THIS PAPER NOT TO BE CITED WITHOUT PRIOR REFERENCE TO THE AUTHORS

International Council for the Exploration of the Sea

CM 1975/H:15
Pelagic Fish (N) Committee

RESULTS OF THE 1975 ACOUSTIC SURVEYS OF BLUE WHITING TO THE WEST OF BRITAIN

by

M G Pawson, Ministry of Agriculture, Fisheries and Food, Lowestoft, Suffolk

and

S T Forbes and J Richards, Department of Agriculture and Fisheries for Scotland, Marine Laboratory, Aberdeen, Scotland

INTRODUCTION

Following the joint acoustic survey of the spawning stock of blue whiting, *Micromesistius poutassou* (Risso), to the west of the British Isles by Norwegian, Scottish and English Research vessels, in 1974, a similar survey was carried out by RV CIROLANA (MAFF) and RV EXPLORER (DAFS) in 1975. The blue whiting begin to congregate at the edge of the slope of the continental shelf in March, and RV CIROLANA surveyed from a position south of Porcupine Bank to 57°30'N, including Rockall Bank, at this time. After an inter-ship calibration exercise with RV CIROLANA, RV EXPLORER continued the survey to the north, to 61°N between the Faroes and Shetland. RV CIROLANA surveyed the whole of this area in April, to 61°30'N, and again in May, to 64°N. This report describes the work of the two ships, and the distribution and preliminary estimates of abundance of the blue whiting in the spawning area.

METHODS

Lowestoft method

Signals from a range gate containing the blue whiting traces were fed to a Simrad QM integrator via a Kelvin Hughes 30 kHz Humber gear using a 20 log R + 2 α R time varied gain amplifier (Burridge *et al*, 1973). A hull-mounted transducer was used throughout the surveys, which were run at a maximum speed of 10 knots, but at lower speeds during bad weather. The range gate was set manually to follow the (usually) easily identifiable blue whiting layer, and ship, sea and reverberation noise levels were measured in order to set the amplitude threshold. Data were printed out at the end of each nautical mile, when the logger and integrator were automatically reset. The acoustic parameters of the system were measured during CIROLANA's cruise in January 1975.

Using 20 log R + 2 α RdB time varied gain the recorded integrated voltages are proportional to fish numbers or biomass, and are independent of the vertical range. After scrutiny of the echo records to delete false echoes and to determine the distribution of blue whiting, the mean integrated voltage per transmission for each nautical mile was raised by a calibration constant to give a fish density. These values were plotted on the survey track charts and contoured, and the contour interval areas could then be raised by their mean density to give total biomass. The calibration constant was derived from the acoustic parameters of the transducer, the gain of the system and the target strength of blue whiting.

Aberdeen method

On EXPLORER the equipment consisted of a Simrad EK38 scientific sounder, with its transducer mounted in a towed body, and the Marine Laboratory Digital Echo Integrator. The entire survey was conducted at a speed of 10 knots. The echo-sounder was used with 20 log R time varied gain, a 3 mS pulse length and 1 kW output power, and signals were taken from the calibrated output to the Echo Integrator. Three depth channels are available from the integrator, but only data from 275 m to 600 m, or to the bottom where shallower, were utilised, as this depth range included practically all the blue whiting echoes with very few unwanted signals.

The output from the integrator was logged manually at half hourly intervals, together with the number of transmissions, and converted to a mean integral per transmission for each period. These figures were then converted to fish density in tonnes per square kilometre by multiplying by a conversion factor based on calibration data obtained from measurements on a standard target, assuming a mean back scattering coefficient for blue whiting of -34 dB per kilogramme. The mean density for the survey track was then calculated, and raised by the area surveyed to give the total biomass.

Calibration was performed by measuring the signal from a brass ball of known target strength using the same echosounder settings as for the survey, and integrating this signal for about 100 transmissions. The target strength was converted to an equivalent scattering coefficient using the effective beam solid angle of -18 dB with reference to one steradian, thus giving the integrator output for a known scattering coefficient.

RESULTS

Distribution

The blue whiting distributions are shown in Figure 1. Towards the end of March the fish were lying in a patchy layer 20 to 50 m thick, at a depth of 380-500 m, rising to a minimum of 280 m at the edge of the continental shelf and banks and in deeper water during darkness. The main concentrations in CIROLANA's survey area

(Figure 1a) were on the southern and western sides of the Porcupine Bank, close to the edge of the shelf, but to the north the fish remained over the deep water in the Rockall Channel. EXPLORER recorded blue whiting between the Lousy, Bailey and Faroe Banks and the Faroe Plateau and the 200 m depth contour to the west of the Hebrides, Orkney and Shetland. The highest concentrations were found to the north and south of the Wyville-Thomson Ridge, towards the eastern edge of the fishes' distribution, and just off the edge of the shelf west of St Kilda.

