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by T. N. Turuk

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SEASONAL CHANGES OF COD FEEDING
IN THE LABRADOR AND NEWFOUNDLAND AREAS IN 1964 - 1966

TRUDY PINRO, Vol. XXIII, Pp. 370 - 382, 1968

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The development of Soviet commercial fishery in North-West Atlantic demands that comprehensive and detailed information be available on the mode of life of important commercial fish, and of cod in particular. The distribution and behaviour of fish are influenced by complex and varying causes among which should be included the manner of fish feeding in different areas of the ocean and during different seasons.

Little information is available, both in the Soviet and foreign literature, on nutrition of cod in the regions of Labrador and Grand Newfoundland Bank. A number of foreign authors mainly furnish information on size - age composition of cod inhabiting these regions, as well on cod migrations, but provide only very general data on composition of cod food and the most important types of food on which cod feed. (7, 8, 9, 10, 11).

The brief information found in the articles of Soviet authors (3, 4) is based upon material obtained during a fairly short period of time or in a comparatively small area.

In the present work we endeavoured to provide information on changes occurring in the nutrition of cod in the above regions in the course of a year.

MATERIALS AND METHODS

Field analysis of cod food - based as it were on great mass of data - served as material for the present work, thus giving one a general idea of the quality of cod food and changes affecting the animals that were ingested by cod (2) (Table 1). Moreover, we carried out a quantitative (weight) analysis of cod food.

This material was gathered by vessels of the PINRO and its commercial reconnaissance between 1964 and 1966 in the regions of South Labrador (2 J), North Newfoundland Bank (3 K), North-West slope of the Grand Newfoundland Bank (3 L) and Flemish Cape Bank (3 M).

The following procedure was adopted by us in treating the material thus obtained: in assessing the results of field analysis one took into account the number of indications pointing to this or that animal organism serving as cod food, and the frequency of the occurrence of that particular food animal in the food found in the number of cod stomachs so examined. The degree of food ingestion was visually determined on a five-point scale, and then an average figure signifying the degree of fullness of the stomach was calculated. To achieve this end, the number of stomachs in a sample with a given fullness was multiplied by the index of fullness - 0, 1, 2, 3, 4 - and the products so obtained were added up, and then the total so arrived at was divided by the number of fish in that particular sample, including the fish with empty stomachs. The final figure so obtained reflected the average index

TABLE I

THE NUMBER OF COD STOMACHS SUBJECTED TO FIELD ANALYSIS DURING
THE PERIOD 1964 - 1966 IN THE REGIONS OF LABRADOR AND GRAND NEWFOUNDLAND
BANK

Month	Year	REGIONS			
		South Labrador	North Newfoundland Bank	Flemish Cape Bank	North East Slope of Grand New- foundland Bank
January	1964	484	179	-	-
	1965	1,000	255	49	491
	1966	1,335	532	-	100
February	1964	415	444	400	375
	1965	1,175	300	523	55
	1966	350	-	80	-
March	1964	1,472	500	-	50
	1965	900	124	520	-
April	1964	427	-	-	-
	1965	1,500	-	-	-
May	1964	2,036	538	100	-
	1965	3,064	-	-	-
	1966	584	250	-	-
June	1964	1,135	1,845	73	539
	1965	845	250	50	525
	1966	450	-	-	149
July	1964	630	310	-	-
	1965	45	-	-	1,068
	1966	-	-	-	125
August	1964	149	101	212	150
	1965	-	-	-	180
	1966	593	561	-	252
September	1964	750	191	226	190
	1965	-	-	489	530
	1966	802	-	-	-
October	1964	1,124	-	-	-
	1965	603	-	50	-
	1966	300	-	-	-
November	1964	1,205	350	60	624
	1965	799	820	-	-
December	1964	1,624	250	150	-
	1965	1,359	250	-	-
TOTAL		27,155	8,050	2,982	5,403

characterizing the degree of fullness of cod stomachs in the sample. In this manner we dealt (by the method of field analysis) with 43,590 individual cod fish (25 individual fish per sample).

The results so obtained were recorded by months and areas. In those cases in which the number of stomachs did not exceed 40 - 50, the material was judged to be of no significance and was excluded from our calculations.

In order to ascertain, as fully as possible, the peculiar traits of cod feeding, we combined the data relating to each month for the entire period of three years during which our investigation was carried out. For example, the average point representing the degree of fullness of the stomach in the month of January (Table 2) was calculated as an arithmetical mean of the indices representing the average point (of the degree of fullness of the stomach) for the month of January of all three years, 1964, 1965, and 1966.

The samples for the quantitative weight analysis of cod food were collected and treated in the following manner.

After a preliminary mass measurement of fish, 25 - 30 individual cod fish were selected from each trawl. The fish were measured, weighed, and their sex and the degree of maturity of sex products was ascertained. The stomachs were fixed on board ship, and the quantitative weight particulars were ascertained at the laboratory of the PINRO.

