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THE EGG PRODUCTION AND SPAWNING STOCK SIZE OF THE NORTH SEA MACKEREL AND HORSE MACKEREL STOCKS IN 1988

by

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Abstract

During the period 5 April to 28 July 1988 the spawning areas of North Sea mackerel and horse mackerel were investigated by research vessels from the Netherlands, Denmark and Norway. Based on the plankton samples and temperature observations obtained during this period the egg production and spawning stock size were estimated. The total egg production of mackerel (25×10^{12} eggs) represents a spawning stock biomass of 37 000 tonnes, which is about 20 % less than the 1986 estimate. The total egg production of horse mackerel (87×10^{12} eggs) represents a spawning stock size of 110 000 tonnes.

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1. INTRODUCTION

During the period 1980-1984 the North Sea was surveyed every summer to estimate the total mackerel egg production. In 1984 it was decided to carry out the egg surveys every second year. The surveys have in recent years been carried out on an ICES basis with several nations participating. The egg survey data from 1988 have been used for stock assessment purposes by the working groups on the assessment of mackerel (Anon.,1989a) and horse mackerel (Anon., 1989b).

2. MATERIAL AND METHODS

The egg surveys in the North Sea were carried out by Denmark, Norway and the Netherlands during the period 5 April - 28 July 1988. The northern area (A) was surveyed by Norway and Denmark to cover the main spawning area of mackerel and the southern area (B) was surveyed by the Netherlands to cover the main spawning area of horse mackerel and sole (Fig.1). The northern area was covered four times and the southern area five times, but both areas were completely covered only three times.

The timing of the surveys are shown in Table 1.

The Norwegian vessel used a 20 cm Bongo net. The Danish and Dutch vessels used a Gulf III sampler. The mesh size for all gears was 500 µm. An echo sounder on the sampler continously measured the sampling depth. This was monitored aboard the vessel and the sampling depth adjusted as necessary. To calculate the water volume sampled each sampler was equipped with a flowmeter.

In the northern area (A) the samplers were towed stepwise in the depths, 20, 15, 10, 5 m and just below the seasurface (0.5m). The Bongo net was towed with a speed of about 3 knots for 5 minutes and the Gulf III sampler at a speed of about 5 knots for 2 1/2 minutes. The plankton samplers were assumed to sample representatively the upper 22.5 m, in which all mackerel and horse mackerel eggs are assumed to occur after the establishment of a thermocline. The plankton samples were sorted onboard, and the sampling effort in the spawning area was adjusted according to the abundance of mackerel eggs.

It is assumed that sole eggs are distributed in the whole water column. For that reason in the southern area (B) the Gulf III sampler was towed at a speed of 5 knots in oblique hauls till about 5 m above the bottom in order to catch the eggs of horse mackerel, sole and mackerel. The sampler fished 3 minutes per 10 meter depth, but in shallow waters where the haul duration was less than 10 minutes more than one haul was carried out.

Figs.2-7 show the stations sampled during each coverage.

The plankton samples were preserved in 4% formaldehyde. The mackerel eggs were aged according to the state of development and the larvae in the Norwegian samples were measured to the nearest mm below.

The data are worked up to numbers of eggs produced per day using the formula for stage 1 eggs for each of the two species:

Mackerel: $\ln \text{Time} = -1.61 \ln \text{Temperature} + 7.76$ (Lockwood et al.,1981)

Horse mackerel: $\ln \text{Time} = -1.61 \ln \text{Temperature} + 7.71$ (Pipe and Walker, 1987)

Where Time is the age of the eggs at the end of stage 1B in hours and temperature is the temperature (^{0} C) at 5 m depth at the station where the eggs were sampled.

Daily egg production was estimated as described by Iversen and Westgård (1984). According to this method the egg productions per day per station are interpolated into a fine grid of rectangles over the surveyed area. Usually the area integrated has been delineated by a polygon. Due to spawning close to the Dutch coast it was difficult to delineate this area by a polygon. The integrated area should therefore be delineated by the coastline. To get as close as possible to the coastal line a very fine grid net was applied (100 x 100 rectangles i.e. 4.8 x 6 nautical miles), Fig.8. However, for presenting the distribution of eggs a coarser grid net of 50 x 50 rectangles was applied.

The fecundity estimates used in 1988 were of potential fecundity rather than realised fecundity. Potential fecundity is the maximum number of oocytes which might be spawned in the current season, with no allowance for resorption (atresia) or de novo formation of oocytes. For potential fecundity it is assumed that the number of eggs destined to be spawned in a season is fixed as identifiable developing oocytes prior to spawning (Anon, 1988).

Fecundity estimates used to determine spawning stock size in 1988 were:

North Sea mackerel (Iversen and Adoff 1983):

$$\text{Fecundity} = 560\ (\text{weight(g)})^{1.14}\ n=67$$

$$\text{Fecundity} = 1.35 \times \text{length (cm)}^{3.6}\ n=67,$$

Horse mackerel (Eltink and Vingerhoed, 1989):

Fecundity = 1653 eggs/gram female horse mackerel in maturity stage 4

3. RESULTS

3.1 Distribution of mackerel eggs

The distribution of mackerel eggs observed during the different coverages are shown in Figs.9-14. Only few eggs were observed in the two first surveys (Figs.9-10). In late May- early June the spawning was more intense with the main concentrations observed off the Dutch coast (Fig.11). Later the center of spawning had shifted northwards and westwards (Figs.12-13). During the last coverage the spawning intensity was reduced and most eggs were observed east of Jutland (Fig.14).

3.2 Distribution of horsemackerel eggs

The distribution of horse mackerel egg is shown in Figs.15-18. During the first coverage no spawning of horse mackerel occured. The first eggs were found in the second coverage in the last week of April, but the egg production was still at a very low level (Fig.15). During the third coverage the last two weeks of May, two main spawning areas were observed, one along the coast from France to the Dutch estuary and the other off the Dutch Wadden isles. The temperature was above 12^{0}C in these areas. During the fourth coverage the main spawning seems to have shifted to the German Bight. However one haul at the southern end of the station grid still contained a rather high number of eggs (Fig.17). During the last coverage at the end of July the egg production was low and spawning mainly located in the German Bight (Fig.18).

The main spawning area of the North Sea horse mackerel is located in the North Sea along the French, Belgian, Dutch and German coast. The spawning takes place in May-July.

3.3 Estimates of egg production and spawning stock size

3.3.1 Mackerel

The text table below shows the timing of the surveys and the applied reference dates for the estimated daily egg production. The reference dates for the different surveys are not necessarily the mid date of the survey period. In coverage four and six the reference date given are based

Coverage	Survey Period	Reference date	Egg prod.x10^{12}	Raising factor	Adjusted egg production 10^{12}
1	5.4-12.4	9.4	0.02	-	+
2	24.4- 5.5	30.4	0.03	-	+
3	16.5-10.6	5.6	0.19	1.3	0.3
4	10.6-29.6	20.6	0.84	1.05	0.9
5	29.6- 9.7	4.7	0.43	1.05	0.5
6	9.7-28.7	12.7	0.02	1.15	0.1

on the timing of the Danish and Norwegian surveys respectively since they contributed the major part of the egg production. The first two Dutch surveys showed that a few mackerel eggs were observed as early as in April in the southern part of the North Sea. Daily plankton samples collected from the central part of the northern North Sea, within the main spawning area in 1981-1983, indicated that spawning in this area started late May (Iversen and Ljøen, 1985). The surveys in May-July did not cover the total spawning area. To adjust for the production in the uncovered areas, the egg production estimates based on the four last coverages were raised by the factors given in the text table above.

The egg production curve is shown in Fig.19. The curves for 1984 and 1986 are also given. Skagerrak was not covered in 1984 and 1986 while the estimated production in the western Skagerrak was included in 1988. The main spawning period has usually been defined as 17 May-27 July. During this period in 1988 the egg production, based on the curve (Fig. 19), was estimated at 25 x 10^{12} eggs which is about 20 % less than estimated in 1986. The egg production in April and early May is not included in this estimate. However, investigations in earlier years (for ex. Iversen, 1982) and the estimated egg production in area B during 1988 indicate that the egg production prior to mid May is insignificant. The estimated egg production equals a spawning stock of 37 000 tonnes.

The decreasing trend in the spawning stock size over the last years is shown in the text table on next page.

Table 2 shows the relative age composition, mean length and weight at age for mackerel caught by Norwegian and Danish research vessels in the period 30 April to 7 July. Three different gears were used, gill net, hook and line and trawl. No adjustment for gear selectivity has been made.

	Total egg production	Total spawning biomass
1984[1]	78 x 10^{12}	118 000 tonnes (Iversen et.al.,1985).
1986[1]	30 x 10^{12}	45 000 tonnes (Iversen et.al.,1987).
1988[2]	25 x 10^{12}	37 000 tonnes

1) Skagerrak and southern North Sea not included
2) Western Skagerrak and southern North Sea included

The age composition does not indicate any outstanding yearclasses. The proportion of fish 10 years and older, which is very high (41%), shows a decreasing trend during the sampled period. The observed age compositions may not, due to gear selection, represent the true age composition in the stock. This may particularly apply for the gill net catches.

3.3.2 Horse mackerel

The text table below shows the timing of the surveys and the applied reference dates for the estimated daily egg productions. The reference dates for the surveys are not necessarily the mid-dates. For horse mackerel the reference date is the mid-date of the Dutch surveys in the southern area (B), since this area contributed to the major production of horse mackerel eggs.

An egg production curve was constructed (Fig. 20). The total production of stage 1 horse mackerel eggs was estmated at 87 x 10^{12} eggs.

Coverage	Period	Reference date	Egg production x10^{12}
1	5.4-12.4	9.4	-
2	24.4- 5.5	30.4	+
3	16.5-10.6	24.5	1.4
4	10.6-29.6	24.6	1.5
5	29.6- 9.7	-	No estimate in area B
6	9.7-28.7	23.7	0.2

By applying 1653 eggs per gram female horse mackerel in maturity stage 4 and assuming a sex ratio of 1:1, the corresponding spawning stock biomass is 105 thousand tonnes horse mackerel in maturity stage 4. The increase in weight from maturity stage 4 fish to spawning fish is about 5 % (Eltink and Vingerhoed, 1989). Therefore, the spawning stock biomass of the North Sea horse mackerel is estimated at 110 thousand tonnes horse mackerel.

4 DISCUSSION AND CONCLUSION

The area covered in 1988 was extended compared with the previous years. For the first time the whole North Sea and most of the Skagerrak were surveyed. The results confirm that the main spawning of mackerel is taking place in the central part of the North Sea. Less than 10 % of the stock was observed to spawn outside the area covered in previous years.

