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Cod Stomach Sampling in West-Greenland Waters 1989

- Some Preliminary Results -

by

F. W. Köster and W. Schober

Institut für Meereskunde Kiel, Dusternbrooker Weg 20
2300 Kiel 1, Federal Republic of Germany

Abstract

Stomach contents of cod sampled during a 24-hour fishery with RV 'Poseidon' on Fyllas Bank in summer 1989 have been analysed in order to describe the feeding activity at different times of the day and to estimate stomach evacuation rates. A pronounced change in the average weight of stomach content over different times of the day is explained by sampling different aggregations of cod. Therefore an estimation of a stomach evacuation rate was not possible. The series of trawl catches gives some information about food selection of cod. All larger cod (> 45 cm) caught in different trawl hauls fed intensively on shrimps, mainly Pandalus borealis, whereas smaller cod (< 46 cm) only contained substantial amounts of shrimps, when caught from dense aggregations with larger cod. High quantities of shrimps, and even more pronounced, of fish, were consumed only by larger individuals, whereas amphipods were eaten by smaller and medium sized cod. Overall, nearly no commercially important fish species were found in the stomachs. The fish consumed were mainly Cottidae, Lumpenidae, Zoarcidae, and to a lesser extent Hippoglossoides platessoides. For the determination of stomach evacuation rates, two tank experiments with cod from trawl hauls in shallow waters were carried out in autumn 1989 on board of RV 'Walther Herwig'. Assuming that gastric evacuation follows a linear function, the evacuation rates have been roughly estimated by comparing the average weight of stomach contents at the beginning and at the end of the experiment. The values of 0.11 g/h for a mean temperature of 0.9 °C and 0.22 g/h for a mean temperature of 3.5 °C are thought to be in the right order of magnitude, but should not be taken as a reliable basis for the estimation of daily consumption, until further experiments planned for summer and autumn 1990 have been conducted.

Introduction

Within the frame of a project[1] designed to examine the interaction of fish stocks in West-Greenland waters, a cod stomach sampling program was started 1989 in inshore and offshore areas of Div. 1F, 1D and 1B. In total 1305 cod stomachs were collected on the cod prerecruit gill-net survey with RV 'Misiliisoq' in June/July and on the long-line survey with RV 'Adolf Jensen' in autumn, both conducted by the Greenland Fisheries Research Institute. In offshore areas 3380 cod stomachs were sampled on a cruise of RV 'Poseidon' in July, carried out by the Institut für Meereskunde Kiel, and during the groundfish survey of RV 'Walther Herwig' conducted by the Institut für Seefischerei Hamburg in October/November.

[1] Project funded by the German Ministry of Research and Technology

Due to the fact that the stomach content analysis is in progress, but far from beeing completed, and that plankton and benthos samples have not been analysed in great detail, this paper presents only some preliminary results about feeding activity of cod during a 24-hour fishery on Fyllas Bank and gives some rough estimations of stomach evacuation rates from tank experiments.

Material and methods

Bottom trawl hauls were carried out on a fixed position on Fyllas Bank in 50-100m depths covering different times of the day on the 23rd and 24th of July 1989. In total 773 cod stomachs were sampled in intervalls of appr. three hours in order to get a picture of day-time dependant feeding activities. Two serial slaughter tank experiments were performed with cod from trawl catches carried out in depths shallower than 100m during the cruise of RV 'Walther Herwig' in autumn 1989. Over a time period of 162 and 99 hours a total of 184 and 228 cod were slaughtered in time intervalls of 9 hours. The mean temperature was appr. 0.9 °C and 3.5 °C respectively.
Collected stomachs were deep frozen on board and subsequently analysed in the laboratory. The total content was measured as wet weight with a precision of appr. 0.1g. Where possible, fish and shrimps were determined down to the species level. The length, weight and degree of digestion was determined for fish, whereas shrimps were only counted and weighed after seperating them into fresh and partially digested portions. All other food items were divided into classes, orders or suborders and weighed in total.
A rough estimation of the stomach evacuation rate in g/h is calculated from the decrease of the average stomach content from one time step to the next, and from the assumed starting point of evacuation to the chosen endpoint. In order to avoid a bias by zero values or by very low contents at the beginning of the experiment (OLSON and MULLEN 1986), the averages were calculated from a constant number of non-zero values from the upper range of the content distribution of each time step. Due to the low number of stomachs, especially of non-empty stomachs, we have summarized the data from the first experiment for two time steps, whereas the second experiment was carried out over a shorter time period with a higher number of fish sampled in each time step. From the second experiment 3 fishes were excluded because of their, contrary to all others, extraordinarily high stomach content filled exclusively with nordic krill.

