AML 53/88

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Ancient Monuments Laboratory
Report 53/88

OYSTER SHELLS FROM OWSLEBURY, HAMPSHIRE.

J M Winder

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Summary

Numbers, size, age and infestation evidence were recorded for oyster shells recovered during archaeological excavations at Owslebury, Hampshire. They came from contexts of Iron Age and Roman date. Both temporal and spatial variation in abundance were demonstrated. Intra-site comparisons of shells from each phase of occupation revealed no significant differences. However, inter-site comparisons of size characteristics of shells from Owslebury with oysters from archaeological and modern sites elsewhere in Wessex, together with infestation evidence, strongly suggested the location of the oyster beds from which the Owslebury oysters may have been derived.

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I AIMS

The oyster shells from this site were examined to determine their characteristics regarding size, age, relative growth rate and infestation; and to see whether there were any intra-site variations in abundance or characters. If temporal variations could be demonstrated, it was intended to see if these could be related to known climatic factors. Additionally, inter-site comparisons were made between the Owslebury samples and others from Wessex to find out how similar or dissimilar they were. It was also hoped that it might be possible to suggest from which coastal location the Owslebury shells may have been collected.

II METHODS

The oyster shells from each context, layer or section were separated into the right (flat) valve and the left (cupped) valve. The numbers of each were counted. Other marine mollusc species such as mussels, saddle oysters and cockles were also counted. The abundance of oyster and other marine mollusc shells was tabulated for each major context type and for each phase of the site. The percentage frequency with which oyster shells occurred in each phase or group of phases was charted in histogram form.

The oyster shells were measured where possible. Many of the shells were too fragmentary to be measured. The maximum width, which is the distance from the umbo or hinge to the margin of shell opposite; and the maximum length, which is taken across the shell at right angles to the width measurement at the greatest point, were taken by placing the shell on a ruler in the correct orientation and recorded to the nearest millimetre.

An analysis of size (using the right valve maximum width measurement - RVMW) was then carried out. Since only two contexts, 642 and 133, yielded an adequate number of shells for analysis (514 and 79 right valves respectively), the smaller samples were grouped according to phase. These groupings were given the notation OWSLE 1 - OWSLE 14 as follows:

OWSLE 1 all contexts dating from BC
OWSLE 2 all contexts dated to 1st century AD
OWSLE 3 all contexts from the mid-1st century AD
OWSLE 4 all contexts from late-1st century AD
OWSLE 5 all contexts dated simply 1st AD
OWSLE 6 all contexts dated 2nd AD
OWSLE 7 all contexts dated 2nd/3rd century AD
OWSLE 8 all contexts from 3rd/4th century AD
OWSLE 9 all contexts dated to the 4th century AD
OWSLE 10 layers 1-3 of context 642 dating to mid-1st century AD
OWSLE 11 layer 4 of context 642 - late 1st century AD
OWSLE 12 layers 5-6 of context 642 - 2nd century AD
OWSLE 13 layer 7 of context 642 - 3rd century AD
OWSLE 14 layers 8-14 of context 642 - 3rd/4th century AD

The right valve maximum width measurements were used to plot size frequency distributions for the fourteen samples. The RVMW measurements

were then put on computer and analysed with the MINITAB program. A summary of the size data was drawn up. Two sample t-tests were carried out to compare the Owslebury samples with each other, and with samples from other sites in Wessex. The results were plotted as matrices, first showing the actual t-values obtained showing the magnitude of the differences observed; secondly showing only presence or absence of a significant difference in size in each two sample comparison.

An analysis of variance was then executed to illustrate the degree of similarity or difference between the size characteristics of the samples from Owslebury, and then of all other samples from Wessex.

The right oyster valve, which tends to be flatter and to have fewer frilly shell outgrowths than the left valve, was then used to determine the age of the oyster when it was originally collected. The shell shows many growth lines concentrically arranged from the hinge end. These lines represent spurts of shell growth. During the growing season an oyster will make several growth shoots. During the warmer weather the growth shoots are larger than during the cold weather. Shell growth does continue during winter but at a minimal rate. This pattern of shell additions is evident on the surface of the shell as a series of growth bands. Each band consists of a comparatively widely-spaced series of lines representing growth in warmer conditions, and a series of closely-arranged lines typical of minimal growth in cold water conditions. One band is formed for each year of the oyster's life. These lines and bands are not generally as easy to distinguish as in other species of marine mollusc such as cockles and mussels because oyster shell growth is morphologically more variable.

It should be noted that the first band at the hinge end usually represents less time than subsequent bands since the oyster is spatted about July and growth slows dramatically by around November/December. The first band therefore represents only half a year's growth. New shell shoots around the margin of the shell are easily damaged before they are consolidated from beneath. The latest shoot can be broken off during dredging, food preparation, burial, disposal or excavation. As the oyster grows older, the shell growth tends increasingly to be in thickness rather than in diameter. The growth bands become progressively narrower with age. Eventually the growth bands may form a series of vertically distinguishable steps at the margin of the shell, the numbers of which are not readily assessed.

It can be seen therefore that aging an oyster is not without complications. Where the oyster shell is badly worn or eroded it can be

difficult to see the growth lines. Sometimes the bands can be felt as a series of low ridges. An oblique light source may also be used to throw any low ridges into relief by casting shadows. It may also help to view the shell edge on. The growth shoots are visible as numerous lamellae forming steps that are equivalent to the growth bands. It must be stated, that in common with such proceedures as aging fish scales, the aging of oyster shells tends to be subjective. However, by an examination of large numbers of shells in a single sitting, the effect of the introduction of human errors is likely to be minimised. The growth achieved by oysters in any one year group exhibits a high degree of variation.

It is not possible to measure the width of individual growth bands but is is possible to record the maximum width measurement of the individuals in each year group. The percentage frequency of oysters in each age group was plotted as a histogram. The mean maximum width of each year group in each sample could then be calculated and used to ploy a curve of absolute growth rate.

Evidence was also sought in the shells of infesting or encrusting organisms which are thought to provide a clue to the whereabouts of the oyster beds in which they originated because different organisms have specific habitat preferences. Traces of such organisms would include any hard parts attached to the oyster shell. These might be the shells or tubes that protected the animals, or borings into the shell caused either by a search for food or shelter.

The two most commonly occurring burrows are easy to tell apart, and are created by two species of the same genus of marine polychaete worm. These are Polydora ciliata and Polydora hoplura. In the first instance the two types of worm create mud tubes in the crevices of the oyster shell. Polydora ciliata is about 25mm long and the holes that it makes as it extends the burrow backwards into the shell proper are narrow and scattered over the general surface of the shell. Heavy infection can make the shell friable. Polydora hoplura is twice as long as P. ciliata (about 50mm) and settles in a muddy tube between the mantle (the fleshy part covering the live oyster and responsible for the manufacture of the shell) and the shell at its margins. In reaction to this irritation, the oyster seals off the worm and mud with a thin layer of shell so that a blister is formed on the inner edge of the shell. The worm with its body typically bent double continues to grow, causing the blister to be enlarged and simultaneously making a u-shaped channel (probably by dissolution by acidic metabolic by-products). The channels and blisters are readily distinguishable from

the small borings on the general outer surface of the shell created by the related species. P. hoplura poses a real threat to the well-being of an oyster since the blisters cause difficulties in closing the valves and much energy has to be diverted by the oyster to constant shell repair.

The two worm species have different habitat preferences. P. ciliata is fairly widespread in its distribution, and is found predominantly on hard sandy or clay grounds, particularly in warm shallow water. P. hoplura is mostly found in the southwest of England where it thrives in oysters on soft ground in still warm waters of creeks and inlets. In oysters from south coast locations the two species are frequently found together. P. hoplura is virtually absent, however, from oyster beds on the Essex and north Kent coasts where only P. ciliata occurs.

There is a sponge, Cliona celata, which bores into oyster shells. In life, infestation by this sponge is apparent by the numerous yellow pustules on the surface of the shell. In shells from archaeological excavations its former presence is signified by the honeycomb appearance of the shell where the sponge has deeply penetrated and ramified its structure. When severely affected, the shells break easily during transit and opening. They are sometimes called "rottenbacks" in the oyster trade. The disease is prevalent in the south and southwest of England.

Two species of mollusc bore straight through oysters, particularly young thin-shelled individuals, to suck out the meat. Successful attack kills the oyster but sometimes the oyster survives and seals off the hole by rapidly laying down new shell. This could happen if, for example, the predator became dislodged. The sealed-off bore holes can be seen in archaeological shells. The most common borer would have been the European rough tingle or sting winkle (Ocenebra erineacea(L.)) although the dog whelk (Nucella lapillus (L.)) is thought to prey on oysters in the same way. Both are gastropods with a spired shell, inhabit shallow water, and feed by means of a long proboscis at the end of which is a small mouth with a tongue-like radula armed with rows of teeth. The teeth rasp the shell to make the entry hole.

Encrusting organisms leaving hard parts on the oyster shells recorded from Owslebury material include the calcareous tube made by the worm Pomatoceros triqueter, barnacles of the Balanus group and Polyzoa which are lace or moss-like encrustations belonging to minute colonial animals.

The presence or absence of evidence of the described organisms was recorded for each measured shell. The numbers and percentage of shells affected in each sample was tabulated. Histograms showing the frequency

of infestation in the samples were drawn up.

Other characteristics were also noted for the shells. These included relative thickness, relative weight, presence of chambering or chalky deposits, degree of wear, colour, irregularity of shape, presence of attached oysters, ligament remains, notches and cuts.

III RESULTS

a. NUMBERS (RELATIVE ABUNDANCE)

Shells of the European flat oyster (Ostrea edulis L.), mussel (Mytilus edulis L.), saddle oyster (Anomia ephippium L.), cockle (Cerastoderma edule (L.)) and carpet shell (Venerupis decussata (L.)) were recovered from 131 contexts during the excavations at Owslebury, together with a few fragments of sea urchin (probably Psammechinus miliaris). Almost without exception these shells were poorly preserved. Many looked as if they had been etched with acid, or were worn and flakey. Many were too badly broken to be measured or aged. Table 1 shows the abundance of oyster shells arranged according to the type of context in which they were found. There were eleven categories: ditches, gullies, quarries, trackways, pits, hollow way, ovens, track gullies, post holes, cobbles and unidentified.

The measureable shells are shown (LV = left valve; RV = right valve) separately from the unmeasureable shells (UMLV = unmeasureable left valves; UMRV = unmeasureable right valves). The two categories of left or right valves are then totalled (TOT LV; TOT RV) and the percentage of damaged shells calculated (%UMLV; %UMRV). The total number of left valves plus right valves is given and the minimum number of individuals (MNI) is presented. The MNI figure is the sum of the MNI's found in each individual context that constitutes the context type category. Whichever has the greatest number - total left or total right valves- gives the MNI. The MNI's shown in the column of Table 1 are therefore greater than would be deduced from the total left and right valves shown in that Table.

The considerable degree of damage in oyster shells can be seen. The lowest level of damage is 41.2% and the highest 100%. The average level of damage in left valves is 60.9% and in right valves 48.2%. The left valves being cupped and ornamented are more susceptible to damage than the right, flat, relatively smooth valves. The numbers of right and left valves are approximately equal (1783 LV; 1814 RV) but with a slight bias to better survival in the right valves.

Ditches yielded the most oyster shells (1312 MNI or 67% of all shells from the site). Gullies were next in importance (with 265 MNI or 13.5%) and quarries third with 166MNI or 8.5%. The eight other context types each contained less than 4% of the total number (10.99% in all).

Table 2 shows the abundance of the oyster shells according to the phase of the site occupation. Oyster shells were found in contexts belonging to 18 phases of the site from the 3rd century BC to the 4th

century AD, with a few modern shells and shells not allocated to phase. The arrangement of the Table is identical to that of Table 1. It must be noted that some of the phases represent more precise divisions of time than others, and there is a certain amount of over-lap. The Table shows that oyster shells are unevenly distributed through the different phases. Only 180 shells (110 MNI) were recovered from all the contexts dated BC. The first significant appearance of oysters occurred in the 1st century AD with 767 shells (MNI 429) 24.79% being found. The peak of oyster consumption was not reached until the 3rd-4th centuries AD - 2035 shells (MNI 1098, 55.4%). The relative abundance of oysters through time is shown in the bar chart form in Figures 1 and 2. Figure 1 shows the percentage frequency of oysters (based on MNI) for each phase of the site. Figure 2 shows percentage frequency of oysters (from MNI) for grouped phases according to the grouping used for computer analysis of size later on.

OWSLEBURY – ABUNDANCE OF OYSTER SHELLS ACCORDING TO CONTEXT TYPE

Table 1

CONTEXT TYPE	LV	UMLV	TOTAL LV	% UMLV	RV	UMRV	TOTAL RV	% UMRV	TOTAL LV + RV	MNI	% OF SITE TOTAL
DITCHES	537	699	1236	56·6	703	583	1286	45·3	2522	1312	67·00
GULLIES	52	181	233	77·7	91	130	221	58·8	454	265	13·53
QUARRIES	51	81	132	61·4	60	79	139	56·8	271	166	8·48
TRACKWAYS	17	56	73	76·7	24	33	57	57·9	130	73	3·73
PITS	13	30	43	69·8	20	21	41	51·2	84	53	2·71
HOLLOW WAY	14	16	30	53·3	15	14	29	48·3	59	35	1·79
OVENS	5	6	11	54·6	10	7	17	41·2	28	19	0·97
TRACK GULLIES	6	6	12	50·0	13	1	14	7·7	26	16	0·82
POST HOLES	2	5	7	71·4	1	3	4	75·0	11	10	0·51
COBBLES	1	1	2	50·0	1	3	4	75·0	6	4	0·20
UNKNOWN	0	4	4	100·0	1	1	2	50·0	6	5	0·26
COLUMN TOTALS	698	1085	1783	60·9	939	875	1814	48·2	3597	1958	100·00

OWSLEBURY – ABUNDANCE OF OYSTER SHELLS ACCORDING TO PHASE

Table 2

PHASE	LV	UMLV	TOTAL LV	% UMLV	RV	UMRV	TOTAL RV	% UMRV	TOTAL LV+RV	MNI	% OF SITE TOTAL
3rd BC	5	11	16	68·8	3	8	11	72·7	27	19	0·96
3rd - 2nd BC	3	3	6	50·0	4	4	8	50·0	14	8	0·40
2nd BC	0	3	3	100·0	0	1	1	100·0	4	4	0·20
2nd - 1st BC	0	1	1	100·0	0	0	0	0·0	1	1	0·05
1st BC	21	38	59	64·4	36	34	70	48·6	129	73	3·68
1st BC - 1st AD	0	3	3	100·0	2	0	2	0·0	5	5	0·25
Early 1st AD	0	1	1	100·0	0	5	5	100·0	6	6	0·30
Mid 1st AD	47	52	99	52·5	66	38	104	36·5	203	104	5·25
Mid - late 1st AD	2	3	5	60·0	4	3	7	42·9	12	7	0·35
Late 1st AD	64	123	187	65·8	95	106	201	52·7	388	221	11·15
1st AD	29	55	84	65·5	48	26	74	35·1	158	91	4·59
1st - 2nd AD	0	1	1	100·0	0	0	0	0·0	1	1	0·05
2nd AD	117	167	274	57·3	139	132	271	48·7	545	294	14·83
2nd - 3rd AD	0	2	2	100·0	0	0	0	0·0	2	2	0·10
3rd AD	108	124	232	53·5	137	124	261	47·5	493	265	13·37
3rd - 4th AD	251	349	600	58·2	319	288	607	47·5	1207	638	32·19
4th AD	45	128	173	74·0	67	96	162	58·6	335	195	9·84
Unknown	11	23	34	67·7	15	13	28	46·4	62	44	2·22
Modern	0	2	2	100·0	2	2	4	50·0	6	4	0·2
COLUMN TOTALS	703	1079	1782	60·6	937	879	1816	48·4	3598	1982	100·0

Figure 1

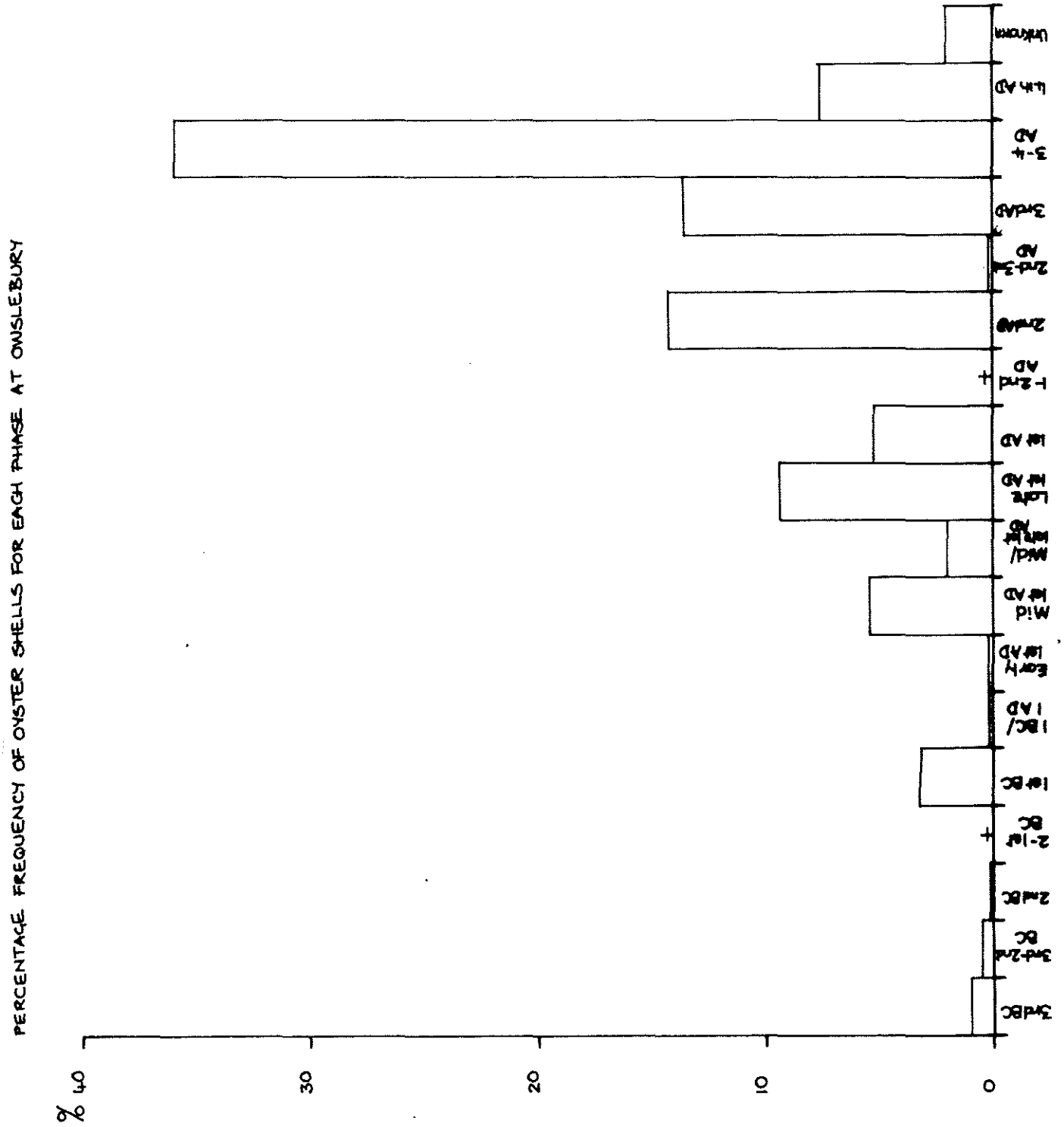
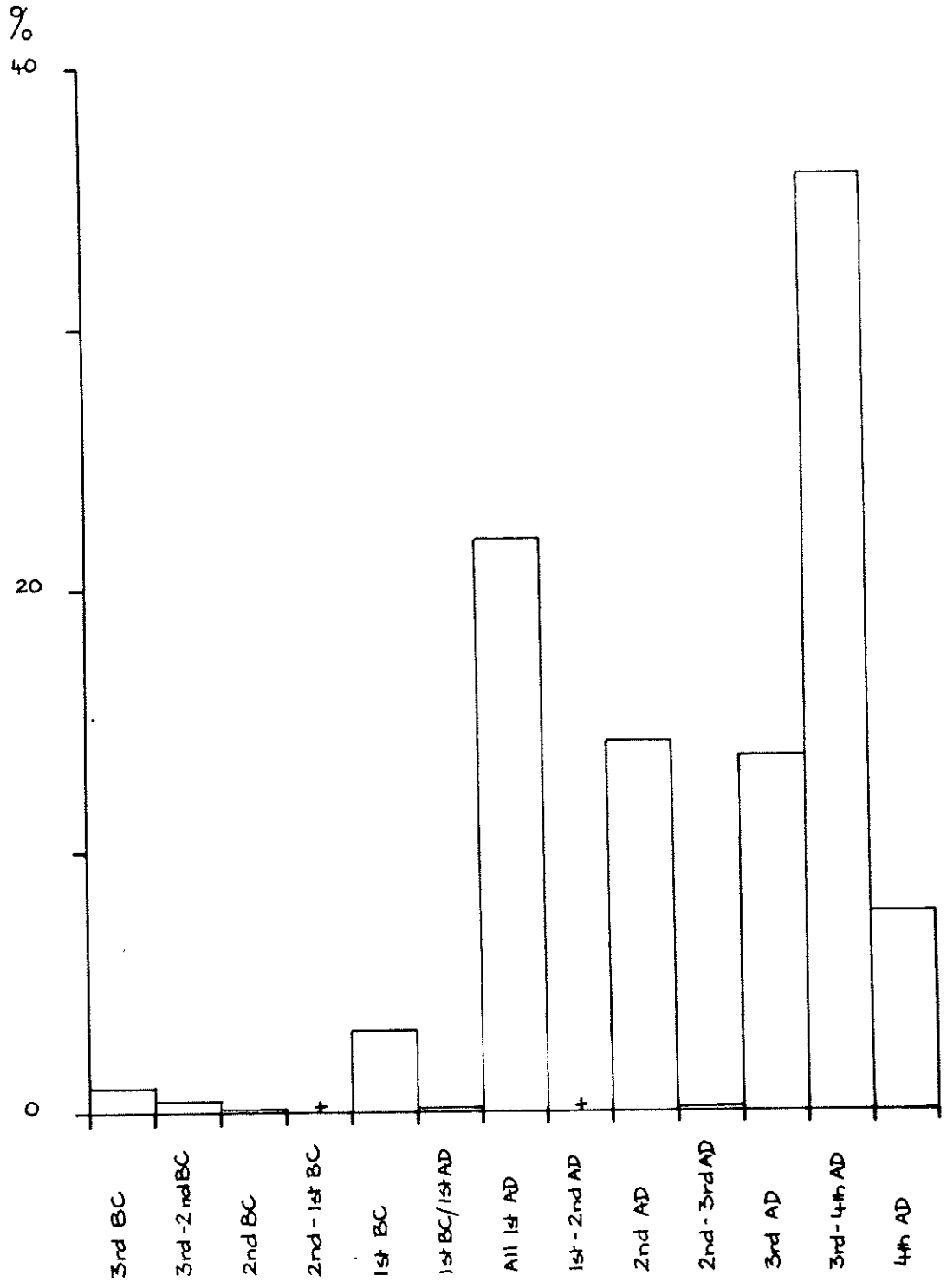

PERCENTAGE FREQUENCY OF OYSTER SHELLS FOR EACH PHASE AT OWSLEBURY
%
40
30
20
10
0
3rd BC
3rd-2nd BC
2nd BC
2-1st BC
1st BC
1 BC/ 1 AD
Early 1st AD
Mid 1st AD
Mid/ late 1st AD
Late 1st AD
1st AD
1-2nd AD
2nd AD
2nd-3rd AD
3rd AD
3-4th AD
4th AD
Unknown

Figure 2

PERCENTAGE OF OYSTERS FROM WHOLE SITE FOUND IN EACH PHASE
(SOME GROUPING)



+ denotes oyster shell present, but in insignificant quantity.

b. SIZE

Table 3 gives a summary of the basic size data for the RVMW measurements of oyster shells from Owslebury. OWSLE 1 - OWSLE14 are the samples as described under methods. The Table gives the number of shells in each sample (N), the mean measurement in millimetres (MEAN), the median or mid-point measurement (MEDIAN), the transformed mean (TRMEAN), the standard deviation (STDEV), the standard error of the mean (SEMEAN), and the minimum (MIN) and maximum (MAX) measurements.

The sample sizes vary a great deal - from 30 to 316 shells. The means show little variation - 69.37mm in OWSLE 9 to 71.95mm in OWSLE 14. The smallest shell recorded measured 31mm and the largest 110mm. The standard deviations of the samples are fairly constant - from 9.97 to 12.93.

Histograms of the distribution of sizes within each sample can be seen in Figures 4 - 17. In these, the horizontal axis represents the maximum width in millimetres. The numbers of shells with each measurement have been grouped into 5mm bars for clarity. The vertical axis represents the percentage of the sample found in each 5mm group. Percentages have been used to aid comparability between the samples since the sample numbers vary so much.

Figures 18, 19 and 20 show these histograms on a reduced scale to assist in making visual comparisons. Some of the samples show a good approximation to a normal curve, eg. OWSLE 13 (n=98) and OWSLE 14 (n=258), but others have an irregular distribution of sizes. In some cases this is probably due to the small sample size, eg. OWSLE 9 (n=35) and OWSLE 11 (n=30) but in others the reason is not obvious. It can be seen that the range of sizes and the optimum size group are fairly constant from sample to sample.

To test whether there are , in fact, statistically significant differences between the samples, two sample t-tests were applied. The results obtained in this way for comparisons of Owslebury samples with each other can be seen in Figures 21 and 22. Figure 21 gives a matrix showing the actual t-values. Where the t-value is 2 or less there is probably no significant difference between the two samples as far as size is concerned. Values above 2 indicate that there probably is a significant difference in the size distribution of the two samples. Figure 22 shows a matrix of the same comparisons as in Figure 21 but here the symbol "+" has been used to denote a significant difference and the symbol "-" no significant difference. The samples from Owslebury, regardless of the phase to which they belong, show a remarkable degree

of similarity. Only OWSLE 5 shows a significant difference in the comparisons but even here the t-values are only just over the arbitrary limit of 2.

Figures 23 and 24 show a matrix of two sample t-test results for comparisons between the Owslebury samples and those from the Six Dials and Stoner Motor sites in Southampton. They show that there is a marked similarity between the majority of the Owslebury shell samples and those from certain Southampton contexts such as 11151, 11275, possibly 242,and 667.

Figure 25 shows matrices of two sample t-test results of comparisons between the Owslebury oyster shell measurements and those of two samples of modern oysters from the West Solent: Sowley Ground and Newtown beds. The Owslebury samples were all significantly different from the modern Sowley Ground oysters but there was no significant difference between the Owslebury and Newtown bed oysters.

Figure 26 shows matrices of t-values for comparisons between Owslebury oyster shell measurements and those for samples from Newport Roman Villa on the Isle of Wight. There was no similarity in size of the shells from these sites.

Figures 27 and 28 show matrices of t-values for comparisons between oyster shell measurements of samples from Owslebury and from modern oysters from the Poole area: Poole Bay wild oysters, and relaid oysters from Wytch Channel and South Deep within the Harbour. All the samples were significantly different. Some of the t-values were very high - upto 18.09.

Figures 29 and 30 give matrices of t-values for comparison of Owslebury oysters with samples from archaeological sites in Poole. Four of the Poole samples show a size relationship with those from Owslebury: PM 21.53, PM 21.58, PM 21.501 and PM 21.504 (all from the Paradise Street site on the waterfront).

