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Predation of cod (*Gadus morhua*) on capelin (*Mallotus villosus*) in
northern Gulf of St. Lawrence (ICNAF Div. 4R-4S-3P) and off Labrador-
East Newfoundland (ICNAF Div. 2J-3K-3L)

by

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I. Introduction.

Feeding of cod in the Northwest Atlantic area has been described in several studies. Among them and for the Gulf of St. Lawrence, those of POWLES (1958) and KOHLER and FITZGERALD (1969) bring valuable data for the southern part of the Gulf.

Research during soviet and polish surveys and studies by TEMPLEMAN (1964) contribute to the knowledge of feeding relationships between cod and capelin in the Labrador and East Newfoundland region. However, little information is available on these relationships during the winter months and on offshore banks.

The present paper, in providing data on the diet of cod in the northern Gulf of St. Lawrence (ICNAF Divisions 4R-4S-3P) and on offshore banks of Labrador and East-Newfoundland (ICNAF Divisions 2J-3K-3L) tries to define the main characteristics of predation of cod on capelin in these two regions at two seasons.

Results obtained on variations of diet according to region, season and size of predator lead to estimate the quantity of capelin ingested annually by cod in the two regions.

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II. Material and methods.

The material used in this paper was collected during three research surveys :

- from 17 January to 24 February 1975, on board the R/V Cryos off the west and south-west coast of Newfoundland (ICNAF Div. 4 R and 3 P),
- from 8 July to 7 August 1975, on board the R/V Thalassa, in the northern Gulf of St. Lawrence (ICNAF Div. 4 R-4 S) and off Labrador-East Newfoundland (ICNAF Div. 2 J - 3 K - 3 L),
- from 8 January to 27 February 1976, on board the R/V Cryos off the west coast of Newfoundland (ICNAF Div. 4 R) and off Labrador-East Newfoundland (ICNAF Div. 2 J - 3 K - 3 L).

A total of 106 trawling stations were occupied (fig.1) at depths ranging from 95 to 315 meters in Divisions 4 R-4 S-3 P and from 130 to 445 meters in Divisions 2 J-3 K-3 L.

On board, after each haul, the cod stomachs were immediately removed from a sample of fish, quickly frozen at -40° C in individual plastic bags and stored at -26° C to avoid deterioration of contents. Fish showing signs of regurgitation or feeding when in the trawl were discarded. For each stomach collected, information on sex, total length (cm), sexual stage of cod as well as details on sampling station were recorded.

In the laboratory, each stomach was weighed. The stage of repletion was estimated using the scale 0, 1, 2, 3 and 4 for respectively empty, quarter-full, half-full, three-quarter-full and completely-full stomachs.

After dissection, preys were separated by species or by systematic group (genus or family) when too far digested. Each group was weighed to the hundredth of a gram and stages of digestion were noted using four categories from the most recently ingested food to those having undergone the digestive process to a greater degree.

A total of 1307 stomachs were sampled and examined for this study : 48 in 4 S, 629 in 4 R, 62 in 3 Pn, 36 in 3 Ps, 160 in 2 J, 234 in 3 K and 138 in 3 L. The major part of stomachs examined were found at stages of repletion 3 and 4.

III. Results.

1. Food of cod.

Data obtained from analysis of 1292 non-empty stomachs are given here in frequency of occurrence to express the relative importance of each food group ingested by cod in the whole area (4R-4S-3P and 2J-3K-3L combined).

On the other hand, the same results are given as percentage of occurrence in Table 1 to allow comparisons of data between ICNAF divisions.

Among the 5 systematic food groups found in the cod stomachs, fish and crustaceans are the most frequent, molluscs, echinoderms and annelids being more or less present.

Teleosts are the most frequent food group found in stomach contents (1063 times on 1292). The most frequent species is capelin Mallotus villosus (798) followed by redfish (155), lantern fish (81), american plaice (24), greenland halibut (17), small cod itself (16) and herring (13). Other fish (93) represented by 14 species are very rare (each occurrence less than 10 times).

Crustaceans, the second food group in occurrence (577), are mainly represented by Parathemisto gaudichaudii (222) and Pandalus borealis (219) followed by Euphausiids Meganycitiphanes norvegica and Thysanoessa spp. (87), other amphipods gammarids

Anonyx mugax (82), other shrimps Pandalus montagui, Sabinea sarsi, Spirontocaris spp. (54) and spider crabs Hyas spp., Chionocetes opilio (50). Rarer groups (29) are mysids, cumaceans, isopods, caprellids and hermit crabs (less than 10 each).

Molluscs are also present in cod stomachs (80) due mainly to gasteropods Buccinum sp., Neptunea sp. and Golus sp. (54), cephalopods Rossia sp., Gonatus fabricii, Illex illecebrosus and Bathypolypus arcticus (26) and some pelecypods Chlamys sp., Yoldia myalis and Cyrtodaria siliqua (6).

Echinoderms, sometimes present (53) are mainly represented by Ophiopholis aculeata (41) and by other items (17) : other brittle stars, holoturians and sea urchins (less than 10 each).

Annelids are also sometimes ingested (53) only due to polychaetes nereids (13), Eunicidae (9) and others non identified (33).

Other very rare food groups are grouped in Table 1 as "others" : Sipunculids (5), Cnidaria (5), ascidians (2) and priapulids (2).

