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Summer Feeding of Cod (*Gadus morhua*) and its Relationship with Other Biological Parameters on Flemish Cap

by

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ABSTRACT

A ramdomly stratified bottom-trawl survey was carried out by C.E.E. on Flemish Cap (NAFO Div. 3M) in July and August 1989 and 1990. Cod stomachs were collected and studied: 1182 in 1989 and 530 in 1990. The cod were classified by age groups.

In a previous paper (Paz et al. 1990) we obtained several cod feeding indices and predation on redfish was also studied.

Here we analyze the empirical relatioship between the Fulness Index (F.I.) variation by age and year-class abundance variation. We also propose a model which links several biological parameters of the Flemish Cap cod population.

Ingestion of Hyperidae (mainly *Themisto sp.*) and young redfish (*Sebastes sp.*) are mainly responsible for F. I. variation in all year-classes in both years.

COD SYMPOSIUM, SEPTEMBER 1991

INTRODUCTION

Cod stomach were collected during two summer cruises carried out by B/O "CRYOS" and "IGNAT PAULIUCHENKOV" (Vazquez, 1990 and 1991).

Is well-known that the qualitative and quantitative composition of fish diets is important to growth, maturity and fecundity changes, but it is not clear how this occurs. Also, predation by Flemish Cap cod on smaller cod and redfish may produce variable mortality in small redfish, and contribute to variability in year class strength (Akenhead, 1978; Lilly, 1985).

It was noted in the Scientific Council Reports (1983): "Average length-at-age for cod increased considererably in recent years...It

was noted that on a qualitative basis, the changes observed in average length-at-age correspond to the perceived reduction in stock size. The stomach fullness index for cod < 60 cm. long was considerably greater in 1983 than in 1978... The relationship between increased food comsumption and a decrease in stock size is not known, but it deserves careful investigation".

Although the stomachs were sampled in summer, these months correspond to the period of highest feeding intensity (Turuk, 1981), and it is known that the diet is not very different during the rest of the year (Albikovskaya et al., 1989).

MATERIALS AND METHODS

The collection and treatment of the biological samples are described in Paz *et al.*, 1991.

The age distributions are shown in table 1 and the mean F. I. values including empty stomachs by age for the two years in table 2.

The fulness index frequency distribution by age appears in **fig. 1**.

The variation of the F. I. by cohort was calculated as the quotient between the mean F. I. at the same age in the two years sampled, i.e with age 3 1.661/0.941= 1.77, is the variation of the F.I. between 1987 and 1986 cohorts.

The variation of abundance between the 1986-1987 cohorts was evaluated as the quotient of the natural logarithms of population numbers for age 2 and 3 in the 1989 survey, and 3 and 4 in 1990. The mean of both values was used. The same process was used for the calculation of the year-class variation between the other cohorts. The results are as follows:

Year-classes	**1982-3**	**1983-4**	**1984-5**	**1985-6**	**1986-7**
Year-class variation	1.50	1.40	1.10	0.98	0.74
F. I. variation	1.22	0.91	1.61	1.32	1.77

The regression line has a negative slope (**fig. 2**). This empirical relationship between an increase in food consumption as year-class abundance decreases number provides a quantitative basis for density dependent growth in Flemish Cap cod.

With regard to the relation between the cod growth and year-class fluctuations in Flemish Cap, one of us (P.-Gandaras *et al.* 1990) obtained a negative relationship.

In 1989, most of the cod diet consisted of only two categories: Hyperiidae (mainly *Themisto sp.*) and *Sebastes sp.*. In tables 3 and 4 the Partial F. I. for these two items and the percentage of Total F. I. are given.

The high percentages indicate that the Flemish Cap F. I. variations depend basically of the two food items, Hyperiidae and redfish, a very simple feeding pattern (Paz et al. 1989) .

DISCUSSION

This results allows us to construct feed-back mechanisms between several biological parameters of the cod population which affect year class size. There are, of course, other underlying mechanisms underlying the recruitment problem. It is known that the formation of year-classes in general depends strongly on survival conditions during early life, i. e. throughout the embryonic, larval, and fingerling stages. But here we relate the year-class feeding (young and adults) with their reproductive variability and their subsequent size variation. The steps proposed are: a poor cod year-class feeds more that the strong year-class. So the former obtains a better condition. A better condition could can produce more favorable weight-at-age or size-at age, both of which can improve fecundity and/or reproductive variability (number and quality of eggs). So the cycle is closed with a higher survival probability in comparison with more abundant year-classes. (**fig. 3**)

Is is clear than many poorly studied problems lie behind each step in the proposed model. For example according to Serebryakov (1990) there is no close relatioship between population fecundity and subsequent recruitment in the Baltic cod. But we refers to the reproductive variability in each year-class, not to stock fecundity as a whole.

