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THE RECOVERY OF THE BARENTS SEA CAPELIN (*MALLOTUS VILLOSUS*) FROM A LARVAL POINT OF VIEW.

By

Petter Fossum

Institute of Marine Research
P.O.Box 1870
N-5024 Bergen,Norway

ABSTRACT

The recovery of the Barents Sea Capelin is studied with larval surveys in the period 1986-91. Very few larvae were found in 1986,1987 and 1988, but the abundance of capelin larvae increased from 1989 back to the normal larval "stock size" found in the early eighties. In 1990 the highest recorded indice of abundance for the period 1981-1990 was found. Distribution maps and abundance indices of capelin larvae are presented. Length frequency distributions of the larvae are shown. The vertical distribution of larvae from a diurnal station is given. These data are discussed with respect to the variations in physical and biological parameters the Barents Sea ecosystem observed in the period.

INTRODUCTION

Heavy exploitation and natural mortality (Mehl 1989) decimated the capelin population in the Barent Sea in the mid-eighties. The result was a collapse in the fishery, but also in the populations of capelin consumers such as cod, seals and seabirds (Hamre 1991). After this "crisis" in the Barents Sea the ecosystem was almost free of predators and rather small spawning stocks of capelin were able to produce large yearclasses.

The recruitment of spring-spawned herring was low in the period 1986-88 and no large schools of herring entered the Barents Sea. This may have had a positiv effect on the recruitment of capelin as there are indications of an inverse relationship between "large" yearclasses of capelin and herring

(Moksness and Øiestad 1987). This allowes the opportunistic capelin to fully recolonize the ecosystem in a five years period.

The objective of the present study was to calculate larval indices and distribution maps for the period 1986-1991. The indices were calculated shortly after hatching had ceased and consequently they are an expression for both hatching and first feeding success.

MATERIAL AND METHODS

The southern part of the Barents Sea was surveyed in the second part of June for the period 1987-91. In 1986 the same area was surveyed by R/V "Eldjarn" in the beginning of June, but no larvae were found. In the same year a hatching investigation for capelin was carried out (Solemdal and Bratland 1987) in the Varangerfjord (see Fig. 1) and some capelin larvae were discovered in this area towards the end of June. In 1987 and 1988 the vessels M/V "Charles" and M/V " Odin Finder" were used to cover the distribution of capelin larvae. In 1989 and 1991 R/V " Michael Sars " and in 1990 R/V "Eldjarn" surveyed the area. All the cruises started in the Varangerfjord, then went into the Russian zone to 35 ^{0} E and surveyed in a northerly direction to the zero line of capelin larvae distribution. In this way every second degree of longitude to 21 ^{0} E was surveyed. For more information about the different cruises see Fossum and Tuene (1987), Fossum (1988), Fossum and Bakkeplass (1989) and Fossum and Bakkeplass (1991).

The sampling of capelin larvae was performed by a Gulf-III plankton sampler (Zijlstra 1970), as recomended in Alvheim (1984). 50 capelin larvae from each station (if present) were measured to nearest mm.

In 1990 a diurnal station was conducted to study the vertical distribution of the capelin larvae. A 1 m^2 Mocness (Wiebe 1976) was used to sample the larvae in the following depths: 100-80, 80-60, 60-50, 50-40, 40-30, 30-20, 20-10 and 10-0 m. Approx. 50 m^3 was sampled in each depth.

RESULTS

The horizontal distributions of capelin larvae for the period 1986-91 are given in Figs. 1-6. In the 1986 survey no capelin larvae were found at all. However, on a separate hatching investigation carried out in the Varangerfjord capelin larvae were found towards the end of June. This is indicated on Fig. 1. The size of the larvae and an earlier finding of capelin larvae indicated that the hatching could have taken place near Vardø in the beginning of June (Solemdal and Bratland 1987).

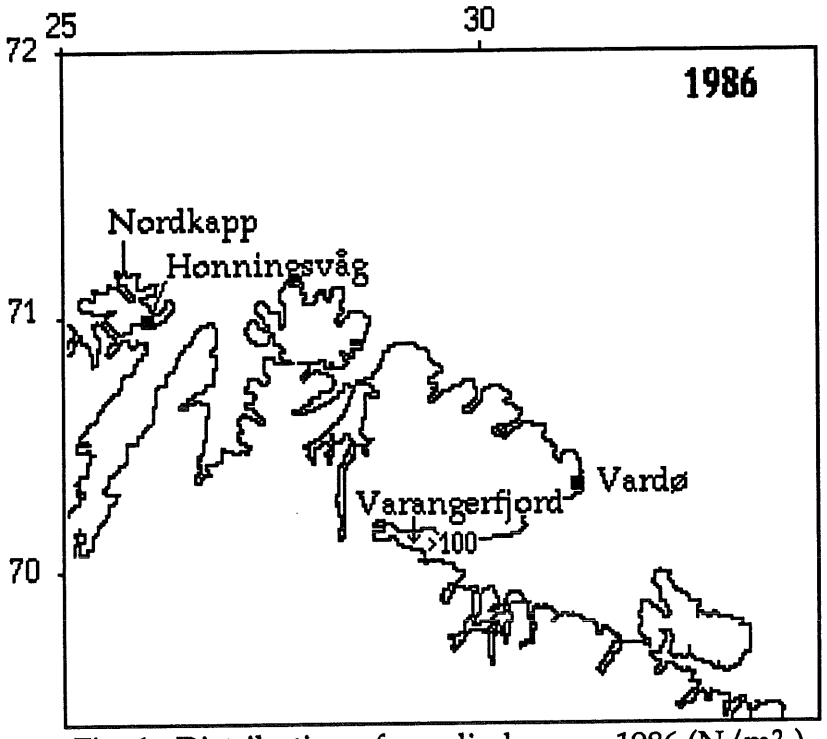

Fig. 1. Distribution of capelin larvae , 1986 (N/m^2).

