

ABUNDANCE ESTIMATES OF THE SPAWNING STOCK OF
BLUE WHITING (*MICROMESISTIUS POUTASSOU* (RISSE, 1810))
IN THE AREA WEST OF THE BRITISH ISLES IN 1972—1974

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ABSTRACT

BUZETA, R. and NAKKEN, O. 1975. Abundance estimates of the spawning stock of blue whiting (*Micromesistius poutassou* (Risso, 1810)) in the area west of the British Isles in 1972—1974. *FiskDir.Skr.Ser.HavUnders.*, 16: 000—000.

An analysis is made on the blue whiting data from the echo surveys conducted during 1972—1974 for assessment of the spawning stock west of the British Isles.

Acoustic data are evaluated using a length dependent density coefficient.

Area and time coverage are discussed for each survey. Mean density and total abundance are calculated for the three years in the investigated area, and a stock size of approximately 6 million tons is suggested for the spawning stock.

INTRODUCTION

The stock of blue whiting has been surveyed for the last three years during the spawning period using the research vessel «G. O. Sars» (JAKUPSTOVU og MIDTTUN 1972, MIDTTUN and NAKKEN 1973, BUZETA *et al.* 1974). The survey grid, trawl stations and fish distribution are shown in Fig. 1—3. The technique applied is described by FORBES and NAKKEN (1972), MIDTTUN and NAKKEN (1973) and DOMMASNES and NAKKEN (1975). The concentrations of spawning blue whiting have been surveyed twice each year — from the Shetland area and southward to 52° N and then northward again. Abundance estimates based on echo integrator data have been worked out for each survey (MIDTTUN and NAKKEN 1973, BUZETA *et al.* 1974). These estimates are listed in Table 1. The figures show large variation, both within and between years. They are, however, based on the assumption that the scattering cross section of blue whiting is proportional to its weight, a rather rough approximation. Both the area and time coverage of the survey have varied from year to year. The time of maturing and accordingly the amount of fish on the spawning grounds may have varied from survey to survey, and the estimates should therefore be considered as fractions of the total spawning stock. In the present paper the acoustic and biological material from the cruises are analyzed in more detail, and some of the factors affecting the fluctuation of the abundance estimates are discussed.

