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REPORT OF THE BLUE WHITING ASSESSMENT WORKING GROUP  
Bergen, 5 - 10 May 1980

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1980-1981  
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Report of the Blue Whiting Working Group  
Bergen, 5 - 10 May 1980.

1. Introduction

The Blue Whiting Working Group met at the Institute of Marine Research, Bergen, from 5 - 10 May 1980. The terms of reference were set by the Council's resolution passed at its 67th Statutory Meeting (C.Res. 1979/2:11) to:

- (a) Assess the current exploitation rate of the blue whiting stocks and advise on the biological need for and form of any regulatory action,
- (b) collate and evaluate the results of the 1979 blue whiting surveys and coordinate the surveys in the remainder of 1980.

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Section 2.

The Blue Whiting Fisheries

The total landings of blue whiting have increased considerably in recent years from approximately 100 000 t in the period 1971-75 to approximately 1100 000 t in 1979 (table 2.1).

The fishery is distributed over a vast area of the North East Atlantic extending from Area IX in the south to Areas I and II in the North. Within this area, however, five main fisheries can be defined (fig. 2.1).

- a) In the Norwegian sea and adjacent waters (Areas I and II and divisions Va and XIVA) (table 2.2) a fishery on feeding blue whiting. By far the greatest catches (642 000 tonnes in 1979) in this fishery are landed by USSR vessels followed by G.D.R. vessels (22 500 tonnes in 1979).
- b) A spawning fishery based on the spawning stock in the spawning area (divisions VIA,b and VIIb,c) and at Faroe (division Vb) on fish migrating to and from the spawning area (table 2.3). The greatest part (185 000 t in 1979) is landed by Norwegian vessels followed by Faroese (37 000 t in 1979), Danish and USSR vessels.
- c) An industrial fishery for Norway pout at Iceland (division Va) (table 2.4) in which mainly 1 group blue whiting are caught as a bycatch.
- d) An industrial fishery for Norway pout and juvenile blue whiting in the North Sea (divisions IVa and IIIa) (Table 2.5). The main landings of blue whiting are by Norway (59 000 tonnes in 1979) and Denmark (19 000 tonnes in 1979).

e) A Southern fishery (Areas VIII and IX and divisions VIIg-k) (table 2.6). The main landings in this fishery are from Spanish vessels (24 000 tonnes in 1979) taken partly in a directed fishery for blue whiting and partly as a bycatch in other fisheries. Most of the fish landed are young immature blue whiting.

In the section below descriptions are given of each national fishery submitted by the working group members.

## Section 2.1. Description of the national fisheries

### Faroese

The Faroese fishery on blue whiting which started in 1975 is mainly based on the spawning stock. The fishery starts in March-April on prespawning and spawning blue whiting in division VIa and continues on postspawners in division Vb in May-June. Some blue whiting are also caught as bycatch in the mixed industrial fishery in the North Sea.

### Federal Republic of Germany

The fishery on blue whiting of the Fed. Rep. of Germany is more or less an experimental fishery. Catch data are available from 1972 onwards. Catches of blue whiting have been used for processing trials for human consumption. The main fishing areas are west of the British Isles, off the Norwegian coast and in the Bear Island -Spitsbergen area.

### German Democratic Republic

The blue whiting catches of the German Democratic Republic mainly originate from the feeding concentrations in the Norwegian Sea and the post-spawning concentrations in the Faroe area. In 1979 the bulk of the catches were taken in the polar-front area south and far to the east of Jan Mayen from

July to November. Fishing in that area was conducted mainly by single-ship trawling, but partly by pair trawling of stern-trawlers operating in conjunction with a mothership. In the past single ship trawling on the summer-autumn concentrations was successful mainly in the upper water layers. As a result during that period the G.D.R. vessels operated mainly in the polarfront area.

The catches in Faroese waters were taken by few factory trawlers from May to July.

### Iceland

The first serious attempt to fish blue whiting by an Icelandic vessel was made by a purse seiner in 1972 in the Norwegian Sea.

During 1973-1975 sporadic attempts to fish blue whiting were made in the Norwegian Sea and at the Faroes both by commercial and research vessels, using pelagic trawls, but the results were not encouraging. In the summer of 1976 successful experimental fishing was conducted at East Iceland and since 1977 Icelandic vessels have fished postspawning blue whiting in Faroese waters in May and at East Iceland in July-August.

For various reasons the development of the Icelandic blue whiting fishery has been rather slow, but it is expected that interest in the fishery will increase considerably in the near future. An industrial fishery for Norway pout has taken place off the Icelandic south coast since the late sixties, a considerable part of the catch consists of juvenile blue whiting.

### Norway

Norwegian catches of blue whiting are taken in a directed fishery with pelagic trawl during the spawning season in March-May, and as bycatch in the mixed industrial fishery with

small meshed bottom trawls throughout the year. While the mixed fishery which takes place in division IVa and in the south eastern part of division IIa has continued for a long period, the directed fishery became commercial from 1975. Before that, there were three years with an experimental fishery.

The fishery during the spawning season in divisions VIa,b, VIIb,c and Vb has developed rather quickly since 1975. More than 50 vessels participate and land the majority of the Norwegian catch.

The fishery starts in mid March in the area west of Ireland. The fleet follows the concentrations as they migrate northwards along the slope, and the fishery terminates at the end of May in the area south and west of the Faroe Islands.

In July/August 1979, a small purse seine fishery for blue whiting took place in the southern part of division IIa. Around 3000 t were caught, consisting of one year old fish.

#### Poland

The fishery started in 1974 when 341 tonnes were caught, mostly to the west and south of Ireland. In 1975 and 1976 the majority of the catches were taken from the main spawning areas west of Ireland and the British Isles. The total catch increased to 4704 t and 11 475 t in the two years respectively. In 1977 about 23% of the total catch (6539 t) originated from feeding concentrations of blue whiting south-east and east of Jan Mayen. This proportion increased in 1978 to about 62% of a total catch of 8206 t. In 1979 catches totalled 8989 t and were equally divided between the Norwegian Sea and the spawning fishery.

The fishing fleet involved in the fishery consists of stern freezer trawlers (above 3000 tons GRT) using pelagic trawls.



The fishery usually begins in March-April in the area west of Ireland (VIIB,c) and follows the northward movement of spawning and post-spawning aggregations. In May, June and July the fishery is conducted on the Faroe Plateau and to the north in subarea IIa. During the following three months the fishing activity concentrates in the area south-east and east of Jan Mayen.

### Spain

Spanish fisheries on blue whiting began many years ago on the continental shelf along the North and Northwest coast of Spain at depths of 100-400 m using bottom trawls. (The directed fishery is carried out by pair trawlers whereas the bycatch is taken by single trawlers.)

The catches have been more or less stable from year to year, perhaps because the market demand both for human consumption and fish meal was also stable as a result of the low price of the fish. In the most recent years the catches increased because the prices rose after the implementation of 200 mile limits.

The bulk of the catches, which are taken mainly in the second half of the year, are composed of individuals from 1 to 3 years old, at least in divisions IXa-VIIIc (west), that is the area where the major part of the fleet fishes. Practically no fish in maturation stages V-VII have been recorded during research vessel groundfish surveys. Every year fish from 14 to 18 cm are recruited to the fishery in the autumn-winter period. The adult stock to which these fish recruit is not known.

### U.K. (England and Wales)

Apart from small quantities taken as bycatches in demersal fisheries the main landings by English vessels have been the

result of a limited experimental commercial fishery. Directed fishing has taken place on spawning aggregations west of Scotland (VIa) and on the migrating adult stock in the Faroe area. Most of the fishing was by large vessels using pelagic trawls. Economic factors have limited the growth of the fishery and total landings have not exceeded 6000 tonnes in any year.

#### UK (Scotland)

A very small midwater trawl fishery has taken place on the spawning concentrations west of Scotland in the spring, the largest catch being 3000 t in 1977. A proportion of the landings have been made in Division Vb as the blue whiting move northwards. Bycatches of blue whiting in the small Scottish industrial fishery for Norway pout are negligible.

#### U.S.S.R.

Investigations on blue whiting as the object of a potential commercial fishery were started by the USSR in the middle of the 1960's, but the catch of this species in general did not exceed 20 000 tonnes until 1976.

The greater part of the catches were taken in February-March on the Irish shelf except in 1971 when blue whiting fishing took place in the area east of Iceland. Catches by pelagic trawl from the end of May to August 1971, in that area, amounted to about 31 000 tonnes.

Blue whiting fishing in the Norwegian Sea developed rapidly after 1976. From 1977 to 1979 the catch by Soviet vessels increased by almost three times and reached 665 000 tonnes. The fishery takes place mainly from May to December when adult fish are distributed in the Norwegian Sea. The catches are mainly composed of blue whiting 28-32 cm in length. In 1979 experimental fishing on fish concentrations by purse seines was carried out. The results of these experiments were promising.

Section 3.

Stock Identity

Excluding the stock of blue whiting in the Mediterranean and the relatively small population in the western Atlantic, it is not clear whether the fish in the North-East Atlantic constitutes one or more stocks. There is clear evidence that a major proportion of the population migrates south from the feeding and overwintering areas in the Norwegian Sea to spawn along the continental slope west of Britain and Ireland. The relationship of peripheral populations to this stock are not known with any certainty.

In the Southern area, (south of Porcupine bank, the Bay of Biscay and the Iberian coast) significant catches of juvenile blue whiting are landed throughout the year (see for example fig.4.2). Although some spawning is recorded at the shelfedge of the Bay of Biscay, the spawning component in this area does not appear to be large. It is thus not clear whether the juvenile fish in this area recruit to local spawning areas or to areas further north.

Prior to the main southward migration, maturing blue whiting concentrate at Porcupine Bank, possibly from wintering areas in the Celtic Sea and Bay of Biscay. It is thus possible that this area supports a stock separate from that further north, but it is undoubtedly true that the migration from the north also reaches Porcupine Bank. Separation of the catches into the two stocks would therefore be totally impossible at present.

Some spawning has been recorded southwest of Iceland, but in this area also it appears to take place on a rather small scale. The relationship between the small spawning population, the nursery area south of Iceland and the populations between the west of Iceland and east Greenland are also unclear, and no well-defined migration pattern has been described for the area.

Although there is a well defined migration from the Norwegian Sea in the early spring, there is also a considerable amount of blue whiting remaining in the area. Off West-Spitsbergen old blue whiting are found throughout the year with the highest concentrations in the period July-October. Analyses of the gonads of these indicate that some of the fish in this area do not spawn every year or may not spawn at all (MAZHIRINA and USHAKOV 1978). Further in the middle of March 1980 a USSR research vessel caught postspawning blue whiting (29-33 cm) in the region between  $63^{\circ}$ - $64^{\circ}$ N and  $0$ - $2^{\circ}$ E. There is also some evidence of spawning along the shelf edge off the Norwegian coast (Zilanov 1968) and in the Norwegian fjords (Monstad, 1979). It is at present obscure whether spawning north of the Wyville Thomson ridge is an annual phenomenon and if so whether it is large enough to account for the residual population in the Norwegian Sea.

The above brief account suggests the possibility that there are separate blue whiting stocks in the northeast Atlantic, but with the present state of knowledge, it would be impossible to define appropriate stock boundaries. It also seems likely that immature fish from one population may be mixed with mature fish from another, or that there is mixing of several populations at certain times of year, such as in the Norwegian Sea in summer. Until methods are developed to identify stock components originating from defined spawning areas, the working group decided to treat the entire northeast Atlantic as a single assessment unit, except for the southern area (VIIg-k, VIII and IXa).

## Section 4.

### Catch Composition

#### 4.1 Age determination

An otolith exchange programme reported to the ICES statutory meeting in 1978 showed that great and unacceptable variability occurred between the age determinations made by otolith readers from different countries. The problems of ageing blue whiting were discussed thoroughly at a workshop during the meeting of the blue whiting planning group in 1979 and are described in the report of that meeting (Anon 1979a). There was at that meeting general agreement that blue whiting otoliths are very difficult to read for a variety of reasons listed. It was, however, felt that there was better agreement between readers at the end of the workshop than at the beginning. An otolith exchange programme to establish whether or not this is true is not yet completed.

The increase in blue whiting catches in recent years indicates the need for estimates of the exploitation rate. In order to do this, the group decided to accept the age readings provided by the working group members. These were not corrected for different interpretation of the first years growth. The difficulties which may arise from age determination problems in interpretation of later sections are obvious and must be stressed.

#### 4.2 Age compositions of the landings (Northern areas)

Age compositions of commercial landings were available for the Northern areas as follows:-

USSR: for all areas and seasons combined from 1970 to 1979.

Norway: from the spawning fishery from 1973 to 1979, and from the industrial fisheries from 1972 to 1979.

Iceland: from the industrial fisheries from 1972 to 1979.

German Democratic Republic: for all areas combined from 1977 to 1979.

Poland: for all areas combined for 1978 and 1979.

Faroe: for the spawning area for 1979.

Age compositions of the total landings were estimated for the Norwegian Sea and Spawning fisheries combined and for the Industrial fisheries. The age composition for Norwegian landings from the Spawning fishery was used for other countries' landings from the Spawning fishery. The USSR age composition was used for other countries' landings from the Norwegian Sea and non-industrial catches from the northern North Sea. For the Industrial fisheries for which there were no age compositions catches were assumed to have the same relative age composition as in the Norwegian industrial fishery. The total age compositions for the spawning fishery, the Norwegian Sea fishery and the Industrial fishery were then summed to give overall total age compositions for the whole Northern area (Table 4.1).

No age composition data were available for the Southern area.

#### 4.3 Age composition

Percentage age compositions for the most important components of the fisheries in Northern areas are shown for 1979 in Fig. 4.1. This shows:-

- a) that the mixed industrial fisheries in the North sea and south of Iceland exploit primarily the younger age-groups (see also table 4.2).
- b) that both the Spawning fishery and the fishery in the Norwegian Sea exploit the older age groups. The modal age indicates that recruitment to these fisheries is not complete until an age of 6-7 years (see also table 4.3).

No data on age compositions were available for the southern areas. Fig. 4.2, however, shows length compositions in the Spanish fishery in Divisions VIIIC and IXa. These indicate that this fishery exploits mainly the young age groups, probably mostly 1- and 2-group fish.

## Section 5.

### Weight at Age

Considering the great effort necessary to prepare weight at age data for all years, it was decided to calculate at this meeting only data for 1979. In order to get an overall weighted mean value at age, mean values were calculated for the spawning area, the Norwegian Sea and the mixed fishery in the North Sea and summarized by weighting these values by the relevant catch in numbers of those areas. The overall mean values used in the stock size and yield per recruit calculations and the basic mean values of the three areas mentioned are given in table 5.1. The overall mean values fit the total catch very well (99.3%).

In table 5.2 mean weight data are given for several countries regarding the main fishing areas and quarters.

#### 5.1. Spawning area

Weight data were available from Faroe, Norway and Scotland. Differences in these data may be due mainly to the areas fished and months of sampling. Summarized weight data for the spawning fishery given in table 5.1 are weighted mean values of the second quarter for the Norwegian and the Faroese fishery which accounted for 85 % of the total catch in the spawning area.

#### 5.2. Norwegian Sea

Weight data for the Norwegian Sea were provided by the USSR, Norway and German Dem. Rep. The USSR weight-at-age data are calculated by means of length-weight data per quarter and an age-length key for the total year available from USSR commercial sampling. Significant differences between the data of the countries reflect the large differences of weight per length and age which exist between the southern and the northern parts of the Norwegian Sea. Fig. 5.1 demonstrates the differences in weight per length group between the areas south and north of 70°N.

Nevertheless, differences in weight at age may arise, as in the other areas mentioned, because of differences in sampling and age determination methods.

In order to get a mean value at age fitting most closely the catch-in-number calculation, the USSR weight data for the third quarter (representing approximately 80% of the total USSR catch) were selected as a representative mean value for the Norwegian Sea for the whole year. Using only the USSR data to provide an overall mean accounts for 94% of the total international catch in this area.

### 5.3. Mixed Fishery (North Sea)

Weight at age data for the industrial mixed fisheries in the North Sea were available for all quarters from Norway. Mean weight data for that fishery for the total year were calculated from data by quarters weighted by the total catch in numbers from the total fishery (Norway, Denmark, Faroe).

## Section 6.

### Natural Mortality

Total mortality coefficients  $Z$  were estimated by catch-curve analysis based on Norwegian samples (mostly from research vessels) from the spawning stock in Divisions VIa-Vb for the years 1973-1979. It was assumed that recruitment to the spawning stock was complete at an age of 8 years. The age compositions are given in Table 6.1. and the regressions of  $\ln (\%N)$  against age are shown in Figure 6.1. The results are given below. Bailey (1978) has estimated mortality by the same method based on Scottish research vessel samples from the spawning stock, assuming complete recruitment at 7 years old, and his estimates are given for comparison.



