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Shrimp (Pandalus borealis) in the Labrador area - A first assessment

by

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A. General distribution and historical development of the fishery

The possible presence of commercial concentrations of shrimps in the offshore Labrador area has been a matter of conjecture for several years. Many sets have been made by the A. T. CAMERON and other vessels; however, on most occasions groundfish gear was used and even when small-meshed codends or liners are used, such nets are noted for their very limited success in catching shrimps. While a few shrimps occurred in most of the several hundred sets made by the A. T. CAMERON in Subarea 2, in only a few sets (notably in the Hawke Channel area) did shrimp catches (30-120 lb/hr when using this inefficient gear) suggest possible commercial concentrations.

Similarly, work done by the research vessel THALASSA in 1966 (Letaconnoux et al., 1967) in which the presence of shrimps in 50 hauls from the Grand Bank to the area off Hopedale, Labrador indicated a wide distribution of the species although only 11 drags (mostly in the northern part of the area) yielded amounts which might be regarded as indicative of commercial potential (maximum was 66 lb/hr using a net with codend mesh size of 2"). Like many others, these authors confirmed that best concentrations of shrimps occurred at depths of 350-400 meters and temperatures of 3-4°C. Fontaine (1970) further suggested that the channels which separate the banks as they run towards the coastline were areas where shrimp concentrations might be expected to occur.

A conversation with A. I. Klimenkov indicated that attempts to fish for shrimp along the outer edge of the Labrador shelf did not indicate any significant concentrations when this area was surveyed by a USSR vessel undertaking research on shrimp in 1975.

Confirmation that shrimp stocks suitable for commercial exploitation existed in the Labrador area did not occur till 1975 when an exploratory fishing cruise was initiated by the Industrial Development Branch of the Fisheries Service in St. John's, Newfoundland (Brothers, 1977). Work at this time was concentrated on the Hawke Channel area and some catches indicating very good

commercial prospects were obtained. Also in 1975, reports that a Norwegian shrimper had obtained some excellent catches in an area north of the Hawke Channel also began to reach us though no shrimp catches were reported to ICNAF from Subarea 2 in 1975.

In 1976, the Norwegian vessel KORALEN, working closely with Fishery Products Ltd. in Newfoundland, confirmed that excellent shrimp fishing was available in a depression on the shelf (Cartwright Channel) (Fig. 1) and this led the way to a joint venture between this Newfoundland company and two Norwegian fishing vessels in 1977.

At the start of 1977, two separate areas had been confirmed as having a definite potential for shrimp (Hawke Channel and Cartwright Channel) (Fig. 1) and a third area had been identified as one where good shrimp fishing was highly likely (Hopedale Channel). Fishing was started by the Norwegian vessel KORALEN on July 11 and this vessel was soon joined by a vessel chartered by the Industrial Development Branch in St. John's and these two vessels were joined by a third in early August. During this period (July 11 to about the end of September) most fishing effort was concentrated in the Cartwright Channel though the IDB chartered vessel made one trip to the Hopedale Channel where excellent shrimp catches were obtained. Following the lead of this vessel and after the catches had started to drop off in the Cartwright Channel area at the end of September, almost all fishing effort was switched to the new northern area of the Hopedale Channel. Fishing was carried out here by six different vessels till the end of 1977.

Approximate catches made in the different areas and the effort required to obtain them are shown in Table 1 for 1977. The catch data used in this paper are those derived from the log records and are likely to be slightly different from those which will end up in the official statistics of landings.

B. Identity of the stocks

The three areas of shrimp fishing which have been identified are well separated from each other and we have no data concerning any movements of shrimps between the different areas.

Despite the fact that there is a tendency for the females to migrate to shallower water when they are carrying eggs and that the return migration to deeper water after the eggs are hatched may not lead them to the same area, I would not anticipate any degree of mixing of the stocks once the young shrimp have settled out in a given area. In the analysis that follows it is assumed that the shrimps in each of the three areas can be regarded as separate stocks with little or no mixing between stocks.

C. Cartwright Channel area

Apart from a small amount of fishing by the Norwegian vessel KORALEN in 1976, the fishery in this area started in July 1977. The area was fished intensively by three vessels (joined by a fourth vessel for a short period) from June to the end of September. During this time about 2.4 million lb (1089 m tons) of shrimp were taken during just over 1900 hours of fishing. After the end of September only occasional sets were made in this area and the catch to the end of the year only increased to about 2.6 million lb (1179 m tons).

