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Status of Roundnose Grenadier Stocks and Possibilities for Their Commercial Removal in the Northwest Atlantic

by

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Abstract

In the present paper the possibility to commercially fish the roundnose grenadier in Subareas 0, 1 and in the ICNAF Divisions 3K and 2G is considered on the basis of the analysis of the size, age and sex composition in catches in 1967-1979. The instantaneous commercial mortality coefficient assessment which may result in the maximal possible catches have been done for Division 3K. The calculations are based on commercial and biological statistics of international fisheries, on Virtual Population Analysis and on the method of Beverton and Holt. The total amount of fish of a proper age having been caught during a series of years of fishing and also total fishing effort (amount of hours of fishing) are calculated. Those calculations indicated that a stable catch in Division 3K equals to 28 000 tons at M = 0.15 and 17 000 tons at M = 0.20. All the drawbacks of such method of the optimal fishery calculation are also indicated.

The size, age and sex composition analysis showed that from 1967 to 1971 in Division 3K the heavy fishery brought about the change in these indices. A catch per unit effort decreased. In subsequent years when the fishery was less intensive these indices again increased to the previous level. Some changes in size composition of catches took place in Division 2G in

1971 when the total removal reached the maximum - 54 000 tons. In Subareas 0 and 1 similar changes were not observed. Basing on the size-age analysis of catches in Division 3K it should be possible to recommend a removal of about 20 000 tons. The grenadier removal in Division 2G and Subareas 0 and 1 can be increased compared with the present one without any fears of the subsequent decline in grenadier abundance.

Introduction

The roundnose grenadier is an abundant deepwater fish widespread along the continental slope from the Cape Hatteras in the south up to the Cumberland Peninsula in the north and also near separate sub-water banks remoted from the slope. It may be found at depths over 2 000 m (Leim and Scott, 1966). The effective removal of this fish (since 1967) is conducted by bottom and mid-water trawls at depths of 500- 1 300 m. The main fishing areas are the ICNAF Divisions 3K, 2G and Subareas 0 and 1. The USSR removes about 90% of the total catch; Poland, GDR and FRG remove only a small amount of this fish. The total annual catch amounts to tens of thousands tons (Table 1). In connection with this assumption the question arises as to how great the removal of this valuable fish can be. The recent years the specialists of different countries made several attempts to assess the possible removal of grenadier. The difficulties are in the fact that commercial and research gears cover only the upper part of the vertical distribution of grenadier by depths. Besides, the grenadiers shoals locality and spawning areas are unknown.
The present article is one of the attempts to assess the optimal removal of roundnose grenadier in the Northwest Atlantic fishing areas.

Material and methods

The greatest number of roundnose grenadier was removed an-

nually in Division 3K where the most complete ichthyologic observations took place and data on the size, age and sex composition in catches for a series of years were collected. This allowed to assess the instantaneous commercial mortality coefficient which should result in the maximal annual removal. The commercial and biological statistics of international fishery (Stat.Bull.ICNAF, 1969-1979), the VPA and Beverton and Holt method were taken as the grounds for calculations. A total amount of removed fish in thousands of specimens of a known age for a certain period of fishing and also a total fishing effort in hours of fishing were calculated (Table 2). The amount of hours of fishing spent for certain species of fish removal were not considered by statistics. That is why it was necessary to choose such months of a year when there was a directed fishery of roundnose grenadier in Division 3K and other fishes removal constituted a small part. The number of hours spent by the similar type of ships on grenadier removal was calculated in the same per cent relation as the grenadier removal related to that of other fishes. Having known an annual removal of grenadier in Division 3K the number of hours of fishing was determined by method of proportionality.

Mass measurings of grenadiers from commercial trawls catches were conducted in Division 3K in 1967-1975 and in 1977-1978. The length distribution sequence for 1976 was obtained by using average data for years 1975 and 1977. Age samples were taken in 1967, 1969, 1970, 1972, 1977 and 1979. Considering that grenadier males and females rate of growth differs slightly and that males and females number in catches is almost constant we have combined these materials. As it turned out a rate of grenadier length and weight growth in different years was almost the same we decided to combine the all years age samples and then to evaluate the length frequency of separate years in the age indices. Thus, the age characteristic of commercial removal of grenadier in 1967-1979 was obtained. The total removal (thousands of spec.) in separate years was distributed proportionally to the age composition in catches during the

same years (Table 2).

The grenadier age-limit was taken conditionally by separate fishes removed which were the oldest (length - 89 cm, age - 19). Age of fishes entering the commercial stock was taken conditionally and equalied to 6-7.

The age of fishes was read from the scales placed in the polarized passing light according to the technique described earlier (Savvatimsky, 1971).

In an attempt to determine the optimum removal of round-nose grenadier in various areas and without having a sufficient number of age indices we have analysed the annual total removal from the ICNAF Statistical Bulletins, the size and sex composition of the catches for the period 1967-1979. The last characteristics are season dependent, therefore, only the data for June-December (a period of directed fishery of grenadier) were considered.

Grenadiers were taken mainly by bottom and only sometimes by midwater trawls which more often took place in Division 2G. As the size composition and average length in the catches by bottom and midwater trawls were almost the same (Table 3), the length frequency distribution of midwater and bottom catches were combined. The sex composition also was almost the same (Table 4). For composing Tables 3 and 4 we have chosen only those months of proper years when the two above-mentioned methods of removal were used.

Fishes length was measured to within 1 cm and subsequently to simplify further calculations the lengths were combined in 3 cm groups (30-32, 33-35, 36-38 cm etc.). Figures 1, 6, 7, 8 give smoothed length distributions. They were smoothed according to the formula:

$$B = \frac{a+2b+c}{4}$$

where a, b, c are previous, middle and subsequent terms of the distribution and B is a term to be determined. In the

right side of the figures the size composition of the catches is presented as deviations from the long-term mean values.

Fig.3 gives the age composition in the catches obtained by evaluating the length distribution sequences for proper years in the age samples for the same years. Grenadiers age composition given in Fig.4 was obtained by evaluating the length distribution sequences for proper years in the total age indices (summarized age samples from 1967 to 1979).

The number of fishes being analysed is given in Tables and in Figures.

On the prospects of grenadier fishery

In 1968 Gulland estimated that as much as 10 000 tons of grenadier can be taken in the North Atlantic (Ann.Meet.ICNAF, 1968). However, since the development of fishery for this species (from 1967) on the Northern Newfoundland Bank (Div.3K) alone the annual catch has been almost twice as much as Gulland's figures. In the subsequent years no attempts to determine the optimum removal of roundnose grenadier have been made as the available commercial and research fishing gears could not cover the entire range of grenadier vertical distribution and, besides, grenadier migrations, spawming grounds, age composition and stock localities were unknown which were the obstacles for estimating the size of the commercial stock. Only in 1974 Pinhorn (Pinhorn, 1974) having used the method of Bertalanffy as well as that of Beverton and Holt found that the optimum grenadier removal in Subareas 2 and 3 should not exceed 30 000 tons. In 1976 Borrmann (1976) on the basis of mathematical calculations relating to the age and size compositions in catches for some years showed that the present fishery does not affect adversely the grenadier stock and that the average annual removal of 34 000 tons in Subareas 2-3 and of 8 000 tons in Subareas 0-1 are within the limits of the calculated possible sustainable catches. In 1976 Parsons (1976) using the same methods sug-

gested to consider a removal of 24 000-37 000 tons as the optimum in Subareas 2-3. Parsons and other researchers (Parsons, Veitch, Legge, 1978) note that during the last 10 years of grenadier fishery in the Northwest Atlantic a catch per hour of trawling remained almost unchanged and this indicates that the biomass is stabilized. They consider that grenadier removal in Subareas 0-1 equal to 8 000 tons and in Subareas 2-3 equal to 35 000 tons is allowable.

