Status of the Northern Shrimp (Pandalus borealis) Resources in the Hopedale and Cartwright Channels (Div. 2H and 2J) Considering Decreasing Fishing Effort in Recent Years

by

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Abstract

Commercial catches rates in the Hopedale Channel in 1981 were generally lower than those observed prior to 1981. These decreases might have been due to reasons other than reduced abundance. Mean biomass estimates compared favourably with those obtained for 1979 and 1980, suggesting some stability in the resource. A high proportion of small shrimp in the research survey data indicates a potential for good recruitment in 1982. There was no new information which provided for a change in the TAC from the 1982 level (4000 t).

Although there has been essentially no fishing in the Cartwright Channel since 1979, biomass indices suggest decreases in shrimp abundance. Predators, especially cod, may be increasing and bottom temperatures during the 1982 survey were around 1°C lower than those observed in previous years. Partially recruited size groups were not abundant at most depths during the 1982 surveys, therefore 1982 recruitment is uncertain. No reduction in TAC (800 t) was advised but it was cautioned that the sustainability of the stock is questionable and signs of natural depletion are evdient.

Preliminary general production modelling and yield per recruit analysis did not provide practical management alternatives for these stocks.

Résumé

Les taux de capture commerciaux dans le chenal Hopedale en 1981 ont été généralement inférieurs à ceux des années précédentes. Il se peut que cette diminution soit due à des causes autres qu'un déclin de l'abondance. Les estimations de biomasse moyenne se comparent favorablement avec celles de 1979 et 1980, ce qui laisse supposer une certaine stabilité de la ressource. Une forte proportion de petites crevettes dans les relevés par navires de recherche laisse entrevoir un bon recrutement en 1982. Nous n'avons pas de données nouvelles justifiant un TPA différent de celui de 1982 (4 000 t).

Bien qu'il n'y ait eu pratiquement pas de pêche dans le chenal Cartwright depuis 1979, les indices de biomasse suggèrent une diminution d'abondance des crevettes. Les prédateurs, surtout la morue, sont possiblement en voie d'augmentation, et les températures du fond, lors du relevé de 1982 sont d'environ 1°C plus basse que celle des années antérieures. Dans le relevé de 1982, les groupes de taille partiellement recrutés ne sont pas abondants à la plupart des profondeurs, signe d'un recrutement incertain en 1982. Un abaissement du TPA (800 t) n'est pas conseillé, mais on attire l'attention sur le fait que l'abondance du stock peut ne pas être soutenue et qu'il y a des signes d'une diminution naturelle.

Un modèle de production généralisée préliminaire et une analyse de rendement par recrue ne fournissent pas, pour ces stocks, d'alternatives de gestion pratiques.

Introduction

Fishing effort for northern shrimp in 1982 was reduced by roughly 50% compared to the previous year. Most catches were reported from Division 0A and Hopedale Channel but TAC's (5,000 and 4,000 t, respectively) were not taken. Cartwright Channel remained virtually unfished for the third consecutive year.

Data from the Labrador stocks (Divisions 2H and 2J) are available for 1982 from the commercial fishery (observer programme) and from the annual (July) research survey. These are compared to data from earlier years and provide the basis for reassessment of the shrimp resource in these areas. It is anticipated that the resulting management advice should be applicable over the next few years and/or until new information necessitates revision.

Catch and Catch Per Unit Effort

Shrimp catches in 1982 off Labrador were reported from three areas: Hopedale Channel - 1,708 t, Cartwright Channel - 167 t, and Division 2G - 5 t. The industry was once again heavily committed to catch as much shrimp as possible from the allocation of 5,000 t in Division 0A. Heavy ice conditions prevailed well into June 1982, limiting fishing effort both in the Davis Strait and Labrador Sea in the earlier months. These conditions and the failure of certain participants to fully utilize their northern shrimp licences, resulted in a significant reduction in effort over the previous year. Consequently, only 43% (1,708 t) of the TAC of 4,000 t in the Hopedale Channel was taken by the end of the year and other areas off Labrador were not extensively exploited.

Fishing effort was standardized to T.C. 5 vessels according to the method of Parsons et al. (1982). The seasonal trend in CPUE in the Hopedale Channel (Fig. 1) generally was similar to that observed for years prior to 1981. Highest catch rates occurred at the beginning and end of the season with an intervening period of low availability (September-October). The figure also shows the numerous periods when no fishing was reported. However, vessel logs are incomplete and periods when no fishing occurred may not be as extensive as suggested in the figure.

Catch rates in the early months of 1982 were slightly higher than those reported in the previous year (Table 1). The June 1982 value is lower possibly due to the heavy ice in the Hopedale Channel which prevented vessels from fishing in the northernmost part of the channel. However, compared to years prior to 1981, these early season catch rates are considerably reduced. Fishing success in September-October 1982 also was lower than in any previous year. The November rate compares favourably with other years and the December rate was lower than in 1981 but effort was considerably less.

August and September catch rates (unweighted) have been used to reflect changes in stock abundance in the Hopedale Channel since 1977.

	1977	1978	1979	1980	1981	1982
CPUE (kg/hr)	622	472	333	390	373	294
Index	1.00	0.76	0.54	0.63	0.60	0.47

The 1982 figure can be interpreted to suggest reductions in abundance in excess of 50% of virgin levels. However, it always has been cautioned that these figures may be misleading since distribution and availability differs between years. This problem is compounded in 1982 by relatively low effort (compared to 1980 and 1981) spread over the entire season. Catch rates in a given area and period can be optimized by cooperation within the fleet. One or two vessels have more difficulty locating concentrations which is often reflected in lower catch rates. A substantial part of the available 1982 data is based on catches of just one vessel (Fig. 1).

Vessel logs, accounting for 143 t of the 167 t caught in the Cartwright Channel in 1982, provide catch rates for June and December (Table 1). No comparisons can be made with data from previous years.

Biomass

A research survey in the Hopedale and Cartwright Channels was conducted from July 7-27, 1982. Recent improvements in the accuracy of information on bathymetry facilitated a stratified random selection of fishing stations. Biomass estimates provided in previous assessments have been generated by applying results of a systematic line survey to the random theory.

Results obtained in the Hopedale Channel show that shrimp were most abundant in depths greater than 400 m (Fig. 2, Table 2), similar to 1979 and 1980 and in contrast to 1981 results (300-400 m). More than 50% of the mean estimate (10,632 t) was calculated from the central part of the channel, whereas in other years the highest proportion of biomass was always found in the northern zone. The similarity in mean estimates for 1979, 1980, and 1982 (~ 11,000-12,000) supports a previous conclusion (Parsons et al. 1982) that the low value obtained in 1981 (4,214) was unreliable due to low availability of shrimp at the time of that survey.

Biomass estimates for shrimp in the Cartwright Channel had been relatively consistent between 1979 and 1981 but inclusion of the 1982 survey results (Table 3) suggests some declining trend in the stock since 1980 (Table 4). This decline has occurred during a period when fishing effort and removals have been negligible. Shrimp were concentrated in depths greater than 400 m in 1982 (Fig. 3, Table 3) which was similar to observations made prior to 1981. In 1981, shrimp were concentrated in slightly shallower water, between 350 and 500 m.

Table 4 summarizes the mean estimates of biomass and their 95% confidence intervals for both channels from 1978 to 1982. Values for 1978 to 1981 were derived from catch rate data obtained from line surveys and should be

interpreted accordingly. The 1982 estimates employed a stratified random design and results 'may' be considered more reliable than those of the previous years. Confidence intervals for estimates from the Hopedale Channel have been extremely wide but those for 1982 are totally impractical. In the Cartwright Channel, the stratified random design in 1982 produced confidence intervals which were very much in line with those obtained from the line surveys.

Unfortunately, many of the rules for conducting a 'pure' random survey have to be bent, indeed broken, during a research cruise. Post-stratification is often necessary in response to: changes in the distribution from what was previously known; concentration of most of the stock in very small areas; dispersal of the stock over much larger areas; inaccuracy of bathymetric charts; high variability within and between strata and general logistics of the research cruise (eg. priorities, weather conditions, vessel performance, etc.). Efforts must be undertaken to develop a practical survey design which, on one hand, will give a resonable index of stock size, and on the other hand, preserve some statistical integrity in the analysis.

Shrimp Size Composition

1. Research

Length frequencies from the Hopedale Channel (Fig. 4) show the characteristic increase in size with depth in all three zones. In areas and depths where most biomass was found, all size groups are well represented. Modes were observed at 12-14, 16-17, 19-22, and 25-26 mm. Modes between 19 and 22 mm were often unclear and in some cases tended towards bimodality.