It was the first time in 1988 that for horse mackerel a complete coverage by egg survey in the North Sea over the whole spawning season was carried out, which survey resulted in a total egg production of 87 * 10^{12} eggs.

In earlier years Macer (1974) combined a number of surveys of different years and calculated a total egg production of 323 * 10^{12} eggs in the English Channel and southern North Sea area based on combined egg surveys carried out in April-May 1962, May 1967, June 1962, July 1968 and September 1962. The egg production in the English Channel west 1^0 E was mainly below 100 eggs/m^2, while much higher concentrations (over 100 to 5 300 eggs/m^2) occured east of 1^0 E in the English Channel and southern North Sea. Therefore, the high concentrations of eggs found at the southern border of the 1988 egg survey were expected to decrease rapidly further to the southwest into the English Channel and the main spawning area of the North Sea horse mackerel was expected to be covered in 1988.

It seems that the horse mackerel migrates northward along the French, Belgian, Dutch and German coast during spawning from the end of April till the end of July. They probably migrate further north in August, where they are observed by the Danish acoustic surveys. The total estimated amount of horse mackerel over the whole area based on the Danish acoustic survey in 1988 was 153 thousand tonnes (Anon., 1989b), which is higher than the estimated 110 thousand tonnes from the egg survey in 1988.

The histometric fecundity estimate of 1653 eggs/gram female is used instead of the volumetric fecundity estimate of 1489 eggs/gram female (Eltink and Vingerhoed, 1989) because in future probably only the histometric fecundity will be estimated and applied and because the two methods did not differ significantly.

5. REFERENCES

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Table 1. The timing of the egg surveys in the North Sea in 1988

Area	Ship	Coverage					
		1	2	3	4	5	6
A (north)	Dana (Denmark) Michael Sars (Norway)			31.5-10.6	10.6-16.6 16.6-29.6	29.6-9.7	9.7-14.7
B (south)	Isis (Netherlands) KW34 (Netherlands) Tridens (Netherlands)	5.4-12.4	24.4-5.5	30.6-2.6 16.5-26.5	21.6-23.6 20.6-29.6		18.7-28.7

Table 2. Relative age composition (%), mean length (cm) and mean weight (gram) at age for mackerel caught by Norwegian and Danish research vessels in the period 30 April to 7 July.

			Age														
DATE	AREA	GEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
30.04	48F3	gill net	0	0	0	0	3	9	4	13	10	6	6	10	3	3	33
03.05	49F3	"	0	0	0	0	2	5	8	9	6	5	1	11	8	3	42
24.05	44F7	"	0	0	1	5	5	8	17	29	4	5	5	8	2	1	10
26.05	42F3	"	0	0	0	1	0	0	3	4	3	3	8	10	13	8	47
27.05	43F4	hook	0	0	0	1	1	7	11	7	7	5	7	6	12	2	34
28.05	44F4	gill net	0	0	5	16	4	1	18	7	10	1	6	9	5	3	15
29.05	45F4	"	0	0	3	12	5	7	8	11	5	15	11	4	5	1	15
02.06	44G0	Trawl	0	4	8	12	8	12	12	12	4	4	8	8	0	0	0
03.06	42F2	Gill net	0	0	0	7	2	15	19	7	15	10	2	2	7	7	8
10.06	41F0	Trawl	0	1	3	15	7	5	6	7	9	6	10	10	8	7	5
11.06	41F2	"	0	2	10	11	10	12	13	7	5	3	5	7	2	4	8
12.06	43F2	"	0	5	15	12	11	22	15	10	2	1	1	1	2	1	1
13.06	42F2	"	0	4	7	8	16	30	20	7	3	0	0	2	0	1	3
14.06	41F2	"	2	0	1	3	6	4	4	5	9	17	10	12	11	8	10
14.06	41F3	"	0	58	8	4	1	4	3	3	2	1	4	2	2	2	4
22.06	41F3	gill net	0	3	14	23	3	14	14	9	3	0	3	3	3	3	6
01.07	45F2	"	0	0	3	8	8	10	27	10	4	2	3	7	3	1	14
07.07	41F5	"	12	4	5	19	5	11	6	12	5	7	1	2	4	1	7
Average			1	5	5	9	5	10	12	9	6	5	5	6	7	3	15
Mean weight in gram			131	275	359	403	520	523	535	590	568	603	670	662	813	723	772
Mean length in cm			24.4	31.3	34.4	35.7	39.1	39.3	39.3	39.6	39.9	40.9	42.5	42.5	43.2	43.3	44.6

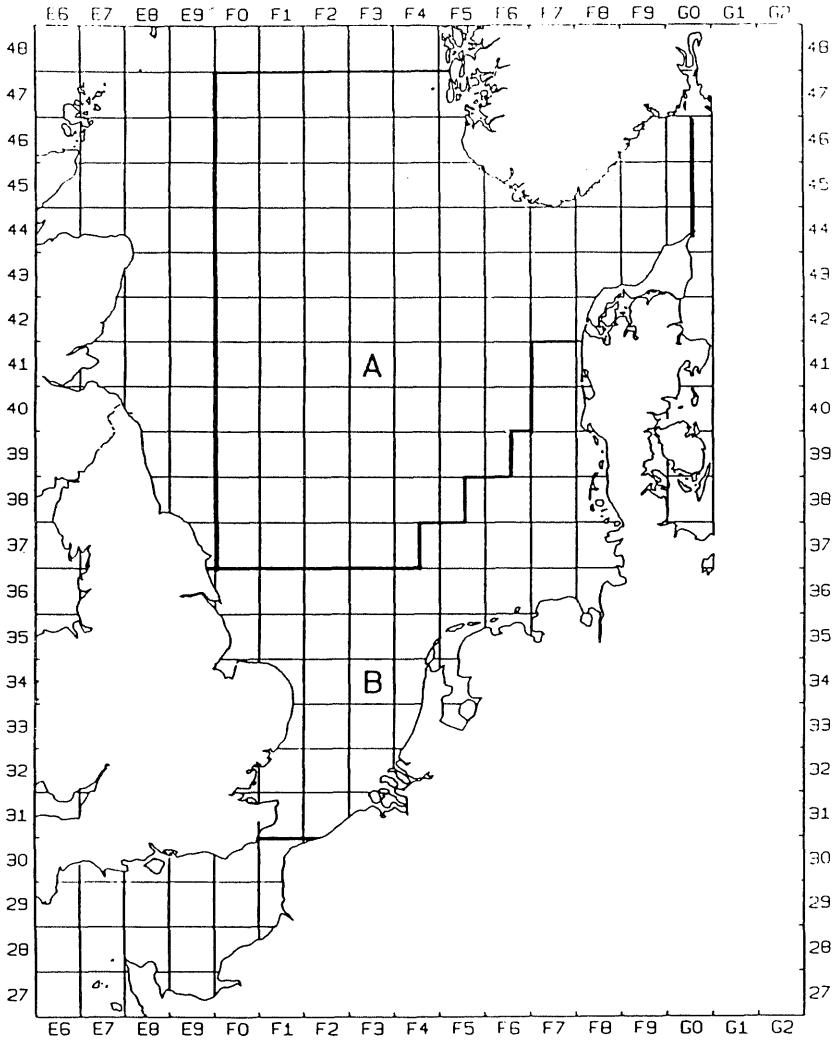

Fig.1 The area surveyed in 1988 by Denmark and Norway (A) and by the Netherlands (B).

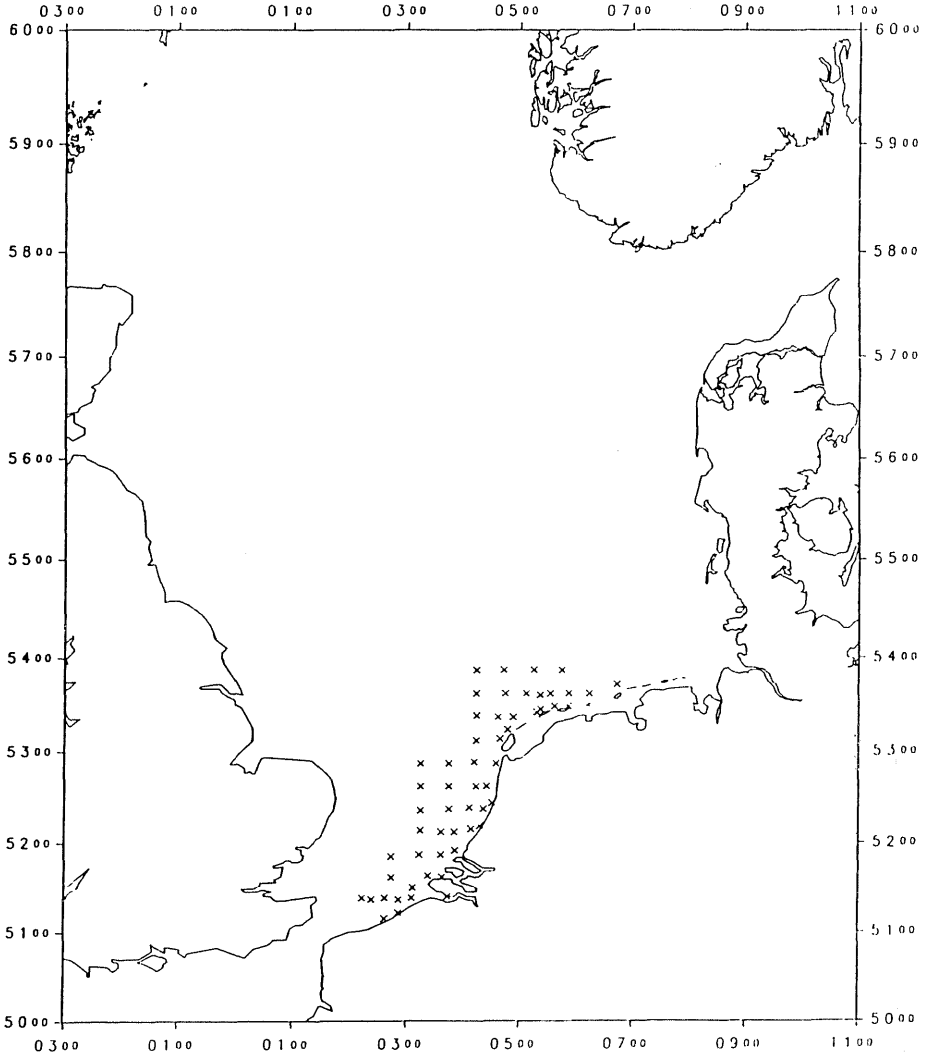

Fig.2 The stations sampled by the Dutch vessel during coverage 1 (05.04-12.04).