Year	Total mortality (Z)	
	Norwegian samples	Bailey (1978)
1973	0.16	0.16
1974	0.26	0.22
1975	0.11	0.45
1976	0.25	0.64
1977	0.44	0.26
1978	0.33	0.33
1979	0.34	
Mean	0.27	0.34

Although the two series give approximately the same mean Z, there are large differences in individual years. There are two possible explanations for this: (a) The samples represent different components of the population, (b) There are differences in ageing.

It should be pointed out that Z's from the catch curves reflect the mean mortality in previous years, and not the mortality in any individual year.

It should also be stressed that one basic assumption for using the catch curve method is that the population is in an approximate equilibrium state. Trends in recruitment or trends in exploitation rate may seriously distort an equilibrium age composition and make it difficult to interpret estimates of Z. Large variations in recruitment may reduce the usefulness of catch curves from individual years, but a mean age composition or a mean of the Z-values over many years may still give useful results if there are no trends.

The large increase in catches of blue whiting from 1975 onwards may to some extent have affected the age compositions for the most recent years. However, assuming that fishing mortality was at a low level compared to natural mortality at least up to 1978, the catch curve method would still be valid for estimating Z in previous years.

The estimated mean Z can be taken as a first approximation of natural mortality, taking into account that it could be a slight overestimate. It was therefore concluded that natural mortality on the mature age groups could be in the range 0.2-0.3.

Section 7.

Stock Rise Estimates

7.1. Acoustic stock size estimates

Quantitative acoustic surveys of the spawning area west of the British Isles have been made every year since 1972. Published results of the earlier surveys are given in Table 7.1, while those carried out in 1979 and 1980 by Norway and the United Kingdom are described in greater detail. In addition, a quantitative survey of the distribution in the southern part of the Norwegian Sea was carried out in June 1979 by the Soviet Union, and a survey of the Faroe area was made by a Faroese research vessel in April 1980.

7.1.1. Methodology

The crucial problem in interpreting the results of acoustic surveys is the factor used to convert back scattering intensity from fish echoes to an equivalent weight or number of fish. On previous blue whiting surveys this has been done in two ways:

- a) using empirical values obtained from single fish echoes during the course of the survey;
- b) using target strength measurements of dead blue whiting suspended in the beam of the echosounder.

The great depth of blue whiting during the surveys provides some problems with the first method. Among others these are the difficulties of defining the volume of water insonified and distinguishing single from multiple echos. Using the second method, the value of target strength of a single blue whiting of ca. 33 cm given by Nakken & Olsen (1977) is -32 dB in maximum dorsal aspect. This was based on only ten fish, but the experiment indicated that the value was very close to that of cod of a similar size. Considerably better values have been obtained for this species (Nakken & Olsen 1977), including values for the true aspect in the sea. Assuming that blue whiting of 30 cm reflect in the same way as cod of 30 cm, values for cod have therefore been used to provide length dependent conversion factors (C-values) for the Norwegian acoustic surveys.

Assuming that the mean weight of spawning blue whiting is ca. 130 g (the value obtained on the 1980 Norwegian survey), Nakken & Olsen's (1977) published value would indicate a target strength of around -32 dB/kg. This value has been used as a reference to standardize the results of the UK surveys in Table 7.1. Because of the different techniques, however, it is not possible to state whether this is the same value used for the Norwegian surveys.

In addition to this approach, an intercalibration was carried out between the Norwegian, Faroese and UK vessels taking part in the survey in 1980. This was carried out in the spawning area in April. The ships steamed 39 nautical miles at about 7 knots, 0.5 nautical mile behind each other, and 0.1 n.m. apart from each other sideways to avoid propeller noise. Examination of the echotraces for comparable lengths of cruise track show that there were small-scale differences of distribution. Nevertheless, the correlation coefficients between the ships using the Norwegian vessel as a standard were 0.84 for the Scottish (Fig. 7.1) and 0.70 for the Faroese vessel. Noise reduced the number of usable data points on the Faroese vessel. This indicates that the distribution of densities recorded by the three ships is likely to be similar. It also provides an indirect means of checking that the target strength values assumed by the Norwegian and Scottish vessels are approximately the same.

The C-value used on the Norwegian survey in 1980 was  $3\ 355$  fish/mm/nm<sup>2</sup>, where nm is a nautical mile ( $C = 5.25 \times 10^6 \times 1^{-2.18}$ , based on observations made by Dalen, Nakken and Smedstad, personal communication).

The mean weight of fish in the population was 132 g and 1 mm deflection was therefore equivalent to 0.129 t/km<sup>2</sup>. Using the slope of the ordinary regression obtained from the intercalibration, and ignoring the intercept:

1 mm deflection on the Norwegian vessel is equivalent to  $6.9 \times$  the Scottish values expressed as t/km<sup>2</sup> (referred to a target strength of -34 dB/kg). Thus, 0.129 t/km<sup>2</sup> on the Norwegian vessel is equivalent to 0.145 t/km<sup>2</sup> on the Scottish vessel. This indicates that the estimates made on the two vessels were

based on very similar assumptions of target strength. (The ratio of 0.145 : 0.129 is equivalent to a difference of only 0.5 dB). Since the value assumed on the Scottish vessel, however, was -34 dB/kg, this implies that the value used on the Norwegian vessel was around -33.5 dB/kg, i.e. significantly lower than the value of -32 dB/kg agreed as the best one available for blue whiting.

In the case of the survey made by the Soviet Union in June 1979, a conversion factor was obtained from echoes of single fish recorded at night at depths of 35-60 m.

#### 7.1.2. Results of surveys

Published estimates of spawning stock biomass in the area west of the British Isles are summarised in Table 7.1. In all cases the UK estimates have been standardized with reference to a target strength value of -32 dB/kg. In surveys carried out before 1979, the Norwegian estimates are based on the single fish counting method. They are on average consistently lower than those from the UK surveys referred to -32 dB/kg. Since the conversion factors used were considerably lower than those based on 30 cm cod, it is likely that the true values would have been higher than those published. Excluding extreme values, the earlier surveys would therefore indicate a range of spawning stock size from 2-15 x 10<sup>6</sup> tonnes in the years 1972-1978, the mean value for all surveys being 8.5 x 10<sup>6</sup> tonnes. It should be pointed out, however, that the timing and area covered by these surveys are different, and the estimates are therefore not strictly comparable.

The areas covered during the surveys in 1979 and 1980 are shown in Figure 7.2. The surveys in 1979 did not cover the area south of 55°30'N. Estimates of total biomass are 14.8 x 10<sup>6</sup> t based on the Scottish survey (standardized to -32 dB/kg) in the first three weeks of April and (Warburton et al., 1979) 7.9 x 10<sup>6</sup> t based on the Norwegian survey in late April. This figure differs from the value reported earlier (Monstad 1979), because of an intercalibration and the use of a more appropriate C-value. During the second of

these surveys, there was evidence from the distribution that the fish had already started moving north and some decrease between the two surveys might therefore have been expected.

In 1980 two surveys were again carried out and the distribution of estimated biomass is shown in Figs. 7.3 and 7.4. The Scottish survey extended west to Rockall Bank, but did not cover the northern and southern parts of the spawning area. The estimated biomass was  $2.9 \times 10^6$  t (reference -32 dB/kg). The Norwegian survey covered the full latitudinal range of spawning ( $52^{\circ}$ - $61^{\circ}30'$ N), but did not cover Rockall Bank. The estimate of biomass was  $5.4 \times 10^6$  t to which might be added perhaps another  $0.7 \times 10^6$  t to cover that part of the area covered by the Scottish, but not by the Norwegian survey (i.e. a total of  $6.1 \times 10^6$  t). It should be stressed, however, that the estimates obtained depend on the estimates of target strength and conversion factor. More reliable estimates based on free-living blue whiting are badly needed.

The results of the survey by the Soviet Union in June 1979 indicated concentrations of blue whiting in the area north and northeast of the Faroes, i.e. considerably further east than at the same time in previous years. This distribution pattern received some confirmation from the absence of concentrations in the normal area immediately to the east of Iceland. The estimate of biomass in the area surveyed (approx.  $62^{\circ}$  -  $65^{\circ}30'$ N and  $2^{\circ}30'$  -  $8^{\circ}$ W) was  $3.4 \times 10^6$  t (Zaferman et al., in press). If one assumes that this is only a part of the total biomass in the Norwegian Sea at this time, then the estimate is not in disagreement with the values given above for the spawning area.

The acoustic survey made by the Faroes in 1980 did not cover a sufficiently large area either to reject or confirm the above estimates.

The acoustic surveys in 1980 indicate a minimum estimate of spawning stock size of around 6 million tonnes. This value, however, is lower than either of the estimates for 1979 ( $8-15 \times 10^6$  t) which covered only the northern part of the spawning area. The

reason for this difference is not known, but it may be relevant to draw attention to the age composition in the spawning area in 1979 compared with that in previous years (Table 6.1).

Unlike previous years, the spawning fisheries contained a much higher percentage of younger fish (2-3 group). A similar difference was commented on by Warburton et al. (1979), on the basis of samples taken during the acoustic survey in April 1979. It is therefore possible that the spawning areas in 1979 contained a much higher proportion of small fish than usual. Data are not yet available for 1980 for comparison.

Since the 1980 surveys are the most recent available, and because of the difficulty of interpreting the 1979 survey results, the working group decided to use the value of 6 million tonnes as a minimum estimate of spawning stock in 1980.

#### 7.2 Stock size estimate from egg and larval survey data

Coombs (1979) derived an estimate of the stock of adult blue whiting which spawns to the west of the British Isles. The estimate is based on the abundance of blue whiting eggs as determined from research vessel hauls made with the Longhurst-Hardy Plankton Recorder during the period 1974-78 combined with larval data from routine Continuous Plankton Recorder Surveys over the period 1958-78. Data for all years were combined and variation between years was ignored.

Data from the Continuous Plankton Recorder were used to delineate the spawning area and the egg data from the Longhurst-Hardy Plankton Recorder were then used to obtain an estimate of total egg production over the whole spawning area. This was then used to derive an estimate for the adult stock of  $9.98 \times 10^6$  tonnes.

Coombs indicates two main sources of potential error. First, the Hardy-Longhurst Plankton Recorder hauls had not been randomly distributed but had been biased towards areas of higher expected egg abundance. Secondly the egg production curve, being based on Continuous Plankton Recorder data, has a

time resolution of one month. The fact that data for several years had been pooled was considered unlikely to result in major errors in view of the relatively unexploited, and therefore probably stable, state of the stock.

### 7.3. Virtual Population Analyses

#### 7.3.1. Input data

Age composition data for the total catches from the Northern areas for 1970-79 (Table 4.1) were used as input data for trial Virtual Population Analyses. It was recognised that this data set had a number of deficiencies. Sampling in the earlier years was less intensive than in recent years. Estimates of bycatches from industrial fisheries for some countries were not available for all years and therefore catches from these fisheries will be underestimates for some of the earlier years. Furthermore comparisons of age determinations had indicated that ageing may not be consistent between all age readers. It has not yet been possible to fully analyse these differences and therefore no attempt was made to correct for ageing differences in the present analysis.

Analysis of mortality from catch-curves for earlier years indicated values of  $Z$  of about 0.2 to 0.3. In the period when there was very little fishing the value of natural mortality  $M$  is likely to be approximately equal to  $Z$ . In the VPA trials values of  $M=0.2$  and  $0.3$  have been used for all age groups.

The Working Group had difficulty in deciding on suitable VPA input values of fishing mortality for all age-groups for each year. The problems relate both to the overall level of  $F$  and to the appropriate exploitation pattern.

The input  $F$  values on the oldest age-groups were chosen to reflect the increasing catch which has approximately doubled each year from 1975 to 1979. The  $F$  values were increased in the same proportion as the catches on the assumption that, in a stock relatively unfished until recently and with a relatively large age range, catches would be roughly proportional

to fishing mortality. The exploitation pattern chosen reflects heavy fishing, mainly in the industrial fisheries, on age-groups one and two, and fishing mortality increasing with age as the fish recruit to the adult stock.

### 7.3.2. Results of VPA

The choice of values of  $M$  and input  $F$  values has a marked effect on the estimates of stock size over the whole range of years. This is illustrated by the results of trial runs for three overall levels of fishing mortality using  $M=0.3$  and a single run using  $M=0.2$

At present it is very difficult to interpret the results of VPA, particularly in view of the fact that all the output values are very sensitive to the choice of input  $F$  values. One possible guide to the likely level of current fishing mortality could be the stock size estimates from echo surveys which can be compared with the adult stock sizes calculated by the different VPA runs. The results of the echo surveys indicate an adult stock size of about 6 million tonnes. With the exploitation pattern used for 1979 an adult stock size from VPA of this level would be produced with an  $F$  of approximately 0.25 on age-groups 9-14. However, in view of the uncertainties associated with the assessment this estimate must be regarded as a very provisional one.

## Section 8.

### Yield and Spawning Stock per Recruit

Yield and spawning stock per 2-year-old recruit were calculated using the weight at age given in Table 5.1 and the same relative  $F$ 's on age as assumed in the VPA for 1979. 0- and 1-group were excluded from the analysis since the fishing mortality on these age groups is mainly generated by the industrial fishery in the North Sea and at Iceland. Regulation of the directed blue whiting fishery will therefore not have any significant effect on  $F$  on 0- and 1-group.



Yield and spawning stock per recruit curves are given in Fig.8.1 and Fig.8.2 for  $M=0.2$  and  $M=0.3$  respectively. In both figures the value of  $F_{0.1}$  and the value of  $F$  where  $S/R$  is one third of  $S/R$  in the unexploited population are indicated.

The curves should be interpreted with great caution since there may be large errors both in the weight at age data and the assumed relative  $F$ 's, and such errors could have drastic effects on the form of the yield per recruit curves and the value of, for example,  $F_{0.1}$ .

## Section 9. Blue whiting research in 1979

The results of research summarised in this section are as reported in papers submitted to the ICES Statutory Meeting and to the Working Group, and from information provided by Working Group members. Their inclusion here does not necessarily imply acceptance of the conclusions by the Working Group.

### 9.1 Review of the 1979 surveys

#### January - February

The main objective of these surveys was to monitor the southward migration of blue whiting towards the spawning grounds. During the pre-spawning period the results obtained in former years in the Shetland - Faroe area on the distribution and migration of the species were confirmed this year. Concentrations were located north and northeast of the Faroes, west of the northern part of Ireland and at Porcupine Bank in February by Germany, Fed. Rep. of r/v WALTHER HERWIG, while only very small concentrations were found in the area between the Hebrides and the north of Ireland. In the Shetland - Faroe area blue whiting were at maturity stage III while west of Donegal Bay and on Porcupine Bank fish at stage V predominated. Juvenile blue whiting were caught in large numbers, particularly with bottom trawl, on Rockall Bank (Schøne, 1979).

An echo-integrator survey (SCOTIA) in February indicated a minimum abundance of 4.7 million tonnes (target strength -34 dB per kg) at Faroes. The fish were mostly at a depth of 300-400 m, although the dense layering characteristic of spawning blue whiting was absent. The general distribution of the fish was similar to that reported in February 1978 (Warburton et al., 1979).

March - April

The study of the abundance and distribution of blue whiting during the spawning season was the fundamental aim of these surveys. Large spawning concentrations were present in depths of 350-450 m north and northeast of Porcupine Bank in March (ORKA and RYBAK MORSKI Polish vessels). Post-spawning concentrations were present on Porcupine Bank and at St. Kilda in April. Good pelagic and bottom concentrations of ripe and running fish were detected west of the Hebrides, on Rockall Bank, west of Ireland and on Porcupine Bank by the Germany Fed. Rep. of, r/v WALTHER HERWIG. The largest fish, predominantly females, were caught in bottom trawl catches.

An acoustic survey by the Norwegian r/v MICHAEL SARS in the spawning area from the west of Scotland to the Faroes, gave a rough and preliminary abundance estimate of 4 million tonnes (Monstad, 1979) (A revised estimate of this figure is discussed in Section 7.1.). Results from echo-integrator surveys (UK. r/v EXPLORER) indicated a minimum abundance of 23.5 million tonnes (target strength - 34 dB per kg) between the continental shelf to the West Scotland and Rockall with fish concentrated normally at a depth of between 400-500 m. Compared to the whole of the period for which April blue whiting spawning stock abundance estimates are available (1973 onwards) those made in 1979 were above average. Changes in the age composition of the population over the past two years suggest that recent strong year classes are now recruiting to the spawning stock and probably contributing to its increased abundance. Further evidence for comparatively high intensity spawning in 1979 may be provided by the unusually large numbers of blue whiting eggs collected by the Continuous Plankton Recorder during the April survey (Warburton et al., 1979).

