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Preliminary report of Investigations of cod-eggs and larvae in the Lofoten area in the years 1968-1972.

by

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INTRODUCTION

The arcto-norwegian cod spawns between February and April on the coastal banks of northern Norway, the main spawning taking place in the Lofoten area in late March. Sampling of fish eggs and larvae has been undertaken regularly along the coast of northern Norway since 1948, but in 1967 a more detailed investigation was started in connection with the International Biological Programme (IBP). This paper gives a review of the results from the investigations in the Lofoten area in the years 1968-1972.

MATERIAL AND METHODS

Fig. 1 shows the area investigated in the period 1968-1972. The area was divided into subareas shown by broken lines. The field work was carried out with R/V"Asterias", R/V"Johan Hjort" and the old R/V"G.O.Sars" (Table 1).

The eggs and larvae was sampled with Juday-net hauled vertically from 75 m or from the bottom to the surface, and with Clarke-

Bumpus apparatuses hauled in steps according to WIBORG (1950). From 1969, five minutes hauls were made with a neuston-net (Zaitsev-net) by R/V "Asterias".

Hydrographical material was sampled with Nansen-bottles and bathythermograph.

At the laboratory the cod-eggs and larvae were sorted out and counted. The eggs were sorted into three stages categories according to DANNEVIG (1919). See Fig. 2.

Egg numbers per square meter were calculated on the basis of the egg-sampling figures, and the total number of eggs in the area was estimated by the isoline method and area integrations.

Spawning potensials are based on the virtual population analyses carried out by the North-East Arctic Fisheries Working Group.

Each year, the stock size of the 1st January was reduced until 30th March by the known amount caught by Norway and by the estimated catch of other countries.

The following egg potensials were calculated using 400 eggs/g/ mature fish as a mean figure (BOTROS 1962).

	1968	1969	1970	1971	1972
Egg x 10^{-11}	1152	1444	1724	1992	1560

Spawning curves were estimated on the basis of biological sampling of the mature fish and adjusted by the egg sampling. (Fig. 3)

On determining the spawning curve and the duration of each stages we were able to estimate the seasonal egg masses within every stages for each area.

$$E_i = \frac{e_i \times 100}{p_i} \quad \text{where } i = I, II, III \qquad (1)$$

e_i = the observed number of eggs within each stage,

p_i = the percentage of eggs spawned within the spawning period of those sampled. The percentage can easily be read from the spawning curve for each stage.

RESULTS

Horizontal distribution of cod eggs.

The horizontal distribution pattern of cod eggs is very similar from year to year (Fig. 4). The main spawning takes place in subarea IA, while the denser concentrations in subarea IV B are probably due to eggs drifting through the inlets between the Lofoten islands. Also, the very strong Moskenescurrent which carries eggs from the inner to the outer side of the islands is slowing up in this area.
Figs. 5 and 6 shows that the abundance of eggs was greatest in 1971 and smallest in 1968. This correlates nicely with the estimated spawning potentials. Estimations of the total number of eggs from equation (1) of different stages are shown in fig. 7. The reduction of eggs from stage I to stages II seems to be of the same magnitude for the years 1968, 1969, 1970 and 1972, while appearing to be far greater in 1971.
The estimations of the number of stages III eggs are very uncertain, but the abundance seems to be greatest in 1970 followed by 1971, 1968 and 1969. In 1972 no stage III eggs were found but only one cruise were undertaken that year.

Vertical distribution of eggs.

According to SUNDNES, LEIVESTAD and IVERSEN (1965) the relative abundance of older eggs should increase with depth.

In our material the amount of all stages decreases in the same order of magnitude with depth, (Table 2). Stages III seems to have a higher concentration than the other two stages from 30-50 m, but the differences are small.
The relative composition of the material sampled with the Zaitsev-net at the surface is very similar to that of the Clark-Bumpus material, (Table 3). So it seems that the different stages have the same pattern of vertical distribution.

Abundance of larvae

In 1970 larvae were found in area I in March, and in the beginning of April the abundance was relatively great. In the other years, however, no larvae were found at that time of year (Table 4).
At the end of April and in the beginning of May we have data only from 1968, 1969 and 1971 from area I. The greatest larvae abundance was found in 1971.
The abundance figures of 1968 and 1969 were almost idential. We have data for the areas outside the Lofotens from April/May of all years except 1968 and 1972, where no cruises were performed in May. The abundance was by far the greatest in 1970 while 1971 seems to be the best of the other years (Tabel 4).

Vertical distriburion.

Fig. 8 shows the daily vertical distribution of cod larvae. The figures is based on the samples from the three standard depths and those from the neuston-net in the period 1970-1971.
According to this figure the main concentration of the larvae is found at depths of 5-25 m. During night time, however, the cod larvae migrate to the surface.

DISCUSSION

Except for 1971 the estimated number of spawned eggs is less than 10 % of the estimated spawning potentials. However, the relative amount of stage I eggs per year correlates well with the relative spawning potentials. In both estimates, 1971 has the highest egg numbers, while 1968 has the lowest. The only disagreement is that fewer eggs are found in 1972 than in 1969. However, only one cruise was undertaken in 1972.

