Disturbance and feeding shorebirds on the Exe estuary

J. D. Goss-Custard & N. Verboven

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The effects of disturbance on shorebirds wintering on the Exe estuary are reviewed. The local level of disturbance varies according to access and habitat type. Most people occur in sandy areas where, at low water, only a minority of the birds of most species feed. By the time most people arrive on the receding tide, most birds have moved to their muddy low water feeding areas where they are little disturbed. Disturbance can be intense on the third major habitat, the mussel beds, where the most numerous shorebird is the Oystercatcher. However, disturbance levels vary greatly between mussel beds, according to access. Few Oystercatchers feed on two small intensively disturbed beds. Disturbance is also common on two large beds near Cockwood and Exmouth and can reduce the rate at which the most vulnerable Oystercatchers feed by as much as 33-50%. However the overall effect is much lower because so much feeding occurs when people are not present (on neap tides; at night; on the receding and advancing tides). The birds also adapt to disturbance by habituating to the presence of stationary people, by moving to other less disturbed mussel beds, or by rescheduling their feeding routine during the tidal cycle The increasing levels of disturbance over the last 10-15 years may have caused some redistribution of birds between beds, with many birds leaving the most intensively disturbed areas at Cockwood. Yet numbers have increased considerably on the beds at Exmouth which are also frequently disturbed. However there is no evidence that the total number of Oystercatchers on the mussel beds over the whole estuary have been reduced by the rising levels of disturbance, their numbers have increased in line with the rise in the whole British wintering population over the same period.

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INTRODUCTION

This paper reports observations on the effect of disturbance on shorebirds during a 15-year study on the Exe estuary, Devon. Over that period, the numbers of people on the estuary over the low-water period has increased noticeably. Activities include dog-walking, casual and commercial shell-fishing, birdwatching and walking. Though most of the direct observations have been made while watching Oystercatchers *Haematopus ostralegus* on mussel beds, surveys of bird distribution elsewhere allow other habitats to be considered.

The Exe supports a generally typical community of wintering and migrating shorebird species, including nationally significant numbers (>1%) of some species. A special feature is that it supports a substantial proportion of the British wintering populations of Black-tailed Godwits *Limosa limosa* and Avocets *Recurvirostra avosetta*. The mean peak number, with season at which it occurs and percentage of British numbers in brackets, over recent years for each of the main species is as follows: Oystercatcher, 5,082 (winter, 1.8%); Ringed plover *Charadrius hiaticula* 454 (spring, 1.5%), Grey plover *Pluvialis squatarola*, 323 (winter,

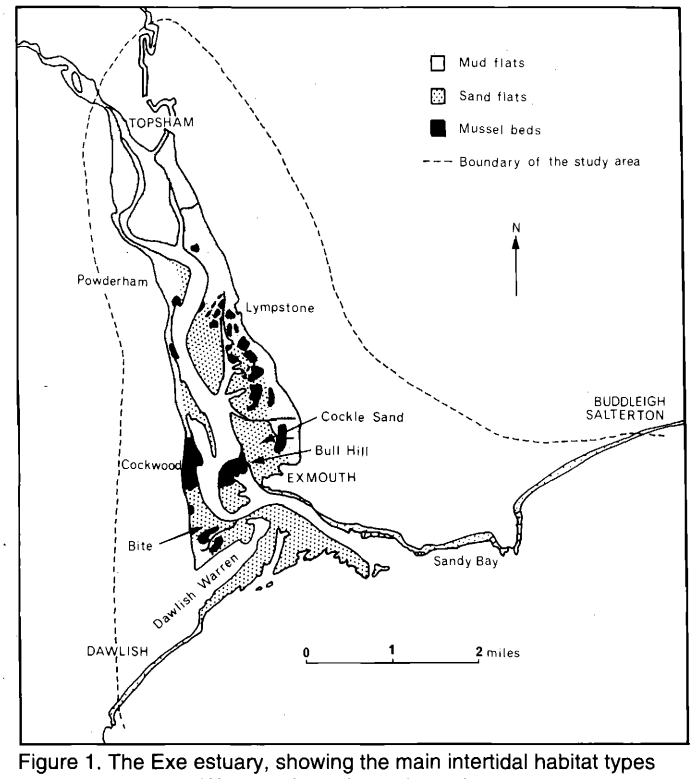

Figure 1. The Exe estuary, showing the main intertidal habitat types and Dawlish Warren where the main wader roost occurs.

