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Norwegian capelin investigations.

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by

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At the Finnmark coast mass spawning of capelin occur fairly regularly. In most years the first spawning runs are observed in February/March, and they are usually followed by fish in abundance, especially cod, and by birds and whales. This event marks the start of the traditional Finnmark spring cod fisheries, but the capelin themselves have also regularly been fished by Norwegian fishermen.

There are scattered information about the capelin fishery as far back as 1734. Until 1916 when capelin was first used for reduction purposes, it was a very small fishery for bait only, and yearly landings remained in the main fairly low until the post-war period.

The modern capelin fishery has during the last decade developed very rapidly and reached a record of more than 220,000 tons in the 1961 season (Fig. 1). The chief method of fishing is purse seining which accounts for more than 95% of the catch.

Material and methods.

In 1960 the Institute of Marine Research, Bergen, started a program of capelin investigations. Research vessel surveys were conducted in September 1960 and August 1961 to the Barents Sea and during the spawning runs in February/March 1961 and February/April 1962.

The work included asdic and echo-sounder surveys, sampling with mid-water trawls and hydrographic observations. During the 1961 capelin season an extensive sampling program of the commercial catches landed at the reduction factories was carried out (Table 1).

Total length in mm was measured to the tip of the lower lobe of the caudal fin in "natural position". The figures given are for fresh material. When frozen material was used a conversion factor was applied to give the corresponding "fresh" length.

Age determinations are from otoliths, which appear to be fairly easy to read, except that difficulties sometimes arise with regard to the interpretation of the very first growth zones.

Detailed catch statistics for the most recent years are fairly complete, and yearly records of time of arrival of the first spawning runs, and to some extent also locality, are available since 1868.

#### Distribution, age and length in September 1960.

During the 1960 September cruise special interest was paid to the frontier area between cold and warm waters, i. e. the area between the  $0^{\circ}$ - and  $4^{\circ}$ -isothermes in 50 m.

The capelin appeared to have a westerly distribution (Fig. 2). Capelin larvae (0-group) were taken in abundance near Hope Island and in smaller numbers further east on the Central Bank. On the Novaya Zemlya grounds and in the south-western Barents Sea no capelin larvae were taken. Concentrations of older age-groups were located in areas of great horizontal temperature gradients between  $75^{\circ}50'$  and  $77^{\circ}20'N$ , and between  $26^{\circ}$  and  $41^{\circ}E$ , particularly NE of Hope Island. Relative to the 1- and 3-yearolds, the II-group was poorly represented (Fig. 3).

The condition of the capelin taken in September 1960 was very good and they were feeding heavily on Euphasiids.

#### Distribution, age and length in August 1961.

This year the investigations were carried out simultaneously with three vessels, and the surveyed area and the sampling program was considerably extended compared with the previous year.

Owing to the loss of fine-meshed gear for catching capelin larvae insufficient data were obtained to show the distribution of the 0-group.

The older age groups appeared to be very sparsely distributed over large areas from about 75°N and northwards (Fig. 4), and no clear, simple relationship between distribution and temperature could be established. Only in the north-western areas, near the ice edge more dense concentrations were occasionally located.

The relative abundance of the various age groups seemed to be related to the latitude. The I- and II-groups dominated in the southern areas of distribution, and the older capelin, as well as the most fast growing ones of the younger age groups were more northerly distributed (Fig. 5 and Table 2).

In samples of large capelin many females contained large residual eggs in the ovaries, thus giving evidence of survival from a previous spawning.

Contrary to the situation in 1960 the condition of the capelin was poor with a low fat content, and most stomachs investigated contained little or no food.

#### Time and distribution of spawning at the Finnmark coast since 1868.

In fig. 6 are plotted for each year since 1868 the date of first arrival of the spawning runs at the East- and West-Finnmark coasts respectively. These are based on old records and reports of the appearance of the capelin, recorded because of their significance in connection with the spring cod fisheries.

The capelin have regularly visited the Norwegian coast, except for the five-year period 1938 to 1942, and again this present spring, when they failed to appear at the regular spawning grounds. The time of arrival, and probably also the magnitude of the spawning stock, have fluctuated greatly, but in most years the first school have reached inshore waters in February or March. It appears that a few years of early or late arrival usually follow in succession, but with no regular periodisity.

Early arrival seems to be associated with a westerly distribution of the spawning capelin, and vice versa. As a rule, though, the first schools usually appear on the East-Finnmark grounds, and this is the area from which they latest disappear at the end of the season.

### The spawning runs in 1961.

During the 1961 season there were three distinctly separated spawning runs at the Finnmark coast (Fig. 7). The first schools struck land on February 17, and were gradually distributed along the coast west of North Cape.

During the days of February 24. to 26. a new influx was located off the coast of East Finnmark. The first schools reached inshore waters in the beginning of March at Vardø, and somewhat later further west on the Varanger Peninsula. These capelin were rapidly distributed along the entire Finnmark coast and led to a second peak in the fishery of the western districts.

The third spawning run came in the beginning of April. It was limited to the coast of the northern Varanger Peninsula and lasted for two to three weeks.

The spawning stock in 1961 was mainly made up of 4-yearold fish (1957-yearclass), and the mean length was high, nearly 2 cm higher than those for 1959 and 1960 reported by Prokhorov (1960). There were only slight differences in age and length distribution between the two first spawning runs, but the capelin of third spawning run were somewhat smaller and contained a significant element of 3-year-old females (22.6 % of the females).

During the season there was a profound change in the sex proportion. In the middle of February males and females were taken in about equal numbers. In late February and during the first half of March the females dominated, but thereafter they were rapidly decreasing in number, and at the end of the season the males were in great majority (Fig. 8).

The capelin taken during the 1961 season were in a very good condition. The fat content was as high as 12 % in the first catches and decreased to 4 - 6 % by the end of the season, as against around 2 % in previous years.

### The 1962 season.

In February and March 1962 capelin were occasionally found in the

stomack contents of cod at various places along the Finnmark coast, and this is a common experience some time in advance of the first main spawning run. This year, however, larger concentrations of capelin were never observed near the Norwegian coast, in spite of continuous surveying with two research vessels from the beginning of February to the middle of April.

