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SPAWNING AND TRENDS IN SPAWNING STOCK SIZE OF THE NORTH SEA MACKEREL DURING THE PERIOD 1973-1980

by

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ABSTRACT

A declinining trend in the size of the spawning stock of North Sea mackerel is described by data obtained from egg surveys. During the period 1973-1980 the spawning stock size was reduced by 60-70%. A similar stock development has been demonstrated by VPA of catch data and on tagging results.

An egg production curve for 1980 based on three egg surveys in the North Sea combined with daily sampling from a fixed position within the spawning area is given. Attempts are made to estimate the size of the spawning stock from the egg production curve and data published on fecundity.

RESUMÉ

Une tendance descendante de la quantité de la population des maquereaux frayants de La mer du Nord a été décrite par les renseignements obtenus des croisiéres consernantes des oefs. Pendent la periode de 1973 - 1980 la population en frai a été

reduite à 60% - 70%. La même developpement de la population a été observé par la metode de VPA du peche et des resultats de marquage.

Une fonction basée sur la production de l'oeuf pour 1980 est donné. La fonction est calculée de trois croisiéres dans La mer du Nord et combinée avec des epreuves journaliéres d'une station fixe dans la zone de frai. Des efforts ont été fait a estimer la quantité de la population en frai aprés la fonction de la production de l'oeuf et les renseignements publisées de la fecondité.

INTRODUCTION

Size estimates and prognoses for the North Sea mackerel stock are usually based on data from tagging experiments (HAMRE 1980, Anon. 1981). The mackerel was tagged internally with a little steel tag. The tagging experiments were designed for a fishery where catches mainly were processed to fish meal. During this production the small steel tags were retained by electromagnets installed in the production line. The stock estimates were based on these recaptures and catch statistics. However, the last two years, the fishery has shifted and the catches are mainly used for human consumption. Few tags have therefore been returned the last two years (Anon. 1980, 1981), stock estimates based on few tags are not very precise. Therefore there is need for an alternative and independent method for stock size estimation. A method which seems to be convenient is to estimate the size of the spawning stock from egg production and fecundity. Such a method was applied for the western mackerel stock in 1977 and 1980 (Lockwood, Nichols and Dawson, 1981, Lockwood, Baxter, Gueguen, Joakimsson, Grainger, Eltink and Coombs, 1981).

A mackerel egg sampling program started in the North Sea in 1968 to delineate the spawning area and to see if changes in spawning stock size were reflected in the results of the egg surveys (Iversen 1977). Attempts were also made to estimate the spawning stock size but due to improper coverage of the spawning

area and because the spawning area were covered just once during the season, the estimates were dubious.

Since 1973 the coverage of the spawning area was fairly extensive and the most important part of the spawning area was surveyed within the same period each year.

Except for 1977 and 1980 the spawning area was surveyed once. Due to investigations concerning the blow out at the Bravo platform in 1977, a second eggsurvey was conducted in July (Bjørke, Ellingsen and Iversen, 1977).

In 1980, three egg surveys were carried out during 18 June - 30 July to estimate total egg production and spawning stock size.

MATERIAL AND METHODS

The mackerel eggs in the North Sea are in the upper 15 m of the water column (Iversen 1973, 1977).

In the years 1976 - 1979 the mackerel eggs were sampled with four Clark-Bumpus plankton samplers (mesh size 500 µ) operating in 15, 10, 5 m and just below the sea surface. The samplers worked for 10 minutes with a towing speed of 2-3 knots (Iversen, 1977). A typical survey grid for this period is shown in Fig. 1. In 1973 - 1976 the stations south of 56°N were not sampled.

In 1980 a 20 cm Bongo net (mesh size 500 µ) was used stepwise in 20, 15, 10, 5 m and just below the sea surface. The sampler worked for 5 minutes with a towing speed of about 2.5 knots in each of the five depths. The sampler was adjusted to the correct depth according to signals from a sounder mounted on the sampler. The survey grid and stations sampled during the three surveys in 1980 are shown in Figs. 2-4. The mackerel eggs in the plankton samples were sorted in two age groups, those without and those with visible larval embryos (Iversen, 1977). The filtered water volume was measured by a flowmeter. The number of eggs per square meter sea surface were estimated for each of the two age groups. Smoothed values of number of eggs per square meter were

plotted in charts and isolines drawn by eye (Fig. 5-12). The number of eggs per square meter sea surface for station b were smoothed according to $\frac{a+2b+c}{4}$, were a, b, and c are three subsequent stations. The area within the different isolines were integrated and multiplied with the value of the isoline for the egg index estimate and with the intermediate value of the actual and the next isoline for estimating the total egg amount. For instance the area delineated by the two isolines 50 and 100 eggs per square meter sea surface were multiplied by 75.

In the years before 1980 the egg surveys were combined with surveys of other purposes. Therefore, as shown below there are some differences in timing of the surveys the different years.

Year		Date of survey
1976		24 May 4 July
1977	(1. coverage)	31 May - 17 July
	(2. coverage)	12 July- 31 July
1978		10 June- 7 July
1979		11 June- 30 June
1980	(1. coverage)	18 June- 3 July
	(2. coverage)	3 July- 16 July
	(3. coverage)	17 July- 27 July

In trying to get comparable egg indices for the different years, the most important part of the spawning area, the central North Sea, was always investigated within the last two weeks of June.

To obtain the spawning curve in 1980 vertical plankton hauls were made with a small Juday net two times a day at 57°04'N, 02°26'E, (Cod platform) in the period 30 May - 15 August. Similar investigations have been carried out since 1976 (Bakken, Bjørke and Afonso, 1977). A sampling program for mackerel eggs were carried out the first week of July in the area south of England, the Channel and in the North Sea south of 55°North. This is the transition area between the spawning areas of the Western and North Sea mackerel stocks.

RESULTS

Spawning area.

The distribution of eggs without visible embryos for the period 1976-1980 are shown in Fig. 5-12. These eggs are less than two days old (Iversen, 1977, Danielssen and Iversen, 1977), and will therefore indicate the spawning area very well. The main spawning area is situated east of 2°E and south of 58°N in the period 1976 - 1980. In the period 1970 - 1975 the spawning area was wider and extended further west. The second coverage of the spawning area in 1977 (Fig. 7) and the second and third coverages of the area in 1980 (Fig. 11-12) demonstrate a considerable reduction in spawning area and spawning intensity with time. Fig. 13 shows the results of the plankton samples from the Channel area the first week of June 1980. It seems that at least during this week the spawning area of the two mackerel stocks are separated by the Channel.

Egg index.

The egg index is defined as estimated number of mackerel eggs without visible embryos in the area north of 56°N or 55°N based on a single survey in June - July.

The egg indices from the period 1973 - 1980 are shown in Fig. 14. Due to poor coverage of the spawning area the earlier years the egg indices the different years since 1973 are based on the area north of 56°N and north of 55°N since 1974. In 1980 with the most comprehensive coverage of the North Sea about 85% and about 60% of the eggs were observed during the first survey in the area north of 55°N and 56°N respectively. The size of the spawning stock as given in Anon. (1981) were also plotted in Fig. 14.

The egg samples from 1975 were reanalyzed because eggs from some of the samples were wrongly classified the first time. This reduced the egg index with about 20% as compared to the data given by Iversen (1977).

Size of spawning stock in 1980.

By using the total egg production, sex ratio, maturity ogive and fecundity the size of the spawning stock was estimated.