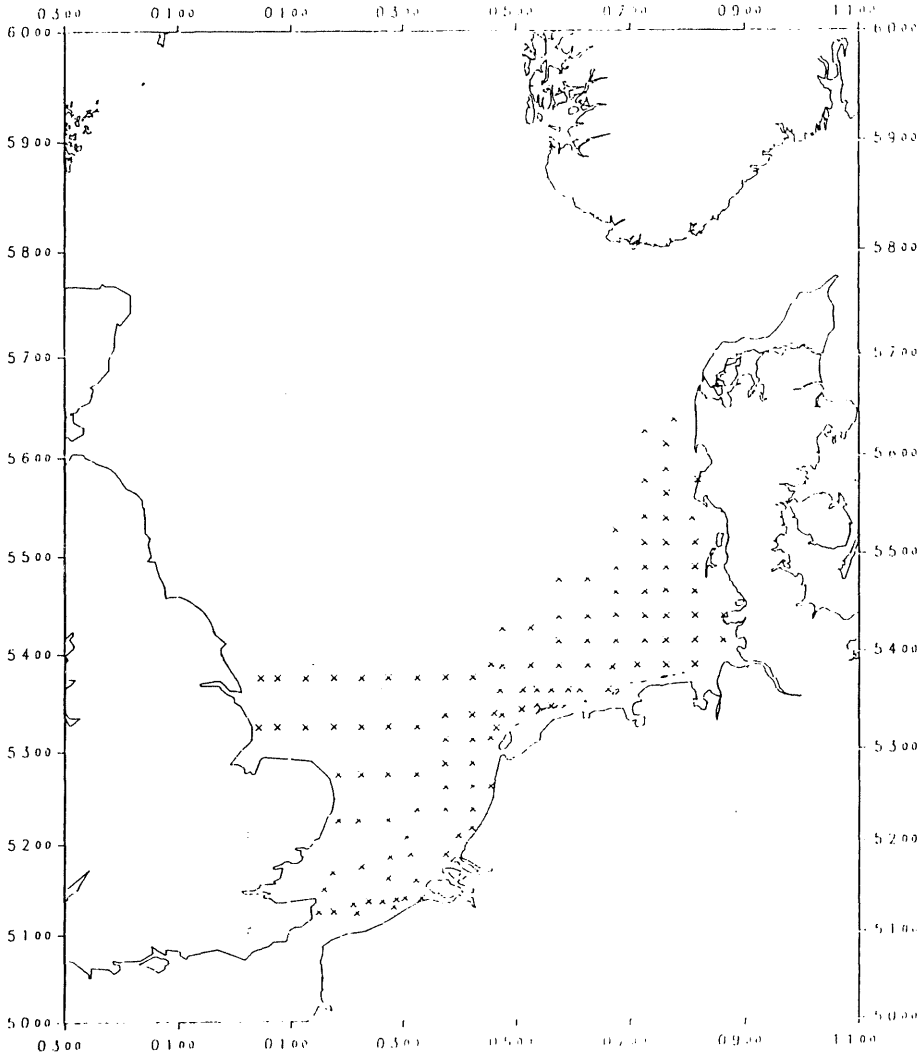

Fig.3 The stations sampled by the Dutch vessel during coverage 2 (24.04-05.05).

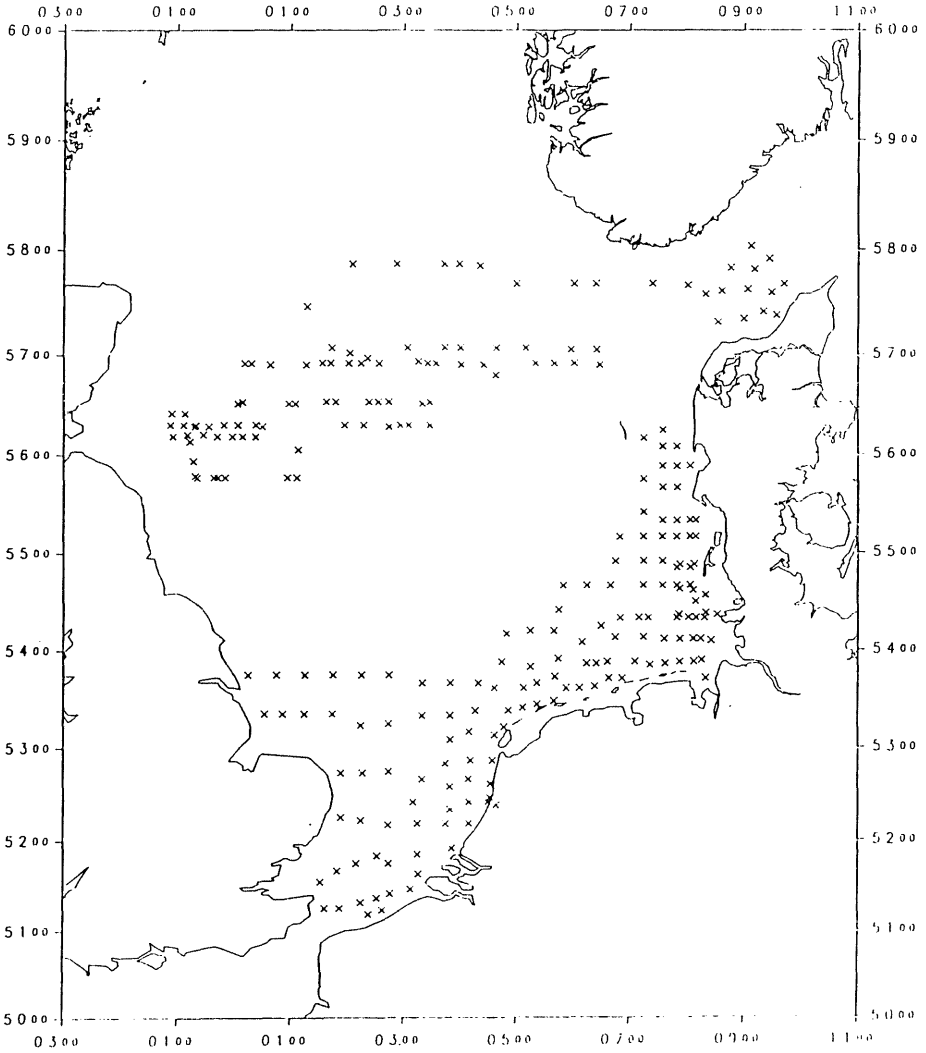

Fig.4 The stations sampled by the Dutch and the Danish vessels during coverage 3 (16.05-10.06).

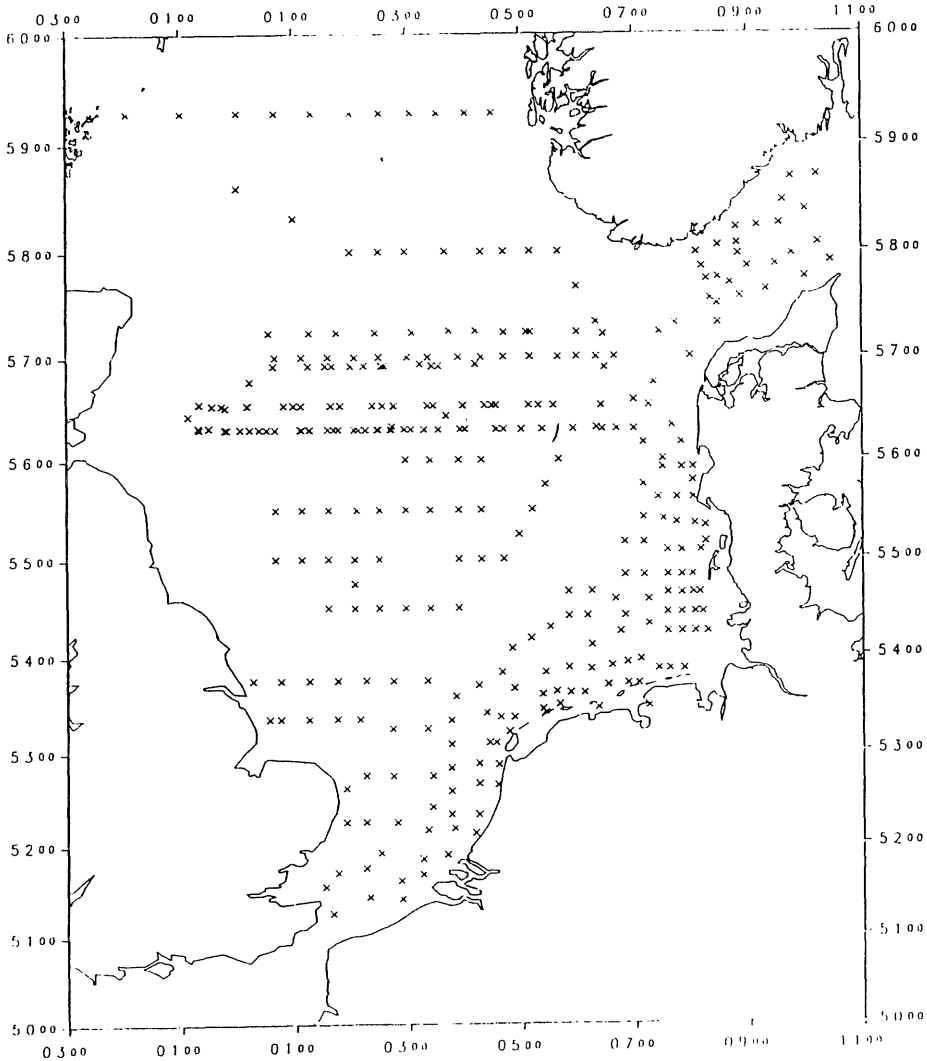

Fig.5 The stations sampled by the Dutch, the Danish and the Norwegian vessels during coverage 4 (10.06-29.06).

