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DIET OVERLAP BETWEEN NORTH-EAST ARCTIC COD AND HADDOCK IN THE SOUTHERN PART OF THE BARENTS SEA IN 1984-1986.

by

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ABSTRACT

The diet composition of North-East Arctic cod (Gadus morhua) and haddock (Melanogrammus aeglefinus) are examined from stomach content data. Fish were collected in the southern part of the Barents sea from 1984 through 1986. A total of 4790 cods and 1361 haddocks were divided according to season (winter, spring, and fall) and fish size in 10 cm size classes. Only fish bigger than 10 cm length were considered.

Diet overlap between the two species for each size group in each season was calculated using the Schoener's index.

North-East Arctic cod show a size dependent shift in the diet. Fish smaller than 20 cm prey mainly on crustaceans (euphauiids, deep sea shrimp and amphipods). Above 20 cm, cod incorporate fish in the diet to a larger degree, the degree increasing with the size of the predator. Some seasonal changes are described.

Haddock, a less ichthiophagous predator, prefer more benthic preys including echinoderms, gastropods, bivalves and polychaetes.

In general the diet overlap is low except in spring and fall when the smaller size groups of both species prey on euphausiids.

The results are compared with previous information on cod-haddock interaction.

INTRODUCTION

The development of a multispecies model for the Barents Sea by the Institute of Marine Research - Bergen has stressed the need of a better understanding of the trophic links among commercially exploited species. Inside this framework, a systematic stomach sampling program was started in 1984 to provide quantitative information on food consumption by the main predators in the area (Mehl et al., 1985). The North East Arctic cod and haddock were chosen as objectives of this sampling program both because of their importance as fisheries resources and because of their ecological significance as carnivorous predators.

The current paper analyses comparatively the use of the prey spectrum by these two gadoid species in the southern Barents Sea, showing an

important segregation in this niche axis.

MATERIALS AND METHODS

The stomachs of cod and haddock were collected aboard research vessels during routine surveys in the Barents Sea from 1984 to 1986. In the present study, a specific subset of samples taken in the southern part of the Barents Sea was selected, representing a region where the geographical distribution of both species overlaps throughout the year. Fig. 1 shows the area referred to as the southern Barents Sea with the geographical location of the samples.

The sampling procedure basically followed that proposed for the North Sea (Anon.,1980; Anon.,1981; Westgård,1982) and it was described in detail in Mehl (1986).

The total information for each species was pooled according to season (winter, spring and fall) and fish total length in 10 cm size classes. Consequently, cod were divided in seven size groups starting with 10-19.9 cm and ending with >70 cm, while haddock were divided into four groups from 10-19.9 cm to >40 cm. Fig.2 and Fig.3 show the size frequency distribution of all the individuals of cod and haddock respectively sampled before they were grouped. Table I summarizes the number of stomachs sampled in each size class during each season.

The average of the weight percentages was computed for each food item within the size class and season as an index of relative importance in the diet composition. The index is calculated as :

$$\overline{\%\ W_i} = \frac{1}{N} \Sigma \frac{W_{ij}}{W_j} \cdot 100$$

Where

$\overline{\%\ W_i}$:is the average of the wet weight percentages of the prey

W_{ij} :is the wet weight of prey item in the predator .

W_j :is the wet weight of the total stomach content of the predator .

N :is the total number of predators with food in their stomachs.

The contribution of the unidentified stomach contents were distributed proportionally among the identified preys. Only those prey items with more than 0.1% of average weight percentages were used in further calculations.

The diet overlap between the different size groups of cod and haddock in each season was examined using the Schoener's index.The expression for this measure is:

$$C_{jk} = 1 - 0.5 \Sigma |P_{ij} - P_{ik}|$$

Where P_{ij} and P_{ik} are the proportions of the prey in the diets of predator j and k respectively (In the present paper those proportions are given by the average weight percentages). The possible values of the Scoener's index ranges from 0 (no diet overlap) to 1 (identical diet composition).

SOME COMMENTS ON THE DATA ANALYSIS

The methods employed in studying the diet composition through stomach content analysis have motivated several reviews (Hynes,1950; Pillay,1952; Windell and Bowen,1978; Berg,1979; Hyslop,1980; Hansson,1980; Wallace,1981). From them, we have drawn some conclusions which account for the way we analyzed the data, its advantages and

limitations.

All the methods commonly in use (Occurrence, Numerical, Volumetric, and Gravimetric) attempt to give a measure of "relative importance" of the components in the diet. However, each method describes a different characteristic of the feeding activity leading sometimes to divergent results and interpretations. The choice of a particular measure is frequently a question of practical constraint, therefore it is advisable to define and examine the term dietary importance in the context of a specific study. Hylsop (1980) and Berg (1979) conclude that instead of a single measure, both numerical and bulk measurements should be presented in order to avoid loosing information.

In the present paper the main goal is to study the diet overlap between two species. Hence, it is neccessary to describe quantitatively their food resource utilization. In agreement with Wallace (1981) and Hansson (1980) we chose a gravimetric method i.e. the average of the wet weight percentages.

The bulk measures like the wet weight have, compared with the numerical and occurence methods, the advantage of giving an idea of the nutritional value of a prey. However, it should be kept in mind that since the water content, the chemical composition and the presence of undigestable material are not being differentiated, bulk and energy content are not equivalent.

The percentage by weight, which is commonly employed in calculations of consumption rates, gives an incorrect picture of the diet composition. It over emphasizes the importance of large single prey eaten by few individuals distributing their weights over the whole population. The use of the average of the weight percentages seems to correct this bias (Wallace,1981). However, this method shares an important source of bias with the other bulk methods: it does not take into account the different rates of digestion of the prey items. Jobling (1987) discusses the influence of prey size, energy content and friability of prey on the digestion rates. Even though this distortion is not solved in this study, the analysis is carried out on the assumption that the general trends in the feeding habits of both predator species are maintained.

The diet overlap was quantified using the Schoener's index (Schoener, 1968). It has been shown, through computer simulation, that this index estimates general overlap satisfactorily over most of the potential range of overlaps tested (Linton et al.,1981).

RESULTS AND DISCUSSION

The food of North-east Arctic cod

The taxonomical list of the identified preys of cod is presented in table II. The relative contributions of the main food items by season and by cod size are shown in fig. 4 and in tables III, IV and V.

The diet of cod is clearly dominated by crustaceans and fish , even though a variety of other prey groups were recognized.