The estimates of grenadier removal given by Pinhorn, Parsons and Borrmann are not final as the techniques used presuppose the constant annual recruitment into the commercial stock and do not allow for the variations in the year classes abundance. Besides, they, like authors of the present article (see section "Material and methods"), use a lot of assumptions and conditional quantities while calculating the allowable catch in Division 3K; that is why the results of such calculations should be assumed only as approximate ones.

Stock assessment and possibilities for grenadier removal in Division 3K was calculated using the VPA method and that of Beverton and Holt. While composing a mathematical model of the grenadier commercial stock the commercial and biological statistics for the period 1967-1978 was taken as the initial data (Tables 2 and 6).

The equation of the grenadier individuals length growth according to Bertalanffy is as following:

$$l_t = 156\ (1-\exp\ (-0.039\ (t + 2.47)))$$

Curves of dependence of possible catch per unit of recruitment Y_w/R on commercial mortality coefficient F calculated for the two values of M=0.15 and M=0.20 have their maximum in the points of F= 0.35 and F= 0.65, respectively (Fig.9).

While plotting the curves of the grenadier possible removal the following values of parameters were taken:

$$t_\rho = 2,\ t_\rho' = 6,\ t_\lambda = 19$$

The possible catch per recruit at M=0.15 is about 337 g and at M=0.20 - about 133 g.

For assessment of the grenadier stock by VPA technique we have calculated, at first, the instantaneous coefficients of total mortality Z of each year class during the last year of life (at the age of 19) as natural logarithms of ratio of mean abundance in a catch per hour of trawling at the age of 19 to mean abundance in a catch per hour of trawling for the proper year class at the age of 20.

The instantaneous commercial mortality coefficients F of each year class at the last year of life were calculated by subtracting M =0.15 and M = 0.20 from the calculated values of Z.

Tables 7-9 give the results of the grenadier stock assessment by VPA at M =0.2.

It may be seen from these tables that the stock in Division 3K approached its maximal value of $17 \cdot 10^4$ tons in 1970 and then gradually decreased to $10 \cdot 10^4$ tons in 1978.

From 1970 there exists a linear dependence between the stock and removal with a correlation coefficient equal to 0.6.

Average abundance of individuals at the age of 2 was $13 \cdot 10^7$ spec. which allows at F=0.65 to obtain a possible catch of $17 \cdot 10^3$ tons if possible catch per recruit equals to 133 g. This removal corresponds to the average removal for the fishing period under review (1967-1978). Hence, the grenadier fishery in Division 3K is conducted rationally.

The results of the roundnose grenadier stock assessment in Division 3K by VPA technique at M= 0.15 are not given in the present article. Average abundance of individuals at the age of 2 at M= 0.15 equals to $82 \cdot 10^6$ spec. which at corresponding catch per recruit = 337 g and F =0.35 provides a possible removal of $28 \cdot 10^3$ tons at F =0.35.

Since the natural mortality coefficient for roundnose grenadier in Division 3K is not determined yet the amount of $20 \cdot 10^3$ tons should be taken as the figures of possible removal for this species.

In 1980, the total yield of grenadier was only about 500 tons. In July 1980 (RV"N.Kononov") the catches there consisted of fishes at age 3-17 (at the average - 9.8 years). Mean length of fishes was 59.6 cm, mean mass - 467.0 g (by 391 spec.). These parameters are similar to the long-term *mean ones*.

A heavy fishery usually results in a change of length and age composition in catches, sexes ratio in catches (if there is a directed fishery of males or females with different gears) and also change of catches per unit of commercial effort. According to a change of these indices we may judge how the fishery affected the fish stocks.

The grenadier fishery in the Northwest Atlantic has begun in 1967. The greatest are annually taken by the fishing fleet in the Newfoundland area (more precisely in Division 3K) with the exception of 1971 when in Division 2G 54 179 tons were taken. Lesser grenadier catches in the northern part of the ICNAF area in 1972 compared with those of 1971 are explained by the fact that the fleet was mainly engaged in the fishery of Greenland halibut whose aggregations appeared in 1972 off Baffin Land following the hydrological conditions favourable for this fish. In Division 3K the grenadier annual catches are approximately equal (Table 1). In 1967-1970 the fishery in this division was concentrated within a limited area extending for 40-50 miles along the continental slope. Grenadiers in this period were heavily fished, the number of large refrigerator trawlers equaled to 20. The fishery was of a short duration and the fishing fleet in this area operated only in October and November.

The fishery in 1967-1970 over a limited area of the continental slope in Division 3K semms to have influenced the grenadier abundance. In the above period there decreased the catch per unit effort, changed the size, age and sex composition of the catches which was not the case in the other ICNAF divisions where a commercial removal of grenadier was small (Savvatimsky, 1972). Fig.1 shows the size composition of grenadier catches by years in Division 3K. From the left side of the

figure it can be seen that from 1967 to 1971 the dominant length of fishes in catches decreased. From the right side of the figure where yearly deviations from the long-term mean values are given it can be seen that during these years a relative number of large fishes in catches also decreased. Mean length of fishes decreased from 62 cm to 42 cm (Fig.2). The age composition of the catches also changed. If in the catches in 1967 dominated fishes at the age of 9-14, in 1970 there dominated fishes at the age of 6-7 (Figs 3 and 4).

Since 1971 the fishing area in Division 3K has increased. If during the first years the fishery in this division was intensive and of short duration then in the subsequent years the fishery was conducted during summer and autumn months. In 1972, for example, the fishery lasted from May till November (Stat. Bull.ICNAF, 1974). In 1972 and later when the fishery was conducted over a large area, at various depths and in different seasons the size composition of the catches was restored (Figs 1 and 2). The sex composition was also restored (Fig. 5 and Table 5). From the materials above it can be drawn that an annual removal of 18 000-20 000 tons of grenadier in Division 3K which is close to the average annual removal for recent years will not affect adversely the grenadier stocks, however, to all appearances it would be unreasonable to exceed this figure.

In Div.2G the annual commercial removal of grenadier is small except 1971 when the catch amounted 54 000 tons. In the period from 1966 to 1970 the grenadiers in the catches were larger than in subsequent years. It can be clearly seen in Fig.6 especially in its right side that before 1970 there was an excess of large and a lack of small fishes in the catches compared with the long-term mean distribution, but from 1971 - just vice versa- an excess of small and a lack of large fishes. Analysing the left side of Fig.6 one can not say that the change in the size composition was very considerable, such as it was in Division 3K from 1967 till 1971. The portion of females in catches by years practically did not change (Table 5). However, indisputab-

ly that the annual catch of 54 000 tons in Division 2G caused some changes in the size composition of the catches in 1971. In subsequent years the catches here were small (Table 1) and in 1978 the size composition of the catches was at mean long-term level and average length of fishes in catches was close to average fishes length in 1966-1970 (Fig.2).

