INTERNATIONAL COUNCIL FOR THE
EXPLORATION OF THE SEA

C.M.1985/H:6

REPORT OF THE WORKSHOP ON THE INTERNATIONAL ACOUSTIC SURVEYS OF BLUE WHITING IN THE NORWEGIAN SEA

Bergen 6-11 May 1985

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1. INTRODUCTION

In the summer of 1980 and 1981 the blue whiting stock feeding in the Norwegian sea was estimated acoustically by Norwegian vessels. The estimates obtained of the adult component of the stock compared reasonable well with acoustic estimates obtained at the spawning areas west of the British Isles during spring. The Blue Whiting Assessment Working Group in 1980 and 1981 had great difficulties in interpreting the results of the spawning surveys and recommended that the summer surveys should be continued in 1982 as an ICES coordinated multinational survey. The main reasons were (Anon. 1981): "Despite the large area which has to be surveyed, this approach has many advantages compared to assessing the spawning stock. The weather conditions are likely to be better on average, the fish are supposedly more stationary or are migrating less rapidly compared to the spawning period, the scattered concentrations are easier to survey and the fish are generally found in shallower water yielding better target strength measurements. Finally, a survey in the Norwegian Sea in the summer/autumn period would cover a major part of the total stock, in contrast to surveys during the spawning period, when only the major part of the spawning stock is found to the west of the British Isles".

This recommendation was endorsed by the ICES Council in 1981, and the surveys have since been conducted in 1982, 1983 and 1984. The estimates of abundance of adult blue whiting from these surveys were considerable lower than estimates from the spawning area, particularly in 1983 and 1984, and the Blue Whiting Assessment Working Group therefore recommended a Workshop to be held where the survey data could be reviewed.

The terms of reference for the Workshop were set by the Council's at its 72nd Statutory Meeting, C.Res. 1984/2:9:

"A Workshop on the Acoustic Survey of Blue Whiting in the Norwegian Sea will be convened (under the chairmanship of Mr T. Monstad) and will meet in Bergen for 5 days at a time to be decided, to:

(i) review the results of the ICES-coordinated acoustic surveys on blue whiting in the Norwegian Sea carried out in 1982, 1983 and 1984,

(ii) plan the coordinated acoustic survey of August 1985 in the light of the analysis made for the previous survey."

The Workshop was then held at the Institute of Marine Research, Bergen from 6 to 11 May 1985. The following persons participated:

S. Ehrich	Fed. Rep. of Germany
H. í Jákupsstovu	Faroe Islands
T. Monstad	Norway (Chairman)
E. Ona	Norway
Ø. Tangen	Norway

2. THE SURVEYS

In Table 2.1 is presented the names of the vessels participating each year and the time period within which the surveys took place. The combined cruisetracks by year is shown in Fig 2.1 together with isolines beyond which no blue whiting was recorded.

The general methodology for the surveys is described in detail in the reports of the planning group for the acoustic surveys (Anon. 1982a, 1983a) and the reports on the surveys (Anon. 1982b, 1983b, 1984). In general the area to be surveyed was divided between the vessels participating taking into account ship time allowed and national obligations. Either prior to or immediately after each survey the echo-sounder and integrator equipment were calibrated for all but one vessel using a standard copper sphere. For one vessel, a calibrated hydrophone was used. The integrator values were apportioned on species by using the composition of trawlcatches together with analysis of the echopaper recordings. During the surveys the integrator values were communicated to the coordinating vessel as averages for every 5 nautical mile sailed, together with biological data on blue whiting from trawl samples and hydrographical observations. The conversion of integrator values to biomass was made on a rectangular basis (1^{o} latitude and $2^{o}30'$ longitude) using the calibration values and a length dependent (C-value) density coefficient.

The total distributions of blue whiting observed in the three years are shown in the respective reports of the surveys (Anon. 1982b, 1983b, 1984). Based on the length distribution in the samples the estimates were divided into age groups, and the distribution shown on Fig. 2.2 for "young" fish and on Fig. 2.3 for "old" fish.

The total biomass in 1982 was estimated to 4.6 mill. tonnes (Table 2.2). Of this 4.3 mill. tonnes were from the yearclasses 1981 and older fish, and 0.3 mill. tonnes from the 1982 yearclass. The blue whiting was found scattered throughout the area surveyed with highest concentrations in the southern area where a fishery by Faroe and USSR vessels on adult fish took place at the same time. The 1982 yearclass was recorded mainly along the shelves in the south.

In 1983 the total biomass was estimated to 2.8 mill. tonnes (Table 2.2). Of this 1.1 mill. tonnes were from the 1981 yearclass and older fish and 1.7 mill. tonnes from the 1982 and 1983 yearclasses combined. Blue whiting was recorded scattered throughout the entire area surveyed similar to 1982 with the highest concentrations found in the southern part of the Norwegian Sea. In contrast to 1982, however, the fishing fleet was not able to find any commercial concentrations of adult fish.

In 1984 the total biomass was estimated to 3.8 mill. tonnes (Table 2.2). Of this 0.4 mill. tonnes was from the yearclass 1981 and older and 3.4 mill. tonnes from the younger yearclasses. As in 1983 the commercial fishery was conducted on the 1982 and 1983 yearclasses only.

Based on these estimates the blue whiting biomass from the 1981 yearclass and older fish appears to have been reduced by 75% from 1982 to 1983 and by 64% from 1983 to 1984. Changing in the abundance of the different stock by latitude is also illustrated in Fig. 2.4. While the portion of "young" fish increases in 1983 and 1984, the remindings of "old" fish appear mostly in the north and in the south (the Norwegian trench).

