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# HORSE MACKEREL EGG PRODUCTION AND SPAWNING STOCK SIZE IN THE NORTH SEA IN 1989

by

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## Abstract

During the period 10 April to 18 July 1989 the spawning area of North Sea horse mackerel (*Trachurus trachurus* L.) was investigated by research vessels from the Netherlands. Based on the plankton samples and temperature observations obtained during this period the egg production and spawning stock size were estimated. The total horse mackerel egg production in 1989 of 171 x $10^{12}$ stage I eggs represents a spawning stock biomass of 217,000 tonnes, which is about twice as high as the 1988 estimate of 110,000 tonnes.

## Introduction

The egg production of horse mackerel in the central and southern North Sea was completely covered in time by several egg surveys in 1988. These egg surveys, carried out by Norway, Denmark and the Netherlands, were aimed at covering the entire egg production season of mackerel, sole and horse mackerel (Iversen et al., 1989). Horse mackerel and sole spawn in the North Sea in the same area, but horse mackerel spawns about three weeks later than sole.

In this paper the total horse mackerel egg production and the spawning biomass is estimated from the 1989 egg survey, which has been carried out by the Netherlands.

## Material and Methods

The egg surveys in the central and southern North Sea were carried out by the Netherlands during the period 10 April - 18 July 1989. The area was covered by 5 surveys in order to cover the spawning period for both sole and horse mackerel. The timing of these 5 surveys in 1989 is shown in the text table below.

| | First date | Last date | Mid-date |
|---|---|---|---|
| Period 1 | 10 April | 18 April | 14 April |
| Period 2 | 24 April | 2 May | 27 April |
| Period 3 | 22 May | 7 June | 29 May |
| Period 4 | 19 June | 28 June | 23 June |
| Period 5 | 10 July | 18 July | 13 July |

The station grid was planned in accordance with the strategy of having more intensive sampling in the high production areas. In order to achieve this, the samples were taken in the middle of the 1/2, 1/4 or 1/8 ICES rectangles. Based on this strategy 1, 2, 3 or 4 samples could be taken in a half ICES rectangle. Figures 1 - 5 show that most intensive sampling took place along the French, Belgian, Dutch, German and Danish coast and that the sampling intensity decreased further off shore and Figure 6 shows as an example the station grid of the third coverage with the 1/2, 1/4 and 1/8 ICES rectangles.

A Dutch Gulf III high speed plankton sampler was used with a mesh size of 500 µm. It was assumed that sole eggs were distributed in the whole water column. For that reason the 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 sole and horse 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 oblique haul was carried out. The plankton samples were preserved in 4% formaldehyde. The horse mackerel eggs were sorted into different developmental stages according to the description by Pipe and Walker (1987).

Using calibrated flowmeter readings to access the volume filtered per haul, the number of eggs in each stage was raised to numbers per $m^3$ and then converted to numbers per $m^2$ by multiplying with the depth at each station. The number of eggs per $m^2$ were then raised to numbers produced per $m^2$ per day using the development equations for horse mackerel given by Pipe and Walker (1987):

| | |
|---|---|
| Stage I | ln Time = -1.608 ln Temperature + 7.713 |
| Stage II | ln Time = -1.548 ln Temperature + 7.927 |
| Stage III | ln Time = -1.819 ln Temperature + 9.123 |
| Stage IV | ln Time = -1.929 ln Temperature + 9.555 |

Where time is the age of the eggs at the end of each stage in hours and temperature is the temperature ($^0$C) at 5 m depth at the station where the eggs were sampled. The numbers produced per $m^2$ per day were then raised by the area of the 1/2, 1/4 or 1/8 ICES rectangles they represented and summed to give numbers in each stage produced over the total survey area for each of the five sampling periods.

To demonstrate the northward progression of spawning over time, the total area was also divided in three sub-areas: the area south of $52^0$ 30' N, the central area and the area east of $6^0$ 00' E (Figure 6).

If more than one observation per 1/2, 1/4 or 1/8 ICES rectangle was available, the arithmetic mean of the observed values was used. No extrapolation was applied to correct for unsampled rectangles.

The total horse mackerel stage I egg production estimate for each survey period was plotted against the mid cruise date (weighted by the number of samples per day) to give a production curve based on five points. The total stage I egg production for the spawning season throughout the area covered by these egg surveys was then calculated by integrating the area under the curve.

To estimate the spawning stock biomass of North Sea horse mackerel, the fecundity-weight relationship of 1655 eggs per gramme pre-spawning female was used, which has been estimated for the western horse mackerel by Eltink and Vingerhoed (1989) . The total number of stage I eggs were then converted into a pre-spawning stock biomass, which was then increased by 5% to obtain the spawning stock biomass (Eltink and Vingerhoed, 1989).

## Results

The distributions of horse mackerel eggs observed during the 5 different coverages are shown in Figures 1 - 5. Table 1 shows by sub-area the horse mackerel egg (stages I - IV) production in millions per day in the North Sea. No horse mackerel eggs were observed during the first and second survey, but during the third coverage (mid-date 29 May) the egg production reached a peak level in the southern area (Figure 7). Not such a clear peak of spawning occurred at mid-June in the central area between the third and fourth coverage. During the fourth coverage the highest peak of spawning occurred at the end of June in the German Bight. The peak of spawning appears to shift progressively from the end of May to the end of June from the south to the north and east (Figure 7).

