Assessment of the Northern Shrimp (Pandalus borealis) Resources in Hopedale and Cartwright Channels, 1986

by

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Abstract

In 1986, the TAC's in both Hopedale and Cartwright Channels were exceeded. The former area was closed on November 24 and fishing in Cartwright continued into the new year. Catch rates in both areas were high compared to previous years, likely due to improvement in gear and reduced discarding of small shrimp.

Data from Hopedale Channel show that biomass, as estimated from a research survey, remains high relative to 1983 and 1984 but about 17% lower than the 1985 estimation. Also, the fishery appeared to be heavily dependent on small male shrimp. Temperatures in 1986 were warmer than in the previous year and abundance of predators was low.

The biomass estimate for Cartwright Channel was below those for 1984 and 1985. Also, the proportion of male shrimp was lower than in 1984 when biomass was at the highest level observed. Poor recruitment is indicated. Potential for predation by cod remains high but temperature could result in increased productivity.

Advice on TAC's for both areas is provided.

Résumé

En 1986 les TPA dans les chenaux Hopedale et Cartwright ont été dépassés. La première de ces régions a été fermée pour la pêche le 24 novembre et dans le chenal Cartwright la pêche s'est poursuivie cette année. Les taux de prise dans les deux régions étaient élevés comparativement aux années antérieures, vraisemblablement en raison d'une amélioration des engins de pêche et de rejets moindres de petites crevettes.

Les données recueillies dans le chenal Hopedale indiquent que la biomasse, telle qu'estimée à partir d'un relevé de recherche, reste élevée par rapport à ce qu'elle était en 1983 et 1984, mais qu'elle est de 17% inférieure à l'estimation obtenue pour 1985. De plus cette pêche semble lourdement tributaire des petites crevettes mâles. Les températures étaient plus chaudes en 1986 et les prédateurs moins abondants.

L'estimation de la biomasse pour le chenal Cartwright indique qu'elle était inférieure à ce qu'elle était en 1984 et en 1985. De plus la proportion de crevettes mâles était également inférieure à ce qu'elle était en 1984, année pour laquelle la biomasse était à son niveau le plus élevé jamais observé. On note qu'il y a faible recrutement. La possibilité de prédation par la morue reste élevée, mais les températures plus élevées pourraient entraîner un accroissement de la productivité.

Introduction

The fishery for northern shrimp in 1986 was concentrated in three areas - Davis Strait (Division 0A), Hopedale Channel (Division 2H) and Cartwright Channel (Division 2J). In Davis Strait, catches of 2995 t were reported[1] from an allocation of 6120 t. Eight vessels (seven foreign and one domestic) participated in this fishery which began in the first week of June and continued into late November (Parsons et al. 1987). The TAC in Hopedale Chanel (3400 t) was exceeded by 83 t[1]. Five vessels (four domestic and one foreign) participated in this fishery which began in the last week of June and continued until November 24, when the area was closed. Fishing in Cartwright Channel did not begin until late November, after the closure of Hopedale Channel. Four vessels (two domestic and two foreign) reported catches of 1248 t[1], 125% of the TAC of 1000 t. The area was not closed and fishing continued into the new year. About 160 t were taken in 1987 before the area was closed due to ice (formally on February 5). No landings from Hawke Channel, Div. 3K and Div. 2G were reported for 1986. However, a winter fishery did take place in the former two areas with reported landings of 793 and 48 t, respectively. Hawke Channel was closed on January 25 and Div. 3K on February 5.

Due to the presence of foreign vessels in the Labrador Channels in 1986, observer data were collected throughout the fishing season, in contrast to the three previous years. The data, however, were collected onboard one or two vessels and might not be entirely representative of the total fleet's activities. Despite the possible limitations of the data, their value as a means of monitoring changes in the resource has increased and a high level of coverage should be maintained in future.

The 1986 research survey was conducted from July 29 to August 13 and provided good coverage for both Hopedale and Cartwright Channels. There were no problems with ice. Data collected during the survey provided information on shrimp abundance, distribution and biology which are compared to results from previous years. For each fishing set, shrimp samples were separated into male, primiparous, multiparous, and ovigerous female groups, and abundance estimates are available for each group, separately. Data on abundance of predators and bottom temperatures also were obtained and are compared to the findings of previous years.

HOPEDALE CHANNEL

Catch and CPUE

Shrimp catches in Hopedale Channel increased from about 1200 t in 1977 to 4000 t in 1980 and then declined to a low of 700 t in 1984 (Table 1). Catch doubled in 1985 to 1400 t and increased substantially to about 3500 t in 1986. TAC's were reached only in 1980 (4000 t) and 1986 (3400 t). The increased catch in 1986 can be partly explained by increased effort as Canadian vessels spent, proportionately, more time off Labrador than in Davis Strait.

