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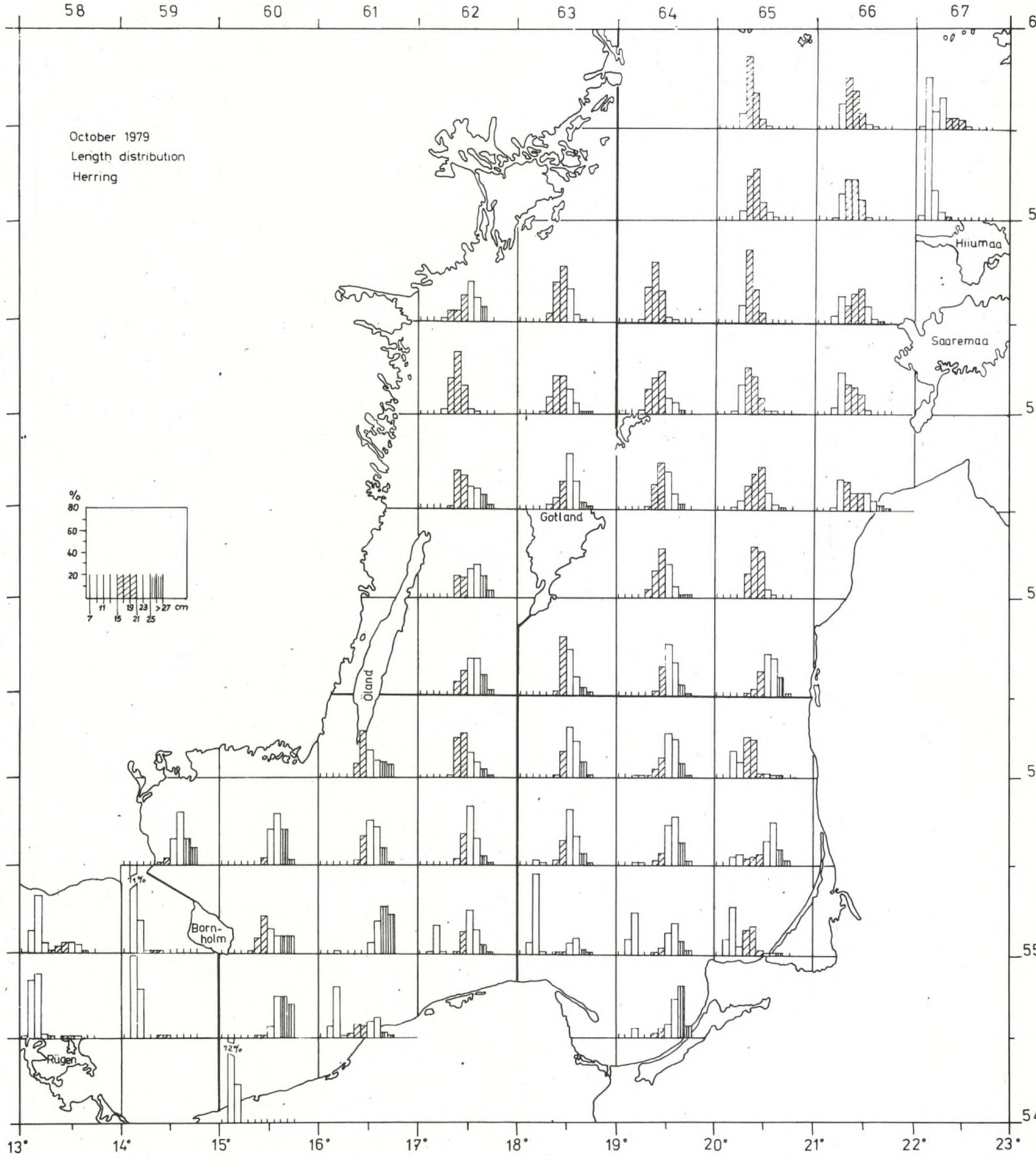

Acoustic estimates of herring and sprat stocks of the Baltic proper in October 1979

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Abstract

A second acoustic survey of the Baltic proper, carried out jointly by the R/V "Argos" and the R/V "Eisbär" gives new estimates of the size of the herring and sprat stocks. Methods are discussed and it is shown that corrections for sound absorption are important. Calibration of the equipment is crucial. The relative distribution of both juvenile and adult herring and sprat is described and comparisons are made with the previous survey in October 1978.

Contents:

1. Introduction

The decline of fish stocks in the north east Atlantic has resulted in an increase in importance of the Baltic fisheries. The landings from the Baltic Sea have risen during the last decade from 700 x 10^3 tonnes in 1969 to 834 x 10^3 tonnes in 1978 with a maximum nominal landing in 1975 of 957 x 10^3 tonnes (Anon., 1980 a). The catches are dominated in terms of weight by herring, sprat and cod which together make up 90 % of the total landings. The herring fishery, with annual catches of more than 400 x 10^3 tonnes, has been one of the most important fisheries for this species in the North Atlantic during the last few years. This rapid development of the fisheries accentuates the need for better knowledge about the status of the Baltic fish stocks in order to prevent overfishing.

Management of fish stocks in the Baltic has so far been based on estimates of stock sizes from virtual population analysis

(VPA). During the most recent years other methods of stock assessment have been applied, such as acoustic surveys (Håkansson et al., 1979) and, in the case of sprat estimation of stock size from egg production (Shvetsov et al., 1978, Lindquist 1980). As pointed out by Håkansson (op. cit.), conditions in the Baltic Sea are particularly favourable for the use of acoustic tehniques, in that this water body is almost entirely landlocked and because there are only three fish species of importance.

In 1978 an acoustic survey provided estimates of the size of the herring and sprat stocks.The total biomasses in that area of the Baltic proper investigated (42 x 10^3 NM^2) were 1.4 and 0.52 million tonnes of herring and sprat respectively.

A second survey was carried out from 24 September-19 October 1979. As in 1978, the survey was a cooperative effort between the Institute of Marine Research, Lysekil, Sweden and the Institute for Deep Sea Fishery and Fish Processing, Rostock, German Democratic Republic; in addition staff members of the Institut für Meereskunde, Kiel, Federal Republic of Germany, took part in the work on board R/V "Argos".

Some of the present findings have been used in the report of the Working Group for Assessment of Pelagic Stocks in the Baltic (see Anon., 1980 b). In that contribution the results from VPA were compared with those from the acoustic surveys and herring migrations and mortalities were discussed. The material has also subsequently been used by Lassen & Sjöstrand (1980) and Lindquist (1980). A preliminary report of the 1979 survey was presented by Falk et al. (1980), to the 1980 Statutory Meeting of ICES.

2. Material and Methods

The 1979 survey followed the same sampling scheme as the 1978 survey to ensure, so far as possible, comparability of results. The same vessels also participated in both surveys, namely the Swedish R/V "Argos" and the GDR R/V "Eisbär".

2.1. Echo integration

R/V "Argos" was equipped with a Simrad EK 120 S echosounder and a QM MK II echo integrator. The settings of the instruments during the survey are given in Table 1 a, and the calibration data in Table 1 b. The echo recordings were compared with the integrator values for each nautical mile (NM). Noise, recordings of scattering layers caused by planktonic organisms and pyknoclines were quantified subjectively and deducted from the integrated value.

Table 1 a: Technical data and settings of the acoustic equipment on board R/V "Argos"

Echosounder Simrad EK 120 S

Frequency	120 kHz
Output power	1/1
Transducer	10 cm Ø, ceramic
10 log ψ	- 18 dB
Band-width/Pulse length	3 kHz, 0.6 ms
TVG and Gain	20 log R - 0dB
Basic range	0 - 100 m
Discriminator	4 - 8 (varying)
Recorder Gain	9
SL + VR	108.93 dB/1 μbar ref. 1 m

Echointegrator QM MK II

	Channel A	Channel B
Gain	10-30 dB	10-30 dB varying
Treshold	0 -	0 - Depending on Gain
Interval	Varying	Varying
Bottom stop	Off	On

Table 1 b: Calibration data for R/V "Argos"

Date of calibration	SL dB// 1 μbar ref. 1 m		VR dB// IV per μbar	(SL + VR) dB	
Power	1/1	1/10	1/1	1/1	1/10
27 Apr 1976	116.9	107.7	-3.2	113.7	104.5
29 Nov 1979	116.7	107.1	-7.8	108.9	99.3
25 Sep 1980	122	113	-4.7	117.3	108.3

A specific problem in the Baltic Sea is the large discrepancy between the actual hydrographic conditions (temperature, salinity) and those used by Simrad to calculate and establish the time varied gain (TVG). Thus, the Simrad TVG-amplifier overcompensates for sound absorption and velocity, which means that the integrated values are too high and that the deviation between the correct and assumed values increases with fish depth (Aglen et al., 1981). An attempt to correct the integrated values for TVG-overcompensation has been made. The mean depths of the fish for each nautical mile (NM) surveyed were estimated subjectively from the echograms. The average sound absorption and velocity for each ICES subdivision were calculated from hydrographic observations made during the survey. The ratio between the Simrad TVG and the calculated TVG in the sub-division at the estimated fish depth was found and thus a correction factor for the integrated values was calculated. The sound absorption and velocity are calculated according to Lindquist & Gullman (1975).

Aglen et al. (1981) reported the following mean target strengths per kg for herring and cod:

23.7 cm herring = - 38.3 dB

41.25 cm cod = - 36.5 dB

If the calibration data from November 1979 are used, the C-values for herring and cod will be 20.9 and 14.2 tonnes/NM^2/mm ref. 1 NM, respectively. (All C-values mentioned are referred to a 20 dB integrator gain and also to the settings in Table 1 a.)

In Håkansson et al. (1979) and Falk et al. (1980) no corrections were made for TVG-deviation. A fixed C-value of 6 tonnes/NM^2/mm was used for all species, irrespective of fish length. The biomass calculations and illustrations in the preliminary paper by Falk et al. (1980), were based on this treatment of the data.

The C-value used by Håkansson et al. (1979) was estimated by counting echoes on the echograms at an average depth of about 15 m. This means a C-value of 7.2 tonnes/NM^2/mm at the transducer if the TVG-deviation is taken into account. This latter C-value corresponds to a mean target strength per kg of -33.6 dB if the calibration data from November 1979 are used and -38.4 dB if the data from the calibration in April 1976 are used. The corresponding fish length could not be calculated owing to lack of trawl data. The biomasses in the present paper are corrected for TVG-deviation.

We have also used the target strength data from Aglen et al. (1981) and compensated for TVG-deviation. Furthermore, a length dependent C-value has been used for herring and sprat (20.9 tonnes/NM^2/mm ref. 23.7 cm fish length). Since the length data for cod are inadequate, a fixed C-value of 14.2 tonnes/NM^2/mm has been used. The observed cod mean lengths are close to the reference length for this C-value. Since the C-value is assumed to be directly proportional to fish length

(Hakken & Olsen,1977), the mean length of herring and sprat has been calculated for each ICES statistical rectangle. In rectangles without fish samples, mean lengths for neighbouring rectangles were used. Sprat were assumed to have the same acoustic properties as herring.

Owing to technical problems, only one integrator channel could be used during the last three weeks of the survey. This is also the reason why the C-value was not determined by echo counting. It was anticipated that calibration after the survey in combination with later cage experiments would provide the required C-values.

2.2. Biological sampling

To identify the echo traces to species and age groups pelagic trawling was performed and the intention was to carry out at least one haul in each ICES-rectangle. When there were discrete echo traces at different depths, hauls were made through each appropriate depth layer. The fishing depth was controlled by a net sonde.

In total 95 hauls (see Fig. 1 a, b and 2) were made, 26 by "Argos" and 69 by "Eisbär". Three hauls were excluded owing to malfunction of the trawls. All other hauls were treated as samples representative of species and age composition. In 30 rectangles one haul was made, in 15 two, and in 9 three to five hauls. Of the 59 rectangles covered by the acoustic survey 7 needed an estimation of species composition from samples in neighbouring rectangles. No echointegration was carried out in two rectangles for which there were trawl samples. Altogether 3 008 NM of track was steamed, covering an area of 42 400 m^2. Some trawl data and fishing parameters are presented in Tab. 2.

