# *Migration strategies of shorebirds during the non-breeding season with particular reference to the Sanderling (Calidris alba)*

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# Migration strategies of shorebirds during the non-breeding season with particular reference to the Sanderling (*Calidris alba*)

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(BSc Hons)



Thesis presented for the degree of
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1987

To my parents, Win and Ken Cooper,
and my husband, Reg

I hereby declare that this thesis has been composed by myself, and that all the work it describes was carried out by myself alone except where stated otherwise.

Rowena H. W. Cooper

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# ABSTRACT

This study comprises two parts, one based at the Wash and one at Teesside.

Dye-marking of samples of oystercatcher, grey plover, knot, sanderling, dunlin, bar-tailed godwit, curlew, redshank and turnstone was undertaken to determine differences in the degree of mobility within the Wash. Most information relates to spring tide roosts. Wash Wader Ringing Group recaptures within the Wash, within a single season, were examined for sanderlings and dunlin. There were few results for grey plover, bar-tailed godwit, curlew or redshank. Results for other species indicate a range of mobility - in order of increasing mobility these are dunlin and turnstone, sanderling, oystercatcher, knot. Underlying reasons for mobility were associated with flights to spring tide roosts, increases in diurnal time spent feeding and, possibly, exploratory flights in search of unpredictable food resources.

At Teesside, individually colour-ringed sanderlings were studied for differences in timing of use of Teesside and differences in degree of mobility. Generally, individuals display consistency in returning to Teesside each year and arrival and departure dates are similar from year to year for each individual. A continuum of sanderling mobility is apparent. There appears to be a balance between net advantages and disadvantages accruing from variations in mobility as estimates of survival rates indicate. Heightened mobility was apparent by some individuals during severe winters and was interpreted as movement in search of better foraging conditions.

## ACKNOWLEDGEMENTS

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# PART I

# CHAPTER I

# INTRAESTUARINE MOVEMENTS OF WADERS AT THE WASH

# INTRAESTUARINE MOVEMENTS OF WADERS AT THE WASH

## INTRODUCTION

The Wash estuary has been the subject of water storage proposals (Wash Feasibility Study 1976, N.E.R.C.) and has a history of reclamation of saltmarsh for agriculture dating from about Saxon times (Doody & Barnett 1987).

The ecological effects of continuing reclamation were not well understood when Lincolnshire County Council (LCC) was preparing its Structure Plan for local planning and development. Consequently, LCC proposed a moratorium on further reclamation from 1980 - 1986 which was upheld following a public inquiry in 1983. The moratorium was intended to allow accumulation and assessment of data on various aspects of the ecology of this large intertidal area. Then an informed decision could be made as to whether agricultural or conservation interests should prevail. Reclamation proposals not requiring planning permission (existing use of land for agricultural purposes can be proven) come under the Wildlife and Countryside Act 1981. Most potential applications are now in this category (see footnote).

Individual reclaims may displace inconsequential numbers of waders but, cumulatively, the effects may be more serious as the intertidal area is reduced. The long-term impact of reclamation, or other developments affecting the Wash, may vary for different species depending on their behaviour.

There have been studies in the Forth Estuary (Symonds et al 1984; Symonds & Langslow 1984) and in parts of the Severn Estuary (Clark 1983) to examine the mobility of different

Footnote:- There are no further applications for reclamation currently being considered; one was withdrawn, another is the subject of a management agreement with the N.C.C. and the R.S.P.B. has purchased land ripe for reclamation and established a reserve.

species of waders which feed on the intertidal areas during the non-breeding season. Preliminary results for the Wash, based on ringing by the Wash Wader Ringing Group (WWRG), have been summarised too (Minton 1975).

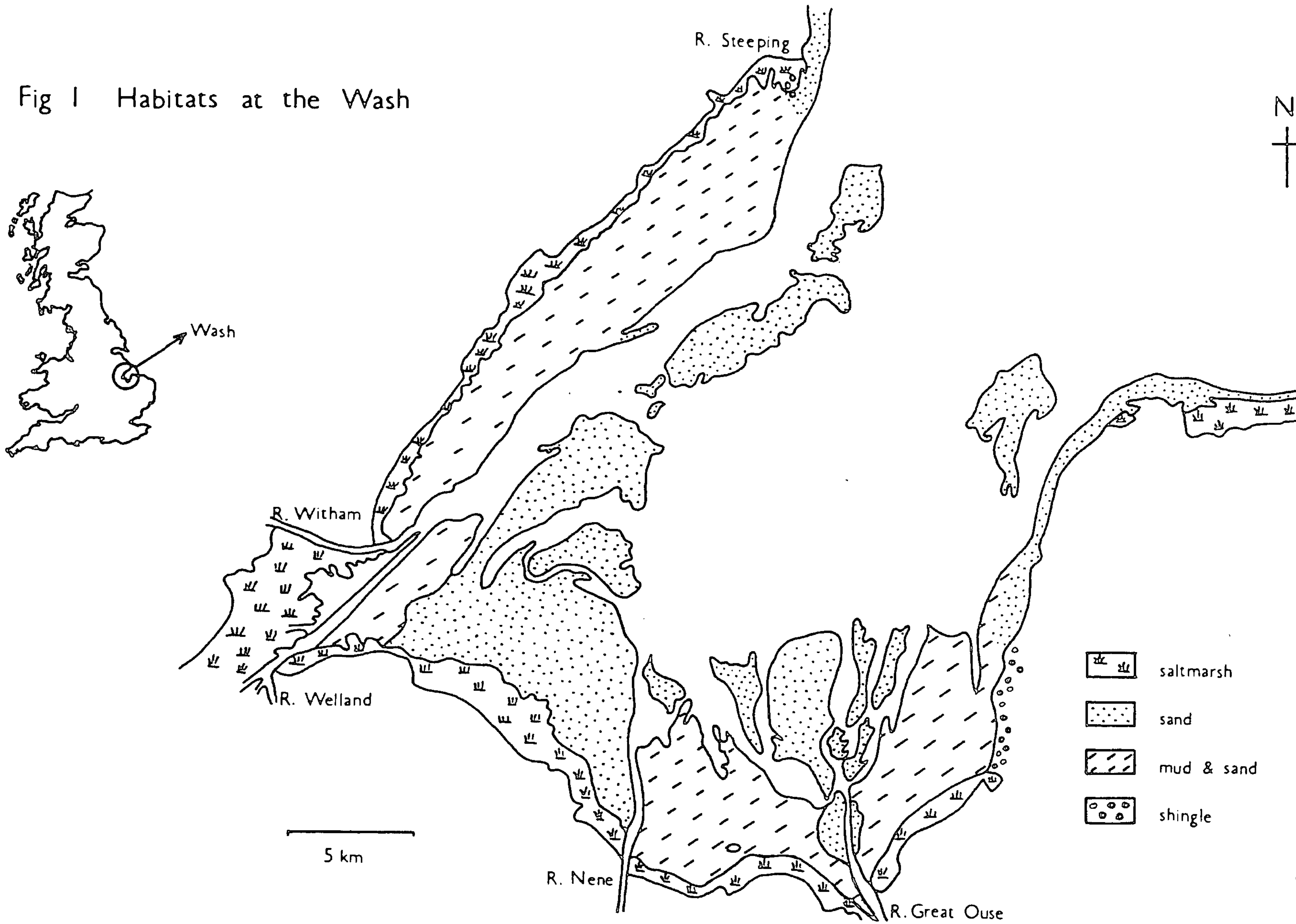
In order to determine the likely impact of continuing reclamation at the Wash, or of other changes, it is necessary to know whether there are sub-groups of waders using discrete areas of the estuary or whether regular interchange between sites occurs. Accordingly, I carried out a study during 1982-1984 with the following aims:-

1 To establish whether different species of wader exhibit different degrees of movement within the Wash estuary during the non-breeding season.
2 To identify age differences, if present, in extent of movement of a wader species.
3 To explain why variations in mobility exist, if they do, between age classes and species of shorebirds.

Location and habitats

The Wash estuary covers approximately 620 km$^2$ of the east coast of England and provides the catchment area for five rivers, the Great Ouse, Nene, Welland, Witham and the smaller Steeping. The northwest and southwest shores are bounded by saltmarsh at various stages of maturity, whilst the southeast shore is of sand and shingle like the contiguous coastline of north Norfolk (Fig. 1). The long history of reclamation of the most mature saltmarsh for agriculture ensures that saltmarsh development is truncated and tidal inundation regular. Saltmarsh, fields bounding the estuary and coastal beaches are all used as roost sites by shorebirds which feed in the inter-

Fig 1 Habitats at the Wash



tidal zone on the mud and sand banks that are exposed at low tide. These are locations for shellfisheries too, mostly at the lowest tidal levels.

Previous Research on Shorebirds at the Wash

The highest numbers of waders at the Wash occur during the non-breeding season. Their timing of arrival depends on species, breeding status, and location of breeding grounds. The Wash is used by each species of wader as a refuelling area during migration, for moult of body and flight feathers, as an overwintering area, or for several of these functions. Waders have been ringed and counted since the late 1950s; details have been summarised up to 1975 by Minton (1975) and Prater (1981).

Information from recaptures of ringed birds indicate that overwintering dunlin, redshank (Branson 1979), sanderling and turnstone (Branson 1981) often return to the same part of the Wash in subsequent non-breeding seasons. Knot and oyster-catcher (Branson 1979; Minton 1975) are considered to be more mobile; 12% of the knot and 8% of the oystercatchers caught on the west Wash between September 1972 and October 1974 bore rings from the east Wash (Minton 1975b). Little information had accrued by 1980 about bar-tailed godwit, curlew and grey plover at the Wash, but relatively few of these species had been caught.

The use of temporary plumage dyes enables detection of wader movements (when they occur) in the short term, without the need for recapture. Prior to my study, some colour marking had taken place at the Wash, principally in 1980/81 and 1981/82. A co-operative colour marking scheme was established as part of the EEC/NCC (Nature Conservancy Council) funded study of

Movements of Wader Populations in Western Europe (M. W. & Ann Pienkowski 1983). The study focussed on a few major European estuaries, including the Wash, to establish the extent of movement by waders from these estuaries to other sites during each non-breeding season and from one year to the next. Specific plumage dyes were used to denote birds caught at each major estuary and to distinguish age of the birds (adult or juvenile). Most subsequent observations of birds marked at the Wash were away from the estuary (M. W. & Ann Pienkowski pers. comm.).

The Wash Water Storage Feasibility Study of the 1970s led to intensification of ringing (Minton 1975) and counting of waders (Prater 1975) and to initiation of sampling of invertebrates (Corlett & Salkeld 1975). The counts contributed to the Birds of Estuaries Enquiry (BoEE) of the British Trust for Ornithology (BTO)/Royal Society for the Protection of Birds (RSPB)/Wildfowl Trust. The BoEE was conducted most intensively from 1969/70 to 1974/75, with monthly counts. Thereafter counts concentrated on the December, January and February period.

My study examined how waders use a large estuary during the non-breeding season. I attempted to quantify the degree to which different species of waders move around the Wash during their stay and whether there is any seasonal variation in the extent of movement. Movement may be associated with changes of roosts or feeding areas or both; it was hoped to establish which of these was involved and to explain why.

A combination of colour marking, field observations and analyses of recaptures of ringed birds (collected by the WWRG) was used. Nine species of shorebird were studied, although not all equally intensively. These species are oystercatcher (*Haematopus ostralegus*), grey plover (*Pluvialis squatarola*), knot (*Calidris canutus*), sanderling (*C. alba*), dunlin (*C. alpina*), curlew (*Numenius arquata*), bar-tailed godwit (*Limosa lapponica*), redshank (*Tringa totanus*) and turnstone (*Arenaria interpres*).

# METHODS AND SOURCES OF DATA

## COUNTS

### a) Birds of Estuaries Enquiry (BoEE)

Contributions to the BoEE included counts from the wardens at Gibraltar Point Bird Observatory (R. Lambert) and the RSPB's reserve at Snettisham (P. R. Gotham) where detailed records were kept throughout the year. I consulted published information in Lincolnshire Bird Club reports too.

### b) This Study

I made counts, mostly at roosts during spring tides so they are comparable with BoEE counts for the Wash; these counts were done in conjunction with checks for dyed waders.

### c) Wash Wader Ringing Group (WWRG)

Counts made during searches for suitable catching sites by members of the WWRG contributed additional information.

## COLOUR MARKING

### a) Colour Markings and their Limitations

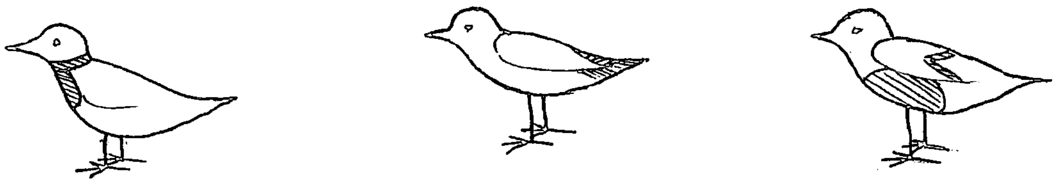
Combinations of alcohol-based plumage dyes and leg flags of coloured plastic adhesive tape were used to colour-mark waders. Samples of waders caught by the WWRG during August 1982 to February 1983 and September 1983 to November 1983 were colour-marked (Fig 2) by myself and assistants (see Table 1 for summaries and Appendix I for a breakdown of catches and colour marking).

Dye marking followed ringing and measuring of birds. Plumage dyes were applied with small brushes or sponges. In warm, dry conditions, the birds were released immediately. In cooler conditions, waders were held in keeping cages to allow the dye to dry prior to release, thus avoiding potential hypo-

## Fig 2 DETAILS OF COLOUR MARKINGS USED AT THE WASH

### POSITION OF SEVRON BLUE DYE 1982/83

| collar + breast | rump + undertail | wing bar + belly |
|---|---|---|



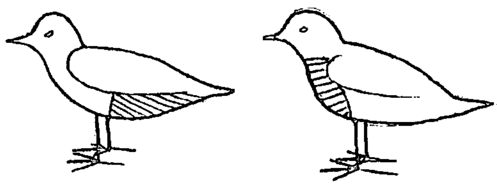
| East Wash | South Wash | North-west Wash |
|---|---|---|
| Thornham to Wolferton | Terrington | Wainfleet to Benington |

### LEG FLAGS 1982/83

| | Adults | Juveniles |
|---|---|---|
| August to September | white | yellow |
| October to December | red | black |
| January to February | green | blue |

### POSITION OF PICRIC ACID 1983/84

| behind legs | in front of legs |
|---|---|



| | | |
|---|---|---|
| Sanderling | juvenile | adult |
| Knot | adult | juvenile |
| Grey Plover | - | adult + juvenile |
| Bar-tailed Godwit | - | adult + juvenile |

TABLE 1 WASH WADER COLOUR-MARKING AND SIGHTINGS TOTALS

NUMBERS COLOUR MARKED / SIGHTINGS AND (RETRAPS)

| | Numbers colour marked 1982/83 | | | 1983/84 | | | | Sightings and (retraps) 1982/83 | | | | 1983/84 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Adult | Juvenile | Total | Adult | Juvenile | Total | Total 1982-84 | Adult | Juvenile | Unknown Age | Total | Adult | Juvenile | Unknown Age | Total | Total 1982-84 |
| OC | 257 | 74 | 331 | - | - | - | 331 | 15 (3) | 16 (19) | 353 | 384 (22) | - | - | - | - | 384 (22) |
| GP | 64 | 2 | 66 | 112 | | 112 | 178 | 2 | - | - | 2 | - | - | 1 | 1 | 3 |
| K | 340 | 54 | 394 | 288 | 111 | 399 | 793 | 2 (3) | 6 | 22 | 30 (3) | 12 | 4 | 1 | 17 | 47 (3) |
| D | 1083 | 106 | 1189 | - | - | - | 1189 | 5 (18) | 1 (1) | 30 | 36 (19) | - | - | - | - | 36 (19) |
| S | 3 | - | 3 | 37 | 1 | 38 | 41 | - | - | - | - | 226 | 3 | - | 229 | 229 |
| BG | 183 | 1 | 184 | 45 | | 45 | 229 | - | - | - | - | - | - | - | - | - |
| C | 81 | - | 81 | - | - | - | 81 | 7 | - | - | 7 | - | - | - | - | 7 |
| RS | 106 | 26 | 132 | - | - | - | 132 | 1 | - | 1 | 2 | - | - | - | - | 2 |
| TS | 52 | 11 | 63 | - | - | - | 63 | 10 (1) | - | - | 10 (1) | - | - | - | - | 10 (1) |

OC, oystercatcher; GP, grey plover; K, knot; D, dunlin; S, sanderling; BG, bar-tailed godwit; C, curlew; RS, redshank; TS, turnstone thermia or loss of dye due to birds bathing whilst the dye was still wet.

With large catches, reduced manpower, or deteriorating weather conditions not all birds caught were colour-marked. When the weather was particularly cold and/or wet no colour-marking took place.

In 1982/83 the temporary plumage dye Sevron Blue was used in conjunction with leg flags of one to 1.5 cm in length stuck over the BTO ring (Fig 2). Dye was used to denote shore of capture and the leg flag indicated age of bird and timing of capture. In autumn 1983, yellow Picric Acid dye was used (Fig 2) without leg flags.

Sevron Blue was variable in its rate of fading. The most reliable period for observation of dyed waders was up to one month following dye-marking. Thereafter, close proximity, good light and/or large expanses of white plumage on which even the palest dye was discernable, enabled dyed birds to be detected for up to 12 weeks following application. Thus, after one month, absence of records of dye-marked birds from a site was often due to loss of dye rather than to dispersal of waders.

Picric Acid is a more reliable dye than Sevron Blue since it maintains its distinctive orangey-red coloration until the feathers are moulted, up to 12 months later.

Searches for dye-marked birds were restricted because I was able to make only a limited number of visits to the Wash, due to concurrent studies at Teesside, and because of the small number of regular local observers.

Leg flags were intended as temporary markings, to last no more than one winter season. However, they proved to be less temporary than was anticipated. Birds were caught or seen during 1982/83 and 1983/84 with leg flags intact (but without dye) from the 1981/82 and 1982/83 winters respectively. Consequently, reports of birds with leg flags but without dye had to be discarded to avoid confusion with other marking schemes.

At the Wash leg flags were very difficult to see on birds roosting or feeding on saltmarsh or mudflats. Most sightings of leg flagged birds were from the shingle and sand of the east Wash or Snettisham Pits. Relatively few sightings in 1982/83 were of known-age birds and most of these were at sites on the east Wash.

The increase in handling time for wader catches due to addition of leg flags, combined with the paucity of results from their use in 1982/83, led to their exclusion from the 1983/84 colour-marking programme.

Comparisons of results from dye marking must be made with caution. This applies particularly to data on proportions of dyed birds in flocks since in many cases not all birds in a flock could be checked for dye. Dyed birds may have a clumped distribution within a flock (Furness & Galbraith 1980; Herrington & Leddy 1982) so differences recorded in estimated proportions at different sites and times may be artefacts. It is known that different methods of capture may also be biassed in favour of particular sectors of the flock (Pienkowski & Dick 1976; Goss-Custard et al 1981) so it is equally likely that, as a result, samples of dyed birds may not be representative of the whole flock. This makes exptrapolation to population level of observations of dyed birds difficult.

Although there is no firm evidence of this, it is possible that some methods of catching may disturb birds sufficiently to cause them to move to other roost sites, movements which may not have taken place otherwise. Thus sightings of dyed birds or recaptures of birds only a few days after capture, are of questionable validity; perhaps for the rest of a particular tidal phase - up to 2 weeks. This factor will have its greatest impact on results from the use of short-lived plumage dyes such as Sevron Blue.

The dye marking programme was less successful than was envisaged in increasing information about movements (or lack of them) within a single non-breeding season. Resightings for most species were made mainly in the autumn period. This was due to the short-lived dye used for my main Wash field season; 1982/83; and the fact that most birds were caught and colour-marked in autumn.

b) Observations

Birdwatchers, BoEE counters and wildfowlers were recruited to check sites around the Wash for colour-marked waders (Appendix II) and to return site check forms whether or not colour-marked waders were seen. Casual sightings were received too. Appendix III lists all those who participated in the observer network. Fig 3 shows the roost sites checked for waders. Short progress reports were sent to observers during the course of the 1982/83 and 1983/84 dye-marking programmes. These reports took the form of lists of sightings received with capture details of these birds.

Complementary to the observer network, I made field visits to the Wash at fortnightly to monthly intervals (Appendix IV).

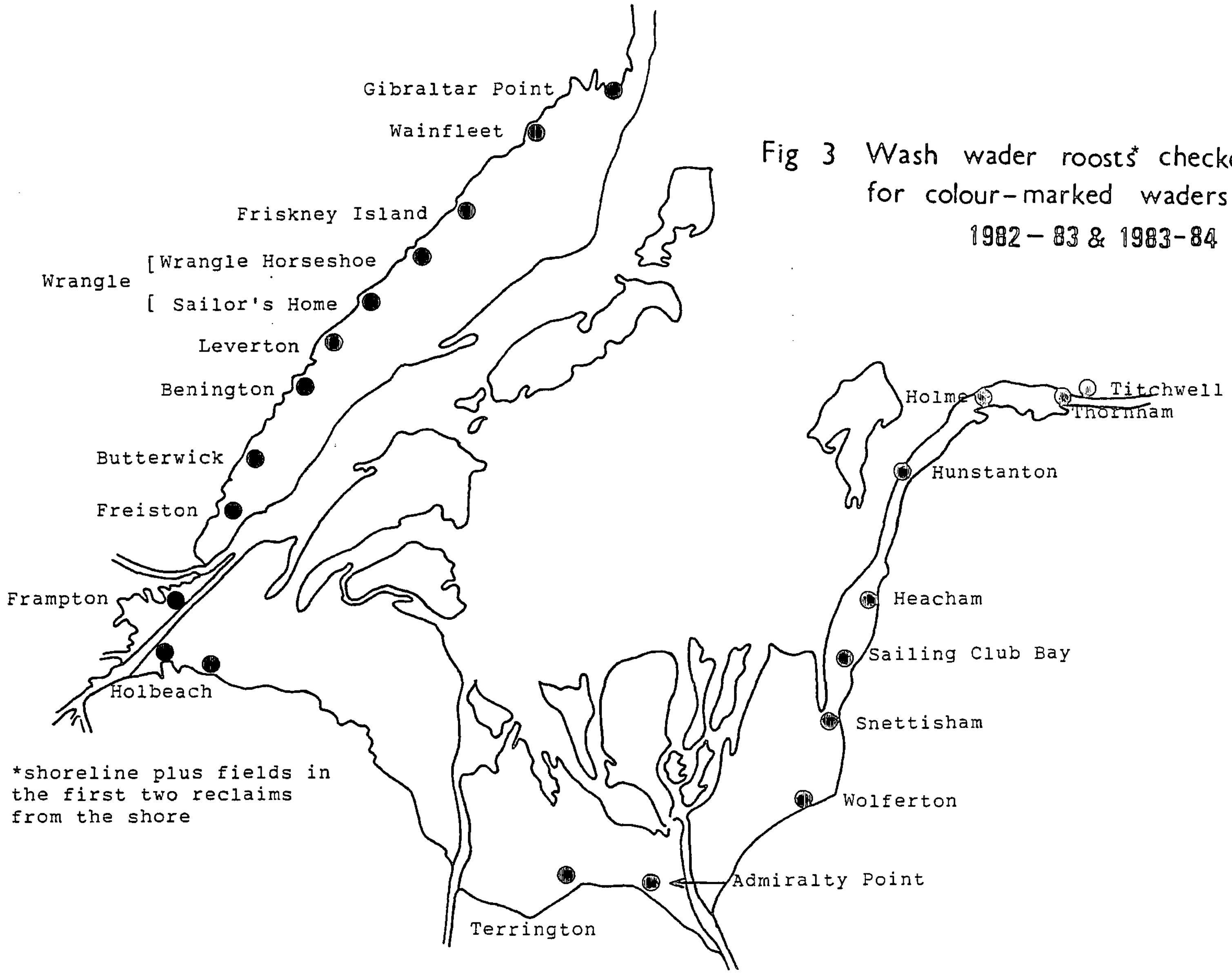



Fig 3 Wash wader roosts* checked for colour-marked waders 1982 – 83 & 1983-84

*shoreline plus fields in the first two reclaims from the shore to coincide with spring tides, from August 1982 to April 1983 and from September 1983 to December 1983. I located wader roosts around the shoreline of the Wash (Fig 3) and on fields within the seaward reclaims. I monitored the species composition and numbers of waders using these roosts and counted any dyed birds present. Any changes in location of roosts or numerical importance of roosts were noted and considered in relation to changes in use of feeding areas. I noted flight directions to and from feeding areas and, where possible, noted timings of arrival at and departure from roosts. Owing to the large intertidal area of the Wash, I did not have time to make detailed feeding observations or sample invertebrate distributions and densities.

The main sites I visited were Thornham, Heacham, Snettisham, Terrington, Leverton and Wrangle. Observations were made using a 15 x to 45 x telescope or 10 x 50 binoculars and details relayed on to a portable cassette recorder and transcribed after each session.

In autumn, high waters of spring tides occur in daylight, providing sufficient light for observations before, during and after high water. It was possible to cover more than one site in a day at this time,particularly because waders roosted for at least 2 to 3 hours either side of high water. Directions of arrival to and departure from roosts were seen easily. Conditions of visibility were usually good, although there were problems at west shore sites of avoiding looking into the rising sun, which made detection of dyed birds difficult.

In winter, however, high water of spring tides was usually in darkness. This reduced the time available for observations.

Often waders were dispersing from roosts by first light and flying to feeding areas where detection of dyed birds was harder on the large expanses of mud. Roosting time was shorter than in autumn, often only one hour either side of high water, depending on the height of tide and the species of wader.

Access was often difficult in winter, and fewer sites could be covered on foot during the best 'tide time'. Observations at Terrington were particularly difficult during my study because of poor visibility due to rain (September and October 1982), fog (September 1982 and November 1982 and 1983), sleet and snow (December 1982) and gales (February 1983).

Waders in loosely gathered roosts were easier to check for dye than those in compact flocks where often only peripheral birds could be checked. This has implications for the distribution of dyed birds. However, studies elsewhere (pers. obs.; Pienkowski 1983) indicate little adverse reaction towards dyed birds by non-dyed individuals, so their distribution should not be governed by exclusion by unmarked birds.

The problems of making observations on large numbers of several species of waders when in mixed flocks led to limitation of the colour-marking to knot, bar-tailed godwit, and sanderling in autumn 1983.

Oystercatcher, knot, sanderling and dunlin produced most sightings of dye marked waders, but still too few for much quantative presentation. Some observers omitted details of birds checked for dye, sending details of colour-marked birds only. Also, few observers returned negative results.

WWRG recapture Data and resightings of dyed waders

Wash Wader Ringing Group data has been extracted from schedules and retrap books which give details of birds caught and recaught, respectively, at the Wash. For 1983 onwards, computer printouts of recapture data were used. The species considered were dunlin and sanderling, for which data collected during 1969/70 to 1984/85 were used, and knot, for which data for 1973/74 to 1984/85 were used. Age composition of each catch during these years was assembled from the field ringing notebooks. Birds of less than one year old were considered to be juveniles whilst older birds were considered to be adults.

There are relatively few relevant within-season, within-Wash recaptures except in autumn - the season of the WWRG's most intensive catching programme. In winter and spring most catches have been at sites on the east Wash or at Terrington, but in autumn catches were made on the west shore too. Thus the chances of recapture on the west shore are low in winter and spring. The few catches in the south west corner of the Wash - River Witham to River Nene - were made in the mid 1970s.

Within-Wash recaptures during any one non-breeding season, i.e. late July to early June, were examined, with the emphasis being on autumn and winter. The non-breeding season was sub-divided as follows:-

i) "autumn" was defined as late July to the end of October incorporating the period of most active moult and visits by passage migrants to refuel.

ii) As most post-nuptial moults are completed by November, "winter" was defined as November to February inclusive.

iii) "spring" was defined as March to early June, since most departures from the Wash occur during this period and passage migrants pause on their way to breeding grounds.

Two distance categories were allocated to simplify assessment of mobility by the Chi-Square Goodness of Fit Test:-

i) at or less than 5 km from the site of capture, so most sites shown on Fig 3 are considered to be separate entities;

ii) more than 5 km from the site of capture.

Where possible, recaptures between catches of at least 10 adults or juveniles in any one non-breeding season were analysed. To calculate expected recapture values for the Chi-Square Test, a modification of capture-recapture formulation (Moss 1985) was used:-

$$\frac{\text{No. recaptures (R)}}{\text{No. caught in subsequent catches*}} = \frac{\text{No. caught in 1st catch}}{\text{Total population}}$$

*and therefore, potentially, including birds from the first catch (recaptures).

| Catch | N | R | T | Observed recaptures A1 | A2 | A3 |
|---|---|---|---|---|---|---|
| A1 | 495 | 5 | 500 | | | |
| A2 | 970 | 30 | 1000 | 20 | | |
| A3 | 184 | 16 | 200 | 1 | 2 | |

A = autumn; N = new birds; R = recaptures; T = total caught.

A1 $\leqslant$ 5 km from A2; A3 $>$ 5 km from A1 and A2.

Number "at risk" of recapture:-

$\leqslant$ 5 km  500 x 1000 = $5 \times 10^5$
$>$ 5 km  [500 x 200] + [1000 x 200] = $3 \times 10^5$
Total = $8 \times 10^5$

(N.B. total population is a constant and therefore excluded from these equations.)

Observed recaptures:-

$\leqslant$ 5 km = 20
$>$ 5 km = 3
Total = 23

Expected recpatures:-

$$\leqslant 5 \text{ km} = 23\frac{(5 \times 10^5)}{(8 \times 10^5)} = 14.4$$

$$> 5 \text{ km} = 23\frac{(3 \times 10^5)}{(8 \times 10^5)} = 8.6$$

Total = 23.0

$X^2$ (Chi Square) with 1 df (degree of freedom) can be calculated from the table below:-

| | observed recaptures | expected recaptures |
|---|---|---|
| $\leqslant$ 5 km | 20 | 14.4 |
| $>$ 5 km | 3 | 8.6 |

No allowance has been made for the method of capture, namely mist-netting or cannon-netting, although it is recognised that the two methods catch different population segments (Pienkowski & Dick 1976). To separate catching methods would have reduced further the already small samples of within-season recaptures of dunlin and only a gross comparison was required. Negligible numbers of sanderling have been caught by mist-netting; certainly fewer than the exclusion sample size of 10, so all catches considered were cannon-netted.

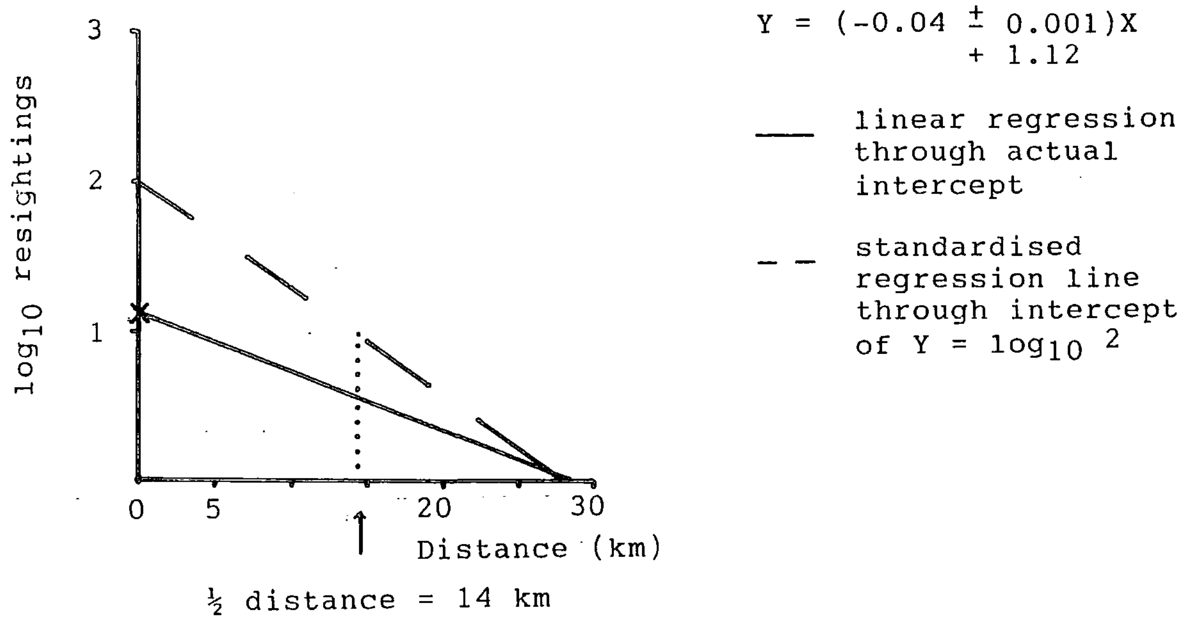
The lack of sightings of knot dyed with Picric Acid after October 1983, prompted an examination of culmen lengths of knot caught in autumn 1983. A comparison was made with values given by Engelmoer (1984) for the Greenland and Siberian races to ascertain whether there had been an influx of Siberian knot at the Wash. Such influxes occur occasionally (Dick et al. 1976; Dugan 1981) and could have provided an explanation for the apparent disappearance of the dyed knot.

Graphical presentation of recaptures and resightings of dye-marked oystercatchers, sanderlings, knot and dunlin were used to try to identify whether there was a mathematical relationship between numbers of marked birds and distance from the site of capture (after Coulson & Brazendale 1968).

Resightings of dyed birds, or recaptures of ringed birds, were recorded per 1000 marked per 1000 checked for dye/recaught and the $\log_{10}$ values plotted against distance from the site of capture (Table 2). These data, usually, displayed a linear relationship and Linear Regression analyses were applied to fit the best straight lines. The graphs were standardised to an intercept of $\log_{10}$ 2 (= 100), best illustrated by example:-

Assume a hypothetical slope of intercept = $\log_{10}$ 1.12
and slope = $-0.04 \pm 0.001$

Standardise to an intercept of $\log_{10}$ 2 by multiplying 1.12 x 1.78; multiply slope by 1.78 = $-0.07 \pm 0.002$




The relationship between numbers of marked birds and distance from the site of capture is analagous to the principle of radioactive decay where a constant of "half-life" is applied to each radioisotope. Accordingly, a value for the "half-distance" has been calculated for each wader species, and is defined as the distance at which the concentration of marked birds decreases by 50%.

The use of average, rather than individual, resightings or recaptures per 1000 marked per 1000 checked for each site improved the correlation coefficients.

Table 2 Distances (km) between sites at the Wash (shortest distances along or between shores) with grid references and co-ordinates for each site

| | Ti | Th | Ho | Hun | He | Sn | Wo | NW | T | Daw | Holb | B'wick | Ben | Lev | Wra | Fri | Wai | Grid ref. | Co-ordinates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Titchwell | | | | | | | | | | | | | | | | | | TF766452 | 52° 59' N 0° 38' E |
| Thornham | 3 | | | | | | | | | | | | | | | | | TF739453 | 52 59 N 0 36 E |
| Holme | 7 | 4 | | | | | | | | | | | | | | | | TF705446 | 52 59 N 0 33 E |
| Hunstanton | 10 | 7 | 3 | | | | | | | | | | | | | | | TF688433 | 52 58 N 0 31 E |
| Heacham | 18 | 15 | 11 | 8 | | | | | | | | | | | | | | TF662365 | 52 54 N 0 29 E |
| Snettisham | 23 | 20 | 16 | 13 | 5 | | | | | | | | | | | | | TF648317 | 52 52 N 0 28 E |
| Wolferton | 26 | 23 | 19 | 16 | 8 | 3 | | | | | | | | | | | | TF633294 | 52 50 N 0 26 E |
| North Wootton | 31 | 28 | 24 | 21 | 13 | 8 | 5 | | | | | | | | | | | TF604265 | 52 48 N 0 22 E |
| Terrington | 33 | 30 | 26 | 23 | 15 | 12 | 10 | 7 | | | | | | | | | | TF540267 | 52 49 N 0 17 E |
| Dawsmere | 36 | 33 | 29 | 26 | 21 | 19 | 17 | 15 | 9 | | | | | | | | | TF468315 | 52 51 N 0 12 E |
| Holbeach | 39 | 36 | 32 | 29 | 25 | 24 | 23 | 21 | 15 | 6 | | | | | | | | TF413347 | 52 53 N 0 07 E |
| Butterwick | 36 | 33 | 30 | 28 | 26 | 27 | 27 | 26 | 22 | 14 | 10 | | | | | | | TF415440 | 52 58 N 0 07 E |
| Benington | 34 | 32 | 28 | 27 | 25 | 27 | 27 | 26 | 22 | 15 | 11 | 2 | | | | | | TF425455 | 52 59 N 0 08 E |
| Leverton | 34 | 31 | 28 | 26 | 25 | 27 | 27 | 26 | 23 | 16 | 13 | 4 | 2 | | | | | TF435465 | 53 00 N 0 09 E |
| Wrangle | 31 | 28 | 25 | 24 | 25 | 27 | 27 | 28 | 25 | 19 | 17 | 9 | 7 | 5 | | | | TF465502 | 53 01 N 0 11 E |
| Friskney | 28 | 26 | 22 | 22 | 24 | 27 | 28 | 29 | 28 | 23 | 22 | 14 | 12 | 10 | 5 | | | TF505534 | 53 03 N 0 14 E |
| Wainfleet | 25 | 23 | 20 | 20 | 24 | 28 | 29 | 31 | 30 | 25 | 25 | 18 | 16 | 14 | 9 | 4 | | TF528560 | 53 04 N 0 17 E |
| Gibraltar Point | 23 | 21 | 19 | 19 | 24 | 28 | 29 | 32 | 32 | 28 | 27 | 22 | 20 | 18 | 13 | 8 | 4 | TF560573 | 53 05 N 0 20 E |

# RESULTS

Each wader species studied will be considered in turn. Appendix V gives details of all sightings of dye-marked waders made during this study and used to prepare the following accounts. For each species, an introductory section describes its general status and distribution at the Wash; there follow sections on the degree of mobility revealed by seasonal changes in roost counts, by colour-marking and by recoveries of ringed birds.

## OYSTERCATCHER

### Introduction

Oystercatchers are widespread around the Wash. My observations, during 1982/83, of flight directions between feeding and roosting areas indicated that their most important feeding grounds lay on the east Wash, to the west of Snettisham. The northwest Wash, notably Wrangle and Friskney flats, is of secondary importance for feeding.

Wintering numbers at the Wash have been relatively stable in recent years (Table 3) with, perhaps, a slight increase, most noticeable for Wolferton and Snettisham (Table 4). Counts from various sources, detailed under the 'Methods' section, have been used to prepare Figures 4 and 5 which show the relative importance in autumn and winter of roosts around the Wash.

### Degree of Mobility Revealed by Roost Counts

The main roosting site for oystercatchers on the east Wash throughout the non-breeding season is at Snettisham (Figs 4 & 5). Ten- to fifteen- thousand birds roost on the shingle-banked area surrounding pools on the RSPB reserve. This area is known as the 'Pits'. During periods of high spring tides, partic-

Table 3 BoEE counts of oystercatchers at the Wash:- Gibraltar Point to Titchwell (Fig 4) 1978/79 to 1983/84

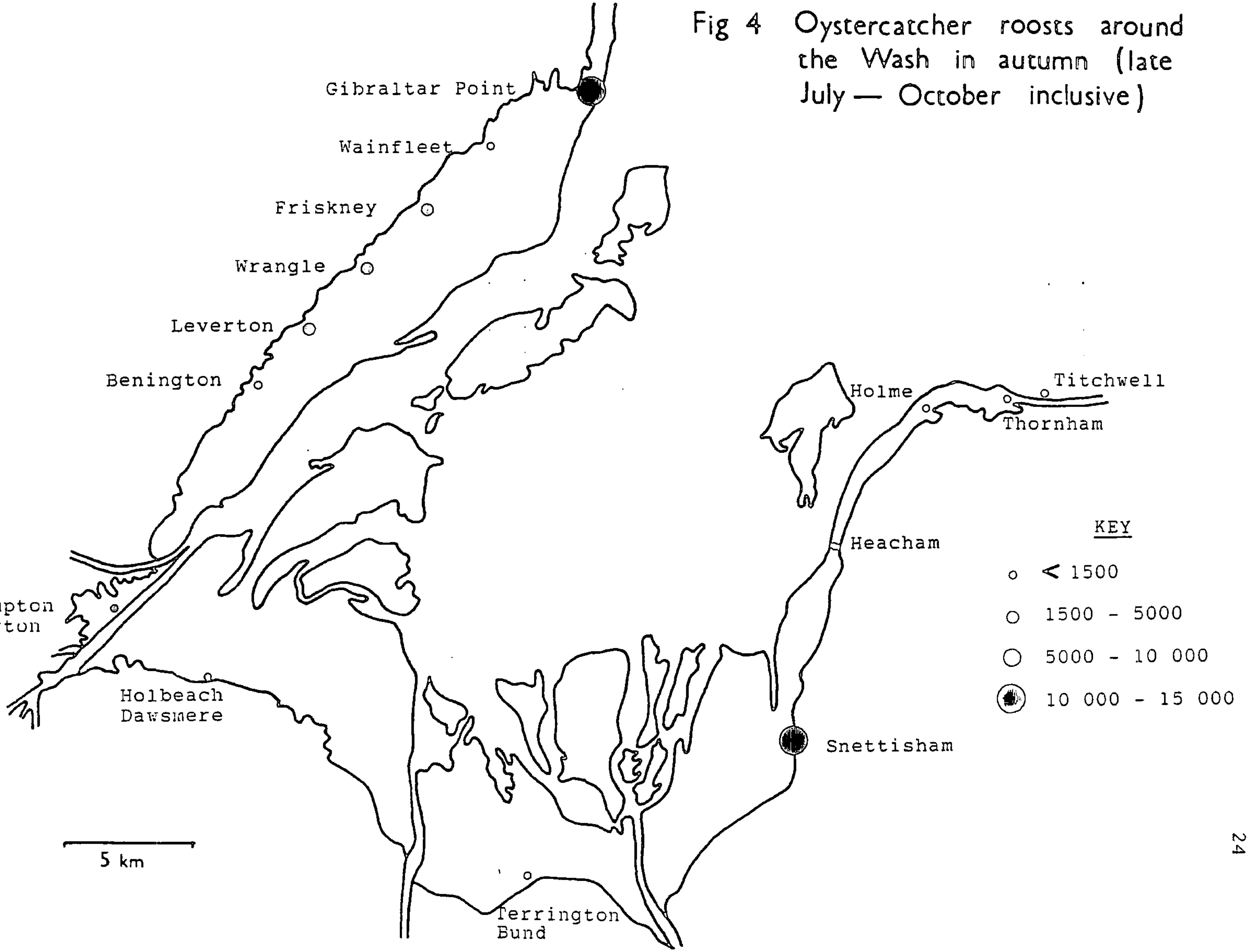
| Month<br>Year | Nov | Dec | Jan | Feb |
|---|---|---|---|---|
| 1978/79 | - | 17 589 | 16 913 | - |
| 1979/80 | - | 18 352 | 17 893 | - |
| 1980/81 | - | - | 16 221 | 22 853 |
| 1981/82 | 26 000 | 19 223 | - | 16 327 |
| 1982/83 | - | 23 803 | 19 380 | 19 558 |
| 1983/84 | - | - | - | 23 009 |

Table 4 BoEE counts of oystercatchers at the Wash:- Wolferton and Snettisham only 1978/79 to 1983/84

| Month<br>Year | Nov | Dec | Jan | Feb |
|---|---|---|---|---|
| 1978/79 | - | 8 486 | 7 282 | - |
| 1979/80 | - | 8 776 | 6 987 | - |
| 1980/81 | 10 090 | - | 8 775 | 8 800 |
| 1981/82 | 13 500 | 11 000 | - | 10 670 |
| 1982/83 | - | 13 300 | 11 150 | 12 000 |
| 1983/84 | 10 875 | - | - | 11 000 |

N. B. counts are combinations of estimates and accurate counts, carried out by experienced individuals and groups.

Fig 4 Oystercatcher roosts around the Wash in autumn (late July — October inclusive)



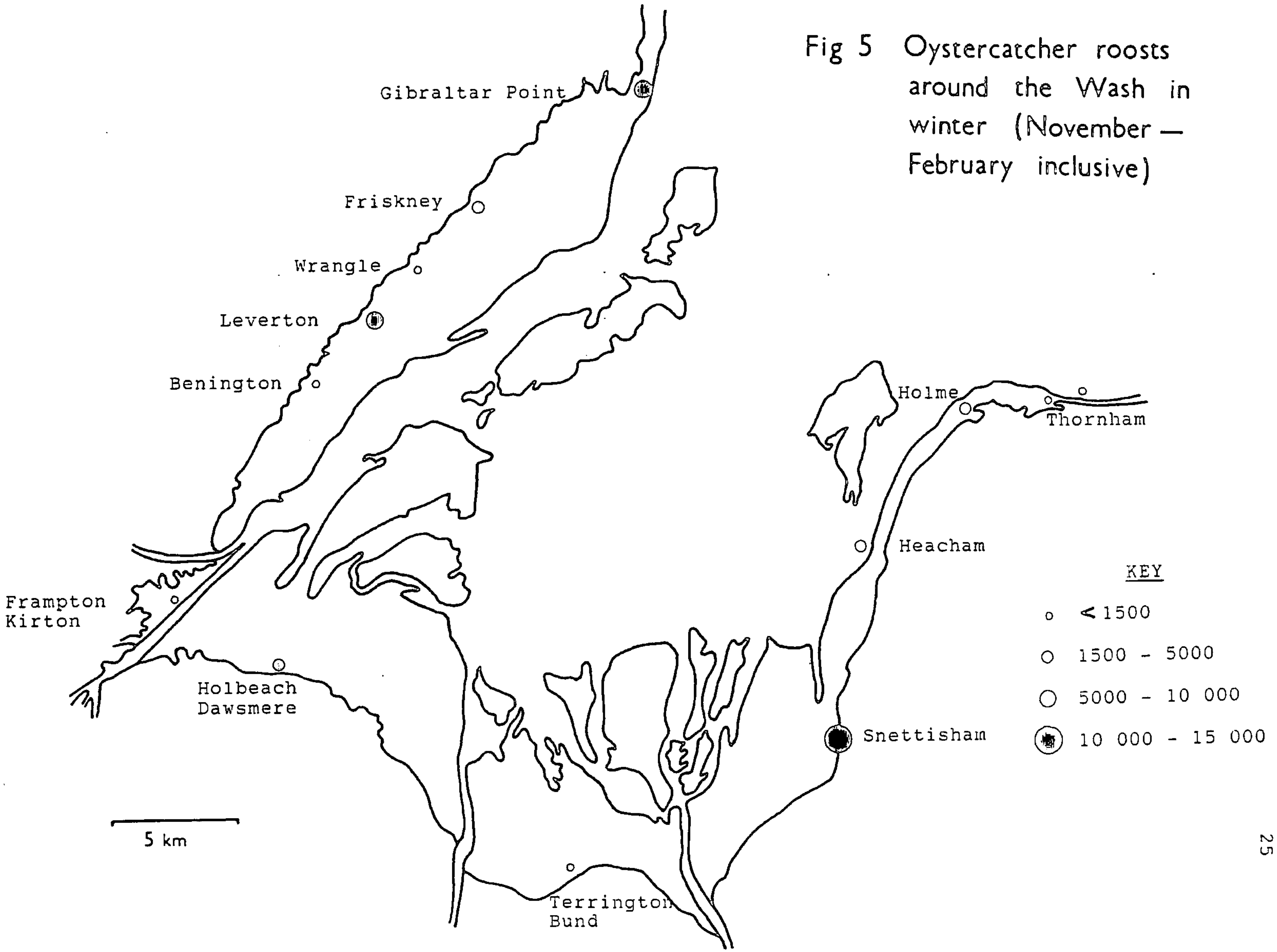



Fig 5 Oystercatcher roosts around the Wash in winter (November — February inclusive)

ularly when these occur during autumn evenings, oystercatchers also fly along the east Wash to Thornham, Titchwell and Holme to roost. In winter, following completion of moult, fewer oystercatchers use Thornham for roosting and numbers are erratic. Tides exceeding 7.7 m are most usual around the equinoxes and force birds to leave Thornham. On such occasions, birds have been seen heading east to Titchwell and beyond.

On the northwest Wash, tides exceeding 7.6 m inundate most saltmarsh, forcing birds to move to other roosts. These may be inland, particularly in autumn, or to Gibraltar Point at all times of year (Fig 6).

In winter, birds extended their low water feeding time by spreading along the flood and ebb tide edge of the east Wash. The birds came to roost when the mudflats were covered, rather than forming a sub-roost ahead of the advancing tide as they did in autumn. The Heacham beach roost increased up to 5 000 birds. Use of this site enabled birds to return to feed on the newly exposed mud soon after the tide turned. However, disturbances - mostly by dog walkers - caused displacement of these roosts to Snettisham Pits.

Variability in roost counts at each site was generally low (Table 5); the highest variability was found at sites which were inundated by the higher tides or otherwise used infrequently.

Seasonal changes in emphasis of roosts used by oystercatchers were observed. Movement was related to tide height and, in winter, birds using upper shore mudflats for additional feeding as the tide rose formed roosts on the adjacent beaches.

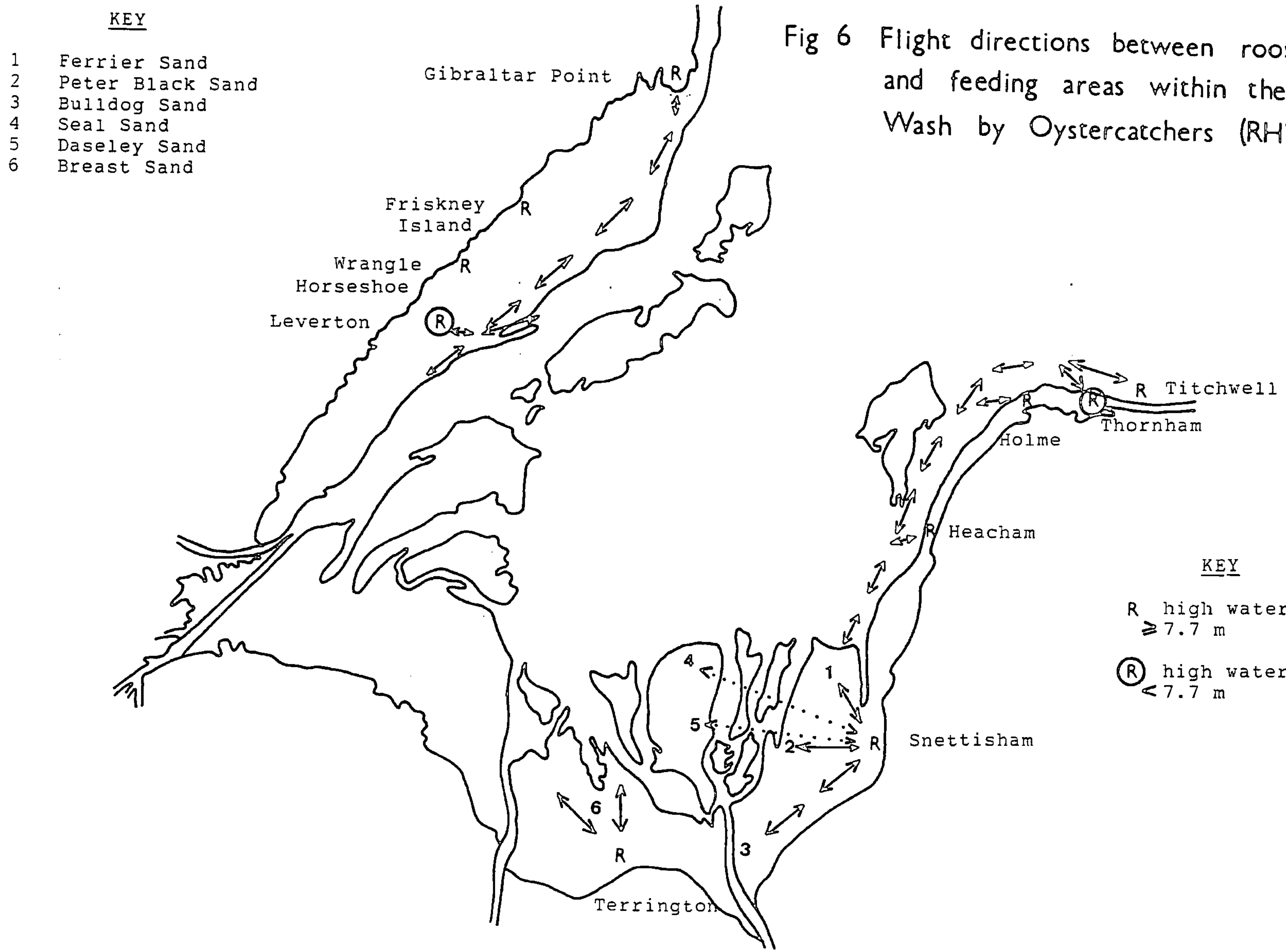



Fig 6 Flight directions between roosts and feeding areas within the Wash by Oystercatchers (RHWC)

Table 5  Variability (Standard Deviation/Mean) of oystercatcher counts at Wash roosts in winter (November to February inclusive)

| Roost (s) counted | Winter | C.V. | No. of counts | Source |
|---|---|---|---|---|
| Leverton/Wrangle[1] | 1982/83 | 1.13 | 5 | RHWC |
| Terrington | 1982/83 | 1.02 | 3 | RHWC |
| Heacham | 1982/83 | 0.88 | 11 | RHWC |
| Snettisham | 1982/83 | 0.09 | 3 | RHWC |
| Snettisham | 1982/83 | 0.12 | 3 | P.[illegible]Gotham |
| All[2] | 1978/79 | 0.03 | 2 | BoEE |
| All | 1979/80 | 0.02 | 2 | BoEE |
| All | 1980/81 | 0.24 | 2 | BoEE |
| All | 1981/82 | 0.11 | 2 | BoEE |
| All | 1982/83 | 1.20 | 3 | BoEE |

C.V. = Coefficient of Variation

[1]these sites are combined since oystercatchers form a sub-roost at Wrangle before roosting on Leverton saltmarsh.

[2]BoEE coverage of the Wash is incomplete; "all" refers to summed counts for those sites which are counted.

## Degree of Mobility Revealed by Colour-marking

Oystercatchers were dye-marked with Sevron Blue during 1982/83 only (Appendix I, Fig 2, Table 1). Oystercatchers are large, conspicuous, birds on which dye was readily visible even when it was fading. There were 384 sightings (Table 1, Appendix I). Fig 7 shows the maximum number of marked birds sighted simultaneously from each catch.

KEY to Wash sites shown in Fig 7

Gib - Gibraltar Point

Wai - Wainfleet

Fri - Friskney

Wra - Wrangle

Lev - Leverton

T - Terrington

W - Wolferton

S - Snettisham

H - Heacham

Hun - Hunstanton

Ho - Holme

Th - Thornham

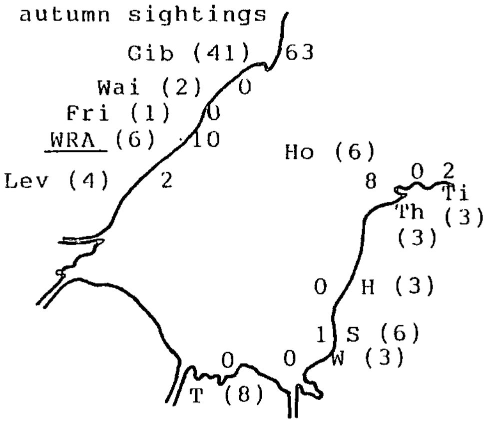
Ti - Titchwell

Site of capture in capital letters and underscored in each diagram.

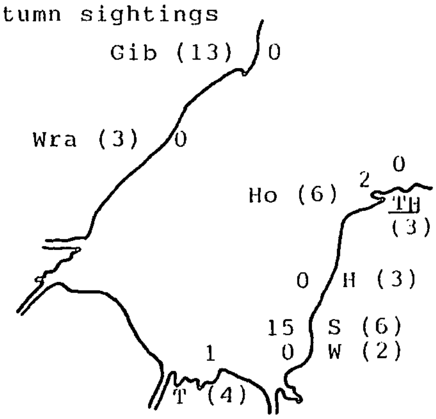
Nos. in parentheses indicate number of site check visits.

