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Herman Björke
Svein Sundby

Abundance indices for the Arcto-Norwegian cod in 1979-1986 based on larvae investigations.

HAVFORSKNINGSINSTITUTTETS EGG- OG LARVEPROGRAM (HELP)

ABUNDANCE INDICES FOR THE ARCTO-NORWEGIAN COD IN 1979-1986 BASED ON LARVAE INVESTIGATIONS.

By

H. Bjørke and S. Sundby

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

ABSTRACT

Postlarvae surveys have been carried out in the western part of the Barents Sea in June/July since 1977. The aim of the investigations has been to study the distribution pattern of fish larvae and their relation to the distribution of water masses; and to establish abundance indices. It has been shown that mesoscale features of the larval distribution are very pronounced, and that they are connected to the circulation features. The survey strategies were changed in 1983, and emphasis was laid on the investigation of cod larvae. Each year, except for 1986, postlarval cod have been especially abundant at the Tromsøflaket bank. This is partly due to reduced diffusion by the existence of an anti-cyclonic vortex above the bank. After three strong year classes in 1983, 1984 and 1985, the results for 1986 indicate a very poor year class, and practically no larvae were found at Tromsøflaket. The anomalous distribution in 1986 is discussed. Postlarvae and 0-group indices are discussed and compared, and a correlation coefficient of 0.82 was found for the period 1979-85.

INTRODUCTION

The Norwegian shelf constitute important spawning grounds for fish of considerable economical interest such as Northeast Arctic cod, saithe,
capelin and Norwegian spring spawning herring (ANON, 1979). Eggs and larvae of these species are transported northwards and eastwards by the residual currents.

The Institute of Marine Research has since 1948 been sampling fish eggs and larvae at different localities along the Norwegian coast (e.g. WIBORG, 1960; HOGNESTAD, 1969; DRAGESUND, 1970; GJØSÆTER and SÆTRE, 1974; ELLERTSEN, SOLEMDAL, STRØMME, SUNDBY, TILSETH, WESTGÅRD and ØIESTAD, 1981; BJØRKE, 1981, 1984; SUNDBY and SOLEMDAL 1984; SUNDBY and BRATLAND 1986). The sampling has taken place during the spring and summer seasons and has partly been aimed at the study of single species, such as herring and cod and capelin.

Sampling of older larvae (postlarvae) offshore started in 1977. The aim was to study the distribution of larvae in June/July and if possible calculate an abundance index of the different species. Results from the period 1977 - 1983 and a discussion of the sampling strategy are presented by BJØRKE and SUNDBY (1984).

RANDA (1981, 1984) found a correlation coefficient of 0.92 between the estimated 0-group indices produced in August/September and the VPA estimates for the same year class at age 3 in the period 1970-1976.

The reliability of an abundance estimate increases if it is supported by other independent estimates. The aim of this paper is to present the results of the postlarvae investigations with respect to cod and to compare the results with the 0-group indices for cod.

The USSR has since 1959 been conducting egg and larvae surveys partly overlapping the area presented in this work. The sampling periods have been April/May and June/July, e.g. BARANENKOVA and KOKHLINA 1964; BARANENKOVA, SOROKINA and KOKHLINA 1973, MUKHINA 1980 and MUKHINA and DVININA 1983.

MATERIALS AND METHODS

The geographical distribution of larvae was found by fishing with a pelagic trawl. A trawl with an effective opening of 4 x 10 m was used in 1977 and from 1978 until 1985 a trawl with an opening of 18 x 18 m was used. In 1985 a trawl with an opening of 29 x 29 m was introduced. The different types of trawls had diminishing mesh sizes towards the end and a 4 m long net with mesh size 4 mm (stretched) at the inner part of the cod end (wrongly described as 15 mm mesh size in BJØRKE and SUNDBY, 1984). Attempts made in 1985 to compare the fishing efficiency between the latter two kinds of trawls failed unfortunately, and the only way to compare the 1985 data with those of previous years was to regard the opening of the two trawls. Regarding the reduced avoidance for larger gears we used the ratio 2.8:1 for fishing efficiency between the largest and smallest trawl.

During the period 1978-1981 two hauls were made at each station, one with the headline in 40 and 20 m depth and a towing time of 15 minutes in each depth interval. The other haul was made at the surface with five big floats on the headline. Towing time was 30 minutes for the latter.

Only one kind of haul was made at each station from 1982 onwards. From 1982 until 1985 the depths and towing time were the same as the previous years and five big floats were used on the headline during the haul. The same procedure was followed in 1985 and 1986, but the towing time at each depth interval was halved.

Towing speed during all the years was 2-3 knots. The catching efficiency of the trawl is not known. Therefore the computed index is based on the number of larvae caught per trawl hour. Oceanographic observations were made with a Neil Brown CTD-microprofiler down to the bottom or to 500 m depth.

All the fish larvae were identified, and a subsample of 50 larvae was taken to measure their length.

