Fol. 41

This paper not to be cited without prior reference to the author

International Council for the
Exploration of the Sea

C.M. 1964
Herring Committee
No. 141

Growth and maturation of the Norwegian herring

by

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During the years 1958 - 1961 the recruitment to the mature stock of the Norwegian spring spawning herring was at a very low level with the result that the average age and length increased (Østvedt 1963). A similar period with low recruitment was observed during the years 1912 - 1915 (Lea 1917) when the year-class 1904 dominated. But although the average age in 1916 was exactly the same as in 1960, 9,8 years, the corresponding mean length was only 32,0 cm against 34,1 cm in 1960. This difference in mean length could therefore suggest an increase in growth of the Norwegian herring as observed in the herring stocks of the North Sea (Cushing & Burd 1957, 1962; Parrish and Craigh 1963), of the Skagerak (Andersson 1954), and of the Baltic (Daniel 1958).

Figure 1 shows the percentage length compositions (cm below+) of all samples, irrespective of gears, secured during the winter herring seasons of 1907 to 1963. In this report distinction has not been made between "large herring" and "spring herring", whereas the reports on length and age composition of Norwegian herring of Lea (1929), Runnstrøm (1936, 1941) and Sund (1943), often refer to "spring herring" only or separately. It is seen that the proportion of herring larger than 35 cm in total length has steadily increased during these years, particularly in the fifties when the rich year-class of 1950 predominated. The mean length of five, seven and ten year old fish during the same period are shown in Figure 2. Fish in all stages of maturity obtained in the samples from the winter herring catches are included. Maturity stages I, II and III were usually represented in small numbers in the youngest age groups only. The ten year old fish were all mature (stage IV to VII during the winter herring fishery). For the years 1941 to 1963 the mean length is given for gill net and purse seine samples separately. The difference in length of the five and seven year olds between purse seine and gill net samples is probably mainly due to mesh selection by gill nets. For the ten year old fish the difference in length observed sometimes may be mostly ascribed to the effects of various other factors, such as depth of fishing, shoaling and fish behaviour. The samples from the winter fishery have in most years mainly been drawn from the purse seine or land seine catches.

Since the beginning of this century the mean length for age (Fig. 2) shows on the whole a trend of increase. The grand average of the mean length of five to fiften year old fish during different periods are given in Table 1. Apparently the length increase in all the age groups was greatest during the last period, from 1951 to 1963

According to Burd (1962) the increase in mean length for age in the herring of the southern North Sea was followed by an earlier

+No corrections are made for the years 1930 (?) to 1962 when the herring were measured to the nearest $\frac{1}{2}$ cm.

maturation and he concluded that the recruitment (maturation) is a function of length and not age. Already Lea (1929) demonstrated the relationship between length and maturation, and he showed that the fast growing herring in the Norwegian spring spawning stock, termed southern type, reach maturity earlier than the slow growing herring of northern type. Runnstrøm (1936) distinguished between several components within the southern and northern types according to the appearance of the winter rings and summer zones. The winter rings were named, according to Leas definitions; coastal, oceanic and spawning rings. Runnstrøm showed that the first spawning generally occurred when the herring had reached a length of about 28-29 cm (figures estimated from backcalculation of scale measurements). This length would be reached at an age ranging from 3 to 7 years, occasionally as much as 8 to 9 years. The conclusion to be drawn on from this is that the age at first maturity in herring is closely related to the growth of the fish. Consequently, it should be expected that the observed increase in mean length for age were accompanied with a corresponding decrease in age at first maturity as suggested by Burd (1962) for the herring of the southern North Sea.

In the previous report (Østvedt 1958) it was shown that the mean age at first spawning for herring of the southern type remained nearly constant at about 4,4 years for the year-classes 1934 to 1944. The northern type of the same year-classes showed on the other hand a decrease in their mean age at first spawning from 7,5 years for the year-class 1934 to 5,1 years for the year-class 1944. The mean age at first spawning for the northern type later increased again, beeing 7,1 year for the year-class 1950. This observed change in mean age at first spawning is probably due to variation in the relative abundance of different growth components within the southern and the northern types of the year-classes. In the year-class 1950 a slow growing type (N_{6-1} i.e. six coastal and one oceanic rings) maturing at an age of eight years was especially abundant. It is therefore of importance when studying the possible effect of this length increase on maturity to consider separately the data of each growth type in the various year-classes.

