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A STUDY OF SOME PROBLEMS RELATING TO QUANTITATIVE SAMPLING OF LOBSTER LARVAE (*Homarus gammarus* L.)

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ABSTRACT

Surveys to sample lobster larvae with neuston nets off the north-east coast of England in 1976 highlighted a sampling problem which needed to be solved before quantitative estimates could be made of the abundance and survival of larvae and of adult spawning stock size. The requirements were to construct and calibrate a new and larger neuston net and to determine whether or not the larvae made regular vertical migrations between the sea bed and sea surface.

In 1979 a new net was used in three surveys to study vertical distribution of lobster larvae in Bridlington Bay. Major changes in the patterns of vertical distribution were seen to occur between surveys but preliminary analysis has found no correlation with the prevailing environmental conditions. For this reason it may be impossible to estimate the abundance of lobster larvae accurately from surveys using neuston nets.

INTRODUCTION

Prior to 1976 little was known about the occurrence of lobster larvae in the coastal waters of northern Europe. The previous records, most of which date back to over fifty years ago, were limited to isolated chance captures, all taken close to the surface. This suggested that their behaviour was similar to that of the larvae of the American lobster (*H. americanus*), which are mainly confined to the near-surface water (Sherman and Lewis, 1967; Lund and Stewart, 1969; Squires, 1969; Scarratt, 1964, 1973).

In a series of surveys off the north-east coast of England between June and November 1976 a total of 133 larvae was caught in 168 hauls at the surface (Nichols and Lawton, 1978). These surveys identified the areas where lobster larvae were most abundant, but failed to produce a satisfactory estimate of the seasonal production of Stage I larvae. An attempt to use these data to calculate the spawning stock size served only to highlight a sampling problem which had to be solved before quantitative surveys could begin. In 1979 these studies were continued in Bridlington Bay, with the aim of determining whether or not quantitative sampling could be confined to the near-surface water. Bridlington Bay was chosen as one of the areas of highest larval concentration in 1976 (Nichols and Lawton, 1978) and where the berried females were known to be abundant.

MATERIALS AND METHODS

Two rectangular box frames, 2 m wide x 0.8 m deep, were constructed from marine aluminium pipe (32 mm outside diameter, 6 mm wall thickness) (Figure 1). A 3 m long conical filtering net, hexagonal mesh size 1.8 mm diameter, was attached to the front section of the frame, with a 0.5 m wide PVC cuff. The net ended in a threaded bucket 0.16 m diameter to which was attached a brass ring and collecting bag of the same mesh as the filtering net. Adjustable attachments for air-filled, plastic floats (Norly boat fenders, size 508) were fitted to the outsides of each frame to allow easy variation of the fishing depth at the surface. Scripps depressors could be attached to each frame, enabling them to be fished at varying depths below the surface. The 14 m long RV NUCELLA was used to tow the nets simultaneously from booms over the port and starboard sides. The 3.5 m long booms enabled the nets to be towed on a straight course and clear of any disturbance produced by the ship's propeller. This system allowed either both nets to be fished at the surface, or for one to be fished at the surface and the other at varying depths. The depth of the sub-surface net was monitored by an electronic depth gauge.

The nets were towed for 30 minutes at 3 knots, the surface net thus sweeping an area of approximately 2800 m^2 and sampling down to 0.8 m. The sub-surface net filtered an estimated volume of 2200 m^3. This net was fishing during veering and hauling and therefore did not take a discrete sample of the depth band in which it was towed.

One hundred and six paired hauls were made on the first survey, 11-26 July, and 112 hauls on the second, 18 August-7 September. Seventy six of the hauls on the first survey were made with both nets fishing in the surface half metre. The remaining 30 paired hauls on this survey and the 112 paired hauls on the second survey were made with the starboard net fishing at various fixed depths below the surface. All hauls were made during daylight hours with the exception of the final 10 hauls, which were made during dusk and darkness on the night of 6/7 September.