Table 2: Trawl data and trawling parameters

	R/V "Argos"	R/V "Eisbär"
Type of trawl	Fotö - Single - Boat pelagic trawl	Pelagic trawl Jagernetz
Vertical Mouth opening	12-15 m	15-23 m
Codend mesh size (bar)	11 mm	11 mm
Trawling speed	3.2-5 knots	3.6-4.2 knots
Number of hauls	26	69
Duration of hauls	30-60 min.	20-60 min.
" " " , mean	37 min.	31 min.
Mean catch per hour	303 kg	785 kg

Catches were sorted and weighed by species. Out of the catch random samples of herring and sprat were measured (total length to the 0.5 cm below) and weighed by length groups. Stratified age samples of at least one hundred specimens were taken by sampling equal numbers of all length classes. Age determination was performed on sprat otoliths and on herring scales and otoliths (see Table 3). The two methods were compared in 1978 (Håkansson op.cit.).

Table 3: Number of age and length determinations

	Herring		Sprat	
	"Argos"	"Eisbär"	"Argos"	"Eisbär"
Length				
Samples	25	67	15	48
Specimens	14 298	27 576	3 946	9 023
Age				
Samples	16	61	5	45
Specimens	3 161	6 029	311	2 411
Method	scales	otoliths	otoliths	otoliths
Reader	Marianne Martinsson	Dieter Kästner	Birgitta Bengtsson	Brigitte Groth

2.3. Calculation of numbers at age

Calculated biomass values for each ICES-rectangle were subdivided into the contributions made by herring, sprat and cod according to the species composition by weight in the trawl hauls. Catches of two or more hauls in one rectangle were averaged. Age-length-keys for herring and sprat were established separately for each ICES-rectangle. Cod is not considered in this paper.

3. Results

3.1. Hydrographic conditions

Hydrographic observations were made out along two sections during the survey. Positions of hydrographic stations with the values of oxygen content, temperature and salinity are shown in Fig. 3. The data obtained were used to correct the mm deflection values (see section 2.1.). Deficiency of oxygen (<3 cm^3/l) was observed over large areas. In the southern part of the Baltic, in the Arkona Basin low oxygen content occurred from 60 m down to the bottom. The isoline of <3 cm^3/l hoped downwards from south to north. In the central and northern parts of the Baltic oxygen deficiency occurred in water below about 80 m. Hydrogen sulphide was found to the east and west of Gotland. The depth of the thermocline was about 30 m in the south and deeper in the north. The salinities indicate no recent influx of water from the Skagerrak-Kattegat area. (The hydrographic data are published by courtesy of J.O. Bladh, Institute of Hydrographic Research, Gothenburg.)

3.2. Distribution of fish

The relative distribution of fish is given in Fig. 1 a, b. Isolines enclosing areas with the same relative densities have been shaded, the darkest patches showing the densest concentrations (these figures are not corrected for TVG-deviation). The area surveyed is surrounded by solid lines. High densities were found E and SE of Svenska Björn, E of Bråviken, E of Gotland, SE of Öland, and SW and NE of Bornholm.

Herring densities and numbers of juvenile and older herring corrected for TVG-deviation are shown in Fig. 4. The highest densities of herring were found E of Bornholm, S and E of Öland, E of Bråviken and in the northern Baltic. Juvenile herring (0, 1 and 2-group) were most numerous E of Bornholm, E of Öland and E of Gotland and most of this juvenile herring was found in sub-division 24 (Fig. 6). Small herring were also found in the southern parts of sub-divisions 25 and 26. Older herring were most numerous E of Bornholm and in the open sea (Fig. 4). The largest herring was found in sub-division 25 (Fig. 6).

Sprat densities were highest in the two rectangles, 3958 and 4065 (Fig. 5). Juvenile sprats (0, 1 and 2-group) were most numerous in both the rectangles given above and in the rectangle facing the Irben sound (Fig. 5). Older sprats were most abundant in rectangle 4065, but were also abundant in rectangle 3958 and in rectangle 3958 and in the area NE of Gotland. Small sprats occurred in the southern and south eastern Baltic, whereas in the north they were larger, Fig. 7.

3.3. Quantities of herring and sprat

The estimates, calculated as described in Section 2, gave a herring stock of 1.05-2.5 x 10^6 tonnes and a sprat stock of 0.26-0.47 x 10^6 tonnes. The highest estimate in each range is based on the calibration data from November 1979 compensated for TVG-deviation, and using a length dependent C-value. The lowest estimate is based on figures corrected for TVG-deviation and not length dependent C-value. The corresponding number per age group on a sub-division basis are

Table 4. Numbers by age groups, October 1978 and 1979

Numbers x 10^6 1978 from Falk et al., 1980; 1979 corrected acc. to TVG-deviation

Herring Age Group	Sub-division 24		25		26		27		28		29		Total	
	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979
0	1047.5	5845.8	1952.4	2111.1	847.7	283.4	–	–	10.5	51.5	48.7	294.3	3906.8	3586.1
1	932.1	217.4	2151.3	167.9	245.2	359.0	776.5	48.6	377.4	638.5	949.3	570.4	5431.8	20001.8
2	131.7	195.9	1431.9	627.0	367.4	165.1	863.2	299.5	1034.0	649.7	1502.8	1259.2	5331.0	3196.4
3	43.8	10.8	1225.2	658.0	505.6	132.5	681.8	474.8	2273.2	567.1	1352.0	617.1	6081.6	2460.3
4	–	6.7	222.3	717.0	158.0	485.1	511.5	369.5	709.2	1042.6	380.4	648.6	1981.4	3269.5
5	8.4	–	336.3	391.6	200.4	188.3	463.9	372.8	659.5	266.3	284.8	132.1	1953.3	1351.1
6	–	–	271.7	354.6	438.2	205.2	575.6	302.9	842.5	235.8	109.9	110.8	2237.9	1209.3
7	–	–	105.8	321.6	156.2	285.3	342.0	330.0	406.1	268.5	123.4	68.2	1133.5	1273.6
8	–	–	39.4	167.6	166.6	185.9	130.4	223.9	233.5	131.0	72.6	68.3	642.5	776.7
9	3.9	1.9	89.9	394.7	298.3	453.5	296.4	331.3	303.5	258.1	124.5	108.3	1116.5	1547.8
Total	2167.4	6278.5	7826.2	5911.1	3383.6	2743.3	4641.3	2753.3	6849.4	4109.1	4948.4	3877.3	29816.3	25672.6

Sprat Age Group	Sub-division 24		25		26		27		28		29		Total	
	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979
0	13.4	2.7	8.3	–	10456.7	635.1	475.9	0.2	138.5	96.7	43.9	43.5	11136.7	778.2
1	1719.3	2280.4	1015.4	324.5	640.3	3255.2	62.3	42.0	178.3	775.8	27.8	146.5	3644.0	6824.4
2	736.4	1576.7	1019.3	96.7	2622.6	597.9	286.7	9.8	2335.4	617.5	1702.9	193.5	8703.3	3092.1
3	258.7	435.1	528.1	89.2	2787.8	1045.7	1264.9	45.2	2593.0	1515.9	4848.2	864.0	12280.7	3995.1
4	63.6	26.0	174.3	32.0	193.3	431.4	457.9	212.1	571.8	1184.1	1301.5	828.5	2762.4	2714.1
5	6.9	6.7	95.5	3.5	62.3	43.1	493.1	96.8	311.6	158.6	1342.6	206.2	2312.0	515.6
6	11.1	–	17.8	1.3	1.2	28.2	255.0	33.4	197.6	48.8	451.8	23.0	934.5	134.7
7	–	–	4.0	0.2	1.0	15.9	110.5	0.9	13.4	6.7	321.4	61.0	450.3	84.7
8	–	–	31.6	0.2	0.2	–	95.9	29.6	37.2	6.1	130.9	6.0	295.8	41.9
9	1.1	–	–	–	–	–	38.3	8.4	–	3.9	40.5	7.0	79.9	19.3
≥10	8.3	–	–	–	–	–	55.4	–	10.6	–	65.0	–	139.3	–
Total	2818.8	4327.6	2894.3	547.6	16765.4	6053.2	3595.9	478.4	6387.4	4414.1	10276.5	2379.2	42738.9	18200.1

presented in Table 4, where also the results from the 1978 survey are included. Table 5 shows the split into subdivisions and the effect of the corrections.

Table 5: Herring and sprat biomasses 1979, corrected and uncorrected for TVG-deviation and not length dependent C-value

	Herring		$t \times 10^{-3}$	Sprat	
sub-division	uncorrected TVG	corrected TVG		uncorrected TVG	corrected TVG
24	101.3	91.6		73.1	66.6
25	414.5	330.8		8.0	7.5
26	176.2	147.7		97.2	71.1
27	167.2	155.2		7.3	7.3
28	231.9	197.2		87.1	70.1
29	138.5	128.9		40.8	35.6
	1 229.6	1 051.4		313.3	258.2

4. Discussion

4.1. Degree of coverage

The degree of coverage was comparable with the survey in 1978. There were some improvements in the coverage of the western and central Baltic and some reduction in coverage in the north east. The echo recordings of R/V "Eisbär" indicate that the biomass in those parts of the Bay of Gdańsk which were not integrated in 1979 was lower than in the same areas in 1978.

4.2. Reliability of species and age-group distribution

Some regions of the Baltic are known for their highly variable and localited species compositions, examples being the central and northern Arkona Basin, Gdansk Deep, off the coast of USSR, north of Gotland. Our results have been calculated by averaging the percentage species composition of all hauls in a rectangle. Another way of handling the data would be to calculate weighted means of the catches per unit effort because the catching power of R/V "Eisbär" seems to be about

2.5 times that of R/V "Argos" (Tab. 2). Using this method the estimate of sprat biomass would be about 50 x 10^3 tonnes higher and the herring biomass about 20 x 10^3 tonnes lower compared with the estimates given above.

Ageing was done by the same methods as in the previous year and the results can be considered comparable. It must be remembered that net selecitivity may cause underestimation of 0-group sprat and herring, and gear avoidance may cause underestimation of the proportion of fast-swimming large fish.

The survey did not cover the surface layer from 0 to about 7 m, or coastal areas. 0- and 1-group fish are therefore likely to be underrepresented.

4.3. Comparison with the survey in 1978

Owing to uncertainties in the biomass estimates and inaccuracies in the TVG-deviations it is only possible to compare differences in the distribution pattern between the surveys. In Figs. 4 and 5 the results are compared with the work done in October 1978 (results taken from Håkansson et al. 1979).

In both years the highest densities of herring were found E of Bornholm and E to SE of Öland. In the northern parts there were some differences between the two surveys, e.g. a concentration E of Gotland was not recorded in 1979. When studying the geographical distribution of juvenile herring the two surveys gave quite different results. However, sub-division 24 was important in both years, as well as the rectangles NE of Gotland. Adult herring were spread all over the open Baltic, and were less abundant in rectangles adjacent to the coasts.

In both years the highest densities of sprats were found around Bornholm and in sub-division 26. Both surveys also demonstrated that sprats were not abundant between Gotland and Öland or to the S and SE of Öland. Sprat concentrations N of Gotland in 1978 were not recorded in 1979. The distribution of juvenile sprats was very similar in both years, with two main areas of concentration, one around Bornholm and one in sub-division 26. In both years juvenile sprats were found to the E and N of Gotland. Older sprats were concentrated in two rectangles in sub-divisions 24 and 25 and a concentration of the oldest fish was found mainly to the NE of Gotland.

The two surveys in 1978 and 1979 thus showed some differences in the distribution of juvenile and adult sprats but also some similarities, such as, for example, the importance of the areas around Bornholm, the south eastern part of the Baltic and the area to the N and NE of Gotland.

4.4. Reliability of acoustic estimates

No improvements have been made to the equipment used since the previous survey in October 1978. General problems and limitations of this equipment have been discussed in several papers (e.g. Hagström et al., 1979, Håkansson et al., 1979).

4.4.1. TVG-deviation

In Aglen et al. (1981) the effect of using a fixed TVG in varying hydrographic conditions is described, and an attempt to correct the integrated values from the present survey has been made. The corrections, however, have not been taken into account when drawing the distribution maps in Fig. 1 a, b, and there are therefore somewhat biased as fish in deeper waters may be overestimated. In future, with the appropriate equipment, different TVG-functions should be used in different areas.

4.4.2. The conversion constant

As pointed out in several other publications, the conversion constant (C) is one of the most important sources of error in the biomass estimates.