Table 2 shown the length at different ages of a few growth types in some year-classes. Backcalculation from scale measurements of the length - age values were carried out for seven to ten year old fish. It is evident that the increase in length has occurred within all the different growth types considered, but there is no indication of an increase in age at first maturity. Fish of the year-class 1950, maturing at an age of four years (S_{2+2}) had at first maturity a mean length of 30,4 cm while the mean length at first maturity for the same growth type of the year-class 1904 was only 26,9 cm.

During the years 1946 to 1962 the mean length of all the first time spawners varied between 30,0 cm to 32,3 cm with a grand average of 30,9 cm. In the early thirties the mean length of first time spawners was generally 28 - 29 cm (Runnstrøm 1936). It is thus obvious that the length at first spawning has increased simultaneously with the observed increase in length for age.

The fluctuation in length at first spawning within the year-class 1950 is shown in Figure 3. The length at first spawning range from 26 cm to more than 34 cm; and fish maturing late were generally larger at first spawning than those maturing earlier. This appears also from the data given by Runnstrøm (1936).

Beverton (1963) estimated the parameter L_∞ of the von Bertalanffy growth equation for the Atlanto-Scandian herring to be 35-37 cm when using the data of Sund (1943) and Runnstrøm (1936). The present data for the year-class 1950 gives an L_∞ of about 38-39 cm. It should also be noted that the average length of the older age groups, mainly the year class 1950, in the samples from the 1964 winter herring fishery was 36,3 cm. Herring samples of old Norwegian herring obtained north of Iceland in June 1964 had a mean length of 37,5 cm. Beverton (1963) has further shown that the ratio L_m/L_∞ for Clupea harengus is rather constant at about 0,80 (L_m = length at first maturity). In accordance with this an increase in L_∞ should result in a higher mean length

at first maturity, as shown by the present data.

The L_I distribution of the different growth types, given in Table 3, shows that there is a trend towards higher values, and most of the increase in length for age is mainly ascribed to higher values of L_I. This is of particular interest in view of the changes in spawning time and place on the Norwegian west coast spawning grounds in recent years.

The data given above show that the length for age may increase without any detectable effect on the age at first spawning. This infers that maturation is not simply a function of growth. Burd (1962) found that there is a minimal length a herring must reach before the gonads commence to ripen. This may be true, but as pointed out by Blaxter and Holliday (1963) the controle of the process of maturation may be due to the interaction of some essential factors, such as food supply, temperature etc. Little is known about the duration of the various maturity stages of first time spawners. Preliminary investigation on the small and fat herring on the Norwegian coast seem to indicate considerably variation and this would also probably be reflected in length and age at first spawning.

The causes of changes in growth of herring have been discussed by several authors and some factors such as food supply (Cushing and Burd 1957, Cushing 1962), temperature (Popiel 1958) and stock density (Andersson 1954) have been considered. Since the increase in length for age of herring has been noticed both in the Norwegian Sea and the North Sea as well as adjacent areas, it is therefore of importance to investigate which common factors may controll the growth in length of herring living in these waters.

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Table 1 Mean length in cm of each age groups of Norwegian herring in different periods

Years	Age											
	5	6	7	8	9	10	11	12	13	14	15	
1908 - 1920	30,1	30,8	31,5	31,9	32,4	32,7	33,1	33,5	34,2	34,3	34,9	(- 1919)
1921 - 1930	29,5	-	31,7	-	-	33,5	-	-	-	-	-	
1931- 1940	29,8	30,9	31,8	32,6	33,2	33,6	33,9	34,2	34,4	34,5	34,7	
1941 - 1950	30,2	31,1	32,0	32,8	33,2	33,6	34,0	34,2	34,7	35,0	35,1	
1951 - 1963	31,3	32,6	33,3	34,0	34,5	34,9	35,3	35,6	35,8	35,9	36,0	

