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Greenland Halibut (*Reinhardtius hippoglossoides*) Feeding in Flemish Pass - NAFO Divisions 3LM

by

E. Rodríguez-Marín and A. Punzón
Instituto Español de Oceanografía, Aptdo. 240, 39080 Santander, Spain

and

J. Paz
Instituto Español de Oceanografía, Aptdo 1552, 36280, Vigo, Spain

ABSTRACT

A qualitative study of Greenland halibut (Reinhardtius hippoglossoides) food composition in NAFO Divisions 3LM was made by analysis on board ship from 4987 stomachs, in 1992.

Fish were caught at unusual depths, ranging from 720 to 1533 m, with an average of 979 m. The frequency of occurrence of food items was used to evaluate the importance of prey groups. Examination revealed a wide prey spectrum. Cephalopods (32%), Decapod crustaceans (22%) and fish (39%) were the main items, with cannibalism reaching 2%. The mean percentage of empty stomachs was 69%.

Variations in diet according to predator size, batimetric distribution, and month between spring and autumn were also found. Furthermore the influence of the fishery on diet, through waste products discarded after processing has been observed.

INTRODUCTION

The Greenland halibut (Reinhardtius hippoglossoides) is one of the major demersal species in the NAFO area, representing at least 20% of the trawlable biomass estimated from annual Canadian bottom-trawl surveys (Bowering & Lilly, 1992).

Since 1990 the Spanish fleet has been developing a new deep water fishery (depths ranging from 800 to 2000 m.) in the Flemish Pass area, with Greenland halibut as the target species. The deepwater demersal fish in this area support the activity of the Spanish, Portuguese and non-member fleets.

The development of this fishery provides the opportunity to study various aspects of the biology of R. hippoglossoides at unusual depths.

The depth range of this species in the area is very wide (Bowering, 1984; Chumakov & Sauvatimsky, 1990) reaching 1600 m (Templeman, 1973), but the biological studies, however, refer to a much narrower range (Bowering & Brodie, 1991; Pedersen & Riget, 1992), not usually exceeding 800 m. (Chumakov & Podrazhanskaya, 1986).

In recent years several papers have been published on the feeding habits of Greenland halibut (Bowering cit.; Yang & Livingston, 1988), but the feeding patterns of this species at great depths remain fairly unknown.

In this paper we provide a description of R. hyppoglossoides feeding, taking into account seasonal and spatial variations, influence of predator size, cannibalism and the influence of the fishery.

MATERIAL AND METHODS

The sampling was carried out on board commercial freezer ships in 1992. The study area was the Flemish Pass, an area situated between Neufoundland Grand Bank and Flemish Cap Bank, where the commercial fleet mainly works in the waters between 48°30'N and 46°N of latitude and 47°30'W and 46°W of longitude, in depths between 720 and 1533 m.

For the analysis of stomach contents, sampling took place from May to November, a total of 4987 stomachs containing food being analysed, while the emptiness index was obtained from sampling for the whole year, with a total of 244599 specimens examined.

In each haul a maximum of 100 Greenland halibut were randomly sampled. Size and sex have been determined for each specimen. The stomach contents were analysed on board, and examination involved separation of food items into three main taxonomic categories: fish, molluscs and crustaceans. Fish, cephalopod molluscs and decapod crustaceans were determined where possible to species.

The frequency of occurrence method was used to characterize fish feeding, only stomachs containing food were used for estimation (Dunn, 1954; Kennedy & Fitzmaurice, 1972). This method does not give quantitative information, but is quick and requires a minimum of apparatus, giving a somewhat qualitative picture of the food spectrum (Hyslop, 1980).

- Frequency of occurrence (percentage), FO:

$$FO = N_p/N_t * 100$$

Where Np is the number of stomachs with a specific prey, and Nt is the total number of stomachs containing food analysed.

For the stomach content analysis, predator length, depth and month of the year were taken into account. In relation to predator length 8 groups of 10 cm. were establised, 4 depth categories were considered, and finally 7 months from May to November. In Table 1a and Table 1b the number of the stomachs for each group are shown.

RESULTS

The proportion of empty stomachs ranged from 62% in August to 84% in December. In general the proportion of empty stomachs was greater in winter compared with the beginning of spring and late summer (Figure 1a). The annual average percentage of empty stomachs was high, at 69%. The percentage of empty stomachs diminishes with size, as can be seen in Figure 1b; the emptiness index also diminishes slightly as depth increases from 800m. (Fig. 1c).

