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Some Data on Feeding of Certain Newfoundland Haddock Populations at Different Depths and Seasons

by

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We have at our disposal only one detailed study regarding western Atlantic haddock, giving qualitative and quantitative characteristics of George's Bank haddock feeding habits (Wigley, 1956). The author brings about the list of organisms edible for this haddock (altogether 172 names), points out the predominance of benthic and epibenthic formations in its food, shows the volume and percentage content of each of the main feeding groups. Wigley distinguishes the difference in feeding of haddock from three areas of the Bank in view of certain zoogeographycal complexes, touches upon age and seasonable changes in the feeding, points out to the decrease in stomach fullness during the spawning period.

Other studies contain either general characteristics of feeding of haddock or during certain months and years. But in all of them there are data reflecting only qualitative side of feeding and they are obtained by field studies.

In the present study the authors for the first time bring about data on Newfoundland haddock feeding, obtained by measuring volume and weight.

The material on feeding of Newfoundland haddock was collected on research vessels within the period from 1963 to 1975. The site of research activities were the Great New-

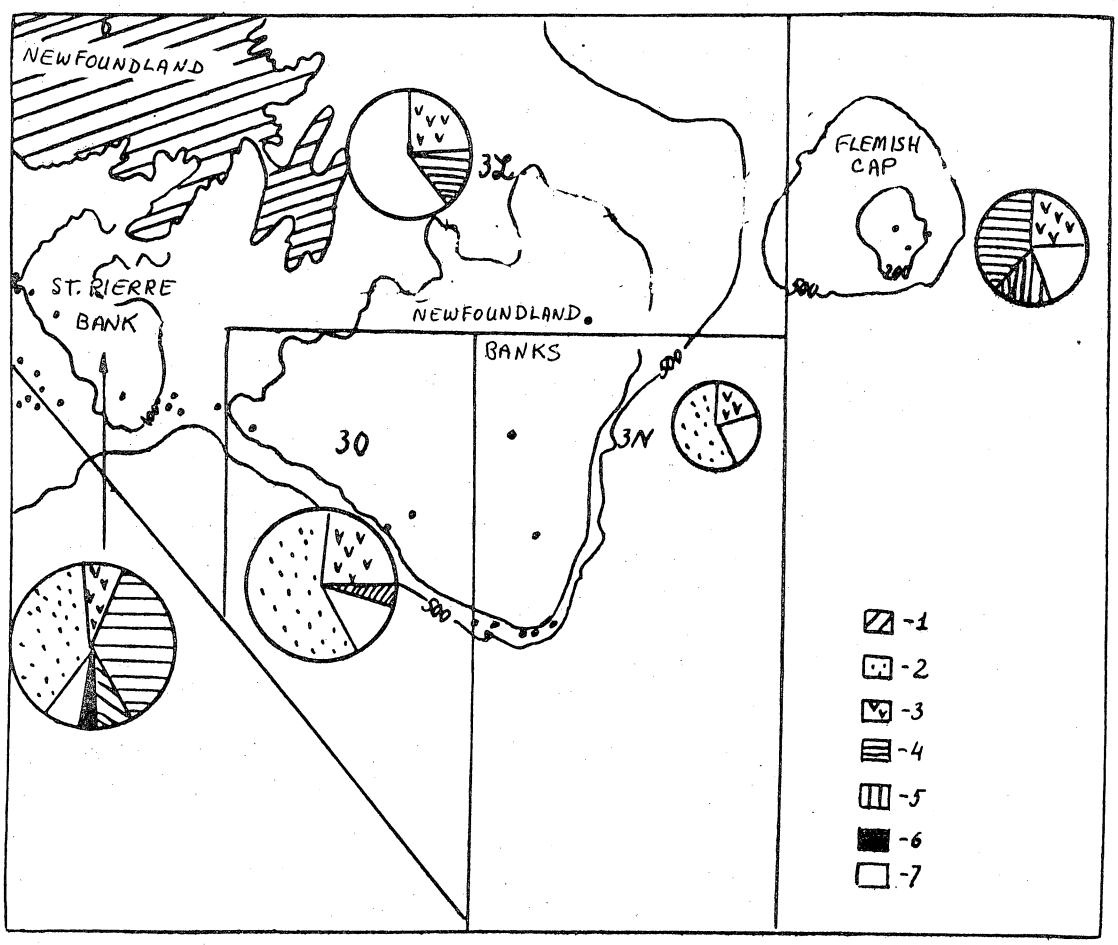
foundland Bank and also the Flemish Cap, Bank and St.Pierre (pict. 1).

