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STOMACH CONTENTS OF NORTH-EAST ARCTIC COD AND POSSIBLE CHANGES IN THE DIET THE LAST YEARS

by

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ABSTRACT

A stomach sampling program has been carried out in connection with the the construction of a multispecies model for the Barents Sea. The results on the contents of 8410 cod (Gadus morhua) stomachs sampled in 1982-1985 are presented. The samples were collected by bottom- and pelagic trawl onboard Norwegian research vessels during routine surveys in the Barents Sea and the Spitsbergen area. For cod > 20 cm the major prey species in percent wet weight of the stomach content were capelin (Mallotus villosus) (40%), deep sea shrimp (Pandalus borealis) (20%) and redfish (Sebastes spp.) (7%). Capelin was the dominating prey species during the first part of the year . In the diet of smaller cod the most important prey species were shrimp (13%), krill (Euphausiacea) (9 %), amphipods (16%) and other small crustaceans (11%). Since 1982 there has been a drop in the average stomach contents weights of cod > 20 cm in periods with a high content of capelin and since 1984 the relative importance of deep sea shrimp as prey species has been reduced. A preliminary estimate of the cod stock's annual food consumption shows a consume of 2-3 times the biomass of the cod stock.

INTRODUCTION

A multispecies model for the Barents Sea is beeing developed at the Institute of Marine Research, Bergen. This will be used to study to what extent recruitment and natural mortality of capelin (Mallotus villosus) is dependent on the stock size and composition of the cod (Gadus morhua) stock, to what extent growt of cod is dependent on the size and composition of the capelin, herring (Clupea harengus) and shrimp (Pandalus borealis) stocks and if the size of the shrimp stock is partially determined by the size of the cod stock (Mehl et al. 1985).

One essential requirement for the model are estimates of the food consumption of the predatory species and there is a need for detailed data on stomach content weights and composition and prey size preference for the different predator age grops. A data base of stomach content is beeing built-up and combined with data on gastric evacuation rates it will be used to determine the preference matrices and the predation pressure.

The food of the North-East Arctic cod is described by Brown and Cheng (1946), Ponomarenko and Yaragina (1978,1979), Zamarro (1985) and others. But in order to get better quantitative diet data for cod an own stomach sampling program was started in 1984. The program aims at producing detailed diet data for different age groups of cod over the area of distribution at different times of the year. Stomachs of haddock (Melanogrammus aeglefinus) and herring is also beeing sampled, but this paper only deals with the diet of cod .

MATERIALS AND METHODS

The methods used for sampling, stomach analysis, data recording, computer input and presentation of data are mainly the same as for the North Sea "Stomach sampling project" (Anon. 1980 and 1981, Westgård 1982, Mehl 1986). Samples have been collected onboard Norwegian research vessels during routine surveys in the Barents Sea and the Spitsbergen area. The gears used are bottom (shrimp) trawl and pelagic trawl. The trawl stations are randomly spread within each stratum of the investigated area and the sampling continues over 24 hours per day. For each station with biological sampling (otoliths etc.) the aim was to collect up to ten stomachs for each 10-cm lengthgroup (10-19cm, 20-29cm etc.). Stomachs of fish which had regurgitated were not included in the samples. Each stomach was frozen seperately, and data on each predators length, age, weigth, sex ,maturity stage and the number caught per hour fishing per trawl station was recorded together with station data for the total sample.

The number of stomachs collected by quarter and year is given in the text table bellow. Some stomachs collected in 1982 is also included in the material.

Year	Q1	Q2	Q3	Q4	Sum
1982	832				832
1984	1087	346	1009	1289	3731
1985	1882	512	1239	214	3847
Sum	3801	858	2248	1503	8410

Fig. 1 shows the geographical distribution of the total number of stomachs sampled. The figure also shows the 8 areas (I-VIII) used by the multispecies model.

In the laboratory the plastic bags containing the stomachs were put in cold water and the stomachs were opened as soon as practically possible. Fishprey and shrimps were identified to species level when possible, other prey was identified to species level when practical. Each recognizable prey species, genus or family were split into size classes and damp dried on bibulos paper. Numbers and total wet weight, measured to the nearest milligram, were recorded for each size class and prey category seperately. The results were than filed in the computer.

RESULTS

Distribution of samples by time, area and predator sizegroup

The sampling is fairly well distributed throughout the area, with a consentration in the southern part (Fig.1). But all the areas are not covered with samples throughout the year (Fig.2).

Area I (Lofoten) is cover in the first quarter in connection with the spawning migration. Area II, III, IV and V are sampled in both the 1, 2 and 4 quarter of the year while area VI and VII only are covered in the third quarter. In area VIII there is only a very small fraction of the cod stock (Raknes and Nakken 1984) and there has been no sampling. The best coverage is in the first quarter of the year, especially in area III and the western part of area V.

The distribution of samples by predator sizegroup and area is shown in Table 1. All sizegroups are represented in the material. In area I almost all samples are of large spawning cod. In the other areas fish > 20 cm is fairly well represented. Small fish (1 and 2 group) is best represented in area V and partly area VI and VII, which are the most important nursery grounds in the Barents Sea. In area II, III and IV samples of fish > 40 cm are most numerous.

Average wet weight of stomach content

The average wet weights of the stomach content by predator sizegroup, year, quarter and area are presented in Table 2. The weights ranged between 0.01-0.03 grams for the smallest cod (< 10cm) and between 4.7-141.2 grams for fish > 70 cm.

For most sizegroups the weights were highest during the first quarter of the year and on average 50 % lower the rest of the year. The highest stomach content weights were found in the southern part of the investigated area. Area III and V are best covered with samples, and since the sampling started in 1982 there has been a decrease in the stomach content weights for fish > 30 cm. The decrease is most pronounced in the first part of the year.

Table 2 also shows the percent of stomachs empty in each predator sizegroup. This percent was highest for the smallest sizegroups. Within each sizegroup the pecent of empty stomachs was highest when the stomach content weights were low. Since 1982 there has been an increase in the percent of empty stomachs for most of the areas and

quarters investigated.

Prey spectrum

The prey spectrum of cod is broad. About 90 prey categories were found in the 8410 stomachs analysed (Table 3). But only 11 categories contributed with more than 1% by weight on average. Fish were the major prey group and capelin the dominating species. Other important fishprey were redfish, polar cod (Boreogadus saida), herring, long rough dab (Hippoglossoides platessoides), cod and haddock. The most important invertebrate prey group were crustaceans, deep sea shrimp beeing the dominating species, but also amphipods (Hyperiidae) contributed a little.

Size related variations in the diet and prey size preference

The relative importance of the main prey categories varied with the cod length (Table 4 and 5). For fish < 20 cm crustaceans were the dominating prey, contributing 60-70 % by weight on average. Amphipods, krill and shrimps were the major prey species. Shrimps were not found in the smallest sizegroup and contributed only a little in the next one. For cod > 15 cm the content of shrimps were about the same (15 - 20 %) for all sizegroups, while the content of amphipods gradually dropped from 15 to 1 %.

