Northwest Atlantic Fisheries Organization

Serial No. N1184

NAFO SCR Doc. 86/67

SCIENTIFIC COUNCIL MEETING - JUNE 1986

Changes in Composition of the Bottom Fish Catches at Different Depths Along the Continental Slope in NAFO Subareas 0, 2 and 3 in 1970-85

by

P. I. Savvatimsky

Polar Research Institute of Marine Fisheries and Oceanography (PINRO)
6 Knipovich Street, Murmansk, 183763, USSR

ABSTRACT

A considerable cooling of the Northwest Atlantic water masses in 1973-85 seemed to influence redistribution of beaked redfish, Greenland halibut and roundnose grenadier which major concentrations moved into greater depths. The change of hydrological conditions turned to be one of the reasons for a sharp reduction in total grenadier catch.

The analysis of the bottom trawl catches taken by research vessels at standard fishing depths within 1970-85 showed that the mean length of grenadier decreased notably by 1985. The length and sex compositions of grenadier catches were also found to have changed with increasing depth of trawling.

In October/November of cold years the dense halibut aggregations were formed at 800-1300 m while in warm years the fish were observed scattered in a wide area of the shelf and continental slope.

INTRODUCTION

The roundnose grenadier (Coryphaenoides rupestris), Greenland halibut (Reinhardtius hippoglossoides) and beaked redfish (Sebastes mentella) were the main objects of deepwater trawl fishery off the Atlantic coast of Canada. Fisheries for redfish, halibut and grenadier were generally conducted in 300-600 m, 300-1000 m and 600-1300 m respectively. The ranges of two latter species coincided to a great extent, that is why the catches were

usually mixed. In the opinion of different authors the ratio of grenadier and halibut in the commercial and research catches has changed recently as well as the removal of these species. So, for a period of 1970-76 the portion of halibut averaged 34.3% in total catch of research and scouting vessels from Subareas 0, 2, 3 and for 1977-83 - 72.2% (Chumakov, Savvatimsky, 1984). The trawl surveys demonstrated a high level of redfish and halibut stocks (Chumakov, 1982; Chumakov, Borovkov, Noskov, 1984; Chumakov, Poletaev, 1985) and their relatively stable catches. The removal of roundnose grenadier on the contrary suffered considerable changes, besides, the ratio of grenadier, halibut and redfish in the bottom trawl catches taken at different depths varied in recent years.

The annual catch of grenadier in the Northwest Atlantic ranged from 15.5 to 83.8 thou.t in early period of fishery (1967-78) constituting on the average 32.3 thou.t per year. The average annual catch of the USSR accounted for 29.0 thou.t, i.e. 89.8% of the total catch. During the following period (1979-83) the total catch was on the average 6.8 thou.t per year, that of the USSR - 3.6 thou.t (52.9% of the total catch).

There occurred a sharp decrease of the total grenadier catch in all NAFO Subareas, first being recorded in Subarea 0 (1977), later - in Subareas 2, 3 (1979) and more later - in Subarea 1 (1980-81) (Table 1). Some reasons of the catch decrease were suggested. Atkinson (1982, 1983, 1984) indicated the decreasing of catches per hour trawling from 1.4 t in 1970 to 0.5 t in 1983 and assumed it to be caused by the intensive fishery of the fish stocks. The assessment of the grenadier stock abundance was associated with great difficulties due to fish inhabiting the depths greater than 2000 m (Wheeler, 1969; Atkinson et al., 1981). Therefore, it was impossible to obtain the abundance and biomass estimates with application of results of the trawl survey or young fish survey. The VPA method yielded rather a rough assessment of the stocks. Nevertheless, it was noted that the 1967-81 fishery did not affect adversely the fish abundance (Atkinson, 1981; Savvatimsky, Shafran, 1981), moreover, the total catch never exceeded initiated by STACFIS TAC (Table 1). It should be also emphasized that in a period of the most intensive fishery (1967-79) the length

and age compositions of grenadier catches from the major fishing areas were stable except for the short-term (1967-71) variations in Div. 3K (Savvatimsky, Shafran, 1981). The length composition slightly decreased in recent years when the commercial removal was minimum. Hence, the unfavourable effect of fishery on the fish stocks was questionable.

The specialists of the NAFO member states pointed out that one of the reasons for the grenadier total catch decrease in a directed trawl fishery was a limitation of halibut by-catch to 10% though the abundance of the latter increased in recent years (Atkinson, 1982, 1984; Bowering, 1983; Chumakov, Savvatimsky, 1983, 1984). The higher halibut numbers were responsible for its by-catch increase and the vessels fishing for grenadier had to trawl the marginal areas and great depths which hindered the active exploitation of grenadier stocks.

It was also supposed that the decrease in grenadier catch and changes of grenadier and halibut ratio in the catches taken at different depths resulted to some extent from the more intensive cooling of the Northwest Atlantic water masses in recent years (Chumakov, Savvatimsky, 1984; Ernst, 1984). In addition, along with the above factors redistribution of fishing efforts by depth and area was indicated to account for the halibut and redfish by-catch fluctuations in a directed fishery of grenadier and for decrease in total grenadier catches (Kulka, 1985).

The aims of the present paper are studying the recent changes of deepwater fish ratio in bottom catches from the Northwest Atlantic and elucidating the reasons of these changes for determining availability of commercial species to the bottom trawl fishery.

MATERIAL AND METHODS

The data on assessment of Greenland halibut abundance and biomass obtained by research vessels during the 1970-85 trawl surveys are used in the paper. The surveys were carried out yearly in the autumn/winter period and the hauls covered a wide range of depths in the area of shelf and continental slope in Subareas 0, 2 and Div. 3K. Besides, during the trawl surveys the most complete

data were collected on different fish ratio in catches which allowed a detailed analysis of the catch composition variations in time and by depth of fishing.

The variational series presented in Figures in the smoothed form permitted to reveal the main tendencies toward changing of parameters under study. The smoothing was made by the formula $B = \frac{a+2b+c}{4}$, where a, b, c are the previous, mean and consequent terms of the series; B is a computed term. The mean Greenland halibut catches taken at different depths in 1979-84 (Table 4) were smoothed by separate 100-metre depth intervals and also by years to reveal the year-to-year variations of catch values. The mean catch per each year was computated through summation of mean catches for depth intervals and division of the sum by the number of intervals. The data from the 1984-85 trawl survey were not presented since due to severe ice conditions the programme of the survey was performed in the limited volume, consequently, the comparison of mean halibut catches by depths and by years was impossible.

The data of Canadian observers obtained during the directed roundnose grenadier fishery conducted by the USSR and GDR fishing fleets in Divs. 2JHG and 3K in 1978-83 were also used in the paper. The series involving the ratio of grenadier, halibut, redfish and other fishes in catches as well as the relative amount of halibut in catches in separate years were compiled from Figs. 6, 8 of the scientific report of D.W.Kulka (1985). The missed values for separate years were obtained as arithmetic mean of values for the nearest years. The series were smoothed by years and also by 100-metre depth intervals.

The mean water temperature in the 200-500 m and 500-1000 m layers on oceanographic section 8-A on the continental slope of South Labrador on 1 November of each year was assumed to be a characteristic of water temperature variations in the Main branch of Labrador Current for 1964-84. The results of water temperature measurements were averaged by three stations in 1964-76 and by two stations in the subsequent years (Table 2).

RESULTS

Quite a number of authors noted a recent cooling of the Northwest Atlantic water masses (Chumakov, Borovkov, Noskov, 1984; Borovkov, Burmakin, 1985; Ernst, 1984). According to our observations the considerable cooling of continental slope waters started in the Labrador area in 1973 (Fig.1), the water temperature being until 1985 much lower than the long-term mean (1964-84). Beyond doubt it affected the distribution of bottom fishes inhabiting the continental slope - Greenland halibut, roundnose grenadier and beaked redfish. It was revealed, for instance, that the ratio of grenadier males and females was subject to seasonal and year-to-year variations and depended on water temperature fluctuations within the fish range (Savvatimsky, 1982). It is also known that the fish distribution is heavily influenced by year-to-year variations of hydrological conditions, therefore, despite the stability of fish stocks the productivity of fishery and catch may change sharply compared with the level of previous years (Burmakin et al., 1984). Greenland halibut was found to prevail in catches from Subarea 0 when the water temperature in its range was lower than the long-term mean while in years with the temperature being higher the long-term mean grenadier predominated (Konstantinov, Noskov, 1977; Burmakin, 1978).