We had observers aboard one of the vessels for a 10-day period and IDB observers were aboard for a longer period of time. It became very clear that the area of good bottom where good shrimp fishing could be obtained was rather limited and usual practice of the vessels was to steam to and fro in a rather narrow corridor with the sets being contained within depth limits of about 210-230 fathoms. Only very occasionally would a vessel venture beyond these depths where they would risk either a tear-up or a smaller catch.

This very limited fishing area and the relatively short period during which fishing was carried out suggested that, in addition to obtaining an estimate of the shrimp stocks by means of the swept volume method, the data might also be amenable to an analysis of catch/effort in relation to catch or effort. To allow this, total catch taken in the area as well as the effort required to obtain it were derived for each day during the period July 11-Sept. 29. All four vessels which had fished in the area used the same sized net (Sputnik 1800 shrimp net) and this simplified the calculations, as effort values could be considered as additive and there was no need for standardization.

Both the method of Leslie (Leslie and Davis, 1939) and the method due to DeLury (1947) were used and, as expected, these yielded rather similar results.

In the former method, a least squares regression of the daily catch/hour on the accumulated catch to the start of the day yielded an estimate of initial biomass of catchable shrimps of 4.7 million lb (2132 m tons) and a catchability coefficient of .00038.

In the latter method, the regression of log values of daily catch/effort on the accumulated effort to the start of that day was fitted and an estimate of initial biomass of shrimps of 4.3 million lb (1950 m tons) obtained with a catchability coefficient of .00040.

Figure 2 shows the plot of daily catch/effort against accumulated catch and the decrease in catch/effort over the period is easily discerned. What is also most striking about this plot is the extreme variation that is apparent over short time periods. That such variation can and does occur casts extreme doubt on the value of the swept volume method as a method of obtaining biomass estimates from surveys which limit their sampling in a given area to a period less than a complete cycle of variation.

Despite this problem, an attempt was made in November to obtain a minimum estimate of trawlable biomass of shrimps in the area using the swept volume method. In doing this, it is customary to use a stratified random design which, in addition to yielding the biomass estimate required, can also provide relevant estimates of error. While we were fairly sure that the requirements of homogeneity would be met by using depth as the main stratification parameter, we could find no charts of the area with reasonable depth contours and when we attempted to do our own charting the electronic aids to navigation available to us were so poor that our efforts can be regarded only as very crude at the best.

The area can be described as a depression in the shelf where one of the valleys separating two banks (Cartwright Channel) deepens to form a hole or depression. The inside (landward) edge of this depression is broken into many gullies and trawling in this inside area was found to be impossible. The seaward edge of the depression is the area where the shrimp fishing is concentrated and where we attempted to obtain a minimum estimate of trawlable biomass. Figure 3

shows our attempts at obtaining a depth chart of the area and this was obtained by rather subjectively incorporating our own attempts at charting with the best available from the Canadian Hydrographic Service. Areas B and C are probably reasonable representations of the area and depths where shrimps are present and trawlable, while Areas A and D much more speculative both from the point of view of the representation of the area and depths and the availability of shrimps.

The A.T. CAMERON attempted to occupy two lines of stations at five depth levels (one in each of the Areas B and C). In this we were only partially successful as we found that the A.T. CAMERON was unable to tow the Sputnik 1600 net which we had planned on using in the survey and this resulted in two different nets being used, one of which was obviously not fishing in a consistent way. A total of five successful sets in three depth strata between 190 and 250 fath provided an average catch/30-minute tow of the #36 shrimp net of 221 lb (100 kg). The total area of B and C within the depth range 190-250 fath was calculated at 130 square nautical miles. Using the usual estimate that the #36 groundfish trawl towed at a speed of 3 knots for 30 minutes covers an area of .00875 square nautical miles (based on estimate of spread of 35 ft derived by Carrothers and Foulkes, 1972), this provides a biomass estimate in November 1977 of 3.3 million lb (1497 m tons) and, with a total catch of 2.6 million lb (1179 m tons), the estimate of initial biomass becomes 5.9 million lb (2676 m tons).

In addition to the line survey undertaken in this area, fishing was also carried out throughout a 24-hour period. During this period when 9 sets were made with a #36 shrimp trawl with catches varying from a high of 465 lb(211 kg)/30-minute tow to a low of 86 lb (39 kg)/30-minute tow, an average catch of 204 lb (93 kg) was obtained over the 26-hour period of the experiment; if this value is used, the biomass estimate for the same area becomes 3.0 million lb (1361 m tons) as in November and 5.6 million lb (2540 m tons) at the start of fishing in July.

Summary of estimates

Method	Biomass estimates (millions of lb) (m tons in brackets) July	December
(a) Leslie	4.7* (2132)	2.1 (952)
(b) DeLury	4.3* (1950)	1.7 (771)
(c) Line Survey	5.9 (2676)	3.3* (1497)
(d) 24-hour Fishing	5.6 (2540)	3.0* (1361)

*denotes the estimate obtained by the given method; the other estimate was obtained by addition or subtraction of the catch.

