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T09007b1

PREDICTION OF POST-BARRAGE DENSITIES OF BIRDS: BIRDS

ETSU Contract: E/5A/CON/4059/1705

ITE Project No: T09007B1

Interim report - April 1988

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INTRODUCTION

The field-work on the birds finished in mid-March, and the preliminary sorting and tabulating of the data has now been completed. From now on, the analysis will be primarily concerned with regressing bird densities against the various environmental variables that have been measured in each of the forty sites studied. While the data for some of these variables are already available, those for the prey densities are not. They are unlikely to be so until late spring or early summer. This is the moment to evaluate what has been achieved so far and to "clear the decks" ready for the arrival of the invertebrate data from IMER.

These were the objectives to be achieved by this date.

1. To compare counts made by different observers to ensure comparability.

2. To count the numbers of waders at low tide on ten occasions in each of the forty study sites in South-west England.

3. To determine the use made by the birds of different sites within the same estuary at different stages of the tidal cycle.

4. To devise a means of comparing directly counts made during the winters of 1986-87 and 1987-88.

5. To calculate the mean densities of each species in each site throughout the winter, and to tabulate the data ready for regression

analysis.

6. To determine by observation the diet of the larger bird species in each site.

7. To measure bird densities at low water in three parts of La Rance, Brittany.

8. To measure the exposure time and shore-width in each site.

9. To obtain data from unpublished sources on salinity in Southampton Water and Poole Harbour.

PROGRESS

All of these objectives have been achieved. This section summarises the main findings under each one.

1. Comparison of observers

Three scientists made the counts, each counting certain sites. To ensure that the results from the different counters were comparable, JGC and ER counted the same flocks of several species at the same time in various parts of the Exe estuary during the winter 1986-87. The agreement was extremely good (Figure 1). An observer not contributing to this contract counted birds on Penarth flats at low water: his area corresponded to sites 35 and 36 in this study. With the exception of one occasion when, unusually for this area, a flock of Dunlin remained in the estuary at low water, the agreement between counters was good

(Figure 1) even though the pairs of counts were often separated by several days. Given these clear results on the reliability of counts, it was considered unnecessary to compare counts made by BP and JGC.

2. Counts in the forty sites

Half the sites were counted at low tide on ten occasions during the winter (October - March) of 1986-87 and the remaining twenty were counted during the winter 1987-88. Though the weather sometimes forced us to make repeat counts, the data were obtained without special difficulty.

3. Usage throughout the tidal cycle

As the tide recedes and the shorebirds arrive from the roosts, they occupy the higher-level flats that expose first. Later, they may move to lower-level areas. Therefore the density of birds in a site at low tide may depend partly on the quality of the feeding areas used at the beginning (and end) of the tidal cycle. To identify these areas, it was necessary to describe how the birds moved between adjacent sites during one tidal cycle. In order to know the food supplies in the different parts of the area, it was necessary to include all parts of the area within the sites to be sampled by IMER.

For this report, the results for Poole Harbour (sites 4 - 9) and the sites situated in the upper reaches of the Exe (numbers 13 - 19) only are presented by way of an example.

In Poole Harbour, sites 4 and 5 (Sandbanks) were treated together as were sites 6, 7 and 8 (Brands Bay). Site 9 (Newton Bay) was considered alone. Counts were made through the short tidal-cycle on several occaions during the winter 1986-87 so the data in Figures 2 -4 are seasonally-adjusted values for the whole winter period. In all these three places, most of the bird species arrived on the receding tide and remained in the area throughout the exposure period. Numbers did not normally dip around low tide as would occur were most birds to move on at that stage of the tide to feed elsewhere in the Harbour.

On the Exe, it took several days to count all the up-river sites through the equivalent of one tidal cycle, so counts were only done once in November 1986. Figure 5 shows how the birds moved between the sites as the tide exposed them. The birds started feeding at the edges of sites 15, 17 and 18. As the tide receded, they gradually spread out over the whole area, particularly downstream towards the lower-lying flats.

Figure 6 shows the total numbers of each species feeding in all these sites throughout the tidal cycle: Shelduck were not studied as few occurred there. Numbers built up rapidly as the tide receded and the birds arrived from the roosts. The numbers of Redshank decreased sharply around low-water as birds moved yet further downstrean and out of the study area. But this did not happen in the other six wader species, apart from a temporary (and unexplained) decrease in the numbers of Godwits and Grey Plovers just as the tide started in. This suggests that, for most species, as in Poole Harbour, the sites chosen formed a "unit" within which a definable group of birds obtained most or all of their food during a tidal cycle.

Similar maps to Figure 5 will be given for each unit in the final report. Counts through the tidal cycle were obtained in some of these other units. However, some sites took so long to count that it was not possible to census all of the units repeatedly throughout one tidal cycle. The data from those sites where this could be done confirmed that we could identify units from watching movement patterns alone.

It was not possible to select all sites so that each site belonged to a cluster constituting a unit. In site 29, birds moved into the site at low tide from other areas that were too large to work. In sites 11, 12, 35 and 36, many birds moved out of the site at low water to places that could not be studied. But in the remaining 35 sites, the birds seen at low water fed in places on the receding and advancing tide that were included in the study and where, therefore, the feeding conditions they exprienced at the beginning and end of the tidal cycle were known.

4. Comparability between years

The counts were spread over two winters because it would not have been possible with the manpower available to count all forty of ten occasions between October and March in one winter. It was therefore necessary to test the comparability of counts made in the same site in different years. This was done in seventeen of the most easily counted sites. These had been counted on ten occasions during 1986-87 and were recounted on five occasions during 1987-88.

The mean of the five repeat counts in each site were compared with the mean of the five counts made on roughly the same date during the preceding winter: count dates were usually only a few days apart. The mean counts were similar in both winters (Figure 7): areas that held many birds one year also held many birds the next. However, three categories of comparison emerged:

i. For Dunlin, Redshank, Curlew and Oystercatcher, the intercepts of the calculated regression lines were not significantly different from zero, and the slopes were not significantly different from unity. Overall, the counts made in the two winters in these species were the same and could be compared directly.

ii. For Grey Plover and Shelduck, the slopes were significantly less than unity, implying that areas that had supported large numbers in 1986-87 held rather fewer birds during the second winter. The calculated regression lines was therefore used in these species to convert the 1986-87 counts to 1987-88 equivalents.

iii. The curves for both Godwit species were significantly non-linear. However a high proportion of the sites supported no birds, so the curves were based on rather a few points. Using non-linear relationships meant that, in some areas, 1986-87 densities had to be adjusted by a factor of ten! It is most unlikely that in reality Godwit numbers changed by so much between these two winters, and we were certainly reluctant to base such a decision on so few data points: were the non-linear functions to have been used to adjust 1986-87 counts to 1987-88 equivalents, severe distortions would probably have been introduced. Given the general trend for numbers in the two years to be similar in the few sites where these species occurred, we simply used the counts made in the two years directly, without adjustment.

5. Mean site densities

These were calculated from the mean of the ten counts made in each site. The counts were made between October and March so the numbers of birds available to feed in a site would have changed according to the annual cycle of numbers in the estuary. Because it was not possible to distribute the counts with respect to season equally in all sites, it was necessary to find a way of seasonally adjusting the counts before the means for all sites could be calculated and compared.

The counts were seasonally adjusted using data on the mean numbers of each species counted in each month of the winter over the last five years. The data had been kindly provided by the BTO. Using these data, the first step was to calculate the mean numbers of each species counted in each estuary during the peak months of December, January and February. The numbers counted during each month of the winter from October to March were then compared with this value to give a correction factor which would allow all counts to be adjusted to the December - February standard. For example, if 1000 birds on average were present from December to February, and 100 were usually counted in October, the October count would be multiplied by ten to adjust it to peak winter equivalents. This was done for each species in each area for each of the six months of the winter. In many cases, the correction factors were close to unity, though there were some much larger values particularly in October and March (Figure ().

The surface-area of each site was measured from 6-inch OS maps: the estimates based on the aerial surveys flown during the autumn of 1987 are not yet available. The values of density shown in Figure 9 were calculated by dividing the mean of the counts, seasonally adjusted to the mean December-Februray values, by the surface area of the flats. The results show that, in most sites and species, the standard errors were quite small. They also show that, in most species, bird densities varied considerably between sites within an estuary and between estuaries. Note that the sites studied in each estuary may not be representative of the whole, so simple comparisons between the Severn estuary and other estuaries would be inappropriate at this stage.

Figure 10 shows the seasonally-adjusted values plotted against the unadjusted mean values of the counts made during the months December to February only. With the exception of Redshank, the values for R^2 exceeds 90% showing that variations in one measure closely follow variations in the other. Therefore there is no need to decide which is the more appropriate measure of density to use in the multiple-regression analysis and only the seasonally-adjusted values will be used because they are based on a larger number of counts. However, the slopes of the relationships shown in Figure 10 are often significantly different from unity, implying that in absolute terms the two measures are not exactly inter-changeable. After the multiple-regression analysis has been completed on the seasonally-adjusted data, and the choice of significant independent variables made, we propose to calculate also the coefficients and constants using the unadjusted counts for December - February.

6. Diet

The foods eaten by many of the larger waders can be seen as they are swallowed, and it is often possible to identify the kinds of organisms being eaten. The foods eaten by the smaller waders and Shelduck cannot usually be determined this way, but a combination of existing knowledge, observations on the feeding methods and a knowledge of the organisms in the sediments do enable the range of probable prey species to be deduced.

In this study, the foods and feeding methods of all the main species have been recorded in most of the sites where the birds occur in reasonable numbers. The procedure with the larger-sized waders was to watch an individual until it had eaten two or three prey, and then to repeat the observations on another bird. With the smaller-sized species, a bird was watched until up to twenty had been swallowed.

Table 1 summarises the results. It contains no surprises, the data being much in line with those obtained from elsewehere. The identification of the small prey items must await the analysis of the invertebrate samples currently underway at IMER. Oystercatchers on mussel beds were not watched as it is well known that most would be eating mussels. This Table, along with published sources of information on the diet of shorebirds, will provide the basis for selecting the prey species to be included in the suite of independent variables against which bird densities will later be regressed.

7. La Rance

The estuary of La Rance was visited in October 1987 to select three sites. Each of these was then counted throughout one complete tidal-cycle during the first week of January 1988, this being the mid-point of the winter (December to February). The invertebrates and sediments were sampled the following day by SM and RR. At the time of writing, the values for bird density in this estuary have not been calculated and the invertebrate and sediment samples await their turn to be processed at IMER.

8. Exposure time and shore width

Exposure time was measured in each site during the two spring-tide periods falling in June 1987. The original plan had been to do this in November and December but the date was changed for the following reasons: (i) the winter was already a very busy period and recording exposure time is very time-consuming, (ii) the short daylength at the end of the year makes it difficult to cover a whole cycle on one day, (iii) the weather can be more stable (and pleasant) in June and (iv) the relative exposure times of the different sites would be unaffected by the absolute height of the water anyway.

The exposure time was measured as follows. The position of the tide at regular intervals throughout the tidal cycle was drawn on a map by reference to such landmarks as buoys, poles of known position etc. Though imprecise, the differences in exposure time between sites are so large that inaccuracies in measurement would be small in comparison. Figure 11 shows for each site (i) the length of time from when the first part of the site was exposed until the last part was covered; (ii) the period for which most (approximately 90%) of the site was exposed at low water, and (iii) the period during which all the site was exposed at slack water. In all measures, the variation between sites within estuaries and between estuaries was large.