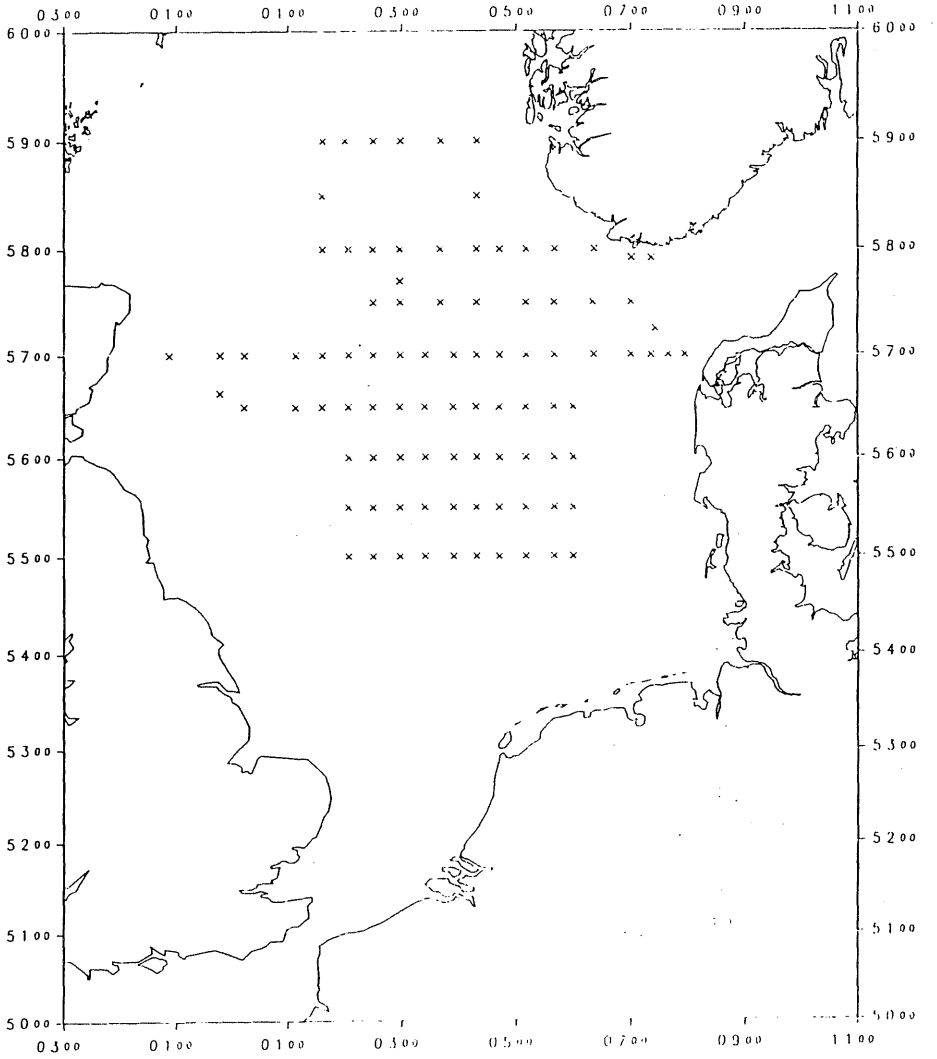

Fig.6 The stations sampled by the Norwegian vessel during coverage 5 (29.06-09.07).

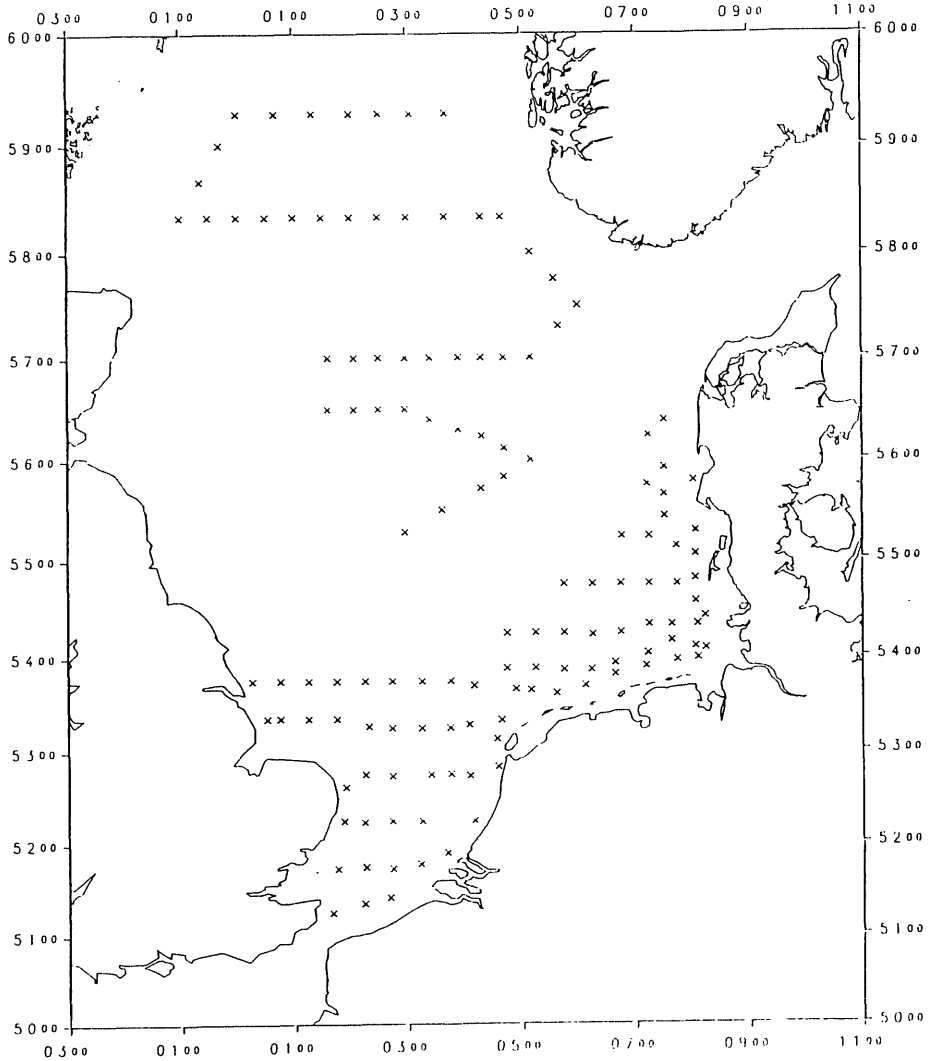

Fig.7 The stations sampled by the Dutch and the Norwegian vessels during coverage 6 (09.07-28.07).

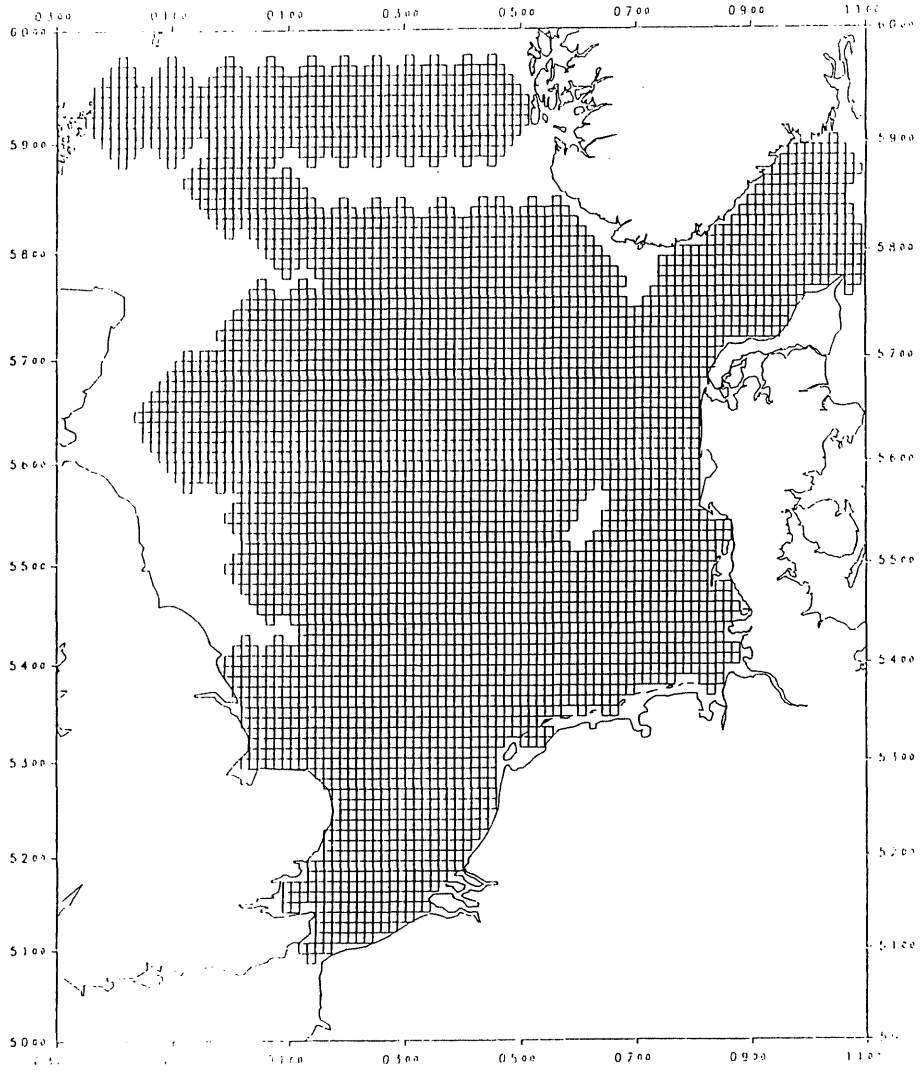

Fig.8 The grid net used in the estimation of egg production per day per rectangel, exemplified by the data from coverage 4.