The present investigation three different ways of calculating the biomasses have been used. The most accurate biomass estimates should be achieved by using the target strength data from Aglen et al. 1981 and by applying a length dependent C-value calculated from the calibration data obtained in November 1979. The integrated values should also be corrected for TVG-deviation. The herring biomass calculated in this way, however, is more than twice as estimated in Anon. 1980 b for 1979, and is also more than twice as high as an estimate of acoustic biomass of herring made in October 1980 (in preparation by the authors). This latter biomass was calculated using the method described above but using calibration data from August 1980. A possible explanation of the extremely high acoustic biomasses is that the calibration in November 1979 was not correct. The November 1979 calibration also showed a radical decrease in voltage response (VR) compared to the previous one (cf. Tab. 1 b).

The other two biomass estimates were based on the C-value from Håkansson et al. (1979), found by counting fish on the echogram, a method that is not very accurate. No calibration was made to correspond with this C-value determination. It is therefore impossible to compare it with any other estimate of fish target strength. It is, however, possible that this C-value was valid during the survey in October 1978.

If we use this C-value also for the present survey, the estimated biomasses seem to be reasonable. We have, however, no adequate data to support that they are correct, especially as it was not possible to use this C-value as base for calculating length dependent C-values.

The discussion above strongly stresses the need for frequent calibrations. The equipment must be calibrated at least at the start and at the end of the survey. Therefore the present authors feel that the estimates of fish quantities from the acoustic survey October 1979 have restricted value for quantitative management purposes.

SUMMARY

From 24 September to 19 October 1979 the GDR R/V "Eisbär" and the Swedish R/V "Argos" carried out a hydroacoustic survey covering about 42 000 NM^2 of the Baltic proper. During the survey 95 hauls were made with pelagic trawls. This was the second joint GDR-Swedish investigation and the methods were the same as those used in October 1978.

The total biomass of herring in 1979 was estimated to be in the order of 1 million tonnes and that of sprat of the order of 0.25 million tonnes. High fish densities were found E and SE of Svenska Björn, E of Bråviken, E of Gotland, SE of Öland, SW and NE of Bornholm. Most herring were found E of Bornholm, S and E of Öland, E of Bråviken and in the northern Baltic. Juvenile herring occurred in sub-division 24, and were also found in the eastern and north eastern Baltic. Adult herring were mainly found in the open sea.

Most sprats were found in sub-division 24 and 26 and E of Gotland. The older age-groups were found mostly SE and E of Gotland.

A comparison of the surveys in October 1978 and September/ October 1979 showed some features in common.

The acoustic methods are discussed in some detail. It is shown that the sound absorption in the Baltic is important when calculating biomasses.

If a not length dependent C-value of 7.2 tonnes/NM/mm (Håkansson et al.,1979) is also used for the present survey, the estimated biomasses seem to be reasonable. There are, however, no adequate data to support their correctness, especially as it was not possible to use this C-value as a basis for calculating length dependent C-values.

The present investigation strongly stresses the need for frequent calibrations, at least at the start and end of the survey. The authors conclude, that the estimates of fish quantities from the acoustic survey in October 1979 have restricted value for quantitative management purposes.

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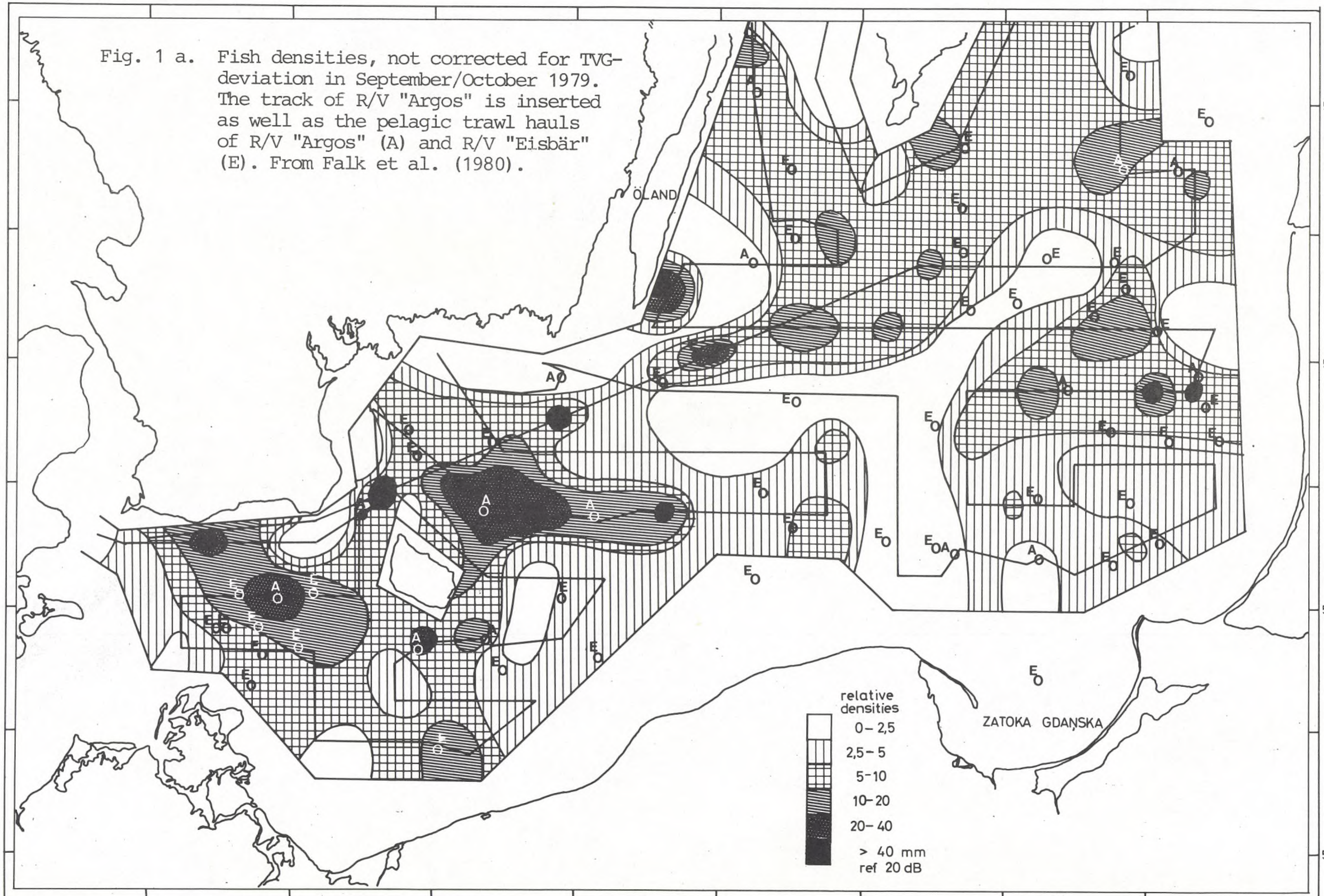


Fig. 1 a. Fish densities, not corrected for TVG-deviation in September/October 1979. The track of R/V "Argos" is inserted as well as the pelagic trawl hauls of R/V "Argos" (A) and R/V "Eisbär" (E). From Falk et al. (1980).

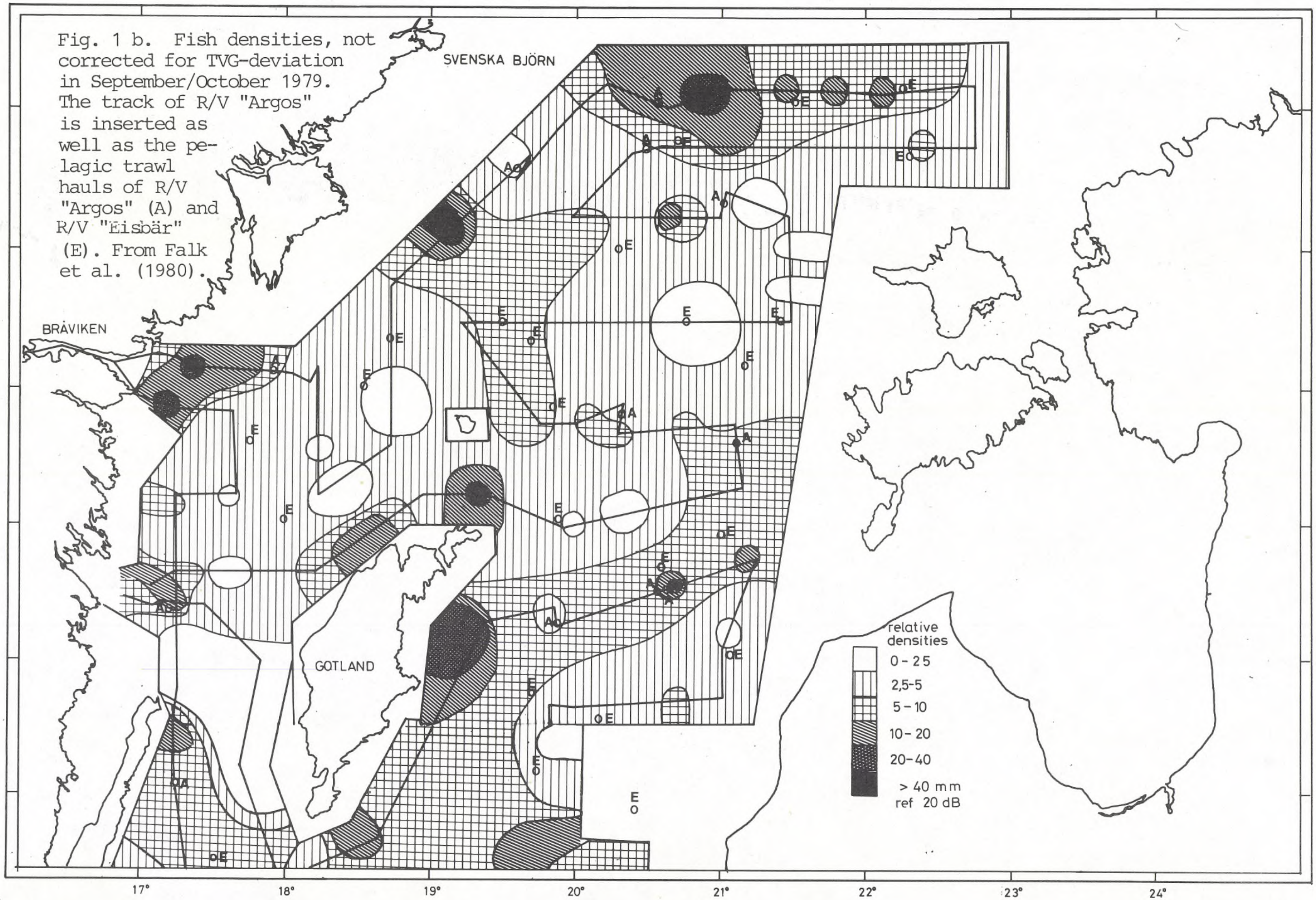


Fig. 1 b. Fish densities, not corrected for TVG-deviation in September/October 1979. The track of R/V "Argos" is inserted as well as the pelagic trawl hauls of R/V "Argos" (A) and R/V "Eisbär" (E). From Falk et al. (1980).

