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CHANGES IN GROWTH AND MATURATION OF THE BARENTS SEA PLAICE (PLEURONECTES PLATESSA L.) IN 70s-90s

by

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Abstract

This paper concerns the dynamics of growth and maturation of the Barents Sea plaice (Pl. platessa L.) in connection with changing enviromental conditions. The comparative data on the plaice growth rate in 1971-1994 are presented. The influence of fish growth change on the rate of specimen sex maturation is shown.

It was noticed, that in 70s-80s, in comparison with 30s, the rate of plaice growth in the Barents Sea has increased, that resulted in acceleration in the specimen sexual maturation rate. Some males of plaice mature being of 23 cm in length and aged 4; females - 25 cm, at age 5, whilst, according to the literature data (Milinsky, 1938), males reach the stage of maturity at the age of 8-9, and females - aged 11-12.

In 70s-90s one could observe the mass maturation of the plaice males (under 70-80% point on the ogive) with the length of 31-38 cm, at the age of 5-9, and females, being of 38-48 cm in length, aged 9-12. The males matured at the age of 12, and females - being aged 15.

Introduction

Due to the changes of abiotic and biotic enviromental conditions, as well as the increase in the influence of the anthropogeneous factors, growth and maturation of fish, including the plaice, significantly vary by years. Different factors may be the reason of changes in the specimen growth (Averintsev, 1929; Milinsky, 1938; Rollefsen G., 1938; Dementyeva, Mankevich, 1966; Ponomarenko, 1968; Rafail, 1968; Kovtsova, 1985; Kovtsova, 1994). Therefore, from time to time we should return to this question to estimate new relations or acknowledge new regularities, basing on the new data.

The rate of fish growth, as a rule, depends on the most variable enviromental factors, such as the temperature and food factors.

Studying age and growth of plaice, all scientists noticed considerable fluctuations of length and weight of specimens from the same age group (Atkinson, 1908; Heincke, 1913; Averintsev, 1929; Milinsky, 1938; Kovtsova, 1976, 1985). According to S.V.Averintsev (1929), the discrepancies in the rate of the plaice growth, which he explained by the dissimilar conditions of juvenile dwelling in some inlets, are futher significant already in the end of the first year of life. The later investigations showed, that the irregular growth of some specimens from the same year-class may be explained by the prolonged spawning (February-July), as well as by the different conditions of dwelling in the first years of life, since the plaice larvae are brought to the different inlets, where they settle and spend 4 first years of life in dissimilar food and temperature conditions. The irregular growth of some specimens results in the prolonged sexual maturation (Kovtsova, 1985).

Material and methods

The persistent PINRO data on the mean length of plaice from the different age groups in 1971-1994 were the material for the paper. Data on length, age and sexual compositions were collected by the PINRO research vessels in the southern Barent Sea the whole year round. Applied fishing gear was the bottom trawl with 120 and 125 mm mesh internal size; in the period of trawl surveys the small mesh net was inserted into the cod-end. Fish length was measured from snout to the end of the tail fin with an accuracy of 1 cm.

To study the maturation time the data, collected during the plaice migration to the spawning and wintering areas in November-April, as well as off the spawning areas, were used. In these months the genital glands of fish, matured for the first time, and the rematured fish (spawning the next year spring) are distinctly different from those ones of the immature specimens. Stages of the plaice genital glands maturity were preliminarily determined using the 6-division scale (Sorokin, 1957; Anon., 1984). Fish with genital glands at I-II stage of maturity were considered as immature; those ones with genital glands at II-III - VI-II stages - as mature. In all 17 600 specimens of plaice were analysed to determine the stages of plaice genital gland maturation.

For studying the linear growth and weight increase 29 170 spec. were analysed.

The plaice were aged by otoliths applying the MVS-1 binocular microscope, in the falling light, under the magnification of 8x2.