Fig 7 Maximum simultaneous sightings of dyed Oystercatchers at the Wash 1982/83

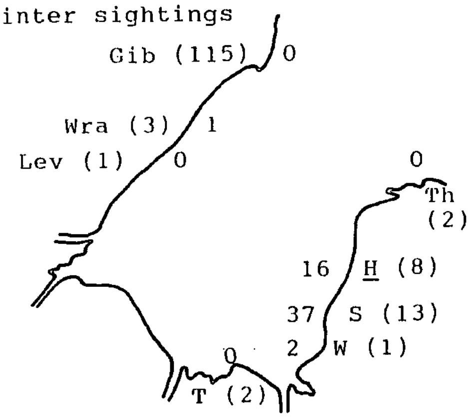
a) date of catch 20.8.82
location of catch Wrangle
autumn sightings



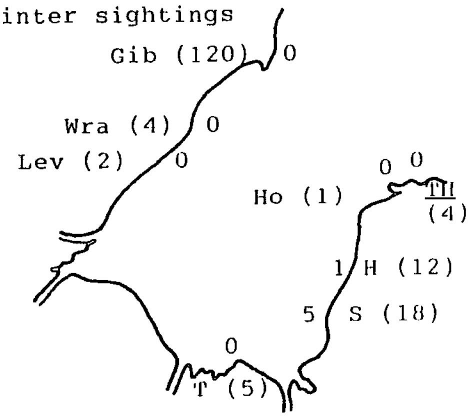

b) date of catch 17.9.82
location of catch Thornham
autumn sightings



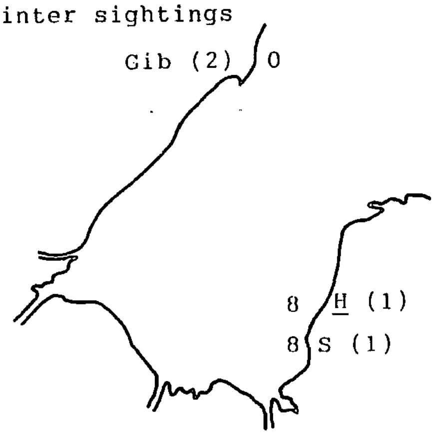

d) date of catch 5.12.82
location of catch Heacham
winter sightings



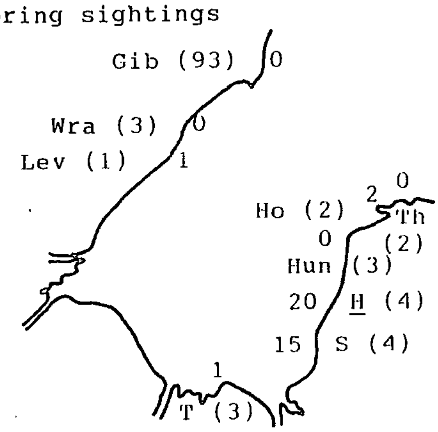

c) date of catch 17.9.82
location of catch Thornham
winter sightings




e) date of catch 26.2.83
location of catch Heacham
winter sightings




f) date of catch 26.2.83
location of catch Heacham
spring sightings



All resightings of birds marked on 20 August 1982 at Wrangle were in autumn (Fig 7). Most resightings were made at Gibraltar Point during the high spring tides in August and September. This movement might have been due, at least in part, to disturbance caused by cannon-netting. However, observations of unmarked flocks indicate that these movements are a feature of spring tides. Several birds were seen again at Wrangle and a few further south at Leverton. Movement across the Wash was also recorded, most of these sightings being at Holme. Three birds marked at Wrangle were recaptured at Heacham on 26 February 1983; the leg flags remained but all traces of dye had gone in six months.

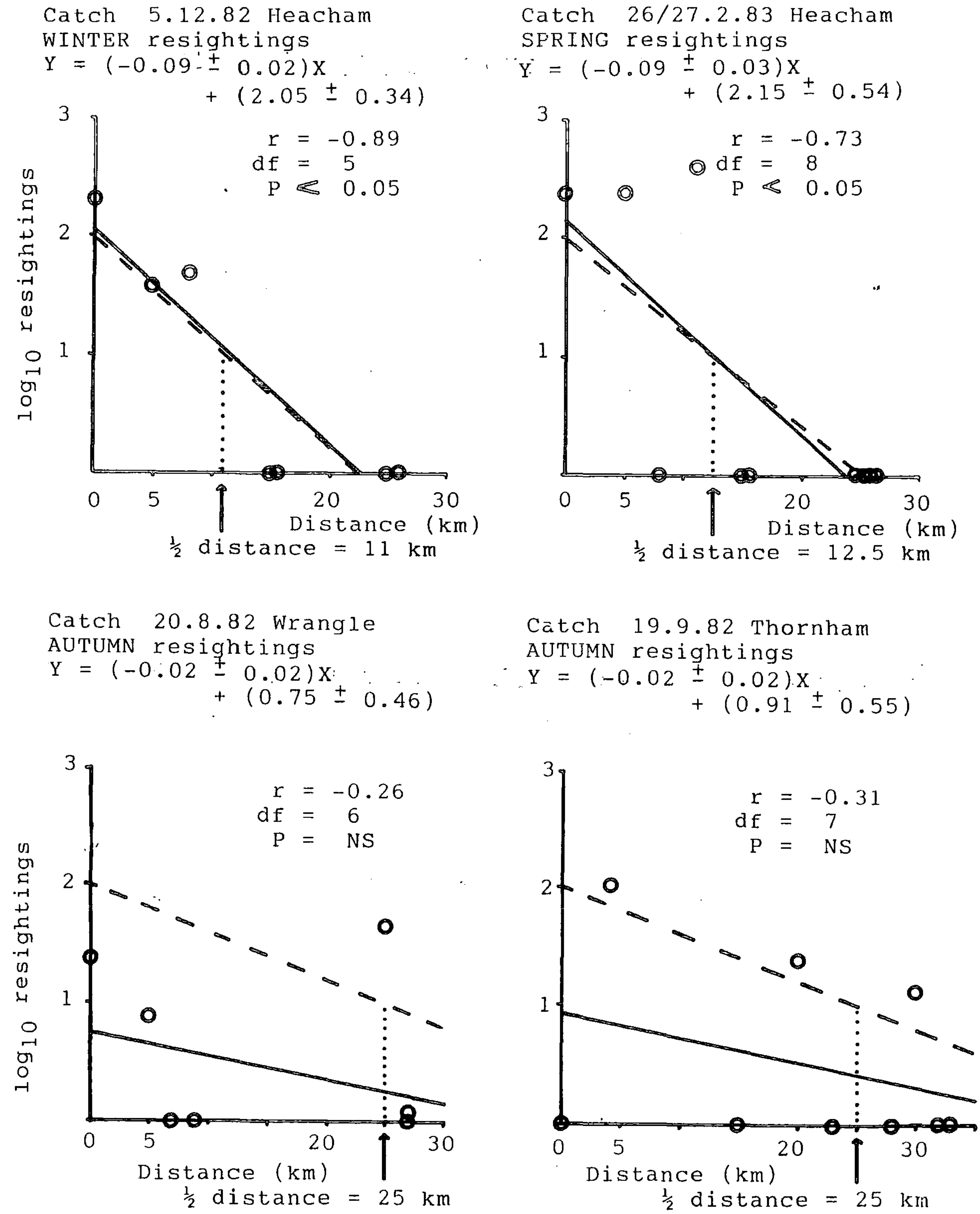
Most resightings of oystercatchers caught and dyed at Thornham on 17 September 1982, on a 7.6 m tide, were made at the main Wash roost at Snettisham during both higher and lower subsequent spring tides (Fig 7). One oystercatcher from Thornham was seen at Terrington in autumn. Winter sightings were all at Snettisham and Heacham.

Birds dyed at Heacham on 5 December 1982 and on 26/27 February 1983 could be distinguished by the intensity of colour as they were marked far enough apart in date. All sightings resulting from the catch on 5 December were on the southeast shore, mostly at Snettisham and Heacham. Winter sightings from the 26/27 February catch were also at Snettisham and Heacham; however, this may be an artefact because these were the main sites checked (Fig 7). All known-aged dyed birds from the Heacham catches that were seen (or recaught) in winter and spring were at Heacham or Snettisham. This emphasises the relative ease with which leg flags on oystercatchers can be identified at sites on the east shore of the Wash, as well as the similarity of choice of roosts by adults and juveniles and the preference for the roost at Snettisham. Movement across the Wash was not detected during the winter from the results of dye-marking.

Spring sightings of oystercatchers, colour-marked at Heacham on 26 February, were spread along the east Wash, mostly at Snettisham and Heacham, reflecting the numerical importance of these roosts. One bird, of unknown age, was seen at Terrington, indicating at least some movement between shores. Dyed oystercatchers were seen as late as May, by which time the dye was disappearing.

Graphs of the average number of dye-marked oystercatchers per 1000 marked per 1000 checked at each site are shown in Fig 8. The "½-distance" calculated from the two autumn catches was 25 km which, although the correlation coefficients were low, was more than for winter (11 km) and spring (12.5 km), indicating greater mobility by oystercatchers in autumn than in the remainder of the non-breeding season. However, the difference between slopes was not significant (autumn v winter & spring $t = 0.9$; $df = 31$; $P = NS$).

Fig 8 Oystercatcher: Seasonal variations in the average number of resightings of dyed oystercatchers per 1000 marked per 1000 checked at each site.




—— linear regression, calculated from actual log values.

– – standardised regression through intercept of Y = 2.

KNOT

Introduction

The majority of knot at the Wash roost at relatively few sites (Figs 9 & 10). Two main roosting flocks are apparent in autumn, one on the east shore and one on the west shore, whilst in winter the east shore has the main flock.

The BoEE counts indicate that winter numbers of knot at the Wash have tended to increase during the 1980s (Table 6). Approximately 50% of the knot counted in the winter are in the Snettisham/Wolferton area (Table 7). The December count of knot at the Wash in 1985 represented 41% of the knot counted in Great Britain in that year (Salmon & Moser 1986). The Wash has the largest numbers of wintering knot at any one site in Britain.

Counts from various sources, detailed under the 'Methods' section, have been used to prepare Figs. 9 & 10 which show the relative importance in autumn and winter of roosts around the Wash. These figures show the most regular roost locations used by knot. However, as the following section shows, fluctuations occur and more than one large concentration does not occur simultaneously on each shore.

Degree of mobility as revealed by counts at roosts

On the east shore, the Snettisham/Wolferton roosts have 20 000 - 30 000, or more, knot in autumn. Generally, Snettisham Pits are used during the highest diurnal spring tides, when high water exceeds 7.7 m and the Wolferton saltings roost is covered. Alternatively, knot may roost on fields close to the foreshore. The Snettisham/Wolferton roosts are close to the main feeding areas for knot in the eastern half of the Wash, namely Bulldog and Peter Black Sands (Fig 13); although birds may feed further offshore too (Goss-Custard 1977a and per. obs.). Flights to roost at Holme, Thornham or Titchwell occur during spring tides, principally on autumn evenings (Fig 12). Then, most of the east Wash knot may roost at any one of these three sites.

On the west shore in autumn, up to 50 000 knot roost in fields within the two reclaims closest to the shore at Wainfleet or Friskney. All or most of the flock usually roosts on only one field, showing a preference for a smooth, bare, field. This area is closest to feeding grounds on the adjacent mudflats. Alternatively, the knot fly to roost at Gibraltar Point, particularly when high water is at night.

In winter, numbers of knot on the west Wash, at Gibraltar Point/Wainfleet/Friskney, decrease, rarely exceeding 15 000 (Fig 10), whilst overall numbers at the Wash usually increase (Table 6 ) particularly at the Snettisham/Wolferton roosts (Fig 10, Table 7) where there may be up to 40 000 - 50 000. The decreased numbers of knot on the west Wash, from autumn to winter, indicate that the western Wash feeding grounds may not contain adequate food resources to sustain the numbers of knot present in autumn through the winter.

Knot which feed in the southeast corner of the Wash (Fig 13) show a preference for a single roost site although they may move between roosts, even within one high water period. At times knot remained airborne over Wolferton saltings or flew along the east Wash during the high water period. During these restless phases, they sometimes landed, briefly, on Heacham beach, as happened in December and January of 1982/83. Otherwise, the use of Heacham beach by roosting knot was erratic, both in frequency and numbers present. Occurrence at

Heacham coincided with some of the tides of 7.6 m or more, but, as has been mentioned, other sites were also frequented during high spring tides so tide height does not provide the full explanation. Knot used Heacham mainly when HW was in darkness.

The BoEE counts for Holbeach/Dawsmere exceeded 10 000 knot regularly (Figs 9 & 10) in autumn and winter. Counts at Terrington in autumn and winter exceeded 10 000 on occasions. Other roost sites had few knot and/or were used erratically.

Table 7 BoEE Wash counts of knot at Snettisham/Wolferton, 1978/79 to 1983/84

| Month - Year | September | November | December | January | February |
|---|---|---|---|---|---|
| 1978/79 | 18 940 | - | 25 000 | 28 560 | - |
| 1979/80 | 10 290 | - | 32 000 | 23 800 | - |
| 1980/81 | - | - | - | 30 000 | 30 000 |
| 1981/82 | - | 17 000 | 32 720 | - | 38 000 |
| 1982/83 | - | - | 44 000 | 45 000 | 35 000 |
| 1983/84 | 21 250 | 39 240 | - | - | - |

Table 6 BoEE counts of knot at the Wash (Gibraltar Point to Titchwell), 1978/79 to 1985/86

| Month - Year | September | November | December | January | February |
|---|---|---|---|---|---|
| 1978/79 | - | - | 51 416 | 42 959 | - |
| 1979/80 | 37 195 | - | 48 843 | 33 644 | - |
| 1980/81 | - | 53 884 | - | 77 770 | 82 400 |
| 1981/82 | - | 54 139 | 72 710 | - | 52 590 |
| 1982/83 | - | - | 108 735 | 80 199 | 61 600 |
| 1983/84 | - | - | - | - | 53 495 |
| 1984/85 | - | - | - | - | 77 050 |
| 1985/86 | - | - | 117 886 | - | - |

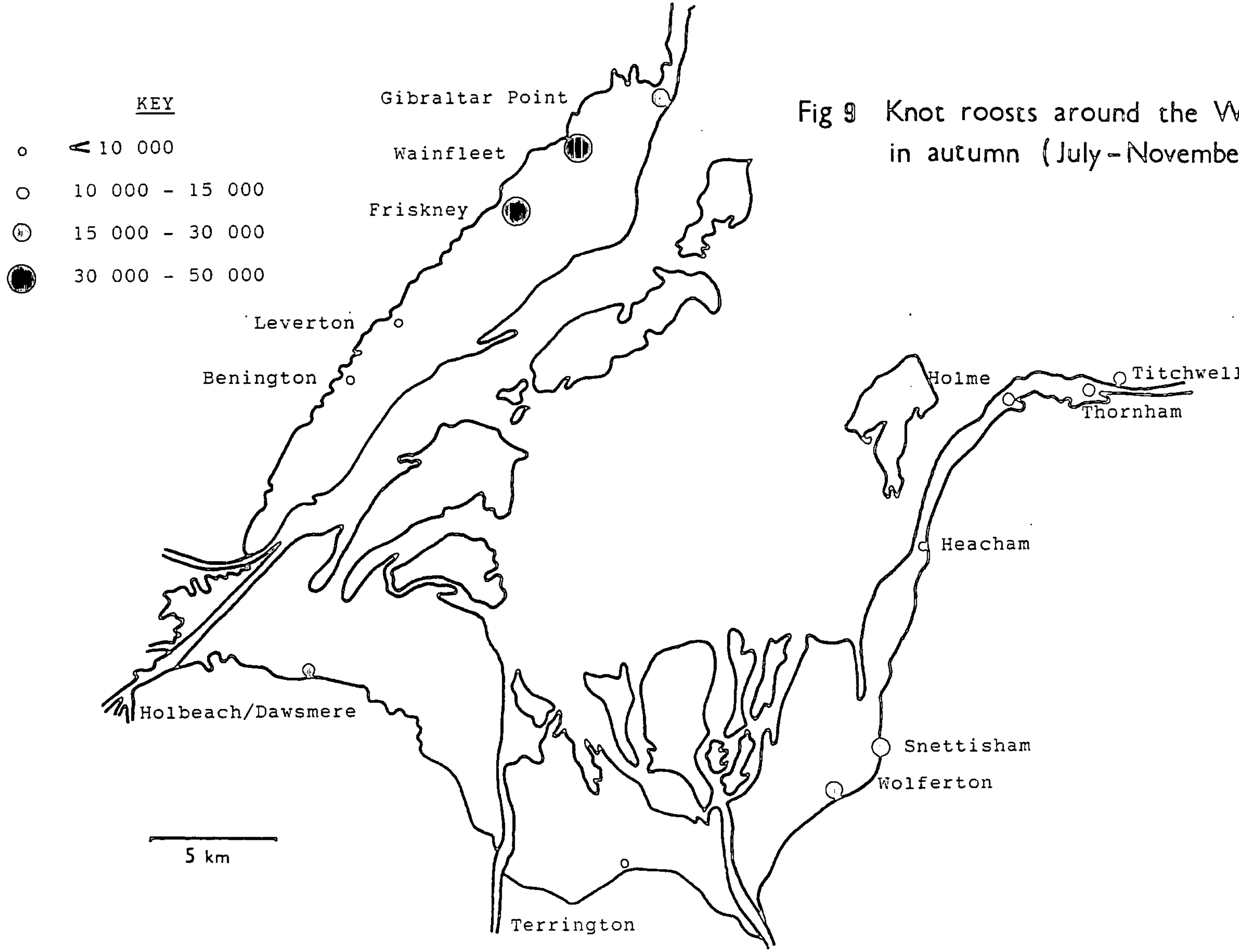



Fig 9 Knot roosts around the Wash in autumn (July - November)

Fig 10 Knot roosts around the Wash in winter (November – February)

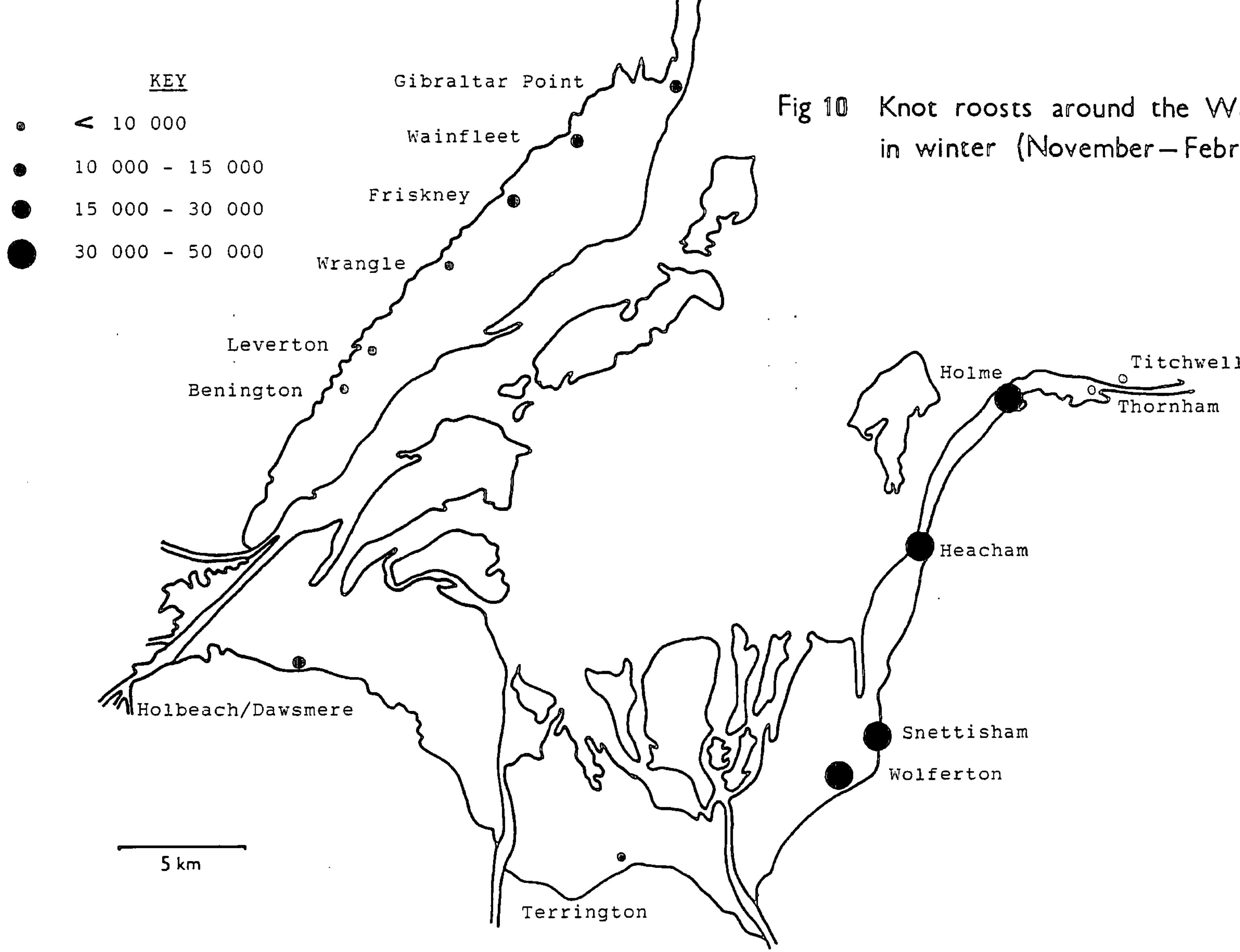


Fig 11 Maximum monthly counts of Knot at Snettisham, the Wash, 1982-83 (PRG)

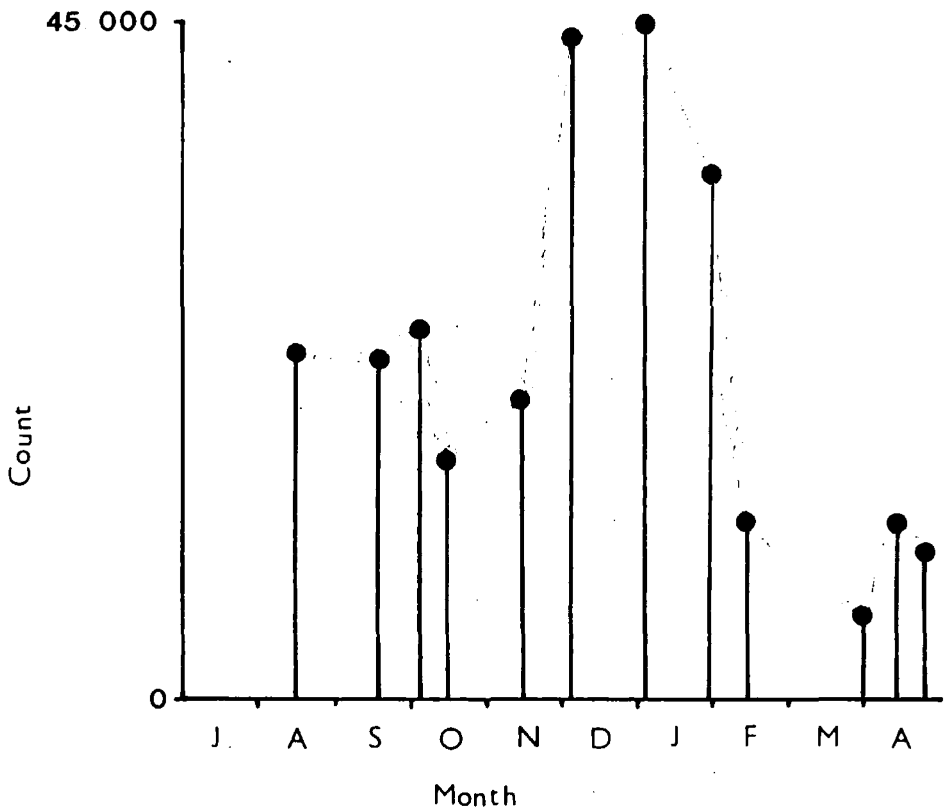
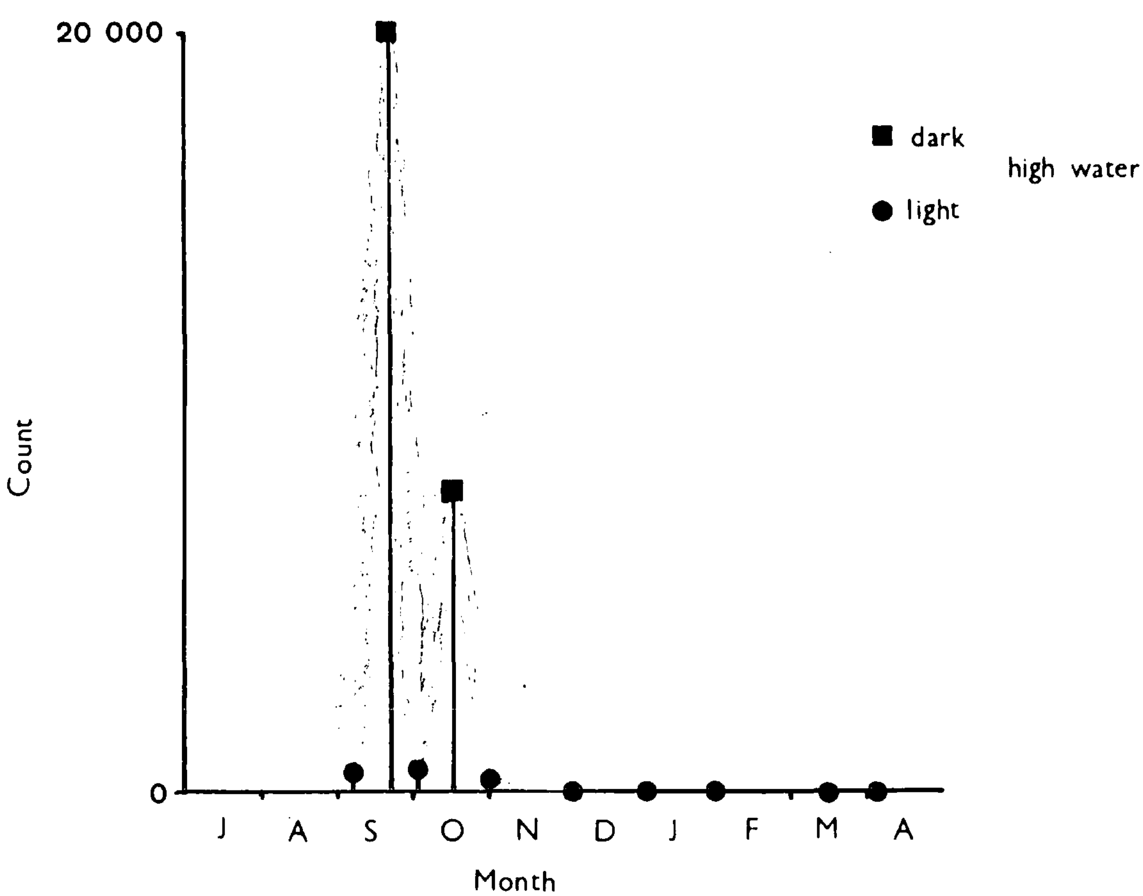



Fig 12 All counts of Knot at Thornham, the Wash, 1982-83 (RHWC)



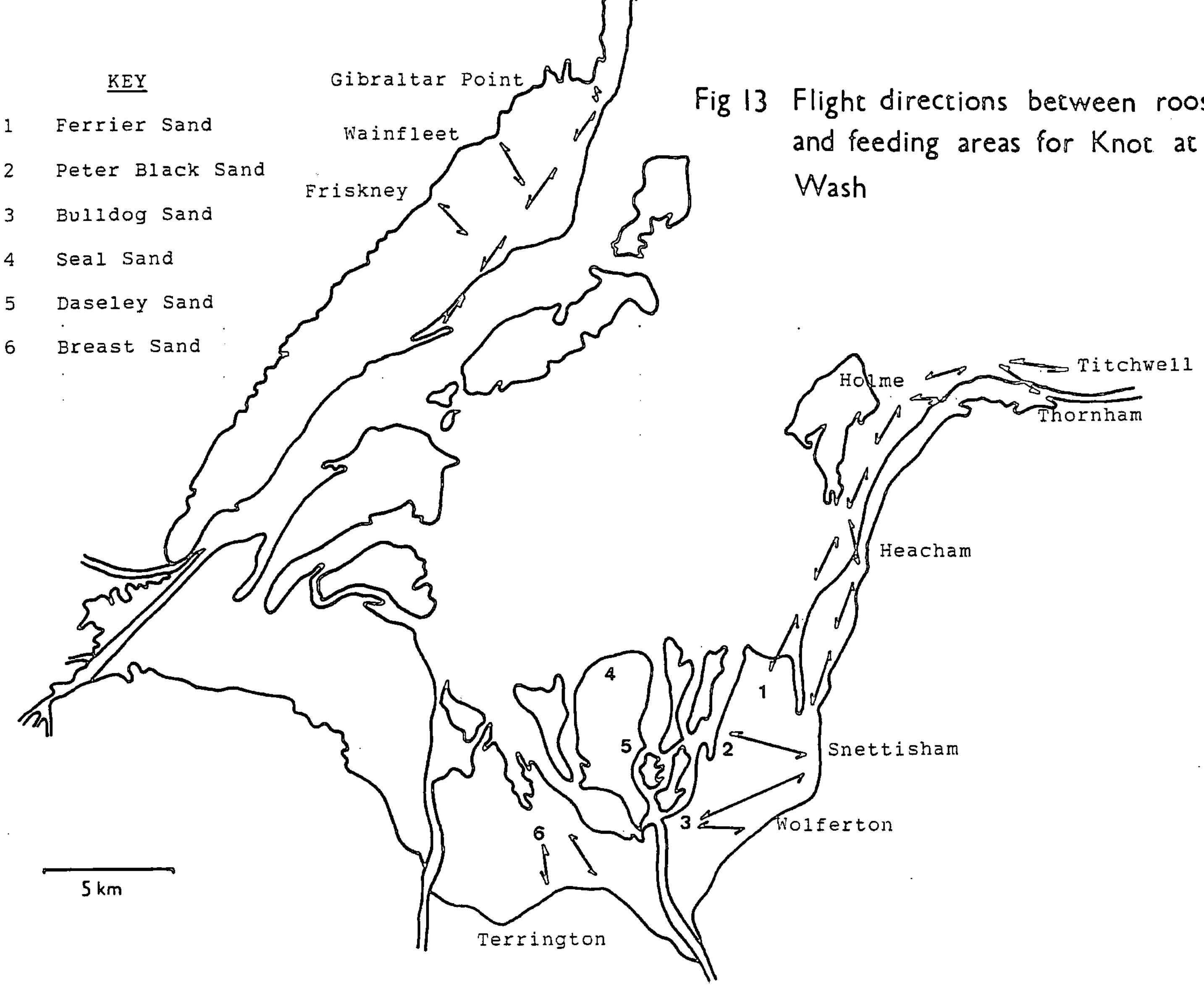



Fig 13 Flight directions between roosts and feeding areas for Knot at the Wash

Degree of mobility revealed by colour-marking

Dye-marking with Sevron Blue in 1982/83 and Picric Acid in 1983/84 (Fig 2) yielded 47 sightings from 793 knot dyed (Table I). Fourteen sightings were of adults and 10 of juveniles, whilst the rest were of unknown age. Results were similar for both years and so are combined (Appendix V shows full details of sightings).

Seven sightings were made away from the Wash (Table 8). Of those sightings at the Wash, all but one were in autumn. As Table 8 shows, this was due in part to movement away from the estuary. However, in 1982/83, the short-lived duration of the dye was a contributory factor.

Table 8 Sightings of dyed knot away from the Wash, 1982/83 & 1983/84

| Date caught | Location caught | Date seen | Location seen | No. seen | Age(s) seen |
|---|---|---|---|---|---|
| 21.08.82 | Snettisham | 13.09.82 | Spurn | 1 | u |
| 19.09.82 or 22.08 | Terrington | 20.10.82 | Redcar | 1 | juv |
| 19.09.82 or 22.08 | Terrington | 18.11.82 | Redcar | 1 | juv |
| 19.09.82 or 22.08 | Terrington | 24.11.82 | Seal Sands | 1 | ad |
| 09.09.83 or 10.09 | Friskney Wainfleet | 07.12.83 | Redcar | 3 | 2 ad & 1 juv |

The lack of sightings at the Wash after early October 1983 is more noteworthy because the permanent dye, Picric Acid, was in use, suggesting that birds had moved on. It is surprising, too, that few knot were seen in Britain away from the Wash in that year. An examination of culmen lengths of knot caught in autumn 1983 was prompted by this lack of sightings. Culmen length is used to distinguish different geographical races of knot and such an examination would identify whether there had been an influx of Siberian knot which, in some years pass through Britain en route to Africa. However, as Table 9 and Figs 14a & b indicate, this does not seem likely in 1983.

Table 9 Culmen lengths of adult knot caught at the Wash in 1983, compared with those values quoted by Engelmoer (1984)

| Date | Location | Sample | Mean | |
|---|---|---|---|---|
| 10.08.83 | Wainfleet | 145 | 32.7 ± 1.9 mm | |
| 10.09.83 | Wainfleet | 290 | 30.9 ± 1.7 mm | |
| Culmen length for knot quoted by Engelmoer:- | | | | |
| Nearctic/western knot | | Male | 32.3 ± 1.6 mm | n = 57 |
| Greenland | | Female | 34.0 ± 2.0 mm | n = 35 |
| Siberian/eastern knot | | Male | 34.4 ± 1.5 mm | n = 57 |
| | | Female | 36.4 ± 1.7 mm | n = 50 |

The use of Probability analysis (Fig 14b) failed to distinguish more than one group. Both means for the two catches at Wainfleet fall into the smaller size-range of Engelmoer's (1984) discrimination of different races of knot (Table 9) and equate with the western/Nearctic population. This agrees with previous analyses (Dick et al. 1976) indicating the presence of predominantly Nearctic knot, from Greenland, at the Wash in autumn.

Results from dye-marking showed widespread dispersal of birds around the Wash from Wainfleet and Friskney (Fig 15 & Appendix V). The sightings at Gibraltar Point, in 1982, during the series of spring tides following the catch at

Wainfleet are likely to have derived from the regular movement observed during high spring tides, although the possibility of disturbance due to cannon-netting cannot be discounted. There was interchange of marked birds between the west and east shores of the Wash (Fig 15) as well as along the shore in autumn.

Only 2 adults and one juvenile were dye-marked in winter. Of these, only the juvenile was seen, in the same winter, at the site of capture; Heacham (Appendix V).

Fig 14a Frequency distributions of knot culmen lengths in catches at Wainfleet on 10.08.83 & 10.09.83

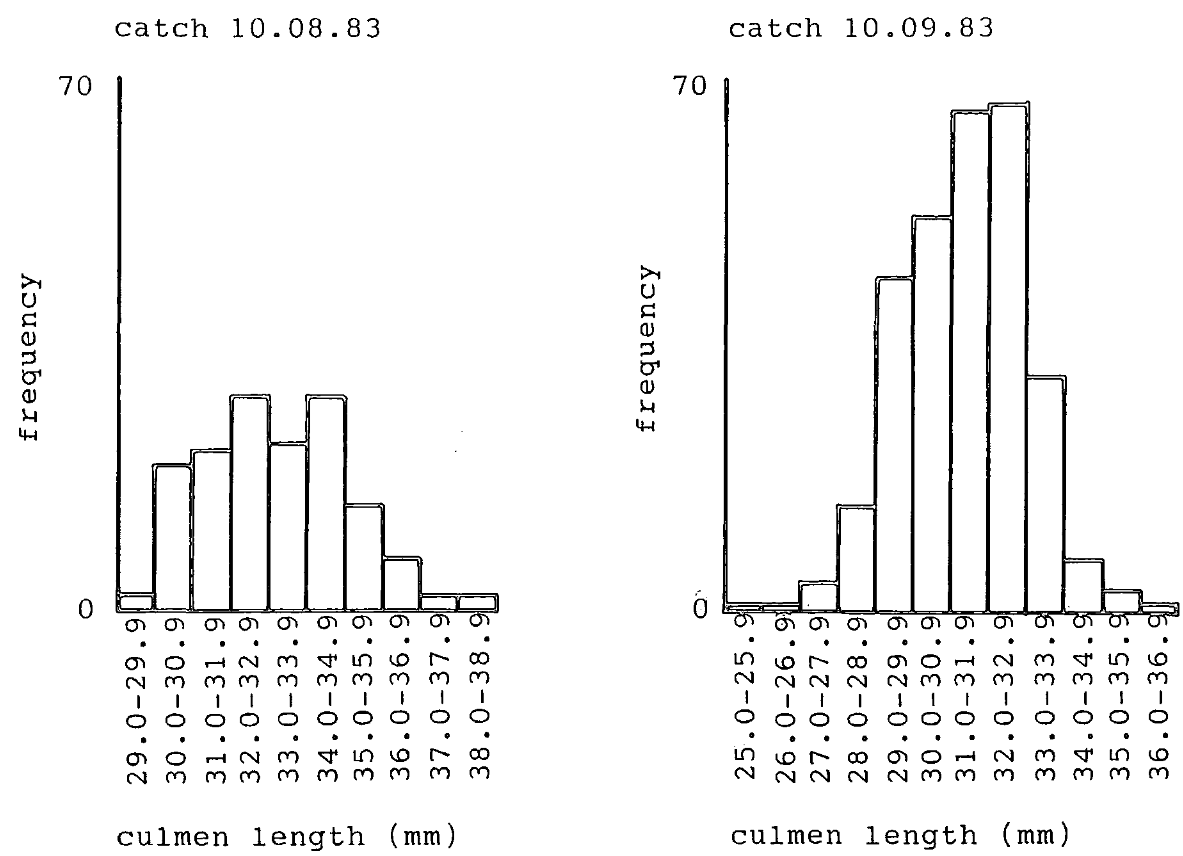
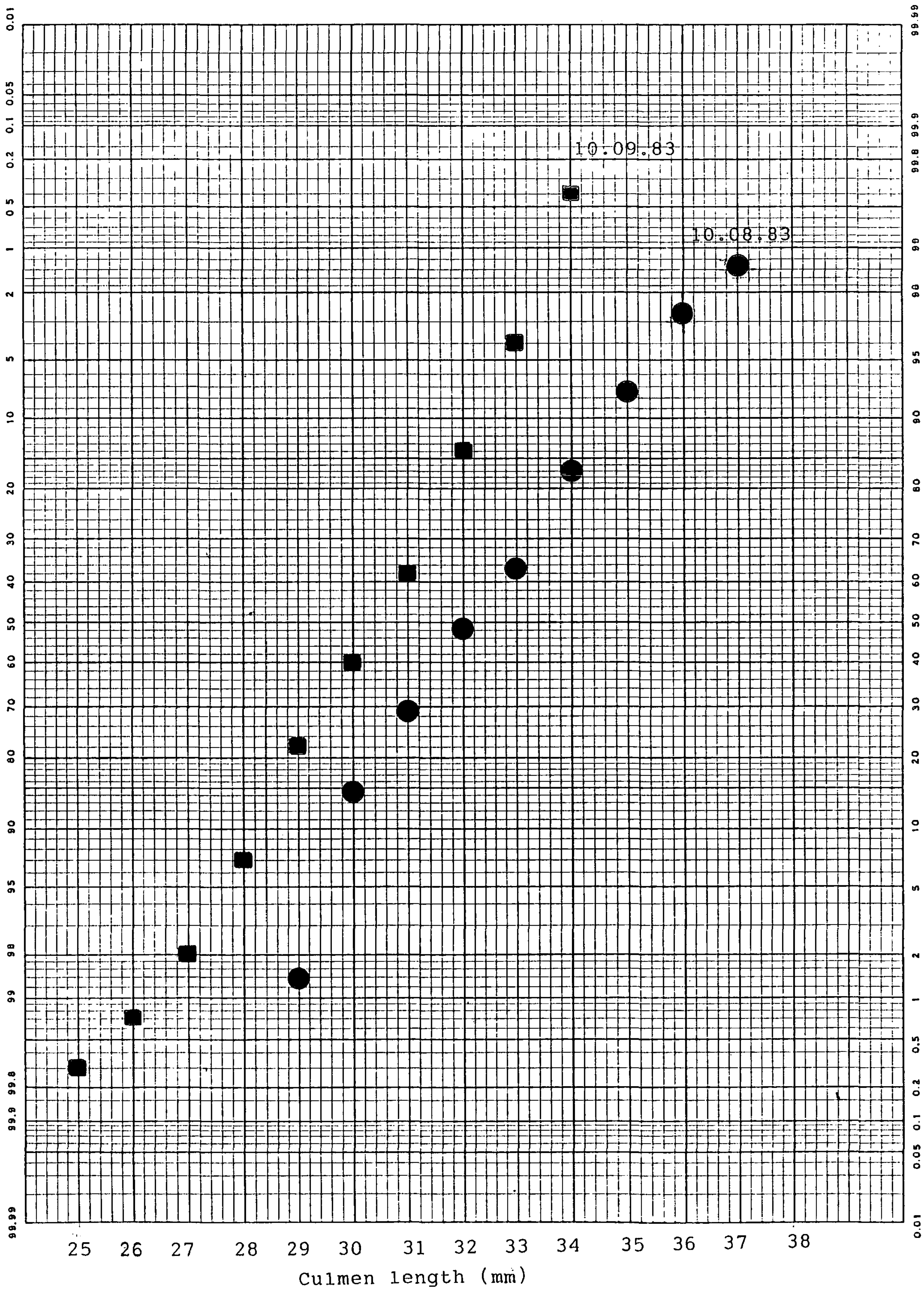


Fig 14b Cumulative distributions of knot culmen lengths for catches at Wainfleet on 10.08.83 and 10.09.83 plotted on probability paper



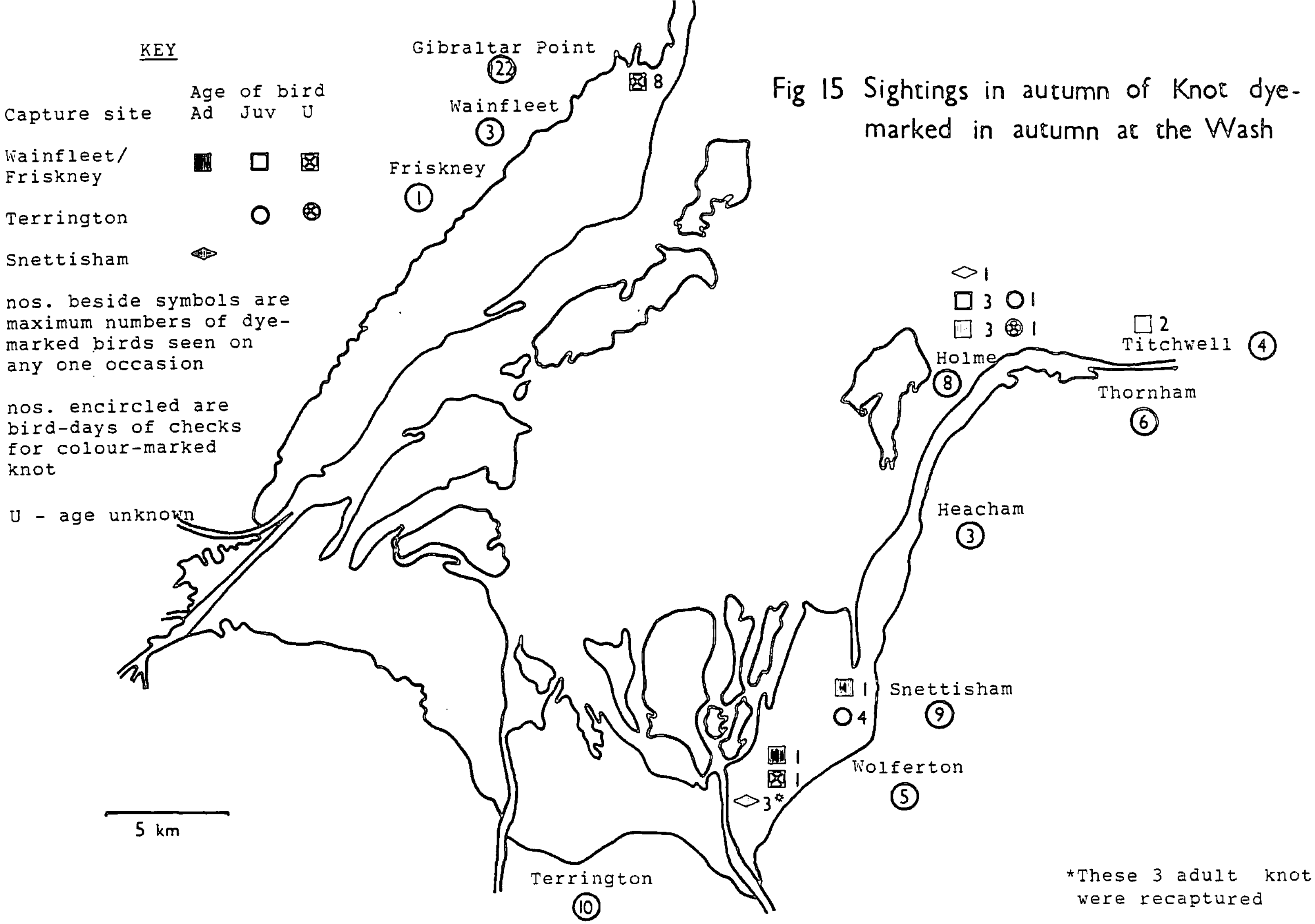
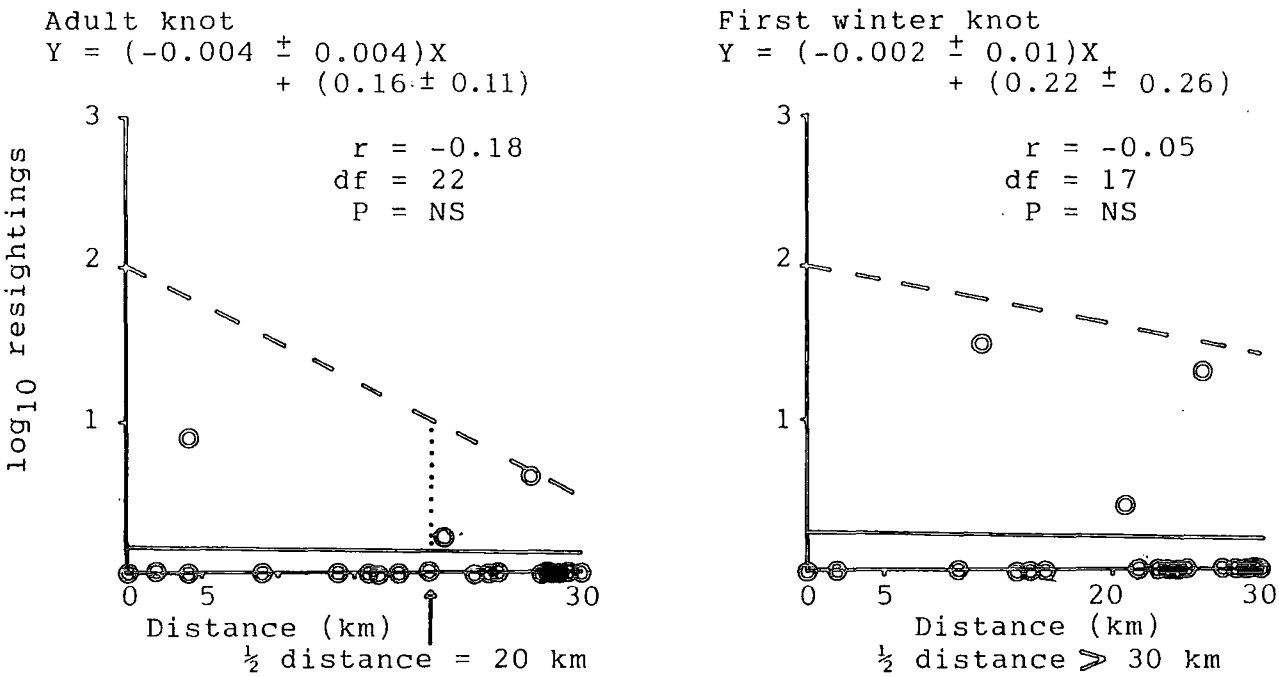



Fig 15 Sightings in autumn of Knot dye-marked in autumn at the Wash

Fig 16 KNOT: Seasonal variations in the average number of resightings of dyed knot per 1000 marked per 1000 checked at each site (all catches combined for 1982/83 & 1983/84)




——— linear regression, calculated from actual log values.
— — standardised regression through intercept of Y = 2.

Graphical presentation of the $\log_{10}$ of the average number of resightings of dyed knot per 1000 marked per 1000 checked at each site (Fig 16) suggests greater mobility amongst juveniles than for adults. However, correlation coefficients were poor due to a wide scatter of points, which is even more apparent when results are plotted individually instead of being averaged. Consequently, the difference in mobility between adults and juveniles may not be real. The estimate of "½-distance" for adult knot was 20 km whilst that for juveniles exceeds 30 km (approximate width of the Wash).

Degree of mobility revealed by recaptures of ringed birds at roosts

Recaptures of knot in autumn, from catches made earlier in the same autumn at Friskney and Wolferton indicate considerable interchange between shores and alongshore movement (Fig 17). However, the majority of recaptures of adults and juveniles caught at Friskney were within 5 km of Friskney. As can be seen from Fig 9, this part of the Wash was a preferred autumn roosting area.

Recaptures in winter of birds ringed in the same winter reflect the bias arising from winter catches being, predominantly, on the east shore of the Wash.

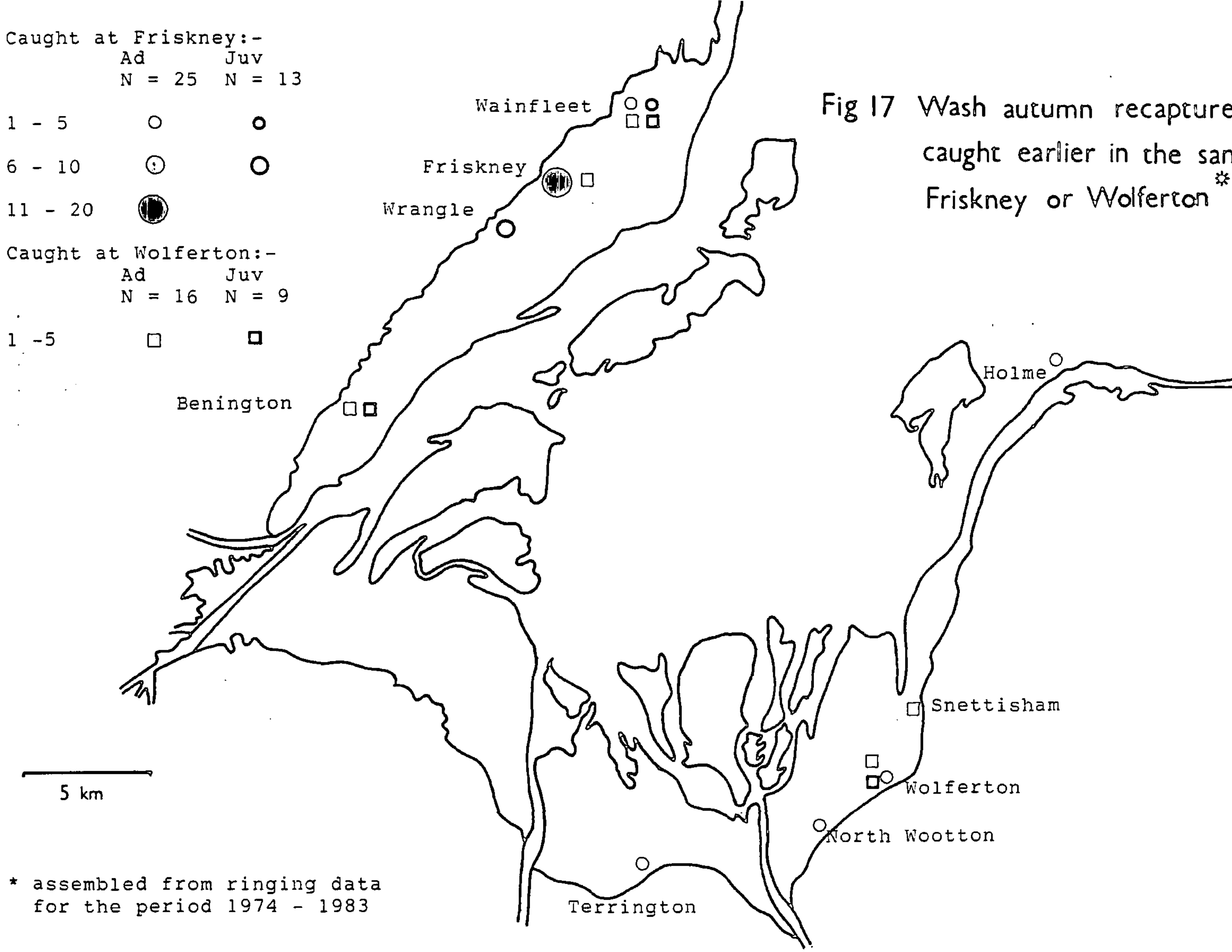
Trends shown by the autumn recaptures agree with those shown by the, similarly small, samples of results from dye-marking. No single year produced sufficient within-Wash recaptures for analyses. Even during the 10 years 1974/75 to 1983/84 few within-Wash recaptures were generated in the same season as capture (Table 10). This reflects the difficulty of catching knot at the Wash in large numbers or several times in the same year.

Table 10 Seasonal recapture totals 1974/75 - 1983/84 of adult and juvenile knot with respect to distance moved from the capture site

| Distance moved | Within same autumn | | Within same winter | |
|---|---|---|---|---|
| | ad | juv | ad | juv |
| 5 km | 28 | 17 | 5 | 16 |
| 5 km | 17 | 16 | 10 | 12 |

ad = adult; juv = juvenile (up to one year old)

Fig 17 Wash autumn recaptures of Knot caught earlier in the same autumn at Friskney or Wolferton*



## SANDERLING

### Introduction

The sanderling is found, mostly, on the sand and shingle beaches of the eastern shore of the Wash, from Wolferton to Titchwell, and on similar habitats at Gibraltar Point, particularly in autumn and spring, when many birds pass through (Figs 18, 19, 20, 21). Elsewhere in the Wash, this species occurs irregularly and then usually only as single birds, except in autumn when small flocks of up to 100 may be encountered.

In winter, there are usually about 200 sanderling along the eastern shore of the Wash, most being at Snettisham (Table 11), where they feed predominantly at the tide edge but also amongst tide wrack, particularly at Thornham and Heacham, and on the sandy mudflats between Wolferton and Snettisham.

### Degree of mobility revealed by counts at roosts

Sanderling use seven main roost sites around the Wash (Figs 22, 23, 24). The most consistently important roost is at Snettisham - notably for moulting adults in autumn - usually on the foreshore, but occasionally on the Pits. Roosts at Gibraltar Point, Holme and Titchwell are used mostly in autumn and spring during passage periods. In winter, however, the relative importance of different roosts changes daily. Snettisham (Fig 19), Sailing Club Bay, Holme, Thornham and Titchwell (Fig 20) all have over 50 sanderling on some days; on one day in February 1984 there were 220 sanderling at Holme, probably the entire wintering population in that year, at the Wash. This suggests that sanderling wintering on the east shore of the Wash are highly mobile along that shore.

