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Migration, Environmental Changes and Otolith Ring Typing in Flemish Cap Cod

by

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ABSTRACT

The otoliths of different Flemish Cap cod cohorts are studied for the period 1980 to 1989.

It is shown that the annual classes of Flemish Cap cod from 1979 to 1989 provide no evidence of migration. This conclusion is based on a study of their otoliths following the characterization of the rings applied to Greenland cod (H-J Ratz, 1990).

INTRODUCTION

There are doubts about the discreteness of the cod population on Flemish Cap.

Extensive Canadian tagging of cod in Newfoundland and Flemish Cap (Templeman, 1974, 1979), and Russian tagging in Subareas 2 and 3 Konstantinov (1967) show no significant records of tagged cod having migrated to Flemish Cap from other areas or vice versa.

Other authors suppose that when cod reaches maturity, a migration from Flemish Cap to Grand Bank would take place (Cardenas et al., 1992) and this can explain the special partial recruitment distribution obtained for this stock (Cardenas and Pereiro, 1990)

Cod otoliths contain a great deal of information concerning the life histories of individuals in their physical, chemical, and morphological structures. The ossification of these rings contains signals which may be periodic in response to daily and annual cycles and which allow the age to be calculated, or they may be aperiodic in response to specific events such as maturation, habitat change, migrations, etc.

In the present work, these aperiodic structures are used with the main aim of deciding whether the migratory strategy of Flemish Cap cod is similar to that of Greenland cod (H-J Ratz, 1990).In that system, each annual growth ring is classified into three possible types (A,B y C)(table III, figs. 1 y 2), and the frequencies with which each type occurs in the area considered are checked. According to Ratz's hypothesis, a significant increase in one ring type for a given area and age of fish can only be explained by a higher immigration rate of fish of this type and of the same age or older than the change. Thus if individuals of age 5 years or more have a typing of rings 1 to 4 clearly distinct from that of ages 1 to 4, we conclude that there has been an immigration of fish of age 5 years or more from an area where the typing of the earlier age groups has a different frequency.

To test this hypothesis in Flemish Cap, 6591 cod otoliths from the area were chosen in such a way as to represent as far as possible all months of the year, the length range in each age group, and the age groups corresponding to the year classes from 1980 to 1989 (tables I y II).

MATERIALS and METHODS.-

The otoliths for this study were obtained by sampling the catches of commercial ships since 1985, as well as during community research cruises on Flemish Cap(1988, 1989, 1990 y 1991).

Those otoliths in the best condition were selected in such a way, that a maximum of 100 were available for each age and sex for each cohort, covering all sizes, and as far as possible all times of the year and all depths (tables I y II).

Biological information (length, sex and weight of each fish) and dates of capture are available for this material .

Otoliths were cleaned by being placed in vials with distilled water, and agitated for 12 hours at 30 centigrade degrees . They were then dried in an oven at 60 degrees for 24 hours. Otolith weights were determined on a Metler H80 balance. The length, width and thickness in the nuclear zone were measured with a Mitutoyo electronic caliper.

A further otolith sample was taken randomly from each age group and cohort. These were used to differentiate the different kinds of otoliths which can exist, as well as detect possible errors in reading.

In a later phase of the study, the entire otolith was embedded in polyester resin, and a 0.8 mm section cut to include the nucleus. These sections were examined with a binocular microscope using transmitted light, to identify features characteristic of each cohort

These new observations (new age estimates, ring types), as well as the subjective degree of confidence in all these (estimated at four levels) were also recorded.

The collection of otoliths sections was stored in slides with numbered envelopes for their rapid localization, and was complemented with a collection of photographs of the same otoliths characterized by their clarity and the high degree of confidence in the age reading, the presence of distinctive features (false rings, spawning rings, strongly or weakly marked hyaline rings) which help us to identify and characterize different kinds of otoliths.

