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Feeding Habits of Redfish, *Sebastes sp.*, in West Greenland Waters with Special Emphasis on Predation on Shrimp

by

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ABSTRACT

A total of 2,708 redfish stomachs were collected in summer and autumn 1990-91 and in winter and spring 1992. The most important prey items in stomachs from small redfish (5-24 cm) collected on the shrimp grounds in summer and autumn 1990/91 were planktonic crustaceans – copepods, mysiids, hyperiids (*Parathemisto sp.*) and euphausiids. *Parathemisto sp.* were dominant by occurrence (13.7-27.0%), number (20.3-35.6%) and weight (13.6-19.9%) in summer and autumn, whereas this prey was seldomly found in the stomachs from winter and spring. In spring euphausiids were dominant. Shrimps (*Pandalus borealis* and *Pandalus sp.*) occurred very infrequently in all seasons (about 2%), but were important food in the diet by weight (20-30%). With increasing predator size shrimp, *Pandalus borealis,* gains in importance. Fish prey, mainly *Sebastes sp.*, was important prey only in stomachs of small redfish collected in autumn 1990 and winter 1992. The mean stomach content weight (% of body weight) decreased with increasing fish size. The daily rations (% of body weight per day) of redfish were calculated to 0.46 (%BWD) for the autumn-winter period and to 0.86 (%BWD) for the spring-summer period using an exponential gastric evacuation rate model. The annual consumption of shrimp was estimated to 33,600 tons and 8,700 tons for 1990 and 1991, respectively. We conclude that an annual shrimp consumption of these levels could have a significant impact on the West Greenland shrimp stock.

INTRODUCTION

During the last two decades the offshore fishery for northern shrimp, *Pandalus borealis,* in the Davis Strait has been one of the largest fisheries for this species in the world. In 1991, the nominal catch of shrimp in the offsh-ore area of West Greenland south of 71° N increased to about 57,000 tons – the highest level in the history of this fishery (Anon., 1992). The distribution area for shrimp coincide with important nursery areas for Greenland halibut and redfish mainly, and large quantities of these two fish species are caught and discarded in the shrimp fishery (Smidt, 1969; Jensen, 1979; Riget et al., 1988; Pedersen and Lehmann, 1989; Parsons and Veitch, 1992).

Little is known about trophic interactions between shrimps and fish and between the key fish species in the marine ecosystem off West Greenland, and little is known about the effects of the shrimp fishery on this ecosystem. Investigations of selective shrimp trawls which reduce the by-catch and discards of small shrimp and fish were started in Greenland waters in 1990. These investigations have raised the question whether increased survival rates of fish will reduce the yield from the shrimp fishery due to increased predation mortality on the shrimp stock.

In order to study the importance and level of predation on the shrimp stock by fish a sampling program for fish stomachs from the key fish species was started in 1990 (Pedersen and Riget, 1991) and continued in 1991 and 1992. The purpose of this paper is to provide a description of the food and feeding habits of redfish in West Greenland waters, including seasonal and spatial variations in the stomach content; influence of predator size; and estimated annual consumption of shrimps.

MATERIALS AND METHODS

The study area was the continental shelf between 61°52'5N and 69°30'N in the Davis Strait from the 3-n.mile limit off the Greenland coast in depths of 150–600 m (Fig. 1). A total of 2708 redfish stomachs were analyzed. The stomachs were collected from catches at 119 trawl locations off West Greenland during six research surveys in summer and autumn 1990 and 1991 and during two commercial trips in winter and spring 1992. The research surveys were not designed to this study. The sampling gear was bottom trawl – commercial shrimp trawl or small meshed research trawls for fish. Except from a few trawl hauls the stomachs were sampled during day–time only. All sampling stations have been divided by year and sampling season (Table 1 and Fig. 1). During winter the sea ice (Westice) forces the commercial shrimp fishing fleet from its main fishing areas off West Greenland to fishing grounds in southwest Greenland. Therefore, in February 1992, fish stomachs were collected from south-west Greenland only. Similarly, the ice situation in April 1992 restricted the area from where fish stomachs could be collected.

When possible the sampling strategy was to collect stomachs stratified by length from the catch in each haul at different locations and seasons within the study area. A substantial amount of redfish in the catches had their stomachs everted and were excluded from this study. Stomachs from fish with no signs of regurgitation were individually tagged and frozen (<–18°C) for later examination (in most cases whole fish). In the laboratory the stomachs were thawed in water and examined. The weight–length equation for the investigated fish was estimated from least-squares regression of individual weight and length measurements on 2262 fish after logarithmic transformation (r^2=0.97):

$$W(g)=0.009565 \times L(cm)^{3.1120}$$

The stomach content was identified to the lowest possible taxon within a reasonable time consume. The degree of digestion of fish prey was judged by a six point scale and of invertebrate prey by a four point scale as proposed by Bromley and Last (1990). Each food category was counted and weighed to nearest 0.1 g. Excess liquid was removed only mechanically. When possible fish prey was measured to the nearest mm total length and/or the length of the vertebral column was measured. Carapace and pleuron length of *Pandalus borealis* were measured with an accuracy of 0.1 mm. In many cases it was possible to measure the length of the pleuron and not the carapace of shrimp found in the stomachs. Therefore, a relationship between the length of the pleuron and the length of the carapace was established from measuring 216 fresh shrimps sampled from a commercial catch. After logarithmic transformation of the two variables least-squares regression of carapace length (CPL) on pleuron length (PL) was calculated (r^2=0.91). Using the equation from the regression, the carapace length was calculated in cases when only the pleuron could be measured:

$$CPL(mm) = 0.8100 \times PL(mm)^{1.2739}$$

The relative importance of individual prey taxa was assessed with indices of frequency of occurrence, number and weight (Clark, 1985) and a stomach fullness index (Lilly, 1991):

Frequency of occurrence: The number of stomachs in which a food item occurred was expressed as a percentage of the total number of stomachs investigated.