In this connection the comparison of bottom catch compositions in relatively warm and cold years was of certain interest. So, in relatively warm 1971 when the water temperature in the 200-500 m and 500-1000 m layers in the Main branch of Labrador Current was higher than 4°C (Fig.1) the largest bottom trawl catches of grenadier and halibut were taken by research vessels at 900-1000 m in Subareas 0 and 2, the portion of grenadier constituting on the average 90%. In depths greater than 1000 m the catches decreased (Fig.2). In 1983 when the water temperature was below the long-term mean the highest catches of grenadier and halibut were obtained at 1100-1200 m, the portion of grenadier making up about 10% and increasing to 30% at 1200-1300 m. These variations seemed to be related to the fish migration into greater depths. To learn the changes in composition of catches from the continental slope of Canada using more plentiful data, the catches of research vessels

were analysed for two periods: 1970-71 and 1983-84. Notable changes were found to happen both in ratio of the main species - grenadier and halibut, and in composition of the by-catch.

The 1970-71 by-catch of other fishes to grenadier and halibut catches taken at 500-1000 m in Subareas 0, 2 averaged 3.7%, in 1983 - 13% and in 1984 - 15%. The increase of the by-catch by 1984 was due to beaked redfish caught at 500-600 m and accounting for 10-40% of catches by weight. It should be noted that in 1970-71 no beaked redfish was in fact trawled deeper than 500 m. The increase in its by-catch was apparently due to migration of the fish concentrations into greater depths.

Excluding a small by-catch we compared the weight of roundnose grenadier and Greenland halibut catches (%) taken at different depths in Subareas 0, 2 in autumn/winter 1970-71 and 1983-84. Over the first period the grenadier weight accounted on the average for 79.1-84.1% of the catches from 500-1000 m (65.3-70.0% of the catches from 500-600 m) and over the second period - for 3.8-9.5% (in fact no grenadier in the catches at 500-600 m) (Table 3). The increase of its portion to 50% in the catches removed from 1300-1400 m in 1983-84 was indicative of the probable migration of grenadier into greater depths (Fig.3).

Variation in species composition of the USSR and GDR catches taken recently in the Northwest Atlantic during the directed fishery for roundnose grenadier was well illustrated by the data of Canadian observers (Kulka, 1985) presented in Fig.4. Both in 1978 and 1983 the portion of grenadier did not exceed 50% in the catches trawled at depths less than 700 m. However, if in 1978 this species accounted for more than 90% of catches from depths greater than 850 m (as deep as 1600 m), in 1983 - just 50-75%.

For the 6-year period under review the beaked redfish concentrations moved into greater depths too. If in 1978 redfish accounted for 10% of total catch fished in 500 m and was not practically found at depths greater than 900 m, in 1983 this species accounted for more than 50% of catches from 500 m and was caught at depths greater than 900 m.

From 1978 to 1983 there were recorded changes in vertical

distribution of Greenland halibut. In 1978 halibut made up the bulk of catches in 450-700 m, its portion being reduced to 10% in 850 m. The largest halibut by-catch was registered in 1983 at 700-1000 m which decreased to 10% at 1300 m (Fig.4). There was a gradual change in halibut by-catch. Its maximum by-catch observed in 1978 at depths less than 500 m (on the average 52%) decreased by 1983 to 35%. Within depths of 801-900 m the halibut by-catch increased from 25 to 43% for this period while in 1201-1400 m - from 5 to 15% (Fig.5). In catches taken at 501-600 m the relative amount of halibut decreased from 1978 to 1983, at 601-700 m it remained nearly constant during this period and deeper than 700 m it increased, the greatest rise from 18% in 1978 to 40% in 1983 being registered at 901-1000 m (Fig.6).

The data from the Soviet trawl surveys on assessment of halibut abundance and biomass supported the conclusion of the migration of halibut concentrations into greater depths. The mean catches were small at depths less than 500 m (below 250 kg per hour trawling) and decreased from 1979 to 1983, catches in 501-600 m were nearly the same during this period and catches fished deeper than 601 m increased by 1983 (Table 4). It is noteworthy that the mean catches on the whole per year increased from 599 kg in 1979 to 1036 kg in 1983, i.e. nearly twofold. It bore out the finding of recent sharp increase in halibut abundance and biomass.

1983 and 1984 were characterized by an intensive cooling of the Northwest Atlantic water masses. In 1983 the increased compared with 1982 spreading of cold waters of Arctic origin was observed both in the area of shelf and continental slope of Subarea 0. In Subarea 2 and northern part of Subarea 3 there occurred in 1983 an extreme cooling of deep shelfy waters, enlargement of the area and growth of vertical extent of cold interjacent waters transported by the Labrador Current (Chumakov, Borovkov, Noskov, 1984). During the trawl survey in Subareas 0, 2 the mean halibut catches were lower than in 1982. The major concentrations were located at depths greater than 1000 m and appeared to be inaccessible in fact to the bottom trawl survey. In 1984 there were also registered negative compared with the long-term mean norm anomalies of water temperature on some standard hydrological sections in the Coastal,

Middle and Atlantic branches of Labrador Current (Borovkov, Burmakin, 1985).

The species composition of catches trawled in the same depths of Subareas 0, 2 was similar during the 1983 and 1984 trawl surveys (Tables 5, 6). Halibut made up the bulk of catches in 600-1300 m, its maximum landings being recorded from 900-1200 m. The grenadier by-catch was small and increased to 50% at depths greater than 1300 m. In 1984 catches comprising mostly beaked redfish were removed from depths less than 600 m. The by-catch of other species was negligible at all the depths (200-1500 m).

To judge by the results of 17 hauls made in Div. 3K in January 1984 beaked redfish accounted for 65-85% of catches taken in 400-600 m, halibut predominated in 800-1100 m and grenadier by-catch reached 35% in catches from 1100-1400 m.

Thus, in abnormally cold 1983 and 1984 halibut, grenadier and beaked redfish were distributed at far greater depths in the Northwest Atlantic than in years prior to water masses cooling. The length and sex compositions of grenadier catches varied too. In Subarea 2 and Div. 3K small fish were mainly caught in 1984 at depths less than 1000 m, the mean length of fish increased with increasing depth of trawling (Figs. 7, 8). Large fish were found at far greater depth than in previous years. A relative number of females increased in landings under the depth of haul growing. So, in Divs. 2JH females comprised 41.3 and 61.0% of catches fished in December 1984 at 760-880m and 1400 m respectively.

In 1985 the hydrological conditions in the Northwest Atlantic were at the level of cold years. The composition of bottom catches fished in 1985 off continental slope in Subareas 0, 2 was like that in 1983 and 1984. Length and sex compositions of roundnose grenadier catches changed as well with increasing depth of haul (Table 7).

Recent variations in vertical distribution of fish were evidently responsible for a general decrease of length composition of grenadier catches from Subareas 0, 2 and Div. 3K. From 1981 to 1985 the mean grenadier length decreased in trawl catches from 59.0 to 52.3 cm though the mean depth of haul slightly increased

(from 830 to 1004 m) (Table 8). The most notable decrease in the mean length (by 14 cm) happened from 1979 to 1985 in Subarea 0 (Fig.9) where hydrological conditions could affect the grenadier distribution to a greater extent. From 1981 to 1985 the mean length of fish decreased by 9.6 cm in Subarea 2 (Fig.10) and by 6.1 cm in Div. 3K (Fig.11).

It should be noted that in 1985 though hydrological conditions in the Northwest Atlantic were at the level of cold years a weakening of Labrador Current was observed, in November the water temperature of the active layer was by 1° higher than in the same period of 1984. During the trawl survey in Subarea 0 the water temperature in the near-bottom layer varied from 1° on the shoal to 3.5° in deep water masses. The 1° isotherm passed along the 300 m isobath, 2° - along 500 m and 3° - along 600 m. In November 1985 the near-bottom water temperature in Subarea 0 was on the average by 0.5-1.0° higher than in abnormally cold 1983. Under these conditions due to feebly marked frontal zone the halibut concentrations were scattered. The maximum catches amounted to 300-500 kg per hour trawling in 900-1000 m.

Thus, availability of halibut to bottom trawling was dependent not only on a general migration of fish concentrations into greater depths occurring under the effect of year-to-year variations in water temperature but also on concrete hydrological conditions in a period of survey.

CONCLUSIONS

A considerable cooling of the Northwest Atlantic water masses in recent years resulted most likely in redistribution of bottom fishes inhabiting the continental slope. Beaked redfish concentrations moved into greater depths and sometimes this species accounted for about 40% of catches trawled in 600 m. Greenland halibut concentrations also migrated to greater depths (more than 1000 m) and were not always available to bottom trawling during the surveys. Roundnose grenadier made up the bulk of catches in depths greater than 1300 m and was actually inaccessible to bottom trawling. It seemed to be one of the reasons for a recent decrease in the total grenadier catch. Under the effect of changing hydrological condi-

tions the length and sex compositions of roundnose grenadier catches from different depths varied. The mean fish length decreased in catches trawled at standard depths in the main fishing areas. These gradual changes occupied a period of 7-8 years.

