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NORWEGIAN CAPELIN INVESTIGATIONS IN THE BARENTS SEA DURING THE
SUMMER SEASONS 1970-1978.

by

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ABSTRACT

During the years 1970-71 and 1973-1978 the Institute of Marine Research carried out surveys of the capelin stock in the Barents Sea during the months May-July. In this paper the capelin distributions, age- and growth data, and hydrographic data collected during the cruises are presented and discussed.

INTRODUCTION

From its feeding and nursery areas in the Barents Sea, the capelin (*Mallotus villosus*, Müller) undertakes spawning migrations every winter and spring to the coasts of Finnmark and the Kola Peninsula. These migrations have been known for generations and also described by a number of authors, e.g. Møller and Olsen (1962) and Prokhorov (1965). In the late 1960's and early 1970's the winter/spring fishery for Barents Sea capelin was one of the most important industrial fisheries in Norway. It took place in coastal areas with purse seining as the chief method of fishing it.

In 1960 the Institute of Marine Research, Bergen, started a programme of capelin investigations. Research vessel surveys were conducted in September 1960 and August 1961 to the Barents Sea, and also during the spawning migrations in February/March 1961 and February/April 1962 (Møller and Olsen 1962). In 1961 and 1962 (Olsen 1963) exploratory summer fisheries for capelin were undertaken, and in 1968 a commercial summer fishery for capelin started far north in the Barents Sea. In the early 1960's little was known about the distribution, migration and abundance of the capelin stock. However, it was obvious that there were considerable changes in the stock abundance. As the capelin is a short-lived species, variations in the relative strength of the year-classes would have an acute and significant effect on the fishery.

Probably connected to the seasonal plankton development a significant part of the capelin stock gradually migrates from the Bear Island areas northwards to Hope Island and Storbanken. From there it continues southwards to the Central Bank area and to the banks off the Murman and Finnmark coasts (Figure 1). Another, and much smaller part of the stock migrates northwards from the Bear Island areas along the western side of Spitzbergen and most probably stays in the area north of Spitzbergen during summer. Some parts of the stock seem to be distributed under the ice cover in the Barents Sea and hence cause the stock assessments to be rather uncertain (Berge et al. 1970).

In addition to an increase of the general knowledge of the Barents Sea capelin, the main aim of the summer surveys was in most of the years to find the status of the stock before the start of the summer fishery, and see if any restrictions on the fishery were needed.

MATERIAL AND METHODS

In the years 1970-78, except for 1972, Norwegian surveys on capelin took place in the Barents Sea and Svalbard area. They were conducted within the months of May-July and the R.V. "G.O. Sars" was used in all these years. A summary of the surveys is given in Table 1.

The purpose of the surveys was to record biological parameters (length, weight, age composition, total numbers and biomass) as well as geographical distribution and hydrographic parameters. For searching and registration of concentrations, an 18 kHz sonar was used together with a 38 kHz echo sounder connected to 3 echo integrators. The integrator channels covered intervals of 50 m from sea surface to 300 or 350 m depths, and in addition one channel covered the water column farther down to bottom. Pelagic and bottom trawls, with fine meshed (8-11 mm) inner-net in cod-end, were used to identify the recordings and for collection of biological samples.

During summer capelin occurred together with polar cod in the eastern parts of the Barents Sea. The paper with echo recordings were daily scrutinized and based on the results of appropriate trawl catches, the mean integrator values (S_A) per 5 nautical miles were interpreted and split on various fish species and groups. The capelin values were then converted into sliding mean values for each 25 nautical miles and mapped along the cruise tracks. For hydrographic observations STD or Nansen-bottles with thermometer were used. In some of the years an additional thermo-salinograph, installed at 6 m depth, was also used.

RESULTS

The distribution and cruise tracks for each year, except for 1972 when no Norwegian summer survey was conducted, are presented in Figures 2A-D. A survey on capelin in autumn 1972 is, however, well described in Gjøsæter et al. (1972 and 1998). Except for 1977, when two summer surveys were conducted, the temperatures at either 50 or 100 m depth are shown on Figures 3A-B. For 1977 the temperature in 50 m is shown for three periods (Figure 4). The sea surface temperatures during summer 1973-1976 are presented in Figure 5.

In Gjøsæter et al. (1998) the time series of abundance estimates by number and biomass for the two years old and older capelin are summarized for the period 1972-1997. These autumn estimates are the annual estimates recorded in ICES files. The summer estimates are less comprehensive, and are not presented here as such. However, the age distributions based on the acoustic estimates during summer are presented in Figure 6.

1970

The main goal of the survey was to register the capelin distribution and its relative abundance from the Finnmark coast to the ice border between 15°E and 40°E (Berge et al. 1970).

The temperature front between cold Barents Sea water and warmer Atlantic water was located from Spitzbergen to Bear Island and further north-eastwards, and the highest concentrations of capelin were found within this polar front area along the slope between Bear and Hope Islands. Capelin occurred in all depths from the sea surface to the bottom, but mostly below 100 m. In general mostly small capelin was recorded, while the larger capelin occurred south of Hope Island and west of the Central Bank only. In these two areas the capelin had full stomachs, while elsewhere only little stomach content was found.

Figure 7 shows the recorded echo intensity per nautical mile in relation to the temperature observed in 6 m depth within the same area. The capelin was widespread in all temperatures from -0.5 to 8.0°C with maximum at 1.5°C .

1971

The survey had as its the main goal the accurate measurements of the year-class strength of juvenile commercial species, with emphasis on cod and haddock (Hyllen et al. 1972). Useful observations were also made on the capelin stock. The highest concentrations of capelin were recorded within an area delimited by 72 and 75°N between 25 and 35°E . The capelin observed west of 40°E was described mainly as immature spring spawners, while at Bear Island and Spitzbergen and in the south-western part of the Barents Sea most of the capelin observed was maturing.

The largest catches of capelin were taken in water with temperature between 0.5 and 4.0°C , while smaller catches were taken in water between -0.1 and 0.5°C and between 4.0 and 5.5°C . The size of the capelin decreased northwards from the coastal area. The highest rates of stomach content were found at Bear Island and Spitzbergen.

1973

The main aim of the survey was to find the status of the capelin stock in the Barents Sea before the start of the summer fishery (Haug and Monstad 1973). The minimum size for capelin had been increased from 13 to 14 cm, and the summer fishery would be based on the adult part of the stock. That meant mainly on the 1970 year-class, which already as 0-group had proved to be a poor one (Anon. 1970).

Most of the capelin was found along the ice border south and southeast of Hope Island, recorded both as small schools and layers in all depths from sea surface to bottom. In the eastern area the recordings were mainly of small schools scattered in depths from 50 – 200m . Young capelin dominated in the north-west, i.e. 2 year olds and some 1 year-olds constituted 88% of the trawl catches. In the south-east adult capelin dominated.