At an age of six months the different year classes of cod were characterized as follows:
1968 - poor, 1969 - average, 1970 - very strong, 1971 - average to strong, 1972 - average to strong (ANON 1968, 1969, 1970, 1971, 1972). Using the indices of HAUG and NAKKEN (1973) we have : 1968:25, 1969:98, 1970:606, 1971: 157, 1972: 140, which means that the 1970 year class is about 4 times as strong as the 1971 year class. As already meantioned the higher mortality of the 1971 year class had already started at the egg stage.

WIBORG (1957) considered the following factors to be of importance in influencing the size of the year classes of Arcto-Norwegian cod:

1. an extensive spawning area
2. a long spawning period
3. a long hatching period
4. strong northgoing currents during the egg and larval drift period.

We have no indications that the spawning area was greater in 1970 than 1971. In the outer part of Vestfjorden no spawning or spent fish were found in the samples of mature fish in 1970, while in 1971, in the last week of March, about 10 % of the species from the outer part were spawning or spent. This may, however, be due to the regulation of the fisheries. Many of the catches had to be landed in the outer part of Vestfjorden because of low capacities

on shore in the inner regions of the fjord.

Wiborg considered a long hatching period as a favourable factor. We have no data on hatching times, but as the hatching is dependent on temperature, this will give indications of any differences. In the beginning of April 1970 the average temperature in the upper 50 m in the main spawning area was about 3,5°C, while at the same time in 1971 the average temperature was about 2,0°C, which was the lowest in the investigation period. Thus, 1971 should have the longes hatching period of all the years. However, as seen from Fig. 7, 1971 had the highest rate of reduction from egg stage I to egg stage II. It is therefore a question of whether or not low temperature really is a favour . 1970 was a successful year, but that year the mean temperature was rather high.

Both spawning period and currents seem to be most favourable in 1970. As seen from Fig. 3, 1970 has the longest spawning period, while the spawning curve for 1971 is rather steep. We have no direct information on the currents, but Fig. 6 shows that the egg abundance in areas III and IV was greates in 1970, and as no spawning fish were recorded in area III we may conclude that the currents had differed from those of other years.

Some of the favourable factors influencing the size of the year classes thus seem to be:

1. long spawning period
2. temperatures not below 3° in the inner part of Vestfjorden
3. strong currents dispersing the eggs.

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Table 1. Survey review of 1968 - 1972 with information about research vessels, numbers of eggs within each stage and total egg and larvae numbers for each survey.

Year	Research vessel	Survey time	area covered (with reference to fig. 1)	eggs x 10^{-9} Stage I	Stage II	Stage III	Total	Larvae x 10^{-8}
1968	G.O. Sars	30.3 - 3.4	I,II,III,IV	880	290	2	1170	0
	Asterias	20.4 - 26.4	0,IA,IIA	480	1160	140	1780	45
	G.O. Sars	24.4 - 26.4	I,II,III,IV	120	370	50	540	60
1969	Asterias	24.3 - 29.3	0,I	960	310	1	1270	0
	Johan Hjort	12.4 - 15.4	I,II,III,IV	1180	780	20	1880	0
	Asterias	14.4 - 18.4	0,I,II,	1020	2230	60	3310	4
	Johan Hjort	25.4 - 28.4	0,I,II,III,IV	450	1440	480	2370	8
	Johan Hjort	7.5 - 10.5	0,I,II,III,IV	80	260	100	440	270
1970	Asterias	16.3 - 24.3	0,I,	920	380	4	1310	1
	Asterias	3.4 - 9.4	0,I,II	2220	2470	150	4840	270
	Johan Hjort	13.4 - 16.4	II*,III,IV,V	2030	880	80	2990	160
	Johan Hjort	24.4 - 28.4	II,III,IV,V,VI*	810	2080	1020	2910	590
	Johan Hjort	18.5 - 22.5	II*,III,IV,V,VI	60	80	4	140	11280
1971	Asterias	29.3 - .5.4	0,I,IIA	6680	780	1	7460	0
	Johan Hjort	2.4 - 9.4	I,II,III,IV,V,VI*	9600	2780	10	12390	0
	Johan Hjort	29.4 - 5.5	I,II,III,IV,V,VI	370	540	200	1110	860
	Asterias	1.5 - 5.5	0,I,IIA	230	1190	320	1740	330
1972	Asterias	4.4 - 7.4	0,I,II	2810	740	0	3550	0

* only partly covered.

Table 2. Average percentage distribution of eggs in different stages at the three standard depths.

Standard depths	Percentage egg stages I	II	III
5 - 25	58.9	64.7	55.9
30 - 50	25.6	22.4	29.1
55 - 75	16.9	12.9	16.2

Table 3. Average percentage distribution of eggs in different stages. The eggs were sampled with a Zeitsev-net at the surface and with Clark-Bumpus apparatus at depths of 5 - 75 m.

	Percentage egg stages I	II	III
Zeitsev-net	61.2	33.3	5.5
Clark-Bumpus	62.1	32.8	5.1

Table 4. Larval figures of each area from the 1968 - 1972 surveys.

