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Possible Reasons for Variations in Roundnose Grenadier Catches Composition in the Northwest Atlantic in 1971-87

by

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Abstract

A sharp reduction of total roundnose grenadier yield took place since 1979, size and sex compositions of the catches taken in all traditional fishing areas of the Northwest Atlantic had changed. The percentage of the main commercial fish in the catches taken with bottom trawl at traditional depths had also changed. Probably those variations were caused by the effect of total water masses cooling off the continental slope started in 1983-84. The concentrations of roundnose grenadier and Greenland halibut displaced into greater depths, that decreased their availability for fishery and probably was one of the reasons for reduction of total grenadier yield. Since 1983 throughout 1987 the decrease of mean grenadier length was registered in the catches taken by research vessels at depths up to 1000 m. For that period in NAFO Subareas 0 and 2 and Div. 3K an increase in fish size and relative number of females, with trawling depth growth up to 1200 m and more, was observed.

Introduction

Roundnose grenadier (Coryphaenoides rupestris) fishery started in Div. 3K in 1967, in subsequent years the USSR commercial fleet operated in the areas located more to the north, near the continental slopes of Labrador, Baffin Island and West Greenland. According to the NAFO statistical data the annual grenadier yield in the Northwest Atlantic in early fishing period

since 1967 to 1978 fluctuated from 15.0 to 83.7 thou.t, the annual mean catch was 32.2 thou. t, the USSR yield constituted 92% of the total yield. During the subsequent period (1979-1987) the total yield sharply decreased, the annual mean catch was equal to 6.3 thou.t, the USSR catch - 2.7 thou. t (42.8% of total yield). Some different assumptions on reasons of yield reduction were stated. Atkinson (Atkinson, 1982,1983,1984) observing the decrease in catches per hour trawling in recent years supposed that it was the consequence of the intensive fishery influence upon the fish stocks. However it should be taken into account that the decrease in catches per fishing effort unit and some change in size compositon of catches took place not in the period of maximum fishery, but in recent years, when the fishing removal of grenadier was minimum. Besides, the total yield never exceeded the optimum allowable catch established by STACFIS.

There was an opinion that one of the reasons of total grenadier yield decrease was the limitation of Greenland halibut by-catch up to 10% in the direct grenadier fishery with bottom trawls at the simultaneous increase in halibut abundance in recent years (Atkinson, 1982,1984; Bowering,1983; Chumakov, Savvatimsky, 1983,1984). It was also assumed that, to some extent the decrease in total yield of grenadier and variations in the ration between grenadier and halibut in catches was related to displacement of those fishes into deeper waters under the influence of water masses cooling observed in recent years (Chumakov, Savvatimsky, 1984,1987; Ernst, 1984; Savvatimsky, 1986).

The results of the investigations on distribution of commercial fish in bottom trawl catches in the Northwest Atlantic aimed at determining the availability of fishing objects, in particular roundnose grenadier, for fishery are given in the paper.

Material and Methods

The data collected by the research vessels of the USSR for the autumn season 1971-1987, mainly, the materials from trawl surveys on Greenland halibut biomass and abundance asses-

sment in Subareas 0, 2 and Div. 3K are used in the paper. Only the catches with roundnose grenadier and Greenland halibut were chosen and divided for three periods (1971-1977, 1978-1982, 1983-1987). The catches were distributed within a 100 m depth range. Relative number of grenadier and halibut was estimated in per cent of the total yield weight, including the other species also.

Due to the USSR research vessels data the size and sex compositions of roundnose grenadier catches are represented for the period 1983-1987. Length frequencies and sets of relative number of grenadier females were obtained from the catches distributed within a 100 m depth range.

The values of the average roundnose grenadier catches per half an hour trawling with bottom trawl and mean water temperature since 1974 throughout 1986 by Canadian research surveys in Subareas 0, 1 and Divs. 2H, 2J, 3K (Atkinson, Power, 1987, Table 1) are used in the paper.

The frequencies in all the figures are smoothed aimed at revealing the mean tendencies in variations of the features studied. The smoothing was made in accordance with the standard method by formula:

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

a, b, c - preceding, average and subsequent members of the frequency, B - mean member estimated.

The frequencies of relative grenadier and halibut numbers at different depths in the catches taken in NAFO Subarea 2 are smoothed by separate 100 m depth ranges, and also by years.

Results and Discussions

Since 1971 throughout 1987 the considerable variations in sizes and compositions of the demersal fish catches while trawlings in traditional fishing depths took place in the Northwest Atlantic. The most numerous species in the catches

taken by the research vessels off the continental slope in Subareas 0, 2 and Div. 3K for 1971-1977 were: cod (101-300 m depths, 26-37% of the catches), beaked redfish (301-500 m, 20-34%), Greenland halibut (101-800 m, 33-55%) and roundnose grenadier (401-1300 m depths, 52-99% of the catches).

In 1971-1977, in the depths over 400 m the catches exceeded one ton per hour trawling, and in depths over 900 m - two tons per hour trawling (Table 1). In subsequent years (1978-1982 and 1983-1987) the catches, trawling depth and also the species ratio in the catches changed to a considerable extent. So, in 1978-1982 the catches per hour trawling in the depth up to 800 m were less than 1 ton and slightly exceeded one ton while trawling deeper than 900 m (Table 2). The Greenland halibut in the catches in depth from 600 m and deeper constituted over 50% and the relative number of grenadier sharply decreased. In 1971-1977 the grenadier constituted over 50% of the catches in a 500 m depth and 80-90% - in 900-1000 m depth. During later periods the percentage of grenadier in the catches taken in depth up to 1000 m was not higher than 20-30%, and the halibut portion constituted 60-80% (Fig.1). Similar variations in the compositions of the catches took place in all the areas mentioned. If one follows the variations in relative numbers of grenadier and halibut in Subarea 2 by years, where during the trawl surveys the most complete data were collected, then it can be stated that the highest percentage of grenadier in the catches was registered since 1971 to 1976 and the lowest one - from 1980 to 1985. The halibut percentage was high in the recent period. Since 1985 the relative number of grenadier in the catches taken from 801-900 m depths and deeper increased (Fig. 2), that could reflect a gradual grenadier migration into smaller depths in relation with the increased water temperature started.

