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Stock size of sprat in the North Sea estimated from an echo integrator survey in January 1981

By

Svein A. Iversen, Asgeir Aglen and Erling Bakken
Institute of Marine Research,
Bergen, Norway

ABSTRACT

The paper presents the results of an echo integrator survey for sprat in the North Sea in January 1981. Integrator readings relating to sprat were determined by continous echo recording combined with frequent trawl sampling, and the biomass was estimated by applying an average acoustic target strength dependent on fish length. About 47 000 tonnes of 1-group sprat (1980 year class) and 49 000 tonnes of older sprat were found within the investigated area. The results are discussed in relation to a similar survey in 1980. Attention is drawn to likely sources of error and to the decisive effect of the target strength value on the biomass estimate.

RESUMÉ

Le rapport présente les résultats d'une cruisiére sur le sprat avec un integrateur d'écho dans La mer du Nord en Janvier 1981.

Des vérifications de l'integrateur en relation de sprats ont été déterminées par des enregistrements continuels d'écho, ce qui ont été combinées avec des pêches au chalut fréquentes et la biomasse fut estimée en employant la force de mesure acoustique moyenne qui est dipendante de la longueur du poisson. Environ 47 000 tonnes du 1-groupe de sprat (la classe de 1980) et 49 000 tonnes des sprats plus vieux ont été trouvé dans le territoire explorée.

Les resultats sont discutés en relation des recherches analogue en 1980. L'attention fut tirée aux sources d'erreur, et á l'effet décisif de la valeur de mesure de force acoustique sur la biomasse estimée.

INTRODUCTION

In January - February 1978 and 1979 a series of echo-integrator surveys for sprat was carried out (Edwards and Bailey 1978; Edwards, Wilson and Bailey 1979; Johnson 1979). The surveys were restricted to the U.K. coastal waters of the North Sea, and the estimated sprat biomass related to part of the stock only. In January 1980 attempts were made to cover the entire area of sprat distribution in the North Sea by a co-ordination of Scottish, English and Norwegian surveys. The results (Johnson 1980; Aglen and Iversen 1980; Edwards and Wilson 1980) were intended to be used for the assessment of the North Sea sprat stock. The assessment working group, however, had reservations in accepting the estimate of total sprat biomass, mainly due to the discrepancies in the value of sprat target strength applied by the three parties (Anon. 1980).

In January 1981 similar co-ordinated surveys were carried out, and the present paper reports on the Norwegian survey in the eastern part of the North Sea.

METHODS

A 38 kHz echo sounder connected to a two channel echo integrator was used for echo integration. Sampling of recordings was mainly done with pelagic trawl. Nansen bottles and CTD sonde were used for hydrographic observations.

Average integrated echo intensities were computed each fifth nautical mile steamed, and given as mm integrator deflection per nautical mile referred to 40 dB integrator gain. According to the composition of the trawl catches and the appearance of the echo recordings the integrator values were allocated to three main categories:

- fish recordings containing sprat
- other fish recordings, mainly bottom fish
- plankton

The "echo fraction of sprat" (Ef_s) was calculated from the species and size composition of the trawl catches as described by Aglen and Iversen (1980).

The biomass (B) of sprat within $\frac{1}{2}^o x \frac{1}{2}^o$ rectangles (450 square nautical mile) was calculated as

$$B = \overline{\overline{Ef}}_s \cdot \bar{M} \cdot C \cdot 450$$

where $\overline{\overline{Ef}}_s$ is the average Ef_s based on trawl catches considered representative, $\bar{M}$ is the average integrator value of the category "fish recordings containing sprat" and C is the factor used for converting echo intensities (mm integrator deflection per nautical mile) to fish densities (kilogram per square nautical mile).

Aglen and Iversen (1980) reported the target strength function $\langle TS \rangle = -10 \log L - 15$ dB/kg for sprat. This function was derived from computations by Foote (1980) which included a normalization of fish tilt angles. To be in line with previous practice the normalization term was excluded in calculating the conversion factor C which was then based on the relationship TS = -10 log L

-25 dB/kg. This calculated C was applied in 1980 (Aglen and Iversen 1980) and the same C, adjusted for small changes in equipment performance, was adopted for the 1981 survey.

