An Analysis and Interpretation of the 1984 Data on Research and Commercial Fishing for Shrimp (*Pandalus borealis*) in the Cartwright and Hopedale Channels

by

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ABSTRACT

Fishing effort for shrimp off Labrador in 1984 was sporadic and catches in both the Cartwright and Hopedale Channels were well below the advised TAC. However, the catch reported from Cartwright Channel was higher than in the previous four years. Biomass estimates from this area showed a decrease in abundance from 1980 to 1983, followed by a substantial increase in 1984. This increase is related to concentrations of shrimp occuring in shallow water on the saddle. Because small shrimp were abundant in 1984, catch rates in 1985 could improve, provided the concentrations do not disperse over a much wider area. Reproductive potential appears reduced in the cold waters of the Cartwright Channel and, under such conditions, instability in the stock can be expected.

The shrimp stock in Hopedale Channel appears to be substantially lower during the 1982-84 period than in 1979-80. Small shrimp were abundant in 1984 and as these become more fully recruited, catch rates in 1985 could improve. The fishery remains self-regulatory in that catch rates determine how heavily the stock is fished. TAC's based on averaging biomass estimates over a number of years are considered inappropriate.

Potential for predation by Greenland halibut and cod remains high in both channels. In 1984, shrimp were most abundant in shallow water where cod abundance was also high.

Résumé

L'effort de pêche à la crevette au large du Labrador en 1984 a été sporadique et les prises dans les chenaux Cartwright et Hopedale étaient bien inférieures au TPA recommandé. Cependant, la prise signalée dans le cas du chenal Cartwright est plus élevée qu'au cours des 4 années précédentes. Les estimations de la biomasse pour cette région ont révélé une diminution de l'abondance de 1980 à 1983, suivie d'une augmentation substantielle en 1984. Cette augmentation est liée à des concentrations de crevettes dans les eaux peu profondes sur le col. Etant donné que les petites crevettes étaient abondantes en 1984, les taux de capture en 1985 pourraient augmenter à moins que les concentrations de crevettes soient dispersées sur une superficie plus vaste. Le potentiel de reproduction semble réduit dans les eaux froides du chenal Cartwright et dans ces conditions, on peut s'attendre à une instabilité du stock.

Le stock de crevettes du chenal Hopedale au cours de la période 1982-1984 semble être substantiellement réduit par rapport à 1979-1980. Les petites crevettes étaient abondantes en 1984 et au fur et à mesure que le recrutement s'intensifie, les taux de capture en 1985 pourraient s'améliorer. La pêche se règle d'elle-même du fait que ce sont les taux de capture qui déterminent dans quelle mesure le stock est pêché. Les TPA fondés sur des estimations de la biomasse moyenne pendant un certain nombre d'années ne sont pas considérés comme appropriés.

Le potentiel de prédation par le flétan du Groenland et la morue demeure élevé dans les deux chenaux. En 1984, les crevettes étaient les plus abondantes dans les eaux peu profondes où la morue était, elle aussi, abondante.

Introduction

The northern shrimp fishery in 1984 was concentrated in the Davis Strait (Division 0A) where only 40% of the 5000 t quota was taken (Parsons et al. 1985). Eight vessels (three domestic and five foreign) participated in this area compared to six (five domestic and one foreign) off Labrador. Sustained fishing effort over the season did not occur in either the Hopedale or Cartwright Channels. Limited access to the former area early in the year (July) resulted in a higher concentration of effort in the Cartwright Channel and, consequently, a higher catch compared to the previous four years.

As in 1983, the observer coverage of vessels fishing off Labrador was minimal. An observer from Scotia-Fundy collected data onboard one vessel fishing in the Hopedale and Cartwright Channels from October 12 to November 12. Another observer from Quebec obtained data from a second vessel which fished later in the year (November 13 to December 11) in Hopedale Channel. Therefore, for the second consecutive year, the value of the commercial sampling data as a means of monitoring changes in the stock is limited.

The 1984 research cruise was conducted from July 5 to July 30. Ice on the Labrador was the heaviest encountered since the July surveys began in 1979. These conditions were ultimately responsible for a change in survey methodology from a stratified random design to a line survey for the Hopedale Channel (see Biomass section). The data collected during the survey provided new information on shrimp abundance, distribution and biology which are compared to similar observations from previous years. Abundance of shrimp predators also was estimated and compared to previous estimates. Bottom temperatures were recorded at each fishing station in both channels and results are compared to the trends evident in recent years (Parsons and Tucker 1984, Parsons and Veitch 1984).

CARTWRIGHT CHANNEL

Catch and CPUE

Shrimp catches in the Cartwright Channel increased from around 1400 t in 1977 to 1500 t in 1978 and declined to around 1000 t in 1979 (Table 1). Between 1980 and 1983, effort was low resulting in catches of 170, 67, 167, and 3 t, respectively. In 1984, ice restricted fishing in Hopedale Channel until late July and, consequently, some vessels exploited good concentrations of shrimp on the Cartwright Saddle. This increased effort resulted in a catch of 312 t[1], most of which was taken early in the season.

CPUE data (standardized to tonnage class 5) from 1977 to 1979 for July-September (unweighted) showed a decrease of 33% (Parsons and Tucker 1984). Data were not sufficient in subsequent years to continue this comparison but monthly catch rates in 1984 were higher than those of the previous three years, especially during the July-September period.

[1]preliminary

Biomass

The research survey in the Cartwright Channel in 1984 was not affected to any great extent by the presence of ice. A total of 47 successful stratified random sets were made in the area (Table 2, Fig. 1). The presence of ice, however, did prevent the implementation of a strategy to fish the less productive strata at night (Parsons 1984). The expanded stratified area, first used in 1983 (Parsons and Tucker 1984), was again surveyed in 1984. The estimate of biomass obtained by areal expansion was 3113 (± 1750) t, 2.80 times the 1983 estimate and the highest reported since the July surveys first began in 1979 (Table 3, Fig. 2)! Only 567 t (18%) of the total estimate came from the old stratified area (700 strata) whereas 2479 t (80%) was estimated for an area farther out over the saddle (300-450 m) where temperatures generally were less than 2°C.

Survey results from 1979 to 1984 are plotted in Figure 3, showing the changes in distribution and abundance between years. In 1979, sampling intensity was low but highest catches were found in the central and deepest part of the channel. More sets were made in 1980, but the same general pattern was apparent. In 1981, shrimp occurred in more shallow water than observed previously and some of the highest catches were obtained in the northern part of the old survey area. Extra sets were made farther north, but catches were not sufficient to warrant an expansion of the stratified area. Abundance was generally low throughout the area in 1982 and regions of highest concentrations were not well-defined. In 1983, abundance was extremely low in the old survey area and extra sets fished over the Saddle produced some of the best catches. This pattern of distribution necessitated an expansion of the stratified area. The 1984 survey indicated a continued decrease in abundance in the 'traditional' grounds but a substantial increase over the Saddle.

Therefore, from six years of survey data, it is apparent that distribution of shrimp in the Cartwright Channel has changed radically over the period. Abundance, too, appears to have fluctuated but as stated in a previous review (Parsons and Tucker 1984), it is not certain how closely changes in density (biomass per sq.n.mi) relate to overall abundance. Obviously, the opportunities for dispersal are not as restricted by cold temperatures as first believed. Also, any shifts in the stock to the western slopes of the Channel would not have been be detected through surveys because of unsuitable conditions for trawling in that area.

Size Composition

Details of the size composition of shrimp in Cartwright Channel only were available from the research survey in 1984. Length frequencies showed the general trend of increasing mean size with depth (Fig. 4). Female shrimp were dominant in depths greater than 450 m, but in areas of highest abundance (301-400 m) the catches were comprised mostly of male shrimp ranging in size from 14-19 mm (Fig. 5). Except for the obvious male and female modal groups, the length distributions showed no clear separation by sizes which might be interpreted as age classes. One commercial sample taken in November showed a predominance of male shrimp with a mode at 18 mm. No data on sizes of shrimp

consumed by cod and Greenland habibut were available at the time of this meeting.

Biological Sampling

A random sample of 1112 shrimp taken from this area in 1984 was examined for details of sex and maturity. This was considered to be particularly important because of the observed anomalies in distribution and abundance in the 1984 survey. Results of the analysis are given in Table 4, Figure 6. Males dominated, comprising 63% of the sample, and were mostly maturing or mature. Lengths ranged from 12.5 mm (CL) to 24 mm with only a single obvious mode at 18 mm. Most first-time spawners (21% of the sample) were still in transition at the time of sampling and ranged in size from 18.5 to 25.0 mm with a single mode at 21.5 mm. Condition of the ovaries indicated that only 3% would not have spawned in 1984. Females which had spawned previously comprised 15% of the total sample and ranged from 21.0 to 28.5 mm. Many individuals possessed undeveloped ovaries and it was observed that 69% of this group would not have spawned in 1984. Only four females were ovigerous. Of the 411 potential spawners (all transitionals and females), 30% would not have produced eggs in 1984. This proportion of non-spawners is higher than those reported from samples taken in previous years (1977-83) (Parsons and Tucker 1984).

A more meaningful comparison at this point is the change between years for the multiple spawning group only. It is generally agreed, that this group comprises two or more age classes.

