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BLUE WHITING

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BLUE WHITING

by M. G. Pawson

INTRODUCTION

Each spring vast quantities of adult blue whiting (Micromesistius poutassou Risso) congregate to spawn over deep water to the west of the British Isles. This area (Figure 1) appears to be the main spawning ground, although spawning fish and/or eggs and larvae have been recorded off south-west Iceland and along the Norwegian coast.

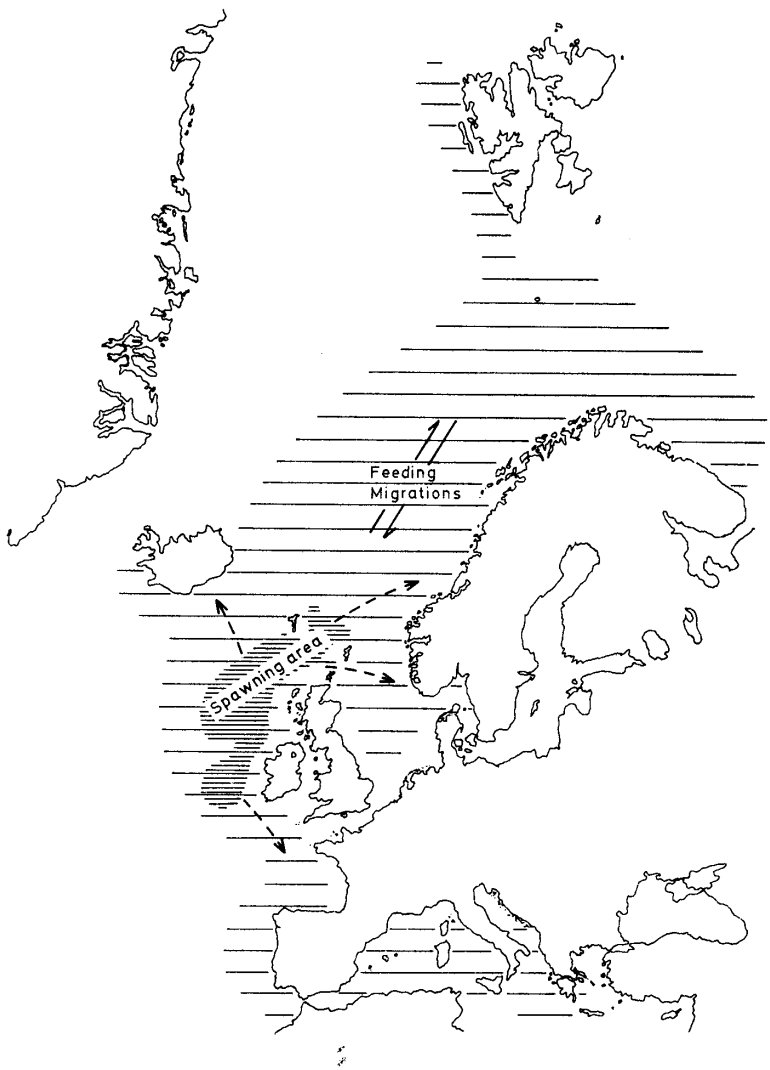

Figure 1 The geographical distribution of the North-east Atlantic blue whiting stock. Broken arrows indicate possible larval drift away from the main spawning area.

The fish probably represent a large proportion of the North-east Atlantic blue whiting stock, whose range extends from the Mediterranean along the edge of the continental shelf west of Europe to Icelandic waters, the Norwegian Sea, and as far north as Spitsbergen. Although this small member of the cod family (Figure 2) has, until recently, been little fished, due mainly to its small size and the problems of capturing it outside the spawning season, it seems likely to become an important resource in the future. For this reason, over the last five years considerable scientific attention has been focussed upon the blue whiting and its migrations to and from the main spawning area, and in 1977 the increased commercial interest in blue whiting prompted the International Council for the Exploration of the Sea (ICES) to set up a planning group to coordinate research programmes of member countries.

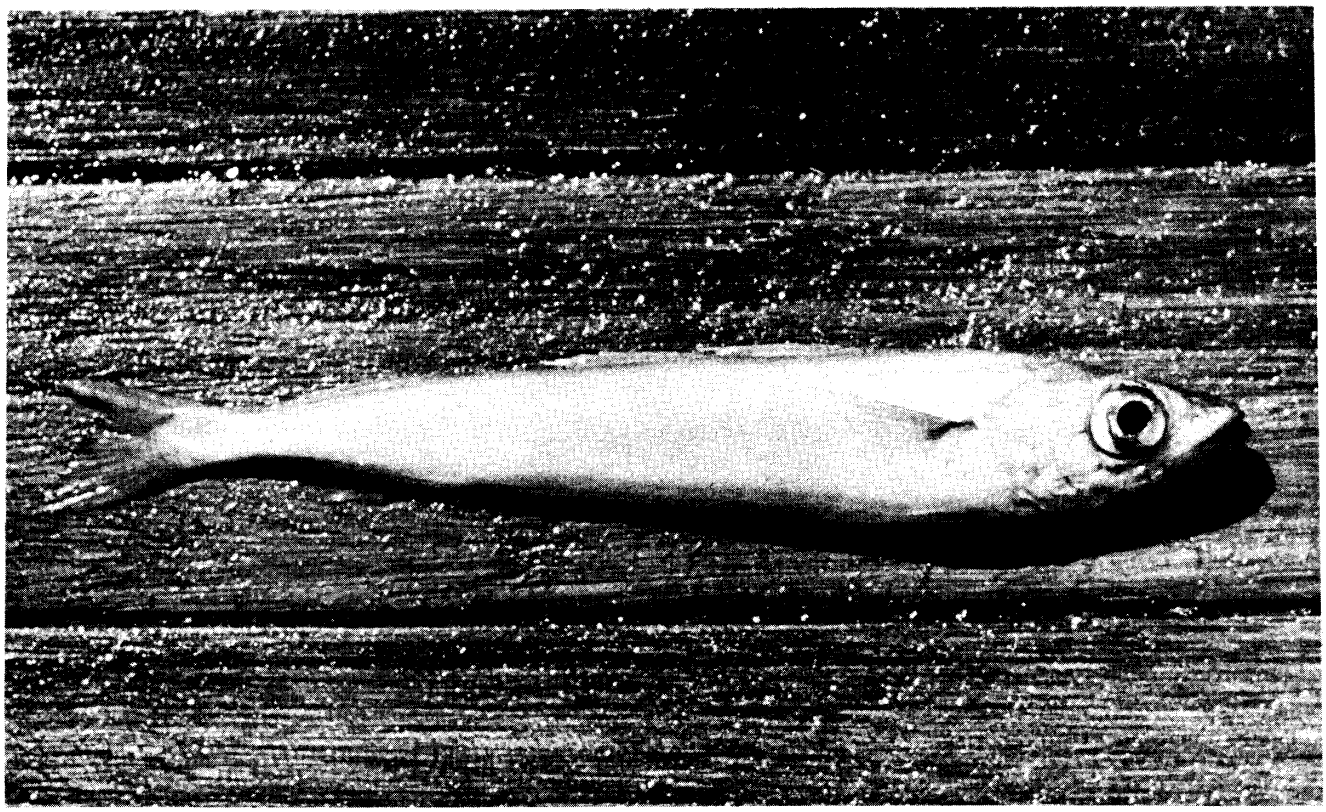

Figure 2 A blue whiting, Micromesistius poutassou Risso.