Unfortunately, we have no data on Subarea 0 (Baffin Land) for 1977 and 1978 but we can state that form 1967 to 1976 no changes in the size and sex composition of catches took place in this area (Fig.7, Table 5). Some decrease in average length (Fig.2) in catches in 1975 and 1976 and the fact that the length frequency curve had two vortices in 1975 were caused by the fact that the grenadiers were removed from comparatively small depths, mainly as a by-catch during a directed fishery of Greenland halibut. The amount of grenadier taken in this area was small. In Subarea 1 (West Greenland) from 1969 to 1972 a small increase of fishes average length in catches was observed, then there was a decrease till 1976 and an increase again up to 1977 (Figs 2 and 8). These changes, probably, were not connected with the commercial fishery.

Conclusions

The presented data show that the fishery in 1967-1978 did not affect substantially the grenadier stocks in the Northwest Atlantic. Judging by year to year trends in the size, sex and age composition of the grenadier catches the optimum catch in Division 3K should be 18 000 - 20 000 tons. The removal of 54 000 tons in Division 2G in 1971 caused some changes in the size composition of catches, therefore, the optimum catch in this division should be less than this figure. One may consider that in the northern part of the continental slope of Canada the grenadier forms more abundant aggregations compared with Division 3K where the fishery is limited by a small area. It is quite possibly that the grenadier abundance in the northern parts of the area is higher than that in the southern part

as it is peculiar to many fishes of high latitudes, for instance, Pacific grenadier (Novikov, 1970).

Taking into consideration that the grenadier aggregations off Labrador, Baffin Land and the Greenland-Canadian Threshold take a much larger area than that off the North Newfoundland Bank (Division 3K) the catches there may be increased at least twice comparing with the present ones and should reach the figure of 20 000 tons, i.e. approximately the same figure as for Division 3K.

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Table 1 Roundnose grenadier total removal according to the ICNAF Stat.Bull.data in 1967-1977 (tons)

Subareas and Divisions	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Subarea 0	1129	5907	2642	545	4172	5783	1054	2661	204	2610	721
Subarea 1	6	284	68	5980	4132	2311	3830	9657	4749	5893	2214
Subarea 2	1085	7104	990	1904	56998	3109	6744	5560	11779	6682	3328
Division 2 G	-	2536	440	25	54179	2161	5880	3220	6489	3841	2597
Subarea 3	16219	24159	11789	22524	18447	21277	10820	22856	15646	13911	12058
Division 3K	16009	23553	11789	22395	18392	21122	10655	22816	15388	13636	11935
Subareas 0-6	18439	37454	15489	30953	83759	32480	22448	40734	32435	29096	18321

Note: Yield in Subareas 0-6 is given by data from: "Mirovye ulovy ryby i nerybnykh obyektov promysla v Severo-Zapadnoy Atlantice (1965-1976)", Moscow, 1978.

Table 2 Total removal (tons) and total amount of fish removed (thou of spec.) of different age and total number of hours of trawling by large refrigerator trawlers in grenadier fishery in Div.3K

Year of fishery	Total catch (tons)	Number of hours of trawling	A					G			E									Total
			2	3	4	5	6	7	8	9	I0	II	I2	I3	I4	I5	I6	I7	I8	I9	
I967	I6009	7350	49	I6	9I	33I	87I	I596	2686	3376	3974	4I58	4I96	3206	2305	I2I7	669	26I	45	2I	290I9
I968	23553	I275I	I73	55I	I2I0	2965	5657	7372	8I64	767I	6008	4458	3905	290I	2I34	I240	725	336	73	29	55572
I969	II789	7009	64	478	896	I523	2629	3636	4I06	384I	3I78	2423	I933	I373	953	530	32I	I52	28	22	28086
I970	22395	84I6	899	3I69	6248	I0350	I3507	I4389	II407	8238	4683	2339	I46I	780	390	I46	97	89	65	8	78I03
I97I	I8392	95I3	4083	I0630	I6I42	I6872	I0424	742I	5862	4390	29I9	I906	I2I2	692	404	203	203	29	28	27	83420
I972	2II22	I0I26	77	37I	9I3	2059	3575	5592	7480	79I8	6474	48I7	3773	2459	I6I6	809	504	202	I00	II	48739
I973	I0655	39I8	59	I35	304	68I	II84	I577	2I9I	2546	2645	24I2	2357	I796	I348	834	489	269	63	30	20920
I974	228I6	I04I9	42	89	335	I3II	2369	3554	5553	6579	664I	5740	505I	3555	2465	I278	843	405	62	93	45965
I975	I5388	7667	436	45	I38	397	I070	2064	3344	4045	4288	3966	3790	2654	I806	I007	607	240	32	3I	29524
I976	I3636	5I35	I25	465	879	I444	I859	2356	3364	3950	3876	3302	2978	2087	I430	745	438	I82	38	5	295I8
I977	I2058	7530	I75	593	I090	I749	2009	2300	3I3I	3583	3423	2828	2420	I679	II65	596	344	I50	3I	I3	27279
I978	I5265	I4249	220	468	807	II9I	I544	2448	3962	48I2	47I6	389I	3232	2I25	I396	750	428	I96	42	I6	32244

Table 3 Roundnose grenadier mean length (in cm) in catches by bottom and midwater trawls in the North Labrador area

Year	Males		Females		Males and females	
	Bottom fishery	Midwater fishery	Bottom fishery	Midwater fishery	Bottom fishery	Midwater fishery
I972	62,93	62,68	63,28	64,8I	63,07	63,5I
I973	57,I4	62,99	58,24	66,62	57,57	64,43
I974	62,86	63,8I	63,00	63,40	62,64	63,76
I975	63,30	6I,45	64,40	6I,44	63,76	6I,II
I976	6I,38	59,78	6I,0I	6I,36	59,63	60,4I
I972-I976	60,74	62,44	62,I2	64,29	6I,54	63,I5
Number of fish	I9I65	I8309	II837	II277	3I002	29586

Table 4 Roundnose grenadier females number (%) in catches by bottom and midwater trawls in the North Labrador area

Year	Bottom fishing		Midwater fishing	
	% of females	Number of fish	% of females	Number of fish
I972	40,I6	3I97	38,98	2486
I973	38,6I	449I	39,59	II486
I974	35,44	II286	34,38	7I73
I975	42,I7	4992	38,35	4409
I976	38,57	7036	39,78	4032
I972-I976	38,I8	3I002	38,I2	29586

Table 5

Roundnose grenadier females number in catches by years and areas in August - December