Figures 31 and 32 show t-values from t-tests comparing Owslebury with Greyhound Yard (Dorchester) oyster shells. All the comparisons showed a significant difference.

Figure 33 is a matrix of t-values for Owslebury versus Alington Avenue (Dorchester) oyster shells. The measurements of all samples show a statistically significant difference.

Figures 34 and 35 give results of comparisons between Owslebuty and Ludgershall Castle oyster shell samples. All the samples were significantly different. Some of the t-values were high - up to 22.14.

Figure 36 shows t-values from comparison of samples from Owslebury with Salisbury (W139). All the samples were significantly different.

To summarise the above information: Owslebury samples of oyster shells were compared with each other and then with 49 other samples derived from archaeological sites and modern oyster beds in the Wessex region. Owslebury oyster shells were found to be consistant in their size characteristics throughout all the phases of occupation of the site in the intra-site comparisons. On an inter-site level the Owslebury oyster shells were found to bear a size relationship to only a few samples from Saxon Southampton, to modern oysters from the Newtown beds in the West Solent, and to some samples from the early medieval waterfront in Poole.

Figure 37 is an analysis of variance of the sizes of the Owslebury oyster shells showing how closely the samples are grouped. The column on the left gives the sample codes, followed by the sample number, mean and standard deviation. On the right side of the diagram there are a series of asterisks, dashes and brackets arranged according to a horizontal scale representing maximum width measurements in millimetres. For each sample there is an asterisk, the position of which indicates the mean of the sample. The dashes on either side of the asterisk, enclosed by brackets, denote the individual 95 percent confidence intervals for the mean, based on the pooled standard deviation.

Figures 38a and 38b are two parts of an analysis of variance diagram of Owslebury and other samples from Wessex. It shows the relationship of the Owslebury/Newtown/Southampton/Poole group of samples with other groups with greater or lesser size characteristics from elsewhere in the region.

Table 3

Summary of size data for Owslebury oyster shells (RVMW)

	N	MEAN	MEDIAN	TRMEAN	STDEV	SEMEAN	MIN	MAX
owsle.1	44	71.52	70.50	71.55	10.74	1.62	45.00	95.00
owsle.2	191	70.073	70.000	70.099	12.533	0.907	38.000	100.000
owsle.3	88	71.50	71.50	71.60	12.61	1.34	38.00	100.00
owsle.4	56	70.82	70.00	70.88	12.95	1.73	46.00	95.00
owsle.5	47	66.51	65.00	66.56	11.41	1.66	40.00	90.00
owsle.6	86	71.01	72.00	71.22	9.98	1.08	35.00	90.00
owsle.7	119	70.16	71.00	70.28	10.96	1.00	41.00	97.00
owsle.8	316	71.703	71.000	71.750	10.286	0.579	31.000	110.000
owsle.9	35	69.37	67.00	69.13	12.23	2.07	46.00	96.00
owsle.10	48	71.31	73.50	71.77	12.37	1.79	38.00	94.00
owsle.11	30	70.67	66.50	70.00	12.93	2.36	50.00	100.00
owsle.12	79	71.15	72.00	71.39	10.19	1.15	35.00	90.00
owsle.13	98	70.93	71.00	70.94	10.49	1.06	43.00	97.00
owsle.14	258	71.950	71.000	72.004	9.968	0.621	31.000	98.000

Figure -

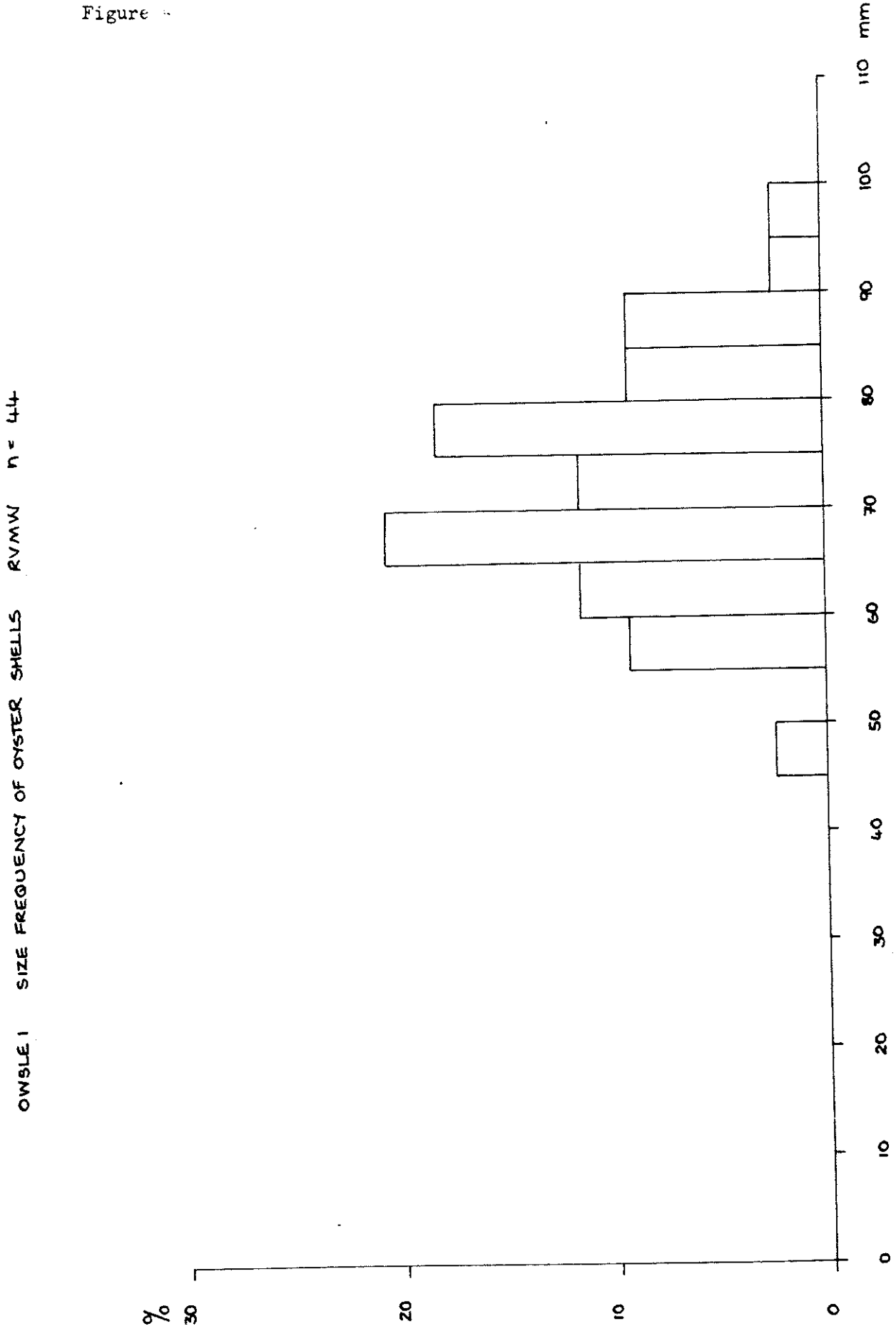

OWSLE 1 SIZE FREQUENCY OF OYSTER SHELLS RVMW n = 44
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110 mm

Figure 5

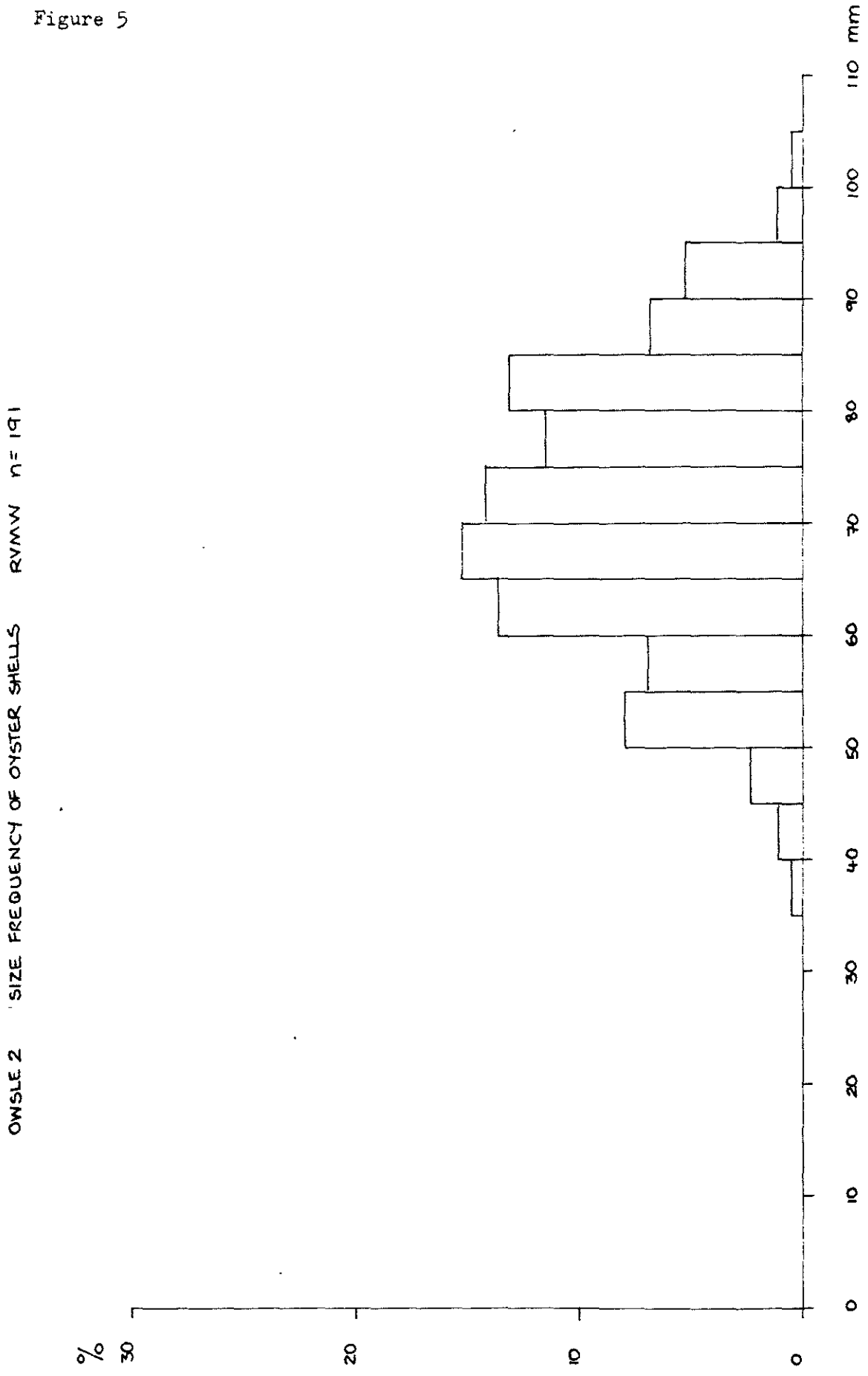

OWSLE 2 SIZE FREQUENCY OF OYSTER SHELLS RVMW n= 191
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110 mm

Figure 6

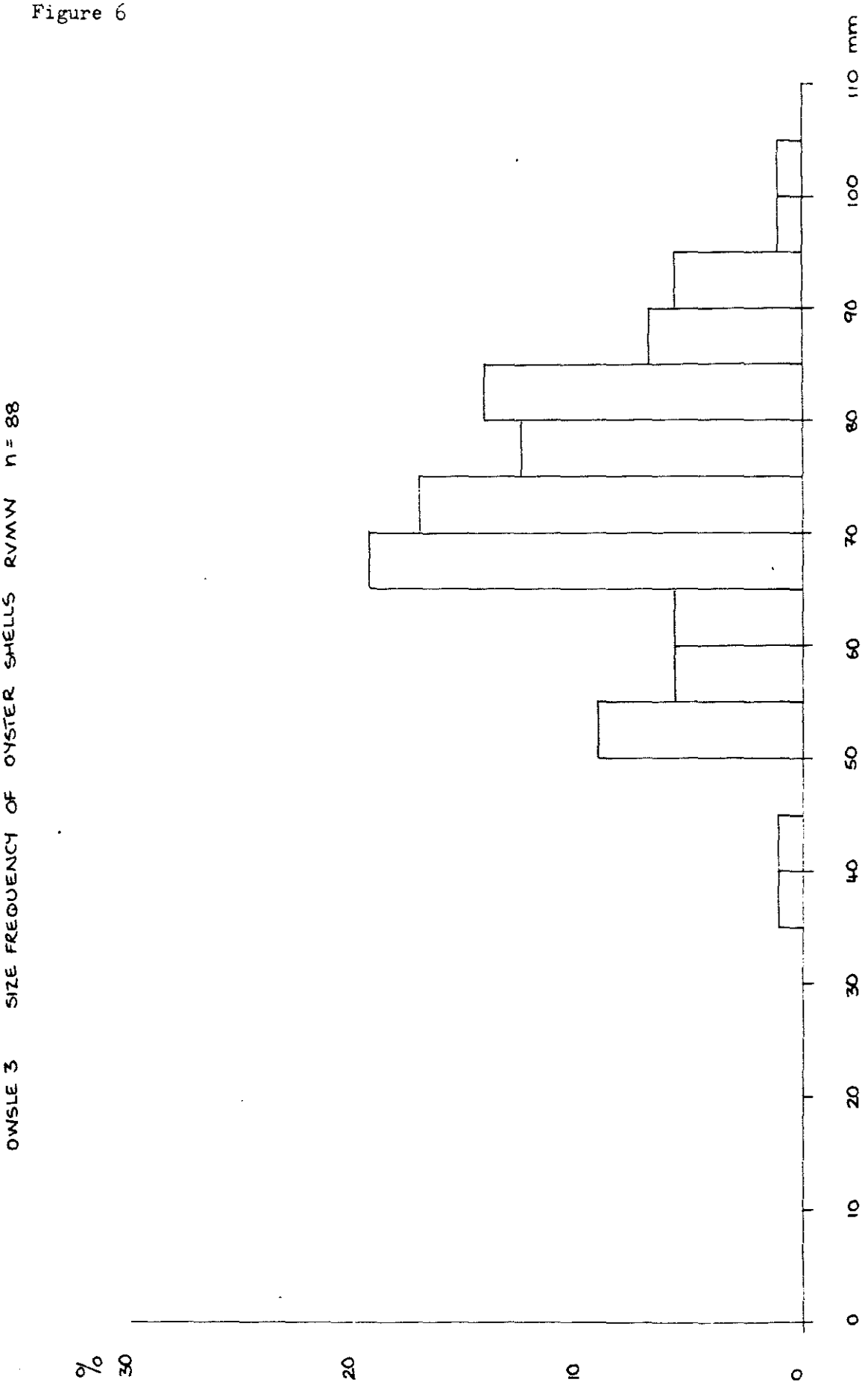

OWSLE 3 SIZE FREQUENCY OF OYSTER SHELLS RVMVV n = 88
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110 mm

Figure 7

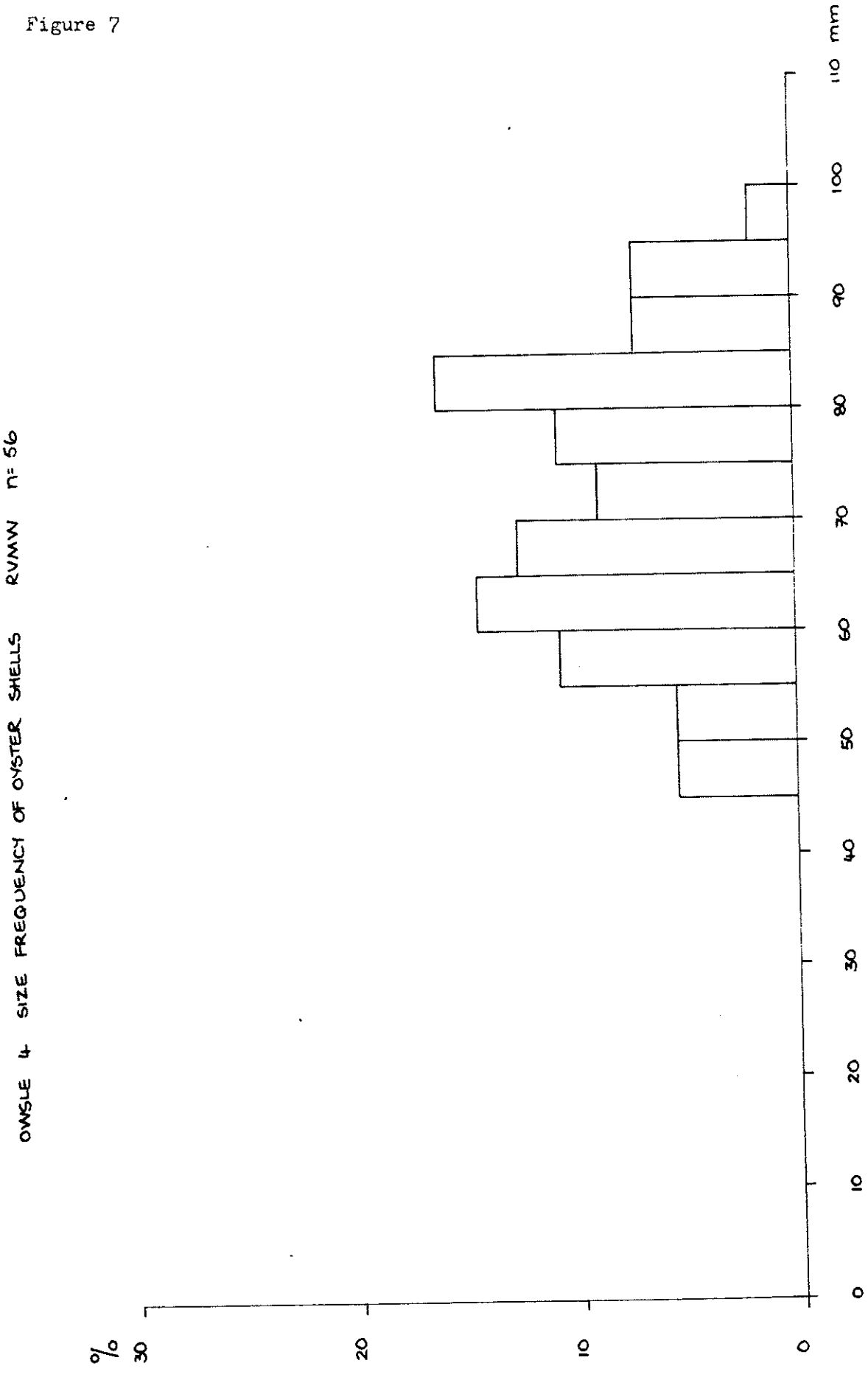

OWSLE 4 SIZE FREQUENCY OF OYSTER SHELLS RVMW n= 56
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110 mm

Figure 8

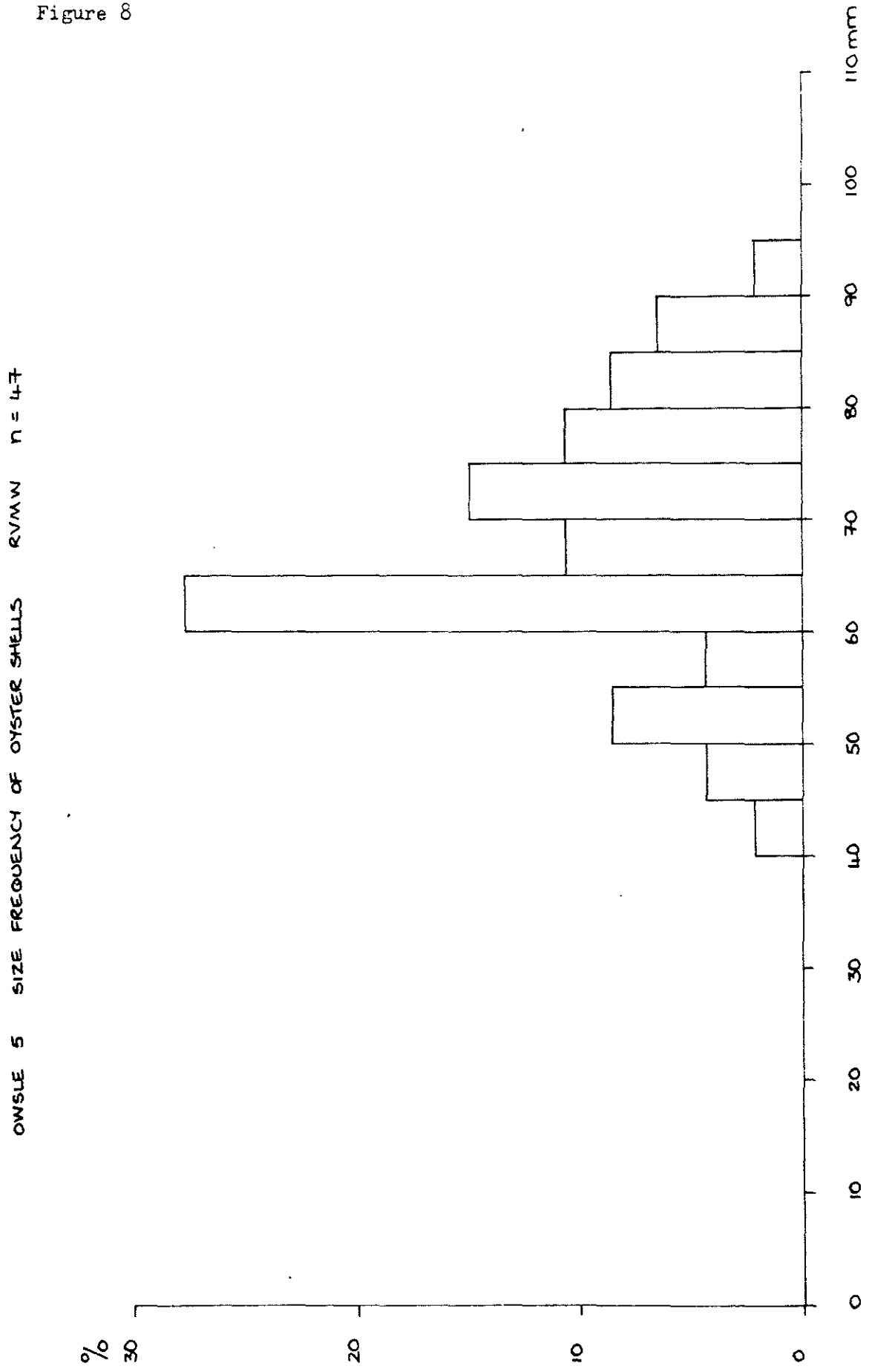

OWSLE 5 SIZE FREQUENCY OF OYSTER SHELLS RVMW n = 47
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110 mm

Figure 9

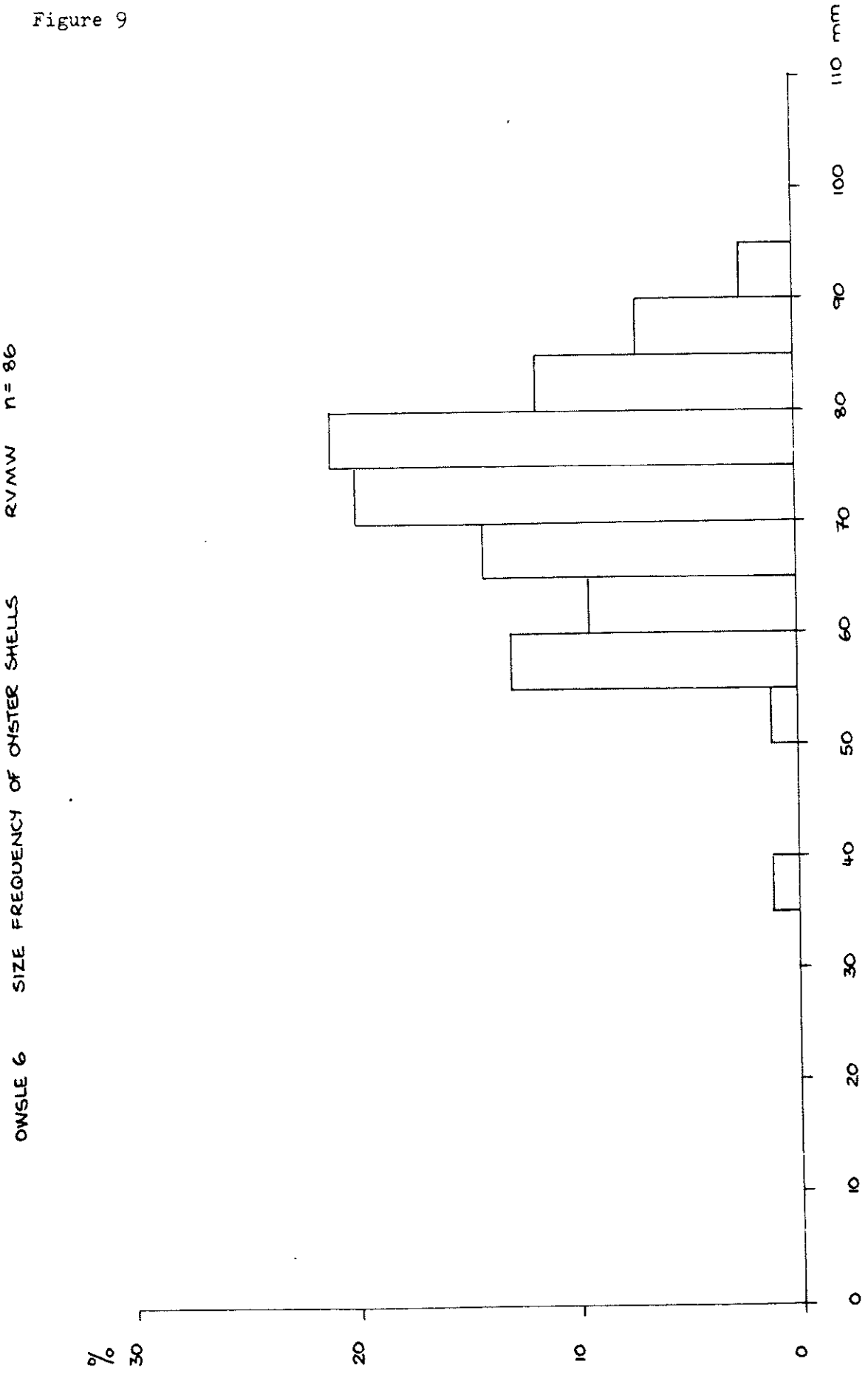

OWSLE 6 SIZE FREQUENCY OF OYSTER SHELLS RVMW n = 86
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110 mm