2. Diet of cod.

Variations in the diet of cod are presented in relation to area and season of sampling and to sex and size of fish.

a - Geographic and seasonal variations.

Results obtained from weighing of food groups in cod stomachs are expressed here as percentage of weight for both areas.

Details for each division at each season are indicated in Table 2.

- In the Northern Gulf of St. Lawrence (ICNAF Div. 4R-4S-3P), the diet of cod is not varied and seasonal variations are not very well marked.

The relative quantity of fish ingested is almost equal from winter (93 %) to summer (91 %). The most important food group in the whole area is capelin, mostly in summer (78 %) but also in winter (59 %). In the summer months, it represents 76 % of food ingested in 4R and 79 % of food ingested in 4S. In winter, it represents 55 % in 4R and 65 % in 3Pn and north of 3Ps.

Small redfish are eaten in summer (5 %) but mainly in winter (19 %). Herring, ingested in 4R-3P in winter (6 %), is only found in stomachs sampled in 4R (13 %) in summer. In winter, american plaice can constitute a secondary fish prey for cod (4 %).

As for crustaceans, they are ingested in small quantities in both seasons (7 % in summer and 6 % in winter) due mainly to predation on northern deepwater prawn (6 % in summer and 3 % in winter).

Finally, small quantities of brittle stars are consumed in winter (3 %) only in 4R.

- On the contrary, on the offshore banks of Labrador and East-Newfoundland (ICNAF Div. 2J-3K-3L) the diet of cod is more varied and balanced. Differences between divisions are important and seasonal variations are very well marked in some of them.

On the Northern Grand Bank (3L), ingestion of fish is very important (94 % in both seasons) mainly due to great predation on capelin in summer (90 %) and even in winter (82 %). Other fish, mainly small cod (8 %) and greenland halibut (4 %) are also consumed in the winter months. Small quantities of squids (4 %) are found in cod stomachs sampled in summer. Crustaceans are ingested in both seasons : 2 % in summer and 6 % in winter due mainly to spider crabs (3 %).

On the offshore banks of South-Labrador (2J) and East-Newfoundland (3K), the situation is completely different.

Predation on capelin occurs in winter : 55 % of food weight in 2J and 14 % in 3K while in the summer months, capelin is almost absent of cod stomachs (0.8 % in 2J and 3.5 % in 3K).

In summer, fish consumption (23 % in 2J and 74 % in 3K) is then mainly due to ingestion of lantern fish (59 % in 3K) cottidae (7 % in 2J) and other small fish (13 % in 2J and 7 % in 3K). In winter, fish consumption (72 % in 2J and 53 % in 3K) based on capelin is also made on lantern fish in 3K (24 %) and small gadoids in 2J (10 %).

Crustaceans are ingested in both seasons. In summer, they are eaten in great quantity in 2J (73 %) due mainly to ingestion of spider crabs (41 %) and northern deepwater prawn (24 %) but in smaller amount in 3K (24 %) due to northern deepwater prawn (11 %) and amphipods (11 %). In winter, they are ingested in comparable quantity in 2J (23 %) and 3K (32 %) due to consumption of northern deepwater prawn (10 % in 2J and 6 % in 3K) and of amphipods (13 % in 2J and 24 % in 3K).

As a remark, it can be noted than redfish, herring and american plaice found in cod stomachs from Div. 4R-4S-3P are absent in Div. 2J-3K-3L where on the contrary greenland halibut, lantern fish and spider crabs are ingested.

b - Variation in relation to sex and size.

Data in percentage of weight obtained in each division are grouped by sex to compare the diet of male and female cod. Since differences could occur between sexes from a season to another because of influences of sexual maturity and reproduction, results are given for summer and winter separated (Table 3).

No significant differences between the diet of male and female cod appear from these results whatever the season.

So, data for males and females are combined to study variations of diet in relation to size. Results, expressed in percentage of weight in each 10 centimeters length-group, are given in details for the Northern Gulf of St. Lawrence (Table 4a) and for the banks off Labrador and East-Newfoundland (Table 4b).

- For sizes ranging from 16 to 25 cm (total length) observed in 2J-3K-3L (fig.2), the diet is mainly based on small crustaceans (89 %) represented by Parathemisto (36 %), young shrimps (29 %) and gammarids (17 %). Polychaetes are also present in food (9 %).

- After 26 cm in length (fig.2), the diet of cod is essentially composed of fish : 72 % to 97 % in both regions up to 95 cm and 100 % after 96 cm - except in 2J-3K-3L where 4 cods ranging from 86 to 95 cm have ingested spider crabs (66 %) and cephalopods (30 %) -.

The species of fish ingested by cod longer than 26 cm vary with its size in each region.

- Predation on capelin decreases very much (in percentage) in Div. 4R-4S-3P (fig.2) from 89 % (26-55 cm length-group) to 55 % (56-75 cm length-group) and 13 % (76-115 cm length-group). In the first length-group, small redfish (6 %) is ingested with capelin while in the second length-group, small redfish (13 %), american plaice (8 %) and cod (6 %) are also consumed, and in the third group, herring is the most important (50 %) followed by redfish (16 %), american plaice (10 %) and cod itself (6 %).

For cod over 106 cm in length, herring represents 85 % of food ingested.

In fact, if capelin intakes decrease in percentage of stomach contents, they are relatively stable in weight since ingested quantities increase with size of cod.