Fig 18 BoEE counts of Sanderling on the east shore of the Wash between North Wootton and Heacham

1969—1974

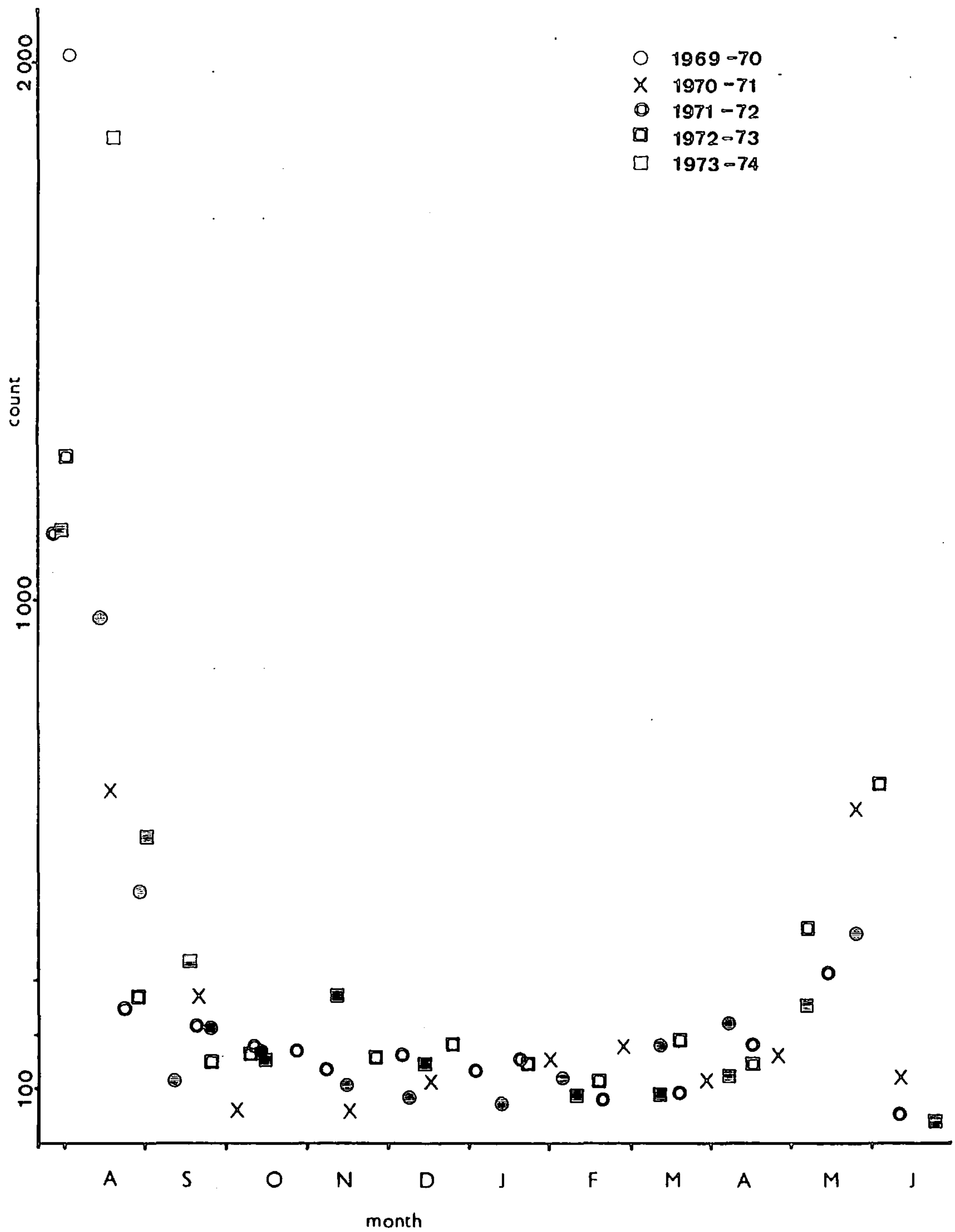


Table 11 BoEE counts of Sanderling at the Wash: North Wootton to Heacham 1975/76 - 1983/84

| Month - Year | Aug | Sep | Nov | Dec | Jan | Feb |
|---|---|---|---|---|---|---|
| 1975/76 | - | - | - | 207 | 169 | 95 |
| 1976/77 | - | - | - | 96 | 170 | 109 |
| 1977/78 | - | - | - | 42 | 38 | 80 |
| 1978/79 | - | 426 | - | 180 | 49 | - |
| 1979/80 | - | 210 | - | 125 | 115 | - |
| 1980/81 | - | - | 190 | - | 134 | 115 |
| 1981/82 | 430 | - | 154 | 146 | - | 80 |
| 1982/83 | - | - | - | - | 60 | 100 |
| 1983/84 | 917 | 367 | 80 | 140 | 125 | 150 |

Fig 1.9 Maximum monthly counts of Sanderling at Snettisham, the Wash, 1982/83 (PRG - o; RHWC - **o** )

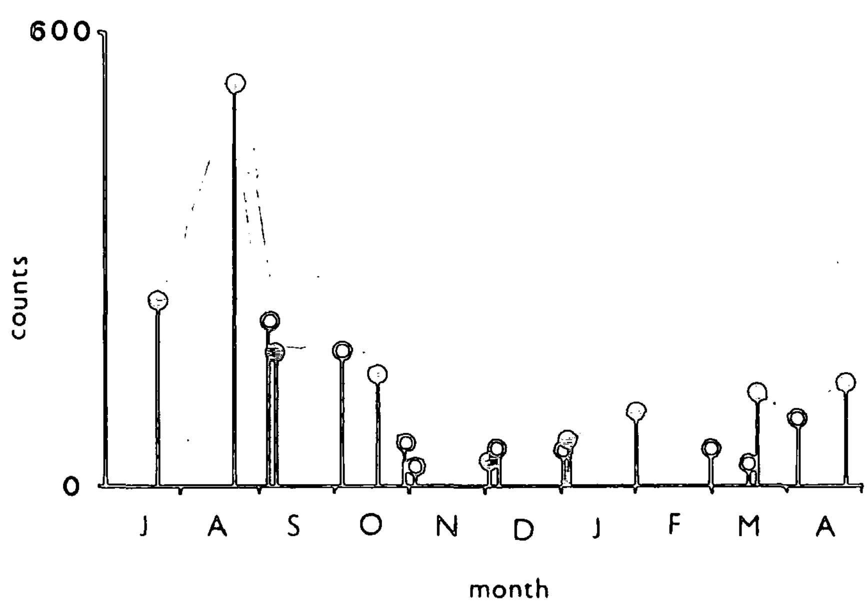


Fig 20 BoEE counts of Sanderling at Thornham and Titchwell, the Wash

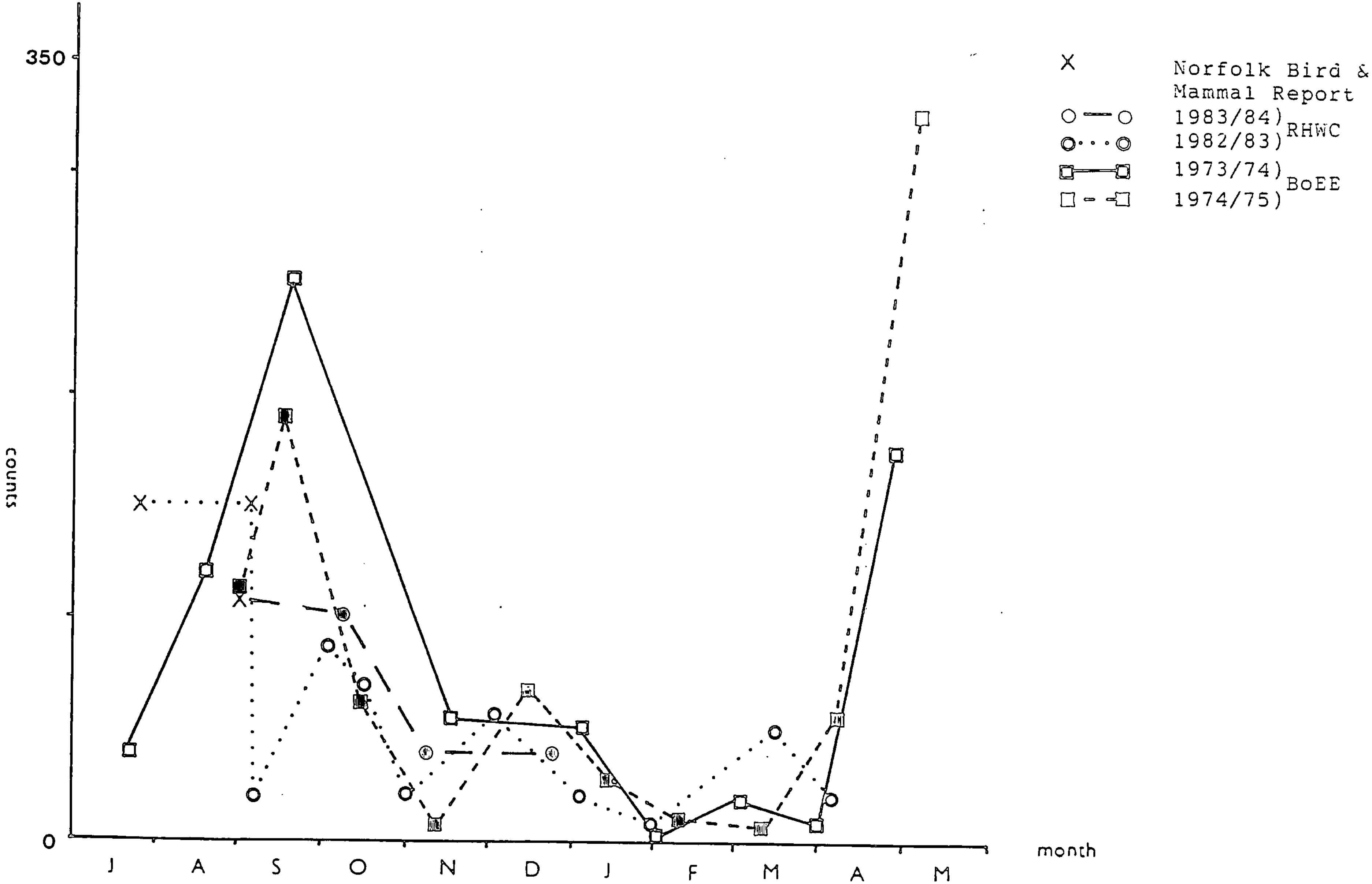
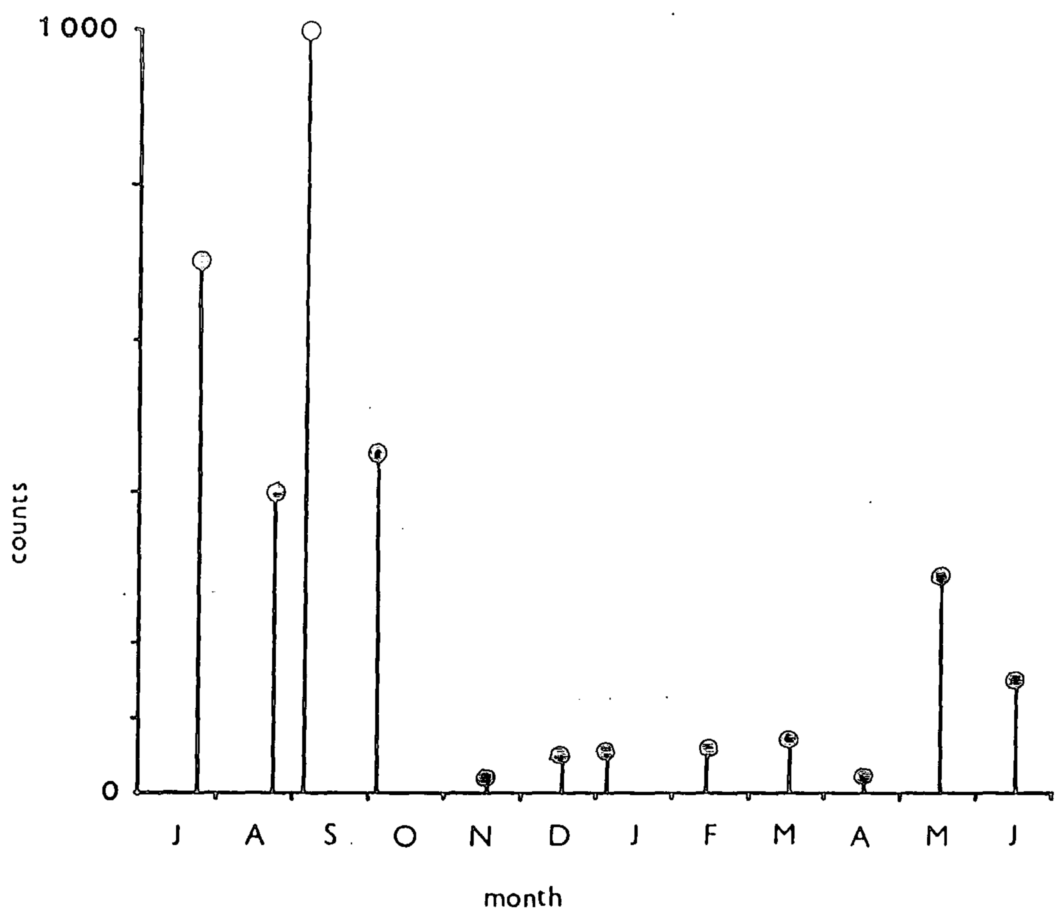
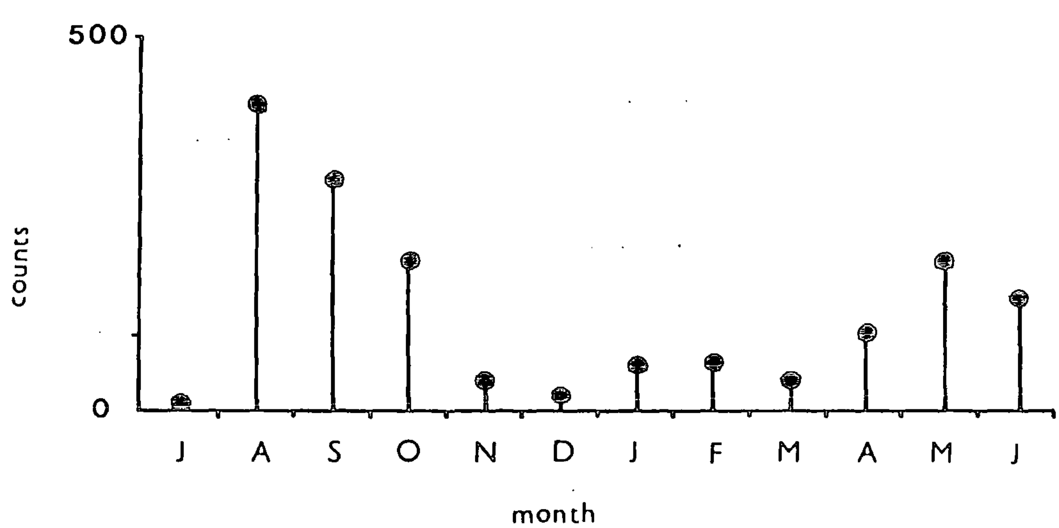


Fig 21 Maximum monthly counts of Sanderling at Gibraltar Point (R. Lambert)

a) 1982-83




b) 1983-84



## Fig 22 Sanderling roosts at the Wash in autumn

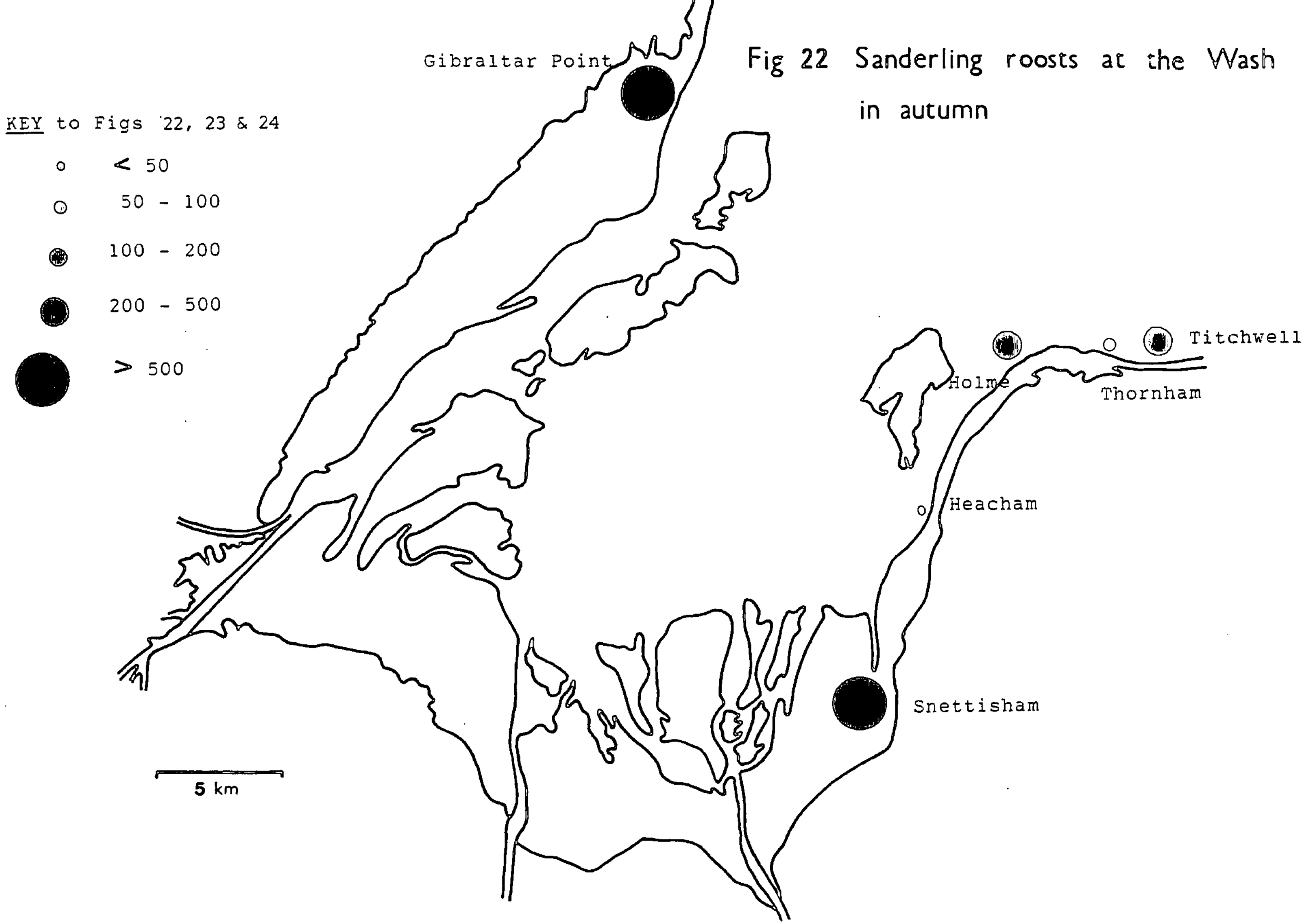


Fig 23 Sanderling roosts at the Wash in winter

<u>KEY</u> - see Fig 22

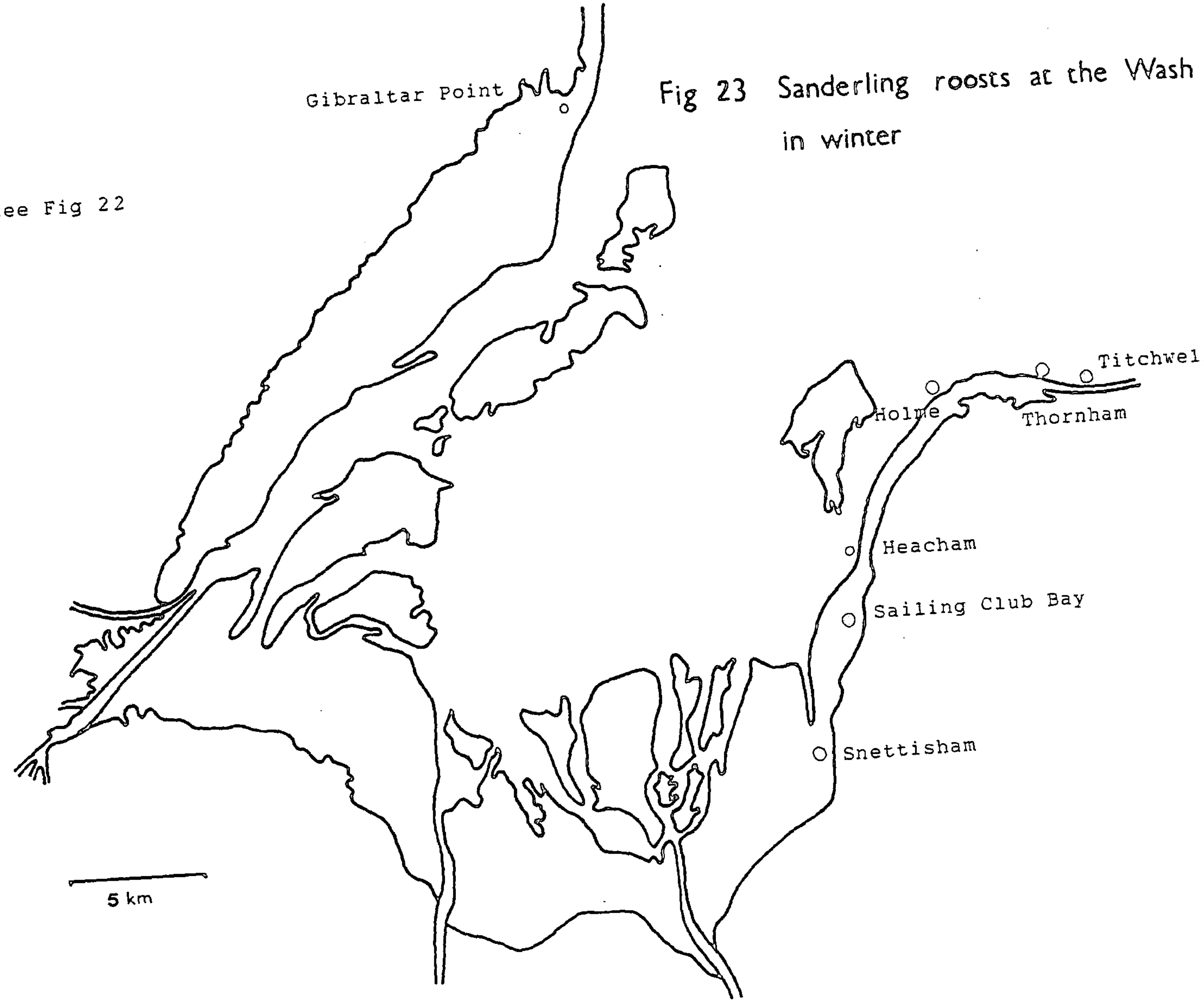
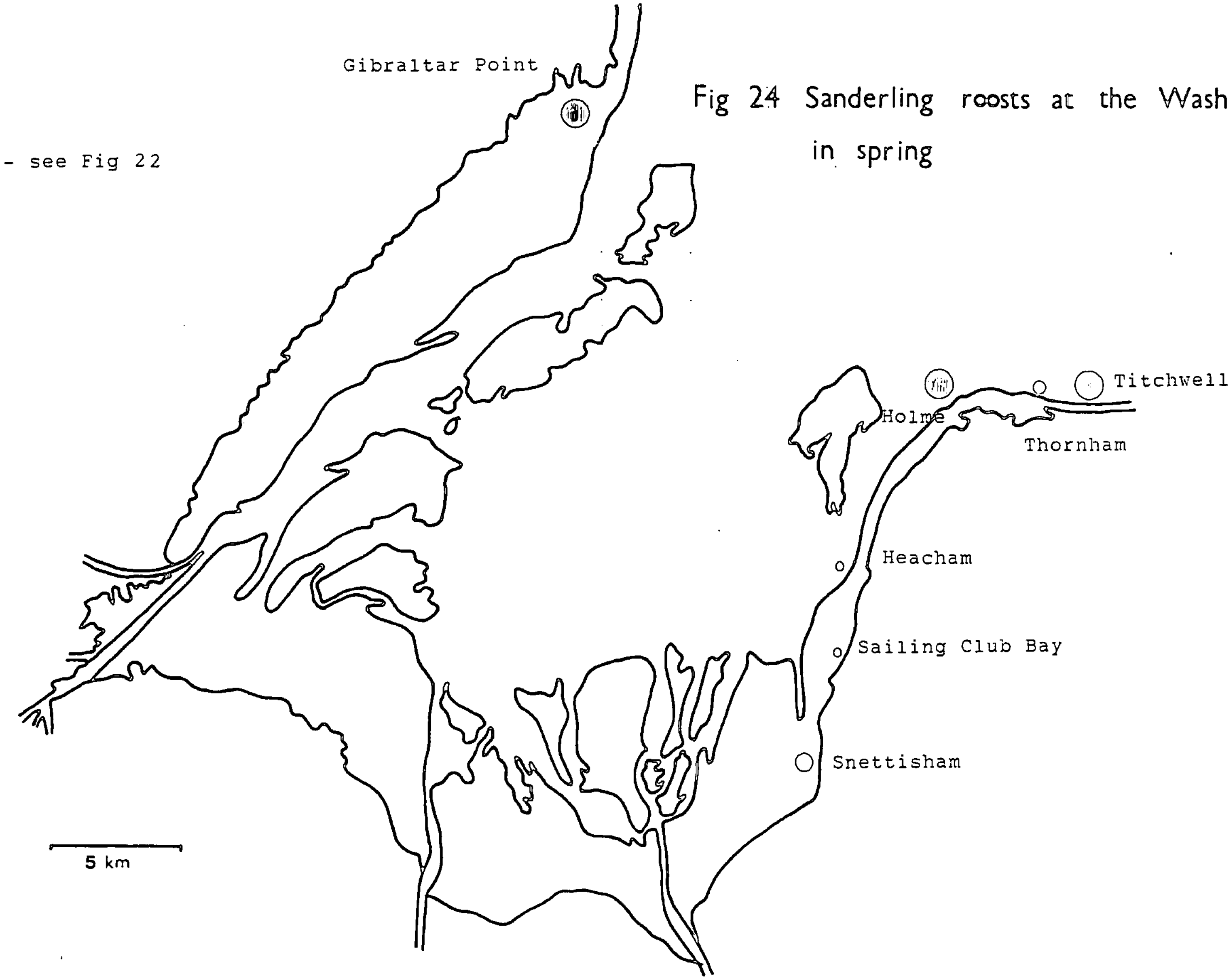


Fig 24 Sanderling roosts at the Wash in spring

KEY - see Fig 22



Degree of mobility revealed by colour-marking

On 6 November 1983, 37 adults and one juvenile sanderling were dyed with Picric Acid (Appendix I, Table 1, Fig 2). The resulting yellow plumage was retained until the birds moulted into breeding plumage.

One hundred and twenty nine observer-days of searches for these dyed sanderling yielded 226 sightings of adults. The juvenile was seen during March 1984 on the Lincolnshire coast at Saltfleetby and, possibly, in June 1984 on the Alt estuary in Lancashire. This juvenile was presumed not to have wintered on the east Wash since it was not seen there again after marking.

Movements of dyed sanderling between roosts along the east Wash during November to April inclusive are summarised in Fig 25. No dyed sanderling were recorded elsewhere in the Wash.

Graphs of $\log_{10}$ average resightings of dyed sanderling per 1000 marked per 1000 checked at each site are shown in Fig 26. Correlation coefficients were high and "half-distances" of 12.5 km for winter and 14 km for spring were obtained.

Degree of mobility revealed by recaptures of ringed birds

Most information is available for adults cannon-netted at roosts, chiefly at Snettisham. Recaptures within the same autumn as birds were ringed at Snettisham have been made all along the east coast of the Wash but most were recaptured where they were caught originally. The predominance of recaptures at Snettisham reflects the concentration of catching effort and success there, although the site is also numerically important for sanderling.

Analyses of recaptures (see "Methods" section) between

Fig 25

Maximum numbers of dye-marked adult Sanderling, seen simultaneously at the Wash, in 1983/84 (from 37 adults marked at Heacham on 6 November 1983)

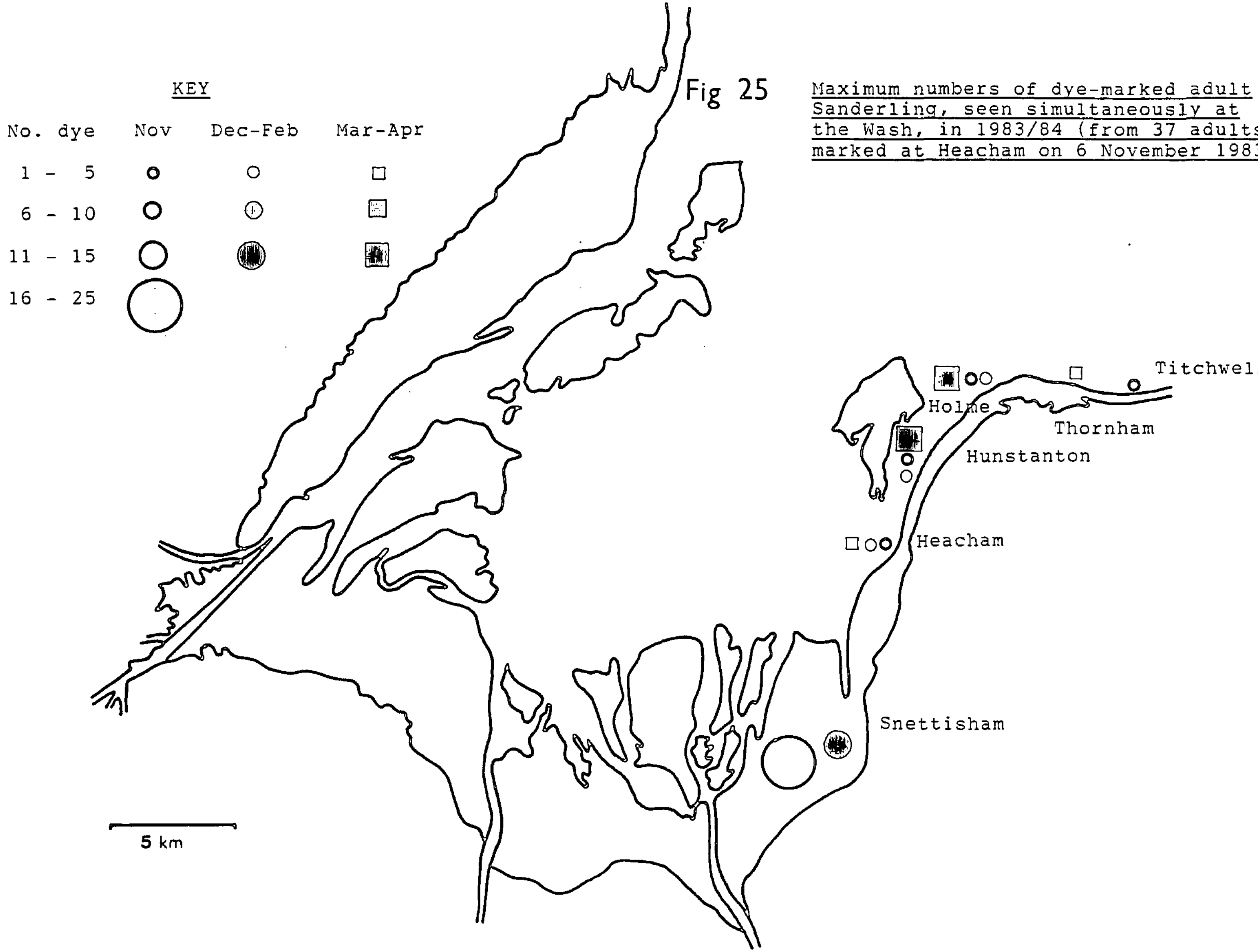
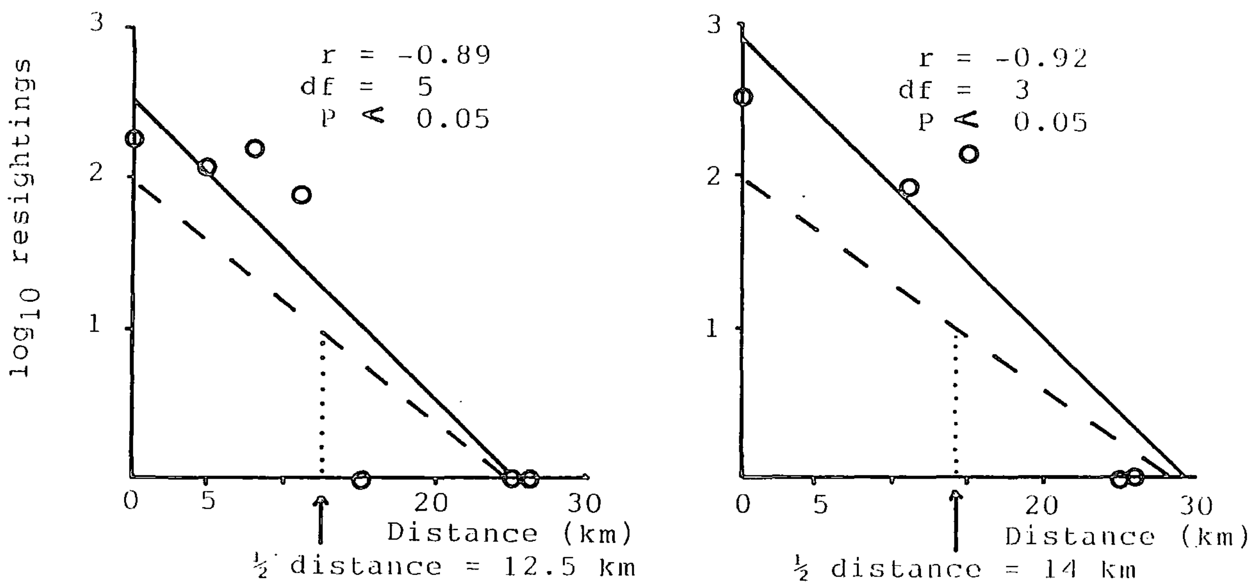


Fig 26 SANDERLING: Seasonal variations in the average number of resightings of dyed sanderling per 1000 marked on 6.11.83 at Heacham per 1000 checked at each site

WINTER resightings
$Y = (-0.1 \pm 0.02)X + (2.52 \pm 0.36)$

SPRING resightings
$Y = (-0.1 \pm 0.23)X + (2.93 \pm 0.48)$




—— linear regression, calculated from actual log values.
– – standardised regression through intercept of Y = 2

pairs of catches in autumn 1974 (Table 12) and autumn 1977 (Table 13) show no significant difference between observed and expected distributions of distances moved. Movement along the east Wash is confirmed, but most recaptures were at or within 5 km of the capture site, since the majority of birds were caught at sites only 5 km apart. Consequently, recapture data are of little value in determining the extent of movement along the east Wash by individual sanderling.

Table 12 Catches of adult Sanderling at the Wash in autumn 1974 with details of recaptures (only catches exceeding 10 birds are presented)

| | Date | Catch site | N | Recaptures A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 20.7 | Snettisham | 144 | | | | | | | |
| B | 4.8 | Snettisham | 416 | | | | | | | |
| C | 17.8 | Snettisham | 25 | 9 | | | | | | |
| D | 23.8 | Snettisham | 194 | 1 | 26 | 5 | | | | |
| E | 24.8 | Heacham | 17 | | | | 3 | | | |
| F | 14.9 | Snettisham | 140 | 9 | 18 | 1 | 26 | 1 | | |
| G | 5.10 | Holme | 27 | | 7 | | 1 | | 4 | |

Observed and expected numbers of recaptures in relation to distance moved from the capture site

| | Observed | Expected | |
|---|---|---|---|
| ≤ 5 km | 99 | 102.7 | $X^2 = 1.65$ |
| > 5 km | 12 | 8.3 | df = 1 |
| total | 111 | 111 | P = NS |

N = total adults caught; df = degrees of freedom;
NS = not significant; $X^2$ = Chi Square; P = probability

Table 13 Catches of adult Sanderling at the Wash in autumn 1977 with details of recaptures (only catches exceeding 10 birds are presented)

| | Date | Catch site | N | Recaptures A | B | C | D | E |
|---|---|---|---|---|---|---|---|---|
| A | 30.7 | Snettisham | 203 | | | | | |
| B | 14.8 | Snettisham | 32 | 1 | | | | |
| C | 21.8 | Snettisham | 209 | 15 | 5 | | | |
| D | 15.9 | Heacham | 117 | 5 | 2 | 34 | | |
| E | 16.10 | Thornham | 32 | 2 | 1 | 5 | | |

Observed and expected numbers of recaptures in relation to distance moved from the capture site

| | Observed | Expected |
|---|---|---|
| $\leqslant$ 5 km | 62 | 60 |
| $>$ 5 km | 8 | 10 |
| total | 70 | 70 |

$\chi^2 = 0.47$

df = 1

P = NS

N = total adults caught; df = degrees of freedom;
$\chi^2$ = Chi Square; P = probability; NS = not significant

DUNLIN

Introduction

Dunlin are widespread around the Wash, feeding mostly on mudflats at upper- and mid- shore levels. In the early 1970s, peak counts of up to 40 000 dunlin were recorded in September, and again in November to March (Prater 1981). More recent counts show similar winter numbers (Table 14) but the few September counts are lower. The largest flocks seen were at the Terrington roost in autumn and contained up to 20 000 or more dunlin.

Table 14 BoEE counts of dunlin at the Wash, between Gibraltar Point and Titchwell, for 1978/79 to 1983/84

| Month - Year | September | November | December | January | February |
|---|---|---|---|---|---|
| 1978/79 | - | - | 11 650 | 23 750 | - |
| 1979/80 | 15 274 | - | 36 983 | 35 209 | - |
| 1980/81 | - | 30 615 | - | 25 016 | 30 193 |
| 1981/82 | - | 40 269 | - | - | 26 346 |
| 1982/83 | - | - | 25 300 | 29 082 | 21 424 |
| 1983/84 | 6 206 | - | - | - | 27 044 |

Counts at Terrington in 1982/83 indicated stable wintering numbers of about 8 000 (Table 15). Although the winter counts in other years were not made in each month, most February counts suggest that 8 000 is the usual wintering level of dunlin at Terrington. However, in January 1980, up to 15 000 dunlin were counted there.

At Wolferton and Snettisham, 6 000 to 7 000 dunlin winter in most years (Table 16). Occasionally over 10 000 dunlin winter in the Holbeach/Dawsmere and Frampton/Kirton areas, but in most years less than 5 000 are present.

Table 15 BoEE counts of dunlin at Terrington, the Wash, for 1978/79 to 1983/84

| Month - Year | September | November | December | January | February |
|---|---|---|---|---|---|
| 1978/79 | - | - | - | 3 600 | - |
| 1979/80 | 5 200 | - | 11 770 | 14 934 | - |
| 1980/81 | - | 7 290 | - | - | 8 040 |
| 1981/82 | - | 13 030 | - | - | 7 710 |
| 1982/83 | - | - | 7 610 | 8 120 | 8 130 |
| 1983/84 | - | - | - | - | 8 862 |

Table 16 BoEE counts of dunlin at Wolferton/Snettisham , the Wash, for 1978/79 to 1983/84

| Month - Year | September | November | December | January | February |
|---|---|---|---|---|---|
| 1978/79 | - | - | - | 6 400 | - |
| 1979/80 | 5 670 | - | 13 000 | 7 050 | - |
| 1980/81 | - | 5 000 | - | 6 000 | - |
| 1981/82 | - | 2 000 | - | - | 6 000 |
| 1982/83 | - | - | - | 6 500 | - |
| 1983/84 | 2 226 | - | - | - | 500+ |

In autumn, dunlin constituted the majority of many mixed species flocks of several thousands of waders roosting in fields around the Wash. Field roosts of dunlin are common, particularly in autumn; in winter small flocks of 20 - 50 were seen regularly. However, in December 1982 up to 1 000 dunlin were observed roosting in a field at Snettisham, so it is possible that substantial flocks may have used fields in other winters without being recorded.

Saltmarsh is also an important roosting habitat, particularly in winter. Possibly, die-back of vegetation at the end of the growing season and flattening by storm tides provide favourable roosting conditions for smaller waders, improving visibility and enabling them to roost closer to their feeding areas. This last point becomes more important as winter progresses and with it daylight feeding time decreases. The closer proximity to the mudflats minimises the time and energy losses for the birds in returning to feed as soon as the mud uncovers.

Degree of mobility revealed by counts at roosts

Localised movements of the roosting flock associated with Wolferton occur. Dunlin usually roosted on the foreshore at Snettisham where up to 1 000 occurred. The sub-roost on the adjacent mudflats numbered 4 000 or more, most of which were presumed to roost at Wolferton (Table 16). Occasionally a wader flock including 5 000 or more dunlin roosted on Heacham beach - presumably the "Wolferton flock". Otherwise this beach was used by only small numbers - less than 50.

Approximately 200 dunlin roosted regularly at Thornham during spring tides or fed on a wet area shielded by the shingle and sand spit over high water.

Dunlin were often difficult to count because they were easily overlooked in saltmarsh vegetation, or amongst brassica crops on fields, or amongst clods of earth on ploughed fields. Hence estimated counts of dunlin might be low and of use for gross comparisons only. It was, therefore, difficult to assess from roost counts of dunlin whether or not much movement occurred between roosts. The BoEE acknowledge the difficulty of counting dunlin.

Degree of mobility revealed by colour-marking

Colour-marking was undertaken in 1982/83 using Sevron Blue dye and leg flags (Fig 2, Table 1, Appendix I). The 1189 dunlin which were dyed yielded only 36 sightings (Appendix V ), probably because of the problems of observing birds at many roost sites and the difficulties mentioned above. Dunlin were most easily checked for colour-markings at sites along the east shore of the Wash and this is where most dyed birds were seen, notably known-aged birds, identified by leg flags.

Sightings at the Wash of dunlin caught in autumn were made before the end of the first quarter of November. Thereafter, sigtings were away from the Wash, with the movement of birds from the Wash (Table 17 ) taking place in early November, and presumably constituting post-moult dispersal. Although limited, results from dye-marking in autumn indicate considerable turnover of dunlin present at the Wash during autumn, once post-nuptial moult was completed (Tables 17 & 18 ). There were sightings from small estuaries for up to 3 months following colour-marking.

Table 17 Wash sightings and recaptures of dye-marked dunlin in relation to distance from site of capture

| season caught | season seen/ recaught | ≤ 5 km | > 5 km | away from Wash | Total |
|---|---|---|---|---|---|
| autumn | autumn | 5 (+16) | 1 | 0 | 6 (+16) |
| autumn | winter | 4 | (3) | 8 | 12 (+ 3) |
| winter | winter | 11 | 2 | 0 | 13 |
| winter | spring | 5 | 0 | 0 | 5 |
| | | | | | 36 (+19) |

recaptures in parentheses

Table 18 Sightings of dunlin away from the Wash

| SIGHTING | | | | CATCH | |
|---|---|---|---|---|---|
| Date | Location | No. dye | Age | Date | Location |
| 06.11.82 | Moray Firth | 1 | u | 16.10.82 | Wolferton |
| 14.11.82) | Clonakilty | 2 | ad | autumn | Terrington |
| 24.12.82) | Eire | 2 | ad | autumn | Terrington |
| 28.11.82) | Hayle | 1 | ad | autumn | Terrington |
| 05.12.82) | Estuary | 1 | ad | autumn | Terrington |
| 18.12.82) | Cornwall | 1 | ad | autumn | Terrington |

Repeat sightings at Clonakilty may have been of the same birds, as may be true for sightings at the Hayle Estuary.

u = unknown age; ad = adult

Tables 17 & 18 seasons as follows: autumn - July - October
winter - November - February
spring - March - June

Most sightings of dyed dunlin at the Wash were at or within 5 km of the site of capture (Table 17). This implies that those dunlin remaining at the Wash during the moulting period and winter and spring move little between roosts and/or feeding areas. Flights along the west shore of the Wash to Gibraltar Point are undertaken by dunlin, but not in large numbers. A dunlin caught at Leverton on 21 August 1982 and seen at Gibraltar Point on 22 August was one of these.

There were also 19 recaptures of colour-marked dunlin at the Wash (Table 17). Most of these were recaught at or within 5 km of their capture site, but 3 exceptions were retrapped over 5 km away after early November. The possibility exists that movement may have taken place earlier than this.

Degree of mobility revealed by recaptures of ringed dunlin

In autumn most adult and juvenile dunlin stayed at or within 5 km of the site of capture (Figs 28 a & b, Table 19), indicating very localised movement of dunlin between roosts, in contrast with knot (Fig 17).

Recaptures in winter of adult and juvenile dunlin caught in autumn at Wolferton and Terrington show dispersal along the east Wash and between the east and south shores of the Wash (Fig 29), although the largest numbers of recaptures were at or near the site of capture (Table 19). To the extent that these recaptures show dispersal, the most likely cause at this time is post-moult movement. The large numbers of recaptures at Snettisham and Heacham in winter reflect catching effort and success.

The small sample of within winter recaptures were from or within 5 km of, the original capture site of adult and juvenile dunlin (Table 19).

Table 19 Within-Wash, within-year, recapture totals of ringed dunlin relative to age and distance from original site of capture (accumulated totals for the period 1969/70 - 1984/85)

| Season caught | Season recaught | Age | Recapture distance $\leqslant$ 5 km | > 5 km | Total |
|---|---|---|---|---|---|
| autumn | autumn | ad | 695 | 62 | 757 |
| | | j | 78 | 11 | 89 |
| total | | | 773 | 73 | 846 |
| autumn | winter | ad | 73 | 30 | 103 |
| | | j | 16 | 7 | 23 |
| total | | | 89 | 37 | 126 |
| winter | winter | ad | 14 | 0 | 14 |
| | | j | 13 | 0 | 13 |
| total | | | 27 | 0 | 27 |

ad = adult; j = juvenile

Comparison of autumn recaptures (see Methods section) of adult dunlin for the years 1974, 1975, 1976, 1977 and 1980 showed significantly little movement outside a 5 km radius of the capture site (Table 20).

The year 1976 was particularly good for large catches of dunlin at a variety of sites, so birds marked at a single roost site - Friskney - could be considered separately. The majority of recaptures were in the same autumn at Friskney (Table 21) but there were also some at Wainfleet, only 4 km away (Table 2). A few were recaptured further along the west shore of the Wash, at Benington, but none elsewhere in the Wash, despite catches being made at other sites (Table 22).

There were too few within autumn recaptures of juvenile dunlin for analysis, except in 1980. The sample showed that juveniles exhibited localised movements (Table 23), akin to those of adults.

Graphs of $\log_{10}$ of the average number of recaptures of adult dunlin per 1000 ringed per 1000 recaptured at each site in autumn of 1975, 1976 and 1977 are shown in Fig 27. (Details of catches and recaptures for these years are given in Table 22 and Appendix VI.) Correlation coefficients were high and an average "½-distance" of 13 km was calculated (Fig 27).

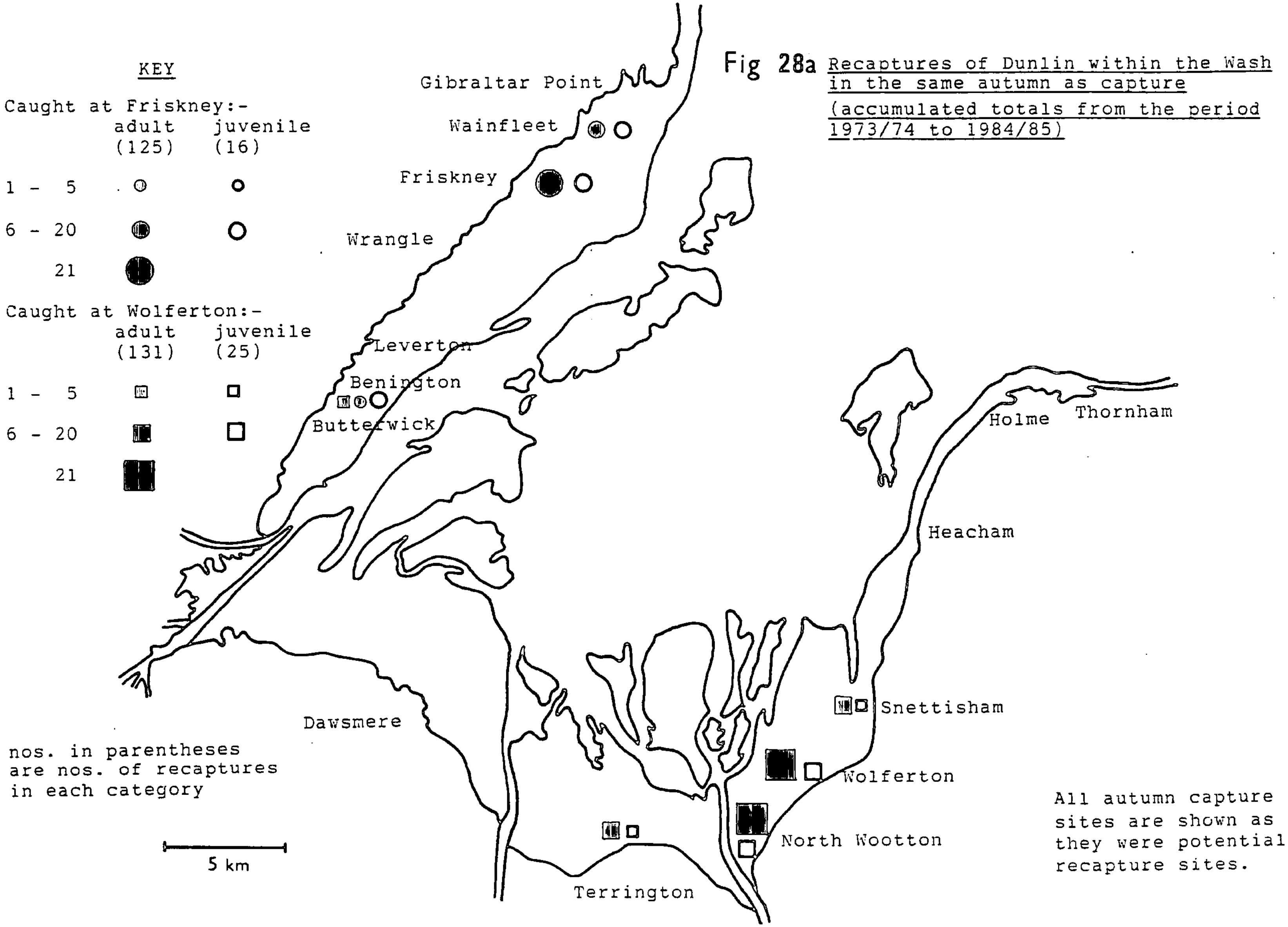


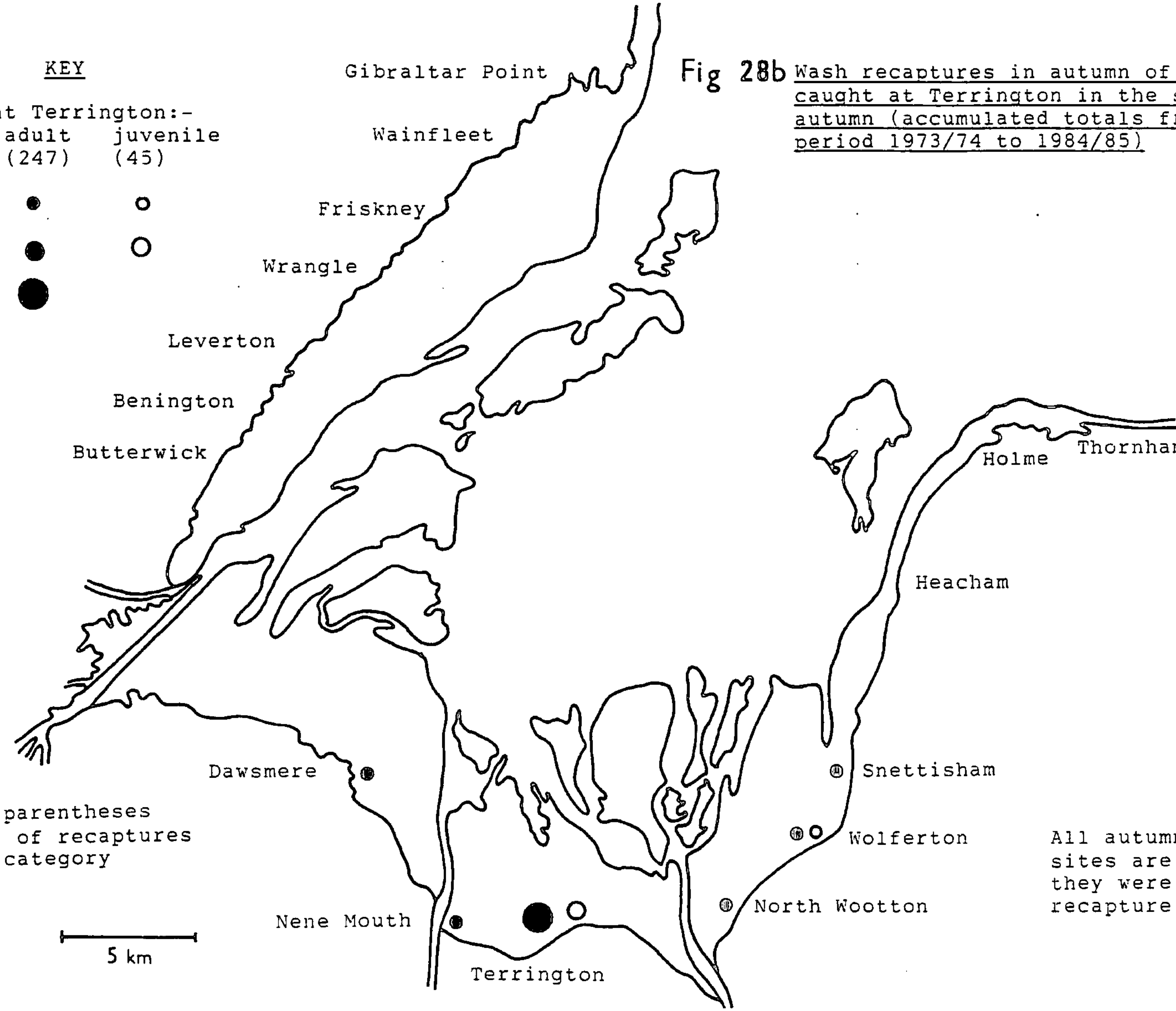

Fig 28a Recaptures of Dunlin within the Wash in the same autumn as capture (accumulated totals from the period 1973/74 to 1984/85)

Fig 28b Wash recaptures in autumn of Dunlin caught at Terrington in the same autumn (accumulated totals from the period 1973/74 to 1984/85)

KEY

Caught at Terrington:-

| | adult (247) | juvenile (45) |
|---|---|---|
| 1 - 10 | ● | ○ |
| 11 - 50 | ● | ○ |
| 200 | ● | |




nos. in parentheses are nos. of recaptures in each category

5 km

All autumn capture sites are shown as they were potential recapture sites.

Fig 29 <u>Wash recaptures in winter of Dunlin caught in immediately preceding autumn (accumulated totals from the period 1969/70 to 1984/85)</u>

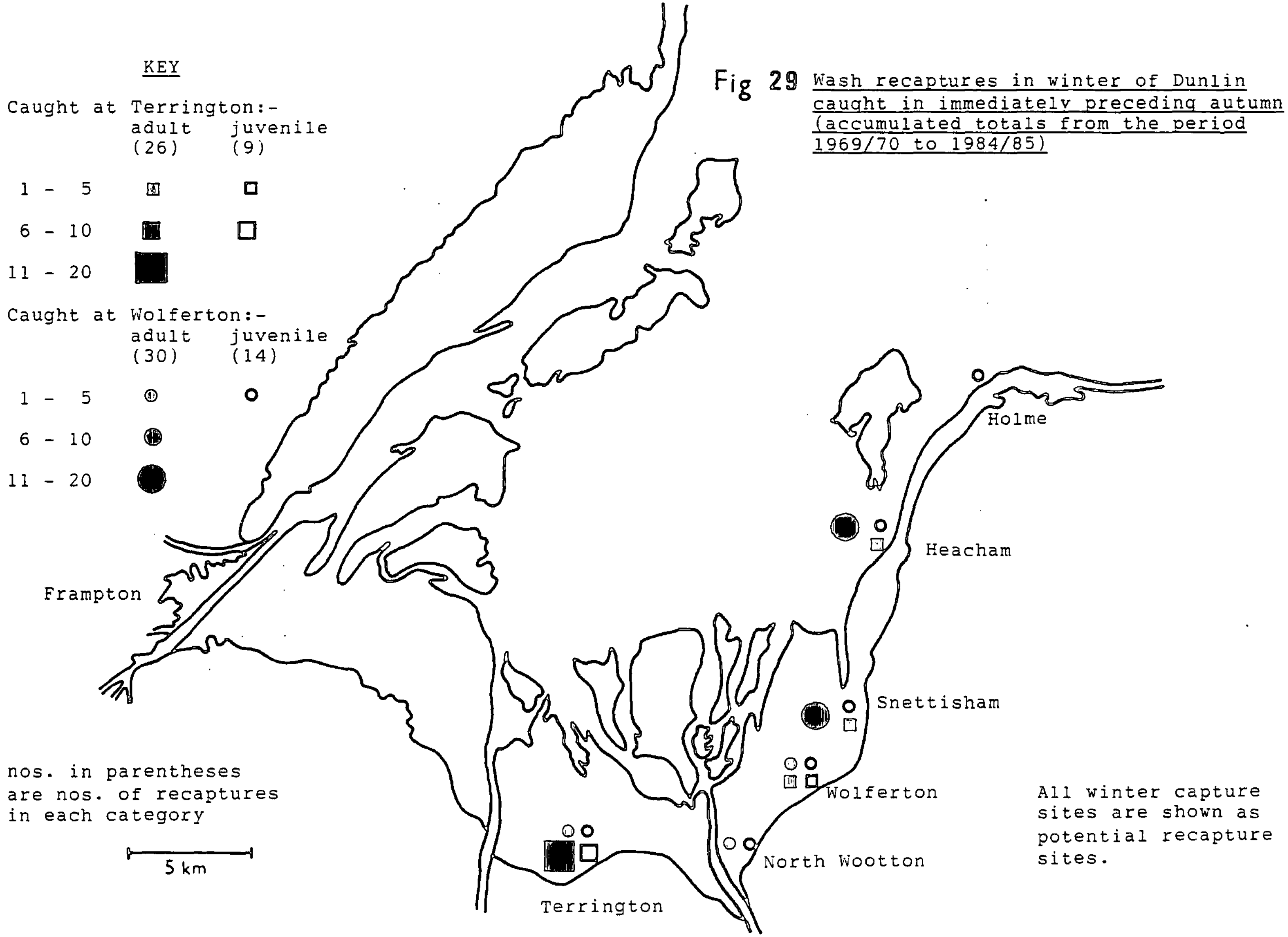


Table 20 Recaptures of adult dunlin within the Wash within a single autumn

| | Observed | | Expected* | | | |
|---|---|---|---|---|---|---|
| Year | ≤ 5 km | > 5 km | ≤ 5 km | > 5 km | $X^2$ | P** |
| 1974 | 17 | 1 | 3.7 | 14.3 | 60.2 | < 0.005 |
| 1975 | 83 | 10 | 20.3 | 72.7 | 247.8 | < 0.005 |
| 1976 | 99 | 8 | 29.1 | 77.9 | 230.6 | < 0.005 |
| 1977 | 102 | 1 | 80.9 | 22.1 | 25.6 | < 0.005 |
| 1980 | 51 | 1 | 17.6 | 34.4 | 95.8 | < 0.005 |

*see Methods section

degrees of freedom in all cases = 1

Information extracted from Table 22 and WWRG sources

**values obtained from Snedecor & Cochran 1980

Table 21 Wash autumn recaptures of adult dunlin caught at Friskney in the same autumn - 1976

| | Recaptures | | | |
|---|---|---|---|---|
| Recapture site | observed | expected* | $X^2$ | P |
| Friskney | 40 | 8.4) | | |
| Wainfleet | 14 | 12.2) | | |
| Benington | 6 | 8.6) | 150.7 | < 0.005 |
| elsewhere | 0 | 30.8) | | |

$X^2$ = Chi Square with 3 degrees of freedom

* see Methods section

Information extracted from Table 22

Table 22 Catches at the Wash of adult dunlin in autumn 1976 with details of recaptures (only catches of 10 or more birds are shown).

| Catch | Date | Location | Total adults caught | No. of adults recaptured from previous catches A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 29.7 | Wol | 14 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| B | 30.7 | Fri | 231 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| C | 30.7 | Ter | 1120 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| D | 31.7 | Fri | 60 | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| E | 31.7 | Wol | 12 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| F | 26.8 | Wai | 13 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| G | 26.8 | Ben | 498 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| H | 27.8 | Ben | 244 | - | - | - | - | - | - | 15 | - | - | - | - | - | - | - |
| I | 27.8 | Ter | 721 | - | - | 28 | - | - | - | - | - | - | - | - | - | - | - |
| J | 27.8 | Fri | 572 | - | 7 | - | 1 | - | - | 1 | - | - | - | - | - | - | - |
| K | 28.8 | Wai | 770 | - | 2 | - | 1 | - | 2 | 1 | - | - | - | - | - | - | - |
| L | 28.8 | Fri | 262 | - | 3 | - | 1 | - | - | - | - | - | 17 | - | - | - | - |
| M | 29.8 | Fri | 339 | - | 2 | - | - | - | - | - | 5 | - | 4 | 11 | 2 | - | - |
| N | 29.8 | Wol | 54 | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - |
| O | 31.8 | Wol | 47 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

Wol = Wolferton; Fri = Friskney; Ter = Terrington;
Wai = Wainfleet; Ben = Benington.

