International Council for the Exploration of the Sea

ICES C.M.1991/H: 11
Pelagic Fish Committee

THE EGG PRODUCTION AND SPAWNING STOCK SIZE OF THE NORTH SEA MACKEREL STOCK IN 1990

by

S.A. Iversen (1), A. Eltink (3) , E. Kirkegaard (2), D.W. Skagen (1)

Abstract

During the period 12 March to 20 July 1990 the spawning area of the North Sea mackerel was 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 estimated total egg production of mackerel (53×10^{12} eggs) represents a spawning stock biomass of 78 000 tonnes, which is about twice the estimate in 1988.

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

1. INTRODUCTION

During the period 1980-1984 the North Sea was surveyed each 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 1990 have been used for stock assessment purposes by the ICES Mackerel Working Group (Anon.,1991).

2. MATERIAL AND METHODS

The egg surveys in the North Sea were carried out by Denmark, Norway and the Netherlands during the period 12 March - 20 July 1990. The northern area (A) was surveyed by Norway and Denmark and the southern area (B) was surveyed by the Netherlands (Fig.1). The northern area was covered three times and the southern area six times. The sampling in the southern area started as early as March because the target species here where sole, horse mackerel etc.

The timing of the surveys is shown in Table 1.

The Norwegian vessels "Michael Sars" and "Eldjarn" used a 20 cm Bongo net and a 80 cm Juday, respectively. The Danish and Dutch vessels used a Gulf III sampler. The mesh size for all gears was 500 um. An echo sounder on the sampler continuously 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 Bongo and Gulf III 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 min. at each level, the Gulf III sampler at a speed of about 5 knots for 2 1/2 min. at each level and the Juday at a speed of about 0.5 m/sek from 30-0 m. The plankton samplers were assumed to sample representatively the upper 22.5 m, in which all 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 to some extent according to the abundance of mackerel eggs.

The sampling in area B (Fig.1) was carried out with a Gulf III sampler towed at a speed of 5 knots in oblique hauls till about 5 m above the bottom.The sampler fished 3 min. per 10 m depth, but in shallow water where the haul duration was less than 10 min. more than one haul was carried out.

Figs. 2-5 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 were worked up to numbers of eggs produced per day using the formula for stage 1 eggs:

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

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.

For presenting the distribution of daily spawned mackerel eggs, charts of isolines were drawn (Figs.2-5).

Daily egg production was estimated as described by Iversen and Westgård (1984) and Iversen et al.(1988). 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 of 100 x 100 rectangles. Due to an extension of the surveyed area to the north in 1990, the size of each rectangle is 30% larger in 1990 than in 1988 (Iversen et al. 1988).

However during the third coverage (Fig.2) this procedure could not be used to estimate the stage 1 egg production, because the egg production increased from the coast to the uncovered area. The applied computer programme extrapolated egg production in covered areas to two uncovered grid rectangles in a way that these rectangles were given values that might even be higher than the production in the last covered rectangle. Therefore the egg production was estimated according to the method described in Eltink (1990)in which the numbers produced per m^2 per day were raised by the area of the 1/2, 1/4 or 1/8 ICES rectangles they represented and summed to give numbers produced over the total area.

During the fourth coverage (Fig. 3) an extremely high egg production was obtained at one station. This was recognized during the survey and five surrounding stations were sampled showing much lower egg production. As mentioned earlier the programme interpolated too high values in such areas, therefore the egg production in this small area (Fig. 3) was estimated by drawing isolines by eye.

The fecundity estimates used in 1990 as in previous years 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 vitellogenic 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).

According to Iversen and Adoff (1983) the fecundity-weight and -length relations of North Sea mackerel are:

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

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

Samples of mackerel were collected by the Danish and the Norwegian vessels during the egg survey and by the Norwegian vessel participating in the International herring acoustic survey in the North Sea June-July 1990. All samples were taken by pelagic trawl hauls in the surface during night time. The positions of the trawl hauls are shown in Fig. 6.

3. RESULTS AND DISCUSSION

3.1 Distribution of mackerel eggs

The distribution of mackerel eggs observed during the different coverages are shown in Figs. 2-5. During the first two Dutch coverages in March, no mackerel eggs were observed. During the third coverage the spawning had started which is two-three weeks earlier than previous years, probably because relatively high water temperatures, 12.8°C, compared to earlier years. In 1988 spawning on a rather small scale was observed in the same area in April (Iversen et al., 1988). 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). Most of the eggs were observed in the North Western Channel, in the German Bight and west of Jutland. During the fourth coverage (Fig. 4) the spawning intensity had increased in this area. The central and western part of the covered area contributed with relatively high egg production. At one station, position N 55°46′ W 00°22′, 787 eggs per m^2 was observed. This station was encircled by several stations to study the extension of this high value (Fig.3). These stations gave values in the range of 1-26 eggs/m^2.

The fifth coverage (Fig.4) was at the peak of the spawning period. The main egg concentrations were observed in the same areas as during the previous coverage. The sixth coverage (Fig.5) covered the area north to 63°N, showed that the egg production in this northern area was low. The spawning was now restricted to the central part of the North Sea.

3.2 Estimates of egg production

The text table below shows the timing of the surveys and the reference dates (mid points of the surveys) for the estimated daily egg production.

