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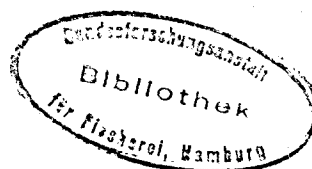
**THE RESULT OF THE 1989 EGG SURVEYS FOR COD AND PLAICE**

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**Abstract.**

This paper presents the results of the egg surveys for cod and plaice carried out in the southern and southeastern North Sea in the 1989 spawning season. Estimates of egg production and mortality are compared to the results of the 1987 and 1988 surveys and show in 1989 a substantial increase in the egg production of cod and a slight increase in plaice. Egg mortality rates in 1989 were intermediate between 1988 and 1987.

**Introduction**

This paper presents the results of plankton surveys carried out to estimate the egg production of cod and plaice in the southern and south-eastern North Sea in the spawning season of 1988/1989. Previous estimates were carried out in the spawning seasons of 1986/1987 and 1987/1988 the results of which were reported by HEESSEN AND RIJNSDORP (1989). The main aim of the surveys is to obtain an independent estimate of the spawning stock biomass which can be compared to the SSB estimate from the VPA. The results of the analysis of distribution and production of other species is reported by VAN DER LAND (1990).

## Material and Methods.

The survey design was similar to the surveys in 1986/1987 and 1987/1988, except that in 1989 an additional survey carried out in the first half of January was included which was carried out by the Fisheries Laboratory Lowestoft. In each statistical rectangle 6 stations were fished with an oblique haul of a high speed Gulf III sampler. The volume of water filtered was measured with a calibrated flow meter mounted in the mouth of the torpedo. The plankton samples were preserved in 4% formaldehyde buffered with 0.5%  $\beta$ -Disodium-glycerophosphate.

Egg stage were determined according to SIMPSON (1959). The total production of eggs was calculated for the various geographical areas and various egg stages separately (Figure 0) by integrating the estimates of daily egg production in each survey over the time interval between the midpoints of the surveys. Estimates of daily production were obtained by calculating the total number of eggs produced over the total surface area of each sub-area and dividing by the mean stage duration calculated from the formulae given by THOMPSON AND RILEY (1981) for cod and RYLAND AND NICHOLS (1975) for plaice. The temperature used in these calculations was the average surface temperature weighted over the abundance of stage 1 eggs. The start and end of the egg production were arbitrary set at 14 December (day -18) and the end of April (day 110). Egg production of stations sampled outside the standard geographical areas were not included in the estimate of the total egg production.

Egg mortality was estimated by regressing the  $\log_e$  transformed egg production values against the mean age of each developmental stage and the production of fertilized eggs was estimated as the egg production at age 0.

For cod the method used to calculate the production of fertilized eggs and egg mortality differed from the method used previously (DAAN, 1979; 1981; HEESSEN AND RIJNSDORP, 1989), so the present result for cod can not be compared directly with the previous estimates.

## Results.

The abiotic conditions in the spawning season of 1989 were characterised by a relatively mild winter and the sea water temperatures were relatively high. In the Southern Bight the surface temperature in February 1989 was with 7.1°C one of the highest recorded during the series of cod egg surveys carried out since 1970 and only lower than in 1974 (Table 3a).

For each survey the distribution charts of stage 1 egg are given in Figure 1 and 2 for respectively cod and plaice. Egg production of cod already started in early January in the Channel and Southern Bight and peaked in survey III in late January. In the German Bight the peak in egg production occurred in February (survey IV). In plaice egg production peaked in early January (survey II) in the Channel, in late January (survey III) in the Southern Bight and in January and February (survey III and IV) in the German Bight. In March egg production almost ceased in both plaice and cod. The overall production curves for the various developmental stages of plaice and cod eggs is shown in Figure 3a-b.

Daily egg production, estimated for each of the sub-areas separately, are given in Table 2a and 2b. In Table 3 the total production estimates are compared with the results of previous surveys. In cod the egg production in 1989 was the highest in the time series in the Southern Bight and also in the rest of the survey area the egg production was higher than in 1987 and 1988. In plaice the egg production estimates of stage 1 eggs were slightly higher than in 1987 and 1988, but the estimated number of fertilized eggs was at the same level as in 1987 and at a slightly lower level than in 1988. Figure 4 shows the decline in  $\log_e$  egg numbers during incubation and indicates that mortality rate of cod eggs was higher than of plaice eggs.