Table 2 shows the horse mackerel egg (stages I - IV) production in millions per day in the North Sea. Figure 8 shows the production curves for stage I horse mackerel eggs in the North Sea in 1989 and for comparison also 1988. The total stage I egg production in 1989 was calculated at 171 x $10^{12}$ eggs by integrating the area under the curve.

The spawning stock biomass in the area covered was estimated at 217,000 tonnes, when applying the fecundity-weight mentioned above and assuming a sex ratio of 1:1.

## Discussion

In 1988 the first complete egg survey for horse mackerel in the North Sea was carried out. This survey resulted in a total egg production of 87 x $10^{12}$ eggs and a spawning stock size of 110,000 tonnes (Iversen et al., 1989). In 1989 a new egg survey was carried out at more or less the same mid cruise dates as the year before and the five coverages were also carried out over more or less the same area.

The method used to estimate the daily production over the whole area for each period in 1989 differed from the method used for the 1988 egg survey (Iversen et al., 1989). The daily egg production for 1988 was estimated as described by Iversen and Westgaard (1984). It is assumed that the methods used for the 1988 and 1989 surveys would not result in any significant differences.

It can be demonstrated that spawning continues progressively from the south to the north and east by splitting the total area into three sub-areas. The peak of spawning appears to shifts from the end of May to the end of June progressively from the south to the north and east (Figure 7). Horse mackerel entering the southern North Sea through the Dover Strait at the end of May seem to be spawning already when entering the southern North Sea, because egg production increases from zero during the second survey to a peak of spawning already in the third survey. Spawning starts in the Eastern Channel and the stock involved possibly migrates progressively northeastward along the continental coast during spawning. However, it is also possible that fish are already in the North Sea and that the onset of spawning is triggered by an increase in temperature.

The total North Sea horse mackerel egg production as estimated over the area covered during the five periods is likely to be an underestimate, because no extrapolation for unsampled rectangles took place and because part of the egg production in the English

Channel is not covered by this egg survey. The highest egg production in the eastern English Channel is expected to occur at the end of May and the beginning of June east of $1^0$ E along the French coast as is indicated by a figure of the distribution of horse mackerel eggs in May-June 1976, R.V. Ernest Holt, Cruise 5/67 (Macer, 1974).

An important question still is what proportion of the total North Sea horse mackerel egg production is spawned in the English Channel. The answer to this question may be obtained in 1991, when an international egg survey will be held in the English Channel and the North Sea. Countries participating in this survey focussed on sole have been asked to sort out and stage also the horse mackerel eggs.

Eltink and Vingerhoed (1989) estimated the fecundity-weight relationship of western horse mackerel at 1655 eggs per gramme pre-spawning female. This seems to be the most appropriate relationship to use although it is based on fish of the western horse mackerel population. This estimate is close to the recalculated fecundity of 1492 eggs per gramme female as estimated by Macer (1974) for the North Sea horse mackerel. Also the threshold of 101 µm above which oocytes should be counted was relatively close to Macer's estimate of 118 µm. The fecundity estimate used was of potential fecundity rather than realized 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 developing 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). However, horse mackerel might be an indeterminant spawner (Eltink and Vingerhoed, 1989).

The total production in 1989 of 171 x $10^{12}$ stage I eggs seems to be about twice as high as the estimate in 1988 (87 x $10^{12}$ stage I eggs). This increase of about 100% in the egg production and biomass from 1988 to 1989 might have been partly caused by relatively more spawning in the English Channel in 1988, which area was not covered. A more northward spawning in 1989 would result then in a higher egg production during the third coverage in the North Sea. However, the higher egg productions during the fourth and fifth coverages in 1989 indicate that spawning took place at a higher level and that spawning continued later until the end of July 1989 (Figure 8).

The increase in egg production and biomass from 1988 to 1989 might be partly due to the recruitment of two good year classes 1985 and 1986 (about 40% of the catch in numbers based on commercial and research vessel sampling). The mean length at age of these year classes was, respectively, 25 cm and 26 cm. Already a large proportion could have spawned. Further biological sampling in 1990 should give more evidence of the existence of these two strong recruiting year classes.

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**Table 1.** Horse mackerel egg production (millions) per day for three subareas in southern North Sea and German Bight in 1989.

| Area | Period | Mid-date | Sum I/day | Sum II/day | Sum III/day | Sum IV/day |
|---|---|---|---|---|---|---|
| South of 52° 30'N | 1 | 14 April 1989 | 0 | 0 | 0 | 0 |
| South of 52° 30'N | 2 | 27 April 1989 | 0 | 0 | 0 | 0 |
| South of 52° 30'N | 3 | 29 May 1989 | 2 446 820 | 477 188 | 227 619 | 82 034 |
| South of 52° 30'N | 4 | 23 June 1989 | 382 260 | 51 889 | 43 264 | 24 493 |
| South of 52° 30'N | 5 | 13 July 1989 | 1 014 | 0 | 76 | 0 |
| Center | 1 | 14 April 1989 | 0 | 0 | 0 | 0 |
| Center | 2 | 27 April 1989 | 0 | 0 | 0 | 0 |
| Center | 3 | 29 May 1989 | 492 508 | 81 672 | 31 746 | 15 336 |
| Center | 4 | 23 June 1989 | 648 596 | 173 338 | 46 470 | 9 660 |
| Center | 5 | 13 July 1989 | 272 436 | 52 255 | 19 832 | 15 025 |
| East of 6° 00'E | 1 | 14 April 1989 | 0 | 0 | 0 | 0 |
| East of 6° 00'E | 2 | 27 April 1989 | 0 | 0 | 0 | 0 |
| East of 6° 00'E | 3 | 29 May 1989 | 267 464 | 62 883 | 15 454 | 3 213 |
| East of 6° 00'E | 4 | 23 June 1989 | 1 447 968 | 287 356 | 125 433 | 15 490 |
| East of 6° 00'E | 5 | 13 July 1989 | 974 233 | 259 570 | 121 070 | 6 573 |