Figure 10

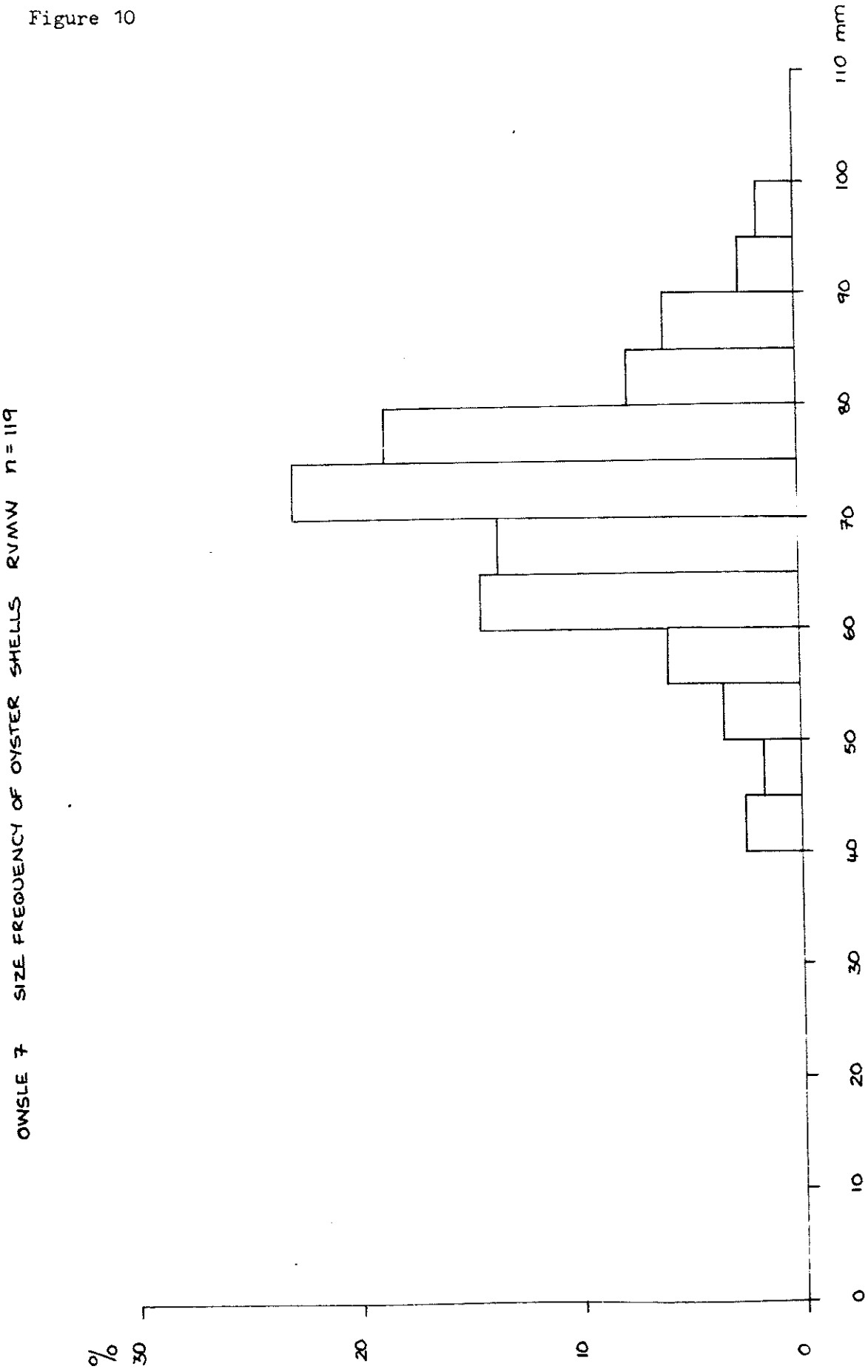

OWSLE 7 SIZE FREQUENCY OF OYSTER SHELLS RVMW n = 119
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110 mm

Figure 11

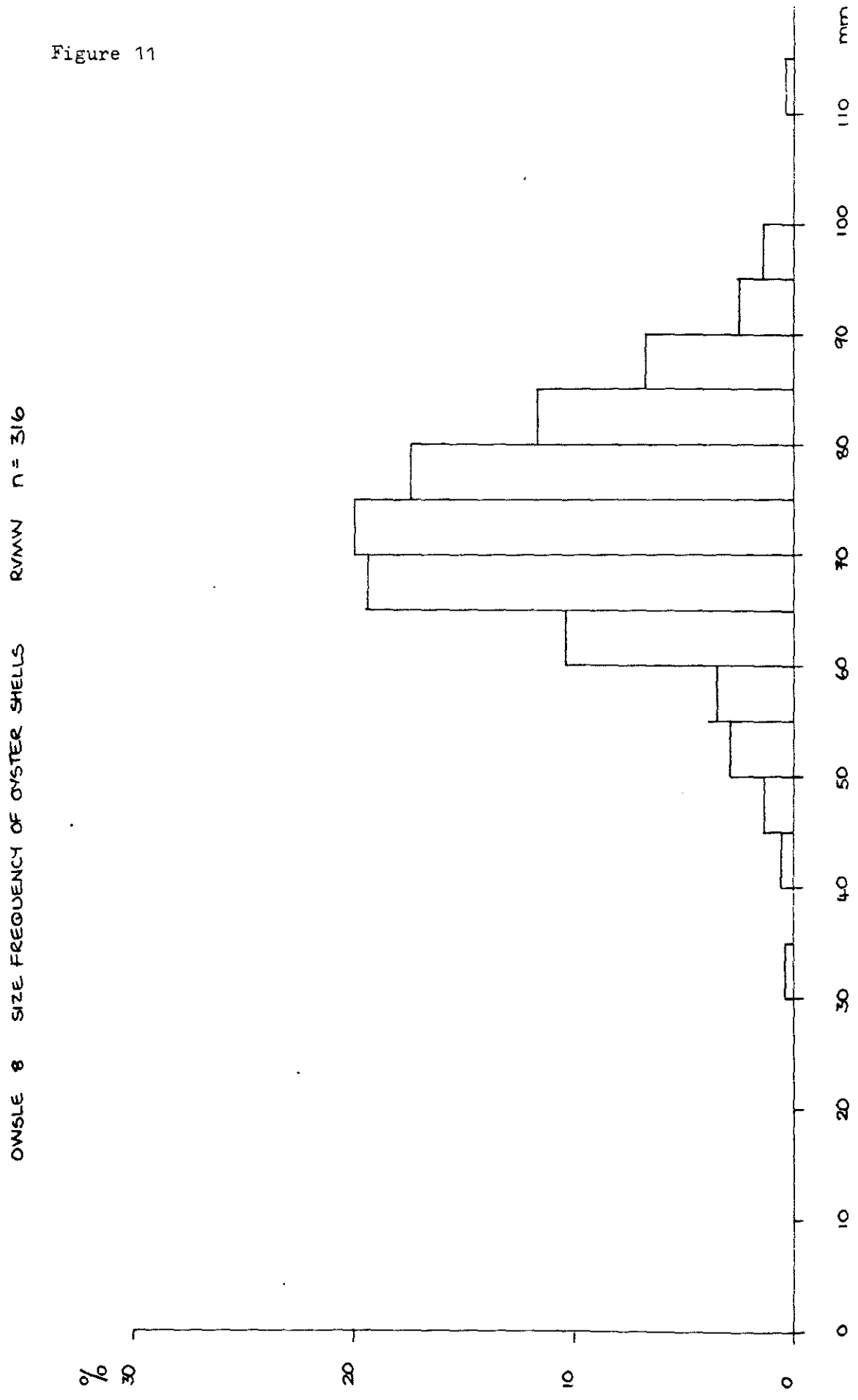
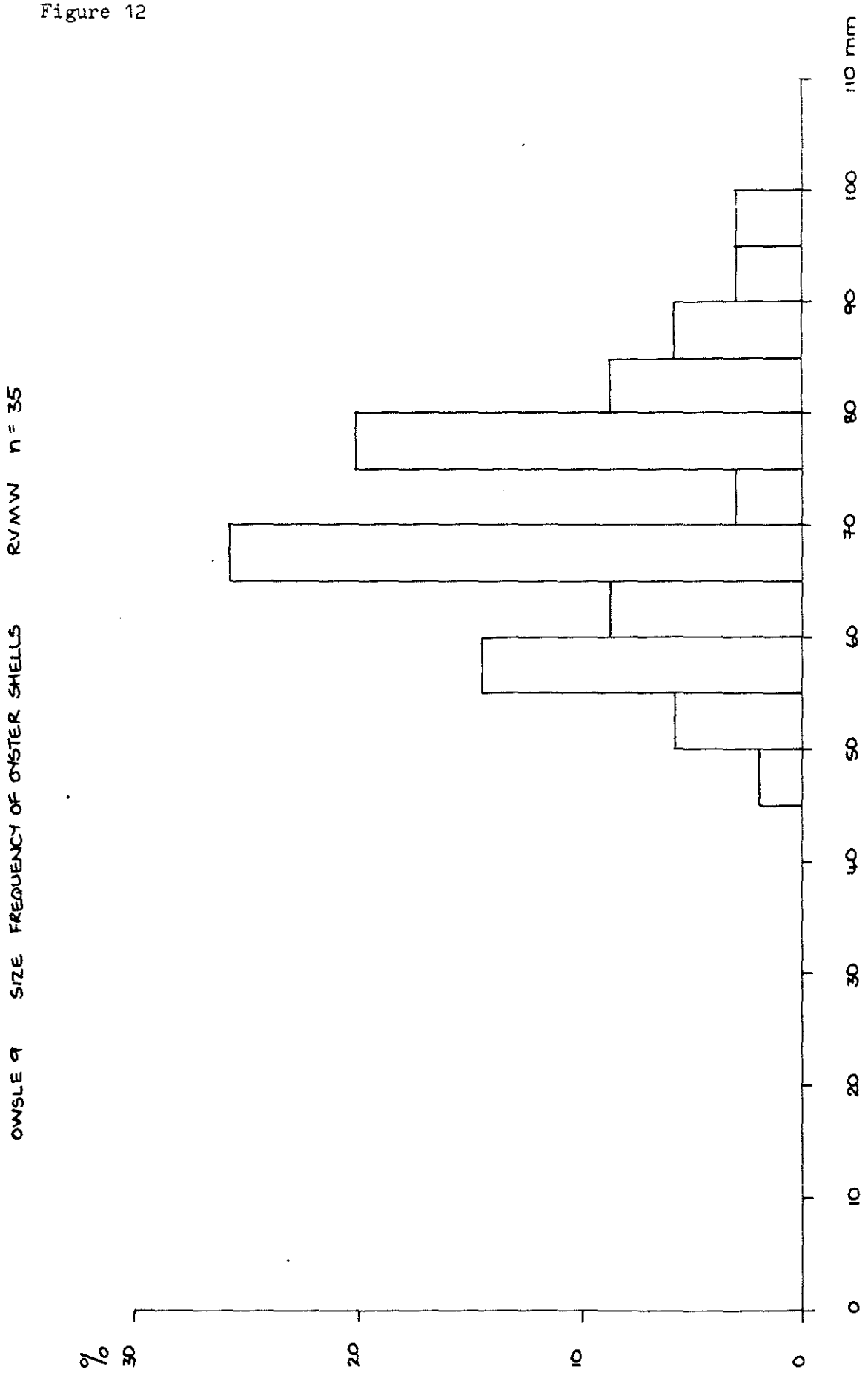

OWSLE 8 SIZE FREQUENCY OF OYSTER SHELLS RVMW n = 316
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
mm

Figure 12


OWSLE 9 SIZE FREQUENCY OF OYSTER SHELLS RVMW n = 35
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110 mm

Figure

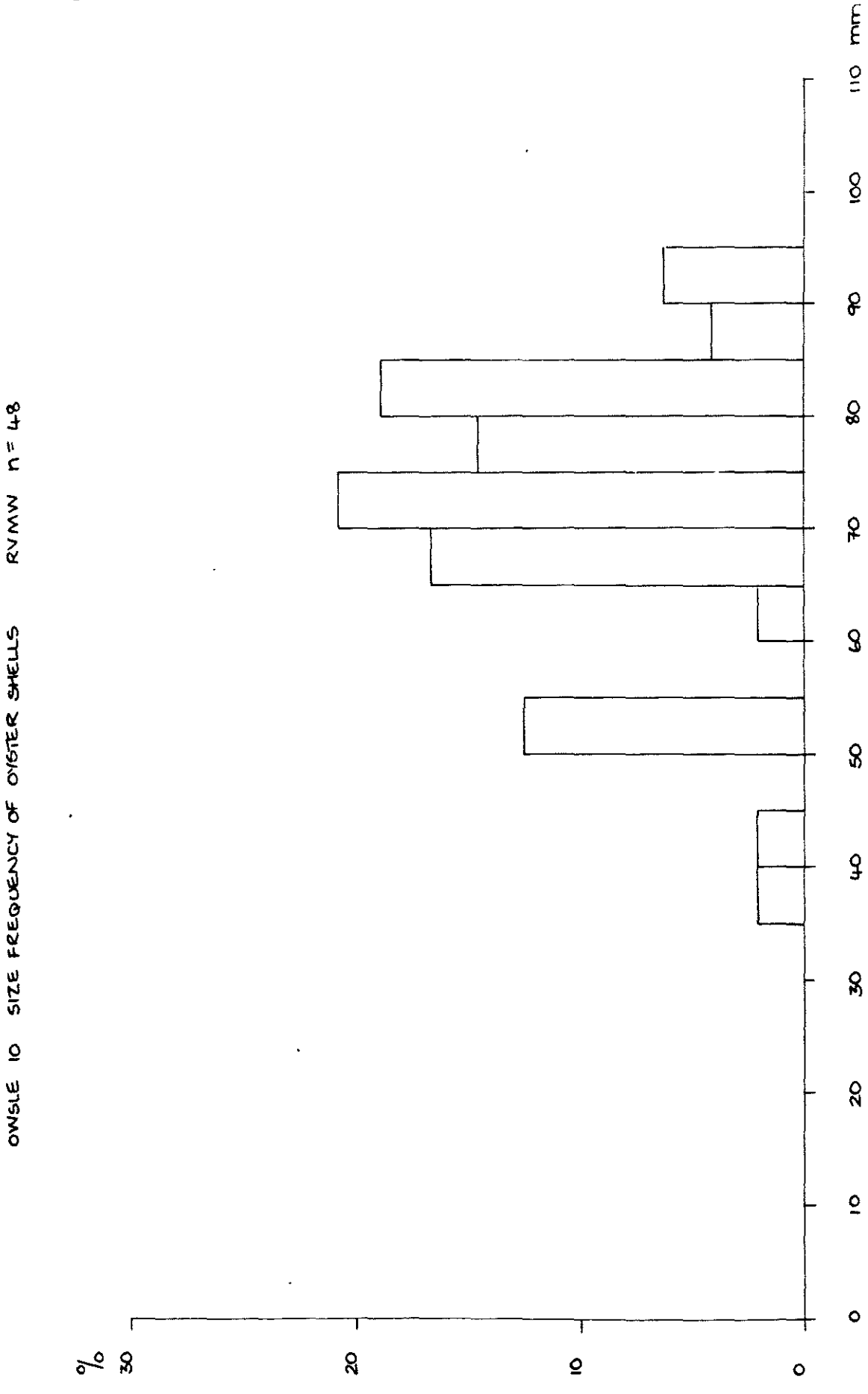

OWSLE 10 SIZE FREQUENCY OF OYSTER SHELLS RVMW n = 48
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110 mm

Figure 14

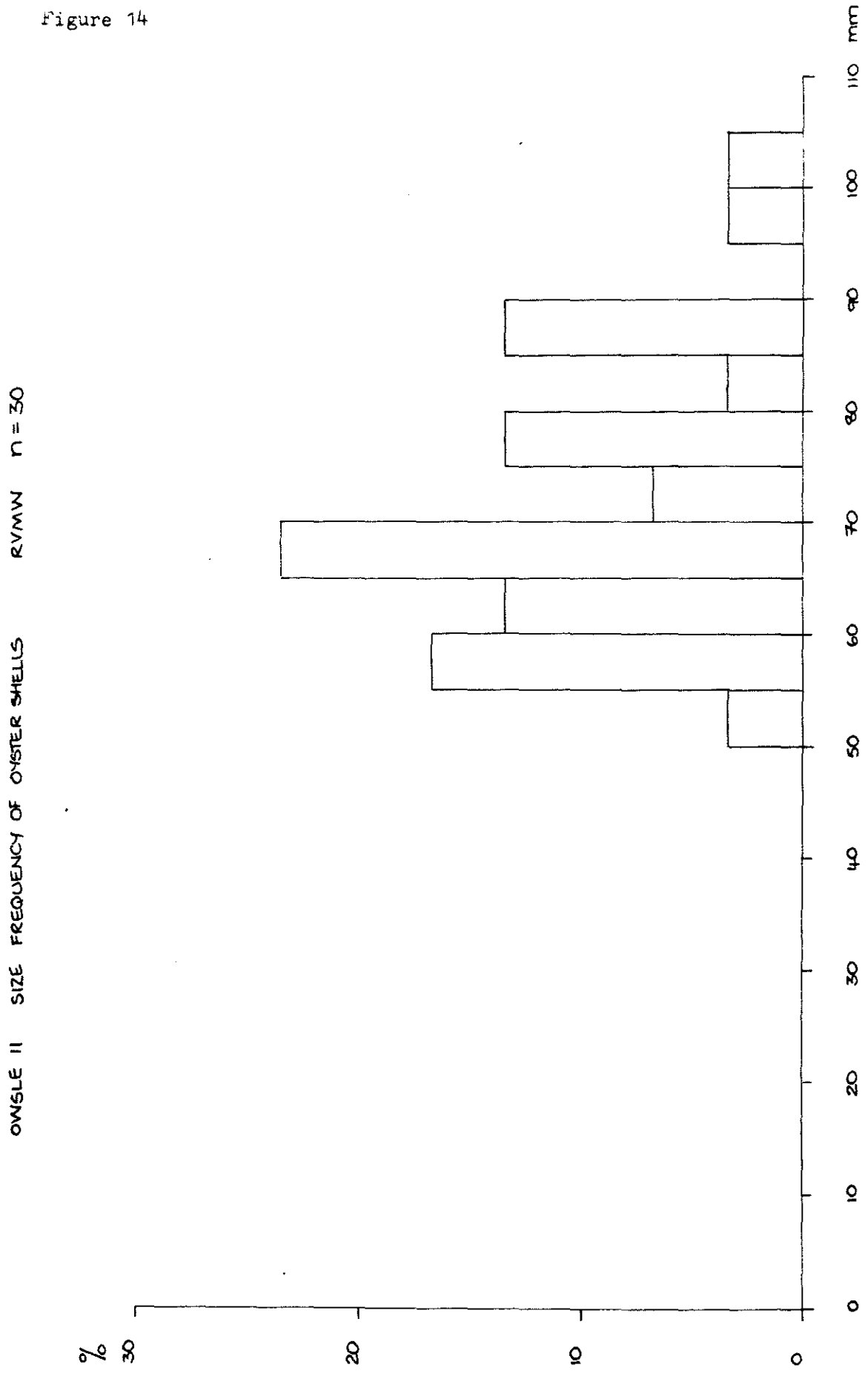

OWSLE II SIZE FREQUENCY OF OYSTER SHELLS RVMW n = 30
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
mm

Figure 15

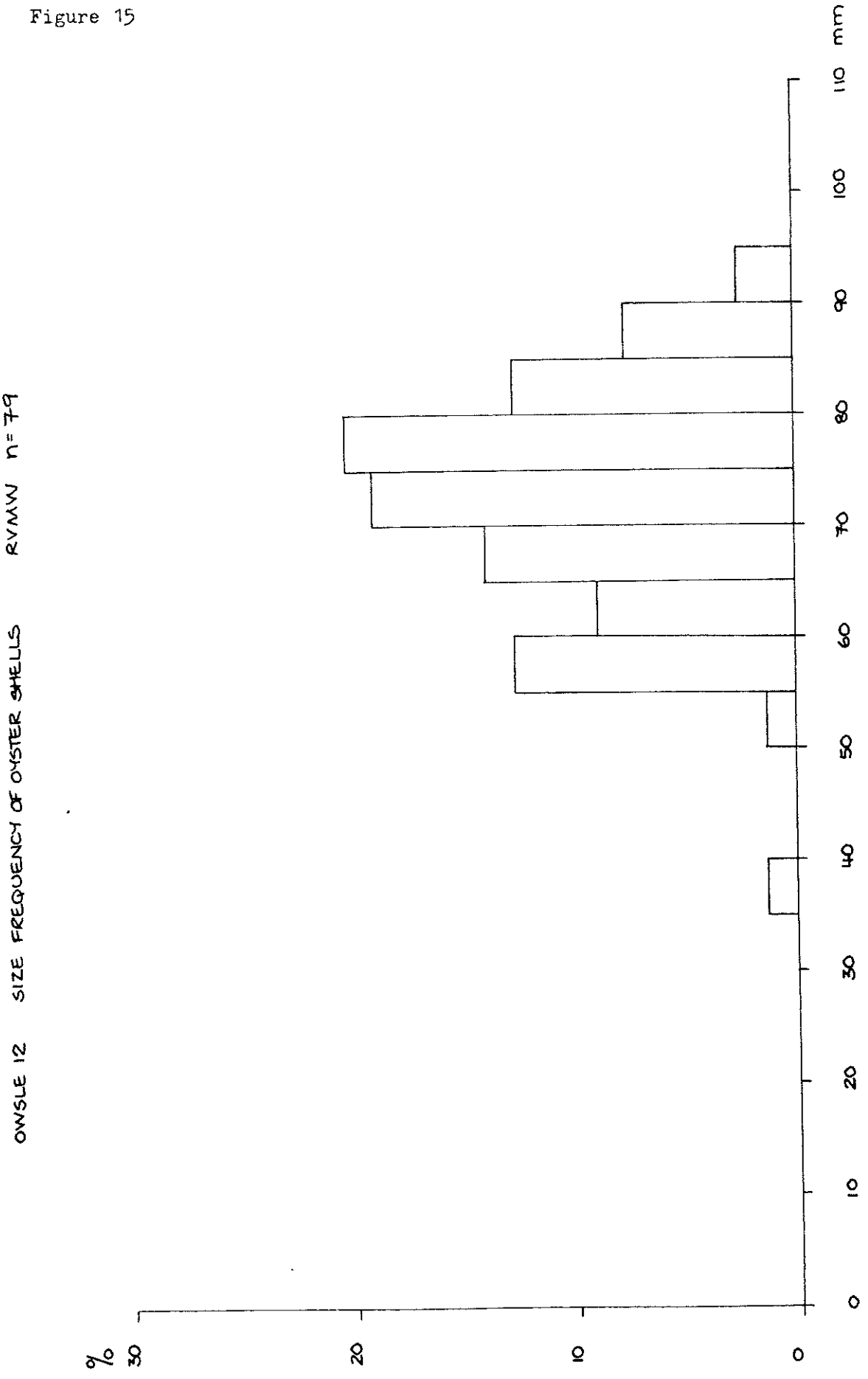

OWSLE 12 SIZE FREQUENCY OF OYSTER SHELLS RVMW n=79
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
mm

Figure 16.

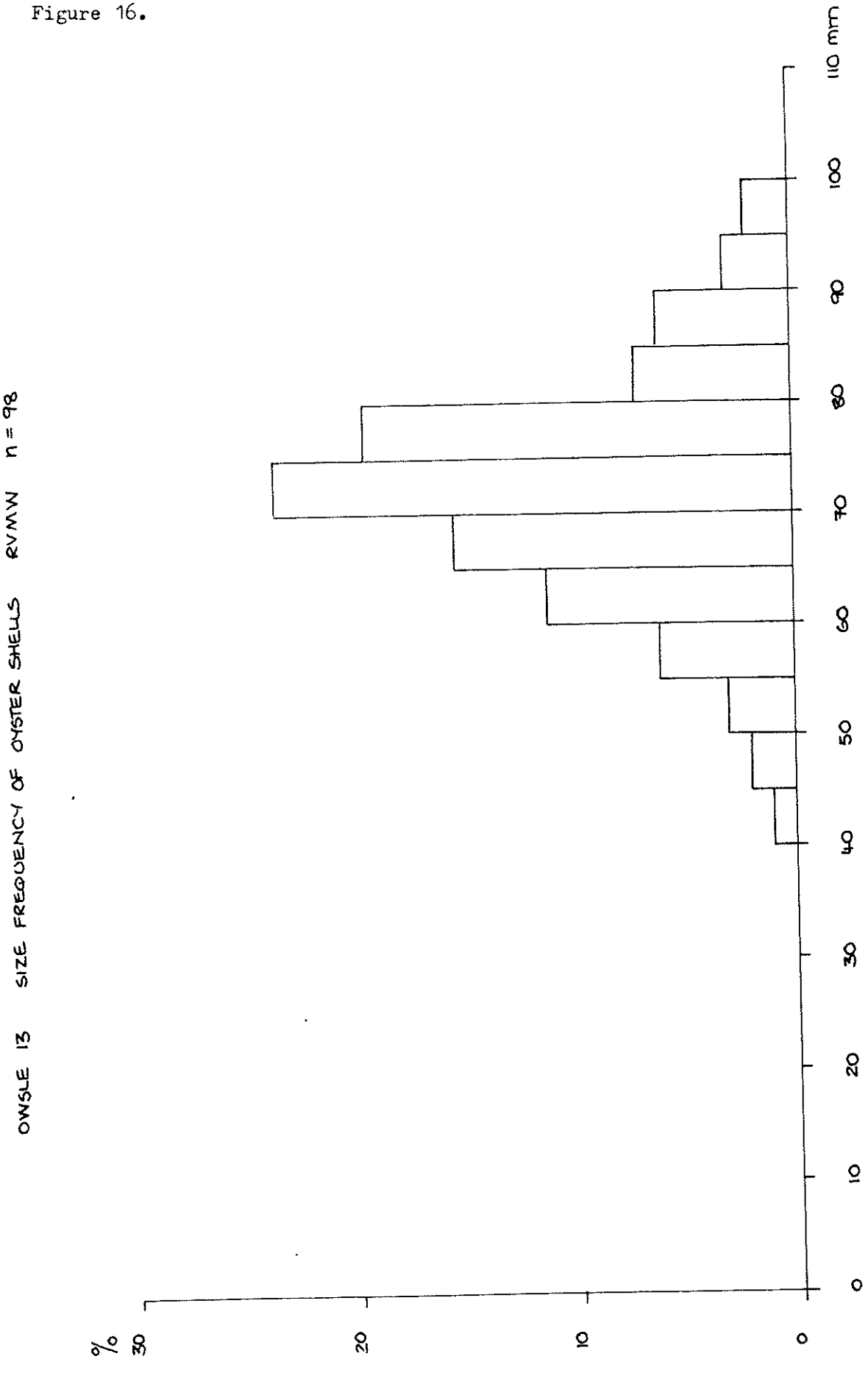

OWSLE 13 SIZE FREQUENCY OF OYSTER SHELLS RVMW n = 98
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110 mm