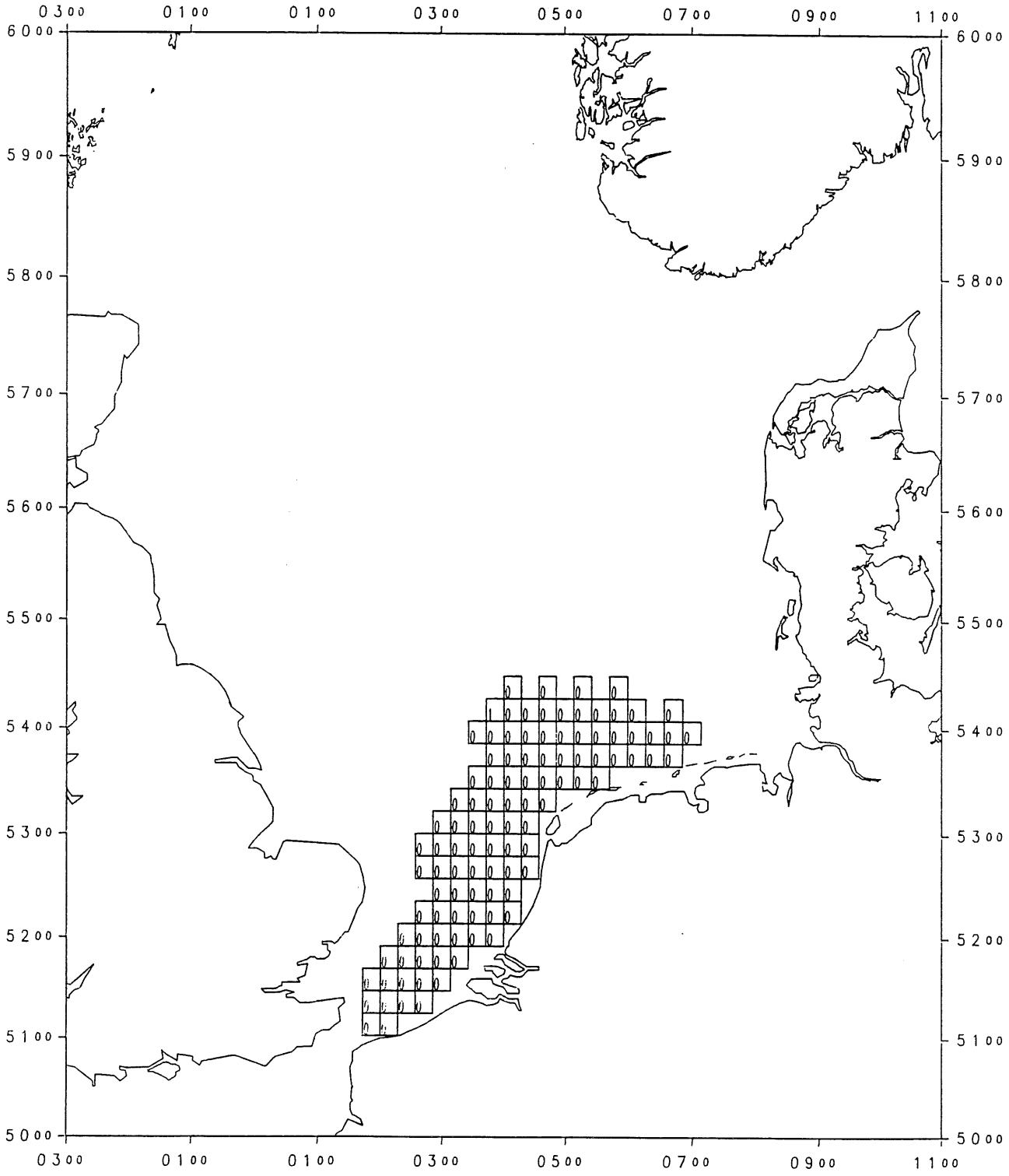

Fig.9 Number of mackerel eggs produced per square m per day in each rectangle during coverage 1.

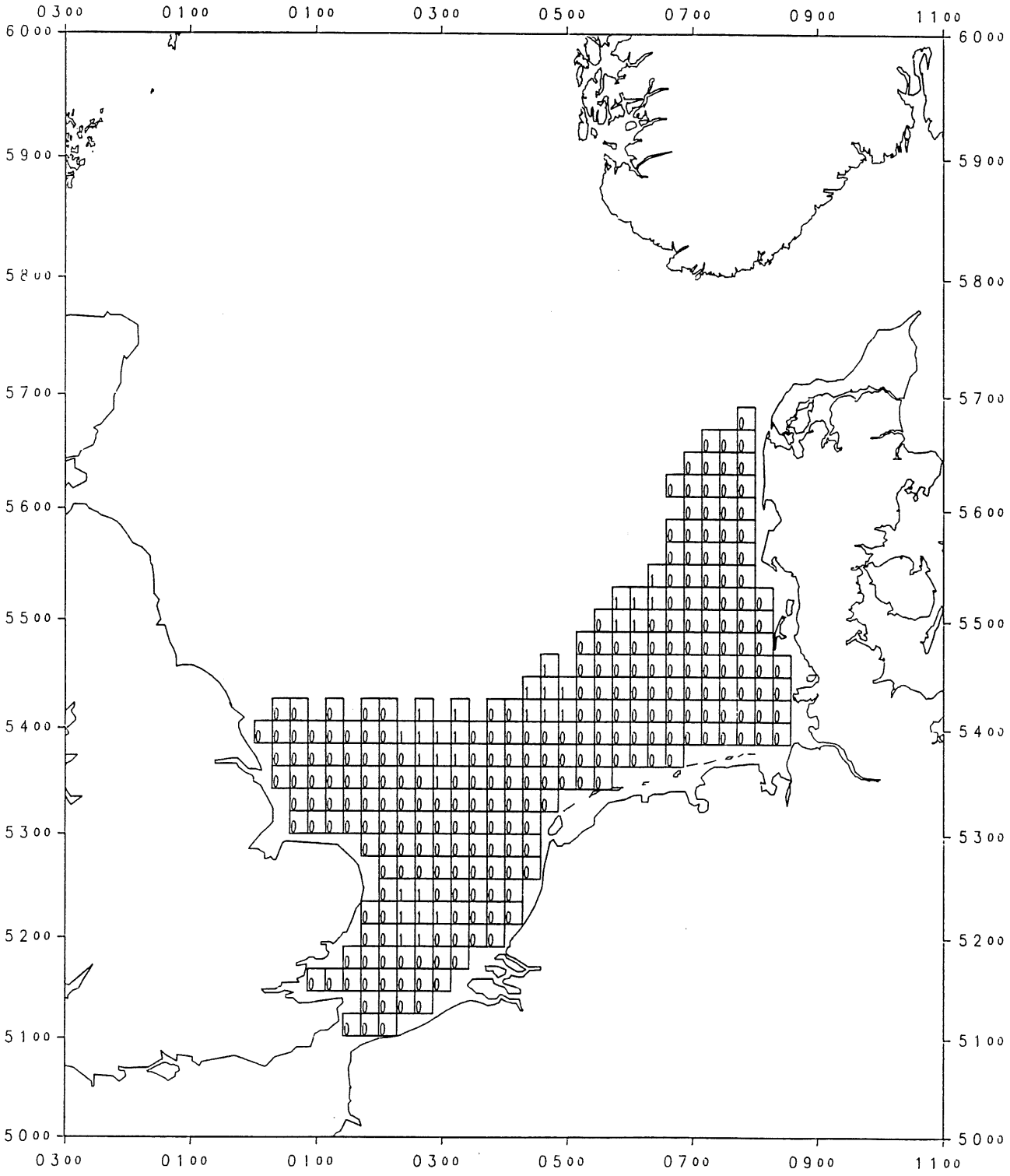

Fig.10 Number of mackerel eggs produced per square m per day in each rectangle during coverage 2.

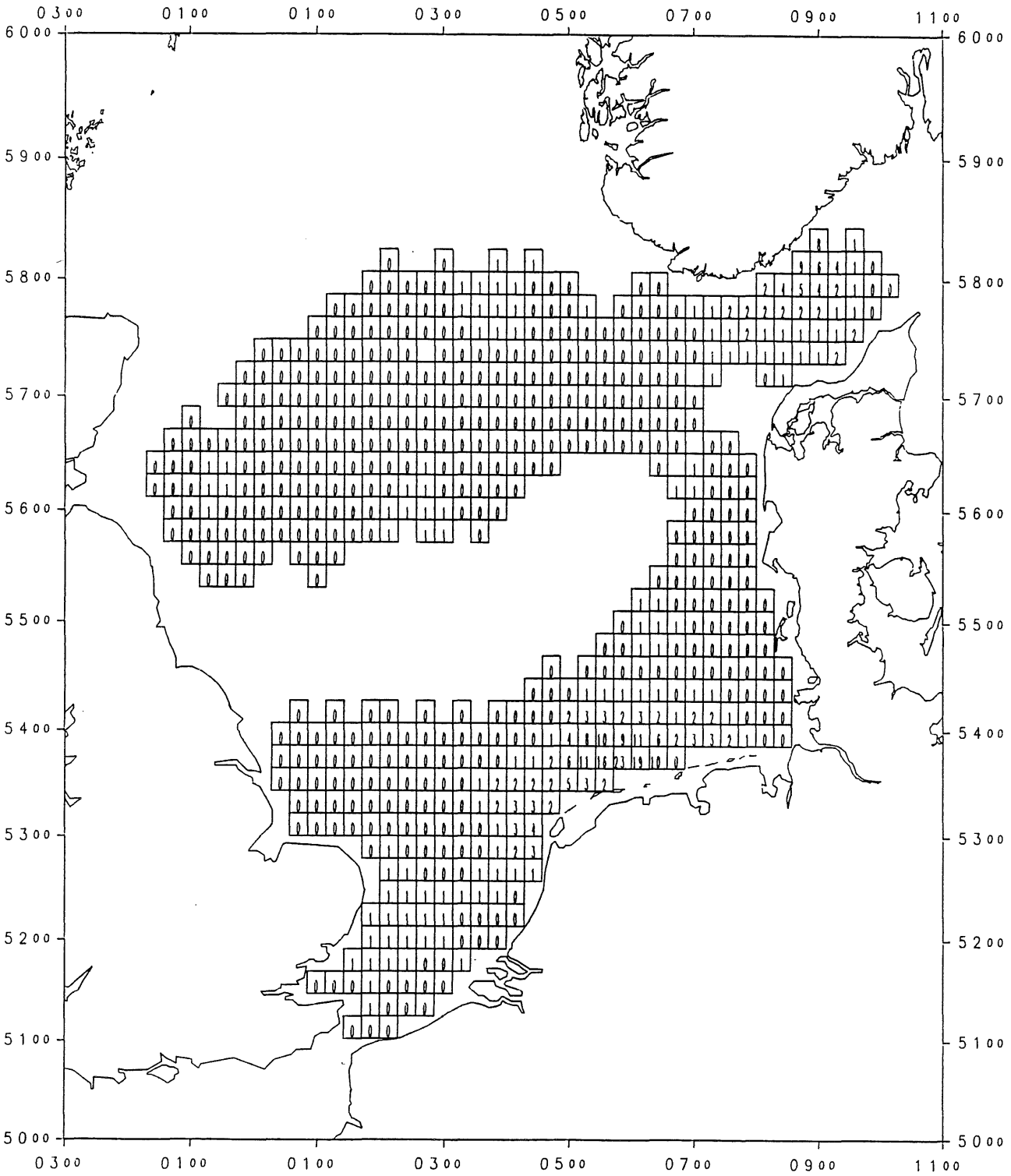

Fig.11 Number of mackerel eggs produced per square m per day in each rectangle during coverage 3.

