This paper not to be cited without prior reference to the author.

International Council for
the Exploration of the Sea

C.M. 1974/H:35
Pelagic Fish (Northern) Committee
Ref. Plankton Committee

The distribution of eggs and larvae of the Blue Whiting, *Micromesistius poutassou* (Risso) in the north east Atlantic.

by

S.H. Coombs

Institute for Marine Environmental Research
Oceanographic Laboratory
Craighall Road
Edinburgh
Scotland

THE DISTRIBUTION OF EGGS AND LARVAE OF THE BLUE WHITING, MICROMESISTIUS POUTASSOU, (RISSO) IN THE NORTH EAST ATLANTIC.

by

S.H. COOMBS

Institute for Marine Environmental Research, Oceanographic Laboratory, Craighall Road, Edinburgh, Scotland.

SUMMARY.

This paper presents results from a cruise in March and April 1974 to the west of the British Isles to investigate the vertical distribution of eggs and larvae and the horizontal distribution of larvae of blue whiting.

A concentration of larvae was found in the vicinity of Porcupine Bank with lower numbers extending to the north and south. Over 99 % of the larvae were found to the west of the 100 fathom line; that is, over deep oceanic water.

The larval distribution corresponds with that of the adults obtained from the same cruise, and both larvae and adults appeared progressively further northwards as the season advanced.

In the Porcupine area the trend of higher numbers of larvae in the nineteen sixties compared with the nineteen fifties has continued into the seventies; around Rockall the trend of lower numbers of larvae in the late nineteen sixties was reversed in 1973 and 1974.

Blue whiting eggs were found from the surface to 460m with peaks of abundance from 0 to 70m and 250 to 400m. There is some evidence to indicate that the eggs are positively buoyant and that the bimodality of distribution in depth is a result of predation on the eggs by Maurolicus muelleri.

The vertical distribution of the larvae corresponded with that of the eggs.

INTRODUCTION.

The Fisheries Laboratory (Lowestoft) of the Ministry of Agriculture, Fisheries and Food undertook a research cruise aboard R.V. Cirolana from March 21 to April 17, 1974 to investigate the spawning concentrations of blue whiting by an acoustic survey

and /

and exploratory trawling in the north east Atlantic between Rockall and the south west of Ireland, including Porcupine Bank.

During the same cruise the Institute for Marine Environmental Research (Edinburgh) carried out a survey of the plankton, including the eggs and larvae of blue whiting using the Continuous Plankton Recorder (CPR) and the Longhurst Hardy Plankton Recorder (LHPR). The intention was to investigate, in detail, the distribution and abundance of the planktonic stages of blue whiting in this area where they have been sampled since 1948 in the course of the routine CPR survey, mounted by IMER (Edinburgh); see Bainbridge and Cooper (1973).

MATERIAL AND METHODS.

The Continuous Plankton Recorder (Hardy, 1939) was towed at 8 knots at 10m depth for most of the cruise track (Figure 1*a*). This gave a continuous record of the plankton, filtered through silk with a mesh size of 0.27mm, and preserved in 4% formaldehyde. The filtering silks were cut into samples, each representing 10 miles of tow, and all fish eggs and larvae from each sample were measured and counted. The arithmetic mean number of larvae per 10 mile sample was used for plotting larval distributions (Figures 1*b* and 1*c*). Routine analysis (Colebrook, 1960) was carried out for the remainder of the plankton on selected samples.

At selected stations (Figure 1*a*) oblique hauls from 460m to the surface were made at 1½ knots using the Longhurst Hardy Plankton Recorder (Longhurst *et al*., 1966). This instrument gives discrete samples of plankton from a recorded volume of water from a known depth range using filtering gauze with the same mesh size as that used in the CPR. The samples were preserved in 4% formaldehyde. For each sample the fish eggs were counted and staged and the larvae counted and measured. These data were standardised to give an estimate of numerical abundance per $10m^3$ for each 10m depth range. In preparing the vertical profiles (Figures 4, 5*a* and 5*b*) a $\log_{10}$ transformation was used to diminish bias resulting from occasional extraordinary counts.

Temperature /

Temperature profiles were obtained by the LHPR for all hauls.

Blue whiting eggs were artificially fertilized on board using material obtained from ripe fish caught by mid-water trawl. The fertilized eggs hatched after four days and the larvae were kept successfully for a further 8½ days. This material, together with information from Seaton and Bailey (1972), was used to stage the eggs and to identify the larvae.

