International Council for the Exploration of the Sea

C.M. 1980/G: 25
Demersal Fish Committee

Growth and maturation of the Lofoten-Barents Sea cod

by

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Abstract

Year-to-year changes in the mean length of 3- to 8-year-old cod in recent thirty years (1949-1978) are considered. Almost all age groups of cod had the greatest length in 1967 and 1971-1972 or 1971-1973. In recent five years the growth rate of cod of all age groups decreased and was close to the mean value for thirty years. A tendency towards a reverse relationship between the population density and cod mean length and a direct relationship between the growth rate and feeding indices were revealed.

On the basis of summarized data obtained for many years from field analysis on maturity stages of cod gonads in the period of fish migration to wintering and spawning grounds (November to February) the percentage of mature and immature cod at different age in years with different growth rate was calculated. The calculation of the percentage of mature cod at different age in autumn/winter will permit to predict the age composition of mature cod at Lofoten spawning grounds in spring of the next year.

A higher rate of cod maturation in the sixties-seventies as compared to the thirties-fifties as well as a lower mean age of spawning cod were registered.

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Résumé

Il s'agit des variations interannuelles de la taille moyenne de la morue de 3 à 8 ans au cours de trente dernières années (1949 - 1978). Les années 1967 et 1971-1972 ou 1971-1973 ont été caractérisées par la taille maximum du poisson de tous les âges. Les cinq dernières années le rythme de croissance de la taille de la morue de tous les âges a baissé et s'est rapproché du rythme moyen pour les trente ans. La tendance a été relevée au rapport inverse entre la densité de la population et la taille moyenne de la morue et au rapport direct entre les indices d'engraissement et le rythme de croissance.

En généralisant les résultats des recherches effectuées pendant plusieurs années sur les stades de maturité des gonades de la morue lors de sa migration vers les lieux d'hivernage et de frai (novembre - décembre) on définit le rapport entre les individus maturés et non-maturés de la morue d'âge différent au cours des années caractérisées par le rythme de croissance différent. Le pourcentage des individus maturés parmi la morue d'âge différent en automne et en hiver permet de prévoir l'âge de la morue maturée dans les frayères des Iles Lofoten au printemps prochain.

On a relevé l'accroissement du rythme de la maturation sexuelle de la morue dans les années 60-70 par rapport aux années 30-50 et la baisse d'âge de la morue pleine.

Introduction

When investigating the regularities of abundance dynamics of the commercial fish populations the study of the fish growth rate and connected with it maturation rate is of paramount significance. Many important population parameters (reproduction and natural mortality rates, duration of life, use of feeding area etc.) depend greatly on these characteristics, the estimation of which is required for working out the biological basis of rational fisheries.

In changing conditions of abiotic, biotic environment and with changes in the effect of antropogenic factor the rates of fish growth and maturation, in particular, those of north-eastern arctic cod (Gadus morhua morhua L.) are also subjected to considerable changes, either one or other factors being the main cause of these changes (Rollefsen, 1938, 1954; Saetersdal & Cadima, 1960; Dementyeva & Mankevich, 1966; Ponomarenko, 1968a; Borisov, 1978). That is why we have once again to consider these problems, to reveal new relationships or to find confirmation to the known regularities on the basis of new data.

It is common knowledge that two environmental factors exert the greatest influence on the fish growth: food (quantity, quality and availability) and temperature determining the intensity of metabolism. When food is sufficient all the time the growth rate is determined by temperature: at lower temperature of water masses - it decreases, and when the temperature rises up to optimum - the growth rate accelerates. When the nutritive base changes and the temperature is more or less constant the fish growth rate depends on the availability of food which in its turn depends on the number of consumers and quantity of food in a reservoir. In any case changes in the growth rate of fish in some periods are found to be

closely connected with those environmental factors which suffer considerable changes.

The first task of the present paper was to determine the amplitude and reasons of year-to-year fluctuations of the mean length of the Barents Sea cod of the same age in recent years.

The second task was to calculate the percentage of mature and immature specimens among females and males of cod at different age, and to determine the maturation rate of cod in 1967-1978 in connection with changes in the growth rate.

Material and methods

Data collected by PINRO for many years on the mean length of cod at different age in some years, results of the field analyses of cod feeding which were assumed as a basis for calculating the average annual indices of cod stomach fullness (Ponomarenko & Yaragina, 1978) and summarized data of field analyses of cod gonads maturity stages were used in the present paper.

Data on cod maturity were collected in the course of cod age sampling during their migration to wintering and spawning grounds (November to February). In this period the gonads of maturing cod (those which will spawn in spring of the year coming) differ most markedly from the gonads of immature cod.

Stages of cod maturity were determined visually by 6-division scale (Borokin, 1957, 1960). Fishes whose gonads in the mentioned season were at the maturity stages I or II were considered immature, and those with gonads at maturity stages II-III to YI-II - mature. The analysis of data on separate age groups permitted to calculate the percentage of mature fish among cod at different age. In all 67629 cod specimens were analysed in November to February to determine the gonads maturity stages for 1966/1967 to 1977/1978. About

76% of all data was collected in the southern Barents Sea (area I), 21.6% - in the Bear Island-Spitsbergen area (IIb) and 2.6% - off the north-western coast of Norway (IIa). The data for the last subarea were collected only in autumn/winter of 1966/1967, 1969/1970, 1970/1971 and 1972/1973.

Results

Year-to-year changes in the mean length of cod of some age groups in comparison with the long-term mean are shown in Fig.1 and 2.

In area I the mean length of cod of all age groups under study decreased sharply from the late twenties to mid-thirties*; then it increased up until the seventies, especially that of younger age groups**.

In 1949 - 1978 the mean length of 3-year-old cod in the southern Barents Sea varied from 39.7 to 42.3 cm, the coefficient of variation of the thirty average annual values was 5.2% (Table 1).

