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Observations on the localised settlement of Ostrea edulis on differently prepared grounds

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Introduction

It is an accepted principle of oyster culture that clean hard surfaces should be provided for the attachment of the oyster spat during the breeding season. Where high density settlement can be anticipated it can be economically worthwhile to set out artificial collectors, but in England it is customary to lay clean shell (cultch) for spat collection in some areas, or to harrow the grounds with the object of turning up clean surfaces.

Early trial experiments in the River Crouch had indicated that harrowing was of doubtful value. The object of experiments conducted in the River Fal during 1961 and 1962, of which this is a preliminary account, was to determine whether an area of ground would be capable of catching substantially greater numbers of spat if suitably cultched with clean mussel shell and whether harrowing would also result in increased spatfall.

It was intended that in 1962 a second laying of mussel shell would be made in order to discover whether clean shell would catch substantially greater quantities of spat than the shell which had been laid for one year. However mussel shell was unobtainable in 1962 and the second part of the experiment was modified. Old shell, complete with epifauna and flora was dredged and relaid within 24 hours on the experimental plot in order to see whether this too would give a substantial increase in spat yield.

The whole experiment was conducted on the River Fal in Cornwall, mainly because spatfall in that river, though variable in intensity, is seldom a complete failure and because the fishery, being a semi-public one, has large areas of bottom which are not cultivated in the normally accepted sense.

The site chosen was 4.04 hectares of fairly uniform bottom on Parsons Bank, north of Carrik Carlys Rocks. Depth of water over the bank at extreme low water was approximately 1½ M.

Preliminary dredge surveys had shown that there were small numbers of oysters on the bank and moderate quantities of shell overlying a substrate of sandy mud with the proportion of mud decreasing from west to east across the plot. There was also a correspondingly slight increase of shell material towards the east.

Method

The ground was marked out with buoys and sinkers as a rectangle of 183 M x 219 M and then subdivided for ease in harrowing and laying shell into six strips each 36.5 M x 183 M running north and south, approximately parallel with the direction of tidal flow. For convenience in surveying, these strips were divided in half giving a northern section, A and southern one, B. Fig. 1.

Spatfall was anticipated in late June 1961 and the ground having been marked out, two strips (1 and 4) were laid with excess clean boiled mussel shell at a density equivalent to 70 tons per hectare. Two more (2 and 5) were harrowed intensively for a week with a heavy agricultural harrow and the remaining two (3 and 6) were allowed to remain fallow. Approximately 2,000 young oysters dredged from elsewhere on the fishery were laid on each strip to add to the natural population on the area.

After the experiment had been set up the ground was left undisturbed until September when bottom samples were collected and examined for spat.

Ten samples of $\frac{1}{2}$ M^2 were taken from each half of each strip using a Baird Grab (Baird 1958). All shell material lying exposed on the surface of the bottom was collected for examination but any blackened or obviously buried shells which would have been incapable of collecting spat were discarded.

The numbers and types of shell in each sample were recorded as were the numbers of spat on them and brief notes were made on the epiphytic population on the shells. In addition the presence of other molluscs in the grab samples was noted.

In 1962, old shell from another part of the fishery was dredged and relaid on two half strips, B2 and A6, until a density equivalent to 30 tons per hectare had been achieved.

On this occasion none of the grounds was harrowed but additional quantities of native oysters were laid at the rate of 6,000 per strip.

In September 1962, $\frac{1}{2}$ M^2 grab samples were again collected and shells examined for spat as before. In this case at least 15 samples were collected from each section.

The area of shell available for settlement was determined approximately by measuring, in plan view, the areas of random collections of the shell types encountered. The distribution of epiphytes on them showed that some shells were lying in such a position that sedentary organisms could attach to both sides whilst others, partly buried, were capable of catching spat on only one side or part of one side. For the purpose of obtaining an estimate of the relative areas of shell available for spat attachment it was assumed that all shells bearing epiphytes were capable of catching spat on one side only and that the surface area corresponded to the plan area.

Results

The 1961 experiment

The spatfall per M^2 of bottom on the six strips, which is shown graphically in Fig. 2A, proved difficult to interpret at first because of the variable distribution of spatfall over the plot.