**Table 2.** Horse mackerel egg production (millions) per day in southern North Sea and German Bight in 1989.

| Area | Period | Mid-date | Sum I/day | Sum II/day | Sum III/day | Sum IV/day |
|---|---|---|---|---|---|---|
| Total area covered | 1 | 14 April 1989 | 0 | 0 | 0 | 0 |
| Total area covered | 2 | 27 April 1989 | 0 | 0 | 0 | 0 |
| Total area covered | 3 | 29 May 1989 | 3 206 791 | 621 743 | 274 819 | 100 583 |
| Total area covered | 4 | 23 June 1989 | 2 478 823 | 512 583 | 215 168 | 49 642 |
| Total area covered | 5 | 13 July 1989 | 1 247 683 | 311 825 | 140 978 | 21 598 |

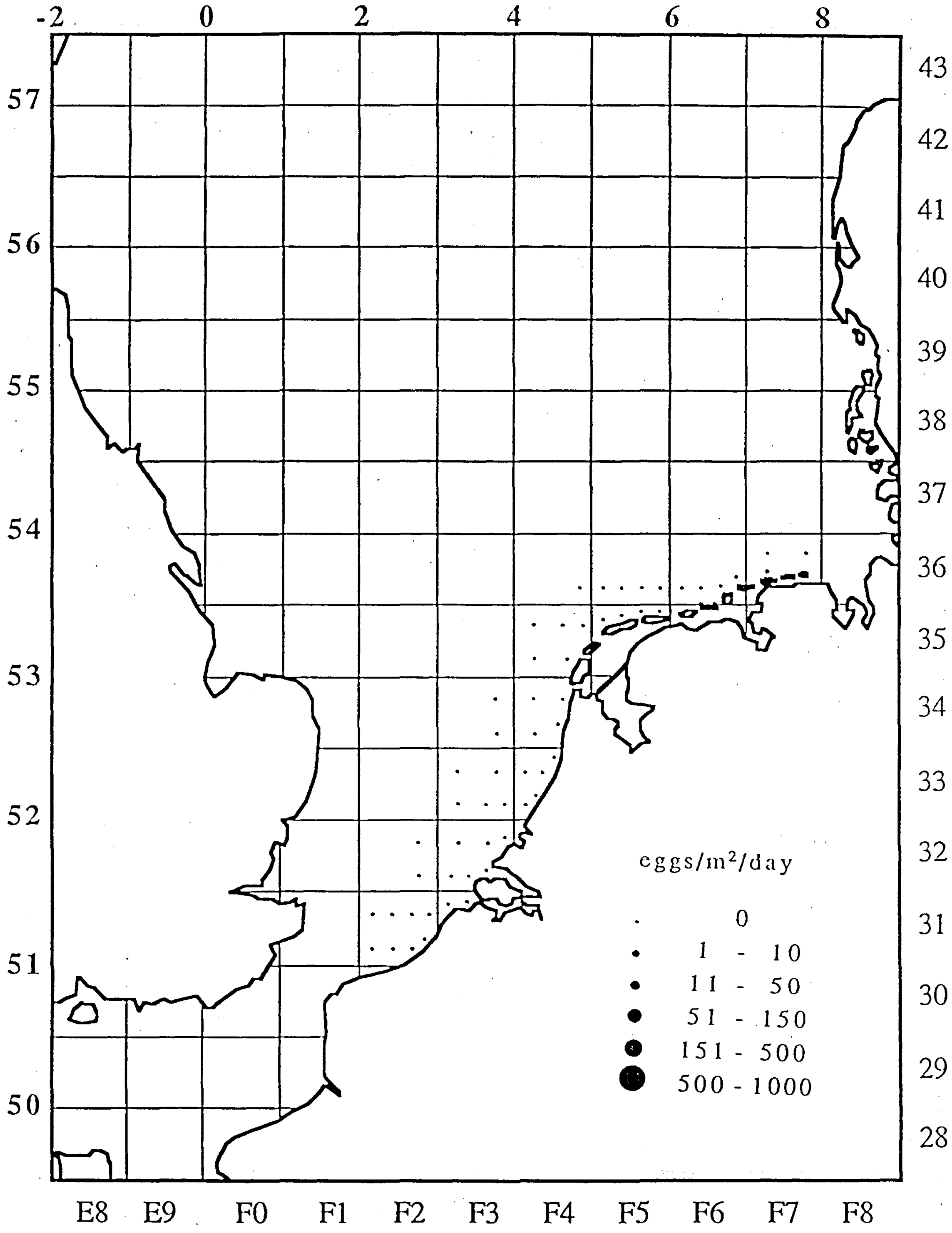


Figure 1. The distribution of stage I horse mackerel eggs as numbers per $m^2$ per day for survey period 1: 10 April - 18 April 1989