According to the way the data were organized, it is possible to follow seasonal and size dependent changes in the food spectrum. In the three seasons studied, there is a conspicuous shift in the diet composition of cod being above and below 20 cm in total length. The smaller group preferentially preys on crustaceans. Euphausiids, amphipods (mainly hyperiids) and the prawn Pandalus borealis

constitute more than 70 % of the nourishment of this group. The importance of these three components varies seasonally and the changes suffered by the euphausiids are particularly noticeable. Krill contribute with a wintry level of 17 %, while during the spring bloom it rises up to almost 70 %. Fish prey represent only around 10 % of the food of cod smaller than 20 cm.

Above 20 cm, cod prey more intensively on fish species. The average contribution of fish preys in winter, spring and fall are about 65 %, 50 % and 35 % respectively. Among the different fish species preyed upon by cod, capelin (Mallotus villosus) play a special role. This species by itself represents more than 60 % of the total fish prey contribution during winter and spring. In the first half of the year cod meet the dense schools of mature capelin which migrate towards the spawning grounds in the coast of Murman and Finmark (Ozhigin and Luka,1984). In the autumn the importance of capelin as a prey in the southern part of the Barents Sea drops. The main concentrations of capelin in this season are located in the feeding grounds, north of the studied area. (See the figures 7-19 in Dommasnes and Røttingen (1984)). The redfish Sebastes spp. and some species of gadids have also a significant contribution to the diet of cod.

Pandalus borelis is the most important crustacean prey of cod larger than 20 cm. Even though the values of relative importance of the P. borealis are higher in spring and autumn than in winter, the seasonal variation is less pronounced than that of capelin and the euphausiids. Ponomarenko and Yaragina (1984), recording frequency of occurence, found the same trend.

The food of North-east Arctic haddock

The taxonomical list of the identified preys of haddock is presented in table VI. The relative contributions of the main food items by season and haddock size are shown in fig. 5 and in tables VII, VIII and IX.

The diet of haddock is characterized by the inclusion of benthic preys as the chief components. Fish preys are not as important as in the cod diet and, in average, contribute only with 10% of the food eaten. Capelin (M. villosus) and the redfish (Sebastes spp.) are the most important fish preys. Capelin are not found in the stomach contents of haddock in the autumnal samples confirming the low availability reflected in cod stomachs. Moreover predation upon euphausiids by haddock follows a pattern similar to that described for small cod. Thus, the contribution of euphausiids in winter is low but during the spring krill becomes one of the main prey items. This is specially true for the smaller group of haddock analysed for which euphausiids represent 65 % of their diet in spring. In autumn, krill is also a very important prey for small haddock. It is worth mentioning that during winter, when the dietary importance of krill is low, haddock prey more intensively on amphipods.

A distinct feature of the predatory habits of haddock is the importance of benthic preys in their diet. Polychaets, molluscs (gastropods and lamellibranchs in particular) and echinoderms are the most important groups. Among the echinoderms the ophiuroids are the dominant class and represent in average more than 90 % of the contribution of this phyllum to the nourishment of haddock. No seasonal pattern was found in the exploitation of the benthos.

The diet overlap between cod and haddock

The values of Schoener's index of diet overlap between the size groups of cod and haddock during the three seasons studied are given

in table X. Unfortunately, it is not posible to analyse the results statistically because they depend too much on the way the prey items are defined. Following the convention adopted by Langton (1982) the values are divided in: low overlap (0.0-0.29), medium (0.30-0.60) and high overlap > 0.60.

From the matrices shown in tabe X it is easy to see that, in general, the values of diet overlap are low. Only during spring and autumn high values are found between the smaller size groups of both species. Heavy predation upon euphausiids seems to be the reason for those high values of diet overlap.

The main features of the comparative feeding behaviour of cod and haddock described in this paper agree with previous studies in the area (Novikova,1966) and in other regions (Kohler and Fitzgerald,1969; Brown and Cheng,1946). Jones (1978) also presents some experimental evidence concerning the different feeding strategies of both gadids during their demersal feeding stage. Cod prey upon conspicuous and lively prey species using a relative high searching rate while haddock spend more time in a patch, looking for slow-moving or sessile preys frequently hidden in the sediments. However, these differences in the use of the resources become less clear when comparing the diet of the the smaller individuals sampled. Therefore, in order to understand the mechanims of co-existence employ for these two important groups of predators in the Barents Sea, a more detailed study of the trophic structure in the pelagic feeding stages should be done.

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TABLE I - Number of stomachs sampled of cod and haddock in the southern part of the Barents sea from 1984 to 1986. Data pooled by season and by predator size. (Only fish bigger than 10 cm total length are considered).

COD (Gadus morhua)

	SIZE CLASS (cm)							
SEASON	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	>70	TOTAL
WINTER								
w/food	239	436	552	647	527	329	200	2930
empty	129	184	167	149	106	068	038	0841
vomited	031	000	000	000	000	000	000	0031
TOTAL	399	620	719	796	633	397	238	3671
SPRING								
w/food	100	106	127	076	060	019	018	0506
empty	056	072	102	088	075	030	013	0436
vomited	000	000	000	000	000	000	000	0000
TOTAL	156	178	229	164	135	049	031	0942
FALL								
w/food	104	166	177	354	221	179	153	1354
empty	058	089	065	113	073	061	043	0502
vomited	001	000	000	000	000	000	000	0000
TOTAL	163	255	242	467	294	240	196	1857

HADDOCK (Melanogrammus aeglefinus)

	SIZE CLASS				
SEASON	10-19.9	20-29.9	30-39.9	>40	TOTAL
WINTER					
w/food	064	153	114	120	451
empty	048	117	085	059	309
vomited	000	000	000	000	000
TOTAL	112	270	199	179	760
SPRING					
w/food	058	141	093	064	356
empty	033	051	035	026	145
vomited	000	001	000	000	001
TOTAL	091	193	128	090	502
FALL					
w/food	061	170	199	133	563
empty	034	070	033	022	159
vomited	000	000	000	000	000
TOTAL	095	240	232	155	722

TABLE II - LIST OF THE PREY ITEMS SORTED FROM THE TOTAL ANALYSED STOMACHS OF COD (*Gadus morhua*).