The polar front was indicated most clearly along the slope between Bear and Hope Islands. In the eastern part of the Barents Sea cold water had penetrated deeper in the water column and hence the polar front was less distinct in the upper 100 meters. Capelin was recorded in water of temperature from 0 to 5°C . The young capelin farthest in the north-western area was found mainly in water from 0 to 3°C , while the adults in south-east was found in water around 2°C . The capelin concentrations recorded east of Vardø, however, occurred in water of 5°C .

The total capelin stock was at a relatively high level, dominated mainly by 2 year olds. It was pointed out that the rich 1971 year-class would be quite notable in the 1974 summer fishery and also be a strong contributor to the spawning stock in 1975.

1974

During the summer survey observations were made on distribution, abundance and year-class composition of capelin in the Barents Sea (Dalen and Dommasnes 1974). West of 40°E temperature conditions were similar to 1973, but east of 40°E it was 1 – 2° colder at the sea surface and 1°C colder at 100 m depth. Capelin was mostly recorded as scattered layers down to 100 m, with schooling tendency only southeast of Bear Island. Dense concentrations of capelin were found over a larger area than in the previous year, especially farther to the north. However, west of 40°E the concentrations were considerable weaker than in 1973.

Both 2 and 3 year-olds showed reduced growth compared to what can be considered normal, but due to the large number of individuals in these two year-classes the total biomass was still at a reasonably high level. No sure conclusion could, however, be drawn about the strength of the 1973 year-class.

1975

As in previous years observations on distribution, abundance and year-class composition of capelin were made. (Buzeta et al. 1976). The hydrographic situation was similar to that of 1973, i.e. the temperature in the area east of 40°E was 1-2° C higher than in 1974. The distribution and abundance of capelin was similar to that in 1974, but higher concentrations were found east of 40°E. These were, however, mixed with polar cod.

There was a change in the stock composition as the proportion of 3 years old fish was much larger than in 1974. Within the distribution area, divided into 4 growth areas, capelin was found to have an increase in growth from north to south.

1976

The intention of the summer survey was also this year to observe the capelin stock prior to the summer fishery (Hamre and Røttingen 1977). Except for the sea surface layer, which was somewhat warmer, there were no significant differences in the hydrographical conditions from the situation in the previous year.

The distribution of capelin west of 36° E was roughly the same as in summer 1975. In the central part of the area, however, the density was higher. The concentrations here were dominated by young fish (10-13 cm) and recorded mostly as scattered layers. Occasionally they formed schools suitable for purse seining. East of 36°E the distribution was larger and thus differed from the situation in 1975. The oldest year-classes dominated, having a length range from 12-14 cm, as in 1975.

1977

During the summer 1977 two surveys on the Barents Sea capelin stock were carried out. As the recordings of capelin during the first survey, in May/June, were significantly smaller than expected, this survey was followed by a new survey in July. The main goal of this survey was to possibly find the reason why so little capelin was observed in June (Dommasnes et al. 1978).

The Barents Sea was considerable colder in 1977 than in the nearest previous years, particularly in the upper water layers, but the same tendency was found at greater depths (Figure 5). The ice was also located farther south than in the corresponding periods of the previous years.

Capelin was mostly recorded as scattered layers, but occasionally also as small schools. In some areas the capelin stayed very close to the bottom, and this was especially the case in the area southwest of the Central Bank during both surveys. During the second survey capelin was also observed in the deeper area between the Central Bank and Hope Island, where it appeared only as a thickening of the bottom line on the echo paper.

Considerably more capelin was observed in July than in June, i.e. 3.2 times more (Table 2). Some of this increase is due to individual growth from June to July, but most of the increase was due to recording of fish not observed in June. All the year-classes have partly avoided being registered in June, and this was most pronounced for the oldest and largest capelin.

As the acoustic instruments were found to be in order during both surveys, the reason for the much smaller amount of capelin recorded in June must be that it was outside the water volume searched by the echo sounder. The most likely explanation is that the capelin occurred very close to bottom and that it was distributed under the ice. The unusually low sea temperature in 1977 might have caused this special situation.

Considering these conditions the calculations from July are also likely to be an underestimate. Hence the number of 2 years and older old capelin found during the second cruise in the Barents Sea in summer 1977, probably was as expected from the investigations in autumn 1976. The growth of these year-classes was also found to be at a “normal” level, and the basis for the summer fishery approximately as in the previous year, but the distribution more westerly.

1978

The aim of the survey was to map abundance and distribution of the stock and examine the growth of 1 year old and older capelin (Dommasnes 1978). In the eastern part of the Barents Sea the water temperature was clearly lower than what had been usual during the last previous years, while farther to the west it was more “normal” for the season.

In all areas the capelin distribution was clear of the ice, and east of Bear Island the capelin was recorded as scattered layers close to bottom. Practically no capelin was recorded east of 35°E. The 3 year-olds and older dominated in north, while the 2 year-olds dominated in southeast. The stock in summer 1978 was found to be smaller than observed for many years, and the 2 year-olds dominated. Considering the natural and fishing mortalities of the year-classes 1974–1976, the development in the numbers was found to be as expected.

The number of 1 year olds was smaller than observed in July 1977. The explanation for this may have been that during the summer season some of the 1 year old capelin was too small to be properly caught by the gear used. Anyhow, the 1977 year-class was considered less significant in numbers than the 1976 year-class. The capelin in summer 1978 had somewhat smaller volume than in summer 1977, but the individual growth still was good compared to previous years (Table 3).

DISCUSSION

During summer capelin is distributed over large areas in the Barents Sea. The highest densities are found in areas with the largest temperature gradients, i.e. in the polar front area from the Bear Island and north-eastwards in the Barents Sea. Capelin occurs in water of temperature from $-0,5$ to $8,0^{\circ}$ C, with maximum at $1,5^{\circ}$ C.

The summer/autumn fishery for capelin started in 1968, taking place in the capelin's feeding and nursery area. The most traditional one became the area east of Hope Island. In 1975 an area south of 75°N and east of 40°E was closed to fishing, to avoid exploitation of the juveniles, and in 1976 the area south of 74°N and east of 35°E was closed. The summer fishery lasted until 1986, and afterwards the capelin fishery in the Barents Sea has been managed as a winter fishery only, in the years it was permitted (1991-1993, 2001). This allowed the stock to make maximum use of the feeding period during summer.

The variations in the capelin distributions from year to year are due to changes in the hydrographic conditions and the stock abundance. The unusually low sea temperature in 1977, particularly in the upper layers, illustrates this. To get as realistic picture as possible of the situation that summer, it was necessary to undertake a survey in July in addition to the ordinary one in June. The ice boarder was located farther south than usual and probably covered part of the capelin stock. Also, capelin in

some areas was observed extraordinarily close to the bottom, making it especially difficult to detect and distinguish from bottom recordings.

