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Distribution and Biology of Grenadiers (Macrouridae) in West Greenland Waters

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Abstract

During the period 1987–94, 11 bottom trawl surveys covering depths from 34 to 1 497 m were conducted at West Greenland. Two grenadier species not previously recorded for the area, *Nezumia bairdi* and *Gadomus longifils*, were caught bringing the number of species recorded in West Greenland waters to ten. A significant amount of new information on grenadier species previously recorded was also collected during the surveys. Geographic distribution in relation to depth and temperature, abundance of the most common species, *Coryphaenoides rupestris*, *Coryphaenoides güentheri* and *Macrourus berglax* and length distributions of all species encountered were analyzed. Growth of *C. rupestris* and *M. berglax*, food of *C. rupestris*, *M. berglax* (in relation to time of the year and predator length), *C. güentheri* and *Coryphaenoides brevibarbis*, length/weight relationships for *C. rupestris*, *C. güentheri* and *M. berglax* are also presented. Further, relationships between total length and pre-anal fin length for *Trachyrhynchus murrayi* and all species mentioned above, except *G. longifilis*, and maturation of *C. rupestris* and *C. güentheri* are given. The available information about three grenadier species not observed during the surveys but previously recorded from the area, i.e. *Nezumia aequalis*, *Coryphaenoides armatus* and *Coryphaenoides carapinus*, is summarized.

Key words: Distribution, food, grenadiers, length, maturation, weight, West Greenland

Introduction

The family Macrouridae is rich in species and representatives are found in most oceans. Macrourids are generally benthopelagic occurring at considerable depths on the continental slopes and the abyssal planes. Knowledge of the distribution and biology of most species is meager due to the great depths they inhabit.

During the period 1987–94, a number of trawl surveys in West Greenland waters were conducted covering depths down to 1 497 m. This has added significantly to our knowledge of macrourid species in West Greenland waters and has revealed two previously unrecorded species; *Nezumia bairdi* and *Gadomus longifilis*. The present paper also presents information on the distribution and a number of biological characteristics of five other species observed during the surveys; *Coryphaenoides rupestris*, *Coryphaenoides güentheri*, *Coryphaenoides brevibarbis*, *Macrourus berglax* and *Trachyrhynchus murrayi*, and reviews the available information on three species previously recorded from West Greenland but not encountered during these surveys; *Coryphaenoides carapinus*, *Coryphaenoides armatus* and *Nezumia aequalis* (Jensen, 1948; Karrer, 1976).

The survey area was bounded on the west by the midline between Canada and Greenland. This is a politically defined boundary without any biological sense. Species such as *C. rupestris* (Atkinson, 1995) and *M. berglax* (Savvatimsky, 1989b; Atkinson and Power, MS 1987) are certainly found west of the midline and a number, if not all, of the species found on the West Greenland side of the boundary are likely to also occur west of the midline.

Materials and Methods

Data and material were collected during 11 bottom trawl surveys which were directed mainly at Greenland halibut (*Reinhardtius hippoglossoides*). The surveys were conducted from 1987 to 1994 at different times between April and December (Table 1). A total of 945 trawl hauls were carried out.

The surveys were conducted at West Greenland from south of Cape Farewell (59°27'N) to 72°51'N, between the 3-mile boundary line and the 200-mile line or the midline between Canada and Greenland, at depths from 34 to 1 497 m. The NAFO Div. 1C and 1D were covered by all surveys except one, while areas north of 69°57'N and south of 63°03'N, were only covered once; the latter area down to 998 m depth only (Table 1, Fig. 1).

All surveys were carried out by the Japanese research vessel *SHINKAI MARU*, a 3 395 GRT stern

TABLE 1. Number of hauls, period, depth range and area covered in the surveys conducted.

Date	Number of hauls	Area covered in NAFO		Depth range (m)
15 Jul – 13 Aug 1987	117	59°27'N–69°57'N	1F–1A	34 – 998
12 Sep – 11 Oct 1988	109	63°06'N–72°51'N	1D–1A	259 – 1 402
30 Apr – 17 May 1989	61	63°03'N–65°43'N	1D–1C	494 – 1 497
09 Jun – 22 Jun 1990a	75	63°05'N–68°26'N	1D–1B	449 – 1 482
27 Aug – 12 Sep 1990b	87	63°11'N–69°42'N	1D–1A	422 – 1 467
04 Aug – 30 Aug 1991a	139	63°07'N–69°57'N	1D–1A	38 – 1 490
12 Nov – 27 Nov 1991b	51	66°21'N–69°57'N	1B–1A	38 – 774
11 Aug – 28 Aug 1992a	90	63°04'N–69°45'N	1D–1A	417 – 1 475
25 Nov – 07 Dec 1992b	49	63°10'N–66°11'N	1D–1C	510 – 1 400
20 Aug – 08 Sep 1993	87	63°11'N–68°25'N	1D–1B	435 – 1 418
02 Aug – 19 Aug 1994	80	63°08'N–68°21'N	1D–1B	439 – 1 472

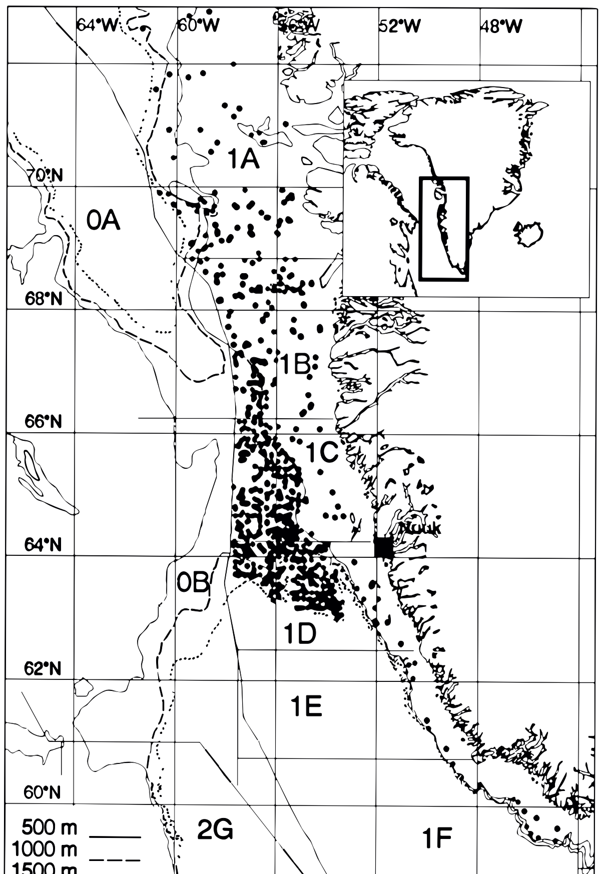

Fig. 1. Distribution of hauls in 11 bottom trawl surveys conducted in the period 1987–94.

trawler with 5 000 HP. Towing time was 30 min and towing speed 3.5 knots. The trawl wingspread and net height were 40 m and 7.5 m, respectively, and the mesh size was 140 mm with a 30 mm mesh codend liner.

After each haul, the catch was sorted by species and weighed to the nearest 0.1 kg. The number of specimens were recorded, and in most cases the length was measured as pre-anal fin length (AFL) (from the tip of the snout to the basis of the first anal fin ray) to 0.5 cm below. In order to make comparisons of abundances and length frequencies of *M. berglax* between surveys and areas possible, Div. 1A (south of 70°N) and 1B, and Div. 1C and 1D were combined as a northern and as a southern area, respectively. Surveys or areas with less than 10 records of *M. berglax* were excluded from the analysis, i.e. Div. 1A north of 70°N in 1988, Div. 1B in the first survey in 1990 and the second survey in 1991. No observations were made at depths between 38–400 m in Div. 1A and 1B in the first survey in 1991, and this depth range was also excluded from the analysis (Table 1). Only data from depths >400 m were thus included in the analysis.

A number of specimens with unbroken tails were measured as total length (TL) (to 1.0 cm below), in order to obtain relationships between AFL and TL. Analyses of covariance were carried out to test the null hypothesis that no difference existed between the slopes or intercepts of the separate relationships for males and females (*C. rupestris* (n = 658), *M. berglax* (n = 498) and *C. güentheri* (n = 752)). Linear regression analyses (Anon., 1985) were then carried out to derive relationships between AFL and TL by sex (*C. rupestris*, the only species with significant difference between sexes) and for sexes combined (*C. güentheri*, *C. brevibarbis* (n = 24), *M. berglax*, *T. murrayi* (n = 22), and *N. bairdi* (n = 27)).

To establish length/weight relationships, a number of specimens were weighed to nearest 1.0 g. Regressions of the form $w = aL^b$ (where w = weight (g), L = length (cm), a = slope and b = intercept) were carried out on mean weights by sex, and for sexes combined for *C. rupestris* (n = 726), *C. güentheri* (n = 842) and *M. berglax* (n = 753) for both AFL (1 cm groups) and TL (3 cm groups) (Anon., 1985).

Scales were collected between the dorsal fins above the lateral line from *C. rupestris* and *M. berglax* for age determination. The age was determined using polarized light (Kosswig, MS 1979; Savvatimsky *et al*., 1977; Savvatimsky, 1994). Mean length-at-age was fitted to the following growth models:

Polynomial regression: $AFL = K \times age^{c}$,

von Bertalanffy: $AFL = L_{\infty} \times (1 - K \times \exp(-t_0 \times age))$

and

Gompertz: $AFL = L_{\infty} \times (\exp(-K \times \exp(-t_0 \times age)))$

where AFL = mean length (cm),

L_{∞} = asymptotic standard length,

age = age in years

and K, t_0 and c constants to be derived.

Least square estimation of parameters was carried out using the NLIN procedure of PC-SAS (Anon., 1985). An F-test was used to test if there was a significant improvement in the estimation of the regressions using a von Bertalanffy or Gompertz growth equation compared to a polynomial regression. For *C. rupestris* age material consisted of 178 males and 185 females sampled in 1988. For *M. berglax*, 164 males and 188 females sampled in 1988, 1989 and 1992.

Stomachs were examined from *C. rupestris*, *C. güentheri*, *C. brevibarbis* and *M. berglax* to determine diets (Table 2). Only fish showing no signs of regurgitation were sampled. Stomachs, or whole fish, were frozen and stored at <-18°C prior to examination. The stomach contents were identified to lowest possible taxon in the laboratory. Each food category was weighed to the nearest 0.1 g wet weight. Diet results are given as frequency of occurrence, i.e. the number of stomachs in which a prey item occurred, expressed as a percentage of the total number of stomachs investigated containing food items, and weight percentage, i.e. the total weight of each prey item or prey group in the sample converted to a percentage of the weight of total stomach contents in the sample.

The gonads of *C. rupestris* (n = 555, covering the period June–December) and *C. güentheri* (n = 293, sampled in August) were weighed to 0.1 g in order to investigate reproductive biology. Further, the reproductive status of 7 816 specimens of *C. rupestris* caught in the period April–December were examined visually in connection with routine sexing during the surveys.