In the northernmost zone (Fig. 4a) small shrimp (16-17 mm) and low biomass were found in depths less than 240 m. All sizes were represented between 240 and 420 m where roughly 20% of the biomass occurred. Larger shrimp (> 23 mm) were dominant in waters deeper than 420 m (20% of biomass).

The smaller sizes were found in depths less than 350 m in the central zone which accounted for approximately 8% of the biomass. Around 45% of the biomass for the whole channel occurred in this central zone between 350 and 500 m where all sizes of shrimp were well represented. The larger shrimp were most prevalent in depths greater than 500 m where biomass was low. The southern zone did not contain a significant biomass relative to the total.

No recruitment assessments can be made from these observations but abundance of smaller size (age) groups appears to be relatively high compared to 1980 when a similar estimated biomass consisted mostly of shrimp larger than 22 mm (Parsons et al. 1981).

Research length frequencies from the Cartwright Channel also exhibited the pattern of increasing size with increasing depth (Fig. 5). Modes were evident at roughly 12, 16, 20-22, and 24-25 mm. The size group around 20-22 mm was not obvious at all depths but did occur in water between 400 and 500 m where over 40% of the total estimated biomass occurred. Their absence from other strata, however, may imply that this size (age) group is not particularly abundant and

although they should be fully recruited in 1983, may not contribute greatly to the fishable stock. The success of the fishery in this area in 1983 (if any) will depend on the relative strength of this group since many of the larger animals (observed in 1982) will have died, while smaller animals will be only partially recruited.

2. Commercial

Commercial length frequencies for the Hopedale Channel in 1982 (Fig. 6) are very similar in structure to those observed in the previous year. In 1981, fishing effort was concentrated in shallower water than previously observed and the research survey showed a higher proportion of biomass in the shallower strata. Patterns of distribution in 1982 were more 'normal' but commercial catches were still dependent on a larger proportion of smaller shrimp than in years prior to 1981. This may account, in part, for lower catch rates observed in 1982 compared to earlier years but the relatively large biomass may suggest better-than-average strength for some of these year-classes.

Commercial length frequencies for the Cartwright Channel are available only for June and August, 1982 (Fig. 7). In June, mostly large animals (~ 24 mm) were sampled from catches in the area. Catches sampled in August showed a slight increase in the proportion of smaller animals. Considering size at recruitment, shrimp at lengths around 20 mm are represented fairly well in the commercial data. This is in agreement with research data which shows a relatively high proportion of animals around this size in depths between 400 and 500 m where a significant amount of the biomass was located.

By-catch and Discards

Information on by-catches in the 1982 shrimp fishery in the Hopedale Channel is available from observer data (Table 5). Greenland halibut, cod and redfish continue to be the major by-catch species. Catch rates of the former two were highest in November, August and September respectively, while redfish appeared to be more plentiful in October and November, similar to the previous year.

Some estimates of discards of shrimp are also available from the observer data (Table 6). Discard rates ranged from 9.1% in June to 2% in November with an overall average of 6.2% of the total observed catch. These rates are similar to those observed in 1981 but must be regarded as minimum due to the difficulties encountered in obtaining reliable estimates.

Length frequencies from discarded animals in the Hopedale Channel (Fig. 8) showed animals between 17 and 21 mm in June and 14 and 18 mm in August. This reflects the change in size distribution between months noted previously and, likely, the necessity to retain smaller animals to maintain a reasonable catch rate.

Hydrography

Temperatures at various depths in the Hopedale and Cartwright Channels during July 1982 are presented in Fig. 9 and 10. Data from the former area show temperatures that are similar to those recorded for other years (2-3.5°C) in depths where shrimp were most abundant (> 300°C). There is some indication in the southern zone (Zone 3) that temperatures might have been slightly colder than in 1981, although differences are fairly subtle.

Water in the Cartwright Channel, however, was considerably colder than observed in previous surveys (Fig. 10). There appears to have been a reduction in temperature of almost a full degree in depths where shrimp are most plentiful.

Alternative Approaches

Some consideration was given to other methods of assessment.

1. General Production Modelling

Graham-Shaefer and Pella-Tomlinson surplus production models can be run (programs by Rivard 1982) to produce estimates of MSY between 3,000 and 5,000 t for the Hopedale Channel. These, however, cannot be given serious consideration since the history of the fishery is not long enough to provide an adequate series of data. Relationships between CPUE and effort are poorly explained by the models, suggesting the likelihood of a significant departure from equilibrium conditions. Seasonal changes in abundance and inconsistent patterns of fishing between years reduces the reliability of even the 'standardized' unit of effort. The use of these types of models for shrimp may not be justified at all since changes in abundance are likely too sensitive to changes in factors other than fishing effort.

2. Yield Per Recruit

A preliminary Thompson and Bell yield per recruit analysis was attempted for shrimp in the Hopedale Channel using the APL program by Rivard (1982). Estimates of the von Bertalanffy growth parameters ($L\infty$ = 34.6 mm, K = 0.22 and t_0 = -0.75) were used to obtain estimates of total, natural and fishing mortality through the catch curve method of Pauly et al. (1981). A value of 0.85 was obtained for M and fishing mortality in recent years (prior to 1982) was estimated at 0.60. Under these assumptions and partial recruitment rates determined for a mesh size of 40 mm, the analysis indicated that recent levels of fishing may have been considerably lower than $F_{0.1}$ (1.44). Confidence in the accuracy of the mortality estimates is low, however, and the results of the exercise are considered only generally.

Regulation of age at entry was not considered to be relevant to this fishery because it implies changes in mesh size. Trawls currently used have 40 mm mesh or larger in the cod end. This is the size the industry prefers to a) eliminate large amounts of small, unmarketable shrimp and b) maintain a

reasonably economical catch rate of the marketable sizes. Therefore, this aspect of the yield per recruit analysis was not considered even though improvements in Y/R might be obtainable by using other mesh sizes.

If the results of the model are correct in that fishing has been somewhere below $F_{0.1}$ for the 40 mm mesh used, then some increase in effort might be advisable. A consequence of this advice would be a reduction in catch rates from previous levels. Considering the economic status of the fleet at present, such action would not be beneficial. It appears that, given the lack of confidence in the biological parameters, the present marketing requirements for the product and the current economic performance of the fleet, Y/R analysis for this fishery does not provide practical management alternatives at this time. A more complete analysis (eg. Ricker 1975) incorporating seasonal changes in fishing and natural mortality might be of some value but will require a much greater refinement of the biological parameters.

DISCUSSION AND CONCLUSION

Although catch rates in the Hopedale Channel in 1982 were similar in trend to those observed prior to 1981, most monthly rates were lower than in these years. This could be interpreted to reflect reduced abundance but may be more a result of: a) low fishing effort throughout the year resulting a reduction in cooperative fleet performance and b) a significant increase in the number of vessels fishing for Greenland halibut in the northern part of the channel which may have dispersed shrimp concentrations through numerous, repetitive trawlings.

The mean estimate of biomass obtained from the July 1982 survey is in good agreement with those for 1979 and 1980, suggesting some stability in the resource in this area. Distribution of this biomass differed from earlier years due to a larger proportion (> 50%) of the total occurring in the central part of the channel. This difference in distribution also may have affected catch rates, at least in the early months of the year.

Length frequencies from the research survey showed a relatively high abundance of smaller animals, which was reflected again in the commercial data. This partial dependency on smaller animals to maintain good catch rates was not so pronounced in years prior to 1981 and may further explain lower rates observed in 1982. Available data on abundance and size composition do not suggest recruitment problems for 1983.

Environmental factors include temperature and abundance of predators. Temperature profiles do not indicate any decrease from previous years. Abundance of cod has shown some indication of only slight increases in recent years while Greenland halibut has shown obvious increases (Parsons, 1983). The shrimp stock has demonstrated some insensitivity to increases in the latter.

In 1982, self-regulating characteristics were identified for the Hopedale Channel (viz. priority in Subarea 0 and attaining most economical catch rates). These characteristics still apply for

1983. Also, there is no additional information which suggests that the present TAC of 4,000 t should be either increased or decreased.

The situation in the Cartwright Channel appears entirely different. The fishery has been eliminated (essentially) during 1980-82, yet mean estimates of biomass have shown deceases during the same period. Abundance of Greenland halibut has varied, but no increasing trend has been identified. Cod have shown indications of increasing in the area based on increased large catches of cod during the research survey (reflected in biomass estimates) and improved performance of the cod fishery in and near this area. Recruitment in 1983 is uncertain due to low abundance of partially recruited animals at most depths in the 1982 research survey. Also, the temperatures at depths where shrimp are abundant have dropped almost a full degree from previous years. Should this continue, the sustainability of this stock becomes questionable.

A reduction in TAC (800 t) does not appear necessary considering removals in the past three years. What might be more appropriate is a management plan which exploits very quickly a resource showing signs of natural depletion, perhaps to very low levels.

