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Changes in the Cohort Growth Rate of Flemish Cap Cod

by

Cerman P-Gandaras and Javier Zamarro

Instituto of Investigations Marinas
Eduardo Cabello 6, Vigo, Spain

ABSTRACT

The cohort growth rate of the Flemish Cap cod was studied, using data from Canadian research surveys in the period 1977 - 1985, fishing data from the Spanish commercial catches between 1986 and 1987, and data from a research survey carried out by Spain in 1988.

We notice that cod growth is linear during the first years of its life. This period may last from five to eleven years in these cohorts.

These growth rates show a positive correlation with water temperature in the upper 50 m. during the year of larvae eclosion, and a negative one with the abundance of the same cohort.

The growth rates seem to be affected only by initial conditions in the history of each cohort, as abundance or temperature, and also seem to be independent of later changes such as fishing effort, food availability or abundance of other cohorts. We think that the biological parameter variations displayed by the different cohorts indicate a strategic response to changes in enviromental conditions.

These growth differences cause size changes in individuals of the same age but belonging to different cohorts. These different sizes show a gradual change, with the smallest sizes for the 1974 and 1982 cohorts and the largets ones in 1978.

The sizes of first maturity of females from 1978 to 1985 vary following the size trends of individuals at the age of four. Thus, we suppose that this must be the minimum age at which ovarian maturation in cod takes place.

INTRODUCTION

Flemish Cap cod is a fit population to study variations in year classes, why they are produced, and generally, to understand the possible interactions between fishing, environment and life strategy of the species (Akenhead 1982).

This cod makes up a relatively large stock, genetically isolated and showing great fluctuations in abundance (Lear 1981,Templeman 1976).

From the environmental point of view the above-mentioned stock is arranged within a small area , with special and well-known oceanografic characteristics, as it is located at the border zone between the cold, salt Labrador Current waters and the warmer and saltier ones of the North Atlantic current. This situation may cause sharp changes in the conditions (Keeley 1982).

Finally, from a political and fishery point of view, this stock forms a population subjected to have been fished since long ago and that, with the 200-mile increase in the Canada economic zone, it had to undergo an intensive fishing activity, what has given place to an overfishing situation and the preventive closing of the bank in 1988.

In dynamics of the vertebrate populations, the factors considered as decisive are; reproduction, growth, dispersion and mortality. Variations in one or several of these factors may give answers,within the life strategy of the species, to particular environmental conditions.

It is well known that the cod growth rate presents geographical and, for the same area, interannual variations. The factors which these changes are usually associated with are basically three; environment, food disponibility and population density.

In Flemish Cap cod these changes have been described by Bishop (1977) and Wells (1983b). In spite of the said works, the relations between biological parameters of the species and environmental conditions is not very clear. This confusion may be due to the consideration of the population studied as a whole at the sampling moment .

On the contrary, we think that parameters like growth, abundance, condition index, sexual maturity etc, are characteristic of every cohort and are related to the environmental conditions existing at "critical moments" of their history.

For all that above mentioned, in the present paper we carry out the analisys of the cod biological variations of the Flemish Cap by cohorts; we find significant relations between the cohort growth rate, abundance and the temperature they were withstanding at the very first moments just after the eclosion .

We think that the differential biological characterization of every cohort is necessary in order to understand the cod stock dynamics in the Flemish Cap.

MATERIAL and METHODS

Cohort growth rates were calculated from mean lenghts by age got in different surveys . For the 1977 - 1985 period the mean sizes obtained by Canada in their annual surveys in 3M(Wells 1983c,1986b) were used; for the years 1986 and 1987 the mean sizes by age of the spanish commercial catch in Flemish Cap were used; and the data 1988 and 1989 are from the EEC surveys in this area.

With all these data we have reconstructed the growth of the cohorts from 1973 to 1983, Tabla I. The age indicated is the one corresponding to the moment of the sampling, considering january as the reference time for the change of age.

In the growing of every cohort two phases were appreciated: the initial one with a fast growing, and a good fitness to a straight line; and another one with a slower growing for the older individuals. In this paper the growth rate used is the slope of the regression line during the initial phase, table II.

We tried relating these growth rates to estimations of the total abundance of the population, cohort size and temperature during the development of the larvae, table III.

