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Abundance estimates of Barents Sea capelin

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Introduction

In a previous report to this committee (Dag Møller and Steinar Olsen 1962) great variations in distribution in time and space of the Barents Sea capelin was demonstrated, and the effects of these variations on the fisheries for spawning capelin was pointed out.

It is equally apparent that the abundance or stock strength of capelin has fluctuated greatly. The impact of these fluctuations is strongly felt, not only in the fisheries for the capelin itself, but since this little fish is a very important food organism for other fish, changes in total abundance and distribution will have a marked effect on the fisheries for other species as well, notably on the cod fisheries.

The capelin is fished commercially only during winter and spring when the mature stock enters coastal waters to spawn. The Norwegian fisheries statistics contain data on capelin catch, number of vessels and duration of season, but it seems that the effects of changes in availability, weather conditions, market demand etc. are so great that CPUE-estimates are of rather doubtful value as realistic indices of stock abundance. Nevertheless, it is quite obvious from the output of the fisheries in recent years, and from observations made on research vessel cruises, that the stock of capelin, which around 1960 was quite numerous, has since the season of 1961 declined greatly. The present paper describes an attempt to estimate the magnitude of this decline on the basis of the available data of age distribution in the mature stock.

Material and Methods

Routine market and research vessel sampling of the mature stock has been carried out by our institute each year since 1961, and combined with the data collected by PINRO in 1959 and 1960 (Prokhorov 1960) they provide estimates of the age distribution in the mature stock for 6 consequtive years, i. e. for the seasons 1959 to 1964. A record of the data is given in Table 1, and they are illustrated in Fig. 1 together with the length distributions

It is clearly seen that the Barents Sea capelin attain maturity mainly at ages 3, 4 and 5, and the lack of older fish strongly indicates a very heavy post-spawning mortality. Templeman (1948) and Prokhorov (1960) have reported observations suggesting that at least some capelin do survive to spawn for a second time. Similar observations, of spent females maturing for another time, were made in August 1961 during a cruise with the R/V "G. O. Sars" to the Hope Island banks. However, for the present purpose we may disregard the small proportions of second time spawners, as well as the very few capelin of 2 and 6 years of age, which in some years occur in the spawning stock. From this follows:

$$p_3 + p_4 + p_5 = 1 \qquad (1)$$

where p_3, p_4 and p_5 denotes the proportions spawning at age 3, 4 and 5 respectively, of the total number of a year- class (N) which have survived, until the age of maturity. These proportions appear to be somewhat different for the two sexes and may also vary from year- class to year- class.

For three consequtive year- classes there are the following relationships:

$$\frac{N_i \cdot {}_ip_4}{N_j \cdot {}_jp_3} = a, \qquad (2)$$

$$\frac{N_i \cdot {}_ip_5}{N_j \cdot {}_jp_4} = b, \qquad (3)$$

$$\frac{N_j \cdot {}_jp_4}{N_k \cdot {}_kp_3} = c, \qquad (4)$$

and

$$\frac{N_j \cdot {}_jp_5}{N_k \cdot {}_kp_4} = d, \qquad (5)$$

where the ratios a, b, c and d are estimated from the percentage age distributions.

Dividing (3) with (2) gives:

$$\frac{{}_jp_3 \cdot {}_ip_5}{{}_jp_4 \cdot {}_ip_4} = \frac{b}{a}, \qquad (6)$$

and similarly, from (4) and (5) :

$$\frac{{}_kp_3 \cdot {}_jp_5}{{}_kp_4 \cdot {}_jp_4} = \frac{d}{c} \qquad (7)$$

It is noticed that these ratios would be identical if there were no difference from year- class to year- class in the p - values. The present data suggest that for some year- classes this appears to be a fair approximation. In this case the indices may be deleted and only one more equation is required to estimate p_3, p_4 and p_5.