The catch per unit effort by month from 1977 to 1986 has shown extreme variation over time, both within and between years. For years prior to 1985, catch

[1] Canadian Atlantic quota reports, preliminary to December 31, 1986

rates for tonnage class 4 vessels were adjusted upward by a factor of 1.26 but in 1985, it was determined that this factor was not appropriate for the single tonnage class 4 vessel that fished in that year (Parsons and Veitch 1986). In reviewing the data base for possible application of the multiplicative model, it became obvious that records of tonnage class had not been reported consistently over the time series. Therefore, the data in Table 1 are unadjusted values. This does not affect interpretation of the series given that the initial change did not affect the trends shown from 1974 to 1981 (Parsons et al. 1982) and, during 1982-85, catch generally has been low and effort sporadic, limiting the value of CPUE as an index of abundance (Parsons and Veitch 1986).

The June 1986 catch rate is not reliable because it is based on so little effort. CPUE increased from 563 kg/hr in July to 713 kg/hr in August followed by a decrease to 472 kg/hr in November (Table 1). The 1986 fishery performance was much better than in the previous three years and the annual CPUE value is the highest in the unadjusted time series. Also, catch rates in September were maintained at high levels compared to previous years when they were characteristically low. However, interpretation of these data as an index of stock size remains a problem given that no appropriate standardization has been achieved. In 1985, high levels of discarding were observed and it was felt that the catch rate data were biased downwards. In 1986, the opposite occurred. A strong market demand for northern shrimp of all sizes resulted in the retention and processing of small animals accounting, in part, for the increases in CPUE. Also, some vessels engaged in the fishery in 1986 reported the use of very large trawls with large horizontal and vertical openings. Such improvements in gear design have been noted in the Davis Strait fishery although quantification of the effect on catch rates has shown to be difficult (NAFO 1987). The specifications of different gears used off Labrador are not included on the vessel logs and have been recorded only generally on observer set and catch sheets. Efforts are now being made to go back through observer narrative summaries in an attempt to specify the gear types for as many years as possible. New gear codes were given to each type of trawl reported in the 1986 fishery but a problem arises when trying to compare performance in previous years. Therefore, another part of the increase in 1986 catch rates is likely due to improvements in gear technology.

Shrimp Biomass

The research survey for shrimp in Hopedale Channel was conducted during the first week of August 1986, and a total of 78 stratified sets were made in the Channel (Table 2), resulting in a biomass estimate of 10,102 (±4848) t. Highest densities were found in the northern zone (Fig. 1) at depths of 350-450 m. Lower densities but most biomass was estimated for the larger central zone (saddle) between 300 and 450 m. The southern zone showed low shrimp densities throughout, although catches improved in the 400-500 m depth range.

A separation of the biomass into male, primiparious, multiparous, and ovigerous female groups shows that about 45% of the biomass consisted of male shrimp, and that most of the female biomass (61%) consisted of non-ovigerous multiparous females (Table 3). In strata of highest density and abundance, the proportion of male biomass ranged from 41 to 47%. Most of the biomass in the northern zone in depths less than 350 m was male shrimp, whereas in deeper water females dominated (by weight). Over the saddle, however, biomass of females was generally higher in depths ranging from 250 to 450 m, whereas males dominated in

deeper water. The southern zone was dominated by females which comprised 73% of the biomass of that area.

These data, alone, are not very informative regarding stock status but, over a series of years, might provide more insight into stock dynamics. It is also hoped that data from previous surveys can be separated in a similar fashion based on biological sampling by area for those years.

Biomass estimates obtained from 1979 to 1986 (Table 4) using the stratification scheme proposed by Parsons and Veitch (1986) show a decline over the 1979-83 period. The 1984 estimate of 8500 t ended this trend and biomass apparently increased to almost 13,000 t in 1985. The 1986 estimate of 10,100 t is about 21% lower than the 1985 estimate but 18-23% higher than the 1983 and 1984 values. Also, at survey time about 500 t had been removed by the fishery which implies a decrease from 1985 of about 17%.

In past assessments, a decrease in the proportion of biomass in the northern zone since 1979 has been observed (Parsons and Veitch 1986). The inclusion of the 1986 survey data in the time series suggests a continuation of this trend.

Percent biomass by zone

	1979	1980	1981	1982	1983	1984	1985	1986
Zone 1	72	65	60	41	46	40	30	26
Zone 2	26	31	36	58	46	54	69	72
Zone 3	2	4	4	1	8	6	1	2

As noted previously, shrimp density remains higher in the northern zone and thus the area remains attractive to the industry.

Biomass of Predators

Estimates of biomass for Greenland halibut increased from about 9000 t in 1981 to over 24,000 t in 1983 (Table 5). This was followed by a period of decline to 5000 t in 1986, the second lowest estimate for the time series. The highest abundance of cod in Hopedale Channel was observed in 1982. Since then, estimates have shown a declining trend to a low of less than 700 t in 1986.

No changes in the percentage of Greenland halibut by zone have been observed. The proportions of cod biomass, however, decreased in the northern zone from 1979 to 1983 with some stability since then.