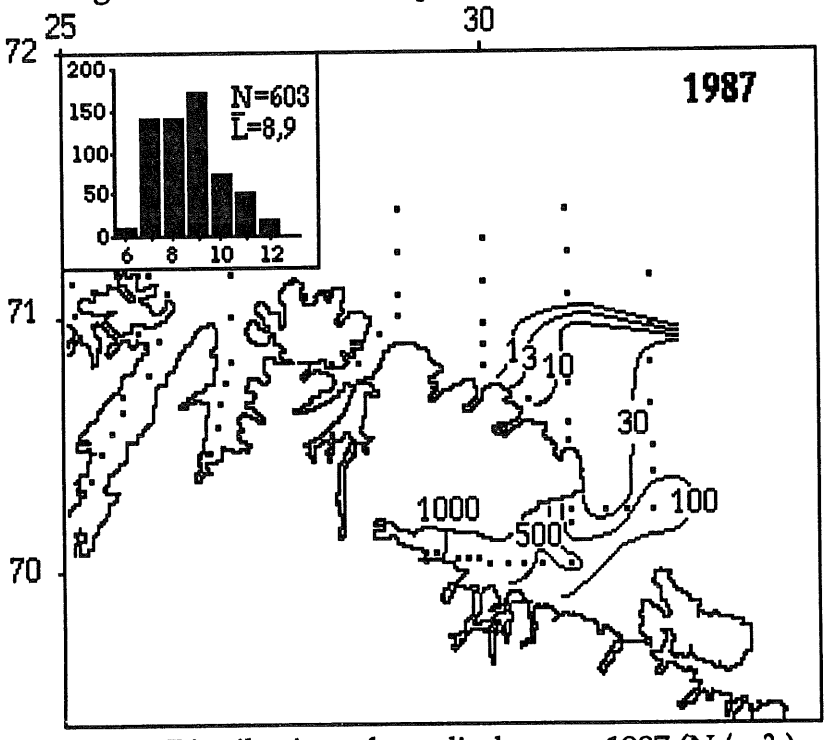

Fig. 2. Distribution of capelin larvae , 1987 (N/m^2).

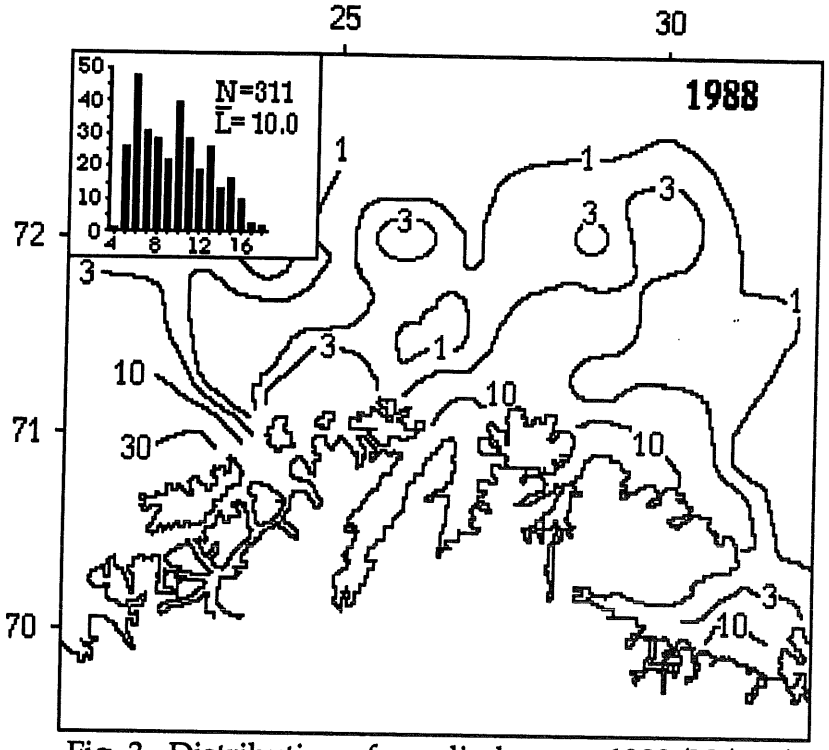

Fig. 3. Distribution of capelin larvae , 1988 (N/m²).

