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Variations in Catch Composition of Roundnose Grenadier from the Northwest Atlantic During 1971-1989

by

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ABSTRACT

As indicated by the trawl survey in Divs. OB, 2GH, 3K in autumn 1989, the average length and age of grenadier were 51.9 cm and 8.6 years. The average length of males and females were found to sharply increase with depth. Because of seasonal vertical migrations of grenadier, its size composition and relative number in catches vary notably within a year and differ from year to year; this influences the total catch and accounts for seasonal fishing pattern.

During 1978-1987 the grenadier were distributed in deep waters and were, in fact, beyond the gears range. In catches from up to 1200 m depth the grenadier occurred only in small numbers. During 1988-1989 the relative amount of this species in catches increased and accounted for 50%, on the average (by weight), at 1001-1100 m and 70-80% at 1200-1500 m. This is an indication of intensive seasonal migrations and earlier, than in previous years, aggregating of grenadier at traditional fishing depths.

INTRODUCTION

Prior to 1979 the total catch of grenadier (Coryphaenoides rupestris Gunn) amounted to tens of thousands tons. After 1979 it decreased sharply and constituted 3.6 thou.t in 1983 (Table 1).

A reduction in catch occurred in all fishing areas. Since 1985 the catch has been gradually growing.

Different reasons were suggested to account for a reduction in the grenadier catch, these are - the impact of intensive fishing, limitations introduced for a by-catch of Greenland halibut in the directed grenadier fishery, year-to-year and seasonal migrations of grenadier to deeper waters, preventing the accessibility of the species to fishing gears.

The present paper has as its purpose a study of causes of variations of grenadier catch by analysing the species vertical distribution.

MATERIAL AND METHODS

The paper considers results from bottom fish surveys conducted on a yearly basis in the autumn period and data collected by research vessels operated in SA 0-2 and Div. 3K. Age composition of grenadier in catches during 1983-1989 was determined through conversion of size frequencies using a size-age key for 1969-1988. Estimates of the total catch of grenadier and halibut by month during 1972-1978 and 1979-1985 have been borrowed from NAFO Statistical Bulletins and preliminary estimates of the total catch of grenadier for 1986-1988 from Atkinson and Power (1989). By-month total catch series and length frequencies, shown in figures, have been smoothed by the formula $B = \frac{a + 2b + c}{4}$, where a, b, and c - preceding, intermediate and subsequent members of the series, B - an estimates one.

RESULTS AND DISCUSSION

Data collected during the trawl survey in Div. OB, 2GH, 3K in autumn 1989 showed that the average length of grenadier from bottom trawl catches was 51.9 cm (Table 2), average age - 8.6 years (Table 3). It should be noted that the average length and age vary much between years, depending on the towed depth. As previously, the average length of males and females in 1989 was found to sharply increase with depth in all surveyed areas (Table 4). On the whole, the average length of grenadier from Divs. OB+2GH+3K was found to increase from 40-43 cm at depth 600-800 m to 60-62 cm in 1300-1400 m. Variations in size composition of grenadier by depth are evident in Figs. 1 and 2, which show deviations from average values.

The size composition and relative number of grenadier in catches from different depths vary between years and within one year, which is due to seasonal vertical migrations of the species. Intensity and time of these migrations have effect on the fishing conditions.

The fishery is conducted in fairly warm, in respect to hydrology, months during summer and autumn, when owing to seasonal vertical migrations the aggregations of grenadier are distributed in less deep waters, and therefore are available to trawls.

As early as in the beginning of fishing for this species (1968) bottom aggregations of grenadier were noted to appear first at fishable depths in high latitudes (near the Baffin Land) and later in more southerly areas of the continental slope (Javvatsimsky, 1969). This is one more confirmation of known regularity, that bottom and near-bottom fish of the same species are distributed in deeper waters in low latitudes compared to high latitudes (Konstantinov, 1980).

Time and intensity of grenadier vertical migrations differ bet-

ween years and seem to be dependent on hydrographic conditions. It was suggested by several authors that a reduction in the total catch of grenadier in the Northwest Atlantic during 1979-1980 and changes in the grenadier/halibut ratio in catches might be associated with cooling of waters near the continental slope, which induced migration of grenadier to deeper waters, and thus reduced its accessibility to fishing gears (Ernst, 1984, Savvatimsky, 1986, 1987; Chumakov, Savvatimsky, 1987). These migrations caused changes in the size, age and sex composition of grenadier as well as in the ratio of different species in catches. For example, if prior to 1977 the grenadier prevailed in exploratory catches from 700 m and deeper, later it accounted for only 50% of catches beginning from 1300-1400 m depth only (Savvatimsky, 1988). In 1987-1988 the relative amount of grenadier from traditional fishing depth (1000-1200 m) increased to 50-60% (Savvatimsky, 1989), which may probably be due to a gradual redistribution of the species into fairly shallow slope areas.

