Northwest Atlantic Fisheries Organization

Serial No. N1931 NAFO SCR Doc. 91/48

SCIENTIFIC COUNCIL MEETING - JUNE 1991

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

by

S. A. Pedersen and F. Riget

Greenland Fisheries Research Institute, Tagensvej 135, 1.
DK-2200 Copenhagen N, Denmark

INTRODUCTION

The most important fishery grounds for shrimp (*Pandalus borealis*) off 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 large quantities of mainly these two fish species are by-catch in the shrimp fishery (Smidt, 1969; Jensen, 1979; Riget et al., 1988; Pedersen and Lehmann, 1989).

Little is known about ecological 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 the ecosystem. In the latest years investigations of selective shrimp trawls which reduces the by-catches and discards of small shrimps and fish have been initiated. These investigations have raised the question if increased survival rates of fish will reduce the yield from the shrimp fishery due to increased predation mortality in the shrimp stock.

In order to study the importance and level of predation on the shrimp stock by fish a sampling program for stomachs from the key fish species on the shrimp grounds was started in 1990 (Pedersen and Riget, 1991). This paper presents preliminary results from investigations of the stomach content of the redfish.

MATERIALS AND METHODS

Stomachs were collected from 578 redfish during four research surveys covering the period from late June to early November 1990. The research surveys were not designed to this study. The sampling gear was bottom trawl, and stomachs were sampled during a total of 27 trawl hauls and in day-time only. The study area was West Greenland (NAFO Subarea 1) on the continental shelf at depths between 150-550 m. This area is an important area for the shrimp fishery.(Table 1 and Fig. 1).

It was intended to collect stomachs stratified by length from the catch of each haul in the study area. A substantial amount of redfish in the catches had their stomachs reversed these were excluded from this study. Stomachs from fish with no signs of regurgitation (in most cases hole fish) were individually tagged and frozen (<-18°C) for later examination. In the laboratory the stomachs (hole fish) were thawed in water.

The 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 of invertebrate by a four point scale as proposed by Bromley and Last (1990). The identification was done to lowest taxonomic level as possible within a reasonable consume of time. 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 the nearest mm total length. Carapax and pleuron length of *Pandalus borealis* 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 a given prey category as a percentage of number of stomachs investigated)

2) Percent weight (total weight of prey category p in all stomachs as a percentage of the total weight of all prey categories)

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

$$\frac{1}{n}\sum \frac{\textit{Weight of prey p in fish f}}{(\textit{Length of fish f})**3} *10000$$

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 of redfish off West Greenland summer-autumn 1990 consisted of prey species belonging to five major animal groups (polychaetes, molluscs, crustaceans, echinoderms and fish)(Table 2). Crustaceans, copepods, mysiids, hyperiids - especially *Parathemisto sp.*, euphausiids and shrimps (*Pandalus borealis*), were the far most important prey items. *Parathemisto sp.* had the highest occurrence and occurred in 8.5-51.0% of the stomachs, but comprised only between 0.4-19.1% of the total prey weight. In stomachs collected in June and July *Pandalus borealis* only occurred in 10.6 and 5.2%, resp., but comprised 32.4 and 48.3% of the total weight. Adding others+unidentified shrimps to *Pandalus borealis*, shrimps occurred in 21.2 and 10.0%, but comprised of 47.0 and 64.3% of the total prey weight in the stomachs collected in June and July. *Pandalus borealis* and other shrimps was rare in the stomachs from small redfish (<20 cm) (see below) and probably therefore did shrimps not occur in the stomachs collected in July/August and early November. Fish prey was rare in stomachs from June, July and July/August but had an occurrence and weight percent of 7.1% and 22.0%, respectively in stomachs from small redfish (5-19 cm) collected in early November. The identified fish prey was mainly redfish, but also Greenland halibut was identified in one stomach. Other prey items as worms, echinoderms and cephalopods had little importance as food for redfish.