Scattered and mobile aggregations were concentrated on fishing grounds off the Faroes and on the northern part of the continental shelf north of Scotland. The gonads of these fish were poorly developed and the fish had an insignificant percentage (3%) of parasite infection (Anisakis) in contrast to the high values (52%) found in samples taken from the spawning concentration in the Porcupine Bank area (Giedz, 1979).

No echo-traces of blue whiting were recorded in the Reykjanes area by the German Dem. Rep. commercial sterntrawler WALTER BARTH in contrast to the Germany, Fed. Rep. of, findings in the same month (April) in 1977 (Freytag and Mohr 1977).

In March a chartered Norwegian purse seiner carried out a survey in Sognefjorden (61°N) in order to record distributions of blue whiting and to exploit the resources for human consumption. Fishing took place during night time, and strong electric lights were used to bring the fish up to a level of around 50 m depth. The amount of each catch varied from 5 to 9 tonnes and the average fish length and weight were 30 cm and 200 g respectively. A sample showed they were mostly prespawners with a few spent specimens.

#### May - June

The goal of these surveys was to monitor the northward post-spawning migration. Population characteristics of the post-spawning stock based on surveys by UK r/v EXPLORER in April and May in the Faroes - West Britain area and samples from commercial landings taken at Stornoway during the same months were described. Maturity studies indicate that the southern migration on to the spawning grounds appears to have occurred rather later in 1979 than in 1978. Sex-ratio data generally agree with previous findings in the area west of the Hebrides, the proportion of males tending to rise as the season progressed. Differences between the condition factors of males and females suggest that the post-spawning recovery proceeds more rapidly in male fish (Warburton et al., 1979).

Large concentrations of spent fish were reported south and east of the Faroes in depths of 80 to 400 m by the Polish vessels RYBAK MORSKI and ORKA. Studies indicate progressively increasing feeding activity with Euphausiids, Calanoids and fish larvae as the main food components (Giedz, 1979). Echo-abundance cruises made by the Faroese r/v JENS CHR. SVABO in Faroese waters indicate that more than 2.5 million tonnes (calibration constant -34 dB

per kg) were present in the area during the peak period in May. The highest mean density appeared on the southern and southwestern side of the plateau, as in the 1978 surveys. The blue whiting migration path around the Faroes can be related to hydrographic differences between the areas east and west of the Faroe plateau (Hansen et al 1979).

Dense concentrations were registered inside the 200-miles zone northeast of the Faroes between 50-200 m depth by joint surveys carried out by the Soviet r/v AKHILL and ANDROMEDA and the Icelandic r/v ARNI FRIDRIKSSON. Analysis of the blue whiting distribution in June over the last 10 years shows that the main concentrations in 1979 were located further east than usual. This could have been caused by anomalously low temperatures in the Norwegian Sea. The formation of exploitable concentrations in the east is explained by favourable feeding conditions in the southern part of the zone. Low densities of blue whiting were found in Icelandic waters at this time (Anon 1979b and Isaev and Shevchenko, in press).

Important concentrations were found in May in the northeastern and southeastern Norwegian Sea, appearing as "walls" of a thickness of up to 100 m, by the German Dem. Rep. vessel WALTER BARTH. Scattered to rather dense aggregations were also recorded east of Jan Mayen in a layer 50 m thick. South of Jan Mayen blue whiting were more scattered. In general fish occurred at depths between 100 and 450 m.

The Soviet r/v ARTEMIDA working in the Norwegian Sea ( $63^{\circ}$ - $64^{\circ}30'$ N and  $1^{\circ}30'$ - $4^{\circ}15'$ W) reported that blue whiting migrated actively northeastwards to feed in the Norwegian Sea offshore waters. A minimum echo-abundance estimation gave a stock biomass figure of 3.4 million tonnes with 6-11 year old fish prevailing in the catches (Zaferman et al. in press).

In June the Norwegian r/v MICHAEL SARS covered the area from western Norway to Iceland between  $62^{\circ}$ N and  $66^{\circ}$ N and continued

north-eastwards along the polarfront up to Bear Island and south again along the Norwegian coast. The highest concentrations of blue whiting were recorded north-east of the Faroes, consisting of a mixture of juvenile and adult fish. Along the polar front from Jan Mayen to Bear Island, smaller and scattered concentrations of blue whiting were recorded. These consisted, however, of adult fish of more than 30 cm. In this area the recordings were similar to those observed in June 1977 and 1978. Some recordings of blue whiting were also made off the Norwegian coast. The distribution was rather scattered, and the fish were mixed with other species.

In contrast to earlier observations by Magnusson (1978), no blue whiting in spawning condition were recorded southwest of Iceland during the WALTHER HERWIG cruise between April 18 and May 22 (Kosswig & Schøne, 1979).

#### July - September

The main objective of these surveys was to investigate the summer distribution of blue whiting in the feeding areas in the Norwegian Sea and in the waters between Faroes and Iceland. In July the German Dem. Rep. r/v EISBÄR investigated the north and west part of the international waters of the Norwegian Sea and located the densest concentrations at 30 m depth in a layer 5-10 m thick between  $67^{\circ}$ - $68^{\circ}$ N and  $5^{\circ}$ W,  $69^{\circ}$ - $90^{\circ}$ N and  $7^{\circ}$ W and in an area between  $73^{\circ}$ - $75^{\circ}$ N  $3^{\circ}$ - $6^{\circ}$ E. In August dense concentrations were detected 20-60 nautical miles southwest of Jan Mayen and in various areas, mainly between  $68^{\circ}30'$ - $70^{\circ}$ N and  $0^{\circ}$ - $4^{\circ}$ W. In the Norwegian Deep rather dense aggregations were observed at the end of August and beginning of September.

Polish investigations in July with the m/t AURIGA on the grounds east and northeast of the Faroes showed fairly dense concentrations of recovering-spent fish migrating eastwards in that month. In addition the Polish r/v PROFESOR BOGUCKI detected concentrations of blue whiting at Jan Mayen during

September. Fish 8-9 years old predominated in the catches while the previous year the 12 year old group was most abundant; this possible indication of the increasing exploitation of the stock was confirmed by the total mortality coefficient derived from the catch curve that was  $Z = .84$  for 1979 against  $Z = 0.46$  for 1978 (Giedz 1979).

In July the Norwegian r/v MICHAEL SARS recorded dense concentrations of blue whiting in the southeastern part of division IIa. The concentration consisted of I-group fish of which the Norwegian purse seine fleet caught 3500 tonnes. 0-group blue whiting were observed in July and August in two separate areas, north and east of Shetland and the Norwegian coast from  $64^{\circ}30'$ - $69^{\circ}$ N extending at least 180 nautical miles from the coast. The 0-group (2-4 cm long) were caught with pelagic trawl near the sea surface, and the highest numbers were found in the area off the Norwegian coast. Comparatively few individuals of 5-8 cm long were found near Shetland. Most probably the small 2-4 cm 0-group caught off Norway could not have originated from the known main spawning area west of British Isles. They also must have been hatched later than in the main spawning season.

In August and September the Norwegian r/v G.O.SARS and JOHAN HJORT made acoustic surveys covering the eastern and central parts of the Norwegian Sea from the Norwegian coast to Iceland, further along the polar front to the Spitsbergen-Bear Island area and in the western part of the Barents Sea. The surveys carried out had other main objectives, but as additional observations, blue whiting were found widely spread almost over the entire area covered. The densest concentrations of blue whiting were recorded in the southern and central parts of the area investigated with a maximum to the east and northeast of Iceland.

The extension of the blue whiting distribution eastwards were limited to the south-western part of the Barents Sea. The samples indicate that the recordings consisted of adult blue whiting (28-38 cm) except off the NW coast of Norway where also a small proportion of juvenile fish were caught.

### October - December

In the first half of November an Icelandic attempt was made to fish for blue whiting at east and southeast of Iceland (Rosen-garten) with a chartered sterntrawler using pelagic and bottom trawls. Only very scattered registrations of blue whiting were recorded and the results were negative.

In December G.O. SARS recorded no distinct pelagic concentrations of 0-group blue whiting in the Norwegian Deeps in contrast to previous years. The concentrations of older mature blue whiting were also less pronounced compared to previous years.

### 9.2. Other research activities in 1979

Results of investigations on the state of gonad development throughout the year were presented to the Working Group in the form of an abstract of a paper which will be presented to the next statutory meeting (MAZHIRINA in press). The author reported that from April to May mainly prespawning blue whiting are feeding in the Norwegian Sea (NE of Jan Mayen and between 65-66°N) along with juveniles and blue whiting not capable of spawning in that year. She considered, furthermore, that the prespawners found in April-May will not spawn until July-August if they spawn at all the same year.

In a paper by ISAEV and SHLEINIK (in press) presented to the Working Group, the distribution and length compositions of blue whiting in the Norwegian Sea in 1979 were described. Feeding of blue whiting by month in 1979 in the Norwegian Sea is treated in a paper presented to the Working Group (SOBOLEVA in press). This indicated that blue whiting in the Norwegian Sea feed mainly on Euphausiids in winter and spring (November-April), changing to feed mainly on Copepods during spring and summer. Hyperiidids were an important food item during the autumn while Chaetognaths, Decapods, Theuthooids and juvenile fish were of secondary importance in the diet.

In a paper presented to the ICES statutory meeting in 1979, Jákupsstovu (1979) discussed the formation of the first winter zone in blue whiting otoliths. In an another paper Gjørøster, Beck and Monstad (1979) presented work done on primary growth zones in blue whiting otoliths.

## Section 10.

### Survey Plans for 1980

Cruises for 1980 already completed and proposed cruises for the remainder of the year with their cruise dates, main objectives and areas are given in Table 10.1. Figure 10.1-10.4 show the expected distribution of research effort in each three-months period in 1980.

Prior to an acoustic survey S.H. i Jákupsstovu should be notified in good time about the name of the ship, the area and time of the survey, in order to facilitate communication between ships for the exchange of acoustic and biological data to ensure continuity of coverage.

## Section 11.

### Management Considerations

It is clear from the data presented in this report that the fisheries for blue whiting are increasing rapidly. Catches have approximately doubled each year since 1975 and in 1979 they exceeded one million tonnes. What is not so clear at present is what levels of catch can be sustained by the stock. The results of echo surveys in 1980 gave a lower value for the size of the spawning stock (6 million tonnes) than the 1979 surveys (8 to 15 million tonnes). Trial runs with Virtual Population Analysis were made by the Working Group, but estimates of stock size and calculated values of fishing mortality were found to be very sensitive to the choice of input F values used for 1979 and for the oldest age-group. As a result it was not possible to come to any definite conclusions with regard to the present levels of fishing mortality or the exploitation pattern. Again because



of the uncertainty about the exploitation pattern it is not possible to use yield per recruit curves with any confidence. Consequently the Working Group can at present only advise caution as far as any further expansion of the fisheries is concerned. This fishery appears to have many features in common with the Atlanto-Scandian herring fishery. The fish are available to capture throughout the year and are especially vulnerable when aggregated on the spawning grounds. The fishery has been developing very rapidly and developments in gear technology are proceeding apace.

Assuming a spawning stock size of 6 million tonnes and a total stock biomass of 8 million tonnes, a rough approximation of the maximum yield  $C_{\max}$  could be derived using Gulland's (1970) relationship cited in Alverson (1971)

$$C_{\max} = 0.4 \times M \times B_0$$

where  $M$  = natural mortality and  $B_0$  is virgin stock biomass. Values of  $M$  of 0.2 and 0.3 would therefore give values of  $C_{\max}$  of 640 000 - 960 000 tonnes.

The Working Group therefore would recommend that for the future the fishery is either stabilized at the present level, or that any further increase in fishing is strictly controlled until more precise estimates of biomass and fishing mortality are available.

Section 12.

Future Research Recommendations

1. Acoustic surveys should be carried out to obtain data on the distribution and migratory patterns of the blue whiting population in the Southern area (Divisions VIIg-k, Sub-areas VIII IX) in order to determine whether this population constitutes a separate stock from that in areas to the north. In particular a survey is required during the period February to March to determine the size of the spawning population in this area.
2. In order to provide data on stock identity biological data already available concerning blue whiting in the Southern area (Div. VIIg-k and Sub-areas VIII and IX including Div. VIIb-c) should be submitted to and compiled by R Schöne whose responsibility it would be to prepare a working paper for the next meeting of the Working Group.
3. Acoustic surveys and biological sampling should be conducted in spring (March-April) in the Norwegian Sea to determine the size of the population remaining in this area during the main spawning season, and to determine the extent of spawning in that area.
4. In order to provide a foundation of historic information about the spawning stock biological data from the main spawning areas west of Britain and Ireland should be submitted to K. Warburton whose responsibility it would be to prepare a working paper for the next meeting of the Working Group.
5. To improve the basis for stock assessment on blue whiting, studies should be carried out on meristic, morphometric and other biological characters in different areas.
6. In view of the difficulties involved in age determination of blue whiting, regular exchanges of otoliths should be continued. In addition, whenever the opportunity arises, otolith-reading methods should be discussed by people actively engaged in the work.

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Table 2.1. Landings (t) of blue whiting from the main fisheries 1970-1979.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 <sup>1)</sup>
Norwegian Sea Fishery, (Sub- division Areas I,II,Va,XIVa)	14807	35219	625	878	146	6746	3436	56923	235227	686704
Spawning Fishery, (divisions Vb, VIa,VIb,VIIb,c)	354	18394	15396	15027	15207	30335	81200	135364	227382	283389
Icelandic industrial Fishery, (division Va)			12	2833	4230	1294	8220	5838	9484	2500
Industrial mixed Fishery, (divisions IVa-c, IIIa)	-	600	27959	56826	62197	39765	28251	37945	97145	57919
Southern Fishery, (divisions VIId,e, VIIg-k, VIII, IX)	22788	21386	33503	27452	25733	31715	35035	30451	29203	24064
Total	37949	75599	77495	103016	107513	109855	156142	266521	598441	1054576

<sup>1)</sup> Preliminary

Table 2.2. Landings (t) of blue whiting from the Norwegian Sea (Areas I and II, Divisions Va and XIVa) fisheries 1970-79.

Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 <sup>1)</sup>
Faroes	-	-	-	-	-	-	-	593	2810	189
German Dem. Rep.	-	-	3	-	-	-	90	2031	7301	22502
Germany, Fed.Rep.of <sup>2)</sup>	-	-	-	3	2	35	33	6701	8422	1121
Iceland <sup>3)</sup>	-	-	622	60	119	3	569	4768	17756	12428
Norway	-	-	-	-	20	31	837	-	-	3528
Poland	-	-	-	-	-	-	95	1536	5083	4346
UK, (England & Wales)	-	-	-	-	-	-	60	165	11	-
UK (Scotland)	-	-	-	-	-	-	-	-	-	32
USSR	14807	35219	-	815	5	6677	1752	41129	193844	642558
Total	14807	35219	625	878	146	6746	3436	56923	235227	686704

1) Preliminary

3) Directed fishery only.

2) Not including catches off the south east coast of East Greenland (Division XIVb) (327 t. in 1977 and 897 t. in 1978).

Table 2.3. Landings (t) of the blue whiting from the Spawning Fishery  
(Divisions Vb, VIa, b, and VIIb, c.) 1970-79.

Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 <sup>1)</sup>
Denmark	-	-	-	-	-	-	-	18745	23498	20000
Faroës	-	-	-	1155	1527	-	12826	29096	39491	36938
German Dem. Rep.	-	-	-	-	-	-	4971	1094	1714	172
Germany, Fed. Rep. of	-	-	-	-	2655	-	85	3260	6363	3270
Iceland	-	-	-	319	-	-	-	5172	7537	24864
Ireland	-	-	-	-	-	-	160	-	-	-
Netherlands	-	-	-	-	-	-	-	-	1172	-
Norway	-	-	651	2445	3247	7301	24691	36791	114969	184611
Poland	-	-	-	-	116	4704	10950	3996	2469	4643
Spain	-	-	6955	6571	6484	8153	5910	183	14	-
Sweden	-	-	-	-	-	-	-	6391	6260	-
UK (England & Wales)	-	-	-	-	-	455	341	1475	5287	4137
UK (Scotland)	-	-	-	-	-	279	1488	3001	1599	1466
USSR	354	18394	7790	4537	1178	9443	19778	26160	17009	23288
Total	354	18394	15396	15027	15207	30335	81200	135364	227382	283389

1) Preliminary.