The data were taken out of 33 trawls in the depth range of 50 - 238 m. The haddock was represented by specimens from 15 to 97 cm, which corresponds to the age range from 1+ to 15+ ; males dominated in the catches. All stomachs were fixed in 4% formalyne for further weight analysis.

To characterize the feeding, the general and individual indices of stomach fullness were calculated (the relation of the mass of food to the mass of fish, multiplied by 10,000) (Zenkevich, Brodskaya, 1931). Indices in $‰$ were calculated by the actual weight of food clod and its separate ingredients. Also we used the relations of the weight of various food groups to the total food content in the stomach. In this case the quantity of stomachs containing a certain food ingredient was expressed in % from the total number of investigated stomachs, irrespective of the fact whether there was some food or not. The stomach fullness was estimated visually by 5 point scale.

The list of feeding organisms showed that haddock is extremely omnivorous. In the food were represented 5 species of fish and practically all groups of sea invertebrates, though mainly Sedentaria or slow moving benthic species. The impression is that haddock eats everything which is easily accessible and could be easily dug out of the silt. Judging by the food composition one could willingly agree with Needler (1931), that haddock prefers not to chase for food.

In Table 1 is given the general food composition of Newfoundland haddock. In the class of invertebrates comprising 41.9% of the weight of the food clod, the substantial part belongs to Crustacea (17.8%) - shrimps, crabs, Eupauseacea, Gammaridae and other species. Of no less importance are Ophiurae and Euchinoidea (11.2% and 4.1% respectively). Rather important part make up Polyhaeta (5.4%) and molluscs (1.3%).



Pict.1. The map of collecting data on feeding and food composition of haddock (in % by mass) in the Newfoundland area.

Symbols: 1 - other organisms
2 - fish
3 - crustacea
4 - Ophiura
5 - Echinodermata
6 - Polyhaeta
7 - digested food

The list of feeding organisms found in the stomachs of Newfoundland haddock.

1. cl.Anthozoa
2. cl.Nematodes
   cl.Priapuloides
3. P.caudatus Lamarck
4. Halicriptus sp.
5. cl.Nemertini
   cl.Solenogastres
6. Chaetoderma nitidulum Loven
7. cl.Loricata
8. cl.Gastropoda
   Natica clausa Broderip et Sewerby
9. Margarites groenlandicus /Chemnitz)
10. Sipho lachaesis (Morch)
11. Cyclihna alba (Brown)
12. Bela sp.
13. Philine sp.
    cl.Scaphopoda
14. Scaphander Lignerius Linne
15. Salariella obscura
    cl.Bivalvia
16. Nucula tenius (Montagu)
17. Cyrtodaria kurriana Dunber
18. Joldia hiperborea (Loven) Torell
19. Leda pernula (Muller)
20. Musculus sp.
21. Crenella decussata (Montagu)
22. Dacridium vitreum (Holloll) Muller
23. Lima Hiperborea Jensen
24. Cardium elegantulum (Beck) Moller
25. Serripes sp.
26. Astarte crenata (Grey)
27. Diplodonta torelli Jeffreys
28. Macoma calcarea (Chemnitz)
29. M.moesta (Deschanes)
30. Mya trunicata linne
31. Thyasira flexuosa (montagu)
32. Cyrpidaria glacialis Sars
    cl.Polychaeta
33. Nereis zonata Malmgren
34. Nephtys sp.
35. Styloroides plumosus (O.F.Muller)
36. Aphrodite aculeata (Linne)
37. Anaitides groenlandica (Oercted)
38. Syllis fasciata Malmgren