Near-bottom temperatures were measured, by 0.1°C, as close as possible to the bottom either by CTD or XBT at 815 of the 945 trawl stations.

Results and Discussion

Coryphaenoides rupestris Gunnerus, 1765 (Roundnose grenadier, Rock grenadier)

Coryphaenoides rupestris is widely distributed in the North Atlantic (Marshall and Iwamoto, 1973), and is the most abundant macrourid in West Greenland waters (the survey had up to 7 302 specimens in one haul). *Coryphaenoides rupestris* was found from south of Cape Farewell (59°27'N) to 67°15'N (a single specimen was caught at 70°44'N) at depths between 223 m and 1 497 m and temperatures ranging from 1.1 to 5.4°C. The species has been reported to occur at depths down to 2 200 m (Iwamoto, 1990), and in West Greenland it was very likely occurring at depths beyond 1497 m; the maximum depth covered in these surveys. *Cory-phaenoides rupestris* was mainly found in waters from approximately 63°03'N to 64°30'N (Fig. 2), at depths >800 m and temperatures between 3.2 and 4.0°C, in agreement with Parsons (1976) who gave an optimum temperature range between 3.0 and 4.5°C for the northern part of the Davis Strait. In 1987, when the surveys covered the area between Cape Farewell and 69°57'N (Div. 1A–1F) at depths between 34 and 998 m, 0.2% of the abundance was found at depths <400 m, and 1% of the abundance was found outside Div. 1C and 1D, the bulk in Div. 1B. Since 1987 *C. rupestris* has been observed outside Div. 1C and 1D only very sporadically. In Div. 1C and 1D at depths >400 m, abundance fluctuated significantly between years from 7 946 specimens per km^2 in 1987 to 399 specimens per km^2 in 1994 (Table 3), despite no commercial fishery directed to *C. rupestris* had been taking place during this period. There were also observed great variations in abundance within the year. In 1990 the abundance increased from 436 specimens per km^2 in June to 1 865 specimens per km^2 in August/September, and in 1992 the abundance decreased from 5 583 specimens per km^2 in August to 507 specimens per km^2 in November/December, indicating annual migrations in and out of the survey area. Generally the abundance increased with depth to 1 000–1 200 m, however, the depth with greatest abundance varied between years and the time of the year, which was also observed by Chumakov and Savvatimsky (MS 1987). When comparing Div. 1C and 1D at the same depth, there was a tendency towards a higher abundance in Div. 1D, except at 1 000–1 200 m depth. This depth stratum was, however, small in Div. 1C and located just north of the border between Div. 1D and 1C. Of the 7 816 specimens examined during the surveys, 56% were male.

TABLE 2. Stomach analyses by species giving number of stomachs sampled (N), including empty stomachs but excluding fish with regurgitated stomachs, number of stomachs containing food items (n), and sampling period, in relation to fish length range (AFL, cm) of the specimens examined, sampling area and depth.

Species	Length range (AFL in cm)	Area	Depth range (m)	Date	N	n
C. rupestris	4.5 – 20.0	63°04'–65°56'N	426 – 1 482	9 Jun – 20 Jun 1990	85	75
				28 Aug – 6 Sep 1990	156	113
				07 Aug – 13 Aug 1991	121	103
				03 Dec – 07 Dec 1992	45	41
C. güentheri	3.0 – 13.0	63°19'–63°57'N	1 083 – 1 424	29 Aug – 30Aug 1990	65	35
				05 Aug – 12 Aug 1991	265	162
C. brevibarbis	4.0 – 6.0	63°11'N	1 490	06 Aug 1991	6	5
M. berglax	3.0 – 38.0	63°04'–69°45'N	351 – 1 430	09 Jun – 20 Jun 1990	110	77
				28 Aug – 12 Sep 1990	49	45
				07 Aug – 25 Aug 1991	83	63
				13 Aug – 24 Aug 1992	204	179
				30 Nov – 07 Dec 1992	87	56

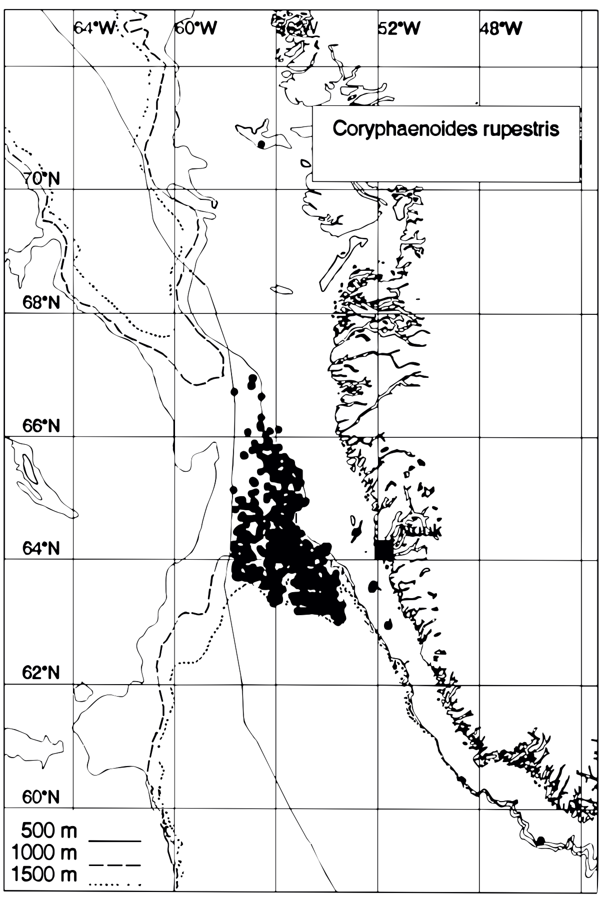

Fig. 2. Distribution of hauls in which *C. rupestris* was caught in the surveys of 1987–94.

Fish length ranged from 1.0 cm to 19.5 cm and 22.5 cm AFL for males and females, respectively. However, length range and length distribution varied significantly between surveys, but generally most *C. rupestris* were between 4 and 14 cm AFL (Fig. 3).

The AFL and TL were highly correlated for both males and females and for sexes combined ($P< 0.01$) (Table 4). Analysis of covariance indicated that the regression coefficients differed significantly between males and females ($P<0.01$). Atkinson (1981) and Magnússon (MS 1987) also found a significant difference in the AFL/TL relationship between the sexes at Canada and Iceland, respectively. They, furthermore, found a ratio of approximately 0.215 and 0.212 between the two types of length measurements, respectively, which is close to the ratio of approximately 0.230 found in the present investigations.

The relationship between both AFL and TL and weight was highly significant for each sex and for sexes combined ($P<0.01$) (Table 5). The weight-at-length was higher than observed by Atkinson (1989) in 1986–87 and Savvatimsky and Atkinson (1993) in the period 1968–80. They stated, however, that weight-at-length varies from time to time in the northern part of the Davis Strait, but the reason is unknown.

Fish age ranged from 4 to 20 years for both males and females. A great range in lengths within

TABLE 3. Mean number of *C. rupestris* caught per km^2 swept, (Standard error of mean and number of tows distributed in 200 m depth intervals in NAFO Div. 1C and 1D.

	Depth stratum										
	401–600		601–800		801–1 000		1 001–1 200		1 201–1 400	1 401–1 500	401–1 500
Year	1C	1D	1C	1D	1C	1D	1C	1D	1D	1D	1C-1D
1987	2 964	–	229	2 256	18 804	12 626	–	–	–	–	7 946
S.E./no.tow	1 081/3	–	139/8	–/1	8 191/5	3 693/6	–	–	–	–	2 474/23
1988	88	–	214	–	2 293	10 871	18 254	7 728	1 855	1 383	4 101
S.E./no.tow	69/5	–	98/18	–	724/11	5 295/7	16 289/2	2 632/17	159/11	–/1	994/72
1989	18	588	3	113	314	295	136	1 275	1 098	3 956	822
S.E./no.tow	9/4	280/2	3/10	-/1	240/8	195/3	27/2	282/14	235/14	6/3	144/61
1990a	417	687	33	12	94	704	76	451	476	3 654	436
S.E./no.tow	331/5	687/2	15/13	9/3	62/13	646/4	11/2	65/14	232/9	2 340/3	134/68
1990b	98	743	286	84	1 967	3 068	4 480	3 284	943	1 194	1 865
S.E./no.tow	74/5	736/2	114/16	-/1	923/11	2 954/7	807/2	631/20	177/4	426/2	393/70
1991	54	3 492	1 729	11 683	13 470	6 974	14 235	4 936	1 530	853	5 247
S.E-/no.tow	17/5	3 474/2	1 122/16	11 110/3	4 743/11	4 814/5	4 044/2	1 171/15	286/10	173/2	1 089/71
1992a	101	977	218	22 832	22 837	10 318	4 041	5 528	2 120	61	5 583
S.E./no.tow	72/5	582/2	162/20	11 397/3	6 845/7	10 093/4	743/2	1 147/16	583/11	–/1	1 295/71
1992b	6	464	119	274	770	316	1 295	670	886	–	507
S.E./no.tow	6/2	–/1	40/14	51/2	139/8	57/3	64/2	108/12	373/5	–	70/49
1993	4	97	35	–	1 439	443	3 105	1 572	1 643	7	925
S.E./no.tow	2/4	27/2	17/22	–	749/9	250/7	2 060/2	314/19	485/11	–/1	166/77
1994	4	–	87	220	538	107	1 673	438	680	377	399
S.E./no.tow	4/4	–	44/16	69/2	244/10	20/4	410/2	111/14	280/13	105/3	78/68