Prior to 1974 very little fishing by any country had been directed at the blue whiting in the spawning area, and information on the extent and duration of the aggregations of fish, and on the quantities involved, was rather limited. It was known, however, that the blue whiting could be found in a layer at several hundred metres depth over deep water off the edge of the continental shelf, an ideal situation for the use of acoustic survey techniques. In March 1974 staff of the MAFF Fisheries Laboratory at Lowestoft conducted the first of an annual series of acoustic surveys in RV CIROLANA in order to determine the distribution of blue whiting during the spawning season, and to obtain information on the abundance and population structure of the stock prior to exploitation, an opportunity which seldom arises in fisheries science. This work was carried out in a programme coordinated

with that of the DAFS Marine Laboratory at Aberdeen, and investigations on catching and processing blue whiting were undertaken respectively by the White Fish Authority's Industrial Development Unit at Hull and MAFF Torry Research Station, Aberdeen.

This leaflet deals mainly with the results of the acoustic surveys and the biological sampling programme run by the Lowestoft Laboratory, but results from investigations by other institutions are included in order to supplement and expand these findings. It is intended as a basis for an understanding of the life history and behaviour of blue whiting, which is essential for the rational exploitation of this resource. Further details may be obtained in the publications listed in the bibliography on page 16 or from the Fisheries Laboratory, Lowestoft.

THE MAFF SURVEYS

Survey area and weather conditions

The area covered by the surveys of spawning blue whiting (Figure 3) normally

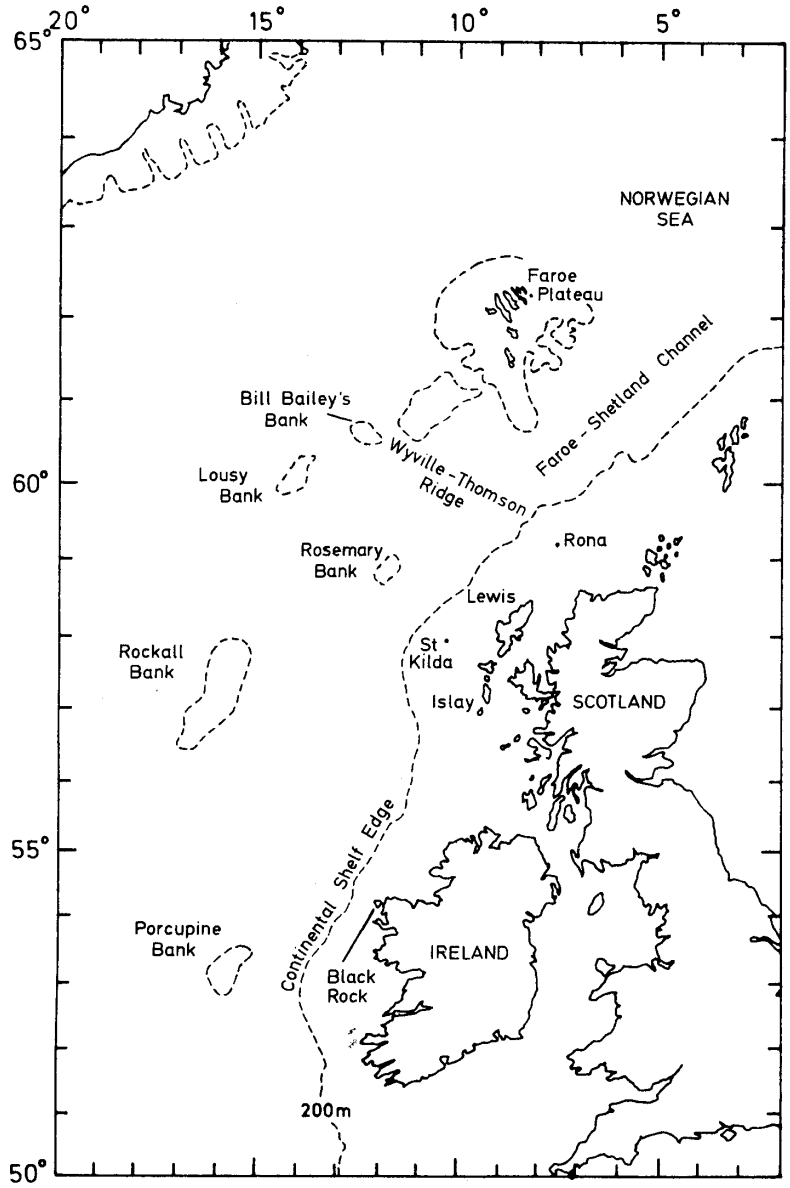

Figure 3 The main areas covered by spawning blue whiting surveys.

extended westwards from the 200 m depth contour at the edge of the continental shelf between latitudes 51°N and 62°N, its westerly limit being determined by the extent of the blue whiting layer. Typical cruise tracks are shown in Figure 4. No attempt was made to keep to