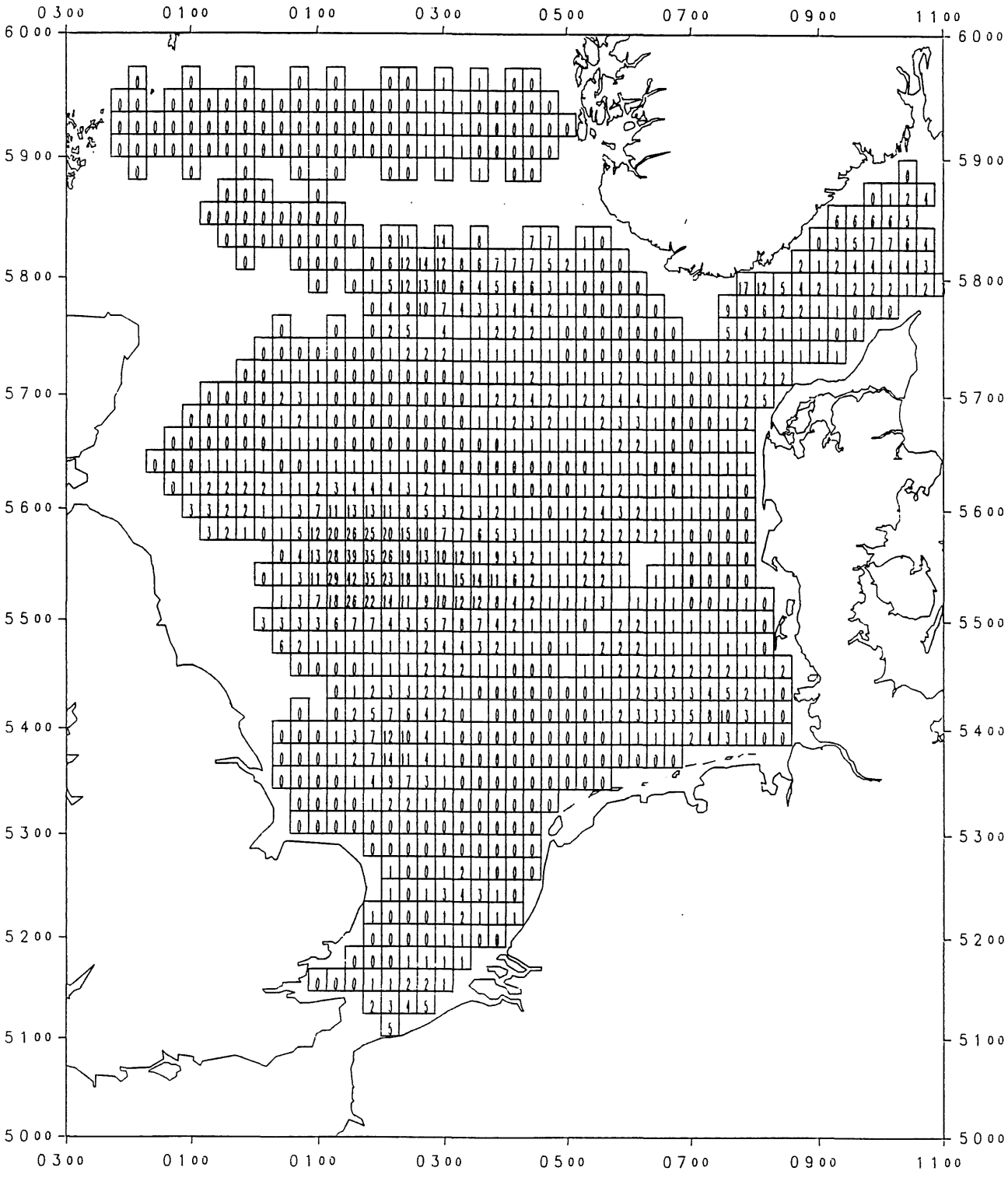

Fig.12 Number of mackerel eggs produced per square m per day in each rectangle during coverage 4.

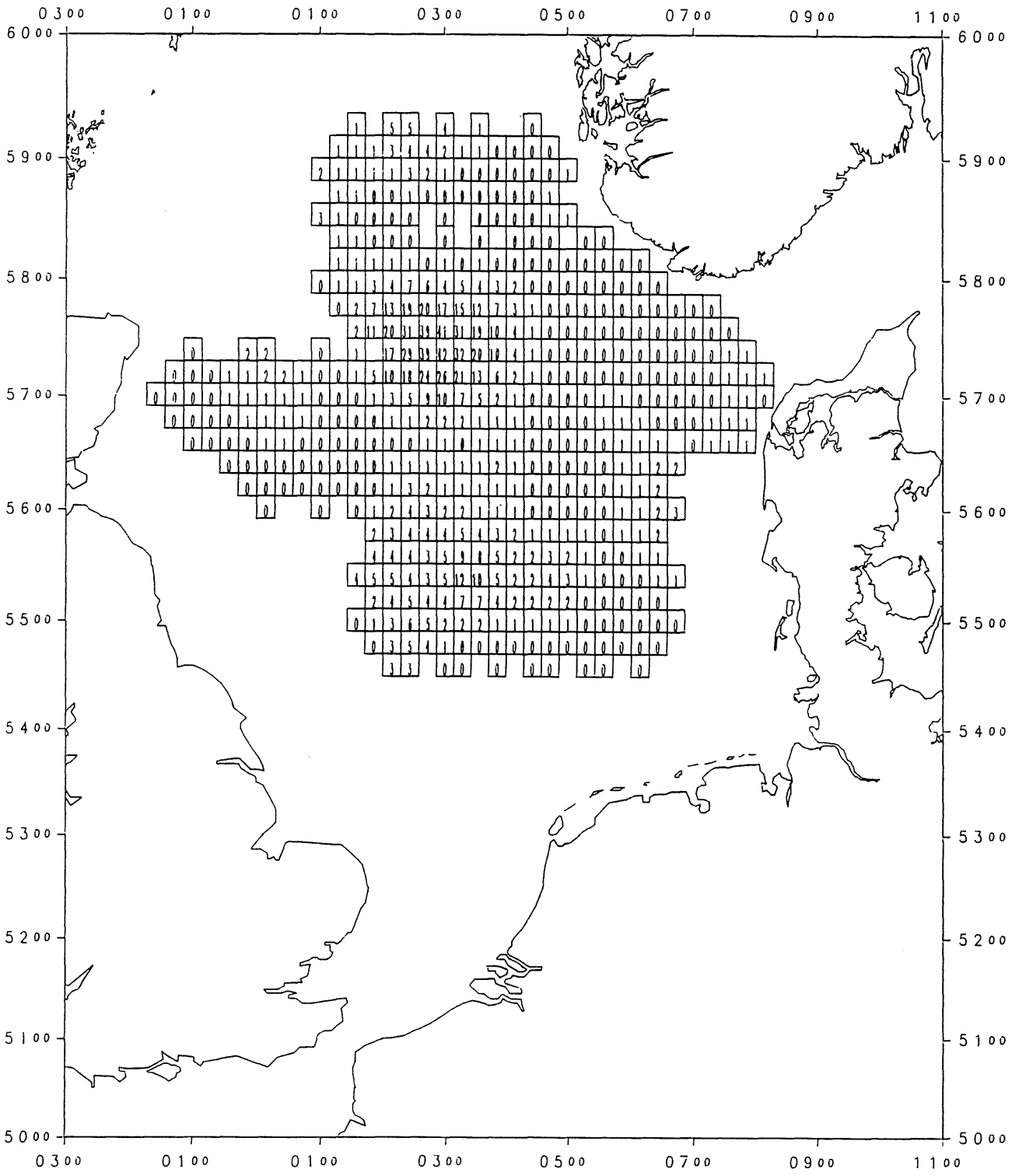

Fig.13 Number of mackerel eggs produced per square m per day in each rectangle during coverage 5.

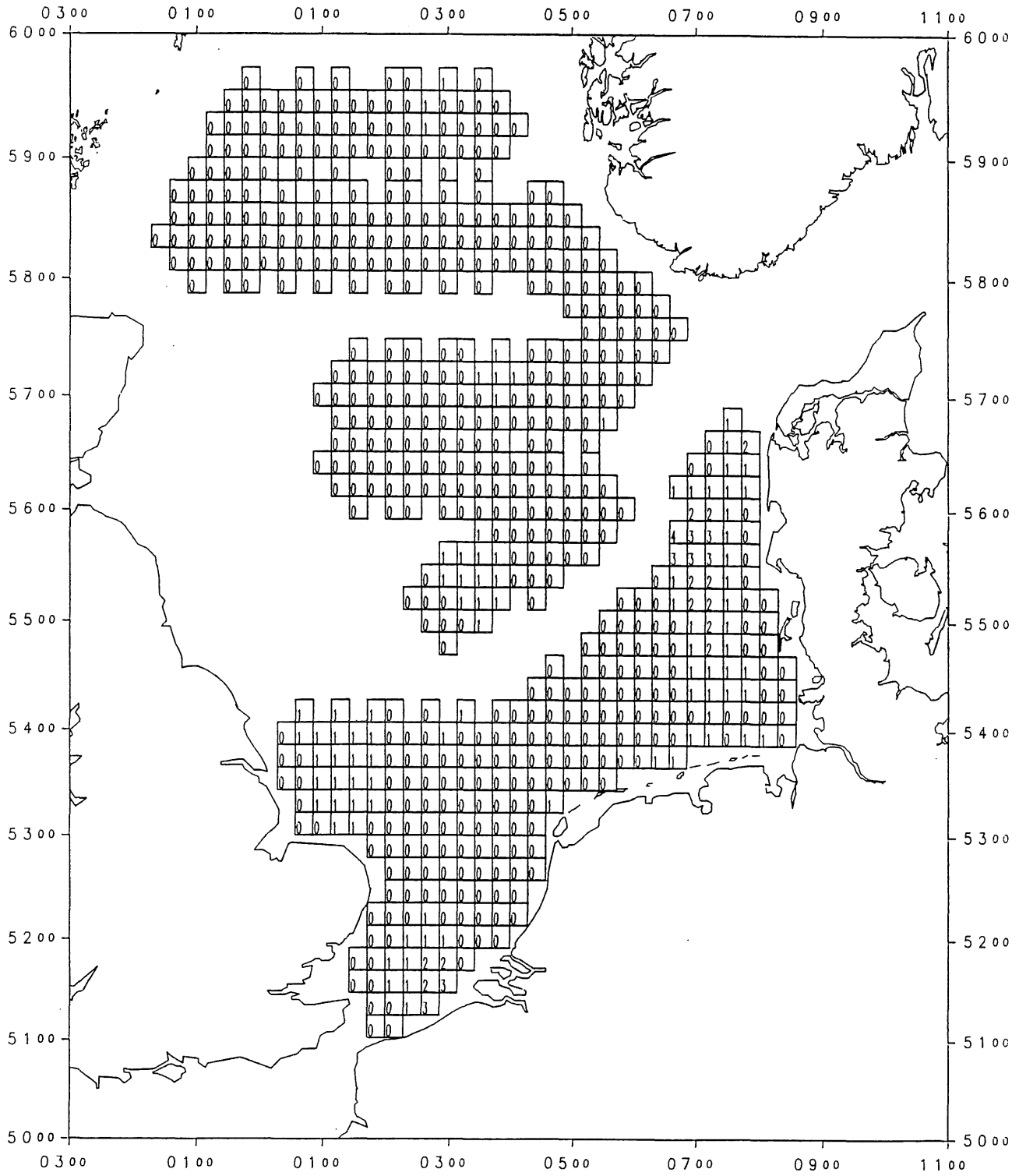

Fig.14 Number of mackerel eggs produced per square m per day in each rectangle during coverage 6.