GEOGRAPHICAL DISTRIBUTION.

Eggs

Although eggs of blue whiting were abundant in the LHPR hauls (see section on VERTICAL DISTRIBUTIONS) they have always been very rare in CPR samples taken at 10 metres and only five were taken by the CPR during the cruise.

Larvae

The distribution and abundance of the larvae taken by the CPR during the cruise in March and April are presented in Figures 1*b* and *c* respectively. These distributions identify Porcupine Bank as a major spawning area with subsidiary spawning further south in the Western Approaches, as previously described by Bainbridge and Cooper (1973). Less than 1% of the larvae were found to the east of the 100 fathom line, and these were very close to it. This larval distribution is similar to that of the spawning adults found between 100 and 200 fathoms over deep water and along the edge of the shelf and banks (Bailey and Seaton, 1969, and Figures 1*d* and 1*e*).

The distribution in late March (Figure 1*b*) shows a concentration to the south west of Ireland extending to Porcupine Bank. In April (Figure 1*c*) the larvae were more numerous and further north, extending from Porcupine Bank northwards into Rockall Channel and along the seaward margin of the continental slope; lower numbers were found to the south west of Ireland. These distributions confirm the seasonal progression northwards of spawning reported by Schmidt (1909) and Bainbridge and Cooper (1973). The northern part of the cruise was operated before peak numbers of larvae would be expected there (Bailey, 1974).

About 90% of the larvae caught during March were under 8 days old and in April 80% of the larvae were less than an estimated age of 21 days (<4.5mm). Assuming an incubation /

incubation period of 4 days, these age distributions show that spawning had been taking place from mid March to the south west of Ireland and had progressed to Porcupine from late March to mid April. Spawning may have continued in the Porcupine area after the survey but by mid April it had finished to the south west of Ireland.

The provisional results from the acoustic survey (carried out by MAFF) during the cruise, are presented in Figures 1d and 1e. There was close correspondence between the larval distributions (Figures 1b and c) and those of the adults (Figures 1d and 1e) which also show the northerly progression of spawning aggregations. Allowing for the effects of drift, dispersion and predation, the distribution of spawning fish for the period 23-31 March (Figure 1d) would be expected to produce larvae aged between 4 and 22 days for the period 1-14 April in approximately the same area. Such a distribution was indeed found (Figures 1c), and 80% of these larvae were less than 21 days old.

The results from the cruise may be compared with those of the normal CPR survey, covering a greater area and longer period. Figure 2a shows the distribution of blue whiting larvae in March, April and May 1974 combined; larvae were abundant north of Porcupine Bank, in Rockall Channel and south of the Faroes. Thus the combination of cruise and survey data in 1974 shows that spawning in that year was spread over a very great area, at least from the south west of Ireland to south of the Faroes. The highest numbers in the CPR survey were found to the north of Porcupine Bank and notably in the Rockall Channel area, but moderate numbers were found in all areas, although the CPR survey (probably because of differences in time of sampling) missed the early spawning to the south west of Ireland, revealed by the cruise.

LONG TERM FLUCTUATIONS IN ABUNDANCE.

In considering data up to 1970 for the Rockall area, C5 (Figure 2b) Bainbridge and Cooper (1973) found highest numbers of larvae in the early nineteen sixties, declining thereafter to the end of that decade. Figure 3 presents their data for the annual fluctuations for area C5, updated to 1974; there appears to have been a reversal of the decline and a return to large numbers of larvae in the last two years.

In /

In the area around Porcupine Bank, D5 (Figure 2b), the trend of increasing numbers of larvae in the nineteen sixties, compared with the nineteen fifties, has continued into the seventies (Figure 3).

Bainbridge and Cooper (1973) interpreted the coincident increase in abundance of larvae in D5 and reduction in C5 in the late nineteen sixties as a reflection of progressive southerly shift in spawning.

VERTICAL DISTRIBUTION.

The results of the LHPR hauls are summarised in Table 1. Hauls 1, 2 and 6 contained too few eggs or larvae to draw useful conclusions from their distributions.

The proportion of "late" eggs (defined as those at developmental stages found during days 3 and 4 of incubation) to "early" eggs (defined as those at developmental stages found during days 1 and 2 of incubation) tended to increase successively in the Longhurst Hardy Plankton Recorder hauls as progressively older populations were sampled.