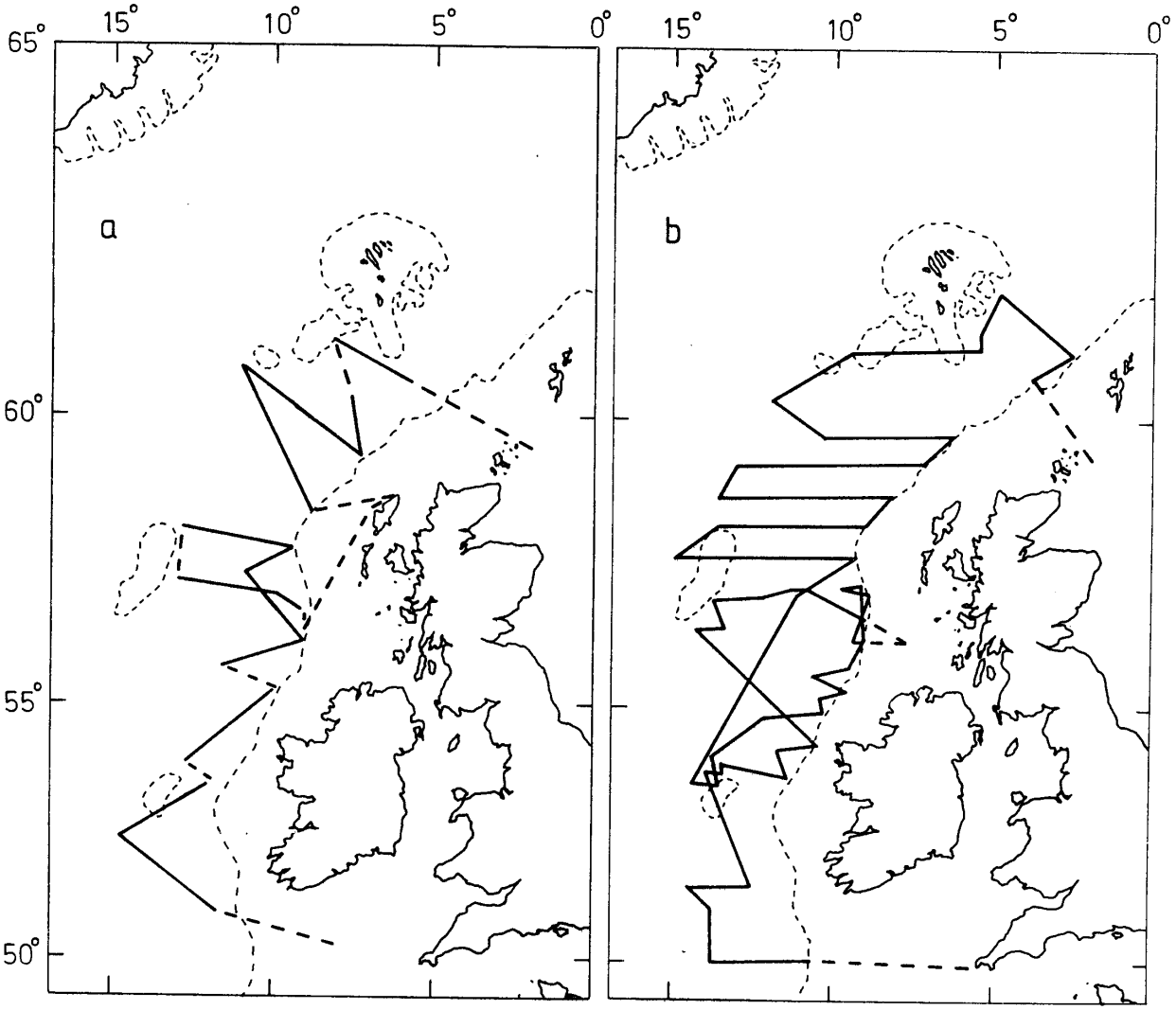

Figure 4 Cruise tracks taken by RV CIROLANA on spawning blue whiting surveys. (a) 26 March-11April 1976, (b) 9-27 April 1975.

a regular grid; not only did the western edge of the blue whiting layer change its position quite rapidly during the spawning season, but the weather often considerably restricted the surveys. During March and April, the peak spawning time, the weather in this region is usually influenced by a series of depressions resulting in rapid changes of wind direction and strength, and is dominated by a westerly airflow which reaches gale force quite frequently (see Figure 5 and Table 1). In order to obtain the maximum working time during each cruise the largest MAFF research vessel, CIROLANA, a 237 ft (72 m) stern trawler of gross tonnage 1731 tons, was used, but even she could not usually carry out acoustic surveys in seas associated with winds above force 6. In marginal conditions (force 5-7) surveying often only proved possible with the wind and swell astern, and in April 1976 the majority of the survey legs had to be run to the east (12 out of 15 days had westerlies force 7 and above).

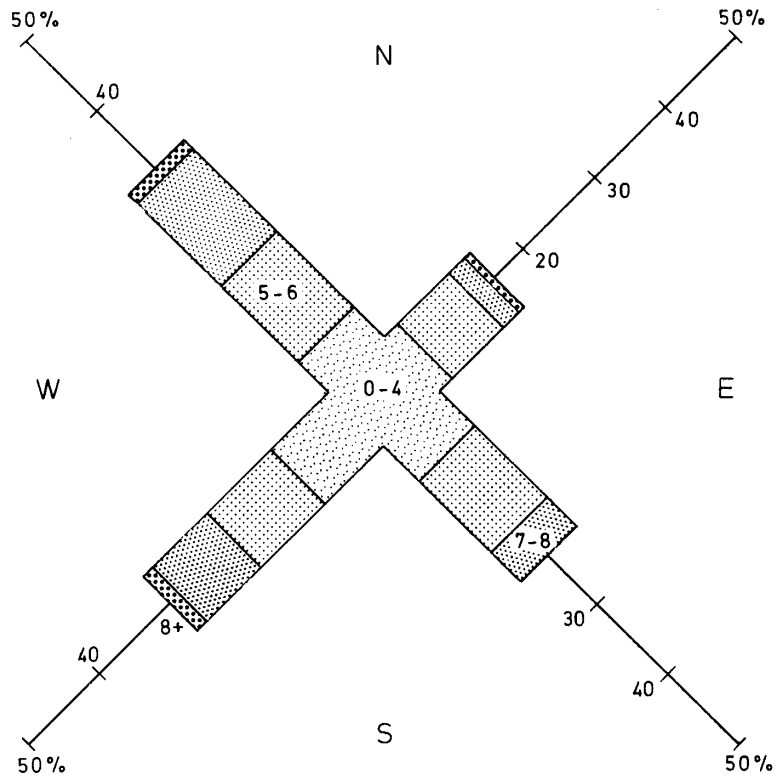

Figure 5 The incidence of winds of strength 0-4, 5-6, 7-8, and over 8 on the Beaufort scale in sectors between the four cardinal points during English blue whiting surveys, 1974-77.

Table 1 Number of days a given wind strength or sea state can be expected in region 55-60°N, 10-15°W during March and April, from long-term data with all directions considered

	March				April			
Wind Force	0-3	4-6	7-12		0-3	4-6	7-12	
Days	7	18	6		8	17	5	
Wind waves Height (ft)	0-3	3-8	8-12	>12	0-3	3-8	8-12	>12
Days	7	14	4	6	8	14	4	4
Swell waves Height (ft)	0-6	6-12	>12		0-6	6-12	>12	
Days	7	13	11		10	14	6	

Research vessels of other nationalities have also surveyed this area, but in general, these have placed more emphasis on the Faroe-Shetland area during the blue whiting migrations to and from the spawning grounds and in 1978 additional effort was directed at the summer feeding grounds to the east of Iceland, in the Norwegian and Barents Seas.

Acoustic survey techniques

A 30 kHz Kelvin Hughes Humber echo-sounding fish detection system, specifically designed for deep-water work, was used during the acoustic surveys. Although a Kelvin Hughes MS29 paper recorder was employed to give a good picture of the depth and density of fish layers, more sophisticated equipment was required to measure and record the blue whiting abundance. This consisted of Simrad echo integrators and their associated amplification sytems from which the echo strength received from a depth zone set to envelop the blue whiting layer was relayed to Hewlett-Packard chart recorders.

The echo strength level is related to the quantity of fish according to the acoustic reflectivity (target strength) of the particular species being insonified. Attempts to determine this relationship for blue whiting have been made using dead fish both at sea and in experimental rigs (Forbes et al., 1974, Nakken and Olsen, 1977) and more recently, by lowering a transducer within 20 m of live fish swimming normally in the open sea (Robinson, 1976). The degree of accuracy of these measurements is probably the major source of error in estimates of the stock size of blue whiting, and further investigation is required before we can have full confidence in fish abundance estimates obtained in this way.

The survey track taken by CIROLANA was plotted on a chart from the information received from the output of a satellite navigation system, and fish abundance values were recorded for every mile steamed. In this way a picture of the distribution of the blue whiting was built up, areas of high and low density could be identified and the total quantity of fish in the survey area could be calculated.