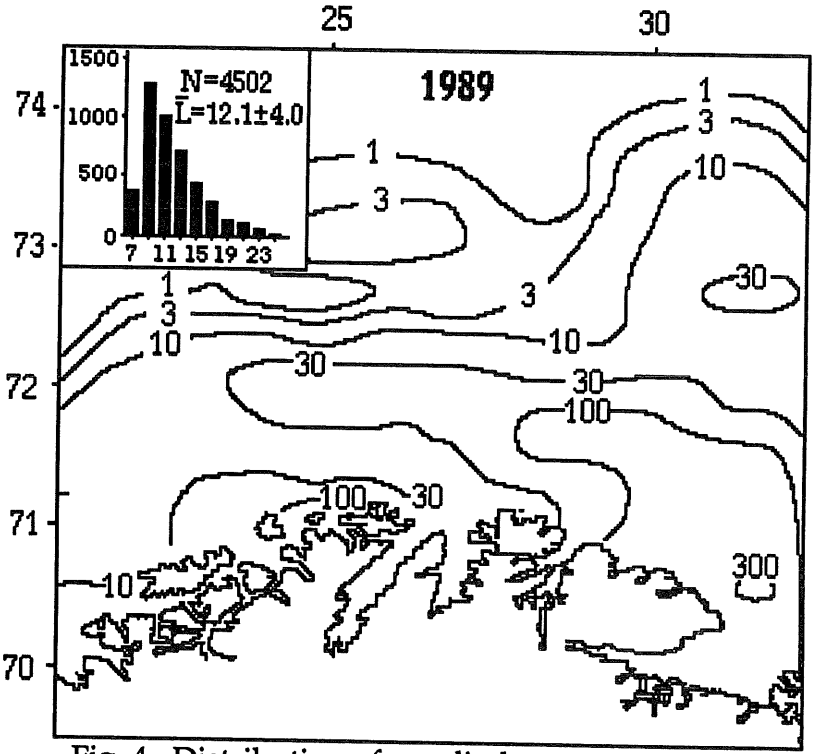

Fig. 4. Distribution of capelin larvae , 1989 (N/m²).

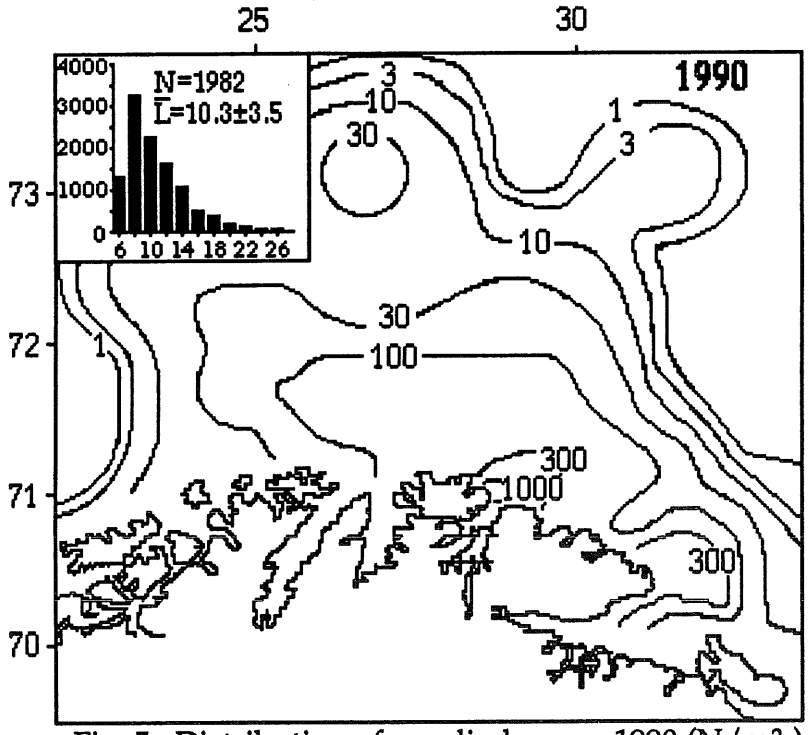

Fig. 5. Distribution of capelin larvae , 1990 (N/m^2).

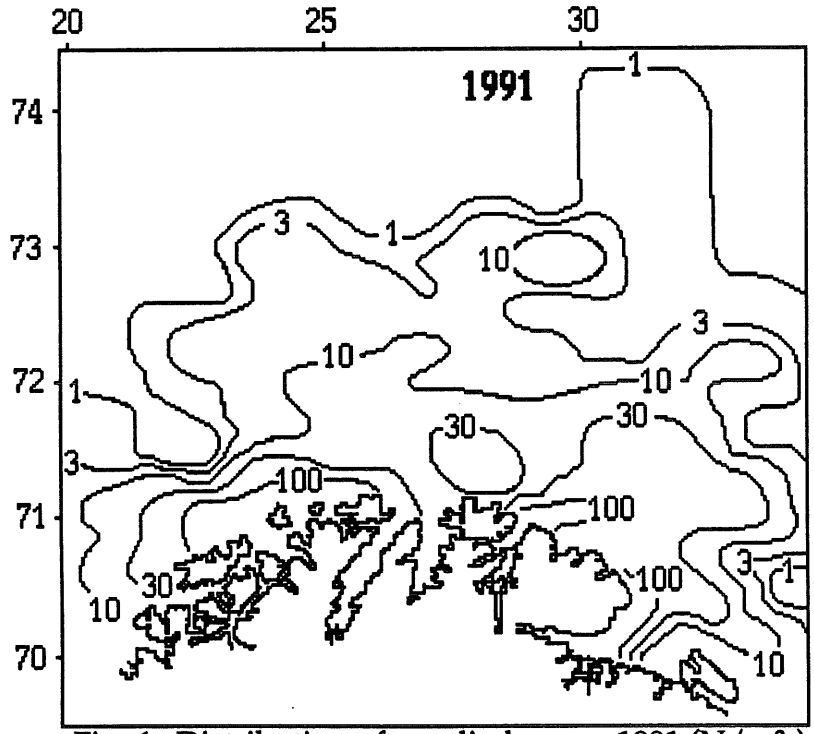

Fig. 6. Distribution of capelin larvae , 1991 (N/m^2).

