International Council for
the Exploration of the Sea

C.M. 1986/C:11
Hydrography Committee
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Some results of ichthyoplankton and hydrographic observations west and northwest of the British Isles in 1983-1985

by

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ABSTRACT

Ichthyoplankton and hydrographic observations in spring 1983-1985 showed that the massive spawning of blue whiting and hatching of the larvae occurred at traditional sites of the main spawning grounds. The majority of larvae was found at the Porcupine bank and west of the Hebrides, where maximal horizontal gradients for the concentrations of dissolved oxygen and phosphates were recorded in April.

An upward trend in water temperature and salinity in the active sea layer was observed in 1984 and 1985, which was indicative of an intensified advection of Atlantic waters. As evidenced by the size composition of larvae in these years the spawning of blue whiting started 10-12 days earlier than in 1983.

RESUME

On a etabli sur la base des donnees des observations ichtyoplanctonniques et hydrographiques qu'en printemps 1983-1985 le

frai massif du poutassou et l'éclosion des larves avaient lieu dans les régions traditionnelles des frayères principales. La plupart des larves a été capturée au large du banc Porcupine et sur les accores ouest des Hébrides, où en avril 1984 des gradients horizontaux des cincentrations de l'oxygène dissous et des phosphates ont été enrégistrées.

Au cours des années 1984 et 1985 on a constaté la tendance des augmentations de la température et la salinité dans la couche active de la mer qui indique le renforcement de l'advection des eaux atlantiques. L'analyse des données sur la composition par longueur des larves du poutassou indique que pendant cette période-lá où, en rapport du réchauffement des eaux, le frai a commencé de 10-12 jours plus tôt, qu'en 1983.

INTRODUCTION

A detailed description of areas, time and conditions of spawning of blue whiting in the Northeast Atlantic was first given by Schmidt (Schmidt, 1909). He showed convincingly that the spawning of blue whiting occurs along the edge of the continental shelf and around oceanic banks from Spain to the Faroe Isles and Iceland at water depths exceeding 200 m.

In recent years the reproduction and early ontogenesis of blue whiting have been studied by Seaton and Bailey (Seaton & Bailey, 1971), Coombs (Coombs, 1974), Bailey (Bailey, 1974), Coombs and Pipe (Coombs & Pipe, 1978), Coombs and Hiby (Coombs & Hiby, 1979), Zilanov (Zilanov, 1984) and others.

The observations showed that the spawning of blue whiting in the main area west of the British Isles occurred in mid-March to early May, with the peak in late March-early April. Although the spawning over the whole area was rather prolonged, at some

sites it was completed in a comparatively short time.

By now major regularities of the blue whiting spawning and distribution of eggs and larvae have been elucidated. However, the relationship between those regularities and abiotic conditions and the influence of the latter on the spawning time, larval drift and distribution are not studied in fact.

In spring (March-May) 1983-1985 the PINRO research vessels "Persey-III" and "Kokshaisk" conducted ichthyoplankton and hydrographic surveys in the areas west of Ireland and Great Britain and south of the Faroe Isles. The results allowed to describe the peculiarities of blue whiting spawning, distribution and size composition of larvae and to evaluate some aspects of their relationship with oceanographic conditions.

MATERIAL AND METHODS

In spring observations over the distribution of blue whiting larvae in 1983 were made during hydrobiological survey from 25 March to 22 April, therefore, the collected ichthyological material was scarce (Table 1).

Table 1. Ichthyoplankton observations made in spring 1983-1985

Year	Number of stations/number of hauls			
	Isaacs-Kidd trawl	IKS-80 net d = 80 cm gauze No.140	Hensen net d = 80 cm gauze No.23	Juday net d = 37 cm gauze No.38
1983	32/32	-	-	-
1984	-	79/505	71/71	95/268
1985	3/3	82/355	47/47	72/161

In 1984 the ichthyoplankton survey was conducted in two stages: from 18 to 30 March and from 21 April to 1 May. In 1985 the first stage was carried out from 3 to 9 April and the second two-leg stage - from 29 April to 4 May and from 10 to 14 May.

Figs. 5-9 show positions of sampling stations.

The larvae were sampled at 0-50, 0-100, 0-200, 0-300, 0-400, 0-500 and 0-600 m. After setting the gears at the given depth the vessel was drifting for 15 minutes.

Besides, the larvae were selected from hydrobiological samples collected during oceanographic survey of the Norwegian Sea in June 1984-1985 (Hensen and Juday nets).

