INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA

C.M. 1983/J : 22
Baltic Fish Committee

THE ABUNDANCE OF BALTIC HERRING AND SPRAT ACCORDING TO ECHO COUNTING IN THE SEAS AROUND FINLAND IN 1982

by

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Abstract

Echo countings were made in the open sea during four weeks in July/August 1982. These countings indicate that the shoals of Baltic herring were more uniformly distributed than in 1981. The average density of Baltic herring, 14.6 tonnes/nm^2, was higher than in previous years. The abundance of Baltic herring has increased in the Archipelago Sea and Bothnian Sea (Sub-divisions 29-30), but decreased in the Bothnian Bay (Sub-division 31) and the Gulf of Finland (Sub-division 32). The abundance of sprat was highest in the southern part of the Bothnian Sea (Sub-division 30). In the Gulf of Finland the abundance of sprat was very low.

Résumé

Des comptages d'échos furent effectués en pleine mer pendant quatre semaines en juillet et août 1982. Ces comptages indiquent que les bancs voyageurs de harengs de la Baltique sont distribués de facon plus homogène qu'en 1981. La densité moyenne de harengs de la Baltique, 14.6 tonnes/nm^2, est plus haute que les années précédentes. L'abondance du hareng de la Baltique s'est accrue dans la mer de l'Archipel et la mer de Bothnie (sous-divisions 29-30). Dans la baie de Bothnie (sous-division 31) et dans le golfe de Finlande (sous-division 32) l'abondance du sprat était à son plus haut point dans la partie sud de la Baie de Bothnie (sous-division 30). L'abondance du sprat a été très basse dans le golfe de Finlande.

Introduction

In recent years several acoustic surveys have been made of Baltic herring and sprat (LINDQUIST et al. 1977, HAKANSSON et al. 1979, Anon. 1981, 1982, ARO et al. 1981, ARO & SJÖBLOM 1982, HAGSTRÖM et al. 1982). These surveys have provided data on the location and density of Baltic herring and sprat and also the number of fish in a given area. However the use of these survey data for stock assessment purposes is still questionable. In Finland the echo counting technique has been used to estimate the abundance of Baltic herring and sprat since 1979. This report gives the results of the survey in 1982 and compares them with those obtained in 1979-81.

Material and methods

The echo soundings and exploratory fishing with a pelagic trawl were made in the Gulf of Finland (ICES Sub-division 32), northern Baltic Sea proper and Aland Sea (29), Bothnian Sea (30) and Bothnian Bay (31) during four weeks in July/August. The SIMRAD EK-S 38 kHz echosounder connected to a five-channel digital echocounter was used. The speed maintained throughout the survey was 10 knots and the total distance covered was 2300 nautical miles. Of these, 471 were travelled by night and echocounted. The hydroacoustic instrument settings were the same as in 1980 (ARO et al. 1981). The gain and threshold settings were adjusted frequently depending on the weather, bottom topography, recordings of scattering layers of plankton, noise disturbance and any other unwanted signals. The echo recordings were compared with the echocounter values fed on to the echosounder recorder display, using one nautical mile as a unit. After rejection of unwanted signals, the corrected counts of the total number of fish were transformed to the total number in every depth layer covered and then to the toal number of fish per square nautical mile. Echo traces were indetified to species and age groups with the aid of a total of 17 hauls carried out along the survey route with a pelagic trawl (Fig. 1). The hauls were made at night at the depth of maximum occurrence of fish. The hauling speed was 3 knots and the hauling time about 1 hour. The length of the trawl when open was 40 m, the distance between the foot rope and the head rope was 10 m and the opening about 140 m^2. The mesh size of the cod-end was 10 mm from knot to knot. A random sample of about 100 Baltic herring and sprat was taken from each haul. Otoliths were used for age determination. For those statistical rectangles in which no samples were taken, data from neighbouring rectangles were used.