Coverage	Survey Period	Reference date	Egg prod.x10^{12}	Raising factor	Adjusted egg production x10^{12}
1	12.3-15.3	14.3	0	-	0
2	26.3-30.3	28.3	0	-	0
3	23.4- 3.5	28.4	0.01	2.0	0.02
4	21.5-13.6	4.6	0.64	1.6	1.02
5	17.6-30.6	24.6	0.70	1.6	1.12
6	30.6-20.7	10.7	0.18	1.2	0.22

None of the surveys covered the total spawning area. To adjust for the production in the uncovered areas, the egg production estimates within the covered area were raised by the factors given in the text table above.

A raising factor 2 was assumed for the third coverage which was only carried out in the southern area (B), assuming the same egg production outside the covered area knowing that spawning starts in the south.

3.3 Spawning stock size

The estimated egg production curve for 1990 is given in Fig. 6. The total egg production was estimated at 53 x 10^{12} eggs, corresponding to a spawning stock of 78 000 tonnes. Usually the 17 May has been assumed as a starting point of the spawning (Fig. 6). In 1990 the spawning was significant even during the third survey in April/May. Since the fourth coverage was carried out a month later the shape of the curve between these two coverages is uncertain. Similarly a line between the fourth and fifth coverages results in a rather flat spawning curve (Fig. 6) compared with previous years. This might be caused by the younger fish entering the spawning stock or just by lack of a survey with a midpoint around 10-15 June. If the spawning curve is adjusted by extending the lines between the coverages 3-4 and 5-6 (indicated as a dotted line in Fig.6), this will increase the egg production estimate by 18 %.

Total egg production		Total spawning biomass
1984[1)]	78×10^{12}	118 000 tonnes (Iversen et.al.,1985).
1986[1)]	30×10^{12}	45 000 tonnes (Iversen et.al.,1987).
1988[2)]	25×10^{12}	37 000 tonnes (Iversen et.al.,1989).
1990[2)]	53×10^{12}	78 000 tonnes.

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

The relative age composition, maturity, ogive, mean length and weight at age for mackerel caught in Divisions IVb and IVa are shown in Table 2.

Most of the stations in the northern area (Division IVa) were taken in July while the catches in Division IVb are from June and early July (Fig.7). The mackerel from the western stock migrate into the North Sea area after spawning (Anon. 1990) and are probably in the northern areas already in July. Therefore to avoid problems with western fish, only samples from Division IVb were used in this analysis.

Juvenile mackerel from the western stock may migrate into the North Sea relatively early in the year and the samples collected in Division IVb may contain juvenile western mackerel. However, the maturity data showing that about 80% of the two year old mackerel were mature, indicate that they belong to the North Sea stock.

From the data available it was not possible to determine the origin of the one year old mackerel. In estimating the total stock size it was assumed that the one year old fish were North Sea fish and that the age composition observed in the central North Sea, was representative for the total stock.

Even though only the samples from Division IVb were used, the data from the northern area, shows the same age composition, with more than 80% of the fish three years old or younger.

The estimated spawning stock and total stock size as number of mackerel per age groups are given in Table 3.

The number of one and two year old fish is underestimated if some of the immature fish were outside the spawning area. The observed high percentage of mature 2-group fish (80%), is twice the value used by the Mackerel Working Group in 1984, when the last VPA was carried out for the North Sea stock (Anon.,1984). This might indicate that the age composition observed is not representative for the total stock.

In 1988 the spawning stock was estimated to be 37 000 tonnes. Assuming a mean weight and maturity ogive in 1988 as shown in Table 2 the number of two years old and older mackerel in 1988 was estimated at 115 x 10^6. The number of mackerel in the same yearclasses (the four years and older mackerel in Table 2) was estimated to be 56.5 x 10^6 in 1990, giving a total mortality of 0.36 per year from 1988 to 1990 which is similar to the total mortality of Western mackerel during the same period (Anon. 1991).

5. REFERENCES

Anon.,1984. Report of the Mackerel Working Group. ICES C.M. 1984/Assess:8.

Anon.,1988. Report of the mackerel egg and recruitment workshop. ICES C.M.1988/H:3 42 pp.

Anon.,1990. Second report of the EEC-Norwegian joint scientific group on migration and area distribution of mackerel (western stock). ICES C.M. 1990/H:5.

Anon.,1991. Report of the Mackerel Working Group. ICES C.M.1990/Assess:19. 90 pp.

Eltink, A., 1990. Horse mackerel egg production and spawning stock size in the North Sea in 1989. ICES C.M.1990/H:20. 13 pp.

Iversen, S.A. 1982. Spawning stock size of North Sea mackerel in 1981. ICES C.M.1982/H:7, 13 pp.

Iversen, S.A. and Adoff, G.R. 1983. Fecundity observations on mackerel from the Norwegian coast. ICES C.M.1983/H:45, 6 pp.

Iversen, S.A. and Westgård, T. 1984. Mackerel egg investigations in the North Sea. ICES C.M.1984/H:38, 20 pp.

Iversen, S.A. and Ljøen, R. 1985. The spawning and distribution of mackerel eggs in the North Sea related to the hydrography. ICES C.M.1985/H:37.

Iversen, S.A., Westgård, T., Kirkegaard, E., Eltink, A., Hopkins, P. and Walsh, M. 1985. The egg production and spawning stock size of the North Sea mackerel stock in 1984. ICES C.M.1985/H:38, 11 pp.