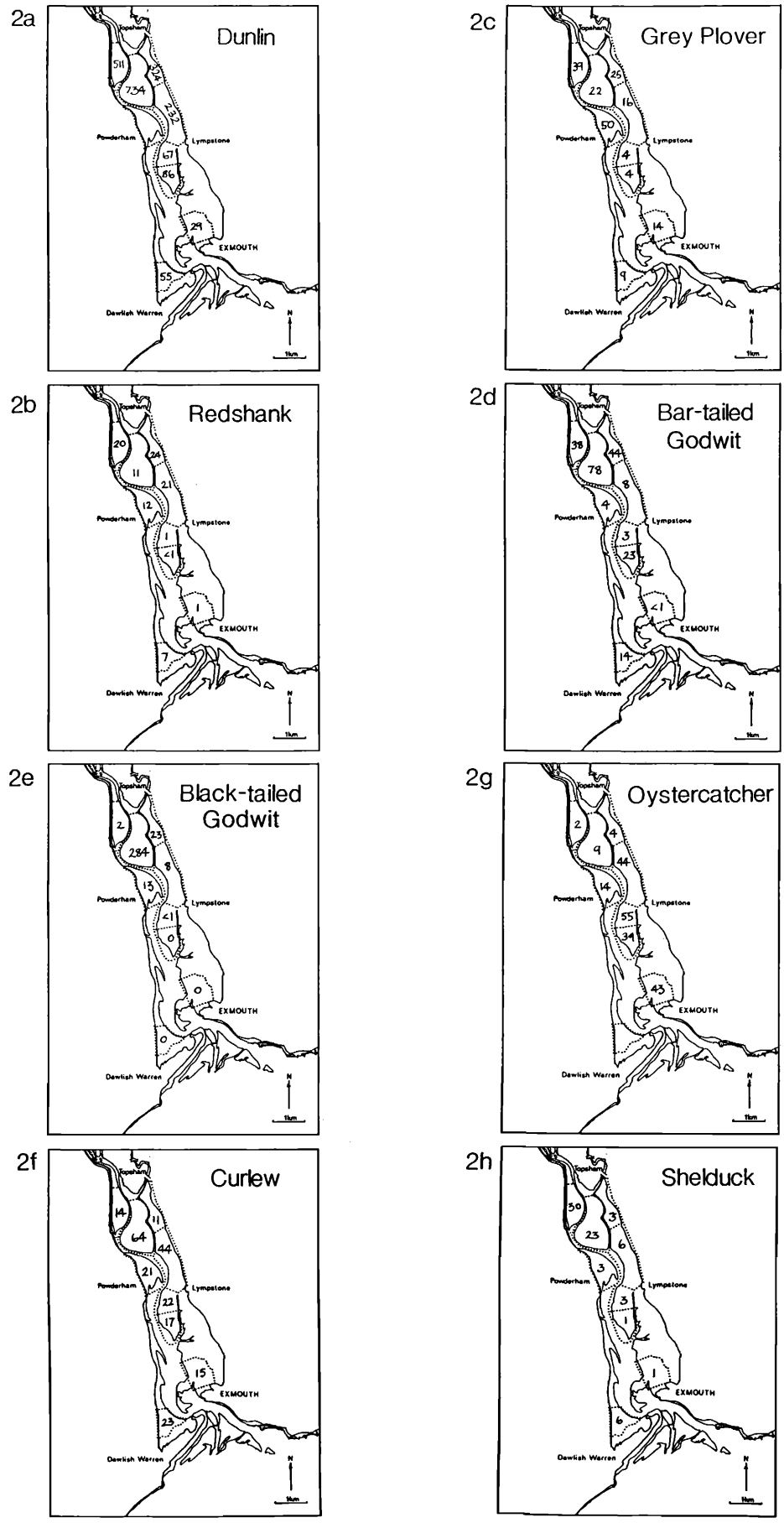

Figure 2. (a-h). The numbers of eight wader species counted on the Exe estuary at low water in nine sample areas (enclosed by dots) during the winter 1986-87.

1.5%); Turnstone *Arenaria interpres*, 211 (winter and spring, 0.5%); Curlew *Numenius arquata*, 926 (winter and spring, 0.9%); Black-tailed Godwit, 657 (winter, 13.1%); Bar-tailed Godwit *Limosa lapponica*, 494 (winter, 0.8%); Redshank *Tringa totanus*, 559 (0.8%); Knot *Calidis canutus* 49 (<0.1%); Dunlin *Calidris alpina*, 5,783 (1.3%); Avocet, 310 (62.0%).

