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Predators of shrimp (Pandalus borealis) in the Cartwright (Div. 2J) and Hopedale (Div. 2H) Channels

by

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Abstract

The abundance and prey composition of Greenland halibut (Reinhardtius hippoglossoides) and cod (Gadus morhua) on shrimp (Pandalus borealis) grounds in Cartwright and Hopedale Channels were determined in July 1981. Greenland halibut, which had increased dramatically in biomass in 1980, returned in 1981 to near pre-1980 levels. These changes are attributed primarily to immigration before the 1980 fishing season and emigration before the 1981 season. The surge of Greenland halibut into the channels may have resulted in increased mortality of shrimp, but such natural mortality cannot be quantified or even demonstrated with present data. Many Greenland halibut stomachs were empty, but a high proportion of those with food contained shrimp. Cod fed predominantly on shrimp, and were found to be significant predators, even though their biomass was low compared with that of Greenland halibut, especially in Hopedale Channel. The examination of predator stomachs may yield information on distribution and growth rate of small shrimp.

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Résumé

L'abondance et la composition des proies du flétan du Groenland (Reinhardtius hippoglossoides) et de la morue (Gadus morhua) sur les bancs de crevettes (Pandalus borealis) dans les chenaux Cartwright et Hopedale ont été déterminées en juillet 1981. Le flétan du Groenland, dont la biomasse avait augmenté de façon dramatique en 1980, retourna en 1981 à des niveaux se rapprochant de ceux d'avant 1980. On attribue ces changements surtout à une immigration avant la saison de pêche de 1980 et à une émigration avant celle de 1981. Cette invasion du flétan du Groenland dans les chenaux peut avoir résulté en une mortalité accrue des crevettes, mais les données dont nous disposons présentement ne nous permettent pas de quantifier ou même de démontrer une telle mortalité naturelle. Plusieurs estomacs de flétan du Groenland étaient vides, mais une forte proportion de ceux qui contenaient de la nourriture renfermait des crevettes. La morue se nourrissait en grande partie de crevettes, et on a constaté qu'elle était un prédateur important, même si la biomasse de morue était faible comparativement à celle du flétan du Groenland, surtout dans le chenal Hopedale. L'examen des estomacs des prédateurs peut nous éclairer sur la répartition et le taux de croissance des petites crevettes.

Introduction

Research and commercial fishing data obtained from the Hopedale and Cartwright Channels in 1980 indicated a substantial increase in the abundance of Greenland halibut (Reinhardtius hippoglossoides) which is presumed to be the chief predator of shrimp in these areas. Cursory interpretation of the data (Bowering and Parsons, 1981) indicated the possibility of management alternatives, depending on whether or not the increase was an anomaly, compared to other years, or more long-standing. It was concluded that the data from the 1981 fishery and research survey could provide information concerning the effects of the increase in Greenland halibut on the shrimp resource and the opportunity to study predator-prey relationships in more detail in these areas. Therefore, in 1981, effort was directed towards the collection and interpretation of detailed information on food and feeding and abundance of Greenland halibut and cod (Gadus morhua), two major predators of shrimp.

This paper addresses the shrimp management implications introduced in the previous work and provides preliminary information on food and feeding habits of these predators in the two Labrador Channels.

Methods and Materials

A stratified survey for shrimp in the Labrador Channels was conducted during July 1981 and estimates of abundance obtained for shrimp, Greenland halibut and cod were compared to those obtained from surveys made in previous years. New information on the bathymetry of the Cartwright Channel facilitated

revision of the stratification scheme in this area (50 m depth zones) and data from earlier surveys were revised accordingly (Parsons et al., 1982). The 80.5 m research vessel Gadus Atlantica was used for the survey and all standard (30 min) fishing sets were made with a lined, Sputnik 1600 shrimp trawl.

Except where stomach samples were collected for detailed analysis, all Greenland halibut caught (or subsamples where catches were large) were measured and sexed and observations on maturity and the two main food items in the stomachs were recorded. Feeding data were sorted into three groups for qualitative analysis: 1) empty stomachs, 2) no shrimp in stomachs of fish that contained food, and 3) shrimp as a main food item in fish stomachs that contained food. Histograms of results for Cartwright and Hopedale Channels separately are presented by sex and with sexes combined.

All cod, or subsamples when catches were large, were measured. In some instances (28 sets, 1043 individuals) the two major prey in the stomachs, as indicated by their contribution to total food mass, were recorded. Stomachs from a further 93 cod from 8 sets were preserved in 10% formalin for detailed examination in the laboratory. The detailed examination involved separating food items into taxonomic categories, the level of identification varying with the relative importance of the items. Items in each taxon were placed briefly on absorbent paper to remove excess liquid, and then weighed to the nearest 0.1 g. Shrimp were counted and whenever digestion was not too far advanced their carapace lengths were measured to the nearest mm with vernier calipers.

Results and Discussion

1. Biomass Indices

Estimates of mean biomass for shrimp, Greenland halibut and cod for 1979-1981 are presented in Tables 1 and 2 for Cartwright and Hopedale Channels, respectively. Surveys for these three years occurred during the same time period (July) and employed a standard gear type. Abundance of shrimp in the Cartwright Channel remained relatively constant during the three years (note that the shallower strata and deepest stratum were not sampled in 1979). Greenland halibut showed a substantial increase in abundance in 1980 (reported previously) but declined again in 1981. Abundance of cod during the survey period in this area was low in 1979 and 1980, but appeared to increase in 1981. It should be pointed out, however, that the relatively large biomass estimate in stratum 708 (Table 1) resulted from the inclusion of data from one very large set.

In the Hopedale Channel (Table 2) shrimp abundance appears to have been stable between 1979 and 1980 but decreased greatly in 1981. Parsons et al. (1982) indicated that this low estimate may be due, in part, to a change in distribution from previous years and the resultant sampling error. Abundance of Greenland halibut was much lower in 1981 than in the previous year, but may have been higher than the 1979 level. Biomass estimates of cod were comparable between 1979 and 1981 but somewhat higher in 1980.

As a general rule, Greenland halibut biomass was highest in depths where shrimp were abundant in both Channels. Results from the Hopedale Channel in

1981, however, showed most Greenland halibut biomass in the deeper water (>422 m) as in previous years while a substantial proportion of shrimp biomass was found in shallower depths. Cod biomass, on the other hand, was not closely associated with distribution of shrimp and most occurred in the shallower strata.

Relative abundance of Greenland halibut from 1977 to 1980 was examined (Bowering and Parsons, 1981) by comparing the ratio of Greenland halibut to shrimp. This was done to minimize errors due to different surveyed areas, seasons, vessels and/or gears. The 1978 point for both Channels was interpolated due to the extremely low abundance of shrimp. Updating this figure to 1981 (Fig. 1) indicated a reduction in abundance from the 1980 level in the Cartwright Channel but no reduction in Hopedale. Because of the very low estimate of shrimp biomass in this area in 1981, this ratio (as in 1978) may be spurious. Figures 2 and 3 show the trend in Greenland halibut biomass for Cartwright and Hopedale Channels (and their 95% confidence intervals) from 1977 to 1981. In the former area abundance of Greenland halibut appears to have returned to levels experienced in years prior to 1980. In the latter, considerable reduction from the 1980 level is indicated, but not quite to pre 1980 levels.

Observer data from recent years also provide some indication of changes in Greenland halibut abundance. Table 3 suggests an increase in catch rates in most months for Greenland halibut in the Cartwright and Hopedale Channels from 1979 to 1980. Highest catch rates were obtained in July and August in the Hopedale Channel for all years but were considerably higher in 1980. Data for Cartwright Channel were lacking in 1981 due to a virtual absence of fishing effort in the area. Observer data, however, should be viewed with some caution since potential for sampling bias is high.

2. Composition of the Greenland halibut stock

Bowering and Parsons (1981) conjectured that the increase in abundance of Greenland halibut in 1980 in the Labrador shrimp channels was most likely related to immigration, with substantial changes in recruitment patterns being ruled out. Average weight of fish in each depth stratum increased between 1979 and 1980 which might reflect slight change in recruitment or immigration of larger animals. In 1981, average weight of fish in each stratum in the Cartwright Channel (Fig. 4) was lower than in the previous two years but more closely related to the pattern observed in 1979. The same type of data from the Hopedale Channel (Fig. 5) also indicated a reduction in average weight from 1980 but (as reflected in biomass indices) values remained higher than those observed in 1979. If there have been no appreciable changes in recruitment patterns, the decrease in Greenland halibut biomass between 1980 and 1981 might have been due in part to emigration of larger fish.

