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BLUE WHITING IN THE NORWEGIAN SEA, SPRING AND SUMMER 1995 AND 1996.

by

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ABSTRACT

The Norwegian Sea is an important feeding area for blue whiting in the Northeast Atlantic. The adult blue whiting migrates into the Norwegian Sea after spawning along the continental slope west of The British Isles. A major part of the spawning products drift northwards where the juveniles find nursery grounds in the southern Norwegian Sea, and among other areas, along the continental shelf off the Norwegian coast.

Estimates of distribution and abundance of blue whiting in the Norwegian Sea have been obtained during acoustic surveys, as have age and length compositions of the stock, and stomach samples have been collected.

The diet of blue whiting is described, both qualitatively and quantitatively, and some simple estimates of consumption are given, as well as differences in prey choice among various age groups.

Key words: Blue whiting, Norwegian Sea, distribution, diet, consumption.

INTRODUCTION

Blue whiting (*Micromesistius poutassou*), a small gadoid fish with wide distribution, is found in most parts of the warmer side of the north-east Atlantic from the Mediterranean Sea to Spitzbergen and into the Barents Sea, between Southeast Greenland and the Kola peninsula (Zilanov, 1984; Bailey 1982; Anon. 1990). The stock most probably consists of several populations of varyin sizes overlapping each other, but is made up of two components, i.e. a northern and a southern one.

In early spring, blue whiting of the northern stock migrates from the feeding areas in the Norwegian Sea to the spawning grounds west of the British Isles, where the peak of spawning takes place in March/April. After spawning, it migrates northwards again and disperses into the Norwegian Sea. It is mostly concentrated along frontal areas of temperature and prefers water of 5 - 7° C, i.e. Atlantic water. However, blue whiting is found to be feeding in water ranging from 0 - 8° C (Monstad and Blindheim, 1986). The spawning products drift either southwards or northwards and end up as juveniles in the Bay of Biscay or in the North Sea and southern part of the Norwegian Sea respectively. The proportions drifting either way most probably vary from year to year.

The commercial catches of blue whiting in the Norwegian Sea were at its maximum in 1979 and 1980. To day the fishery in the Norwegian Sea is rather modest, the main activitiy taking place during spring west of the British Isles. The stock in the Norwegian Sea has been surveyed during summer and autumn by research vessels from various nations since the 1960's, e.g. USSR/Russia (Ushakov and Mazhirina, 1978) and Norway (Jakupsstovu and Nakken, 1971; Blindheim and Monstad, 1981). In the period 1982-1986 the surveys were coordinated by ICES and up to 8 research vessels from six nations participated (Monstad, 1990a). The acoustic assessments from these surveyes, considered as relative indices due to probable incomplete coverage of the total northern stock, indicate a steady decrease of the stock from 1980 onwards (Monstad, 1990a and b).

The diet of blue whiting is mainly pelagic zooplankton and lesser mesopelagic fish. Timokhina (1974) and Zilanov (1982) found that euphauciasees and copepods were the most common food. Plekhanova (1989) found that blue whiting started to feed on copepods of copepodite stages I-IV, and that the duration of the feeding time depended on the development of the copepods. In the Barents Sea it also feeds largely on juvenile fish (Zilanov, 1982). In the North Sea and in some Norwegian fjords blue whiting is found to feed mainly on krill and mesopelagic fish. In the Norwegian Sea it is observed to also have significant numbers of 0-group herring in the stomach, as well as squids.

MATERIAL AND METHODS

Data of blue whiting were obtained during the surveys conducted in the Norwegian Sea in 1995 and 1996, which were part of international investigations on pelagic fish and environment with special emphasis on herring. Research vessels from Russia, Iceland, The Faroe Islands and Norway participated in the investigations. The surveys were also part of "Mare Cognitum", i.e. the Norwegian Sea programme of Institute of Marine Research, Bergen.

For continuous acoustic echo recordings of fish and plankton the BEI-system (Bergen Echo Integrator) was used, connected to a calibrated 38 kHz Simrad EK500 echo sounder with the range of 10 - 1000m. Pelagic trawls with vertical openings of 20-30m and with innernet in the cod end of 22mm mesh size, were used for collection of biological samples and identification of the echo recordings. A net of hydrographic stations was worked by use of CTD-sonde.

The biological samples of blue whiting were worked with emphasize on length, weight, otholiths for ageing, sex and maturity. In addition stomachs for analyses of diet were collected at every station during surveys with R.V. "Johan Hjort" in July 1995, two suveys with R.V. "G.O. Sars" in March-April and one in July-August 1996. Stations were evenly distributed around the clock. The stomachs were carefully checked for signs of regurgitation, and random samples of 20-35 stomachs lacking signs of regurgitation were collected at stations with catches of more than about 30 individuals, otherwise all stomachs were quickly deep frozen. These samples were later stratified allowing two fish in each 1-cm length group to be used for stomach content analyses following the ideas presented by Bogstad et al. (1995) concerning the cost-efficiency of a study like this one.

The stomachs were later analysed at the Institute of Marine Research (IMR), Norway. All identifiable prey were identified to the lowest possible taxonomic group. Dry weights of the different prey categories were measured separately after being kept in a drying oven at 70°C for 24 hours or until a constant weight was obtained. Composition of the stomach contents was described by percentages by weight, i.e. total weight of a particular food item as percentages of the pooled contents of all stomachs examined in a given age-group.

Degrees of overlap between diets of different age groups were assessed using Schoener's index (Schoener 1970):

$$C_{jk} = 1.0 - 0.5 \Sigma (|p_{ij} - p_{ik}|)$$

where p_{ij} and p_{ik} are the estimated proportions by weight of prey 'i' in the diets of age group 'j' and 'k'. The index ranges from 0.0 for entirely dissimilar diets to 1.0 for identical diets. Niche breadth of each age group 'j' was expressed by:

$$B_{ij} = 1 / \Sigma p^2_{ij}$$

Input data to these calculations were percentage by weight figures of prey categories which contributed 2.5 % or more to the contents of a given age group. Unidentified items, e.g. 'Indeterminatus', 'Crustacea indet.' and 'Amphipoda indet.', were redistributed proportionally among the identified lower taxa.

To make rough estimates of the consumption of the most important prey groups by blue whiting, we had to modify models developed by dos Santos and Jobling (1995) and Bogstad and Mehl (1996) for cod in the Barents Sea. The consumption of prey species 'i' in a given time interval l = one month (30 days) ($C_{i,l}$) is given by:

$$C_{i,l} = \Sigma R_{i,l,n} * N_{l,n} * \text{const}$$

where $R_{i,l,n}$ is the ration (g/hour) of prey species 'i' in month l for blue whiting age group 'n', $N_{l,n}$ is the number of individuals (millions) of age group n in month l. Const is a scaling factor in order to get the consumption in tonnes per month.

Only stomach content data from the july/august cruises 1995 and 1996 were used in the calculations.

The consumption is calculated for age groups 1-6+ separately, and the following prey categories have been used: Copepods, Amphipods (*Themisto* spp.), *Meganyctiphanes norvegica*, *Thysanoessa* spp., fish and other food. The model used to estimate the food consumption is based upon a function describing the gastric evacuation of different prey and if one assumes that over a period of time the fish reach a steady state, i.e. the amount ingested equals the amount evacuated, the consumption (ration in g) of prey 'i' per hour, R_i, is given by:

$$R_i = (\ln 2\, e^{\gamma T} W^{\delta} S_i) / (\alpha_i S_0^{\beta})$$

where T is ambient temperature (set to 5.5°C), W is body weight (g), S_i is content of prey i (g), S_0 is initial meal size, α_i is a prey-specific half-life constant, which has the following values for the prey species considered in this paper: Krill and copepods 41, Amphipods 72, fish 70 and other food 58. γ=0.13, δ=0.26 and β=0.13. Initial meal size S_0 is normally not known in field work and as a further simplification, may be approximated by kS, where k is a constant factor. Following Bogstad and Mehl (1996) k has been set to 1.78.

For assessment of the blue whiting abundance and biomass the same methods were as used as for previous blue whiting surveys, e.g. in Monstad (1986) with the target strength as:

$$TS = 21.8 \log L - 72.8 \text{ dB}$$

where L is fish length. This give the density coefficient of

$$C_F = 1.488 \times 10^6 \times L^{-2.18}.$$

RESULTS AND DISCUSSION

Hydrography

The temperature in the sea surface as well as at greater depths, was found to be approximately 0.5° C higher during the summer survey in 1996 than in 1995, which could indicate a stronger influx of Atlantic water to the Norwegian Sea. The temperature distributions at 200m depth for summer 1995 and 1996 are shown in Figures 1 and 2 respectively.

Distribution and composition

1995:

During the survey in spring 1995, R.V. "G.O.Sars " from 26 May-22 June, covered the area off the coast of Norway from 62° N to 73° N westward to the Jan Mayen area and eastwards to Finnmark at 20° E.

The distribution of blue whiting stretched from the Faroes area to approximately 70° 30' N between Norway and 5° W. In the central Norwegian Sea south of 69°N it was mainly at 100-300m depth. Off western Norway south of 66°N and east of 1°E rather dense concentrations were recorded (Figure 3). The trawl samples of blue whiting were dominated by 3-6 year old fish of 26 - 33 cm in length (Misund, 1995).