39. Lumbricus gragilis (O.F.Muller)
40. Onophis couchylega M.Sars
41. Sabellidae
42. Pectinaria koreni (Malmgren)
43. P.hyperborea (Malmgren)
44. Ampharetidae
45. Ophelia limacina (H.Rathke)
46. Ammotrypane aulogaster Rathke
47. Travisia forbessi Johnston
48. Arenicola marina (Linne)
49. Maldanidae
50. Oweniidae
51. Brada villosa (H.Rathke)
52. Cirratulidae
53. Scalibregmidae
54. Goniada maculata Oersted
55. cl.Pantopoda
    cl.Crustacea
56. Philomedes globosus (Lilljeborg)
57. Cirripedia
58. Nibelia bipes (Fabricius)
59. Mysidacea
60. Parathemisto libellula Mandt
61. P.abyssorum (Boeck)
62. P.compressa f.compressa (Goes)
63. Hyperia medisarum
64. Gammarus Locusta (Linne)
65. Melita dentata (Kroyer)
66. Lembos articus (Nansen)
67. Anonyx nugay (Phipps)
68. Lysianassidae
69. Siphonoecetes sp.
70. Photis sp.
71. Unciola irrorata
72. Corophiidae
73. Ampelisca eschrichti Kroyer
74. Oediceros sp.
75. Monoculodes pallidus Sars
76. Caprella septentrionalis Kroyer
77. Campilaspis sp.
78. Diastylis rathkey (Kroyer)
79. Mesidothea entomon (Linne)
80. Synidothea nodulosa (Kroyer)
81. Aega
82. Meganyctiphanes norvegica (M.Sars)
83. Nyctiphanes couchi (Bell)
84. Brachiura
85. Hyas areneus (Linne)

86. Chionoecetes opilio (Fabricius)
87. Balanus sp.
88. Anomura
89. Macrura natantia
90. Pagurus capillatus (dict)
91. P.pubescens Kroyer
92. Pandalus borealis Kroyer
93. P.annulicornis Leach
94. Sergestidae
95. cl.Sipunculoidae
Phascolosoma sp.
96. Phascolion strombi (Montagu)
cl.Holothuroidea
97. Cucumaria sp.
98. Thyonidium commune Forbes
99. Psolus plantapus Strussenfelt
100. Chiridota irrirata
101. Ch.tufti
cl.Asteroidea
102. Ctenodiscus crispatus Retzius
cl.Ophiuroidea
103. Ophiopholis aculeata Linnaeus
104. Ophiocanthidae
105. Ophiura borealis Dan et Koren
106. O.sarsi Lutken
107. O.albida Forbes
108. O.rebusta Ayres
109. Stegochiura nodosa Lutken
cl.Echinoidea
110. Strongylocentrotus droebachionsis O.F.Muller
111. Olypeastroidea
cl.Ascidicea
112. Pelonaria corrugata Forb and Goods
113. cl.Bryosca
cl.Pisces
114. Paralepis sp.
115. Sebastes sp.
116. Mallotus villosus villosus (Muller)
117. Lycedes sp.
118. Anarhichas sp.

Fish is not the main food of haddock. Though by weight it accounts for 37.3%, its presence in the food of haddock is small (only 6.3%). Capelin is the fish one comes across most often (16.7%), next comes Sebastes (11.8%).

The investigation of morphoecological properties of Newfoundland haddock allows to classify haddock of the Great Newfoundland Bank and St. Pierre Bank as two different stocks; there is or scarce isolated stock on the Flemish Cap Bank. Therefore the further analysis of feeding is fiven taking into account the above populations.

The results of investigation of feeding in different stocks of Newfoundland haddock are shown on drawing 1, where the circle area is in proportion to the general index of stomach fullness, and section area - to the percentage value of different food ingredients based on individual indices. The highest rate of stomach fulness was registered on St.Pierre - 59.5‰. The main part of food comprised Sebastes (43.4%). Sufficiently important were also Ophiurae (22.6%). Practically equal parts represented Crustacea and Auchinoidea (accordingly 6.8 and 4.7%).

The indices of stomach fullness of haddock on the Great Newfoundland Bank differ from one area to another and fluctuate from 7.7‰ in the zone 3N upto 46.8‰ in the zone 3O. Fish is very important element in food of haddock on this Bank. In the zone 3N the fish food (Capelin) accounted for 33.7% of the food clod; in the zone 3 O capelin (30.5%) was rarely accompanied by juveniles of wolffish and paralepis. Also rather abundant was different fish which we failed to identify. However, in the zone 3L fish was not found at all in the stomachs of haddock but here the data are not comprehensive (only 15 stomachs are investigated).