After the samples were examined, the larvae were selected and fixed in 2% formalin. A binocular microscope was used to take the larval length to within 0.1 mm.

Hydrographic observations were made simultaneously with ichthyoplankton sampling. At all stations water samples for temperature and salinity measurements were taken at 0, 50, 100, 200, 300, 400, 500 and 600 m depths. During 1984 survey hydrochemical observations were conducted including determination of the content of oxygen and phosphates dissolved in water.

In all surveys in 1983-1985 the hydrographic section along 53°N comprising 8 fixed stations was completed. Water temperature and salinity at all standard depths from the bottom to the surface were determined at each station. The dates of observations along the section were as follows: 1983- 5 to 6 April, 1984 - 25 to 26 March and 1985 - 27 to 29 March.

In the analysis of hydrographic conditions mean monthly surface

water temperatures from three 5° rectangles in April 1983-1985 were used, they were estimated in the USSR Hydrometeorological Centre based on the observations of voluntary and research vessels.

Fig.1 shows positions of stations along the section and in 5° rectangles.

RESULTS

Hydrographic and hydrochemical conditions

In spring 1983 and 1984 hydrographic conditions at the shelf west of the British Isles were in general close to the average climatic conditions. A persistent downward trend in water temperature commonly observed in this area from the south to the north was recorded. A "tongue" of relatively warm waters along the slope between 56° and 58°N (Fig.2) was peculiar for the water temperature field in 1983. Hydrographic observations in late March-early April 1984 showed a slight warming-up of water as compared to 1983, primarily in the southern part of the area between 52° and 56°N. This was evident in both the dislocation of the isotherms northeastwards (Fig.2) and higher temperatures in the 0-200 m layer at some stations of the hydrological section along 53°N (Table 2). Simultaneously almost at all stations of the section salinity was found to increase by 0.01-0.06‰, which was indicative of an intensified advection of Atlantic waters on the shelf. Largest increments of water temperature and salinity in the 0-200 m layer (by 0.5-0.6° and 0.05-0.06‰) were recorded in the western (St.1) and eastern (St.8) parts of the section along 53°N. The advective

nature of these changes may be also illustrated by an upward trend in the mean monthly surface water temperatures in three 5° rectangles observed in April which increased by 0.2-06° in 1984 against 1983 (Table 2). Similar trend was recorded in the Norwegian Sea during oceanographic survey in June (Shevchenko & Isaev, 1985).

In spring 1985 a higher heat content of waters was observed over a considerable part of the survey area when the surface temperatures exceeded 10°C (Fig.2). At most stations along the 53°N section temperatures and salinity in the 0-200 m layer were found to increase(Table 2). At the same time in the eastern part of the section (St.8) an essential drop of temperature and salinity (by 0.64° and 0.20°/..), manifested in the distribution of surface isotherms (Fig.2), was recorded. This may result from a relative weakening of the eastern constituent of the North-Atlantic Current in April, since alongside with overall warming of waters a slight reduction of temperature was observed in the north-east, in rectangle III, too (Table 2). A preliminary analysis of June oceanographic survey results showed that in summer similar changes occurred in the Norwegian Sea, where the temperature inreased in the western branch of the Norwegian Current and decreased in the eastern sea simultaneously.

Available data allow to describe the peculiarities of the spatial structure of hydrochemical regime elements only for the spring period of 1984.

In accordance with the general regularity of latitudinal distribution of dissolved oxygen its absolute concentrations

Table 2. Mean temperature and salinity in the 0-200 m layer at some stations of the 53°N hydrographic section in late March-early April and mean monthly surface temperatures in the three 5° rectangles in April 1983-1985.

Area	Station, Rectangle	Year					
		1983		1984		1985	
		T, °C	S, °/..	T, °C	S, °/..	T, °C	S °/..
Section along 53°N	1	10.07	35.45	10.69	35.50	10.62	35.53
	2	10.03	35.45	9.96	35.46	10.07	35.52
	3	9.70	35.45	9.78	35.46	9.86	35.53
	4	9.67	35.45	9.76	35.45	9.85	35.52
	5	9.65	35.45	10.03	35.48	10.09	35.56
	6	9.77	35.46	10.19	35.50	10.26	35.53
	7	9.85	35.47	9.97	35.50	10.04	35.47
	8	9.27	35.43	9.77	35.49	9.13	35.29
Rectangle 5° x 5°	I	10.1	-	10.3	-	10.5	-
	II	9.0	-	9.6	-	9.7	-
	III	8.1	-	8.5	-	8.4	-

were found to increase persistently northwards. Within the area the increments were generally small except the zone west of the Hebrides, where notable horizontal gradients, to 0.09 ml/l per mile, were observed (Fig.3). Maximal values, 143-153%, of water oversaturation with oxygen were also recorded here in April.