Discussion

The methods used to obtain the above biomass estimates could be quite sensitive to any incorrectness of the assumptions inherent in the methods.

(a) Leslie and DeLury methods

These methods are relatively insensitive to the daily variations in catchability which will tend to average out over the period under review. Variations of this type were prominent in this data set. The methods assume

that natural mortality, recruitment and growth are insignificant over the 3 months that were examined (or if they were not significant the biomass added due to recruitment and growth is balanced by that lost through natural mortality). Over the 3 months in question, this assumption is not likely to be critical; if all shrimps present undergo a moult, a maximum increase in biomass of about 20% could be expected. This is relatively insignificant when compared to the decrease in biomass due to removals by the fishery. It would also tend to cause an underestimate of catchability and an overestimate of initial biomass.

Another assumption on which this method relies rather heavily is that the catch/effort represents a true index of abundance of the area and that there is no secular trend in catchability taking place over the period in question, other than that due to decreased abundance of the stock due to fishing. This assumption is a much more difficult one to justify and most persons who are familiar with shrimp catch and effort statistics will recognize that a decrease in catch/effort during the period July-September is a relatively common phenomenon which one suspects is often due to a change in catchability or availability as well as a decrease in abundance in the stock. Such a decrease has been noted in the large ICNAF Division 1B shrimp fishery as well as in the Gulf of St. Lawrence and in both these instances the decrease in catch/effort appears to be greater than that due to decrease in stock size alone. If a decrease in catchability occurs during the period, catch/effort values will be lower and the method will indicate an initial biomass lower than it should be.

Because the area where fishing took place was rather limited, and the estimates of initial biomass refer to this area only and not to the total surrounding area where commercial and non-commercial concentrations of shrimps will occur, the biomass estimate is obviously a minimum for the area.

(b) Swept area method

This method is extremely sensitive to daily variations in catchability and, with observations limited to 3 or 4 days, no information is available with which we can judge at what point in the short term cycle of catchability the observations were made. This can lead to errors in our estimates of stock size which may be either considerably too high or too low.

Even more critical to the estimates is the problem of defining the area over which each set or combination of sets represents a suitable sample of the population. Because our depth contours are so arbitrary, this exercise was subjective and unsatisfactory. While errors are unlikely to be extreme in the area where most of the fishing took place, outside this area we are ignorant and really have no idea of the biomass of shrimps that exists in the surrounding areas. It seems likely that shrimps from these areas can, to some extent, recolonize those areas where densities have been reduced by fishing.

Several other assumptions could be discussed (Hoydal, 1976), all of which reinforce the conclusion that the population estimate derived from this method must be considered as minimum.

It is concluded that a minimum estimate of the fishable stock size in the Cartwright Channel fishing area before the start of fishing in 1977 was of the order of 5 million lb (2268 m tons). In general production models it is assumed that maximum yield is obtained when the fishable stock biomass is reduced to 50% of that of the virgin stock. Because the biomass estimates were minimum

and the area where shrimps occur in concentration is larger than that which can be fished, it is suggested that a TAC of 2.5 million lb (1134 m tons) might be appropriate for this area until better data become available. If the average rate of catch remains similar to what it was in 1977, this catch could be obtained in about 2200 vessel hours or, assuming a fishing day with 17 hours when the net was fishing, it could be obtained in about 130 vessel days.

D. Hopedale Channel

Though this area was explored in August and the potential for excellent shrimp catches demonstrated at that time, fishing on a regular basis did not start until September. Between this date and the end of the year, a total of six vessels fished the area with approximately 3.3 million lb (1497 m tons) being removed during 2965 hours of trawling. (These figures do not include the effort or landings made by two Norwegian vessels from their last trips of the year to the area.)

The fishing area, Cartwright Channel, is characterized as a depression in the Labrador shelf which is part of the Labrador Marginal Trough. Though depths exist to about 450 fath, the major area for shrimp distribution is confined to depths between about 190 and 250 fath or the seaward side of the depression. The shoreward side of the trough is very broken and not suitable for fishing.

The area is very much larger than the Cartwright Channel and stretches in a north-south direction over about 100 nautical miles. Because of the considerably larger area and because the fishing area was constantly changed as the captains sought greener pastures, Leslie and DeLury methods cannot be used and we are forced to rely on the results of the research vessel survey for biomass estimates.