Fish were the major prey for cod > 20 cm, contributing 60 - 85 % on average. Capelin was the most important fishprey for all sizegroups and made up more than 50 % of the stomach content on average (unweighted mean of all samples). The content was highest for the sizegroups between 40 and 70 cm. Herring contributed only 1-3 %, while polar cod and redfish contributed about 4 and 6 % respectively for cod > 30 cm. Both small haddock, cod and long rough dab were reprecented in the stomachs of all sizegroups > 20 cm. Haddock made up 1 % of the diet for cod > 40 cm, while small cod and long rough dab mainly was found in the to largest sizegroups, especially the largest (5 % by weight).

Data on the different predator sizegroup's prey size preference is presented in Table 5. For cod < 20 cm the dominating crustacean prey size was 2-4 cm, but most of the crustacean prey was so digested that the length could not be measured. The fishprey was mainly of the size 5-9 cm.

For all predator sizegroups > 20 cm the dominating crustacean prey size was 5 - 9 cm, there was no increase of the prey size with increasing length. Among the fishprey, the sizegroup 10 -14 cm contributed most for all lengths, but there was also an increase of the largest prey size and of the importance of larger prey with increasing length. For cod > 70 cm, the largest prey size was 30 - 39 cm.

Regional variations in the diet

Tables 6 to 9 present more detailed stomach content data for areas I, II+IV, III+V and VI+VII by main predator sizegroup, year and quarter. Prey sizeclass is given for the predominant prey categories only.

Area I is only sampled in one time period (Q1 1985). Crustaceans dominated the stomach content of the few fish < 60 cm and Munida

sarsi was the most important species. Fish were the major prey for cod > 60 cm, contributing more than 90 % by weight. Of this only 1 % was identified to species level (haddock). About 50 % of the stomachs were empty and the average stomach weights were less than half of those in the neighbouring area (II+IV) in the same time period.

Area II+IV is covered with samples in five time periods (Q1 and Q4 1984; Q1, Q2 and Q4 1985) and better represented with stomachs from all predator sizegroups. For fish < 20 cm, the diet was totally dominated by crustaceans of which amphipods seemed to be of greatest importance. Average stomach content wet weight was 0.2 g and about 44 % of the stomachs were empty. The larger cod had a more mixed diet, but fish were the major prey for all 3 sizegroups > 20 cm, contributing 60, 62 and 80 % respectively on average. Of this capelin made up 30-35 % on a yearly average (unidentified fishprey not included). Other fishprey of importance were redfish (8-6 %), and in the largest predator sizegroup blue whiting (Micromesistius potassou) (7 %), rough rattail (Macrorus berglax) (5 %), Norway pout (Trisopterus esmarkii) (5%), cod (8 %) and haddock (2 %). Of the crustacean prey deep sea shrimp contributed 22-16 % and M.sarsi about 5 % on average. 37-33 % of the stomachs were empty and average wet weight of the stomach content was 4.5, 18 and 48 grams for the 3 sizegroups respectively.

In the south-eastern part of the Barents Sea, area III+V, the stomach content composition was in many ways the same as in the south-western part (II+IV). Crustaceans made up about 70 % of the smallest cod's diet, and amphipods, krill and shrimp contributed 18, 24 and 6 % respectively. In the western area fishprey contributed little (3 %), while in east small fish (<10 cm) made up 19 % of the smallest cods diet. Beside capelin, small herring and redfish were found in smaller amounts. Average stomach weight was also higher than in west (0.4g) and 35 % were empty. For the 3 largest sizegroups of cod, 65, 69 and 72 % of the average stomach content were fish. Capelin contributed 30 - 25 %, redfish 6-9 % , herring 3-1 % and polar cod 3 %. In the two largest sizegroups haddock made up 8-5 % of the stomach content, and in the largest sizegroup cod contributed 20 %, rough rattail 2 %, blue whiting 1 % and long rough dab also 1 % on average for all the 7 periods investigated. Deep sea shrimp, the only crustacean prey of any importance, contributed 20-25 %. The average weight of the stomach content was 5.6, 18 and 58 g for the 3 groups respectively, and about 24 % of the stomachs were empty.

The Spitsbergen - Bear Island area (VI+VII) has only been sampled in 2 periods, Q3 1984 and 85. 65 % of the smallest cod's stomach content was crustaceans, mainly amphipods, krill and various decapods. The fish part of the stomach content (26%) was mostly unidentfied, but a small part was identified to capelin (2%), redfish (1%) and snake blenny (Lumpenus lampretaeformis) (4%). The wet weight of the stomach content was on average 0.78 g, and 35 % of the stomachs were empty. In the diet of the larger cod (>20 cm), fish contributed 47, 58 and 72 % in the 3 groups respectively. Of this 18-14 % was capelin, 1-15 % redfish, 2-4 % herring and 3-1 % snake blenny. Cod and haddock made a small contribution in the 2 largest sizegroups (1-3 %), and long rough dab contributed 14 % in the largest sizegroup. Among the crustaceans, which in total made up 45-27 % of the largest cods stomach content, deep sea shrimp contributed 11-18 %, amphipods 13-5 %, Spirontocaris spinus about 2 % and krill and Ponthophilus norvegicus about 1-2 % each. 20-10 % of the stomachs were empty, and their weigths were 4.3, 19 and 58 g on average.

Seasonal and year-to-year variations in the diet

There were seasonal variations in both the total wet weights of the stomach content (Table 2) and in the stomach content composition (Tables 7 and 8). For the smallest cod (<20 cm) there was no clear variation in the stomach weights between different seasons, but the content of fish, mainly capelin, was highest during the first part of the year. For larger cod, the total weights as well as the content of capelin were highest during the first part of the year, especially in Q1 when the weights were more than 50 % higher than the average for the year. In most areas investigated during Q1 capelin made up 51-96 % of the stomach content of cod > 20cm. The rest of the year deep sea shrimp and other decapods were more important for the medium predator sizegroups, usually contributing 25-50 % of the stomach content. For the largest cod also other fishprey than capelin were more important during the rest of the year. In the Spitsbergen - Bear Island area, where there only has been sampling in Q3, the diet was in general the same as in other areas in Q2 - Q4.