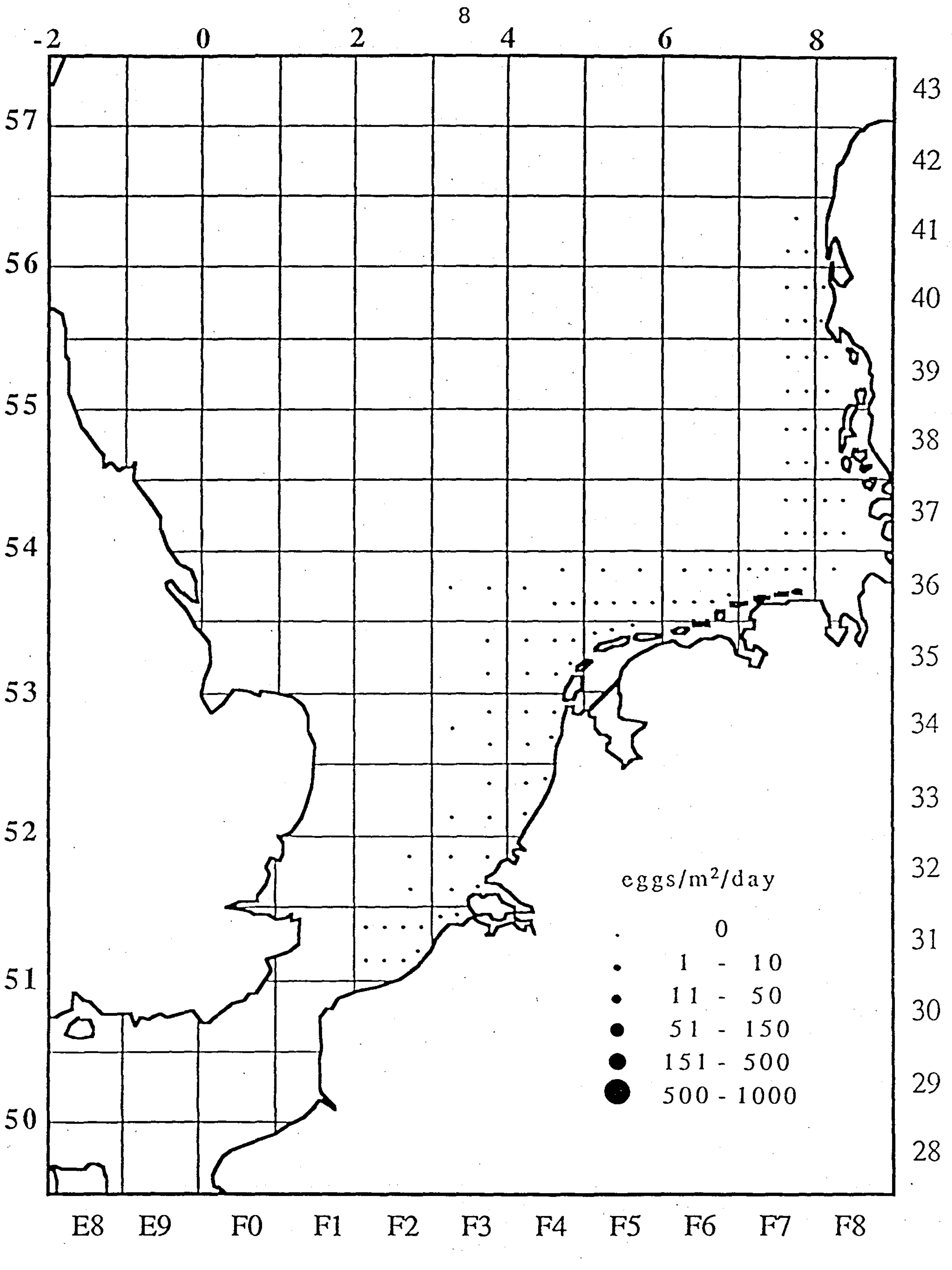


Figure 2. The distribution of stage I horse mackerel eggs as numbers per $m^2$ per day for survey period 2: 24 April - 2 May 1989

