Golden Plover. There was a similar peak in numbers two hours after low tide but no equivalent peak at high tide. Whereas most of the Golden Plover were recorded roosting, the majority of Lapwing were feeding. Two drops in the percentage feeding occurred at two hours after high tide and two hours after low tide (Fig. 4.16). Most of the feeding Lapwing were in count area 3 (Fig. 4.17). Any roosting birds were also in this area (Fig. 4.18). These results agree with those of Pr_s-Jones *et al.* (1989) who found that the largest concentration of Lapwing on the Burry occurred with that of Golden Plover in the Weobley area.

The effects of disturbance on this species were very similar to those described for Golden Plover.

4.3.8Dunlin

No Dunlin were present between two hours before and three hours after low tide but over the high tide period up to 1,400 birds were recorded (Fig. 4.19). The majority of these continued to feed whenever any part of the intertidal area was exposed. The most important feeding site was count area 1 where they tended to concentrate at the mouth of the pill at the eastern end (Fig. 4.20). Only very small numbers of birds were observed roosting and these occurred on count areas 1 and 2 (Fig. 4.21). Major concentrations of roosting Dunlin have been shown to occur all along the southern shore of the Burry from Pen-clawdd westwards, while at low tide large numbers of Dunlin have been found throughout much of the estuary (Pr_s-Jones *et al.* 1989).

Dunlin had always commenced feeding at the tideline before the tractors started driving across the sandflats. The favoured area was the eastern-most third of the stretch of water's edge in section 1. Consequently, the arrival of the cockling vehicles caused them to shift further east into approximately half that length of tideline. Few birds moved further west.

Apart from this avoidance of the area occupied by the cocklers, Dunlin appeared little disturbed by the presence of either men or vehicles.

4.3.9Curlew

Up to 140 Curlew were observed within the study area, the majority of which were usually roosting. A peak occurred four hours before low tide and thereafter numbers declined as birds moved out of the roost to feed. No birds were seen between one hour before and four hours after low tide but birds returned again as the other intertidal areas were covered by the tide (Fig. 4.22). The majority of feeding birds were observed in count area 3, most of which were birds feeding on the saltmarsh (Fig. 4.23). The main roost extended from count area 2 into count area 3 (Fig. 4.24) from which birds dispersed throughout a large area to feed (Pr_s-Jones *et al.* 1989).

The progress of tractors across the sandflats to the cockle beds always involved disturbance of the large Curlew roost causing all the birds to take flight and leave the study area. Although the birds may have left the study area anyway, the sharpness of the drop in numbers present after high tide shown in Figure 4.22 is due to this disturbance.

4.3.10 Redshank

Relatively small numbers of Redshank were observed within the study area. Maximum numbers were present around high tide but at other states of tide none were seen (Fig. 4.25). This pattern of presence and absence is the same as that for the other intertidal feeders. However, it is possible that there was considerable undercounting in the case of this particular species because of its preference for river channels and saltmarsh areas where it may be hidden from view. The main feeding area was at the mouth of the pill at the western end of the study area (Fig. 4.26). A few birds roosted at the eastern end of the study area (Fig. 4.27). Pr_s-Jones *et al.* (1989) also noted this species' preference for saltmarsh areas and experienced counting problems as a result.

The small numbers of birds present made assessing the level of disturbance to this species difficult. Redshank fed near the saltmarsh and in creeks and gullies rather than at the water's edge and were therefore probably affected very little by the cockling activity.

4.4Conclusions

The extent to which birds were affected by cocklers' use of the track as access to Llanrhidian Sands varied between species. The large Oystercatcher and Curlew roosts were most obviously affected. The smaller wader species and the wildfowl appeared least affected. In addition, there was undoubtedly an 'exclusion zone' around the cocklers into which feeding birds did not venture. The size of this zone of avoidance varied between species. The minimum distance between birds and cocklers was estimated to be 50 metres. This was most noticeable between four and three hours before low tide when the tide had not receded far and the birds were feeding on and around the cockle beds. Tractors arriving from the traditional access point did not produce either of these effects because they were not on the area at this time.