On the basis of the long-term variations in thermal state of the South Labrador waters a relative rise in water temperature can be expected in Subareas 0, 2 in 1986-87 but no marked change is likely to occur in distribution of commercial fishes within the next few years. Since the major halibut concentrations dwell in depths greater than 1000 m the trawlings carried out yearly in afore-named Subareas to assess the fish abundance and biomass should cover the depths to 1500 m.

Availability of halibut to bottom trawling depended also on concrete hydrological conditions in the course of surveys. In hydrologically cold years the dense halibut concentrations were formed in October/November at 800-1300 m which ensured a high fishing efficiency. By December the centre of concentrations was displaced to greater depths. In warm years halibut were dispersed over a wide area of shelf and continental slope, and did not form dense and stable concentrations which resulted in much lower trawl survey indices of the fish abundance and biomass.

REFERENCES

Atkinson, D.B. 1981. Roundnose grenadier in NAFO Subaread 2+3. NAFO SCR Doc. 81/VI/60, Serial No. N344 (mimeo).

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 (mimeo).

Atkinson, D.B. 1983. Roundnose grenadier in Subareas 0+1 and 2+3. NAFO SCR Doc. 83/VI/37, Serial No. 690 (mimeo).

Atkinson, D.B. 1984. An update on the status of roundnose grenadier 0+1 and 2+3. NAFO SCR Doc. 84/VI/20, Serial No. N793 (mimeo).

Atkinson, D.B., W.R.Bowering, S.A.Horsted, J.P.Minet, and D.G.Parsons. 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. N290 (mimeo).

Borovkov, V.A., and V.V.Burmakin. 1985. Hydrographic conditions off the Labrador and Newfoundland in 1983-1984. NAFO SCR Doc. 85/59, Serial No. N1009 (mimeo).

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 (mimeo).

Burmakin, V.V. 1978. Influence of water temperature on the catches of roundnose grenadier and Greenland halibut off the Baffin Island. Trudy PINRO, Murmansk, 40: 148-152 (in Russian).

Burmakin, V.V., K.G.Konstantinov, A.I.Postolaky, P.I.Savvatimsky and A.K.Chumakov. 1984. Influence of water temperature on the fishing efficiency and composition of bottom fish catches in the Northwest Atlantic. In: Ecology of biological resources of the North basin and their fisheries, Murmansk, p. 17-23 (in Russian).

Chumakov, A.K. 1982. On trawl survey of Greenland halibut stocks in Canadian zone of the North Atlantic. In: Abundance and mode of life of the Northwest Atlantic commercial fishes, Murmansk, p.21-31 (in Russian).

Chumakov, A.K., and P.I.Savvatimsky. 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 (mimeo).

Chumakov, A.K., and P.I.Savvatimsky. 1984. Roundnose grenadier - Greenland halibut ratio in bottom trawl catches taken in NAFO area in 1970-1983. NAFO SCR Doc. 84/VI/37, Serial No. N822 (mimeo).

Chumakov, A.K., V.A.Borovkov, and A.S.Noskov. 1984. USSR Research Report for 1983. NAFO SCR Doc. 84/VI/17, Serial No. N837 (mimeo).

Chumakov, A.K. and V.A.Poletaev. 1985. USSR investigations in NAFO Subareas 0, 2, 3 in 1984. NAFO SCR Doc. 85/VI/14, Serial No. N1013 (mimeo).

Ernst, P. 1984. Contribution to by-catch of Greenland halibut (Reinhardtius hippoglossoides Walb.) in the roundnose grenadier (Coryphaenoides rupestris Gunn.) directed fishery in NAFO Subarea 2. NAFO SCR Doc. 84/IX/96, Serial No. N891 (mimeo).

Konstantinov, K.G., and A.S.Noskov. 1976. Report on the USSR investigations in the ICNAF area. ICNAF Summ. Doc. 77/VI/15, Serial No. 5071 (mimeo).

Kulka, D.W. 1985. The effect of changing effort patterns of catch composition in the roundnose grenadier fishery, 1978-83. NAFO SCR Doc. 85/VI/16, Serial No. N956 (mimeo).

Savvatimsky, P.I. 1982. Reproduction and sex composition of the North Atlantic roundnose grenadier. In: Abundance and mode of life of the Northwest Atlantic commercial fishes, Murmansk, p.32-53 (in Russian).

Savvatimsky, P.I., and I.S.Shafran. 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 (mimeo).

Wheeler, A. 1969. Anacanthini. In: The fishes of the British Isles and North-West Europe, London-Melbourn-Toronto, p. 255-259.

Table 1 Roundnose grenadier catches of all countries in Subareas in 1967-84 and TAC (t)
(Stat.Bull. ICNAF and NAFO , 1968-84)

Year	0	1	Total 0+1	TAC 0+1	2	3	Total 2+3	TAC 2+3
1967	1129	6	1135		1085	16219	17304	
1968	5907	284	6191		7104	24159	31263	
1969	2642	68	2710		990	11789	12779	
1970	545	5980	6525		1904	22524	24428	
1971	4172	4132	8304		56998	18447	75445	
1972	5783	2311	8094		3109	21277	24386	
1973	1054	3830	4884		6744	10820	17564	
1974	2661	9657	12318		5560	22856	28416	
1975	204	4749	4953	10000	11779	15646	27425	32000
1976	2610	5893	8503	14000	6682	13911	20593	35000
1977	721	2214	3656	8000	3328	12058	15386	35000
1978	-	5839	5839	8000	5437	15265	20702	35000
1979	106	6815	6921	8000	4563	3218	7781	35000
1980	32	1721	1753	8000	1498	555	2053	30000
1981	87	392	392	8000	3123	3962	7085	27000
1982	43	48	91	8000	1635	2709	4344	27000
1983	46	22	68	8000	1566	2003	3569	11000
1984[1]	25	35	60	8000	399	3474	3873	11000

[1]Figures for 1984 are provisional

Table 2. Positions of water temperature measurements in the 200-500 m and 500-1000 m layers in the South Labrador area

Year	No. of station	Positions		Depth, m
		N	W	
1964-76	1	54°55'	53°22'5''	1550
	2	55°00'	53°12'	2150
	3	55°13'	52°52'	2925
1977-84	1	54°47'	53°00'	1306
	2	55°04'	52°30'	2636

Table 3 Per cent of roundnose grenadier by weight (numerator) and number of catches (denominator) in autumn/winter 1970-71 and 1983-84 in Subarea 0 and Divs. 2GHJ

Depth, m	Years			
	1970	1971	1983	1984
501 - 600	70,0 / 1	65,3 / 16	0,4 / 11	6,2 / 13
601 - 700	73,8 / 18	75,1 / 84	1,8 / 11	10,6 / 16
701 - 800	81,5 / 77	79,4 / 123	2,1 / 19	5,2 / 21
801 - 900	92,8 / 26	81,0 / 69	1,8 / 19	13,3 / 23
901 -1000	100,0 / 1	95,3 / 11	5,9 / 30	10,2 / 18
501 -1000	84,1 / 123	79,2 / 303	3,8 / 90	9,5 / 91

Table 4 Mean catches (kg) of Greenland halibut per hour trawling at different depths in Subarea 0 and Divs. 2GH in 1979-84 according to the trawl survey data (smoothed series; in brackets - number of hauls)

Depth, m	Month, year				
	Sep - Nov 1979	Nov - Dec 1980	Dec 1981- Jan 1982	Nov 1982- Jan 1983	Nov 1983- Jan 1984
301 -400	264(16)	124(4)	49(13)	-	-
401- 500	242(16)	138(2)	131(3)	193(4)	198(3)
501- 600	278(32)	212(6)	248(6)	329(8)	342(6)
601- 700	418(24)	416(8)	489(4)	578(10)	570(10)
701- 800	687(30)	891(5)	993(6)	988(12)	922(14)
801- 900	934(14)	1386(10)	1530(9)	1430(18)	1418(17)
901-1000	1004(8)	1443(21)	1595(15)	1592(14)	1630(28)
1001-1100	965(6)	1221(12)	1339(4)	1469(20)	1565(18)
1101-1200	-	1288(1)	-	1362(2)	1465(16)
1201-1300	-	-	-	-	1219(6)
301-1300	599	791	797	993	1036

Table 5 Composition of bottom trawl catches from different depths in Subarea 0 and Divs. 2GHJ on 7 November-31 December 1983 according to the trawl survey data (% by weight)