The USSR trawl survey provided evidence that in 1989 the percentage of grenadier in catches from traditional fishing depths in Divs. OB, 2GH and 3K was also considerable (Tables 5 and 6). The analysis of historic trawl survey data and data from exploratory tows by research vessels allows to infer, that during 1971-1988 the grenadier were distributed in fairly shallow waters of the above divisions and accounted for more than 50% in bottom trawl catches from 501-600 m and deeper (Fig. 3). During 1978-1982 the percentage of grenadier in catches down to 1100-1200 m did not exceed 20%. No tows were made deeper than 1200 m in these years, therefore, the distribution pattern of grenadier in deep waters is unknown. During 1983-1987 the fishing depth increased to as deep as 1500 m. The amount of grenadier in catches from depth to 801-900 m was insignificant and it increased to 50% in 1300-1500 m.

In 1988-1989 the relative amount of grenadier was much larger than in the previous years, the species accounted, on the average, for 50% by weight in 1001-1100 m and 70-80% in 1200-1500 m. Variations in the relative amount of grenadier in catches from depths accessible for fishing during this period are in good conformity with the variations of the total catch of this species (Table 7).

Seasonal and year-to-year migrations of grenadier and its vertical distribution have impact on the fishery and total catch. During the period favourable for fishing (1972-1978) a greater part of the total catch in SA 0, 2 and 3 was withdrawn during summer and autumn months (from July to November), whereas in the period from 1979 to 1985 a shift occurred in the time of fishing towards September-December (Fig. 4). No such changes were observed in SA 1, with the catch being more or less regular during the year, due to the influence of the relatively warm West-Greenland

current. A shift in the time of fishing and total catch withdrawal towards the end of the year is also typical of other plentiful deepwater species of commercial importance in the Northwest Atlantic - Greenland halibut (Reinhardtius hippoglossoides Walb.). Aggregations of this species were also found to be redistributed in deeper waters, which handicapped fishing (Savvatimsky, 1988). Most of the catch during 1979-1985 was obtained in the end of the year, when the halibut aggregated in wintering and pre-spawning concentrations, later than in previous years. However, this was characteristic for SA 0 and 2 only, where the fishing was conducted predominantly near the continental slope (Fig. 5). In SA 3, where most of the catch occurred on the shelf, the time of fishing remained the same (July-September).

Preliminary data for 1986-1989 show that along with the increase of the percentage of grenadier in catches from traditional fishing depths, its total catch increased compared to the previous years. In SA 2+3, the greatest catch occurred in August-October (Table 8), i.e. earlier than in the period from 1979 to 1985. USSR ships fished for grenadier earlier than in 1979-1985. Most of the USSR catch in 1986 was taken in August-September (prevailing fishing depths from 910 to 1450 m), in 1987 - in August (110-1250 m), in 1988 - in July-August (900-1300 m), in 1989 - in August (980-1460 m). This may be an indication of intensive seasonal migrations of grenadier and its earlier aggregating in traditional fishing depths, compared to the period of 1979-1985, unfavourable for fishery. Redistribution of the grenadier into less deep waters of the continental slope allows to suspect, that the 1990 fishery will be more effective.

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Table 1. Total catch of roundnose grenadier in SA 0,1,2,3 in 1971-1988 (t)

Year	0	1	0+1	2G	2H	2J	3K	Other	2+3	0-3
1971	4172	4132	8304	54179	2738	81	18392	55	75445	83749
1972	5783	2311	8094	2161	655	293	21122	155	24386	32480
1973	1054	3830	4884	5880	232	632	10655	165	17564	22448
1974	2661	9657	12318	3220	2007	333	22816	40	28416	40734
1975	204	4749	4953	6489	3536	1754	15388	258	27425	32478
1976	2610	5893	8503	3841	1460	1381	13636	275	20593	29096
1977	721	2214	2935	2597	525	206	11935	123	15386	18321
1978	-	5839	5839	3112	1412	913	15250	15	20702	26541
1979	106	6815	6921	1035	3090	438	3200	18	7781	14702
1980	32	1721	1753	279	493	726	451	104	2053	3806
1981	87	392	479	967	1693	463	3920	42	7085	7564
1982	43	48	91	719	734	182	2709	-	4344	4435
1983	46	22	68	140	1390	36	1916	87	3569	3637
1984	25	25	50	107	289	3	3362	112	3873	3923
1985	16	39	55	-	80	13	4642	213	4948	5003
1986*	1	85	86	-	117	56	7222	32	7427	7513
1987*	-	319	319	80	254	204	6682	1059	8279	8598
1988*	120	424	544	330	226	9	4659	1071	6295	6839