The catch from each net was washed into the collecting bag, removed into an 8 l bucket and sorted onboard ship. The catch most frequently consisted of airborne insects and terrestrial debris in which lobster larvae could be easily seen and removed. The whole sample was fixed in 4% formalin and returned to the laboratory for accurate sorting. All the larvae were subsequently staged and measured.

Measurements of total quantum irradiance (400-700 nm) at deck level were made during each haul on the second survey.

RESULTS

The two surveys were divided into three sampling periods, 11-26 July, 18-22 August and 30 August-7 September. A total of 821 lobster larvae (695 Stage I, 83 Stage II, 29 Stage III, 14 Stage IV) was caught during the whole period of the survey. Of these, 436 (431 I, 5 II) were taken during the first sampling period, 147 (135 I, 9 II, 3 III, 14 IV) during the second period and 238 (129 I, 69 II, 26 III) during the third period.

The search for a suitable patch of lobster larvae in which to study their distribution in the water column covered a wide area of Bridlington Bay. During this search both nets were fished at the surface, allowing a comparison of the catches in each net to be made. Using the 29 hauls when lobster larvae were caught in at least one of the nets, the mean catch per haul and 95% confidence limits were 3.41 ± 1.17 for the port net and 4.94 ± 1.88 for the starboard net (t-test, P 0.5). There was no significant difference between the catches of the two nets.

The subsequent vertical distribution studies were conducted in an area *ca* 7 nautical miles offshore where lobster larvae were most abundant in the surface hauls. The data are presented as total catch in the paired surface and sub-surface nets (Table 1). The catch per haul has been calculated using only hauls where lobster larvae were taken in at least one of the two nets. In the first and second sampling periods the catch rate was highest at the surface (Table 1), with approximately 80% of the total catch, whilst in the third period, less (40%) were caught at the surface than at depth (Figure 2). The surface and sub-surface catches have also been preliminarily examined in relation to spring and neap tidal height fluctuations (Figure 3). These data show no apparent relationship between either the surface or sub-surface catch rates and the spring and neap cycle.

The effect of direction of tidal flow has been examined by grouping the surface and sub-surface catches for each period into those caught during ebbing and flooding tides (Table 2). Whilst these data show some variation in ebb and flood tide catch rates during the first two periods, there is no pattern to suggest that these differences are produced by anything other than random variation. These data await statistical analysis.

There was a suggestion of a relationship between bright sunlight and low catches at the surface during the first sampling period. This hypothesis was tested during the subsequent surveys by measuring the total quantum irradiance between 400 and 700 nm wavelengths at deck level during each haul. The total catch at the surface and sub-surface has been grouped into 250 microeinsteins m^{-2} s^{-1} bands for the two periods (Table 3). The standard deviation of each haul is so high that no significant relationship between light levels and total catch of lobster larvae can be detected in these data. Only one series of hauls was completed during a dusk/darkness period. These hauls have been separated from the daylight hauls for that period in Table 1, and suggest somewhat higher catch rates at the surface at night than in daytime.

DISCUSSION

The low density and high variation in catch rates of lobster larvae, observed during the 1976 surveys (Nichols and Lawton, 1978), has again been a feature of these studies. This has rendered preliminary interpretation of the results extremely difficult, and must in itself cast considerable doubts on the value of future attempts at quantitative sampling. However, it might be possible to overcome this problem by sampling on more intensive grids than have been used in the quantitative surveys of the larvae of *H. americanus*. From a practical point of view this could only be achieved if sampling could be confined to the near-surface waters. In the first two sampling periods, although the catch rates at the surface were much higher than those from below, there were nevertheless significant proportions of the larvae down to below 3 m. It could be argued that a few of these larvae in the sub-surface nets may have been captured as the net passed through the surface during shooting and hauling. In the final sampling period the sub-surface catches were higher than those from the surface net. When the sub-surface catch is plotted as a proportion of the mean surface catch for each sampling period (Figure 2), the change in vertical distribution of the larvae on the final survey is clearly shown.

This major change demands an explanation, and an assessment made of the significance of such a change to quantitative sampling. However, in the preliminary analysis of the data none of the variables so far examined have provided that explanation.