Composition of catches	Depth, m										
	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-1000	1001-1100	1101-1200	1201-1300
R.hippoglossoides	45,9	19,0	58,9	81,6	66,8	82,8	90,1	87,2	78,3	75,6	52,9
C.rupestris	-	-	-	0,3	1,3	1,8	1,7	5,5	9,7	16,1	31,5
M.berglax	-	-	0,8	0,9	5,0	2,5	1,5	1,2	1,3	0,5	0,9
S.mentella	-	2,0	8,6	8,3	3,2	1,5	0,2	0,1	0,1	-	0,1
A.latifrons	-	34,1	25,6	8,4	5,3	5,8	2,9	4,1	6,7	4,5	7,9
Rajiformes	0,8	-	0,6	-	1,2	1,1	0,8	0,8	1,0	0,9	0,8
Alepocephalidae	-	-	-	-	-	-	-	-	0,2	0,2	4,6
A.rostrata	-	-	-	-	0,3	0,1	0,3	+	0,3	0,2	0,2
Squaliformes	-	-	-	-	13,7	3,4	2,1	0,2	1,2	1,3	0,7
Other fishes	53,3	44,9	5,5	0,5	3,2	1,0	0,4	0,8	1,2	0,7	0,4
Mean catch, kg/hour	69,0	59,0	146,2	477,4	708,6	1608,1	1737,8	2224,5	1389,9	2493,0	1779,0
No. of catches	2	1	4	11	11	19	19	30	25	16	7

Table 6 Composition of bottom trawl catches from different depths in Subarea 0 and Divs. 2GHJ on 14 September-30 December 1984 according to the trawl survey data (% by weight)

Composition of catches	Depth, m											
	401-500	501-600	601-700	701-800	801-900	901-1000	1001-1100	1101-1200	1201-1300	1301-1400	1401-1500
R.hippoglossoides	9,3	39,6	76,4	90,6	79,7	84,6	75,6	59,6	58,1	29,6	38,1
C.rupestris	0,1	2,6	9,0	5,0	12,2	9,6	18,0	15,3	24,8	46,0	55,3
M.berglax	-	0,1	0,3	0,4	1,3	1,0	0,4	0,3	3,7	-	2,3
S.mentella	66,5	42,6	10,6	0,6	0,4	1,0	+	10,7	0,4	14,7	-
A.latifrons	1,1	2,1	1,3	1,5	0,8	2,0	2,5	10,3	8,4	0,4	0,2
Rajiformes	-	0,4	0,4	0,3	0,7	0,4	1,2	0,7	2,3	0,2	-
Alepocephalidae	-	-	-	-	-	+	0,1	0,1	-	3,2	-
A.rostrata	-	+	0,2	0,3	0,1	0,2	0,2	1,0	0,2	0,5	4,1
Squaliformes	-	-	0,2	0,4	4,4	0,1	0,9	1,5	1,4	4,6	-
Other fishes	23,0	12,5	1,6	0,9	0,4	1,0	1,0	0,5	0,7	0,8	-
Mean catch, kg/hour	916,7	480,5	249,4	511,2	511,3	813,3	616,9	380,2	430,0	477,2	176,7
No. of catches	6	13	16	21	23	18	15	10	5	6	3

Table 7 Mean length of roundnose grenadier in the catches taken with a bottom trawl using the fine-meshed netting at different depths in Subareas 0, 2 and Div. 3K in 1985 (according to results of the trawl survey)

Depth, m	Mean length, cm	No. of females %	No. of fish, spec.
Less than 900	44,5 ± 0,7	40,5	385
900-1000	52,0 ± 0,3	47,1	1086
1000-1100	51,1 ± 0,2	44,9	2198
1100-1200	51,9 ± 0,3	45,0	1671
More than 1200	57,3 ± 0,3	48,3	1417
Total	52,3 ± 0,1	45,8	6757

Table 8 Change of trawling depth, mean length of roundnose grenadier and relative number of females in the bottom trawl catches from Subareas 0, 2 and Div. 3K in 1981-85 (according to results of the trawl survey)

Year	Trawling depth, m			Mean length cm	Relative nb of females%	No. of fish, spec.
	from	to	mean			
1981	420	1110	830	59,0±0,1	37,4	6641
1982	580	1250	906	58,0±0,1	40,5	7346
1983	510	1290	972	56,3±0,1	39,2	13296
1984	540	1440	1064	58,4±0,1	45,1	11796
1985	680	1240	1004	52,3±0,1	45,8	6757
1981-1985	420	1440	979	56,9±0,1	41,6	45836

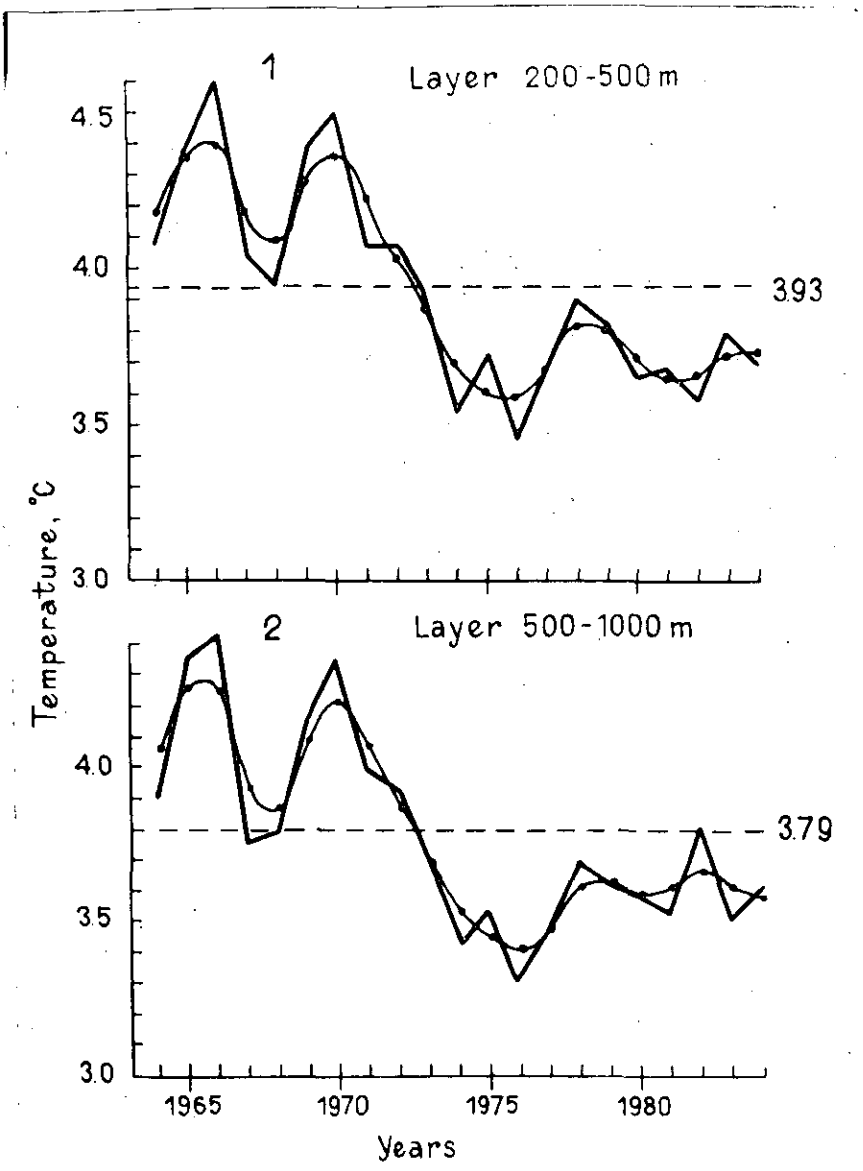

Fig.1 Water temperature on 1 November in the 200-500 m (1) and 500-1000 m (2) layers on continental slope of the South Labrador area (Standard hydrological section 8A, sector C). Broken line designates the long-term mean water temperature.