RESULTS

The main conclusions are that there was no indication of immigration of the year classes from 1980 to 1989 in the area considered, and that the different annual ring structures are produced by environmental changes in Flemish Cap itself.

fig. 3 shows the percentages of ring types grouped by age class and zones of annual growth. We can see that the percentage of type A has a tendency to increase in rings of greater age independently of the age groups considered. Thus according to Ratz hypothesis, there is no evidence of immigration of cod from other areas.

We can see from the year class data (fig. 4) that percentage appearances of each ring type follow different patterns according to which cohort is considered. For example, the 1986 cohort has a minimum of type A in the first annual ring, that of 1985 in the second, etc.

Fig. 5 shows these data by cohort according to the year in which each ring formed. The years marked in gray are those in which the mean temperature was particularly low (Drinkwater et al., 1991). The ordinate indicates the proportion in which type A appears, but for greater clarity the cohorts are separated. The minimal percentages for each cohort are entered below the corresponding curves.

We can see from fig. 5 that immediately after the particularly cold years the percentage of type A rings in each cohort is minimal.

We conclude that ring type variations are more closely related to environmental changes than to any possible migrations.

The same figure shows that cohorts which originate in cold years tend to have higher proportions of type A rings at each age.

DISCUSSION

The main conclusions of this study are that there are no indications of immigration into the year classes from 1980 to 1989 in the area studied, and that the different structures found in the annual rings are produced by environmental changes in Flemish Cap waters themselves.

Using Ratz's hypothesis to calculate the extent of migration in Greenland cod, we can deduce that immigration of cod to Flemish Cap does not take place.

But if we take into account the different types of ring grouped by cohorts, we can show that the general pattern of frequencies is linked to the occurrence of cold years in the Flemish Cap area. These cold years on Flemish Cap do not coincide with those on the Grand Banks, so that we anticipate different typing patterns in cod from the latter region.

It is also shown that cohorts which originate in cold years tend to have a higher proportion of type A rings at each age than other cohorts.

Thus for Flemish Cap cod year classes, we see that less rings of type A are produced in cold years in all cohorts which appear in the fishery in those years.

In an earlier work (G. Perez-Gandaras and J. Zamarro 1990) we found a relationship for Flemish Cap which links cold years to the appearance of more slowly growing but more abundant cohorts.

All the processes identified can be integrated into a hypothesis which relates the availability of food in the area to intraspecific competition between the different age groups.

If a cold year favours the appearance of a very abundant year class, competition for the limited food resources will be intensified. This will produce a higher proportion of poorly fed individuals, which we suppose leads to lower growth and the production of type A rings. But at the same time, these large concentrations of juveniles can boost, directly or indirectly, the feeding of older cod. The mean rate of cannibalism in samples collected between 1988 and 1990 was about 2% in this area (Paz et al 1991). This higher availability of food for other age groups will produce a higher frequency of well fed individuals, resulting in better growth and more rings of types B and C.

The demonstrated importance of special oceanographic conditions in certain years to Flemish Cap cod, and the absence of immigration to this population, should complement similar studies of cod in zone 2J3KL which are subjected to different conditions, and which may indicate that the recent disappearance of cod from this zone is more related to environmental changes than to overfishing.

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TABLE I.- Otoliths number by age for the cohorts 1980-89

AGE	COHORTS										
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	TOTAL
1	-	-	-	-	-	-	10	20	117	61	208
2	-	-	-	-	-	50	139	100	179	176	644
3	-	-	-	-	135	161	206	206	276	-	984
4	-	-	-	142	182	191	405	219	1	-	1130
5	-	-	155	136	210	331	359	2	-	-	1193
6	-	189	53	179	258	379	1	-	-	-	1059
7	187	91	96	149	302	-	-	-	-	-	825
8	36	73	60	141	-	-	-	-	-	-	310
9	16	32	97	-	-	-	-	-	-	-	145
10	9	52	-	-	-	-	-	-	-	-	61
11	32	-	-	-	-	-	-	-	-	-	32
TOTAL	280	437	461	747	1087	1112	1120	537	573	237	6591