As indicator of the population abundance the catch per half an hour trawl in the canadian surveys from 1977 to 1985 (Wells et alia 1985) was used.

The ab1 was calculated as the square root of the number of individuals at the age of four obtained in the canadian surveys from 1977 to 1985 (Wells 1983a, Wells et alia 1985). For the calculation of ab2 the catch per hour of trawling from the soviet surveys reported by Bulatova (1984) was used; from these values the square root was obtained and the table got was normalized by ages; in this way we got three estimates corresponding to ages 1, 2 and 3 for each cohort. Finally, the relative abundance considered was the average of these three values.

The mean temperature up to 50 metres deep in the soviet station 4A (Konstantinov 1981) was used as representative of that one which the first stages of each cohort were developped in.

RESULTS

The growth by cohorts from 1973 to 1983 is expresed in figure 1. The parametres used to calculate these regression lines are in table II. This linear growth took place between 5 and 12 years depending on the given cohort.

The good fitness of the mean size by age to a straight line, during the linear phase of growing, is indicative of a very early determination of this growth rate. On the other side, the coexistence in the fishery of about ten cohorts with differnt fixed growth rates shows that these differences, once defined, are independent of factors like food availability , abundance and enviroment.

In order to know how many factors during the early stages of development may determine the growth rates found we looked for possible relations between these rates and the available information in the beginning of each cohort.

The linear growth rates present a significant and negative correlation with the size of the cohort (fig. 2), in such a way that strong year classes have comparatively lower growth rates.

With regard to the mean temperature in may, up to 50 meters deep in the station 4A (Konstantinov 1980), the correlation is significant and positive (Figure 3). High mean temperatures happen in 4A at the same time that cohorts with comparatively higher growth rates.

The graphic representation of the mean size by age from 1978 to 1988 (Figure 4) shows that the changes in cohort growth are not sharp but there is a continuous tendency during some years. So for the mean size at the age of 4 there is a minimum in 1978, with a tendency to be increased up to the maximun in 1983, to decrease again later.

There is not available information about the first maturation by cohorts, but if we express the annual size of first maturation of Flemish Cap cod (Wells 1986a) in figure 4 we may observe that there is an association of the changes of this size with the changes of the mean size at the age of 4.

We found neither significant correlations between the total biomass of the stock and the growth rates nor too significant correlations between cohort abundance and temperature up to the depth of 50 m in station 4A.

DISCUSSION

The relation between size and age in sexual maturation is, at present time, little clear. While in species like the American plaice the size is the determinant of its maturation (Pitt 1975), for others like the witch flounder (Bowering 1987) and cod (Beachham 1983) there are changes both in size and the age of maturation.

In figure 4, as the changes in the mean size at the age of 4 are associated with the changes in the first maturation, we may observe the same wave in both series of values. Then, we can suppose that this maturation depends on the age and not on the size, and the minimum necessary age for ovary maturation would be four years.

Kontastinov (1980, 1981) found a negative relation in Flemish Cap between temperature and year-class size. We have also found similar correlations but not significant. However, when relating the mean temperature during the first 50 metres in station 4A, used by Konstantinov, to the growth rates we get a significant and positive correlation. High temperatures are associated with favourable conditions for the cohort growing. For Solemdal (1970) the cod larvae have a growing directly correlated to the temperature, what agrees with our results.

The growth changes in the commercially interesting North West Atlantic species have been associated with different factors. Thus, in cod, Kohler (1964) conditions these changes to environmental factors, mainly temperature; Fleming (1960) and Pinhorn (1969) to food availability. But, the most frequent factor considered as responsible of the growth changes has been the population density, Pitt (1975) in Hippoglossoides platessoides, Bowering and Brodie (1984) in Glyptocephalus cynoglossus , Templeman and Bishop (1979) in Melanogrammus aeglefinus and May (1966), and Wells (1983b, 1984) inGadus morhua. Other authors consider that the growing of adults is not densodependent (van Beek 1989).

Our results show the existence of a densodependency in the growth of the Flemish Cap cod, but such a dependency is originated only between individuals of the same cohort and in very early stages of their development.