Results

For the series of bottom trawl catches carried out on the southeastern slope of Fyllas Bank, the average total stomach 0content and different food components, i.e. crustacea, benthic invertebrates and fish (including the portion of identified benthic fish), are presented in figure 1. In figure 2 the main food component crustacea is divided into shrimps (including the portion of whole specimens classified as fresh), amphipods and benthic crustacea. The terminus shrimps refers predominantly to Pandalus borealis, to a smaller amount of Pandalus montagui and a few Lebeus spec. as well as some unidentified species. Fish as food items were mainly benthic, belonging to the families Cottidae, Lumpenidae and Zoarcidae (comprising 70% of the consumed number of fish) and the species Hippoglossoides platessoides (17%) as well as some Anarhichas spec.(3%).
From both figures a pronounced change in the average stomach content is obvious, with high values during the second half of the night and the middle of the day. Throughout day and night, shrimps were the main food item. The percentage of shrimps found in an advanced stage of digestion is appr. 30 to 50% during the period from 20.00 to 8.00, which is slightly higher than the percentages of 20 to 30% during daytime.
In figure 3, the length frequency distribution of cod analysed from each haul is presented. With the exception of the hauls at 1.30, 10.10 and 13.40 hours mean catching time, the length frequency represents the total catch. From the three larger

catches of 600 to 2000 kg representative subsamples were taken. Comparing the figures 1 and 3 it is obvious, that the smaller fish from trawl hauls at 7.20, 16.35, 20.00 and 22.25 hours contained in average smaller amounts of food in their stomachs.
Figures 4 and 5 present the average amount of total food and of different components eaten by fish larger than 45 cm (comprising appr. half of the analysed fish). In figures 6 and 7 the stomach content of fish smaller than 46 cm is shown. Only the smaller fish show a substantial change in the average stomach content. Larger fish had fed throughout the whole day with a minimum of amphipods and a maximum of fresh shrimps in the middle of the day. The amount of fresh shrimps in the stomachs of smaller fish is higher if the cod were caught from larger aggregations, i.e. from the hauls at 1.30, 10.10 and 13.40 hours.
Figures 8 and 9 present the total stomach content and the amount of shrimps, amphipods and fish in relation to predator length. Only data from the three larger catches and the 4.20 hour catch, assumed to be sampled from the same aggregation, were included in this figure. The scatterplots of the total content and of shrimps show a very similar picture with low values for smaller fish and a great variability in larger fish. For the fish component the trend is even more pronounced. Only a portion of fish larger than 50 cm were predating intensively upon fish, whereas smaller fish were feeding to a greater extent on amphipods.

Figure 10 presents results from the first tank experiment, i.e. total stomach content values as well as the amount of crustacea and fish in g wet weight. Over a period of 162 hours 10-11 fishes (mean length: 46 cm) were sampled every 9 hours. The reference sample from the original trawl haul contained 89 fishes. The mean temperature in the tanks was appr. 0.9 °C. No clear indication of an evacuation can be seen from the scattered data of the first 45 hours. Crustacea as well as fish remains were found in some stomachs after a period of 153 hours. Figure 11 shows the same information for the second experiment. 17-18 fishes (mean length: 45 cm) were sampled every 9 hours with the exception of the last sample after 99 hours which contained 58 fish. The fish were kept in tanks with a water temperature of appr. 3.5 °C.
Supposing a continued evacuation after 36-45 and 27 hours for both experiments respectively, averages of the 10 and 11 highest content values for 18 and 9 hour time-steps were calculated. The endpoint of the calculation was chosen according to a minimum of 10 non-empty stomachs per time-step, i.e. 144-153 and 72 hours. The rate of decrease of the average content from one time-step to the next and from the assumed starting point of evacuation to the selected endpoint is presented in table 1 as a rough estimation of the evacuation rate in g/h.

Discussion

From the series of bottom trawl catches on a fixed position a diurnal feeding activity of cod in summer on Fyllas Bank is not evident. The change in the average stomach content over the different times of the day is introduced by a horizontal effect, fishing different aggregations of cod. An estimation of a stomach evacuation rate was therefore not possible. On the basis of cod stomachs from bottom trawl hauls carried out at different times of the day (6.00 to 21.00 hour) on different positions in spring and autumn 1981 as well as in autumn 1983, TIEDTKE (1988) also found no evidence of a diurnal feeding rythm. To check this result for seasons with a pronounced cycle of daylight, material was sampled on the cruise of RV 'Walther Herwig' in autumn 1989.
An interesting observation in respect to the food selection of cod was the fact, that smaller cod (< 46 cm) only had larger quantities of fresh shrimps in their stomach when they were caught in dense aggregations together with larger individuals. Larger cod (>45 cm) were feeding intensively on shrimps throughout the whole day, even if only very few individuals were caught. In total the amount of shrimps, and even more pronounced of fish, was length dependant, whereas amphipods were consumed in higher quantities by smaller or medium-sized cod. Although data material from the other trawl stations on Fyllas Bank covered during the summer cruise is not presented in this paper, we observed that the

amount of fish eaten by cod is in the same order of magnitude as found during the 24-hour fishery. Commercially important fish were extremely rare. In a total of 1323 cod stomachs only 3 cod were found. During the offshore autumn cruise, on the other hand, a relatively high percentage of the stomach content consisted of small redfish (< 10 cm).