Year	Div.3K		Div.2G		Subarea 0		Subarea 1	
	Month	Females number	Month	Females number	Month	Females number	Month	Females number
I967	VIII-XI	69I 36,4	XI	6I8 35,I	VIII-X	II06 3I,0		
I968	X-XII	I64 3I,3	X-XI	I438 39,8				
I969	XI	79I 30,6	X	I42 40,5	VIII-X	2597 29,I	VIII-IX	2I07 32,2
I970					VIII-IX	2543 30,2	VIII	785 29,6
I97I	VIII	349 35,6	X-XII	3293 45,9	IX-X	I00I 25,5	IX-X	2I40 35,I
I972	X	20I 3I,8	VIII-X	3449 37,4	VIII-X	2I98 32,8	VIII-XI	663I 38,9
I973	X-XI	3I87 4I,7	VIII-X	3866 39,3	VIII-X	662 27,0	VIII-XII	607I 38,3
I974	VIII	693 46,8	VIII-XII	4956 36,4	VIII-X	2708 28,2	VIII-XII	7033 38,8
I975	VIII, XI	I57I 40,6	VIII-XI	502I 44,0	VIII	505 37,0	VIII-XII	8I85 40,I
I976			VIII-X	6389 38,I	VIII-X	6073 33,0	VIII-XII	I087I 3I,7
I977	VIII,XII	I549 49,7	VIII,IX,XII	5220 42,I	XI	I2 4I,4	VIII-IX	606 32,I
I978	VIII,X,XII	I844 38,3	IX	708 40,0				
I979			X-XI	2626 39,9	IX-XI	I234 34,0		

Numerator - number of females (in specimens)

Denominator - number of females (in per cents)

Table 6 Mean weight (g) and mean length (cm) of roundnose grenadier of different age in Division 3K

Year of fishery		Years of age / Age																		
		2	3	4	5	6	7	8	9	I0	II	I2	I3	I4	I5	I6	I7	I8	I9	2-I9
I967 - I979	mean length, cm	25,75	34,II	35,89	39,36	44,96	49,II	53,I5	56,03	59,75	63,78	67,0I	69,92	72,42	75,56	77,02	80,59	86,43	89,00	59,22
	mean weight, g	54,5	I02,6	I22,6	I54,9	2I8,6	28I,8	333,2	388,4	466,9	552,I	638,7	728,4	8I5,5	869,8	942,3	I065,3	I29I,4	I320,0	494,2
	number of fish	4	I7	39	66	98	I45	I94	209	I9I	I68	I63	I33	I04	66	4I	22	7	3	I670

Table 7 Mean annual stock (tons) of roundnose grenadier in Div.3K by year classes (M=0.2)

Age	Years of fishery											
	I967	I968	I969	I970	I97I	I972	I973	I974	I975	I976	I977	I978
2	II497	II354	I0729	I0005	8875	7634	56I2	4022	327I	2892	2687	2853
3	I8706	I7690	I7469	I6376	I4849	I3484	II757	8643	6I96	4999	4422	4II0
4	I8892	I8228	I7225	I6693	I488I	I3929	I3I54	II5I2	8443	6007	4802	4248
5	I893I	I9567	I8662	I6973	I5565	I4206	I4298	I3489	II8I9	86I6	6024	4806
6	I9823	2I240	22056	I9962	I7547	I6090	I6099	I6206	I535I	I3422	9608	6636
7	I8204	I9797	2I25I	20949	I8472	I6533	I6344	I6362	I654I	I5752	I3630	9566
8	I4364	I6049	I7476	I8I68	I736I	I5623	I4874	I4689	I4799	I5I75	I4409	I2224
9	III8I	II776	I3282	I44I4	I4695	I4088	I3233	I2565	I2352	I2826	I3254	I23I9
I0	8467	8929	9408	II240	II953	I2096	II755	I0963	I0II6	I0478	II070	II254
II	6973	604I	6653	7746	9308	9563	9608	8222	8037	79I5	8490	886I
I2	6783	423I	3978	5207	6342	7086	7068	679I	5978	5625	5863	6253
I3	4I20	4026	2357	2868	4I77	4639	4865	4540	3909	37I6	3769	3970
I4	3I2I	I8I7	2388	I564	2207	29I4	2899	279I	2275	2I37	2248	23I7
I5	I632	I384	686	I693	II39	I4I6	I622	I470	II72	I055	II2I	I225
I6	7I3	633	643	376	I349	678	7I7	682	54I	464	498	560
I7	258	I84	233	4I5	29I	I052	267	I95	I77	I67	I75	208
I8	I65	86	37	II4	347	204	897	I02	26	49	65	75
I9	34	95	22	I2	44	268	I02	I28	32	4	I3	26
2-I9	I63864	I63I27	I64555	I64775	I59402	I5I503	I45I7I	I33372	I2I035	III299	I02I48	9I5II

Table 8 Mean annual stock (thou of spec.) of roundnose grenadier in Div.3K by year classes (M=0.20)

Age, years	I967	I968	I969	I970	I97I	I972	I973	I974	I975	I976	I977	I978
2	2I0948	208330	I96858	I83587	I62838	I40082	I02977	73806	600I5	53062	4930I	52357
3	I82320	I72422	I7026I	I59609	I44732	I3I422	II4592	84242	60388	48727	43I04	40063
4	I56094	I48679	I4050I	I36I55	I2I378	II36I6	I07295	9390I	68867	48996	39I68	34649
5	I222I7	I26322	I20480	I09577	I00485	9I7I0	92306	87082	76300	55624	38893	3I030
6	9068I	97I64	I00899	9I3I9	80269	73605	73645	74I35	70225	6I398	43955	30357
7	64599	70254	754I2	74339	65552	58668	57998	58062	58697	55898	48367	33948
8	43II0	48I67	52450	54525	52I03	46888	4464I	44084	444I4	45545	43245	36687
9	28787	303I9	34I97	37III	37834	3627I	34070	32350	3I803	33023	34I24	3I7I8
I0	I8I35	I9I25	20I50	24074	2560I	25907	25I77	2348I	2I667	22442	237I0	24I03
II	I2630	I0942	I2050	I403I	I6860	I7322	I7403	I4893	I4558	I4336	I5378	I6050
I2	I0620	6625	6229	8I52	9930	II094	II067	I0633	9359	8807	9I80	979I
I3	5656	5528	3236	3938	5735	6369	6679	6233	5367	5I0I	5I74	545I
I4	3827	2228	2928	I9I8	2706	3573	3555	3422	2790	2620	2757	284I
I5	I876	I59I	789	I046	I3I0	I628	I865	I690	I348	I2I3	I289	I409
I6	757	672	683	399	I432	720	76I	724	574	493	529	594
I7	242	I73	2I9	390	273	988	25I	I83	I66	I57	I64	I95
I8	I28	67	29	88	269	I58	695	79	20	38	50	58
I9	26	72	I7	9	33	203	77	97	24	3	I0	20

Table 9 Instantaneous coefficients of commercial mortality (F) of roundnose grenadier in Div.3K
(M= 0.2)