Biological sampling

Samples of the echo-producing layer which was assumed to be blue whiting, were taken with an Engel 1600 midwater trawl fished at the depth of the layer as indicated on the echo-sounder paper. A headline transducer was used to determine the net's fishing depth.

The catches were sub-sampled to obtain the biological data necessary for stock assessment and to improve our knowledge of the life history and biology of blue whiting. This involved measuring 200-300 fish per haul in order to determine their length distribution, and taking otoliths (ear stones) from a size range to determine their age, age-length relationships, and hence growth rates. Additional observations on stomach contents, parasite burden, sexual maturity and condition factor (weight for length) were also made, and various samples were preserved for tests at the laboratory.

Most of these research cruises also involved investigations on the distribution and development of blue whiting eggs and larvae, carried out in cooperation with staff from the Institute of Marine Environmental Research, Plymouth. Various oceanographic studies were also undertaken by MAFF personnel, in particular observations were made of the temperature, salinity and current systems in the water masses of the spawning area. Although this work was ancillary to the main aims of the blue whiting surveys, it is none the less of great importance in furthering our understanding of the life history of blue whiting and the mechanism of their migrations.

SURVEY RESULTS

Distribution of adult blue whiting

Figures 6-10 show the monthly distributions of blue whiting in the spawning area to the west of Britain, according to the results of acoustic and fishing surveys of MAFF and

research institutes of other countries since 1972. Although the pattern changes quite rapidly during the spawning season it has remained remarkably consistent at the equivalent time each year. CIROLANA surveys have covered the spawning area from mid-March to May, and the results of surveys by other research vessels are included to give information on blue whiting distribution at other times.

During January the fish appear to be moving southwards along the eastern edge of the Faroe Plateau at a depth of 200-500 m, where catches of around 5 tonnes per hour were reported by Schöne (1978). Scottish (Walsh et al., 1978), Norwegian (Blindheim et al., 1973) and Polish (Giedz, 1978) surveys have shown (Figure 6) that in February there are considerable quantities of blue whiting throughout the Faroe-Shetland Channel, along the shelf edge west of the Hebrides, and on the north-western edge of the Porcupine Bank, the latter yielding catches of up to 30 tonnes per hour. During the second half of March

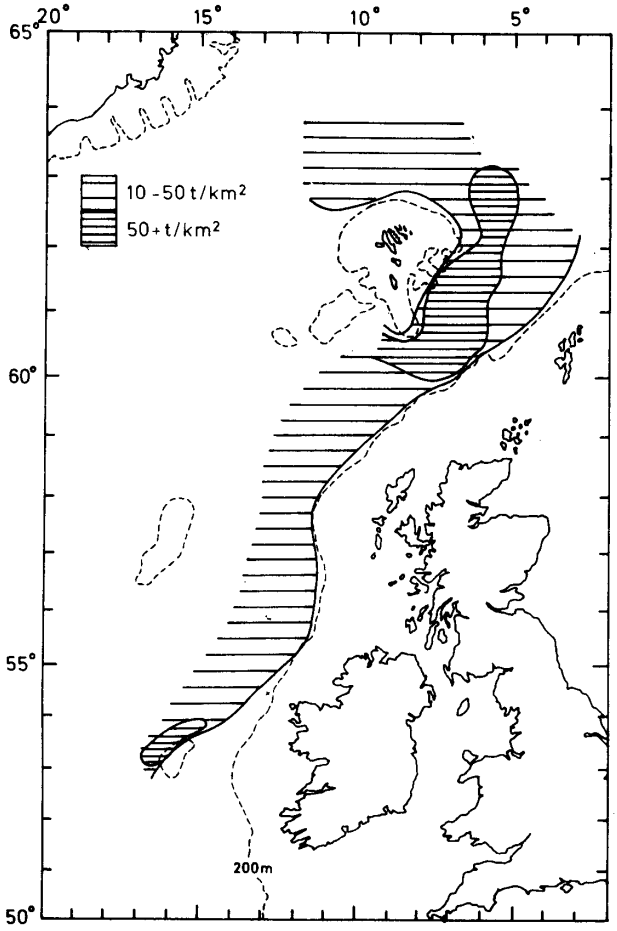

Figure 6 Blue whiting density distributions recorded in early February by Scottish, Norwegian and Polish surveys.

the southern limit of the spawning fish is around 53°N (Pawson, et al., 1978), although smaller, immature blue whiting have been found to the south and into the Bay of Biscay. At this time the highest concentrations have been found on the western edge of Porcupine Bank, west-north-west of Black Rock, west of Lewis and south of the Faroe Plateau on the north side of the Wyville-Thomson Ridge (Pawson et al., 1975; Buzeta and Nakken, 1975) - see Figure 7. By mid-April the main body of the blue whiting spawning population lies along the edge of the continental shelf from Porcupine Bank northwards to 61°N and extends westwards to the north-eastern slope of Rockall Bank and northwards to the

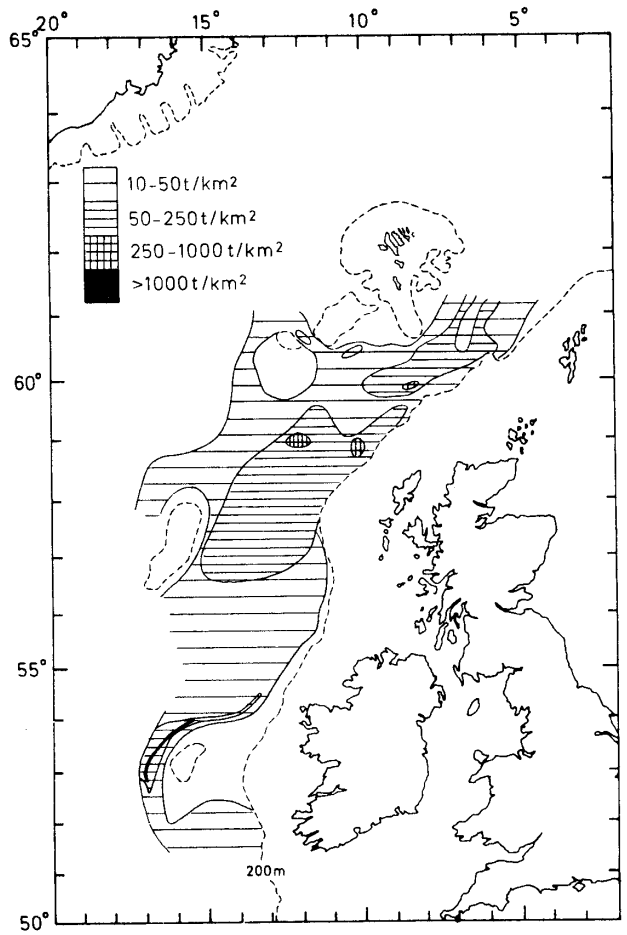

Figure 7 Blue whiting density distributions recorded during the cruises of RV CIROLANA (MAFF) and RV EXPLORER (DAFS), 15 March-7 April 1975.