PHYLLUM	CLASS	SUBCLASS	ORDER	SUBORDER (SECTION)	FAMILY	SPECIES
ALGAE	PHAEOPHYCEA					
PORIFERA						
CNIDARIA	SCYPHOZOA					
	ANTHOZOA		ACTINARIA		METRIDIIDAE	*Metridium senile*
ANNELIDAE	POLYCHAETA					
MOLLUSCA	GASTROPODA					
	BIVALVIA					
	CEPHALOPODA		DECAPODA			*Rossia* sp.
						Gonatus fabricii
						Ommastrephes sagi
ARTHROPODA	CRUSTACEA	COPEPODA	CALANOIDA			*Calanus finmarchicus*
			CYCLOPOIDA			
		MALACOSTRACA	MYSIDACEA		MYSIDAE	
			ISOPODA			
			AMPHIOPDA	HYPERIIDEA		
			EUPHAUSIACEA		EUPHAUSIDAE	*Meganyctiphanes norvegica*
						Thysanoessa sp.
			DECAPODA	NATANTIA		
				(PENAEIDA)	SERGESTIDAE	*Sergestes arcticus*
				EUCYPHIDEA	HIPPOLYTIDAE	*Spirontocaris spinus*
					PANDALIDAE	*Pandalus borealis*
					CRANGONIDAE	*Crangon allmanni*
						Sclerocrangon ferox
						Pontophilus norvergicus
				REPTANTIA		
				(ANOMURA)	PAGURIDAE	*Pagurus bernardus*
					GALATHEIDAE	*Munida sarsi*
				(BACHIURA)	MAJIDAE	*Hyas coarctatus*
						Hyas araneus
					GERYONIDAE	*Geryon tridens*
SIPUNCULIDA						
ECHINODERMATA	ASTEROIDEA					*Ceramastes granularis*
	OPHIUROIDEA					
	ECHINOIDEA					
	HOLOTHUROIDEA					
CHORDATA	ASCIDIACEA					
	CHONDRICHTHYES	ELASMOBRANCHII	RAJIFORMES		RAJIDAE	
	OSTEICHTHYES	ACTINOPTERYGII			CLUPEIDAE	*Clupea harengus*
					OSMERIDAE	*Mallotus villosus*
					STERNOPTYCHIDAE	*Maurolicus mulleri*
					GADIDAE	*Boreogadus saida*
						Gadus morhua
						Melanogrammus aeglefinus
						Trisopterus esmarkii
						Merlangius merlangius
						Micromesistius poutassou
					ZOARCIDAE	*Lycodes vahli*
						Lycodes esmarkii
					MACROURIDAE	*Macrourus berglax*
					SCORPENIDAE	*Sebastes* sp.
					COTTIDAE	*Artediellus atlanticus*
					AGONIDAE	*Agonus decagonus*
					LIPARIDAE	*Careproctus reinhardti*
					ANARHICHADIDAE	*Anarichas* sp.
					LUMPENIDAE	*Lumpenus lampretiformis*
						Leptoclinus maculatus
					AMMODYTIDAE	
					PLEURONECTIDAE	*Hippoglossoides*
						platessoides

TABLE III -Diet composition in average of the wet weight percentages of the different size classes of North-east Arctic cod in autumn.

	Length classes of Cod in cm						
Prey species	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	>70
PHAEOPHYCEA	-----	-----	-----	-----	-----	-----	-----
PORIFERA	-----	-----	-----	-----	-----	-----	-----
CNIDARIA	-----	-----	-----	-----	-----	-----	-----
Scyphozoa	-----	-----	-----	-----	-----	-----	1.2
Antozoa	-----	-----	0.5	-----	0.6	-----	0.4
POLYCHAETA	3.9	1.9	2.1	0.8	0.6	1.1	0.9
MOLLUSCA							
Gastropoda	-----	-----	-----	-----	0.2	-----	0.7
Bivalvia	-----	-----	-----	-----		0.6	-----
Cephalopoda	-----	-----	0.8	0.8	1.5	0.9	1.7
CRUSTACEA							
Copepoda	-----	2.4	-----	-----	-----	-----	-----
Mysidae	-----	-----	-----	-----	-----	-----	-----
Isopoda	-----	0.8	-----	0.3	0.3	0.5	0.7
Amphipoda Hyperiidae	14.2	5.6	15.1	10.5	14.6	19.1	5.4
Other Amphipoda	4.7	0.5	0.7	0.2	0.1	-----	0.2
Euphausiiacea	53.9	21.8	7.5	7.8	8.9	5.3	0.6
Sergestidae	-----	-----	-----	-----	-----	-----	-----
Hipolytidae	-----	-----	-----	-----	0.3	-----	-----
Pandalidae	16.7	27.1	38.5	38.2	35.9	33.0	40.8
Crangonidae	-----	11.9	1.5	0.9	1.5	0.9	0.8
Anomura	-----	0.3	1.6	2.5	3.8	1.1	1.4
Brachiura	-----	-----	-----	0.4	1.1	1.0	1.4
SIPUNCULA	-----	-----	-----	0.3	-----	-----	-----
ECHINODERMATA	-----	-----	-----	-----	-----	-----	-----
Asteroidea	-----	-----	-----	-----	0.2	-----	-----
Ophiuroidea	-----	-----	-----	-----	0.1	0.1	-----
Echinozoa	-----	-----	-----	-----	-----	-----	-----
Holothuroidea	-----	0.6	-----	0.2	0.6	-----	-----
ASCIDIACEA	-----	-----	-----	-----	-----	-----	0.4
PISCES							
Rajidae	-----	-----	-----	-----	-----	-----	-----
Clupea harengus	-----	-----	6.2	7.3	3.4	1.2	2.1
Mallotus villosus	-----	-----	4.6	10.2	8.0	8.8	2.2
Maurolicus muelleri	-----	-----	-----	-----	-----	0.6	-----
Benthosema glaciale	-----	-----	-----	-----	-----	-----	-----
Gadidae	-----	1.5	1.9	3.9	4.2	10.0	17.1
Zoarcidae	-----	-----	-----	-----	-----	1.2	-----
Macrourus berlax	-----	-----	-----	-----	-----	3.3	2.2
Sebastes spp.	6.7	12.1	12.9	12.9	4.8	2.1	13.6
Cottidae	-----	-----	0.3	0.9	1.3	-----	0.2
Agonidae	-----	-----	-----	-----	-----	-----	-----
Liparidae	-----	-----	-----	-----	-----	-----	-----
Anarchidae	-----	-----	-----	-----	-----	-----	-----
Lumpenidae	-----	3.7	0.8	-----	-----	1.4	-----
Ammodytidae	-----	1.2	1.6	0.9	3.4	2.0	-----
Pleuronectidae	-----	7.8	3.7	0.9	4.0	5.9	5.0

TABLE IV -Diet composition in average of the wet weight percentages of the different size classes of North-east Arctic cod in winter.