### Discussion.

The production estimate for cod and plaice in 1989 is an underestimate in comparison with the 1987 and 1988 estimates. The distribution charts of stage 1 eggs show that in early January (survey II) already substantial egg production occurred at the northern border of the survey area in the Southern Bight for both cod and plaice. In addition the Fisher Bank could not be sampled completely due to adverse weather conditions in January and February 1989 and the production was estimated by extrapolation the survey results at peak spawning in February. On the other hand the survey area was extended eastwards in the German Bight between  $7^{\circ}00' - 7^{\circ}30' \text{ E}$  and southward between  $53^{\circ}45' - 54^{\circ}00' \text{ N}$ . In particular this extension will have increased the egg production estimate for cod as a substantial production of cod eggs occurred in February between  $54^{\circ}00' - 55^{\circ}00' \text{ N}$  and  $7^{\circ}00' - 7^{\circ}30' \text{ E}$ .

### Acknowledgement.

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Table 1. Summary of the plankton surveys carried out in the spawning season of 1988/1989 in the southern and south eastern North Sea.

Survey	Period	Date	Vessel	Number of hauls
Ia	December-I	12 - 16	KW34	64
Ib	December-II	20 - 23	KW34	62
II	January-I	6 - 1	RV Cirolana	104
III	January-II	16 - 20	KW34	55
		10 - 20	RV Isis	73
IV	February	13 - 3/3	KW34	157
		20 - 23	RV Isis	37
V	March	28 - 6/4	RV Isis	96
		28 - 5/4	RV Tridens	83

Table 2a Cod: numbers of eggs produced in the survey area per day and by egg stage during each of the plankton surveys in 1988/1989, together with the survey periods, midpoints of the survey (day relative to 1 January) and the ambient temperature for stage 1 eggs.

survey	midpoint	Temp °C	Egg production (10 <sup>9</sup> .day <sup>-1</sup> )				
			egg-1	egg-2	egg-3	egg-4	egg-5
COD							
Eastern English Channel							
Dec-I	-18.0	9.9	0.3	0.0	0.0	0.2	0.0
Dec-II	-10.0	-	0.0	0.0	0.0	0.0	0.0
Jan-I	10.7	9.7	9.6	5.3	2.0	0.0	0.0
Feb	52.3	9.1	3.6	4.9	1.8	1.5	0.8
Southern Bight							
Dec-I	-18.0	-	.0	.0	.0	.0	.0
Dec-II	-10.0	-	.0	.0	.0	.0	.0
Jan-I	9.0	8.8	46.0	18.4	2.7	1.4	.0
Jan-II	17.1	7.6	159.4	87.7	27.0	17.3	5.1
Feb	50.7	7.1	120.6	115.2	43.7	27.8	22.8
Mar	83.8	8.4	1.5	1.4	.3	.3	.1
Transition Area							
Jan-II	18.9	7.5	83.2	70.0	16.5	8.6	3.2
Feb	56.7	6.9	53.5	70.5	32.0	39.4	30.6
Mar	89.6	7.2	1.3	2.2	.6	.2	.1
German Bight							
Jan-II	23.5	7.1	31.2	20.9	7.1	9.0	3.8
Feb	53.9	6.6	74.7	103.4	40.3	23.7	17.6
Mar	89.4	7.1	1.0	2.0	.3	.5	.2
Fisher Bank							
Feb	53.7	6.8	9.7	8.2	4.1	6.5	3.0
Mar	89.4	6.2	.3	.0	.1	.5	.1

Table 2b Plaice: numbers of eggs produced in the survey area per day and by egg stage during each of the plankton surveys in 1988/1989, together with the survey periods, midpoints of the survey (day relative to 1 January) and the ambient temperature for stage 1 eggs.