As in Cartwright Channel, the main parameter we would wish to use in this area for stratification in a stratified-random type survey was that of depth and, once again, we were unable to find good large-scale charts of the area with reasonable depth contours. In deriving the depth contours shown in Fig. 4, we have used the best chart information available to us and this has been supplemented by some of our own rather subjective position and depth data. For the area on the outside of the depression but not including the two end zones A and I, the contours are probably not too far removed from fact and the areas derived from these contours must for the present be regarded as the best we have. Definition of the zones A-I was done arbitrarily, so that a line from the line survey undertaken by the A. T. CAMERON lay approximately in the middle of each zone. The A. T. CAMERON lines in turn were arbitrarily placed at various positions on the chart in such a manner that about eight lines would cover the complete shrimp area in the depression. On each line the following depth strata were sampled: 170-190 fath, 191-210 fath, 211-230 fath and 230-250 fath. Attempts to sample depths below 250 fath and shallower than 170 fath were not successful though five sets in the shallower area indicated considerably fewer shrimps in these depths in four out of the five lines where sets were made.

In Areas A and I, not only were we unable to sample but we were also unable to obtain any reasonable estimates of the area of each depth stratum where shrimp catches might be expected, and these zones have been completely omitted in deriving the total biomass estimate for the Hopedale Channel area. This estimate can thus be regarded as an even more minimum estimate than it would have been had these areas been included.

Table 2 shows the basic catch data as derived from the A. T. CAMERON cruise (daylight sets only) and from our best estimates of stratum areas as well as the derived estimate of biomass for each cell, assuming that the #36 shrimp net towed at 3 knots for 30 minutes covers an area of .00875 square nautical miles. Three separate estimates of minimum fishable biomass were derived as follows:

(a) Summing the biomass obtained for each cell (zone and depth stratum) 11,050 metric tons (24.4 million lb)

(b) Computing the biomass for each zone and summing these 10,340 metric tons (22.8 million lb)

(c) Computing the biomass for each depth layer and summing these 12,445 metric tons (27.4 million lb)

These estimates were made in November when close to 3 million lb (1360 metric tons) had already been removed by the fishery, and to estimate the "virgin" stock size the above estimates would need to be raised by this amount.

When the area was first surveyed in August, a single depth stratum was examined throughout much of the area and this allows a comparison to be made between the biomass estimate derived for this area at this time with that derived by the A. T. CAMERON some 2 months later. Limiting the comparison to sets during daylight periods only and assuming the area swept by a Sputnik 1800 shrimp trawl when towed at 3.5 knots for 1 hour is .0567 square nautical miles (Hoydal, 1976), we derive an estimate for zones B-H in the depth stratum of 211-230 fath of 16.6 million lb (7530 m tons) which compares with the estimate obtained by the A. T. CAMERON near the end of the fishing season for the same depth layer of 13.3 million lb (6033 m tons). With a fishery that has removed about 3 million lb (1361 m tons) in the interim period, the agreement of the two estimates is amazingly similar. Intuitively, I would have expected the biomass estimate to be lower in November which would be in keeping with the general impression that the shrimp distribution is more spread out through more depth zones at this time than it is in the summer when a temperature barrier is likely to confine them to the deeper parts of the area.

E. Hawke Channel

Though this was the first area which suggested that commercial concentrations of shrimp were present in ICNAF Subarea 2, Hawke Channel has not as yet been subjected to the test of a commercial fishery. Exploratory fishing by IDB as well as a rather abhortive trip of the A.T. CAMERON (weatherwise) have indicated reasonable prospects for a commercial fishery. However, to date, probably because of the presence of higher yields in better defined areas, no fishery has yet occurred.

We have neither a good description of bathymetry nor adequate standardized catches of shrimp to be able to obtain even the crudest estimates of biomass. However, expectation, based on both the oceanographic climate and the slim knowledge that we have, indicates that the area has a potential that has not as yet been realized. Perhaps if a TAC is allocated to the total Labrador area, and a lowered catch/effort results from exploitation of the Cartwright and Hopedale Channels then industry may devote some effort to exploring the shrimp potential of the Hawke Channel.

Summary

Using the biomass estimates derived from each cell and summed over the whole area, we obtain an estimate of the initial minimum trawlable biomass of about 12,250 metric tons or 27.0 million lb for the Hopedale Channel. In view of the fact that this is an estimate derived from rather sketchy data, it is suggested that a TAC of 12 million lb or 5450 metric tons would be appropriate at this time and should, provided there is no change in the production system and recruitment remains similar to what appears at present, be generally sustainable on a long-term basis.

References

Brothers, G. 1976. Commercial Explorations for Shrimp and Turbot, Labrador. Industrial Development Branch, P.O. Box 5667, St. John's, Nfld. Ms. 36 p.