Number: The number of each prey item was expressed as a percentage of the total number of food items in all stomachs.

Weight: The weight of each prey item was converted to a percentage of the weight of the total stomach contents.

The mean partial fullness index of prey was calculated as:

$$PFI_i = \frac{1}{n}\sum_{j=1}^{n} \frac{W_{ij}}{L_j^3} \times 10^4$$

where W_{ij} is the weight of prey i in fish j, L_j is the length of fish j, and n is the number of fish in the sample. Mean total fullness index (TFI) was calculated by adding values of mean partial fullness index.

The stomach content data were seasonnally combined and the prey was compared among season. Within each season the data were divided by fish length into 5 cm size groups and the mean PFI of each prey categori was calculated.

RESULTS

Seasonally and spatial variations in prey and stomach fullness

The proportion of stomachs identified as empty by sampling period regardless of fish length increased from 23 % in spring and summer to 32-33% in autumn and to 80% in winter (Table 1).

The composition of redfish stomach contents consisted of prey taxa belonging to five major animal groups – polychaetes, molluscs, crustaceans, echinoderms and fish. Crustaceans, especially *Parathemisto sp.*, but also mysiids, euphausiids, copepods and shrimps (*Pandalus borealis*) were important prey items (Table 2). *Parathemisto sp.* was dominant by occurrence (13.7-27.0%), number (20.3-35.6%) and weight (13.6-19.9%) in summer and autumn, whereas this prey was seldomly found in stomachs from winter and spring. Except for spring fish prey (mainly redfish and Greenland halibut) also occurred in the stomachs. In winter copepods and fish (mainly redfish) were dominant. The high percentage (30.7%) by weight of *Pandalus borealis* in winter is due to one shrimp of 9.4 grams found in one redfish 36 cm long. In spring euphausiids were dominant. Shrimps (mainly *Pandalus borealis* and *Pandalus sp.*) occurred very infrequently in all seasons (about 2%), but were important food in the diet by weight (20-30%).

The mean total fullness index (TFI) is highest for the stomachs sampled in spring (3.47) and lowest for those sampled in winter (0.55) (Table 2;Fig. 2). Except for the redfish collected in summer 1990 and spring 1992 there is a tendency of decreasing TFI with increasing predator size, this might be due to changes in vertical distribution and feeding habits with predator size.

The relative importance of the various prey changes with fish size. From the partial fullness indices (PFI) it is seen that *Pandalus borealis* gradually becomes more important as prey with increasing predator size. Contrary, the hyperiid, *Parathemisto sp.*, and other small crustaceans a.o. copepods gradually become less important as prey with increasing predator size (Fig. 2). In stomachs collected in autumn 1990 and 1991 copepods, mysiids and *Parathemisto sp.* are the most important prey for small redfish in length 5-19 cm. Fish (mainly redfish) is also important prey for redfish length group 10-19 cm in autumn 1990, but not in autumn 1991 for the same length group. In winter copepods are dominant prey for redfish in length 5-9 cm whereas fish (mainly redfish) is dominant prey for redfish in length 10-24 cm.

To study the variation in total stomach content between sampling periods the mean total fullness index (TFI) was calculated for each sampling station for fish between 5 and 20 cm. Only stations with at least 10 fish investigated were selected. A one-way ANOVA with sampling period as class variable shows significant ($F=3.38$, $P=0.0083$) effect on mean TFI of sampling period. However, the total variance explained by the model was only 18%. The mean TFI of stomachs collected in spring 1992 (mean TFI=3.8) is significant different from the mean TFI of stomachs collected in most of the other time periods. Excluding the spring sampled stomachs a one-way ANOVA shows no significant effect of sampling period. A one-way ANOVA for difference in mean TFI between 100 m depth zones regardless of sampling period shows no significant ($F=0.75$, $P=0.56$) differences between depth zones.

Shrimp size preference

The relationship between carapace length and predator length based on actual measured carapace length and pleuron back-calculated carapace length is shown in Fig. 3. Shrimp size and predator size seem to be correlated, but shrimps have only been found in a small number of redfish stomachs and few of these could be size measured. The most frequent shrimp size found in the stomachs is carapace length 20 mm (Fig. 4). This shrimp size was also the most frequent shrimp size found in Greenland halibut stomachs (Pedersen and Riget, 1992).

Weight of shrimps in total population stomachs

The mean weight of shrimp (*Pandalus borealis*) in the stomachs of the redfish population by 5 cm groups was calculated from the total material in average for two half year periods autumn-winter and spring-summer, respectively. Unidentified crustaceans have been allocated to the shrimp category in proportion to the weight of identified shrimp (*Pandalus borealis*) relative to other crustaceans. (Table 3).