Figures 4 and 5 show the vertical distribution of the eggs and larvae of blue whiting and a temperature profile for each haul. Eggs were found from 0 to 460m with peaks of abundance from 0 to 70m and 250 to 400m. The majority of early eggs were found between 250 and 450m; this is the depth range in which ripe adult fish were generally found on the cruise and identifies it as the depth in which the majority of spawning occurs.

It is possible that the different groups of eggs, "early" and "late", may have been spawned at different depths. However, the agreement between hauls 3, 4 and 5 and the small time interval (mean of 2 days) separating the two groups of eggs are against this possibility. "Late" eggs were found over a wider depth range and somewhat nearer the surface than "early" eggs. The increase in depth range of the eggs may be attributed to dispersion effects, whilst the shift towards the surface suggests that the eggs are positively buoyant.

There /

There is some disagreement over the buoyancy of blue whiting eggs: Fluchter and Rosenthal (1965) found the eggs positively buoyant until the day before hatching whilst Polonsky (1968) found the eggs slightly negatively buoyant. Seaton and Bailey (1971) reported both living and dead eggs slightly negatively buoyant. In artificial fertilization experiments carried out during the cruise it was found that non-viable eggs sank and viable eggs floated.

The bimodal distribution of the eggs (Figures 4, 5a and 5b) may be the result of either (a) an artifact of sampling, (b) a true distribution of spawning, (c) a distribution of the eggs due to a physical process, (d) predation on the buoyant eggs as they move towards the surface, or (e) some combination of these.

However, the bimodal distribution is confirmed by Bailey's (1974) results obtained in 1968 with a different sampling instrument and,although blue whiting adults have been observed to rise from 100-300m to the surface layers (Zilanov 1968), none were observed in the surface layers during the cruise. The temperature profiles for hauls 4 and 5 (Figures 5a and 5b) show layering of the water in the upper 50m. The eggs may be transported to the upper layers from the lower depths by vertical mixing and then retained above the thermocline by density changes associated with it, but there was a bimodal distribution of the eggs in haul 3 (Figure 4) when no thermocline was observed. An undulating layer, attributed to large numbers of Maurolicus muelleri (Gmelin) was found over much of the area covered by the cruise. The layer was found predominantly at 150-250m by day and 0-70m by night. Thus, they moved into the upper depth range of blue whiting eggs only at night, when many fish which feed visually have ceased to feed. Stomachs from Maurolicus taken at dusk were mostly empty but those from specimens caught during the afternoon were well filled. Stomach contents were examined from fifty Maurolicus caught in two separate trawls; specimens from each trawl contained blue whiting eggs which comprised a high percentage of the total food found in the stomachs.

Assuming blue whiting eggs are positively buoyant, therefore the reduction in numbers between 200m and 50m may have been due to predation by Maurolicus muelleri

at /

at these depths, as the eggs passed towards the surface.

The surface maximum of eggs may be caused by a build up of eggs which have floated up from deeper layers into a zone in which they are not subject to heavy predation.

Figure 5 also shows the vertical distribution of the larvae. There are two main maxima, the upper one at about 30m and the lower one at about 430m, very few being caught between 70 and 280m. Their distribution thus corresponds with, but is deeper than, that of the 'late' eggs. Many larval fish are negatively photosensitive and the disappearance of the older blue whiting larvae from the 10m depth has been noted previously (Henderson 1957).

ACKNOWLEDGEMENTS.

I should like to acknowledge the opportunity offered by the Ministry of Agriculture, Fisheries and Food, Lowestoft, to participate in the cruise aboard R.V. Cirolana and for the assistance I received. I am especially grateful to Dr D.H.Cushing for permission to make use of information and to publish some provisional results from the cruise. Analysis of the samples showing annual variations in abundance was carried out by present and past colleagues in the Edinburgh Laboratory (Dr G.T.D. Henderson, the late Mr V. Bainbridge and Mr G.A. Cooper).

REFERENCES.

Bailey, R.S. 1974 The life-history and biology of blue whiting in the northeast Atlantic. 1. The planktonic phase in the Rockall area. Mar. Res., 1974, (1).

Bailey, R.S. & Seaton, D.D. 1969 Observations on the spawning and distribution of spawning products of blue whiting at Rockall. I.C.E.S. C.M. 1969/F:31 (mimeo).

Bainbridge, V. & Cooper, G.A. 1973 The distribution and abundance of the larvae of the blue whiting, *Micromesistius poutassou* (Risso), in the north-east Atlantic 1948-1970. Bull. mar. Ecol., 8: 99-114.