3. Greenland halibut stomach observations

A total of 5053 Greenland halibut stomachs were examined from the Hopedale Channel in 1981. For practical purposes, the length frequency distributions and feeding patterns were identical for males and females (Fig. 6). A breakdown of these data into 10 cm groups indicated that Greenland halibut greater than 30 cm which had food in their stomachs fed mainly on shrimp. More than 70% of the Greenland halibut beyond 30 cm in length that were feeding contained shrimp as a major food item. It is also clear that the importance of shrimp in the diet of Greenland halibut in this area increased in the progressively larger size groups.

A total of 7337 Greenland halibut stomachs were examined from the Cartwright Channel area. The results were very similar to those of Hopedale Channel in that substantial numbers containing food fed on shrimp, particularly at the larger sizes (Fig. 7). No appreciable differences occurred between the sexes.

A comparison between Channels with the sexes combined is presented in Fig. 8. The patterns were basically similar for the two Channels except that there appears to be a slightly higher proportion of smaller fish (<20 cm) in the Cartwright Channel. These also appear to have fed more heavily on shrimp than the same size group in Hopedale Channel. For both Channels, however, the porportion of larger ($\geq$30 cm) Greenland halibut with stomach contents that were feeding on shrimp was quite substantial.

It is also clear from these data that a large portion of these fish had empty stomachs during the survey period. There are at least two explanations of this observation: 1) that at any time a large proportion of Greenland halibut are not feeding and shrimp mortality from this component of predation must be estimated accordingly and 2) that the high proportion of empty stomachs may result from regurgitation as a result of being captured and hauled to the surface.

4. Cod stomach contents

The major prey of cod in both Cartwright and Hopedale Channels was shrimp (Table 4). In Cartwright Channel, in both the stratified area and adjacent areas, shrimp occurred as the first or second most important prey in more than

80% of the cod examined. Greenland halibut was also important but occurred less frequently (11-33%). The intensity of sampling was far less in Hopedale Channel, where in 3 sets in Zones 2 and 3, shrimp occurred in 57% of the cod.

To determine whether shrimp abundance was reflected in percentage occurrence in cod stomachs, the observations from Cartwright Channel were grouped into two depth zones: <350 m and 350-500 m. Shrimp were more abundant in the deeper zone (Table 1). Occurrence of shrimp in cod stomachs differed little between the 2 zones (Table 4). However, Greenland halibut occurred more frequently in depths <350 m, possibly reflecting greater abundance of small (<14 cm) Greenland halibut at shallow depths (Bowering and Parsons, 1981 and this paper).

To determine the influence of cod size on the extent of predation on shrimp, the cod from Cartwright Channel were grouped into 9 cm length-groups in each of the 2 depth zones described above. Length frequencies included all cod caught in each depth zone. The majority of cod in both depth zones were large (54-71 cm) (Fig. 9). Only in the smaller (<36 cm) cod did shrimp occur in less than 50% of the stomachs.

The detailed sample was small, but provided some quantitative measure of the intensity of predation by cod on shrimp (Table 5). In Cartwright Channel the mean number of shrimp per stomach was 12.7 (range in individual sets: 3.9 - 19.3), and the mean weight per stomach was 49.8 g (range in individual sets: 22.8 - 80.1). In the single set examined in Hopedale Channel (Zone 1) the mean number and weight of shrimp per stomach were 7.5 and 40.8 g respectively.

The number and weight of shrimp recovered from stomachs of cod from the Cartwright Channel increased with cod size (Fig. 10), but there was great variability in number and weight for cod of a given size. The largest quantity of shrimp found in a single stomach was 86 individuals weighing 307 g recovered from a 71 cm cod. The relationship between cod size and maximum number or maximum weight of shrimp could not be determined accurately, for the sample size was small and there were few cod less than 54 cm.

The cod preyed upon a wide size range of shrimp (6-28 mm) (Fig. 11). To facilitate a comparison between sizes of shrimp recovered from cod stomachs and shrimp caught by the trawl, the original measurements of the latter, which had been recorded to the nearest 0.5 mm below, were grouped into 1 mm length-classes with the whole integer as the midpoint of the interval. Peaks in the length frequency distribution of shrimp from cod stomachs tended to mirror peaks in the distribution of shrimp from the trawl, but the former tended to be offset to the left, especially for the larger shrimp. The cod stomachs yielded a much higher proportion of small shrimp, and peaks at 7-8 mm and 12 mm were more pronounced.

The wide size range of shrimp consumed by cod is somewhat surprising, since cod are known to be size-selective predators (e.g. Daan, 1973; Lilly and Fleming, 1981). The consumption of many small shrimp may simply reflect a relatively higher abundance of these sizes.

Greenland halibut recovered from cod stomachs ranged in length from 9 to 31 cm total length, but most were 10-12 cm and all but one were less than 20 cm.

A high proportion of the cod caught in Cartwright and Hopedale Channels were preying on shrimp, but the quantity of shrimp recovered from stomachs during the detailed examination was not large compared to the quantity of capelin sometimes found in cod stomachs in other areas (Lilly and Fleming, 1981). Nevertheless, the consumption of shrimp by cod might be significant compared with the commercial shrimp catch.

The quantity of shrimp which might be consumed by cod annually in Cartwright Channel may be crudely estimated under the following assumptions:

1) The number of cod in the channel is on the average equal to the trawlable number estimated during the 1981 survey. If one very large set (1669 individuals, 3347 kg) is excluded, the number of cod estimated by areal expansion of arithmetic mean catch rates is 386.2×10^3.

2) The average weight of shrimp per cod stomach is 50 g (Table 5).

3) The cod refill their stomachs every 3 days. The rate of evacuation of shrimp from the stomachs of Labrador cod at 2-3°C is not known, but other investigators (e.g. Minet and Perodou, 1978; Tiews, 1978) have assumed a refilling time of 3 days.

4) The period of feeding by cod on shrimp is one half year. There is no information to support this, but Turuk (1968) reported that cod of southern Labrador feed most intensively from June to December.

Under these assumptions, the annual consumption of shrimp by cod within the stratified area of Cartwright Channel might be about 1200 t (actual computation 1172 t).

A comparison between the predatory impact of cod and that of Greenland halibut is not possible until detailed examination of Greenland halibut stomachs has been completed and more extensive information on cod stomachs is available. However, the percentage occurrence of shrimp is much higher in cod, and the cod are larger, possibly enabling them to ingest more shrimp per unit biomass. In Hopedale Channel the cod biomass is relatively very low, and Greenland halibut should be the major predator, but in Cartwright Channel cod may approach Greenland halibut in importance.

The intensity of predation on shrimp will depend on the abundance of predators at different periods of the year, the intensity of predator feeding, the abundance and availability of shrimp, and the abundance and availability of alternate prey, particularly small Greenland halibut. More reliable estimates of shrimp consumption will require better information on predator abundance, stomach contents and gastric evacuation rates.

Conclusions

Data from research and commercial fishing in the Cartwright and Hopedale channels indicated that abundance of Greenland halibut in 1981 was less than that observed in the previous year. In the former area, abundance declined to levels observed prior to 1980 but in the latter, the decline was not so pronounced. No dramatic fluctuations in abundance of cod were observed during the same period.

Shrimp biomass in the Cartwright Channel (1979-81) did not change significantly based on biomass estimates obtained from research surveys. This apparent stability occurred during a period when shrimp landings were reduced from over 1000 t in 1979 to less than 200 in 1980 and less than 100 in 1981. Although the increase in Greenland halibut biomass in 1980 does not appear to have greatly affected the shrimp resource in this area, it might have limited any resurgence of the stock which could have occurred as a result of a reduction in fishing mortality.

Abundance of shrimp in the Hopedale Channel was stable between 1979 and 1980 but results of the 1981 survey indicated a sharp reduction. Since commercial catch rates for the season were at the lowest levels during the survey period in 1981 (as in 1978) the biomass index is likely underestimated. However, since peak catches in 1981 were somewhat lower than in previous years (Parsons et al., 1982) and the decline in Greenland halibut does not appear to balance the increase observed in 1980, the presumed increased predation may have affected the shrimp resource in the area in terms of distribution and/or abundance.

There is some indication that immigration and emigration are involved in the changes in abundance of Greenland halibut observed between 1979 and 1981 in these areas. It appears that all sizes of fish are involved but there is also circumstantial evidence which suggests the migration may be particularly associated with larger animals. The age composition of Greenland halibut should be examined in each year to determine whether or not this is true. Emigration might have balanced the previous immigration in the Cartwright Channel but apparently not in the Hopedale Channel.

Greenland halibut fed mainly on shrimp in these areas during the survey period. This is particularly true for the larger sizes. However, incidence of empty stomachs was high, casting some uncertainty on the frequency of feeding for individuals. Shrimp are also the major prey of larger cod in the channels and related shrimp mortality may be significant relative to the commercial catch. Although Greenland halibut are more closely associated with shrimp in terms of depth distribution and are more plentiful than cod, the latter may be able to ingest more shrimp per unit biomass. This becomes increasingly important if and when shrimp move into shallower waters and/or cod migrate into the channels at certain times of the year.