Data courtesy of the Wash Wader Ringing Group.

Table 23 Wash catches of juvenile dunlin in autumn 1980 with details of recaptures (only catches of 10 or more birds are shown )

| Catch | Date | Location | Total juvs caught | No. of juveniles recaptured from previous catches A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 27.8 | Lev | 30 | - | - | - | - | - | - | - |
| B | 29.8 | Ben | 62 | 2 | - | - | - | - | - | - |
| C | 29.8 | Ter | 60 | - | - | - | - | - | - | - |
| D | 30.8 | Ter | 26 | - | - | - | - | - | - | - |
| E | 25.9 | Ter | 197 | - | - | - | - | - | - | - |
| F | 27.9 | Ter | 309 | - | - | 2 | 1 | 12 | - | - |
| G | 27.9 | Wol | 69 | - | - | - | - | - | - | - |
| H | 28.9 | Ter | 321 | - | - | - | - | 10 | 13 | - |

Lev = Leverton; Ben = Benington; Ter = Terrington;
Wol = Wolferton.

| | Recaptures of juveniles observed | expected* |
|---|---|---|
| $\leqslant$ 5 km | 40 | 26.4) |
| $>$ 5 km | 0 | 13.6) |
| total | 40 | |

$X^2$ = 20.6, 1 degree of freedom
P $\leqslant$ 0.005

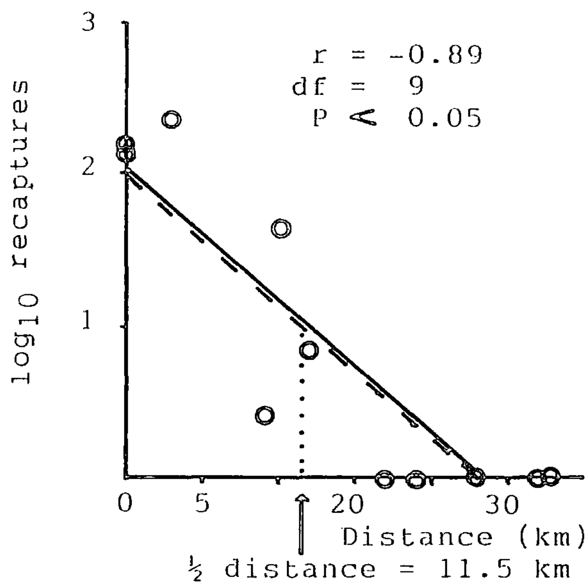
*see Methods section

Data courtesy of the Wash Wader Ringing Group.

Fig 27 DUNLIN: Seasonal variations in the average number of recaptures of dunlin caught during autumn in 1975, 1976, and 1977 at various sites (recaptures within the same autumn as ringing)

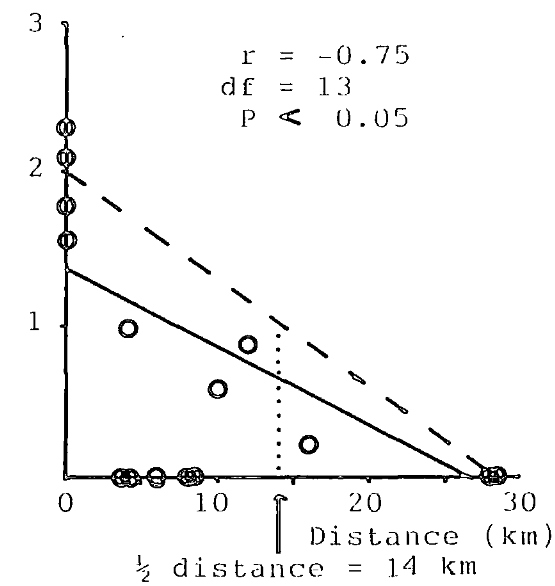
1975

$Y = (-0.09 \pm 0.04)X + (2.05 \pm 0.24)$



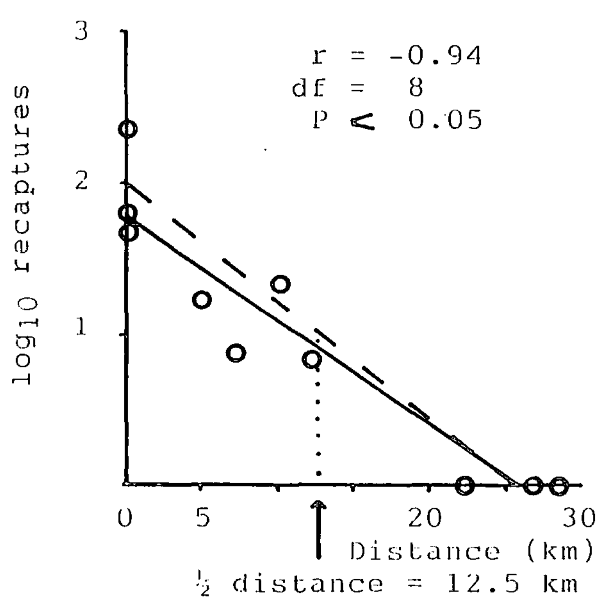

1976

$Y = (-0.05 \pm 0.01)X + (1.36 \pm 0.01)$




1977

$Y = (-0.07 \pm 0.02)X + (1.79 \pm 1.41)$




——— linear regression, calculated from actual log values.

— — standardised regression through intercept of Y = 2.

## GREY PLOVER

### Introduction

Grey plover is a difficult species to count at the Wash because it roosts in flocks with other species, although it occurs only in small numbers at most sites. Feeding distributions were not ascertained.

The BoEE counts for grey plover at the Wash are incomplete but show a tendency for greater numbers in autumn than in winter (Table 24). Wintering numbers have increased in recent years. Snettisham and Terrington are consistently important sites throughout the non-breeding season.

Table 24 BoEE counts of Grey Plover at the Wash for 1978/79 to 1983/84

| Month - Year | September | November | December | January | February |
|---|---|---|---|---|---|
| 1978/79 | 3 055 | - | 1 123 | 1 639 | - |
| 1979/80 | 3 279 | - | 1 410 | 2 026 | - |
| 1980/81 | - | 3 398 | - | 2 073 | 8 264 |
| 1981/82 | - | 6 456 | - | - | 1 616 |
| 1982/83 | - | - | 2 807 | 2 726 | 2 418 |
| 1983/84 | - | - | - | - | 2 694 |

### Degree of mobility revealed by counts at roosts

On the eastern shore of the Wash, the main roost was on the foreshore at Snettisham in a mixed flock with dunlin and sanderling. Occasionally, in midwinter, all or part of this flock roosted on Heacham beach. Up to 2 000 grey plover were counted at roost in this sector of the Wash.

Grey plover were seen occasionally at Thornham, particularly in autumn when they were one of the species seen flying along the east Wash during spring tides. A maximum of 150 were counted at Thornham.

At Terrington, fields close to the sea wall were used for roosting throughout the non-breeding season during spring tides, although principally in autumn. Tides of approximately 7.9 m flooded the saltmarsh, forcing birds to roost elsewhere or to remain airborne. Counts were incomplete.

On the west shore of the Wash, grey plover roosted in fields at various locations between Butterwick and Friskney, in autumn, usually in mixed flocks of wader species. A preference was apparent for bare or newly sown fields or young crops of less than 15 cm in height, presumably because these provided the best all-round visibility. Rarely more than 2 000 grey plover roosted on any one field. The largest grey plover winter roost on the west Wash was of 1 500 birds on the Leverton saltings on 2 February 1983. On this occasion many waders spent the high water period airborne as the tide exceeded the predicted height of 7.3 m and flooded the marsh. Some birds flew to Gibraltar Point during spring tides, but rarely more than 250.

These limited observations indicate that the BoEE counts may underestimate numbers of grey plover at the Wash, particularly in autumn when field roosts are most common. Given the difficulties of observation already mentioned, together with the resultant incomplete counts, it is difficult to establish to what extent grey plover move between roosts during a season.

Degree of mobility revealed by colour-marking

Sixty six grey plover were colour-marked in 1982/83 (Fig 2, Table 1, Appendix I ). Only 2 were seen subsequently, one at the Wash (an adult bird marked and seen subsequently in autumn at Terrington) and the other at the Vendée in France in autumn (an adult caught in autumn at Wainfleet).

During 1983/84, 112 grey plover were dyed, but adults and juveniles were not distinguished by marking (Table 1, Fig 2, Appendix I). Only one was seen - a grey plover from the Friskney catch on 9 September 1983 was seen at Hunstanton on 11 January 1984.

It is impossible to draw firm conclusions from these few results, except that the Friskney bird had crossed to the east shore of the Wash after it had completed wing-moult. Grey plover at the Wash require considerably more study.

## BAR-TAILED GODWIT

### Introduction

The BoEE counts of bar-tailed godwit at the Wash indicate that most birds are found in the Snettisham/Wolferton area in winter, with Wrangle to Gibraltar Point having highest counts in autumn (Tables 25, 26, 27). These 2 areas of the Wash hold most of the bar-tailed godwit.

Table 25 BoEE counts of bar-tailed godwit at the Wash for 1978/79 to 1983/84

| Month - Year | September | November | December | January | February |
|---|---|---|---|---|---|
| 1978/79 | - | - | 9 280 | 11 849 | - |
| 1979/80 | 13 733 | - | - | 8 691 | - |
| 1980/81 | - | - | - | - | 10 936 |
| 1981/82 | - | 4 951 | 5 064 | - | 8 359 |
| 1982/83 | - | - | - | 8 131 | - |
| 1983/84 | --------------------none complete-------------------- | | | | |

Table 26 BoEE counts of bar-tailed godwit at Wolferton/ Snettisham, the Wash, 1978/79 to 1983/84

| Month - Year | September | November | December | January | February |
|---|---|---|---|---|---|
| 1978/79 | 2 250 | - | 3 100 | 3 700 | - |
| 1979/80 | 1 847 | - | 1 500+ | 4 100+ | - |
| 1980/81 | - | - | - | 3 500 | 5 010 |
| 1981/82 | - | 1 100 | 1 530 | - | 7 000 |
| 1982/83 | - | - | - | - | 6 000 |
| 1983/84 | 3 006 | 4 317 | - | - | 5 000 |

The BoEE counts show considerable variation between years, presumably genuine fluctuations caused by varied breeding success in Siberia, since it is a feature noted nationally (Salmon 1981, 1982).

Table 27 BoEE counts of bar-tailed godwit at the Wash from Wrangle to Gibraltar Point (inclusive) for 1978/79 to 1983/84

| Month - Year | September | November | December | January | February |
|---|---|---|---|---|---|
| 1978/79 | - | - | 5 400 | 6 200 | - |
| 1979/80 | 11 000 | - | 3 800 | 3 000 | - |
| 1980/81 | - | 6 250 | - | - | 3 150 |
| 1981/82 | - | 3 450 | 2 700 | - | 800 |
| 1982/83 | - | - | 1 375 | 5 400 | 1 200 |
| 1983/84 | ------------------none complete-------------------- | | | | |

Degree of mobility revealed by counts at roosts

In the Wolferton/Snettisham area, roosts were in fields, the Snettisham Pits, or on Wolferton saltings. Flights to Thornham, of up to 400 birds, were recorded in autumn.

On the west Wash, fields at Wainfleet held most roosting bar-tailed godwit - up to an estimated 5 000 - but smaller flocks of 500 to 1 000 were seen in fields at Wrangle, Benington or Butterwick. Leverton saltmarsh was the main roost on saltings, holding 500 - 1 500 in autumn at the time when fields or Gibraltar Point were the main spring tide roosts. In winter, up to 2 500 bar-tailed godwit roosted on Leverton saltmarsh.

The main feeding areas observed were on the sandy mudflats to the west of Snettisham and on the mudflats offshore from Wainfleet to Wrangle.

Counts at roosts did not highlight inter-roost movement except alongshore flights during high spring tides.

Degree of mobility revealed by colour-marking

In 1982/83, one juvenile and 183 adult bar-tailed godwit were colour-marked and , in 1983/84, a further 45 bar-tailed godwit were colour-marked without distinguishing age by marking (Table 1, Fig 2, Appendix I). All these birds were caught in autumn. No sightings resulted.

No advance was made in determining the degree of mobility exhibited by bar-tailed godwit at the Wash.

CURLEW

The largest flocks recorded were at Terrington, with up to 2 500 in autumn on saltings or in fields close to the sea wall. After autumn and through most of the winter only a few hundred remained at Terrington. The BoEE counts also show Terrington to be a main site for curlew, with the other important roost being in the Wolferton/Snettisham area. According to the BoEE counts there are up to 2 000 curlew at Terrington in autumn and late winter and up to 1 700 in autumn and 500 to 1 000 in winter at Snettisham.

On the east Wash curlew fed mostly in fields behind Heacham beach during the high water period in autumn and winter.

Catches at Terrington and Heacham in autumn 1982 produced 81 colour-marked adult curlew (Table 1, Fig 2, Appendix I). Seven of the Terrington birds caught on 20 September were seen at Terrington on 5 October. These were the only sightings.

## REDSHANK

Redshank are widespread at the Wash, feeding on mudflats and saltmarsh - particularly in and alongside the borrow pits. Redshank were also seen on coastal fields around the Wash throughout the non-breeding season, feeding and roosting at various tidal stages.

Redshank were observed roosting in mixed flocks of waders in fields and on saltmarsh around the Wash and, consequently, some may have been overlooked during counts. The main redshank roosts seen were at Snettisham, where up to 1 000 roosted on the Pits or on the foreshore, and at Terrington, where they roosted on the Bund saltings.

The BoEE estimates a wintering population at the Wash of about 2 000 redshank, most being in the southeast corner, at Snettisham and Terrington.

In 1982/83, 132 redshank were colour-marked, of which 26 were juveniles (Table 1, Fig 2, Appendix I). Of the 2 sightings, only one was at the Wash: a redshank of unknown age colour-marked at Terrington on 19 or 22 August was seen there on 4 September. Colour-marking thus yielded little information concerning movements of redshank at the Wash.

TURNSTONE

Most turnstone were observed on the east Wash, with up to 300 roosting on Heacham beach, on the foreshore at Sailing Club Bay or at Snettisham in autumn and winter. They often fed amongst tidal wrack during the high water period. This flock seems to be fairly mobile along a 5 km stretch of beach. The BoEE shows the southeast corner of the Wash, notably Snettisham, to be the main area for turnstone in the Wash with up to 500 in some years. Turnstone often spent high tide in fields all around the Wash, thereby obtaining additional feeding hours in winter.

In 1982/83, 63 turnstone were colour-marked (Table 1, Fig 2, Appendix I). There were 10 sightings, all of adults, at the Wash (Table 28), all but one of which were at or within 5 km of the site of capture, indicating little movement between roosts during winter or spring. The exception was a bird in autumn which moved along the west Wash only one day after capture during a period of spring tides. Whilst this type of movement was observed in most species, possible disturbance due to capture cannot be ignored.

Table 28 Wash sightings of dye-marked turnstone

| SIGHTINGS | | | CATCH | |
|---|---|---|---|---|
| Date | Location | No. seen | Date | Location |
| 22.08.82 | Gibraltar Point | 1 | 21.08.82 | Leverton |
| 29.01.83 | Heacham | 1 | 01.01.83 | Heacham |
| 28.02.83 | Heacham | 3 & 1 | Jan/Feb | Heacham |
| 01.03.83 | Snettisham | 2 | Feb | Heacham |
| 16.03.83 | Heacham | 1 | Feb | Heacham |
| 17.04.83 | Heacham | 1 | 27.02.83 | Heacham (retrap) |

# DISCUSSION

The mobilities within the Wash of the five species for which adequate data were collected are summarised in Table 29. Owing to the paucity of results for grey plover, bar-tailed godwit, curlew and redshank at the Wash, these species will not be considered further.

Table 29 Mobilities of waders around the Wash - summary of main features

| Species | Period of year | | | Effect of high spring tides |
|---|---|---|---|---|
| | Autumn (July - Oct) adult post-nuptial moult | Winter (Nov - Feb) | Spring (March - May) adult pre-nuptial moult | |
| Oystercatcher | Exchange east & west, & east & south shores | East Wash localised movement | East Wash localised movement | Fly to Snettisham and Gibraltar Point. Fields autumn |
| Knot | Exchange between east & west, & east & south shores. | Exchange between east & west shores | No data | Fly to Snettisham or Thornham, Holme or Titchwell and to Gibraltar Point - unsettled. Fields autumn. |
| Sanderling | Mobile along east Wash but most Snettisham | Movement along east Wash | Movement along east Wash but most at Holme/ Thornham | Sometimes fly to Snettisham or air-borne when shore flooded |
| Dunlin | Mostly short distance moves | | | Fields, some fly to Gibraltar Point |
| Turnstone | Localised | Localised | Localised | Roost/feed on fields |

Comparison of average "half-distance" (Table 30) for oystercatcher, knot, sanderling and dunlin (Figs 8, 16, 26 & 27) highlight the variations in mobility exhibited by these species.

In order of increasing mobility, these are dunlin, sanderling, oystercatcher and knot.

It was not possible to obtain values of "half-distance" for all species in autumn, winter and spring, but the possibility that there may be differences between seasons should be considered. For species where seasonal data were available, correlation coefficients were not significant for the linear regression of sightings*, of knot and oystercatcher in autumn, on distance from the site of capture (Figs 8 & 16). In both cases this arose because of a wide scatter of points; i.e. oystercatcher and knot tended to move between roost sites in autumn (Figs 4 & 9). Oystercatcher "half-distance" declined in winter (Fig 8) although not significantly (autumn v winter, standardised plots, 't' = 1.01; df = 22; P = NS). There was insufficient information for knot to detect any seasonal changes in mobility. The maximum distance from the marking site at which dyed knot and oystercatcher were seen was greater than that for dunlin and sanderling (Table 30).

Sanderling and dunlin average "half-distance" and maximum distance (Table 30) are similar (Figs 26 & 27, standardised plots, 't' = 0.46; df = 46; P = NS), but the data were collected in different seasons.

* In relation to regression analyses and estimates of "half-distance", sightings are defined as $\log_{10}$ of the average sightings of dyed waders per 1000 marked per 1000 checked at each site.

Table 30 Maximum distance from marking site at which dyed waders were seen/ringed birds recaught and "half-distances" established from linear regression of $log_{10}$ average resightings of dyed waders/recaptures per 1000 marked per 1000 checked/recaught at each site, on distance from marking site

| data source | species | ½-distance (km) | maximum distance (km) |
|---|---|---|---|
| dye-marking | [ oystercatcher | 16 | 30 |
| | [ knot | 25 | 27 |
| | [ sanderling | 13 | 15 |
| ringing recaptures | dunlin | 12.7 | 12.5 |

Table 31 Recaptures in the same autumn as capture at the Wash for sanderling and dunlin, in relation to distance moved

| distance moved | sanderling % recaptures* (n = 181) | dunlin % recaptures** (n = 303) |
|---|---|---|
| ≤ 5 km | 88.9 | 93.7 |
| > 5 km | 11.1 | 6.3 |

*Table 12 - 1974; Table 13 - 1977
**Table 20 - 1975, 1976 & 1977

Comparison of the average standardised slopes for each pair of species, using Student's 't' test, yielded only two significant results: Knot were more mobile than dunlin (Figs 16 & 27: 't' = 3.63; df = 77; P < 0.001) or sanderling (Figs 16 & 26: 't' = 6.3; df = 53; P < 0.001). Knot tended to be more mobile than oystercatcher (Figs 8 & 16: 't' = 1.85; df = 75; P = NS, but significance level at P = 0.05 is 't' = 1.99).

Several factors affect all five wader species studied in detail, both adults and juveniles, and provide some explanations for the differing degrees of movement; spring tides, seasonal changes in food abundance and availability, and changes in bird numbers.

Spring tides

The highest of each fortnightly series of high tides flood the saltmarsh, forcing waders to move their roosts from the edge of the saltmarsh to isolated coastal sandspits, e.g. Gibraltar Point, or to fields just inland of sea walls.

During the early 1970s, Thornham was considered to be the main roost used during spring tides on the east Wash, particularly in winter (Berry 1971). Snettisham Pits have provided an additional spring tide roost of increasing importance since they received protection and were "improved" by the Royal Society for the Protection of Birds (RSPB) in the early 1970s - Prater (1975) comments on the "recent" tendency to roost on the Pits. Flights to Thornham are now a feature, principally, of autumn evenings and then of variable magnitude owing to a preference for Snettisham Pits. This apparent preference may be due to the shorter distance from the main feeding areas to a 'safe' roost on the Pits, compared with flying to Thornham. Whilst oystercatcher and knot are the main species making these flights, other species do so too occasionally. Counts and dye-marking results for dunlin (Appendix V) and turnstone (Table 28) indicate this.

On the west Wash during high spring tides, birds flew to roost at Gibraltar Point as well as on coastal fields. Many sightings of knot and oystercatcher, colour-marked on field catches were made at Gibraltar Point during subsequent spring tides (Figs 7 & 15). Although some of these movements of dyed birds may have resulted from the disturbance caused by cannon-netting, they probably indicate genuine changes in roosting behaviour which take place for other reasons. Disturbances from field roosts by farming operations or by raptors and skuas (pers. obs.) certainly occur; leading to a change of field roost site or flight to Gibraltar Point for the remainder of high water. Raptor disturbance is well documented elsewhere (e.g. Page & Whitacre 1975; Kus et al 1984; Whitfield 1985).

Roost sites normally used during spring tides are relatively safe from tidal inundation, although exceptionally high tides may force birds to leave or remain airborne (this study; Berry 1971). A sheltered location with good all-round visibility are likely to be important features of a roost site. Knot, particularly, have been seen to change their roost site within a single high water period (this study) and to cross between east and west shores within a single spring tide series (this study). Their mobility cannot be explained in terms of tides alone, however, but disturbance may be a contributory factor.

Feeding

The Wash Water Storage Feasibility Study of the early 1970s included detailed studies of waders (Goss-Custard et al 1975), concerning their feeding distribution and diet (Goss-Custard et al 1977a), time spent roosting and intensity of feeding (Goss-Custard et al 1977b), and density-related behaviour on the feeding grounds (Goss-Custard 1977). There was also sampling of distribution of macroinvertebrates (Corlett & Salkeld 1975).

These studies showed feeding distributions of knot, dunlin and oystercatcher coincided with areas of highest density of their preferred prey, namely Macoma, Hydrobia and Nereis, and Cerastoderma (cockles) respectively. Rands and Barkham (1981) showed feeding densities of oystercatchers at the Wash were highly correlated with density of second-year cockles and feeding density of dunlin correlated with densities of Hydrobia on muddy substrates and Nereis on sandy substrates. The main areas of Macoma were fairly localised (Corlett & Salkeld 1975) which may explain why knot tend to remain in large concentrations, but then have to move to locate alternative food resources when one food patch is depleted.

In autumn, waders were able to obtain their food requirements in relatively few hours. Knot, particularly, were observed roosting for up to 5 hours on either side of high water during spring tides in autumn at Friskney, before flying to distant low water feeding grounds on the Friskney and Wrangle Flats. It seems unlikely that these were the only suitable feeding areas on the west Wash and that the birds were not obtaining enough food as this would not provide a sound strategy for survival. Sampling indicated other suitable feeding areas (Corlett & Salkeld 1975) which were used later in the autumn (Goss-Custard et al 1977a). Thus it must be supposed that the birds were able to find enough food each day in the two 2½ hour periods of feeding.

As winter progressed, all wader species were seen to feed over more of the upper shore intertidal areas, spreading along the tide edge to feed as the flood tide reduced the band of mud exposed. This in turn led to formation of new, and increased use of existing, roosts along the adjacent shoreline. Dunlin often roosted in small groups along the saltings edge close to where they had been forced to stop feeding, and resumed feeding once the mud started to uncover. Thus small roosts developed away from the main concentrations, as diurnal feeding time increased.

Sanderling moved along the shore of the east Wash from Snettisham towards Holme, Thornham and Titchwell and back as they fed during the flood and ebb tides. Whilst the extent of movement by individuals appeared to be varied, c.f. numbers roosting at several sites which showed daily fluctuations, sanderling exhibited greater mobility between feeding patches than was the case for oystercatcher, dunlin or turnstone.

The Wash Feasibility Study indicated that increased diurnal feeding times, most noticeable in knot and dunlin in winter were related to difficulties in obtaining food requirements (Goss-Custard et al 1977b). It seems likely, therefore, that increased diurnal feeding time and associated use of upper-shore feeding areas, which were little used or unused in autumn, during flood and ebb tides, are responses to reduced availability and densities of prey.

In contrast, sanderling feed most actively during flood and ebb tide throughout the non-breeding season because their preferred prey items become active when the tide reaches or covers them. Movement of birds alongshore whilst feeding may be to overcome disturbance of free-swimming prey in one patch by the actions of other birds. Sanderling feeding will be considered further in Part 2.

The varied responses to changing feeding conditions from autumn to winter reflect species differences in the impact of these changes on their ability to balance energy requirements and the methods employed to do so.

Bird numbers

In feeding for longer and so occupying an ever-decreasing band of mud as the tide rises during winter days, waders are subjected to higher feeding densities unless they spread linearly along the tide edge. This aspect of shorebird ecology is the subject of a current study by John Goss- Custard and his co-workers (M. Yates pers. comm.) and includes the use of exclusion cages to assess the impact of wader predation on invertebrate numbers and densities (C. Kelly pers. comm.) at the Wash. In the study with which this report is concerned, oystercatchers were seen to spread out, probably to combat the increased bird density.

Numbers of knot (Table 6) and possibly of dunlin (Table 14, but see comments too) are highest at the Wash in winter and so these species may be expected to exhibit evasive responses to increased bird density on preferred feeding areas. Dunlin are widespread and no density-related feeding behaviour was recognised. Goss-Custard et al (1977) found sequential occupation of feeding areas as feeding densities increased due to the arrival of more birds to the estuary. Knot started to feed on Breast Sand (Fig 13) from November onwards and oystercatchers spread to Daseley and Seal Sands (Fig 6) after July. I found more knot roosting at Terrington from midwinter onwards, presumably due to the arrival of birds to feed on Breast Sand for which Terrington provides an adjacent roost.

Age differences in movement

Where comparisons were possible, no difference was detected in the extent of movement by adults and juveniles of any wader species. Dunlin tend to be more mobile in late autumn, after completion of moult by adults, but there was no noticeable difference between the behaviour of adults and juveniles, even though it might be expected that adults should be less mobile than juveniles whilst in primary moult.

It has also been suggested (Baker 1980) that juvenile birds make exploratory flights to acquaint themselves with conditions on various possible wintering grounds, and so may be more mobile than adults. As inexperienced birds, juveniles may be more vulnerable to reduced food availability as a result of cold weather, or increased bird density, and so be more likely to move in search of better feeding opportunities.

The apparent similarity of mobility exhibited by adults and juveniles has also been identified for dunlin on the south shore of the Severn Estuary by Clark (1983).

Comparison with other studies

Comparison was made with the study of wader movements within the Firth of Forth (Symonds et al 1984; Pienkowski & Clark 1979). This study found that turnstone and oystercatcher tended to be sedentary, whilst dunlin were more mobile and knot ranged widely throughout the estuary.

Oystercatchers at the Wash seem to be rather more mobile than on the Forth, although most movement at the Wash was associated with flights to spring tide roosts. Any changes in roosts associated with changes in feeding area were localised. The distances involved in local movements at the Wash probably compare with those distances considered to represent movement at the Firth of Forth. In consequence, the apparent difference in oystercatcher mobility between the Wash and the Forth may not be a real one.

My study and that of Clark (1983) on the southern shore of the Severn Estuary considered dunlin to be principally sedentary with most movements being very local in winter. A high proportion of dunlin on the Forth were sedentary and some movement was attributed to a lack of suitable roosts forcing birds to fly to other sites. However, changes of feeding area were identified too. Thus there seems to be a real difference in degree of mobility of dunlin at the Wash and on the Forth. It is uncertain why this should be the case.

Studies at the Wash (this study; Minton 1975) and at the Forth (Symonds et al 1984) are in accord concerning the sedentary nature of turnstone and the highly mobile tendency of knot.

# CONCLUSIONS

Dye-marking, and recaptures in one season, of several wader species at the Wash show variations in the extent of movements. The order of decreasing mobility within the Wash is knot, oystercatcher, sanderling, dunlin and turnstone.

Knot are highly mobile within the estuary in all seasons. Oystercatcher are mobile within the estuary in autumn. In winter, there is localised movement along the east shore as birds feed for a greater part of the tidal cycle during spring tides. Sanderling occur predominantly on the east Wash, along which there is a spring tide feeding movement on the flood and ebb tide edge. Dunlin and turnstone are, generally, very localised in their movements between feeding and roosting areas. There is no evidence to suggest changes in feeding area for these 2 species.

No age differences were detected in the degree of mobility displayed by a species.

Three underlying reasons are suggested for most mobility observed:-

1) In winter, birds attempt to maximise their diurnal feeding time with minimum interference from other waders by spreading along the spring tide edge to feed on flood and ebb tides, e.g. oystercatcher.
2) Flights are made to spring tide high water roosts where the birds feel 'safe', e.g. knot.
3) Exploratory flights may be made to locate unpredictable food resources, e.g. knot.

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APPENDIX I  Wash wader colour-marking 1982/83 and 1983/84

| Species | Date | Place | Total caught | Colour-marked Adult | 1st Year | Total |
|---|---|---|---|---|---|---|
| Oystercatcher | 19.08.82 | Terrington | 3 | 3 | 0 | 3 |
| | 20.08.82 | Wrangle | 735 | 105 | 4 | 109 |
| | 17.09.82 | Thornham | 182 | 73 | 0 | 73 |
| | 05.12.82 | Heacham | 83 | 41 | 42 | 83 |
| | 26.02.83 | Heacham | 239 | 33 | 28 | 61 |
| | 27.02.83 | Heacham | 2 | 2 | 0 | 2 |
| | | | 1244 | | | 331 |
| Grey Plover | 22.08.82 | Wainfleet | 24 | 24 | 0 | 24 |
| | 19.09.82 | Terrington | 34 | 22 | 0 | 22 |
| | 20.09.82 | Terrington | 2 | 2 | 0 | 2 |
| | 16.10.82 | Wolferton | 7 | 7 | 0 | 7 |
| | 02.01.83 | Heacham | 10 | 9 | 1 | 10 |
| | 27.02.83 | Heacham | 1 | 0 | 1 | 1 |
| | 09.09.83 | Friskney | 176 | 112 | | 112 |
| | 19.02.84 | Heacham | 89 | 87 | | 87 |
| | | | 343 | | | 265 |
| Knot | 21.08.82 | Heacham | 163 | 163 | 0 | 163 |
| | 22.08.82 | Wainfleet | 595 | 174 | 5 | 179 |
| | 22.08.82 | Terrington | 2 | 1 | 1 | 2 |
| | 19.09.82 | Terrington | 52 | 0 | 47 | 47 |
| | 02.01.83 | Heacham | 2 | 1 | 1 | 2 |
| | 27.02.83 | Heacham | 1 | 1 | 0 | 1 |
| | 09.09.83 | Friskney | 87 | 5 | 82 | 87 |
| | 10.09.83 | Wainfleet | 678 | 283 | 29 | 312 |
| | | | 1580 | | | 793 |
| Dunlin | 19.08.82 | Terrington | 17 | 13 | 4 | 17 |
| | 21.08.82 | Heacham | 43 | 43 | 0 | 43 |
| | 21.08.82 | Leverton | 155 | 133 | 10 | 143 |
| | 22.08.82 | Terrington | 353 | 339 | 14 | 353 |
| | 23.08.82 | Leverton | 7 | 7 | 0 | 7 |
| | 19.09.82 | Terrington | 1327 | 211 | 17 | 228 |
| | 16.10.82 | Wolferton | 47 | 18 | 29 | 47 |
| | 02.01.83 | Heacham | 730 | 319 | 32 | 351 |
| | | | 2679 | | | 1189 |
| Sanderling | 17.10.82 | Thornham | 3 | 3 | 0 | 3 |
| | 06.11.83 | Heacham | 40 | 37 | 1 | 38 |
| | | | 43 | | | 41 |

APPENDIX I (continued)

| Species | Date | Place | Total caught | Colour-marked Adult | 1st Year | Total |
|---|---|---|---|---|---|---|
| Bar-tailed Godwit | 20.08.82 | Heacham | 54 | 54 | 0 | 54 |
| | 21.08.82 | Heacham | 129 | 129 | 0 | 129 |
| | 20.09.82 | Terrington | 1 | 0 | 1 | 1 |
| | 08.09.83 | Wrangle | 105 | 45 | | 45 |
| | | | 289 | | | 229 |
| Curlew | 20.08.82 | Heacham | 4 | 4 | 0 | 4 |
| | 21.08.82 | Heacham | 15 | 15 | 0 | 15 |
| | 20.09.82 | Terrington | 66 | 62 | 0 | 62 |
| | | | 85 | | | 81 |
| Redshank | 19.08.82 | Terrington | 4 | 4 | 0 | 4 |
| | 21.08.82 | Heacham | 1 | 1 | 0 | 1 |
| | 21.08.82 | Leverton | 37 | 23 | 8 | 31 |
| | 22.08.82 | Terrington | 86 | 69 | 17 | 86 |
| | 19.09.82 | Terrington | 1 | 1 | 0 | 1 |
| | 20.09.82 | Terrington | 6 | 5 | 1 | 6 |
| | 16.10.82 | Wolferton | 1 | 1 | 0 | 1 |
| | 26.02.83 | Heacham | 1 | 1 | 0 | 1 |
| | 27.02.83 | Heacham | 1 | 1 | 0 | 1 |
| | | | 138 | | | 132 |
| Turnstone | 19.08.82 | Terrington | 19 | 10 | 9 | 19 |
| | 21.08.82 | Heacham | 3 | 3 | 0 | 3 |
| | 21.08.82 | Leverton | 8 | 7 | 0 | 7 |
| | 22.08.82 | Terrington | 11 | 11 | 0 | 11 |
| | 19.09.82 | Terrington | 6 | 5 | 1 | 6 |
| | 20.09.82 | Terrington | 2 | 1 | 1 | 2 |
| | 01.01.83 | Heacham | 4 | 4 | 0 | 4 |
| | 26.02.83 | Heacham | 1 | 1 | 0 | 1 |
| | 27.02.83 | Heacham | 13 | 10 | 0 | 10 |
| | | | 67 | | | 63 |

APPENDIX II Wash observer network site checks for colour-marked waders 1982/83 and 1983/84

| SITES + CO-ORDINATES | DATES VISITED | OBSERVER* |
|---|---|---|
| Blakeney 52°58'N 01°02'E | Jul 25, Aug 22, Oct 17, Nov 14, Jan 16 1982/83<br>Nov 20, Dec 18, Feb 19 1983/84 | MAS |
| Morston 52°58'N 00°58'E | Nov 14, Dec 19, Jan 16, 1982/83<br>Nov 20, Dec 18, Feb 19 1983/84 | MAS |
| Burnham Overy 52°59'N 00°45'E | Oct 9, Dec 5, 1982/83<br>Feb 19 1984 | MAS |
| Brancaster 52°58'N 00°40'E | Nov 10, 18, 22, 23, 24, 25 & 30; Dec 6 & 13 1983 | REK |
| Holme 52°59'N 00°33'E | Aug 22, Sept 19, Mar 20 1982/83 | JN |
| | Oct 8 & Nov 27 1983 | BB |
| Holme to Hunstanton 52°58'N 00°32'E to 52°57'N 00°30'E | Nov 24, 25 & 27<br>Dec 6, 7, 9, 11, 13, 14, 15, 16, 24, 25, 29 & 31<br>Jan 1, 3, 10, 12, 21, 26, 28, 30 & 31<br>Feb 3, 8, 10, 11, 14, 15, 18, 20 & 28<br>Mar 6 & 11 1983/84 | HR |
| Hunstanton to Heacham 52°58'N 00°30'E to 52°53'N 00°28'E | Nov 12 & 15, Dec 9 & 27, Jan 1 & 11 1983/84 | IJS |
| Snettisham 52°51'N 00°27'E | Oct 22 & 29, Nov 5, 12 & 19, Dec 12, Jan 7 & 22 1982/83 | MK |
| Holbeach 52°54'N 00°06'E | Jan 2, 17 & 31, Feb 28 1983<br>Sept 11 & 25, Oct 9, Dec 22, Jan 21, Feb 19, Mar 18 1983/84 | R & K H |
| | Oct 9 & 22, Nov 6 & 23 1983 | PT |
| Witham Mouth to Butterwick 52°56'N 00°05'E to 52°59'N 00°06'E | Sept 4, 5, 6 & 19, Oct 2, 6, 7, 8 & 19, Nov 4, 7, 13 & 20, Jan 1, 18 & 30, Feb 15, 19 & 27, Mar 1 & 19, Apr 1 1982/83<br>Sept 10 & 24, Oct 8 & 25, Nov 8, Jan 7 & 8, Feb 4, 5 & 18, Mar 3, 4 & 19 1983/84 | R & K H |
| | Jul 25, Aug 8, 21 & 22, Sept 5 & 19, Oct 3, 10 30 & 31, Nov 6 & 13, Dec 4 & 5, Jan 1, 15, 16 & 30, Feb 12 & 13 1982/83 | SK |

Appendix II continued

| SITES + CO-ORDINATES | DATES VISITED | OBSERVER* |
|---|---|---|
| Witham Mouth to Butterwick | Nov 6 & 20, Dec 26 & 28 1983 | SK |
| Gibraltar Point 53°06'N 00°20'E | Aug 20, 21, 22, 23, 24, 26 & 27, Sept 19 1982** | RL |

* See Appendix III for identification of observers.
**Completed site check forms received for these dates only, but counts consulted for July to November 1982 & 1983.

APPENDIX III Observers of Wash colour-marked waders 1982/83 and 1983/84

J. Andrils
T. J. Barker
W. Boyd (BB)
I. and K. Burroughs
A. J. Clarke
T. Clifford
M. R. Coates
S. Cochrane
D. Cohen
R. Cripps
M. Duggan
S. Foster
A. Goodall
P. R. Gotham
A. Grieve
M. Harris
E. Harrison
S. J. Hayhow
R. and K. Heath (R & K H)
A. H. and A. Izzard
Javelin Press
S. Keightley (SK)
M. Kelsey (MK)
R. Kimber (REK)
P. Kiy
R. Lambert (RL)
R. A. Langston
J. Metcalf
R. A. Morgan
P. Newbery
J. Newton (JN)
B. O'Mahoney
A. Parker
T. Piersma
H. Ramsey (HR)
G. R. Robinson
R. A. F. Wyton O. S.
B. Rumsey
P. A. Rutter
N. Sills
I. J. Simper (IJS)
B. Spence
M. A. Spriggs (MAS)
F. Symonds
P. Todd (PT)
Wash Wader Ringing Group
P. N. Watts
P. G. Welberry-Smith
P. A. Whittington
A. G. Wood

Observers whose initials follow in parentheses feature in Appendix II and checked sites regularly.

APPENDIX IV Fieldwork dates and locations at the Wash 1982/83 and 1983/84 for RHWC (Rowena Cooper)

| SITE + CO-ORDINATES | DATES VISITED | | | COMMENTS |
|---|---|---|---|---|
| Thornham | Sept | 6 & 17 | ) | |
| 52°58'N 00°35'E | Oct | 2, 15 & 17 | ) | |
| | Nov | 1 | ) | |
| | Dec | 2 | )1982/83 | |
| | Jan | 3 & 31 | ) | |
| | Mar | 15 | ) | |
| | Apr | 5 | ) | |
| | Oct | 10 | ) | |
| | Nov | 8 | )1983 | |
| | Dec | 23 | ) | |
| Holme | Oct | 2 | ) | |
| 52°58'N 00°32'E | Dec | 2 | )1982/83 | |
| | Mar | 15 | ) | |
| | Nov | 8 | ) | |
| | Mar | 17 | )1983/84 | |
| Hunstanton | Mar | 15 | 1983 | |
| 52°57'N 00°30'E | | | | |
| Heacham | Aug | 19 | ) | |
| 52°53'N 00°28'E | Sept | 18 | ) | |
| | Oct | 19 & 31 | ) | |
| | Dec | 1, 3, 4, 5 & 6 | ) | |
| | Jan | 1, 2, 4, 5 & 29 | )1982/83 | |
| | Feb | 28 | ) | |
| | Mar | 15 & 16 | ) | |
| | Apr | 3 & 17 | ) | |
| | Nov | 7 | 1983 | |
| Snettisham | Sept | 5 | ) | |
| 52°51'N 00°27'E | Oct | 3, 4, 18 & 31 | ) | |
| | Nov | 1, 2 & 3 | ) | fog 3 |
| | Dec | 3, 5 & 6 | )1982/83 | |
| | Jan | 4, 5, 29 & 31 | ) | |
| | Mar | 1 & 16 | ) | |
| | Apr | 3 | ) | |
| | Oct | 10 | ) | |
| | Nov | 7 | )1983 | |
| | Dec | 21 & 23 | ) | |
| Wolferton | Sept | 5 | ) | mist |
| 52°50'N 00°26'E | Oct | 3 & 17 | )1982 | |
| | Oct | 11 | ) | |
| | Nov | 8 | )1983 | |

Appendix IV continued

| SITE + CO-ORDINATES | DATES VISITED | | | COMMENTS |
|---|---|---|---|---|
| Terrington | Aug | 24 | 1982/83 | heavy rain |
| 52°50'N 00°14'E | Sept | 4, 6, 7, 18 & 19 | | thick fog 18 |
| | Oct | 4 & 5 | | rain 4 & 5 |
| | Nov | 3 & 4 | | fog 3 & 4 |
| | Dec | 1 | | |
| | Jan | 30 | | snow/sleet |
| | Feb | 1 | | gales |
| | Mar | 2 & 17 | | |
| | Oct | 8 & 9 | 1983 | |
| | Nov | 5 | | fog |
| | Dec | 22 | | |
| Benington | Aug | 19, 21 & 23 | 1982/83 | |
| 52°59'N 00°08'E | Sept | 10 | | |
| and Leverton | Nov | 6 | | |
| 53°00'N 00°09'E | Feb | 3 | | |
| | Mar | 19 | | |
| | Sept | 6, 7 & 11 | 1983 | |
| | Oct | 6 | | |
| Wrangle | Aug | 19, 20 & 23 | 1982/83 | |
| 53°01'N 00°10'E | Sept | 8 & 9 | | |
| Sailor's Home | Oct | 5, 6 & 7 | | |
| | Nov | 5 | | |
| | Dec | 31 | | |
| | Feb | 2 & 3 | | |
| | Mar | 3, 18 & 19 | | |
| | Sept | 6, 7 & 8 | 1983 | |
| Friskney | Sept | 8 | 1982 | |
| 53°02'N 00°14'E | | | | |
| | Sept | 7 & 9 | 1983 | |
| | Dec | 20 | | |
| Wainfleet | Aug | 21 & 22 | 1982 | |
| 53°05'N 00°18'E | | | | |
| | Sept | 6, 7 & 10 | 1983 | |
| | Oct | 7 | | |
| | Dec | 20 | | |

APPENDIX V Details of results from colour-marking 1982/83 and 1983/84 for oystercatcher, knot, sanderling and dunlin (counts and numbers checked for dye are included) at the Wash.

1) OYSTERCATCHER 1982/83

catch - Wrangle 20.08.82

| Date | Location | count | No. checked | No. dye | Observer |
|---|---|---|---|---|---|
| 20.08 | Gibraltar Point | 5 130 | 5 130 | 11 | RI |
| 21.08 | " | 2 400 | 2 400 | 8 | " |
| 22.08 | " | 5 000 | 3 000 | 63 | " |
| 23.08 | " | 1 500 | 1 500 | 13 | " |
| 23.08 | Wrangle | 1 000 | 1 000 | 1 | RHWC |
| 24.08 | Gibraltar Point | 100 | 100 | 4 | RL |
| 27.08 | " | 240 | 240 | 6 | " |
| 05.09 | Snettisham | 15 000 | 8 000 | 1 | RHWC |
| 09.09 | Wrangle | 2 500 | 2 000 | 10 | " |
| 10.09 | Leverton | 2 000 | 1 500 | 2 | " |
| 19.09 | Titchwell | 650 | 185 | 2 | N. Sills |
| 19.09 | Holme | 880 | 880 | 8 | JN |
| 19.09 | Gibraltar Point | 25 000 | 1 000 | 3 | RL |

catch - Thornham 17.09.82

| Date | Location | count | No. checked | No. dye | Observer |
|---|---|---|---|---|---|
| 24.09 | Holme | - | - | 1 | A. J. Clarke |
| 02.10 | " | 280 | 270 | 2 | RHWC |
| 03.10 | Snettisham | 11 500 | 3 800 | 4 | " |
| 04.10 | " | 7 500 | 3 000 | 15 | " |
| 09.10 | Terrington | 225 | 225 | 1 | P. R. Gotham |
| 18.10 | Snettisham | 11 000 | 3 000 | 9 | RHWC |
| 02.11 | " | 10 500 | 5 000 | 14 | " |
| 05.12 | Heacham | 200 | 100 | 1 | " |
| 06.12 | " | 1 600 | 850 | 1 | " |
| 06.12 | Snettisham | 9 000 | 4 000 | 5 | " |

catch - Heacham 05.12.82

| Date | Location | count | No. checked | No. dye | Observer |
|---|---|---|---|---|---|
| 06.12 | Heacham | 1 600 | 850 | 7 | RHWC |
| 06.12 | Snettisham | 9 000 | 4 000 | 37 incl. 4ad & 3j | " |
| 28.12 | Wolferton | 500 | 500 | 2 | J. Reynolds |
| 04.01 | Snettisham | 9 000 | 2 000 | 10 | RHWC |
| 05.01 | Heacham | 2 000 | 1 500 | 21 | " |
| 29.01 | Heacham | 450 | 200 | 16 | " |
| 31.01 | Snettisham | 5 000 | 3 000 | 5 | " |

catch - Heacham 26.02.83 or 27.02.83

| Date | Location | count | No. checked | No. dye | Observer |
|---|---|---|---|---|---|
| 28.02 | Snettisham | 1 300 | 1 300 | 8 incl. 2ad & 2j | P. R. Gotham |
| 28.02 | Heacham | 400 | 300 | 11 | RHWC |
| 01.03 | Snettisham | 6 000 | 3 000 | 15 incl 2j | " |
| 02.03 | Terrington | 270 | 270 | 1 | " |
| 12.03 | Hunstanton | - | - | 1 | P. Newbery |

Appendix V continued

| Date | Location | Count | No. checked | No. dye | Observer |
|---|---|---|---|---|---|
| 1) | Oystercatcher catch - Heacham 26.02.83 or 27.02.83 | | | | |
| 15.03 | Holme | 80 | 80 | 2 | RHWC |
| 15.03 | Heacham | - | 800 | 7 incl 1ad & 2j | " |
| 16.03 | Snettisham | 4 500 | 1 500 | 14 incl 2ad & 1j | " |
| 16.03 | Heacham | 400 | 400 | 20 incl 2ad & 2j | " |
| 20.03 | Holme | 4 | 4 | 1 | JN |
| 03.04 | Snettisham | 1 500 | 1 200 | 6 incl 2ad & 4j | RHWC |
| 01.05 | " | 220 | 220 | 7 incl 1ad | P. R. Gotham |
| 2) | KNOT a) 1982/83 catch Heacham 21.08.82 | | | | |
| 22.08 | Holme | - | - | 1ad | JN |
| | catch Wainfleet 22.08.82 | | | | |
| 23.08 | Gibraltar Point | 9 000 | 9 000 | 5 | RL |
| 24.08 | " | 1 000 | 1 000 | 7 | " |
| 26.08 | " | 5 000 | 5 000 | 8 | " |
| | catch Terrington 19.09.82 (or possibly 22.08.82) | | | | |
| 24.09 | Snettisham | - | - | 1j | P. R. Gotham |
| 02.10 | Holme | 900 | 600 | 1j | RHWC |
| 03.10 | Snettisham | 176 | 176 | 1j | " |
| 08.10 | Holme | 1 500 | 1 000 | 1 | S. J. Hayhow |
| | catch - Heacham 02.01.83 | | | | |
| 29.01 | Heacham | 8 | 0 | 1j | RHWC |
| | b) 1983/84 catch - Friskney 09.09.83 or Wainfleet 10.09.83 | | | | |
| 12.09 | Snettisham | - | - | 4ad | A.H. & A. Izzard |
| 08.10 | Titchwell | 20 000 | 2 000 | 2ad | P.L. Ireland WWRG |
| 08.10 | Holme | 2 000 | 2 000 | 3ad & 3j | BB |
| 10.10 | Wolferton | - | - | 1 | BB |
| 11.10 | Wolferton | 30 000 | 10 000 | 1ad | RHWC |

Appendix V continued

3) SANDERLING 1983/84
catch - Heacham 06.11.83

| Date | Location | Count | No. checked | No. dye* | Observer |
|---|---|---|---|---|---|
| 07.11 | Snettisham | 141 | 141 | 24 | RHWC |
| 07.11 | Heacham | 1 | 1 | 1 | " |
| 08.11 | Titchwell | 27 | 27 | 1 | " |
| 12.11 | Heacham | 25 | 25 | 5 | IJS |
| 15.11 | Hunstanton | 37 | 37 | 2 | " |
| 24.11 | Hunstanton-Holme | 72 | 72 | 3 | HR |
| 25.11 | " | 76 | 76 | 4 | " |
| 27.11 | " | - | - | 1 | " |
| 27.11 | Holme | 101 | 101 | 5 | BB |
| 06.12 | Hunstanton-Holme | - | - | 3 | HR |
| 07.12 | " | 36 | 36 | 1 | " |
| 09.12 | " | 28 | 28 | 2 | " |
| 09.12 | Heacham | 6 | 6 | 1 | IJS |
| 11.12 | Hunstanton-Holme | 47 | 47 | 4 | HR |
| 13.12 | " | 38 | 38 | 2 | " |
| 14.12 | " | 42 | 42 | 2 | " |
| 15.12 | " | 26 | 26 | 3 | " |
| 16.12 | " | 27 | 27 | 3 | " |
| 21.12 | Snettisham | 78 | 78 | 12 | RHWC |
| 21.12 | Heacham | 6 | 6 | 2 | " |
| 25.12 | Hunstanton | 4 | 4 | 1 | IJS |
| 27.12 | Heacham | 4 | 4 | 1 | IJS |
| 29.12 | Snettisham | - | - | 1 | B. Rumsey |
| 29.12 | Hunstanton-Holme | 80 | 80 | 5 | HR |
| 31.12 | " | 42 | 42 | 3 | " |
| 31.12 | Snettisham | 40 | 40 | 8 | M. Harris |
| 01.01 | Hunstanton | 50 | 50 | 1 | R. A. Morgan |
| 03.01 | Hunstanton-Holme | 70 | 70 | 4 | HR |
| 10.01 | " | 56 | 56 | 5 | " |
| 11.01 | Hunstanton | 40 | 40 | 1 | IJS |
| 12.01 | Hunstanton-Holme | 24 | 24 | 2 | HR |
| 21.01 | " | 30 | 30 | 2 | " |
| 26.01 | " | 36 | 36 | 3 | " |
| 28.01 | " | 37 | 37 | 4 | HR |
| 30.01 | " | 28 | 28 | 3 | " |
| 31.01 | " | 21 | 21 | 1 | " |
| 03.02 | " | 23 | 23 | 3 | " |
| 05.02 | Hunstanton | 8 | 8 | 4 | A. Parker |
| 05.02 | Snettisham | - | - | 3 | P. Varney WWRG |
| 05.02 | Heacham | 20 | 20 | 2 | A. Parker |
| 08.02 | Hunstanton-Holme | 50 | 50 | 2 | HR |
| 10.02 | " | 28 | 28 | 3 | HR |
| 11.02 | " | 20 | 20 | 1 | " |
| 14.02 | " | 17 | 17 | 4 | " |
| 15.02 | " | 114 | 114 | 7 | " |
| 18.02 | " | 220 | 220 | 15 | " |
| 18.02 | Snettisham | - | - | 1 | P. Varney |
| 19.02 | " | 25 | 25 | 1 | RAF Wyton O.S. |
| 19.02 | Heacham | - | - | 1 | RAL |

Appendix V continued

3) Sanderling 1983/84
catch - Heacham 06.11.83

| Date | Location | Count | No. checked | No. dye* | Observer |
|---|---|---|---|---|---|
| 20.02 | Hunstanton-Holme | 70 | 70 | 7 | HR |
| 21.02 | Hunstanton | 28 | 28 | 3 | S. Foster |
| 25.02 | - | 45 | 45 | 7 | Javelin Press |
| 26.02 | - | 24 | 24 | 1 | G. R. Robinson |
| 28.02 | Hunstanton-Holme | 17 | 17 | 2 | HR |
| 29.02 | Hunstanton | - | - | 1 | R. Cripps |
| 06.03 | Hunstanton-Holme | 37 | 37 | 4 | HR |
| 11.03 | " | 57 | 57 | 4 | " |
| 17.03 | Holme | 200 | 200 | 6 | RHWC |
| 17.03 | Thornham | 14 | 14 | 2 | A. Parker |
| 17.03 | Holme | - | 100 | 12 | R. A. Morgan |
| 08.04 | Holme | - | - | 1 | D. Cohen |
| 14.04 | Heacham | 6 | 6 | 2 | A. Parker |

*all sightings of sanderling shown here represent sightings of adult birds.

4) Dunlin 1982/83
catch - Leverton 21.08.82

| | | | | | |
|---|---|---|---|---|---|
| 22.08 | Wainfleet | - | - | 1 | RHWC |
| 10.09 | Leverton | 2 000 | 300 | 1 | " |

catch - Terrington 22.08 82 (or possibly 19.08.82)

| | | | | | |
|---|---|---|---|---|---|
| 04.09 | Terrington | 4 000 | 500 | 1 | " |

catch - Terrington Aug/Sept

| | | | | | |
|---|---|---|---|---|---|
| 01.12 | Terrington | - | - | 1 | RHWC |

catch - Terrington 19.09.82

| | | | | | |
|---|---|---|---|---|---|
| 04.10 | Terrington | 500 | 500 | 2 | RHWC |

catch - Wolferton 16.10.82

| | | | | | |
|---|---|---|---|---|---|
| 29.10 | Snettisham | 29 | 29 | 1 | MK |
| 02.11 | " | 250 | 200 | 2 | RHWC |
| 05.11 | " | 375 | 375 | 1 | MK |

catch - Heacham 02.01.83

| | | | | | |
|---|---|---|---|---|---|
| 05.01 | Snettisham | 745 | 745 | 9 incl 1j | RHWC |
| 22.01 | " | 1 | 1 | 1 | MK |
| 30.01 | Terrington | 300 | 300 | 1 | RHWC |
| 31.01 | Thornham | 170 | 170 | 1 | " |
| 31.01 | Snettisham | 800 | 300 | 1 | " |
| 01.03 | " | 1 300 | 500 | 3 | " |
| 16.03 | " | 100 | 100 | 2 | " |

APPENDIX VI Catches at the Wash of adult dunlin in autumns 1975 and 1977 with details of recaptures (only catches of 10 or more birds are shown)

1975

| Catch | Date | Location | Total adults caught | No. of adults recaptured from previous catches A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 13.7 | Ter | 337 | - | - | - | - | - | - | - | - | - | - |
| B | 27.7 | Ter | 197 | - | - | - | - | - | - | - | - | - | - |
| C | 9.8 | Sne | 271 | - | - | - | - | - | - | - | - | - | - |
| D | 10.8 | Ter | 595 | 9 | 5 | - | - | - | - | - | - | - | - |
| E | 11.8 | Ter | 1586 | 15 | 20 | 1 | 20 | - | - | - | - | - | - |
| F | 5.9 | Sne | 278 | 1 | | 11 | 1 | 2 | - | - | - | - | - |
| G | 7.9 | Ter | 23 | - | - | - | - | 3 | - | - | - | - | - |
| H | 9.9 | Daw | 1912 | 1 | 1 | - | - | 2 | - | - | - | - | - |
| I | 10.9 | Fri | 79 | - | - | - | - | - | - | - | - | - | - |
| J | 11.9 | Sne | 11 | - | - | - | - | - | - | - | - | - | - |
| K | 4.10 | Wol | 22 | - | - | - | 1 | - | - | - | - | - | - |

Ter = Terrington; Sne = Snettisham; Daw = Dawsmere; Fri = Friskney
Fri = Friskney; Wol = Wolferton.

Data courtesy of the Wash Wader Ringing Group.

Appendix VI continued

1977

| Catch | Date | Location | Total adults caught | No. of adults recaptured from previous catches A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 31.7 | Fri | 736 | - | - | - | - | - | - | - | - | - | - | - | - |
| B | 1.8 | Fri | 52 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| C | 2.8 | Ben | 845 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| D | 3.8 | NW | 442 | - | - | - | - | - | - | - | - | - | - | - | - |
| E | 3.8 | Ter | 547 | - | - | - | - | - | - | - | - | - | - | - | - |
| F | 15.8 | Ben | 230 | 1 | 44 | - | - | - | - | - | - | - | - | - | - |
| G | 16.8 | Fri | 119 | 7 | 1 | - | - | - | - | - | - | - | - | - | - |
| H | 17.8 | Ter | 353 | - | - | - | 1 | 9 | - | - | - | - | - | - | - |
| I | 17.8 | Fri | 243 | 9 | 1 | - | - | - | - | - | - | - | - | - | - |
| J | 19.8 | Wol | 64 | - | - | - | - | - | - | - | - | - | - | - | - |
| K | 20.8 | Wol | 141 | - | - | - | 1 | - | - | - | 1 | - | - | - | - |
| L | 17.9 | Fri | 411 | 17 | - | - | - | - | - | - | - | 8 | - | - | - |
| M | 17.9 | Wol | 142 | - | - | - | 1 | - | - | - | - | - | - | - | - |

Fri = Friskney; Ben = Benington; NW = North Wootton;
Ter = Terrington; Wol = Wolferton.

