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Observation on The Relationships Between Shrimp (*Pandalus borealis*) and Greenland Halibut (*Reinhardtius hippoglossoides*) in two Labrador Channels

by

W. R. Bowering and D. G. Parsons[1]
Fisheries and Oceans
Research and Resource Services
P. O. Box 5667
St. John's, Newfoundland
A1C 5X1

ABSTRACT

A pronounced increase in abundance of Greenland halibut has been observed in recent years in the Labrador shrimp channels. Biomass estimates and distribution of both species and food and feeding data for Greenland halibut in these areas were reviewed to provide a preliminary assessment of the relationship. Results indicated increases in abundance for Greenland halibut in 1980 of two to four times the 1979 level attributed mainly to immigration. It was also shown that mainly Greenland halibut feed heavily on shrimp in these areas. The observed increase may have a significant effect on shrimp mortality but the magnitude may not be evident until the research survey in 1981. During this survey the interaction should be studied in detail.

RESUME

On a observé ces dernières années une augmentation sensible du flétan du Groenland dans les chenaux à crevettes du Labrador. Les estimations de biomasse et la distribution des deux espèces, de même que les données sur la nourriture et les moeurs alimentaires du flétan du Groenland ont été examinées en vue d'une évaluation préliminaire de la relation. Les résultats indiquent qu'en 1980, l'abondance du flétan du Groenland était de deux à quatre fois supérieure à celle de 1979 et que l'immigration était en grande partie responsable de cette augmentation. On a également constaté que le flétan du Groenland était la principale espèce à se nourrir de crevettes dans ces régions. L'augmentation observée peut influer de façon significative sur la mortalité des crevettes. On ne pourra toutefois connaître l'amplitude de ces mortaltiē avant le relevé par navire de recherche de 1981. On devrait alors étudier l'interaction en détail.

[1] Authorship in alphabetical order.

INTRODUCTION

Recent research in areas of shrimp abundance off Labrador has shown that considerable concentrations of Greenland halibut also occur in these areas (Axelsen et al. 1979, Parsons et al. 1979, 1980). Studies on the food and feeding habits of Greenland halibut at West Greenland reveal that shrimp (Pandalus borealis) is a principal food item and that dense concentrations of Greenland halibut can be expected where these shrimp are plentiful (Atkinson et al. 1981, in prep., Smidt 1969). Any increase in the abundance of Greenland halibut in such areas may be interpreted as an added component to the natural mortality (M) of shrimp provided other related factors remain relatively constant. An unprecedented (and detectable) increase in M has far-reaching effects in the management of the shrimp resource since it is more expedient to exert fishing mortality than to let significant numbers die through natural mortality. This situation can be easily described by simulating a situation using the approximate formula $Y = 0.5\ M\ B_0$ (Gulland 1974). When M is small, less biomass is removed permitting contribution to the total stock size and sustainable yield through growth and repeated reproduction. With a higher M more of the stock is available for harvesting in a given year since contributions through growth and reproduction are reduced. When M is very high (which may be true for Pandalids, generally) any "sustainable" concept in the above equation becomes somewhat nebulous.

Results of a research survey in the Labrador shrimp channels in 1980 have indicated a significant increase in the abundance of Greenland halibut from the previous year. Consequently, a preliminary investigation was carried out in an attempt to determine the magnitude of this increase, project what implications it might have on the shrimp resources and provide appropriate management advice.

METHODS AND MATERIALS

Estimates of trawlable biomass of shrimp and Greenland halibut were obtained from stratified biomass surveys for shrimp conducted in the Labrador channels (Fig. 1) during 1977-80 using a lined Sputnik 1600 shrimp trawl. The areas were stratified by 40 meter depth zones and the data were organized and presented as such in order to highlight possible relationships. The two channels considered here are Hopedale and Cartwright which are the areas of commercial importance for shrimp abundance off the eastern Labrador coast.

During August 1978 and September 1979 research surveys (100 meter zones up to 500 meters) for groundfish were conducted in NAFO Div. 2G and 2H using an Engels high-rise ground otter-trawl with a small mesh liner in the cod-end. During both surveys immediate visual stomach examinations were carried out on large numbers of Greenland halibut by estimating the degree of stomach fullness (0-10 scale) and recording the principal food item in each. In order to determine any relationships that might have existed between the feeding behaviour of Greenland halibut and the commercial reserves of shrimp, only stomach samples taken in Hopedale and Cartwright channels were considered here.

RESULTS AND DISCUSSION

1. BIOMASS INDICES

Estimates of minimum trawlable biomass for shrimp and Greenland halibut are available for the years 1977 to 1980. To eliminate inconsistencies between years when comparing actual results the biomass ratios of Greenland halibut to shrimp for each year for the same strata were plotted (Fig. 2) thus giving comparable relative abundance indices of one species to the other. Assuming that shrimp biomass has remained relatively constant (Parsons et al. 1981), the data suggest a marked increase in the Greenland halibut abundance for both channels from 1979-80. The 1978 data have been interpolated since the survey in that year occurred in September at a time when the abundance of shrimp is generally very low (Parsons et al. 1979, 1980). The 1977 survey was conducted in November when shrimp densities are high but the deepest strata in both channels were not surveyed in that year and the amount of Greenland halibut and/or shrimp may be underestimated. Both the 1979 and 1980 surveys occurred when shrimp densities are high and covered the complete range of shrimp distribution, therefore, the relative abundance indices for these years are probably representative of the actual situation.

More information can be obtained by examining the densities of shrimp and Greenland halibut in each depth stratum. Figure 3 shows the density/depth relationship for both species in the Cartwright Channel. Patterns of distribution appear similar except that in 1980 there is considerably more biomass of Greenland halibut in the deeper strata where shrimp are concentrated (Table 1). The increase is even more pronounced in the Hopedale Channel (Fig. 4, 5 and 6). In all zones surveyed for this large area (Fig. 7) the density of Greenland halibut is considerably higher in 1980 than in 1979, especially in the deeper strata. It should be noted that a significant proportion of the Greenland halibut biomass in 1980 is found in deeper waters of zones 2 and 3 where shrimp are relatively scarce. This is especially important in the interpretation of Fig. 2 which represents the whole area. Over sixty precent of the shrimp biomass is concentrated in Zone 1 (Table 2) where the biomass ratio of Greenland halibut to shrimp is more on a one-to-one basis. This does not detract from the fact that an increase has occurred but has relevance when considering impact on the shrimp resource. The biomass ratio of Greenland halibut to shrimp in 1979 in this zone was only 0.28.

In August of 1978 and September of 1979 groundfish research surveys were conducted in the waters of northern Labrador (NAFO Div. 2GH) by the research vessel "Gadus Atlantica". The area was not stratified therefore definitive biomass estmates could not be obtained. However, in order to make the two surveys comparable the catch per unit effort was calculated and broken down by age. In the more northerly area (2G) there were large percentages of old fish with substantial numbers of pre-recruits also present. Most obvious was a tremendous increase in CPUE from 1978 to 1979 (Bowering 1980). In NAFO Div. 2H where Hopedale Channel is located, the increase in CPUE from 1978 to 1979 is even more marked than Div. 2G. More important is the fact that the 1975, 1976, and 1977 year-classes in this area appeared in extremely large numbers, much higher than any of the partially or fully recruited year-classes. Bowering (1979) indicated that the year-classes representing the fully recruited age groups appear to be very strong and since these pre-recruit year-classes appear even stronger the projected stock size in the near future should even be larger than at present.

Research vessel surveys for groundfish in Div. 2J (where Cartwright Channel is located) were carried out in November 1977, 1978 and 1979. Estimates of overall abundance did not appear to differ greatly over the three surveys however the age groups 2 and 3 were considerably more abundant in 1979 as shown in Div. 2H. Future expectations of an increase in stock biomass would therefore appear obvious.

Estimates of relative biomass from these surveys indicated that most of the Greenland halibut stock is located in Div. 2J and a crude estimate of minimum trawlable biomass for Div. 2J3KL were in the order of 200,000 mt for late 1979. A biomass survey conducted by the German Democratic Republic in Div. 2GH during October-November, 1979 yielded an estimate of approximately 100,000 mt for these Div., a total of over 300,000 mt for the stock area most of which is located near the commercial shrimp reserves of eastern Labrador. The information presented by Bowering (1980) would therefore suggest a further increase in the stock size of Greenland halibut.

2. COMPOSITION OF THE GREENLAND HALIBUT STOCK

Increase in biomass can occur for a number of reasons including growth, knife-edge recruitment of a strong year-class and/or immigration. Figures 8 and 9 suggest that knife-edge recruitment can be ruled out for the moment since if this were the case, one would expect the average weight for an individual to be less than that observed in the previous year, especially in some of the shallower depths. Length distributions by depth (Fig. 10-13) also indicate no disproportionate increase of any small animals for either area in 1980. All these figures show a strong relationship of Greenland halibut size and depth with larger animals generally preferring the deeper water. In an equilibrium situation with relatively constant environmental parameters a notable increase in size at depth between years would not be expected. However, evidence suggests that the average size in 1980 was considerably larger than in 1979 (Fig. 8-9) indicating recruitment failure in the latter year or an immigration factor. Since the sampling data do not support any noticeable changes in recruitment patterns, then we can conclude that the increase in Greenland halibut biomass that has occurred between 1979 and 1980 in the Labrador Channels is most likely related to immigration.