- On the contrary, predation on capelin (in percentage) is relatively stable in Div. 2J-3K-3L (fig.2) since it represents 59 % in the stomachs of 26-55 cm cod, 54 % for the 56-75 cm length-group and 56 % for the 76-115 cm length-group. In the first length-group, lantern fish (14 %) are mainly ingested with small quantities of greenland halibut. In the second length-group lantern fish (12 %) are ingested in equal quantity with gadoids (7 %) and greenland halibut (5 %). In the third length-group, polar cod and cod are mainly eaten (15 %) with greenland halibut (8 %) and lantern fish (3 %).

Two cods found over 106 cm feed only on polar cod and cod (77 %) and greenland halibut (23 %).

In fact, if capelin proportions in stomach contents are stable in each length-group, the weights of capelin increase with size of cod.

3. Predation on capelin.

Study of the diet of cod shows that capelin is the basic food in the two regions in winter and summer : average of 64 % of weight ingested by cod in our samples from 4R-4S-3P and average of 56 % in our samples from 2J-3K-3L.

a - Mean weight of capelin ingested by an average cod in one meal.

Results of previous section indicate that predation of cod on capelin varies with the size of predator. Basic data on total weight of capelin consumed by cod in each 10 cm length-group for both regions, used as percentage in Tables 4a and 4b, are considered here. These total weights, divided by the number of cod stomachs examined in each length-group, give the mean weight of capelin (Pm in gram) ingested by one cod in each length-group for the two areas separately (Tables 5a and 5b). Since Pm is obtained from samples where stomachs are mostly at stages 3 and 4, it can be considered as the mean weight of capelin ingested by one cod in one food intake.

Length compositions of cod in 4R-4S-3P and 2J-3K-3L are obtained from measurements on research catches made during the same 1975-76 surveys. From 5,484 fish in 4R-4S-3P and 12,814 fish in 2J-3K-3L measured (total length) length frequencies ($N \text{ }^{\circ}\text{oo}$) are given in each 10 cm length-group (Tables 5a and 5b).

The total weight of capelin ingested in one meal by 1000 cod of our sample is then obtained in adding the total weights (P in gram) consumed in each length-group. The results indicate that the mean weight of capelin ingested in one meal by an average cod is :

- 29.4 g in Div. 4R-4S-3P

- 27.8 g in Div. 2J-3K-3L

b - Mean weight of capelin ingested by an average cod in one year.

The mean weight of capelin consumed in one meal by an average cod is calculated from samples collected in both areas during the winter and summer periods, when the geographic distributions of the two species are intermingling and so when availability of capelin as a prey for cod is greater than in other periods of the year.

Indeed, during the winter months, both species undertake joint southward migration along the west coast of Newfoundland (4R-3Pn) and on Labrador-East Newfoundland offshore banks (2J-3K). In summer, when reproduction is completed, cod feeds intensively on capelin in inshore waters after a common migration to the North shores of the Gulf of St. Lawrence (4R-4S) and to Labrador-East Newfoundland coasts (2J-3K-3L).

During other months of the year, the quantities of capelin ingested by cod are certainly smaller. Thus, the annual period during which cod uses capelin as a prey can be estimated to range from 6 to 8 months.

On the other hand, results from BARRINGTON (1957) indicate that cod takes food only when stomach is empty and gastric digestion completed. An average duration of 5 days being necessary to digest a meal of fish, it can be estimated that cod consumes an average of 6 meals of fish in one month. This means that, for the period of predation considered, an average cod can ingest each year from 36 to 48 meals of capelin.

In div. 4R-4S-3P, the mean weight of capelin ingested annually by an average cod therefore ranges from :

$$29.4 \times 36 = \underline{1058} \text{ g}$$
$$\text{to } 29.4 \times 48 = \underline{1411} \text{ g}$$

Mean weight of cod in this region, calculated from research surveys, being $\bar{W} = 1326 \text{ g}$ indicates that an average cod consumes 0.80 to 1.06 time its own weight in capelin annually.

In Div. 2J-3K-3L, the mean weight of capelin ingested annually by an average cod therefore ranges from :

$$27.8 \times 36 = \underline{1000} \text{ g}$$
$$\text{to } 27.8 \times 48 = \underline{1334} \text{ g}$$

Mean weight of cod in this region, calculated from research surveys, being $\bar{W} = 1317 \text{ g}$ indicates that an average cod consumes 0.76 to 1.01 time its own weight in capelin annually.

IV - Conclusion.

From the results obtained in this paper, following conclusions can be drawn :

- 1 - Fish are the most frequent group found in the cod stomachs of both regions in summer and winter (present in 82 % of examined stomachs). Among them, capelin is the most frequent species (62 %) at the two seasons with redfish (12 %) and lantern fish (6 %). Crustaceans are found in 45 % of the stomachs examined because of amphipods (24 %) and shrimps (21 %) and occurrence of spider crabs. Other present food groups are molluscs (6 %), echinoderms (4 %) and annelids (4 %).
- 2 - Studies of geographic and seasonal variations of diet indicate that few changes occur in Div. 4R-4S-3P where capelin is ingested in large quantity in summer (78 % of weight) and also in winter (59 %).

For the sector studied in the Gulf of St. Lawrence, the common winter migration towards the south of cod and capelin from the Strait of Belle Isle to the southwest coast of Newfoundland is known (MINET, 1976). In spring and summer, inverse migration of cod is observed towards northern coastal waters where the two species are again mixed together.

