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Food Habits and Consumption Rates of Cod from the Southwestern Gulf of St. Lawrence (1979)

by

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Abstract

Stomach content analysis was conducted on over 1200 cod from the southern Gulf of St. Lawrence (1979). Invertebrates, mainly euphausiids and brachyuran crabs accounted, by weight, for 60-90% of the total food intake. Fish prey increased in importance with increasing predator size. By comparison to earlier studies, the percent occurrence of fish prey was lower, particularly that of herring. On the other hand, capelin occurrence was higher than previously observed. Using the above data, population estimates, and the Ursin growth theory estimates of the biomass of capelin and flatfish consumed by cod in the study area in 1978 were made.

Résumé

Les contenus stomacaux de plus de 1,200 morues recoltés dans le golfe Saint-Laurent méridional en 1979 ont été analysés. De 60 à 90%, en poids, de toute la nourriture ingérée est constitué d'invertébrés, surtout des euphausides et des crabes brachyoures. A mesure que le prédateur croît, les poissons deviennent plus abondants dans la diète. Par comparaison avec des observations antérieures, l'incidence en pourcentage des proies qui sont des poissons, surtout du hareng, est faible. D'autre part, le capelan est plus commun qu'auparavant. Nous avons fait une estimation de la biomasse de capelan et de poissons plats consommée par la morue en 1978 dans la région étudiée, à partir des données de l'analyse des contenus stomachaux, de l'évaluation de l'abondance de la morue et de la théorie de la croissance développée par Ursin.

INTRODUCTION

The following study was initiated to determine the composition of prey in the diet of cod inhabiting the southern Gulf of St. Lawrence. Of particular interest was the extent of predation by cod on commercially important species including herring, capelin and flatfishes. Previous studies (Corbeil 1953; Powles 1958; Kohler and Fitzgerald 1969) have indicated a significant occurrence of these prey species in the diet of Gulf cod but no detailed stomach content analyses have been reported for over 15

years. The above analysis has been used in conjunction with the Ursin fish growth theory to predict consumption rates of capelin and flatfish by cod in the southwestern Gulf of St. Lawrence.

MATERIALS AND METHODS

Collection and analysis of cod stomachs

Over 200 cod stomachs were collected from commercial fishing boats during the period May 28 to July 14, 1979. Details of the sampling are given in Table 1. Freshly landed cod were sorted by fork-length into three categories: 35-55, 56-65 and greater than 65 cm. Each fish was weighed to the nearest 100 g with a spring balance. The mouth of each cod was examined to exclude those fish showing evidence of regurgitation. The stomach was removed, care being taken to avoid any loss of contents. An identifying label and the stomach were then wrapped in gauze and secured with an elastic band. Approximately 10 mL of neat formalin was injected into the stomach by inserting a syringe needle through the gauze and stomach wall. The stomachs were then placed in 2-gal plastic pails containing 10% formalin. The pail lids were secured and the material was transported to St. Andrews for analysis.

The preserved stomachs were soaked in tap water for several hours before they were removed from the gauze and dissected. Prey items were removed and sorted into taxonomic groups. After identification, the food items were weighed to the nearest 0.01 g. Teleost prey were identified to species level (physical condition permitting) with the exception of flatfishes which were not considered beyond the family taxon. Invertebrates were identified to order and, in some cases, to family. The percent

occurrence (by weight) of the various food items was calculated for seven size categories corresponding to the following age groups 3 and 4, 5, 6, 7, 8, 9 and 10, and 11+ years.

In addition to the above, cod stomachs were examined, on board, during the annual groundfish survey in the Gulf (September 5 to October 3, 1979). Over 990 cod, (≥40 cm) were examined from 74 sets. Total stomach volume and the volume of capelin, mackerel and herring were estimated by visually matching the contents with plasticene models representing specific volumes.