The Planning Group on ICES-coordinated herring and sprat acoustic surveys (Anon. 1981a) recommended for sprat an average target strength of -29 dB per kilogram, independent of fish length. The conversion factors corresponding to the two target strength values calculated from performance data for January 1980 and January 1981 are shown below:

Average target strength dB/kg	Conversion factor (C) $[kg/(n.mile)^2$ per mm per n.mile] 1980	1981
-10 log L -25	34 L	39 L
-29	77	88

RESULTS

Survey routes and trawl stations are shown in Figure 1, and the composition of the trawl catches in Table 1. 107 hydrographic stations were taken in the surveyed area.

Sprat biomass estimates based on $\overline{\overline{TS}}$ = -10 log L -25 dB/kg were calculated separately for the 1980 year class and for older sprat. This is shown in Figure 2 and 3 expressed as 1000 tonnes per $\frac{1}{2}^{o} x \frac{1}{2}^{o}$ rectangle. The total biomass within the covered area was estimated to 47 000 tonnes of the 1980 year class and 49 000 tonnes of older sprat. Figure 4 shows the length distributions within divisions of the North Sea. In the eastern part of ICES Division IVb which cover the main part of the survey area, catches were dominated by 1-group sprat with modal length about 6 cm. In the western part of ICES Division IVb and in Division IVc older sprat, 10-13 cm in length, appeared more dominant. In the individual samples the 1-group was easily separated from the older age groups at a length of 6-8 cm.

The average weight was 1.3 grams for the 1980 year class and about 10 grams for the older sprat. This gives an estimate of

36 x 10^9 individuals of the 1980 year class and 5 x 10^9 individuals of the older sprat within the covered area. Table 2 shows the estimates both from the 1980 and 1981 surveys. For comparison the estimates based on a target strength of -29 dB/kg are also shown.

DISCUSSION

The surveys during the winter 1979-80 indicated that the sprat occurred in areas not influenced by Atlantic water masses (Aglen and Iversen 1980), and hence the distribution of the sprat was restricted to areas with "North Sea water" characterized by salinities below 35^{o}/oo. The same appears from the 1981 sprat distribution as indicated by the salinity iso-lines at 20 m depth (Fig. 2). In 1981 no influx of Atlantic water was observed in the southern part of the North Sea.

The sprat occurred scattered and only low densities were observed. The estimated total abundance was much lower than in January 1980. The 1980 year class was estimated to 36 x 10^9 individuals in January 1981 while the 1979 year class was estimated to $660 \cdot 10^9$ individuals in January 1980. The sprat distribution area was not completely covered during the 1981 survey. However, reports from English and Scottish surveys in the uncovered areas (Anon. 1981 b) confirm that the 1980 year class is much weaker than the 1979 year class. This is also supported by the average catch of 1-group sprat obtained by R/V "Johan Hjort" with the same trawl in 1980 and 1981. In 1980 the catch was 15145 fish per nautical mile towed compared to 880 in 1981.

The conditions for echo integration seemed to be as suitable in 1981 as in 1980. Trawl hauls in the surface layer gave very small catches of sprat. Integrator values obtained during daytime were close to the values obtained at night both as an average through the whole survey and when compared along the same track lines. It is therefore reasonable to assume that the amount of sprat lost for echo integration at the surface and close to bottom was small.

Recordings classified as bottom fish were usually sampled by towing the pelagic trawl close to bottom. Only two hauls were made with bottom trawl. The pelagic trawling close to the bottom will not catch fish nearer than about 2 meters off bottom. Sprats occurring close to bottom have therefore probably been classified as "bottom fish".

The problems and sources of errors associated with the estimation of the echo fraction of sprat (Ef_s) and separation of contributions from plankton were discussed by Aglen and Iversen (1980). The conclusion was that these errors would not be serious as long as sprat was the major echo contributor. In 1981 the echo contribution from sprat was estimated to be about 50% of the "fish recordings containing sprat", calculated for areas where sprat was recorded.

Bad weather giving air bubbles in the upper layers may have led to some underestimation due to increased sound absorbtion.

The acoustic instruments and settings in 1981 were nearly identical to those applied in 1980. Calibration by aid of a -29 dB steel sphere in January 1981 gave a sum of source level and voltage respons of 143.1 dB which is 0.6 dB lower than in January 1980.