The investigations were first started in the south-western part of the Barents Sea, whereafter the south-eastern part was covered. The first of March concentrations of capelin were located over a fairly wide area in the Goose Bank - Prestneset area. During the next four weeks there was a slow movement in south-westerly direction and at the same time a disintegration and dispersal of the schools (Fig. 9). Some schools reached as far west as the Kildin Bank, and around the first of April there was apparently capelin spawning at and off the coast in the Kildin - Cape Teriberski area. Off the coast in this area spent capelin were found in the beginning of April, and in the middle of May masses of dead capelin were observed afloat. One might however raise the question, whether the capelin in 1962 to a large extent spawned farther off the coast on the banks of the south-eastern Barents Sea.

Only a few samples of the 1962 spawning stock is available, mainly of the concentrations located in the beginning of March. They show a majority of 4-yearolds, but with 5-yearolds (1957-yearclass) amounting to as much as 30%. In spite of the high mean age, the mean length was smaller than in 1961, and the capelin were in poor condition with a fat content in the beginning of March of 6 to 7 % only.

### Discussion.

Paired with Soviet observations for 1959 and 1960 (Prokhorov 1960) these investigations show age and length distributions of the capelin spawning stock for four consecutive years (Fig. 10). These seem to indicate that capelin spawn at ages from two to six, but mainly as three- and four-yearolds. Considerable fluctuations in relative yearclass strength are evident and may effect the magnitude of the spawning stock several seasons in succession. Thus, the rich 1957-yearclass which yielded about 95 % of the record catch in 1961, also contributed substantially to the good fishing in 1960. Similarly, the 1956 yearclass was the main contributor to the spawning stock

in 1959 and in 1960. This does not necessarily postulate a high rate of repeated spawning, and is probably to a great extent effected by gradual maturing of a yearclass at different ages.

It is evident from the regular observations of large masses of dead capelin after the spawning season and failure to find specimens older than 6 years of age in the capelin population, that postspawning mortality is very high, at least from age four and onwards.

Survival after spawning is demonstrated by the observation in August 1961 in the northern Barents Sea of recovering spent females maturing for a second time, and by Soviet observations reported by Prokhorov (1960). No data exist however, to indicate the relative magnitude of post-spawning survival in capelin, and quite likely great yearly fluctuations would occur, as the survival is likely to be effected by variations in age distribution and condition of the spawning capelin.

The sex proportion of the various age groups show a majority of females in the youngest age groups, but more males than females from age five and six. This indicates a slightly lower mean age at sexual maturity for the females and possibly also a higher survival rate for the males.

In 1961 the larger and older fish arrived first on the spawning grounds. This is probably a general feature for the capelin (Templeman, 1948) as well as for other species of spawning fish. We have previously mentioned that an early spawning run seems to be associated with a westerly distribution, and it is conceivable that the size and age distribution of the spawning stock may have some bearing on the time and location of spawning, as well as environmental conditions during maturing and spawning season.

The geographical distribution of spawning in 1962 was entirely different from that of the previous year. One might have expected that this to some extent, at least, was related to a change in hydrographic conditions. A comparison between the temperature distribution in these two years, however, (Fig. 11) does not reveal a very great difference. In 1962 the waters at the Finnmark coast and in adjacent areas were slightly warmer than at the same time in 1961, but not a great deal. Consequently, also the spawning temperature for the capelin in 1962 differed much from the conditions of 1961. It seems therefore just to

conclude that the range of temperature for capelin spawning in the Barents Sea is wide, as has been reported for Newfoundland waters by Templeman (1948), and the choice of spawning locality is probably less effected by temperature than by other factors.

#### Summary.

The modern Norwegian capelin fishery for reduction in the post-war period has developed very rapidly from less than 5,000 tons per year until 1950, to more than 220,000 tons taken in 1961. The chief method of fishing is purse seining, and the number of vessels engaged in this fishery increased from 43 in 1951 to 168 in 1961.

The Institute of Marine Research, Bergen, started a program of capelin investigations in 1960. Data of distribution, age and length for all age groups were collected in September 1960 and August 1961 in the northern and eastern Barents Sea, and for the spawning stock in winter and spring 1961 and 1962 in coastal and adjacent waters. An extensive sampling program of the commercial landings was carried out during the 1961 season.

In September 1960 capelin both larvae and older age-groups appeared to have a westerly distribution.

In general the survey indicated that capelin of one year and older were accumulated in areas of large horizontal temperature gradients.

In August 1961 all sizes of capelin seemed to be very sparsely distributed over large areas from about 75°N and northwards, and contrary to the situation in September 1960 no clear, simple relationship between distribution and temperature could be established.

There was a clear trend of an increase in size and age with increasing latitude, and this was paralleled with a similar increase in mean size of each age group, i. e. the largest and most fastgrowing fish were distributed farthest to the north.

Annual records since 1868 show that the capelin have regularly visited the Norwegian coast, except for the five-year period 1938 to 1942, and again this present spring. The time of arrival at the coast of the first capelin schools, and probably also the magnitude of the spawning stock, have fluctuated very greatly, but in most years the

first schools have reached inshore waters in February or March. It appears that early arrival is associated with a westerly distribution of the spawning capelin and vice versa, and a few years of early or late arrival usually follow in succession, but with no regular periodicity.

During the 1961 season there were three distinctly separated spawning runs at the Finnmark coast. The first schools struck land on February 17, and were gradually distributed along the coast west of North Cape. The next influx came to the coast of the Varanger Peninsula during the first days of March, and thereafter moved westwards. Finally, in April there was a new invasion limited to the coast of the northern Varanger Peninsula.

There were only slight differences in age and length composition between the two first spawning runs with 4-yearolds averaging 94% of the total. The capelin of the third run were somewhat smaller and contained a significant element of 3-yearold females (22.6% of the females).

During the season there was a profound change in the sex proportion. In February males and females were taken in about equal numbers. In March the females dominated, but at the end of the season the males were in great majority.

In 1962 the capelin schools were first observed in the beginning of March in the Goose Bank - Prestneset area. During the next four weeks there was a slow movement in south-westerly direction and at the same time a disintegration and dispersal of the schools. Some spawning apparently took place at and off the coast in the Kildin - Cape Teriberski area where spent capelin were found in the beginning of April and in the middle of May masses of dead fish were observed afloat. No schools of capelin were ever observed west of the Kildin Bank.

