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Feeding of Greenland Halibut in the Northwest Atlantic

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Abstract

Seasonal feeding and food composition of Greenland halibut at different depths of NAFO Divisions are studied by the results of field analysis of feeding from 1969 to 1981. Roundnose grenadier, beaked redfish, cod, Greenland halibut juveniles, capelin, sand lance, squid and various crustaceans are the most important food items for Greenland halibut. The consumption of the above food organisms is closely connected with their distribution and bathypelagic way of life of Greenland halibut. In the northern part of the area (Subareas 0, 1, 2) large fish - redfish, grenadier and in the southern one (Divs. 2J, 3KL) small shoaling fish - capelin, sand lance, crustaceans, young cod and halibut are the major prey of Greenland halibut.

The data on daily ration of different age groups and the total amount of food consumed by the Greenland halibut population from July to December are presented.

Introduction

With the development of a specialized Greenland halibut fishery on the continental slope in the Northwest Atlantic, the necessity to study their feeding became urgent. This is

the more so that feeding of fish from bathypelagic complex, in which Greenland halibut belong, is the least developed section in biology of deepwater species, and the investigations of Greenland halibut feeding is another step in studies into deepwater fauna.

Literature on feeding of Greenland halibut Reinhardtius hippoglossoides (Walbaum) dwelling in the Northwest Atlantic is rather scant. A fuller account of this problem is given for the Barents Sea halibut (Nizovtsev, 1977) and for those from the fjords of the West Greenland (Jensen, 1935; Smidt, 1969). Some of our contributions contain sporadic data on feeding of Greenland halibut from the Northwest Atlantic (Podrazhanskaya, 1969, 1977, 1982; Chumakov, 1969; Konstantinov, Podrazhanskaya, 1972), however, characterizing only its quantitative aspect.

The paper aims at studying seasonal peculiarities of Greenland halibut feeding in different areas of the Northwest Atlantic, the estimation and analysis of food consumption by the population.

Material and methods

The materials on Greenland halibut feeding were collected by the ships of PINRO and Fishery Reconnaissance from 1969 to 1981. The data are listed in Table 1. Samples on feeding were collected and processed in conformity with the Manual (1974).

The length of fish examined for feeding ranged from 21 to 99 cm at ages from 2 to 19 years. Stomachs for weight analysis were taken from 8 catches at 270-1020 m of depth (Fig. 1). They were preserved in 4% formalin. Fish were weighed, measured, sex and gonad maturity stage were determined.

To characterize feeding general and individual indices of stomach fullness were used (Zenkevich, Brotskaya, 1931). Indices (in‰) were calculated from the actual weight of food bolus and its components. Besides, the percentage relation of the weight of separate groups of food organisms to the weight of the total contents of the stomach was utilized. The

number of stomachs with some food component was expressed in the percentage of a total amount of examined stomachs whatever the availability of food in them (Shorygin, 1952). Stomach fullness was estimated visually according to the 5-point scale. The organisms found in the stomachs were identified with a different degree of accuracy. A daily ration of Greenland halibut was calculated.

Results and discussion

Food composition of Greenland halibut in the Northwest Atlantic is rather variable (Table 2). Above 40 species - representatives of different systematic and ecological groups - were found in the stomachs (see the List). Food organisms given in the List include mainly typical bathypelagic and plakton species save for Echinodermata, worms, sponge and crabs representing bottom fauna, however, being rare in halibut stomachs. This is indicative of the bathypelagic way of life of Greenland halibut but not the bottom one.

The external morphological features prove that: long body, typical of a fast swimmer, protective colouring of both sides, the position of one eye providing the two-side range of peripheral vision unlike other flatfishes, Atlantic halibut included, which have two eyes on one side of the body (Konstantinov, 1967, 1976; Konstantinov, Podrazhanskaya, 1972; DeGroot, 1970).

The studies into morphological and ecological peculiarities of Greenland halibut dwelling on the shelf and continental slope of the Baffin Island, Labrador and Newfoundland give reasons to consider this population single (Chumakov, 1975; Chumakov, Serebryakov, MS 1982). This area is included into the united system of water circulation and extends from polar latitudes to temperate ones. Connected with variable conditions some peculiarities in Greenland halibut feeding are also detected in different parts of the above areas. In the northern part of the area (in Div. 0B and Subareas 1, 2), where mainly mature Greenland halibut occur, large fish - beaked redfish, roughhead grenadier - prevail in food. In the south of the area small Greenland halibut feed mainly

on mass shoaling fish - capelin, sand lance as well as different crustaceans (Table 2), primarily, Pandalus borealis (1.0 - 7.4%).