3. GREENLAND HALIBUT FOOD AND FEEDING

No quantitive stomach analysis is available for 1980 but limited information was collected in 1978 and 1979 for the Cartwright and Hopedale Channels. In the former area 163 stomachs were examined and 95 contained food of which 20 (21%) had shrimp (*P. borealis*) as the primary food item. In the Hopedale Channel 178 of 389 stomachs examined contained food and 59 (33%) of those contained primarily shrimp.

A breakdown of these data by 10 cm length groups indicated that Greenland halibut between 20 and 60 cm feed heavily on shrimp (Fig. 14). Fifty percent of animals from 30 to 39 cm had shrimp as the primary food item. The length frequencies (Fig. 10-13) show that higher proportional biomasses for both shrimp and Greenland halibut occur within the same depth range where relatively large Greenland halibut are found.

CONCLUSIONS

Indications are that Greenland halibut undertake a northward migration when they approach sexual maturity (Bowering 1979). This would suggest that as the large year-classes found in the more southerly regions begin to approach sexual maturity they possibly at some time find themselves in the deep channels of north Labrador where rich food (i.e. shrimp) is abundant. During 1980 a Greenland halibut tagging program was conducted in northern Labrador and the areas of highest abundance of Greenland halibut for tagging were found to be the channels containing the commercial reserves of shrimp. The Greenland halibut caught and tagged were among the largest ever taken in research catches and considerably more abundant than in previous surveys. This might suggest that such a northward migration of big fish from large year-classes could currently be taking place, especially since the biomass of Greenland halibut has increased in the channels over the last couple of years. If stock conditions persist, as proposed by Bowering (1980), there may even be further increases of Greenland halibut in the shrimp channels in the near future provided an abundance of food remains available.

Recent data on a detailed quantitative analysis of food and feeding of Greenland halibut is not readily available except for the general observations made during groundfish cruises as presented in this document. Even the general observations here, however, would suggest heavy predation on shrimp especially where shrimp are concentrated. The only relevant published data is that of Smidt (1969) who performed an analysis of food and feeding data of Greenland halibut in the Davis Strait-West Greenland region (NAFO Subarea 1). It was evident from this analysis that shrimp was considered to be the most significant food item in the diet of Greenland halibut in Greenland waters. His investigations indicated that the largest concentrations of Greenland halibut were always found in areas of shrimp abundance. This applied to not only the offshore stocks of the Davis Strait but also in the fiords where commercial shrimp fisheries occur. In view of this information it would appear that the situation in the commercial shrimp channels of eastern Labrador (and possibly other areas) is similar in nature and the impact of predation of Greenland on shrimp may have serious effects upon the population dynamics of shrimp in these areas.

If shrimp biomass has remained relatively constant between 1979 and 1980 then the increases observed in Greenland halibut biomass are around 2 to 4 times the 1979 level in areas where shrimp are concentrated. The increase appears precipitous since there were no obvious deleterious effects on shrimp biomass between the two years. Commercial catch data from previous years indicate some resurgence in catch rates late in the fishing season (November-December). This did not occur in 1980 in the Cartwright Channel.

Data forthcoming from the fishery and research survey in 1981 should give some indication of what these relationships mean in terms of impact on the shrimp resources in these areas. In the meantime we can only predict the possibility of a significant increase in shrimp mortality through predation by Greenland halibut. It has been suggested that shrimp have not always existed in great numbers in these channels (Sandeman, pers. comm.) and such a predator-prey relationship may be one of the reasons.

The possibility of profound effects of the increase in Greenland halibut stocks on commercial shrimp resources appears real with perhaps little or no time for effective management strategies. Some increase in natural mortality for these shrimp is imminent and for 1981 higher options of TAC should be considered.

This unique situation also provides an ideal opportunity to study the interaction in some detail. It is therefore suggested that considerable effort be expended along these lines during the 1981 survey of the area.

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Table 1. Estimates of biomass for shrimp and Greenland halibut (Cartwright Channel).

	Biomass (mt)			
	1979		1980	
Stratum	Shrimp	Greenland halibut	Shrimp	Greenland halibut
4			1.1	18.5
5	13.6	75.4	82.3	261.4
6	18.8	77.6	56.9	169.9
7	37.0	134.0	183.5	378.9
8	137.8	367.6	391.0	415.8
9	724.0	721.2	434.6	994.1
10	570.5	387.6	787.5	1819.5
11+	690.5	184.4	391.3	658.7
Total	2192.2	1947.8	2328.2	4716.8

Table 2. Estimates of biomass for shrimp and Greenland halibut (Hopedale Channel).

		Biomass (mt)			
		1979		1980	
Zone	Stratum	Shrimp	Greenland halibut	Shrimp	Greenland halibut
1	102	67.6	30.0		
	103	337.9	17.8	14.0	41.9
	104	53.4	20.2	24.1	50.8
	105	119.1	62.9	147.7	136.0
	106	343.3	81.7	88.0	289.5
	107	728.2	137.8	143.3	452.6
	108	582.6	132.5	454.2	725.4
	109	1900.5	397.9	838.1	1334.1
	110	2000.7	1021.1	3797.8	2562.8
	111+	1972.6	370.5	1848.1	2160.4
2	204			150.1	72.1
	205	62.2	182.2	142.2	95.6
	206	734.3	79.3	229.8	70.0
	207	17.0	15.8	269.3	246.5
	208	2137.9	148.0	2159.8	720.4
	209	45.5	153.4	259.3	1070.1
	210	23.2	107.3	103.9	1126.9
	211	129.1	540.9	38.9	2923.0
	212	15.6	395.5	127.4	2516.2
	213+			39.1	1472.0
3	304			18.3	173.6
	305	11.7	105.1	47.8	276.6
	306	78.1	61.7	96.5	333.5
	307	144.1	51.2	127.8	199.2
	308	97.9	23.6	130.1	331.0
	309			82.0	156.7
	310	3.7	1.6	71.4	164.6
	311			120.3	302.8
	312	1.9	1.7	66.6	515.2
	313+			203.7	2765.8
Total		11608.1	4139.7	11839.6	23285.3

Table 3. Depth Interval by Stratum - Labrador

Stratum	Depth range	
	fm	m
2	111-130	202-238
3	131-150	239-274
4	151-170	275-311
5	171-190	312-348
6	191-210	349-384
7	211-230	385-421
8	231-250	422-457
9	251-270	458-494
10	271-290	495-530
11	291-310	531-567
12	211-330	568-603
13	≥331	≥603