In all zones of the Great Newfoundland Bank haddock feeds on Crustacea, practically in equal quantities (respectively 17.1%, 19.4% and 15.8%). The difference was noticed only in the quantity of used species: while in the zone 3O the representatives of all groups of Crustacea were found, in the zone 3N only those of 3 families. In the zones 3O and 3N haddock prefered Ephausseacea, wheras in the zone 3L in its food there was a lot of Gammaridae.

Rather often in the food of haddock of this Bank we came across Ophiurae and Polyhaeta.

Table 1. Composition of haddock food in Newfoundland area in 1963-1975.

Feeding organisms	% by mass	% by frequency
Nemertini	0.1	0.3
Gastropoda	0.2	-
Bivalvia	1.1	-
Mollusca, total	1.3	10.1
Polychaeta	5.4	3.1
Pantopoda	0.1	0.8
Mysidacea	0.1	
Hyperiidea	0.6	
Gammaridae	3.2	
Cumacea	2.3	
Isopoda	0.2	
Euphauseacea	4.4	
Decapoda	4.5	
Crustacea, indef.	2.5	
Crustacea, total	17.8	13.4
Sipunculoidea	0.1	1.0
Holothuroidea	0.8	3.1
Ophiurae	11.2	25.3
Euchinoidae	4.1	15.8
Ascidicea	1.0	5.1
Paralepis sp.	2.4	
Sebastes sp.	11.8	
M.villosus	16.7	
Anarchichas sp.	2.1	
Pisces indef., total	41.7	6.3
Digested food	19.6	10.0
Ground	1.1	5.7
General index of stomach fullness, $\%_{oo}$	31.3	
Total number of stomachs pcs.	452	452
including empty stomachs	21.7	20.9

For the haddock habitating the Flemish Cap Bank the index of stomach fullness is $20.9\%_{oo}$. The substantial part here belongs to Ophiurae sarsi, Polyhaeta and Crustacea. Rather usual are Euchinoidea (Str. droebachiensis).

The problem of quantity of food and its composition at different depths is a part of a problem of changes in feeding habits.

Table 2 gives the general food composition of haddock at the different depths. As it follows from the table the index of stomach fullness of haddock at the depth range of 50-100m has the lowest value and accounts only for 5.37‰. The main food of haddock at this depth is fish (41.4%) and Crustacea (36.2%). Other organisms are met rather seldom.

Table 2. FOOD COMPOSITION OF HADDOCK AT DIFFERENT DEPTHS IN NEWFOUNDLAND AREA (IN % BY MASS)

Food organisms	50-100	101-150	151-200	over 200
	depth, m			
Mollusca	0.1	0.9	1.8	8.9
Polyhaeta	3.2	3.9	2.5	23.7
Crustacea	36.2	4.5	13.6	35.1
Other Echinodermata	0.3	7.3	3.1	17.7
Ophiurae	2.7	22.3	10.4	7.2
Fish	41.4	50.4	36.2	-
Ground	1.9	0.7	1.4	1.6
Digested food	14.1	8.7	30.7	3.1
Others	0.1	1.1	0.3	2.7
General index of stomach fullness in‰	5.37	70.0	40.0	11.7
Number of stomachs	83	224	117	28
incl.empty, %	10.8	22.1	31.6	32.1

Within the depth range of 101-150 m the observations show the maximum satiation of haddock - 70‰. The substantial part of the food is fish (50.4%). Very important in this case are Ophiurae (22.3%). Other Echinodermata, Crustacea and Polyhaeta are rather abundant (respectively 7.3%, 4.5%, 3.9%), but not predominant.

At the depth of 151-200 m the satiation of haddock is still sufficiently high and is equal to 40‰. At this depth fish is the main part of feeding (36.2%). The presence of Crustacea is higher compared with previous level (13.6%) and that of Ophiurae lower (10.4%). There appeared a lot of digested food (30.7%). At the depth over 200 m the satiation

of haddock steeply falls down to 11.7‰ only. Fish, unlike upper depth levels, is absent completely and the basic food are Crustacea (35.1%) and Polyhaeta, the number of which increased sharply (23.7%). In bigger numbers we come across Opiurae and other Echinodermata (24.9%). Mollusca are not vital in the food composition though are used quite enough (8.9%).