The stomach contents were weighed, and then an average of the degree of fullness (in % per 1,000) for all fish in a single sample was calculated. Thereafter,

TABLE 2

COMPOSITION OF COD FOOD IN THE VICINITY OF SOUTH LABRADOR DURING THE PERIOD 1964-1966

Month	Average Mark Denoting the Degree of Stomach Fullness	Frequency of Occurrence of Different Components in Percentages								
		Plankton	Euphausiidae	Hammaridae	Themisto	Shrimps	Benthyc Animals	Sand Eel	Golden Anchovy	Sea Pike
January	.54	8.0	6.8	12.7	34.6	9.5	25.8	-	2.3	.3
February	.58	9.1	13.7	5.9	45.5	5.4	15.5	-	6.0	-
March	.54	15.2	10.4	10.9	21.8	5.9	32.2	-	3.4	-
April	.78	18.9	6.6	13.6	12.4	16.4	22.3	-	7.7	-
May	1.03	29.6	2.1	26.8	5.6	9.8	46.4	-	4.6	.4
June	1.6	21.3	4.8	34.5	3.7	6.7	45.2	-	7.7	2.0
July	1.24	4.7	5.8	69.4	16.1	19.1	48.0	-	.4	-
August	2.61	4.2	4.1	9.9	38.0	7.1	12.9	8.0	12.4	35.6
September	2.32	5.7	2.2	7.8	17.0	8.8	8.1	3.2	14.5	53.0
October	2.18	22.0	5.3	4.5	17.8	10.3	7.8	15.9	5.1	54.8
November	2.11	18.9	3.9	8.0	42.1	7.6	9.2	-	3.3	30.9
December	1.31	12.9	8.3	19.0	30.1	8.5	21.2	-	3.9	14.9

the food of each fish was subjected to the qualitative composition analysis. As far as possible, the individual components of food were determined down to the species level, counted and weighed. The significance of each component in cod nutrition was characterized by its percentage of the total weight. In addition, the degree to which animals found in food were digested was visually determined in accordance with a three-point scale. Altogether, 735 individual cod were subjected to the quantitative weight method of treatment.

The results of qualitative analysis are represented graphically by circular diagrams in which the radius was a square root of the figure representing the degree of fullness of the stomach, and the area of sectors corresponds to the weight figure, in percentages, of each individual component of cod food (6).

To determine the relative fatness* of cod their livers were weighed.

SOUTH LABRADOR (2 J)

As has been shown by the Soviet and foreign investigations, the regions of Labrador and North Newfoundland Bank are inhabited by an independent cod population possessing a very slow tempo of growth and early sexual maturity: in these areas cod attain sexual maturity at the age of 5 - 6 years, the length of the body being 40 - 50 cm. In the first half of the year the cod form here dense pre-spawning, spawning and post-spawning concentrations along the oceanic bed incline. Spawning occurs in February - March at the South and South East slopes of the Hamilton Bank at a depth of 250 - 300 meters. After spawning cod feed intensively and move away

* The conditional index selected by us was the ratio of the weight of the liver to the total weight of fish, expressed in percentage.

in the beginning of summer to the shores, to the bays and shallow water. Here cod feed, during summer months on the moyva (sea-pike) which spawn here along the sea shores. Beginning in September cod move away from the coast and remain throughout the winter at the depths of 200 - 300 meters (4, 7).

According to our observations, winter is the period of the least intensive feeding of Labrador cod. The average monthly figures representing the degree of fullness of the stomach are very low in January and February (Table 2). Starting in April, the rate of feeding gradually begins to increase and reaches its maximum in August, i.e. when cod begin intensively to feed on moyva. From September on, to the end of the year, the average figure expressing the degree of fullness of the stomach remains on fairly high level. (Table 2).

Changes affecting the quality of cod food during a year have been worked out by us on the basis of material gathered in 1964. During the first half of the year (January - June) the cod fed on the invertebrates among which benthic animals occurred more frequently than did other animals; during the second half of the year (July - December) fish predominated in cod food: sand-eels, golden anchovy, and particularly so moyva. (Table 2; Fig. 1).

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Benthic fauna of South Labrador is rich and diversified. Here the cod mainly consumed among the Ophiuræ, Ophiopholis aculeata, Ophiura robusta, Ophiocten sericeum; worms (Polychaeta sp., Phascolosoma sp., Anaitides groenlandica, Stylarioides plumosa, Brada sp., Nicomache lumbricalis, Maldane sarsi); and the Holothuroidea (Thyonidium sp.).

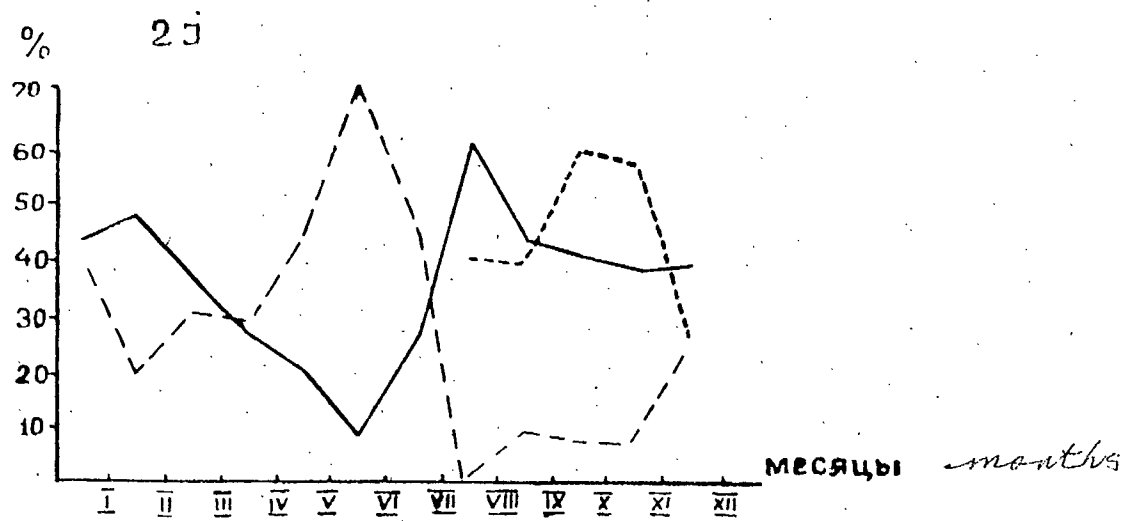


Рис. 1. Изменение состава пищи трески на Южном Лабрадоре в 1964 г.
 (частота встречаемости, %):
 1 — батипелагические ракообразные; 2 — донные беспозвоночные;
 3 — мойва