Year	Survey time	Larvae x 10^{-8} within each area. 0	I	II	III	IV	V	VI
1968	30.3 - 3.4	-	0	0	0	0	-	-
	20.4 - 26.4	1	41	3	-	-	-	-
	24.4 - 26.4	-	36	0	0	25	-	-
1969	24.3 - 29.3	0	0	-	-	-	-	-
	12.4 - 15.4	-	0	0	0	0	-	-
	14.4 - 18.4	0	4	0	-	-	-	-
	25.4 - 28.4	1	6	0	0	1	-	-
	7.5 - 10.5	7	145	3	0	115	-	-
1970	16.3 - 24.3	0	1	-	-	-	-	-
	3.4 - 9.4	2	240	31	-	-	-	-
	13.4 - 16.4	-	-	0	0	89	75	-
	24.4 - 28.4	-	-	31	2	420	130	3
	18.5 - 22.5	-	-	48	18	945	1970	8300
1971	29.3 - 5.4	0	0	0	-	-	-	-
	2.4 - 9.4	-	0	0	0	0	0	0
	29.4 - 5.5	-	555	83	0	140	0	0
	1.5 - 5.5	71	255	85	-	-	-	-
1972	4.4 - 7.4	0	0	0	-	-	-	-

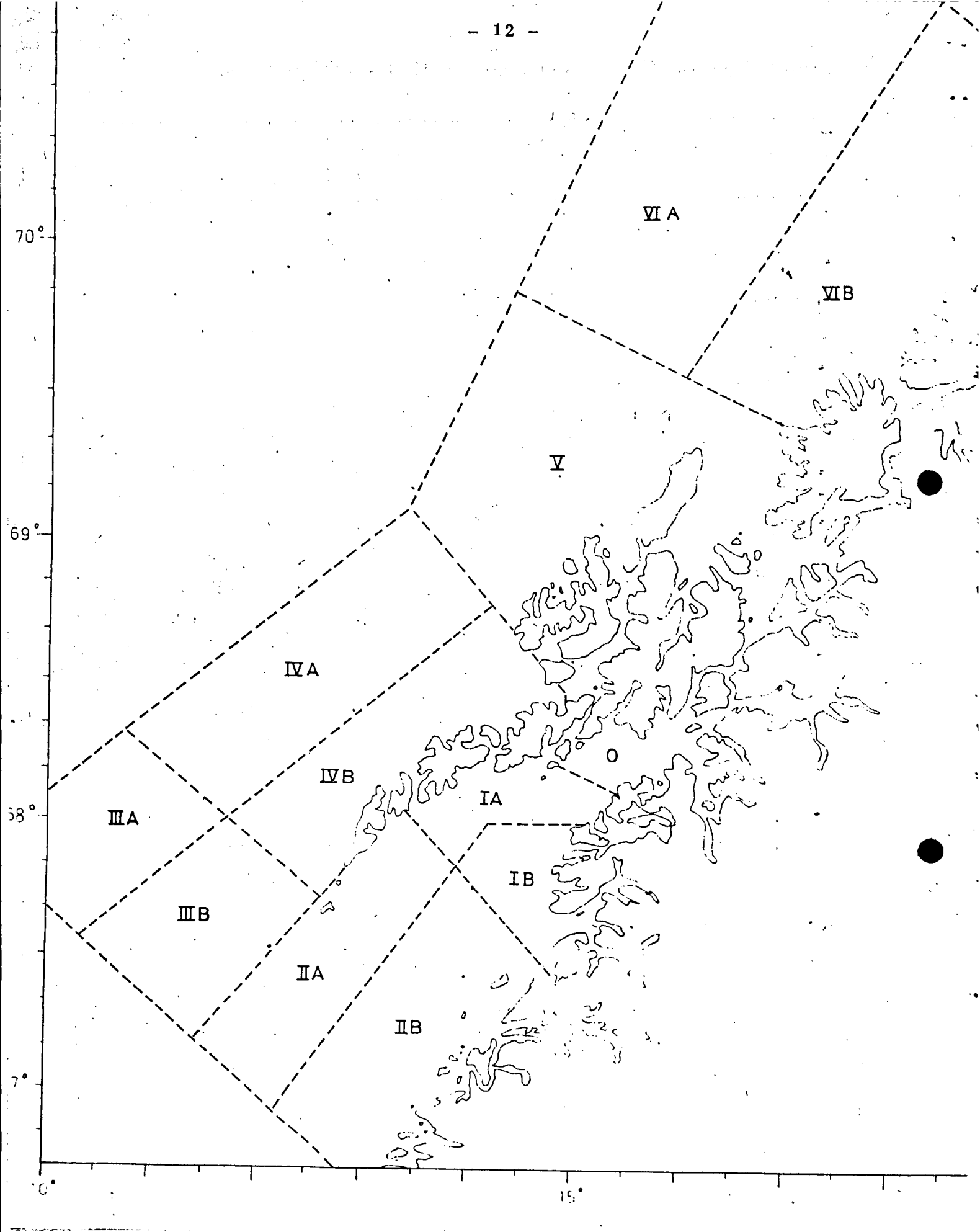

Fig. 1. Investigation area of 1968 - 1972 showing sub-areas.

