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Stock Assessment, Age-Length Composition and Maturity Stages of the Flemish Cap Cod

by

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Abstract

The estimate of the Flemish Cap cod stock calculated from the 1989 trawl-acoustic survey and the previous surveys (1977-1988) data is presented.

The stock of cod has become to recover gradually since 1989; cod biomass has increased by a factor of 2.5 compared to 1988 while the abundance has increased insignificantly. The increase in biomass was conditioned by increment in weight of growing immature cod of the 1986 year-class, the portion of which in the whole population was 77%. The portion of mature fish did not exceed 3.9% which proves that the reproductive part of the stock remained in a depressive state in 1989.

It is noted that males begin to mature at age 3, females - at age 4; 50% of males and females become mature at average age of 4.8 years. In 1986-1989 the growth rate of cod was higher compared with the 1949-1981 period.

Introduction

Regular observations on the stock of the Flemish Cap cod were carried out in June-July 1989 by R/V MB-1202 "Persey III". The cruise was aimed to assess the cod stock and analyse age-length and sex composition of the fish, and also to estimate the ratio of mature/immature cod in the stock.

Material and methods

The trawl survey was carried out according to a random-stratified scheme (Doubleday, 1981) with a parallel acoustic survey in positions of trawl sets and in between them. This allowed us to estimate the abundance and biomass of cod distributed over the bottom trawl fishing zone. The total stock size was determined as a sum of estimates of cod both in the bottom layer (trawl survey) and pelagic layers (acoustic survey) (Mamylov, 1988).

To characterize year to year fluctuations of the stock state the results of the 1989 survey were compared with retrospective data of the 1977-1988 trawl surveys and with those of the 1987-1988 trawl-acoustic surveys.

To analyse age, growth and maturation of cod the data on length, weight, age, sex and maturity of gonads of 1623 fishes sampled in June-July 1986-1989 were taken.

Results

Stock assessment

In June-July 1989 main concentrations of cod over the Flemish Cap Bank were distributed at depths 230-330 m. In the bottom layer a higher density of concentrations was registered in the strata 7, 8, 11, where catches averaged to 100-200 kg, and the maximum ones reached 400-1100 kg per 30 minutes hauling with a bottom trawl. The density of pelagic concentrations was higher in the strata 4 and 8 (Figs 1 and 2).

Figure 2 presents the length composition of cod in catches depending on depth of hauling. Cod 27-44 cm long, at age 3-4 belonging to the 1986 and 1985 year-classes constituted the bulk of catches. Immature cod of the 1986 year-class constituted 77% of the total amount of cod taken (Table 1). Recruitment of young fish (1987 and 1988 year-classes) to the stock was weak (3.6%). One of the reasons of low abundance of fish of those year-classes could be a low level of the spawning stock; during the period 1985-1988 the per cent of adult fish in the stock had decreased from 26.1 to 1.8% (Table 2, Fig. 3).

According to the trawl survey data the abundance of cod in 1989 (70.4×10^6 specimens) was 2.6 times higher than that in 1988 and 1.5 times higher than mean long-term calculated for the period 1977-1989 (47.9×10^6 specimens, in average) (Table 3). This considerable increase of abundance could occur due to strong recruitment, though it was not observed on the Bank. More presumably that the density of cod concentrations in the near-bottom layer was higher in 1989 than in 1988, which resulted in a higher value of the stock size assessment. A trend in fluctuation of the stock size is fairly well reflected by the trawl-acoustic survey data which being compared with similar data of 1988 indicated that at insignificant increase of abundance (from 150.5×10^6 to 159.1×10^6 specimens) the biomass of cod has increased by a factor of 2.5 (from 34.2×10^3 to 78.3×10^3 tons) (Table 4). This increase in biomass was conditioned by increment in weight of an individual fish from the dominating 1986 year-class.

The investigations testify that there occurs a gradual recovery of the cod stock on the Flemish Cap Bank. To increase the spawning stock size the ban for cod fishery should be prolonged for another two years.

Growth rate

Using the data from Table 5 the parameters of allometric cod growth equation were calculated by the formula:

$$W = aL^b \qquad (1)$$

where W - weight, g

L - length, cm

These allometric growth parameters for the Div. 3M cod were as follows:

Parameters	Males	Females	Males + Females
a	.00689	.00582	.00599
b	3.06171	3.10665	3.09983
r	.9991	.9996	.9996
R^2	.9981	.9992	.9993

Judging by the factor b females had a higher growth rate compared with males, which is quite compatible with the data presented in previous years by R.Wells (1979).