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Table 1. Catch per hour fished, 1977-82 (monthly values determined from vessel logs) adjusted to tonnage class five.

	1977		1978		1979		1980		1981		1982	
	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)
Hopedale Channel												
May									5,455	253		
June					196,741	957	28,970	872	408,457	539	171,265	467
July			131,544	773	965,454	706	736,840	645	360,770	356	302,674	397
Aug.	93,695	611	85,570	560	812,378	368	589,206	475	474,218	344	219,227	376
Sept.	206,111	631	68,591	383	81,907	297	599,724	304	555,279	402	62,621	211
Oct.	330,574	361	584,589	580			390,295	423	406,217	404	246,110	389
Nov.	641,516	780	470,170	555			163,316	598	469,023	418	471,095	569
Dec.			-[3]	-					168,375	607	113,325	366
Total[1]	1,271,896	573	1,340,464	569	2,056,480	507	2,508,351	449	2,847,794	409	1,586,317	420
Total[2]	1,203,000		2,109,000		2,693,000		3,938,000		3,382,266		1,707,900	
Cartwright Channel												
June					-[3]	-	23,134	212			113,580	382
July	311,838	834	155,813	479	147,498	730	11,770	453	6,875	262		
Aug.	514,633	624	399,501	664	148,268	318	22,465	368	5,035	155	1,020	322
Sept.	234,037	465	638,159	463	353,821	235	55,919	326	907	202		
Oct.	14,378	187	45,439	264			405	73				
Nov.	73,616	802					3,535	135				
Dec.	9,650	566									28,710	380
Total[1]	1,158,152	614	1,238,912	500	649,587	299	117,228	294	12,817	203	143,310	381
Total[2]	1,414,000		1,521,000		1,034,000		170,000		67,419		167,200	

[1] based on catches from vessel logs
[2] based on statistics from landings
[3] months with catches but no vessel logs

Table 2. Minimum trawlable biomass - 1982 research.
Hopedale Channel

Stratum	Depth (m)	Area (sq. n. mi)	No. sets	Biomass (t)
102	202-238	48.7	3	86
103	239-274	44.4	3	148
104	275-311	38.8	3	189
105	312-348	38.8	3	391
106	349-384	40.7	4	586
107	385-421	37.9	4	983
108	422-457	39.3	4	727
109	458-494	41.6	3	204
110	495-530	109.9	4	1202
111	531-567	51.5	3	181
204	275-311	290.1	3	589
205	312-348	174.0	2	209
206	349-384	134.7	3	419
207	385-421	95.0	4	1250
208	422-457	147.8	2	2657
209	458-494	161.9	3	297
210	495-530	168.0	3	217
211	531-567	168.4	2	25
212	568-604	163.3	2	98
213	605-641	63.6	2	17
304 & 305	275-348	77.7	3	11
306	349-384	23.4	2	17
307	385-421	18.7	2	51
308	422-457	18.3	2	7
309	458-494	18.7	2	18
310	495-530	24.3	2	28
311	531-567	30.9	2	21
312	568-604	37.9	2	4
TOTAL		2,308.3	77	10,632

Table 3. Minimum trawlable biomass - 1982 research.
Cartwright Channel

Stratum	Depth (m)	Area (sq. n. mi)	No. sets	Biomass (t)
702	301-350	89.7	2	103
703	251-300	19.9	3	23
704 & 705	<300	66.6	3	3
706	301-350	45.7	4	82
707	351-400	36.0	5	87
708	401-450	45.0	6	489
709	451-500	53.9	6	345
710	501-550	89.7	6	335
711	451-500	15.6	4	59
712	>551	41.3	3	397
Total		503.4	42	1,923

Table 4. Biomass estimates, 1978-82[1] and 95% confidence intervals.

	Year	Mean	Upper	Lower	Area (sq. n. mi)	n
Hopedale	1978	1,825	3,054	597	1,306	23
	1979	11,608	19,730	3,487	1,878	54
	1980	11,840	19,134	4,545	2,496	83
	1981	4,213	5,974	2,452	2,434	56
	1982	10,634	37,764	-16,496	2,308	77
Cartwright	1978	1,138			417	25
	1979	1,892	2,879	904	286	22
	1980	2,789	3,422	2,157	417	37
	1981	2,367	3,380	1,355	503	49
	1982	1,923	2,876	971	503	42

[1] 1978-81 estimates are derived from systematic line surveys

1982 estimates are derived from a stratified random design

Table 5. By-catches (kg per hour) in the Hopedale Channel, 1982, estimated by observers.

	Turbot	Cod	Redfish	Shark	Skate	Plaice	Wolffish
June	12	-	13	17	3	2	7
July	28	11	19	5	12	12	5
August	42	51	11	2	2	1	2
September	40	48	17	-	3	-	6
October	19	6	35	-	2	-	2
November	85	3	52	-	1	-	-

Table 6. Shrimp discards, Hopedale Channel, 1982.

	Catch	Amount Discarded (kg)	% Discarded
June	164,232	14,902	9.1
July	260,117	21,221	8.2
August	230,459	8,800	3.8
September	57,110	3,620	6.3
October	165,215	10,630	6.4
November	106,475	2,105	2.0
Total	983,608	61,278	6.2

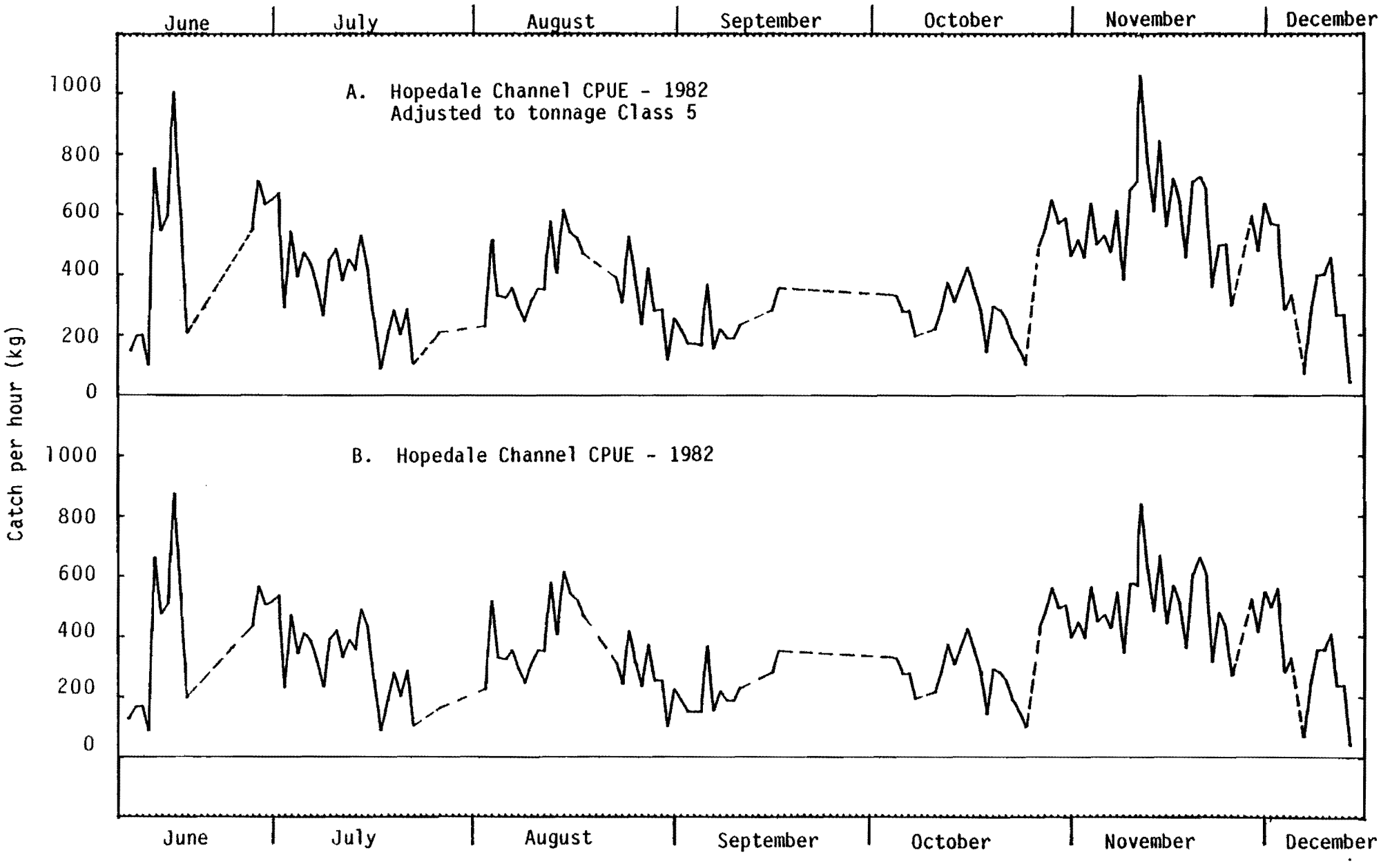

Fig. 1. Catch per unit effort - 1982, A = standardized; B = not standardized.

