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DEVELOPMENT OF A COLONY OF GREEN MUSSELS, *PERNA CANALICULUS* IN COROMANDEL HARBOUR, 1971-72

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C O N T E N T S

DEVELOPMENT OF A COLONY OF GREEN MUSSELS, PERNA CANALICULUS, IN COROMANDEL HARBOUR, 1971-72

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SUMMARY

Settlement, growth and condition of green mussels are followed on a raft moored in Coromandel Harbour during 1971-72. There are indications that previous estimates of average growth in the 0+ year class may be excessive. Possible movements amongst young mussels and their re-settlement are observed and these may cause difficulties in cultivation. Comments are made on optimum size in relation to meat yields and time to harvest.

INTRODUCTION

Following the results obtained from a small raft moored in Te Kouma Harbour during 1967-69 (Greenway 1969a), a larger raft was constructed during 1969 and 1970 and was moored in the Waitemata Harbour, first at Islington Bay and later off Stanley Point, for about one year at each place (Figure 1). Satisfactory natural settlements were not obtained despite there being adult mussels on adjacent wharf piles at both places. Experimental transplants of young stock ($<$5.0 cm) were therefore taken from the west coast (Muriwai) and Crusoe Rock (Hauraki Gulf) and suspended from the raft for growth rate experiments. There was no significant difference in the growth rates of the two mussel stocks. After six months however, these experiments had to be terminated due to the loss of mussels caused by rope entanglement brought about by the swift currents off Stanley Point. Harbour debris also added to the fouling of the ropes, and the experiment was discontinued and the raft moved to Coromandel Harbour, north of Te Kouma, late in 1970. In the past this area was known for prolific stocks of outsize ($>$15.0 cm) green mussels dredged from the muddy seafloor. The whole Coromandel area has been seriously depleted of bottom mussel stocks through dredging (Greenway 1969b). Supplies to the Auckland market now come from dredged cultivated sources in Marlborough. However, new settlements have been observed to attach readily on boat moorings during recent years in the harbour (Fisheries Inspectors pers. comm.). By use of the raft it was hoped to obtain more accurate information on growth, condition and times of settlement through more regular and frequent visits than had been achieved in the previous experiment at Te Kouma. The results are described in this report.

METHODS

Structure of the Raft

The raft measured 7.62 x 4.11 m and conformed with marine farming regulations. The floats were three 61 cm diameter spirally welded steel pipes coated with black plasticised paint. Above these 9 cm thick decking was fixed and supported on angle iron cross members leaving about 1 m freeboard. Spaces 30 cm wide were left between the decking for hanging ropes and experimental equipment. The raft was moored some 400 m off Pa Point on the south side of Coromandel Harbour in 5.5 m of water at extreme low water spring tide, (Fig. 1) on 8 December 1970. It remained in that position until blown ashore in a strong north-westerly gale on 11 January 1973.

Spatfall and Settlement

(a) Monitoring frames

Ten coir strings 10 cm long having an average thickness of 0.5 cm were threaded on to one decimetre square tanalised wooden frames. Two sets, each containing three frames, were placed one at either end of the raft. Each set had one frame just below the water surface, one at mid-water level and the other just off the bottom. They were suspended by light braided nylon line and attached with swivel snap hooks and eyes to facilitate replacement. The bottom was weighted to keep the line vertical.

(b) Synthetic Ropes

Pairs of clean polypropylene ropes were also hung in the water once a month and inspected the following month for settlement. Two polypropylene ropes were also taped to 2.5 cm diameter hollow plastic tubing sealed at the ends so that it floated horizontally close to the surface. There had been indications from the past Te Kouma experiment (Greenway 1969a) that the first major settlement during spring occurred close to the surface. If this were so then these horizontally placed ropes would be expected to receive a well distributed catch along their entire length. They could then be removed from the plastic tubes and hung vertically from the raft in the normal way.

(c) Large Frames of Coir and Sisal String

During 1972 two tanalised wooden frames measuring 2 x 1 m were hung just below the surface. Each frame held windings of sisal and coir string in equal proportions for spat collection. After catching spat it was proposed to bind these strings directly on to larger ropes for growing on in a similar manner to that already tried, with some success, by Victoria University in the Marlborough Sounds.

Growth and Development

The first visit to the raft was not made until 5 May 1971, five months after the initial mooring. By this time all the floats had an excellent covering of mussels. These ranged from 0.5 cm to 5.5. cm with a mean length of 2.2 cm. On account of their small size it was presumed these mussels had probably settled shortly after the raft was moored, during the previous December-January. The few larger mussels ($>$4.0 cm) were thought to be fast growers, able to increase very rapidly in size with little competition for space.

From May 1971 onwards growth and development was followed by taking large samples from these established mussels. Subsequent visits were timed, as far as was practical, at monthly intervals, June 1972 being missed due to toheroa survey commitments. Each sample was collected randomly from the undersides of the floats by removing scattered clumps of mussels. Visual judgement was used to try and keep total numbers between samples roughly equal. The samples were measured for total length to the nearest 0.5 cm below on a board similar to that used for measuring other bivalves, notably toheroa, described by Cassie (1955).