survey	midpoint	Temp °C	Egg production (10 <sup>9</sup> .day <sup>-1</sup> )				
			egg-1	egg-2	egg-3	egg-4	egg-5
Plaice							
Eastern English Channel							
Dec-I	-18.0	11.9	5.9	3.7	1.7	1.7	.7
Dec-II	-10.0	11.7	3.8	3.2	1.9	.5	.8
Jan-I	10.7	10.7	57.8	43.7	22.9	8.7	6.9
Feb	52.3	9.5	26.3	14.8	9.2	6.1	5.3
Southern Bight							
Dec-I	-18.0	-	.0	.0	.0	.0	.0
Dec-II	-10.0	-	.0	.0	.0	.0	.0
Jan-I	9.0	9.0	29.1	16.8	10.5	3.5	1.2
Jan-II	17.1	7.6	49.5	34.0	19.7	14.8	6.1
Feb	50.7	7.4	34.0	28.3	17.1	18.3	9.5
Mar	83.8	8.2	1.7	2.0	.8	.7	.2
Transition Area							
Jan-II	18.9	7.5	90.6	64.6	34.6	20.1	9.2
Feb	56.7	6.9	50.5	43.1	39.4	38.1	28.8
Mar	89.6	7.4	.8	.9	.9	1.7	1.4
German Bight							
Jan-II	23.5	7.1	31.4	18.6	6.6	6.9	3.6
Feb	53.9	6.8	68.6	62.3	40.9	30.8	19.7
Mar	89.4	6.8	5.0	3.4	2.6	2.1	2.2
Fisher Bank							
Feb	53.7	6.8	24.8	19.6	8.9	11.7	7.5
Mar	89.4	6.5	.6	.0	.5	.7	1.0



Table 3a. Cod production of fertilized eggs ( $\times 10^9$ ), ambient water temperature in February ( $T_{\text{febr}}$  in  $^{\circ}\text{C}$ ), total development until hatching (D in days), instantaneous daily mortality rate (Z), and the spawning stock biomass (SSB in '000 t) from VPA (Anon., 1988), in comparison with the data for 1970-1974 from DAAN (1981) and 1987-1988 from HEESSEN AND RIJNSDORP (1989).

Year	Southern Bight	Rest	$T_{\text{febr}}$	D	Z	SSB
1970	7449	-	5.2	18.4	0.027	271
1971	8989	-	5.9	17.2	0.411	269
1972	2258	-	6.1	16.8	0.277	225
1973	2201	-	7.0	15.5	0.245	197
1974	2307	-	7.4	17.9	0.297	210
1987	1632	7560	4.0	21.3	0.141	95
1988	5160	5386	6.5	15.8	0.215	96
1989 <sup>d</sup>	10457	10120	7.1	14.9	0.205	-

<sup>d</sup> In 1989 the method of estimating number of fertilized eggs was different from the method used in other years (see text).

Table 3b. Egg production of plaice by subarea (see Fig.1) in 1989 in comparison with 1987 and 1988 and the estimated daily mortality rate of eggs until hatching.

Area	Surface Area (km <sup>2</sup> )	1987	1988	1989
Stage 1 eggs (x 10 <sup>12</sup> )				
Eastern English Channel	13818	2.02	-	2.92
I Southern Bight	20720	2.63	1.80	2.68
II Transition Area	40028	2.70	2.98	3.92
III German Bight	28468	2.99	2.27	3.07
IV Fisher Bank	30870	2.60	2.77	2.45 <sup>e</sup>
V Flamborough	10736	0.80 <sup>a</sup>	0.75 <sup>a</sup>	-
North Sea total (I-IV)		10.9	9.8	12.1 <sup>d</sup>
Fertilized eggs (x10 <sup>12</sup> ):				
North Sea total (I-V)		14.4	18.8	14.0 <sup>d</sup>
North Sea + eastern English Channel		16.2	21.2 <sup>b</sup>	17.6 <sup>d</sup>
Total development time until hatching (days):				
North Sea total (I-V)		25.9	15.8	17.7
Instantaneous daily mortality rate (Z):				
North Sea total (I-V)		0.068	0.165	0.096

a Extrapolated from one survey at peak spawning

b Extrapolated, assuming in 1988 an equal contribution of the eastern Channel to the total as in 1987

c Extrapolated for missing stations in area IV (Fisher Bank).

d excluding area V (Flamborough)