The basis for the summer fishery in 1977 was expected to be the same as in 1976, and reduction in numbers of 2 and 3 years old capelin was anticipated to be partly compensated by increased individual growth. The results from the two summer surveys and the autumn survey in 1977 confirmed this development. While the reduction in stock biomass of 2 years old and older capelin was 11%, the reduction in numbers was 27%. The 1974 and 1975 year-classes were considerably less numerous than the previous ones (1971-1973), but the reduced recruitment was partly compensated by increase in the growth rate (Anon. 1978).

In 1978 there was still unusually low sea temperature in the Barents Sea, especially in the eastern part. The capelin was also this year occurring close to bottom, and practical no recordings of it was made east of 35°E. The 1976 year-class was at a more normal level, but the individual volume of the capelin was smaller than observed in summer 1977.

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Table 1. Norwegian acoustic surveys on the Barents Sea capelin, with R.V. "G.O. Sars" during summer 1970 – 1978.

Year	Time period	Reference
1970	1 – 18 June	Berge et al. 1970
1971	1 – 27 June	Hylen et al. 1972
1972	No survey	-
1973	25 May – 25 June	Haug and Monstad 1974
1974	18 May – 13 June	Dalen and Dommasnes 1974
1975	3 – 21 June	Buzeta et al. 1976
1976	9 June – 9 July	Hamre and Røttingen 1977
1977	30 May – 4 July and 10 – 21 July	Dommasnes et al. 1978
1978	14 June – 15 July	Dommasnes 1978

Table 2. Numbers of individuals ($\times 10^{10}$) of capelin year-classes, summer 1977.

	Year-class				SUM
	1976	1975	1974	1973 +	
2-24 June	9.2	11.3	4.8	1.7	27.0
10-23 July	16.4	23.4	13.4	5.1	58.7

Table 3. Mean volumes in ml of capelin from the year-classes 1971-1978. The values from summer 1978 are underlined.

Year-class	2 years		3 years		4 years	
	Summer	Autumn	Summer	Autumn	Summer	Autumn
1971		7.1	5.7	8.1	9.0	15.0
1972	2.8	5.2	5.7	10.1	10.5	17.0
1973	3.6	6.5	8.2	12.2	13.3	21.0
1974	5.2	7.9	10.2	16.7	<u>12.4</u>	
1975	5.2	8.1	<u>9.6</u>			
1976	<u>4.4</u>					

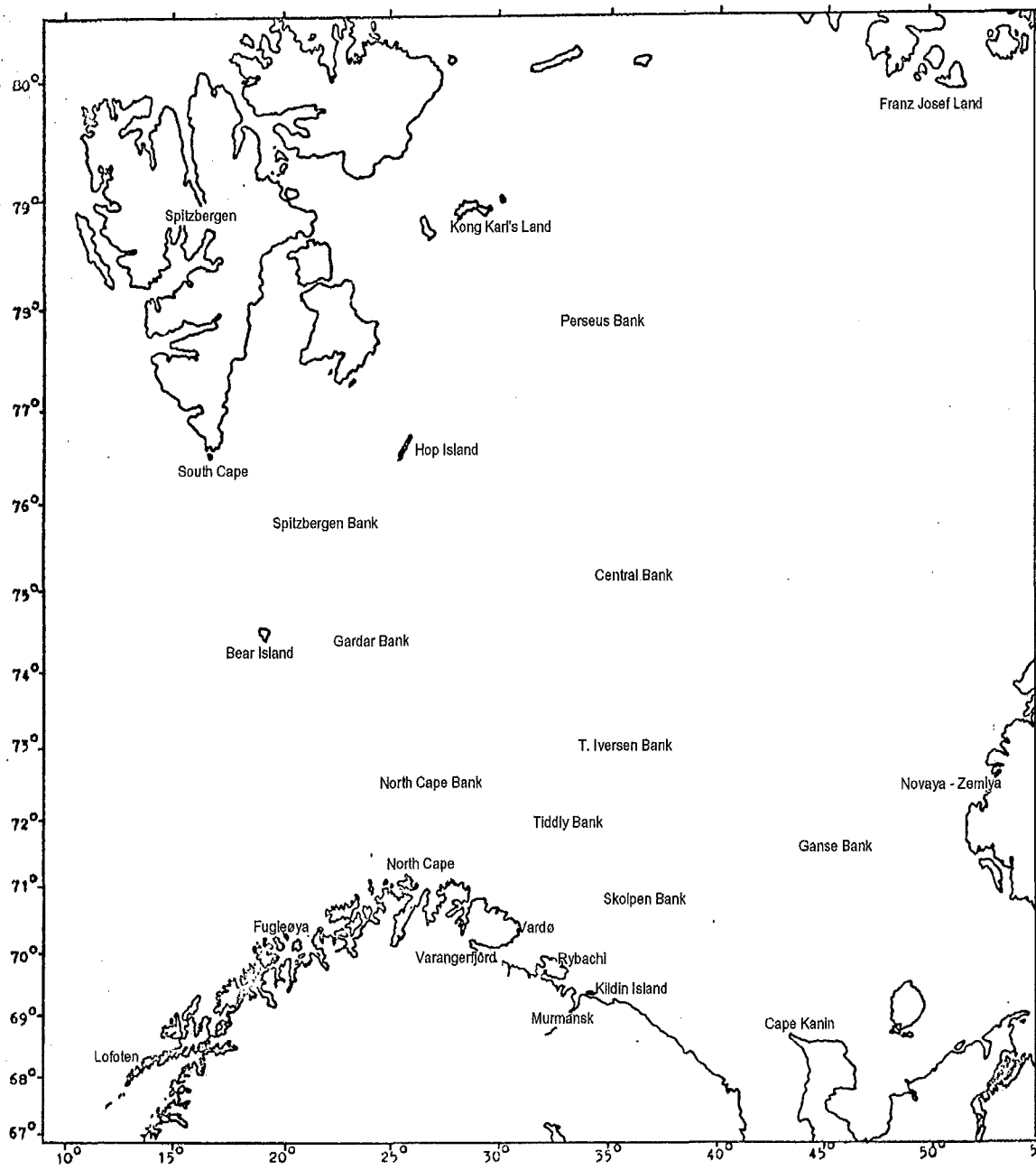


Figure 1. The Barents Sea.