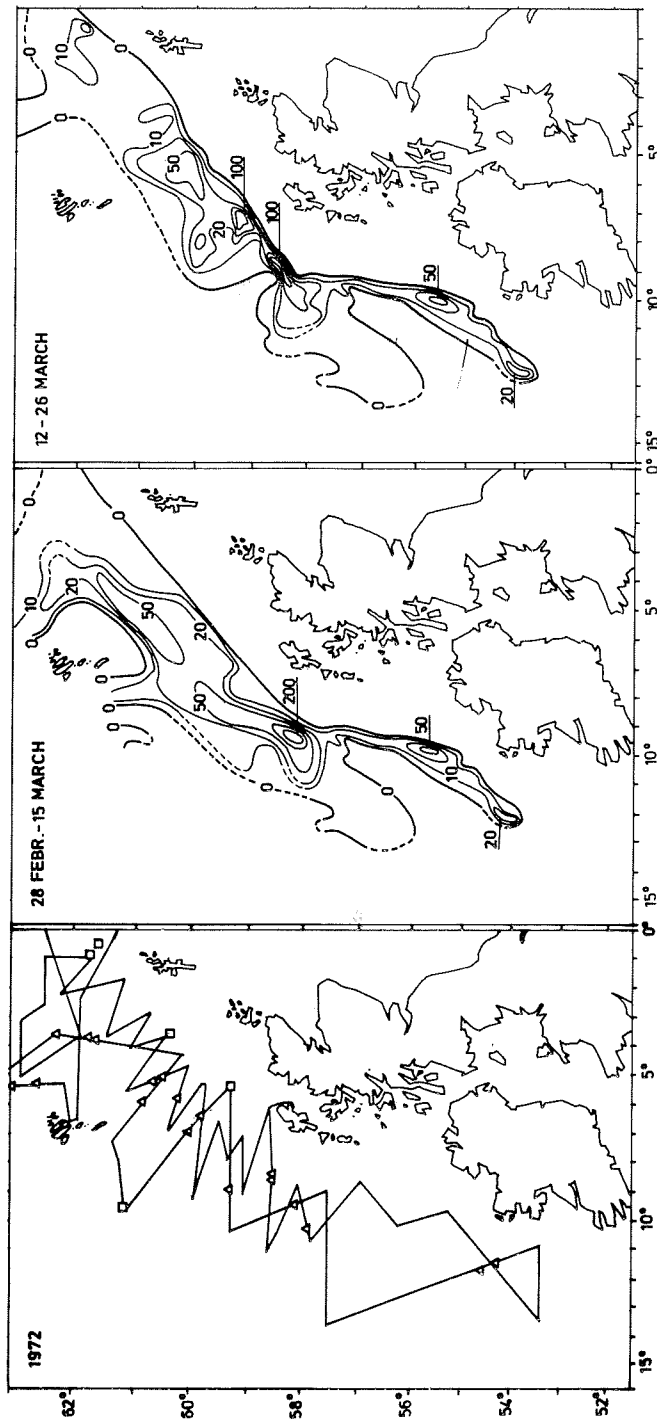


Fig. 1. Survey grid, trawl stations and distribution of integrated echo intensity (mm deflection) in 1972.