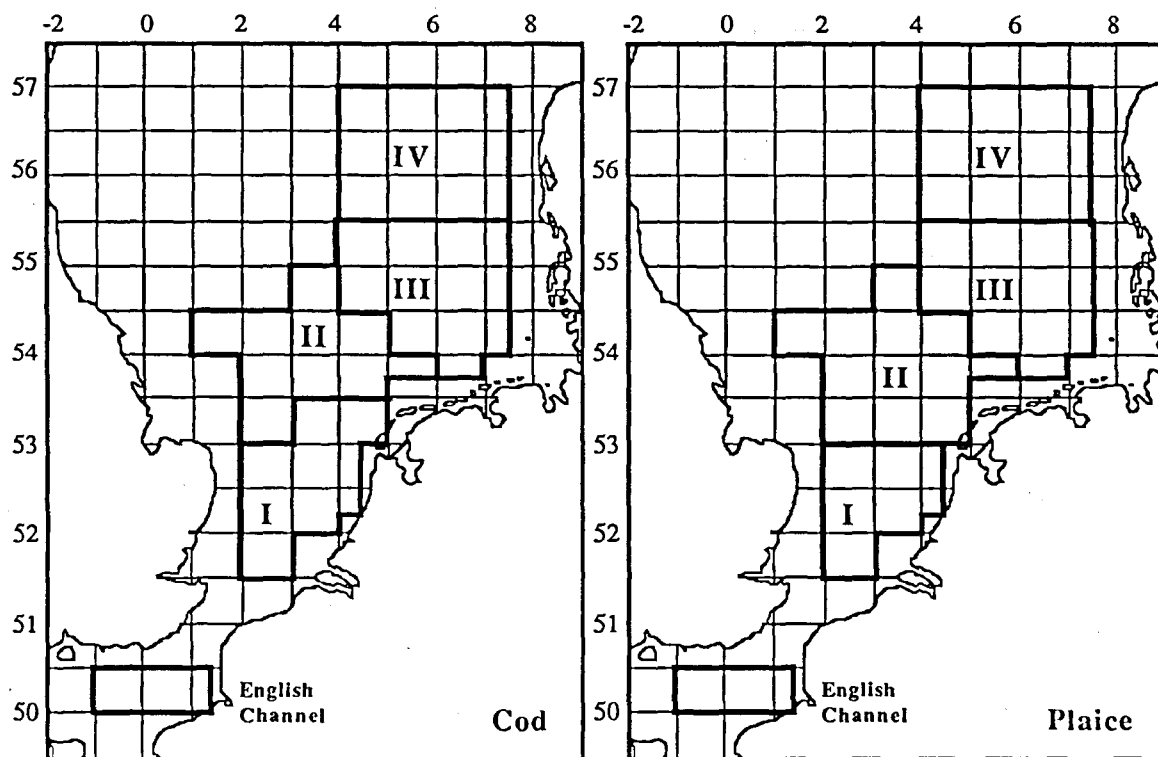


Figure 0. Survey area and the sub-areas distinguished for cod and plaice.  
 Eastern English Channel  
 I: Southern Bight  
 II: Transition Area;  
 III: German Bight;  
 IV: Fisher Bank