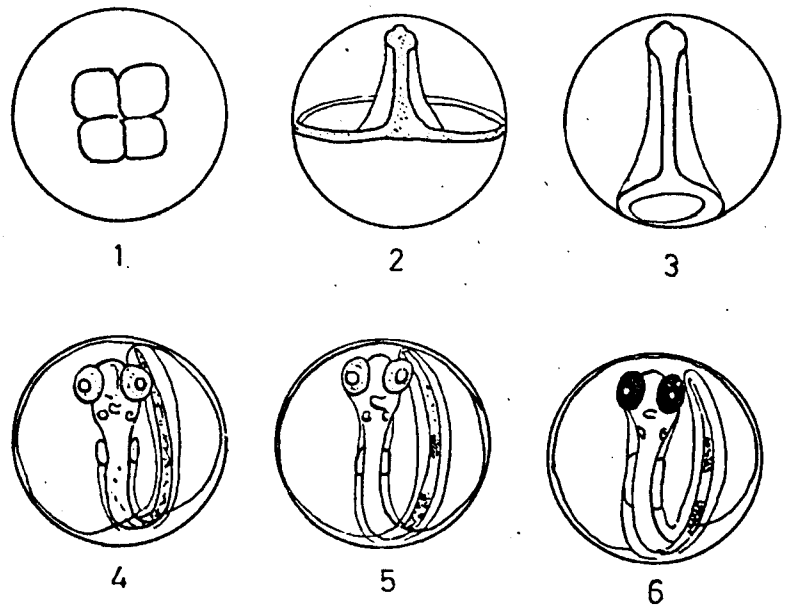

Fig. 2. Development stages of cod eggs. 1 - 2 = stage I, 3 - 4 = stage II, 5 - 6 = stage III (from DANNEVIG 1919).

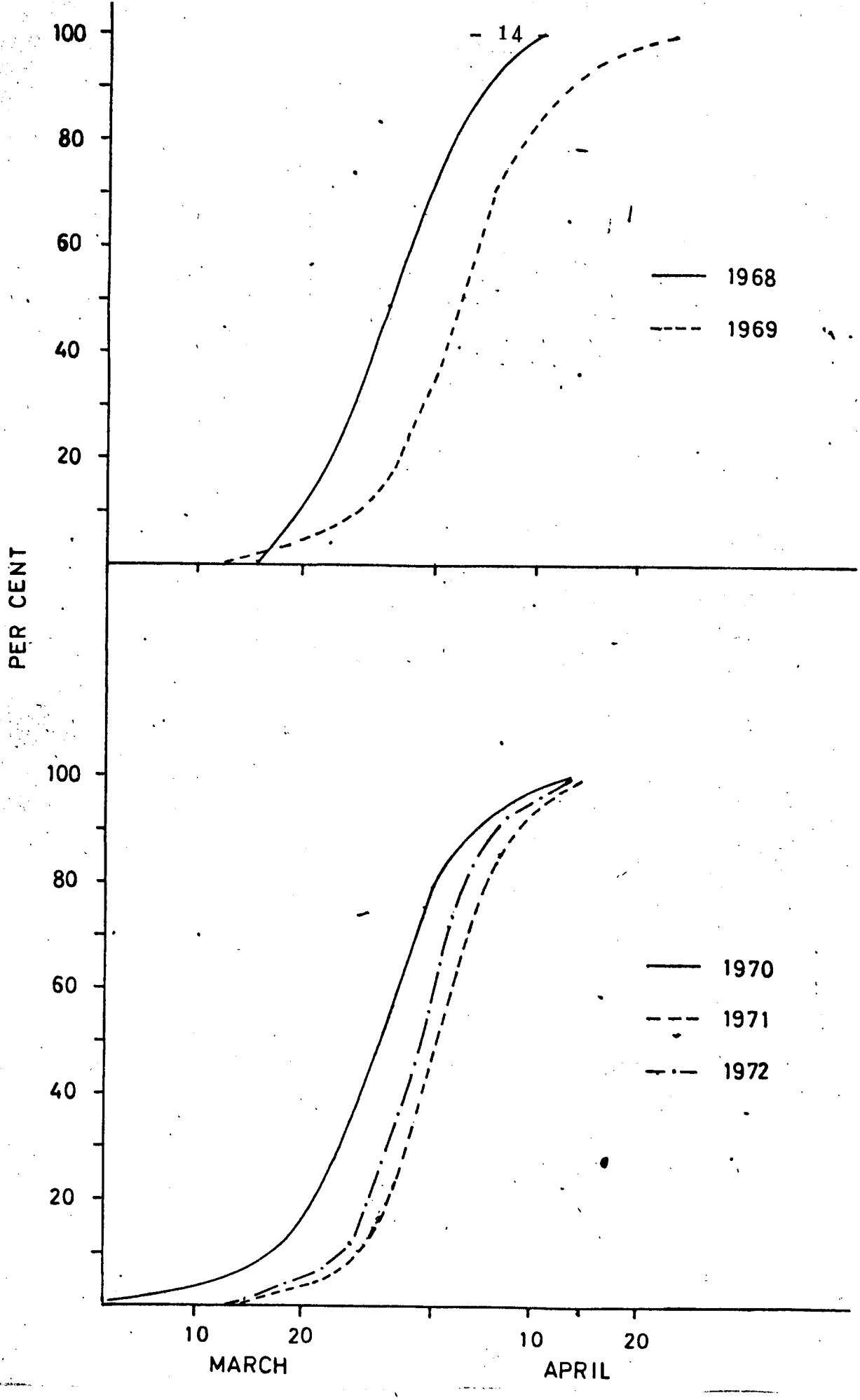

Fig. 3. Yearly spawning curves from 1968 - 1972 based upon sampling results from mature fish, adjusted according to egg sampling figures.