The available material, however, does not suffice for a solution. As a guide the average age distribution is therefore assumed to indicate the order of magnitude of the p - values, and four series of estimates have been calculated, applying different values of the ratio p_3 / p_5 , of which the middle ones approximate those derived from the average age distribution for the first three years.

From equations (1) , (2) , (3) , (4) and (5) a formulae for N_j is established:

$$N_j = N_i \left(\frac{{}_ip_4}{a} + \frac{{}_ip_5}{b} + \frac{{}_ip_5 \cdot d}{bc} \cdot \frac{{}_kp_4}{{}_kp_3} \right) \qquad (8)$$

If the various parametres for the i-th year-class are known, N_j may be estimated, provided that some measure of the ratio ${}_kP_4 \,/\, {}_kP_3$ can be established. As a first approximation it is assumed that this ratio does not differ much from that of the j-th year class, and hence:

$$N_j \approx N_i \left(\frac{{}_iP_4}{a} + \frac{{}_iP_5}{b} + \frac{{}_iP_5 \cdot d}{bc} + \frac{{}_jP_4}{{}_jP_3} \right) =$$

$$N_i \left(\frac{{}_iP_4}{a} + \frac{{}_iP_5}{b} + \frac{ad(\, {}_iP_5 \,)^2}{b^2 c \cdot {}_iP_4} \right) \qquad (9)$$

From this ${}_jP_3$, ${}_jP_4$ and ${}_jP_5$ are estimated and thereafter the various parametres for the k-th year-class, and so on.

These first approximate estimates are then used for a second series of calculations, which for the present data give values differing only slightly from those of the first estimates.

Tables 2a and 2b give a record of the four series of parametres estimated for males and females separately, and in Table 3 are given the corresponding figures for the estimated relative abundance of the spawning stock.

It is noticed that the results obtained for males and for females fluctuate in the same manner from year to year, and particularly for the middle series of estimates the agreement is quite good. In view of the fact that this good agreement is obtained from two quite independant sets of data, it would seem reasonable to conclude that the various assumptions made in establishing the population model applied are not unreasonable.

In Fig. 2 are shown the estimated stock strength of the capelin spawning runs in the years 1959 to 1964. They are calculated as the combined means of males and females from series B and C in Table 3, and a provisional estimate for 1964 is added.

For comparison the Norwegian catch of capelin for the corresponding years is illustrated on the same figure (double-hatched columns).

It is noted that the trend in stock strength estimates is very similar to that of the yield of the fishery, except for the year 1962 when the capelin did not appear at the Norwegian coast at all.

In the 1965 spawning run the 1961-year-class is expected to be at its peak, but all available evidence indicates that this year-class is another one of low abundance, and the outlook for the next capelin season is therefore pretty grim. This is confirmed by the observations made during a survey of the Barents Sea in August this year. Very few maturing capelin were found, and it is safely concluded that the capelin stock in the Barents Sea is presently at a very low level of abundance.

References

Møller, Dag and Olsen, Steinar, 1962. Norwegian Capelin Investigations. I.C.E.S., C.M. 1962, No. 34. (Mimeographed).

Prokhorov, V.S. 1960. Post-spawning survival of the Barents Sea Capelin. I.C.E.S., C.M. 1960, No. 165. (Mimeographed).

Templeman, W. 1948. The life history of the capelin in Newfoundland waters. Newfoundland Govt. Biol. Sta., Res. Bull., no. 17.

Table 1. Percentage age distribution in the spawning stock of Barents Sea Capelin, 1959 to 1964.

YEAR	1959 x)		1960 x)		1961		1962		1963		1964	
AGE \ SEX	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
2	1.8	2.6							.2	.1		.3
3	67.0	70.4	33.1	49.5	1.2	4.7	2.0	8.4	2.3	7.7	1.9	6.5
4	31.2	27.0	66.1	50.0	94.2	94.5	63.9	66.9	93.5	91.1	47.2	58.0
5			.8	.5	4.6	.8	33.9	24.4	4.0	1.1	50.9	35.2
6							.2	.2				

x) Data from Prokhorov (1960).