Data courtesy of the Wash Wader Ringing Group.

# PART 2

# MIGRATIONS AND MOVEMENTS OF SANDERLINGS IN THE NON-BREEDING SEASON

# CHAPTER 2

# SANDERLING MOVEMENTS TO, THROUGH AND WITHIN NORTH-EAST ENGLAND

## INTRODUCTION

Neo-Darwinian evolutionary theory predicts that individuals of a species should be adapted to their environment in such ways that they maximise reproductive success in terms of contributing offspring to future generations (e.g. Horn, in Ch. 14 in Krebs & Davies 1978). In the arctic, the potential breeding season is short; in some years too short to permit nesting and rearing of young due to late snow melt (Green, Greenwood & Lloyd 1977,1978). Therefore, arctic breeding birds such as the sanderling need to ensure high adult survival during the long non-breeding season, if they are to have several attempts at breeding in successive years. Their survival is enhanced by migration to temperate and tropical regions which provide a choice of wintering area.

Increasingly, differences in behaviour amongst individuals within a single species are being recognised, particularly in migratory shorebirds during the non-breeding season. Studies of grey plovers at Teesside showed that during the winter some birds defended feeding territories for several months whilst others on the same mudflats fed non-territorially (Townshend, Dugan & Pienkowski 1984). Also, some grey plovers visited Teesside only in some years, when severe weather affected the Wadden Sea area where they wintered in most years. Townshend (1985) showed that patterns of behaviour were established by juveniles in their first autumn of life and were maintained thereafter.

Studies of sanderlings at Teesside (Brearey 1982) also involved colour-ringed individuals, whose foraging behaviour was qualified. Brearey found that some individuals were seen less often than expected in his main study area. Reports of a few of these colour-ringed birds from St. Mary's Island, approximately 50 km north of the River Tees, by amateur ornithologists, led to the suggestion that some individual sanderlings are mobile during the non-breeding season whereas others are not (Evans 1981).

Thus the sanderling appeared to be a suitable study species for further investigation of migration strategies; Teesside sanderlings particularly so because of the availability of a sample of individually colour-ringed birds.

If a species contains individuals which are mobile and others which are site faithful, loss of a particular wintering habitat could be less serious than for a species in which all individuals are site faithful.

The use of Teesside by sanderlings: the national context

Winter counts for the Birds of Estuaries Enquiry (BoEE) rank Teesside as the third most important site for sanderlings in Britain, after the Ribble estuary and the Uists (Prater 1981), in terms of maximum numbers present at any one time. During the Winter Shorebird Count of 1984/85, over 2 000 sanderlings were found on the Uists (Moser & Summers 1987) whilst in other winters the Ribble has held up to 2 000 (Prater 1981; Salmon 1981; Salmon 1982). At Teesside, the peak winter count usually exceeds 800, but over 1 000 were present in November 1978 (Davidson 1980).

Along the east coast of England, sanderlings are found,

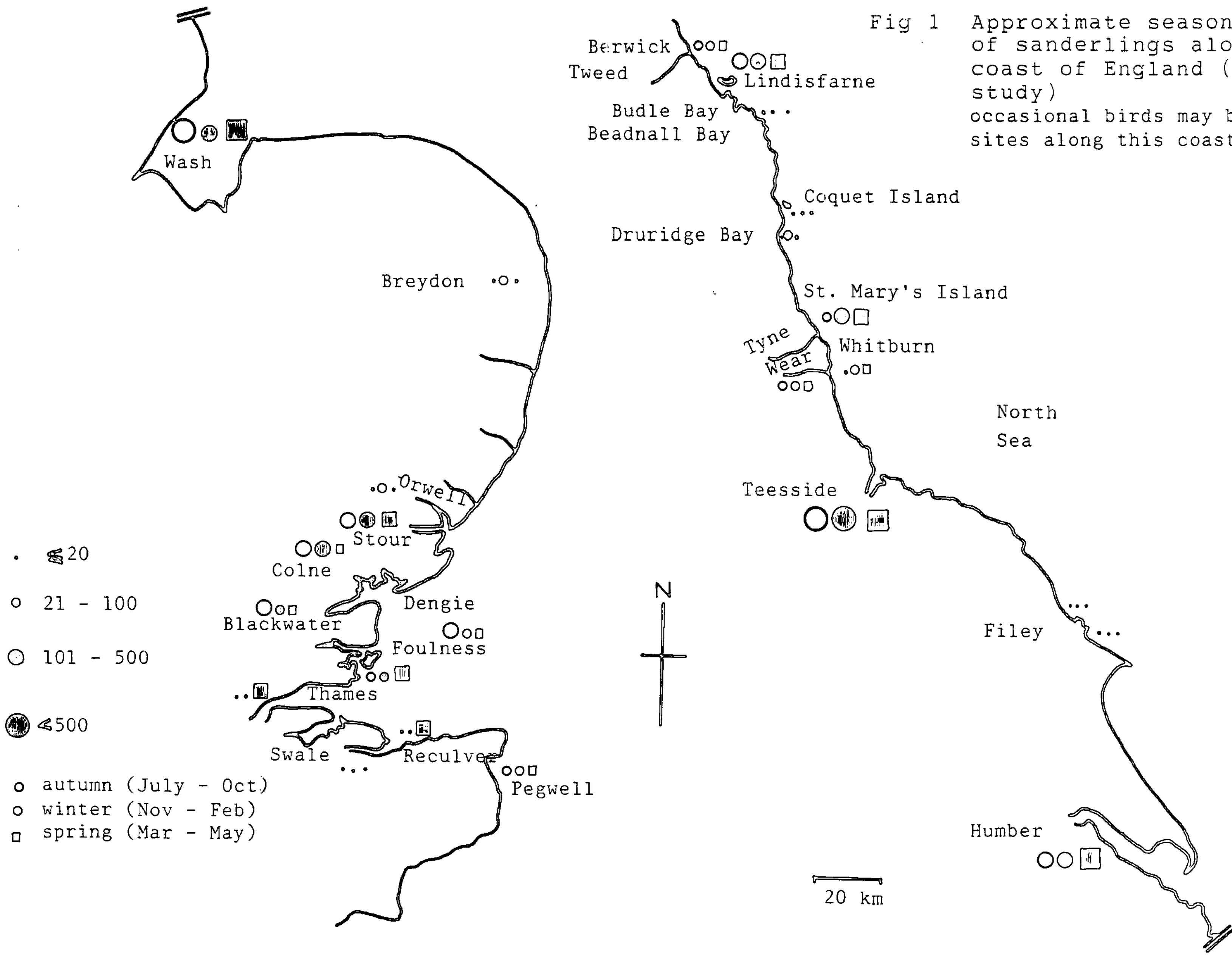



Fig 1 Approximate seasonal distribution of sanderlings along the east coast of England (BoEE and this study)
occasional birds may be seen at other sites along this coast

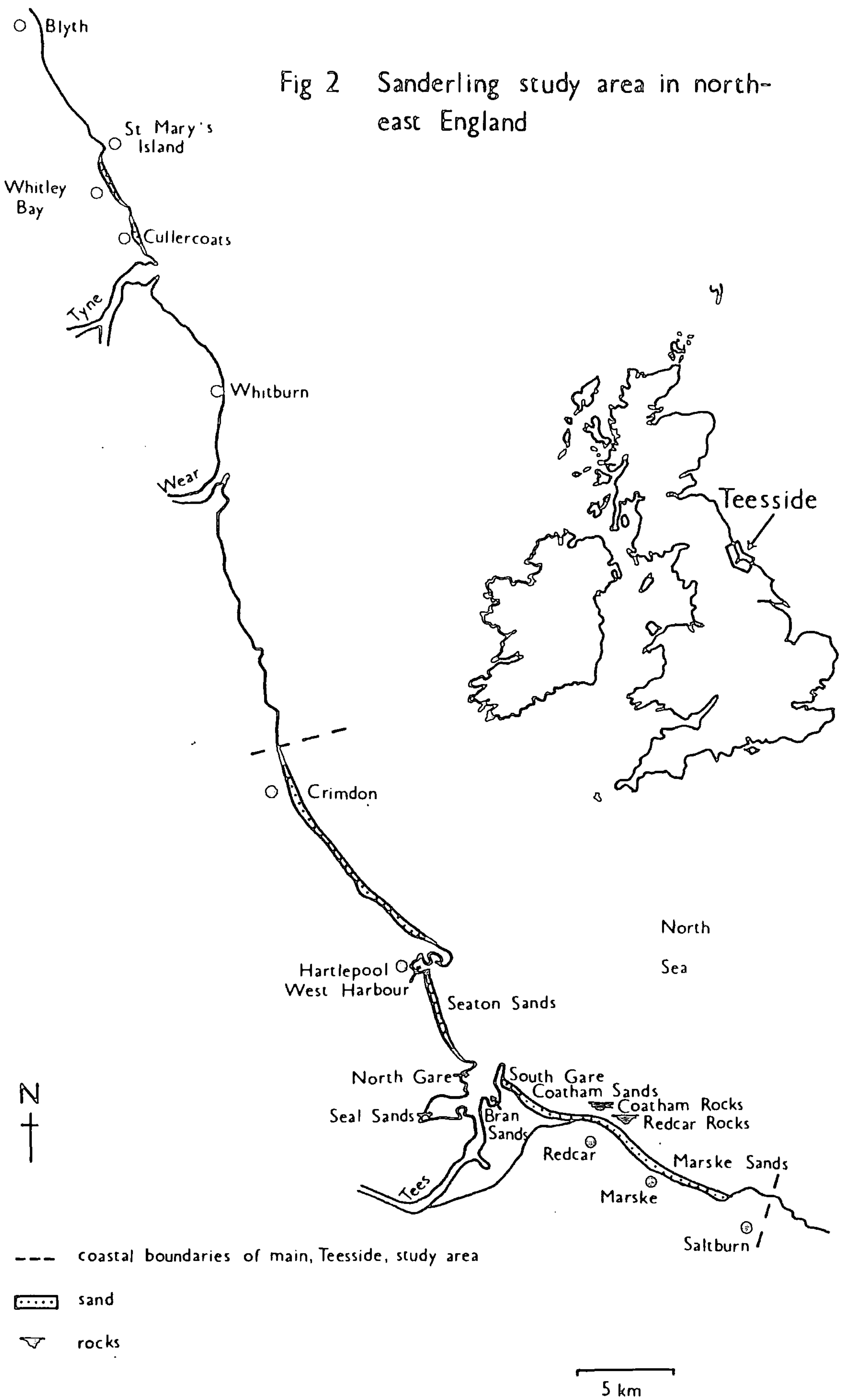



Fig 2 Sanderling study area in north-east England

chiefly, at the Wash, the Humber and Teesside; few other sites have more than 100 in winter and very few winter north of the River Tweed (Fig 1). Teesside is a relatively discrete area for sanderlings since there are few suitable beaches immediately to the north or south.

During passage periods, estuaries in north-west England, notably Morecambe Bay, have large numbers of sanderlings in spring, whilst in autumn east coast estuaries, notably the Wash, hold the main moulting and refuelling concentrations of sanderlings (Prater 1981).

Location and habitats

The main study area covered the coastline from Crimdon to Saltburn inclusive (Fig 2), although a longer stretch of coast, from Lindisfarne in the north to Filey in the south was checked in winter (Fig 1). Sanderlings occurred mainly on sandy beaches, but roosts were located on rocky shores too, notably at St. Mary's Island and Whitburn (Fig 2).

Along the northeast coast of England, sediment particle size varies considerably from fine sand through to coarse pebbles. At Saltburn, spring tides may cause major upheavals of the shingle to form ridges which are used by sanderlings for their main nocturnal winter roost. The changing topography of this site occasionally leads to the roost being illuminated by street lamps, unsettling the sanderlings.

Towards the northern end of Coatham Sands is a raised sand and shingle plateau on the upper shore, backed by sand dunes. This area, known as the Ducky, provides the main roost site at times of moult, in autumn and spring. The site is a good vantage point and has a brackish pool which is used by bathing sanderlings.

Freshwater streams cross the beaches at Saltburn and Crimdon, attracting bathing sanderlings and thus encouraging roost formation at these sites.

Within the Tees estuary, particularly on Bran Sands, muddy sand provides an additional feeding habitat to the sandy beaches of the open coast.

Limestone rocks are exposed at low water at several places, notably at Redcar where they provide an important low water feeding habitat. Coal seams also outcrop subtidally offshore and are eroded during storms which wrest mussels and kelps, and their associated fauna, from their rocky attachments and deposit them on the beaches as tidal wrack.

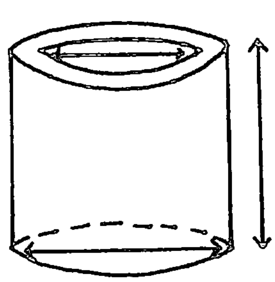
## METHODS AND SOURCES

In order to increase the sample of individually marked sanderlings for studies of their mobility, I began a programme of catching and colour-ringing. Birds were caught by cannon-netting at daytime roosts or at the tideline whilst feeding or by mist-netting at the nocturnal winter roost at Saltburn. Catching was done with the co-operation of members of the Durham University Shorebird Research Group and the South Cleveland Ringing Group (Tom Dewdney).

Ninety two new colour-ring combinations were used during my study, providing me with 181 adult and juvenile sanderlings to study (Appendix I shows those assigned to mobility groups).

Colour-rings were made with 0·5 mm darvic foil (Fig 3).

Figure 3 Dimensions of darvic foil colour rings used on sanderlings



internal diameter = 3 mm
(BTO metal ring = 2.8 mm)

external diameter = 5 mm

height = 7 mm

Colours used were white (W), lime/pale green (L), green (G), blue (B), red (R), orange (O) and yellow (Y). The first colour-ring combinations used in 1975/76 (Brearey) were of 2 darvic rings. Subsequent combinations used 3 or 4 colour rings. In 2- and 3- colour-ring combinations, the BTO numbered metal ring was placed on the right tarsus below a single darvic ring. In 4- colour-ring combinations the BTO ring was positioned above the right 'knee'.

A single case is known of a recaptured sanderling wearing 4 colour-rings in which the metal ring above the 'knee' was embedded in a fleshy growth. It was not clear whether the ring had induced the swelling or exacerbated a swelling due to another cause. Deformities due to damage to or loss of whole or part digits and limbs are common in most wader species due to bivalves, foraging amongst rocks, or injuries sustained such as broken limbs (pers. obs. & various sources). This case was considered to be coincidence, but 4-ring combinations were, nontheless, discontinued for the remainder of my study.

Colour-ring losses occurred in 7 individuals, most of which could be identified from partial combinations.

Observations

Counts of sanderlings along the coast from Crimdon to Saltburn (Fig 2) were made at least twice each month during 1981/82 and once or twice each month during 1982/83. Only occasional counts were possible during 1983/84. These counts were conducted by two people walking or driving along the beaches north and south, respectively, of the Tees estuary. Thus numbers of sanderlings were monitored for this discrete area which holds most of the sanderlings in northeast England.

My fieldwork (Appendix II gives dates) alternated from the coastline south of the River Tees to that to the north of the river and I was able to obtain satisfactory counts of either stretch unaided. Total numbers were recorded at each site visited, along with numbers and proportions of colour-ringed birds.

The locations of individually colour-ringed sanderlings and their activities were recorded. Timing of use of sites was related to season, tidal state, food availability and weather. These observations enabled me to identify when movements occurred, which birds moved, and possible reasons for movement.

Visits to St. Mary's Island and Whitburn, north of Teesside, were made at least monthly during 1981/82, and infrequently thereafter. Other sites along the northeast coast of England, from Lindisfarne in the north to Filey in the south were checked for colour-ringed sanderlings during the winter of 1981/82 and 1982/83 (Appendix II).

All observations were made using a Mirador 20 x - 45 x telescope or Zeiss 10 x 50 binoculars.

Other members of Durham University and non-university people provided additional sightings of colour-ringed sanderlings (Appendix III).

# RESULTS

## Counts

Total numbers of sanderlings between Crimdon and Saltburn, and, separately, for the coast north and south of the River Tees are summarised in Figs 4 & 5 for the non-breeding seasons of 1981/82, 1982/83 and 1983/84, with the addition of 1980/81 (courtesy of L. R. Goodyer) for comparison. The following seasonal changes in numbers of sanderlings at Teesside may be distinguished:-

1) The return of adults from the breeding grounds commences in the second half of July with numbers rising steeply, up to 600 to 700 by August or September.
2) Numbers fluctuated during autumn (August to November) indicating passage of sanderlings which pause briefly at Teeside and influxes from other moulting areas. Numbers to the north of the river are later to peak than those to the south (Fig 5).
3) A midwinter peak often occurs of over 800 birds. The timing of this peak is variable. Usually, numbers both north and south of the river show an increase, particularly those along the north shore.
4) Spring passage peaks in April and May. Numbers show fluctuations, suggesting considerable turnover of the sanderlings present at Teesside.
5) Numbers drop steeply in late May/early June to leave a summering population of fewer than 20 sanderlings.

The exact dates of count peaks and troughs, especially in early autumn, show some annual variation. This is due, in part,

Fig. 4 Counts of Sanderlings at Teesside
Teesside total:Saltburn to Crimdon

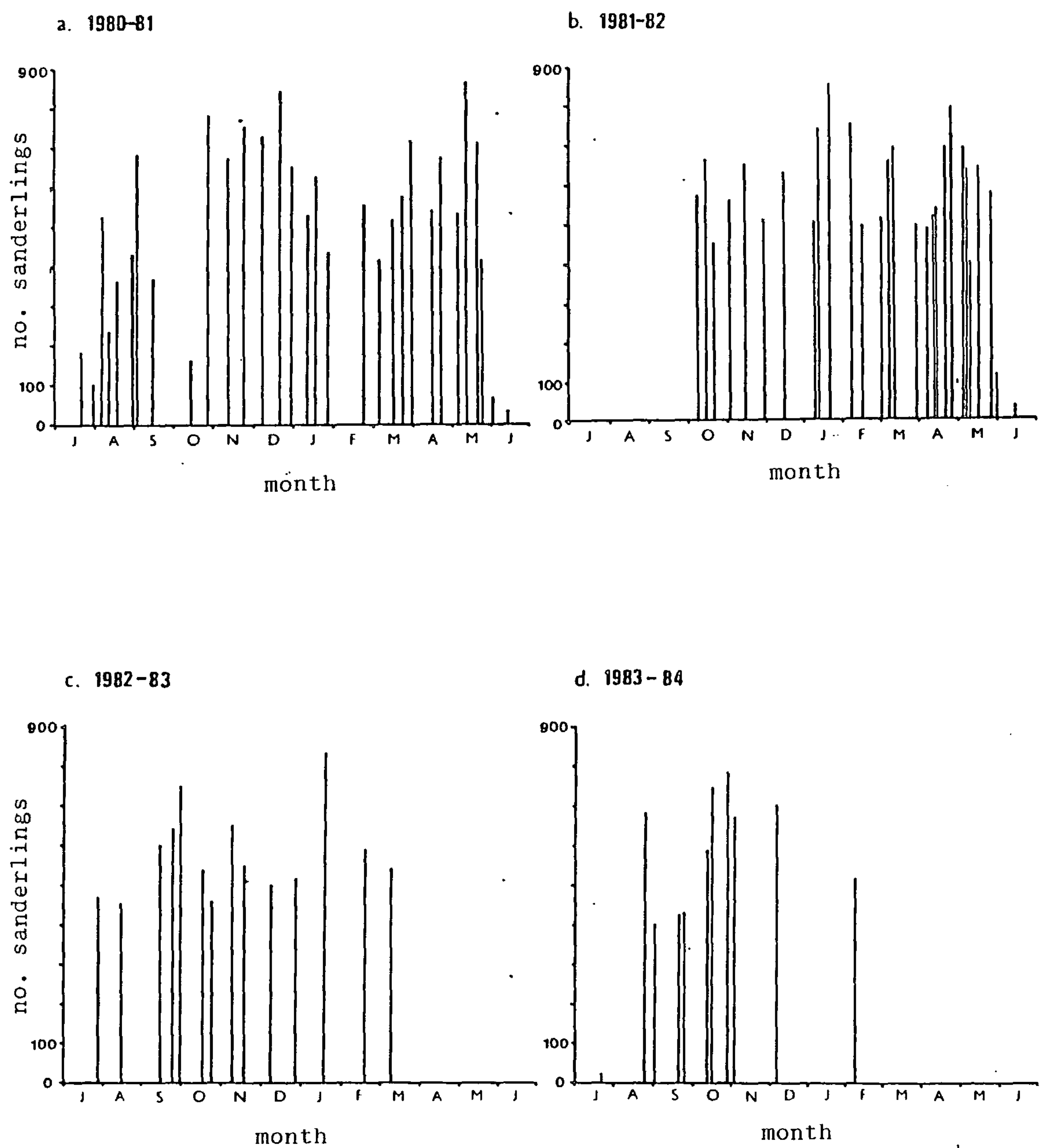
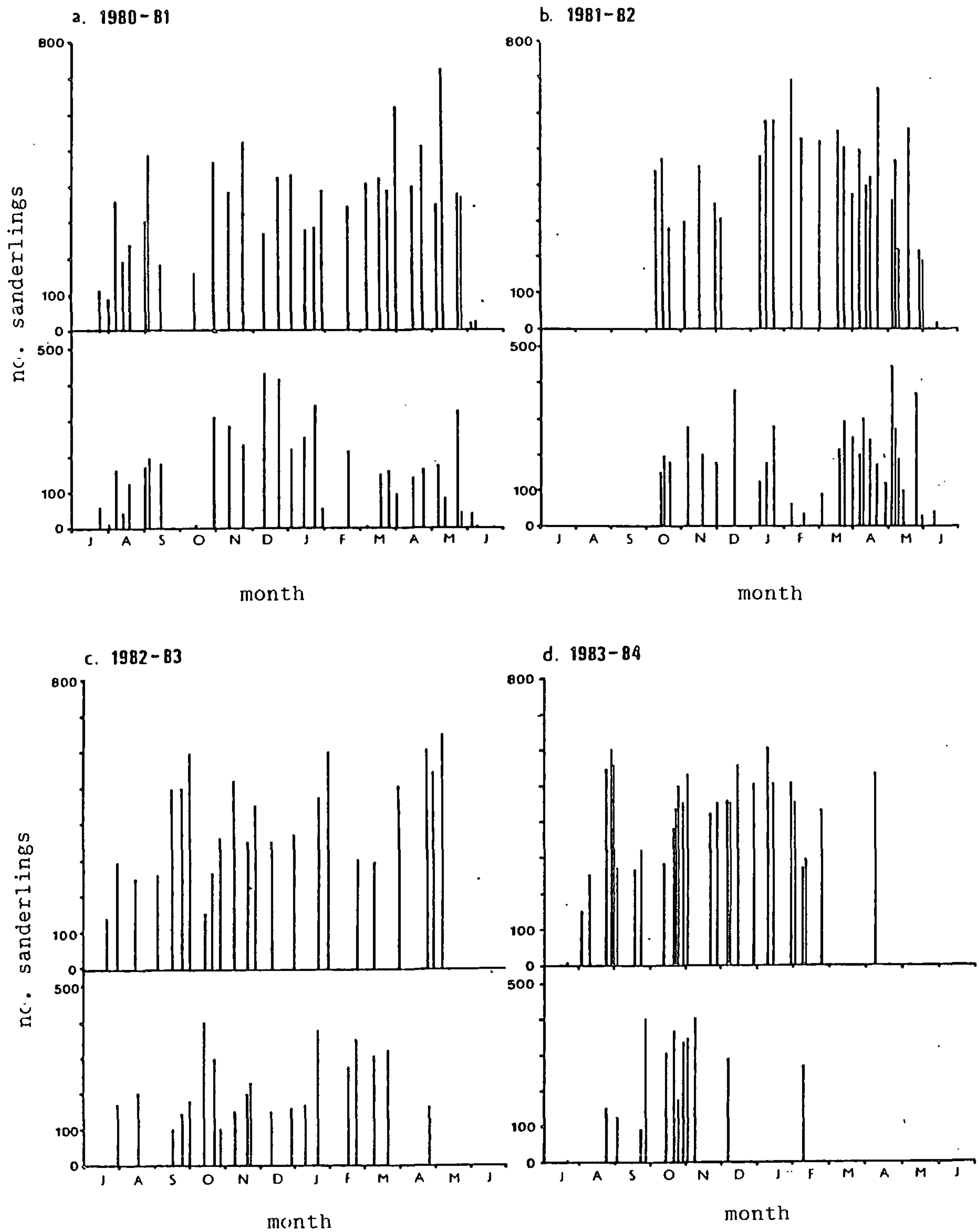


Fig. 5 Counts of Sanderlings at Teesside
South of River Tees
plotted above
North of River Tees to Crimdon



to the vagaries of the arctic breeding season and to the timing of counts which may have missed peaks of passage.

Sightings of individually-marked Sanderlings

General observations of arrival and departure dates of colour-ringed sanderlings, combined with sightings at Teesside, show similarities between years but variations between individuals. Trends in numbers of colour-ringed birds reflect these differences (Fig 7). Some increases in the numbers of colour-ringed sanderlings are due to additional colour-ring combinations from catches, for which details are shown on Figs 6 & 7).

The number of colour-ringed birds increased most rapidly from July to September as sanderlings returned from breeding grounds (origins and destinations are discussed in Appendix IV). Few passage migrants have been colour-ringed but those which have been individually marked have been seen at Teesside during autumn and/or spring in several years (Fig 8). The absence of sightings in some years may have arisen because their stay at Teesside was short, so that they were missed, or may indicate that they do not stop at Teesside on every migration. The wintering destinations of such birds remain unknown.

Following completion of post-nuptial moult (Fig 9), more colour-ringed sanderlings arrived in late October/early November. This influx of birds from other moulting areas, including the Wash (Fig 10), coincided with onward movement by some birds which had moulted at Teesside (e.g. Fig 11). Thus there is some changeover of colour-ringed individuals whilst the proportion colour-ringed shows little change (Figs 6 & 7).

Throughout the non-breeding season, increases in numbers of colour-ringed birds tended to coincide with larger numbers of

Fig. 6 % colour-ringed Sanderlings at Teesside 1981–82

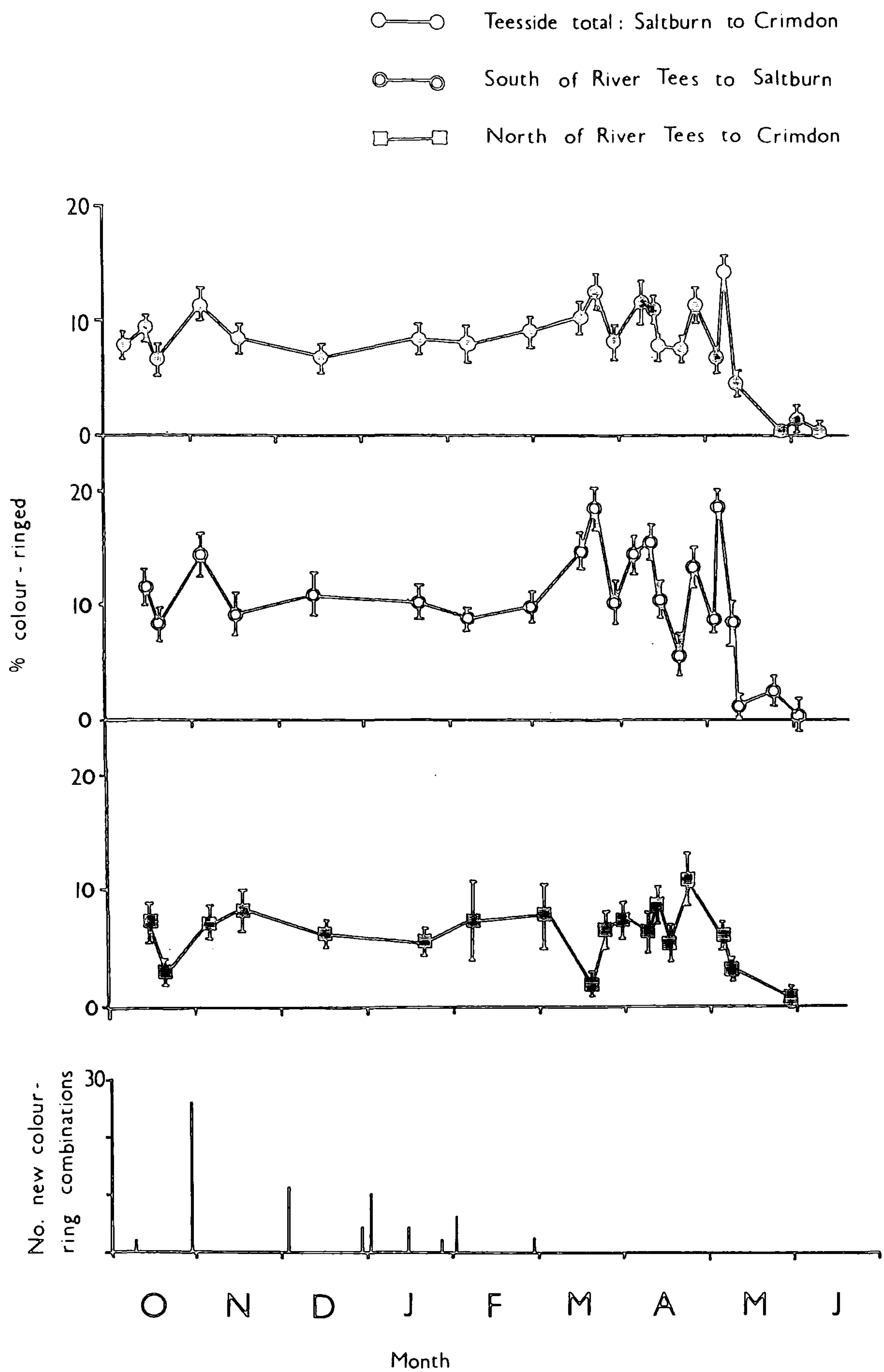


Fig. 7 Numbers and proportions of colour-ringed Sanderlings at Teesside

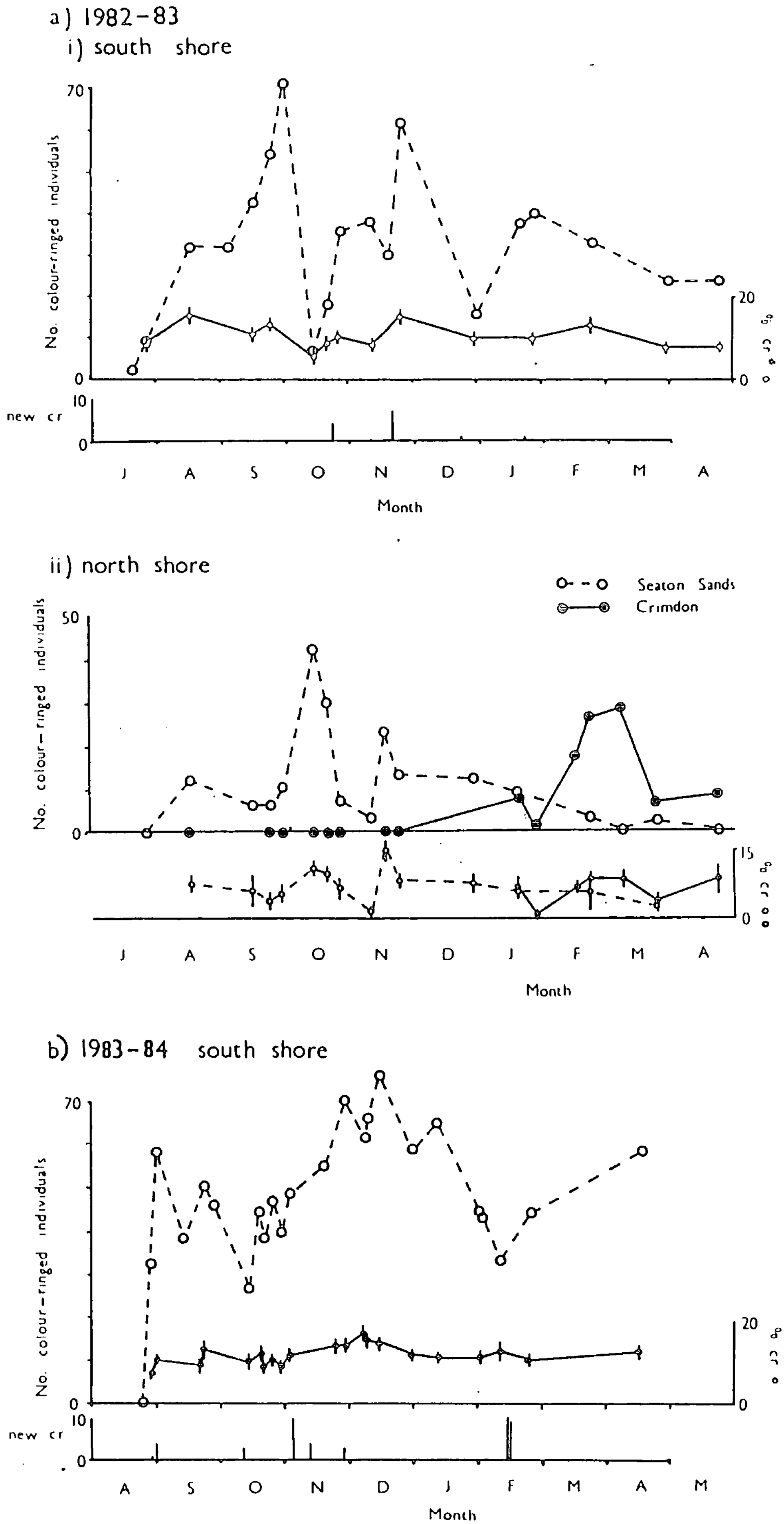
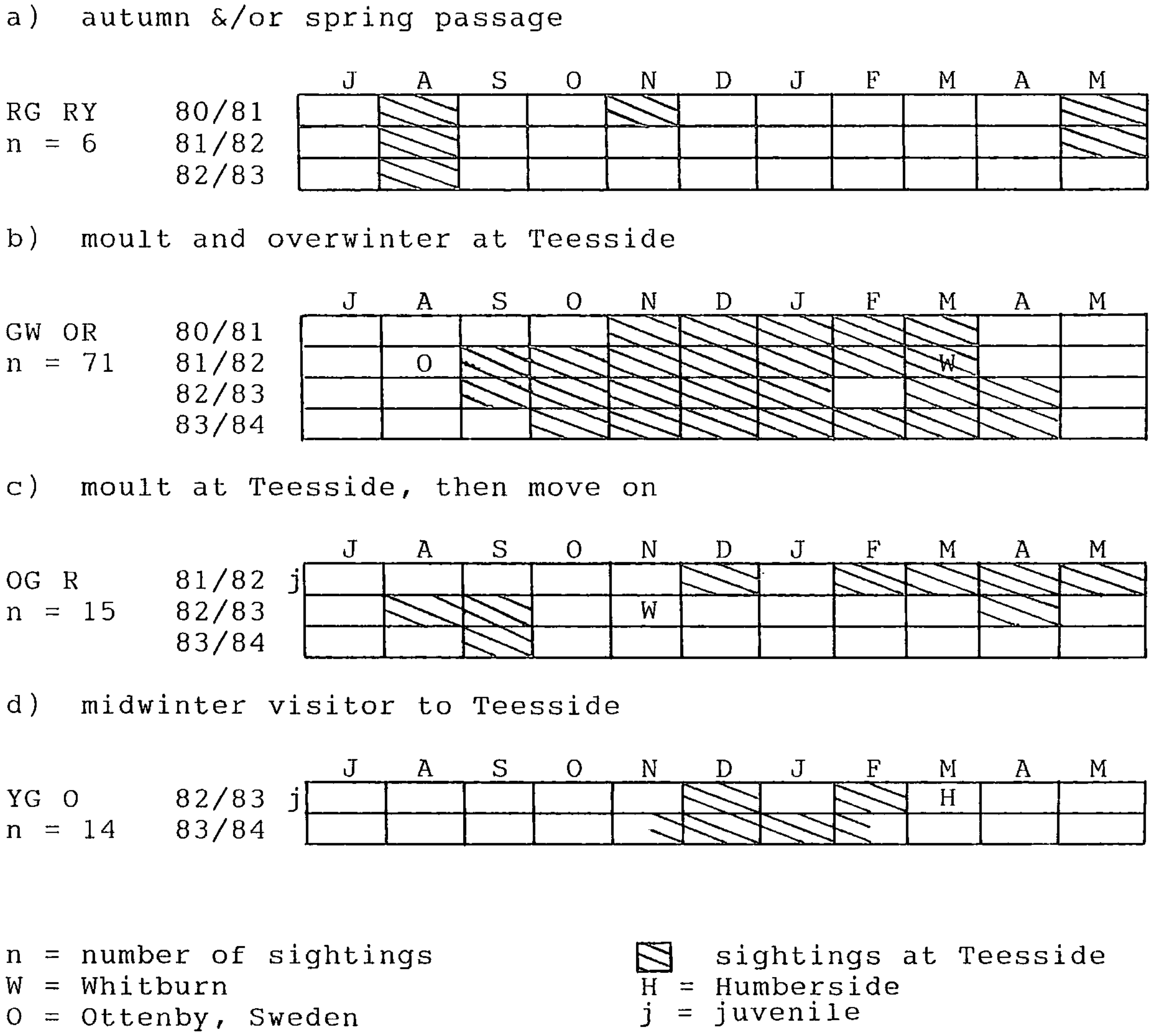


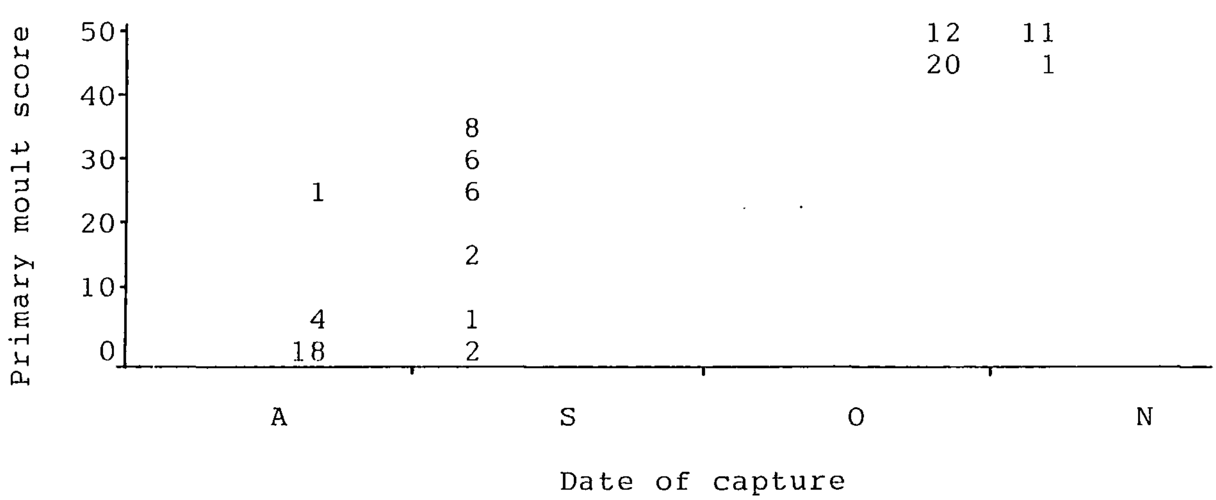
Fig 8 Examples to illustrate timing of use of Teesside by colour-ringed Sanderlings




sanderlings such that the overall proportion of marked birds present was almost stable. The indication of changes amongst the colour-ringed individuals present at Teesside is borne out by sightings records. There were some individuals which visited only during mid-winter (e.g. Fig 8). Winter sightings away from Teesside are discussed later.

In spring, there have been occasional sightings of colour-ringed sanderlings elsewhere (Figs 8, 10, 20b). These sightings coincided with large numbers of birds at these sites (Figs 21 & 22), and with fluctuating numbers at Teeside (Fig 4). Dates of spring sightings of GO Ym (Fig 10) at the Wash and Teesside are variable, implying that either this bird does not visit the Wash each spring or that its date of arrival is inconsistent. Counts at the Wash tended to be slightly later to increase than those at sites on the northeast coast of England (Ch. 1; e.g. Figs 18 & 20) in spring. Most overwintering sanderlings leave Teesside in April and May.

Fig 9 Primary moult scores in a sample of autumn-caught Sanderlings at Teesside, providing evidence for the duration of moult.




N.B. numbers plotted represent numbers of sanderlings within ranges of moult scores shown.

As shown in Fig 7, there was a tendency for numbers of colour-ringed sanderlings north and south of the River Tees to mirror each other, i.e. increases on one side were reflected in similar decreases on the other side of the river. The extent of

Fig 10 Date colour-ringed and subsequent sightings of individual Sanderlings at the Wash and at Teesside

The first date at Teesside for each bird represents the date of colour-ringing. Subsequent dates of first and last sightings at Teesside in each non-breeding season are shown.

Y Rm
n = 37

| | S | O | N | D | J | F | M | A | M |
|---|---|---|---|---|---|---|---|---|---|
| 76/77 | | | 23 | | | | 8 | | |
| 77/78 | | | | 5 | | | | 17 | |
| 78/79 | | | | | 11 | | 8 | 9 | |
| 79/80 | | 16 | | | | | | 9 | |
| 80/81 | | 28 | | | | | | | 7 |
| 81/82 | | | | 16 | | | 23 | | |
| 82/83 | Ti 17 | 16 | | | | | | | |

YY Rm 23.09.72 Adult Gibraltar Point $m = 5^6 4^1 2^1 0^2$

n = 23

| | S | O | N | D | J | F | M | A | M |
|---|---|---|---|---|---|---|---|---|---|
| 81/82 | | 28 | | | | | | | 5 |
| 82/83 | | 26 | | | | | | 2 | |

OR Ym 04.08.74 Adult Snettisham $m = 1^3 0^7$

n = 41

| | S | O | N | D | J | F | M | A | M |
|---|---|---|---|---|---|---|---|---|---|
| 81/82 | | | | 2 | | | | | 27 |
| 82/83 | Ti 10 | 13 | | | | | | | 18 |
| 83/84 | | 22 | | | | | | | 29 |

OG Ym 20.11.76 Juvenile Heacham

n = 23

| | S | O | N | D | J | F | M | A | M |
|---|---|---|---|---|---|---|---|---|---|
| 81/82 | | | | 2 | | | 23 | | |
| 82/83 | | 26 | | | | | 15 | | |
| 83/84 | | 24 | | | | | | | |

GO Ym 22.04.78 Juvenile Heacham
31.08.80 Adult Heacham $m = 5^4 4^1 2^1 0^4$

n = 21

| | S | O | N | D | J | F | M | A | M |
|---|---|---|---|---|---|---|---|---|---|
| 81/82 | | | | | | 1 | Hu 25 | | |
| 82/83 | Sn 4 & 5 | 20 | | | | | 15 | | |
| 83/84 | | | 2 | | | | | | 17 |
| 84/85 | | | | | | | 19 | He 6 | |

[hatched] Teesside sightings    n = number of sightings    m = primary moult score
Wash sites:-
Ti = Titchwell    He = Heacham    Sn = Snettisham    Hu = Hunstanton

Sightings prior to 1981 - DMB & LRG
Sightings during 1981 -1984 - RHWC
Sightings after March 1984 GAG

this imbalance varies seasonally and with the availability of particular feeding situations, which will be discussed elsewhere.

Several strategies are apparent in the use of Teesside by sanderlings (Appendix I) and are identifiable as follows:-

1) Approximately 7% are passage migrants which stop at Teesside during autumn and/or spring migration on their way to other moulting and wintering sites.
2) Approximately 7% moult at Teesside before moving on to other wintering areas, including some movement to sites along the northeast coast of England. There may be return visits to Teesside on occasions in winter.
3) Over 50% of colour-ringed sanderlings moult and remain at Teesside for the winter.
4) Approximately 30% moult elsewhere, for example the Wash, before moving to Teesside for the winter.
5) About 5% visit Teesside during midwinter only.

Sanderlings belonging to categories 2 to 5 inclusive formed the main subjects of my study, as I was seeking to establish the extent and, where possible, causes of variations in the mobility of individual birds in winter.

On the basis of counts and observations of colour-ringed individuals, the non-breeding season was sub-divided thus:-

| | |
|---|---|
| July - September | passage migration and post-nuptial moult. |
| October - November | completion of post-nuptial moult; onward migration. |
| December - February | midwinter. |
| March - May/June | spring migration and pre-nuptial moult. |

However, observations did not always fall exactly into these categories; hence some overlap is inevitable.

Movement patterns of sanderlings at Teesside during the tidal cycle: the main seasonal changes

a) South of the river mouth

i) July - September

Most adult sanderlings arriving from mid/late July onwards joined the moulting flock which roost on the "Ducky" (Fig 11). The general pattern of tidal movements of these birds is summarised as a flow diagram (Fig 12). Most moulting birds feed only to the south of the river mouth. Bran Sands (Fig 11) was used also at times of peak numbers at Teesside (Fig 13).

Redcar Rocks provided the main low water feeding area, south of the River Tees, throughout the non-breeding season (Figs 11, 12, 16). Most birds fed on Redcar Rocks for 2 - 3 hours either side of low water, although during neap tides parts of the rocks are available for longer. Coatham Rocks are exposed only during low water of spring tides, for about 2 hours; but for up to 4 hours during extreme low water spring tides (ELWS). There was little seasonal variation in the use of these feeding habitats.

Coatham Sands was used for feeding only during the mid to high water period except when suitable wrack beds were available, when sanderlings sometimes remained to feed on them throughout the tidal cycle.

ii) October - February

Changes to the above pattern took place in late autumn with the additional use of Marske Sands (Figs 11, 12, 14 & 15). Its use coincided with that of the nocturnal high water roost at Saltburn (Figs 11, 12, 14), which developed in late October, following completion of post-nuptial moult and the disbanding of the Ducky roost. Recaptures of colour-ringed sanderlings at the Saltburn roost indicated roosting movements from north of the River Tees. The Saltburn roost declined after mid February and sanderlings were then seen feeding on Coatham Sands during high water neaps even in darkness.

During diurnal high water at this time of year, sanderlings continued to feed, particularly during neap tides, pausing to roost only for short periods in groups of variable size close to the tide edge. These roosts developed at any stage of the tidal cycle and were in a state of flux.

iii) March - early June

After March, the Ducky roost reformed for the period of the pre-nuptial moult and spring passage (Fig 17). Numbers of sanderlings feeding on Marske Sands declined at this time (Fig 14). Birds feeding both north and south of the River Tees roosted on the Ducky.

b) <u>North of the river mouth</u>

North of the River Tees, a tidal pattern of feeding movement was less apparent than to the south of the river. This may have been due, at least in part, to the greater levels of disturbance along Seaton Sands. Notable amongst types of disturbance was collection of sea coal which brought vehicles and people to most of the beach as soon as the tide ebbed. This led to unsettled feeding by sanderlings.

Generally, numbers of sanderlings feeding along Seaton Sands (Figs 2 & 18) were lower than those feeding south of the River Tees, except when tidal wrack attracted birds from both sides of the river. Rocks offshore from Hartlepool headland were used for low water feeding.

Fig 11 Study area south of the River Tees

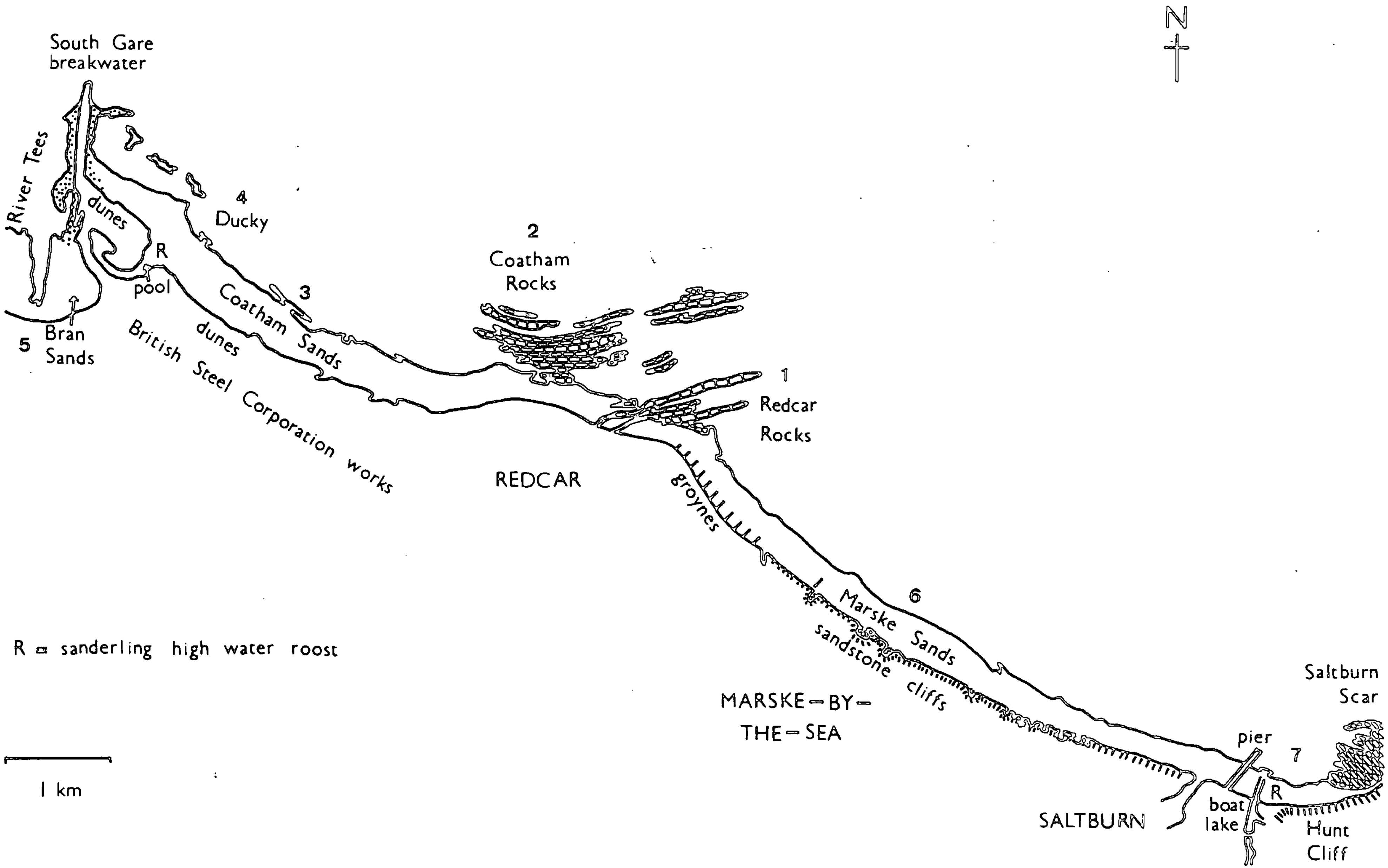
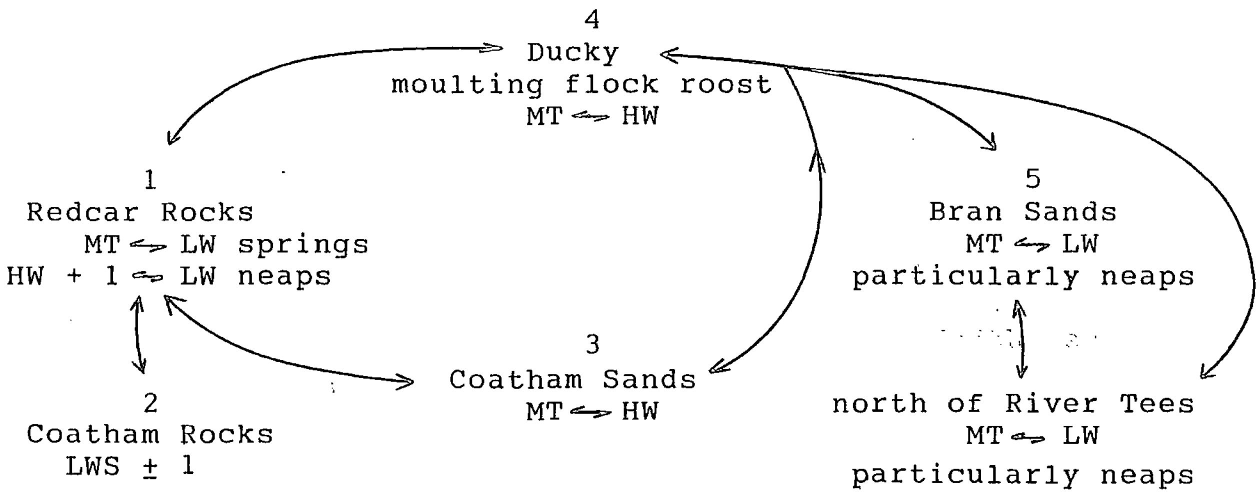
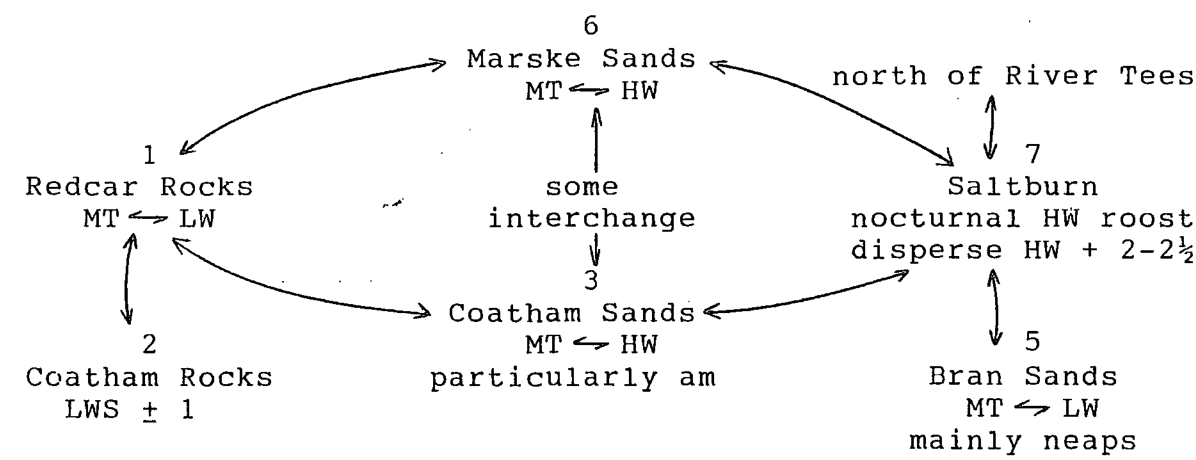


Fig 12 Flow diagrams illustrating tidal patterns of movement of Sanderlings at Teesside, south of the River Tees

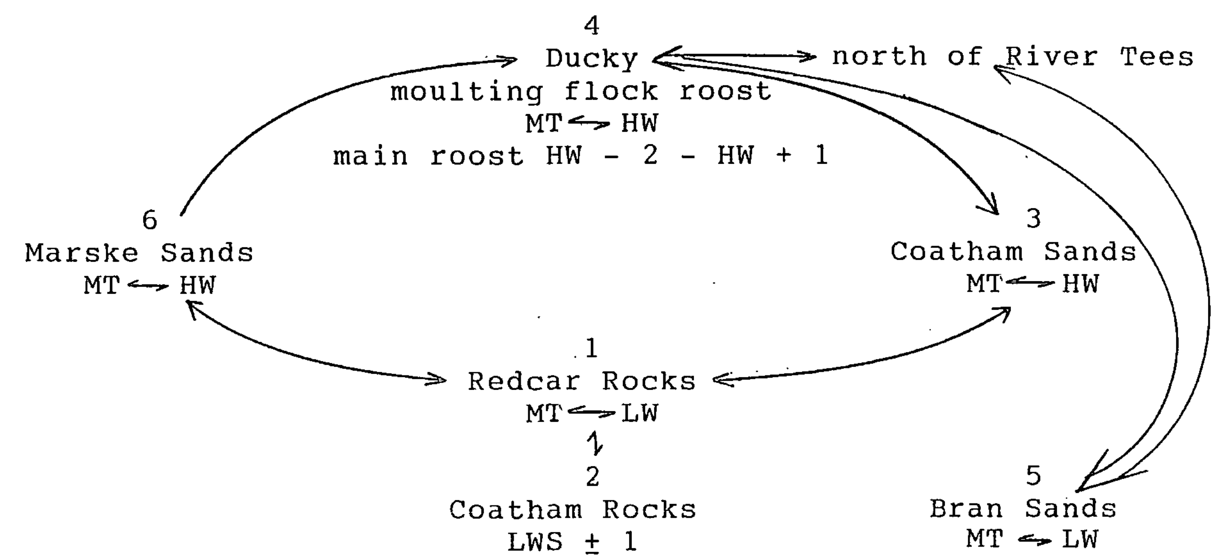
a) late summer/early autumn - July to early October inclusive




b) late autumn and winter - October to February inclusive




c) spring - March to May



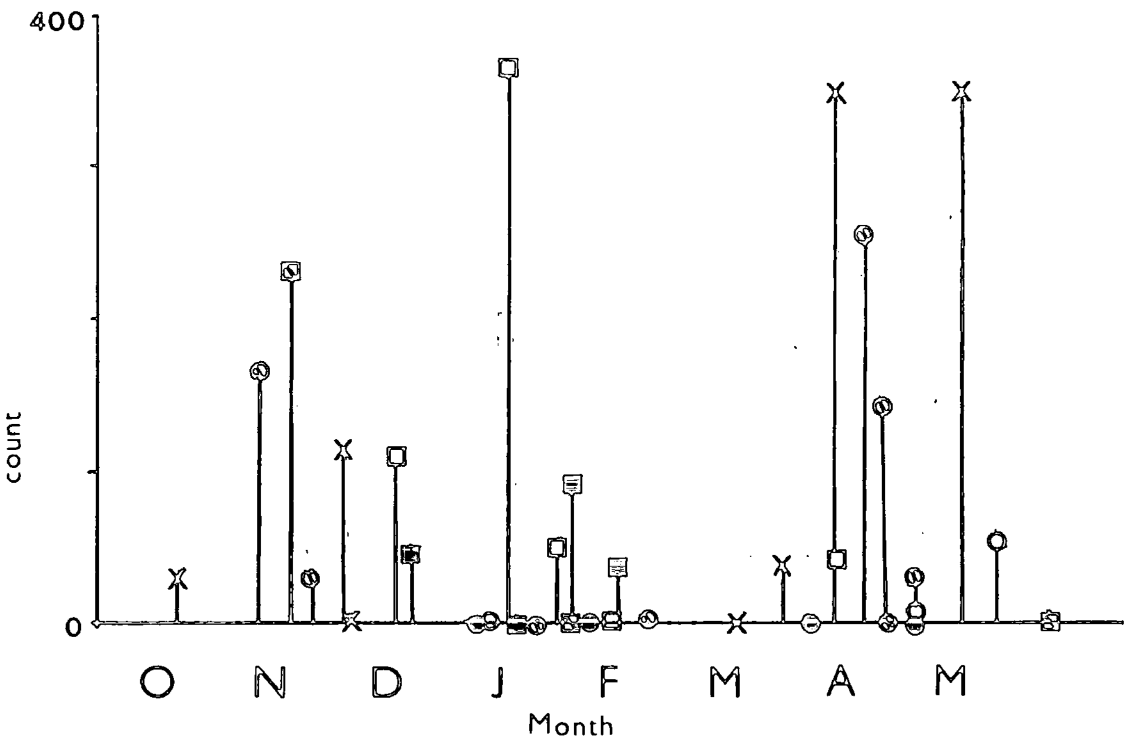

HW = high water; LW = low water; MT = mid tide; LWS = low water at spring tide

KEY to Figures 13a & 14 - 19 inclusive

| Neap tides:- | | Spring tides:- |
|---|---|---|
| □ | high water | ○ |
| X | mid ebb | ⊘ |
| □ | low water | ○ |
| ⧅ | mid flood | ⦸ |