The results from the years 1979, 1980, 1981, 1983, 1984, 1985 and 1986 are plotted on horizontal maps and the indices were estimated by using a planimeter tracking the isolines. In 1977 a smaller trawl was used and in 1978 and 1982 the station net was not dense enough to reveal the mesoscale features, and therefore the abundance indices for these years are not calculated. From 1983 the sampling program was stratified to map the mesoscale features more correctly.
The abundance index may be formulated

$$A = \int_{x,y} \int N(x,y)\, dxdy$$

where A is the abundance index
N is the concentration of larvae expressed as number caught per trawl hour
x and y are the geographical coordinates.

The abundance indices, appearing in Table 1, has the unit no. larvae per trawl hour x km^2 $x10^6$.

RESULTS AND DISCUSSION

Figure 1 shows the local names used in the text. Figures 2 - 8 show the horizontal distribution of postlarval cod for the years 1979 - 1981 and 1983 - 1986. Except for 1986 there is one pronounced feature common for all the years: The postlarval cod were particularly abundant at the Tromsøflaket bank at the entrance of the Barents Sea. Between 45% and 90% of the cod were found within this limited area.
Higher concentrations of postlarval cod were also found at the North Cape Bank (Nordkappbanken). These features correspond well with the circulation features in the area of investigation. There is a clock-wise circulation above both banks which reduces the diffusion of larvae.

After three strong year classes in 1983 - 1985 the results from 1986 indicate a very poor year class. Only in 1980 was the postlarvae index lower. The horizontal distribution was also exceptional in 1986 inasmuch as no larvae were found at Tromsøflaket (Figure 8). That year the larvae was distributed in three main patches. One separated patch extends within the Spitsbergen current branch of the Norwegian current between Norway and Bear Island (Bjørnøya). These larvae constituted 9% of the postlarvae index. Another main patch was found at the North Cape Bank (Nordkappbanken) extending eastwards to the

Thor Iversen Bank, and the larvae in this patch constituted 43% of the postlarvae index. The third main patch (shaded in Figure 8) extended along the coast of East-Finnmark and partly into the East Finnmark fjords, and the larvae in this patch constituted 45% of the postlarvae index. Most probably these larvae originate from the spawning of coastal cod in the Finnmark fjords. The coastal cod in Finnmark has been described by JAKOBSEN (1986). It migrates from the feeding areas at the coast of Finnmark to spawn in the East Finnmark fjords. Eggs and larvae are subjected to the transport of estuarine circulation in the fjords and then to the eastwards transport by the Norwegian coastal current. The horizontal distribution of the larvae within the shaded area in Figure 8 corresponds well with such a circulation (SÆTRE and LJØEN, 1971).

The extremely easterly distribution in 1986 may have several reasons. Firstly the spawning of cod in Lofoten was very low, due partly to a small spawning stock (RAKNES and SUNNANÅ. 1986). The low spawning activity in Lofoten could be due to the fact that a larger fraction of the stock may have been spawning at the northern spawning area between Andøya and Sørøya, or that the survival of larvae in Lofoten was lower than at the northern spawning areas. Eggs and larvae from these spawning areas will tend to have a more easterly distribution at the postlarval stage than the eggs and larvae from Lofoten. The large fraction of the postlarvae that originates from the Finnmark fjords contributes also to an easterly distribution. Finally the easterly distribution may be due to an extreme anomaly of the atmospheric forcing occurring on the current system previous to this investigation. At present this has not been investigated.

In spite of the anomalous distribution of the postlarval cod the distribution of watermasses does not show anomalous features. Figure 9 shows the distribution of salinity at 20 m depth and indicates a normal developed vortex which have been observed previous years above the Tromsøflaket bank (BJØRKE and SUNDBY 1984).

Table 1 shows the abundance indices for cod from the postlarvae surveys in June/July and from the 0-group surveys in August/September (ANON, 1985). The latter indices are logarithmic and calculated according to RANDA (1984). Figure 10 shows the two sets of indices and the regression line.

Table 1. Abundance indices for cod from the postlarvae surveys in June/July and from the 0-group surveys in August/September.

Year	1979	1980	1981	1983	1984	1985	1986
Post-larvae	7.2	0.4	15.4	74.7	23.5	56.5	1.9
0-group (logarithmic)	0.40	0.13	0.10	1.69	1.55	2.46	-

Assuming that logarithmic transformation normalize the 0-group indices, a Pearson product moment correlation coefficient can be calculated from the data in Table 1. The computed coefficient equals 0.82, significant at the 5 per cent level.

Both in 1981 and 1983 a very large fraction of the postlarvae index

resulted from the abundance of larvae at Tromsøflaket. Both years the 0-group indices were low compared to the postlarvae indices. The abundance based on the 0-group estimates of both these years have been adjusted upwards during the last years(ANON 1982, 1984 and 1986)and recent estimates from acoustic surveys indicate that the 1981 year class is 1/5 of the 1983 year class. (HYLEN, JAKOBSEN, NAKKEN and SUNNANÅ, 1985). This may imply that the 0-group station grid may fail to record very patchy distributions such as those recorded on Tromsøflaket by the postlarvae surveys in 1981 and 1983.