Also some year-to-year variations has been observed. In the south - eastern area (III+V) polar cod contributed 16-22 % by weight in the stomach content of cod > 20 cm during the first quarter of 1982. In Q1 1984 the content was on average 3 % and later polar cod has hardly been found in the stomachs analysed. Redfish of 5-9 cm made a large contribution, about 35 % in all the three largest sizegroups, in the same area during Q1 1984. In other periods and other areas the content of redfish has normaly been 1-10 %. Herring first showed up in the stomach content in Q2 1984 and so far the content was highest during the autumn 1984, when herring on average contributed 5-6 % in area III +V and area VI+VII. In general there has been a decrease in the total stomach content weights of cod > 20 cm in areas and periods with a high stomach content of capelin since 1982. In most areas, timeperiods and predator sizegroups there has been a decrease in the content of deep sea shrimp since 1984. Other crustaceans play a more important part in the diet of the small and medium sized cod, while other fishprey than capelin contribute more in the stomach content of larger cod. In the largest cod the relative importance of small cod as prey (cannibalism) increased by about 30 % from 1984 to 1985, but the content is still low (about 5 % on average).

The cod stock's consumption - preliminary estimates

A preliminary estimate of the cod stock's food consumption in 1984 has been made, using the same method of calculation as in Mehl and Westgård (1983). The consumption in tonnes in quarter 1 of prey species i by predator age group n, C_{lin} is given by :

$$C_{lin} = \sum_{k} F(n) \cdot \bar{W}_{lnk} \cdot R_{lnik} \cdot XN_{ln} \cdot XP_{lnk} \cdot D \cdot Q \cdot S$$

where

F(n) = rate of gastric evacuation (per hour) for predator age group n

$\bar{W}_{lnk}$ = mean stomach content in grams in quarter 1 for predator age group n in area k

R_{lnik} = proportion of the weight of the stomach content that in quarter l for predator age group n was of prey species i in area k

XN_{ln} = number of individuals of predator age group n in quarter l

XP_{lnk} = proportion of individuals of predator age group n in quarter l and area k

D = 24, number of hours in one day

Q = 91.25, number of days in one quarter of the year

S = 1000000, scaling factor to get the consumption in tonnes

The rate of gastric evacuation is found by combining data on digestion times for different sizes of cod from the North Sea (Daan 1973) with length at age data for the Barents Sea cod (Anon. 1985a).

The number in each age group in the North-East Arctic cod stock by quarter in 1984 is based on Anon. (1986). For each quarter the numbers have been reduced, using 1/4 of the yearly natural and fishing mortality. Number by age group and quarter is given in Table 10.

The proportion of individuals of each age group by quarter and area is compiled from Raknes and Nakken (1984) and presented in Table 11.

The total biomass consumed by the cod stock in 1984 was estimated to about 3300000 tonnes, and Table 12 gives the consumption in tonnes by quarter of deep sea shrimp, capelin, herring, cod, haddock and redfish. The unidentified fish is allocated to capelin.

DISCUSSION AND CONCLUSIONS

The diet of the North-East Arctic cod shows individual, area, seasonal and year-to-year variations. The same was found by Zatsepin and Petrova (1939), Brown and Cheng (1946) and Ponomareko and Yaragina (1978,1979).

The general trend is that crustaceans are the dominant food of smaller cod and fish are the major prey for larger cod. This general trend was also found in the North Sea (Daan 1973), in the Icelandic waters (Palsson 1981) and in the Northwest Atlantic (Minet and Perodou 1978, Langton and Bowman 1980).

The diet of the smallest cod (<20 cm) showed less variations both in total wet weight of the stomach content and in stomach content composition than the larger cod. In most areas and time periods investigated crustaceans dominated the diet totally. Amphipods seemed to be most important during the autumn and winter months and occasionally made up almost 100 % of the stomach content. In the southern part of the Barents Sea krill was more abundant during the spring and early summer, as found by Ponomarenko and Yaragina (1979). In the same area small capelin was the major prey during the first part of 1984, but later capelin and other fish species has been of minor importance as prey for small cod. There seemed to be no connection between the stomach weights and the composition of the

stomach content. It looks like the small cod is capable of finding enough suitable prey species in most areas throughout the year. Small cod has a shorter digestion time (Daan 1973, Karpevich and Bokoff 1937). That explains the higher percentage of unidentified stomach content and of empty stomachs in small cod.

With increasing predator length fishprey become more and more important. For sizegroup 20-39 cm fish were the major prey in 2/3 of the investigated areas and periods, while for cod > 60 cm fish always were the dominating prey category. And with increasing predator length the size and importance of larger fishprey increased gradually.

During the first part of the year capelin was the dominant fishprey for all sizegroups > 20 cm in the southern Barents Sea. This is in agreement with the long term observations of Ponomarenko and Yaragina (1978). And in the same period the average stomach content weights were the highest and the percents of empty stomachs the lowest. Lilly (1984) also found the highest stomach weights in periods with a high relative importance of capelin. In the southeastern part of the Barents Sea (area III+V), where a major part of the cod stock stands (Raknes and Nakken 1984), there has beeń a drop in the stomach weights during the first part of the year since 1982. From 1982 to 1984 the capelin stock decreased by about 50 % (Anon. 1982 and 1984a). Ponomarenko and Yaragina (1978) also found large year-to-year variations in the content of capelin in the cod stomachs, the content beeing highest when the year-classes of capelin were the strongest.

From 1982 to 1984 the stomach content of shrimp and redfish increased in the same area. But the average stomach content weights were lower in 1984, so there was only a partial replacement of capelin in the diet of cod, as found by Lilly (1984).

Redfish was found in the stomach content in most of the areas and timeperiods investigated, and came out as the second most important fishprey after capelin. The last year-classes of redfish have all been good ones (Anon. 1985b).

After capelin, deep sea shrimp was the most important prey species for cod > 20 cm in all the areas investigated. The relative importance was highest in the second half of the year and over the shrimp fishing grounds. In 1985 there was a marked drop in the content of shrimp in most of the areas, timeperiods and predator sizegroups investigated. From 1984 to 1985 the biomass of the shrimp stock decreased by about 50 % in the Barents Sea and 35 % in the Spitsbergen area (Tveranger and Øynes 1985).

The percent of larger fishprey than capelin in the diet increased with increasing cod length. Polar cod was the dominating prey species of this category in the areas investigated in Q1 1982. In later investigations the content of polar cod has been low or nothing at all. Since 1982 the polar cod has had a more eastern distribution (Borkin and Shleinik 1985).

In the later years other fish species such as cod, haddock, Norway pout, blue whiting, rough rattail and long rough dab have made up an increasing part of the stomach content, especially in the largest predator sizegroup. The content of small cod and haddock (0, 1 and 2-group) were highest in the south-eastern part of the Barents Sea (area III+V). In 1984 and 1985 on average about 20 % of the stomach content of the largest cod (> 60 cm) was small cod in that area. About 75 % of

the 1- and 2-group of cod is found in that area (Raknes and Nakken 1984) and both the 1983, 1984 and 1985 year-classes are strong ones (Anon. 1985b). Daan (1973) found the ammount of cannibalism to be dependent on the year-class strength of young cod.