Colebrook, J.M. 1960 Continuous plankton records: methods of analysis, 1950-1958. Bull. mar. Ecol., 5: 291-302.

Fluchter, J. & Rosenthal, H. 1965 Beobachtungen über das Vorkommen und Laichen des blamen Wittlings (*Micromesistius poutassou* (Risso) in der Deutschen Bucth. Helgolander wiss. meeresunters., 12: 149-145.

Hardy, A.C. 1939 Ecological investigations with the Continuous Plankton Recorder: Object, plan and methods. Hull Bull. mar. Ecol., 1: 1-57.

Henderson, G.T.D. 1957 The distribution of young *Gadus poutassou* (Risso). Bull. mar. Ecol., 4: 179-202.

Longhurst, A.R. Reith, A.D., Bower, R.E. & Seibert, D.L.R. 1966 A new system for the collection of multiple serial plankton samples. Deep Sea Res., 13, (2): 213-222.

Polonsky, A.S. 1968 Materials on the biology of poutassou. Rapp. P-v. Reun. Cons. perm. int. Explor. Mer, 158: 105-108.

Schmidt, J. 1909 The distribution of the pelagic fry and spawning regions of the gadoids of the North Atlantic from Iceland to Spain. Rapp. P-v. Reun. Cons. perm. int. Explor. Mer, 10: 1-229.

Seaton, D.D. & Bailey, R.S. 1972 The identification and development of the eggs and larvae of the blue whiting *Micromesistius poutassou* (Risso). J. Cons. perm. int. Explor. Mer, 34: 76-83.

Zilanov, V.K. 1968 Some data on the biology of *Micromesistius poutassou* (Risso) in the north-east Atlantic. Rapp. P-v. Reun. Cons. perm. int. Explor. Mer. 158: 116-122.