Features of the Exe estuary are shown in Figure 1. The main high-water roost is on Dawlish Warren, a sandy peninsula across the estuary mouth. Birds leave as the tide recedes and begin feeding on the upper level flats that expose first. Later, they disperse to other areas where better feeding is found. This pattern is reversed on the advancing tide. There are approximately 30 mussel beds, of which only 10 are of significant size and contain high densities of mussels. Mudflats are most widespread in the higher reaches of the estuary but also occur at the higher shore levels in the lower reaches. The third major habitat type is the sand that occurs in the lower reaches, including just outside the mouth. Because the numbers of birds and people depend largely on the habitat, they are considered in turn.

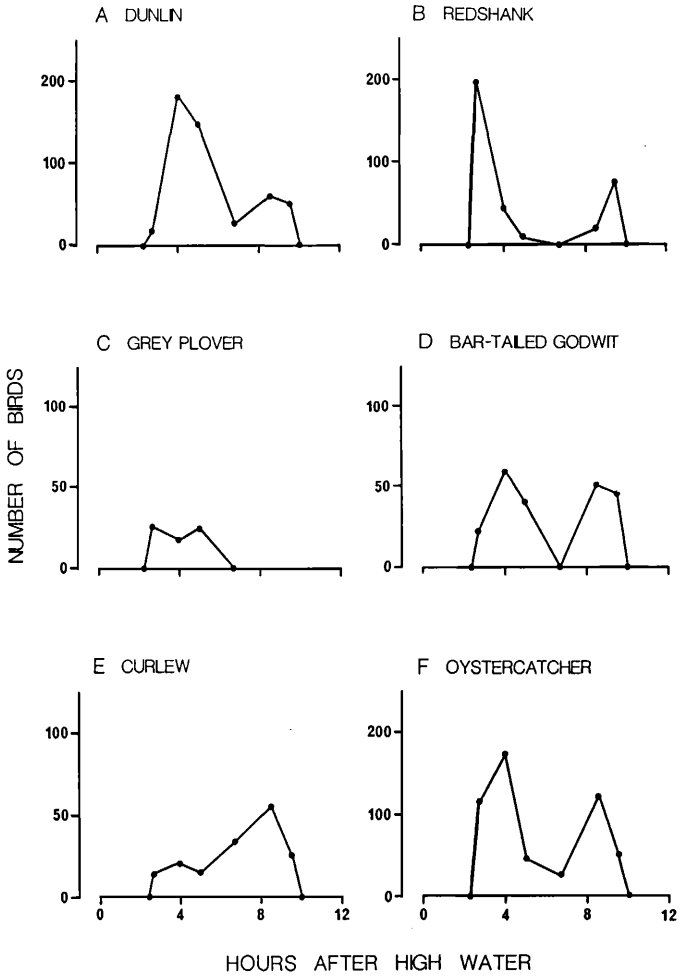

Figure 3 (a-f). The numbers of six species of waders in the south-west corner of the Exe estuary (the Bite) throughout one winter tidal cycle.

SANDFLATS

People are more attracted to sandflats than to the other habitat types. Bait-digging and dog-walking are common there throughout the year and in summer yachtsmen and windsurfers visit the sandy islands at the estuary mouth.

The potential impact on the birds depends, in part, on the numbers of birds using the sandflats. Mainly Oystercatchers use the coarse sand and gravel flats at the mouth where people occur regularly at low water in late summer and autumn. By mid-winter, where the birds are most hard-pressed for food, few people occur there. Accordingly, the approximately 10% of the Exe Estuary Oystercatcher population that uses this area in winter is usually undisturbed for the short period (1-2 hrs) for which these sandy areas are exposed at low water.

A greater variety of birds uses the generally less coarse sandflats within the estuary itself. Ten surveys covering most of the sandflats and mudflats that expose at low water (mussel beds excluded) were made during the winter (October-March) 1986-87. The mean numbers counted in each area are shown in Figure 2. Of the birds using both mudflats and sandflats, the greatest proportion in all species, except the Oystercatcher, occurred in areas dominated by mud. The proportions of the mean numbers (shown in brackets) counted over the winter on sandflats were as follows; Black-tailed Godwit, 0.3% (331); Redshank 10.2% (98); Dunlin, 11.2% (2121); Shelduck *Tadorna tadorna,* 14.5% (76); Grey Plover, 16.9% (183); Bar-tailed Godwit, 19.2% (213); Curlew, 33.3% (231) and Oystercatcher, 73.4% (274). All the Avocets feed in the softest mud in the upper reaches of the estuary. Thus, only a minority of the populations using mud- and sandflats at low water are exposed to disturbance by people on the sandflats.