However the differences observed in spatfall per unit area on similarly treated strips were due to a basic decrease in spatfall across the width of the plot from east to west. This is shown in Fig. 2B where the spat occurring on the introduced mussel shell has been excluded from the data. That the difference is probably characteristic of the area is shown in Fig. 2C which illustrates a similar gradation in the numbers of old oyster shells from east to west. In the 1962 grab samples this observation was repeated (Table 1)

TABLE 1

Mean numbers of old oyster shells per M^2 observed in grab samples during the 1961 and 1962 surveys

			1961			
Strip No.	1	2	3	4	5	6
Section A	3.2	7.4	8.6	12.2	15.6	18.6
Section B	10.6	7.4	9.0	12.2	14.0	24.0
			1962			
Section A	8.7	7.7	8.4	12.0	12.7	46.1
Section B	11.6	47.0	8.1	13.6	11.9	19.2

Note that in 1962, figures for A6 and B2 include the old oyster shells laid during the summer of 1962.

1961 Experiment

Number of treated strip on experimental plot	1 Mussel shell	2 Harrowed	3 Fallow	4 Mussel shell	5 Harrowed	6 Fallow
TYPE OF SHELL						
Ostrea edulis	6.9(0.7)	7.4(0.3)	8.8(5.4)	12.2(4.0)	14.8(9.3)	21.3(11.8)
Mytilus edulis	333.1(6.1)	0.6(0.1)	0.9(0.1)	200.5(50.5)	0.9(0.2)	1.3(1.3)
Chlamys varia	1.7(0.2)	3.0(0.2)	1.6(0.6)	4.0(5.6)	3.0(0.8)	2.4(0.3)
Venerupis pullastra	17.1(0.3)	6.2(0.1)	10.0(0.2)	23.6(0.9)	18.5(2.3)	16.4(1.5)
Venerupis aurea	37.3(0.1)	15.8(0.0)	12.0(0.0)	45.3(0.0)	32.7(0.1)	24.2(0.1)
Crepidula fornicata	5.4(0.0)	- -	- -	2.3(0.0)	- -	- -
Cardium edule	3.2(0.0)	0.2(0.0)	- -	4.1(0.0)	0.2(0.0)	0.1(0.0)
Other shells	- -	- -	- -	- (0.4)	- -	- -
Living O. edulis	0.8(0.1)	0.6(0.4)	1.0(4.2)	2.4(3.6)	1.5(6.4)	3.1(8.8)
Living M. edulis	- -	- -	- -	- -	0.1(0.0)	0.2(0.0)
Living C. varia	0.2(0.0)	- -	0.1(0.0)	0.9(0.9)	0.2(0.9)	0.5(0.6)
Total No. of Spat/M^2	7.5	1.1	10.5	65.9	20.0	24.4
No. of Spat on Dead Shells only	7.4	0.7	6.3	61.4	12.7	15.0

TABLE 2. Showing the mean numbers of shells of various types per M^2 on the differently treated strips. The mean number of oyster spat on each type of shell is shown in brackets.

1961 Experiment

Number of treated strip on experimental plot	1	2	3	4	5	6	Mean
TYPE OF SHELL							
Ostrea edulis	2.6(9.3)	49.3(27.3)	49.5(51.4)	6.6(6.1)	45.6(46.5)	53.7(48.4)	34.6(31.5)
Mytilus edulis	91.0(81.3)	2.9(9.1)	3.6(1.0)	79.5(77.1)	2.0(1.0)	2.4(5.3)	30.2(29.1)
Chlamys varia	0.6(2.7)	9.3(18.2)	8.3(5.7)	2.0(8.6)	8.5(4.0)	5.5(1.2)	5.7(6.7)
Venerupis pullastra	1.9(4.0)	12.5(9.1)	16.9(1.9)	3.9(1.4)	17.1(11.5)	12.4(6.1)	10.8(5.7)
Venerupis aurea	2.6(1.3)	19.5(0.0)	12.4(0.0)	4.5(0.0)	18.5(0.5)	11.2(0.4)	11.5(0.4)
Cardium edule	0.3(0.0)	0.3(0.0)	- -	0.5(0.0)	0.1(0.0)	0.6(0.0)	0.3(0.0)
Crepidula fornicata	0.5(0.0)	- -	- -	0.3(0.0)	- -	- -	0.1(0.0)
Live O. edulis	0.5(1.3)	6.1(36.3)	8.6(40.0)	2.0(5.5)	6.9(32.0)	11.8(36.1)	5.0(25.2)
Live M. edulis	- -	- -	- -	- -	0.4(0.0)	0.6(0.0)	0.2(0.0)
Live C. varia	0.1(0.0)	- -	0.7(0.0)	0.7(1.4)	0.9(4.5)	1.7(2.5)	0.7(1.4)

TABLE 4. Showing the percentage of the total available shell area available for settlement by each type of shell per M^2 of bottom and the percentage, in brackets, of the total spat, settling on each type.