Shore width has so far only been measured from OS maps. The lengths of six to ten equally-spaced transects, running from HWM to LWM, were measured in each site, the number chosen depending on the variability in shore-width. At the same time, the width of the entire estuary at these transects was also measured in case the overall "openess" of the estuary affected the densities of some species. An arbitrary maximum value of 3km was set for estuary width, since greater distances were unlikely to affect the birds' perception of an area. As Figure 12 shows, shore-width and estuary width vary considerably between sites within an estuary and between estuaries.

9. Salinity in Southampton Water and Poole Harbour

Unpublished values for salinity in various parts of these two estuaries have been obtained from the University of Southampton and from the local Water Authority. The data have been sent to IMER for inspection and collation.

FURTHER PROGRAMME

The main task is to relate the variations in density to various features of each site, including (A) the particle size distribution of the sediments, their organic content and geotechnic properties, the exposure time, the shore-width and (B) the numerical and biomass densities of the prey. The analysis of the factors listed under (A) can begin soon, but it will later in the summer before the data on the prey will become available. JG-C intends to spend 4-6 weeks on secondment to IMER when this stage of the analysis is reached.

FIGURE LEGENDS

Figure 1 Comparison between the counts made by two observers. (A) Dots. JG-C and ER counted the same groups of birds of various at the same time. (B) Crosses. JG-C and DW counted the numbers of birds feeding on same area but on different days.

Figure 2 (A-E) The numbers of birds of each species at Sandbanks (sites 4 and 5) throughout the tidal cycle.

Figure 3 (A-G) The numbers of birds of each species in Brands Bay (sites 6 - 8) throughout the tidal cycle.

Figure 4 (A-G) The numbers of birds of each species in Newton Bay (site 9) throughout the tidal cycle.

Figure 5 The movements of birds within the upper reaches of the Exe (sites 13 to 19) on the receding and advancind tides.

Figure 6 (A-G) The numbers of each species of wader in the upper reaches of the Exe throughout the tidal cycle in November 1986.

Figure 7 (A-H) Comparison between counts made in the same sites in two winters. The means of five counts are shown.

Figure 8 Frequency histogram of the factors by which the monthly counts were multiplied to adjust them to peak winter (December to

February) equivalents.

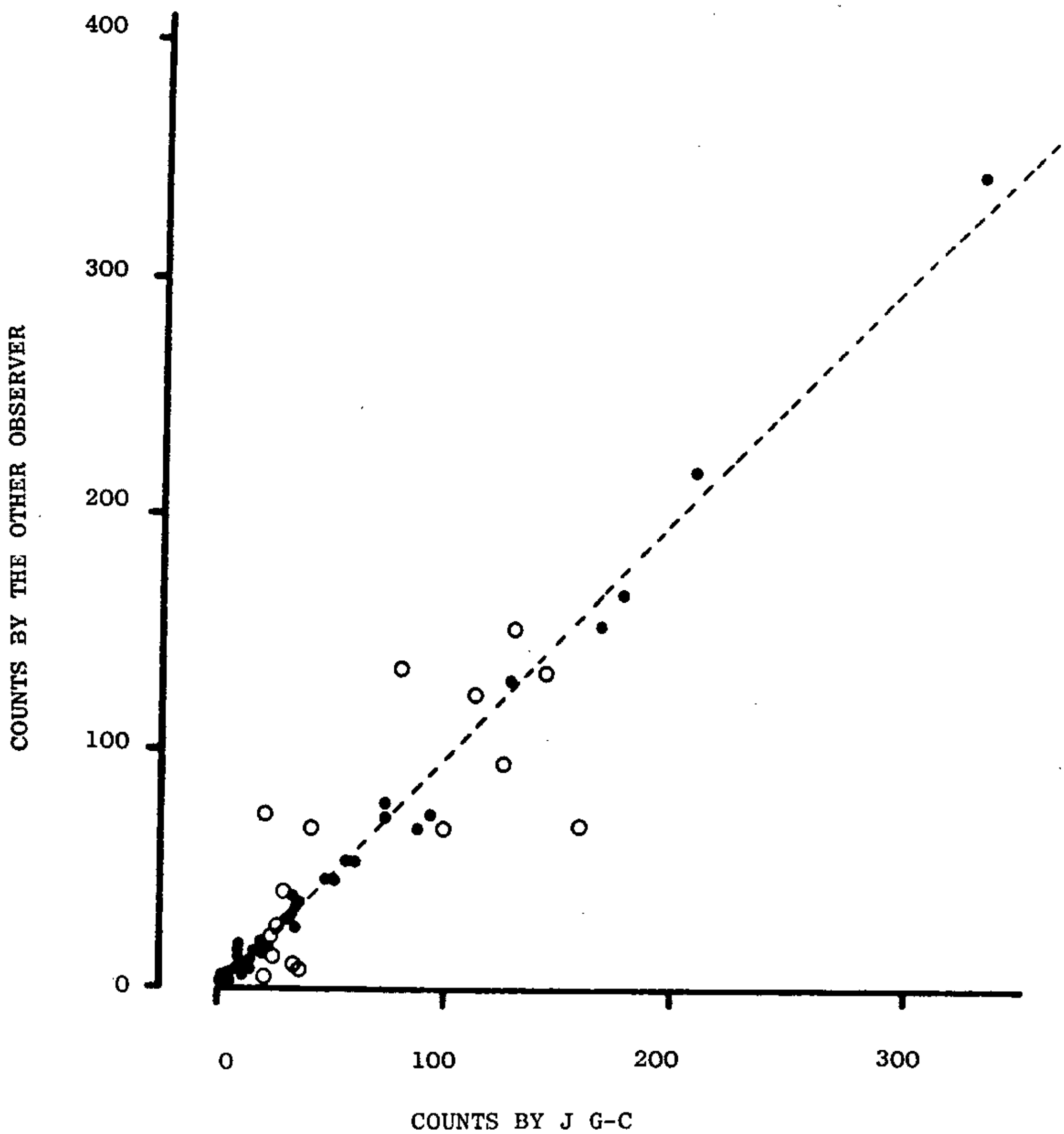
Figure 9 (A-G) The mean densities, seasonally-adjusted to December to February mean values, of each species in each site. The shading identifies the estuary: Southampton Water - ( ); Poole Harbour - ( ); Exe estuary - ( ); Plymouth estuaries - ( ) and Severn estuary - ( ). Vertical bars show 1 SE.

Figure 10 (A-G) Comparison between the seasonally-adjusted values for the densities of waders and those based on unadjusted counts made during December, January and February only.

Figure 11 The exposure time in each site measured in three ways. (A) the maximum time for which any part was exposed,ie. from the time the first part was exposed to the time the last bit was covered, (B) the time for which most of the area (>90%) was exposed, and (C) the time the whole area was exposed over slack water.Shading as in Figure 9.

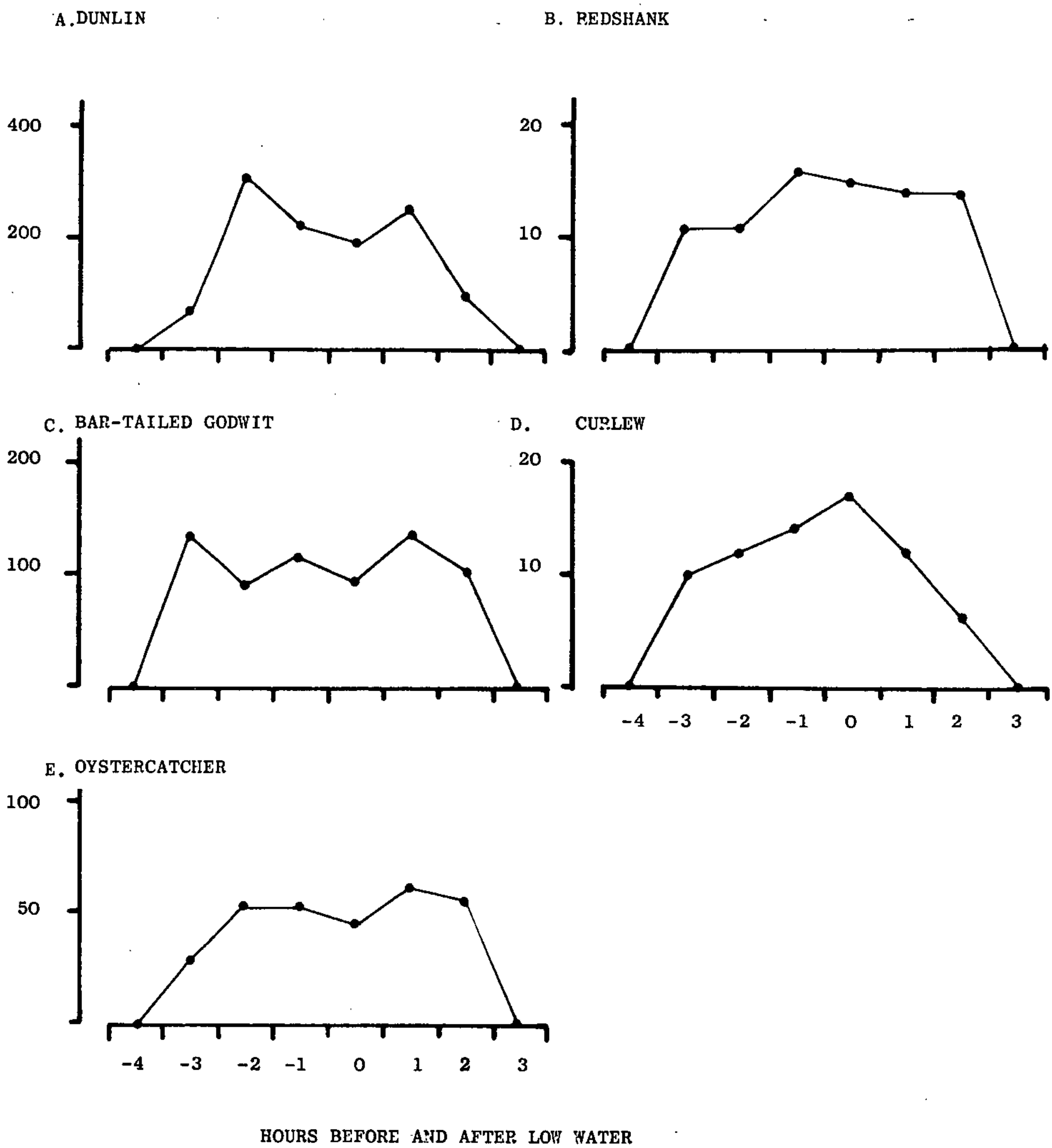
Figure 12 The mean (+- 1SE) shore-widths and estuary widths at each site measured from OS maps. Shading as in Figure 9.