It should be noted that features typical of predators are prominent in adult Greenland halibut, namely, a great amount of empty stomachs, low occurrence of food objects, a high degree of stomach fullness in feeding specimens, and a low average index of stomach fullness. The results of quantitative analysis of feeding are shown in Fig. 2, where the area of the circle is proportional to the total index of stomach fullness (Zenkevich, Brotskaya, 1931) and the area of sectors - to the percentage values of different food components by individual indices.

The highest index of stomach fullness of Greenland halibut (417.2 °/₀₀₀) was in Div. 2H (Table 3).

Fish were the main food object here (89.1%), the half of them being represented by cod and polar cod (45.7%). Greenland halibut consumed also rather a high amount of squid (9.9%).

The lowest index of stomach fullness in Greenland halibut was in Div. 3K (151.0°/₀₀₀). The major food items in this area contained fish(81.8%), in particular, cod, polar cod (22.1%), Greenland halibut (14.1%) and eelpout (10.0%). Shrimp Pandalus borealis were also frequent in Greenland halibut stomachs (6.9%).

Composition and amount of food for Greenland halibut from different depths are part of the problem on local changes in feeding. It is well known that on the continental slope in the Northwest Atlantic the densest concentrations of Greenland halibut keep to the depths of 700-1100 m (Barrett, 1968; Chumakov, MS 1981). As is seen in Fig. 3, the feeding intensity of Greenland halibut grows with depth and attains its maximum 600-700 m deep. This is confirmed by the maximum index of stomach fullness (417.2°/₀₀₀). Fish are the main prey at this depth (89.1%), in particular, cod (45.7%), and also squid (9.9%). The similar trend is observed in relation to the Barents Sea halibut, but the depth of their feeding is shifted: fish from the depths of 100-400 m

have the highest stomach fullness (Nizovtsev, 1977).

In order to charcterize the feeding of Greenland halibut at different depths more accurately, we attempted to analyse feeding of the species on the shelf and continental slope (Table 4).

The difference between feeding of Greenland halibut on the shelf and continental slope turned out rather important. Though on the shelf and continental slope fish were the major prey, their species composition differs greatly: if on the shelf cod, polar cod (23.1%) and juvenile halibut (11.6%) were most important, then on the slope cod amounted to only 2.3%, juvenile halibut disappeared completely, and deepwater species - beaked redfish (62.5%) and roundnose grenadier (0.9%), not found on the shelf before, became primary.

Shrimp were rather important in feeding of Greenland halibut on the shelf (16.4%), while on the slope their value was minimum (below 0.1%). Feeding of Greenland halibut on squid is quite different: with the increase of depth the amount of consumed squid grows, which conforms well with the data of K.N. Nesis (1971) on existence of squid in the bathyal and bathypelagial of the Arctic and northern areas of the Atlantic.

Stomach fullness of Greenland halibut on the continental slope is higher than on the shelf and amounts to 319.9‰ (Fig. 4). This is also proved by a number of empty stomachs (4.4% - on the slope and 12.1% - on the shelf).

The analysis of feeding at minimum and maximum depths confirms the assumption that feeding intensity grows with depth. Thus, Table 5 presents food composition at minimum and maximum depths in the North Labrador where the material was collected.

The analysis of numerous field data on Greenland halibut feeding also proves our conclusions: sand lance, capelin, cod, juvenile halibut are predominant on the shelf while roundnose grenadier, squid, octopus, Paralepis occur on the slope.

Thus, the major food of Greenland halibut in all areas

of the Northwest Atlantic was composed mainly of mass fish, bathypelagic fish and Cephalopoda dominating on the continental slope, pelagic and some bottom fishes and shrimp - on the shelf; other organisms - sea cucumbers, Ophiura, sea anemones, worms, sponge - were occasional food objects of Greenland halibut in any area of the Northwest Atlantic.

The analysis of data on Greenland halibut feeding in different seasons showed that the relative amount of feeding fish grew on the whole in summer-autumn and declined sharply by winter (Table 6). Apparently, the main feeding of Greenland halibut occurs in summer-autumn. It is confirmed by the average index of stomach fullness growing till autumn (Fig. 5). The trend to increasing stomach fullness of Greenland halibut in the Northwest Atlantic in summer-autumn is typical not only of this species. The similar situation is observed in feeding both of deepwater species dwelling on the slope, namely, roundnose grenadier (Podrazhanskaya, 1969), beaked redfish (Konchina, 1970), and fish dwelling on the shelf: haddock (Podrazhanskaya, Shestov, 1980) and cod (Turuk, 1968).