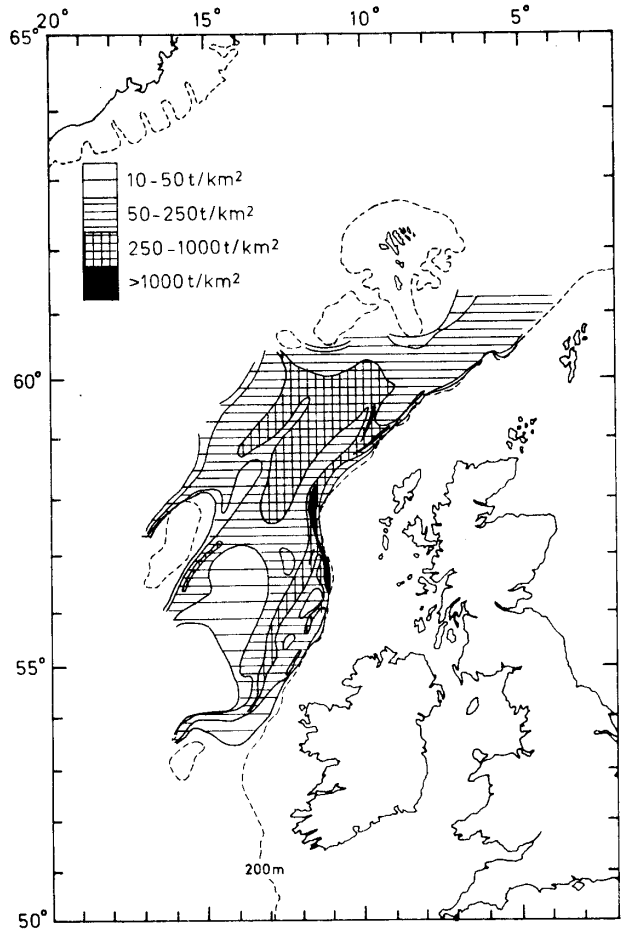

Figure 8 Blue whiting density distributions recorded on cruise 4/75 of RV CIROLANA, 9-27 April 1975.

southern slopes of Lousy, Bill Bailey's and Faroe Banks. This is probably the time of peak abundance of blue whiting in the spawning area, and densities greater than 500 tonnes per square kilometre have been recorded by UK research vessels (Walsh et al., 1978) at the shelf edge to the west of the islands of Islay and St Kilda, and between Rosemary Bank and Rona (Figure 8). Catches in excess of 200 tonnes per hour have been made here at this time.

The northwards retraction of the areas of high fish abundance, as the spent blue whiting leave the spawning area, occurs more rapidly in May (Figure 9), when the largest concentrations are to be found along the edge of the Faroe Plateau to the south and west of the Faroe Islands (Jakupsstovu, 1978). Although blue whiting are still present at the shelf edge to the south of the Hebrides and in the Faroe-Shetland Channel, they are higher in the water and more dispersed. By June most of the spawned blue whiting have left the

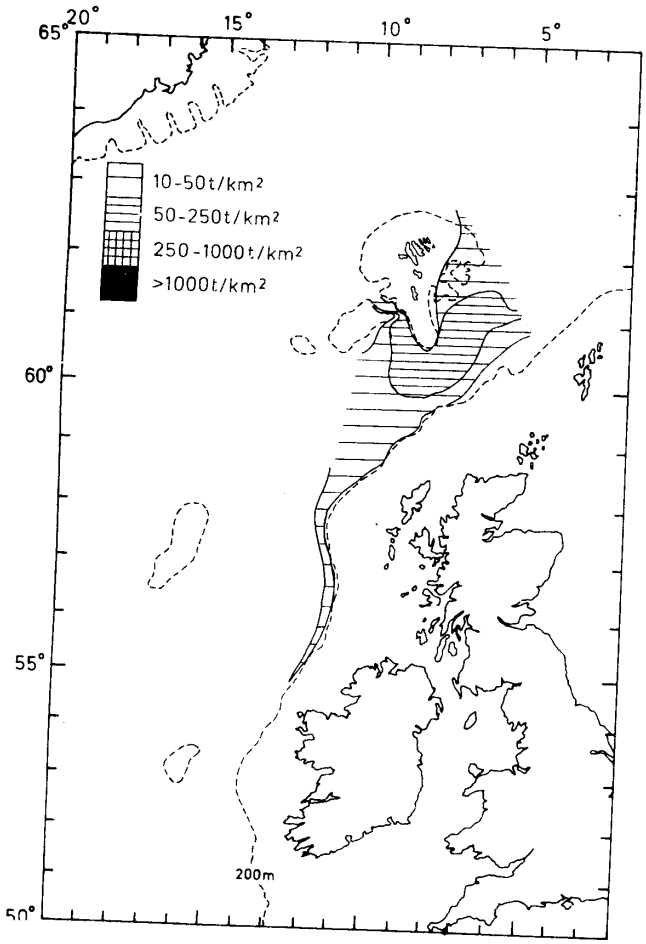

Figure 9 Blue whiting density distributions recorded on CIROLANA cruise 5/75, 11-27 May 1975. Densities to the north and east of the main concentration are underestimates due to the blue whiting having risen in the water above the usual sampling depth.

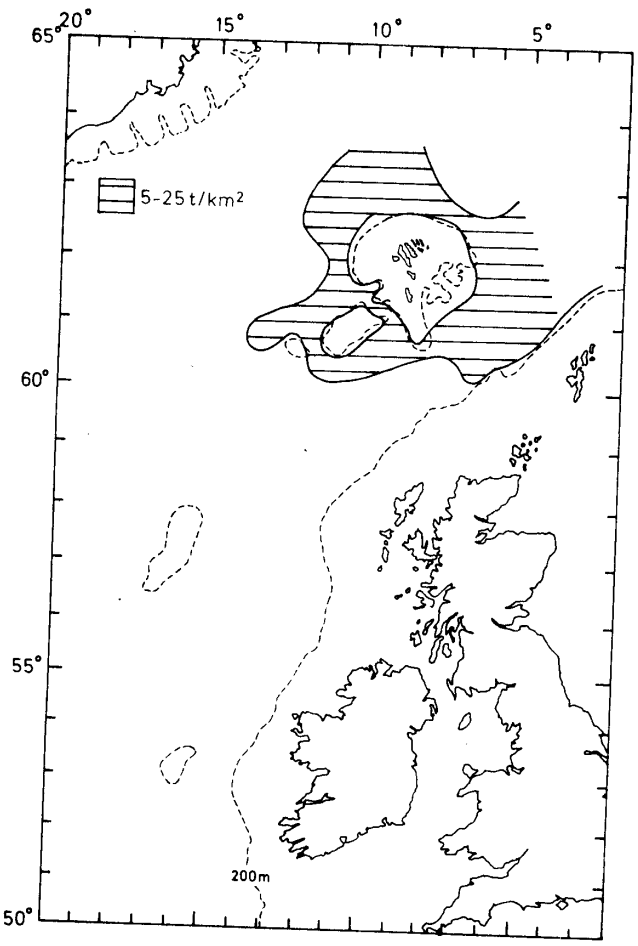

Figure 10 Blue whiting density distributions recorded by Scottish and Faroese research vessels in June.

spawning area (Walsh et al., 1978) and spread northwards to the west (mainly) and east of the Faroes, towards Iceland, and into the Norwegian Sea, as shown in Figure 10.