Since the proportion of small shrimp in cod stomachs is high compared to the proportion obtained in the research trawl catch, the use of predators as sampling devices should be explored. Shrimp from stomachs of predators might yield more detailed information on the distribution of small shrimp and provide estimates of relative strengths of cohorts. Even the limited observations presented above suggest two modal (year) classes around 7 and 12 mm carapace length which are rarely seen so definitively in trawl catches. Such detail will provide valuable information on age and growth of shrimp, especially in the interpretation of the size of the first age group.

Due care must be given to the correct identification of partially digested shrimp. This is of particular importance when samples are taken in relatively shallow water and the proportions of small shrimp are high. In shallower, colder water, the probability of predators (especially cod) consuming the striped pink shrimp (Pandalus montagui) and Eualus mascilentus is high. Identification becomes progressively difficult with increased digestion and mixing the two or more prey species could produce spurious results.

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Table 1. Estimates of mean biomass (t) for shrimp, Greenland halibut and cod in the Cartwright Channel, 1979-81[1].

Stratum	Depth Range (m)	1979 Shrimp	1979 Greenland Halibut	1979 Cod	1980 Shrimp	1980 Greenland Halibut	1980 Cod	1981 Shrimp	1981 Greenland Halibut	1981 Cod
702	301-350				189.9	381.4	201.1	54.4	44.3	47.1
703	351-400				-	-	-			
704	<250				-	-	-	9.0	17.8	81.0
705	251-300				-	-	-			
706	301-350	7.5	41.3	81.8	3.0	117.8	46.8	25.4	29.9	251.0
707	351-400	17.1	94.5	57.9	99.0	240.8	36.8	239.7	94.1	130.1
708	401-450	115.9	319.4	35.2	405.0	535.5	27.2	887.3	401.5	973.9
709	451-500	528.6	553.9	51.5	512.9	1018.2	60.2	612.0	316.0	60.2
710	501-550	1222.6	730.0	17.1	992.0	1804.5	76.5	341.7	234.7	41.4
711	451-500				63.8	304.3	20.5	66.9	92.6	2.9
712	>551	-	-		523.5	929.9	42.6	131.1	146.6	7.2
Total		1891.7	1739.1	243.5	2789.1	5332.4	511.7	2367.5	1377.5	1594.8

[1]Based on revised stratification system (Parsons et al. 1982).

Table 2. Estimates of mean biomass (t) for shrimp, Greenland halibut and cod in the Hopedale Channel, 1979-1981.

Stratum	Depth Range (m)	1979 Shrimp	1979 Greenland Halibut	1979 Cod	1980 Shrimp	1980 Greenland Halibut	1980 Cod	1981 Shrimp	1981 Greenland Halibut	1981 Cod
102	202-238	67.6	30.0	3.8						
103	239-274	337.9	17.8	162.9	14.0	41.9	21.4	301.6	23.4	18.2
104	275-311	53.4	20.2	12.9	24.1	50.8	39.3	219.4	54.9	4.3
105	312-348	119.1	62.9	43.2	147.7	136.0	72.5	634.5	156.4	22.4
106	349-384	343.3	81.7	55.5	88.0	289.5	132.6	628.7	286.6	55.6
107	385-421	728.2	137.8	72.8	143.3	452.6	139.4	203.2	207.0	26.2
108	422-457	582.6	132.5	41.8	454.2	725.4	151.9	301.4	412.3	11.6
109	458-494	1900.5	397.9	42.9	838.1	1334.1	24.1	184.5	618.9	53.6
110	495-530	2000.7	1021.1	0.0	3797.8	2562.8	110.5	348.6	1885.8	25.3
111	531-567									
112	568-603	1972.6	370.5	1.4	1848.1	2160.4	16.6	49.8	484.7	0.0
113	604-639									
204	275-311				150.1	72.1	81.2	366.5	33.7	55.5
205	312-348	62.2	182.2	84.4	142.2	95.6	142.2			
206	349-384	734.3	79.3	21.5	229.8	70.0	31.0	197.3	36.1	21.0
207	385-421	17.0	15.8	0.0	269.3	246.5	80.1			
208	422-457	2137.9	148.0	0.0	2159.8	720.4	110.8	295.8	372.3	159.3
209	458-494	45.5	153.4	8.3	259.3	1070.1	77.2			
210	495-530	23.2	107.3	0.0	103.9	1126.9	17.9			
211	531-567	129.1	540.9	0.9	38.9	2923.0	11.4	206.8	2621.7	0.0
212	568-603	15.6	395.5	0.0	127.4	2516.2	0.0			
213	604-639				39.1	1472.0	0.0			
214	640-675									

Table 2. (Cont'd)

Stratum	Depth Range (m)	1979 Shrimp	1979 Greenland Halibut	1979 Cod	1980 Shrimp	1980 Greenland Halibut	1980 Cod	1981 Shrimp	1981 Greenland Halibut	1981 Cod
304	275-311				18.3	173.6	267.0			
305	312-348	11.7	105.1	43.7	47.8	276.6	62.1	13.4	33.3	16.5
306	349-384	78.1	61.7	19.4	96.5	333.5	80.8	21.2	43.8	286.0
307	385-421	144.1	51.2	4.0	127.8	199.2	18.4	]86.7	250.7	54.1
308	422-457	97.9	23.6	0.0	130.1	331.0	22.8			
309	458-494	] 3.7	1.6	0.0	82.0	156.7	5.1	33.3	65.7	0.5
310	495-530				71.4	164.6	0.9	22.9	12.9	1.1
311	531-567				120.3	302.8	2.0	8.5	7.1	0.0
312	568-603	1.9	1.7	0.0	66.6	515.2	2.9	13.7	13.6	1.0
313	604-639				]203.7	2765.8	0.0	75.3	929.6	0.0
314	640-675									
Total		11608.1	4139.7	619.4	11839.6	23285.3	1722.1	4213.1	8551.4	812.2

Table 3. Estimates of catch per hour (kg) for Greenland halibut from observers' reports.

	Cartwright			Hopedale		
	1979	1980	1981[1]	1979	1980	1981
May						23
June	4	24		18	7	8
July	-	49		26	97	63
Aug.	17	50		36	119	35
Sept.	31	31		19	38	12
Oct.	-	4		-	15	20
Nov.	-	3		-	11	26
Dec.	-	-		-	5	23

[1]Fishing effort too low to obtain reliable estimates.

Table 4. Occurrence of shrimp and Greenland halibut in stomachs of cod from Cartwright and Hopedale Channels, July 1981.

	Depth (m)	No. of sets	No. of cod	Shrimp[1] %	Greenland[1] halibut %
Cartwright Channel					
Stratified area	<350	4	190	86.3	31.6
Stratified area	350-500	17	370	80.0	10.8
N of stratified area	405-482	3	143	82.5	13.3
E of stratified area	287	1	224	92.9	33.0
Hopedale Channel					
Zones 2 and 3	345-396	3	116	56.9	9.5

[1]Percentage occurrence as first or second most important prey in all cod, including those with empty stomachs.

Table 5. Average number and weight of shrimp in stomachs of cod from individual sets in Cartwright and Hopedale Channels, July 1981.

Set	Depth (m)	No. of cod caught	No. of cod examined	Cod[1] length(cm)	No. shrimp per cod	Wt. shrimp per cod (g)
Cartwright Channel						
29	282	34	14	60(28-72)	7.3	27.3
30	304	3	3	66(63-76)	4.7	22.8
28	328	5	5	54(26-66)	8.8	35.2
9	331	19	18	66(55-91)	19.3	80.1
45	405	9	9	56(21-69)	3.9	23.7
36	424	1669	13	62(49-89)	14.8	54.3
41	440	73	16	58(27-86)	15.8	55.9
Average					12.7	49.8
Hopedale Channel						
154	471	15	15	63(53-76)	7.5	40.8

[1]Median length (range in brackets) of cod examined.