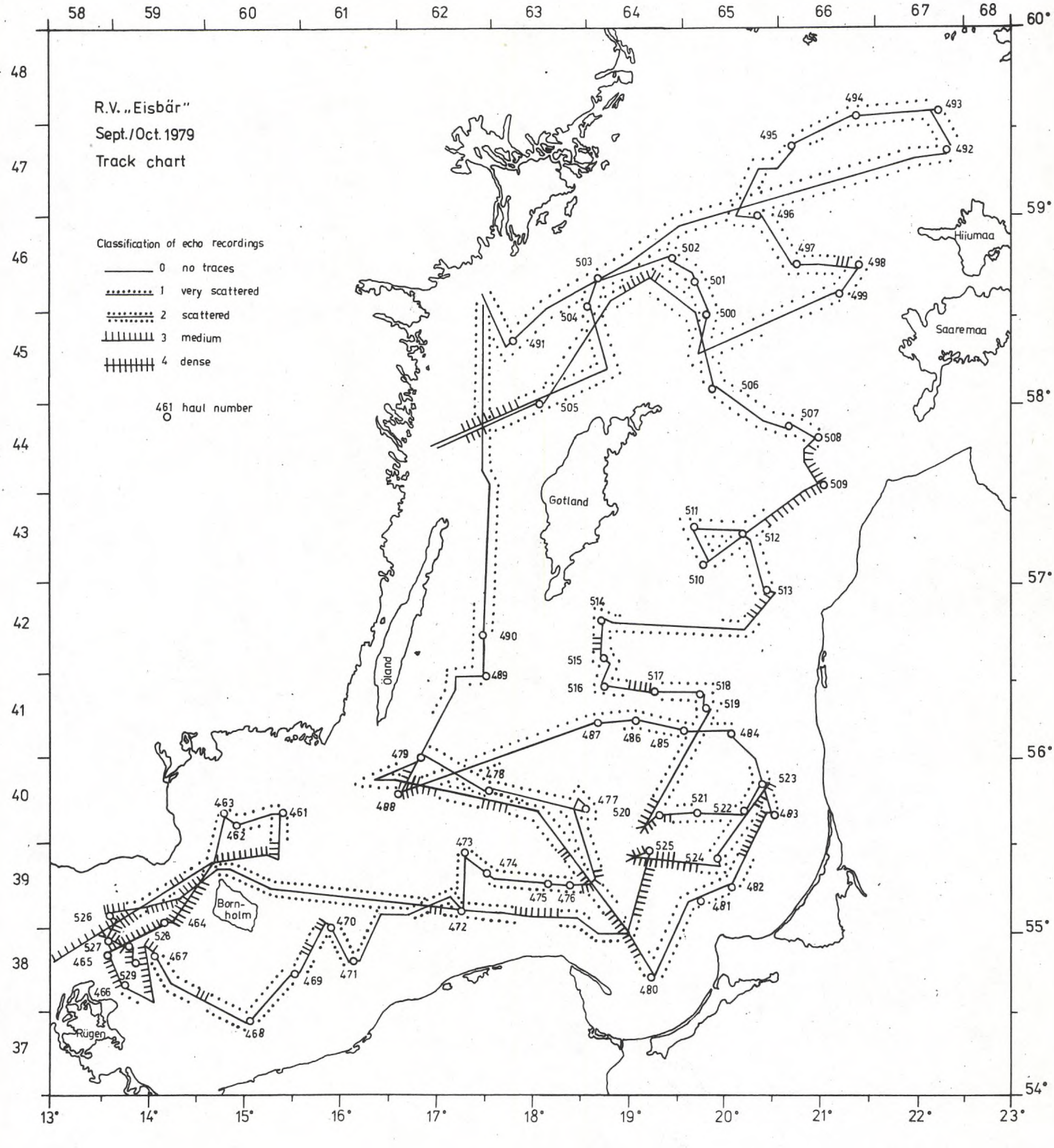
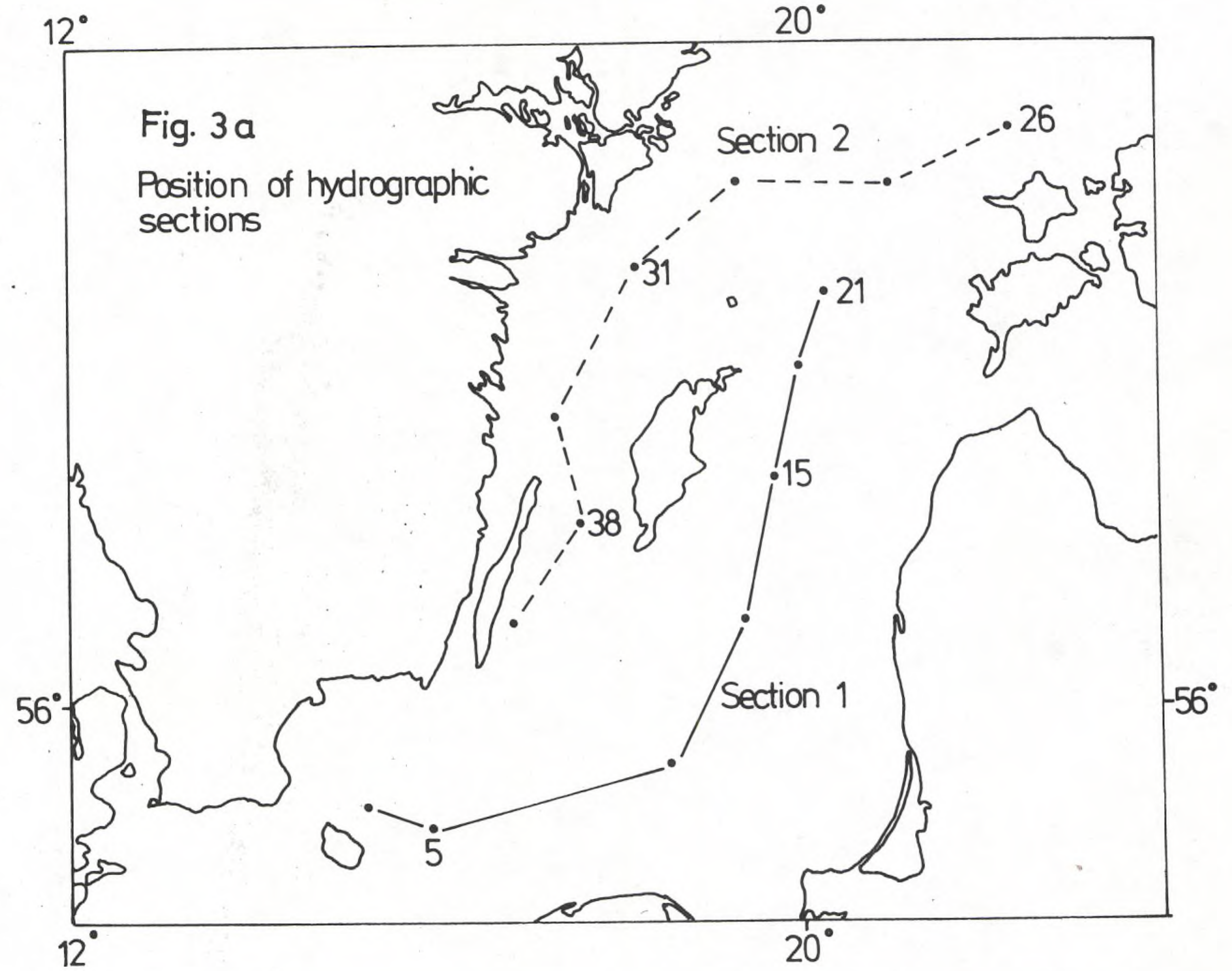
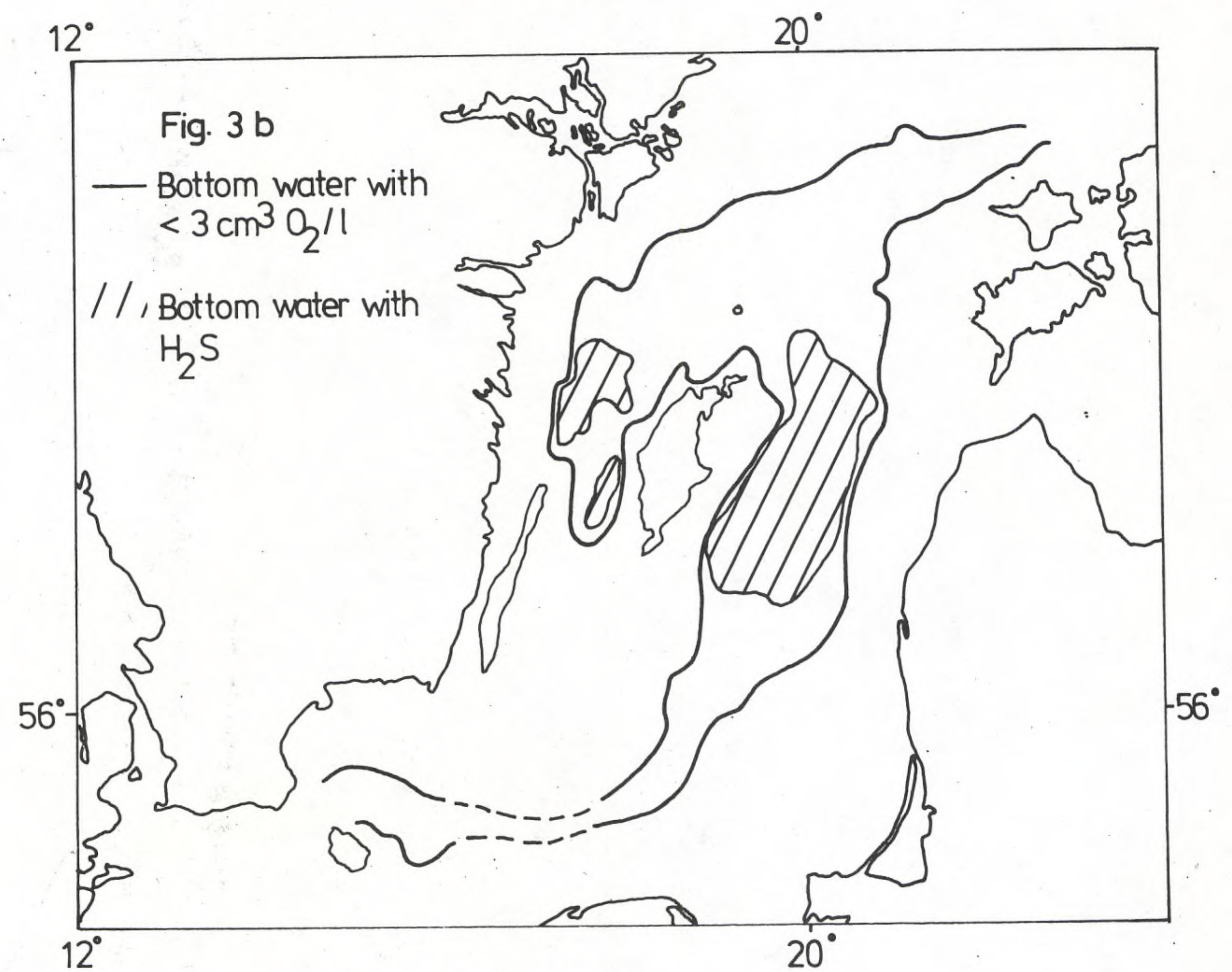


Fig. 2. Echorecordings in September/October 1979. The figure shows the track of the R/V "Eisbär", the position and number of pelagic trawl hauls, and the density of echo recordings.


12°
20°
Fig. 3 a
Position of hydrographic sections
Section 2
26
31
21
15
38
Section 1
5
56°
56°
12°
20°


12°
20°
Fig. 3 b
— Bottom water with $< 3\ cm^3\ O_2/l$
/// Bottom water with H_2S
56°
56°
12°
20°