From the two tank experiments carried out, it can be concluded that stomach evacuation rates can be determined by serial slaughter experiments using fish caught by trawls. Comparing the used method with normal feeding experiments, two advantages can be stated: firstly that the fish are feeding under natural conditions and secondly that the technical and laboratory effort is relatively small and straightforward. Adversely, these advantages may be outweighed by the trawling and handling stress as well as the limited space in the tanks for each single fish, at least at the beginning of the experiment. A high variability in the stomach contents causes additional problems. A number of actions may help to overcome some of the problems. To reduce the trawling stress and the variability of the stomach contents, short trawl hauls should be carried out in shallow waters, directed to single aggregations of fish. To reduce the handling stress, the total catch should be relatively small. Comparing figures 10 and 11, the difference in the evacuation delay may be explained by the longer trawling time of 30 min for the first experiment (a standard survey haul), compared to 15 min. for the second (directed to fish aggregations visible on the echosouder). The total catch in both cases was well below 1000 kg. The longer evacuation delay in the first experiment may also be caused by the lower temperature in the tanks, although it corresponds to the bottom temperature of appr. 1.1 °C on the trawling track. In order to obtain a picture of the stress condition of the cod in the experiments, blood samples were centrifuged and the serum was conserved for an analysis of the content of the stress hormone cortisol, which is emitted at a fairly slow rate. First results from these experiments will be presented at the ICES statutory meeting 1990. The overall survival of cod was high in both experiments. Because of damages caused by trawling and handling appr. 20% of the fish were removed from the tanks after some hours. During the course of the experiment the mortality of the remaining individuals was less than 10%. If food was available the cod were feeding after 2 days. This indicates an overall good condition of the fish.

The rough estimation of the stomach evacuation rate from the average content at the assumed starting point of evacuation to the chosen endpoint, implying a linear function of evacuation, resulted in slightly lower values as estimated by BROMLEY (1989) for North Sea cod from single meal feeding experiments. He estimated a gastric evacuation of 0.29 g/h for Nephrops and 0.83 g/h for sprat at mean temperatures of 8.8 and 12.9 °C. The differences may be explained by the higher temperatures and different prey items. However, the higher rates of decrease at the beginning of our experiments may indicate that the evacuation rate is not independant from the level of stomach content, i.e. the gastric evacuation does not follow a linear function. To answer this widely discussed question (ANON 1989) the data material is too incomplete, and at the present stage not sufficient for an estimation of daily consumption of cod in Greenlandic waters. In order to obtain a more reliable average of the highly variable stomach content, the number of time steps should be reduced in future tank experiments, whereas the number of fish taken out per time step should be increased significantly.

Acknowledgement

We would like to thank the Greenland Fisheries Research Institute for their participation and support in this project. We are grateful for the enthusiastic assistance given by Mrs. E. Grunwald, Mrs. C. Lecour and Mr. A. Ruinies and also for the valuable help and constructive criticism from our colleagues, Dr. A. Temming and Mr. K. Wieland.

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Table 1
Average stomach content in g for each time of sampling, rate of decrease in g/h, sample size and mean temperatures for both tank experiments performed on bord of RV 'Walther Herwig' in October-November 1989

Experiment 1 T=0.9 °C				Experiment 2 T=3.5 °C			
hours	sample size	average in g	rate of decrease in g/h	hours	sample size	average in g	rate of decrease in g/h
40.5	10	14.71		27	11	12.87	
			0.20				0.58
58.5	10	11.03		36	11	7.61	
			0.24				0.19
76.5	10	6.64		45	11	5.89	
			0.18				0.13
94.5	10	3.38		55	11	4.68	
			-				0.15
112.5	10	3.41		63	11	3.29	
			-				0.04
130.5	10	3.94		72	11	2.96	
			0.05				
148.5	10	3.06					
Rate of decrease from starting point to endpoint in g/h: 0.11				Rate of decrease from starting point to endpoint in g/h: 0.22			