1962 Experiment

Number of treated section	1		2		3		4		5		6	
	A	B	A	B	A	B	A	B	A	B	A	B
TYPE OF SHELL												
Ostrea edulis	8.7(3.9)	11.6(16.5)	7.7(10.8)	47.0(78.2)	8.4(9.5)	8.1(11.7)	12.0(17.9)	13.6(26.3)	12.7(14.5)	11.9(21.7)	46.1(63.8)	19.2(18.0)
Mytilus edulis	154.4(50.0)	227.6(100.9)	1.3(1.9)	4.7(4.6)	3.3(1.5)	0.3(0.3)	161.2(52.4)	200.3(142.1)	2.8(5.0)	4.4(8.7)	1.1(1.9)	0.7(0.6)
Chlamys varia	3.2(2.3)	3.3(5.9)	1.9(4.2)	11.2(26.2)	2.5(1.1)	1.3(3.6)	3.7(5.7)	2.9(3.6)	2.2(4.8)	1.7(2.3)	7.5(11.3)	3.3(3.1)
Venerupis pullastra	18.0(3.6)	19.9(1.5)	12.3(4.5)	32.6(12.0)	9.7(2.0)	19.5(2.9)	31.9(4.4)	41.2(16.1)	26.2(5.2)	18.5(6.0)	50.6(17.2)	23.8(5.5)
Venerupis aurea	67.5(1.5)	54.3(2.5)	56.6(3.3)	58.9(2.1)	34.7(0.7)	44.4(2.3)	88.4(1.3)	78.0(4.5)	42.2(1.1)	37.7(2.7)	84.5(3.6)	48.5(3.3)
Cardium edule	2.9(0.0)	7.7(0.0)	0.7(0.1)	0.3(0.0)	0.4(0.0)	0.3(0.0)	2.8(0.8)	2.7(1.3)	0.4(0.1)	0.3(0.0)	1.5(0.1)	0.1(0.1)
Crepidula fornicata	2.4(0.3)	1.7(0.3)	0.1(0.0)	– –	– –	– –	0.9(0.0)	0.9(0.0)	– –	– –	– –	– –
Other shells	(0.0)	(0.1)	(0.0)	(0.6)	(0.0)	(0.0)	(0.0)	(0.0)	(1.1)	(0.3)	(2.3)	(0.5)
Live O. edulis	1.3(7.3)	4.7(39.2)	2.2(22.6)	11.4(58.2)	1.2(7.5)	1.1(13.6)	2.0(13.3)	1.2(8.5)	3.2(26.7)	1.3(5.3)	7.4(32.7)	1.2(10.0)
Live M. edulis	– –	0.1(0.0)	– –	– –	0.7(0.0)	– –	0.5(0.0)	0.4(0.0)	0.6(0.0)	– –	– –	– –
Live C. varia	0.5(0.1)	1.1(1.3)	0.5(5.7)	1.7(7.9)	0.4(1.1)	0.3(4.1)	0.3(0.4)	1.2(2.7)	0.5(2.8)	0.4(0.8)	2.8(19.4)	0.3(0.3)
Total No. of spat per M^2	(68.1)	(168.2)	(53.1)	(189.8)	(23.4)	(38.5)	(96.1)	(205.1)	(61.3)	(47.8)	(152.3)	(41.4)
No. of spat per M^2 on shells only	(60.7)	(127.6)	(24.8)	(123.1)	(14.8)	(20.8)	(82.4)	(193.9)	(30.7)	(41.4)	(97.9)	(30.6)

TABLE 3. Showing mean numbers of shells per M^2 of each type on the treated sections and the mean numbers of spat on them.

