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THE EGG PRODUCTION AND SPAWNING STOCK SIZE OF THE NORTH SEA MACKEREL STOCK IN 1984

by

S.A. Iversen (1), T. Westgård (1), E. Kirkegaard (2), A. Eltink (3), P. Hopkins (4) and M. Walsh (4)

Abstract

During the period 22 May to 17 July the spawning area of North Sea mackerel was investigated by research vessels from Scotland, the Netherlands, Denmark and Norway. Based on the 629 plankton samples and temperature observations obtained during this period the egg production and spawning stock size were estimated.

1) Institute of Marine Research, Bergen, Norway
2) Danish Institute for Fisheries and Marine Research, Copenhagen, Denmark
3) Netherlands Institute for Fishery Investigations, Ijmuiden, the Netherlands
4) DAFS Marine Laboratory, Aberdeen, U.K.

Introduction

Since 1980 the mackerel spawning area in the North Sea has been covered several times each year during the spawning season to estimate total egg produciton and thereby the spawning stock size. Prior to 1980 the spawning area or parts of it was covered once during June/July (Iversen 1977, 1981).

In 1982 (Iversen and Eltink, 1983, Hopkins and Walsh, 1983) and in 1984 these investigations have been carried out as a joint venture by several countries.

Material and methods

During the period 22 May to 17 July 1984 the spawning area in the North Sea was covered six times by the Dutch ("Tridens"), Danish ("Dana"), Scottish ("Scotia") and the two Norwegian vessels ("Michael Sars" and "Eldjarn"). Table 1 shows the periods the different vessels worked t area.

The stations for each of the six coverages are shown in Figs.1-6. During May, "Tridens" worked the area south of 57^{0}N with the main sampling effort in the area between 55^{0}30'N and 57^{0}N. The second and third coverages were made by three vessels in six and four days respectively. The fourth coverage was carried out by two vessels during ten days and the two last coverages were done by one vessel in 14 and 6 days respectively. The total effort of the five vessels during the period of the investigations was 75 survey days. The different vessels worked the area with different plankton samplers (Table 2). The samplers worked stepwise for five minutes at each of the depths 20, 15, 10, 5 m and just below the sea surface,and were assumed to sample representatively a water column depth of 22.5 m . A mounted sounder on the sampler continously measured the sampling depth. This was monitored aboard the ship and the sampling depth adjusted as necessary. To calculate the water volume sampled each sampler was equipped with a flowmeter.

The plankton samples were preserved in 4% formaldehyde. On some of t. vessels the plankton samples were analysed a couple of hours after collecting while in others they were stored and analysed after the survey. The mackerel eggs were aged according to the state of development and the larvae were measured to the nearest mm below.

In this investigation the mackerel eggs in stage 1A and 1B (Lockwood et.al., 1981), including the stage of the blastodisc formation, are used to estimate the daily egg production at each station. The age of stage 1A and 1B egg were estimated according to the formula given by Lockwood et.al. (1981)

$$\ln \text{Time} = -1.61 \ln \text{Temperature} + 7.76$$

Where Time is the age of the egg at the end of stage 1B in days and Temperature is the temperature of the sea surface where the eggs were sampled in degrees celsius. Temperature was measured on each plankton station.

Daily egg production was estimated in two ways as described by Iversen and Westgård (1984) and Pope and Woolner (1984). In the first method the egg production per day per station are interpolated into a finer grid of rectangles over the survey area, and confidence limits estimated empirically. In the latter method the mean number of eggs spawned per day per m^2 are estimated by rectangle and raised to the area of the rectangle to give a total production estimate. The variance is estimated using the assumption of constant coefficient of variation as suggested by Pope and Woolner (1984).

Spawning area

During the first coverage relatively few eggs were observed (Fig.1).

Fig.2 shows the distribution of the eggs during the second survey. Eggs were observed over a much wider area than during the first survey. The Skagerrak was also partly covered during this survey. It seems from the egg distribution obtained during this coverage that the total spawning area in the North Sea was covered. The main concentrations of eggs were observed in the area delinated by the coordinates $57^0 30'$ to 56^0 North and $2^0 30'$ to 5^0 East.