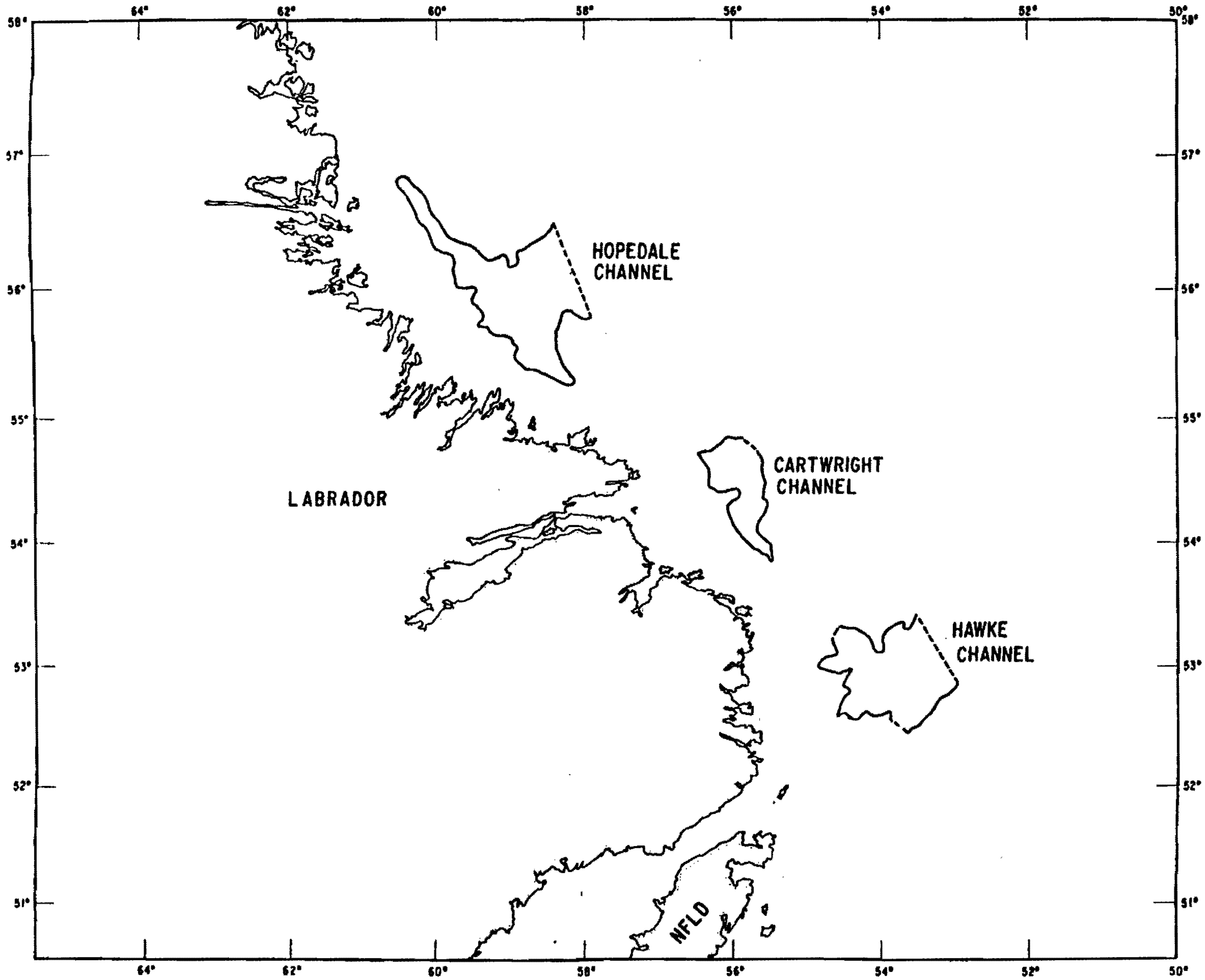

Fig. 1. Deepwater channels of the eastern Labrador Coast where the commercial shrimp reserves are located.

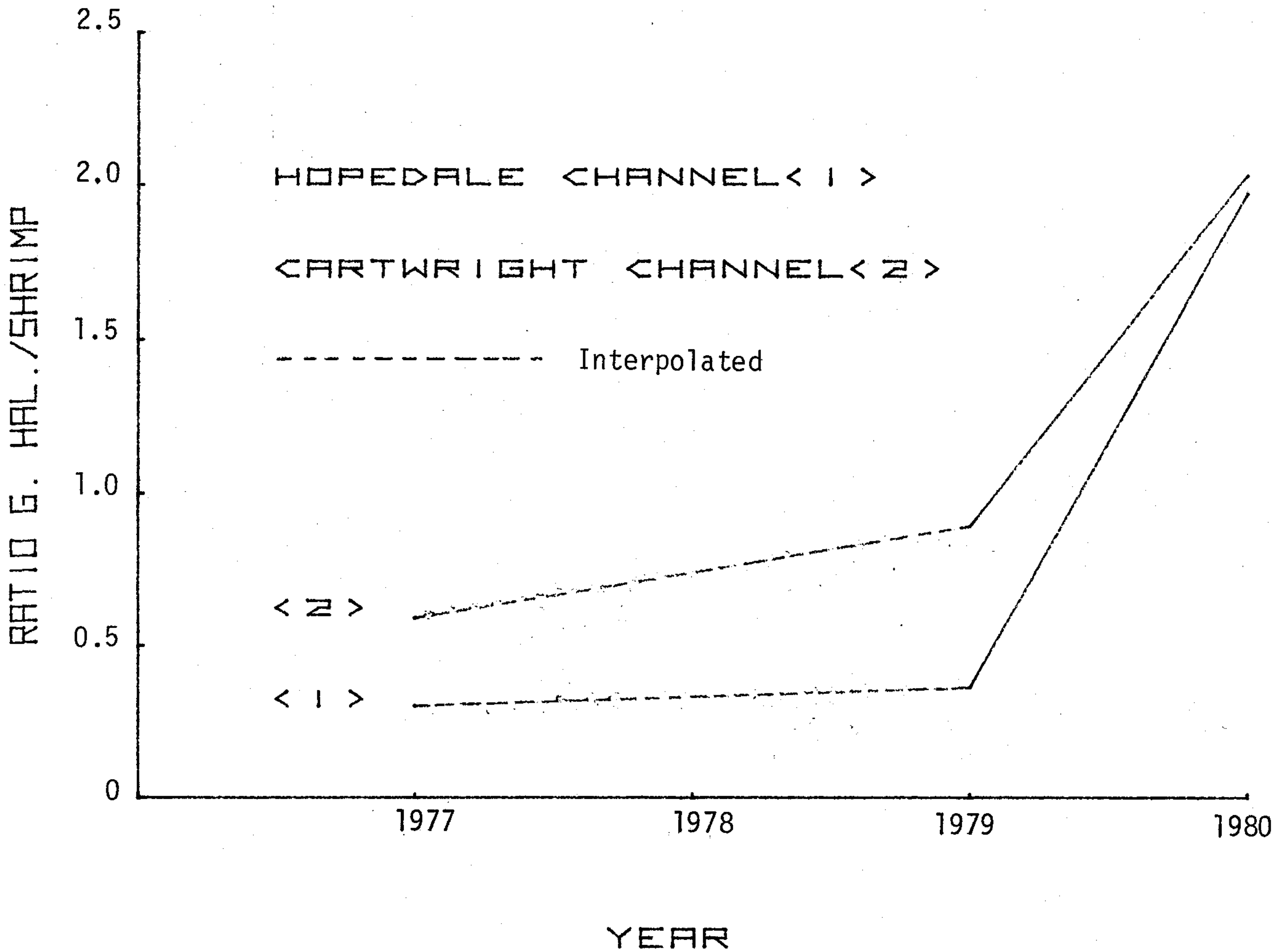

Fig. 2. Ratio of Greenland halibut to shrimp biomass in Cartwright to Hopedale Channels from 1977-80 research surveys for shrimp.

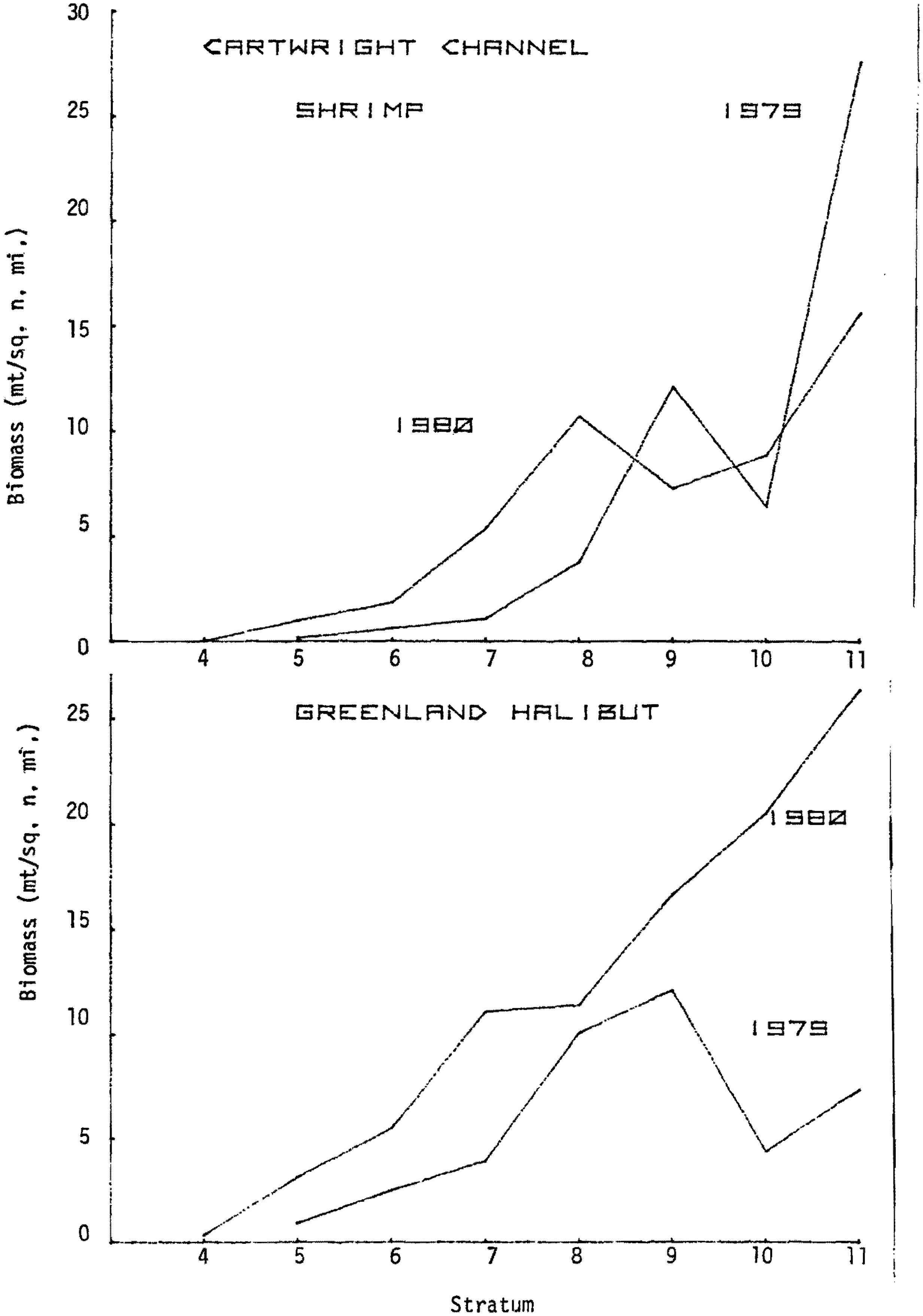

Fig. 3. Density of shrimp & Greenland halibut by stratum from 1979 and 1980 shrimp research surveys in Cartwright Channel. (refer depth interval - Table 3.)