* Preliminary data

catch estimate for 1988 has been borrowed from NAFO SCS Doc. 89/21, Ser.No.N1699

Table 2. Size composition of exploratory catches of grenadier from the Northwest Atlantic (SA 0,2,3) during 1983-1989, %

Length, cm	Year						
	1983	1984	1985	1986*	1987*	1988	1989
21-23	0.5	-	0.4	0.3	0.2	1.4	0.1
24-26	0.8	0.1	0.9	0.7	0.3	1.9	1.3
27-29	1.6	0.3	1.7	1.8	0.8	2.2	2.4
30-32	1.4	0.5	1.6	1.6	2.5	3.2	2.3
33-35	2.4	1.2	2.9	2.9	4.2	6.6	3.1
36-38	3.5	2.1	4.4	3.8	5.8	8.9	4.5
39-41	4.4	2.2	5.8	5.0	6.6	9.6	5.9
42-44	4.7	3.9	7.5	6.0	8.3	11.8	8.0
45-47	5.9	6.0	9.1	6.6	8.4	9.5	8.8
48-50	8.0	7.9	10.2	9.2	10.6	10.0	10.1
51-53	7.6	8.4	9.7	9.0	8.8	8.4	8.3
54-56	8.3	11.2	10.5	8.8	9.6	7.5	9.3
57-59	9.3	11.0	9.0	9.8	9.8	7.2	8.9
60-62	6.9	10.4	6.8	7.9	6.9	4.0	6.9
63-65	8.2	10.1	7.0	8.4	7.2	3.6	6.8
66-68	8.1	7.5	4.5	5.9	3.9	2.0	4.4
69-71	5.2	5.6	3.4	4.1	2.5	1.1	3.1
72-74	4.6	3.9	2.1	3.1	1.6	0.8	2.4
75-77	3.4	3.0	1.2	1.9	1.0	0.2	1.4
78-80	2.4	2.0	0.7	1.3	0.6	0.1	1.1
81-83	1.1	0.8	0.3	0.5	0.3	-	0.4
84-86	0.9	0.8	0.2	0.7	0.2	-	0.3
87-89	0.4	0.4	0.1	0.3	-	-	0.1
90-92	0.2	0.4	-	0.2	-	-	-
93-95	0.2	0.2	-	0.1	-	-	-
Mean length, cm	56.3	58.3	52.2	54.3	51.4	46.5	51.9
Number of fish	13296	11796	5837	6679	9996	11931	12797

* Data for SA 1 are included

Table 3. Age composition of exploratory catches of roundnose grenadier from the Northwest Atlantic (SA 0,2,3) in 1983-1989, %

Age, years	Years						
	1983	1984	1985	1986*	1987*	1988	1989
2	2.0	0.3	1.9	1.6	0.6	1.9	0.6
3	2.9	1.1	2.7	2.8	3.6	4.2	3.0
4	3.5	1.8	3.5	3.3	6.3	8.9	5.1
5	5.9	3.6	6.4	5.6	9.4	13.1	8.4
6	7.3	6.1	8.0	6.6	9.0	12.2	8.9
7	9.5	9.7	11.9	9.9	10.9	12.7	10.8
8	11.1	12.5	13.6	12.2	13.2	13.4	13.2
9	10.9	13.4	13.0	12.2	12.6	11.2	12.4
10	10.1	12.8	11.8	12.0	11.0	8.9	11.2
11	9.2	11.2	8.9	10.0	8.5	5.5	8.7
12	8.9	9.8	7.5	8.9	6.6	4.1	7.2
13	6.4	6.5	5.1	6.3	3.9	2.1	4.6
14	5.0	4.7	2.7	3.7	2.1	1.0	2.8
15	3.2	2.8	1.5	2.4	1.1	0.4	1.6
16	2.0	1.8	0.8	1.4	0.6	0.2	0.9
17	1.2	1.1	0.4	0.9	0.4	0.1	0.6
18	0.4	0.5	0.1	0.2	0.1	-	0.1
19	0.3	0.3	0.1	0.1	-	-	0.1
Mean age	9.3	9.8	8.7	9.2	8.3	7.4	8.6
Number of fish	13296	11796	5837	6679	9996	11931	12797

* Data for SA 1 are included.

