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Feeding Habits of Greenland Halibut in West Greenland Waters with Special Emphasis on Predation on Shrimp and Juvenile Redfish

by

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INTRODUCTION

The most important shrimp grounds of West Greenland are in Subarea 1B and 1C where the catches in the latest years have been about 40,000 tons. These areas are also important nursery grounds for Greenland halibut and redfish and it is well known that great numbers of these fish are caught as by-catch in the shrimp fishery (Smidt, 1969; Riget et al. 1988; Pedersen and Lehmann, 1989).

Some of the key factors effecting the shrimp stock seem to be the stocks of Greenland halibut and redfish and the shrimp fishery. Little is known about the impact on the Greenland halibut and the redfish stocks from the shrimp fishery, but also the impact on the shrimp stock from the fish stocks are uncertain. In the latest years work has been carried out in changing the trawl in the shrimp fishery in order to protect the small shrimps and thereby reducing the discard. Changing the selectivity of the shrimp trawl may also change the by-catch of fish, and the question arise whether a higher survival of small fish will have a negative effect on the shrimp stock by a higher predation.

Therefore, in 1990 a sampling of fish stomachs from the shrimp grounds was started to evaluate the importance of the shrimp predators (Pedersen and Riget, 1991a). This paper presents preliminary results from investigations of the stomach content of the Greenland halibut.

MATERIALS AND METHODS

The study area was West Greenland (Subarea 1) on the continental shelf to a depth of about 550 m. This area is an important area for the shrimp fishery. The sampling has been done during five research trawl surveys and in the day-time only, covering the period from late June to early November. The trawl surveys were not designed to this study but have a different kind of purposes. A total of 665 stomachs were collected from a total of 38 trawl hauls (Fig. 1 and Table 1).

It was intended to collect stomachs stratified by length from the catch of each haul. The procedure of handling empty stomachs was different between the surveys. In the sampling during the surveys in July 19-30th. and September 10th. all stomachs collected were frozen for later examination in the laboratory.

During the surveys in July 30 - August 4 and November 6-11 the stomachs appearing to be empty were not collected, and in the survey June 20-22 empty stomachs from two hauls were collected while empty stomachs in two other hauls were not collected.

Stomachs from fish sharing signs of regurgitation were not collected. Stomachs were individually tagged and frozen for later examination.

In the laboratory stomach content was divided into taxonomic categories with equal degree of digestion. The degree of digestion of fish was judged by a six point scale and that of invertebrates by a four point scale as proposed by Bromley and Last (1990). The identification was done to lowest taxonomic level possible within a reasonable consume of time. The number of items in each food category were counted and weighed to nearest 0.1 g. Excess liquid was removed only mechanically. When possible fish prey were measured to nearest mm total length and for shrimp prey carapax length and pleuron length of shrimp were measured with an accuracy of 0.1 mm.

Three indices were used to evaluate the importance of food category:

1) Percent occurrence (the number of stomachs with prey as a percentage of number of stomachs investigated).

2) Percent weight (the total weight of prey as a percentage of the total weight of all prey).

3) Mean partial fullness index of prey p (PFI) =

$$\frac{1}{n} \sum_{j=1}^{n} \frac{Weight}{Length^3} \times 10^4$$

where N is the number of fish. Mean total fullness index was calculated by adding values of mean partial fullness index.

RESULTS

Prey items:

The food composition show great similarities between sampling periods (Table 2). Fish was one of the most important prey items, occurring in 7-33% of the stomachs and constituting between 33 and 86% of the total prey weight. By far the most dominating fish species was Sebastes sp. Other species such as Mallotus villosus, Reinhardtius hippoglossoides, Boreogadus sp, Arctogadus sp and Leptoclinus maculatus were found in minor quantities.

Crustaceans occurred in 14-59% of the stomachs constituting between 14 and 67% of the total prey weight. The northern shrimp Pandalus borealis was by far the most dominating crustacean in the stomachs and found in all sampling periods. Shrimp constitute between 14 and 62% of the total prey weight, these values are minimum values because shrimp may constitute a significant part of the unidentified crustacean found in the stomachs. The hyperiid, Parathemisto sp. were present in relative high number of the stomachs but constituted only little weight.