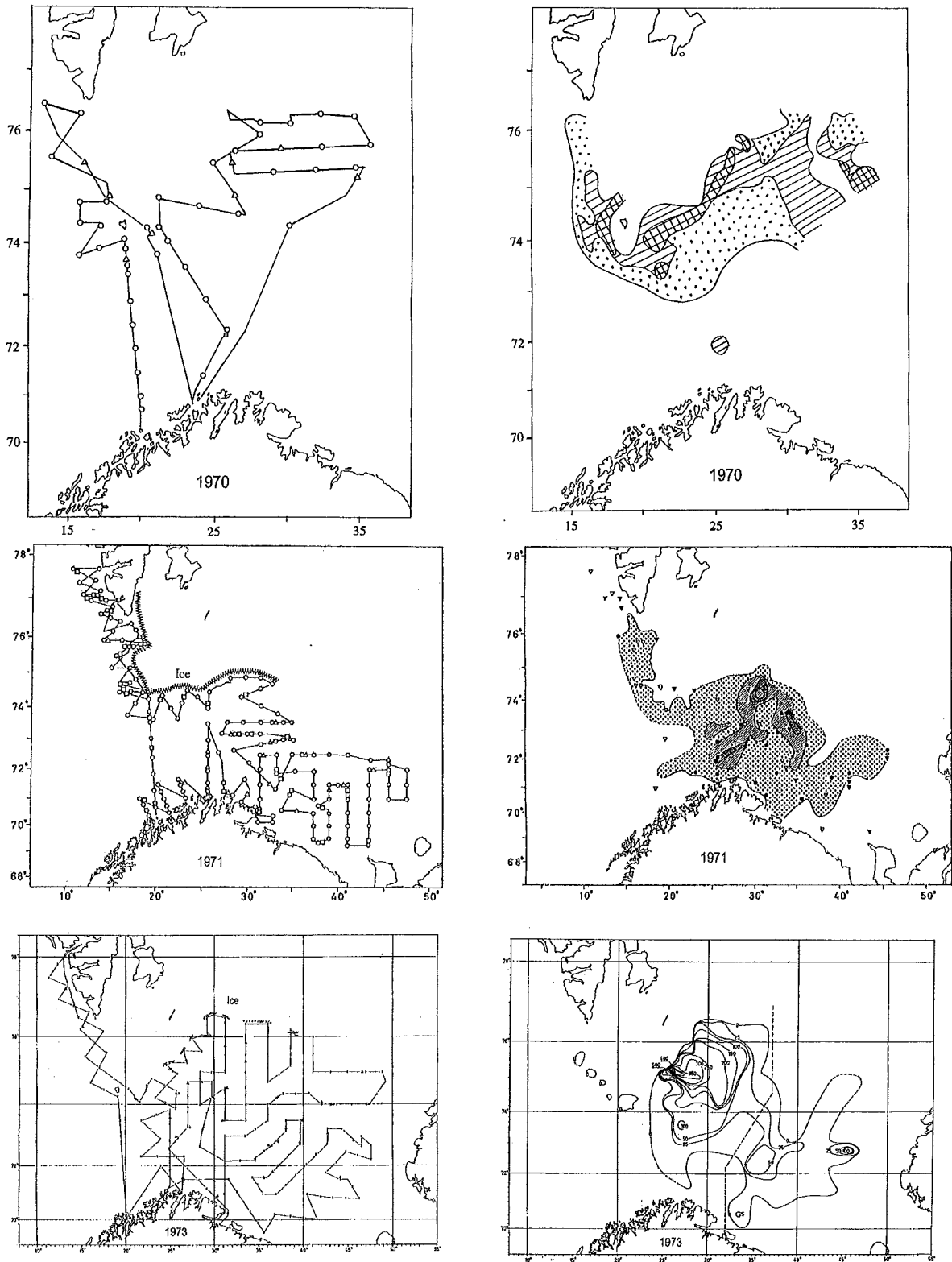


Figure 2A. Cruise tracks and distribution of capelin during summer 1970, 1971 and 1973.