A larger number of birds use high-level sandflats when the tide ebbs and flows and the preferred low-water feeding areas are covered by water. The main places are situated in the two bays in the south-west and south-east corners of the estuary (Figure 1). Cockle Sand is a popular place for dog-walking and bait-digging, and people arrive very soon after the sandflats begin to expose. However, wide and deep creeks prevent them reaching any but the inshore areas. By the time the more distant areas become accessible, many birds have left to feed farther upriver.

A similar sequence of events occurs in the high-level sandflats in the Bite. Being less accessible, few dog-walkers go there. The main users are bait-diggers and anglers and some shell-fishermen who maintain racks for cultivating oysters along, or near to, the Low Water Mark (LWM). As counts through the tidal cycle on one

occasion in winter illustrate (Figure 3), the largest numbers of birds occur on the receding tide. This extreme south-west corner of the estuary is one of the first to expose and, being close to the main roosts on Dawlish Warren, birds begin feeding there in large numbers. But by the time the bait-diggers and anglers arrive, most birds have moved elsewhere. By the time the oyster racks are exposed almost all of the waders have left. Those that remain are spread over the large expanse of sandflats above the LWM and can easily avoid people. Though not shown in Figure 3, many wildfowl, especially Wigeon *Anas penelope* and Brent Geese, also use the Bite. They mainly occur in the muddy areas at the top of the shore and feed on marine grasses. As few people go there, disturbance is infrequent.

MUDFLATS

Few people use the mudflats in the upper half of the estuary where the majority of most of the shorebirds obtain their food at low water. Marines sometimes train over a small area in the north-east corner, but infrequently. The main disturbance occurs along the west side, to the north of Powderham, where on the receding tide people walk along the embankment, usually looking at birds. At low water, most birds are too far out on the flats to be affected.

Elsewhere, small numbers of shell-fishermen maintain pots and slates for catching 'peeler' crabs for bait. Since the small numbers of people involved walk slowly and are well dispersed over the flats, the disturbance seems to be minor; birds normally fly only a short distance and quickly resume feeding.

Muddy areas are unattractive for most leisure activities, and they contain few harvestable animals. This is fortunate as the main feeding areas of most waders in the Exe are muddy. This spatial separation between most people and most waders may be quite general on estuaries, except where boats are moored in muddy places. In the Wash in east England, for example, five of the eight most numerous shorebirds had a strong preference for muddy sites (Goss-Custard & Yates 1992). High levels of potential disturbance in muddy areas can occur in narrow creeks where people on the shore may be very close. But, even here, many birds may adapt, though with unknown effects on local densities. For example, there are many narrow creeks in south-west England where footpaths and roads occur immediately alongside places where many shorebirds, including territorial Redshank, feed throughout the winter. Unless new sports or commercial fisheries arise that attract a much great number of people to mudflats, levels of disturbance in many of the birds, most important feeding areas may not generally be very significant.