Prey species	Length classes of Cod in cm						
	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	>70
PHAEOPHYCEA	-----	-----	-----	-----	-----	-----	-----
PORIFERA	-----	-----	-----	-----	-----	-----	-----
CNIDARIA							
Scyphozoa	-----	-----	-----	-----	-----	-----	-----
Antozoa	-----	-----	-----	-----	0.1	0.1	0.1
POLYCHAETA	2.5	0.9	0.2	0.2	0.2	-----	-----
MOLLUSCA							
Gastropoda	-----	-----	-----	-----	-----	-----	-----
Bivalvia	-----	-----	-----	-----	-----	-----	0.1
Cephalopoda	-----	-----	0.2	0.2	0.1	0.2	-----
CRUSTACEA							
Copepoda	1.0	0.3	0.2	-----	-----	-----	-----
Mysidae	4.6	1.9	0.6	0.6	0.2	0.2	-----
Isopoda	-----	-----	0.2	0.1	0.1	0.4	-----
Amphipoda Hyperiidae	21.9	0.6	3.4	4.4	5.2	3.0	1.2
Other Amphipoda	1.9	0.8	-----	0.4	0.2	0.5	-----
Euphausiiacea	17.3	1.7	3.1	2.3	1.9	1.5	0.2
Sergestidae	-----	-----	0.1	-----	-----	0.1	0.1
Hipolytidae	-----	-----	-----	-----	-----	-----	0.2
Pandalidae	35.4	36.3	22.4	19.2	22.0	28.5	20.0
Crangonidae	4.4	2.5	1.9	0.9	1.5	1.6	0.6
Anomura	-----	-----	0.1	-----	-----	-----	0.9
Brachiura	-----	0.6	0.2	0.1	0.5	1.6	1.7
SIPUNCULA	-----	-----	-----	0.2	-----	-----	-----
ECHINODERMATA							
Asteroidea	-----	-----	-----	-----	-----	-----	-----
Ophiuroidea	-----	-----	0.1	-----	0.2	-----	-----
Echinozoa	-----	-----	-----	-----	-----	-----	0.1
Holothuroidea	-----	0.2	0.5	0.1	0.2	0.6	0.1
ASCIDIACEA	-----	-----	-----	-----	-----	-----	0.1
PISCES							
Rajidae	-----	-----	-----	-----	-----	-----	-----
Clupea harengus	-----	4.1	4.0	3.9	1.2	0.9	0.4
Mallotus villosus	5.4	27.4	34.9	49.5	45.6	39.7	47.5
Maurolicus muelleri	-----	-----	-----	-----	-----	-----	-----
Benthosema glaciale	-----	0.5	-----	0.3	1.0	0.4	0.6
Gadidae	2.7	1.3	0.9	1.2	1.2		11.2
Zoarcidae	-----	-----	-----	-----	-----	2.6	0.4
Macrourus berlax	-----	-----	-----	-----	-----	-----	-----
Sebastes spp.	2.7	20.1	26.4	16.1	18.2	17.1	14.0
Cottidae	-----	0.3	-----	-----	-----	-----	-----
Agonidae	-----	-----	0.3	-----	-----	-----	-----
Liparidae	-----	0.5	-----	-----	-----	-----	-----
Anarchidae	-----	-----	-----	-----	-----	-----	-----
Lumpenidae	-----	-----	0.6	-----	-----	-----	-----
Ammodytidae	-----	-----	-----	-----	-----	-----	-----
Pleuronectidae	-----	0.5	-----	-----	0.1	0.7	0.6

TABLE V -Diet composition in average of the wet weight percentages of the different size classes of North-east Arctic cod in spring.

Prey species	Length classes of Cod in cm						
	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	>70
PHAEOPHYCEA	-----	-----	-----	-----	-----	-----	-----
PORIFERA	-----	-----	-----	-----	-----	-----	-----
CNIDARIA							
Scyphozoa	-----	-----	-----	-----	-----	-----	-----
Antozoa	-----	-----	0.8	-----	-----	-----	-----
POLYCHAETA	3.7	0.7	1.9	1.3	-----	-----	-----
MOLLUSCA							
Gastropoda	-----	-----	-----	-----	-----	-----	-----
Bivalvia	0.1	-----	-----	-----	1.7	-----	-----
Cephalopoda	-----	-----	-----	-----	-----	-----	-----
CRUSTACEA							
Copepoda	0.1	0.5	-----	-----	-----	-----	-----
Mysidae	-----	-----	1.1	-----	-----	-----	-----
Isopoda	1.1	-----	-----	-----	2.0	5.3	-----
Amphipoda Hyperiidae	4.0	1.6	-----	3.0	1.9	-----	-----
Other Amphipoda	1.3	2.7	0.9	1.4	-----	-----	-----
Euphausiiacea	68.8	24.9	7.4	6.9	-----	6.8	3.4
Sergestidae	-----	-----	-----	-----	-----	-----	-----
Hipolytidae	-----	-----	-----	-----	-----	-----	-----
Pandalidae	6.8	15.9	37.9	48.3	51.7	39.7	29.1
Crangonidae	3.3	-----	-----	0.6	0.1	-----	-----
Anomura	-----	-----	0.9	1.4	2.0	-----	-----
Brachiura	-----	-----	-----	2.8	2.1	-----	-----
SIPUNCULA	-----	-----	-----	-----	-----	-----	-----
ECHINODERMATA	-----	-----	-----	-----	-----	-----	-----
Asteroidea	-----	-----	-----	-----	-----	-----	-----
Ophiuroidea	-----	-----	0.8	-----	-----	-----	0.1
Echinozoa	-----	-----	-----	0.6	-----	-----	-----
Holothuroidea	-----	-----	-----	-----	-----	-----	-----
ASCIDIACEA	0.1	-----	-----	-----	-----	-----	-----
PISCES							
Rajidae	-----	-----	-----	-----	-----	-----	-----
Clupea harengus	2.1	-----	-----	-----	-----	-----	-----
Mallotus villosus	8.6	49.1	30.8	28.5	36.7	12.1	26.0
Maurolicus muelleri	-----	-----	-----	-----	-----	-----	-----
Benthosema glaciale	-----	-----	-----	-----	-----	-----	-----
Gadidae	-----	-----	2.9	-----	1.6	36.1	32.0
Zoarcidae	-----	-----	-----	-----	-----	-----	8.8
Macrourus berlax	-----	-----	-----	-----	-----	-----	-----
Sebastes spp.	-----	-----	5.3	2.0	-----	-----	-----
Cottidae	-----	-----	1.4	-----	-----	-----	-----
Agonidae	-----	-----	-----	-----	-----	-----	-----
Liparidae	-----	-----	-----	-----	-----	-----	-----
Anarchidae	-----	-----	-----	-----	-----	-----	-----
Lumpenidae	-----	-----	-----	-----	-----	-----	-----
Ammodytidae	-----	4.4	7.6	2.8	-----	-----	-----
Pleuronectidae	-----	-----	-----	-----	-----	-----	-----

TABLE VI - LIST OF THE PREY ITEMS SORTED FROM THE TOTAL ANALYSED STOMACHS OF HADDOCK (*Melanogrammus aeglefinus*)