Other prey items such as polychactes, molluscs and cephalopods occurred only rarely.

Stomach fullness:

The proportion of empty stomachs in the different periods varied between 29% and 71%. The two samplings where the judgement of the fullness have been done in the field show the highest proportion the empty stomachs (71 and 61%). The other samplings have a mean proportion of empty stomachs of 43%.

To study the variation in total stomach content between sampling periods and depths of sampling, fish between 15 and 44 cm were selected and the mean total fullness index (TFI) was calculated for each sampling station. Only stations with at least 10 fish investigated were selected.

A one-way ANOVA shows no significant (F=0.85, p=0.51) difference between sampling periods and neither does a one-way ANOVA between 100 m depth zones (F=1.08, p=0.38). This indicates that the variation in TFI is greater between sampling stations than between periods and between depth zones.

Predator size influence:

No general trend can be seen between the total fullness index and 10 cm length groups (Fig. 2). Fish are found as prey only in Greenland halibut greater than 14 cm. Partial fullness index for fish prey increased with increasing size of the predator in the samples from June, July/August and November, while the opposite seems to be the case in the sample from July and no clear pattern is seen in the sample from September.

The partial fullness index for crustaceans are dominated by the hyperiid, Parathemisto sp. and the northern shrimp. The hyperiid, Parathemisto sp. only has importance for the smallest size group (5-14 cm) in which northern shrimp is not found in the stomachs. The partial fullness index for northern shrimp shows a clear tendency to increase with increasing predator size.

Shrimp size preference:

In many cases it was possible to measure the length of the pleuron and not the carapax of the shrimp found in the stomachs. Therefore, a relationship between the length of the pleuron and the length of the carapax was established from measuring 216 fresh shrimp from a commercial sampling. After logarithmic (base e) transformation of the two variables least-squares regressions of carapax length (mm) on pleuron length (mm) were calculated. The results of the regression were:

$$LOG(Carapax) = 1.2739 \times LOG(Pleuron) - 0.21077, \quad R\text{-squared}=91.4\%$$

Using the equation from the regression, the carapax length was calculated in cases where only the pleuron could be measured. The relationship between carapax length and predator length based on the total material (31 specimens) is shown in Fig. 3. Shrimp size and predator size seems to be significant but weakly correlated (r=0.30, p=0.01). However, the regression is highly dependent on two shrimps found in two small fish.

Shrimp between 12 and 15 mm carapax length peaks the length distribution of the shrimp found in the stomachs from the total material (Fig. 4).

Weight of shrimp and redfish in stomachs of population:

The mean weight of shrimp (*Pandalus borealis*) and redfish in the stomachs of fish (10 cm groups) were calculated from the total material, as no significant difference between sampling periods could be seen. Unidentified crustaceans have been allocated to the shrimp category in proportion to the weight of identified shrimp (*Pandalus borealis*) relative to other crustaceans. Likewise unidentified fish have been allocated to redfish in proportion to the weight of identified redfish to other fish species. Based on catches of Greenland halibut during the shrimp survey, July/August 1990, the abundance of Greenland halibut by 10 cm groups was estimated for the area shown in Fig. 1 (Kanneworff and Pedersen, 1991) and the total weight of shrimp and redfish in the stomachs were estimated to about 7,6 and 8,6 tons, respectively (Table 3).

DISCUSSION

The most important prey of Greenland halibut in the area around St. Hellefisk Bank were shrimp and redfish. This is in accordance with investigations made in September 1955 and July 1964 in the same area (Smidt, 1969).

Our investigation has been concentrated on the shrimp grounds off West Greenland and may not be representative for the feeding of Greenland halibut in the hole area of distribution. Chumakov and Podrazhanskaya (1986) made an intensive study of feeding of Greenland halibut in the Northwest Atlantic, covering Subarea 1 with a greater range both geographically and by depth. They also found shrimp and redfish as important prey but shrimp and redfish where not found as frequently in the stomachs as in our investigation. Another important prey in their investigation was grenadiers.