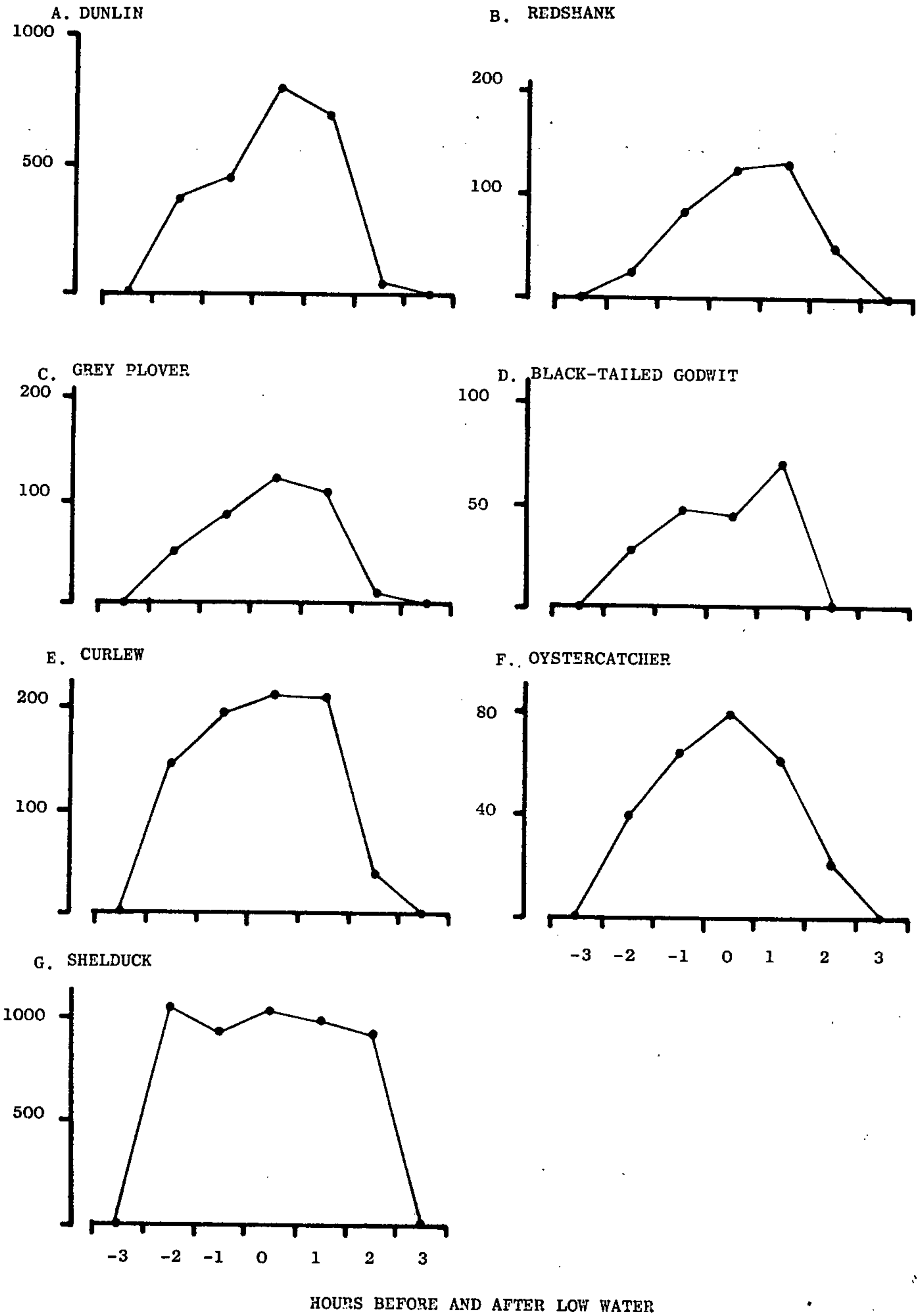
FIGURE 1



400
300
200
100
0
COUNTS BY THE OTHER OBSERVER
0
100
200
300
COUNTS BY J G-C

FIGURE 2


A. DUNLIN
400
200
B. REDSHANK
20
10
C. BAR-TAILED GODWIT
200
100
D. CURLEW
20
10
-4 -3 -2 -1 0 1 2 3
E. OYSTERCATCHER
100
50
-4 -3 -2 -1 0 1 2 3
HOURS BEFORE AND AFTER LOW WATER


A. DUNLIN
1000
500
B. REDSHANK
200
100
C. GREY PLOVER
200
100
D. BLACK-TAILED GODWIT
100
50
E. CURLEW
200
100
F. OYSTERCATCHER
80
40
-3 -2 -1 0 1 2 3
G. SHELDUCK
1000
500
-3 -2 -1 0 1 2 3
HOURS BEFORE AND AFTER LOW WATER