Iversen, S.A., Kirkegaard, E., and Westgaard, T., 1987. Mackerel egg production and spawning stock size in the North Sea 1986. ICES C.M.1987/H:8, 12 pp.

Iversen, S.A., Eltink, A., Kirkegaard, E., and Skagen, D.W., 1989. The egg production and spawning stock size of the North Sea mackerel and horse mackerel in 1988. ICES C.M. 1989/H:16, 22 pp.

Lockwood, S.J., Nichols, J.H. and Dawson, W.A. 1981. The estimation of a mackerel (Scomber scombrus L.) spawning stock size by plankton survey. J.Plank.Res.,3:217-233.

Table 1. The timing of the egg surveys in the North Sea in 1990.

Area	Ship	Coverage					
		1	2	3	4	5	6
A (north)	Dana (Denmark)	-	-	-	9.6-18.6	-	-
	Michael Sars (Norway)	-	-	-	-	17.6-30.6	30.6-14.7
	Eldjarn (Norway)	-	-	-	-	-	3.7-20.7
B (south)	Isis (Netherlands)	12.3-14.3	-	1.5-3.5	21.5-13.6	18.6-27.6	11.7-12.7
	KW34 (Netherlands)	-	26.3-30.3	-	-	-	-
	Tridens (Netherlands)	12.3-15.3	-	23.4-3.5	-	-	17.7-20.7

Table 2 Relative age composition, mean weight, mean length. Maturity ogive and mean weight at age of spawners based on mackerel sampled during the egg survey and the Norwegian herring acoustic survey 1990 in Division IVb and IVa.

	Division IVb					Division IVa			
Age	Relative age composition(%)	Mean weight(g)	Mean length(cm)	Maturity ogive	Mean weight spawners	Relative age composition(%)	Mean weight(g)	Mean length(cm)	Maturity ogive
1	23.3	138	25.0	+	235	15.9	142	25.5	0.03
2	28.0	230	29.5	0.8	255	40.4	241	30.1	0.83
3	32.1	314	32.5	1.0	314	31.1	302	32.6	1.0
4	8.6	357	34.0	"	357	5.1	340	33.7	"
5	2.5	438	35.7	"	438	2.5	395	35.6	"
6	1.4	464	36.8	"	464	1.9	440	37.0	"
7	0.3	418	36.8	"	418	0.3	531	38.7	"
8	1.2	471	38.0	"	471	0.6	584	39.6	"
9	0.7	529	38.7	"	529	0.7	526	40.0	"
10	0.8	545	38.5	"	545	0.3	534	39.7	"
11	+	550	39.0	"	550	0.4	566	40.2	"
12	0.4	630	41.0	"	630	0.2	500	38.8	"
13	0.1	660	42.5	"	660	0.0	-	-	"
14	+	680	44.0	"	680	0.2	575	40.2	"
15+	0.6	690	44.8	"	690	0.5	698	44.5	"

Table 3. Estimated spawning size and total stock size as number and biomass at age.

	SPAWNING STOCK		TOTAL STOCK	
Age	Number (x 10^{-6})	Biomass ('000 tonnes)	Number (x 10^{-6})	Biomass ('000 tonnes)
1	0	0	73.8	10.2
2	76.6	19.5	95.7	22.0
3	109.8	34.5	109.8	34.5
4	29.3	10.5	29.3	10.5
5	8.5	3.8	8.5	3.8
6	4.8	2.2	4.8	2.2
7	1.0	0.4	1.0	0.4
8	4.1	1.9	4.1	1.9
9	2.4	1.2	2.4	1.2
10	2.7	1.5	2.7	1.5
11	0.1	0.1	0.1	0.1
12	1.4	0.8	1.4	0.8
13	0.3	0.3	0.3	0.3
14	+	+	+	+
15+	2.0	1.4	2.0	1.4
Total	242.9	78.1	335.8	90.7