Age	Years of fishery											
	I967	I968	I969	I970	I97I	I972	I973	I974	I975	I976	I977	I978
2	0,000	0,00I	0,000	0,005	0,025	0,00I	0,00I	0,00I	0,007	0,002	0,004	0,004
3	0,000	0,003	0,003	0,020	0,073	0,003	0,00I	0,00I	0,00I	0,0I0	0,0I4	0,0I2
4	0,00I	0,008	0,006	0,046	0,I33	0,008	0,003	0,004	0,002	0,0I8	0,028	0,023
5	0,003	0,023	0,0I3	0,094	0,I68	0,022	0,007	0,0I5	0,005	0,026	0,045	0,038
6	0,0I0	0,058	0,026	0,I48	0,I30	0,049	0,0I6	0,032	0,0I5	0,030	0,046	0,05I
7	0,025	0,I05	0,048	0,I94	0,II3	0,095	0,027	0,06I	0,035	0,042	0,048	0,072
8	0,062	0,I69	0,078	0,209	0,II3	0,I60	0,049	0,I26	0,075	0,074	0,072	0,I08
9	0,II7	0,253	0,II2	0,222	0,II6	0,2I8	0,075	0,203	0,I27	0,I20	0,I05	0,I52
I0	0,2I9	0,3I4	0,I58	0,I95	0,II4	0,250	0,I05	0,283	0,I98	0,I73	0,I44	0,I96
II	0,329	0,407	0,20I	0,I67	0,II3	0,278	0,I39	0,346	0,272	0,230	0,I84	0,242
I2	0,395	0,589	0,3I0	0,I79	0,I22	0,340	0,2I3	0,475	0,405	0,338	0,264	0,330
I3	0,567	0,525	0,424	0,I98	0,I2I	0,386	0,269	0,570	0,494	0,409	0,324	0,390
I4	0,602	0,958	0,325	0,203	0,I49	0,452	0,379	0,720	0,647	0,546	0,422	0,49I
I5	0,648	0,779	0,672	0,075	0,I55	0,497	0,447	0,756	0,747	0,6I4	0,462	0,532
I6	0,883	I,077	0,470	0,243	0,I42	0,700	0,642	I,I64	I,057	0,888	0,650	0,720
I7	I,075	I,939	0,69I	0,228	0,I06	0,204	I,069	2,208	I,440	I,I59	0,9I2	I,003
I8	0,35I	I,076	0,953	0,734	0,I04	0,629	0,09I	0,779	I,554	0,986	0,6I4	0,7I5
I9	0,790	0,40I	I,236	0,8I5	0,797	0,054	0,389	0,I87	I,256	I,256	I,202	0,762

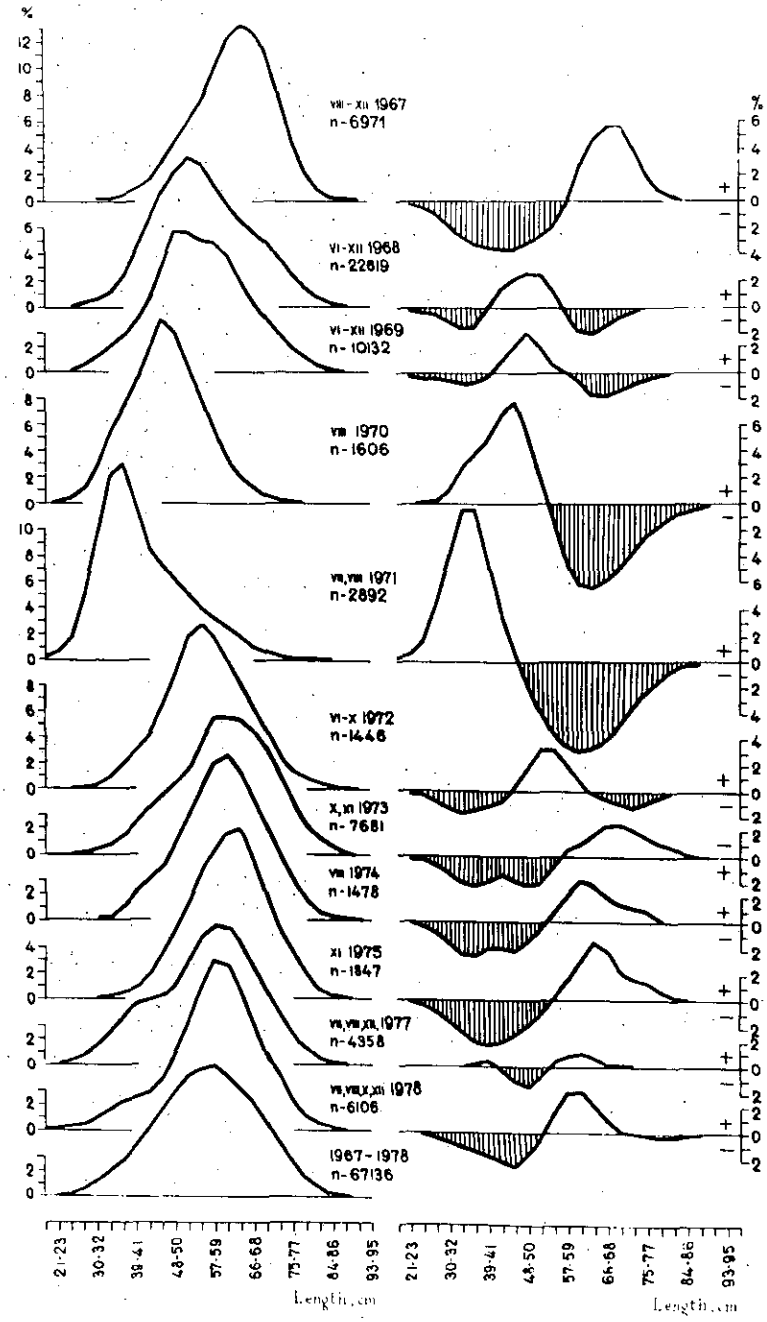

Fig.1 Size composition of roundnose grenadier in catches by years in Div.3K (by smoothed sequences).