Fig. 1 Changes in the composition of cod food in South Labrador in 1964.
 (frequency of occurrence and percentage)
 1. Bathypelagic crustaceans; 2. benthic invertebrates; 3. Sea Pike (Molva molva).

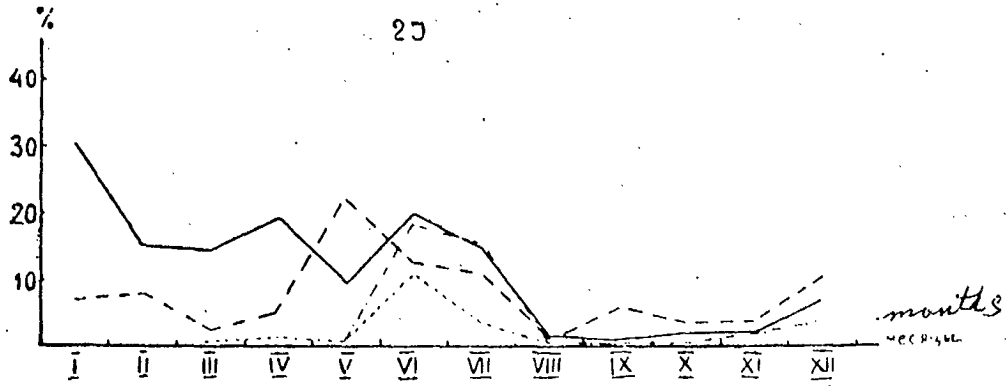


Рис. 2. Потребление треской донных животных в 1964 г.
(частота встречаемости, %):

1 — офиуры; 2 — черви; 3 — голотурии; 4 — кумовые раки

Fig. 2 Consumption by cod of benthic animals in 1964
(frequency of occurrence, percentage)

1. _____ Ophiuræ; 2. _____ Worms;
3. ----- Holothuridae; 4. _____. Cumaceans.

During the summer (June - July) cumacean crayfish occurred much more frequently in the stomachs of cod (Fig. 2).

Among the molluscs the cod consumed Cardium elegantulum and also the representatives of large Gastropoda molluscs Sipho sp., Buccinum finmarchianum. Small bivalve molluscs of the Leda pernula, Macoma calcarea species were encountered in cod stomachs comparatively seldom. From among the Cephalopoda molluscs we found only one boreal species, Gonatus fabricii.

The importance of benthic animals in the nutrition of Atlantic cod is far greater than it is in the nutrition of cod in the southern part of the Barents Sea. In the total annual food intake of Barents Sea cod benthic animals play an unimportant role. According to the data of V.I. Zatsepin and N.S. Petrova (1), the benthos accounts for just 6 per cent of the annual index representing the degree of fullness of the stomach. As indicated by these authors, benthic animals are found in the stomachs of cod mainly at the time it experiences a sharp lack of such food as herring, moyva and krill. No direct connexion was brought to light between the distribution of the benthic fauna and locations of the greatest concentrations of cod.

In the region of South Labrador, as we can see, the benthos occupies the first and leading place in cod food during the first half of the year. This is explained by the absence of fish serving as feed in the first place and by presence of rich and diversified benthic fauna.

In August cod begin to feed on fish. Thus, in the stomachs of Labrador cod, caught at the depths of 200 - 300 meters, moyva begins to play an important role. In

TABLE 3

FREQUENCY OCCURRENCE OF SEA PIKE AND BATHYPELAGIC CRUSTACEANS IN COD STOMACHS AT DIFFERENT DEPTHS IN THE REGION OF SOUTH LABRADOR IN AUGUST - DECEMBER OF THE PERIOD 1964 - 1966 IN PERCENTAGES

Depths in Meter	Sea Pike					Bathypelagic Crustaceans				
	VIII	IX	X	XI	XII	VIII	IX	X	XI	XII
100-200	-	22.5	13.7	26.3	8.2	4.6	23.2	5.6	9.8	2.9
201-300	35.6	26.7	43.5	18.8	11.4	43.4	12.0	27.7	26.7	30.5
301-400	-	29.7	2.0	5.3	2.1	3.6	5.8	.8	18.4	12.4