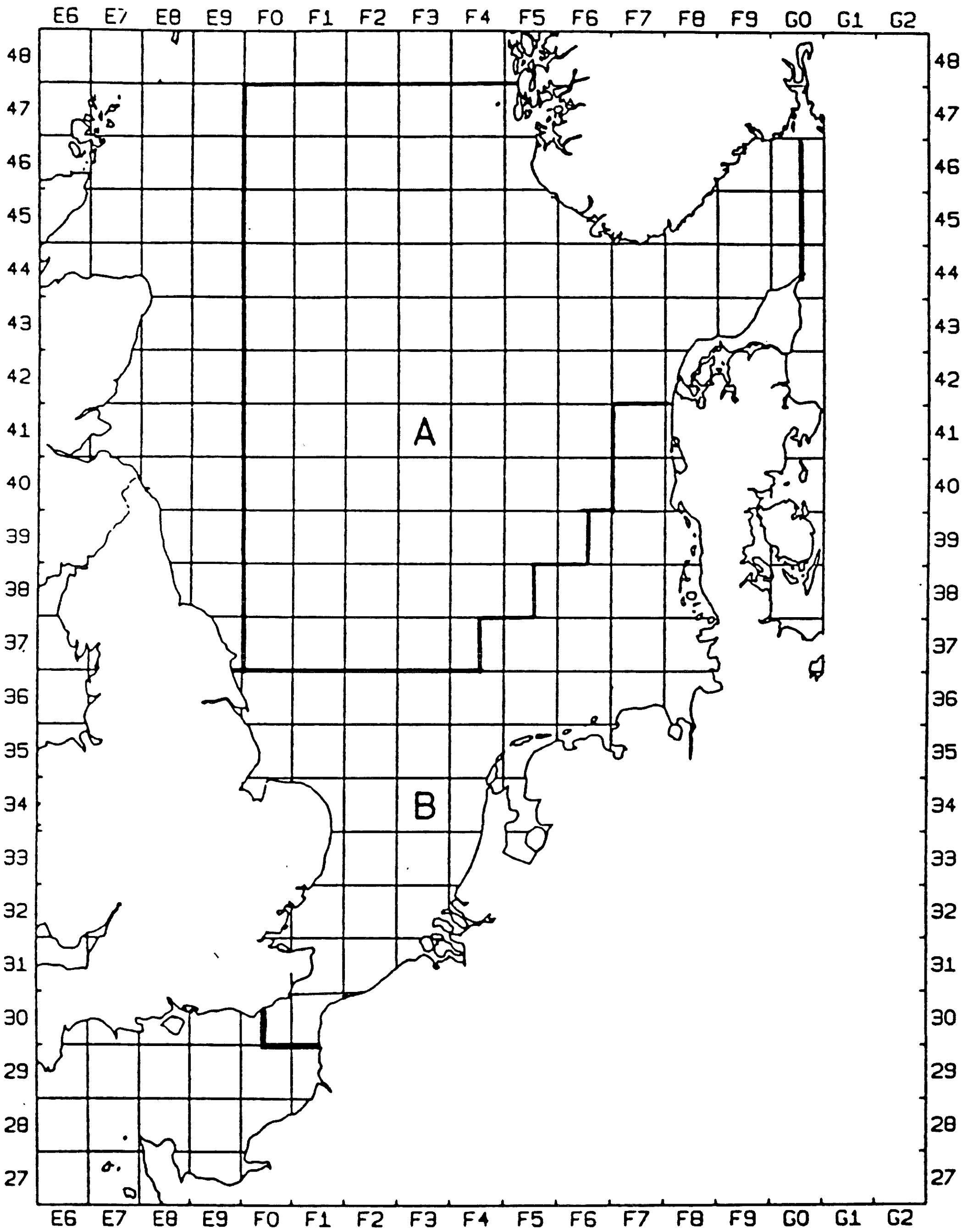

Fig.1 The area surveyed in 1990 by Denmark and Norway (A) and by the Netherlands (B).