Essential irregularities in the horizontal distribution of phosphates were observed in the shelf part west of the Hebrides, whereas over the whole area their concentration varied only slightly, within 0.7-0.9 μg-at/l (Fig.4). Minimum content of phosphates, 0.32 μg-at/l, was recorded in the above shelf part in April.

Coincidental occurrence of the dissolved oxygen maximum and phosphate minimum in the upper layer was indicative of higher concentrations of primary production present in this area. Highest numbers of larvae were caught here.

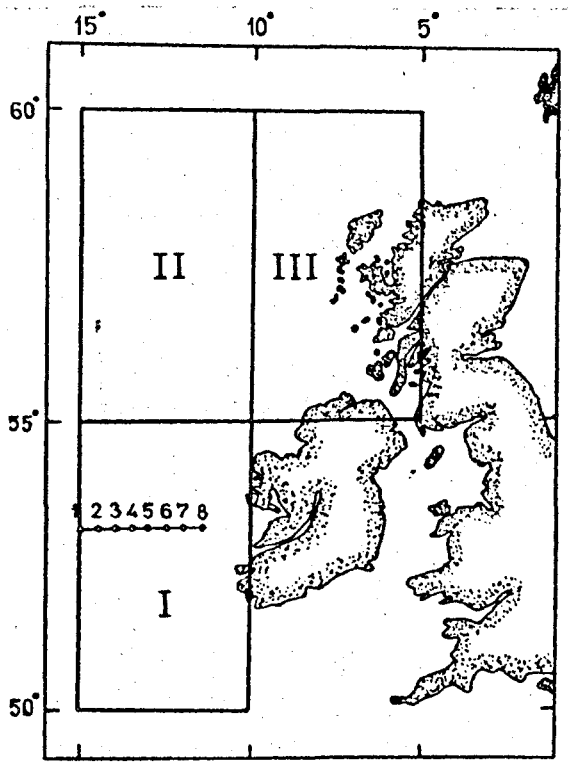

Fig. 1 Positions of stations along the 53°N section and three 5° rectangles.

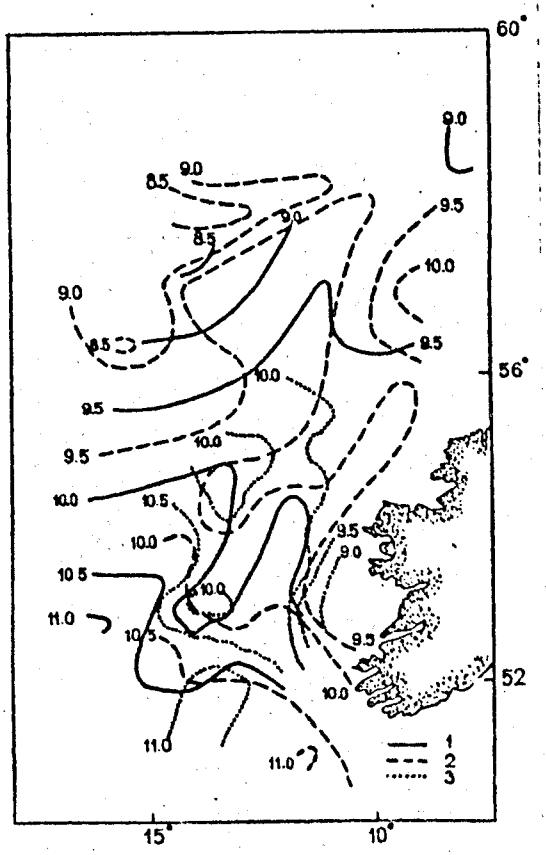

Fig. 2 Distribution of water temperatures at the surface in spring 1983 (2), 1984 (I), 1985 (3)