According to Shepher and Cushing (1980) the densodependent regulation of the recruitments would happen during the first year of their lives. The mechanism of recruitment regulation proposed by them is based on the existence of a "critical size" for the larvae, under which mortality is very high. The time spent by the larvae in achieving the said size would depend on growth, which at the same time, also depends on the food and this last on the larva abundance.

This hypothesis turns out to be attractive because it relates the densodependent survival to the densodepedent growth, but there is not much empiric evidence to support it. The present paper shows a densodependent growth determined in early stages, supporting in this way this aspect of the mechanism for the recruitment regulation proposed by Sheperd and Cushing.

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TABLE 1 Average size by age for the diffent cohorts of Flemish Cap cod

COHORT	73		74		75		76	
	AGE	SIZE	AGE	SIZE	AGE	SIZE	AGE	SIZE
	-	-	-	-	-	-	-	-
	-	-	-	-	2.17	20.15	2.17	19.5
	-	-	3.17	26.05	3.17	27.88	3.17	29.47
	4.17	44.46	4.17	35.16	4.17	40.64	4.17	40.40
	5.17	48.40	5.17	45.77	5.17	54.26	5.17	52.24
	6.17	56.07	6.17	59.48	6.17	62.50	6.17	66.82
	7.17	69.37	7.17	66.43	7.17	74.57	7.17	76.37
	8.17	75.73	8.17	79.19	8.17	82.19	8.17	92.31
	9.17	-	9.17	83.71	9.17	95.17	9.17	94.00
	10.17	94.79	10.17	95.29	10.17	104.50	-	-
	11.17	100.85	11.17	106.80	-	-	-	-
	12.17	106.70	-	-	-	-	-	-

COHORT	77		78		79		80	
	AGE	SIZE	AGE	SIZE	AGE	SIZE	AGE	SIZE
	-	-	-	-	-	-	-	-
	2.17	24.49	2.17	22.86	-	-	2.17	30.97
	3.17	36.15	3.17	37.53	-	-	3.17	43.95
	4.17	48.08	4.17	52.31	4.17	50.96	4.17	58.18
	5.17	60.85	5.17	66.37	5.17	65.95	5.17	66.60
	6.17	72.50	6.17	80.64	6.17	76.00	6.83	66.91
	7.17	85.11	7.17	88.90	7.83	86.45	7.66	84.00
	8.17	91.40	8.83	96.47	8.66	93.00	8.58	92.00
	9.83	105.63	9.66	100.00	-	-	-	-

COHORT	81		82		83	
	AGE	SIZE	AGE	SIZE	AGE	SIZE
	-	-	1.17	12.37	1.17	14.64
	2.17	23.61	2.17	21.83	2.17	21.40
	3.17	35.32	3.17	30.60	3.83	40.86
	4.17	45.30	4.83	45.55	4.66	48.00
	5.83	55.42	5.66	55.00	5.58	60.60
	6.66	65.00	6.58	71.70	-	-
	7.58	83.80	-	-	-	-

TABLE II Analisys of the regression of the mean size by age during the linear phase of the growing by cohorts in Flemish Cap cod (Y.C = Year classe, SL = Slope, SD = Standar deviation, R.M = Residual mean square, N = number of years analised, R = Correlation coeficient, P = Provability ** > .99 * > .95

Y.C	SL	SD	R.M	N	R	P
1973	8.31	7.34	5.61	8	.996	**
1974	9.98	-5.15	3.99	9	.998	**
1975	10.71	-3.66	2.65	9	.999	**
1976	11.41	-5.79	9.37	8	.995	**
1977	11.54	0.14	3.48	7	.998	**
1978	14.44	-8.27	0.07	5	1.000	**
1979	12.52	-0.43	4.07	3	.994	-
1980	12.11	5.47	3.83	4	.995	*
1981	10.07	1.78	19.45	6	.983	**
1982	10.41	-1.42	10.64	6	.991	**
1983	10.48	0.61	3.78	5	.996	**

TABLE III Estimations of the cohort size (ab1 and ab2) and mean temperature up to 50 meters in the soviet station 4A (Konstantinov 1981)

COHORT	AB 1	AB 2	TEMP-4A
1971		0.030	
1972		-0.260	
1973	5.22	2.560	0.03
1974	3.94	0.620	0.68
1975	2.37	-0.350	1.67
1976	1.55	-0.650	0.83
1977	3.94	-0.180	1.99
1978	1.26	-0.650	3.23
1979	0.55	-0.840	1.64
1980	-	-0.360	2.35
1981	-	0.200	-
1982	-	-0.160	-