Figure 17

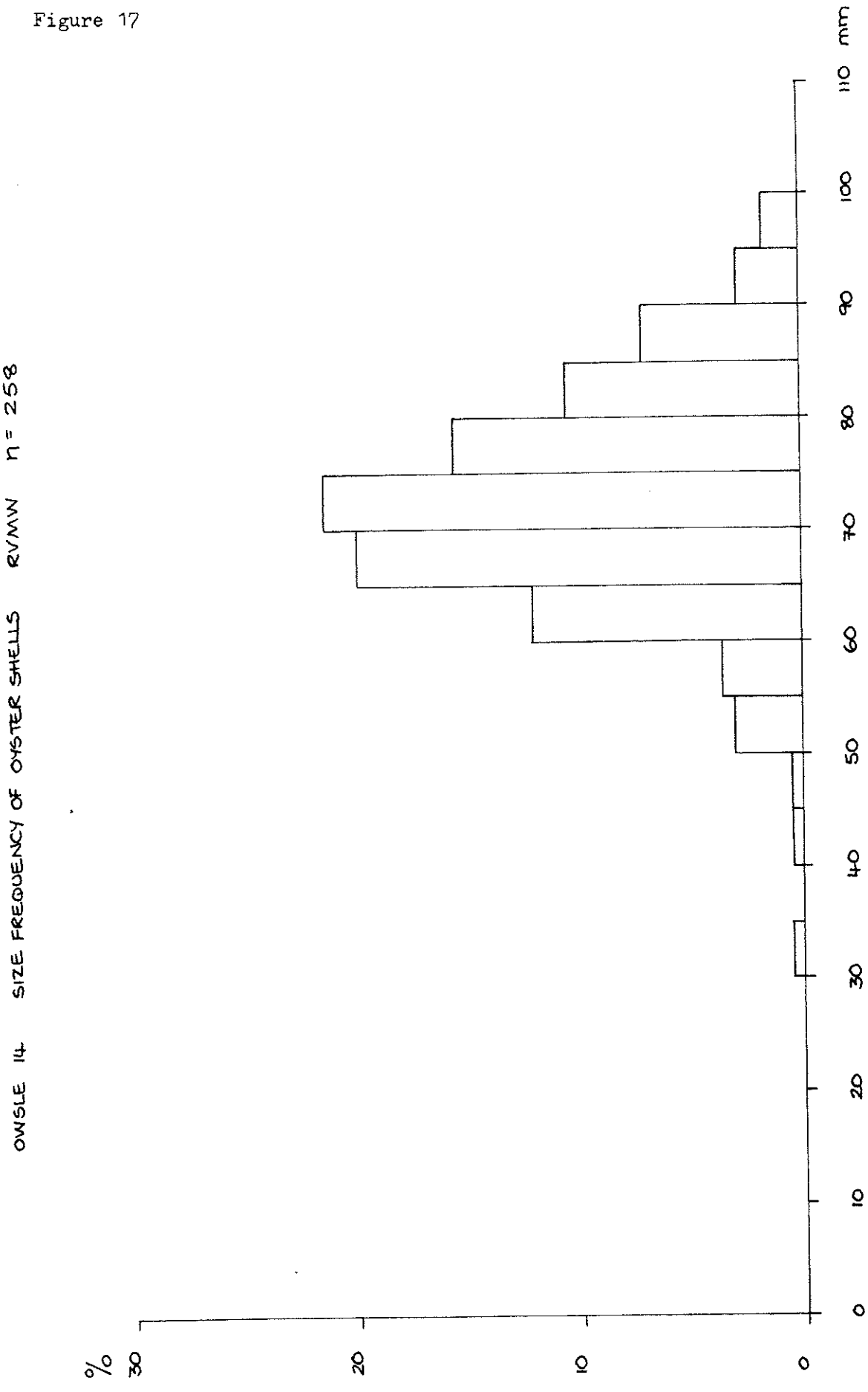

OWSLE 14 SIZE FREQUENCY OF OYSTER SHELLS RVMW n = 258
%
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
mm

Figure 18

Size frequency of oyster shells

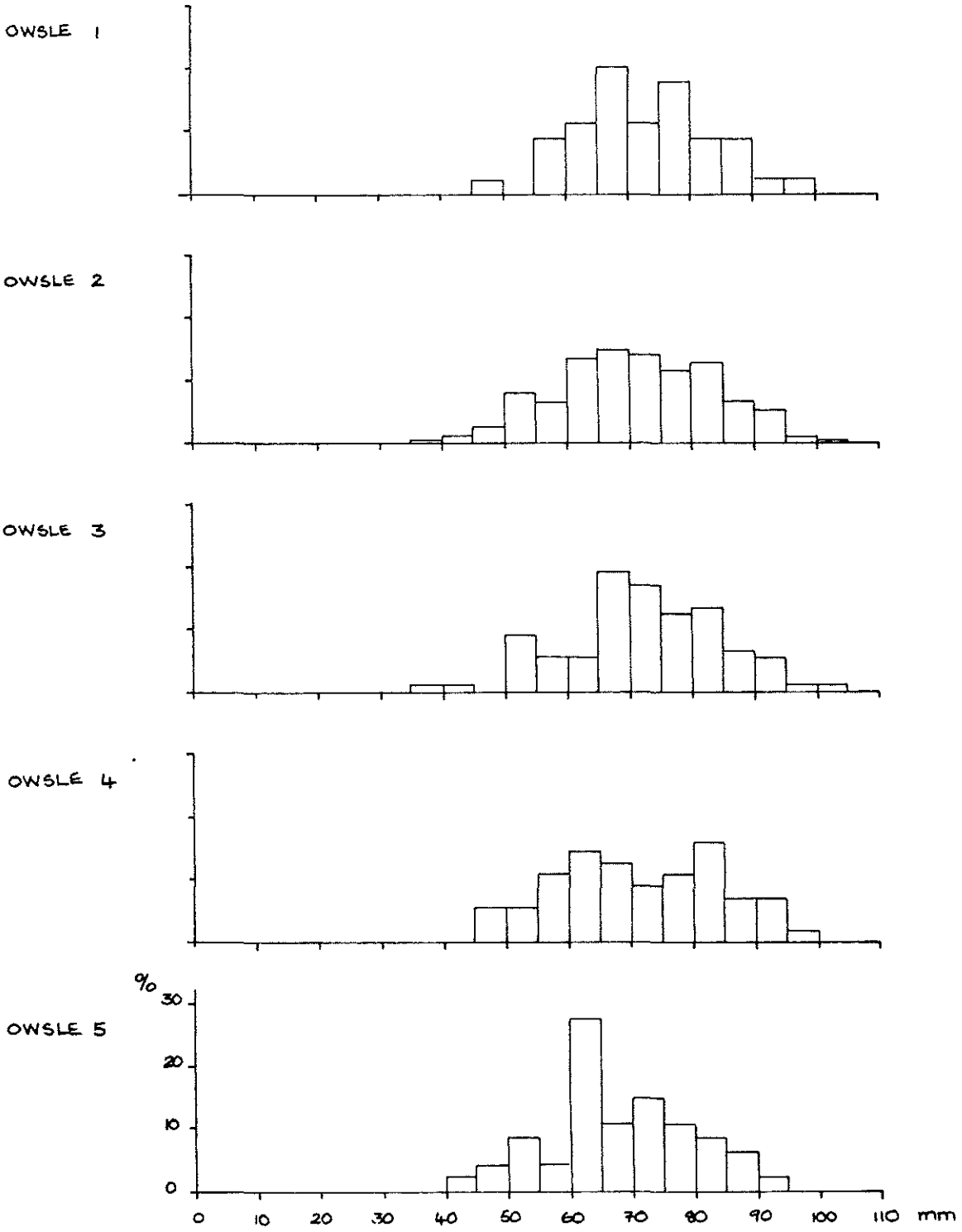


Figure 19

Size frequency of oyster shells

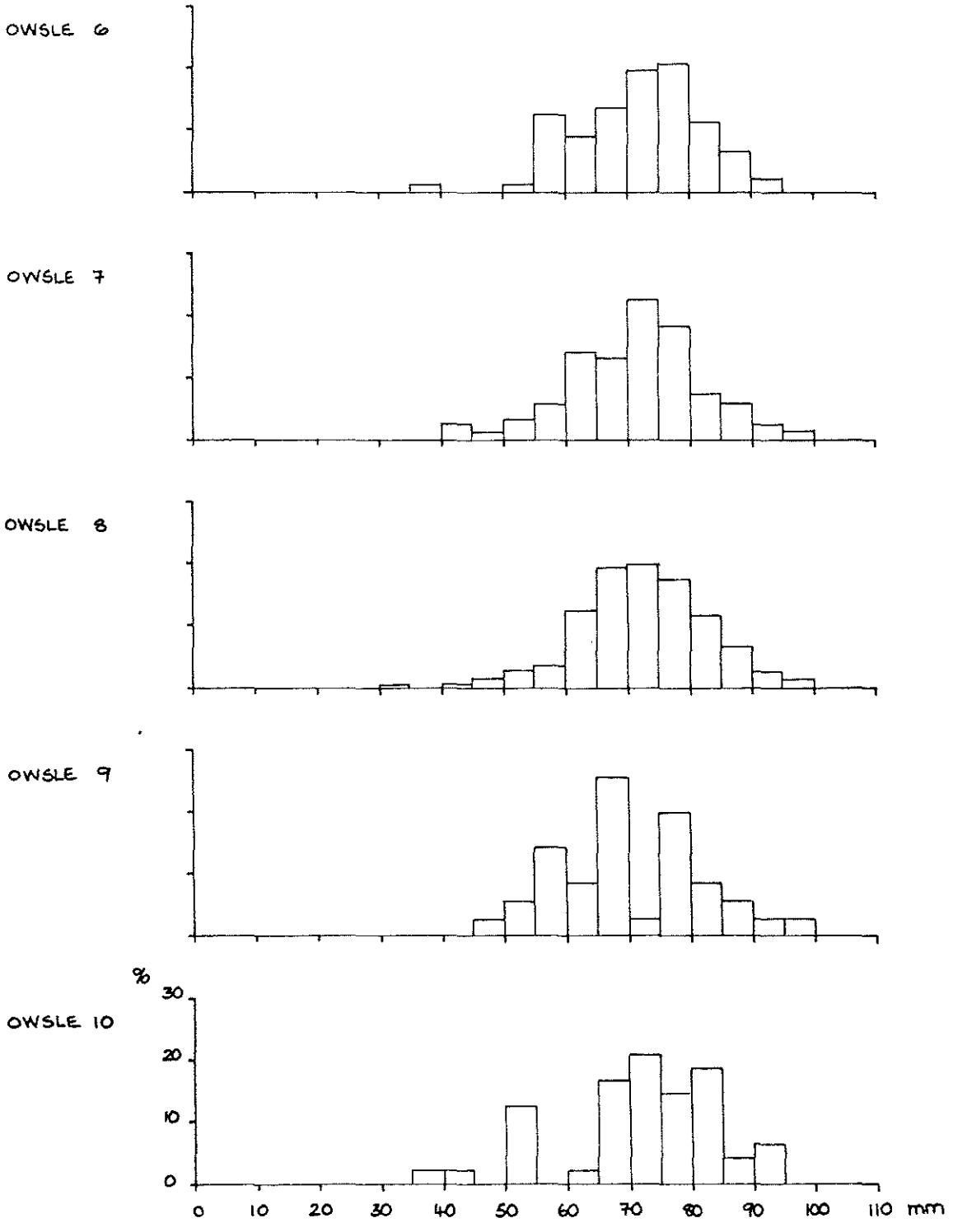


Figure 20
Size frequency of oyster shells

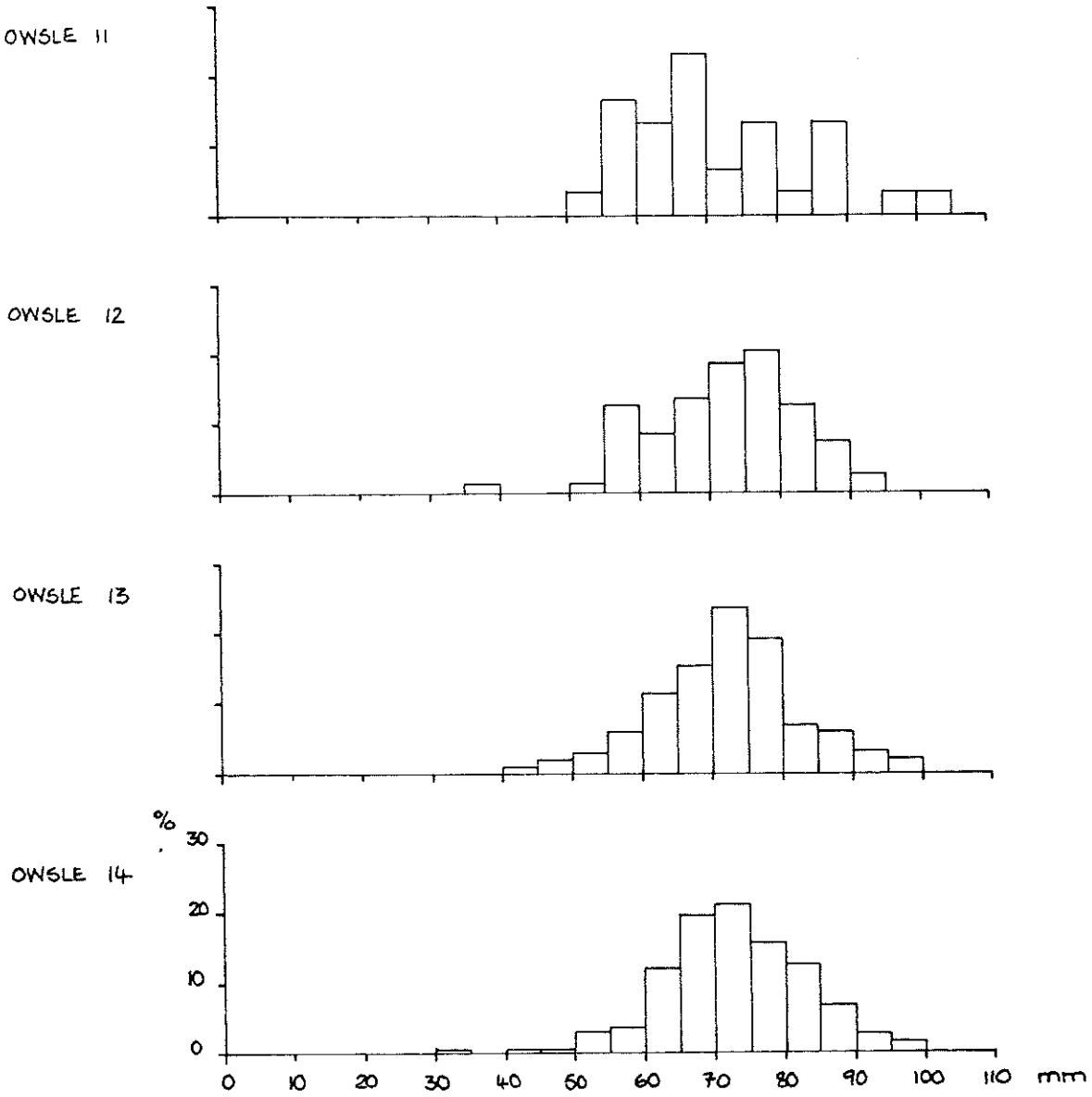


Figure21 Matrix of two sample t-test results of comparisons of oyster shell samples from Owslebury. Actual t-values.

	Owsle 1 allbc	Owsle 2 all1stad	Owsle 3 mid1stad	Owsle 4 late1stad	Owsle 5 1stad	Owsle 6 2ndad	Owsle 7 2nd 3rdad	Owsle 8 3rd 4thad	Owsle 9 4thad	Owsle 10 642 mid1stad	Owsle 11 642 late 1stad	Owsle 12 642 2ndad	Owsle 13 642 3rdad	Owsle 14 642 3rd 4thad
Owsle 1		0·78	0·01	0·30	2·16	0·26	0·72	-0·10	0·82	0·09	0·30	0·19	0·31	-0·25
Owsle 2			-0·88	-0·38	1·88	-0·67	-0·06	-1·51	0·31	-0·62	-0·23	-0·74	-0·61	-1·71
Owsle 3				0·31	2·33	0·28	0·80	-0·14	0·86	0·08	0·31	0·20	0·33	-0·30
Owsle 4					1·80	-0·09	0·33	-0·48	0·54	-0·20	0·05	-0·16	-0·05	-0·61
Owsle 5						-2·27	-1·88	-2·95	-1·08	-1·97	-1·44	-2·30	-2·24	-3·06
Owsle 6							0·58	-0·57	0·70	-0·14	0·13	-0·09	0·06	-0·76
Owsle 7								-1·33	0·34	-0·56	-0·20	-0·65	-0·53	-1·52
Owsle 8									1·09	021	0·43	0·43	0·64	-0·29
Owsle 9										-0·71	-0·41	-0·75	-0·67	-1·19
Owsle 10											0·22	0·08	0·18	-0·34
Owsle 11												-0·18	-0·10	-0·53
Owsle 12													0·14	-0·61
Owsle 13														-0·83
Owsle 14														

Figure 22 Matrix of two sample t-test results for oyster shells from Owslebury. Symbols: "+" for significant difference, "-" for no significant difference.

	Owsle 1 allbc	Owsle 2 all1stad	Owsle 3 mid1stad	Owsle 4 late1stad	Owsle 5 1st ad	Owsle 6 2ndad	Owsle 7 2nd3rdad	Owsle 8 3rd4thad	Owsle 9 4thad	Owsle 10 642 mid1stad	Owsle 11 642 late1stad	Owsle 12 642 2ndad	Owsle 13 642 3rdad	Owsle 14 642 3rd4thad
Owsle 1		-	-	-	+	-	-	-	-	-	-	-	-	-
Owsle 2			-	-	-	-	-	-	-	-	-	-	-	-
Owsle 3				-	+	-	-	-	-	-	-	-	-	-
Owsle 4					-	-	-	-	-	-	-	-	-	-
Owsle 5						+	-	+	-	-	-	+	+	+
Owsle 6							-	-	-	-	-	-	-	-
Owsle 7								-	-	-	-	-	-	-
Owsle 8									-	-	-	-	-	-
Owsle 9										-	-	-	-	-
Owsle 10											-	-	-	-
Owsle 11												-	-	-
Owsle 12													-	-
Owsle 13														-
Owsle 14														

Figure 23 Matrix of two sample t-test results for oyster shells from Owslebury compared with Southampton (Six Dials and Stoner Motor sites). Actual t-values.

	8568 Sousax	8600 Sousax	8686 Sousax	8709 Sousax	9959 Sousax	11151 Sousax	11275 Sousax	242 Sousax	667 Sousax	896 Sousax	3571 Sousax	9901 Sousax	9820 Sousax
Owsle 1	-2·32	-5·86	-2·30	-3·90	-2·86	-0·59	-0·51	-2·41	-0·07	4·43	-2·85	-6·41	-3·50
Owsle 2	-2·27	-8·28	-2·16	-4·16	-2·74	-0·08	0·17	-2·34	1·09	7·37	-2·68	-6·85	-3·61
Owsle 3	-2·67	-6·93	-2·59	-4·30	-3·10	-0·62	-0·55	-2·74	-0·07	5·06	-3·04	-6·84	-3·84
Owsle 4	-1·83	-5·12	-1·84	-3·42	-2·47	-0·33	-0·19	-1·94	0·30	4·57	-2·49	-5·97	-3·06
Owsle 5	0·45	-2·81	0·31	-1·49	-0·67	1·22	1·69	0·25	2·65	6·94	-0·85	-4·41	-1·16
Owsle 6	-2·75	-8·00	-2·62	-4·46	-3·10	-0·45	-0·34	-2·79	0·28	6·12	-3·01	-7·04	-3·94
Owsle 7	-2·21	-7·70	-2·12	-4·07	-2·72	-0·11	0·11	-2·29	0·96	6·95	-2·67	-6·76	-3·55
Owsle 8	-4·45	-13·60	-3·89	-5·72	-3·89	-0·79	-0·80	-4·21	-0·32	7·22	-3·64	-8·01	-5·02
Owsle 9	-0·92	-3·64	-0·98	-2·45	-1·68	0·17	0·39	-1·05	0·91	4·61	-1·77	-4·99	-2·15
Owsle 10	-2·04	-5·24	-2·04	-3·57	-2·63	-0·50	-0·40	-2·14	0·04	4·22	-2·65	-6·07	-3·21
Owsle 11	-1·34	-3·75	-1·38	-2·70	-1·99	-0·24	-0·10	-1·45	0·29	3·62	-2·07	-5·05	-2·43
Owsle 12	-2·74	-7·69	-2·62	-4·43	-3·11	-0·51	-0·40	-2·79	0·17	5·81	-3·03	-6·99	-3·92
Owsle 13	-2·72	-8·03	-2·58	-4·44	-3·07	-0·42	-0·29	-2·76	0·35	-6·23	-2·98	-7·03	-3·92
Owsle 14	-4·59	-13·34	-4·03	-5·82	-4·00	-0·89	-0·94	-4·35	-0·56	6·87	-3·74	-8·08	-5·13

Figure 24 Matrix of two sample t-test results for oyster shells from Owslebury compared with Southampton sites. Symbols.

	Sousax 8568	Sousax 8600	Sousax 8686	Sousax 8709	Sousax 9959	Sousax 11151	Sousax 11275	Sousax 242	Sousax 667	Sousax 896	Sousax 3571	Sousax 9901	Sousax 9820
Owsle 1	+	+	+	+	+	−	−	+	−	+	+	+	+
Owsle 2	+	+	+	+	+	−	−	+	−	+	+	+	+
Owsle 3	+	+	+	+	+	−	−	+	−	+	+	+	+
Owsle 4	−	+	−	+	+	−	−	−	−	+	+	+	+
Owsle 5	−	+	−	−	−	−	−	−	+	+	−	+	−
Owsle 6	+	+	+	+	+	−	−	+	−	+	+	+	+
Owsle 7	+	+	+	+	+	−	−	+	−	+	+	+	+
Owsle 8	+	+	+	+	+	−	−	+	−	+	+	+	+
Owsle 9	−	+	−	+	−	−	−	−	−	+	−	+	+
Owsle 10	+	+	+	+	+	−	−	+	−	+	+	+	+
Owsle 11	−	+	−	+	−	−	−	−	−	+	+	+	+
Owsle 12	+	+	+	+	+	−	−	+	−	+	+	+	+
Owsle 13	+	+	+	+	+	−	−	+	−	+	+	+	+
Owsle 14	+	+	+	+	+	−	−	+	−	+	+	+	+

Figure 25 Matrix of two sample t-test results for oyster shells from Owslebury compared with modern oysters from Sowley Ground and Newtown beds in the West Solent. Actual t-values and symbols.

	Sowley ground (modern)	Newtown beds (modern)	Sowley ground	Newtown beds
Owsle 1	4.15	0.89	+	—
Owsle 2	5.10	0.88	+	—
Owsle 3	4.81	0.94	+	—
Owsle 4	3.55	0.60	+	—
Owsle 5	1.29	-1.07	—	—
Owsle 6	5.29	0.78	+	—
Owsle 7	4.85	0.41	+	—
Owsle 8	8.16	1.20	+	—
Owsle 9	2.38	0.04	+	—
Owsle 10	3.71	0.77	+	—
Owsle 11	2.63	0.46	+	—
Owsle 12	5.16	0.83	+	—
Owsle 13	5.28	0.75	+	—
Owsle 14	8.19	1.31	+	—

Figure 26 Matrix of two sample t-test results for oyster shells from Owslebury compared with Newport Roman Villa on the Isle of Wight. Actual t-values and symbols.

	Newport 1 Newport Roman Villa, Isle of Wight	Newport 2 Newport Roman Villa, Isle of Wight		Newport 1 Newport Roman Villa, Isle of Wight	Newport 2 Newport Roman Villa, Isle of Wight
Owsle 1	-3.47	-2.78		+	+
Owsle 2	-6.00	-6.16		+	+
Owsle 3	-3.96	-3.32		+	+
Owsle 4	-3.65	-3.00		+	+
Owsle 5	-5.99	-5.64		+	+
Owsle 6	-4.86	-4.49		+	+
Owsle 7	-5.66	-5.57		+	+
Owsle 8	-5.61	-6.40		+	+
Owsle 9	-3.81	-3.22		+	+
Owsle 10	-3.32	-2.65		+	+
Owsle 11	-2.90	-2.29		+	+
Owsle 12	-4.60	-4.13		+	+
Owsle 13	-4.96	-4.63		+	+
Owsle 14	-5.29	-5.75		+	+

Figure 27 Matrix of two sample t-test results for oyster shells from Owslebury compared with modern oysters from Poole Bay and Poole Harbour - South Deep and Wytch Channel. Actual t-values.

	Poole Bay 11.11.87	Poole Bay 17.11.87	Poole Harbour, Wytch Channel 11.11.87	Poole Harbour, South Deep 17.11.87
Owsle 1	-3.11	-2.93	-9.93	-9.99
Owsle 2	-5.94	-5.64	-16.08	-16.12
Owsle 3	-3.62	-3.41	-11.49	11.55
Owsle 4	-3.32	-3.15	-9.78	-9.83
Owsle 5	-5.78	-5.60	-12.43	-12.48
Owsle 6	-4.62	-4.36	-13.79	-13.84
Owsle 7	-5.51	-5.23	-15.07	-16.11
Owsle 8	-5.65	-5.27	-18.08	-18.09
Owsle 9	-3.50	-3.36	-9.06	-9.11
Owsle 10	-2.98	-2.81	-9.27	-9.23
Owsle 11	-2.59	-2.46	-7.53	-7.58
Owsle 12	-4.32	-4.07	-13.11	-13.17
Owsle 13	-4.73	-4.47	-13.99	-14.04
Owsle 14	-5.25	-4.88	-17.38	-17.39

Figure 28 Matrix of two sample t-test results for oyster shells from Owslebury compared with modern oysters from Poole Bay and Poole Harbour - South Deep and Wytch Channel. Symbols.

	Poole Bay 11.11.87	Poole Bay 17.11.87	Poole Harbour, Wytch Channel 11.11.87	Poole Harbour, South Deep 17.11.87
Owsle 1	+	+	+	+
Owsle 2	+	+	+	+
Owsle 3	+	+	+	+
Owsle 4	+	+	+	+
Owsle 5	+	+	+	+
Owsle 6	+	+	+	+
Owsle 7	+	+	+	+
Owsle 8	+	+	+	+
Owsle 9	+	+	+	+
Owsle 10	+	+	+	+
Owsle 11	+	+	+	+
Owsle 12	+	+	+	+
Owsle 13	+	+	+	+
Owsle 14	+	+	+	+

Figure 29 Matrix of two sample t-test results for oyster shells from Owslebury compared with Poole sites. Actual t-values.

	PM21.53 Paradise Street, Poole	PM21.58 Paradise Street, Poole	PM21.501 Paradise Street, Poole	PM21.502 Paradise Street, Poole	PM21.504 Paradise Street, Poole	PM21 ran Paradise Street, Poole	PM9 Thames Street, Poole	PM Ship (32) Shipwright's Arms, Poole
Owsle 1	1.05	-0.26	0.06	-2.45	-0.12	1.91	5.39	3.22
Owsle 2	2.20	0.89	0.89	-2.32	0.62	3.21	9.43	6.46
Owsle 3	1.17	0.28	0.08	2.73	-0.12	2.10	6.27	3.64
Owsle 4	1.32	0.14	0.36	-2.01	0.18	2.14	6.47	3.41
Owsle 5	3.33	2.54	2.27	0.02	2.00	4.10	8.02	5.68
Owsle 6	1.56	0.05	0.34	-2.74	0.12	2.55	7.74	4.44
Owsle 7	2.09	0.76	0.81	2.28	0.56	3.07	8.78	6.16
Owsle 8	1.36	-0.71	-0.02	-3.82	-0.25	2.49	10.02	4.95
Owsle 9	1.76	0.78	0.89	-1.17	0.71	2.69	5.35	3.61
Owsle 10	1.08	-0.13	0.15	-2.20	-0.03	1.90	6.08	3.10
Owsle 11	1.13	0.17	0.35	-1.55	0.20	1.81	4.23	2.74
Owsle 12	1.44	-0.06	0.26	-2.75	0.05	2.42	7.30	4.21
Owsle 13	1.61	0.12	0.39	-2.71	0.16	2.61	7.89	4.53
Owsle 14	1.19	-0.96	-0.17	-3.95	-0.39	2.32	9.49	4.67

Figure 30 Matrix of two sample t-test results for oyster shells from Owslebury compared with Poole sites. Symbols.