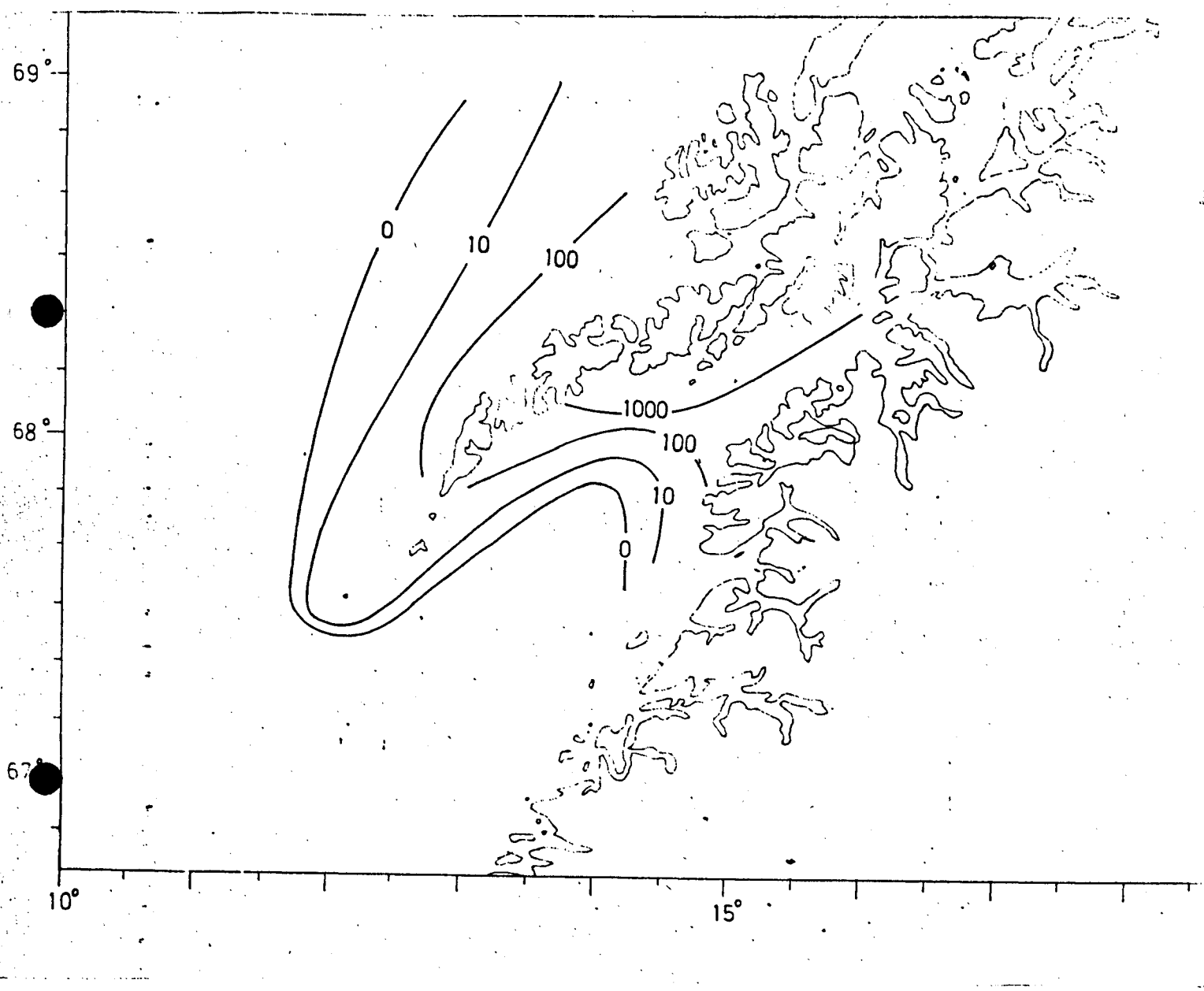

Fig. 4. The usual horizontal distribution pattern of cod eggs in sub-areas 0 - IV in early April.