Mean annual water temperature at the depth of 0-200 m (and its anomalies) on the "Kolsky meridian" Section (st.3-7) is considered as the index of the heat content of waters in the southern Barents Sea.

Results of investigations

In 70s-90s, in the Barents Sea, the mean length of plaice from all investigated age groups significantly varied. In some periods, the mean length of plaice aged 5-10, especially, it was peculiar to younger specimens, sharply decreased, in another ones - noticeably increased (Table 1,2). According to the analysis, in 1990-1994 mean length of males and females of plaice aged 5-6 was higher by 3.0-3.4 cm, than in 1977-1982, aged 7-8 - by 3.0-3.7 cm, respectively. When growing up the differencies in the mean length of specimens from the same age group decreased, as a rule. But, in some periods (1983-1989 and 1990-1994) those differencies have been retained in all age groups investigated, in another ones (1971-1976 and 1977-1982) -in growing up the differencies only in the female growth, and in some periods the differences in growth of males and females from the same age groups were observed. It should be assumed, that the differencies are caused by the dissimilar influence of the same enviromental factors on the growth of plaice males and females from the different age groups.

The data analysis showed, that the noticeable increase in the plaice growth rate was in 1990-1994, when the mean length in all age groups was well above, than in the second half of 70s and in 80s. These differences are especially marked when comparing mean lengths of the same age specimens in 70s-90s and 30s-40s (see Table 1,2). In 1990-1994 mean length increments in specimens aged 5-10 were well above, than in 1984-1989, 1977-1982 and 1971-1976, that was indicative of the high growth rate of plaice in early 90s (Fig.1). The curve of increments of the plaice same age specimens in different periods agree well with the periods of the Barents Sea cooling and warming up (see Fig.1, Table 3). The higher the positive anomalies of water temperature (1°C) at the depth of 0-200 m, on the "Kolsky meridian" section are, the higher the rate of the plaice growth is recorded. The noticeable relationship between these parameters ($r=0.79+/-0.16$, under $n=20$) indicates the significant influence of temperature on the growth rate of the plaice from the Barents Sea. The years, when abundance and biomass of the commercial stock sharply increase, for instance, 1971-1976, are excluded. In those years the sharp reduction in the specimen growth rate under the high temperature of the southern Barents Sea waters was noticed, that was explained by the increase in population density (Kovtsova, 1980). In the period investigated the plaice abundance and stock were at the highest level in 1971-1976, that resulted in the deterioration in the food supply and competition. for benthos food, and, as a consequence, the slowing down of the specimen growth rate. However, in 80-90 the plaice growth rate was accelerated. The growth rate accelaration couldn't help influencing the rate of sex maturation. So, according to the conducted analysis, in 70s-80s some males matured at age 4, having the length of 23 cm, females - at the age of 5 years and with the length of 25 cm, and in 90s - mature males at age 3 and females aged 4 were recorded. 62%, 79% and 94% of males and 4.5%, 5.0% and 10% of females matured at age 5, 6 and 7, respectively;

50% - sex maturation point - conformed with 9 years (Fig.2).

In 70s-80s mass males matured at the age of 6-9 years, females - aged 9-11, in contrast to 90s, when 70-90% of males matured at age 5-8, and females - aged 10-12, i.e. in early 90s the noticeable acceleration of the male sexual maturation and certain deceleration of female maturation rate were recorded. However, in comparing the curves of sexual maturation of the plaice males and females in 30s-40s, we may conclude, that in 70s-90s the growth rate of the plaice sexual maturation increased (see Fig.2). In 30s-40s 50% of plaice males matured at age 9, females - aged 12 (Milinsky, 1938).

Thus, as investigations showed, in 70s-80s, against 30s-40s, the 50% point of male sex maturation shifted to 3, in 90s - by 4 years out of the way of the younger age, and, as for females, - by 3 years, respectively.