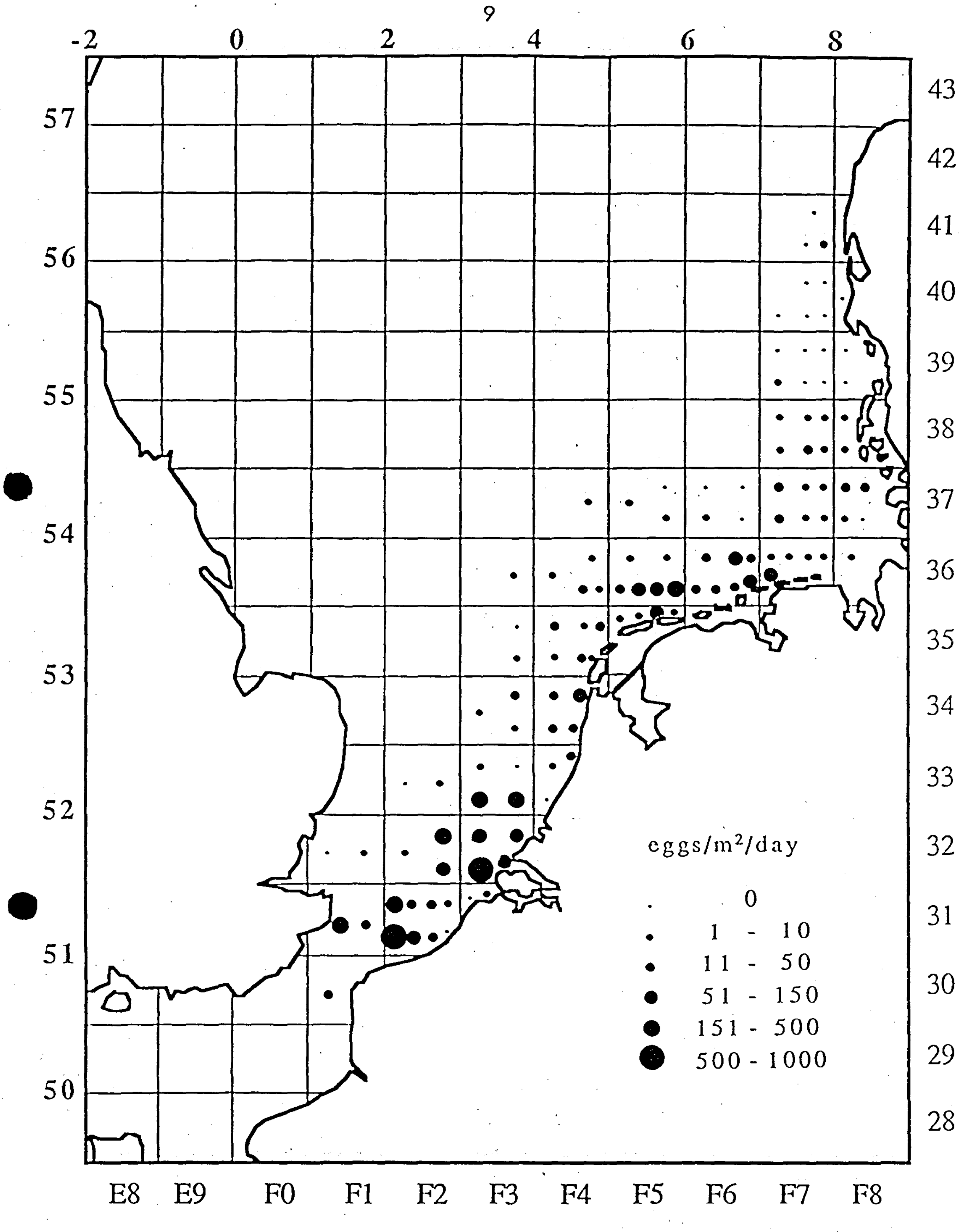


Figure 3. The distribution of stage I horse mackerel eggs as numbers per $m^2$ per day for survey period 3: 22 May - 7 June 1989

