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SEA FISH INDUSTRY AUTHORITY
Marine Farming Unit, Ardtoe

CROWN ESTATE COMMISSIONERS
MUSSEL STOCKING DENSITY TRIALS

Sea Fish Report No. 386
Crown Estate Commissioners

J.T. MacMillan
October, 1990

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SUMMARY

During 1987, thirty spatted mussel collector ropes were used as a basis for a suspended culture trial to determine the effects of reduced stocking density on the production of market size mussels. Excess spat were retubed for ongrowing in "Pergolari" mesh and marketable yields from thinned and tubed stocks were compared with those from untouched ropes.

Growth of mussels in the various treatments was measured over a 20 month period to December 1989 during which time the average shell length increased from 22mm to 45mm.

Results clearly indicated that reducing stock density and retubing the thinnings caused a considerable increase in yields of market size mussels. The tremendous benefits in terms of increased production by retubing mussel spat is noted, especially with respect to availability of supply.

Application of these trial results will be most helpful to growers in maximising the harvest from mussel cultivation.

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1. INTRODUCTION

Suspended culture of the mussel (Mytilus edulis L.) relies upon proven techniques for the collection of natural spat which can be ongrown using various methods. The density at which the mussels are held is an important factor in achieving optimum growth rates and hence maximum production.

Typically, spat are collected by suspending ropes of a coarse, fibrous nature in the water column at sites where good natural spatfall can be expected. The ropes have wooden or plastic pegs placed through them at regular intervals in order to prevent the mussels sliding off as they grow. The pegs also serve to increase the surface area available for spat settlement. The young mussels are often thinned in order to prevent stunting of growth due to overcrowding. The excess stock removed from the collector ropes is utilised by placing it in mesh tubing, of various descriptions but collectively known as "Pergolari", which is suspended in the water column in the same manner as the ropes.

Amongst mussel growers, there currently exists some confusion regarding the optimum stocking density for ongrowing ropes and also the most productive use of collected spat. Both the efficiency and methods of thinning spatted ropes, together with the density at which the mussels should be retubed to achieve maximum yields, have not been fully investigated and the lack of this knowledge may have led to inefficient working practices in the past.

The work described in this report was intended to determine the effects of thinning mussel ropes and retubing excess stock, on the overall yields of marketable size mussels obtained.

2. MATERIALS AND METHODS

The suspended cultivation of the stock was carried out in the North Channel of Loch Moidart using an 8 tonne mussel raft typical of those developed in the Western Isles. Spatted ropes were obtained from Loch Etive during October 1987 and transported by road to Ardtoe, before being transferred to Loch Moidart. A total of 30 ropes was set out with minimal spat loss and mortalities. The stock was left undisturbed on the mussel raft for 5 months prior to the start of the thinning and retubing trials in the spring of 1988.

The spatted ropes consisted of 4m lengths of 12mm diameter polypropylene rope with wooden pegs of 0.2m length inserted through them at 0.5m intervals, which resulting in a total of 7 pegs per rope. These were used to compare three different treatments with respect to the density and growth of the mussels:

(i) Untouched - stock left intact

(ii) Peg stripped - the mussels covering the wooden pegs were completely removed while the main rope was left untouched.

(iii) Thinned - mussels were removed evenly from the entire length of the rope including the pegs.

The initial quantity of mussels on each rope was reduced by approximately one quarter for the peg stripped treatment and by two thirds for the evenly thinned treatment. The strippings from the two treatments were placed in 4m lengths of Pergolari tubing at a stocking density of 1.9kg m^{-1}. This allowed assessment of a fourth, additional cultivaton method:-

(iv) Pergolari tubing.

The trial was undertaken using 10 spatted ropes for the untouched and thinned treatments and 5 for the peg stripped treatment with each rope randomly positioned on the mussel raft to prevent any bias. The growth of the mussels was monitored on a regular basis by measuring the shell lengths of at least 50 individuals sampled from each treatment. At the end of the trial, all of the stock was harvested and samples of at least 100 individuals from each of the cultivation methods were obtained. These mussels were measured for length and wet meat weight. The total weight of mussels harvested from each treatment was determined together with that from the retubed stock. The mussels were then graded using a commercial machine into 3 size categories based on shell length, >50mm, 50-30mm and <30mm with those of >50mm considered to be marketable stock.

3. RESULTS

The growth of the mussels throughout the trial for the 3 different rope treatments is shown in Figure 1. There was found to be little difference between the treatments in terms of growth in shell length throughout the 20 month period, and by the end of the trial the average length of mussels varied by no more than 2mm between any of the treatments.