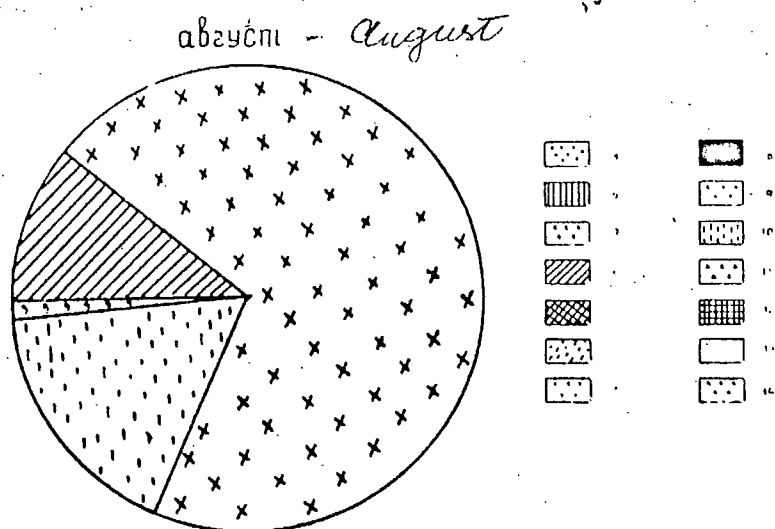


Рис. 3. Весовое значение (в %) различных пищевых компонентов трески у Южного Лабрадора в августе 1964 г.
 1 — Euphausiacea, 2 — Amphipoda, 3 — Decapoda, 4 — Themisto, 5 — креветка, 6 — донные животные, 7 — светящийся анчоус, 8 — песчанка, 9 — треска, 10 — мойва, 11 — камбала, 12 — переваренная рыба, 13 — грунт, 14 — переваренная пища

Fig. 3

Weight value (in percentages) of different food components of cod in the region of South Labrador in August, 1964.

1. Euphausiacea; 2. Amphipoda; 3. Decapoda; 4. Themisto;
5. Shrimps; 6. Benthic Animals; 7. Golden Anchovy; 8. Sand - eel;
9. Cod; 10. Sea Pike; 11. Plaice; 12. Digested fish;
13. Bottom soil; 14. Digested food.

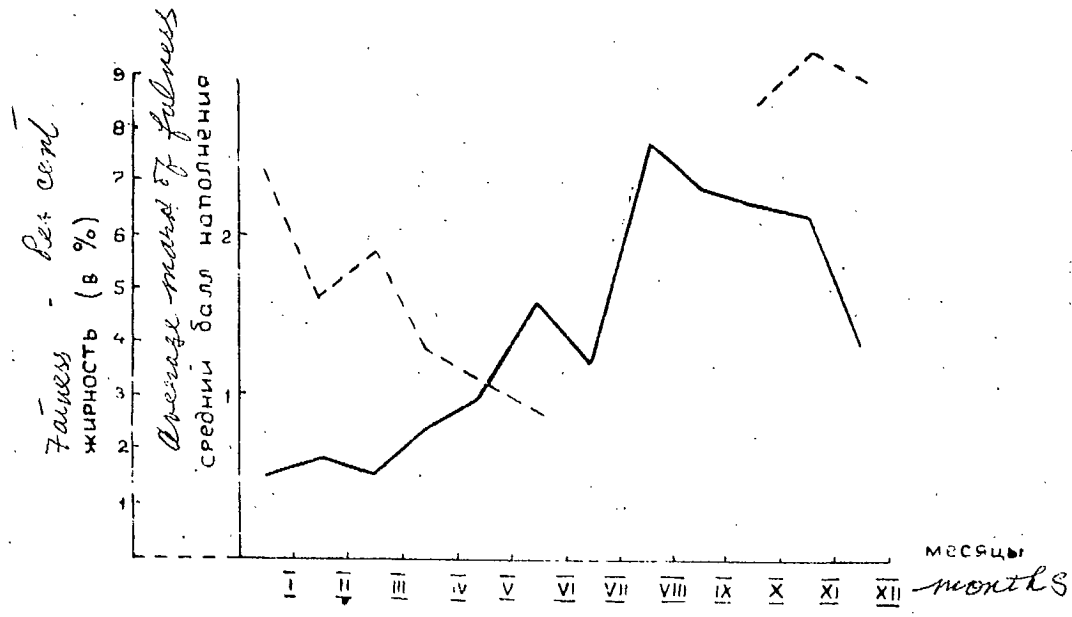


Рис. 4. Изменение интенсивности питания и жирности трески у Южного Лабрадора по месяцам в 1964--1966 гг.:
 ----- средний балл наполнения; - - - - - жирность

Fig. 4 Changes of feeding intensity and fatness of cod in the region of South Labrador during each month in the years 1964 - 1966.
 _____ Average mark denoting degree of stomach fullness
 ----- Fatness

TABLE 4

FATNESS OF COD IN THE REGION OF SOUTH LABRADOR DURING THE PERIOD
1964 - 1966

(WEIGHT OF THE LIVER AS PERCENTAGE OF BODY WEIGHT OF FISH)

YEARS	MONTHS									
	I	II	III	IV	V	VI	VIII	X	XI	XII
1964	7.6	3.8	5.6	3.8	3.6	3.2	-	-	-	-
1965	6.3	6.1	6.0	-	2.8	2.2	-	8.5	-	8.3
1966	7.8	-	-	-	-	-	9.3	-	9.4	9.5
Average (For 1964- 1966 Period)	7.3	4.9	5.8	3.8	3.2	2.7	9.3	8.5	9.4	8.9

the south and centre of this region the frequency of moyva occurrence remains fairly high throughout the autumn-winter period, whereas in the north cod fed on bathypelagic crustaceans; Themisto, Euphausiidae (Meganyctiphanes norvegica) and shrimps (Pandalus sp.) (Table 3).

At a depth of 350 meters and over the cod fed on golden anchovy the importance of which by weight attained is maximum of 70.8 per cent in stomachs during August. The indices of the degree of fullness of the stomach were at that time very large - 665.4 per cent per 1,000. (Fig. 3).