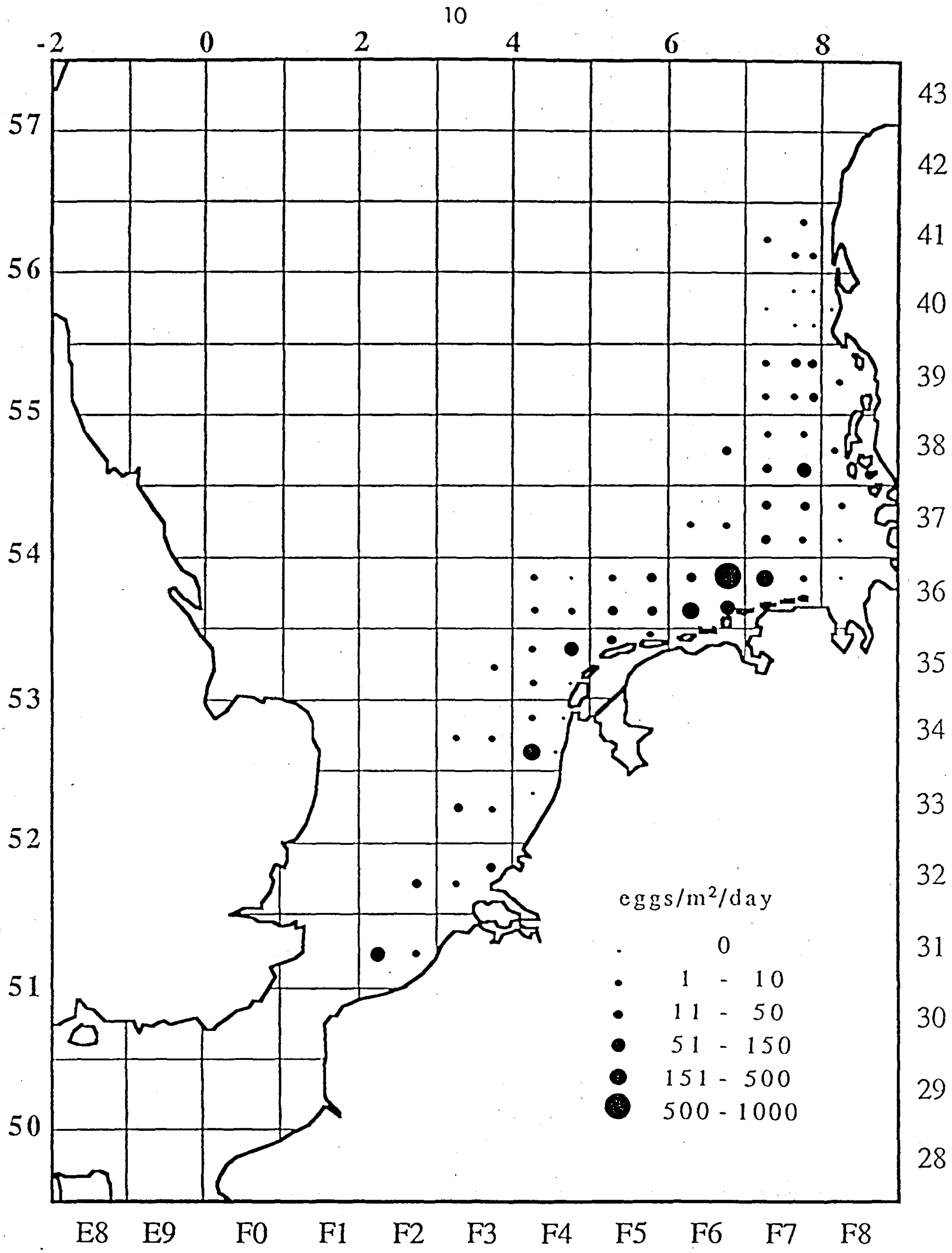


Figure 4. The distribution of stage I horse mackerel eggs as numbers per $m^2$ per day for survey period 4: 19 June - 28 June 1989

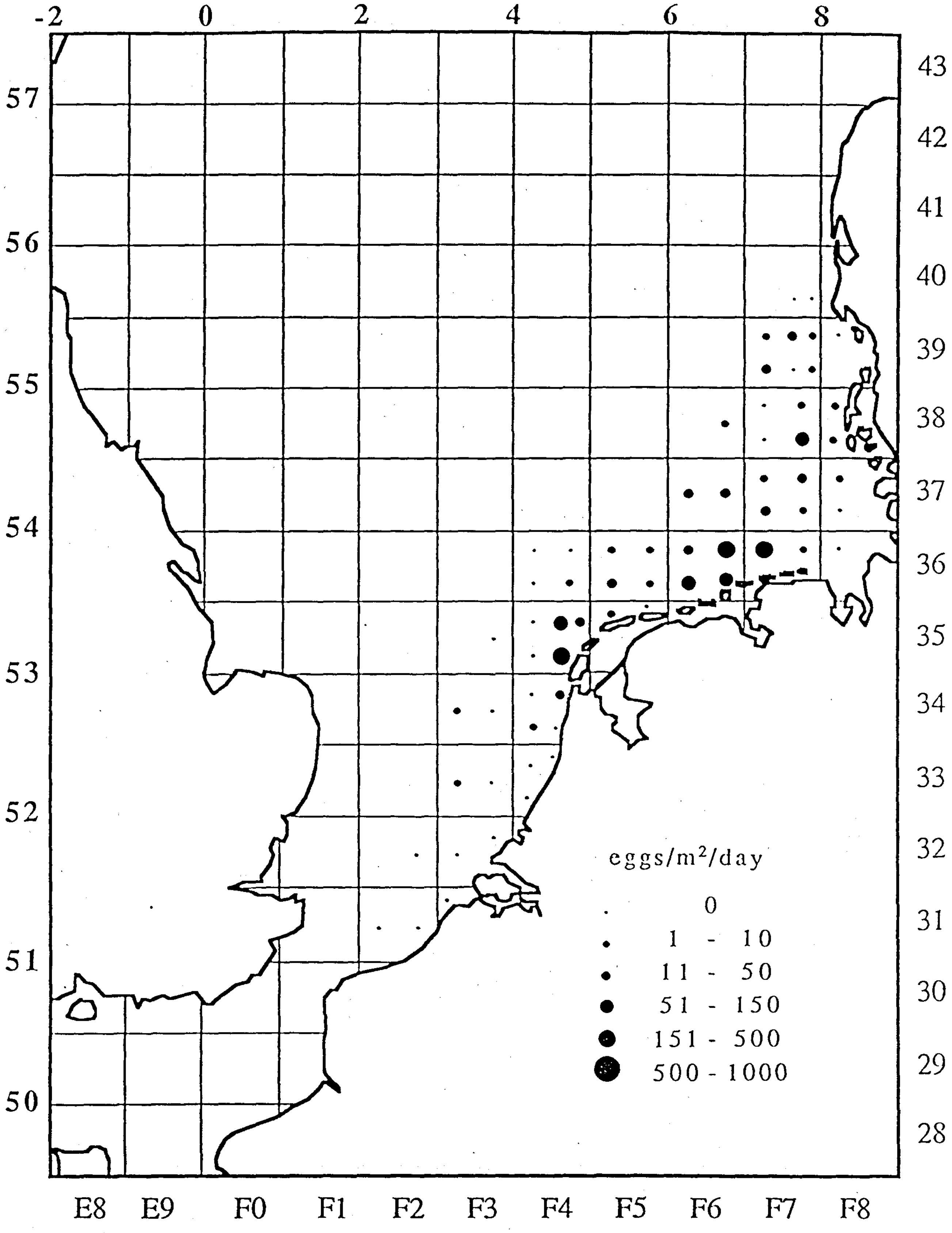


Figure 5. The distribution of stage I horse mackerel eggs as numbers per $m^2$ per day for survey period 5: 10 July - 18 July 1989