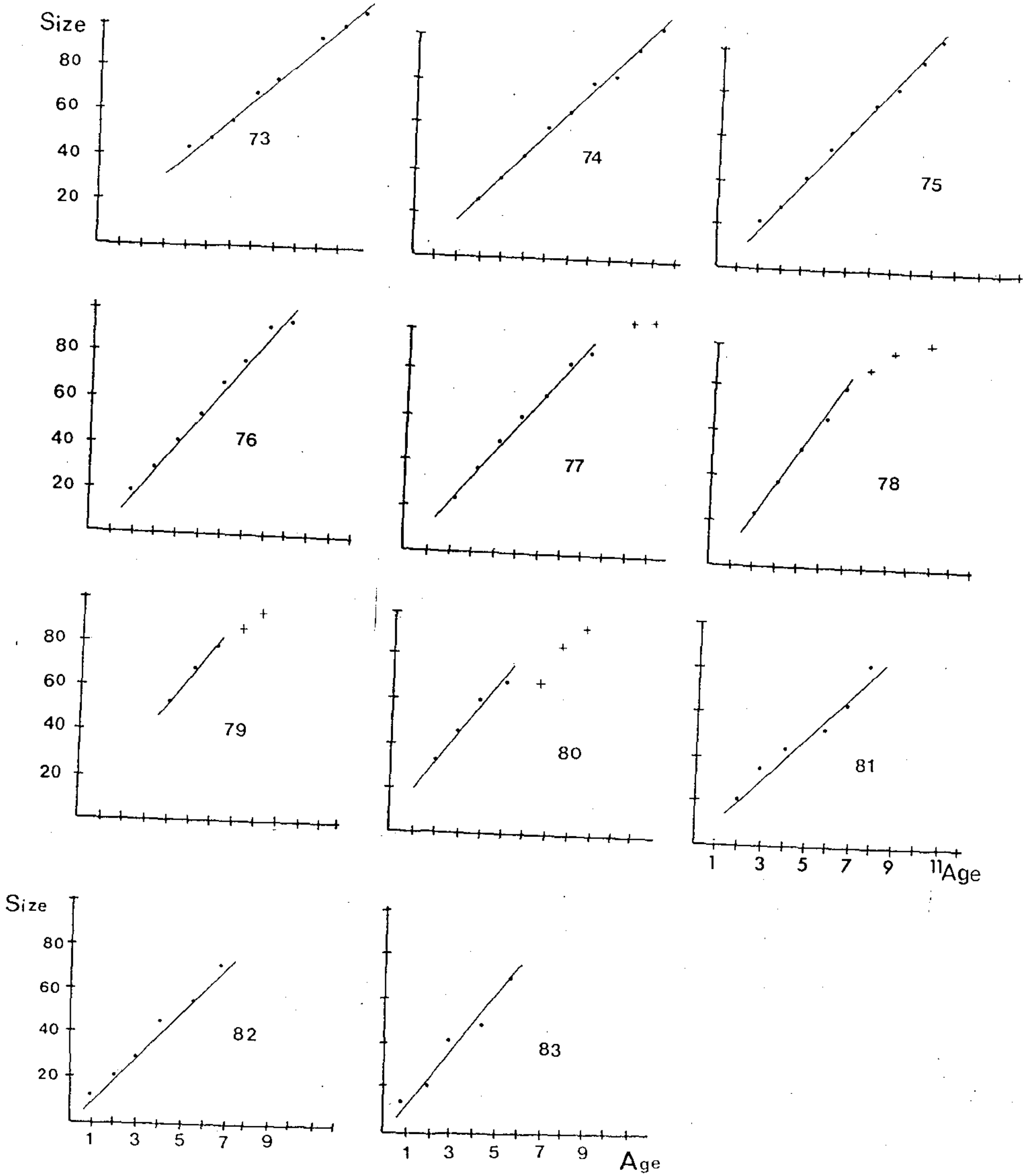

Figure 1. Linear growth by cohorts from 1973 to 1983 in Flemish Cap cod.