During the third coverage (Fig.3) the main egg concentrations were observed in the same area as during the former survey. However, the distribution pattern indicates that the total area was not covered during this survey. In the next survey (Fig.4) the main concentrations of eggs were observed to the north and south of those observed in preceding surveys. Skagerrak was not covered during this survey. The main egg concentration was observed north of 57^0 north during the fifth coverage (Fig.5). It seems that the investigated area especially to the north did not cover the total spawning area. A few samples were collected in the entrance of the Skagerrak, but no eggs were observed. During the last survey very few eggs were observed (Fig.6). Due to lack of time only the most important part of the spawning area was covered. By this time it seems that the spawning has more or less ended. Therefore during this survey the spawning area was probably fully covered.

Total egg production

The estimated average daily egg production based on each of the six surveys is shown in Table 3. As in earlier years the production in late May and in July was observed to be rather low. Peak egg production took place in June. Therefore the seasonal pattern of spawning in 1984 seems to be similar to that of recent years. Since 1982 the spawning period in the North Sea has been defined as the period 17 May to 25 July (Iversen and Eltink, 1983, Iversen and Westgård, 1984). This is based both on the surveys and daily plankton samples collected at fixed positions in the Cod - Ekofish area in May - August during the years 1976-1983.

Egg production estimates using the method of Iversen and Westgård (1984) are given for each survey and for all surveys combined in Table 3a together with data on area coverage. As mentioned earlier the first, second and last surveys are supposed to cover the spawning area properly. The second survey covers the largest area. The third, fourth and fifth surveys covered areas which were 22 %, 8 % and 28 % lesser than the area investigated during the second survey.

If the following two conditions are fullfiled:

1. There were no major changes in total spawning area during the period 5 June - 11 July (coverages: 2,3,4 and 5).
2. The average distribution pattern of eggs over the sampled and unsampled parts of the spawning area were the same.

Then the egg production estimates based on the third, fourth and fifth survey can be adjusted by the above mentioned percentages. By applying such adjustments the total egg production is estimated at 78×10^{12} eggs. The Skagerrak and Kattegat are usually not included in these estimates. Earlier investigations indicate that the contribution from these areas may be approximately 10 % (Iversen, 1973).

By applying the fecundity weight relation given by Iversen and Adoff (1983) and a sex ratio of 1:1, the spawning stock is estimated to about 120 000 tonnes (Table 3a). This is a reduction of about 50 % compared to the 1983 estimate (Iversen & Westgård, 1984). According to that paper the 95 % confidence limits of the egg production estimate is about ± 30 %. In addition variance on the fecundity is unknown and thereby the 95 % confidence limits of the spawning stock estimate is greater than ± 30 %.

When the method of Pope and Woolner (1984) was applied the data from all the cruises were pooled and the spawning season arbitrarily divided into 6 x 10 day periods. Within each period the arithmetic mean number of eggs/m^2/day was calculated for each statistical rectangle (1^0 longitude x $1/2^0$ latidude), and raised to the area of the rectangle and period duration (Fig.7). These raised production estimates were summed over all rectangles and periods to estimate egg production over the whole spawning season, see Table 3b. The 95% confidence limits of the production estimates in sampled rectangles in each survey are also given.

Production in unsampled rectangles was estimated by interpolation. One possibility was to interpolate from adjacent rectangles but since there does seem to be some spatial structure in the distribution of spawning this might have been misleading, particularly since priority was given to those rectangles where production was expected to be high. It was thought preferable to consider production in any one rectangle through time, and to linearly interpolate missing values from hauls made in the same rectangle in adjacent time periods. In effect, production curves were calculated for each rectangle, zero values being assumed prior to the first period and subsequent to the last period. Where a rectangle was unsampled throughout the spawning season,no interpolation was possible and egg production in that rectangle was presumed zero. This should not present too many problems if high production rectangles were given priority in sampling, because those which are never sampled ought to be those which contribute relatively little to the production anyway, and are likely to be on the periphery of the spawning area. The method gives a total production estimate of 80×10^{12} eggs and includes the interpolated values for the first and last periods. It is probably wrong to include the interpolated values for these two periods due to the observed egg distribution during the first and last coverages. If these are subtracted the total estimate is 72×10^{12} eggs. The estimate is based on the upper 20m of the water column, while the other method is based on the upper 22.5m . The adjusted estimate is then 81×10^{12} eggs. This demonstrates that the two applied methods for estimating the total egg production give rather close resuls.