One of the most important indices of good nutritional state of cod is its fatness. One may obtain the most accurate idea of seasonal changes affecting cod fatness by studying the data gathered in South Labrador. The degree of fatness of cod of South Labrador for the period 1964 - 1966 is illustrated in Table 4. As will be seen from the Table, fatness reached its peak during the second half of the year. In the beginning of the year (January) it still remained at a fairly high level. Later, in February, April, and particularly so in May, fatness decreased. In August, after summer time feeding, fatness increases and remains high to the end of the year. Fatness was found to be particularly high in wintering cod examined during November - December (Fig. 4).

Such changes occurring month by month in the process of fat accumulation depend on the type of food consumed by cod. In the spring, when, in the region of South Labrador, spawning takes place, the cod feed very little. Moreover, the basis of cod ration in February - June period consisted of benthic invertebrates. Beginning in August fish begin to predominate in cod ration, on which (fish food)

TABLE 5

COMPOSITION OF COD FOOD IN THE REGION OF NORTH NEWFOUNDLAND BANK DURING THE PERIOD 1964 - 1966

Months	Average Mark Designating Degree Of Fullness of the Stomach	Frequency of occurrence of different components in percentages								
		Plankton	Euphausiidae	Hammaridae	Themisto	Shrimps	Benthyc Animals	Sand Eel	Golden Anchovy	Sea Pike
January	1.09	15.5	2.9	18.6	24.5	19.4	22.0	-	1.8	11.9
February	.95	8.9	6.9	7.7	50.2	20.2	16.2	2.4	8.0	2.8
March	.92	21.0	8.5	5.5	58.5	16.9	14.3	1.5	3.6	.4
May	1.18	17.2	3.6	7.2	21.0	22.6	39.5	-	-	6.1
June	1.10	5.2	4.2	8.2	2.2	17.7	41.5	.1	.1	17.3
July	2.10	2.1	5.8	-	2.9	31.0	9.9	-	26.0	-
August	1.85	1.9	30.6	9.8	18.6	31.9	13.6	14.3	5.2	13.6
September	1.94	13.1	1.7	9.9	59.0	19.3	38.1	9.2	8.0	-
November	1.24	5.5	2.2	.9	39.0	10.6	44.7	-	.9	49.8
December	1.41	2.3	4.5	6.2	30.2	8.2	5.7	-	.6	67.9

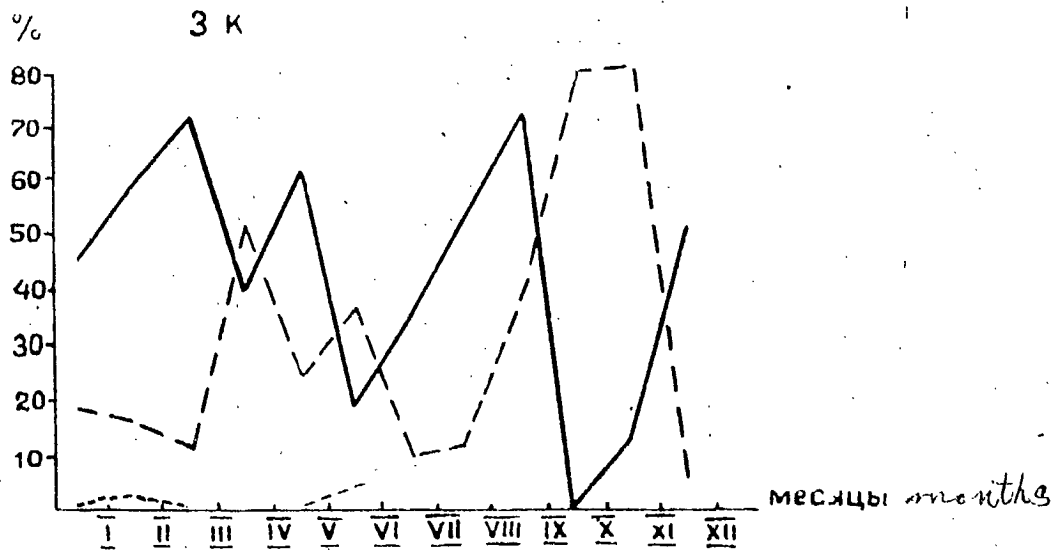


Рис. 5. Изменение состава пищи трески на Северной Ньюфаундлендской банке в 1964 г. (частота встречаемости в %):

1 — батипелагические ракообразные; 2 — донные беспозвоночные;
3 — мойва

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Fig. 5

Change of composition of cod food in the region of North Newfoundland Bank during 1964 (frequency of occurrence in per cent)

1. _____ Bathypelagic crustaceans; 2. - - - - benthic invertebrates; 3. _____ Sea Pike.

cod feed more intensively than they do on benthic animals. Accordingly, the degree of fatness is higher at the end of the year than it is during the spring-summer period. (Fig. 4)

To our regret we possess no data on the degree of cod fatness relating to other regions.

NORTH NEWFOUNDLAND BANK (3 K)

A similar picture of seasonal process of cod feeding is observed at North Newfoundland Bank. The average figure expressing the degree of fullness of the stomach reaches its maximum value in June - August, remaining at a high level throughout the autumn months. During the winter the rate of feeding undergoes a slight decrease (Table 5).