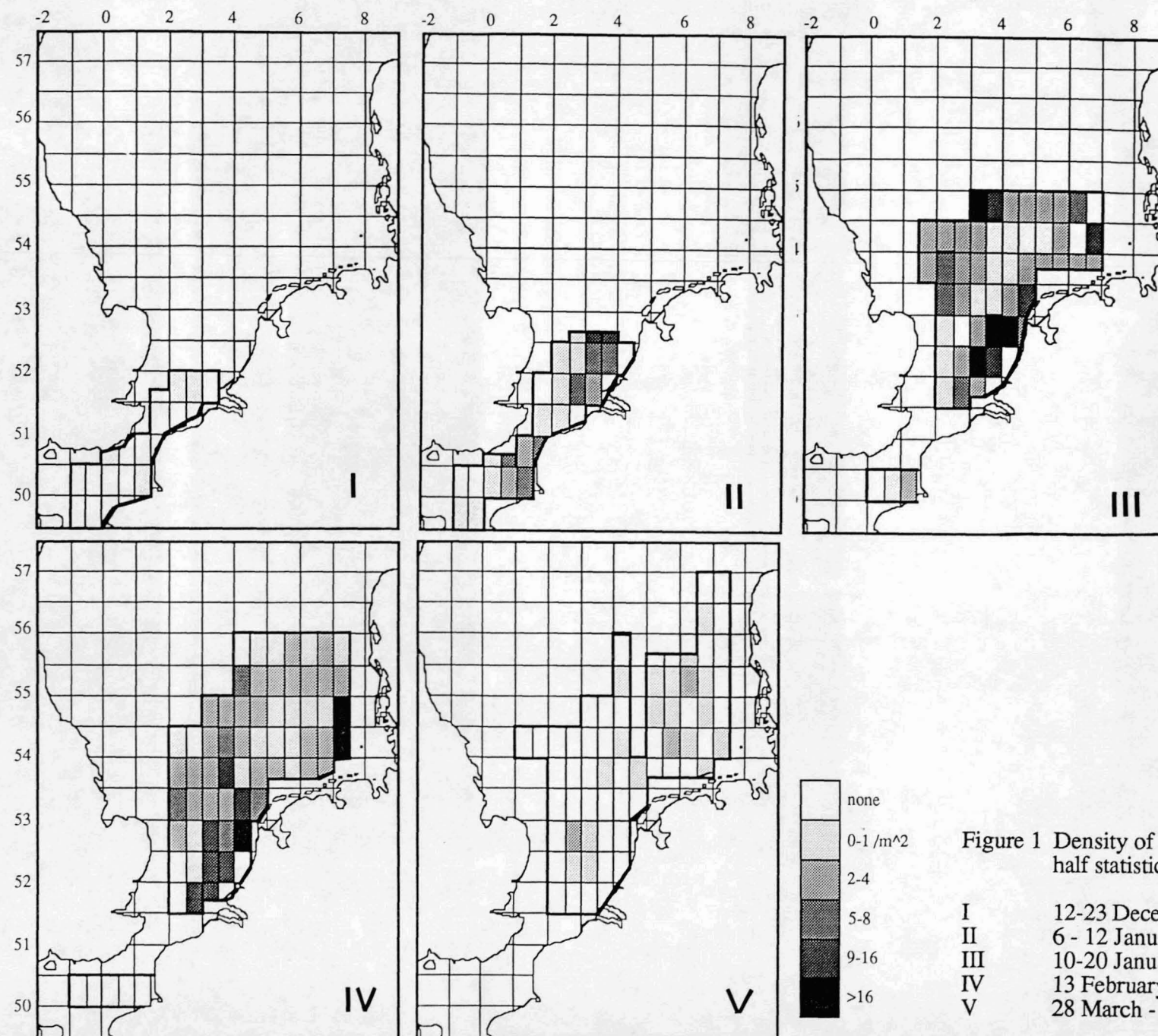


Figure 1 Density of stage 1 eggs of cod per half statistical rectangle

I 12-23 December 1988  
 II 6 - 12 January 1989  
 III 10-20 January  
 IV 13 February - 3 March 1989  
 V 28 March - 6 April 1989