Results

According to the echo counting, the fish were fairly uniformly distributed in the open sea and very dense patches were noted only in Sub-division 29. In large sea areas the shoals of Baltic herring and sprat were very scattered. On average, the density of herring was higher than in 1981 in the northern Baltic Sea proper and Aland Sea (29) and in the Bothnian Sea (30), but lower than in 1981 in the Bothnian Bay (31) and in the Gulf of Finland (32) (Fig. 2, Table 1.). The highest density of Baltic herring was recorded in the northern parts of Sub-division 29 near the Archipelago Sea (62.0 tonnes/nm^2). The mean density of Baltic herring was 14.6 tonnes/nm^2.

The average density of sprat was very low in the Gulf of Finland (0.1 tonnes/nm^2), and lower in the northern Baltic proper than in 1981. In the Bothnian Sea the average density was at the same level as in the previous year. The mean density of sprat was 1.3 tonnes/nm^2.

According to the exploratory trawlings, Baltic herring were dominant in all the Sub-divisions (Table 2). Sprat were abundant only in the northern parts of Sub-division 29 and southern parts of Sub-division 30 (number of hauls 8, 9 and 17). The age distribution of the Baltic herring samples from the exploratory trawl catches shows that the strong year classes 1975 and 1979 are well represented in the catches in Sub-divisions 30 and 31. In Sub-divisions 29 and 32 age groups 2 and 3 were the most abundant (Table 3).

Like the commercial sprat catches, the exploratory sprat catches consisted mainly of the year classes 1975 and 1980. In the Gulf of Finland the year class 1980 was the most abundant (Table 4).

Discussion

In the seas around Finland the conditions in July/August are fairly suitable for gathering acoustic data. The sea and the wind are usually calm and the Baltic herring and sprat show stable behaviour, dispersing uniformly in the thermocline layer at night, away from the sea surface and bottom. Their density may thus be interpreted by echo counting as the mean rate at which they occur per unit area. Echo counting has certain advantages when fish density is low, but when fish density increases the problem of overlapping echoes arises and improper processing of signals may occur. The echo counting method also involves the assumption that the echoes counted are not multiple. This assumption was not always completely correct and this would lead to under-

estimation of fish densities and thus of biomass. In the seas around Finland the echo counting technique can be used only at night, when Baltic herring and sprat are scattered, and this made it impossible to cover the survey area adequately in our survey time. Several statistical rectangles were traversed only once with a few zig-zags and in some rectangles no echo counting was performed at all. Some fish concentrations may therefore have been missed, which would cause an underestimate of the densities. The observed distribution and density of Baltic herring and sprat may also be biased by several other factors. In this case the lack of trawling stations in several rectangles and the use of information from neighbouring trawling stations may bias estimates of the species composition and thus also the estimates of the numbers and densities of Baltic herring and sprat. At higher fish densities the echo counting technique has obvious limitations, because multiple echoes cannot be avoided.

The densities given by our echo countings in 1982 are at the same level as the figures obtained in October 1981 for herring in Sub-division 30 by echo integration (HAGSTRÖM et al. 1982). According to echo integration, the density of Baltic herring in the Bothnian Sea ranged from 2.9 tonnes/nm^2 to 26.8 tonnes/nm^2 (average 11.0 tonnes/nm^2). In our echo countings the density of Baltic herring ranged from 8.4 tonnes/nm^2 to 20.8 tonnes/nm^2 (average 11.9 tonnes/nm^2). Our density estimates for Sub-division 29 are lower than that obtained by echo integration; the average density given by that method in October 1981 was 30.7 tonnes/nm^2 and the value obtained by echo counting in July/August 1982 was 25.1.

According to echo integration, the density of sprat in the Bothnian Sea ranged from 0.1 tonnes/nm^2 to 14.1 tonnes/nm^2 in October 1981 (HAGSTRÖM et al. 1982) and the values given by echo counting in July/August 1982 ranged from 0.1 tonnes/nm^2 to 7.4 tonnes/nm^2. During both surveys the highest density was recorded in the area north of the Åland Islands (Sub-division 30).

In 1982 the average density of Baltic herring was the highest recorded for the period 1979-82. Because of the unusually cold weather at the beginning of June spawning was about two weeks delayed. After a very short spawning period almost all the herring migrated from the coastal areas to the open sea to feed. During the survey the distribution of the fish was not so patchy as in previous years and higher mean densities were recorded (Table 1).