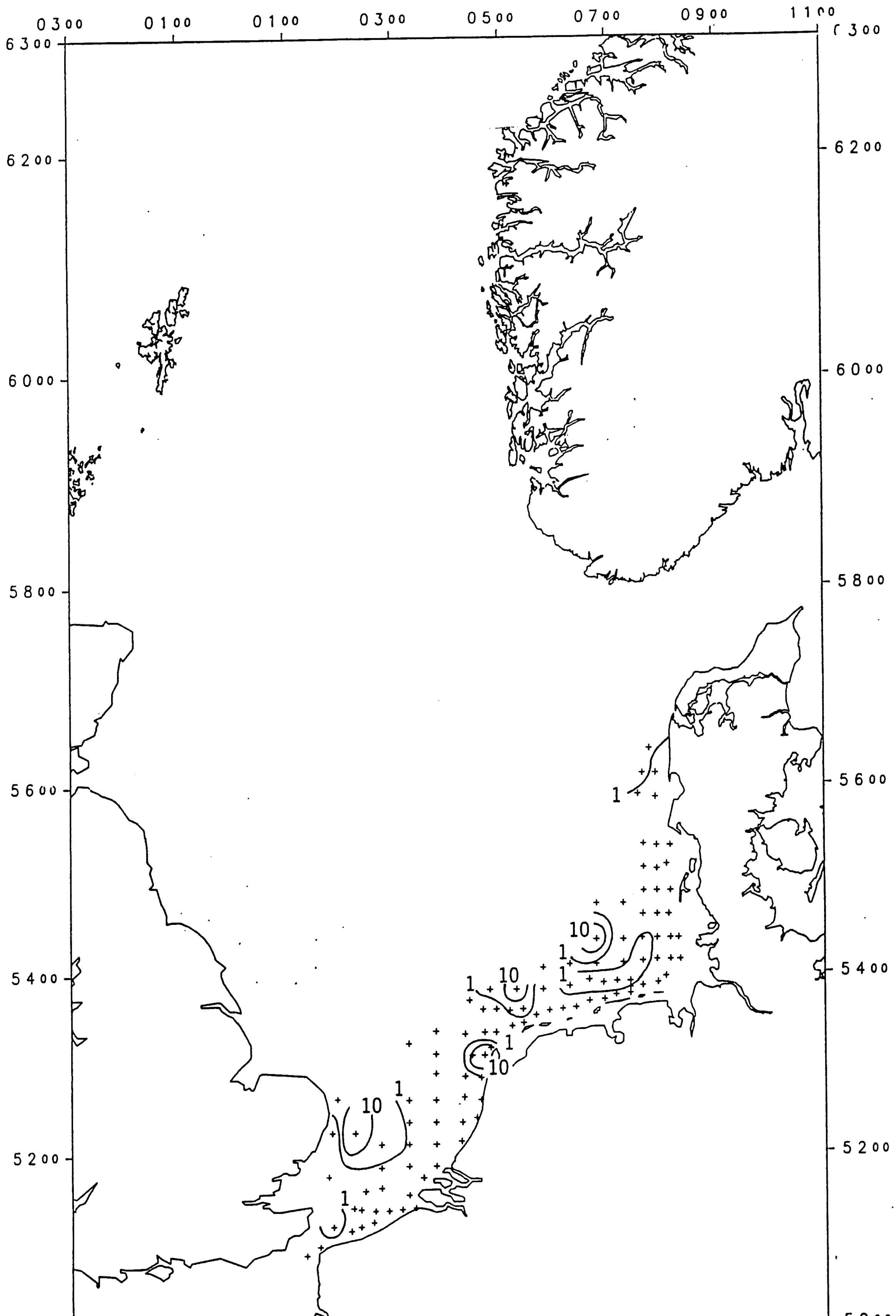

Fig.2 The station grid sampled during the three first coverages (12-15.3, 26-30.3 and 23.4-3.5) and the distribution of daily production of mackerel eggs per m² during the third coverage (23.4-3.5).

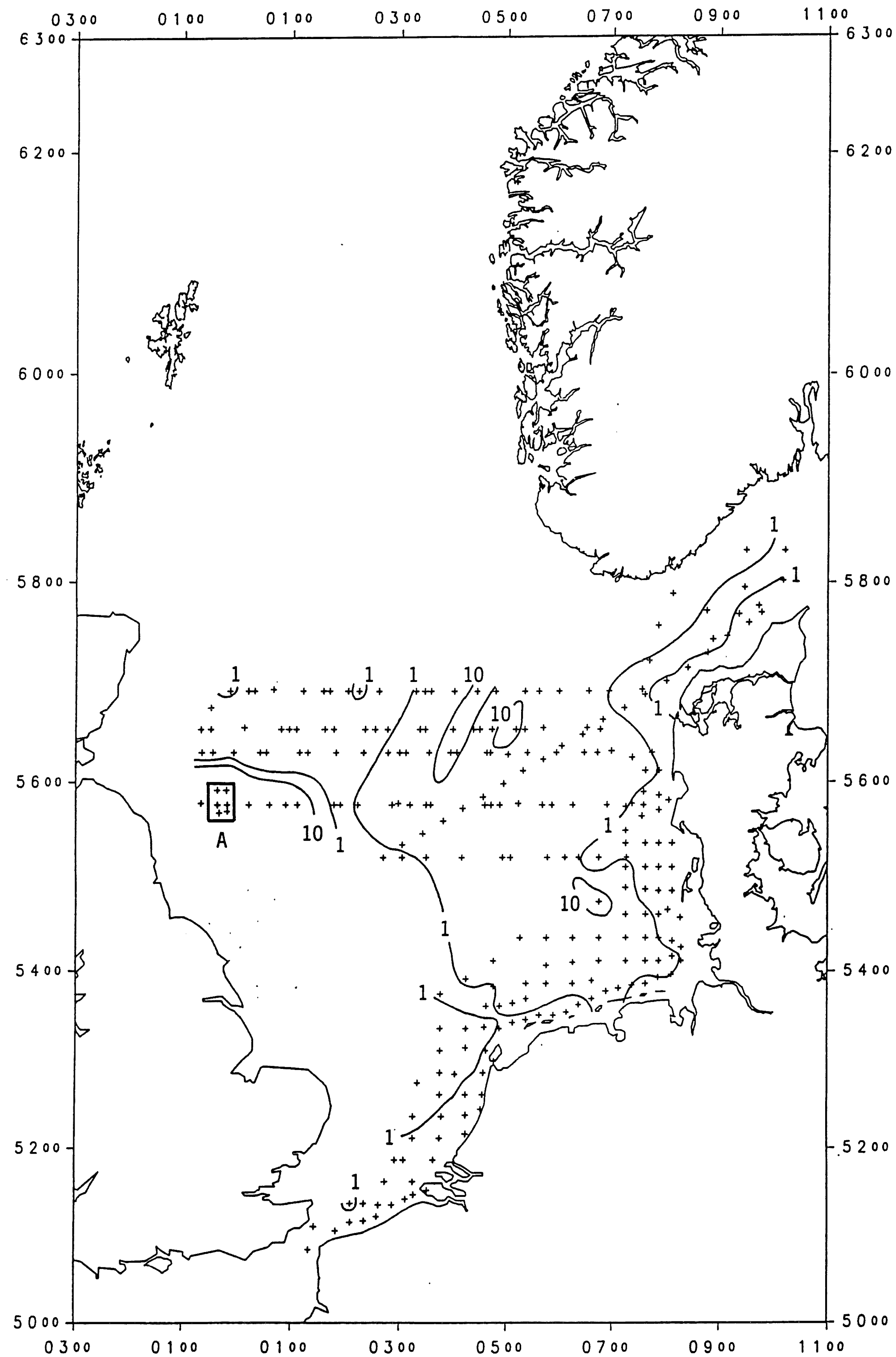

Fig.3 The distribution of daily production of mackerel eggs per m² during the fourth coverage (21.5-13.6) and the stations sampled. The framed area (A) is the high production area.