	1979	1980	1981	1982	1983	1984
Multiple spawners	503	757	242	340	362	172
Non-spawners	320	191	16	136	155	118
% Non-spawners	63.62	25.23	6.61	40.00	42.82	68.60

The proportion of non-spawners in the multiple spawner group sampled in 1984 was the highest observed since the July surveys began in 1979. It also should be noted that in samples taken prior to 1984, the proportions of ovigerous females were higher, substantially so in 1979 and 1982. Some of these ovigerous females were likely multiple spawners which, at this stage, cannot be separated from first-time spawners. Therefore, the proportions of non-spawners for all years given in the above table are over-estimated but to a lesser extent in 1984. Certainly, since 1981, there appears to have been a decrease in the reproductive capacity of the multiple spawner group.

Abundance of Predators

The expanded stratified area used for shrimp in 1983 and 1984 makes it difficult to interpret changes in predator abundance because, in the earlier years, abundance of predators over the Saddle was not known. Some observations can be made, however (Table 5). Abundance of Greenland halibut appears to have decreased throughout the area in 1984. In 1983, most biomass was found in the old stratified area whereas in 1984, abundance was proportionately higher in

the deep water over the Saddle, nearer the grounds where shrimp were abundant. Cod biomass was slightly higher over the whole area in 1984 but considerably less in the old area than in the previous year. In 1984, most cod were found in depths where shrimp were abundant over the Saddle.

By-Catch and Discards

Data on by-catches from observers were only available in November 1984 when catches and catch rates were low compared to earlier months. Observations from seven fishing sets showed that Greenland halibut was the major by-catch species accounting for 37% of the total observed catch. Catch rates averaged 85 kg per hour compared to shrimp at 97 kg per hour. Redfish and cod occurred less frequently, each accounting for less than 6% of the total observed catch.

Estimates of shrimp discards from vessel logs declined from around 6% in July to less than 1% in September. Reported discards remained low in October and increased to almost 4% in November. No reliable discard estimates or length frequencies of discarded shrimp were collected in this area by observers in 1984.

Discussion

Results of the July research survey and data from the commercial fishery in Cartwright Channel in 1984 show that abundance and/or availability of shrimp were considerably higher than in previous years. However, because spatial distribution has been changing, the magnitude of change in abundance is difficult to quantify. Distribution of shrimp over the Saddle prior to 1983 was not determined because, historically, the area did not support high concentrations. Survey design is flexible in a given year to cover the area of shrimp distribution. Generally, strata are sampled until no substantial amounts of shrimp are found. Therefore, the areas covered by the surveys in different years change to reflect changes in distribution within the Channel. Because of this flexibility in sampling, we are confident that abundance over the Saddle prior to 1983 was negligible compared to the old stratified area. Also, it is likely that any significant concentrations outside the traditional grounds would have been located and fished by the fleet.

Size compositions available from the survey, and supported by limited data from the fishery, show a high proportion of male shrimp in the depths of highest abundance. Detailed sampling also shows a predominance of males of similar size (~ 18 mm). Maturity data for 1984 compared to previous years suggested that the spawning success of older females varies substantially between years. Most females in 1981 sampling data were capable of spawning and it is possible that part of the recruitment in 1984 reflects the spawning success three years earlier and subsequent hatching of larvae in 1982.

Maturity of females also indicated that approximately 70% of older females would not have spawned in 1984. This situation might suggest a shift toward biennial spawning as described by Teigsmark (1983) for some cold water

populations of Pandalus borealis in the Barents Sea. In fact, in 1984, some segregation by age group might be reflected in the data, viz.:

1st year females - spawning in 1984, $\bar{x}$ = 21.96 mm
2nd year females - no spawning in 1984, $\bar{x}$ = 23.83 mm
3rd year females - spawning in 1984, $\bar{x}$ = 24.78 mm

A quick review of the 1984 bottom temperatures indicated that the cold conditions (similar to 1983) prevail in this area. The temperatures observed in recent years appear to be critical for either complete (annual) or incomplete (biennial) spawning. Warmer conditions were evident at most depths in 1981 when there was evidence of good spawning success (Parsons and Tucker 1984). Concentrations of shrimp in colder, shallow water in 1984 showed considerably reduced reproductive potential. Sensitivity to environmental conditions as described above can result in variability in growth as well as reproductive capacity, affecting overall stock productivity. Under such conditions one can expect:

a) unstable growth and reproduction;
b) unstable recruitment and, consequently,
c) unstable stock size.

Predator abundance is still a concern in the Cartwright Channel since there is evidence in 1984 of a shift in distribution of Greenland halibut and cod to the area where most shrimp were found. Also, in 1984, shrimp were most abundant at depths where the highest concentrations of cod occurred.

The recruiting males in 1984 should be more fully recruited in 1985. Mean selection size for a 40 mm codend is around 18.5 mm (Parsons 1981). Therefore, catch rates in 1985 could be maintained at relatively high levels, if the shrimp remain concentrated and do not disperse over a much wider area. Beyond 1985, prospects for recruitment cannot be evaluated but recruitment may be affected by the apparently reduced reproductive capacity since 1981. Management advice, in terms of TAC, becomes increasingly difficult to rationalize in situations where environmental factors appear so important in determining distribution, productivity and size of the stock.

HOPEDALE CHANNEL

Catch and CPUE

Heavy ice in the Hopedale Channel in June and July resulted in a decrease in fishing effort in those months in 1984. In fact, some vessels suffered damage attempting to reach the more productive areas north of the Cartwright Channel. Preliminary catch statistics indicate that only 651 t were taken in 1984, less than 20% of the 3500 t TAC. In addition to ice as a limiting factor, partial and non-utilization of licences also occurred in 1984 as in the previous two years.

Standardized catch per unit effort (tonnage class 5) by month is summarized in Table 6. Most fishing occurred late in the season but catch

rates were not as high as those obtained during the same period prior to 1983. The catch rate data have been used in past assessments to reflect changes in stock abundance between years. Even when effort levels were high, interpretation of these data were difficult due to changes in distribution of shrimp and changes in distribution of the fishing effort between years. The low effort levels in 1983 and 1984 make such comparisons even more difficult and less representative of changes in stock size. Generally, it can only be restated that abundance has apparently declined from high levels encountered in the early years of the fishery.

Biomass

The survey for shrimp in the Hopedale Channel in 1984 was severely hampered by heavy ice. The original stratified random survey design had to be scrapped in favour of the old line survey. Seven lines were fished, three in the northern zone and two in each of the central and southern zones (Table 7, Fig. 7). The 'lines' themselves were not well-defined since at any given time, the presence of ice at a certain location necessitated an alternative site. When comparing the results to those of previous surveys, these differences must be recognized.

Results showed that in all three zones shrimp were abundant in more shallow water (~ 275-450 mm) compared to most other years (> 400 m). The estimated biomass of 7738 (± 1902) t was 12% higher than the 1983 estimate but less than those obtained in 1979, 1980 and 1982 (Table 8, Fig. 8). Comparison of shrimp densities (biomass/sq n mi) showed a similar trend but the increase between 1983 and 1984 was 35%. The distribution of biomass by zone was very similar to that observed in 1983 and reflected the decrease in the proportion of biomass in the northernmost zone since 1979 (Parsons and Veitch 1984).

	Percent of biomass by zone					
	1979	1980	1981	1982	1983	1984
Zone 1	70	62	68	41	50	49
Zone 2	27	30	25	57	40	43
Zone 3	3	8	7	2	10	8

Size Composition

1. Research

Length frequencies from the research cruise in the Hopedale Channel, July 1984 (Fig. 9) showed increasing mean size with depth in the northern and southern zones. This trend was not so apparent over the Saddle where shrimp ranging from 13 to 28 mm occurred in most depths with no predominating size groups. In the northernmost zone, there were fewer small shrimp (< 15 mm) than observed in 1983. Over the Saddle, there was a relative scarcity of larger (female) shrimp in deep water (> 450 m). A size (age) group with a mode around 17-18 mm was dominant in most depths in the southern zone which might represent the same yearclass that was prominent at 14-15 mm in 1983 (Parsons and Veitch

1984). In most samples, however, modal lengths of males were indistinct making the interpretation of ages difficult.

In the previous section, it was shown that most biomass in 1984 occurred in relatively shallow depths where, as indicated above, small shrimp were abundant, especially over the saddle. Because these sizes were only partially recruited to the fishery in 1984 and fishing mortality was low, recruitment in 1985 could improve. The effect on catch rates is uncertain and will depend not only on abundance of recruiting year-classes but their distribution as well.

An extensive collection of cod stomachs was obtained during the 1984 survey but details on the importance of shrimp as a prey species and sizes encountered are not yet available.

2. Commercial

Information on sizes of shrimp caught in the fishery was only available for two vessels which fished during the October-December period. In October and November, catches were comprised mostly of large (female) shrimp around 23-24 mm, with slightly larger animals in deeper water (Fig. 10). In December, shrimp of similar sizes were caught in depths ranging from 400 to 500 m but in shallower water there were higher proportions of smaller (male) shrimp around 20 mm. These results are similar to those observed from limited sampling data obtained in 1983.

Abundance of Predators

The inclusion of the 1984 research survey results shows that estimates of Greenland halibut biomass increased from 8550 t in 1981 to 24,180 t in 1983 followed by a decline to 18,184 t in 1984 (Table 9). This level of abundance, however, is still considerably higher than those estimated for 1979, 1981 and 1982. Therefore, the potential of Greenland halibut as an important shrimp predator in this area remains high.