The postlarvae index for the 1984 year class is obviously an underestimate since the northernmost area of distribution was not examined. The direction of these adjustments of the 0-group estimates in 1981 and 1983 are indicated in Figure 10. In view of these factors it is likely that the correlation between the real abundance of cod larvae at these two stages is better than indicated from the two sets of data in Figure 10. Bearing in mind the improved coverage of the cod larvae distribution since 1983 it seems reasonable to believe that the postlarvae indices produced in July give a fairly good indication for the yearclass strength of cod as 0-group.

CONCLUSIONS

After three strong year classes of cod produced in 1983-85 the postlarvae index for 1986 indicates a very poor year class.

Except for the year 1986 postlarval cod were especially abundant at the Tromsøflaket bank in the southwestern part of the Barents Sea. Previously have 45 - 90% of the postlarvae have been found over this bank. This was caused by the presence of the anti-cyclonic vortex above the bank which greatly reduces the diffusion of postlarval cod.

The absence of postlarvae at Tromsøflaket and the extreme easterly distribution in 1986 may have been caused by a more northernly spawning of cod, a lower survival of cod larvae at the southern spawning areas and/or an extreme anomaly of the circulation system.

The postlarvae indices produced in July seem to give a reasonable good indication for the year class strength as 0-group cod.

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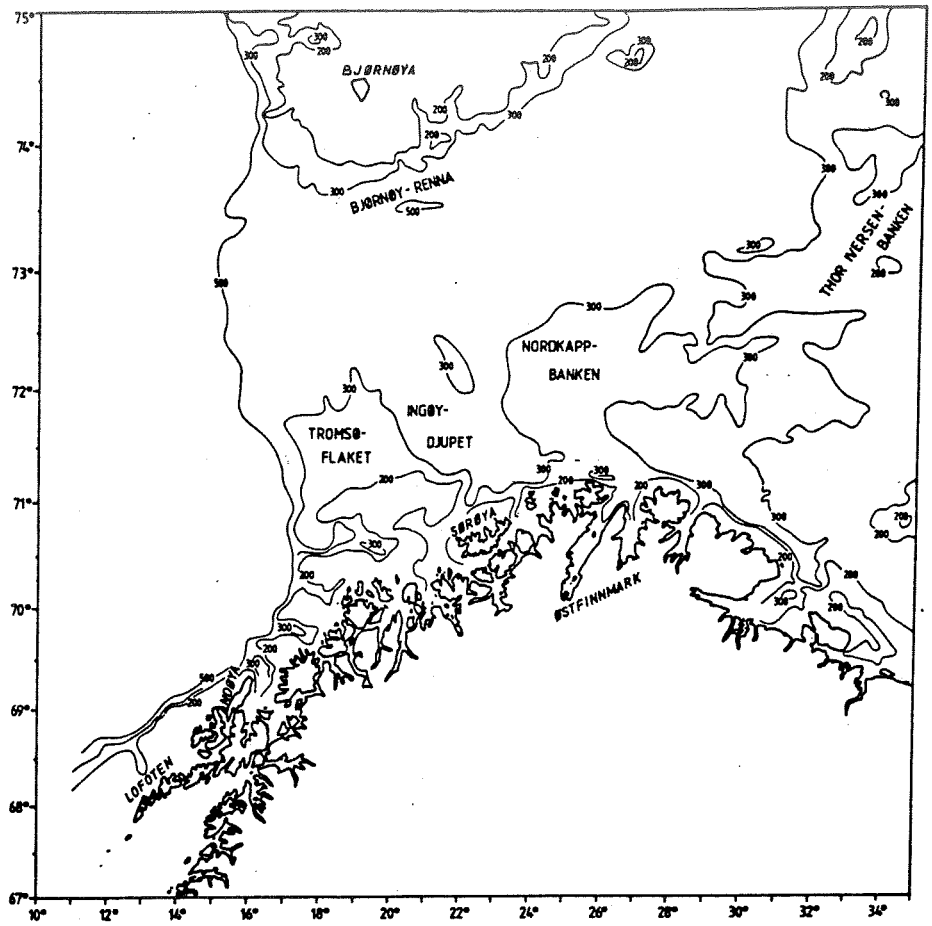

Fig. 1. Local names used in the text.