Alongside with qualitative characteristics of Greenland halibut feeding, we made an attempt to give a quantitative estimate of feeding of this species. For this purpose we determined the daily ration of Greenland halibut in the Northwest Atlantic by means of the balance equality (Vinberg, 1956):

$$R = 1.25 / I + 2E /$$ where

R - daily ration, I - daily increment, 2E - energy spent for metabolism, 1.25 - the coefficient of food digestion. All values are expressed in the percentage of fish body weight.

It was found out that Greenland halibut feed only during the second half-year (Table 6), their feeding intensity growing in summer-autumn. This is most typical for Greenland halibut from more northerly areas. On this account we calculated the average daily increment assuming that a half-year, i.e. 180 days, is the time of increment. Increments were

calculated by the formula:

$$\Delta P = \frac{2(W_n - W_0)}{n(W_n - W_0)} 100\%$$

where W_0 - weight of fish in the beginning of the investigated period; W_n - weight of fish at the end of the investigated period; n - 180 days.

Average weight and increment of different age groups of Greenland halibut are presented in Table 7. As far as growth rate of males and females is different, our further calculations are made for females and males separately.

Thus, the average daily increment of Greenland halibut ranges from 0.02 to 0.30% for males and from 0.01 to 1.1% for females, correspondingly, from 0.9 to 3.1 g for males and from 0.2 to 1.7 g for females.

To calculate the amount of energy spent for metabolism (E) we used the formula of metabolism and fish weight relationship (Vinberg, 1956). On account of lack of data on energy metabolism for Greenland halibut, for calculating the energy spent on basal matabolism we used the experimental data on breathing of Atlantic cod (Chekunova, 1972) dwelling under similar temperature conditions as Greenland halibut (cod - at 4-5°C, Greenland halibut - at 3-4°C).

The level of standard metabolism is described by the equation : $Q = 0.269W^{0.725}$ where Q is the value of oxygen consumption (ml/hr; W - fish weight, g).

The level of standard metabolism of Greenland halibut was calculated by means of parameters of this equation (Table 8). The oxycaloricity coefficient of 4.86 cal/ml O_2 was used (Ivlev, 1934).

The caloricity of 1 g of the weight of Greenland halibut is assumed to be 1 960 cal (Budagyan, 1976). Q for 5-year old males is 25.40 cal/hr; consequently, the daily consumption of oxygen is:

$$Q = 25.40 \times 24 \times 4.86 = 2962.60 \text{ cal/day.}$$

The correction for food caloricity should be introduced into the ration value. There is no information on caloricity of food objects of Greenland halibut, that is why we had to use

the data on caloricity of similar species from other regions of the World Ocean. Thus, we assumed that the caloricity of fish Electrona japonica is 2 000 cal (Kleymenov, 1962), the caloricity of shrimp (Pandalus latirostris) - 850 cal (Vinogradova, 1962) and the caloricity of Cephalopoda (Todarodes pacificus) - 890 cal (Ertel, 1970). Assuming that Greenland halibut food is composed mainly of fish (80%), shrimp (10%) and Cephalopoda (10%) and knowing the caloricity of these food objects, we calculated the average caloricity of 1 g of food. It appeared to be 1 774 cal.

Thus, the daily ration of 5-year old males of Greenland halibut with fish as a primary food object was

$$R = \frac{3116.4 + 5925.2}{0.8 \times 1774 \times 530} 100 = 1.2\% \text{ of body weight}$$

Thus, the daily ration of different age groups of Greenland halibut was also calculated (Table 9). The daily ration of Greenland halibut dwelling in the Northwest Atlantic calculated on the basis of all these data ranges from 1.2% to 0.4% for males aged 5 to 16 years and from 1.19% to 0.3% for females aged 5 to 20 years.

Proceeding from the total abundance of males and females of Greenland halibut in the Canadian zone of the North Atlantic (Chumakov, 1 982) we estimated preliminarily that for 6 months of feeding the population of the investigated species consume more than 730 thou. t of food.

Conclusions

1. Greenland halibut is a typical bathypelagic predator feeding on actively swimming organisms - fish, squid, octopus, shrimp. Beaked redfish, roundnose grenadier are the major prey in the northern part of the area where mature part of halibut population dwell, while capelin, sand lance, crustaceans, juvenile cod and halibut - in the southern one.

2. The main feeding of Greenland halibut occurs from July to November, attaining its maximum at 600-700 m of depth.

3. The natural daily ration of Greenland halibut ranges

from 1.2 to 0.4% of body weight for males aged 5 to 16 and from 1.2 to 0.3% for females aged 5-20, The total amount of food consumed by Greenland halibut for 6 months exceeds 730 thou. t.