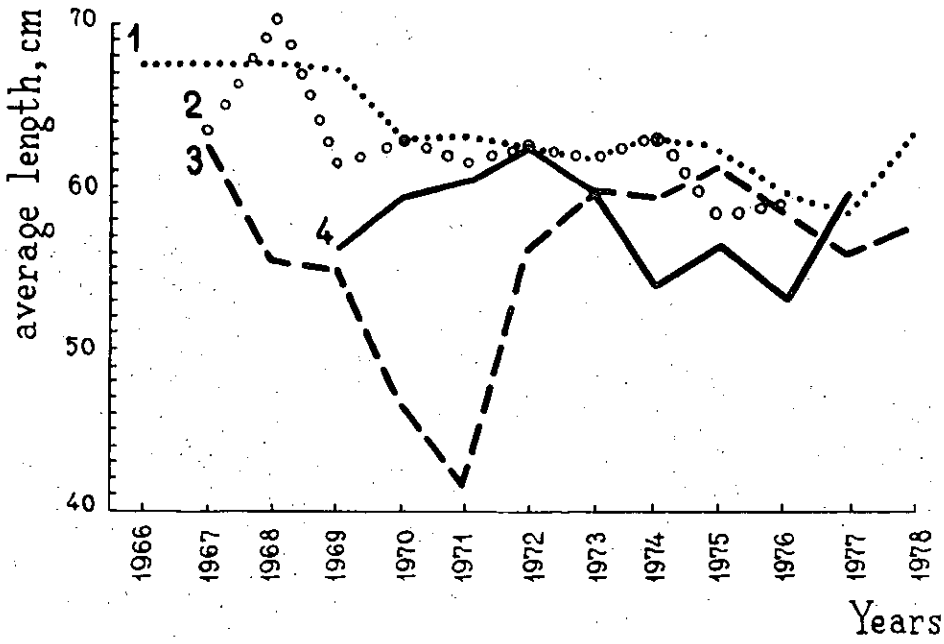

Fig.2. Grenadiers mean lengths in catches in 1966–1978

1 - Division 2G, 2 - Subarea 0

3 - Division 3K, 4 - Subarea 1

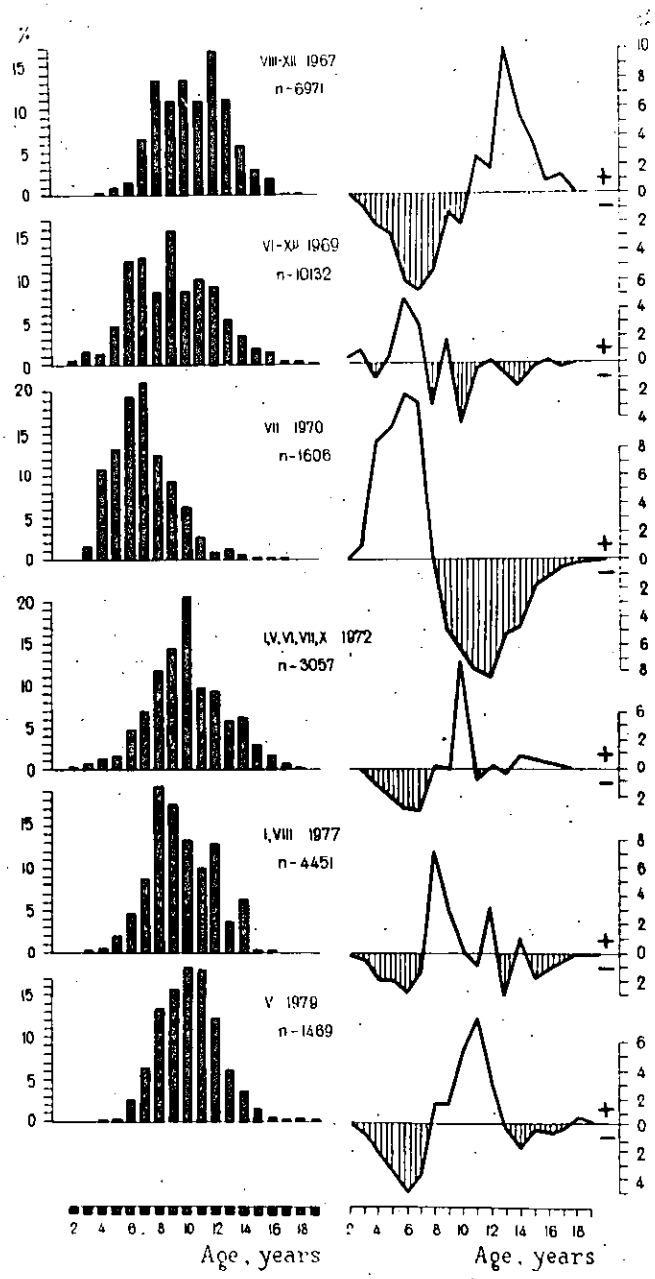

Fig.3 Age composition of roundnose grenadier in catches by years in Div.3K (age samples evaluated in length frequency in catches).

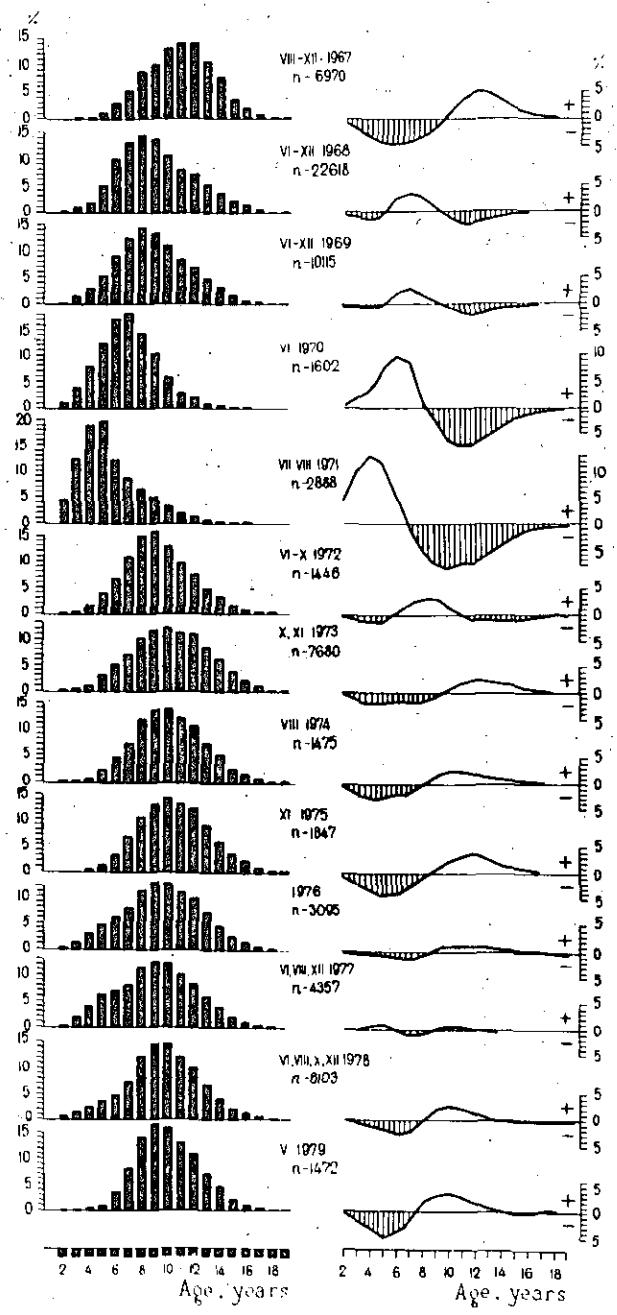

Fig.4 Age composition of roundnose grenadier in catches by years in Div.3K (total age indices evaluated in length distribution in catches).