Fig 13 Counts of Sanderlings at Bran Sands 1981–82

a) spot counts at different tidal states (by RHWC)




b) consecutive counts during one neap tide sequence in each month shown (by NCD/LRG)

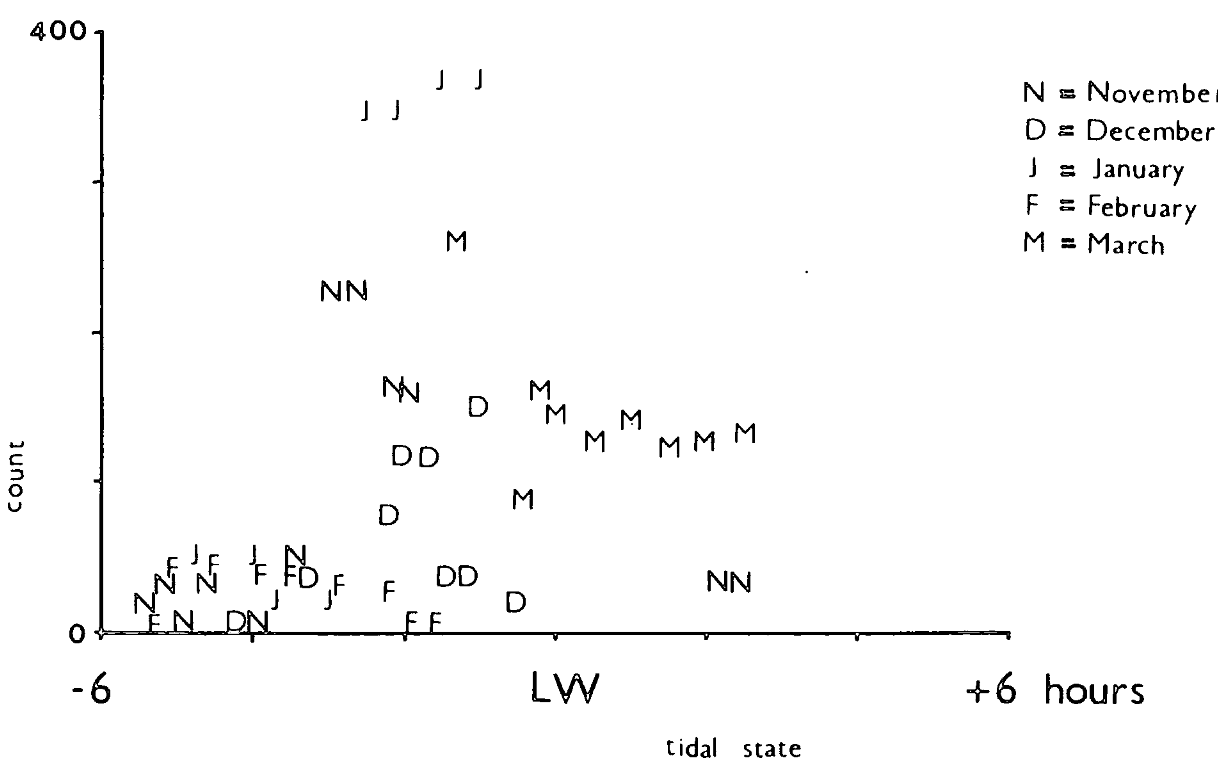


Fig 14 Counts of Sanderlings at Marske Sands 1981-82

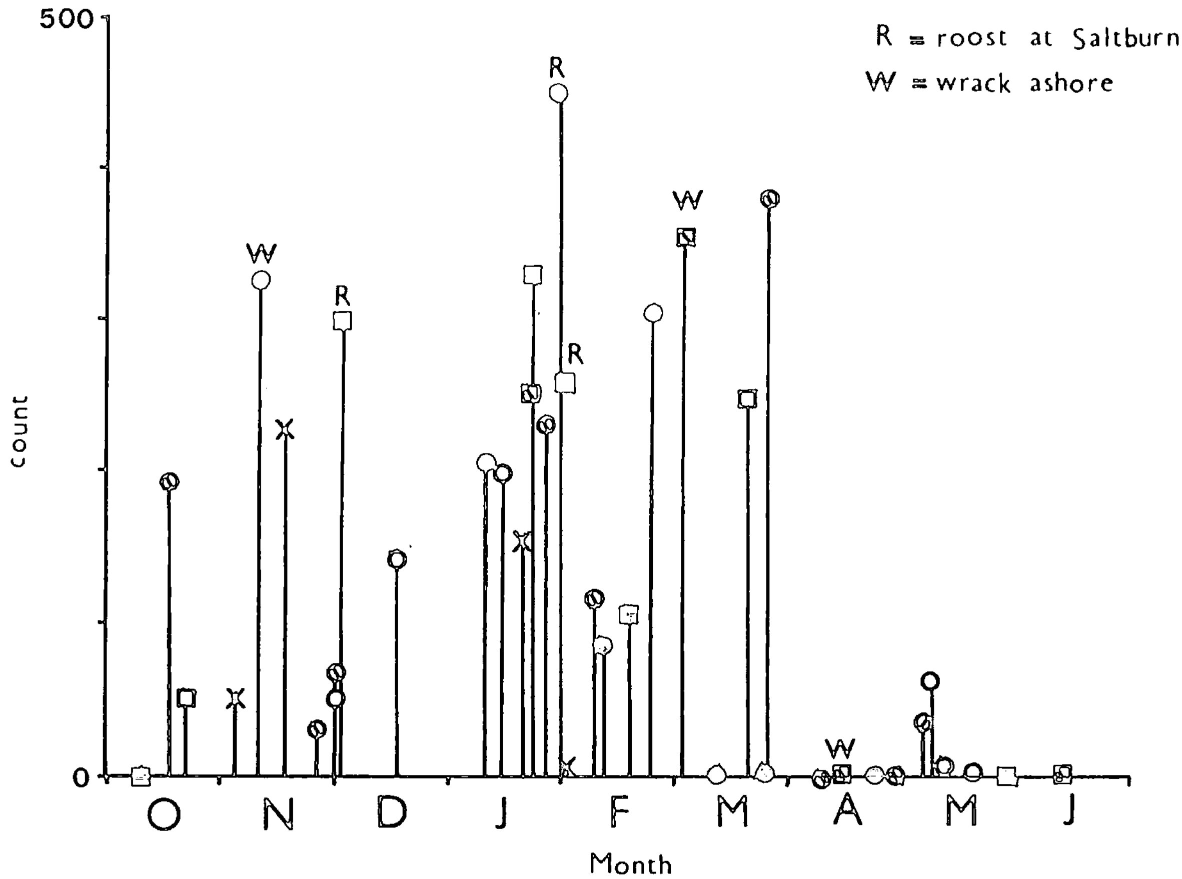



Fig 15 Counts of Sanderlings at Marske Sands 1983-84

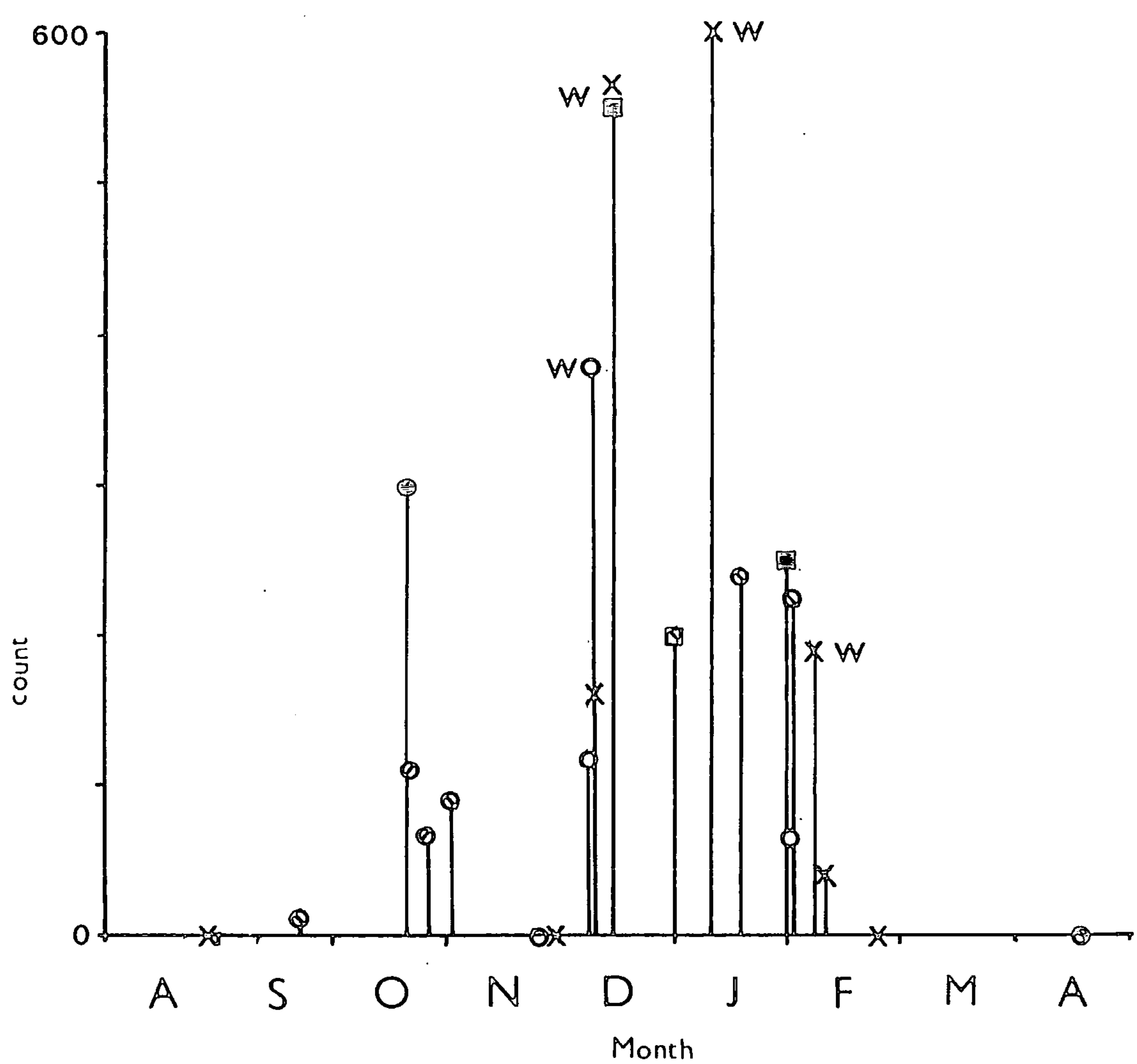


Fig 16 Counts of Sanderlings on Redcar Rocks Teesside 1981–82

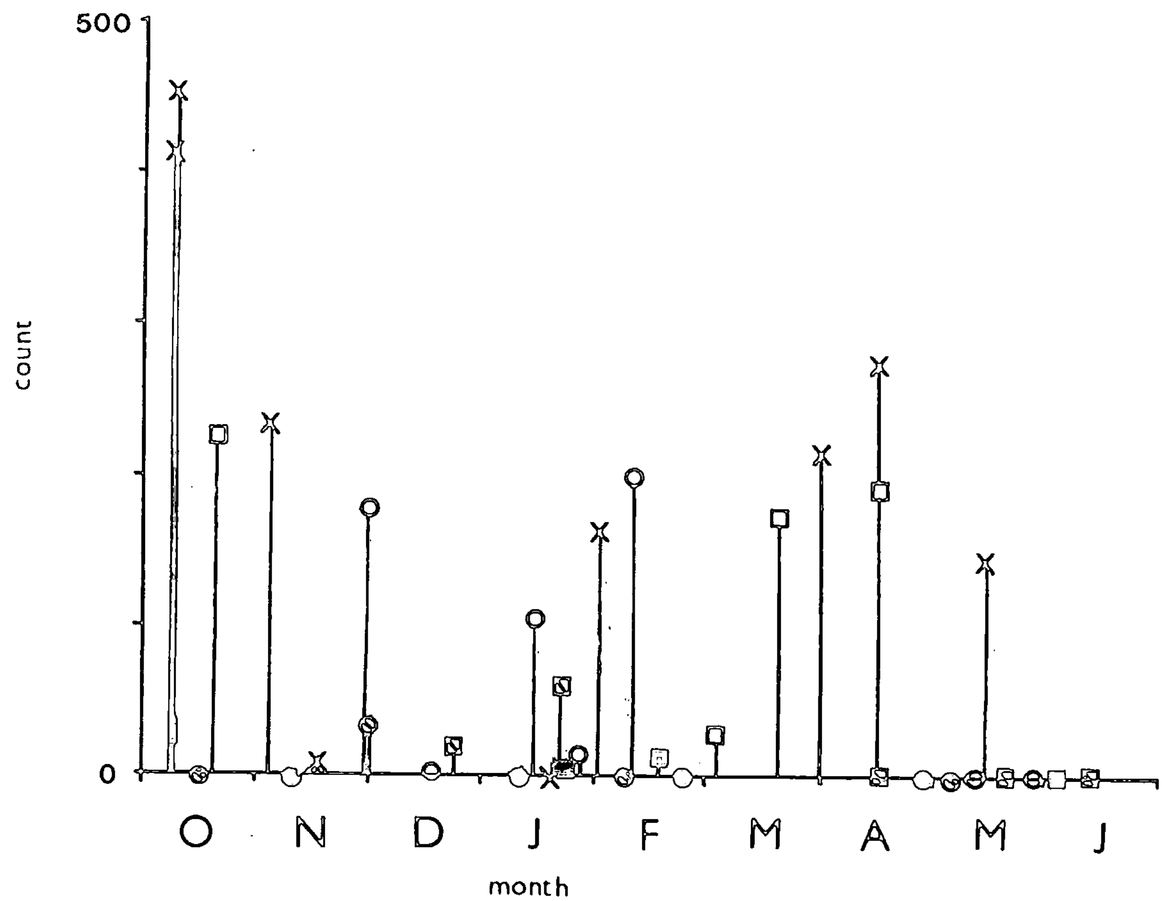



Fig 18 Counts of Sanderlings at Seaton Sands Teesside

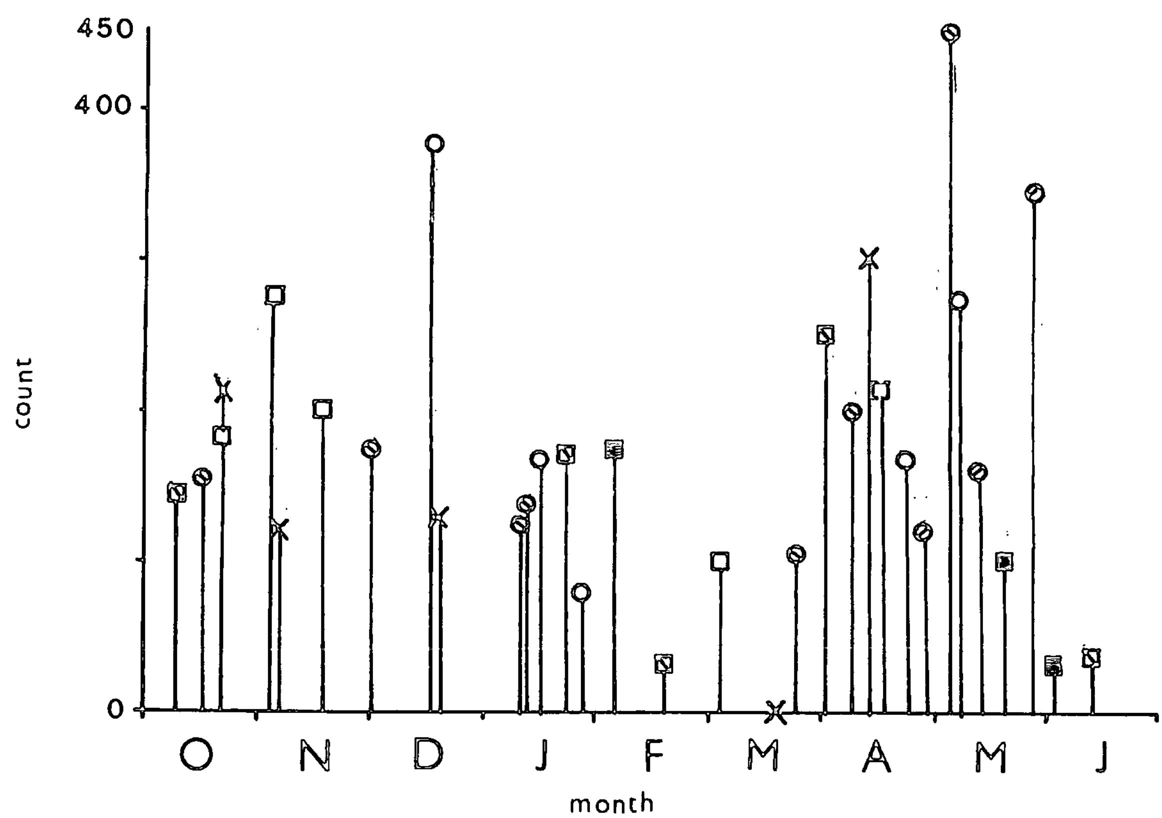
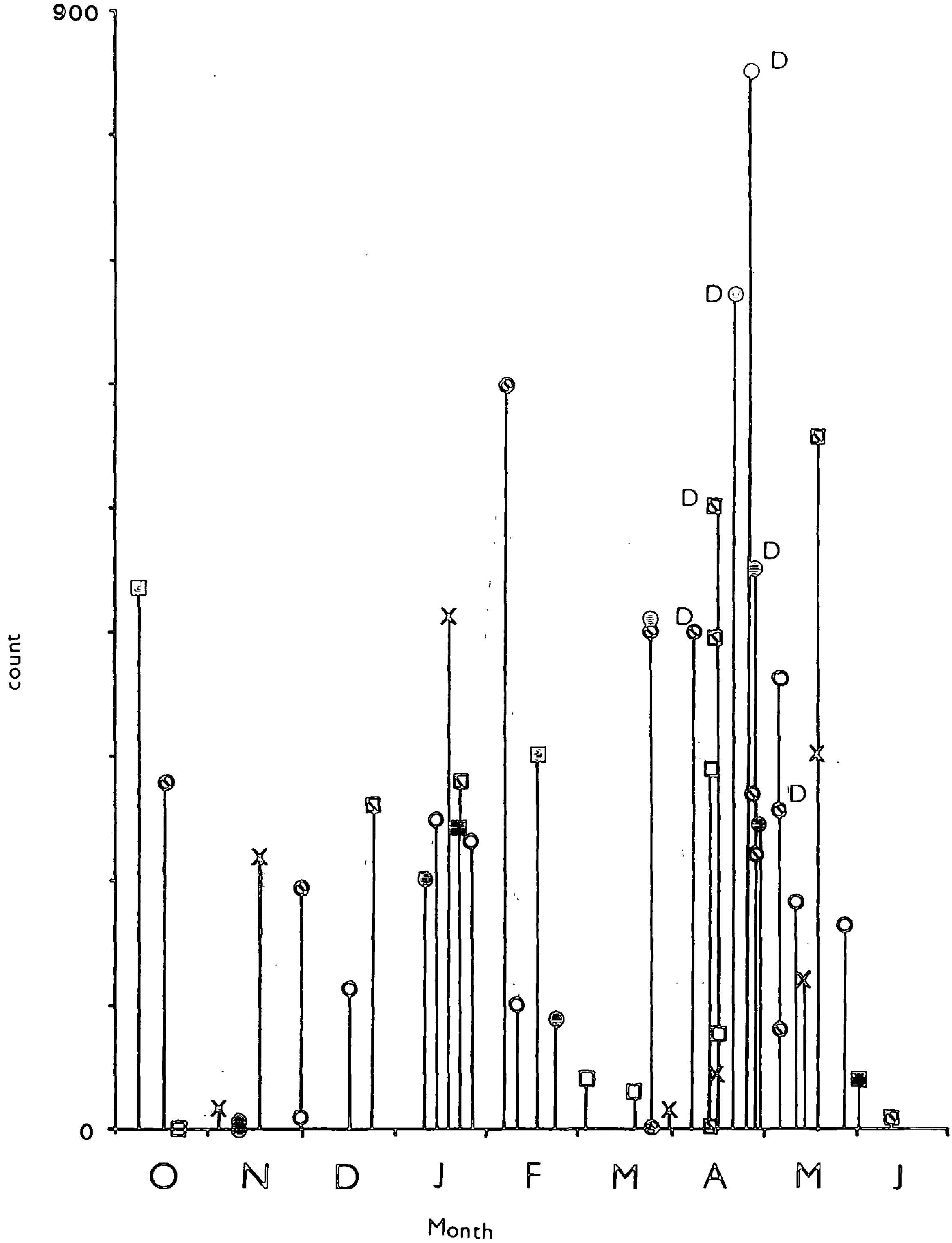


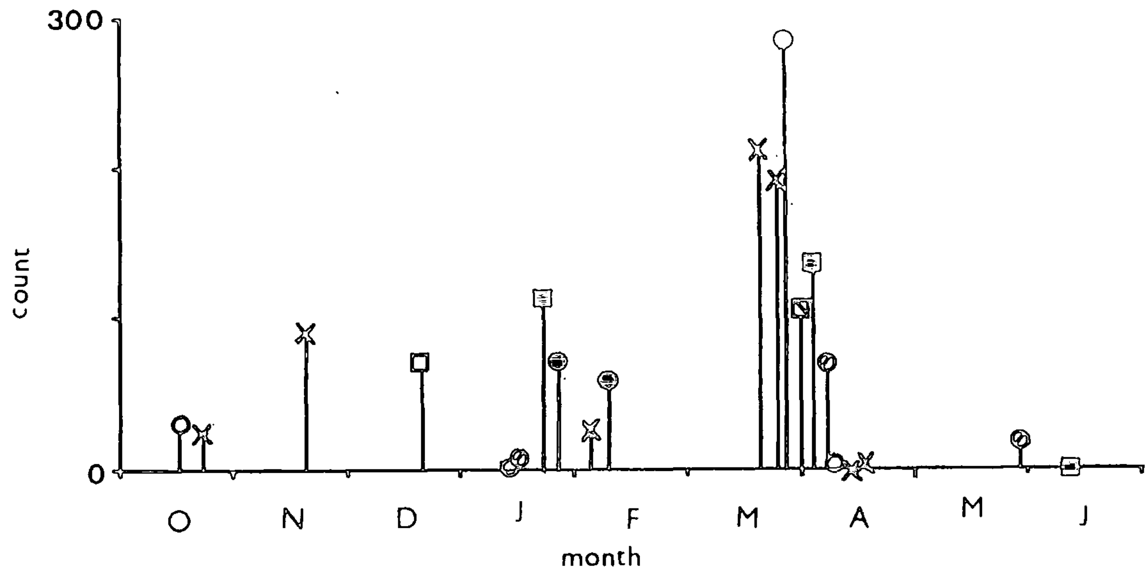
Fig 17 Counts of Sanderlings on Coatham Sands Teesside 1981–82



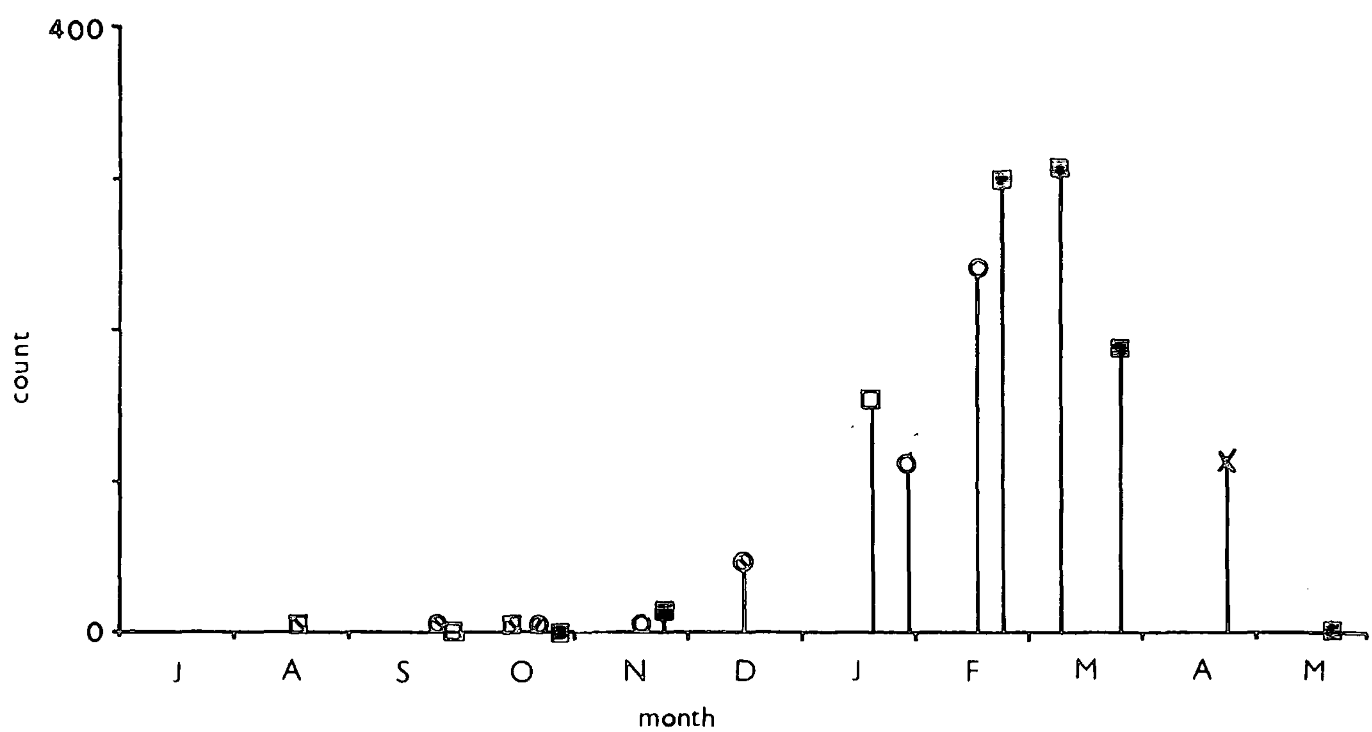

D = Ducky roost

Fig 19 Counts of Sanderlings at Crimdon

a) 1981—82




b) 1982—83



No regular large roost was located north of the river, but numbers at Saltburn at night did not account for all the sanderlings seen on both sides of the river in daylight. Yet recaptures at Saltburn of colour-ringed birds included 2 which were seen only rarely feeding south of the river. Occasionally, a neap tide high water roost formed on North Gare sands (Fig 2) during daylight in early winter.

Numbers at Crimdon (Fig 2) were highest during late February and through March (Fig 19). Elsewhere north of the Tees numbers were comparatively low at this time. Small roosts formed at Crimdon by the freshwater stream crossing the beach. Birds which had been seen south of the Tees during the winter, as well as those seen north of the river, were seen at Crimdon during this period.

Sites away from Teesside

Visits to coastal sites in northeast England, other than Teesside, were limited (Appendix II) and so sightings may be under-represented. However, the sightings available indicate predominantly shorter distance movements between sites (Fig 20).

Whitburn and St. Mary's Island

Whitburn and St. Mary's Island are approximately 40 km and 50 km (Fig 2), respectively, north of the River Tees. Few sanderlings use these sites before October (Figs 21 & 22). Numbers increase to a peak during November. Sightings of colour-ringed sanderlings at Whitburn and St. Mary's Island indicate that birds dispersed from Teesside after completion of post-nuptial moult and counts there substantiate this (Figs 4,5).

Most of the colour-ringed individuals seen at Whitburn or St. Mary's Island were seen also at Teesside later during the same winter (Fig 23). Thus the indication is that they move between sites rather than remain at one.

Numbers of sanderlings reached their highest levels at St. Mary's Island during late February/early March. This increase coincided with a decrease at Teesside. Results from colour-ringing provide evidence for the decrease at Teesside being due to movements to sites including St. Mary's Island, Whitburn and the Wash. Increased numbers of sanderlings at St. Mary's Island and the Wash at this time may represent early spring migration. However, resightings during April and May at Teesside of most colour-ringed birds which had moved to St. Mary's Island in February/March may indicate only a temporary exodus. Thus these sightings may represent an extension of mobile behaviour displayed during winter, rather than early spring migration.

<u>Other sites</u>

The one adult sanderling seen at Filey in January had been seen previously at Teesside, where it was seen subsequently too, which could imply movement between sites. The bird seen at Monifieth was not seen again; previous sightings were at Teesside during the winter. This might suggest movement between sites during the winter.

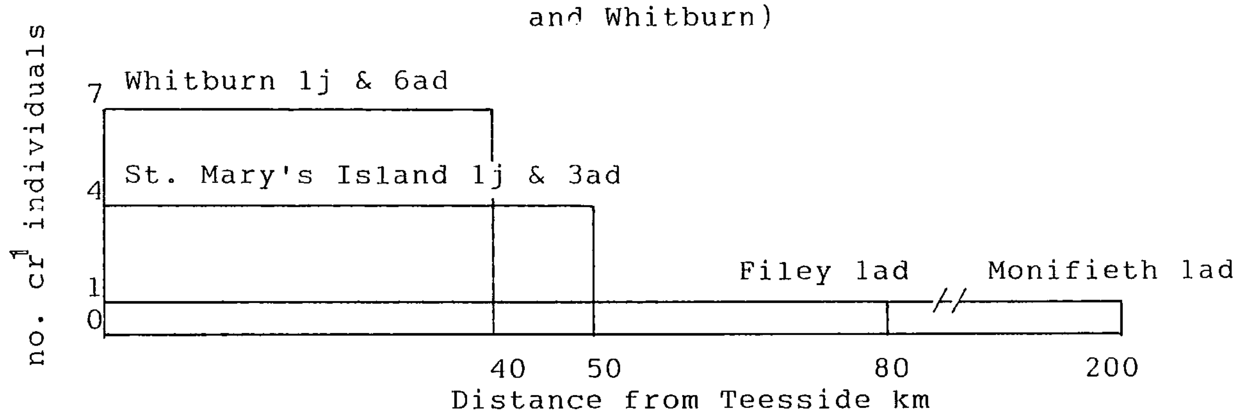
Firm conclusions about movements of sanderlings cannot be drawn from such limited information. They may represent cold weather movements, to be considered in Chapter 3.

<u>Deviations from the basic pattern of movement at Teesside</u>

Birds which observations indicated remained within a localised part of Teesside in winter were considered to be resident, principally along the south shore of Teesside. Birds which moved extensively within Teesside, during the winter were

Fig 20  Sightings of colour-ringed[1] Sanderlings away from Teesside

a) autumn/winter n = 12 (1 adult was seen at St. Mary's Island and Whitburn)




b) spring n = 16

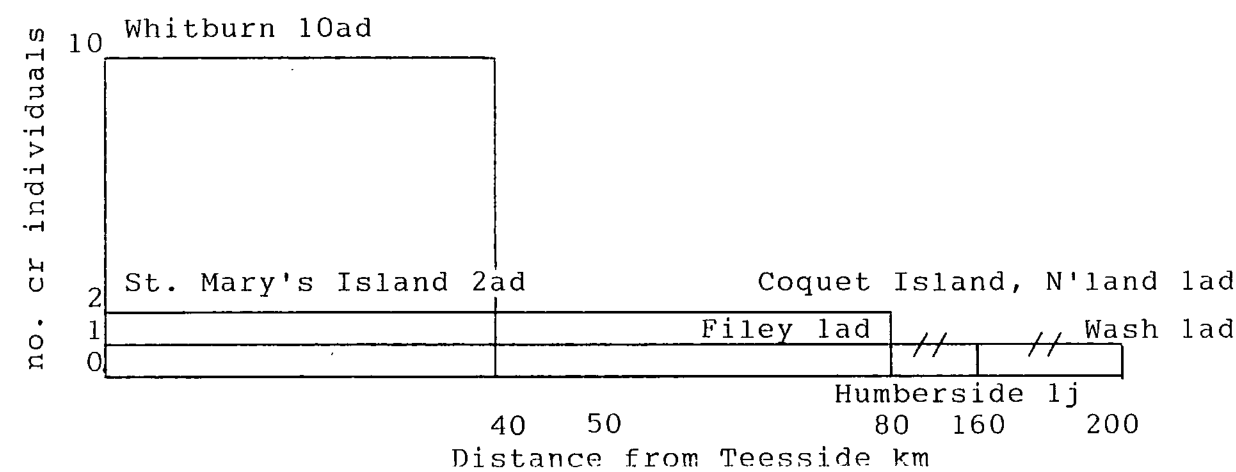



Fig 23  Colour-ringed Sanderlings at Whitburn and St. Mary's Island - examples

| | | J | A | S | O | N | D | J | F | M | A | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RW RG | 80/81 | | S | S | | N | C | M | M | M | M | M |
| adult | 81/82 | S | S | S | N | NM | | | NCM | CW | N | N |
| n = 65 | 82/83 | | NS | S | NS | N | | NC | C | C | S | |
| | 83/84 | | S | S | S | S | S | | S | | | |

| | | J | A | S | O | N | D | J | F | M | A | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BY OY | 80/81 | | | N | NS | M | | M | M | M | M | |
| adult | 81/82 | | N | NS | NS | NSM | S | M | M | M | | |
| n = 31 | | | | | | | | | | | | |

n = no. sightings; N north of River Tees; S south of River Tees; M St. Mary's Island; W Whitburn; C Crimdon

Fig 21 Counts of Sanderlings at St. Mary's Island 1981–82

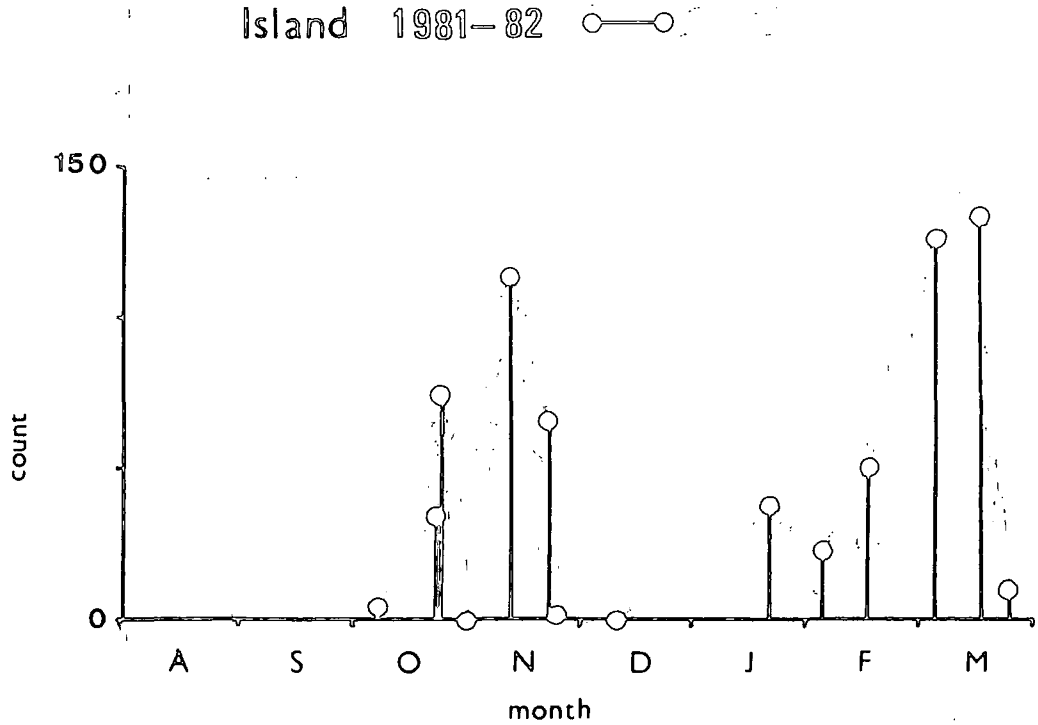
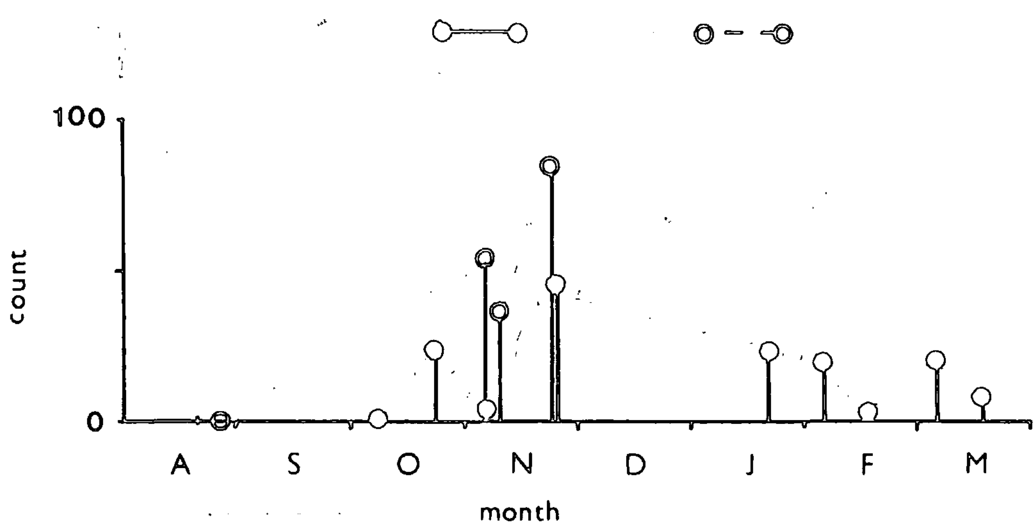



Fig 22 Counts of Sanderlings at Whitburn 1981–82 & 1983–84



categorised as being semi-mobile. Birds which moved between Teesside and other sites in at least one winter were considered to be itinerant in that winter/winters.

Differences in the degree of movement of individuals at Teesside were observed indicating that, in reality, there is a continuum of mobility by sanderlings, from sedentary to mobile. Distinction of itinerant birds was possible because Teesside is a discrete area, i.e. adjoining stretches of coastline have few or no sanderlings.

Thus 3 mobility categories were established. These categories cannot be adhered to rigorously owing to the paucity of sightings made each year when compared with the number of days available for movement. Even assuming that an individual will be seen every field day it is present - and there are always circumstances precluding this - the frequency of field days did not permit statistical completion of gaps in the sightings record. However, it was hoped that examination of these groupings might provide an insight into the underlying reasons for variations in mobility of sanderlings.

It is unlikely that a colour-ringed individual could be overlooked for several consecutive days if it was present. Consequently, 2 sets of 3 consecutive days of observations were undertaken to establish consistency of day to day movements of sanderlings at Teesside. The dates for these observations were 7, 8, and 9 December 1983 and 30 and 31 January and 1 February 1984. Most observations were made on the south shore owing to short day length preventing checks being made on both shores on the same day.

Unfortunately, fieldwork on 9 December was curtailed by strong northerly winds and heavy rain and so results were incomplete. There is the possibility of some colour-ringed individuals being overlooked on any one day, although efforts were made to check all birds present. Also, some absences from checks south of the river could be accounted for by birds being on the north shore; for example, 4 sanderlings seen on the south shore on 8 December had been seen on the north shore on the 7 December.

Even allowing for the possibility of birds being north of the river and birds being missed, the number of colour-ringed sanderlings seen on all 3 days in January/February was low - only 9 out of a total of 73 combinations seen over the three days (Table 2). Comparison of any 2 days in this series enabled only about 50% of the combinations to be accounted for (Table 2). But of the 73 combinations seen during 7 and 8 December, 81% could be accounted for (Table 1).

Table 1 Sightings of colour-ringed[1] sanderlings south of the River Tees during 7 and 8 December* 1983

| | Count | No. checked for cr[1] | No. cr |
|---|---|---|---|
| 07.12.83 | 400 | 370 | 57 |
| 08.12.83 | 455 | 430 | 61 |
| total cr seen during 7.12 & 8.12 | 73 | | |
| no. cr seen both days | 46 | | |
| no. cr seen north of River Tees on 7.12 or 8.12 | 13 | | |
| no. cr accounted for during 7.12 & 8.12 | 59 = 81% of total cr seen (73) | | |

*09.12.83 is excluded here because deteriorating weather conditions curtailed observations.

Table 2 Sightings of colour-ringed Sanderlings south of the River Tees during 30 and 31 January and 1 February 1984

| | count | no. checked for cr | no. cr |
|---|---|---|---|
| 30.01.84 | 500 | 450 | 40 |
| 31.01.84 | 500+ | incomplete | 43 |
| 01.02.84 | 450 | 400 | 35 |
| total cr[1] seen during 30.1, 31.1 & 1.2 | 73 | | |
| no. cr seen all 3 days | 9 | | |
| no. cr[2] seen north of River Tees on one or more days of the 3 | 20 | | |
| no. cr accounted for during 30.1, 31.1 & 1.2 | 29 = 40% of total cr seen (73) | | |
| total cr seen during 30.1 & 31.1 | 65 | | |
| no. cr seen both days | 19 | | |
| no. cr seen north of River Tees on 30.1 or 31.1 | 13 | | |
| no. cr accounted for during 30.1 & 31.1 | 32 = 49% of total cr seen (65) | | |
| total cr seen during 30.1 & 1.2 | 56 | | |
| no. cr seen both days | 20 | | |
| no. cr seen north of River Tees on 30.1 or 1.2 | 10 | | |
| no. cr accounted for during 30.1 & 1.2 | 30 = 54% of total cr seen (56) | | |
| total cr seen during 31.1 & 1.2 | 62 | | |
| no. cr seen both days | 20 | | |
| no. cr seen north of River Tees on 31.1 or 1.2 | 15 | | |
| no. cr accounted for during 31.1 & 1.2 | 35 = 57% of total cr seen (62) | | |

[1]total colour-ringed birds seen south of the River Tees

[2]only cr seen south of the River Tees on other day(s) included

Fig 24 Timings of sightings of midwinter visitors to Teesside

| | | A | S | O | N | D | J | F | M | A |
|---|---|---|---|---|---|---|---|---|---|---|
| YO RY | 80/81 | S | | | | | S | | | |
| n = 3 | 81/82 | | | | | | S | | | |

| | | A | S | O | N | D | J | F | M | A |
|---|---|---|---|---|---|---|---|---|---|---|
| GW YO | 81/82j | | | S | N | | N | C | S | S/N |
| n = 16 | 82/83 | | | | | | | C | | |
| (7 in winter) | 83/84 | | | | | | | S | | |

| | | A | S | O | N | D | J | F | M | A |
|---|---|---|---|---|---|---|---|---|---|---|
| WB G | 76/77 | | | | | | S | | | |
| n = 10 | 77/8+78/9 | | | | not seen | | | | | |
| (5 in | 79/80 | | | | S | | | | S | S |
| winter) | 80/81 | | | | not seen | | | | | |
| | 81/82 | | | | | | S | | F | |

n = number of sightings
N = north of Tees
F = Filey, North Yorkshire

S = south of Tees
C = Crimdon
winter = Nov - Feb

The early period was before the midwinter influx (Figs 4, 5) at a time when counts are relatively stable, but the second period came towards the end of the influx (Figs 4, 5). The latter period coincided with the timing of sightings away from Teesside too. Thus colour-ringing results indicate that, at least in 1984, late January was a period of high mobility.

Midwinter visitors to Teesside

Three individual sanderlings were seen at Teesside only in January or February of the two or more winters for which there were sightings of these birds as adults. It is not known where these birds spent the rest of the winter, but their appearances at Teesside coincided with the periods of influxes to overall numbers of sanderlings at Teesside (Figs 4, 5) ; also mentioned above. Figure 24 summarises sightings details for these birds.

# CONCLUSIONS

It is apparent that there are varying degrees of mobility exhibited by individual sanderlings in northeast England. Whilst a continuum of mobility is recognised, 3 broad categories were separated:

1) The discrete nature of Teesside enables ITINERANT birds, which move between Teesside and other sites, to be distinguished;
2) RESIDENT birds remain, predominantly, localised south of the River Tees;
3) SEMI-MOBILE birds move extensively within Teesside.

The degree of mobility of an individual seems to vary seasonally with heightened mobility apparent in northeast England during autumn and spring passage periods. The winter period, the latter half of November to February, is relatively free from large scale immigration or emigration, except for a short spell, usually, in late January/early February. The winter will be the main concern of the rest of this report.

Before considering possible reasons for variations in mobility, other differences between itinerant, semi-mobile and resident birds were looked for.

# CHAPTER 3

# THE CAUSES AND CONSEQUENCES OF MOBILITY OF SANDERLINGS IN WINTER

## INTRODUCTION

Variations in mobility of individual sanderlings on the wintering grounds may arise as a result of 3 possible mechanisms:-

1) Once at a suitable wintering area, birds are genetically programmed to be sedentary or to move. There should, therefore, be a balance between net advantages of moving or remaining at one site.
2) At a suitable wintering area, birds may compete for the best sites, the losers being forced to move and perhaps become itinerant. Such competition might occur:-
    a) each autumn/winter between all age classes;
    b) in the first winter amongst juveniles and/or between juveniles and adults, establishing a pattern of behaviour which is maintained in subsequent winters, as in grey plover (Townshend 1981).
3) Individuals may choose to move, in all or only in some winters, in response to e.g. reduced densities of available prey.

1) and 2b) would lead to repetition of the behaviour pattern each year, whereas 2a) might lead to changes and 3) would, probably, lead to changes in movements.

If competition leads to variations in mobility amongst sanderlings, several features might be expected:-

1) Smaller birds would be more mobile than large birds if size equated with competitive ability.
2) Juveniles, as inexperienced foragers, might be forced into

mobility as a result of competition with adults, over food.

3) Early arrivals at Teesside in autumn might have an advantage in establishing residence before late arrivals. In the case of grey plover juveniles which took up territories before the return of adult territory holders, a few were able to retain their acquisitions (Townshend 1985).

4) Survival rates should be consistently higher for resident birds than for itinerant or semi-mobile birds.

If sanderling mobility is determined genetically;

1) Mobility need not be related to size.

2) Survival rates measured in the long-term should be similar for itinerant, semi-mobile and resident birds.

If mobility is a response to prey availability, factors affecting their availability will be more relevant than morphological aspects of sanderlings. Annual survivorship will fluctuate with 'good' and 'bad' years for foraging.

Underlying reasons for variations in mobility are likely to be associated with food availability. Times of feast and famine may favour individuals of differing mobility. This chapter attempts to identify the cause(s) by examining the birds' behaviour in relation to the predictions made above.

Unfortunately, sanderlings cannot be sexed reliably in the field (Cramp & Simmons 1983), nor from single biometrics such as wing length. However, discriminant analysis of several biometrics has achieved reasonable separation of male and female sanderlings (Wood 1987). Consequently, the influence of a bird's sex on its degree of mobility or competitive strength and, hence, survival rate has been considered only to a limited extent.

## METHODS AND SOURCES OF DATA

Observations, outlined in Chapter 2, led to counts and estimates of proportions of juveniles in flocks of sanderlings. Juveniles were easily recognisable in the field until late October, after which they became increasingly difficult to distinguish as they moulted into winter plumage. By mid-November, estimates of proportions were unreliable since juveniles were certainly missed.

Biometric data were taken from individually colour-ringed birds, which could be recognised subsequently as resident, semi-mobile or itinerant. Wing and culmen lengths were used in analyses. Variances of all paired samples to be compared were first tested for equality using the F-test (Snedecor & Cochran). Sample means were compared using Student's "t" distribution for samples of equal variance but unequal size.

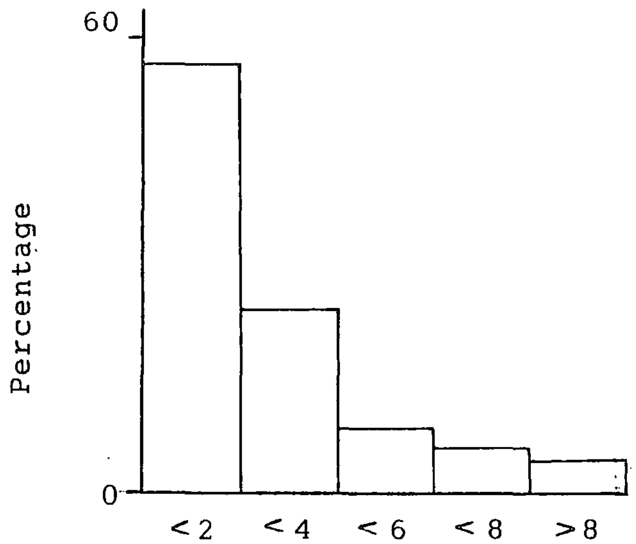
### Survival Rates

Estimates of annual survival rates were obtained for colour-ringed sanderlings. Disappearance of a colour-ringed bird between November and March, followed by non-appearance during subsequent winters, out of character with known behaviour, was considered to represent mortality during the winter.

Non-appearance in autumn of a bird known to have departed in the previous spring was considered to be the result of mortality associated with migration or breeding.

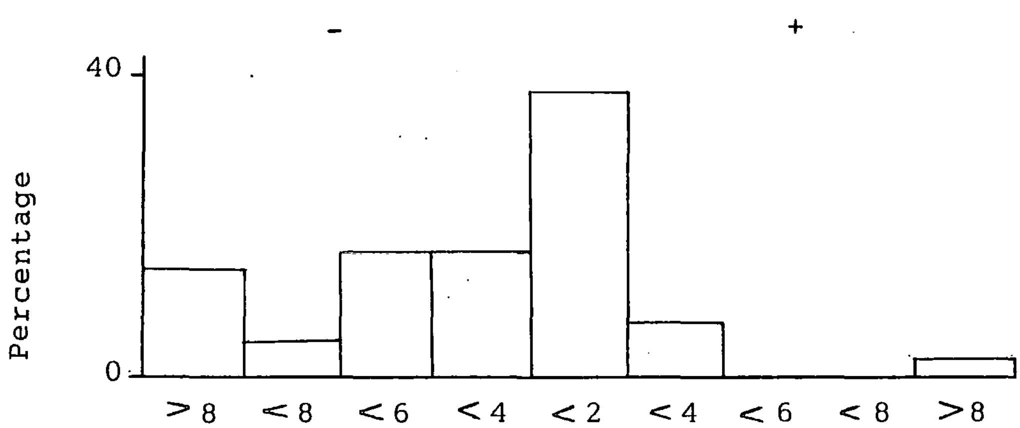
Dates of last sightings each year indicate that individual adult sanderlings depart from Teesside at a similar time each spring (Fig 25). Juveniles tend to leave later in their first spring than in subsequent ones (Fig 26). Estimates of

Fig 25 Consistency of spring departure dates from Teesside of 116 adult sanderlings (information for at least 2 springs from the period 1981 - 1984 for each bird, which returned to Teesside in the following autumn/winter).




weeks between dates last seen in spring at Teesside

Fig 26 Departure dates in spring from Teesside of 42 sanderlings as juveniles compared with the same individuals as first-year adults.




departure earlier as adult than as juvenile

departure later as adult than as juvenile

weeks between dates last seen in spring at Teesside as a juvenile and as a first-year adult survival, based on disappearance, were not calculated until the following autumn/winter, when influxes of wintering birds were complete. This method of estimating survival rates is justified by the repetition of behaviour displayed by most individual sanderlings from year to year.

Survival rates of itinerant, semi-mobile and resident birds were compared to see if they differed.

Meteorological Data

Daily wind speed, direction and strength of maximum gust for Teesmouth and minimum and maximum air temperatures for Hartlepool were obtained from the meteorological office at Newcastle-upon-Tyne.

Data for the midwinter period - December, January and February - of each of the years 1981/82, 1982/83 and 1983/84 were examined to assist with interpretation of annual variations in survival rates.

Macroinvertebrate Sampling

Macroinvertebrates were extracted from sand samples taken on Marske Sands (Fig 2) on 27 November 1981 and 23 February 1982 to provide early and late winter prey densities. Four transects were sampled (Fig 30) from the level of high water neaps (HWN) downshore. Paired samples of 10 $cm^3$ were taken at each station, at 10 m intervals from 20 m to 100 m below HWN and at 130 m and 160 m, except where stated otherwise.

Additional samples were taken at 20 m, 60 m, 100 m and 160 m for estimation of particle size and sorting coefficient. In the laboratory, dry sediment samples of about 100 gm were sieved through a set of sieves of meshes 20, 40, 60, 80, 100, and 200 meshes per inch for one minute. The quantity of sediment retained by each sieve was weighed and the weights converted into percentages. Graphs of accumulated percentage weight against standard average particle size for each mesh size were used to estimate the median grain size and the sorting coefficient (half the difference between the grain size values at 16% and 84% of the cumulative percentage frequency graph).

The results of sampling at other intertidal sites around Teesside were consulted (Davidson 1980, Davidson & Evans 1981, Brearey 1982).

# RESULTS

## Clarification of mobility categories (Appendix I)

1) Itinerant (Fig 27)

Three subsets of itinerant birds were recognised:-

i Birds which moved, regularly, between Teesside and known locations elsewhere e.g. St. Mary's Island (see Ch. 2). Most of these birds were, apparently, absent from Teesside for several weeks in the winter (Fig 27).

ii Birds which visited Teesside, from unidentified locations, for only part of the winter, usually in January or February - coinciding with periods of influxes to overall numbers of sanderlings at Teesside (Figs 4 - 6; Ch. 2).

iii Birds which moved away from Teesside for part of one or more winters (Ch. 2) e.g. to Filey in North Yorkshire.

Additionally, 8 other sanderlings which were not seen at Teesside for several consecutive weeks in winter (Fig 27) of one or more years were considered to be itinerant in those years because the duration of their apparent absence was akin to that for birds which were known to move away from Teesside during the winter.

Six of these birds 'disappeared' during part of winter 1981/82, 3 of which also were not seen during part of winter 1982/83 (Fig 27). Whilst at Teesside, these birds had been seen, almost exclusively, south of the River Tees. It was more difficult to assess genuine absences from Teesside of birds which moved extensively within Teesside. Consequently, itinerancy may have been underestimated.

Increased movement is apparent in November and the latter half of February with individuals flying between Teesside and

St. Mary's Island or Whitburn (Fig 27; Ch. 2). During the period in-between, few return visits to Teesside were observed, implying that most birds moving to these sites remain there for the midwinter period. So, even within winter, variations in the degree of mobility are evident.

Birds in subset i repeated this movement trend annually, whereas variations were noted from year to year for birds adopting ii or iii.