The Blue Whiting Assessment Working Group both in 1983 and 1984 discussed the great reduction found in the estimates of older fish in the Norwegian Sea without giving any satisfactory explanation. The Group, however, found the reduction unlikely as the spawning stock in the spring of 1983 and 1984 was estimated to 4.4 and 2.7 mill. tonnes respectively. The analytical assessment in 1984 therefore was based only on the spawning surveys.

3. REVIEW OF THE SURVEYS AND THE METHODOLOGY

The members of the Workshop analysed the data available from the three surveys and found no major reason to alter the estimates presented earlier. However, in the following a number of possible sources of errors are presented which combined could have lead to the reduction in the estimates from 1982 to 1983, but it was not possible to quantify the biases for recalculation.

3.1 Area coverage

In Fig. 3.1.1 is shown a chart summarizing the migration pattern and areas of concentration of adult blue whiting (Baily 1982). Based on this, the major distributional areas for adult blue whiting of the northern stock have been covered during the summer surveys in 1982 - 1984. With regard to the individual surveys (Fig. 2.1), the areas of Spitsbergen, south of the Faroes and the Norwegian Deep were not covered in 1982. The survey in 1983 was not extended to the Dohrn Bank and in 1984 a large area in the western central Norwegian Sea was not covered. During none of the surveys the area west of the British Isles was investigated for residual population of adult blue whiting from the Northern Stock.

A significant change from 1982 - 1984, however, was a change of vessels covering the northern and northwestern parts of the Norwegian Sea. As the acoustic performance has varied greatly between vessels (sea section 3.2), this might have introduced a major bias in the total estimates.

3.2 "Intercalibration"

Up to a certain degree vessel specific differences could explain the steep decline of the stock size estimate in 1983 and for the differences in the spring and summer estimates of the adult blue whiting stock in 1983. Average integrator values for each vessel in overlapping rectangles were calculated to illustrate these vessel specific differences.

Comparing the average integrator values of the Soviet vessel "Persey III" with the values from three Norwegian vessels and from the Faroese vessel, the factor is continuously smaller than 1 (N = numbers of observations):

"Persey III" = 0.38 x J. Hjort (N= 9)
= 0.31 x G.O. Sars (N=19)
= 0.28 x M. Sars (N=32)
= 0.59 x M. Heinason (N=36)

In contrast to that the factor of "M. Heinason" related to the other vessels is higher as well as lower than 1:

"M. Heinason" = 0.26 x M. Sars (N=19)
= 1.4 x Eldjarn (N= 9)
= 0.65 x A. Fridriksson (N= 9)
= 1.7 x Persey III (N=36)

The differences between the integrator values of one vessel within a rectangle could be very high if the distribution pattern of the fish in time and space is not uniform during the survey. The workshop consideres this to be a plausible explanation for the different factors of "M. Heinason", whereas the consistently smaller factors of "Persey III" might indicate a vessel specific difference.

Looking at 7 rectangles of the northern area in 1983 from where integrator values of "Persey III" and "G.O. Sars" were available, the estimated biomass within these rectangles changed from 26 thousand tonnes using the USSR data only, to 69 thousand tonnes, using the Norwegian data only. Original weighted mean biomass was 50 thousand tonnes.

Taking this into account the total biomass estimate depends on to what degree a certain vessel was engaged in the survey. To get an idea for a possible affect, the proportion of each vessel in the total biomass has been calculated and is shown in Fig. 3.2.1. For all the covered rectangles the weighted mean biomasses for each vessel and year were separately determined and summarized.

The figure further shows that the three Norwegian vessels in 1982 combined were responsible for 81% of the total biomass value. The Norwegian proportion decreased in 1983 to 52% and to 31% in 1984, whereas the proportion of the USSR vessel increased from 5% in 1982 to 19% in 1984.

3.3 Threshold effects and equipment consideration

When surveying areas with a generally low fish density in which a major part of the biomass is registered as single fish, the threshold effect can be severe when low performance equipment is used, AGLEN (1982). In the surveys on blue whiting in the Norwegian Sea, low densities are found in most of the area compared to the density in the spawning area. The equipment demands, in regard to source level and noise level, are comparably high.

For proper single-fish integration it is desireable to detect the smallest fish of interest at an unfavourable tilt over the significant part of the beam. This can be stated as:

$$\frac{I_o \cdot b_b \cdot \sigma_{bs}}{R^4_{max} \cdot e^{2\beta R}} > I_n \cdot B/d$$

where:

I_o = sound intensity on the acoustic axis, ref. 1 m.

b_b = directivity at the border of the significant part of the beam, $20 \log b_b = -12$ dB,

σ_{bs} = backscattering cross section of the smallest fish of interest at an unfavourable tilt,

R_{max} = maximum depth of the fish of interest,

I_n = noise intensity level in a 1 Hz band around the center frequency ref. to 1 meter from the receiver,

B = bandwidth,

d = directivity index.

In logarithmic terms,

$$SL + 20 \log b_b + TS_{min} - 40 \log R_{max} - 2\alpha R_{max} > NL + 10 \log B - DI$$

Using the following typical values:

$20 \log b_b$ = -12 dB
R_{max} = 250 m
NL = 65 dB//1µPa per Hz ref 1 m
B = 3000 Hz
DI = 28 dB
TS_{min} = -50 dB a 20 cm fish at ±10 - 15° tilt.