Rijnsdorp *et al.* (1991) say that the conditions for growth vary substantially between years but are independent of stock size for the North Sea cod. But in the Flemish Cap cod, an increase in average length-at-age occurs when stock size decreases (Wells, 1983).

Although there is insufficient information to test the model at all steps, severals publications provides provisional support.

Kjesbu, (1989) studied the spawning activity of cod and found a positive correlation between egg diameter and female length. Thus growth is positively related to reproductive variability in cod.

According to Walsh *et al.* (1986), during the 1978-85 period in Flemish Cap, on average 1/3 of the mature females did not spawn; this was probably related to the poor quantity and quality of their food. Waiwood (1982) indicates that in mature females cod fecundity is

related to growth during June to September. Woodhead and Woodhead (1965) concluded that in the Barents Sea cod, feeding condition (and hence growth) in the summer prior to spawning could influence fecundity in the next spawning season. In this way much of the individual variability in relative fecundity, encountered in nature, can be explained by differences in summer growth. Also Wells (1983) showed that egg numbers in Flemish Cap cod are *significantly* related to length, gonad volume and liver volume.

In short, it can be proposed that density reproduction (Ware, 1980) in Flemish Cap cod operates in conjuntion with density dependent growth as a buffer mechanism for year-class size variation.

However are necesary concret studies about fecundity variations and the reproductive variability in the Flemish Cap cod for to test our hypothesis.

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Cod age	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
1989 stomach numbers	-	7	7	242	467	387	55	9	6	2
1990 stomach numbers	14	30	85	44	106	103	86	28	17	17

Table 1.- Numbers of cod stomachs at age collected during summer 1989 and 1990 on Flemish Cap (NAFO Div, 3M).

Cod age	0	1	2	3	4	5	6	7	8	9+
1989										
Total F.I.	-	0.527	0.551	0.941	1.292	1.183	1.940	2.016	2.527	1.250
1990										
Total F.I.	4.6	1.168	1.472	1.661	1.710	1.900	1.758	2.453	1.731	1.063

Table 2.- Total Fullness Index for Atlantic cod by age groups in Flemish Cap. (summer 1989 and 1990)

Age Group	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Hyperiidae	.233	.341	.826	.755	.382	.056	.026	-
Sebastes sp.	-	-	.021	.348	.592	1.568	.826	2.527
Total F.I.	.527	.551	.941	1.292	1.183	1.940	2.016	2.527
% Hy.+Seb.	*44.2*	*61.9*	*90*	*85*	*82.3*	*83.7*	*42.3*	*100*
Nº stomachs	7	7	242	467	387	55	9	8
% empty stomachs	14.3	14.3	4.5	6.2	10.1	0	0	0

Table 3.- Total and Partial Fulness Index for the two main items. Atlantic cod by age groups in Flemish Cap. (July 1989).

Age Group	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Hyperiidae	.864	.787	1.207	1.566	1.524	1.523	.370	.034	.006
Sebastes sp.	1.885	-	.016	-	-	.115	.968	2.382	1.712
Total F.I.	4.60	1.168	1.472	1.661	1.71	1.90	1.758	2.453	1.731
% Hy.+Seb.	*59.9*	*67.4*	*83.1*	*94.3*	*89.1*	*86.2*	*76.1*	*98.5*	*99.2*
Nº stomachs	14	30	85	44	106	103	86	28	17
% empty stomachs	0	3.3	0	0	2.8	1.9	0	0	5.9

Table 4.- Total and Partial Fulness Index only for the two main items. Atlantic cod by age groups in Flemish Cap. (July 1990).