The final mean yields of mussels per spatted rope, for each treatment and cultivation method, are presented in Table 1. The results are based on the total harvested stock of 25 ropes and the mussels grown in Pergolari mesh. As would be expected, the yields from the ropes only were found to be greatest for the untouched stock followed by the peg stripped and thinned treatments in decreasing order. Much more importantly, however, the retubed thinnings from the peg stripped and thinned treatments produced considerable yields of mussels which equalled (peg stripped) or exceeded (thinned) those of the respective ropes. Consequently the total yields of mussels from the peg stripped and thinned treatments for both cultivation methods were considerably greater than for the untouched ropes.

Table 2 shows the percentage of mussels from the total harvested stock for each treatment within each of the 3 graded size groups. Both the peg stripped rope and Pergolari tubing cultivated stock showed the highest, and similar, yields of marketable size mussels (>50mm length) with the untouched rope stock showing a slightly lower percentage. The lowest percentage yield of marketable size mussels was found for the thinned rope cultivation method. The highest percentage yield of the smallest size group (<30mm) of mussels was found for the untouched and thinned rope cultivation methods with <10% of the total yield for the other two methods within the <30mm range.

Data obtained at the end of the trial allowed comparisons of the relationship between the shell length and meat weight of mussels produced for each of the cultivation methods. There were found to be no appreciable differences between any of the cultivation methods with respect to the average meat yields for mussels of comparable lengths, with the average wet meat weight for a 50mm individual found to be 4.1g (Figure 2).

The total marketable yields of mussels of >50mm length per spatted collector rope are presented in Table 3 for each treatment. The marketable yields of mussels from both the peg stripped and thinned treatments were found to be considerably greater than those from the untouched spatted ropes. The peg stripped treatment showed the highest overall yield, being almost double that for the untouched stock.

4. DISCUSSION

Regardless of the treatment used, the overall growth rates of the mussels were found to be similar, there being no appreciable differences between cultivation methods with respect to meat yields of comparable size individuals. Consequently, it appears that the density of mussels on the collector ropes, combined with the cultivation conditions, did not prevent good growth in terms of length and weight for any of the treatments. However, the

percentage of small mussels of <30mm for the untouched rope at the end of the trial was found to be higher than for any of the other treatments. This indicates that in comparison with other treatments, growth was restricted for a higher proportion of the mussels in the untouched treatment, indicating that they were possibly too densely stocked. It should also be noted that the thinned rope treatment also produced a high percentage of <30mm mussels. Although the exact reason for this is not known, the possibility exists that the considerably reduced density of mussels on the thinned rope at the start of the trial allowed a higher level of fouling by other marine organisms which subsequently restricted the mussels' growth.

The difference between the treatments with respect to the total marketable yields was considerable. Both peg stripped and thinned treatments produced higher marketable yields than the untouched ropes, which indicates that these forms of stock management are extremely beneficial. The highest yield per spatted rope was achieved by stripping the pegs and retubing the thinnings. The removal of mussels from the pegs allows individuals from the rope to migrate to the cleared areas thereby causing an overall lowering of the stocking density. In terms of time and effort, removal of mussels from pegs is a simple and relatively quick task compared to selectively and evenly thinning the complete rope, and consequently is considered to be a far more cost effective method to use.

It can be seen from the results that in comparison with untouched ropes, reduced stocking density on spatted ropes did not in itself produce a higher marketable yield of mussels per rope. The average marketable yields per spatted rope for untouched and peg stripped ropes were found to be 10.7 and 10.2 kg respectively. Therefore the use of the stock thinned from the ropes is the important factor which can considerably increase the total marketable yields. The retubing of mussels is by far the most time consuming part of the operation but the investment of time and effort in retubing can effectively double the marketable

yield of mussels from each spatted collector rope.

The results also show that retubing of stock can be an extremely efficient use of mussel spat in relation to final yields. With respect to the peg stripped treatment, removal and retubing of approximately one quarter of the total spat from the collector rope gave a marketable yield which was similar to that from the remainder of the spat which were left on the rope. Consequently, maximum production would appear to be able to be obtained if collector ropes are completely stripped of spat which could then be retubed for ongrowing. This would involve a far higher input of time and effort and also an increase in costs in terms of Pergolari mesh and retubing equipment. However, because of the massively increased yields that could be obtained, the additional effort is likely to be fully justified. Based on these findings it is also pertinent to note that if spat are in short supply, maximum yields of marketable size mussels are likely to be obtained if the stock is ongrown in Pergolari mesh.