The importance of shrimp measured as the weight percent of the total stomach content ranged between 14 and 62% and this is equal to the findings on the shrimp grounds in Hopedale and Cartwright Channels off Labrador by Bowering et al. (1983). Also on the shrimp grounds in the fjords of West Greenland shrimp is the most important food component (Smidt, 1969). It may therefore be concluded that shrimp is a very important prey of Greenland halibut especially on the shrimp grounds.

Fish is known to be an important component of the diet of Greenland halibut. The area around St. Hellefisk Bank is an important nursery ground for redfish, especially Sebastes mentella, and these small redfish constitute a major part of the fish found in the stomachs. In areas were redfish are not abundant other species dominate the stomach content. In an area off southern Labrador/Northeastern Newfoundland capelin is the most important fish prey (Bowering and Lilly, 1990) as it is in the fjords of West Greenland (Smidt, 1969).

The proportion of empty stomachs of the samples analyzed in the laboratory were 29-57% and close to the findings by Bowering and Lilly (1990) in the area of Southern Labrador and Northeastern Newfoundland. However, the average degree of stomach fullness was lesser than found by Bowering and Lilly (1990). Chumakov and Podrazhanskaya (1986) found a higher proportion of empty stomachs in their investigation of Greenland halibut in Northwest Atlantic (63-82%) but their evaluation of the fullness of the stomachs are made in the field and comparable with our samples from July/August and November with a proportion of empty stomach between 61 and 71%.

The samples of Greenland halibut covered the period from late June to early November and it was not possible to detect any seasonal difference in average degree of stomach fullness. It may not be expected to see differences in feeding activity in the period covered by our samples. Chumakov and Podrazhanskaya (1986), who sampled each month of the year, indicated increased feeding activity during summer and autumn and a sharp decline to very low levels during winter and spring.

Chumakov and Podrazhanskaya (1986) found an increase in feeding activity with depth with a higher activity on the slope than on the shelf. In the Barents Sea the trend in feeding activity was opposite with the highest activity in shallower water (Nizovtsev, 1977). We found no difference in stomach fullness with depth, however, our sampling has a much narrower depth range than the above mentioned studies.

The diet composition varied with fish size. Other crustaceans mainly the hyperiid Parathemisto, was only found in the stomachs of the smallest length group (5-14 cm). Shrimp was found in the stomachs from length group 15-24 cm and upward with an tendency of increasing importance. Bowering et al. (1984) also found an increasing importance of shrimp up to a predator size of 60-69 cm in their investigation on the shrimp grounds in Cartwright Canals off Labrador. There also seems to be an increased importance of fish in the diet of Greenland halibut with increasing size. The most important fish species in the stomachs was redfish which was fed upon by Greenland halibut of 15 cm and upward.

The length distribution of shrimp found in the stomachs peaked at 12-15 mm carapax length. Compared to the length distributions obtained by the shrimp survey (Carlsson and Kanneworff, 1991), the shrimp eaten by Greenland halibut are generally of smaller size.

Based on the abundance estimate of Greenland halibut from the shrimp survey in the area shown in Fig. 1 the weight of shrimp found in the stomachs was estimated to 7,6 tons. This value must be looked at with great caution, not only is there variability in data of the stomach content but also the abundance of Greenland halibut is estimated with uncertainties. Variations between years must be expected of that reason alone that the abundance of Greenland halibut variate. In 1990 the abundance of Greenland halibut was significant lower than the estimate for 1988 (Kanneworff and Pedersen, 1991).

In order to give an rough idea of the annual consumption of shrimp (*Pandalus borealis*) by Greenland halibut it is necessary to make several assumptions. These assumptions are the same as those made by Bowering and Lilly, (1990), who also gives the argumentation.