$SL > NL + 10 \log B - DI + 40 \log R_{250} + 2\alpha R_{250} - TS_{min} - 20 \log b_b$
$= 65 + 34.8 - 28 + 101.2 - (-50) - (-12)$
SL>235 dB/µPa ref 1 m (250 m)

When the echosounder and integrator settings and performance are given, the maximum range for proper single-fish integration can be calculated through the same equation.

$$20 \log R(max) = C(e) - 20 \log U(rms)$$

where C(e) is an echosounder constant including the minimum desired target strength of interest.

C(e) = SL+VR+G -20 log R(u) -2αR(u)+TS(min)+20 log b(b)
SL + VR = source level and voltage response ref. 0 dB attenuator
G = attenuator setting
R(u) = the distance where 20 log R TVG is expired
TS(min) = the minimum target strength of interest.
Here TS(min)= -50dB, that is a 20 cm fish (cod) at ±10 deg. tilt

Using an ideal threshold level for most of the vessels of 10 mV, or, as reported, 30 mV for "Persey III" and "Eisbäer", the maximum range for proper single-fish integration has been calculated. The results are shown in Table 3.3.1. The assumed attenuator settings during surveying have been marked with an asterisk, or as reported in brackets (Att.).

For comparison of the performance of the vessels, the maximum range has also been calculated using -10 dB attenuator for all vessels, without changing the ideal threshold.

As seen, all vessels have problems with single-fish integration at depths below 100 meters, even at ideal threshold levels. Deeper than R(max), low densities are significantly underestimated, and are severely underestimated by the two low-performance vessels.

As the threshold effect will be vessel specific and also density and depth dependent, a recalculation for estimates of total bias is not possible.

In order to minimize the threshold effect, an increase of the receiver gain should be tried, but as this also will increase the noise level, only some reduction of the threshold effect can be achieved here.

Generally, a higher source level or the use of towed bodies should be considered.

3.4 Sampling errors

The trawls used during the surveys have varied extensively between vessels (Table 3.4.1) from small capelin trawls with an vertical opening of 12 m and stretched mesh size in the front panels of 60 cm to very big commercial blue whiting trawls with a vertical opening of 60 m and stretched mesh size in the front panel of 16 m.

The Workshop analyzed the different selectivity which might have arised from these differences by comparing the length distribution of blue whiting in samples obtained by different vessels in same statistical rectangles and by the same vessel using two different trawls in the same rectangle (Table 3.4.2). From this comparison it appears that the length distribution of blue whiting obtained was not significantly different from one vessel to another or between two different trawls, and were less than found between 5 samples obtained by one vessel within two neighbouring rectangles (Table 3.4.2).

It is therefore concluded that the decline in the acoustic biomass observed from 1982 to 1983 could not be explained by sampling biases.

3.5 Apportion of integrator values

In Fig. 3.5.1 - 3.5.3 is presented three typical echo recordings from blue whiting surveys. A picture of the recording from an area with several species is shown (Fig. 3.5.1) where plankton and lantern fish dominated in two different layers and blue whiting is scattered below in a depth around 250 m. Nearest to the bottom there are recordings of greater silver smelt and other demersal fish species. Fig. 3.5.2 shows the recordings of blue whiting appearing in the depth from 300 to 350 m as small and medium sized schools. In Fig. 3.5.3 the blue whiting appear as scattered recordings in the upper 100 m water column. The recording of plankton and lantern fish in the three different years could to a certain extent be misidentified as blue whiting.

3.6 Summary

After analysing the data available the Workshop members did not find any major reason to alter the estimates presented earlier. A number of possible biases were identified which combined could have caused the reduction in the estimates observed from 1982 to 1983, but it was not possible to quantify these for a recalculation.

In 1983 the area coverage was reasonably good, but minor parts of the adult component might, however, be located outwith the area surveyed. In 1984 this might also have been the case.

In contrast to 1982, the fishing fleet did not find any commercial concentrations of adult fish in 1983 and 1984. Superficially this supports the estimates, but could as well have been caused by a different distribution of the stock within the Norwegian Sea. A new analysis of the threshold effect shows that integrating very scattered concentrations of small fish with low performance equipment might lead to serious underestimates.

An analysis of the length distributions of blue whiting in samples from different vessels in the same area did not indicate these to be biased. The number of samples analysed, however, was small.

No comparison of the scrutinizing procedure between scientists from the various countries have been performed. As the northern and northwestern area of the Norwegian Sea has been covered by different vessels each year, a different scrutinizing procedure might easily have introduced biases. Especially as the fishing power of the gears used has varied simultaneously.

In order to obtain reliable estimates of the blue whiting stock in the Norwegian Sea from acoustic surveys, the stock apparently has to be above a certain level or found distributed in a smaller area in larger concentrations. This minimum size level of the stock has yet to be determined.

4. RECOMMENDATIONS FOR THE 1985 SURVEY

4.1 Area

Four nations will participate with a total of 7 research vessels:

USSR:	"Persey III"
	"Kokshaik"
Norway:	"Eldjarn"
	"Michael Sars" (central vessel)
Faroe Islands:	"Magnus Heinason"
Iceland:	"Arni Fridriksson"
	"Bjarne Sæmundsson"

In addition to blue whiting investigations the research vessels will also have other objectives to attend which influence survey pattern.

The Norwegian Sea is planned to be covered between 73°N and 60°N from the Norwegian Coast to the Denmark Strait. Fig. 4.1.1 shows the planned cruise tracks and areas suggested to be covered by the different nations.

The Icelandic waters will be surveyed by the two Icelandic vessels which also take part in 0-group fish and capelin investigations. The area west of Iceland is suggested surveyed up to 37°W if time permits for it.

The Faroese vessel will survey the area north of Faroe Islands with some overlapping with the Icelandic vessel.