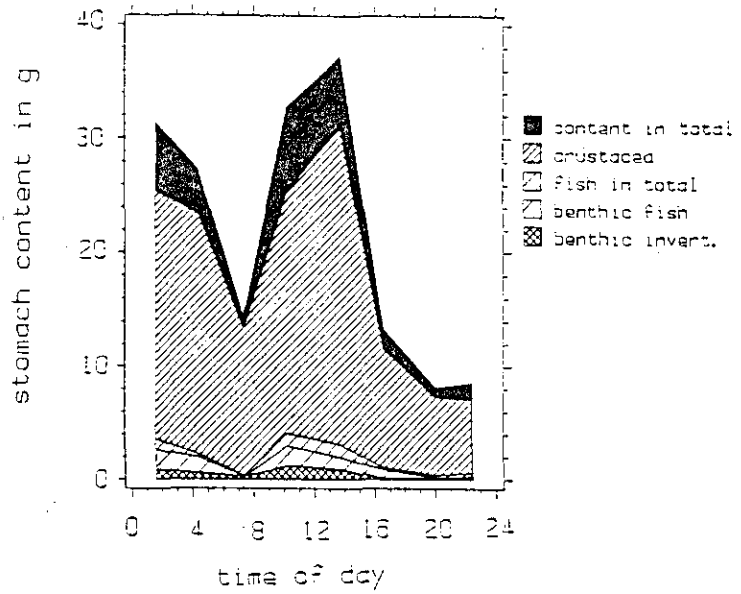


Figure 1:
Average stomach content and main food components (g wet weight) at different times of the day during a 24-hour fishery on Fyllas bank (non cumulative)

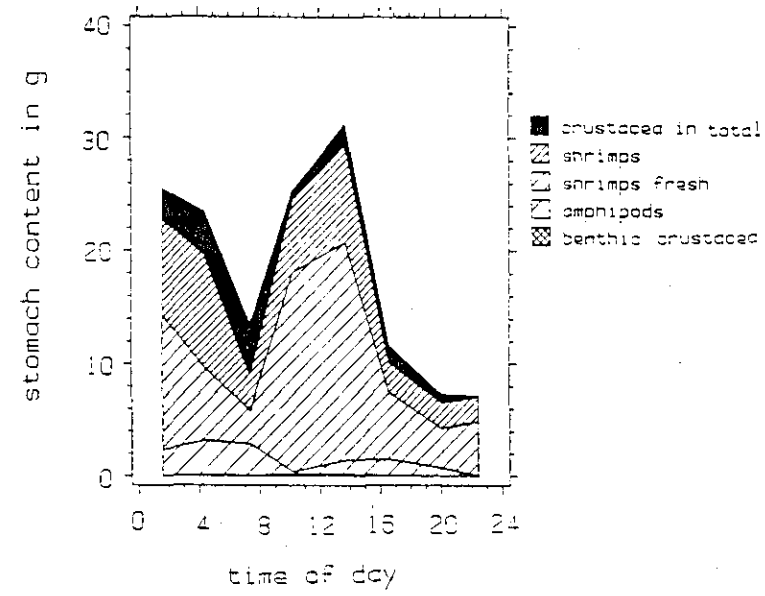


Figure 2:
Average stomach content of crustacea subgroups (g wet weight) at different times of the day (non cumulative)