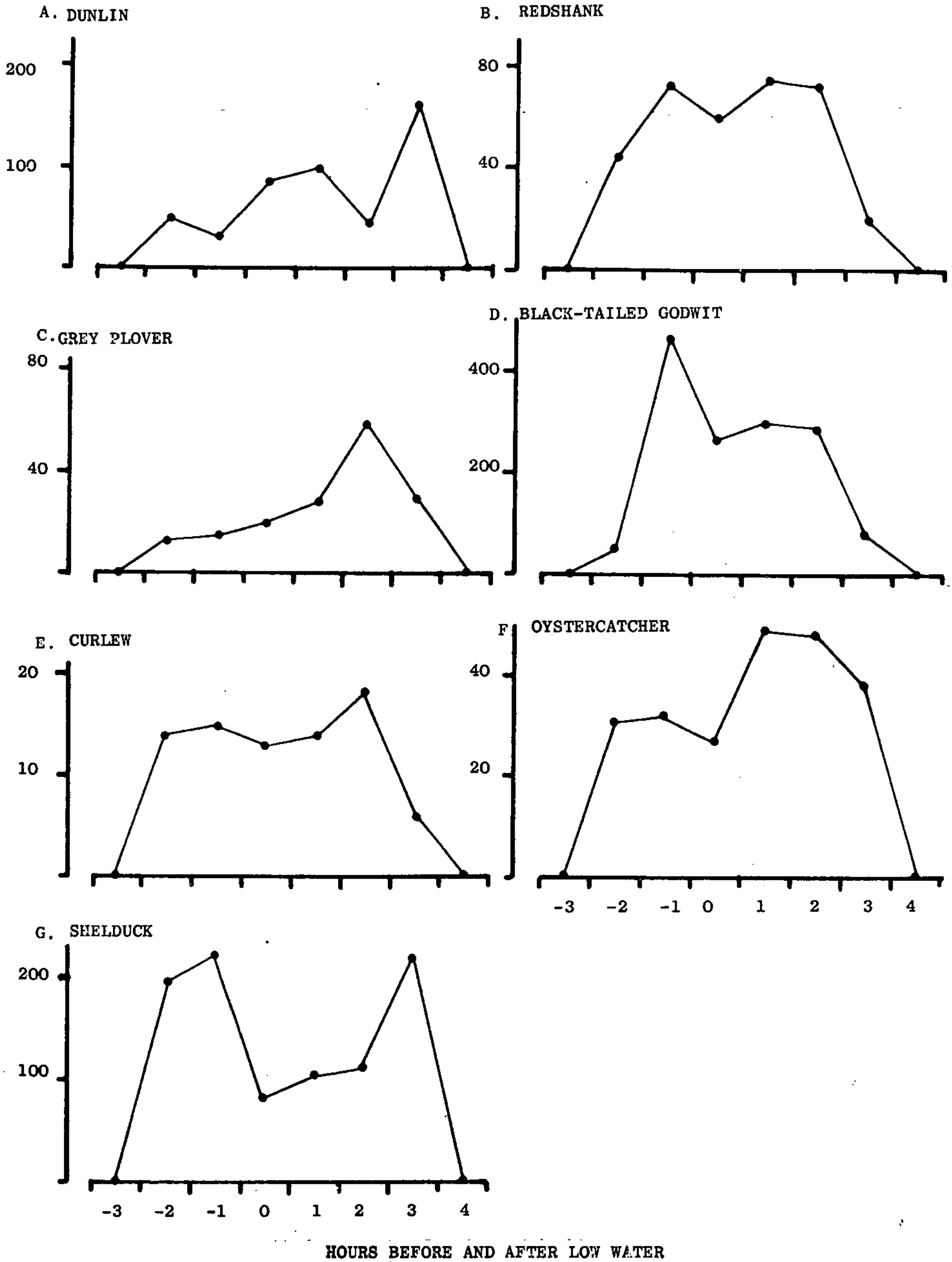
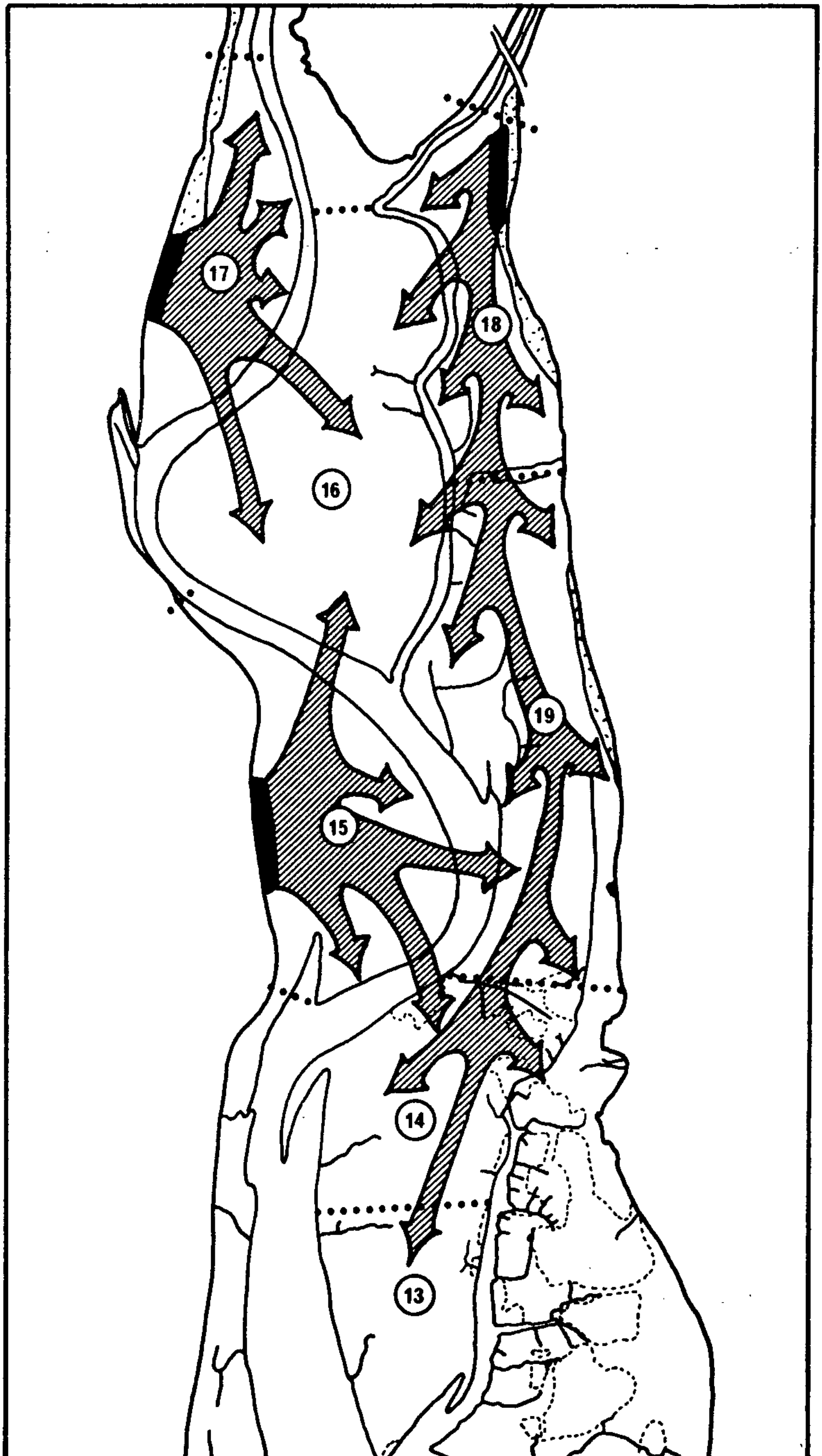
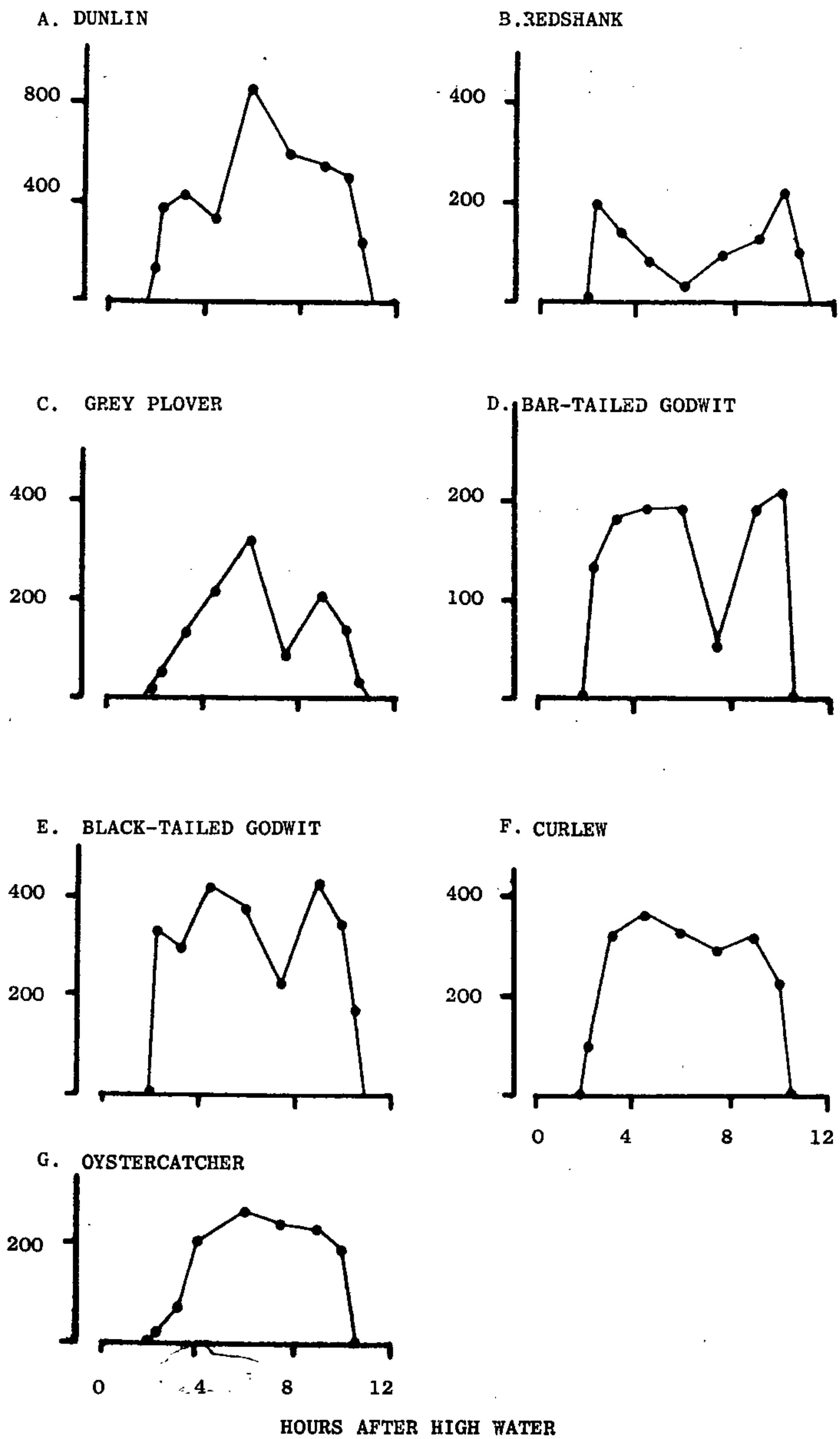
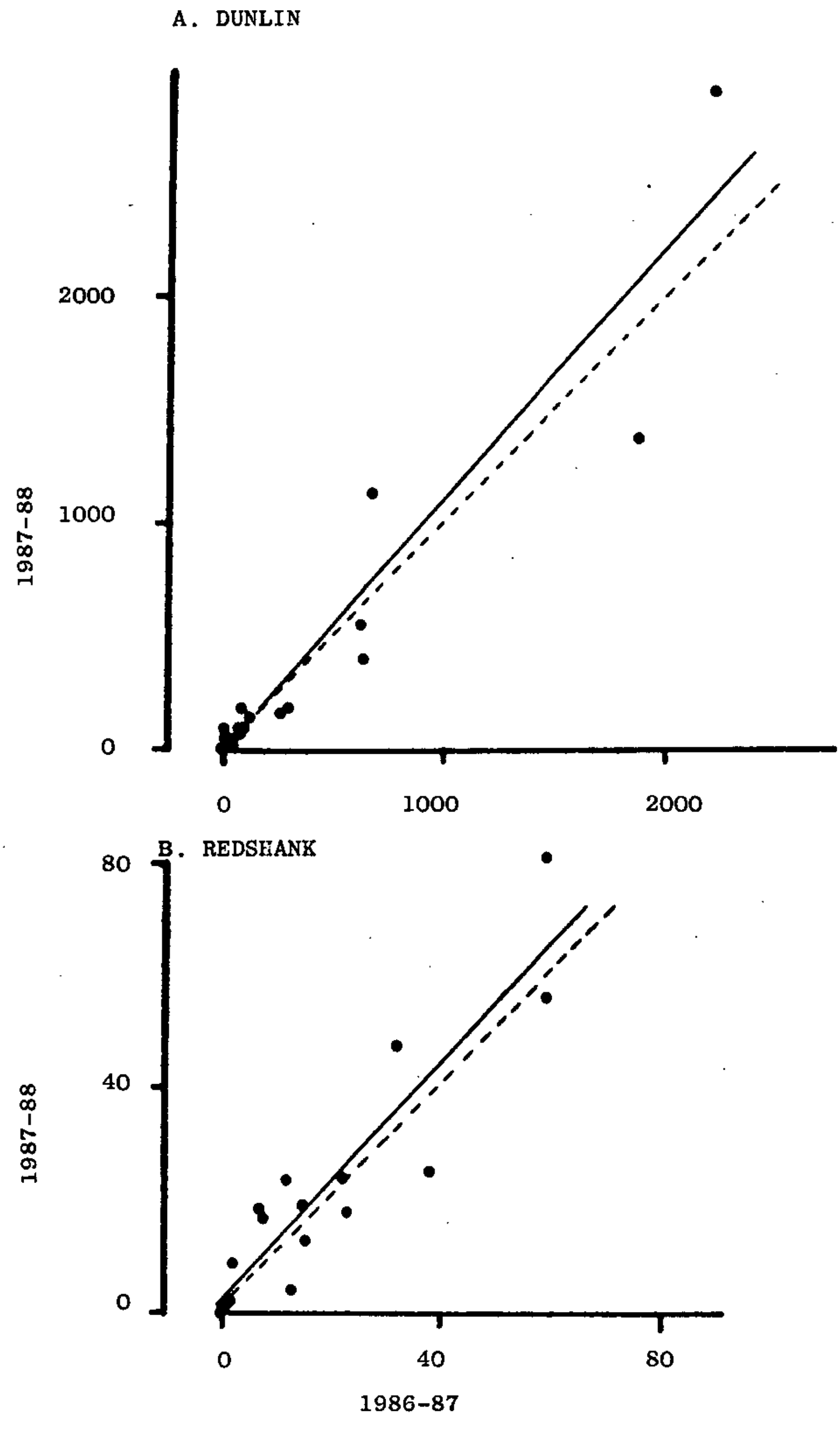
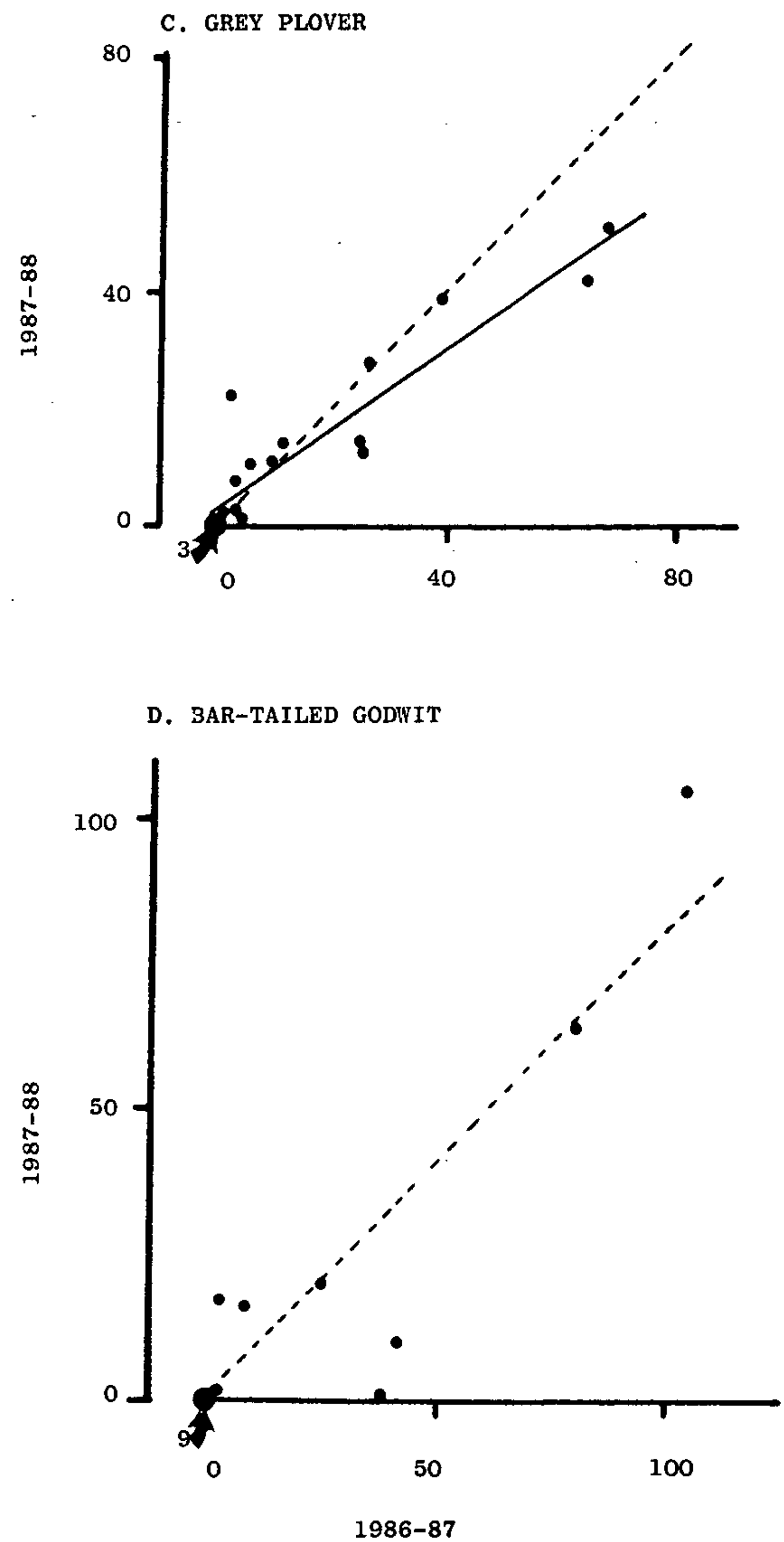