The annual food consumption of the North-East Arctic cod stock in 1984 is preliminary estimated to about 3 million tonnes. This is about 2.7 times the biomass of the cod stock, and in well agreement with the results of Daan (1973) in the North Sea. Laevastu and Larkins (1981) report annual food consumption of 3 to 4 times the mean biomass per year for different fish stocks. Ponomarenko et al. (1978) found that in 1974-1976 the cod stock's annual consumption of capelin was 2.4-2.7 times the biomass of the cod stock, while Ponomarenko and Ponomarenko (1975) calculated the consumption of capelin during the period of intensive feeding (February - April) in 1971-1973 to about 3.3 times the biomass of the cod stock. The preliminary estimates from the present investigation gave a consumption of capelin of about 1 time the biomass of the cod stock in 1984. The results of the two former works are based on the diurnal coefficient of nutrition found by Novikova (1962). He found a much higher content of capelin in the cod stomachs he examined than found in the present investigation. Since gastric evacuation data from the North Sea (Daan 1973) has been used here, one should expect the consumption data for 1984 not to be on the lower side. They are also in better accordance with the results of Campell and Winters (1973) and Minet and Perodou (1978).

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Table 1. Number of cod stomachs sampled in the Barents Sea in 1982-85 by model area and sizegroup.

Size group (cm)	Model area							Sum
	I	II	III	IV	V	VI	VII	
<10	0	0	0	29	11	3	0	43
10-14	0	3	8	14	151	49	16	241
15-19	0	16	21	35	302	147	67	588
20-29	1	62	129	130	647	315	172	1456
30-39	3	103	243	166	586	286	108	1495
40-49	1	227	385	223	556	243	76	1711
50-59	8	184	346	206	318	192	54	1308
60-69	35	132	216	158	187	105	35	868
>70	40	116	190	141	111	65	37	700
Sum	88	843	1538	1102	2869	1405	565	8410

Table 2. Average stomach content wet weight (grams) and percent of empty stomachs (in parenthesis) by predator sizegroup, year, quarter and area.

Year	Quarter	Area	Predator sizegroup (cm) < 10	10-14	15-19	20-29	30-39	40-49	50-59	60-69	> 70
1982	1	III+V	-	-	-	2.7	11	22	50	111	97
						(14)	(7)	(9)	(6)	(8)	(11)
		II+IV	-	.02	.01	2.4	11	29	30	39	75
	1			(0)	(50)	(0)	(3)	(2)	(4)	(3)	(3)
		III+V	.03	.14	.47	2.9	5.4	11	19	23	43
			(30)	(15)	(20)	(13)	(16)	(6)	(6)	(2)	(8)
	2	III+V	-	.16	.65	2.4	6.8	18	38	47	58
1984				(30)	(35)	(22)	(23)	(5)	(4)	(0)	(17)
	3	VI+VII	.01	.29	1.3	2.0	6.3	12	23	32	77
			(67)	(24)	(31)	(21)	(16)	(13)	(11)	(11)	(3)
		II+IV	-	-	.28	1.0	3.3	6.7	8.8	12	35
	4				(64)	(46)	(43)	(34)	(34)	(30)	(39)
		III+V	-	.26	.40	1.3	4.9	7.9	9.2	19	38
				(50)	(50)	(40)	(23)	(22)	(26)	(21)	(24)
		I	-	-	-	-	3.5	19	6.6	29	75
							(33)	(0)	(38)	(60)	(55)
	1	II+IV	-	-	.15	1.1	10	31	52	91	141
					(0)	(33)	(29)	(21)	(23)	(19)	(8)
		III+V	-	.11	.44	2.9	10	29	35	36	97
				(36)	(46)	(37)	(24)	(18)	(20)	(22)	(30)
		II+IV	-	.14	.12	.61	1.7	2.8	0.8	13	4.7
1985	2			(67)	(75)	(41)	(62)	(80)	(88)	(72)	(64)
		III+V	-	.01	.20	2.9	5.2	5.1	7.6	4.3	108
				(75)	(57)	(46)	(52)	(48)	(50)	(57)	(50)
	3	VI+VII	.01	.31	.60	2.5	7.2	18	26	42	84
			(66)	(49)	(28)	(24)	(15)	(9)	(14)	(14)	(10)
	4	II+III	-	.57	1.3	3.7	5.7	3.9	13	11	123
				(0)	(8)	(11)	(44)	(27)	(46)	(54)	(24)

Table 3. The total number of prey categories found in 8410 cod stomachs collected in the Barents Sea in 1982-1985, with weight percentages of average stomach content wet weights. The figures are unweighted means of all samples.

	PREY CATEGORY	WEIGHT %
1	Phaeophycea	.0
2	Porifera	.0
3	Scyphozoa	.0
4	Anthozoa	.0
5	Actinaria	.0
6	Metridiidae	.0
7	Rhynchocoela (nemertina)	.0
8	Annelida	.0
9	Polychaeta	.2
10	Gastropoda	.0
11	Bivalvia	.0
12	Cephalopoda	.1
13	Sepiolidae	.0
14	Rossia	.0
15	Gonatus fabricii	.0
16	Ommastrephes sagittatus	.5
17	Octopodidae	.0
18	Pycnogonida	.0
19	Crustacea	.2
20	Copepoda	.0
21	Calanoida	.0
22	Calanus finmarchicus	.0
23	Cyclopoida	.0
24	Cirripedia	.0
25	Malacostraca	.1
26	Mysidae	.0
27	Isopoda	.0
28	Amphipoda	.0
29	Gammaridae	.0
30	Hyperiidae	1.8
31	Parathemisto	.1
32	Euphausiidae	.2
33	Meganyctiphanes norvegica	.0
34	Thysanoessa	.0
35	Decapoda	.0
36	Sergestes arcticus	.0
37	Caridea	1.2
38	Spirontocaris spinus	.2
39	Pandalidae	.0
40	Pandalus	.0
41	Pandalus borealis	13.1
42	Crangonidae	.1
43	Crangon allmanni	.0
44	Sclerocrangon ferox	.0
45	Pontophilus norvegicus	.3
46	Paguridae	.2
47	Pagurus bernhardus	.0
48	Galatheidae	.0
49	Munida sarsi	.4
50	Brachyura	.6
51	Hyas coarctatus	.0
52	Hyas araneus	.1
53	Geryon tridens	.1
54	Sipuncula	.0
55	Asteroidea	.0
56	Ophiuroidea	.0
57	Echinozoa	.0
58	Holothuroidea	.1
59	Cucumaridae	.0
60	Ascidiacea	.0
61	Teleostei	10.8
62	Clupea harengus	1.9
63	Mallotus villosus	48.0
64	Argentina silus	.1
65	Maurolicus muelleri	.0
66	Benthosema glaciale	.0
67	Lophius piscatorius	.0
68	Gadidae	.1
69	Boreogadus saida	4.5
70	Gadus morhua	1.9
71	Melanogrammus aeglefinus	1.1
72	Trisopterus esmarkii	.2
73	Merlangius merlangus	.1
74	Micromesistius poutassou	.8
75	Zoarcidae	.0
76	Lycodes vahlii	.1
77	Macrourus berglax	.8
78	Scorpaenidae	.0
79	Sebastes	6.1
80	Icelus bicornis	.0
81	Cottidae	.5
82	Artediellus atlanticus	.1
83	Agonidae	.0
84	Agonus decagonus	.1
85	Anarhichas	.0
86	Lumpenus lampretaeformis	.3
87	Leptoclinus maculatus	.0
88	Ammodytidae	.0
89	Pleuronectidae	.4
90	Glyptocephalus cynoglossus	.2
91	Hippoglossoides platessoides	1.8
92	Indeterminatus	.4

Table 4. Stomach content composition in percent wet weight by predator size-group for the main food items in the diet of cod sampled in the Barents Sea in 1982-1985. The figures are unweighted means of all samples.