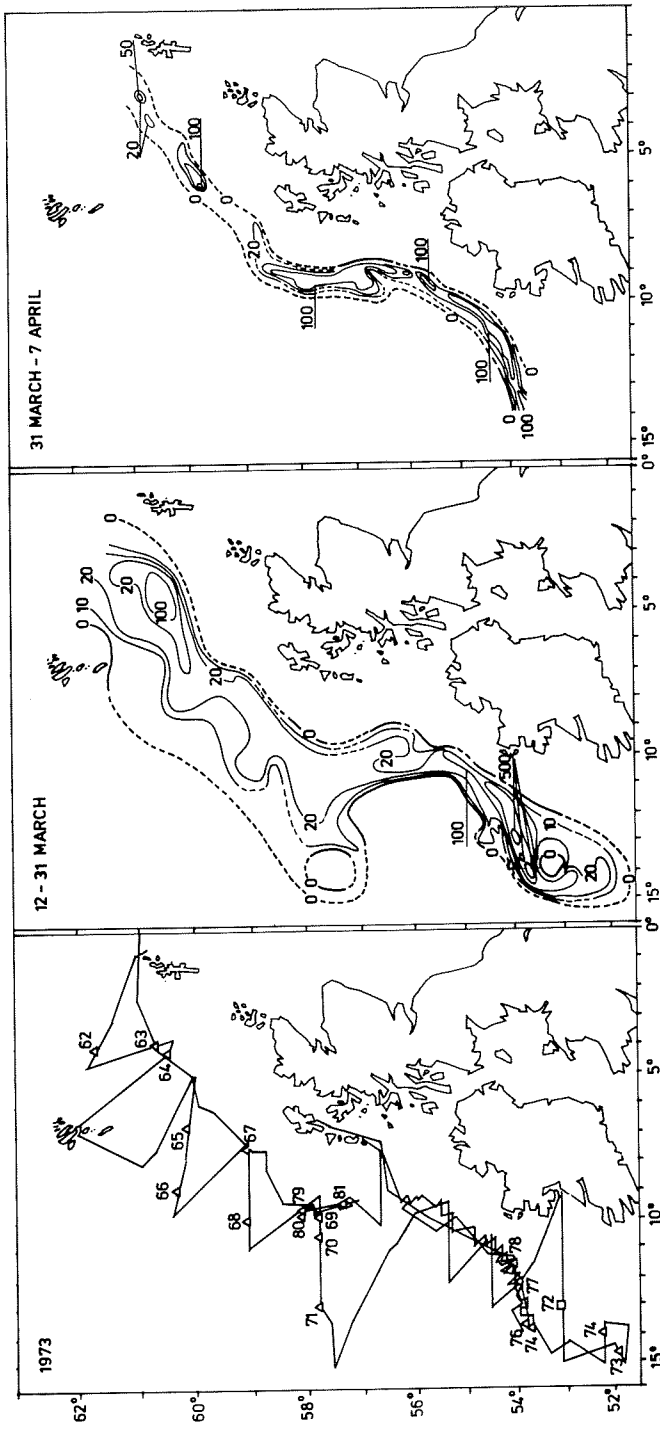


Fig. 2. Survey grid, trawl stations (numbered) and distribution of integrated echo intensity in 1973.

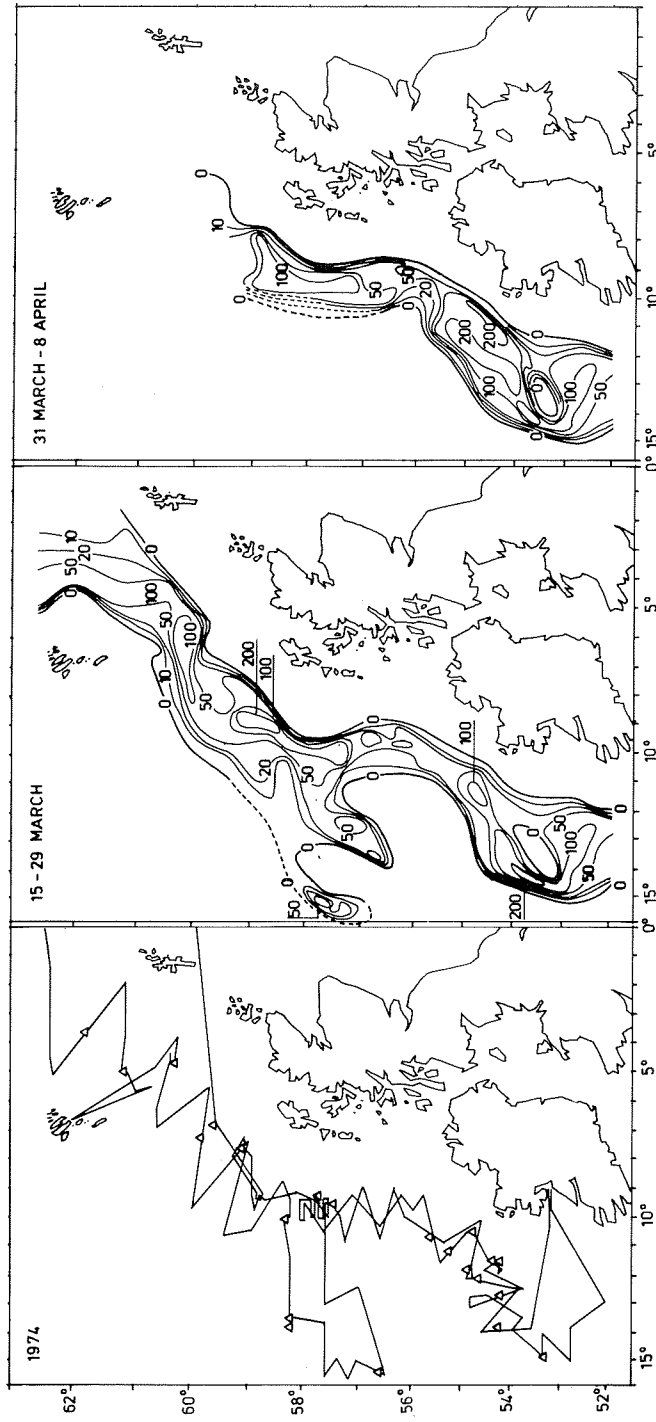


Fig. 3. Survey grid, trawl stations and distribution of integrated echo intensity in 1974.