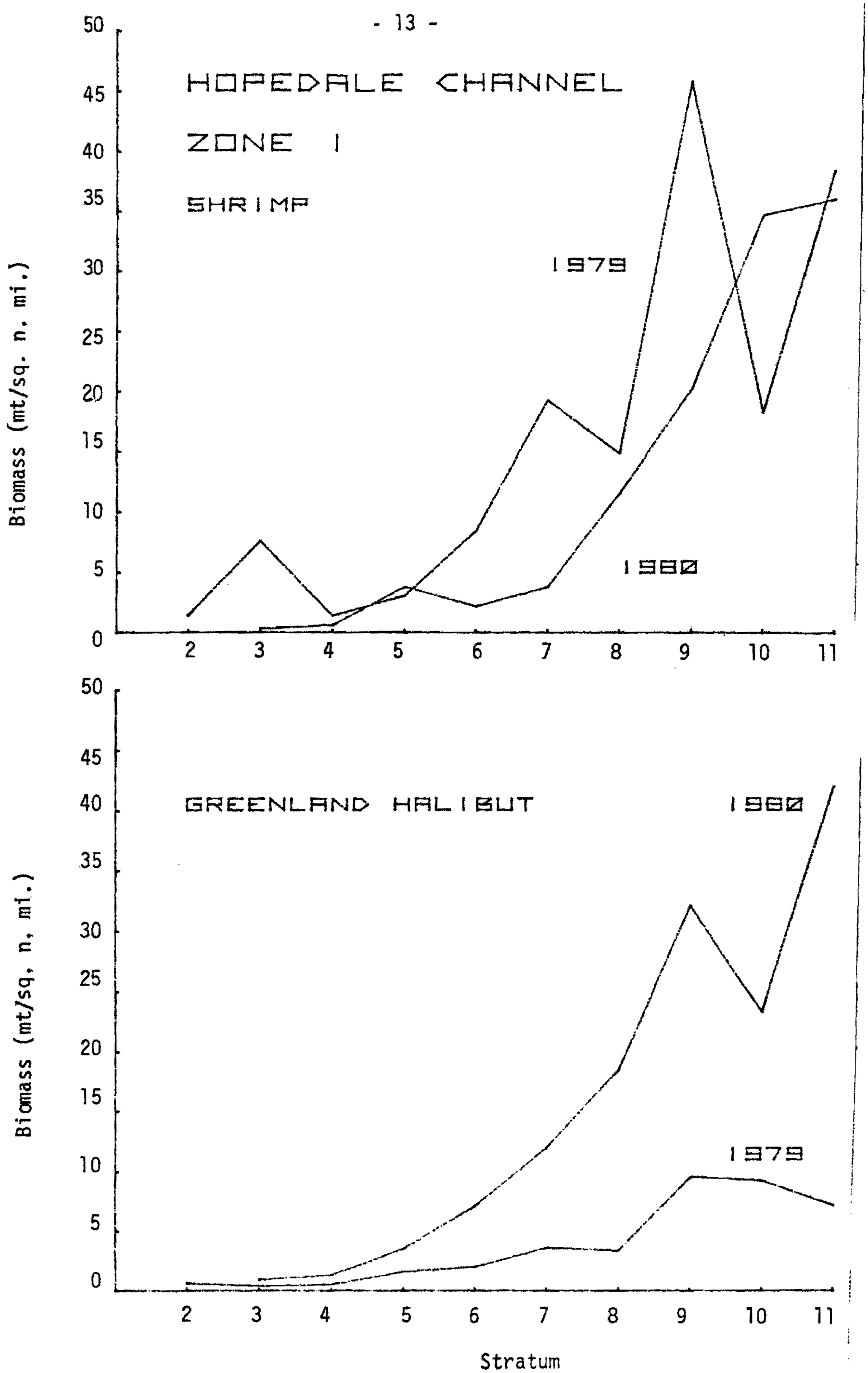

Fig. 4. Density of shrimp & Greenland halibut by stratum from 1979 & 1980 shrimp research surveys from Zone 1 of Hopedale Channel

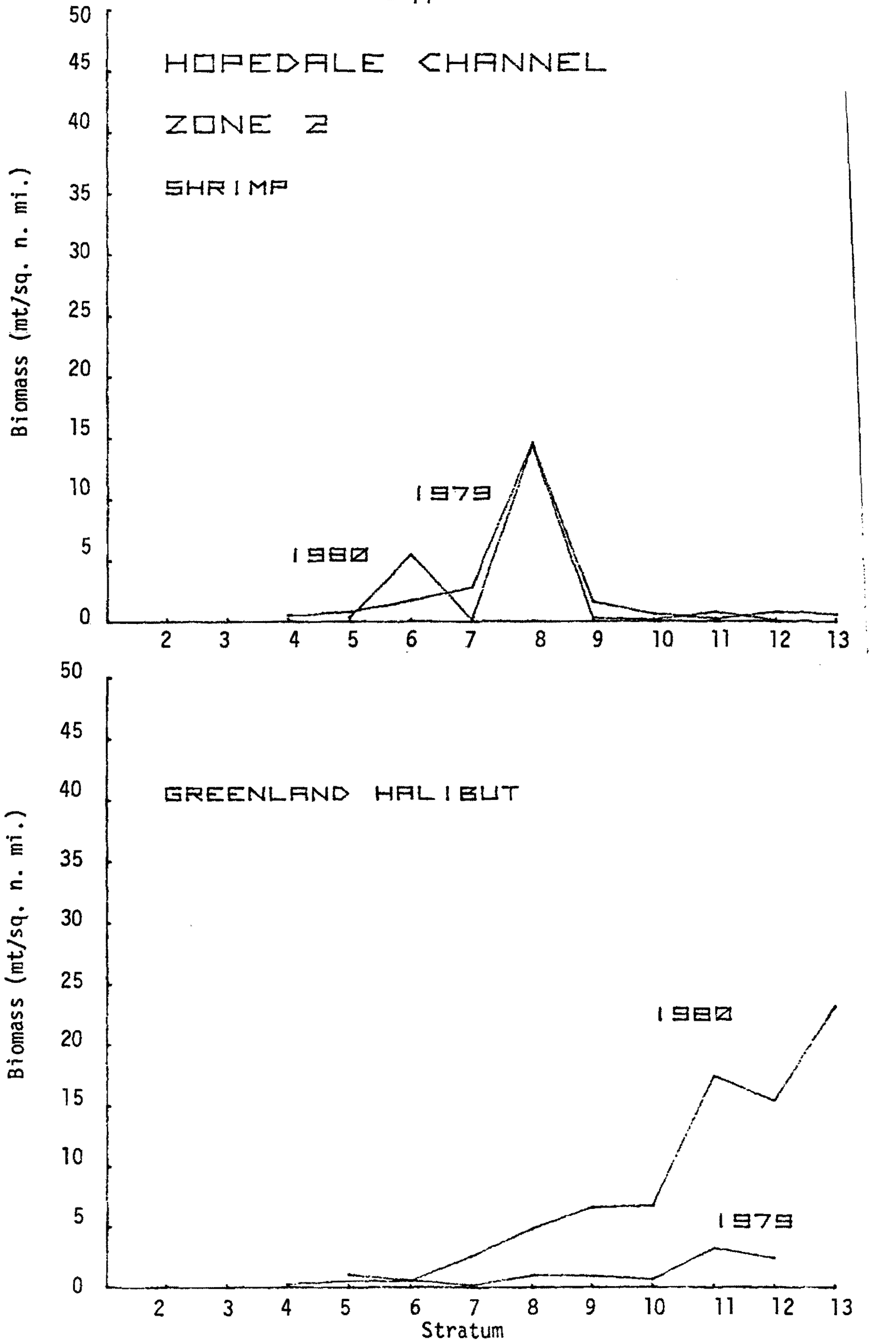

Fig. 5. Density of shrimp & Greenland halibut by stratum from 1979 & 1980 shrimp research surveys from Zone 2 of Hopedale Channel.