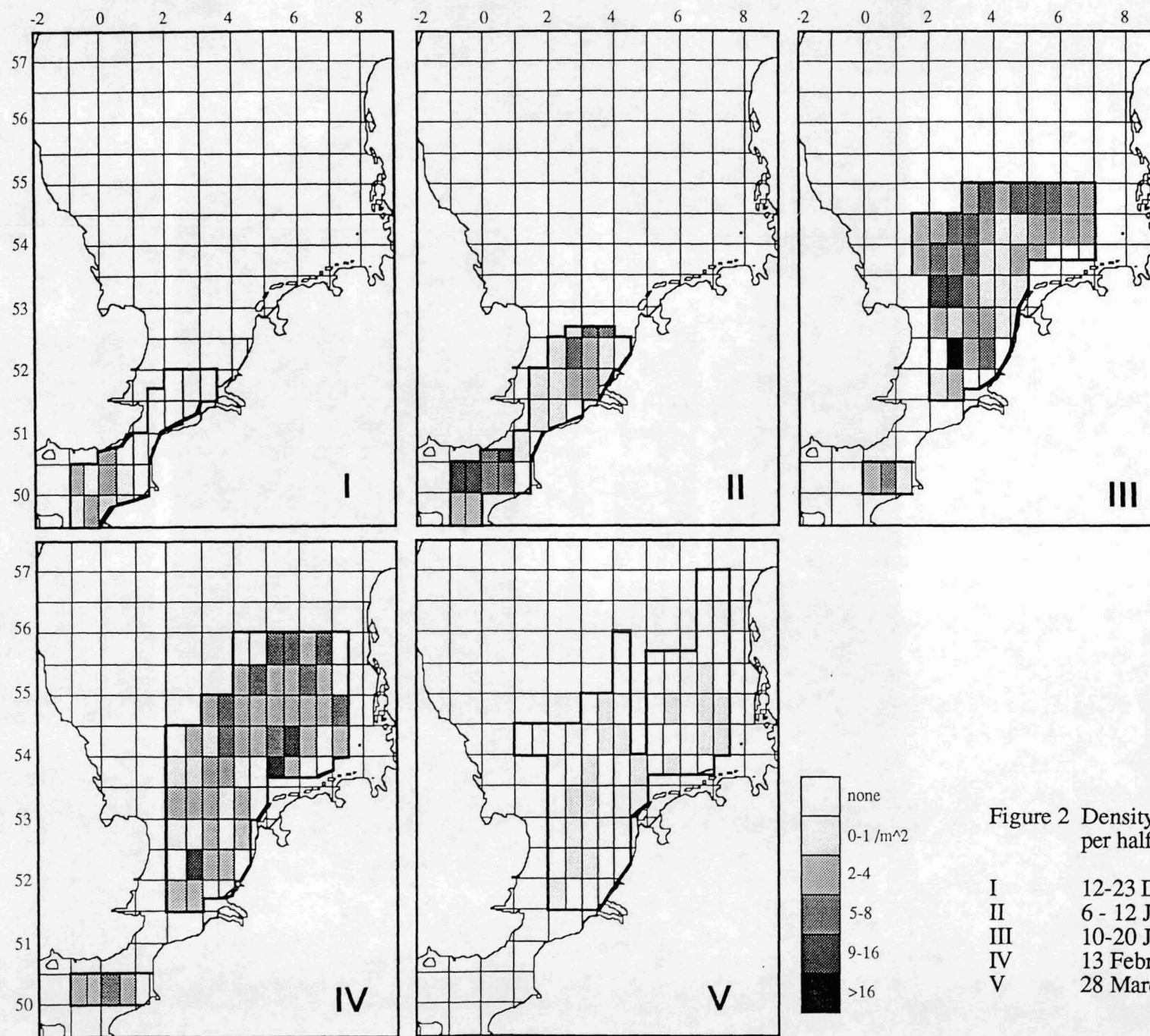


Figure 2 Density of stage 1 eggs of plaice per half statistical rectangle

I 12-23 December 1988  
 II 6 - 12 January 1989  
 III 10-20 January  
 IV 13 February - 3 March 1989  
 V 28 March - 6 April 1989