TABLE II.- Otoliths number by month for the cohorts 1980-89

MONTHS	COHORTS										
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	TOTAL
JAN	-	-	1	-	6	13	65	3	-	-	88
FEB	37	62	50	36	27	19	12	-	-	-	243
MAR	57	69	43	32	46	35	35	23	15	1	356
APR	-	4	15	32	39	41	58	24	4	-	217
MAY	3	23	35	74	62	78	89	37	34	17	452
JUN	25	37	26	19	27	22	16	4	19	-	195
JUL	12	54	80	293	443	612	595	377	450	213	3129
AUG	43	45	49	45	90	42	25	4	-	-	343
SEP	46	36	29	70	52	69	38	-	-	-	340
OCT	35	48	44	50	118	85	69	30	11	1	491
NOV	18	46	68	61	124	47	45	16	26	5	456
DEC	4	13	21	35	53	46	73	19	14	-	281
TOTAL	280	437	461	747	1087	1112	1120	537	573	237	6591

TABLE III.- Descriptions of the 3 types of annual growth zones in cod otoliths

Type A - The annula growth zones is divided into a compact opaque and hyaline zone. The hyaline zone consists of either a compact ring or a only few rings laying close together and clearly separated from the neighbouring opaque zones.

Type B - The opaque and hyaline components of the annual growth zones are no compact. The diffuse character originates from fine ring structures wich forms a relatively broad transitional zones or secundary (check) rings. No sharp borders exists between the zones but they still form an easily seen system of annuli.

Type C - Some of the innermost annual growth zones are relatively easy to identify and could eventually be classified as type A or B, although the hyaline component seems to be of slighty different nature, in some cases it has a middle opaque part giving the character of a hyaline double zone. Thereafter the otolith looses the clear separation between hyaline and opaque zones and changes to a diffuse nature. Sometimes these rings appear as an unclear and shadowy structures.

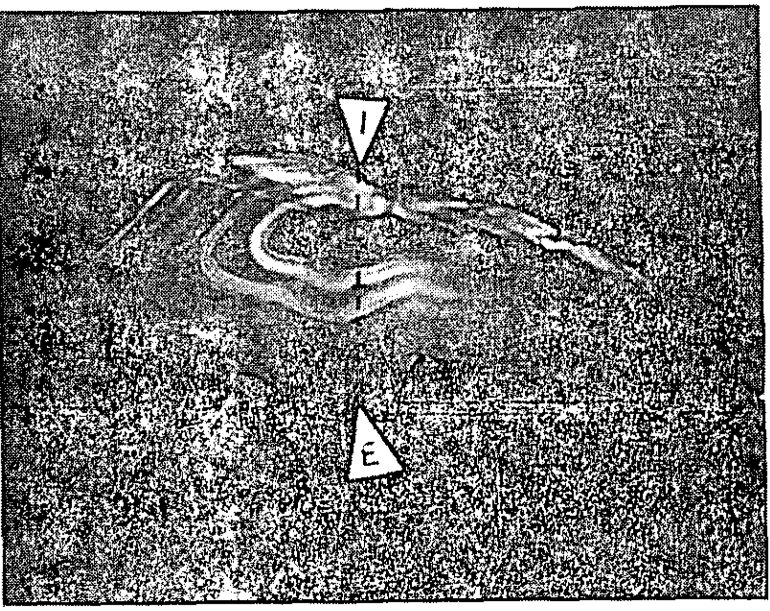

Fig 1 .- Annual growth zones type A. Top view on the surface of cut of a otolith showing 5 annual growth zones type A.