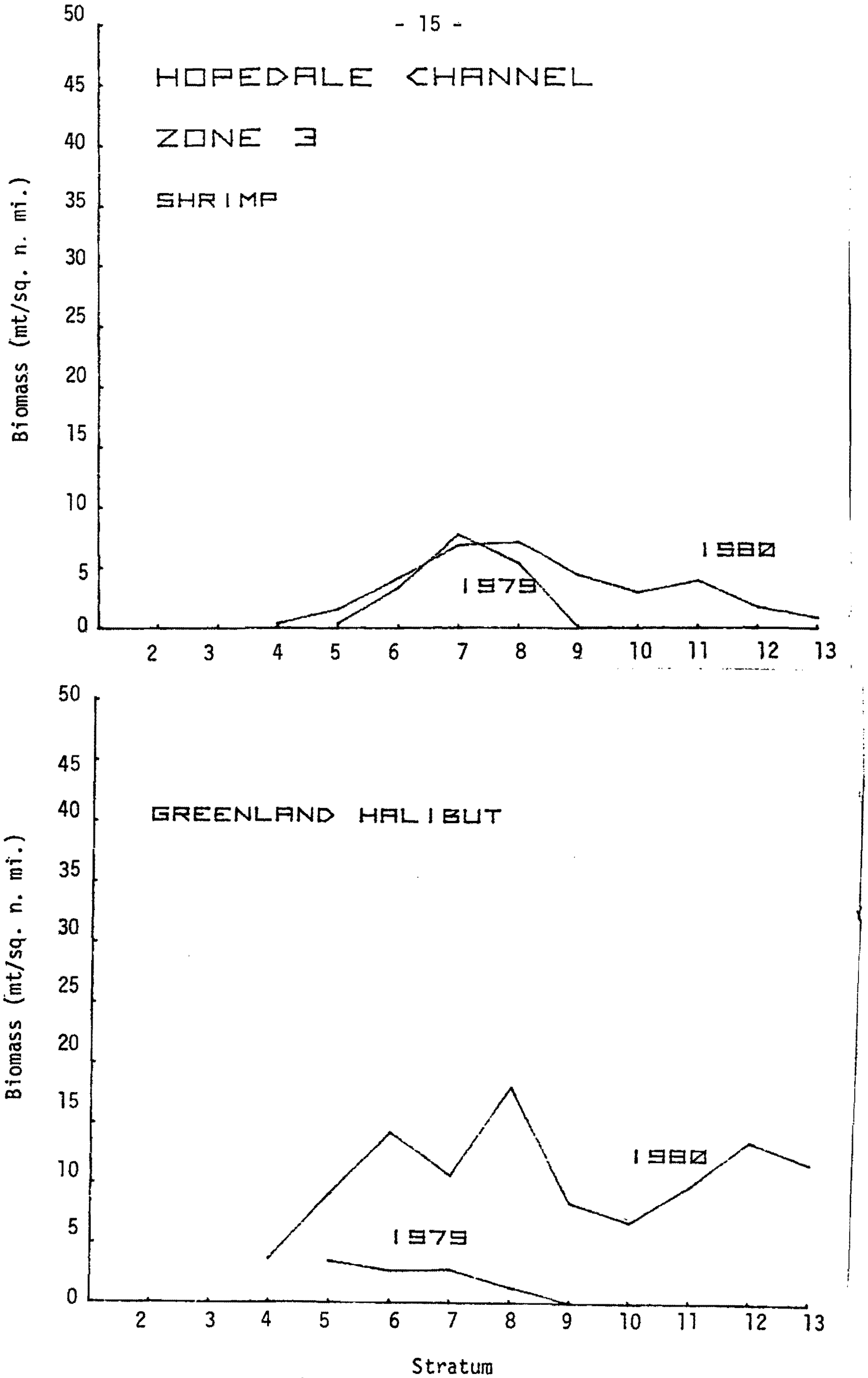

Fig. 6. Density of shrimp & Greenland halibut by stratum from 1979 & 1980 shrimp research surveys from Zone 3 of Hopedale Channel.

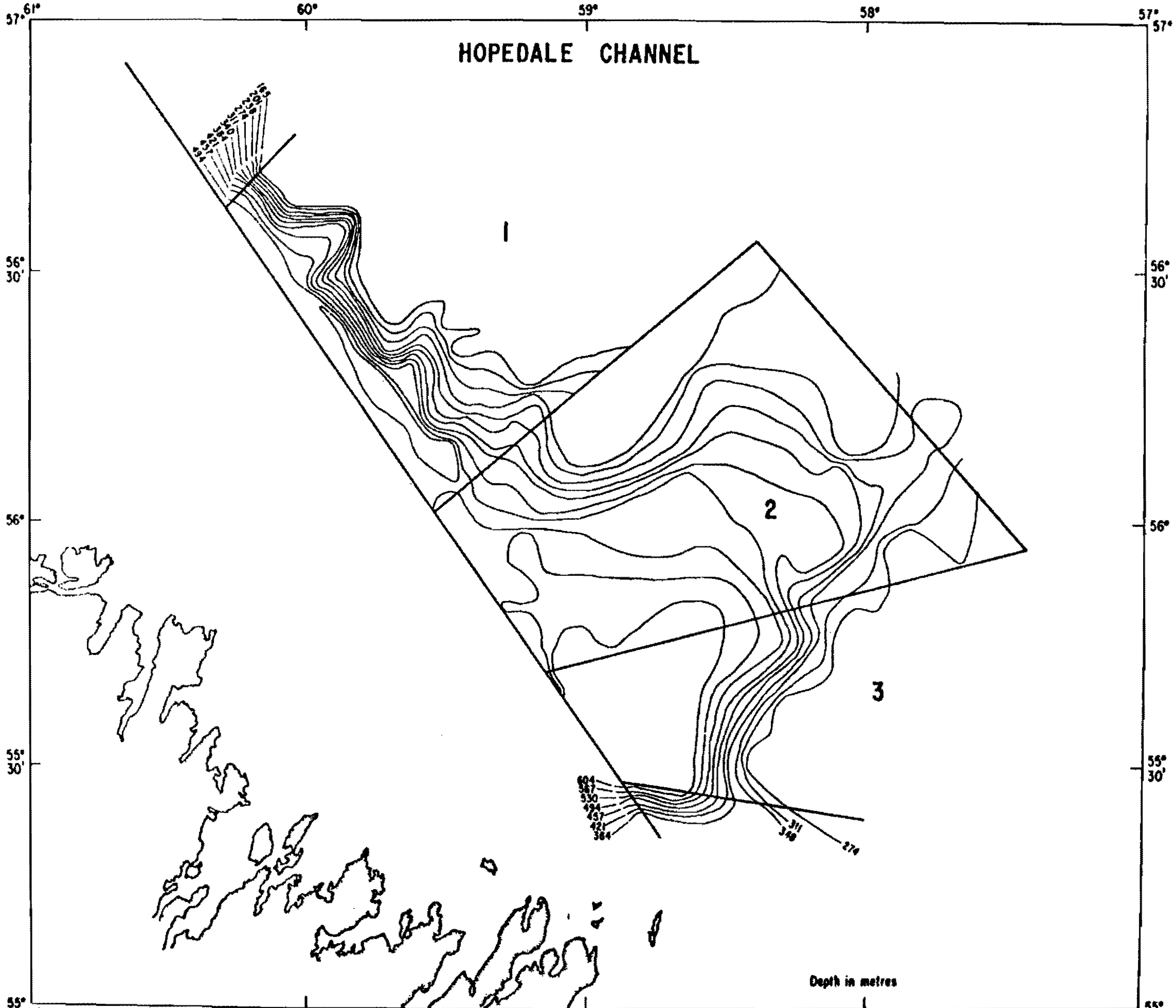

Fig. 7. Bathymetic view of research survey zones located in Hopedale Channel.