During the summer blue whiting was recorded by several of the participating research vessels. From 7 July - 2 August the R.V. "Johan Hjort" surveyed the eastern part of the Norwegian Sea from 62° to 69° N westwards to 5° W (Monstad et al., 1996). and blue whiting were distributed rather evenly over the whole area surveyed. The area overlapped the area surveyed by R.V. "G.O.Sars" from 29 July - 15 august, i.e. westwards to Jan Mayen and northwards to 74° N. A combination of the two vessels' recordings showed scattered distribution westwards to the Jan Mayen area and northwards to74° N (Figure 4). The best recordings made by R.V. "Johan Hjort", were along and off the Norwegian shelf edge between 64° and 68° N, mostly at depths from 200-350m., It was also located within the whole water column from 25-500m, especially in the north-westernmost area.

As the distribution of blue whiting continued beyond the area surveyed, the total stock in the Norwegian Sea was not competely covered. The biomass estimate of the concentrations observed by R.V. "Johan Hjort"was 1.8 mill. tonnes, representing an abundance of 15.6 x 10^9 individuals (Table 1). The biomass by rectangle is shown in Annex I A.

Including the blue whiting recordings of R.V. "G.O.Sars" a biomass of 2 mill. tonnes blue whiting was estimated. Although this is a reasonable result it has to be considered an underestimate. The spawning stock to the west of the British Isles, however, was estimated to 6.1 mill. tonnes in March/April 1995 (Monstad et al., 1995), which demonstrates that only a part of the total stock was measured during the feeding season in the Norwegian Sea.

In the Norwegian Sea the blue whiting stock is in constant migration during the feeding season. From May to September the distribution expanded northwards about 200 nautical miles, from approximately 70° 30' to 74°00'N. It also expanded westwards, but not so significantly. The densest concentations, however, remained in the area off the Norwegian coast.

The 1 year old blue whiting dominated in the stock, and in July made up 45% of the total numbers recorded by R.V. "Johan Hjort". The length ranged from 20-39cm with the peak of the 1 year olds at 23cm (Figure 5). The smallest and youngest fish were mainly distributed in the coastal area and in the south, where the 1994 yearclass contributed with more than 50%. The oldest ones were, however, more frequent in north, where the 5 year olds dominated in the area (Annex II A).

1996:

During two surveys by R.V. "G.O.Sars" in March-April in the central Norwegian Sea, blue whiting, mainly the 1995 yearclass, was recorded from the Norwegian shelf and westwards to the polar front area at 0° C (Figure 7). In March the highest concentrations were observed off the Norwegian coast, mainly consisting of 1 year old blue whiting. The peak of the length distribution was 15cm (Melle, 1996). In early April blue whiting with length distribution from 16 to 22cm were recorded further north and northwest up to 67°30' N 01°30'W. In the

southeastern part of the area surveyed the concentrations were encountered at 300-400m depth (Misund, 1996a).

Also in April-May the R.V. "G.O.Sars" recorded blue whiting along the continental slope off Norway, between 62°N and 71° N with highest concentrations in the south (Figure 8). The catches consisted mostly of 1 year old fish with length from 15 - 35cm (Misund, 1996b).

From 19 July-15 August R.V. "G.O.Sars" carried out a survey covering an area similar to the corresponding survey in 1995, i.e. between 62° and 72° N and from the coast of Norway westwards to 3° W (Monstad et al., 1997). Blue whiting were recorded throughout the entire area surveyed (Figure 9), and as last year the highest concentrations were recorded in the continental shelf area. The limit of the distribution was only observed in coastal areas, indicating that only a part of the total stock was surveyed.

The biomass, shown by rectangle on Annex I B, was estimated to 1.7 mill. tonnes (Table 2), i.e. at the same level as in 1995. Due to the high number of 1 year olds, the abundance, however, was much higher in 1996 than in 1995, i.e 27.9 x 10^9 individuals and 15.6 x 10^9 respectively. The 1995 yearclass, which also proved its strength during the spring survey west of the British Isles (Monstad et al., 1996), contributed with 84% in numbers (Figure 6) and thus confirmed its strength. The length distributions by subareas are shown on Annex II B.

The 1995 yearclass is the strongest observed since 1989, and as 0-group it is estimated to be at the same level as the three strongest yearclasses of blue whiting ever registered, i.e.of 1989, 1982 and 1983 (Anon., 1997).

Diet and consumption

Information on diet was obtained from stomachs collected at 31, 20 and 37 stations during the cruises in July 1995, March/April 1996 and July/August 1996 respectively. The composition of the stomach content for fish caught during these 3 cruises is given for various age-groups in tables 3-5. About 12 % of the stomachs were empty and this proportion decreased with age. These tendencies were found in all the 3 different situations studied, and the proportion of empty stomachs is lower than in other studies on the diet of blue whiting in the Norwegian Sea (Plekhanova, 1989) and in the Norwegian Deep (Bergstad, 1991 a).

Krill was the dominant prey of all age-groups during summer feeding both in 1995 and 1996 (Table 3 and 4). The most important species was *Meganyctiphanes norvegica*, but also the smaller krill species, *Thysanoessa inermis* and *T. longicaudata*, seemed to be of some importance. The second most important prey group during summer feeding was the hyperid amphipods of the genus *Themisto*. In 1995 the oldest fish had been feeding on *T. libellula*, this species making up 20-32 % of the dry weight of the stomach contents in the 4+ age-groups, while being of minor importance in 1996, when *T. abyssorum* dominated among the hyperids. Copepods were of minor importance in all age-groups both 1995 and 1996, except for the 1-group in 1996, where *Calanus finmarchicus* and *Euchaeta* comprised 9 and 8 % of the diet respectively. The other fish had very little *Calanus* in their diet, but the larger *Euchaeta* contributed with around 4 % of the dry weight. As shown in Figure 10, the crustaceans were the most important prey-group, but also other prey groups were of some importance. These were mostly larger prey, such as fish and in some cases the squid *Gonatus fabricii* as for the 5-

group fish in 1996. Tendencies of larger prey with age were only seen in 1996. Among the fish found in the stomachs, myctophids (*Benthosema glaciale*) was found most frequently. A single occurrence of a big (20 cm) barracudina (*Notolepis rissoi*) in a 4 year old fish in 1995 contributed in weight with 14 % of the total stomach content of this age-group. In 1996 we found a great deal of 0-group gadids in the stomachs, where haddock (*Melanogrammus aeglefini*) was the most important species. A lot of haddock was also caught by the pelagic trawl in a large part of the area covered during the cruise (Monstad et al., 1997). Large prey items like fish and squid did not occur frequently, but because of their size, single meals of this kind of prey very often comprised a relatively large proportion of the diet. This kind of large but infrequent meals probably play an important role in the diet of blue whiting as well as the generally smaller crustaceans.

Table 5 gives the composition of the diet in March/April 1996. At this time of year the adult part of the stock spawns west of the British Isles, and most of the fish examined were 1 year old fish (of the strong 1995 yearclass), and less than 10 % were older. Because of the scarce material for the older age-groups, they were all pooled as 2+ -group. Most of them were 2 and 3 years old. The dominant prey of the 1-group was *C. finmarchicus* contributing with 78 % of the stomach content. This was very different from the older fish, which had a diet more similar to the one of during summer feeding, with dominance of krill (mostly *T. inermis*) and pearlsides (*Maurolicus muelleri*) contributing with 86 and 11 % respectively.

Bailey (1982) reviewed earlier studies on the feeding of blue whiting, and our findings generally correspond well with these and other studies from the Norwegian Sea (Timokhina, 1974; Plekhanova and Soboleva, 1982; Zilanov, 1984 and Plekhanova, 1989) and in the Norwegian Deep (Bergstad, 1991 a). Studies in Norwegian fjords have described a greater proportion of mesopelagic fish than in this study (Rasmussen and Giske, 1994; Bjelland, 1995), but the individuals caught in these fjords generally tends to be larger than the ones in the Norwegian Sea.

Figure 11 gives indices of diet similarity and estimates of niche breadth for various age-groups in summer 1995 and 1996. The diet similarity was strong between the age-groups both in 1995 and 1996. The 5-group was the only group with a more moderate overlap with the other groups, but this might just be due to the relatively low sample size (30 stomachs with content) giving the one occurrence of a relatively large *Gonatus fabricii* a strong influence. No tendency of increasing niche breadth with age could be found as has been shown by Bergstad (1991 b) for gadoids in the Norwegian Deep, and based on our findings blue whiting generally has broader niches in the Norwegian Sea than Bergstad (1991 b) found in the Norwegian Deep.

Estimated consumption of different prey groups by blue whiting during one month of summer feeding is given in Figure 12. Following our calculations about 600 000 and 800 000 tonnes crustaceans measured by dry weight was consumed in July/August 1995 and 1996 respectively. The consumption of krill alone was almost 500 000 tonnes in each of the years, while about 100 000 tonnes of amphipods were consumed. Only the consumption of copepods seems to vary between the two years studied, with twice as much in 1996 as in 1995 being consumed. Table 6 shows that this is mainly because of the high consumption by the one year old fish. Also in 1995 the 1-group fish have the highest consumption of most of the prey-groups.