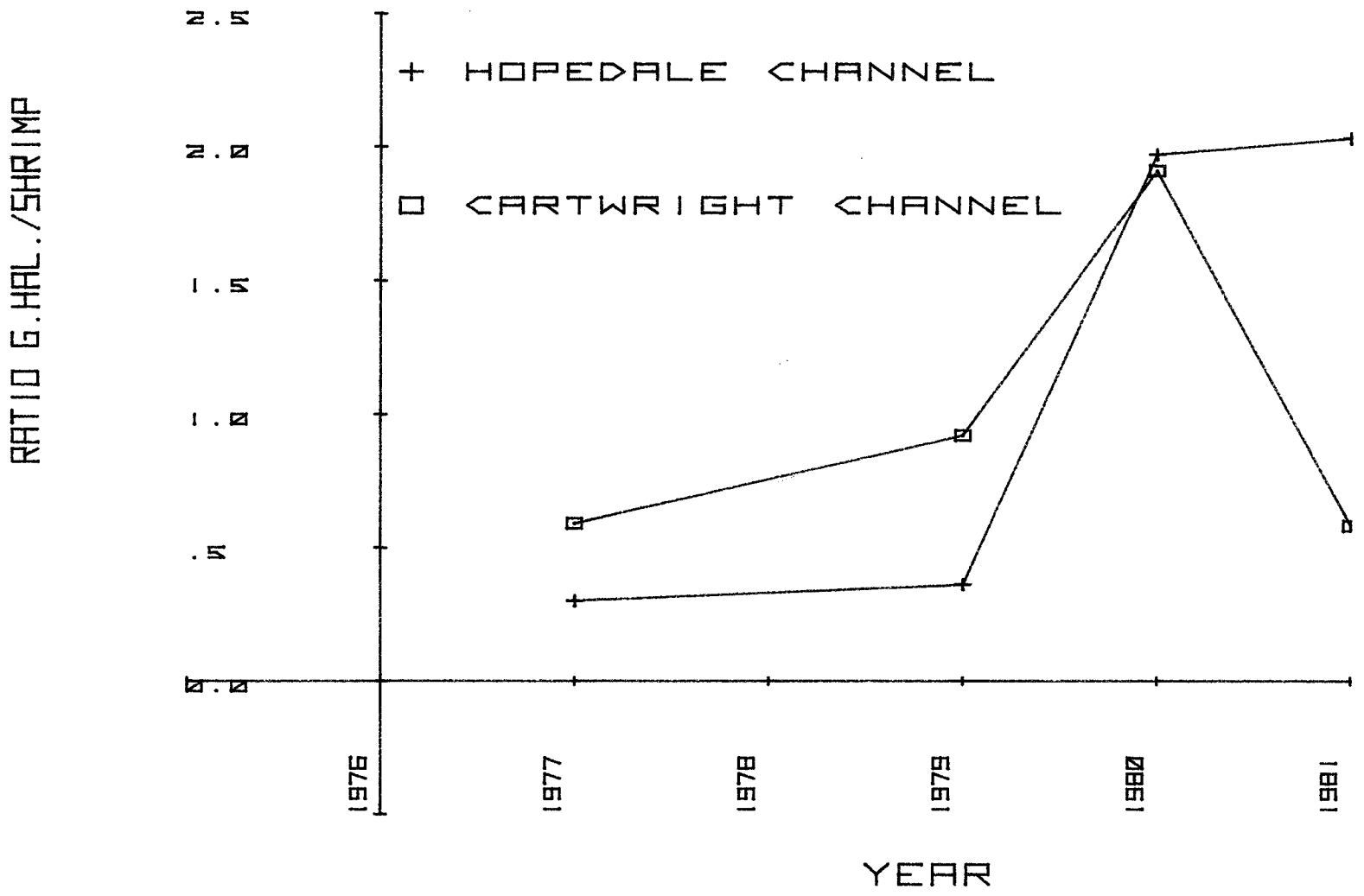

Fig. 1. Ratio of Greenland halibut biomass to shrimp biomass in two Labrador channels from 1977 to 1981. The 1978 values are interpolated.

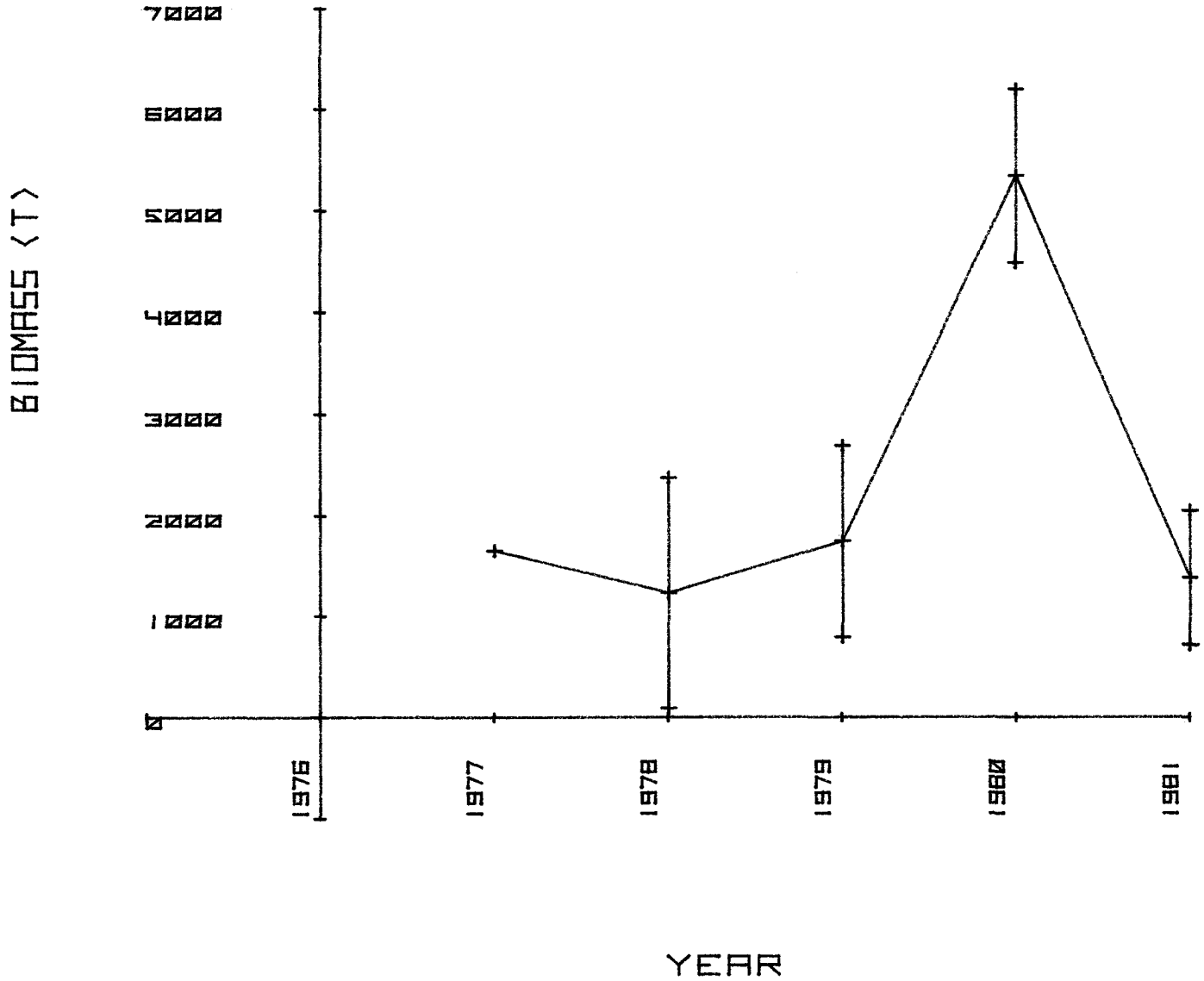

Fig. 2. Mean estimates of Greenland halibut biomass and 95% confidence intervals, 1977-1981, in the Cartwright Channel.