For 1978-1982 not only the ratio between halibut and grenadier in the catches and their distribution by depths changed, but also the trawling depth for many other fishes - roughhead grenadier, redfishes, northern wolffish, cod - increased (see Tables 1-3). Those variations were probably

related to hydrological regime. It is known that the areas with concentrations of commercial fish mentioned are observed in shelf and slope waters of the Labrador Current and year-to-year variations in temperatures of water masses effect the fish distribution and conditions of commercial concentrations formation. Due to the Canadian trawl surveys data,e.g., the relationship between the roundnose grenadier catches and water temperature in the areas of their inhabitance (Atkinson, Power, 1987, Fig. 3) was observed.

Since 1981 throughout 1985 in Subareas 0, 2 and Div. 3K a decrease in grenadier length in the catches with bottom trawl was earlier marked, that was apparently related with the variations in fish distribution by depths (Savvatimsky, 1986). From 1983 to 1987 in those areas the mean length of males and females in the catches taken in depths over 1000 m more decreased than that in depths less than 1000 m (Fig. 4), the relative number of females also changed (Fig. 5). Those variations were undoubtedly related to vertical distribution of fish.

Length compositions of grenadier catches in different areas of the Northwest Atlantic essentially differ and the variations in length compositions of the catches with trawling depth growth are unequal (Sahrhage, 1986; Atkinson, Power, 1987). According to the Canadian trawl surveys data in Subareas 0, 1, 2 and 3 for 1974 - 1986, in Divs. 3L and 3M large fishes were caught at small depths (201-300 m) and in Divs. 2H and 2J - at depths over 1200 m (Atkinson, Power, 1987). Earlier, on the basis of short information an increase in grenadier length in the catches with trawling depth growth was repeatedly registered: in Subareas 0 and 1 in 1986 (Atkinson, Power, 1987a), in Div. 2H in November and December 1983 (Ernst, 1984), in Subareas 0 and 2 in 1985 (Chumakov, Borovkov, 1986), in Div. 3K and Subareas 0 and 2 in 1986 (Chumakov et al., 1987), in Div. 3K in June 1968 and in January 1981 (Savvatimsky, 1982a), in Divs. 2J in December 1984 and 3K in January 1984, in Subareas 0 and 2 and Div. 3K in 1985; the attention was also paid to increase in relative number of females in great depths (Savvatimsky, 1986, 1987).

The common regularity typical for distribution of the young fish, adult meso- and bathypelagic fish is known: the large specimens compared to the small ones are observed in deeper depth (Vinigradov, 1959), that is related to increased efficiency of food resource exploitation in deep oceanic layers. It is also known that many marine fishes in the high latitudes are found in considerably smaller depth than in the low latitudes, which is typical for roundnose grenadier also. This is apparently accounted for the discrepancies in length compositions of the catches in differen areas. While trawling in equal depths the mean grenadier length in the catches in Div. 3K is always smaller than that in the areas located more to the north (Savvatimsky, 1969; Savvatimsky, 1977; Savvatimsky, Shafran, 1981). Apparently, the main grenadier concentrations in Div. 3K are distributed in considerably greater depth than those in Subareas 0 and 2 and are less available for fishing with bottom trawl. Therefore, with gradual displacement of the concentrations into the greater depth their availability for fishing can be more decreased.

The analysis of size composition of grenadier catches taken by the USSR research vessels for 1983-1987 shows that only small fishes are observed in the depths less than 1000 m in Div. 3K, and in the depths over 1000 m - fairly larger fishes, of the same mean length as in Subareas 0 and 2 in the depth up to 1000 m (Tables 4 and 5). If in Subareas 0 and 2 the mean fish length in the catches increases gradually with the trawling depth growth, then in Div. 3K the catches taken in depths less than 1000 m consisted of small fishes (mean length - 48-50 cm) and only in the depth over 1000 m the mean length starts to increase (Fig. 6). Relative number of females in trawl catches increases with trawling depth growth.

Unfortunately, we cannot follow the variations in size and sex compositions of the catches in depths over 1200 m, but judging by separate experimental catches from the underwater elevation Orfan located north of the Flemish Cap Bank apart from the continental slope, in depths 1750-2600 m large grenadier (Konstantinov, 1980) distribute. The same situation was observed for the Flemish Cap Bank. In March 1978, on this

bank in the catches taken by the RV "Artemida" in 1000-1180 m depth the mean length of males was 56-59 cm, of females - 57-61 cm, and in 1240-1570 m depths the mean length of males increased to 62-65 cm, of females - to 66-69 cm. The males were predominant in the catches taken in depths not deeper than 1360 m and in depths over 1400 m the females constituted 61% (Savvatimsky, 1982). On 27 October 1969 in Div. 2H the grenadier length in the catch taken by the RV "N. Kononov" in in depth 1470-1520 m was 60-97 cm (mainly, more than 72 cm), whereas the grenadier of fairly smaller length were caught in smaller depths (Savvatimsky, 1972).

Taking into account the fact that the roundnose grenadier is observed in depths up to 2500 m (Atkinson et al., 1981), and according to the latest data - up to 3000 m (Sahrhage, 1986), it can be stated that commercial and research fishing gears cover only the upper part of the vertical range of this fish and our knowledge of its mode of life and distribution distribution of the concentrations is limited. It can be assume that in Div. 3K the main concentrations of roundnose grenadier are observed off the continental slope in the depth not available for modern fishery. It is known that this fish has seasonal vertical migrations across the continental slope displacing into small depths during the hydrologically warm summer-autumn season and into the great depths during the cold winter-spring period (Savvatimsky, 1969; Pechenik, Troyanovsky, 1970). Since 1974 a cooling of water masses near the continental slope took place (Savvatimsky, 1986, 1987; Chumakov, Savvatimsky, 1987). It is unknown yet how the similar variability in hydrological situation influences upon the behaviour and, in particular, the vertical migrations of roundnose grenadier, but it can be assume that the concentrations of this fish displaced into great depths that decreased their availability for fishery and was one of the reasons for reduction in total yield. By 1990-1991 an increase of water temperature off Labrador up to the level above the long-term mean (Chumakov, Savvatimsky, 1987) is expected, that can influence upon the vertical distribution of grenadier and change their fishery conditions.