One should keep in mind that the models used for calculation of consumption were developed for another species (cod), and the estimates should be treated with caution. Anyhow we believe that these calculations clearly show that blue whiting consume a significant portion of at least the krill and to some extent amphipod and copepod production. Because of incomplete coverage of the blue whiting distribution in the Norwegian Sea during the surveys, we might even regard these as minimum estimates. Few good estimates on the production and total biomass of krill and amphipods are available, but Ellertsen (1996) estimated the total biomass of krill to be about 50 mill tonnes wet weight. Taking into account that our figures are given in dry weight, it can be assumed that blue whiting consumes approximately 5 % of the krill biomass during one month of summer feeding.

Further studies have to be done to clarify the role of blue whiting in the pelagic food-web of the Norwegian Sea. Both interactions between blue whiting and it's prey and their potential competitors. The large stock of Norwegian spring spawning herring also utilises this area as feeding grounds as does mackerel and horse mackerel to some extent, and the dynamics of the food-web should be studied to assess to what extent these stocks act controlling on each other.

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Table 1. Abundance estimate of blue whiting in the Norwegian Sea, R.V. "Johan Hjort" July/August 1995.

Length	Age in years											Biomass
cm	1	2	3	4	5	6	7	8	9	10	tot. N	t x 10 E-3
16												
17	15										15	0.4
18											0	0.0
19											0	0.0
20	368										368	17.6
21	883	19									902	47.2
22	1888	58									1946	116.7
23	2156	150			18						2324	162.0
24	947	86		20							1053	84.1
25	471	163	136	10							780	69.1
26	112	767	192								1071	113.5
27	62	747	506	30	5						1350	159.2
28	31	507	338	21	13						910	119.9
29	41	263	252	191	145	46	1				939	135.5
30		23	297	271	283	81					955	153.4
31		16	148	225	443	126	33	8			999	169.5
32		12	85	155	326	144	33	9			764	146.2
33			26	173	207	115	56				577	120.8
34			19	73	77	90	16	22		1	298	67.9
35				33	70	52	15	11			181	43.4
36					24	54	14	3			95	24.5
37				7	7	41	5				60	19.8
38						19				9	28	7.0
39					4	7		8	1		20	6.5
40										5	5	1.8
N x10 E-6	6974	2811	1999	1209	1622	775	173	61	1	15	15640	
mean l (cm)	23.2	27.1	28.8	31.4	31.9	33.3	33.5	34.8	39.5	38.9	26.8	
Biomass	472.5	318.2	272.9	212.4	298.1	158.4	36.6	13.4	0.3	4.9	1787.9	
mean w (g)	67.8	113.2	136.5	175.7	183.8	204.4	211.5	220.2	345.0	327.9	114.3	

Table 2. Abundance estimate of blue whiting in the Norwegian Sea, R.V. "G.O.Sars" July/August 1995.

Length	Age in years											Biomass
cm	1	2	3	4	5	6	7	8	9	10	tot. N	t x 10 E-3
16	30										30	0.6
17	548										548	14.3
18	2566										2566	80.3
19	6658										6658	245.3
20	6985	98									7083	319.5
21	4341	19									4360	244.6
22	1904	141									2045	130.6
23	352	217									569	39.8
24	80	82	9								171	14.1
25		98	5								103	9.6
26		135	157	29							321	35.7
27		138	193	42	40	2					415	50.5
28		106	236	138	17						497	66.5
29		21	232	177	48	17	8				503	71.4
30		2	24	121	118	93	64				422	66.8
31			43	97	94	118	154	13			519	88.1
32				41	57	118	186	9			411	74.9
33				4	39	90	128	10	8	12	291	56.9
34					16	40	133	4	15	20	228	47.7
35					7	26	44	23	1	2	103	22.7
36						1	38	10	12		61	14.1
37							5		5	2	7	1.6
38										14	14	3.9
39												
40												
N x10 E-6	23464	1057	899	649	436	505	755	69	41	50	27925	
mean l (cm)	20.3	24.9	28.3	29.7	31.0	32.3	33.0	34.2	35.3	35.5	21.8	
Biomass	1051.3	94.7	119.4	95.9	71.1	89.7	142.4	14.8	8.5	11.4	1699.2	
mean w (g)	44.8	89.6	132.8	147.8	163.1	177.6	188.6	213.8	208.0	228.0	60.8	

Table 3. July 1995. Stomach contents of blue whiting in different age groups in terms of percentage by weight (%W) of different prey taxa. Total weights of the stomach contents, numbers of stomachs and empty stomacs are also given.

July 1995

Prey taxon	% W in age group						
	1	2	3	4	5	6+	total
Calanus finmarchicus	+	+	-	+	-	-	+
Euchaeta	2.3	5.6	5.3	3.4	3.7	5.0	**4.1**
Themisto abyssorum	8.4	6.9	7.7	6.7	7.8	16.0	**8.9**
Themisto compressa	2.3	0.6	0.6	1.0	3.1	2.3	**1.8**
Themisto libellula	-	12.0	7.7	32.1	27.0	19.9	**22.5**
Meganyctiphanes norvegica	46.6	34.4	58.4	27.3	48.4	40.4	**39.9**
Thysanoessa inermis	3.1	9.1	9.8	9.6	4.8	2.6	**6.5**
Thysanoessa longicaudata	18.7	0.9	1.0	0.5	0.2	0.3	**1.6**
Sergestes arcticus	-	-	6.9	-	1.4	-	**0.9**
Gonatus fabricii	-	2.4	-	+	+	4.4	**1.0**
Benthosema glaciale	2.9	23.3	-	3.4	1.3	5.0	**4.7**
Notolepis rissoi	-	-	-	13.7	-	-	**4.1**
0-group gadids	13.1	-	-	0.2	-	-	**0.9**
Other	2.7	4.9	2.6	2.1	2.2	4.2	**2.9**
Weight of stomach content (g DW)	7.61	11.39	9.28	35.00	32.12	21.71	**117.11**
Number of stomachs examined	89	90	80	65	92	55	**471**
Number of empty stomachs	22	19	10	2	5	-	**58**

Table 4. July/August 1996. Stomach contents of blue whiting in different age groups in terms of percentage by weight (%W) of different prey taxa. Total weights of the stomach contents, numbers of stomachs and empty stomacs are also given.

July/August 1996

Prey taxon	% W in age group						
	1	2	3	4	5	6+	total
Calanus finmarchicus	9.0	+	0.1	+	+	+	**1.3**
Euchaeta	8.0	4.6	5.8	4.4	0.6	6.0	**5.5**
Themisto abyssorum	14.7	23.5	11.2	16.0	11.4	17.7	**15.7**
Themisto compressa	1.1	6.7	7.0	7.7	1.2	7.1	**5.8**
Themisto libellula	-	-	0.2	0.6	0.3	1.6	**0.7**
Meganyctiphanes norvegica	37.2	27.0	31.9	34.6	21.8	35.0	**33.0**
Thysanoessa inermis	22.1	19.0	19.2	4.7	30.4	1.5	**12.2**
Thysanoessa longicaudata	2.6	3.5	6.4	1.3	1.5	1.6	**2.8**
Sergestes arcticus	-	-	-	-	-	-	**0.0**
Gonatus fabricii	-	-	5.1	+	19.3	+	**2.5**
Benthosema glaciale	1.4	-	10.4	-	11.6	12.3	**7.5**
Notolepis rissoi	-	-	-	-	-	-	**0.0**
0-group gadids	-	13.8	-	27.9	-	14.7	**10.3**
Other	2.7	4.9	2.6	2.1	2.2	4.2	**3.3**
Weight of stomach content (g DW)	10.09	5.61	14.04	10.02	5.41	24.56	**69.73**
Number of stomachs examined	143	34	61	45	32	116	**431**
Number of empty stomachs	32	-	11	-	2	7	**52**

Table 5. March/April 1996. Stomach contents of blue whiting in different age groups in terms of percentage by weight (%W) of different prey taxa. Numbers of stomachs and empty stomacs are also given.

Prey taxon	% W in age group		
	1	2+	total
Calanus finmarchicus	77.6	+	**62.5**
Themisto abyssorum	1.0	1.4	**1.1**
Meganyctiphanes norvegica	6.3	17.1	**7.2**
Thysanoessa inermis	10.9	69.0	**24.1**
Thysanoessa longicaudata	1.3	-	**0.4**
Chaetognatha	1.3	1.2	**1.2**
Maurolicus muelleri	-	11.1	**2.1**
Other	1.5	0.3	**1.3**
Number of stomachs examined	186	17	**203**
Number of empty stomachs	24	1	**25**

Table 6. Consumption of various prey-groups by blue whiting during one month of summer feeding in the Norwegian Sea 1995 and 1996, given in 1000 tonnes dry weight.