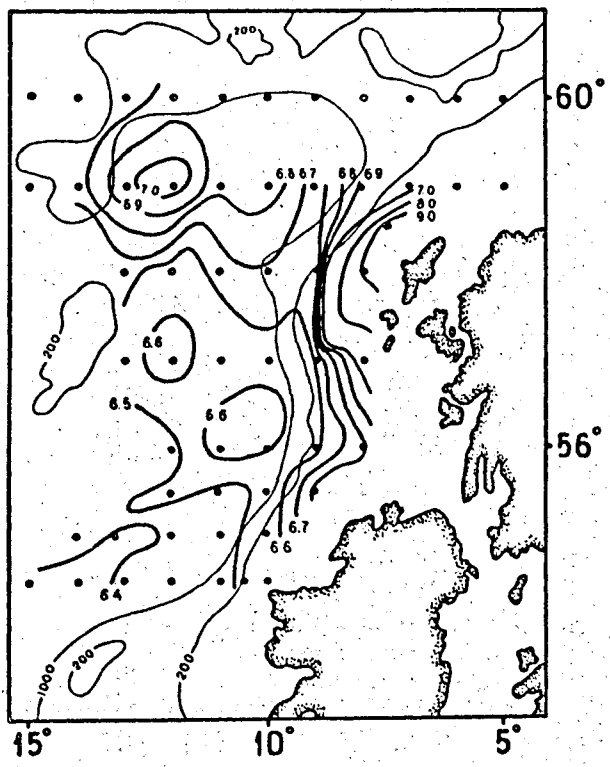

Fig. 3 Distribution of dissolved oxygen content on the surface in April 1984

Spawning of blue whiting, distribution and drift of larvae

Observations made in spring 1983 allowed to discover the spawning sites only northwest of Ireland (Fig.5). Highest numbers of larvae were found above 400 m, their size ranged from 3.2 to 18.0 mm.

During the first stage of the 1984 survey the larvae were sampled west of Ireland (Fig.6). At this time (according to biological analysis results) blue whiting were spawning at the Porcupine bank and east of it, where the abundance of the larvae was the highest, their size varied from 2.2 to 10.6 mm (Table 3). Eggs 0.9-1.0 mm in the diameter occurred in samples in large quantities. During the second stage of the survey (21 April to 1 May) maximal numbers of larvae were observed west and north of the Hebrides (Fig.7). Their length varied from 3.0 to 15.1 mm. In May 4 larvae 4.1 to 9.9 mm long were caught and 10 larvae 4.6 to 18.4 mm during oceanographic survey of the Norwegian Sea in June (Table 3).

As it is indicated by Table 3 the variability of larval length was the highest in June and the lowest in March (data for May are not reliable because of insufficient sampling). This might indicate the extension of the larvae distribution area from March to June.

Ichthyoplankton sampling with IKS-80 net (Table 4) showed that in March the average number of larvae per haul was higher in the 0-500 m and 0-200 m layers and in the 0-100 m layer in April. As it was reported by Coombs (Coombs, 1974), Coombs and

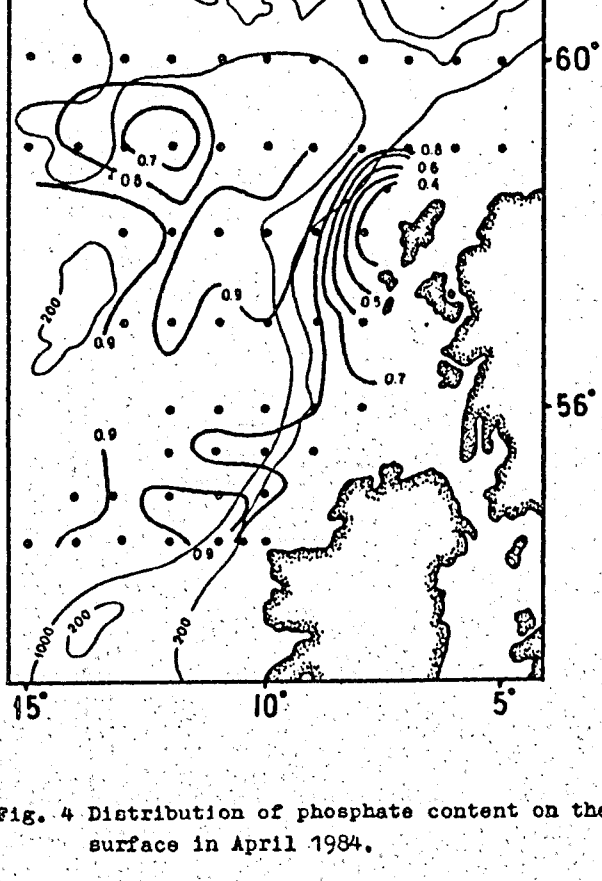

Fig. 4 Distribution of phosphate content on the surface in April 1984.