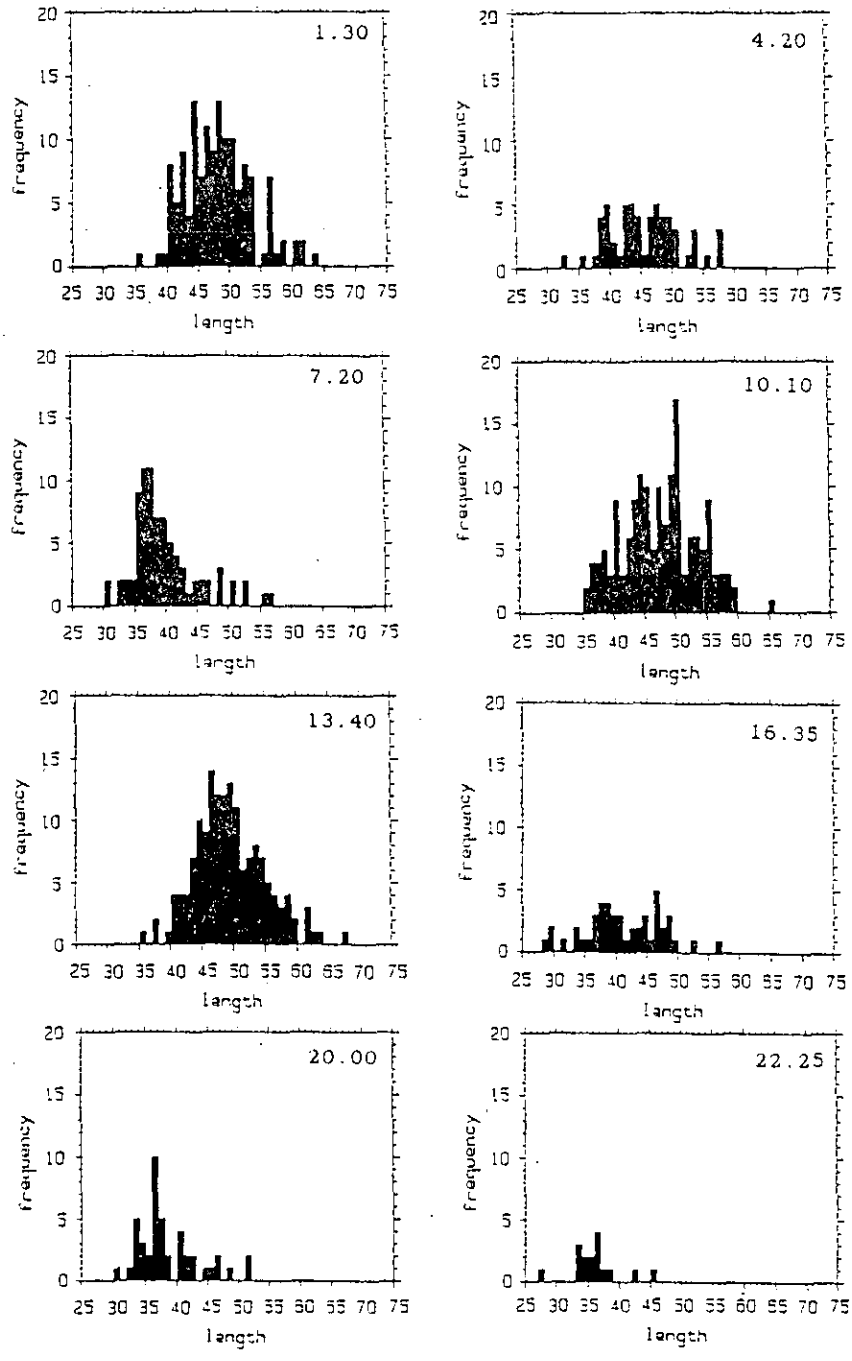


Figure 3:
Length frequency distribution of cod analysed from each haul of the 24-hour fishery on Fyllas Bank in summer 1989

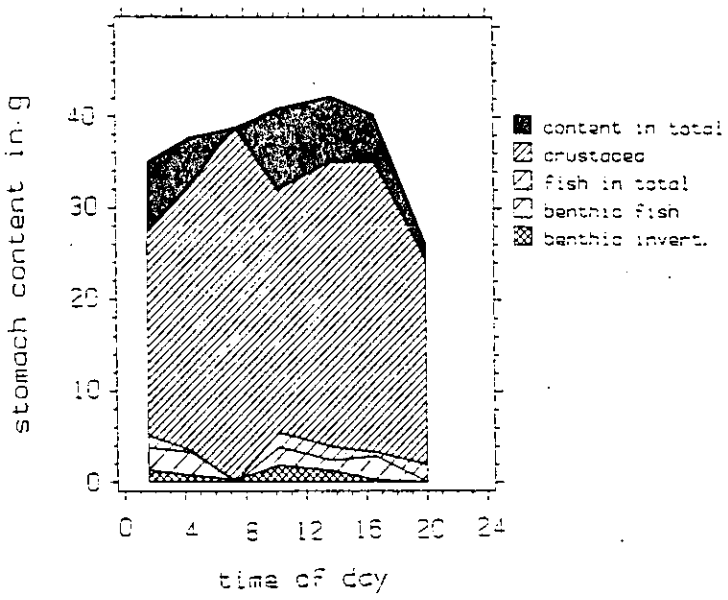


Figure 4:
Average stomach content and main food components (g wet weight) of cod > 45cm at different times of the day (non cumulative)

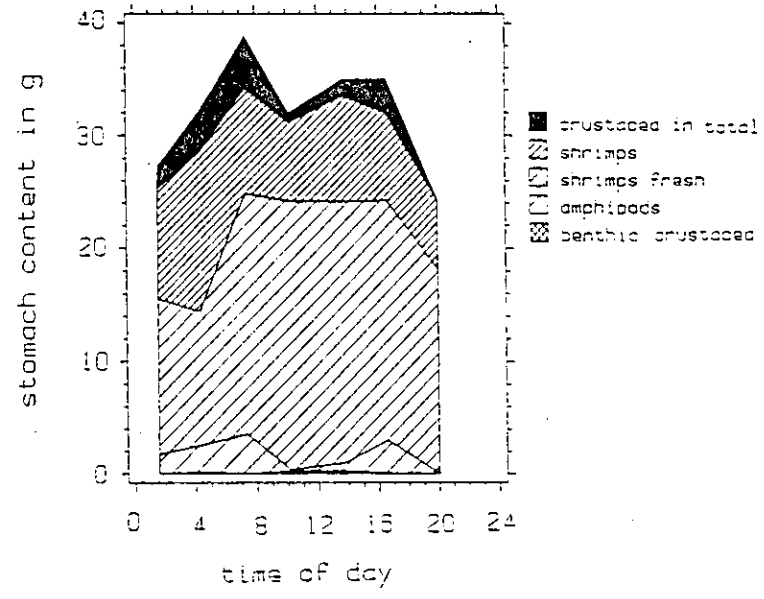


Figure 5:
Average stomach content of crustacea subgroups (g wet weight) in cod > 45cm at different times of the day (non cumulative)