In 1979-82 Baltic herring dominated in all the Sub-divisions. In the 1950's and 1960's exploratory fishing with the pelagic trawl indicated that the average density of sprat was greater than that of Baltic herring in Sub-division 29 (SJÖBLOM & PARMANNE 1982).

The echo counting estimates of Baltic herring biomass show that in Sub-divisions 29 and 30 the total biomass has increased during 1981-82 (Table 1). This agress with the figures obtained by the Working Group on Assessment of Pelagic Stocks in the Baltic (Anon. 1983). In Sub-division 31 the biomass has increased as well, but in the Gulf of Finland (32) the biomass has decreased, as estimated by VPA (Anon. 1983).

The biomass of sprat has decreased during 1979-82 in the Gulf of Finland (Sub-division 32) and increased in the Bothnian Sea (Sub-division 30), especially in the southern part (Fig. 3). In the northern Baltic proper and Aland Sea the biomass has remained the same.

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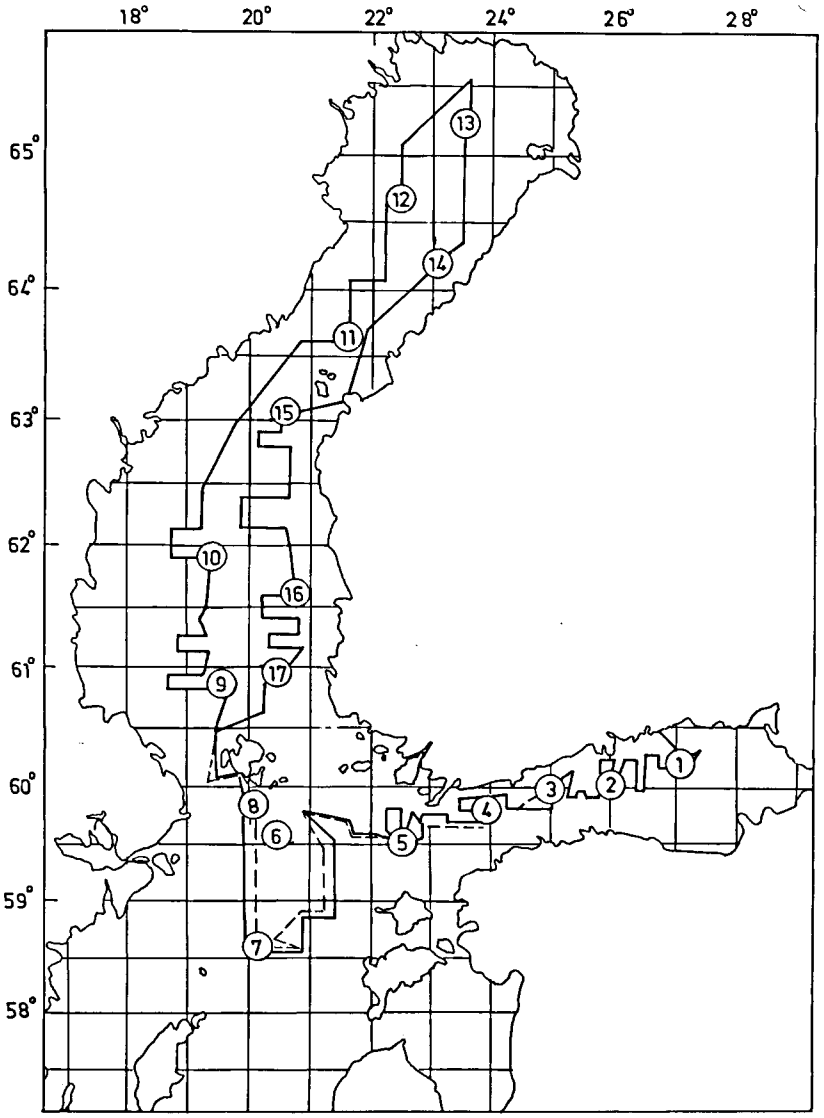

Figure 1. The survey route in July/August 1982 and the position of the exploratory trawling stations in 1979-82.