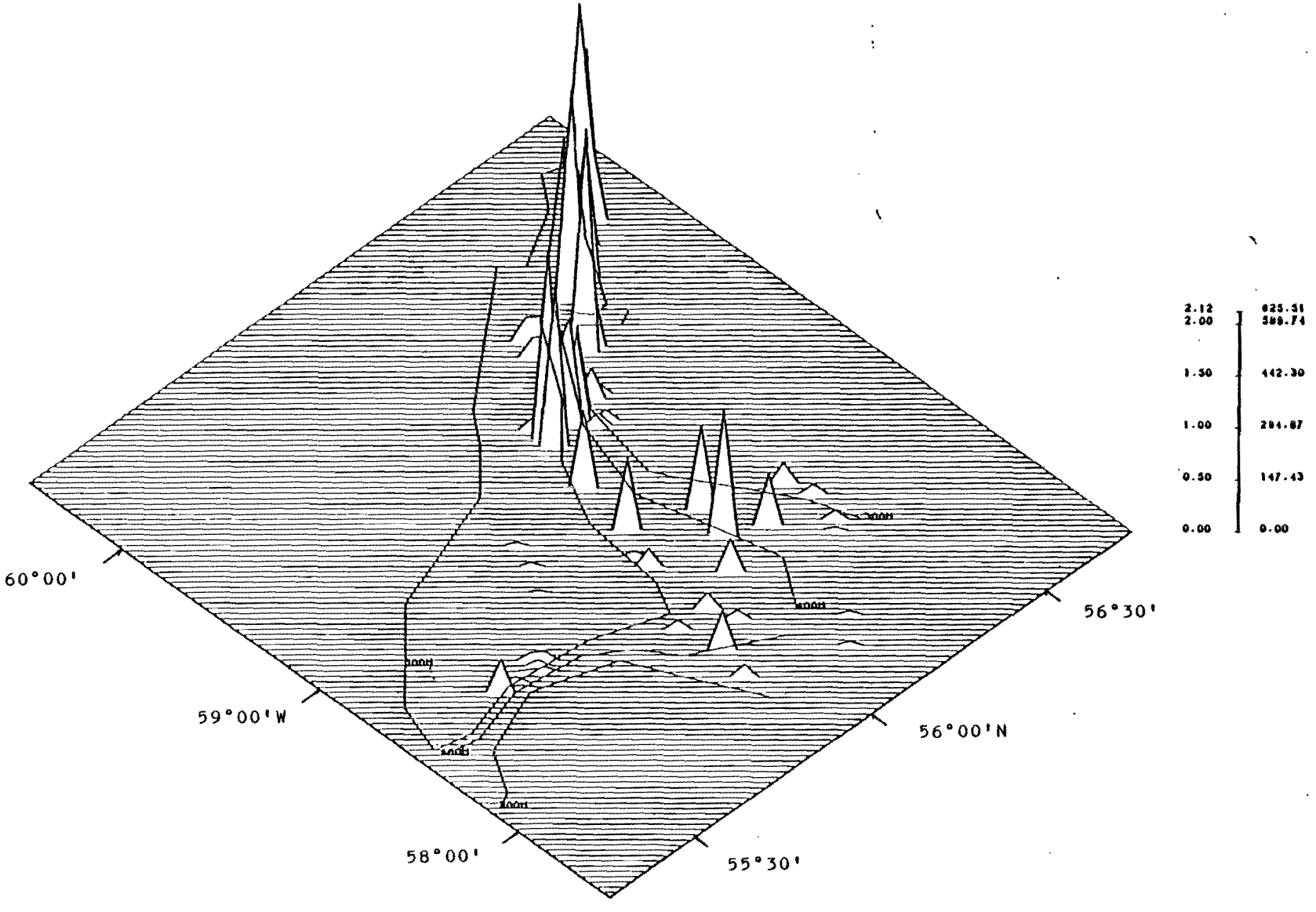

Fig. 2 SHRIMP CATCHES PER 30 MIN TOW HOPEDALE CHANNEL 1982 GADUS/67

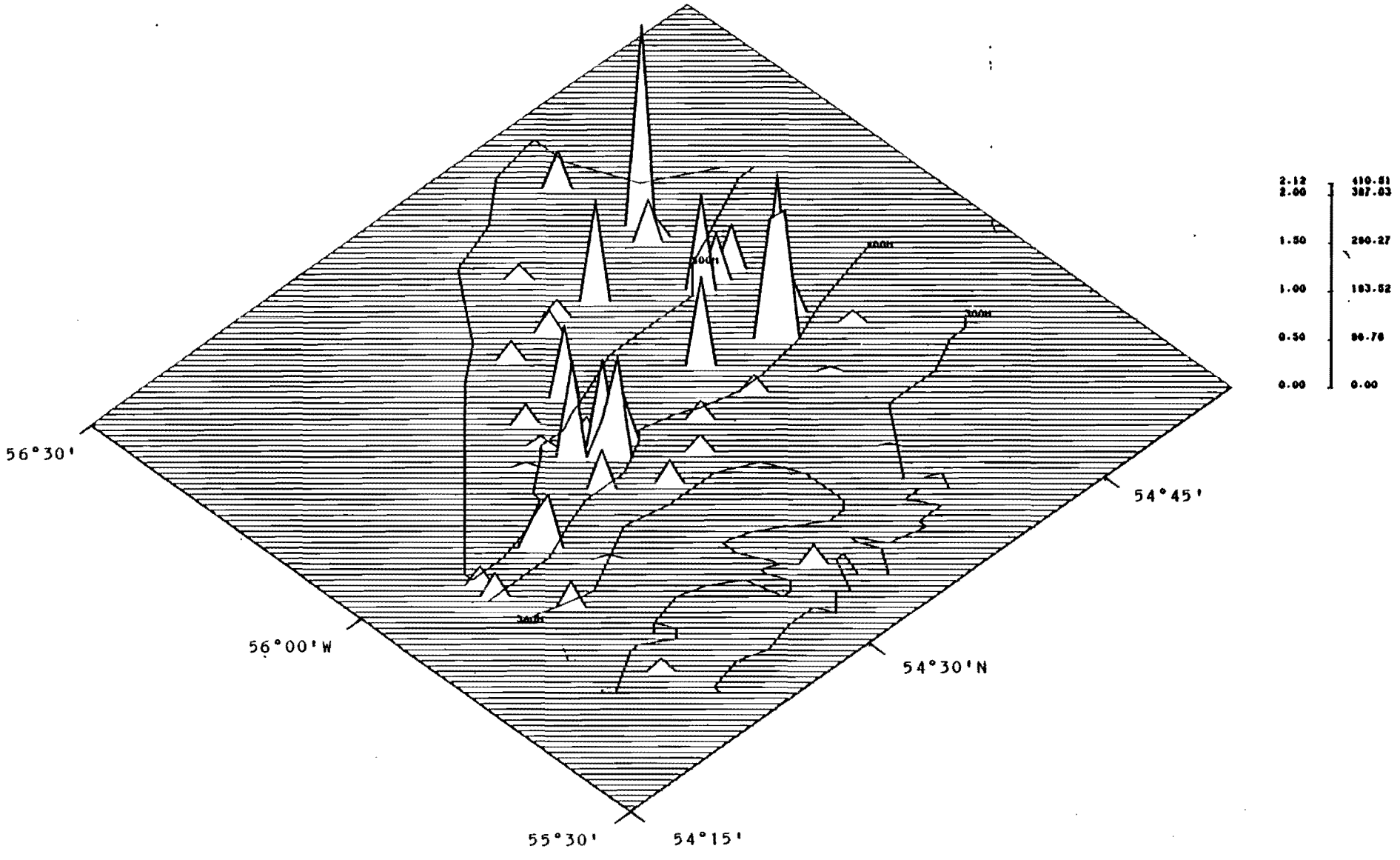

Fig. 3 SHRIMP CATCHES PER 30 MIN TOW - CARTWRIGHT CHANNEL, 1982

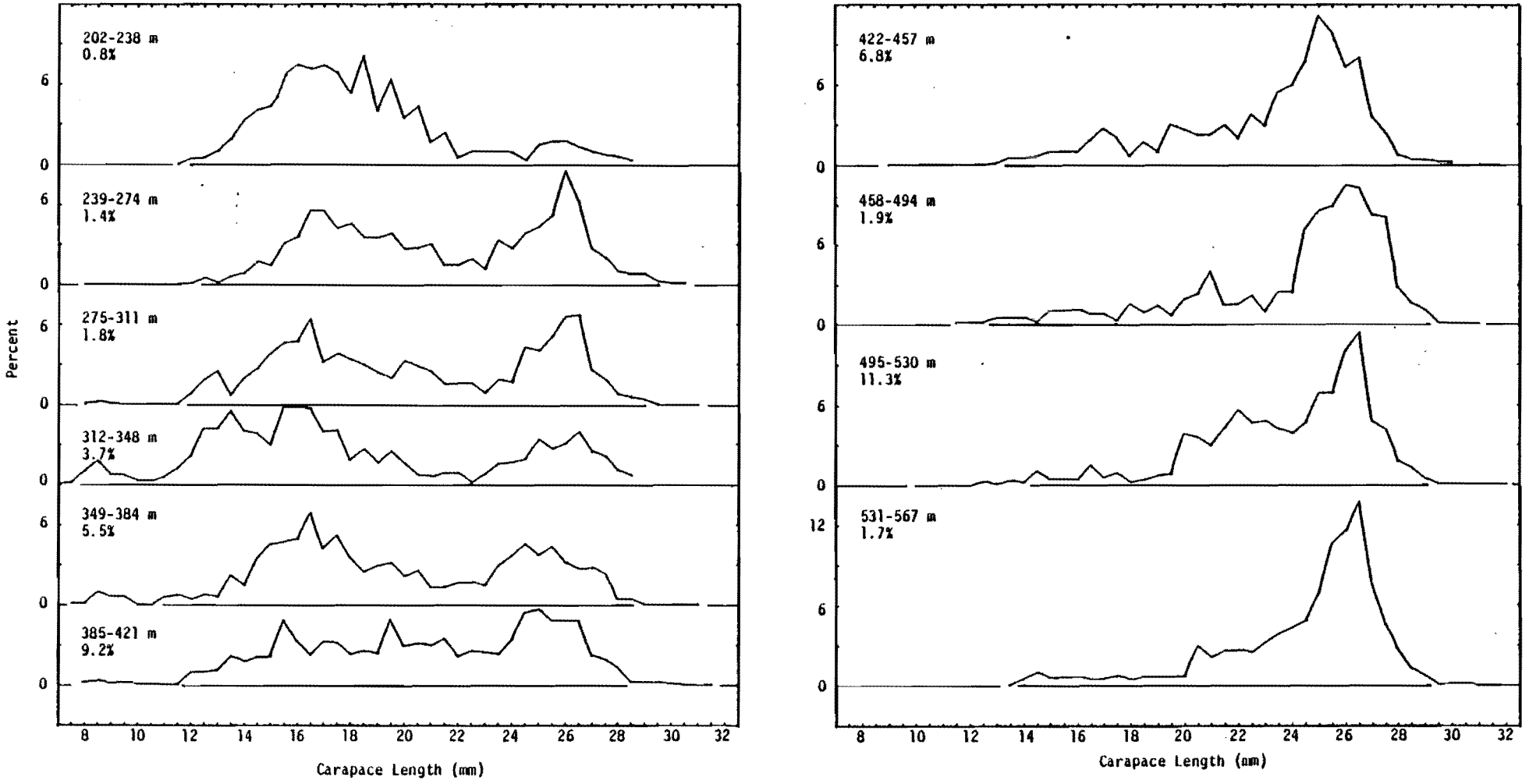