By assuming a constant abundance of redfish throughout the year the total weight of shrimp in stomachs of the redfish population at the time of sampling in average for the two periods autumn-winter and spring-summer was estimated (Table 3). The abundance of redfish by 5 cm length groups in the study area was estimated from the catches of redfish during the Greenland research survey for shrimp in summer 1990 and 1991 (Pedersen and Kanneworff, 1992). The weight of shrimp in stomachs of the population is generally much higher in the spring-summer period (249 and 63 tons in 1990 and 1991) than in the autumn-winter period (86 and 24 tons in 1990 and 1991) (Table 3). The calculated weight of shrimp in stomachs of the redfish population at the time of sampling was much higher in 1990 compared to 1991. This difference between years is due to a much higher abundance of larger redfish (15-44 cm) in 1990 compared to 1991.

Annual consumption of shrimp by redfish

In order to give a rough estimate of the annual consumption of shrimp we use the model of Elliott and Persson (1978) to calculate daily ration (D.R.). This model assumes that the rate of gastric evacuation (R) is exponential and temperature dependent:

$$R = a \times e^{bT}$$

Information on gastric evacuation rates in redfish is lacking. It was, therefore, necessary to make assumptions based on the literature. Durbin et al. (1983) concluded that the slope (b) is fairly constant for different prey types and fish species (b=0.115) whereas the constant (a) changes with prey type. We use the value of a=0.0143 found by Dwyer et al. (1987) for fish prey in gastric evacuation experiments on walleye pollock. These experiments were used by Yang and Livingston (1988) when calculating daily ration of Greenland halibut in the eastern Bering Sea. Although gastric evacuation rate (R) changes with prey type there seems not to be significant differences in R between shrimp, herring and capelin as prey in feeding experiments with cod judged from the data presented by Dos Santos and Jobling (1991). Therefore, we have used the value of the constant (a=0.0143) for the prey type shrimp. A general observation of temperature in the study area is a higher bottom water temperature during the autumn-winter period than in the spring-summer period (Buch, 1982). Based on bottom temperature distributions in Buch (1982) we have assumed an average bottom water temperature during the autumn-winter period of 4.5°C for the whole study area and an average bottom water temperature during the spring-summer period of 3.0°C.

Using the above assumptions and stomach content data the daily rations for each period can be calculated as:

$$D.R. = 24 \times S \times R$$

where S is the mean stomach content weight (% of body weight) calculated for all stomachs in each 5 cm length group. There is a decreasing trend of S values with increasing fish size (Table 4). However, the overall mean value of S used was S=0.95 (%BW) for the autumn-winter period and S=1.5 (%BW) for the spring-summer period. Furthermore we assume no diel pattern in the stomach content and feeding. The daily ration regardless of fish size was calculated to 0.46 (%BWD) for the autumn-winter period and to 0.86 (%BWD) for the spring-summer period.

To convert the mean stomach content of shrimp to daily consumption we simply multiplied the calculated daily rate of evacuation (24 x R) with the estimated total weight of shrimp in stomachs of the population at the time of sampling. The annual consumption was calculated by multiplying daily consumption by each half-year period (182 days) and summation of the two. The annual consumption of shrimp was calculated to 33,600 tons and 8,700 tons for 1990 and 1991, respectively.

DISCUSSION

The proportion of empty redfish stomachs in our study was lowest in spring and summer (23%) and highest in autumn and winter (33 and 80%,respectively). These proportions are close to findings by Magnússon et al. (1990), but they are generally lower than the proportions of empty stomachs found by Konstantinov et al. (1985) during field investigations.

Our investigation has been concentrated on the shrimp grounds and the estimated food composition may not be representative for redfish in the whole area of distribution off West Greenland.

According to Konchina (1983) who studied redfish feeding in areas off Baffin Land and South Labrador redfish (*S. mentella*) possess a high plasticity in their feeding. In these areas young *S. mentella* feed mainly on euphausiids, small crustaceans, squids (*Gonatus fabricii*), hyperiids and fish. With increasing predator size fish and shrimp became more important in the diet. For redfish in the Flemish Cap ecosystem Konstantinov et al. (1985) found that the main food items of *S. mentella* were planktonic invertebrates (copepods, amphipods and euphausiids), which were significant in most months of the year but were dominant during summer (June–August). On the average, shrimps were less significant as food but occurred more frequently than the other components in April–May and December. According to results of data processing for many years Albikovskaya and Gerasimova (1989) set the following pattern of *S. mentella* on Flemish Cap: In winter and early autumn redfish do not feed. Low feeding in spring. Summer should be regarded as feeding start. Importance of *P. borealis* chiefly consumed by redfish over 20 cm increases in autumn and winter when major food item biomass is at a low level.

In Icelandic waters euphausiids and copepods especially *Calanus sp.* are the dominating prey for redfish, with fish prey occurring in all seasons predominantly in the largest predator length groups (Pálsson, 1983). According to Pálsson (1983) zooplanktonic prey provide the bulk of the food of redfish in Icelandic waters and redfish should therefore be classified as "pelagic" rather than "demersal" as usually done. Investigating the feeding habit of redfish in East Greenland waters in October 1985, Magnússon and Pálsson (1988) found marked differences compared to redfish in Icelandic waters. The main difference was the high frequency of fish (*Sebastes sp.* and Myctophidae) in East Greenland waters. In 1985, the Icelandic abundance index of 0-group redfish was high in the East Greenland area and Magnússon and Pálsson (1988) therefore assume that 0-group redfish were well available as food for cod and redfish. They conclude that 0-group redfish probably are of major importance to both cod and redfish as food component in this region in autumn/early winter. Further studies of the feeding habits of redfish in East Greenland waters were made in 1987 and 1989 by Magnússon et al. (1988 and 1990). In 1989 they found that plankton was by far the most important food component for young redfish (<14 cm) with euphausiids, *Meganyctiphanes norvegica* ranking top. For both *Sebastes marinus* and *S. mentella* nekton gains on importance for species larger than 15 cm. Shrimps and benthos was of minor importance to both species, but became a noticeable part of the diet of the larger *S. mentella*.