The Jan Mayen area will be covered by the Norwegian vessel "Eldjarn" of which the main objective is capelin investigations in cooperation with the Icelandic vessels. The other Norwegian vessel "Michael Sars" will survey the area along the Norwegian Coast between 70° and 60°N. The shelf area will be covered with extension westwards in accordance with time allowance.

The two USSR vessels are suggested to cover the central area of the Norwegian Sea, from the Barents Sea to Faroe Islands and between the Norwegian shelf edge area to Jan Mayen. If there is more disposal time, the area to be covered is suggested enlarged towards southwest.

Data obtained in the different overlapped areas will give valuable informations for comparison between the vessels.

4.2 Calibration

In order to get comparable datamaterial from all vessels, the ICES standards for calibration of hydroacoustical equipment, that is echosounder and integrator, should be followed.

A detailed list of the measured parameters from the last vessel calibration should be tabulated (Appendix I).

This should contain all the necessary information for calculating the instrumental constant

$$C_I = \frac{\sigma_{ST}}{M_{ST} \cdot D^2 \cdot \psi} \cdot 3.43 \cdot 10^6 \ [m^2/nm^2]$$

where a standard target with known backscattering cross section σ_{ST} is used. (Foote et al. 1981).

In addition to this, all echosounder and integrator settings should be tabulated, both for calibration and survey, and the sheet form shown in Table 4.2.1 should be used.

The participating vessels are recommended to be aware of any possibility to perform "ship to ship"-calibrations. These will give valuable additional information for calculations of factors between the vessels.

4.3 Procedures at Sea

Guidelines for data handling and procedure at Sea are given in Anon. (1983a). These should be followed using the sheets A-D (Anon. 1983a) plus the new one, sheet E (Appendix I), for acoustic information and trawl-specifications.

The "central" vessel to which the data should be communicated in 1985, is "Michael Sars". Her survey period, however, starts 15 August only, with duration up to 5 September. Radio contact will be on 2056 kHz at 0900 hrs and 2100 hrs GMT.

4.4 Data Handling

If the data of the participating vessels have not been fully received of the "central" vessel (by daily communication after 15 August), the data forms i.e. sheet A-E, should be transmitted as soon as possible after the cruise to T. Monstad, Institute of Marine Research, Bergen, Norway.

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Bailey, R.S., 1982. The population biology of Blue Whiting in the North Atlantic. Adv. Mar. Biol., 19: 257-355.

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Table 2.1. Time period for the participating vessels in the Norwegian Sea Acoustic Blue Whiting Survey in 1982, -83 and -84.

Vessel	Nation	1982	1983	1984
"Persey III"	USSR	3 - 23 Aug	1 - 20 Aug	26 Jul - 20 Aug
"Michael Sars"	Norway	3 - 19 Aug	1 - 20 Aug	-
"G.O. Sars"	Norway	10 - 20 Aug	1 - 20 Aug	-
"Johan Hjort"	Norway	3 - 20 Aug	-	-
"Eldjarn"	Norway	-	1 - 20 Aug	1 Aug - 5 Sep
"Magnus Heinason"	Faroe Island	5 - 17 Aug	6 - 30 Aug	20 Aug - 1 Sep
"Arni Fridriksson"	Iceland	5 - 31 Aug	7 - 27 Aug	9 - 29 Aug
"Bjarne Sæmundsson"	Iceland	5 - 31 Aug	15 - 28 Aug	8 - 25 Aug
"Eisbäer"	GDR	29 Jul - 22 Aug	27 Jul - 20 Aug	1 - 27 Aug

Table 2.2. Blue whiting biomass estimates splitted in two year groups. Numbers of vessels participating and survey period for each year.

Year	No of vessels	Biomass estimates in million tonnes		Survey period
		1981-yearclass + older fish	1982-yearclass + younger fish	
1982	8	4.3	0.3	29.7 - 31.8
1983	8	1.1	1.7	27.7 - 28.8
1984	6	0.4	3.4	26.7 - 5.9

Table 3.3.1 Examples of maximum range (R(max)) for proper single-fish integration by different vessels participating in the surveys.

Vessel	SL+VR (dB)	Att. (dB)	C(e) (dB)	R(max) (m)	R(max) Ref.Att. -10dB
G.O. Sars	134.5	(-10)	-2.0	112	112
M. Sars	141.0	(-20)	-5.3	77	244
Eldjarn	140.8	(-20)	-5.8	73	230
Persey III	133.3	(0)	-13.6	103	31
B. Sæmundsson	136.0	(-10*)	-0.5	133	133
M. Heinason	139.5	(-10)	-7.0	63	200
Eisbäer	120.7	(0*)	-5.8	24	8

*Assumed attenuator settings.

Table 3.4.1. Vertical opening (m) of the pelagic trawls used by the different vessels each year.

Vessel	Nation	1982	1983	1984
"Persey III"	USSR	40	40	60
"Michael Sars"	Norway	16	16	-
"G.O. Sars"	Norway	20	30	-
"Johan Hjort"	Norway	20	-	-
"Eldjarn"	Norway	-	20-60	45
"Magnus Heinason"	Faroe Island	40	40	40
"Arni Fridriksson"	Iceland	25	12	17
"Bjarne Sæmundsson"	Iceland	25	-	15
"Eisbäer"	GDR	40	40	20

Table 3.4.2. Length distribution (N) of blue whiting samples from different trawl catches of different vessels within some rectangles in 1983. E.B. = "Eisbäer", Eld. = "Eldjarn", M.H. = "Magnus Heinason", M.S. = "Michael Sars"