Table 2.4. Landings (t) of blue whiting from the Icelandic mixed industrial trawl fisheries Division Va 1970-79.

Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Iceland	-	-	12	2833	4230	1294	8220	5838	9484	2500 <sup>1)</sup>

1) Preliminary.

Table 2.5. Landings (t) of blue whiting from the Mixed Industrial Fisheries and caught as by catch in ordinary fisheries in the North Sea Divisions IV a-c and IIIa).

Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 <sup>1)</sup>
Denmark	-	-	-	-	-	-	-	16071	54804	19089
Faroes	-	-	-	3714	2610	428	1254	-	1177	3900
German Dem.Rep. <sup>2)</sup>	-	-	-	-	-	-	-	-	988	49
Germany, Fed.Rep.of <sup>2)</sup>	-	-	-	-	-	-	-	76	1514	13
Norway	-	-	27609	50835	59151	38020	26827	20293	37260	33582
Poland <sup>2)</sup>	-	-	-	-	55	-	45	838	601	-
Spain <sup>2)</sup>	-	-	350	350	318	195	47	-	-	-
Sweden <sup>3)</sup>	-	-	-	-	-	-	-	639	648	1249
UK (England & wales) <sup>2)</sup>	-	-	-	-	-	-	-	3	+	-
UK (Scotland)	-	-	-	-	-	414	58	25	153	37
USSR <sup>2)</sup>	-	600	-	1927	63	708	20	-	-	-
Total	-	600	27959	56826	62197	39408	28251	37945	97145	57919

1) Preliminary

2) Reported landings in human consumption fisheries

3) Reported landings assumed to be from human consumption fisheries.



Table 2.6. Landings (t) of blue whiting from the Southern Areas. (Areas VIII and IX and Divisions VII g-k and VII d, e.)

Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 <sup>1)</sup>
German, Dem. Rep.	-	78	-	-	-	-	-	-	-	-
Germany, Fed. Rep. of	-	-	-	-	-	-	-	-	25	-
Ireland	-	-	-	-	-	-	-	-	-	1
Netherlands	-	-	-	-	-	-	-	-	7	-
Poland	-	-	-	-	170	-	385	169	53	-
Portugal	-	-	-	-	-	-	-	1744	114	-
Spain <sup>2)</sup>	16360	11800	28090	26741	24627	30790	29470	24800	29000 <sup>1)</sup>	24000 <sup>1)</sup>
UK(England & Wales)	-	-	-	-	-	-	-	+	-	-
UK(scotland)	-	-	-	-	-	-	-	-	-	63
USSR	6428	9508	5413	711	936	925	5180	3738	4	-
<b>Total</b>	<b>22788</b>	<b>21386</b>	<b>33503</b>	<b>27452</b>	<b>25733</b>	<b>31715</b>	<b>35035</b>	<b>30451</b>	<b>29203</b>	<b>24064</b>

2) Significant quantities taken in subdivisions VII g-k not included in the table are discarded every year.

1) Preliminary

Table 4.1 Catch in number  $10^{-6}$  of blue whiting in the Norwegian Sea, Spawning fishery and Industrial fishery (grand total).

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 <sup>⌘</sup>
0		16.5	1067.2	1751.0	376.9	748.4	102.6	408.5	870.3	2.1
1	0.4	11.3	99.2	342.2	477.5	208.7	687.6	448.5	950.6	1211.0
2	14.6	17.5	54.0	49.4	54.4	72.3	93.0	151.1	216.7	220.7
3	20.3	54.8	19.1	28.9	18.0	56.2	55.1	121.4	150.7	323.0
4	24.5	75.0	23.7	23.5	23.9	41.0	75.9	197.7	413.3	480.2
5	28.5	87.8	28.4	15.6	22.1	26.6	28.5	188.0	437.9	456.1
6	17.5	73.6	27.8	15.0	17.6	36.2	55.6	156.8	484.9	522.0
7	11.9	59.1	21.2	20.1	15.7	34.8	73.4	140.1	530.4	680.5
8	7.3	36.8	19.1	9.0	16.0	28.5	61.2	180.0	476.5	856.7
9	4.7	19.8	6.0	12.8	3.9	29.2	69.3	122.6	366.5	828.2
10	1.7	12.7	2.7	11.0	4.7	14.6	77.5	135.1	308.7	743.6
11	0.4	4.7	1.3	8.9	4.0	13.7	32.1	112.4	157.9	475.8
12		1.9	0.4	5.7	3.0	11.8	39.0	57.6	122.1	350.8
13		0.5		2.7	1.7	7.7	20.0	18.6	50.4	158.7
14				1.1	0.8	4.9	10.5	13.8	20.6	73.6
≥15				1.0	1.1	3.7	6.7	7.0	16.2	37.5
Total	131.8	472.0	1370.1	2297.9	1041.3	1338.3	1488.0	2459.2	5573.7	7420.5

⌘) Preliminary

Table 4.2 Catch in number ( $10^{-6}$ ) by age group in the mixed Industrial Fisheries  
(Sub-area IV and Divisions IIIa and Va).

Age	1970 <sup>1)</sup>	1971 <sup>1)</sup>	1972 <sup>2)</sup>	1973 <sup>2)</sup>	1974 <sup>2)</sup>	1975 <sup>2)</sup>	1976 <sup>2)</sup>	1977 <sup>2)</sup>	1978 <sup>2)</sup>	1979 <sup>⊛</sup>
0			1066.4	1748.0	376.9	746.3	102.7	408.5	870.3	2.1
1			98.7	336.2	476.9	206.4	682.8	448.5	950.6	1147.8
2			48.2	44.7	48.4	67.0	79.1	106.1	153.2	66.7
3			5.7	20.7	12.9	25.9	29.6	32.3	81.6	27.4
4			1.7	11.5	7.5	12.9	18.0	30.3	67.3	18.9
5										15.3
6										17.6
7										9.2
8										7.4
9										11.8
10										5.3
11										0.9
12										3.7
13										
14										
≥15										
Total			1220.7	2161.1	922.6	1058.5	912.2	1025.7	2123.0	1334.1

1) No data available.

2) Age four is a plus group.

⊛) Preliminary

Table 4.3 Catch in number ( $10^6$ ) by age-group in the adult fisheries.

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 <sup>Ⓢ</sup>
0		16.5	0.7	3.0		2.0				
1	0.4	11.3	0.4	6.0	0.6	2.3	4.8			63.3
2	14.6	17.5	5.8	4.6	6.0	5.3	13.9	45.0	63.5	154.0
3	20.3	54.8	13.5	8.2	5.0	30.3	25.6	89.1	69.1	295.7
4	24.5	75.1	22.0	12.0	16.4	28.2	57.9	167.4	346.0	461.3
5	28.5	87.8	28.4	15.7	22.1	26.6	28.5	188.0	437.9	440.7
6	17.5	73.6	27.8	15.0	17.6	36.2	55.6	156.8	484.9	504.3
7	11.9	59.0	21.2	20.0	15.7	34.8	73.4	140.1	530.4	671.4
8	7.3	36.8	19.1	9.0	16.0	28.5	61.2	180.0	476.5	849.3
9	4.7	19.8	6.0	12.8	3.9	29.2	69.3	122.6	366.5	816.4
10	1.7	12.7	2.7	11.0	4.7	14.6	77.5	135.1	308.7	738.3
11	0.4	4.7	1.3	8.9	4.0	13.7	32.1	112.4	157.9	474.9
12		1.9	0.5	5.7	3.0	11.8	39.0	57.6	122.1	347.1
13		0.5		2.7	1.7	7.7	20.0	18.6	50.5	158.7
14				1.1	0.8	4.9	10.4	13.8	20.6	73.6
≥15				1.0	1.1	3.7	6.6	7.0	16.1	37.4
Total	131.8	472.0	149.4	136.7	118.6	279.8	575.8	1433.5	3450.7	6086.4

Ⓢ) Preliminary

Table 5.1. Overall mean weight (g) at age.

AREA	Spawning Area	Norwegian Sea	Mixed fishery	Weighted mean
Age				
0	-	-	32	32
1	50	62	29	30
2	81	93	82	84
3	106	97	125	105
4	118	90	146	109
5	138	110	161	129
6	142	149	175	147
7	150	163	195	160
8	153	173	198	170
9	155	180	210	177
10	158	192	227	188
11	156	200	176	193
12+	156	208	300	199
Weighted mean	132	174	46	141

Table: 5.2 MEAN WEIGHT (g) PER AGE-GROUP IN 1979

Norwegian Sea-fishery																
Country	USSR	USSR	Norway	Mean weight	USSR	Norway	German Dem. Rep.			Mean weight <sup>1)</sup>	Mean weight <sup>2)</sup>	Mean weight <sup>3)</sup>	Mean weight <sup>4)</sup>	USSR	Norway	
ICES-division	IIa	IIa	IIa	IIa	IIa	IIa (S-Norw. Sea)	IIa (65-68°N 2-6°W)	S-J. Mayen	73°-75°N 5°-6°E	IIa	IIa	IIa	IIa	IIa	IIa	
Quarter of year	I	II	II	II	III	III	III	III	III	III	III	III	III	IV	IV	
age 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	age 0
1	54	54	55	54	62	-	-	-	-	62	62	62	62	63	-	1
2	94	92	63	78	93	92	75	77	-	92	84	87	84	96	-	2
3	98	93	114	104	97	156	100	117	-	126	98	118	118	98	165	3
4	90	87	137	112	90	171	130	150	169	130	110	130	142	94	170	4
5	106	102	159	130	110	192	156	164	173	151	133	153	159	104	179	5
6	145	132	173	152	149	200	153	177	201	174	151	167	176	147	187	6
7	160	145	187	166	163	216	167	178	216	190	165	182	178	160	198	7
8	175	154	193	174	173	234	175	187	217	204	174	194	197	172	209	8
9	180	160	190	175	180	241	174	185	221	210	177	198	200	182	233	9
10	192	168	184	176	192	240	176	193	220	216	184	203	204	193	220	10
11	196	173	216	194	200	230	234	185	223	215	217	221	214	198	210	11
12+	210	190	192	190	208	227	186	190	249	218	197	207	212	210	-	12+

Industrial mixed fisheries					Spawning area					
Country	NORWAY				Norway	Faeroe-Isl.	Scotland	Norway	German Dem. Rep.	
ICES-division	IVa	IIIa	IIIa	IV	VIIb-c	Vb	VIa	Vb/VIa	Vb/IIa	
Quarter of year	I	II	III	IV	I	II Apr.-May	II (Apr.)	II (Apr.- May)	II (June)	
age 0	-	-	-	32	-	-	-	-	-	age 0
1	20	35	62	71	-	46	36	50	-	1
2	55	90	111	124	60	81	54	81	-	2
3	94	127	151	161	86	103	79	106	101	3
4	135	134	226	245	123	107	96	119	120	4
5	149	152	213	255	154	123	107	140	123	5
6	142	161	216	241	172	131	116	144	142	6
7	184	184	254	321	183	141	130	153	139	7
8	163	186	280	401	212	148	143	154	150	8
9	194	206	255	344	243	150	143	156	166	9
10	-	223	289	328	-	147	142	161	148	10
11	-	176	209	-	-	149	152	158	167	11
12+	249	311	337	320	-	153	160	157	193	12+

- 1) Mean weight USSR-Norway
- 2) " " USSR-GDR (S-J. Mayen)
- 3) " " USSR-GDR-Norway
- 4) " " from all countries and areas

Table 6.1 Age composition from Norwegian samples from the Spawning area 1973-1979, and estimates of Z by the catch curve method.

Age	1973	1974	1975	1976	1977	1978	1979
	Via+Vib Mar.-Apr. %	Via+VIib,c Mar.-Apr. %	Vb+VIA May %	Vb <sub>1</sub> +VIA+Vib Mar.-May %	Via+Vb <sub>1</sub> Apr.-May %	Vb <sub>1</sub> +Vb <sub>2</sub> Apr.-May %	Vb <sub>1</sub> +VIA+VIib,c Mar.-Apr.-May %
1		.20	.78				3.04
2	2.26	10.10	2.48	2.60	1.39	.87	5.69
3	3.26	2.23	14.42	5.67	6.25	6.12	12.71
4	7.02	12.02	10.70	12.86	15.97	6.12	16.03
5	14.54	15.76	8.22	3.68	17.36	5.83	13.66
6	12.28	12.63	11.32	10.11	14.24	11.08	12.52
7	20.30	11.41	8.06	10.72	11.11	11.66	9.96
8	5.76	13.64	7.29	10.57	13.19	12.24	7.69
9	8.52	2.83	9.15	11.49	6.60	12.83	5.12
10	7.02	5.66	6.51	12.10	3.82	10.20	3.98
11	8.27	4.55	5.58	4.90	6.60	9.04	3.61
12	5.76	3.54	6.36	3.83	1.39	7.00	2.37
13	2.26	2.02	4.19	4.13	1.39	1.75	1.14
14+	2.01	2.42	4.96	7.35	.69	5.25	2.47
Total fish sampled	399	900	645	653	288	343	1054
Z <sub>8-13</sub>	0.16	0.26	0.11	0.25	0.44	0.33	0.34
r <sub>8-13</sub>	0.62	0.73	0.82	0.87	0.90	0.84	0.97

Table 7.1. Acoustic estimates of spawning stock biomass ( $\text{tx}10^{-6}$ ) present in the area west of the British Isles, 1972-1979.

		Norwegian surveys	U.K. surveys standardized to a target strength of -32 dB/kg
1972	28 Feb. - 15 Mar.	2.6	
	12-26 Mar.	1.6	
1973	12-30 Mar.	6.6	
	31 Mar. - 11 Apr.	2.4	
1974	15-29 Mar.	2.3	
	31 Mar. - 8 Apr.	2.3	
	6-22 Apr.		10.5
1975	15 Mar. - 7 Apr.		9.3
	9-27 Apr.		44.7
	6-14 May	1.8	
	11-27 May		6.6
1976	22 Mar. - 11 Apr.		16.8
	23 Mar. - 12 Apr.	3.1	
	10 Apr. - 2 May		11.2
1977	23 Mar. - 1 Apr.		3.8
1978	1-7 Apr.		13.8
	8-25 Apr.		5.3
1979	8-21 Apr.		14.8
	18 Apr. - 4 May	7.9	

Values from Buzeta & Nakken (1975); Pawson et al. (1975); Pawson et al. (1976); Jakupsstovu & Midttun (1977); Richards (1977); Pawson et al. (1978); Walsh et al. (1978); Warburton et al. (1979); data provided to working group.



(NB: Table 7.2 taken out)

Table 7.3 Virtual Population Analysis: Trial Runs Input F values for 1979 and corresponding estimates of stock numbers at age 1 and of adult (ages 5-14) stock biomass.

Age-group	INPUT FISHING MORTALITY IN 1979			
	M=0.3			M=0.2
	Run 1	Run 2	Run 3	Run 4
1	0.10	0.20	0.4	0.20
2	0.06	0.12	0.24	0.12
3	0.03	0.06	0.06	0.06
4	0.04	0.08	0.16	0.08
5	0.05	0.10	0.20	0.10
6	0.06	0.12	0.24	0.12
7	0.08	0.16	0.32	0.16
8	0.12	0.24	0.24	0.24
9-14	0.15	0.3	0.60	0.30

YEAR	ESTIMATES OF STOCK NUMBERS X(10 <sup>-9</sup> )			AT AGE 1
1970	99	56	35	22
1971	81	46	28	20
1972	73	39	23	19
1973	66	36	21	19
1974	49	27	16	16
1975	38	20	11	13
1976	36	19	11	14
1977	24	13	7	10
1978	7	4	3	4
1979	15	8	4	7

	ESTIMATES OF STOCK BIOMASS OF AGE GROUPS 5-14 (Millions of tonnes)			
1970	3.8	2.2	1.4	1.1
1971	5.3	3.1	2.0	1.5
1972	7.6	4.4	2.8	2.3
1973	10.1	6.1	4.1	3.4
1974	12.0	7.1	4.7	4.3
1975	12.8	7.5	4.8	5.0
1976	12.9	7.4	4.7	5.4
1977	12.7	7.2	4.4	5.7
1978	11.6	6.3	3.7	5.5
1979	10.1	5.3	2.9	5.1

INPUT VALUES OF FISHING MORTALITY ON AGE GROUP 14

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Run 1	.003	.01	.01	.01	.01	.01	.02	.04	.08	.15
2 and 4	.006	.02	.02	.02	.02	.02	.04	.08	.16	.30
3	.012	.04	.04	.04	.04	.04	.08	.16	.32	.60

Table 10.1. Blue whiting cruises 1980.