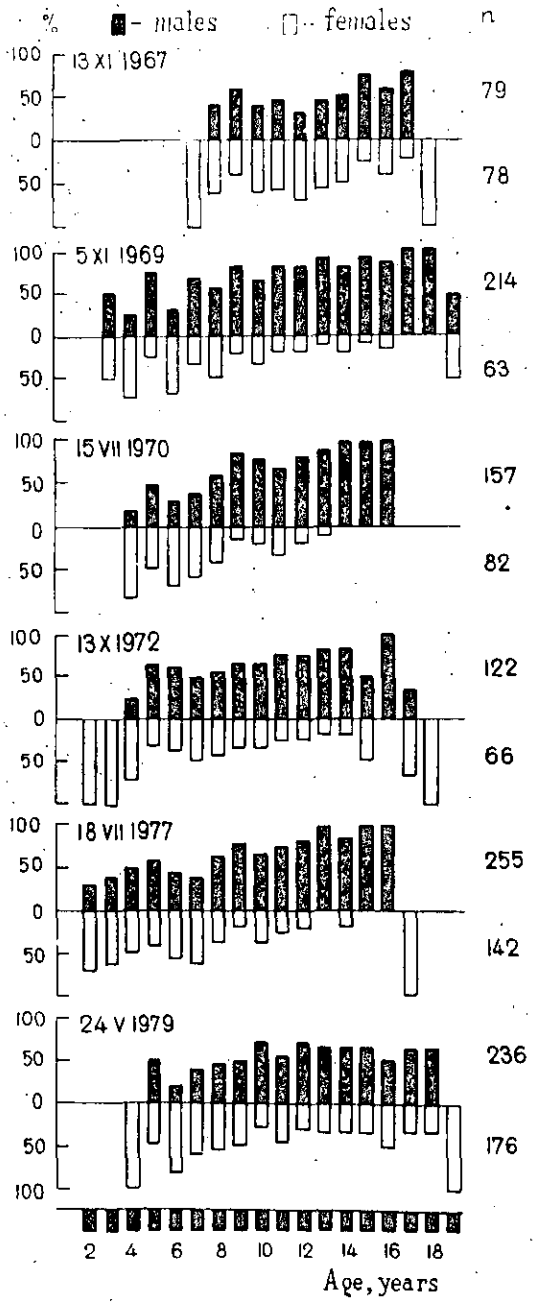

Fig.5 Sex composition of roundnose grenadier in catches in Div.3K.

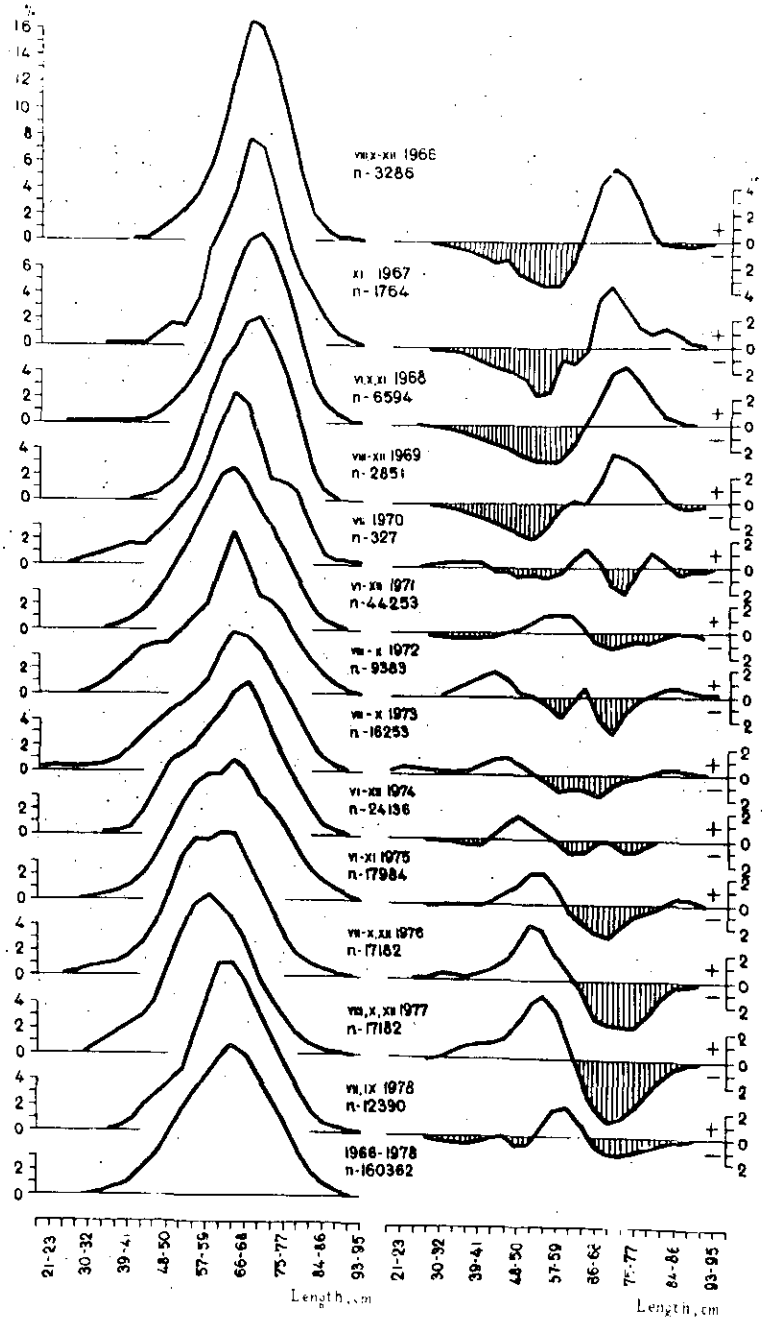

Fig.6 Size composition of roundnose grenadier in catches by years in Div.2G (by smoothed sequences).