Food item	Predator sizegroup in cm								
	5-9	10-14	15-19	20-29	30-39	40-49	50-59	60-69	> 70
Amphipoda	18	15	15	9	4	2	2	2	1
P.borealis		5	14	20	21	15	14	15	12
Teleostei		18	13	27	12	10	8	6	15
M.villosus			8	23	39	56	56	55	37
G.harengus			1	3	2	3	1	1	2
B.saida				1	3	2	5	8	4
G.morhua				+	+	+	+	1	5
M.aeglefinus				+	+	1	1	1	1
Sebastes spp.			1	3	6	5	7	6	7
H.platessoides				+	+	+	+	1	5
Other	72	62	48	14	13	7	6	4	11
Grams pr stom.	0.01	0.21	0.66	2.4	7.6	17	28	48	76
% empty	58	30	35	29	21	20	20	19	19

Table 5. Percent wet weight of different prey category sizegroups by predator sizegroup in the stomach content of cod sampled in the Barents Sea in 1982 - 1985. The figures are unweighted means of all samples.

Prey category sizegroup	Predator sizegroup in cm								
	5-9	10-14	15-19	20-29	30-39	40-49	50-59	60-69	> 70
Crustaceans									
unknown	71	39	50	21	17	10	10	9	6
0 - 1 cm		4	2	2	1	1	+	1	+
2 - 4 "		16	8	3	2	1	2	1	1
5 - 9 "			1	11	9	7	6	6	5
10 - 14 "				1	2	1	2	2	2
Fish									
unknown		1	16	35	29	34	27	24	35
0 - 1 cm			+	+	+	+			
2 - 4 "			2	1	1	+	+	+	+
5 - 9 "		21	6	7	9	7	7	6	3
10 - 14 "				16	23	24	33	31	22
15 - 19 "				+	4	14	12	18	11
20 - 24 "			3		+	+	1	1	6
25 - 29 "						+	+	1	2
30 - 39 "								+	4
Other									
unknown	29	19	11	3	3	1	+	+	2
0 - 1 cm		+		+	+	+	+	+	+
2 - 4 "			+	+	+	+	+	+	+
5 - 9 "		+	1	+	+	+	+	+	+
10 - 14 "				+	+	+	+	+	+
15 - 19 "					+	+	+	+	+
20 - 24 "				+	+	+	+	+	+
25 - 29 "						+	+		
30 - 39 "							+	+	+

Table 6. Stomach content composition in weight percent by predator sizegroup for cod sampled in area I in Q1 1985.

Prey category	size class(cm)	Predator sizegroup in cm 20 - 39	40 - 59	> 60
Caridea,	ind	50	43	+
P.borealis	5-9	-	-	1
	10-14	-	-	+
Munida sarsi	5-9	50	34	1
Crustacea, tot.		100	77	2
Teleostei,	ind.	-	23	94
	20-24	-	-	2
M.aeglefinus	10-14	-	-	1
Pisces, tot.		-	23	97
Indeterminatus		-	-	1
Grams pr stomach		2.6	8	54
% empty		50	33	57

Table 7. Stomach content composition in weight percent by predator sizegroup, year and quarter for cod sampled in area II + IV in 1984 - 1985.

Prey category size	Predator sizegroup in cm: < 20					20-39					40-59					> 60				
	1984		1985			1984		1985			1984		1985			1984		1985		
	Q1	Q4	Q1	Q2	Q4	Q1	Q4	Q1	Q2	Q4	Q1	Q4	Q1	Q2	Q4	Q1	Q4	Q1	Q2	Q4
Var. evertebr.	-	-	-	-	-	+	+	-	2	-	+	1	-	+	2	+	+	-	-	-
Amphipoda	-	32	100	-	-	-	1	4	-	-	+	2	+	-	-	+	1	+	-	-
Euphausiacea	-	-	-	-	-	+	3	-	3	-	+	-	-	-	-	+	-	-	4	-
Var. decapoda	-	-	-	-	-	+	13	1	3	-	1	15	+	1	1	1	1	+	-	-
Pontophilus norv.	-	-	-	-	-	+	1	-	2	-	-	+	+	3	-	-	+	-	2	-
P.borealis, ind.	-	-	-	-	-	+	9	4	20	-	1	5	1	3	24	1	4	1	31	7
2-4	-	-	-	-	-	+	1	-	-	-	+	-	-	1	-	+	+	-	-	-
5-9	-	-	-	-	-	8	22	5	22	18	5	20	+	30	7	5	13	+	-	3
10-14	-	-	-	-	-	-	-	-	14	-	+	2	+	8	6	1	5	-	4	5
Munida sarsi	-	-	-	-	-	-	3	-	-	15	-	17	-	16	5	-	9	-	-	-
Crustacea, tot.	100	50	100	100	100	8	55	15	69	35	7	61	1	62	45	8	33	1	41	15
Teleostei, ind.	-	-	-	-	-	4	26	5	17	61	3	25	3	33	37	2	12	1	27	4
M.villosus, ind.	-	-	-	-	-	9	-	55	-	-	12	-	36	-	-	18	-	36	-	-
5-9	-	-	-	-	-	2	-	6	2	-	3	-	3	-	-	7	-	1	-	-
10-14	-	-	-	-	-	42	-	12	-	-	46	2	33	-	-	47	+	28	-	-
15-19	-	-	-	-	-	17	-	6	-	-	7	-	24	-	-	8	-	28	-	-
C.harengus 15-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
G.morhua 10-14	-	-	-	-	-	2	-	-	-	-	-	-		-	-	-	-	-	-	-
20-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-
30-39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	31
M.aeglefin. 10-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
15-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
20-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
T.esmarkii	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-	24
Micr.poutassou	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-	-	21	13
Macrorus berglax	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	-	11	-
Sebastes 2-4	-	15	-	-	-	1	2	-	-	2	+	+	-	-	1	+	-	-	-	-
5-9	-	-	-	-	-	13	11	-	10	2	21	1	-	5	-	9	-	-	-	-
10-14	-	-	-	-	-	-	-	-	-	-	1	10	-	-	-	-	1	-	-	-
15-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-
20-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	-	-	-
H.platessoides	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-	2	-	-	-
Pisces, tot.	-	15	-	-	-	92	39	84	29	65	93	38	99	38	53	92	67	99	59	85
Indeterminatus	-	35	-	-	-	+	6	1	-	-	+	+	+	-	+	+	+	+	-	-
Grams pr stomach	.01	.28	.15	.3	.46	9.7	1.9	7.2	1.1	2.4	29	7.3	40	1.9	13	52	23	113	10	40
% empty	33	64	0	71	50	3	45	31	52	53	3	34	22	84	25	3	35	14	69	44