The hatching investigation showed that the abundance of capelin larvae was more than 100 per square meter in the central part of the Varangerfjord on 20 June, but the hatching investigation provided no information about the horizontal distribution of the larvae.

In 1987 there was an increase in the abundance of capelin larvae as indicated by Fig. 2. All the larvae were found in the area near Varanger with a maximum abundance of over 1000 larvae per m2 in the inner Varangerfjord . The coverage was not good in east and some larvae may have drifted along the Murman coast. The mean length of the larvae were 8.9 mm.

In 1988 the larvae were distributed in the way typical for the distribution in the early eighties. The horizontal distribution of the capelin larvae in 1988 is shown in Fig.3. They were distributed over the southern part of the Barents Sea, but in very low densities. The mean length had increased to 10.0 mm.

In 1989 the abundance of capelin larvae, shown in Fig. 4, had increased to a level not far from the level seen before the collapse. The coverage was somewhat incomplete in the east, but experience from previous years indicates that most of the larvae were confined within the area covered. The larvae were distributed from the coast to 74^0 N with a maximum density of 300 per m^2 surface. The mean standard length was 12.1 mm, the highest recorded in the investigated period.

The highest number of capelin larvae was recorded in 1990. The coverage is shown in Fig.5. The maximum density was more than 1000 larvae per m^2. Most of the larvae were found east of Nordkapp (see Fig.1.) with maximum densities of more than 1000 larvae per m^2. The mean length was reduced to 10.3 mm.

In 1991, however, the number of larvae was reduced with a maximum density of 100 larvae per m^2. The horizontal distribution of capelin larvae found in 1991 is shown in Fig.6, and is typical of distribution since 1988. The mean length was 10.8 mm.

The larval indices for the period 1986- 1991 were calculated according to the system described in Knutsen and Westgård (1988); the parameters used are given in Fossum and Bakkeplass (1989). The values for 1981-1984 are taken from Alvheim(1984) and data for 1985 from H. Gjøsæter (Institute of Marine Research Bergen, Pers. comm. ,1989). The indices are shown in Fig. 7. In the early eighties the index was about $10x10^{12}$ capelin larvae, after

which the population collapsed and very few larvae were found in the period 1986-1988. In 1989 the larval population size had increased to 85% of the level in 1985,

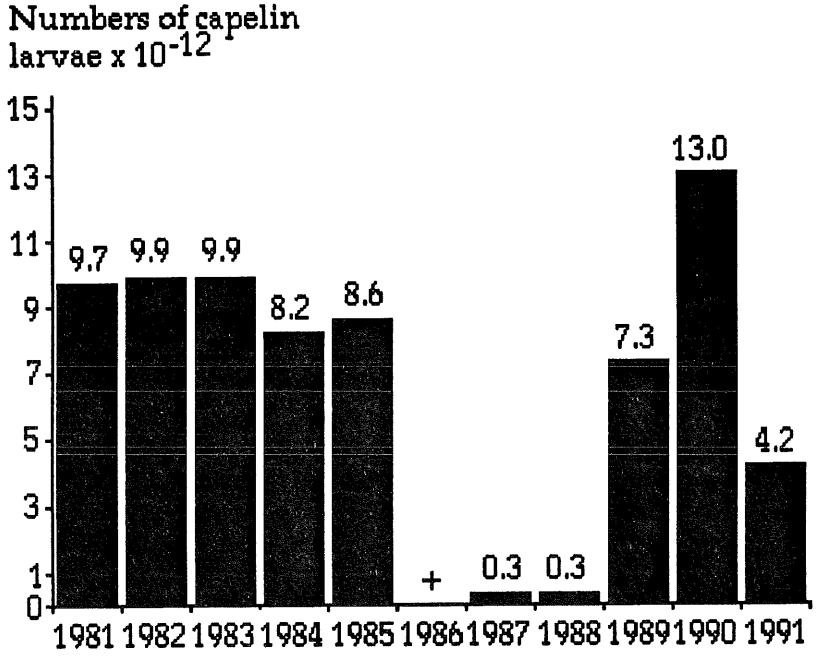

Fig. 7. The indices of capelin larvae for the period 1981-1991.

and in 1990 the highest indice in the whole period of $13x10^{12}$ was found. In 1991 the indice was reduced to 32% of the value found in 1990.

The capelin larvae hatch near the coast and drift in northerly and easterly directions. This is shown for 1990 in Figs. 8-11. In these figures the larval sample is shown in size categories. From the figures it is evident that the smallest larvae ≤ 9mm stay closest to land. The other size groups are more evenly dispersed in the Barents Sea , and the center of their distribution is in the area between 71 ^{0} 30´-72 ^{0} 30´N.