Using the data on mean length of cod at different age (Table 6) coefficients of linear growth of cod were calculated were calculated according to the von Bertalanffy growth equation:

$$l_t = L_\infty (1 - 1^{-k\ (t-t_o)}) \qquad (2)$$

Estimates of cod growth rate for 1986-1989 compared with similar ones obtained using the data from Wells (1983) for the period 1949-1951, 1964, 1968 and Postolaky (1983) for 1981 are presented in Table 7.

An increase of the factor K from 1949 to 1989 testifies to a higher growth rate of cod during the recent years.

Sex composition and maturity

An analysis of sex composition and maturation of cod was made using the materials of combined age samples for the period 1986-1989.

Differences in ratio of males and females (depending on their length and age) were revealed for immature and mature cod. This ratio was approximately 1:1. Within the immature stock females were predominant among fish over 30 cm in length, at age 3 and older. Within the mature stock females were predominant among fish with length over 75 cm, at age over 6 years (Fig. 4, Table 8).

Males became to mature at age 3 having reached the length of 36 cm; mature females were found beginning from length 48 cm, at age 4 (Fig. 5, Table 9). About 50% of fish became mature having reached the length of 54 cm (males) and 60 cm (females) and mean age of 4.8 years.

Mature and immature cod of the same age had different mean length and weight (Tables 6, 10) which could, presumably, be explained by earlier maturation of individuals with higher growth rate.

In 1989 the abundance of mature cod in the stock was 3.9%. It may be expected that because of prohibition of the fishery the abundance of mature cod will increase by 35-40% till 1991 due to growth and maturation of cod of the rich 1986 year-class.

Conclusion

In 1989 a gradual recovery of the Flemish Cap cod stock was registered The abundance of cod has increased by 8.6×10^6 individuals, thier biomass - by 44.1×10^3 tons. Immature cod at age 3 belonging to the 1986 year-class constituted the bulk of the stock (77%). The stock recruitment by juveniles of the 1987 and 1988 year-classes was poor. In 1986-1989 the growth rate of cod was higher compared with 1949-1981. About 50% of cod become mature at age 4.8 years, in average. The abundance of mature fish did not exceed 3.9% in 1989 which testifies to a depressive state of the reproductive part of the stock. To recover the spawning stock the cod fishery should be prohibited at least until 1992.

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Table 1. Mean number of cod from various age groups in catch per hauling in Div. 3M (from trawl surveys data for 1983-1989, specimens)

Age, years	1983	1984	1985	1986	1987	1988	1989
1	14.65	3.07	0.95	0.40	44.10	0.08	2.41
2	38.06	16.06	1.31	26.10	4.40	27.03	1.36
3	22.43	33.10	13.69	9.62	5.98	13.51	80.74
4	5.30	24.99	23.47	8.25	1.35	1.84	19.69
5	9.36	8.03	12.85	9.75	1.59	0.17	0.42
6	3.93	2.71	2.30	0.77	1.00	0.17	0.10
7	1.71	1.44	0.39	0.17	0.18	0.13	+
8	0.88	0.45	0.12	0.06	+	-	+
9	0.35	0.18	0.01	0.06	+	-	+
10	0.22	0.09	0.01	0.01	+	-	-
11	0.24	0.09	-	0.05	-	-	-
12	0.12	+	-	-	-	+	-
13	0.10	-	-	0.05	-	-	-
14	-	-	-	0.01	-	-	-
Total number of specimens	97.4	90.2	55.1	55.3	58.6	42.9	104.7
Number of haulings	103	103	106	108	104	97	109

Table 2. Number of mature and immature cod in average catch per hauling (from bottom trawl survey data, 1983-1989)

Year of survey	Number of immature fish specimens	Number of mature fish, specimens	Number of mature fish, %	Total, specimens
1983	83.50	13.90	14.3	97.40
1984	76.50	13.70	15.2	90.20
1985	40.71	14.38	26.1	55.09
1986	44.66	8.64	15.6	55.30
1987	56.28	2.32	4.0	58.60
1988	42.12	0.78	3.9	104.72