Food consumption estimates

The methods used to calculate total food consumpton of 4T cod are described fully in Majkowski and Waiwood (1980). Briefly, the analysis involved the estimation of (1) individual food consumption for cod aged 1 to 15 years (by application of various physiological parameters relating growth and food consumption), (2) population growth rate for 1978-79 (from empirical data) and (3) numbers-at-age (Gray 1979). Estimates of population parameters for 1978 were used in the absence of the corresponding values for 1979. It was assumed that cod predation patterns were not significantly different in 1978 and 1979.

As mentioned, detailed food data were collected from a limited area in the Gulf. Using fall research cruise population estimates, the fraction of cod inhabiting this area (strata 17, 20 and 22) was estimated to be 0.37. Accordingly, the above area represented (by numbers) 20, 56, 38, 31 and 40% (mean 37%) of the estimated population in area 4T for the years 1977, 76, 75, 74 and 73, respectively. Total food consumption was adjusted in accordance with the above correction.

Consumption rates of specific prey were calculated by multiplying the total consumption rate by that fraction of the diet represented by the prey item. This was repeated for each age category of cod.

RESULTS

Stomach analysis

The percent prey composition of cod in the study area is summarized in Figure 1 and Table 2. Further details are given in Appendix I.

The percent occurrence of fish prey increased with cod size reaching a maximum of 40% in 80+ cm fish. In 3- to 10-year-old cod, capelin was the most important fish prey contributing 5 to 15% of the total diet (mean 9%). Capelin were not found in cod larger than 80 cm. Flatfish, mainly plaice (Hippoglossoides platessoides), were found in cod larger than 53 cm but their highest occurrence was in fish greater than 71 cm. In order of importance, other fish prey included snake blenny (Lumpenus lumpretaeformis), eelpout (Zoarcidae), alligatorfish (Aspidophoroides monopterygius) and mackerel (Scomber scombrus). Herring and juvenile cod were not found in any stomachs examined.

Invertebrate prey accounted for 60 to 90% of the total food intake of cod. Their importance generally decreased with increasing cod size (Figure 1, Table 2). Euphausiids were replaced by Brachyurans (Hyas araneus and Chionoecetes opilio) as the major invertebrate prey in cod larger than 65 cm. The occurrence of other invertebrate prey remained relatively constant irrespective of cod size.

Unfortunately, the effect of season, sampling location and gear on the food composition of cod could not be evaluated as an unanticipated reduction in sampling effort resulted in the confounding of these variables.

The occurrence of capelin, mackerel and herring in 998 cod stomachs examined during the 1979 fall groundfish survey (EEP 229) is summarized in Fig. 2. Fewer than 4% of the cod examined contained one or more of the above prey. There was a complete absence of these prey in cod taken east of longitude 63°W. In the region roughly equivalent to the previous study area, capelin accounted for approximately 9% of the diet of cod larger than 40 cm. Herring was found in only 4 cod stomachs from the entire Gulf.

Food consumption rate estimates

Of the approximate 260,000 tons of food consumed in 1978 by cod in the study area, 19,996 (7.7%) and 584 tons (0.2%) were attributable to predation on capelin and flatfish, respectively (Table 3). These estimates are presented as first approximations since it was assumed that feeding patterns were not different in 1978 and 1979. Individual consumption rates of capelin increased with increasing size of cod, up to 4,000 g, and fall thereafter (Table 3, Figure 3). Accordingly, in the study area, cod aged 3-10 years consumed 23, 18, 31, 8, 15, 18, 13 and 11%, respectively, of their body weight as capelin. About 65% of the consumed capelin was eaten by 4 and 5-year-old cod (43.1-53.1 cm). On the other hand, cod larger than 80 cm (15+ years) consumed almost 50% of all flatfish.