Condition

The condition of "fatness" of the mussels relative to the volume of their shell cavity was measured by the wet displacement method (Baird 1958). The twenty largest mussels were taken for processing from the samples measured for growth above.

Index of condition was defined as:

$$I.C. = \frac{\text{Meat volume (ml)}}{\text{Shell cavity volume (ml)}} \times 100$$

During 1972 the meats were also dried at 85°C as a check on the wet method when:

$$I.C. = \frac{\text{Dry weight of meat (g } 85^{\circ}\text{C)}}{\text{Shell cavity volume (ml)}} \times 100$$

Small mussels (<7.5 cm) were processed in four groups of five each so as to obtain satisfactory displacements. From February 1972 onwards when the mussels were larger they were displaced individually.

RESULTS

Spatfall and Settlement

(a) Monitoring Frames

Figure 2 shows the results of spat settlement as an average number of mussel spat per 10 cm coir string.

Two peak periods of settlement were recorded, the first in September and the second in January. The September settlement was heaviest near the surface where more than 20 spat per string were recorded. The midwater and bottom set strings yielded less than 5 spat each. The January settlement was heavier and showed no marked difference in density between collecting levels. However, the length frequency distribution was distinctly bimodal indicating more than one settlement. The smallest spat noted were about 0.3 mm but positive identification of species at this stage was difficult. At about 1.0 mm the valves begin to show distinct red-tinged zig zag striations. Most samples contained at least a few of this size. Samples were measured for total length to the nearest 0.1 mm below. Mean lengths for the larger samples are shown in brackets on figure 2.

(b) Synthetic Ropes

(i) Vertical

Only a light patchy settlement was obtained on the vertical ropes. Small mussels were first observed in October 1971 but these were not confined to the most recently placed ropes. They were approximately 0.5 cm in length and were scattered from near surface to the bottom.

(ii) Horizontal

In November 1971 some settlement was observed on the ropes attached to flotation tubes. Some of these mussels were up to 1.0 cm in length and were clustered both on the rope and on the flotation tube. Large numbers were found hidden in the crevice formed between the rope and tube. It is likely they were present there during the previous month but had been missed through cursory examination.

(c) Large frames of coir and sisal string

A light settlement was first observed on these strings in November 1972 and was seen to be mainly concentrated towards the wooden frames. There was less settlement on the sisal than on the coir strings. Random samples of mussels were taken for measurement from the coir string and its surrounding framework and the length frequencies are shown in figure 3. The distribution from the strings shows marked negative skew whilst that from the frame has marked positive skew.

Growth and Development

Figure 4 shows the percentage length frequencies of monthly samples taken from the raft floats. Figure 5 shows the average increase in shell length between the twenty largest mussels obtained from each of the above samples. The earliest possible date for settlement was 8 December 1970. Starting from this date, growth during the first year was 8.0-9.0 cm and in the second year 3.0 to 4.0 cm, making a total of 11.0-13.0 cm in 24 months.

Condition

Figure 6 shows the average condition index of mussels taken during the two years together with water temperature measured from 2 m below the surface. The dried weight condition index measured as a further check in 1972 is also shown. The curves of both indices are similar. The mean and variability of each sample of 20 mussels are plotted. Peak condition occurred during late winter and early spring after which it declined, probably as a result of spawning. During summer months when water temperature rose to about 20°C, the average condition became very poor falling below 50%.

Figure 7 illustrates relationships between total length of mussels, their cavity volume and the displacement of meat and shells. In order to avoid confusion, only the mean points are shown for mussels $<$ 8.0 cm in length.

DISCUSSION

Spatfall

The monitoring frames caught few spat during autumn and winter but there were significant settlements from August through to January with the greatest settlement in the surface water during September of both years. Observations on the settlement of *Mytilus edulis* in the United Kingdom describe settlement as almost invariably occurring initially at the upper edge of submerged panels, etc. Chipperfield (1953). The apparent preference for initial settlement to occur near to the surface has implications for spat collection since the surface area is limited when compared to the water column later available for growing on. It was also noticed that many small mussels on the sides of the raft floats moved upwards into the "swash" areas where they were only intermittently covered by water. Consequently, their development was retarded and during hot summer calms many died from heat and exposure.

Settlement directly on to hanging ropes was only partially successful. All the ropes were so lightly covered that they were lifted at the end of the season. Because the synthetic rope did not appear to be a good collecting surface on its own, large frames of coir and sisal collecting strings were set in spring of 1972 for spat collection, with the idea of binding the string on to the synthetic ropes after settlement and sufficient growth had been made. The horizontally floating ropes were quite thickly covered with mussels, so they were cut and weighted at one end to hang but still with the flotation tubes attached. To have removed the latter would have meant disturbing numbers of mussels which would probably have been lost. Unfortunately, the eventual yield from these could not be measured on account of the raft becoming beached on 11 January 1973.