Table 2 Length for age of different growth types of the Norwegian herring

	S 2 + 1						S 2 + 2					N 3 + 1							N 3 + 2					N 4 + 2		
	Year-class						Year-class					Year-class							Year-class					Year-class		
	1904	1923	1925	1944	1947	1950	1904	1918	1923	1925	1950	1904	1918	1923	1925	1944	1947	1950	1904	1918	1923	1925	1950	1904	1923	1950
l_1	8,8	9,3	9,7	9,6	10,4	10,3	8,4	10,7	8,9	9,8	10,3	8,1	9,7	8,3	10,4	8,9	9,2	9,6	7,5	9,4	8,6	9,8	9,4	7,0	8,0	8,5
l_2	16,9	17,4	16,8	17,1	18,8	17,8	15,8	17,7	16,9	15,7	16,8	14,2	15,5	14,4	15,2	16,1	15,5	15,4	12,9	15,0	14,0	14,4	15,3	11,9	13,3	14,0
l_3	23,4	23,8	23,2	24,8	25,1	24,9	22,4	23,7	22,7	21,2	23,5	19,4	20,8	18,9	19,7	21,0	19,6	20,0	17,2	20,0	18,1	19,0	19,5	15,2	17,3	17,3
l_4	26,9	27,9	27,6	29,6	29,6	29,4	25,9	27,8	27,1	25,7	28,7	24,3	25,8	24,2	24,5	26,5	25,8	26,6	22,1	24,6	22,7	23,7	26,0	19,4	21,4	20,6
l_5	28,6	29,8	29,8	31,4	31,4	31,1	28,3	30,4	29,5	29,0	31,1	27,3	29,5	27,7	28,3	30,0	30,2	29,7	25,7	28,6	26,6	27,7	29,5	23,7	25,4	25,7
l_6	29,8	30,9	31,1	32,3	32,7	32,2	29,5	31,6	30,7	30,8	32,4	28,8	31,1	2 1,6	30,5	31,5	32,3	31,4	28,2	30,9	29,3	30,4	32,0	27,1	28,6	29,3
l_7	30,8	31,6	32,1	33,5	33,4	33,2	30,5	32,6	31,6	31,9	33,4	30,0	32,2	30,8	31,8	33,0	33,4	32,8	29,6	32,2	30,7	31,8	33,0	29,3	30,4	31,7
l_8	31,5	32,2	-	34,2	-	-	31,2	-	32,2	-	-	31,0	-	31,7	-	33,9	-	-	30,7	-	31,6	-	-	30,7	31,5	32,7
l_9	32,3	32,8	-	34,8	-	-	32,0	-	32,8	-	-	31,8	-	32,5	-	34,6	-	-	31,6	-	32,4	-	-	31,8	32,3	33,5
l_{10}	32,8	-	-	35,3	-	-	32,5	-	-	-	-	32,4	-	-	-	35,0	-	-	32,3	-	-	-	-	32,5	-	34,2
Age at first spawning	4						5					5							6					7		
Age at sampling	10	9	7	10	7	7	10	7	9	7	7	10	7	9	7	10	7	7	10	7	9	7	7	10	9	10
No	57	101	55	25	24	28	120	30	129	79	29	32	85	44	31	32	23	30	72	23	56	103	19	63	36	74

S 2 + 1 : Southern type, 2 coastal + 1 oceanic winter rings

N 3 + 1 : Northern type, 3 coastal + 1 oceanic winter rings

Table 3

L_1 distribution of different growth types of Norwegian herring ($\frac{1}{2}$ cm below)

L_1 cm	Growth type																									
	S 2 + 1						S 2 + 2					N 3 + 1							N 3 + 2					N 4 + 2		
	Year-class						Year-class					Year-class							Year-class					Year-class		
	1904	1923	1925	1944	1947	1950	1904	1918	1923	1925	1950	1904	1918	1923	1925	1944	1947	1950	1904	1918	1923	1925	1950	1904	1923	1950
13					1																					
			3		1			3	1						1											
12		2	2	3		2		2	2	2					1		2	1				1	2			
		5	2	3	4	1	1	1	2	5	1		3		5		2	3		1		6				
11	1	6	3	1	3		1	4	3	6	2		7		6	4	1	6		1	3	9	3			1
	2	6	6	2	6	4	2	3	11	10	7		10	1	3	2	3	2		1	2	13	2			1
10	3	12	6	4	2	3	2	11	6	7	3	1	16	1	4	3	1	4		4	3	17	1		1	2
	1 1	9	10	6	4	6	5	4	15	13	6	1	16	4	5	11	5	5		4	5	18	4		4	2
9	10	19	7	2	1	5	21	2	17	17	7	1	15	6	1	4	2	4	4	3	6	6	3	1	4	5
	10	19	4	1	1	3	24		18	14	2	7	10	8	1	4	3	4	6	4	8	19	3	2	4	12
8	6	9	9	2		4	26		23	3		8	5	8	3	1	2		15	2	10	9	1	5	6	15
	8	7	1	1			19		14	1	1	9	2	6	1		2		12	3	8	4		10	4	15
7	4	4	1				11		10	1		2	1	5		2		1	15		8			16	6	12
	1	2					4		5			3		2		1			9		2			14	5	8
6	1	1					3		2					3					9		1			10	1	1
																								4		
5																								1	1	
Total	57	101	55	25	23	28	120	30	129	79	29	32	85	44	31	32	23	30	72	23	56	102	19	63	36	74
Mean	1.8.8	9.3	9.7	9,6	10,2	10,3	8,4	10,7	8,9	9,8	10	8,1	9	8,3	10,4	8,9	9,2	9,6	7,5	9,	8,6	9,8	9,4	7,0	8,0	8,5