Fig. 4a. Research length frequencies, Hopedale Channel Zone 1 - 1982.
(% of biomass indicated).

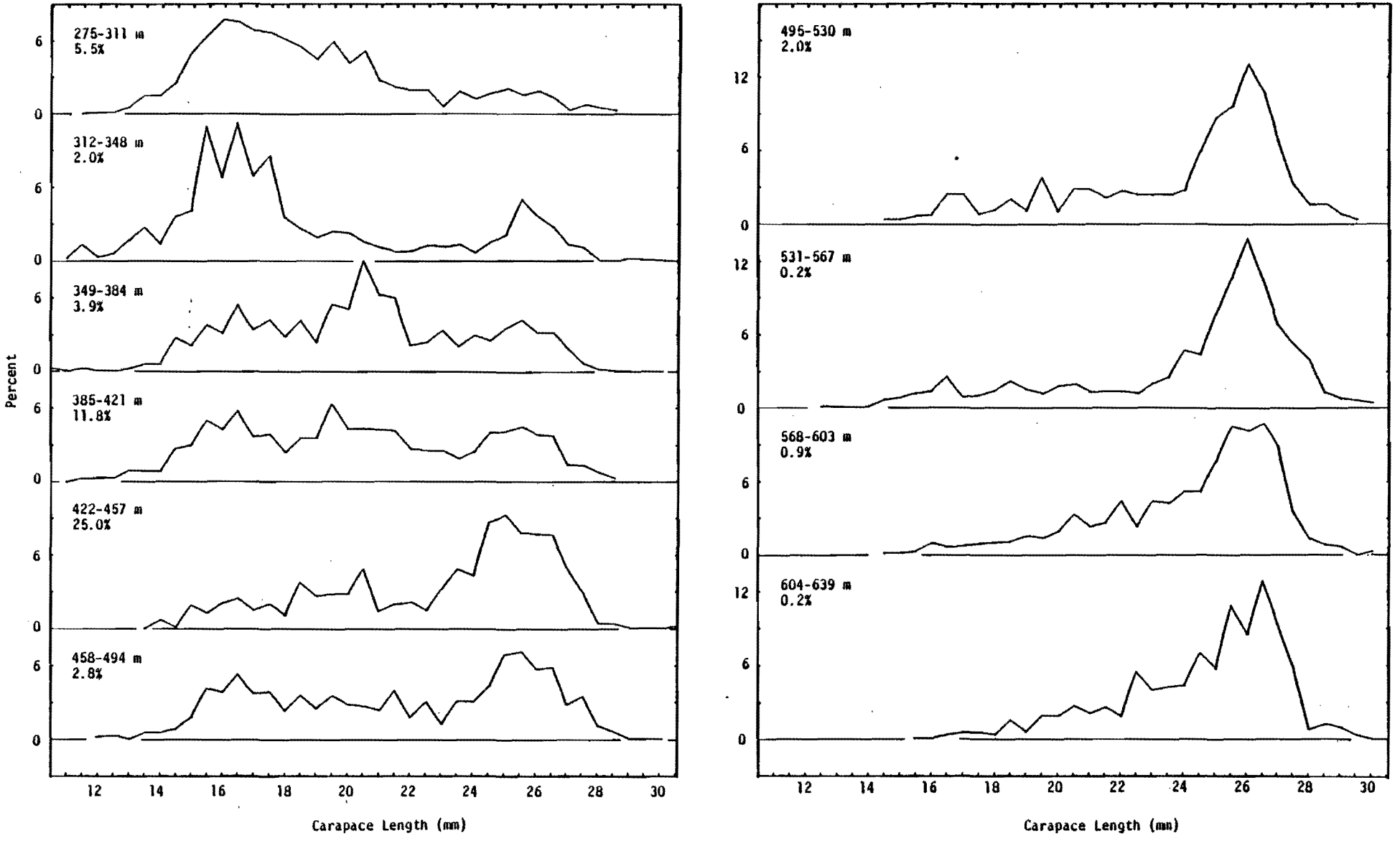

Fig. 4b. Research length frequencies, Hopedale Channel Zone 2 - 1982.
(% of biomass indicated).