Percent biomass by zone

	1979	1980	1981	1982	1983	1984	1985	1986
Zone 1	52	35	27	33	9	10	15	22
Zone 2	39	47	35	66	88	62	65	66
Zone 3	9	18	38	1	3	28	20	12

Size Composition - Research

Length frequencies from the research survey in Hopedale Channel in August 1986 (Fig. 2) show increasing mean size and proportion of females with depth in the northern and southern zones. In the central zone, however, the trend is not apparent as females were abundant in some of the shallow areas while males dominated in the deeper strata. These data are consistent with observations on the distribution of biomass by sexual stages.

In the northern zone, small (male) shrimp ranging in size from 15 to 20 mm CL dominated in depths less than 300 m. There was a broad range of sizes in depths of 300-600 m where most biomass was found and females clearly dominated only in depths greater than 600 m. Male shrimp exhibiting modes at roughly 17 and 19 mm were dominant in some shallow (<300 m) water strata on the Saddle but abundance in these areas was low. Over the range of depths where most biomass was found (300-450 m), a broad size range was observed with both males and females well-represented. Shrimp only were abundant in depths between 400 and 500 m in the southern zone and here, again, a broad size range was observed.

Size distribution in 1986 from areas of high biomass appear to be very similar to those obtained in 1985. Wide size ranges were found in both years and prospects for recruitment were good. However, the possible increase in fishing mortality on the smaller sizes in 1986 due to changes in the markets might be reflected in reduced catch rates in 1987.

Size Composition - Commercial

Length frequencies by depth zone from July to October 1986 (Fig. 3) show a high proportion of small (male) shrimp around 18-19 mm occurring in the catches in all months. The sampling data suggest that most fishing occurred in the 300-400 m range in all months but that in July and August effort was confined to those depths and deeper where the proportion of small shrimp was less. Later in the year, however, the high catch rates in the 200-300 m range attracted effort to those depths despite a higher proportion of smaller shrimp in the catch.

It was previously noted that in 1985, high proportions of male shrimp occurred in the catches, as well. In October and November of that year, males formed a major part of the catches at times when, in the previous two years, there had been a dominance of ovigerous females (Parsons and Veitch 1986). Since the fishery began in this area in the late 1970's, a dependency throughout the season on males in the 18-19 mm mode had not been observed until 1986. Although this size group also was present in the catches in 1985 it did not dominate in any month.

By-catch and Shrimp Discards

Observer data from July to November showed that Greenland halibut was the dominant by-catch species in July, August and November comprising 5-7% of the observed total catch weight. Redfish was the major by-catch in September (2%) and cod and redfish in October (2%). By-catch comprised about 10% of the total catch in all months except November when the proportion increased to 26%. This was due to a combination of a decrease in the amount of shrimp and increases in the amounts of American plaice, cod, redfish, and Greenland halibut occurring in the catches.

Virtually no discards were reported from available vessel logs in 1986 in contrast to the extremely high levels recorded in 1985 (up to 23% in September). Observer estimates of discarded shrimp from July to November showed slight increases from 1.0% in July and August to 1.2% in September, 1.5% in October, and 1.7% in November. These results reflect the change in market acceptability of small shrimp in 1986. There was no sufficient sampling of discarded shrimp for comparison with previous years' data.

Analysis of Biological Samples

Samples from Hopedale Channel dating back to 1981 (Table 6) have been analyzed for sex and maturity stages and subjected to model analysis by the Macdonald and Pitcher (1979) method. Mean lengths of modal (age?) and maturity groups plotted by year (Fig. 4) show reasonable consistency over the time series. Three groups of males are readily distinguishable at roughly 17.5, 19.0, and 21.0 mm. Smaller males ranging from 13.5 to 15.5 are also evident but only in one year (1984) are two modes obvious. Primiparous females (presumably a year-class) occur within a size range of 22.5 to 24.0 mm and multiparous females form one, two or three modes at larger sizes.

Although preliminary, the data show potential for interpreting age and growth for shrimp in this area. If the results can be applied to survey and commercial fishing data, work can begin on estimation of mortality rates and possibly interpreting year-class strength.

Temperature

A review of bottom temperatures by stratum in the Hopedale Channel (Table 7) shows an increasing trend in most areas and depths in the early 1980's. Slight cooling occurred in the northern zone between 1983 and 1984 and temperatures throughout the channel were much colder in 1985, especially in the southern area (Zone 3). The 1986 data show that water was generally warmer compared to the previous year with temperatures more similar to those observed in 1979 and 1980.

Temperatures in the northern zone in 1986 were approximately 3°C in depths where shrimp were most heavily concentrated (350-450 m). In depths of 300-450 m over the saddle (central zone) where most biomass was found, temperatures ranged from 3 to 3.5°C compared to less than 3°in 1985. In the southern zone in depths from 400 to 500 m where the only good shrimp catches were found, mean temperatures ranged from 2.8 to 3.8° compared to 1.4 to 2.2°C in 1985.