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Table 1 Time and coverages of the spawning area by the different research vessels.

Research vessel	Coverage					
	1	2	3	4	5	6
Tridens	22.-31.5	5.- 6.6	13.-14.6			
Dana		4.- 9.6	10.-14.6			
Scotia		4.-10.6	10.-13.6	16.-21.6		
Michael Sars				15.-25.6		
Eldjarn					27.6-11.7	11-17.7

Table 2. Type of plankton samplers applied by the different vessels.

Research vessel	Type of sampler	Mesh size	Applied filtration efficiencies
Tridens	Gulf III	500 μ	1
Dana	Gulf III	500 μ	0.83
Scotia	High Speed Lock Ewe	500 μ	1
Michael Sars	Bongo, 20 cm	500 μ	1
Eldjarn	Bongo, 20 cm	500 μ	1

Table 3. Production estimate 1984

a) The Iversen and Westgård (1984) method:

Time	Egg production $\times 10^{-12}$	Covered area $m^2 \times 10^{-9}$	Adjusted egg production $\times 10^{-12}$
22-31.5	0.56	94	0.56
4.6-10.6	2.58	200	2.58
10-14.6	2.25	164	2.75
15-25.6	1.80	185	1.94
27.6-11.7	0.56	156	0.72
11-17.7	0.11	36	0.11
Total egg production	72	-	78
Spawning stock 1000 tons	109	-	118

b) The Pope and Woolner (1984) method:

For sampled rectangles:

Period	Production $\times 10^{-12}$	No.replic. rects	Coefficient of variation	No.of rects	95% conf. limit(+/-)
20-29.5	4.21	14	0.69	21	80%
30.5-8.6	16.27	33	1.93	52	85%
9-18.6	18.37	47	1.42	61	58%
19-28.6	7.62	29	1.26	33	75%
29.6-8.7	6.64	39	0.85	48	64%
9-18.7	0.74	14	0.49	18	31%
Overall	53.85	176	1.22		30%

Interpolated component:

Period	Production $\times 10^{-12}$
20-29.5	5.87
30.5-8.6	4.90
9-18.6	3.24
19-28.6	8.08
29.6-8.7	2.03
9-18.7	2.33
Overall	26.44