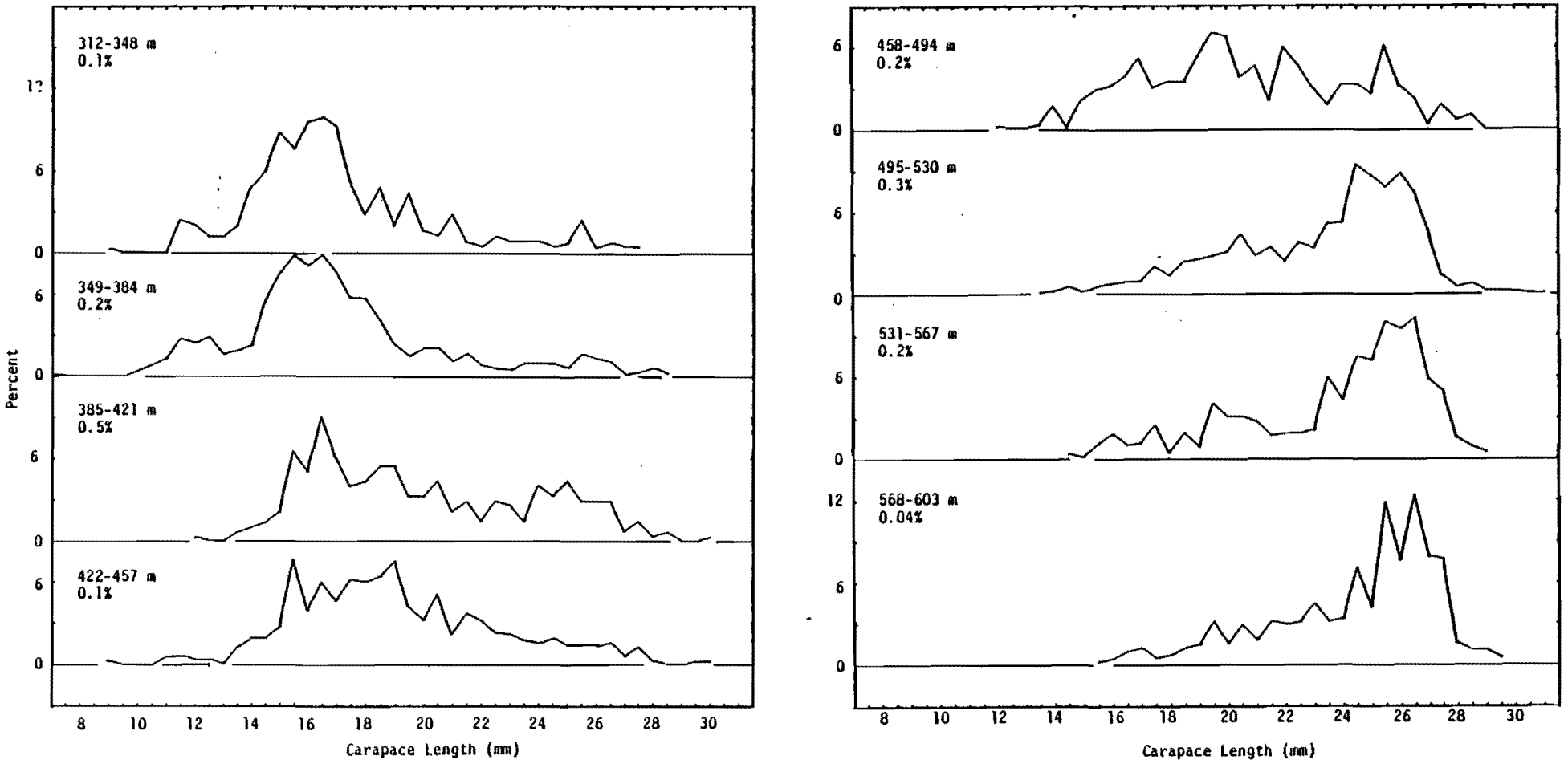

Fig. 4c. Research length frequencies, Hopedale Channel Zone 3 - 1982.
(% of biomass indicated).

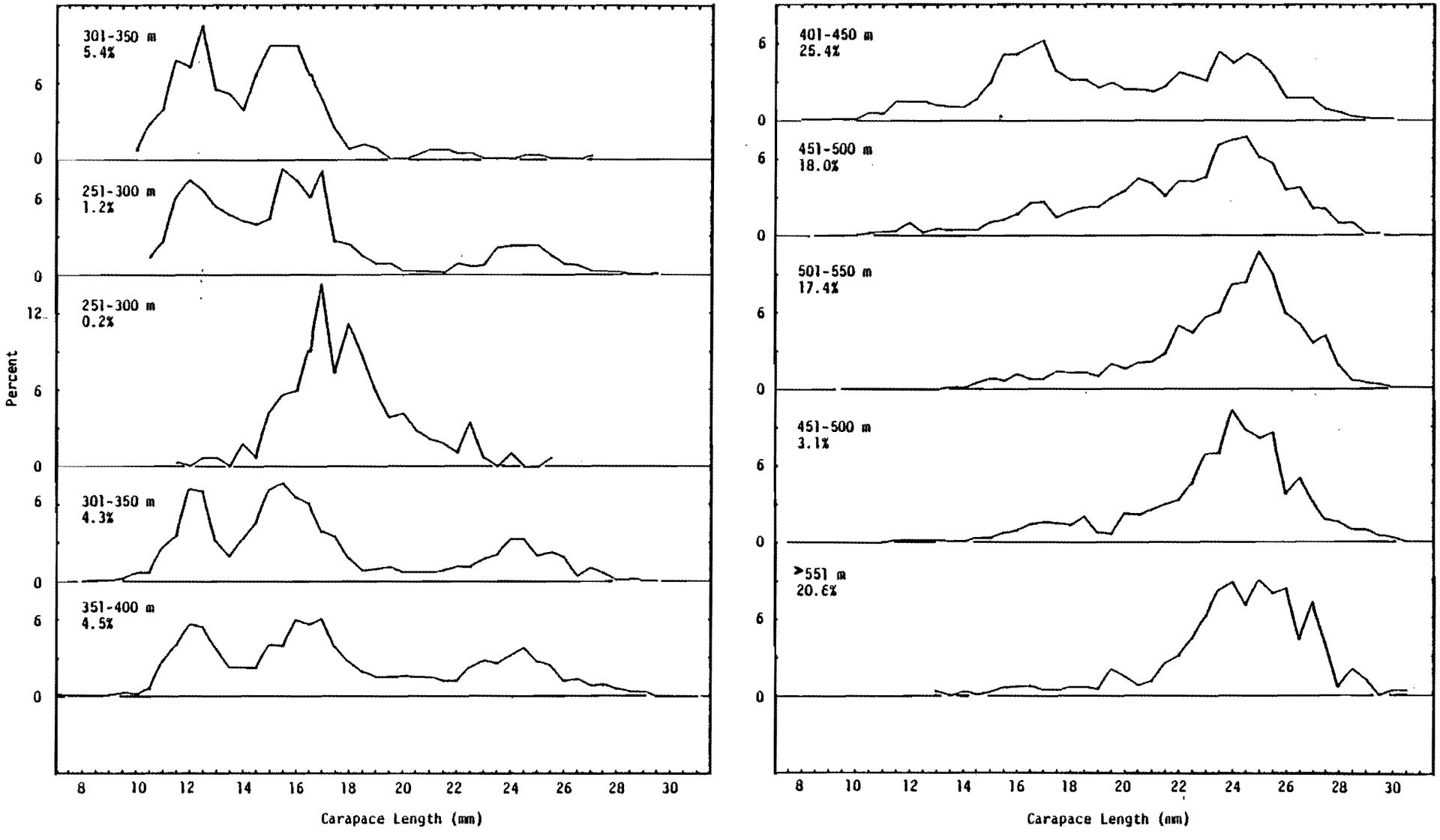

Fig. 5. Research length frequencies, Cartwright Channel - 1982.
(% of biomass indicated).