With the increase in the cod age coefficients of variation of the average annual lengths decreased and were 4.1% for the 4- and 5-year-olds, and 3.1%, 2.7% and 1.9% for the 6-, 7- and 8-year-olds respectively. In subarea IIb coefficients of variation of the thirty average annual length values were higher and varied from 8.0% for 3-year-olds to 3.5% for 8-year-olds (Table 1).

* In the twenties-thirties the cod age was determined by scale, in the successive years- by otoliths. It is quite possible that a great difference in the mean lengths of cod of the same age in the twenties-thirties is caused to a great extent by errors in determining the age and different reading of the first annual ring by various scientists. That is why we calculated the long-term mean length of cod of some age groups using the data for the recent thirty years (1949-1978) when the cod age was determined only by otoliths.

** It may be to some extent caused by the increase of mesh size in fishing gears which were used for age sampling: until 1961 the 90 mm mesh size was used in trawls, in 1961/1962 - 110 mm, in 1963-1966 - 120 mm, from 1967 - 130 mm (manila).

In the southern Barents Sea in recent thirty years almost all age groups of cod had the smallest mean length in 1949-1953 and the greatest one and consequently the highest growth rate in 1967 and 1971/1972. Judging by average figures the growth rate of cod in recent five years decreased and was close to the mean value for thirty years. The same tendencies in variations of the mean length of cod of some age groups were registered also in subarea IIb in recent years (Fig.2). Tables 2-5 show the increase in length and weight of cod of some year classes in area I and subarea IIb (according to observations data).

Dementyeva T.F. and Mankevich E.M. (1966) who studied the changes in the cod growth rate for 1934-1960 registered a good correlation between the cod mean lengths in some years and the sum of temperatures in periods of feeding during the fish life. The authors have come to the conclusion that temperature was one of the main factors that influenced on the cod growth rate, and "the curve of water heat-content almost repeats the curves of cod growth rate up until 1955/1956".

However, the situation was different in the successive years. From the fifties to the seventies the mean length of cod of some age groups increased notwithstanding a steady cooling of the Barents Sea which does not seem to favour the increase in growth rate of cod. Ponomarenko V.P. (1968a) concluded that the main reason of the increase in growth rate of cod in these years was scattering of the population caused by the intensive fishery and lack of strong year classes in the stock.

Borisov V.M. (1978) considers that the increase in rates of cod growth and maturation from the thirties to the seventies is

connected not so much with a better supply of fish with food as with a selective effect of the intensive fishery on the structure of cod population. With an increase in fishery intensity the abundance of slow-growing and late-maturing cod in years preceding their first spawning decreases so that they almost do not participate in the reproduction. At the same time the role of fast-growing and early-maturing specimens in the reproduction increases, on the contrary, and they have advantages in the forming of future year classes.

We do not deny that the suggested hypothesis is quite logical and right but still consider the scattering of the population and better food supply of fish resulted from it to be the main reasons of the increase in growth rate of cod from the thirties-fifties to the seventies. A tendency to the reverse relationship between the cod stock size in the Barents Sea in some years (the average annual catch per unit of fishing effort may serve as an index of cod stock) and growth rate proves this. Scattering of the cod stock under the influence of fishery and due to appearance of some very poor year classes (1961, 1965, 1966, 1967) contributed to the increase in growth rate in the sixties and early seventies notwithstanding a low heat content of the Barents Sea water masses. But when some rich year classes entered the commercial stock in the seventies (Trambachev, 1979) the mean length of cod of all age groups decreased (Fig. 1,2) which was indicative of the growth rate reduction.

The tendency to the reverse relationship mentioned above is not, however, always distinct. This results, first of all, from food supply of fish depending not only on the number of consumers but

also on the quantity of food in a reservoir which changes by years as well. Thus, for example, in 1964 due to poor abundance of capelin (Ponomarenko & Yaragina, 1978) the mean index of stomach fullness of cod and their growth rate were comparatively low notwithstanding the poor abundance of cod in this year (Fig.3). Evidently the more stable the nutritive base is, the more distinct the negative relationship between the abundance and growth rate of cod and vice versa. In a thirty-year period the relationship between the mean length of 4-year-old cod and average annual catches of the fish per trawling hour by Murmansk side trawlers may be expressed by correlation coefficient equal to -0.49, between the mean length of 4-year-olds and mean indices of stomach fullness of cod in corresponding years (n=20) - +0.60 (southern Barents Sea), between the mean length of 6-year-olds of fourteen year classes and abundance indices of corresponding year classes - -0.69 (Bear Island-Spitsbergen area). The negative relationship between the abundance and mean length of cod of some age groups was the most distinct in recent years (Fig.3,4).

On the basis of this relationship the next increase in the cod growth rate should be expected in the first half of the eighties due to appearance of some poor year classes (1976-1979).

Using the data of numerous field analyses on gonads maturity obtained during the cod age sampling in the period of their migration westwards to wintering and spawning grounds (November to February) we made an attempt to determine the ratio of mature and immature specimens of cod at different age and just how these ratios differ depending on region, sex and also in years of the highest and the lowest growth rate of cod.

According to the analysis made some specimens of cod in the ICES area I and subareas IIa and IIb in the period from 1966/1967 1977/1978 matured at the age of 4 and even 3 years (0.5 and 0.2% respectively of the total number of examined fish of these age groups). 2.4, 5.3 and 13.2% of specimens matured at the age of 5, 6 and 7 years respectively, 30.8 and 57.4% - at the age of 8 and 9 years. Only at the age of 14 years all 100% of cod were mature (Table 6). The maximum cod age in our samples was 19 years.

The percentage of mature specimens of the same age was higher in subarea IIb than that in area I (Table 6). This resulted evidently from a higher growth rate of cod in the Bear Island-Spitsbergen area (Tables 1-5). Off the north-western coast of Norway (IIa) where the main spawning grounds of cod are situated the percentage of mature fish among cod of some age groups is higher than that in feeding areas (I and IIb). It is natural as mainly mature fish migrate from feeding areas to spawning grounds.