July 1995

Prey taxon	1000 tonnes DW/month by age group					
	1	2	3	4	5	6+
Copepods	19	16	12	13	14	11
Amphipods	23	17	11	23	25	17
Meganyctiphanes norvegica	82	39	36	34	49	31
Thysanoessa	57	22	16	21	17	9
Fish	29	20	4	16	8	7
Other	15	10	10	7	7	10

July/August 1996

Prey taxon	1000 tonnes DW/month by age group					
	1	2	3	4	5	6+
Copepods	139	6	7	5	1	13
Amphipods	76	9	7	6	3	14
Meganyctiphanes norvegica	202	14	17	13	6	29
Thysanoessa	166	13	15	6	7	9
Fish	25	6	6	7	3	15
Other	49	3	6	3	4	7

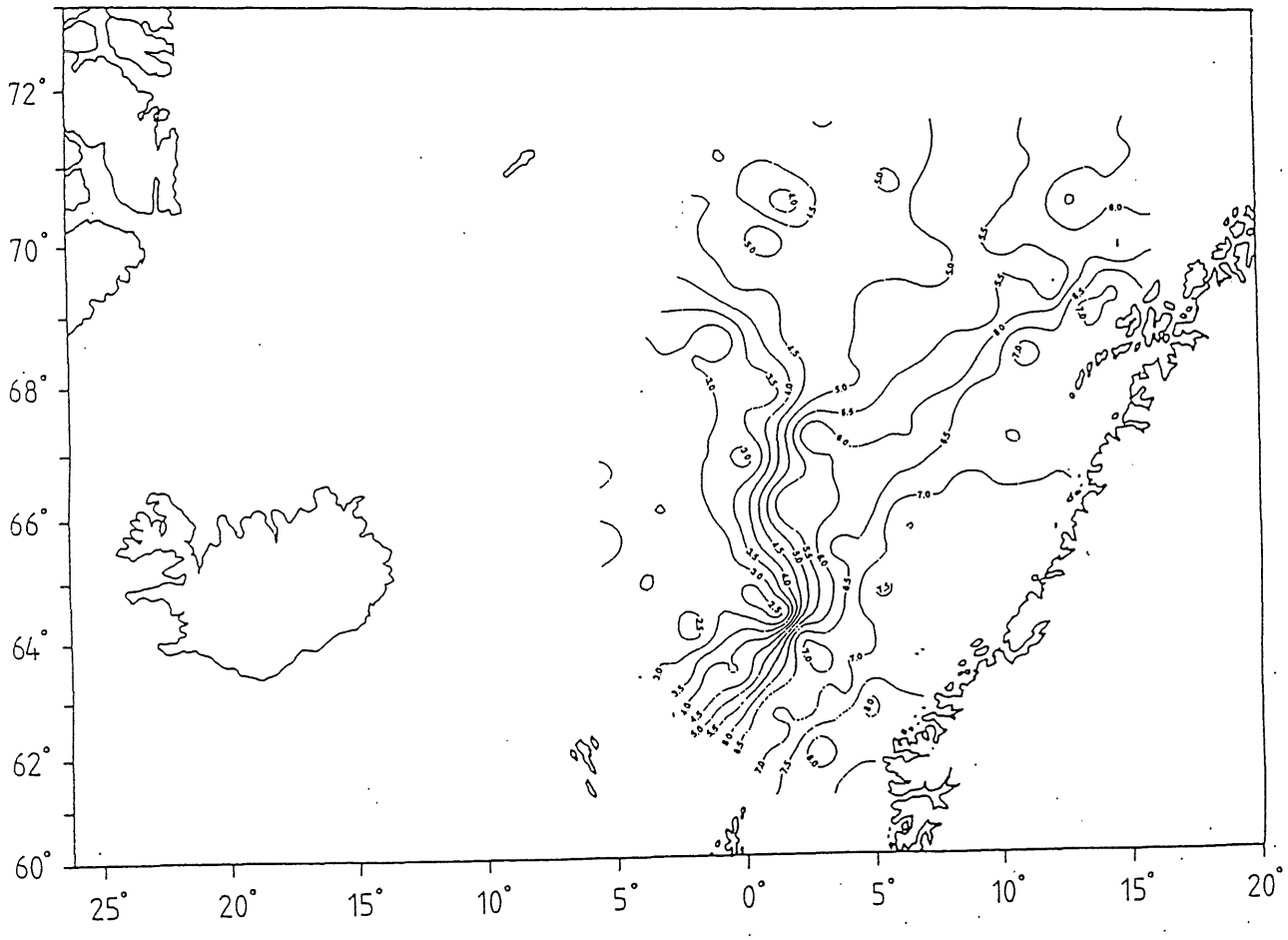


Figure 1. Temperature, t° C, in 200m depth, July/August 1995.

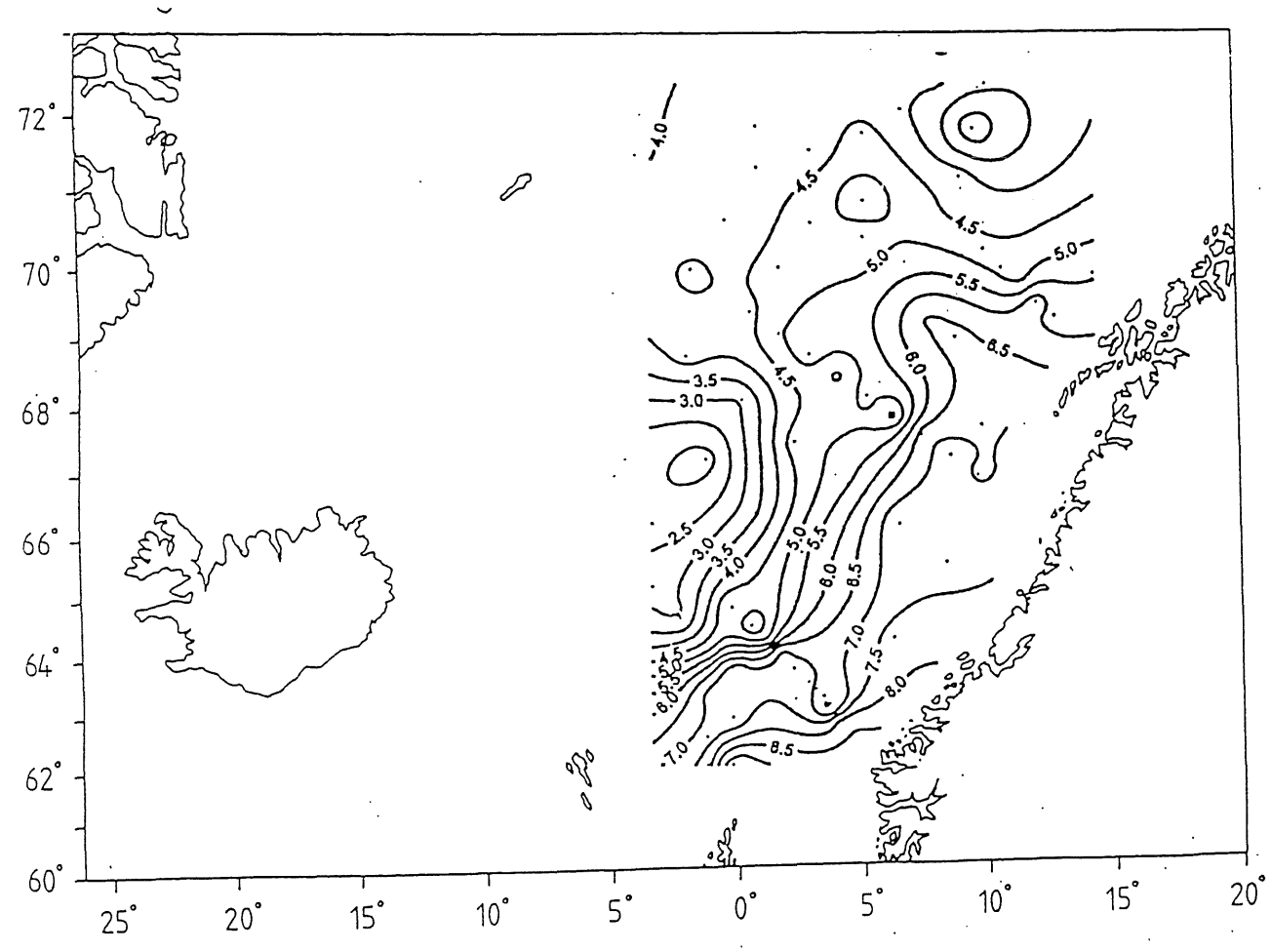


Figure 2. Temperature, t° C, in 200m depth, July/August 1996.