Total production estimate = 80.2832×10^{12} eggs

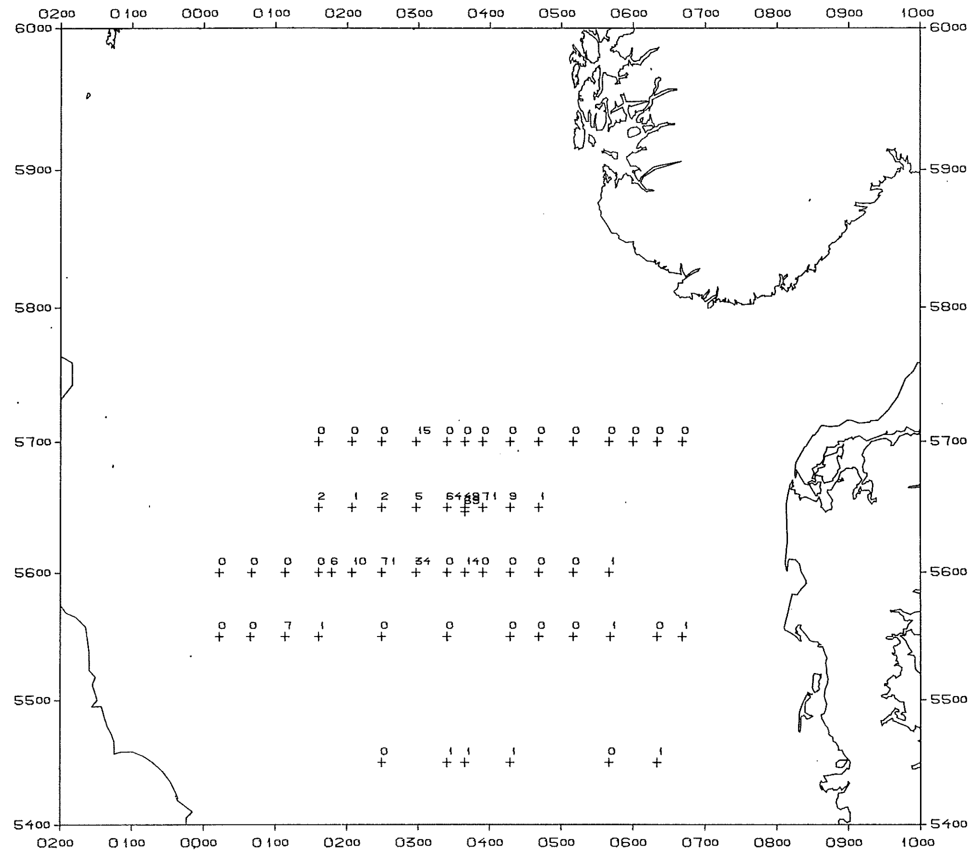

Fig.1. The stations grid and distribution of stage 1A and 1B mackerel eggs produced per square metre per day during the first survey, + = Tridens.