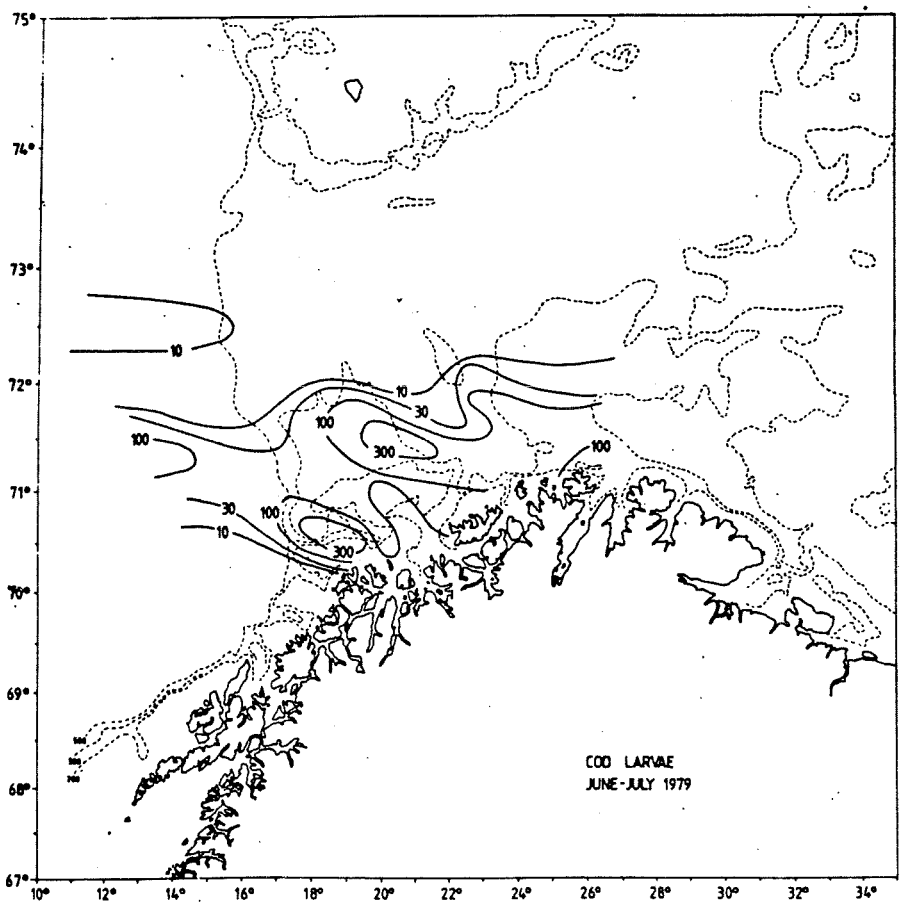

Fig.2. Distribution of postlarval cod 20 June-10 July 1979. Number per trawl hour.

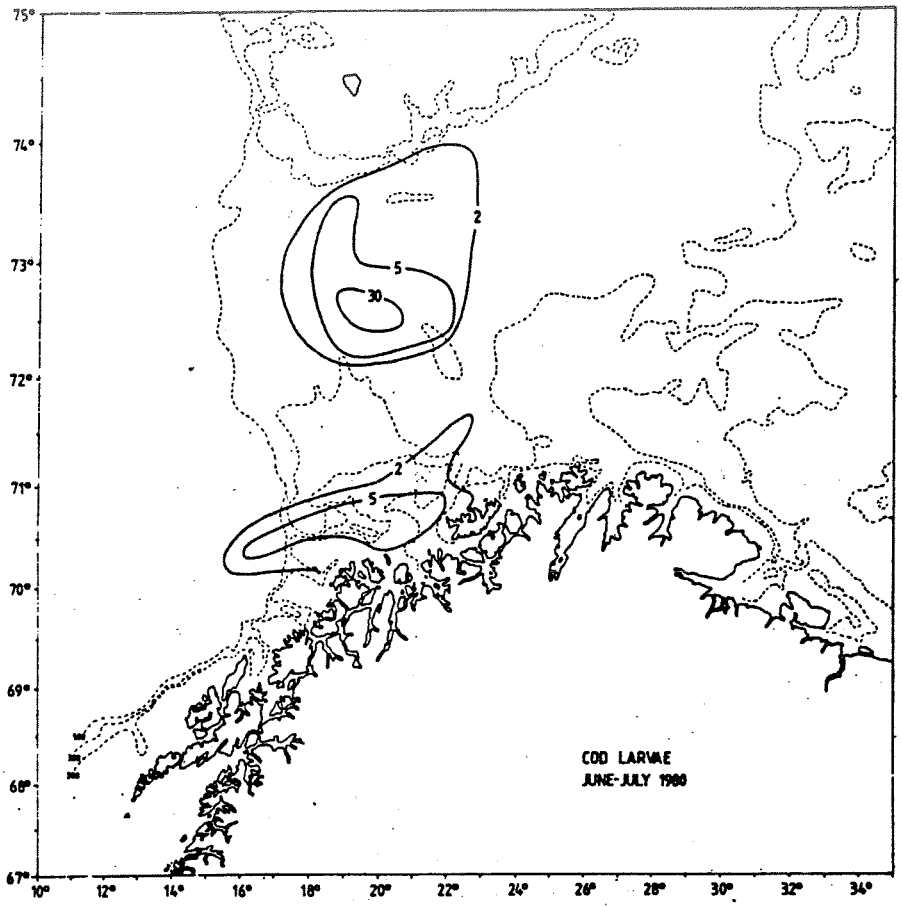

Fig.3. Distribution of postlarval cod 24 June-10 July 1980. Number per trawl hour.