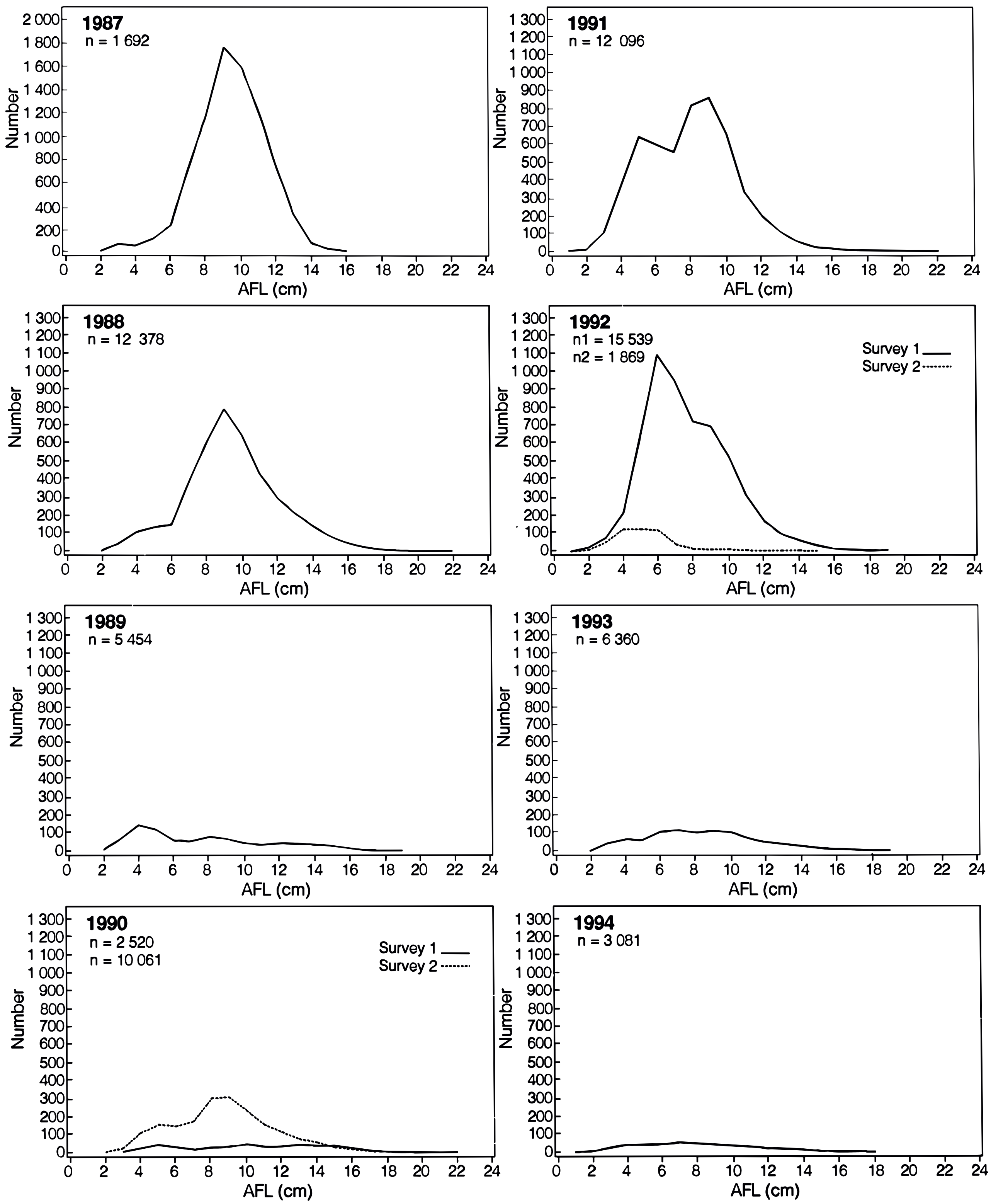

Fig. 3. Length distribution (AFL, 1-cm groups) of *C. rupestris* collected in numbers (n) per km^2 swept in Div. 1C+1D at depths >400 m in the period 1987–94.

TABLE 4. Relationship between total length (TL) (cm) and preanal fin length (AFL) (cm).

Species	n	Expression	r^2	Length range AFL	Length range TL
C. rupestris					
Sexes combined	658	TL = -4.126 + AFL 4.672	0.92	4.5–19.5	17–85
Males	363	TL = -5.786 + AFL 4.853	0.92	5.0–18.0	19–80
Females	295	TL = -2.973 + AFL 4.538	0.93	4.5–19.5	17–85
C. güentheri					
Sexes combined	752	TL = 2.378 + AFL 3.246	0.93	3.0–13.0	10–43
C. brevibarbis					
Sexes combined	24	TL = 0.075 + AFL 3.511	0.87	3.5–8.0	10–26
M. berglax					
Sexes combined	498	TL = 5.744 + AFL 2.273	0.98	3.0–38.0	10–89
T. murrayi					
Sexes combined	22	TL = 3.985 + AFL 2.238	0.98	7.0–23.0	19–55
N. bairdi					
Sexes combined	27	TL = 13.967 + AFL 2.351	0.57	5.0–9.5	22–38

TABLE 5. Relationship between preanal fin length (AFL cm) and weight (g); and total length (TL cm), and weight for *C. rupestris*, *C. güentheri* and *M. berglax.*

Species	n	Regression Slope	Regression Intercept (ln)	Regression r^2
C. rupestris				
Male AFL	332	2.9530	-1.4042	0.999
Female AFL	318	2.8638	-1.1872	0.999
Sexes comb. AFL[a]	726	2.6869	-0.7384	0.988
Male TL	244	2.5610	-4.1657	0.997
Female TL	194	2.6102	-4.2964	0.989
Sexes comb. TL[a]	513	2.5126	-3.9512	0.996
C. güentheri				
Males AFL	406	2.6566	-1.1890	0.993
Females AFL	436	2.7552	-1.3842	0.997
Sexes comb. AFL	842	2.7046	-1.2819	0.997
Males TL	371	2.6073	-4.3310	0.984
Females TL	385	2.6772	-4.5376	0.986
Sexes comb. TL	756	2.6574	-4.4756	0.986
M. berglax				
Males AFL	323	2.6570	-1.3544	0.996
Females AFL	430	2.7449	-1.5359	0.997
Sexes comb. AFL	753	2.7258	-1.4818	0.997
Males TL	224	2.9571	-5.0742	0.998
Females TL	283	3.1009	-5.4612	0.992
Sexes comb. TL	507	3.0987	-5.4707	0.996

[a] Including unsexed individuals.

each age group was observed as is seen for several other slow growing deep water species (Table 6). Growth curves were calculated according to the formulas: AFL = 2.516 × age$^{0.678}$ and AFL = 2.219 × age$^{0.755}$ (Polynomial regression), AFL = 29.250 × (1-0.965 × exp(-0.050 × age)) and AFL = 51.142 × (1-0.969 × exp(-0.025 × age)) (von Bertalanffy) and AFL = 22.810 × (exp(-2.051 × exp(-0.117 × age))) and AFL = 28.828 × (exp(-2.196 × exp(-0.097 × age))) (Gompertz) for males and females, respectively. An F-test comparing the Polynomial regression with the von Bertalanffy and Gompertz growth models, showed that the von Bertalanffy and Gompertz growth models fitted data significantly better (P <0.05) than the Polynomial regression for males, while no significant improvement in the data fit to the model was obtained by going from the simple Polynomial regression model to the more complex von Bertalanffy or Gompertz models, for females. The Gompertz model fitted mean size-at-age data a little better compared to the von Bertalanffy model in terms of slightly smaller residuals in the non-linear least square procedure (Anon., 1985). Mean size-at-age calculated according to the Gompertz model differed considerably for males and females with the largest size being observed for females (Fig 4). This difference in size-at-age between males and females was also observed at Newfoundland (Savvatimsky, 1972) and at Iceland, although size-at-age at West Greenland was larger in most age groups than at Iceland (data from Magnússon, MS 1987, fitted to a Gompertz growth curve) (Fig. 4). By using the conversion factor previously obtained (Table 4), the relationship TL = 103.000 × (exp(-2.328 × exp(-0.125 × age))) and TL = 125.845 × (exp(-2.327 × exp(-0.101 × age))) were achieved for males and females, respectively. Size-at-age data for sexes combined from Kosswig (MS 1980) fitted to a Gompertz growth curve corresponded well with the size-at-age estimated in this study, while the size at age at Newfoundland also fitted to a Gompertz growth curve was somewhat higher than at West Greenland (Savvatimsky, 1972) (Fig. 5). Very little work has been done on intercalibration between age readers from different laboratories, and the differences in mean size-at-age observed between different investigations, need not necessarily be due to differences in growth, but can be caused by differences in the interpretation of growth zones especially in the central part of the scales and for older fish. Gordon (MS 1978) found size-at-age for sexes combined based on otoliths at West Scotland in the same range as seen at West Greenland and Savvatimsky *et al*. (1977) showed that there was a good agreement between age readings based on scales and otoliths sampled from the same fish. Atkinson *et al*. (1982) found, however, great discrepancies in the results of the two methods. These discrepancies need to be resolved, and both age reading methods still have to be properly validated.

A total of 407 stomachs were sampled at different times of the year (Table 2) of which 18.4% were empty. The percentage of empty stomachs varied from 9% in December to 22% in August/September. Overall, 38 different food items or groups of food items were identified in the stomachs, representing five major animal classes or super-classes; Polychaeta, Cephalopoda, Crustacea, Echinoidea and Pisces (Table 7). The most important prey group throughout the year, both in terms of weight and

TABLE 6. Mean preanal fin length (AFL cm)-at-age; minimum and maximum length-at-age, number of observations (n) and Standard Error of mean (S.E.) by sex for *C. rupestris*.

	Males					Females				
Age	Length	Min.	Max.	n	S. E.	Length	Min.	Max.	n	S.E.
4	6.33	6.0	7.0	6	.167	6.75	6.5	7.0	2	.250
5	7.00	6.5	7.5	2	.500	6.92	6.5	7.5	6	.154
6	8.50	7.5	10.5	14	.234	9.08	8.0	9.5	6	.271
7	9.50	8.5	12.5	19	.276	9.44	7.5	10.5	17	.210
8	10.09	8.5	11.5	16	.234	10.50	8.5	13.5	15	.384
9	11.31	10.0	12.5	13	.208	11.58	10.5	14.0	13	.329
10	11.80	10.0	13.0	10	.271	12.41	10.0	15.5	23	.279
11	13.08	11.0	15.5	12	.353	13.32	11.0	16.5	19	.377
12	13.34	11.5	16.5	19	.289	14.13	12.0	17.0	20	.278
13	14.98	13.5	16.5	20	.222	15.48	13.0	17.0	20	.265
14	15.39	13.5	17.5	19	.197	16.56	15.0	18.5	18	.235
15	16.33	15.5	17.5	3	.601	18.14	17.0	19.5	7	.322
16	16.25	15.0	17.5	6	.382	18.25	16.0	22.0	14	.441
17	16.87	16.5	18.0	8	.183	18.50	18.0	19.0	2	.500
18	18.25	17.5	19.5	6	.335	–	–	–	–	–
19	18.50	17.5	19.5	4	.456	21.00	20.5	21.5	2	.500
20	18.50	18.5	18.5	1	–	20.50	20.5	20.5	1	–

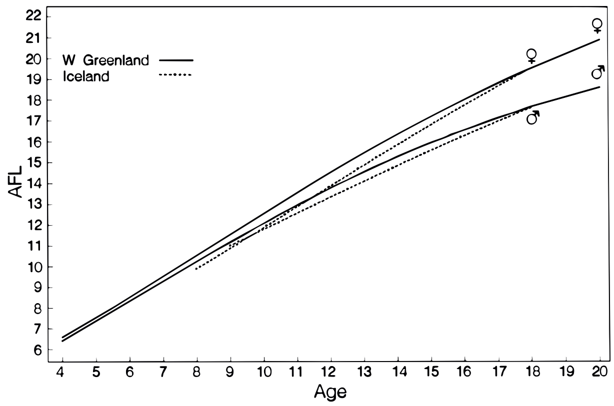

Fig. 4. Age-length relationship (AFL cm) for *C. rupestris* at West Greenland and Iceland (Magnússon, MS 1987) fitted to a Gompertz growth curve.