The upper area of sandflats on to which the proposed Weobley exit track leads is the only intertidal area on the south shore left uncovered on some heights of tide and the last to cover on spring tides. This area therefore represents both the first and the last opportunity for waders to feed. BoEE counts of the study area reveal that, for many species, Weobley is the most important site on the south shore of the Burry over the high tide period and that, overall, up to between 15,000 and 20,000 birds use the area. Pr_s-Jones *et al.* (1989) conducted low tide counts during the winter of 1987/88 and compared these with results obtained as part of the BoEE. They found that Weobley was relatively less important at low tide. During the present study the peak numbers of birds were observed roosting and feeding on the upper mud and sand flats within the study area when the other areas were covered on neap tides and two to three hours before and after spring high tides. This area may therefore provide vital feeding grounds for up to 20,000 waders during severe weather when they must feed for as long as possible in order to survive (Clark *et al.* 1993). If this were the case, then any disturbance to these feeding areas, before other areas become available on which to feed, may result in increased mortality through starvation during periods of severe weather.

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Figure 2.1 The study sites on western Swansea Bay (Mumbles, Blackpill and Marina) with their constituent count areas.

Figure 2.2 The study sites on eastern Swansea Bay (Crymlyn) with its constituent count areas.

Figure 2.3 The Blackpill study site with its 11 count areas.

Figure 2.4 The average number of feeding Oystercatchers recorded on each count area within the Blackpill study site in the period between three hours before and three hours after low tide during February 1993.

Figure 2.5 The average number of Oystercatchers present on the upper areas and the average number present on the lower areas within the Blackpill study site throughout the core usage period (between three hours before and three hours after low tide) in February 1993.

Figure 2.6 The average number of Oystercatchers present on the upper areas and the average number present on the lower areas throughout the tidal cycle within the Blackpill study site during the 1991-92 winter.

Figure 2.7 The average number of feeding Ringed Plover recorded on each count area within the Blackpill study site in the period between three hours before and three hours after low tide during February 1993.

Figure 2.8 The average number of Ringed Plover present on the upper areas and the average number present on the lower areas within the Blackpill study site throughout the core usage period (between three hours before and three hours after low tide) in February 1993.

Figure 2.9 The average number of Ringed Plover present on the upper areas and the average number present on the lower areas throughout the tidal cycle within the Blackpill study site during the 1991-92 winter.

Figure 2.10 The average number of feeding Grey Plover recorded on each count area within the Blackpill study site in the period between three hours before and three hours after low tide during February 1993.

Figure 2.11 The average number of Grey Plover present on the upper areas and the average number present on the lower areas within the Blackpill study site throughout the core usage period (between three hours before and three hours after low tide) in February 1993.

Figure 2.12 The average number of Grey Plover present on the upper areas and the average number present on the lower areas throughout the tidal cycle within the Blackpill study site during the 1991-92 winter.

Figure 2.13 The average number of feeding Sanderling recorded on each count area within the Blackpill study site in the period between three hours before and three hours after low tide during February 1993.

Figure 2.14 The average number of Sanderling present on the upper areas and the average number present on the lower areas within the Blackpill study site throughout the core usage period (between three hours before and three hours after low tide) in February 1993.

Figure 2.15 The average number of Sanderling present on the upper areas and the average number present on the lower areas throughout the tidal cycle within the Blackpill study site during the 1991-92 winter.

Figure 2.16 The average number of feeding Dunlin recorded on each count area within the Blackpill study site in the period between three hours before and three hours after low tide during February 1993.

Figure 2.17 The average number of Dunlin present on the upper areas and the average number present on the lower areas within the Blackpill study site throughout the core usage period (between three hours before and three hours after low tide) in February 1993.