Total egg production in 1980:

The eggs without visible embryos are less than 1.7 and 1.9 days old depending on the sea temperature in the spawning area (Danielssen and Iversen, 1977). The temperature in the surface layer varied between 11.5^{o} - 15.5^{o}C during the investigation period. By dividing the total number of eggs by these factors the daily egg production was estimated within the period of each survey (Fig. 15). Daily catches of eggs without visible embryos from the Cod area are shown in the same figure. Based on these data an egg production curve for the North Sea was drawn by eye. By integrating the area below the curve the egg production was estimated to 60 x 10^{12} eggs during the spawning period. Assuming an egg mortality of 10% the first day the total number was 66 x 10^{12}. The spawning in 1980 started at the end of May and lasted till about 10 August with the most intense spawning the last week of June and first week of July.

Sex ratio:

During June - July in the period 1960 - 1979 11 081 North Sea mackerels were investigated and 5 223 were females and 5 828 males. Therefore a sex ratio of 1 male per female were applied in the estimate of the spawning stock. The same sex ratio is observed in the Western stock (Lockwood et al. 1981).

Maturity ogive:

In this estimate the spawning part of the total stock was defined as three years old or older mackerel. This is the same maturity ogive applied by the mackerel working group for the North Sea mackerel (Anon 1980).

Fecundity:

Several publications deal with the fecundity of mackerel. Most of the available data are from mackerel in other areas than the North Sea. For the Western stock data are published by Macer (1976) and Lockwood (1978) and Lockwood, Nichols and Dawson (1981) which is the most extensive because new and old data from the former publications are included here. Morse (1978) is dealing with fecundity of the Northwest Atlantic mackerel. For the North Sea, however, few fecundity observations are available (Kändler, 1957, Borges, Iversen and Dahl, 1980).

All the publications referred to are dealing with fecundity related to fish length. Due to regulations in the fishery it is difficult to get representative fish samples from the North Sea during the spawning season. For age-length composition three samples from the purse seine fishery in the central North Sea during the period 24 July - 30 August were selected (Fig. 16). All these fish were spent, and the mean length was 38 cm. To estimate the weight of the fish during the spawning period samples from the net fishery along the Norwegian coast during the last week of June were selected. The mean weight of fish of about 38 cm were then 508 grams.

By applying different types of fecundity length relationships the following estimates of the size of the North Sea spawning stock were made.

Fecundity	tonnes
Lockwood, Nichols and Dawson (1981)	138 000
Morse (1978)	112 000
Kändler (1957)	90 000
Borges et al. (1980)	406 000

DISCUSSION

The Western stock starts spawning in March with maximum spawning in May - June (Lockwood, Nichols and Dawson, 1981, and Lockwood et al., 1981) which is the time the mackerel start spawning in

the North Sea. The plankton samples from the first week of June demonstrate no mackerel spawning in the Channel area. This, together with the information of the egg distribution in the North Sea in the period 1968 - 1980 given in this paper, Iversen (1977), Johnson and Dawson (1978) and for the Western stock in 1977 (Lockwood, Nichols and Dawson, 1981) and in 1980 (Lockwood et al. 1981) indicate that the spawning areas of the Western stock and North Sea stock are geographically separated in this area.

The spawning stock size of the North Sea mackerel as estimated from VPA and tagging experiments demonstrate a dramatic decline from 1973 to 1980. This decline is also, except for 1975, reflected in the egg indicies. The high index in 1975 is difficult to explain, mainly because this year the surveyed area north of 56^{o}N was lesser than usual (Iversen, 1977).

In 1979 the egg index indicates an increase in the spawning stock which is not observed in the stock estimates based on the tagging experiments. As mentioned before too few tags were returned the last years to give a precise estimate of the stock. Neither is the egg index of such precision that low scale changes in the stock could be reflected. The egg index indicates a stabilization of the spawning stock size from 1979 to 1980.

In 1980 the Clark-Bumpus plankton samplers were replaced by a Bongo net. Due to this shift in gear it could be argued that the egg index for 1980 is not comparable to the indices obtained the previous years. But it is unlikely to think that one of the samplers are more efficient in catching immobile fish eggs than the other. The Clark-Bumpus samplers were replaced by the Bongo net because the latter is more efficient in catching fish larvae.

The VPA estimates indicate a reduction in spawning biomass of about 60% from 1973 to 1980 and the egg indices indicate a reduction of the same magnitude (70%).

It is important to establish the spawning curve in order to estimate the egg production. In 1980 as previous years since 1976 the spawning intensity was obtained by daily sampling from a fixed position (Bakken, Bjørke and Afonso, 1977). Unfortunately this position (Ekofish-Cod) was in the western border of the spawning area during these years. For 1976 Bakken, Bjørke and Afonso (1977) indicated a constant level of spawning during the spawning period. In 1980 and in the other years of the period it seems that the spawning reach a maximum and then decline. The reason for the difference in obtained spawning pattern in 1976 could be that the sampling was carried out in the border of the spawning area. In 1980 the maximum was in the last week of June and first week of July. The three surveys in 1980 and the two surveys in 1977 confirm the decline of spawning in July. The spawning pattern in the western area has a similar development with the maximum a month earlier (Lockwood, Nichols and Dawson, 1981, and Lockwood et al., 1981). The extention of the spawning period is also different for the two areas. In the western area the mackerel spawn during March - July and in the North Sea during June - July.

The estimated spawning stock is highly dependent of the applied fecundity. The spawning stock size estimate based on fecundity data given by Borges et al. (1980), fits very well with estimates from VPA and tagging data (Anon. 1981). The fecundity data giving this estimate is based on too few observations to give a fecundity as precise as that given for the Western stock (Lockwood, Nichols and Dawson, 1981). The fecundity given for investigated size groups of North Sea mackerel is lower than the fecundity given for the same size groups of Western mackerel. In this stock a significant increase in fecundity with increasing length was observed. A similar relation was not significantly observed in the North Sea stock. Data from this stock indicate just a slight if any increase in fecundity with fish length (Borges et al. 1980).

Kändler (1957) investigated a few mackerels from the southern part of the North Sea and observed an even higher fecundity in these fish than reported from the Western stock. Applying these

data the highest estimate is reduced by about 70%.

To get a more precise estimate of the spawning stock size of North Sea mackerel based on this method, more effort should be put into:

- fecundity investigation
- increase the activity at sea with at least one more survey in the beginning of the spawning season
- daily egg samples from a few fixed positions within the spawning area to see if the spawning pattern is the same in different locations.

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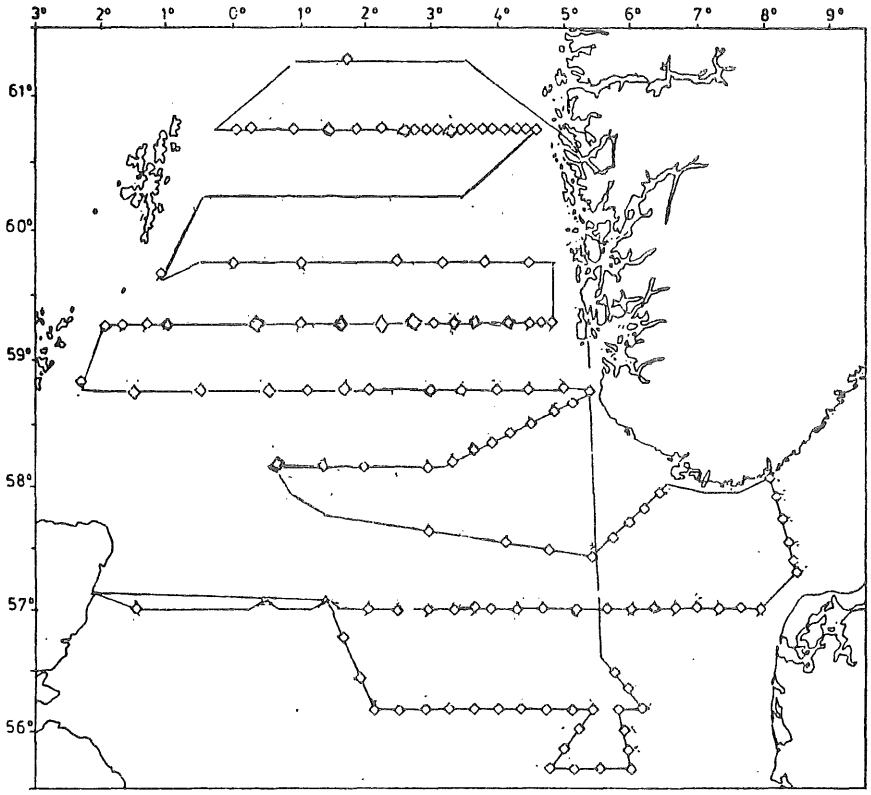

Fig. 1. Station grid 1979.