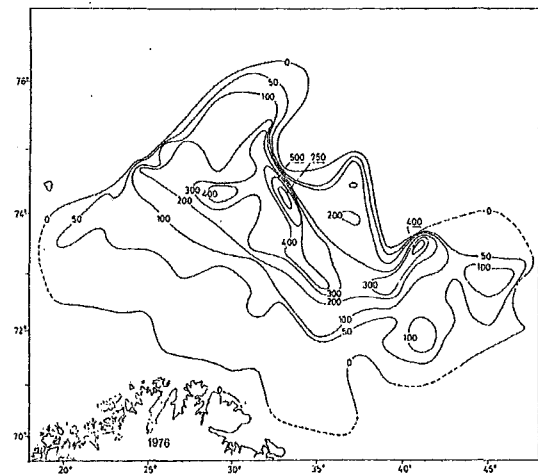
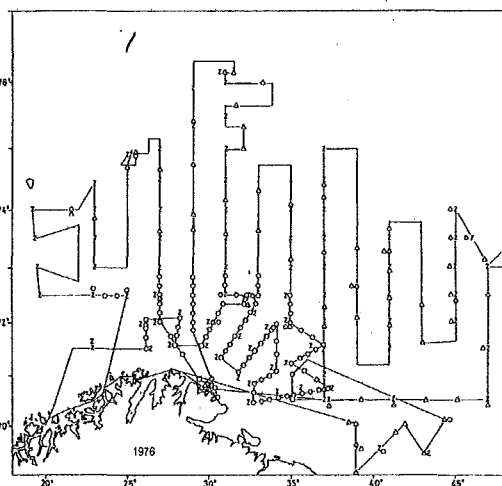
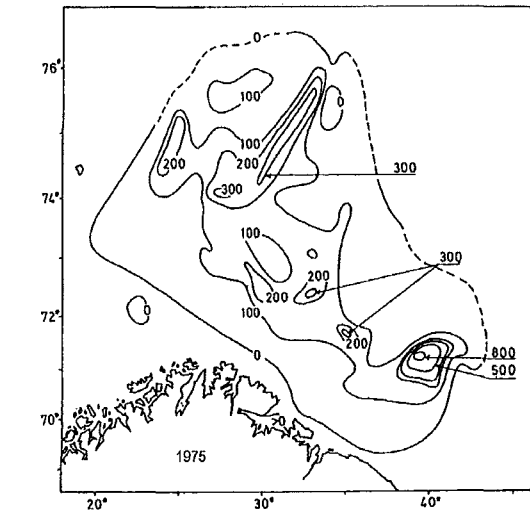
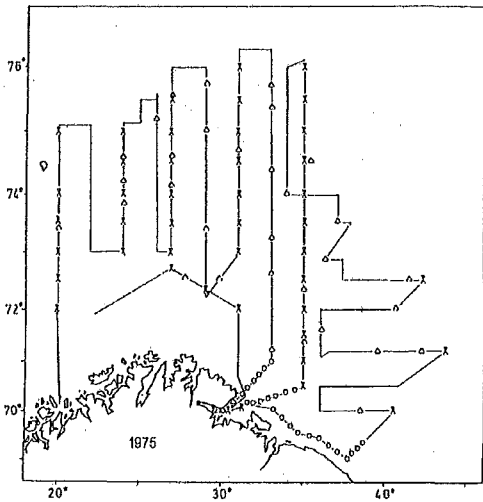
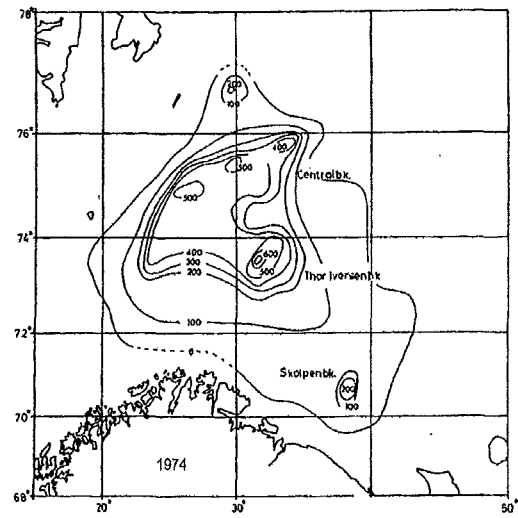
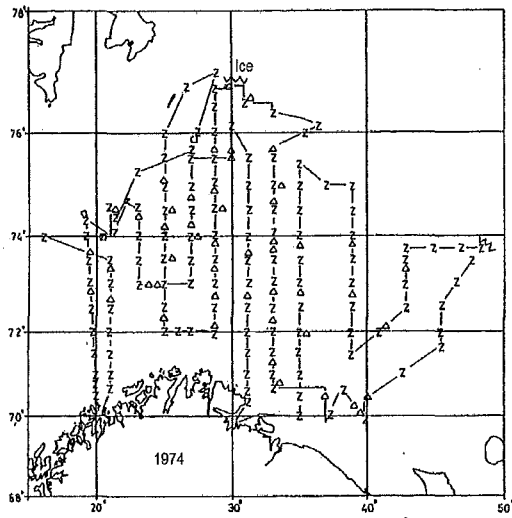
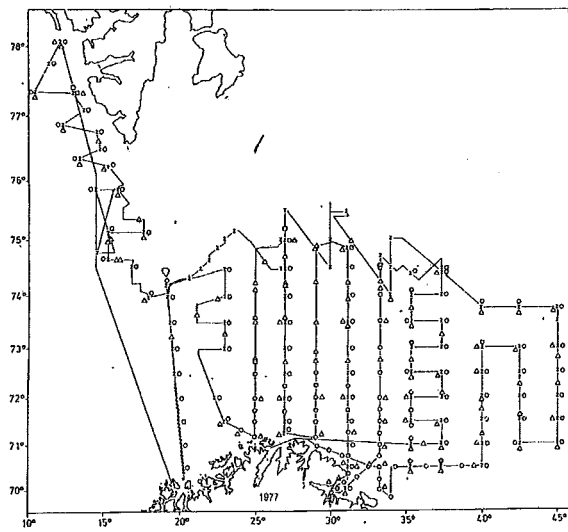
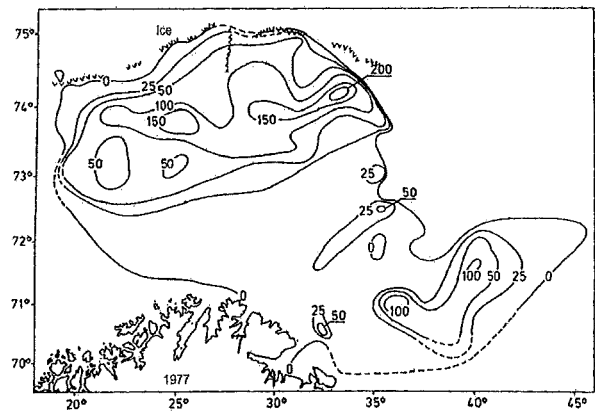


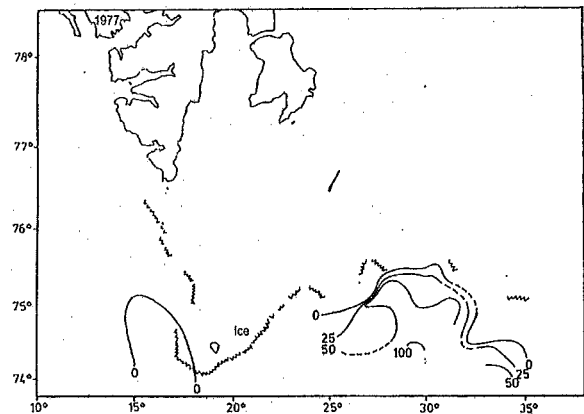
Figure 2B. Cruise tracks and distribution of capelin during summer 1974-1976.



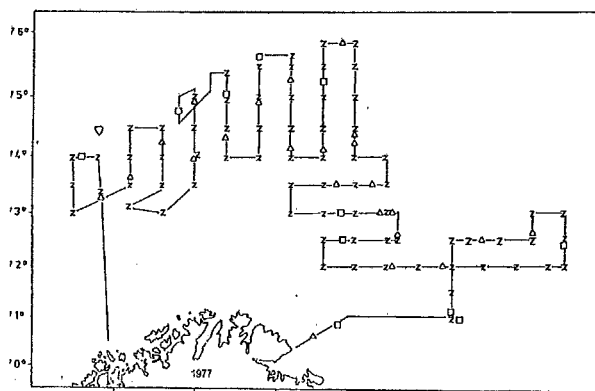
2-30 June



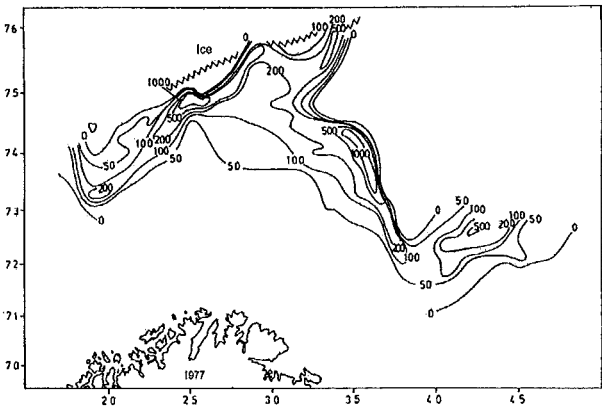
2-24 June



24-30 June



10-30 July



10-30 July

Figure 2C. Cruise tracks and distribution of capelin in 3 periods during summer 1977.