Paired with Soviet observations in 1959 and 1960 (Prokhorov 1960) these investigations seem to indicate that fluctuations in relative yearclass strength may significantly effect the magnitude of the spawning stock several seasons in succession. This does not necessarily postulate a high rate of repeated spawning, and is probably to a great extent effected by partly maturing of a yearclass at different ages.

It is evident that at least from age four postspawning mortality is extremely high, and no specimen older than 6 years of age was ever



found. The sex proportions for the various age groups might indicate a slightly lower mean age at sexual maturity for the females and a higher survival rate for the males.

The detailed studies of the 1961 spawning runs showed that also in capelin the larger and older fish arrive first at the spawning grounds. Considering that early arrival seems to be linked with a westerly distribution it is conceivable that the size and age distribution of the spawning stock may have some bearing on the time and location of spawning, as well as environmental conditions before and during the spawning season.

The range of temperature for capelin spawning in the Barents Sea is wide, and the choice of spawning locality is probably less effected by temperature than by other factors.

#### References.

- Prokhorov, V. S. 1960. Post-spawning survival of the Barents Sea capelin. Int. Coun. Exp. of the Sea, C.M.1960, no. 165.
- Templeman, W. 1948. The life history of the capelin in Newfoundland waters. Newfoundland Govt. Biol. Sta., Res. Bull., no. 17.

Table 1. Material capelin 1960 - 1962.

Investigation	Length-measurements	Otolith-readings
Summer 1960	1 747	145
Winter 1961	9 824	2 207
Summer 1961	7 775	949
Winter 1962	2 781	495
Total	22 127	3 796

Table 2. Mean sizes in different localities summer 1961.

Locality	Year class	1961	1960	1959	1958	1957
	Age group	0	I	II	III	IV
A.Hope Island W			10.16	12.55		
B.Hope Island E			11.63	12.45		
C.Central Bank NE			11.83	12.45		
D.Great Bank SW			12.05	13.15	14.96	
E.Hope Island N			12.45	14.31	15.80	16.86
F.Great Bank NW			13.18	14.49	16.65	18.37
Average			11.88	13.23	15.80	17.62

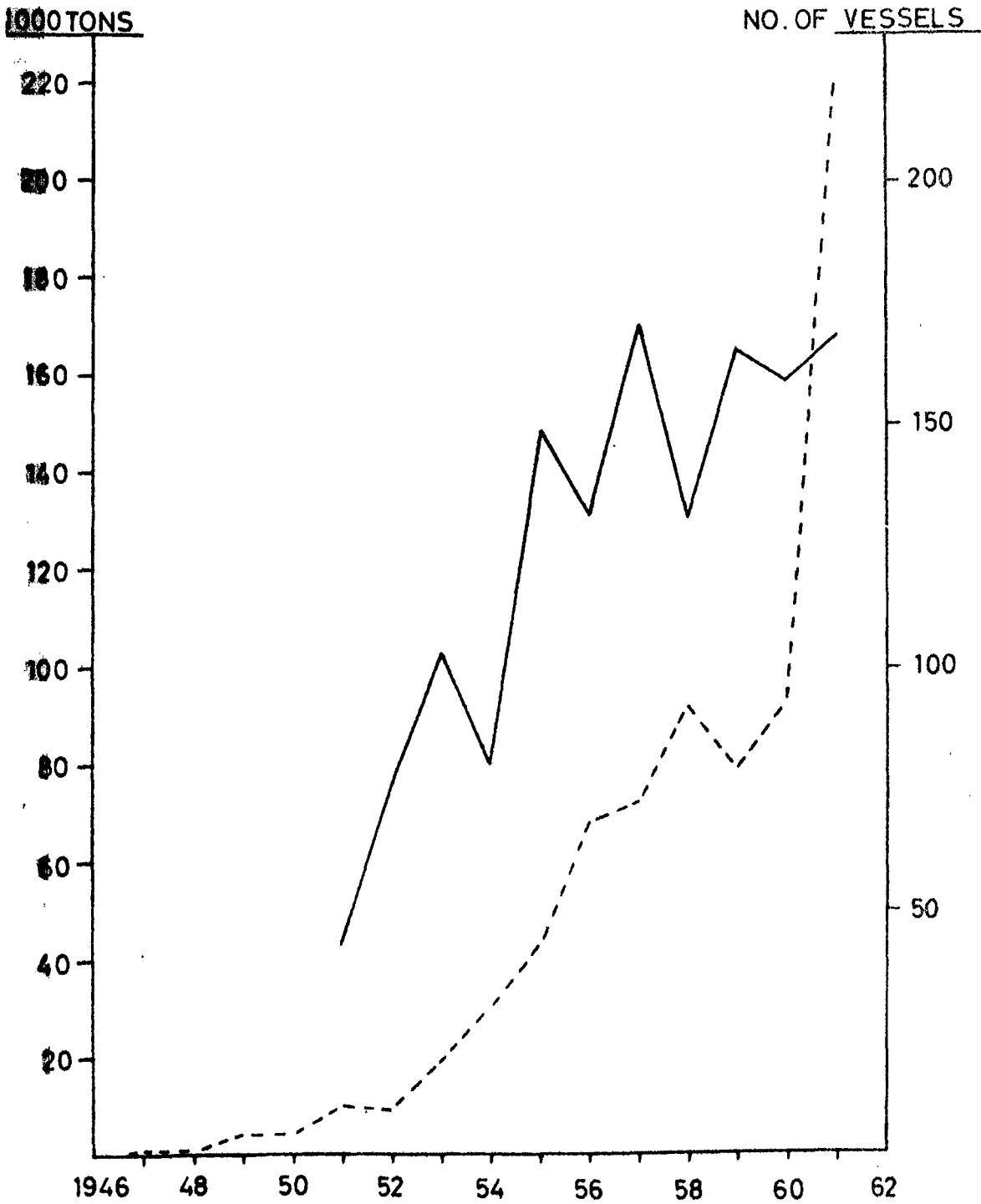


Fig. 1. Catch of capelin in Norwegian waters 1946 - 1961. Number of vessels in Norwegian capelin fisheries 1951 - 1961.