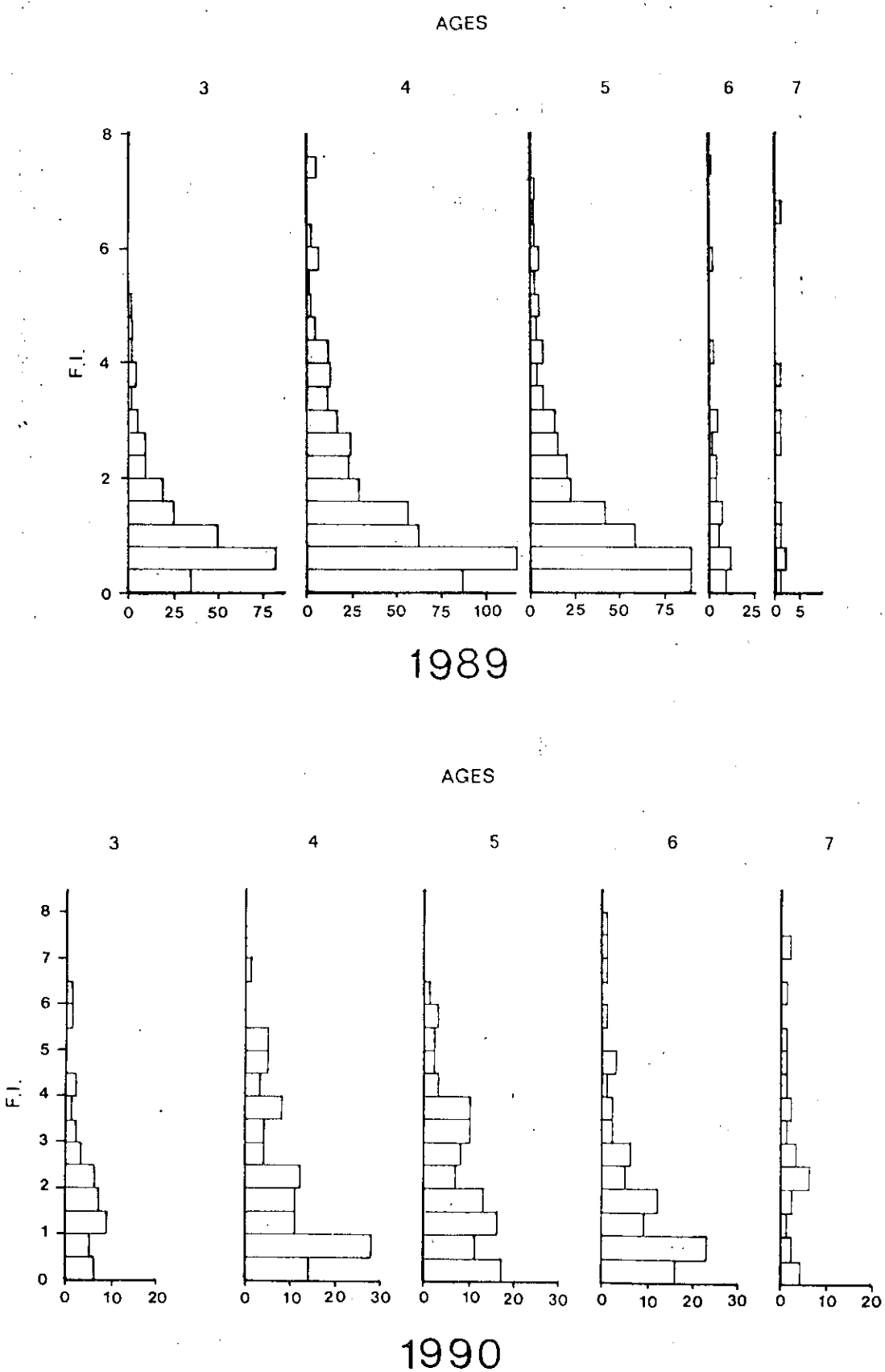
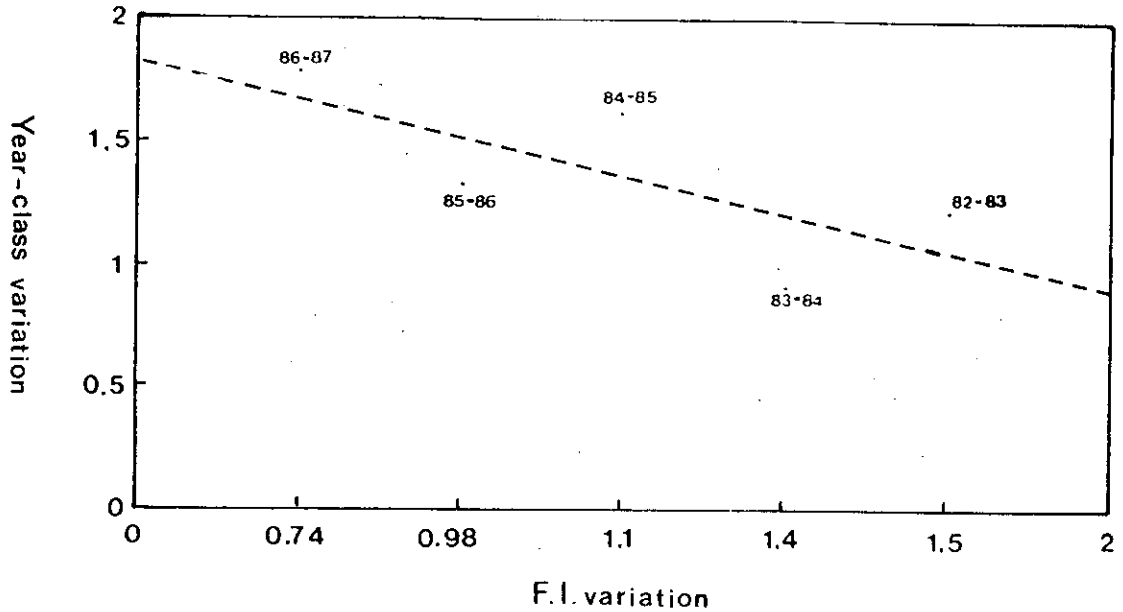


Figure 1.- Fullness Index frequency distribution by age groups Flemish Cap cod: 1989, 1990.