Only in the third sampling period were substantial numbers of Stages II to IV larvae caught. Even then it has not been possible to relate stage of development and vertical distribution. The low numbers of Stage IV larvae may have been due to some settling to the benthic stage. Most of the larvae found below the 1 m depth in all three periods were still in the first stage of development.

The difference in catch rates at the surface on ebbing and flooding tides on the first survey was reversed on the second survey and absent on the final one. Furthermore, no differences in catch rates are apparent in the sub-surface samples. If there is any tidal effect on catches its significance is not apparent from either these data or from the examination of catch rates in relation to the spring and neap tidal cycle. It must be remembered that no specific experiment to study the effect of tide on catches was conducted, and the data have only received preliminary analysis.

Similarly, examination of the catch data in relation to surface irradiance offers no explanation of the change on the final survey. Few opportunities however occurred to sample continuously during bright sunlight and these data are therefore limited in their coverage at the higher end of the irradiance scale. The sampling during dusk and darkness was limited but indicated somewhat higher catch rates at the surface at night, though sub-surface day and night catch rates were similar.

All the data obtained during these surveys indicate great difficulties in any attempts to quantitatively sample lobster larvae in this area. It may not be unreasonable to draw the same behavioural conclusion for the larvae of *Homarus gammarus* over the whole of its distribution range. This would render any attempt to use larval abundance as an adult stock index very difficult.

These data warrant additional analysis, but even so further studies of the vertical distribution of the larvae need to be conducted to conclude this work. The emphasis should be on taking large, discrete samples and on eliminating as many of the physical variables as possible.

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Table 1 Summary of catch rates of lobster larvae (all Stages) from surface and sub-surface samples for the three sampling periods

Sampling period	Catch (numbers)/haul				Number of paired hauls	
	Surface 0-0.5 m		Sub-surface below 0.5 m			
11-26 Jul	6.4		1.4		28	
18-22 Aug	3.1		1.2		34	
30 Aug-7 Sep	1.7		2.5		57	
	Day	Night	Day	Night	Day	Night
30 Aug-7 Sep	1.5	2.8	2.6	2.4	46	10

Table 2 Numbers of lobster larvae in surface and sub-surface hauls divided into hauls made during flooding and ebbing tides

Sampling period	Ebbing		Flooding	
	No. of hauls	Total catch/haul	No. of hauls	Total catch/haul
Surface hauls				
13-24 Jul	93	1.6	80	3.0
18-22 Aug	26	3.1	23	1.0
30 Aug-7 Sep	36	1.6	21	1.7
Sub-surface hauls				
13-24 Jul	18	0.9	15	1.5
18-22 Aug	26	0.3	23	0.7
30 Aug-7 Sep	36	2.4	22	2.3

Table 3 Numbers of lobster larvae, all Stages combined, in surface and sub-surface hauls, tabulated against surface irradiance

Surface irradiance microeinsteins m^{-2} s^{-1}	Surface < 0.9 m			Sub-surface > 0.8 m		
	No. of hauls	No./haul	S.D.	No. of hauls	No./haul	S.D.
18-22 August						
0- 249	7	3.6	2.0	7	1.1	1.3
250- 499	6	2.0	2.8	6	0	0
500- 749	14	1.9	2.5	14	1.0	1.1
750- 999	11	2.3	3.5	11	0.7	1.4
1000-1249	4	1.8	1.5	4	0	0
1250-1499	1	0	0	1	0	0
1500-1749	4	1.0	1.2	4	1.5	1.3
1750-1999	2	3.5	3.5	2	2.5	2.1
2000-2249	1	0	0	1	0	0
30 August-7 September						
0- 249	8	4.5	2.5	8	1.4	0.7
250- 499	8	2.5	4.1	8	4.4	4.4
500- 749	9	1.2	1.4	9	1.9	1.4
750- 999	9	0.3	0.5	9	2.2	1.7
1000-1249	7	0.4	0.8	7	1.9	1.9
1250-1499	10	0.8	0.9	10	1.7	1.8
1500-1749	2	0	0	2	4.0	5.7