PHYLLUM	CLASS	SUBCLASS	ORDER	SUBORDER (SECTION)	FAMILY	SPECIES
ALGAE	PHAEOPHYCEAE					
PORIFERA						
CNIDARIA	SCYPHOZOA					
	HYDROZOA					
	ANTHOZOA				METRIDIIDAE	*Metridium senile*
RHYNCHOCOELA						
ANNELIDA	POLYCHAETA				APHRODITIDAE	*Aphrodite aculeata*
MOLLUSCA	GASTROPODA					
	BIVALVIA				PECTINIDAE	
	CEPHALOPODA		DECAPODA			
ARTHROPODA	CRUSTACEA	COPEPODA	CYCLOPOIDA			
		MALACOSTRACA	MYSIDACEA		MYSIDAE	
			ISOPODA			
			AMPHIOPDA	HYPERIIDEA		
			EUPHAUSIACEA		EUPHAUSIDAE	*Thysanoessa inermis*
			DECAPODA	NATANTIA (PENAEIDA)	SERGESTIDAE	*Sergestes arcticus*
					PANDALIDAE	*Pandalus borealis*
					CRANGONIDAE	*Pontophilus norvergicus*
				REPTANTIA (ANOMURA)	PAGURIDAE	
					GALATHEIDAE	*Munida sarsi*
					CALLIANASSIDAE	
				(BACHIURA)	MAJIDAE	*Hyas araneus*
					GERYONIDAE	*Geryon tridens*
SIPUNCULIDA						
ECHINODERMATA	ASTEROIDEA					
	OPHIUROIDEA					
	ECHINOIDEA					*Echinus acutus*
	HOLOTHUROIDEA					
CHORDATA	ASCIDIACEA					
	OSTEICHTHYES	ACTINOPTERYGII			CLUPEIDAE	*Clupea harengus*
					OSMERIDAE	*Mallotus villosus*
					GADIDAE	*Melanogrammus aeglefinus*
						Trisopterus esmarkii
					SCORPENIDAE	*Sebastes* sp.
					COTTIDAE	
					LUMPENIDAE	*Lumpenus lampretiformis*
					AMMODYTIDAE	
					PLEURONECTIDAE	*Hippoglossoides platessoides*
					MYCTHOPHIDAE	*Benthosema glaciale*

TABLE VII- Diet composition in average of the wet weight percentages of the different size classes of North-east Arctic haddock in autumn.

	Length classes of Haddock in cm			
Prey species	10-19.9	20-29.9	30-39.9	>40
PHAEOPHICEA	2.1	-----	-----	-----
PORIFERA	-----	-----	-----	-----
CNIDARIA				
Hydrozoa/scyphozoa	-----	-----	0.4	-----
Antozoa	-----	1.8	0.5	5.2
NEMERTINA	-----	-----	0.4	0.7
POLYCHAETA	3.5	4.7	5.1	6.6
MOLLUSCA				
Gastropoda	-----	4.5	7.6	1.8
Bivalvia	5.1	7.8	12.5	9.7
Cephalopoda	-----	-----	-----	1.3
PICNOGONIDA	-----	-----	-----	-----
CRUSTACEA				
Mysidacea	0.7	-----	-----	-----
Isopoda	-----	-----	-----	0.4
Amphipoda Hyperiidae	8.1	6.5	2.2	7.7
Other Amphipoda	-----	3.1	6.4	2.9
Euphausiiacea	38.0	12.2	4.1	6.6
CARIDEA	11.2			
Pandalidae	-----	6.2	5.2	6.0
Crangonidae	-----	1.0	-----	-----
Brachiura	-----	0.9	-----	1.7
Anomura	0.4	7.1	7.4	2.9
SIPUNCULIDA	-----	-----	0.7	2.0
ECHINODERMATA				
Ophiuroidea	15.6	29.2	31.3	27.0
Echinozoa	-----	0.1	1.8	4.8
Holothuroidea	-----	0.6	2.5	6.9
Asteroidea	-----	0.3	1.1	1.4
ASCIDIACEA	-----	-----	-----	1.2
PISCES				
Clupea harengus	-----	-----	-----	-----
Mallotus villosus	-----	-----	-----	-----
Trisopterus esmarkii	-----	-----	-----	-----
M. aeglefinus	-----	1.7	-----	-----
Sebastes sp	16.1	9.9	10.7	2.1
H. patessoides	-----	-----	-----	2.1
Bentosema glaciale	-----	-----	-----	-----
Lumpenus lampretiformis	-----	-----	-----	-----
Cottidae	-----	1.7	-----	-----

TABLE VIII -Diet composition in average of the wet weight percentages of the different size classes of North-east Arctic haddock in winter.

	Length classes of Haddock in cm			
Prey species	10-19.9	20-29.9	30-39.9	>40
PHAEOPHICEA	-----	1.5	2.0	0.9
PORIFERA	-----	-----	-----	-----
CNIDARIA				
Hydrozoa/Scyphozoa	-----	-----	-----	-----
Antozoa	-----	-----	-----	3.2
NEMERTINA	-----	-----	-----	-----
POLYCHAETA	18.1	7.2	5.3	3.1
MOLLUSCA				
Gastropoda	10.8	8.7	5.3	3.4
Bivalvia	17.4	8.7	8.8	7.1
Cephalopoda	-----	-----	-----	-----
PICNOGONIDA	-----	-----	1.0	-----
CRUSTACEA				
Mysidacea	-----	-----	-----	-----
Isopoda	3.0	1.0	1.2	1.1
Amphipoda Hyperiida	8.5	14.6	9.5	18.1
Other Amphipoda	23.7	9.4	5.9	9.7
Euphausiiacea	8.5	6.2	9.1	10.9
CARIDEA				
Pandalidae	-----	5.3	7.0	6.6
Crangonidae	-----	2.5	-----	1.5
Brachiura	-----	1.0	0.9	-----
Anomura	-----	-----	-----	2.3
SIPUNCULIDA				
ECHINODERMATA	-----	-----	-----	-----
Ophiuroidea	4.3	20.3	29.1	22.0
Echinozoa	-----	-----	-----	0.4
Holothuroidea	-----	-----	-----	0.9
Asteroidea	-----	-----	-----	-----
ASCIDIACEA	-----	-----	-----	-----
PISCES	5.4			
Clupea harengus	-----	----	1.2	-----
Mallotus villosus	-----	12.6	9.1	1.2
Trisopterus esmarkii	-----	-----	1.0	1.2
M. aeglefinus	-----	-----	-----	-----
Sebastes sp	-----	1.0	4.6	6.4
H. patessoides	-----	0.2	-----	-----
Bentosema glaciale	-----	-----	-----	-----
Lumpenus lampetriformis	-----	-----	-----	-----
Cottidae	-----	-----	-----	-----

TABLE IX - Diet composition in average of the wet weight percentages of the different size classes of North-east Arctic haddock in spring.