The overall increase in temperatures from 1985 to 1986 appears to be represented in the sampling data for females. In 1985, over 20% of all females were not expected to spawn based on maturity observations. The proportion of non-spawners from the 1986 sampling data was only 1.1%.

Discussion

The catch rate series for shrimp in Hopedale Channel continues to be inconclusive in terms of abundance, particularly given the change in market conditions and the participation of some larger trawlers using larger nets in 1986. The biomass estimate from the research survey of 10,102 t remains at a high level relative to 1983 and 1984 values but was about 17% lower than the 1985 estimate, if 500 t of catch are added.

Data from both the research survey and especially the commercial fishery in 1986 show the occurrence of a high proportion of males in the catches. More importantly, the fishery appeared to be heavily dependent on males in the 18-19 mm size (age) group. This suggests a loss in yield per recruit but no reliable data on growth and mortality rates are yet available to estimate optimal strategies. In addition to the possibility of loss in yield, a dependency on the first significantly recruiting size (age) class will be vulnerable to annual variations in year-class strength which could lead to disasterous fisheries in some years. Also, heavy fishing mortality on these male shrimp will result in a reduced spawning stock some years hence. Finally, as quickly as market conditions changed in 1986, they could change back in some future year when there may be again preference for larger animals. Even if recruitment remains strong, it may take 2-3 years to rebuild the larger (older) size (age) groups to levels sufficient to sustain a fishery.

On a more optimistic note, previous concerns about declining bottom temperatures and possible reductions in stock productivity were allayed with the return of warmer temperatures throughout the area. Also, abundance estimates for Greenland halibut and cod were low in 1986, indicating that natural mortality might be reduced compared to years of high predator abundance.

CAFSAC has used the exploitation rate of 35% applied to an appropriate estimate of biomass to formulate advice on TAC. The following options might be considered appropriate:

1) Average biomass from 1984 to 1986 representing the period after the initial decline from a virgin stock; 10,631 x 35% = about 3700 t.

2) Average biomass for 1985 and 1986 which were based on the revised stratification and represents a period of higher abundance relative to 1983 and 1984;
11,679 x 35% = about 4100 t.

3) Status quo (i.e. 3400 t) given a decrease in biomass between 1985 and 1986 and an apparent dependency in 1986 on small, male shrimp.

CARTWRIGHT CHANNEL

Catch and CPUE

Shrimp catches in Cartwright Channel decreased from about 1400 to 1500 t in 1977-78 to about 1000 t in 1979 (Table 8). Since then, effort in this area has been low and sporadic resulting in catches of 2 to 312 t during the 1980-85 period. The fishery in 1986 began after the closure of the Hopedale Channel on November 24 and by December 31, the TAC of 1000 t was exceeded by 248 t. TAC's of 800 t also were exceeded in 1978 and 1979.

CPUE data showed a decrease from 1977 to 1979 but effort in subsequent years was so low that meaningful comparisons could not be continued. It was previously noted that in 1984 monthly catch rates were higher than those of the three previous years, especially during the July-September period (Parsons and Veitch 1985). There was virtually no fishery in 1985 but data from November and December in 1986 show the highest catch rates ever attained in this area during those months.

As for Hopedale Channel, the interpretation of the CPUE in 1986 as a measure of abundance is affected by changes in the market acceptability of small shrimp and by improvements in gear technology as described previously. Thus, the 1986 CPUE values are likely biased upward by an unknown amount, compared to other values.

Shrimp Biomass

The research survey for shrimp in Cartwright Channel was conducted during the second week of August 1986. A total of 45 successful random sets were made (Table 9) and an estimate of biomass of 1803 (±692) t was obtained. Highest densities of shrimp and most biomass were found well within the channel (Fig. 5) in the old stratified zone at depths between 450 and 550 m. Over the saddle, shrimp were less abundant except in the deeper water (>450 m) toward the centre of the channel.

A breakdown of the biomass by maturity stages (Table 10) shows that about 63% was comprised of females and most of the female biomass (68%) was ovigerous. In strata of highest density and abundance, females accounted for 55 and 76% of the biomass. Most of the biomass in depths less than 350 m consisted of males.

Biomass estimates from 1979 to 1986 (Table 11) show a steady decline in abundance from 1980 to 1983. However, in 1984, an increase was observed to over 3000 t, the highest in the series. From this level, estimates have decreased by 17 and 42% for 1985 and 1986, respectively. It is noted, however, that in both these years, between 75 and 80% of the biomass has been estimated to be well within the channel (old stratified zone) compared to 1984 when over 80% was found in shallower water over the saddle.

Biomass of Predators

Biomass estimates for Greenland halibut have varied extensively over the period 1979-86 (Table 12). The estimate of 2255 t for 1986 is one of the lowest levels observed and represents a decrease of 60% from the previous year. Conversely, the estimate for cod is the third highest in the series and, although 25% lower than the 1985 value, remains considerably higher than levels observed in 1983 and 1984.