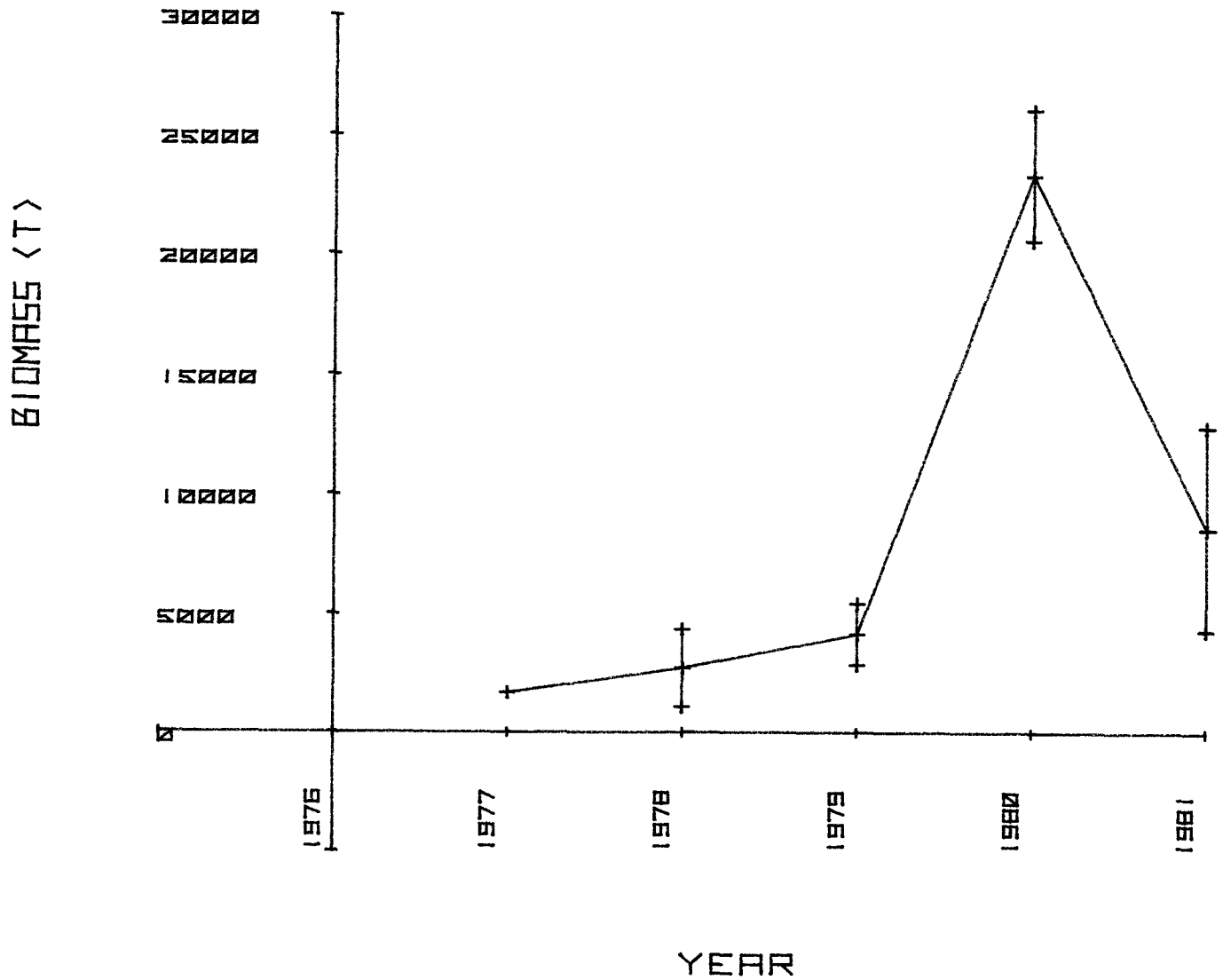

Fig. 3. Mean estimates of Greenland halibut biomass and 95% confidence intervals, 1977-1981, in the Hopedale Channel.

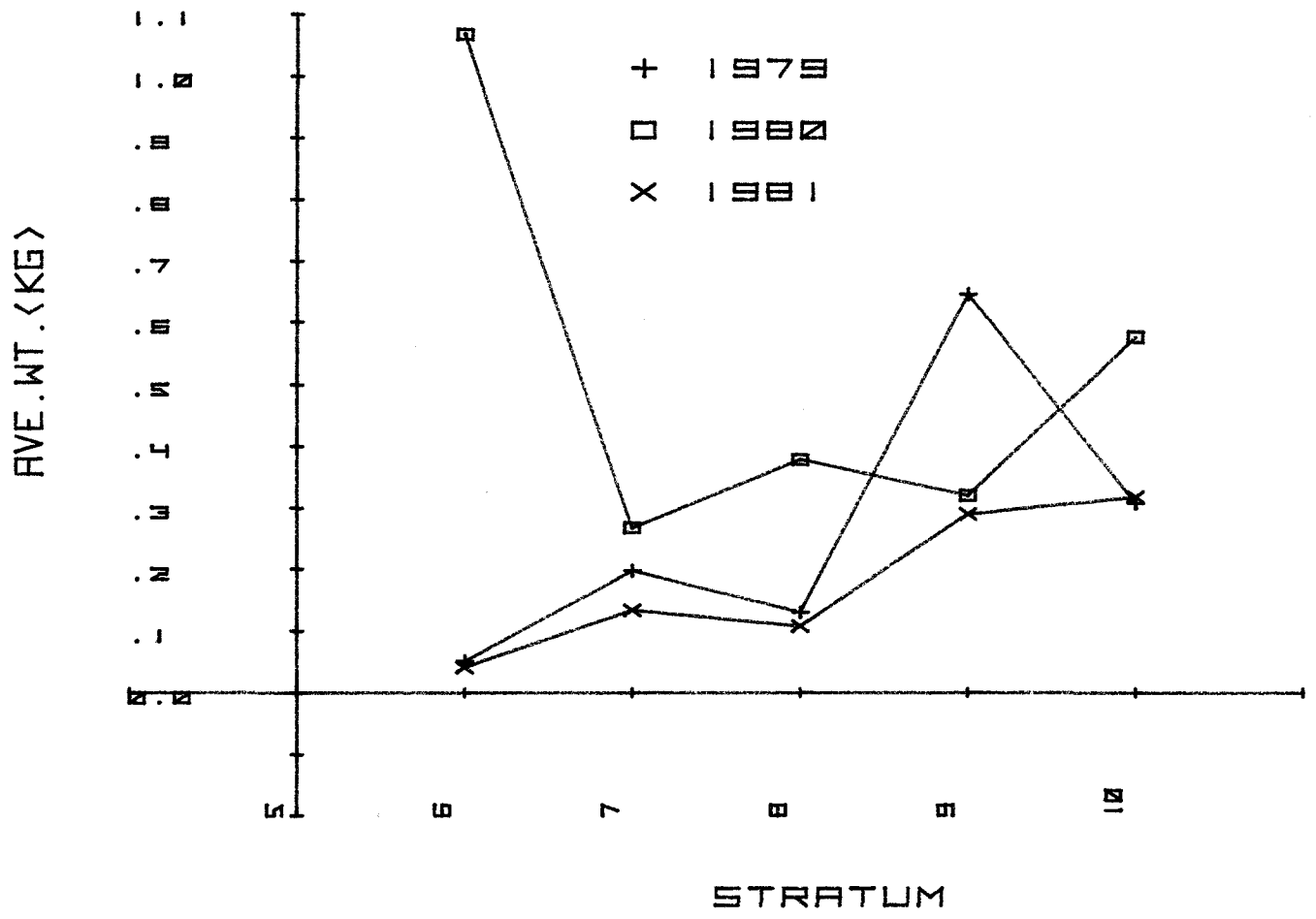

Fig. 4. Average weight of Greenland halibut by stratum, 1979-1981, in the Cartwright Channel. (Depths corresponding to stratum numbers are given in Table 1.)