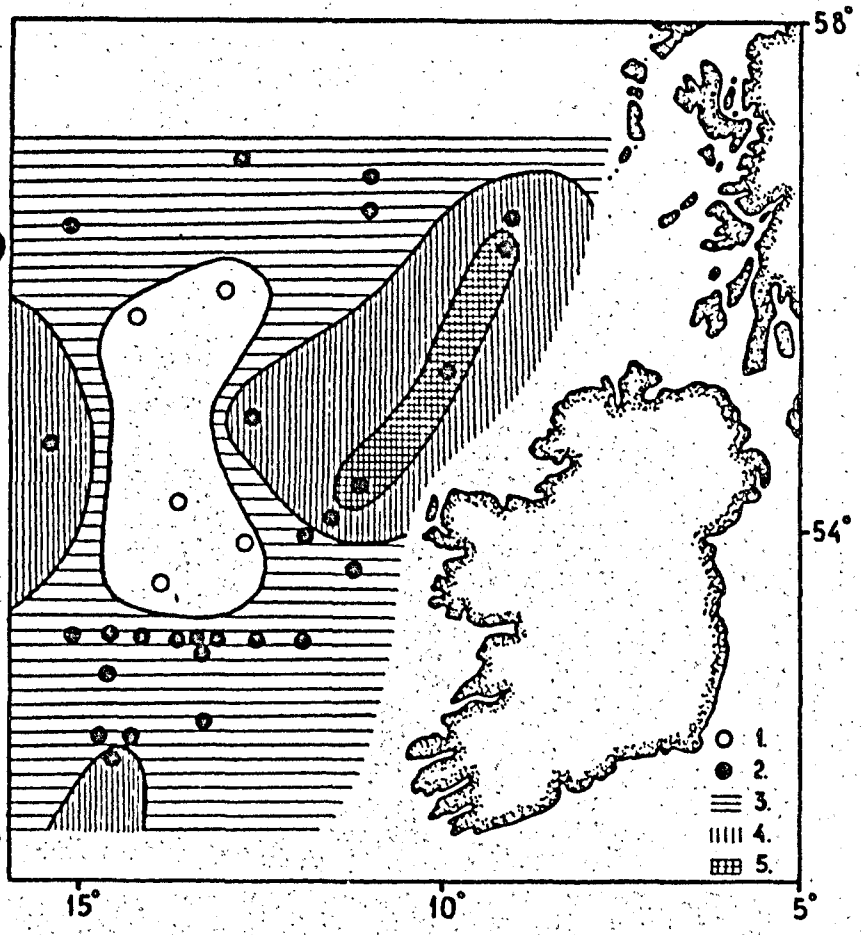

Fig. 5 Distribution of blue whiting larvae in March-April 1983, individuals per m^2
1-negative haul (no larvae); 2-positive haul (with larvae); 3-1-10 ind.; 4-11-100 ind.; 5-100 ind.