According to the data furnished by the laboratory of marine biology for the past years, the following seasonal periodicity of cod feeding was observed in this region: winter (December - February) - amphipods and plankton; spring (March - April) - amphipods and Euphausiidae; summer (June - August) - in the south and west of the zone - moyva, and in the east - shrimps; autumn (October - November) - moyva. Our own observations confirmed that picture, but an important role of benthic food was also brought to light (Table 5 and Fig. 5). The importance of benthic invertebrates in cod feeding is particularly great during spring - summer (April-June) and autumn (September - November) months.

A qualitative analysis of benthic fauna in stomachs of cod during 1964 showed that in the spring the fish consumed considerable quantities of worms (Anaitides

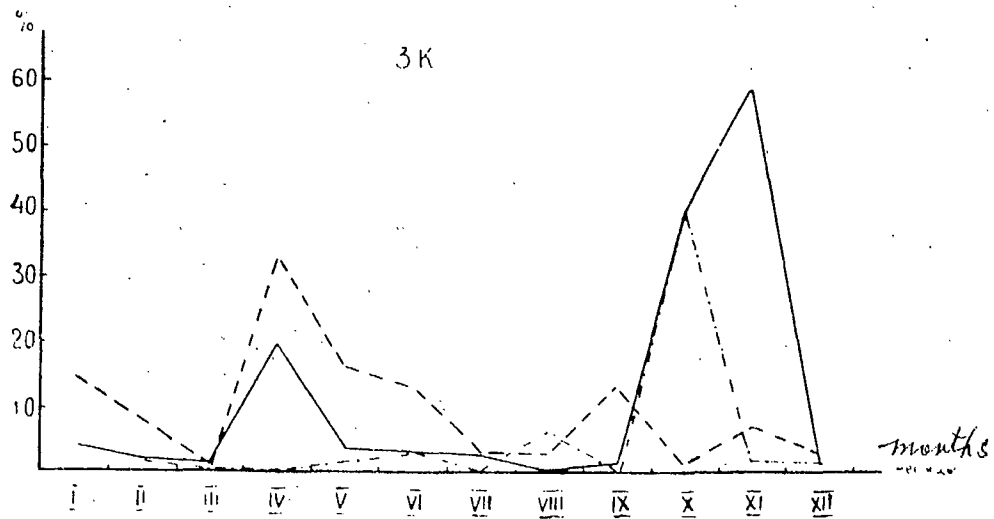


Рис. 6. Потребление треской донных животных в 1964 г. (частота встречаемости в %):
 1 ———— оphiуры, 2 — — — черви, 3 ······ кумовые раки

Fig. 6

Consumption by cod of benthic animals during 1964 (Frequency of occurrence in percentages).

1. _____ Ophiuræ; 2. _____ Worms;
 3. _____ Marine Crayfish.

TABLE 6

FREQUENCY OF OCCURRENCE OF SEA PIKE IN COD STOMACHS AT DIFFERENT DEPTHS IN THE REGION OF NORTH NEWFOUNDLAND BANK IN NOVEMBER & DECEMBER OF THE PERIOD 1964 - 1966 IN PERCENTAGES

Depths in Meters	November	December
100 - 200	-	20.6
201 - 300	50.5	46.2
301 - 400	20.8	22.6

TABLE 6

FREQUENCY OF OCCURRENCE OF SEA PIKE IN COD STOMACHS AT DIFFERENT DEPTHS IN THE REGION OF NORTH NEWFOUNDLAND BANK IN NOVEMBER & DECEMBER OF THE PERIOD 1964 - 1966 IN PERCENTAGES

Depths in Meters	November	December
100 - 200	-	20.6
201 - 300	50.5	46.2
301 - 400	20.8	22.6

TABLE 7

COMPOSITION OF COD FOOD IN THE REGION OF NORTH EAST SLOPE OF THE GRAND NEWFOUNDLAND
BANK DURING THE PERIOD 1964-1966

Months	Average Mark Designating the Degree of Fullness of the Stomach	Frequency of occurrence of different components in percentages								
		Plankton	Euphausiidae	Hammaridae	Themisto	Shrimps	Benthyc Animals	Sand Eel	Golden Anchovy	Sea Pike
January	1.63	32.2	8.2	38.3	10.6	8.2	19.4	2.2	.7	15.8
February	1.37	7.0	19.8	19.6	37.4	13.1	35.0	1.0	7.7	40.0
March	.86	-	14.3	3.6	28.6	14.3	32.2	-	-	-
June	1.82	2.8	1.1	19.0	10.4	5.7	13.0	38.5	-	32.6
July	2.09	4.7	11.7	9.0	12.6	5.0	15.9	12.1	-	55.2
August	2.26	4.7	5.1	10.3	10.6	14.9	19.0	29.3	2.6	43.6
September	1.34	2.8	4.5	8.9	15.7	3.1	20.7	10.8	15.8	21.6
November	.51	.9	1.9	2.3	5.2	8.5	59.9	-	.9	-

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groenlandica, Nephtys sp., Onuphis conchylega) and Ophiuræ (Ophiopholis aculeata, Ophiura sarsi, Ophiura robusta); and in the fall the basic food consisted of Ophiuræ and marine crayfish [Pantulus sp?]. (Fig. 6).

In winter and summer cod fed on bathypelagic crustaceans: in wintertime these were mainly Themisto crustaceans, and in summertime - shrimps of Pandalus sp.

During the fall (November - beginning of December), in the north of Newfoundland shelf there was observed feeding on moyva, a characteristic common to all three years (1964 - 1966). According to V.A. Rikhter (5), spawning of the Newfoundland moyva occurs in summertime in the south of the Newfoundland shelf. After spawning the moyva move northward following along the 200 meters isobath. Therefore, the frequency with which moyva was found in cod stomachs perceptibly increased at the depths of 200 - 300 meters (Table 6).