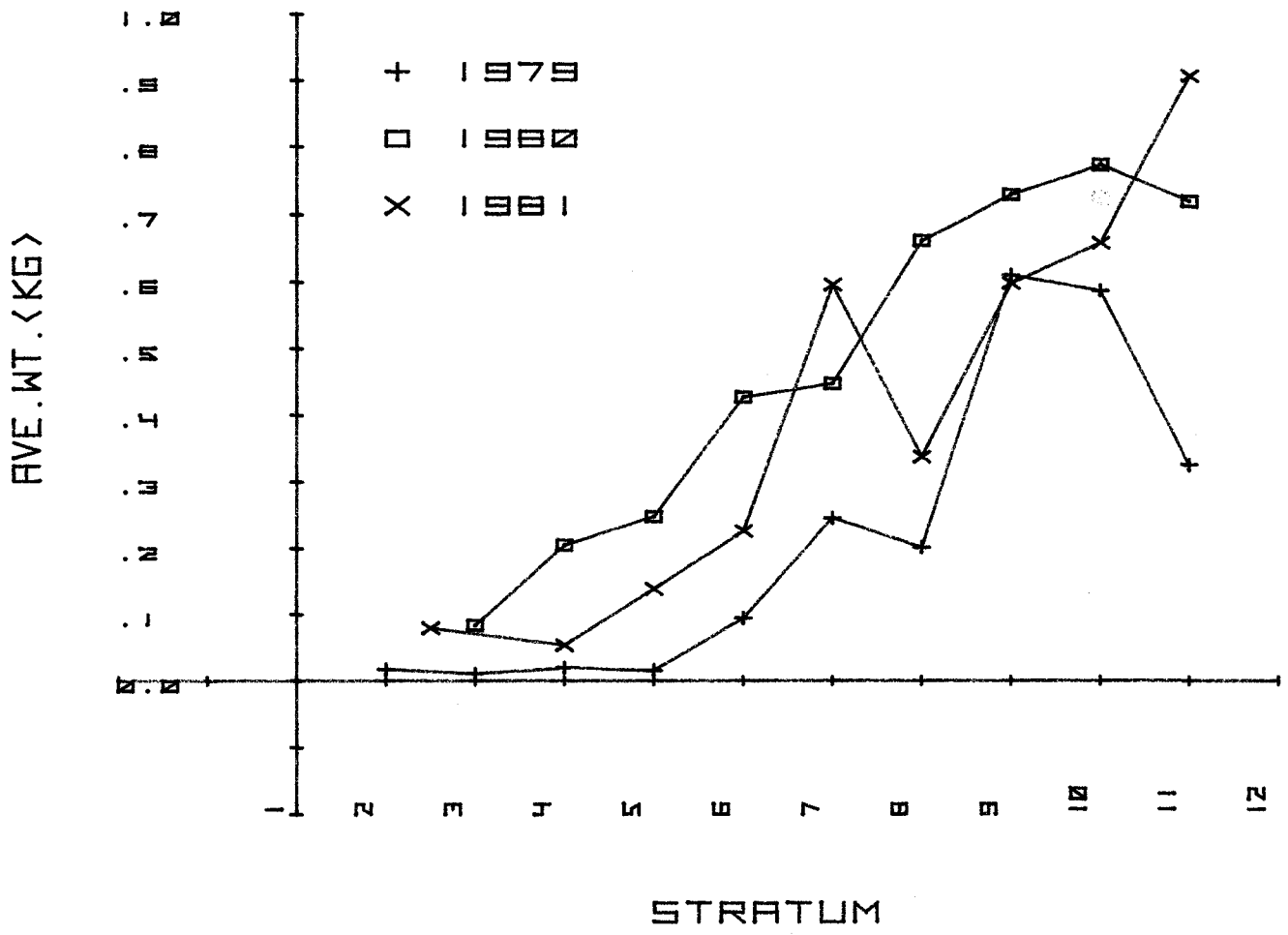

Fig. 5. Average weight of Greenland halibut by stratum, 1979-1981, in the Hopedale Channel (Zone 1). (Depths corresponding to stratum numbers are given in Table 2.)

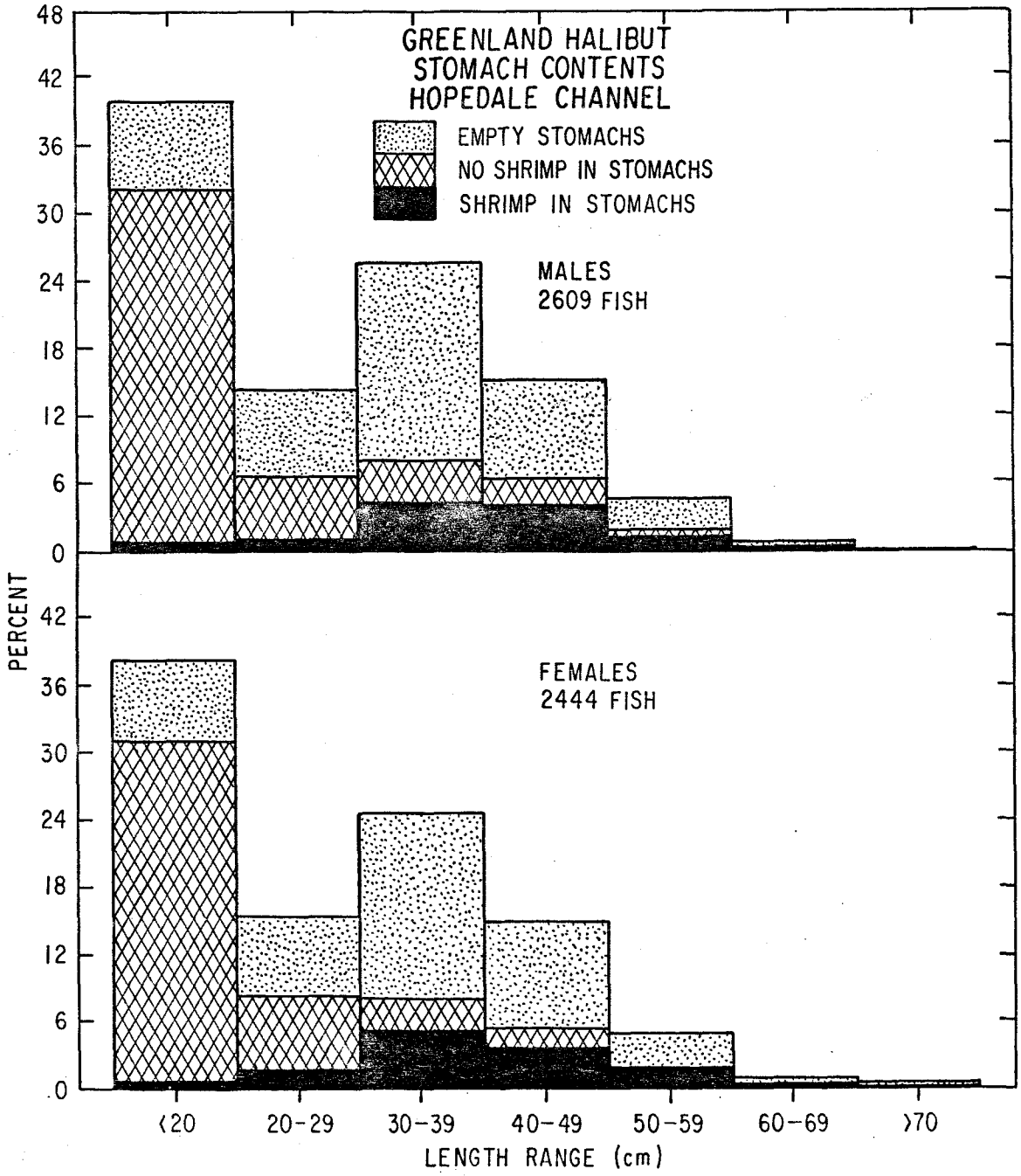

Fig. 6. Length frequencies and stomach contents of Greenland halibut by sex, Hopedale Channel, 1981.

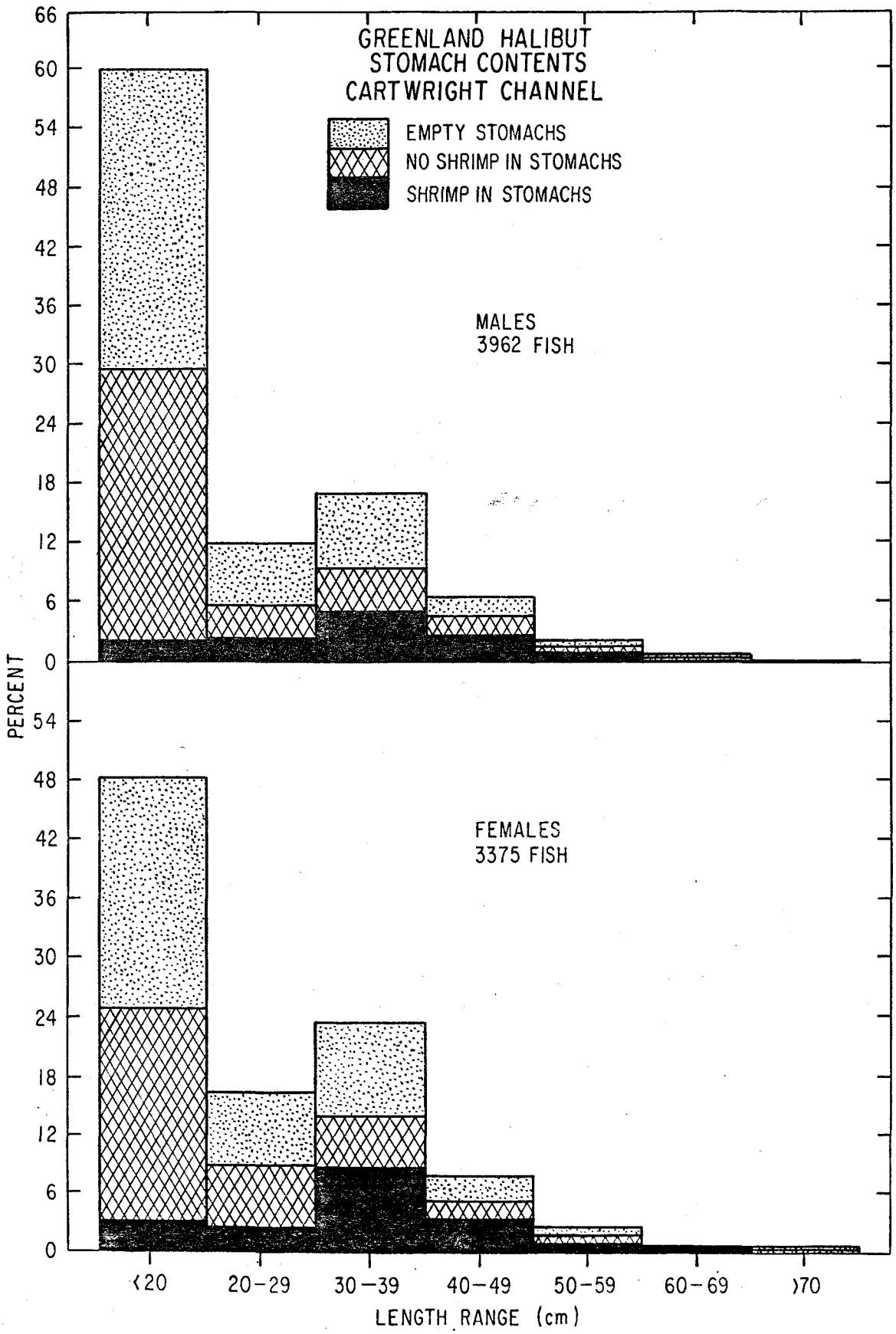

Fig. 7. Length frequencies and stomach contents of Greenland halibut by sex, Cartwright Channel, 1981.