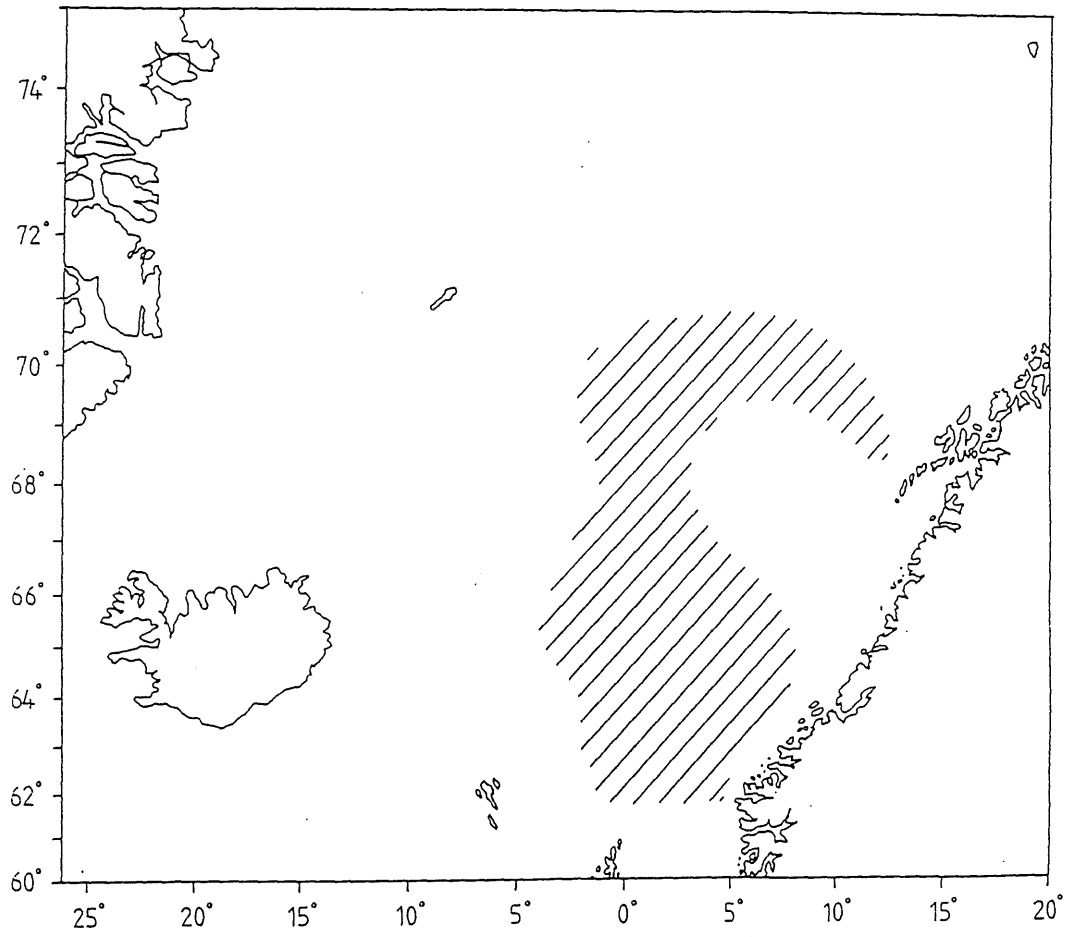


Figure 3. Blue whiting, May/June 1995.

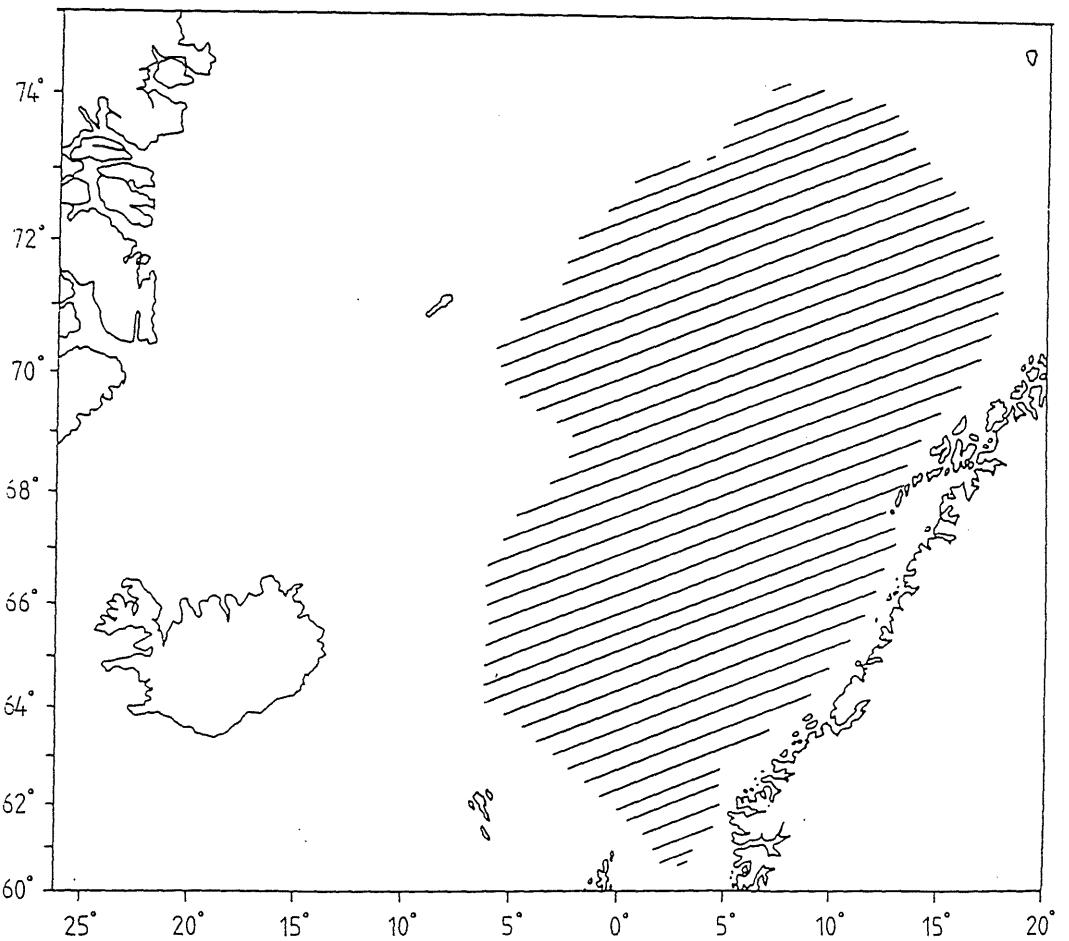


Figure 4. Blue whiting, July/August 1995.

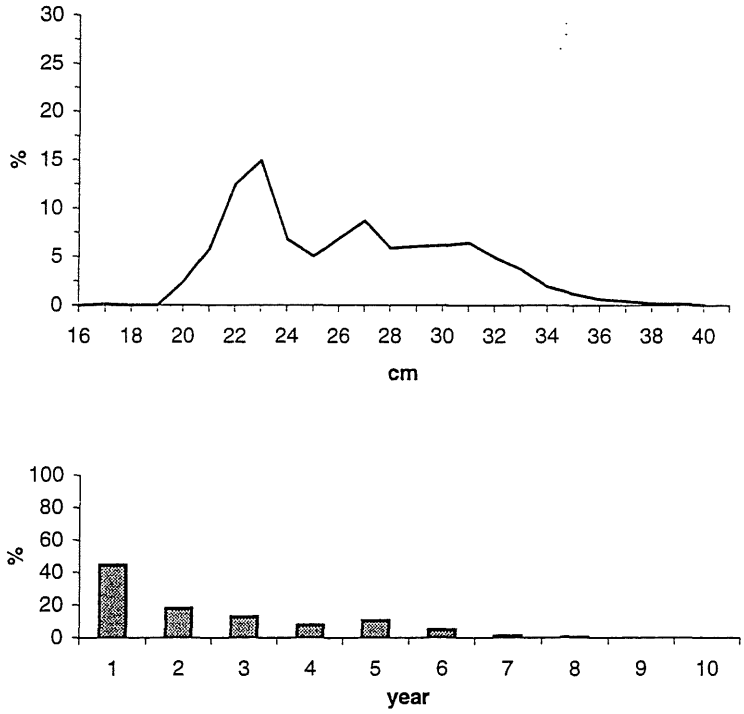


Figure 5. Length and age distribution of blue whiting in the Norwegian Sea, July/August 1995. Weigthed by abundance. N= 15.6 x 10^9.

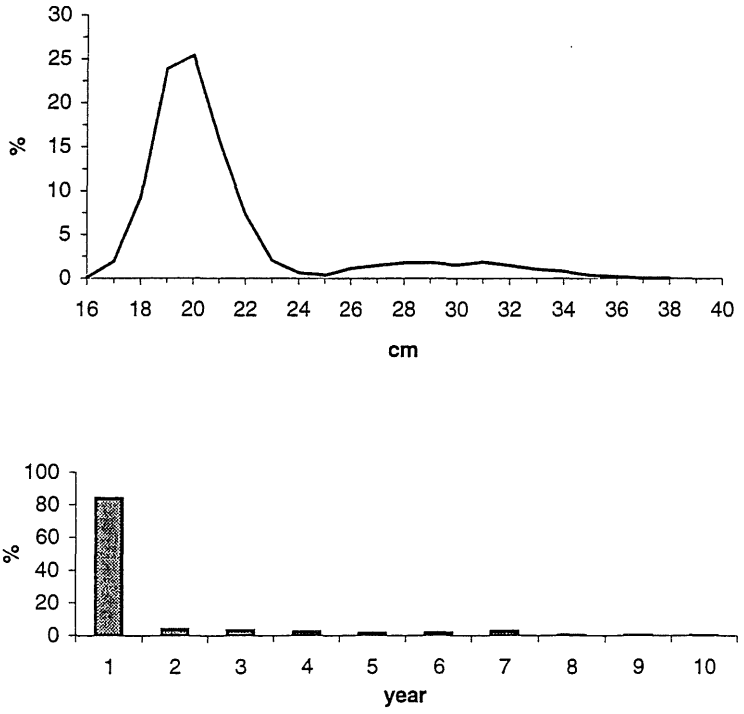


Figure. 6. Length and age distribution of blue whiting in the Norwegian Sea, July/August 1996. Weigthed by abundance. N= 27.9 x 10^9.