2) Semi-mobile

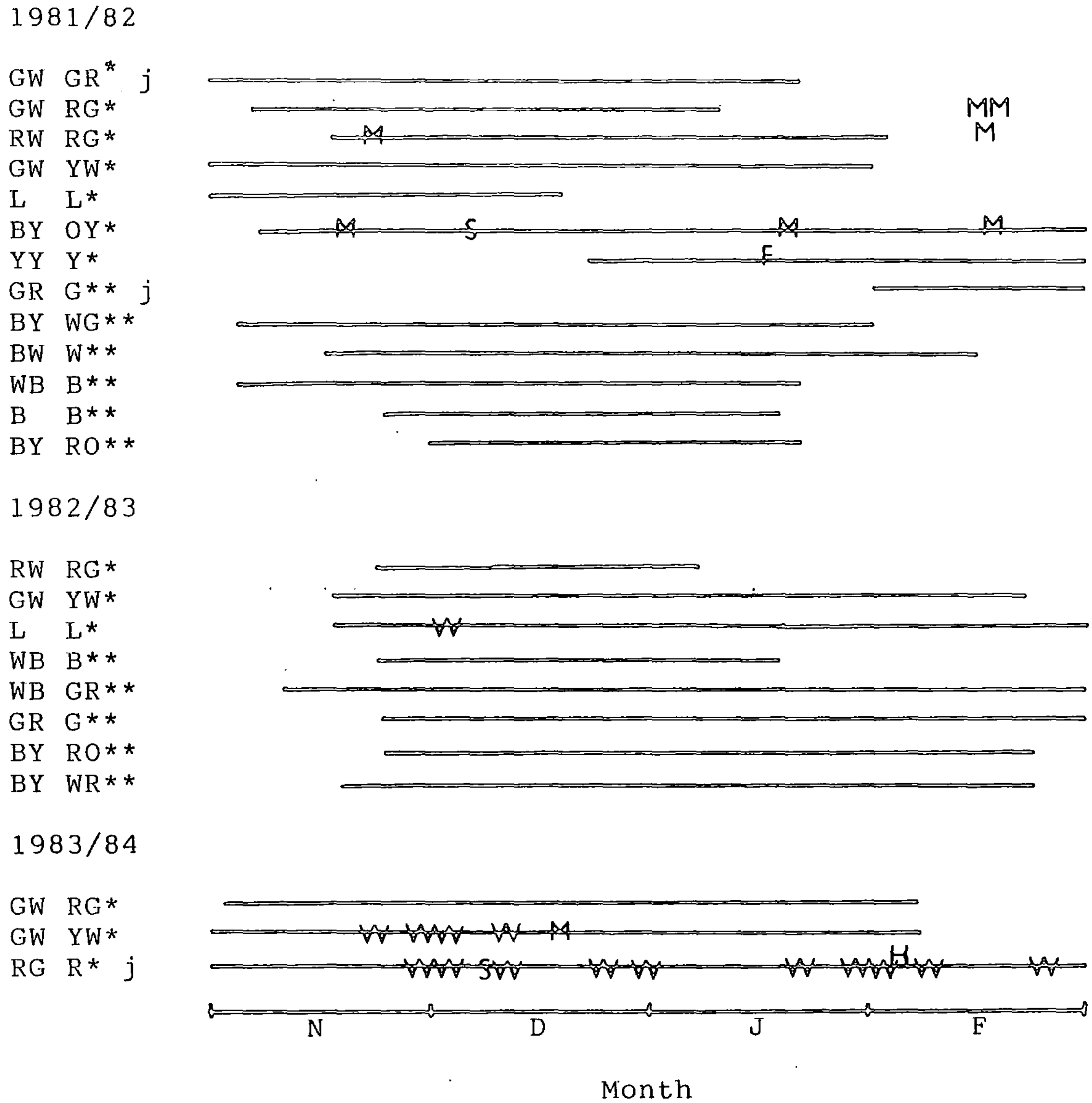
Semi-mobile birds moved between north and south shores of the River Tees, sometimes within a single high water plus low water phase, or from Crimdon to north and/or south shores of the river. The extent of movement varied from one individual to another, as would be expected if there is a spectrum of mobility displayed by sanderlings. Some of these birds showed site preference in as much as they were seen more often at one site than at others.

3) Resident

Resident sanderlings were seen, predominantly, south of the River Tees, exceptions being single sightings north of the river, particularly at Crimdon in late February.

No significant difference was apparent in the distribution of adults and juveniles amongst the winter mobility categories Table 3: $X^2$ = 1.09; df = 2). About 50% were residents, 30% were semi-mobile and less than 20% were itinerant at times. Similarly, no distinct difference was observed between the distributions of male and female sanderlings (using Wood's discriminant 1987) amongst winter mobility categories (Table 3a: $X^2$ = 0.06; df = 1; P = NS).

Fig 27 Duration of apparent absences from Teesside of sanderlings thought to be itinerant, compared with those known to move away during the period November to February




* known movers
**suspected itinerant birds
—— 'absence' from Teesside except:-
S sighting on the south shore of the River Tees
M sighting at St. Mary's Island
W sighting at Whitburn
H sighting at Hendon, Tyne & Wear
F sighting at Filey, North Yorkshire

Table 3 Summary of timing of use of Teesside and degree of mobility adopted there by adult and juvenile sanderlings

| Timing of visit to Teesside | Mobility category | Adult | Juvenile |
|---|---|---|---|
| autumn &/or spring passage | | 8 | 4 |
| winter | (resident | 75 | 23 |
| | (semi-mobile | 43 | 17 |
| | (itinerant | 21 | 10 |
| | Total | 147 | 54 |

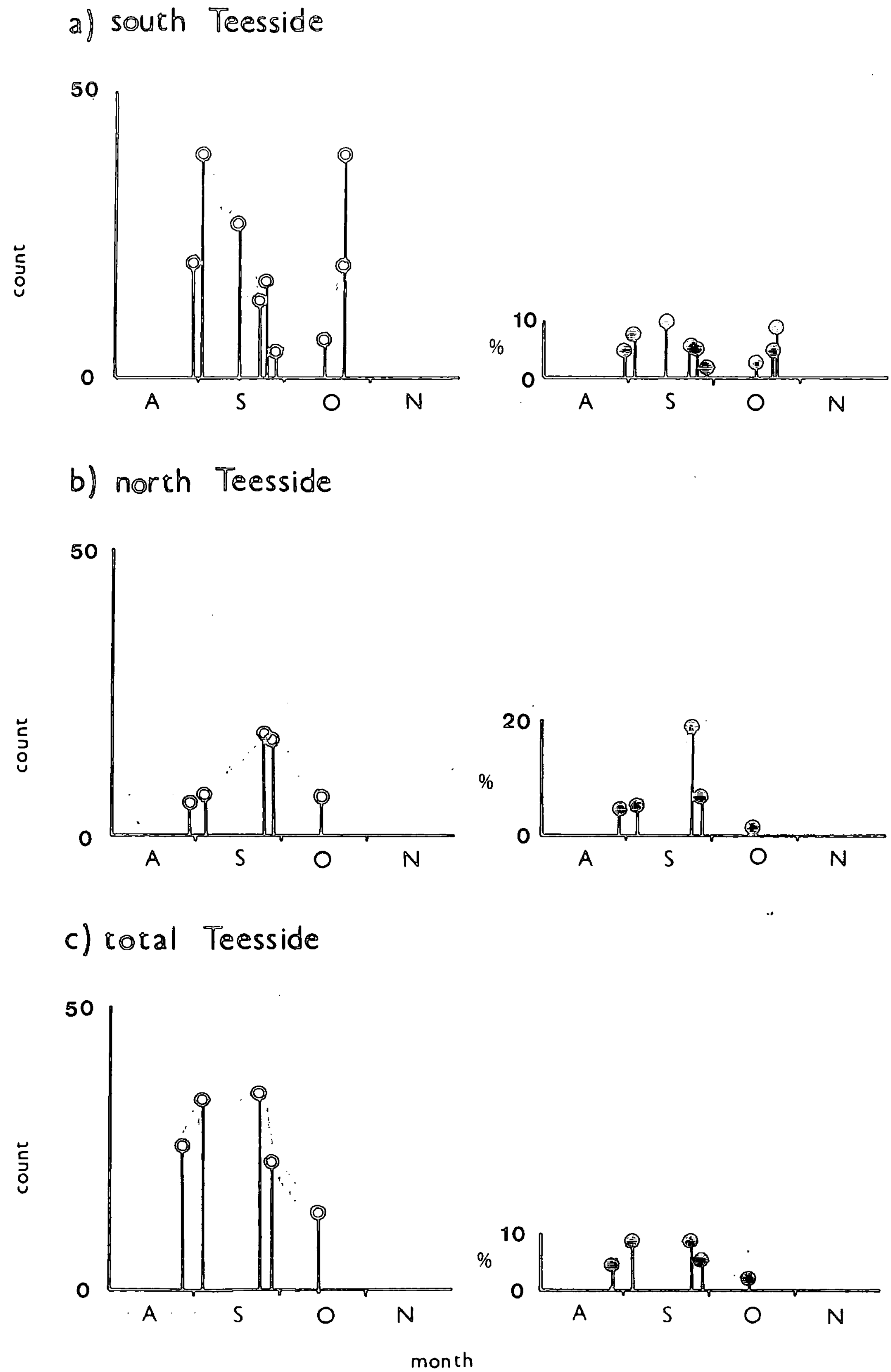
Table 3a Summary of winter mobility of male and female sanderlings at Teesside

| Mobility category | Male | Female |
|---|---|---|
| resident | 17 | 8 |
| semi-mobile | 13 | 4 |
| itinerant | 0 | 0 |
| Total | 30 | 12 |

## Arrivals, departures and mobility of juvenile sanderlings

Juveniles arrive at Teesside from late August, reaching peaks during September (Fig 28 ) and late October, coinciding with high total counts of sanderlings at Teesside (Figs 5). Onward migration is indicated for some early arrivals since the proportion of juveniles decreases following the September peak (Fig 28 ) and few juveniles colour-ringed in August or September have been seen throughout the winter (Table 4). Most juveniles colour-ringed during October and November spent at least part of the winter at Teesside (Table 4), but at least one apparently moved on. All juveniles colour-ringed in December to February were seen later during the winter (Table 4).

Fig. 28 Counts and proportions of juvenile sanderlings at Teesside 1983 84



Of 81 sanderlings colour-ringed as juveniles, only 4 were not seen again. Forty two of the juveniles, returning to Teesside as adults, were seen in the moulting flock irrespective of date colour-ringed as juveniles (Table 5: $X^2 = 4.03$; df = 1; $P < 0.05$). Forty five sanderlings provided adequate information to compare their mobility as juveniles with, subsequently, their mobility as adults (Table 6; Appendix I). There appears to be a slight reduction in mobility, but this is not significant (Table 6: $X^2 = 0.99$; df = 2; P = NS).

Table 4 Subsequent sightings, in the same non-breeding season, of juvenile sanderlings colour-ringed in different months (1978 - 1984) at Teesside

| date cr* | total juvs cr | not seen again | seen autumn &/or spring | seen winter |
|---|---|---|---|---|
| Aug/Sept | 6 | 1 | 3 | 2 |
| Oct/Nov | 45 | 3 | 1 | 41 |
| Dec-Feb | 30 | 0 | 0 | 30 |
| Total | 81 | 4 | 4 | 73 |

Table 5 Dates of return to Teesside, as adults, of juveniles colour-ringed in different months

| | date of return | |
|---|---|---|
| date cr* | July - Sept (moulting flock) | Oct - Nov (post moult) |
| Aug-Oct | 29 | 4 |
| Dec-Feb | 13 | 9 |
| Total | 42 | 13 |

*cr = colour-ringed

Table 6 Summary of behaviour of sanderlings at Teesside as juveniles and, subsequently, as adults

| Strategy | Juvenile | Adult |
|---|---|---|
| autumn &/or spring passage | 4 | 5 |
| resident | 15 | 19 |
| semi-mobile | 16 | 13 |
| itinerant | 10 | 8 |
| total | 45 | 45 |

Mobility of several individuals as juveniles support the theory of exploratory flights being made (Baker 1980) in order to establish the behaviour pattern which will be adopted as an adult:-

W RG was seen at Teesside in November and December 1982, immediately following colour-ringing. It was next seen at Teesside, as an adult, during autumn passage in 1984.

GW GR was apparently absent from Teesside from late October, after colour-ringing as a juvenile, until late January (Fig 27). As an adult, this bird was considered to be resident at Teesside in winter, because it was seen there regularly throughout the non-breeding season.

GW YO was seen at Teesside in its first winter but was thought to be absent from the latter half of November until late January. As an adult, this bird was seen at Teesside only in February of winters 1983 and 1984.

Unfortunately, many juveniles were caught and colour-ringed in January and February and could not be assigned to mobility categories as juveniles because they were, consequently, seen for only part of the winter.

Mobility of adult sanderlings

Generally, adults maintained a similar behaviour pattern from year to year, both in timing of arrival at Teesside (Table 7) and degree of mobility adopted there. There was no significant difference in degree of mobility of birds moulting at Teesside and those moulting before arrival at Teesside (Table 7: $X^2 = 0.98$; df = 2; P = NS).

Of 147 colour-ringed adult sanderlings observed, only 5 were thought to change their use of Teesside from year to year (Tables 3 & 7). All 5 were considered to be itinerant in one or more winters. Two birds - BW Y and YY Y - moved away from Teesside in midwinter 1981/82. In other years, they had been considered to be semi-mobile, one moulting at Teesside and the other arriving after moulting elsewhere. Three Tees moulters - BY RO, BY WR and WB GR - were thought to move away from Teesside for most of one or more winters (Fig 27), having spent most of other winters south of the River Tees.

Table 7 Summary of behaviour adopted by adult sanderlings in relation to presence in or absence from the moulting flock at Teesside

| strategy | moult at Teesside | moult before arrival at Teesside |
|---|---|---|
| resident | 50 | 25 |
| semi-mobile | 32 | 11 |
| itinerant | 12 | 4 |
| change | 4* | 1** |
| total | 98 | 41 |

* 3 resident to itinerant; 1 semi-mobile to itinerant
** 1 semi-mobile to itinerant

Comparison of the behaviour of adults and juveniles

Competition between adults each year to establish winter behaviour patterns seems unlikely since most adults repeated their movement behaviour each year, and no difference was apparent in arrival date and subsequent mobility. Also, comparison of body size of different mobility groups showed little variation (Tables 8 & 9).

So, are many juveniles forced into mobility through competition with adults or with other juveniles? Juveniles tend to have shorter wings than adults, but the differences between means are mostly less than 2 mm. No significant difference was registered in culmen length of adults and juveniles. No difference in body size was detected for juveniles of differing mobility.

Table 8 Body size and mobility of Teesside sanderlings

| sample | measurement (mm) | Adult $\bar{x}$ | se | n | Juvenile $\bar{x}$ | se | n |
|---|---|---|---|---|---|---|---|
| all birds | wing | 127.18 | ± 0.26 | 174 | 125.60 | ± 0.45 | 48 |
| | culmen | 24.71 | ± 0.11 | 170 | 24.73 | ± 0.19 | 49 |
| resident | wing | 126.91 | ± 0.52 | 43 | 125.91 | ± 0.64 | 17 |
| | culmen | 24.36 | ± 0.19 | 47 | 24.56 | ± 0.28 | 16 |
| semi-mobile | wing | 127.03 | ± 0.59 | 28 | 124.67 | ± 0.96 | 15 |
| | culmen | 24.43 | ± 0.25 | 28 | 24.16 | ± 0.40 | 12 |
| itinerant | wing | 126.60 | ± 2.06 | 5* | | | * |
| | culmen | | | * | | | * |

* samples too small to test    $\bar{x}$ = mean; se = standard error; n = sample size

Wing length can be an unsatisfactory measure of body size (Pienkowski & Minton 1973) owing to abrasion and variations between moults in an individual as well as errors which may account for differences of the magnitude observed. Year to year differences of up to 6 mm were recorded for wing lengths of Teesside sanderlings - nearly 5% variation.

Culmen length is a short measurement with small differences registered between means; too small to indicate any statistical significance.

Total head-length was available for too few sanderlings to be considered in these analyses.

Thus analyses of biometrics are inconclusive in determining whether competition leads to some juveniles tending to greater mobility. However, competition seems an unlikely cause because average differences in body size are small.

Table 9 Student's 't' distributions for paired samples of sanderling biometrics, comparing age and mobility

| sample | wing | culmen |
|---|---|---|
| ad v j | t = 3.04 P 0.001 | t = 0.09 P = NS |
| r ad v ½ ad | t = 0.15 P = NS | t = 0.22 P = NS |
| r j v ½ j | t = 1.07 P = NS | t = 0.82 P = NS |
| r ad v r j | t = 1.21 P = NS | t = 0.59 P = NS |
| ½ ad v ½ j | t = 2.09 $P < 0.05$ | t = 0.57 P = NS |
| r ad v i ad | t = 0.15 P = NS | t * |
| ½ ad v i ad | t = 0.20 P = NS | t * |

ad = adult; j = juvenile
r = resident; ½ = semi-mobile; i = itinerant
* samples too small

Survival Rates

Sanderling survival rate was generally high (Tables 10 & 11 a & b), particularly when considering these estimates to be minima. Juveniles displayed a higher winter survival rate than adults in the period 1979/80 to 1982/83 for which a comparison could be made (Table 10: $X^2 = 4.17$ with Yates' correction; df = 1; P = 0.05).

Table 11a Comparison of adult survival rates in winter and during the breeding season (data assembled from Table 10)

| | survival rate | presumed dead | % survival rate |
|---|---|---|---|
| winter | 444 | 42 | 91.3% |
| breeding season | 394 | 50 | 88.7% |

Table 11b Winter survival rates of male and female sanderlings combined for 1981/82, 1982/83 and 1983/84

| | survive to following winter | presumed died during winter | % survival rate |
|---|---|---|---|
| Male | 74 | 10 | 88.1% |
| Female | 36 | 6 | 85.7% |

Where year to year comparisons of adult survival rates were possible, no significant differences were detected in winter, breeding season, or overall survival rates, with one exception. The exception was lower annual survival rate in 1981/82 than in 1979/80 (Table 10: $X^2 = 4.50$ with Yates' correction; df = 1; $P < 0.05$). Winter and breeding season survival rates did not differ appreciably (Table 11a: $X^2 = 1.50$ with Yates' correction; df = 1; P = NS).

Combining the three winters of severe weather conditions

Table 10 Estimated winter and summer survival rates of colour-ringed[1] sanderlings at Teesside

| Year | no. cr[1] at start of winter* | no. new cr during year | | total cr observed during year | | survivors at end of winter (%) | | survivors at end of following breeding season (%) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ad | Juv | Ad | Juv | Adult | Juvenile | Adult | Juvenile |
| 1975/76 | 0 | 4 | 0 | 4 | 0 | 4 (100) | - | 4 (100) | - |
| 1976/77 | 4 | 38 | 0 | 42 | 0 | 41 (97.6) | - | 38 (92.7) | - |
| 1977/78 | 38 | 0 | 0 | 38 | 0 | 37 (97.4) | - | 35 (94.6) | - |
| 1978/79 | 35 | 17 | 0 | 52 | 0 | 45 (86.5) | - | 41 (91.1) | - |
| 1979/80 | 41 | 4 | 8 | 45 | 8 | 41 (91.1) | 8 (100) | 39 (95.1) | 8 (100) |
| 1980/81 | 47 | 45 | 13 | 92 | 13 | 84 (91.3) | 13 (100) | 73 (86.9) | 13 (100) |
| 1981/82 | 86 | 36 | 31 | 122 | 31 | 101 (82.8) | 29 (93.5) | 84 (83.2) | 25 (86.2) |
| 1982/83 | 109 | 1 | 11 | 110 | 11 | 95 (86.4) | 11 (100) | 84 (88.4) | 11 (100) |
| 1983/84 | 95 | 1 | 11 | 96 | 11 | ** | ** | ** | ** |

* All juveniles surviving to one year are classified as adults here.
**Fieldwork terminated before timing of mortality could be established.

Each year represented here starts in July; winter ends at the end of February.

(Table 12); namely 1978/79, 1981/82 and 1982/83, and comparing them with other winters yielded a significantly poorer survival rate than in the first mentioned winters (Table 10: $X^2 = 8.37$ with Yates' correction; df = 1; $P < 0.005$).

Table 12 Timing of winter mortality of colour-ringed sanderlings in cold winters at Teesside

| | periods of severe weather | | | | | |
|---|---|---|---|---|---|---|
| | 1978/79 | | 1981/82 | | 1982/83 | |
| | 29 D - 31 J* | 1-28 F* | 7-29 D | 6-16 J | 15-20 D | 28 J - 11 F |
| cold weather mortality | 4 | 2 | 5 | 4 | 7 | 5 |
| total | 6 | | 9 + 9 (F)** | | 12 | |
| total winter mortality | 7 | | 21 | | 15 | |
| % winter mortality in or following cold spell | 85.7% | | 85.7% | | 80.0% | |

* source of severe weather dates - Davidson 1982a
**probably died as a result of severe weather
D = December; J = January; F = February

The degree of mobility adopted in winter by adult sanderlings did not affect their survival rate (Table 13, Fig 29: $X^2$ comparisons all P = NS).

The sample of colour-ringed sanderlings which could be sexed using Wood's discriminant function (Wood 1987) showed no significant difference in survival rate of males and females (Table 11b: $X^2 = 0.01$ with Yates' correction; df = 1; P = NS). This result must be treated with caution for the reasons given by Wood.

Table 13 Annual disappearance/mortality of colour-ringed[1] sanderlings at Teesside

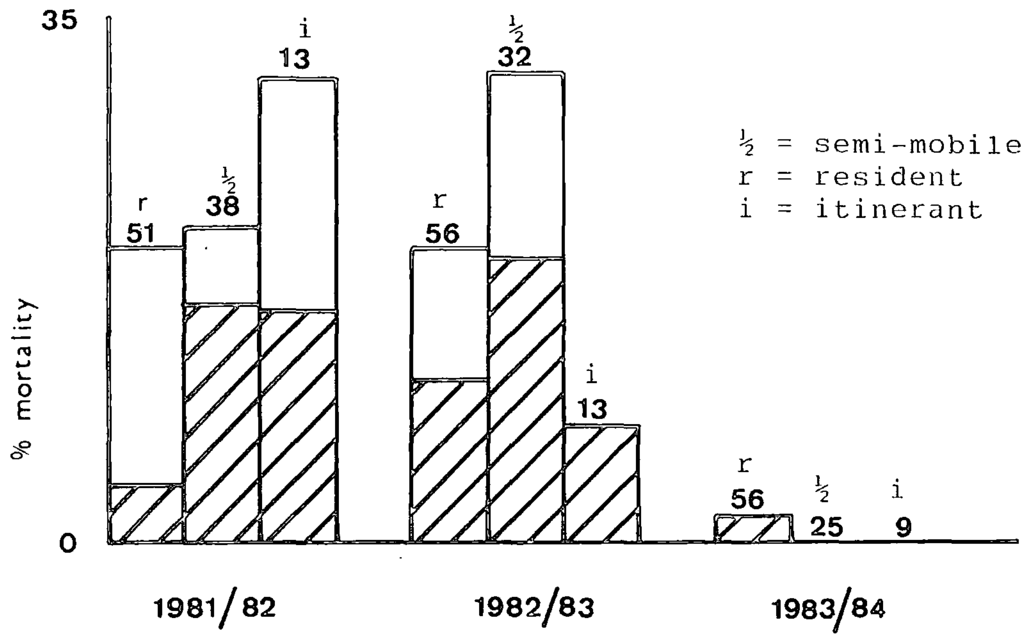
| | year | cr[1] present early winter | mortality by end of winter (%) | mortality before following autumn | total mortality (%) |
|---|---|---|---|---|---|
| r ad | 1981/82 | 51 | 2 ( 3.9) | 8 | 10 (19.6) |
| | 1982/83 | 56 | 6 (10.7) | 5 | 11 (19.6) |
| | 1983/84 | 56 | 1 ( 1.8) | - | - |
| ½ ad | 1981/82 | 38 | 6 (15.8) | 2 | 8 (21.0) |
| | 1982/83 | 32 | 6 (18.8) | 4 | 10 (31.2) |
| | 1983/84 | 25 | 0 | - | - |
| i ad | 1981/82 | 13 | 2 (15.4) | 2 | 4 (30.8) |
| | 1982/83 | 13 | 1 ( 7.7) | 0 | 1 ( 7.7) |
| | 1983/84 | 9 | 0 | - | - |
| r j | 1981/82 | 4 | 0 | 0 | 0 |
| | 1982/83 | 5 | 0 | 0 | 0 |
| | 1983/84 | 8 | 0 | - | - |
| ½ j | 1981/82 | 4 | 0 | 0 | 0 |
| | 1982/83 | 4 | 0 | 0 | 0 |
| | 1983/84 | 1 | 0 | - | - |
| i j | 1981/82 | 5 | 0 | 1 | 1 (20.0) |
| | 1982/83 | 1 | 0 | 0 | 0 |
| | 1983/84 | 1 | 0 | - | - |

N.B. Birds were included in calculations of mortality of a particular category only in the years they were considered to belong to that group, c.f. itinerant birds.

Most of the mortality occurred during or soon after the periods of harshest weather (Table 12). The cold spell of 1978/79 came in January and February (Davidson 1982a & b) when temperatures were slightly less severe but wind speeds greater than in 1981/82. Unfortunately, only seven suspected instances of mortality in these years were confirmed by the finding of corpses.

Inspection of last sightings dates at Teesside each year for colour-ringed sanderlings indicate early departures in some years by a few individuals (Table 14), particularly in 1978/79 (2), 1981/82 (4) and 1982/83 (5). All except one have been seen back at Teesside in subsequent winters. That this single bird departed early, rather than died at Teesside, was confirmed by a sighting at Monifieth, near Dundee, on 7 February 1982. Since lower survival rate was registered in these 3 winters, the early departures may represent attempts to find more favourable conditions.

Fig 29 Annual and winter (November to March) percentage disappearance/mortality of colour-ringed adult sanderlings at Teesside in 1981/82, 1982/83 and 1983/84




N.B. each bar represents total annual losses, with the hatched portion representing winter losses.

Table 14 Unusually early departure dates from Teesside indicated by date of last sighting in some winters

| Colour-ring | Date last seen |
|---|---|
| BW B | 07.05.80 |
| | 07.04.81 |
| | 15.02.82* |
| | 19.01.83* |
| BW Y | 28.03.79 |
| | 24.01.80* |
| | 21.03.81 |
| | 01.02.82* |
| LW Y | 26.02.79* |
| | 09.04.80 |
| | 17.03.81 |
| | 05.05.82 |
| | 23.04.83 |
| Y R | 08.03.79* |
| | 09.04.80 |
| | 07.05.81 |
| | 23.03.82 |
| O R | 18.04.79 |
| | 01.05.80 |
| | 23.04.81 |
| | 06.05.82 |
| | 22.02.83* |
| | 08.05.84 |
| GO Y | 23.02.82* |
| | 15.03.83 |
| | 17.05.84 |
| WB WG | 05.05.82 |
| | 23.01.83* |
| | 04.05.84 |
| GY W | 28.04.82 |
| | 23.02.83* |
| YY W | 22.04.82 |
| | 07.03.83* |
| | 21.04.84 |

Meteorological Data

Table 15 provides a summary of wind speeds at Teesmouth and air temperatures at Hartlepool. Details are given in Appendix V.

Table 15 Summary of wind speed for Teesmouth (knots) and air temperature ($^{o}C$) for Hartlepool

| | wind speed (knots) | | | temperature $^{o}C$ | |
|---|---|---|---|---|---|
| | | | no. days | no. days sub zero | |
| Month | monthly $\bar{x}$ wind | no. days $\bar{x}$ $\geq$ 25 knots | max gust $\geq$ 40 knots | minima (min temp) | maxima |
| Nov 81 | 17.1 | 4 | 10 | 0 | 0 |
| Dec 81 | 14.7 | 1 | 5 | 17 (-9.5) | 0 |
| Jan 82 | 14.2 | 0 | 8 | 11 (-9.7) | 2 (-2) |
| Feb 82 | 14.2 | 0 | 5 | 6 (-3.0) | 0 |
| Mar 82 | 16.0 | 4 | 12 | 0 | 0 |
| Nov 82 | 16.3 | 4 | 12 | 3 (-0.5) | 0 |
| Dec 82 | 14.9 | 3 | 8 | 19 (-3.9) | 0 |
| Jan 83 | 21.4 | 7 | 23 | 3 (-1.8) | 0 |
| Feb 83 | 15.5 | 5 | 8 | 15 (-4.7) | 0 |
| Mar 83 | 16.2 | 3 | 7 | (-0.8) | 0 |
| Nov 83 | 11.9 | 0 | 0 | 6 (-5.2) | 0 |
| Dec 83 | 17.2 | 4 | 11 | 6 (-4.8) | 0 |
| Jan 83 | 19.0 | 7 | 16 | 11 (-4.3) | 0 |
| Feb 84* | 21.3* | 3* | 8* | 6* (-3.6) | 0 |
| Mar 84 | - | - | - | (-0.3) | 0 |

*Records of wind speed at Teesmouth ceased 09.02.84, so these averages are over 9 days.

1 knot = 1.84 km/h $\bar{x}$ = mean wind speed

The winter of 1981/82 was cold with prolonged periods of low temperatures during 7 - 29 December and 6 - 16 January. Winds, generally, were light to moderate. The winter of 1982/83 generally, was mild but winds often were strong. Wind chill was likely during mid-December and early February. The winter of 1983/84 was milder than 1981/82, but winds often were stronger. Wind chill was likely, particularly in January.

Macroinvertebrate Sampling and related Sanderling Distribution

The results of the sampling at Marske Sands are shown in Figs 30 - 33 and Appendix VI. In November 1981, T13 contained the highest densities of the sampling transects on Marske Sands (Figs 30, 31 & 33), particularly of Bathyporeia pelagica (Fig 30, Table 16). The sediments here were the finest sampled (Table 17). B. pelagica and Scololepis squamata (also known as Nerine cirratulus) were the main macroinvertebrates and occurred at highest densities at 60 m - 90 m and 60 m below HWN (high water neaps), respectively (Fig 31). Haustorius arenarius and Eurydice pulchra were found at low densities and only in T10 and T13 (Fig 32 & 33). H. arenarius had a lower shore distribution, the highest densities occurring at 130 m, whilst E. pulchra was found mostly in the mid-tide region at 80 m. T11 and T12 had coarse sediments (Table 17) and a poor fauna (Figs 30 - 33, Table 16).

Table 16 Paired 't' test comparisons of distributions of Bathyporeia pelagica (B.p.) and Scololepis squamata (S.s.) both between transects in November 1981 and within transects between November 1981 and February 1982

November v February

| | Transect | 't' | df | P |
|---|---|---|---|---|
| B.p. | T10 | 2.26 | 4 | NS |
| | T13 | 2.57 | 6 | $< 0.05$ |
| S.s. | T10 | 1.96 | 4 | NS |
| | T13 | 0.56 | 3 | NS |

Comparisons of transects in November

| | Transect | 't' | df | P |
|---|---|---|---|---|
| B.p. | T10 v T11 | 1.00 | 2 | NS |
| | T11 v T13 | 8.65 | 2 | $< 0.05$ |
| | T10 v T13 | 4.83 | 5 | $< 0.05$ |
| S.s | T10 v T13 | 1.41 | 7 | NS |

KEY to Figs 30 - 33

| | |
|---|---|
| ns | not sampled |
| | absent |
| | 1 - 200 $m^{-2}$ |
| | 200 - 500 $m^{-2}$ |
| | 500 $m^{-2}$ |

Fig 30 Downshore distribution of _Bathyporeia pelagica_ on Marske Sands

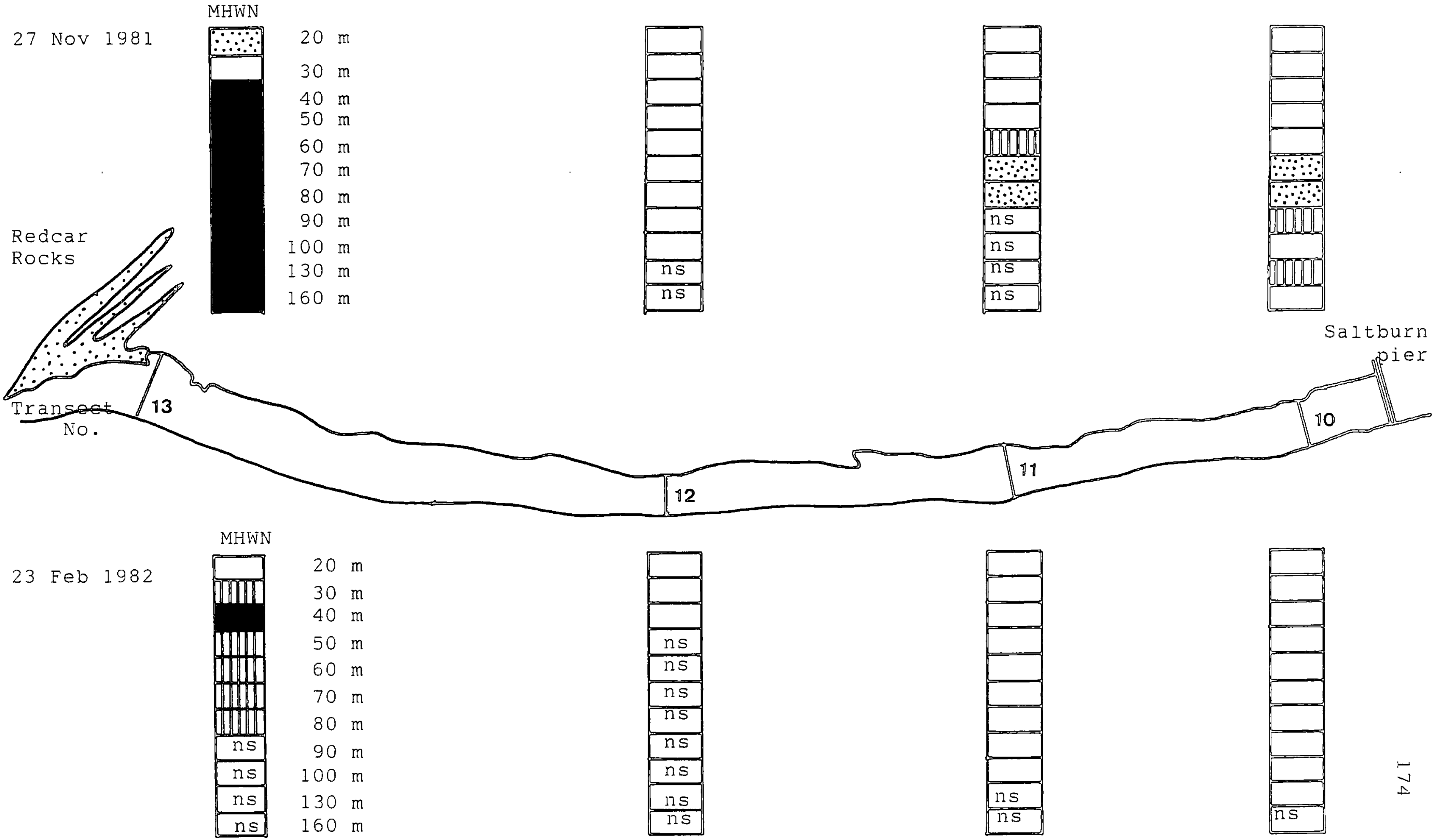


Fig 31 Downshore distribution of *Scololepis squamata* (also known as *Nerine cirratulus*) on Marske Sands

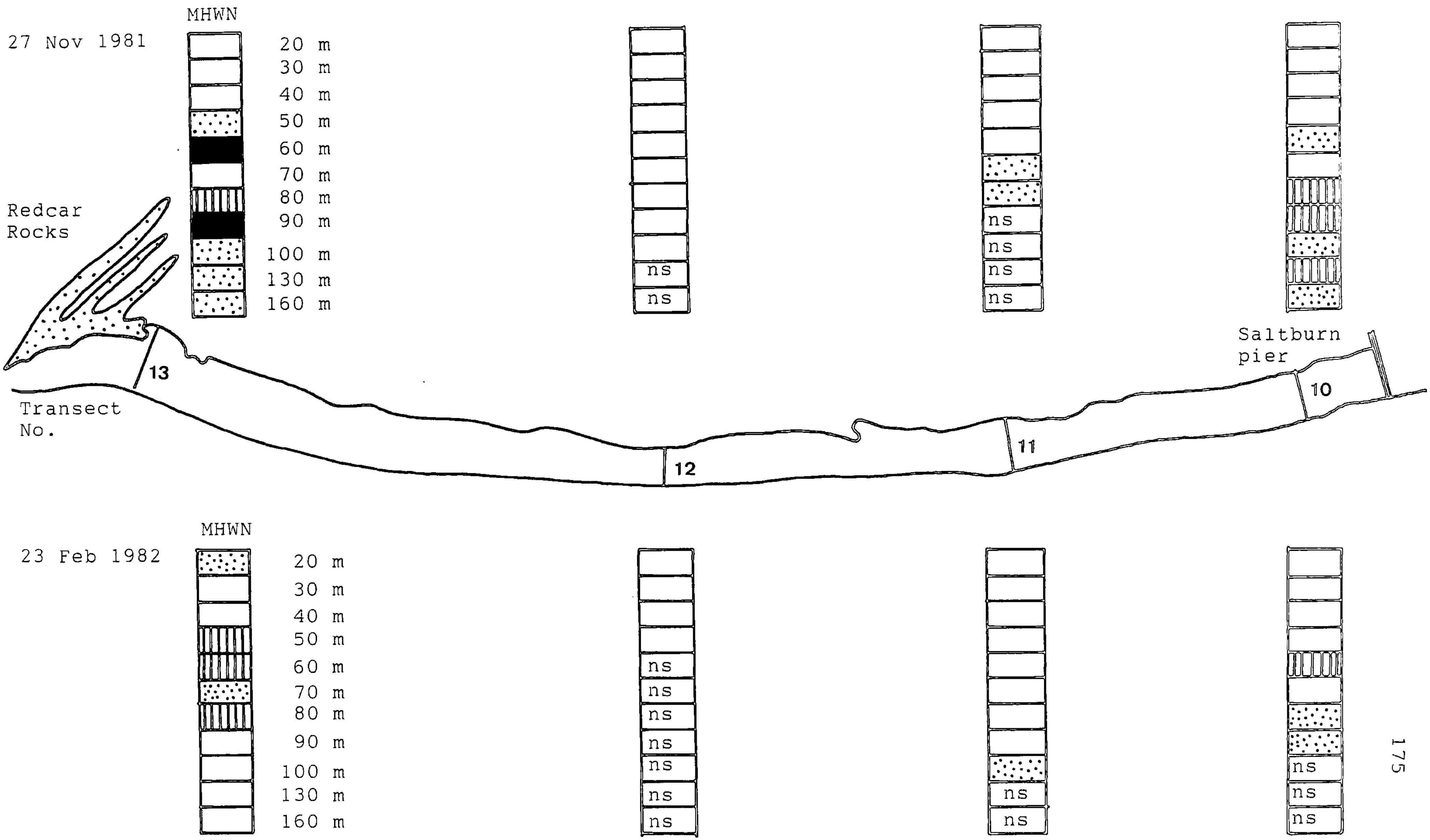
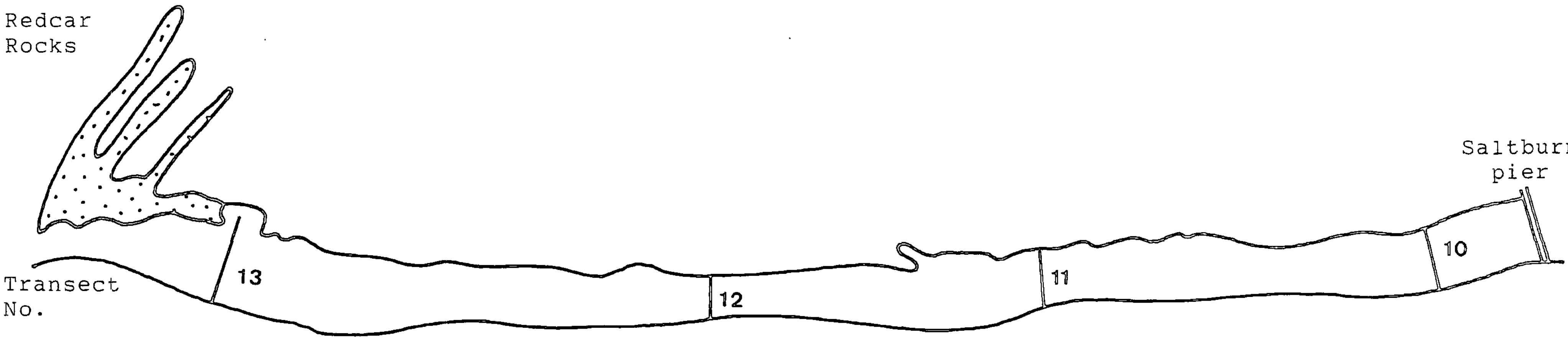


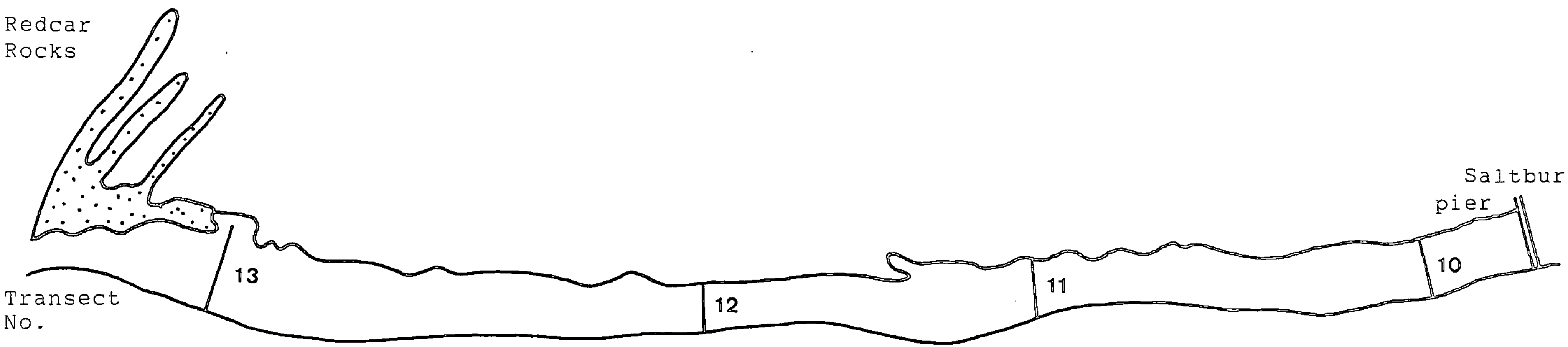
Fig 32 Invertebrate sampling at Marske Sands: Mean densities per downshore transect for each sampling date ($m^{-2}$)




| Species | 13 | 12 | 11 | 10 | Date |
|---|---|---|---|---|---|
| *Haustorius arenarius* | 23 | 0 | 0 | 9 | 27 Nov 1981 |
| | 0 | 0 | 0 | 0 | 23 Feb 1982 |
| *Bathyporeia pelagica* | 1973 | 0 | 70 | 64 | 27 Nov 1981 |
| | 429 | 0 | 0 | 0 | 23 Feb 1982 |
| *Scololepis squamata* | 250 | 0 | 30 | 100 | 27 Nov 1981 |
| | 171 | 0 | 6 | 35 | 23 Feb 1982 |
| *Eurydice pulchra* | 9 | 0 | 0 | 27 | 27 Nov 1981 |
| | 0 | 0 | 0 | 0 | 23 Feb 1982 |

Fig 33 Maximum densities ($m^{-2}$) along each downshore transect on Marske Sands of invertebrates sampled

| | | | | | |
|---|---|---|---|---|---|
| *Haustorius arenarius* | 50 | 0 | 0 | 150 | 27 Nov 1981 |
| | 0 | 0 | 0 | 0 | 23 Feb 1982 |




| | | | | | |
|---|---|---|---|---|---|
| *Bathyporeia pelagica* | 4250 | 0 | 200 | 350 | 27 Nov 1981 |
| | 1200 | 0 | 0 | 0 | 23 Feb 1982 |
| *Scololepis squamata* | 1200 | 0 | 100 | 250 | 27 Nov 1981 |
| | 450 | 0 | 50 | 200 | 23 Feb 1982 |
| *Eurydice pulchra* | 50 | 0 | 0 | 100 | 27 Nov 1981 |
| | 0 | 0 | 0 | 0 | 23 Feb 1982 |

Table 17 Marske Sands sediment properties

| Transect | Station | Ø | Sorting coefficient* |
|---|---|---|---|
| T10 | 20 m | 0.85 | 1.37 |
| | 60 m | 1.15 | 0.32 |
| | 100 m | 1.10 | 0.52 |
| | 160 m | 1.20 | 0.46 |
| T11 | 20 m | -0.10 | 1.17 |
| | 60 m | too coarse for measurement on this scale | |
| | 100 m | 0.65 | 0.62 |
| T12 | 20 m | 1.00 | 0.62 |
| | 60 m | -0.10 | coarse |
| T13 | 100 m | 1.30 | 0.25 |
| | 160 m | 1.25 | 0.30 |

Ø = median particle size

* see Methods section for definition

By February, there were decreases in prey densities, although only in T13 were any significant decreases recorded; for B. pelagica (Table 16: 't' = 2.57; df = 6; $P < 0.05$). Peak densities of B. pelagica and S. squamata occurred at 40 m and 50 - 60 m but, unfortunately, samples were not taken below 80 m so the possibility of downshore movement cannot be ruled out. Brearey (1982) found downshore movement of B. pelagica but not of S. squamata.

Comparison of sampling of Marske Sands in winter 1981/82 with sampling of Coatham Sands in winters 1977/78 and 1978/79 (Brearey 1982) is complicated by annual variations in prey densities. However, some general trends were observed. Coatham Sands held far higher densities of S. squamata and E. pulchra, up to maxima of, respectively, 2 950 $m^{-2}$ and 2 400 $m^{-2}$ in November and 3 950 $m^{-2}$ and 3 800 $m^{-2}$ in February, compared with 1 200 $m^{-2}$ and 100 $m^{-2}$ in November and 450 $m^{-2}$ and none in February on Marske Sands. For B. pelagica, T13 was comparable with the highest densities on Coatham Sands, otherwise Marske Sands had lower densities than Coatham Sands in November and February.

Most of Marske Sands would appear to be a poorer feeding habitat, in terms of its resident fauna in the sediments, than Coatham Sands. Sanderlings fed there from late September/ early October until spring (Figs 12 & 13), mainly as they dispersed from the roost at Saltburn and made their way to Redcar Rocks or when wrack was washed ashore, in which case they would remain to feed there (Figs 16 & 17). T13, at the Redcar end of Marske Sands, forms an extension of the shore adjacent to Redcar Rocks and is used for feeding as the flood tide inundates the rocks.

Table 18 Comparison of sanderling numbers for sections of Marske Sands corresponding to macroinvertebrate sampling transects

| | Transect | | |
|---|---|---|---|
| | T13 | T10 | T11/12 |
| no. counts | 33 | 29 | 29 |
| average count | 189.61 | 126.55 | 36.21 |
| standard error | 25.24 | 18.30 | 9.52 |

| | | | |
|---|---|---|---|
| T13 v T11/12 | t = 5.69 | df = 60 | $P < 0.001$ |
| T13 v T10 | t = 2.02 | df = 60 | $P < 0.05$ |
| T10 v T11/12 | t = 4.38 | df = 56 | $P < 0.001$ |

Counts for sections corresponding to macroinvertebrate sampling transects (Appendix VII) were compared using Student's 't' test. Counts made when wrack was present on the shore were excluded in order to test the distribution of sanderlings in relation to resident invertebrates. Ranked in order of decreasing counts of sanderlings; T13 > T10 > T11/12 (Table 18), i. e. most sanderlings were seen at the Saltburn end or by Redcar Rocks, coinciding with the richer feeding patches on Marske Sands, as would be expected.

T10 and T13 had comparable or slightly higher densities of S. squamata and B. pelagica than Seaton Sands (Davidson & Evans 1981) in winter, and had more Haustorius arenarius.

Whether the decreases in densities of sandy shore fauna recorded on Marske Sands in February 1982 were due to depletion or downshore migration, the results indicate a probable reduction in available prey in late winter. If this is so, then sanderlings may be more reliant on other sources of food if the shortage of sand invertebrates is critical.

## DISCUSSION

Winter gales combine with spring tides to produce storm tides which scour the beaches, removing sand and the fauna therein and alter, radically, the topography. Species such as Bathyporeia pelagica and Eurydice pulchra, both important prey animals for sanderlings (Brearey 1982 unpubl) become pelagic at such times (Perkins 1974). Low temperatures lead to down-shore migration and reduced activity of intertidal invertebrates. Pienkowski (1983) found little activity by crustaceans such as B. pelagica at temperatures of 4 $^{o}$C or less. Consequently, sandy shore invertebrates are subject to considerable variations in their availability to sanderlings. Wind speeds of about 35 knots or more were seen to impede feeding as sand blow was severe (pers. obs.).

Strong wave action rips kelps and mussels from lower tidal areas and they are deposited on beaches in varying quantities with coal dust, depending on whether subsequent spring tides remove them. These wrack beds are often available during neap tides in winter, but their location is determined by prevailing winds.

The kelp constituent of wrack provides the environment for development of coelopid larvae (Dobson 1974). There may be tiny flies, Thoracichaetae bosphori, mites and staphylinid beetles too, and Gammarus in the cool lower zone of the wrack bed (Rowell pers. comm.). Wrack beds provide an important feeding opportunity for sanderlings along the northeast coast of England, a feature noted elsewhere too, for example the Uists (Wells pers. comm.; pers. obs.).

Sanderlings feed on mussel fragments and spat deposited on the beaches under similar circumstances to wrack beds or at the same time. They will also clean out large mussels left by oystercatchers. At Redcar, fish cleaning operations provide scraps which attract feeding sanderlings. Sanderlings also feed on other seasonal items, such as sand eels and small crabs.

Thus it seems that the sanderling is capable of opportunistic foraging, presumably an adaptation to erratic feeding situations prevailing on Teesside - and probably other - beaches. Mobile birds may be better able to take advantage of sudden food sources, such as those offered by wrack beds, than sedentary birds.

If mobile sanderlings 'patrol' the coastline, they may locate suitable feeding situations by observing conspecifics feeding and/or by noting where wrack is present. Theories of roosts as centres of information exchange have been considered elsewhere (e.g. Ward & Zahavi 1973; Ydenberg & Prins in Evans et al 1984). Just how mobile sanderlings detect good feeding locations must remain speculation.

It is not known whether or not sanderlings can predict when and where a wrack bed may occur. Wind strength and direction dictate the duration and position of wrack beds, although the tidal influence is important.

Not all sanderlings identified as itinerant or semi-mobile were seen feeding at every wrack bed at Teesside. However, they may well have fed at other wrack beds along the northeast coast. The series of observations from 7 - 14 December 1983 coincided with the appearance of wrack on Marske Sands. Sightings of colour-ringed sanderlings indicated a build-up of itinerant and semi-mobile birds in successive days (Table 19 ).

Table 19 Build-up of colour-ringed itinerant and semi-mobile sanderlings at a developing wrack bed

| | | | |
|---|---|---|---|
| Date | 07.12.83 | 08.12.83 | 14.12.83 |
| High Water | 5.2 m | 5.0 m | 4.2 m |
| wrack* | sparse | thick | moderate |
| count on wrack | incomplete 100+ | 380 | 550 |
| cr check south shore Teesside | 400/370/62cr | 455/430/66cr | 550/525/76cr |
| itinerant/ semi-mobile cr sanderlings seen at wrack | | | |
| Adults | YB RB ½ | YB RB | YB RB |
| | RB RY ½ | RB RY | RB RY |
| | YG G ½ | | YG G |
| | | B G ½ | B G |
| | | OY R ½ | OY R |
| | | RW B ½ | RW B |
| | | YR RG ½ | YR RG |
| | | GW WY ½ | GW WY |
| | | GO Y ½ | |
| | | RG G ½ | |
| | | | RW RG i |
| | | | OR R i |
| | | | WB WY ½ |
| | | | GR W ½ |
| | | | WB GY ½ |
| | | | GW OR ½ |
| | | | YB RB ½ |
| Juveniles | | RG R i | |
| | | | RO G i |

*strong wind and wave action removed some of the wrack 09.12.83
cr = colour-ringed birds
½ = semi-mobile; i = itinerant

Overall numbers feeding on the wrack increased, presumably because, by 14 December, the coelopid larvae in the wrack which survived the spring tides may have reached the pupal stage. Coelopid development is temperature-dependent but the pupal stage is usually attained after about 7 days (Dobson 1974). The pupae occupy the upper zone of the wrack bed and so are readily accessible to foraging sanderlings (Rowell pers. comm.).

Of the three winters, covered by this study, 1983/84 produced the best combination of wind (Table 15) and tides for wrack availability. The gales also led to reduced sandy shore invertebrate densities by February. Sampling of macroinvertebrates on Coatham Sands on 8 February 1984 (Durham University MSc Ecology course) yielded low prey densities along the transects and intensive sampling of the Scololepis band, using an 8 x 8 quadrat of 10 $cm^3$ samples, yielded a total of only 2 Scololepis specimens (c. 3 $m^{-2}$).

The beaches froze at times during 1981/82 which reduced the availability of sandy shore prey. The tendency for mortality to occur after the cold spells (Table 10, Fig 29) as well as during them implies that, for some birds, other sources of food (e.g. occasional wrack) and fat reserves (Dugan et al 1981) lasted them through the cold spells. But some birds could not compensate for this depletion rapidly enough to avert starvation. Four juveniles disappeared in winter 1981/82, one during the December cold spell and another, found on 1 February 1982, presumably died during the January cold spell. The remaining two disappeared in February. However, the rather small samples of juveniles have shown better survival rates than adults (Table 10) although this may in fact represent greater site faithfulness owing to the way in which survival rates were estimated.

There remains a questionmark over why some birds move further than others. Exploratory movements by juveniles, for which there is some support in this work (but not substantiated statistically) and from other work at Teesside (Townshend unpubl.), may determine the behaviour to be adopted by sanderlings as adults. These exploratory flights may also provide a sanderling with optional sites to move to in severe winters or for part of each winter. Some birds were, apparently, itinerant only in some winters and these movements coincided with periods of cold weather. The movement away from Teesside by YY Y, in January 1982, to Filey in North Yorkshire, may represent a 'cold weather' movement in search of less severe conditions, as may unusually early departures from Teesside (Table 14). Cold weather movements have been documented elsewhere for a few other wader species, such as lapwings (e.g. Hale 1980) and grey plover (Townshend 1982). Generally, increased mobility in midwinter has been indicated in this thesis at times when peak numbers of sanderlings (perhaps including birds from the Wadden Sea?) occur at Teesside (e.g. Fig 4).

The hypothesis of competition leading to variations in sanderling mobility is not supported when points raised in the introduction to this chapter are reconsidered:-

1) If body size is a determinant of competitive strength, it seems unlikely that variations in mobility arise as a result of competition between juveniles, between adults and juveniles or between adults.
2) No statistically significant difference in the distribution of adults and juveniles, or males and females, amongst winter mobility categories was established.
3) Arrival date at Teesside had no apparent effect on the mobility behaviour adopted subsequently.
4) No survival advantage was evident for any one of the mobility categories.

Itinerant birds often returned to Teesside at times during the winter, contributing to peak counts in midwinter. If competition forced mobility on them, there would seem to be no advantages, particularly in the presence of large numbers of conspecifics, in returning to Teesside. The costs, in energetic terms, of moving there, combined with, presumably, poorer foraging in competition with resident birds would seem to quash competition as the cause of mobility variations. Estimates of survival rates indicate a balance of advantages maintaining a probable continuum of mobility. Competition would be unlikely to produce this result.

There was little behavioural indication of competition between colour-ringed birds, although aggressive encounters were commonplace between feeding sanderlings, particularly on mussels or sometimes on wrack beds. Possession of mussels or personal space were defended but territoriality was infrequent. Territoriality was observed on 3 occasions; on 19 November 1981, 19 January 1982 and 11 January 1984 involving 8, 2 and 1 territory holders respectively. All observations coincided with neap tides and involved linear territories (8 m - 100 m), initially close to the tide edge, defended on wet sand during the ebb tide. Boundaries were generally fixed, although some contraction and expansion were observed as more intruders came and went. On 19 January 1982, the 2 territories on Marske Sands were abandoned by HW + 2 hrs.. The intertidal area had been frozen at times during January 1982. The rise in temperatures, combined with the need to feed, presumably led to territoriality being worthwhile. However, common to all these instances was the persistence of intruders leaving little opportunity for feeding by the territory holder. Unfortunately, no marked birds were observed holding territories. Both juveniles and adults held territories at Crimdon on 19 November 1981.

The low incidence of territoriality at Teesside contrasts with findings at Bodega Bay, California, where territoriality is common although there is a wide variation in duration (Myers, Connors & Pitelka 1979a & b).

Both Bodega Bay and Teesside experience fluctuations in prey availability due to movements of sediments which may be critical at times (this study; Maron & Myers 1985). However, wind speeds at Teesside are generally higher (Table 20) which, combined with low temperatures, leads to greater wind chill. Thus conditions at Teesside appear to be harsher than at Bodega Bay and sanderlings have a greater reliance on a variety of mobile food sources. Territoriality may not be a sensible strategy if the food supply within its boundaries is subject to large fluctuations which at times include levels of food availability too low to sustain the territory holder. So, whilst similarities, in terms of returning to the same wintering area each year and exhibiting mobile and site faithful behaviour, exist between the sanderlings of Bodega Bay (Myers pers. comm.) and Teesside, there are differences arising from adaptations to different environments.

The balance of net advantages and disadvantages of differing sanderling mobility strategies, combined with the usually consistent mobility behaviour of individual sanderlings from year to year, lend support to the hypothesis of genetic control of sanderling mobility. This would obviate the need

Table 20 Comparison of mean annual wind speeds for Bodega Bay in California (Maron & Myers 1985) and Teesside (this study) for November to March km/h (knots)

| Year | Average annual wind speed Bodega Bay | Teesside |
|---|---|---|
| 1977/78) | | |
| 1978/79) | | |
| 1979/80) | 15.9 ( 8.6) | |
| 1980/81) | | |
| 1981/82) | | 28.2 (15.3) |
| 1982/83 | 21.2 (11.5) | 31.1 (16.9) |
| 1983/84 | | 30.4 (16.5) |

1 knot = 1.84 km

for exploratory behaviour by all juveniles, for which there is no proof in this thesis. However, the presence of some changes in individual behaviour indicate that genetic control of mobility, if it occurs, is modified by environmental adaptations, which permit increased mobility under certain circumstances (such as severe winter weather and consequent foraging hardship). The risks involved in moving to other sites would be too high if birds had not had any previous experience of them. This point favours the principle of exploratory flights by juveniles. However, the potential benefits of such flights must depend on the duration of memory and the time elapsed before a bird needs to call upon the information so accrued. Perhaps the heightened mobility apparent in many sanderlings in autumn and spring enhances recollection of proximal sites.