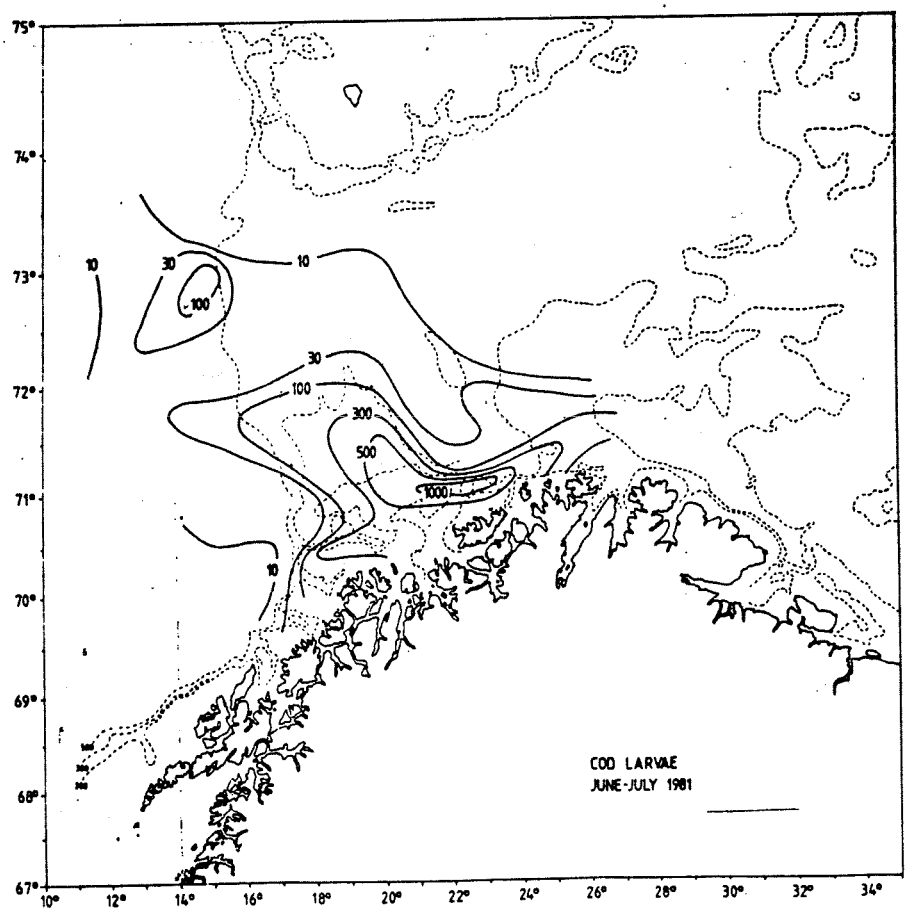

Fig.4. Distribution of postlarval cod 29 June-23 July 1981. Number per trawl hour.

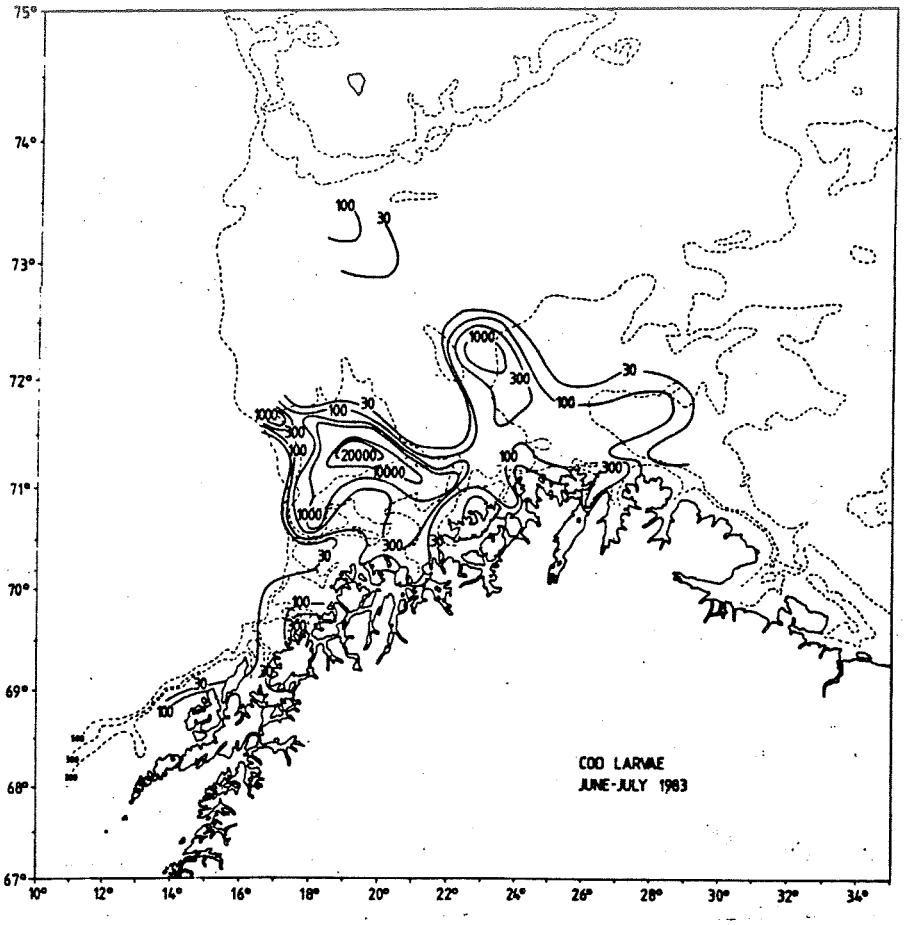

Fig.5. Distribution of postlarval cod 24 June-17 July 1983. Number per trawl hour.