REFERENCES

ATKINSON, D.B. 1982. Status of roundnose grenadier stocks in Subareas 0+1 and 2+3. NAFO SCR Doc. 82/VI/55, Serial No. N548: 9 p.

ATKINSON, D.B. 1983. Roundnose grenadier in Subareas 0+1 and 2+3. NAFO SCR Doc. 83/VI/37, Serial No. N690:6 p.

ATKINSON, D.B. 1984. An update on the status of roundnose grenadier stocks in Subareas 0+1 and 2+3. NAFO SCR Doc. 84/VI/20, Serial No. N793:6 p.

ATKINSON, D.B., POWER, D. 1987. Distribution of Roughhead and Roundnose Grenadiers in the Northwest Atlantic. NAFO SCR Doc. 87/94, Serial No.N1398: 28 p.

ATKINSON, D.B., POWER, D. 1987a. An Evaluation of the Status of Roundnose Grenadier in Subareas 0+1 and 2+3. NAFO SCR Doc. 87/39, Serial No. N1324:11 p.

ATKINSON, D.B., BOWERING, W.R., HORSTED, Sv.A., MINET,J.P., PARSONS, D.G. 1981. A Review of the Biology and Fisheries of Roundnose Grenadier (Macrourus rupestris), Greenland Halibut (Reinhardtius hippoglossoides) and Shrimp (Pandalus borealis) in Davis Strait (NAFO Subareas 0 and 1). NAFO SCR Doc. 81/VI/22, Serial No. 290:58 p.

BOWERING, W.R. 1983. By-catch Levels of Greenland Halibut in the Roundnose Grenadier Directed Fishery of NAFO Subareas 2+3, NAFO SCR Doc. 83/VI/28, Serial No. N680:4 p.

CHUMAKOV, A.K., SAVVATIMSKY, P.I. 1983. On the Greenland halibut by-catch in the directed fishery for roundnose grenadier on the Labrador continental slope and in Davis Strait (NAFO Subareas 0, 1, 2 and 3K). NAFO SCR Doc. 83/IX/91, Serial No. N757:14 p.

CHUMAKOV, A.K., SAVVATIMSKY, P.I. 1984. Roundnose Grenadier-Greenland Halibut Ratio in Bottom Trawl Catches Taken in NAFO Area in 1970-1983. NAFO SCR Doc. 84/VI/37, Special No. N822:15 p.

CHUMAKOV, A.K., SAVVATIMSKY, P.I. 1987. Distribution of Greenland Halibut and Roundnose Grenadier in the Northwest Atlantic in Relation to Hydrographic Conditions in 1968-1986. NAFO SCR Doc. 87/93, Serial No. N1397:38 p.

CHUMAKOV, A.K., BOROVKOV, V.A. 1986. USSR Fishery and Investigations in NAFO Area in 1985. NAFO SCS Doc. 86/17, Serial No. N1179:31 p.

CHUMAKOV, A.K., BOROVKOV, V.A., NOSKOV, A.S. 1987. USSR Research Report for 1986. NAFO SCS Doc. 87/15, Serial No. N1328:39 p.

ERNST, P. 1984. German Democratic Republic Research Report for 1983. NAFO SCS Doc. 84/IX/24, Serial No. N892:11 p.

KONSTANTINOV, K.G. 1980. Note on Deep-Sea Trawling Beyond the Limits of the Canadian 200-mile zone. NAFO SCR Doc. 80/VI/52, Serial No. N089:2 p.

PECHENIK, L.N., TROYANOVSKY, F.M. 1970. Raw material for trawl fishery on the continental slope of North Atlantic. Murmansk: 86 p.

SAHRHAGE, D. 1986. Wirtschaftlich wichtige Grenadierfische des Nordatlantiks. Mitteilungen aus dem Institut für Seefischerei der BFA für Fischerei. Hamburg, Nr., 37:81 s.

SAVVATIMSKY, P.I. 1977. Prospects of roundnose grenadier fishery in the Northwest Atlantic. ICNAF Res. Doc. 77/VI/30, Serial No. 5055:17 p.

SAVVATIMSKY, P.I. 1982. Reproduction and sex composition of roundnose grenadier in North Atlantic. Abundance and life of commercial fish in the Northwest Atlantic. In: Sbornik nauchnykh trudov. Murmansk, PINRO:32-53.

SAVVATIMSKY, P.I. 1969. Grenadier in North Atlantic. Murmansk, PINRO:72 p.

SAVVATIMSKY, P.I. 1972. On the age of rock grenadier of Northwest Atlantic and a possible influence of fishery on their abundance. Trudy PINRO, vol. XXVIII: 116-127.

SAVVATIMSKY, P.I. 1982a. Fatness of grenadiers in North Atlantic. Abundance and life of commercial fish in the Northwest Atlantic. In: Sbornik nauchnykh trudov. Murmansk, PINRO: 97-111.

SAVVATIMSKY, P.I., SHAFRAN, I.S. 1981. Status of Roundnose Grenadier stocks and possibilities for their commercial removal in the Northwest Atlantic. NAFO SCR Doc. 81/IX/106, Serial No. N410:29 p.

SAVVATIMSKY, P.I. 1986. Changes on Composition of the Bottom Fish Catches at Different Depth Along the Continental Slope in NAFO Subareas 0, 2 and 3 in 1970-85. NAFO SCR Doc. 86/67, Serial No. N1184:26 p.

SAVVATIMSKY, P.I. 1987. Changes in Species Composition of Trawl Catches by Depth on the Continental Slope from Baffin Island to Northeastern Newfoundland, 1970-85. Sci. Coun. Studies. NAFO, No. 11:43-52.

VINOGRADOV, M.E. 1959. Vertical migrations of deepwater zooplankton. In: Results of science /Achievements of oceanology/. Moscow, AN SSSR press, vol. I:213-240 (in Russian).

