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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)

by

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Abstract

The distribution of roundnose grenadier overlaps that of Greenland halibut, and in this connection bottom-trawl catches taken by commercial vessels are of mixed character. The proportion of Greenland halibut in commercial and research vessel catches is the greatest in Subareas 0 and 1, and the lowest - in Subareas 2 and 3 (averaging 42-47% in all Subareas). In winter/spring, the grenadier concentrations inhabit depths greater than 1000 m. In this period, Greenland halibut constitute the bulk of catches (60-70%) in Subareas 2 and 3, whereas in summer/autumn it is roundnose grenadier who do it. In Subareas 0 and 1 the proportion of the halibut in the catches increases as summer approaches winter. As trawled depths increase from 500 to 1000 m, the grenadier-halibut ratio varies negligibly.

Introduction

Bottom-trawl fisheries on the Canadian continental slope are primarily directed towards mixed concentrations of roundnose grenadier, Coryphaenoides rupestris, and Greenland halibut, Reinhardtius hippoglossoides. While managing reasonable exploration of the commercial stocks, these fishes ratio in the catches should be kept in mind, since a directed fishery

for one species is sure to affect vitally the other stock. The idea of this paper is to study the Greenland halibut by-catch amount in different periods of a year and by various depths in main areas of fishery for roundnose grenadier. It is to aid in both scientific substantiation of allocating the allowable by-catch of Greenland halibut in the directed fishery for the grenadier and solution to management problems of the fisheries for these species.

Materials and methods

This paper is based on the VNIRO data on the roundnose grenadier and Greenland halibut catches taken by Soviet BMRTs (large refrigeratory trawlers) in NAFO Subareas 0,1, 2 and 3 in 1973-77, as well as on the data on the 1974-76 catches of PINRO research vessels and scouting ones of Administration of Fishery Reconnaissance and Scientific Research Fleet. Commercial vessel data were called into action to study the Greenland halibut by-catch by different months; besides, the data of research and scouting vessels were also applied to study the halibut by-catch by depths trawled. Curves of variations of the Greenland halibut by-catch by months are plotted in Fig. 1. The percentage series were smoothed out by the formula:

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

where a,b,c - the antecedent, middle and succedent terms of the series, B - the calculated value.

Results and conclusions

The distribution of roundnose grenadier overlaps that of Greenland halibut during the summer/autumn feeding on the continental slope of the Northwest Atlantic. Because of this, catches taken in this period are of mixed character. The grenadier fishery is the most efficient in summer/autumn, when main concentrations of the fish are distributed at the shallowest depths (800-900 m) and the most

exploitable. In winter/spring the grenadier concentrations are found in depths greater than 1000 m and, as is the case for southern parts of the Canadian continental slope, below 1200 m. Modern commercial vessels are in ability for fisheries only near the upper boundary of distribution of the concentrations. In this period fisheries are of low efficiency.

The most successful bottom-trawl fishery for Greenland halibut is possible in autumn/winter (from November to December), when the density of concentrations inclines at the expense of more dense wintering and prespawning concentrations being formed at the 500-900 m depths. In this period the directed fishery towards Greenland halibut is possible (with almost no other species by-catch), especially in the north of its distribution.

In 1969-74 in the region of the Baffin Island continental slope (Subarea O), the fishery for the grenadier was primarily carried on in summer/autumn. As a rule, Greenland halibut were by-caught while fishing for the grenadier. The amount of the by-catch varied substantially by years (often exceeding 70%). The highest catches of Greenland halibut were taken at depths of 450-700 m. The fish were distributed in this layer unevenly. In some areas of the shelf and continental slope, where the halibut were abundant, a yield amounted to 1-2 tons per hour trawling. Commonly, those were deep-water valleys and terraces situated along the continental slope. Greenland halibut concentrations were attributed to the waters with temperature next to 3°C. Concentrations of roundnose grenadier and Greenland halibut may be distributed both near the bottom and in the bathypelagial with the grenadier predominating in the latter. Roundnose grenadier form the most dense concentrations, as the core of warm Atlantic waters (above 4°C) approaches directly the continental slope at the 800-1000 m depth of the sea.