<u>Period</u>	<u>Ship</u>	<u>Nationality</u>	<u>Area</u>	<u>Main objective</u>
8.1 - 18.3	Walther Herwig	Germany, Fed.Rep.of	S.W. Ireland W British Isles, Faroes, SW Iceland	Biol. invest. fish processing.
<sup>x</sup> 13.3 - 11.4	Anton Dohrn	Germany, Fed.Rep.of	W of the British Isles and SW of Ireland	Ground fish survey, egg and larvae survey
10.1 - 10.3	S.Brestisson & Krúnborg	Faroes	Faroesse waters	Exploratory fishing
2.4 - 22.4	Scotia	U.K.	W British Isles (spawning area)	Acoustic survey
8.4 - 15.5	G.O. Sars	Norway	W British Isles Faroes	Acoustic survey
10.4 - 1.6	J.C. Svabo	Faroes	Faroesse waters	Acoustic surveys
15.4 - 15.5	Poisk	USSR	Faroes, SW Norwegian Sea	Acoustic survey, Biol. sampling
May	Eisbär	Germany, Dem.Rep.	Norwegian Sea	Acoustic survey biol. invest.
May	Bodo Uhse	"	"	Acoustic survey Expl. fishing
<sup>x</sup> June	Walther Herwig	Germany, Fed.Rep.of	East Greenland	Ground fish survey
15.5 - 30.6	Adm. Arciszewski	Poland	S Norwegian Sea	Expl. fishing, biol. invest.
9.6 - 21.6	Chartered vessel	Norway	Norwegian fjords	Juvenile blue whiting
July	Odissey	USSR	NE Norwegian Sea	Acoustic survey biol. invest.
<sup>x</sup> 17.6 - 1.8	Johan Hjort	Norway	N North Sea	0-gr. godoid survey
1.7 - 15.9	Rybak Morski	Poland	Norwegian Sea	Expl. fishing biol. invest.
July	Arni Fridriksson	Iceland	E Icelandic waters	Acoustic survey biol. invest.
<sup>x</sup> 4.6 - 24.8	G.O. Sars	Norway	Norwegian Sea	Acoustic survey, geographical distri- bution, biol. in- vest. 0-gr. survey
<sup>x</sup> 4.8 - 8.9	Johan Hjort	"	"	
<sup>x</sup> 4.8 - 8.9	Michael Sars	"	"	
August-Sept.	Hafthor	Iceland	E Icelandic waters Norwegian Sea	Expl. fishing biol. invest.
Sept. - Oct.	"	"	W Iceland Irminger Sea	Expl. fishing biol. invest.
Sept. - Oct.	Chartered trawler	Germany, Fed.Rep.of	W British Isles, Norwegian Sea, East Greenland	Expl. fishing biol. inves.
20.9 - 31.12	Rybak Morski	Poland	N Norwegian Sea	Expl. fishing biol. invest.
<sup>x</sup> 4.11 - 7.12	G.O. Sars	Norway	North Sea	0-group survey

<sup>x</sup> Asterisk denotes blue whiting as subsidiary objective.

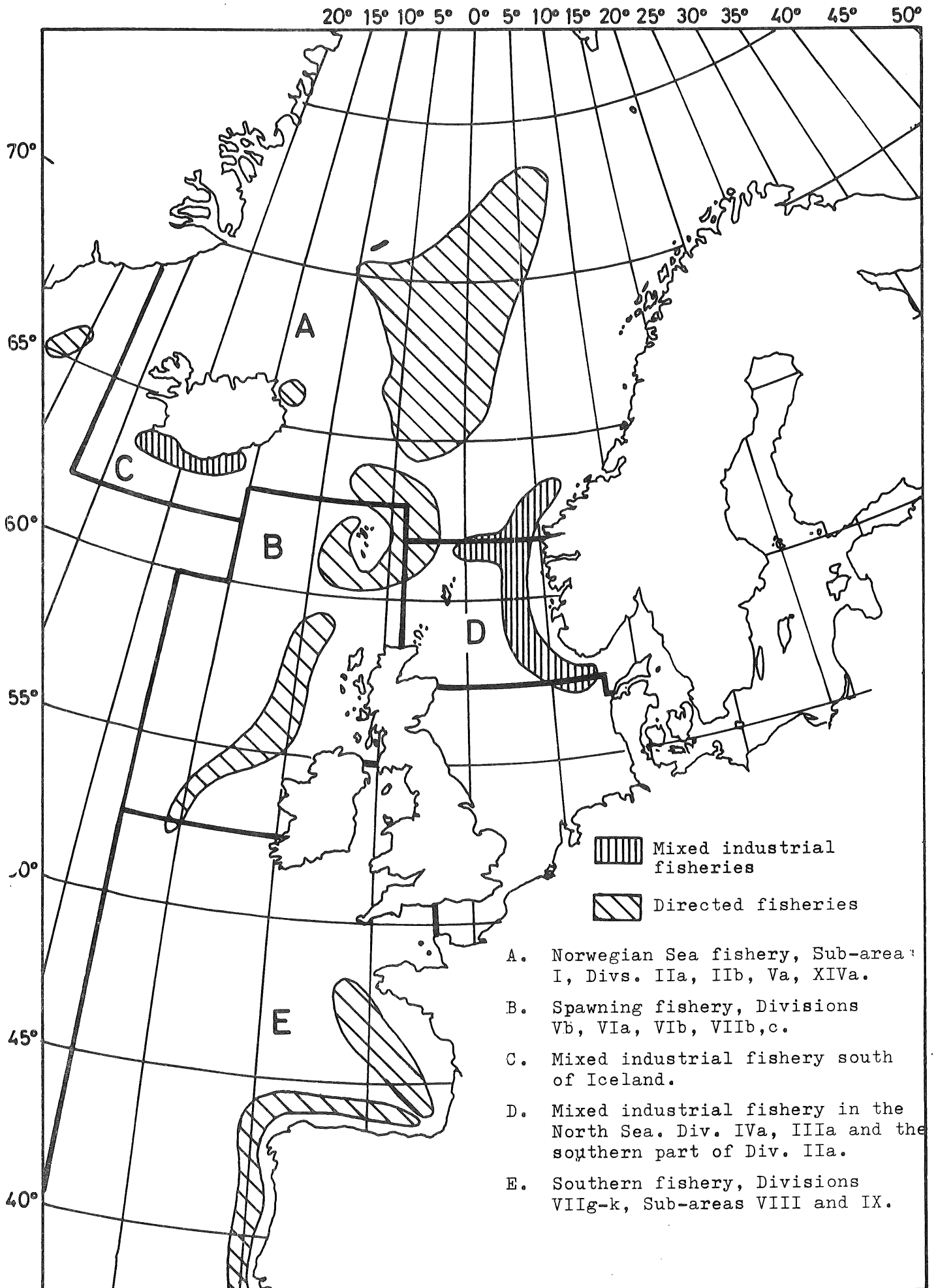
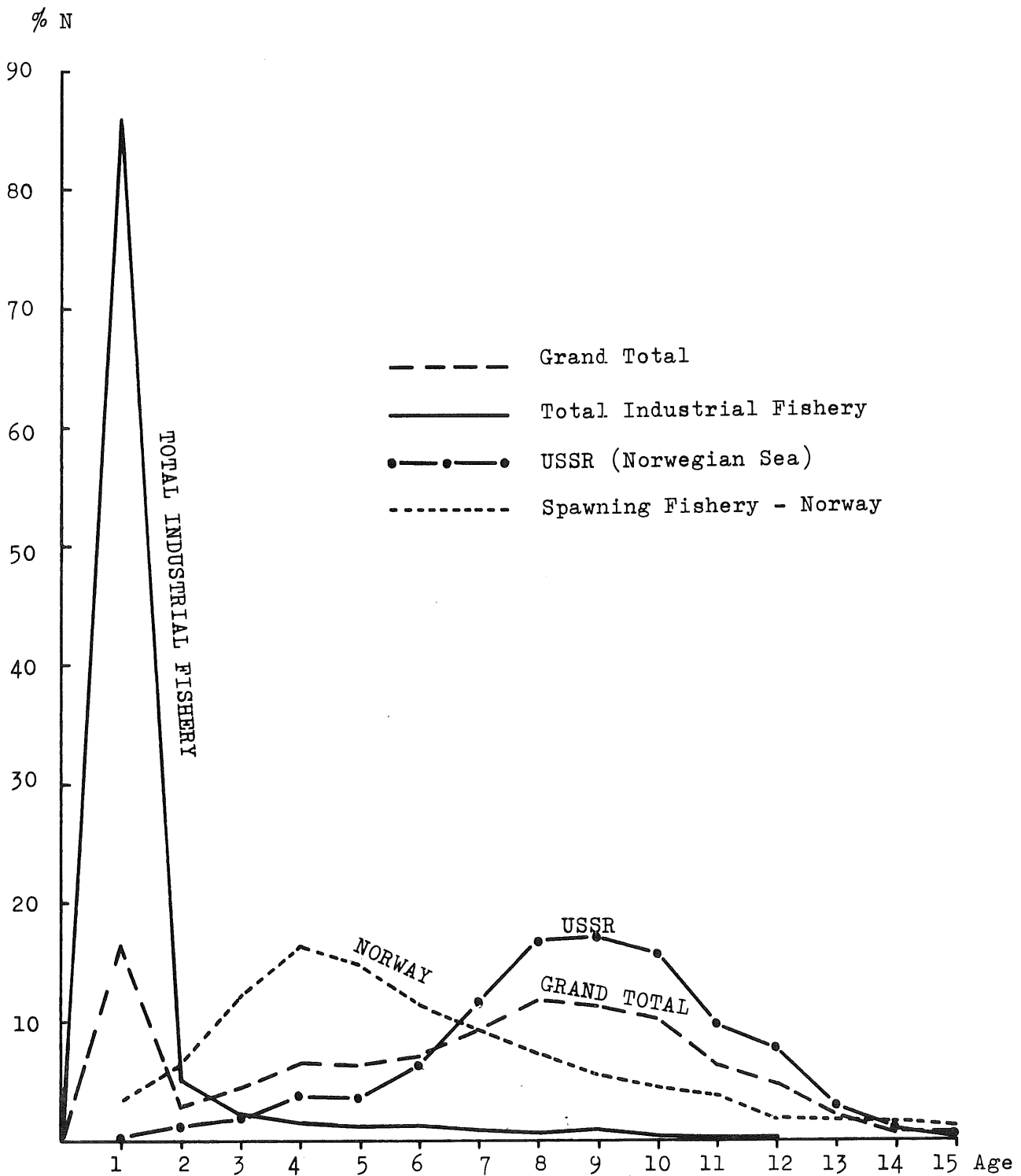


Figure 2.1 The main blue whiting fishing areas.



**Figure 4.1** Percentage age compositions of landings from blue whiting fisheries in the northern areas in 1979.

SPAIN

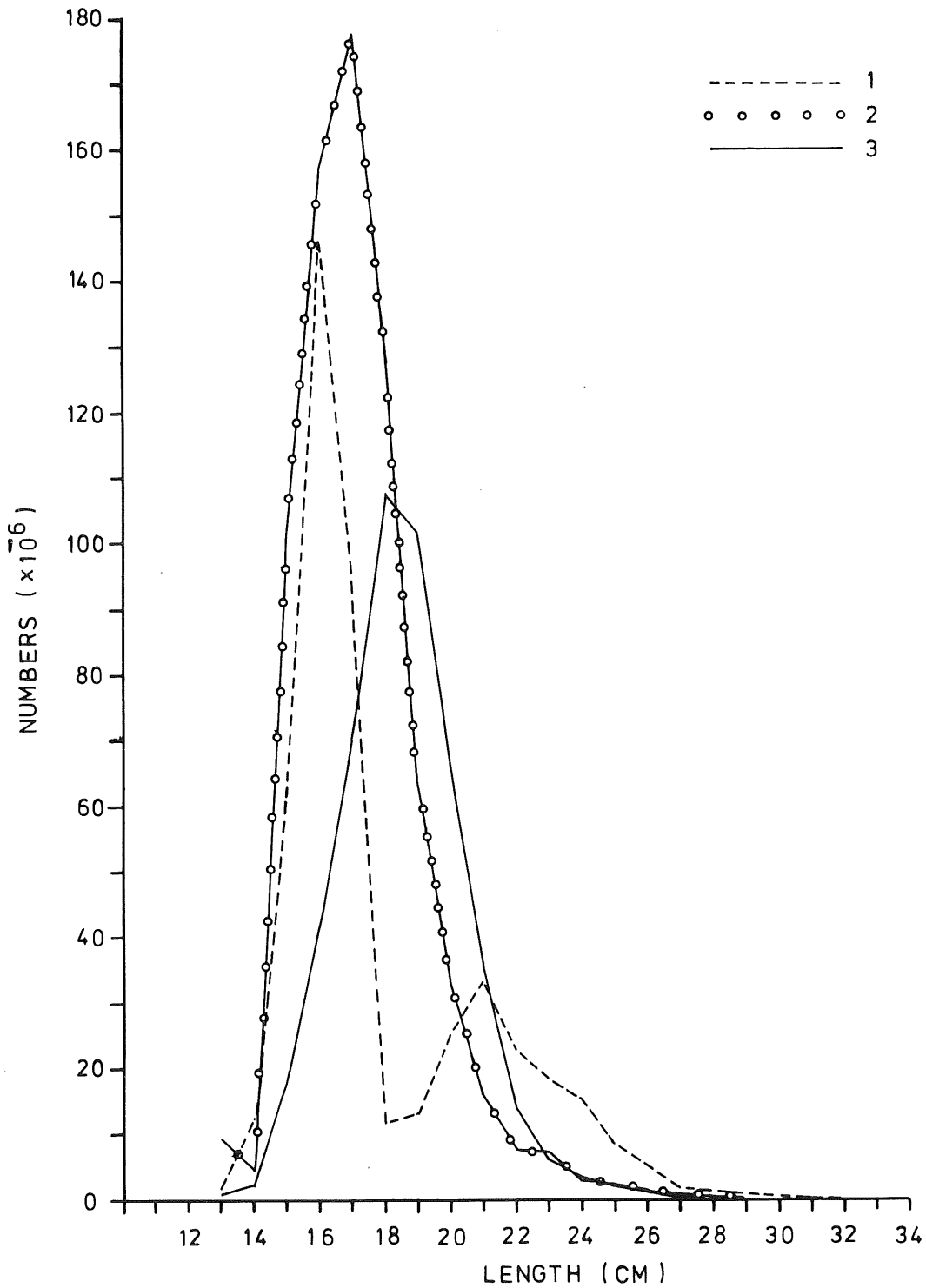


Fig.4.2. Length composition of the catches in Divisions VIIIc + IXa.