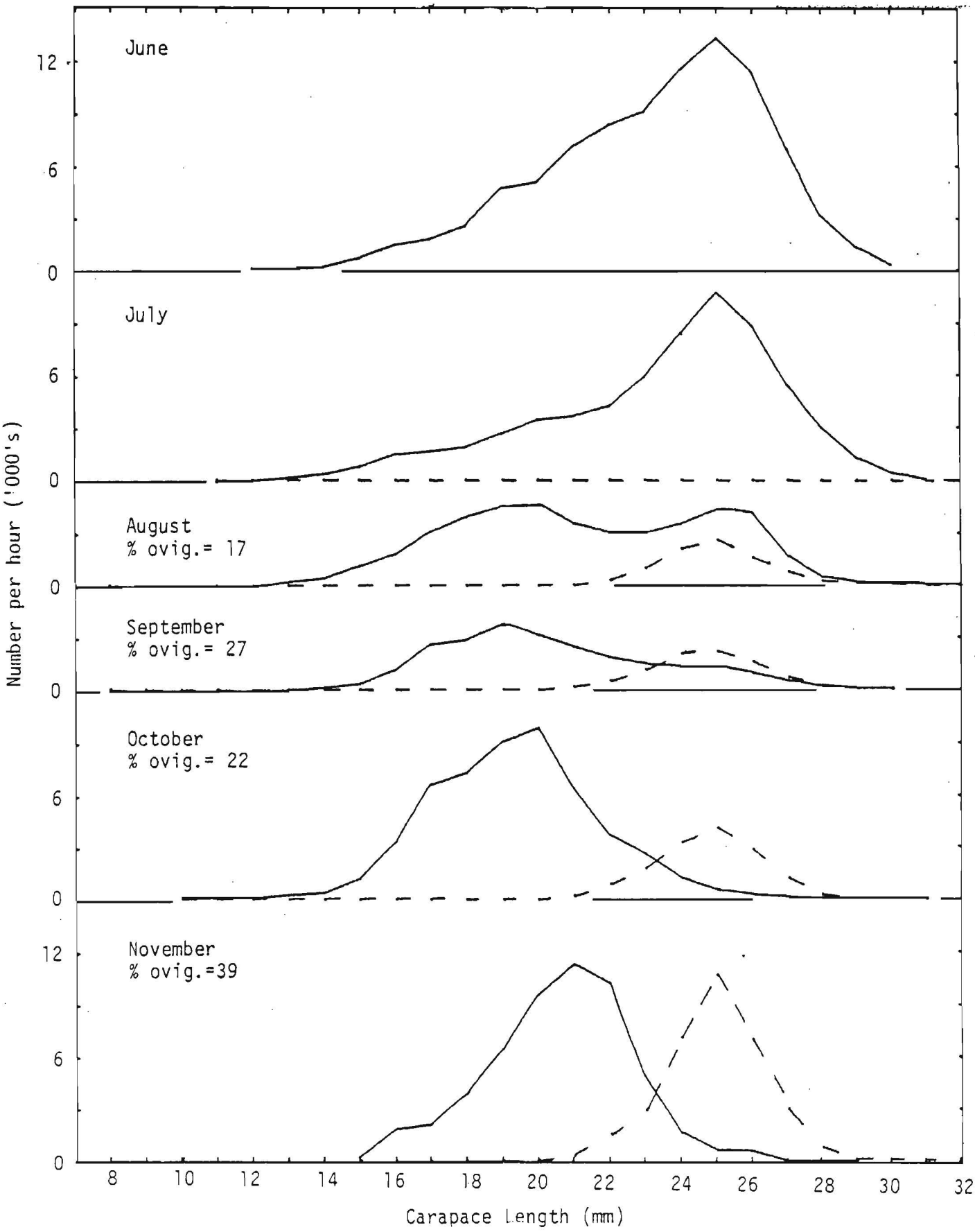

Fig. 6. Commercial length frequencies, Hopedale Channel, 1982.
(broken line = ovigerous.)

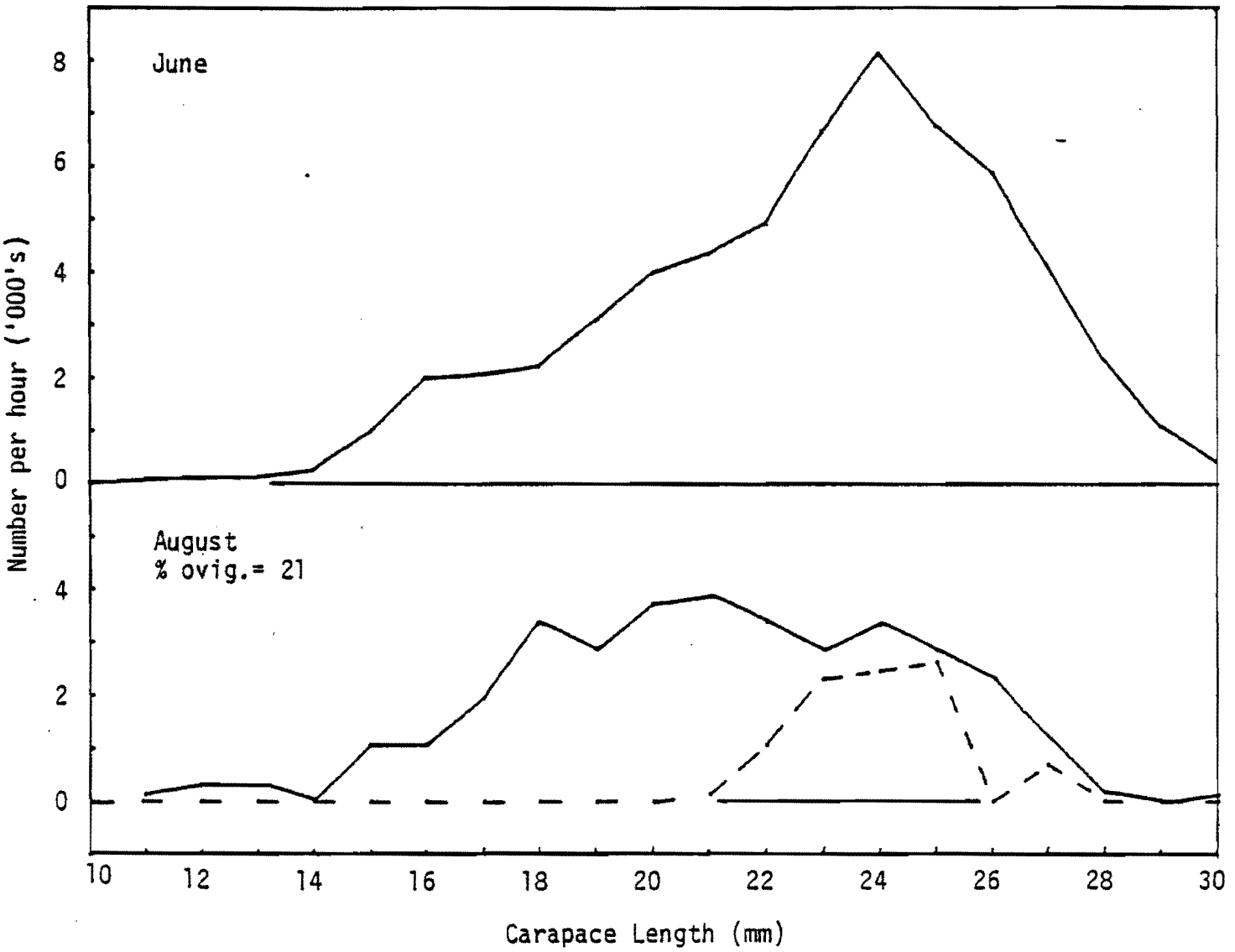

Fig. 7. Commercial length frequencies, Cartwright Channel - 1982.
(broken line = ovigerous).

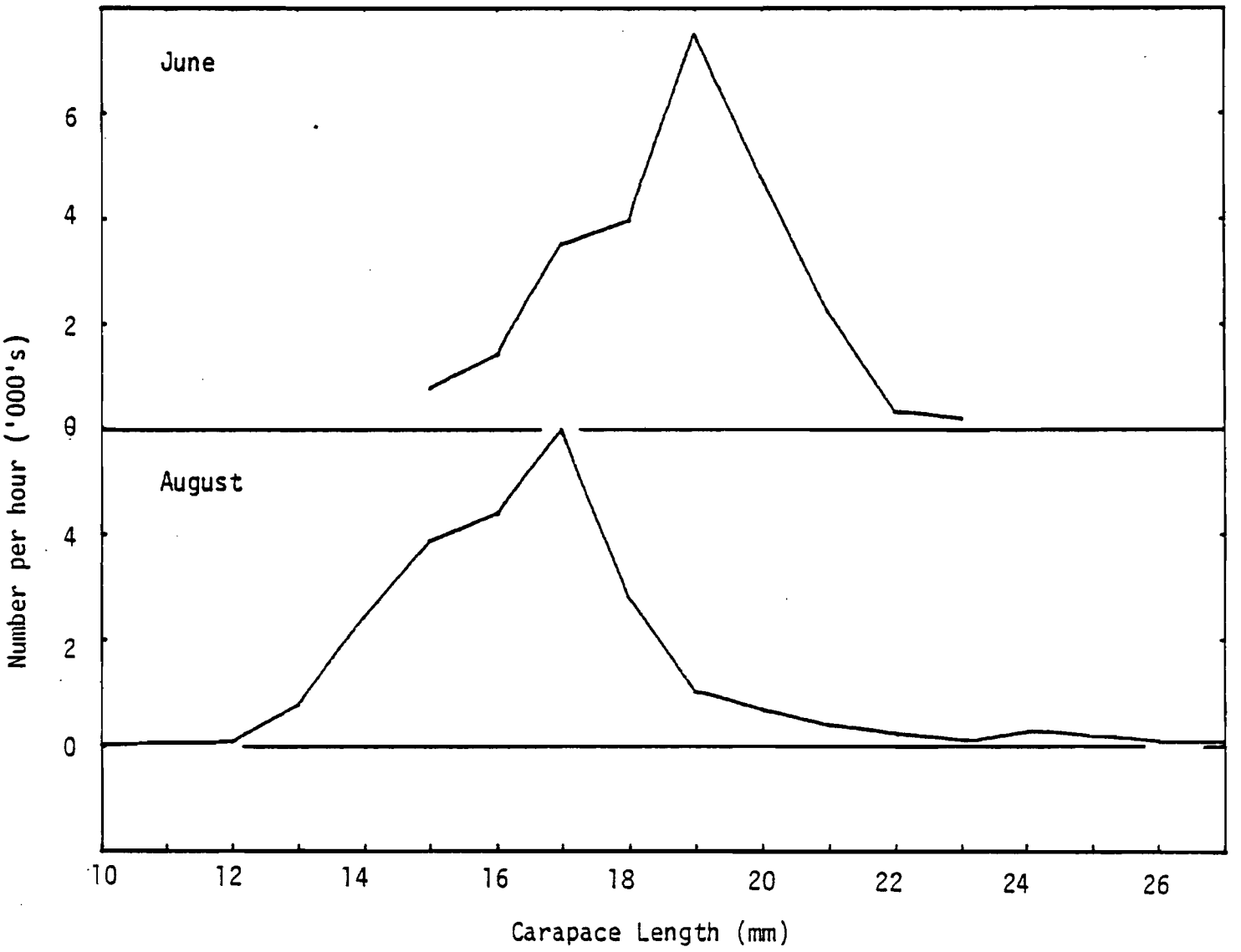

Fig. 8. Discard Length frequencies, Hopedale Channel, 1982.