In our opinion, the plaice sex maturation rate could accelerate not only due to increasing growth rate of specimens, since males and females started maturing not only being younger, but under the less length, but also because of the other enviromental factors, that should be cleared up later on. So, in the Barents Sea, the acceleration of the sexual maturation rate of the most bottom fish: cod, haddock, Greenland halibut, Sebastes marinus (Ponomarenko, Yaragina, 1985; Kovtsova, Nizovtsev, 1985; Sorokin, Shestova, 1988; Kovtsova, Novoselov, 1987) was noted.

Conclusions

The growth of plaice in the Barents Sea changes due to the varying enviromental conditions. In 70s-90s, as compared to 30s-40s, the acceleration of the plaice growth rate was recorded, the growth of specimens especially sharply increased in early 90s, that was caused by the high temperature of the southern Barents Sea waters. The higher the positive anomalies of water are, the higher the plaice growth rate is noted. In increasing the density of population, this regularity is violated. When the abundance of the commercial stock is high, the growth rate slows down even under the positive anomalies (1°C) of the temperature of water.

Relative to the acceleration of the fish growth rate, the rate of plaice maturation was accelerated. In 70s-80s, in comparison with 30s-40s, the 50% point of male sexual maturation shifted to 3, in 90s - by 4 years out of the way of the younger age, and, for females, - by 3 years, respectively. In 70s-90s most males matured at age 9-12, under the length of 31-38 cm, and females - aged 9-12, having the length of 38-48 cm, the 50% point of male sexual maturation conforms with 4-5 years, the female ones - with 8-9 years, while in 30s-40s the point mentioned for males was 9 years, for females - 12 years.

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Table 1 Indices of linear and weight growth of plaice in the Barents Sea.

Age, years	Mean length, cm							
	1971-1976 гг.:		1977-1982 гг.:		1983-1989 гг.:		1990-1994 гг.	
	males	fem.	males	fem.	males	fem.	males	females
3							23.5	24.1
4	24,3	25,0	24,2	27,2	27,5	27,7	20,0	29,1
5	29,5	29,6	28,8	28,4	29,0	30,6	32,1	31,4
6	32,0	32,6	30,6	30,4	31,6	32,4	34,0	34,5
7	34,0	34,8	32,6	33,3	33,6	34,7	36,5	37,0
8	35,7	38,0	34,8	36,6	35,7	36,5	37,9	39,6
9	37,3	40,0	37,6	40,1	36,8	40,1	40,3	42,9
10	38,4	42,8	38,0	43,0	37,8	41,9	41,3	45,3
11	38,4	43,7	40,5	44,8	38,3	43,7	41,5	47,8
12	41,4	45,1	42,1	47,8	39,9	45,9	42,7	49,7
13	42,5	48,3	42,9	50,7	45,4	47,9	44,2	51,6
14	43,7	49,5	43,0	53,0	-	50,4	44,5	54,2
15	-	51,2	-	56,2	-	51,3	51,6	58,4
mean	36,1	40,0	36,0	40,9	35,6	40,3	38,5	42,0
number of spec.	2800	2943	6560	6058	3546	3300	1921	2042
$\sigma \pm$	5,8	8,2	6,3	9,8	5,4	7,9	7,3	10,4
$m_{Mcp.} \pm$	1,77	2,39	1,89	2,85	1,69	2,28	2,03	2,83

