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On the identification of recruit spawners in the
Norwegian herring stock

by

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As already has been shown by Hjort (1914) one of the most striking characteristics of the Atlanto-Scandian herring, is the great fluctuations in numerical strength of the year classes, especially in the Norwegian spring spawning stock. The fluctuations in stock abundance are, however, smaller than one should expect because of the wide range in age at first spawning in herring of the same year class.

An analysis of the rings in the herring scales of the 1950 year class shows that the recruitment to the spawning stock of this year class took place during the years 1953 to 1959 at an age from 3 to 9 years. The majority of the year class matured at an age of 4-7 years. Also in 1959 there seemed to be a relatively large proportion of recruit spawners from the 1950 year class.

During the Norwegian winter herring fishery in the years 1954 to 1963, the 1950 year class constituted more than 50 per cent of the total catch of adult herring. In view of the decline in the fishery already in 1957 - 1958 (Østvedt 1963) it seems possible, however, that the proportion of recruit spawners in the samples from 1958 and 1959 were overestimated. During the same years the spawning grounds shifted northwards (Devold 1963); there is no evidence, however, that the migration pattern of the older spawners differed from that of the recruits and that these were less available during the fishing season.

Since regular estimation of the age at first spawning in the Norwegian herring was introduced by Runnstrøm (1936), it has also been noticed that the proportion of recruit spawners often are too high compared with the second time spawners the following year (Østvedt 1963).

To study these problems the present analysis has been undertaken on the identification of the spawning rings and the recruitment pattern of the 1950 year class.

Material and Methods

During the winter herring fishery on the Norwegian west coast, herring have been sampled from the commercial catches taken with purse seine, land seine and gill net.

The age at first spawning has been estimated from the number of coastal, oceanic and spawning rings in the scales (Lea 1929, Runnstrøm 1936). According to Lea (1929) the number of the types of winter rings correspond with the number of years, the herring have been living under the various environmental conditions. The coastal rings, ranging from one to six, may be

separated in a fastgrowing southern type (S) with diffuse winter rings and large summer growth, and a slowgrowing northern type (N) with sharp winter rings and small summer growth. In both groups the oceanic rings, usually one or two, seldom three (Runnström 1936), are more diffuse, separated from the coastal rings by a zone of large summer growth.

The winter rings do not appear at the edge of the scales until March or April. The recruit spawners may therefore be distinguished from the immature herring by the stage of maturity only. It is supposed that during the winter herring season, herring which are in maturity stage III, do not spawn until next winter. According to the growth type and winter rings, herring taken during the spawning season are classified e.g., as S 2-1-0, which means a 4 years old recruit spawner of the southern type (S) with two coastal rings, one oceanic ring and no spawning rings. The first spawning ring cannot be seen at the edge of the scale until after the spawning season. As second time spawners the following year, herring of the same group are classified as S 2-1-1.

Groups of spawners in the 1950 year class

Fig. 1 shows the percentage distribution of the different groups of spawners of the 1950 year class in samples from the winter herring fisheries 1954 to 1962. Herring of the southern type (S) recruited the spawning stock in 1954 and 1955 (a few in 1953, not included in the figure). Already in 1956 the northern type (N) was more abundant, and when fully recruited, in 1959 at the latest, the northern type constituted more than 67 per cent of the herring sampled. It appears from the figure that the relative abundance of a group as second time spawners is often low compared with the same group as recruit spawners and as third time spawners. According to the data given in fig.1 the recruit spawners S 2-2-0 were for example far more abundant than the second time spawners S 2-1-1 in 1956. In the following year, 1957, the latter group was again predominant, and later on these two groups were about equally abundant. Similar changes in the proportion of N 3-1 and N 3-2 also appear from the figure.

A large reduction in the relative abundance of the group N 4-2-0 was noted in 1958 when it appeared as second time spawners (N 4-2-1). In 1957 the recruit group N 4-2-0 constituted nearly 40 per cent of the herring sampled. In 1958 as second time spawners, the same group N 4-2-1 made out less than 10 per cent, and a group of recruit spawners identified as N 6-1-0 were predominant.