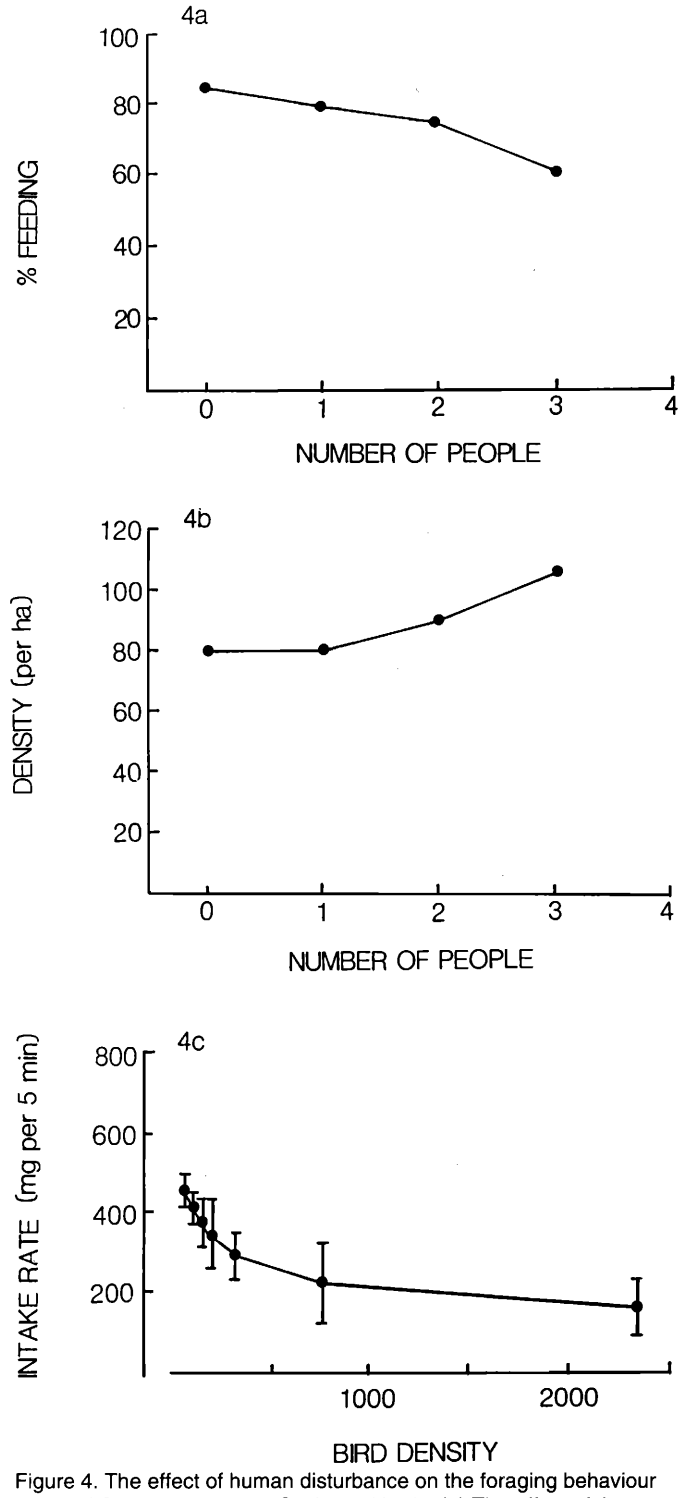

Figure 4. The effect of human disturbance on the foraging behaviour of Oystercatchers on Cockwood beds. (a) The effect of the number of people on the bed on the proportion of birds feeding and (b) the density of foraging birds. (c) The effect of bird density on the rate of food intake of juvenile Oystercatchers (from Goss-Custard & Durell 1987).

MUSSEL BEDS

Two of the smallest mussel beds on the Exe are seldom used by birds in daylight because people occur there almost continuously. One is at a high level on the shore, close to the point of access at the northern end of the

Bite. The other is a low-level bed further to the north on the west side where anglers fish on most tides. Though some birds do feed in these areas when people are present, the beds are too small to allow birds to avoid people so densities are much reduced. If present in sufficient numbers, people certainly can prevent birds using otherwise suitable feeding habitat.

Some of the largest and most important mussel beds also attract many people. But because birds can usually move sufficiently far (>75 m) to continue feeding, some birds usually remain there throughout low water. The large beds most visited by people are those close to access points or those that do not require a long walk over mud to reach and are reasonably firm underfoot. The most disturbed are the two large beds lying to the west of Exmouth, on the west (Cockwood beds) and east (Bull Hill beds) sides of the river. In general, the other large beds are only visited by shell-fishermen who usually limit their activities to the bed edges.

The Cockwood and Bull Hill beds are used by people for dog-walking, birdwatching, casual cockle-, mussel- and winkle-picking, angling and for launching boats and placing moorings. A few professional shell-fishermen pick winkles and, occasionally, collect mussels. The mussel beds are most used for recreational purposes in summer and early autumn, but people do occur there throughout the winter, especially on the Cockwood beds. In fact, these beds are the most disturbed on the estuary because they are so accessible. By contrast, the Bull Hill beds are 600 m from the shore and half of them lie beyond a deep creek that can only be crossed on foot around low water.

Most birds on the mussel beds are Oystercatchers along with small numbers of Redshank, Curlew, Turnstone and Greenshank *Tringa nebularia*. Most of the several thousand Oystercatchers that winter on the Exe feed on mussels; very few eat the cockles, winkles and ragworms that also occur on the beds (Goss-Custard & Durell 1983).