Possible Resettlement and Movements

The second large spatfall which occurred in January had a distinctly bimodal length frequency distribution indicating the presence of two separate settlements. These may have arisen from successive spatfalls, the first exhibiting particularly rapid growth during a period when warm sea temperature prevailed. Alternatively, the second settlement of larger mussels might be accounted for by detachment from one position and re-attachment to another with current drift acting as a means of dispersal. Such behaviour has been demonstrated for Mytilus edulis in the United Kingdom, Bayne (1964). It has been noted that young green mussels 0.5 - 2.0 cm in length placed in dishes of seawater make considerable journeys by extending the 'foot' and drawing themselves along with and without byssus attachment. Something of this nature may have happened on the large wooden frames (figure 3). The length frequencies from strings and frames appear complementary, as though settlement first occurred on the string and then the mussels moved to the frames. Neither frequency fits normal nor when lumped together, Chi^2 in each case having a probability < 0.005 thus tending to make the hypothesis seem unlikely. However, since the frames were in the water over the whole spatting period 10 August 1972 to 11 January 1973 it is likely that several spatfalls are present. These, together with an obvious tendency towards aggregation may account for high Chi^2 values.

Suitability of Settlement Surfaces

From previous observations (Greenway 1969a) some settlement by mussels could be expected at Coromandel during December and January, the period when the raft was first moored there. Mussels readily attached their byssus to the clean black plasticised paint covering the floats. It has also been noted in the laboratory that they will attach to the formica sink bench, the bottoms of plastic buckets and even to the bare stainless steel of the sink itself. These are all very smooth clean surfaces, perhaps akin to that of algae, (especially Gigartina spp), to which spat become attached in profusion along the west coast. After samples were removed from the sides and bottom of the raft floats no fresh settlements of young mussels were noted on the cleared parts. Nor was there any real attempt by the densely aggregated and already attached larger mussels ($>$ 5.0 cm) to spread out into these areas which had become covered by a slimy film of algal and hydrozoan growths mixed with a deposit of mud. This presumably offered only an insecure 'foothold'.

Growth

Monitoring of spatfall using coir strings (figure 2) shows three very prominent modes, one at September 1971, another January 1972 and again at September 1972. The length frequency distributions of larger individuals which settled on the raft floats (figure 4) also show three prominent and corresponding modes at 1.0-1.5 cm which in each case occur two months later. The first at November 1971 (marked IIa in figure 4), a rather less well defined one March 1972 (marked IIb) and the third again at November 1972 (marked IIIa). In the first length frequency distribution of May 1971 (figure 4) there is definite positive skew and the range is very wide, 0.5 - 6.0 cm. The larger mussels would have to grow extremely fast to attain lengths in excess of 5.5 cm over a maximum period of five months, (the time the raft had been in the water). Possible movement in the early stages with later re-settlement has been mentioned above. Some of the larger mussels in the May 1971 sample could be representatives from some secondary settlement. However, by far the greater part of the length frequency distribution, with its mode at 1.5 - 2.0 cm is more likely to have arisen from a January spatfall. The first length frequency distribution has, therefore, been marked Ia plus b and its month by month progress can be followed along the right hand side of the graphs in figure 4. The last two length frequencies for November and December 1972 show a rather flattened middle prominence probably representing the fusion of modes IIa and IIb.

An average growth curve has been drawn in figure 5 for the 20 largest mussels in each monthly sample. The May 1971 mean is 4.1 cm and if the curve is interpolated backwards to an origin in the second week of December 1970, (the time when the raft was first in position), it rises very sharply. However, if the origin is extended backwards to September, (a month when heavy spatfalls occurred in two successive years) a sigmoidal curve results which is nearer what might be expected in normal growth. If this is taken as the starting point, then a further 8 months age (September-May) would need to be added to the curve plotted in figure 5. About 6.5 cm growth could then occur in the first year followed by 5.5 cm in the second, making 12.0 cm in two years. This compares with a previous estimate of 12.0 cm in 20 months at nearby Te Kouma (Greenway 1969), when no account was taken of the early settlement stages at spatfall and resettlement was not suspected. It is much slower than that shown for raft grown mussels in the Marlborough Sounds (Flaws 1971), where 12.0 cm was reached in only 15 months. Even the fastest growing specimen which reached 12.0 cm on 6 April 1972 would be about 18 months old using the new estimate. An average growth of 12.0 cm in two years agrees well with the estimate made by a commercial concern (McFarlane 1971) and is still a fast rate of growth for large marketable mussels.

Condition and Yield

The shell cavity volume represents the maximum space available for occupation by the meats but the average condition of the mussels determines the yield of meat. Increases in cavity volume relative to growth in length are shown in figure 7. At 6.5 cm (i.e. about one year old) the cavity volume is only 13 ml and the average drained meats filling it 8 ml. However, at the end of the second year's growth the mussel is about 12.0 cm, the cavity volume will be slightly in excess of 70 ml and the average meats about 40 ml representing a fivefold increase.

There is therefore little point in considering sales within two years.

Table 1 below sets out various weights of meat for two different lengths at three stages of condition. The data was obtained during condition analyses.