Size Composition - Research

Length frequencies from the research survey in Cartwright Channel in August 1986 (Fig. 6) show a clear dominance of smaller (<20 mm) shrimp to depths of 450 m. Most biomass was found in depths greater than 450 m where the proportions of female shrimp were higher. In deeper water (>450 m), ovigerous females comprised 27 to 48% of the samples compared to 2-15% in depths less than 450 m. A strong mode of males around 18.5 mm was dominant in 350-450 m and a smaller group at 15 mm dominated the 250-350 m range.

Size distributions in 1986 from areas of high biomass appear to be similar to those obtained in 1985. In 1984, when biomass was estimated at more than 3000 t, small male shrimp (14-19 mm) dominated in depths of highest abundance (300-400 m). The proportion of males in both 1985 and 1986 appears to be lower than in 1984. This, coupled with a decrease in biomass estimates, suggests that recruitment in the past two years was lower than the 1984 level. Further growth and recruitment

into the fishery of the males could occur, but these were heavily targeted by the 1986 fishery, thereby reducing their contribution to the 1987 biomass.

Size Composition - Commercial

Data from commercial vessels for November and December 1986 (Fig. 7) show a wide range of sizes occurring in the catches. In November, catches sampled from 400-500 m contained a high proportion of berried females as well as several size (age) groups of males and non-ovigerous females. In December, length distributions in three depth intervals were similar. Modes occurred in the non-ovigerous animals at roughly 16, 20-21 and 25 mm while ovigerous females were essentially unimodal at 24 mm. Importance of the larger modes (24 and 25 mm) increased with increasing depth but the mode of presumably males around 20-21 mm remained prominent throughout the depth range.

Commercial data from previous years are lacking but it appears that the size composition of catches in 1986 was similar to that observed in 1978 (Parsons et al. 1979). The same modal groups were represented with a dominant mode of 21 mm.

By-catch and Shrimp Discards

Observer data from November and December in Cartwright Channel show that Greenland halibut was the most important by-catch species in both months comprising 13 and 9% of the total catch, respectively. The proportion of cod in the catches decreased from 8% in November to 4% in December. Proportions of total by-catch decreased from 28% in November to 16% in December.

Estimates of shrimp discards from vessel logs were 4.8% in June (only 4 hours of effort), 0% in November and 0.2% in December. These were similar to the low levels reported in 1984. Observer estimates were 1.8% for November and 1.3% for December and can be considered as more reliable. The low levels observed and reported again reflect the acceptability of small shrimp in the market.

Analysis of Biological Samples

Shrimp samples from Cartwright Channel from 1980 to 1986 (Table 13) have been analyzed by maturity stages and possible age composition. Mean lengths of modal and maturity groups for all years form parallel lines which appear to define shrimp growth in this area remarkably well (Fig. 8). Four size (age) groups of males can be seen at approximately 12.0, 15.5, 17.5, and 20.0 mm. The decline in mean size of primiparous females during the period 1981-85 can be related to the general decline in bottom temperatures observed over the same period. A similar pattern is noted for the older multiparous female groups. At least three groups of females have been identified: primiparous - 20.5-23.5 mm, multiparous - 23-24.5 mm, and a larger (older) multiparous group at 25-27 mm.

Temperature

Mean bottom temperatures by 50 m depth intervals in Cartwright Channel from 1979 to 1986 (Table 14) indicate considerable variation from year to year. Bottom water generally was colder in 1980 than either 1979 or 1981. Temperatures dropped considerably at all depths in 1982, showed some recovery in 1983 and 1984, then declined again in 1985 to the lowest levels observed over the period. In 1986, waters were much warmer, returning to levels observed in 1979 and 1981. Most

biomass in 1986 was located in depths greater than 450 m where mean temperatures ranged from 2.6 to 3.1°C.

Changes in temperature can be related to changes in spawning success over the same period. Temperatures observed in 1981 were among the warmest recorded from 1979 to 1986 and the proportion of spawning females from sampling data was over 95%. Adjacent cold years (1980, 1982) resulted in reduced proportions of spawners at 84 and 80%, respectively. The coldest year (1985) showed a further reduction to 67% followed by an increase to 81% in the warmer year of 1986.

Discussion

The same problems that are associated with interpreting the catch rate data for Hopedale Channel also apply to Cartwright Channel. Therefore, despite the highest catch rates ever observed in this fishery, little can be concluded in relation to abundance. The biomass estimate of 1803 t is below both the 1984 and 1985 estimates and is the second lowest in the series. The proportion of males both in research and commercial catches in 1985 and 1986 was lower than in 1984 when biomass was at the highest level observed and this, coupled with decreasing biomass, could reflect poor recruitment. Also, small male shrimp around 20 mm were heavily targeted by the fishery in 1986 and the TAC was overrun by 25%.

Predation by Greenland halibut is not a major concern at this time due to low abundance in 1986 but potential for predation by cod remains high. The increase in bottom temperatures in 1986 could result in increased productivity (eg. egg production, growth), reversing the decreasing trend observed between 1981 and 1985.