Table 3. Mean catches per hauling, abundance and biomass of cod in Div. 3M from trawl survey data, 1977-1989

Years	Area, sq.miles	Number of haul.	Mean catch		Abundance (10^6 specimens)			Biomass (10^3 tons)		
			Number of specimens	Weight, kg	Maximum	Mean	Minimum	Maximum	Mean	Minimum
1977	9081	24	234.30	201.30	262.88	157.61	52.33	262.58	135.40	8.23
1978	7467	30	42.35	39.90	38.24	23.42	8.60	30.79	22.07	13.36
1979	9081	64	80.60	60.95	102.73	54.22	5.70	71.78	40.99	10.21
1980	9081	76	14.60	17.90	12.64	9.82	7.00	16.31	12.02	7.74
1981	7745	29	28.35	43.45	24.58	16.28	7.98	34.83	24.93	15.02
1982	9081	62	15.35	20.55	14.03	10.34	6.66	23.87	13.83	3.79
1983	9081	103	97.40	34.30	100.39	65.53	30.67	31.07	23.07	15.06
1984	9081	103	90.20	46.40	75.40	60.68	45.96	39.29	31.21	23.13
1985	9081	106	55.09	41.70	44.64	37.06	29.48	34.66	28.07	21.48
1986	9081	108	55.30	38.70	53.29	37.20	21.11	36.76	26.06	15.36
1987	8479	104	58.60	16.20	50.96	36.82	22.68	13.28	10.15	7.02
1988	8411	97	42.90	12.40	37.90	26.73	15.50	10.45	7.72	4.99
1989	9081	109	104.72	54.30	107.91	70.44	32.98	53.89	36.52	19.14

Table 4. Abundance (x 10^6 specimens) and biomass (x 10^3 tons) of cod from bottom and acoustic surveys data, 1987-1989

Type of survey	1987		1988		1989	
	abundance	biomass	abundance	biomass	abundance	biomass
Trawl	36.8	12.3	26.7	7.7	70.4	36.5
Acoustic	40.2	9.3	123.8	26.5	88.7	41.8
Total	77.0	21.6	150.5	34.2	159.1	78.3

Table 5. Mean weight of cod liver by length groups of cod (from combined age samples data, 1986 - 1989)

Length of fish, cm	Males		Females		Males + Females	
	mean weight, g	number of spec.	mean weight, g	number of spec.	mean weight, g	number of specimens
I2- I4	I9	I7	I8	I2	I9	29
I5- I7	30	5I	33	29	3I	80
I8- 20	54	43	56	42	55	85
2I- 23	9I	42	83	32	88	74
24- 26	I40	47	I39	43	I40	90
27- 29	I83	53	I83	48	I83	I0I
30- 32	244	43	234	50	239	93
33- 35	353	42	338	4I	346	83
36- 38	455	45	440	50	447	95
39- 4I	549	42	553	50	55I	92
42- 44	68I	42	686	50	684	92
45- 47	835	40	8I6	4I	825	8I
48- 50	I020	38	I030	3I	I024	69
5I- 53	I23I	35	I220	30	I226	65
54- 56	I46I	37	I45I	35	I456	72
57- 59	I645	38	I725	4I	I687	79
60- 62	2080	25	I992	40	2026	65
63- 65	2308	32	2295	25	2302	57
66- 68	2660	25	2655	2I	2658	46
69- 7I	3I26	I5	3038	I3	3085	28
72- 74	3486	I4	3343	II	3423	25
75- 77	4068	I6	39I8	25	3977	4I
78- 80	4223	I2	4586	I2	4405	24
8I- 83	5340	2	4929	7	5020	9
84- 86	5450	2	6I30	7	5979	9
87- 89	6350	I	5785	4	5898	5
90- 92	6590	3	7027	6	688I	9
93- 95	8259	6	7683	3	8067	9
96- 98	I0063	2	8465	2	9264	4
99-I0I	-	-	9868	5	9868	5
I02-I04	-	-	-	-	-	-
I05-I07	-	-	-	-	-	-
I08-II0	I2800	I	-	-	I2800	I
III-II3	-	-	-	-	-	-
II4-II6	I0400	I	I6050	I	I3225	2
II7-II9	-	-	I7580	I	I7580	I
I20-I22	-	-	-	-	-	-
I23-I25	-	-	2I200	I	2I200	I
Total		8I2		809		I62I