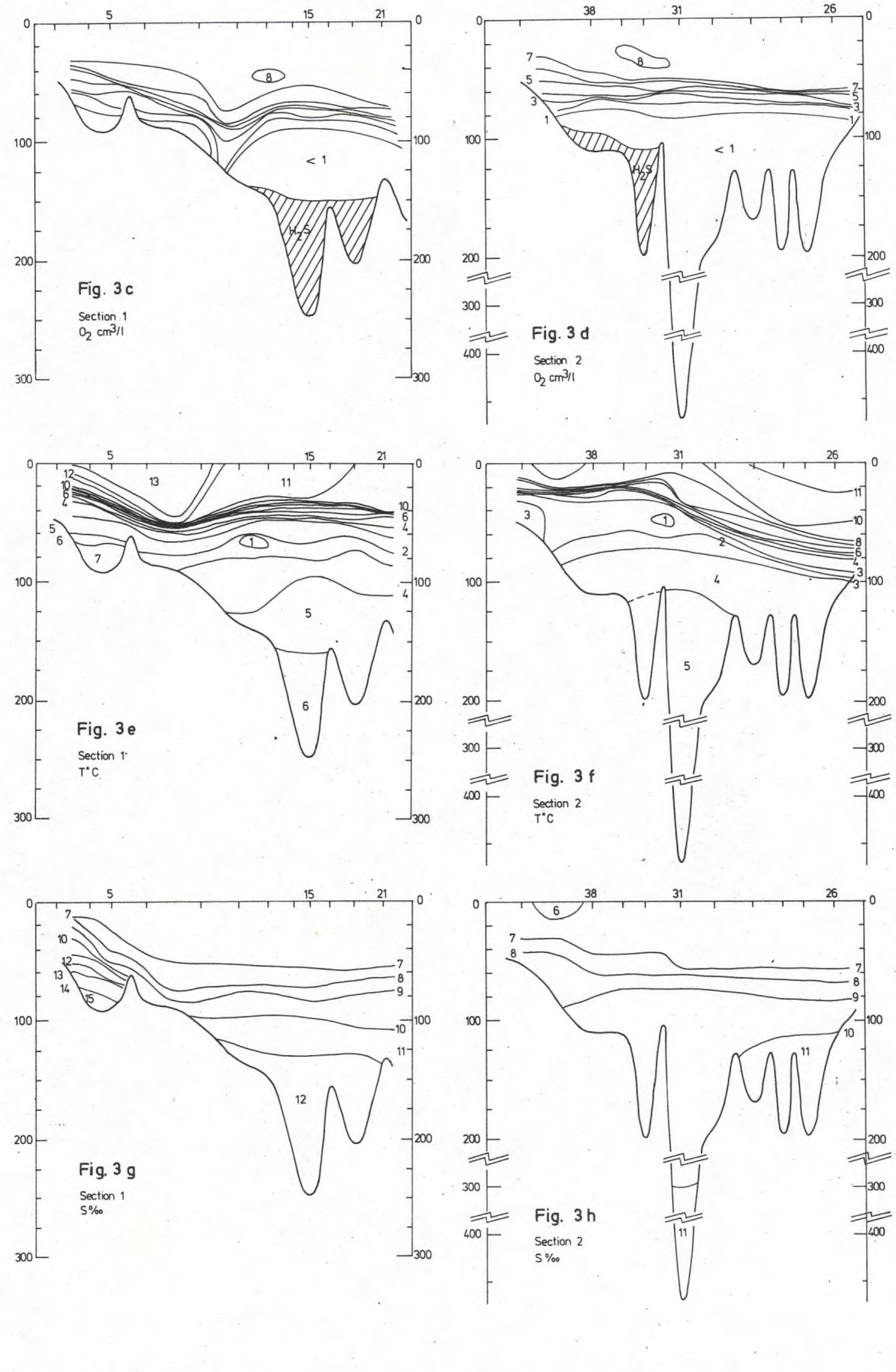
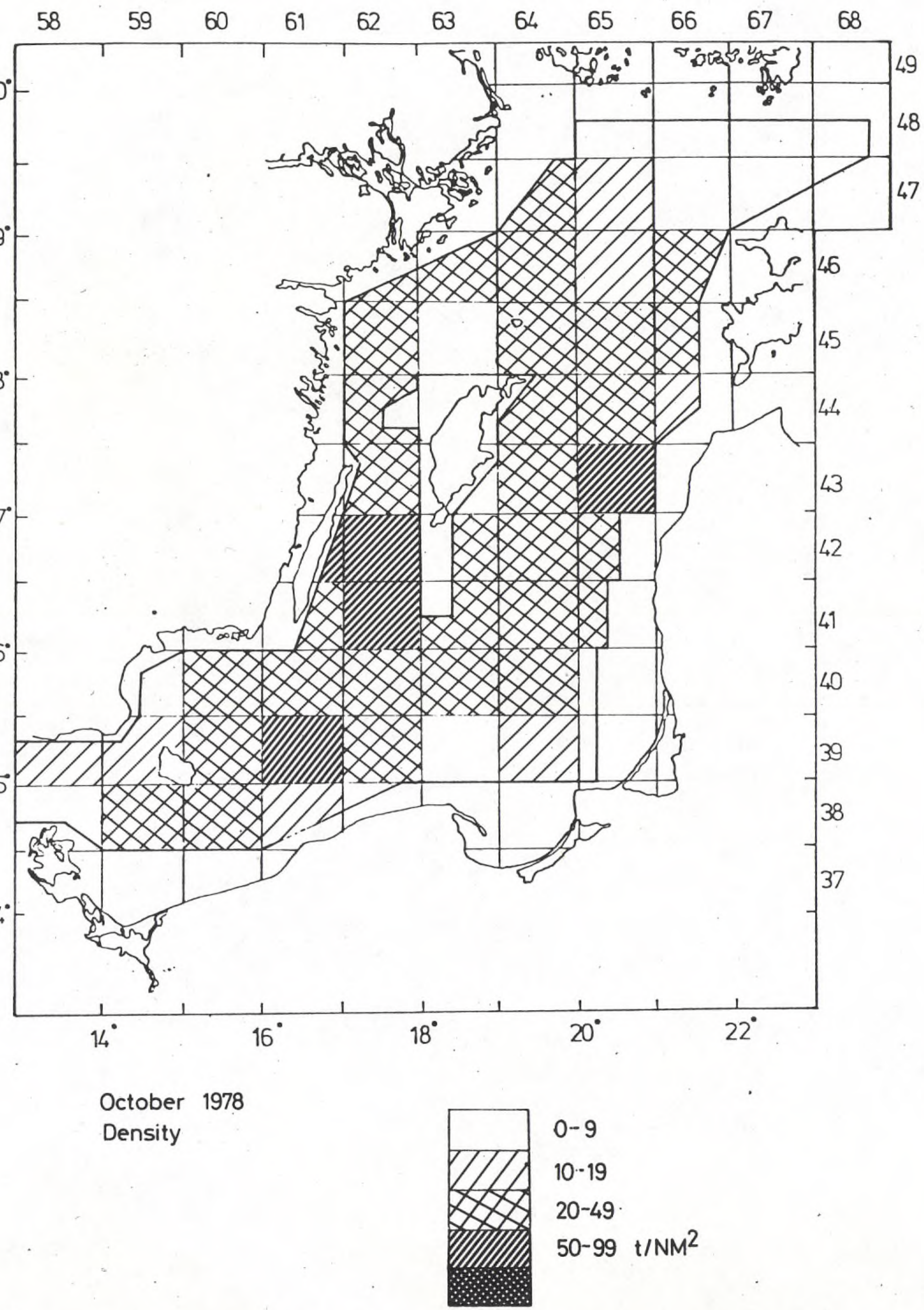


Fig. 3 c-h-
O_2, T^oC and S ^{o}/oo
on sections 1 & 2.



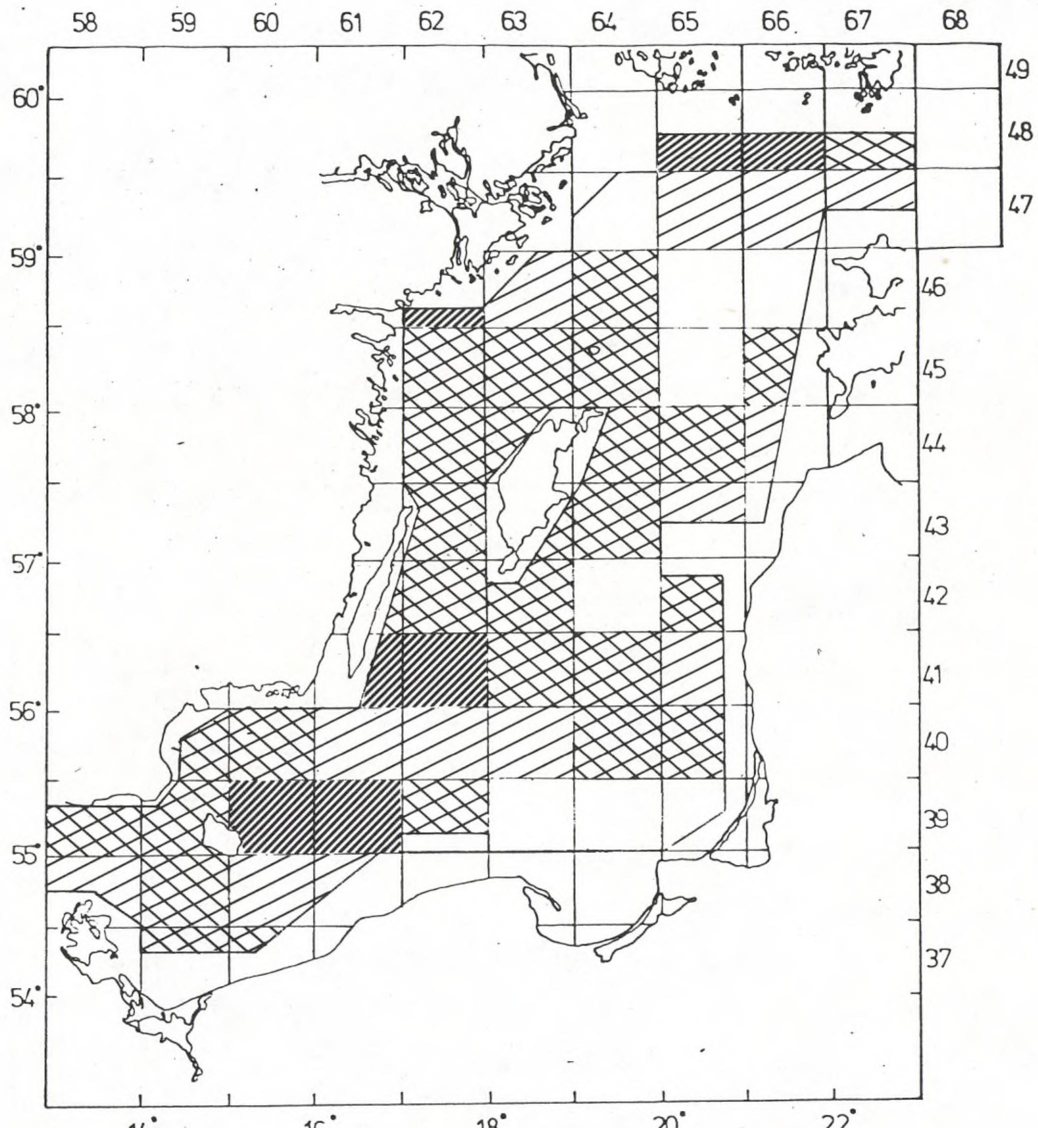
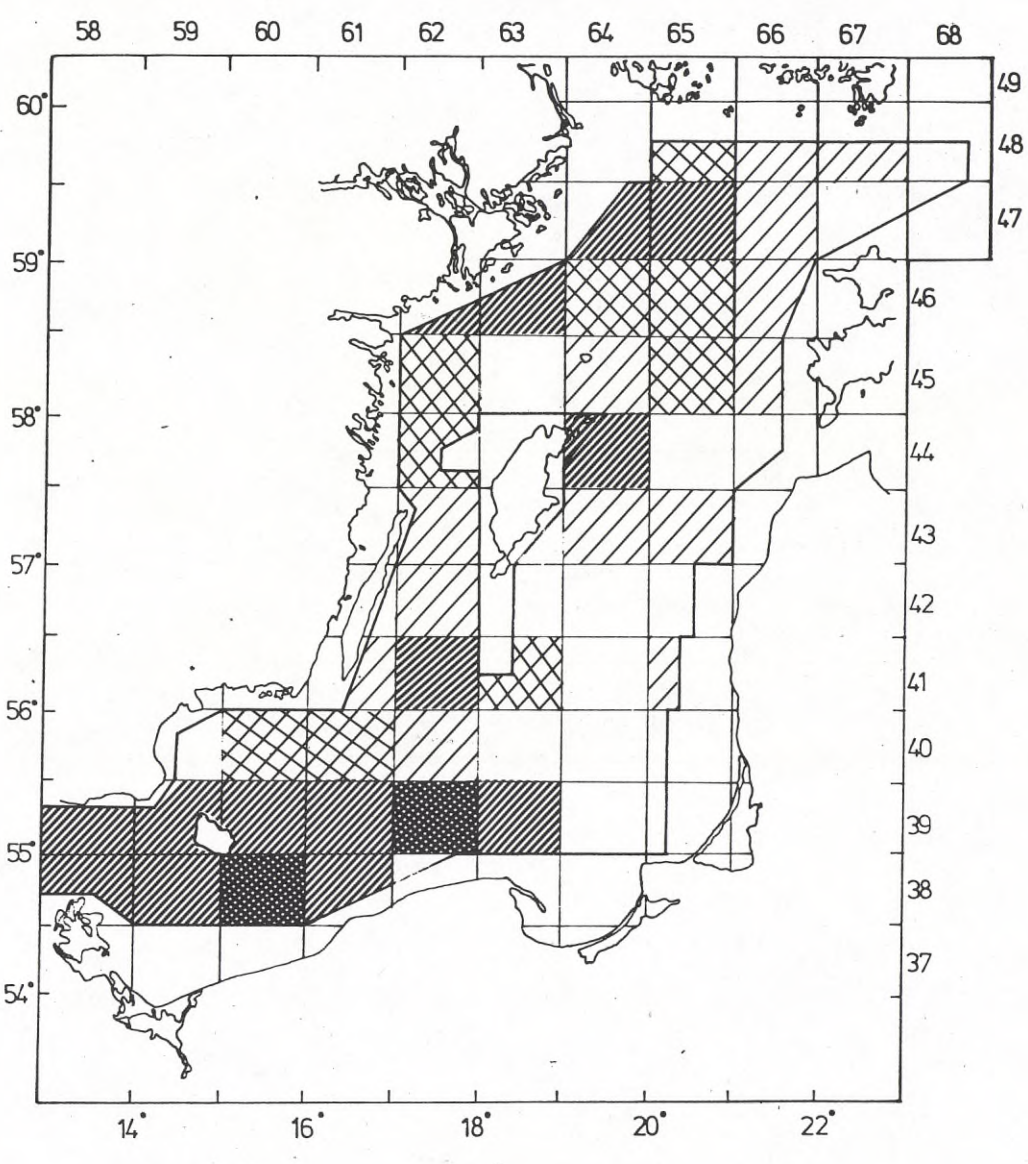
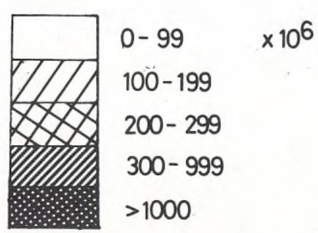