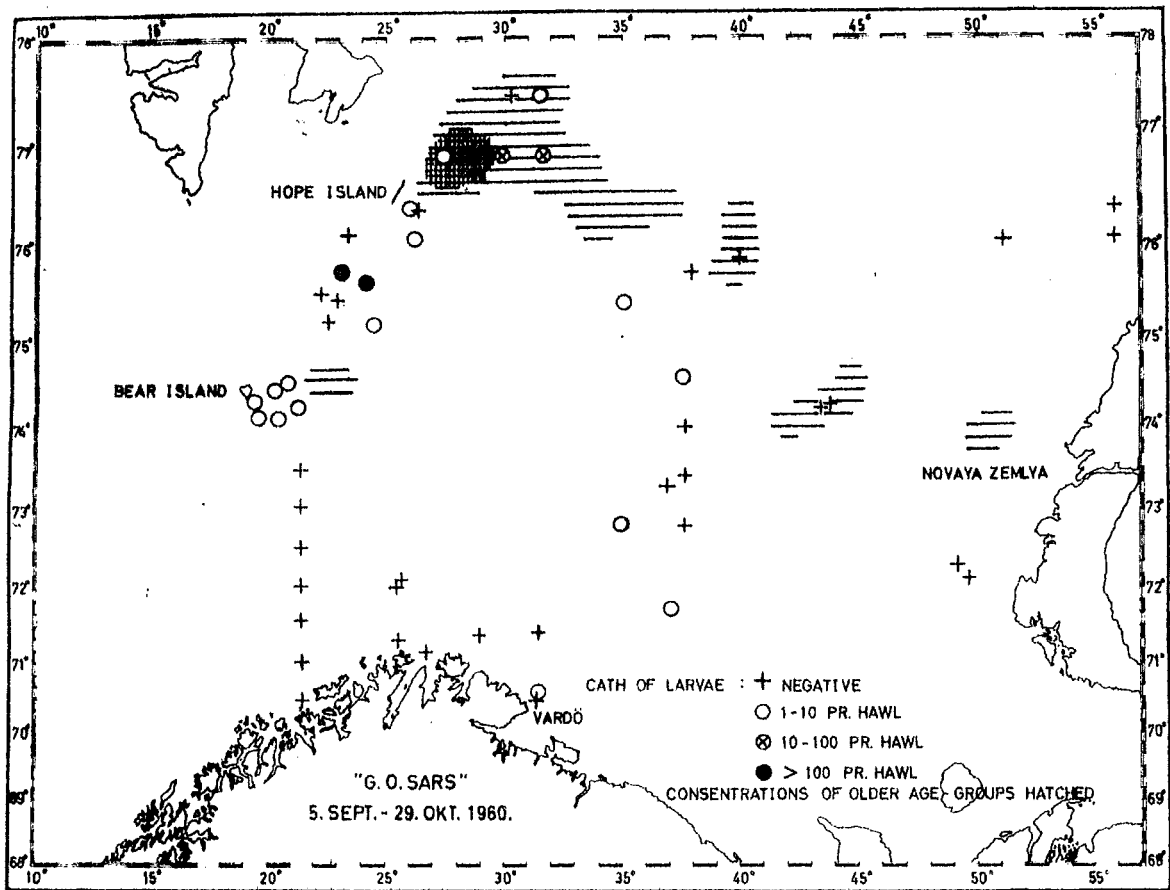


Fig. 2. Capelin distribution September - October 1960.