$Y = 2.36 - 0.87X$, $r = 0.80$

Figure 2.- Year-class cod increment and fullness index variation by cohort.

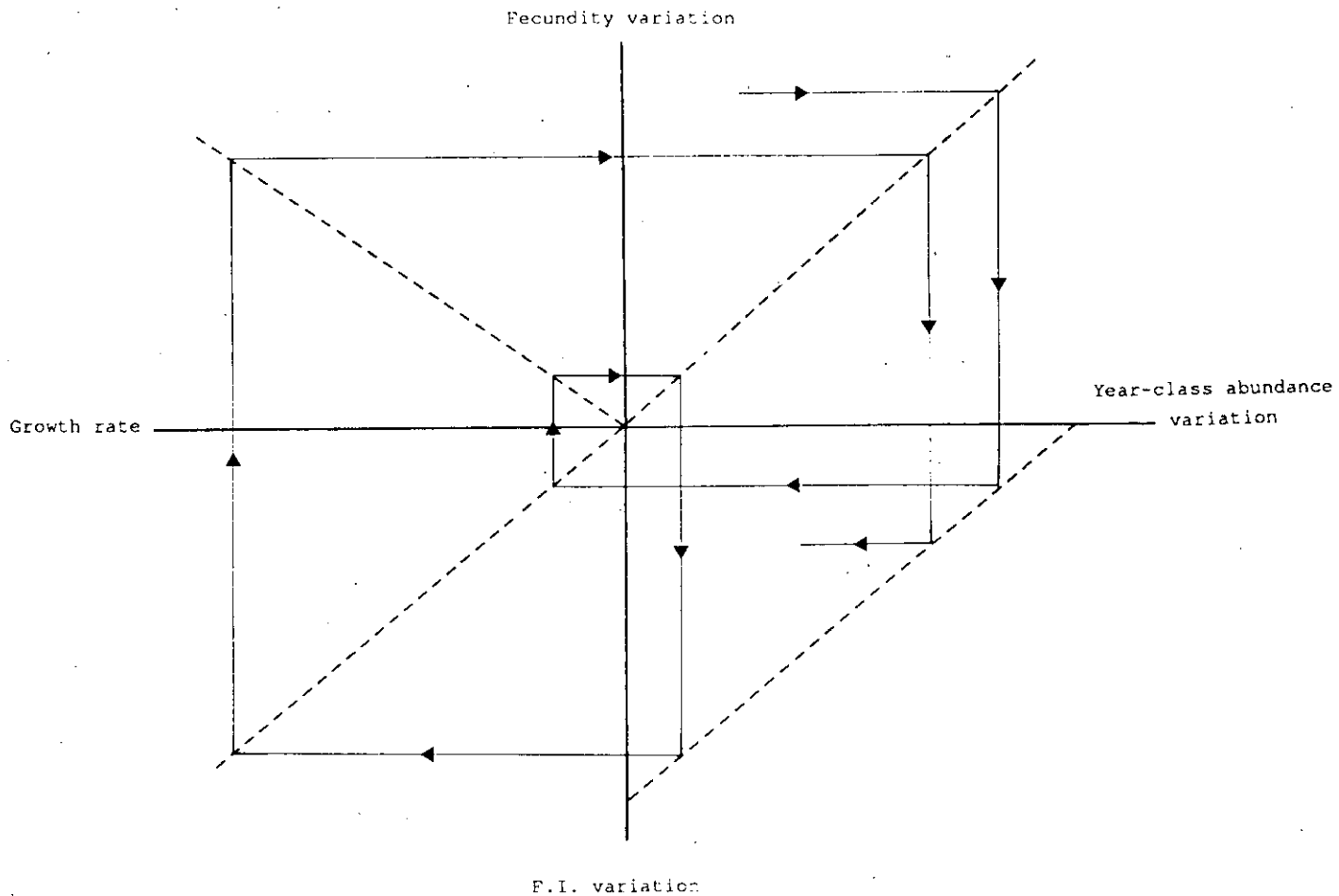


Figure 3.- Proposed model for Flemish Cap cod (see text).