TABLE 1

Length cm	Weight (Dry)	Weight (Wet)	Condition
	5	27.5	Poor
12.0	9	37.0	Average
(approx. 2 years)	12	58.0	Good
	9	37.0	Poor
14.0	13	62.5	Average
(2+ years)	18	83.0	Good

Mussel spat setting in September can be expected to be in good condition two years later as it reaches 12.0 cm. It should then yield about 12 g dried meat. If it were left to grow until March it might reach about 14.0 cm but the expected condition would be poor, yielding only about 9 g of dried meat. This is obviously uneconomic and the mussels would best be sold in September as two year olds. On the other hand, December-January settled spat would not be expected to be in very good condition as two year olds. They could be held until the following winter and sold as 2½ year olds at about 14.0 cm length. The yield then could be as much as 40% higher than that for equivalent two year olds thus fully justifying the extra growing time.

CONCLUSIONS

1. Since there is a relatively long spatfall period and condition can be variable, accurate prediction of

spatfall may be difficult. As a rough guide only, catching materials need to be ready for putting out by the end of August although it may be possible to obtain a settlement anytime up to the following March.

2. Because early settlements appear to concentrate near the top of the water column it will be necessary to present compact surfaces which occupy as small an area as possible, yet can be lowered later to take full advantage of the whole water column for growing on.

3. Relatively smooth clean surfaces favour settlement and may be enhanced if they also provide entangling crevices.

4. Once the initial settlement has been obtained, possible detachment with dispersal and/or movements towards aggregation may present problems. Only further detailed studies of early development could point to ways of channeling such behaviour into sound cultivation technique.

5. Considerable end differences can be expected between mussels which have settled at different times of the year. Although mussel condition can be very variable it is generally poorest during summer months, so that in order to obtain the best return, it may be necessary to try and keep the various settlements separated. This could be especially beneficial where peak settlements occur at long intervals such as September and January.

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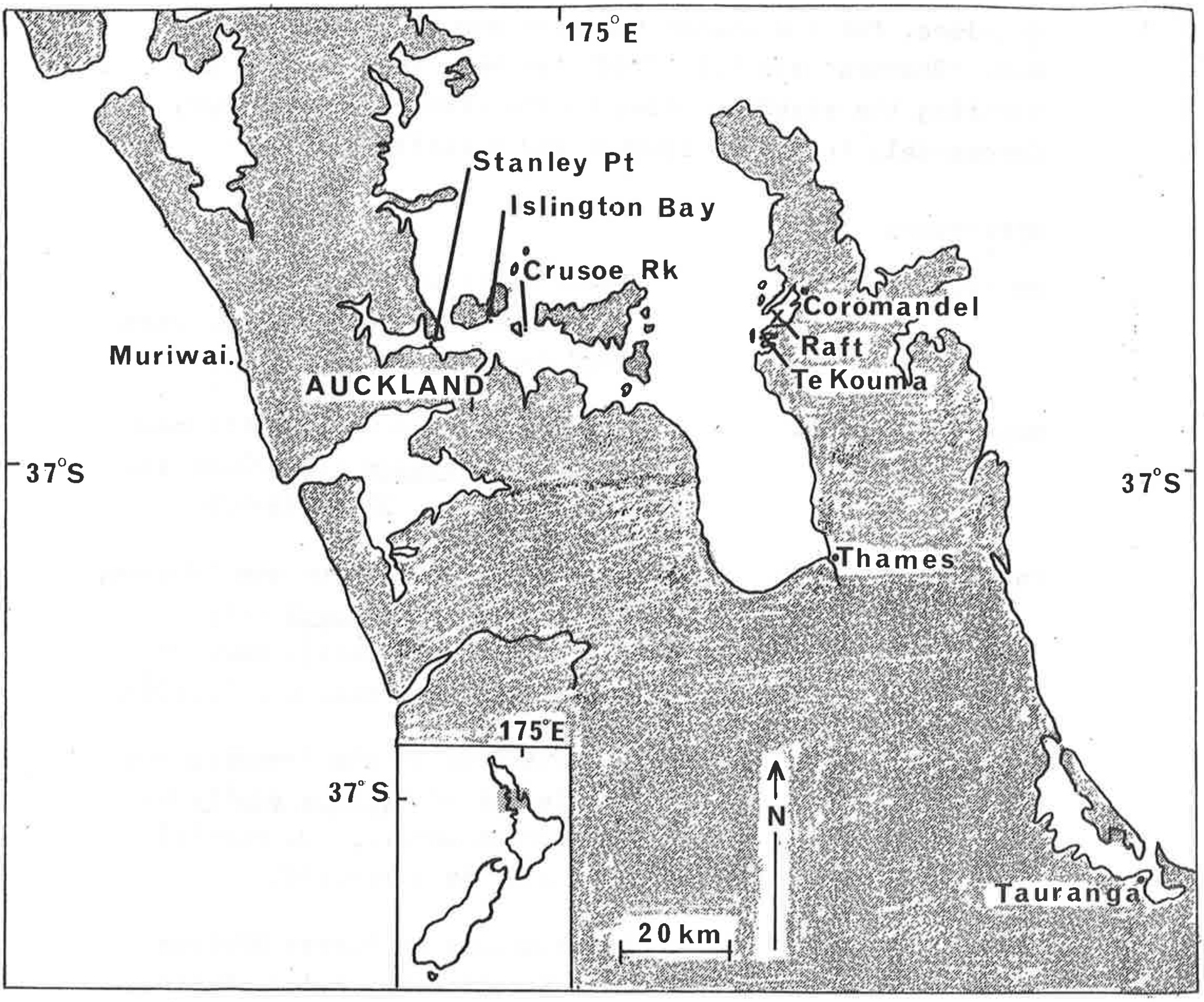

Fig 1.