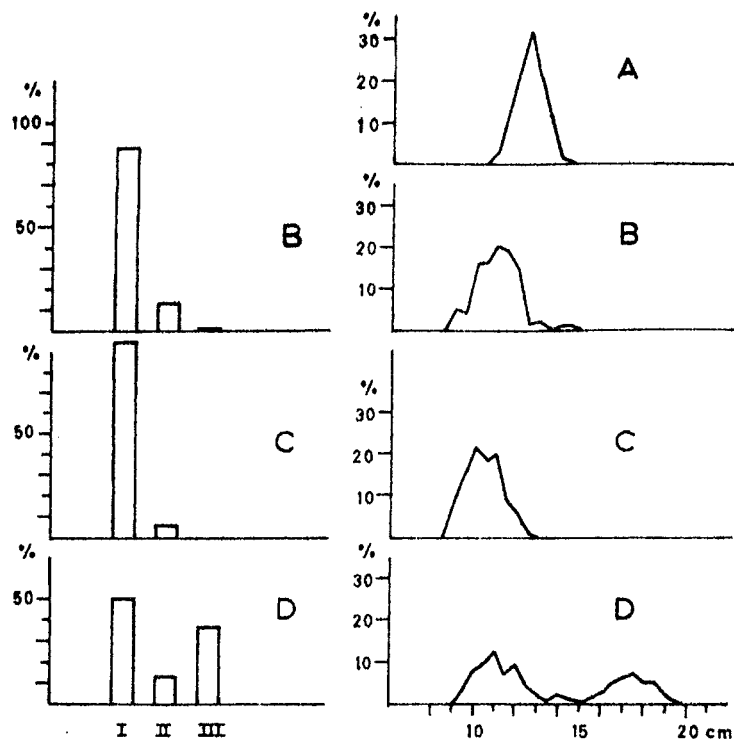
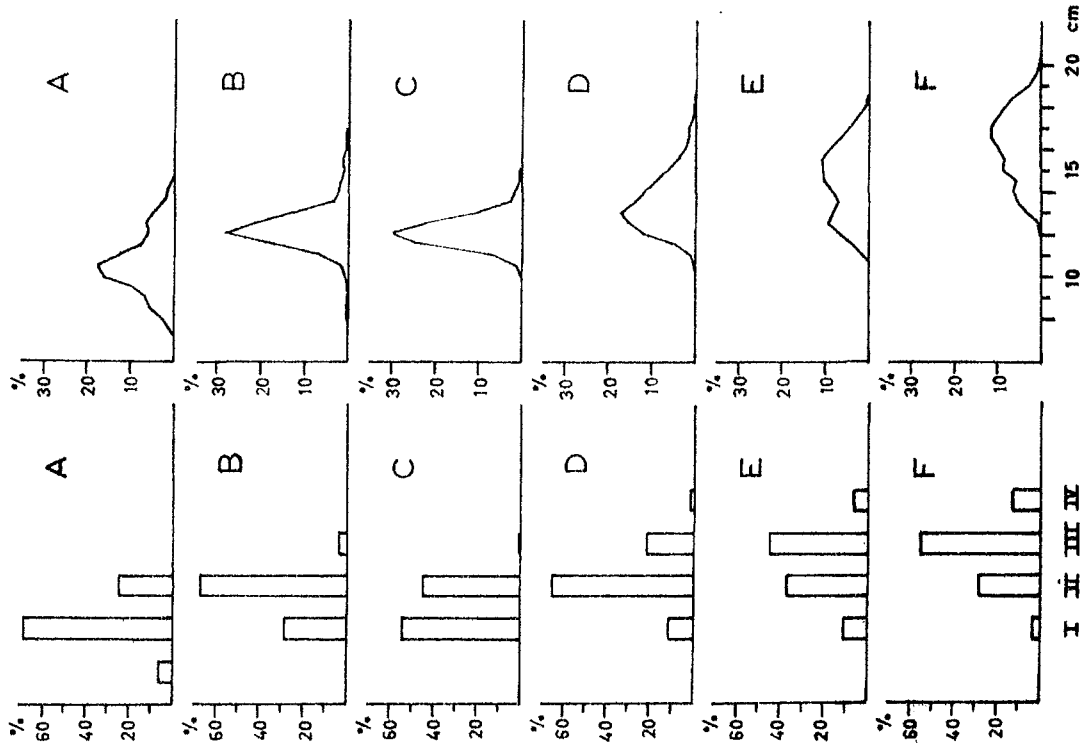
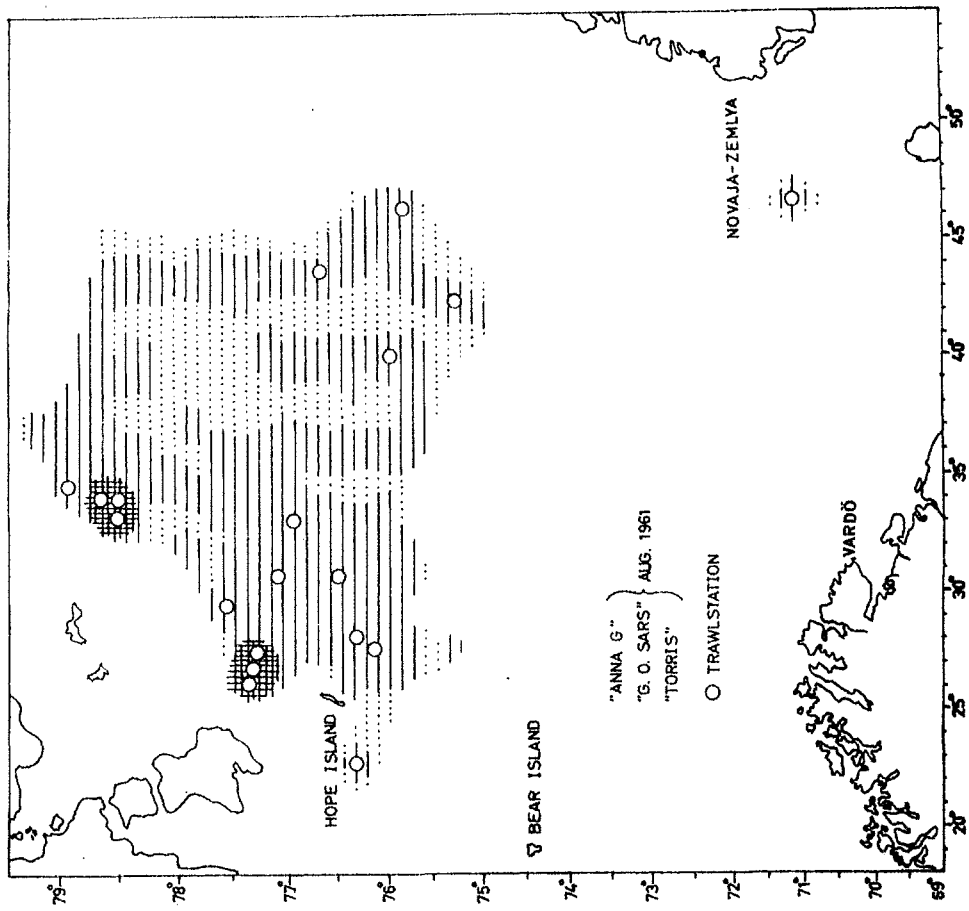


Fig. 3. Age and length distributions September 1960.  
A. Novaya Semlya    B. Central Bank SE  
C. Central Bank NW    D. Hope Island E



**Fig. 5. Age and length distributions August 1961.**  
 A. Hope Island W    B. Hope Island E  
 C. Central Bank NE    D. Great Bank SW  
 E. Hope Island N    F. Great Bank NW