Vessel	Eld.	Eld.	EB.	M.H.	E.B.	E.B.	M.S.	M.H.	M.H.	M.H.	M.H.	M.H.
St.No.	223	219	224	64	219	184	253	7	30	22	28	35
Trawl opening m	20	60	40	40	40	40	16	40	40	40	40	40
Rectangle		1		2		3				4		
cm												
12								1		1		
13								2		3		
14								2		4		
15			2					1		1	1	
16			2					1		–	1	
17			–					1		–	1	
18			1					–	2	–	–	1
19	1	1	–					7	–	1	2	9
20	1	–	3	3				34	7	1	17	42
21	9	5	23	7		1		71	21	20	39	32
22	29	45	100	4	4	2		46	17	79	40	8
23	31	19	152	6	7	3		15	20	65	12	5
24	16	22	114	–	2	3	1	2	12	37	1	1
25	2	5	22	1	1	3	–		2	7		–
26	3	1	2	1	2	–	–		4	3		1
27	–	–	–	2	2	–	–		–	–		
28	–	1	–	6	7	2	–		3	1		
29	1	–	–	13	35	6	2		4	–		
30	2	–	–	24	56	6	7		1	–		
31	–	–	–	23	55	6	6		1	1		
32	3	1	–	22	68	3	10		–			
33	–		1	11	59	8	5		1			
34	–			10	32	4	4					
35	–			10	8	1	1					
36	–			3	1	1						
37	1											

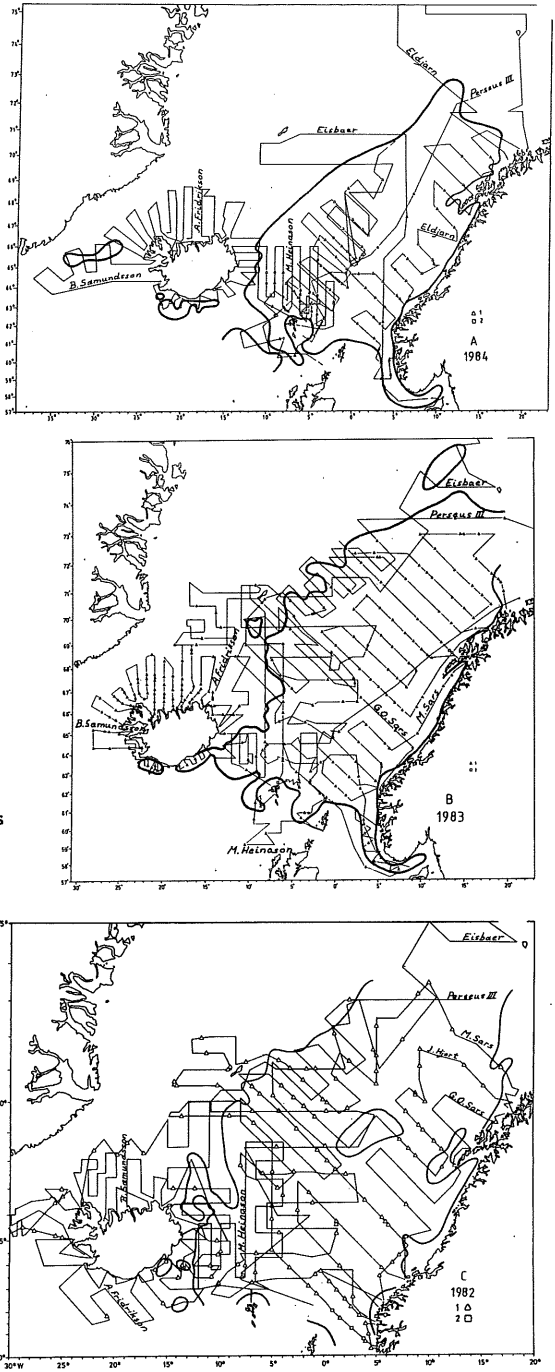

Fig. 2.1. Combined cruise tracks with trawlstations and the outline (thicker line) of the blue whiting distribution 1982-84. 1) Pelagic trawl. 2) Bottom trawl.