Table 3. Estimates of relative abundance of the spawning stock of Barents Sea Capelin, 1959 to 1963.

YEAR	MALES				FEMALES			
	A	B	C	D	A	B	C	D
1959	.158	.382	.454	.664	.218	.340	.400	.564
1960	1.027	1.574	1.685	1.930	1.257	1.530	1.624	1.833
1961	2.302	2.229	2.144	1.937	2.631	2.461	2.387	2.187
1962	1.008	.618	.551	.384	.630	.529	.472	.353
1963	.505	.196	.163	.085	.265	.141	.117	.063

Table 2a. MALES. Estimates of the parametres p_3, p_4, p_5 and N_1 applying different values for the ratio $_{55}p_3 \,/\, _{55}p_5$ and taking N_{56} as unity.

YEAR-CLASS.	A $_{55}p_3 = {}_{55}p_5$				B $_{55}p_3 = 2{,}5 \cdot {}_{55}p_5$				C $_{55}p_3 = 3 \cdot {}_{55}p_5$				D $_{55}p_3 = 5 \cdot {}_{55}p_5$			
	p_3	p_4	p_5	N	p_3	p_4	p_5	N	p_3	p_4	p_5	N	p_3	p_4	p_5	N
1955	.120	.760	.120	.075	.185	.741	.074	.119	.203	.730	.068	.131	.248	.702	.050	.168
1956	.120	.760	.120	1.000	.185	.741	.074	1.000	.203	.730	.068	1.000	.248	.702	.050	1.000
1957	.120	.760	.120	3.202	.185	.741	.074	2.025	.203	.730	.068	1.821	.248	.702	.050	1.436
1958	.040	.931	.029	.779	.062	.920	.018	.308	.066	.917	.017	.255	.085	.902	.013	.150
1959	.026	.600	.374	.884	.046	.684	.270	.191	.050	.694	.255	.145	.069	.727	.203	.061
1960	(.026)	(.600)	(.374)	(.508)	(.046)	(.684)	(.270)	(.070)	(.050)	(.694)	(.255)	(.050)	(.069)	(.727)	(.203)	.016

Table 2b. FEMALES.

YEAR-CLASS.	A ($_{55}p_3 = 2{,}5 \cdot {}_{55}p_5$)				B ($_{55}p_3 = 4 \cdot {}_{55}p_5$)				C ($_{55}p_3 = 5 \cdot {}_{55}p_5$)				D ($_{55}p_3 = 7{,}5 \cdot {}_{55}p_5$)			
	p_3	p_4	p_5	N	p_3	p_4	p_5	N	p_3	p_4	p_5	N	p_3	p_4	p_5	N
1955	.189	.736	.076	.098	.231	.711	.058	.123	.253	.697	.051	.137	.295	.665	.093	.170
1956	.198	.777	.026	1.000	.240	.742	.019	1.000	.260	.723	.017	1.000	.306	.681	.013	1.000
1957	.189	.757	.054	4.060	.237	.724	.040	3.102	.253	.711	.036	2.825	.297	.676	.028	2.273
1958	.200	.796	.005	.765	.244	.753	.004	.458	.260	.736	.003	.384	.301	.697	.002	.254
1959	.176	.687	.137	.434	.220	.674	.106	.197	.247	.663	.091	.144	.325	.615	.060	.068
1960	(.176)	(.687)	(.137)	(.143)	(.220)	(.674)	(.106)	(.051)	(.247)	(.663)	(.091)	(.033)	(.325)	(.615)	(.060)	.011