By April (Figure 1b) the most southerly fish appeared to have retreated to the north and moved closer to the edge of the continental shelf. The highest concentrations were recorded within 10 km of the 200 m contour on the easterly edge, and the majority appeared to be contained between this boundary and Lousy, Bailey and Faroe Banks and the Faroe Plateau on the west and north. Only a small proportion occurred to the north of the Wyville-Thomson Ridge. Over the whole area the blue whiting were confined to a 20-40 m thick layer at 300 to 500 m depth, which thickened and intensified towards the edges of the banks and shelf.

The May survey indicated that the main body of fish had moved quickly to the north of the Wyville-Thomson Ridge, leaving only a narrow (10 km) band along the edge of the continental shelf running northwards from 55°N (Figure 1c). The blue whiting were concentrated south of the Faroes and extended northwards along the east, and possibly west, sides of the Plateau. Identification of traces during this survey was difficult due to the fish having scattered towards the surface, particularly in the north.

QUANTITIES

The biomass of blue whiting calculated for each survey depends mainly on the target strength used. Estimates range from -29.1 dB/kg, based on measurements of single, dead blue whiting with swimbladders intact made during CIROLANA's 1974 survey (Forbes *et al*, 1974) to -34 dB/kg (Nakken and Olsen, 1973). This latter value was also obtained from single, dead fish, but the maximum target strength is corrected for the mean aspect assumed for blue whiting in the sea. Goddard and Welsby (1973) measured the target strength of gadoids swimming freely in a cage and their "all species" equation gives a mean value of -32.2 dB/kg for a large number of observations of dorsal aspect target strengths. The quantities of blue whiting obtained with each of these target strengths for the 1975 and 1974 surveys respectively, are given in Table 3. The increased stock estimate of the 1975 April survey over that obtained in 1974 may be due to the relatively late spawning of blue whiting in 1974, when fish were probably still entering the survey area during the cruises.

Another source of bias is due to the fact that the attentuation of acoustic energy between transducer and target is different from the compensation by the TVG amplifier. If the attenuation coefficient (α) is too large the biomass will be overestimated. Underestimates of stock may result if the sampling volume of the transducer beam is limited by noise at the target range, and although this error was corrected in CIROLANA's 1974 survey results, the present analysis assumes no noise limitation. It is unlikely that CIROLANA's stock estimates are biased by the method used to calculate the mean density from the integrated voltage per nautical mile, since the variance of the data in each density contour interval is smaller than the mean.

BIOLOGY

Echo traces were sampled, using mid-water or bottom trawls where necessary, to identify the species present and to collect biological data on blue whiting. A representative sample of blue whiting from each catch was measured and otoliths (5 or 10 per cm size group) collected. The otolithed fish were also examined to determine sex, maturity stage, level of parasitic infection and stomach content. Fish were also sampled for measurement of weight and length during the April survey by CIROLANA.

The mean lengths of blue whiting were very similar on each of the CIROLANA surveys and on the EXPLOERER survey, ranging from 29.7 to 30.2 cms and with the overall length distributions being unimodal (Figure 2). Male blue whiting had a lower modal length (28-30 cm) than females (31-32 cm). This reflects the lower mean length at age for males (Table 1), the percentage age distribution of the two sexes being similar (Figure 3). The largest male and female fish recorded were 39 cm and 45 cm respectively.

The age composition of the fish sampled (Figure 3) suggests that recruitment to the spawning stock is not complete until an age of 8-9 years. However, all the fish appear to be mature by the time they reach a length of 27 cm for males and 28 cm for females (Figure 4), that is at 5 years old (Table 1). This suggests either that not all the younger mature fish spawn to the west of Britain, or that the length/maturity curves are not representative, or possibly that some fish although having passed the age of first maturity do not spawn every year, the percentage not spawning decreasing with age.

Although the distribution of maturity stages varied considerably from haul-to-haul during the surveys, a clear trend can be seen with time (Table 2). In the March cruise no spent fish were recorded and over 50% of both males and females were at stage 1, ie maturing with small eggs visible to the naked eye. During April the proportion of spent and recovering fish increased, until by the middle of May less than 15% appeared not to have already spawned. At any one time the number of ripe or running fish was very small, less than 5%. Whether this reflects very rapid ripening or avoidance of the trawl by spawning fish was not determined.