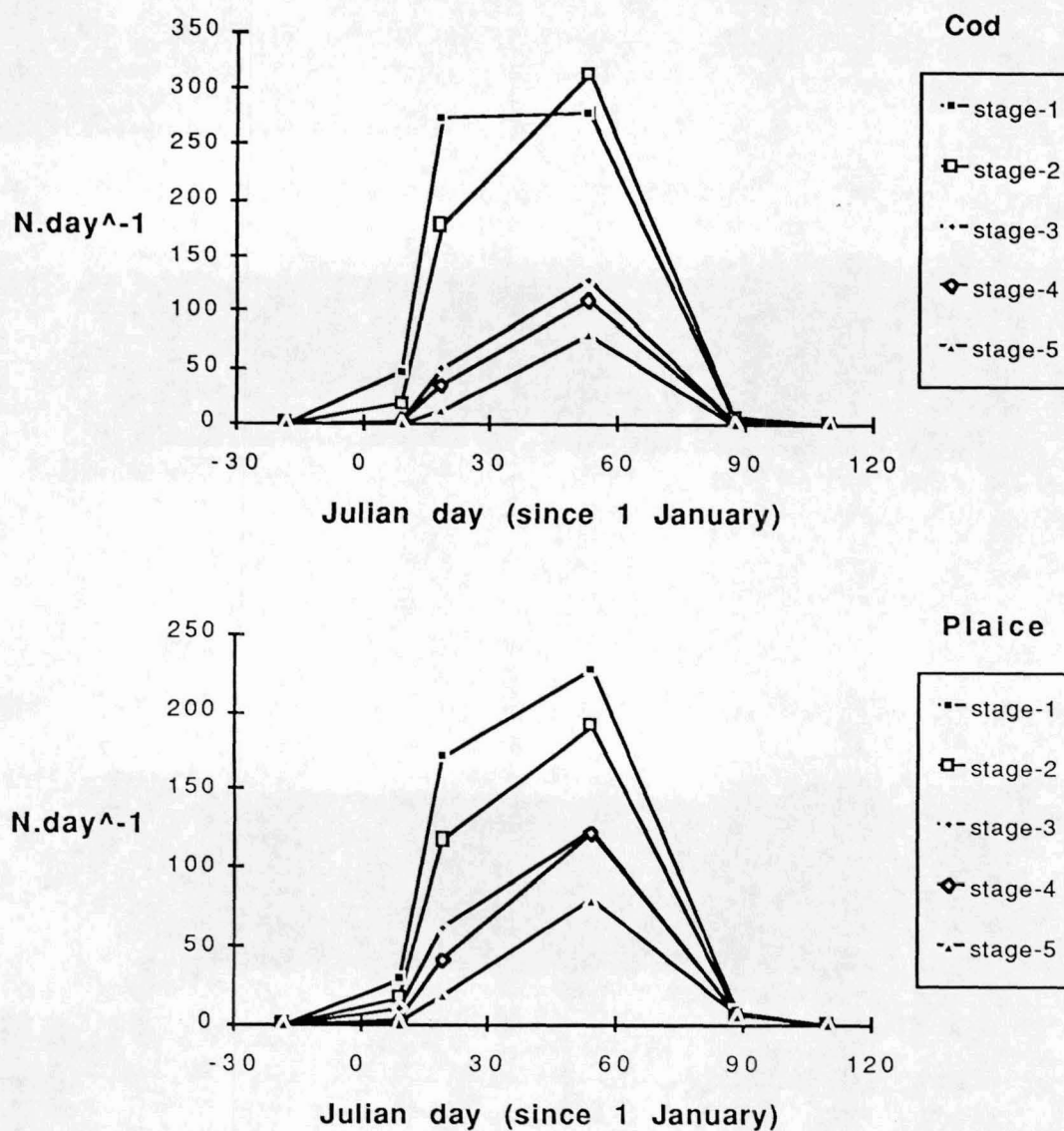


Figure 3. Production curves of cod and plaice eggs of developmental stage 1 to 5 for the North Sea total.

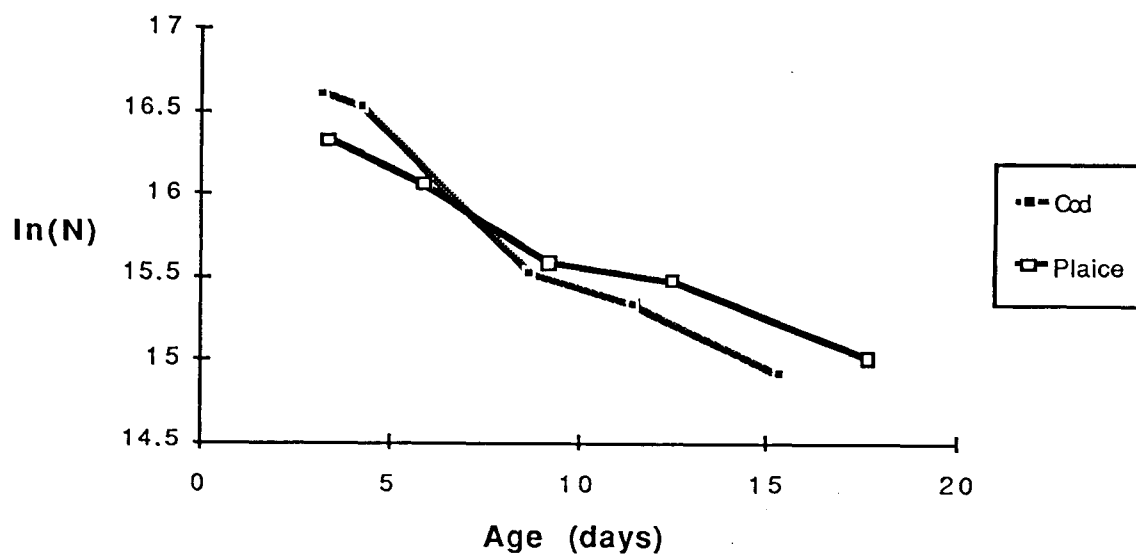


Figure 4. Decline in  $\log_e$  transformed egg numbers with the age of the eggs for cod and plaice in the North Sea total.