The general characteristics of feeding of haddock in the Newfoundland area is the following: while the number of Mollusca at the lower levels is growing, the consumption of Polyhaeta, Crustacea, Ophiurae and other Echinodermata fluctuates at different depths. Fish comprising sometimes a half of the food clod in the shallow waters is practically completely absent in stomachs of haddock habitating at the depth over 200 m.

Ground at different levels is present in the same quantities.

The analysis of feeding of haddock at the different depths in Newfoundland area allows to assume that the feeding conditions for haddock improve during transition from smaller depths (50-100m) to deeper water layers (101-150m); in this depth range (101-150m) the feeding conditions apparently are optimum (the index of fullness at these depths is the highest and equals to 70‰). Further, at lower levels the feeding conditions deteriorate which is proved both by the desreasing stomach fullness and the number of empty stomachs (Table 2.).

A selective data on feeding of the Newfoundland haddock allowed to find out certain regularity. Therefore we tried to evaluate the obtained data unifying them by separate biological seasons.

The general dynamics of phenomena within the investigated field is represented as follows: March - May - the season of biological spring; June - August - apparently could be considered as summer months - at that time the biomass of plankton is the highest and reaches 500 mg/m^3; in August the plankton starts changing into its autumn stage and this season continues in September when the biomass of zooplankton is steeply falling (Vladimirskaya, 1962); the biological winter lasts till March and is characterized by the minimum development of zoo and

phytoplanktons (Mevchan, 1962). The division of seasons taken for the purposes of our analysis is conditional because within the same zone the biological seasons in some regions and from one year to another may somewhat change. In spite of all kind of fluctuations we nevertheless tried to trace some trends in the development and sequence of seasonable phenomena in the feeding of haddock.

The qualitative changes in the food composition of haddock by seasons are represented in Table 3. As it follows from the shown data, in the spring the feeding of haddock is accounted for various organisms. So, e.g. haddock of the Great Newfoundland Bank feeds on fish (63.7%), the main fish used is Capelin. Occasionally present are the juveniles of wolffish and paralepis. At the Bank of St.Pierre the feeding in the spring is based on Holothurioidea, Echinoidea, Ophiurae (47.1%) (Oph.aculeata, O.Sarsi, O.albida, O.robusta); fish is also rather important (21.6%) but the composition of fish by species sharply differs from the above: while at the Great Newfoundland Bank Sebastas mentella was practically absent in the stomachs of haddock at the Bank of St.Pierre it constitutes the main part of the food. As it was already pointed out the highest stomach fullness 57.9% was registered at the Bank of St.Pierre. At the Flemish Cap Bank the feeding of haddock in the spring is based on Ophiurae which , much to our regret, we failed to identify; substantially important as food are Polyhaeta, among them were observed the representatives of the following families: Nereidae, Cirratulidae, Glyceridae, Oweniidae etc. and Crustacea.

In the summertime haddock of the Great Newfoundland Bank as well as in the spring was feeding on fish (69.6%) of which 59.8% was constituted by capelin. The food of St.Pierre Bank haddock also consisted of fish (58.1%). Similar picture was noted by A.S.Noskov (Noskov, 1962) when he was pointing out intensive feeding of Newfoundland haddock on capelin, particularly in summer.

In autumn the material on haddock feeding was collected only in the Great Newfoundland Bank area. The total of 27

Table 3. COMPOSITION OF HADDOCK FOOD IN NEWFOUNDLAND AREA IN 1963-1975 IN DIFFERENT SEASONS (IN % BY MASS)