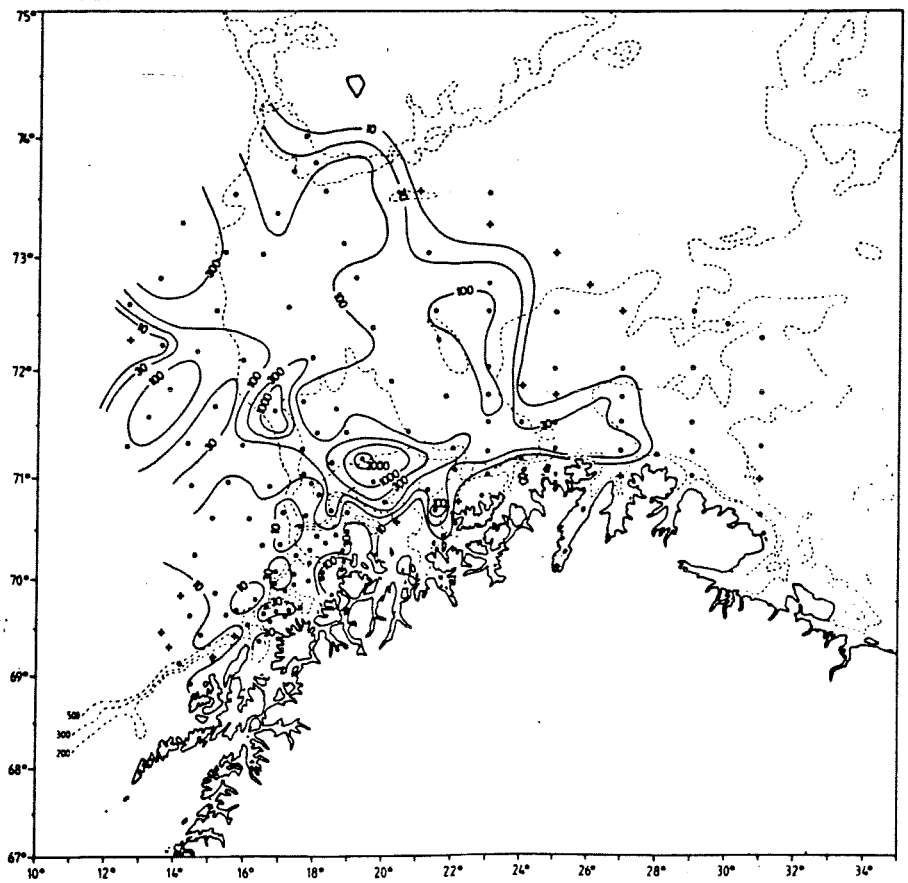

Fig.6. Distribution of postlarval cod 24 June-20 July 1984. Number per trawl hour.