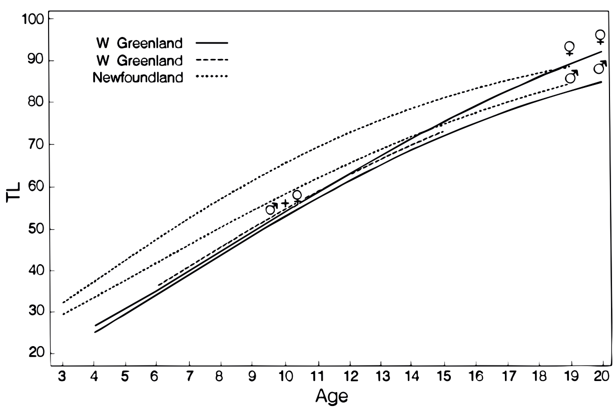

Fig. 5. Age-length relationship (TL cm) for *C. rupestris* at West Greenland in 1979 (sexes combined) (Kosswig, MS 1980), from the present studies and Newfoundland (Savvatimsky, 1972) fitted to a Gompertz growth curve.

frequency of occurrence was Crustacea. Their importance increased during the year from 23% of the food by weight in June to 78% in winter, corresponding to 73% and 100% frequency of occurrence, respectively. The most important Crustaceans (by weight) were Natantia, Copepoda and Euphausiacea. Overall, Pisces and Cephalopoda were the second and third most important groups by weight, contributing 18% and 16%, respectively. While the weight percentage of fish was relatively stable throughout the year, the weight percentage of Cephalopoda fell from 22% in June to 1% in December. Polychaeta were found in 25% of the stomachs, but contributed only 2% by weight. The total number of fish species encountered was rather low, however, each specimen contributed a large proportion by weight. The frequency of occurrence of Pisces was relatively high, due to the fact that a number of stomachs contained fish scales, which might have been consumed in the trawl during trawling and hauling.

The importance of Crustacea as food (by weight) (with the exception of Natantia) declined with increasing fish size, while the importance of Pisces and Cephalopoda increased dramatically with size, both in weight and frequency of occurrence (Table 8).

Gushchin and Podrazhanskaya (1984) found a similar overall distribution in the food composition at West Greenland. The only significant difference observed in this study was that Amphipoda and Mysidacea were more dominant, 28% and 18% by weight, respectively. Gushchin and Podrazhanskaya (1984) also observed the increase in the importance of Pisces and Cephalopoda, and a decrease in the importance of Crustacea as food, with increasing fish size.

The results reported by Konstantinov and Podrazhanskaya (1972) from the central part of the Davis Strait are, however, rather different when compared to these studies, in that they report a high occurrence of Amphipoda and Natantia, 60% and 54%, respectively. The only similarity between their results and those presented in this study is in the high occurrence of Calanus (45%). The large differences between the investigations, especially in the occurrence of Amphipoda, probably reflects variations in the abundance of Amphipoda rather than changes in *C. rupestris* preference for this prey.

The composition of the food indicates that *C. rupestris* is a benthopelagic feeder, foraging to a large extent in the water column. This conclusion is supported by a number of observations of pelagic behaviour both at West Greenland, where as many as 390 kg were taken in one hour of pelagic trawling (Jørgensen and Akimoto, MS 1991), as well as other places in the North Atlantic (Haedrich, 1974; Savvatimsky, 1985).

There was no difference in gonad weights at different times of the year for 252 female and 303 male gonads sampled in the period June–December, but a tendency towards an increase in gonad weight by size was observed. In total 7 females between 14.5 and 23 cm AFL had gonads with weights above 10 g (maximum of 31 g), however, eggs were not visible and the gonads were immature. Gonad weights of 1.0 g or above were observed in 155 females, of which the smallest was 7.5 cm AFL. Only 3 males, ranging between 15–20 cm AFL, had gonads with weights above 5 g, while 21 males, of which the smallest was 11.5 cm AFL, had gonads with weights of and above 1.0 g. None

TABLE 7. Food of *C. rupestris* expressed as weight percentage and frequency of occurrence at different times of the year.

	Weight percentage				Frequency of Occurrence			
Food item	Jun	Aug/Sep	Nov/Dec	All	Jun	Aug/Sep	Nov/Dec	All
Polychaeta	5.56	0.93	2.67	1.92	38.67	17.59	39.02	25.00
Cephalopoda	22.18	15.30	0.94	16.10	36.00	33.33	2.44	30.12
Crustacea (total)	23.37	45.62	78.29	42.49	73.33	92.13	100.0	88.86
Ostracoda		0.01		0.01		0.46		0.30
Copepoda		0.07		0.05		3.70		2.41
Calanoida	1.81	2.32	5.50	2.35	48.00	77.31	75.61	70.48
Mysidacea	0.44	0.07		0.14	2.67	1.85		1.81
Gnathophausia	0.69	1.12		0.99	1.33	0.93		0.90
Isopoda		0.02		0.01		0.46		0.30
Hyperiidae unident.	0.03	0.02	1.57	0.08	1.33	0.93	12.20	2.41
Parathemisto	0.03	0.14		0.11	1.33	2.31		1.81
Gammaridea		0.11	0.47	0.11		4.63	4.88	3.61
Euphausiacea	2.19	12.43	6.45	10.16	2.67	41.20	48.78	33.43
Natantia (total)	9.96	20.17	12.26	17.83	10.67	17.13	7.32	14.46
Pasiphaeidae		2.68		2.04		1.85		1.20
Hoplophoridae		1.56		1.19		1.85		1.20
Achanthephyra sp.		5.71		4.35		2.31		1.51
Bythocaris sp.		0.28		0.21		0.46		0.30
Pandalus sp.		0.28		0.21		0.46		0.30
Pandalus borealis	2.31	1.07		1.28	1.33	0.46		0.60
Natantia unident.	7.65	8.59	12.26	8.55	9.33	10.65	7.32	9.94
Crustacea unident.	8.22	9.14	52.04	10.65	42.67	33.80	92.68	43.07
Echinoidea	0.03			0.01	1.33			0.30
Pisces (total)	10.84	20.39	14.94	18.28	33.33	16.20	7.32	18.98
Bathylagus euryops		3.76		2.86		0.46		0.30
Cyclothone microdon		0.18	14.47	0.71		0.46		0.60
Holtbyrnia anomala		1.63		1.24		0.46		0.30
Macrouridae sp.		12.32		9.39		0.46		0.30
Pisces sp.	10.84	2.50	0.47	4.08	33.33	14.35	4.88	17.47
Unidt. organic mat.	38.02	17.76	3.14	21.20	61.33	31.94	17.07	36.75
All	100	100	100	100				
Stomachs	75	216	41	332	75	216	41	332

of the gonads showed signs of maturation. Out of 7 816 specimens, sampled in the period April–December, which were examined visually, only one female, 21 cm AFL, sampled in September showed signs of maturation, having gonads with a weight of 105 g and containing eggs of 0.8 mm. The remaining specimens had gonads with eggs not yet visible or small testes with no signs of maturation. No specimens seemed to be newly spent. There was thus no indication of spawning at West Greenland.

The existing information on *C. rupestris* spawning biology is scarce and is in many ways conflicting. According to Grigorev (1972), Savvatimsky (1982) and Gordon (MS 1978) *C. rupestris* spawns throughout the year, with a tendency towards a more intensive spawning in June–December, while Geistdoerfer (1979) showed that spawning takes place in spring. There has been very little evidence of spawning in the Northwest Atlantic. Savvatimsky (1972) and Grigorev (1972) found no maturing or mature specimens at East Canada or West Greenland. Savvatimsky (1972) ascribed this to the lack of trawl hauls at relevant depths. He mentioned that maturing specimens were taken in a single haul at 1 500 m off Labrador in October, and that post- and pre- spawning individuals were observed at depths between 850 and 1 270 m in May off Nova Scotia. Further, Geistdoerfer (1979) also observed a few spent specimens taken at depths of 720–920 m in July–August off Labrador.

According to Zakharov and Monaku (1970) *C. rupestris* spawn at Southwest Iceland, and eggs and larvae drift by current to West Greenland and Baffin Island where they then settle. As fish grow larger they migrate back to Iceland to spawn. Savvatimsky (1982) agreed that the *C. rupestris* found in the Northwest Atlantic could have been spawned in Icelandic waters, but judging from the

TABLE 8. Food of *C. rupestris* expressed as weight percentage and frequency of occurrence for fish below and above 10 cm preanal fish length, respectively.

	Weight percentage		Frequency of occurrence	
Food item	<10 cm	>10 cm	<10 cm	>10 cm
Polychaeta	4.00	1.73	28.46	22.97
Cephalopoda	0.53	17.49	5.69	44.50
Crustacea (total)	73.82	39.70	91.06	87.56
Ostracoda		0.01		0.48
Copepoda	0.23	0.03	2.44	2.39
Calanoida	12.98	1.40	80.49	64.59
Mysidacea	1.06	0.06	3.25	0.96
Gnathophausia		1.08		1.44
Isopoda		0.01		0.48
Hyperiidae unident.	0.45	0.05	3.25	1.91
Parathemisto	0.08	0.11	0.81	2.39
Gammaridea	0.30	0.09	2.44	4.31
Euphausiacea	14.04	9.82	23.58	39.23
Natantia (total)	7.55	18.76	4.07	20.57
Pasiphaeidae		2.23		1.91
Hoplophoridae		1.30		1.91
Achanthephyra sp.		4.74		2.39
Bythocaris sp.		0.23		0.48
Pandalus sp.	2.57		0.81	
Pandalus borealis		1.39		0.96
Natantia unident.	4.98	8.87	3.25	13.88
Crustacea unident.	37.13	8.28	47.15	40.67
Echinoidea		0.01		0.48
Pisces (total)	0.60	19.86	6.50	26.32
Bathylagus euryops		3.12		0.48
Cyclothone microdon		0.77		0.96
Holtbyrnia anomala		1.35		0.48
Macrouridae sp.		10.23		0.48
Pisces sp.	0.60	4.39	6.50	23.92
Unidt. organic	21.06	21.22	28.46	41.63
All	100	100		
Stomachs	123	209	123	209

morphology of the species, Savvatimsky (1982), Grigorev (1972) and Parsons (1976), concluded that it is a poor swimmer, not capable of migrating over long distances. They therefore discounted Zakharov and Monaku's (1970) theory, and concluded, based on among others the observations of small individuals (Grigorev, 1972) and larvae (Jensen, 1948), that *C. rupestris* spawn in the Northwest Atlantic at depths greater than 1 000 m. The finding of only immature fish, except one, in the present study, and the fact that the abundance seems to decrease beyond about 1 100 m, does not support this hypothesis. A number of fish species in West Greenland are recruited from spawning areas at Iceland indicating that *C. rupestris* in West Greenland might also be recruited from Icelandic waters. Duschenko (1985) also reached the conclusion, that the population in the Davis Strait is completely dependent on recruitment from outside. He considered the West Greenland population as an expatriate population, because of the lack of evidence for spawning migrations back to the Mid-Atlantic Ridge.