	Length classes of Haddock in cm			
Prey species	10-19.9	20-29.9	30-39.9	>40
PHAEOPHICEA	-----	0.8	-----	-----
PORIFERA	0.8	-----	-----	-----
CNIDARIA				
Hydrozoa/Scyphozoa	-----	-----	-----	-----
Antozoa	-----	1.8	1.4	0.6
NEMERTINA	-----	-----	-----	-----
POLYCHAETA	6.4	2.9	3.5	3.0
MOLLUSCA				
Gastropoda	-----	0.1	1.5	-----
Bivalvia	-----	3.3	3.1	2.0
Cephalopoda	-----	-----	-----	
PICNOGONIDA	-----	-----	-----	1.9
CRUSTACEA				
Mysidacea	-----	-----	-----	-----
Isopoda	-----	-----	-----	0.1
Amphipoda Hyperiidae	4.9	4.2	4.6	1.3
Other Amphipoda	11.9	3.6	6.5	-----
Euphausiiacea	65.4	41.9	32.0	19.9
CARIDEA				
Pandalidae	-----	7.3	5.2	5.8
Crangonidae	-----	-----	-----	-----
Brachiura	-----	-----	-----	0.1
Anomura	4.9	2.8	2.0	15.3
SIPUNCULIDA				
ECHINODERMATA				
Ophiuroidea	5.7	16.4	23.0	35.3
Echinozoa	-----	0.8	3.7	4.2
Holothuroidea	-----	1.0	0.4	-----
Asteroidea	-----	3.1	0.5	0.5
ASCIDIACEA	-----	-----	-----	-----
PISCES				
Clupea harengus	-----	-----	-----	-----
Mallotus villosus	-----	4.3	12.0	11.9
Trisopterus esmarkii	-----	-----	-----	-----
M. aeglefinus	-----	-----	-----	-----
Sebastes sp	-----	4.3	-----	-----
H. patessoides	-----	-----	-----	-----
Bentosema glaciale	-----	-----	0.3	-----
Lumpenus lampretiformis	-----	-----	0.3	-----
Cottidae	-----	-----	-----	-----

TABLE X - Seasonal matrices of diet overlap values between size groups of cod and haddock. (Schoener's index of niche overlap).

COD

HADDOCK	WINTER	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	⩾70
	10-19.9	0.27	0.09	0.12	0.13	0.13	0.11	0.07
	20-29.9	0.39	0.26	0.28	0.27	0.29	0.27	0.22
	30-39.9	0.39	0.27	0.30	0.30	0.31	0.29	0.24
	⩾40	0.47	0.33	0.24	0.24	0.25	0.23	0.18

COD

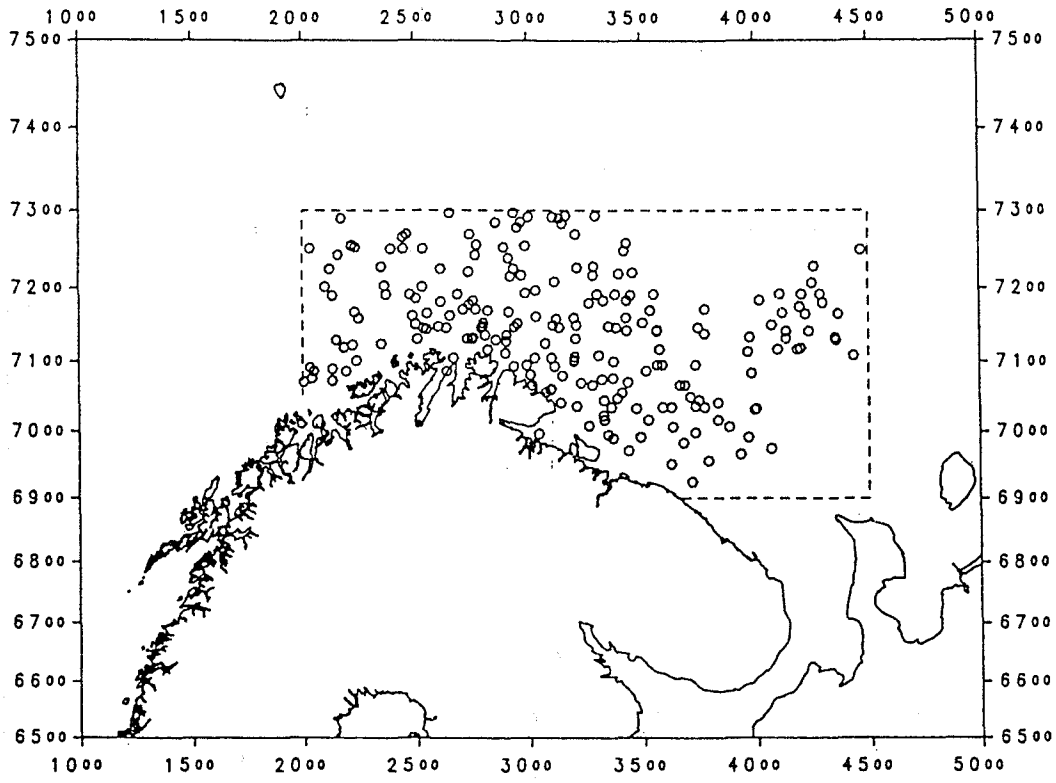
HADDOCK	SPRING	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	⩾70
	10-19.9	0.74	0.30	0.12	0.14	0.04	0.07	0.04
	20-29.9	0.60	0.42	0.29	0.28	0.17	0.20	0.15
	30-39.9	0.53	0.47	0.30	0.32	0.23	0.24	0.21
	⩾40	0.38	0.39	0.28	0.28	0.22	0.24	0.20

COD

HADDOCK	AUTUMN	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	⩾70
	10-19.9	0.67	0.53	0.42	0.41	0.34	0.29	0.19
	20-29.9	0.35	0.40	0.38	0.38	0.36	0.26	0.30
	30-39.9	0.26	0.26	0.27	0.22	0.23	0.24	0.18
	⩾40	0.29	0.26	0.29	0.28	0.32	0.28	0.21

Figure 1 Geographical locations of the sampling stations of a) Cod.- (opened circles, 216 stations) and b) Haddock- (squares, 87 stations). The area referred to in the text as the southern part of the Barents Sea is marked with dashed lines.

a)



b)