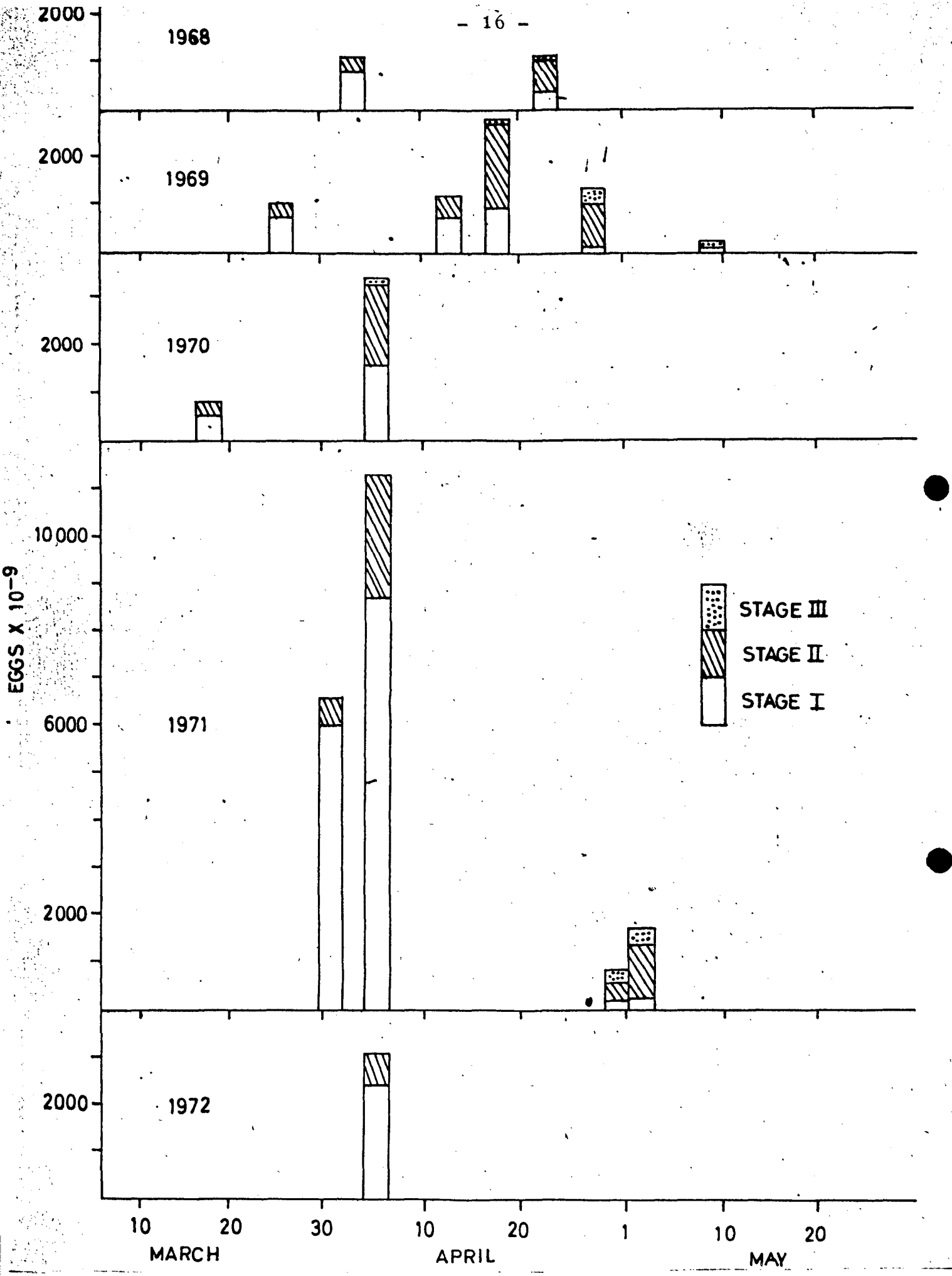

Fig. 5. The abundance figures of each egg stage from every survey of areas 0 - II.