DISCUSSION

The relatively low consumption of fish prey and the virtual absence of herring in the diet of cod remain the striking features of this study. All previous food habit studies have indicated that herring is the major fish prey of cod inhabiting the southwestern Gulf of St. Lawrence (Corbeil 1953; Powles 1958; Kohler and Fitzgerald 1969). It must be remembered, however, that in the latter two studies, stomach collections were made during the

outbreak of epizootic disease (mid-50's) which left large numbers of herring vulnerable to cod predation (Kohler 1964). The present situation may reflect the decline in herring biomass in the southern Gulf since the early 70's (Winters 1976; Winters and Moores MS 1979) and/or an increase in cod biomass (Koeller 1980). Accordingly, based on population parameters for 1978, we have calculated the maximum possible contribution of herring in the food of cod to be less than 0.2% (Majkowski and Waiwood 1980). Ponomarenko and Yaragina (1978) have reported, also, a shift in the predation patterns of Barents Sea cod. During the period of 1968-76, predation on capelin grew while feeding on herring sharply decreased.

Roughly 584 tons of flatfish were estimated to be consumed in 1978 by cod in the study area. The maximum possible contribution of plaice in the cod diet was less than 0.2% or one order of magnitude lower than the maximum possible contribution (2.8%) calculated for 4T from population parameters (Majkowski and Waiwood 1980).

Considering the sampling limitations and the use of 1979 stomach content data, the above estimates of individual prey consumption by the cod population in 1978 must be considered as preliminary. Further analysis, using 1979 population estimates and a more detailed analysis of the cruise data, should provide better estimates for 1979.

These data indicate that capelin was the major fish prey of cod sampled during the study. Cod age 3 to 10 years consumed about 20,000 tons of capelin in the study area. This corresponded to approximately 8% of the total food consumed. Minet and Perodou (1978) calculated an individual annual consumption rate of capelin equivalent to 1001-1764 g/year for a 1,320-g cod (ICNAF Divisions 2J, 3K, 3L, 3Pn, 4R and 4S). The corresponding value in this study was 230 g/year. However, this difference can be accounted for by the respective percent occurrence of capelin in the diet.

The decline in percent occurrence of capelin in the food of cod over 80 cm in length is consistent with the findings of Minet and Perodou (1978). This suggests that, for large cod, the energetic costs of capture outweigh the nutritional benefits of the relatively small prey.

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Table 1. Sampling summary for 1979 cod stomach collections.

Sample	Date	Location	Gear	Total no. fish landed	No. fish per size class (cm) 35-55.0	55.1-65.0	65 + above
I	May 28	Shediac Valley	Danish seine	8	3	3	2
	May 29	Shediac Valley	Danish seine	31	9	13	9
	May 30	Shediac Valley	Danish seine	15	5	5	5
	Combined			54	17	21	16
II	June 20	Ste- Marie	Gillnet	37	10	6	21
	June 22	sur-Mer	Gillnet	13	12	1	0
	Combined			50	22	7	21
III	June 26	Miscou Bank	Side dragger	15	4	8	3
	June 27	Miscou Bank	Side dragger	19	6	9	4
	June 28	Miscou Bank	Side dragger	16	6	7	3
	June 29	Miscou Bank	Side dragger	11	5	5	1
	June 30	Miscou Bank	Side dragger	11	4	4	3
	July 01	Miscou Bank	Side dragger	4	1	2	1
	Combined			76	26	35	15
IV	July 10	Ste-Marie	Gillnet	20	1	4	15
	July 14	sur-Mer	Gillnet	15	2	0	13
	Combined			35	3	4	28
	Total			215	68	67	80

Table 2. Percent prey composition, by weight, of southwestern Gulf of St. Lawrence cod. Values are averaged over all sampling intervals (see Table 1).