	PM21.53 Paradise Street, Poole	PM21.58 Paradise Street, Poole	PM21.501 Paradise Street, Poole	PM21.502 Paradise Street, Poole	PM21.504 Paradise Street, Poole	PM 21 ran Paradise Street, Poole	PM 9 Thames Street, Poole	PM Ship (32) Shipwright's Arms, Poole
Owsle 1	−	−	−	+	−	−	+	+
Owsle 2	+	−	−	+	−	+	+	+
Owsle 3	−	−	−	+	−	+	+	+
Owsle 4	−	−	−	+	−	+	+	+
Owsle 5	+	+	+	−	−	+	+	+
Owsle 6	−	−	−	+	−	+	+	+
Owsle 7	+	−	−	+	−	+	+	+
Owsle 8	−	−	−	+	−	+	+	+
Owsle 9	−	−	−	−	−	+	+	+
Owsle 10	−	−	−	+	−	−	+	+
Owsle 11	−	−	−	−	−	−	+	+
Owsle 12	−	−	−	+	−	+	+	+
Owsle 13	−	−	−	+	−	+	+	+
Owsle 14	−	−	−	+	−	+	+	+

Figure 31 Matrix of two sample t-test results for oyster shells from Owslebury compared with Greyhound Yard, Dorchester. Actual t-values.

	GREY ERB Greyhound Yard, Dorchester	GREY LRB Greyhound Yard, Dorchester	GREY RBD Greyhound Yard, Dorchester	GREY ARB Greyhound Yard, Dorchester	GREY EN Greyhound Yard, Dorchester	GREY EM2 Greyhound Yard, Dorchester	GREY 22 Greyhound Yard, Dorchester
Owsle 1	-3.70	-4.66	-6.93	-6.28	-7.79	-7.43	-6.44
Owsle 2	-4.51	-7.29	-10.01	-10.45	-11.73	-11.16	-6.57
Owsle 3	-3.85	-5.24	-7.71	-7.25	-8.80	-8.38	-5.70
Owsle 4	-3.85	-4.80	-6.97	-6.32	-7.78	-7.44	-5.56
Owsle 5	-5.16	-7.05	-9.19	-8.84	-10.16	-9.79	-7.02
Owsle 6	-4.13	-6.19	-8.84	-8.77	-10.25	-9.75	-6.10
Owsle 7	-4.44	-6.94	-9.60	-9.80	-11.16	-10.63	-6.46
Owsle 8	-4.09	-7.02	-10.01	-11.07	-12.15	-11.46	-6.19
Owsle 9	-4.06	-4.83	-6.77	-6.10	-7.43	-7.14	-5.67
Owsle 10	-3.67	-4.46	-6.61	-5.91	-7.37	-7.04	-5.35
Owsle 11	-3.52	-3.86	-5.66	-4.91	-6.18	-5.93	-4.99
Owsle 12	-4.06	-5.92	-8.62	-8.33	-9.84	-9.36	-5.99
Owsle 13	-4.17	-6.29	-8.95	-8.92	-10.38	-9.88	-6.15
Owsle 14	-3.99	-6.73	-9.71	-10.58	-11.76	-11.09	-6.07

Figure 32 Matrix of two sample t-test results from oyster shells from Owslebury compared with Greyhound Yard, Dorchester. Symbols.

	GREY ERB Greyhound Yard, Dorchester	GREY LRB Greyhound Yard, Dorchester	GREY RBD Greyhound Yard, Dorchester	GREY ARB Greyhound Yard, Dorchester	GREY EM Greyhound Yard, Dorchester	GREY EM2 Greyhound Yard, Dorchester	GREY 22 Greyhound Yard, Dorchester
Owsle 1	+	+	+	+	+	+	+
Owsle 2	+	+	+	+	+	+	+
Owsle 3	+	+	+	+	+	+	+
Owsle 4	+	+	+	+	+	+	+
Owsle 5	+	+	+	+	+	+	+
Owsle 6	+	+	+	+	+	+	+
Owsle 7	+	+	+	+	+	+	+
Owsle 8	+	+	+	+	+	+	+
Owsle 9	+	+	+	+	+	+	+
Owsle 10	+	+	+	+	+	+	+
Owsle 11	+	+	+	+	+	+	+
Owsle 12	+	+	+	+	+	+	+
Owsle 13	+	+	+	+	+	+	+
Owsle 14	+	+	+	+	+	+	+

Figure 33 Matrix of two sample t-test results for oyster shells from Owslebury compared with Alington Avenue, Dorchester. Actual t-values and symbols.

	Aling 30 Alington Avenue, Dorchester	Aling 40 Alington Avenue, Dorchester	Aling 50 Alington Avenue, Dorchester		Aling 30 Alington Avenue, Dorchester	Aling 40 Alington Avenue, Dorchester	Aling 60 Alington Avenue, Dorchester
Owsle 1	-3.64	-2.63	-3.26		+	+	+
Owsle 2	-4.56	-3.51	-4.60		+	+	+
Owsle 3	-3.81	-2.77	-3.52		+	+	+
Owsle 4	-3.79	-2.81	-3.44		+	+	+
Owsle 6	-5.22	-4.29	-5.24		+	+	+
Owsle 6	-4.13	-3.08	-3.99		+	+	+
Owsle 7	-4.47	-3.43	-4.46		+	+	+
Owsle 8	-4.10	-2.99	-4.06		+	+	+
Owsle 9	-4.00	-3.08	-3.67		+	+	+
Owsle 10	-3.60	-2.62	-3.20		+	+	+
Owsle 11	-3.42	-2.52	-2.96		+	+	+
Owsle 12	-4.04	-2.99	-3.86		+	+	+
Owsle 13	-4.17	-3.11	-4.05		+	+	+
Owsle 14	-4.00	-2.89	-3.90		+	+	+

Figure 34 Matrix of two sample t-test results for oyster shells from Owslebury compared with Ludgershall Castle, near Andover. Actual t-values.

	Lud HL4 Ludgershall Castle, nr. Andover	Lud. HL5 Ludgershall Castle, nr. Andover	Lud. DJ4 Ludgershall Castle, nr. Andover	Lud. DJ6 Ludgershall Castle, nr. Andover	Lud. DL3 Ludgershall Castle, nr. Andover	DCD Ludgershall Castle, nr. Andover	FCD Ludgershall Castle, nr. Andover
Owsle 1	-6.51	-9.51	-6.22	-7.73	-8.62	-8.78	-9.42
Owsle 2	-8.09	-12.22	-7.69	-9.96	-11.21	-13.55	-18.44
Owsle 3	-7.38	-10.75	-7.05	-8.81	-9.81	-10.47	-10.99
Owsle 4	-5.85	-8.71	-5.57	-6.99	-7.84	-7.83	-8.61
Owsle 5	-3.80	-6.76	-3.52	-4.95	-5.83	-5.59	-6.39
Owsle 6	-8.09	-11.89	-7.70	-9.76	-10.91	-12.44	-12.65
Owsle 7	-7.76	-11.72	-7.38	-9.52	-10.71	-12.44	-12.58
Owsle 8	-10.83	-15.55	-10.38	-13.25	-14.68	-22.14	-19.02
Owsle 9	-4.46	-6.99	-4.22	-5.43	-6.17	-5.90	-6.60
Owsle 10	-5.95	-8.75	-5.68	-7.09	-7.89	-7.87	-8.54
Owsle 11	-4.50	-6.75	-4.29	-5.36	-6.02	-5.72	-6.37
Owsle 12	-7.89	-11.58	-7.53	-9.50	-10.61	-11.85	-12.17
Owsle 13	-8.08	-11.93	-7.71	-9.79	-10.95	-12.55	-12.73
Owsle 14	-10.85	-15.48	-10.40	-13.20	-14.61	-21.32	-18.70

Figure 35 Matrix of two sample t-test results for oyster shells from Owslebury compared with Ludgershall Castle, near Andover. Symbols.

	Lud. HL4 Ludgershall Castle, nr. Andover	Lud. HL5 Ludgershall Castle, nr. Andover	Lud. DJ4 Ludgershall Castle, nr. Andover	Lud. DJ6 Ludgershall Castle, nr. Andover	Lud. DL3 Ludgershall Castle, nr. Andover	DC,D Ludgershall Castle, nr Andover	FC,D Ludgershall Castle, nr. Andover
Owsle 1	+	+	+	+	+	+	+
Owsle 2	+	+	+	+	+	+	+
Owsle 3	+	+	+	+	+	+	+
Owsle 4	+	+	+	+	+	+	+
Owsle 5	+	+	+	+	+	+	+
Owsle 6	+	+	+	+	+	+	+
Owsle 7	+	+	+	+	+	+	+
Owsle 8	+	+	+	+	+	+	+
Owsle 9	+	+	+	+	+	+	+
Owsle 10	+	+	+	+	+	+	+
Owsle 11	+	+	+	+	+	+	+
Owsle 12	+	+	+	+	+	+	+
Owsle 13	+	+	+	+	+	+	+
Owsle 14	+	+	+	+	+	+	+

Figure 36 Matrix of two sample t-test results for oyster shells from Owslebury compared with Salisbury (W139). Actual t-values and symbols.

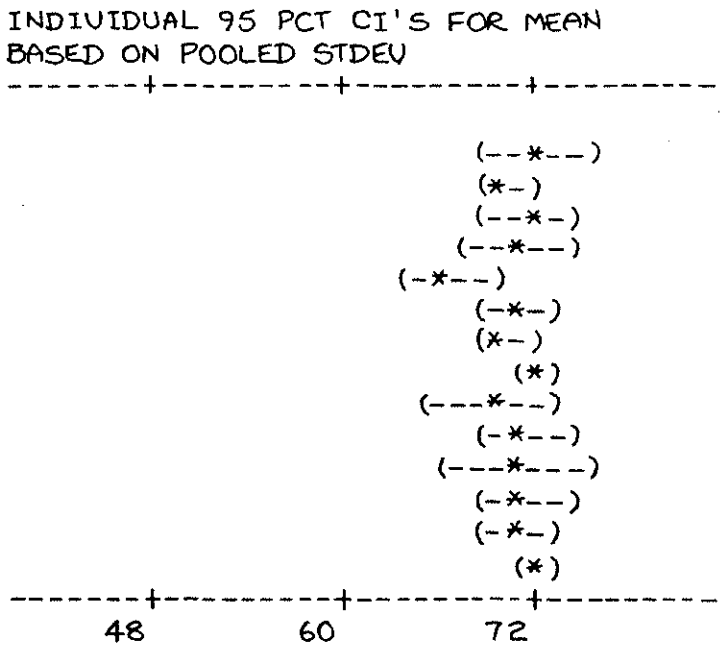
	Salis 2 W139, 39 Brown St., Salisbury	Salis 3a W139, 39 Brown St., Salisbury	Salis 5 W139, 39 Brown St., Salisbury		Salis 2 W139, 39 Brown St., Salisbury	Salis 3a W139, 39 Brown St., Salisbury	Salis 5 W139, 39 Brown St., Salisbury
Owsle 1	6.10	5.72	6.67		+	+	+
Owsle 2	6.79	5.83	7.80		+	+	+
Owsle 3	6.65	5.97	7.38		+	+	+
Owsle 4	5.59	5.38	6.07		+	+	+
Owsle 5	3.83	4.06	4.19		+	+	+
Owsle 6	6.96	6.03	7.89		+	+	+
Owsle 7	6.65	5.79	7.58		+	+	+
Owsle 8	8.32	6.63	9.82		+	+	+
Owsle 9	4.48	4.63	4.79		+	+	+
Owsle 10	5.70	5.49	6.17		+	+	+
Owsle 11	4.56	4.75	4.82		+	+	+
Owsle 12	6.88	6.02	7.76		+	+	+
Owsle 13	6.95	6.02	7.89		+	+	+
Owsle 14	8.39	6.69	9.87		+	+	+

Figure 37

ANALYSIS OF VARIANCE

LEVEL	N	MEAN	STDEV
owsle.1	44	71.52	10.74
owsle.2	191	70.07	12.53
owsle.3	88	71.50	12.61
owsle.4	56	70.82	12.95
owsle.5	47	66.51	11.41
owsle.6	86	71.01	9.98
owsle.7	119	70.16	10.96
owsle.8	316	71.70	10.29
owsle.9	35	69.37	12.23
owsle.10	48	71.31	12.37
owsle.11	30	70.67	12.93
owsle.12	79	71.15	10.19
owsle.13	98	70.93	10.49
owsle.14	258	71.95	9.97

POOLED STDEV = 12.22



ANALYSIS OF VARIANCE Figure 36a

LEVEL	N	MEAN	STDEV
lud.h14	145	59.11	12.14
lud.h15	93	53.26	9.98
lud.dJ4	105	59.67	10.30
lud.dJ6	92	57.04	9.05
lud.d13	87	55.33	8.89
lud.dgd	1034	57.04	10.38
lud.fgd	239	55.07	10.14
salis.2	25	57.72	7.69
salis.3a	21	55.90	12.02
alis.5	77	57.65	11.48
poole.11	163	77.08	10.23
poole.17	182	76.78	10.89
dling.30	27	82.78	13.70
dling.40	32	79.28	13.94
dling.50	93	79.53	17.77
pm21.53	106	73.78	14.59
pm21.ran	75	75.76	18.17
pm.ship	157	77.80	13.61
newport1	130	78.08	11.16
newport2	746	76.14	10.49
wytch.11	133	89.42	9.12
south	102	89.57	8.09
grey.erb	27	83.93	16.24
grey.rbd	108	86.89	13.45
grey.em	193	86.76	15.23
grey.em2	137	86.16	13.11
grey.22	66	88.23	19.62
bowley	135	64.17	8.35
pm21.502	153	66.56	15.03
09	65	63.82	10.85
9969	30	64.93	8.99
3571	43	64.35	12.68
9820	48	63.96	9.91
newtown	19	69.26	8.52
pm21.53	106	73.78	14.59
pm21.58	435	71.07	14.07
pm21.501	71	71.66	13.05
pm21.502	153	66.56	16.03
pm21.504	60	71.25	13.02
8568	134	67.34	9.16
8686	125	67.11	11.50
9959	30	64.93	8.99
11151	37	69.89	13.47
11275	51	70.37	11.20
242	163	66.98	12.26
667	226	71.39	11.91
3571	43	64.35	12.68

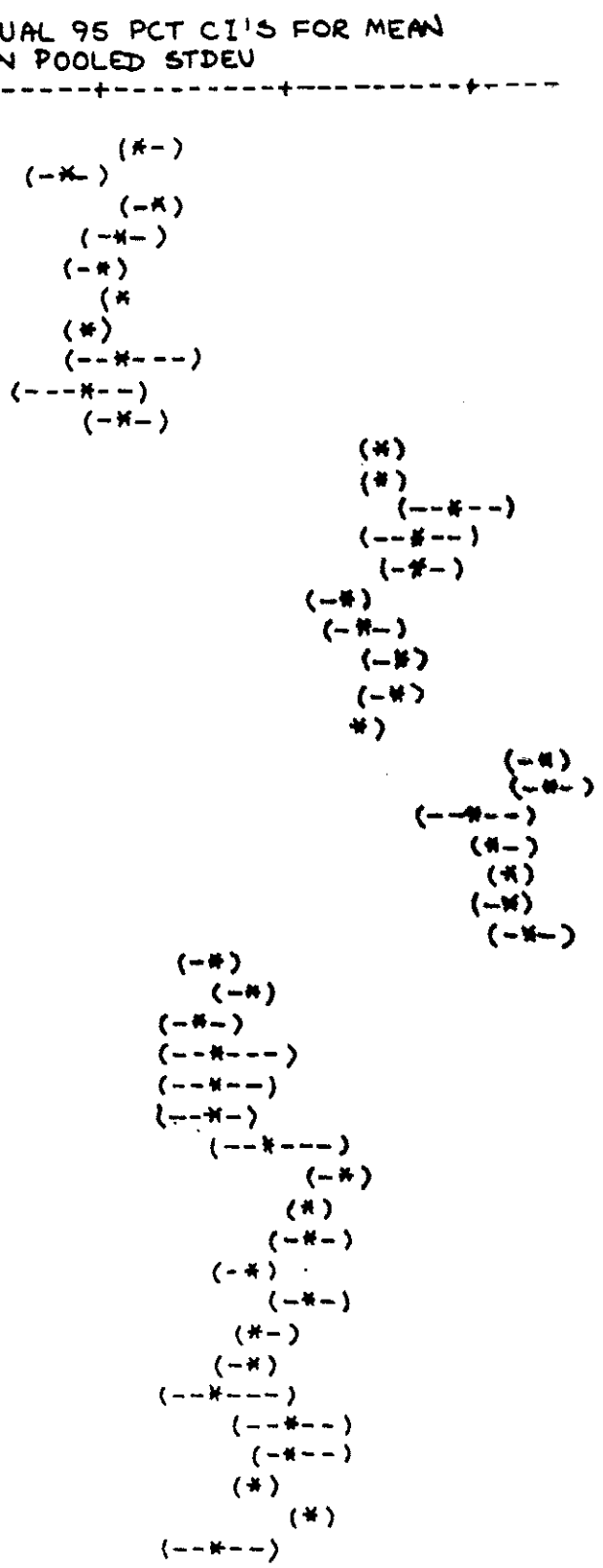
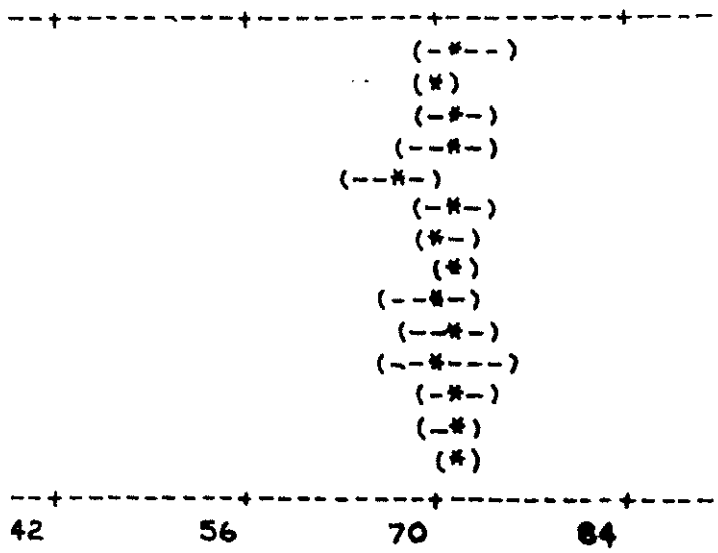


Figure 38b

LEVEL	N	MEAN	STDEV
owsle.1	44	71.52	10.74
owsle.2	191	70.07	12.53
owsle.3	88	71.50	12.61
owsle.4	56	70.82	12.95
owsle.5	47	66.51	11.41
owsle.6	86	71.01	9.98
owsle.7	119	70.16	10.96
owsle.8	316	71.70	10.29
owsle.9	35	69.37	12.23
owsle.10	48	71.31	12.37
owsle.11	30	70.67	12.93
wsle.12	79	71.15	10.19
owsle.13	98	70.93	10.49
owsle.14	258	71.95	9.97
POOLED STDEV =		12.20	



c. AGE AND GROWTH RATE

Figures 39 to 42 show the age distribution of the shells in the fourteen Owslebury samples. In each histogram the horizontal axis is marked in years and the vertical axis as percentage. The bars represent the percentage of oyster shells of the sample in each age group. The samples are characterised by a wide age range, usually from 2 or 3 years up to 11 years. In some cases 1 year to 13 years (Owsle 8). The most frequently occurring sizes are in the 4 to 5 year groups. It is important to examine the ages of oysters to eliminate the possibility that it is the age of the oysters that has influenced the sizes in the sample. Oysters of young age only might account for a sample of small sized oysters. The ages found in the sample might also reflect the degree of selectivity used in their collection.

Using the data collected for age and size of oyster shells, growth rate curves could be drawn. The curves for the 14 samples are seen in Figures 43 to 56. The horizontal axis of the graph is marked in years. The vertical axis represents mean maximum width in millimetres. The encircled points represent the mean measurement for each age group. The vertical bars extending from the points are the 95 percent confidence intervals. Where the latter are absent, the point represents only one measurement. Points which represent the mean measurement of an age group comprising less than 5% of the sample are not connected to other points because the mean may not be truly representative of the age group.

The growth rate curves obtained show a marked similarity to each other, despite the fact that the small numbers of specimens in some samples have resulted in somewhat erratic curves. When the Owslebury curves are compared with those for samples from other sites they appear middle of the range. Other sites have produced oyster shells which have developed at faster or slower rates.