There is a wide prey taxa spectrum in the diet of R. hippoglossoides, with 38 representatives of different systematic groups (Table 2). Fish make up the major prey group, contributing with a frequency of occurrence of 39%, and within this group the families Macrouridae, Gadidae, Pleuronectidae and the species Antimora rostrata stand out (Figure 2). Decapod crustaceans, F=22%, and cephalopoda (mainly Illex illecerebrosus), F=32%, represent another important part of the diet. The waste products, fundamentally heads of Greenland halibut appear with a high percentage, F=10%.

Diet composition in relation to length

Decapod crustaceans are the main food source for specimens

smaller than 50 cm, while cephalopoda remain important for species of greater size, the consumption of decapod cephalopods by octopods changing upwards of 70 cm. Fish become important from 40cm, increasing from this point until reaching over 50% of the diet in large specimens of Greenland halibut. The same occurs with waste products (table 2). The diet composition is size-related, with an abrupt change from feeding on crustaceans and molluscs to fish and waste products at about 60-69cm. (Figure 3).

Diet composition in relation to season and length

In general large seasonal differences are not observed in the diet of specimens smaller than 50 cm. In larger specimens, consumption of crustaceans is more important from August, an identical tendency to that seen in molluscs. Nevertheless, the waste products diminish from July, with a parallel increase in the consumption of fish, albeit discreetly (Figure 4). The insufficient number of stomachs per month of specimens greater than 70 cm. prevents the evaluation of differences existing between these and the rest of the length ranges.

Diet composition in relation to depth and length

Food composition varied greatly with depth (Chumakov & Podrazhanskaya, 1986) as illustrated by the stomach contents of specimens by depth strata (Table 3). Fish and waste products are the major prey at greater depth, while crustaceans are more important at shallower depth (Figure 5).

The rate of cannibalism was 2%. The predator length range was wide: from 37 to 98 cm. increasing with fish length (Figure 7). No significant relationship was found between predator length and prey length, the determination coefficient being $r^2 = 0.41$.

DISCUSSION

The adundance of pelagic and bathypelagic species present in the diet of R. hippoglossoides shows that this species leaves the bottom to feed (Smidt, 1969; Chumakov & Podrazhanskaya, 1986; Yang & Livingston, 1988; Albikovskaya et al., 1988). Some of its morphological characteristics indicate its active displacement in the water column, such as the pigmentation on both sides of the body and the apical position of the left eye.

Analysis of Greenland halibut feeding by month (Figure 1a) indicates increasing feeding activity during the beginning of spring and late summer. This pattern, which is similar to that found by Chumakov & Podrazhanskaya (1986), is common in species which live in slope areas. The emptiness index diminishes as length and depth increase in specimens greater than 45 cm. The results obtained by Yang & Livingston (1988) are similar to ours with respect to length, while Bowering & Lilly (1992) found that the percentage of emptiness increased with depth, and this may be due to the high consumption of waste products by large specimens found at greater depth. The waste products are an extra provision of food introduced by fishing activity, a new component in the diet which represents a high mean percentage, FO=10%, reaching values higher than 45% in specimens larger than 70 cm.

A direct relationship between the emptiness index and frequency of occurrence was elucidated, the higher the frequency of fish prey occurrence, the lower the number of empty stomachs. The same relationship is found in the Barents Sea. (Shvagzhdis, 1990)

Greenland halibut is a fundamentally ichthyophagous species (Yang & Livingston, 1988; Bowering & Lilly, 1992), although in small specimens decapod crustaceans and cephalopods (mainly squid) form an important part of their diet (Figure 3). It is precisely in the frequency of occurrence of these two last prey groups that the present work differs from the literature of this

area, since crustaceans and especially cephalopods have been reported as having low occurrence. This disparity in diet may be related to depth, as the consumption of prey organisms is intimately associated with their distribution and the bathypelagic way of life of Greenland halibut (Chumakov & Podrazhanskaya, 1986).

It would seem that at great depths (700-1200m.) squid play a similar role in the diet of Greenland halibut to that of capelin in the continental shelf, given that their maximum occurrence appears in predators smaller than 60cm, and disappears from the diet of larger specimens. From 60cm. an abrupt diet change takes place (Figure 3), fish and waste products becoming dominant.