Table 1

Composition of the catches taken with bottom trawl at different depths in Subareas 0, 2 and Div. 3K in 1971-1977 by data on the research vessels (in % by weight)

Composition of catches	Depth, m											
	101 200	201 300	301 400	401 500	501 600	601 700	701 800	801 900	901 1000	1001 1100	1101 1200	1201 1300
Reinhardtius hippoglossoides	55.0	39.7	36.2	25.8	33.2	33.1	35.0	25.0	9.6	6.9	1.1	0.6
Hippoglossus hippoglossus	-	-	0.1	-	0.1	-	0.2	+	-	-	-	-
Coryphaenoides rupestris	-	6.3	7.9	52.5	59.9	64.2	63.8	74.3	90.2	93.1	98.6	98.8
Macrourus berglax	+	0.5	0.1	0.1	0.1	0.1	+	0.1	+	+	+	+
Sebastes mentella	2.2	1.9	34.0	20.4	5.2	2.0	0.4	0.1	+	+	+	+
Sebastes marinus	3.3	0.2	3.7	+	0.1	+	+	+	+	-	-	-
Anarhichas denticulatus	0.9	1.7	1.2	0.3	1.1	0.2	0.1	0.1	0.1	+	+	+
Anarhichas minor	0.4	1.0	0.3	0.1	0.1	+	+	+	+	-	-	-
Anarhichas lupus	0.4	1.8	0.4	+	+	+	-	-	-	-	-	-
Rajiformes	2.2	1.0	0.4	+	+	+	+	+	+	-	+	+
Somniosus microcephalus	-	-	-	-	0.1	0.3	0.2	0.1	+	-	0.3	0.4
Other Squaliformes	-	-	-	+	+	0.1	0.1	0.2	0.1	+	+	+
Alepocephalidae	-	-	-	-	-	+	0.2	+	+	-	+	0.1
Antimora rostrata	+	+	+	+	+	+	+	+	+	-	+	+
Gadus morhua	26.4	36.9	10.9	0.4	+	+	+	-	-	-	-	-
Glyptocephalus cynoglossus	+	0.1	1.8	0.1	+	+	-	-	-	-	-	-
Hippoglossoides platessoides	9.2	8.3	2.7	0.3	+	+	+	+	+	-	-	-
Others	-	0.6	0.3	+	0.1	+	+	0.1	+	-	+	+
Mean catch, kg/hour	114	430	510	1085	1209	1118	1277	1448	3041	2666	3086	2611
Number of catches	4	55	72	191	459	362	453	288	109	83	37	15

Table 2 Composition of the catches taken with bottom trawl at different depths in Subareas 0, 2 and Div. 3K in 1978–1982 by data on the research vessels (in % by weight)

Composition of catches	Depth, m										
	101 : 200	201 : 300	301 : 400	401 : 500	501 : 600	601 : 700	701 : 800	801 : 900	901 : 1000	1001 : 1100	1101 : 1200
Reinhardtius hippoglossoides	2.7	3.3	18.9	44.2	38.0	61.3	67.5	77.1	74.5	73.6	71.9
Hippoglossus hippoglossus	-	+	+	0.2	0.1	0.2	0.1	+	+	+	-
Coryphaenoides rupestris	-	+	2.7	3.1	11.3	10.8	18.1	11.7	21.7	17.6	21.0
Macrourus berglax	+	+	0.2	0.7	0.6	5.7	0.5	0.9	0.7	5.3	2.0
Sebastes mentella	+	1.1	23.4	35.1	37.7	8.7	6.9	2.2	0.2	0.1	-
Sebastes marinus	-	0.2	0.2	0.2	0.3	0.2	+	+	-	+	-
Anarhichas denticulatus	2.9	1.8	1.7	4.4	3.8	5.4	3.8	2.3	1.7	1.7	4.4
Anarhichas minor	1.6	0.3	0.3	0.3	0.5	0.1	+	+	+	-	-
Anarhichas lupus	0.2	0.6	0.3	0.2	+	-	-	-	-	-	+
Rajiformes	0.1	0.2	0.3	0.2	0.2	0.2	0.3	0.1	0.2	+	0.1
Somniosus microcephalus	-	-	-	0.7	1.0	3.9	0.3	1.9	0.3	1.1	-
Other Squaliformes	-	-	0.3	-	0.4	0.3	1.3	0.5	0.3	0.3	0.1
Alepocephalidae	-	-	-	+	+	+	0.2	1.8	+	+	-
Antimora rostrata	-	+	+	+	+	0.2	0.1	0.3	0.1	0.1	0.1
Gadus morhua	72.5	88.9	48.2	4.0	0.6	+	+	+	+	-	-
Glyptocephalus cynoglossus	-	+	0.4	4.0	4.8	1.0	0.2	0.6	+	+	-
Hippoglossoides platessoides	19.5	3.0	2.7	2.3	0.3	1.3	0.3	0.1	0.1	-	-
Others	0.5	0.6	0.4	0.4	0.4	0.7	0.4	0.5	0.2	0.2	0.4
Mean catch, kg/hour	552	592	752	499	606	631	922	1229	1522	1736	944
Number of catches	11	112	128	84	90	81	69	92	79	54	9

Table 3 Composition of the catches taken with bottom trawl at different depths in Subareas 0, 2 and Div. 3K in 1983-1987 by data on the research vessels (in % by weight)