Upon deepening of the polar front, that is usually attributed to strengthening of the Arctic component of the Labrador Current, thermal conditions arise to be most favourable

for Greenland halibut to concentrate. On weakening of the Arctic component of the current, the grenadier make up the bulk of bottom-trawl catches. Thus, in cold - from the point of view of hydrography - years fishery is efficient when directed towards Greenland halibut, while in warm years - towards roundnose grenadier. The shelf and slope waters of the Labrador Current are directly associated with areas where the grenadier and halibut concentrate. Year-to-year fluctuations of water temperature affect these species distribution and determine conditions for formation of exploitable concentrations.

Owing to simultaneous strengthening of the cold and warm components of the Labrador Current (Elizarov, 1962), cold waters force Greenland halibut out from coastal shelf shoals and make them to form more dense concentrations on the continental slope in a narrow zone next to the temperature gradient. This phenomenon has been observed in cold years.

In such years, roundnose grenadier, being a more heat-loving species, inhabit great depths. Its concentrations are dispersed in the water column and can hardly be explored. In warm years, when a part of the continental slope is occupied by relatively warm Atlantic waters, roundnose grenadier make dense exploitable concentrations. The distribution of these concentrations is closely connected with hydrographic conditions. The grenadier concentrations are unstable, e.g. in summer/autumn their density varies in conformity with variations in thermal conditions. This gives account of variations in the fishery efficiency, catch-per-unit-effort values and the fishes under question ratio in the catches.

Thus, catch-per-unit-effort values in the fisheries for Greenland halibut and roundnose grenadier and the ratio of these species in the catches are dependent upon hydrographic conditions and their seasonal variations in certain climatic zones. Areas of fisheries for these species are stretched latitudinally. Therefore, the proportion of each species in the catches taken in different NAFO Subareas are

not identical. In 1973-77 in the northern Subareas (0 and 1) the proportion of Greenland halibut relative to the joint grenadier-halibut catch taken by USSR BMRTs consistently averaged more than 50% (58 and 66% in Subareas 0 and 1, respectively). In areas to the south, the grenadier prevailed in the catches. In the Newfoundland area, Greenland halibut comprises, on the average, only 16.5% of the catches (Table 1).

The percentage of the halibut relative to the joint grenadier-halibut catch taken in the Northwest Atlantic (Subareas 0,1,2 and 3) varies significantly during a year, because the fishery for Greenland halibut is being carried on primarily in autumn and winter. As is the case for winter, the grenadier concentrations practically are not available for exploration. Since January till May, the proportion of the halibut amounts to 60-70% being substantial in the catches from the Newfoundland area too. In July, at the expense of the fishery for the grenadier intensified, the proportion of Greenland halibut declines (up to 10% in the Newfoundland area). This phenomenon has not been observed in the northern part of the Canadian continental slope (Subareas 0 and 1), where this proportion increases as summer approaches winter (Fig. 1).

Results obtained by scouting and research vessels confirm the data of commercial BMRTs. The percentage of Greenland halibut is the greatest in the catches taken by scouting and research vessels in NAFO Subarea 0. This proportion is significant throughout a year declining slightly upon increasing of depths trawled (Tables 2-4). A decrease (from 62-88% to 43%) in the proportion of the halibut has been observed in catches taken at depths of 500-1000 m. In NAFO Subareas 1,2 and 3 the percentage of Greenland halibut averages 47.5%. This proportion is the highest in winter/spring (Table 5).

In the recent years the Greenland halibut by-catch amount while fishing for roundnose grenadier has inclined elsewhere. It is probably associated with an increase in the Greenland halibut stock abundance. Certainly, present-day allowable

by-catches of the halibut restrain the fishery for roundnose grenadier. Consequently, the USSR fleet does not take up the quota for the grenadier fully.