Estimates for cod have continued to be highly variable with no indication of a trend in abundance. The 1984 estimate of biomass (1246 t) was lower than those of the previous two years. Compared to the high abundance of Greenland halibut, cod still appears to be the less important predator in this area even though they can consume more shrimp per unit biomass (Bowering et al. 1984). It should be noted, however, that as in the Cartwright Channel, shrimp were abundant in the shallower strata where most of the cod were found (< 400 m). Although cod biomass appeared to be lower than in the previous two years, their effectiveness as shrimp predators could have been greatly enhanced because of the distribution of the shrimp, themselves. Greenland halibut, on the other hand, were more heavily concentrated throughout the Channel in deep water (> 400 m) where shrimp abundance was comparatively low.

By-catch and Discards

Observer data for October and November showed that Greenland halibut was the major by-catch species in both months, comprising 7% of the observed catch in October and 22% in November. Catch rates were 29 kg and 57 kg per hour, respectively, similar to those obtained late in 1983. Catch rates of cod and broadhead wolffish (Anarhichas denticulatus) were higher in November and accounted for a higher proportion of the observed catch weight. Redfish catch rates (~10 kg/hr) were similar to those obtained late in 1983, remaining well below those observed in the previous two years.

Estimates of shrimp discards from vessel logs for July and August were approximately 10% of the total shrimp catch. Reported discards were lower from September to December, ranging from 0.5% to 1.5%. These low rates are supported by observer data for the period October-December.

Length frequencies of discarded shrimp (Fig. 11) showed that in both October and November most ranged from 18 to 21 mm. Because of the relatively large size of discarded animals, it is assumed that most discarding in these months was due to damage rather than small size.

Discussion

Fishing effort in the Hopedale Channel in 1984 was the lowest reported since the fishery began in 1977. There are three primary reasons for this reduction in effort:

a) ice on the Labrador was extremely heavy even in late July, preventing access to Hopedale Channel and causing damage to vessels fishing shrimp in the region;
b) some northern shrimp licences were not utilized in 1984 while others were used only partially;
c) catch rates late in the season were not as good as those experienced prior to 1983, removing the incentive to fish as late as possible in the year.

Because of the sporadic distribution of effort in 1983 and 1984, catch rate indices are no longer an acceptable measure of changes in stock abundance. The 1984 biomass survey results showed that the observed decline in abundance between 1980 and 1983 did not continue in 1984. Shrimp densities (biomass per sq n mi) suggest a possible increase. As in the previous two years, higher proportions of the biomass were found in the two southern zones than in years prior to 1982.

Most of the 1984 biomass was found in relatively shallow water where small shrimp predominated. Varying proportions of these size (age) groups will be recruiting to the fishery in 1985 and catch rates could improve over 1984 levels. Temperatures in 1984 were similar to those in 1983 over the Saddle and in the southern zone. However, in the northern zone, temperatures were lower, especially in the shallower strata where shrimp were concentrated. Just how

this might affect distribution in 1985 is uncertain, especially considering the high abundance of shrimp in cold waters of the Cartwright Channel in 1984.

Greenland halibut abundance, although lower than the estimate for 1983, suggests that potential for shrimp predation remains high. This mortality in 1984 might have been minimized because most shrimp were found in shallower water. Although affording some protection from the more numerous Greenland halibut, this pattern of distribution made the shrimp readily available to the more voracious cod. Any deleterious effect this might have on the shrimp stocks will not become evident until fishing (research or commercial) commences in mid 1985.

Fishing effort by the fleet has been decreasing during the past three years, primarily due to economic and political considerations. The TAC's implemented have not been taken in any year except 1980 and, at current catch levels, are nominal only. Biomass estimates from 1982 to 1984 suggest that the stock is at a lower level than in preceding years and to advise on a TAC based on the average of all these estimates is not a conservative approach.

Stock status determines catch rates which, in turn, determines how heavily the stock will be fished, given the present economic conditions. In this sense, the fishery has regulated itself since 1981. Unless the fishing plan for this stock includes a substantial increase in the number of northern shrimp licences, there is no need to advise a TAC based on the average of highly variable estimates of stock size.

Conclusions

Recently, the rationale for the 35% exploitation rate for shrimp stocks was reviewed by CAFSAC and it was suggested that 'such a level corresponds to an acceptable reference point for a species which experiences natural mortality rates of the order of 0.5 to 0.8 per year'. This exploitation rate might well apply as a first estimate of potential removal in a developing fishery (used as a TAC or a basis to control effort) or for a stock which has demonstrated relative stability in abundance over a number of years. For shrimp stocks off Labrador, estimates of potential removals were first used to determine the number of vessels which might be appropriate to harvest the resource. These catch levels were sometimes used in the early years as TAC's in cases when the possibility for overfishing became obvious (eg. Cartwright Channel 1979, Hopedale Channel 1980).

Data analyzed in recent years indicate that the Labrador stocks are unstable and, in cases like the Cartwright Channel, changes in environmental conditions likely affect stock size and/or distribution more than an active fishery. Obviously, in such cases, TAC's based on average abundance estimates from past surveys are not a reliable basis from which to project a future TAC. In fact, fishery models, generally, are inappropriate in such situations. Thus, scientific advice at the Subcommittee level has veered away from strict management by TAC in these areas. This is not to be interpreted as protecting a resource when it is healthy and not protecting it when depressed. Rather, it is a situation which utilized an initial strategy based on limited information

from a developing fishery, refined the advice when more information became available, identified that management by TAC under unstable conditions was inappropriate and suggested a progression towards alternative management strategies. This sequence of events is not unprecedented and is a logical approach to fisheries management.

References

Bowering, W. R., D. G. Parsons, and G. R. Lilly. 1984. Predation of Shrimp (Pandalus borealis) by Greenland halibut (Reinhardtius hippoglossoides) and Arctic cod (Gadus morhua) off Labrador. ICES C.M.1984/G: 54: 30 p.

Parsons, D. G. 1981. Gear selectivity in the Labrador shrimp fishery. CAFSAC Res. Doc. 81/43, 7 p.

1984. Estimation of Abundance of Shrimp (Pandalus borealis) from stratified random surveys - problems of variation in distribution and availability. CAFSAC Res. Doc. 84/26, 18 p.

Parsons, D. G., and G. E. Tucker. 1984. A Review of Shrimp (Pandalus borealis) Biology and Environmental Changes in the Cartwright Channel (Division 2J), 1977-83. CAFSAC Res. Doc. 84/22, 25 p.

Parsons, D. G. and P. J. Veitch. 1984. The Fishery for Shrimp (Pandalus borealis) and Status of the Stock in the Hopedale Channel (Div. 2H), 1983. CAFSAC Res. Doc. 84/21, 28 p.

Parsons, D. G., P. J. Veitch and G. E. Tucker. 1985. Catch, Effort, CPUE and Biological Data from the Canadian Fishery for Shrimp (Pandalus borealis) in Division OA, 1984. NAFO SCR Doc. 85/14, Ser. No. N938, 19 p.

Teigsmark, G. 1983. Populations of the deep-sea shrimp (Pandalus borealis Krøyer) in the Barents Sea. Fisk. Dir. Skr. Ser. Havunders. 17: 337-430.

Table 1. Catch (kg) and catch per hour fished adjusted to tonnage class 5 vessels, 1977-84, Cartwright Channel (monthly values compiled from available vessel logs).

	1977		1978		1979		1980		1981		1982		1983		1984	
Month	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)
June							23,134	212			113,580	382	2,790	111		
July	311,838	834	155,813	479	147,498	730	11,770	453	6,875	262					50,675	301
Aug.	514,633	624	399,501	664	148,268	318	22,465	368	5,035	155	1,020	322			38,200	350
Sept.	234,037	465	638,159	463	353,821	235	55,919	326	907	202			160	53	143,210	315
Oct.	14,378	187	45,439	264			405	73							18,895	233
Nov.	73,616	802					3,535	135							6,925	157
Dec.	9,650	566									28,710	380			90	23
Total[a]	1,158,152	614	1,238,912	500	649,587	299	117,228	294	12,817	203	143,310	381	2,950	105	257,995	307
Total[b]	1,414,000		1,521,000		1,034,000		170,000		67,419		167,196		3,000		312,000[c]	

[a]Totals from available vessel logs.

[b]Totals from reported landings.

[c]Preliminary.

Table 2. Minimum trawlable biomass - 1984 research - Cartwright Channel.

Stratum	Depth (m)	Area (sq n mi)	No. sets	Biomass (t)
701	251-300	57.8	2	51
702	301-350	89.7	2	109
703	251-300	19.9	2	0
704	<250	37.9	2	0
705	251-300	28.7	2	1
706	301-350	45.7	3	74
707	351-400	36.0	3	19
708	401-450	45.0	3	128
709	451-500	53.9	4	115
710	501-550	89.7	5	58
711	451-500	15.6	2	9
805	<300	79.4	2	32
806	301-350	78.2	3	1373
807	351-400	66.9	3	779
808	401-450	47.3	2	327
809	451-500	37.3	2	23
810	501-550	6.5	2	2
712 + 812	>551	44.3	3	14
Total		879.8	47	3114

Table 3. Biomass estimates (tons) and 95% confidence intervals for shrimp, 1979-84, Cartwright Channel.