On the contrary, geographical variations appears between Divisions 2J-3K and Division 3L. Few changes are noted in the diet of cod in 3L where capelin is consumed in large quantities in summer (90 %) and winter (82 %). But important changes occur between summer and winter in 2J-3K where capelin is consumed in winter (55 % in 2J and 14 % in 3K) but not in summer (0.8 % in 2J and 3.5 % in 3K).

On Northern Grand Bank, cod and capelin are found together in winter along the northern slope where capelin seems to overwinter. In spring and summer, as the mature portion of the capelin stock migrates towards the Avalon Peninsula coastal waters and Southeast Shoal followed by most of cod, non-migrant immature capelin constitutes the basic fish prey for local cod (TEMPLEMAN, 1964 - WINTERS, 1975).

On the Labrador-East Newfoundland offshore banks, capelin and cod undertake a common southwards migration during winter. However, in Div. 2J, the two species are more mixed on the banks than in Div. 3K where distribution of capelin is more coastal.

In spring and summer, capelin migrates towards the South Labrador and East Newfoundland shores for spawning followed by large quantities of cod (TEMPLEMAN, 1964). Therefore, cod remaining offshore in summer feed on the few fish present and mainly lantern fish.

- 3 - No variation in the diet with sex of cod was observed but variations according to the size of predator are important. Below 25 cm in length, 2J-3K-3L cod consumes mainly minute crustaceans as shown by POWLES (1958) for the Southern Gulf of St. Lawrence. Over 25 cm, fish is the major prey for cod in both regions during the two seasons (72 % to 97 %).

In the Northern Gulf of St. Lawrence, percentages of capelin ingested decrease (89 % to 13 %) as size of cod increases. Capelin is then replaced by redfish, american plaice and mainly herring. However, in total weight, quantities of capelin ingested are stable with size of cod.

On the Labrador-East Newfoundland offshore banks, percentages of capelin ingested are stable (50 to 60 %) as size of cod increases. Capelin is consumed here with lantern fish, greenland halibut and gadoids. In total weight, quantities of capelin ingested increase with size of cod.

- 4 - Predation of cod on capelin is important during winter and summer in the two regions (average of 64 % in 4R-4S-3P and average of 56 % in 2J-3K-3L).

The mean weight of capelin ingested by an average cod in one meal was found to be 29.4 g in 4R-4S-3P and 27.8 g in 2J-3K-3L. Taking an annual period of predation on capelin of 6 to 8 months, an average cod consumes annually from 1058 g to 1411 g in 4R-4S-3P and from 1000 g to 1334 g in 2J-3K-3L. These results indicates that an average cod consumes from 0.80 to 1.06 time its own weight in 4R-4S-3P and from 0.76 to 1.01 time its own weight in 2J-3K-3L.

These ratios for 2J-3K-3L are very similar to those given for this region in previous estimates (CAMPBELL and WINTERS, 1973 - WINTERS, 1975) but mean weight \bar{W} of cod in the stock complex was different.

Therefore, assuming that the cod total biomass in the Northern Gulf of St. Lawrence is about 500,000 metric tons, annual consumption of capelin by cod can be estimated almost equal (400,000 to 500,000 metric tons).

Assuming that the average stock size in 2J-3K-3L is about $2000 \cdot 10^6$ (PINHORN and WELLS, 1972), the consumption of capelin by cod in this region can be estimated to range from 2,000 000 to 2,600 000 metric tons.

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Table 1. - Diet of cod as measured by occurrence percentage of preys in stomachs of each sample, 1975-76.

Stomach contents	4 S		4 R		3 P		2 J		3 K		3 L	
	Summer 1975	Winter 1975	Summer 1975	Winter 1976	Winter 1975	Summer 1976	Summer 1975	Winter 1976	Summer 1975	Winter 1976	Summer 1975	Winter 1976
• Annelida Polychaeta Errantia		6.1		0.4	1.0		15.5	5.9	5.2	10.2	4.3	2.9
• Mollusca												
• Pelecypoda	2.1	9.2	1.4	1.6	1.0		12.1	11.8	4.4	23.5	4.3	5.9
• Gasteropoda Buccinidae		1.8					1.7		0.7			
• Cephalopoda	2.1	7.9	0.7	1.2	1.0		8.6	6.9	3.7	10.2	1.4	5.9
			0.7	0.4			1.7	4.9		14.3	2.9	
• Crustacea												
• Amphipoda Gammaridea	25.6	39.9	19.7	23.3	32.7		91.4	74.5	61.5	93.9	38.6	36.8
• Hyperiidea (Parathemisto gaudichaudii)	2.1	10.1	2.0	0.8			20.7	6.9	11.9	14.3	2.9	2.9
• Caprellidea				3.3			19.0	51.0	31.1	83.7	20.0	17.6
• Euphausiacea	4.2	13.2	5.4	4.5	27.6		3.4	1.0	2.2	4.1		
• Decapoda Pandalidae	19.1	18.4	11.6	12.7	2.0		53.4	33.3	30.4	30.6	4.3	14.7
• Paguridae		0.4	0.7	0.4					0.7			
• Maiidae (Byas spp. - Chionocetes opilio)	2.1	3.5	0.7	0.8	2.0		31.0	1.0	5.1	4.1	1.4	5.8
• Others		3.0	1.4	4.8	2.0		17.2	1.0	2.1	18.3	1.4	1.4
• Others (Mysidacea - Cumacea - Isopoda)					3.1		3.4	2.0	1.4	9.2	1.4	1.5
• Echinodermata												
• Ophiuroidea (Ophiopholis aculeata - Ophiura spp.)		13.2	0.7	0.8			1.7	7.9	2.2	8.1		3.0
• Holothuroidea (Thyone spp. - Mesothuria intestinalis)		13.2	0.7	0.8			1.7	6.9	1.5	6.1		1.5
• Teleostei									0.7	2.0		1.5
• Clupea harengus	95.7	82.9	98.6	97.6	98.0		32.8	65.7	63.7	51.0	98.6	85.3
• Mallotus villosus		4.4	3.4	0.8							1.4	
• Myctophidae	80.9	60.1	93.9	89.0	85.7		1.7	45.1	5.2	8.2	95.7	79.4
• Gadidae							1.7		44.4	19.4	2.9	
• Sebastes mentella	2.1	1.8		2.0			10.3	1.0	1.5	2.0	2.9	2.9
• Cottidae	8.5	26.8	11.6	12.2	31.6		3.9	3.9	1.5	6.1		
• Pleuronectidae		6.6		2.0			8.6	1.0	0.7	1.0		
• Others	6.4	3.9	1.4	0.4	1.0		6.9	7.8	3.7	3.1	2.9	4.4
• Not identified	2.1	0.9					3.4	2.0	10.4	4.1	2.9	
• Others								10.8	1.5	15.3		1.5
• Not identified		3.1						5.9				
• Pebbles and shell fragments		4.0	0.7	0.4	2.0		6.9	6.9	0.7	1.0		
		7.0	0.7	1.2	5.1		1.0	1.0	1.5	4.1		1.5
Number of stomachs with food	47	228	147	245	98		58	102	135	98	70	68