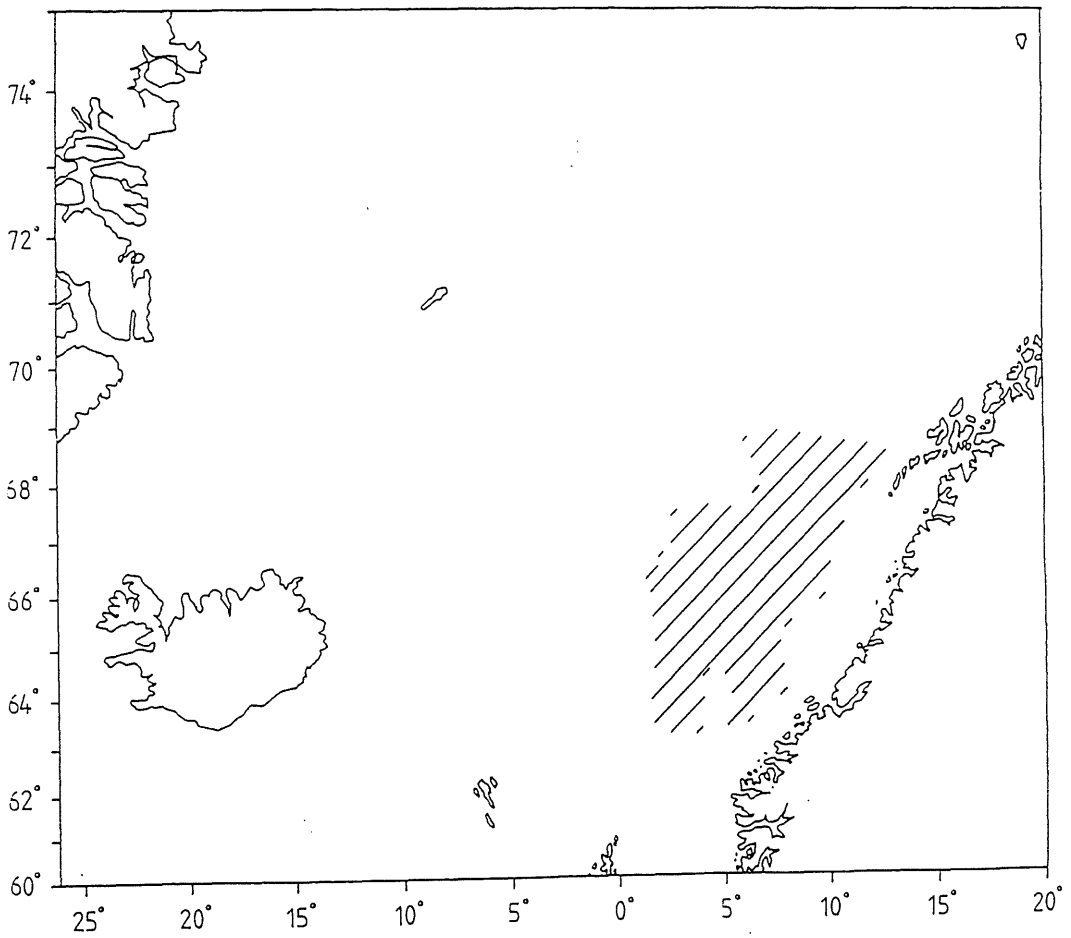


Figure 7. Blue whiting, March/April 1996.

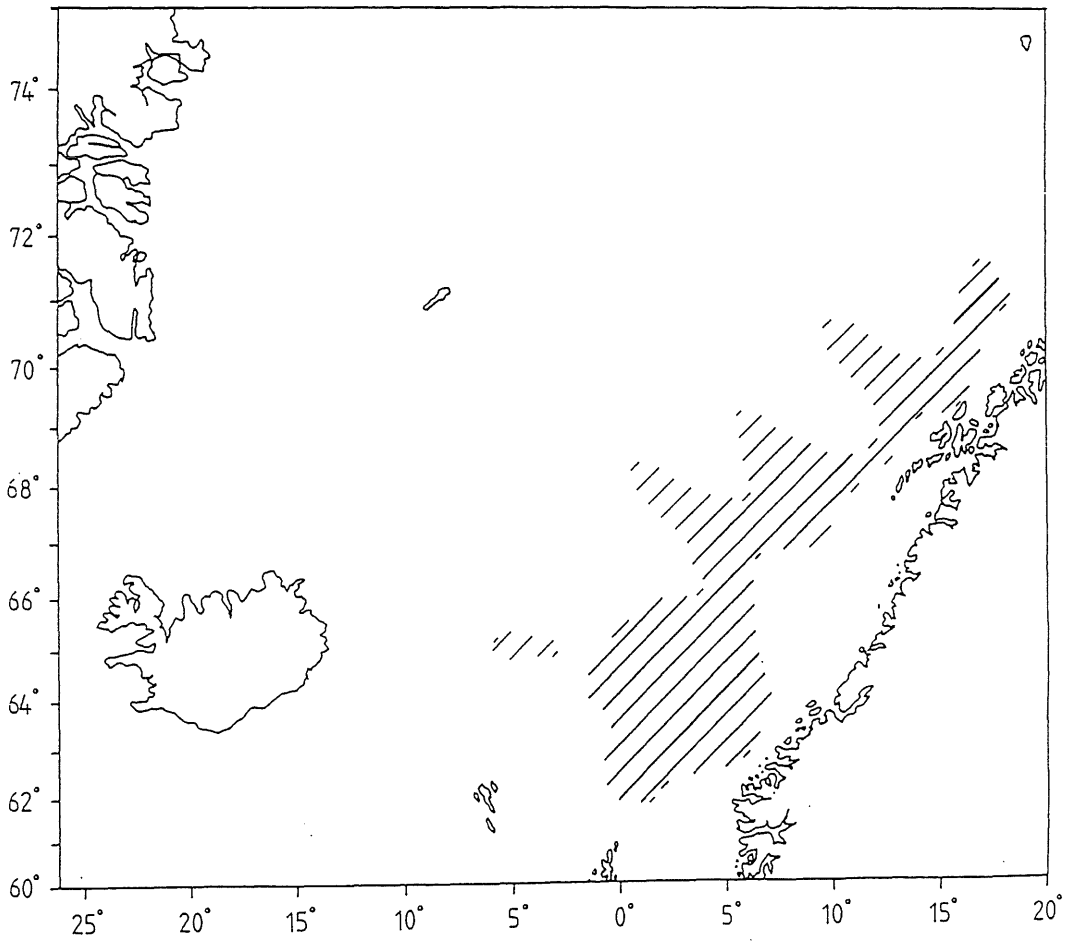


Figure 8. Blue whiting, April/May 1996.

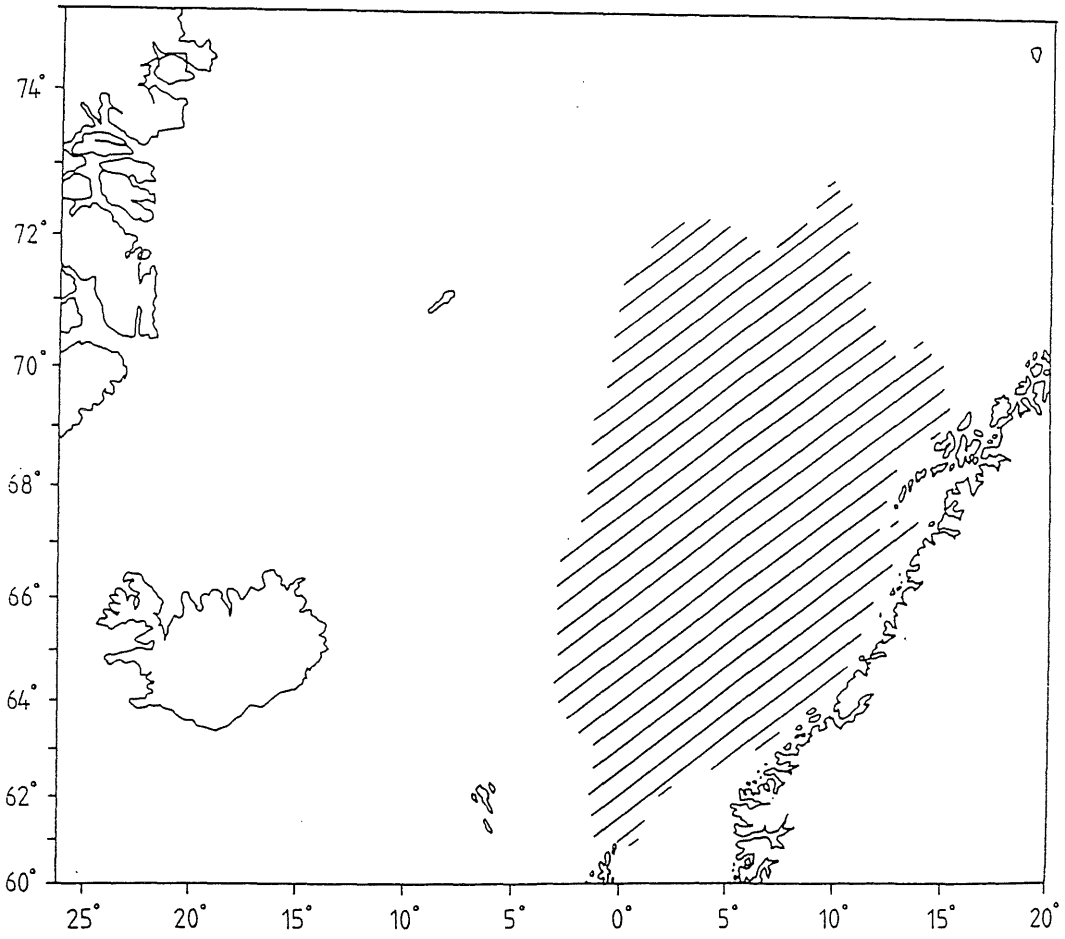


Figure 9. Blue whiting, July/August 1996.