After 1959, when all the groups of the 1950 year class had been recruited, the percentage distribution of the groups were nearly constant from year to year, as one might expect if the reading of the winter rings in the scales is consistent from year to year.

The Composition of the immature herring of the 1950 year class

Herring in maturity stages I,II and III are usually scarce in the samples from the winter herring fishery and are mainly taken in purse seine or land seine catches. In years when a rich year class is recruited, the proportion of immature herring in the winter herring catches may increase considerably. In 1954 nearly 20 per cent of the herring in the samples were immature (stages I - III).

In Table 1 the total number of immature herring of the 1950 year class in the samples from the winter herring fishery 1953-1959 is presented according to growth type and stage of maturity together with the different types of spawners recruited in the same years. Except for the years 1957 and 1958 the occurrence

of the different groups in stages II and III correspond to the groups of recruit spawners during the following year. In 1957 herring of the group N 4-2 in stages II and III were most abundant, but during the following spawning season, in 1958, only recruit spawners of N 6-1-0 were identified. In 1958 and also in 1959 no herring of the 1950 year class in maturity stages II and III were recorded in the samples from the winter herring season.

Table 1 also indicates that the largest individuals in stages II and III attain maturity during the following summer and autumn and spawn the next winter. But the small sized herring taken during the winter in maturity stage II probably need two years more before spawning.

The growth in length of the different group of spawners

In fig.2 is shown the length frequency distribution of the northern and the southern types of the 1950 year class in the years 1954-1962. Only herring in maturity stage IV-VIII are included. In 1957 a slow growing northern type appeared as recruit spawners. From the scale analysis the majority was identified as N 4-2-0, and a few as N 6-0-0 (fig.1) the latter being recruits without an oceanic ring.

Figure 3 shows the length frequency distribution of the most common groups of spawners and also the length of the same groups in maturity stages II and III. Except in 1957 recruit spawners with two oceanic rings had almost the same length distribution as the second time spawners with the same number of coastal rings and with only one oceanic ring. In 1957 the recruits N 4-2-0 had a bimodal length distribution and the dominant group (below 30.5 cm in length) had a mean length of 29.2 cm (fig.7). The second time spawners, N 4-1-1 had a mean length of 32.0 cm. When comparing the length of the recruit spawners N 4-2-0 in 1957 with the immatures N 4-1 in 1956 which should be expected as recruit spawners the following year, this group was apparently not present in the winter herring samples in 1956. In 1958 all the herring identified as N 4-2-1, second time spawners, had a mean length of 32.8 cm and a length distribution corresponding with the length of the third time spawners N 4-1-2 (mean length 32.7 cm) with one oceanic ring, as appear to be the case for herring of northern or southern type with the same number of coastal rings (fig.3).

The recruits in 1957, below 30.5 cm in total length identified as N 4-2-0 were evidently not present among the second time spawners in 1958 unless they had had an exceptional growth in length from the first year of spawning to the second. In 1958 about 27 per cent of the herring in the samples were identified as recruits of the type N 6-1-0 with a mean length of 31.0 cm, an increase of 1.8 cm compared with the mean length of the recruits N 4-2-0 in 1957, which is about the average growth in length of spawners at this age. It seems therefore possible that the group of small spawners identified as N 4-2-0 in 1957, in the following year were identified as recruit spawners N 6-1-0. If this holds true, the recruit spawners in 1957 smaller than 30.5 cm were of the type N 6-0-0, thus spawning without an oceanic ring. Further evidence that these herring were of a similar growth type as the recruits identified as N 6-1-0 is provided by studying the growth in length of the different groups as shown in fig.4 (data obtained by backcalculation from the scales). The growth curve obtained for the recruits in 1957 is identical with the growth curve of the recruits N 6-1-0 in 1958 and different from the growth curve obtained for the second time spawners, N 4-2-1 in 1958. It thus seems likely that part of the group of herring identified as recruits spawners N 6-1-0 in 1958 in fact were second time spawners N 6-0-1. Herring in maturity stages II and III of the type N 6 were also present in 1957 and probably appeared as recruits N 6-1-0 in 1958. There seems at present to be no methods of splitting the two groups of

spawners in 1958, the recruits N 6-1-0 with one oceanic ring and the second time spawners N 6-0-1 without an oceanic ring. Also in 1959, part of the spawners identified as recruits may have been either second time spawners N 6-1-1 or third time spawners N 6-0-2.