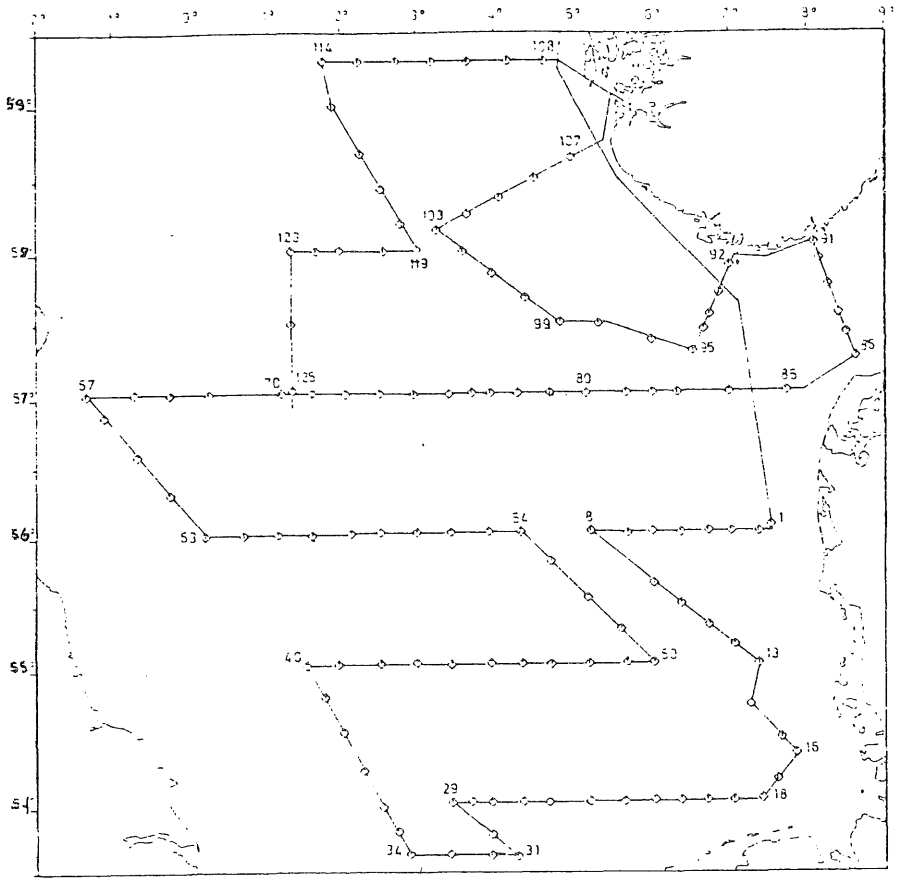

Fig. 2. Station grid first survey 1980.

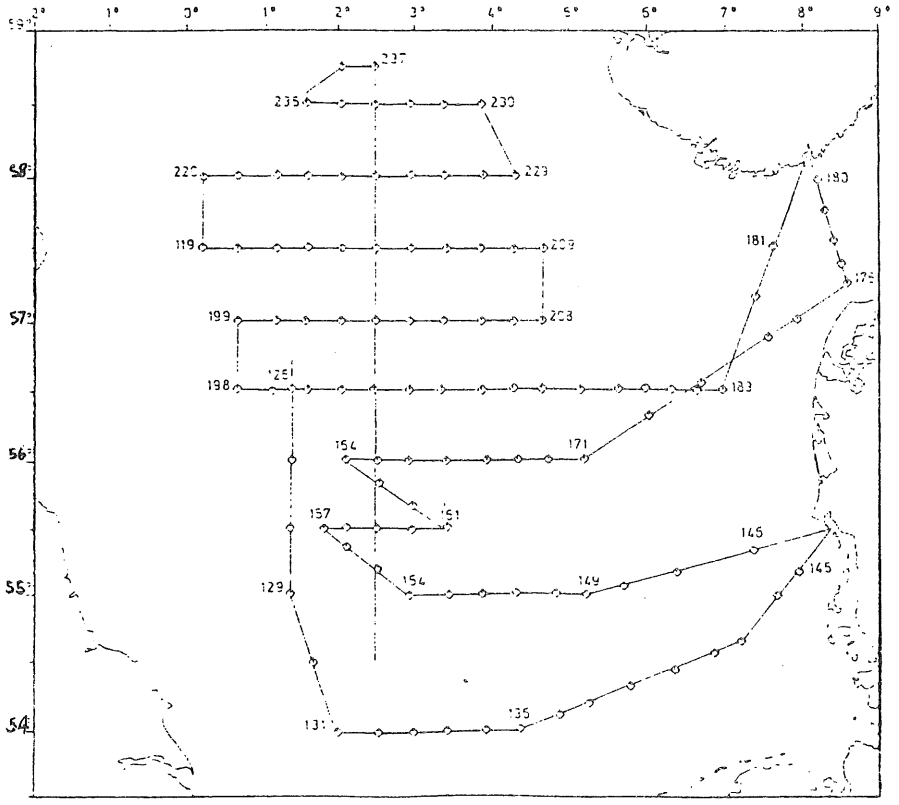

Fig. 3. Station grid second survey 1980.

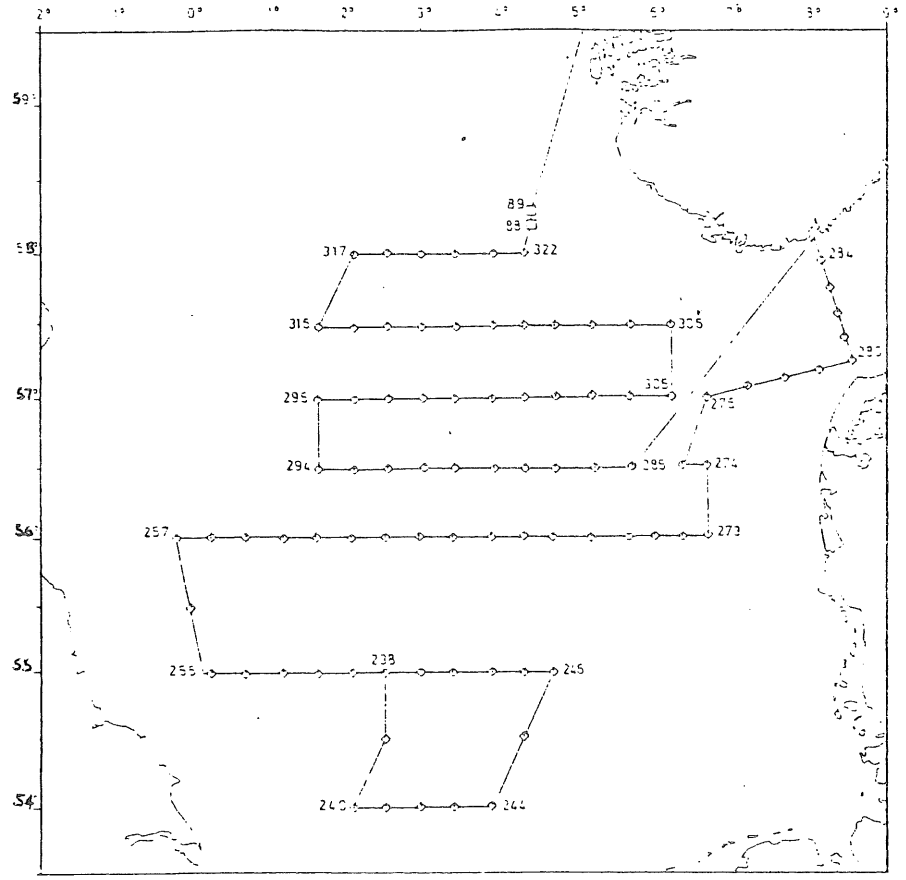

Fig. 4. Station grid third survey 1980.