**Fig. 4. Capelin distribution August 1961.**

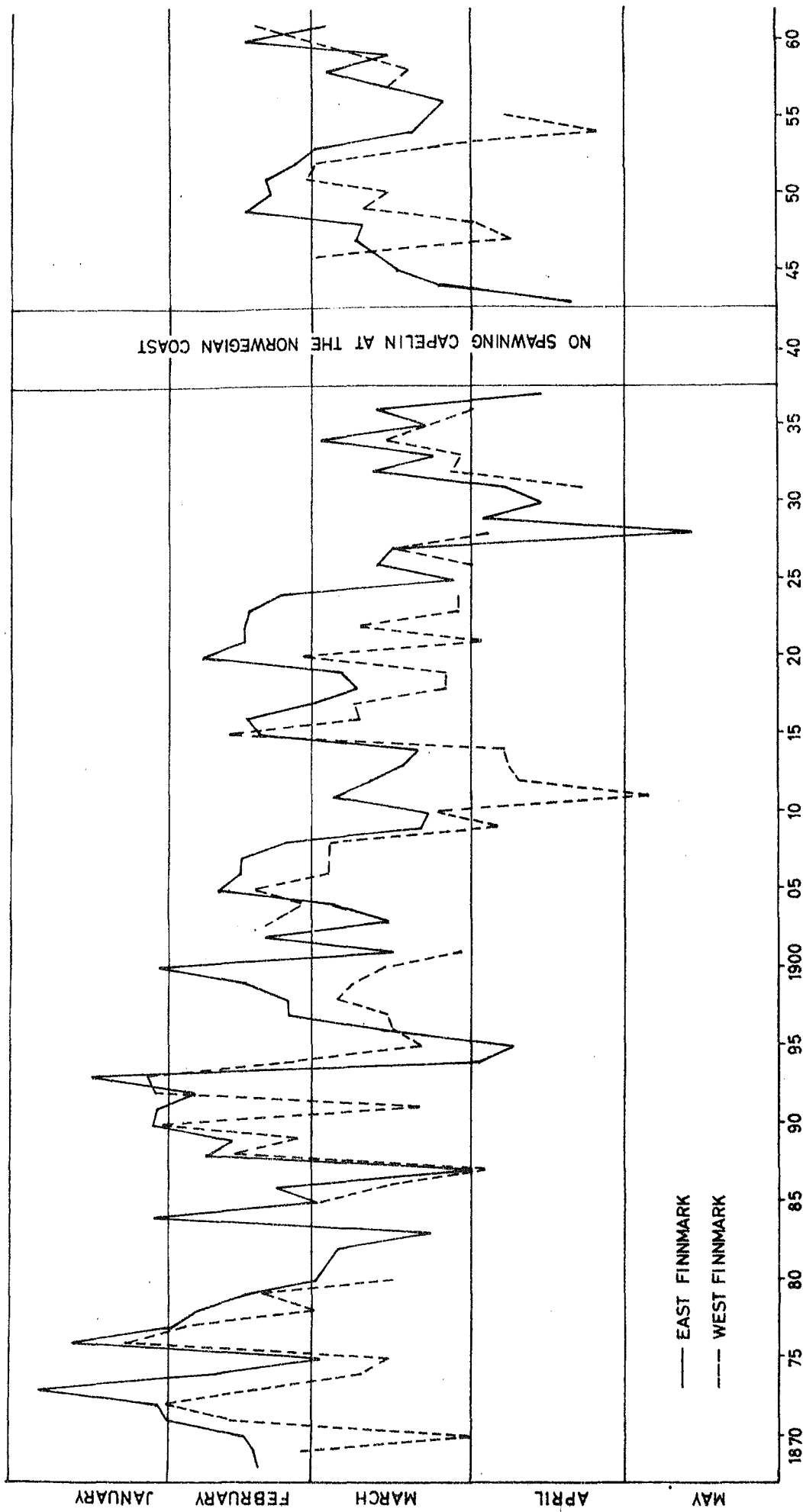


Fig. 6. Date of first arrival on the Norwegian coast of spawning capelin 1868 - 1961.

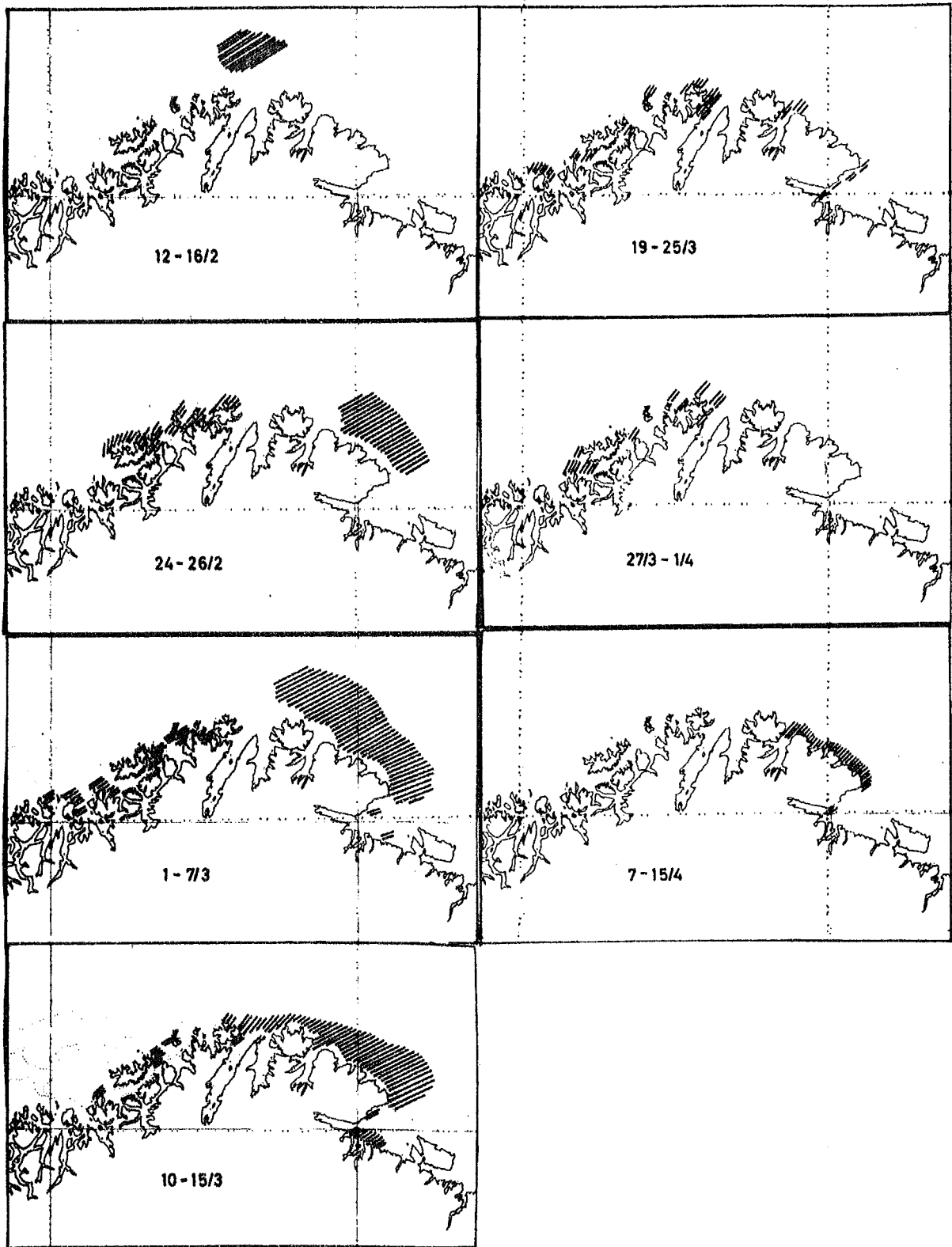


Fig. 7. Capelin distribution February/April 1961.