Year	Mean[a]	Upper	Lower	Area (sq n mi)	n	Biomass per sq n mi
1979	1,892	2,879	904	286	22	6.62
1980	2,789	3,422	2,157	417	37	6.69
1981	2,367	3,380	1,355	503	49	4.71
1982	1,916	2,867	965	503	42	3.81
1983	1,111[b]	1,446	775	713	56	1.56
	694[c]	855	503	561	51	1.24
1984	3,113[b]	4,863	1,362	880	47	3.54
	579[c]	937	222	561	32	1.03

[a]1978-81 estimates are derived from systematic line surveys.
1982-84 estimates are derived from random-stratified surveys.
[b]Expanded stratification.
[c]Old stratification.

Table 4. Sex and maturity of shrimp taken in the Cartwright Channel, July 1984.

Sex	Maturity	No.	% of Total
Juvenile	Immature	0	0.00
Male	Immature	3	0.27
Male	Maturing (small vas deferens)	129	11.60
Male	Mature (large vas deferens)	569	51.17
Transitional	Small ovary	5	0.45
Transitional	Large ovary	226	20.32
Female (non-ovigerous)	Sternal spines, small ovary	1	0.09
Female (non-ovigerous)	Sternal spines, large ovary	3	0.27
Female (non-ovigerous)	No spines, small ovary	118	10.61
Female (non-ovigerous)	No spines, large ovary	54	4.86
Female	Ovigerous	4	0.36
TOTALS		1112	100.00

Table 5. Biomass estimates (tons) and 95% confidence intervals for Greenland halibut and cod, 1979-84, Cartwright Channel.

Year	Greenland halibut			Cod		
	Mean	Upper	Lower	Mean	Upper	Lower
1979	1,739	2,685	793	224	426	62
1980	5,332	6,189	4,476	331	502	160
1981	1,367	2,042	710	751	1,403	99
1982	3,061	3,934	2,188	1,017	1,414	620
1983[a]	4,586	5,512	3,661	513	755	271
1983[b]	3,538	4,420	2,656	413	633	193
1984[a]	2,900	5,296	503	602	951	253
1984[b]	1,691	2,359	1,023	175	861	-510

[a]Expanded stratification.

[b]Old stratification.

Table 6. Catch per hour fished, 1977-84, Hopedale Channel (monthly values determined from vessel logs) adjusted to tonnage class 5.

	1977		1978		1979		1980		1981		1982		1983		1984	
	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	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	166,729	390		
July			131,544	773	965,454	706	736,840	645	360,770	356	302,674	397	253,121	336	39,890	571
Aug.	93,695	611	85,570	560	812,378	368	589,206	475	474,218	344	219,227	376	6,625	981	35,190	276
Sept.	206,111	631	68,591	383	81,907	297	599,724	304	555,279	402	62,621	211	2,125	123	49,855	207
Oct.	330,574	361	584,589	580			390,295	423	406,217	404	246,110	389			335,304	336
Nov.	641,516	780	470,170	555			163,316	598	469,023	418	471,095	569	370,427	353	100,031	350
Dec.			-[c]	-					168,375	607	113,325	366	71,302	239	55,946	260
Total[a]	1,271,896	573	1,340,464	569	2,056,480	507	2,508,351	449	2,847,794	409	1,586,317	420	870,329	341	616,216	318
Total[b]	1,203,000		2,109,000		2,693,000		3,938,000		3,382,266		1,707,900		1,014,000		651,000[d]	

[a]Based on catches from vessel logs.

[b]Based on statistics from landings.

[c]Months with catches but no vessel logs.

[d]Preliminary.

Table 7. Minimum trawlable biomass - 1984 research, Hopedale Channel.

Stratum	Depth (m)	Area (sq n mi)	No. sets	Biomass (t)
102	202-238	48.7	4	157
103	239-274	44.4		
104	275-311	38.8	15	3142
105	312-348	38.8		
106	349-384	40.7		
107	385-421	37.9		
108	422-457	39.3		
109	458-494	41.6	9	484
110	495-530	109.9		
111	531-567	51.5		
204 + 205	275-348	464.1	9	3015
206	349-384	134.7		
207	385-421	95.0		
208	422-457	147.8		
209	458-494	161.9	8	287
210	495-530	168.0		
211	531-567	168.4		
212	568-604	163.3		
304	275-311	47.3	6	507
305	312-348	30.4		
306	349-384	23.4		
307	385-421	18.7	8	146
308	422-457	18.3		
309	458-494	18.7		
310	495-530	24.3		
TOTALS		2175.9	59	7738

Table 8. Biomass estimates (tons) and 95% confidence intervals and density (tons/sq n mi) for shrimp in the Hopedale Channel, 1979-84.

Year	Mean	Upper	Lower	Area (sq n mi)	No. sets	Biomass per sq n mi
1979	11,608	19,730	3,487	1,878	54	6.18
1980	11,840	19,134	4,545	2,496	83	4.74
1981	4,213	5,974	2,452	2,434	56	1.73
1982	9,498	12,003	6,993	2,308	76	4.12
1983	6,882	8,330	5,434	2,606	89	2.64
1984	7,738	9,640	5,837	2,176	59	3.56

Table 9. Biomass estimates (tons) and 95% confidence intervals for Greenland halibut and cod, 1979-84, Hopedale Channel.

	Greenland halibut			Cod		
Year	Mean	Upper	Lower	Mean	Upper	Lower
1979	4,140	5,422	2,857	435	899	-30
1980	23,045	25,894	20,197	1,763	2,284	1,242
1981	8,550	12,805	4,295	504	900	107
1982	11,118	15,218	7,018	2,204	3,247	1,162
1983	24,180	34,456	13,904	1,584	3,792	-695
1984	18,184	22,123	14,244	1,246	1,929	563