It may be concluded that equipment, methods and survey conditions in January 1981 were quite similar to those in January 1980, and that both surveys gave fairly good estimates of echo intensities of sprat within the surveyed area. Hence, the relative estimates (integrator readings) from the two years should be comparable. The absolute estimates (biomass) are, however, doubtful due to uncertainties associated with the applied average target strength.

The -10 log L length dependence is a consequence of a length^3/weight relationship and a length^2/scattering cross section relationship (Nakken and Olsen 1977, Foote 1980). -29 dB/kg is an assumed "field" value taken to be 6 dB below the maximum dorsal aspect value for a 12 cm sprat measured by Nakken and

Olsen (1977). None of the values have been verified to be representative for sprat in the field. The length dependent value are, however, assumed to give a more correct ratio between small and large sprat. The length independent (-29 dB/kg) and the length dependent (-10 log L -25 dB/kg) target strength values are equal for a 2.5 cm sprat, but differs by 6 dB (a factor of 4) for a 10 cm sprat. This clearly illustrates the need for "in situ" measurements of target strength and tilt angle distributions.

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Table 1. Composition of trawl catches. (number of fish per nautical mile towed). Salps, ctenophores and jellyfish are excluded.

St. number	Time (GMT)	Depth of headrope (m)	1-group sprat	≥ 2-group sprat	1-group herring	≥ 2-group herring	Cod	Whiting	Flatfish	Other fish < 10cm	Other fish > 10cm	Evertebrates (kg)
1	12	110	-	-	-	-	-	5	-	200b	-	-
2	06	75	42	2	-	59	1	189	10	5a	70e	-
3	20	65	-	-	-	-	-	100	3	-	22e	0.1c
4	19	0	-	-	-	-	1	-	-	-	-	1.0d
5	17	20	700	-	6	-	-	-	2	-	10	-
6	24	22	521	-	27	-	1	3	115	6a	15	-
7	04	16	-	-	-	-	-	1	4	5a	1	-
8	08	40	2474	440	+	191	1	56	16	-	25e	-
9	12	18	136	10	-	7	3	104	1	13a	2h	-
10	21	15	430	18	-	10	-	8	6	17a	-	-
11	00	14	3800	200	-	-	-	12	26	38a	6	-
12	14	19	2000	-	7	-	-	4	158	1a	1	-
13	16	17	4	2	-	5	-	12	15	100a	9h	0.2c
14	22	7	5	44	-	3	-	1	2	1	1h	-
15	16	10	365	3925	-	32	-	6	5	-	1h	-
16	13	10	864	136	-	47	1	104	4	-	1	-
17	19	8	30	111	1	27	1	1	2	-	1e	-
18	05	11	56	775	1	1	-	3	136	1	20h	0.5f
19	13	0	26	-	800	-	1	-	-	2200g	1	0.1f
20	02	16	16	8	-	-	-	-	20	6g	-	0.5d
21	08	25	1802	813	2	1	1	-	109	1	18h	-
22	13	20	-	-	-	-	-	-	-	2000a	1	0.1c
23	20	0	-	-	-	-	-	-	1	3a	1	-
24	01	0	-	5	-	-	-	-	-	11a	6h	0.5d
25	09	0	-	-	-	-	-	-	-	8a	1	0.1c
26	16	20	1000	-	1	1	-	1	15	-	1h	-
27	20	0	350	7	17	-	-	2	80	-	4h	-
28	04	0	-	-	2	6	-	5	10	2a	-	0.2f
29	13	10	415	-	89	-	-	-	-	43a	-	-
30	14	20	2455	-	8	-	-	5	4	21a	1	-
31	22	0	318	3	35	-	-	2	18	-	2h	0.1d
32	04	0	-	-	-	-	-	-	7	-	3h	1.0d
B 33	14	64	-	-	-	1	1	58	11	-	694e	0.3e
34	01	30		-	-	-	-	-	-	27a	-	0.6d
35	08	50	-	-	-	-	-	-	-	-	3050h	-
36	23	0	-	-	-	-	-	-	1	1a	-	-
37	03	10	325	-	-	-	1	-	2	41a	-	0.6d
38	09	10	-	-	-	-	-	-	1	-	-	-
39	13	10	560	-	107	-	-	-	4	25a	-	-
40	17	15	202	-	100	1	-	10	2	31a	-	0.1d
41	19	25	250	-	50	-	-	3	4	2a	-	0.2d
42	02	0	-	-	-	-	-	-	-	-	1	-
B 43	12	72	-	40	-	42	35	80	144	144b	1123e	0.1c
44	18	40	3	27	-	-	1	-	-	2	18e	-
45	21	0	246	34	2	12	-	1	-	31a	-	-
46	02	0	23	40	-	16	11	5	5	2a	17	-
47	10	10	8	1	2	-	-	-	1	5a	1	-
48	12	30	3	-	1	-	-	-	-	5a	-	-