If we represent the frequency of occurrence of waste products versus Greenland halibut catch by month (Figure 6), we see that there is a certain relationship, with the exception of the months from August. This could be due to the fact that the number of specimens larger than 70 cm. sampled from August was minimal, these being the main consumers of waste products.

The cannibalism rate was greater, FO=1.73%, than that calculated by Chumakov & Podrazhanskaya (1986) for Subarea 3, FO=0.3%, but similar to the average obtained by Bowering & Lilly (1992), FO=1.37%. The predator length range was wide: 37 to 98 cm., and the prey range was from 13 to 46 cm. Of the 86 cases of cannibalism found, 19 were under 60 cm. That is to say, 77.9% are within the length range in which fish have an increased presence in the diet. No clear relationship appears between predator length and prey length (r^2=0.41), (Figure 7).

CONCLUSIONS

1.- Mean stomach emptiness index in 1992 for Greenland halibut was 69%. Feeding activity increases at the beginning of spring and in late summer.

2.- Fish were the most important prey group, FO=39.4%, and cephalopods the second, FO=32%.

3.- An abrupt change of diet composition occurs at 60-69 cm. from feeding on decapod crustaceans and cephalopods to fish and waste products.

4.- The waste products are a important prey compound in the largest specimens (>60 cm.)

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MONTHS	<30	30-39	40-49	50-59	60-69	70-79	80-89	>89	TOTAL
MAY	0	56	368	277	136	60	20	12	929
JUNE	0	26	146	216	110	39	25	10	572
JULY	0	45	278	213	117	54	15	6	728
AUGUST	6	117	359	183	71	15	1	0	752
SEPTEMBER	12	229	466	182	42	3	0	0	934
OCTOBER	1	73	209	152	32	8	5	0	480
NOVEMBER	0	60	253	204	60	15	0	0	592
TOTAL	19	606	2079	1427	568	194	66	28	4987

(b)

DEPTH GROUPS	<30	30-39	40-49	50-59	60-69	70-79	80-89	>89	TOTAL
<800	2	304	728	280	31	1	0	0	1346
800-1000	14	247	959	657	228	60	15	2	2182
1000-1200	3	52	354	451	271	101	33	12	1277
>1200	0	3	38	39	38	32	18	14	182
TOTAL	19	606	2079	1427	568	194	66	28	4987

Table 1.- a) Number of stomachs analysed by length range and month, b) Number of stomachs analysed by length range and depth.