Discussion

The data presented above indicate that a part of the spawners of the 1950 year class attained first maturity without forming an oceanic ring in the scales. When these herring appeared as second time spawners the first spawning ring was identified as an oceanic ring. The frequency distribution of the various groups of spawners and the corresponding length distribution also indicate that the proportion of recruits with two oceanic rings tend to be overestimated, part of them being second time spawners with one oceanic ring only. That the first spawning ring in the second time spawners may be interpreted as an oceanic ring is certainly difficult to prove. Samples from earlier years give, however, some indication.

In April and May 1935 herring in maturity stages VII and VIII were taken south of Lofoten; the scale readings showed that a winter ring had already been formed at the edge of the scales. Since the herring had just spawned, the last winter ring was definitely a spawning ring and the herring were identified as N 3-1-1 of the 1930 year class. But according to Thorolv Rasmussen (personal communication) who did most of the age readings on the Norwegian herring from 1919 to 1955, the first spawning ring would definitely have been recorded as an additional oceanic ring (N 3-2), if the herring had been caught after passing into maturity stage III later in the summer, or during the next spawning season.

As has been shown by Runnstrøm (1936) the number of oceanic rings usually varies between one and three, one and two rings being most common. In the intermediate oceanic stage the herring are rarely caught near the Norwegian coastal waters. Lea (1929) supposed they were living in the central Norwegian Sea wherefrom they migrated to the spawning grounds on the Norwegian west coast and joined the older spawners. One might therefore expect that if herring are spawning without an oceanic ring, they have attained maturity without passing the oceanic stage.

In June 1956 samples from catches taken in Norwegian coastal waters (off Møre and Halter) almost exclusively consisted of herring of the 1950 year class identified as N 4-2 in maturity stage III. The samples taken in the Norwegian Sea later in the summer contained only very few herring of the same type and length. The estimated growth curve for the group of herring identified as N 4-2 in coastal samples shows a similar growth as for the group of "small" spawners in 1957 of the type N 6-0-0. This observations indicate that the recruit spawners without an oceanic ring mainly were living near to the Norwegian coastal waters during the summer before spawning in the winter of 1957.

Runnstrøm (1936) showed that in 1935 herring were spawning in the Lofoten region. The samples from the catches consisted of recruit spawners of the 1930 year class mainly identified as N 3-1-0. The data sheets indicate that several individuals, in one sample as many as 15 per cent, were of the type N 4-0-0, recruit spawners without an oceanic ring.

During the winter herring seasons in 1963, 1964 and 1965, spawning herring have been caught in relative great quantities in the Lofoten region. In 1963 the catches consisted of recruit spawners of the 1959 year class (about 90 per cent) and the 1960 year class, mixed with immature herring of the same year classes. In 1964 recruits of the 1959 year class were also predominant and only

6 per cent were second time spawners. In 1963 the recruit spawners S 2-1-0 were most abundant in the 1959 year class while in 1964 herring of this group made out only 6 per cent of the year class, the recruit groups S 2-2-0 and N 3-1-0 dominating (Table 2). In both years, however, some herring have been identified as spawners without an oceanic ring, N 3-0-0 in 1963 and N 4-0-0 in 1964.

No spawning herring were taken in the Lofoten region in 1957 when spawning herring without an oceanic ring were taken in the winter herring catches further south along the Norwegian west coast; but no surveys for location of herring were carried out in the Lofoten region.

In March 1958 spawning herring were found near Røst and a total of about 60 000 hl were taken in a few days. These herring had the same distribution in age and groups of spawners as those in the samples taken on the spawning grounds further south. About 15 per cent of the herring were recruit spawners, mainly identified as N 6-1-0.

In the early fifties the herring fished by the Soviet fleet were mainly feeding in the northern Norwegian Sea south of Mohm's Ridge (Marty 1956). The eastern part of the area was characterized by a surplus of young maturing herring. Further west, near Jan Mayen and north of latitude 72°N older fish prevailed. Marty also writes that the recruit spawners often spawn near to their feeding grounds. One might therefore expect that in years when a relatively large proportion of maturing herring emigrate from the Barents Sea, and feed off the coast of Northern Norway, spawning takes place also in the Lofoten region, as in fact has been demonstrated during the years, 1963 - 1965. The last year before attaining maturity and spawning in Lofoten these herring have mainly been feeding in off the coast northern Norway are close to the continental shelf.