LOCATION SKETCH MAP OF EXPERIMENTAL SITES.

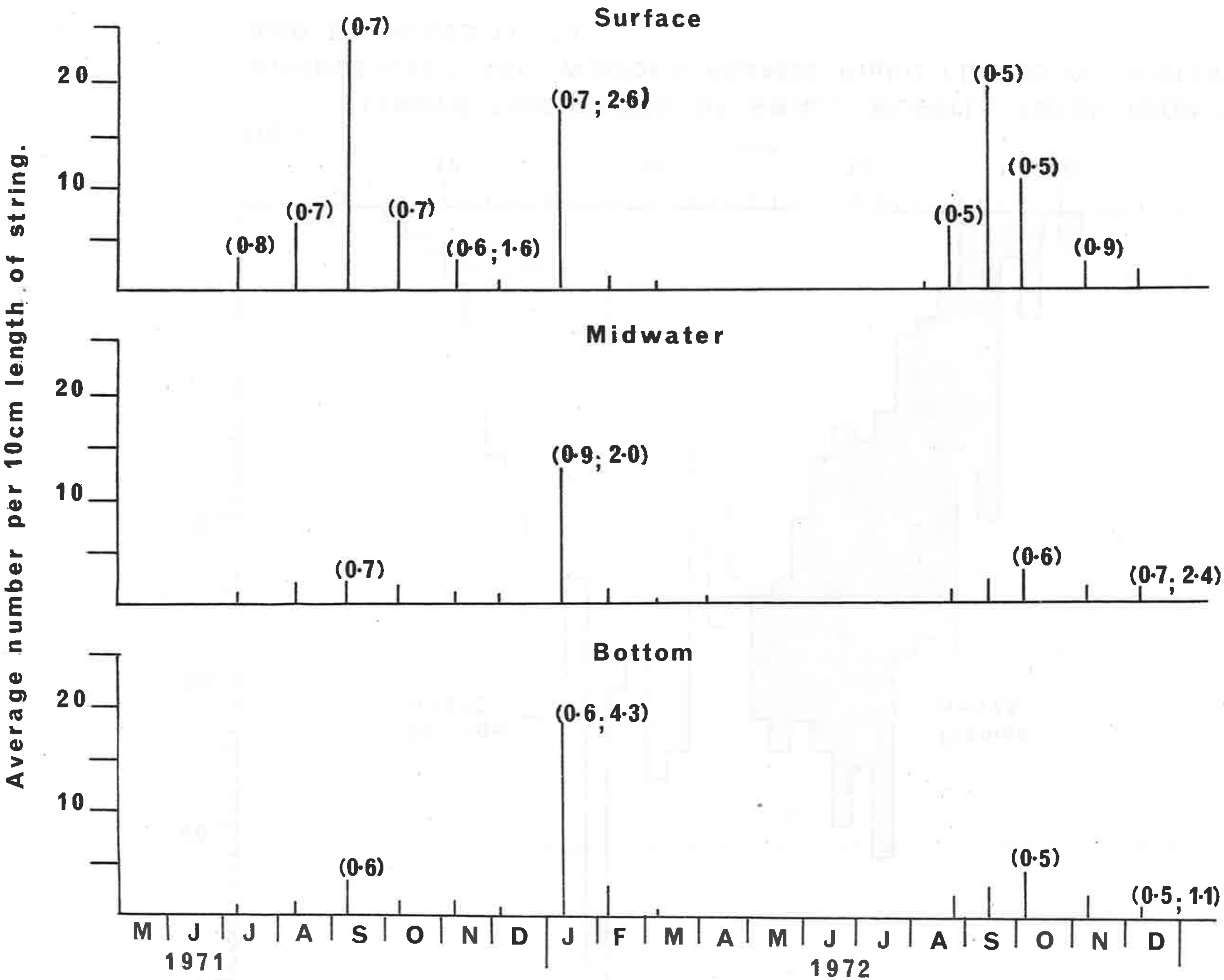

Fig 2. AVERAGE SETTLEMENT OF MUSSEL SPAT ON COIR STRING COLLECTORS.
N.B. Mean lengths of spat in mm from larger samples shown in brackets.