Brothers, G. 1977. Exploratory Fishing for Shrimp and Crab 1976. Industrial Development Branch, P.O. Box 5667, St. John's, Nfld. Ms. 26 p.

Carrothers, P.J.G. and T. J. Foulkes. 1972. Measured Towing Characteristics of Canadian East Coast Trawls. ICNAF Res. Bull. 9: 11-20.

Fontaine, B. 1970. La Crevette Profonde (Pandalus borealis) dans la Region du Nord-ouest Atlantique. Science et Pêche, Bull. Inst. Pêches marit., No. 197, November 1970, 16 p.

Letaconnoux, R., Ch. Allain, J. Morice and Cl. Nedelec. 1967. Peche sur les Bancs Septentrionaux de Terre-Neuve et le Plateau Oriental du Labrador pendant l'ete 1966. Science et Pêche, Bull. Inst. Pêches marit., No. 155, January 1967, 14 p.

Table 1. *Pandalus borealis* catches from Labrador area, 1977.

Area	Catch		Effort (hr)	Catch/hr	
	lb.	metric tons		lb.	metric tons
Cartwright Channel	2,614,000	1186	2,229	1,173	532
Hopedale Channel	3,312,000	1502	2,965	1,117	507
Hawke Channel	1,700	77	6	283	128

Table 2. Hopedale Channel. Catches obtained by A. T. CAMERON in each stratum, area of each stratum and biomass for each stratum, November 1977. (i) Catch (kg), (ii) Area (square nautical miles), (iii) Biomass (kg).

Zone	1 170-190 fath	2 191-210 fath	3 211-230 fath	4 231-250 fath
B (i)	51	167	244	316
(ii)	37.5	15.1	43.3	15.9
(iii)	218,571	288,194	1,207,451	574,217
C (i)	59	205	46	98
(ii)	37.5	10.1	20.2	5.8
(iii)	252,857	236,629	106,194	64,960
D (i)	103	248	228	96
(ii)	20.2	12.3	33.9	9.4
(iii)	237,783	348,617	883,337	103,131
E (i)	9	44	42	49
(ii)	15.9	17.3	62.0	33.9
(iii)	16,354	86,994	297,600	189,840
F (i)	72	143	73	2
(ii)	70.0	63.5	90.1	57.7
(iii)	576,000	1,037,771	751,691	13,189
G (i)	18	36	160	7
(ii)	62.7	38.9	141.3	64.9
(iii)	128,983	160,046	2,583,771	51,920
H (i)	79	58	33	26
(ii)	22.4	18.0	59.1	29.6
(iii)	202,240	119,314	222,891	87,954