Table 2. - Diet of cod as measured by weight percentage of preys in stomachs of each sample, 1975-76.

Stomach contents	4 S		4 R		3 P		2 J		3 K		3 L	
	Summer : 1975	Winter : 1975	Summer : 1975	Winter : 1975	Summer : 1975	Winter : 1975	Summer : 1975	Winter : 1975	Summer : 1975	Winter : 1975	Summer : 1975	Winter : 1975
. Annelida Polychaeta Errantia		0.5					1.2	0.2	0.4	0.1		
. Mollusca												
. Pelecypoda	0.4	1.1	0.3	0.1	0.2		1.9	1.2	0.7	9.0		0.1
. Gastropoda Baccinidae		0.4										
. Cephalopoda	0.4	0.7	0.3	0.1	0.2		1.7	0.9	0.4	1.3		0.1
. Crustacea	7.5	7.2	5.6	5.2	5.0		73.4	22.8	24.3	31.8		5.6
. Amphipoda Gammaridea	0.1	0.2	0.2	0.1			1.0	0.1	3.6	0.1		1.1
. Hyperiidea (Parathemisto gaudichaudii)							5.5	12.6	7.4	24.0		
. Caprellidea										0.1		
. Euphausiacea		0.9	1.2	0.9	4.1		0.1		0.3			
. Decapoda Pandalidae	7.0	3.4	4.0	3.7	0.5		23.9	10.0	11.0	5.9		1.3
. Paguridae		0.2							0.1			
. Mollusca (Hyas spp. - Chiono-cetes opilio)	0.4	2.3	0.1	0.2	0.1		40.9	0.1	1.7	0.9		3.2
. Others		0.2	0.1	0.3	0.2		0.3	0.1	0.2	0.7		0.1
. Others (Mysidacea - Cumacea - Isopoda)												
. Echinodermata		5.8		0.6			0.1	1.3	0.9	1.3		
. Ophiuroidea (Ophiopholis aculeata - Ophiura spp.)		5.8		0.6				1.3	0.8	0.9		
. Holothuroidea (Thyone spp. - Mesothuria intestinalis)							0.1		0.1	0.4		
. Teleostei	92.0	84.0	94.0	94.1	94.7		23.2	71.7	73.7	53.4		94.2
. Clupea harengus		11.3	12.9	5.8			0.8	55.3	3.5	13.8		81.7
. Mallotus villosus	79.3	39.9	75.6	71.0	64.7		0.2	0.2	59.4	24.3		0.5
. Myctophidae												
. Gadidae	3.6	1.8		6.0				9.7				7.8
. Sebastes mentella	5.2	19.2	5.4	8.6	28.7			2.1	0.1	1.0		
. Cottidae												
. Pleuronectidae		8.6		2.7			6.8	0.3		0.4		
. Others	3.9	3.0	0.1		1.3		1.3	2.0	3.9	4.4		4.4
. Not identified		0.2					13.0	0.2	6.6	2.9		0.9
. Others							1.1	2.1	0.2	6.6		0.3
. Not identified		0.5										
. Not identified		0.2			0.2			1.5		0.4		
. Pebbles and shell fragments		0.7		0.1			0.2			0.5		
TOTAL	99.9	100.0	99.9	100.1	100.1		100.0	99.8	100.0	99.9		99.9
Number of stomachs with food	47	227	147	245	98		58	102	134	97		68

Table 3. - Diets of male and female cod for both regions in summer and winter.