Table 6. Mean lengths of immature and mature cod (June–July, 1986–1989)

Age, years	Immature						Mature					
	mean length of males cm	number of males spec.	mean length of females cm	number of femal. spec.	mean length of males + females cm	number of males + females, spec.	mean length of males cm	number of males, spec.	mean length of females, cm	number of females spec.	mean length of males + femal. cm	number of males + femal. spec.
I	I7.62	I04	I8.3I	67	I7.89	I7I	–	–	–	–	–	–
2	25.3I	I56	25.I3	I48	25.22	304	–	–	–	–	–	–
3	37.26	I96	37.7I	225	37.50	42I	47.I7	6	–	–	47.I7	6
4	49.I2	I02	49.50	I38	49.34	240	52.96	3I	55.50	I0	53.58	4I
5	53.47	40	57.63	58	55.93	98	62.6I	97	65.I5	75	63.72	I72
6	65.50	2	70.58	I2	69.86	I4	70.85	55	74.68	4I	72.49	96
7	85.00	I	77.50	2	80.00	3	82.84	I2	86.65	23	85.34	35
8	–	–	–	–	–	–	9I.33	6	95.67	3	92.78	9
9	–	–	–	–	–	–	97.00	I	99.50	2	98.67	3
I0	–	–	–	–	–	–	I08.00	I	II0.00	2	I09.33	3
II	–	–	–	–	–	–	–	–	I08.00	2	I08.00	2
I2	–	–	–	–	–	–	II6.00	I	–	–	II6.00	I
I3	–	–	–	–	–	–	–	–	II9.00	I	II9.00	I
I4	–	–	–	–	–	–	94.00	I	–	–	94.00	I

Table 7. Parameters of the von Bertalanffy equation for Div.3M cod

Equation parameters	1949-1951 July-August (Wells, 1983)	1964, 1968 July-September (Wells, 1983)	1981 June (Postolaky, 1983)	1986-1989 June-July (Kuzmin)
L_∞	77.0105	86.2325	88.0016	112.58
k	.1682	.2188	.2022	.2491
t_o	.8905	.1110	.8153	.8018

Table 8. Number of mature and immature males and females in various age groups (from the data of age samples, 1986 - 1989)

Age, years	Immature			Mature			Immature + mature		
	number of males	number of females	relative number of females %	number of males	number of females	relative number of females %	number of males	number of females	relative number of females %
I	I04	67	39	-	-	-	I04	67	39
2	I56	I48	49	-	-	-	I56	I48	49
3	I96	225	53	6	-	0	202	225	53
4	I02	I38	58	3I	I0	24	I33	I48	53
5	40	58	59	97	75	44	I37	I33	49
6	2	I2	86	55	4I	43	57	53	48
7	I	2	67	I2	23	66	I3	25	66
8	-	-	-	6	3	33	6	3	33
9	-	-	-	I	2	67	I	2	67
I0	-	-	-	I	2	67	I	2	67
II	-	-	-	-	2	I00	-	2	I00
I2	-	-	-	I	-	0	I	-	0
I3	-	-	-	-	I	I00	-	I	I00
I4	-	-	-	I	-	0	I	-	0
Total	60I	650		2II	I59		8I2	809	

Table 9. Number of mature cod by age groups (from the data of combined age samples, 1986–1989)

Age, years	Males			Females			Males + females		
	Total number of specimens	Number of mature specimens	Number of mature fish, %	Total number of specimens	Number of mature specimens	Number of mature fish, %	Total number of specimens	Number of mature specimens	Number of mature fish, %
I	I04	-	0	67	-	0	I7I	-	0
2	I56	-	0	I48	-	0	304	-	0
3	2C2	6	3	225	-	0	427	6	I
4	I33	3I	23	I48	I0	7	28I	4I	I5
5	I37	97	7I	I33	75	56	270	I72	64
6	57	55	96	53	4I	77	II0	96	87
7	I3	I2	92	25	23	92	38	35	92
8	6	6	I00	3	3	I00	9	9	I00
9	I	I	I00	2	2	I00	3	3	I00
I0	I	I	I00	2	2	I00	3	3	I00
II	-	-	-	2	2	I00	2	2	I00
I2	I	I	I00	-	-	-	I	I	I00
I3	-	-	-	I	I	I00	I	I	I00
I4	I	I	I00	-	-	-	I	I	I00
Total	8I2			809			I62I		