Stomach fullness:

The proportion of stomachs identified as empty among the periods varied between 14.5 and 33.3%. To study the variation in total stomach content between sampling periods and depths of sampling, fish between 5 and 20 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. An one-way ANOVA shows no significant (F=0.55, P=0.50) difference between sampling periods neither did an one-way ANOVA for difference between 100 m depth zones (F=0.22, P=0.92). This indicates that the variation in TFI is greater between sampling stations than between periods and between depth zones.

Predator size influence:

The total fullness index (TFI) of fish collected during surveys in July and August are lower for fish between 10-14 cm compared to the other size groups (Fig. 2). TFI of fish collected during the survey in early November are generally lower than TFI calculated for fish from the summer surveys. From the partial fullness indices it is seen that *Pandalus borealis* gradually become more important as prey with increasing predator size. Contrary hyperiids, *Parathemisto sp.* and other small crustaceans a.o. copepods gradually become less important as prey with increasing predator size. In stomachs collected in early November Copepods, Mysiids and *Parathemisto sp.* are the most important prey for the small redfish between 5-19 cm, but also *Sebastes spp.* is important prey.

Weight of shrimps in total population stomachs:

Mean weight of shrimp (*Pandalus borealis*) in the redfish stomachs in 5 cm groups were calculated from the total material, as no significant difference between sampling period 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. Based on redfish catches during the shrimp survey, July/August 1990, the abundance of redfish by 5 cm groups was estimated for the area shown in Fig. 1 (Pedersen and Kanneworff, 1991) and the total weight of shrimp in the stomachs was estimated to about 672 tons (Table 3).

DISCUSSION

Our investigation has been concentrated on the shrimp grounds and the estimated food composition may not be representative for redfish in the hole area of distribution off West Greenland. The most important prey items in stomachs from small redfish (5-24 cm) collected on the shrimp grounds around St. Hellefisk Bank in 1990 were planktonic crustaceans - copepods, mysiids, hyperiids (*Parathemisto*) and euphausiids. With increasing predator size copepods, mysiids and hyperiids gradually becomes less important prey while first euphausiids and then shrimps especially *Pandalus borealis* became most important. Fish prey mainly *Sebastes spp.* was only important prey in stomachs from small redfish (10-14 cm) collected in early November.

According to Konchina (1983) who studied feeding of redfish in areas off Baffin Land and South Labrador *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 shrimps 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 they occurred more frequently than the other components in April-May and December.

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 East Greenland area and Magnússon and Pálsson (1988) therefore assume that 0-group redfish have been well available as food for cod and redfish. They conclude that 0-group redfish probably is of major importance to both cod and redfish as food component in this region in autumn/early winter months. Further studies of the feeding habits of redfish in East Greenland waters have been done 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 the 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 is some marked differences. The main differences are the high frequency of *Parathemisto sp.* 8.5-51.0% (mainly in small redfish stomachs, <19cm) and the high percent weight of *Pandalus borealis* in June and July, 32.4 and 48.3% (mainly in larger redfish stomachs). Our findings on feeding habits of redfish from West Greenland have some similarities with findings by Konatantinov et al. (1985) on Flemish Cap.

The increased importance of *Sebastes sp.* in the diet of small redfish (length group 10-14 cm) in early November is probably caused by an increased abundance of 0-group redfish recruited from breeding areas in the Irminger Sea Southwest of Iceland. In September-November pelagic redfish fry probably age 0+ (length: 40-68 mm) have been observed drifting northward from Kap Farvel along the West Greenland coast in large quantities (Zakharov, 1966; Pedersen, 1990; Wieland, 1991). Since the 1920's no breeding of redfish have been observed off West Greenland, and it is assumed that the redfish populations in West Greenland waters are 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). We assume that newly recruited 0-group redfish probably is of major importance to redfish and Greenland halibut as food component in the West Greenland shelf area in autumn/early winter months. However, this aspect should be further investigated.

The proportion of empty stomachs of the samples analyzed in the laboratory were between 14.5-33.3% and close to the findings by Konstantinov et al. (1985) and Magnússon et al. (1990). The mean total fullness index of stomachs were in our investigations high compared to findings by Konchina (1983) and Konstantinov et al. (1985), who found the points of the stomachs fullness for *S. mentella* were not higher than 1.5 in the most intensively feeding period in spring-summer, decreasing in winter.