Comparing the feeding habits of redfish in our investigation with feeding habits of redfish in the above mentioned investigations off Baffin Land and South Labrador, in Icelandic and East Greenland waters there are some marked differences. The main differences in the prey spectrum are the high frequency occurrence of *Parathemisto sp.* 13.7–27.0% in small redfish stomachs (<19cm) and the high percent weight (20–30%) and PFI of *Pandalus* *borealis* in larger redfish stomachs (>20 cm). Our findings on feeding habits of redfish from West Greenland have some similarities with findings by Konatantinov et al. (1985) and Albikovskaya and Gerasimova (1989) on Flemish Cap. Unfortunately, in our study we were able to collect stomachs from only a small number of redfish larger than 20 cm in winter 1992 and none in spring 1992 due to very low catches of these larger redfish.

The increased importance of *Sebastes sp.* in the diet of small redfish length group 10–14 cm seen in autumn 1990 and in length group 10–24 cm winter 1992 seems to be caused by increased abundance of 0-group redfish off southwest Greenland during the autumn and winter months. In September–November pelagic redfish fry (length: 40–70 mm) has been observed drifting northward from Kap Farvel along the West Greenland coast in large quantities (Zakharov, 1966; Pedersen, 1990; Wieland, 1992). Since the 1920's no breeding of redfish have been observed off West Greenland, and the redfish population in West Greenland waters is believed to be recruited from breeding areas in the Irminger Sea southwest of Iceland (Zakharov, 1966; Anon., 1984; Pavlov et al., 1989; Anon., 1990; Magnússon et al., 1990). Newly recruited 0-group redfish seem to be of major importance to both redfish and Greenland halibut (Pedersen and Riget, 1992) as food component in the West Greenland shelf area especially in autumn and winter.

In the trawl catches redfish with intact stomachs are found in only minor quantities. The majority of the redfish caught has their stomachs everted. The bias made by using selected redfish with intact stomach in the investigation of stomach content, calculation of average degree of stomach fullness, daily ration and annual consumption of the redfish population is unknown and need to be investigated. However, Dolgov and Drevetnyak (1990) estimated the daily rations of the Barents Sea redfish (*Sebastes mentella*) by applying the Winberg equation and they found the daily rations to range from 1.6–2.0 (% of body weight) to 0.3–0.4%. These values are close to our findings of daily rations of the redfish in West Greenland using an exponential gastric evacuation rate model.

The estimated annual consumption of shrimp presented in this paper is based on many assumptions and may be improved in several ways. First of all the information on gastric evacuation rate in redfish is needed together with the influence of different natural food types. More stomach content data from redfish >20 cm especially from the winter and spring seasons are required. The abundance of redfish in the study area is estimated with great uncertainties from bottom trawl surveys and in the summer period only. These estimates should be verified by a better knowledge of trawl catchability together with information on seasonnal variability and vertical distribution.

We estimate a consumption of 33,600 tons and 8,700 tons of shrimp by redfish for 1990 and 1991. These values should be compared with an estimated fishable biomass of the shrimp stock in the study area of 132,200 tons and 95,400 tons for 1990 and 1991 (Carlsson and Kanneworff, 1992). An annual shrimp consumption of these levels could have a significant impact on the shrimp stock. We have estimated the annual consumption of redfish by Greenland halibut to be a significant part of the redfish stock (Pedersen and Riget, 1992). We, therefore, conclude that the food links between shrimp, redfish and Greenland halibut are of major importance for the dynamics between these resources and the shrimp fishery, and that they should be considered in the management of the fishery in the area.

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Table 1 Number of redfish stomachs analysed for food by predator length groups, year and seasons of sampling (Seasons: **Summer**=June–August 90/91, **Autumn**=September and November 90, November 91, **Winter**=February 92, **Spring**=April 92).

Total number of stomachs investigated		LENGTH (CM)									
		5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-	ALL	Percent empty
		n	n	n	n	n	n	n	n	n	
YEAR	SEASON										
1990	SUMMER	196	299	103	23	9	8	3	1	642	23
	AUTUMN	17	94	49	.	.	1	.	.	161	33
1991	SUMMER	443	317	234	176	68	49	31	12	1330	23
	AUTUMN	144	101	44	7	11	1	2	1	311	32
1992	WINTER	35	129	20	12	3	1	2	.	202	80
	SPRING	48	13	1	.	.	.	.	.	62	23
ALL		883	953	451	218	91	60	38	14	2708	29

Table 2 Percentages of occurrence (O), numbers (N), and weight (W) and mean partial fullness indices (PFI) of prey items in the stomach contents of redfish at West Greenland by year and seasons of sampling.