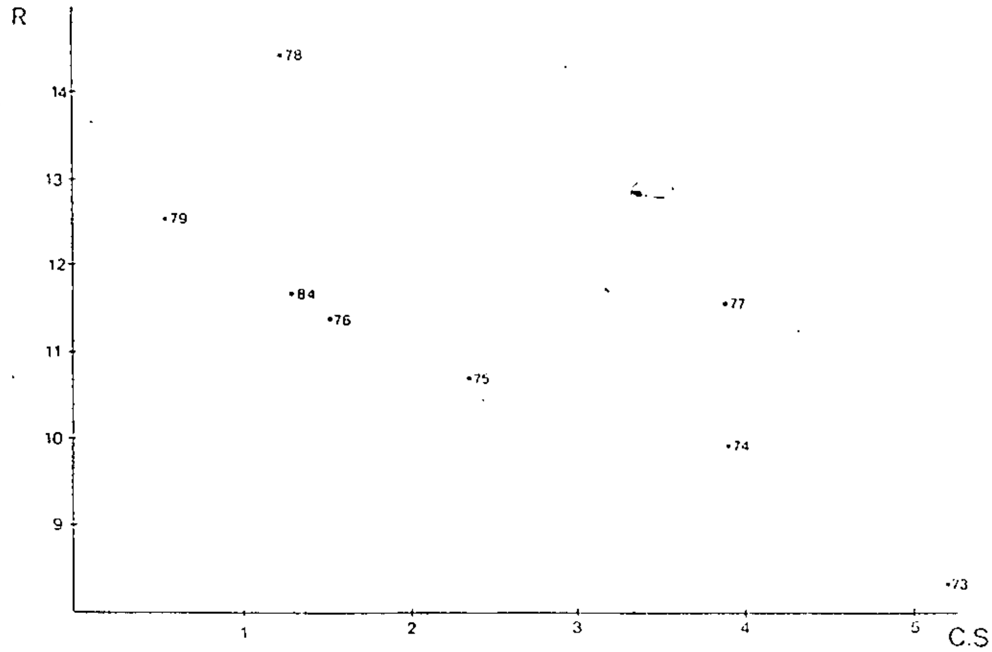

Figure 2. Relationship between linear growth rates by cohorts (R) and size of the cohort (C.S) (r = -0.79)

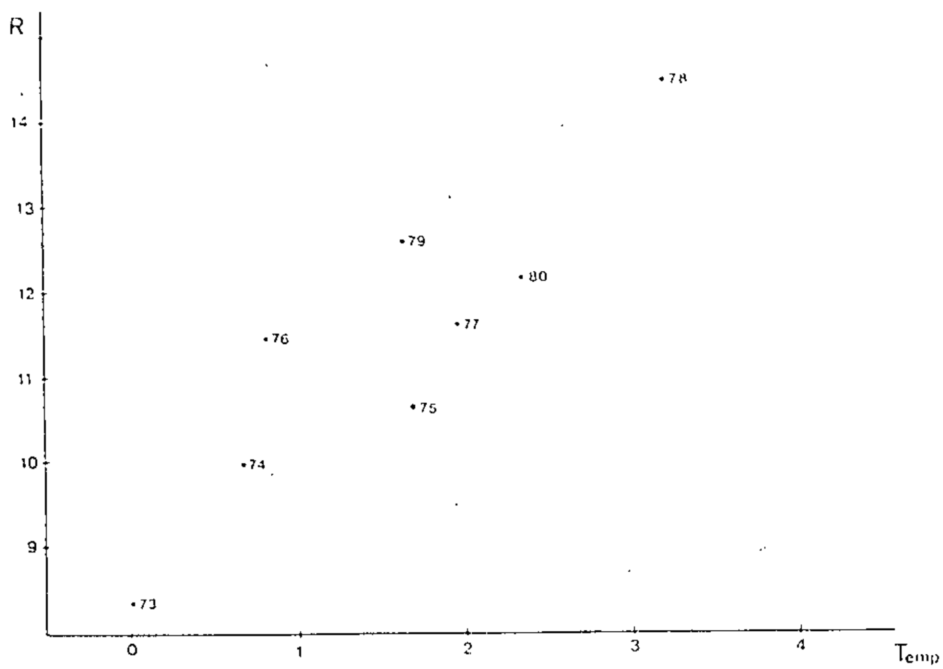

Figure 3. Relationship between the mean temperature in may up to 50 meters, in station 4A, and linear growth rates by cohorts (R) (r = 0.88)