Reference

Elizarov, A.A. 1962. On the vertical stability of water layers on the fishing grounds of Newfoundland Banks. Soviet Fisheries Investigations in North-Western Atlantic. VNIRO-PINRO, M.:173-187.

Table 1. Joint roundnose grenadier-Greenland halibut catches (tons) taken in 1973-77 by USSR BMRTs with a bottom-trawl (numerator) and the percentage of the halibut (denominator).

Sub-area	Month												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
0	330 100,0	7 0,0	-	2 0,0	-	71 92,0	432 30,7	4020 54,5	4294 62,8	2232 56,2	2866 50,4	713 77,8	14967 57,9
1	1610 55,5	157 3,8	85 100,0	308 23,0	5 20,0	113 9,7	882 43,5	2436 29,0	3065 55,9	5629 68,0	13423 71,1	27225 69,7	54939 66,5
2	5748 82,5	1968 78,6	880 93,5	1241 77,2	1375 100,0	2094 65,4	6691 55,2	6642 32,7	5898 19,9	2963 38,3	2522 50,1	8144 39,0	46166 50,8
3	1569 40,5	2835 34,2	682 75,6	2444 52,9	1995 86,6	2502 40,4	7096 10,3	11767 6,8	10198 10,8	8365 13,5	15897 12,7	11627 10,5	76976 16,5
0-3	9257 71,3	4967 50,8	1647 86,5	3995 58,2	3375 91,9	4781 51,4	15101 32,8	24865 23,6	23455 29,4	19189 38,3	34708 40,4	47702 49,9	193049 42,1

Table 2. Average catches (tons) per hour trawling in the bottom-trawl fisheries for roundnose grenadier and Greenland halibut taken in 1974-76 by scouting and research vessels in NAFO Subarea O (numerator) and the halibut catch percentage (denominator).

Trawled depth, m	Month					Monthly mean
	Jun	Jul	Aug	Sep	Oct	
50I-600	-	$\frac{0,84}{55,0}$	$\frac{0,76}{36,5}$	$\frac{0,29}{80,0}$	$\frac{0,52}{77,5}$	$\frac{0,66}{62,3}$
60I-700	$\frac{0,4}{95,0}$	-	$\frac{0,42}{80,3}$	$\frac{0,48}{96,7}$	$\frac{0,25}{80,0}$	$\frac{0,43}{88,0}$
70I-800	$\frac{1,08}{90,6}$	$\frac{0,64}{93,4}$	$\frac{0,94}{69,8}$	$\frac{0,6}{87,2}$	$\frac{0,2}{75,0}$	$\frac{0,89}{83,2}$
80I-900	$\frac{1,26}{70,8}$	$\frac{0,57}{78,6}$	$\frac{0,81}{57,3}$	$\frac{0,52}{85,0}$	$\frac{0,10}{90,0}$	$\frac{0,74}{76,3}$
90I-1000	-	$\frac{0,1}{100,0}$	$\frac{0,3}{10,0}$	$\frac{0,3}{20,0}$	-	$\frac{0,25}{43,3}$

Table 3. Average catches (tons) per hour trawling in the bottom-trawl fisheries for roundnose grenadier and Greenland halibut taken in 1974-76 by scouting and research vessels in NAFO Subarea 1 (numerator) and the halibut catch percentage (denominator).