5. ESTIMATED PRODUCTION COSTS FOR ONGROWING METHODS

Combining the results obtained during the present study with known production costs, such as materials and labour, allows the benefits of the stock management techniques to be more fully assessed. However, it needs to be recognised that the following estimates are based on the results of one series of trials undertaken at one site. While comparisons between techniques can be made together with broad generalisations regarding the likely benefits, the actual production from any particular site will be affected by biological and environmental factors. This must be recognised when considering the projections of production costs for the following three methods of ongrowing spat:

(i) Untouched spatted rope
(ii) Peg stripped spatted rope and excess stock retubed
(iii) Completely stripped spatted rope with stock retubed.

The projections exclude costs for the installation and maintenance of flotation systems i.e. longlines or rafts, and also harvesting costs. It is also assumed that all work is undertaken on site with no additional transport costs. Equipment costs in terms of a workbench/hopper for manual retubing of spat have also been omitted as such items are usually "home made" and inexpensive. Consequently the estimates of costs kg^{-1} of marketable mussels are presented for comparison purposes only.

The assumptions upon which the estimates are based are as follows:

The basic production unit is taken as a spatted collector rope, being 12mm polypropylene length 5m, of which 4m is in the water and fitted with a 200 x 15 x 15mm wooden peg every 0.5m (7 in total).

The time requirement for removing a collector rope, stripping the pegs and replacing it in the water is estimated as 4 minutes. The complete stripping of a rope is estimated to take 5 minutes.

Retubing of spat into Pergolari mesh at a stocking density of 1.9kg m^{-1} is estimated to take 2 min m^{-1}, which includes returning the dropper to the water.

Calculations are based on each metre of collector rope surface having 2kg of spat attached and the spat average shell length being 25mm.

The calculations used to estimate relative production costs and marketable yields of mussels per collector rope for each of the cultivation methods is as follows:

(i) Untouched spatted rope

	Material Cost(£)	Labour Time(Min)	Marketable Yield (kg)
5m of rope @ £0.12 m^{-1}	0.60		
7 pegs @ £0.02 each	0.14	2	10.7
TOTALS	0.74	2	10.7

(ii) Peg stripped spatted rope and excess stock retubed

Collector rope	0.74	2	
Peg stripping (Yield 2.8kg of spat)		4	10.2
Retubing - 1.5m of Pergolari @ £0.03 m^{-1}	0.045	3	10.7
TOTALS	0.785	9	20.9

(iii) Completely stripped spatted rope with stock retubed

Collector rope	0.74	2	
Complete strip (Yield 10.8kg of spat)		5	
Retubing - 5.7m of Pergolari @ £0.03 m^{-1}	0.17	11.4	41.3
TOTALS	0.91	18.4	41.3

Comparisons between the cultivation methods in terms of capital and time invested in relation to the marketable yield of mussels are shown in Table 4. The economic cost kg^{-1} of production is based on the capital and time invested, with the operatives' time costed at £2.50 h^{-1}.

It can be seen from Table 4 that the lowest cost of production kg^{-1} of marketable mussels (£0.04) is likely to be achieved when spatted ropes are completely stripped and the stock retubed in Pergolari mesh. While both the material and labour costs are

higher compared to those for the other methods, the increase in production far outweighs the higher investment of resources. In comparison to the method of leaving spatted ropes untouched, peg stripping also results in a lowering of the total production costs kg^{-1} of marketable mussels for exactly the same reasons. Consequently peg stripping is likely to considerably increase the production of marketable size mussels and result in comparatively lower production costs. Complete stripping of ropes is likely to further increase production with an additional lowering of unit costs.

6. CONCLUSIONS

i) Stock management in terms of selective thinning of spatted mussel collector ropes and the retubing in Pergolari mesh of the excess stock can considerably increase yields of market size mussels.

ii) The highest yield of market size mussels per spatted collector rope was achieved by peg stripping and retubing the excess stock.

iii) Reduction of the stocking density of spatted ropes did not in itself produce a greater marketable yield of mussels per rope. The retubing of the excess stock was responsible for the increase.

iv) The retubing of mussels in Pergolari mesh involves additional investment in both materials and labour. However, overall production costs have been shown to be able to be minimised, and production maximised by the use of such techniques.

Table 1. Mean yields of mussels per spatted rope for each treatment and cultivation method at the end of the trial.

Treatment	Mean Yield/Spatted Rope (Kg)		
	Rope	Pergolari	Total
Untouched	19.1	-	19.1
Peg stripped	16.5	16.8	33.3
Thinned	13.5	16.6	30.1

Table 2. Percentage of the total yields falling within each of the 3 graded size groups for each cultivation method.