The fish did not appear to be feeding during March and early April, although swimbladder distension during hauling from 300 or 400 m depth could result in some loss of food from the stomach. In late April, however, some fish caught at similar depths contained food, and by May between 95 and 100% had food in their stomachs when sampled. A high incidence of nematode infection of the body cavity was noticed throughout the surveys.

A weight/length relationship of $W = 7.2\ L^{2.886}\ 10^{-3}$ was obtained from the April data.

REFERENCES

BURRIDGE, A. J., and others, 1973. Time-varied gain echo sounder receiver systems for use with fish echo signal processing equipment. ICES/ICNAF/FAO Symp. on Acoustic Methods in Fish. Res., Bergen 1973, paper 27, 13 pp.

FORBES, S. T., and others, 1974. The Blue Whiting Surveys by RV SCOTIA and RV CIROLANA. ICES CM 1974/H:44, Demersal Fish (Southern) Committee, 9 pp.

GODDARD, G. C., and WELSBY, V. G., 1973. Statistical Measurements of the Acoustic Target Strength of Live Fish. ICES/ICNAF/FAO Symp. on Acoustic Methods in Fish. Res., Bergen, 1973, paper 40, 9 pp.

NAKKEN, O. and OLSEN, K., 1973. Target strength measurements of Fish. ICES/ICNAF/FAO Symp. on Acoustic Methods in Fish. Res., Bergen, 1973, paper 24, 31 pp.

TABLE 1 Mean length at age of Blue Whiting

Length cm		
Age	Males	Females
1	-	-
2	17.1	-
3	21.6	23.6
4	24.5	26.0
5	27.0	28.4
6	28.2	30.6
7	29.3	31.2
8	29.8	31.2
9	29.6	31.7
10	29.6	32.0
11	30.5	32.6
12	30.1	32.1
13	30.0	31.9
14	28.6	32.5

TABLE 3 Estimates of Blue Whiting stock (10^6 t) using different target strengths

Target strength db/kg	March 1975		April 1975	May 1975	April 1974
	CIROLANA	EXPLORER			
29.1	2.7	2.1	22.8	3.3	5.4
32.2	5.5	4.2	47.9	6.9	11.0
34.0	8.4	6.3	70.9	10.4	16.6

TABLE 2 The percentage distribution of maturity stages for Blue Whiting

Cruise		♂							♀						
		0	1	2	3	4	5	6	0	1	2	3	4	5	6
CIROLANA 3b/75 9 March	%	0	82	11	7	0	0	0	0	57	9	29	5	0	0
EXPLORER 2/3 April	%	6	43	33	18	0	0	0	2	50	47	1	0	0	0
6 April	%	7	0	0	58	4	31	0	5	3	2	46	0	45	0
CIROLANA 4/75 9-24 April	%	0.6	22	8	0	2	15	52	6	37	10	1	1	7	38
CIROLANA 5/75 14/19 May	%	14	9	0	3	1	19	55	9	35	7	5	2	20	22