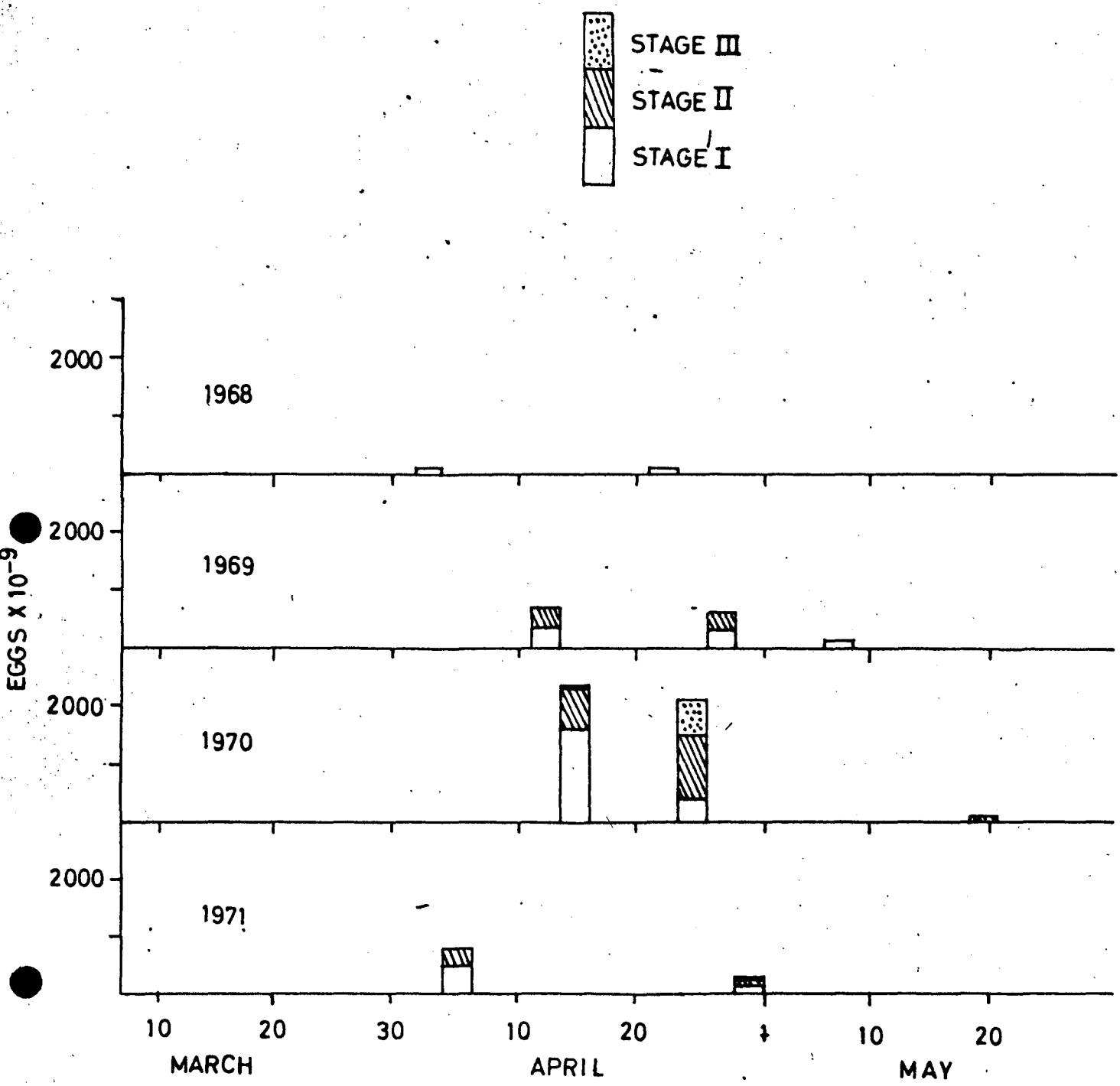

Fig. 6. The abundance figures of each egg stage from every survey of areas III and IV, excepting 1972 when no survey was conducted.