TAXA	<30	30-39	40-49	50-59	60-69	70-79	80-89	>90	Total
CRUSTACEA									
Other Crustacea			0.05	0.07					0.04
Decapoda									
Other Decapoda	52.63	20.63	29.87	20.88	3.70	0.52			21.59
Aristeidae									
Plesiopenaeus edwardsianus			0.14						0.06
Oplophoridae									
Acanthephyra pelagica		0.50	0.53	0.35					0.38
Pasiphaeidae									
Pasiphaea tarda		0.50	0.82	0.14					0.44
Total CRUSTACEA	52.63	21.62	31.31	21.44	3.70	0.52			22.47
MOLLUSCA									
Other Bivalvia			0.05						0.02
Other Gasteropoda				0.21					0.06
Cephalopoda									
Other Cephalopoda	26.32	47.85	30.64	18.01	7.34	2.06			24.74
Decapoda									
Illex illecebrosus		7.76	10.63	4.27	1.23	2.06			6.82
Octopoda									
Other Octopoda				0.22		1.03	3.03	3.57	0.22
Mollusca									
Other Mollusca		0.17	0.10	0.07	0.35			3.57	0.14
Total MOLLUSCA	26.32	55.76	41.37	22.99	8.63	5.15	3.03	7.14	31.98
OTHER INVERTEBRATES									
Cnidaria			0.10						0.04
Polychaeta			0.17						0.02
Total O. INVERTEBRATES		0.17	0.10						0.06
OTHERS									
Unidentified	10.53	0.50	2.50	6.03	9.51	7.22	6.55	7.14	6.33
Stones							1.52		0.02
Waste products		0.50	1.68	9.38	28.05	46.91	52.52	57.14	9.56
Total OTHERS	10.53	0.99	4.18	15.00	37.58	51.55	54.55	60.71	13.56
PISCES									
Serrivomeridae									
Serrivomer beani				0.07					0.02
Synaphobranchidae									
Synaphobranchus kaupi				0.14					0.04
Gadidae									
Gadus morhua			0.05	0.14					0.06
Gaidropsarus spp.			0.12	0.91	1.23	0.52	3.03		0.52
Urophycis spp.			0.05	0.21	1.06	1.06	3.03	3.57	0.38
Total Gadidae			0.24	1.26	2.29	3.61	6.06	3.57	0.96
Macrouridae									
Coryphaenoides rupestris		0.17	0.29	2.73	5.81	5.67	7.58	3.57	1.93
Macrourus berglax			0.58	1.47	4.65	5.06	1.52		1.16
Nezumia bairdi		0.17	1.15	5.06	5.58	4.98	4.06		2.15
Other Macrouridae		0.17	0.17	1.77	1.18	0.15	1.06	3.57	0.45
Total Macrouridae		0.50	1.99	11.04	17.25	14.93	15.15	7.14	7.56
Moridae									
Antimora rostrata			0.48	2.38	4.48	3.61	4.55	7.14	1.63
Myctophidae									
Other Myctophidae		0.50	0.48	0.14	0.35	0.52			0.34
Notacanthidae									
Notacanthus chemnitzi					0.18			3.57	0.06
Other Pisces									
Pisces unidentified	10.53	25.41	25.83	30.69	28.17	21.13	15.15	17.86	27.03
Anarhichadidae									
Anarhichas spp.				0.07	0.18				0.04
Scorpaenidae									
Sebastes spp.			0.10	0.07	0.35	1.55	1.52		0.18
Zoarcidae									
Lycodes spp.					0.35	1.55			0.10
Pleuronectidae									
Hippoglossoides platessoides					0.18				0.02
Reinhardtius hippoglossoides		0.17	0.05	1.19	5.81	8.76	15.15	25.00	1.73
Total Pleuronectidae		0.17	0.05	1.19	5.81	8.76	15.15	25.00	1.73
Chauliodontidae									
Chauliodus sloani			0.05						0.02
Osmeridae									
Mallotus villosus		0.33	0.19						0.12
Other Squaliformes							1.52		0.02
Rajidae									
Raja radiata			0.10						0.04
Total PISCES	10.53	26.90	30.84	47.58	57.39	51.55	54.55	57.14	39.35
NO. STOMACHS:	19	606	2078	1427	568	194	66	28	4987
MEAN LENGTH:	28	36	45	54	64	74	83	94	50

Table 2.- Prey items found in Greenland halibut stomachs, expressed as frequency of occurrence by length groups (cm).