A. DUNLIN
200
100
B. REDSHANK
80
40
C. GREY PLOVER
80
40
D. BLACK-TAILED GODWIT
400
200
E. CURLEW
20
10
F OYSTERCATCHER
40
20
-3 -2 -1 0 1 2 3 4
G. SHELDUCK
200
100
-3 -2 -1 0 1 2 3 4
HOURS BEFORE AND AFTER LOW WATER

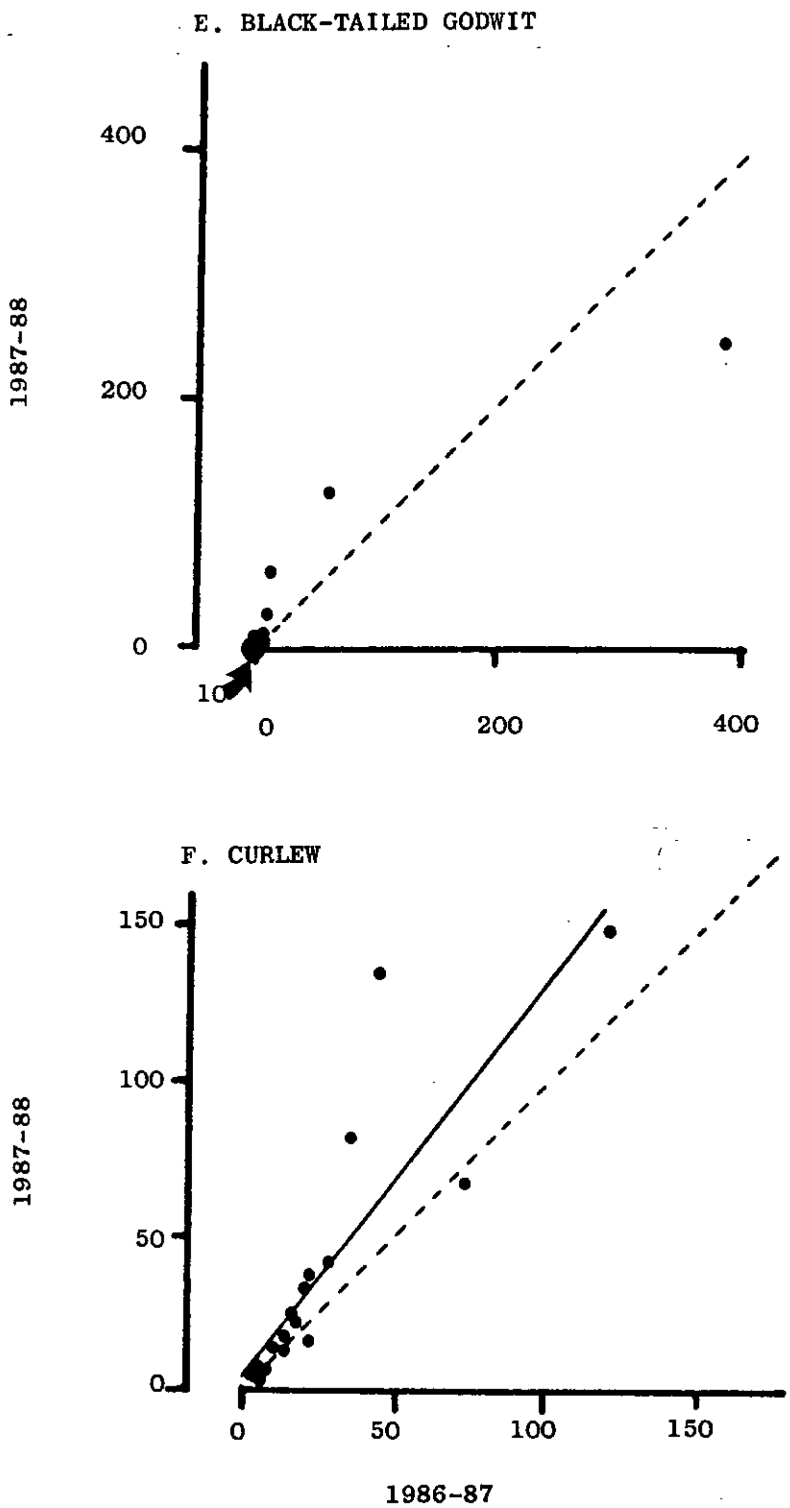
FIGURE 5



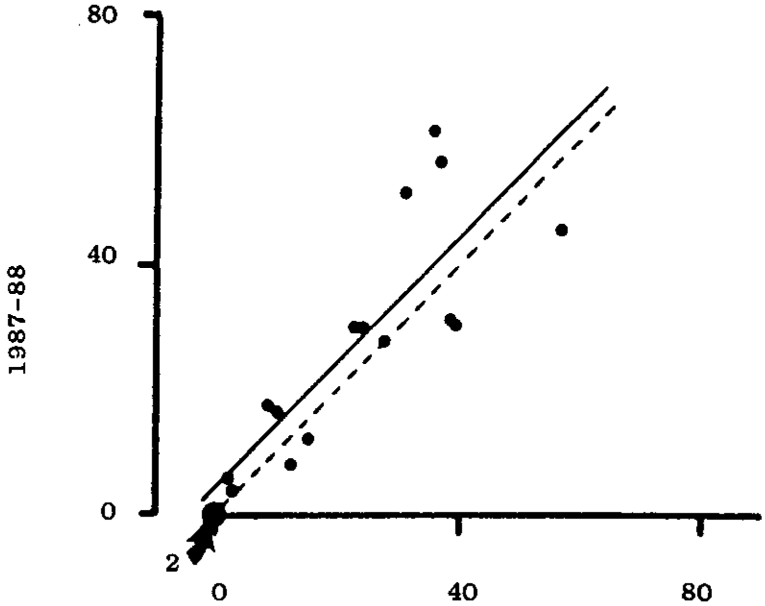

A. DUNLIN
800
400
B. REDSHANK
400
200
C. GREY PLOVER
400
200
D. BAR-TAILED GODWIT
200
100
E. BLACK-TAILED GODWIT
400
200
F. CURLEW
400
200
0
4
8
12
G. OYSTERCATCHER
200
0
4
8
12
HOURS AFTER HIGH WATER