Composition of catches	Depth, m													
	101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-1000	1001-1100	1101-1200	1201-1300	1301-1400	1401-1500
Reinhardtius hippoglossoides	86.9	2.4	16.2	23.4	66.9	60.0	83.3	86.8	81.2	75.9	57.5	64.7	29.6	25.2
Hippoglossus hippoglossus	-	-	0.1	+	0.1	+	+	-	-	+	+	-	-	-
Coryphaenoides rupestris	-	+	-	0.4	2.1	13.0	8.3	6.9	12.5	16.9	31.4	25.4	61.4	49.9
Macrourus berglax	-	-	0.1	0.2	0.3	4.2	1.2	1.0	1.1	1.1	1.0	1.2	1.2	-
Sebastes mentella	-	1.0	43.9	30.6	14.1	9.3	3.3	1.8	+	0.1	+	0.1	-	-
Sebastes marinus	-	+	0.4	0.1	0.1	0.2	0.3	+	0.3	0.3	0.9	3.9	-	-
Anarhichas denticulatus	10.8	0.2	0.5	1.6	1.8	4.5	1.7	1.5	2.0	3.3	4.7	2.4	-	-
Anarhichas minor	-	0.2	0.5	0.2	0.1	0.1	+	+	0.3	-	+	-	-	-
Anarhichas lupus	5.4	0.1	0.2	-	-	-	+	-	-	-	-	-	-	-
Rajiformes	-	0.1	0.6	0.1	0.1	0.8	0.1	0.6	0.4	0.6	1.2	0.3	-	-
Somniosus microcephalus	-	-	2.2	8.9	-	3.4	0.7	0.5	0.7	0.5	0.7	-	-	-
Other Squaliformes	-	-	-	+	+	0.6	0.3	0.4	0.3	0.2	0.3	0.3	0.6	-
Alepocephalidae	-	-	-	-	-	-	-	-	+	+	+	0.1	-	-
Antimora rostrata	-	-	-	-	-	+	0.2	0.2	0.1	0.3	0.2	0.2	2.3	-
Gadus morhua	7.7	87.3	30.9	33.5	12.9	-	0.3	-	-	-	-	-	-	
Glyptocephalus cynoglossus	-	-	0.4	0.6	1.3	1.8	+	-	-	-	-	-	-	-
Hippoglossoides platessoides	39.2	8.4	3.0	0.3	0.1	0.8	-	0.1	0.3	0.3	+	-	-	-
Others	-	0.3	1.0	0.1	0.1	1.3	0.3	0.2	0.8	0.5	2.1	1.4	4.9	24.9
Mean catch, kg/hour	8	646	224	162	331	430	502	681	1015	701	963	828	427	168
Number of catches	9	64	69	59	73	73	84	140	110	94	42	20	6	5

Table 4 Mean length of males and females and relative number of roundnose grenadier females in the catches taken with bottom trawl at depths less than 1000 m and over 1000 m in 1983-1987 by data on the research vessels

Subarea, Division	Depth, m	Mean length of males, cm	Number of males spec.	Mean length of females, cm	Number of females, spec.	Number of females, %
0	less than 1000	54.2±0.2	2103	55.6±0.4	1143	35.2
	over 1000	59.4±0.2	3569	62.0±0.2	2573	41.9
2	less than 1000	54.2±0.2	3752	55.6±0.2	3126	45.4
	over 1000	58.9±0.2	5886	62.0±0.2	4484	43.2
3K	less than 1000	48.7±0.2	5448	47.9±0.2	3569	39.6
	over 1000	52.5±0.2	4668	54.8±0.2	3708	44.3
0+2+3K	less than 1000	51.5±0.1	11303	52.1±0.1	7838	40.9
	over 1000	56.9±0.1	14123	59.5±0.1	10765	43.3

Table 5 Mean length of males and females and relative number of roundnose grenadier females in the catches taken with bottom trawl at different depths by data on the research vessels in Subareas 0, 2 and Div. 3K in 1983-1987

Subarea, Division	Depth, m	Length of males, cm	Number of males spec.	Length of females, cm	Number of females, spec.	Number of females, %
0	601-700	34.2±1.8	40	31.9±2.6	27	40.3
	701-800	47.4±0.8	184	47.4±1.2	87	32.1
	801-900	54.8±0.6	294	53.8±1.1	138	31.9
	901-1000	55.3±0.3	1585	57.4±0.4	891	36.0
	1001-1100	55.5±0.4	851	56.6±0.5	570	40.1
	1101-1200	60.4±0.4	1068	62.2±0.4	738	40.9
	>1200	60.8±0.3	1650	64.6±0.3	1265	43.4
2	501-600	51.2±1.3	71	54.3±1.2	67	48.6
	601-700	51.2±0.8	235	50.5±0.9	147	38.5
	701-800	54.1±0.3	1021	55.7±0.3	1036	50.4
	801-900	53.5±0.3	981	54.7±0.4	751	43.4
	901-1000	55.3±0.3	1444	56.9±0.3	1125	43.8
	1001-1100	56.6±0.2	3164	58.6±0.3	2235	41.4
	1101-1200	57.7±0.3	1189	60.0±0.4	916	43.5
	>1200	64.6±0.3	1533	69.1±0.3	1333	46.5
3K	501-600	48.9±0.6	166	47.7±0.7	130	43.9
	601-700	49.8±0.3	1439	48.9±0.4	739	33.9
	701-800	50.5±0.4	1065	49.1±0.4	683	39.1
	801-900	47.9±0.4	1067	47.0±0.5	784	42.4
	901-1000	47.1±0.3	1711	47.1±0.3	1233	41.9
	1001-1100	50.6±0.3	1572	53.8±0.4	1068	40.5
	1101-1200	51.8±0.3	1973	52.6±0.3	1481	42.9
	>1200	56.3±0.3	1123	58.5±0.4	1159	50.8
0+2+3K	501-600	49.6±0.6	237	49.9±0.7	197	45.4
	601-700	49.6±0.3	1714	48.6±0.3	913	34.8
	701-800	51.8±0.2	2270	52.8±0.3	1806	44.3
	801-900	51.1±0.2	2342	51.0±0.3	1673	41.7
0+2+3K	901-1000	52.3±0.2	4740	53.3±0.2	3249	40.7
	1001-1100	54.7±0.2	5587	57.0±0.2	3873	40.9
	1101-1200	55.6±0.2	4230	57.0±0.2	3135	42.6
	>1200	61.0±0.2	4306	64.3±0.2	3757	46.6