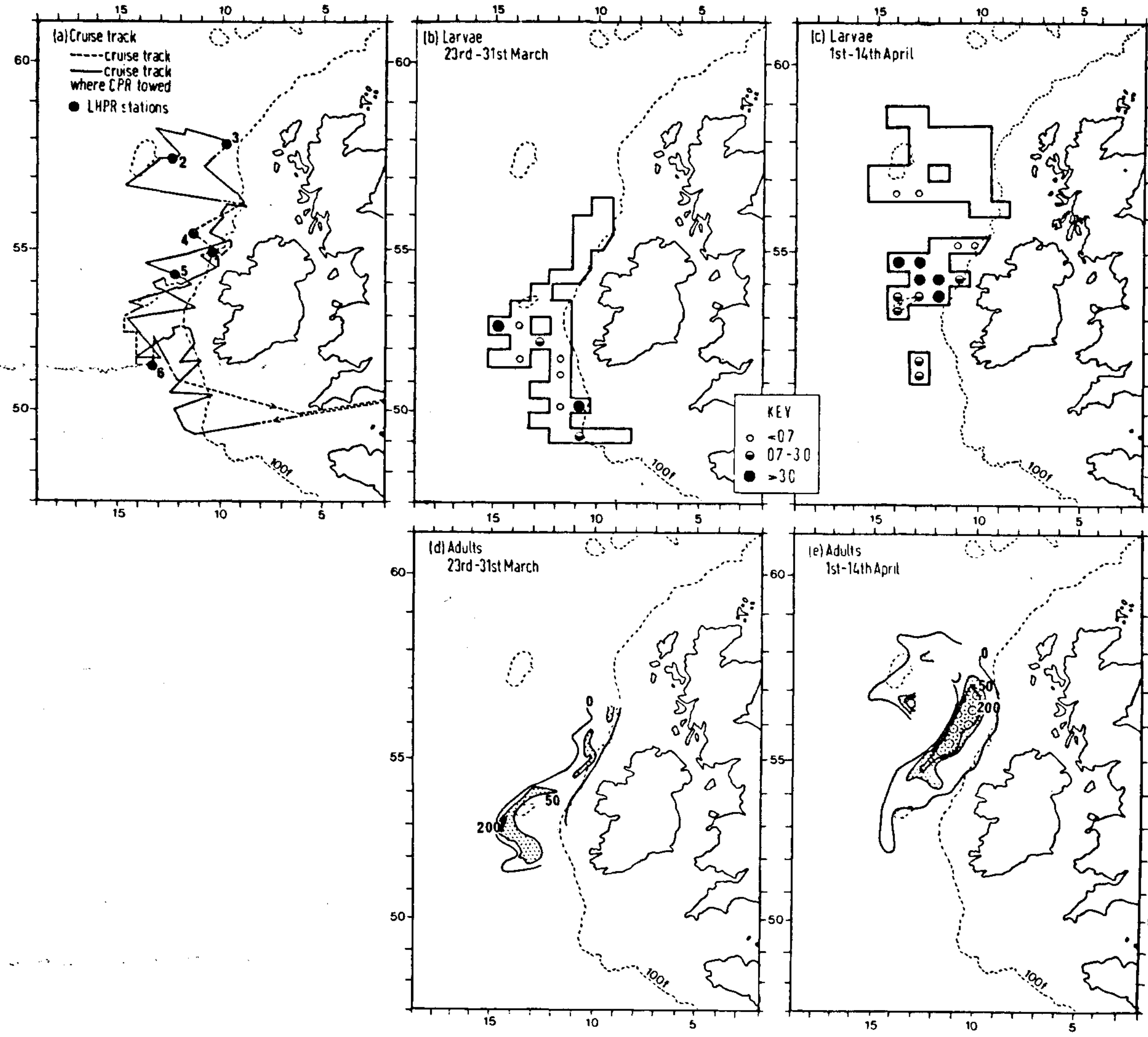

FIGURE 1. - (a) Cruise track 23 March-14 April 1974 showing positions of Continuous Plankton Recorder and Longhurst Hardy Plankton Recorder tows. (b) The distribution and abundance of blue whiting larvae during 23-31 March and (c) during 1-14 April as obtained from Continuous Plankton Recorder tows on the cruise. Symbols represent the average number per Recorder sample in each statistical rectangle of $\frac{1}{2}^{\circ}$ latitude by 1° longitude. The sampled area is outlined. (d) Provisional results from the acoustical survey (by MAFF, Lowestoft) showing adult distribution and abundance during 23-31 March and (e) during 1-14 April. Contour levels are relative echo abundance.

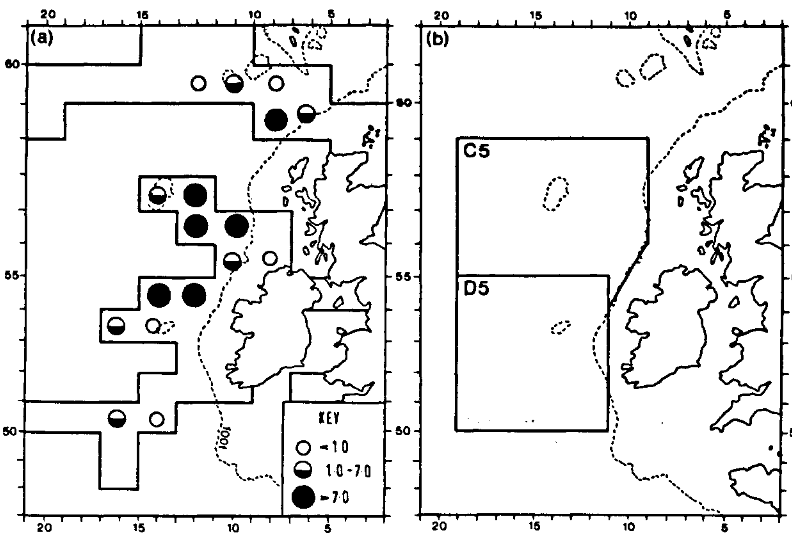

FIGURE 2. - (a) Results from the routine survey by CPR showing the distribution and abundance of blue whiting larvae for March, April and May 1974 combined. Symbols represent the average number per Recorder sample in each statistical rectangle of 1^{o} latitude by 2^{o} longitude. The sampled area is outlined.

(b) Chart showing sub-areas for which data are presented in Figure 3.