When maturing, some herring have may live under similar environmental conditions as in their earlier years of life. The last winter ring before the herring attain maturity may therefore be of a similar type as the coastal rings and the herring are thus spawning without an oceanic ring in the scales.

Summary and conclusions

The data on the distribution and the growth of the different groups of spawners in the 1950 year class have been considered. It is shown that a group of recruit spawners in 1957 probably feeding near to Norwegian coastal waters during the summer before attaining maturity had no oceanic ring in the scales.

It appears that this type of herring is frequently found among recruit spawners in Lofoten. The herring spawning in Lofoten during 1963 - 1965 had been feeding off the coast of Northern Norway. It is concluded that spawning herring without an oceanic ring may occur when emigrants from the Barents Sea mature under similar environmental conditions as in their earlier years of life.

The present analysis also indicates that the first spawning ring may be identified as an additional oceanic ring. This applies especially to recruit spawners with one oceanic ring. The result is that the proportion of recruit spawners is overestimated, and that of the second time spawners underestimated.

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Table 1. Immature herring in the winter herring samples according to growth type and stage of maturity (in numbers) and the groups of recruit spawners each year.

Year of sampling	Type	Maturity stage			Group of recruit spawners
		I	II	III	
1953	S	16	39	7	
	S 1+1	-	6	2	S 1 + 1 + 0
	S 2	44	28	7	
	N	1	-	1	
	N 2	136	19	-	
1954	S	-	5	11	
	S 1+2	-	-	12	S 1 + 2 + 0
	S 2+1	2	123	222	S 2 + 1 + 0
	N	12	83	29	N 1 + 2 + 0
	N 2+1	4	137	50	N 2 + 1 + 0
	N 3	80	246	24	N 3 + 0 + 0
1955	S 2+2	-	3	41	
	N 2+2	-	2	7	N 2 + 2 + 0
	N 3+1	4	75	147	N 3 + 1 + 0
	N 4	49	170	39	N 4 + 0 + 0
1956	N	-	-	2	
	N 2+3	-	-	1	
	N 3+2	-	2	7	N 3 + 2 + 0
	N 4+1	-	23	85	N 4 + 1 + 0
	N 5	-	8	7	N 5 + 0 + 0
1957	N	-	1	7	
	N 3+3	-	1	1	N 3 + 3 + 0
	N 4+2	-	30	62	N 4 + 2 + 0
					N 5 + 0 + 0
	N 6	-	58	63	N 6 + 0 + 0
1958					N 6 + 1 + 0
1959					N 6 + 2 + 0

Table 2. Lofoten 1963 - 1964. Groups of spawners in the 1959 year class (%)

Age at 1. spawning	Groups of spawners	1963 %	1964 %
4	S 1+2+0	0.5	
	S 2+1+0	89.4	
	N 2+1+0	6.3	
	N 3+0+0	3.8	
5	S 2+2+0		24.1
	N 2+2+0		1.4
	N 3+1+0		61.6
	N 4+0+0		4.7
4	S 2+1+1		6.7
	N 2+1+1		1.5
Total number		368	949