Figure 39 Age distributions of oyster shells in Owslebury samples

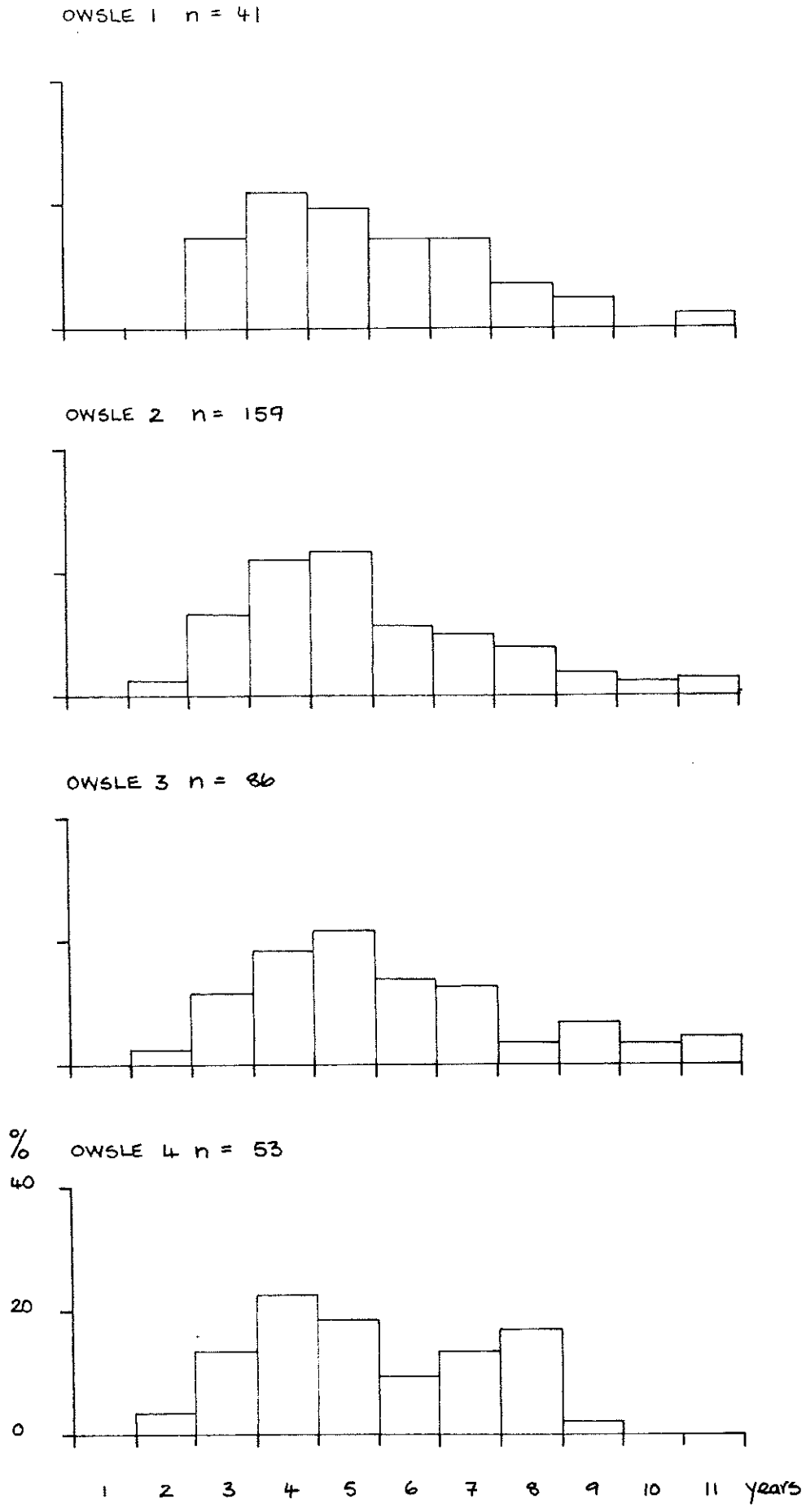


Figure 40 Age distributions of oyster shells in Owslebury samples

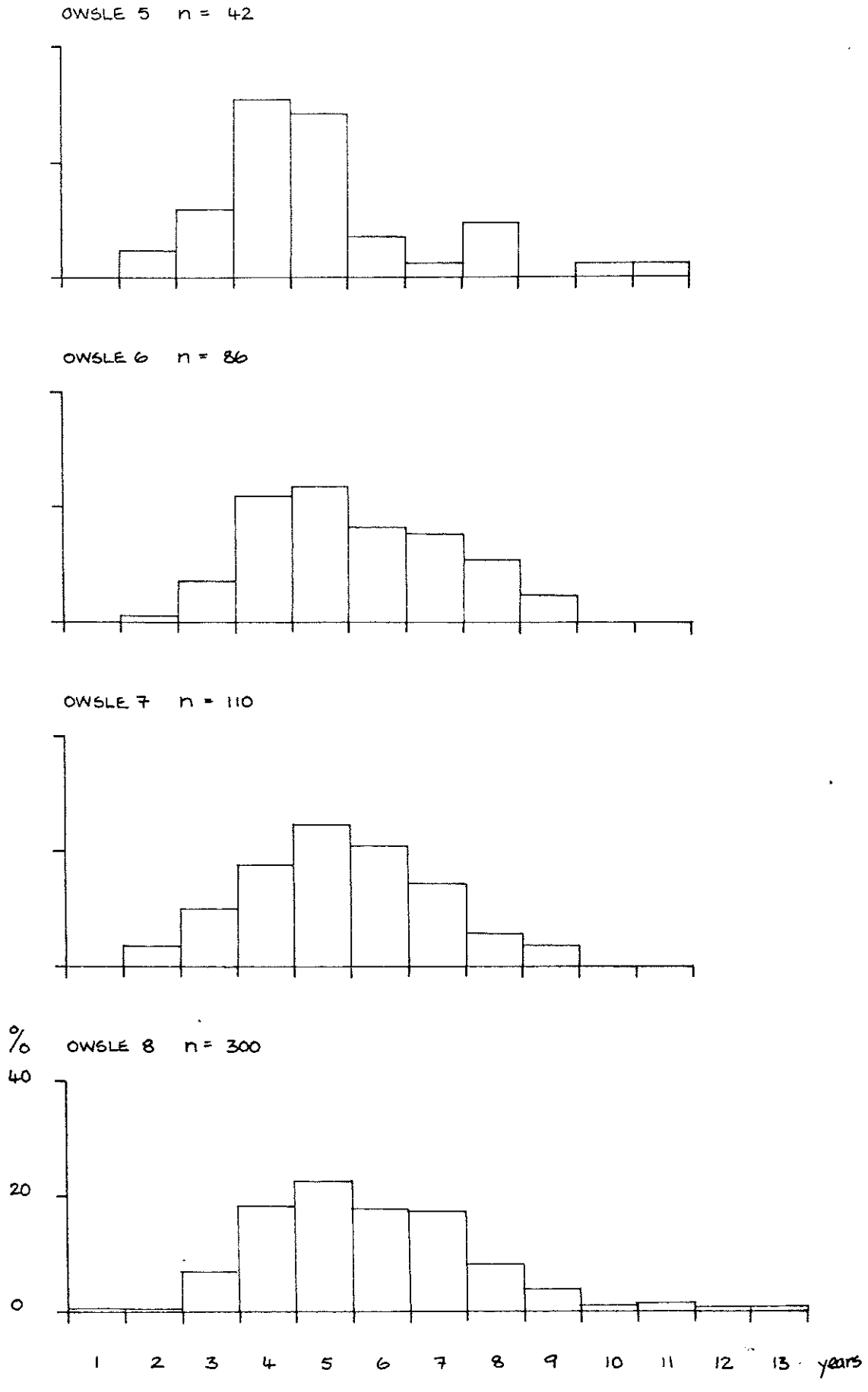


Figure 41 Age distributions of oyster shells in Owslebury samples

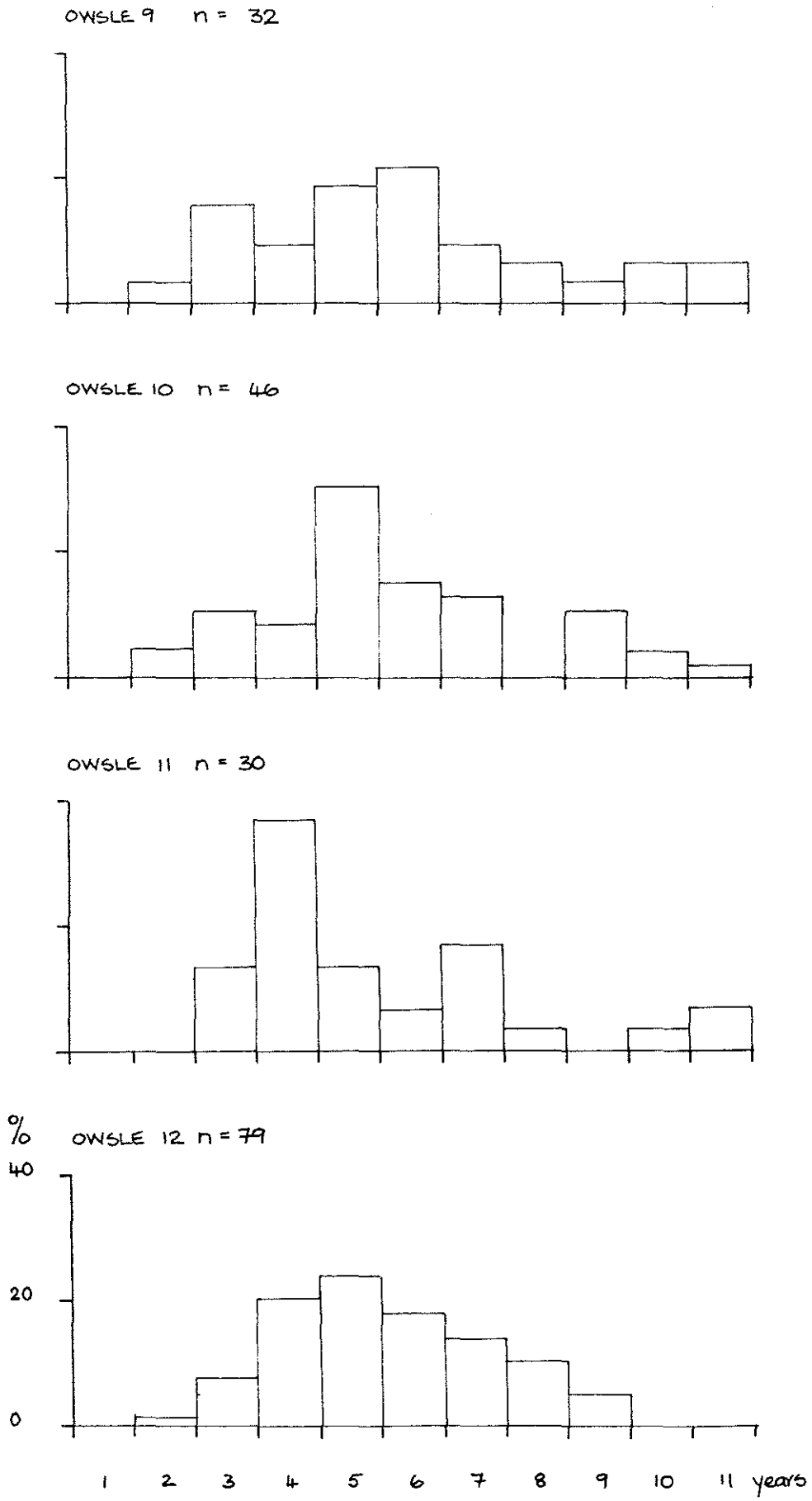


Figure 42 Age distributions of oyster shells in Owslebury samples

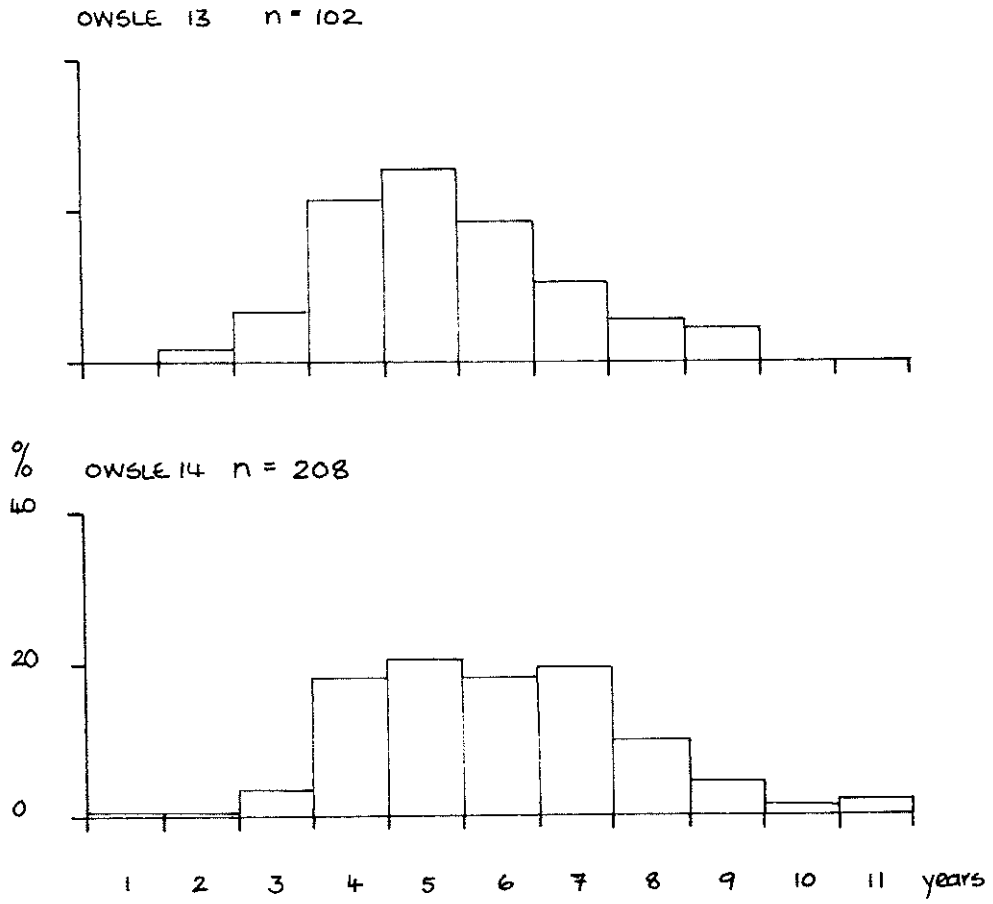


Figure 43

GROWTH RATE OF OYSTER SHELLS FROM OWSLE 1 n = 44

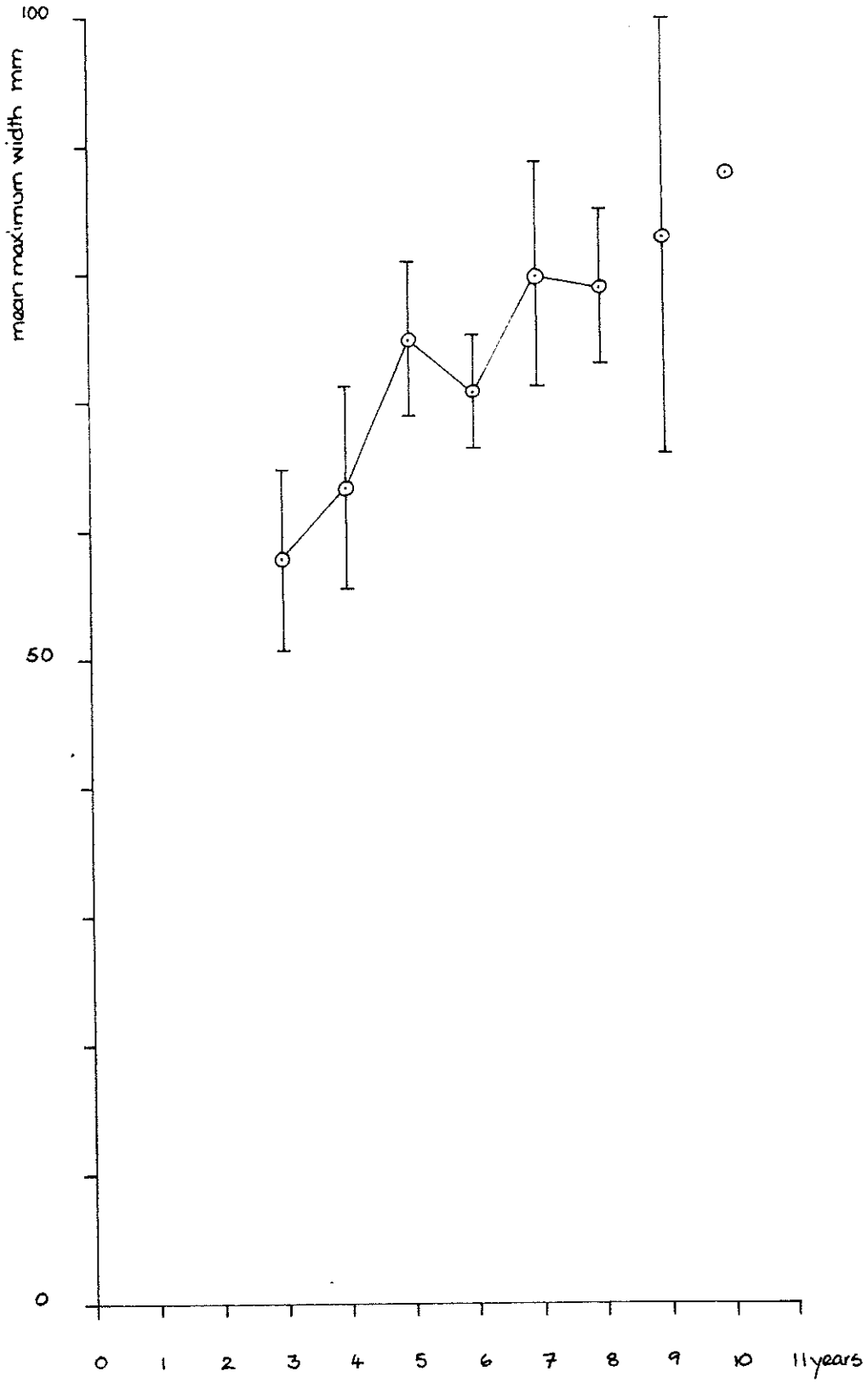


Figure 44

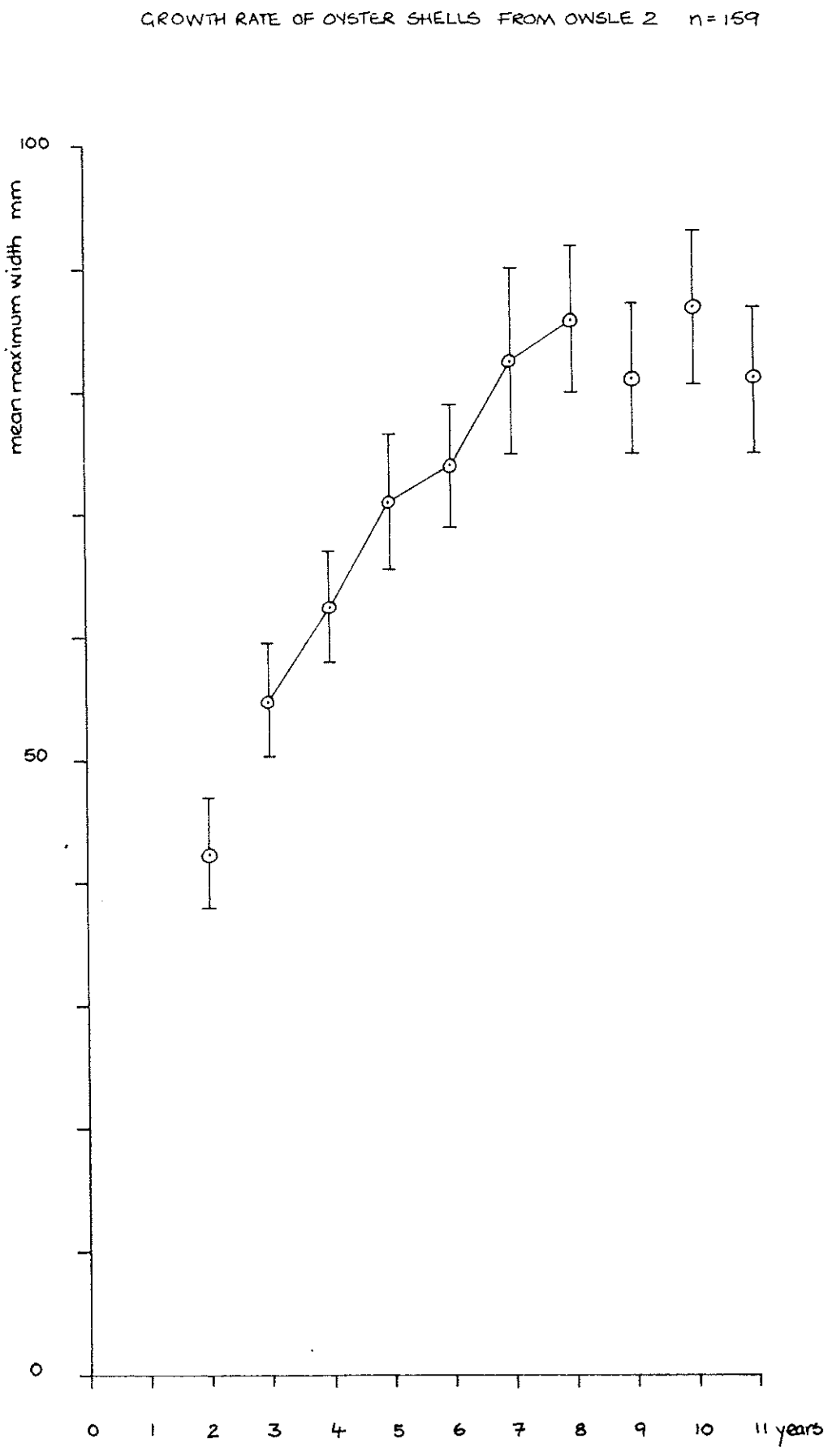

GROWTH RATE OF OYSTER SHELLS FROM OWSLE 2 n = 159
mean maximum width mm
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 years