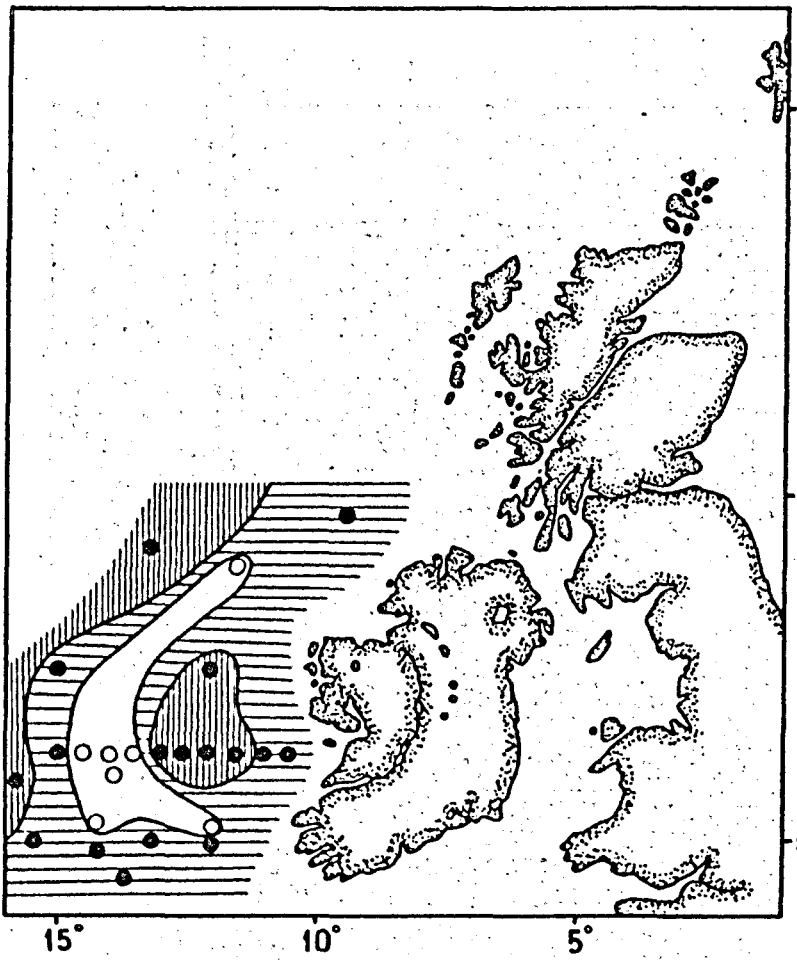

Fig. 6 Distribution of blue whiting larvae in March 1984, individuals per m^2.
For symbols see Fig.5 .

Pipe, 1978), this may be due to the fact that immediately after hatching the larvae are aggregated in waters deeper 300 m and as they grow they go up and are concentrated in the 0–100 m layer.

Table 3. Variations in the length of blue whiting larvae in March –July 1984 (from IKS-80 net sampling)

Month	Length variation range, mm	Mean length, mm	Standard deviation	Error in standard deviation	Total number, ind.
March	2.2-10.6	4.4	1.58	0.35	147
April	3.0-15.1	5.3	1.66	0.48	106
May	4.1-9.9	5.8	0.94	0.54	4
June*	4.6-18.4	8.4	4.79	1.81	10

*Sampling with Juday and Hensen nets.

In 1985 during the first stage of the survey (3-9 April) maximal numbers of larvae were found in the area west of Ireland with the centre at about 54°N 13°W (Fig.8). The majority of larvae was distributed at 200–400 m, their length varied from 2.2 to 3.6 mm (Table 5), which indicated that they were newly hatched.

At the second stage of the survey during its first leg (29 April – 4 May) largest quantities of larvae occurred above 200 m at 55°30'-57°00'N 9°00'-11°30'W (Fig.9). Their length varied from 2.4 to 7.0 mm (mode 5.6 mm). No larvae were found at the Rockall bank probably due to earlier spawning here.

On the second leg of the survey maximal quantities of larvae were observed west and northwest of the Hebrides in the zones of massive development of phytoplankton and high numbers of Calanus nauplii. The majority of larvae were distributed in the

0-100 m layer (Table 5) with their size 3.5 to 12.1 mm (mode 6.2 mm).

DISCUSSION

The time of the beginning of massive spawning of blue whiting on the spawning grounds west of the British Isles is, as it is demonstrated in the paper by Kuznetsov V.N and Kolpikov Yu.E. (Kuztetsov and Kolpikov, 1981), in the direct relationship with thermal conditions: the spawning occurs earlier at higher heat content of waters and later - at lower. Observations for 1983-1985 confirm in general such relationship.

Approximate dates of the beginning of massive spawning may be determined from the average size of the larvae, bearing in mind that after hatching they are about 2 mm in length (Seaton & Bailey, 1971), the growth rate is within 3-5% of the length per day (Bailey, 1974) and the incubation period is 4-6 days (Coombs and Hiby, 1979). Hence, in 1983 the massive spawning at the Porcupine bank started approximately on 8-10.March and in 1984 25-26 February, i.e. 10-12 days earlier. As it was mentioned before in spring 1984 the water temperature on the shelf was observed to increase exceeding the temperature in the corresponding period of 1983. This trend was recorded in 1985 too, therefore the massive spawning might be considered to start in about mid-February. Unfortunately the first stage of the 1985 survey was conducted with a 2-week delay as compared to 1984, therefore, the generation of larvae observed at the main spawning sites of the Porcupine bank might belong to the second "wave" in the spawning.