Prey item	Age Class 3+4	5	6	7	8	9+10	11+
TELEOSTEI							
-Mallotus villosus	7.9	15.2	6.7	10.0	12.0	9.1	0
-Pleuronectidae	0	0	0.4	0.1	0	5.0	12.0
-Other fish + fish remains	5.6	3.7	4.4	6.9	13.0	11.1	28.3
-Herring (Clupea harengus)	0	0	0	0	0	0	0
Total	13.5	18.9	11.5	17.0	25.0	25.2	40.3
CRUSTACEA							
-Amphipoda	1.1	0.9	0.3	0.6	0.6	0.2	0
-Euphausiidae	69.0	33.8	67.4	53.5	35.4	10.3	5.0
-Decapoda-Carida	2.8	4.0	1.3	2.2	1.4	5.4	1.6
-Brachyura	3.9	15.4	7.2	11.1	21.4	37.8	25.1
Total	76.8	54.1	76.2	67.4	58.8	53.7	31.7
MOLLUSCA							
-Pelecypoda	0.2	6.3	2.0	3.9	5.3	2.4	1.0
-Gastropoda	0.6	1.6	1.4	6.7	1.2	0	0
Total	0.8	7.9	3.4	10.6	6.5	2.4	1.0
ANNELIDA	0.4	0	2.8	0.9	0.1	2.4	0.1
ECHINODERMATA							
-Holothuridae	0	2.1	0	0.3	0.1	0.7	4.2
-Ophiuroidae	0	0.5	0	0.4	0	0	0
Total	0	2.6	0	0.7	0.1	0.7	4.2
OTHER ITEMS (unidentified invertebrates, pebbles, plant material, egg masses, etc.)	7.5	16.4	7.1	3.8	8.5	16.5	21.7
Total	99.0	99.0	100.1	100.04	99.0	100.9	99.0
Total no. of stomachs (215)	29	36	42	27	31	26	24

Table 3. Estimation of food consumption rates and population parameters for Gulf of St. Lawrence cod. (W_i, mean weight at age (Gray 1979); dR_{4Ti}, food consumption in area 4T for one fish of the ith age (Majkowski and Waiwood 1980); $\bar{N}_{4Ti}$, mean numbers-at-age (1978) for the ith age group of cod (Gray 1979); $\bar{N}_{SAi}$, mean numbers-at-age (1978) for the study area (.37 x $\bar{N}_{4Ti}$); $\bar{N}_{SAi} \frac{dR_{4Ti}}{dt}$, total food consumption for the ith age from the study area; $\frac{dR_{capelin}}{dt}$, capelin consumption for one fish of the ith age; $\bar{N}_{SAi} \frac{dR_{capelin}}{dt}$, total consumption of capelin for the ith age from the study area; $\bar{N}_{SAi} \frac{dR_{flatfish}}{dt}$, total consumption of flatfish for the ith age from the study area.

Age group		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1-15
(1) W_i	(g)	100	200	380	680	1040	1670	2260	2730	4050	4320	5850	5540	6260	5040	7000	
(2) $\frac{dR_{4Ti}}{dt}$	(g/yr)	443	625	1089	1575	2116	2932	3622	4022	5751	5433	8432	8145	8393	7308	9033	
(3) $\bar{N}_{4Ti}$	(in thousands)	142364	116558	94970	113000	65534	22892	12468	4712	932	984	332	300	104	32	24	575206
(4) $\bar{N}_{SAi}$	(in thousands)	52674	43126	35139	41810	24248	8470	4613	1743	345	364	123	111	38	12	9	212825
(5) $\bar{N}_{SAi} \frac{dR_{4Ti}}{dt}$	((g/yr) x 10^6)	23334	26953	38266	65850	51308	24834	16708	7010	1984	1977	1037	904	318	87	81	260651
(6) $\frac{dR_{capelin}}{dt}$	(g/yr)	0	0	86	124	321	137	348	483	523	494	0	0	0	0	0	
(7) $\bar{N}_{Sai} \frac{dR_{capelin}}{dt}$	((g/yr) x 10^6)	0	0	3023	5202	7799	1167	1604	841	180	180	0	0	0	0	0	19996
(8) $\bar{N}_{SAi} \frac{dR_{flatfish}}{dt}$	((g/yr) x 10^6)	0	0	0	0	0	99	17	0	89	89	124	108	38	10	10	584