Table 4. Mean length of males and females of roundnose grenadier from bottom trawl catches during survey by RV "Kapitan Shaitanov" in September-November 1989.

SA, Div.	Depth, m	Male		Female		Number of females, %
		Length, cm	Number	Length, cm	Number	
0B	701-800	30.6 ± 1.4	22	31.0 ± 2.1	14	38.9
	801-900	44.1 ± 1.2	61	45.8 ± 2.0	25	29.1
	901-1000	42.7 ± 0.7	229	43.6 ± 1.2	101	30.6
	1001-1100	39.4 ± 0.9	104	38.7 ± 1.1	75	41.9
	1101-1200	52.3 ± 0.6	252	53.0 ± 0.8	173	40.7
	1201-1300	53.0 ± 1.2	68	54.5 ± 1.9	46	40.4
	1301-1400	59.8 ± 0.6	295	64.3 ± 0.7	266	47.4
2CH	601-700	40.0 ± 1.2	113	43.3 ± 1.2	112	49.8
	701-800	42.9 ± 0.5	393	42.5 ± 0.7	241	38.0
	801-900	41.5 ± 0.8	164	45.8 ± 0.9	99	37.6
	901-1000	49.4 ± 0.4	539	49.8 ± 0.5	295	35.4
	1001-1100	54.8 ± 0.3	1067	57.9 ± 0.5	516	32.6
	1101-1200	53.7 ± 0.3	795	55.6 ± 0.5	427	34.9
	1201-1300	56.6 ± 0.3	1518	60.8 ± 0.4	804	34.6
3K	1301-1400	59.2 ± 0.4	541	60.7 ± 0.6	333	38.1
	701-800	46.8 ± 0.8	73	46.8 ± 1.5	30	29.1
	801-900	43.5 ± 0.8	102	41.7 ± 1.0	46	31.1
	901-1000	46.6 ± 0.7	290	44.4 ± 0.9	172	37.2
	1001-1100	46.1 ± 0.3	1062	47.6 ± 0.4	666	38.5
	1101-1200	42.4 ± 0.7	201	45.0 ± 1.0	165	45.1
0, 2, 3K	1201-1300	48.3 ± 0.9	172	50.0 ± 1.0	126	42.3
	601-700	40.0 ± 1.2	113	43.3 ± 1.2	112	49.8
	701-800	43.0 ± 0.5	488	42.4 ± 0.6	285	36.9
	801-900	42.6 ± 0.5	327	44.7 ± 0.7	170	34.2
	901-1000	47.2 ± 0.3	1058	47.1 ± 0.5	568	34.9
	1001-1100	50.1 ± 0.2	2233	51.3 ± 0.4	1257	36.0
	1101-1200	51.6 ± 0.3	1248	52.7 ± 0.4	765	38.0
1201-1300	55.7 ± 0.3	1758	59.1 ± 0.4	976	35.7	
1301-1400	59.4 ± 0.3	836	62.0 ± 0.4	599	41.7	

Table 5. Distribution and composition of catches from various depths during trawl survey by RV "Kapitan Shaitanov" in 1989

Div.	Depth, m	Mean catch per hour, kg	Number of catches	Species composition of catches in % by weight			
				Greenland halibut	Redfish	Roundnose grenadier	Other
OB	20I-300	0.9	4	44.4	-	-	55.6
	30I-400	16.4	12	95.0	2.0	-	3.0
	40I-500	70.4	12	64.3	34.5	-	1.2
	50I-600	64.1	6	61.1	35.0	-	3.9
	60I-700	157.7	7	68.7	29.9	-	1.4
	70I-800	69.4	4	74.3	7.7	1.9	16.1
	80I-900	92.2	4	89.8	-	6.4	3.8
	90I-1000	170.8	4	86.8	-	13.2	-
	100I-1100	227.9	3	91.8	-	8.2	-
	110I-1200	315.5	4	87.1	-	12.9	-
	120I-1300	267.1	3	59.3	-	40.5	0.2
	130I-1400	36.0	1	26.9	-	73.1	-
	140I-1500	232.3	1	4.3	-	95.7	-
	2GH	40I-500	38.5	12	60.2	36.5	-
50I-600		118.1	9	61.2	24.3	13.2	1.3
60I-700		109.2	4	53.9	45.9	0.2	-
70I-800		208.0	7	38.3	7.6	52.0	2.1
80I-900		77.0	3	93.2	-	6.8	-
90I-1000		670.8	6	39.6	-	60.4	-
100I-1100		783.3	8	37.7	-	62.3	-
110I-1200		1686.3	4	28.3	-	71.7	-
120I-1300		782.0	11	18.1	-	81.9	-
130I-1400		355.5	1	40.4	-	59.6	-
3K	50I-600	1257.7	2	2.5	96.7	-	0.8
	60I-700	230.8	2	23.0	73.6	-	3.4
	70I-800	164.5	2	51.7	24.8	9.4	14.1
	80I-900	192.2	2	66.8	-	9.3	23.9
	90I-1000	267.5	2	55.8	-	35.6	8.6
	100I-1100	255.5	8	54.9	-	43.4	1.7
	110I-1200	180.5	2	31.7	-	60.7	7.6
	120I-1300	132.5	2	51.5	-	46.2	2.3