Table 4. Vertical distribution of blue whiting larvae in 1984 (from IKS-80 net sampling)

Period	Layer, m	Positive hauls, %	Negative hauls, %	Number of larvae by layers	Number of hauls	Average per haul	Total number caught
18 March -30 Mar	0-5	14.3	85.7	2	14	0.14	
	0-100	31.2	68.8	70	48	1.46	
	0-200	23.8	76.2	21	21	1.00	147
	0-300	47.1	52.9	28	17	1.65	
	0-400	45.5	54.5	10	11	0.91	
	0-500	33.3	66.7	4	9	0.44	
	0-600	28.6	71.4	12	7	1.72	
21 Apr- 1 May	0-5	8.0	92.0	8	56	0.14	
	0-100	15.2	84.8	80	109	0.73	
	0-200	9.8	90.2	13	45	0.29	
	0-300	7.7	92.3	3	43	0.06	110
	0-400	7.7	92.3	3	43	0.06	
	0-500	2.6	97.4	1	41	0.02	
	0-600	2.6	97.4	2	41	0.05	

Data on the distribution of larvae and hydrochemical elements show that the highest concentrations of ichthyoplankton are associated with the areas of maximal horizontal gradients of content of dissolved oxygen and phosphates, where the conditions are favourable for higher bioproductivity. Hydrochemical observations for 1984 and fragmentary data for 1983 evidence that one of those quasiconstant areas is located west of the Hebrides where largest quantities of larvae have been found.

Up to now no complete description of peculiarities of the drift of blue whiting larvae and eggs is given. Undoubtedly,

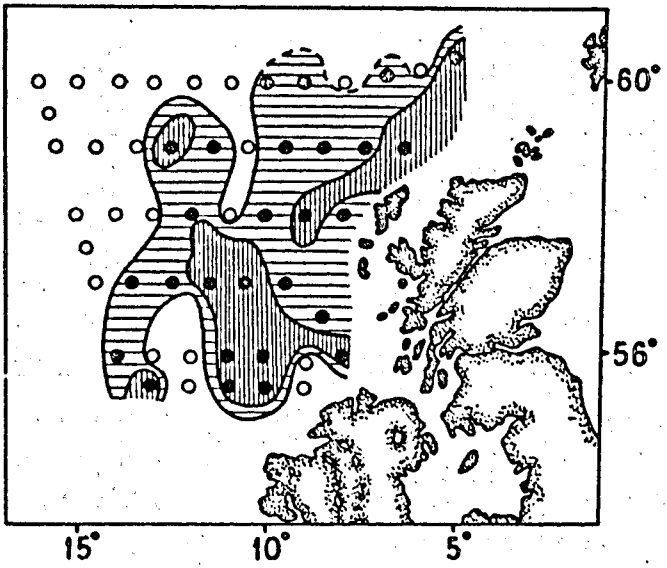

Fig. 9 Distribution of blue whiting larvae on 29.April-14 May 1985, ind./sq.m
For symbols see Fig.8.