Figure 2.18 The average number of Dunlin present on the upper areas and the average number present on the lower areas throughout the tidal cycle within the Blackpill study site during the 1991-92 winter.

Figure 2.19 The average number of feeding Bar-tailed Godwit recorded on each count area within the Blackpill study site in the period between three hours before and three hours after low tide during February 1993.

Figure 2.20 The average number of Bar-tailed Godwit present on the upper areas and the average number present on the lower areas within the Blackpill study site throughout the core usage period (between three hours before and three hours after low tide) in February 1993.

Figure 2.21 The average number of Bar-tailed Godwit present on the upper areas and the average number present on the lower areas throughout the tidal cycle within the Blackpill study site during the 1991-92 winter.

Figure 2.22 The average number of feeding Curlew recorded on each count area within the Blackpill study site in the period between three hours before and three hours after low tide during February 1993.

Figure 2.23 The average number of Curlew present on the upper areas and the average number present on the lower areas within the Blackpill study site throughout the core usage period (between three hours before and three hours after low tide) in February 1993.

Figure 2.24 The average number of Curlew present on the upper areas and the average number present on the lower areas throughout the tidal cycle within the Blackpill study site during the 1991-92 winter.

Figure 2.25 The average number of bait-diggers recorded on each count area within the Blackpill study site in the period between three hours before and three hours after low tide during February 1993.

Figure 2.26 The average number of bait-diggers present on the upper areas and the average number present on the lower areas within the Blackpill study site throughout the core usage period (between three hours before and three hours after low tide) in February 1993.

Figure 3.1 The location of the 11 count areas and the location of the spring high tide and neap high tide roosts within the Blackpill study site during February 1993.

Figure 4.1 The locations of the three count areas within the study site on the Burry Inlet.

Figure 4.2 The pattern of presence and absence of cocklers within the study site on the Burry Inlet during February 1993.

Figure 4.3 The average number of Brent Geese present and the percentage feeding within the study site on the Burry Inlet throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

Figure 4.4 The average number of feeding Brent Geese recorded on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.5 The average number of Shelduck present and the percentage feeding within the study site on the Burry Inlet throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

Figure 4.6 The average number of feeding Shelduck recorded on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.7 The average number of Oystercatchers present and the percentage feeding within the study site on the Burry Inlet throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

Figure 4.8 The average number of feeding Oystercatchers recorded on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.9 The average number of Oystercatchers recorded roosting on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.10 The average number of Golden Plover present and the percentage feeding within the study site on the Burry Inlet throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

Figure 4.11 The average number of feeding Golden Plover recorded on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.12 The average number of Golden Plover recorded roosting on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.13 The average number of Grey Plover present and the percentage feeding within the study site on the Burry Inlet throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

Figure 4.14 The average number of feeding Grey Plover recorded on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.15 The average number of Grey Plover recorded roosting on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.16 The average number of Lapwing present and the percentage feeding within the study site on the Burry Inlet throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

Figure 4.17 The average number of feeding Lapwing recorded on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.18 The average number of Lapwing recorded roosting on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.19 The average number of Dunlin present and the percentage feeding within the study site on the Burry Inlet throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

Figure 4.20 The average number of feeding Dunlin recorded on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.21 The average number of Dunlin recorded roosting on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.22 The average number of Curlew present and the percentage feeding within the study site on the Burry Inlet throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

Figure 4.23 The average number of feeding Curlew recorded on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.24 The average number of Curlew recorded roosting on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.25 The average number of Redshank present and the percentage feeding within the study site on the Burry Inlet throughout the tidal cycle. The percentage feeding is only plotted when more than 50 birds were counted in total throughout the winter.

Figure 4.26 The average number of feeding Redshank recorded on each count area within the study site on the Burry Inlet during February 1993.

Figure 4.27 The average number of Redshank recorded roosting on each count area within the study site on the Burry Inlet during February 1993.