In all years and throughout the surveyed area as a whole mature cod made up 8.3% of the total number of specimens examined (67629 spec.), in area I mature cod constituted 5.9%, in subarea IIb - 10.9% and in subarea IIa - 58.0%. 8- and 9-year-old fish predominated among mature cod (Table 6, Fig.5). There were only 21 specimens of 13-year-old cod and 10 specimens of 14-year-old fish. That is why notwithstanding a 100% maturation the portion of 14-year-olds in the total number of mature fish of all age groups (0.2%) was considerably lower than that of 5-year-olds (8.6%) though only 2.4% of 5-year-olds were mature.

Among mature cod males predominated at the age up to 10 years and females at the age from 10 years and older. The oldest age groups (17-18-19 years) were presented by females exclusively. The

prevalence of males was the greatest among mature specimens at the age of 6-7-8 years (Fig.5). The percentage of mature specimens of these age groups is higher among males than that among females (Table 7) which is indicative of earlier maturation of males.

In years with the highest growth rate of cod (1967, 1971/1972) the percentage of mature specimens of all age groups was somewhat higher than the mean values given above (Table 7) and in recent 12 years with the lowest growth rate (1969, 1974, 1975) - somewhat lower. For example, in the first case the portion of mature cod among 5-year-olds was 5%, in the second case - 1.4%, among 6-year-olds - 7.3% and 3.9% respectively, and among 7-year-olds - 19.6% and 10.7% etc. (Table 7).

Garrod (Garrod, 1967) using the data obtained by Rollefsen (Rollefsen, 1954) and Ponomarenko V.P. (Ponomarenko, 1968b) attempted to determine earlier on the basis of other methods the percentage of mature fish among cod of different age groups. If to ignore differences in methods of determining the percentage and to compare our data with those obtained by the authors mentioned above we may state that the percentage of mature cod of some age groups increases especially that of younger age groups (Table 8). Thus, we may conclude that the maturation rate of cod increases. If in the thirties-fifties 50% of cod became mature between the 10th and 11th year of life (Rollefsen, 1954, quot. according to Garrod, 1967), now - between the 8th and 9th year of life, i.e. a 50% point of maturation shifted by two years towards younger age.

The increase in maturation rate of cod could hardly be wholly attributed to the increase in linear growth rate. Figures 1 and 2 show that in recent five years the growth rate of cod in area I

and subarea IIb was close to the long-term mean (30 years).

We consider the hypothesis of a selective effect of intensive fishery on the structure of cod population quite real (Borisov, 1978). As a result of such selection the portion of late-maturing fish in the population decreases steadily as they have much fewer chances to survive prior to spawning and to spawn in comparison with fast-growing specimens.

We can agree with V.I.Borisov that the artificial simplification of the age structure of the long-lived fish stock and particularly that of cod leads to the exhaustion of genetic fund of the population, lowering of its resistance to the influence of the environment, reduction in the foraging area and underexploitation of the reservoir nutritive base.

Shortening of a life cycle of the population and mean age of mature fish is one of the first symptoms of the influence of intensive fishery on the population structure. According to our data for 1967-1978 the mean age of mature cod in the ICES area I and subareas IIb and IIa was 7.9 years including 7.8 years in area I, 7.6 years in subarea IIb and 8.7 years in subarea IIa. For comparison we calculated the mean age of spawning cod in Murman in 1936-1946 using data from previous papers (Glebov, 1963). The mean age was 8.5 years.

In subarea IIa the mean age of spawning cod caught by a longline in the Lofoten area in 1932-1937 was 10.3 years (Saetersdal & Hylen, 1964), in the successive years - 9 years (Hylen & Dragesund, 1973, quot. according to Anon. 1979). Our data indicate to a decrease in the mean age of mature cod in area I by 0.7 of a year compared to 1936-1946.

To verify obtained by us data on the percentage of mature fish

among cod of different age groups in foraging areas we made an attempt to determine the age composition of spawning cod (skrei) on the Lofoten spawning grounds in spring 1978 using the data for November 1977 to February 1978. During calculations we also used data on the total stock (number of specimens) of cod at different age in the beginning of 1978 given in the Report of the ICES Working Group (C.M. 1979/G:20, Table 10).

Knowing the number of specimens and percentage of mature fish of each age group we determine the number of specimens of mature cod of each age group and the percentage of some age groups. A great similarity between the calculated and actual age composition of skrei (Yakobsen, 1979) indicates that the determined percentages of mature fish among cod at different age (especially those of young cod - up to 10 years) are very close to actual (Table 9). There was also noted a great similarity between the calculated and actual data on the age composition of skrei in 1976 and 1977. Evidently it will be possible to predict the age composition of skrei in spring of the next year on the basis of determined percentages of mature fish among cod of different age groups during their migration to wintering and spawning grounds.

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Table 1.

Limits of variation, long-term mean values and coefficients of variation of the mean length of 3- to 8-year-old cod in a 30-year period (1949-1978).

Age	Southern Barents Sea (I)			Bear Island - Spitsbergen area (IIb		
	Limits of variation of average annual values	Mean length, cm	Coefficient of variation of 30 average annual values, %	Limits of variation of average annual values	Mean length, cm	Coefficient of variation of 30 average annual values, %
3	33,70-42,30	38,44	5,2	28,05-45,85	38,86	8,0
4	4I,00-49,15	45,I5	4,I	42,90-50,55	47,I4	4,2
5	48,69-57,30	52,54	4,I	50,55-60,65	54,95	4,7
6	56,07-65,00	60,89	3,I	57,90-67,60	63,29	3,9
7	64,39-72,06	69,37	2,7	65,I0-78,50	7I,84	4,0
8	75,64-8I,50	77,80	I,9	73,65-87,00	80,07	3,5

Table 2.