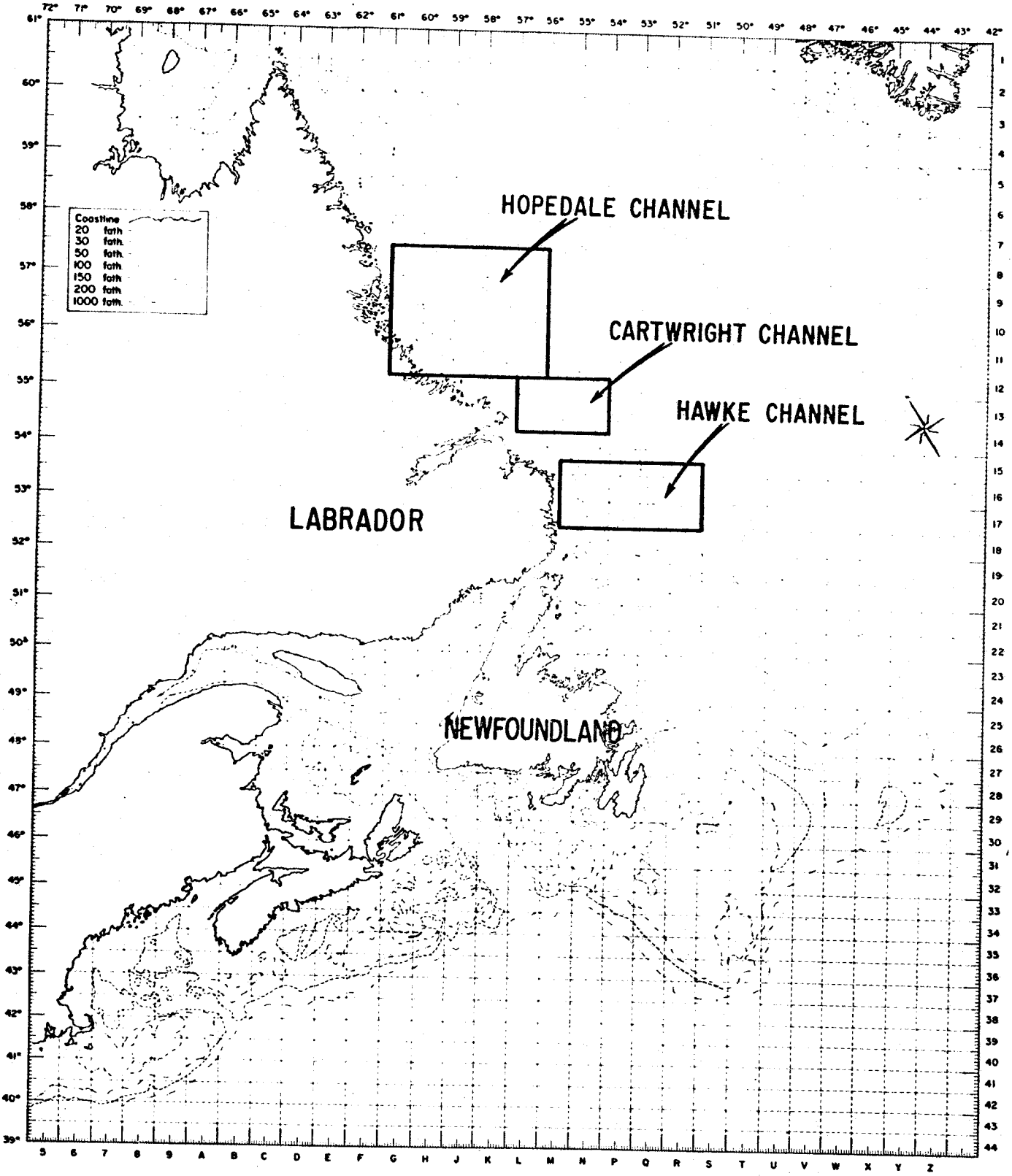

Fig. 1. Chart showing the principal shrimp fishing grounds in the Labrador area.