NORTH EAST SLOPE OF THE GRAND NEWFOUNDLAND BANK (3 L)

The region of North East slope embraces the northern extremity of Grand Newfoundland Bank. Here is found the largest cod (70 - 80 cm.), the tempo of growth of which is much higher than it is in Labrador cod or cod from North Newfoundland Bank. It spawns at the end of April-May, feeding very little at that time. The period of the most intensive feeding of cod in the region of North East slope is July - August (Table 7).

Its basic food consists of fish: mainly moyva, to a less extent golden anchovy and sand-eel (Table 7).

TABLE 8

CONSUMPTION BY COD OF SEA PIKE AND SANDER AT DIFFERENT DEPTHS IN THE REGION OF NORTH EAST SLOPE OF THE GRAND NEWFOUNDLAND BANK DURING THE MONTHS JUNE - AUGUST. OF THE PERIOD 1964-1966

(FREQUENCY OF OCCURRENCE IN PERCENTAGES)

Depths in Meters	Sea Pike			Sand - eel		
	June	July	August	June	July	August
100-200	27.8	41.8	46.6	40.4	25.1	38.4
201-300	4.7	26.4	16.2	11.6	.9	-
301-400	-	.1	3.3	-	-	18.7

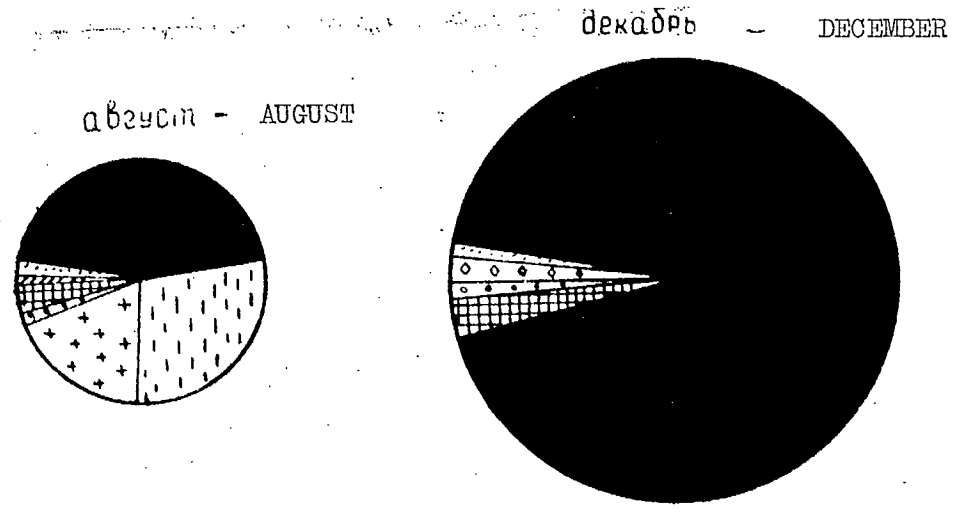


Рис. 7. Весовое значение (в %) различных пищевых компонентов трески на Северо-восточном склоне Большой Ньюфаундлендской банки в августе и декабре 1965 г. (обозначения те же, что на рис. 3)

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Fig. 7 Weight values (in percentages) of different food components of cod in the region of North East slope of the Grand Newfoundland Bank during the months of August and December of 1965. (Legend: The same as given in Fig. 3)

The period of fattening on moyva is very long on the North East slope, for here moyva spawn in July - August, which fact explains its concentration there (5). Large schools of moyva keep mainly at a depth of 100 - 150 meters.

Thus, the shallow waters of Newfoundland is the region which has very favourable conditions for summer feeding of cod.

Our data enabled us to come to the conclusion that moyva was consumed mainly by cod of regular and small size (35 - 70 cm. long), whereas the larger cod kept to the areas of greater depth (over 300 meters) where moyva was absent. Feeding on moyva, cod repeated the moyva's diurnal vertical migrations. Parallel with the approach to the edge of slope drop and an increase in the depth from 150 to 350 meters, the importance of moyva as cod food declined (Table 8).

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An important article of cod diet at the North East slope during the summer months (June, July and August) were sand-eels, too; the frequency of their occurrence in cod stomachs reached 38.5 per cent. Cod fed on sand-eel in shallow water of the Bank not only in summer months but also during winter (Table 8; Fig. 7). In August the weight value of sand-eel in cod stomachs was 41.9 per cent of the total contents, and in December-93 per cent (Fig. 7).

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Among the benthic invertebrates of this region of the greatest importance were some benthic forms of side-swimmers and also different species of Gastro-poda and bivalve molluscs. However, benthic forms did not play an important role in cod nutrition in this region on account of scarcity of local benthic fauna.