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1962 Experiment

Number of treated section	1		2		3		4		5		6		MEANS
	A	B	A	B	A	B	A	B	A	B	A	B	
TYPE OF SHELL													
Ostrea edulis	6.0(5.6)	5.6(9.8)	26.9(20.3)	46.6(41.4)	21.8(40.8)	31.7(30.4)	7.3(18.6)	7.0(12.8)	32.9(24.1)	37.5(45.7)	46.2(42.5)	46.6(44.0)	26.3(28.0)
Mytilus edulis	77.1(72.6)	80.0(60.0)	3.3(3.6)	3.4(2.4)	10.9(6.3)	0.8(0.7)	71.8(54.4)	75.4(69.3)	5.3(8.3)	10.1(18.2)	0.8(1.3)	1.3(1.5)	28.5(24.9)
Chlamys varia	2.0(3.3)	1.5(3.5)	6.1(7.9)	10.2(13.8)	10.5(4.6)	4.7(9.3)	2.1(6.0)	1.4 (1.8)	5.3(8.0)	4.9(4.8)	6.9(7.5)	7.4(7.6)	5.3(6.5)
Venerupis pullastra	3.7(5.2)	2.9(0.9)	12.8(8.5)	9.7(6.3)	13.2(8.6)	22.7(7.6)	5.9(4.6)	6.4(7.9)	20.4(8.6)	17.5(12.6)	15.2(11.5)	17.4(13.4)	12.3(8.0)
Venerupis aurea	8.5(2.2)	4.3(1.5)	36.2(6.2)	10.7(1.1)	29.0(2.9)	31.8(5.9)	10.0(1.4)	7.4(2.2)	20.1(1.8)	21.8(5.6)	15.6(2.4)	21.6(8.1)	18.1(3.4)
Cardium edule	0.4(0.0)	0.3(0.0)	0.6(0.2)	0.1(0.0)	0.4(0.0)	0.3(0.0)	0.4(0.8)	0.3(0.6)	0.2(0.2)	0.3(0.0)	0.3(0.1)	0.1(0.2)	0.4(0.2)
Crepidula fornicata	0.4(0.2)	0.2(0.2)	0.1(0.0)	– –	– –	– –	0.1(0.0)	0.1(0.0)	– –	– –	– –	– –	0.08(0.03)
Live O. edulis	1.3(10.6)	3.4(23.3)	11.6(42.6)	16.9(30.8)	8.2(32.2)	6.4(35.3)	1.8(13.9)	0.9(4.2)	12.4(44.4)	6.2(11.2)	11.1(21.8)	4.4(24.4)	7.1(24.6)
Live M. edulis	– –	0.1(0.0)	– –	– –	3.4(0.0)	– –	0.3(0.0)	0.2(0.0)	1.6(0.0)	– –	– –	– –	0.5(0.0)
Live C. varia	0.5(0.1)	0.8(0.8)	2.4(10.7)	2.3(4.2)	2.5(4.6)	1.6(10.7)	0.2(0.4)	0.8(1.3)	1.8(4.7)	1.8(1.7)	3.9(12.9)	1.4(0.7)	1.8(4.3)

TABLE 5. Showing the percentage of the total available shell area afforded for settlement by each type of shell per M^2 and the percentage in brackets of the total spat settling on each type.

The decrease on the west, despite the presence of abundant mussel shell, indicated either that there were fewer larvae in suspension on that side or that tidal conditions, i.e., a shorter period of slack water, were less suitable for settlement.

If the different treatments are considered separately, it is seen that the spatfall per unit area on the mussel shell treated strips, 1 and 4, was significantly greater than on the adjacent harrowed strips 2 and 5 ($p > 0.01$ and > 0.001 respectively). Thus the addition of mussel shell had resulted in a much increased set per unit area. Harrowing, however, did not result in increased spatfall, in fact the settlement on the harrowed strip 2 was significantly less ($p > 0.001$) than on the adjacent fallow strip 3 and the settlement on the harrowed strip 5 was less than on the fallow strip 6, though the difference was not significant.

The 1962 experiment

The spatfall per M^2 of bottom cannot be illustrated in the same way as for 1961 because the northern and southern sections of strip 6 and strip 2 respectively were treated by adding old shell to them and this shell was (to all intents and purposes) indistinguishable from the shell already present on these two sections. Figs. 3A and B illustrate the observed density per M^2 of bottom on the northern and southern half of the plot.

In 1962 there was a generally heavier and more even spatfall all over the plot compared with 1961, though a slight tendency for decreased settlement from east to west remained.

The presence of the mussel shell on strips 1 and 4 still resulted in a substantially better catch of spat per unit area of bottom than the untouched grounds between. But, the old shell introduced on to A6 and B2 also resulted in a much increased settlement per unit area on these two sections.