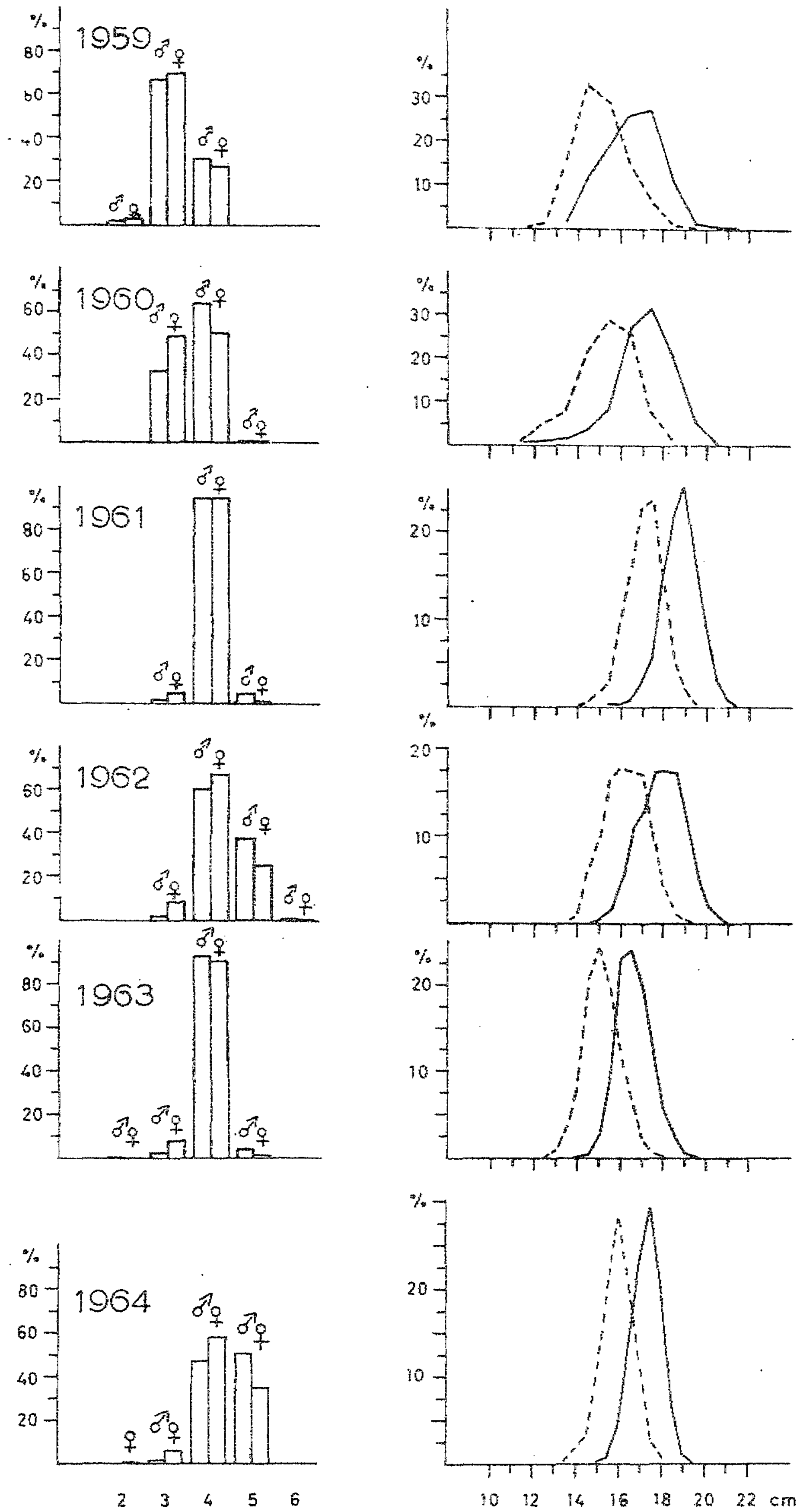

Fig. 1. Age and length distribution of the spawning stock of capelin, 1959 to 1964.