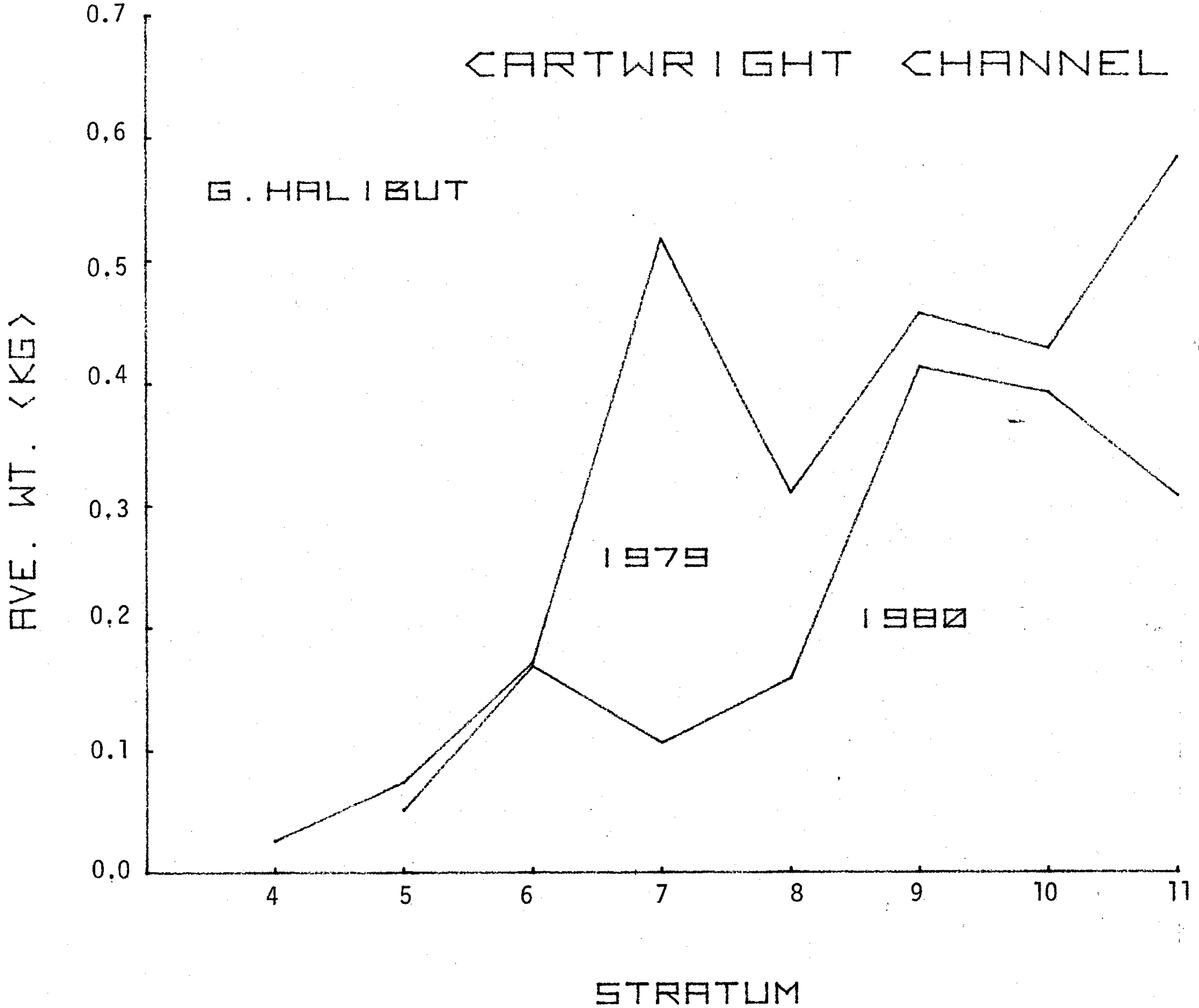

Fig. 8. Average weight of Greenland halibut by stratum from 1979 & 1980 shrimp research surveys in Cartwright Channel.

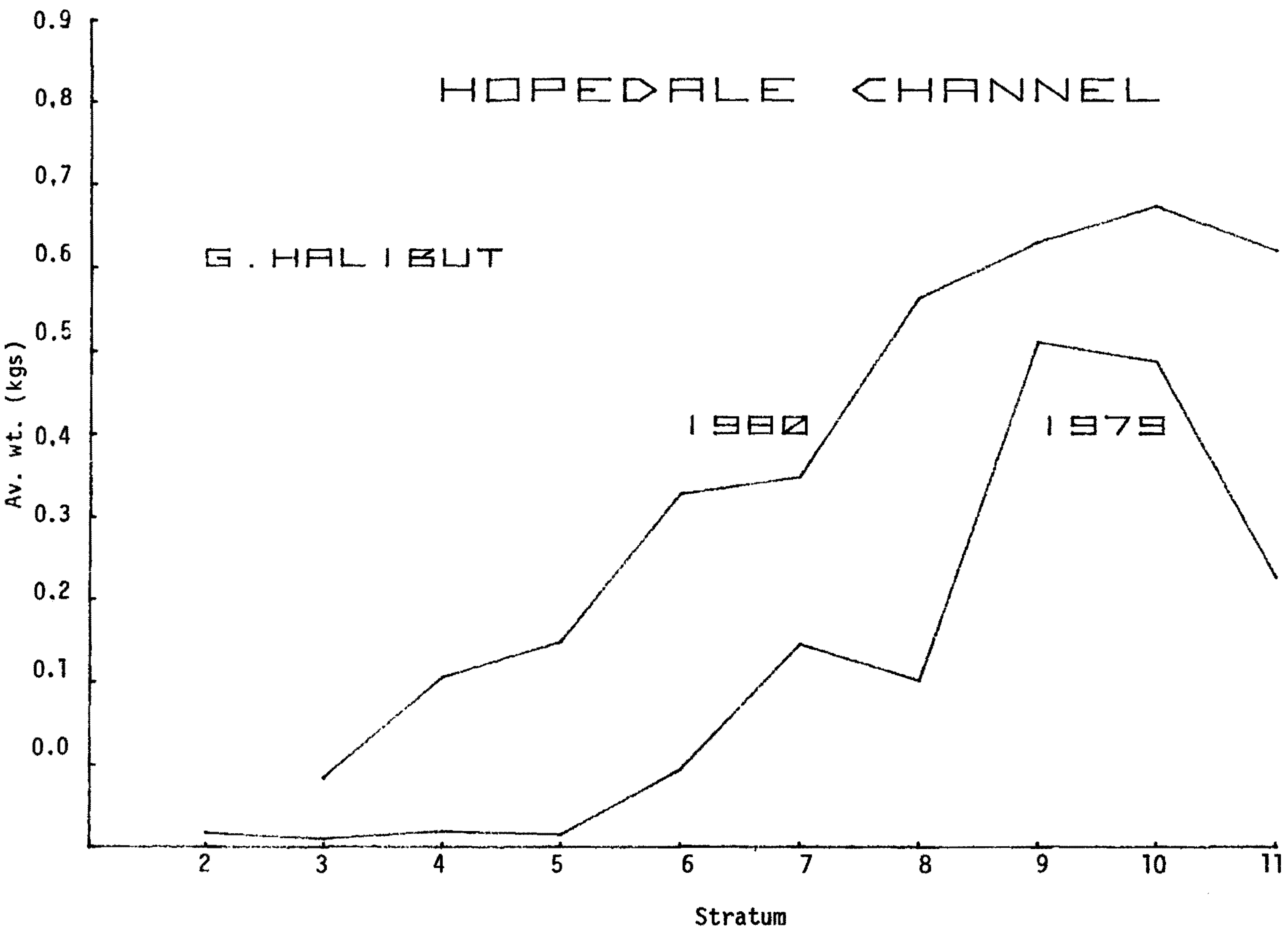

Fig. 9. Average weight of Greenland halibut by stratum from 1979 & 1980 shrimp research surveys in Hopedale Channel. (Zone 1)