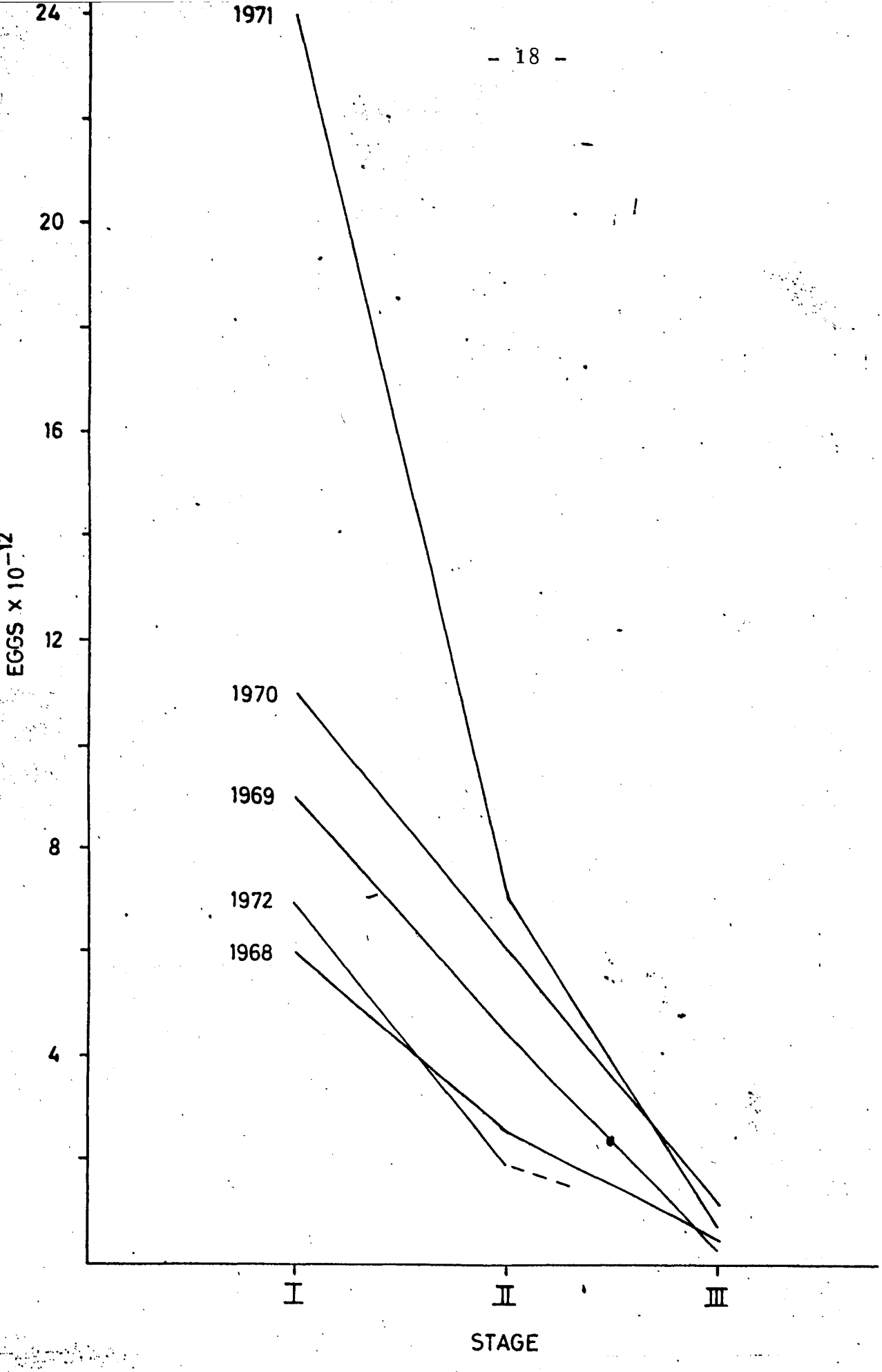

Fig. 7. Total estimates of eggmasses of each stage in areas 0 - II.

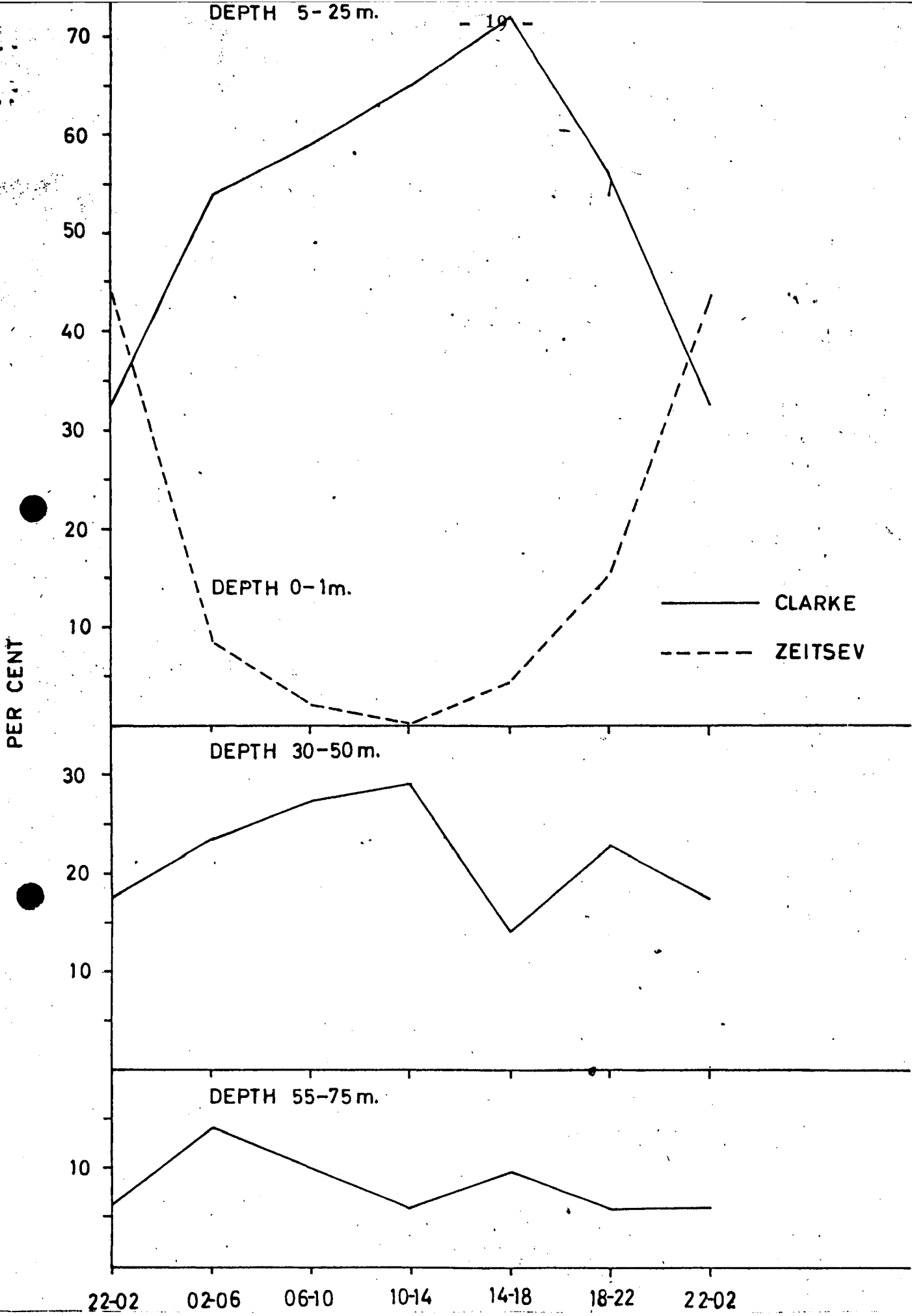

Fig. 8. Larval figures from stations where three standard depth hauls and the surface haul were taken i 1970 and 1971. Haul times over 24 hours are divided into 6 intervals. The curves show the percentage