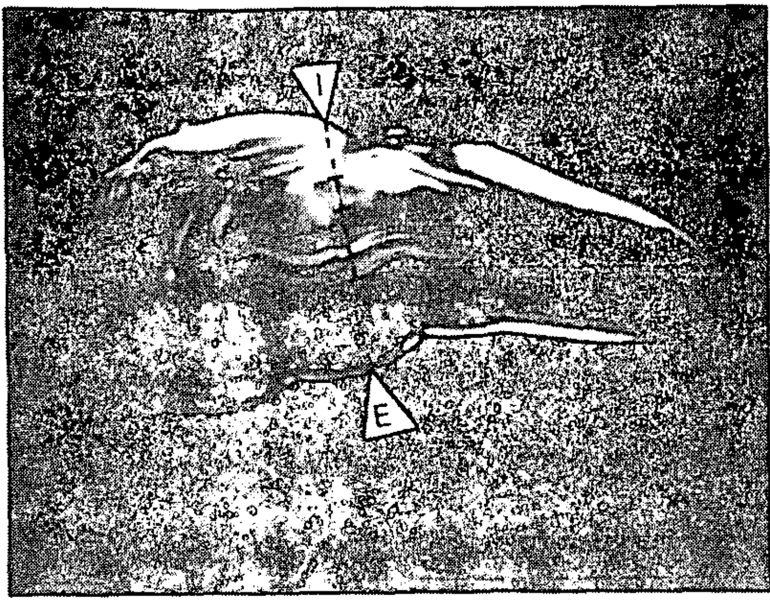

Fig 2 .- Annual growth zones type B. Top view on the surface of cut of a otolith showing 6 annual growth zones type B.