B. bottom trawl. a) Mainly gobies. b) Mainly Müllers pearlside.
c) Mainly squid. d) Mainly euphausiids. e) Mainly haddock.
f) Mainly swimming crab. g) Mainly stickle-back. h) Mainly gurnard.

Table 2. Biomass estimates (1000 tonnes) of 1-group sprat and older sprat based on two different target strength references. L = fish length (cm)

Average target strength (dB/kg)	Sprat biomass (1000 tonnes) Jan 1980 1-gr	Jan 1980 ≥ 2 gr	Jan 1981 1-gr	Jan 1981 ≥ 2-gr
-10 log L -25	660	350	47	49
-29	300	80	19	11

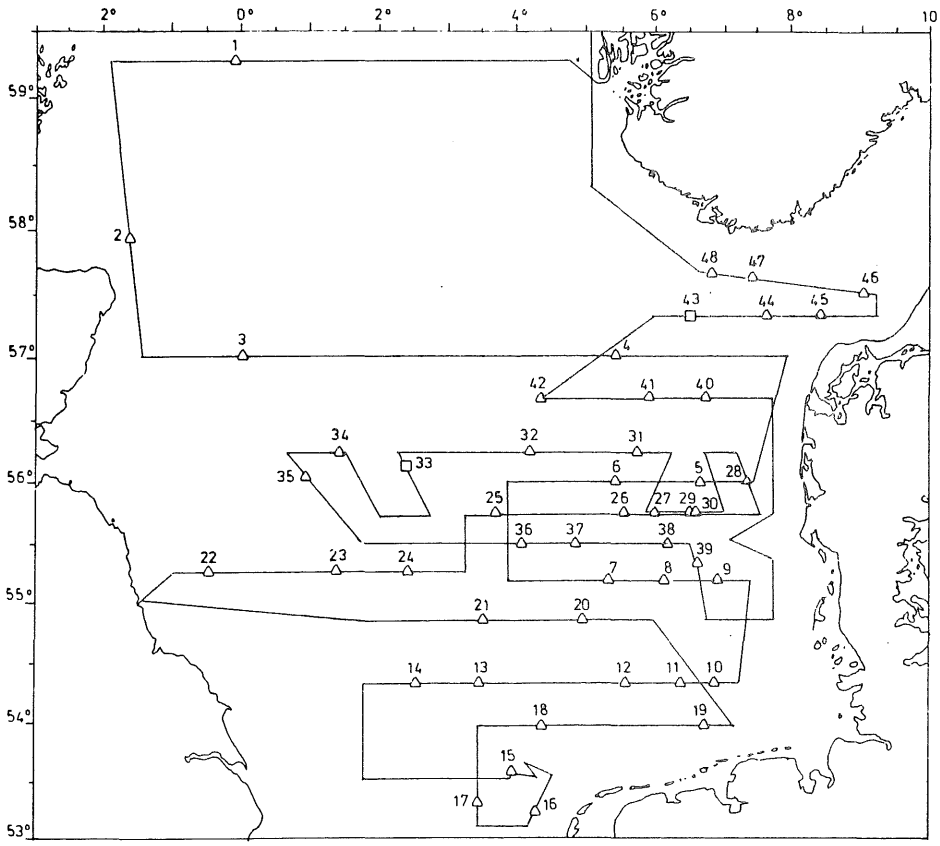

Fig. 1. Survey track and positions of trawl hauls. R/V "Johan Hjort" - January 1981.