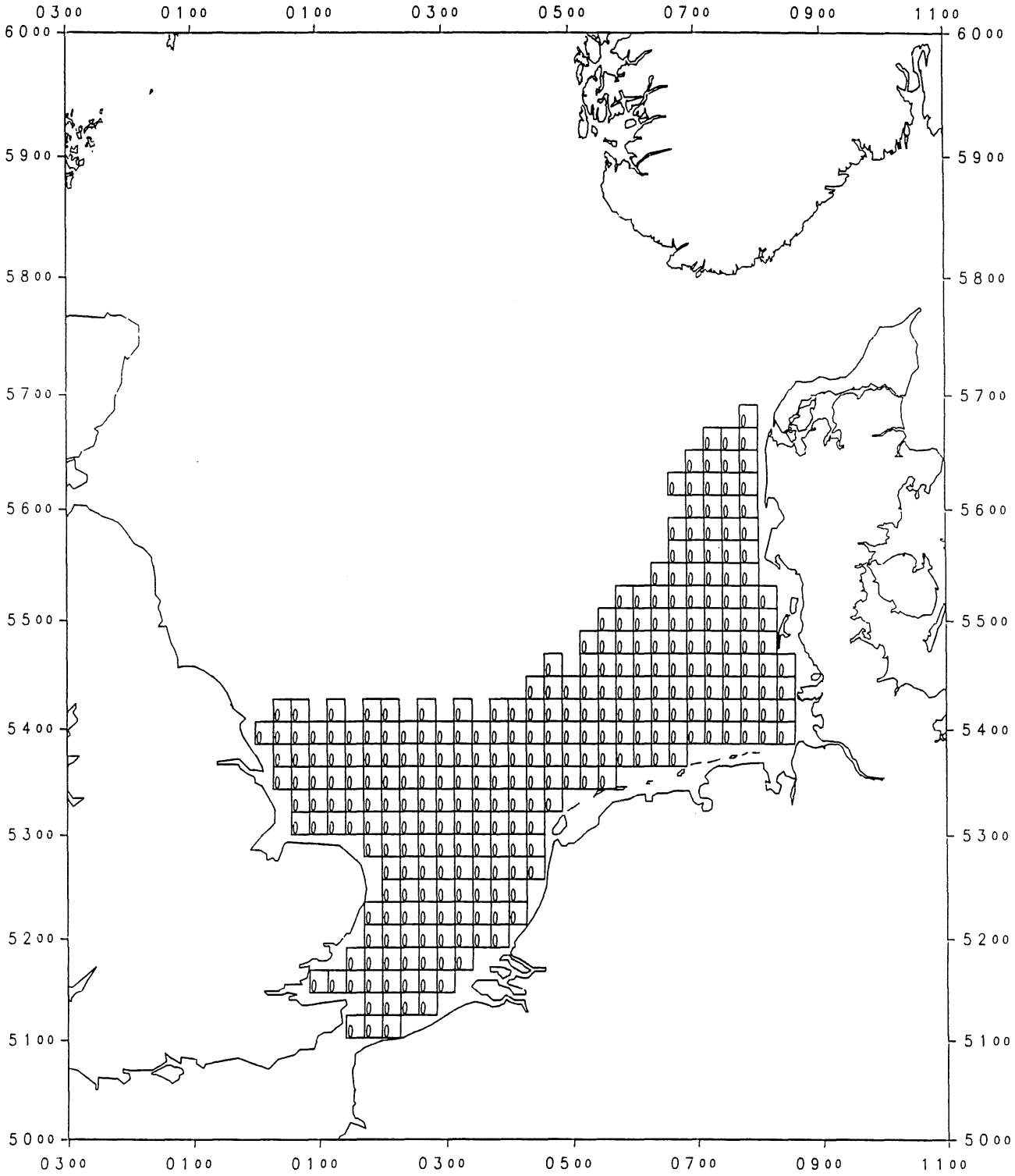

Fig.15 Number of horse mackerel eggs produced per square m per day in each rectangle during coverage 2.

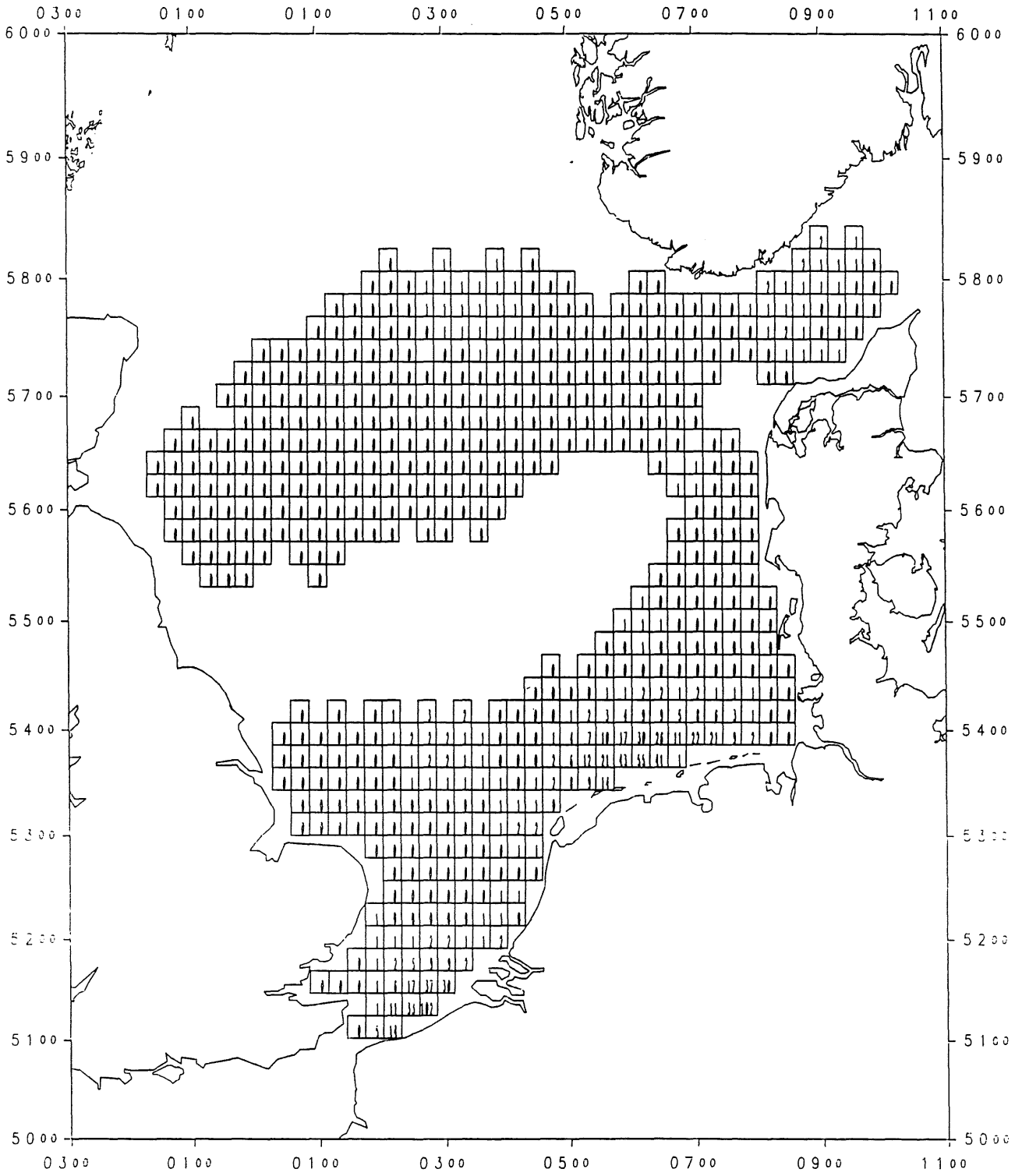

Fig.16 Number of horse mackerel eggs produced per square m per day in each rectangle during coverage 3.