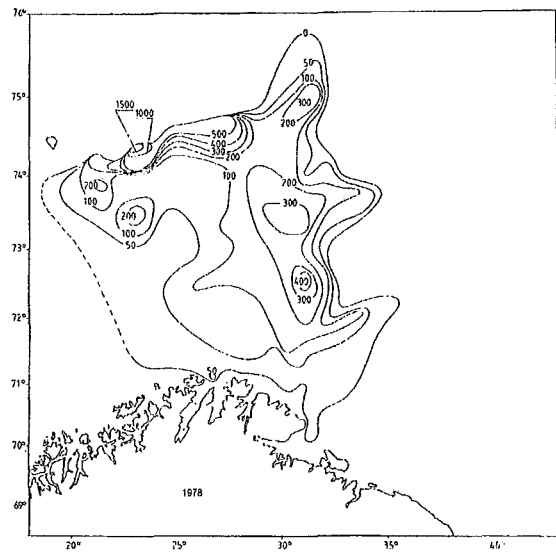
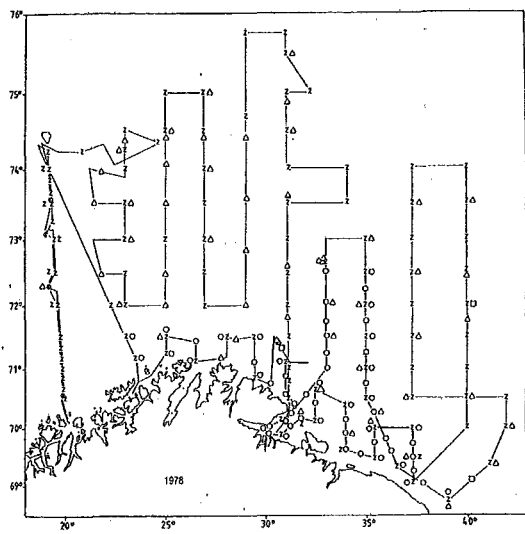


Figure 2D. Cruise tracks and distribution of capelin during summer 1978.

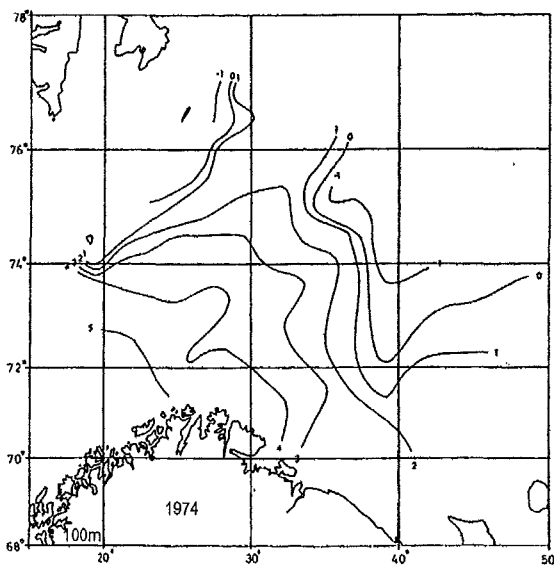
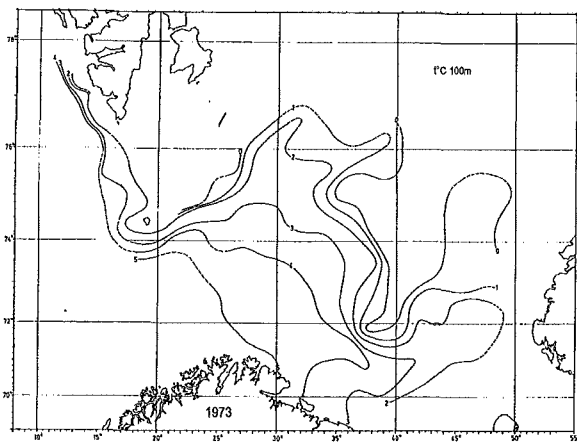
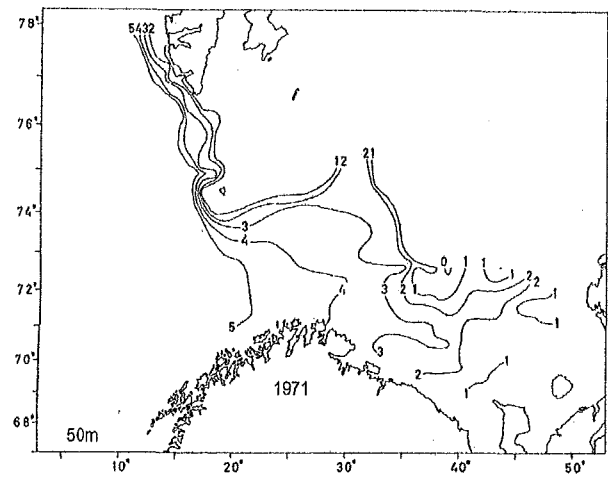
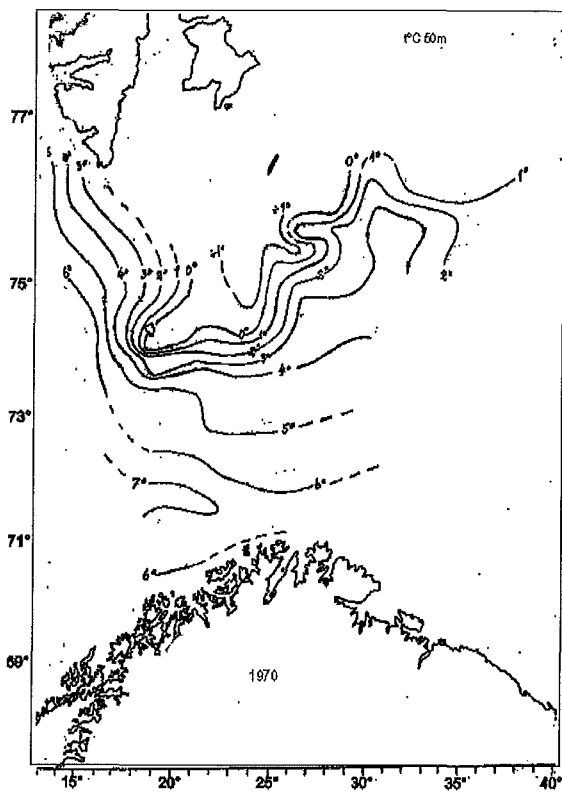


Figure 3A. Temperatures, $t^{\circ}C$, during summer 1970 and 1971 (50 m) and summer 1973 and 1974 (100 m).