Stomach contents	Summer		Winter	
	males	females	males	females
. Annelida Polychaeta Errantia	0.1	0.3	0.1	0.2
. Mollusca	0.5	2.2	0.8	1.1
. Pelecypoda				0.1
. Gasteropoda Buccinidae	0.1	0.3	0.4	0.3
. Cephalopoda	0.4	1.9	0.4	0.7
. Crustacea	15.7	14.8	11.0	8.2
. Amphipoda Gammaridea	0.5	1.1	0.1	
. Hyperiidea (Parathemisto gaudichaudii)	3.3	1.6	3.3	3.2
. Caprellidea				
. Euphausiacea	0.3	0.6	1.5	0.4
. Decapoda	7.3	6.1	3.5	3.9
. Pandalidae				0.1
. Paguridae				0.1
. Maiidae (Hyas spp. - Chiono-cetes opilio)	3.8	5.2	2.4	0.4
. Others	0.4	0.2	0.2	0.2
. Others (Mysidacea - Cumacea - Isopoda)	0.1			
. Echinodermata	0.2	0.1	1.9	1.5
. Ophiuroidea (Ophiopholis aculeata - Ophiura spp.)	0.2	0.1	1.8	1.5
. Holothuroidea (Thyone spp. - Mesothuria intestinalis)			0.1	
. Teleostei	83.5	82.3	85.4	88.0
. Clupea harengus	5.0	3.9	5.3	3.6
. Mallotus villosus	58.1	60.3	61.9	59.5
. Myctophidae	8.9	12.7	1.4	1.7
. Gadidae	1.0		4.7	5.1
. Sebastes mentella	2.6	2.0	6.5	11.9
. Cottidae	0.2	1.0		0.1
. Pleuronectidae	2.7	0.3	2.8	4.9
. Others	4.7	2.0	1.7	0.6
. Not identified	0.3	0.1	1.1	0.6
. Others			0.1	0.4
. Not identified			0.6	0.3
. Pebbles and shell fragments			0.3	0.1
TOTAL	100.0	99.7	100.2	99.8
Number of stomachs with food	213	242	384	453

Table 4a. - Variation of the diet of cod in relation to size in ICNAF Div. 4R-S - 3 as measured by weight percentage in 10 cm length-groups.

Stomach contents	Cod length groups									
	28-35 CM	36-45 CM	46-55 CM	56-65 CM	66-75 CM	76-85 CM	86-95 CM	96-105 CM	106-115 CM	
. Annelida Polychaeta Errantia						0.6				
. Mollusca										
. Pelecypoda	0.8		0.3	0.6	2.2	0.3	0.1			
. Gastropoda Buccinidae			0.1	0.4			0.1			
. Cephalopoda			0.2	0.1	1.6	0.3				
. Crustacea										
. Amphipoda Gammaridea	2.6	2.5	3.7	12.5	10.7	3.9	2.7			
. Hyperiidia (Parathemisto gaudichaudii)	0.1	0.1	0.1	0.1	0.1					
. Caprellidea										
. Euphausiacea	1.3	0.5	0.8	3.5	1.5					
. Decapoda .Pandalidae	1.2	1.6	2.4	7.0	5.7	3.8	0.3			
. Paguridae					0.3		0.6			
. Mairidae (Hyas spp. - Chionocetes opilio)		0.3	0.1	1.6	2.8		1.8			
. Others			0.1	0.3	0.3	0.1				
. Others (Mysidacea - Cumacea - Isopoda)			0.1							
. Echinodermata			1.0	4.4	5.3					
. Ophiuroidea (Ophiopholis aculeata - Ophiura spp.)			1.0	4.4	5.3					
. Holothuroidea (Thyone spp. - Mesothuria intestinalis)										
. Teleostei										
. Clupea harengus	96.6	97.1	94.6	81.6	81.4	94.8	95.5	99.6	98.5	
. Mallotus villosus				0.4	0.3	30.1	41.1	57.4	85.4	
. Myctophidae	95.4	94.1	85.4	56.0	52.1	19.9	12.2	7.4	4.2	
. Gadidae				1.3	6.8	14.2	3.0		8.9	
. Sebastes mentella	1.2	3.0	7.8	22.3	8.8	25.1	25.8	15.8		
. Cottidae			1.4	0.4	12.1	4.5	13.0	19.0		
. Pleuronectidae				1.1	1.0	1.0	0.4			
. Others				0.1	0.3					
. Not identified										
. Others			0.1	0.2	0.2		0.3			
. Not identified		0.1		0.2	0.2					
. Pebbles and shell fragments			0.1	0.2	0.1	0.3	1.4	0.3		
TOTAL	100.0	99.7	99.9	99.9	100.1	99.9	100.0	99.9	100.0	
Number of stomachs with food	51	224	221	186	39	21	14	6	2	

Table 4b. - Variation of the diet of cod in relation to size in ICNAF Div. 2J - 3K-L as measured by weight percentage in 10 cm length-groups.