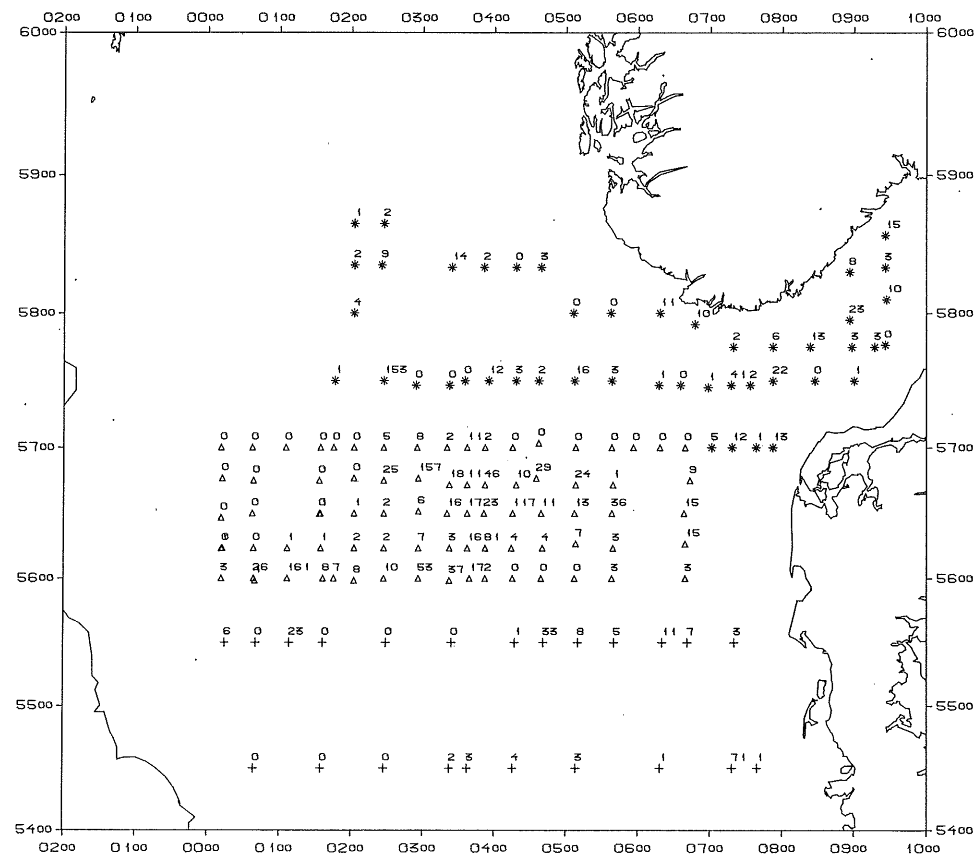

Fig.2. The stations grid and distribution of stage 1A and 1B mackerel eggs produced per square metre per day during the second survey, + = Tridens, * = Dana, Λ = Scotia.

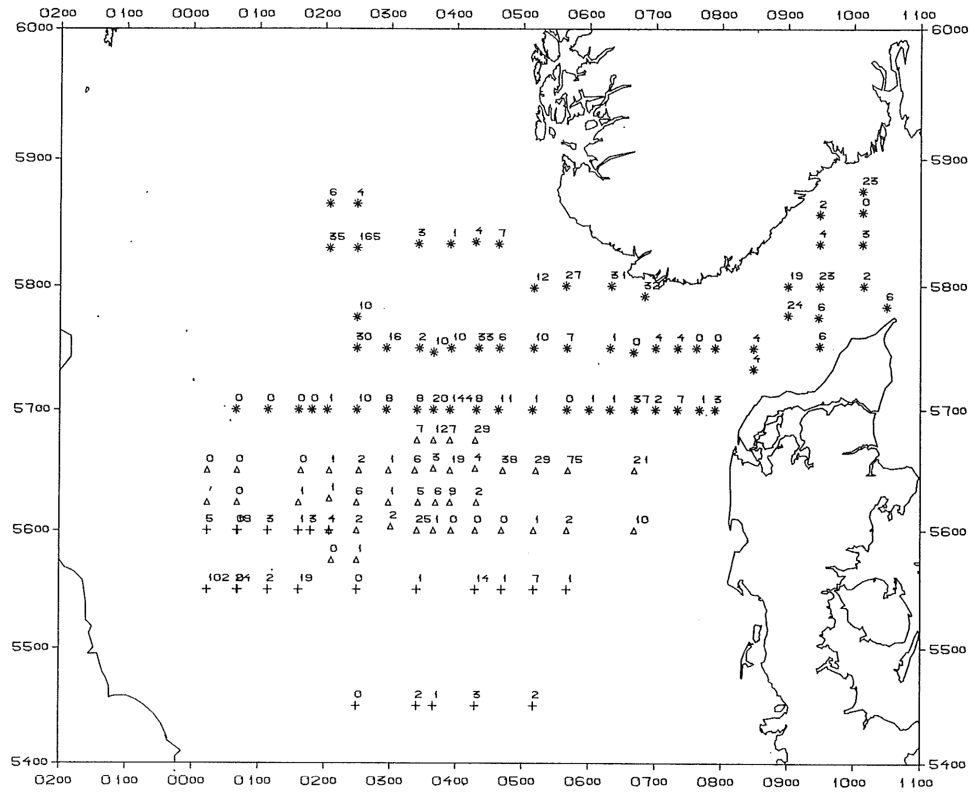

Fig.3. The stations grid and distribution of stage 1A and 1B mackerel eggs produced per square metre per day during the third survey, + = Tridens, * = Dana, Λ = Scotia.