TAXA	< 800	800-999	1000-1199	>1200	Total
CRUSTACEA					
Other Crustacea	0.07	0.05		7.14	0.04
Decapoda					
Other Decapoda	25.71	24.27	14.64		21.59
Aristeidae					
Plesiopenaeus edwardsianus	0.15	0.05			0.06
Oplophoridae					
Acanthephyra pelagica	0.74	0.41			0.38
Pasiphaeidae					
Pasiphaea tarda	0.15	0.92			0.44
Total CRUSTACEA	26.75	25.54	14.64	7.14	22.47
MOLLUSCA					
Other Bivalvia		0.05			0.02
Other Gasteropoda		0.05			0.06
Cephalopoda					
Other Cephalopoda	43.24	18.13	17.62	16.48	24.74
Decapoda					
Illex illecebrosus	1.19	9.16	8.93	5.49	6.82
Octopoda					
Other Octopoda		0.05	0.47	2.20	0.22
Mollusca					
Other Mollusca		0.18	0.16	0.55	0.14
Total MOLLUSCA	44.50	27.55	27.25	24.73	31.98
OTHER INVERTEBRATES					
Cnidaria		0.09			0.06
Polychaeta	0.07				0.02
Total O. INVERTEBRATES	0.07	0.09			0.06
OTHERS					
Unidentified	0.97	5.72	5.79	2.20	4.33
Stones				0.55	0.06
Waste products	1.41	8.93	16.68	46.04	9.17
Total OTHERS	2.30	14.58	21.89	29.67	13.56
PISCES					
Serrivomeridae					
Serrivomer beani		0.05			0.02
Synaphobranchidae					
Synaphobranchus kaupi		0.09			0.04
Gadidae					
Gadus morhua	0.07	0.09			0.06
Gaidropsarus spp.	0.07	0.82	0.55		0.52
Urophycis spp.		0.05	0.55	5.04	0.38
Total Gadidae	0.15	0.96	1.10	5.04	0.96
Macrouridae					
Coryphaenoides rupestris	0.15	0.55	4.23	13.74	1.93
Macrourus berglax	0.45	1.05	1.80	0.55	1.06
Nezumia bairdi	1.04	3.02	4.04	1.65	2.15
Other Macrouridae	1.04	2.70	1.80	2.75	1.45
Total Macrouridae	2.15	7.92	11.12	18.13	7.56
Moridae					
Antimora rostrata	0.07	1.28	3.68	2.75	1.63
Myctophidae					
Other myctophidae	0.45	0.41	0.16		0.34
Notacanthidae					
Notacanthus chemnitzi		0.09	0.08		0.06
Other pisces					
Pisces unidentified	32.32	26.51	23.57	17.58	27.03
Anarhichadidae					
Anarhichas spp.		0.05		0.55	0.04
Scorpaenidae					
Sebastes spp.	0.07	0.18	0.16	1.10	0.18
Zoarcidae					
Lycodes spp.		0.09	0.08	1.10	0.10
Pleuronectidae					
Hippoglossoides platessoides		0.05			0.02
Reinhardtius hippoglossoides	0.22	0.64	3.99	7.14	1.71
Total Pleuronectidae	0.22	0.69	3.99	7.14	1.73
Chauliodontidae					
Chauliodus sloani		0.05			0.02
Osmeridae					
Mallotus villosus	0.22	0.14			0.12
Other Squaliformes				0.55	0.02
Rajidae					
Raja radiata		0.09			0.04
Total PISCES	35.59	38.55	42.91	50.55	39.35
No. STOMACHS:	1346	2182	1277	182	4987
MEAN LENGTH:	45	69	86	84	50

Table 3.- Prey items found in Greenland halibut stomachs, expressed as frequency of occurrence by depth groups.

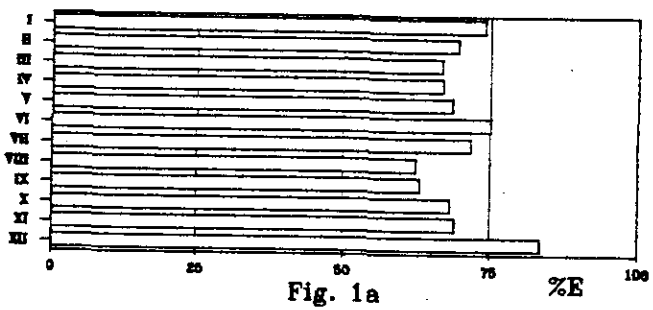

Fig. 1a

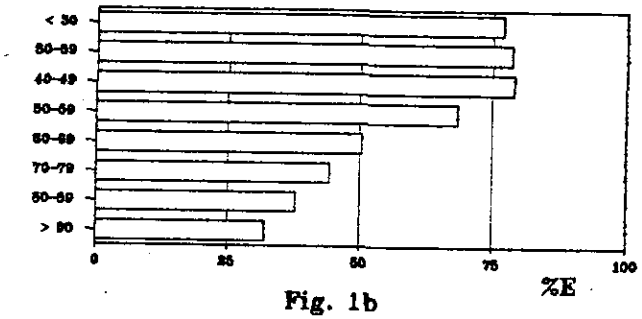

Fig. 1b

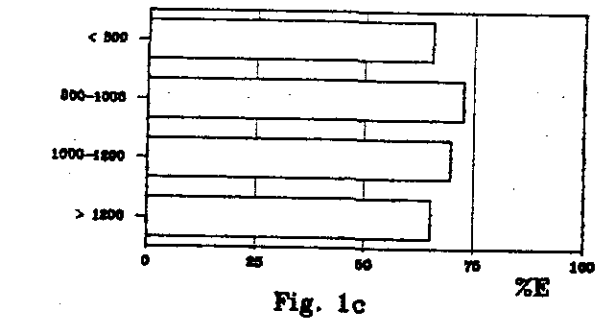

Fig. 1c

Figure 1.- Emptiness index of Greenland halibut in 3LM NAFO Divs., (a) by month, (b) by length (cm.), and (c) by depth (m.).