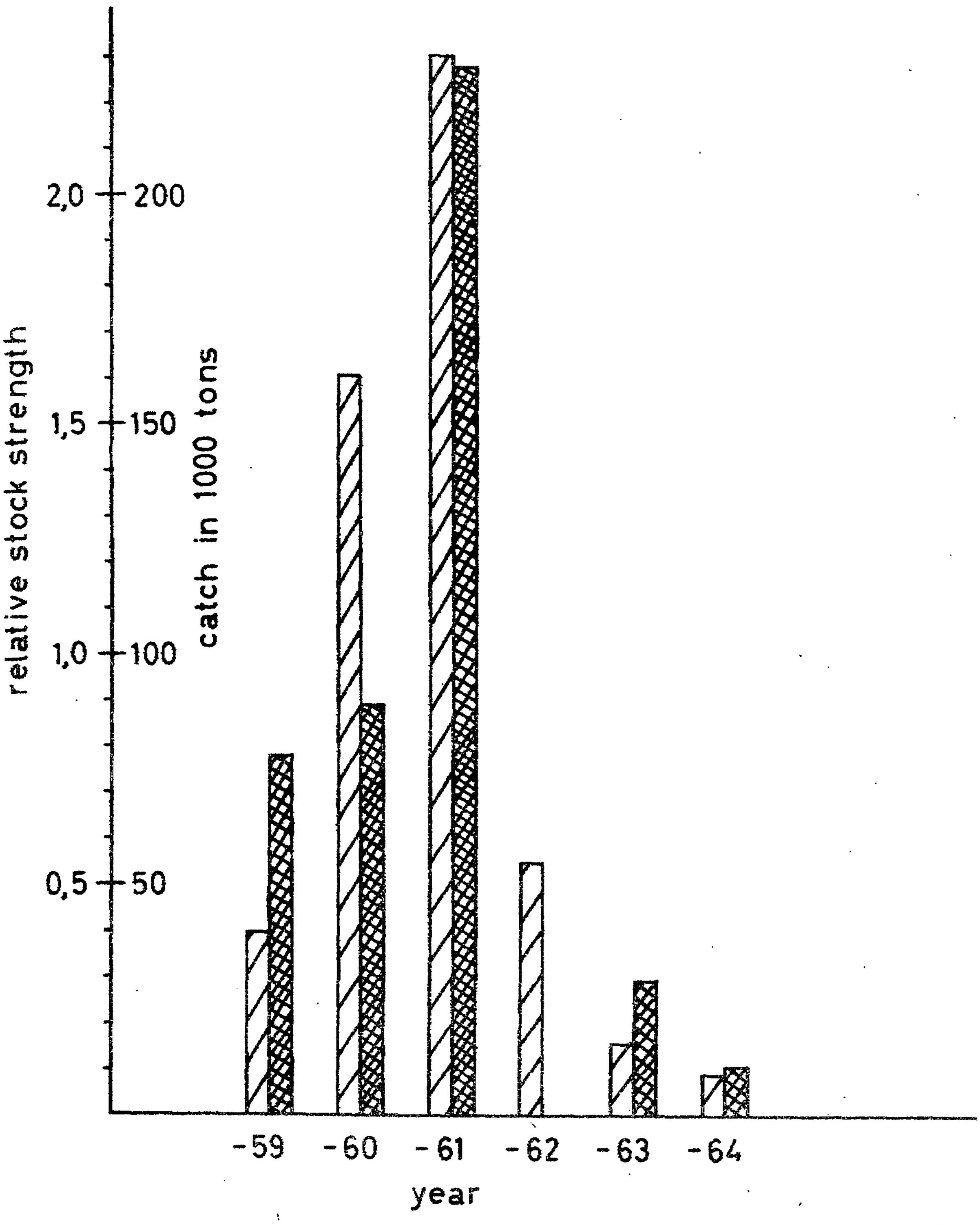

Fig. 2. Norwegian catch of capelin (double hatched columns) in the years 1959 to 1964, and corresponding estimates of stock strength.