Age, years	Mean weight, kg							
	1971-1976 гг.:		1977-1982 гг.:		1983-1989 гг.:		1990-1994 гг.	
	males	fem.	males	fem.	males	fem.	males	females
3	-	-	-	-	-	-	0,239	0,263
4	0,213	0,280	0,270	0,240	0,303	0,269	0,265	0,373
5	0,342	0,344	0,320	0,253	0,368	0,295	0,408	0,412
6	0,408	0,426	0,392	0,324	0,428	0,391	0,491	0,490
7	0,500	0,520	0,476	0,436	0,476	0,478	0,559	0,614
8	0,572	0,685	0,562	0,579	0,524	0,578	0,663	0,778
9	0,638	0,719	0,616	0,787	0,59	0,676	0,741	0,889
10	0,672	1,102	0,724	0,945	0,626	0,798	0,848	1,166
11	0,704	1,186	0,851	1,088	0,657	0,916	0,948	1,419
12	0,893	1,334	0,900	1,306	0,709	1,064	1,022	1,632
13	0,920	1,500	1,100	1,554	0,805	1,249	-	1,828
14	1,100	1,700	-	1,725	1,111	1,255	-	2,093
15	-	1,750	-	1,850	-	1,407	-	2,521
mean	0,56	0,96	0,62	0,84	0,60	0,78	0,67	1,18
σ	0,21	0,53	0,27	0,53	0,23	0,40	0,24	0,71
$m_{Mcp.}$	0,07	0,15	0,09	0,16	0,07	0,11	0,09	0,21

Table 2 Mean length and weight of plaice in 1935-1936 and 1944-1945

Age, years	1935-1936*	1944-1945**		1944-1945***	
	Observations	Observations		Calculations	
	Length, cm	Length, cm	Weight, g	Length, cm	Length increm, cm
		Males			
1				9.3	
					4.1
2				13,4	
					4.1
3				17.5	
					4.5
4				22.0	
					4.2
5	29.5	26.5	250.0	26.2	
					4.0
6	32.0	30.2	350.0	30.2	
					2.4
7	34.4	32.6	490.0	32.6	
					3.6
8	36.9	36.2	600.0	36.2	
					1.7
9	38.6	38.0	710.0	37.9	
					1.1
10	38.7	39.0	800.0	39.0	
					3.7
11	42.6	42.0	950.0	42.7	
					2.0
12	44.1			44.7	
		Females			
1				8.8	
					4.2
2				13.0	
					3.5
3				16.5	
					5.0
4				21.5	
					3.4
5	30.9	28.0	350.0	24.9	
					4.5
6	32.2	29.3	400.0	29.4	
					3.0
7	33.8	33.9	510.0	32.4	
					3.6

(continued)

Table 2 Mean length and weight of plaice in 1935-1936 and 1944-1945

Age, years	1935-1936*	1944-1945**		1944-1945***	
	Observations	Observations		Calculations	
	Length, cm	Length, cm	Weight, g	Length, cm	Length increm, cm
8	36.0	37.0	700.0	36.0	
					3.4
9	38.3	39.4	790.0	39.4	
					2.4
10	40.3	41.8	900.0	41.8	
					3.1
11	44.2	48.0	1100.0	44.9	
					2.6
12	46.8			47.5	
13	49.7				
14	52.7				

* According to G.I.Milinsky (1938)
** According to T.S.Berger (1952)
*** According to M.V.Kovtsova (1976)

Table 3 Temperature characteristic of the southern Barents Sea waters in 30s-90s.

Periods, years	Anomalies of mean annual temperature (1°C) on the "Kolsky meridian" Section, St.3-7, at the depth of 0-200m	"Temperature" regime of period **
1935-1936	+ 0,3*	warm
1940-1942	- 0,4	cold
1944-1945	+ 0,2	moderate
1965-1969	- 0,4	cold
1970	+ 0,3	warm
1971	- 0,4	cold
1972-1976	+ 0,3	warm
1977-1982	- 0,6	cold
1985	- 0,2	moderate
1986-1988	- 0,3	cold
1989-1994	+ 0,4	warm