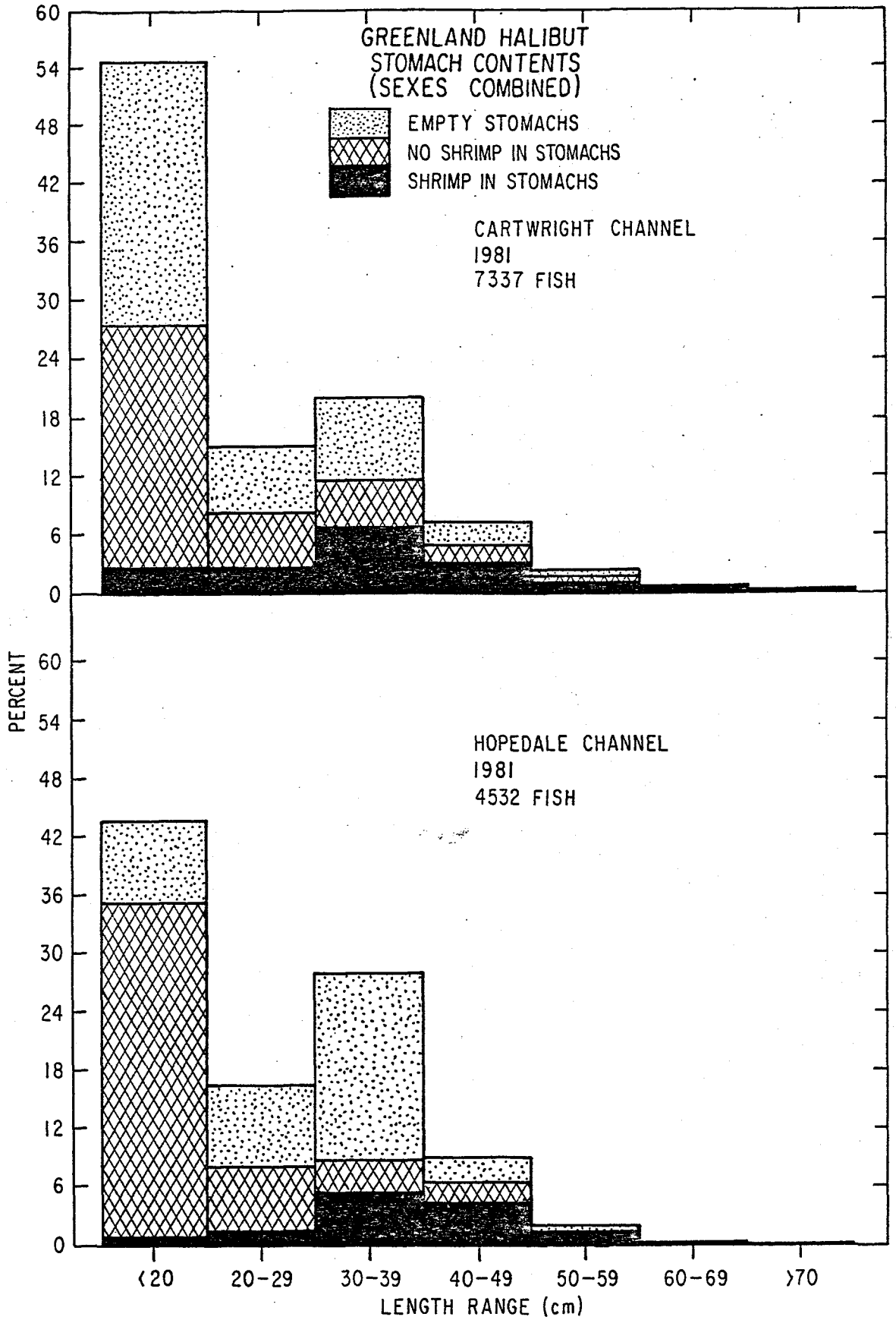

Fig. 8. Length frequencies and stomach contents of Greenland halibut for Cartwright and Hopedale channels, 1981 (sexes combined).

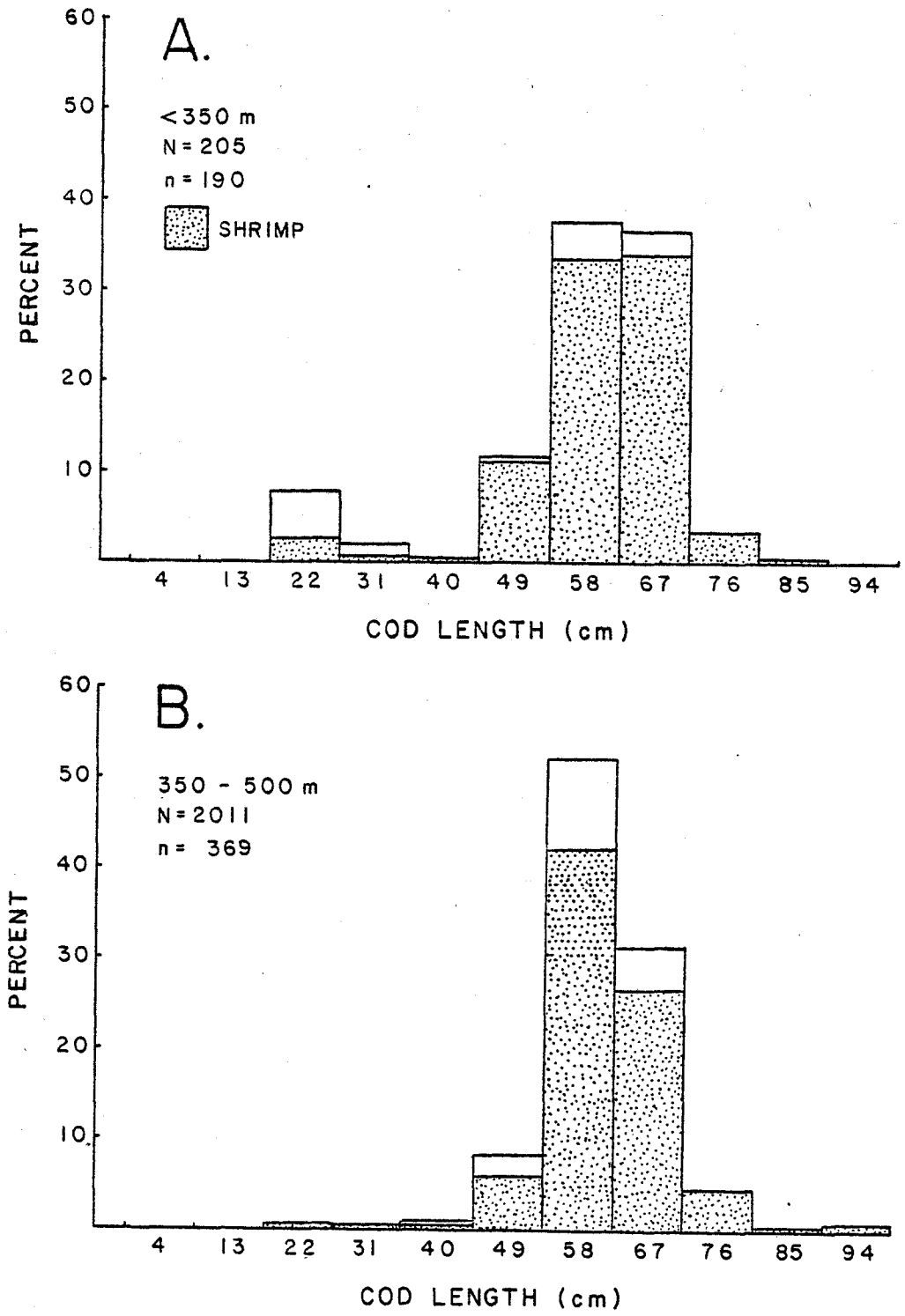

Fig. 9. Length frequencies of cod caught in Cartwright Channel in (A) <350 m and (B) 350-500 m. Shaded areas indicate the proportion of cod in each length-group in which shrimp occurred as the first or second most important prey. N = number of cod caught, n = number of cod stomachs examined.