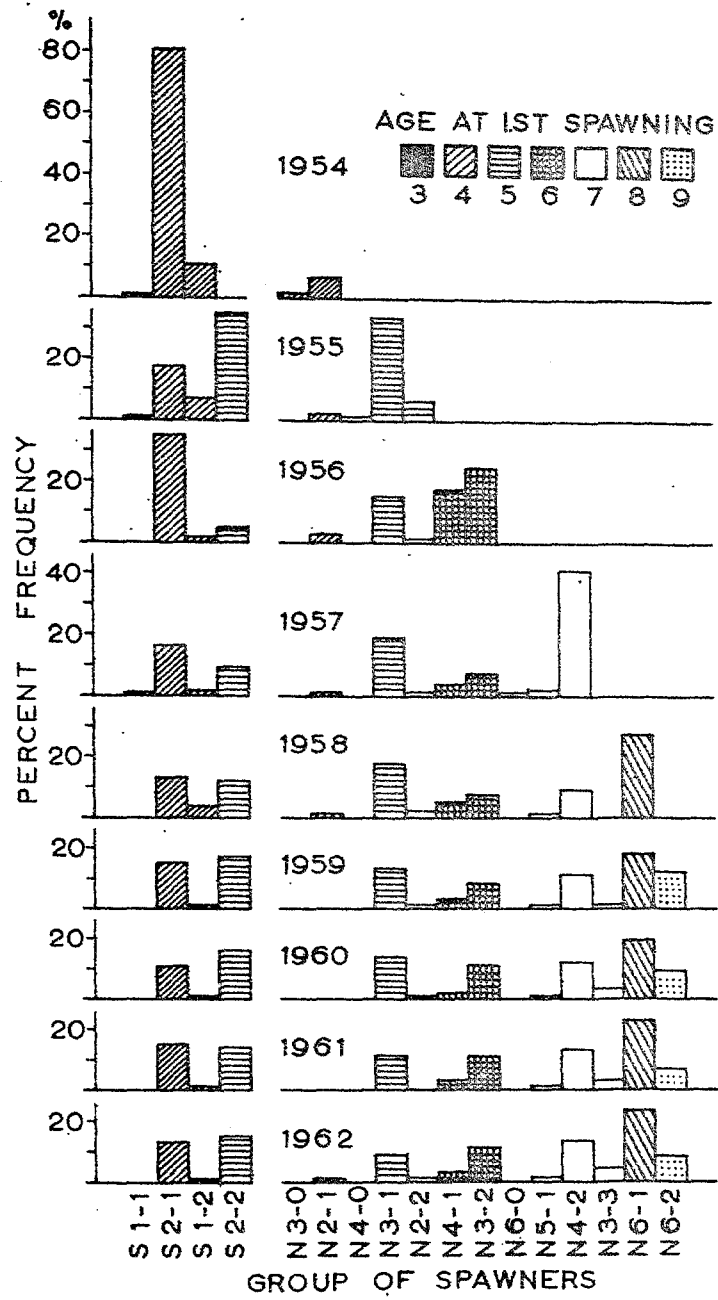


Fig. 1. Percentage distribution of groups of spawners in the 1950 year class.