Mean length of cod of the 1946-1976 year classes at different age in the southern Barents Sea, cm

Year class	Age						
	3	4	5	6	7	8	9
I946	36,30	43,I3	50,I0	59,90	68,90	80,I8	85,95
I947	37,80	42,80	50,30	60,62	72,06	78,90	86,80
I948	35,I5	44,05	50,40	62,49	69,65	79,45	86,80
I949	37,75	4I,50	52,98	59,55	69,25	78,00	82,25
I950	34,I5	45,I3	50,50	59,80	68,65	76,90	83,55
I95I	38,78	43,45	5I,80	6I,70	69,50	76,20	85,I5
I952	33,70	45,50	52,45	6I,I0	67,60	76,95	83,75
I953	37,80	44,70	5I,70	60,05	69,75	77,60	84,25
I954	37,00	45,50	5I,85	6I,65	7I,50	79,65	89,I5
I955	40,45	46,30	53,55	62,I0	70,65	78,85	88,55
I956	38,90	46,20	53,55	6I,40	69,65	8I,50	90,45
I957	38,30	44,25	5I,20	60,00	7I,00	79,45	84,20
I958	38,20	45,45	5I,75	59,85	69,55	76,20	83,70
I959	39,85	45,50	49,60	59,55	67,65	77,70	83,75
I960	40,30	44,20	5I,I5	60,55	7I,80	77,00	84,05
I96I	38,60	44,95	53,35	65,00	69,55	77,60	83,20
I962	37,00	46,55	57,30	62,35	69,85	76,80	84,75
I963	4I,I0	48,65	54,20	6I,00	68,65	77,75	86,45
I964	39,I0	46,25	52,85	60,25	7I,I0	80,05	90,55
I965	39,35	46,70	53,25	62,65	70,40	78,90	84,50
I966	4I,20	46,05	56,I0	64,50	72,00	76,70	84,00
I967	39,75	49,I5	56,00	63,00	7I,45	77,40	83,35
I968	4I,25	48,75	55,90	60,75	68,25	77,25	86,75
I969	42,30	44,65	5I,60	60,75	69,50	79,I0	83,75
I970	38,I0	43,40	53,20	6I,05	70,I5	77,I0	83,05
I97I	36,60	44,75	53,00	6I,40	69,90	76,95	
I972	39,45	45,I5	53,90	62,25	70,00		
I973	38,70	45,90	55,I0	6I,00			
I974	38,35	44,85	5I,55				
I975	37,95	42,35					
I976	33,90						

Table 3.

Mean weight of cod of the 1946-1976 year classes at different age in the southern Barents Sea, g.

Year class	Age 3	4	5	6	7	8	9
I946	575	885	I039	I969	2735	3780	52I4
I947	624	772	II4I	I90I	3234	3856	5366
I948	388	783	II36	230I	2977	4029	5774
I949	458	635	I274	I69I	27I6	4038	4700
I950	362	829	II73	2288	2754	3868	5089
I95I	553	759	I08I	20I9	2967	3885	5757
I952	36I	79I	I30I	2052	2723	4055	5006
I953	5I3	849	I200	I940	3074	4059	5203
I954	45I	825	I304	2079	3238	4I40	5687
I955	594	942	I420	2I28	2963	3949	5484
I956	556	929	I385	I976	2780	4495	6083
I957	544	8I5	I23I	I795	2822	3947	548I
I958	546	880	II78	I730	2757	3888	53I7
I959	590	830	985	I766	2658	4090	5090
I960	588	706	II59	I93I	3I92	3889	5006
I96I	499	8I6	I409	2293	279I	39I4	5234
I962	537	9I6	I552	2005	2389	4008	5559
I963	63I	I000	I3I5	I823	2824	4226	6III
I964	536	792	I228	I927	3236	4728	6223
I965	488	876	I334	2230	3I24	4363	52I3
I966	585	888	I607	2364	3I03	39I3	5223
I967	565	II07	I532	207I	3I32	4274	5630
I968	647	I02I	I459	I897	2938	4244	5793
I969	708	75I	II68	I923	3020	436I	5200
I970	468	703	I327	2I00	2927	3832	4903
I97I	423	796	I359	2023	28I8	3766	
I972	552	834	I38I	2040	2927		
I973	530	879	I425	I884			
I974	506	777	II7I				
I975	479	662					
I976	363						

Table 4.

Mean length of cod of the 1946-1976 year classes at different age in the Bear Island - Spitsbergen area, cm.

Year class	Age						
	3	4	5	6	7	8	9
I946	28,05	45,80	52,50	63,30	73,4I	83,00	92,80
I947	40,40	47,65	54,55	67,40	75,00	87,00	88,05
I948	33,60	47,95	59,80	66,98	78,50	79;I0	88,I0
I949	38,70	45,40	53,77	64,90	70,65	79,50	83,45
I950	37,I5	47,66	59,30	64,30	72,70	80,50	86,30
I95I	37,88	50,05	54,90	64,I5	7I,40	78,85	90,35
I952	40,25	49,20	56,55	63,90	70,70	83,35	85,55
I953	38,95	46,45	53,20	62,20	72,55	80,25	84,90
I954	39,50	47,05	54,65	63,70	74,00	79,30	83,25
I955	4I,40	48,I0	55,55	64,90	7I,70	77,05	86,80
I956	40,50	47,90	56,30	63,65	69,60	79,95	86,I5
I957	39,45	48,50	54,I5	6I,05	70,60	80,05	87,65
I958	42,25	47,80	53,65	60,65	70,90	78,I0	83,65
I959	38,00	43,80	50,55	60,50	70,80	79,20	86,60
I960	35,75	44,75	52,20	63,05	72,45	79,42	85,I0
I96I	36,55	46,20	54,75	64,25	69,80	77,05	85,55
I962	38,80	46,35	56,85	62,60	69,70	79,I0	87,70
I963	42,00	49,45	54,40	60,65	69,65	8I,05	92,30
I964	39,70	45,50	53,I0	6I,65	73,55	84,60	92,50
I965	36,I8	47,00	54,65	66,90	76,60	83,05	9I,05
I966	38,05	49,00	59,40	67,60	75,80	84,45	89,60
I967	39,70	50,35	60,65	66,60	75,25	8I,70	87,25
I968	40,I5	50,55	58,40	66,I5	74,85	79,50	87,60
I969	45,85	49,85	56,80	64,00	7I,20	8I,20	89,05
I970	42,55	47,40	54,60	6I,20	73,25	8I,20	94,50
I97I	37,20	44,55	52,30	62,I0	70,25	83,35	
I972	38,65	45,60	54,80	6I,65	7I,80		
I973	40,75	45,I0	53,25	62,30			
I974	38,00	46,35	53,90				
I975	39,85	44,I5					
I976	35,00						