Figure 45

GROWTH RATE OF OYSTER SHELLS FROM OWSLE 3 n = 86

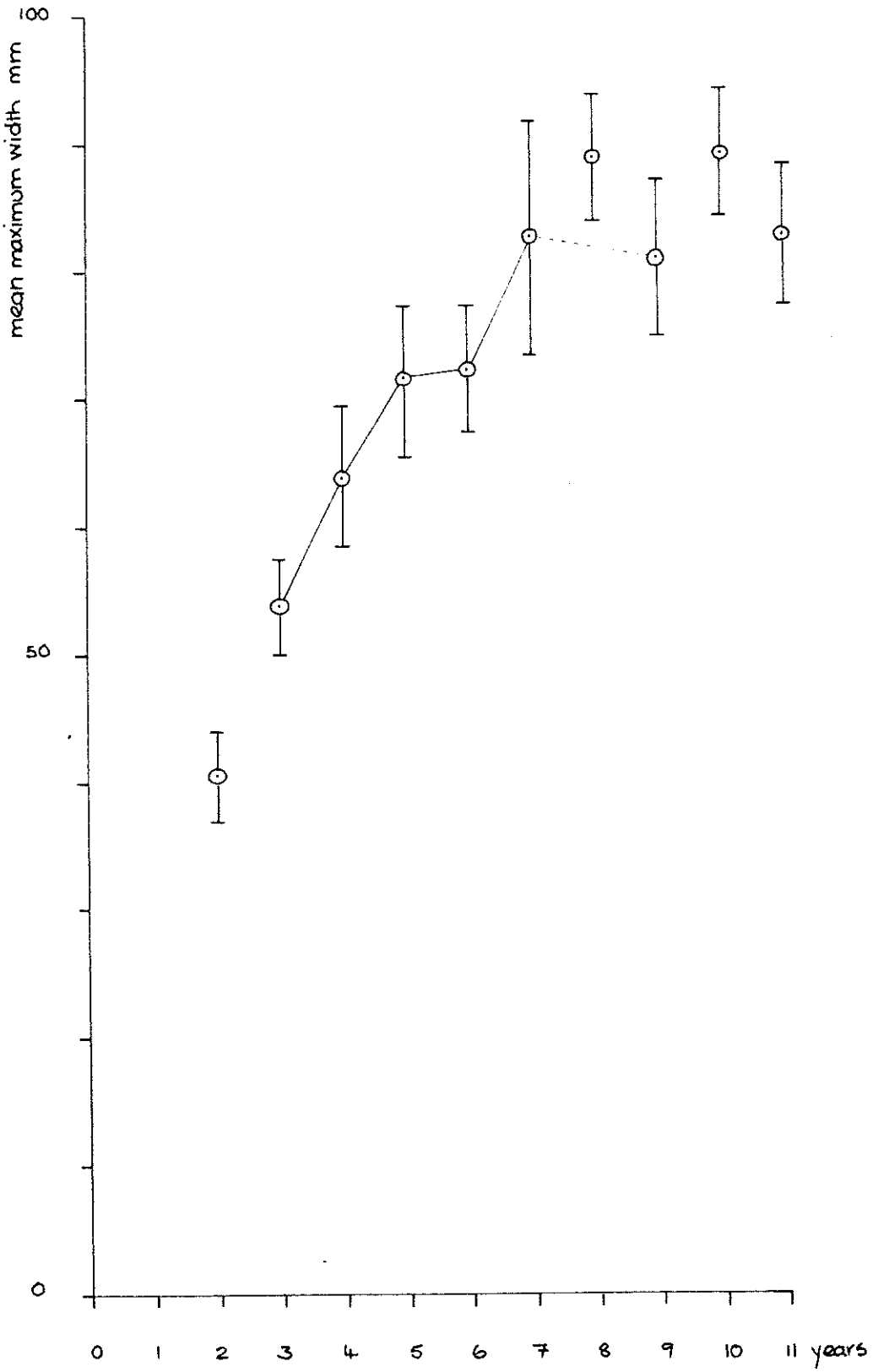


Figure 46

GROWTH RATE OF OYSTERS SHELLS FROM OWSLEY n = 53

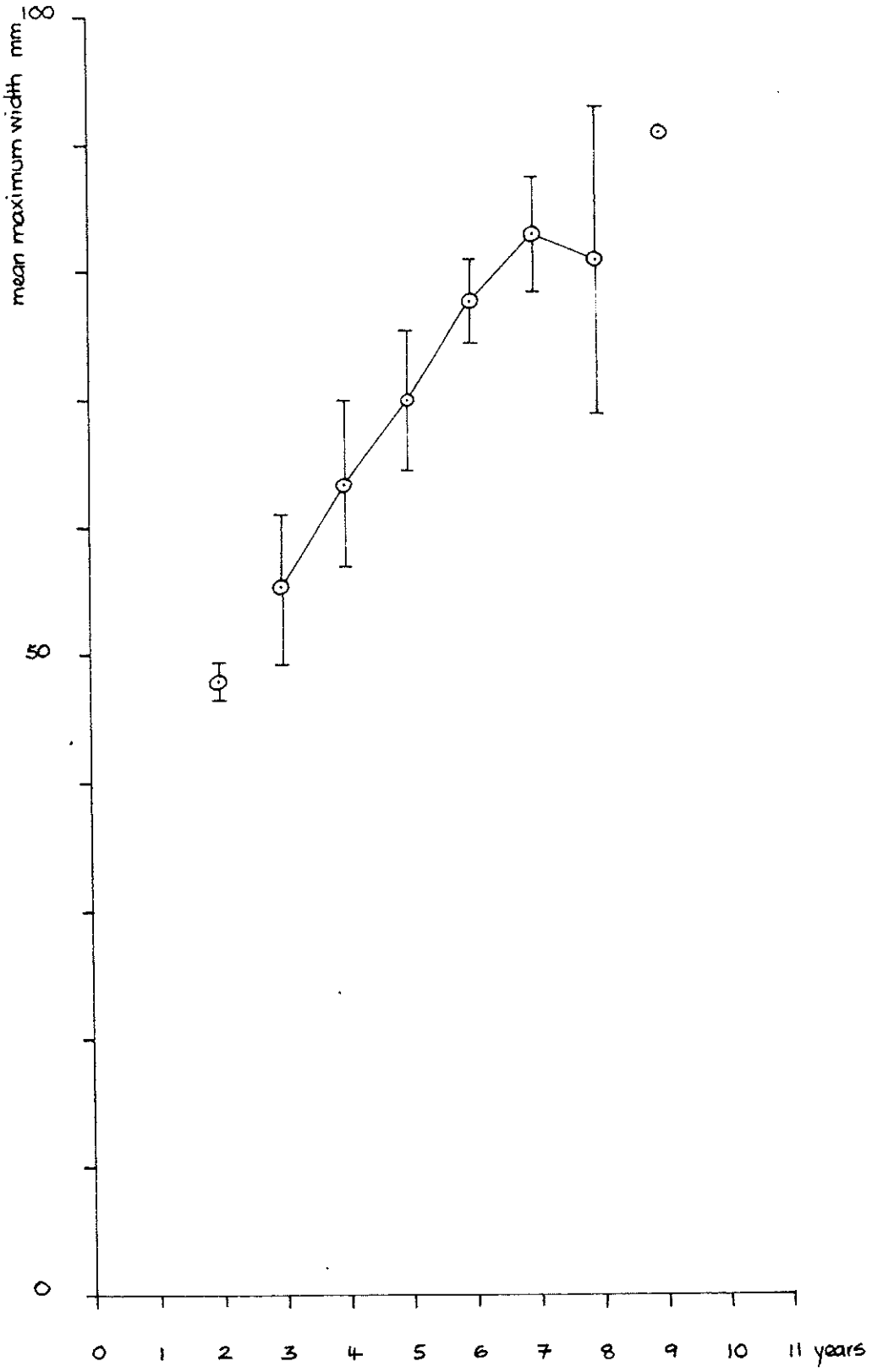


Figure 47

GROWTH RATE OF OYSTER SHELLS FROM OWSLE 5 n=42

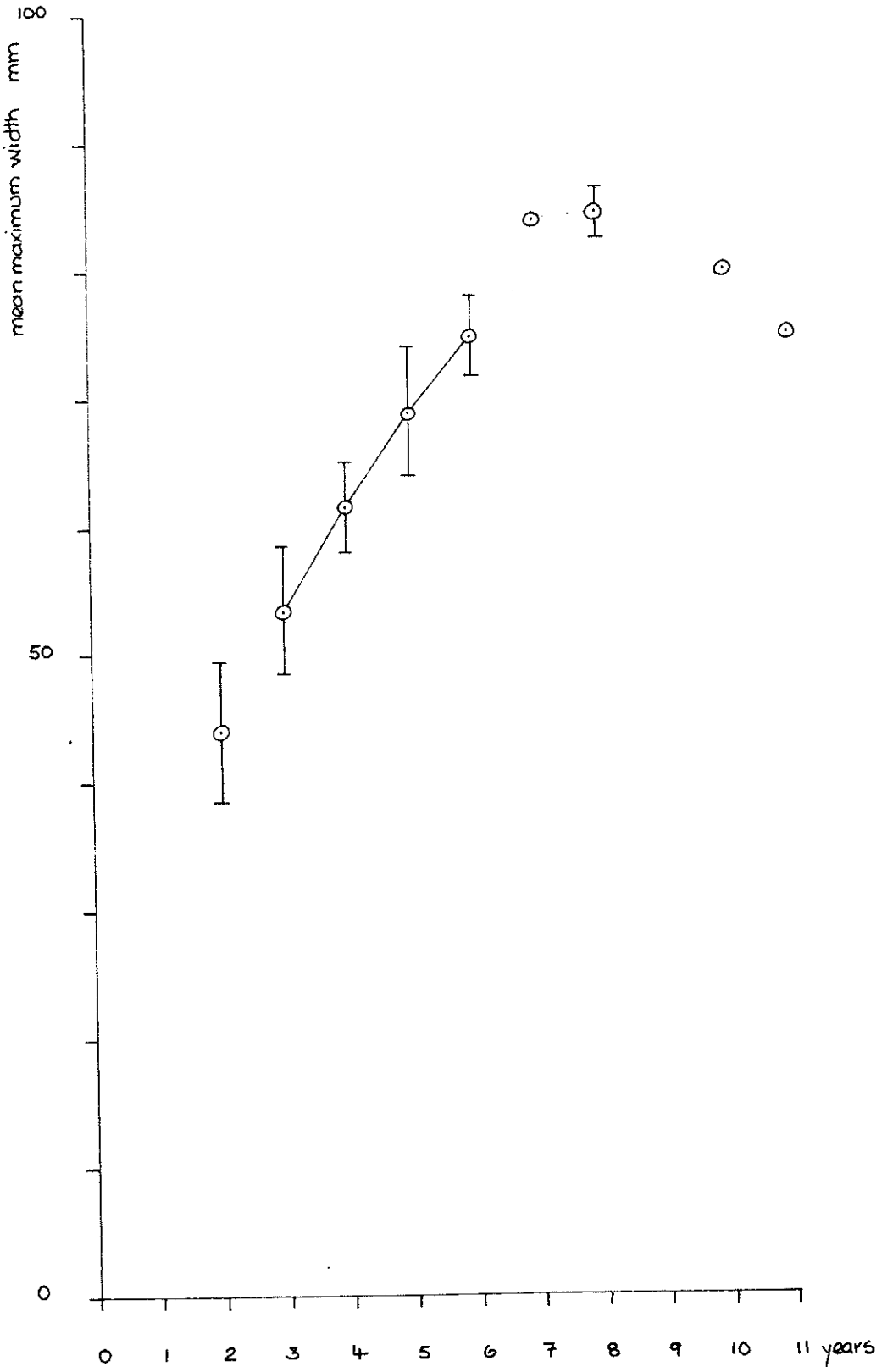


Figure 48

GROWTH RATE OF OYSTER SHELLS FROM OWSLE 6 n = 86

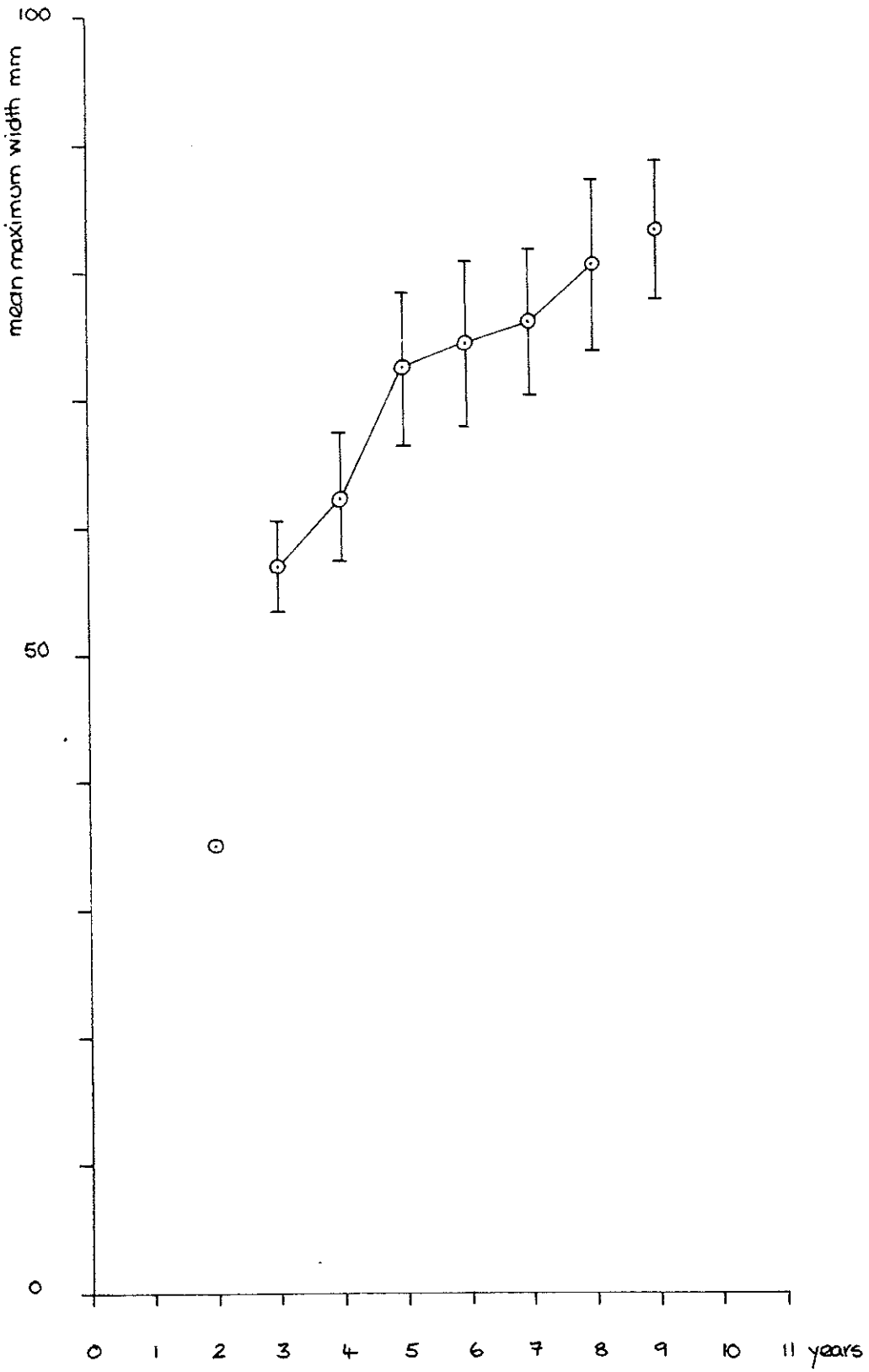


Figure 49

GROWTH RATE OF OYSTER SHELLS FROM OWSLE 7 n = 110

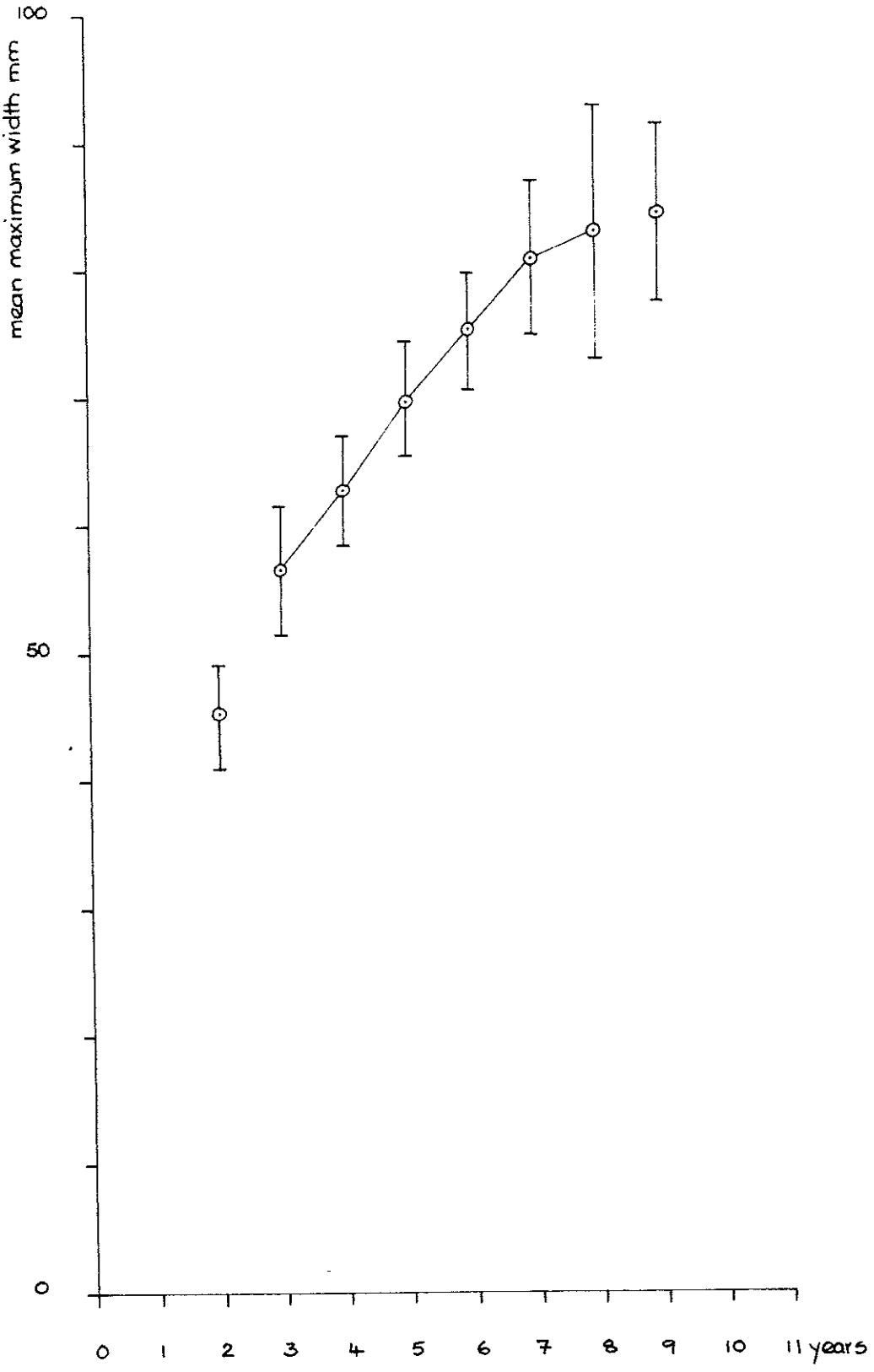


Figure 50

GROWTH RATE OF OYSTER SHELLS FROM OWSLE 8 n = 300

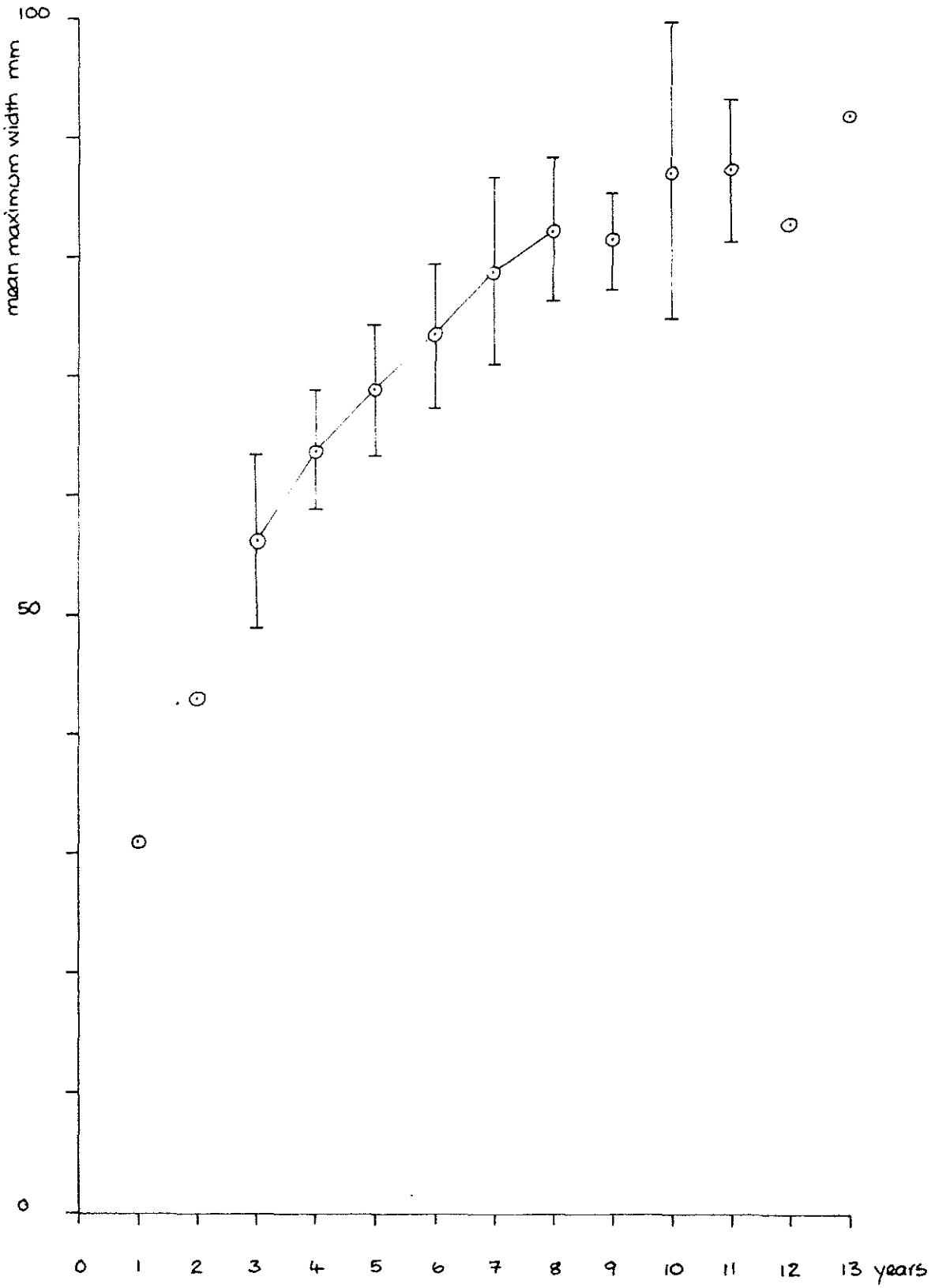


Figure 51

GROWTH RATE OF OYSTER SHELLS FROM OWSLE 9 n = 32

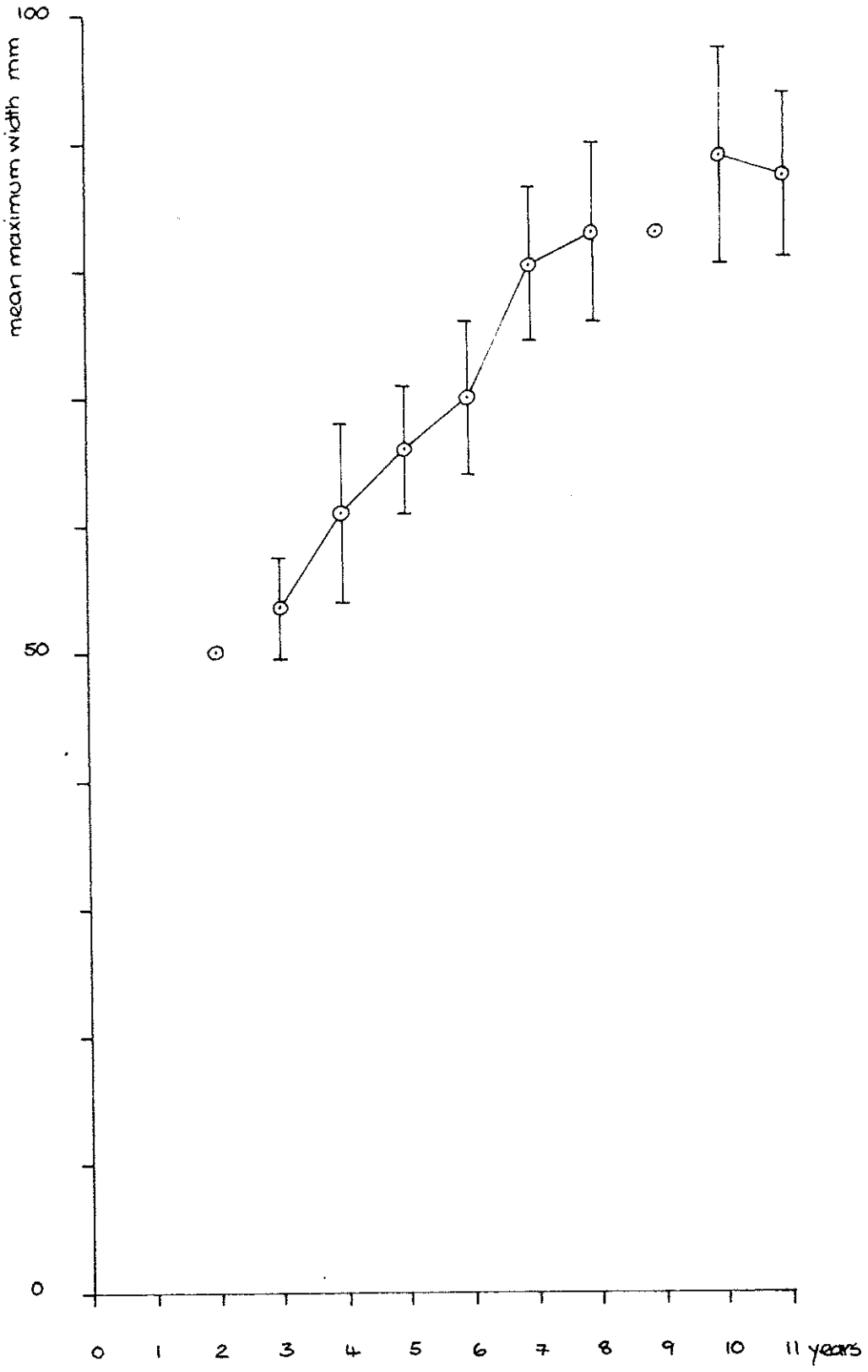


Figure 52

GROWTH RATE OF OYSTER SHELLS FROM OWSLE 10 n = 46

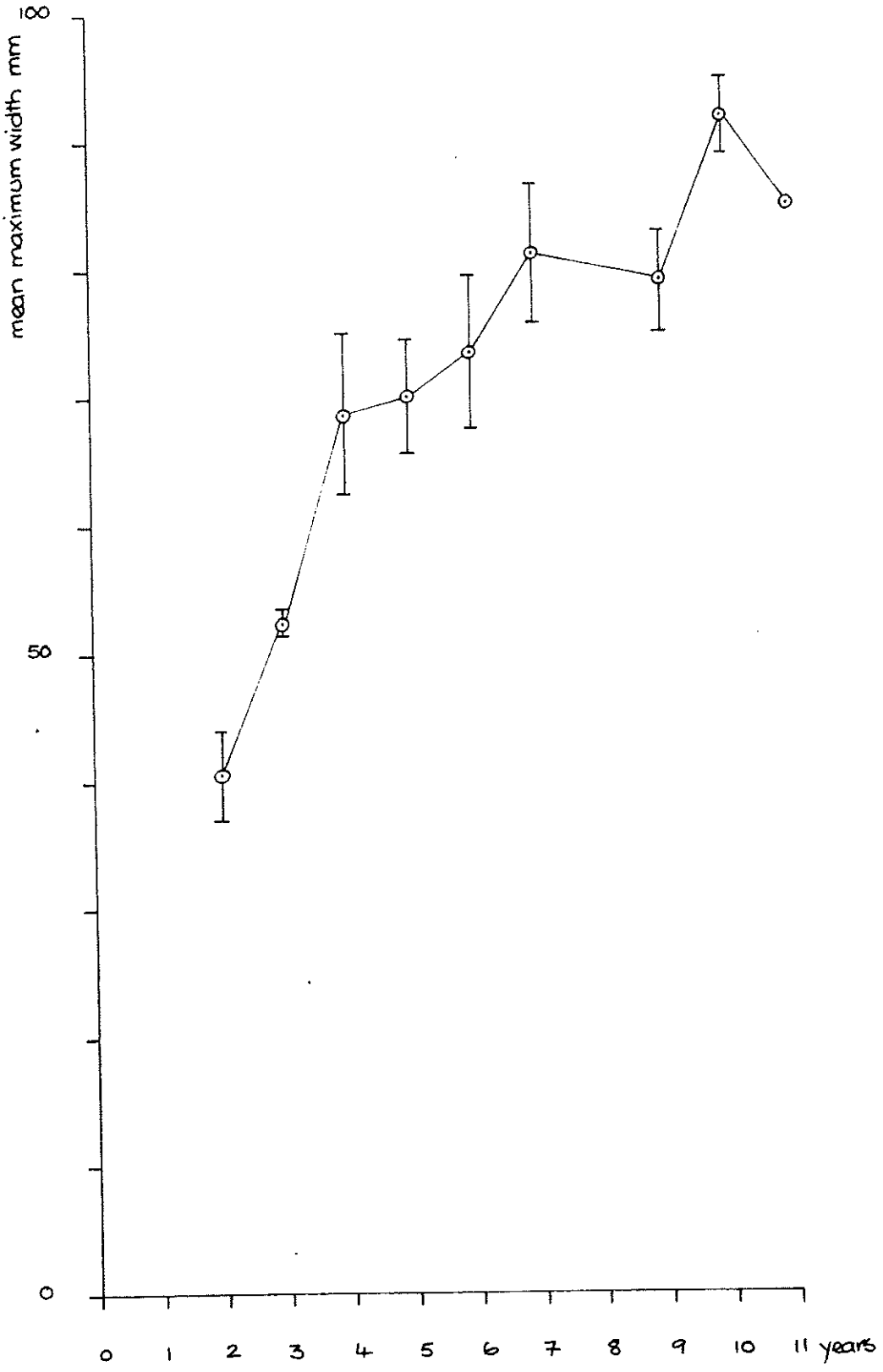


Figure 53

GROWTH RATE OF OYSTER SHELLS FROM OWSLE 11 n = 30

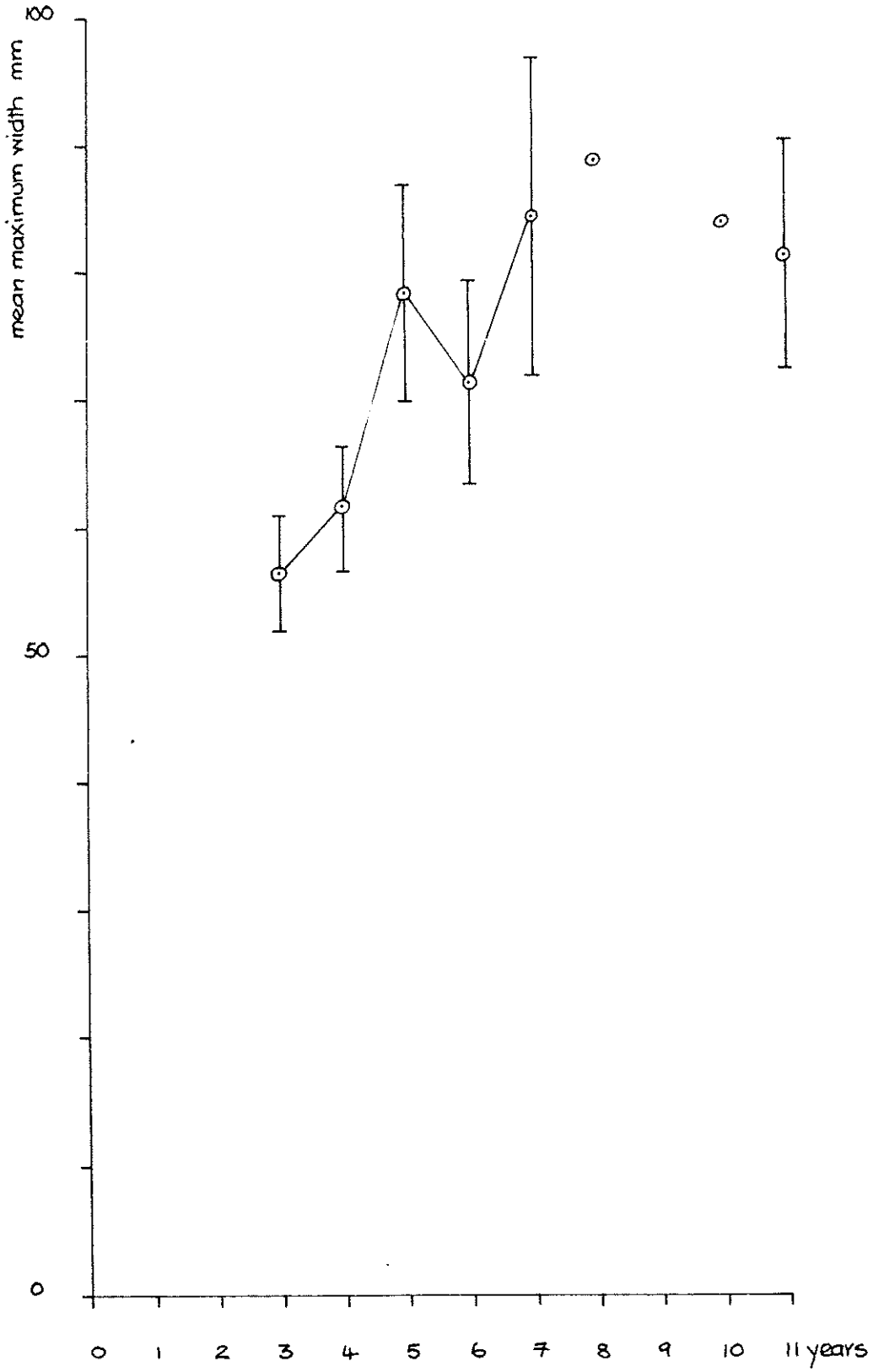


Figure 54

GROWTH RATE OF OYSTER SHELLS FROM OWSLE 12 n = 79

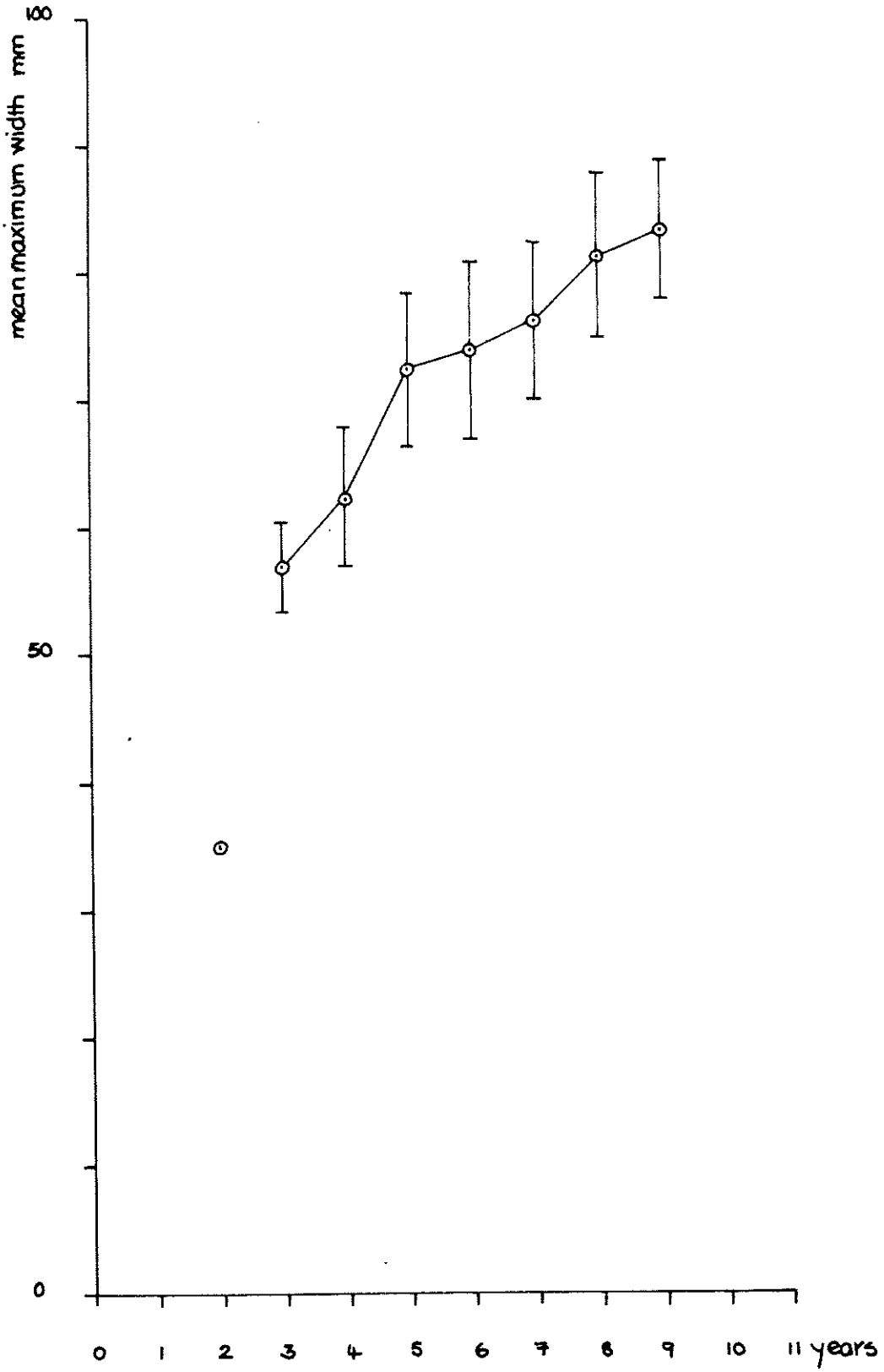


Figure 55

GROWTH RATE OF OYSTER SHELLS FROM OWSLE 13 n = 102

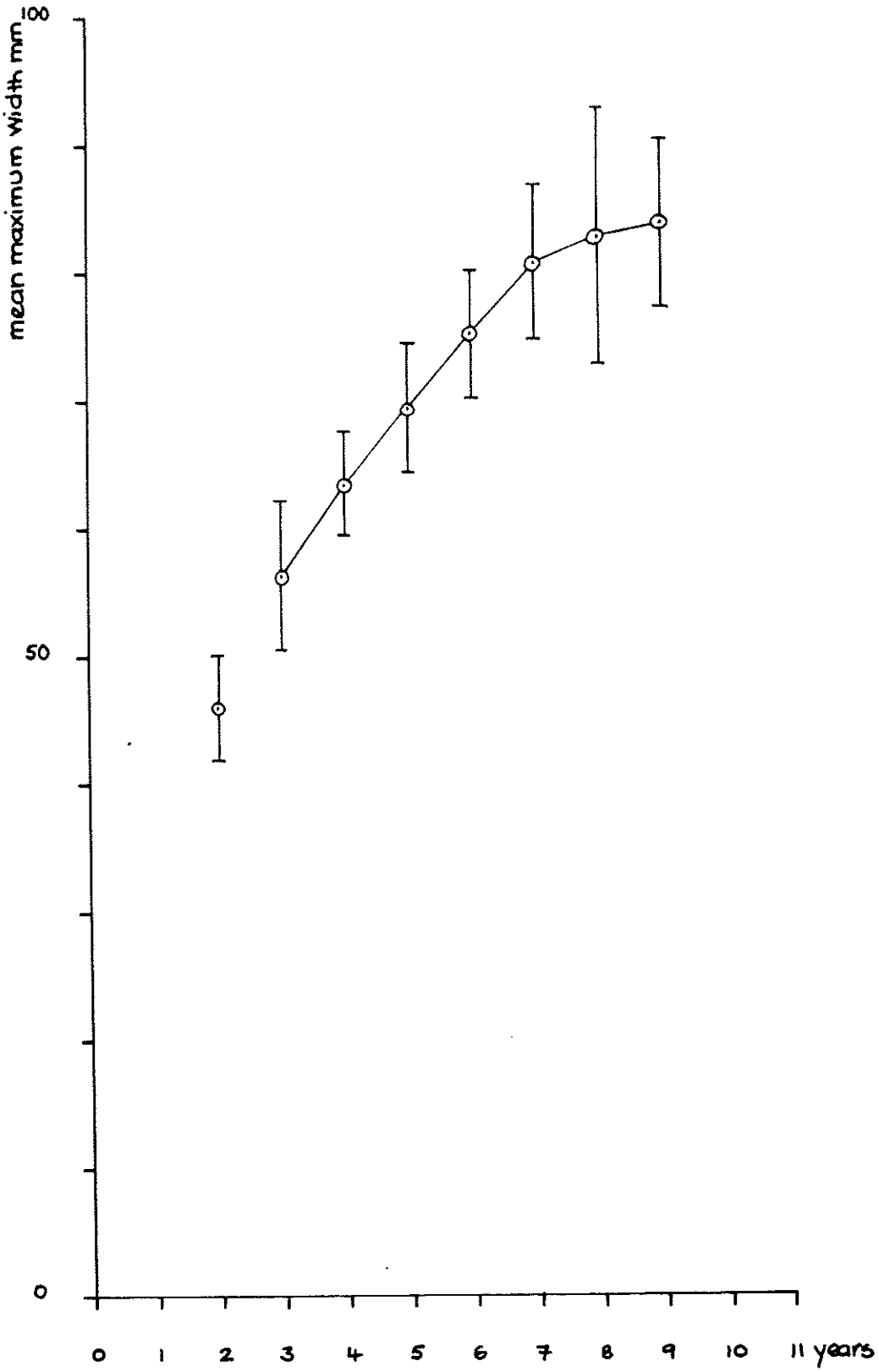
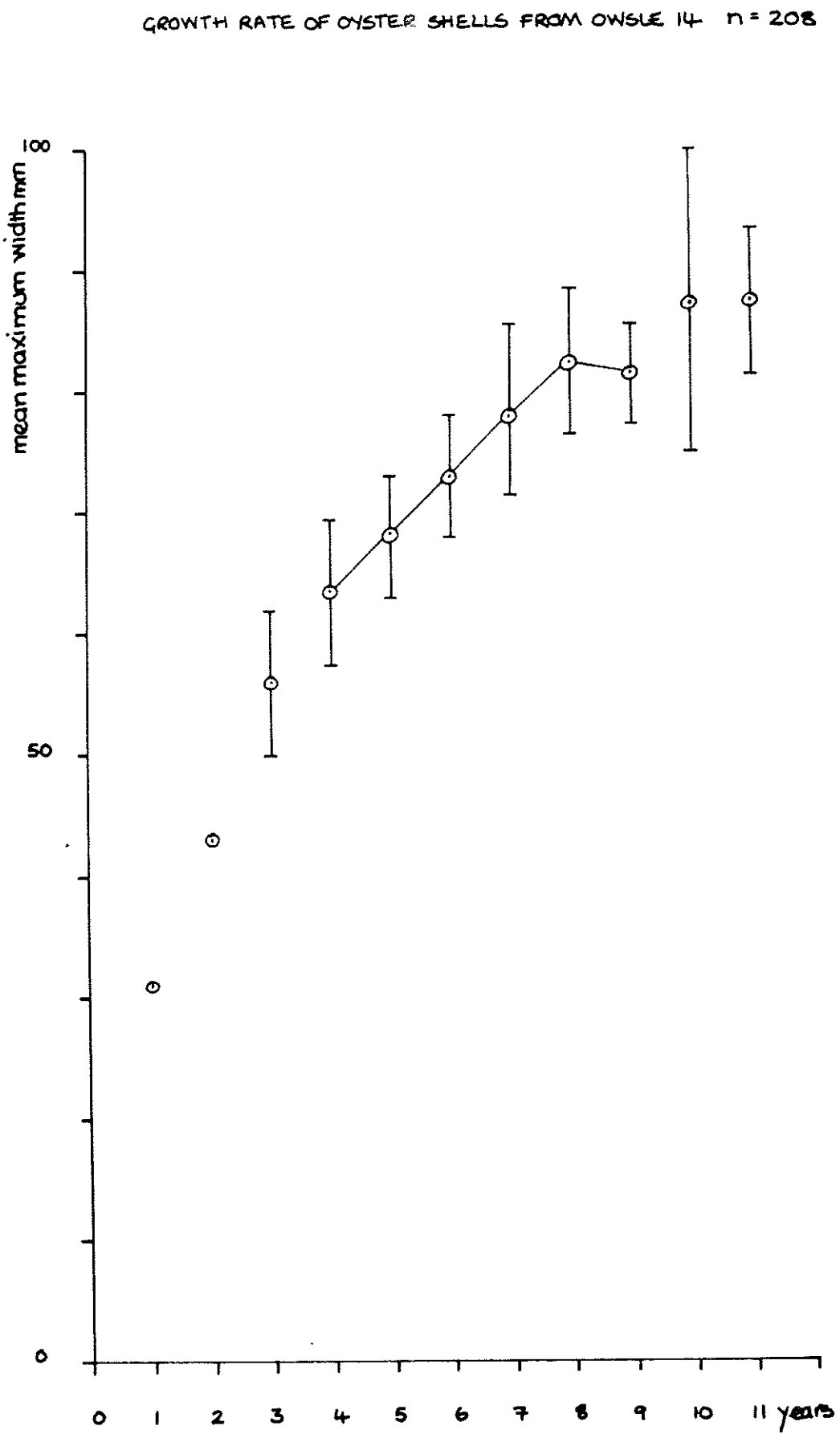


Figure 56


GROWTH RATE OF OYSTER SHELLS FROM OWSLE 14 n = 208
mean maximum width mm
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 years

d. INFESTATION

Table 4 shows the numbers and percentage of shells within each sample that have been affected by various types of infesting or encrusting organisms. The most obvious evidence of infestation is the boreholes left by Polydora ciliata. All samples were affected in percentages varying from 21.67% to 49.33%. The holes made by Polydora hoplura were also common to all samples but they were less frequent - 7.55% to 16.67%.

Bore holes, probably made by the sting winkle, were also recorded in all samples but the frequency was low - 1.25% in OWSLE 1 to 5.63% in OWSLE 14. Cliona sponge affected small numbers of shells in ten of the samples. Encrusting calcareous tubes, barnacles and sea mats were uncommon.

The infestation data is also presented in bar chart form in Figures 57 to 60. Here it is easier to see how the two Polydora species were predominant. Evidence of organisms that burrowed into the shell was more common than that of attached animals.

Table 4

OWSLEBURY - SUMMARY OF INFESTATION DATA FROM OYSTER SHELLS
(RIGHT AND LEFT VALVES COMBINED RESULTS)

	number	i Polydora ciliata	% sample affected	ii Polydora hoplura	% affected	iii Cliona celata	% affected	iv Calcareous tube	% affected	v Barnacles	% affected	vi Polyzoa	% affected	vii Bore holes	% affected
OWSLE 1 (allbc)	80	27	33·75	8	10·00	0	0	0	0	0	0	0	0	1	1·25
OWSLE 2 (all1stad)	330	148	44·85	37	12·57	5	1·52	4	1·21	0	0	2	0·61	10	3·03
OWSLE 3 (mid1stad)	151	63	41·72	18	11·92	2	1·32	4	2·65	0	0	0	0	4	2·65
OWSLE 4 (late1stad)	70	27	38·57	7	10·00	0	0	0	0	0	0	0	0	2	2·86
OWSLE 5 (1stad)	75	37	49·33	10	14·29	3	4·00	0	0	0	0	2	2·67	4	5·33
OWSLE 6 (2ndad)	161	54	33·54	22	13·67	3	1·86	0	0		0	0	0	5	3·11
OWSLE 7 (2nd3rdad)	217	69	31·8	22	10·14	2	0·92	0	0	1	0·46	0	0	5	2·30
OWSLE 8 (3rd4thad)	559	194	34·71	44	7·87	12	2·15	0	0	0	0	0	0	27	4·83
OWSLE 9 (4thad)	60	13	21·67	9	15·00	2	3·33	2	3·33	0	0	1	1·67	4	6·67
OWSLE 10 (642 mid1stad)	84	30	35·71	14	16·67	2	2·38	4	4·76	0	0	0	0	2	3·38
OWSLE 11 (642 late1stad)	53	25	47·17	4	7·55	0	0	0	0	0	0	0	0	2	3·77
OWSLE 12 (642 2ndad)	144	49	34·03	19	13·19	2	1·39	0	0	0	0	0	0	5	3·47
OWSLE 13 (642 3rdad)	185	62	33·51	20	10·81	0	0	0	0	1	0·54	0	0	4	2·16
OWSLE 14 (642 3rd4thad)	462	157	33·98	35	7·58	12	2·60	0	0	0	0	0	0	26	5·63

Figure 57 Rates of infestation in oyster shell samples from Owslebury

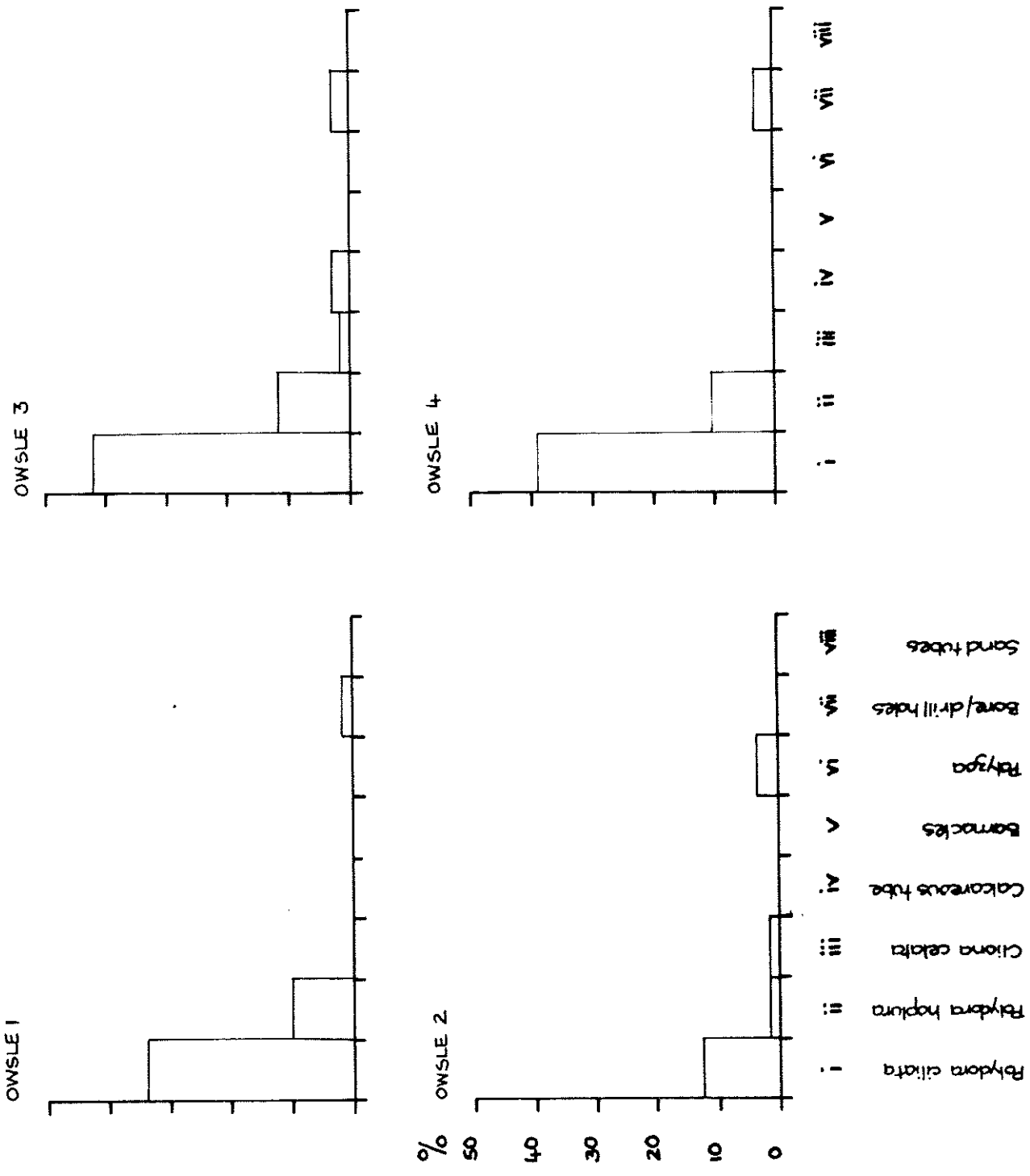


Figure 58 Rates of infestation in oyster shell samples from Owslebury

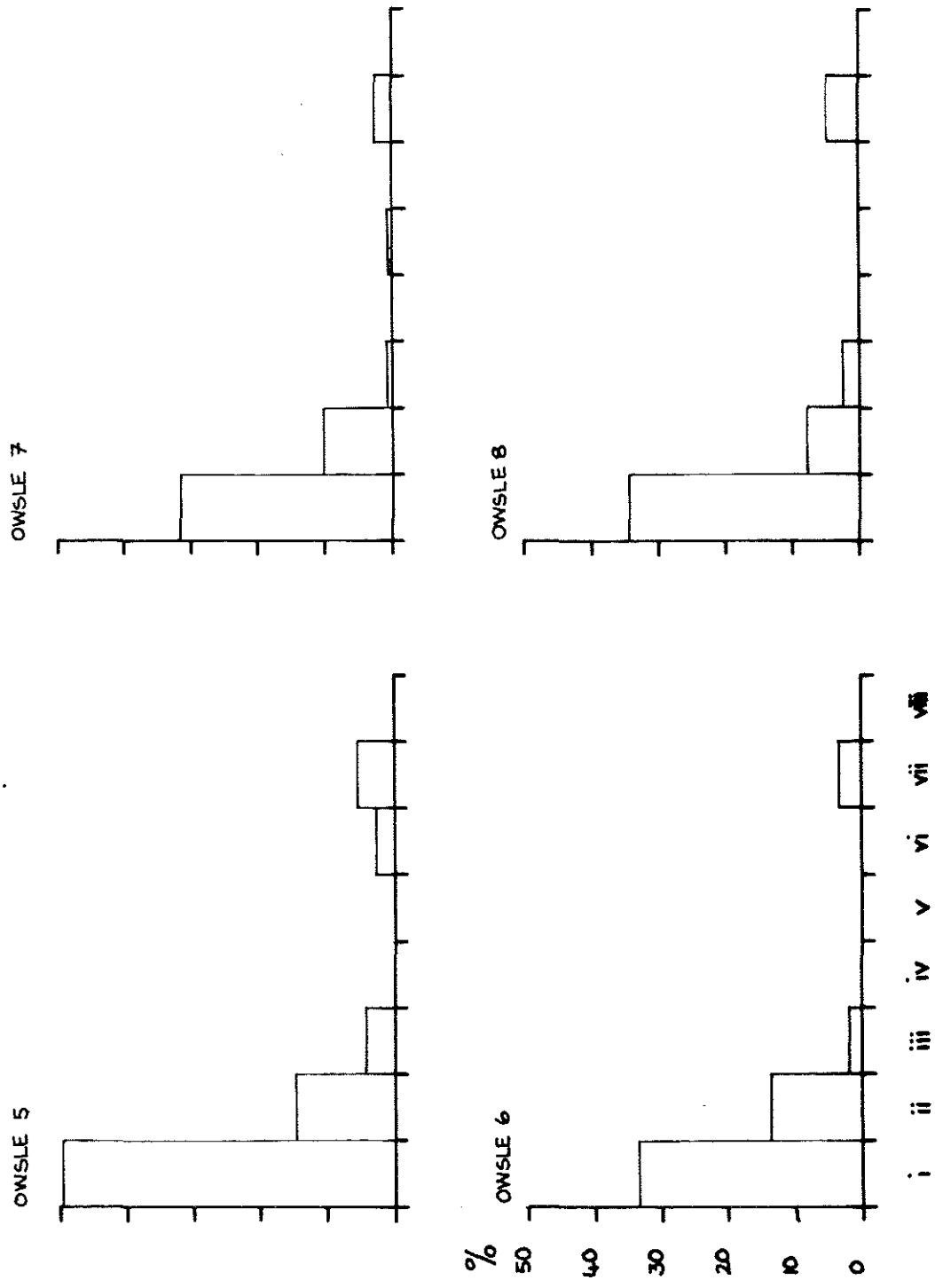


Figure 59 Rates of infestation in oyster shell samples from Owslebury

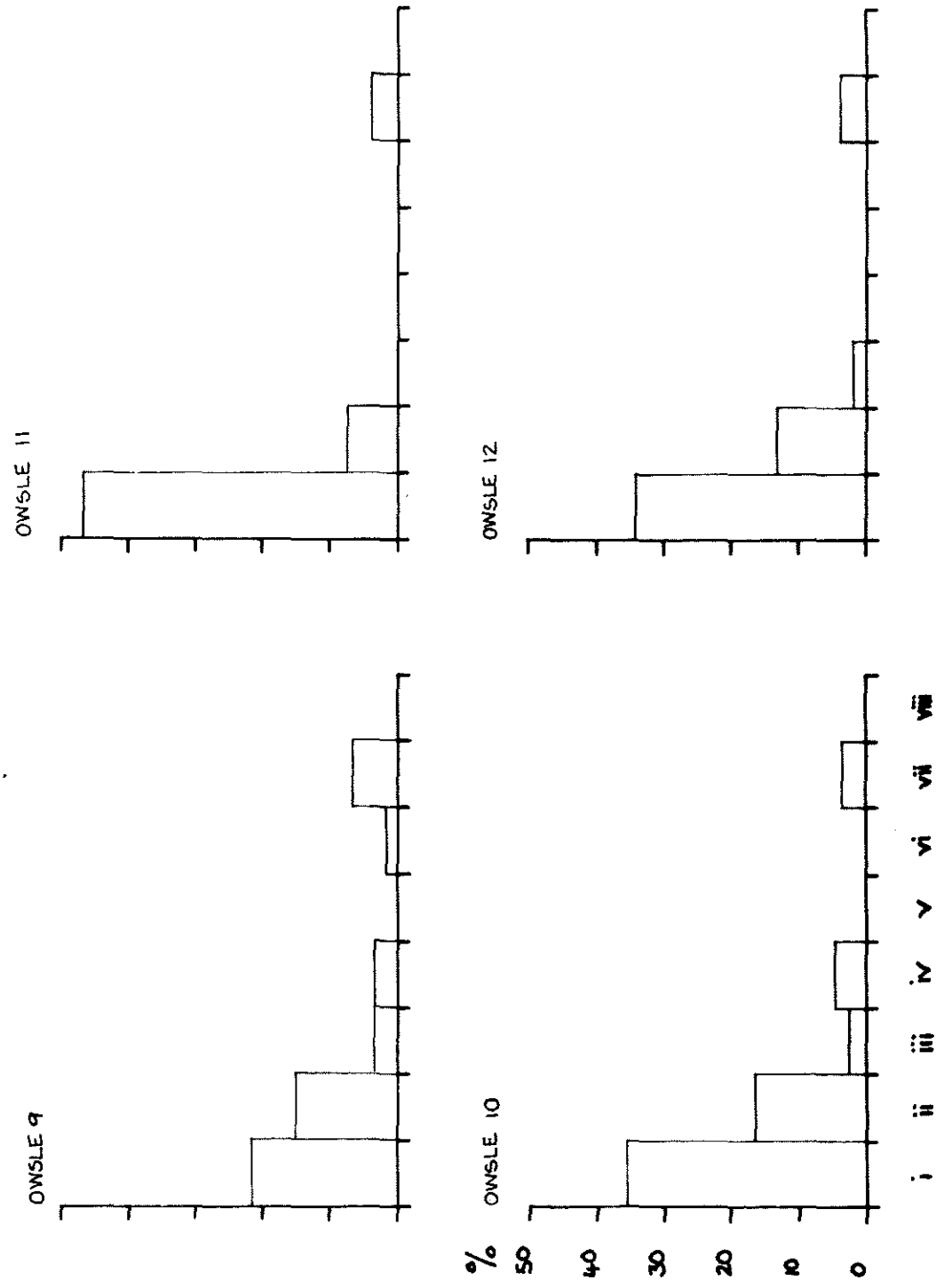
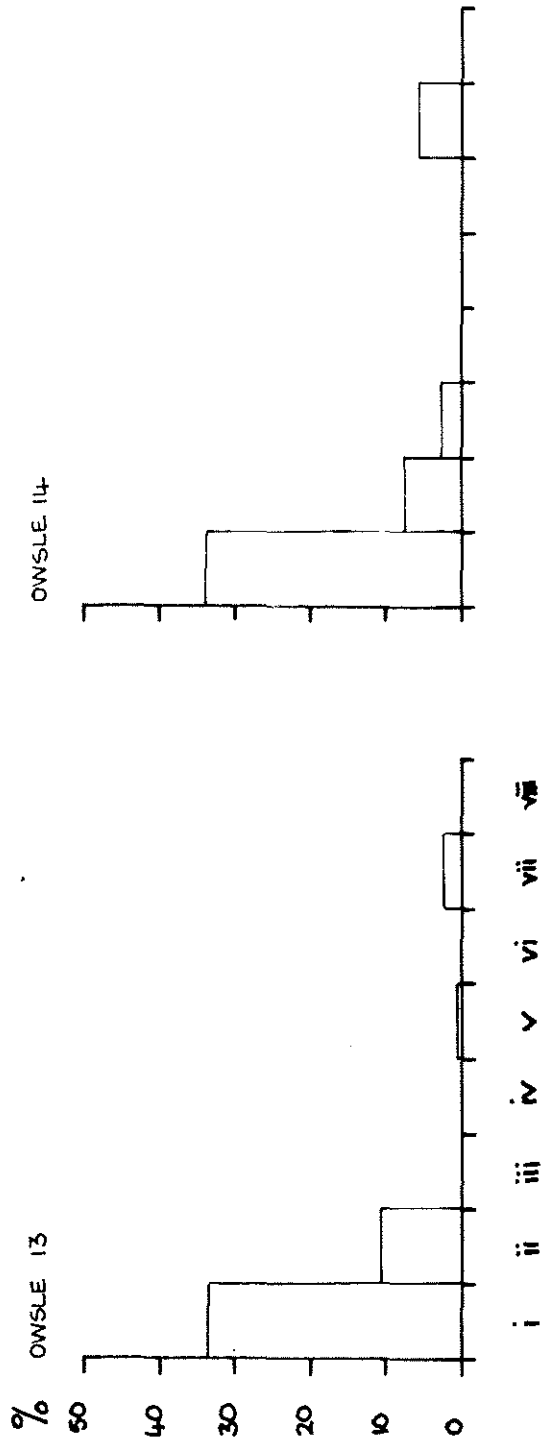


Figure 60 Rates of infestation in oyster shell samples from Owslebury



IV CONCLUSIONS AND DISCUSSION

Considering the number of years that the site at Owslebury was occupied, there were not many oyster or other marine mollusc shells. The surviving shells were poorly preserved and a high proportion of them were damaged to such an extent that measuring and aging them was not possible. The condition of the shells may have been worsened by post-excavation washing.