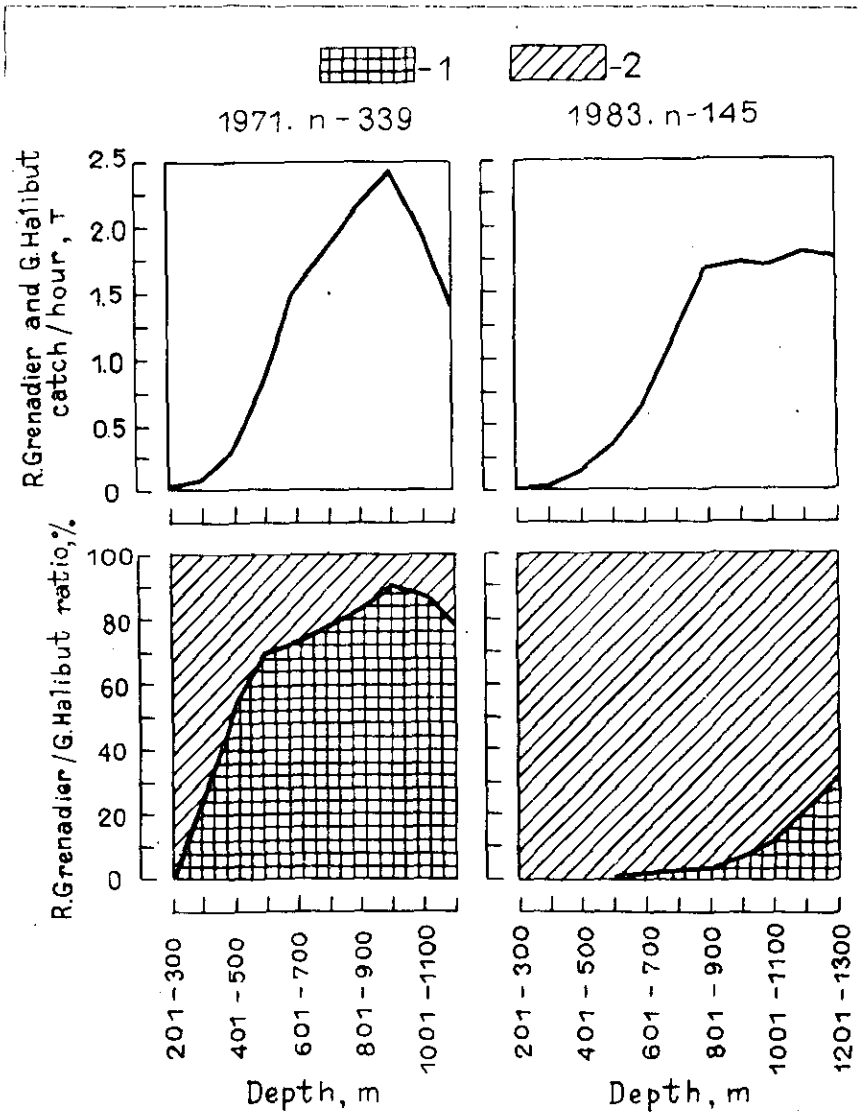

Fig.2 Mean catches of Greenland halibut and roundnose grenadier per hour trawling by research vessels using a bottom trawl and weight ratio of fishes (%) at different depths of NAFO Subareas 0 and 2 in autumn/winter 1971 and 1983 (1 - roundnose grenadier, 2 - Greenland halibut, n - number of catches).

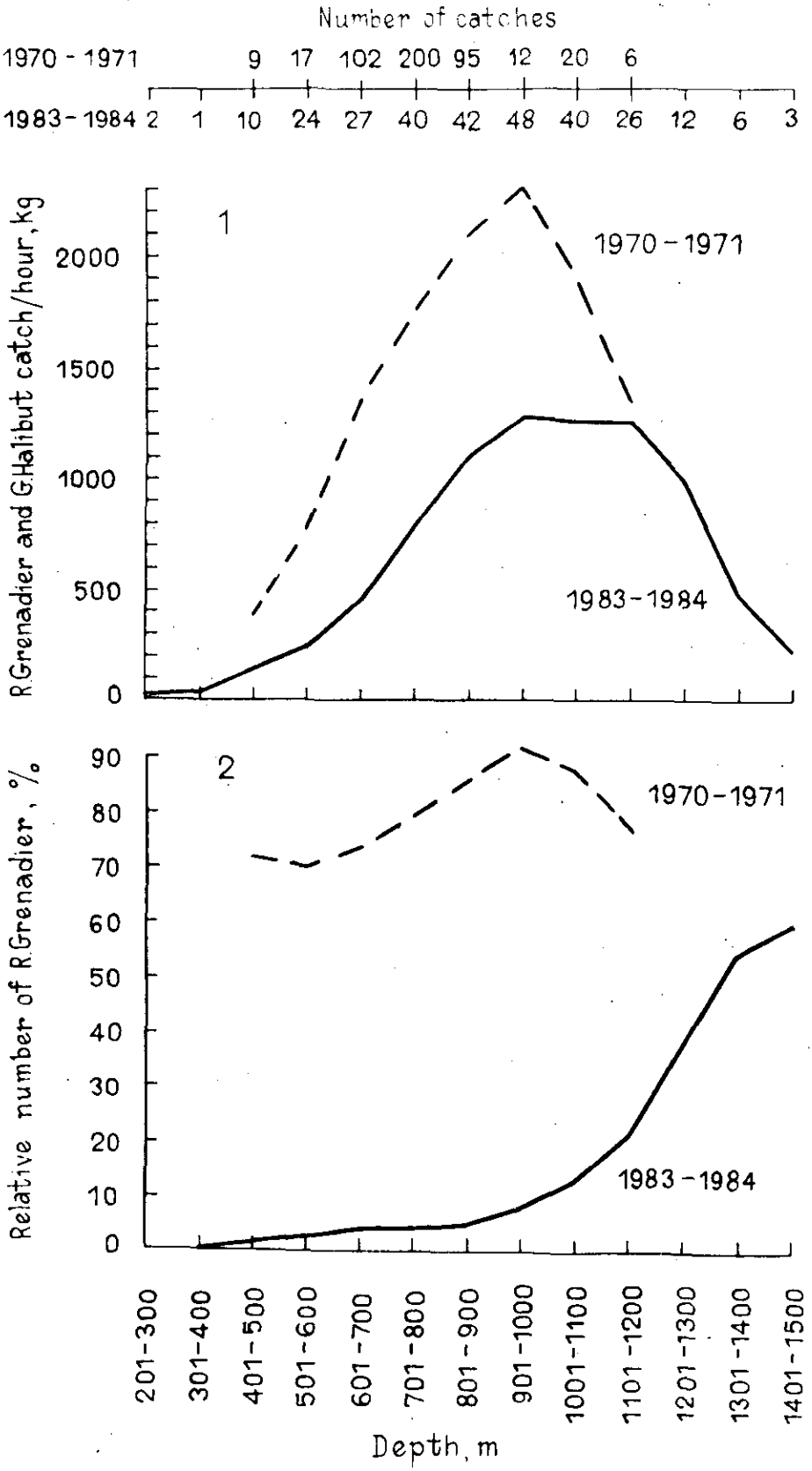

Fig.3 **Mean catches of Greenland halibut and roundnose grenadier per hour trawling by research vessels using a bottom trawl (1) and relative weight of grenadier in per cent (2) at different depths of Subareas 0 and 2 in autumn/winter 1970-71 and 1983-84 (by smoothed series).**

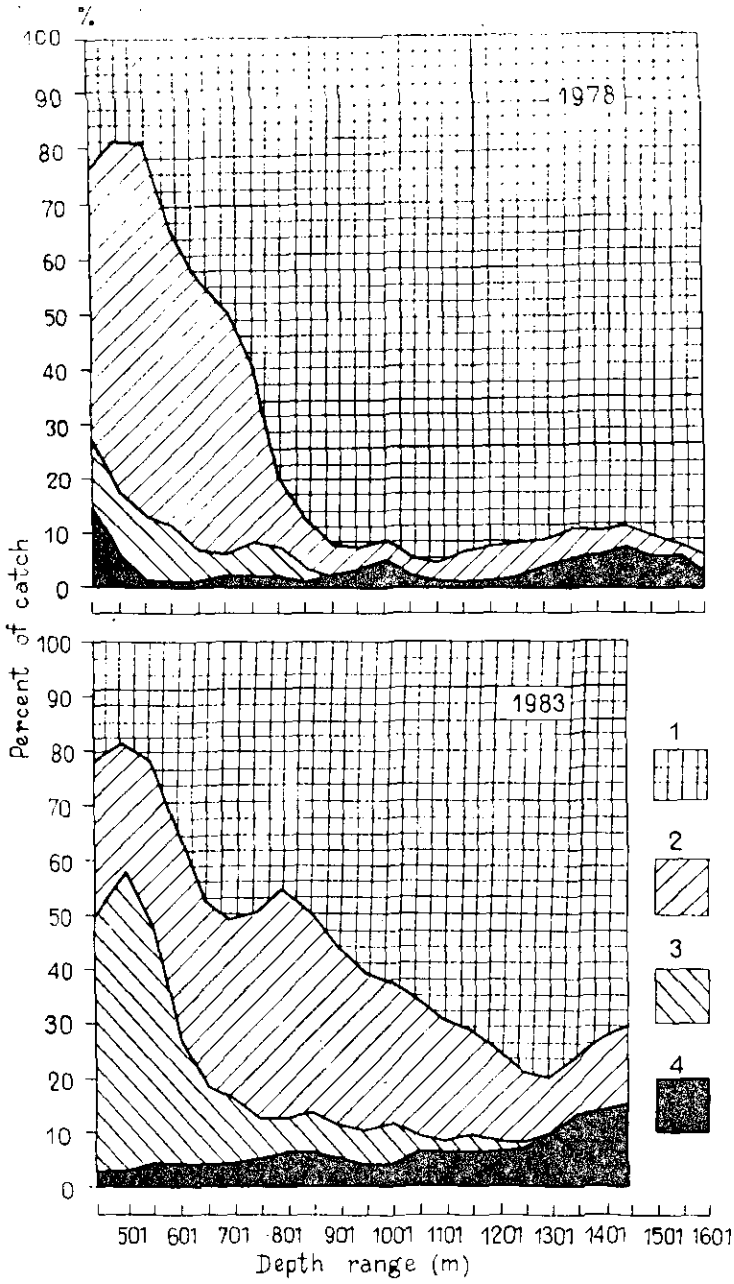

Fig.4 Composition of USSR and GDR catches during the directed fishery for roundnose grenadier in 1978 and 1983 at different depths according to the data of Canadian observers (Kulka, 1985) (1 - roundnose grenadier, 2 - Greenland halibut, 3 - beaked redfish, 4 - others).