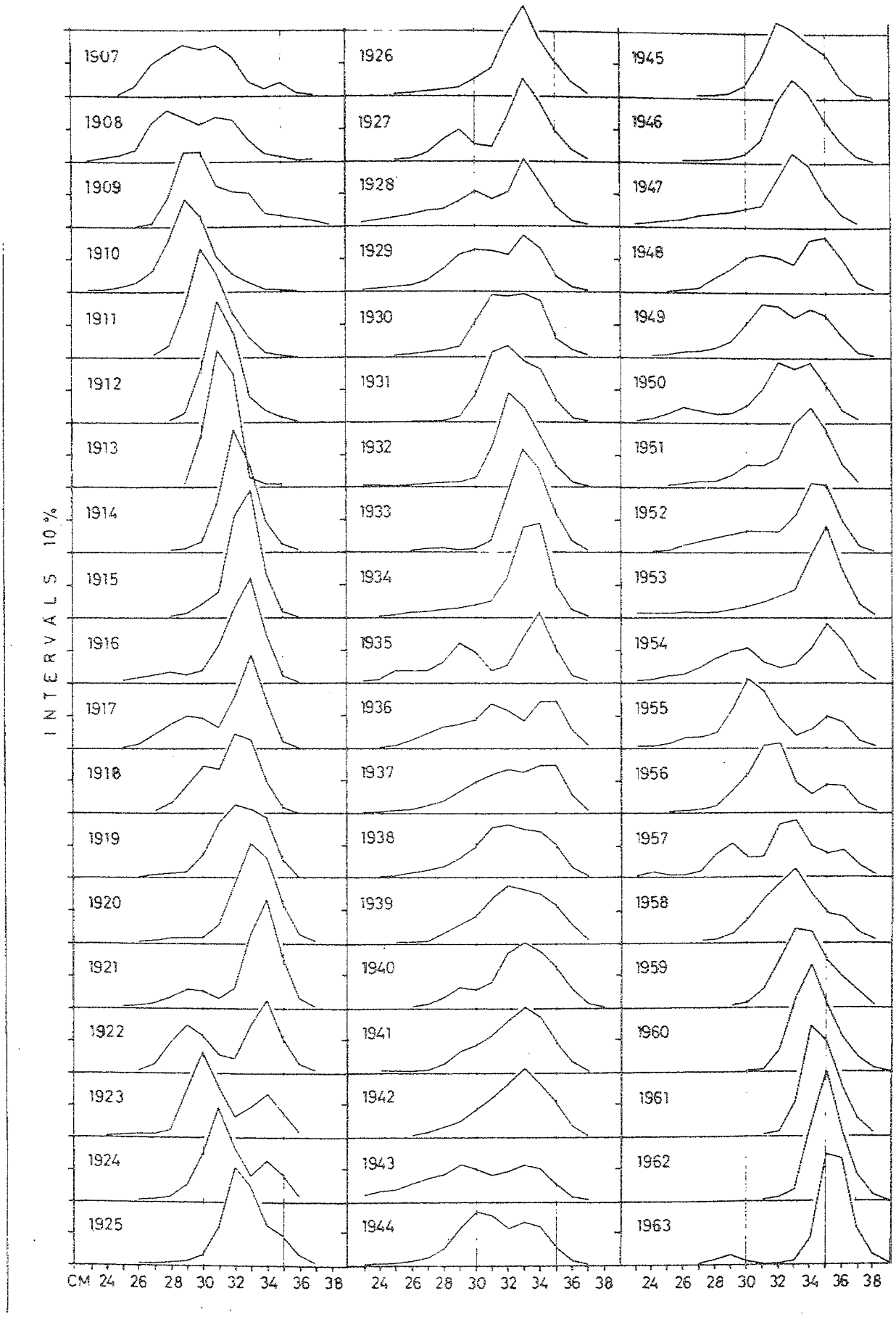

Fig. 1 Length distribution of samples from the Norwegian winter herring fishery 1907 - 1963.