A. DUNLIN
2000
1000
0
1987-88
0
1000
2000
B. REDSHANK
80
40
0
1987-88
0
40
80
1986-87

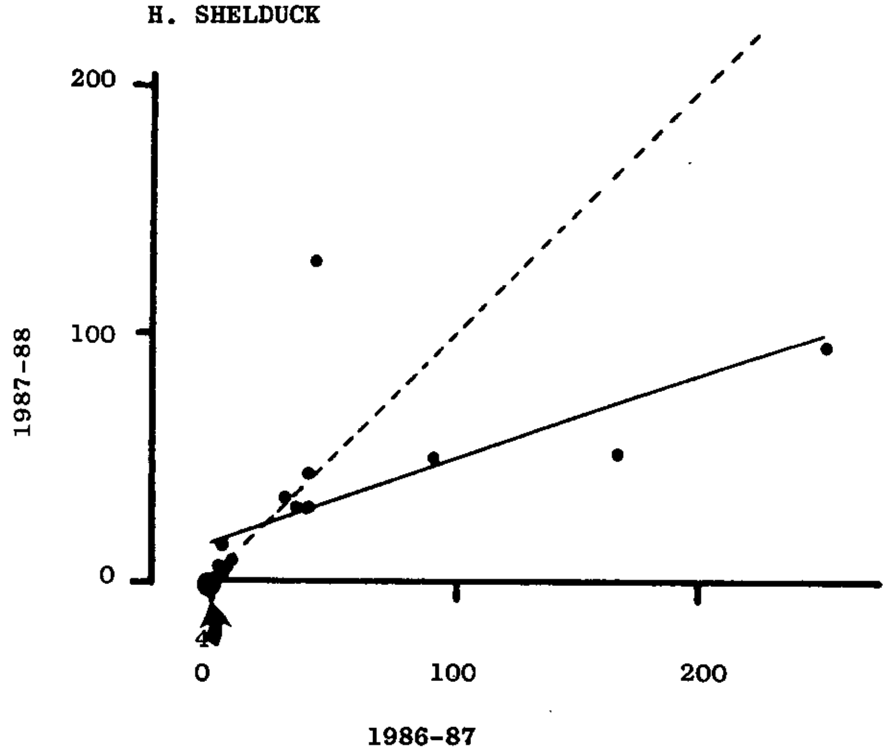

C. GREY PLOVER
80
40
0
1987-88
3
0
40
80
D. BAR-TAILED GODWIT
100
50
0
1987-88
9
0
50
100
1986-87

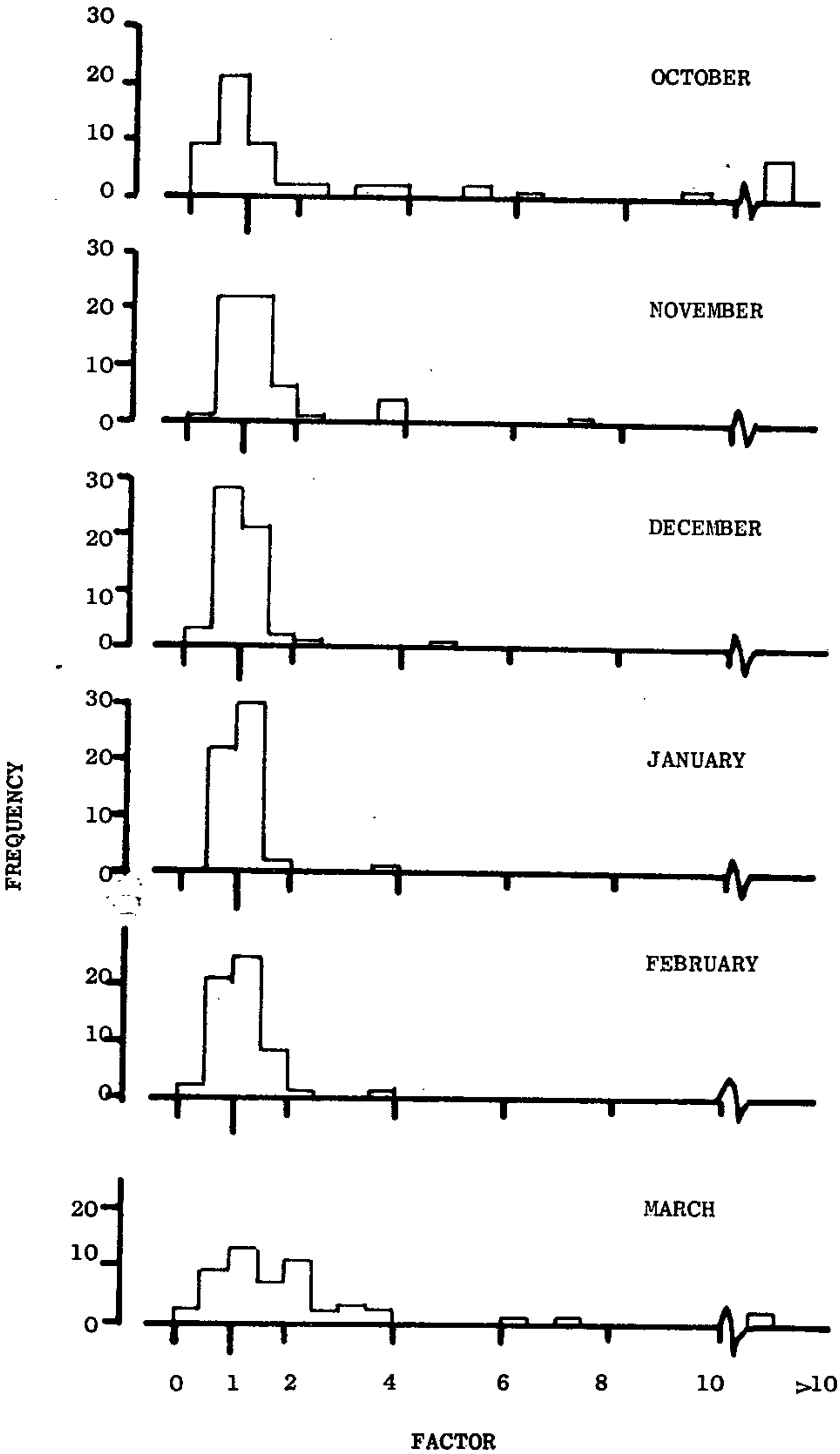

E. BLACK-TAILED GODWIT
1987-88
400
200
0
10
0
200
400
F. CURLEW
1987-88
150
100
50
0
0
50
100
150
1986-87

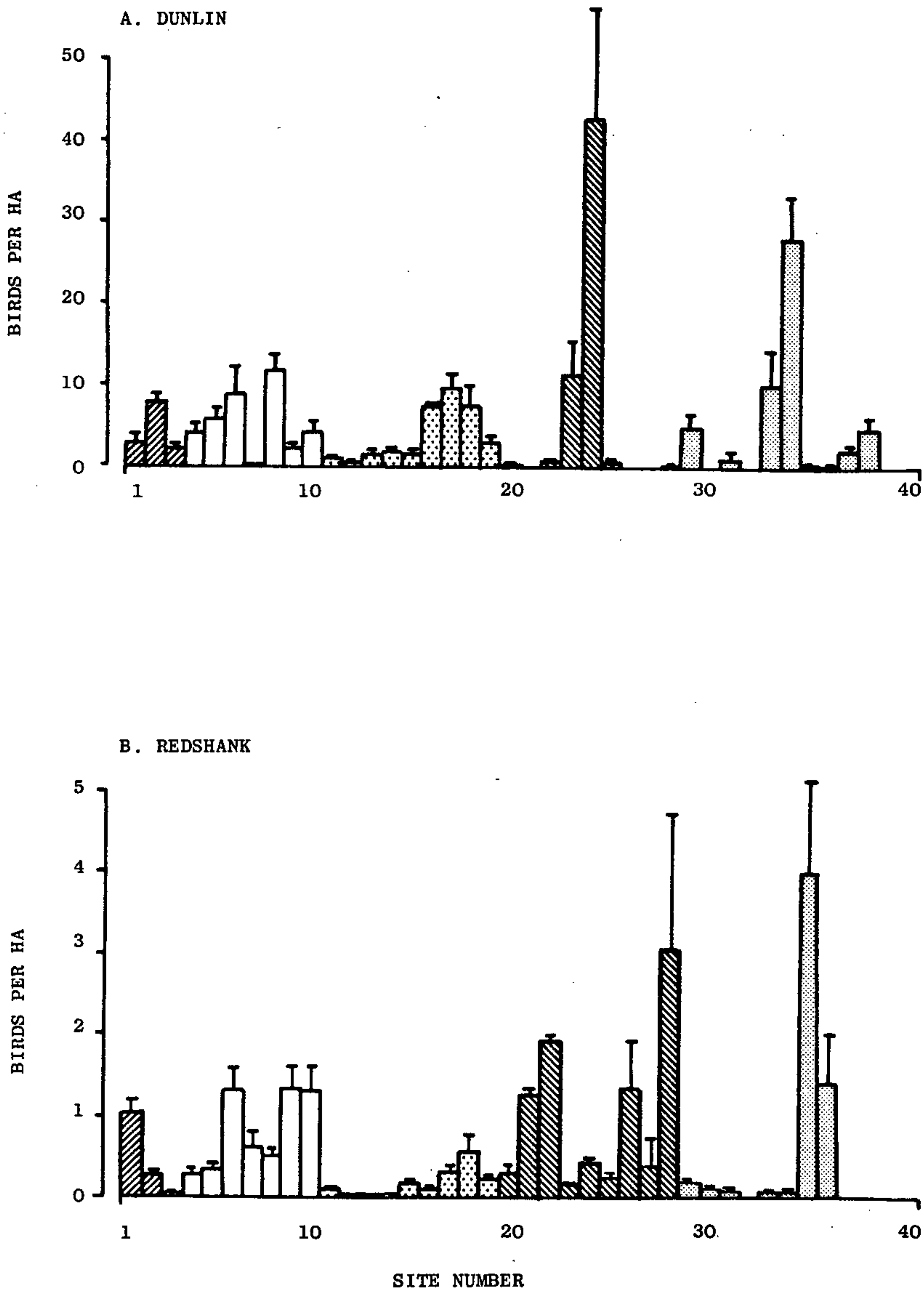
G. OYSTERCATCHER



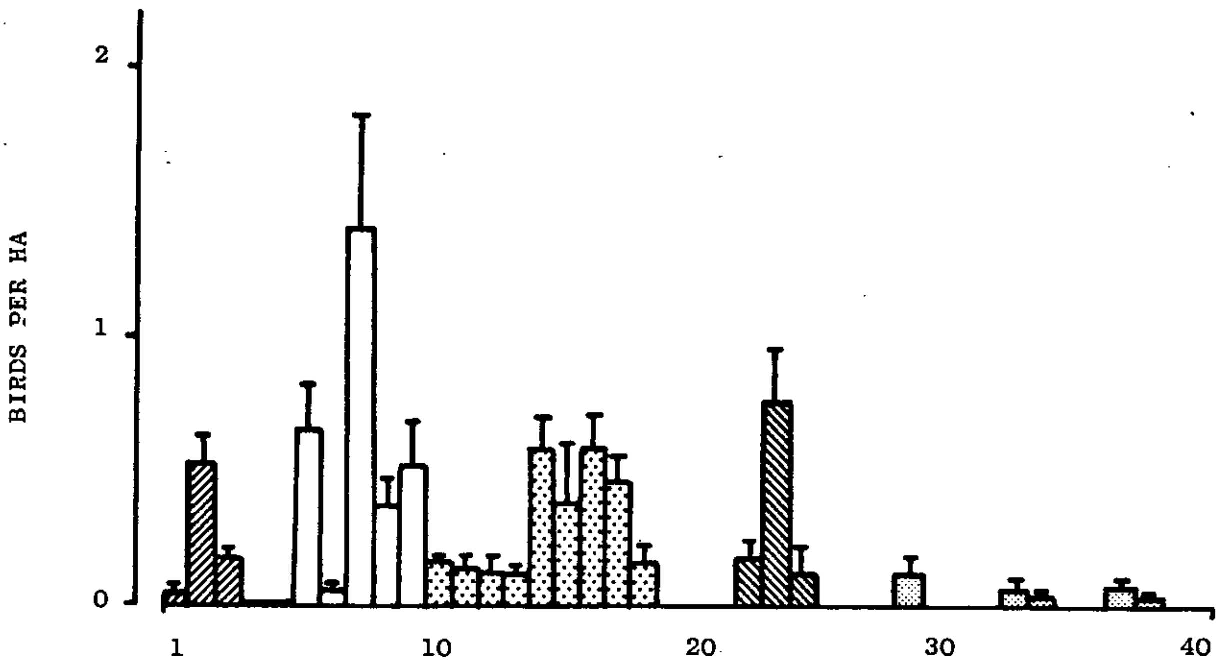
H. SHELDUCK



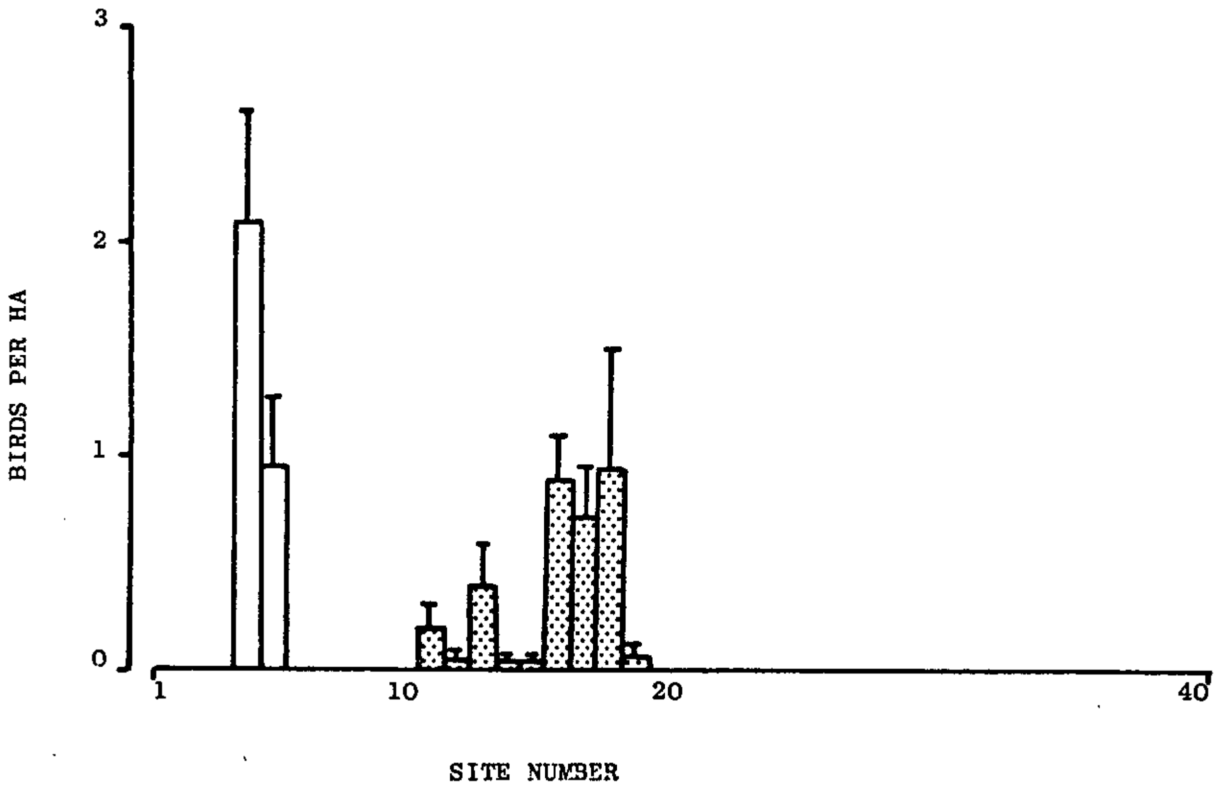

FREQUENCY
30
20
10
0
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
0
1
2
4
6
8
10
>10
FACTOR