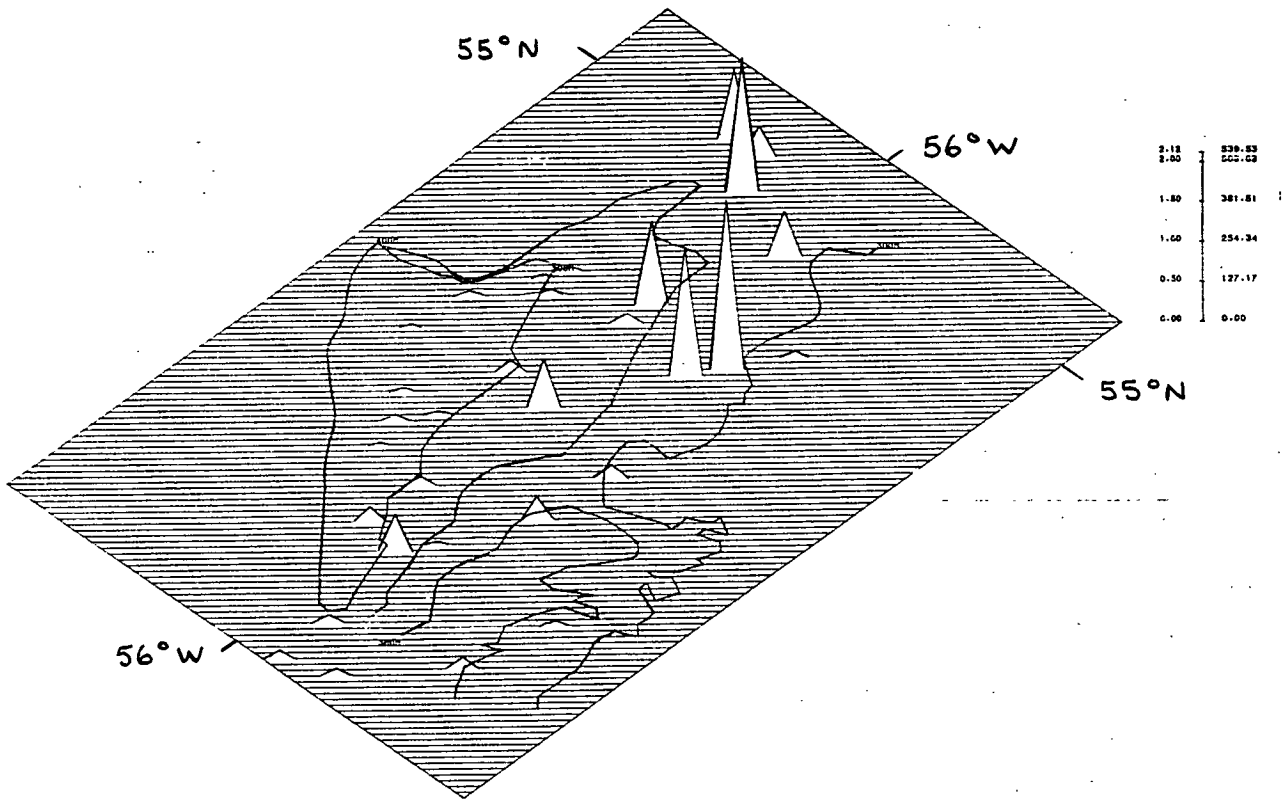


Fig. 1. SHRIMP CATCHES PER 30 MIN TOW - CARTWRIGHT CHANNEL GADUS 097 1984

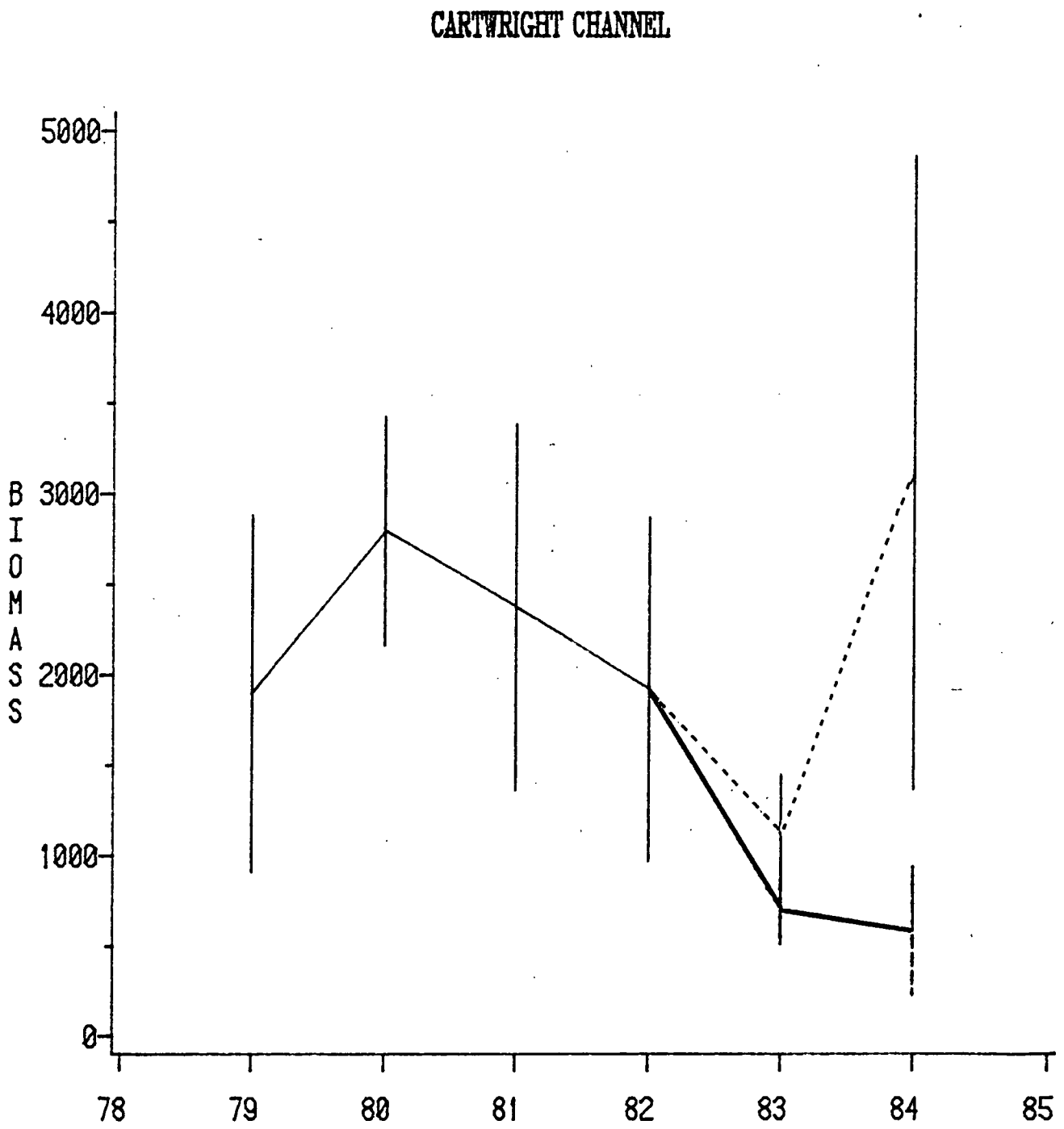


Fig.2. Biomass of shrimp (and 95% confidence limits) in Cartwright Channel, 1978-1984. Expanded stratified area 1982-1984= broken line.

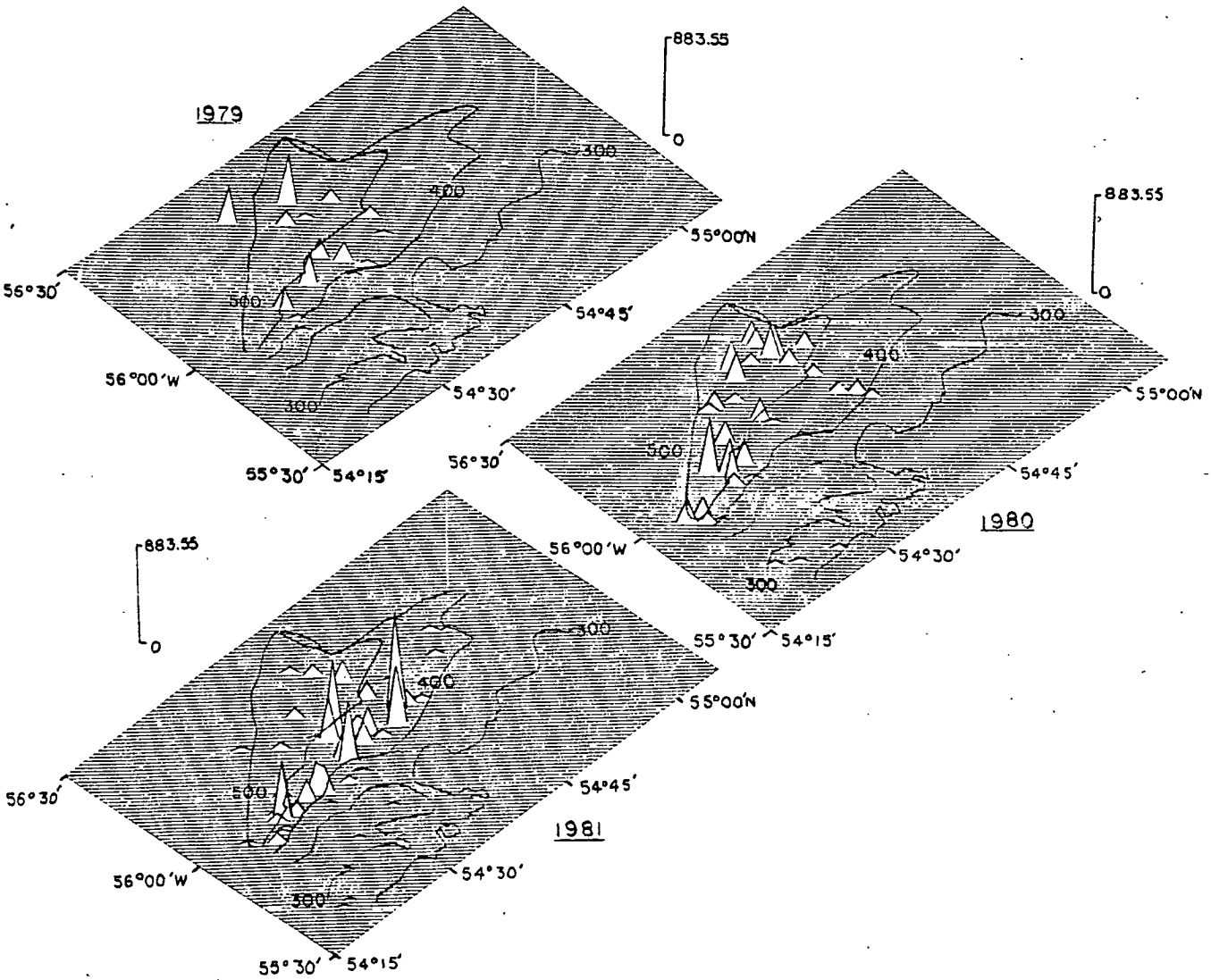


Fig.3.Distribution and abundance of shrimp in Cartwright Channel-1979-1984 July research surveys.