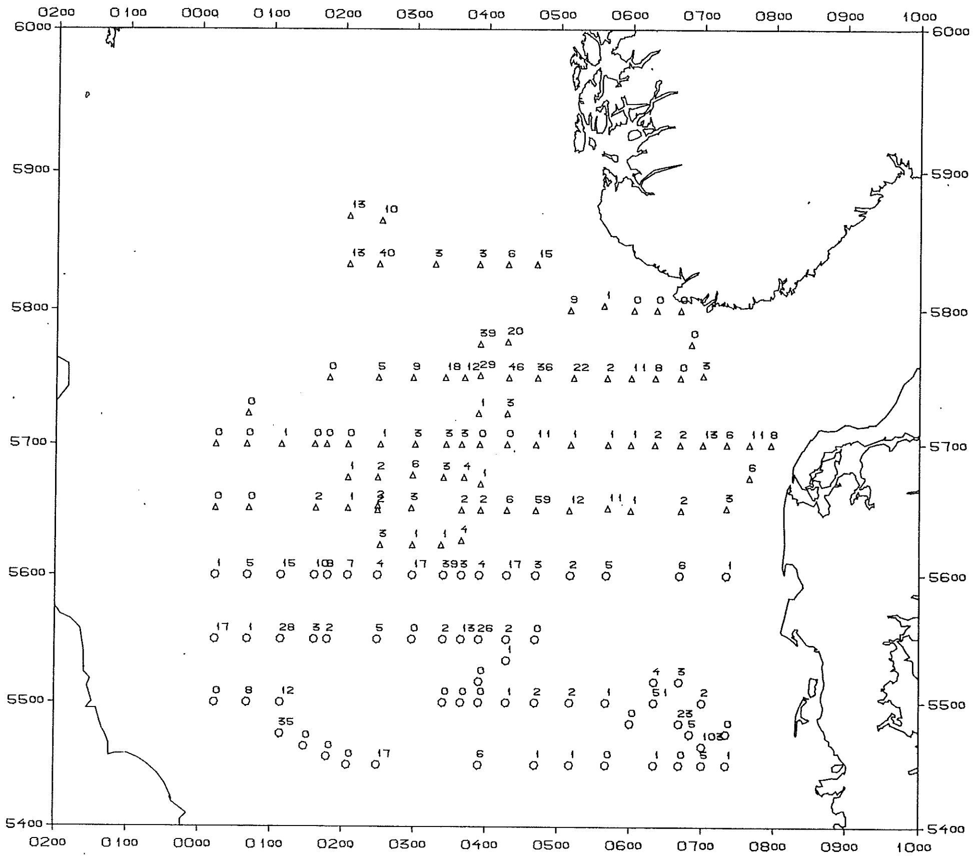

Fig.4. The stations grid and distribution of stage 1A and 1B mackerel eggs produced per square metre per day during the fourth survey, Λ = Scotia, = Michael Sars.