Table 5.

Mean weight of cod of the 1946-1976 year classes at different age in the Bear Island - Spitsbergen area, g.

Year class	Age 3	4	5	6	7	8	9
I946	500	947	I274	2226	3562	5730	6642
I947	609	946	I406	2690	4308	5866	5588
I948	332	933	I840	3058	4430	4208	6235
I949	457	922	I49I	2578	2865	43I7	4646
I950	550	980	I993	2I60	3I82	4236	5978
I95I	II67	II99	I378	2307	2985	43I7	677I
I952	735	I0I9	I597	2I50	3029	5623	599I
I953	48I	924	I283	I965	3457	4568	5I73
I954	578	933	I357	2263	3538	4050	5339
I955	643	984	I493	24I7	3027	406I	5470
I956	6I4	99I	I607	2I77	2943	42II	6556
I957	6I0	I059	I379	I978	2957	5I96	6I70
I958	764	984	I366	I9I6	3338	4343	5I86
I959	5I8	787	II44	I982	3224	4299	42I9
I960	453	822	I300	2250	3200	3688	6035
I96I	458	9I2	I500	2306	2675	4273	5766
I962	57I	898	I625	2038	3077	4682	626I
I963	675	I094	I363	I962	3I05	4776	767I
I964	596	646	I3I7	2064	3358	5584	7386
I965	4I2	I002	I463	2574	40I9	48I4	8720
I966	49I	I077	I9II	27I9	38I0	7760	5923
I967	488	II96	I92I	26I8	5389	4500	7033
I968	608	III8	I769	3922	3582	5I38	6202
I969	834	II5I	2554	2253	3524	5070	687I
I970	697	I559	I370	2I59	3254	4974	86I8
I97I	904	756	I306	2088	3073	5429	
I972	503	840	I408	203I	3I36		
I973	655	8I7	I3I9	2052			
I974	48I	828	I38I				
I975	5II	754					
I976	38I						

Table 6.

Number and percentage of mature fish among cod of different age during their migration to wintering and spawning grounds (November-February), in foraging areas (I, IIb) and spawning grounds (IIa) (summarized data for 1966/67 - 1977/78).

Area / Age	Southern Barents Sea (I)			Bear Island-Spitsbergen area (IIb)			North-western coast of Norway (IIa)			I, IIa, IIb		
	Number of fish examined	Number of mature fish	Percentage of mature fish	Number of fish examined	Number of mature fish	Mature fish, %	Number of fish examined	Number of mature fish	Mature fish, %	Number of fish examined	Number of mature fish	Mature fish, %
I+(2)	62	0	0							62	0	0
2+(3)	3740	9	0,4	207	0	0	II	0	0	3958	9	0,2
3+(4)	I2049	68	0,6	4507	I8	0,4	II9	2	I,7	I6675	88	0,5
4+(5)	I4485	I55	I,I	5099	327	6,4	I25	I	0,8	I9709	483	2,4
5+(6)	I0692	402	3,8	I969	220	II,2	I30	56	43,I	I279I	678	5,3
6+(7)	5428	554	I0,2	I094	I8I	I5,4	345	I73	50,I	6867	908	I3,2
7+(8)	2966	758	25,6	776	255	32,8	438	275	62,8	4I80	I288	30,8
8+(9)	I273	672	52,8	6I2	335	54,7	339	270	79,6	2224	I277	57,4
9+(I0)	408	274	67,2	205	I53	74,6	I67	I52	9I,0	780	579	74,2
I0+(II)	I08	83	76,9	75	66	88,0	77	7I	92,2	260	220	84,6
II+(I2)	37	32	86,5	2I	I6	76,2	22	20	90,9	80	68	85,0
I2+(I3)	7	6	85,7	7	6	85,7	7	7	I00	2I	I9	90,5
I3+(I4)	I	I	I00	4	4	I00	5	5	I00	I0	I0	I00
I4+(I5)				2	2	I00	3	3	I00	5	5	I00
I5+(I6)	I	I	I00				3	3	I00	4	4	I00
I6+(I7)				I	I	I00				I	I	I00
I7+(I8)				I	I	I00				I	I	I00
I8+(I9)	I	I	I00							I	I	I00
Total	5I258	3016	5,9	I4580	I585	I0,9	I79I	I038	58,0	67629	5639	8,3

Table 7.

Percentage of mature specimens among males and females of cod at different age in foraging areas (November-February 1966/67 - 1977/78) and among cod of both sex in years with different growth rate.

Age	♂♂	♀♀	♂& ♀	♂ & ♀	
				in years with a high growth rate(1967, 1971- 1972).	in years with a low growth rate (1969, 1974, 1975).
3+(4)	0,4	0,5	0,5	0,9	0,I
4+(5)	2,5	2,I	2,3	5,0	I,4
5+(6)	5,7	2,8	4,5	7,3	3,9
6+(7)	I5,0	5,6	I0,2	I9,6	I0,7
7+(8)	35,0	I5,9	25,I	42,0	27,7
8+(9)	65,2	40,4	5I,9	73,4	47,2
9+(I0)	77,4	62,5	69,I	83,6	72,0
I0+(II)	83,8	79,8	8I,4	9I,9	74,2
II+(I2)	95,0	75,0	82,I	97,I	80,0
I2+(I3)	I00	8I,8	85,7	I00	I00
I3+(I4)	I00	I00	I00	I00	I00

Table 8.