Given the decrease in estimated biomass between 1984 and 1986 in the virtual absence of a commercial fishery, the high removals of male shrimp and the overrun of the TAC in 1986, some reduction in TAC for 1987 should be considered. The average biomass from 1983 to 1986 is 2150 t and, if the exploitation rate of 35% is applied results in a TAC of 750 t. Estimate from these years were calculated based on the expanded stratified area. Using the average from 1984 to 1986 (2500 t), the most recent period of apparent decline, a TAC of 875 t is implied. The former estimate is more consistent with the observed decrease in biomass of about 30% between 1985 and 1986.

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Table 1. Catch per hour fished, 1977-86, Hopedale Channel.

Month	1977		1978		1979		1980		1981		1982		1983		1984		1985		1986	
	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)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)
May									5,455	201										
June					196,741	902	28,970	812	408,457	454	171,265	396	166,729	366					8,830	268
July			131,544	735	965,454	594	736,840	596	360,770	300	302,674	351	253,121	297	39,890	453	80,082	245	172,874	563
Aug.	93,695	532	85,570	506	886,678	314	589,206	397	474,218	329	219,227	348	1,625	191	35,190	238	452,948	310	406,395	713
Sept.	206,111	638	68,591	328	110,807	263	605,794	292	555,279	360	67,731	192	2,125	123	49,855	201	182,158	148	814,357	501
Oct.	330,574	316	584,589	477			390,295	334	406,217	380	246,110	367			335,304	309	404,431	202	722,905	485
Nov.	641,516	696	470,170	432			163,316	536	469,023	363	471,095	491	370,427	311	100,031	350	370,217	252	219,420	472
Dec.									168,375	524	113,325	336	71,302	198	55,946	261	30,492	330		
Total[a]	1,271,896	516	1,340,464	467	2,159,680	424	2,514,421	399	2,847,794	365	1,591,427	375	865,329	299	616,216	298	1,520,328	231	2,344,781	522
Total[b]	1,203,000		2,109,000		2,693,000		3,938,000		3,382,266		1,707,900		1,014,000		712,000		1,409,000[c]		3,483,000[c]	
TAC (T)			4,500		3,200		4,000		4,000		4,000		4,000		3,500		2,800		3,400	

[a]Based on catches from vessel logs.

[b]Based on statistics from landings.

[c]Preliminary.

Table 2. Minimum trawlable biomass (t) - 1986 - Hopedale Channel.

Stratum no.	Depth (m)	Area (sq. n. mi.)	No. sets	Av./set (kg)	Biomass (t)
101	151-200	54	2	0.38	1.17
102	201-250	46	2	70.50	182.08
103	251-300	40	4	69.77	156.69
104	301-350	40	4	128.02	287.50
105	351-400	54	4	255.27	773.89
106	401-450	52	6	248.16	724.49
107	451-500	66	4	77.15	285.87
108	501-550	177	3	16.25	161.48
109	551-600	38			
110	>600	3	5	25.23	58.07
Total		570	34	122.70	2631.24
202	201-250	84	2	0.65	3.09
203	251-300	174	2	16.28	159.04
204	301-350	398	6	128.43	2869.75
205	351-400	319	8	151.42	2711.83
206	401-450	304	6	75.12	1282.09
207	451-500	173	3	14.03	136.27
208 + 308	501-550	247	3	5.30	73.54
209	551-600	185	2	0.65	6.80
211	251-300	184	1		
212	201-250	91	1	2.20	33.97
210	601-650	305	1		
214	>550	42	1	1.15	22.40
Total		2506	36	70.35	7298.78
302	201-250	33	1		
303	251-300	37	1		
304	301-350	30	1	1.17	7.92
305	351-400	20	1		
306	401-450	25	2	68.22	95.75
307	451-500	31	2	39.50	68.76
Total		176	8	27.52	172.43
Grand Total		3252	78	85.63	10,102.45

Table 3. Shrimp biomass (t) - 1986 - Hopedale Channel, by maturity stage.

Stratum no.	Males	Primiparous females	Multiparous females	Ovigerous females
101	0.82	0.00	0.35	0.00
102	180.97	0.21	0.90	0.00
103	109.85	4.64	33.79	8.42
104	168.19	14.82	63.60	40.89
105	337.11	62.04	233.38	141.37
106	310.26	72.76	225.37	116.10
107	97.22	27.79	101.26	59.60
108	44.88	20.97	66.02	29.61
109 110	17.90	3.93	27.97	8.27
Total	1267.20	207.16	752.64	404.26
202	1.79	0.05	0.54	0.71
203	22.32	21.30	84.70	30.72
204	1195.10	226.46	1161.96	286.23
205	1286.54	319.62	821.82	283.86
206	523.68	168.23	461.01	129.17
207	96.09	4.40	22.66	13.11
208 + 308	49.78	0.93	16.69	6.15
109	2.86	0.21	1.97	1.77
211 212	27.10	1.31	5.56	0.00
210 214	14.51	0.49	4.48	2.92
Total	3219.77	743.00	2581.39	754.64
302 303 304 305	7.48	0.10	0.29	0.05
306	22.50	6.51	45.78	20.97
307	16.76	1.99	25.93	24.07
Total	46.74	8.60	72.00	45.09
Grand Total	4533.71	958.76	3406.03	1203.99

Table 4. Biomass estimates (t) and 95% confidence intervals for shrimp in Hopedale Channel, 1979-86.