* - normal for 1900-1990 - 3.88°C
** - Bochkov Yu.A., 1991

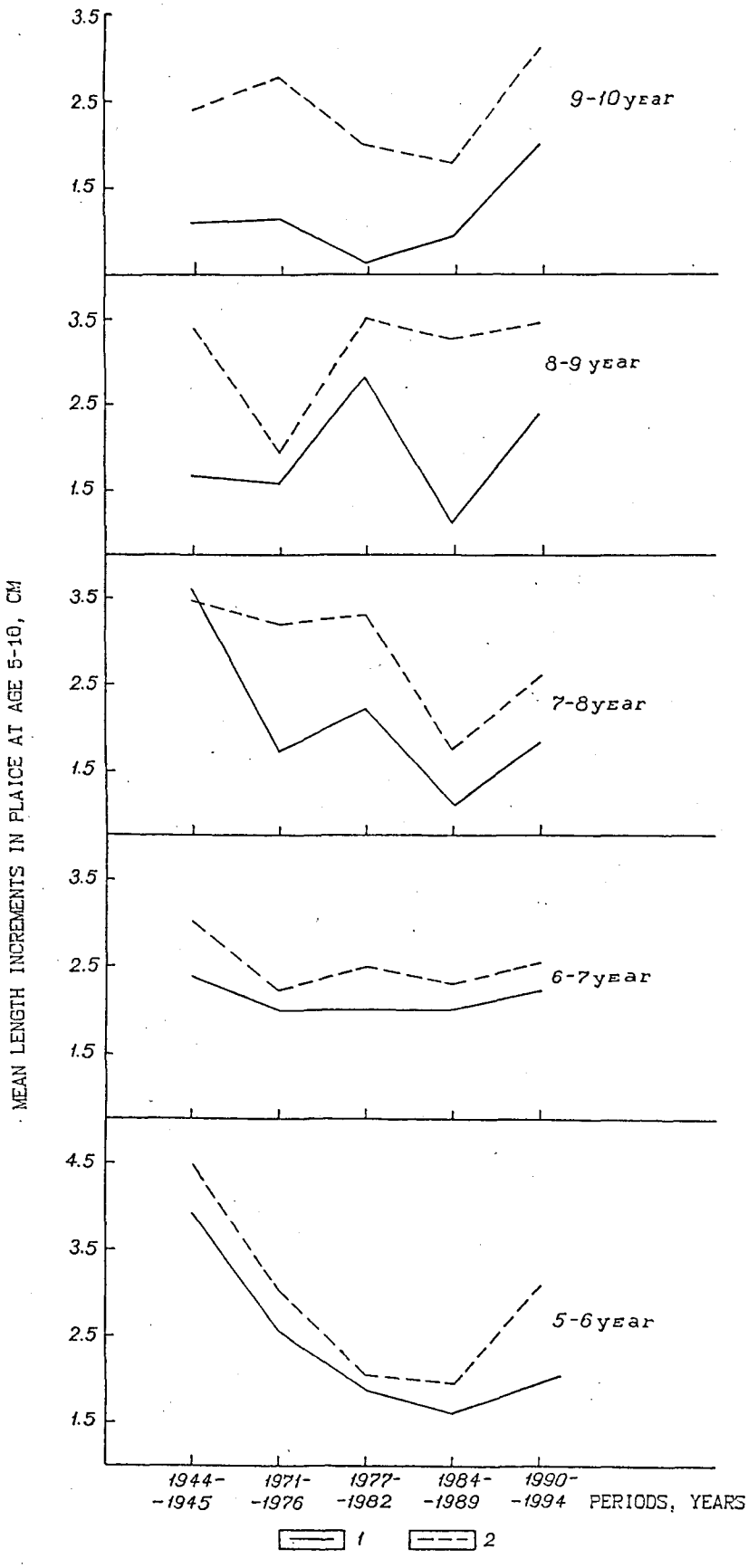

Fig.1 Changes in the length increments of the same age specimens from the different age groups of plaice in the Barents Sea in 30s-90s (1 - males; 2 - females)