Discussion

A direct comparison of the catching efficiency of year old and fresh laid mussel shell was not possible because fresh mussel shell was unobtainable in 1962. Instead it was intended to compare the catching efficiency of old cultch (laid in 1962) with that of one year laid mussel shell. In addition, however, it proved possible to compare the suitability of different types of shell for spat collection during the two year period. Tables 2 and 3 show the mean numbers of shells of each type per unit area and the mean numbers of spat per shell. Knowing the mean plan area of each type of shell it is possible to estimate the relative area of shell of any one type available on 1 M^2 of bottom and the percentage of the total spat settling in that area, which attached to the particular type of shell (Tables 4 and 5).

Using the above figures the numbers of spat which would have settled on 100 cm^2 of each type of shell was calculated. From this a percentage distribution of the spat in relation to shell type was obtained for 1961 and 1962 (Table 6).

TABLE 6

Calculated % distribution of spatfall that could have occurred if each type of shell had been of equal area.

TYPE OF SHELL	1961	1962
Ostrea edulis	9.7	10.1
Mytilus edulis	10.4	9.8
Chlamys varia	11.1	12.2
Venerupis pullastra	5.2	6.1
Venerupis aurea	0.2	1.6
Cardium edule	0.0	4.9
Crepidula fornicata	0.0	2.0
Live O. edulis	38.6	34.3
Live M. edulis	0.0	0.0
Live C. varia	24.8	19.0

On the basis of plan area there was very little difference between the relative catching efficiency of the shells of Ostrea edulis, Mytilus edulis and Chlamys varia and equally there was no difference between the catching efficiency of the shells of Mytilus edulis in 1961, when they were clean and in 1962 when they were dirty. The shells of Venerupis pullastra, which were common on the bottom, caught approximately half as many spat, area for area, as the three previously mentioned and Venerupis aurea shells, which were abundant, caught only between 1/5th and 1/10th of the spat caught by the other shells. The figures for the shells of Cardium edule and Crepidula fornicata cannot be considered as reliable because the numbers of shells were small and the chance settlement of spat on 1 or 2 of them weighted the result.

Living Ostrea edulis and Chlamys varia caught relatively very many more spat than their corresponding dead shells. It could be argued that in the case of Ostrea edulis, gregariousness was contributing to the increased rate of attachment but this could not apply to the shells of Chlamys varia. It is however, possible that the shell movements of the living animals had the effect of reducing the amount of silt on the shells, so keeping them more free for spat attachment.

Harrowing the grounds does not keep shells clean satisfactorily as silt still remains on, or resettles on, shells that have been overturned by harrows. Underwater observation has shown that any good which might result from harrowing can be lost in one tidal cycle if storm conditions cause a greater than normal amount of suspended silt in the water which then resettles on the shells. It is much more likely that the dredging and relaying of shells is of use because, once on the bottom, they lie at a variety of angles and so offer many overhanging surfaces, which cannot become silted, for spat attachment. If the bottom is harrowed the effect seems to be to level the shells and so reduce the variety of angles of exposure.

Observations such as those described here also make it possible to estimate the survival of the naturally attached spat during their first year of life. Most observations of survival after metamorphosis have been carried out under semi-artificial conditions, but in the present case it has been possible to estimate the actual survival under natural conditions. In Table 7 the numbers of spat per unit area which settled on each section in 1961 is shown together with the numbers per unit area which were still surviving 12 months later. A mean mortality of 87% is similar to that observed by Walne (1961) amongst oysters kept under tray conditions.

Summary

Observations on the River Fal, Cornwall, showed that spatfall over a limited area was variable, but that the variation was apparently a fairly constant feature. Settlement of oyster spat per unit area of bottom was not increased as a result of harrowing but the addition of shell cultch resulted in a substantially greater catch of spat. There was no apparent difference in the catching efficiency of oyster, mussel and Chlamys varia shell, or in the relative catching efficiency of fresh and 1 year old mussel shell.

It was also possible to obtain a figure for the natural mortality under natural conditions of newly metamorphored spat during their first year of life.

References

Baird, R. H. 1958. "A preliminary account of a new half sq. metre bottom sampler". Int. Coun. Explor. Mer. 1958, paper 4.

Walne, P. R. 1961. "Observations on the mortality of Ostrea edulis". Journ. Mar. Biol. Ass. U.K. 41, No. 1. p.p. 113-122.