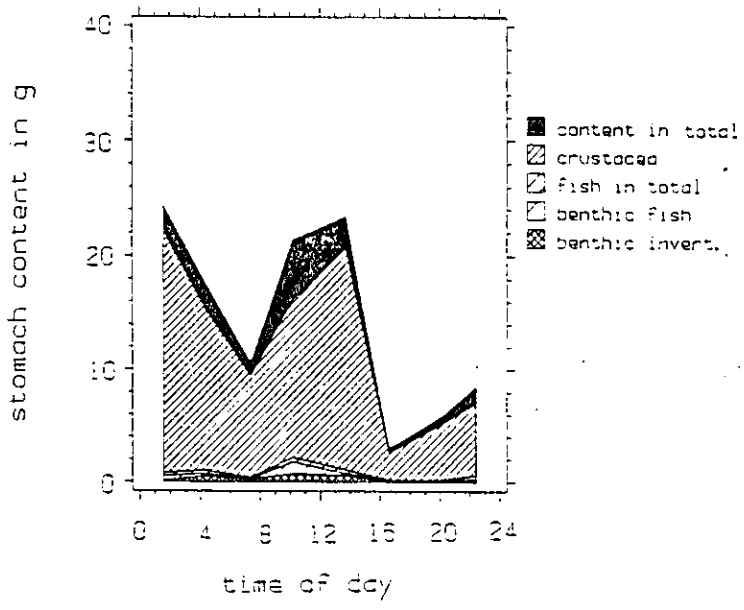


Figure 6:
Average stomach content and main food components (g wet weight) of cod < 46cm at different times of the day (non cumulative)

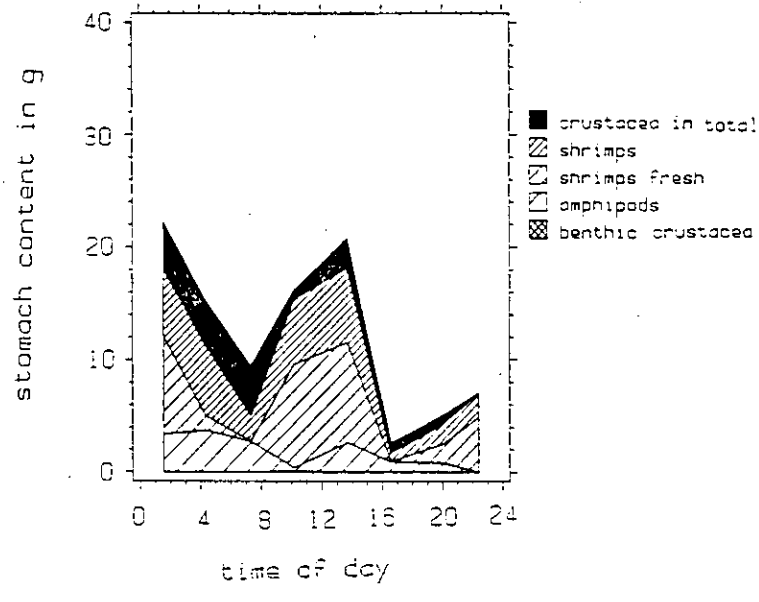
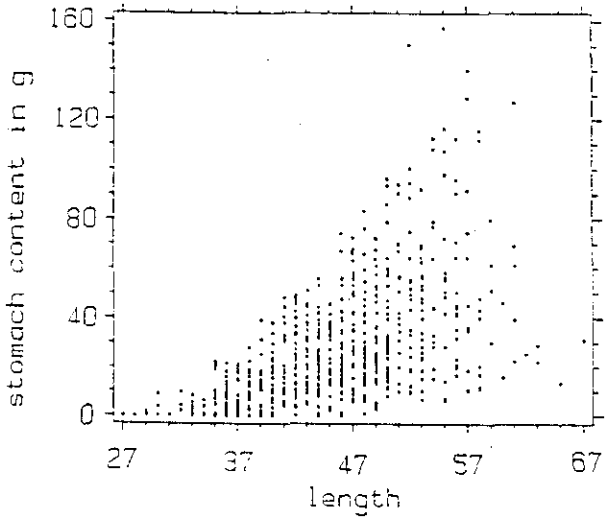


Figure 7:
Average stomach content of crustacea subgroups (g wet weight) in cod < 46cm at different times of the day (non cumulative)

(a)



(b)