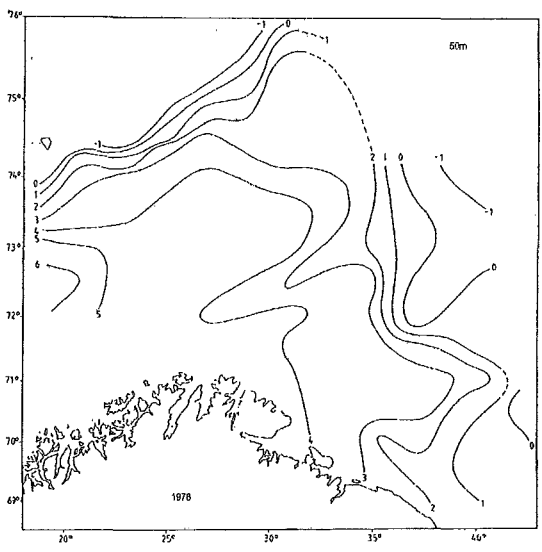
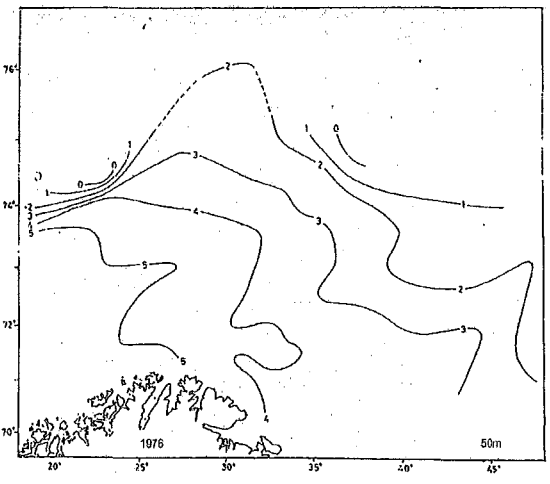
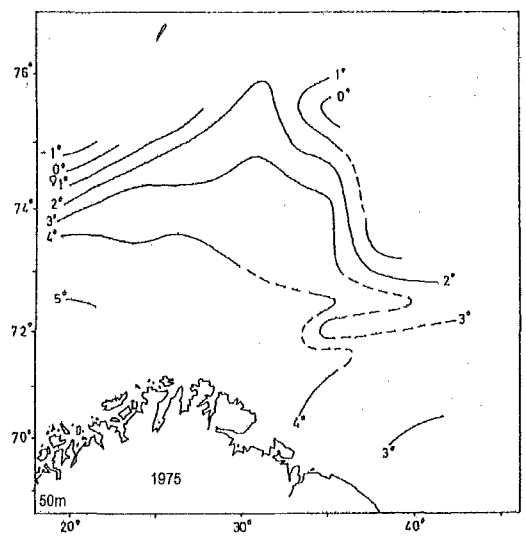


Figure 3B. Temperatures, t°C, in 50 m during summer 1975, 1976 and 1978.

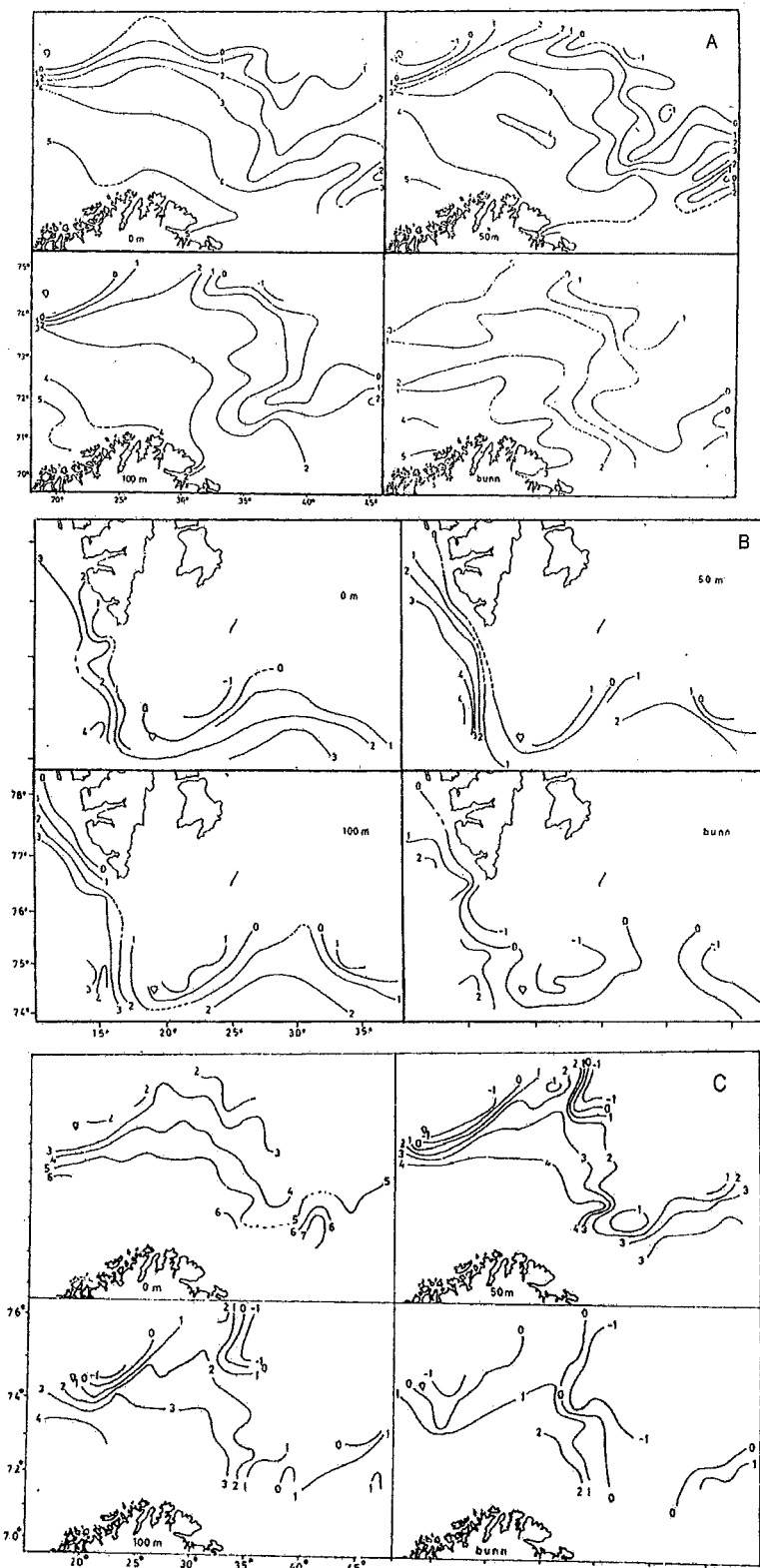


Figure 4. Temperatures, $t^{\circ}\text{C}$, at sea surface, 50 and 100 m and bottom in 3 periods during summer 1977: A) 2-24/6, B) 24-30/6, C) 10-23/7.