A. DUNLIN
BIRDS PER HA
50
40
30
20
10
0
1
10
20
30
40
B. REDSHANK
BIRDS PER HA
5
4
3
2
1
0
1
10
20
30
40
SITE NUMBER

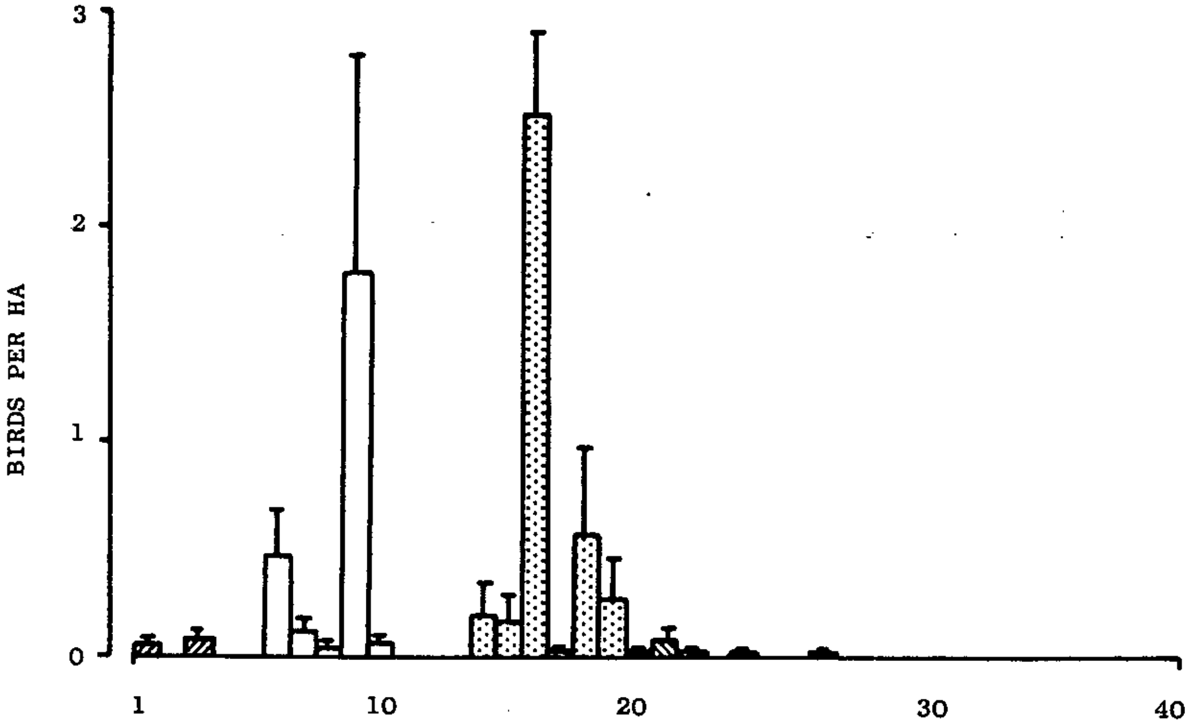
C. GREY PLOVER



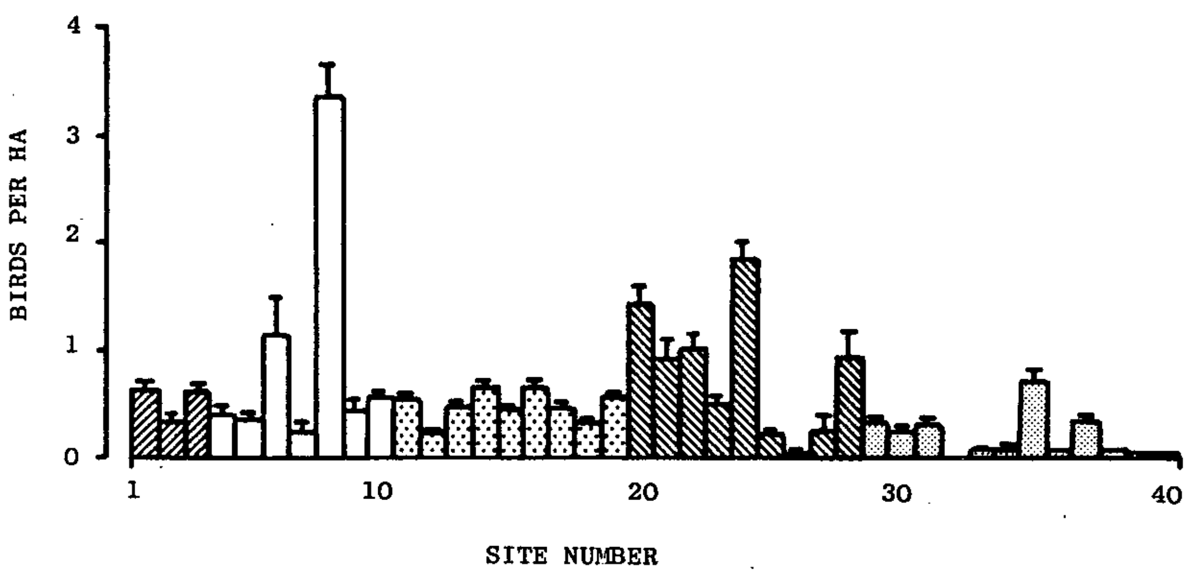
D. BAR-TAILED GODWIT

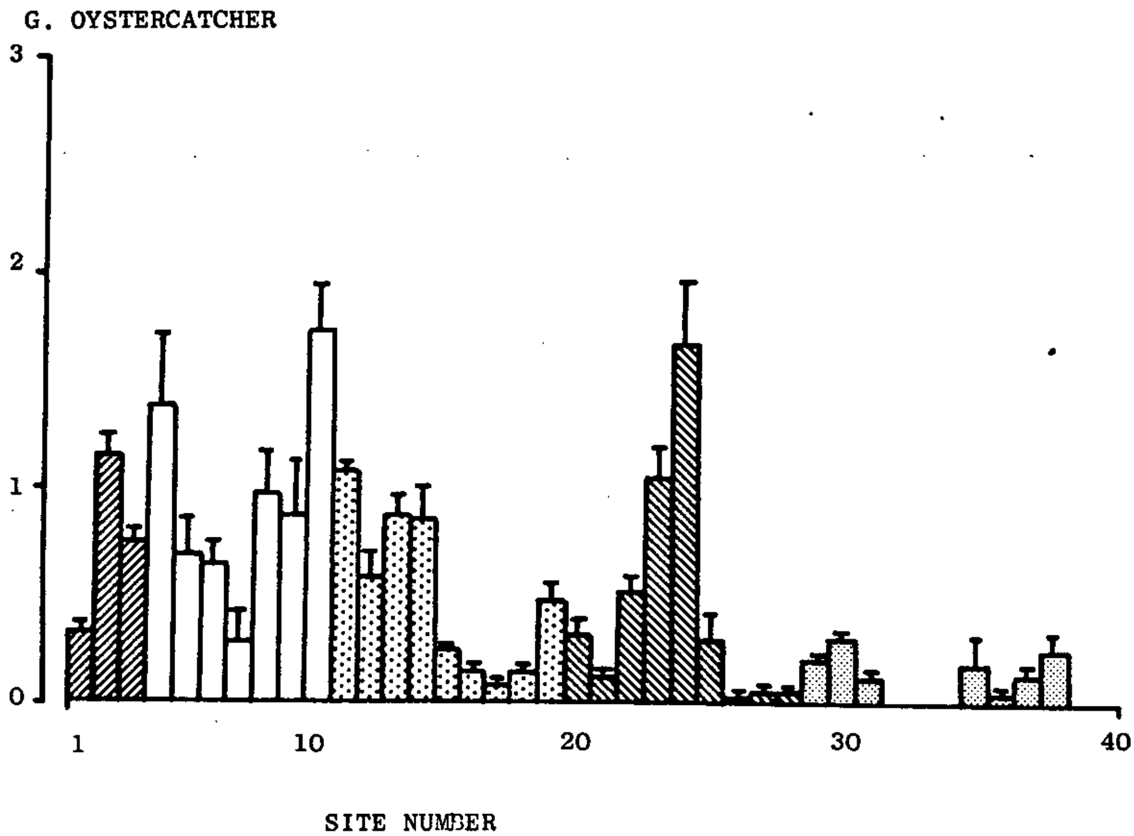


E. BLACK-TAILED GODWIT



F. CURLEW





(Data for shelduck not yet available)