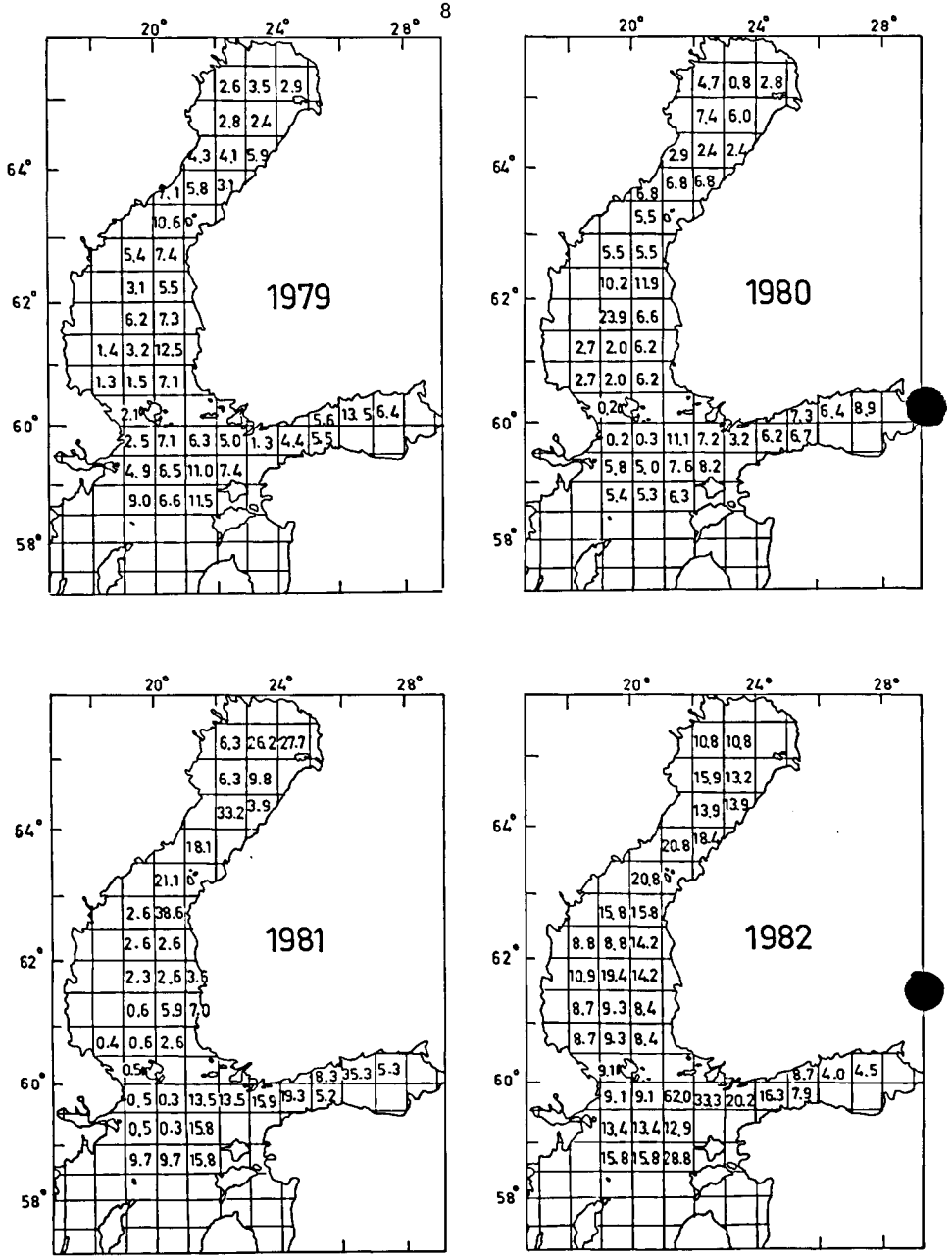

Figure 2. Distribution of Baltic herring (tonnes/nm^2) according to echo counting in 1979-82.