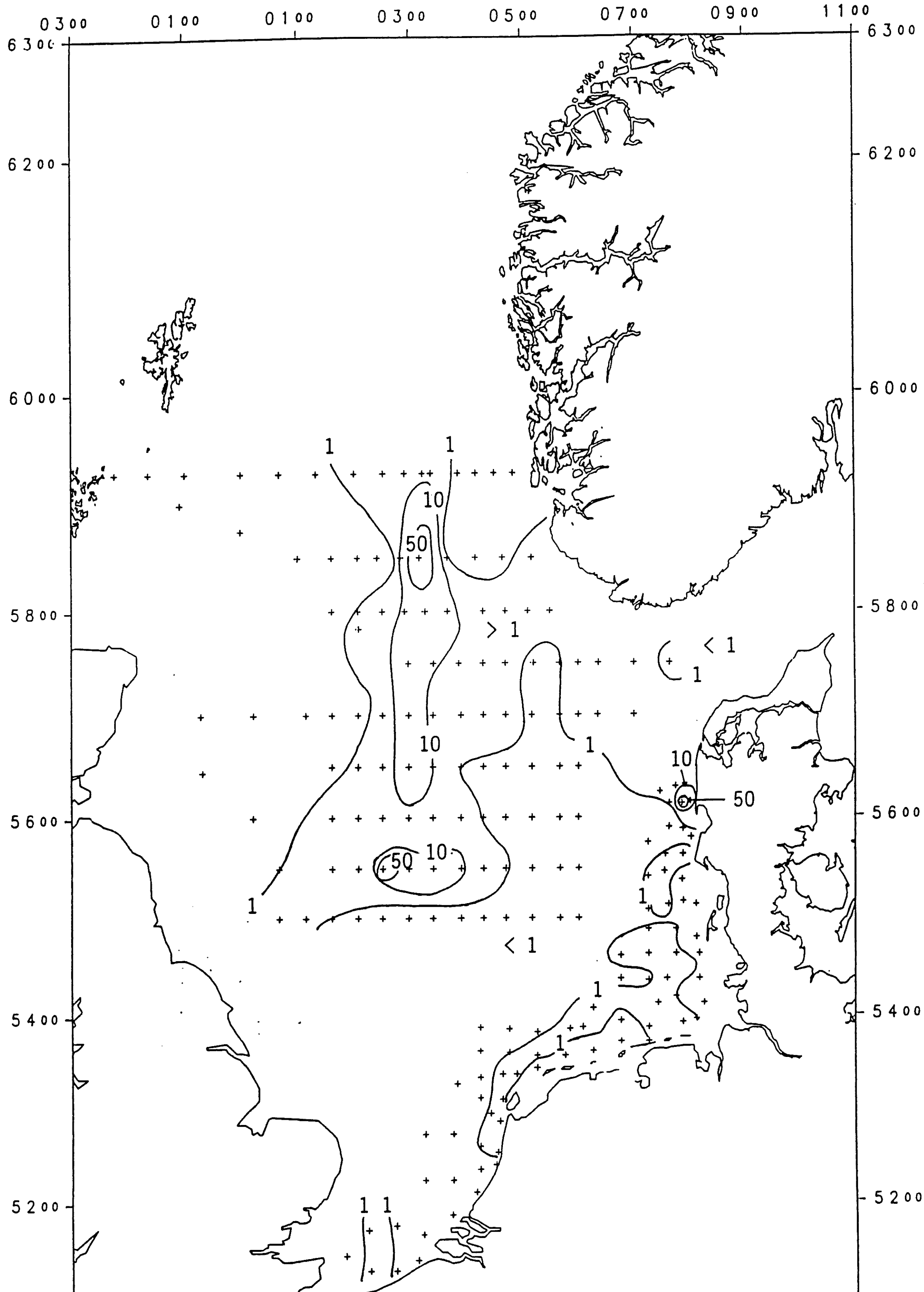

Fig.4 The distribution of daily production of mackerel eggs per m^2 during the fifth coverage (17-30.6) and the stations sampled.