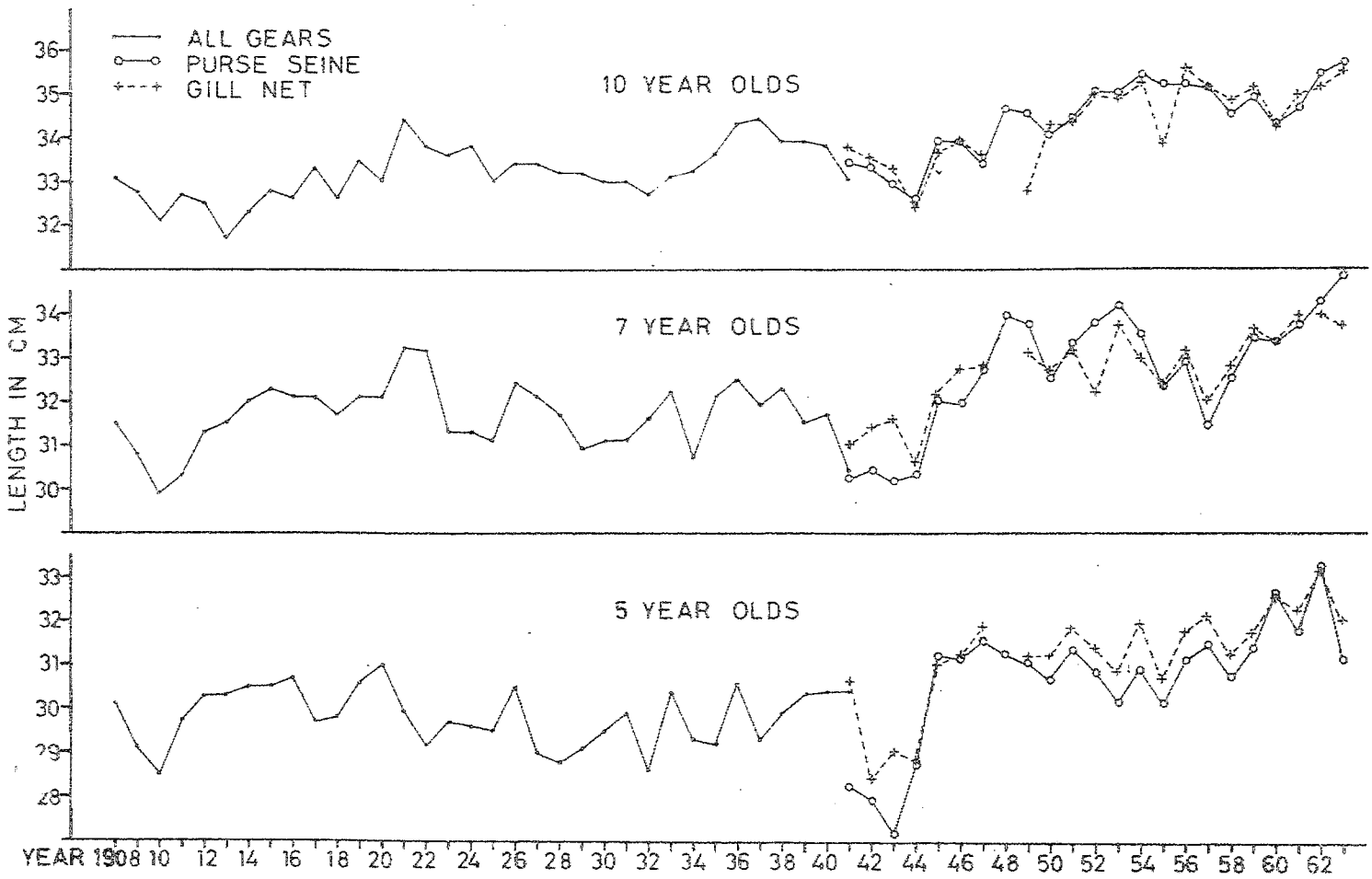

Fig. 2 Mean length of five, seven and ten year old fish in the Norwegian winter herring fishery.