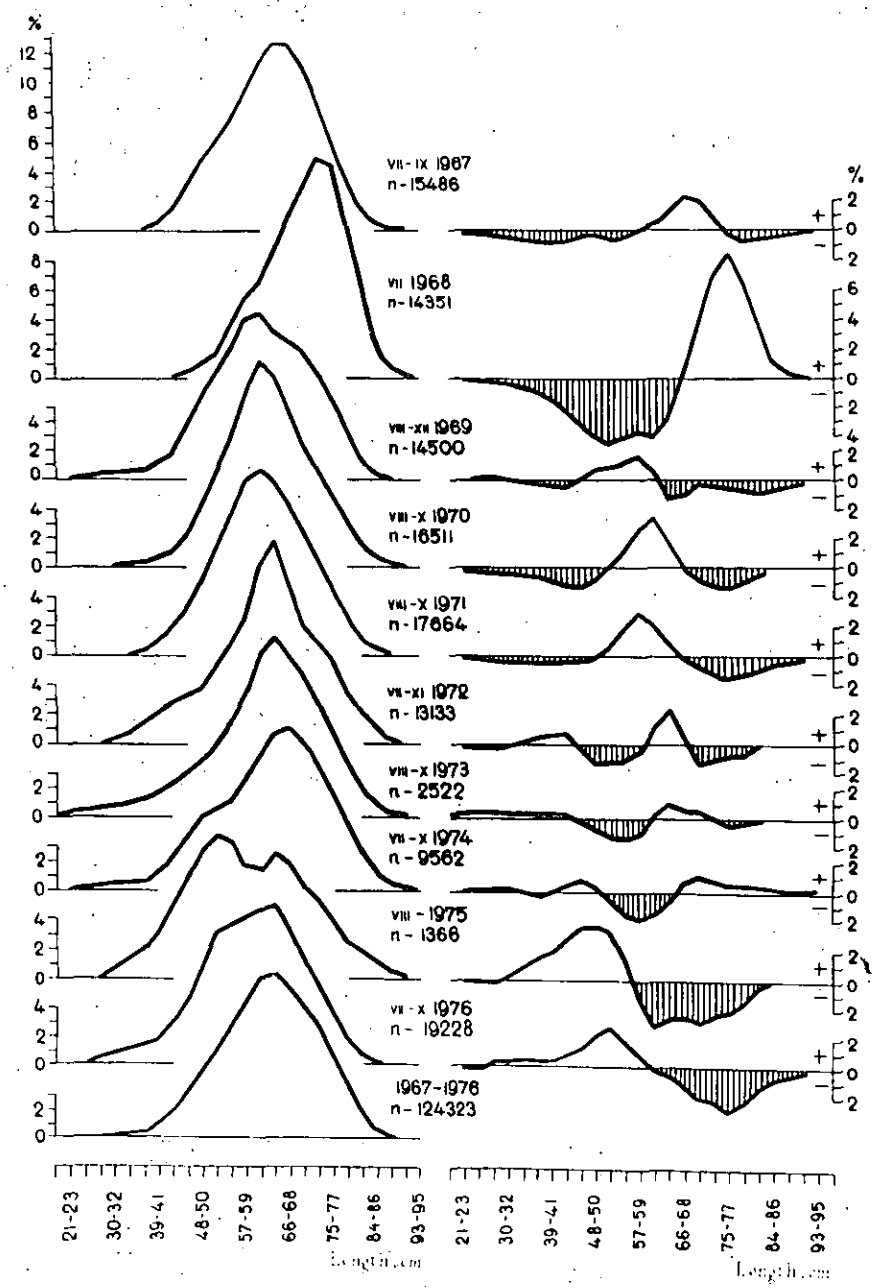

Fig.7 Size composition of roundnose grenadier in catches by years in Subarea 0 (by smoothed sequences).

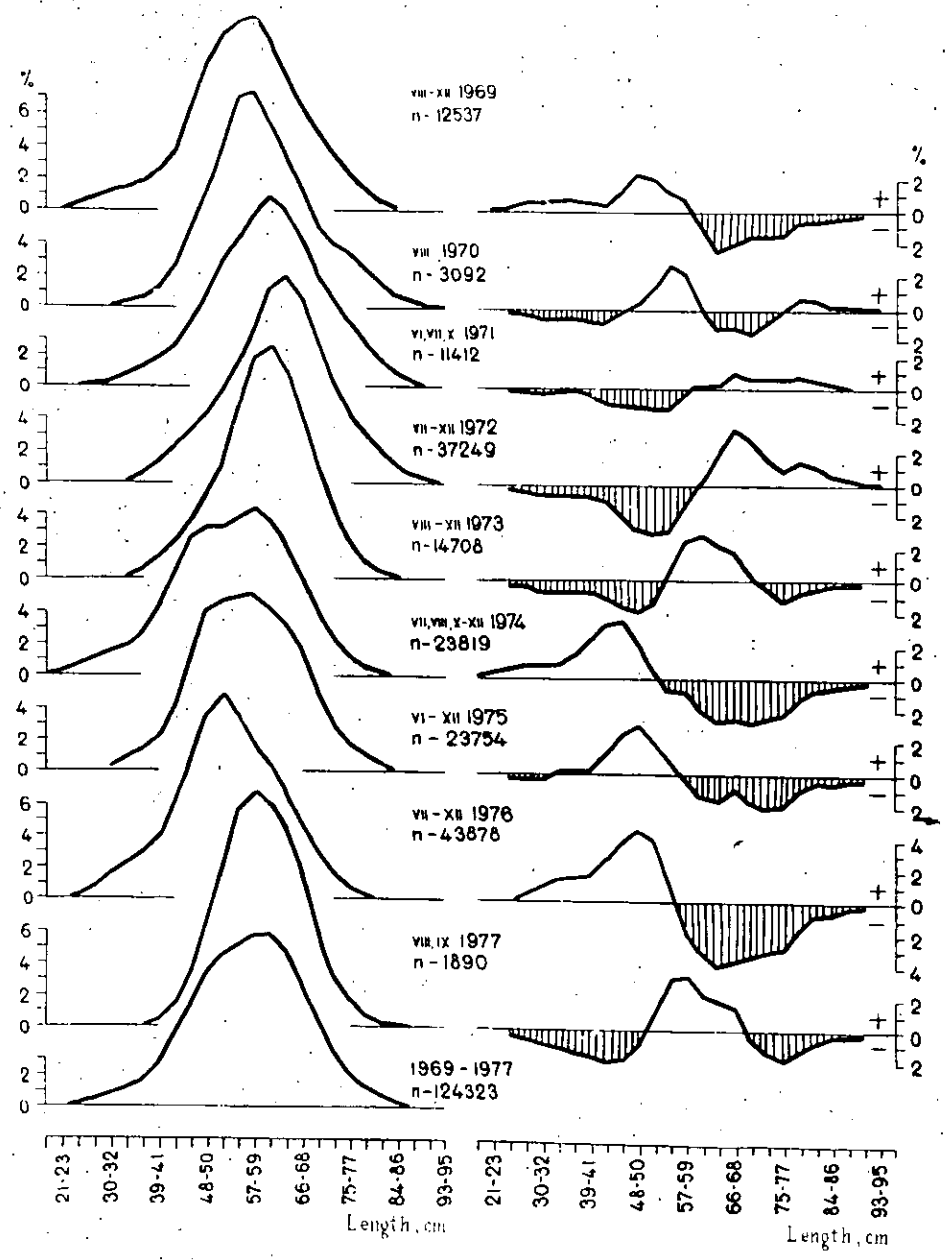

Fig.8 Size composition of roundnose grenadier in catches by years in Subarea 1 (by smoothed sequences).

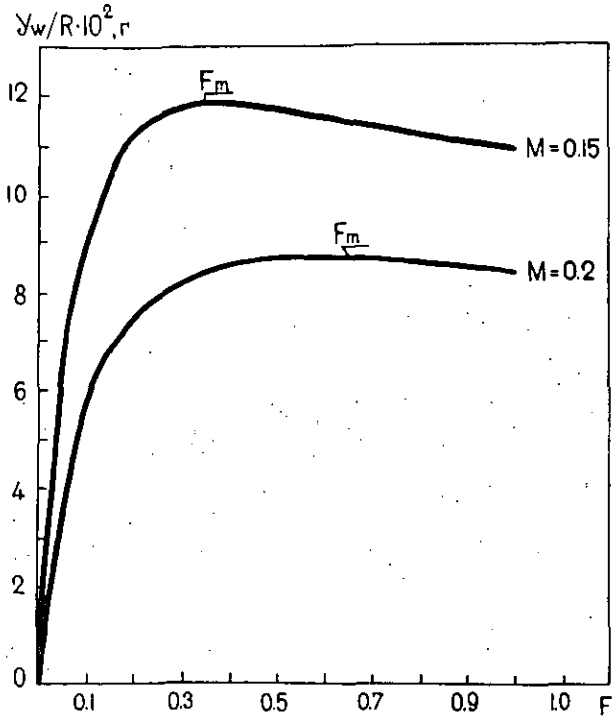

Fig.9 Dependence of the roundnose grenadier catch index in Div.3K on commercial mortality coefficient at different values of natural mortality coefficient.