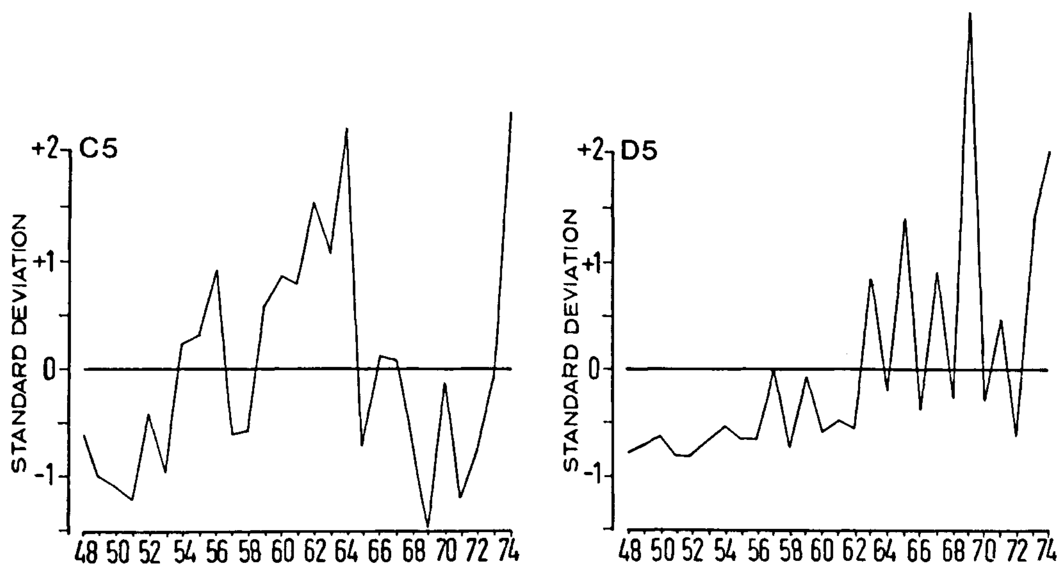

FIGURE 3. - Graphs showing fluctuations in annual abundance of blue whiting larvae for March, April and May in sub-areas C5 and D5. A logarithmic transformation was applied to the original counts; means for each rectangle were calculated and combined to give means per sample in each sub-area.

TABLE 1. - Numbers of blue whiting eggs and larvae from full depth range for each Longhurst Hardy Plankton Recorder haul.

Haul number	Total eggs	Total larvae	Early eggs Days 1&2 % of total	Late eggs Days 3&4 % of total	Day 1 Eggs % of total	Day 2 Eggs % of total	Day 3 Eggs % of total	Day 4 Eggs % of total
1st April 1	4	0	100	0	100	0	0	0
3rd April 2	12	0	83	17	83	0	17	0
6th April 3	418	0	98	2	95	3	1·5	0·5
8th April 4	764	22	56	44	24	32	26	18
10th April 5	55	58	24	76	0	24	52	24
13th April 6	2	2	50	50	0	50	50	0

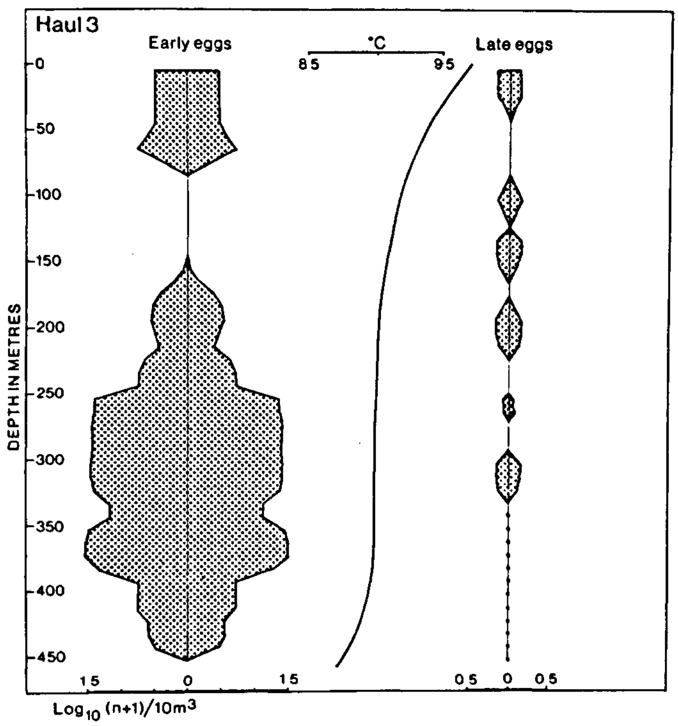

FIGURE 4. - Vertical distribution of blue whiting eggs at 10m depth intervals from Longhurst Hardy Plankton Recorder Haul No. 3, 6 April. "Early eggs" include all eggs at developmental stages found during the first two days of incubation and "late eggs" include all eggs at developmental stages found during the third and fourth days of incubation. The temperature profile taken concurrently with the haul is also shown.