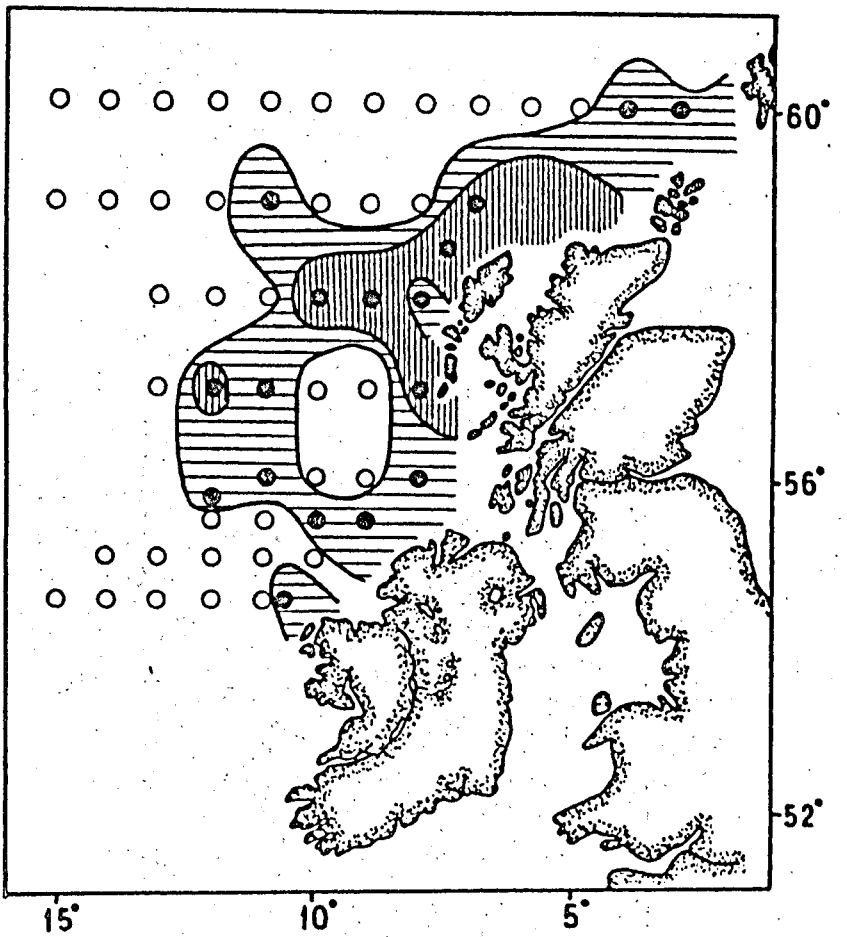

Fig.7 Distribution of blue whiting larvae in April-May 1984, ind./sq.m
For symbols see Fig.5.

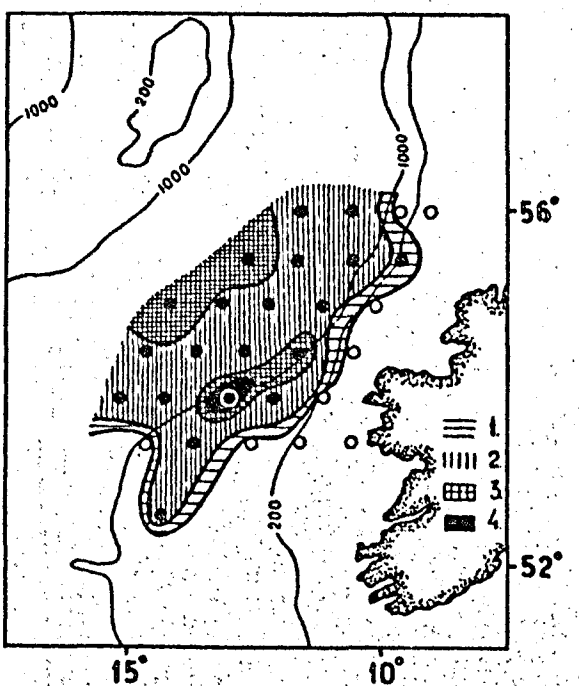

Fig. 8. Distribution of blue whiting larvae 3-9 April 1985, ind./sq.m
1 - 1-10 ind.; 2 - 11-100 ind.; 3 - 101-1000 ind.
4 - over 1000 ind.

Table 5. Vertical distribution of blue whiting larvae in 1985 from IKS-80 net sampling.

Period	Layer, m	Negative hauls, %	Positive hauls, %	Number of larvae caught	Number of hauls	Average per haul	Total number of larvae caught
3 Apr – 9 Apr	0-5	82.1	17.9	59	28	2.1	
	0-100	69.0	31.0	119	29	4.1	
	0-200	48.0	52.0	405	25	16.2	
	0-300	35.0	65.0	247	20	12.4	
	0-400	26.3	73.7	211	19	11.1	1342
	0-500	50.0	50.0	198	18	11.0	
	0-600	29.4	70.6	103	17	6.1	
29 Apr-4 May	0-5	76.9	23.1	37	26	1.4	
	0-100	53.8	46.2	43	26	1.7	
	0-200	55.0	45.0	28	20	1.4	
	0-300	66.7	33.7	18	18	1.0	158
	0-400	70.6	29.4	8	17	0.5	
	0-500	-	100.0	15	2	7.5	
	0-600	-	100.0	9	2	4.5	
10 May-14 May	0-5	95.0	5.0	6	20	0.3	
	0-100	60.0	40.0	26	20	1.3	
	0-200	76.5	23.5	4	17	0.2	45
	0-300	75.0	25.0	6	16	0.4	
	0-400	86.7	13.3	3	15	0.2	

the major part of ichthyoplankton is transported from the spawning grounds in streams of the North-Atlantic Current north-north-eastwards (Schmidt, 1974) with a likely speed of 110 km per 8-10 days (Bailey, 1974). At the same time the possibility exists that some larvae are transported north-westwards of the Hebrides.

During ichthyoplankton surveys in 1984–1985 it was attempted to record such a drift. However, no larvae were found at any of the stations located north and west of 58°N 13°W. But the possibility of the northwest transport of larvae cannot be completely excluded.

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Подп. в печ. 30/VI 1986 г. Формат 60x84 1/16 Заказ 283
Объем 1,5 п.л. Бесплатно Тираж 265

Ротапринт ВНИРО
107140. Москва, Верхняя Красносельская, 17