Table 8. Stomach content composition in weight percent by predator sizegroup, year and quarter for cod sampled in area III+V, 1982-8

Prey category	Predator sizegroup in cm																												
	< 20						20-39							40-59							> 60								
	1984			1985			1982	1984			1985			1982	1984			1985			1982	1984			1985				
	Q1	Q2	Q4	Q1	Q2	Q4	Q1	Q1	Q2	Q4	Q1	Q2	Q4	Q1	Q1	Q2	Q4	Q1	Q2	Q4	Q1	Q1	Q2	Q4	Q1	Q2	Q4		
Var. evertebr.	-	5	1	+	-	-	+	+	+	+	+	-	+	+	1	-	2	+	2	1	2	1	-	2	+	-	52		
Amphipoda	1	1	5	10	-	96	+	+	+	1	1	-	44	1	1	+	1	+	-	1	+	1	-	+	+	-	-		
Euphausiacea	6	31	22	5	77	-	1	+	1	4	+	1	2	+	-	+	+	+	+	-	+	-	+	+	-	-	-		
Var. decapoda	5	4	18	35	7	-	+	3	5	21	2	3	-	+	1	2	8	1	3	-	+	3	-	5	1	-	-		
Pontophilus norv.	-	-	-	1	-	-	-	+	-	2	1	-	-	-	+	-	+	+	+	-	-	+	-	+	+	-	-		
P.borealis, ind.	1	-	-	1	-	-	29	3	6	11	5	1	-	16	6	4	5	2	4	24	12	3	-	11	4	1	-		
2-4	25	5	1	-	-	-	-	1	1	+	+	-	-	-	1	4	1	+	-	-	-	1	-	+	-	-	-		
5-9	-	-	-	4	-	-	-	14	31	13	5	7	-	-	22	22	20	3	16	11	-	21	2	15	5	15	1		
10-14	-	-	-	-	-	-	-	5	8	-	1	-	-	-	4	14	3	1	-	3	-	3	27	3	2	-	1		
Crustacea, tot.	42	43	50	87	86	96	31	27	53	55	15	12	47	17	35	47	39	8	24	39	14	32	29	35	12	16	2		
Teleostei, ind.	25	2	4	4	13	4	+	6	2	21	24	76	23	1	8	3	35	6	48	13	+	2	-	33	10	-	-		
M.villosus, ind.	-	31	-	-	-	-	7	+	3	2	37	10	13	3	+	4	1	48	11	-	8	-	-	-	50	-	-		
5-9	11	7	-	-	-	-	3	1	2	2	+	-	-	3	-	3	1	+	1	-	2	-	9	-	+	-	-		
10-14	-	-	-	-	-	-	39	19	29	-	7	2	11	45	4	32	1	16	1	-	36	1	43	-	4	-	-		
15-19	-	-	-	-	-	-	3	3	-	-	7	-	-	15	-	6	-	16	-	-	17	1	-	-	4	-	-		
B.saida	-	-	-	-	-	-	16	6	-	-	-	-	-	16	3	-	-	-	-	-	22	-	-	-	-	-	-		
C.harengus 5-9	-	8	-	-	-	-	-	-	-	2	2	-	-	-	-	-	2	+	-	-	-	-	-	-	-	-	-		
10-14	-	-	-	-	-	-	-	-	-	10	5	-	-	-	-	-	9	3	-	-	-	-	-	-	-	-	-		
15-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	8	-	-		
G.morhua 5-9	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
15-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	2	-	-	-		
20-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	7	-	1	-	-	-		
25-29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-		
30-39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	84	28		
M.aeglefin. 10-14	-	-	-	-	-	-	-	-	3	2	+	-	-	-	3	-	+	+	-	11	-	4	-	-	+	-	-		
15-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-	1	-	35	-	-	19	2	1	-	4		
20-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	-	-	5		
Micr.poutassou	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	1	-	9		
Macrorus berglax	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	-	-		
Sebastes 2-4	-	-	-	-	-	-	+	2	-	+	-	-	-	-	2	-	1	-	-	+	-	8	-	+	-	-	-		
5-9	4	-	-	-	-	-	-	35	1	1	1	-	-	+	37	-	2	+	6	1	-	36	-	1	+	-	-		
10-14	-	-	-	-	-	-	-	-	2	-	-	-	-	+	1	-	3	1	7	-	+	1	-	1	1	-	-		
15-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-		
20-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	3	-	-		
H.platessoides	-	-	-	-	-	-	-	-	-	1	-	-	-	-	+	-	2	+	-	-	1	1	-	3	4	-	-		
Pisces, tot.	40	48	4	4	13	4	69	72	46	41	84	88	53	83	63	53	58	92	74	60	86	67	71	63	88	84	46		
Indeterminatus	18	4	46	9	1	-	+	1	1	4	1	+	-	+	1	-	1	+	-	-	+	+	-	+	-	-	-		
Grams pr stomach	.29	.42	.44	.39	.16	1.2	9.7	4.2	5.1	2.8	6.1	3.8	7.5	34	15	26	8	32	6.1	5.2	107	31	54	30	58	28	101		
% empty	19	33	50	45	61	0	8	15	23	33	32	48	0	8	6	5	23	19	49	59	9	4	10	23	25	56	36		

Table 9. Stomach content composition in weight percent by predator sizegroup and year for cod sampled in area VI + VII in Q3 1984-85.