Depth of blue whiting layer

During the spawning season the blue whiting are normally found in a layer 20-100 m thick at around 400 m over deep water, and though their depth varies somewhat from place to place and from year to year, the average has been very consistent, both by day and at night. At the edge of the continental shelf and on the banks the fish rise to 250-300 m and it is here, where they are often in a very dense layer just above the sea bottom, that most of the fishing has so far taken place. An echo trace showing this situation is given in Figure 11, together with estimates of the quantity of blue whiting present. Other typical echo records made in deeper water are shown in Figures 12 and 13. At this time the blue whiting are not feeding and catches from these echo-producing layers consist almost exclusively of blue whiting. There is often another echo layer seen at 150-200 m depth

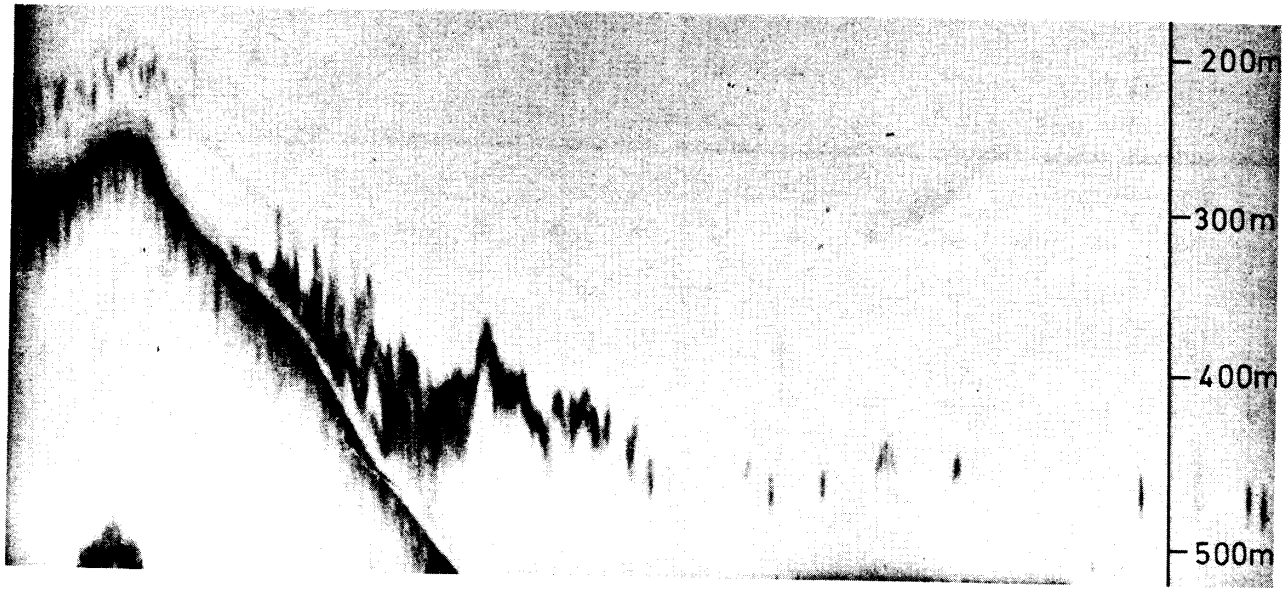

Figure 11 Paper record of echoes from blue whiting on the shelf edge where densities of over 1 000 tonnes per square kilometre were recorded in April 1975.

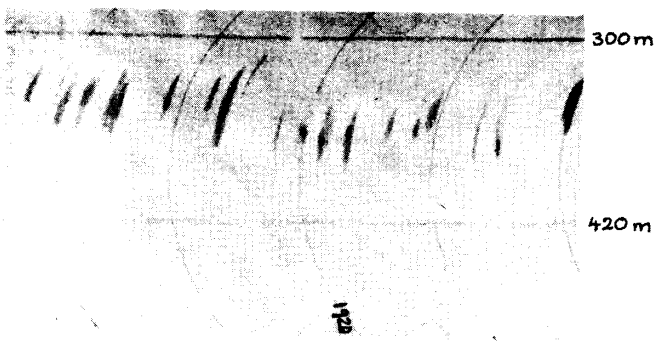

Figure 12 Echo record of blue whiting layer in Rockall Channel, April 1975; fish density estimated at 80 tonnes per square kilometre.

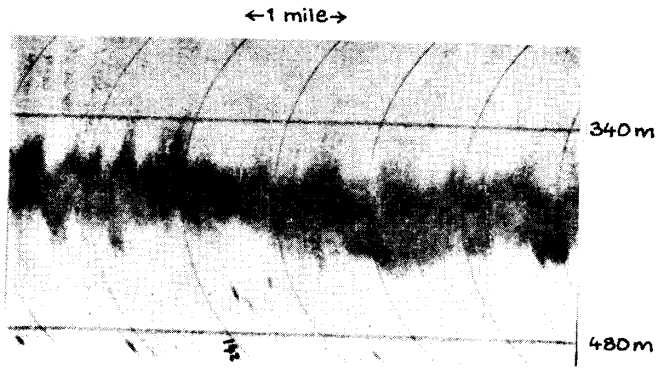

Figure 13 Echo record of blue whiting near Rosemary Bank, April 1975; fish density approximately 700 tonnes per square kilometre.

during daylight which, unlike the blue whiting layer, appears to rise towards the sea surface at dusk, descending again at dawn. This layer is composed mainly of small fish (myctophids) and/or shrimp-like euphausiids (krill) upon which the blue whiting begin to feed as they migrate northwards after spawning. During this migration the blue whiting rise to within 200 m of the sea surface (see Figure 9) and disperse widely, making acoustic determination of their distribution and abundance difficult.

Distribution outside the spawning season

Adult blue whiting are caught as far north as Bear Island and Spitsbergen, where they have been found along the polar front, before returning to their spawning area via Jan Mayen and east of Iceland (Schultz et al., 1978). Since 1960 blue whiting have been reported with increasing frequency in accidental catches by the Icelandic herring purse-seine fleet, and although the wide distribution of feeding blue whiting make location difficult and catch rates unreliable, the occasional good hauls taken from dense shoals on their return journey to the spawning grounds in the autumn have recently stimulated research into fishery prospects at this season.

The full extent of the feeding migrations of the blue whiting which spawn to the west of Britain is not known, since it is impossible to obtain live fish in good condition for tagging from a depth of over 200 m; nor is there any evidence to suggest that there is more than one stock using this spawning area. Investigations on the variation in some biological characteristics (e.g. body dimensions, fin ray counts, parasite burden) of blue whiting caught throughout the year at different localities have recently begun (Anderson and Jakupsstovu, 1978; Smith and Wootten, 1978); these have indicated that there are probably two or three (geographical) races in the feeding area.