Based on the abundance estimate of redfish from the shrimp survey in 1990 in the area shown in Fig. 1 the weight of shrimp found in the stomachs was estimated to about 672 tons. This value must be looked at with great caution, not only is there variability in data of the stomach content also the abundance of redfish is estimated with uncertainties. Variations between years must be expected of that reason alone that the abundance of redfish variate. In 1990 the estimated abundance of redfish off West Greenland was lower than for 1988 (Pedersen and Kanneworff, 1991).

In order to give a rough idea of the annual consumption of shrimp (*Pandalus borealis*) by redfish it is necessary to make several assumptions. These assumptions are the same as made by Bowering and Lilly (1990) in calculation of the annual consumption of capelin by Greenland halibut.

1) The number of redfish as estimated by the shrimp survey is constant from June to December.
2) The period of feeding on shrimp is one half year.
3) No dial pattern of stomach fullness.
4) The ratio of daily ration is 0.48 of the mean stomach content.

The annual consumption of shrimp under the above assumptions can be calculated to 59,000 tons. This value should be compared with the estimated biomass of shrimp stock for the area of 132,000 tons (Carlsson and Kanneworff, 1991).

Small redfish less than about 24 cm seems to feed mainly on planktonic food but as the redfish grow there seems to be a switch in their feeding habit from planktonic food to the mainly benthic living prey - shrimp. Due to their high abundance redfish seems to eat a significant part of the shrimp stock and might therefore compete with the commercial shrimp fishery for shrimps. A significant part of redfish is eaten by Greenland halibut (Riget and Pedersen, 1991). We conclude that the food links between shrimps, 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.

ACKNOWLEDGEMENTS

The authors thank the staff at Institute für Meereskunde, Kiel and Institute für Seefischerei, Hamburg for the fish stomachs collected during the surveys with R/V "Poseidon" and R/V "Walther Herwig", especially we thank F.W. Köster who organized the sampling. Thanks also go to Jette Jensen, Karen L. Nielsen, Rita Larsen and Susanne Hansen for their assistance on stomach content analyses and figures.

REFERENCES

Anon., 1984. Report on the joint NAFO/ICES study group on biological relationships of the West Greenland and Irminger Sea redfish stocks. ICES C.M. 1984/G:3.

Anon., 1990. Report of the study group on oceanic-type *Sebastes mentella*. ICES C.M. 1990/G:2.

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.

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.

Jensen, J.M., 1979. Redfish at West Greenland, Subarea 1. ICNAF Res. Doc. 79/VI/54.

Konchina, Yu.v., 1983. Main Trophic Relationships of Redfish in the Northwest Atlantic. NAFO SCR Doc. 83/IX/75.

Konstantinov, K.G., T.N. Turuk and N.A. Plekhanova, 1985. Food Links of Some Fishes and Invertebrates on Flemish Cap. NAFO Scientific Council Studies, No. 8.

Magnússon, J.V. and O.K. Pálsson, 1988. The Feeding Habits of Cod and Redfish in East Greenland Waters with special Emphasis on Predation on Juvenile Redfish. ICES ELHS 1988 Paper No.72.

Magnússon, J., K. Kosswig and J.V. Magnússon, 1988. Young Redfish on the Nursery Grounds in the East Greenland Shelf Area. ICES C.M. 1988/G:38.

Magnússon, J., K. Kosswig and J.V. Magnússon, 1990. Further Studies on Young Redfish in the East Greenland Shelf Area. ICES C.M. 1990/G:43.

Palssón, O.K., 1983. The Feeding Habits of Demersal Fish Species in Icelandic Waters. Rit. Fiskideildar 7(1):1-60.

Pavlov, A.J., V.S. Mamylov, A.S. Noskov, A.N. Romanchenko and A.V. Ivanov, 1989. Results of USSR investigations of *Sebastes mentella* Travin in 1981-1988 (ICES Subareas XII and XIV). ICES Paper C.M. 1989/G:17.