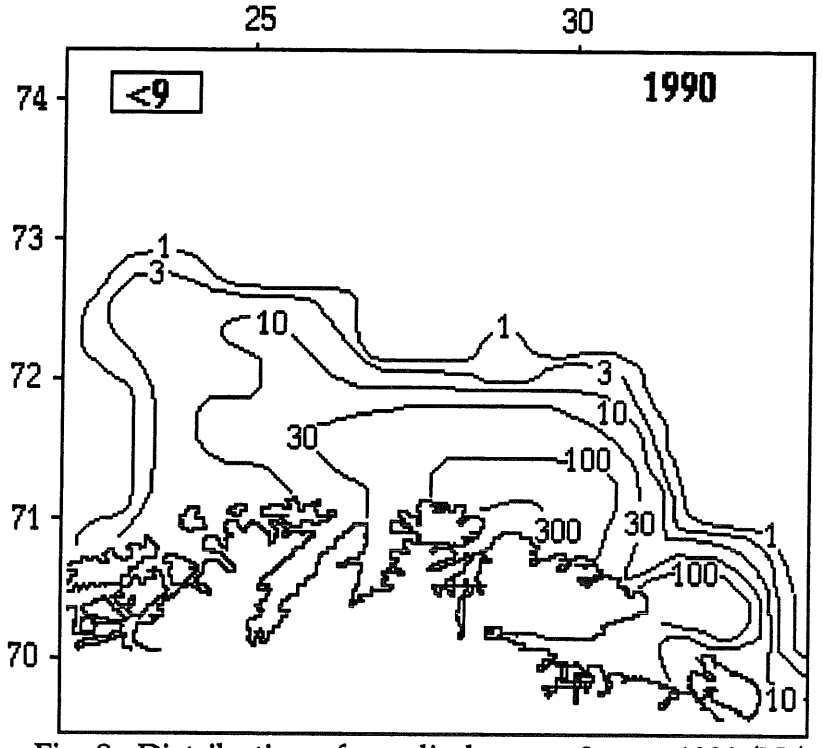

Fig. 8. Distribution of capelin larvae ≤9mm., 1990 (N/m²).

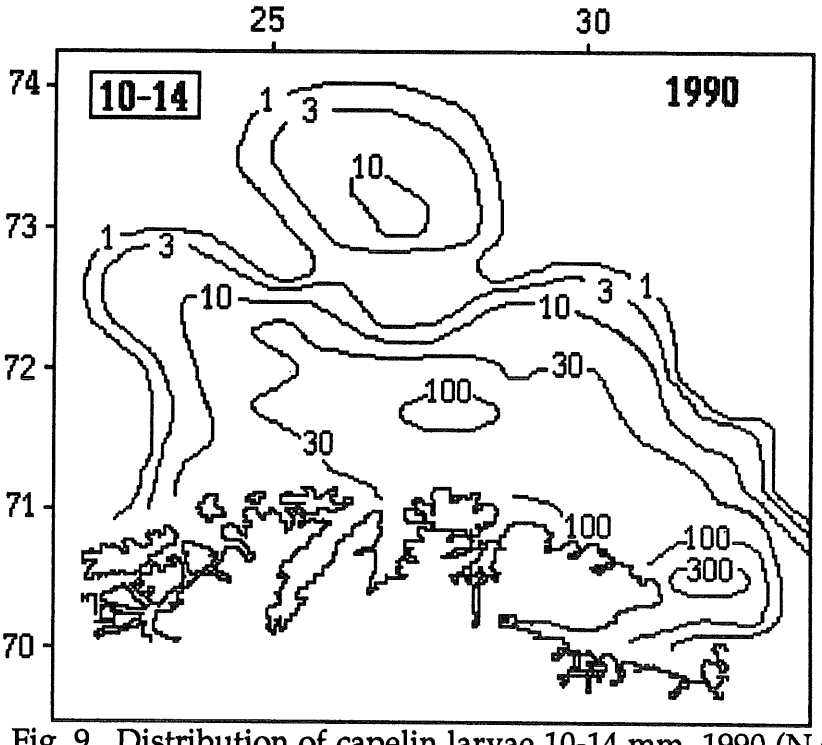

Fig. 9. Distribution of capelin larvae 10-14 mm, 1990 (N/m²).

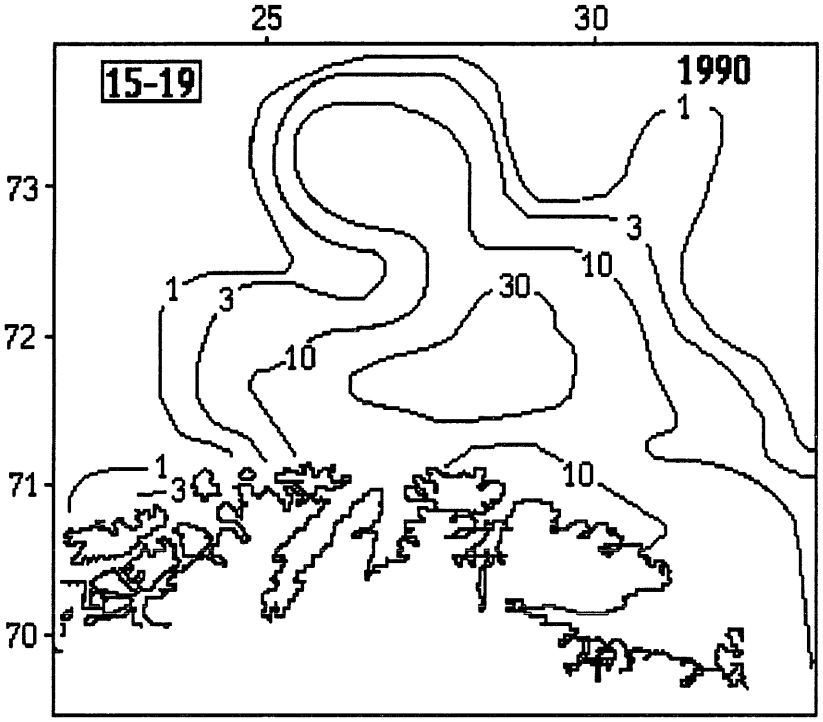

Fig. 10. Distribution of capelin larvae 15-19 mm, 1990 (N/m^2).