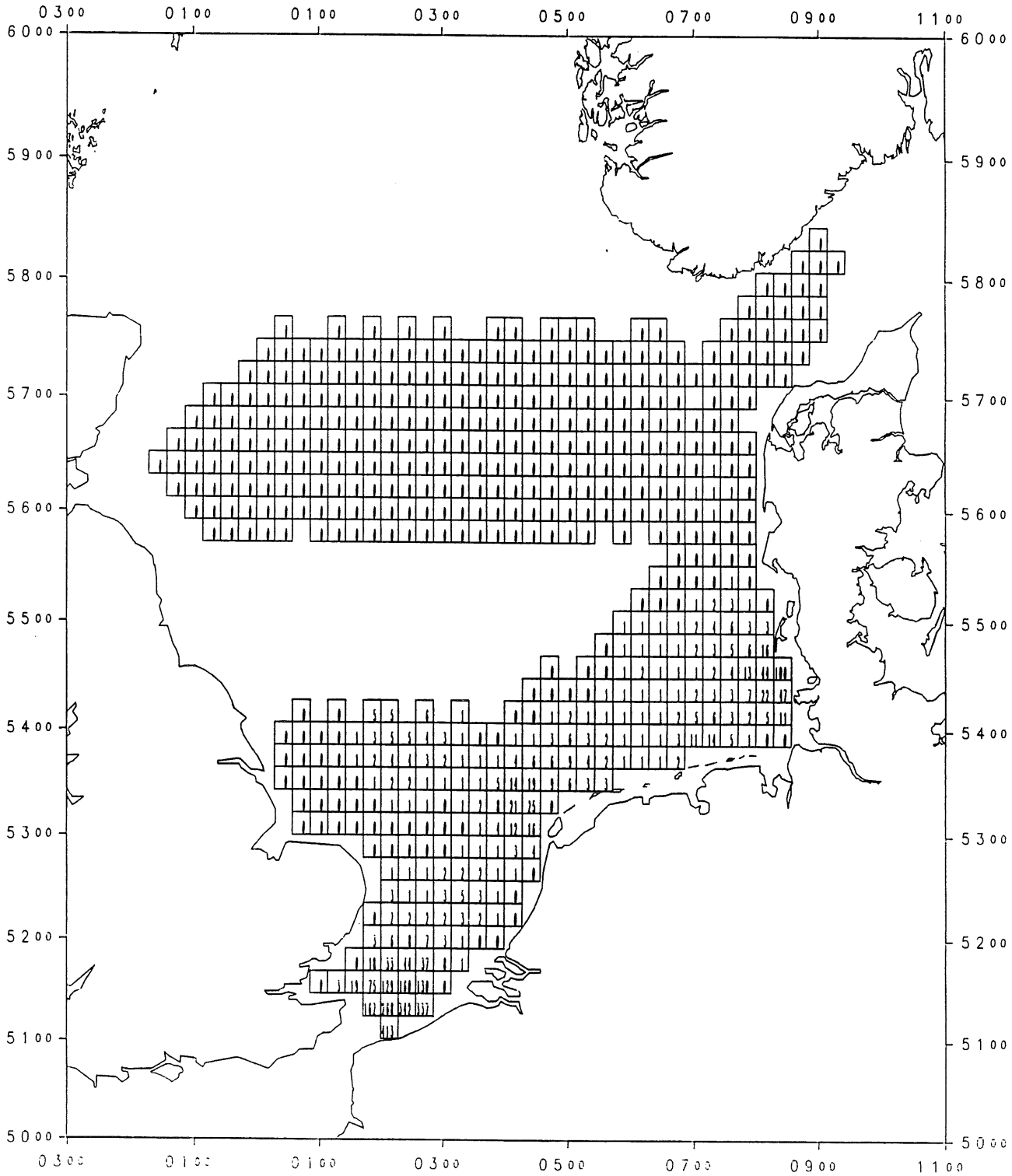

Fig.17 Number of horse mackerel eggs produced per square m per day in each rectangle during coverage 4.

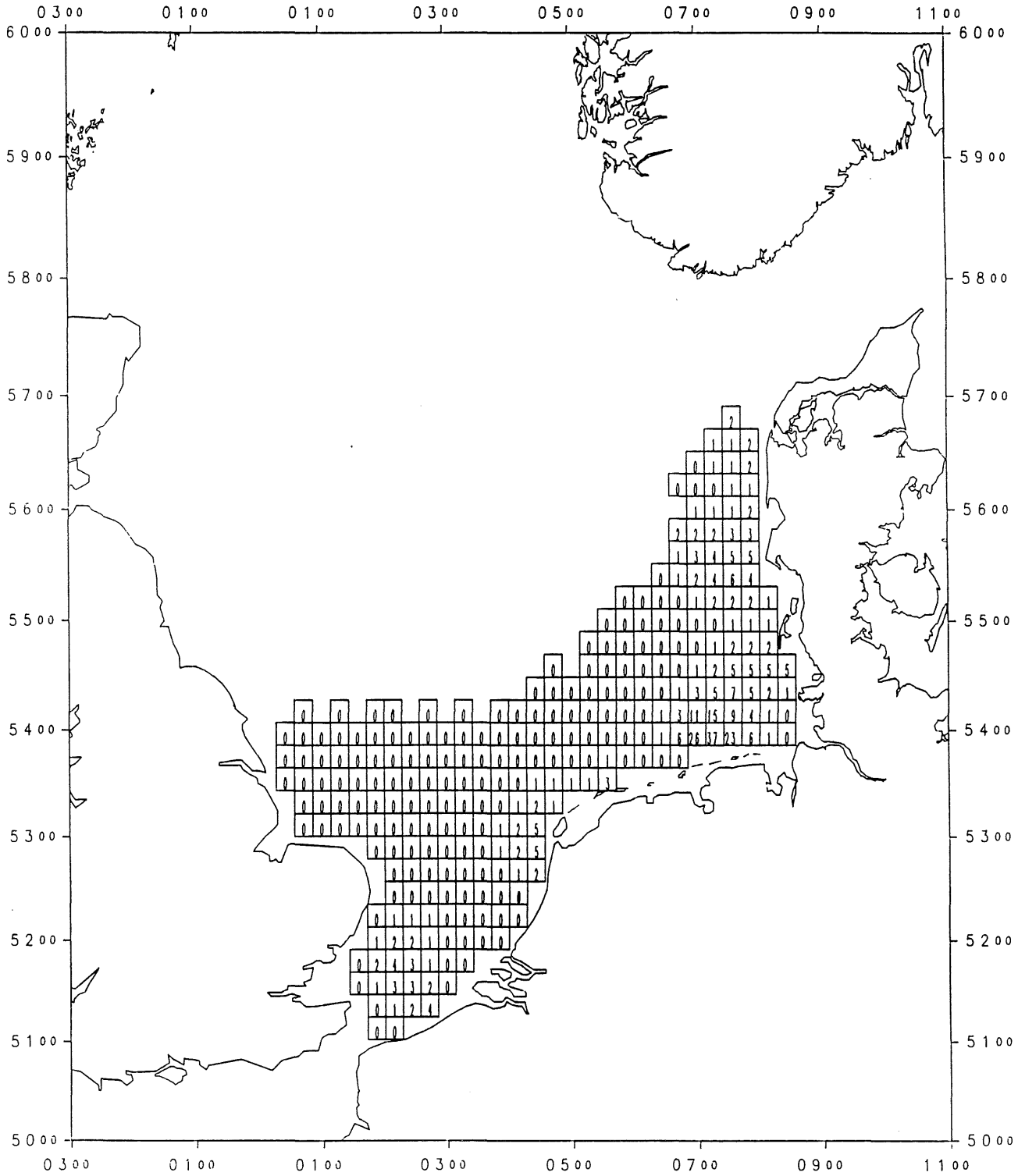

Fig.18 Number of horse mackerel eggs produced per square m per day in each rectangle during coverage 6.

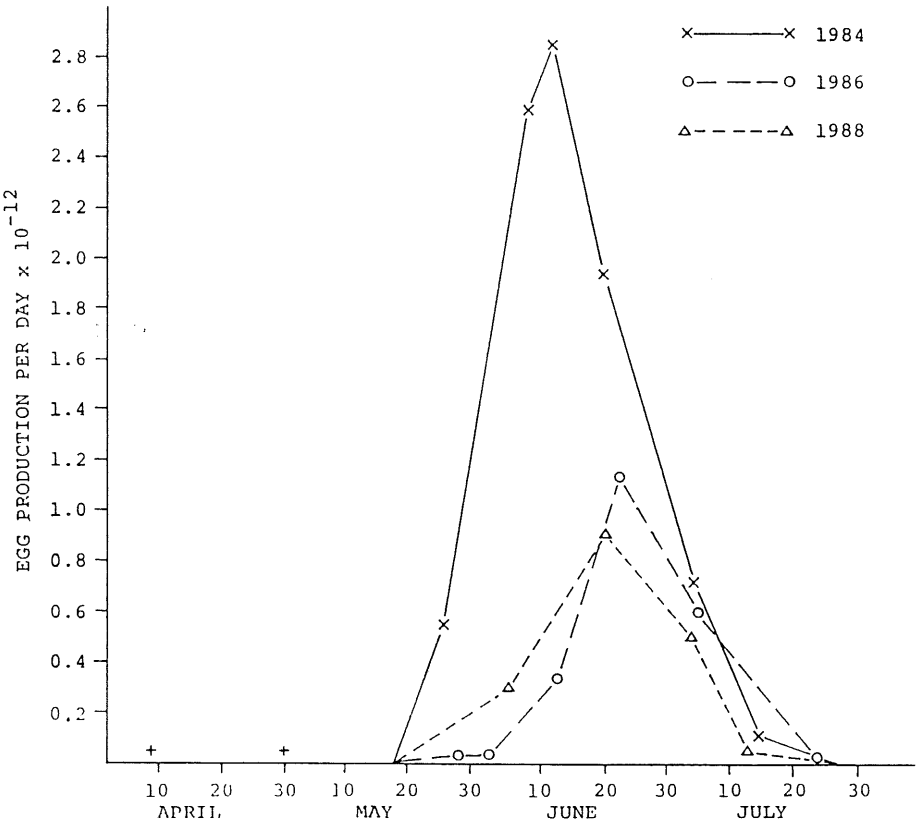

Fig.19 Mackerel egg production curves for 1984, 1986 and 1988.

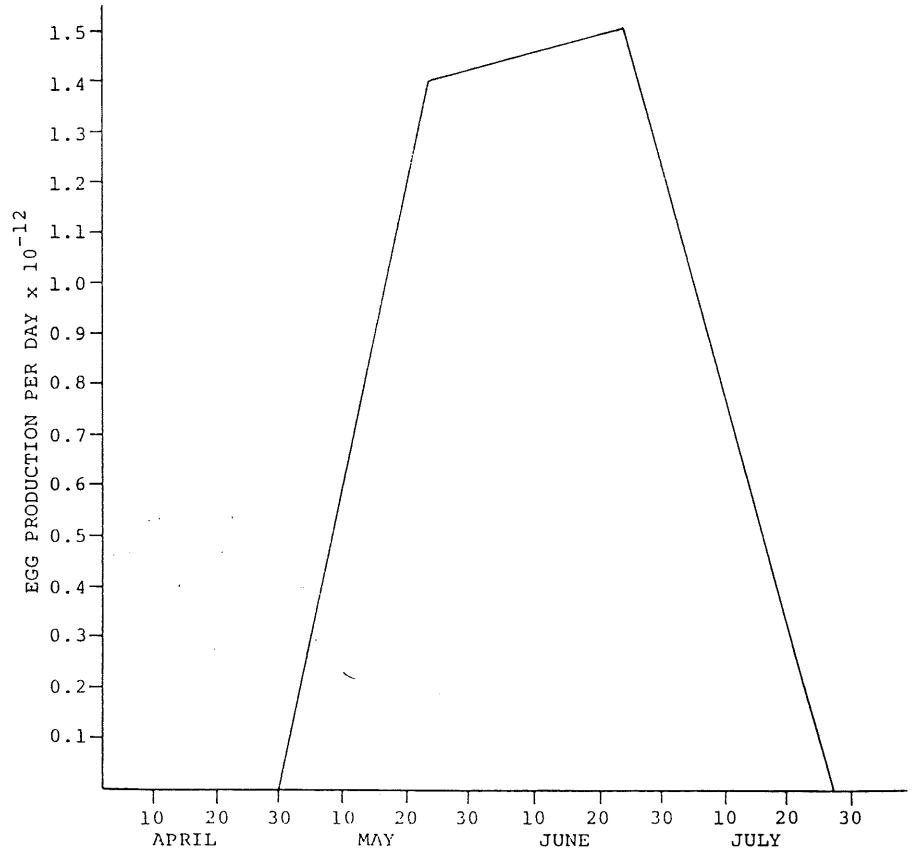

Fig.20 Horse Mackerel egg production curve for 1988.