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Table 1 Amount of data collected

Type of analysis	West Greenland	Baffin Island	Labrador	Newfoundland Bank	Number of stomachs
Field analysis	34498	I5769	I4276	I2I50	76693
Weight analysis	-	-	82	43	I25

Table 2 Food composition of Greenland halibut in the Northwest Atlantic in 1969-1981 (occurrence in % of stomachs examined)

Food organisms	NAFO regions			
	OB	1	2	3
Gastropoda	+	+	0,1	0,2
Bivalvia	+	-	+	-
Decapoda	1,3	1,5	0,3	1,5
Octopoda	0,7	0,5	0,8	0,2
Mollusca, not determined	0,8	0,9	0,3	3,7
Mollusca, total	2,4	2,9	0,5	5,6
Spongia	0,1	-	+	+
Pandalus borealis	1,0	3,8	2,1	7,4
Hyas spp.	+	-	-	-
Euphausiacea	0,1	+,	0,4	1,5
Amphipoda	-	-	-	0,7
Copepoda	0,1	+	+	+
Mysidacea	-	+	+	0,1
Crustacea, not determined	-	-	-	3,7
Crustacea, total	1,4	3,9	2,6	13,4

Table 2 (contd.)

Food organisms	NAFO regions			
	OB	I	2	3
Hexacorallia	+	-	-	-
Scyphomedusae	+	-	0,1	-
Ctenophora	-	-	+	-
Holothuridea	-	-	+	-
Echinodermata	0,1	-	0,1	0,1
Polychaeta sp.	-	-	0,1	+
Raja sp.	+	-	-	+
Alepocephalidae	-	-	-	+
Paralepis rissoi kroyeri	0,5	0,4	0,9	+
Antimora rostrata	+	+	+	+
Gadus morhua morhua	-	-	1,3	0,3
Boreogadus saida	0,4	-	0,2	-
Coryphaenoides rupestris	3,4	5,0	2,8	0,6
Anarhichas spp.	-	+	+	-
Lycodes pallidus	+	+	+	+
Sebastes mentella	5,4	7,3	0,9	0,2
Reinhardtius hippoglossoides	0,3	0,2	0,2	0,3
Hippoglossoides platessoides	+	+	0,1	0,8
Cottidae	+	+	-	-
Lumpenus spp.	0,1	+	+	-
Leptogonus decagonus	+	-	-	-
Liparis spp.	0,4	0,2	-	-
Mallotus villosus villosus	-	-	2,6	9,9
Myctophidae	0,4	+	3,5	0,3
Triglopes spp.		-	-	+
Ammodytes spp.	+	0,4	+	2,5
Cyclopterus spp.	-	+	+	+
Pisces, not determined	4,1	3,2	6,6	7,4
Pisces, total	15,2	17,2	19,7	21,9
Digested food	1,3	0,1	0,4	
Total number of stomachs	15769	34498	14276	12150
Empty stomachs, %	82,3	76,7	76,2	63,2

Table 3 Food composition of Greenland halibut in Divs. 2GHJ and 3K in 1980, % by weight

Food organisms	NAFO regions			
	2G	2H	2J	3K
Squid	2,0	9,9	0,6	I,0
Hyperiidea	0,I	0,I	-	-
Shrimp	0,4	0,9	-	I7,2
Cod, polar cod	I,0	45,7	-	22,I
Grenadier	I,3	-	-	-
Patterned eelpout	-	-	-	I0,0
Beaked redfish	73,6	-	36,7	-
Greenland halibut	-	-	-	I4,I
Digested fish	I9,9	43,4	62,7	35,6
Digested food	I,7	-	-	-
Total index of stomach fullness, °/₀₀₀	246,I	4I7,2	276,9	I5I,0
Total number of stomachs	63	I2	7	43
Empty stomachs, %	6,3	8,3	I4,2	9,3

Table 4 Food composition of Greenland halibut at different depths (in % by weight)

Food organisms	Shelf (to 500m)	Slope (above 500 m)
Squid	0.8	2.1
Parathemisto	0.2	0.1
P. borealis	5.7	-
Shrimp, not determined	10.7	0.1
Shrimp, total	16.4	0.1
Cod, polar cod	23.1	2.3
Grenadier	-	0.9
Eelpout	8.2	-
Beaked redfish	-	62.5
Halibut (juvenile)	11.6	-
Digested fish	39.7	30.8
Fish, total	82.5	96.5
Digetsed food	-	1.2
Total index of stomach fullness, °/oo	151.5	319.9
Total number of stomachs	58	67
Empty stomachs, %	12.1	4.4