Studies on the northern half of the Cockwood beds (known as bed 4) have identified some of the effects that people have on foraging Oystercatchers. When disturbed, most Oystercatchers fly to another part of bed 4 where many then rest. As a consequence, more birds stop feeding as the numbers of people on the bed increase (Figure 4a). Because those that do feed are forced together into a smaller area, the density of foraging birds also increases (Figure 4b). Oystercatchers steal mussels from each other with increasing frequency as the density of foraging birds, and thus opportunity to steal from subordinate individuals, increases (Ens & Goss-Custard 1984). As a consequence, the intake rates of sub-dominant birds decreases at high bird densities (Ens & Goss-Custard

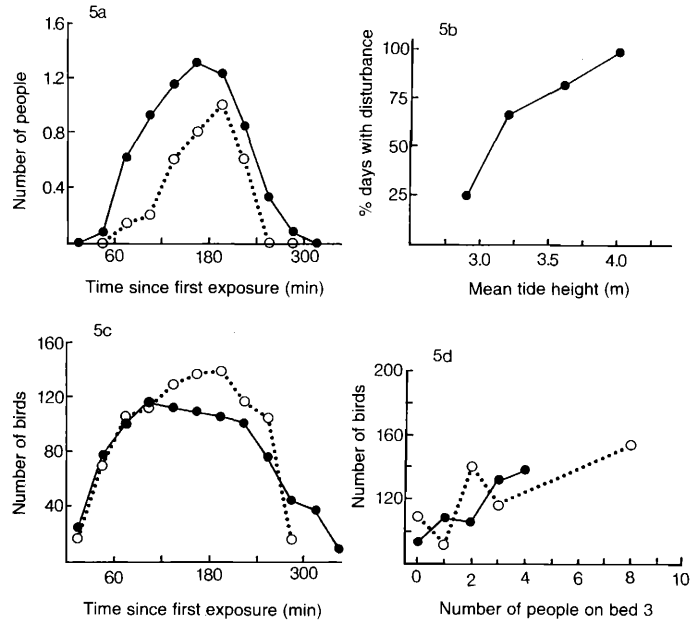

Figure 5. The frequency of occurrence of people on mussel bed 4 at Cockwood during autumn and winter 1989. (a) The mean numbers of people on the bed throughout the tidal cycle on neap (○) and spring (●) tides. (b) The proportion of days with human disturbance according to the height of the tide. The mean tide height is the mean of the high waters occurring before and after the low-water period. (c) The mean numbers of Oystercatchers on bed 4 throughout the tidal cycle on neap (○) and spring (●) tides. (d) The numbers of birds on bed 4 in relation to the level of disturbance on the adjacent bed 3 on the neap (○) and spring (●) tides; when people arrive on bed 3, birds are regularly seen flying the short distance to bed 4 where bird numbers consequently increase.

1984, Goss-Custard & Durell 1988). Figure 4c illustrates how intake rate decreases as bird density rises in juveniles, which are amongst the least dominant of Oystercatchers. The conclusion therefore, is that as the numbers of people increase on the mussel bed, most birds spend less time feeding and do so at a lower rate. The important question, though, is whether the reduced feeding opportunity actually has a significant effect on the birds. The most convincing demonstration would be that disturbance reduced the birds' fitness; that is, their chances of surviving the winter, or to acquire energy reserves to migrate successfully or to maintain a good enough body condition to breed well in summer. As this cannot yet be examined, the indirect approach of assessing the effect of these levels of disturbance on gross intake rate must be used instead.

Figure 4a shows that the presence of three people (there are seldom more) reduces the average proportion of birds feeding from approximately 85% to 65%; that is, the average bird feeds for 20-25% less of the time. Figure 4b shows that average bird densities increase from 80 to 110 birds per ha when three people are on the bed. Figure 4c shows that such an increase in density would decrease the intake rate of juveniles by 13%, from approximately 460 to 400 mg per 5 min of foraging. With three people on the bed, the average

Table 1. Numbers of oystercatchers (± SE) in 1978-81 and 1988-91 on three groups of mussel beds with different levels, and increases, of disturbance over the decade.

Mussel beds	Mean winter numbers: 1978/79-1980/81	1988/89-1990/91	Percentage change	Level, and change in disturbance
Cockwood	311 ± 16	198 ± 22	−36	v high & increased
Bull Hill	397 ± 18	659 ± 47	+66	high & increased
Remaining beds*	578 ± 29	861 ± 22	+49	v low throughout
Total	1,286 ± 6	1,718 ± 30	+34	–
National Index**	173 ± 9	235 ± 7	+36	–

* Beds 1, 20, 22, 25, 26 and 27 (in Goss-Custard *et al.* 1982)
** From the BTO British January Index

juvenile would therefore feed for 75-80% of the time and at 85-90% the rate compared with when no people were present. Its overall intake rate would therefore be reduced by some 65-75%.