MATERIAL AND METHOD

The method applied during the acoustic surveys is described by FORBES and NAKKEN (1972) and MIDTTUN and NAKKEN (1973). More details are given by CRAIG (1973) and DOMMASNES and NAKKEN (1975). The relation between fish density, ϱ_A , and integrated echo intensity, M , is:

$$\varrho_A = C \cdot M + b \quad (\text{I})$$

where ϱ_A is the number of fish per unit area and M is the integrated echo intensity. The density coefficient C represents the density of fish causing 1 mm deflection on the echo integrator, and it is a constant as long as fish specie and size remains constant. The constant b is a threshold density. Below this there is no contribution to the integrated echo intensity.

When three size groups of fish contribute to M , the following expressions for the density of fish within each size group are valid (DOMMASNES and NAKKEN 1975):

$$\begin{aligned} \varrho_{A1} &= k_1 \cdot K \cdot M \\ \varrho_{A2} &= k_2 \cdot K \cdot M \\ \varrho_{A3} &= k_3 \cdot K \cdot M \end{aligned} \quad (\text{II})$$

and

$$K = \frac{C_1 \cdot C_2 \cdot C_3}{k_1 \cdot C_2 \cdot C_3 + k_2 \cdot C_1 \cdot C_3 + k_3 \cdot C_1 \cdot C_2}$$

where k_i is the percentage of the i -th sizegroup in the catches, and C_i is the value of C for the length L_i . The numerical values of the density coefficient, C_i , are found from a L - C cruve (Fig. 4).

The total number of fish in the i -th sizegroup within an area A is given by

$$N_i = \int_A \varrho_A da = \overline{k_i \cdot K} \int_A M \cdot dA \quad (\text{III})$$

where the bar denotes the average over the area A . Finally, the total weight of each sizegroup is found by applying a weight—length relationship. Due to the relative low number of trawl stations, length data from the whole area were pooled each year, and consequently k_i and C_i were averaged over the whole investigated area.

RESULTS

The abundance estimates, which are given in Table 1, were recalculated according to the procedure outlined above. The relation between the density coefficient and the length of blue whiting is shown in Fig. 4.

Table 1. Estimates of abundance and mean density from the different surveys (MIDT-TUN and NAKKEN 1973, BUZETA *et al.* 1974).

Year	Survey	Period	Trawl station	Area (NM ²)	Abundance (Ton)	Density (Ton/NM ²)
1972.....	1 (S)	28.2—15.3	20	41 940	4.4×10^6	104.9
	2 (N)	12.3—26.3	11	33 090	2.7×10^6	81.6
1973.....	3 (S)	12.3—30.3	17	94 500	10.7×10^6	113.2
	4 (N)	31.3— 7.4	3	12 960	4.0×10^6	208.6
1974.....	5 (S)	15.3—29.3	16	67 500	1.8×10^6	36.6
	6 (N)	31.3— 8.4	8	34 950	1.8×10^6	51.5

(S) Southward crossing.

(N) Northward crossing.

NM Nautical mile.

The curve is based on the target strength—length relationship reported by NAKKEN and OLSEN (1973) and on the values of the density coefficient arrived at by MIDTTUN and NAKKEN (1973) and BUZETA *et al.* (1974). The change in the ordinate scale from 1973 to 1974 is caused by a change in the settings of the echo sounder onboard the «G. O. Sars».