Coryphaenoides güentheri (Valliant, 1888). (Günther's grenadier)

Coryphaenoides güentheri is distributed in the Mediterranean, in the Eastern Atlantic, off Iceland and East Greenland at depths between 800 and 2 800 m (Iwamoto, 1990). In our surveys, it was found south of 66°04'N at depths between 534 and 1 497 m and at temperatures ranging from 3.0 to 4.3°C, but it was most abundant at temperatures between 3.2 and 3.6°C (Fig. 6). The species has been observed at depths of 1 956 m in the Davis Strait (Karrer, 1976). *Coryphaenoides güentheri* was common with as many as 190 specimens being caught in a single haul. The main distribution area was in Div. 1D at depths greater than 1 000 m where 97.3% of the catches were made. In this area abundance varied from 39 specimens per km^2 in 1990 to 395

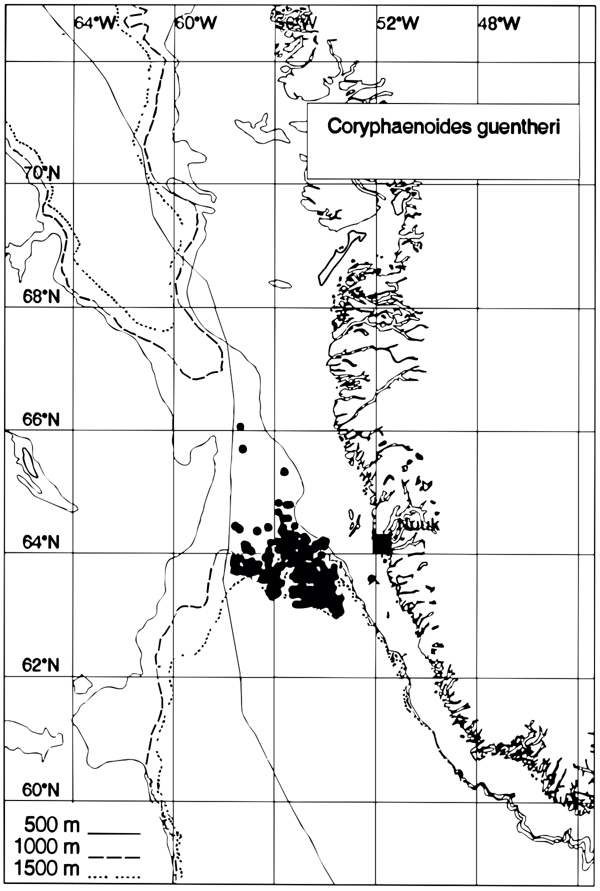

Fig. 6. Distribution of hauls in which *C. güentheri* was caught in the surveys of 1987–94.

specimens per km^2 in 1991. In most surveys there was a tendency towards an increase in abundance by depth, but the opposite was observed in 1989 and 1992 (Table 9). Of the 162 examined specimens, 49% were male.

In the five surveys, from which length frequency data were available, fish length (AFL) ranged from 2.0 to 14.5 cm. Most length distributions were dominated by one clear mode between 5 and 7 cm (Fig. 7).

The AFL and TL were highly correlated for each sex and for sexes combined ($P<0.01$) (Table 4). Analysis of covariance indicated that the regression coefficients did not differ significantly between sexes ($P = 0.177$) and the relationship between AFL and TL was estimated at $TL = 2.378 + AFL \times 3.246$.

The relationship between both AFL and TL and weight was highly significant for each sex and for sexes combined ($P <0.01$) (Table 5).

A total of 330 stomachs, of which 40% were empty, were investigated (Table 2). Overall, 22 different food items or groups of food items were identified, representing six major animal classes or super-classes; Polychaeta, Cephalopoda, Crustacea, Echinodermata, Mollusca and Pisces (Table 10). The most important prey was Crustacea, of which Gammaridea were dominant, both in terms of weight and percentage occurrence, closely followed by Polychaeta. Other important prey were Holothuroidae and Bivalvia, while Pisces and Cephalopoda only occurred sporadically. The composition of food items indicates that C. *güentheri* is a benthic feeder.

None of the gonads taken from 160 females and 133 males, ranging from 4 to 13 cm AFL sampled in August, showed any signs of maturation or being recently spent. There was, however, a tendency towards an increase in gonad weight by size for females. Hence, 12 females between 10 and 13 cm AFL had gonads with weights above 1.0 g, the maximum weight being 1.7 g and two of the females sampled had barely visible eggs. One male, 11 cm AFL, had gonads with a weight of 0.2 g. The rest had gonad weights equal to or less than 0.1 g. Thus there were no indications of spawning at West Greenland, at least not during summer.

Coryphaenoides brevibarbis (Goode and Bean, 1896). (Shortbeard grenadier)

Coryphaenoides brevibarbis is distributed from the Bay of Biscay, west of Ireland to south of Iceland and east of southern Greenland, and in the Western Atlantic off the coast of North America (Geistdoerfer, 1986). The species is reported to be most common at depths between 1 500 and 3 200 m in the Western Atlantic (Marshall and Iwamoto, 1973). At West Greenland, it was found between 63°08'N and 64°26'N at depths from 984 to 1 490 m and temperatures ranging from 2.9 to 3.5°C (Fig. 8). However, it has previously been observed to 1 955 m in the Davis Strait (Karrer, 1976). A total of 57 specimens were caught, of which 17 were taken in a single haul at 1 490 m at a temperature of 3.1°C. Of the 12 specimens examined, 50% were male.

Fish length, in all surveys combined, ranged from 2.5 to 8.0 cm AFL, with most being between 3.0 and 5.0 cm (Fig. 9). The relationship between TL and AFL was estimated to $TL = 0.075 + AFL \times 3.511$ (Table 4).

Crustacea were found in all of the 6 stomachs examined, except one which was empty. Gammaridea was the most common group but Copepoda was found in a single stomach.

TABLE 9. Mean number of *C. güentheri* caught per km^2 swept, standard error (S.E.) of mean and number of tows distributed on 200 m depth intervals by year and cruise number in Div. 1D at depths >1 000 m.

	Depth stratum			
Year	1 001–1 200	1 201–1 400	1 401–1 500	1 001–1 500
1988	136	194	286	163
S.E./no.tow	33/17	50/11	–/1	27/29
1989	171	136	77	146
S.E./no.tow	33/14	23/14	30/3	19/31
1990a	34	40	62	39
S.E./no.tow	8/14	22/9	15/3	9/26
1990b	124	148	212	134
S.E./no.tow	19/20	42/4	134/2	18/26
1991	345	406	720	395
S.E./no.tow	72/15	46/10	204/2	48/27
1992a	165	126	20	145
S.E./no.tow	54/16	45/11	–/1	36/28
1992b	271	186	–	246
S.E./no.tow	105/12	39/5	–	75/17
1993	119	150	0	126
S.E./no.tow	27/19	23/11	-/1	19/31
1994	111	359	222	230
S.E./no.tow	28/14	85/13	51/3	44/30

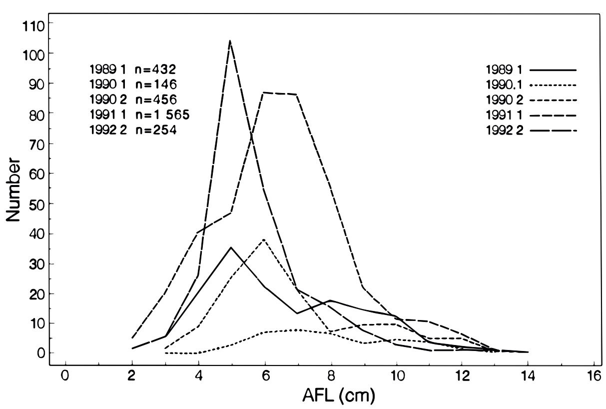

Fig. 7. Length distribution (AFL, 1-cm groups) of *C. güentheri* collected in numbers (n) per km^2 swept in Div. 1D at depths >1 000 m in the five surveys in the period 1989–92.

Polychaeta were found in four stomachs, indicating that the species is a benthic feeder.

Coryphaenoides carapinus Goode and Bean, 1883. (Carapine grenadier)

Coryphaenoides carapinus is distributed in the central/eastern North Atlantic from about 60°N to the Equator, along the Mid-Atlantic Ridge and between Cape Hatteras and Nova Scotia (Geistdoerfer, 1986). According to Marshall and Iwamoto (1973), most of the individuals recorded were sampled between 1 400 and 2 800 m, however, it has been reported to occur as deep as 5 610 m. The species was not caught during these 1987–94 surveys, but a single specimen, 18.3 cm TL, taken at 62°58'N 57°42'W, at a depth of 1 950 m was reported by Karrer (1976) (Fig. 8).

Coryphaenoides armatus (Hector, 1875.

Coryphaenoides armatus is distributed worldwide at depths between 257 and 4 700 m, usually below 2 000 m (Geistdoerfer, 1986). The species was not caught during the 1987–94 surveys, but Jensen (1948) reported two specimens, of which the largest was 36.1 cm TL, from the southern part of the Davis Strait at depths of 2 600 and 3 235 m.

TABLE 10. Food of *C. güentheri* expressed as weight percentage and frequency of occurrence.

Food item	Weight percentage	Frequency of occurrence
Polychaeta	24.82	75.13
Cephalopoda	0.16	0.51
Crustacea (total)	29.34	80.71
Copepoda	0.08	0.51
Calanoida	2.06	12.18
Cumacea	0.06	1.02
Mysidacea	2.14	6.60
Isopoda	0.08	0.51
Hyperiidae unident.	1.11	7.11
Parathemisto	0.16	1.02
Gammaridea	7.61	41.62
Bythocaris sp.	0.79	0.51
Natantia unident.	0.24	1.02
Crustacea unident.	14.91	68.02
Holothuroidea	11.66	3.55
Ophiuroidea	0.08	0.51
Gastropoda	0.16	1.02
Bivalvia	6.82	34.01
Pisces sp.	0.08	0.51
Unidt. organic mat.	26.88	62.94
All	100	
Stomachs	197	197

A further, two specimens, 16.1 and 18.5 cm TL, caught at a depth of 1 955 m at 63°N 58°W, were reported by Karrer (1976) (Fig. 8).