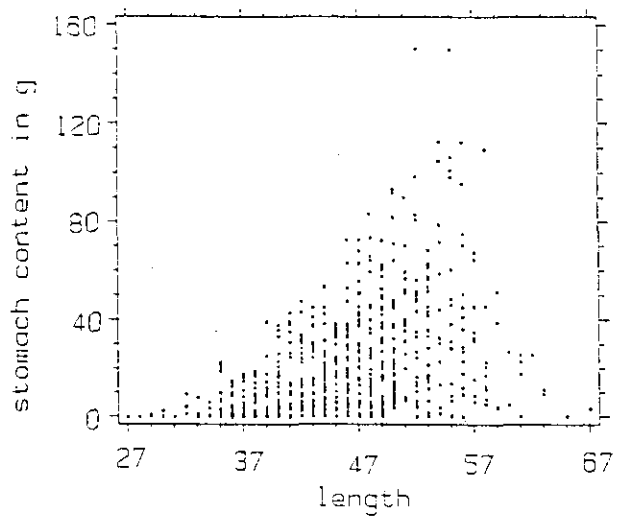


Figure 8:
Total stomach content (a) and amount of shrimps (b) in g wet weight in relation to cod length

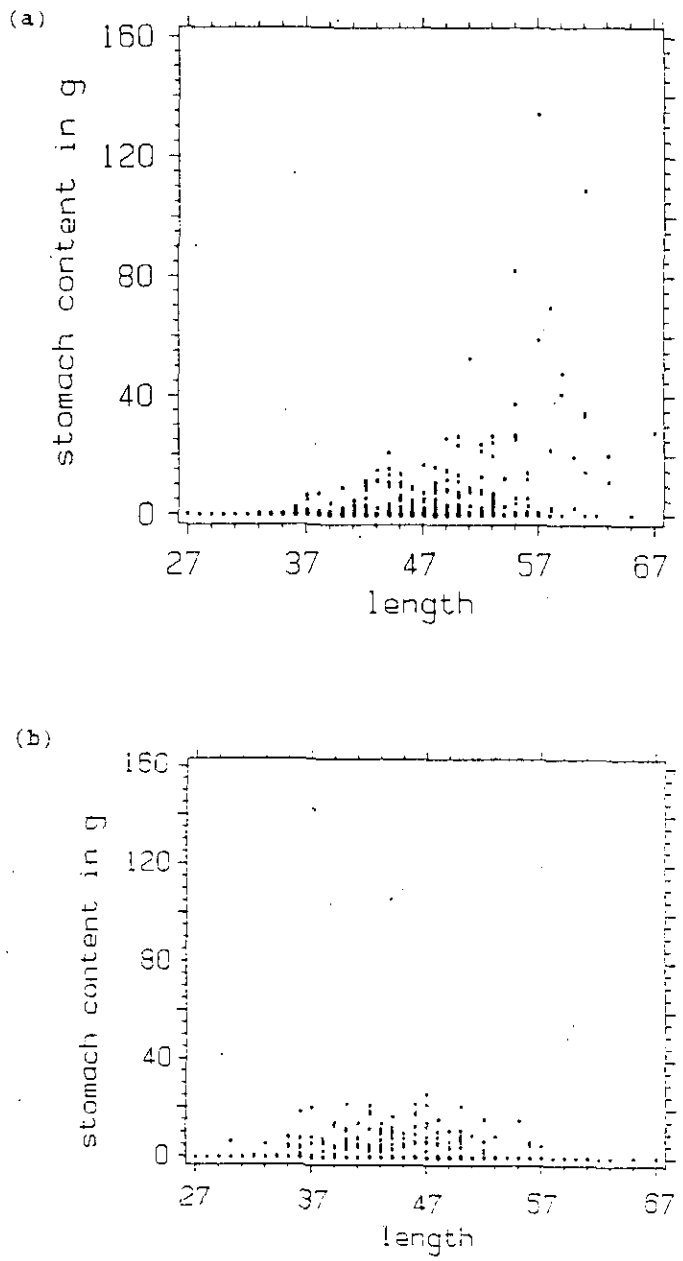


Figure 9:
Amount of fish (a) and amphipods (b) in g wet weight in relation to cod length