Table 5 Food composition of Greenland halibut at different depths in the North Labrador area (% by weight)

Food organisms	270-300m	960-1020m
Parathemisto	1,0	-
Shrimp	12,9	-
Cod, polar cod	28,9	-
Beaked redfish	-	76,9
Grenadier	-	3,5
Squid	-	0,2
Digested fish	28,9	14,6
Digested food	-	4,7
Total index of stomach fullness, °/oo	152,9	213,2
Total number of stomachs	15	25
Empty stomachs, %	20,0	4,0

Table 6 Number of feeding specimens (%) and average degree of stomach fullness of Greenland halibut in the Northwest Atlantic throughout the year (1969-1981)

Month	NAFO regions							
	0B		I		2		3	
	amount	av. d.	amount	av. degree	amount	av. degree	amount	av. degree
January	5,0	0,I	7,6	0,2	II,7	0,2	20,0	0,5
February	-	-	7,I	0,2	I8,6	0,6	I7,0	0,4
March	-	-	-	-	I7,5	0,4	II,7	0,3
April	-	-	-	-	4,0	0,I	I6,7	0,4
May	-	-	-	-	2,9	0,I	36,0	0,9
June	-	-	-	-	I2,7	0,2	45,0	I,0
July	II,0	0,2	I4,7	0,I	I2,5	0,2	38,I	0,9
August	I3,7	0,4	23,I	0,4	25,8	0,4	62,4	I,4
September	25,2	I,I	20,0	0,4	38,6	0,9	67,6	2,0
October	37,3	I,0	4I,2	I,0	54,6	I,5	5I,0	I,5
November	I0,8	0,3	I5,3	0,5	27,8	0,8	28,3	0,8
December	8,6	0,I	I0,7	0,5	I6,4	0,4	2I,4	0,5
Total number of stomachs	I5769		34498		I4276		I2I50	

Table 7 Average weight and mean daily increment of Greenland halibut in the Northwest Atlantic

Age, years	Average weight, g		Mean daily increment, %	
	males	females	males	females
4	300	300	—	—
5	530	550	0,30	0,32
6	8I0	850	0,23	0,23
7	II40	I220	0,I8	0,I9
8	I520	I670	0,I5	0,I7
9	I940	2680	0,I3	0,25
I0	2400	2750	0,II	0,0I
II	2880	3390	0,I0	0,II
I2	3360	4090	0,08	I,II
I3	3820	4840	0,07	0,09
I4	4260	5640	0,04	0,08
I5	4630	6480	0,03	0,07
I6	4880	7360	0,02	0,I5
I7	—	8280	—	0,06
I8	—	9220	—	0,05
I9	—	I0I50	—	0,05
20	—	II050	—	0,04

Table 8 Energy spent on basal metabolism in Greenland halibut of the Northwest Atlantic

Age, years	Intensity of oxygen consumption			
	ml/hr		cal/day	
	males	females	males	females
4	I6,6	I6,6	I935,0	I935,I
5	25,4	25,7	2962,6	2997,6
6	33,9	34,7	335I,8	4043,9
7	43,7	45,7	509I,3	5330,4
8	53,7	57,5	6263,6	67II,5
9	63,I	79,4	7358,8	9264,7
I0	75,8	8I,3	8847,I	9480,5
II	85,I	95,5	9927,2	III37,9
I2	95,4	I09,6	III30,9	I2376,6
I3	I04,7	I23,0	I22I3,4	I4349,I
I4	II2,2	I38,0	I3087,0	I6099,8
I5	I20,2	I54,9	I4020,I	I8065,2
I6	I23,0	I65,9	I4349,I	I9356,4
I7	-	I82,0	-	2I224,9
I8	-	I99,5	-	23272,0
I9	-	2I3,8	-	24936,5
20	-	223,9	-	26II2,2

Table 9 Daily ration of different age groups of Greenland halibut

Age, years	Weight of food bolus, % of body weight		Weight of food bolus, g	
	males	females	males	females
5	I,20	I,I9	6,37	6,55
6	I,32	0,86	I0,70	7,36
7	0,87	0,72	I0,00	8,89
8	0,90	0,64	I3,80	I0,70
9	0,7I	0,55	I3,87	I4,87
I0	0,67	0,48	I6,II	I3,42
II	0,63	0,46	I8,35	I5,76
I2	0,57	0,62	I9,38	25,56
I3	0,54	0,42	20,89	20,80
I4	0,48	0,4I	20,79	23,26
I5	0,46	0,40	2I,66	25,96
I6	0,44	0,38	2I,56	28,36
I7	-	0,36	-	30,33
I8	-	0,35	-	33,I5
I9	-	0,34	-	35,50
20	-	0,33	-	36,86