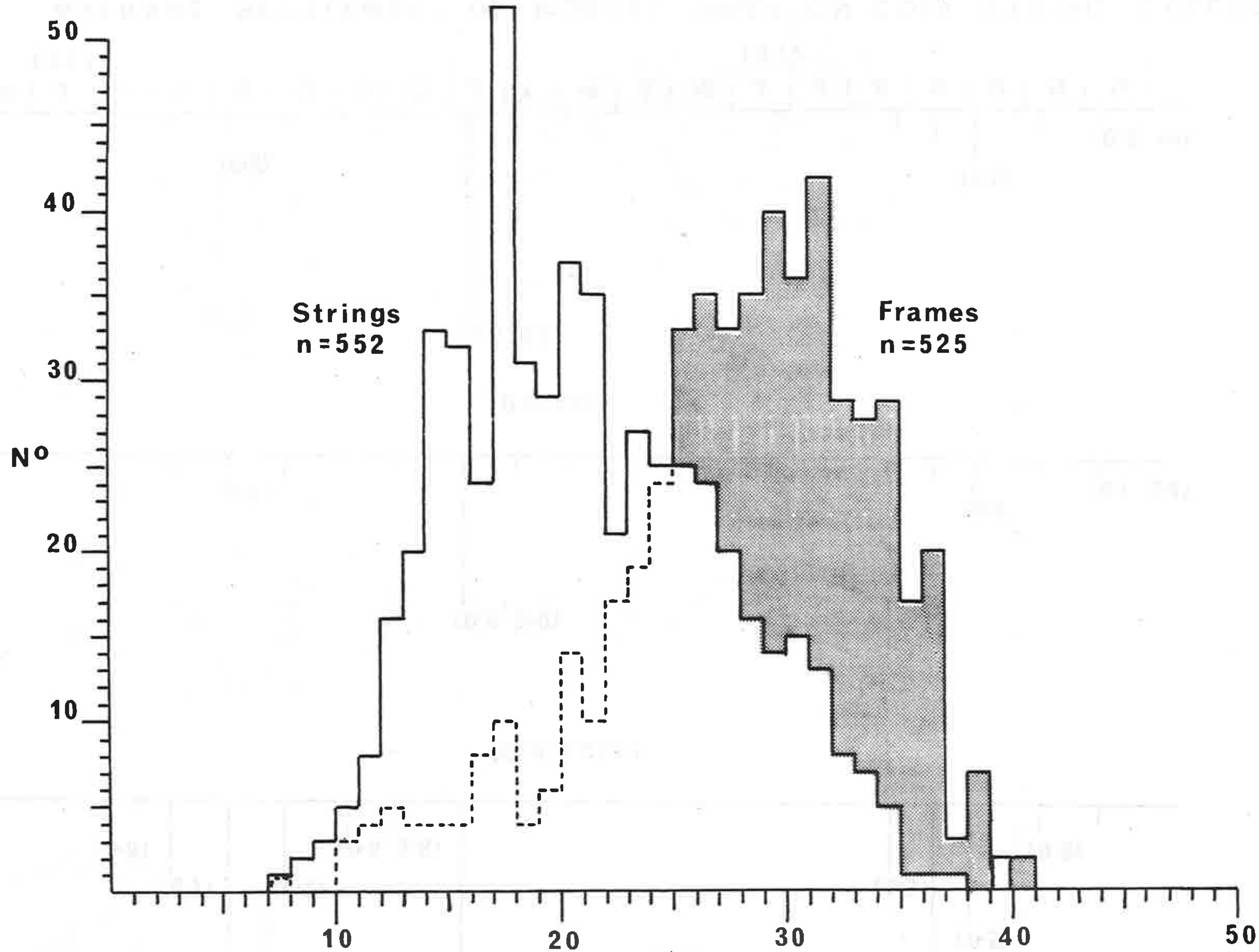

Fig 3.

LENGTH FREQUENCIES OF SMALL MUSSELS TAKEN FROM COIR STRINGS (Left) AND WOODEN FRAMES (Right), PLACED IN WATER 10·8·72 AND EXAMINED 11·1·73