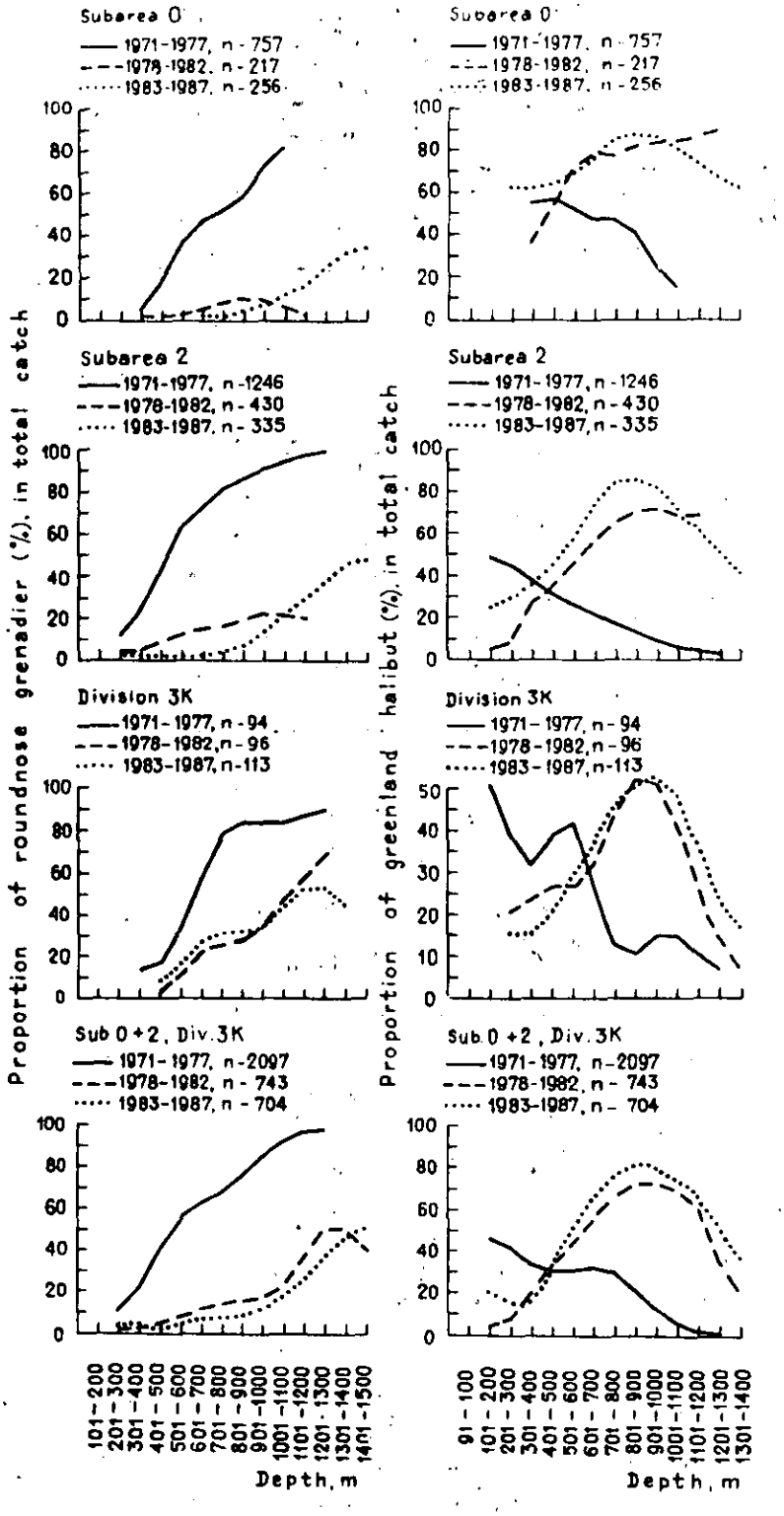

Fig. 1 Relative number of roundnose grenadier and Greenland halibut (in % by weight) in research bottom catches at different depths in NAFO Subareas 0, 2 and Div.3K in 1971-1977, 1978-1982 and 1983-1987 (n - number of catches).