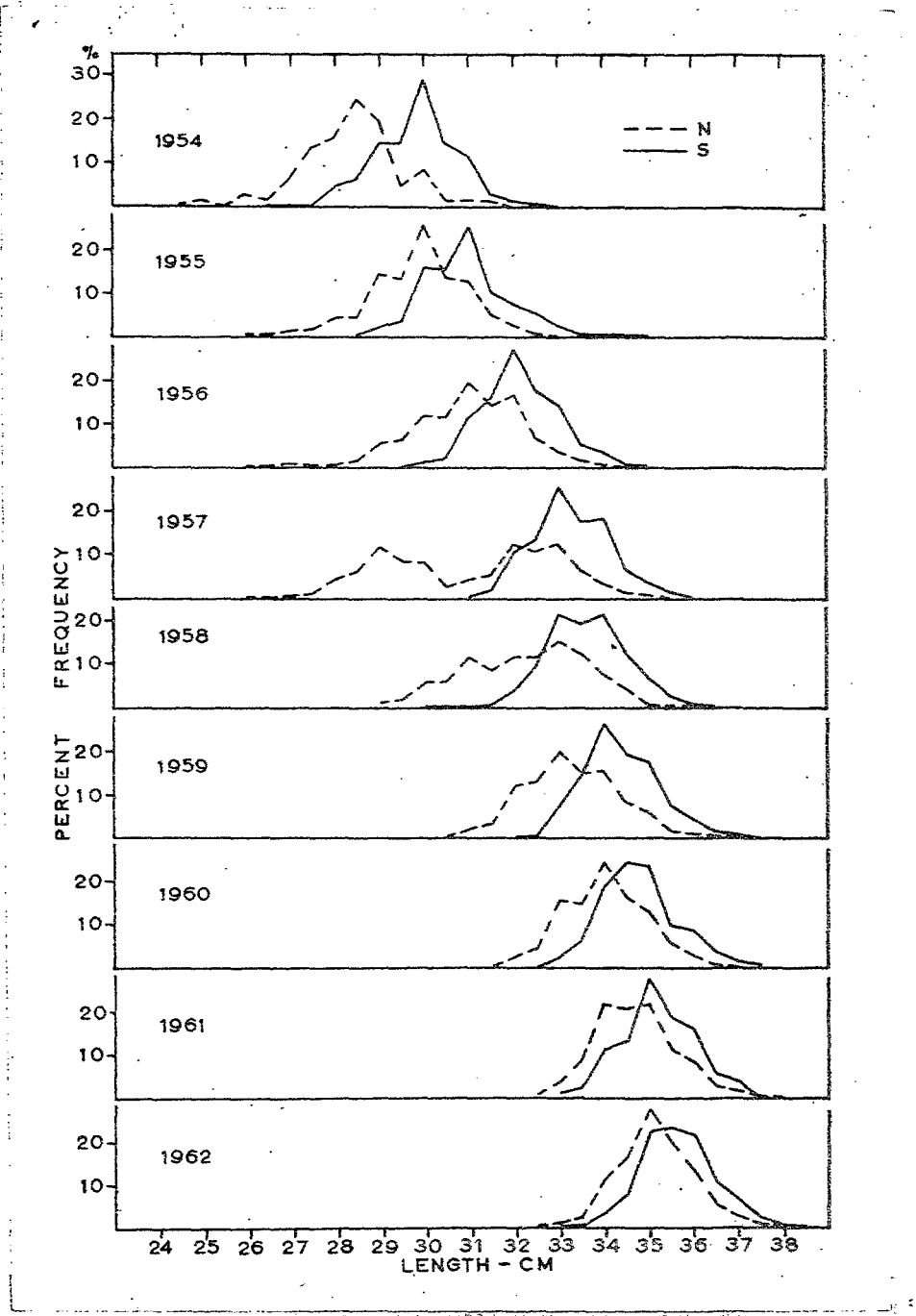


Fig. 2. Length distribution of Northern (N) and Southern (S) type of herring in the 1950 year class .