Trawled depth, m	Month												Monthly mean
	Jan	Jun	Jul	Aug	Sep	Oct	Nov	Dec					
50I-600	-	-	0.58 59.7	0.58 47.0	0.59 60.0	0.63 58.3	1.26 97.8	-	-	-	-	-	0.7 64.6
60I-700	-	0.59 67.5	0.9 9.6	1.02 39.4	0.80 43.1	0.40 39.6	1.16 38.2	0.25 75.0	-	-	-	-	0.92 44.6
70I-800	-	0.43 83.3	1.71 8.8	1.49 13.4	1.04 22.9	0.23 36.5	0.67 34.6	0.17 68.0	-	-	-	-	1.26 38.1
80I-900	1.0 61.0	0.2 30.0	1.10 10.5	0.63 19.0	1.06 13.0	0.29 50.4	0.92 49.6	1.33 68.2	-	-	-	-	1.11 34.4
90I-1000	0.97 40.0	0.3 5.5	1.0 30.0	-	-	-	-	1.44 60.8	-	-	-	-	1.34 32.1

Table 4. Average catches (tons) per hour trawling in the bottom-trawl fisheries for roundnose grenadier and Greenland halibut taken in 1974-76 by scouting and research vessels in NAFO Subarea 2 (numerator) and the halibut catch percentage (denominator).

Trawled depth, m	Month						Monthly mean
	Jun	Jul	Aug	Sep	Oct	Nov	
50I-600	$\frac{0.8}{95.0}$	$\frac{0.8}{75.6}$	$\frac{0.58}{55.0}$	$\frac{2.43}{18.6}$	$\frac{1.3}{33.5}$	$\frac{1.24}{36.2}$	$\frac{1.4}{52.3}$
60I-700	-	$\frac{0.2}{100.0}$	-	$\frac{0.7}{18.6}$	$\frac{0.8}{25.0}$	$\frac{1.18}{37.3}$	$\frac{1.0}{45.2}$
70I-800	-	$\frac{0.28}{86.0}$	$\frac{0.9}{33.8}$	$\frac{1.87}{11.5}$	$\frac{1.79}{19.8}$	$\frac{0.83}{13.3}$	$\frac{1.4}{32.9}$
80I-900	$\frac{3.33}{17.3}$	$\frac{1.36}{60.0}$	$\frac{2.09}{36.0}$	$\frac{2.15}{19.0}$	-	$\frac{0.63}{70.0}$	$\frac{1.97}{40.5}$
90I-1000	$\frac{6.1}{12.2}$	$\frac{2.26}{12.1}$	$\frac{1.34}{23.8}$	$\frac{2.7}{10.6}$	-	$\frac{1.0}{55.0}$	$\frac{2.29}{22.7}$

Table 5. Average catches (tons) per hour trawling in the bottom-trawl fisheries for roundnose grenadier and Greenland halibut taken in 1974-76 by scouting and research vessels in NAFO Subareas 0,1 and 2 in toto (numerator) and the halibut catch percentage (denominator).

Trawled depth, m	Month												Monthly mean	
	Jan	Jun	Jul	Aug	Sep	Oct	Nov	Dec						
50I-600	-	$\frac{0.8}{95.0}$	$\frac{0.8}{67.0}$	$\frac{0.7}{45.1}$	$\frac{1.8}{35.2}$	$\frac{0.8}{51.5}$	$\frac{1.2}{46.0}$	-	$\frac{1.1}{56.6}$					
60I-700	-	$\frac{0.5}{76.7}$	$\frac{0.8}{19.7}$	$\frac{0.9}{50.4}$	$\frac{0.8}{48.0}$	$\frac{0.5}{38.4}$	$\frac{1.2}{38.0}$	$\frac{0.3}{75.0}$	$\frac{0.9}{49.3}$					
70I-800	-	$\frac{1.0}{90.0}$	$\frac{1.4}{30.4}$	$\frac{1.2}{43.4}$	$\frac{1.2}{30.5}$	$\frac{0.9}{38.3}$	$\frac{0.7}{30.3}$	$\frac{0.2}{68.0}$	$\frac{1.1}{47.3}$					
80I-900	$\frac{1.0}{61.0}$	$\frac{1.8}{50.7}$	$\frac{1.0}{40.3}$	$\frac{1.1}{50.3}$	$\frac{1.3}{46.4}$	$\frac{0.2}{61.7}$	$\frac{0.9}{53.4}$	$\frac{1.3}{68.2}$	$\frac{1.2}{54.0}$					
90I-1000	$\frac{1.0}{40.0}$	$\frac{5.2}{2.8}$	$\frac{2.1}{18.3}$	$\frac{1.2}{22.5}$	$\frac{2.4}{11.8}$	-	$\frac{1.0}{55.0}$	$\frac{1.4}{60.8}$	$\frac{1.8}{30.2}$					
50I-1000	$\frac{1.0}{54.5}$	$\frac{1.5}{72.8}$	$\frac{1.4}{40.3}$	$\frac{1.07}{44.3}$	$\frac{1.2}{39.4}$	$\frac{0.7}{46.9}$	$\frac{1.1}{31.0}$	$\frac{1.3}{65.6}$	$\frac{1.1}{47.5}$					