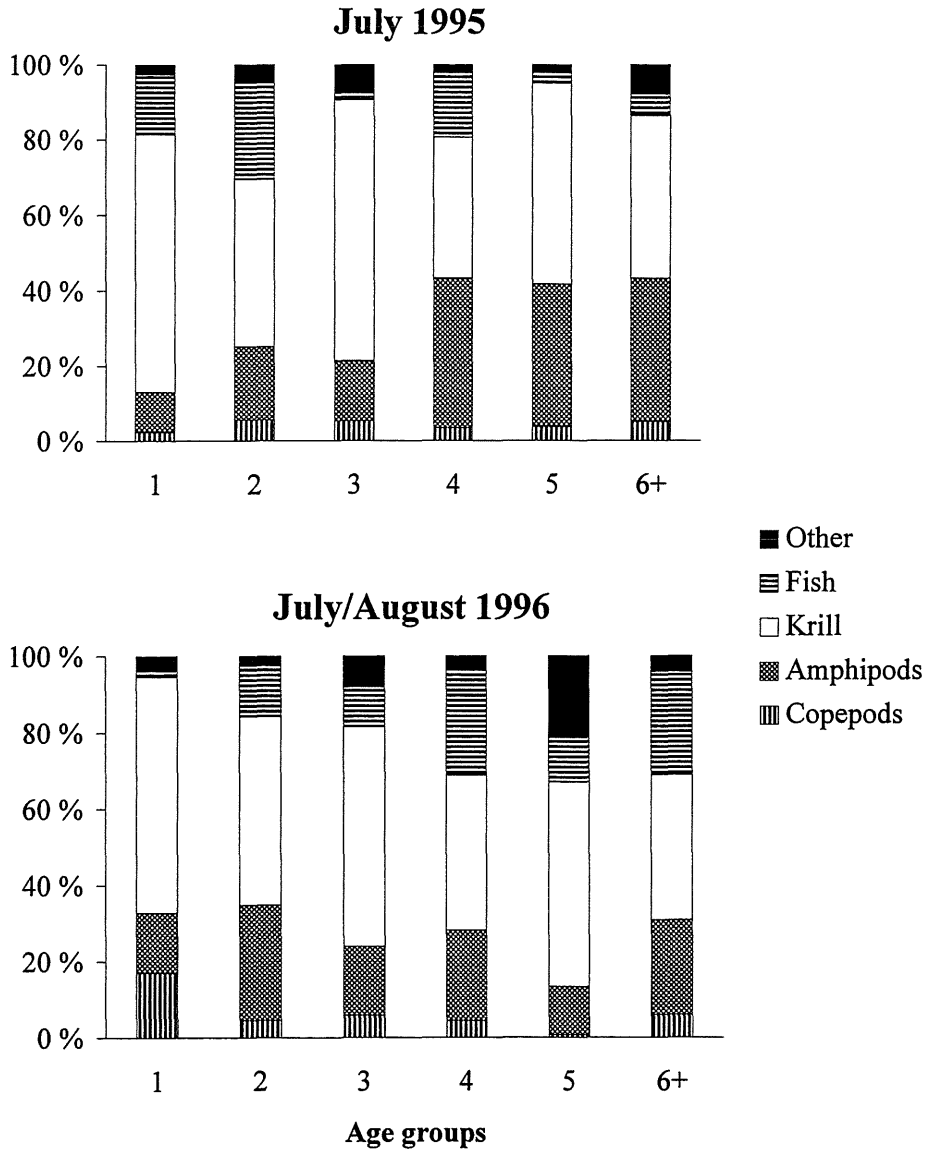


Figure 10. Composition in terms of weight of the stomach contents in July 1995 and July/August 1996.

July 1995

Age-group	1	2	3	4	5	6+
1		.54	.63	.46	.64	.60
2			.68	.67	.67	.71
3				.59	.78	.67
4					.74	.67
5						.79
6+						
Niche breadth	3.6	4.9	2.7	4.7	3.1	4.2

July/August 1996

Age-group	1	2	3	4	5	6+
1		.72	.82	.64	.61	.63
2			.74	.76	.56	.74
3				.63	.72	.71
4					.43	.83
5						.51
6+						
Niche breadth	4.5	5.2	5.7	4.3	4.9	5.0

.30 < I < .60 - moderate overlap

I > .60 - high overlap

Figure 11. Intraspecific similarity of diets and niche breadth for blue whiting. Schoener's similarity indices are given above the diagonal. the same data are given below the diagonal where degree of similarity is rated as moderate and high.

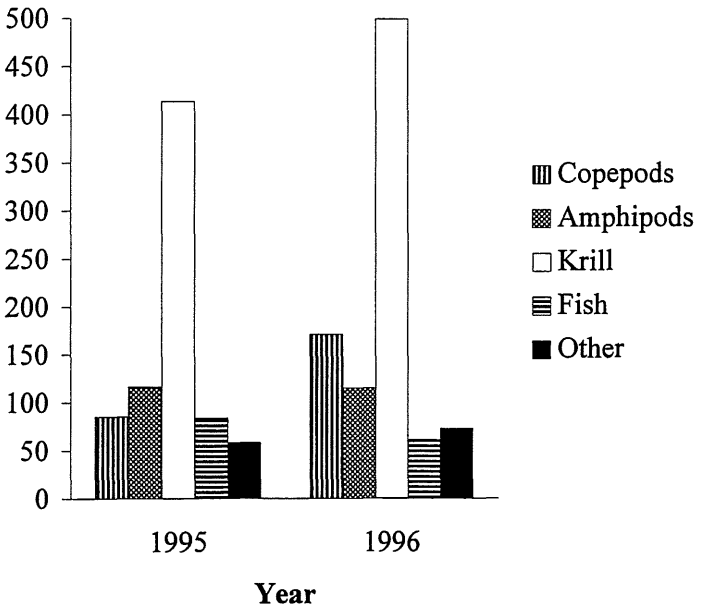
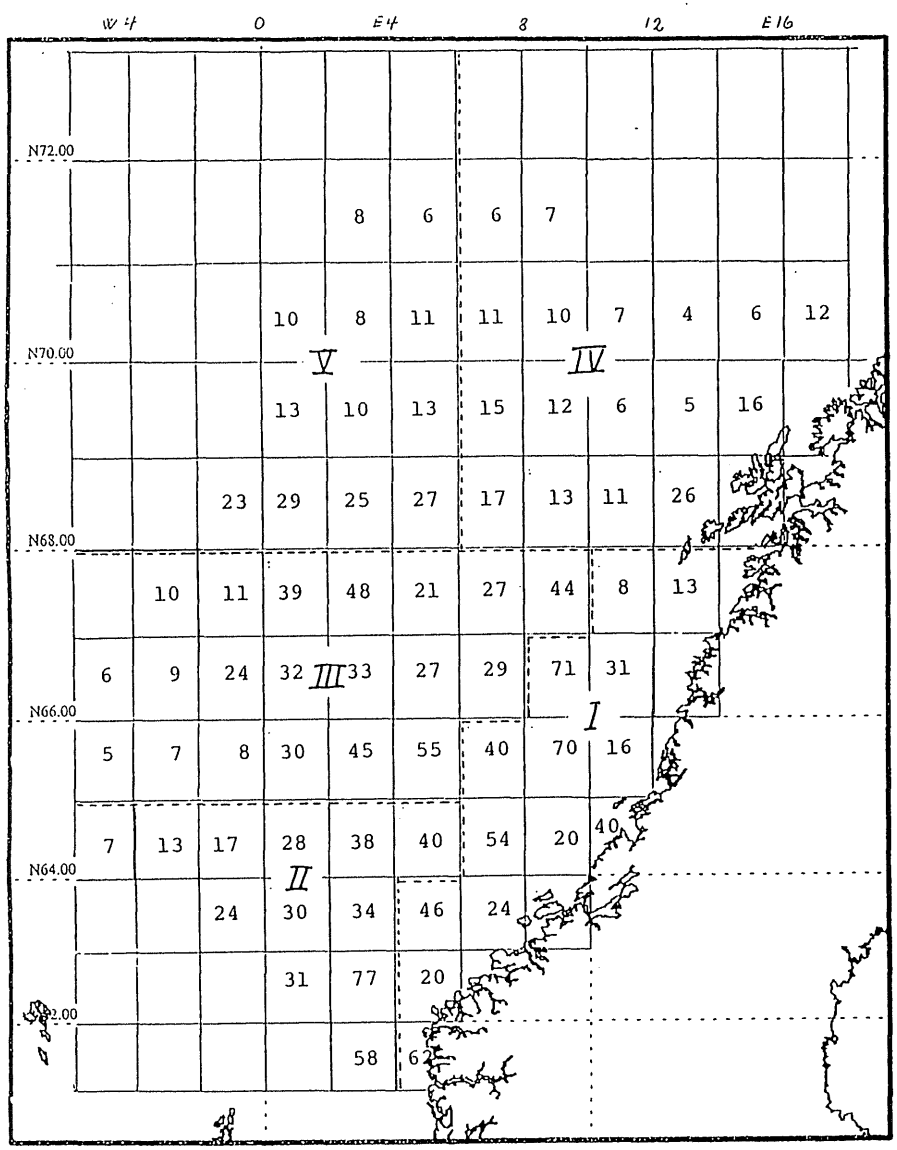
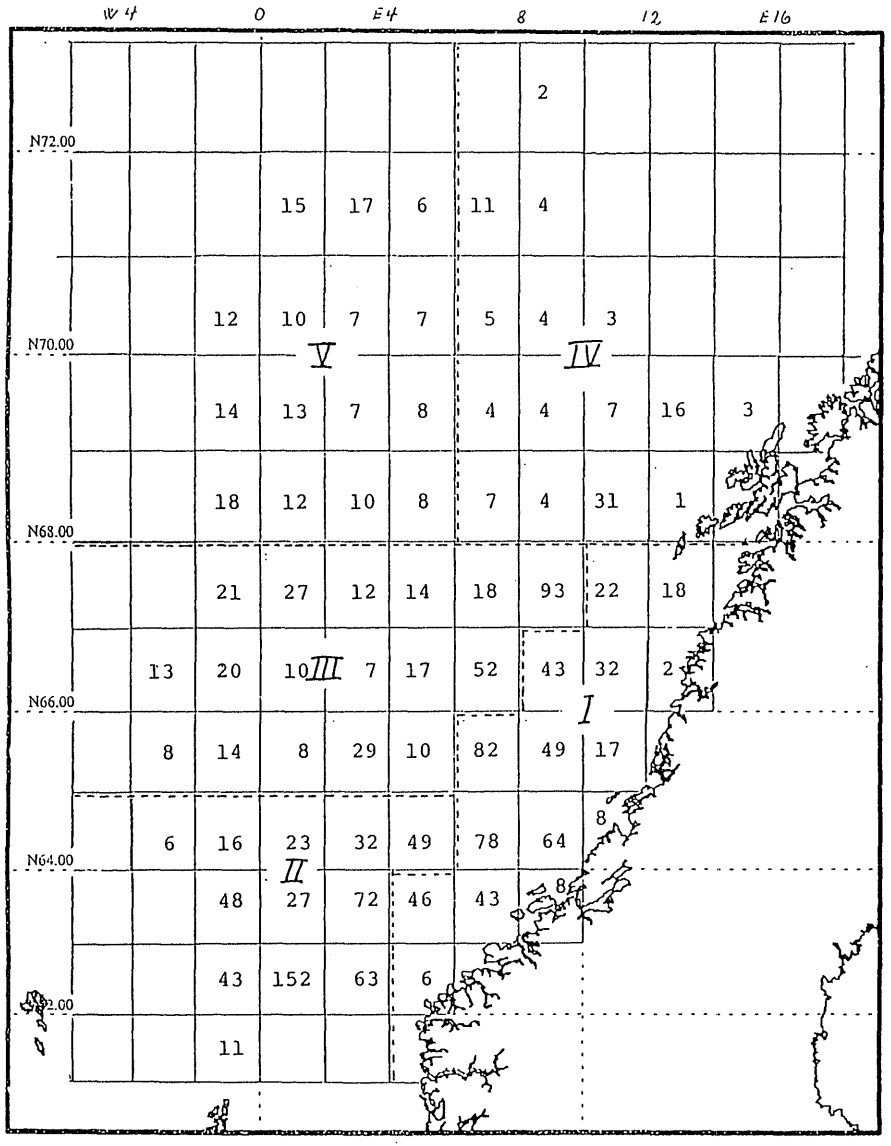