Macrourus berglax Lacépède, 1801. (Roughhead grenadier)

Macrourus berglax is widely distributed in temperate and arctic waters in the North Atlantic (Iwamoto, 1990). In these surveys it was found from 63°03'N to 72°47'N at depths between 280 and 1 497 m and temperatures ranging from 0.1 to 4.6°C, but with the highest abundance at temperatures between 3.0 and 4.2°C (Fig. 10). *Macrourus berglax* was common in the present study (up to 148 specimens in a single haul) and was caught in almost all hauls south of 67°N at depths >400 m. The species was mainly found between 63°03'N and 66°15'N (Div. 1CD) where the abundance fluctuated between 182 specimens per km^2 in 1991 and 36 specimens per km^2 in 1994. The highest abundance was found at depths from 600 to 1 200 m (Table 11). Of the 7 078 specimens examined, 54% were male. *Macrourus berglax* has been taken down to 2 000 m offshore, but is probably found at even greater depths (Boje and Hareide, MS 1993). According to Wheeler (1969) it was caught as deep as 2 740 m. The species was, furthermore, found in almost all fjords at West Greenland up to 72°N (Jensen, 1948). The lack of offshore records between 63°03'N and Cape Farewell must be due to poor coverage of this area during the surveys, because it is frequently caught on long lines along the southwest coast (J. Boje, Greenland Institute of Natural Resources, Nuuk, Greenland, pers. com.).

Specimens in this study ranged from 0.5 cm to 27.0 and 42.5 cm AFL for males and females, respectively. The length distributions, differed, however, markedly between years and areas and within years in the same area (Fig. 11).

AFL and TL were highly correlated for both males and females and for sexes combined ($P < 0.01$). Analysis of covariance indicated that the regression coefficients did not differ significantly between males and females ($P = 0.165$), and the relationship between TL and AFL for sexes combined was estimated to TL = 5.744 + AFL × 2.273 (Table 4). Several other authors have also found a linear correlation between AFL and TL and no significant difference between males and females (see Atkinson, 1991, for a review). Atkinson (1991) and Magnússon (MS 1987) estimated a ratio of 0.3783 and 0.3835 between AFL and TL in Canadian and Icelandic waters, respectively, which is close to the ratio 0.3752 found at West Greenland.

The relationship between both AFL and TL and weight was highly significant for both sexes and sexes combined ($P<0.01$) (Table 5). The weight-at-

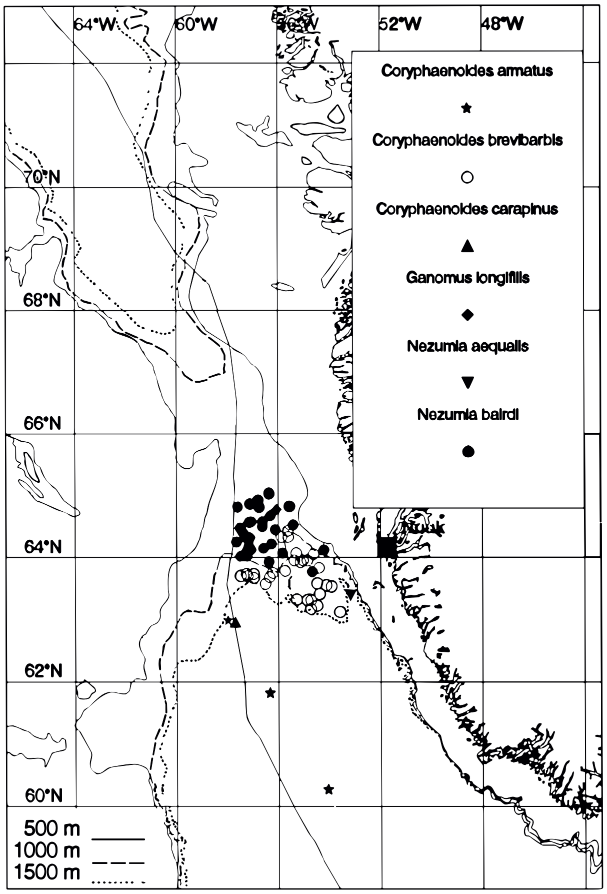

Fig. 8. Distribution of hauls in which *C. brevibarbis*, *G. longifilis* and *N. bairdi* were caught in the surveys of 1987–94. The position of observations of *C. armatus*, *C. carapinus* and *N. aequalis* given in Karrer (1976) and Jensen (1948) are also shown.

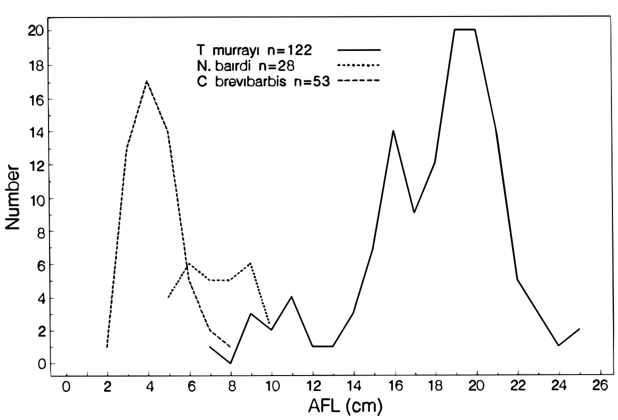

Fig. 9. Length distribution (AFL, 1-cm groups) of *T. murrayi*, *N. bairdi* and *C. brevibarbis* collected in numbers (n) per km^2 swept pooled for the period 1987–94.

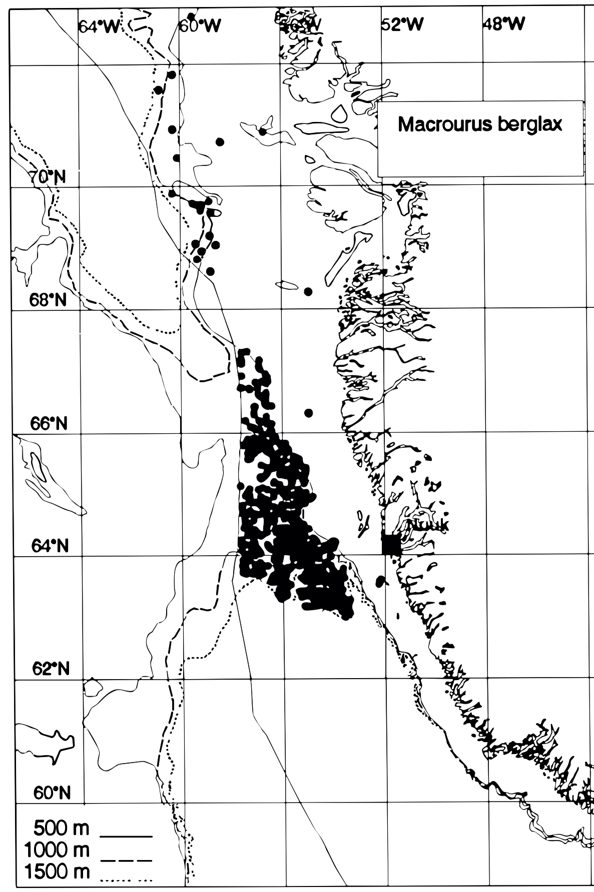

Fig. 10. Distribution of hauls in which *M. berglax* was caught in the surveys of 1987–94.

length was slightly higher compared to what was found by Savvatimsky (1989b and 1994) at East Canada in the period 1963–83 and in 1985, respectively, and by Magnússon (MS 1987) in Icelandic waters.

Scales were sampled in 1988, 1989 and 1992, but there was no significant difference in size-at-age between years and data were pooled. Fish age ranged from 4 to 13 years and 3 to 19 years for males and females, respectively. As was the case with *C. rupestris*, a great variation in length within each age group was observed (Table 12). Growth curves were calculated according to the formulae: AFL = $2.917 \times \text{age}^{0.798}$ and AFL = $2.579 \times \text{age}^{0.875}$ (Polynomial regression), AFL = $28.556 \times (1–1.205 \times \exp(-0.125 \times \text{age}))$ and AFL = $108.421 \times (1-0.995 \times \exp(-0.019 \times \text{age}))$ (von Bertalanffy) and AFL= $24.562 \times (\exp(-3.035 \times \exp(-0.244 \times \text{age})))$ and AFL = $45.718 \times (\exp(-2.594 \times \exp(-0.111 \times \text{age})))$ (Gompertz) for males and females, respectively. An F-test comparing the Polynomial regression with the

TABLE 11. Mean number of *M. berglax* caught per km^2 swept, S.E. of mean/number of tows distributed on depth strata and areas (Div. 1A + 1B and Div. 1C + 1D) by year and cruise number. (Div. 1A south of 70°N).

	Depth stratum													
	401–600		601–800		801–1 000		1 001–1 200		1 201–1 400		1 401–1 500		401–1 500	401–1 500
Year	1A–1B	1C–1D	1A–1B	1C–1D	1A–1B	1C–1D	1A–1B	1C–1D	1A–1B	1C–1D	1A–1B	1C–1D	1A–1B	1C–1D
1988	53	75	113	122	76	162	–	91	0	82	–	159	62	115
S.E./no.tow	22/8	41/5	10/3	25/18	23/3	25/18	–	14/19	0/2	12/11	–	–/1	14/16	11/72
1989	–	95	–	67	–	84	–	143	–	127	–	48	–	105
S.E./no.tow	–	29/6	–	31/11	–	21/11	–	24/16	–	20/14	–	34/3	–	11/61
1990a	–	47	–	32	–	54	–	56	–	34	–	80	–	47
S.E./no.tow	–	18/7	–	6/16	–	11/17	–	8/16	–	7/9	–	17/3	–	4/68
1990b	6	19	27	39	22	61	35	73	0	83	–	54	13	56
S.E./no.tow	4/10	11/7	6/3	9/17	0/3	9/18	/1	8/22	/1	22/4	–	0/2	3/18	5/70
1991	15	60	77	206	40	238	–	199	0	122	–	80	29	182
S.E./no.tow	9/11	22/7	40/4	24/19	8/2	17/16	–	23/17	0/2	18/10	–	8/2	11/19	12/71
1992a	7	37	50	117	92	158	–	85	7	47	0	.7	22	95
S.E,/no.tow	5/11	18/7	15/5	17/23	/1	26/11	–	11/18	/1	6/11	/1	–/1	7/19	9/71
1992b	–	34	–	47	–	112	–	113	–	98	–	–	–	85
S.E./no.tow	–	28/3	–	10/16	–	14/11	–	14/14	–	41/5	–	–	–	9/49
1993	–	37	–	51	–	132	–	153	–	65	–	0	–	96
S.E./no.tow	–	19/6	–	8/22	–	14/16	–	47/21	–	7/11	–	–/1	–	14/77
1994	–	4	–	14	–	37	–	65	–	34	–	52	–	36
S.E./no.tow	–	2/4	–	5/18	–	8/14	–	11/16	–	7/13	–	13/3	–	4/68