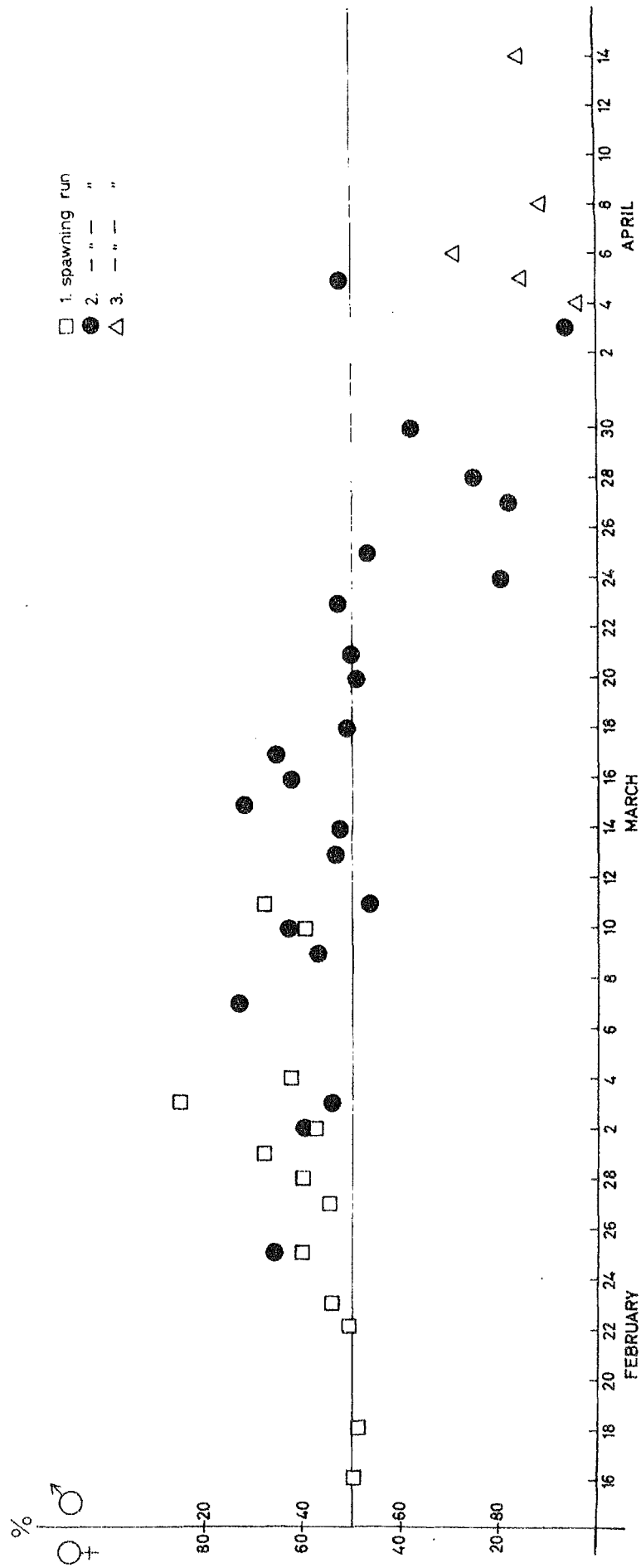


Fig. 8. Sex proportion of capelin during the spawning season 1961.