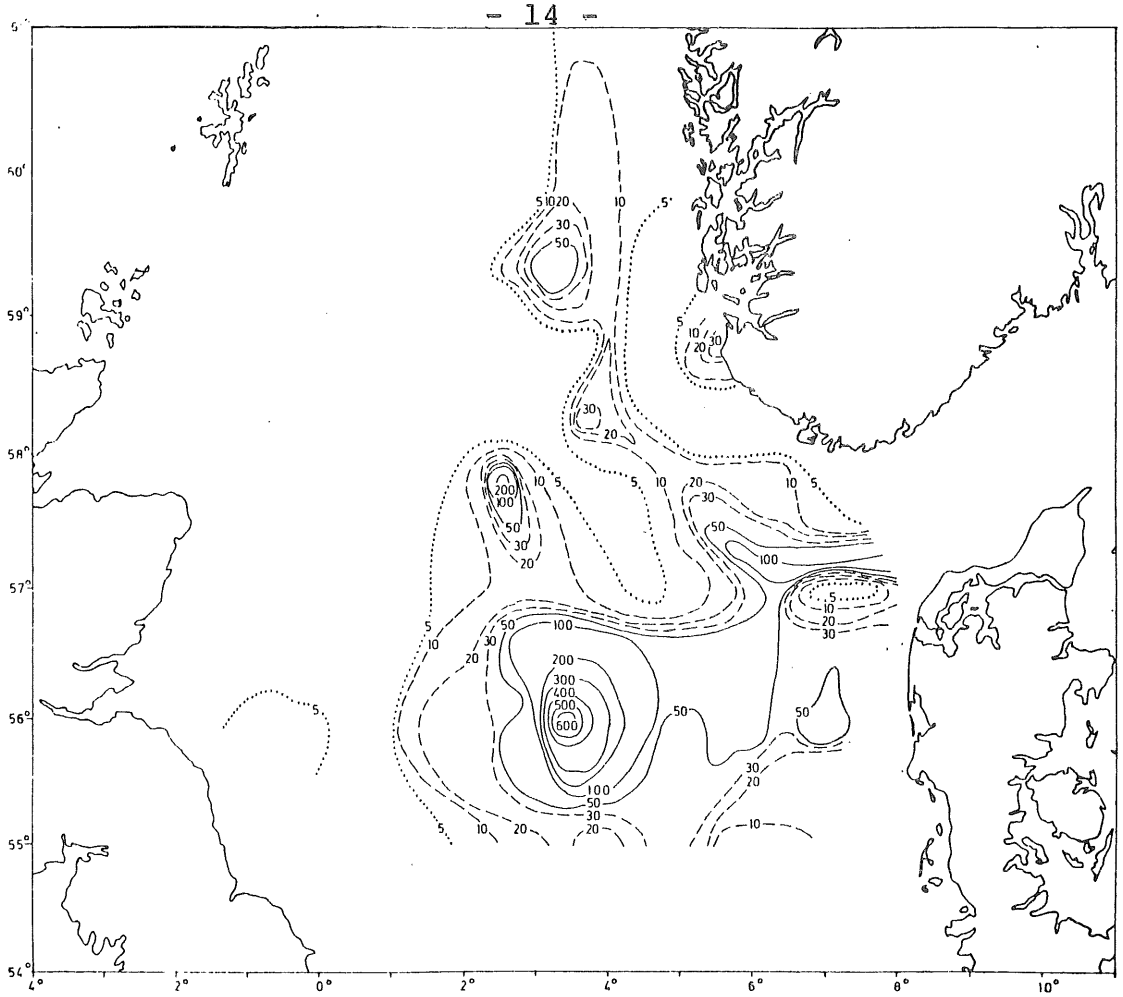

Fig. 5. The distribution of mackerel eggs without visible embryo during the survey in 1976 (eggs per m^2 sea surface).

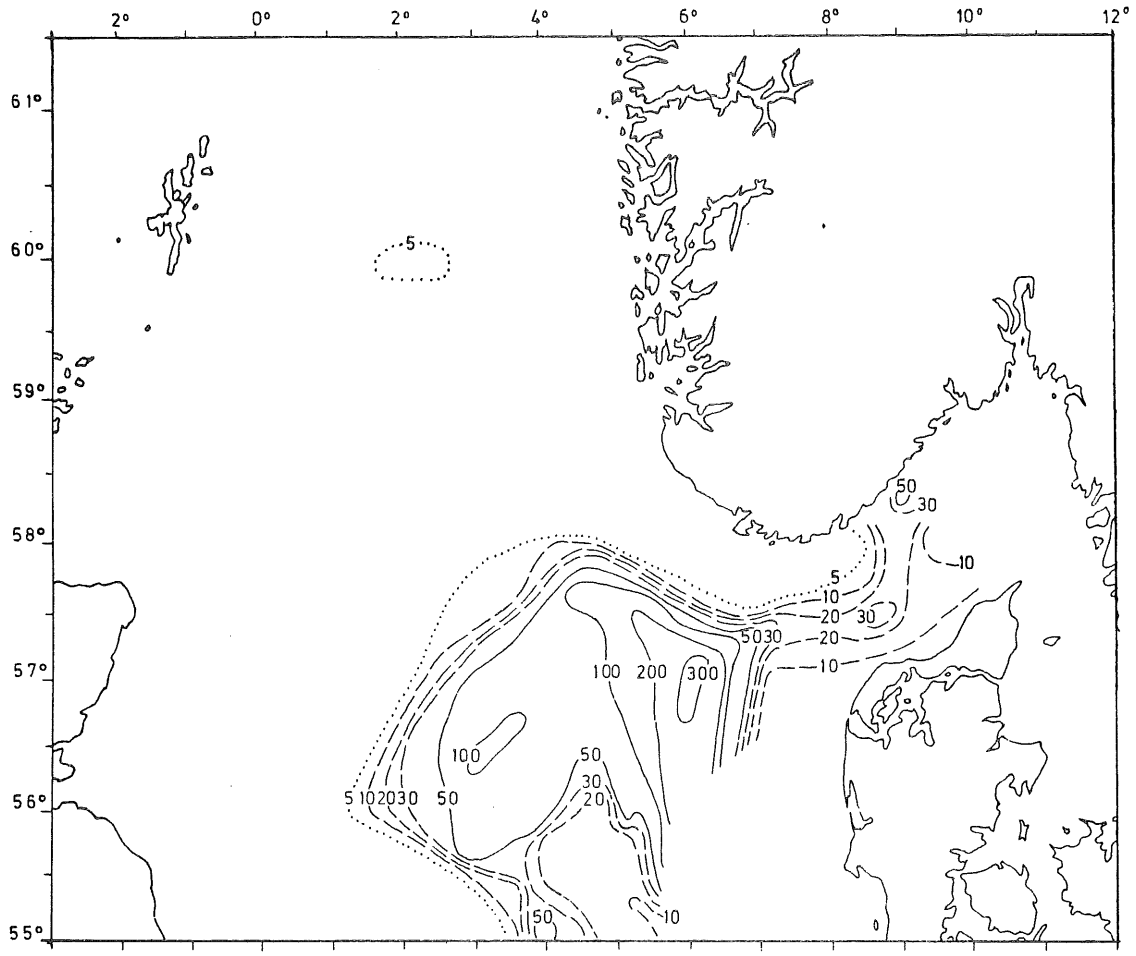

Fig. 6. The distribution of mackerel eggs without visible embryo during the first survey in 1977 (eggs per m^2 sea surface).