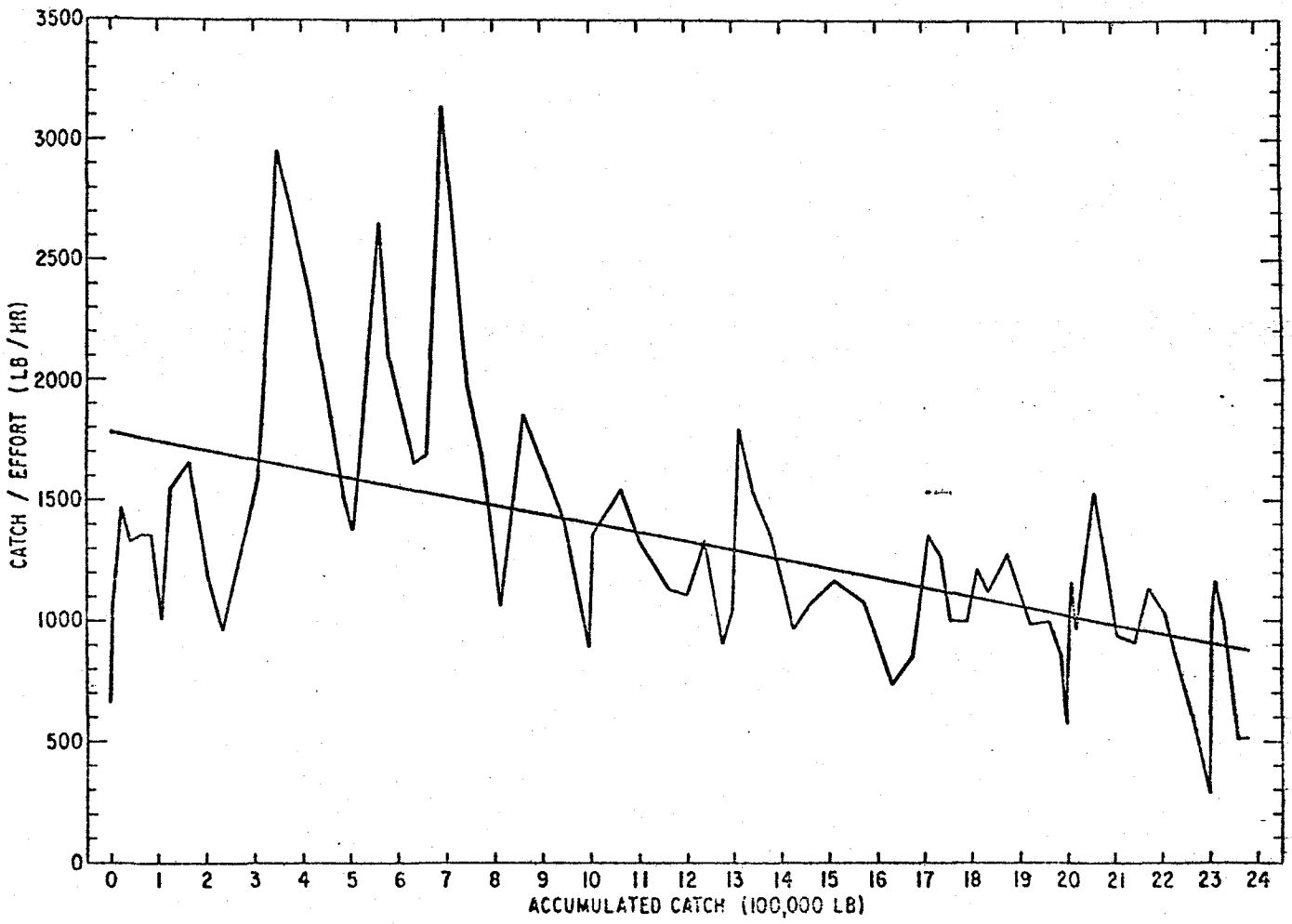

Fig. 2. Leslie plot of catch/effort obtained on each day against the accumulated catch to the start of that day's fishing - Cartwright Channel - July 11 to September 30, 1977.