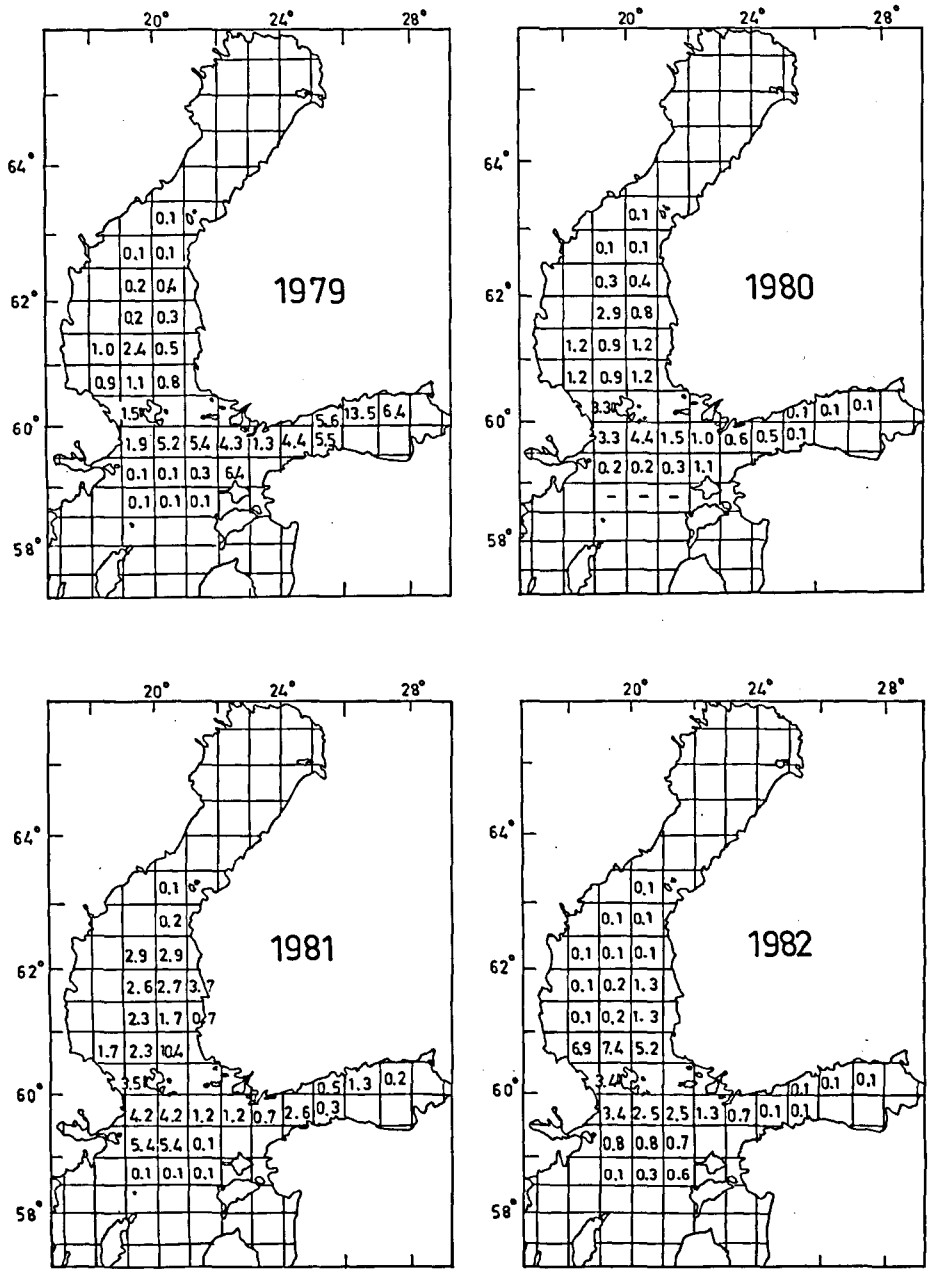

Figure 3. Distribution of sprat (tonnes/nm^2) according to echo counting in 1979-82.

Table 1. The mean abundance of Baltig herring and sprat (tonnes/nm^2) according to echo countigs in July-August 1979-82 (Sub-divisions 29-32, n = number of nautical miles covered).