- 1) 1977: Total number: 476.0 x 10<sup>6</sup>
- 2) 1978: Total number: 712.6 x 10<sup>6</sup>
- 3) 1979: Total number: 471.1 x 10<sup>6</sup>

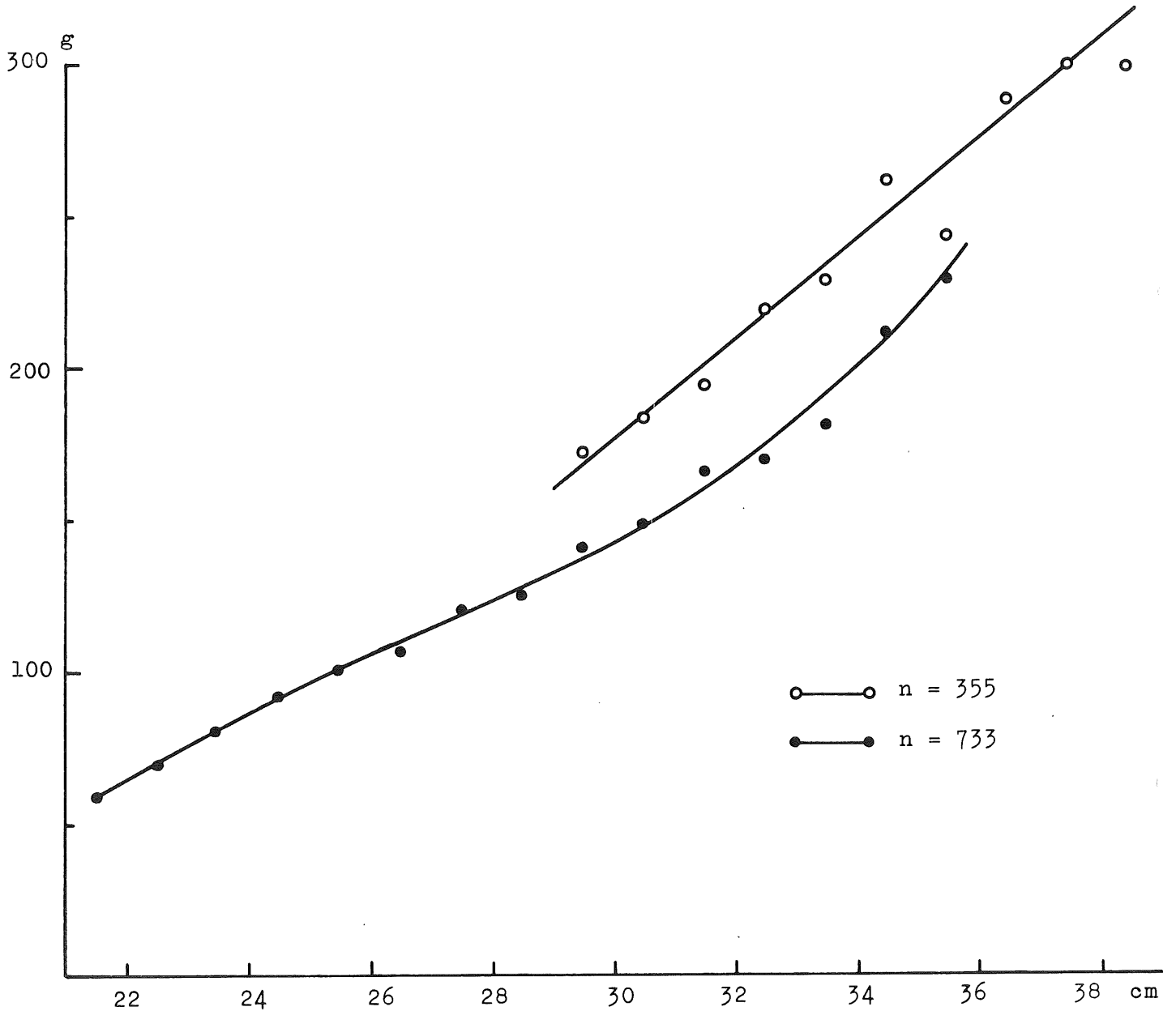
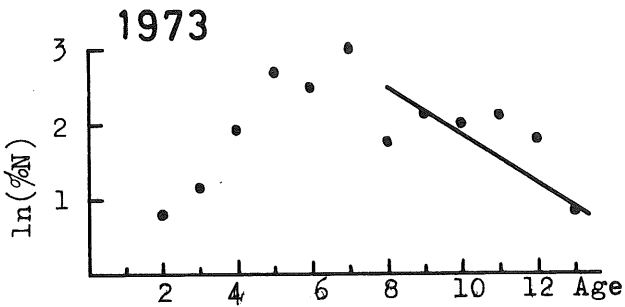
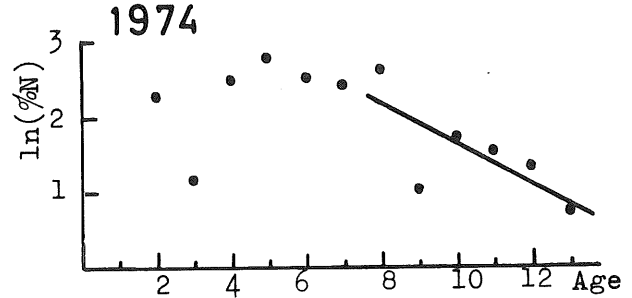


Figure 5.1 German Democratic Republic data per length group in the northern (73°N) ( o—o ) and southern ( ●—● ) part (67°N) of the Norwegian Sea, August 1979.

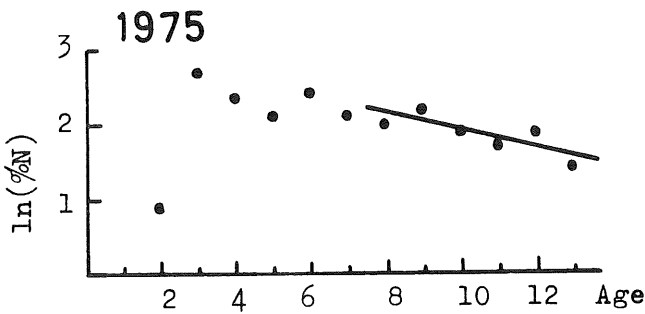
FIGURE 6.1



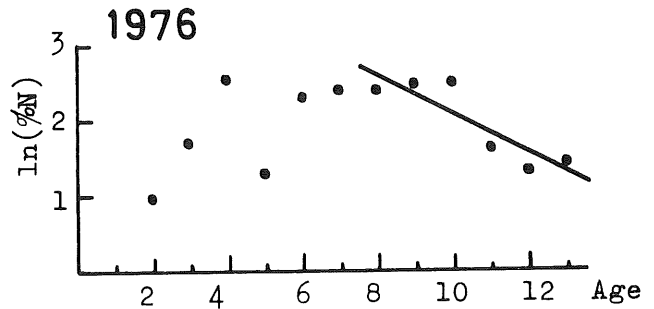
Regression of  $\ln(\%N)$  against age from Norwegian samples from the spawning stock 1973-79 (age 8-13).



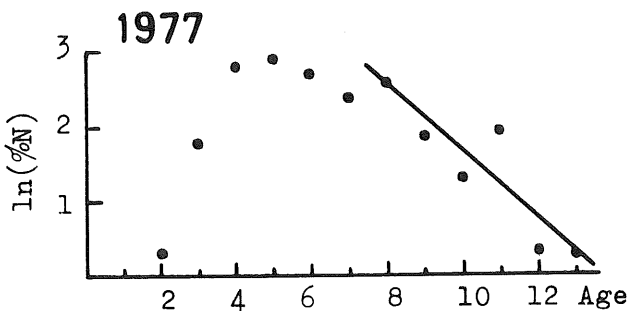
Regression of  $\ln(\%N)$  against age from Norwegian samples from the spawning stock 1974 (age 8-13).



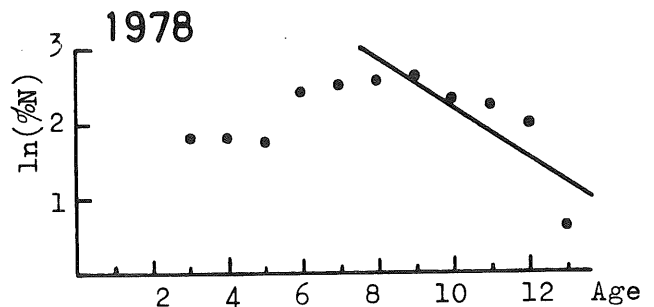
Regression of  $\ln(\%N)$  against age from Norwegian samples from the spawning stock 1975 (age 8-13).



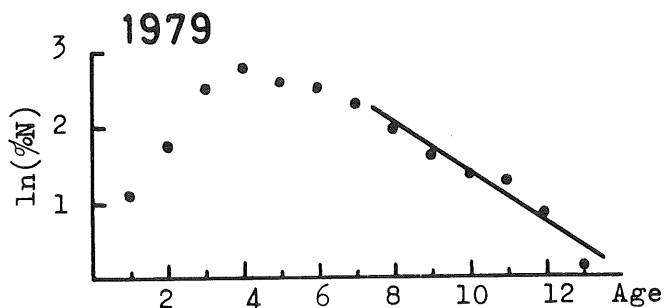
Regression of  $\ln(\%N)$  against age from Norwegian samples from the spawning stock 1976 (age 8-13).



Regression of  $\ln(\%N)$  against age from Norwegian samples from the spawning stock 1977 (age 8-13).



Regression of  $\ln(\%N)$  against age from Norwegian samples from the spawning stock 1978 (age 8-13).



Regression of  $\ln(\%N)$  against age from Norwegian samples from the spawning stock 1979 (age 8-13).

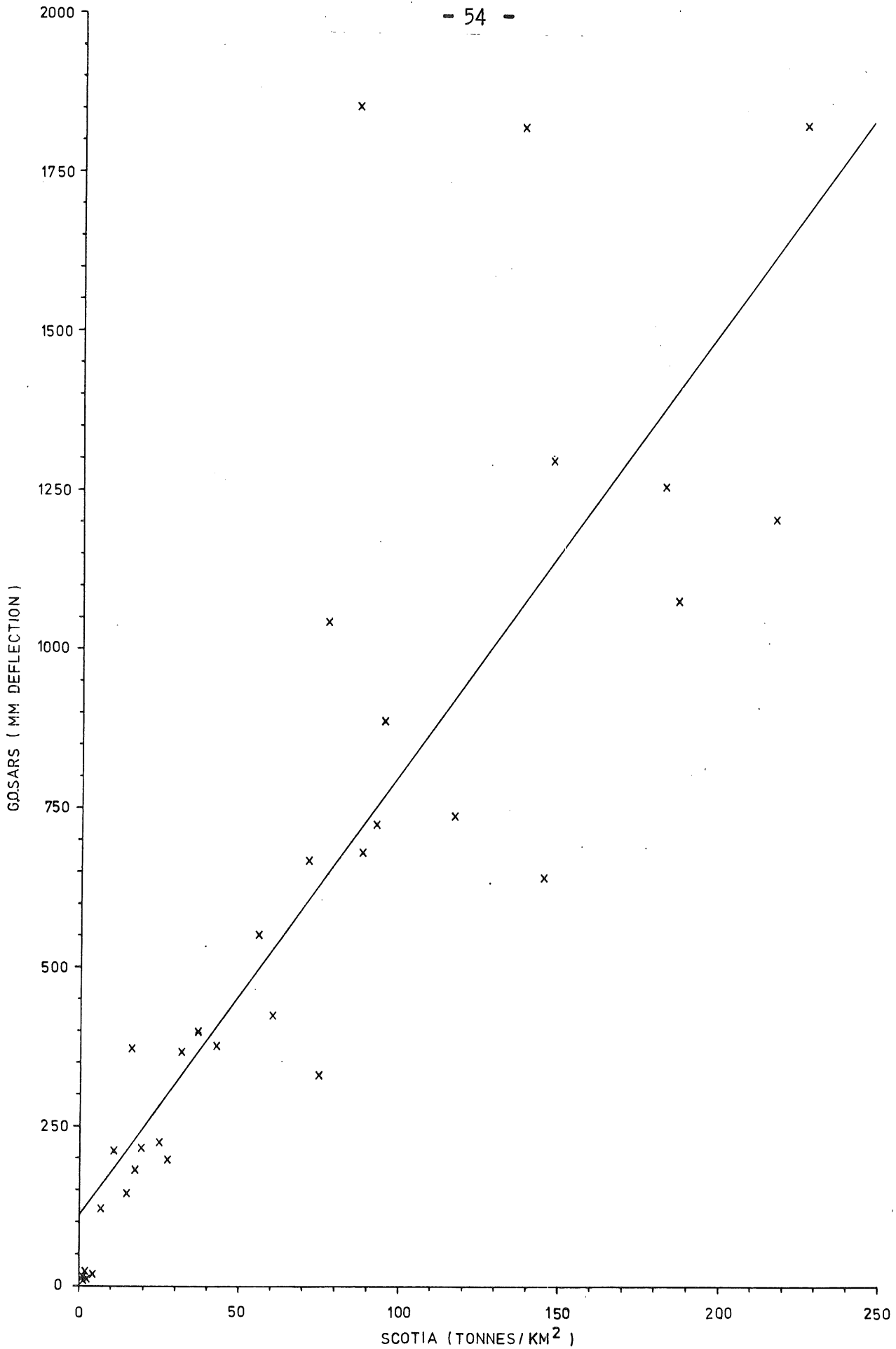
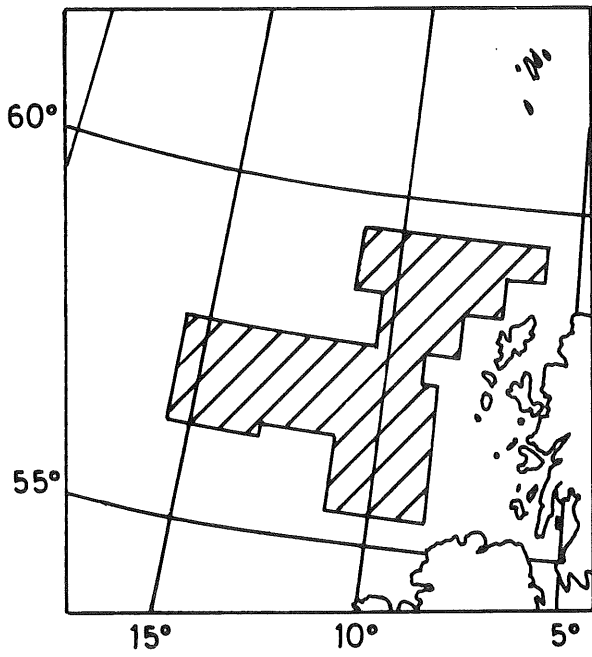
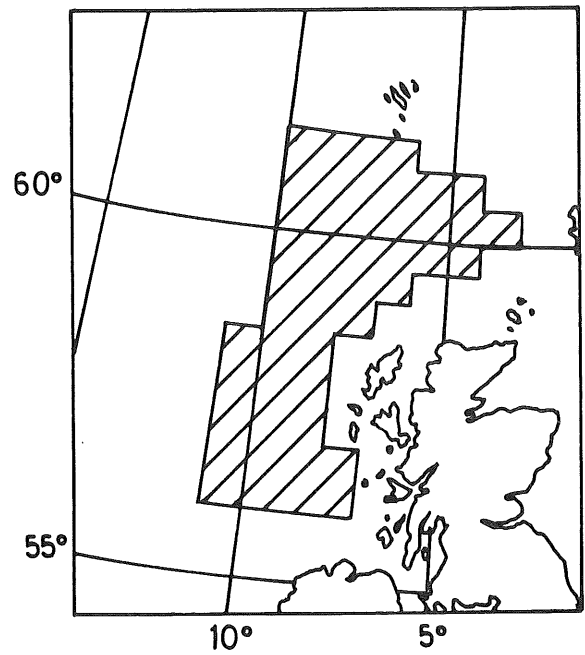


Figure 7.1 Results of intercalibration between "G O Sars" and "Scotia", April 1980 with ordinary regression line.