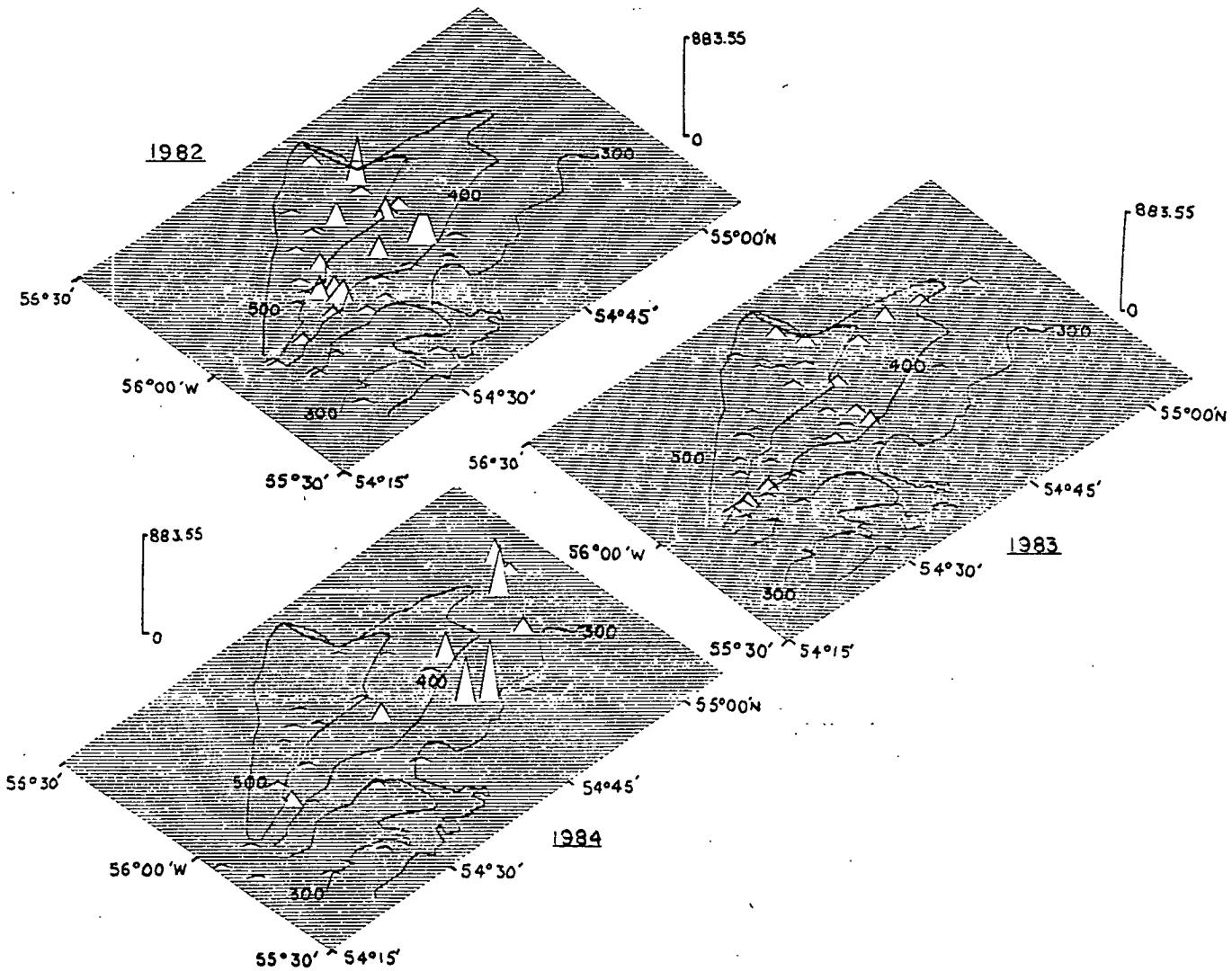
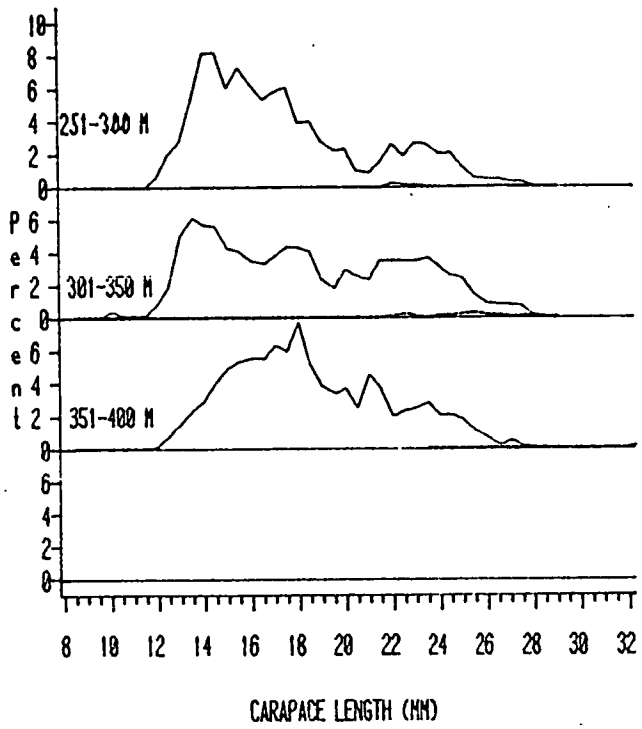

883.55
0
1982
300
400
55°00'N
56°30'
500
54°45'
56°00'W
54°30'
55°30'
54°15'
883.55
0
300
400
55°00'N
56°30'
500
54°45'
1983
56°00'W
54°30'
300
55°30'
54°15'
883.55
0
56°00'W
300
400
55°00'N
56°30'
500
54°45'
1984
54°30'
300
55°30'
54°15'

Fig.3.(cont'd.)



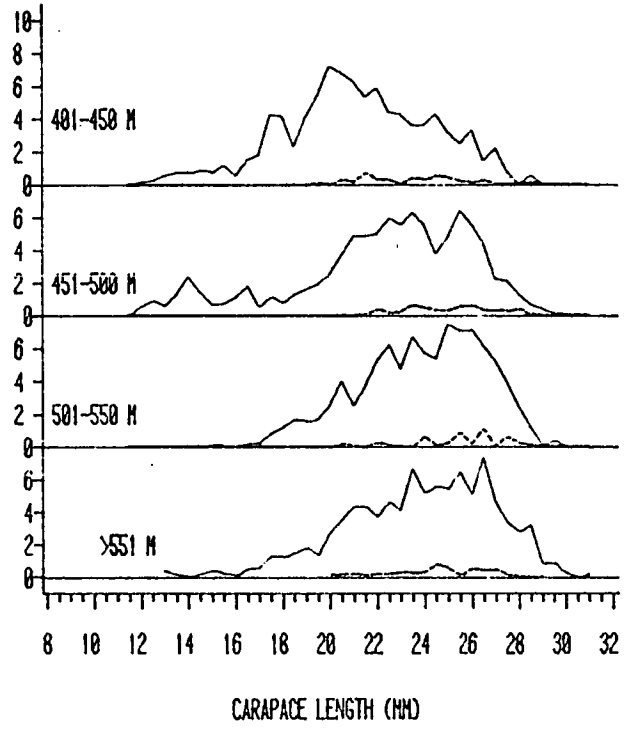


Fig.4. Length frequencies of shrimp from the Cartwright Channel-research survey, July 1984. Ovigerous females=broken line.

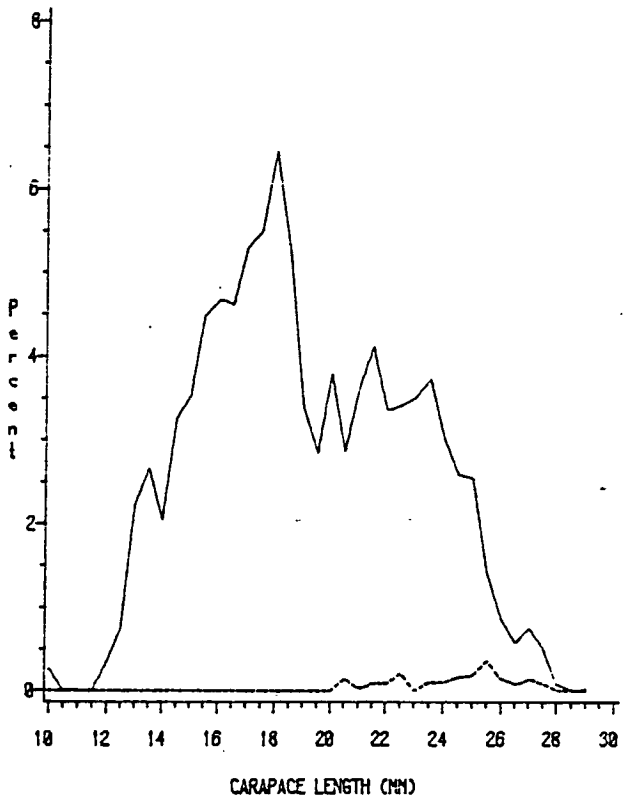


Fig. 5. Length frequencies of shrimp from two depth strata (806 and 807) in the Cartwright Channel, July, 1984. Ovigerous females=broken line.

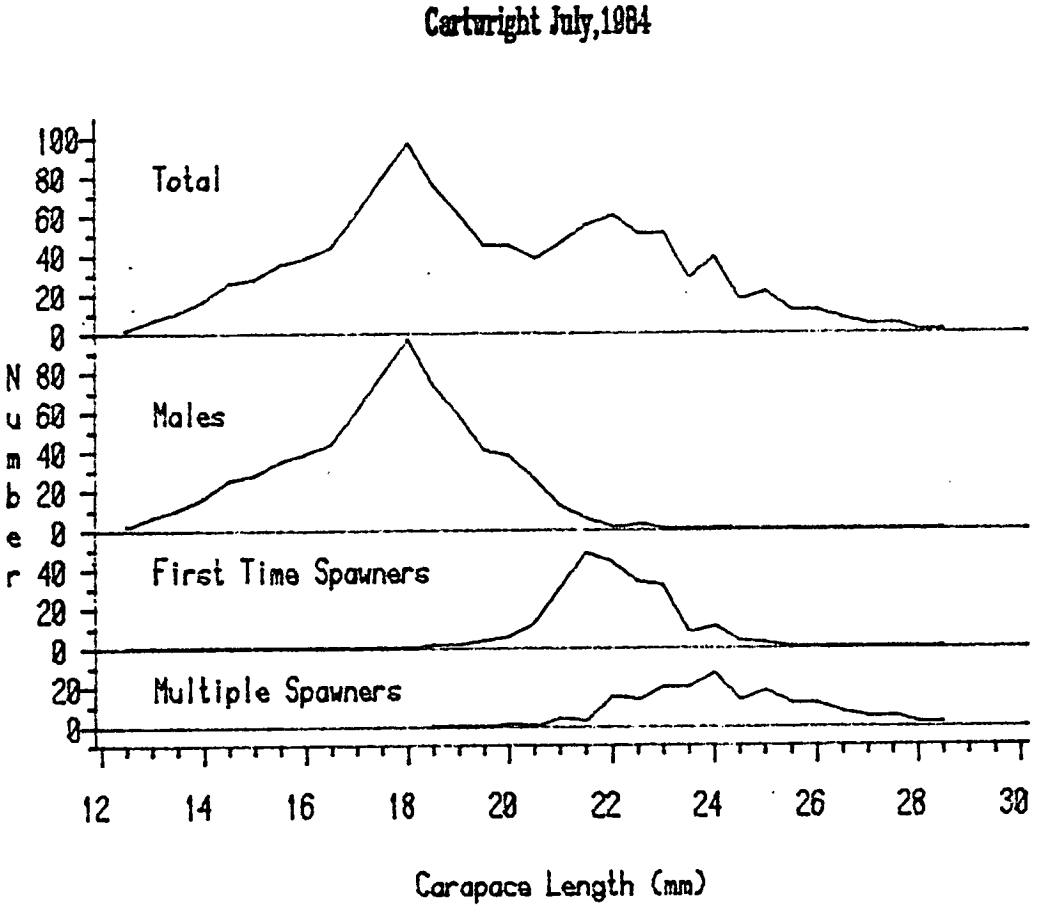


Fig.6.Separation of a shrimp sample obtained in the Cartwright Channel July,1984,by stages of sexual development.