Year	Sub-division	Herring			Sprat		
		$\bar{x}$	Range	S.D.	$\bar{x}$	Range	S.D.
1979	29 (n = 284)	6.7	2.1 - 11.5	2.9	2.1	0.1 - 5.2	2.5
	30 (n = 202)	5.6	1.3 - 12.5	3.5	0.6	0.1 - 2.4	0.6
	31 (n = 154)	4.1	2.6 - 7.1	1.6	-	-	-
	32 (n = 144)	6.1	1.3 - 13.5	4.0	2.1	0.3 - 7.7	2.8
1980	29 (n = 262)	5.2	0.2 - 11.1	3.4	1.7	0.2 - 4.4	1.6
	30 (n = 168)	7.0	2.0 - 23.9	5.9	0.9	0.1 - 2.9	0.9
	31 (n = 116)	4.5	0.8 - 7.4	2.3	-	-	-
	32 (n = 140)	6.5	3.2 - 8.9	1.9	0.2	0.1 - 0.6	0.3
1981	29 (n = 153)	6.7	0.3 - 15.8	7.2	2.4	0.1 - 5.4	2.3
	30 (n = 144)	8.8	0.4 - 38.6	11.9	2.6	0.2 - 10.4	2.8
	31 (n = 60)	17.9	3.9 - 33.2	11.5	-	-	-
	32 (n = 107)	14.9	5.2 - 35.3	11.5	0.9	0.2 - 2.6	0.9
1982	29 (n = 99)	25.1	9.1 - 62.0	17.2	1.4	0.3 - 3.4	1.1
	30 (n = 151)	11.9	8.4 - 20.8	3.8	2.7	0.1 - 7.4	3.1
	31 (n = 99)	15.5	10.8 - 20.8	3.6	-	-	-
	32 (n = 122)	10.3	3.9 - 20.2	6.0	0.1	0.01 - 0.7	0.6

Table 2. The proportions of Baltic herring and sprat by weight (%) in exploratory pelagic trawl catches in July/August 1979-82 (Subdivisions 29-32).

Subdivision	Haul number and position	Herring				Sprat			
		1979	1980	1981	1982	1979	1980	1981	1982
29	5. 59°30'N 22°30'E	53.8	87.8	91.9	96.2	46.2	12.2	8.1	3.8
	6. 59°31'N 20°33'E	97.6	96.2	4.6	94.7	2.4	3.8	95.4	5.3
	7. 58°32'N 20°30'E	99.7	100.0	99.9	98.1	0.3	-	0.1	1.9
	8. 59°47'N 20°03'E	57.5	5.4	11.8	76.2	42.5	94.6	88.2	27.4
30	9. 60°40'N 19°35'E	57.7	68.7	20.0	55.5	42.3	31.3	80.0	44.5
	10. 61°52'N 19°21'E	93.6	96.9	47.1	99.1	6.4	3.1	52.9	0.9
	15. 63°20'N 20°24'E	99.0	99.7	99.5	99.3	1.0	0.3	0.5	0.7
	16. 61°48'N 20°51'E	96.5	89.1	48.9	91.4	3.5	10.9	51.1	8.6
	17. 61°04'N 20°30'E	90.3	80.9	90.4	61.7	9.7	19.1	9.6	38.3
31	11. 63°33'N 21°26'E	100.0	100.0	100.0	100.0	-	-	-	-
	12. 64°35'N 22°35'E	100.0	100.0	100.0	100.0	-	-	-	-
	13. 65°18'N 23°36'E	100.0	100.0	100.0	100.0	-	-	-	-
	14. 64°21'N 23°10'E	100.0	100.0	100.0	100.0	-	-	-	-
32	1. 60°12'N 27°06'E	95.4	99.2	96.4	99.7	4.6	0.8	3.6	0.3
	2. 60°00'N 26°00'E	74.8	99.0	94.7	99.8	25.2	1.0	5.3	0.2
	3. 59°59'N 25°15'E	91.8	93.2	88.1	99.7	8.2	6.8	11.9	0.3
	4. 59°45'N 24°00'E	11.1	84.0	95.7	96.9	88.9	16.0	4.3	3.1

Table 3. The age distribution (%) of Baltic herring samples from exploratory pelagic trawl catches in July/August 1979-82 (Sub-divisions 29-32).