	YEAR=90 SEASON=SUMMER			
	O(%)	N(%)	W(%)	PFI
Polychaeta	0.3	0.1	0.1	0.00
Gastropoda				
Cephalopoda	0.5	0.1	0.0	0.00
Crustacea(total)	50.7	99.0	97.6	2.40
Copepoda				
Calanus finmarcius	0.2	0.1	0.0	0.00
Unid. Copepoda	12.7	17.8	3.3	0.18
Hyperiida				
Parathemisto sp.	27.0	35.6	11.6	0.55
Unid. Hyperiida	0.3	0.1	0.2	0.00
Gammaridea	2.0	0.5	0.2	0.01
Other Amphipoda	0.2	-	0.3	0.01
Mysidacea	5.2	2.7	5.4	0.06
Euphausiacea	19.2	40.4	31.6	1.16
Natantia				
Pandalus borealis	2.0	1.0	21.8	0.09
Pandalus montagui	0.2	0.1	0.0	0.00
Pandalus sp.	0.8	0.3	5.1	0.02
Others and unid.	0.5	0.1	2.3	0.02
Unidenti.Crustacea	1.6	0.5	15.8	0.30
Echinodermata	0.2	0.1	0.0	0.00
Pisces(total)	2.0	0.7	2.2	0.02
Reinhardtius hipp.				
Sebastes sp.	0.2	0.1	0.0	0.00
Others and unid.	1.8	0.6	2.2	0.02
Unidentified and POM	0.2	0.1	0.0	0.00
TOTAL				2.42

	YEAR=90 SEASON=AUTUMN			
	O(%)	N(%)	W(%)	PFI
Polychaeta	0.7	0.3	0.7	0.01
Gastropoda				
Cephalopoda	3.3	1.8	8.6	0.06
Crustacea(total)	35.7	92.9	67.9	1.07
Copepoda				
Calanus finmarcius				
Unid. Copepoda	8.4	48.2	4.9	0.12
Hyperiida				
Parathemisto sp.	26.0	20.3	19.9	0.27
Unid. Hyperiida	0.7	0.3	0.2	0.01
Gammaridea	1.3	0.6	0.2	0.00
Other Amphipoda				
Mysidacea	5.2	20.0	25.7	0.29
Euphausiacea	4.0	3.0	4.9	0.07
Natantia				
Pandalus borealis				
Pandalus montagui				
Pandalus sp.				
Others and unid.				
Unidenti.Crustacea	1.3	0.6	12.6	0.30
Echinodermata	0.7	0.3	0.1	0.00
Pisces(total)	5.8	3.6	21.7	0.26
Reinhardtius hipp.	0.7	0.3	0.2	0.00
Sebastes sp.	3.9	2.1	20.5	0.24
Others and unid.	2.6	1.2	0.9	0.01
Unidentified and POM	2.0	1.2	0.5	0.00
TOTAL				1.40

Table 2 (continued) Percentages of occurrence (O), numbers (N), and weight (W) and mean partial fullness indices (PFI) of prey items in the stomach contents of redfish at West Greenland by year and seasons of sampling.

	YEAR=91 SEASON=SUMMER			
	O(%)	N(%)	W(%)	PFI
Polychaeta	0.0	0.0	0.1	0.00
Gastropoda				
Cephalopoda	0.2	0.1	0.1	0.00
Crustacea(total)	42.6	99.6	94.7	1.18
Copepoda				
<u>Calanus finmarcius</u>	0.1	0.0	0.0	0.00
Unid. Copepoda	20.7	38.5	9.3	0.36
Hyperiida				
<u>Parathemisto sp.</u>	14.5	24.2	13.6	0.25
Unid. Hyperiida	3.6	5.8	8.8	0.17
Gammaridea	1.9	1.0	0.5	0.01
Other Amphipoda				
Mysidacea	11.8	16.0	14.6	0.09
Euphausiacea	3.3	1.9	3.9	0.12
Natantia				
<u>Pandalus borealis</u>	1.1	0.4	25.6	0.04
<u>Pandalus montagui</u>	0.1	0.0	0.0	0.00
<u>Pandalus sp.</u>	0.3	0.1	6.3	0.01
Others and unid.	0.6	0.3	5.5	0.02
Unidenti.Crustacea	1.3	11.4	6.6	0.13
Echinodermata				
Pisces(total)	1.1	0.3	5.1	0.02
<u>Reinhardtius hipp.</u>				
<u>Sebastes sp.</u>	0.5	0.2	4.1	0.01
Others and unid.	0.6	0.2	1.1	0.01
Unidentified and POM	0.0	0.0	0.0	0.00
TOTAL				1.23

	YEAR=91 SEASON=AUTUMN			
	O(%)	N(%)	W(%)	PFI
Polychaeta	0.0	0.0	1.1	0.00
Gastropoda				
Cephalopoda				
Crustacea(total)	23.2	99.0	84.2	1.32
Copepoda				
<u>Calanus finmarcius</u>				
Unid. Copepoda	12.0	51.0	7.1	0.24
Hyperiida				
<u>Parathemisto sp.</u>	13.7	27.7	17.8	0.41
Unid. Hyperiida	0.7	0.8	3.5	0.09
Gammaridea	0.4	0.4	0.0	0.01
Other Amphipoda				
Mysidacea	6.0	12.9	11.1	0.17
Euphausiacea	1.4	3.2	7.5	0.19
Natantia				
<u>Pandalus borealis</u>	1.1	1.2	23.2	0.04
<u>Pandalus montagui</u>				
<u>Pandalus sp.</u>	1.1	1.2	6.8	0.01
Others and unid.				
Unidenti.Crustacea	0.7	0.8	9.4	0.17
Echinodermata				
Pisces(total)	0.7	1.0	14.5	0.02
<u>Reinhardtius hipp.</u>	0.4	0.4	9.4	0.01
<u>Sebastes sp.</u>	0.4	0.4	2.7	0.01
Others and unid.	0.0	0.0	0.0	0.00
Unidentified and POM				
TOTAL				1.34