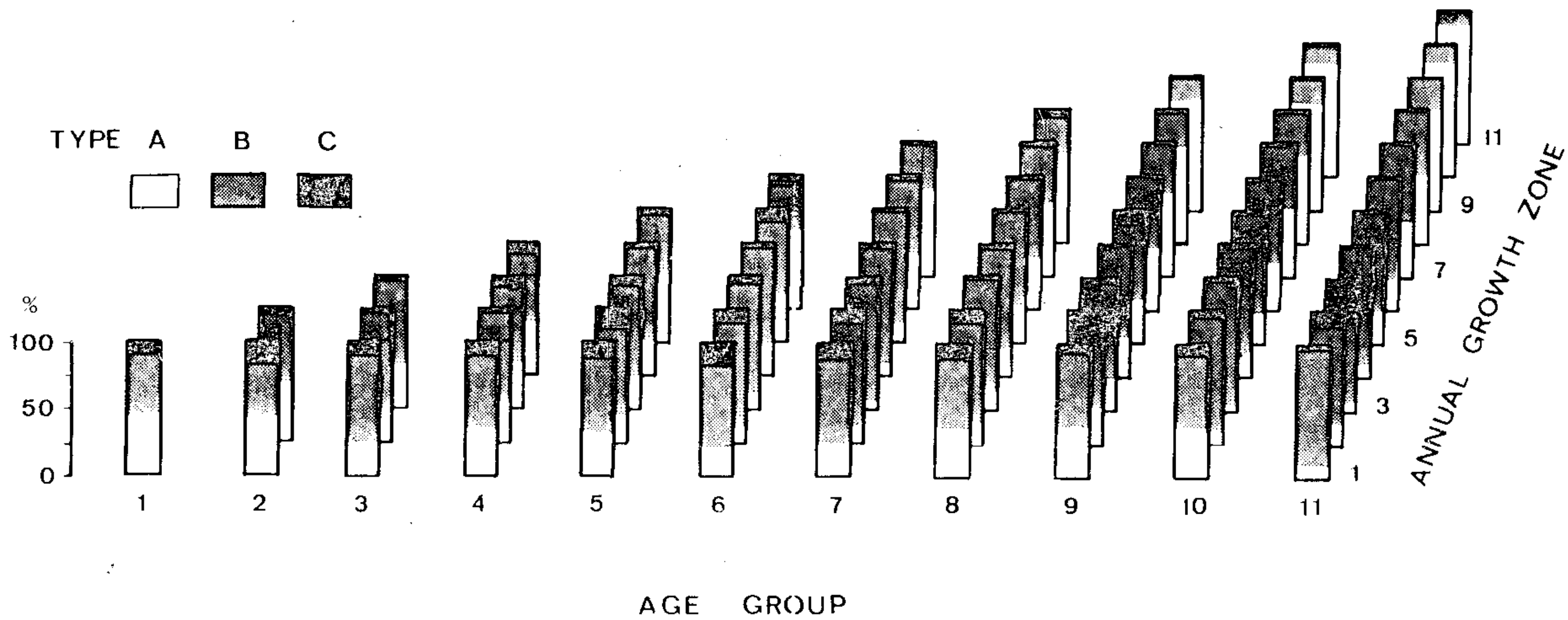

Fig 3.- Percentage ocurrence of the types of annual growth zones by age group.

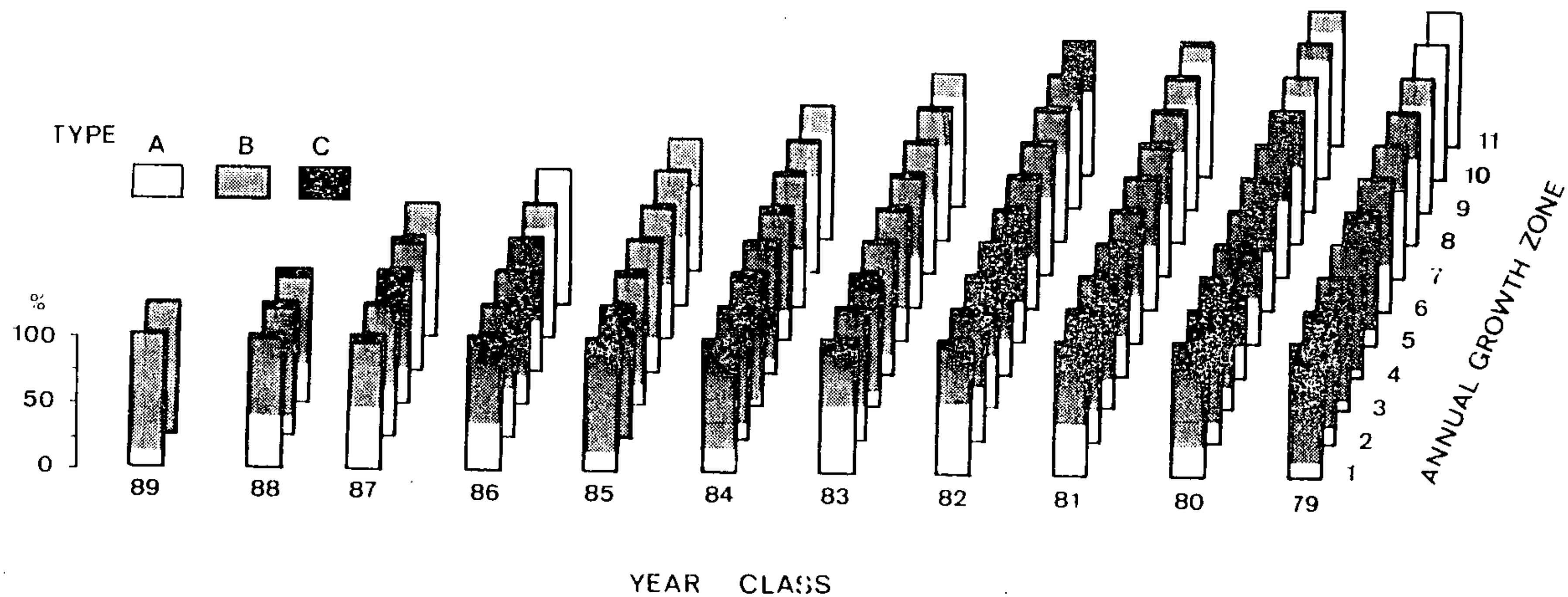

Fig 4.- Percentage ocurrence of the types of annual growth zones by year class.