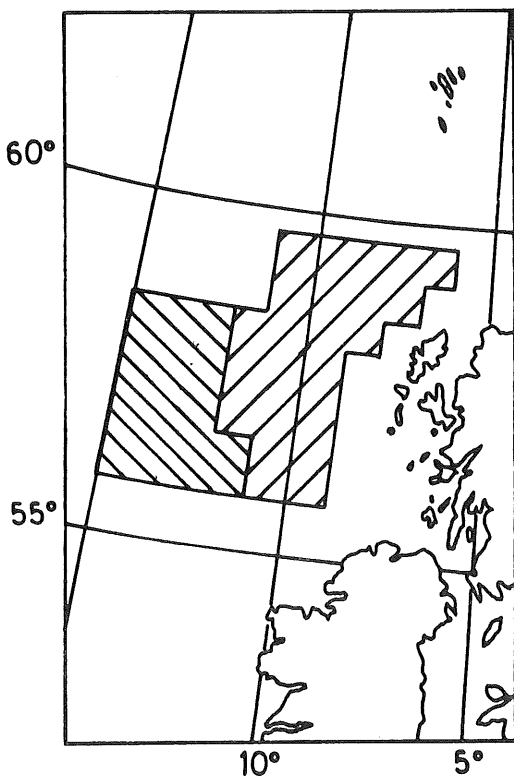




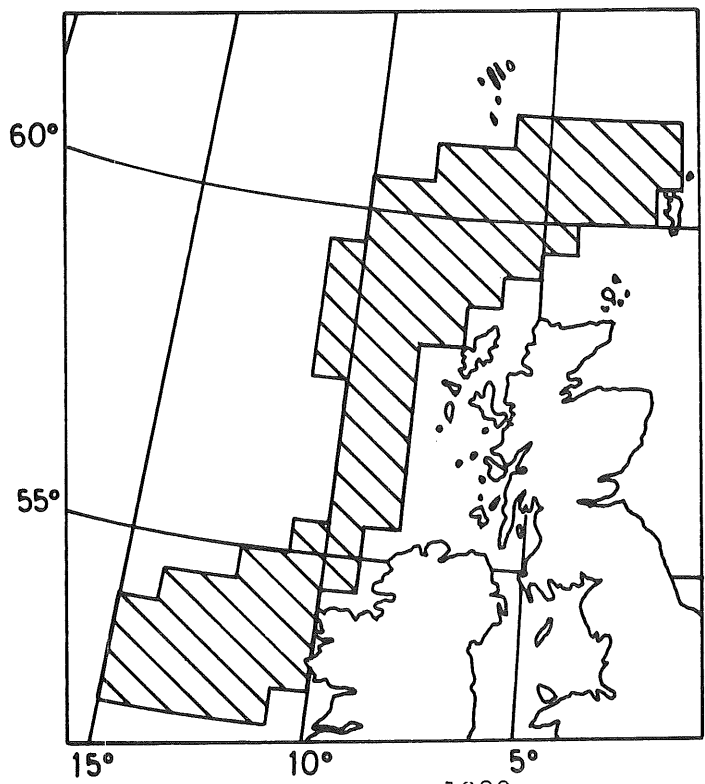
Scotland 1979



Norway 1979



Scotland 1980



Norway 1980

**Figure 7.2** Areas surveyed during acoustic surveys of the spawning area in 1979 and 1980.

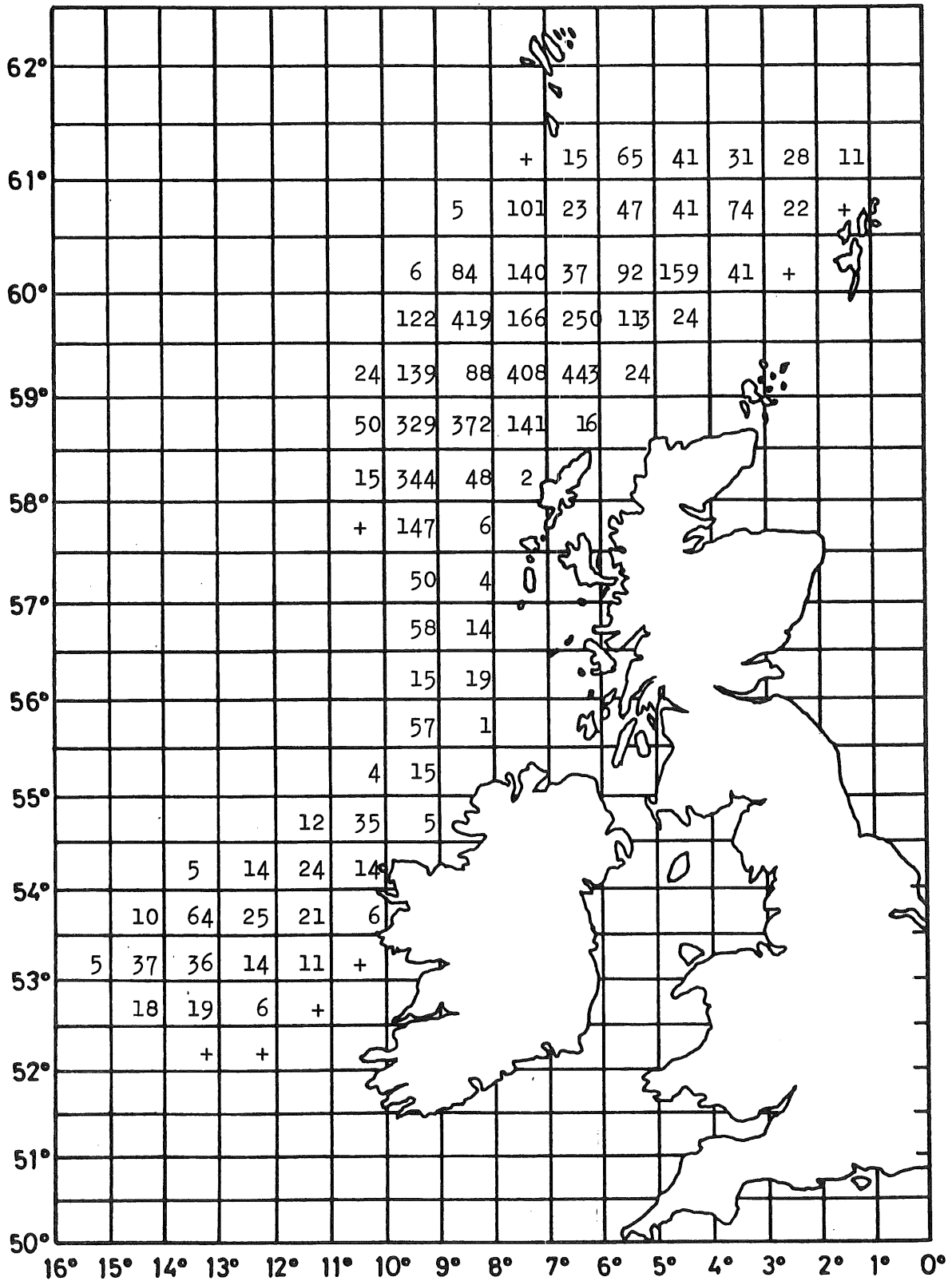


Figure 7.3 Estimated biomass of blue whiting by statistical rectangle Norwegian survey, April 1980 (thousand tonnes).

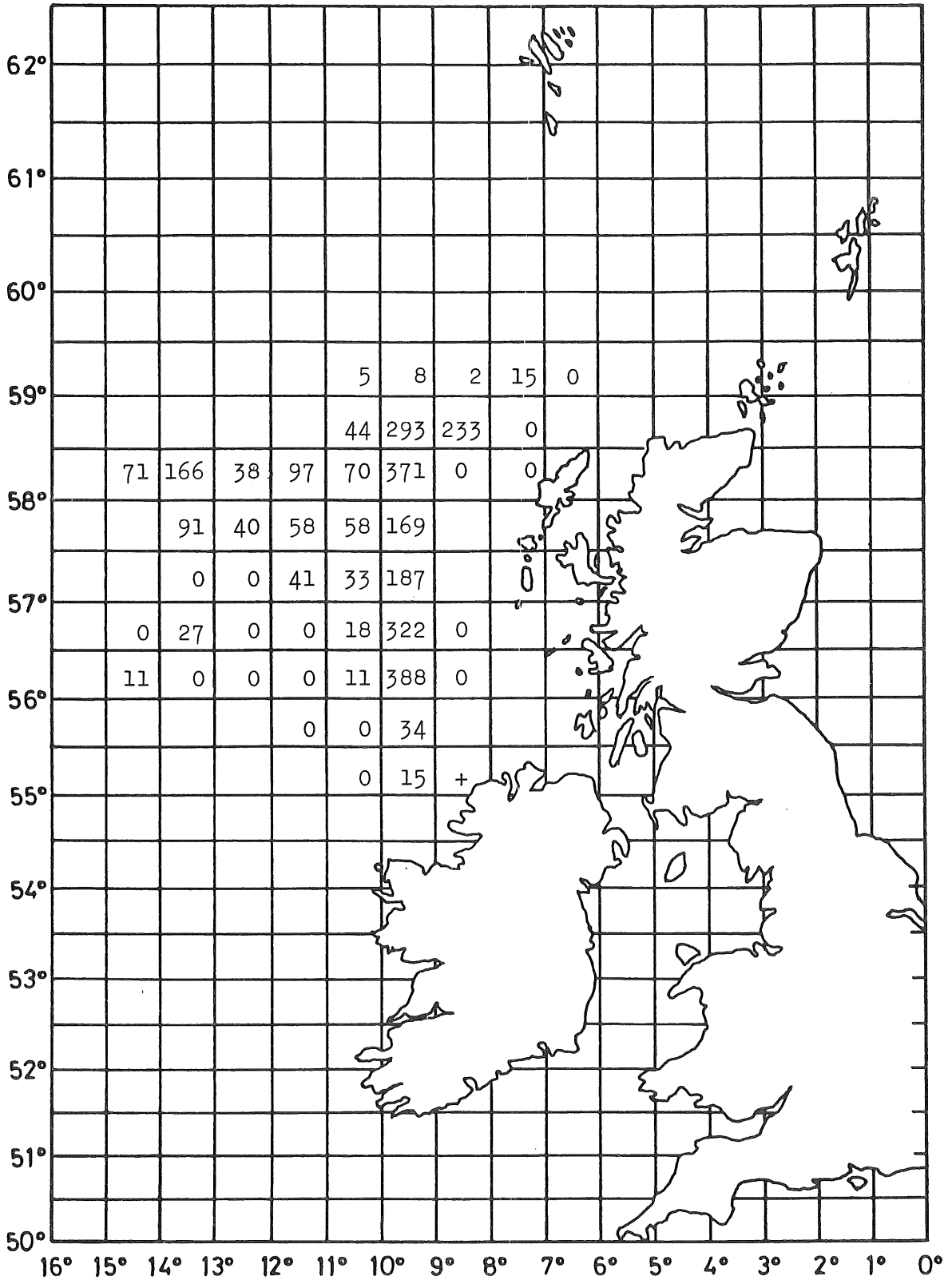


Figure 7.4 Estimated biomass of blue whiting by statistical rectangle Scottish survey, April 1980 (thousand tonnes) (standardised to -32dB/kg).

Figure 8.1 Yield and spawning stock per recruit ( $M = 0.2$ ).

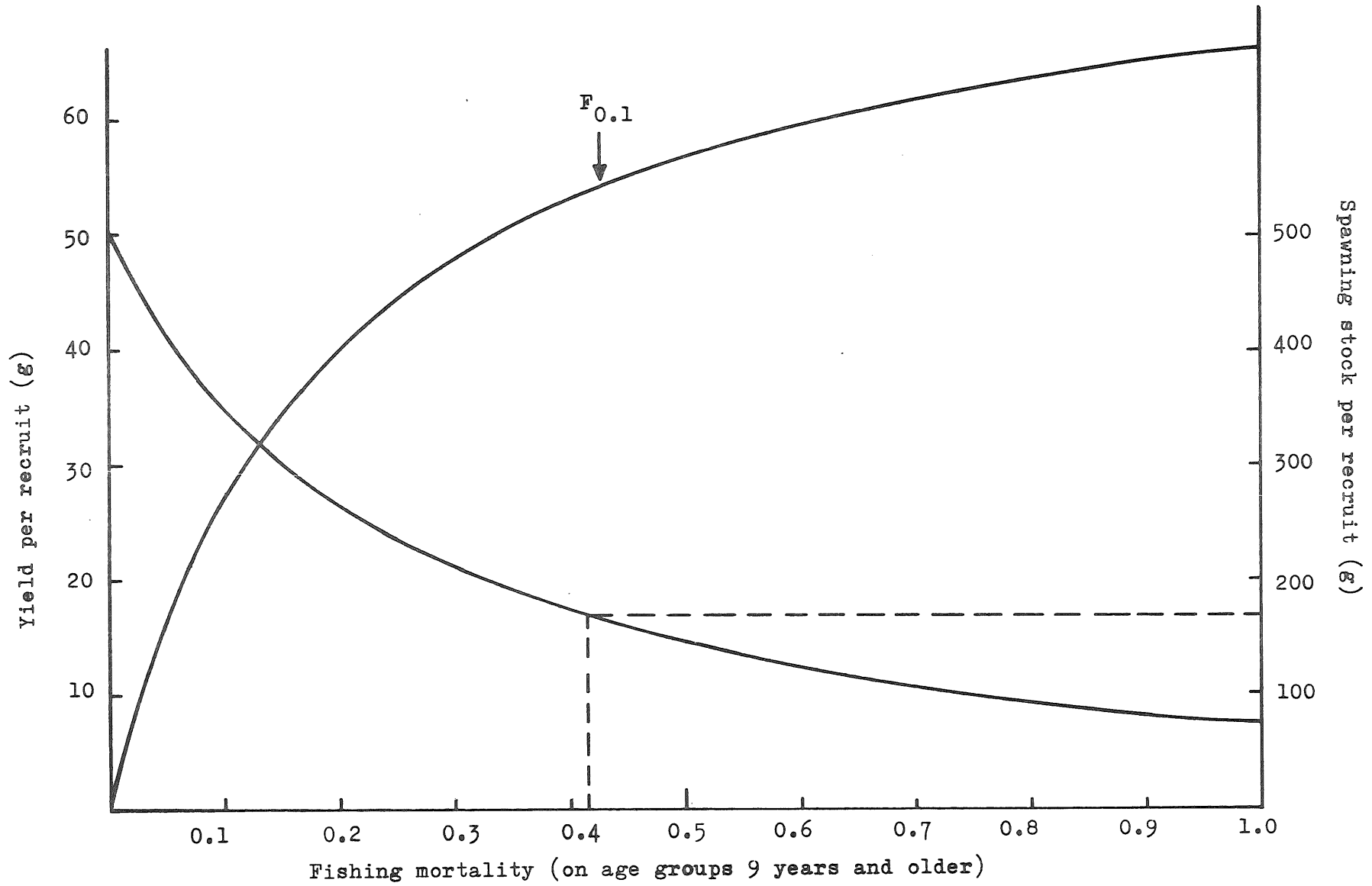
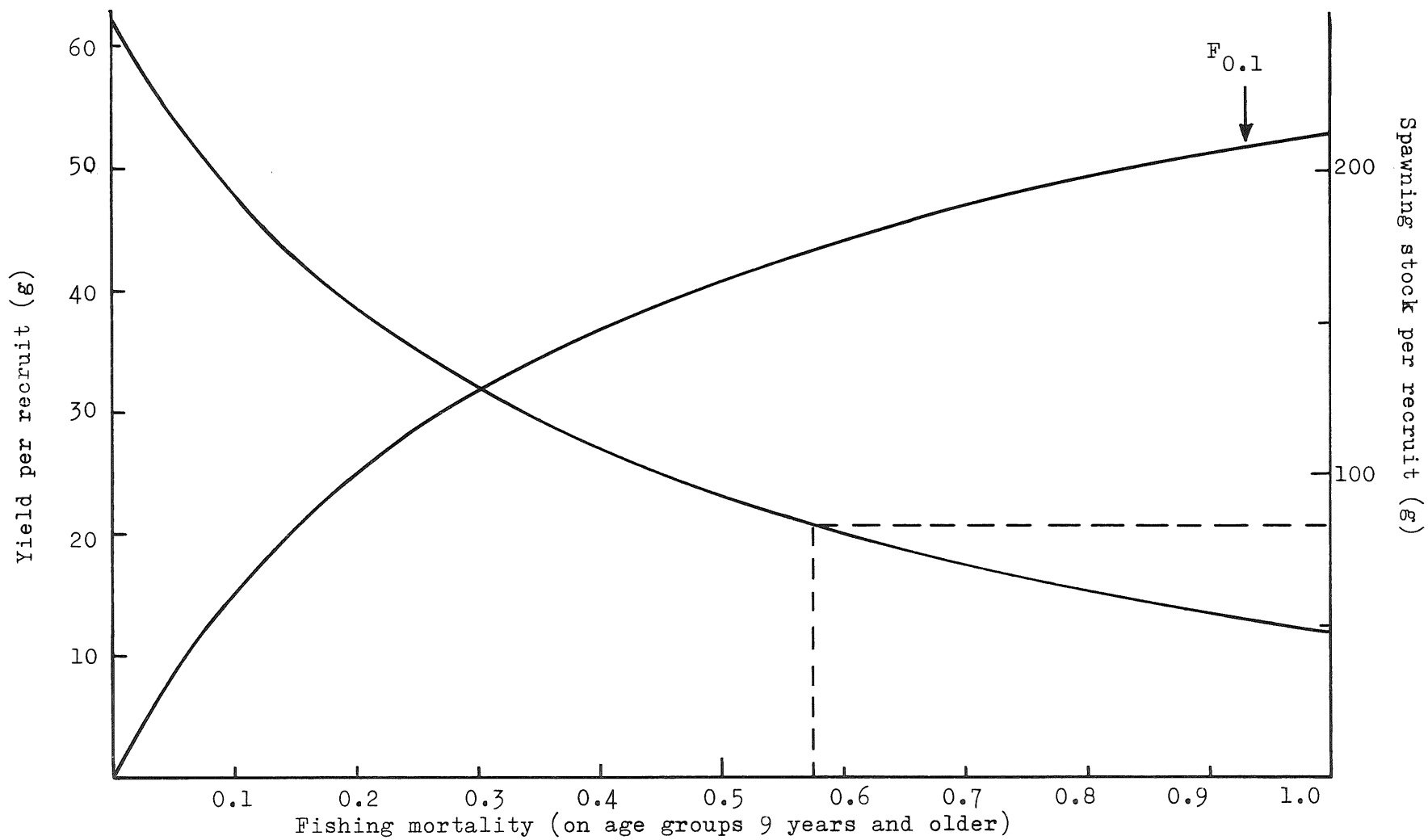


Figure 8.2 Yield and spawning stock per recruit ( $M = 0.3$ ).