Stomach contents	Cod length groups										
	16-25 cm	26-35 cm	36-45 cm	46-55 cm	56-65 cm	66-75 cm	76-85 cm	86-95 cm	96-105 cm	106-115 cm	
. Annelida Polychaeta Errantia	8.7	2.2	0.2	0.2	0.1	0.1		0.6			
. Mollusca											
. Pelecypoda											
. Gasteropoda - Buccinidae							0.1	30.2			
. Cephalopoda							0.1	30.2			
. Crustacea											
. Amphipoda Gammaridea	89.3	20.6	15.5	23.3	14.6	25.3	7.1	68.1	1.8		
. Hyperiidæ (Parathemisto gaudichaudii)	17.4	0.3	0.3	0.2	0.7	1.4					
. Caprellidæ	36.4	10.2	6.2	15.9	6.3	5.8					
. Euphausiacea	0.5		0.4								
. Decapoda Pandalidae	29.3	9.0	7.9	6.9	6.3	8.4	2/3	1.2			
. Paguridae											
. Maidæ (Hyas spp. - Chionocetes opilio)	5.4		0.3	0.1	0.9	9.5	4.4	66.3	1.8		
. Others		0.8	0.3	0.2	0.3	0.2	0.4	0.6			
. Others (Mysidacea - Cumacea - Isopoda)	0.3	0.3	0.1		0.1						
. Echinodermata											
. Ophiuroidea (Ophiopholis aculeata - Ophiura spp.)											
. Holothuroidea (Thyone spp. - Mesothuria intestinalis)											
. Teleostei	1.9	75.9	83.3	72.4	80.5	72.6	91.6	0.7	98.2	100.0	
. Clupea harengus							0.2				
. Mallotus villosus	1.9	69.6	68.6	49.7	58.5	46.2	77.0	0.7	78.4		
. Myctophidae		2.9	10.2	17.2	13.8	8.0	6.8				
. Gadidae							1.7				
. Sebastes mentella		0.5	1.0	0.3	1.0	8.7	1.7		6.2	76.7	
. Cottidae											
. Pleuronectidae		1.0	0.4	2.6	1.5	2.3	5.9		13.6	23.3	
. Others		0.9	0.9	1.3	2.0	3.8					
. Not identified		1.9	1.7	1.2	2.1	1.3					
. Others											
. Not identified		1.1	0.3	1.3	1.4	0.2					
. Pebbles and shell fragments								0.5			
TOTAL	99.9	100.0	99.9	99.9	100.0	99.9	100.1	100.1	100.0	100.0	100.0
Number of stomachs with food	13	71	122	118	119	63	14	4	2	2	2

Table 5a. - Calculation of mean weight of capelin ingested in one meal by an average cod in ICNAF Div. 4 R-S - 3 P from:

Pm (g) : mean weight of capelin ingested in one meal by one cod in each length-group
 N^o/oo : observed length frequency.

Cod length group (cm)	Mean weight of capelin ingested in one meal by one cod Pm (g)	Length frequency N(‰)	Total weight of capelin P(g) = N x Pm
16-25	-	22	-
26-35	17.9	71	1,270.9
36-45	26.1	251	6,551.1
46-55	37.7	342	12,993.4
56-65	27.2	254	6,908.8
66-75	34.5	42	1,449.0
76-85	21.8	7	152.6
86-95	23.4	6	140.4
96-105	16.8	2	33.6
106-115	9.8	2	19.6
116-125	-	1	-
Total	-	1,000	29,419.4

Table 5b. - Calculation of mean weight of capelin ingested in one meal by an average cod in ICNAF Div. 2 J - 3 K-L from:

Pm (g) : mean weight of capelin ingested in one meal by one cod in each length-group
 N^o/oo : observed length frequency

Cod length group (cm)	Mean weight of capelin ingested in one meal by one cod Pm (g)	Length frequency N (‰)	Total weight of capelin P(g) = N x Pm
16-25	0.1	11	1.1
26-35	8.6	193	1,659.8
36-45	16.9	265	4,478.5
46-55	18.9	215	4,058.5
56-65	45.9	189	8,675.1
66-75	42.0	90	3,780.0
76-85	180.5	25	4,512.5
86-95	1.2	8	9.6
96-105	296.1	2	592.2
106-115	0.0	1	0.0
116-125	-	1	-
Total	-	1,000	27,777.3