Feeding organisms	Saint Pierre Bank			Great Newfoundland Bank				Flemish Cap Bank	
	winter	spring	summer	winter	spring	summer	autumn	spring	summer
1	2	3	4	5	6	7	8	9	10
Bivalvia	3.7	0.9	0.9	-	0.3	0.1	-	,9	0.1
Gastropoda	1.4	0.1	0.6	-	0.2	0.1	-	-	0.2
Mollusca	-	0.3	-	-	0.1	-	-	0.4	-
Mollusca	5.1	1.3	1.1	-	0.6	0.1	-	5.3	0.3
Polychaeta	1.3	.3	1.8	-	0.3	4.4	0.4	20.9	12.7
Amphipoda	0.4	3.8	0.1	-	2.4	8.5	68.7	5.3	0.3
Cumacea	7.6	0.3	0.1	-	1.2	0.1	-	-	-
Isopoda	-	-	0.1	-	0.1	0.1	-	-	-
Euphausiacea	-	0.5	9.2	-	9.5	-	-	-	-
Mysidacea	-	-	-	-	0.1	-	-	-	-
Decapoda	-	1.3	-	-	0.3	-	13.1	0.3	2.3
Crustacea	0.1	1.8	-	-	0.6	0.2	16.0	20.0	-
Crustacea	8.1	7.7	9.5	-	14.2	8.9	97.8	26.4	2.6
Echinoidea	0.1	8.6	1.8	-	0.9	0.1	-	11.5	19.4
Ophiurae	32.7	36.3	1.8	-	7.9	2.0	-	31.2	15.4
Holothuroidea	1.6	2.2	-	-	0.8	0.2	-	-	-
Euhinodermata	34.4	47.1	2.8	-	9.6	2.3	-	42.	34.8
Anarchichas sp.	-	-	-	-	11.6	-	-	-	-
Locodes sp.	-	-	-	-	0.1	-	-	-	-
Paralepis sp.	-	-	-	-	11.9	-	-	-	-
M.villossus	-	-	-	-	29.0	59.8	-	-	-
Sebastes sp.	-	19.8	-	-	-	-	-	-	-
Pisces	49.8	1.8	58.1	-	11.1	9.8	-	-	-
Pisces	49.8	21.6	58.1	-	63.7	69.6	-	-	-
Ground	0.6	1.1	1.6	-	0.5	3.2	-	1.7	-
Other	0.7	3.4	0.1	-	0.5	0.1	-	1.6	-
Digested food	-	13.5	25.0	-	8.2	11.3	1.8	1.4	49.6
General index ‰ of stomach fullness	63.5	57.9	70.4	0.0	39.3	78.2	106.6	10.0	20.3
Mean point of stomach fullness	2.2	1.2	1.9	0.0	2.0	2.8	-	1.7	1.9
Number of feeding individuals %	100.0	71.5	100.0	0.0	8.9	84.4	88.9	71.5	100.0
Total number of stomachs, pcs.	9	210	15	15	113	32	27	21	10
including empty %	0.0	28.5	0.0	100.0	14.1	15.6	11.1	28.5	0.0

stomachs was studied, of which 11.1% were empty. The main food of haddock in this area consisted of crustacea (97.8%), mainly Hyperidae(Par.compressa, Par.lebellula) and shrimps (Pand.annulicornis).

The data concerning haddock feeding in winter are extremely limited and by no means representative. All the 15 stomachs studied in the Great Newfoundland Bank area turned out to be empty. In the Saint Pierre Bank area the major part of food of 9 haddocks was made by remainder of fish (49.8%) and Ophiurae (32.7%).

It should be marked that the total number of feeding haddock individuals in the Newfoundland area increases from spring to summer and autumn, going down by winter. The main feeding of haddock is likely to take place in summer and autumn. The mean point of stomach fullness testifies to it.

Conclusions

1. Species composition of feeding organisms found in Haddock stomach in the Newfoundland area comprises 118 names. The main part of food is represented by bottom species, small benthos in the first hand: crustacea, Ophiurae, sea urchins, polychaetae. The role of fish is rather important, mainly of capelin and redfish. Wolffish and paralepis juveniles were found rarely in stomachs.

2. The biggest amount of food in haddock stomach was observed in the Saint Pierre Bank area where the bulk of its food was made by redfish and Ophiurae. In different parts of the Great Newfoundland Bank the general index of stomach fullness for haddock varied within the limit of 7.7 - 46.8‰ with food consisting of crustacea and capelin. The haddock of Flemish Cap Bank has the index of fullness 20.9‰. Polychaetae, crustacea and ophiurae play an important role here.

3. The analysis of feeding of haddock inhabiting different depths showed that as a whole feeding conditions are better at small depths than at big ones. Optimum feeding conditions for haddock in the Newfoundland area are likely to be at the depth interval of 100-150 m.

4. Seasonal changes in haddock feeding make it possible to assume that the main feeding period is summer - autumn which is proved by a big number of feeding individuals and maximum indexes of stomach fullness. Modification of quality composition of food is rather noticeable: while in spring the main part of food is fish, crustacea and ophiurae and on Flemish Cap Bank polychaetae, in spring haddock was consuming mainly fish. In autumn haddock feeds mostly on crustacea.

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