1) The number of Greenland halibut as estimated by the shrimp survey is constant from June to December.
2) The period of feeding on shrimp is one half year.
3) There is no diel pattern of stomach fullness.
4) The ratio of daily consumption is 0.48 of the mean stomach content.

The annual consumption of shrimp under the above assumptions is 670 t. This value should be compared with the estimated biomass of the shrimp stock for the area of 132,000 t (Carlsson and Kanneworff, 1991), however, it must be remembered that the size distributions are different.

Although the predation of Greenland halibut on shrimp is not estimated to be of great importance, the Greenland halibut stock may have an impact on the shrimp stock by eating redfish, another shrimp predator (Pedersen and Riget, 1991b). To give a rough idea of the impact on the redfish stock the weight of redfish in the stomachs in the time of the survey is calculated to be 8,6 t. Making the same assumptions as done for estimation of the annual consumption of shrimp, the annual consumption of redfish is 751 t which should be compared with a biomass estimate of 10,000 t for the area (Pedersen and Kanneworff, 1991). However, the redfish eaten by Greenland halibut are generally smaller than the redfish eating shrimp.

We conclude that the food links between shrimp, redfish and Greenland halibut seems to be of major importance on the West Greenland shrimp grounds, and these food links should therefore be further investigated in the future.

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REFERENCES

Bowering, W.R. and G.R. Lilly, 1990. Greenland Halibut *Reinhardtius hippoglossoides* off Southern Labrador and Northeastern Newfoundland (Northwest Atlantic) feed primarily on Capelin *Mallotus villosus*. International flatfish symposium 1990.

Bowering, W.R., D.G. Parsons and G.R. Lilly, 1983. Predation on Shrimp *Pandalus borealis* by Greenland Halibut *Reinhardtius hippoglossoides* and Atlantic Cod *Gadus morhua* off coastal Labrador (Div. 2H and 2J). NAFO SCR Doc. 83/IX/88.

Bromley, P.J. and J.M. Last, 1990. Feeding in the trawl and the consequences for estimating food consumption in natural fish populations. ICES CM 1990 / G:35.

Carlsson, D.M. and P. Kanneworff, 1991. Report on Stratified-random Trawl Surveys for Shrimp (*Pandalus borealis*) in NAFO Subarea 0+1 in July-August 1990, and a Comparison with Earlier Surveys. NAFO SCR Doc. 91/70.

Chumakov, A.K. and S.G. Podrazhanskaya, 1986. Feeding of Greenland Halibut *Reinhardtius hippoglossoides* in the Northwest Atlantic. NAFO Sci. Coun. Studies. 10: 47-52.

Kanneworff, P. and S.A. Pedersen, 1991. Survey Biomass of Greenland halibut (*Reinhardtius hippoglossoides*) off West Greenland (NAFO Subareas 0+1), July-August 1988, 1989 and 1990. NAFO SCR Doc. 91/45.

Nizovtsev, G.P. 1977. On feeding of Greenland Halibut *Reinhardtius hippoglossoides* (Walbaum), in the Barents Sea. Deponent TsNIITEIRKh, 44: 1-44.

Pedersen, S.A. and P. Kanneworff, 1991. Survey Biomass of Redfish (*Sebastes spp.*) off West Greenland (NAFO Subarea 0+1), July-August 1988, 1989 and 1990. NAFO SCR Doc. 91/46.

Pedersen, S.A. and K. Lehmann, 1989. By-catch of Redfish and Greenland halibut in the Shrimp Fishery off West Greenland, 1988. NAFO SCR Doc. 89/41.

Pedersen, S.A. and F. Riget, 1991a. Preliminary Studies on Feeding Habits of Demersal Fish Species in West Greenland Waters with Special Emphasis on Predation on Shrimp. NAFO SCR Doc. 91/47.

Pedersen, S.A. and F. Riget, 1991b. Feeding Habits of Redfish, *Sebastes spp.*, in West Greenland Waters with Special Emphasis on Predation on Shrimp. NAFO SCR Doc. 91/48.