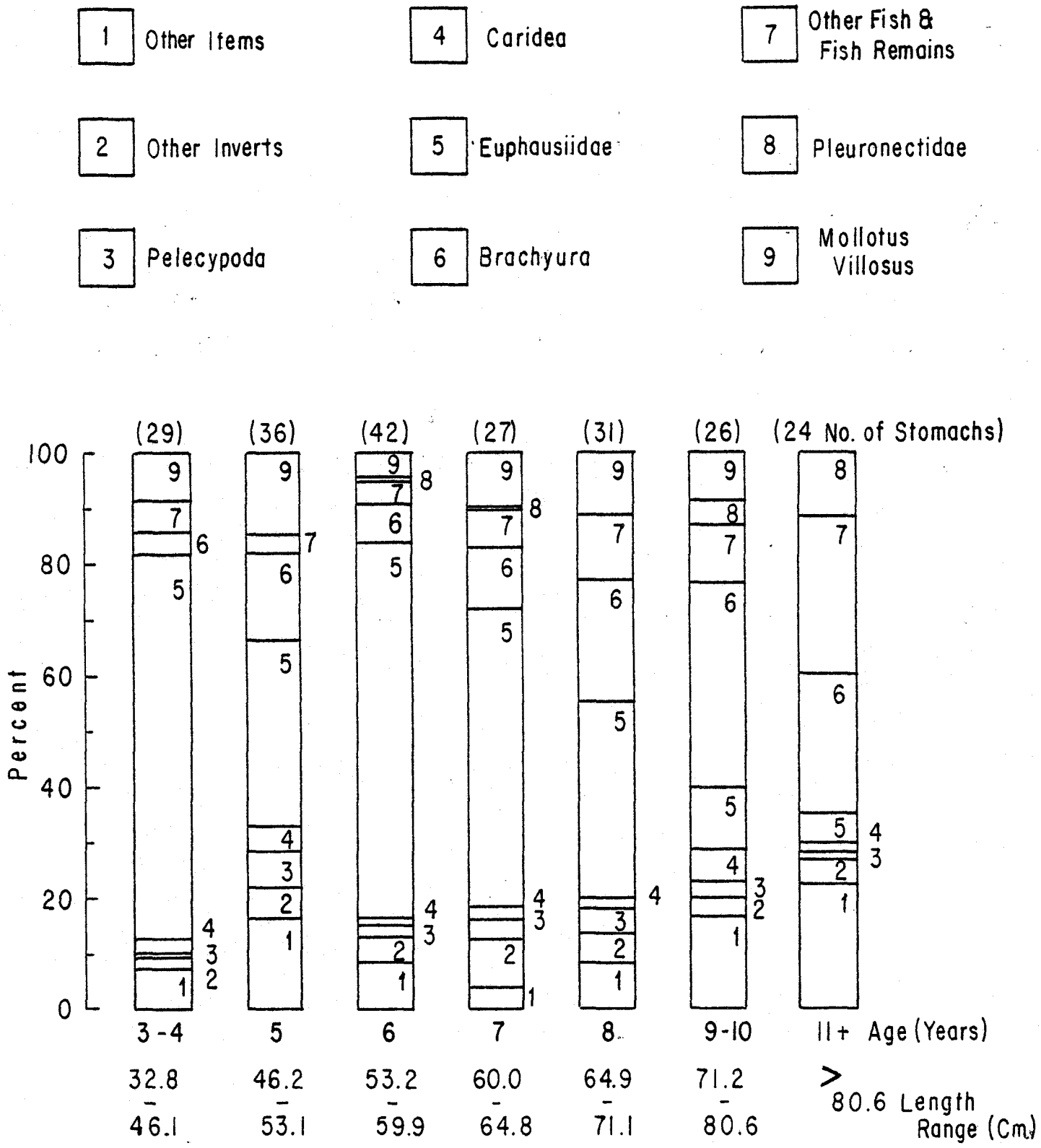

Figure 1. Percent prey composition (by weight) of cod from the south-western Gulf of St. Lawrence (May 28 to July 14,1979).