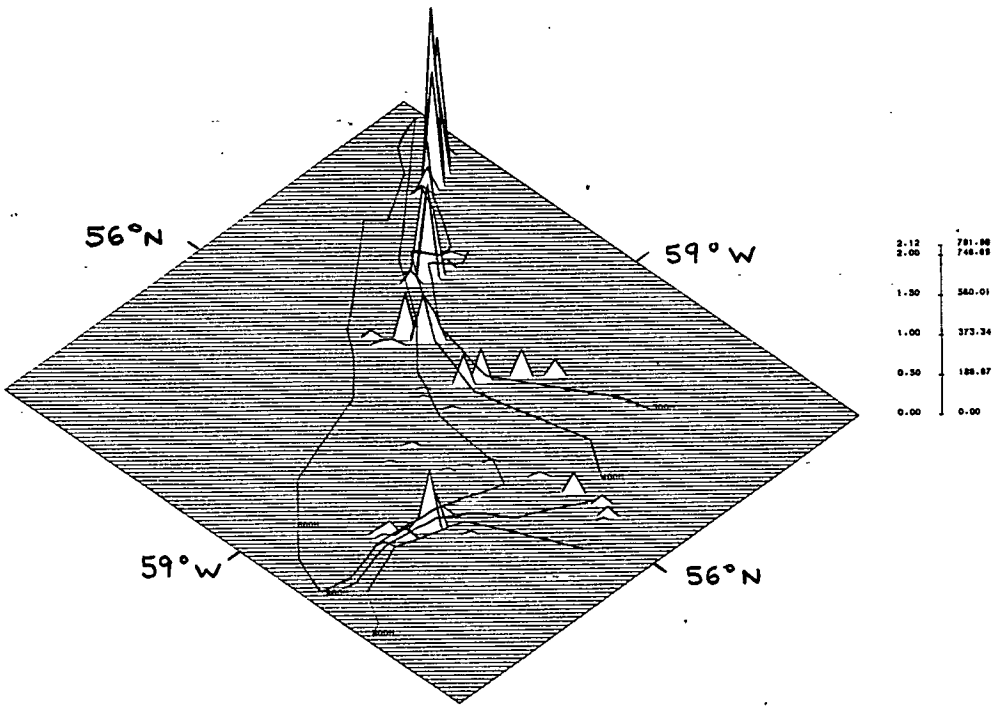


Fig. 7. SHRIMP CATCHES PER 30 MIN TOW HOPEDALE GADUS 097 1984

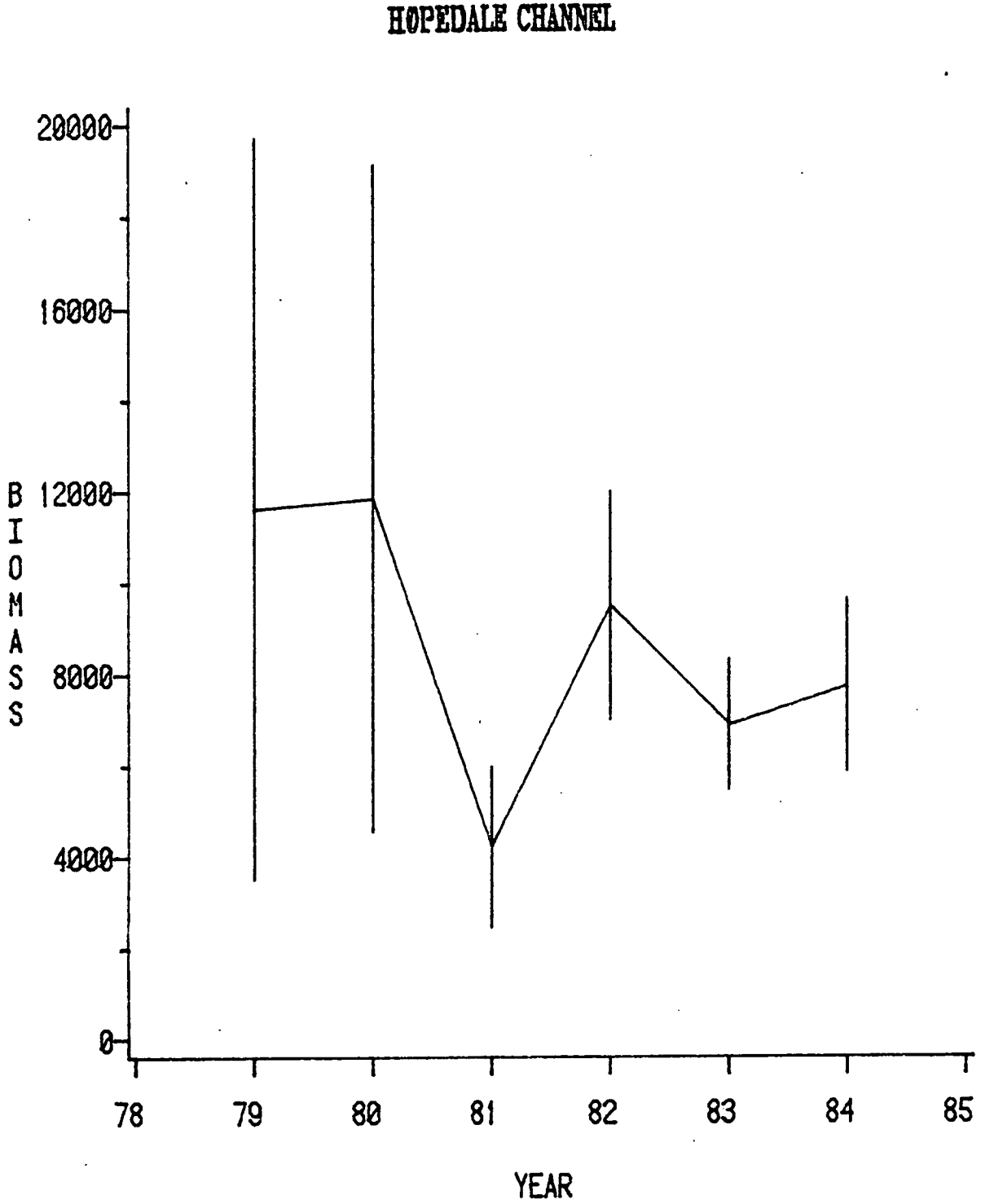


Fig.8.Biomass of shrimp(and 95% confidence limits)in Hopedale Channel,1979-1984.