Riget, F., J. Boje and K. Lehmann, 1988. By-catches of Greenland halibut and Redfish in the Shrimp Fishery at West Greenland. NAFO SCR Doc. 88/12.

Smidt, E., 1969. The Greenland Halibut *Reinhardtius hippoglossoides* (Walb.). Biology and Exploitation in Greenland Waters. Medd. Danm. Fish.- og Havunders. N.S., 6: 79-148.

<u>Tabel 1.</u> Number of Greenland halibut stomachs analysed for food by predator length groups and sampling periods, in 1990.

	"Shinkai Maru" bottom trawl survey	"Manitsoq" shrimp survey	"Poseidon" bottom trawl survey	"Shinkai Maru" bottom trawl survey	"Walter Herwig" bottom trawl survey
date	20-22.6	19-30.7	30.7-4.8	10.9	6-8.11
depth, m	444-547	284-531	254-355	427-540	180-554
cm.					
5-14	3	10	9		
15-24	13	88	41		8
25-35	48	65	86	31	74
35-44	32	28	7	56	26
45-54	15	6		12	5
55-64	1		1		
Total	112	197	144	99	113
% empty	57.1	44.2	70.8	28.7	61.1
number of stations	4	13	4	5	6

<u>Table 2.</u>

The food composition of Greenland Halibut caught off St. Hellefisk Banke during 1990.

	Occurrence (%)					Weight(%)					Mean PFI				
Sampling period(month)	6	7	7/8	9	11	6	7	7/8	9	11	6	7	7/8	9	11
Polychaeta	0.9	0.5		1.1	0.9	0.1	0.1		x	x	x	x		x	x
Bivalvia				1.1					0.1					x	
Cephalopoda	0.9	0.5				0.4	x					x			
Crustacea (total)	21.4	38.1	24.3	58.5	14.2	29.5	56.3	63.0	67.1	14.2	0.07	0.40	0.27	0.38	0.13
Hyperidae															
<u>Parathemisto sp.</u>	1.8	7.1	4.2	8.5	0.9	0.1	0.3	0.4	0.6	x	x	0.02	0.01	0.01	x
Euphausiacea		3.6	1.4				0.4	0.4				0.02	0.01		
Natantia					1.8					0.3					x
<u>Pandalus borealis</u>	9.8	16.2	12.5	28.7	8.8	24.9	52.4	62.2	58.5	13.7	0.06	0.32	0.23	0.32	0.13
Others+unidentified	7.1	7.7		11.7		4.4	2.1		6.5			0.02		0.04	
Others	1.8	4.6		2.1	0.9	x	0.2		0.1	0.1	x	0.01		x	x
Unidentified	5.4	4.1	8.3	11.7	1.8	0.1	0.9	2.0	1.4	0.1	0.01	0.01	0.02	0.01	x
Pisces (total)	32.6	26.9	6.9	22.3	31.0	69.9	43.0	34.9	33.0	85.9	0.40	0.58	0.11	0.22	0.68
<u>Mallotus villosus</u>		2.0					7.0					0.16			
<u>Sebastes sp.</u>	25.0	11.2	4.8	10.6	28.3	58.9	13.5	30.0	8.4	77.0	0.30	0.20	0.09	0.04	0.63
<u>Reinhardtius hippoglossoides</u>		0.5		2.1			8.3		11.6			0.01		0.07	
Others	0.9	1.5	1.4	1.1	1.8	6.0	1.9	3.6	2.5	2.6	0.05	0.05	0.01	0.03	0.02
Unidentified	8.0	13.2	0.7	9.6	5.3	5.0	12.3	1.3	10.5	6.3	0.05	0.16	0.01	0.08	0.03
Unidentified	0.9	0.5			1.8	x	0.6			x	x	x			x
Total											0.47	0.99	0.38	0.60	0.81

<u>Table 3.</u>
Contents of shrimp and redfish in stomachs of Greenland halibut by 10 cm length groups.