Table 6. Distribution and composition of catches of roundnose grenadier from various depths during trawl surveys in Divs. 3K, 2GH and SA OB in 1988, 1989

Year	Depth, m	Mean catch/1 hour, kg	Number of catches	Species composition of catches in % by weight			
				Green-land halibut	Redfish	Roundnose grenadier	Other
1988	10I-200	2.0	8	100.0	-	-	-
	20I-300	5.1	21	100.0	-	-	-
	30I-400	17.2	21	89.2	6.0	-	4.8
	40I-500	50.0	30	60.1	29.6	8.9	1.4
	50I-600	67.7	13	50.0	49.3	-	0.7
	60I-700	72.8	25	52.8	38.9	6.0	2.3
	70I-800	117.3	11	62.9	11.1	23.6	2.4
	80I-900	144.4	18	78.9	0.3	19.7	1.1
	90I-1000	165.2	11	85.0	0.5	14.5	-
	100I-1100	290.6	28	41.4	-	58.4	0.2
	110I-1200	152.9	11	52.9	-	47.1	-
120I-1300	117.0	1	7.7	-	92.3	-	
1989	20I-300	0.9	4	44.4	-	-	55.6
	30I-400	16.4	12	95.0	2.0	-	3.0
	40I-500	54.5	24	62.8	35.3	-	1.9
	50I-600	233.1	17	24.0	71.3	3.5	1.2
	60I-700	154.0	13	55.0	43.5	-	1.5
	70I-800	158.7	13	45.3	10.3	38.5	5.9
	80I-900	109.4	9	81.6	-	7.6	10.8
	90I-1000	436.9	12	47.4	-	51.7	0.9
	100I-1100	473.4	19	45.7	-	53.9	0.4
	110I-1200	836.8	10	37.3	-	62.3	0.3
	120I-1300	604.3	16	22.4	-	77.5	0.1
130I-1400	195.8	2	39.1	-	60.9	-	
140I-1500	232.3	1	4.3	-	95.7	-	

Table 7. Average annual total catch of grenadier in the Northwest Atlantic in the periods 1971-1977, 1978-1982, 1983-1987, 1988-1989 in per cent of the average annual catch during 1971-1989 and relative number of grenadier in per cent of the total catch during these periods according to research vessel data, depths - 601-800 m, 601-1000 m and 601-1200 m.

Parameter	Years			
	1971-1977	1978-1982	1983-1987	1988-1989
Total catch in % of average annual catch	60.7	18.7	9.4	11.2
Percentage of grenadier in 601-800 m	64.0	14.4	10.6	17.8
Percentage of grenadier in 601-1000 m	73.1	15.5	10.2	23.5
Percentage of grenadier in 601-1200 m	80.7	16.8	14.8	35.0

Note: Catch for 1989 is not included.

Table 8. Total catch of roundnose grenadier in SA 2+3 by month in 1986-1988* (t)

Year	Month												Yearly total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1986	9	5	-	-	-	-	117	2817	2093	1555	494	336	7426
1987	71	111	45	96	75	5	22	2722	1627	1558	1319	628	8279
1988	415	33	37	-	8	74	993	836	736	1443	1484	278	6337
1986-1988	495	149	82	96	83	79	1132	6375	4456	4556	3297	1242	22042
%	2.2	0.7	0.4	0.4	0.4	0.4	5.1	28.9	20.2	20.7	15.0	5.6	100%