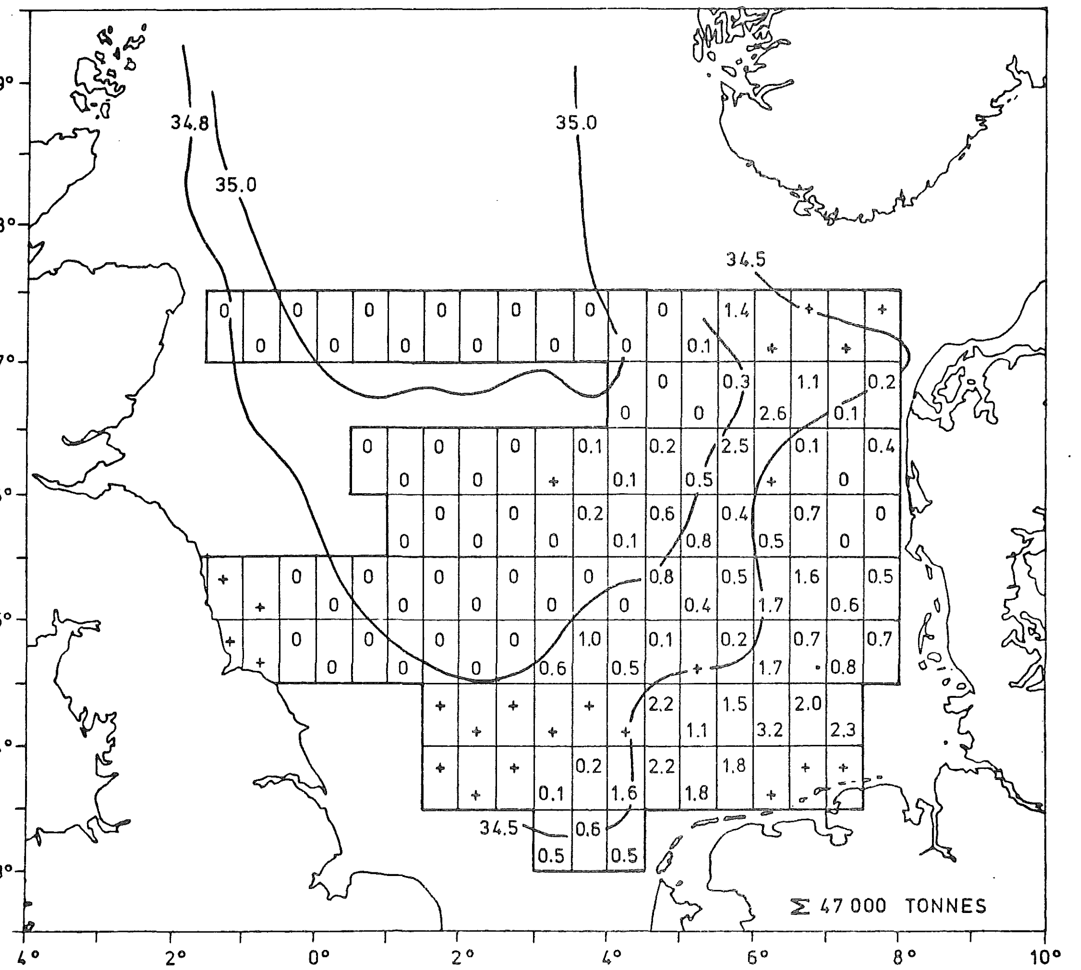

Fig. 2. Biomass of sprat, 1980 year class, January 1981. 1000 tonnes per statistical rectangle. Isohalines at 20 m depth are shown. +: Less than 50 tonnes.