Length (cm)	Abundance ('000)	Mean contents of shrimp (g)	Total weight of shrimp (kg)	Mean contents of redfish (g)	Total weight of redfish (kg)
5-14	10650	0	0	0	0
15-24	14037	0.21	2948	0.24	3369
25-34	3323	0.64	2127	0.94	3124
35-44	884	2.28	2016	1.46	1291
45-	192	2.91	559	4.12	791
Total			7650		8575

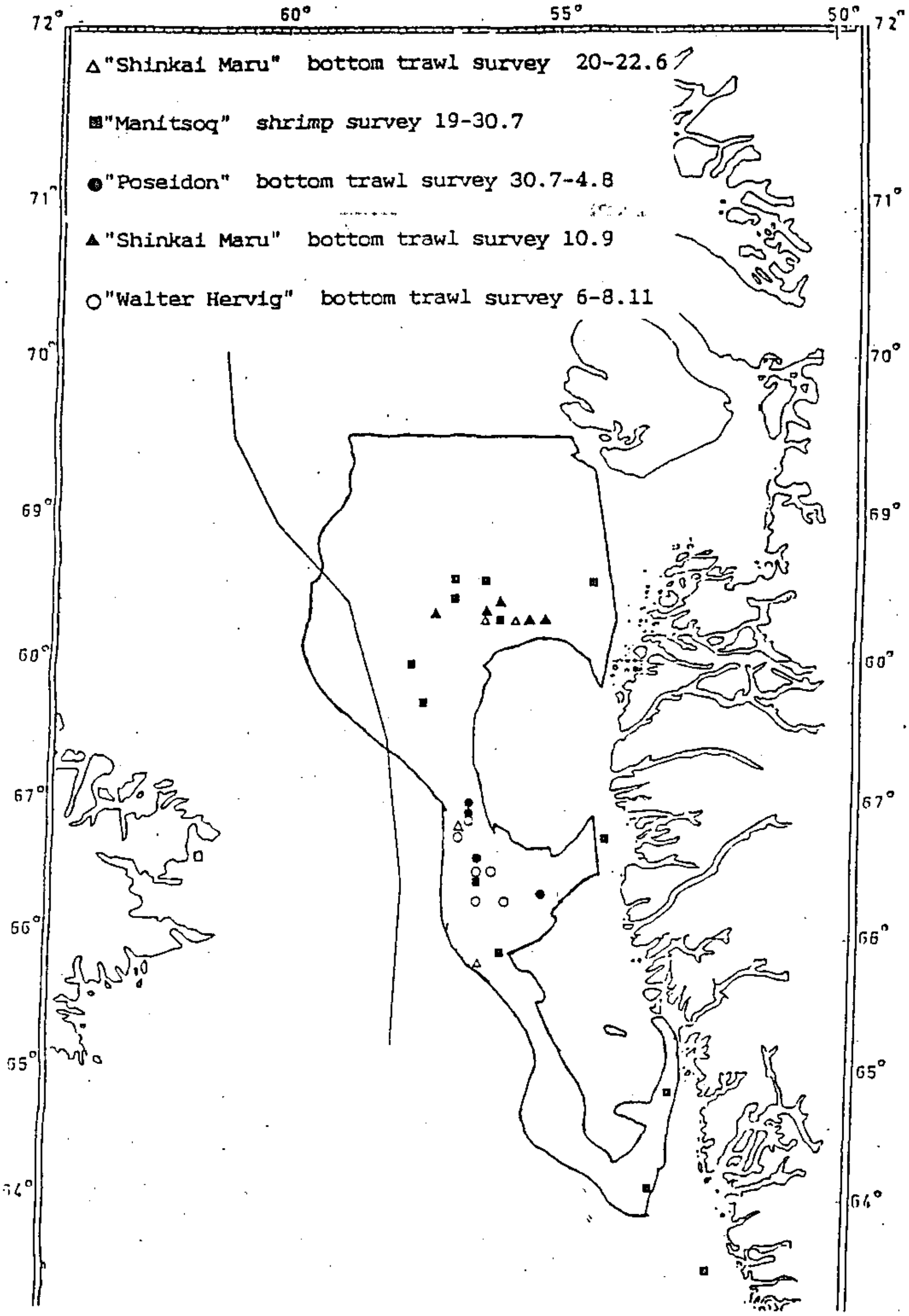

Fig.1
Map of study area together with hauls positions

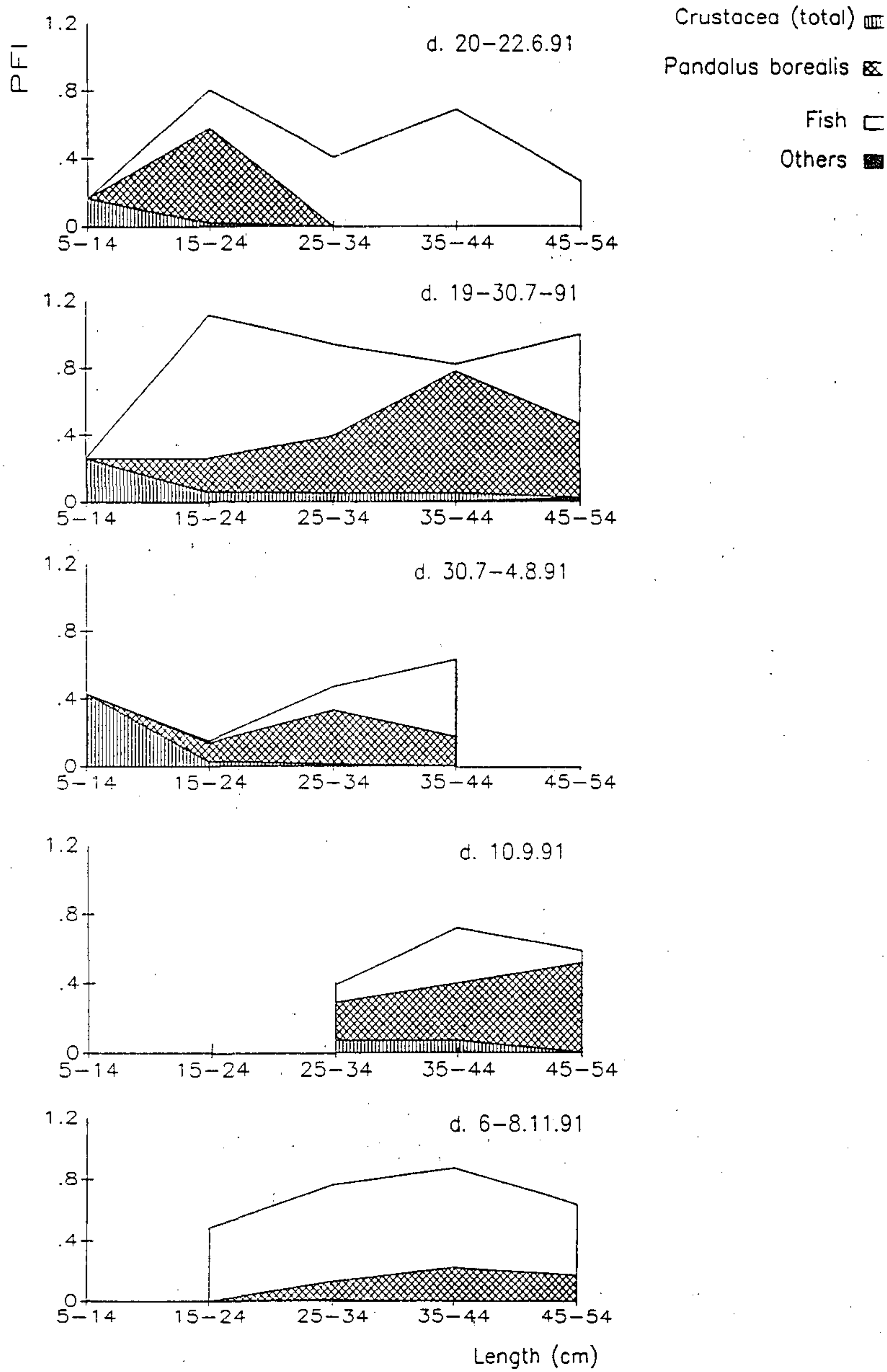

Fig.2

Mean partial fulness index (PFI) of prey items in relation to predator length for Greenland halibut collected on the surveys.