## CONCLUSIONS

There appears to be a balance between net advantages and disadvantages for itinerant, semi-mobile and resident sanderlings which maintains the variations in mobility. But for the discrete nature of Teesside, there would be a continuum of mobility.

Mobility may be heightened at times of harsh environmental conditions, perhaps to locate more favourable foraging conditions, particularly temporary wrack beds. Competition does not appear to be the cause of variations in mobility. Exploratory flights by juveniles may provide the adult sanderling with optional sites to visit when food availability at the preferred wintering site is reduced. This experience may modify the effects of genetic programming of sanderling mobility, if this is the controlling factor.

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APPENDIX I Colour-ringed Sanderlings at Teesside, alive during 1981-1984, or for part of this period and used in preparation of mobility categories

| Col.-rings left | Col.-rings right | Date col.-ringed | Age | Timing of use of with location(s) most frequently | Teesside seen | Date last seen* |
|---|---|---|---|---|---|---|
| B | B | 30.11.76 | ad | m i? | S | 11.05.82 |
| B | G | 30.11.76 | ad | ½ | S | |
| B | O | 28.05.79 | ad | p | | |
| BO | G | 01.02.82 | j | r ad | S | |
| BO | O | 20.11.82 | j | m r j r ad | S | |
| BO | R | 28.02.82 | j | m r ad | S | |
| BO | W | 22.10.82 | j | m r j r ad | S | |
| BO | Y | 28.02.82 | j | r ad | S | |
| BW | B | 05.10.79 | j | r j r ad | S | 19.01.83 |
| BW | G | 05.10.79 | j | m r j r ad | -BW s | |
| BW | R | 17.11.78 | ad | ½ | N | 04.11.81 |
| BW | W | 05.10.79 | j | m i? | S -BW - | |
| BW | Y | 17.11.78 | ad | ½ - i | | 07.02.82 |
| BY | BY | 05.09.80 | ad | m r | N/S | 10.12.82 |
| BY | GO | 05.09.80 | ad | m r | S | |
| BY | GR | 05.09.80 | ad | p | | |
| BY | GY | 05.09.80 | ad | m r | S | 26.10.82 |
| BY | OR | 05.09.80 | ad | m r | S -s OR | |
| BY | OY | 05.09.80 | ad | m i | SMI | 24.03.82 |
| BY | RG | 05.09.80 | ad | m r | S | 19.01.83 |
| BY | RO | 05.09.80 | ad | m r - i? | S | |
| BY | RW | 05.09.80 | ad | m r | S | 15.04.82 |
| BY | RY | 05.09.80 | ad | m r | S | |
| BY | WG | 05.09.80 | ad | m i? | S | 23.02.82 |
| BY | WR | 05.09.80 | ad | m r - i? | S | |
| BY | WY | 05.09.80 | ad | m ½ | C | |
| BY | YG | 05.09.80 | ad | m r | S | 26.01.82 |
| BY | YR | 05.09.80 | ad | m r | S | 13.04.82 |
| BY | YW | 05.09.80 | ad | m r | S | 24.11.82 |
| G | OR | 02.12.81 | ad | r | S | |
| GG | G | 28.10.81 | ad | r | S | 18.03.82 |
| GG | R | 28.10.81 | ad | m r | S | |
| GG | Y | 28.10.81 | ad | m r | S | |
| GO | R | 01.02.82 | j | r ad | S | 29.03.83 |
| GO | W | 01.01.82 | j | m r ad | S | |
| GO | Y | 01.02.82 | ad | ½ | S | |
| GR | G | 01.01.82 | j | m i? | | |
| GR | R | 01.01.82 | j | m r ad | S | |
| GR | W | 01.01.82 | j | m ½ | | |

KEY ad = adult; j = juvenile
m = present in moulting flock at Teesside in autumn
r = resident; ½ = semi-mobile; i = itinerant; p = passage migrant in autumn and/or spring
S = south Teesside; N = north Teesside; C = Crimdon;
SMI = St. Mary's Island; W = Whitburn
s = loss of part of a limb, resulting in loss of colour-rings;
- = loss of colour-ring(s) only
*last sighting - or found dead - before end of study

Appendix I continued

| Col.-rings left | right | Date col.-ringed | Age | Timing of use of with location(s) most frequently | | | | Teesside seen | Date last seen* |
|---|---|---|---|---|---|---|---|---|---|
| GY | G | 14.01.82 | j | | ½ | j | r ad | S | |
| GY | W | 14.01.82 | j | | | | r ad | | |
| GY | Y | 01.02.82 | j | | i | | | | 06.05.82 |
| GO | GO | 28.10.81 | ad | | r | | | S | 05.05.82 |
| GO | GY | 26.01.82 | ad | | r | | | S | |
| GW | GO | 28.10.81 | ad | m | r | | | S | |
| GW | GR | 09.10.81 | j | | i | j | r ad | | |
| GW | GY | 09.10.81 | j | | p | | | | 17.11.81 |
| GW | OG | 28.10.81 | j | | ½ | | | N | 13.04.82 |
| GW | OR | 05.11.80 | ad | m | ½ | | | S/N/C | |
| GW | RG | 05.11.80 | j | m | i | | | | |
| GW | RW | 05.11.80 | j | m | r | | | S | |
| GW | RY | 05.11.80 | j | m | ½ | | | S/N/C | |
| GW | WG | 05.11.80 | ad | m | ½ | | | N/S | |
| GW | WO | 28.10.81 | ad | | r | | | S | 06.05.82 |
| GW | WR | 28.10.81 | ad | m | r | | | S | 17.03.83 |
| GW | WY | 28.10.81 | ad | m | ½ | | | S | |
| GW | YG | 28.10.81 | ad | m | r | | | N/S | |
| GW | YO | 28.10.81 | j | | i | | | | |
| GW | YR | 28.10.81 | ad | m | r | | | S | |
| GW | YW | 28.10.81 | ad | | i | | | | |
| L | B | 28.10.81 | ad | m | r | | | S | |
| L | G | 17.11.78 | ad | | ½ | | | N/C -s G | |
| L | L | 17.11.78 | j | | i | | | | |
| L | R | 09.02.78 | ad | m | ½ | | | N | 15.02.82 |
| L | W | 23.11.76 | ad | m | r | | | S | |
| LO | W | 28.11.83 | j | | r | j | | S | |
| LR | G | 23.11.83 | j | | r | j | | S | |
| LR | L | 31.08.83 | ad | m | r | | | S | |
| LW | Y | 05.02.77 | ad | | r | | | S | |
| LY | L | 23.11.83 | j | | r | | | S | |
| LY | R | 31.08.83 | j | | r | | | S | |
| LY | Y | 05.02.77 | ad | m | r | | | S | 15.02.84 |
| O | R | 17.11.78 | ad | m | ½ | | | N | |
| O | WR | 01.02.82 | ad | m | r | | | S | |
| OG | G | 02.12.81 | j | m | r | | | S | |
| OG | O | 02.12.81 | ad | m | r | | | S | |
| OG | R | 02.12.81 | j | m | i | | | | |
| OG | W | 28.10.81 | ad | m | r | | | S -Os W | |
| OG | Y | 02.12.81 | ad | | r | | | S | |
| OO | W | 07.11.80 | j | m | r | | | S | 07.03.83 |
| OR | G | 22.10.82 | j | m | r | | | S | |
| OR | O | 10.11.81 | ad | | r | | | S | |
| OR | R | 02.12.81 | j | i | | | | | |
| OR | W | 20.11.82 | j | m | ½ | | | N/C/S | |
| OR | Y | 02.12.81 | ad | | ½ | | | N/C | |
| OW | G | 02.12.81 | j | | r | | | S | |
| OW | R | 28.12.81 | j | m | | | r ad | S | |
| OW | W | 28.12.81 | j | m | | | r ad | S | |
| OY | G | 01.01.82 | j | | | | r ad | | |
| OY | O | 01.01.82 | j | | | | r ad | S | |

Appendix I continued

| Col.-rings left | right | Date col.-ringed | Age | Timing of use of with location(s) most frequently | | | | Teesside seen | Date last seen* |
|---|---|---|---|---|---|---|---|---|---|
| OY | R | 02.11.81 | j | m | ½ | | | | |
| RG | G | 20.11.82 | j | m | ½ | | | | |
| RG | R | 11.10.83 | j | | i | j | | | |
| RG | W | 22.10.82 | j | m | ½ | j | r ad | | |
| RG | Y | 22.10.82 | j | m | r | | | | |
| RO | G | 11.10.83 | j | | i? | | | | |
| RO | O | 11.10.83 | j | | r | | | | |
| RO | R | 20.11.82 | ad | | r | | | S | |
| RO | W | 29.08.83 | j | | p | | | | |
| RW | B | 05.05.77 | ad | m | ½ | | | S | |
| RW | G | 05.05.77 | ad | m | ½ | | | S/N/C | |
| RW | W | 28.01.82 | j | m | | | r ad | S | 23.09.82 |
| RB | RO | 01.09.77 | ad | | p | | | | 11.09.81 |
| RB | RW | 20.08.80 | ad | m | r | | | S | 06.05.82 |
| RB | RY | 20.08.80 | ad | m | ½ | | | S | |
| RG | RY | 20.08.80 | ad | | p | | | | 26.07.82 |
| RO | RW | 06.09.79 | ad | m | ½ | | | N | 05.05.82 |
| RW | RB | 20.08.80 | ad | | p | | | | 07.03.83 |
| RW | RG | 20.08.80 | ad | m | i | | | SMI/W | |
| RW | RO | 20.08.80 | ad | | p | | | | 19.11.81 |
| RY | RG | 05.10.79 | j | m | r | | | S | 15.02.82 |
| WB | B | 05.10.79 | j | m | i? | | | | |
| WB | G | 22.01,77 | ad | | i | | | | |
| WB | GO | 28.10.81 | ad | m | r | | | S | |
| WB | GR | 28.10.81 | ad | m | r | - i? | | S | |
| WB | GW | 28.10.81 | ad | m | r | | | S | |
| WB | GY | 28.10.81 | ad | m | ½ | | | S | 07.03.83 |
| WB | OG | 28.10.81 | ad | m | r | | | S | |
| WB | OR | 05.11.80 | ad | | p | | | | |
| WB | OW | 25.03.81 | j | m | | | i ad | C/N | |
| WB | RG | 28.10.81 | ad | m | ½ | | | S/N | 02.04.83 |
| WB | RO | 05.11.80 | j | m | ½ | | | N | 18.01.83 |
| WB | RW | 05.11.80 | ad | | ½ | | | C | 16.03.82 |
| WB | RY | 05.11.80 | j | m | ½ | | | N/C | |
| WB | WG | 28.10.81 | j | m | r | | | S | |
| WB | WR | 28.10.81 | ad | | r | | | S | |
| WB | WY | 22.01.81 | ad | m | ½ | | | C/N | |
| WB | YG | 25.03.77 | ad | m | r | | | S | 26.01.83 |
| WB | YO | 05.11.80 | ad | | ½ | | | N | 22.04.83 |
| WB | YW | 05.11.80 | ad | m | ½ | | | C/N/S | |
| WL | R | 31.08.83 | j | | p | | | | |
| W | OR | 02.12.81 | ad | m | r | | | S | |
| W | OY | 28.12.81 | j | m | ½ | | | | |
| W | RG | 20.11.82 | j | | i | | | | |
| WW | B | 07.11.80 | j | m | ½ | | | N | |
| WW | O | 07.11.80 | j | | ½ | | | N | |
| WW | R | 07.11.80 | j | m | ½ | | | N/S | 17.11.81 |
| WW | W | 07.11.80 | j | m | r | | | S | 29.09.82 |
| Y | R | 23.11.76 | ad | | ½ | | | S | 18.11.82 |
| Y | RO | 20.11.82 | j | | r | | | S | |

Appendix I continued

| Col.-rings left | right | Date col.-ringed | Age | Timing of use of with location(s) most frequently | Teesside seen | Date last seen* |
|---|---|---|---|---|---|---|
| YB | RB | 06.09.79 | ad | m ½ | S | |
| YB | RO | 27.08.80 | ad | m ½ | N/C | 22.04.83 |
| YB | RY | 27.08.80 | j | p | | 06.05.82 |
| YG | G | 22.01.83 | j | m ½ | S/N | |
| YG | O | 22.12.82 | j | r ad | S | |
| YG | R | 12.11.83 | j | r | S | |
| YG | W | 12.11.83 | j | r | S | |
| YG | Y | 12.11.83 | j | ½ | S/N | |
| YG | RW | 20.08.80 | ad | m ½ | S/N | 23.11.82 |
| YG | RY | 20.08.80 | ad | m r | S/N | 13.05.82 |
| YO | G | 17.11.78 | ad | m ½ | N | 01.02.82 |
| YO | W | 17.11.78 | ad | ½ | N -Ys W | 17.11.82 |
| YO | RO | 05.10.79 | j | m ½ | S/N | 09.10.81 |
| YO | RY | 20.08.80 | ad | i | | 18.01.82 |
| YR | G | 12.11.83 | j | r | S | |
| YR | W | 04.11.83 | ad | r | S | |
| YR | RB | 01.09.77 | ad | m r | S | |
| YR | RG | 29.08.80 | ad | m ½ | S/N | |
| YR | RO | 29.08.80 | j | m ½ | N | 23.11.82 |
| YR | RY | 29.08.80 | ad | m r | S | 27.04.83 |
| YW | B | 17.11.78 | ad | m ½ | N | 17.11.82 |
| YY | G | 28.10.81 | ad | r | S | 14.04.82 |
| YY | R | 28.10.81 | ad | r | S | 02.04.83 |
| YY | W | 28.10.81 | ad | m r | S | |
| YY | Y | 28.10.81 | ad | ½ - i | | 26.01.83 |

APPENDIX II Dates of fieldwork on sanderlings at Teesside (No. of visits to each site in each month) (RHWC)

| Month | Marske Sands | Coatham Sands | Bran Sands | Seaton Sands | Crimdon | Elsewhere |
|---|---|---|---|---|---|---|
| 1981/82 | | | | | | |
| Oct | 1 | 5 | 2 | 5 | 2 | W -2<br>SMI - 4<br>L - 1 |
| Nov | 6 | 5 | 0 | 2 | 1 | SMI - 2<br>W - 1 |
| Dec | 5 | 3 | 1 | 2 | 1 | SMI - 1<br>F - 1<br>L - 1 |
| Jan | 7 | 8 | 4 | 4 | 1 | SMI - 1<br>W - 1<br>NLD - 1 |
| Feb | 7 | 7 | 4 | 4 | 4 | L - 1<br>F - 1 |
| Mar | 4 | 4 | 2 | 5 | 4 | SMI - 2<br>W - 1<br>F - 1 |
| Apr | 4 | 8 | 5 | 7 | 5 | SMI - 1<br>F - 1 |
| May | 1 | 8 | 6 | 8 | 2 | |
| June | 0 | 2 | 1 | 2 | 0 | |
| 1982/83 | | | | | | |
| Jul | 1 | 2 | 2 | 2 | 0 | |
| Aug | 1 | 2 | 2 | 2 | 1 | |
| Sept | 1 | 4 | 2 | 3 | 1 | |
| Oct | 3 | 3 | 0 | 3 | 3 | |
| Nov | 4 | 3 | 2 | 3 | 2 | |
| Dec | 2 | 3 | 1 | 2 | 1 | |
| Jan | 2 | 2 | 1 | 2 | 2 | |
| Feb | 1 | 1 | 1 | 2 | 2 | |
| Mar | 1 | 2 | 1 | 2 | 2 | |
| Apr | 0 | 2 | 2 | 1 | 1 | |
| May | 0 | 4 | 3 | 3 | 1 | |
| 1983/84 | | | | | | |
| Jul | 0 | 1 | 1 | 1 | 1 | |
| Aug | 0 | 6 | 3 | 1 | 0 | SMI - 1<br>W - 1 |
| Sept | 2 | 6 | 3 | 4 | 1 | |
| Oct | 3 | 5 | 2 | 2 | 0 | |
| Nov | 3 | 3 | 0 | 0 | 0 | SMI - 1<br>W - 1 |
| Dec | 5 | 4 | 0 | 0 | 0 | |
| Jan | 4 | 4 | 1 | 0 | 0 | |
| Feb | 4 | 5 | 0 | 1 | 1 | |
| Apr | 0 | 1 | 0 | 0 | 0 | |

SMI - St Mary's Island, W - Whitburn, L - Lindisfarne, F - Filey & Cayton, NLD - Northumberland coast

APPENDIX III Observers of colour-ringed sanderlings originating from Teesside

C. A. & I. P. Bainbridge
D. Baines
K. Barratt
T. Cadwallender
D. K. Chesterman
A. Cruikshanks
T. G. Dewdney
Durham University Shorebird Research Group
B. Galloway
M. Gibbs
P. Gill
E. Gray
F. Grey
D. Jackson
B. D. Kerr
R. McAndrew
S. Muller
R. K. Norman
D. Pullens
D. Radford
M. Riesch
C. D. Roach
D. Richardson
RSPB Beached Bird Survey via T. Stowe & L. Underwood
M. Shimmin
Tay Ringing Group via R. F. K. Kiddie
G. C. Tompsett
D. M. Turner
Tyneside Bird Club via A. Heavisides & C. Thomas
D. G. Walker
J. Webb

## APPENDIX IV Origins and destinations of Teesside Sanderlings

Examinations of recaptures and of sightings of colour-ringed individuals sheds some light on the origins and destinations of sanderlings which visit Teesside during the non-breeding season. This paper will consider 1) passage migrants and 2) wintering birds.

### 1) Passage Migrants

Little is known of the origins or destinations of sanderlings which pause at Teesside in autumn. There are records of onward migration to sites along the Northumberland coast (Fig A4i).

There have been several recaptures at the Wash, one within the same non-breeding season (Fig A4i). Numbers (Figs 4 & 5, 21 - Ch. 2; Figs 18, 19, 20 - Ch. 1) and departure dates from Teesside (Table A4i) of colour-ringed individuals point to commencement of spring migration along eastern England in March, although there may be a trickle in February. This is earlier than on the west coast and is considered to be on a smaller scale (Ferns 1980).

Most colour-ringed sanderlings leave Teesside in the first half of May. Later spring passage influxes occur. Two recaptures in southern Spain in January and on the Vendee in October following capture at Teesside in the preceding spring indicate a throughput of probable African winterers.

### 2) Wintering Birds

Most information about origins and destinations of Teesside winterers comes from colour-ringed individuals.

Several autumn sightings have come from around the Baltic which are more likely to represent refuelling stopovers of

Appendix IV continued

Table A4i Departure dates of colour-ringed sanderlings from Teesside in late winter/early spring (data collated from the period 1976 - 1984)

| Date | | Adult | Juvenile |
|---|---|---|---|
| February | 1 - 15 | 1 | 0 |
| | 16 - 28/29 | 0 | 3 |
| March | 1 - 15 | 1 | 1 |
| | 16 - 31 | 9 | 4 |
| April | 1 - 15 | 13 | 8 |
| | 16 - 30 | 31 | 14 |
| May | 1 - 15 | 78 | 29 |
| | 16 - 31 | 20 | 7 |
| June | 1 - 15 | 1 | 0 |
| variable* | | 24 | 0 |
| Total | | 178 | 66 |

*dates of departure for these individuals varied annually by more than one month.

Table A4ii Autumn dates at the Baltic and Teesside for 3 colour-ringed sanderlings

| Individual | Refuelling stopover | | Date first seen at Teesside in autumn |
|---|---|---|---|
| GW OR | 20.08.81 | Ottenby Sweden | 11.09.81 |
| OY R | 07.08.82 | Rostock DDR | 16.08.82 |
| WY O | 08.08.81 | Kalmar Sweden | 09.09.81 |

Palaearctic breeders rather than Nearctic sanderlings (Table A4ii). Bearing in mind recent findings of Nearctic knot in northern Norway in spring (Davidson et al 1986), there remains a possibility of sanderlings migrating along a similar route as well as via Iceland. The sightings in southwest Iceland, of colour-ringed birds in the springs of 1985 and 1986 confirm the presence of Nearctic sanderlings at Teesside in winter.

Appendix IV continued

Thus it seems likely that representatives of both Nearctic and Palaearctic sanderling breeding populations spend the winter at Teesside.

Within Britain, movements along east and west coasts are apparent during spring, whilst in autumn, most sightings and recaptures have been along the east coast. Migration through the Wash, where post-nuptial moult is completed before movement to Teesside for the winter, may occur in both autumn and spring, e.g. GO Y (Fig 10, Ch 2).

There is evidence of changes in wintering strategy in adulthood of sanderlings ringed at the Wash as juveniles in winter and spending subsequent winters at Teesside after visiting the Wash in autumn, e.g. OG Y (Fig 10, Ch 2).

Most colour-ringed sanderlings leave Teesside in April and May, particularly in the first half of May. Variable departure dates of more than one month relate mostly to itinerant sanderlings, but dates of sightings at the Wash and Teesside also indicate that return migration through the Wash in spring either does not occur each year or the timing of its use is highly variable (Fig 10, Ch 2).

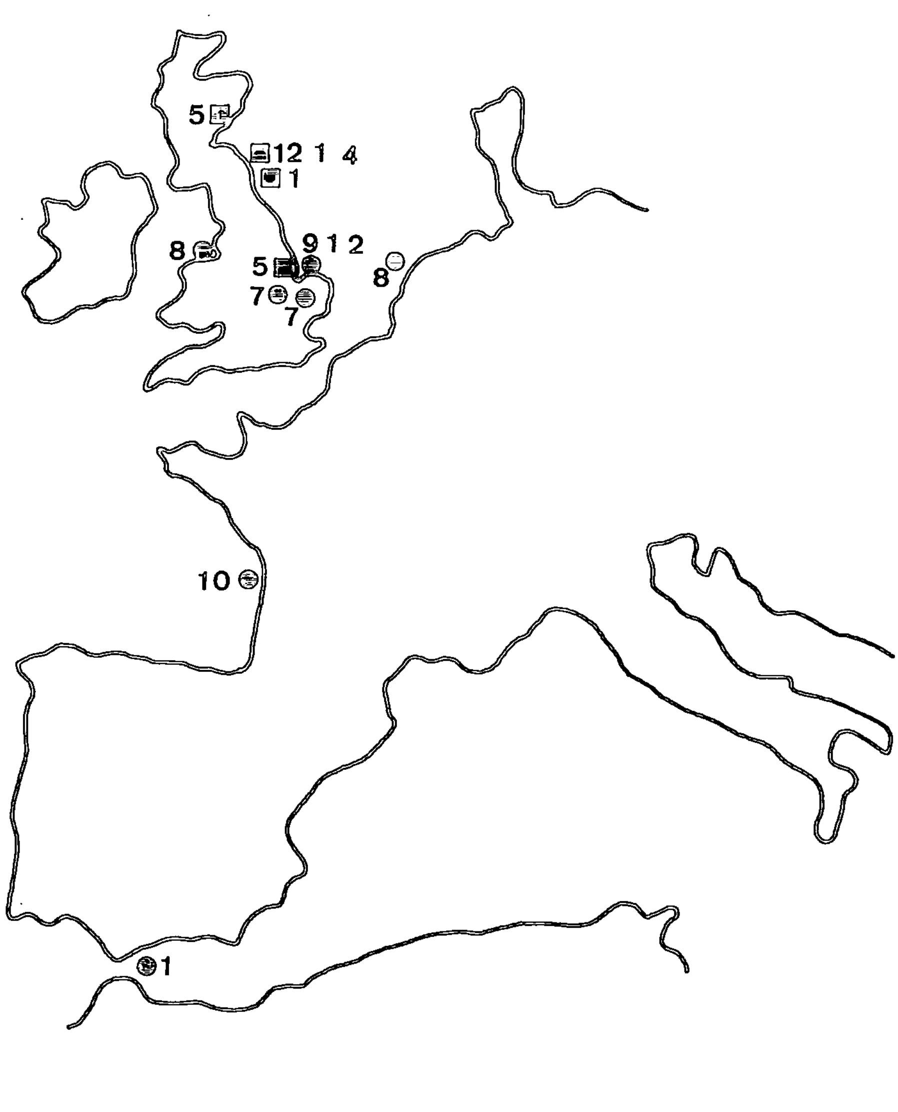
Spring migration along eastern England's coast is in a series of hops, as sightings in March at Filey in North Yorkshire and at Humberside suggest.

References

Ferns, P. N. 1980 The spring migration of sanderlings _Calidris alba_ through Britain in 1979. WSG Bull. 30:22-25

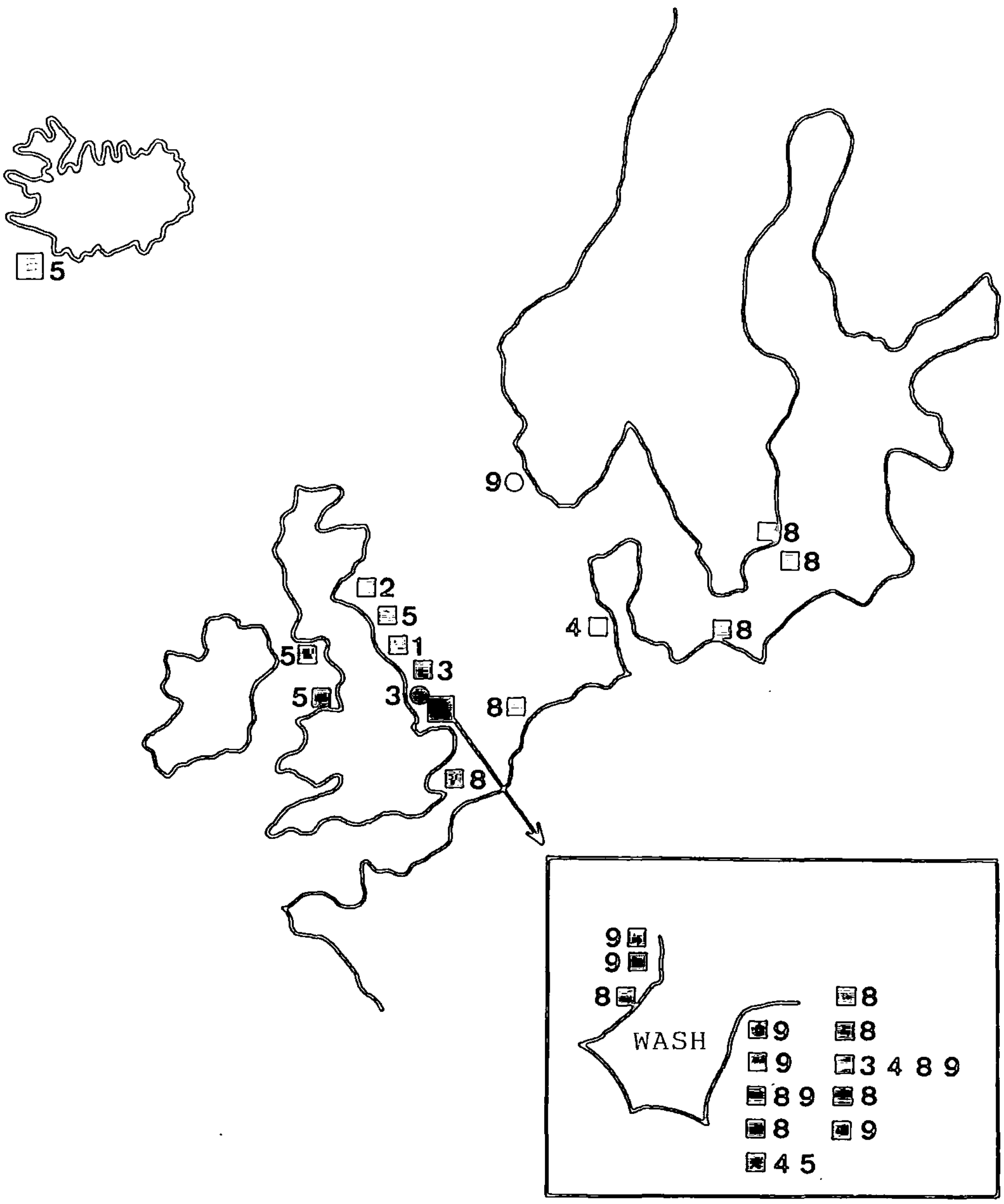
Davidson, N. C., K-B Strann, N. J. Crockford, P. R. Evans, J. Richardson, L. J. Standen, D. J. Townshend, J. D. Uttley, J. R. Wilson, & A. G. Wood 1986 The origins of knots _Calidris canutus_ in arctic Norway in spring. ORNIS. SCAND. 17:175-179

Fig A4i  Origins and recaptures of sanderlings caught at Teesside in spring (late March to May), or autumn (late July to September)




⊜ autumn)
at Teesside
▣ spring)

Fig A4ii Sightings of colour-ringed individual sanderlings and recaptures of sanderlings wintering at Teesside




adult juvenile

1 1

≥ 10

## APPENDIX V Meteorological Data - wind speeds (knots) for Teesmouth and air temperatures ($^{o}C$) for Hartlepool

Figs A5i, A5iii and A5v show the minimum air temperature ($^{o}C$) recorded at Hartlepool for each 24 hour period (0900 - 0900 hrs.) for December, January and February of 1981/82, 1982/83 and 1983/84, respectively. The range of maximum air temperatures is quoted too.

Figs A5ii, A5iv and A5vi show average daily wind speeds (knots) for each 24 hour period (0000 - 2400 hrs.) for December, January and February of 1981/82, 1982/83 and 1983/84, respectively. The daily maximum gust is shown, where this exceeds 34 knots (equivalent to gale force 8 or stronger on the Beaufort scale) along with the predominant wind direction.

Access to the data was permitted by the Meteorological Office at Newcastle-upon-Tyne.

Fig A5i 1981/82 Minimum, and for January Maximum, temperature °C at Hartlepool, recorded over 24 hr. periods (0900 - 0900 hrs.) for December, January and February (courtesy of the Meteorological Office, Newcastle-upon-Tyne)

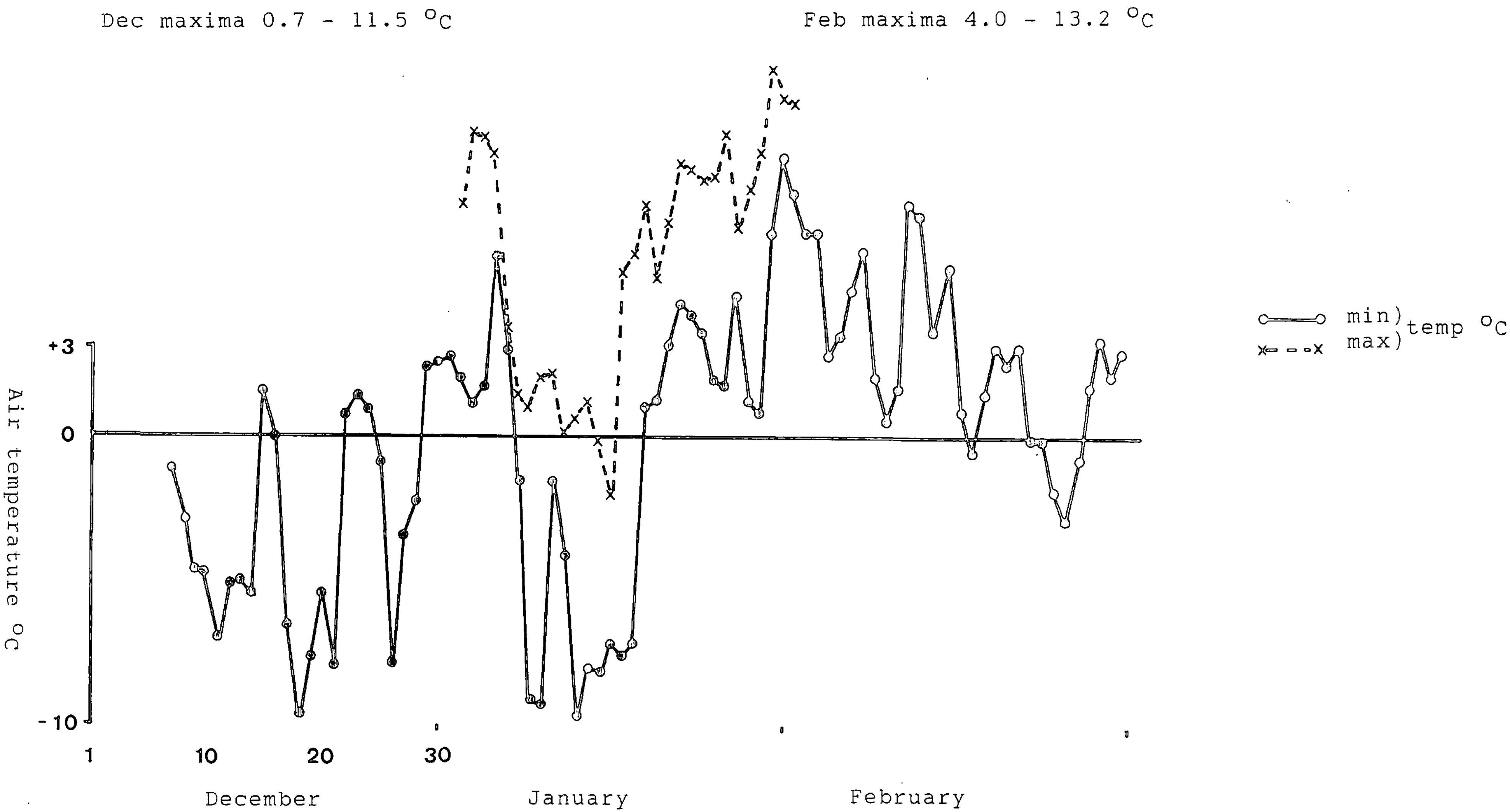


Fig A5ii Teesmouth average daily wind speed (knots) 0000 - 2400 hrs, showing daily maximum gust - when this exceeded 34 knots (gale force 8 or greater) - and principle wind direction (courtesy of the Meteorological Office, Newcastle-upon-Tyne)

1981/82

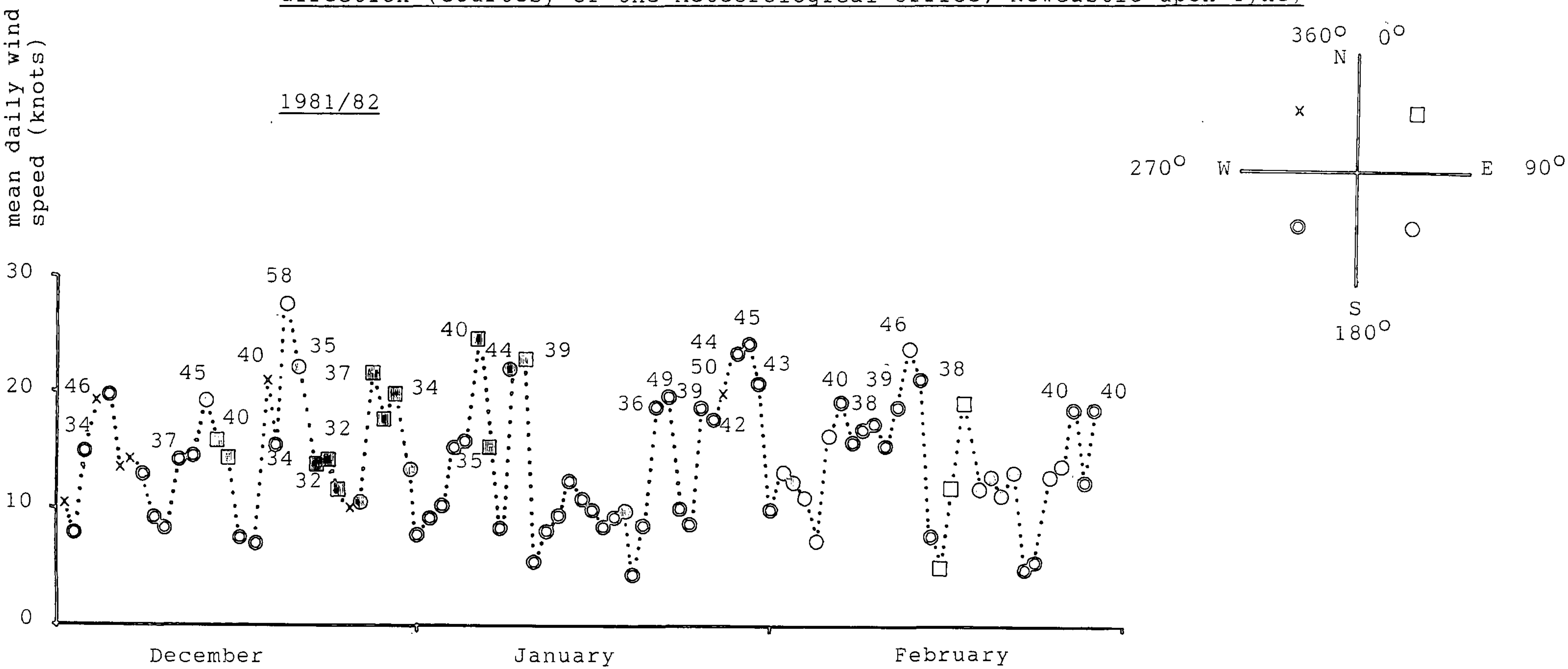


Fig A5iii 1982/83 Minimum temperature °C at Hartlepool, recorded over 24 hr. periods (0900 - 0900 hrs.) for December, January and February (courtesy of the Meteorological Office Newcastle-upon-Tyne)

January maxima 3.8 - 13.5 °C

Dec maxima 1.6 - 13.5 °C

February maxima 2.8 - 8.5 °C

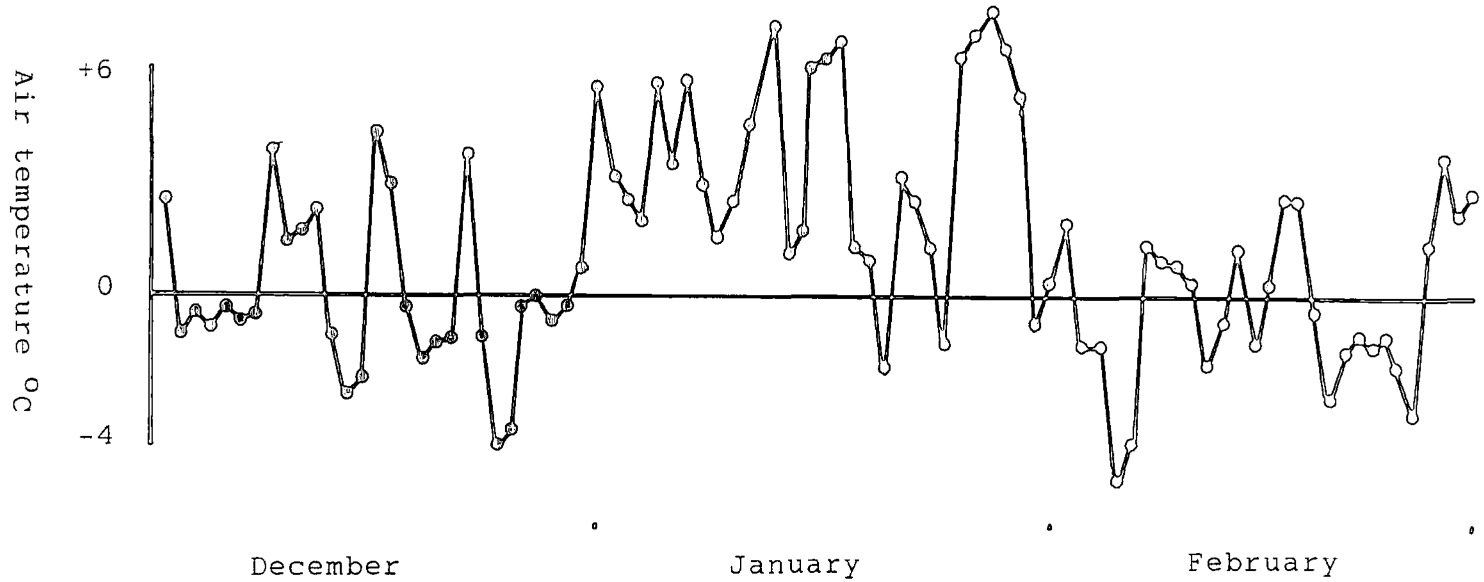
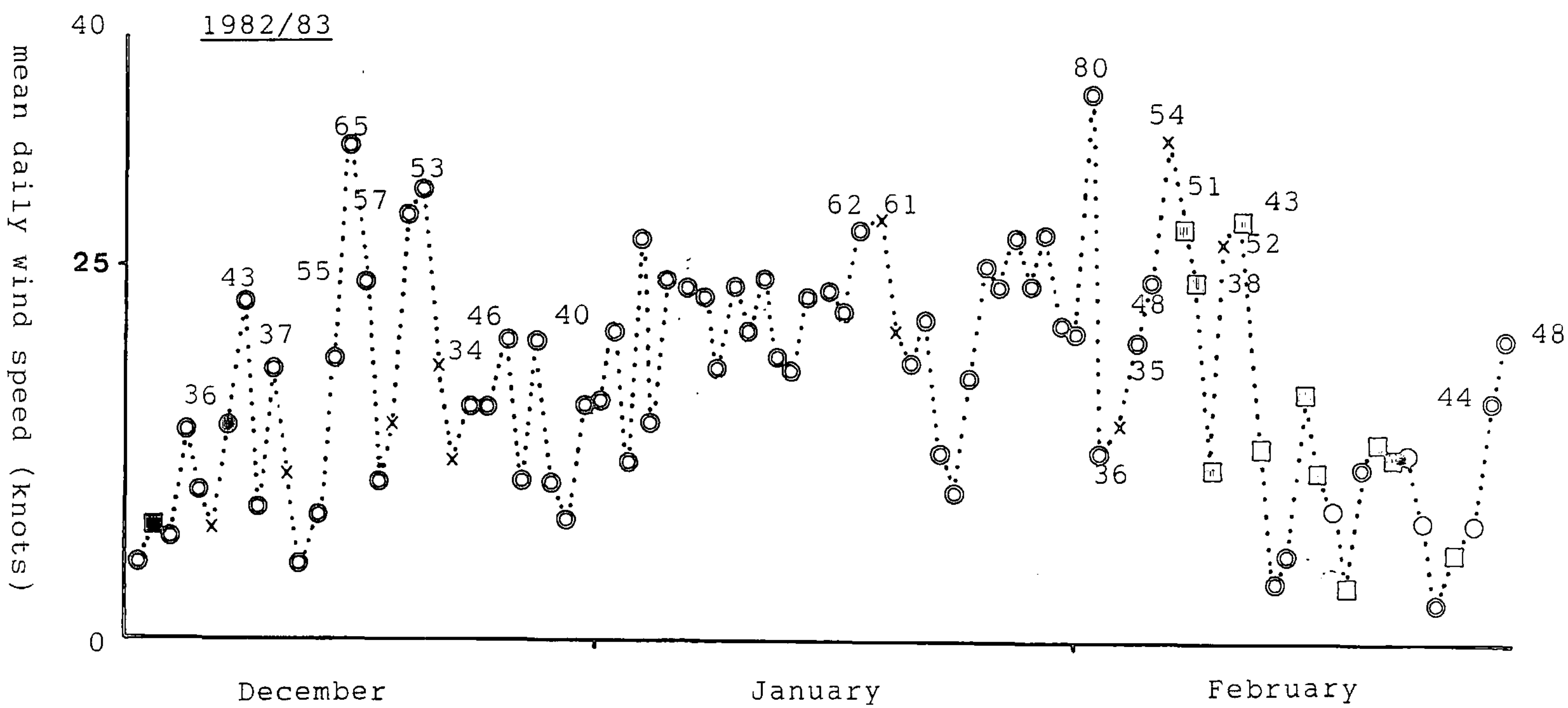


Fig A5iv Teesmouth average daily wind speed (knots) 0000 - 2400 hrs., showing daily maximum gust* - when this exceeded 34 knots (gale force 8 or greater) - and principle wind direction (courtesy of the Meteorological Office, Newcastle-upon-Tyne)




N.B. See Fig 32b for key to wind directions.

*Daily max gust in January exceeded 34 on all but 2 days, so only monthly max shown.

Fig A5v 1983/84 Minimum temperature $^{o}C$ at Hartlepool, recorded over 24 hr. periods (0900 - 0900 hrs.) for December, January and February (courtesy of the Meteorological Office Newcastle-upon-Tyne)

Dec maxima 2.3 - 13.2 $^{o}C$

Jan maxima 1.5 - 13.1 $^{o}C$

Feb maxima 2.1 - 11.3 $^{o}C$

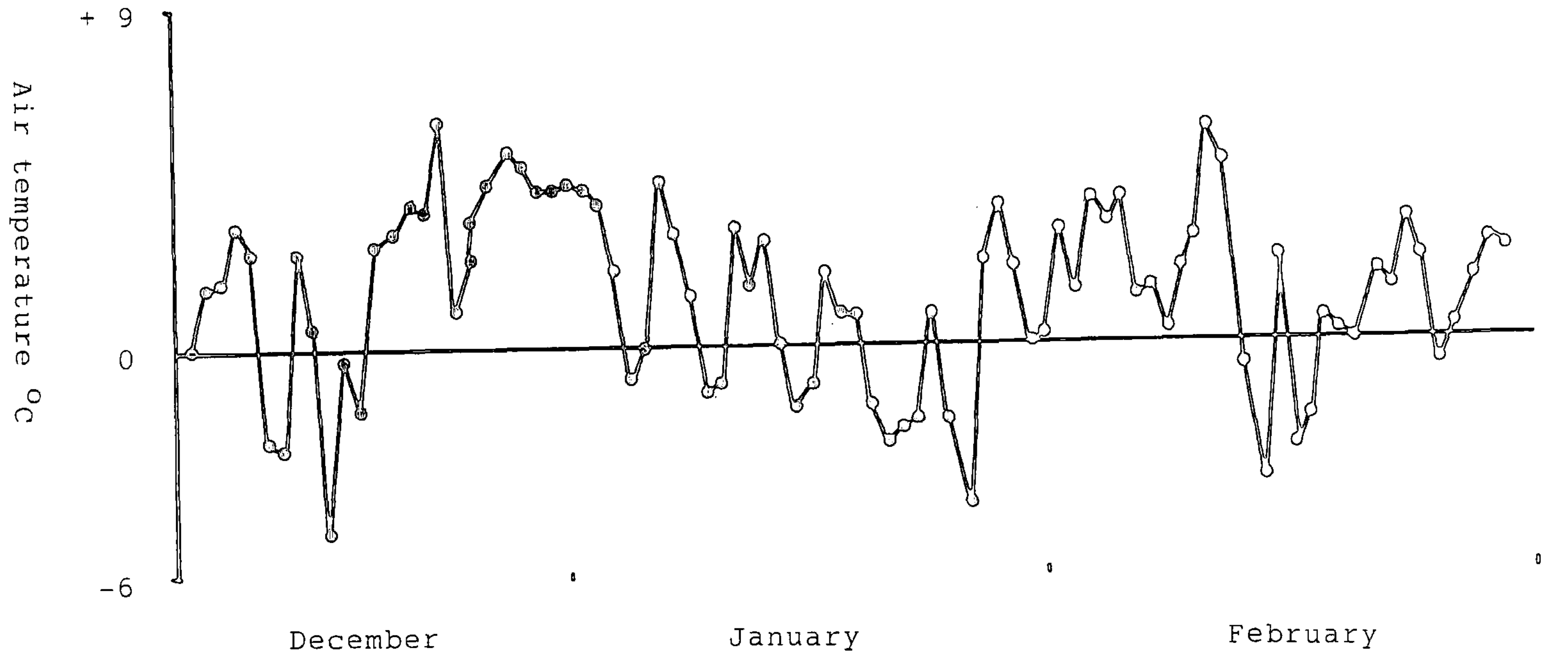
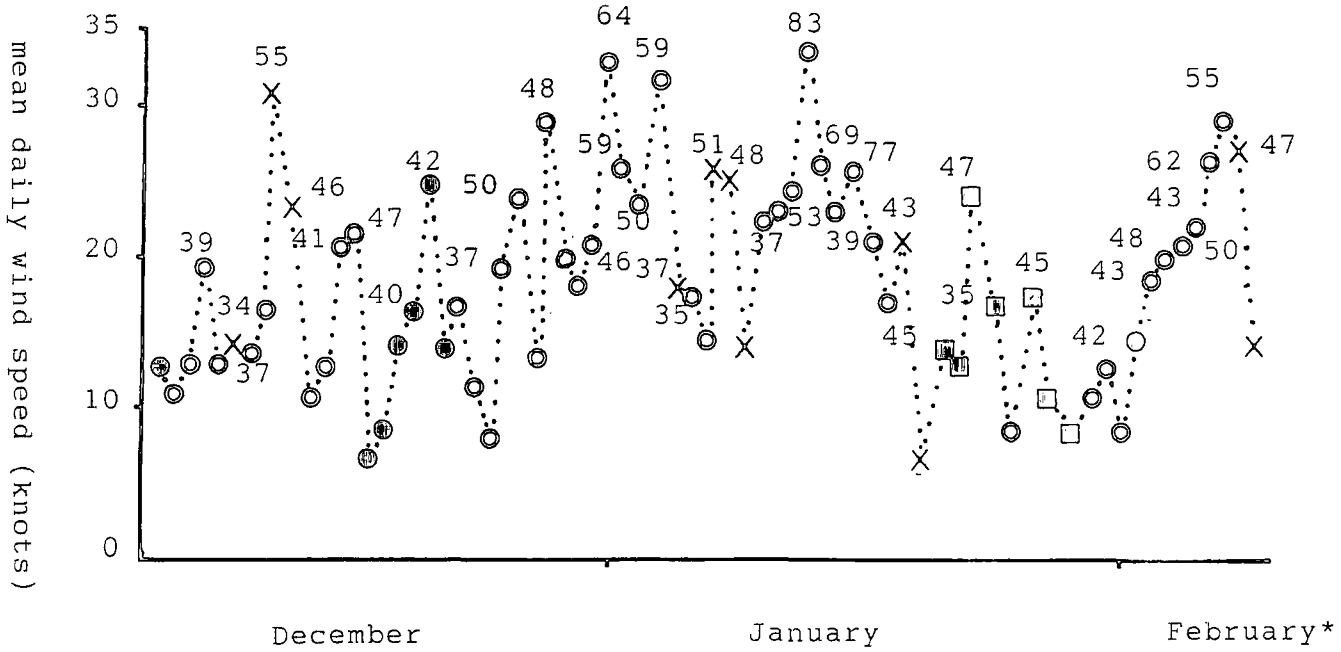


Fig A5vi Teesmouth average daily wind speed (knots) 0000 - 2400 hrs., showing daily maximum gust - when this exceeded 34 knots (gale force 8 or greater) - and principle wind direction (courtesy of the Meteorological Office, Newcastle-upon-Tyne)

1983/84




*records ceased 09.02.84

N.B. See Fig 32b for key to wind directions.

# APPENDIX VI Invertebrate sampling of Marske Sands (no. $m^{-2}$)

| Sampling Station (HWN +) | T10 | | | | T11 | | | | T12 | | | | T13 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bp | Ss | Ep | Ha | Bp | Ss | Ep | Ha | Bp | Ss | Ep | Ha | Bp | Ss | Ep | Ha |
| 27/11/81 | | | | | | | | | | | | | | | | |
| 20 m | - | - | - | - | - | - | - | - | - | - | - | - | 50 | - | - | - |
| 30 m | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 40 m | - | - | - | - | - | - | - | - | - | - | - | - | 1450 | - | - | - |
| 50 m | - | - | - | - | - | - | - | - | - | - | - | - | 2700 | 100 | - | - |
| 60 m | - | 100 | 50 | 50 | 200 | - | - | - | - | - | - | - | 3000 | 1200 | - | - |
| 70 m | 50 | - | 50 | - | 50 | 100 | - | - | - | - | - | - | 4250 | - | - | - |
| 80 m | 100 | 200 | 100 | 50 | 100 | 50 | - | - | - | - | - | - | 3900 | 350 | 50 | 50 |
| 90 m | 350 | 250 | 50 | - | | | nt | | - | - | - | - | 3000 | 750 | - | - |
| 100 m | - | 150 | - | - | | | nt | | - | - | - | - | 1350 | 100 | - | - |
| 130 m | 200 | 300 | 50 | 150 | | | nt | | | nt | | | 1100 | 100 | 50 | 50 |
| 160 m | - | 100 | - | - | | | nt | | | nt | | | 950 | 150 | - | - |
| 23/02/82 | | | | | | | | | | | | | | | | |
| 20 m | - | - | - | - | - | - | - | - | - | - | - | - | - | 100 | - | - |
| 30 m | - | - | - | - | - | - | - | - | - | - | - | - | 500 | - | - | - |
| 40 m | - | - | - | - | - | - | - | - | - | - | - | - | 1200 | - | - | - |
| 50 m | - | - | - | - | - | - | - | - | - | - | - | - | 450 | 450 | 50 | - |
| 60 m | - | 200 | - | - | - | - | - | - | | nt | | | 300 | 400 | - | - |
| 70 m | - | - | - | - | - | - | - | - | | nt | | | 250 | 50 | - | - |
| 80 m | - | 100 | - | - | - | - | - | - | | nt | | | 300 | 200 | - | - |
| 90 m | - | 50 | - | - | - | - | - | - | | nt | | | | nt | | |
| 100 m | - | - | - | - | - | 50 | - | - | | nt | | | | nt | | |
| 130 m | - | - | - | - | | | nt | | | nt | | | | nt | | |
| 160 m | | nt | | | | | nt | | | nt | | | | nt | | |

Bp = Bathyporeia pelagica; Ss = Scololepis squamata; Ep = Eurydice pulchra;
Ha = Haustorius arenarius
nt - samples not taken due to flooding by tide
Average nos. $m^{-2}$ calculated from paired samples.

APPENDIX VII Counts of sanderlings along sections of Marske Sands corresponding to sampling transects for macroinvertebrates

| Date | tide ht. (m) HW | counts and tidal state when these were made in each sector T10 | | T11/12 | | T13 | |
|---|---|---|---|---|---|---|---|
| 8.10.81 | 4.2 | - | | - | | 180 | LW |
| 9.10 | 4.4 | - | | - | | 454 | Mt |
| 15.10 | 5.8 | - | | - | | 0 | Mt |
| 20.10 | 4.2 | - | | - | | 225 | LW |
| 4.11 | 4.3 | - | | - | | 224 | Mt |
| 17.11 | 5.0 | 193 | Mt | 0 | Mt | - | |
| 30.11 | 5.0 | - | | - | | 49 | LW |
| 16.12 | 5.1 | - | | - | | 3 | Mt |
| 22.12 | 4.8 | - | | - | | 57 | LW |
| 10.01.82 | 5.7 | 78 | HW | 0 | HW | - | |
| 14.01 | 5.2 | 33 | LW | 96 | LW | 104 | LW |
| 19.01 | 4.3 | 97 | Mt | 54 | Mt | 20 | Mt |
| 21.01 | 4.6 | 110 | Mt | 55 | Mt | 128 | Mt |
| 25.01 | 5.3 | - | | - | | 0 | Mt |
| 27.01 | 5.5 | 63 | Mt | 180 | Mt | 24 | Mt |
| 1.02 | 4.6 | - | | - | | 82 | Mt |
| 1.02 | 4.6 | - | | - | | 164 | Mt |
| 5.02 | 4.9 | - | | - | | 53 | HW |
| 15.02 | 4.4 | - | | - | | 200 | LW |
| 17.02 | 4.1 | - | | - | | 24 | HW |
| 23.02 | 5.3 | 302 | Mt | 28 | Mt | - | |
| 20.10.82 | 5.5 | - | | - | | 194 | Mt |
| 26.10 | 4.1 | - | | - | | 360 | Mt |
| 10.11 | 4.6 | - | | - | | 310 | Mt |
| 10.11 | 4.6 | - | | - | | 400 | Mt |
| 18.11 | 5.3 | 0 | Mt | 140 | Mt | - | |
| 24.11 | 4.1 | 200 | HW | 20 | HW | 160 | Mt |
| 24.11 | 4.1 | 178 | LW | 27 | LW | - | |
| 10.12 | 4.7 | 40 | HW | 45 | HW | - | |
| 29.12 | 5.5 | 120 | Mt | 70 | Mt | - | |
| 19.01.83 | 4.8 | 70 | Mt | 0 | Mt | - | |
| 19.01 | 4.8 | 300 | LW | 100 | LW | - | |
| 26.01 | 5.0 | 304 | HW | 112 | HW | - | |
| 23.02 | 4.4 | 0 | HW | 10 | HW | 120 | LW |
| 13.10.83 | 4.5 | - | | - | | 270 | Mt |
| 19.10 | 5.0 | 300 | HW | 0 | HW | 90 | Mt |
| 20.10 | 5.2 | 112 | LW | 0 | LW | 261 | Mt |
| 24.10 | 5.4 | 67 | Mt | 0 | Mt | 193 | Mt |
| 28.10 | 4.6 | - | | - | | 450 | LW |
| 02.11 | 5.2 | 92 | Mt | 0 | Mt | - | |
| 24.11 | 5.3 | - | | - | | 406 | LW |
| 28.11 | 4.5 | 0 | LW | 0 | LW | 450 | LW |
| 07.12 | 5.3 | 117 | LW | 0 | LW | 242 | LW |
| 17.01.84 | 5.3 | 126 | Mt | 113 | Mt | - | |
| 30.01 | 4.8 | 250 | HW | 0 | HW | - | |
| 31.01 | 5.0 | 64 | LW | 0 | LW | - | |
| 1.02 | 5.2 | 224 | Mt | 0 | Mt | - | |
| 7.02 | 4.7 | 190 | Mt | 0 | Mt | - | |
| 10.02 | 4.2 | 40 | Mt | 0 | Mt | - | |
| 24.02 | 4.3 | 0 | Mt | 0 | Mt | 360 | LW |

HW = high water; LW = low water; Mt = mid tide