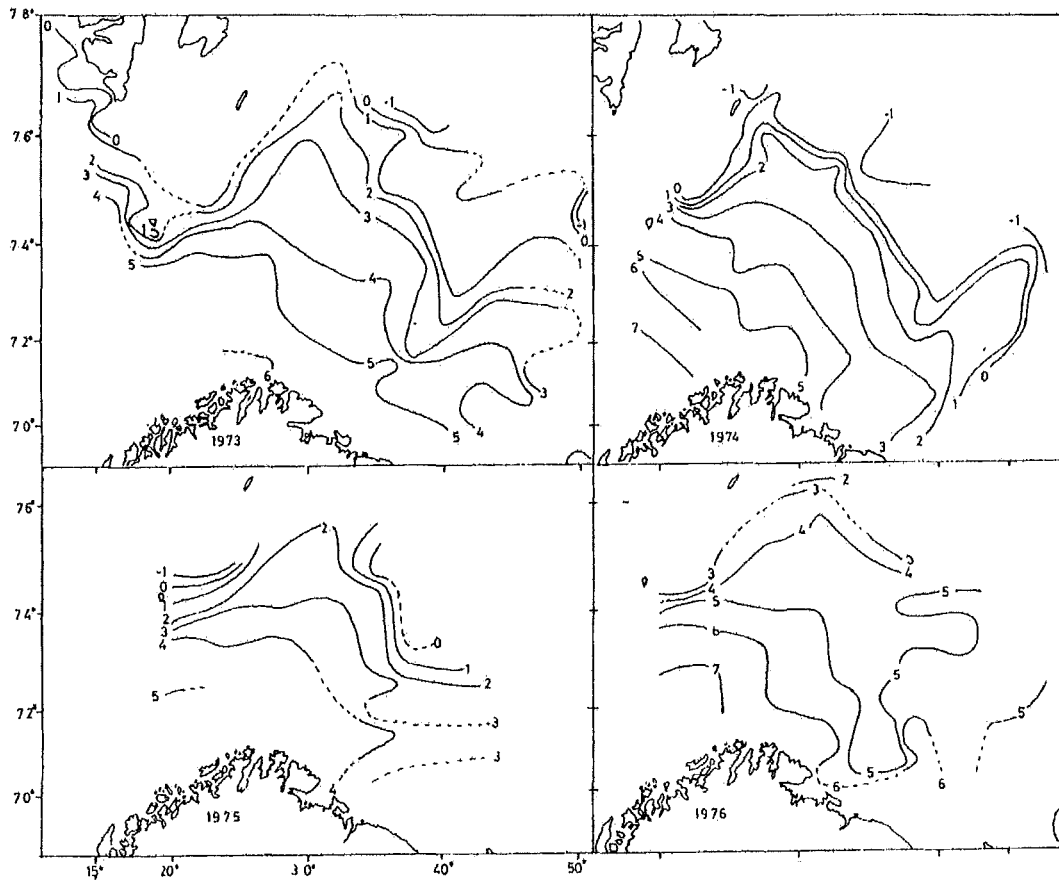


Figure 5. Sea surface temperatures, t° C, during summer 1973-1976.

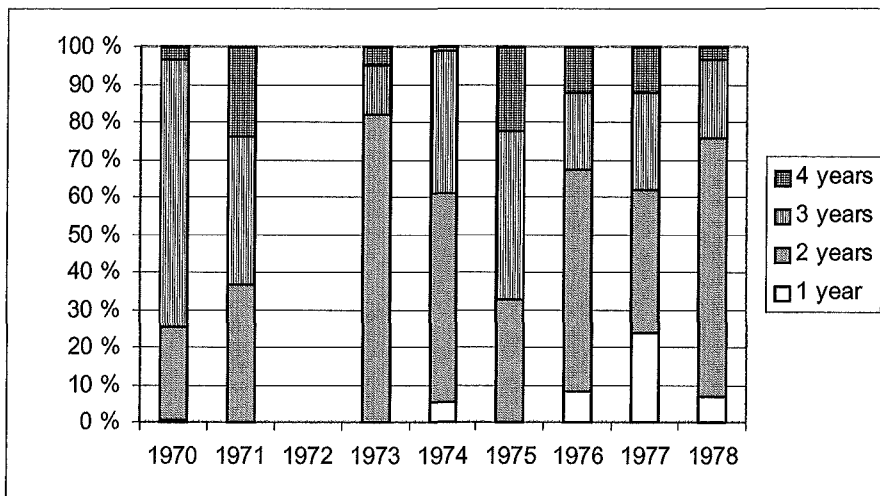


Figure 6. Age composition (N %) of capelin in the Barents Sea during the summer seasons 1970-1978. The four years old in 1975-1977 are plus-groups.

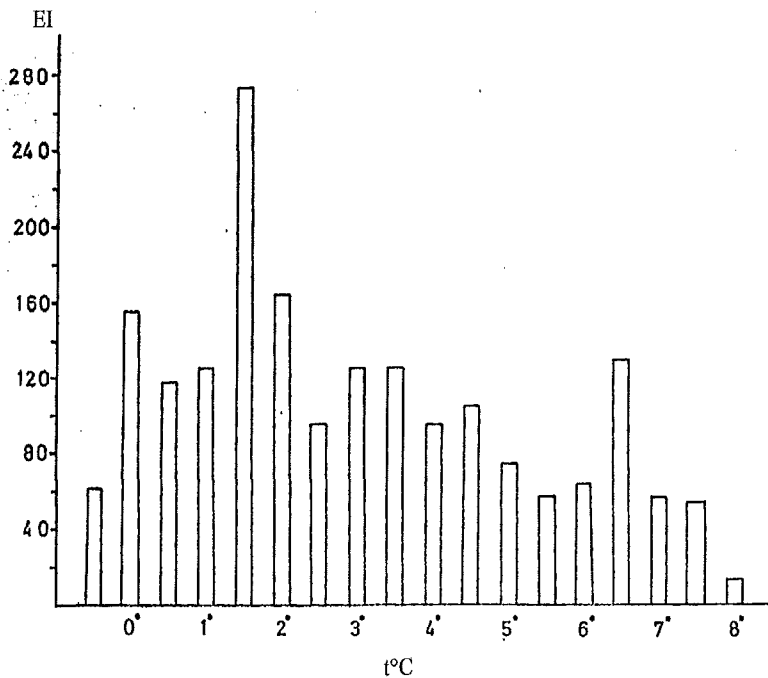


Figure 7. Echo intensity, $EI = m^2$ per (nautical mile)², of capelin in relation to the temperature at sea surface, recorded in the Barents Sea, July 1970.