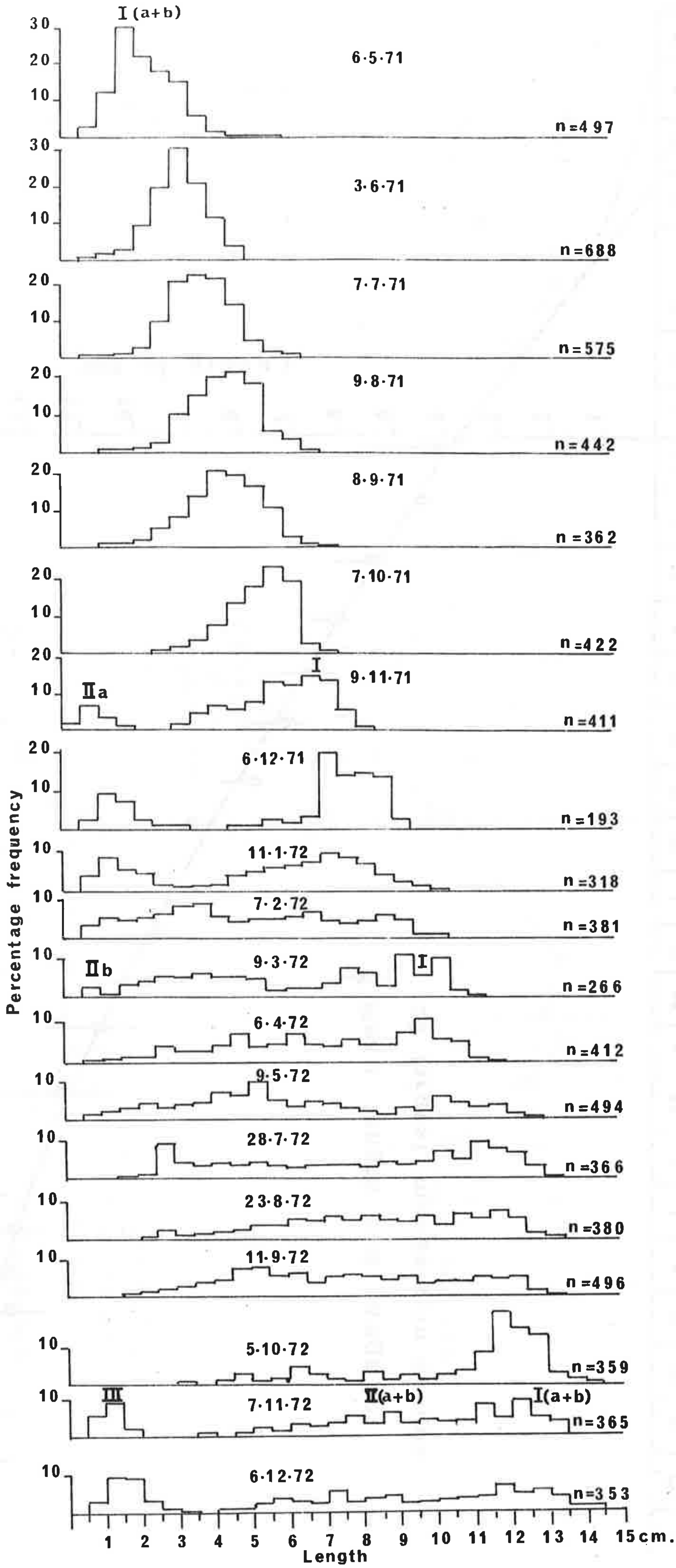

Fig 4. LENGTH FREQUENCIES OF MUSSELS FROM RAFT AT PA POINT, COROMANDEL.