0 - Immature

1 - Maturing and recovering

2 - Ripening 1/3

3 - Ripening 2/3

4 - Running

5 - Spent - with gametes remaining

6 - spent - recovering

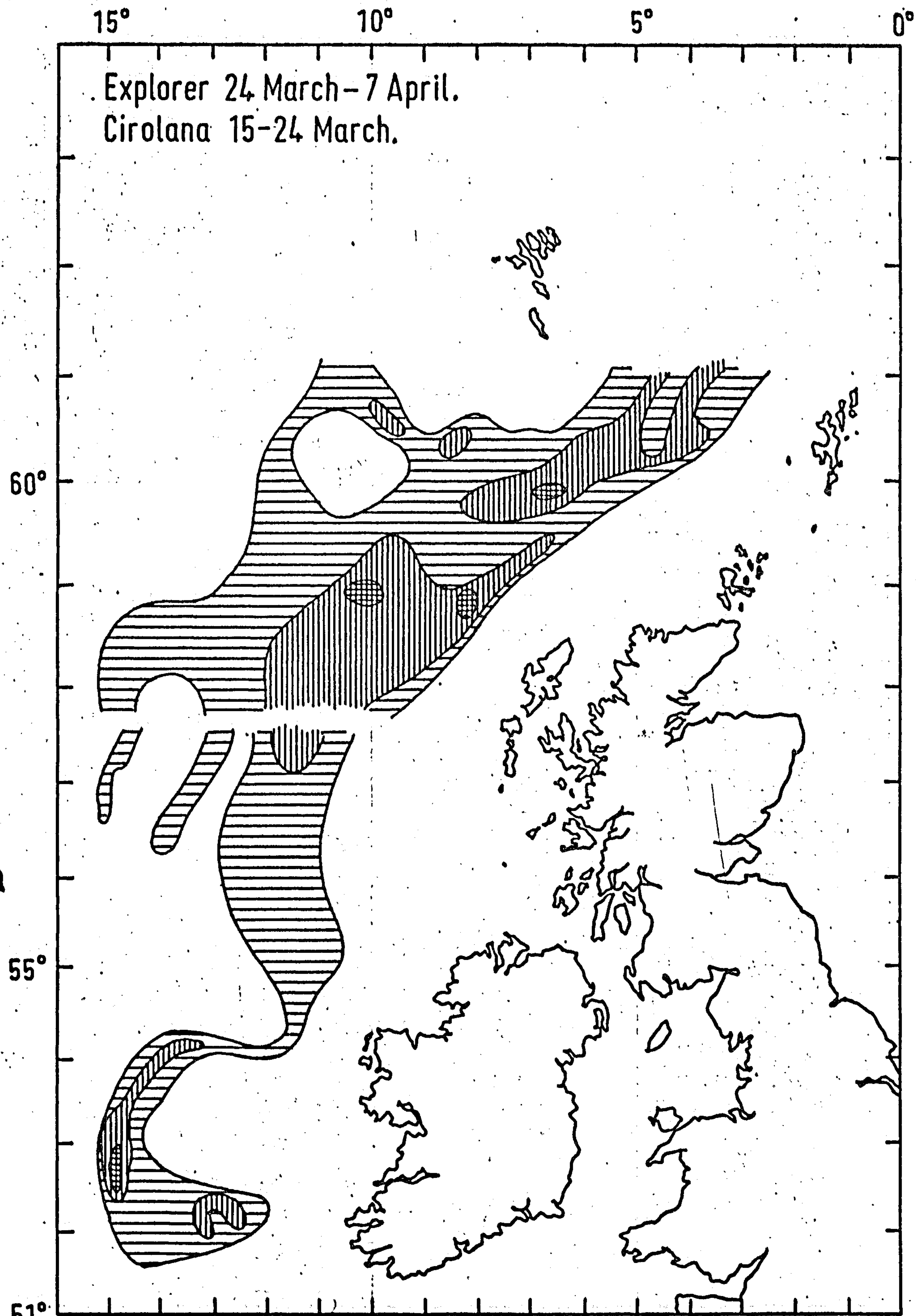
15°
10°
5°
0°
Explorer 24 March – 7 April.
Cirolana 15–24 March.
60°
55°
51°