Section No.	1961 spat/M^2 on cultch only	Surviving 1961 spat on cultch in 1962	% Mortality	Section No.	1961 spat/M^2 on cultch only	Surviving 1961 spat on cultch in 1962	% Mortality
A1	5.0	1.2	76%	B1	9.8	2.5	74%
A2	0.6	0.2	67%	B2	0.8	2.9	-
A3	9.2	0.3	97%	B3	3.4	0.0	100%
A4	74.2	3.6	95%	B4	48.6	4.3	91%
A5	15.4	3.5	77%	B5	10.0	0.7	93%
A6	13.8	3.4	-	B6	16.2	0.8	95%

TABLE 7. Showing the mean numbers of spat per M^2 which settled on shells only during 1961 and the survivors per M^2 in 1962 together with the calculated percentage mortality. The mean for the whole area was 87%. Spatfall on A6 and B2 is ignored because some 1961 spat may have been introduced with the cultch relaid in 1962.

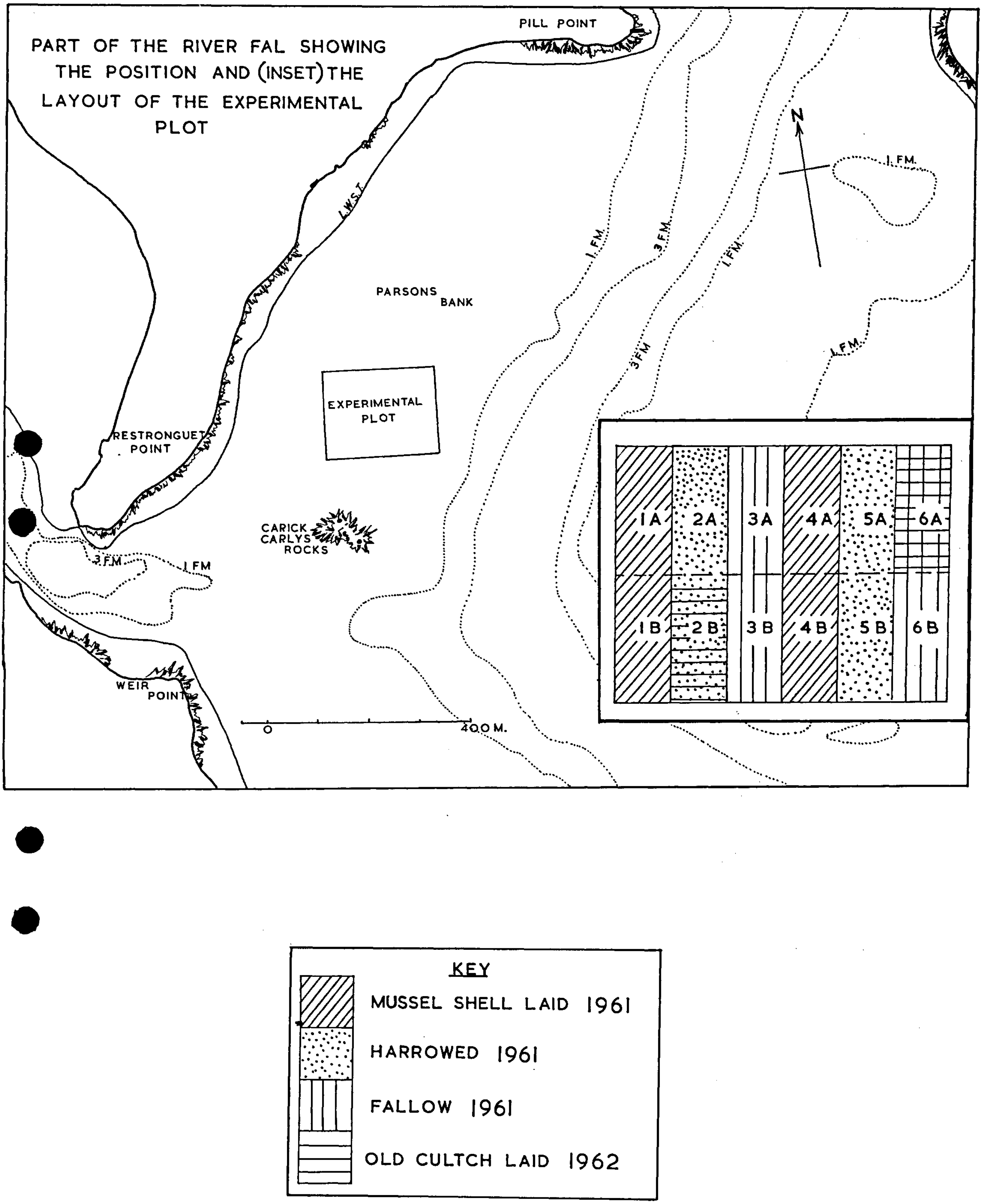

FIGURE 1.