R.V. Zagreb Trip 4, July, 1979
Cartwright Channel

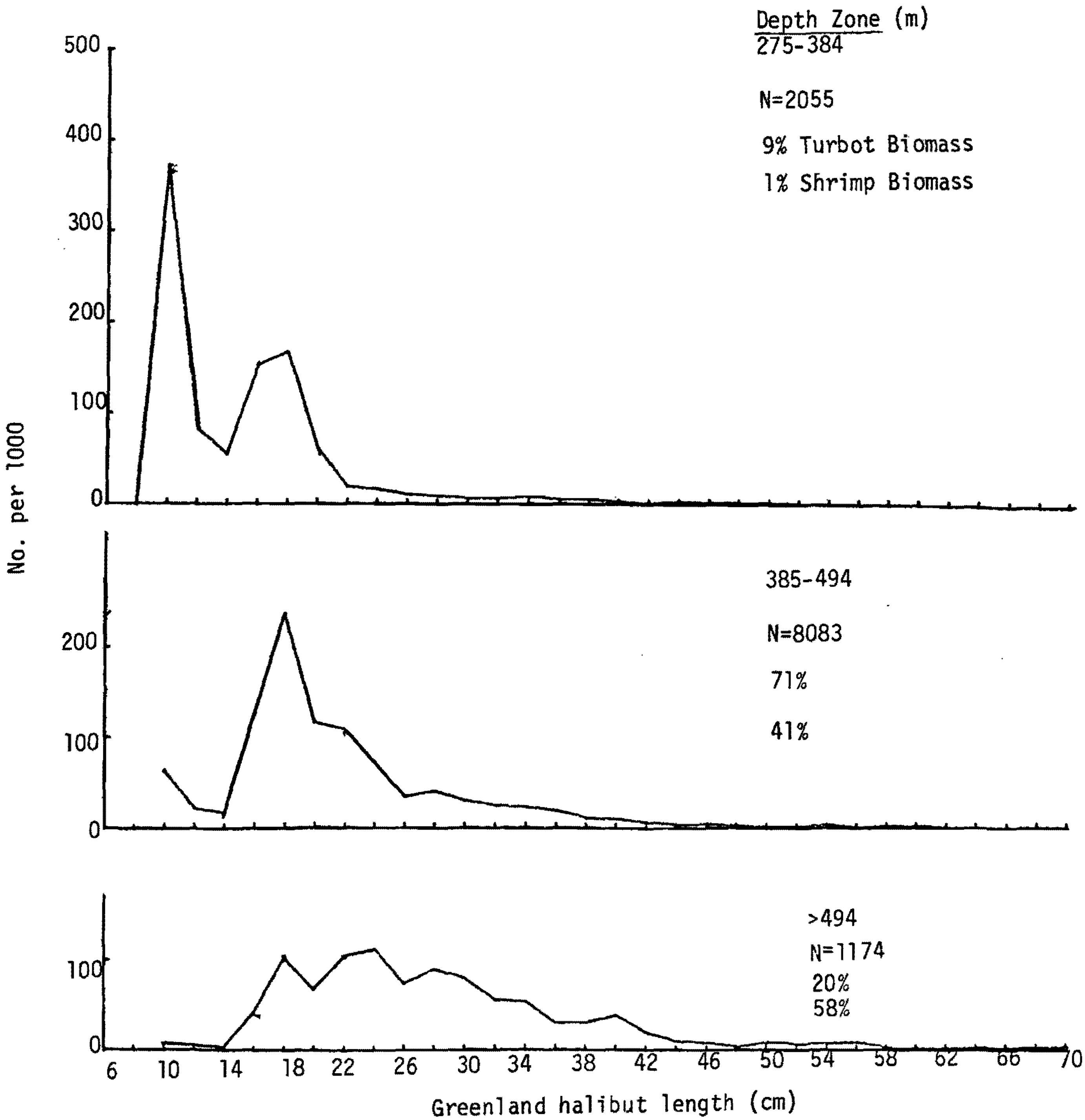

Fig. 10. Length distribution by depth of Greenland halibut from a research vessel survey in Cartwright Channel, July 1979.

R.V. Gadus Atlantica Trip No. 39
July, 1980
Cartwright Channel

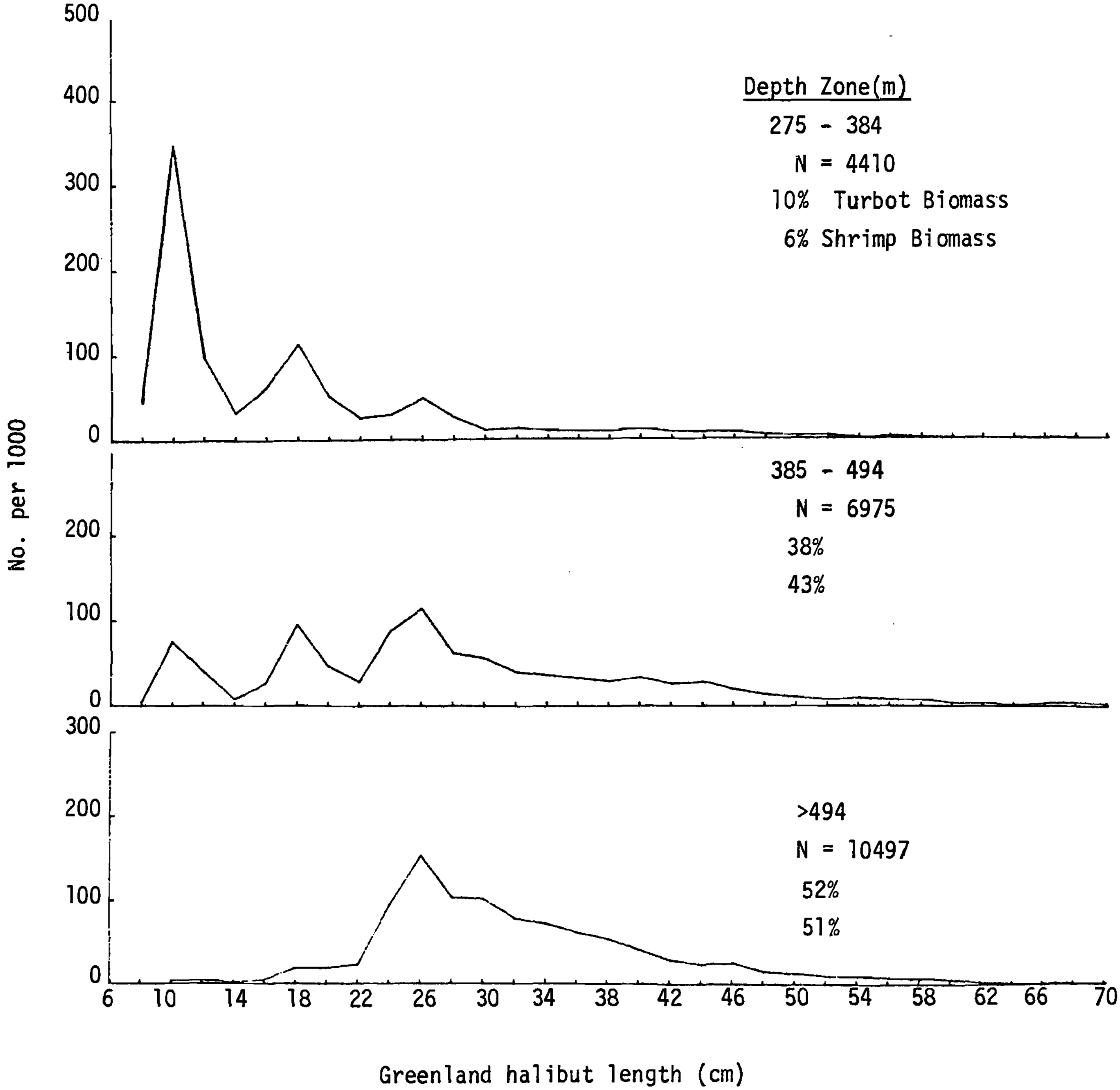

Fig. 11. Length distribution of Greenland halibut from a research vessel survey in Cartwright Channel, July 1980.

R.V. Zagreb Trip 4, July, 1979
Hopedale Channel

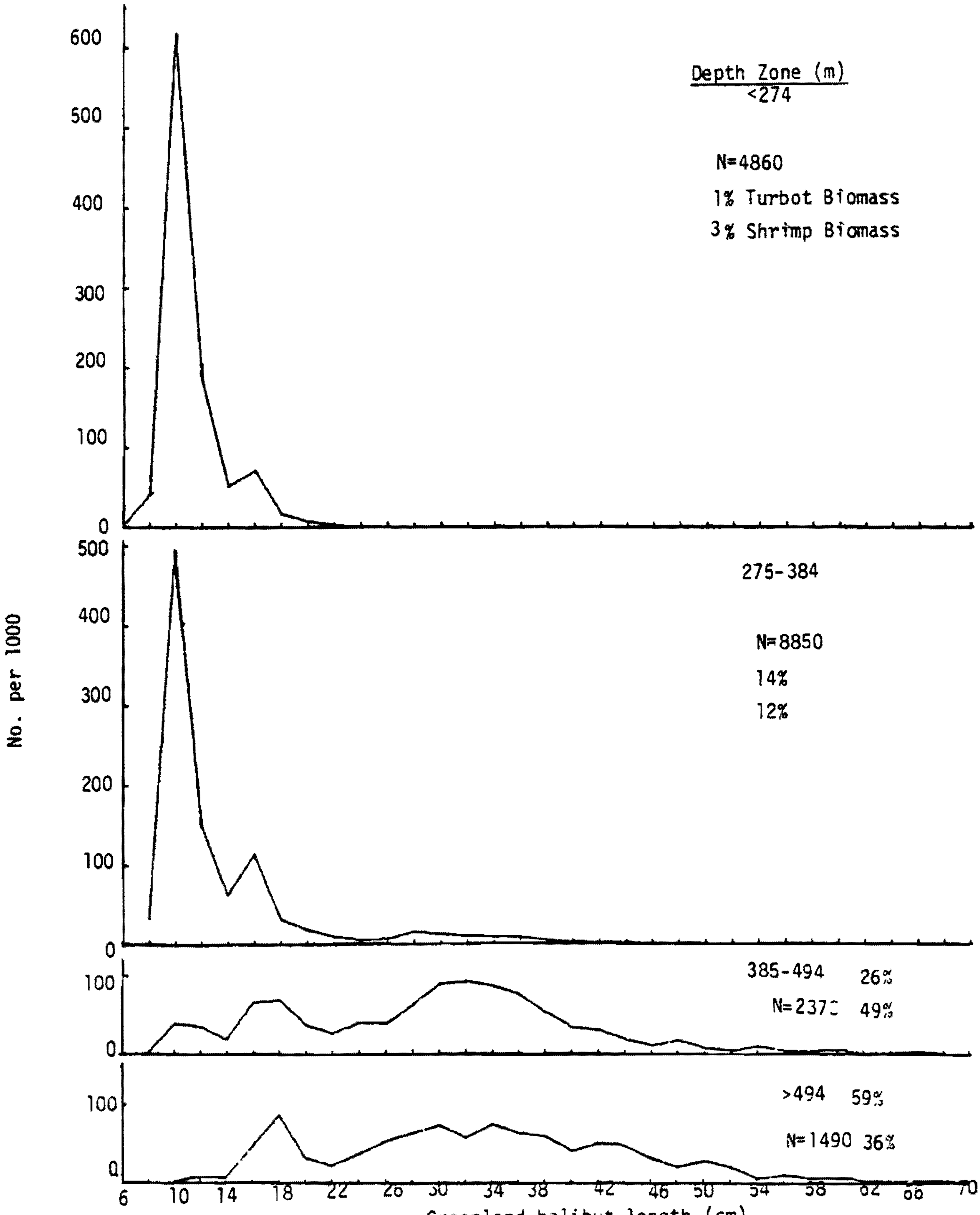

Fig. 12. Length distribution of Greenland halibut from a research vessel survey in Hopedale Channel, July 1979