Pedersen, S.A., 1990. Rødfisk (*Sebastes spp.*) ved Grønland. Rapport til Grønlands Hjemmestyre fra Grønlands Fiskeriundersøgelser. January 1990/"Redfish at West Greenland". (in Danish).

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

Riget, F. and S.A. Pedersen, 1991. Feeding Habits of Greenland halibut in West Greenland Waters with Special Emphasis on Predation on Shrimp and Juvenile Redfish. NAFO SCR Doc. 91/49.

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.

Wieland, K., 1991. Distribution of larval and 0-group fish of West Greenland in Summer and Autumn 1989 and 1990. NAFO SCR Doc. 91/35.

Zakharov, G.P., 1966. The Distribution of Pelagic Redfish Fry in the East and West Greenland Areas. ICNAF Research Bulletin Number 3, 1966 :27-31.

Tabel 1. Number of Redfish 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	"Walter Herwig" bottom trawl survey
date	20-22.6	19-30.7	30.7-4.8	6-8.11
depth, m.	444-541	262-528	86-355	300-512
cm.				
5-9	4	33	69	17
10-14	5	100	81	87
15-19	12	85	1	49
20-24	3	18		1
25-29		6		
30-34	4	3		
35-39		3		
40-44	1			
Total	29	248	151	154
% empty	33.3	14.5	19.9	33.1
number of stations	4	15	5	3

Table 2.
The food composition of Redfish caught off St. Hellefisk Banke during 1990.

	Occurrence (%)				Weight (%)				Mean PFI			
Sampling period(month)	6	7	7/8	11	6	7	7/8	11	6	7	7/8	11
Polychaeta		2.0	0.7	3.2		0.1	0.1	0.6		x	0.01	0.01
Echinodermata	2.1	0.4		0.6	0.2	x		0.1	x	x		x
Cephalopoda	2.1	0.8		4.5	0.2	x		8.8	x	x		0.06
Crustacea (total)	46.8	85.1	83.8	64.3	96.7	97.0	99.8	55.4	0.44	2.28	3.02	1.08
Copepoda		39.9	9.3	13.6		4.1	1.8	4.5		0.30	0.11	0.11
Mysidacea	2.1	13.3		5.8	24.2	4.3		26.6	0.07	0.14		0.29
Hyperiidea												
Parathemisto sp.	8.5	50.4	51.0	45.5	0.4	10.9	17.3	19.1	0.04	0.53	0.61	0.25
Other Amphipoda	4.3	6.0	0.7	1.3	0.2	1.0	0.1	0.2	0.02	0.03	x	x
Euphausiacea	6.4	12.5	47.0	4.5	5.4	23.5	71.9	5.0	0.08	0.65	1.99	0.07
Natantia												
Pandalus borealis	10.6	5.2			48.3	32.4			0.15	0.23		
Others+unidentified	10.6	4.8			16.0	14.6			0.03	0.12		
Unidentified	25.5	20.6	27.2	27.3	2.1	6.2	8.7	12.3	0.05	0.28	0.31	0.26
Pisces (total)	2.1	4.4		7.1	2.9	2.8		22.0	0.01	0.06		0.25
Sebastes sp.		0.4		4.5		x		21.3		x		0.24
Others				0.6				0.1				x
Unidentified	2.1	4.0	0.7	3.2		2.8	0.1	0.6	0.01	0.06	x	0.01
Unidentified				1.9				0.5				x
Total									0.45	2.34	3.03	1.40

Table 3. Contents of shrimp in stomachs of redfish by 5 cm length groups.