Year	Mean	Upper	Lower	Area (sq. n. mi.)	No. sets
1979	17,800	33,642	1,958	2,302	56
1980	14,739	23,220	6,258	2,802	84
1981	4,914	7,015	2,813	2,724	56
1982	11,563	15,370	7,757	2,724	76
1983	8,236	9,688	6,784	2,778	87
1984	8,534	12,238	4,830	2,456	60
1985	12,756	20,372	5,140	3,385	69
1986	10,102	14,951	5,254	3,252	78

Table 5. Biomass estimates (t) and 95% confidence intervals for Greenland halibut and cod in Hopedale Channel, 1979-86.

	Greenland halibut			Cod		
Year	Mean	Upper	Lower	Mean	Upper	Lower
1979	4,785	6,563	3,007	649	3,341	-2,042
1980	23,621	27,876	19,365	2,043	2,642	1,443
1981	9,105	13,363	4,848	788	2,093	-517
1982	12,239	14,049	10,430	2,655	4,123	1,187
1983	24,018	27,434	20,602	1,622	2,367	878
1984	18,602	21,759	15,445	1,435	2,488	383
1985	11,746	18,354	5,138	897	1,356	437
1986	5,000	8,915	1,084	688	972	403

Table 6. Detailed samples for Hopedale Channel (Zone 1), 1979-86.

Month	Year	Males	Primiparous females	Multiparous females	Ovigerous females	Total
7	1981	750	125	367	14	1256
7	1982	1499	286	269	-	2054
7	1983	563	146	255	1	965
7	1984	530	222	210	-	962
8	1985	606	159	145	17	927
8	1986	379	18	191	144	732

Table 7. Mean bottom temperatures (°C) for Hopedale Channel, 1979-86.

Stratum	Year							
	1979	1980	1981	1982	1983	1984	1985	1986
101	-1.2				-1.0	-1.3	-1.4	-0.7
102	-0.2		0.2	-0.6	-0.6	-1.1	-0.2	0.1
103	2.3	2.0	1.5	1.8	1.9	0.7	0.2	0.9
104	2.9	2.7	2.7	2.2	3.0	2.2	1.5	2.2
105	3.0	2.9	3.3	3.3	3.7	2.7	2.1	2.8
106	3.5	3.1	3.2	3.3	3.8	3.5	2.7	3.1
107	3.3	3.0	3.3	3.4	3.9	3.7	2.6	3.2
108	3.1	3.3	3.6	3.9	3.8	3.7	2.8	3.5
109	3.2	3.2	3.2	3.4	4.0	3.6	2.6	3.2
110	3.2	3.2						
201							-1.3	
202		1.7				1.0	-0.3	2.5
203		2.6	3.6	1.6	2.8	3.0	1.3	2.9
204	3.5	3.0	3.0	1.6	2.1	2.9	1.1	3.4
205	3.2	3.1	3.5	3.5	3.6	3.4	2.9	3.5
206	3.4	3.2	3.7	3.3	3.7	3.7	2.8	2.9
207	3.3	3.4		3.4	3.9	4.0	3.1	3.4
208	3.3	3.5	3.6	3.7	3.8	3.9	3.4	3.3
209	3.2	3.3	3.4	3.5	3.8	3.8	2.8	3.1
210	3.5	3.5	3.3	3.6	3.9		2.2	3.3
211					0.8		1.5	2.9
212							-0.7	0.6
213							-1.6	
214							3.2	3.2
301							-1.6	
302							-1.7	-0.3
303		2.2	1.9	0.3	-0.6	0.4	0.1	0.3
304	1.4	1.6	2.5	0.8	1.9	0.9	0.4	1.9
305	2.1	2.8	2.3	2.6	2.7	2.9	0.6	2.1
306	2.4	3.1	2.9	2.4	3.2	3.9	1.4	2.8
307	3.3	3.0	3.1	3.0	3.8	3.6	2.2	3.8
308	2.9	3.3	3.3	3.2	3.8	3.5	2.3	3.0

Table 8. Catch (kg) and catch per hour fished, 1977-86, Cartwright Channel.