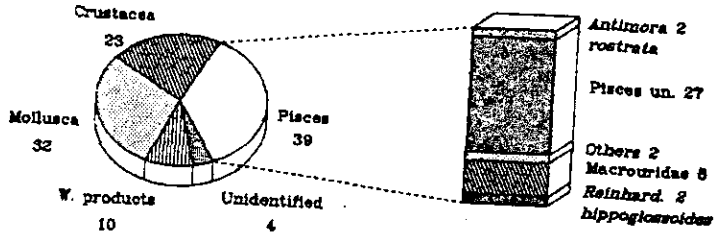

Figure 2.- Food of Greenland halibut in 3LM NAFO Divs. Prey groups expressed as frequency of occurrence.

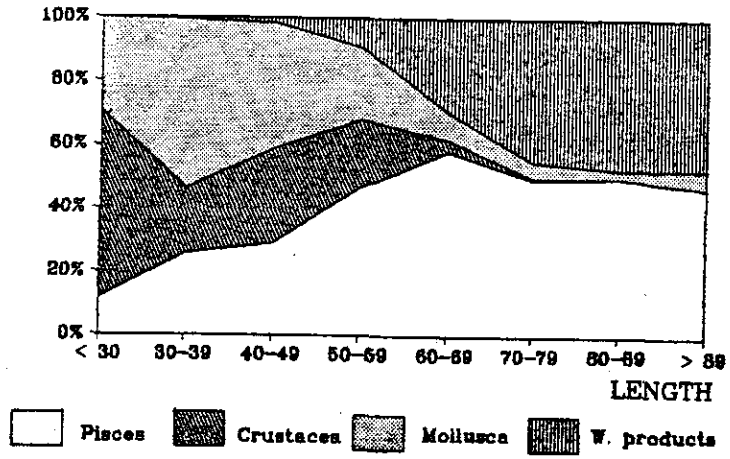

Figure 3.- Greenland halibut diet compounds by length groups, expressed as frequency of occurrence.

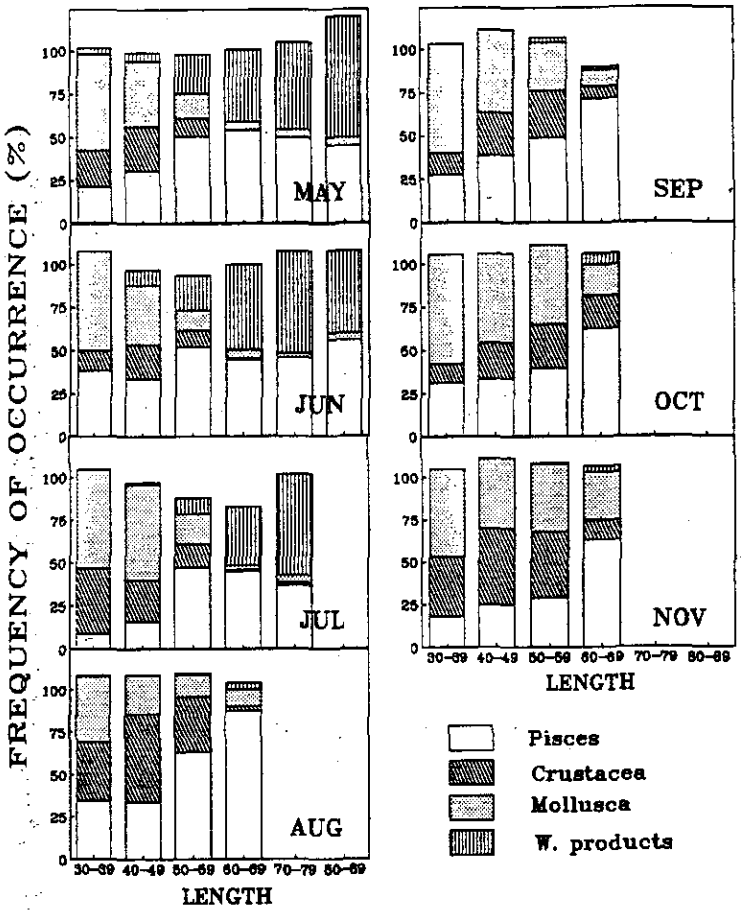

Figure 4.- Greenland halibut compounds by months and length groups (cm.).