TABLE 9

COMPOSITION OF COD FOOD IN THE REGION OF FLEMISH-CAPE BANK DURING THE PERIOD 1964 - 1966

Months	Average Mark Designating the Degree of Fullness of the Stomach	Frequency of occurrence of different components in percentages								
		Plankton	Euphausiidae	Hammaridae	Themisto	Shrimps	Benthyc Animals	Sand Eel	Golden Anchovy	Sea Pike
January	.45	6.6	-	20.0	20.0	20.0	13.3	-	-	-
February	.56	30.4	9.2	8.3	1.2	37.9	23.6	-	1.7	1.5
March	.27	4.4	3.3	6.6	-	37.4	27.4	-	5.5	-
May	1.04	4.8	-	-	-	65.0	9.5	-	-	-
June	1.45	-	4.5	-	8.2	33.9	29.5	-	7.1	-
August	1.26	-	2.4	1.6	4.0	8.0	1.6	-	11.3	4.8
September	1.70	3.1	3.3	1.8	14.4	4.8	6.7	32.0	46.0	6.1
October	.94	-	-	-	9.4	31.1	3.1	-	40.5	-
November	1.46	4.1	2.0	2.0	2.0	16.3	10.1	-	8.1	-
December	.86	13.3	1.3	2.6	2.6	37.3	12.0	-	12.0	-

FLEMISH CAPE BANK

In the Flemish Cape Bank region an independent stock of cod is located, differing from other stocks in other regions of Newfoundland and Labrador by their age-size composition, their growth tempo, and the period of spawning. The predominant size of this stock is 60 - 70 cm. Spawning occurs in February - March on the South West slope of the bank; and after spawning the cod dispersed all over shallow water area of the Bank.

The character of cod nutrition at Flemish Cape Bank is quite distinctive. A narrow sub-surface strait, 1,200 meters deep, separating Flemish Cape from the Grand Bank, is virtually an insurmountable obstacle for most of the benthic animals and many fish. Here are entirely absent such mass food species of fish as sand-eel and moyva.

The intensity of feeding in this region is inconsiderable. The average figure representing the degree of fullness of the stomach is relatively low in winter and spring months, increasing in the summer and the fall (Table 9).

According to our observations over a period of three years, four seasons can be distinguished in feeding habits of cod at Flemish Cape: winter - shrimps; spring - shrimps and ocean perch young; summer - Paralepis (sp.), golden anchovy and amphipods; fall - amphipods, plankton, ocean perch young. The cod consumed in winter and spring the shrimps of Pandalus sp. (Table 9).

During summer and in the fall feeding on shrimps and benthic invertebrates is reduced to a minimum. The role of food fish increases considerably, : Paralepis sp., ocean perch young and, especially, golden anchovy (Table 9).

In southern and western part of the Bank cod fed intensively on the young of ocean perch. The young were consumed in large quantities in November - December 1964 by cod 35 - 40 cm. long and mainly during the day. Apparently, the young of perch travel to deeper layer of water, owing to the greater degree of illumination of the sea during the day, and form therefore the basic food of benthic fish including the cod.

Fish represented an inconsiderable percentage of cod diet in the central shallow water part of the Bank.

In February, in cod food at the Flemish Cape large quantities of plankton animals predominated (Table 9). Particularly large quantities of sea-combs and worms of Sagitta sp. were consumed by the cod. This phenomenon was characteristic of 1964 - 1965, whereas in 1966 the frequency with which plankton was found in cod stomachs was at a minimum. Such differences in the consumption of plankton during these three years were apparently due to hydrological factors. According to the data of Laboratory of Hydrology, the water in benthic layers of the Bank was warmer in February, 1966, than it was during winters of five preceding years. The warming -up resulted in a greater approach of schools of golden anchovy to Flemish Cape Bank. Cod fed intensively on that fish, and the role of plankton became insignificant.

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On the basis of the data yielded by the material gathered by us in some regions of North West Atlantic one may arrive at some conclusions which are briefly stated below:

1. Bathypelagic crustaceans, benthic animals and small fish form the basic food of cod in the regions of Labrador and Newfoundland.

2. Two periods of feeding are characteristic for the cod of South Labrador: the period of spring-summer feeding on benthic animals (Ophiuræ, worms and Holothuroidea; and the period of fall-winter feeding on fish (moyva and golden anchovy).

3. For the North Newfoundland Shelf cod feeding on fish is characteristic only for the winter (cod feeding on moyva). During all other seasons of the year cod food consists of crustaceans and benthos.

4. In the region of North East slope of Grand Newfoundland Bank cod feed throughout the year on moyva, sand-eel and golden anchovy.

5. In the region Flemish Cape cod feed in summer-fall months on fish (Paralepis sp. , golden anchovy and ocean perch young); and in winter-spring months - mainly on shrimps.

6. As has been shown by our data on cod nutrition, sand-eel are found in cod stomachs mainly at depths of 100 - 200 meters; moyva (spawning) - at depths of 100 - 200 meters, and after spawning - at depths of 200 - 300 meters; and Paralepis sp. and golden anchovy - at depths of 300 - 350 meters.

7. In the region of South Labrador cod attain the greatest fatness during the second half of the year while they feed on fish; fatness decreases during the first half of the year, remaining at a reverse ratio to the degree of nutritional "finish" of cod. Yet, this question requires further study and more precise clarification.

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SUMMARY

As a result of studying the stomach content of 43 590 cods by the method of a field analysis and that of 735 cods through the use of a quantity/weight method it is estimated that cod in Labrador and Newfoundland areas mainly feed on benthos in the

first half of the year. Principal benthic forms being food for cod in areas mentioned are brittle stars, worms and sea-cucumbers. The rest of water organisms play a minor role in cod feeding. In the second half of the year cod chiefly feed on fishes. Some differences are found in the composition of this kind of food by depths and areas. Seasonal fluctuations in fatness of South Labrador cod are closely connected with the fact whether cod feed on fish or benthos. The greater the role of fish in cod feeding the higher the index of stomach fullness and fatness.