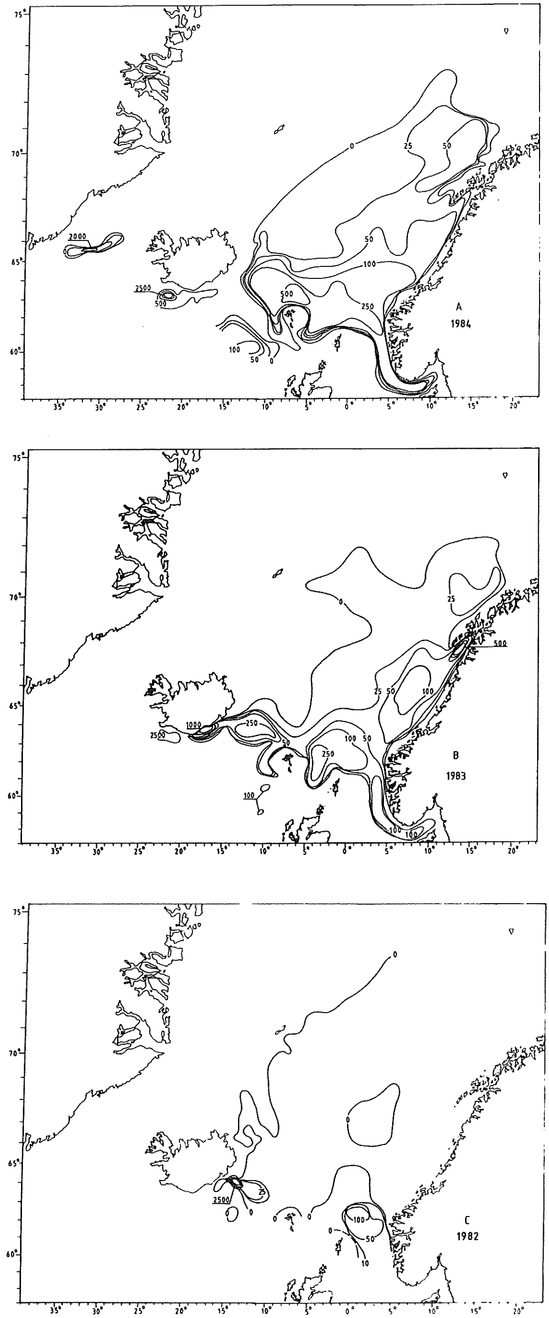

Fig. 2.2. Distribution and density of young blue whiting, i.e. the 1982-yearclass and younger in 1982-84.

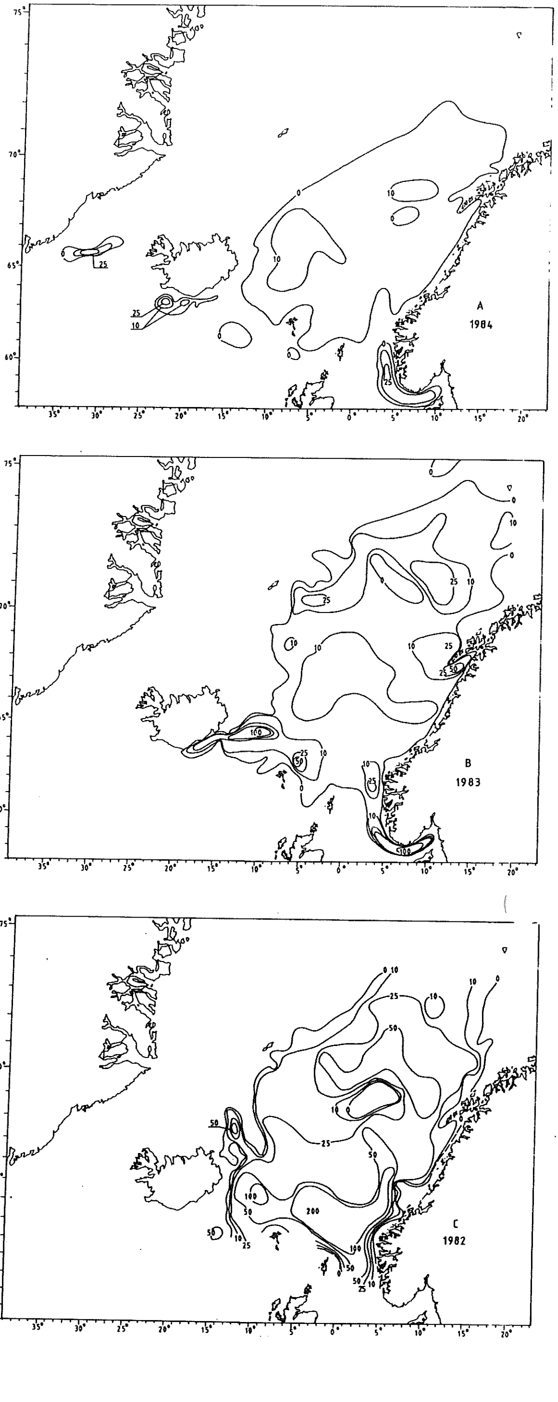

Fig. 2.3. Distribution and density of "old" blue whiting, i.e. the 1981-yearclass and older in 1982-84.

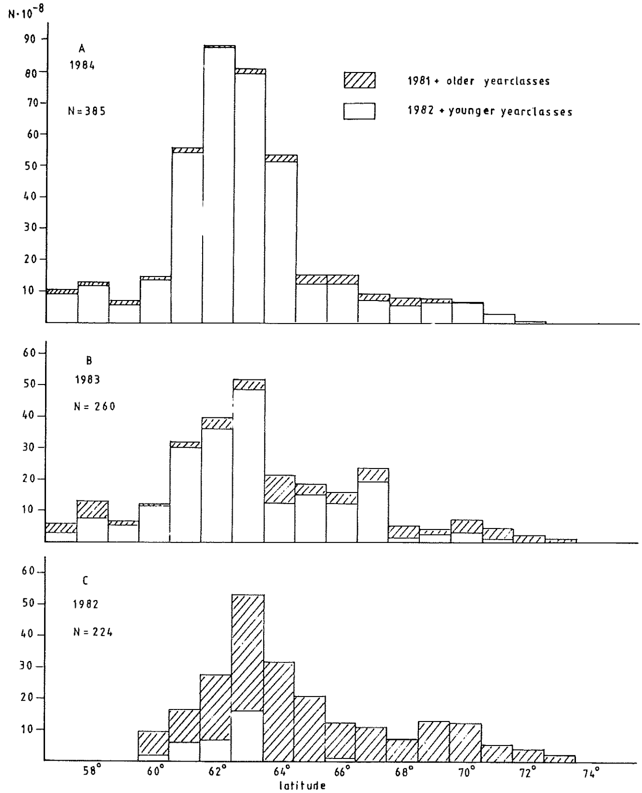

Fig. 2.4. Abundance estimate and distribution of blue whiting by latitude, with the "old" (1981 + older yearclasses) and the young (1982 + younger yearclasses) separated. N in 10^8.