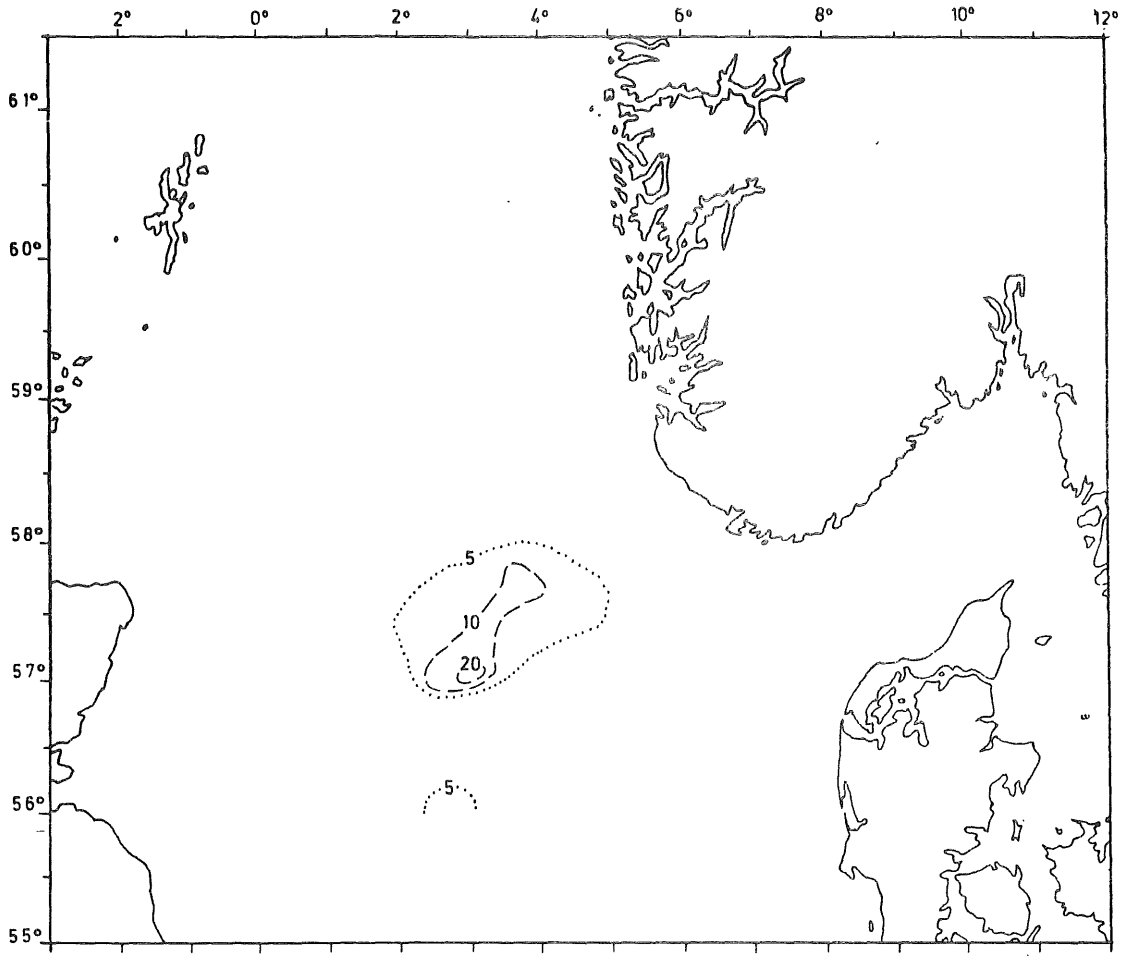

Fig. 7. The distribution of mackerel eggs without visible embryo during the second survey in 1977 (eggs per m^2 sea surface).

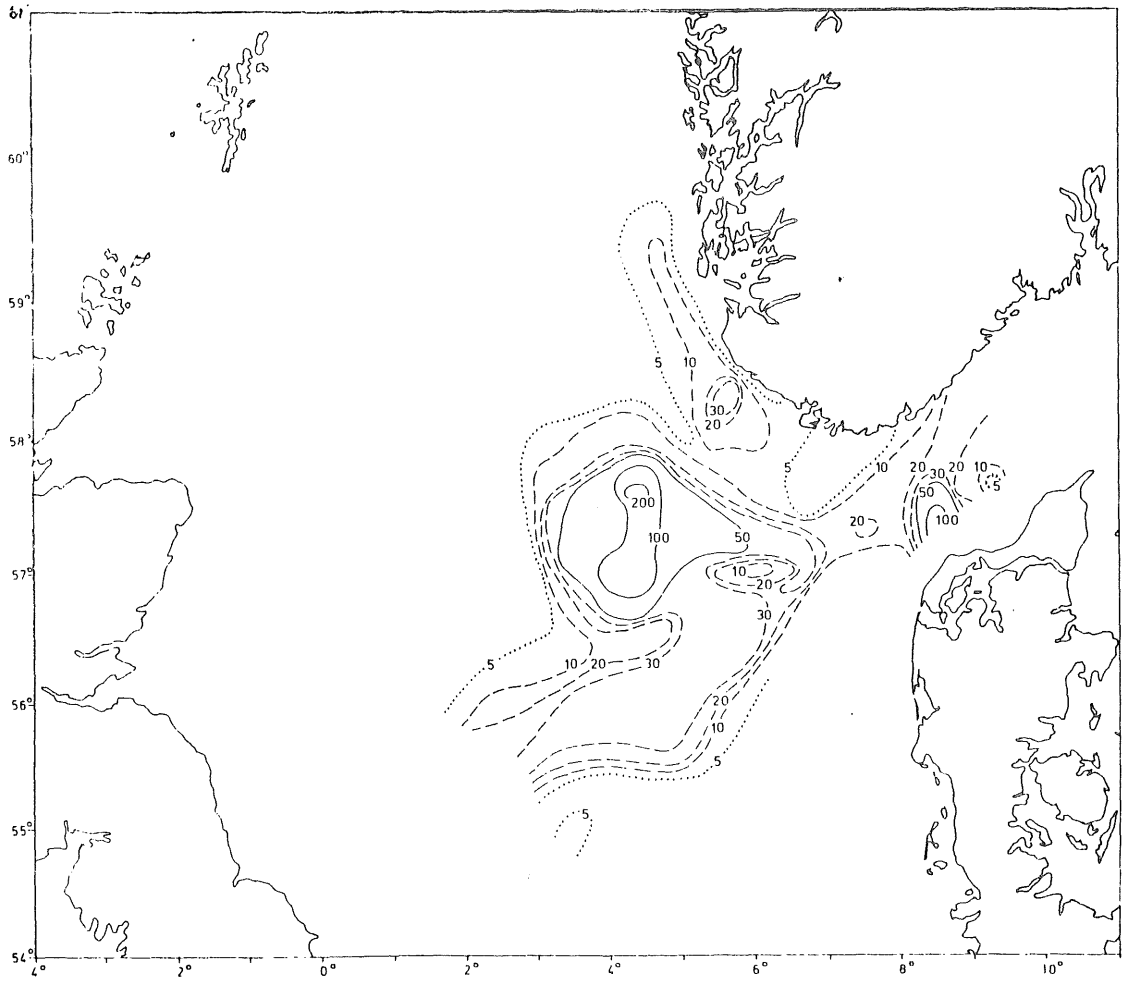

Fig. 8. The distribution of mackerel eggs without visible embryo during the survey in 1978 (eggs per m^2 sea surface).