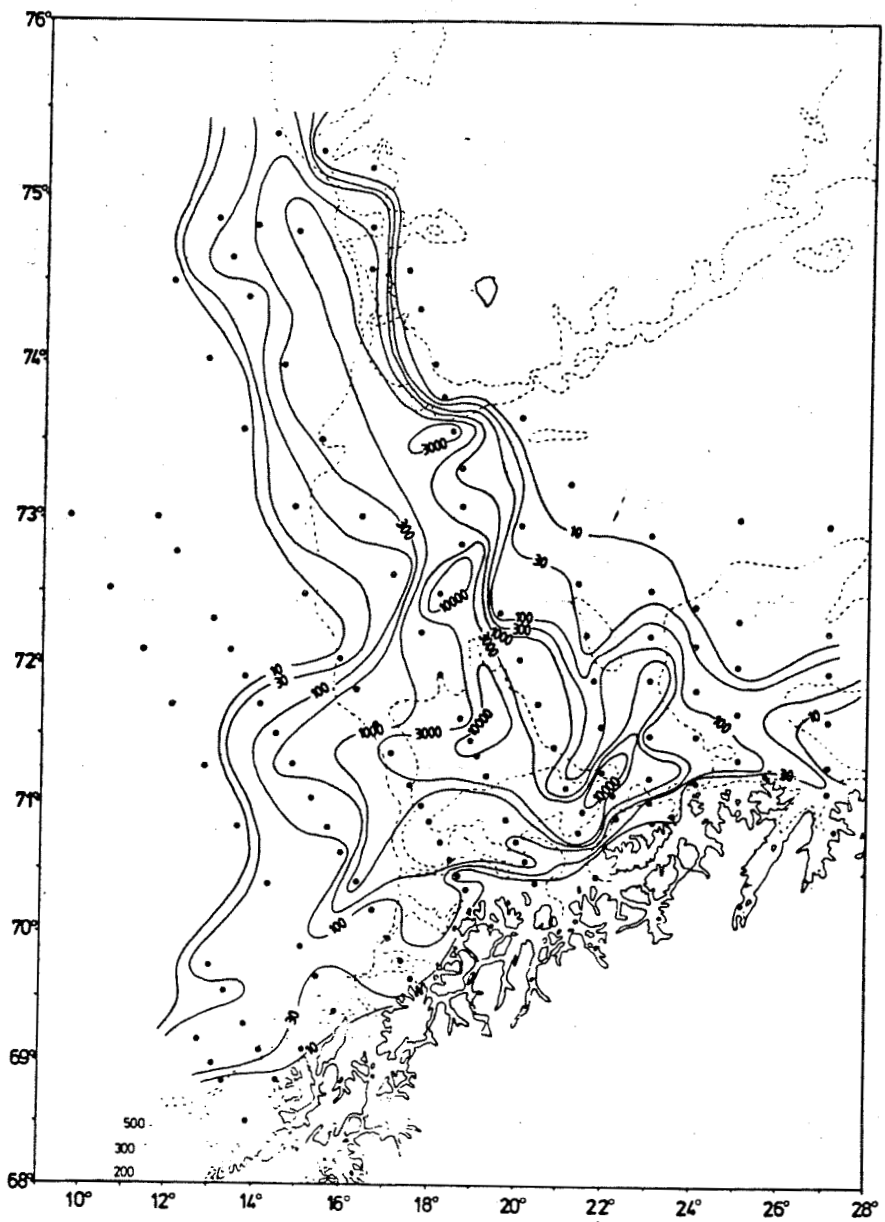

Fig.7. Distribution of postlarval cod 21 June-15 July 1985. Number per trawl hour.

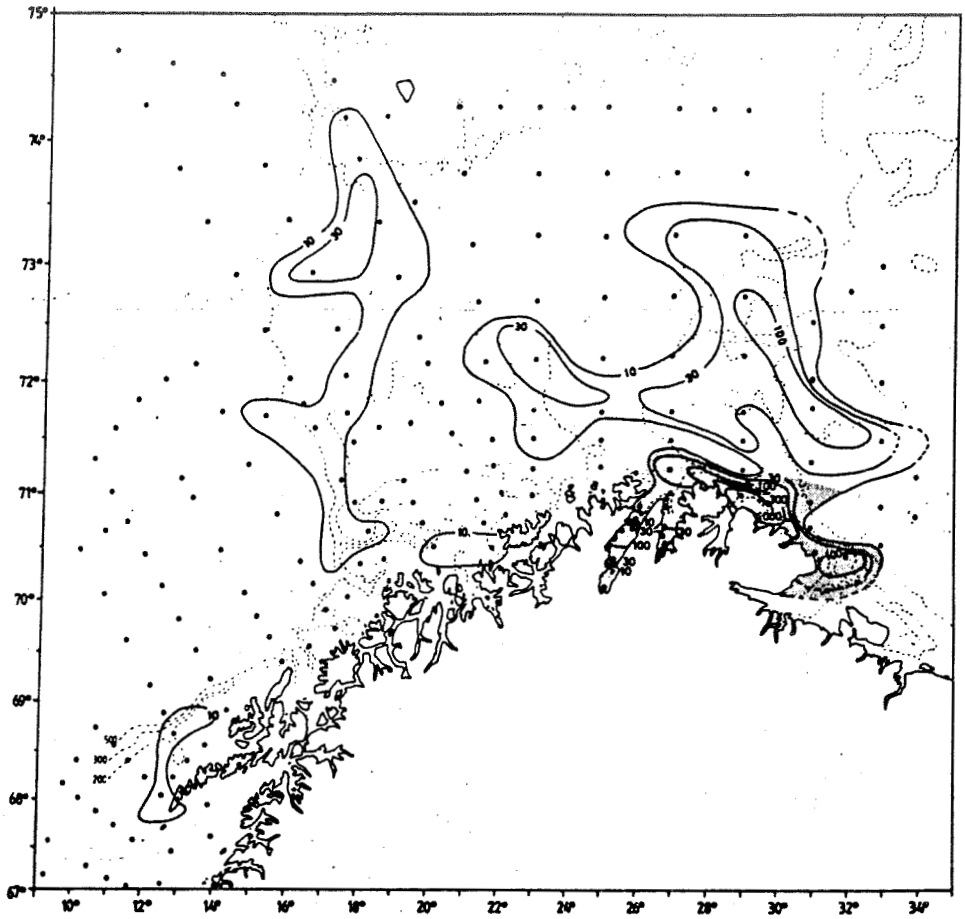

Fig.8. Distribution of postlarval cod 1 July-18 July 1986. Number per trawl hour.