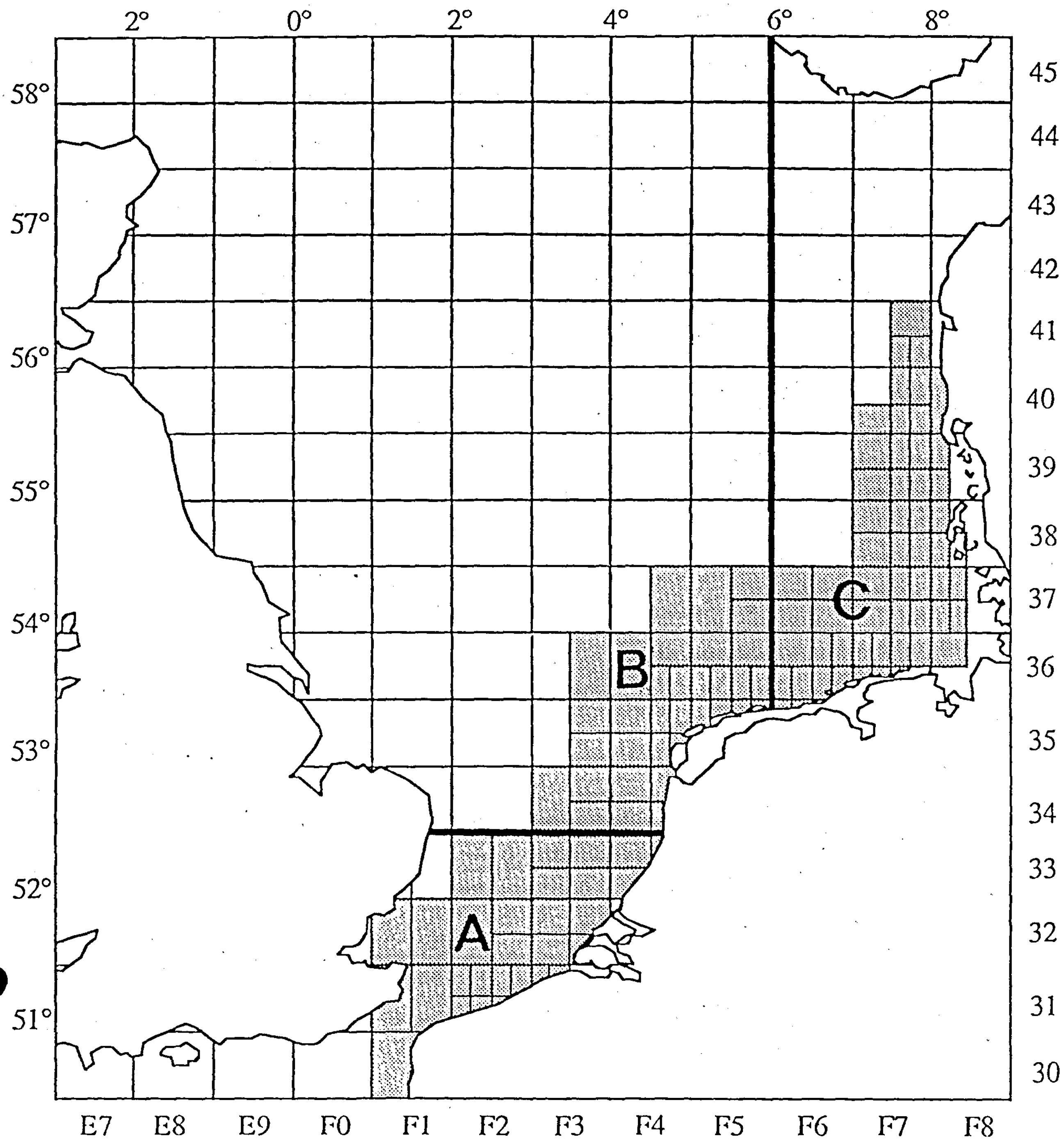


Figure 6. The area covered by the North Sea egg surveys is devided in three sub-areas (the third coverage as example):