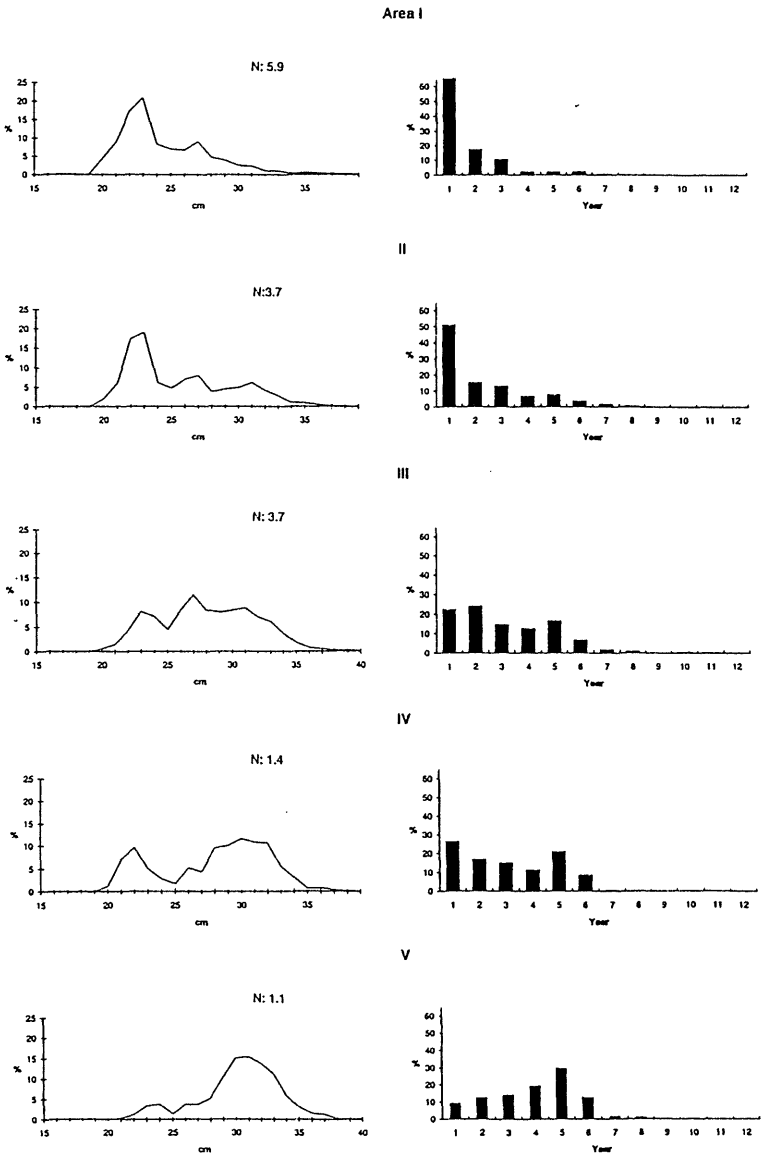
Figure 12. Total consumption by the blue whiting stock during one month of summer feeding in 1995 and 1996, given for various prey-groups in 1000 tonnes dry weight.



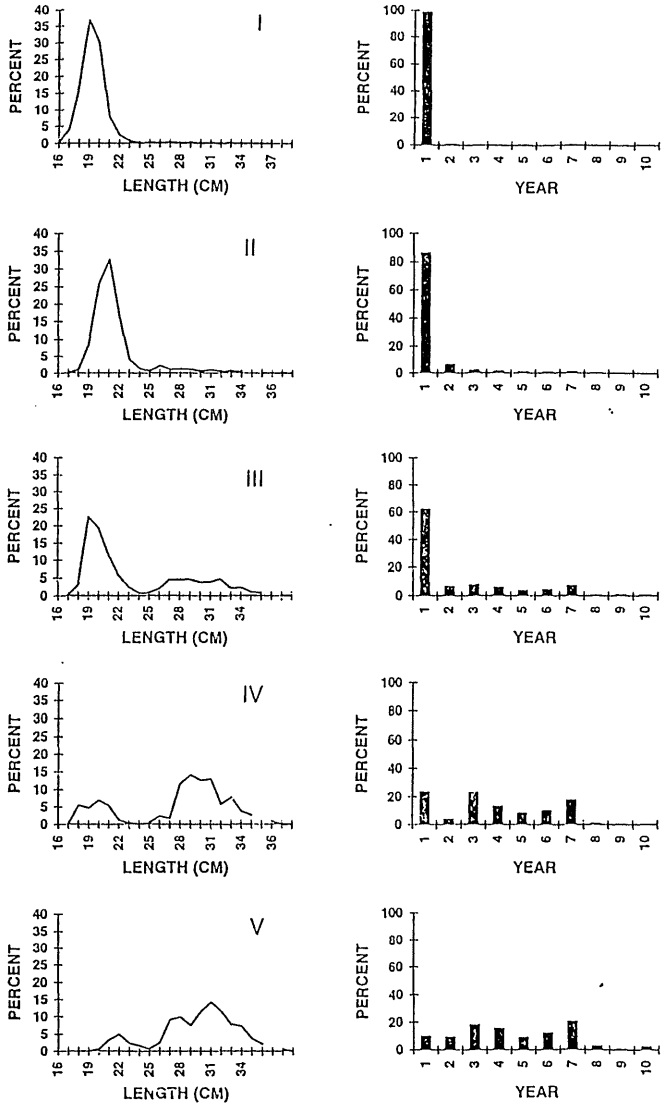
A. Blue whiting biomass in 1000 tonnes.
R.V. "Johan Hjort", July/August 1995.



B. Blue whiting biomass in 1000 tonnes,
R.V. "G.O. Sars, July/August 1996.



A. Length and age distributions (N%) of blue witing by subareas I-V marked on ANNEX I, July/August 1995.



B. Length and age distributions (N%) of blue witing by subareas I-V marked on ANNEX I, July/August 1996.