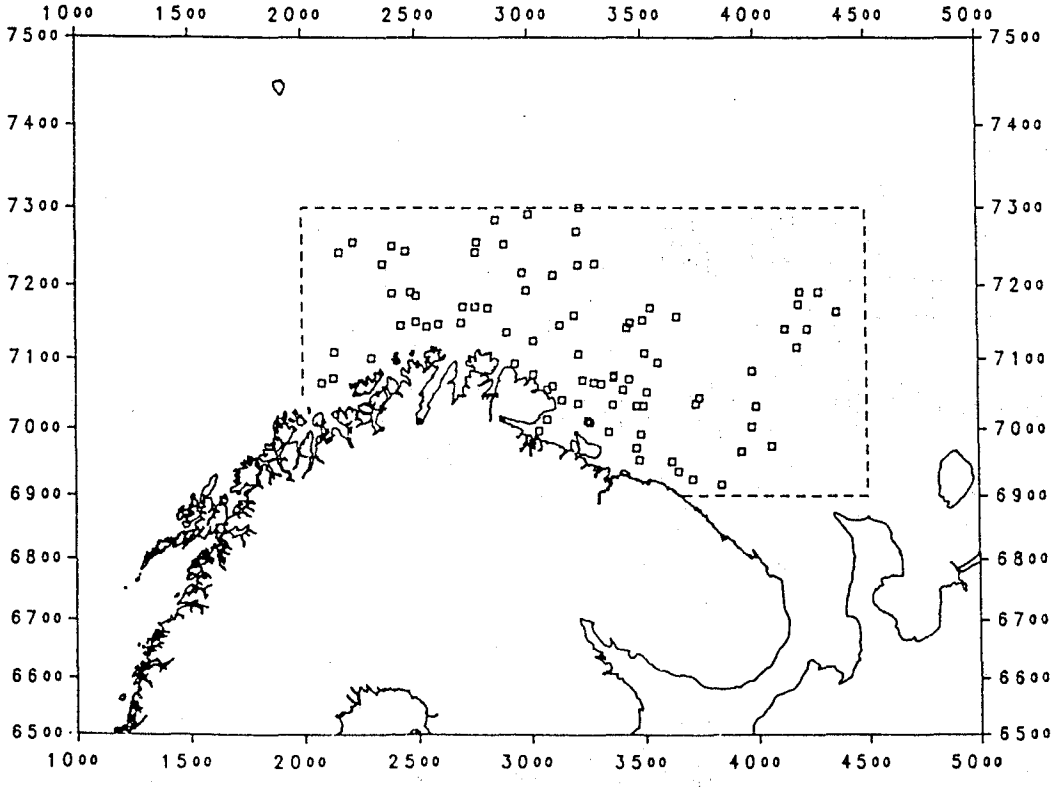


Figure 2 Seasonal length frequency distributions of cod examined during the stomach sampling program in the Southern part of the Barents Sea. Period 1984/86. Individuals with food (white bars), Individuals with empty stomachs (black bars) individuals with vomited food (hatched bars). N: total number of observations. $\bar{L}$: mean length.

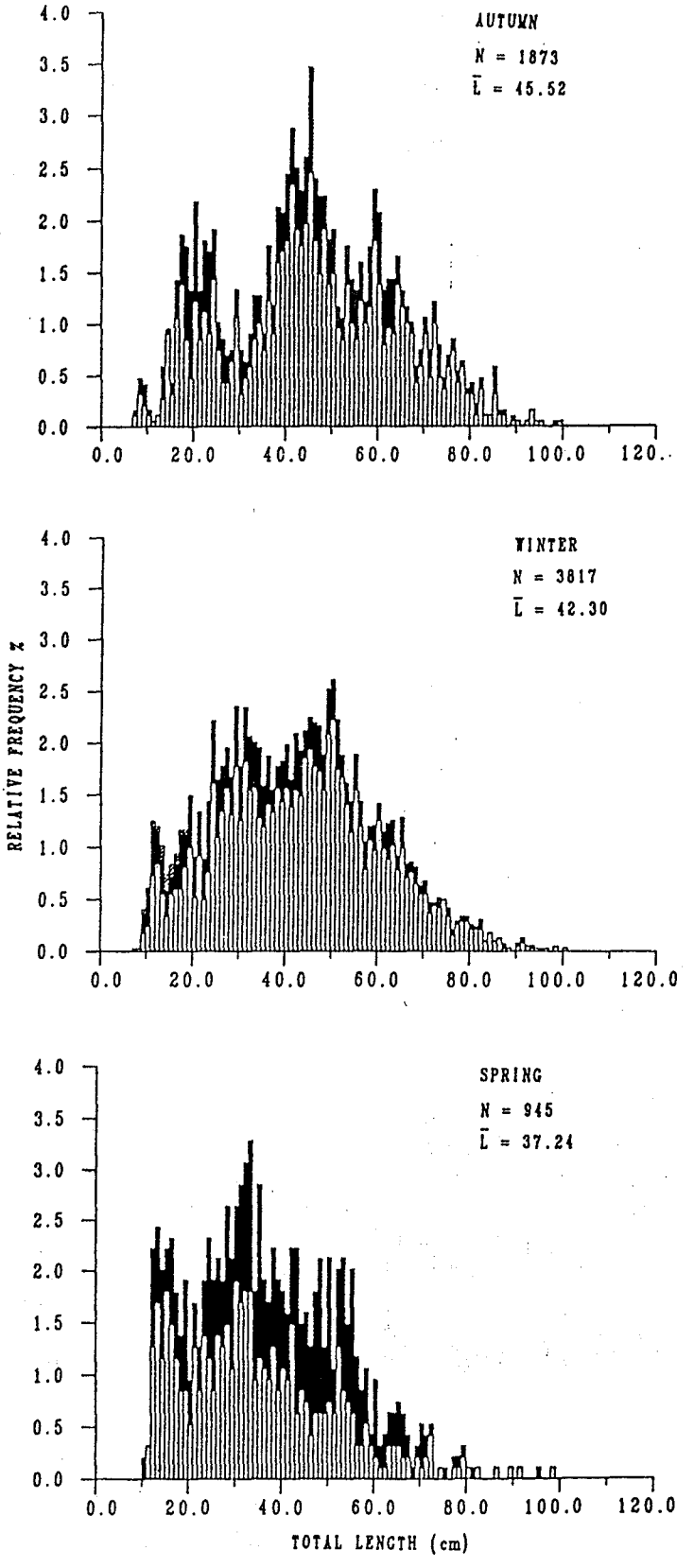


Figure 3 Seasonal length frequency distributions of haddock examined during the stomach sampling program in the Southern part of the Barents Sea. Period 1984/86. Individuals with food (white bars), Individuals with empty stomachs (black bars), individuals with vomited food (hatched bars). N: total number of observations. L: mean length.