A. The southern area south of 52° 30' N
B. The central area
C. The eastern area east of 6° E

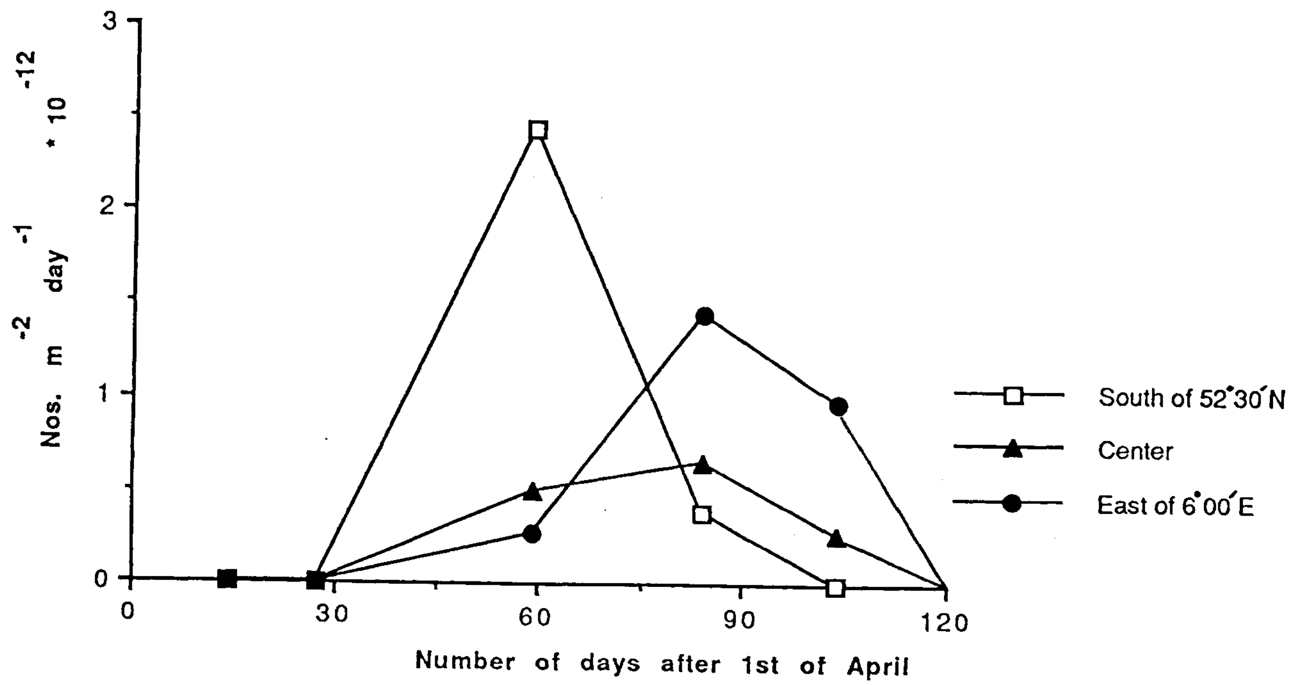


Figure 7. Production curves for stage I horse mackerel eggs for the southern, central and eastern sub-area in the North Sea in 1989.

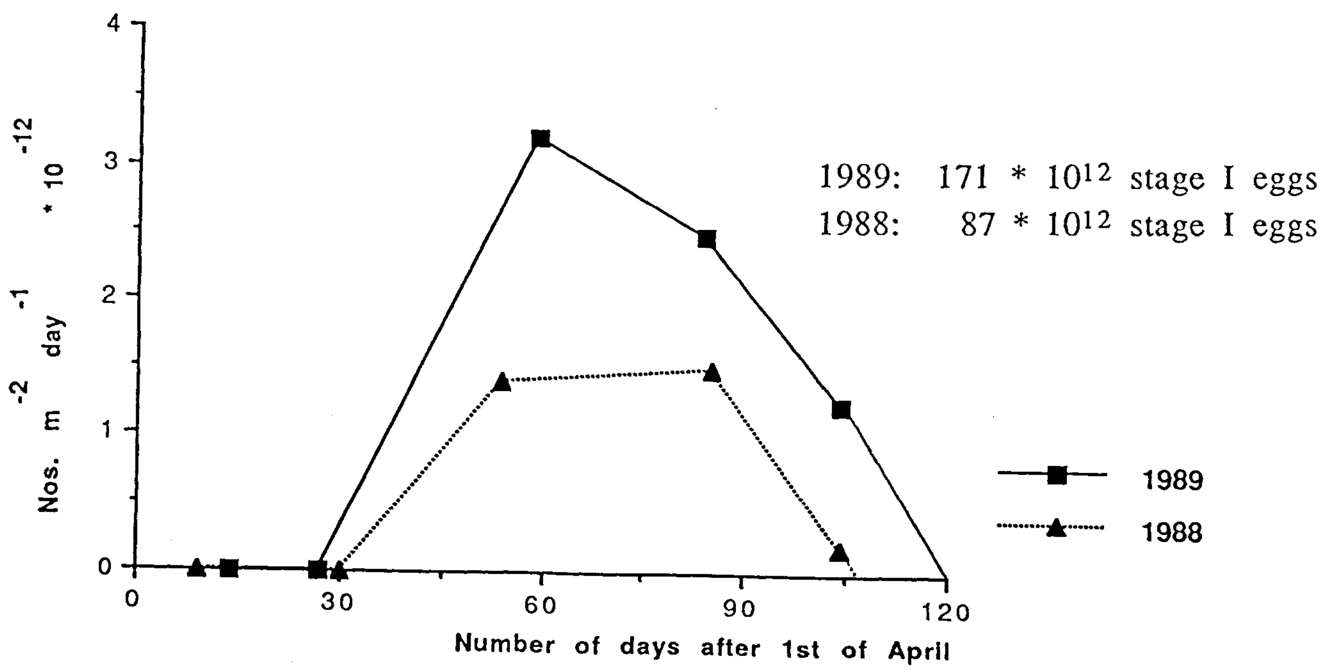


Figure 8. Production curves for stage I horse mackerel eggs for the total area covered by egg surveys in the North Sea in 1988 and 1989.