Percentage of mature specimens among North-eastern Arctic cod of different age, according to data by some authors.

Age, years	Garrod, 1967 (according to data by Rollefsen for 1941 – 1953)	Ponomarenko, 1968b.	Our data
3			0,2
4			0,5
5			2,4
6	+	+	5,3
7	3	7	I3,2
8	I0	26	30,8
9	24	42	57,4
I0	42	55	74,2
II	6I	68	84,6
I2	79	79	85,0
I3	92	87	90,5
I4	99	92	I00
I5	99	97	I00
I6	I00	I00	I00

Table 9.

Estimated and actual age composition of spawning cod ("skrei") in 1978.

Year class	Age	Stock by the beginning of the year, thou. of specimens*	Mature fish, %**	Number of mature fish, thou. of specimens	Age composition, %	
					Estimated	Actual ***
I977	I	33I2	0			
I976	2	435685	0			
I975	3	475570	0			
I974	4	I93I68	0,2	386	0,7	0,I
I973	5	245I9I	0,6	I47I	2,8	2,5
I972	6	I35423	3,3	4469	8,6	8,0
I97I	7	56II4	II,6	6509	I2,5	I3,5
I970	8	72044	32,0	23054	44,3	47,0
I969	9	I8339	55,8	I0233	I9,7	20,0
I968	I0	25I4	69,I	I737	3,3	6,0
I967	II	I907	8I,4	I552	3,0	0,8
I966	I2	III5	82,I	9I5	I,8	0,8
I965	I3	I794	85,7	I537	2,9	0,8
I964	I4	I75	I00	I75	0,3	0,2
I963	I5	66	I00	66	0,I	0,3
		I6424I6		52I04	I00	I00

* According to data of the ICES Working Group (C.M.1979/G:20,Table10

** According to data from the analysis of maturity stages of cod gonads in November-February 1977/78 in Subareas I and IIb. The percentage of mature fish among 10 to 15-year-old cod was determined on the basis of long-term mean data (Table 7), as there were few fish of such an age in samples in 1977/78.

*** According to T.Jakobsen (Jakobsen, 1979); figures are taken from the graph.

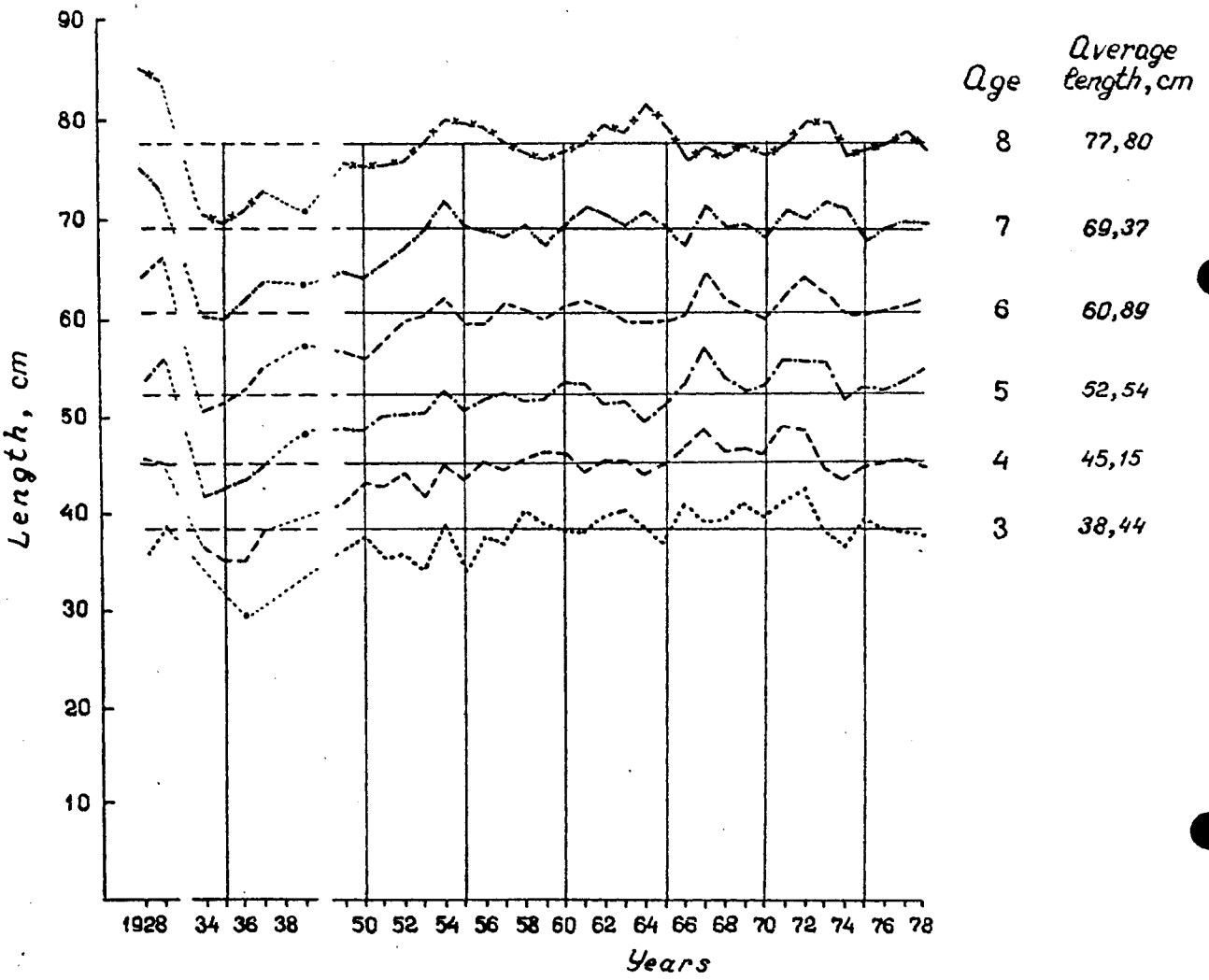

Fig. 1. Year-to-year changes in the mean length of 3- to 8-year-old cod in the southern Barents Sea. Horizontal lines and figures show long-term mean values for 1949-1978.