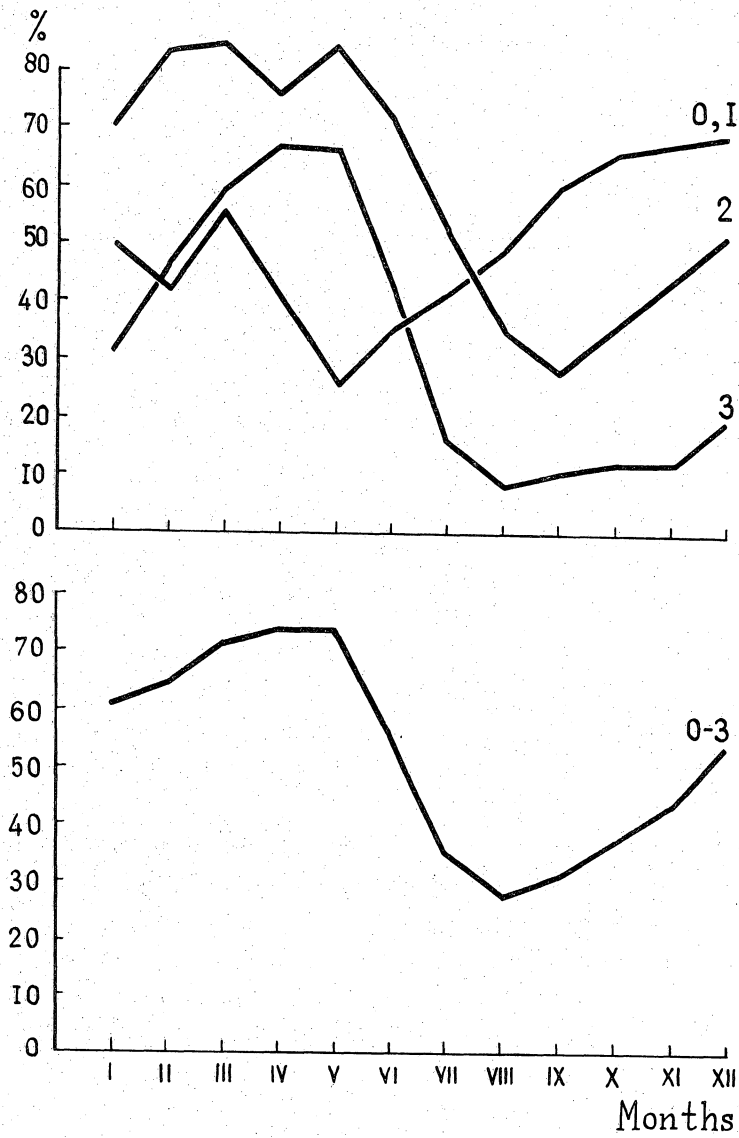


Fig. 1. Curves of catches of Greenland halibut (in the percentage relative to the joint grenadier-halibut yield) taken in 1973-77 in NAFO Subareas 0,1,2 and 3 (in the smoothed form).