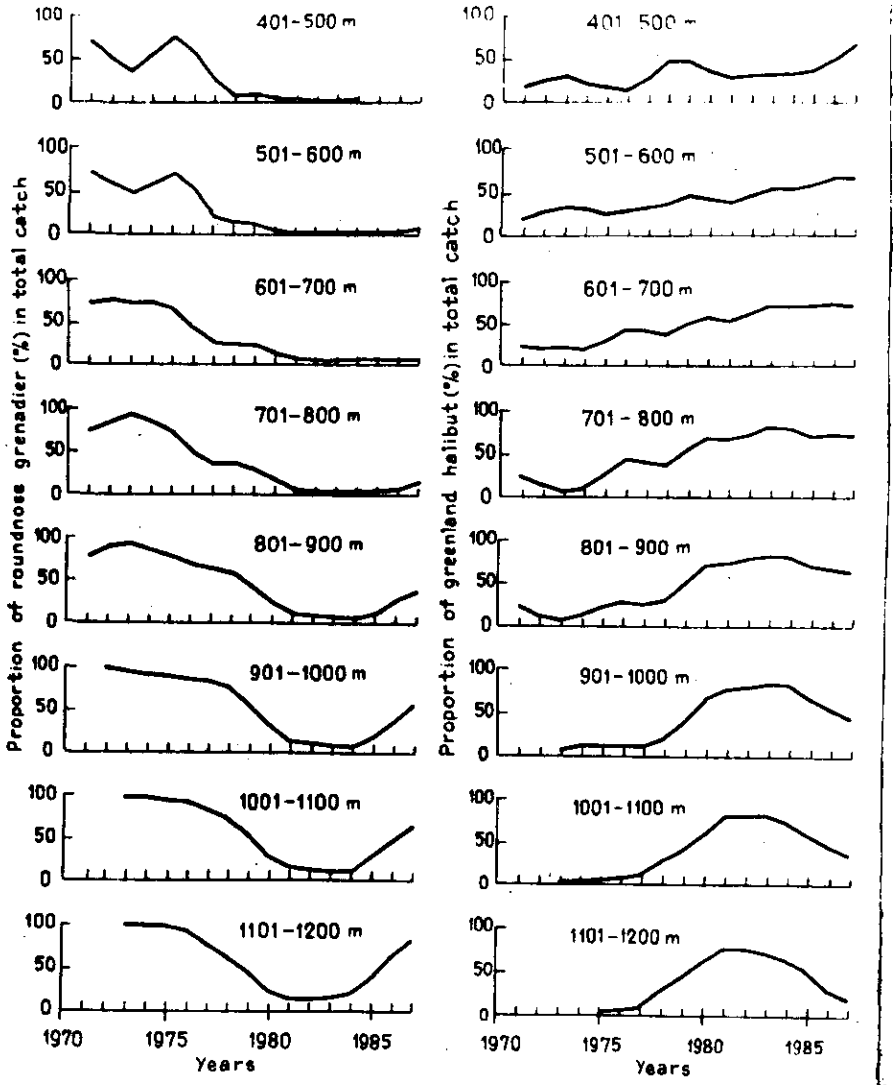

Fig. 2 Relative number of roundnose grenadier and Greenland halibut (in % by weight) in bottom catches taken by the USSR research vessels at different depths in Subarea 2 in 1971-1987.

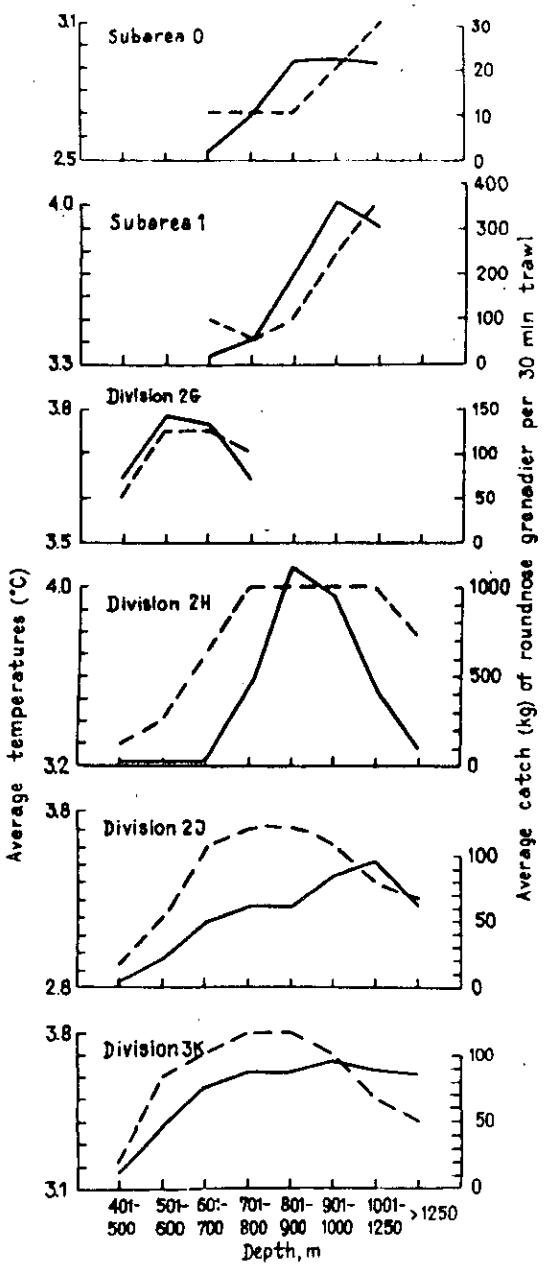

Fig. 3 Average catches(in kg per 0.5 hour trawling; solid line) within a 100 m depth range and mean water temperature (°C; dash line) by data on research surveys for 1974-1986 (Atkinson, Power, 1987).

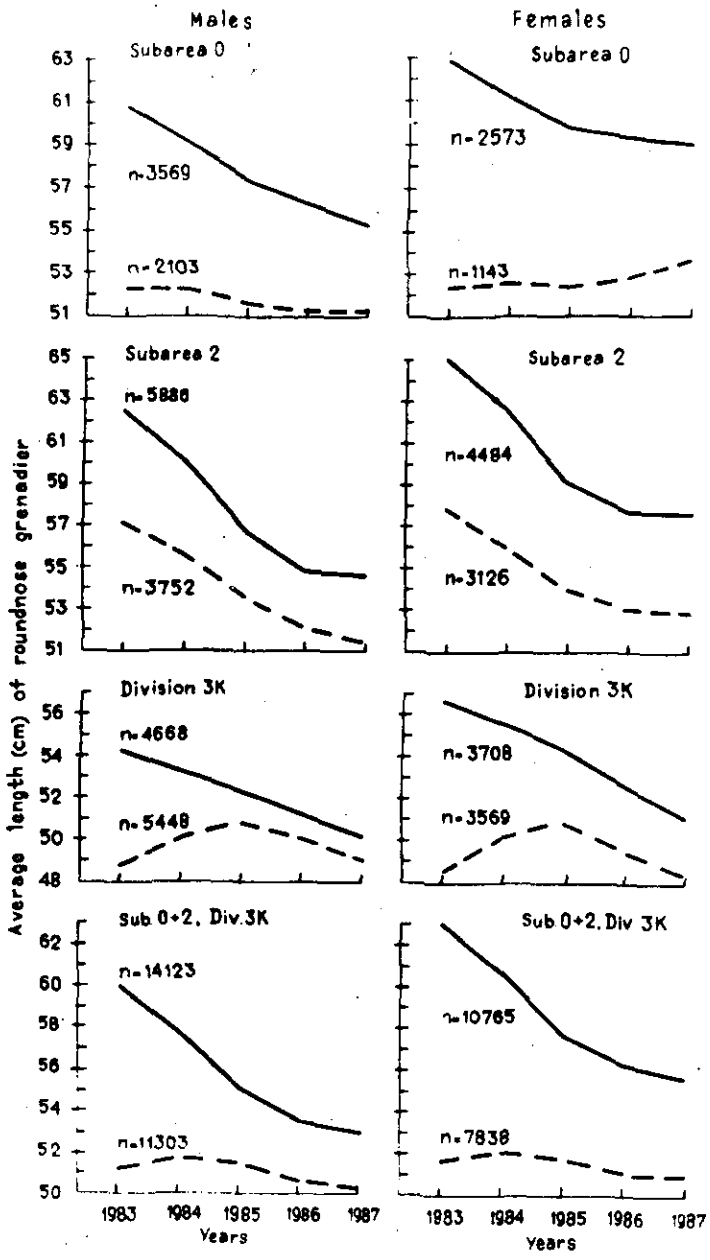

Fig. 4 Average length of roundnose grenadier males and females in the catches taken with bottom trawl at depths less than 1000 m (dash line) and over 1000 m (solid line) in 1983-1987 by data on the USSR research vessels.