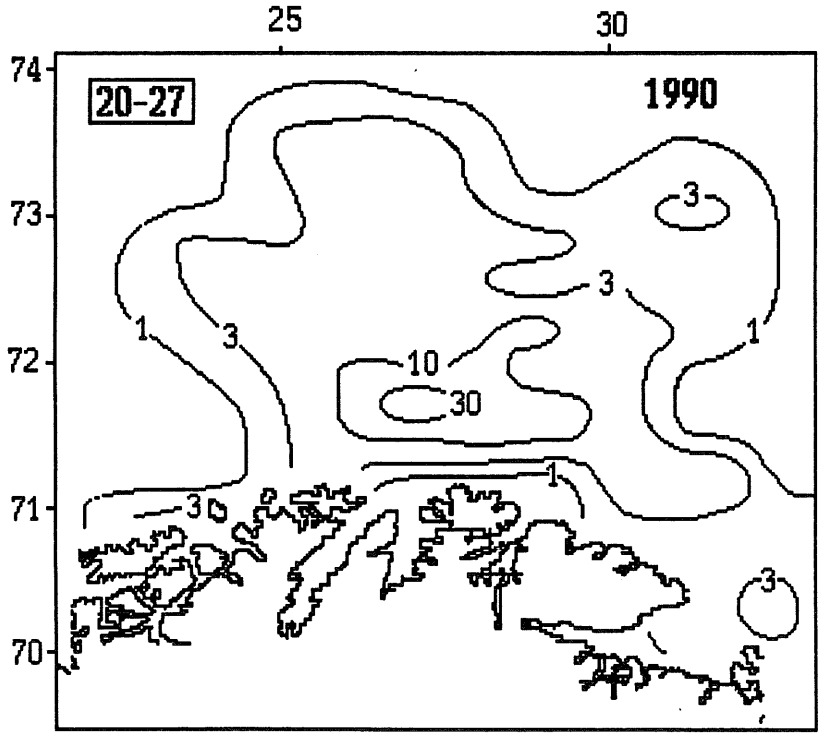

Fig. 11. Distribution of capelin larvae 20-27 mm, 1990 (N/m^2).

A diurnal station was performed in 1990 to investigate the vertical distribution of the capelin larvae. The result of this investigation is shown in Fig. 12.

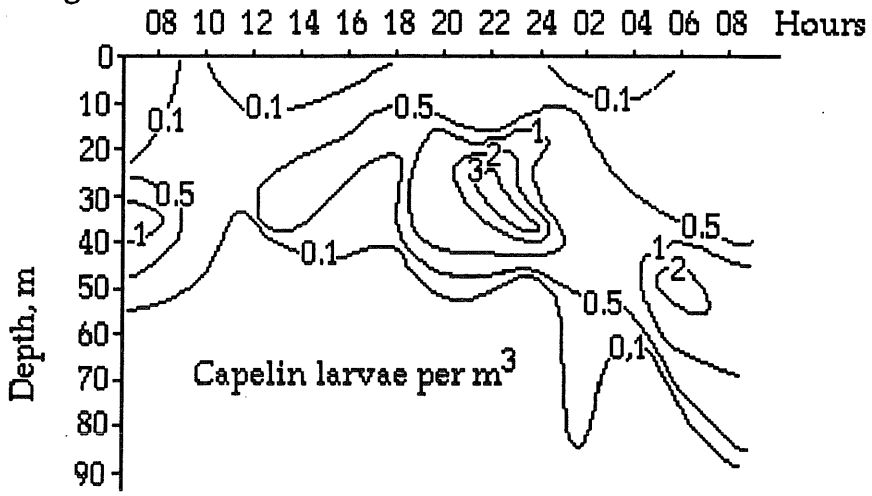

Fig. 15. The vertical distribution of capelin larvae.