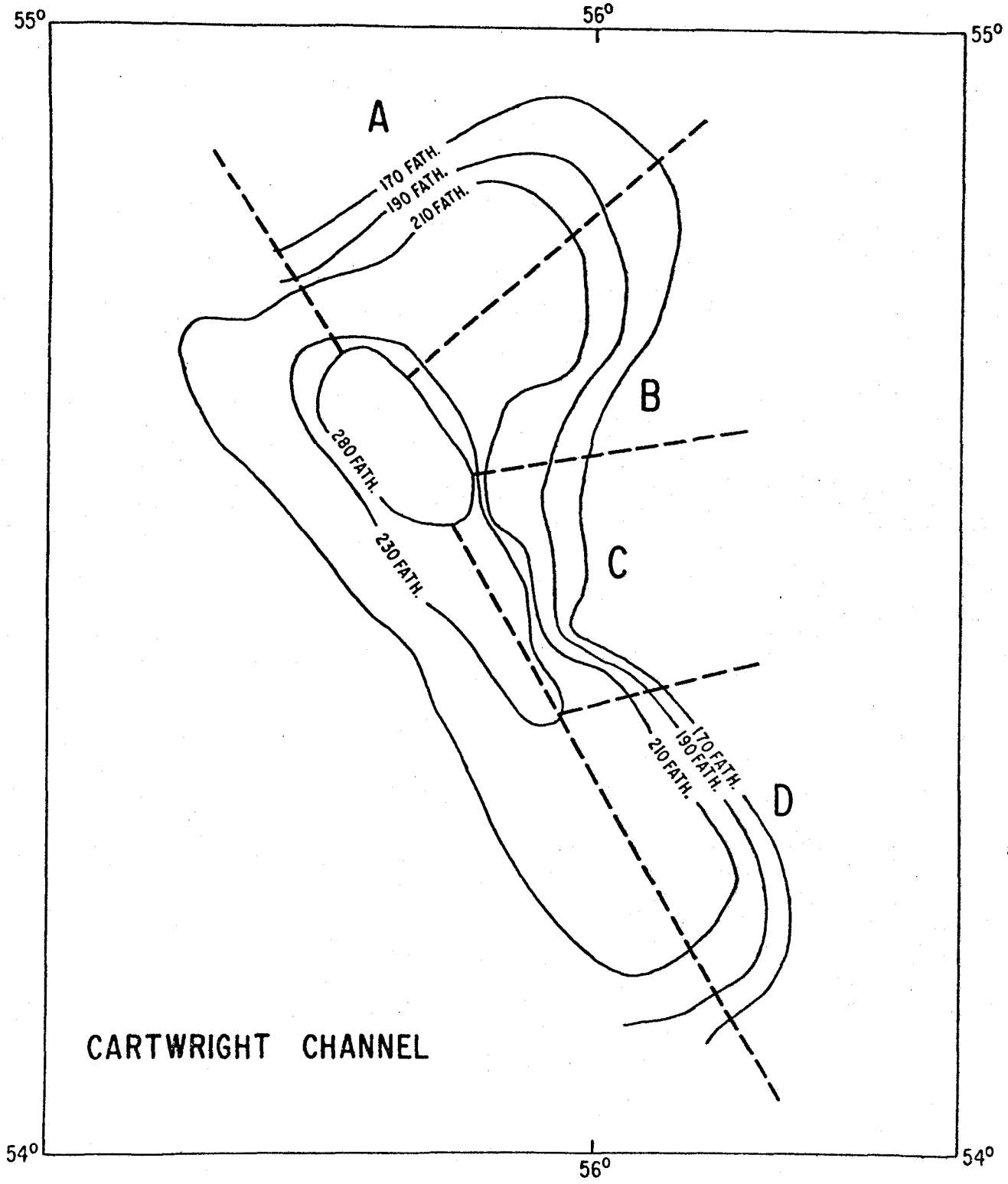

Fig. 3. Cartwright Channel - Location of isobaths and strata used in the biomass survey.

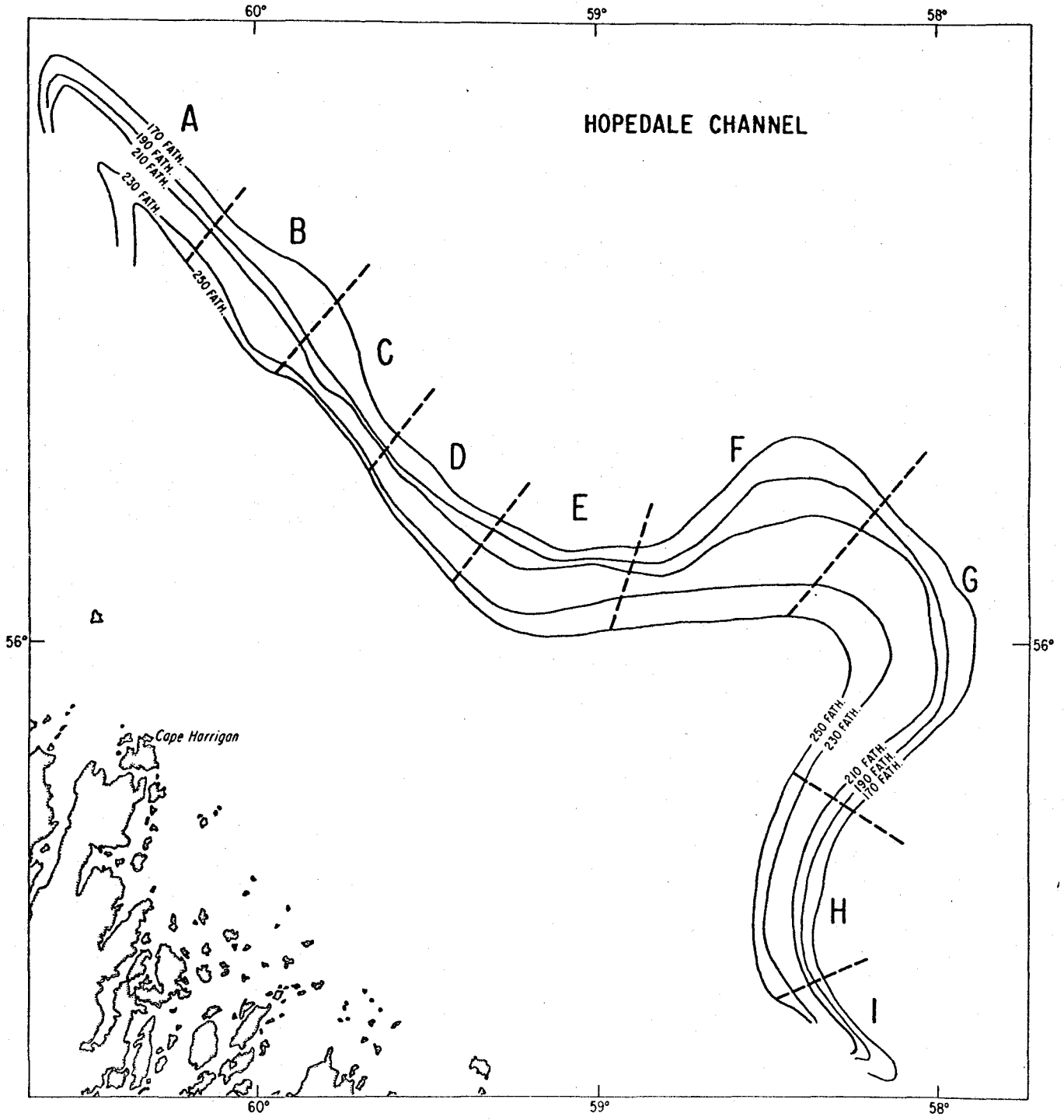

Fig. 4. Hopedale Channel - Location of isobaths and zones used in delimiting the strata used in the biomass survey.