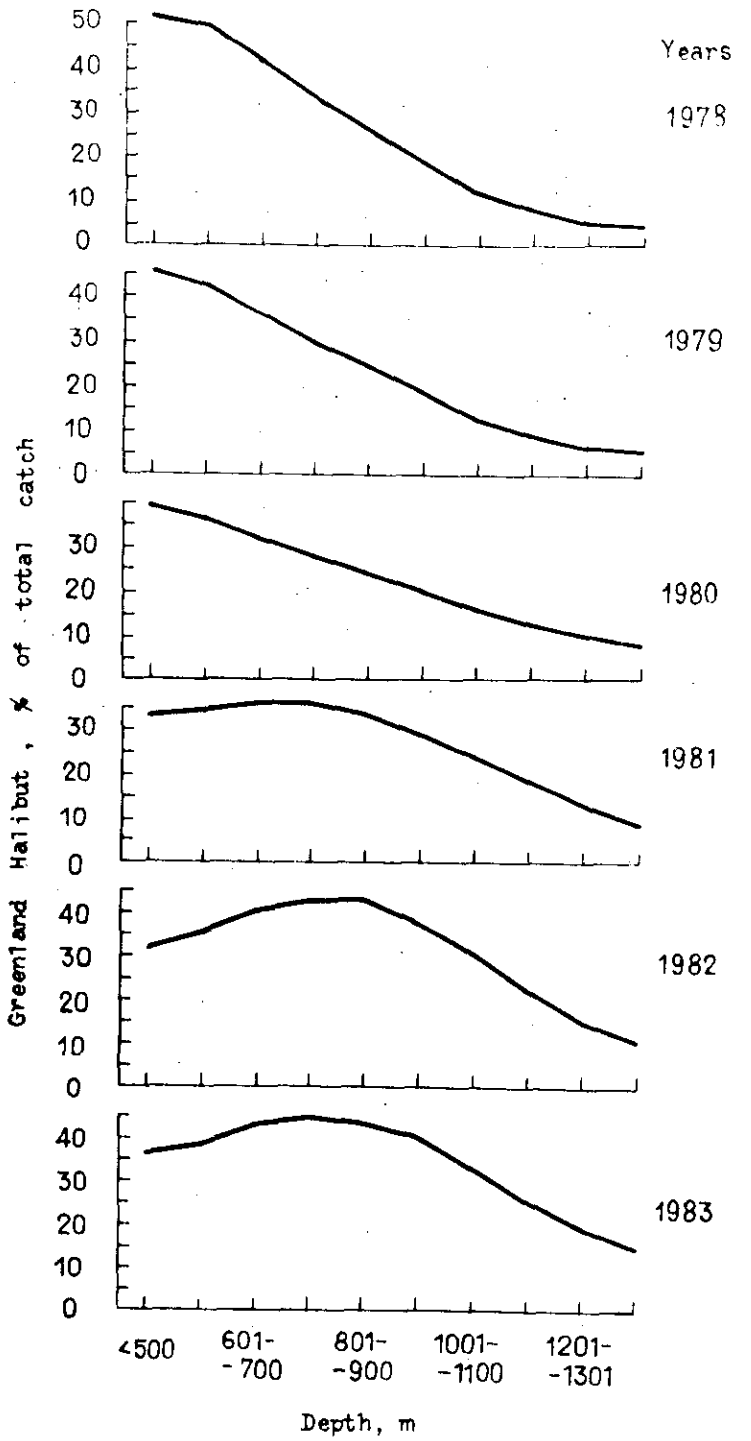

Fig.5 Variation of relative number of Greenland halibut by depth on the average in catches from Divs. 3K2GH in 1978-83 (based on data from Kulka, 1985; smoothed series).

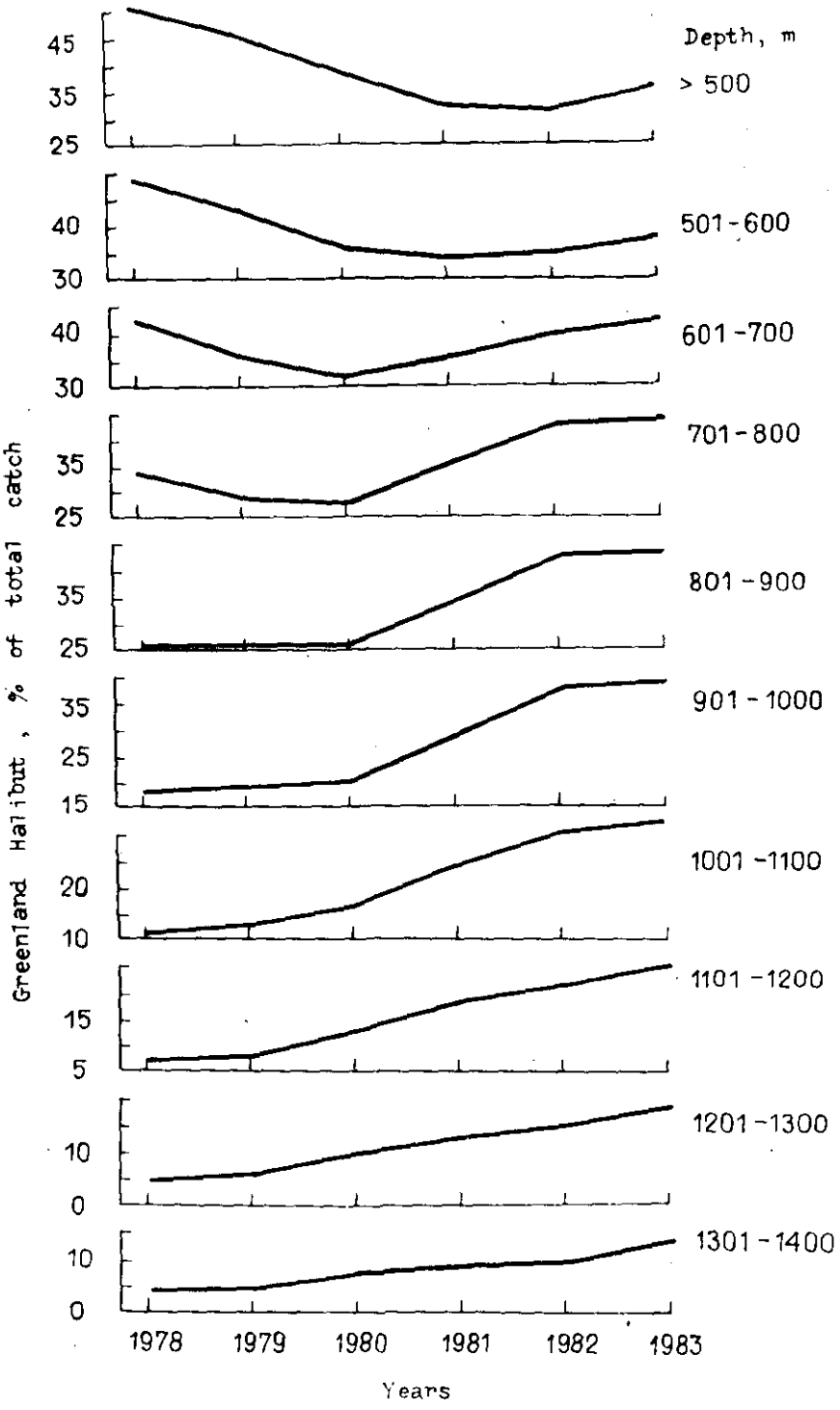

Fig.6 Variation of relative number of Greenland halibut by years on the average in catches from depths of 501-1400 m in Divs. 3K2GH in 1978-83 (from Kulka, 1985; smoothed series).