Distribution of juvenile blue whiting

From the foregoing it can be seen that the adult blue whiting spawn at a depth of 300-500 m over deep water and along the edge of the continental shelf and banks. The peak spawning time varies with latitude, from February in the Western Approaches/Celtic Sea to April at St Kilda and May at south Faroe, i.e. it moves northwards with the advance of spring. The eggs and larvae move slowly towards the water surface as they develop (Coombes and Pipe, 1978), although the direction in which they drift away from the spawning area is still uncertain, since we do not know the distribution of juvenile blue whiting up to 2 years old. It seems likely that many live within the upper 100 m of the open ocean in the North-east Atlantic and Norwegian Sea, and as they grow some may join older fish which have been found living near the sea bed at the edge of the continental shelf at depths of 100-600 m throughout most of the year. Members of this population are taken in the Norwegian industrial fishery along the western edge of the Norwegian Deeps in the North Sea. The majority, however, probably remain pelagic and eventually recruit to the breeding population when they mature.

Blue whiting population age structure

Midwater trawling south of Porcupine Bank in April has yielded mainly 2- and 3-year-old fish with mean lengths of around 17 and 21 cm respectively, whilst the same gear fished to the north at this time caught a representative sample of the spawning population with a mean length of approximately 30 cm. It is not known whether these small fish are derived from the main spawning area to the north or from a population living in the Bay of Biscay. Robles and Porteiro (1978) report that the majority of blue whiting taken in the Spanish fishery in the Bay of Biscay are less than 4 years old. The depth of

midwater fishing in each of these two areas (at least between 200-500 m) has little effect on the size of blue whiting caught. In contrast, the size and age of blue whiting taken by bottom trawls appears to be related mainly to depth, and is largely independent of latitude; as bottom trawl fishing depth increases there is a progressive inclusion of more and older age groups, raising the average length from 18 cm at 150 m to 25 cm at 500 m, again in April. It seems likely that this relationship holds throughout the year, but considerably more investigation is required to explain the occurrence of both 'pelagic' and 'demersal' populations of blue whiting along the shelf edge, and to understand the basis for these behavioural differences in one species of fish. Similar findings have been reported in studies on the smaller spawning area to the south-west of Iceland (Magnusson, 1978).

Figure 14 illustrates the differences in age composition of samples of blue whiting taken by bottom trawl above and below the 250 m depth contour, and by midwater trawl from the spawning population. Although the relative dominance of the most abundant age

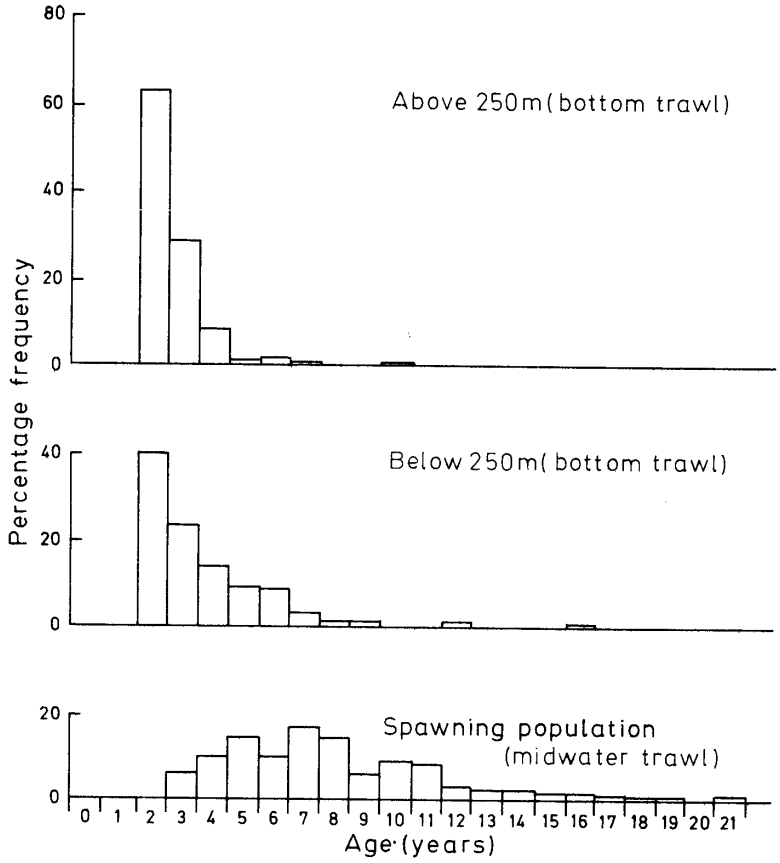

Figure 14 Age distribution of blue whiting taken by bottom (Granton) trawl at depths above and below 250 m, and by mid-water (Engel) trawl in the spawning layer, during April 1978.

groups in the spawning population varies somewhat from year to year, its general structure remains the same. This implies that some blue whiting mature for the first time in their third year, but recruitment to the breeding population is not complete until most fish are 7 or 8 years old. In common with many species of fish male blue whiting mature earlier and reach their maximum length quicker than females (Figure 15), resulting in the age and length structures seen in Figures 16 and 17.

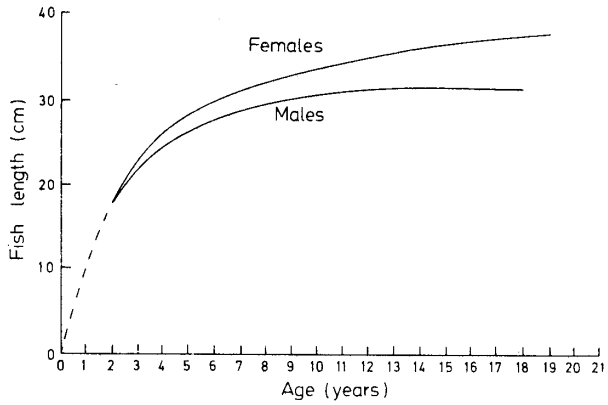

Figure 15 Typical growth curves for male and female blue whiting.

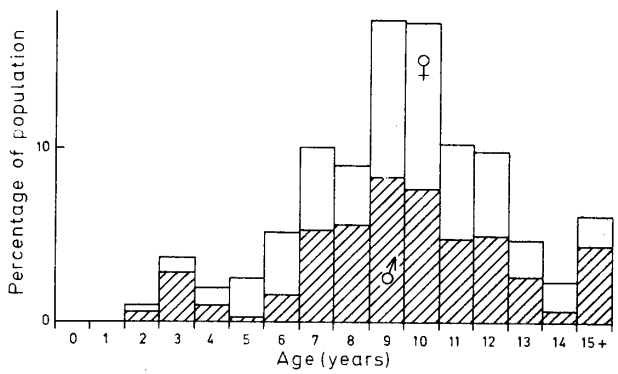

Figure 16 The age composition of male (♂) and female (♀) blue whiting taken from the midwater layer in the spawning area during April 1975.