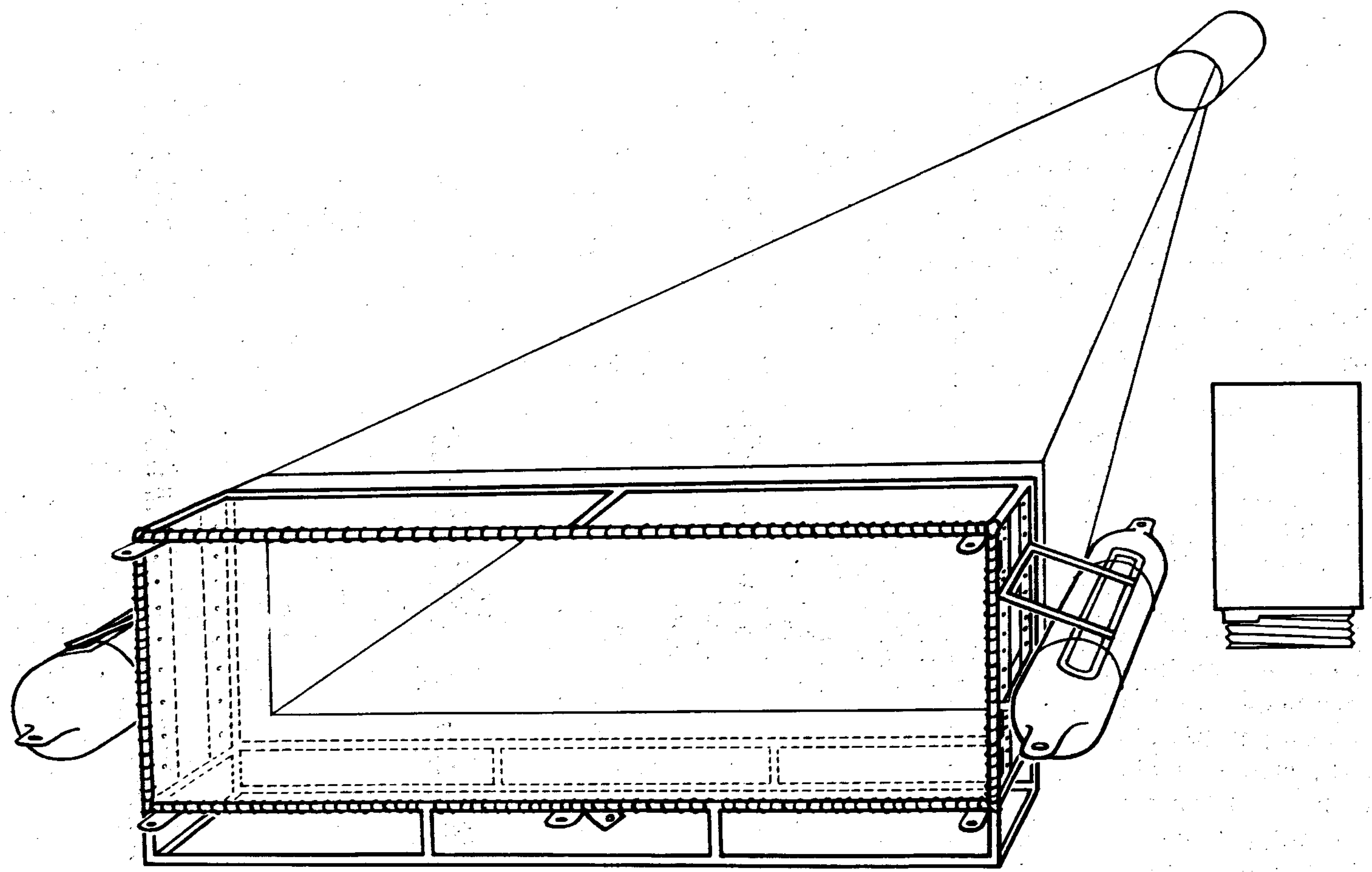

Figure 1   The 2 m x 0.8 m deep neuston net.