Table 10. Mean weight of immature and mature cod (June - July, 1986 - 1989)

Age, years	Immature						Mature					
	Mean weight, of males, g	Number of males, spec.	Mean weight of females g	Number of females spec.	Mean weight of males+females,g	Number of males + females spec.	Mean weight of males,g	Number of males, spec.	Mean weight of females, g	Number of females spec.	Mean weight of males + females	Number of males + females, spec.
I	46.7I	I04	5I.6I	67	48.63	I7I	-	-	-	-	-	-
2	I5I.00	I56	I44.I7	I48	I47.67	304	-	-	-	-	-	-
3	470.03	I96	506.7I	225	489.63	42I	970.83	6	-	-	970.83	6
4	II03.23	I02	II3I.66	I38	III9.58	240	I360.48	3I	I6I2.50	I0	I42I.95	4I
5	I22I.25	40	I754.3I	58	I536.74	98	222I.5I	97	2489.06	75	2338.I7	I72
6	2805.00	2	3I69.I7	I2	3II7.I4	I4	3283.63	55	3843.65	4I	3522.8I	96
7	5I00.00	I	43I0.00	2	4573.33	3	5459.I7	I2	6I24.I2	23	5896.I4	35
8	-	-	-	-	-	-	7662.50	6	83I6.67	3	7880.56	9
9	-	-	-	-	-	-	III05.00	I	I0390.00	2	I0628.33	3
I0	-	-	-	-	-	-	I2800.00	I	I5I90.00	2	I4393.33	3
II	-	-	-	-	-	-	-	-	I3500.00	2	I3500.00	2
I2	-	-	-	-	-	-	I0400.00	I	-	-	I0400.00	I
I3	-	-	-	-	-	-	-	-	I7580.00	I	I7580.00	I
I4	-	-	-	-	-	-	82I0.00	I	-	-	82I0.00	I