Figure 1a

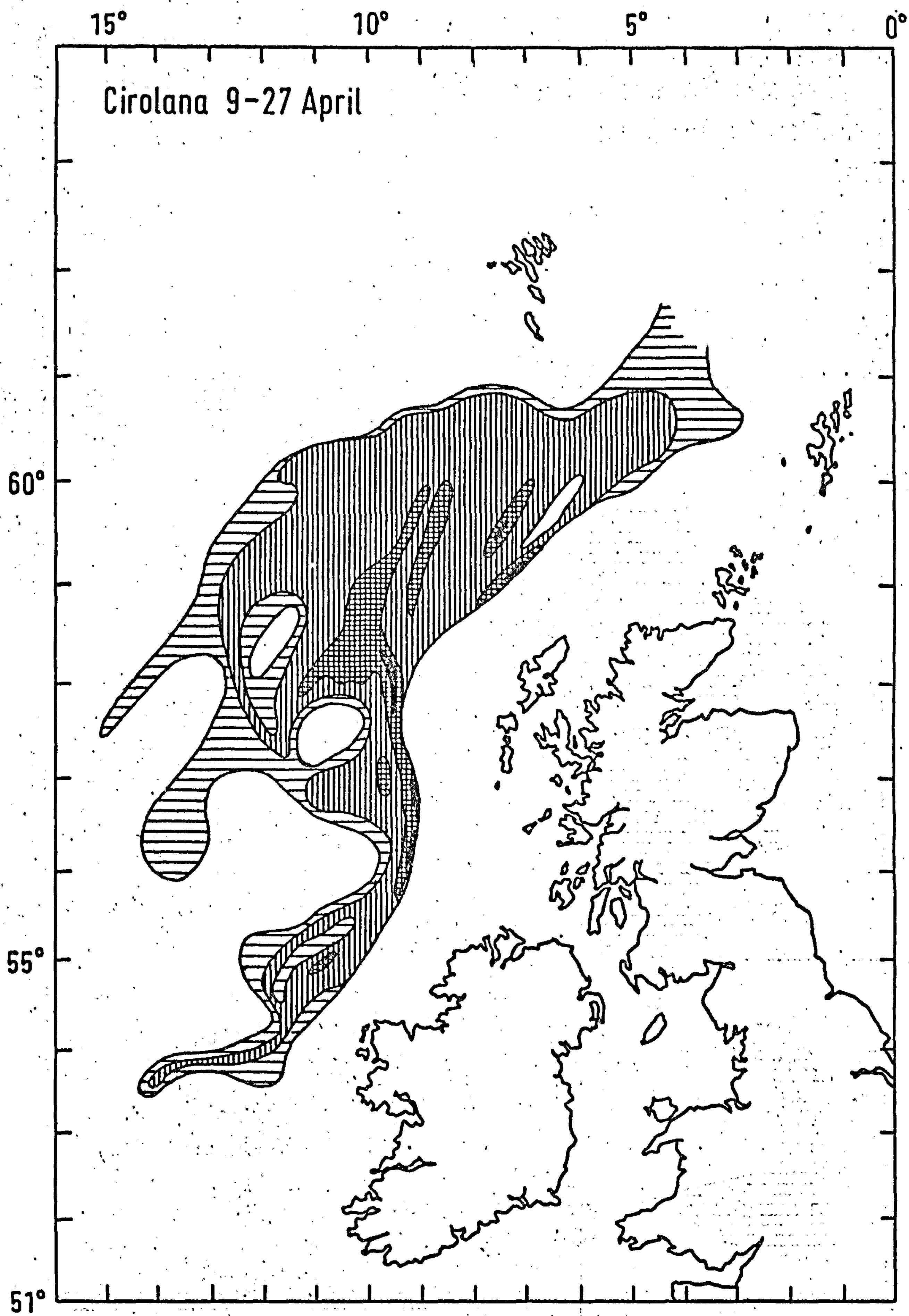

Figure 1b

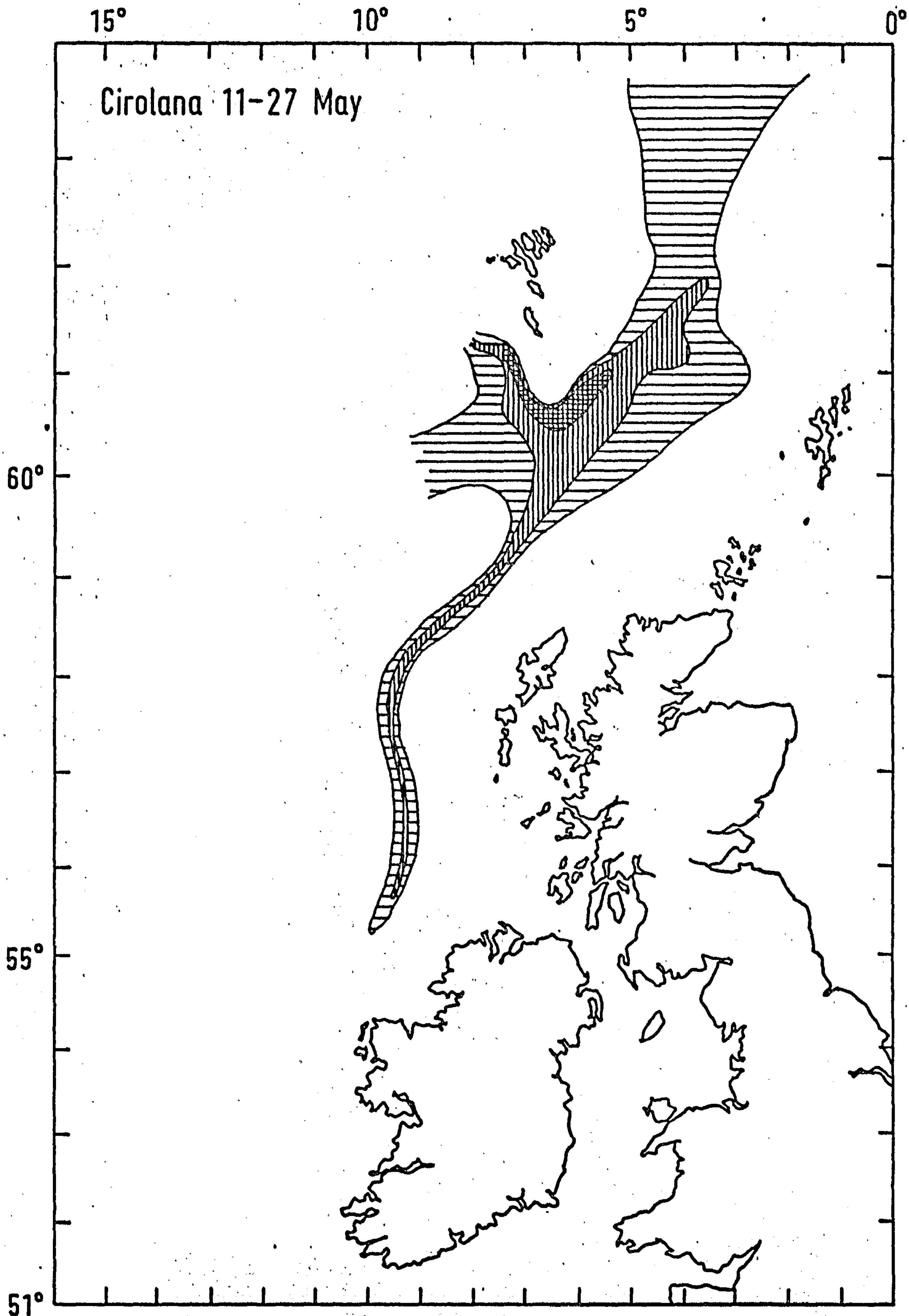

Figure 1c