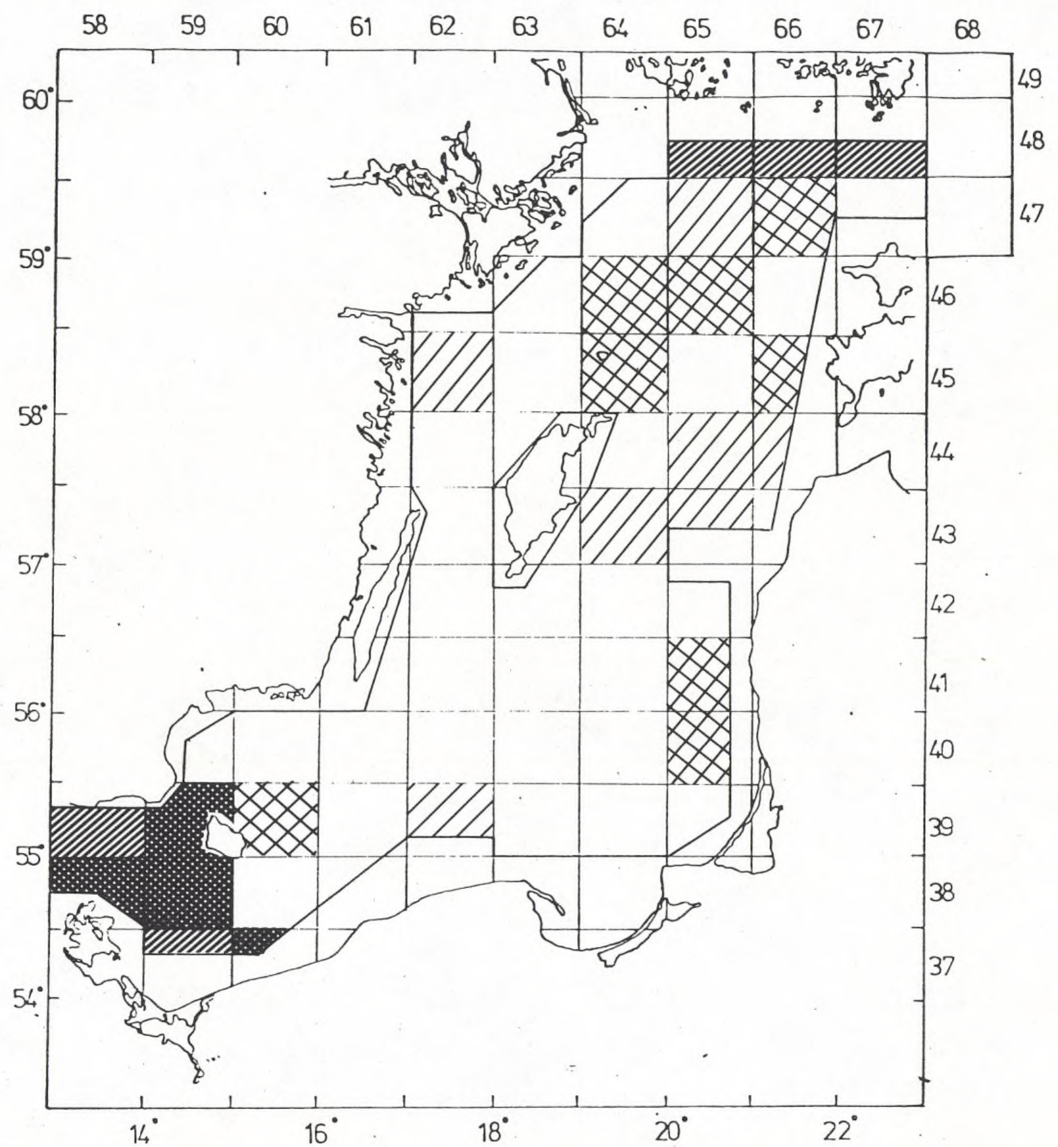
Fig. 4 a.

Distribution of herring (1978 from Håkansson et al. 1979, redrawn). 1979 corrected for TVG-deviation.



October 1978
0, 1, 2-groups

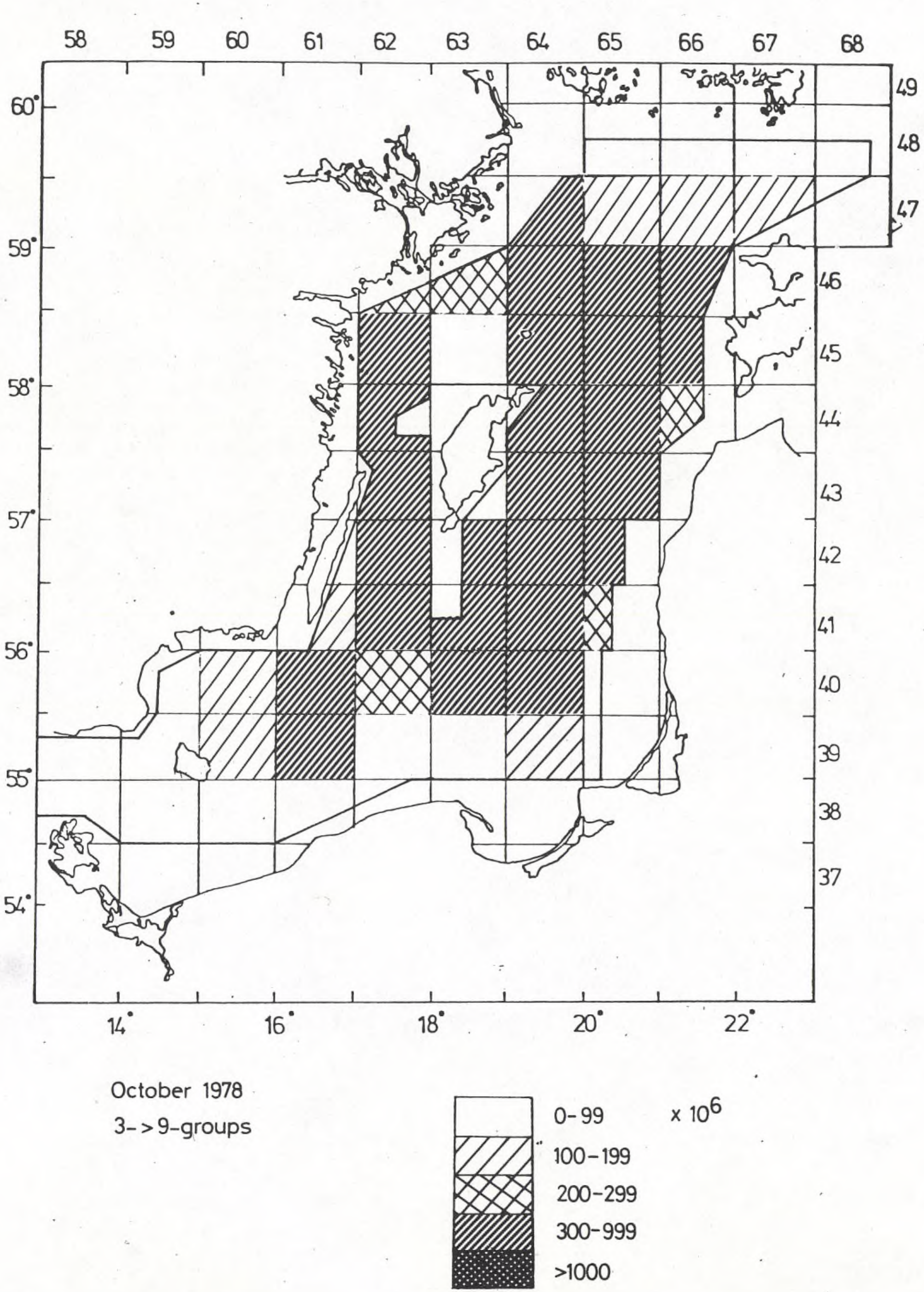




October 1979
0, 1, 2-groups

Fig. 4 b.

Distribution of herring (1978 from Håkansson et al. 1979, redrawn). 1979 corrected for TVG-deviation.



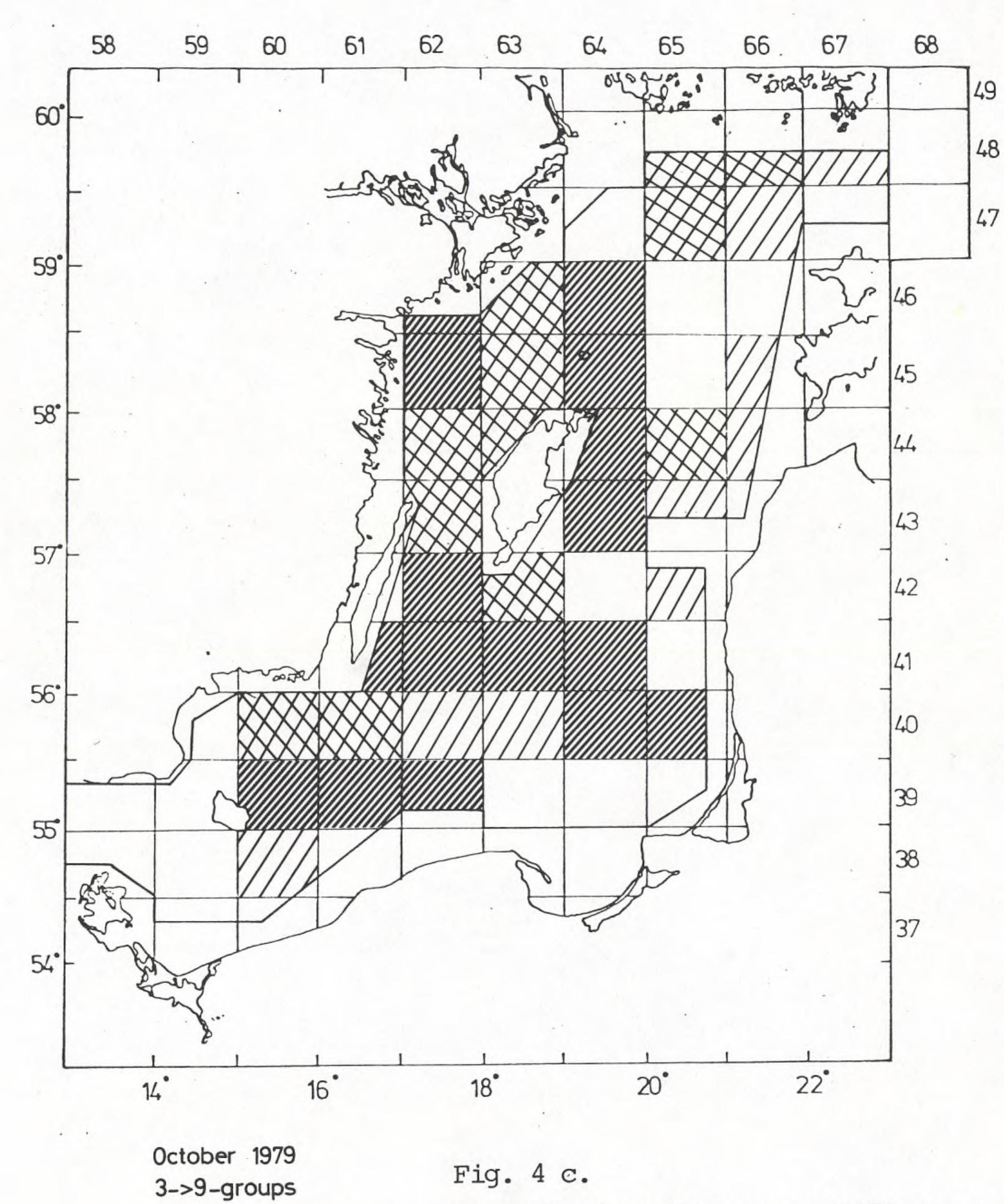


Fig. 4 c.