This is an average value, of course, and there would be variation between individuals in the effect of disturbance according to their age, feeding method and dominance (Goss-Custard & Durell 1988). A decrease of a third perhaps even half, might occur in the most vulnerable groups with three people on the bed. However, such high levels of disturbance are untypical for three reasons. First, people are seldom there during the first and last hour of the exposure period (Figure 5a); this represents one-third and two-fifths of the exposure period on spring and neap tides respectively. Second, there is only seldom more than one person on the bed throughout the low-water period, especially on neap tides (Figure 5a). Third, the probability that people will occur on the bed at some point during the low-water period is much lower on neap tides (mean tide height <3.25 m) than on higher tides (Figure 5b). Fourth, people seldom occur on the beds at nights where Oystercatchers feed throughout the year, though at only 40% the daytime rate (Goss-Custard & Durell 1987). In other words, the average number of people on the bed throughout the feeding time of the birds as a whole is considerably less than three.

When disturbance does occur, birds compensate by moving elsewhere or by feeding at a greater rate during undisturbed periods of the day. Compared with neap tides, more birds leave the mussel beds to feed on other mussel beds at low water on spring tides (Figure 5c), partly in response to the higher levels of disturbance. In the same way, birds move from adjacent bed 3 to bed 4 when large numbers of people occur there (Figure 5d). The birds may also reschedule their foraging through the tidal cycle. Captive Oystercatchers have been shown experimentally to compensate for lost foraging time by raising their intake rate at the end of the low-water feeding period (Swennen *et al.* 1989). Birds may thus be able to fill their crops before flying to the roost so, in effect, extending their foraging time. This may be why adult Oystercatchers on the Bull Hill mussel beds increased their intake rate at the end of the tidal cycle in September and October when disturbance at low water was severe (Goss-Custard, Clarke & Durell 1984). However, young birds did not do so, perhaps because they lacked the experience to know when it was required or because high densities of feeding adults at the end of the tidal cycle depressed their intake rates (Goss-Custard & Durell 1987; 1988).

If increasing disturbance has significantly affected Oystercatchers over the last 15 years, it should be reflected in changes in their numbers. The Cockwood beds are most disturbed because access is so easy. The Bull Hill beds are less disturbed because access to half the area is only possible for two-three hours over low water. Few people visit the five other major beds. If disturbance has had an effect, bird numbers would be expected to have decreased on the Cockwood and Bull Hill beds, but not elsewhere.

The total bird-days per winter on the three groups of beds between 1976-77 and the present are shown in Table 1. Bird-days were calculated from late September, when peak numbers occur, through to January, just before birds start migrating to the breeding grounds. Despite increased disturbance, Oystercatcher numbers have increased over the decade on the main or 'priority' beds (Goss-Custard *et al.* 1982) combined by a third, almost identical to the increase record in Britain as a whole over the same period.

When different mussel beds are compared, there is no clear association between changes in Oystercatcher numbers and disturbance levels. Numbers have decreased by a third on the Cockwood beds where the disturbance has been both the most intense and increased most. But numbers have increased by two-thirds on the Bull Hill beds which also have been increasingly subjected to disturbance. The increase in Oystercatcher numbers on Bull Hill has been larger than

that occurring on the remaining, largely undisturbed, beds. This probably happened because many birds displaced from Cockwood moved to Bull Hill, as studies on marked individuals show. The counts therefore suggest no clear link between the increase in disturbance over the years, and its present level, and the changes in bird numbers on the various mussel beds of the Exe.

Why have the changes in bird numbers over the decade been so different on the various beds? There is no clear association between the changes in the numbers and in the food supply (unpublished information), though further tests are required and are in progress. Oystercatchers may have been driven off the Cockwood beds by Carrion Crows *Corvus corgne*) which steal mussels from Oystercatchers (Goss-Custard, Durell & Ens 1982). However, there is no clear evidence of this (unpublished information), though further tests are also planned. It is possible that disturbance has reached a critical level on the Cockwood beds at which birds are driven away, and not on Bull Hill, but this is again untested.

DISCUSSION

Oystercatchers

The increase in the winter numbers of Oystercatchers on Bull Hill was surprising in view of the high levels of disturbance occurring there. However, our impression of disturbance levels on this bed, as on others, will be highly exaggerated. Like us, most people visit the beds at low water spring tides in daylight. Yet the birds feed there all the time; on receding and advancing spring tides in daylight, throughout daylight neap tides and throughout both neap and spring tides at night. Over the winter as a whole, at least two-thirds of their feeding is done at times when people seldom occur on the beds. On the other hand, the mussels available at the higher shore levels on the receding and advancing spring tides and throughout the tidal cycle on neap tides contain less flesh than those available at the lower levels of the shore on spring tides (Goss-Custard & Durell 1987). Furthermore, birds feed at night at under half the daytime rate (Goss-Custard & Durell 1987). In terms of its effects on the overall feeding opportunities for Oystercatchers, disturbance may occur for over half the effective time that the birds feed during the winter.