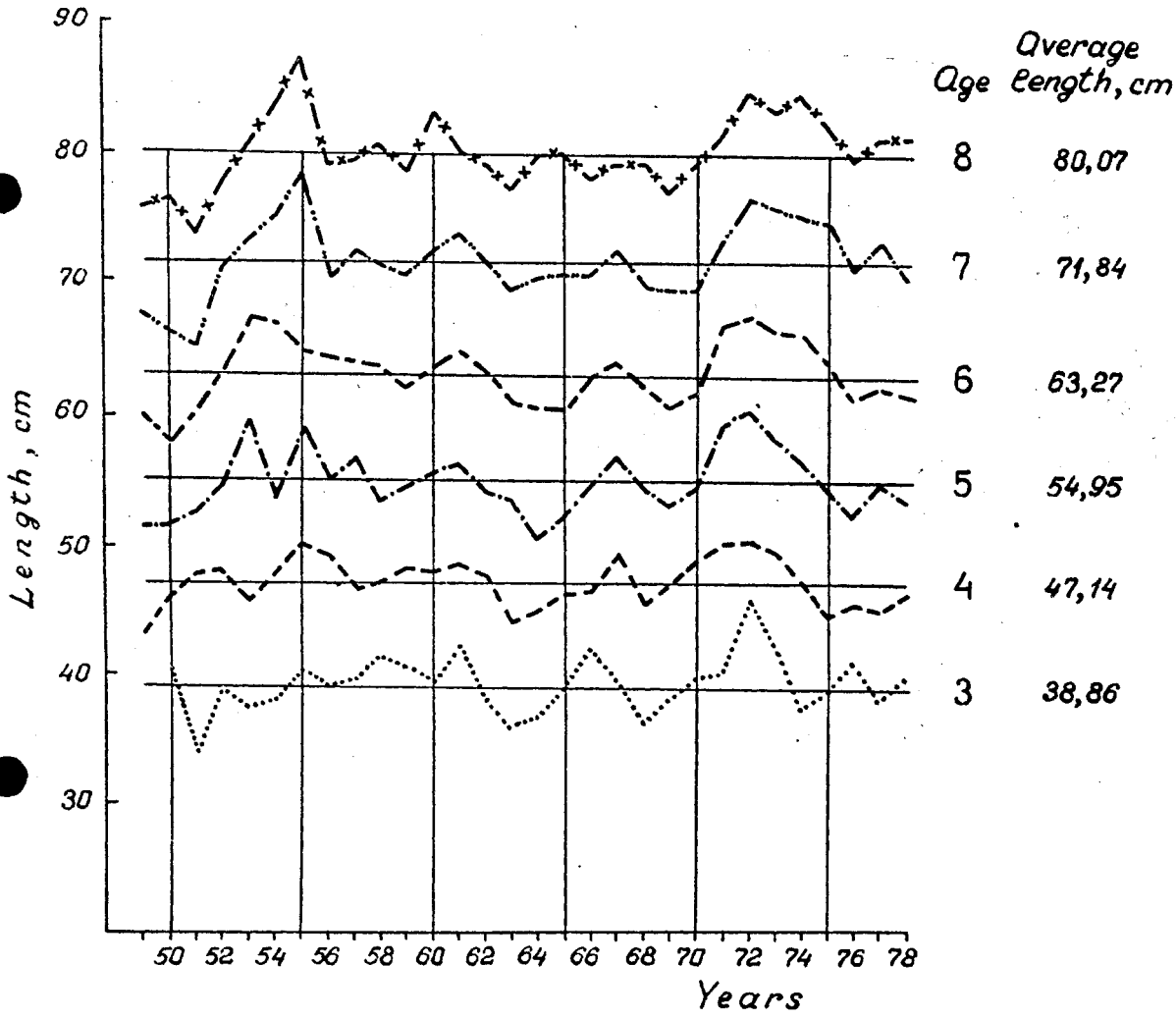

Fig. 2. Year-to-year changes in the mean length of 3- to 8-year-old cod in the Bear Island - Spitsbergen area. Horizontal lines and figures show long-term mean values for 1949-1978.