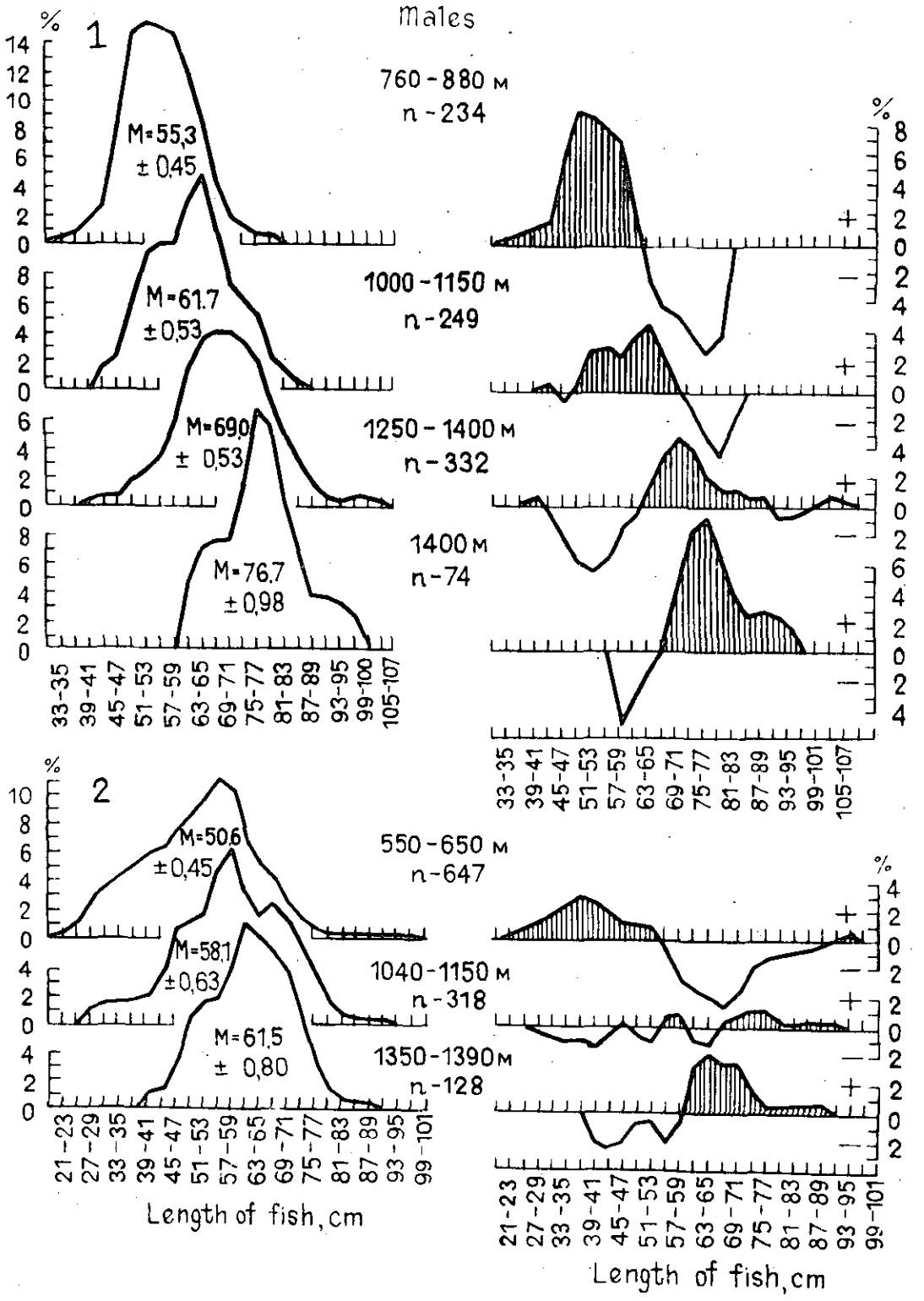

Fig.7 Length composition of roundnose grenadier males in bottom trawl catches taken by research vessels at different depths in Div. 2J on 17-30 December 1984 (1) and in Div. 3K on 14-17 January 1984 (2) by smoothed series (M - mean length, cm; n - number of fish measured, spec.).

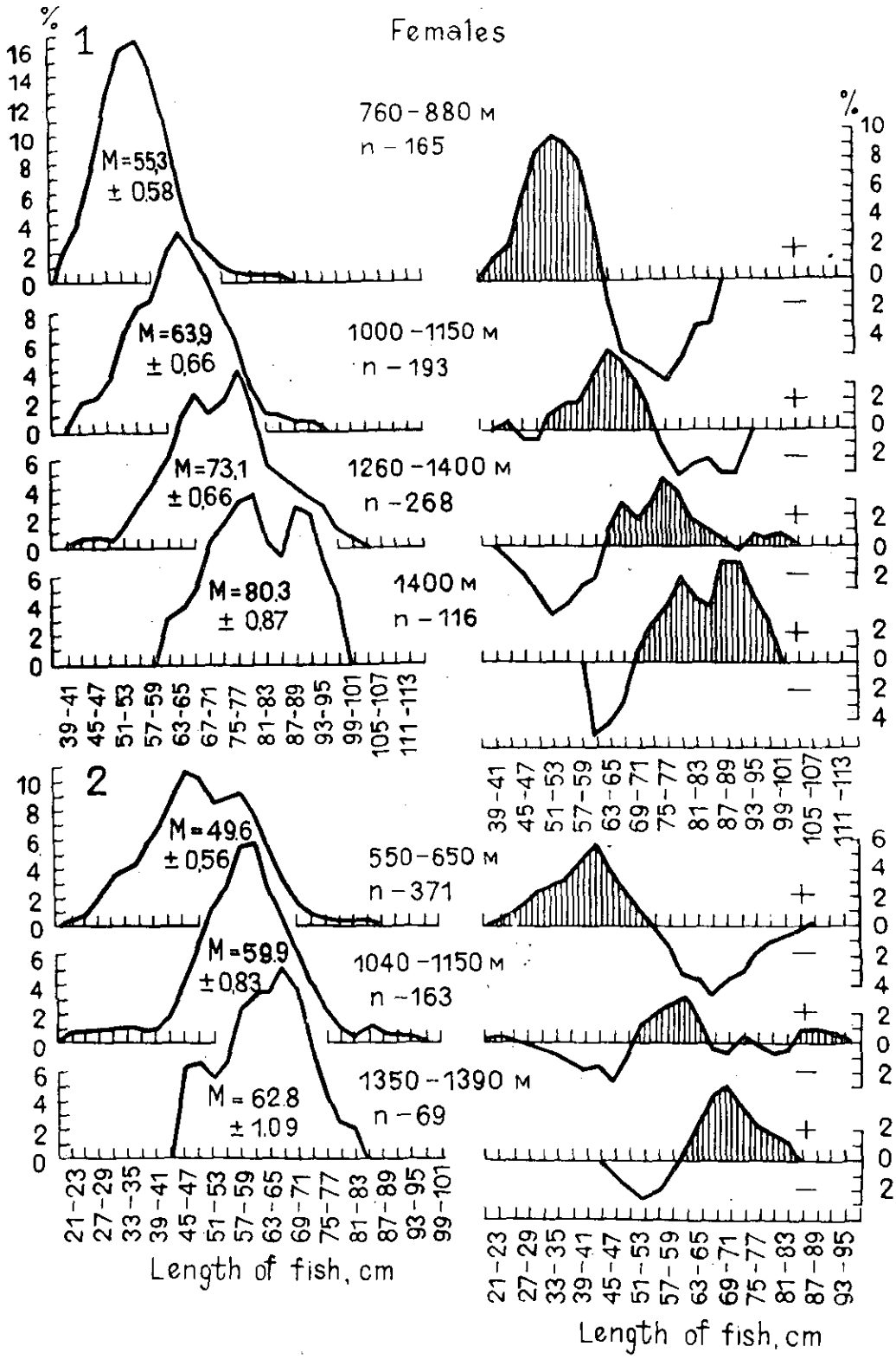

Fig.8 Length composition of roundnose grenadier females in bottom trawl catches taken by research vessels at different depths in Div. 2J on 17-30 December 1984 (1) and in Div. 3K on 14-17 January 1984 (2) by smoothed series (M - mean length, cm; n - number of fish measured, spec.).