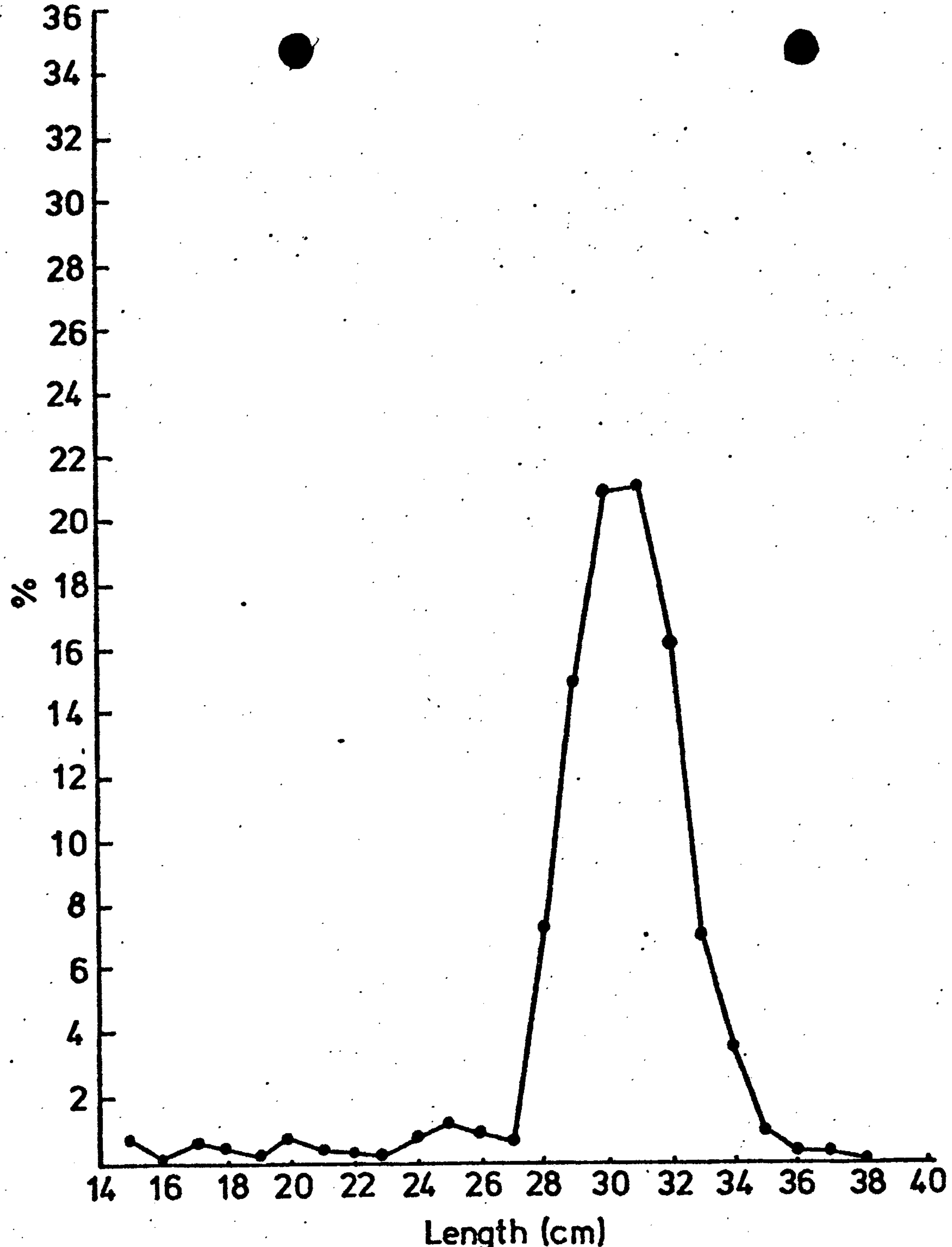

Fig 2. The Percentage Length Distribution of Blue Whiting Caught in April 1975.