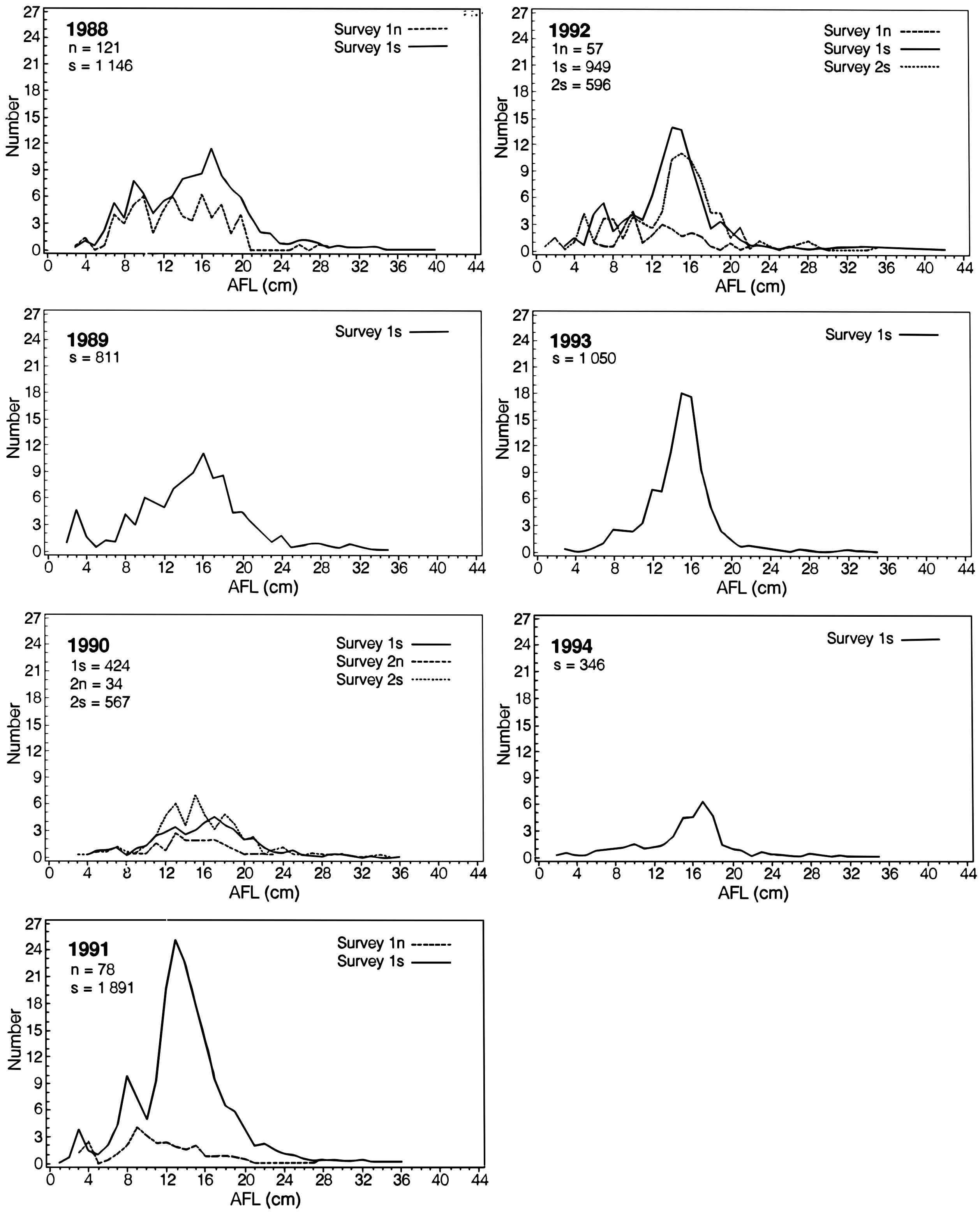

Fig. 11. Length distribution (AFL, 1-cm groups) of *M. berglax* collected in numbers per km^2 swept in Div. 1A+1B (n) and Div. 1C+1D (s) at depths >400 m in the period 1988–94.

TABLE 12. Mean preanal fin length (AFL cm)-at-age; minimum and maximum length-at-age, number of observations (n) and Standard Error of mean (S.E.) for *M. berglax*.

	Males					Females				
Age	Length	Min.	Max.	n	S. E.	Length	Min.	Max.	n	S.E.
3	–	–	–	–	–	7.17	6.5	7.5	3	.333
4	8.11	6.5	11.0	9	.431	7.75	5.0	9.5	6	.642
5	9.71	7.0	12.5	7	.616	10.16	9.0	13.0	16	.218
6	11.88	10.0	13.0	8	.430	12.40	10.0	15.0	15	.346
7	14.42	10.5	17.5	32	.262	14.33	12.5	18.5	18	.375
8	16.03	14.0	18.5	34	.197	16.39	14.0	19.0	31	.247
9	17.69	15.0	21.0	31	.248	17.61	16.0	19.5	22	.257
10	18.74	16.5	21.5	23	.279	18.86	15.0	22.0	21	.375
11	20.29	19.0	21.5	14	.201	21.03	16.5	24.5	15	.527
12	20.13	19.0	21.5	4	.657	23.29	21.0	29.5	7	1.138
13	22.00	21.5	22.5	2	.500	23.89	19.0	27.0	9	.798
14	–	–	–	–	–	27.23	25.0	28.5	11	.333
15	–	–	–	–	–	28.50	27.0	30.0	5	.500
16	–	–	–	–	–	29.70	28.0	35.5	5	1.463
17	–	–	–	–	–	28.50	28.5	28.5	2	.000
18	–	–	–	–	–	31.50	31.5	31.5	1	–
19	–	–	–	–	–	35.00	35.0	35.0	1	–

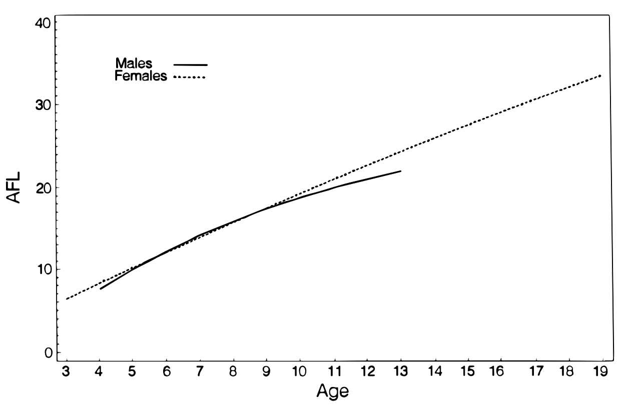

Fig. 12. Age-length relationship (AFL cm) for *M. berglax* at West Greenland fitted to a von Bertalanffy growth curve.

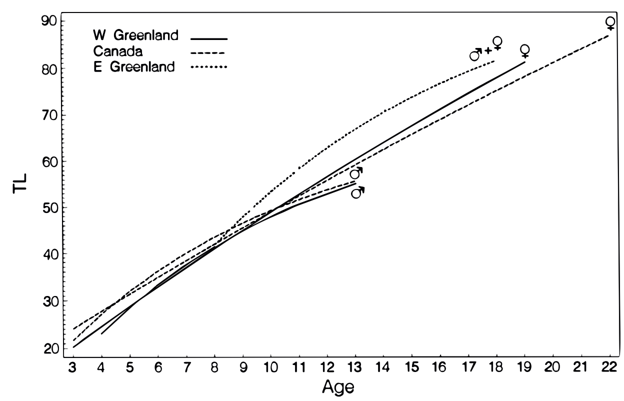

Fig. 13. Age-length relationship (TL cm) for *M. berglax* at West Greenland, Canada (Savvatimsky, 1994) and East Greenland (sexes combined) (Kosswig, MS 1979) fitted to a von Bertalanffy growth curve.

von Bertalanffy and Gompertz growth models showed, as for *C. rupestris*, that the von Bertalanffy and Gompertz growth models fitted data significantly better ($P < 0.05$) than the Polynomial regression for males, while no significant improvement in the data fit to the model was obtained by going from the simple Polynomial regression model to the more complex von Bertalanffy or Gompertz models, for females. The Gompertz model fitted mean size-at-age data for males a little better compared to the von Bertalanffy model, in terms of slightly smaller residuals in the non-linear least square procedure (Anon., 1985), while the von Bertalanffy model fitted data for females substantially better than the Gompertz model. Until age 10 the size-at-age were the same for males and females. After that the size-at-age for males was lower than for females (Fig. 12), which was also observed by Savvatimsky (1994) (Fig. 13). To make data comparable to other studies on growth of *M. berglax* in the Northwest Atlantic, the conversion factor previously obtained (Table 4) was used to estimate the following von Bertalanffy relationships between TL and age: $TL = 70.655 \times (1-1.107 \times \exp(-0.125 \times age))$ and $TL = 252.180 \times (1-0.973 \times \exp(-0.019 \times age))$, respectively. Size-at-age reported from East Canada (Savvatimsky, 1994) and West Greenland were close to each other, while size-at-age at East Greenland (Kosswig, MS 1979) seemed to be somewhat higher above age 9 (Fig. 13). As for *C. rupestris*, very little work has been done on this species on intercalibration between age readers from different laboratories, and the differences in mean size-at-age observed between different investigations could be caused by different interpretation of growth zones.

A total of 533 stomachs, of which 21% were empty, were sampled at different times of the year (Table 2). The percentage of empty stomachs was lowest during August/September, on average 15%, however, this varied from 8% to 24% during the three years sampling was carried out. The percentage of empty stomachs was highest in December (36%). Overall, 58 different food items or groups of food items were identified in the stomachs, representing nine major animal classes or super-classes (Table 13). Cephalopoda, Pisces, Crustacea and Echinodermata were the most important prey by weight, whereas Crustacea and Polychaeta were the most important in terms of percentage occurrence. Generally, the food composition was rather stable throughout the year. There was, however, a tendency towards an increase in percentage occurrence of Crustacea from 44% in June to around 70% in August–December. This increase was mainly due to an increase in the occurrence of Mysidacea and

TABLE 13. Food of *M. berglax* expressed as weight percentage and frequency of occurrence at different time of the year.