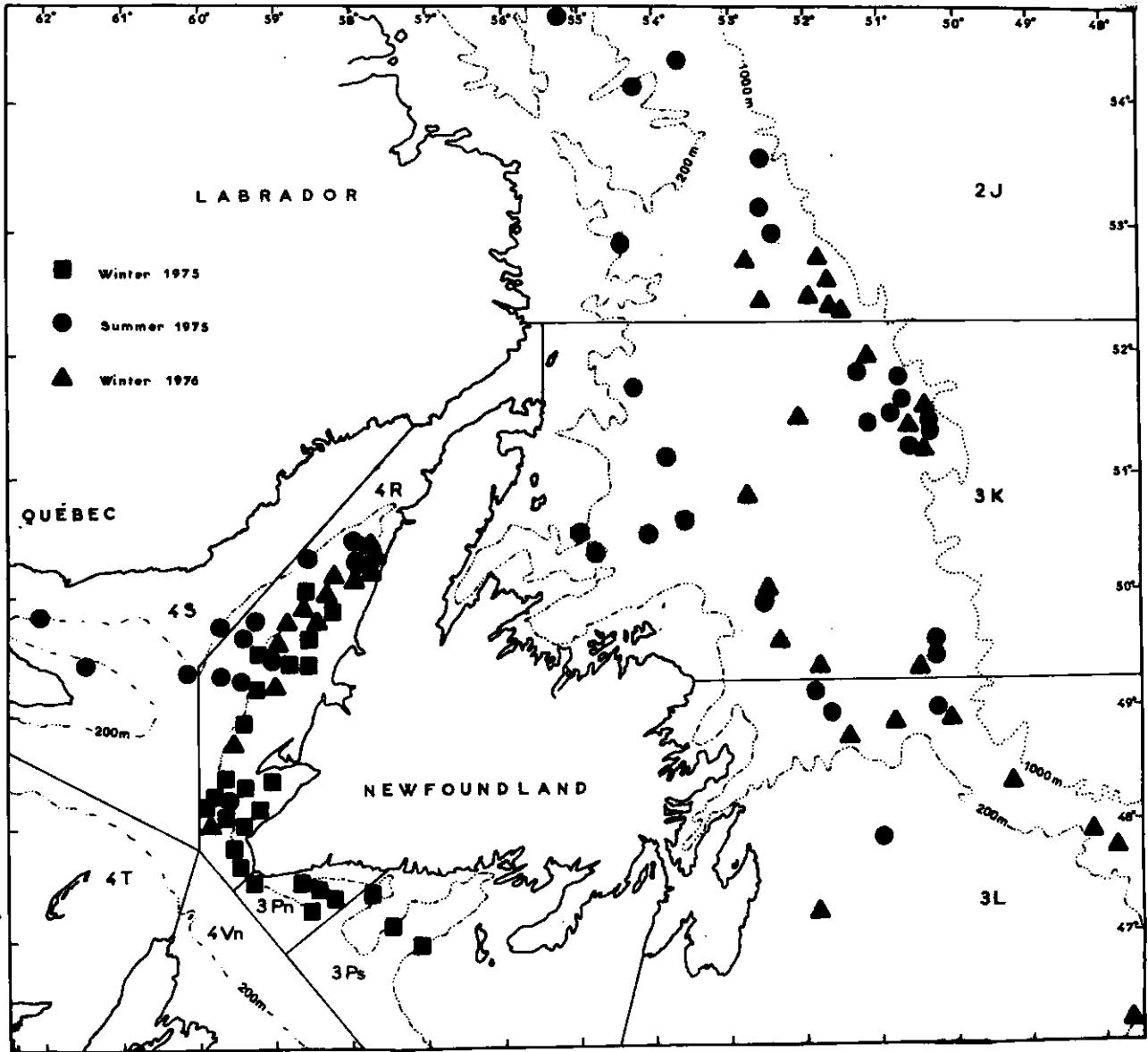
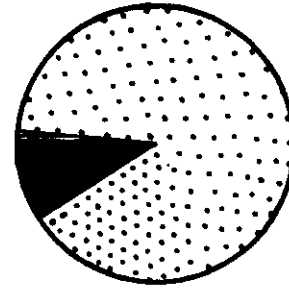
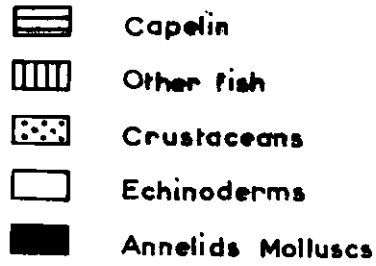
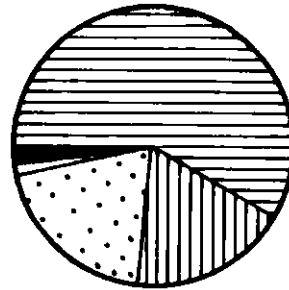
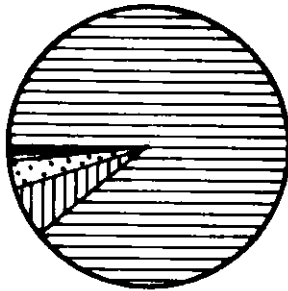


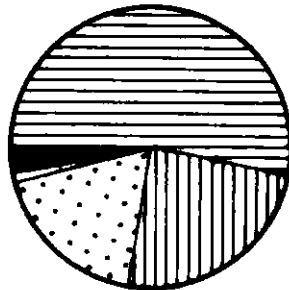
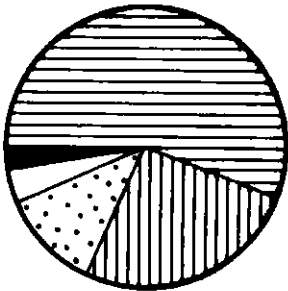
Fig. 1 - Position of stomach sampling stations in ICNAF Divisions 4 R-S - 3 P and Divisions 2 J - 3 K-L, 1975-76.



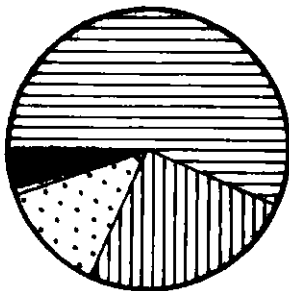
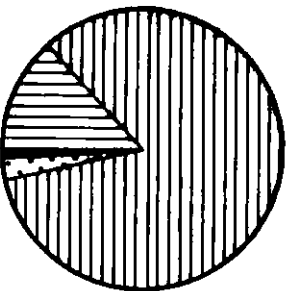
Cod 16 to 25 cm



Cod 26 to 55 cm



Cod 56 to 75 cm



Cod 76 to 115 cm

A

B

Fig. 2 - Variation of the diet of cod in relation to size (4 length-groups) expressed by weight percentage of preys ingested :

A - in ICNAF Divisions 4 R-S - 3 P

B - in ICNAF Divisions 2 J - 3 K-L