FIGURE 10

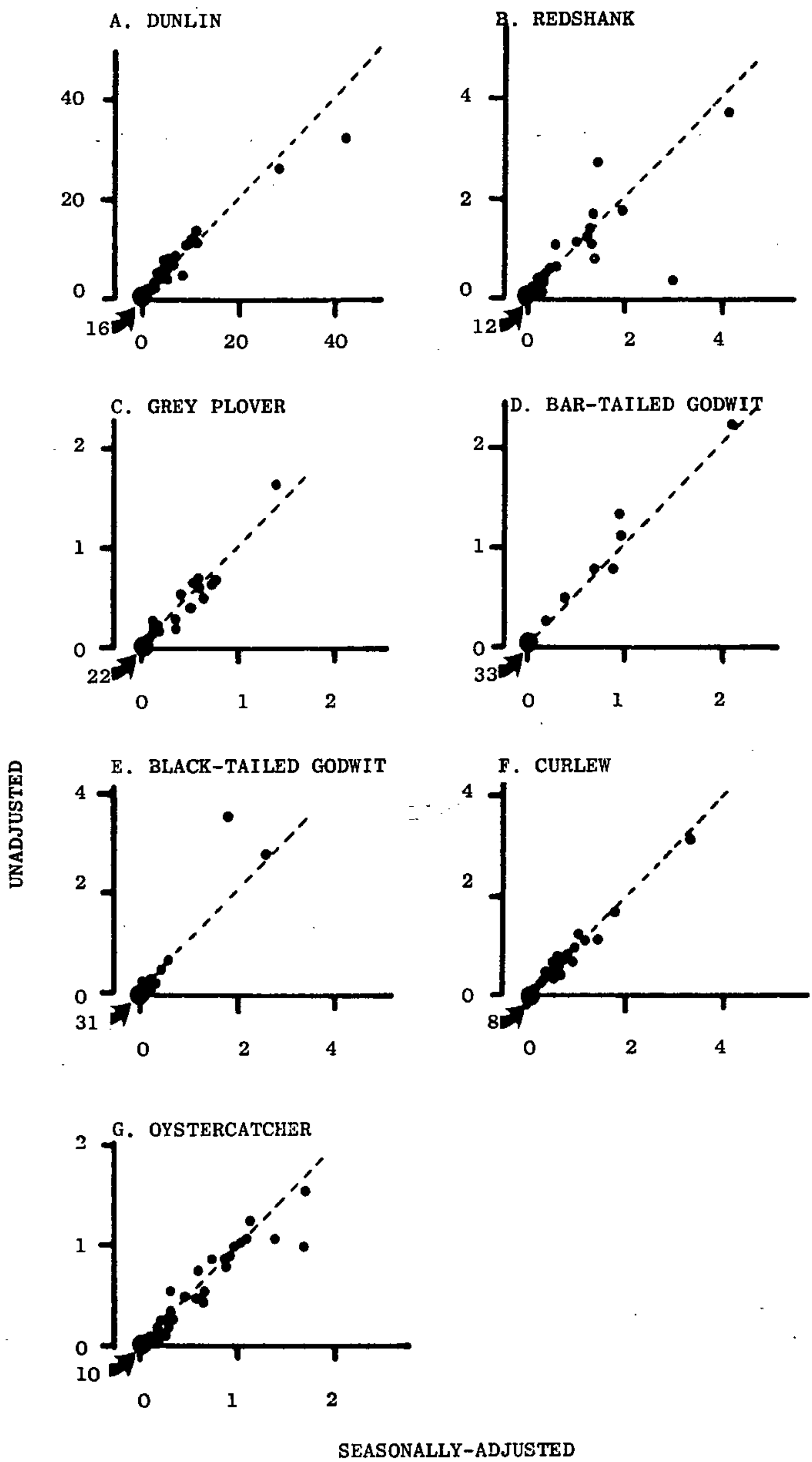
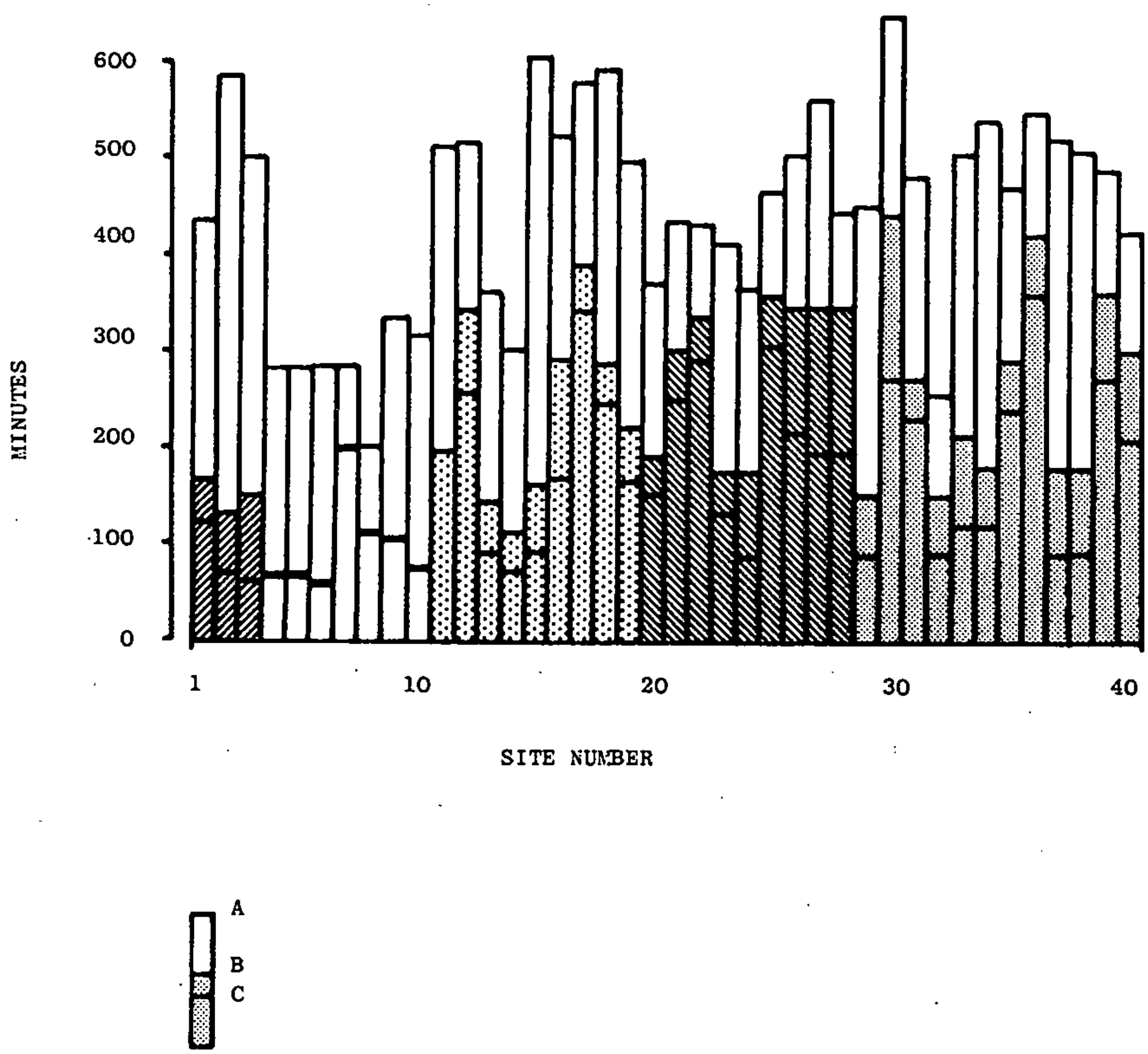

A. DUNLIN
B. REDSHANK
C. GREY PLOVER
D. BAR-TAILED GODWIT
E. BLACK-TAILED GODWIT
F. CURLEW
G. OYSTERCATCHER
16
12
22
33
31
8
10
UNADJUSTED
SEASONALLY-ADJUSTED

FIGURE 11



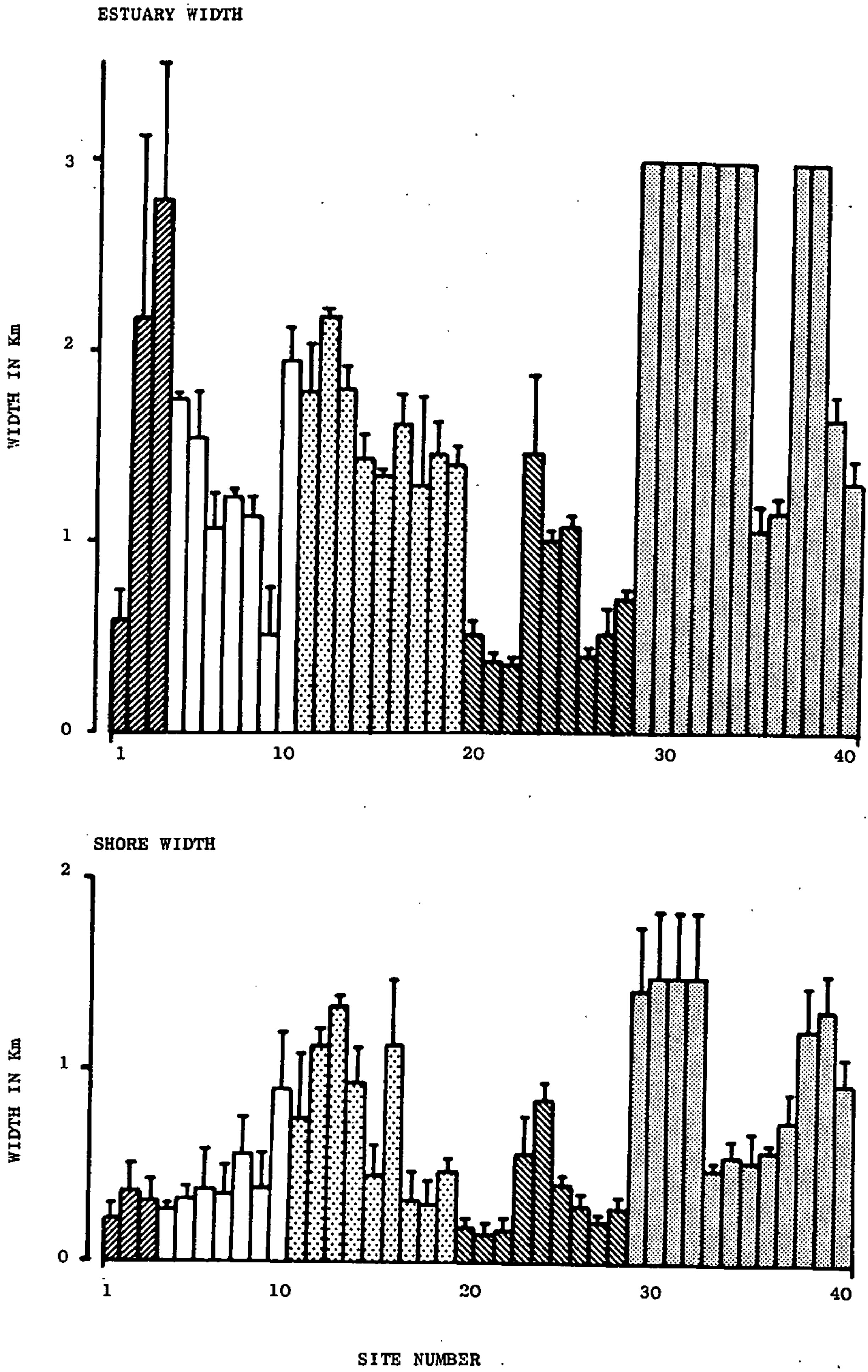

ESTUARY WIDTH
WIDTH IN Km
0
1
2
3
1
10
20
30
40
SHORE WIDTH
WIDTH IN Km
0
1
2
1
10
20
30
40
SITE NUMBER

TABLE 1 THE PREY SPECIES SEEN TAKEN BY N INDIVIDUALS OF EACH WADER SPECIES

Species	Location	N	Unidentified items	Worms	Crabs	Clams	Cockles	Small Bivalves	Winkles	Sites studied
Redshank	Southampton	15	600	7	6					1 2 3
	Poole Harbour									
	Exe	24	219	25						11 15 17 18 19
	Plymouth	53	226	91						20 22 23 25 26 27 28
	Severn	37	219	44				3		29 33 34 35 36
	TOTAL									
Grey Plover	Poole Harbour									
	Exe	41	86	121				6		11 15 17 18
	Plymouth	15	72	19				2		23 24 25
	Severn	30	148	58				14		29 33 34 37
	TOTAL									
Bar-tailed Godwit	Poole Harbour									
	Exe	26	21	60				2		11 15 17 18 19
	TOTAL									
Black-tailed Godwit	Southampton	9		9				9		1
	Poole Harbour									
	Exe	42	56	1				96		11 15 17 18 19
	Plymouth	14	-	7				28		
	TOTAL									
Curlew	Southampton	21	62	46	3	1				1 2 3
	Poole Harbour									
	Exe	64	26	109	1			7		11 15 17 18 19
	Plymouth	139	18	209	10			2		20 21 22 23 24 25 27 28
	Severn	74	106	155						
	TOTAL									
Oystercatcher	Southampton	24		7	1	3	24		2	
	Poole Harbour									
	Exe	62	-	37		55	11	6		11 15 17 18 19
	Plymouth	76	10	51		27		8		20 21 22 23 24 25 26
	Severn	16	-	20				30		
	TOTAL									