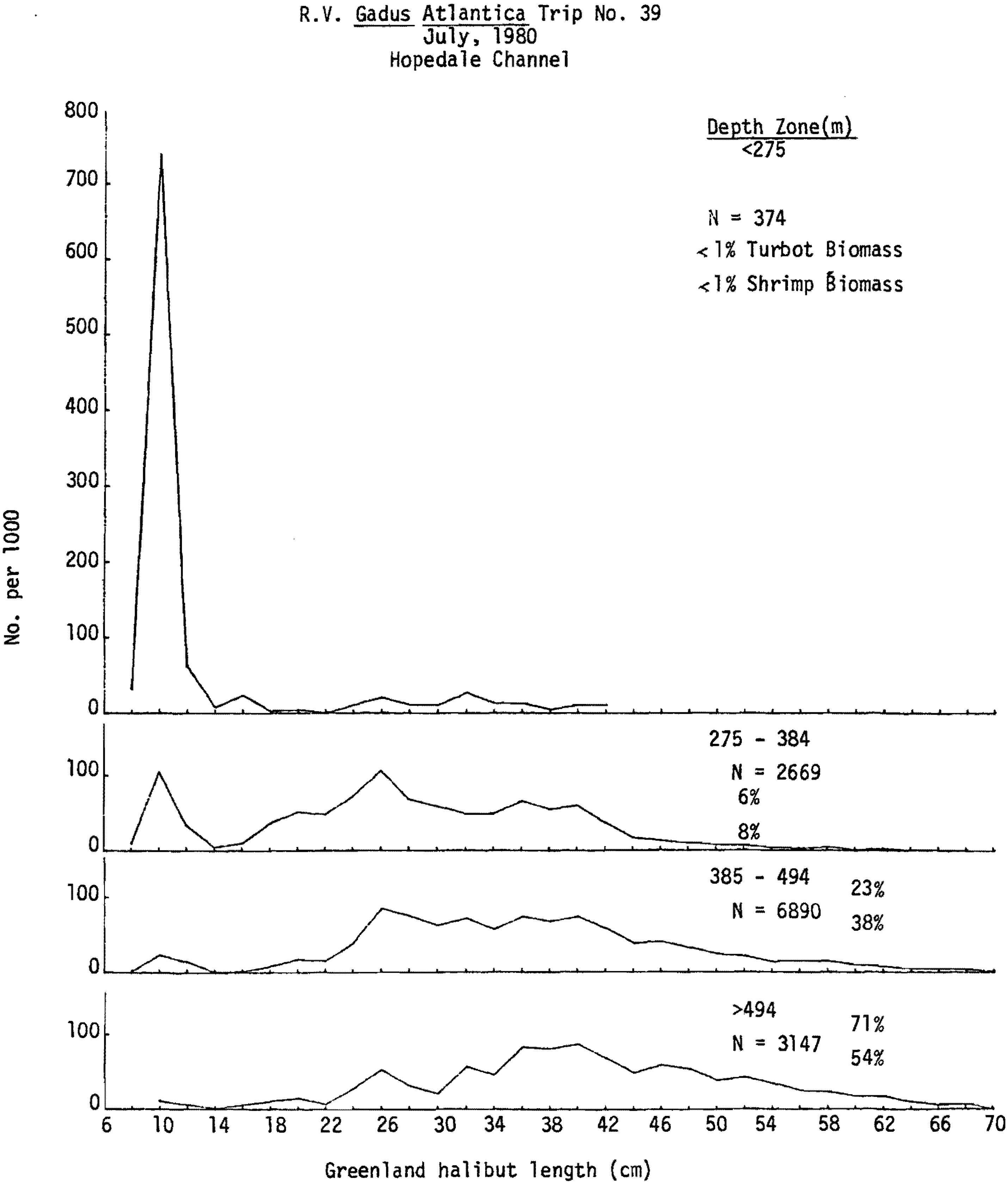

Fig. 13. Length distribution of Greenland halibut from a research vessel survey in Hopedale Channel, July 1980

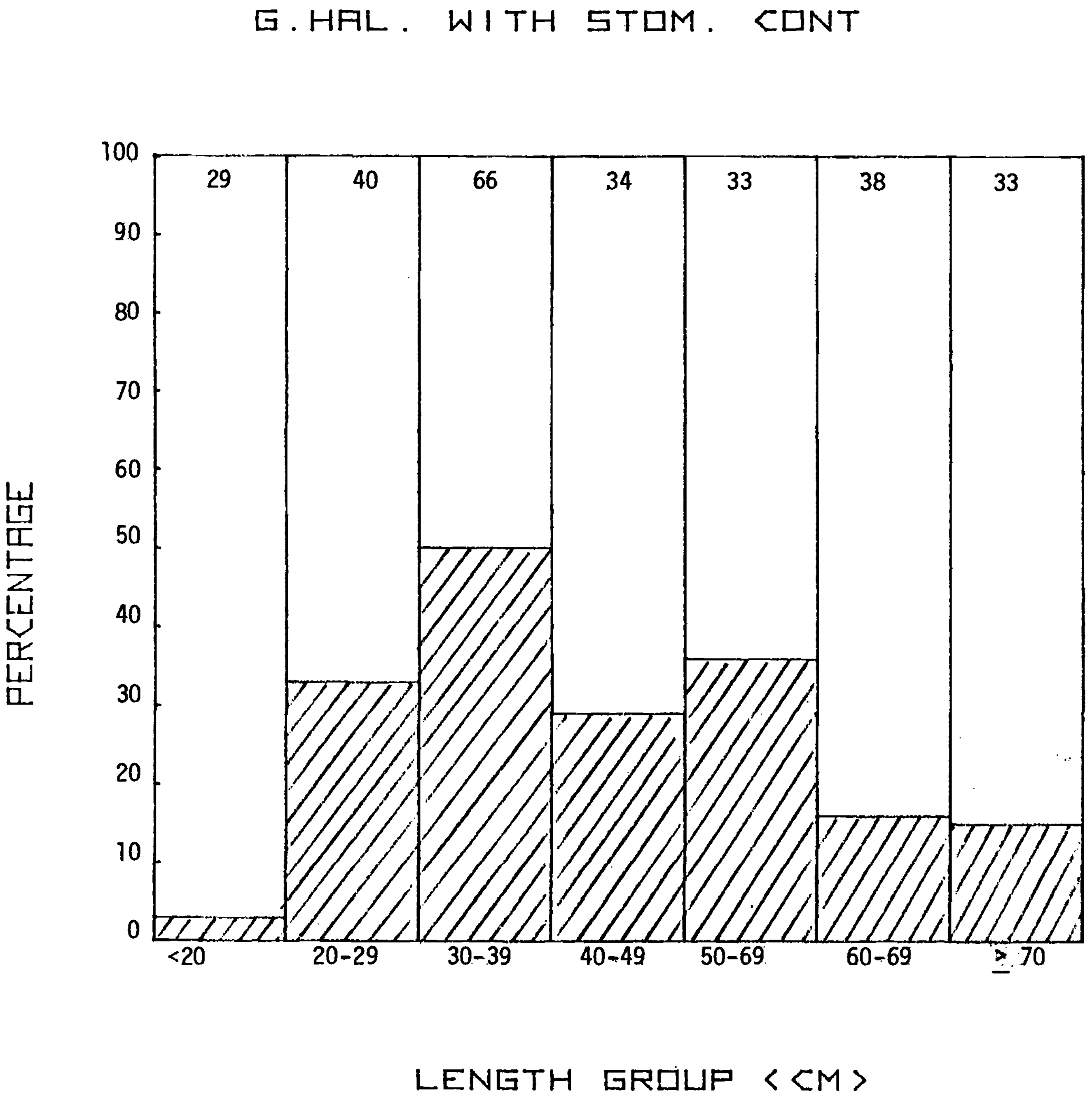

Fig. 14. Percentage of Greenland halibut stomachs containing shrimp as the primary food item broken down by length group.

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