	Weight Percentage				Frequency of Occurrence			
Food item	Jun	Aug/Sep	Nov/Dec	All	Jun	Aug/Sep	Nov/Dec	All
Coelenterata		0.38		0.28		1.05		0.71
Polychaeta	12.27	10.07	18.08	11.15	74.03	71.43	64.29	70.95
Mollusca	0.04			0.01	2.60			0.48
Gastropoda	1.55	0.37	16.73	1.99	6.49	2.44	8.93	4.05
Bivalvia	0.18	0.75	0.49	0.63	10.39	19.86	16.07	17.62
Cephalopoda	4.56	34.73	0.65	26.41	7.79	3.83	1.79	4.29
Crustacea (total)	9.61	17.16	13.51	15.49	44.16	72.47	71.43	67.14
Ostracoda		0.01		0.01		0.35		0.24
Copepoda		0.00		0.00		0.35		0.24
Calanoida	0.04	0.16	0.12	0.14	1.30	11.50	5.36	8.81
Mysidacea	0.47	2.24	1.14	1.83	5.19	11.50	12.50	10.48
Isopoda		0.01	0.69	0.07		0.70	5.36	1.19
Hyperiidae unident.	0.04	0.18		0.14	2.60	7.67		5.71
Parathemisto	0.08	0.19		0.15	1.30	6.97		5.00
Gammaridea	1.49	1.62	3.51	1.76	15.58	32.40	35.71	29.76
Euphausiacea			0.04	0.00			1.79	0.24
Cumacea		0.02	1.47	0.14		1.74	14.29	3.10
Natantia unident.	5.54	3.87	0.82	3.91	3.90	3.14	3.57	3.33
Pandalus sp.		1.27		0.93		0.35		0.24
Pandalus borealis		2.37		1.74		1.05		0.71
Anomura	0.87	4.03	1.31	3.23	3.90	4.53	3.57	4.29
Crustacea unident.	1.08	1.19	4.41	1.44	23.38	36.24	37.50	34.05
Asteroidea	0.75		0.08	0.14	1.30		1.79	0.48
Ophiuroidea	3.26	1.54	6.08	2.24	19.48	8.36	14.29	11.19
Echinoidea	2.28	3.53	18.94	4.63	12.99	13.59	14.29	13.57
Holothuroidea	20.21	5.03	15.47	8.64	23.38	5.23	21.43	10.71
Crinoidea		0.00		0.00		0.35		0.24
Chaetognatha		0.04		0.03		0.35		0.24
Pisces (total)	40.85	24.40	4.65	25.65	10.39	8.36	10.71	9.05
Bathylagus euryops		3.77		2.78		0.70		0.48
Synaphobranchus kaupi		1.43		1.05		0.35		0.24
Lycodes sp.		1.12		0.82		0.35		0.24
Sebastes sp.		4.74		3.49		1.74		1.19
Triglops sp.		3.38		2.49		0.70		0.48
Careproctus reinhardti		2.02		1.48		0.35		0.24
Macrouridae	38.14			6.82	1.30			0.24
Pisces sp.	2.71	7.94	4.65	6.72	10.39	5.92	10.71	7.38
Unidt. organic mat.	4.42	1.98	5.31	2.70	25.97	14.29	14.29	16.43
All	100	100	100	100				
Stomachs	77	287	56	420	77	287	56	420

Gammaridea. The weight percentage of Pisces fell from 41% in June to 5% in December, but these figures were based on few observations. The percentage occurrence was stable, around 10%, throughout the year.

The importance of Crustacea and Polychaeta as food declined with increasing fish size, while the importance of Pisces and Cephalopoda increased drastically with size, both in terms of weight percentage and percentage occurrence (Table 14). The only Crustacea which increased in percentage occurrence with fish size were Mysidacea, Natantia and Anomura.

Polychaeta, Natantia and *Ophiura* sp. were the most frequent prey items off East Canada, occurring in 21%, 18% and 18% of the stomachs, respectively (Konstantinov and Podrazhanskaya, 1972). Savvatimsky (1969) found that Echinodermata dominated both at Labrador and Newfoundland, and that benthic Mollusca, benthic Crustacea and Pisces were also important, but the importance of the different prey groups varied between the areas. The

TABLE 14. Food of *M. berglax* expressed as weight percentage and frequency of occurrence at different length groups preanal fin length.

	Weight percentage			Frequency of occurrence		
Food item	<12 cm	12–20 cm	>20 cm	<12 cm	12–20 cm	>20 cm
Coelenterata		0.16	0.36		0.85	1.67
Polychaeta	31.44	20.85	4.15	70.40	77.02	48.33
Mollusca		0.02			0.85	
Gastropoda	0.41	4.46	0.49	2.40	3.83	8.33
Bivalvia	3.12	1.10	0.22	18.40	19.57	8.33
Cephalopoda		7.04	39.79		5.53	8.33
Crustacea (total)	41.34	23.28	9.48	82.20	63.40	48.33
Ostracoda		0.02			0.43	
Copepoda		0.01			0.43	
Calanoida	3.39	0.11	0.01	20.00	4.68	1.67
Mysidacea	4.07	4.17	0.25	4.80	13.62	10.00
Isopoda	0.27	0.16		1.60	1.28	
Hyperiidae unident.	1.49	0.25	0.01	6.40	6.38	1.67
Parathemisto	1.22	0.27	0.03	5.60	5.11	3.33
Gammaridea	15.04	3.14	0.32	47.20	25.96	8.33
Euphausiacea			0.01			1.67
Cumacea	0.81	0.33		4.00	3.40	
Natantia unident.	2.17	5.37	3.06	0.80	2.98	10.00
Pandalus sp.			1.57			1.67
Pandalus borealis		4.62			1.28	
Anomura	0.14	2.46	3.85	0.80	4.68	10.00
Crustacea unident.	12.74	2.37	0.37	53.60	28.09	16.67
Asteroidea		0.02	0.22		0.43	1.67
Ophiuroidea	1.63	3.10	1.72	9.60	11.06	15.00
Echinoidea	0.54	7.22	3.18	2.40	14.47	33.33
Holothuroidea	5.42	16.46	3.84	1.60	14.89	13.33
Crinoidea		0.01			0.43	
Chaetognatha			0.05			1.67
Pisces (total)	9.35	11.36	35.39	4.00	5.96	31.67
Bathylagus euryops		2.61	3.00		0.43	1.67
Synaphobranchus kaupi			1.77			1.67
Lycodes sp.			1.38			1.67
Sebastes sp.		0.30	5.65		0.43	6.67
Triglops sp.		1.45	3.25		0.43	1.67
Careproctus reinhardti			2.48			1.67
Macrouridae			11.42			1.67
Pisces sp.	9.35	7.00	6.44	4.00	5.11	23.33
Unidt. organic mat.	6.78	4.94	1.11	12.80	19.15	13.33
All	100	100	100			
Stomachs	125	235	60	125	235	60

same prey groups were dominant at eastern Grand Bank (Savvatimsky, 1984, 1989b). Off northwest Norway Crustacea, especially Amphipoda, was by far the most dominant class, occurring in 42% of the stomachs, while Polychaeta, Mollusca, Echinodermata and Pisces were of almost equal importance, occurring in about 5% of the stomachs (Eliassen and Jobling, 1985). As in the present study, Savvatimsky (1989b) observed a change in diet with size. Crustacea and Polychaeta became less important with increasing fish size while Pisces, Natantia and Anomura became more important.

Based on investigations covering most of the North Atlantic, it may be concluded that *M. berglax* is an opportunistic feeder, feeding on a large number of different prey items which it finds mainly on the bottom. Hureau *et al.* (1979) therefore categorized *M. berglax* as a benthic feeding type, eating less than 30% pelagic food.

Trachyrhynchus murrayi Günther, 1887. (Murray's longsnout grenadier, Roughnose grenadier)

Trachyrhynchus murrayi occurs in the central part of the North Atlantic (Geistdoerfer, 1986). At West Greenland it was fairly common (n = 192) with up to 11 specimens caught in a single haul. It was found between 63°03'N and 64°49'N at depths from 775 to 1 409 m and temperatures ranging from 3.1 to 3.8°C (Fig. 14). Of the 56 specimens examined, 47% were male.

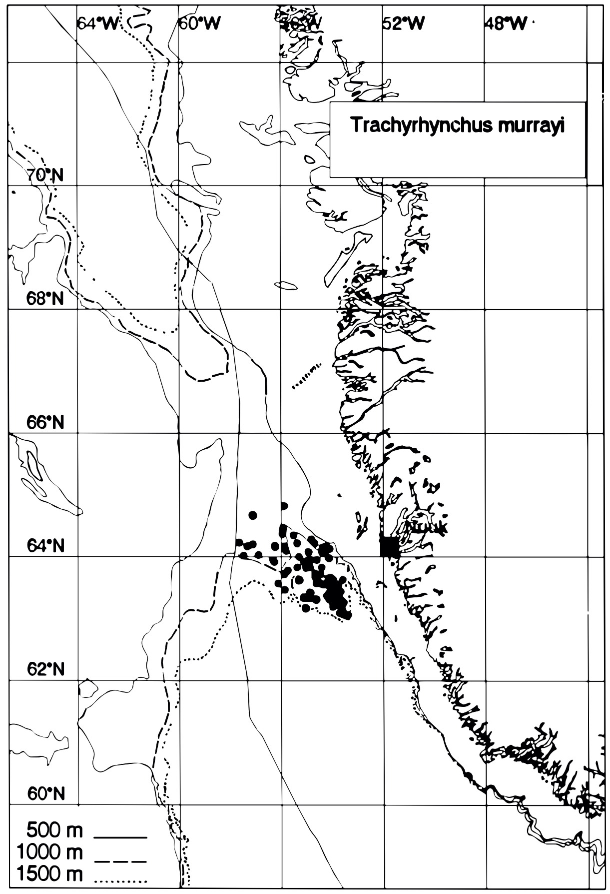

Fig. 14. Distribution of hauls in which *T. murrayi* was caught in the surveys of 1987–94.

Fish length, in all surveys combined, ranged from 7.0 to 25.0 cm AFL with most fish around 15–21 cm and a primary mode at 19–20 cm (Fig. 9). AFL and TL were highly correlated (P<0.01), and the relationship was estimated to TL = 3.985 + AFL × 2.238 (Table 4).

Nezumia aequalis (Günther, 1878). (Common Atlantic grenadier)

Nezumia aequalis is widely distributed in the North Atlantic, from northern Angola to south of Iceland and in the Mediterranean Sea in the east, and from northern Brazil to the Davis Strait in the west at depths between 200 and 1 000 m (Iwamoto, 1990). *Nezumia aequalis* was not caught during the 1987–94 surveys, but a single specimen, 28.5 cm TL, caught at 63°24'N 53°10'W at a depth of 860 m was reported by Jensen (1948). (Fig. 8).

Nezumia bairdi (Goode and Bean, 1877). (Common grenadier, Marlin-spike)

Nezumia bairdi is distributed along the eastern coast of North America (Iwamoto, 1990; Parsons, 1976), at depths between 16 and 2 285 m (Scott and Scott, 1988). It was recorded for the first time at West Greenland during the 1987–94 surveys between 63°46'N and 65°02'N at depths from 690 to 1 169 m and temperatures ranging from 3.2 to 4.0°C (n = 35) (Fig. 8). According to Parsons (1976) it is most abundant at depths between 500 and 775 m at temperatures between 3°C and 4°C. Savvatimsky (1989a) observed maximum catches off the east coast of Canada at 500–700 m, however, temperatures were as high as 7–8°C. Of the 8 specimens examined, 7 were female. Savvatimsky (1989a) also found a dominance of females, 73.4% (n = 428), in the most northern part of his investigation area (55°N).

Fish length, for all surveys combined, ranged from 5.0 to 10.0 cm AFL, with an fairly even distribution between the length groups (Fig. 9). The relationship between TL and AFL and was estimated to TL = 13.967 + AFL × 2.351 (Table 4).

Gadomus longifilis (Goode and Bean, 1986). (Threadfin grenadier)

Gadomus longifilis is distributed in the eastern Atlantic off the Azores, Madeira and Morocco northward to northern Portugal, and in the Caribbean in the Western Atlantic at depths between 620 and 2 165 m (Geistdoerfer, 1986). A single specimen, 17 cm TL, was observed for the first time at West Greenland at 64°47'N 56°05'W at 891 m and at a temperature of 3.4°C (Fig. 8).

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