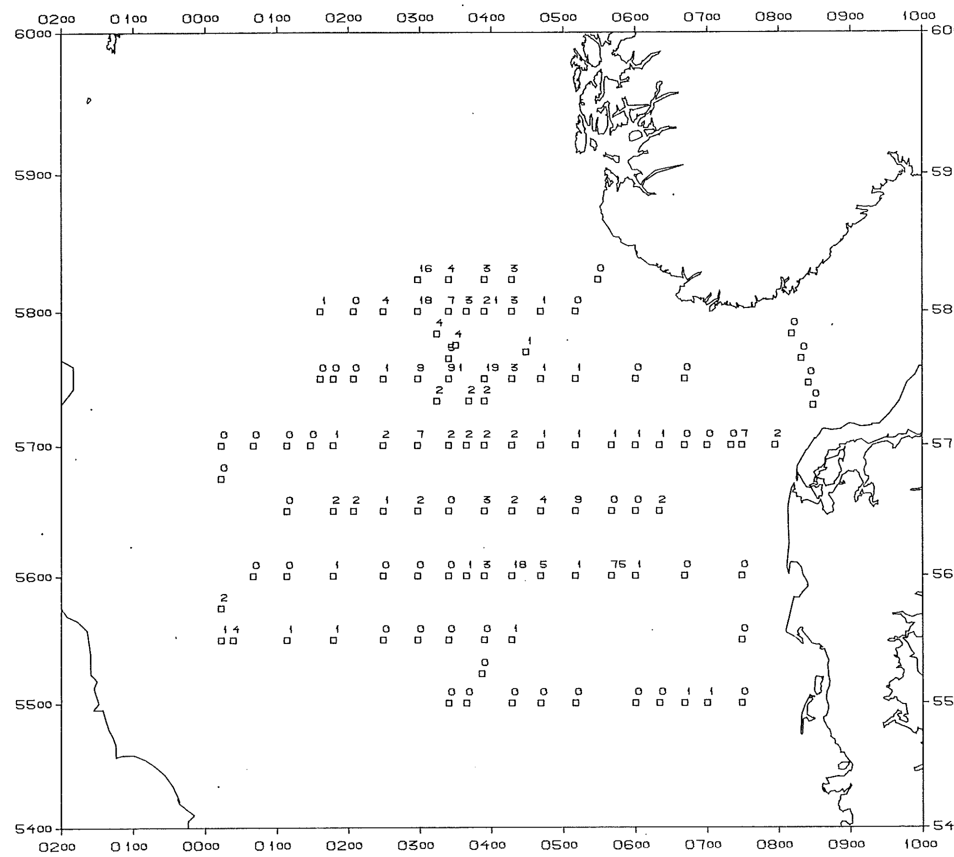

Fig.5. The stations grid and distribution of stage 1A and 1B mackerel eggs produced per square metre per day during the fifth survey, o = Eldjarn.

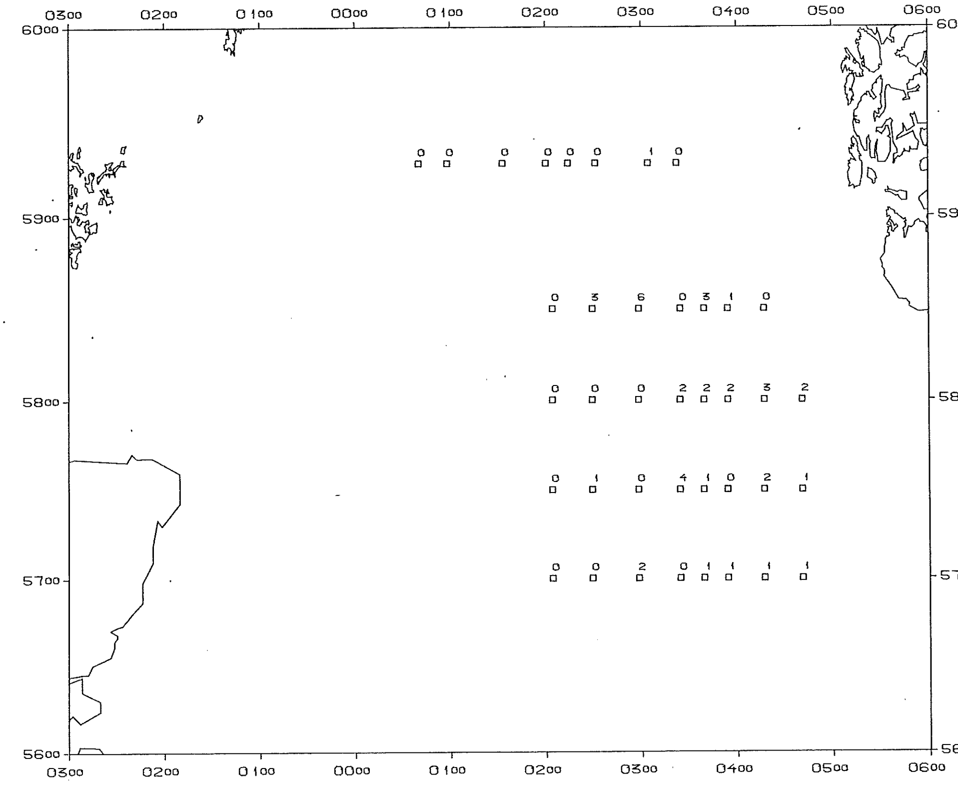

Fig.6. The stations grid and distribution of stage 1A and 1B mackerel eggs produced per square metre per day during the sixth survey, o = Eldjarn.