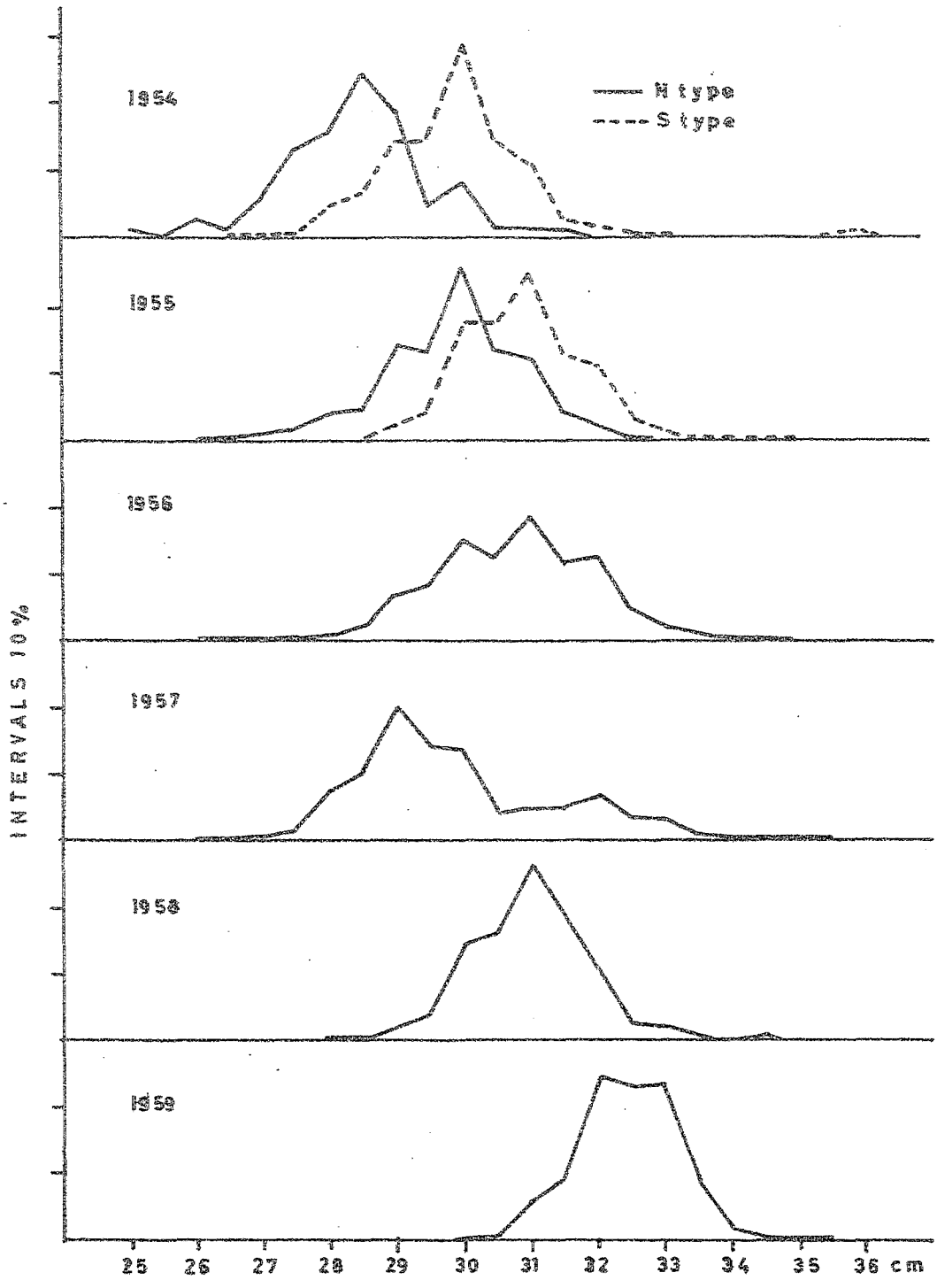

Fig. 3 Length distribution of first time spawners of the year-class 1950.