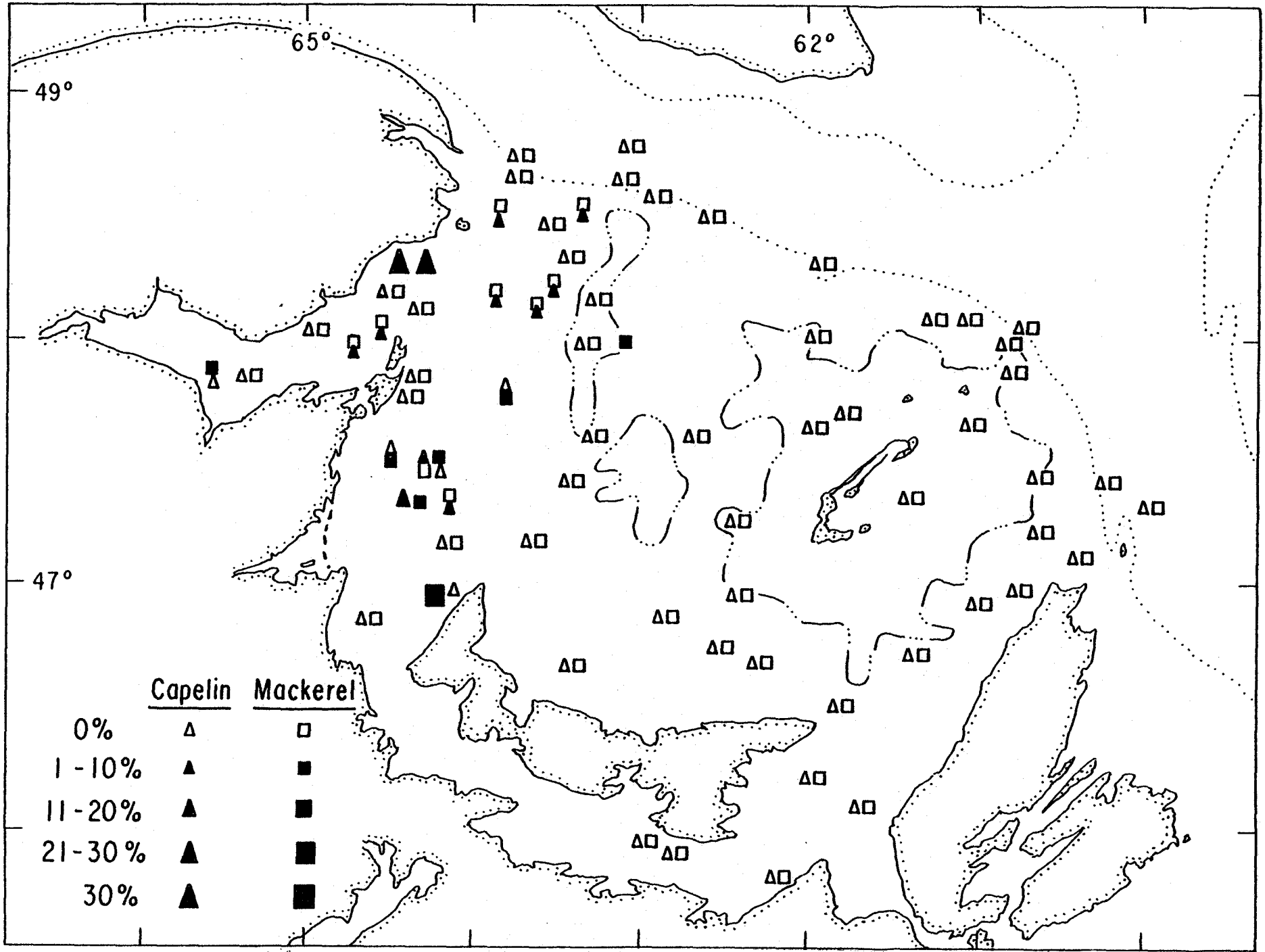

Figure 2. Percent occurrence of capelin and mackerel in the stomachs of 4T cod (≥ 40 cm). Values were determined during the fall groundfish survey (EEP 229) in September - October, 1979.