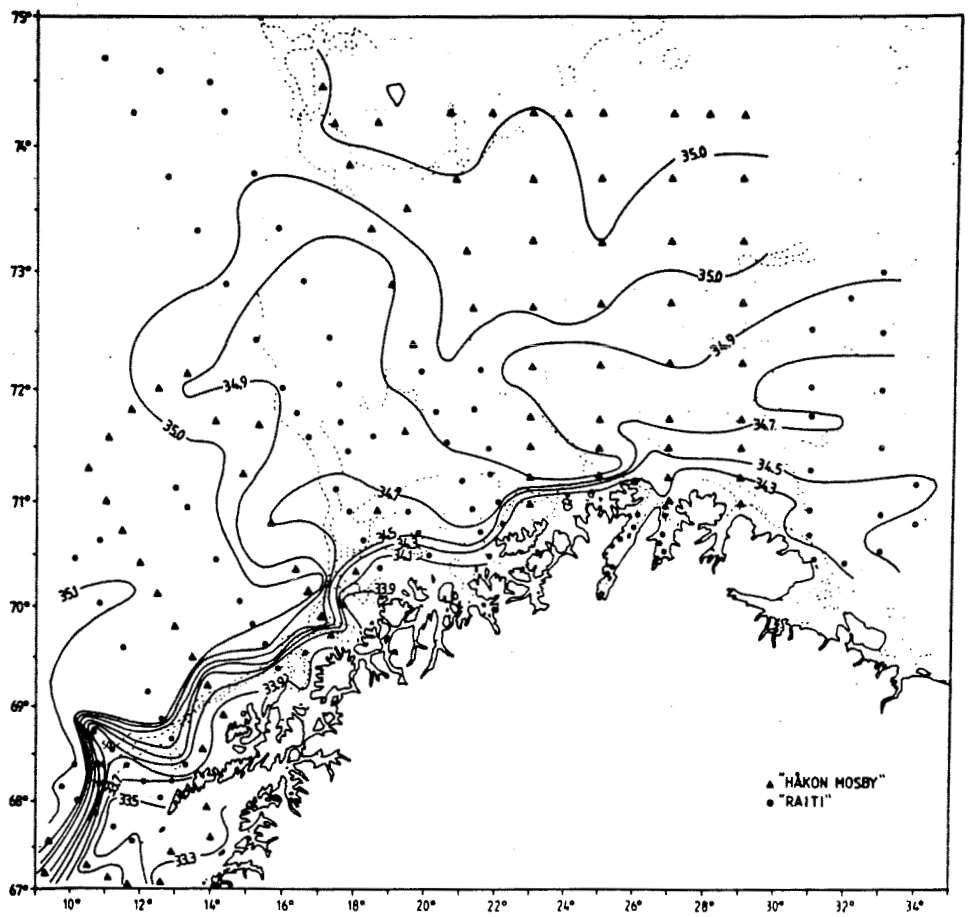

Fig. 9. Salinity at 20 m depth in 1986.

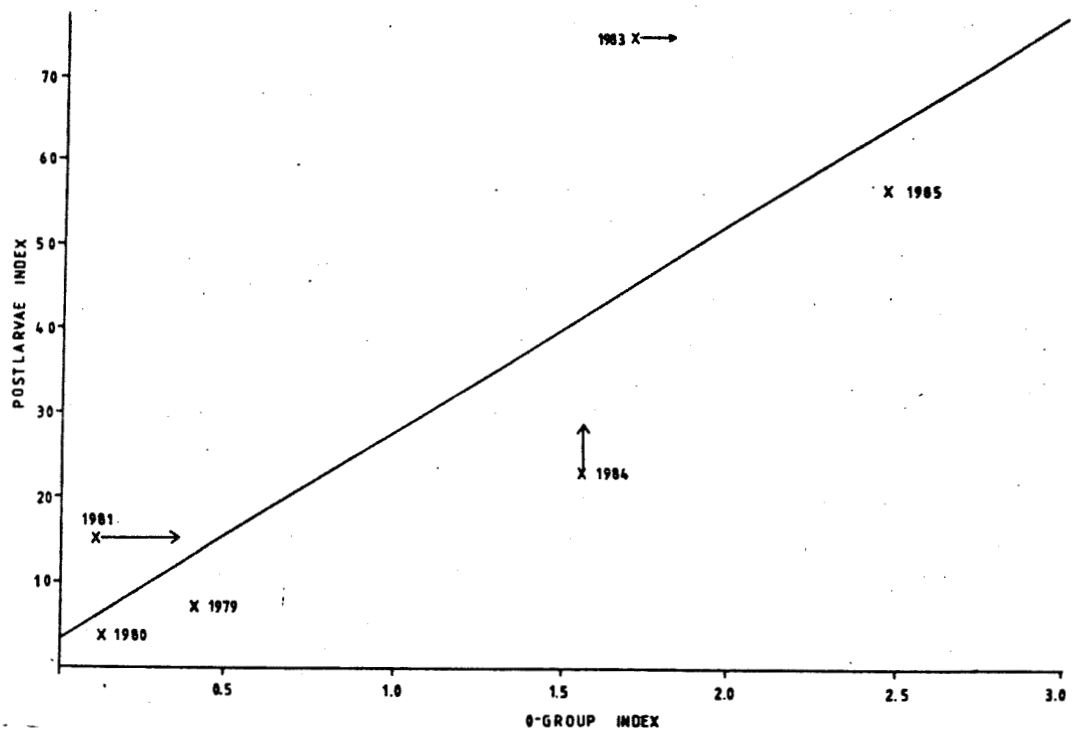

Fig.10. The regression line between the cod postlarvae and the 0-group indices. Arrows indicate direction of adjustments.

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