Sub-div.	29				30				31				32			
Age group	1979	1980	1981	1982	1979	1980	1981	1892	1979	1980	1981	1982	1979	1980	1981	1982
1	-	0.3	11.5	1.5	-	4.0	23.1	3.6	0.3	45.4	0.5	-	8.3	43.5	48.0	20.3
2	24.3	23.3	38.6	50.8	6.6	17.4	21.1	23.5	0.6	0.6	40.3	5.3	52.4	18.5	36.3	47.8
3	18.8	29.8	11.5	17.4	7.4	12.0	5.8	15.8	1.6	1.9	6.0	32.0	7.3	15.5	8.0	26.0
4	23.0	18.0	9.9	4.3	40.6	5.8	8.5	1.4	19.8	2.8	1.5	4.0	19.8	2.0	4.3	1.3
5	9.5	14.3	5.7	4.3	13.2	33.2	9.1	5.2	6.6	24.4	5.0	2.3	3.8	8.0	0.8	2.8
6	10.0	4.0	12.6	5.3	14.8	11.2	20.1	9.4	25.2	7.5	21.0	9.5	2.0	2.8	1.8	1.0
7	7.8	5.5	3.1	9.1	5.6	9.4	7.3	23.5	16.4	8.6	5.5	16.8	1.0	2.3	0.3	0.5
8	3.5	2.5	0.8	1.0	4.2	3.2	2.3	6.4	14.2	5.0	8.0	11.3	0.5	2.8	-	-
9	2.0	1.3	3.4	1.8	4.2	1.6	1.5	6.8	8.8	3.1	5.5	9.8	3.0	2.0	-	-
10	0.7	1.0	0.8	0.8	1.2	1.4	0.8	2.0	3.8	0.6	3.5	3.3	1.2	2.0	0.5	-
10+	0.5	0.3	2.2	3.8	2.2	0.8	0.5	2.4	2.8	0.3	3.3	6.0	0.7	0.8	-	0.5
n	400	400	262	396	500	500	398	499	318	361	400	400	399	400	400	400
Mean weight (g)	32.8	30.2	32.4	32.1	32.0	27.2	24.6	31.1	43.1	24.0	33.1	41.0	28.6	22.0	19.4	23.8

Table 4. The age distribution (%) of sprat samples from exploratory pelagic trawl catches in July/August 1979-82 (Sub-divisions 29, 30 and 32).

Sub-div.	29				30				32			
Age group	1979	1980	1981	1982	1979	1980	1981	1982	1979	1980	1981	1982
1	1.2	-	-	-	0.6	0.5	0.8	-	0.8	36.7	6.3	1.0
2	1.6	2.0	3.0	19.1	0.2	1.2	1.7	16.8	0.8	2.6	29.4	54.6
3	8.9	2.3	5.4	14.4	3.8	0.7	1.7	4.2	2.5	1.3	6.3	8.6
4	46.4	5.0	2.4	6.2	61.2	3.5	0.5	1.6	82.0	1.0	1.6	2.5
5	1.2	65.3	7.7	0.6	0.4	63.1	3.5	0.5	0.8	48.6	3.5	-
6	5.2	0.7	71.7	2.9	8.6	0.7	70.7	1.8	1.5	0.6	45.3	1.0
7	22.6	3.0	0.3	48.2	10.0	7.2	6.2	57.6	9.5	1.9	0.3	27.8
8	1.6	17.0	1.3	-	0.2	12.6	7.9	1.1	-	4.2	0.6	0.5
9	2.8	-	5.4	1.5	5.0	0.5	1.0	4.2	0.3	-	5.7	-
10	2.4	-	2.0	5.6	4.0	1.0	1.0	8.4	0.8	0.3	0.3	3.0
10+	6.0	4.7	1.4	1.5	6.0	8.9	4.9	3.9	1.3	2.9	0.6	1.0
n	248	300	298	340	500	404	402	382	400	313	316	198
Mean weight (g)	15.3	14.6	16.3	15.4	13.4	12.4	13.9	13.6	16.1	11.5	14.9	14.0