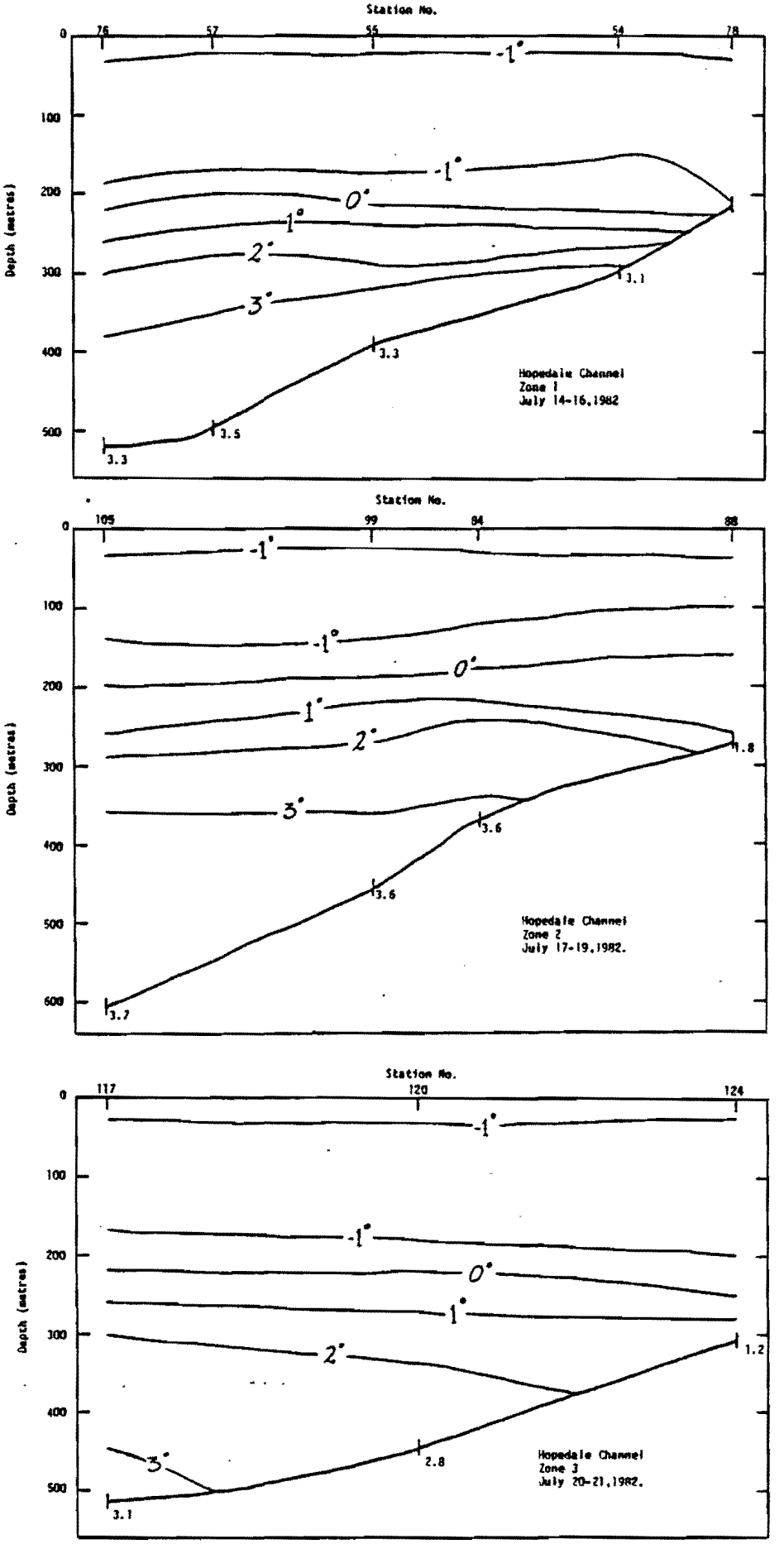

Fig. 9. Hydrographic sections, Hopedale Channel - 1982.

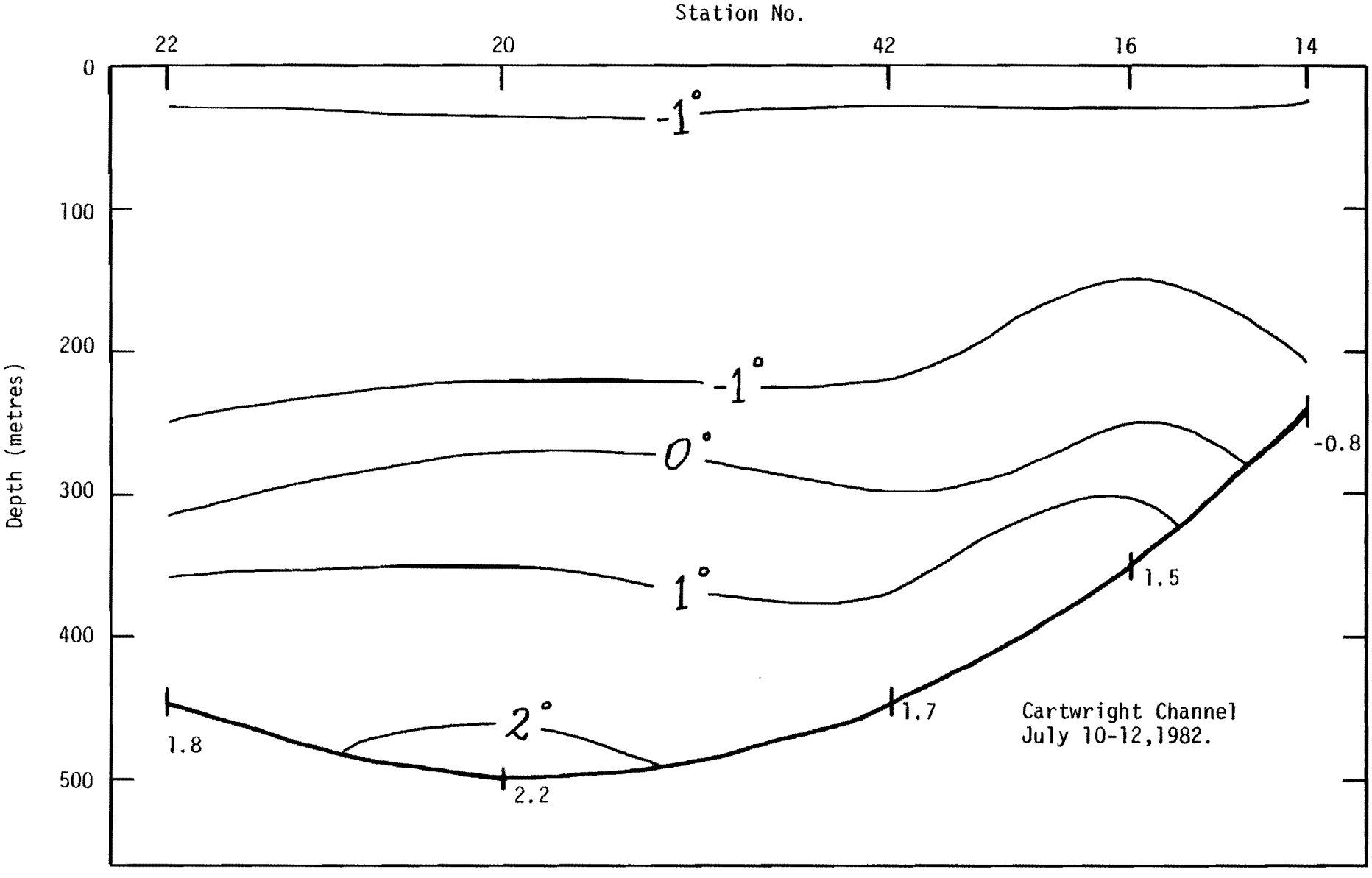

Fig. 10. Hydrographic section, Cartwright Channel, 1982.