This would be serious if this meant that the birds were actually prevented from feeding for over half the time. But this is not so: Oystercatchers can adapt to minimise the effects of disturbance. They can move some distance to avoid people, though this could cause their food intake to decrease through unfamiliarity with the area and increased interference resulting from elevated bird densities. They may also reschedule their foraging routine by, for example, increasing their intake rates as the tide advances. Many can also feed in fields at high water, except when low temperatures render their earthworm prey unavailable (Goss-Custard & Durell 1987). They can also habituate to people themselves, though this depends critically on the extent to which the people move about. Anglers and the local winkle and mussel pickers usually move rather little; having found a suitable place, they remain there for much of the tidal cycle. After the initial disturbance, the Oystercatchers settle down and even feed nearby. Such activities seem to cause little more disturbance than the scares caused by the increasing numbers of birds of prey that hunt over the estuary. Severe disturbance from people usually arises if several casual winkle- and cockle-pickers, along with people walking their dogs or birdwatching, roam over the mussel beds. This gives the birds little chance to settle down or to get used to people, and so they leave.

With continuous intense disturbance of this kind, birds may desert the mussel bed, as has virtually happened on two small beds on the west side of the estuary. But with the much lower levels of disturbance that typically occur on most beds, the effects on most birds might be insignificant because they can adapt their foraging behaviour. There is, in fact, no evidence from counts made on the Exe that the total numbers of Oystercatchers have been affected by the increased levels of disturbance over the last decade. Bird numbers on the main mussel beds of the Exe have increased roughly in line with the rise in the British wintering population. There may only have been some local redistribution within the estuary. Numbers on the highly disturbed beds at Cockwood have decreased by a third, whereas they have increased by between one- and two-thirds elsewhere. Yet the largest increase occurred on the disturbed Bull Hill beds, underlining the point that the frequency and intensity of disturbance is critical in determining how seriously the birds are affected. The mere presence of people on the feeding grounds is clearly not sufficient reason in itself for believing the disturbance is deleteriously affecting the birds.

Despite the absence of any evidence to suggest that Oystercatcher numbers on the Exe have decreased as disturbance levels have increased, some vulnerable sections of the population may now find it more difficult to obtain their food requirements. The first- and second-winter birds are most at risk of dying in winter. Being amongst the least efficient foragers and poorest competitors on the mussel beds, young birds may suffer disproportionately from disturbance. This difficulty would be greatest in cold weather when energy requirements are high yet the opportunities to feed – in fields at high water, for example – are least. In the circumstances,

disturbance might have a more severe effect on some Oystercatchers than merely to redistribute them locally during a three- to four-hour period over low water on spring tides that fall in daylight. This could be significant, because modelling shows that the overall population size can be much affected by the winter mortality rates of young birds (Goss-Custard & Durell 1990). However, the counts provide no evidence that disturbance of young birds has actually reached the point at which the population size is being affected, despite the marked increase in human activities that has taken place over the same period.

Other shorebirds

Many of the points made on Oystercatchers apply to other species of waders. Our casual impression of disturbance levels is again likely to be exaggerated because people tend to be present on the feeding ground at similar times. The many occasions when birds feed undisturbed, at night and on neap tides, for example, are just not noticed. Furthermore, in many cases, birds occur on the flats at largely different times, or in different places, to people. Most waders on the Exe, occur on muddy places which are least popular with people. On the higher level sandflats, most birds have left before most people arrive. The birds may also be able to adapt to the presence of people, though this might be less easily done in the smaller species which seem generally to be more hard-pressed in winter than the large birds, such as the Oystercatcher (Goss-Custard *et al.* 1977). Nonetheless, on the Exe, there has been no trend in the peak winter numbers of any species recorded by the BTO Estuaries Enquiry over the last 15 years; the significance level of the correlations of bird numbers against year in the main species varies between 0.1 and 0.8. There is therefore no evidence that current levels of human disturbance significantly affect the feeding, and thus numbers, of overwintering shorebirds on this apparently rather typical estuary.

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Bar-tailed godwit