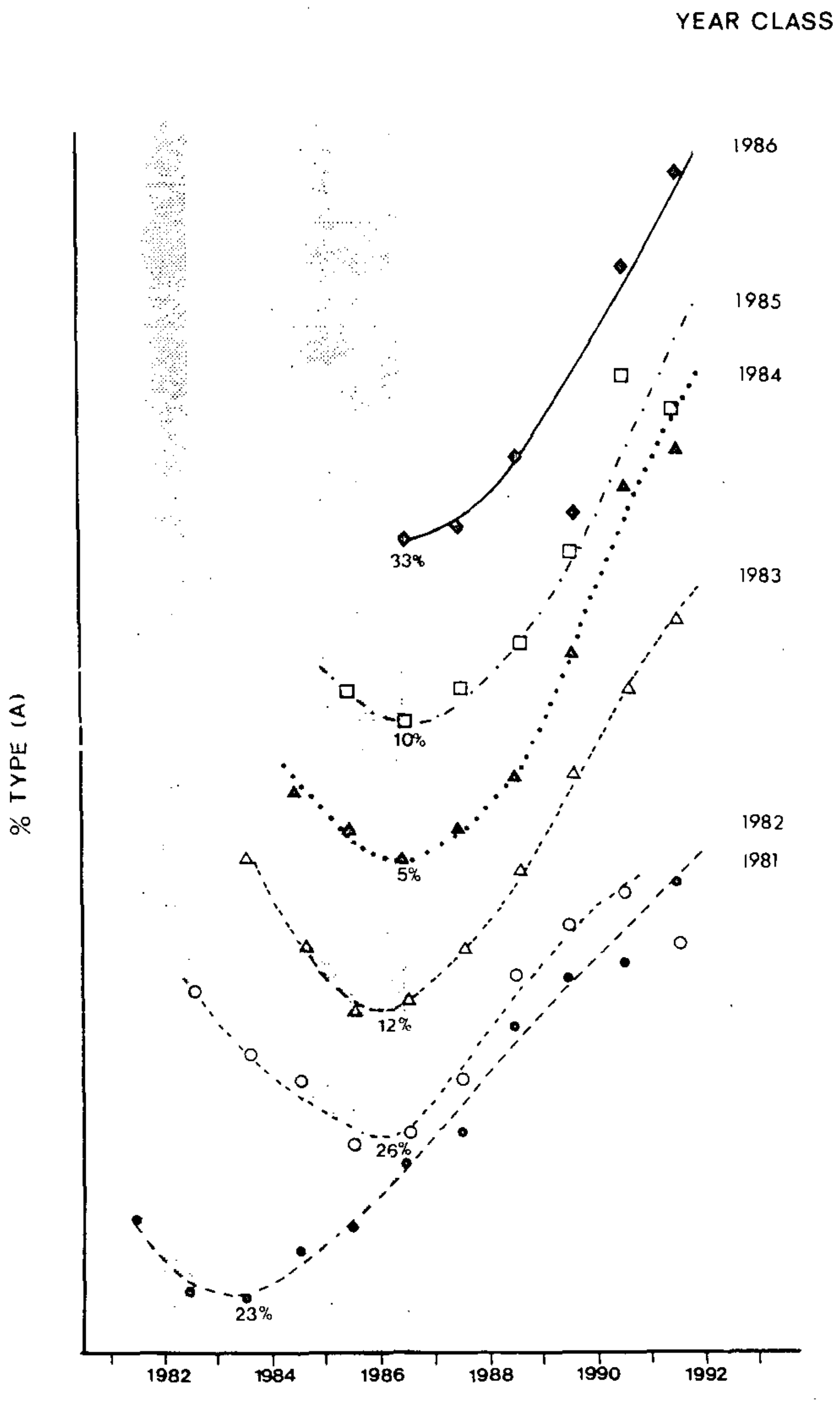

Fig 5 .- Percentage ocurrence of annual growth zones of type A by years and cohorts. The years with negative annual seasurface temperatures anomalies (1982, 1985 and 1986), are shaded.