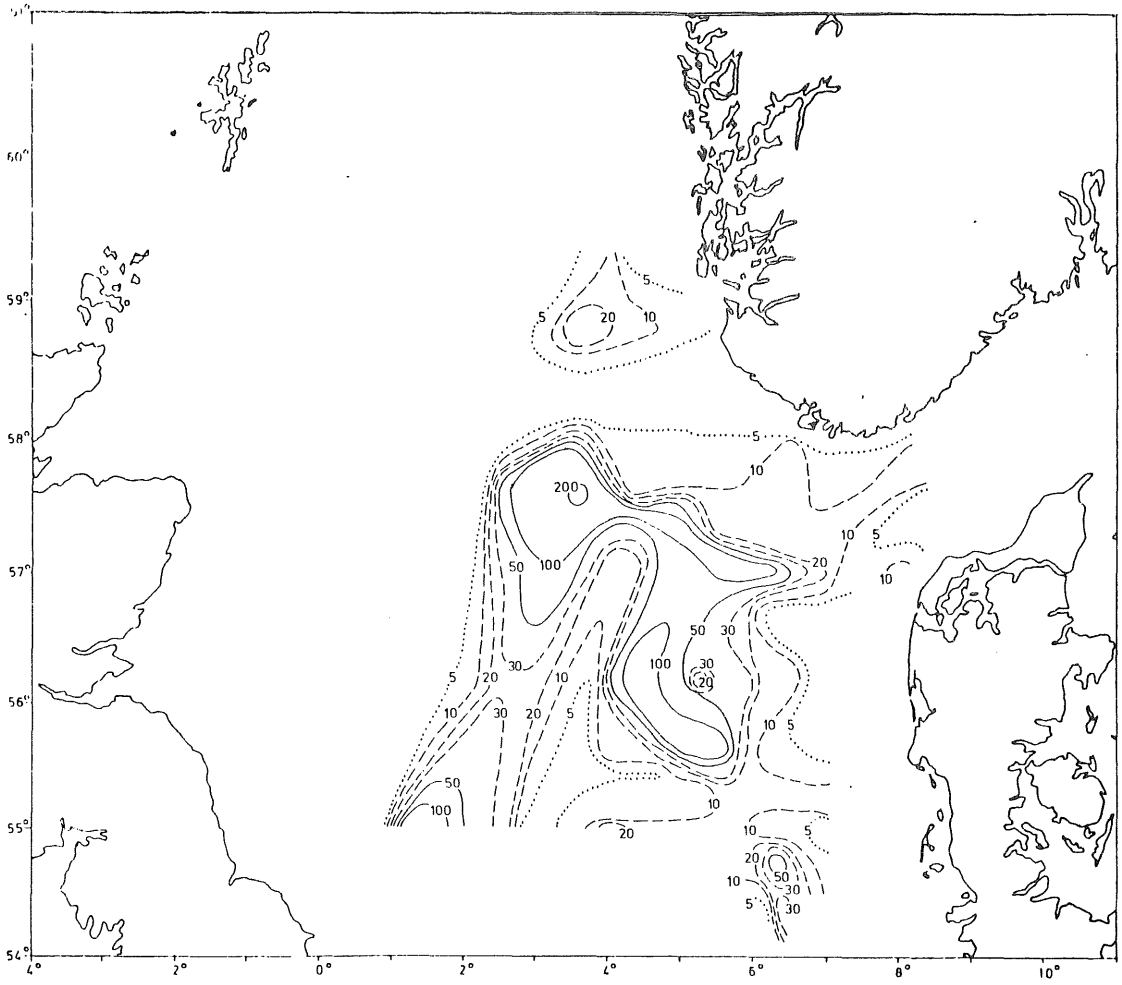

Fig. 9. The distribution of mackerel eggs without visible embryo during the survey in 1979 (eggs per m^2 sea surface).

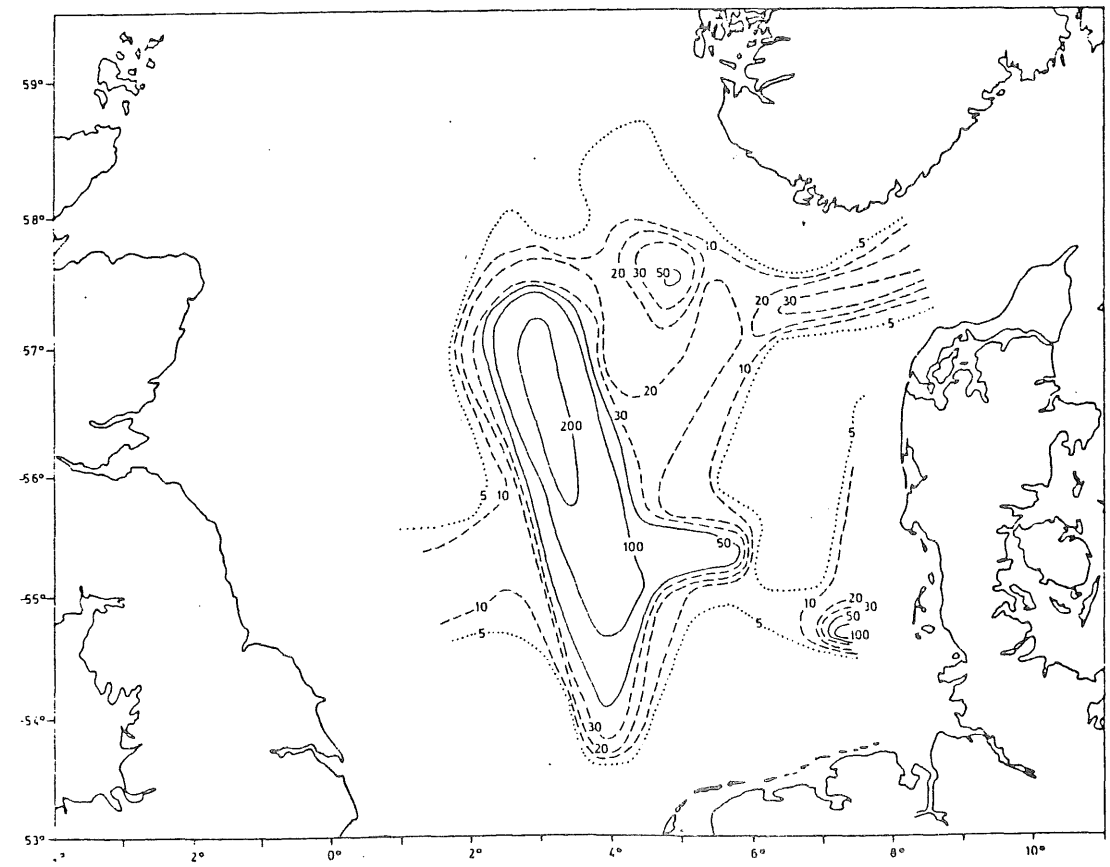

Fig. 10. The distribution of mackerel eggs without visible embryo during the first survey in 1980 (eggs per m^2 sea surface).