Prey category	Size class(cm)	Predator sizegroup in cm: < 20 1984	< 20 1985	20 - 39 1984	20 - 39 1985	40 - 59 1984	40 - 59 1985	> 60 1984	> 60 1985
Var. evertebrata		1	-	1	1	+	1	+	1
Polychaeta		1	3	4	2	1	1	+	+
Cephalopoda		-	-	+	1	+	+	+	-
Copepoda		1	-	+	-	-	-	-	-
Amphipoda		4	43	1	24	1	14	2	7
Euphausiacea		5	1	7	1	1	+	+	-
Var. decapoda		10	3	14	7	14	5	4	3
Spirontocaris spinus		-	-	4	3	2	2	+	+
Ponthophilus norv.		4	-	3	3	2	1	1	+
P.borealis, ind.		-	-	1	4	1	8	4	5
	2-4	1	-	1	+	1	+	+	+
	5-9	+	-	10	4	16	2	16	2
	10-14	-	-	1	1	3	1	7	1
Crustecea, tot.		61	68	43	48	43	35	35	18
Teleostei, ind.		15	22	20	15	24	15	15	14
C.harengus	10-14	-	-	5	-	3	-	5	-
	15-19	-	-	-	-	1	-	3	-
M.villosus, ind.		1	-	1	9	1	14	-	14
	5-9	3	-	3	1	1	1	1	-
	10-14	-	-	8	10	4	13	3	9
	15-19	-	-	-	-	1	1	1	-
B.saida		-	-	-	-	1	-	-	-
G.morhua	5-9	-	-	-	1	-	+	-	-
	10-14	-	-	-	-	-	1	-	1
	20-24	-	-	-	-	-	-	1	3
	25-29	-	-	-	-	-	-	2	-
M.aeglefin.	10-14	-	-	-	-	2	1	-	+
	15-19	-	-	-	-	-	1	-	1
	20-24	-	-	-	-	-	-	-	2
M.poutassou		-	-	-	-	-	-	3	6
Macrorus berglax		-	-	-	-	1	-	2	-
Sebastes	2-4	+	1	-	+	-	+	-	-
	5-9.	-	-	1	+	8	3	8	6
	10-14	-	-	-	1	1	5	2	11
	15-19	-	-	-	-	-	1	2	-
Cottidae		-	+	5	4	2	4	1	1
Artediellus atlanticus		-	-	+	2	-	2	-	-
Lumpenus lampretaf.		9	1	4	2	3	1	1	1
H.plates-	10-14	-	-	+	1	+	+	+	+
soides	15-19	-	-	-	-	-	-	2	-
	20-24	-	-	-	-	-	-	3	3
	25-29	-	-	-	-	-	-	2	3
	30-39	-	-	-	-	-	-	8	6
Pisces tot.		28	24	47	46	53	63	64	81
Ideterminatus		9	5	5	2	3	+	1	+
Grams pr stomach		1.12	0.44	4.1	4.6	16	22	53	63
% empty		30	39	19	20	12	12	7	12

Table 10. Millions of individuals of each age group by quarter for the North-East Arctic cod stock in 1984 (from ANON., 1986).

	Age group						
Quarter	1	2	3	4	5	6	7+
1	4204	977	144	76	65	56	62
2	4013	934	136	69	58	49	52
3	3823	888	128	62	51	42	42
4	3634	844	119	55	43	35	33

Table 11. Proportion of individuals by age group, area and quarter for for the North-East arctic cod stock (from Raknes and Nakken, 1984).

		Age group						
Area	Quater	1	2	3	4	5	6	7+
	1	0.000,	0.000,	0.000,	0.000,	0.000,	0.117,	0.390,
I	2	0.000,	0.000,	0.000,	0.000,	0.000,	0.117,	0.386,
	3	0.000,	0.000,	0.000,	0.000,	0.000,	0.033,	0.090,
	4	0.000,	0.000,	0.000,	0.000,	0.026,	0.110,	0.133,
	1	0.050,	0.033,	0.083,	0.167,	0.243,	0.320,	0.203,
II	2	0.046,	0.030,	0.086,	0.166,	0.243,	0.320,	0.210,
	3	0.050,	0.030,	0.060,	0.083,	0.106,	0.130,	0.130,
	4	0.046,	0.043,	0.083,	0.106,	0.130,	0.100,	0.256,
	1	0.500,	0.517,	0.516,	0.450,	0.410,	0.260,	0.170,
III	2	0.480,	0.517,	0.490,	0.453,	0.407,	0.260,	0.170,
	3	0.420,	0.433,	0.340,	0.330,	0.293,	0.250,	0.230,
	4	0.420,	0.433,	0.327,	0.320,	0.250,	0.230,	0.193,
	1	0.050,	0.026,	0.060,	0.120,	0.160,	0.127,	0.070,
IV	2	0.050,	0.020,	0.083,	0.120,	0.167,	0.127,	0.070,
	3	0.050,	0.020,	0.110,	0.120,	0.153,	0.143,	0.130,
	4	0.043,	0.033,	0.120,	0.133,	0.143	0.130,	0.117,
	1	0.250,	0.267,	0.223,	0.143,	0.106,	0.100,	0.123,
V+	2	0.263,	0.273,	0.223,	0.147,	0.110,	0.100,	0.117,
VIII	3	0.307,	0.347,	0.327,	0.313,	0.303,	0.300,	0.293,
	4	0.303,	0.327,	0.307,	0.303,	0.300,	0.307,	0.240,
	1	0.150,	0.157,	0.117,	0.117,	0.073,	0.073,	0.036,
VI+	2	0.157,	0.157,	0.120,	0.117,	0.073,	0.070,	0.036,
VII	3	0.173,	0.177,	0.163,	0.157,	0.147,	0.147,	0.133,
	4	0.173,	0.160,	0.160,	0.147,	0.147,	0.133,	0.057,

Table 12. The North-East Arctic cod stock's consumption in tonnes of main prey categories by quarter in 1984. Preliminary estimate.

	Quarter of the year				
Prey category	1	2	3	4	Sum
Deep sea shrimp	123114	107070	303342	284376	817902
Capelin	244326	356681	226137	208052	1035196
Herring	4130	8155	19004	16597	47886
Cod	8537	370	3439	2123	14469
Haddock	5578	18881	26619	24764	75842
Redfish	181753	33841	38821	39936	294351
"Others"	168947	233176	325898	292546	1020567
Sum	736385	758174	943260	868394	3306213