	YEAR=92 SEASON=WINTER			
	O(%)	N(%)	W(%)	PFI
Polychaeta	0.0	0.0	0.3	0.01
Gastropoda	0.5	1.8	0.7	0.05
Cephalopoda				
Crustacea(total)	6.5	78.2	42.9	0.30
Copepoda				
<u>Calanus finmarcius</u>				
Unid. Copepoda	3.3	60.0	1.8	0.12
Hyperiida				
<u>Parathemisto sp.</u>	0.0	0.0	0.3	0.01
Unid. Hyperiida	0.0	0.0	0.3	0.00
Gammaridea	0.0	0.0	0.3	0.01
Other Amphipoda				
Mysidacea	1.1	5.5	1.1	0.02
Euphausiacea				
Natantia				
<u>Pandalus borealis</u>	0.5	1.8	30.7	0.01
<u>Pandalus montagui</u>				
<u>Pandalus sp.</u>				
Others and unid.	1.1	9.1	6.5	0.07
Unidenti.Crustacea	0.5	1.8	1.8	0.07
Echinodermata				
Pisces(total)	4.9	20.0	56.1	0.20
<u>Reinhardtius hipp.</u>				
<u>Sebastes sp.</u>	3.8	16.4	43.1	0.15
Others and unid.	1.1	3.6	13.1	0.05
Unidentified and POM	0.0	0.0	0.0	0.00
TOTAL				0.55

	YEAR=92 SEASON=SPRING			
	O(%)	N(%)	W(%)	PFI
Polychaeta				
Gastropoda				
Cephalopoda				
Crustacea(total)	35.1	100.0	100.0	3.47
Copepoda				
<u>Calanus finmarcius</u>				
Unid. Copepoda	1.8	8.6	0.3	0.03
Hyperiida				
<u>Parathemisto sp.</u>	1.8	1.8	0.7	0.04
Unid. Hyperiida	3.5	3.5	0.7	0.05
Gammaridea				
Other Amphipoda				
Mysidacea				
Euphausiacea	28.1	82.8	83.2	2.91
Natantia				
<u>Pandalus borealis</u>				
<u>Pandalus montagui</u>				
<u>Pandalus sp.</u>	1.8	3.4	5.2	0.04
Others and unid.				
Unidenti.Crustacea	0.0	0.0	10.0	0.40
Echinodermata				
Pisces(total)				
<u>Reinhardtius hipp.</u>				
<u>Sebastes sp.</u>				
Others and unid.				
Unidentified and POM	0.0	0.0	0.0	0.00
TOTAL				3.47

Table 3 Weight of shrimp (*Pandalus borealis*) in stomachs of the population of Redfish by half year period, length and year.

Spring-summer:

Length (cm)	Mean weight(g) of shrimp	Abundance 1990 ('000)	Abundance 1991 ('000)	Total weight(kg) of shrimp 1990	Total weight(kg) of shrimp 1991
5-9	0	95039	1732500	0	0
10-14	0.01	123606	289800	1236	2898
15-19	0.068	79060	29400	5376	1999
20-24	0.33	26907	12600	8879	4158
25-29	1.75	27277	6300	47734	11025
30-34	6.44	16708	4200	107599	27048
35-39	7.5	10369	2100	77767	15750
40-44	0	6242	630	0	0
			SUM	248,593	62,878

Autumn-winter:

Length (cm)	Mean weight(g) of shrimp	Abundance 1990 ('000)	Abundance 1991 ('000)	Total weight(kg) of shrimp 1990	Total weight(kg) of shrimp 1991
5-9	0	95039	1732500	0	0
10-14	0	123606	289800	0	0
15-19	0	79060	29400	0	0
20-24	0.52	26907	12600	13991	6552
25-29	0.43	27277	6300	11729	2709
30-34	3.6	16708	4200	60148	15120
35-39	0	10369	2100	0	0
40-44	0	6242	630	0	0
			SUM	85,869	24,381

Table 4 The mean stomach content weight of redfish, expressed as a percentage of body weight (% BW±SE). Data from autumn-winter and spring-summer and all times of the day were combined. N=number of stomachs.

	Autumn-winter		Spring-summer	
Length (cm)	N	% BW±SE	N	% BW±SE
5-9	186	1.65± 0.118	590	1.81± 0.084
10-14	194	0.79± 0.094	504	1.60± 0.091
15-19	105	0.36± 0.157	258	1.14± 0.127
20-24	18	0.53± 0.379	109	0.62± 0.196
25-29	11	0.37± 0.485	27	0.84± 0.394
30-34	3	0.33± 0.929	27	0.68± 0.394
35-39	4	0.44± 0.805	9	1.14± 0.681
40-	1	0.04± 1.610	5	0.14± 0.915