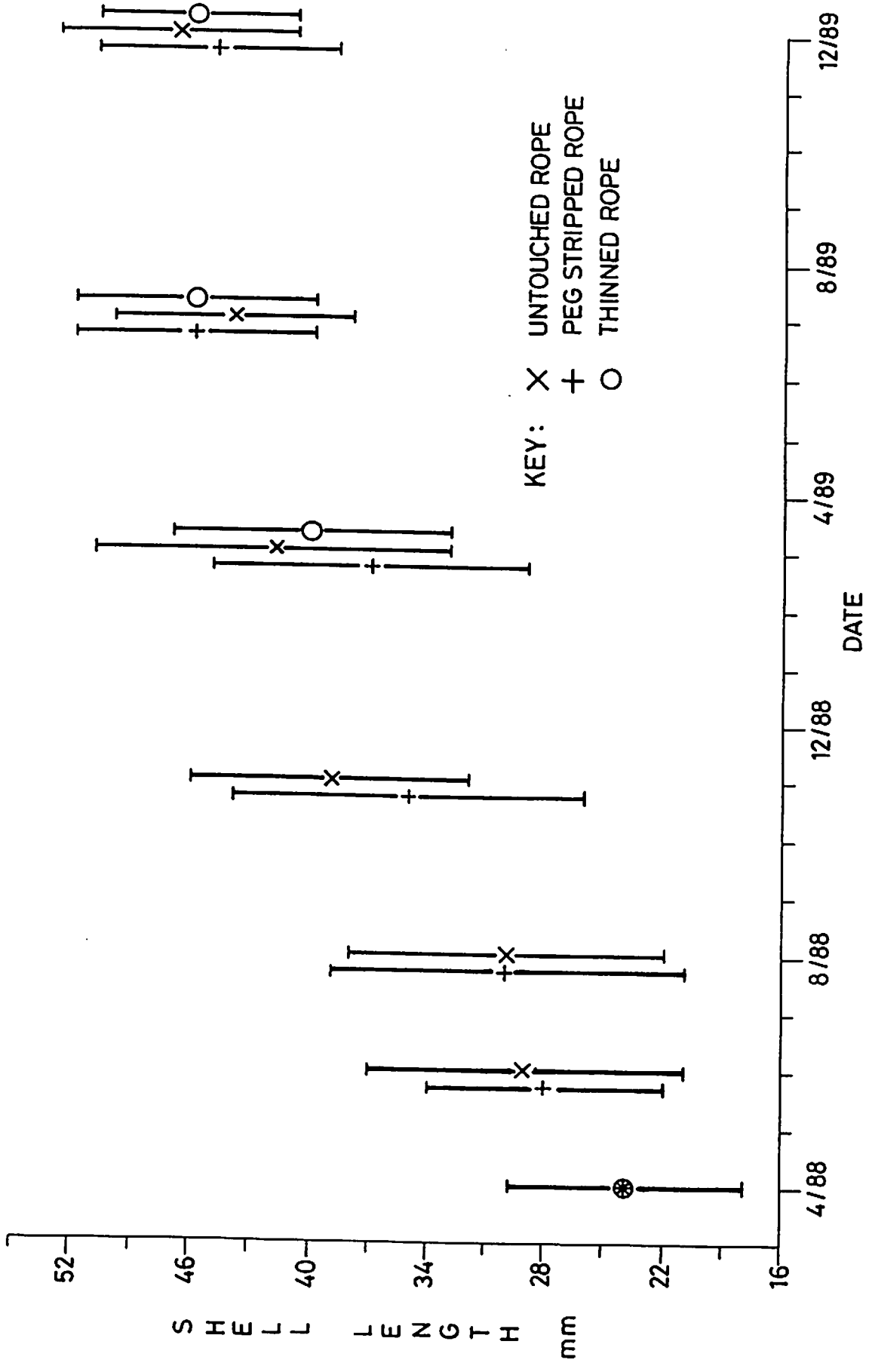
Cultivation Method	Percentage of Total Yield		
	> 50mm	50-30mm	< 30mm
Untouched rope	56	21	23
Peg stripped rope	62	29	9
Thinned rope	47	34	19
Pergolari tubing	64	27	9

Table 3. Total marketable yields of mussels per spatted collector rope for each treatment.