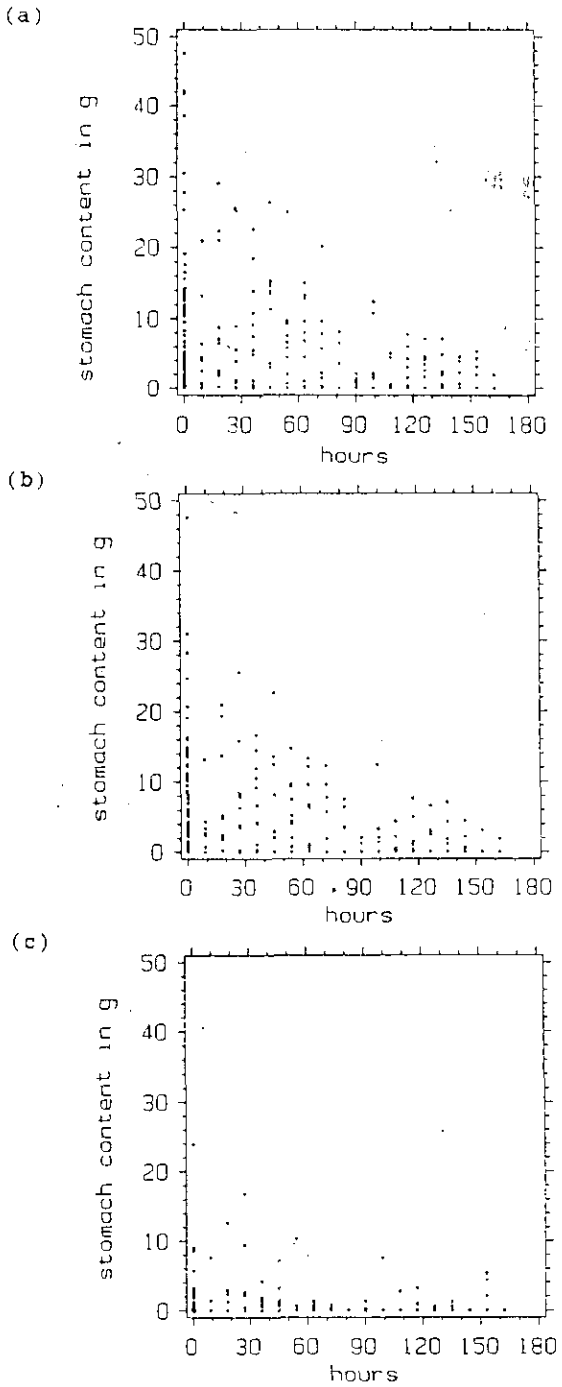


Figure 10:
First tank experiment: Total stomach content (a), amount of crustacea (b) and fish (c) in g wet weight over the period of 162 hours

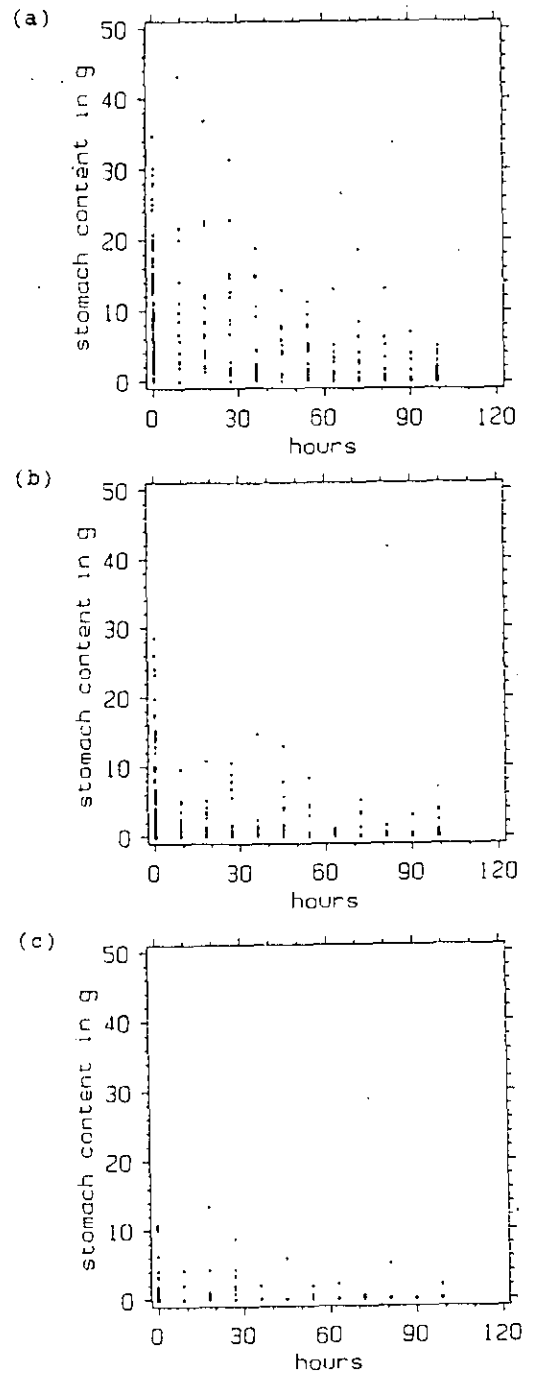


Figure 11:
Second tank experiment: Total stomach content (a), amount of crustacea (b) and fish (c) in g wet weight over the period of 99 hours