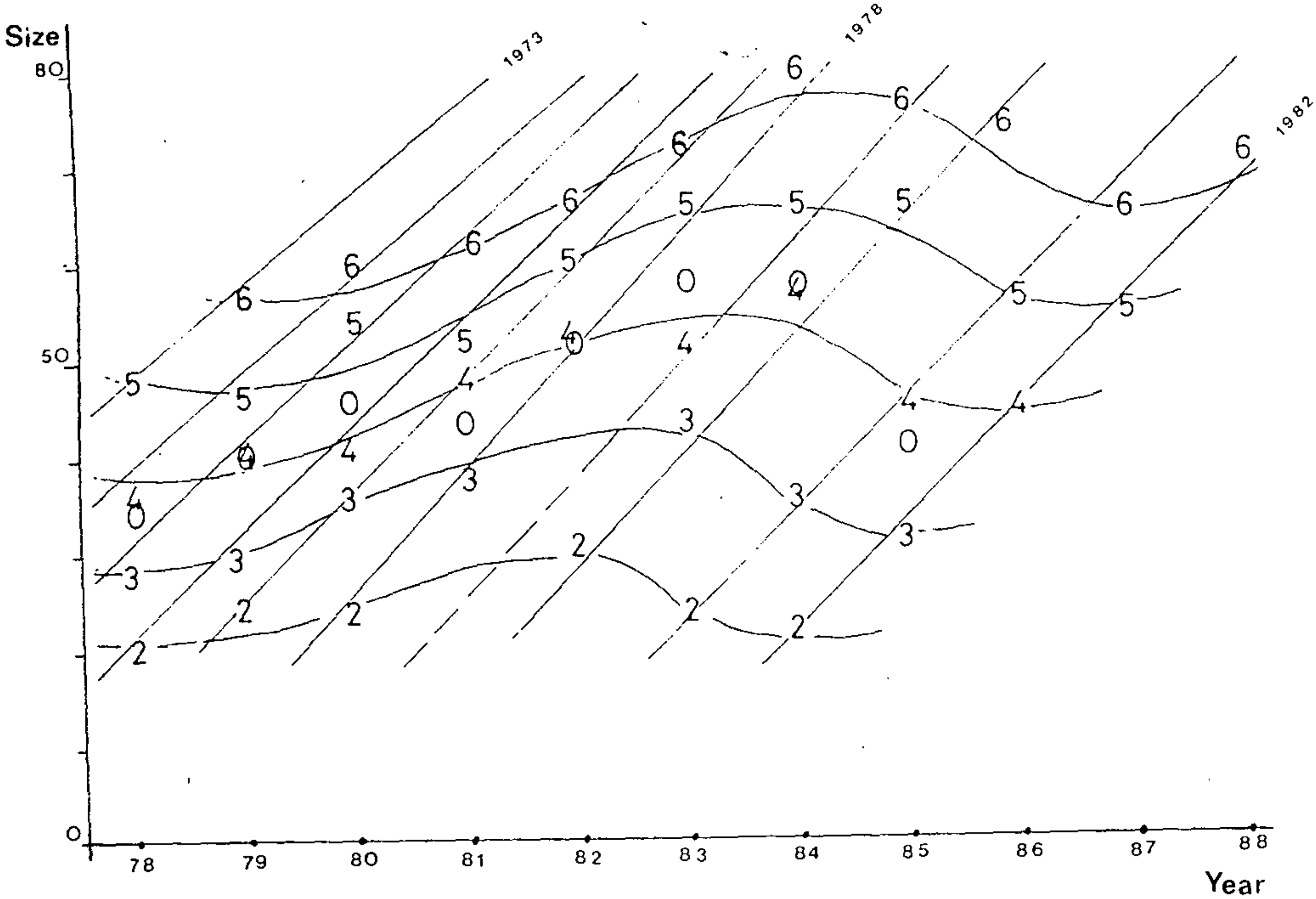

Figure 4. Relationship between mean size by age from 1978 to 1988, showing the tendency changes in cohort growth and the changes in the size of first maturation.(O)