Distribution of herring (1978 from Håkansson et al. 1979, redrawn). 1979 corrected for TVG-deviation.

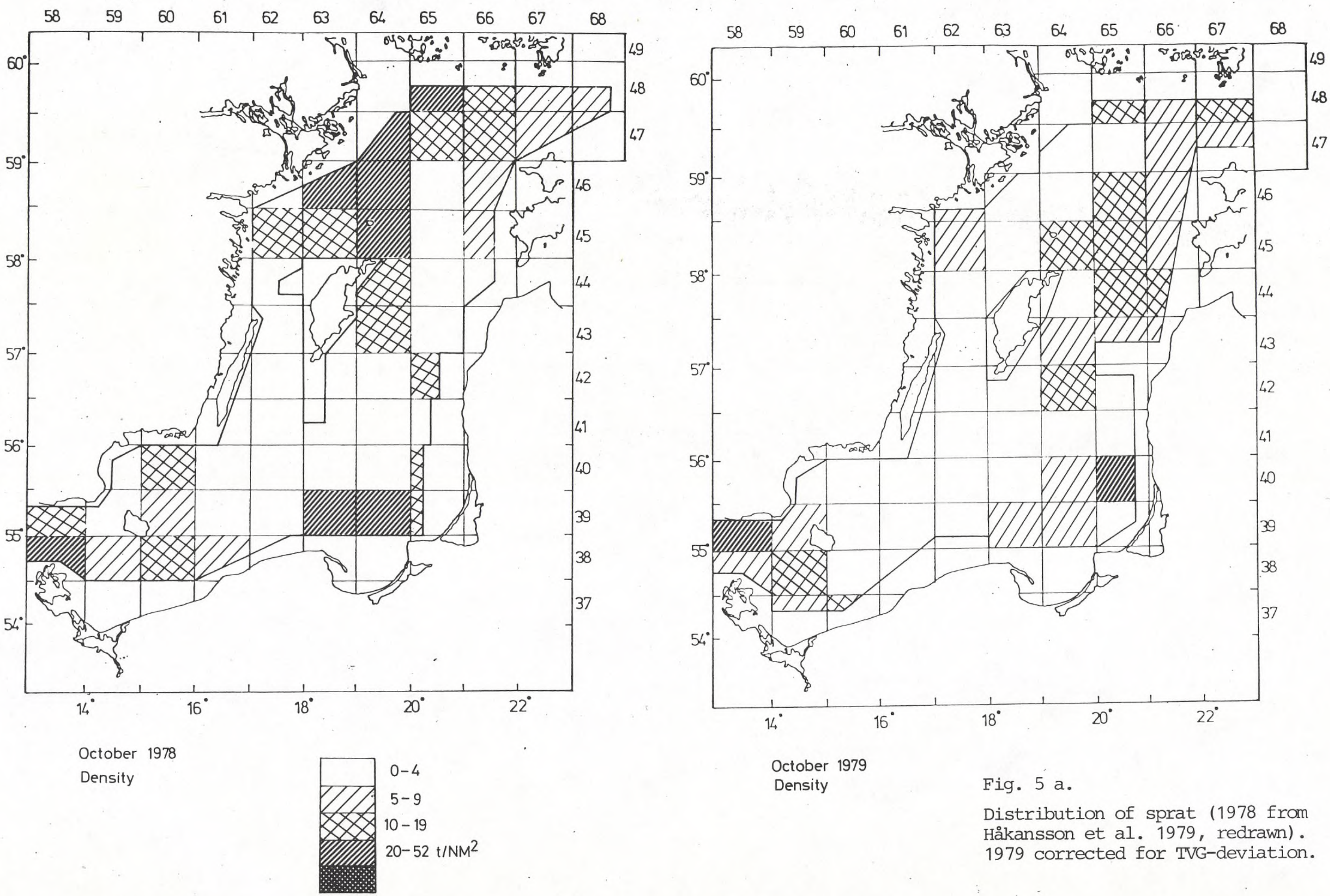
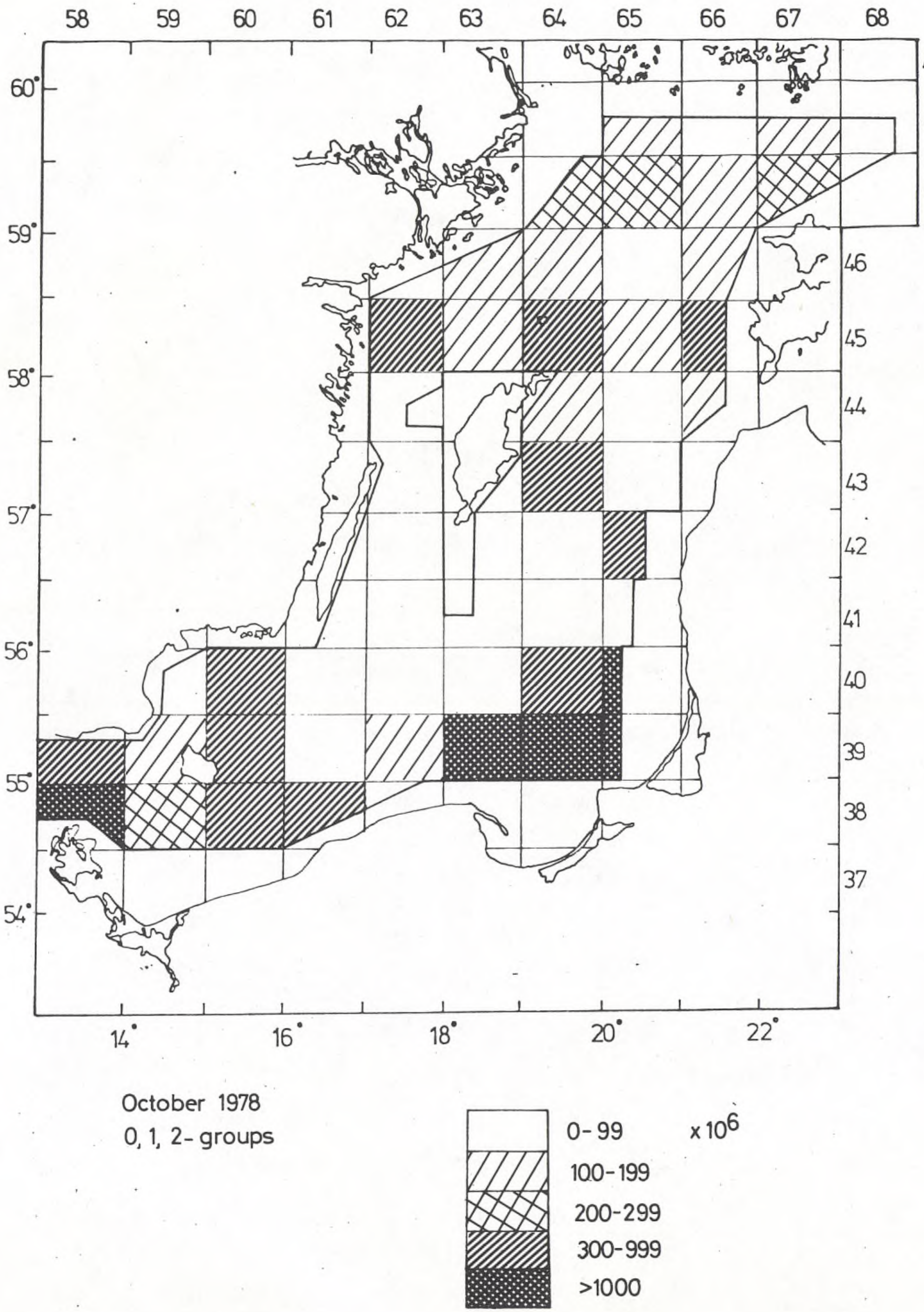
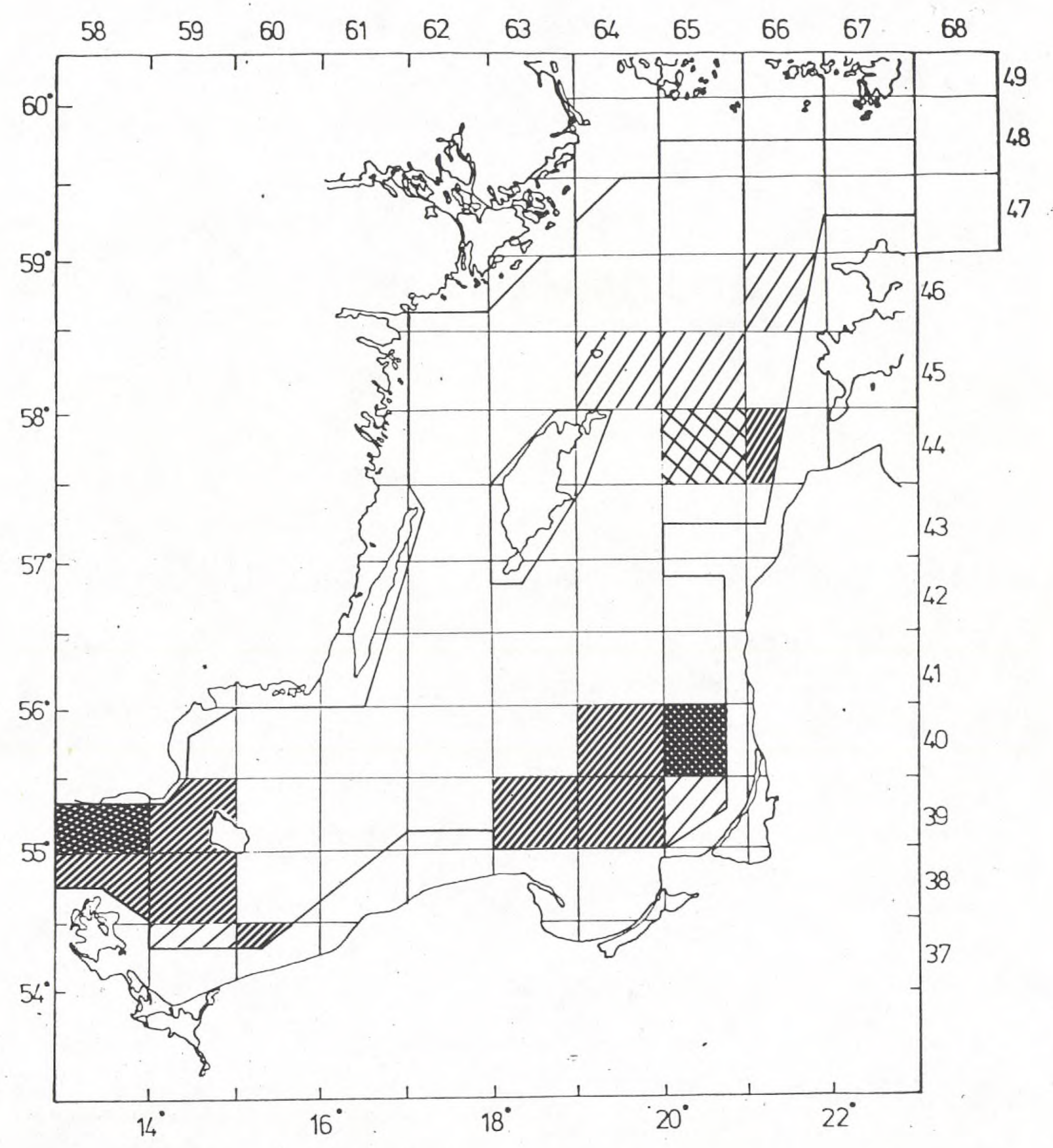


Fig. 5 a.