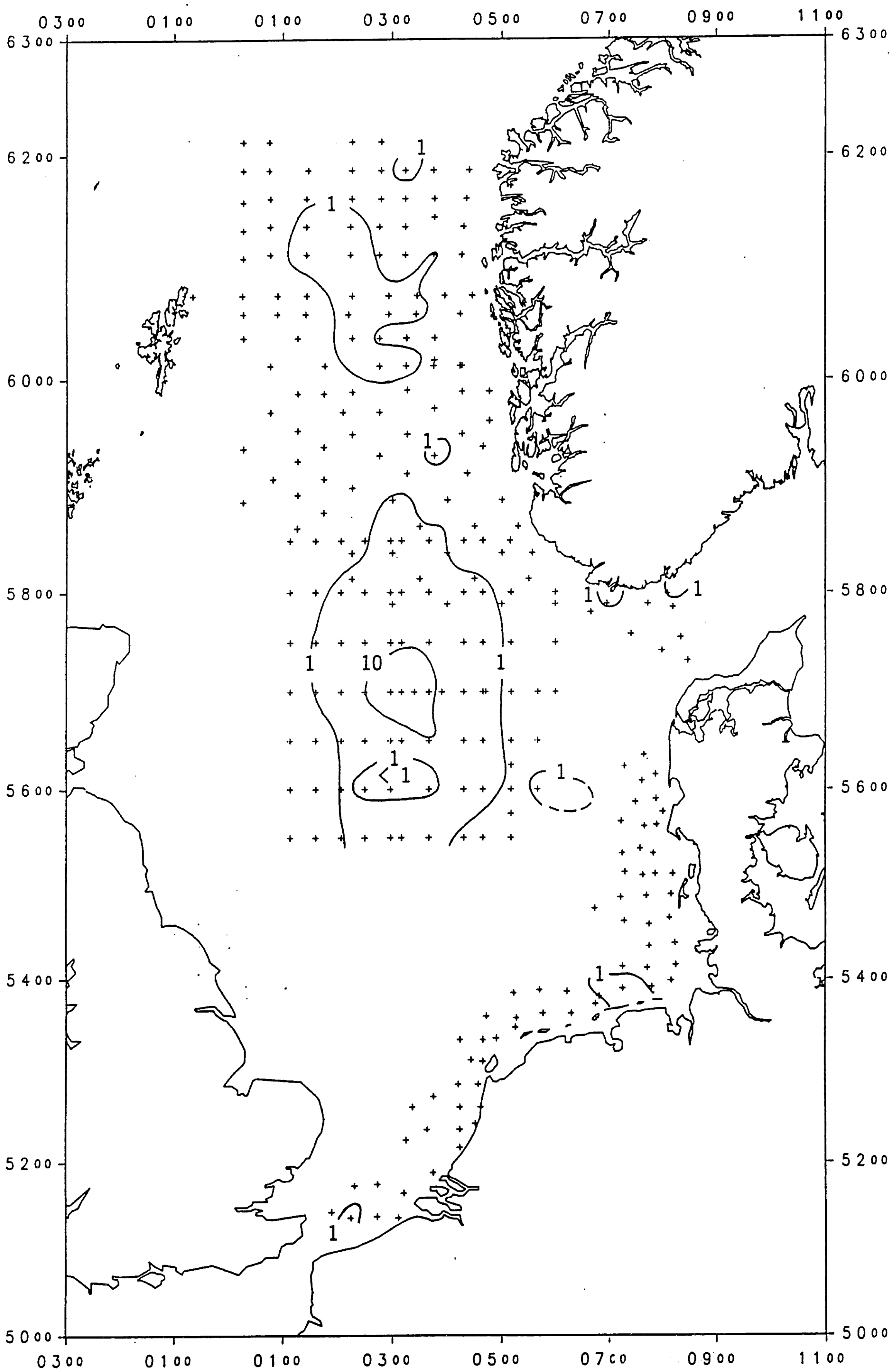

Fig.5 The distribution of daily production of mackerel eggs per m^2 during the sixth coverage (30.6-20.7) and the stations sampled.