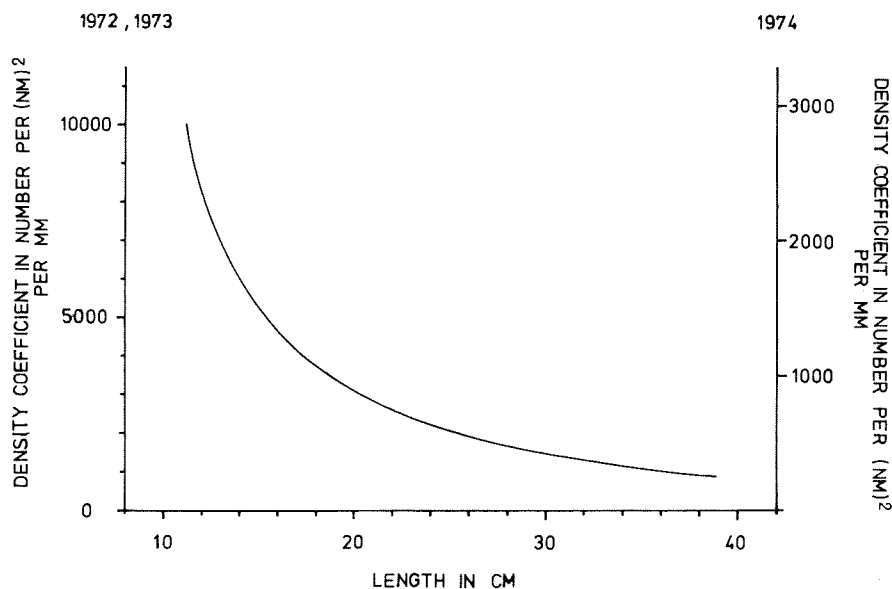


Fig. 4. The density coefficient C as a function of length for blue whiting the different years.

The length distributions of the blue whiting are given in Fig. 5. In these distributions the three modal groups were selected as size-groups, and C -values corresponding to the modal lengths were found in Fig. 4. The values of k were also found from the length distributions in Fig. 5 by accumulation of the percentages within each modal group. The age of the fish within each of the three modal length groups was found from Fig. 6. This figure shows the age—length relationship for blue whiting as per available literature.