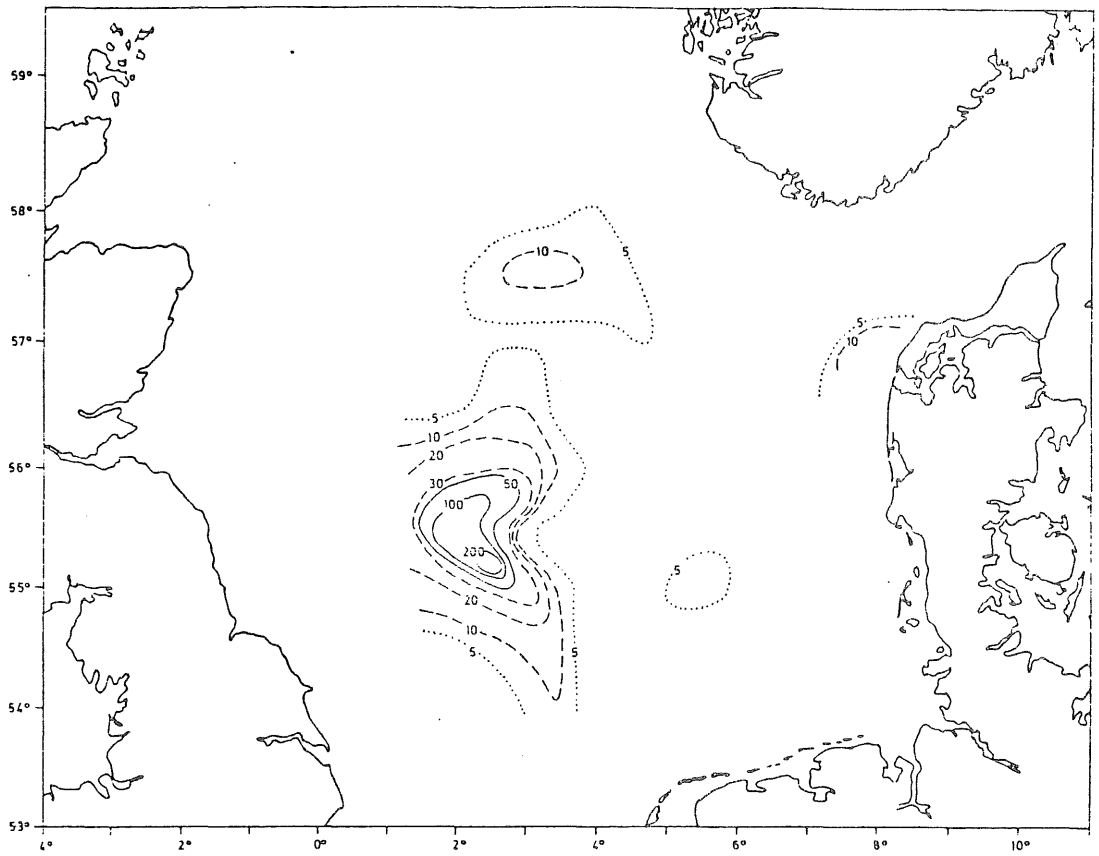

Fig. 11. The distribution of mackerel eggs without visible embryo during the second survey in 1980 (eggs per m^2 sea surface).

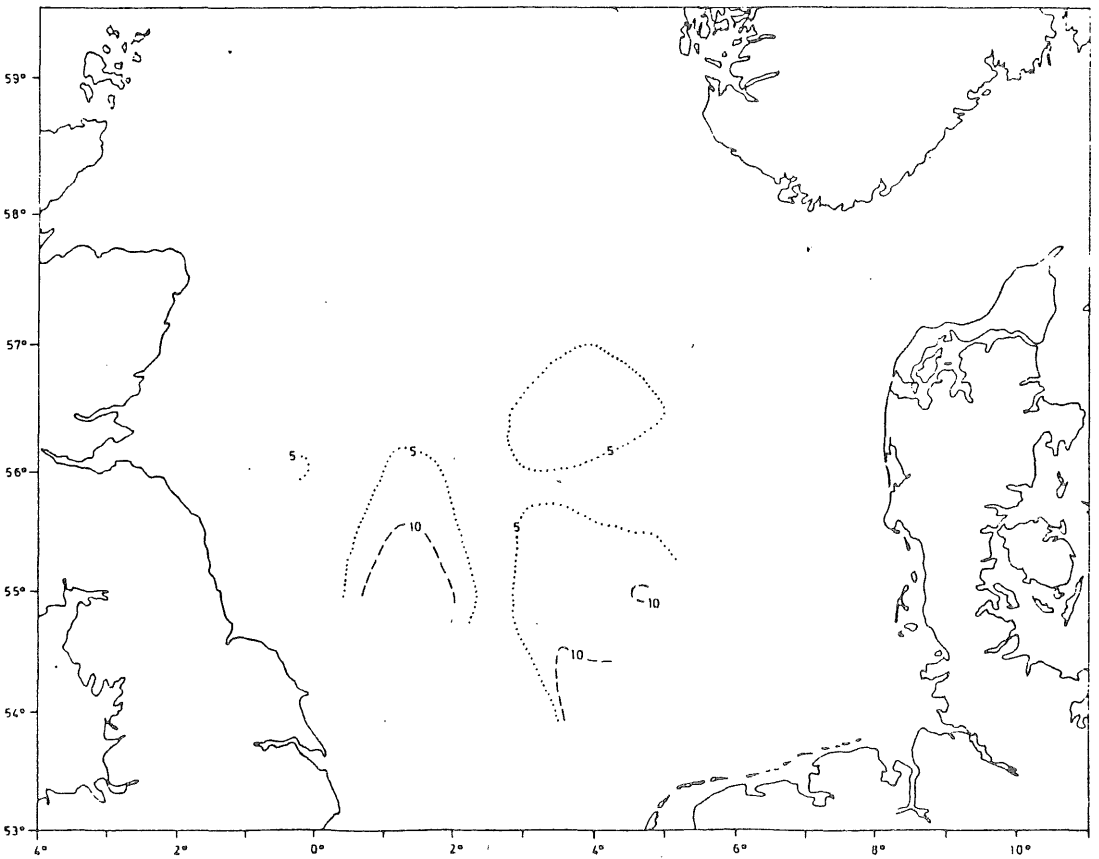

Fig. 12. The distribution of mackerel eggs without visible embryo during the third survey in 1980 (eggs per m^2 sea surface).