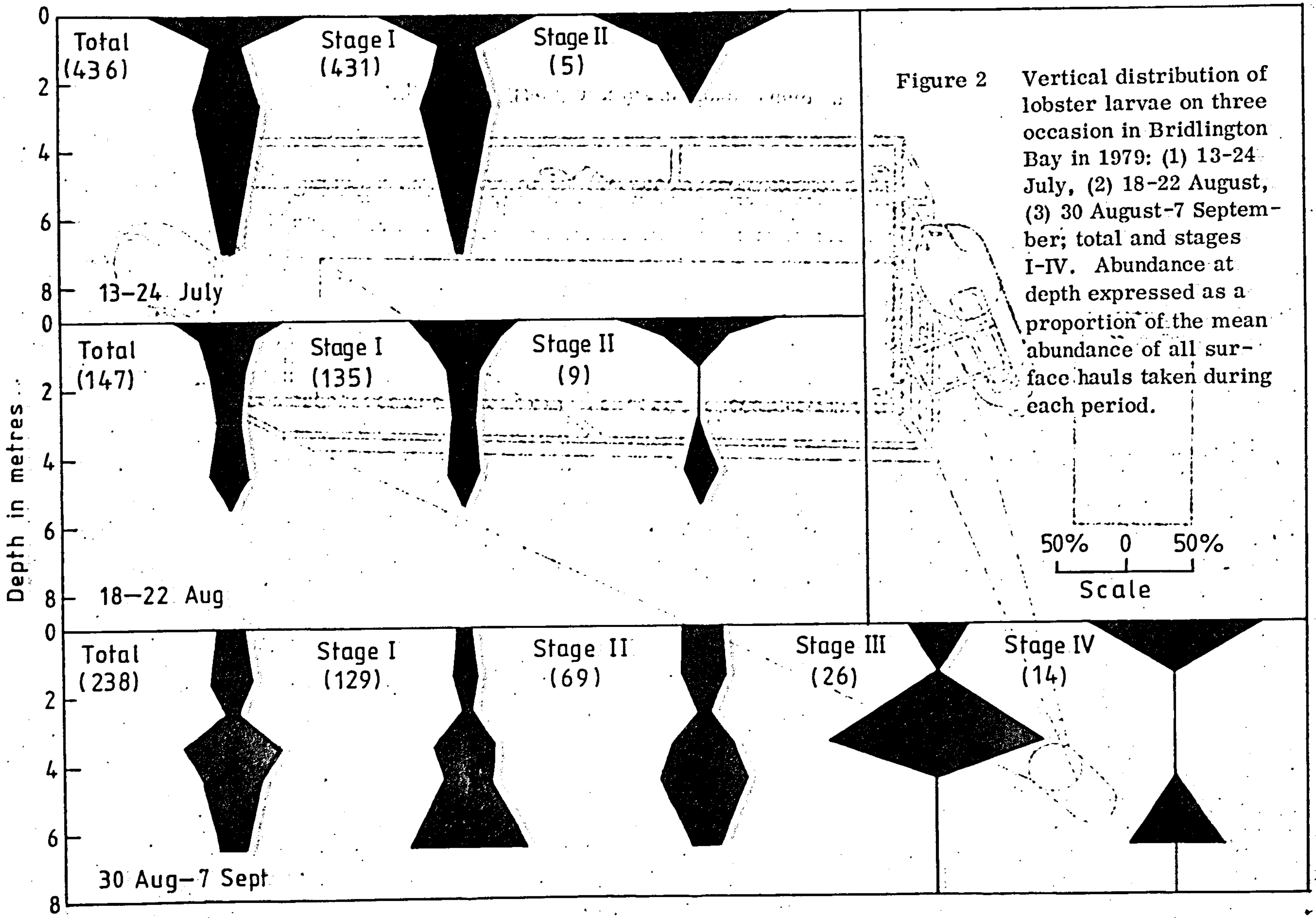

Figure 2 Vertical distribution of lobster larvae on three occasion in Bridlington Bay in 1979: (1) 13-24 July, (2) 18-22 August, (3) 30 August-7 September; total and stages I-IV. Abundance at depth expressed as a proportion of the mean abundance of all surface hauls taken during each period.