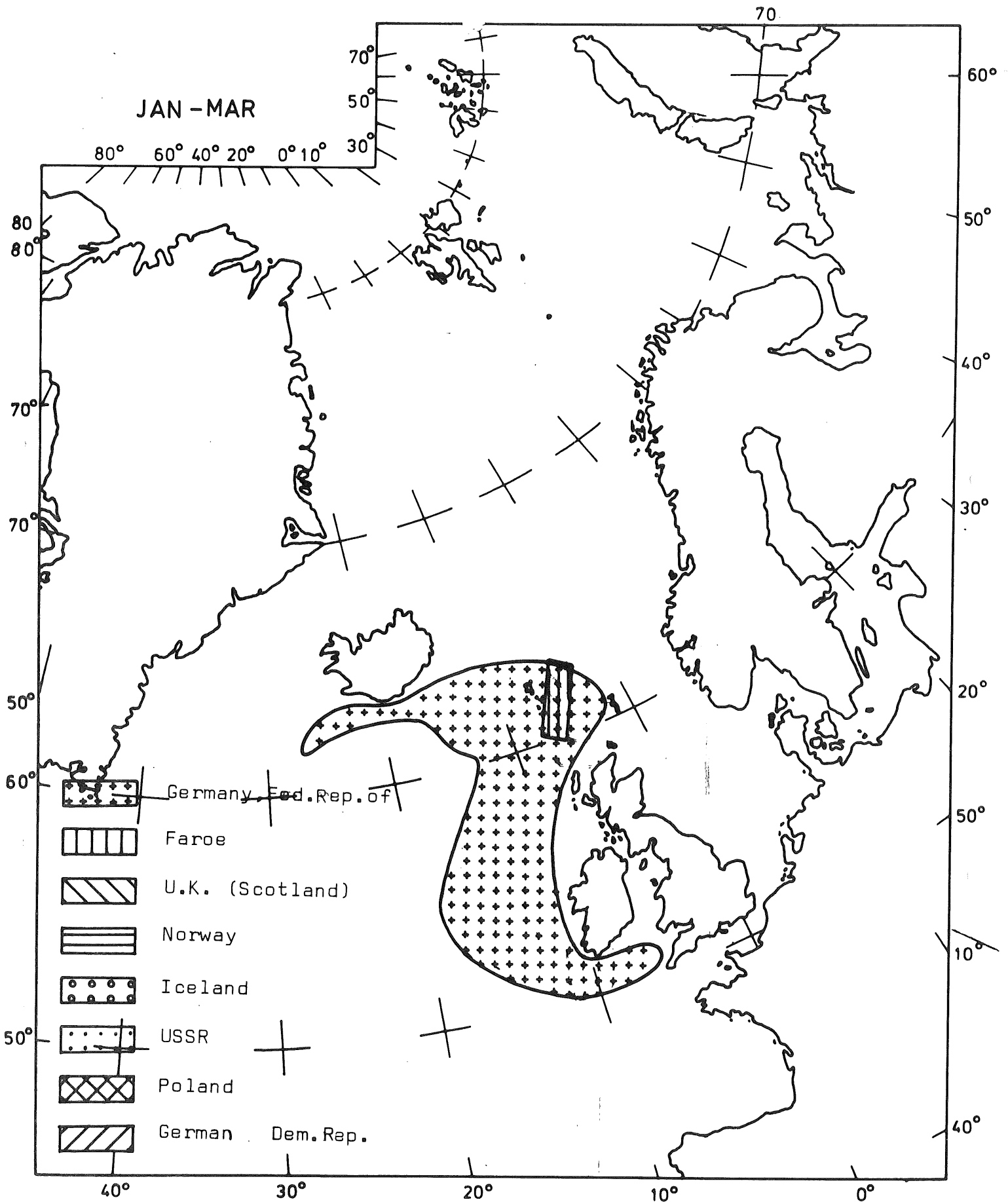


Fig. 10.1-4. Distribution of blue whiting research effort in 1980.

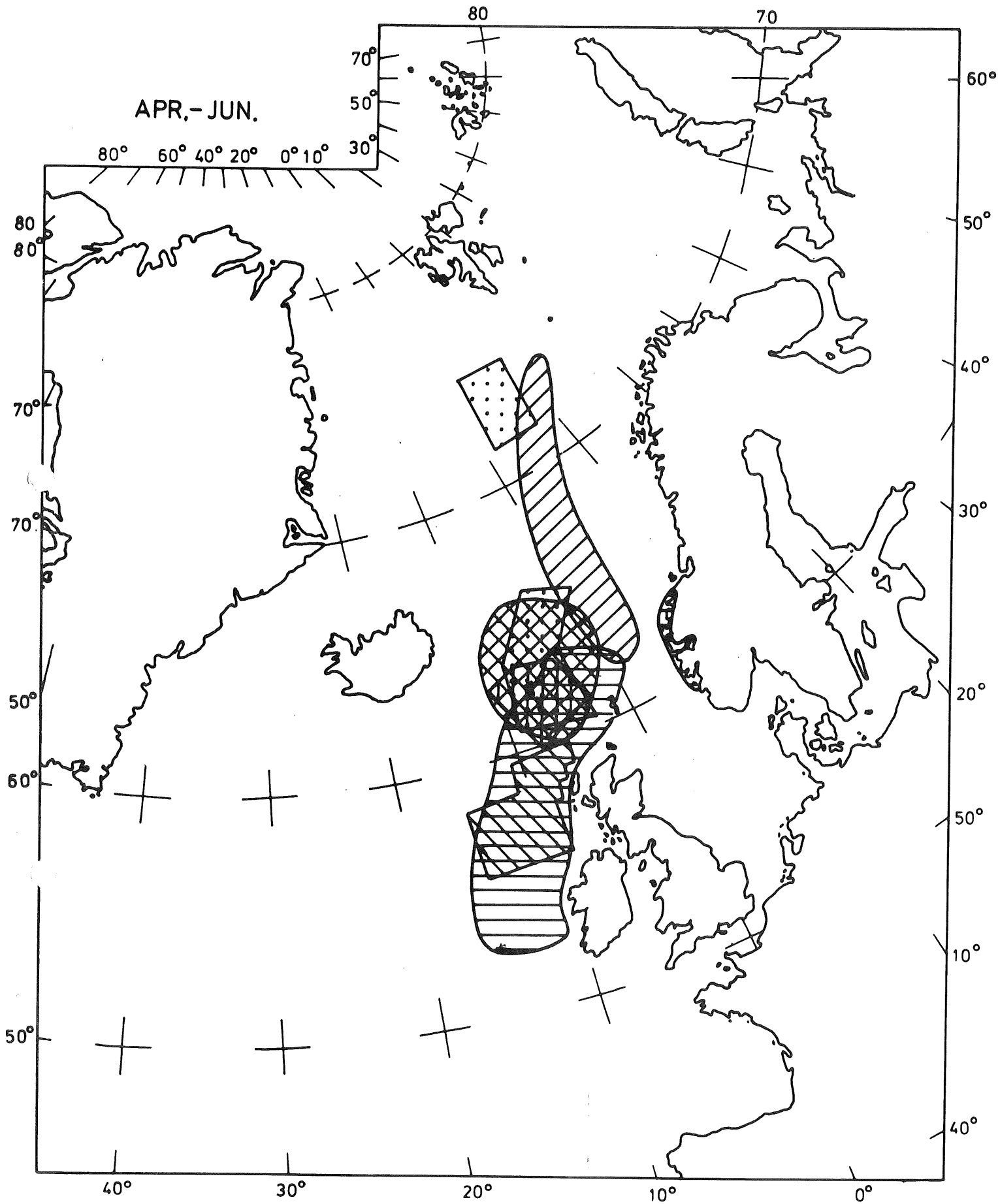


Fig. 10.2

JULY - SEP.

80° 60° 40° 20° 0° 10°

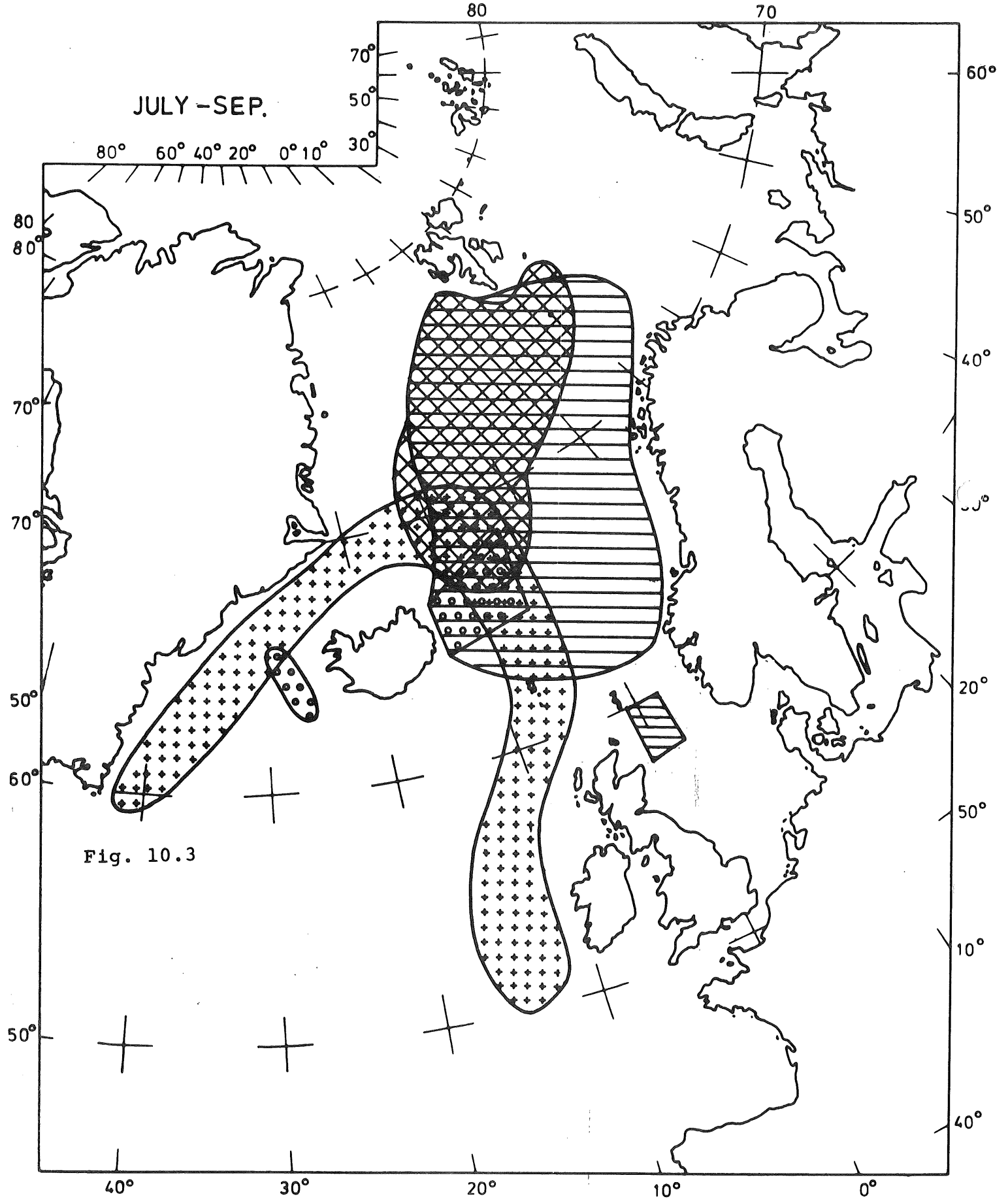
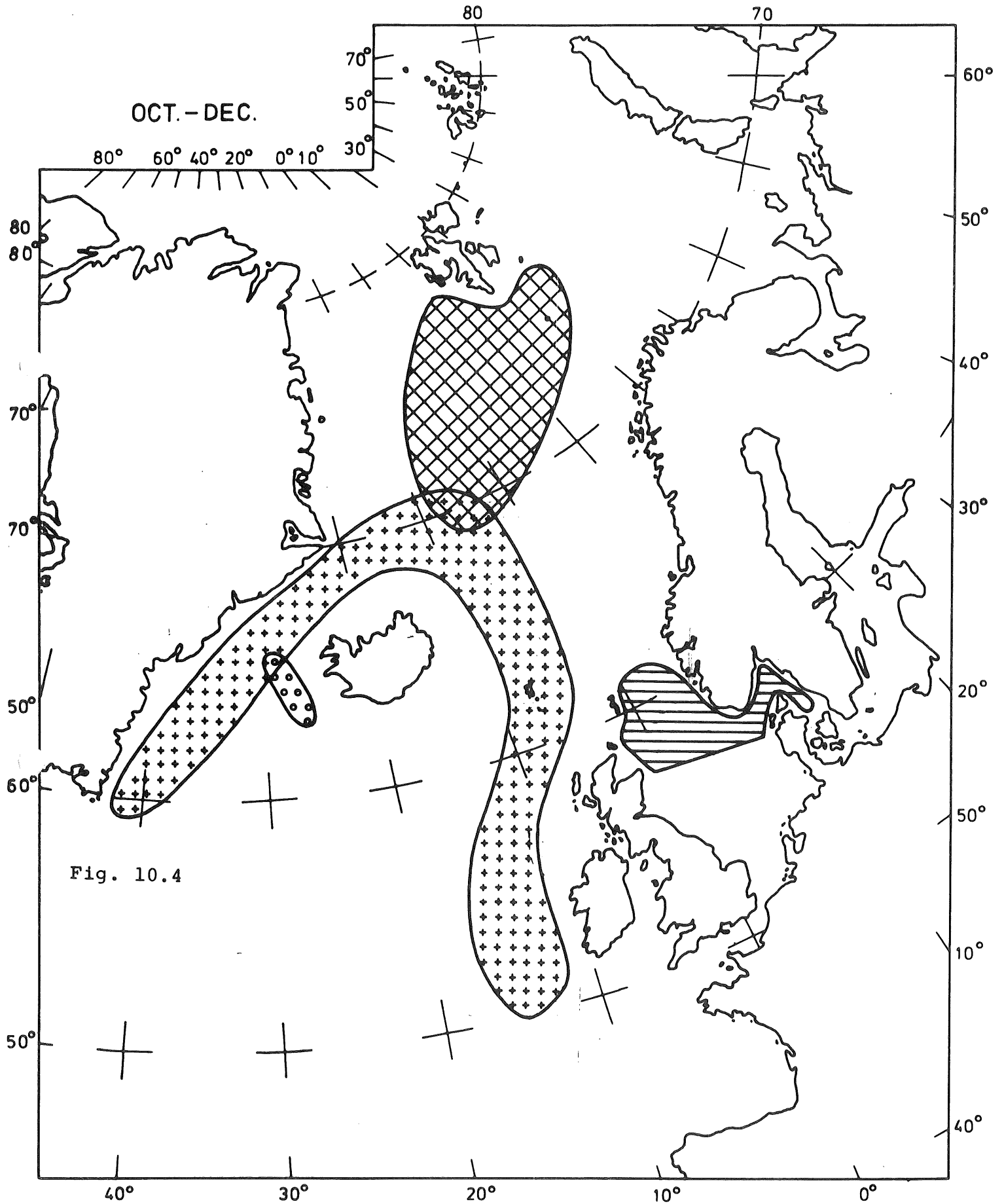


Fig. 10.3





ANNEX

SOVIET RESEARCH AND RESEARCH/SCOUTING CRUISES TO SURVEY BLUE WHITING IN THE  
NORWEGIAN SEA IN 1980

Cruise No.	Vessel name	Working period	Duration	Tasks	
1	MB 452 "Slavgorod"	22.01-19.02	29	Collection of biological and hydrographical samples, studies of distribution and behaviour of blue whiting.	
2	"	15.05-05.10	144		
3	MB 436 "Zarnitsa"	11.04-12.05	32		
4	MB 454 "Cap. Demidov"	26.02-23.04	58		
5	"	13.06-31.06	18		
6	MV 0004 "P. Kaikov"	28.05-25.06	29		
7	MB 422 "N. Kononov"	01.09-31.12	122		
8	MU "Prof. Klenova"	01.05-01.08	93		
9	"	01.09-31.12	122		
10	MI 838 "Onego"	22.05-30.08	102		
11	MI 841 "Velikiy Ustyg"	14.03-24.06	103		
12	MI 448 "Novokubansk"	29.03-21.05	54		Collection of hydrographical, hydro-chemical and hydro-biological samples. Hydroacoustic surveys of blue whiting stocks.
13	MI 846 "Ahill"	15.05-09.07	56		
14	MI 4441 "Andromeda"	20.05-06.07	48		
15	MI 833 "Poisk"	20.04-20.05	31		
16	MI 8202 "Alaid"	27.03-25.06	91		