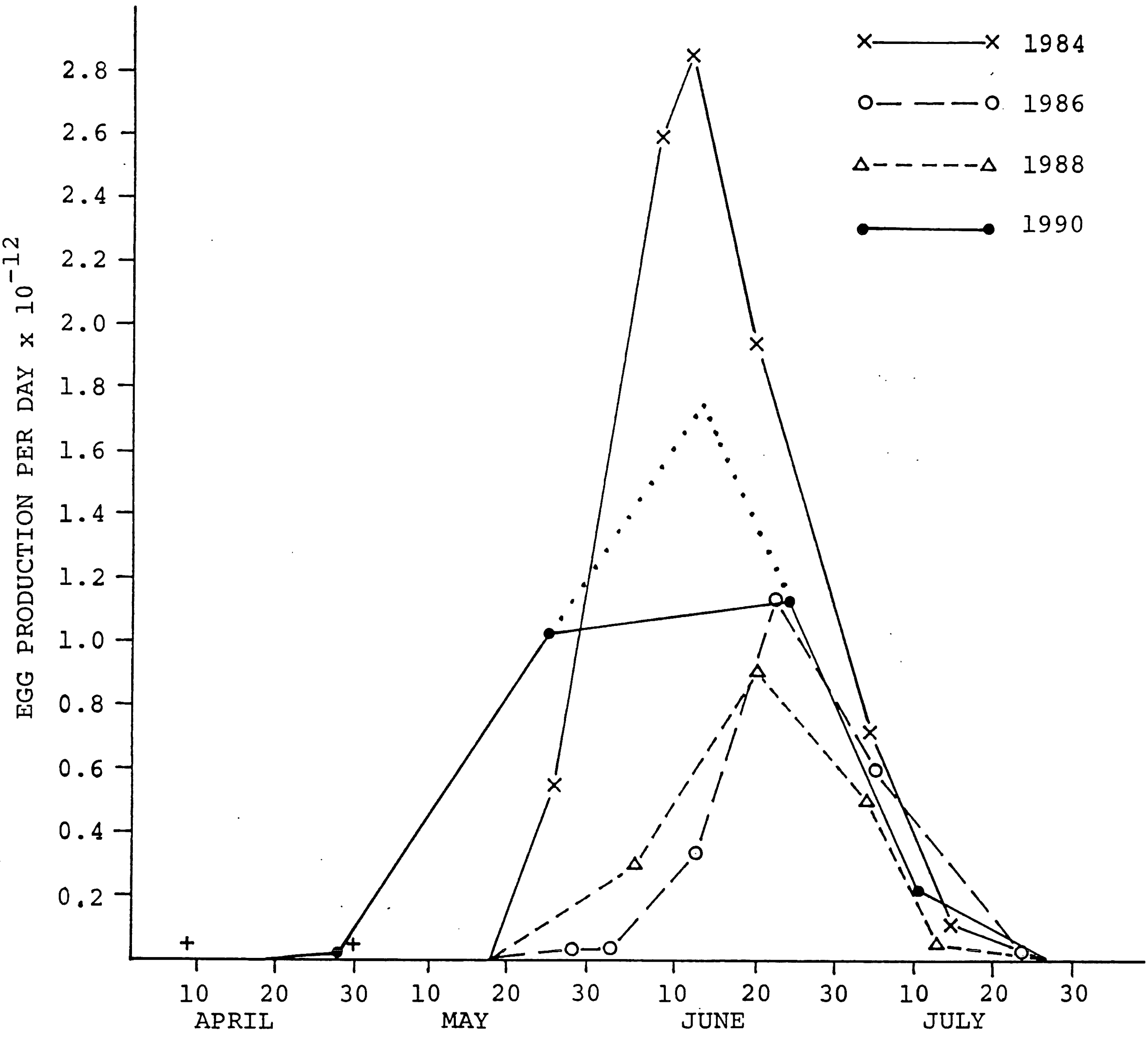

Fig.6 Mackerel egg production curves for 1984, 1986, 1988 and 1990. The + indicates that few eggs were observed during coverages early and late April in 1988. (Dotted line indicates suggested alternative spawning curve between coverages 4 and 5 in 1990.)

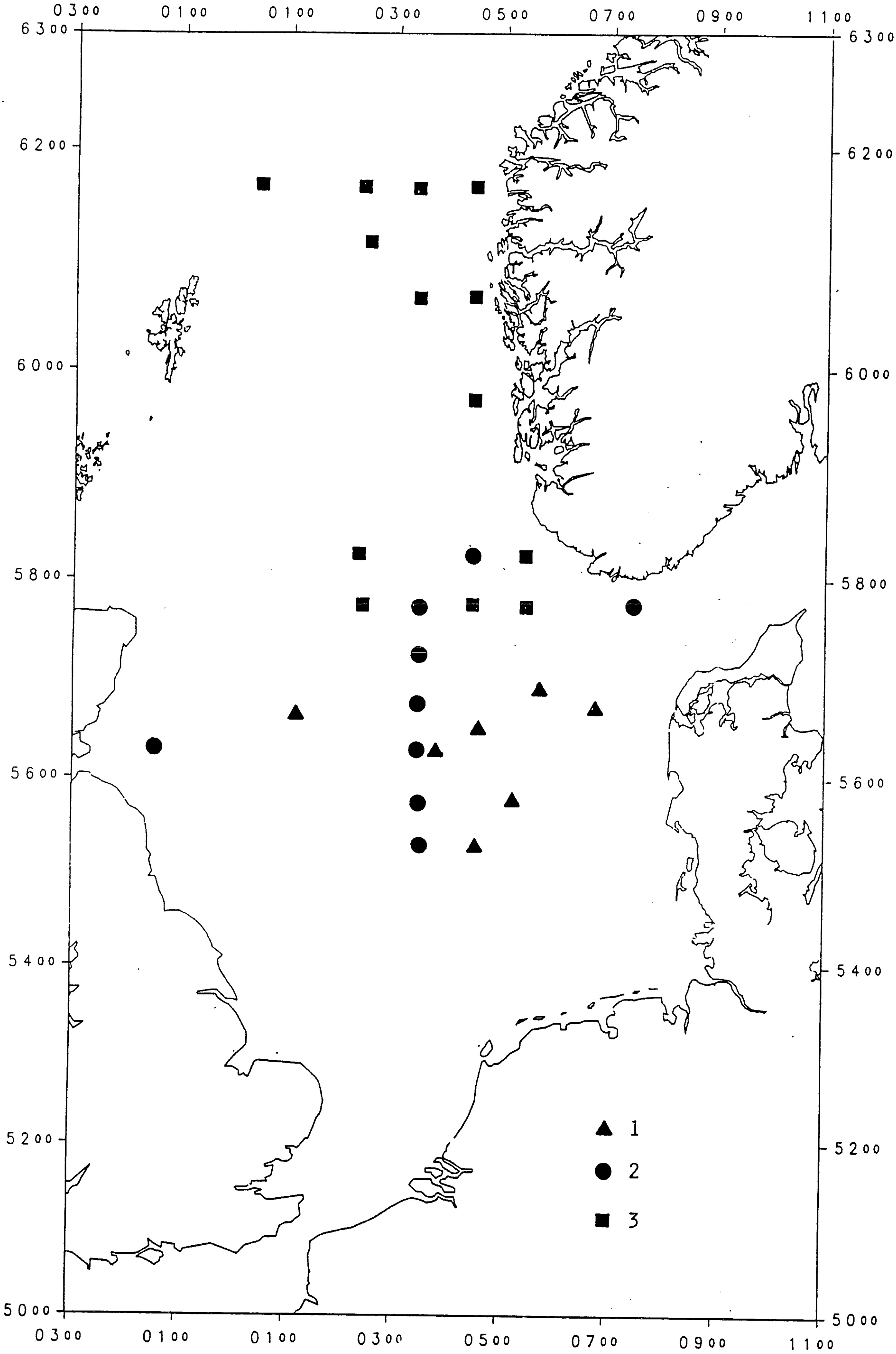

Fig.7 Positions of trawl hauls with catches of mackerel.
1. R/V "Dana" 9.-18.6
2. R/V "Michael Sars" 20.6 - 7.7.
3. R/V "Eldjarn" 4.-19.7