Length (cm)	Mean weight of shrimp (g)	Abundance ('000)	Total weight of shrimp in population (kg)
5-9	0	95039	0
10-14	0.09	123606	11125
15-19	1.22	79060	96453
20-24	4.14	26907	111395
25-29	8.95	27277	244129
30-34	10.27	16708	171591
35-39	3.65	10369	37847
40-44		6242	
Total		385208	672540

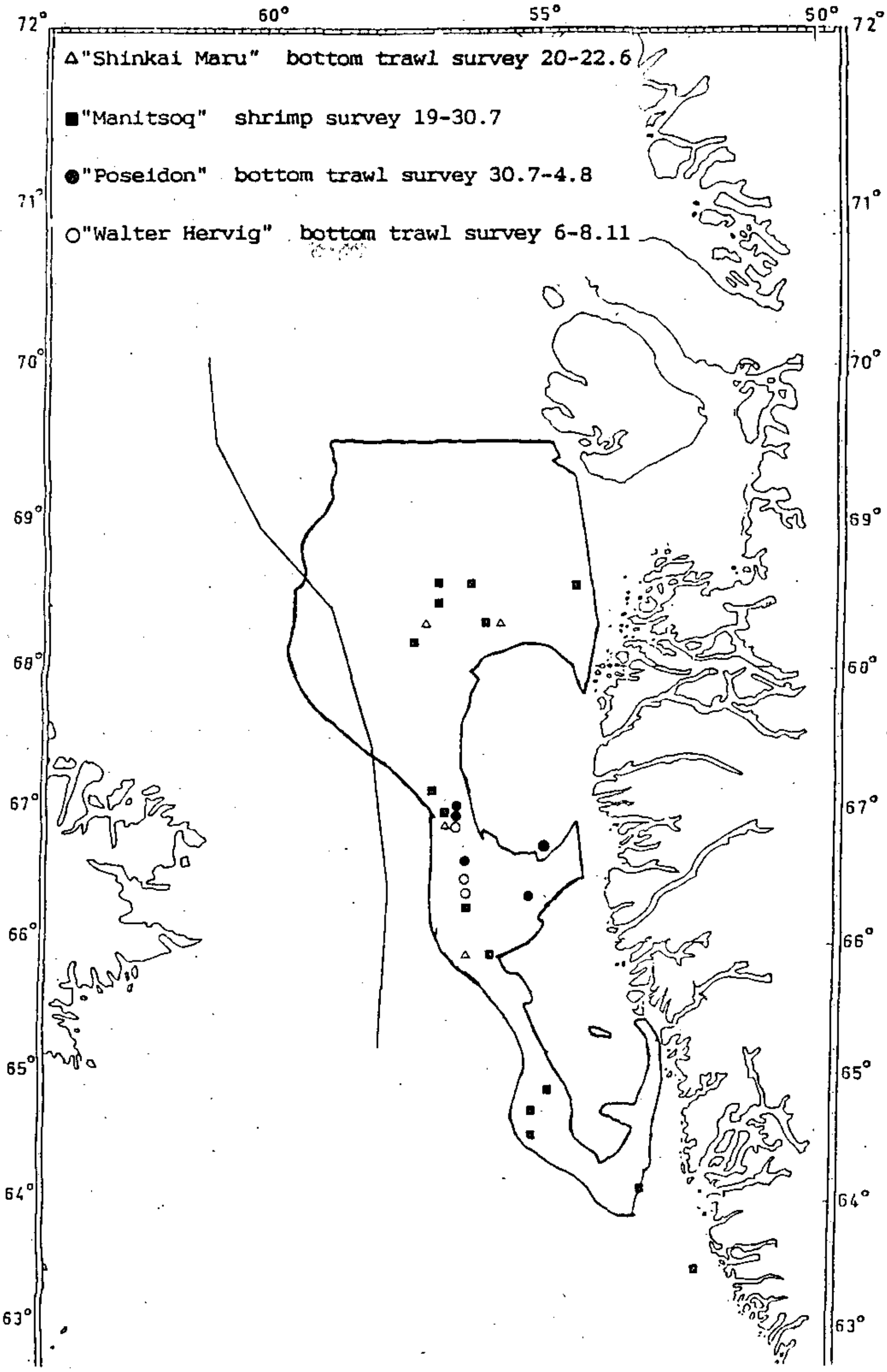

Fig. 1 Map of study area and sampling locations.