List of species found in the stomachs of Greenland halibut of the Northwest Atlantic in 1969-1981

Class	Spongia
	Calcarea sp.
Subclass	Hecacorallia
Class	Scyphozoa
	Scyphomedusae sp.
"	Ctenophora
"	Gastropoda
"	Bivalvia
"	Cephalopoda
Order	Decapoda
	Gonatus fabricii (Lichtenstein)
	Oegopsida sp.
Order	Octopoda
	Sepioides sp.

Class Polychaeta
" Crustacea
Order Copepoda
" Mysidacea
" Amphipoda
Parathemisto sp.
" Euphausiacea
" Decapoda
Pandalus borealis
Hyas sp.
Class Holothurioidea
" Ophiuroidea
Ophiura spp.
" Echinoidea
Echinodermata sp.
Pisces
Family Rajidae Raja spp.
" Alepocephalidae
" Osmeridae
Mallotus villosus villosus (Müller)
" Sudidae
Paralepis rissoi kroyeri Luthken
" Myctophidae
" Moridae
Antimora rostrata Gunther
" Gadidae
Gadus morhua morhua Linne
Boreogadus saida (Lepechin)
" Macruridae
Coryphaenoides rupestris Gunnerus
" Anarhichadidae
Anarhichas spp.
" Lumpenidae
Lumpenus spp.
" Zoarcidae
Lycodes pallidus Collet
" Ammodytidae
Ammodytes spp.
" Scorpaenidae
Sebastes mentella Travin
" Triglidae
" Cottidae
" Agonidae
Leptagonus decagonus (Schneider)
" Cyclopteridae
Cyclopterus spp.
" Liparidae
Liparis spp.
" Pleuronectidae
Reinhardtius hippoglossoides (Walbaum)
Hippoglossoides platessoides (Fabricius)