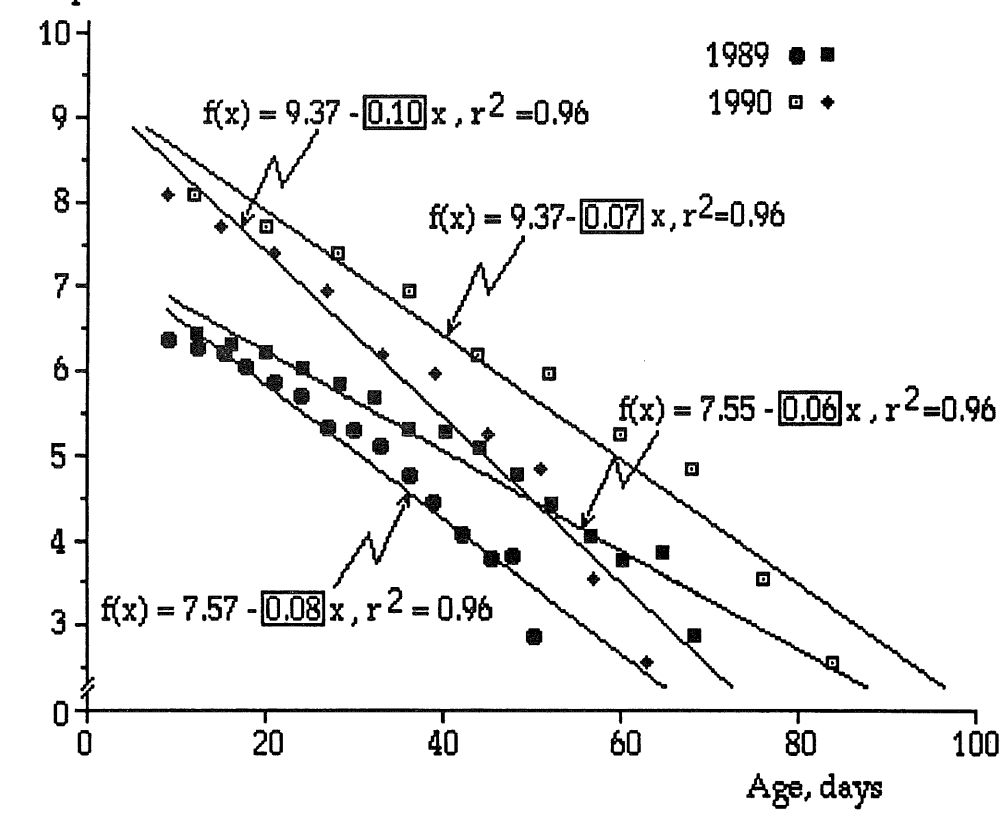

Fig.13. Instantaneous mortality rate in capelin larvae in 1989 and 1990.

The center of larval distribution varied between 30-50 m depth, and some vertical migration was observed. At this time of the year there is continous day-light in this area, but the light penetrating to this depth layer at midnight is only a fraction of what is observed at the surface at daytime.

The length frequency distributions for 1989 and 1990 shown in Figs. 4 and 5 can give the impression of constant larval production and mortality rate in both years. A logarithmic plot of number of larvae in different age- (length) groups versus age is shown in Fig. 13. There are two plots for each year, the upper one for the growth rate 0.25 mm per day and the lower one for a growth rate of 0.33 mm per day. With these assumptions, the instantaneous mortality rate was estimated to be 0.06 and 0.08 per day in 1989 and 0.07 and 0.10 in 1990 with a growth rate of 0.25 and 0.33 mm per day respectively.

DISCUSSION

The Barent Sea capelin is an opportunist in the Barents Sea ecosystem (Hamre 1991). With its short life-expectancy it is able to respond quickly to and utilize new niches in the system. The growth rate of the capelin shows a fast responce to changes in the food supply. Its short generation time and the ability to turn over much of the biomass into spawning products are the main reasons for its adjustment to the system.

The capelin spawn in the near-shore area, and the larvae drift north and east into the cental and northern part of the Barents Sea. The capelin feeds on the prespawning patches of zooplankton in connection with the polar front (Loeng et al. 1986).

The capelin is very vulnerable to predation and if the larvae drifts goes through stocks of young herring, cod and haddock, the number of capelin larvae will be heavily reduced on their way up to the nurcery area.

The collapse in the capelin stock in the mid-eighties occured for different reasons. The large yearclasses of herring and cod produced in 1983 preyed heavily on the capelin larvae, and although the larval production both in 1984 and 1985 was good very few larvae survived. The zooplankton biomass was reduced in 1983- 84 compared to the biomass found in 1980-82 (Skjoldal and Rey 1989). This reduced the growth rate of the capelin and few fish reached maturation. The small spawning stocks were also heavily preyed upon by immature cod during the spawning migration. The result was that the capelin stock was reduced almost to extinction.

The interesting aspect, however, is how quickly the capelin responded when the conditions in the Barents Sea became more favorable for growth and survival. In the spring and early summer 1986 the 1983 yearclass of spring-spawning herring left the Barents Sea and cannibalism had reduced the hords of hungry cod and left the ecosystem open for the capelin.

A very small spawning stock of approx. 20000 metric tonns spawned near Vardø in May 1986, and gave birth to a yearclass of very strong growth and survival. In the spring 1989 this yearclass had grown to an order of 200000 metric tonns (Anon 1989) and was the origin of one of the largest yearclasses of capelin ever seen in the Barents Sea. Two warm years 1989 and 1990 (Loeng et al. 1991) and steadily increasing abundance of zooplankton since 1983 (A. Hassel, Institute of Marine Research Bergen, Pers. comm., 1991) accelerated capelin growth rate. Now in 1991 -only 5 years after the collapse- the capelin has fully recolonized the Barents Sea ecosystem.

In the present study the recovery was followed by larval surveys and from the figures it is evident that larval abundance has increased in the period 1988-1990. In Fig. 14, spawning-stock size, index of larval abundance and yearclass size as two-year old capelin are shown.The reason for using an estimate of 0.5 mill. metric tonns for spawning stock in the period 1981-1985 is that the objective of regulations in that period was to ensure that after winter fishery the size of the spawning stock should be in this order of magnitude to ensure successful spawning. The spawning stock data for the period 1986-1988 are very uncertain because of the heavy predation by cod on capelin in this period. It is, however, known that the spawning stocks were very small given the values 20000 metric tonns in 1986 and 50000 in 1987 and 1988. The spawning stock data for 1989 and 1990 are taken from working-group reports (Anon. 1989, Anon. 1990). The spawning stock data for 1991 and the data for the two-year old capelin of the 1987, 1988 and 1989 yearclasses are from H. Gjøsæter (Institute of Marine Research, Pers. comm., 1991). Remaining data for the abundance of two-year old capelin comes from a report on the yearly summary of fish resources (Anon 1990) issued by the Institute of Marine Research, Bergen.