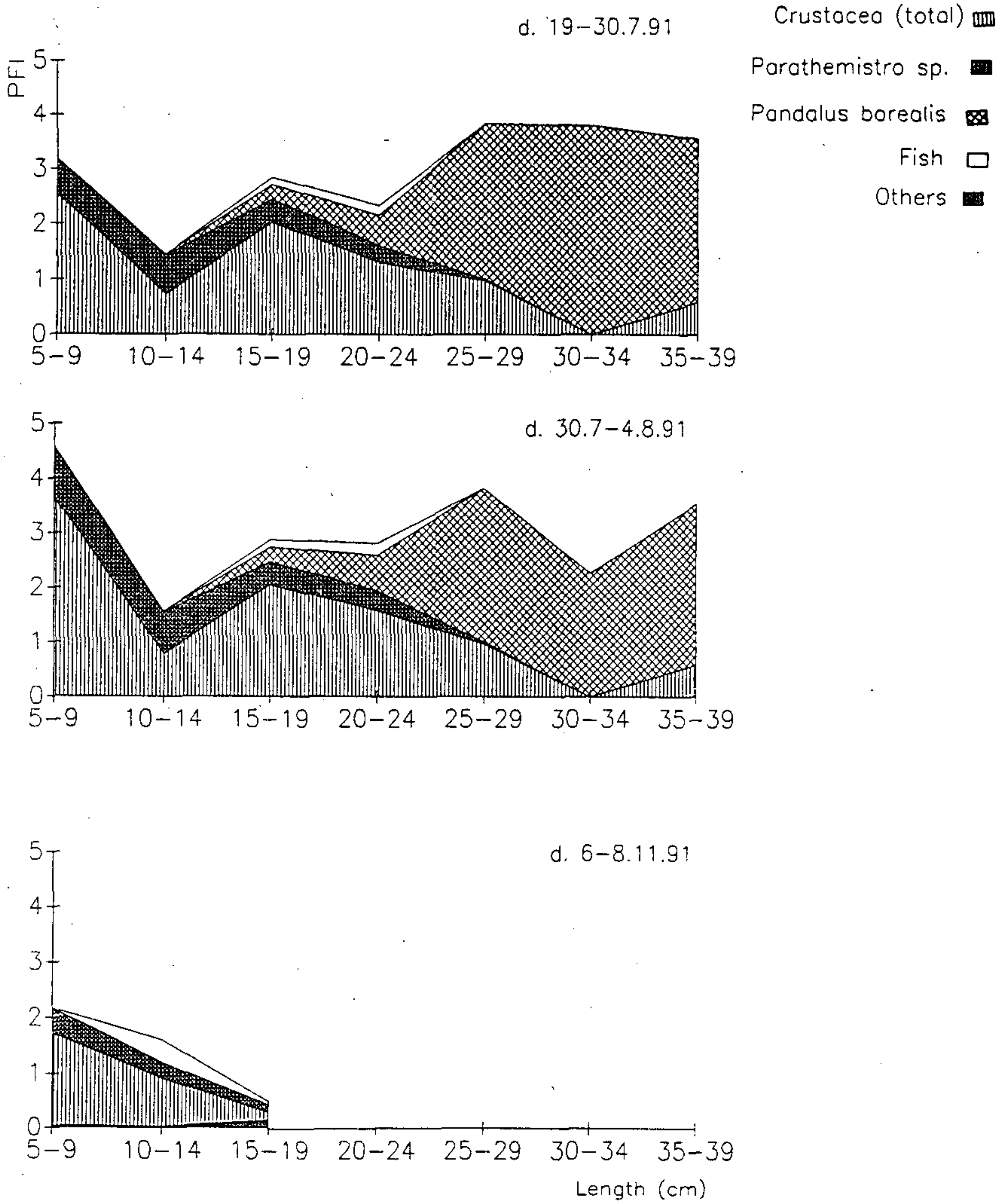

Fig. 2 Mean partial fullness index (PFI) of prey items in relation to predator length for redfish collected during different surveys.