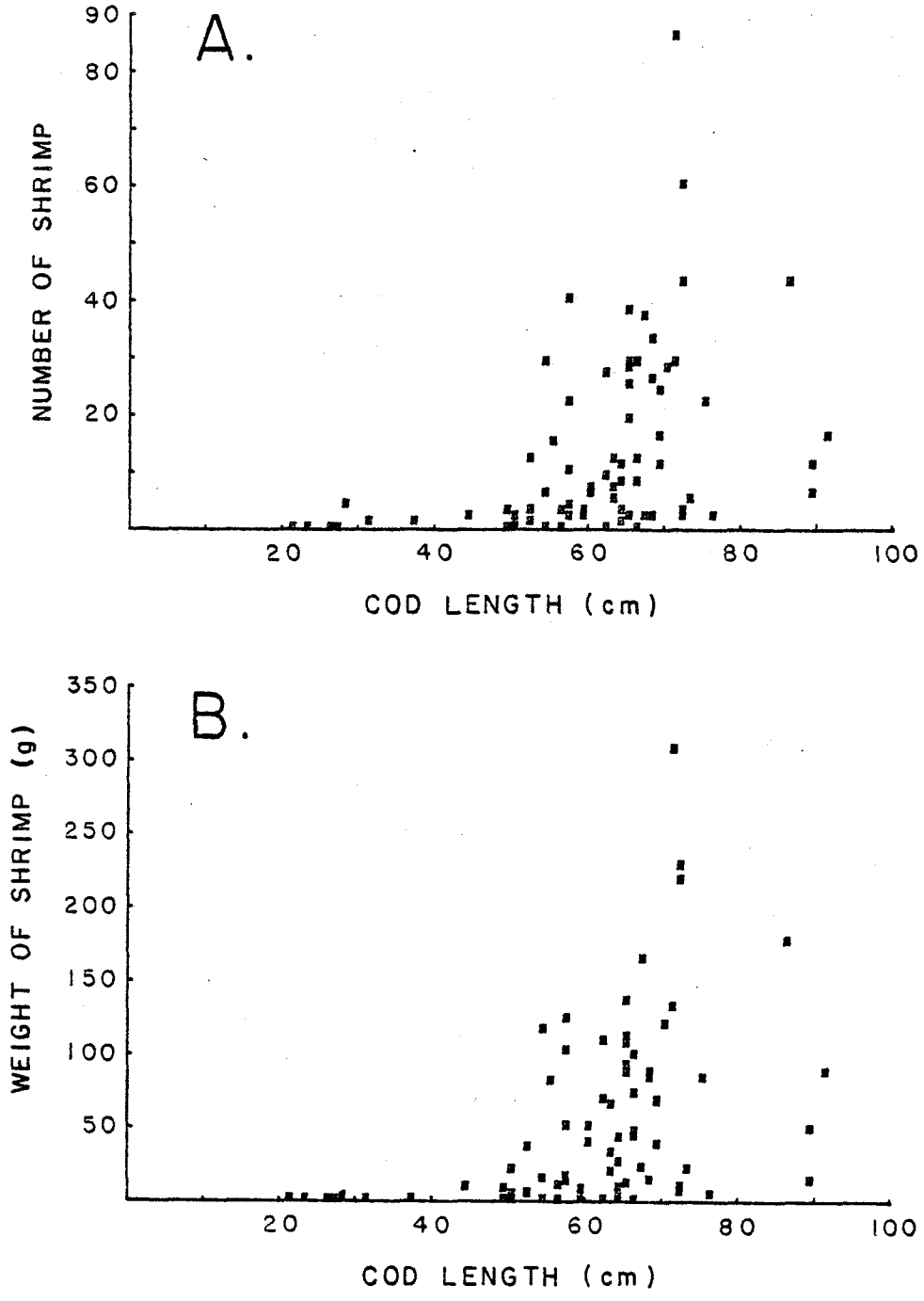

Fig. 10. Relationship between length of cod and (A) number and (B) weight of shrimp recovered from cod stomachs. Cod were caught in Cartwright Channel.

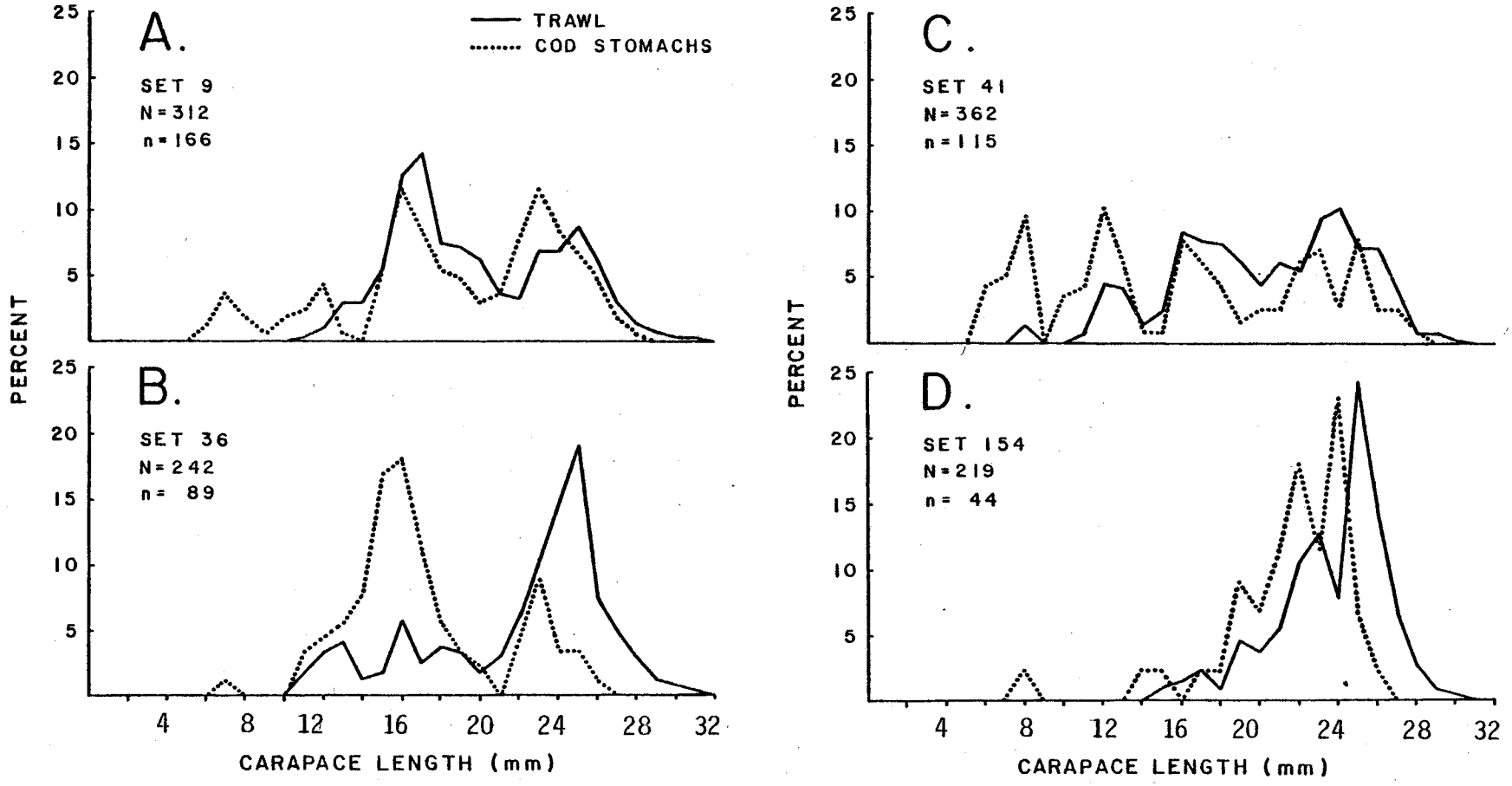

Fig. 11. Length frequencies of shrimp caught by the trawl and recovered from cod stomachs in (A) set 9, Cartwright Channel, 331 m; (B) set 36, Cartwright Channel, 424 m; (C) set 41, Cartwright Channel, 440 m; (D) set 154, Hopedale Channel, zone 1, 471 m. N and n are the number of measured shrimp from the trawl and from cod stomachs respectively.