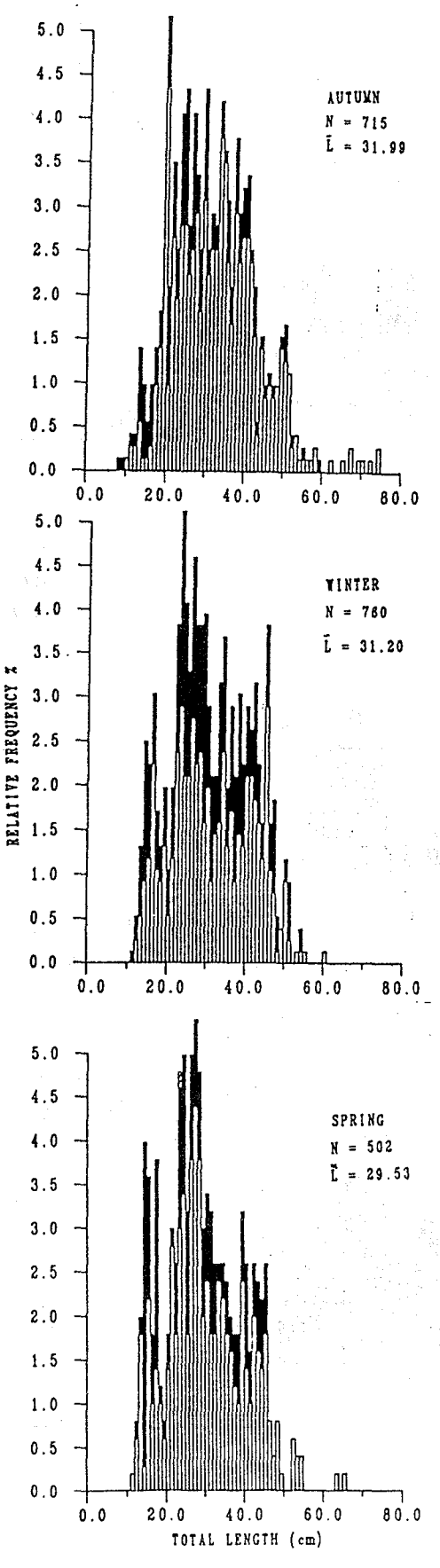
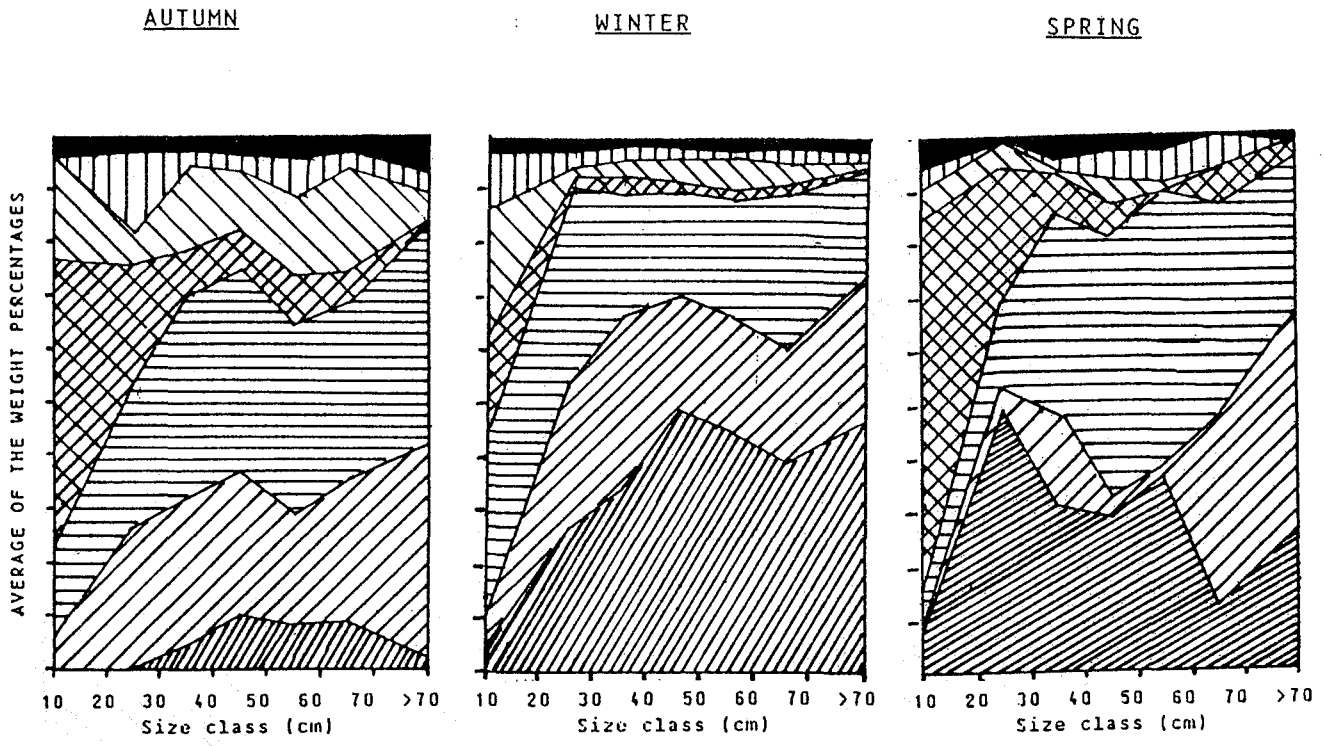


Figure 4 Average of the wet weight percentages of the major prey categories by season and by size class of North-East Arctic cod.



REFERENCES :

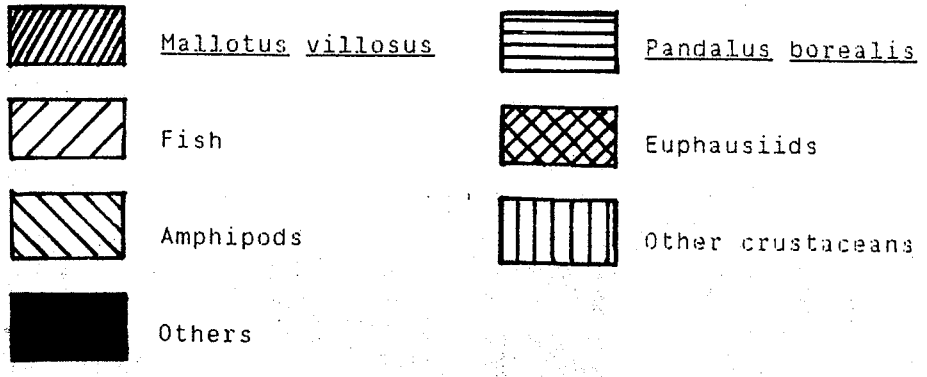


Figure 5 Average of the wet weight percentages of the major prey categories by season and by size class of North-East Arctic haddock.