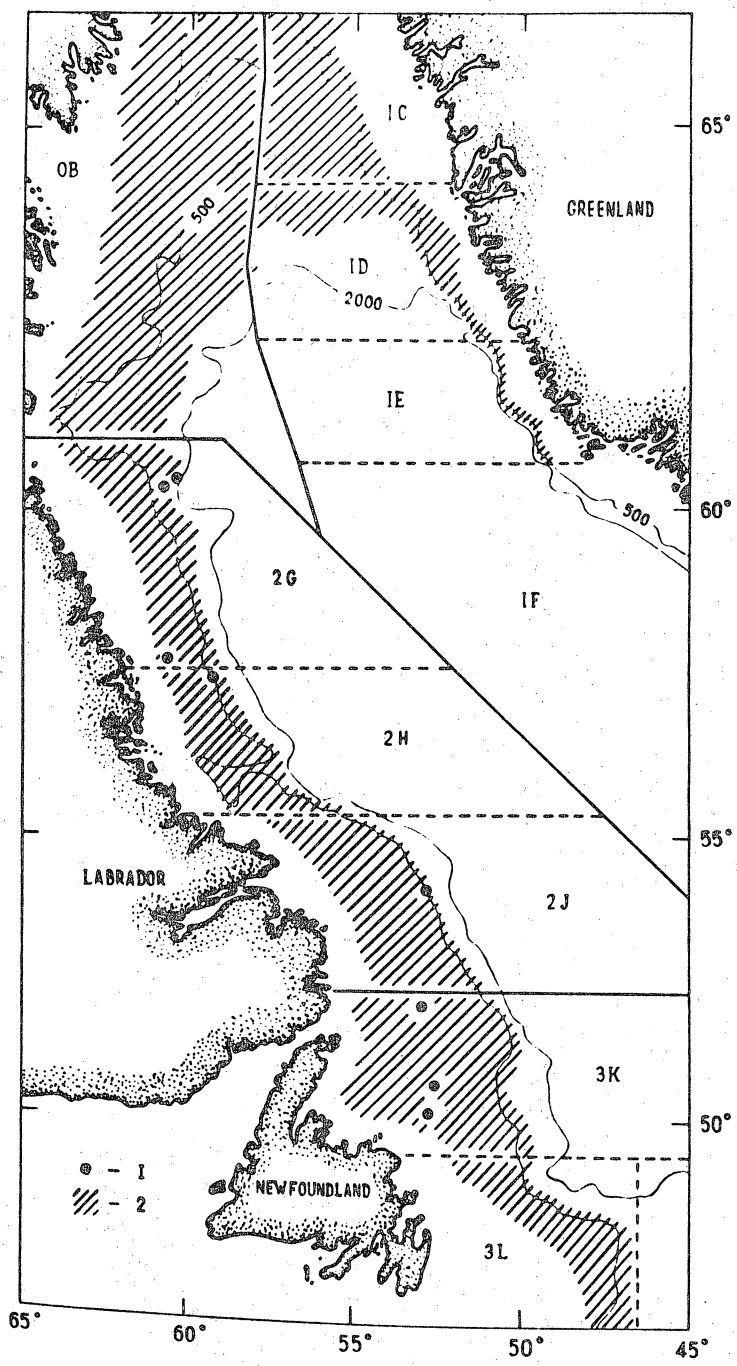

Fig. 1. Areas of sampling the material on Greenland halibut feeding. 1 - laboratory analysis, 2 - field analysis.

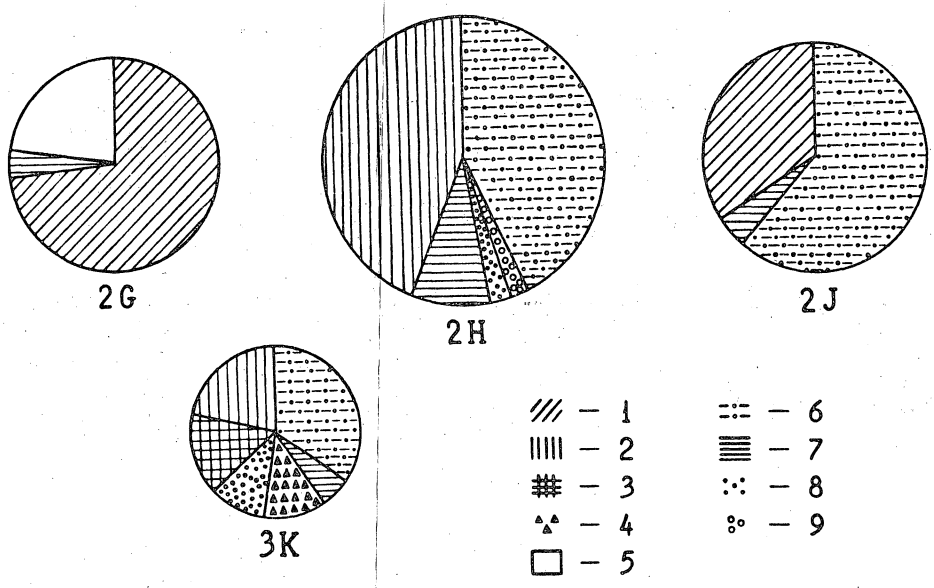

Fig. 2. Food composition of Greenland halibut in Divs. 2G, 2H, 2J and 3K, % by weight.
Radii of circles are proportional to the index of stomach fullness: 1 - redfish; 2 - cod, polar cod; 3 - Greenland halibut; 4 - eelpout; 5 - digested food; 6 - digested fish; 7 - squid; 8 - shrimp; 9 - Themisto.