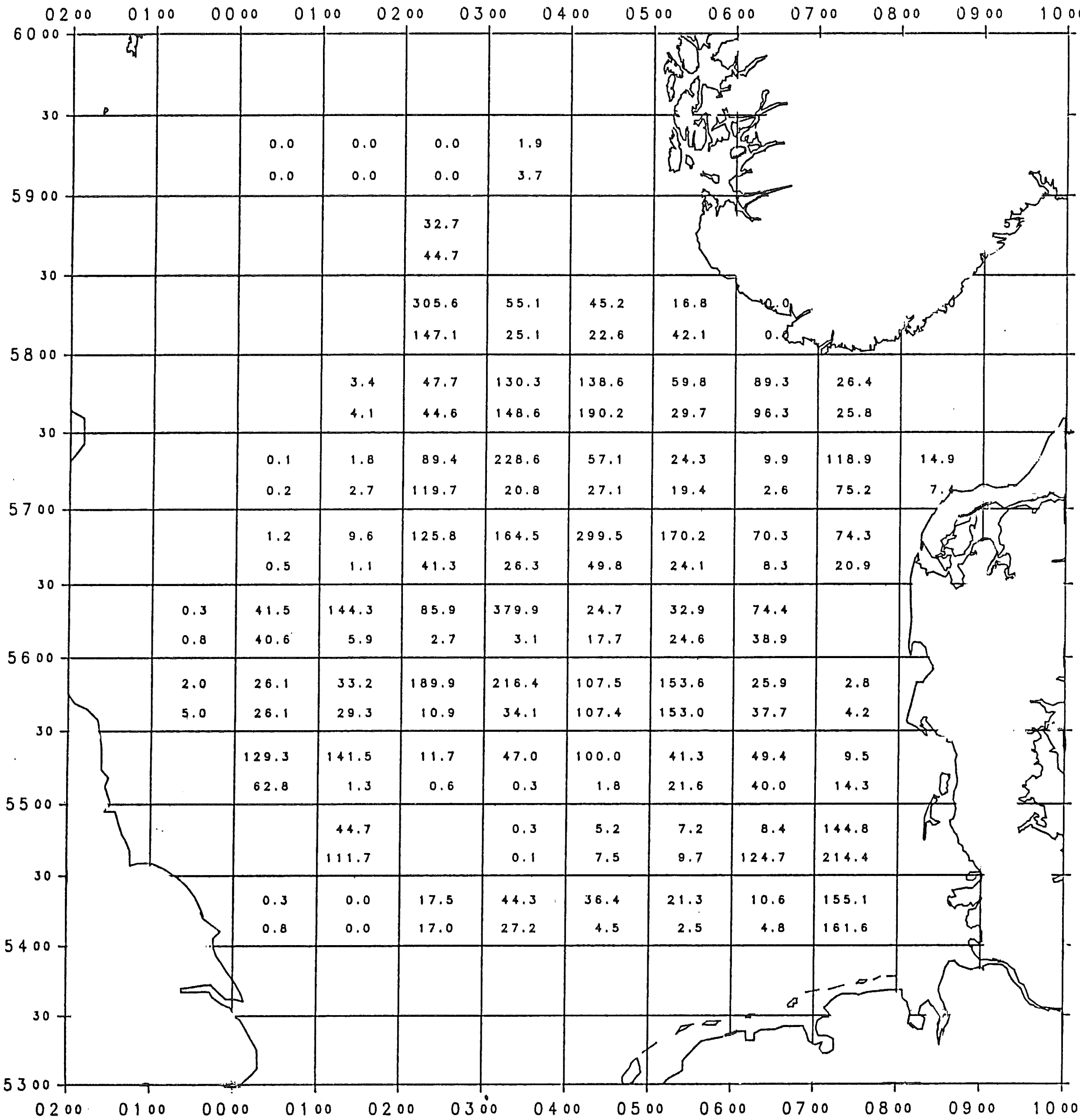

Fig.7. Egg production by ICES statistical rectangle, eggs x 10^{-10}.
Upper figure: sampled component
Lower figure: unsampled component (interpolated)