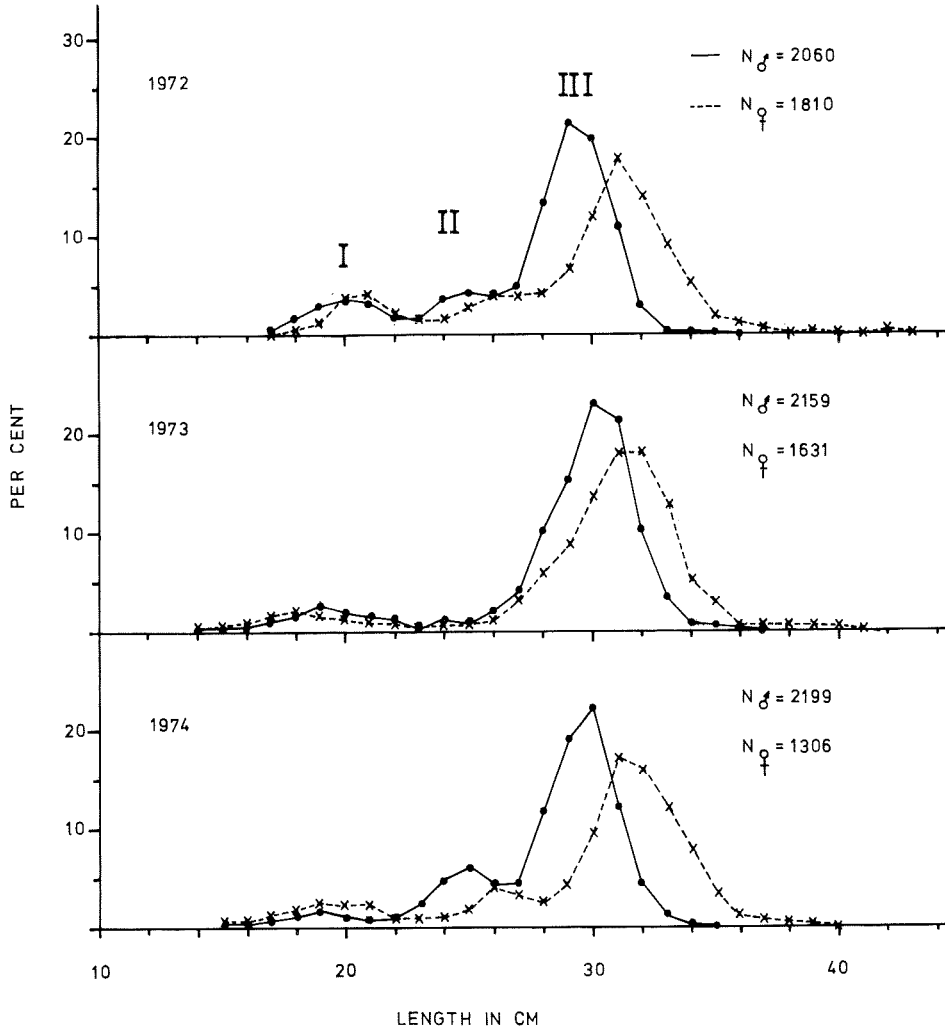


Fig. 5. Length distribution of blue whiting in the samples. (I, II and III are modal lengths).

Table 2. Estimated weights (gr) of blue whiting according to length the different years.

Year	Length (cm)													Weight-length relationship and correlation coefficient
	14	16	18	20	22	24	26	28	30	32	34	36	38	
1972			33	46	63	82	106	134	166	203	246	295	349	W = 0.0037 L ^{3.15} r = 0.99
1973	14	22	32	45	61	81	105	134	167	206	250	301	359	W = 0.0028 L ^{3.24} r = 0.99
1974		23	33	46	61	80	102	128	159	194	233	278	329	W = 0.0045 L ^{3.08} r = 0.99

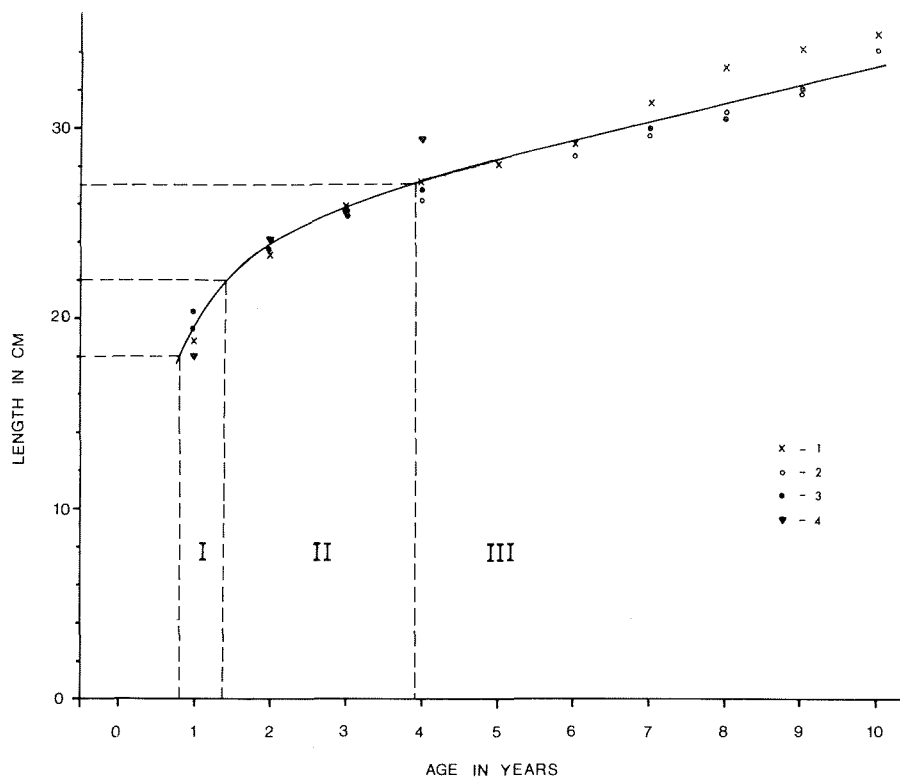


Fig. 6. Blue whiting growth curve (Data in RAITT 1968).