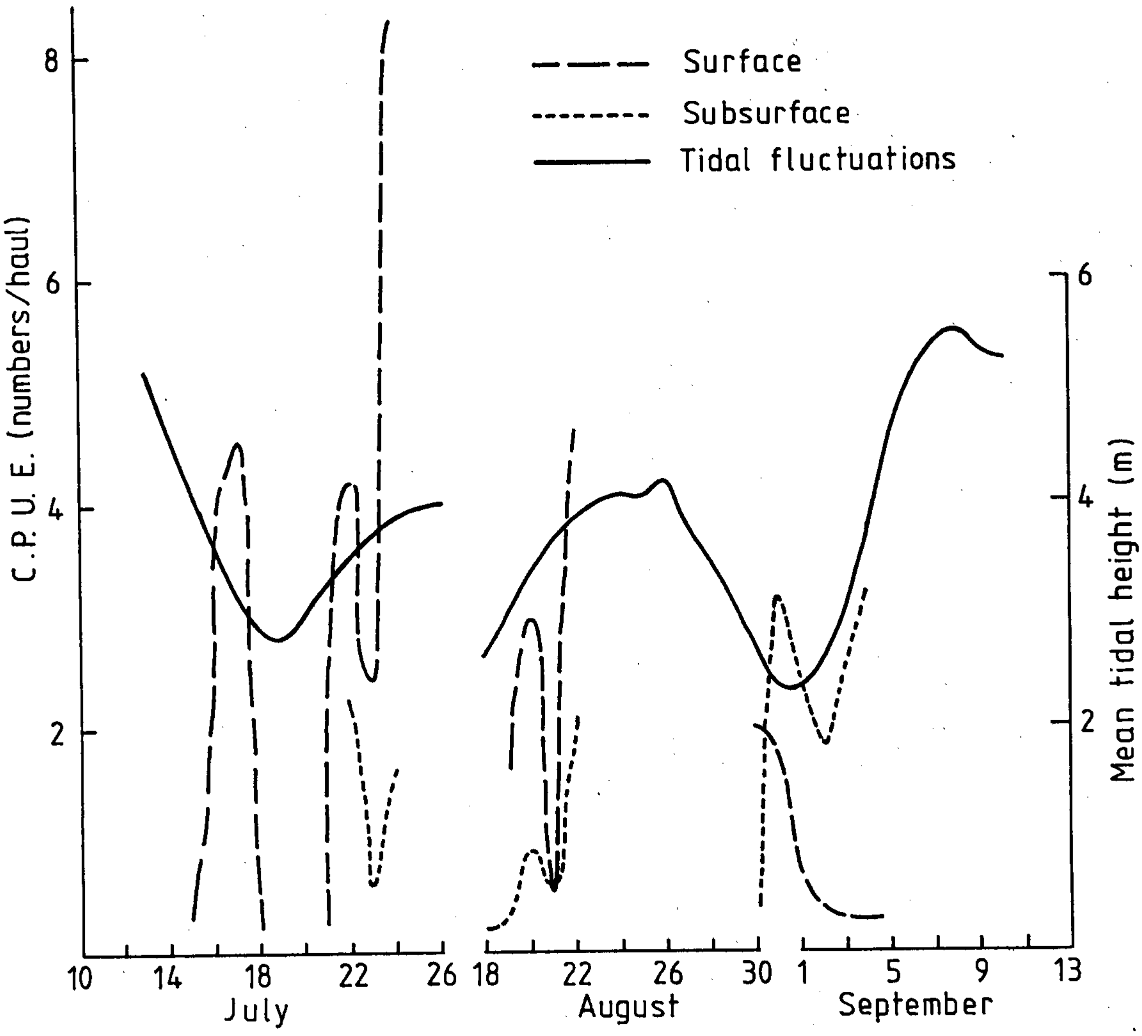

Figure 3 Catch rates of lobster larvae from all hauls in surface and sub-surface nets, plotted against the spring and neap tidal cycle.