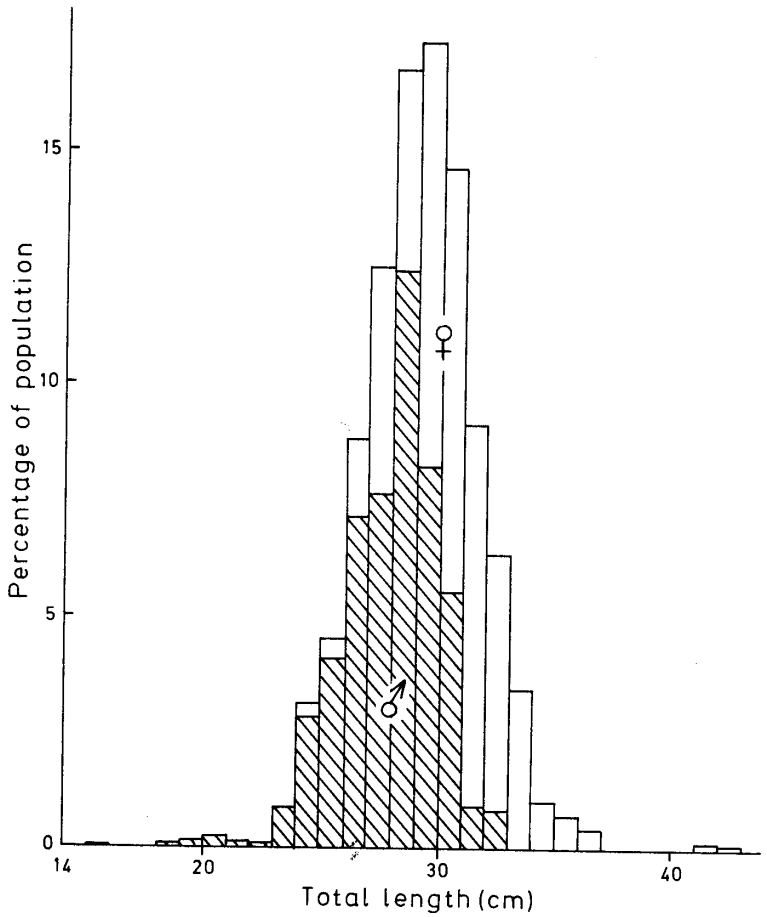

Figure 17 The length distribution of the blue whiting sampled as in Figure 16.

Abundance estimates

Acoustic estimates of the quantities of blue whiting to be found in the main spawning area at any one time have varied from around 1 million tonnes to over 20 million tonnes, depending on the timing of the survey, the area covered, and the target strength used in the calculations. Scottish, Norwegian and English results agree, however, that an average of 40-50 tonnes per square kilometre were present in the first week of April in each of the years from 1973 to 1978, although much higher densities were found in the areas of high abundance shown in Figures 7 and 8. At this time the blue whiting were spread over at least 100 000 square kilometres, which indicates a stock size of approximately 5 million tonnes. The MAFF surveys have shown, however, that the peak of abundance at the spawning grounds occurs later, around the middle of April, and that in early April unspawned fish still enter the area as spent fish leave. Thus, the total spawning stock must be greater than 5 million tonnes and may be in excess of 10 million tonnes. Additionally the age structure of the spawning population (Figure 16) suggests that, as many fish are not mature until their fourth or fifth years, a large proportion of the total blue whiting stock must remain outside the spawning area each year.

In the first half of 1978,220 000 tonnes of blue whiting were landed by the countries shown in Table 2, and it seems likely that catches will increase rapidly over the next few years.

Table 2 National blue whiting landings for 1977 and 1978 (thousands of tonnes). Figures in parentheses are estimates at the time of going to press.

Country	1977	1978
Norway	40.1	117.5
USSR	71.0	(200)
Faroe	29.7	(40)
Denmark	34.8	(10)
Spain	15.0	(15)
Germany	13.2	(17)
Iceland	10.0	(30)
Poland	6.5	(5)
Sweden	8.0	(6)
England and Wales	1.5	4.7
Scotland	3.0	1.6
Netherlands	-	(1)

COMMERCIAL FISHING METHODS

Throughout most of the year blue whiting are too dispersed to make directed fishing economic, and most fishing effort now occurs at the spawning grounds. In the majority of cases single midwater trawls have been responsible for good catches of blue whiting, although high-headline bottom trawls may be effective where the fish are congregated close to the shelf edge (see Figure 11). In general, vessels of over 40 m in length and with an engine power of 1 200-2 500 hp have been found necessary, in view of both the weather and sea conditions encountered in the spawning area to the west of Britain (see

summary in Table 1) and the power required to tow large (40 m mouth gape, 250 m long) midwater trawls at 200-500 m depth. In future this limitation may be reinforced by the need for increased hold capacity, although the development of trawls with wing meshes of 10 m and more has allowed vessels of 1 500 hp to achieve the manoeuverability required to catch blue whiting (Rasmussen, 1977; Anon, 1978). Headline transducers firing both towards the surface and downwards are essential, in the first place to enable the net to be fished at the correct depth over very deep (1 000 m+) water, and in the second to allow fishing near the edge of the shelf where the fish layer may be only a few metres from the sea bed. The downward-firing transducer will also give an indication of the amount of fish passing into the net under the headline. Burst nets resulting from excessive catches have occurred quite frequently, and cod-end-stretch indicators are now available which give more accurate information on the amount of fish in the net. Most net bursts have happened during hauling, when the air bladders of the blue whiting expand enormously with the decrease in pressure. Catches are usually pumped from the cod-end if they are too large to be hauled aboard directly. Catch rates of around 10 tonnes per hour have been maintained whilst fishing on the blue whiting layer over deep water, and up to 200 tonnes for a 20 minute tow in the very dense aggregations on the shelf edge have been recorded during daylight. At night the blue whiting are often less densely aggregated and catch rates are lower. Further information on fishing techniques can be obtained from the Industrial Development Unit of the White Fish Authority, or from the publications marked with an asterisk in the bibliography.

UTILIZATION OF BLUE WHITING

The blue whiting is potentially a very important resource in view of its great abundance, relative ease of capture and edibility. The prospect of a decrease in landings of white fish for direct human consumption has led to various attempts to supplement this market with blue whiting. Difficulties have been encountered due to the fish's small average size, keeping qualities and poor condition at the time that it is most easily caught. Reports on trials designed to overcome these problems are available from the MAFF Torry Research Station at Aberdeen.

Small blue whiting feed on plankton including the eggs of other fish (e.g. mackerel), graduating to euphausiids (krill) and myctophid fish as they grow. As krill are hosts to larvae of the Anisakis parasite, known as herring worm, adult blue whiting are often quite heavily burdened with this parasite, which is found in the liver and gut. Their flesh, however, is normally clear of parasites unless processing is delayed after capture, and/or the fish are not quickly deep frozen. The quality of their flesh deteriorates during the spawning migration when the blue whiting do not appear to feed, reaching a minimum after spawning when a 30 cm fish may weigh less than 120 g and have an oil content of less than 1%. The same fish would have quite oily flesh and weigh around 160 g in August/September. Unfortunately the post-spawning fish are the most easily caught, although efforts are being made to locate shoals prior to spawning, when fish are in better condition and more suitable for direct human consumption.

A pilot scheme to manufacture surimi, the basic ingredient of a traditional Japanese fish sausage, run by the White Fish Authority at Stornoway in April/May 1978, showed that the blue whiting may give an acceptable end product with a potentially very large export market. The UK fish-meal industry has so far shown little interest in blue whiting, probably due to a seasonal clash with the Cornish mackerel fishery, and the low oil yield. The main catcher at present is Norway and the 117 000 tonnes taken by Norwegian vessels in 1978 was used for fish meal.

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