- 1) The western coast of Scotland (RAITT 1966),
- 2) the Færoes (RAITT 1966),
- 3) Iceland (RAITT 1966),
- 4) Iceland (SÆMUNDSSON 1929).

I, II and III are modal lengths according to length distribution in the samples.

The weight—length relationship of blue whiting for the three years are shown in Table 2. The figures in the table are estimated weights using the length-weight equation.

In Table 3 are listed the observed values of the different parameters used in the calculations and the estimates of abundance for each size-group and year.

Table 4 gives the total abundance in number and tons, the sampled area and the average density in tons per unit area for the three years. The percentages of fish in the different maturity stages are also shown in Table 4. From the correlative changes in percentage from mature to spent fish between the first and the second part of the cruise the top of the spawning season is indicated.

Table 3. Corresponding values of modal length (L), density coefficient (C), calculated weight (W), length frequency (k) and relative and absolute abundance in each modal length group the different years.

Year	L (cm)	C (n/mm/ (nm) ²)	W (gr)	k %	Relative abundance (mm.(nm) ²)	Absolute abundance	
						(number)	(tons)
1972...	20	3 200	46	13	11 . 10 ⁶	2.2 . 10 ⁹	0.10 . 10 ⁶
	25	2 100	93	9		1.7 . 10 ⁹	0.16 . 10 ⁶
	30	1 500	166	78		14.3 . 10 ⁹	2.37 . 10 ⁶
1973...	18	3 700	32	10	26 . 10 ⁶	4.1 . 10 ⁹	0.13 . 10 ⁶
	30	1 570	167	90		38.9 . 10 ⁹	6.49 . 10 ⁶
1974...	19	1 133	39	9	31 . 10 ⁶	1.5 . 10 ⁹	0.06 . 10 ⁶
	25	700	91	18		3.1 . 10 ⁹	0.28 . 10 ⁶
	30	500	159	73		12.4 . 10 ⁹	1.97 . 10 ⁶

Table 4. Calculated abundance, density and observed maturity of sampled fish in per cent on the different cruises.

Year	Survey	Sampled area (nm ²)	Abundance (Tons)	Density (Ton/nm ²)	Maturity		
					I	M	S
1972.....	1 (S)	41 940	2.6 × 10 ⁶	62.6	19	75	6
	2 (N)	33 090	1.6 × 10 ⁶	49.1	36	46	18
1973.....	3 (S)	94 500	6.6 × 10 ⁶	70.1	75	22	3
	4 (N)	12 960	2.4 × 10 ⁶	190.4	1	77	22
1974.....	5 (S)	67 500	2.3 × 10 ⁶	34.4	67	29	4
	6 (N)	34 950	2.3 × 10 ⁶	66.0	8	64	28

(S) Southward crossing, (N) Northward crossing, I = Immature, M = Mature, S = Spent.

Table 5. Maturity distribution (%) and mean length (cm) in the samples from cruise 3 and 4 (1973). Area south of 59 °N.

Maturity	Cruise 3 Trawl Station 69—71		Cruise 4 Trawl Station 72—80	
	%	cm	%	cm
	Immature*	43.3	31	0.8
Matur	56.7	30	76.6	29
Spent			22.2	30

* Juveniles (<22 cm) disregarded.

In 1973 the maturing process was investigated in details. Table 5 shows the percentages and mean lengths of fish at each maturity stage in different periods of time. It appears that the fish changes from the prespawning stage into the stages spawning and spent within a very short period (time difference between St. 71 and 72 is one week). There were no significant differences in mean lengths between prespawning, spawning and spent fish.