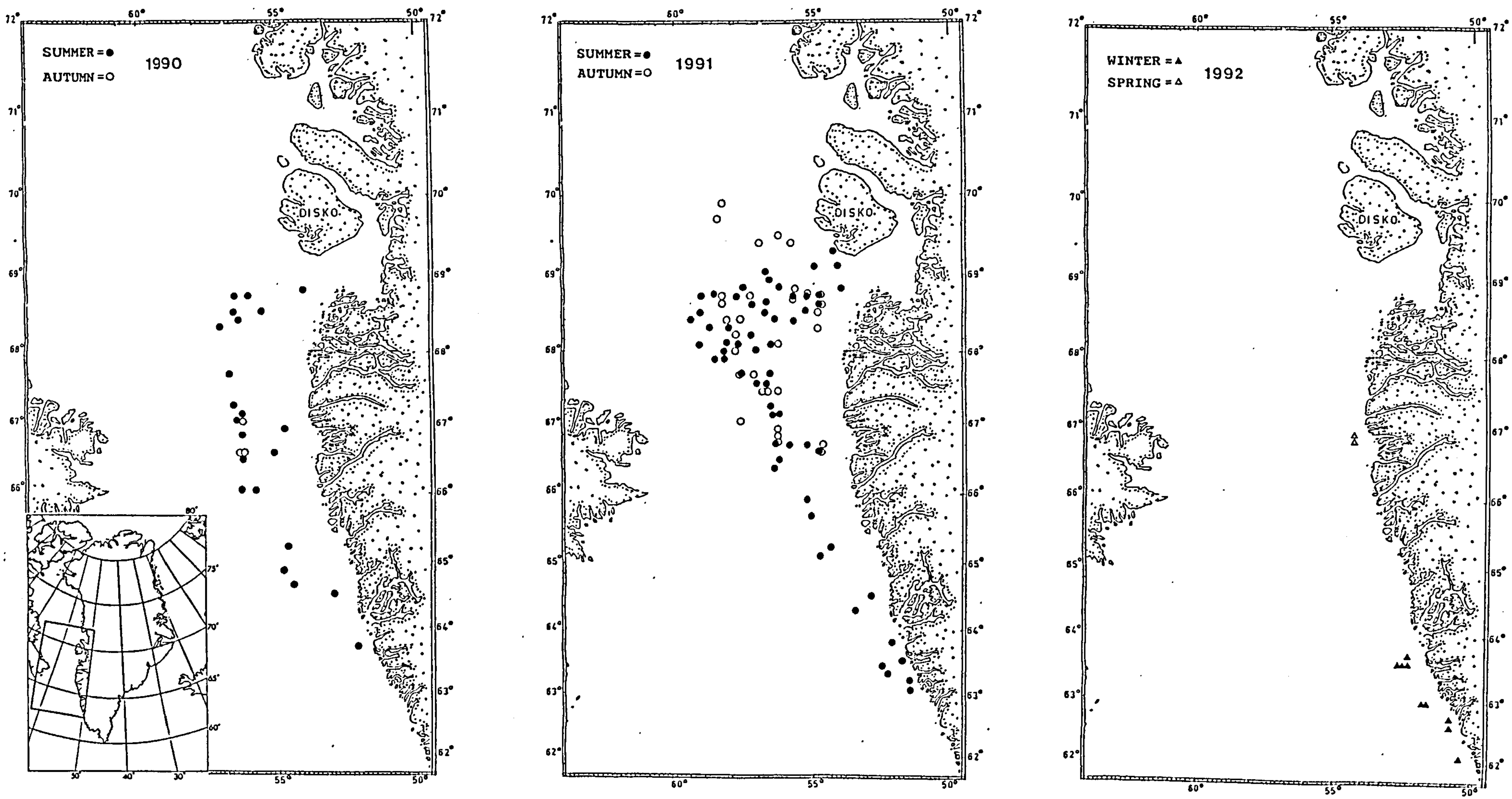

Fig. 1 Sampling stations on the West Greenland continental shelf at depths between 150–600 m by year and seasons of sampling (Seasons: **Summer**=June–August 90/91, **Autumn**=September and November 90, November 91, **Winter**=February 92, **Spring**=April 92).