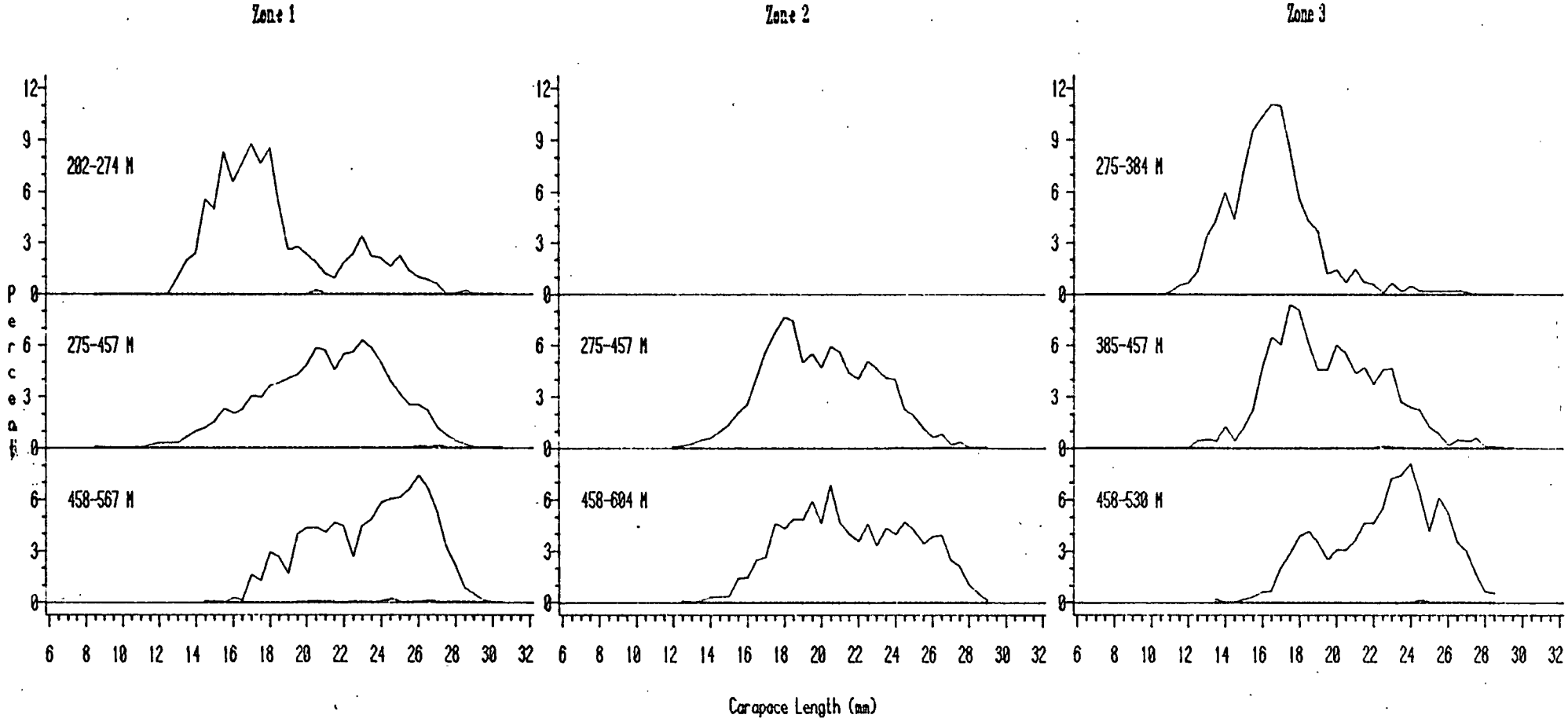


Fig.9. Length frequencies of shrimp from the Hopedale Channel-research survey, July 1984. Ovigerous females=broken line.

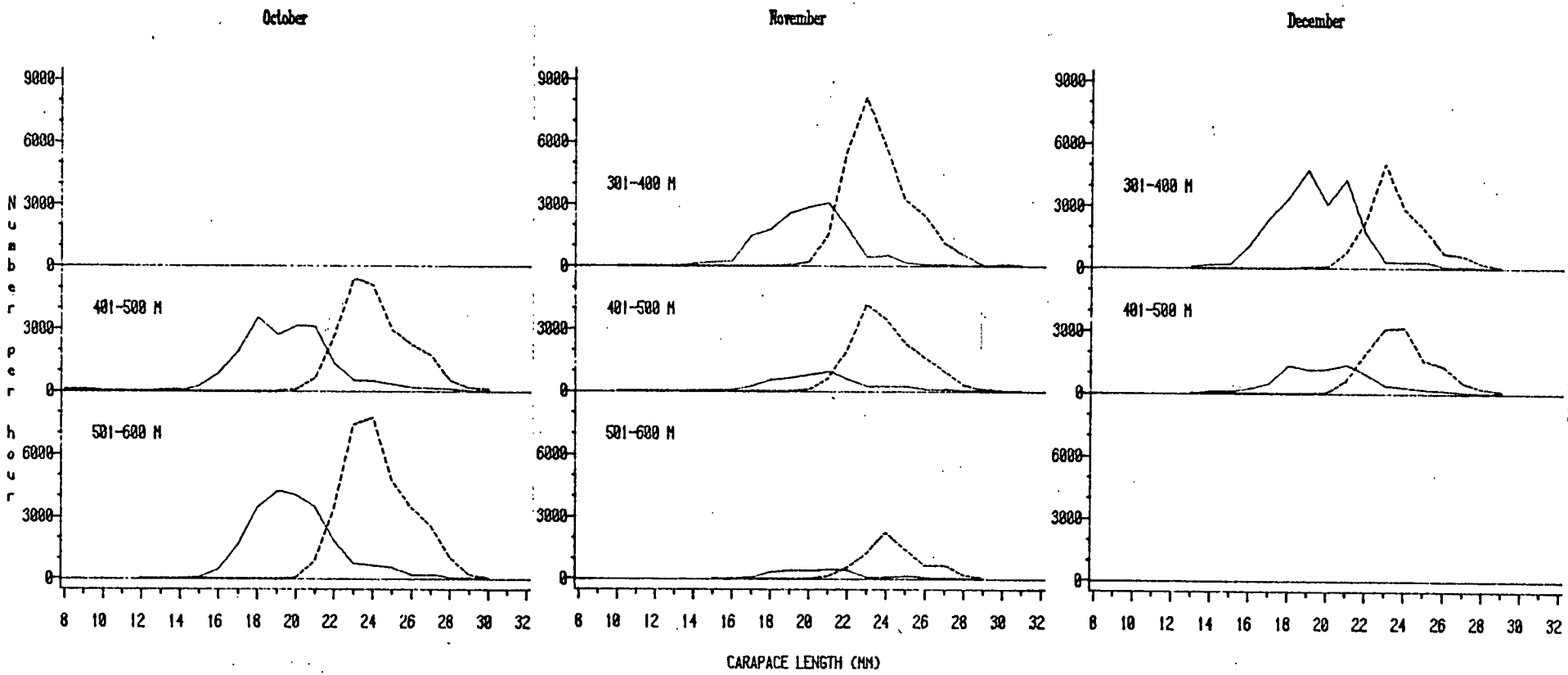


Fig.10.Commercial length frequencies of shrimp from the Hopedale Channel,1984. Ovigerous females=broken line.

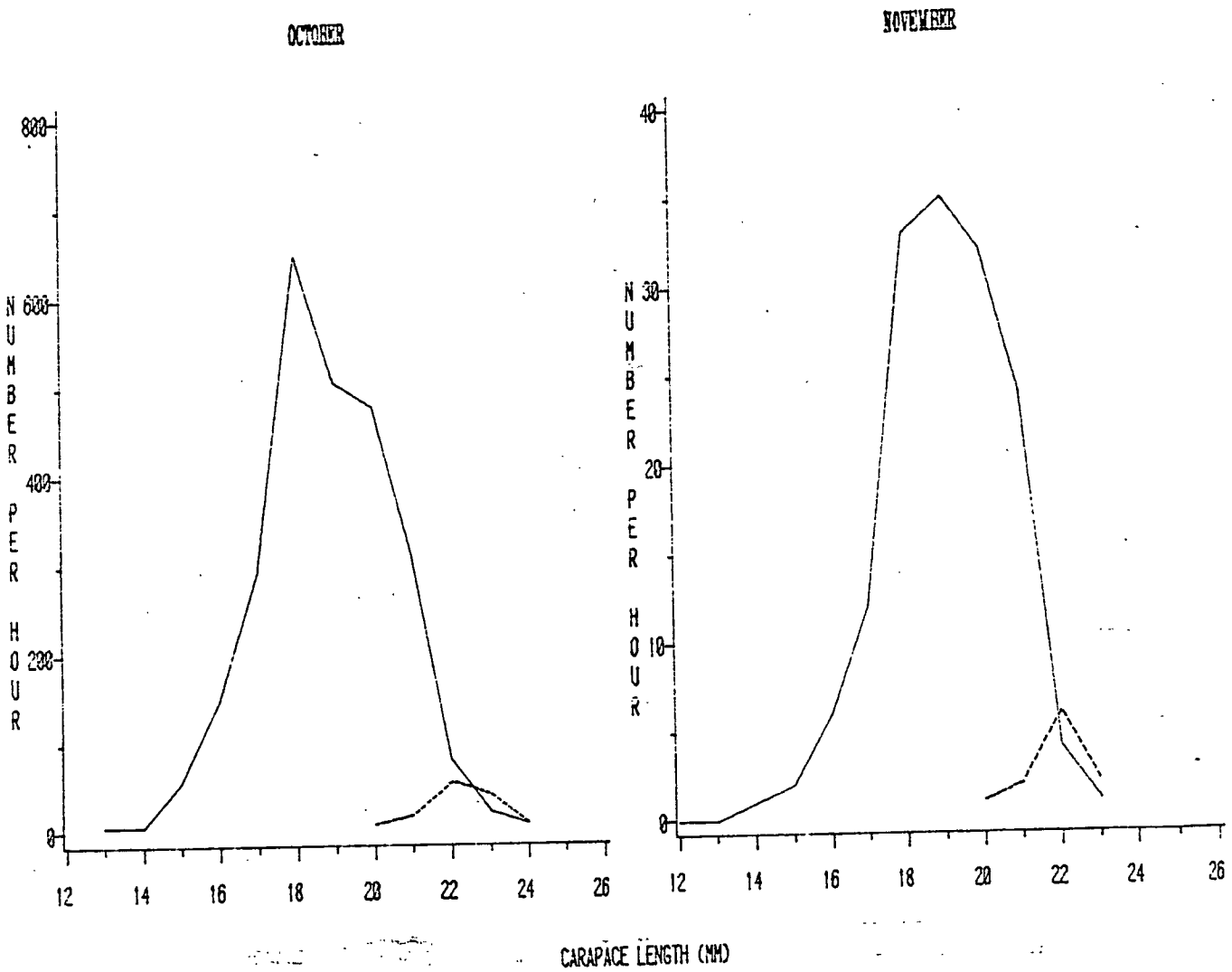


Fig.11. Length frequencies of shrimp discards from the Hopedale Channel, 1984. Ovigerous females=broken line.