* Preliminary estimates from Atkinson, Power, 1989

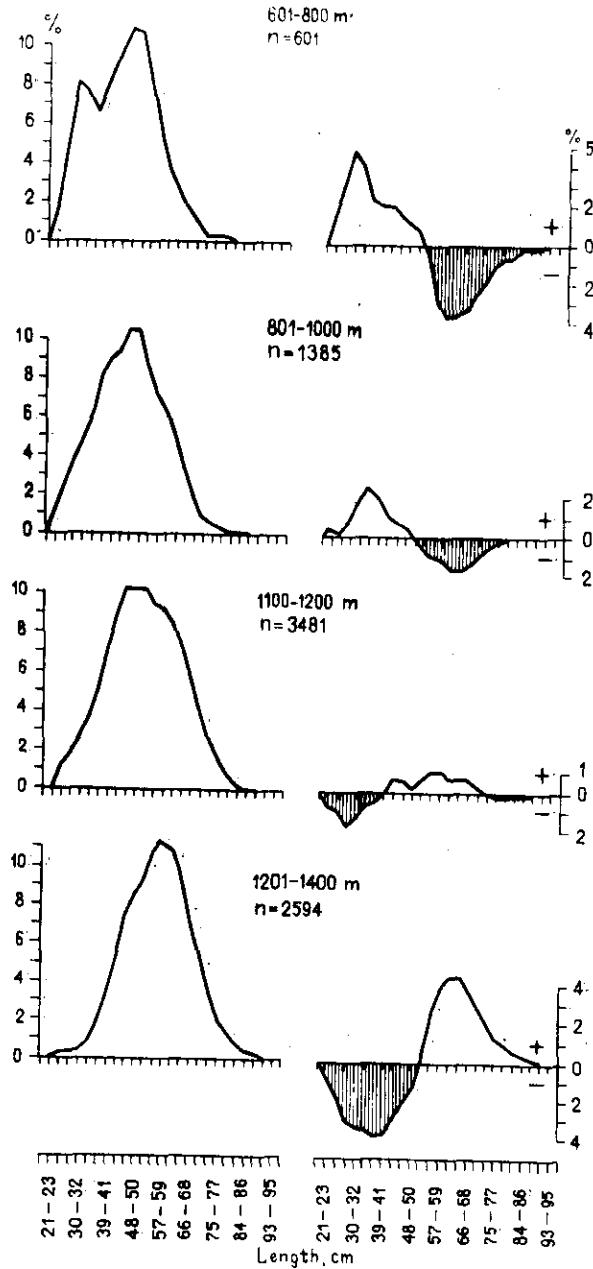


Fig. 1 Size composition of male roundnose grenadier in different depths in Divs. OB, 2GH, 3K in 1989, data from trawl survey by RV "Kapitan Shaitanov" (smoothed series, n - number of males measured).