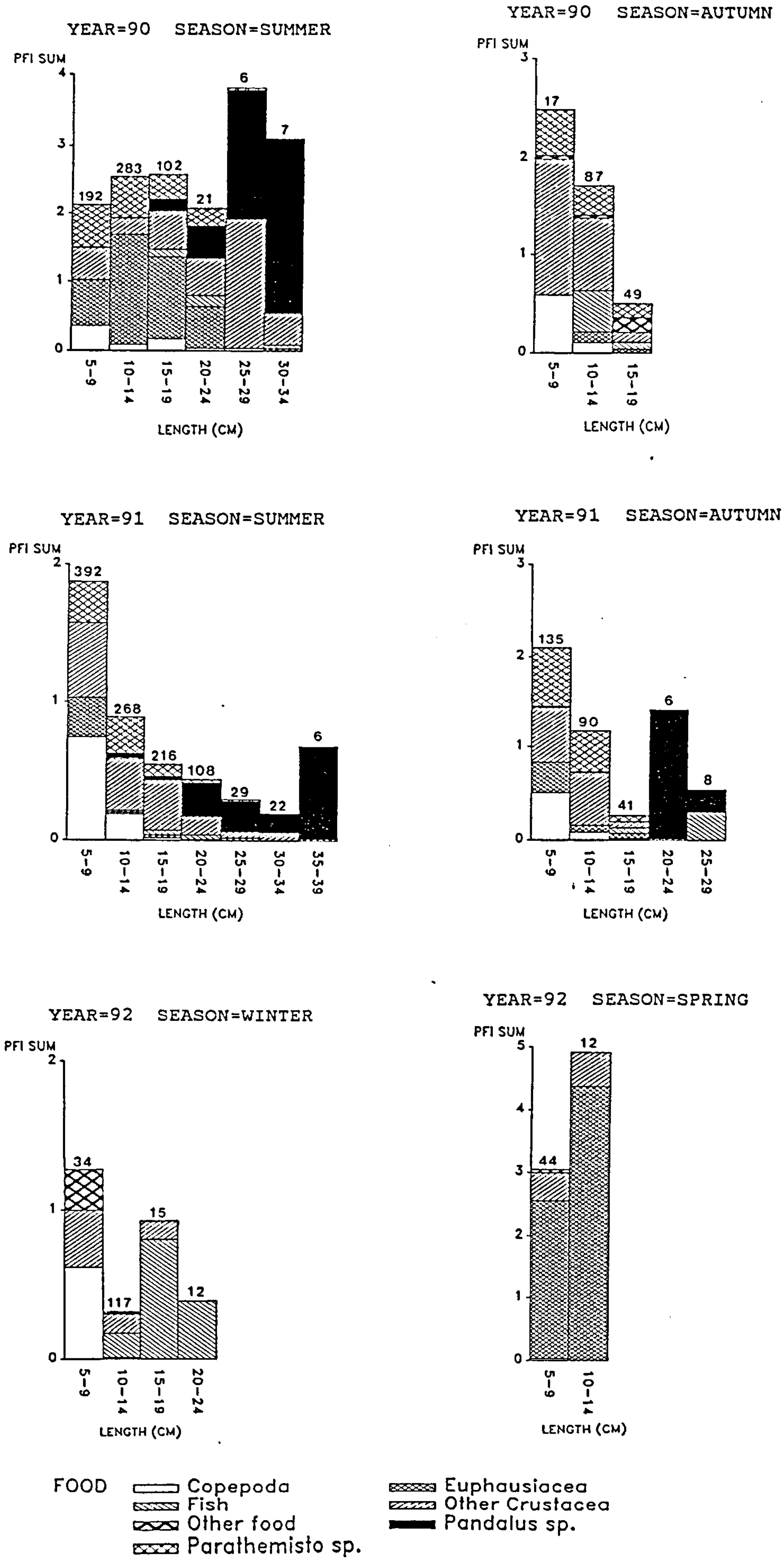

Fig. 2 Stomach contents (expressed as partial fullness indices) in relation to predator length, year and seasons of sampling. Sample sizes are given at the top, only length groups with sample sizes larger than five are presented.

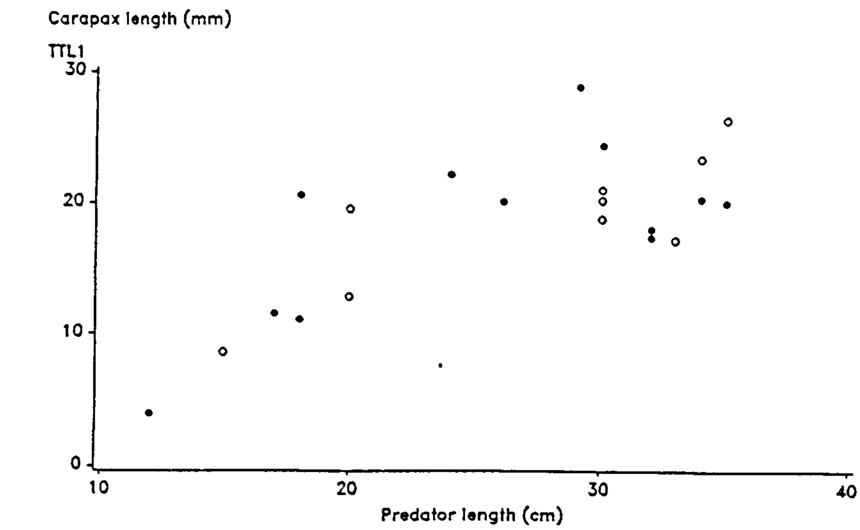

Fig. 3 Plot of carapace length of shrimps found in redfish stomachs versus predator length. (Dots=actual measured carapace length, Circle=pleuron calculated carapace length).

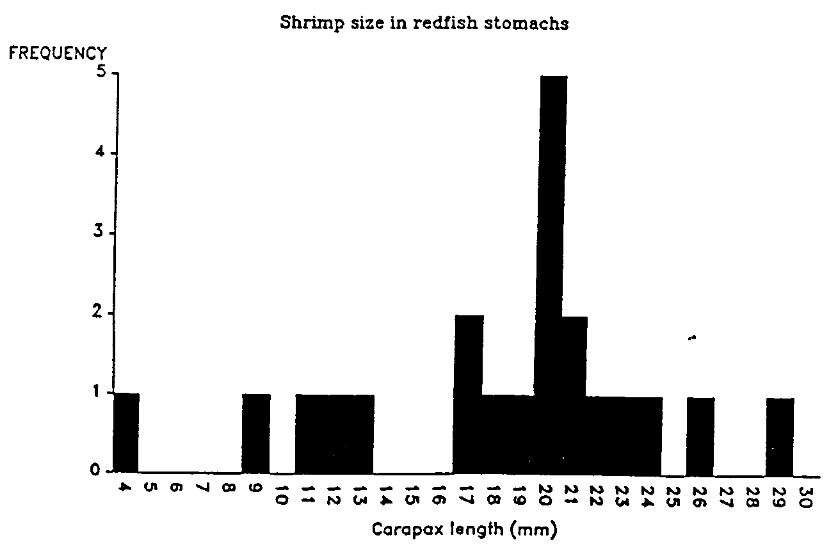

Fig. 4 Shrimp size frequencies found in the redfish stomachs.