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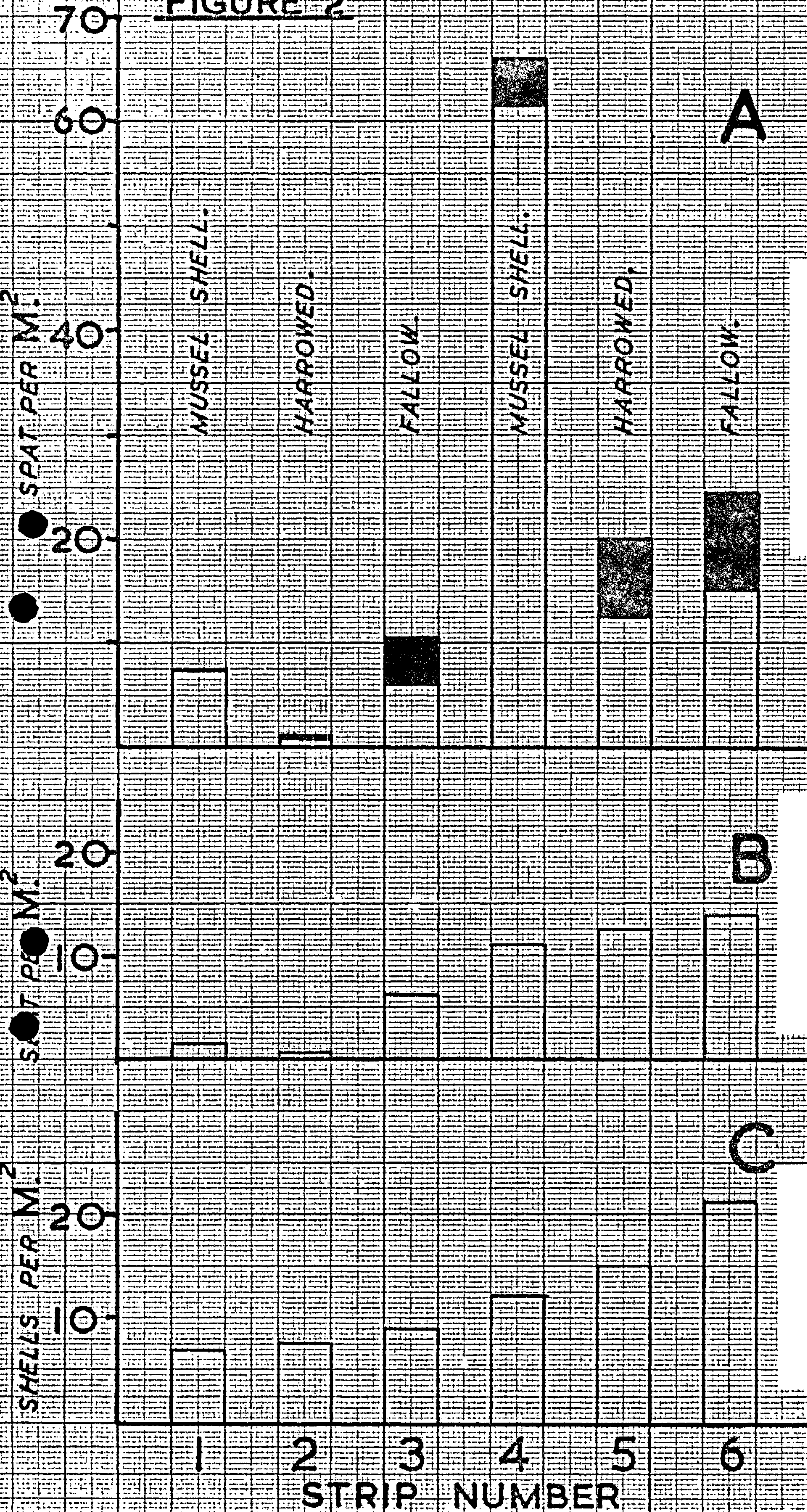
FIGURE 2



A. Showing the mean numbers of oyster spat per M^2 settling on the treated strips and the mean numbers settling on live oysters only (black).