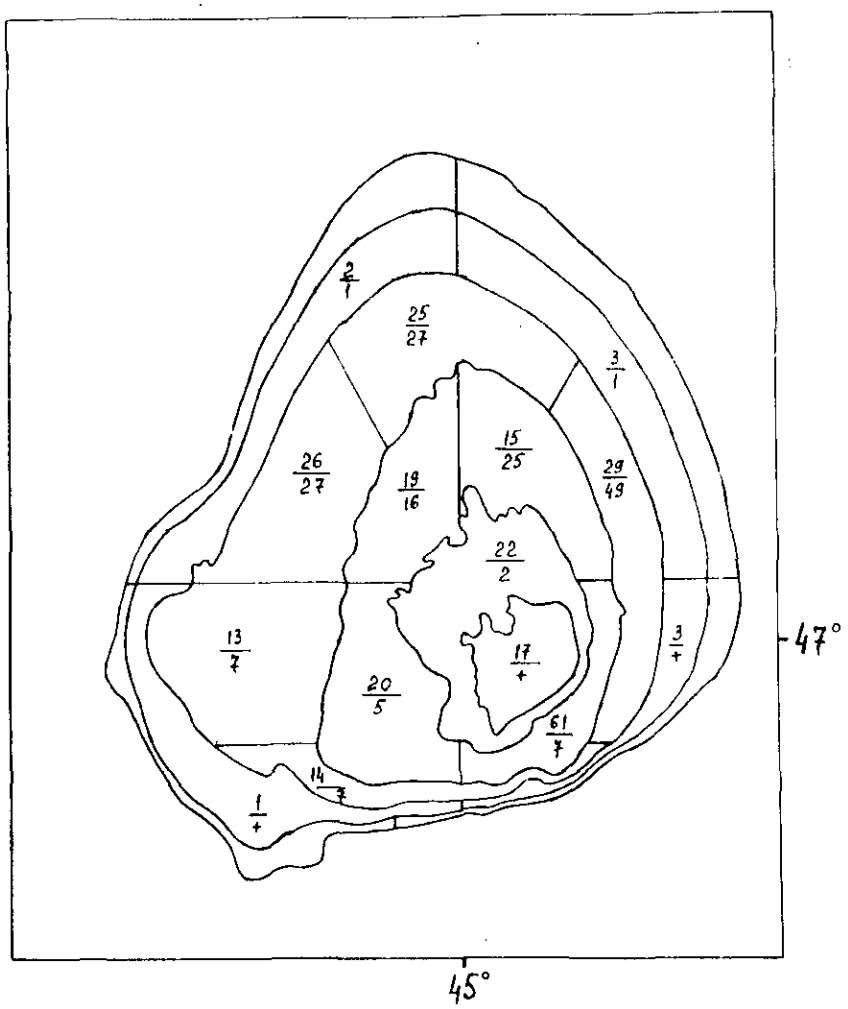

Fig. 1. Distribution of cod on the Flemish Cap Bank (by the acoustic survey data, June - July 1989).
Figures present densities of cod concentrations expressed in mean echo-intensity units by strata: in pelagic layers (numerator), in the bottom layer (denominator)

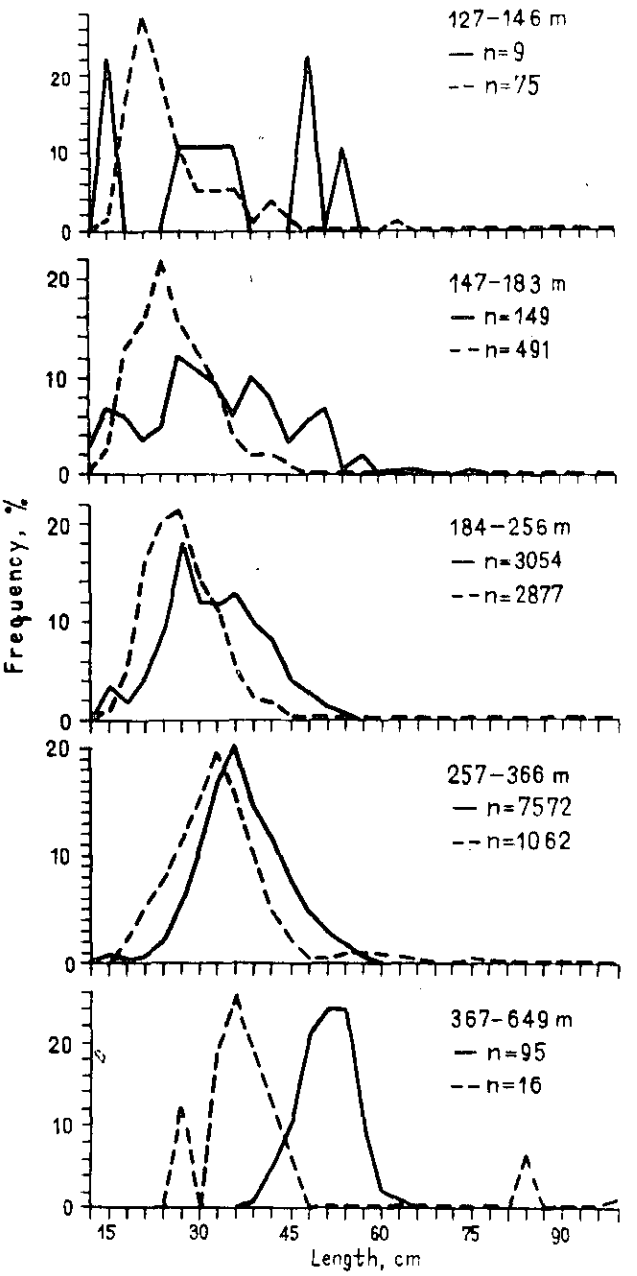

Fig. 2. Distribution and length composition of cod on the Flemish Cap Bank by strata (the 1988 bottom trawl survey data (brocken line) and the 1989 bottom trawl survey data (solid line)).
n - number of fish taken