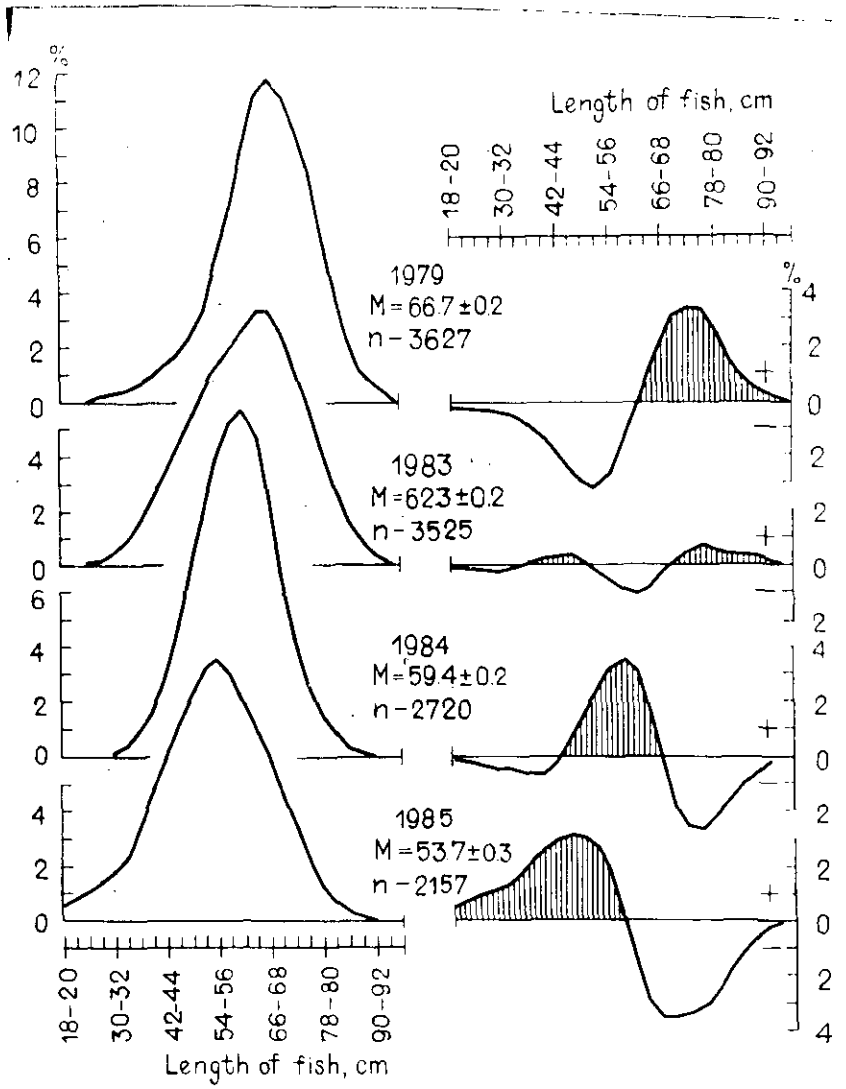

Fig.9 Length composition of roundnose grenadier catches taken with a bottom trawl using the fine-meshed netting in Subarea 0 in 1979-85 by smoothed series (M - mean length, cm; n - number of fish measured, spec.).

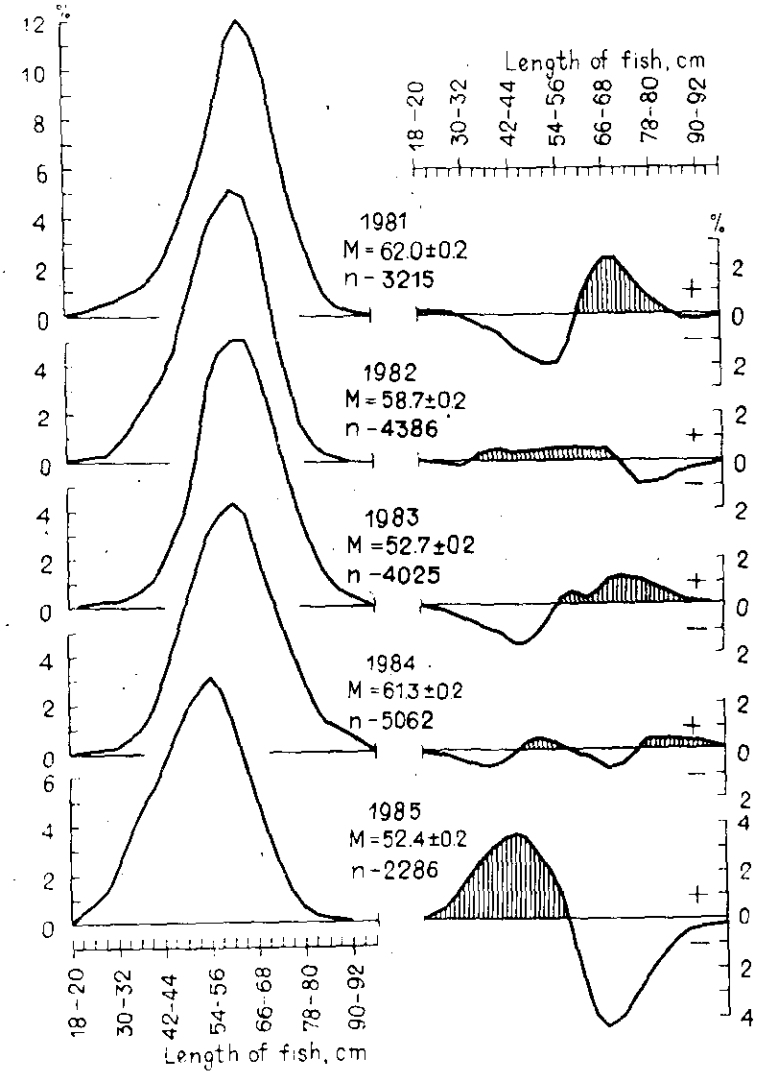

Fig.10 Length composition of roundnose grenadier catches taken with a bottom trawl using the fine-meshed netting in Subarea 2 in 1981-85 by smoothed series (M - mean length, cm; n - number of fish measured, spec.).

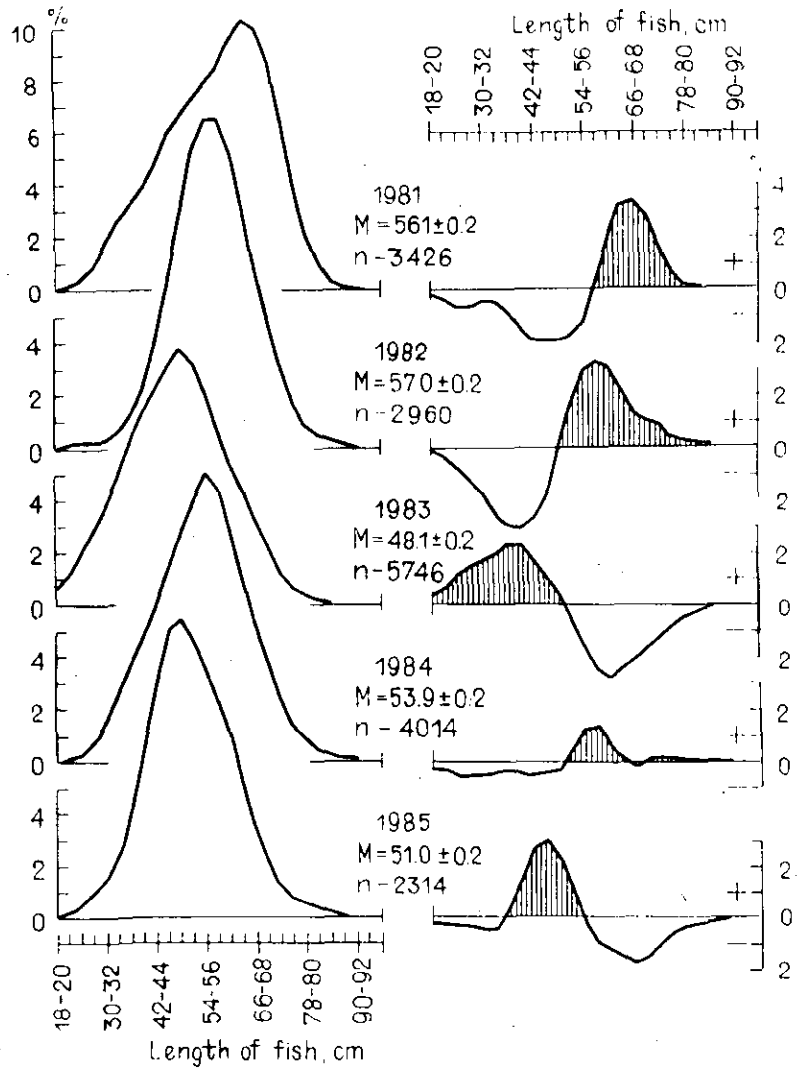

Fig.11 Length composition of roundnose grenadier catches taken with a bottom trawl using the fine-meshed netting in Div. 3K in 1981-85 by smoothed series (M - mean length, cm; n - number of fish measured, spec.).