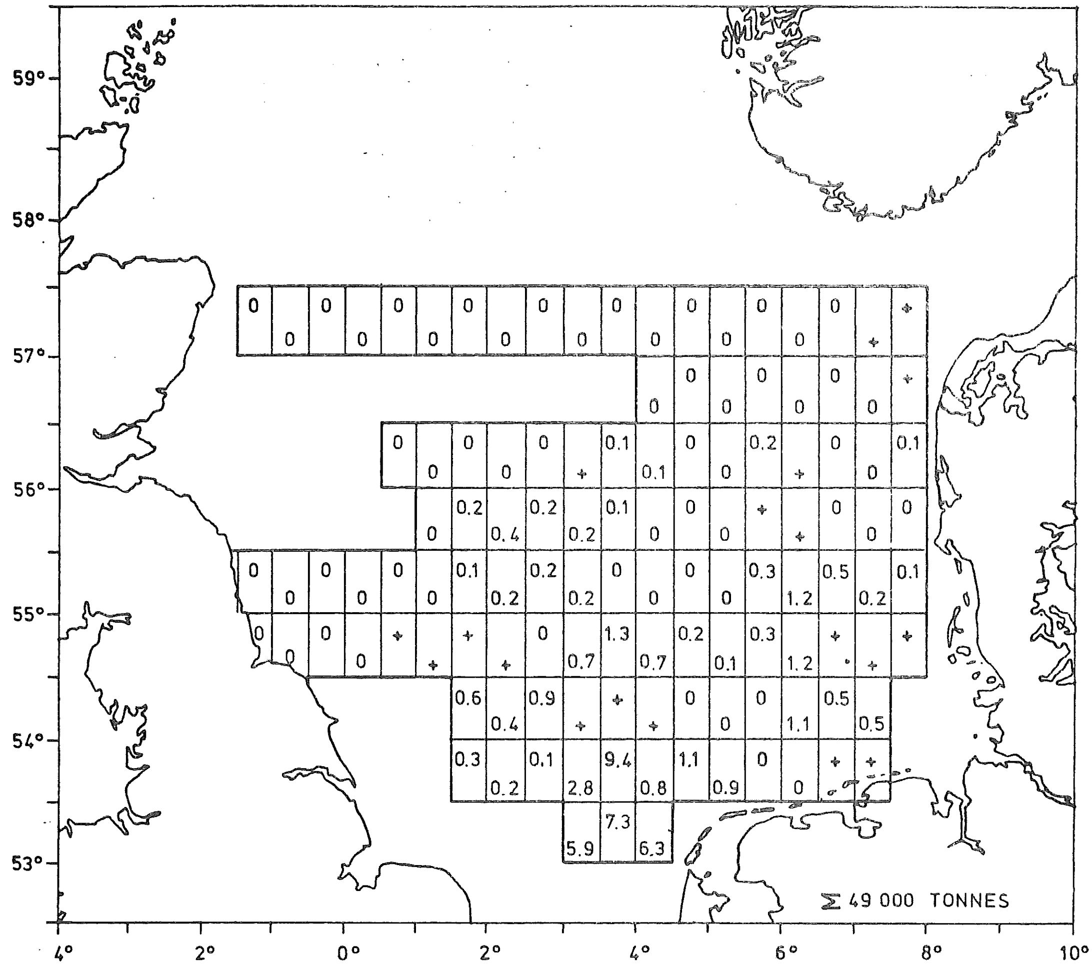

Fig. 3. Biomass of sprat, pre-1980 year classes, January 1981. 1000 tonnes per statistical rectangle. +: Less than 50 tonnes.

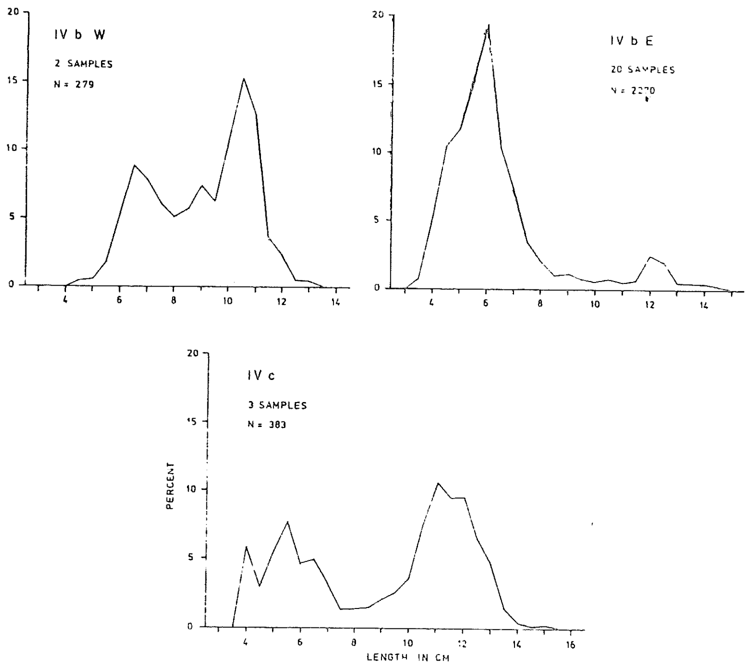

Fig. 4. Length distribution of sprat in ICES divisions IVb West of 3°E, IVb East of 3°E and IVc of the North Sea. Lengths measured in half cm intervals.