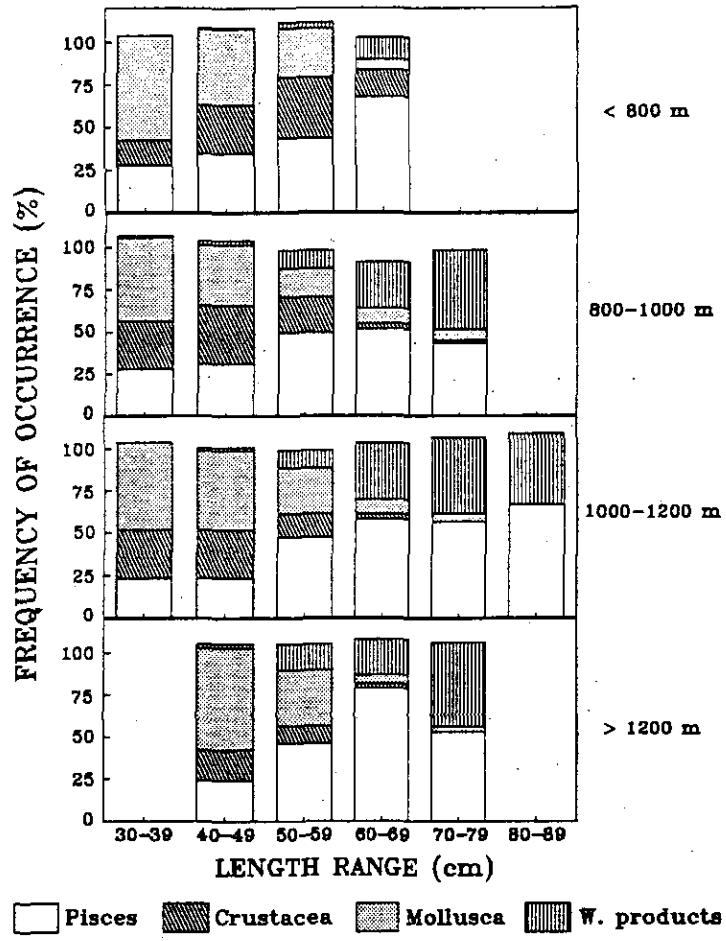

Figure 5.- Greenland halibut *compounds* by depth and length groups (cm.).

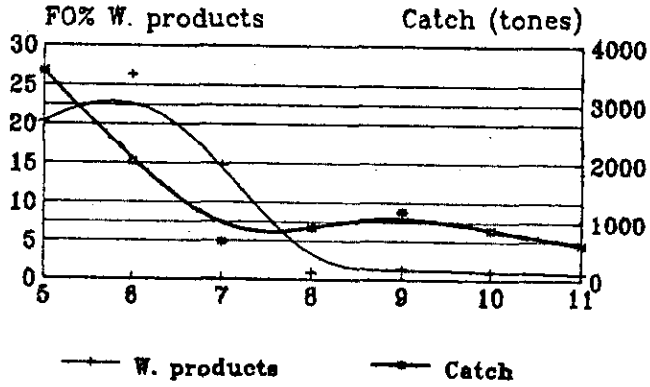

Figure 6.- Waste products (FO%) vs. Greenland halibut commercial catch by month in 3LM NAFO Divs. 1992.

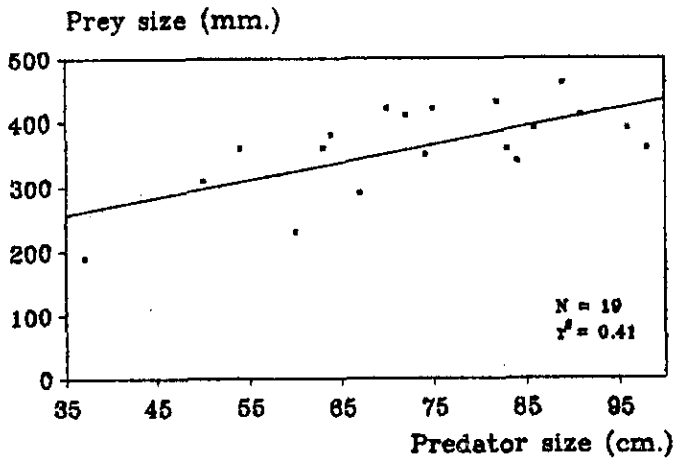

Figure 7.- Regression line between predator length and prey length (cannibalism).