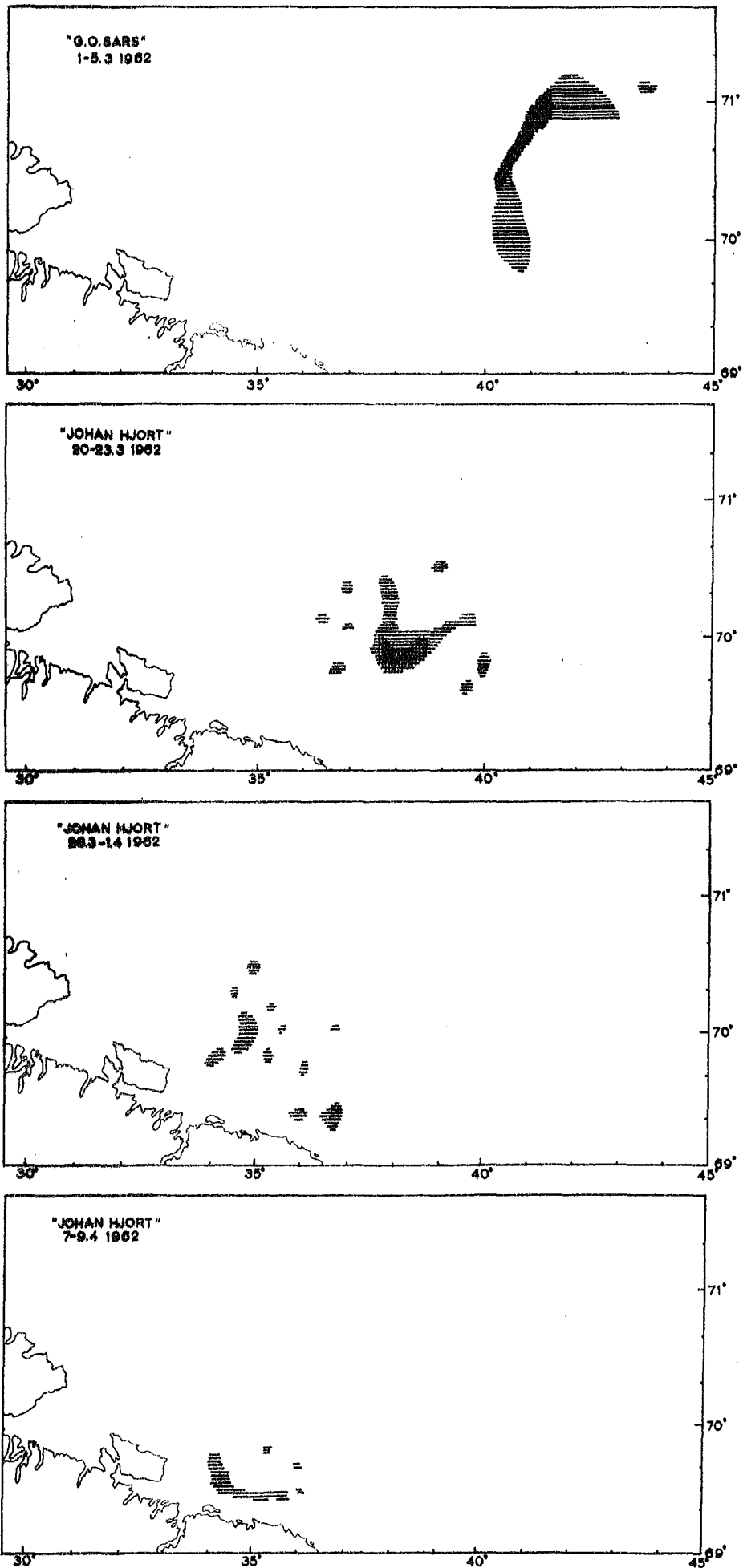


Fig. 2. Capelin distribution March/April 1962.

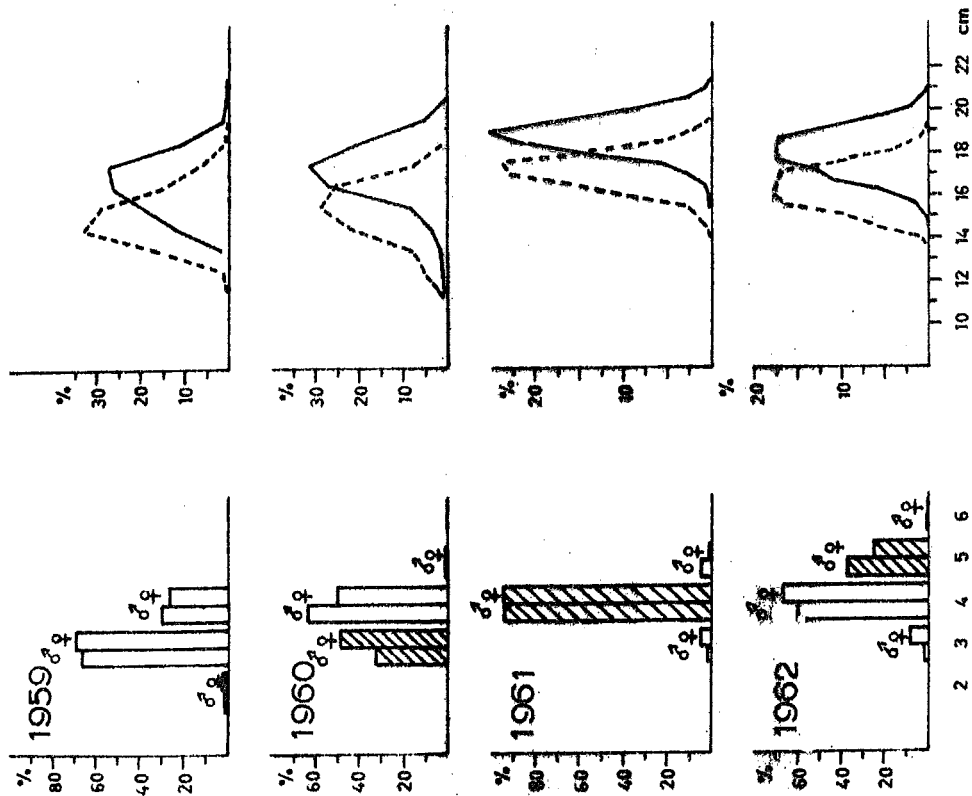


Fig. 10. Age and length distributions of spawning capelin 1959 - 1962. (For 1959 and 1960 reconstructed from Prokhorov, 1960).

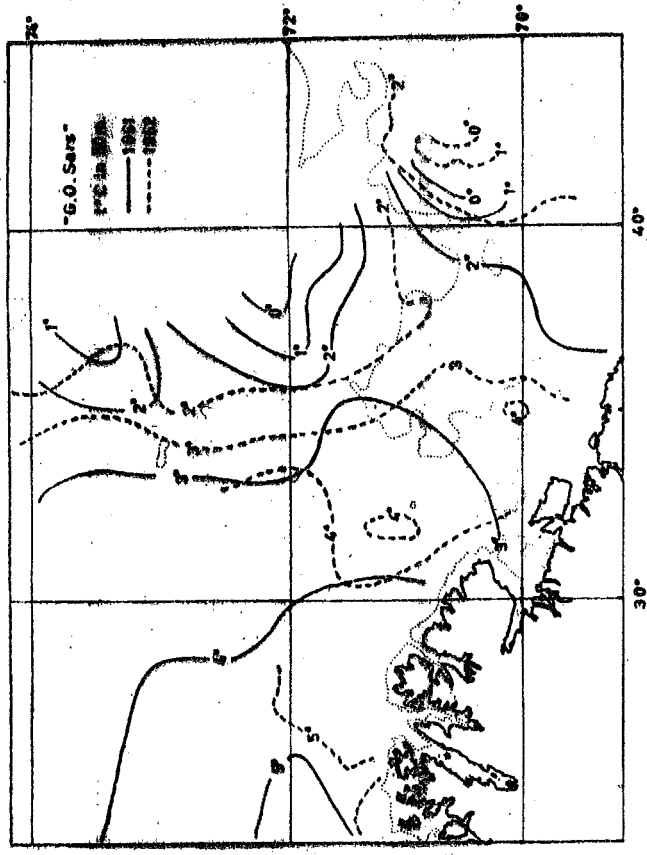


Fig. 11. Temperature distribution April 1961 and March 1962.