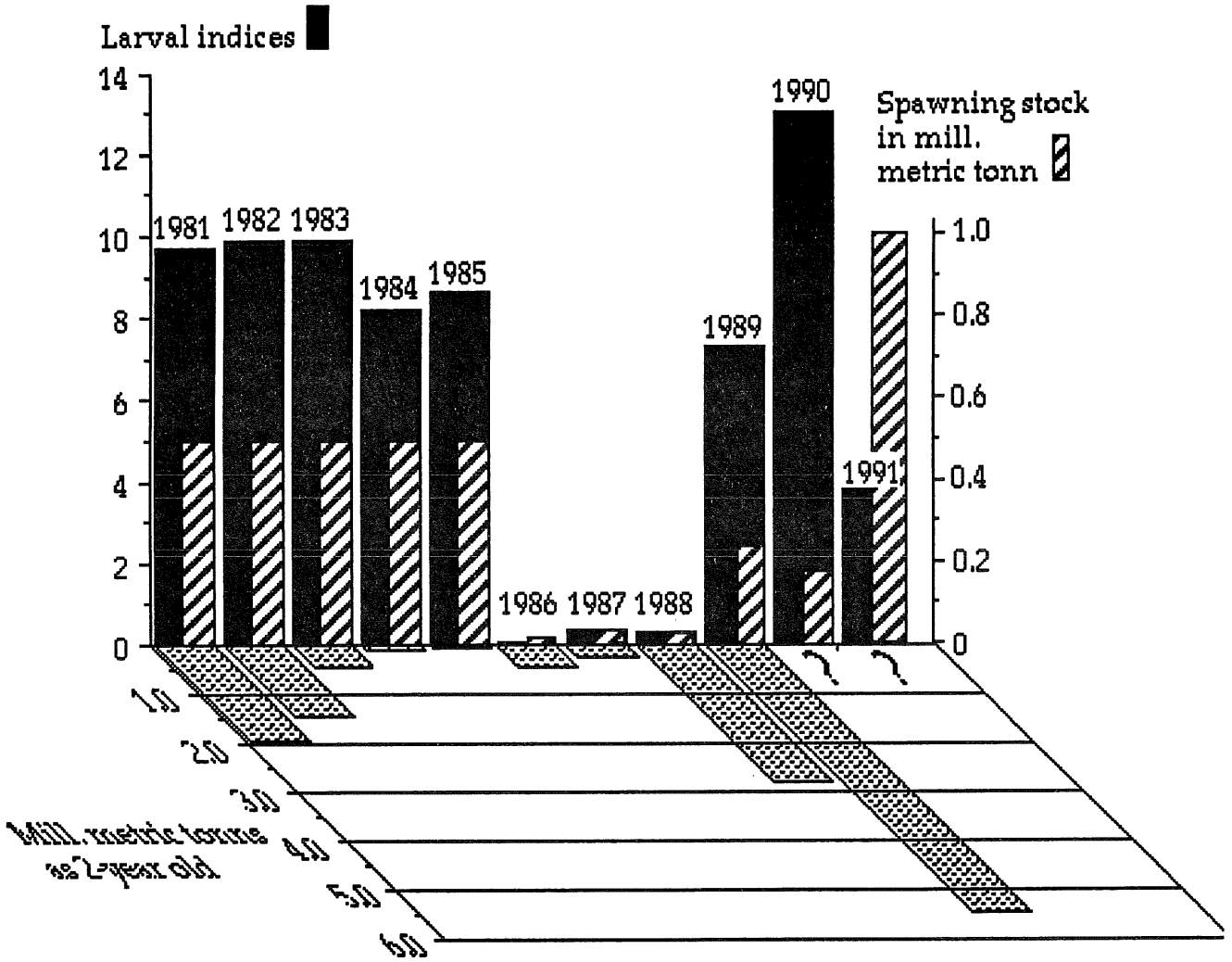

Fig. 14. The larval indices , spawning stock and size of the yearclass as two year old capelin.

The figure clearly demonstrates how the mortality of the progeny changed from the period of heavy predation in 1983-1985 to that of little predation in 1986-1989. The increase in the population coincide with that the herring left the Barents Sea in early summer 1986, with reduced predation on larvae and the youngest stages in the period 1986-1989. The fate of the capelin in the years to come is very uncertain as large yearclasses of herring and cod have entered the system, and the larval production in 1991 have already been strongly reduced.

In the present paper two aspects from the investigations are addressed- the vertical distribution of the capelin larvae and the calculation of the instantaneous mortality rate of the larvae. The vertical distribution study is interesting both in connection with the sampling of the larvae and in connection with exploration of the gas and oil reserves in the area. From this investigation it can be recommended that the sampling of larvae should extend down to 75 meters depth to ensure that all the capelin larvae are sampled representatively. Few larvae were found in the upper 10 m and this makes them less vulnerable to oilspill if detergents are not used. The method of estimating the instantaneous mortality rate is perhaps somewhat specultative, since the present length distribution could orginate from a regime where the larvae hatching late in the season are exposed to an increasing mortality rate. The reason to include the result in the present study is that the mortality appears to be low and constant in 1989, and that the results seem to be useful if one is aware of the limitations.

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