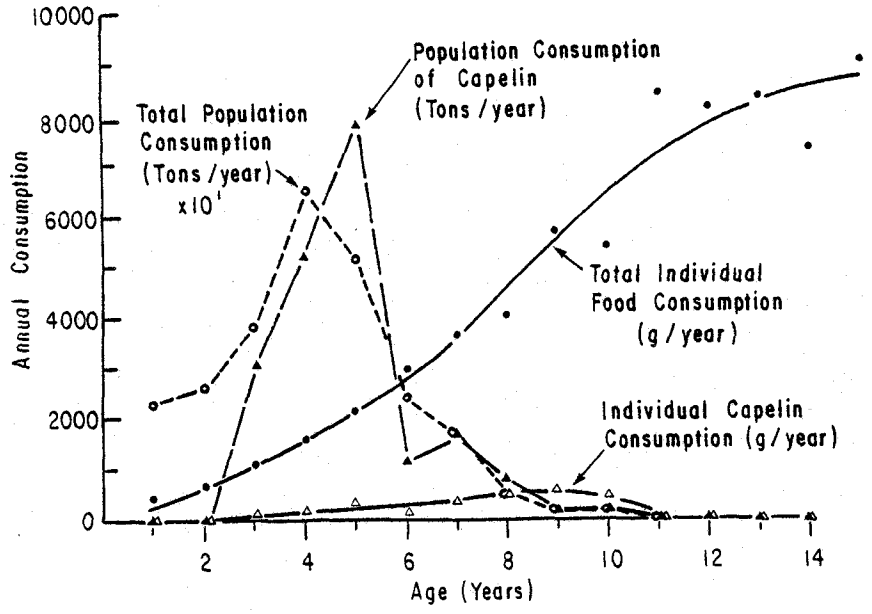

Figure 3. Individual and population consumption rates, by age, for 4T cod (1978). Total food consumption and consumption of capelin are indicated.

Appendix I. Percent prey composition (by weight) of 4T cod during four sampling periods (1979). Sampling period: (I) May 28-30; (II) June 20, 22; (III) June 26-July 1; (IV) July , 14.

	I							II						
	AGE CLASS							AGE CLASS						
Prey	3-4	5	6	7	8	9-10	11	3-4	5	6	7	8	9-10	11+
TELEOSTEI														
-Mallotus villosus	13.0	23.4	13.3	17.9	14.7	27.0	-	5.6	6.9	0	21.6	26.8	6.3	0
-Pleuronectidae	0	0	1.1	0	0	5.9	-	0	0	0	0	0	0	18.2
-Other fish + fish remains	7.6	2.5	2.4	8.3	17.0	3.0	-	13.5	0.6	17.5	0	24.4	0	39.4
Total	20.6	25.9	16.8	26.2	31.7	35.9	-	19.1	7.5	17.5	21.6	51.2	6.3	57.6
ANNELIDA	0.7	0	0	0.4	0.2	0	-	0.8	0	20.0	5.8	0	0	0
MOLLUSCA														
-Pelecypoda	0	2.2	6.4	0.1	10.5	10.8	-	0.6	13.8	0	35.0	0	2.3	0
-Gastropoda	0.1	0	4.7	5.9	1.5	0	-	2.0	0.8	0	19.7	0	0	0
Total	0.1	2.2	11.1	6.0	12.0	10.8	-	2.6	14.6	0	54.7	0	2.3	0
CRUSTACEA														
-Amphipoda	0.6	2.3	0.5	1.2	0.9	0.6	-	0	0.4	1.6	0	0	0	0
-Euphausiidae	77.6	66.1	66.2	59.7	44.6	35.1	-	51.8	13.8	20.0	6.6	0	0	1.5
-Decapoda-Carida	0	1.6	0.9	0.4	0.4	0.3	-	7.9	9.6	1.0	0.3	0.6	13.2	0
-Brachyura	0.4	0.3	2.0	3.5	6.9	1.1	-	14.0	42.0	20.0	1.4	39.0	71.9	33.4
Total	78.6	70.3	69.6	64.8	52.8	37.1	-	73.7	65.8	42.6	8.3	39.6	85.1	34.9
ECHINODERMATA														
-Holothuridae	0	0	0	0	0.3	0	-	0	1.9	0	0	0	0	0
-Ophiuroidae	0	0	0.2	0	0	0	-	0.7	3.1	0	9.6	0	0	0
Total	0	0	0.2	0	0.3	0	-	0.7	5.0	0	9.6	0	0	0
OTHER ITEMS (Unidentified invertebrates, pebbles, plant material)	0	1.6	0.6	2.4	3.0	16.0	-	3.2	7.1	20.1	0	9.2	6.4	6.6
Total	100.0	100.0	98.3	99.8	100.0	99.8	0	100.1	100.0	100.2	100.0	100.0	100.1	99.1
Total no. of cod stomachs	6	13	10	10	10	5	0	8	13	5	3	3	7	11