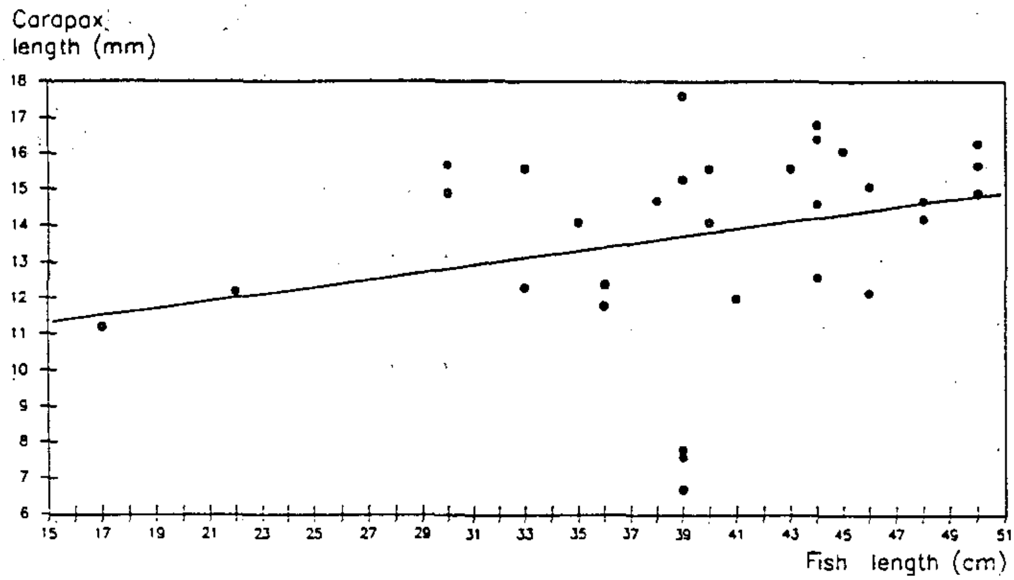

Fig.3

Plot of carapax length of shrimp found in the stomachs versus predator length together with the regression line.

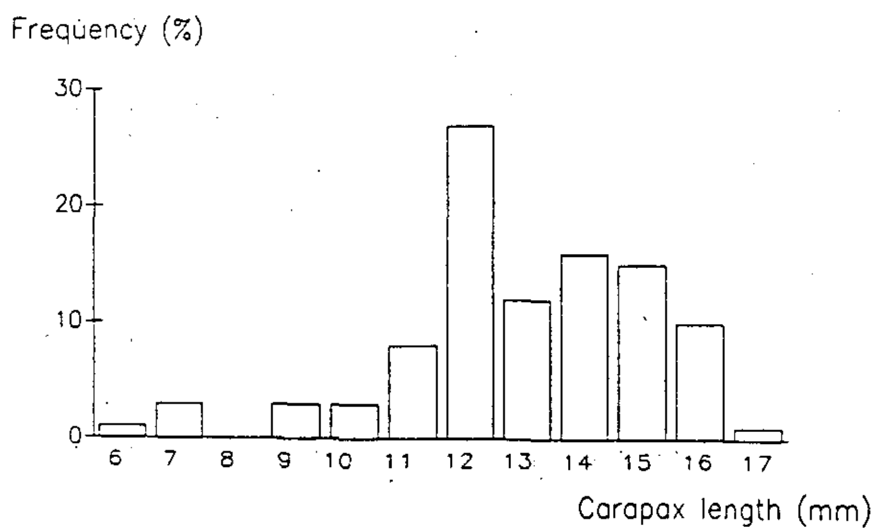

Fig.4

Carapax length frequencies of shrimp found in the stomachs of Greenland halibut.