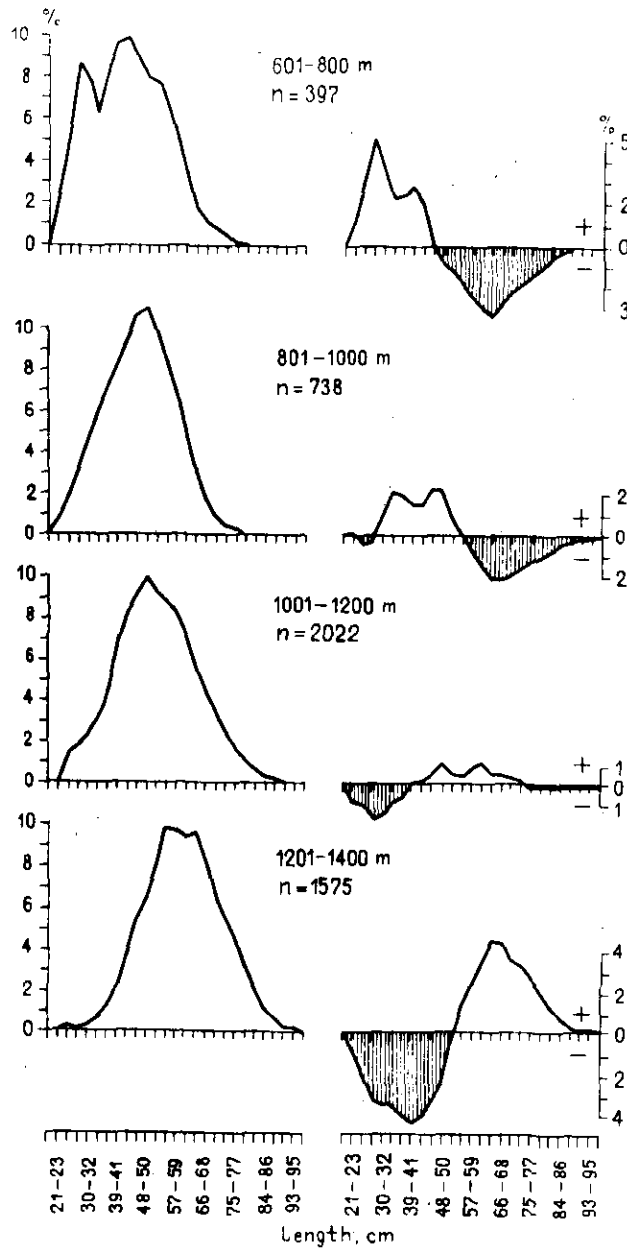


Fig. 2 Size composition of female roundnose grenadier in different depths in Divs. OB, 2GH, 3K in 1989, data from trawl survey by RV "Kapitan Shaitanov" (smoothed series, n - number of females measured).

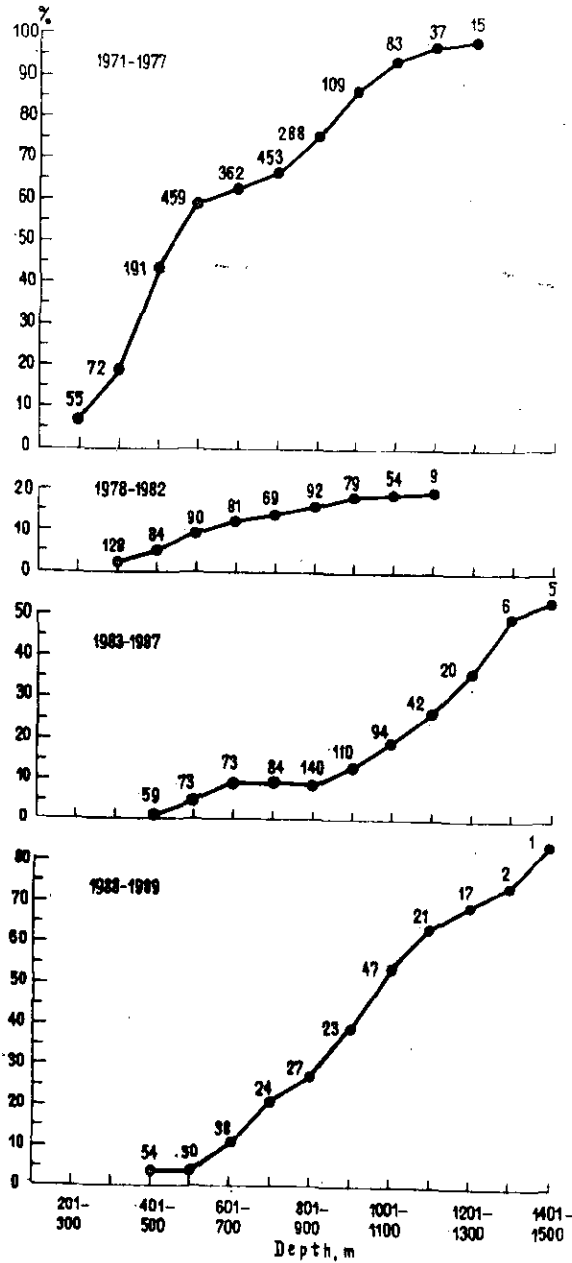


Fig. 3 Relative amount of roundnose grenadier in % by weight in exploratory bottom trawl catches from various depths in SA O,2 and Div 3K in 1971-1977, 1978-1982, 1983-1987, 1988-1989 (smoothed series, figures along plots - number of catches).