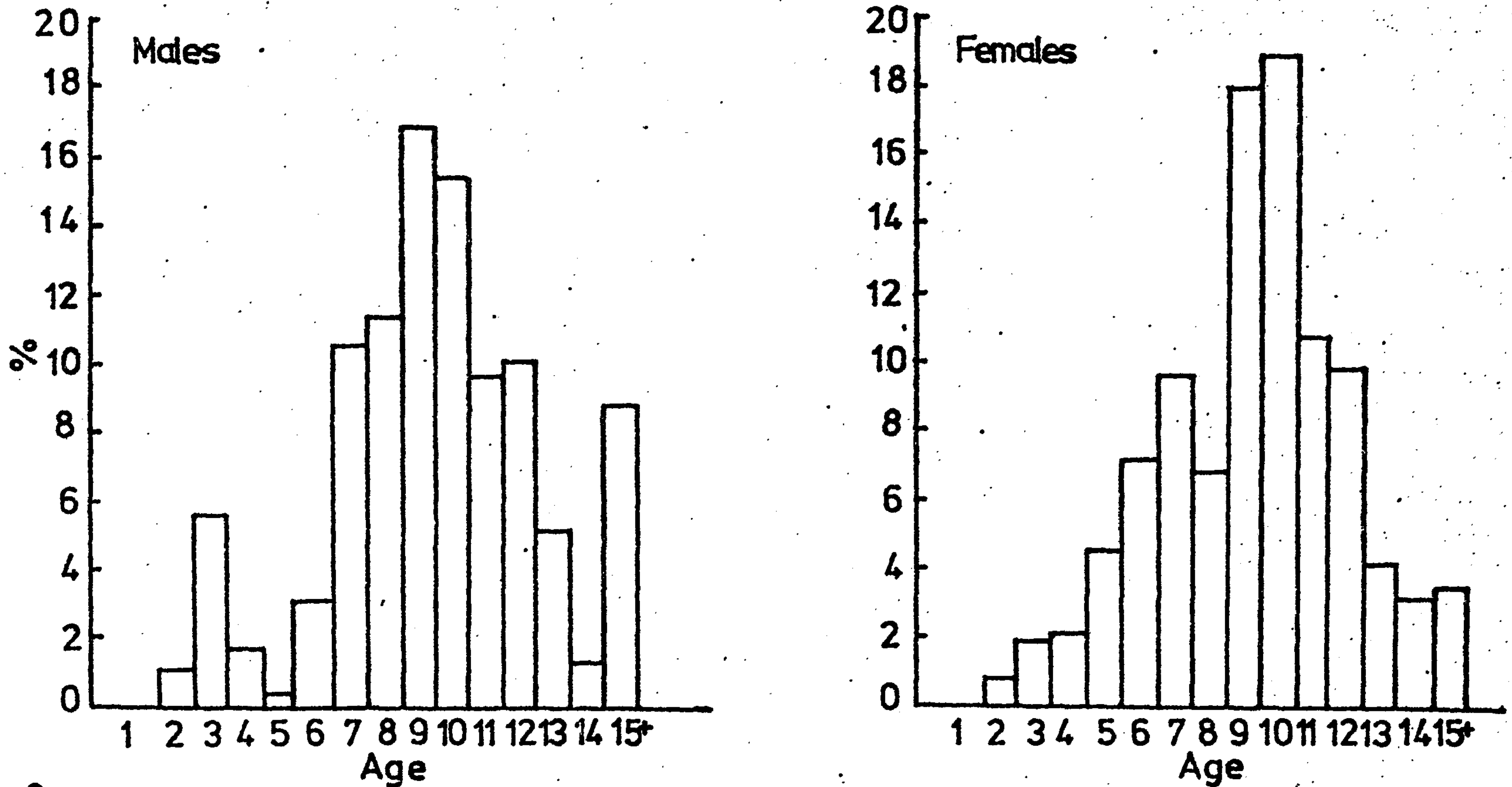

Fig 3 The Percentage Age Distribution of Blue Whiting Caught in April 1975.