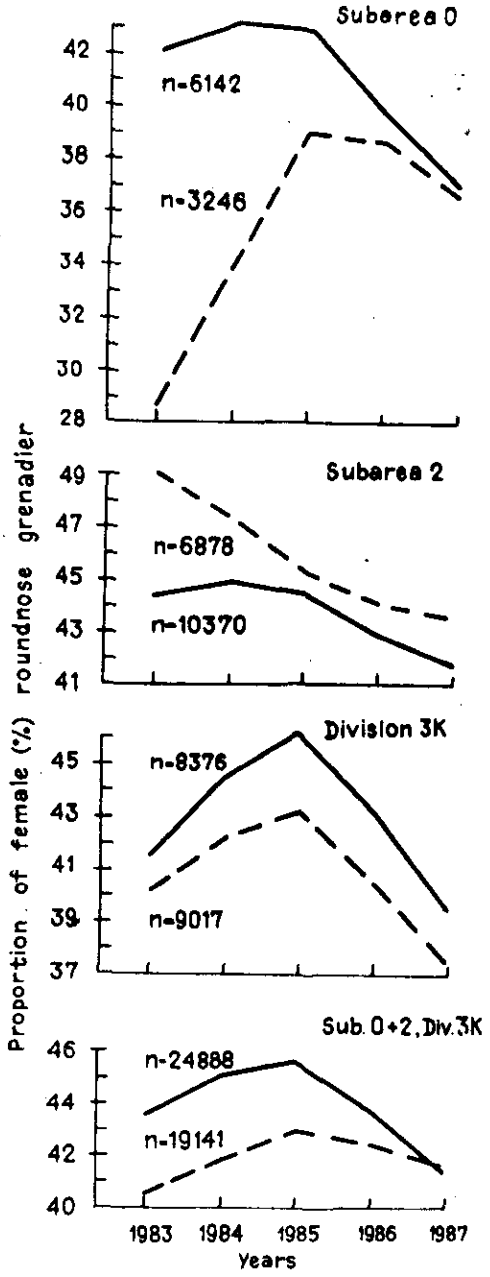

Fig. 5 Relative number of roundnose grenadier females in the catches taken with bottom trawl at depths less than 1000 m (dash line) and over 1000 m (solid line) in 1983-1987 by data on the USSR research vessels.

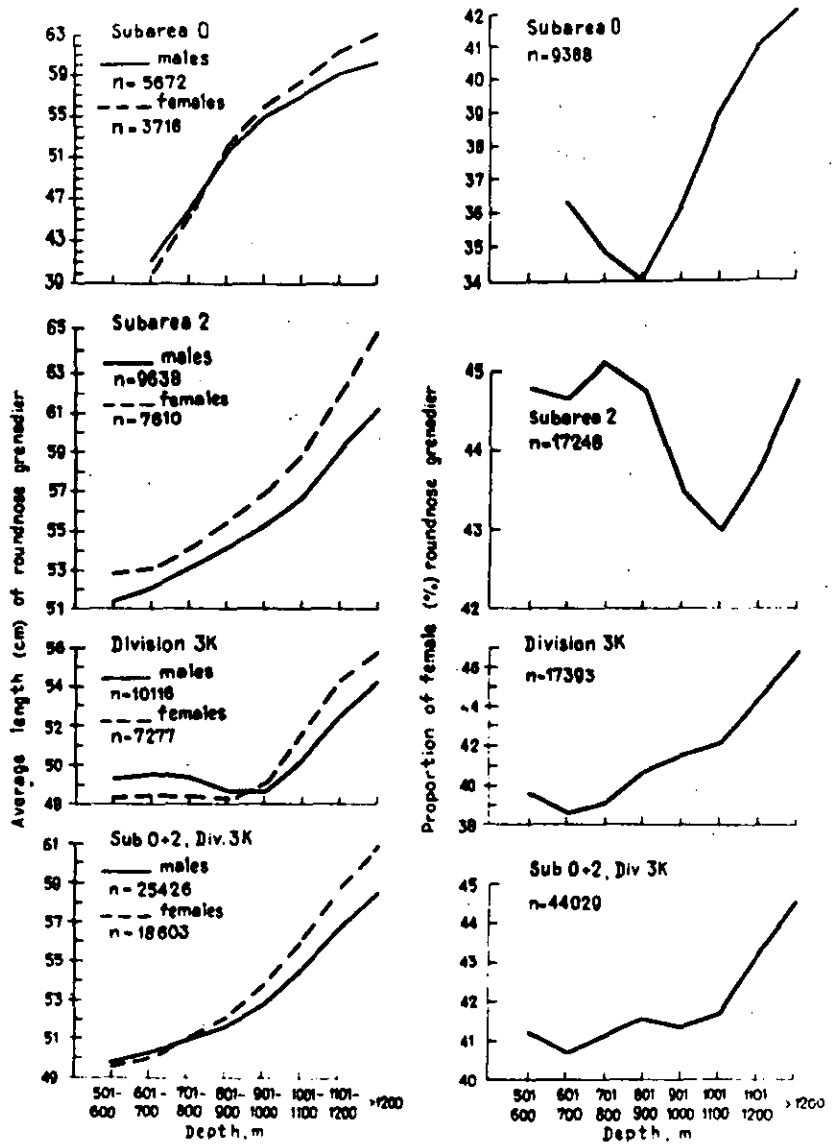

Fig. 6 Average length of males and females and relative number of roundnose grenadier females in the catches taken with bottom trawl at different depths in Subareas 0, 2 and Div. 3K in 1985-1987 by data on the USSR research vessels.

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