Prey	III AGE CLASS 3-4	5	6	7	8	9-10	11	IV AGE CLASS 3-4	5	6	7	8	9-10	11
TELEOSTEI														
-Mallotus villosus	8.9	22.1	4.7	2.0	6.2	0	0	0	0	-	0	11.8	1.3	0
-Pleuronectidae	0	0	0	0.2	0	0	43.5	0	0	-	0	0	1.1	0
-Other fish + fish remains	0.8	10.0	2.8	0.3	5.4	7.1	1.4	0	0	-	100.0	13.3	23.0	22.1
Total	9.7	32.1	7.5	2.5	11.6	7.1	44.9	0	0	-	100.0	25.1	25.4	22.1
ANNELIDA	0.1	0	0.8	0.2	0	0	0	0	-	0	0	0	5.8	0.2
MOLLUSCA														
-Pelecypoda	0	2.4	0	0	0	0	0	0	0	-	0	9.8	0	2.2
-Gastropoda	0	4.9	0	4.8	0	0	0	0	0	-	0	3.7	0	0
Total	0	7.3	0	4.8	0	0	0	0	0	-	0	13.5	0	2.2
CRUSTACEA														
-Amphipoda	2.2	0.3	0	0.4	0.1	0.4	0	0.2	1.0	-	0	1.3	0	0
-Euphausiidae	80.9	37.7	77.9	63.6	54.4	33.1	0.7	49.8	0	-	0	0	0	9.1
-Decapoda-Carida	1.4	0	1.5	4.2	1.5	14.4	0	0	1.0	-	0	3.5	0.7	3.5
-Brachyura	0.1	0.5	7.3	20.0	28.7	27.5	50.0	0	0	-	0	22.3	31.8	12.2
Total	84.6	38.5	86.7	88.2	84.7	75.4	50.7	50.0	2.0	-	0	27.1	32.5	24.8
ECHINODERMATA														
-Holothuridae	0	0	0	0.6	0	0	0	0	50.0	-	0	0	1.7	9.1
-Ophiuroidae	0	0	0.5	1.5	0	0	0	0	48.0	-	0	0.5	0	0.3
Total	0	0	0.5	2.1	0	0	0	0	98.0	-	0	0.5	1.7	9.4
OTHER ITEMS (Unidentified invertebrates, pebbles, plant material)	4.4	22.1	3.1	1.9	3.7	17.1	4.1	49.1	0	-	0	33.6	33.3	41.2
Total	98.8	100.0	98.6	99.7	100.0	89.6	99.7	99.1	100.0	-	100.0	99.8	98.7	99.9
Total no. of cod stomachs	12	10	24	13	6	11	11	3	1	0	1	6	11	11