DISCUSSION

The estimates of abundance, calculated here, tend to be lower than the previous. The main reason for this is that the previous estimates were obtained under the assumption that all fishes were reflecting as if they were 30 cm in length. As the smaller fish will contribute more per unit weight to the echo integrator output than the larger one, the estimates will be reduced when a length dependent density coefficient is used. The variation from survey to survey is still present to a considerable extent, and in the following some possible reasons for this variation are discussed.

In the introduction the grid coverage is mentioned as a possible source to large variances. To assess the blue whiting spawning stock abundance, the best procedure will be to cover most of the spawning grounds during the period when most of the spawning stock is present on these grounds.

There is no doubt that the cruises satisfactory cover large parts of the spawning area at least for some of the surveys. This is evident from maps of larvae distribution (BAINBRIDGE and COOPER 1973) which show that Rockall and Porcupine banks and the continental margin of the southwestern Celtic Sea are the main spawning grounds for blue whiting. It can, however, be questioned whether both the area and time coverage are sufficient for any of the surveys.

Table 1 shows the sampled areas on each cruise. According to this table the widest coverage were made during cruise number 3 (1973) and cruise number 5 (1974). Although the main spawning areas were covered in 1972, the coverage of the Rockall and Porcupine banks was very poor that year.

To find which survey has the best time coverage, it is necessary to analyse the maturity distribution in the samples. The highest percentage of mature fish will be an indication of the peak of the spawning, and table 4 shows that the higher percentage of mature fish coincide with the higher density values.

It is difficult to say whether the spawning takes place massively or by consecutive groups of spawners entering the spawning ground. A short

duration of the spawning period is suggested as some of the cruises have missed by days the peak of the spawning season (BUZETA *et al.* 1974) and also because of the quick maturing process during cruise 3 and 4 (1973). This indicates a massive spawning.

Cruises 1, 4 and 6 seem to have the best time coverage as most of the fish were in a spawning stage, which would mean that most of the spawning stock was present at the time of the investigation. With the exception of cruise number 4 the mean densities are also similar. Cruise 4 (1973) has a much higher density owing to a selection of course lines through the most dense concentrations. A high percentage of immature fish is present in the samples on cruise 3 (Table 4). The size distribution of these fish was investigated to see if the mature fish in the 2nd part was different from these immature fish. Table 5 shows that it is the same group of fishes. Cruise 3 (1973) is therefore chosen as the best abundance estimate assuming that during this survey, when most of the spawning ground was covered, the major part of the spawning stock was already present.

Although there is a small amount of juvenile fishes in the samples, most of the fish entering the area are spawners. When the size distribution of the fish (Fig. 5) is compared with the age-length curve in Fig. 6, mode I represents fishes of 1 year which are not spawning and thus are not quantitatively well represented in the samples. Modal size II representing fish of 2—3 years, which is the approximate age of first maturity (RAITT 1968), is also poorly represented in the spawning area. (Fig. 5). Thus the bulk of the spawning stock is represented by fish of ≥ 4 years (mode III). This fish spawn on the continental slope west of the British Isles and on the Porcupine, Rockall and Rose Mary banks, an area representing roughly 90,000 square nautical miles. The mean density, attained by the fish on the peak of the spawning season, is around 70 ton per square nautical miles which means that the size of the spawning stock is of the order of 6 million tons.

The fluctuation of the total spawning stock abundance between years should be studied in the light of the strength of the age groups of spawners since the age composition of the spawning stock may vary between years, i.e. scarce amount of 2—3 years spawners in 1973 (Fig. 5).

ACKNOWLEDGEMENTS

We wish to express our gratitude to S. H. JAKUPSTOVU and D. F. S. RAITT for their comments on the manuscript.

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Received 11 March 1975
Printed 10 December 1975