B. Showing the mean numbers of oyster spat per M^2 which settled on shells other than mussel shells.

C. Showing the mean numbers of old oyster shells per M^2 which occurred on the different strips.

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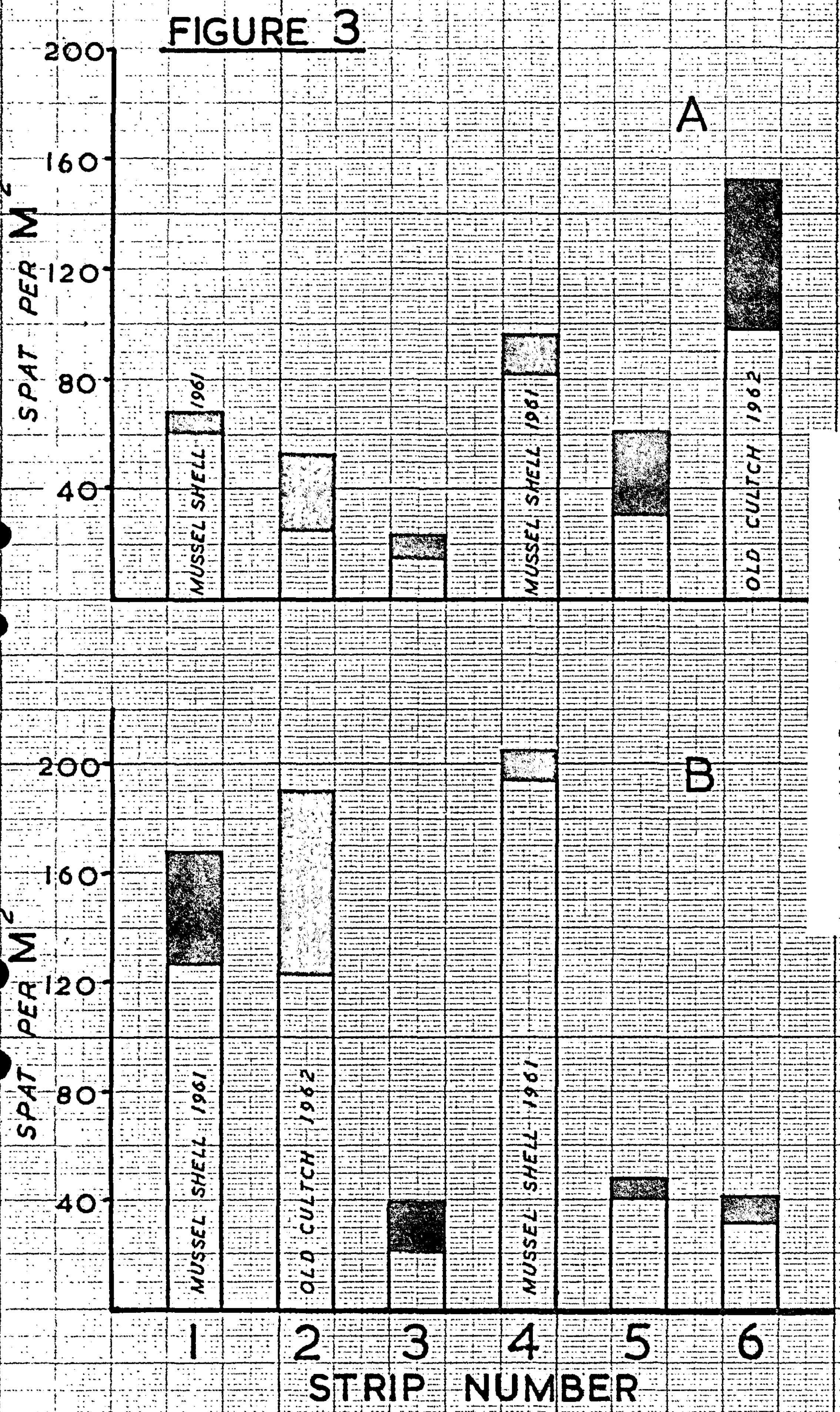

Showing the mean numbers of oyster spat per M^2 which settled on the Northern (A) and Southern (B) sections of the treated strips in 1962. The mean numbers settling per M^2 on live oysters only, are shown in black.

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