Distribution of sprat (1978 from Håkansson et al. 1979, redrawn). 1979 corrected for TVG-deviation.





October 1979
0,1, 2-groups

Fig. 5 b.

Distribution of sprat (1978 from Håkansson et al. 1979, redrawn). 1979 corrected for TVG-deviation.

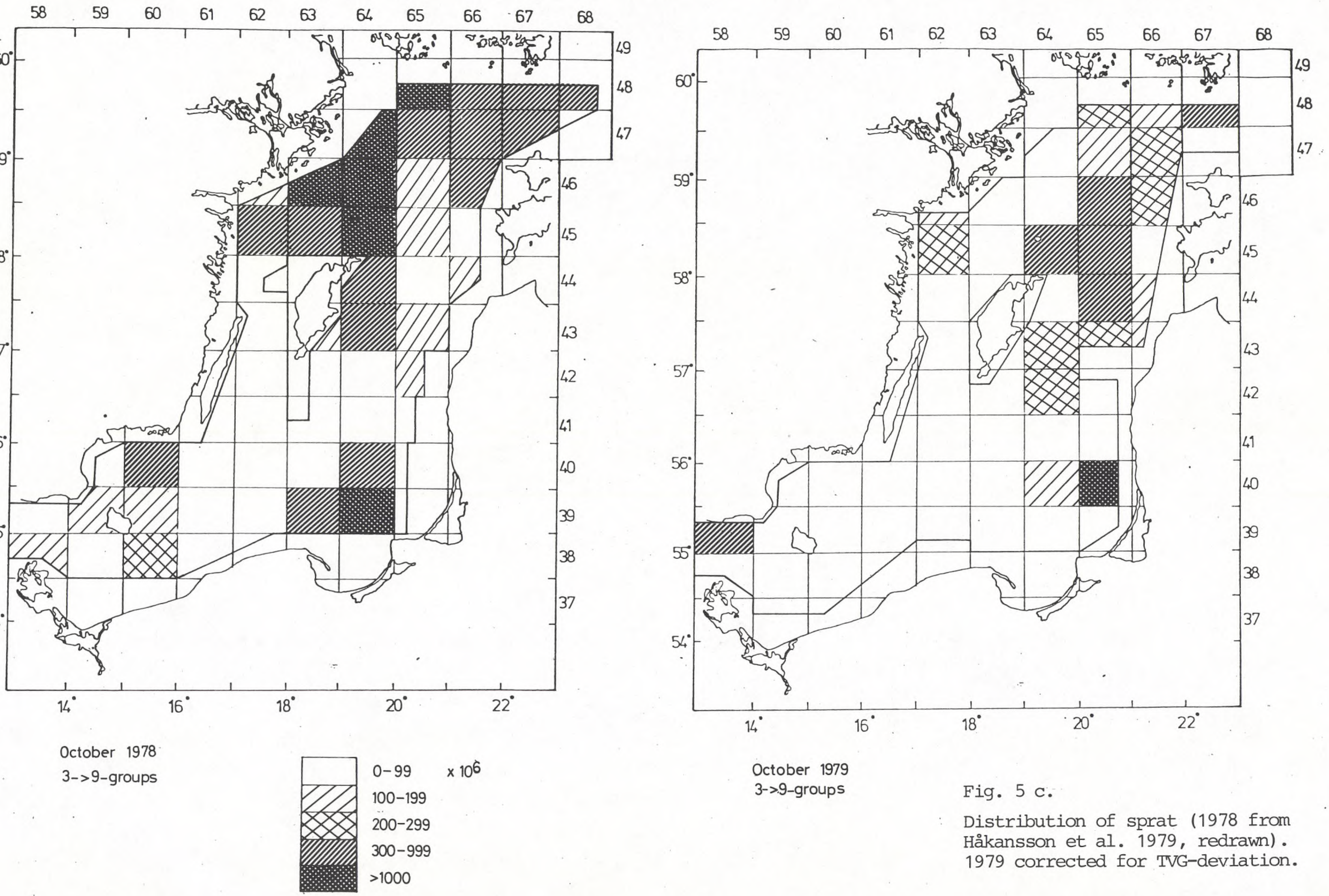


Fig. 5 c.

Distribution of sprat (1978 from Håkansson et al. 1979, redrawn). 1979 corrected for TVG-deviation.

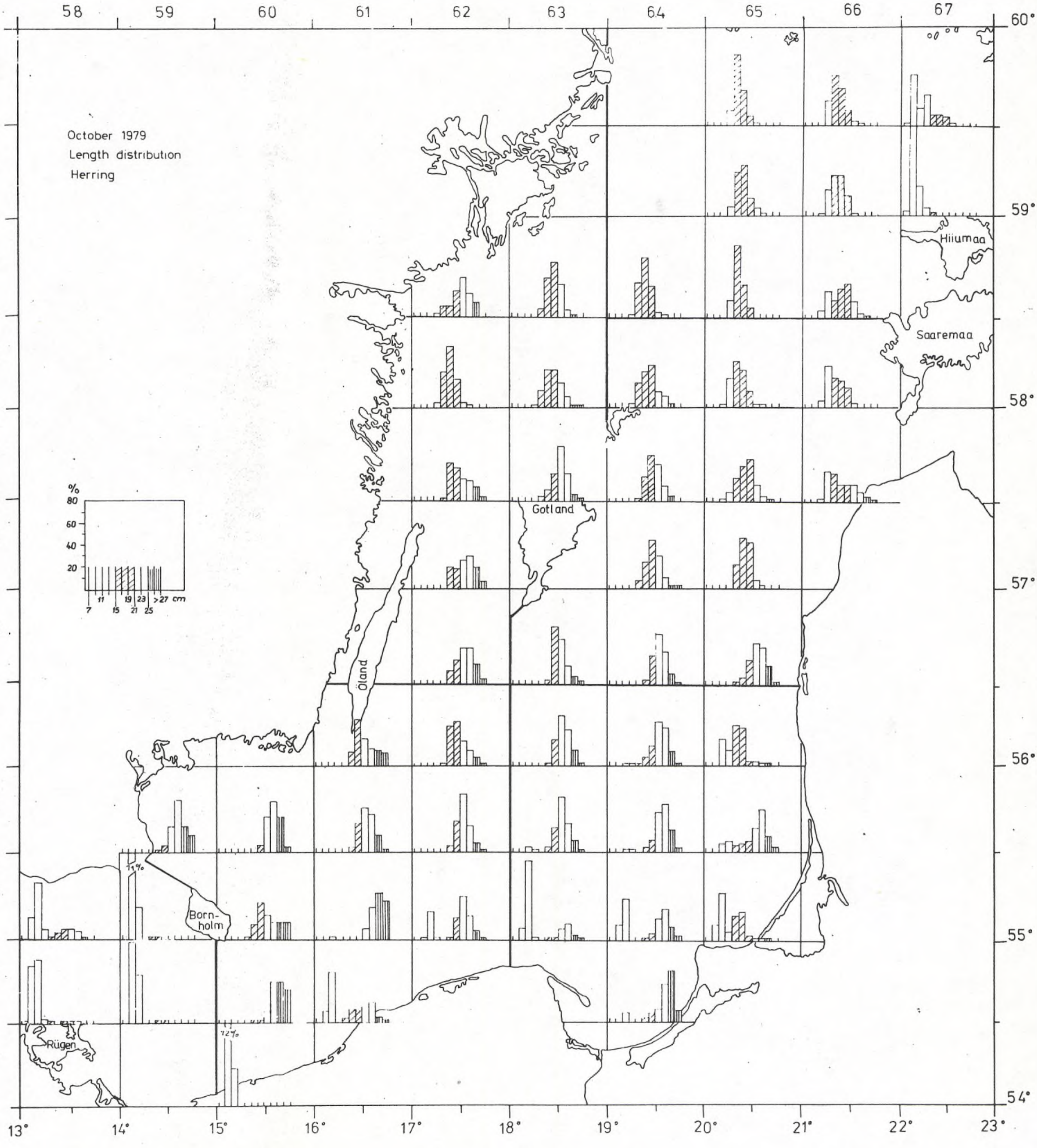


Fig. 6. Length distribution of herring in September/October 1979 in the Baltic proper.

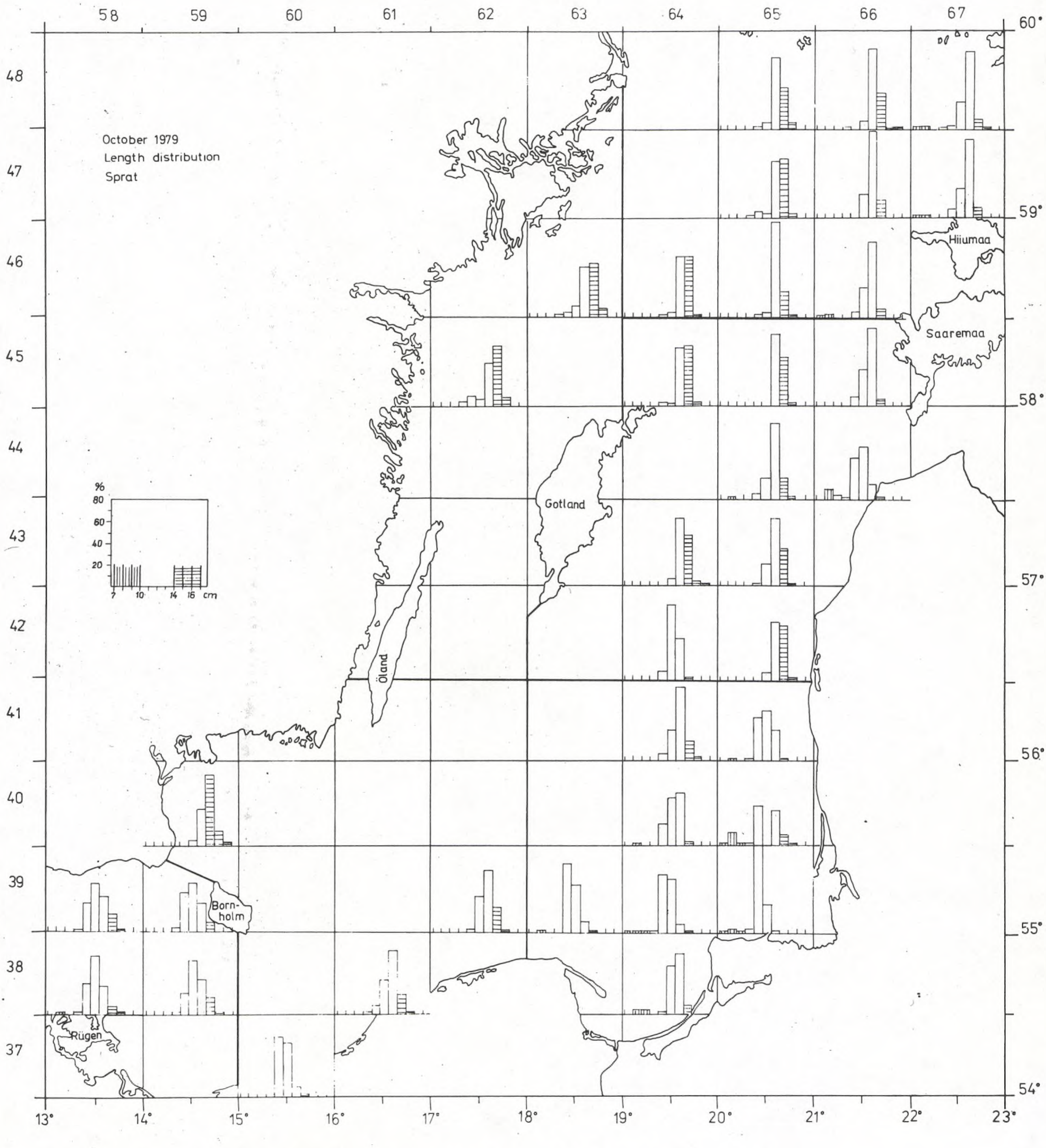


Fig. 7. Length distribution of sprat in September/October 1979 in the Baltic proper.