Treatment	Cultivation Method	Per Spatted rope			
		Total Yield(kg)	% Marketable	Marketable Yield (kg)	Total Marketable Yield(kg)
Untouched	Rope	19.1	56	10.7	10.7
Peg strip	Rope	16.5	62	10.2	21.0
	Pergolari I	16.8	64	10.8	
Thinned	Rope	13.5	47	6.3	16.9
	Pergolari I	16.6	64	10.6	

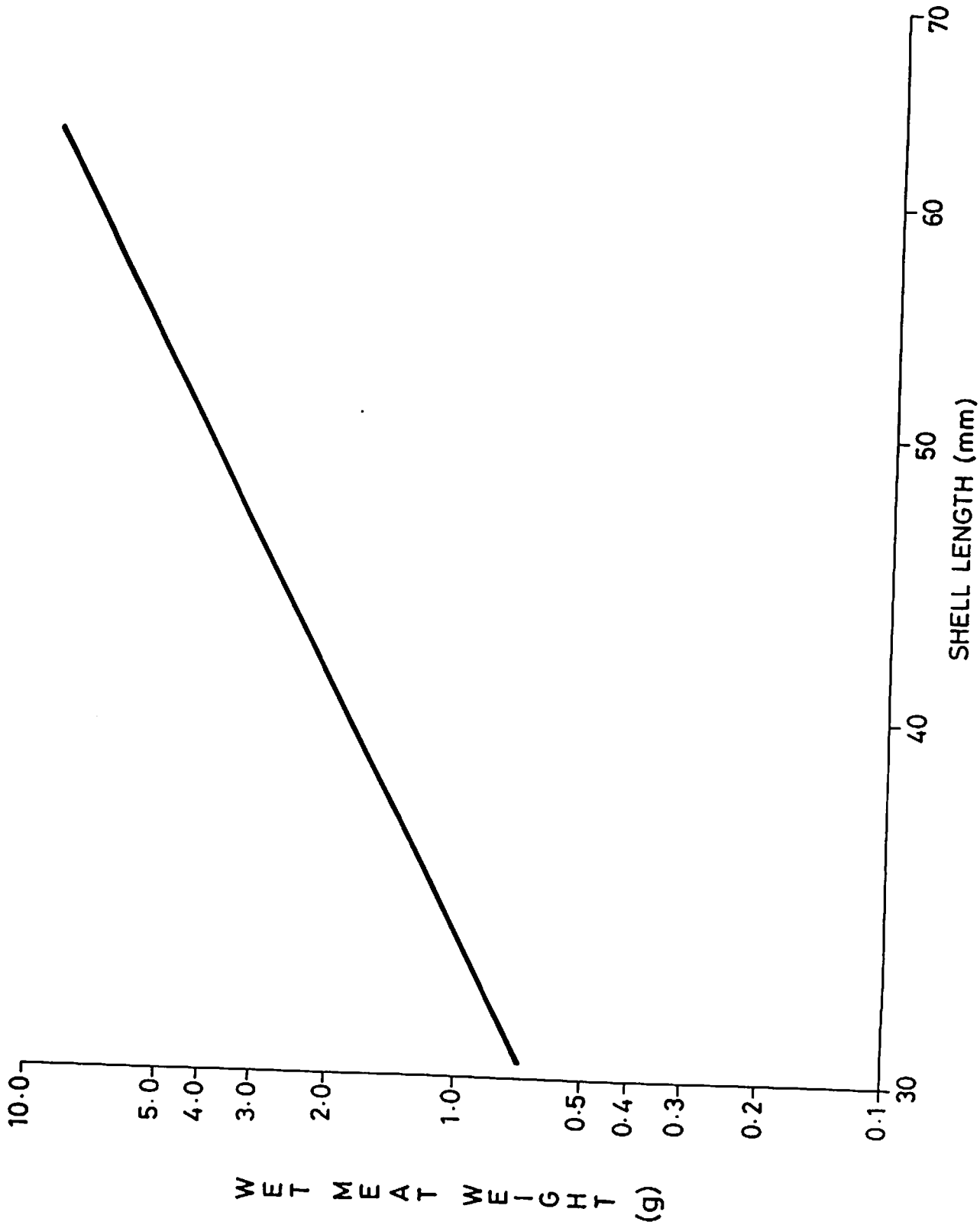
Table 4. Estimated costs and marketable yields of mussels for each cultivation method based on 100 collector ropes, together with the total cost per kg of production (1h = £2.50).

Cultivation method	Material costs (£)	Labour costs (min)	Marketable yield (kg)	Cost per kg		Total (£)
				Capital (£)	Time (min)	
Untouched rope	74.00	200	1070	0.07	0.19	0.08
Peg stripped rope	78.50	900	2090	0.04	0.43	0.06
Completely stripped rope	91.00	1840	4130	0.02	0.45	0.04



Mean (± ISD) Size of Mussel for Each Treatment at the Start and Throughout the Trial.

Fig.1



General Relationship Between Shell Length and Wet Meat Weight Based on Combined Data for All Cultivation Methods.

Fig.2