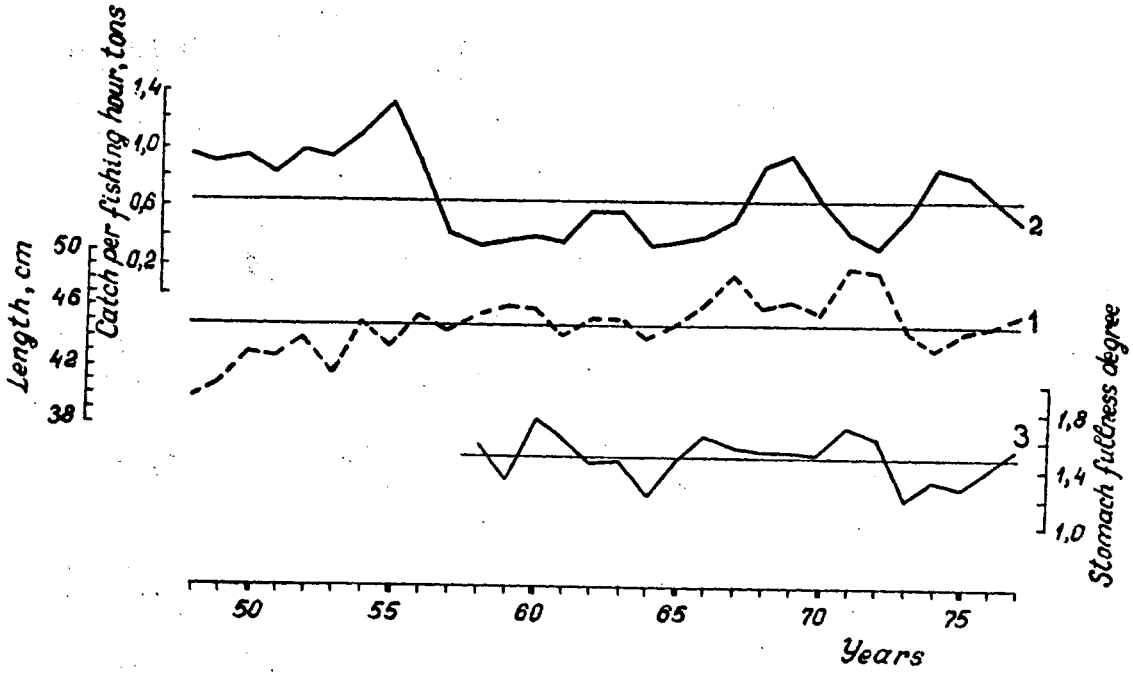

Fig. 3. Year-to-year changes in the mean length of 4-year-old cod in the southern Barents Sea (I) in comparison to year-to-year changes in catches of cod per fishing effort (2) and long-term mean indices of stomach fullness of cod (3).

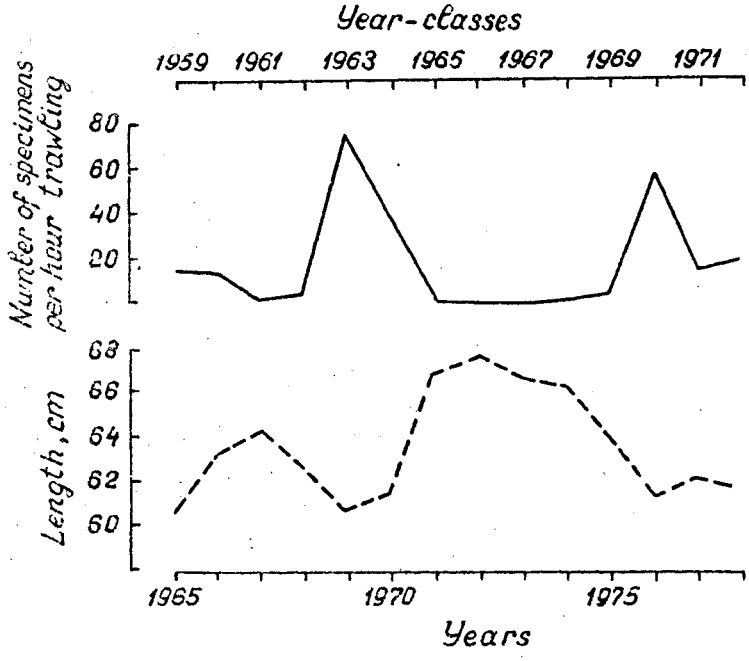

Fig. 4. Mean length of 6-year-old cod of the 1959-1972 year classes in the Bear Island - Spitsbergen area in comparison to abundance indices of the corresponding year classes according to the young fish survey data (the mean catch per trawling hour at age 1+ and 2+, specimens).

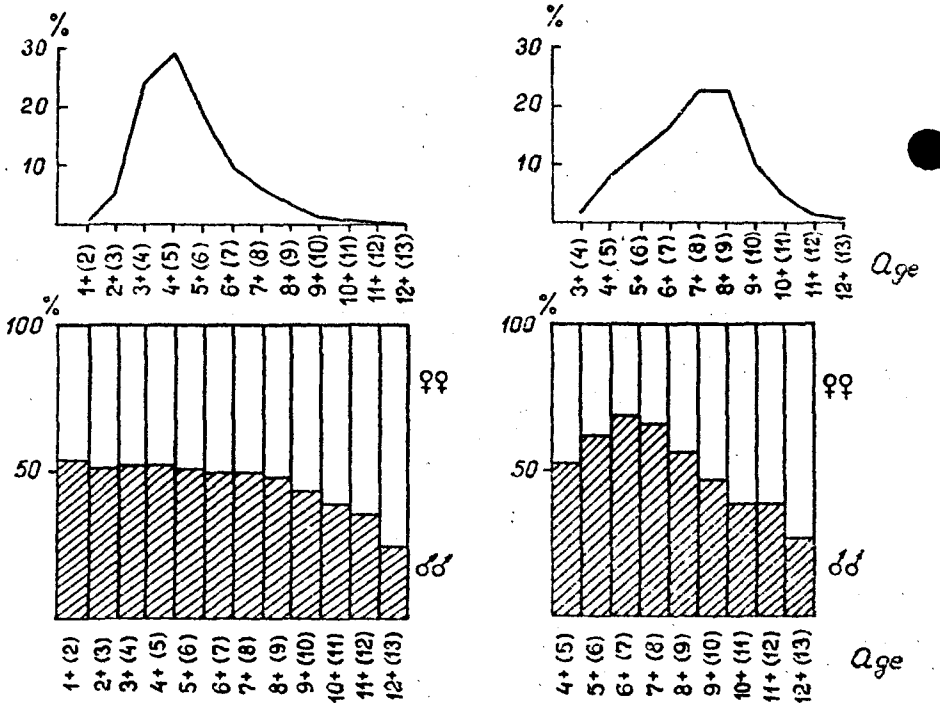

Fig. 5. Age and sex composition of all examined cod (left) and mature cod (right) in November-February 1966/67 - 1977/78.