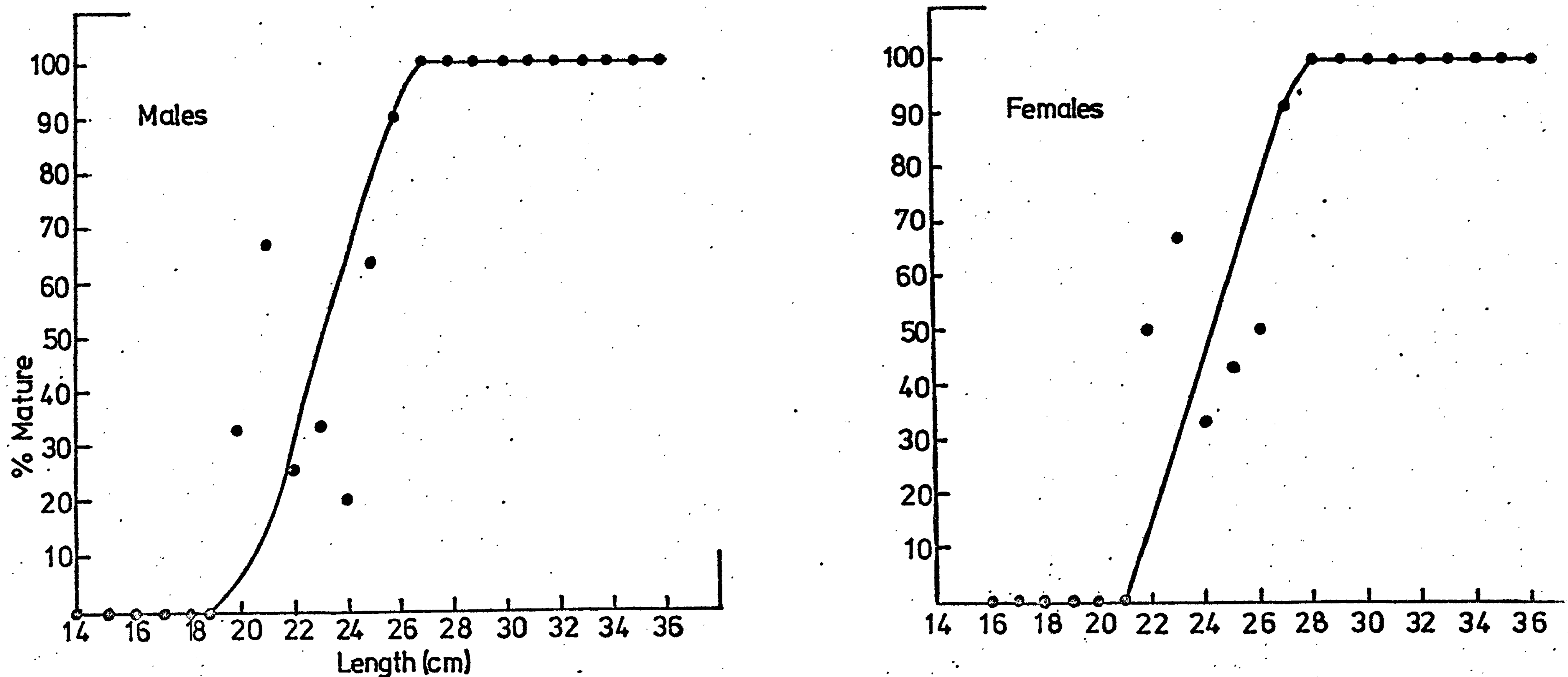

Fig 4. The Percentage of Mature Blue Whiting as a Function of Length.