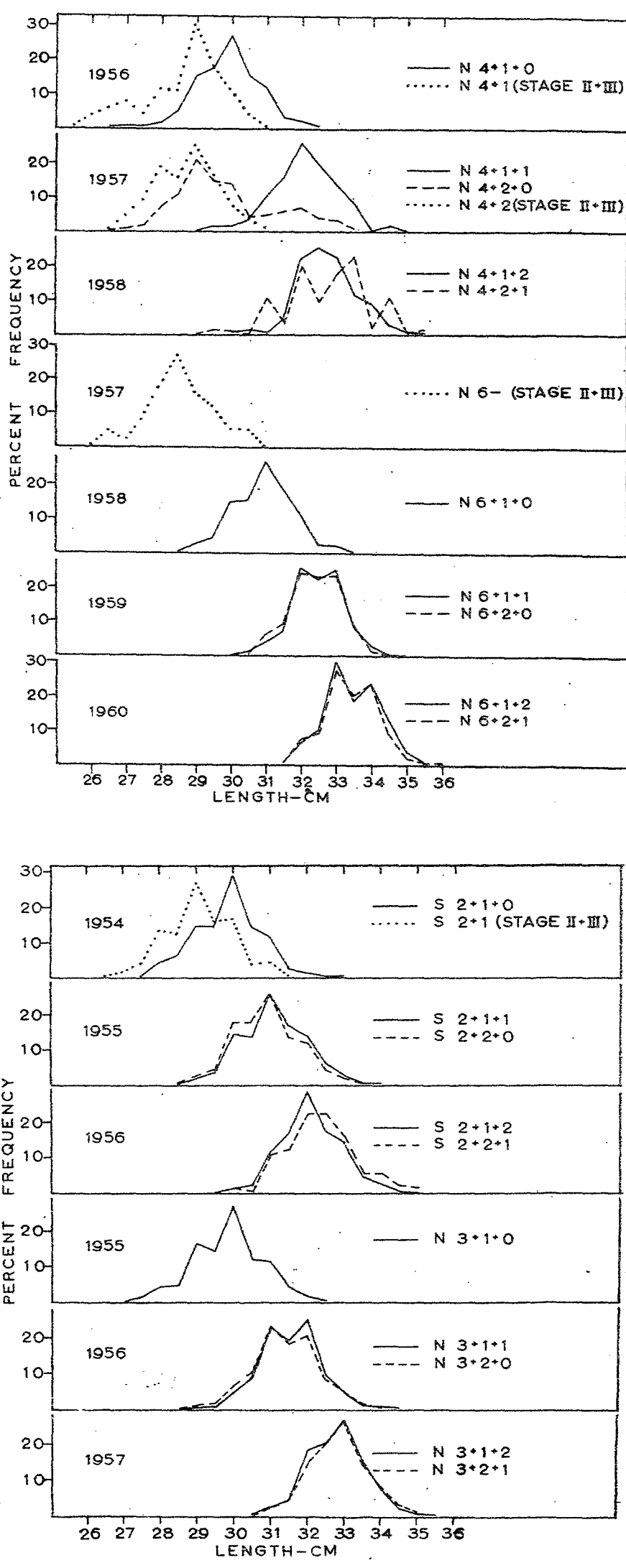


Fig. 3. Length distribution of groups of spawners and pre-recruits in the 1950 year class.

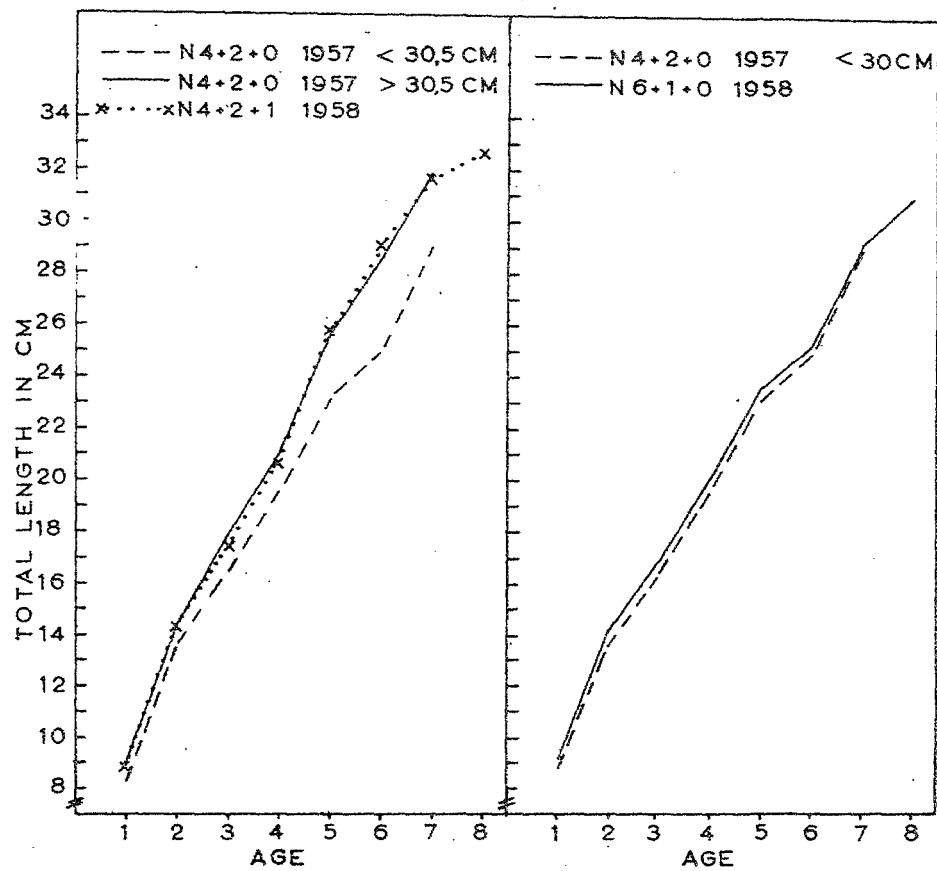


Fig. 4. Calculated growth in length of groups of spawners in the 1950 year class .