Slings. Try suspending the bird in a sling made of cloth and suspended with a string so that the birds feet just touch the ground. The bird should be placed in a quiet place with subdued light to discourage struggling. If recovery proceeds the string is lengthened to gradually place more of the bird's weight on its legs. This process may take hours or even days. In the latter case the bird has to be fed. Suitable foods are chopped boiled eggs and tinned catfood preferably laced with meal-worms whose movement encourages the bird to peck. As the bird recovers take care not to panic it again - a bird which had recovered flapped, kicked and struggled and became cramped again necessitating further treatment.
Warmth. Some success has followed immersing the bird's legs in warm water and massaging them gently for a period of up to 30 minutes. This presumably encourages blood flow.

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D.J.Stanyard, Court Farm, Groeslon, Caernarfon, Gwynedd, LL54 7UE, Wales

(Although the whole of this paper has been attributed to Derek Stanyard the guidelines and recommendations section takes into account observations and comments from many people. The following points were made in discussion and omitted in error from the above. During capture and handling of Curlews and other long-legged waders precautions should be taken to avoid folding the legs to the body. Such birds should not be carried in sacks or bags, but if this is unavoidable they should remain therein for a minimal time (less than 5 minutes). When handling the bird the legs should be allowed to dangle and not be folded to the body. These precautions appear to help prevent cramp. - Eds.)

SUMMARIES OF CURRENT RESEARCH ON WADERS

From time to time we have published brief descriptions of the current work undertaken by ringing groups or by workers in a particular area. Up to now these articles have not been concerned with programmes investigating ecological and other aspects of waders additional to ringing. The article below by Dr. Peter Evans describing studies centred on the Tees estuary is thus something of an innovation for the Bulletin. We hope that other research team organisers will provide similar outlines of their achievements, objectives and future plans. We think this will be particularly valuable and important in encouraging associated co-operative studies by other groups and individuals who may be able to collect additional supporting data. For example, team work on many sites will be required to work out the network or sequence of areas used by individual waders, a matter of great importance in studying 'turnover' and 'carrying capacity' as Peter Evans explains - The Editors.

SHOREBIRD RESEARCH ON THE TEES ESTUARY, NE ENGLAND

by P.R.Evans

Since the late autumn of 1970, a succession of research projects have been carried out, by members of the Zoology Department of Durham University, on shorebirds at Teesmouth, one of the most heavily polluted and industrialized estuaries in Britain. Our aim was to predict the effects on wintering shorebird populations of a 60% reduction in the area of intertidal land known as Seal Sands. Reclamation of the site took place in 1973 to provide storage and refinery facilities, following the development of the Ekofisk oilfield in the North Sea.

In 1971 and 1972 we surveyed the invertebrate populations on Seal Sands, established the life histories of the most important species, measured the average feeding time required by each shorebird species during a tidal cycle, and identified their preferred diets and feeding sites. From this information (ref.1) we predicted which bird species would be affected by the reduction in food resources resulting from removal of 60% of the intertidal land, and which species by the reduction in feeding time (since reclamation preferentially removed the feeding areas at higher tidal levels).

Between 1973 and 1975, i.e. during the winter of active reclamation and the two winters following it, we monitored the changes in numbers of birds feeding in Seal Sands (ref.2). These changes accorded qualitatively with most of our predictions based upon the reductions in food resources, but not so well with those based upon reduction in potential feeding time, because some species found suplementary feeding areas elsewhere in the estuary, which they used when Seal Sands were covered by the tide (ref.3).

Food resources which are not continually replenished can provide food for a certain number of 'animal-days' of use. If the number of days is predetermined, then the number of animals which can be supported by the resources can be calculated. (This is the basis of the concept of "carrying capacity" of grasslands for sheep and cattle in winter.) There is very little information from wild animal populations to indicate whether this concept has any practical value in ecological studies, though it forms the basis for several mathematical models of the natural regulation of animal populations.

Since the invertebrate populations which form the foods of shorebirds do not breed during most of the period when the birds are present, the opportunity exists for examining how birds adjust their numbers on intertidal land to the food resources. One of the most important findings of our studies in 1973-75 was that, when the food resources were cut by reclamation, the subsequent reduction in bird-days of use of Seal Sands resulted from reductions in the numbers of birds using the estuary, rather than in the period for which species stayed. This suggests that shorebirds regulated their numbers on the area when they settled, after their return from the breeding grounds.We attempted to measure, in the field, by direct observation, the quantity of food required by an average bird of each species each day, to determine how closely the number of bird-days of use of Seal Sands related to the maximum number of bird-days which the food resources could have supported. It proved possible to do this for only a few species, and the confidence limits on the estimates of daily food intake were wide. We suspected that this imprecision stemmed only in part from our sampling techniques, and chiefly reflected true differences in food requirements and foraging abilities between individual birds of a species. Another important finding from our 1973-75 studies was that the percentage reduction in numbers of birds, following the reclamation of part of Seal Sands, varied markedly between species, and that whenever several species took similar invertebrate foods, albeit by different foraging techniques, the largest-sized bird species of each group suffered the least reduction in numbers. This suggested that the behavioural reactions of one species to another may also be important in determining the number of each which settle in autumn.