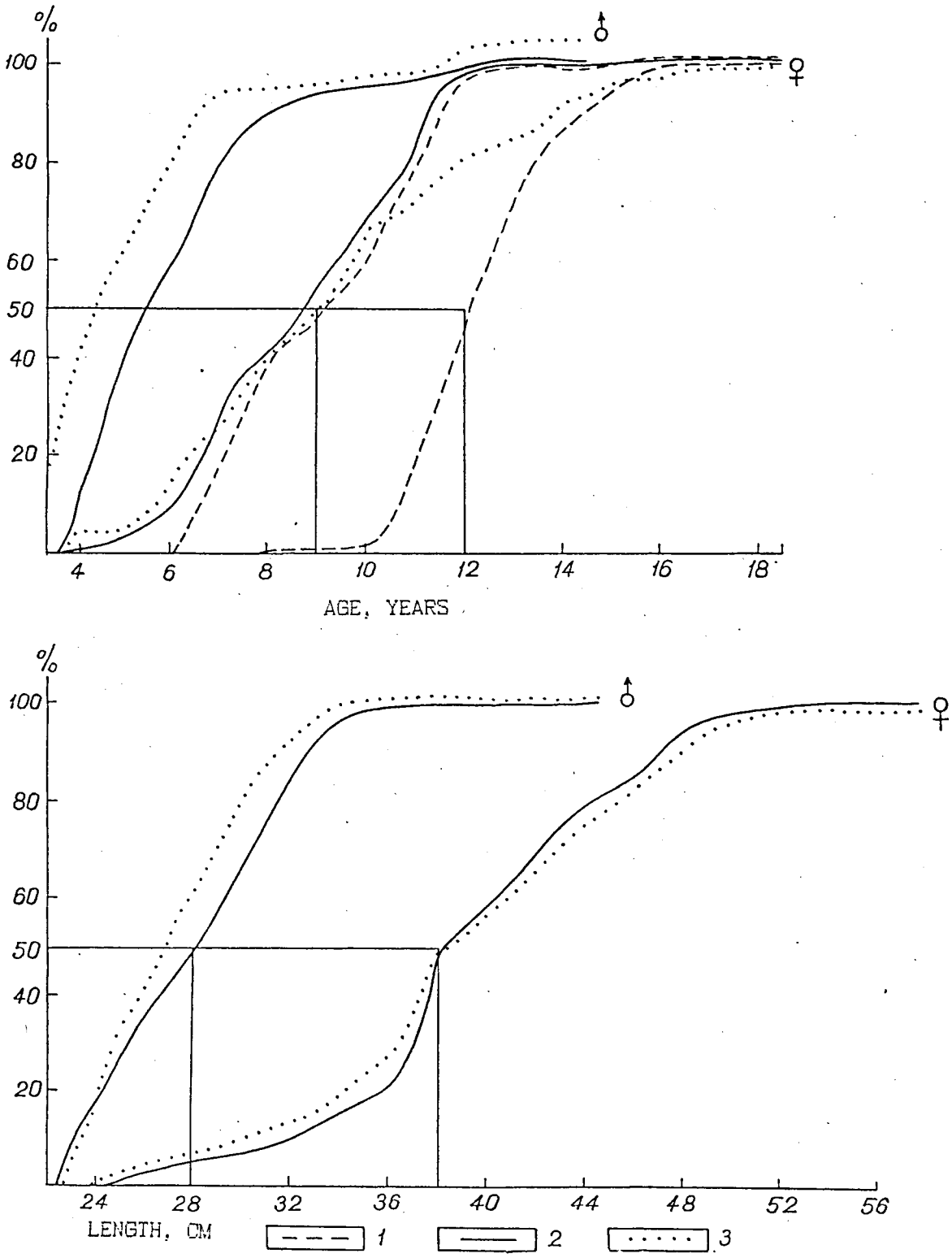

Fig.2 Ogives of the sexual maturation of the plaice males and females in different periods (Legend: 1 - mean for 1935-1936; 2 - 1975-1981; 3 - 1984-1994)