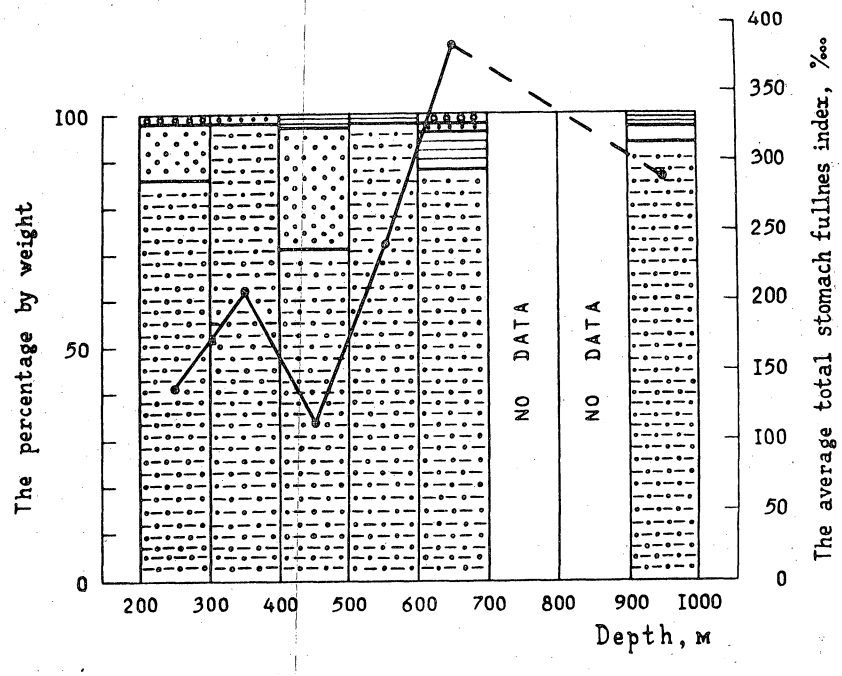

Fig. 3. Food composition and stomach fullness of Greenland halibut in the Northwest Atlantic at different depths in 1969-1981. For notation see p. 2.

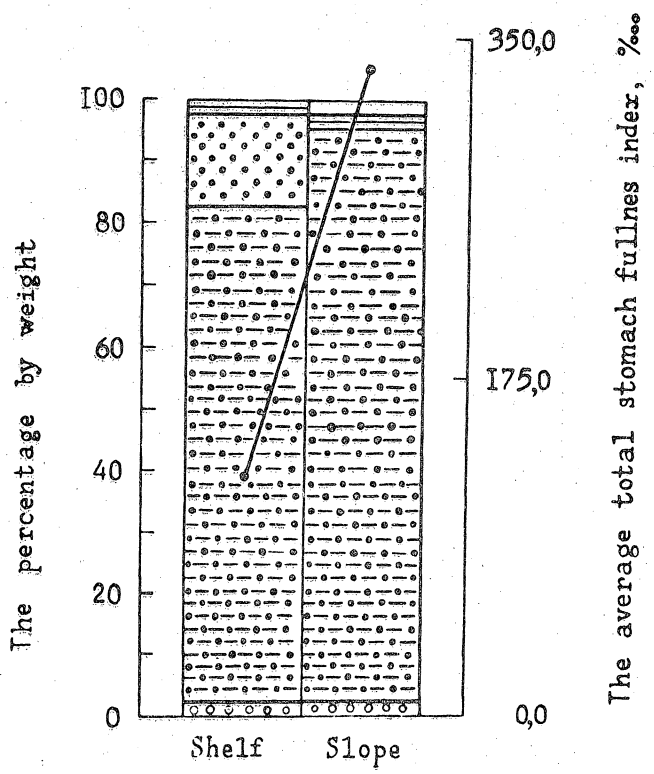

Fig. 4. Food composition and stomach fullness of Greenland halibut on the shelf and continental slope in 1969-1981. For notation see Fig. 2.

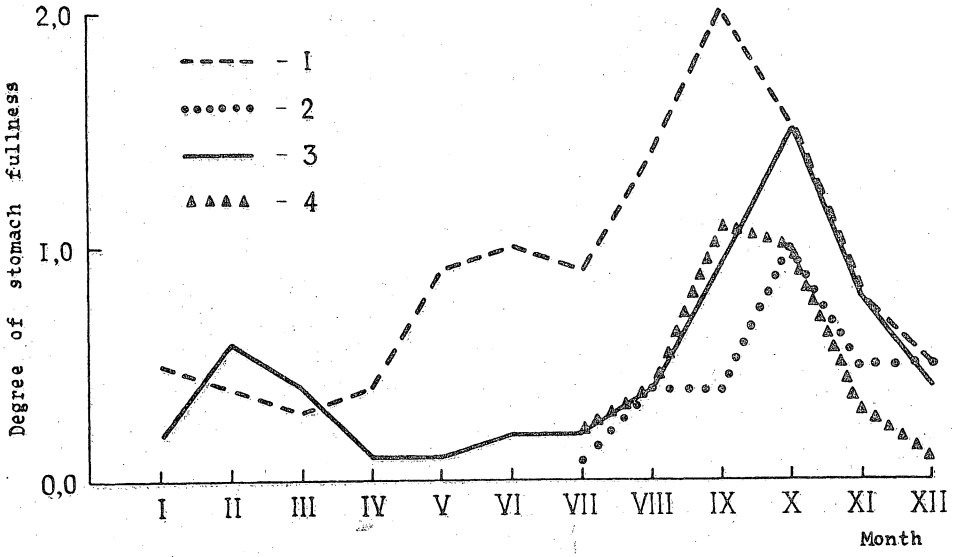

Fig. 5. Average degrees of stomach fullness of Greenland halibut in different areas of the Northwest Atlantic throughout the year: 1 - Subarea 3, 2 - Subarea 1; 3 - Subarea 2; 4 - Subarea OB.