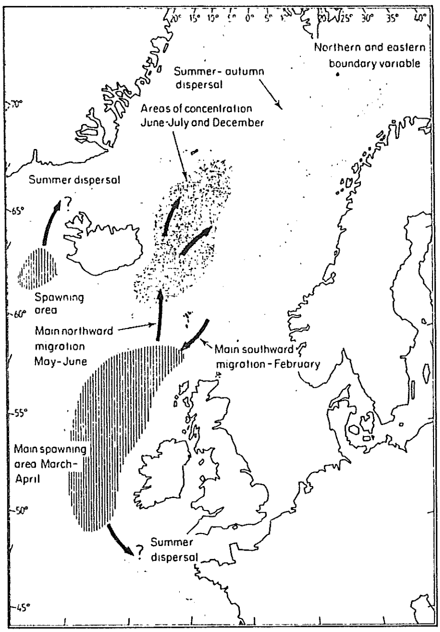

Fig. 3.1.1. Areas of concentration and migration pattern in general of adult blue whiting. After Bailey (1982).

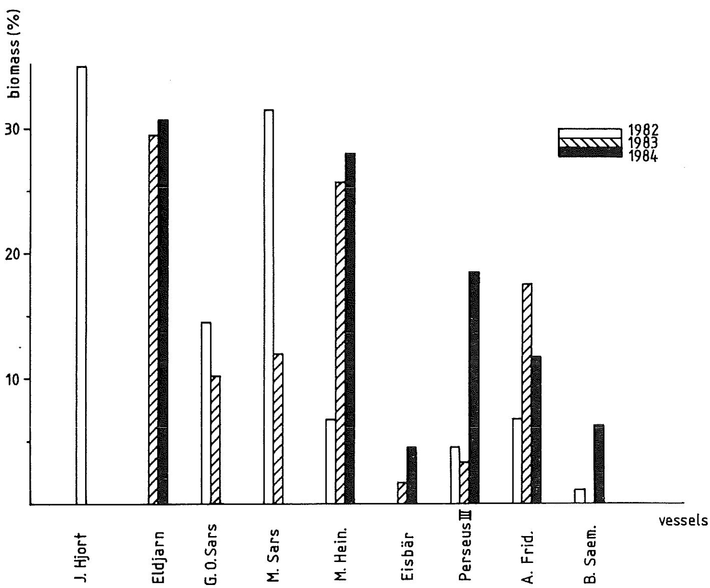

Fig. 3.2.1. Proportion (per cent) of each vessels contribution to the estimated biomass in 1982-84.

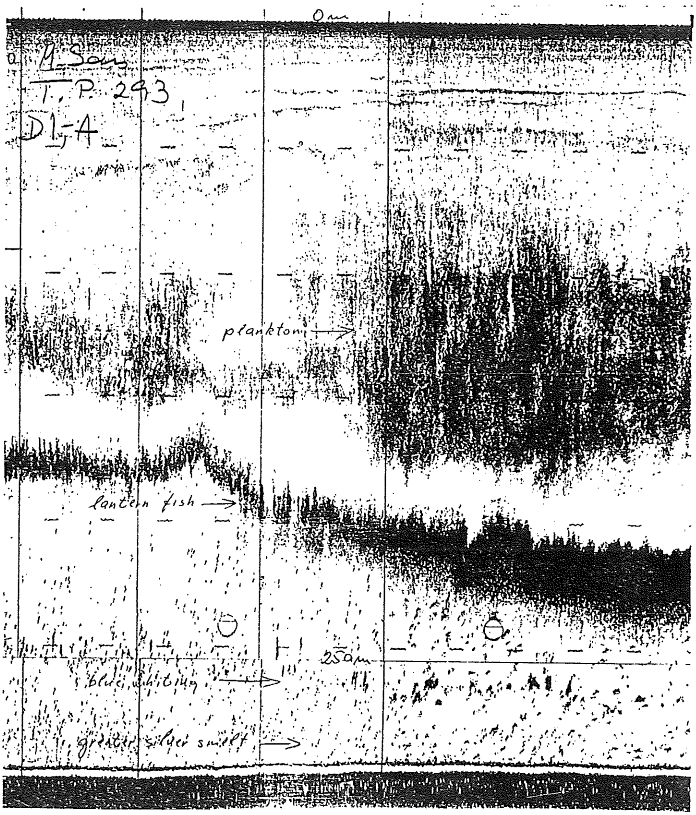

Fig. 3.5.1. Example of echo recordings from the Norwegian Sea in August 1984, showing a layer of plankton uppermost, then a layer of lantern fish with scatters of blue whiting below, and greater silver smelt and other demersal species nearest to the bottom.

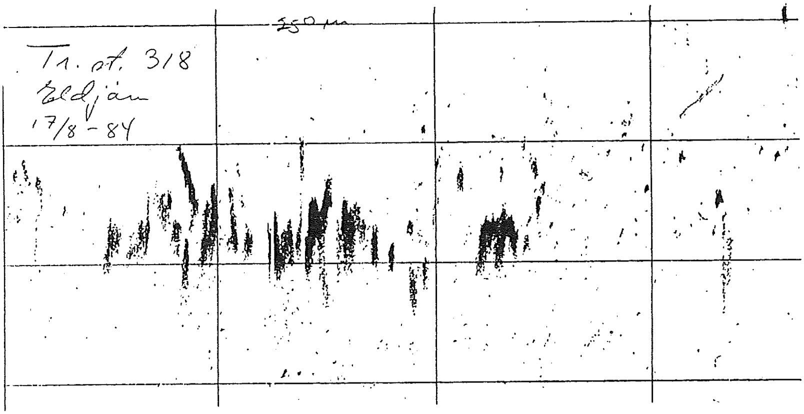

Fig. 3.5.2. Example of echo recordings from the Norwegian Sea in August 1984, showing small and medium sized shoals of blue whiting between 300 and 350 m depth.