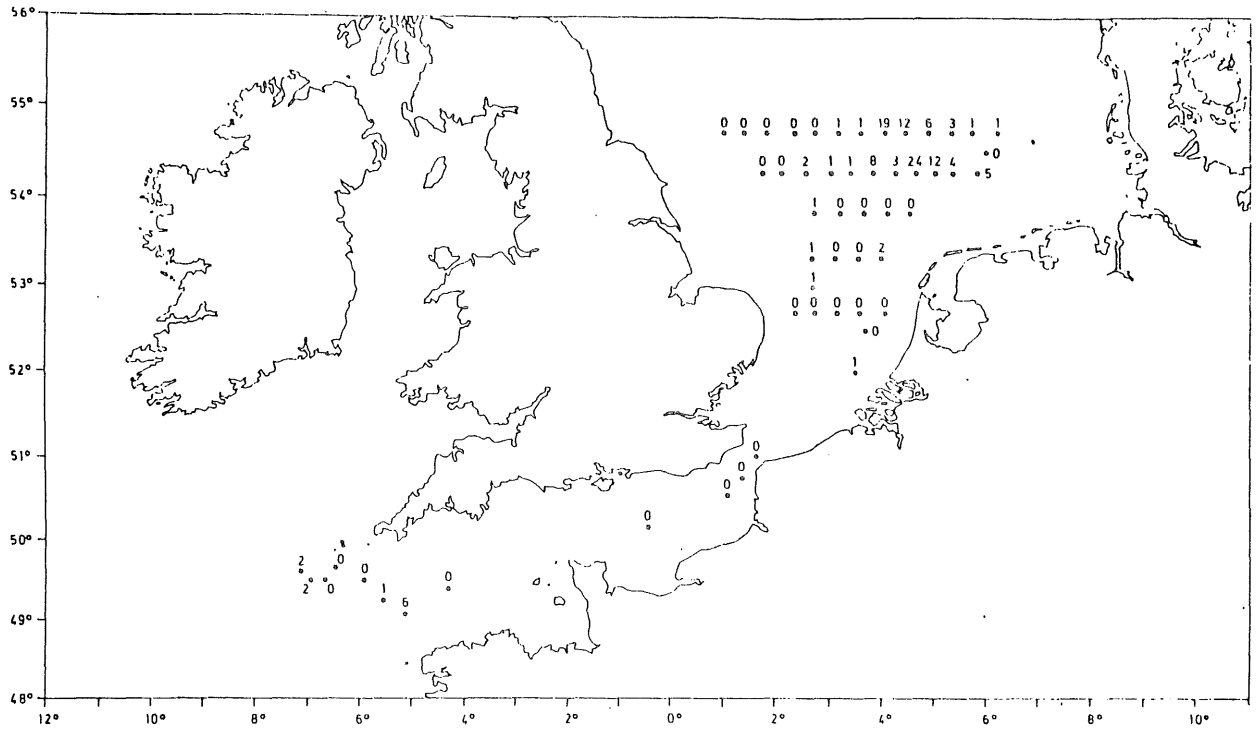

Fig. 13. Numbers of mackerel eggs without visible embryo from Juday net samples the first week of June 1980.

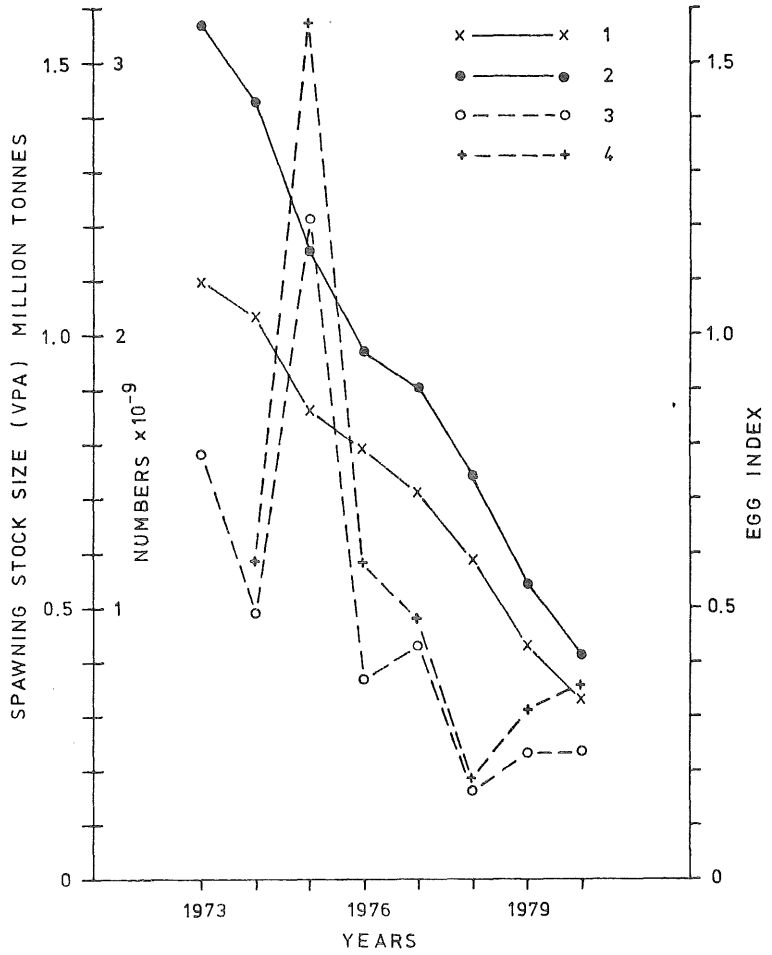

Fig. 14. The size of the spawning stock and egg indices for the years 1973 - 1980.

1) Biomass of spawning stock (VPA)
2) Numbers of spawners (VPA)
3) Egg indices for the area north of 56°N
4) Egg indices for the area north of 55°N

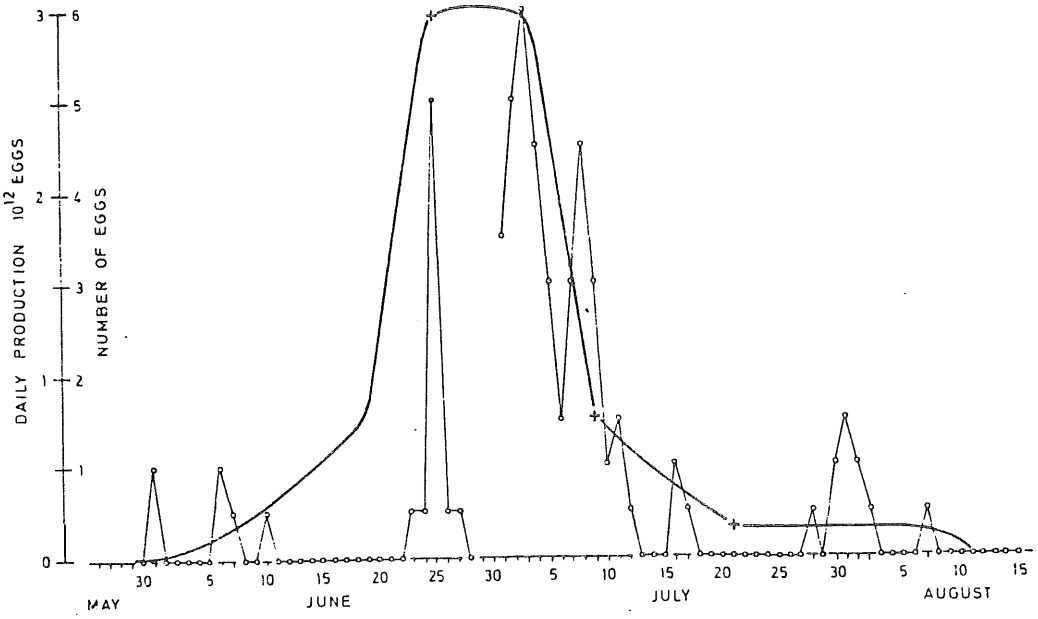

Fig. 15. The egg production curve based on the three surveys (+) and daily eggsampling at the Cod platform (o) in 1980.

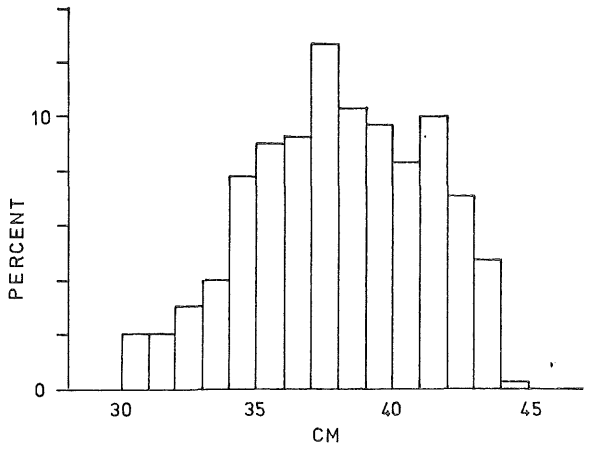

Fig. 16. Length distribution of mackerel from the purse seine fishery July/August 1980.