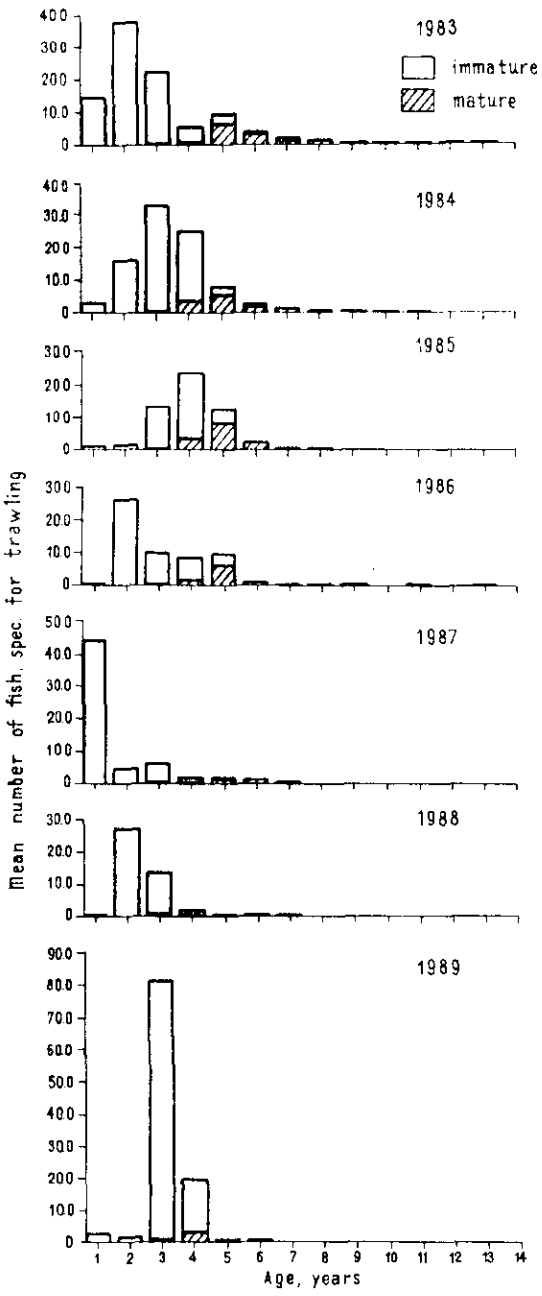

Fig. 3. Number (specimens) of immature and mature cod of various age in a mean catch per hauling (the 1983-1989 bottom trawl survey data)