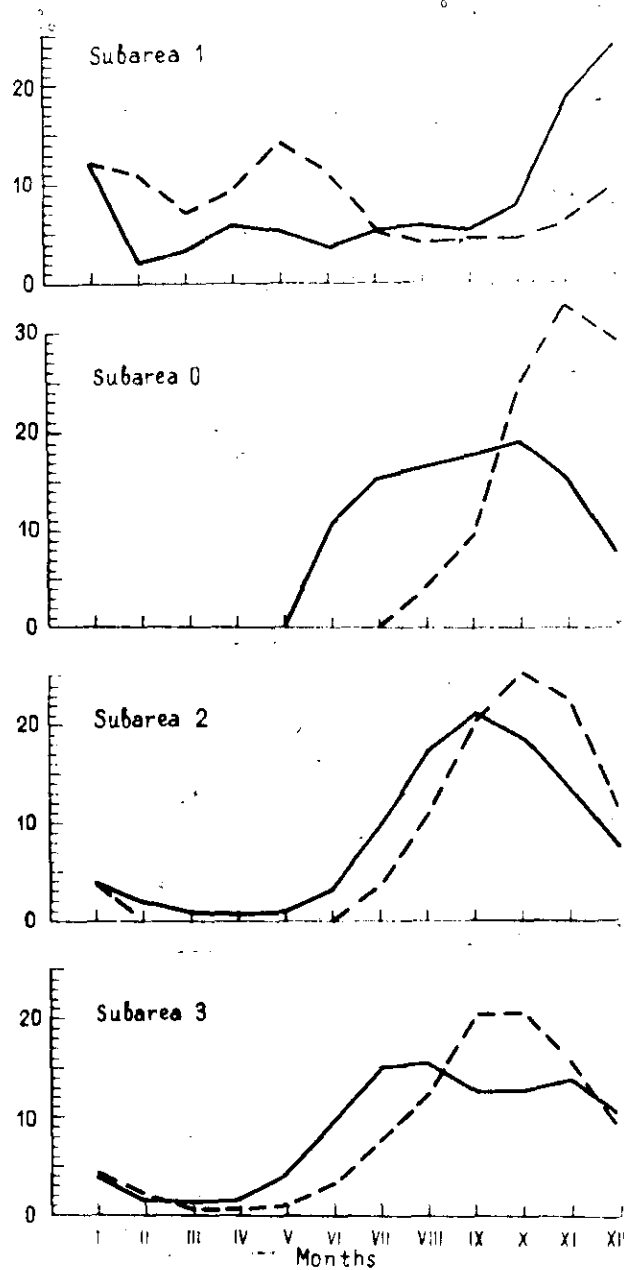


Fig. 4 Roundnose grenadier catch by month in % of catch during 1972-1978 (solid line) and 1979-1985 (dash line), smoothed series.

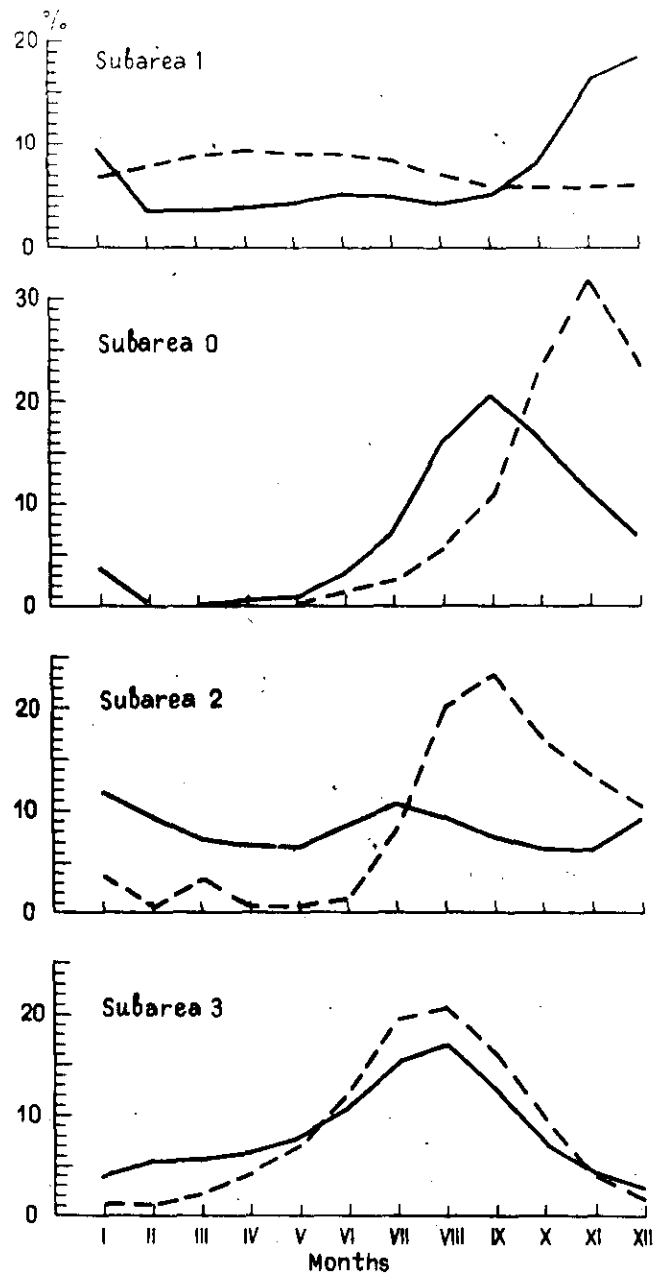


Fig. 5 Greenland halibut catch by month in % of catch during 1972-1978 (solid line) and 1979-1985 (dash line), smoothed series.