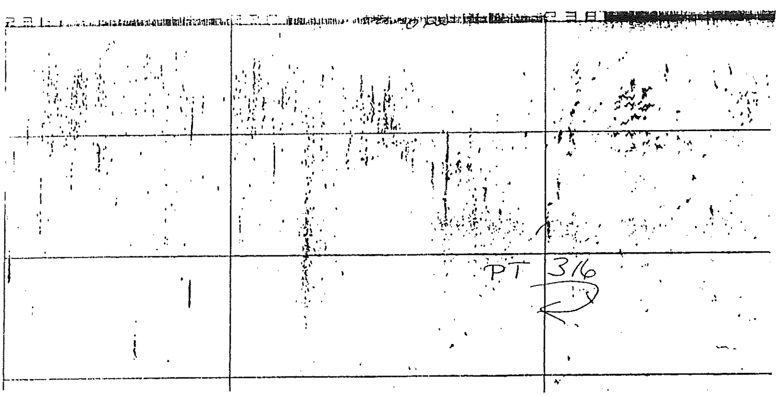

Fig. 3.5.3. Example of echo recordings from the Norwegian Sea in August 1984, showing scattered traces of blue whiting from surface to 100 m depth.

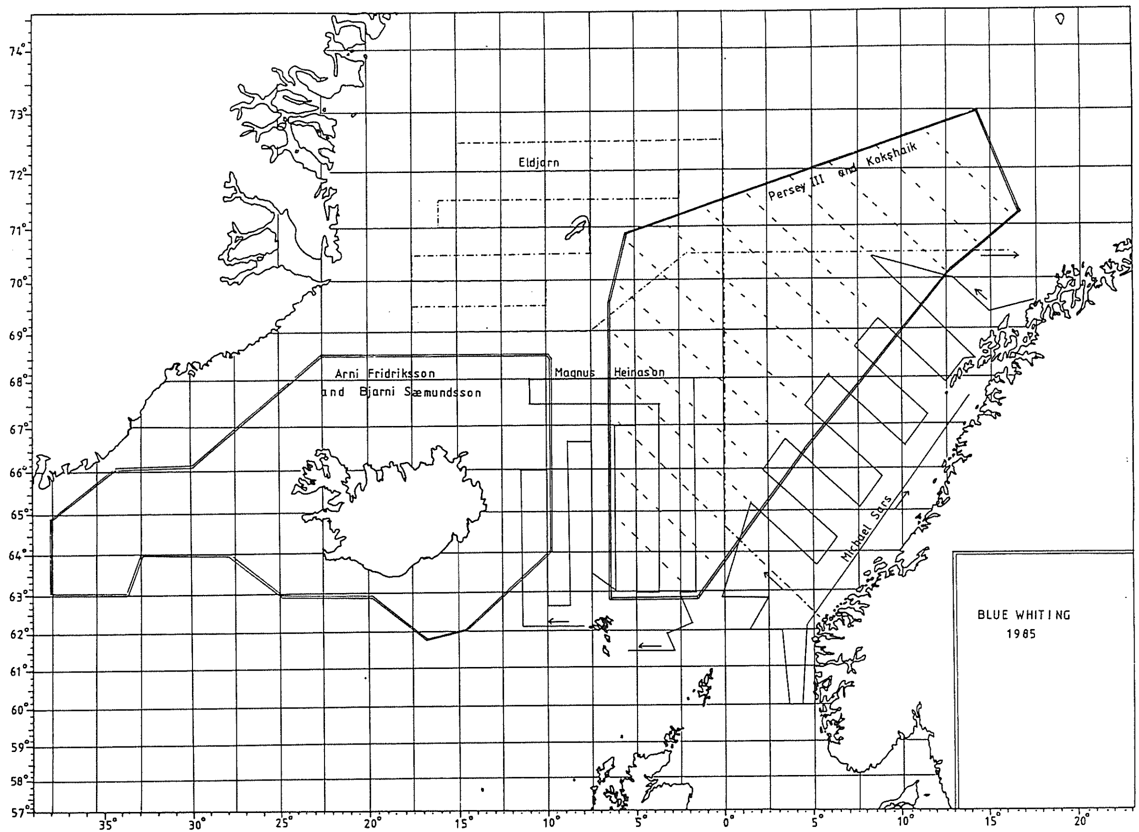

Fig. 4.1.1. Planned cruise tracks a area suggested to be surveyed during August 1985.

E

BLUE WHITING

Ship: ______________________ Year: ______ Month: ____________

ACOUSTIC INSTRUMENTS

Echo sounder

Transducer dimension:

Frequency:

Basic range:

Bandwidth:

TVG and gain:

Recorder gain:

Transmitter power:

Discriminator:

Integrator

Threshold:

Gain:

Calibration

Standard target (ST)

Type:

Target strength, TS_{ST}:

Deflection, M:

Distance, D:

Beam angle, ψ:

Source level + voltage response, SL + VR:

Date of measure:

Instrumental constant (for survey setting):

$$C_I = \frac{\sigma_{ST}}{M_{ST} \cdot D^2 \cdot \psi} \cdot 3.43 \cdot 10^6 = \_\_\_\_\_\_\_\_\_\_\_\_$$

OBS!! $(\sigma_{ST} = 4\pi \cdot 10^{0.1\, TS_{ST}})$ Refer to ________ dB integrator gain

TRAWL SPECIFICATIONS

	1	2	3
Type			
Vertical opening, m			
Horizontal opening, m			
Circumference			
Mesh size in cod end			