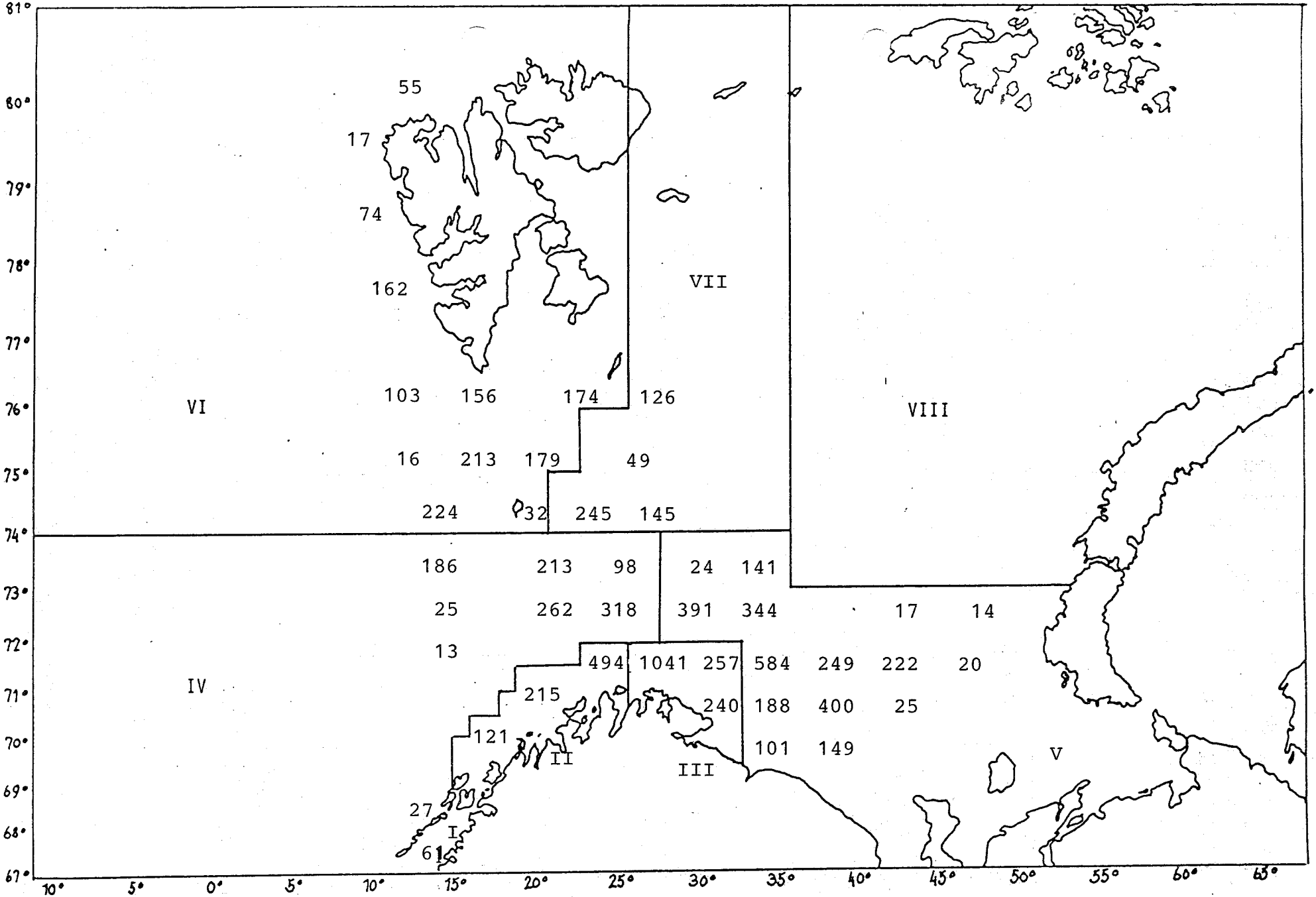

Fig.1. Total number of cod stomachs sampled in different areas of the Barents Sea (I - VII) in 1982 - 85. Sum = 8410.

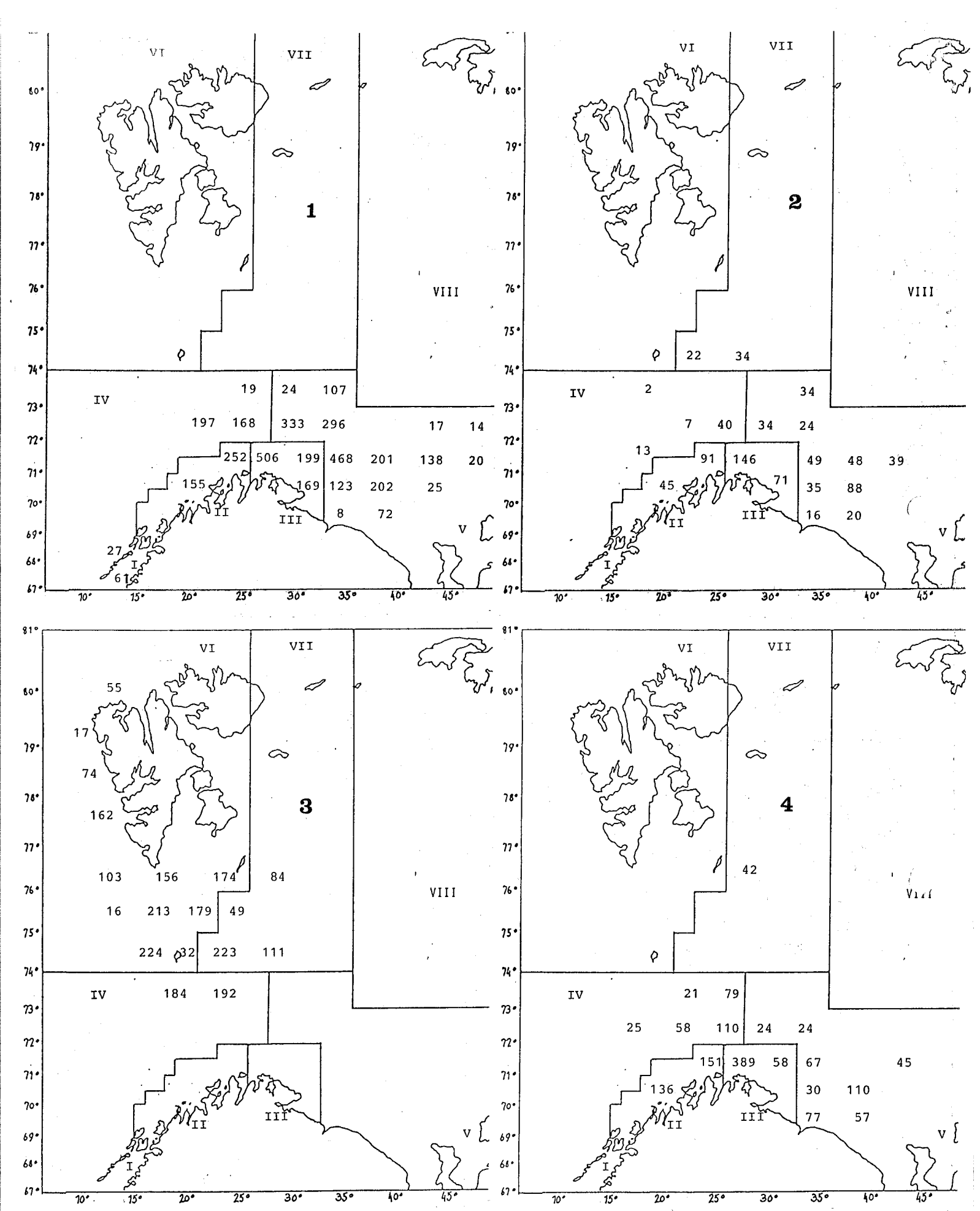

Fig.2. Number of cod stomachs sampled in the Barents Sea in 1982-85 by quarter and area.