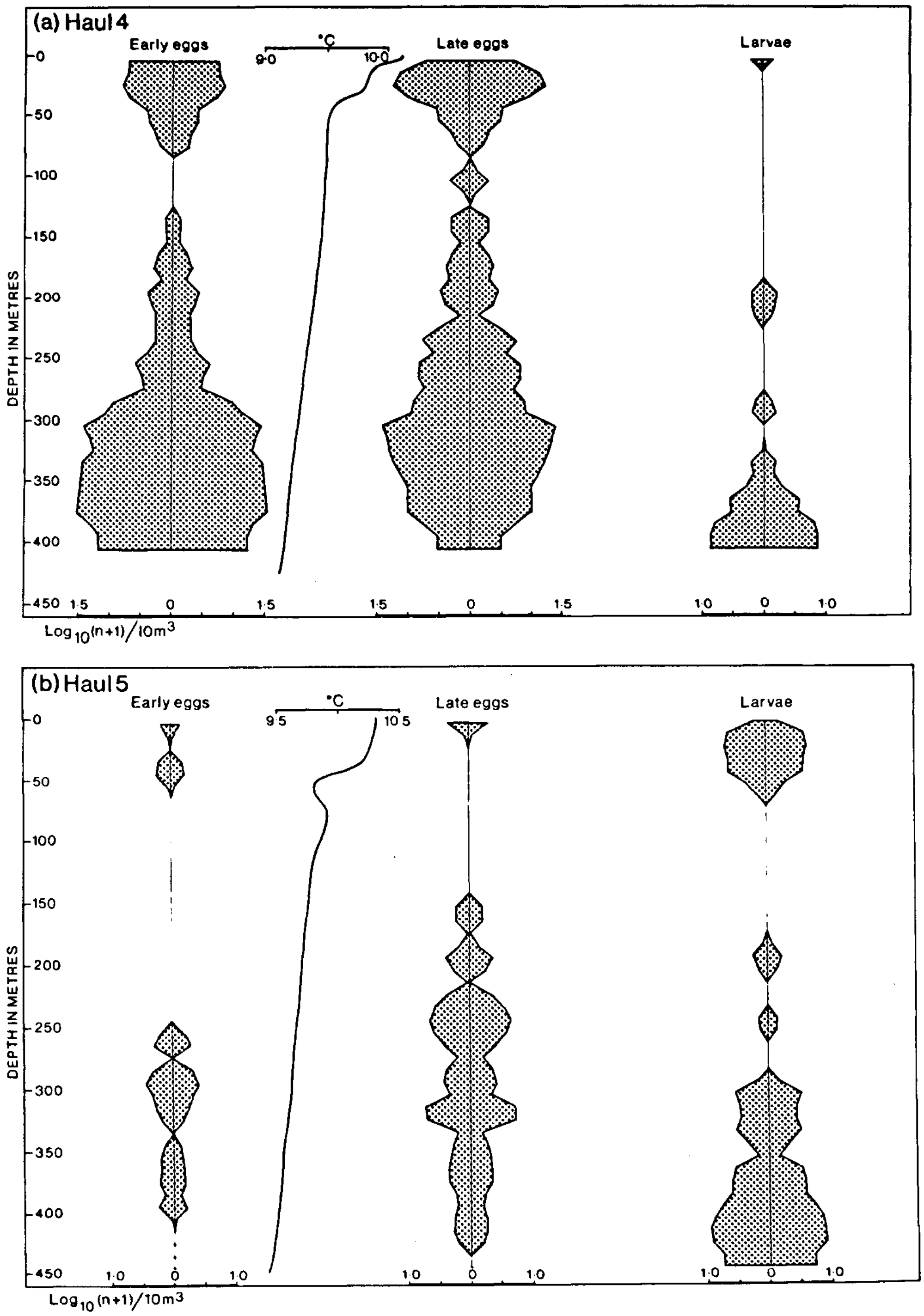

FIGURE 5. - Vertical distribution of blue whiting eggs and larvae at 10m depth intervals for Longhurst Hardy Plankton Recorder hauls. "Early eggs" include all eggs at developmental stages found during the first two days of incubation and "late eggs" include all eggs at developmental stages found during the third and fourth days of incubation. Temperature profiles taken concurrently with the hauls are also shown. (a) Haul No. 4, 8 April, (b) Haul No. 5, 10 April.