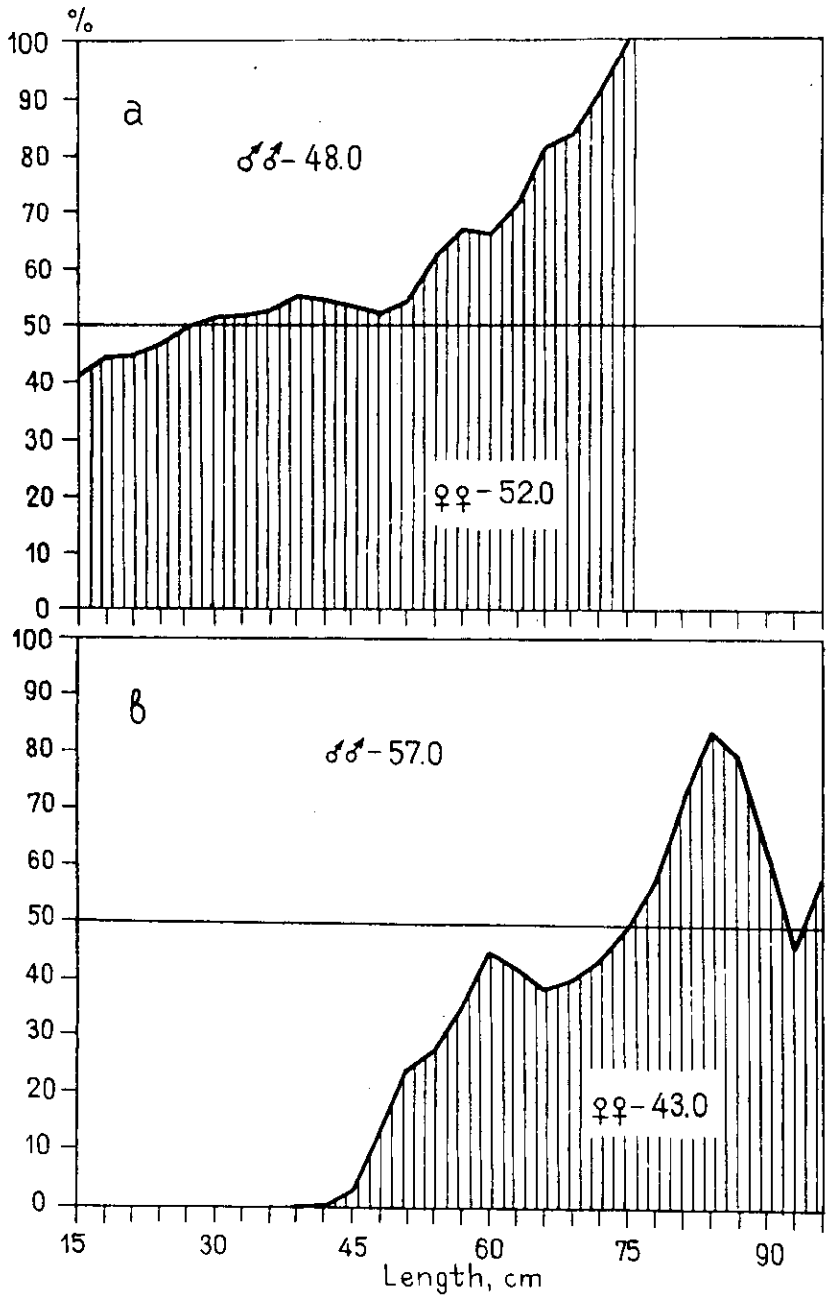

Fig. 4. Relative amount of males and females among immature (a) and mature (b) of various length (per cent)

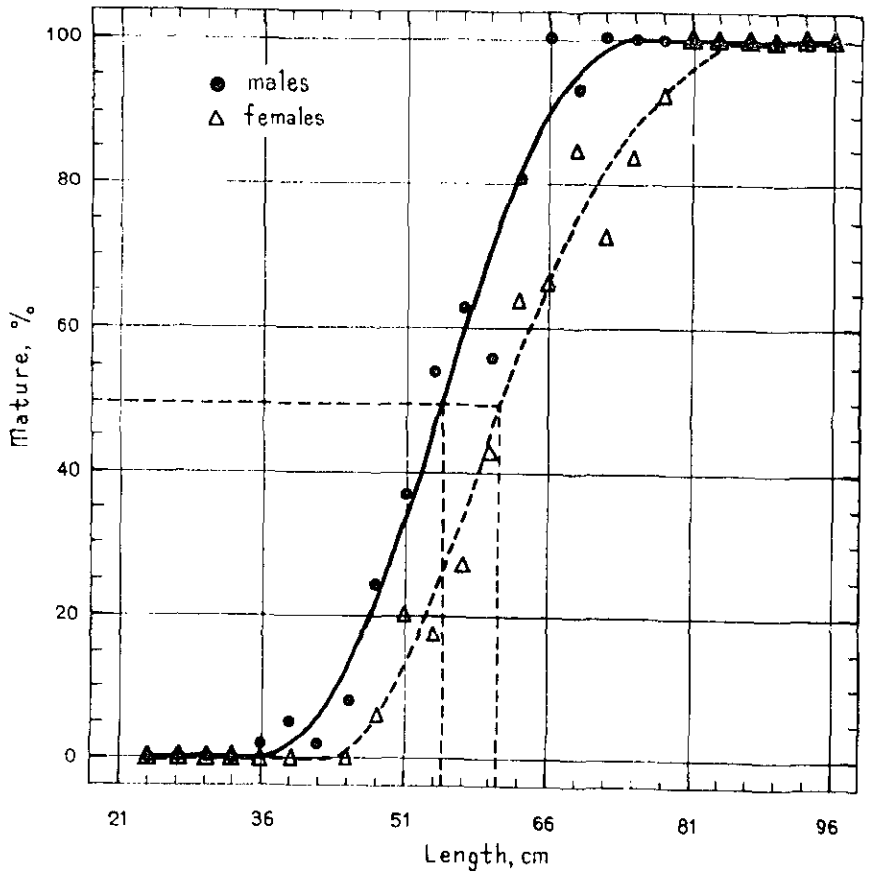

Fig. 5. Relative amount of mature cod depending on their length (by the results of polynomial smoothing)
Solid line - males
Brocken line - females