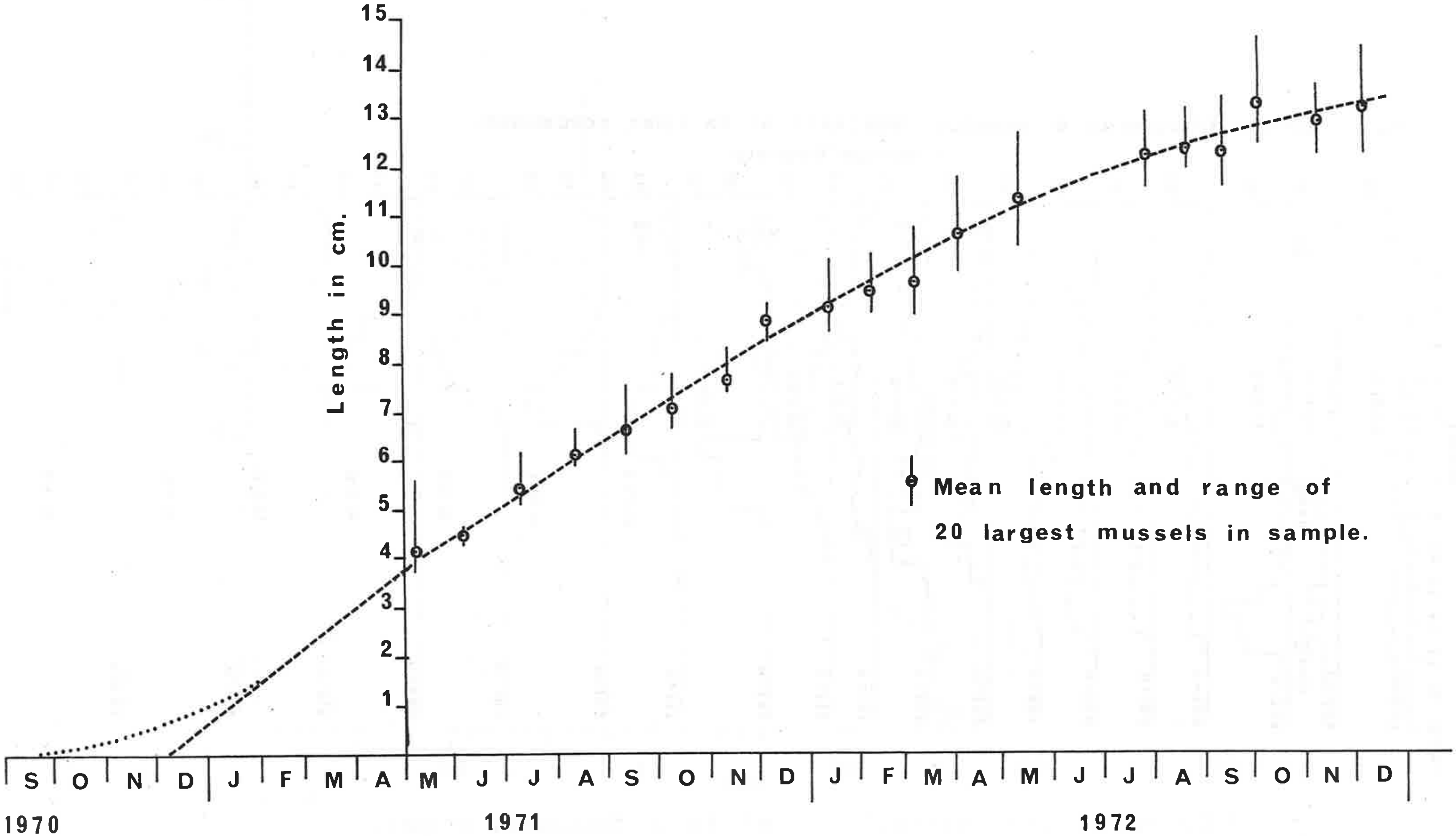

Fig 5. AVERAGE INCREASE IN LENGTH.

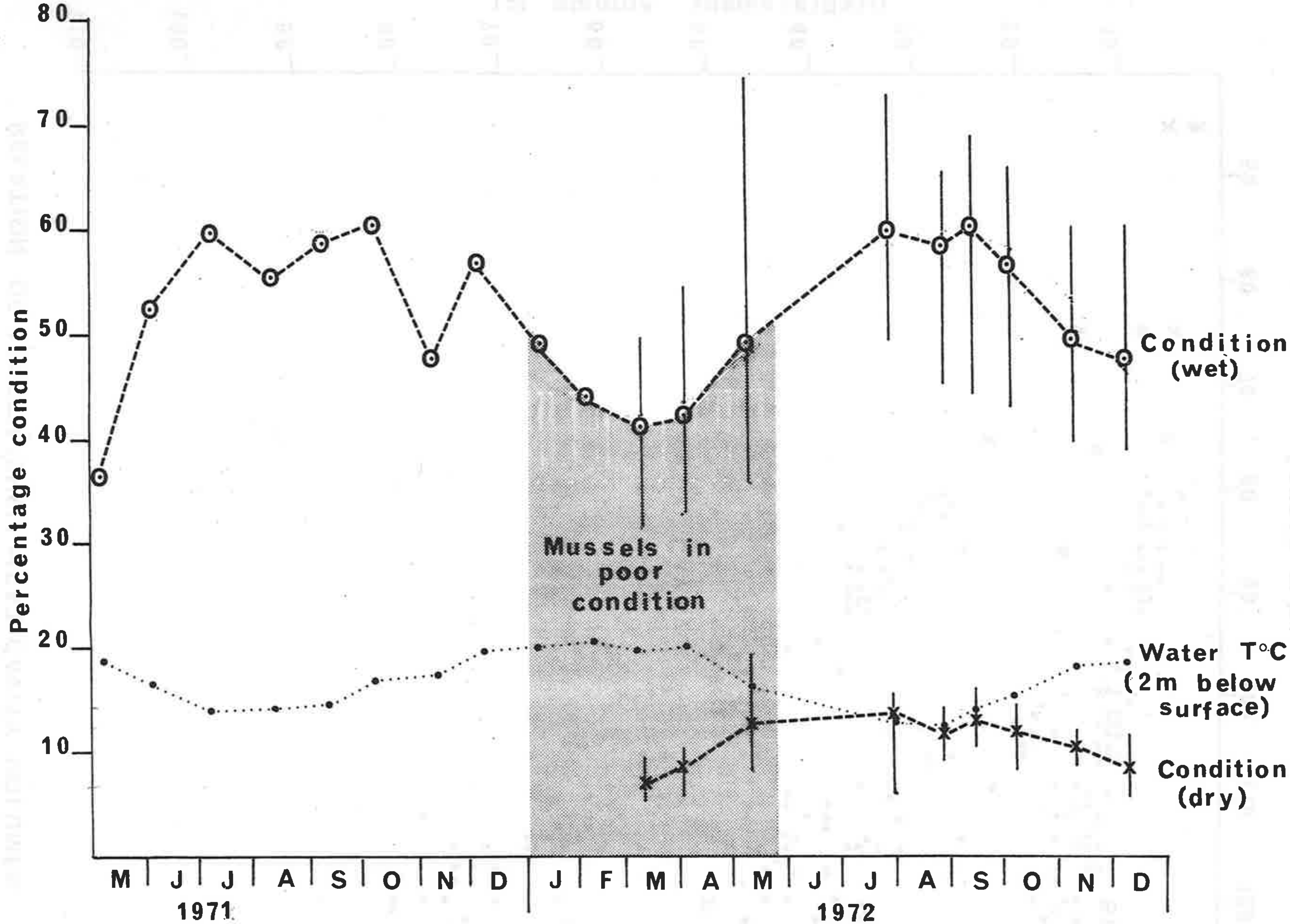

Fig 6.

CONDITION OF MUSSELS AND WATER TEMPERATURE.

Fig 7.

RELATION OF LENGTH/SHELL,MEAT,CAVITY VOLUMES.