The majority of contexts yielded only a few shells with the exception of contexts 642 and 133. To make the analysis more manageable, details of oysters were amalgamated in two types of groupings. First according to the phase of occupation and then the type of context. Most oyster shells were recovered from ditches, followed by gullies and quarries. Other context types had few shells. The considerable damage in all types of context makes it seem likely that the shells were redeposited after lying around on the surface for some time. Oysters first appeared in significant numbers in the 1st century AD which coincided with the first finds of imported Gallo-Belgic wares. The peak of oyster consumption was reached in the third and 4th centuries AD. The relative scarcity of oyster shells on the site, the inland rural position, and the relatively high status of the community may be an indication that oysters were a luxury item of food.

The analyses of the sizes of shells in the grouped samples from each phase showed that with the possible exception of OWSLE 5 the size charácteristics of all the samples were alike. In comparisons with samples of oyster shell from both archaeological and modern sites at various locations in Wessex, it was discovered that samples from only three localities were similar to those from Owslebury. These included a few contexts from the Six Dials and Stoner Motor sites of Saxon Southampton, modern live oysters from the Newtown beds in the West Solent, and several contexts from the early medieval waterfront in Poole at Paradise Street. Thus the Owslebury shells could only be matched for size with nine out of a possible fortynine samples with which they were compared.

The connection with the Southampton shells and the live oysters from the West Solent is of particular significance. The simple test used does not prove that the oysters from the archaeological sites were collected from the Newtown beds, but it is an exciting indication that this is so. In an analysis carried out in parallel with this one, the remaining Southampton archaeological samples have been shown in similar extensive comparisons with material from all over Wessex to be closely related in

their size characteristics only to modern oysters from the Sowley Ground in the West Solent. Additionally, oysters statistically indistinguishable in size from modern wild and relaid oysters in the Poole area can be detected in samples from archaeological excavations in Poole and Dorchester.

It seems probable on the present evidence that there are oysters with regional characteristics; and that the size characteristics, at least of wild oysters from any one locality, may remain constant - the matching characteristics being detectable in archaeological material.

A multivariate or discriminant analysis of all the recorded shell features, including age structure, growth rate and rate of infestation, is needed to verify this notion of constant regional characteristics. More samples of both old and modern shells must be examined. The anomalies must be clarified. For example, the similarity between some of the Paradise Street samples and those from Owslebury and Newtown may be more apparent than real. The Poole shells could have originated in the West Solent - the same population as that exploited for the Owslebury shells. However, it is equally possible that a natural population of oysters with similar characteristics existed or exists nearer to Poole for which no sample has been obtained.

The small size of the Owslebury oyster shells compared with other samples is not due to their young age because a wide range of ages is found in all samples. Neither is the growth rate particularly slow. No importance can be attached to the lack of encrusting organisms or to the relative proportions of the various types because it seems likely that the encrustations may have been removed by a combination of the adverse disposal and burial conditions and , possibly, by post-excavation washing proceedures. The other infestation evidence supports the logical view that the oysters came from the south coast, and that the oyster bed was in open water on a hard substrate.

ACKNOWLEDGEMENTS

The author would like to acknowledge with sincere thanks Dave Cooling for help provided with statistics and computing; David Davies of Sea Harvest, Poole for making samples of live oysters available for examination; Dorset Institute of Higher Education for use of computing facilities; and Lawrence Hawkins of the Oceanography Department at Southampton University for allowing access to live specimens of oysters from the Solent.