A very limited programme of catching and individually colour-marking birds in 1975 and 1976 immediately produced two disconcerning results (1) that although numbers of some species did not fluctuate much during the course of the autumn, winter and spring (suggesting that the concept of "carrying capacity" was relevant), there was considerable turnover of individuals within each population, with immigrants approximately balancing emigrants in numbers (2) that within a single species, different individuals used the intertidal habitat in different ways in their search for food: some defended and fed within a single small area; others defended a territory at mid-tidal level and then used a second area near low-water level, when this was uncovered by the tide; yet others fed in groups without antagonism between adjacent birds.

Between 1976 and 1979 we have attempted to discover why each shorebird species uses the intertidal habitats, in space and time, in the way it is seen to do. As is generally known, shorebirds have two foraging methods - visual and tactile. Those species hunting visually look for movements of the invertebrate prey at the surface of the sand or mud. Most invertebrates lie buried in the sediment and come to the surface only occasionally to breathe, feed or defaecate. As the sediments dry out, the invertebrates become less active, and so the density of available prey decreases. As a result, most birds follow the tide edge as it ebbs and flows, since prey activity is highest there. Other bird species hunt by touch; they do not rely on movement of prey for its detection, but its accessibility is determined by the depth at which it lies in the sediment, in relation to the length of the bird's beak. Some invertebrates, e.g. marine worms, burrow deeper as the sediment dries out; others, e.g. bivalve shells such as cockles, do not alter their depth during the period for which the sands are uncovered by the tide. Thus birds feeding on bivalves can search the whole expanse of intertidal land, whereas those searching for worms must feed in wet areas, often at the tide edge. Some invertebrate species occur in discrete bands at particular tidal levels on a beach or mudflat. Hence they are available to birds only at certain stages of the tidal cycle. The position of these bands may vary with season; in colder weather they often move downshore. This affects the feeding areas used by the shorebird species, so that they may exploit the intertidal habitat in different ways in winter and spring (ref.4).

In 1977 and 1978 we have also managed to ring some 6000 shorebirds at Teesmouth. Most individuals of the less common species - Shelduck *Tadorna tadorna*, Grey Plover *Pluvialis squatarola*, Curlew *Numenius arquata*, Turnstone *Arenaria interpres* and Sanderling *Calidris alba* - have also been marked with unique combinations of coloured rings. This has provided the necessary marked populations of several species to carry forward research on the way in which the behaviours of individual birds control the numbers of each species which settle on a mudflat or beach. The extensive colour-marking programme has already provided estimates of the survival of Sanderling, Grey Plover, Curlew and Turnstone between one winter and the next, figures which indicate that previous published estimates of survival, from recoveries by the general public of ringed birds, are unreliable and too low.

As well as identifying the times of passage of different groups of birds, of each species, through Teesmouth during the autumn, winter and spring periods, we are also attempting to identify the immediate origins and destinations of each group. This study has already indicated movement of adult Dunlin *Calidris alpina*, Sanderling and Knot *C.canutus* from the Wash to the Tees in late autumn, and onward movement of Knot to the Forth and the Ayrshire coast in late winter (see abstract by P.J.Dugan in this Bulletin). Identification of the sequence of estuaries used by particular groups of birds is a necessary preliminary to any attempt to understand why such movements take place and why they occur at the particular times of year that they do. Although it seems likely that changes in the densities of available food are important in the timing of movements, it is not known whether these act as proximate or ultimate timing factors. It is hoped that measurements of food resources on the Tees will help to answer this question.

As a side-line to the main study of behavioural ecology of shorebirds, we have also collaborated with Dr. Peter Ward of the Institute of Terrestrial Ecology in a project on seasonal cycles in heavy metals in shorebird tissues. We have evidence that although the birds are taking food which contain relatively high concentrations of mercury, lead and cadmium, the levels in their livers and kidneys decrease in the first few months after they arrive at Teesmouth. The changes in concentrations of these non-essential metals parallel the changes in concentration of zinc (except that cadmium excretion is slower). When zinc requirements rise in spring, during the moult into the breeding plumage (and in preparation for egg-laying in females), the concentrations of the potentially toxic metals rise also.

In parallel with the studies on heavy metal contamination, we have accumulated information on seasonal changes in body composition of shorebirds, particularly Dunlin, Redshank *Tringa totanus* and Knot. Some of the results of these investigations have been summarised elsewhere in this Bulletin (see also ref.5).

Our main aims for the future are (i) to determine whether the annual survival rates differ between individuals of a single species arriving at Teesmouth at different times of the year (ii) to identify the sites to and from which individuals move at different times of the year (iii) to explain why several different forms of habitat use are found at Teesmouth within a species (iv) to understand what determines the numbers of each species found on the estuary at different times of the year, and thus to assess whether the term "carrying capacity" has any validity in the context of shorebird/invertebrate relationships (v) to measure the changes in body condition of all species using the estuary, particularly during cold weather, and to examine how this affects measurable levels of heavy metals in various tissues.

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Dr.P.R.Evans, Department of Zoology, University of Durham, South Road, Durham DH1 3LE, England.