Month	1977		1978		1979		1980		1981		1982		1983		1984		1985		1986	
	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)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)
June							23,134	187			113,580	340	2,790	111					625	156
July	311,838	813	155,813	479	147,498	658	11,770	453	6,875	255					50,675	301				
Aug.	514,633	624	399,501	633	148,268	264	22,465	292	5,035	155	1,020	255			38,200	343	854	131		
Sept.	234,037	454	638,159	395	422,021	217	55,919	264	907	202			160	53	143,210	313	1420	49		
Oct.	14,378	181	45,439	190			405	58							18,895	224				
Nov.	73,616	691					3,535	107							6,925	157			23,169	866
Dec.	9,650	449									28,710	370			90	23			912,785	623
Total[a]	1,158,152	600	1,238,912	441	717,787	263	117,228	245	12,817	200	143,310	345	2,950	105	257,995	297	2,274	64	936,579	626
Total[b]	1,414,000		1,521,000		1,034,000		170,000		67,419		167,196		3,000		312,000		-		1,248,000[c]	
TAC (t)			800		800		800		800		800		800		700		770		1,000	

[a]Totals from available vessel logs.

[b]Totals from reported landings.

[c]Preliminary.

Table 9. Minimum trawlable biomass (t) - 1986 - Cartwright Channel.

Stratum no.	Depth (m)	Area (sq. n. mi.)	No. sets	Av./set (kg)	Biomass (t)
701 + 801	251-300	137	2	2.59	19.92
702 + 703	251-350	110	2	10.65	65.77
704 + 705	201-300	67	2	0.06	0.24
706 + 806	301-350	124	6	1.46	10.19
707	351-400	36	3	40.70	82.25
708	401-450	45	4	46.98	118.69
709	451-500	54	5	111.44	337.84
710	501-550	90	4	111.57	563.74
711	451-500	16	3	45.01	40.43
712 + 812	>550	44	4	55.90	138.10
807	351-400	67	3	34.07	128.17
808	401-450	47	2	33.28	87.82
809	451-500	37	2	88.65	184.15
810	501-550	7	3	64.82	25.47
Total		881	45	49.96	1802.78

Table 10. Shrimp biomass (t) - 1986 - Cartwright Channel, by maturity stage.

Stratum no.	Males	Primiparous females	Multiparous females	Ovigerous females
701 + 801	16.92	0.27	1.65	1.08
702 + 703	54.59	1.64	9.42	0.12
704 + 705	0.24	0.00	0.00	0.00
706 + 806	6.18	0.11	2.53	1.37
707	39.59	0.45	25.34	16.88
708	78.44	0.35	17.68	22.20
709	153.39	2.68	59.79	121.99
710	136.99	6.72	102.43	317.59
711	5.90	0.05	9.00	25.47
712 + 812	26.33	0.46	25.11	86.20
807	77.15	1.49	23.37	26.16
808	26.99	0.63	22.39	37.80
809	39.85	1.88	38.83	103.58
810	7.62	0.11	5.88	11.86
Total	670.18	16.84	343.42	772.30

Table 11. Biomass estimates (t) and 95% confidence intervals for shrimp in Cartwright Channel, 1979-86.

Year	Mean	Upper	Lower	Area (sq. n. mi.)	No. sets
1979	1892	2879	904	286	22
1980	2789	3422	2157	417	37
1981	2367	3380	1355	503	49
1982	1916	2867	965	503	42
1983[a]	1111	1446	775	713	56
1984	3113	4863	1362	880	47
1985	2574	3523	1625	633	45
1986	1803	2494	1111	881	45

[a]Expanded stratified area from 1983 to 1986.

Table 12. Biomass estimates (t) and 95% confidence intervals for Greenland halibut and cod in Cartwright Channel, 1979-86.

	Greenland halibut			Cod		
Year	Mean	Upper	Lower	Mean	Upper	Lower
1979	1739	2685	793	244	426	62
1980	5332	6189	4476	331	502	160
1981	1376	2042	710	751	1403	99
1982	3061	3934	2188	1017	1414	620
1983	4586	5512	3661	513	755	271
1984	2900	5296	503	602	951	253
1985	5512	7595	3430	1266	2393	139
1986	2255	2872	1639	954	1565	343

Table 13. Detailed samples for Cartwright Channel (Zone 1), 1980-86.

Month	Year	Males	Primiparous females	Multiparous females	Ovigerous females	Total
7	1980	992	223	518	64	1797
7	1981	431	131	242	13	817
7	1982	479	192	293	3	967
7	1983	323	156	284	5	768
7	1984	702	235	173	4	1114
8	1985	289	23	104	177	593
8	1986	141	3	107	354	605

Table 14. Mean bottom temperatures (°C) for Cartwright Channel, 1979-86.

Depth (m)	Year							
	1979	1980	1981	1982	1983	1984	1985	1986
250-300	0.50	0.00	1.72	-0.25	0.55	0.58	-1.30	2.25
301-350	1.50	1.05	2.30	0.56	1.04	1.08	-0.40	2.21
351-400	2.30	1.78	2.40	1.30	1.89	1.44	0.41	2.45
401-450	2.45	2.18	2.81	1.70	1.99	1.84	0.60	2.58
451-500	2.93	2.68	2.65	2.02	2.36	2.39	1.14	2.79
501-550	3.08	2.89	3.00	2.25	2.60	2.64	1.27	3.01
>550	-	2.95	2.80	2.20	2.40	2.85	1.20	3.08

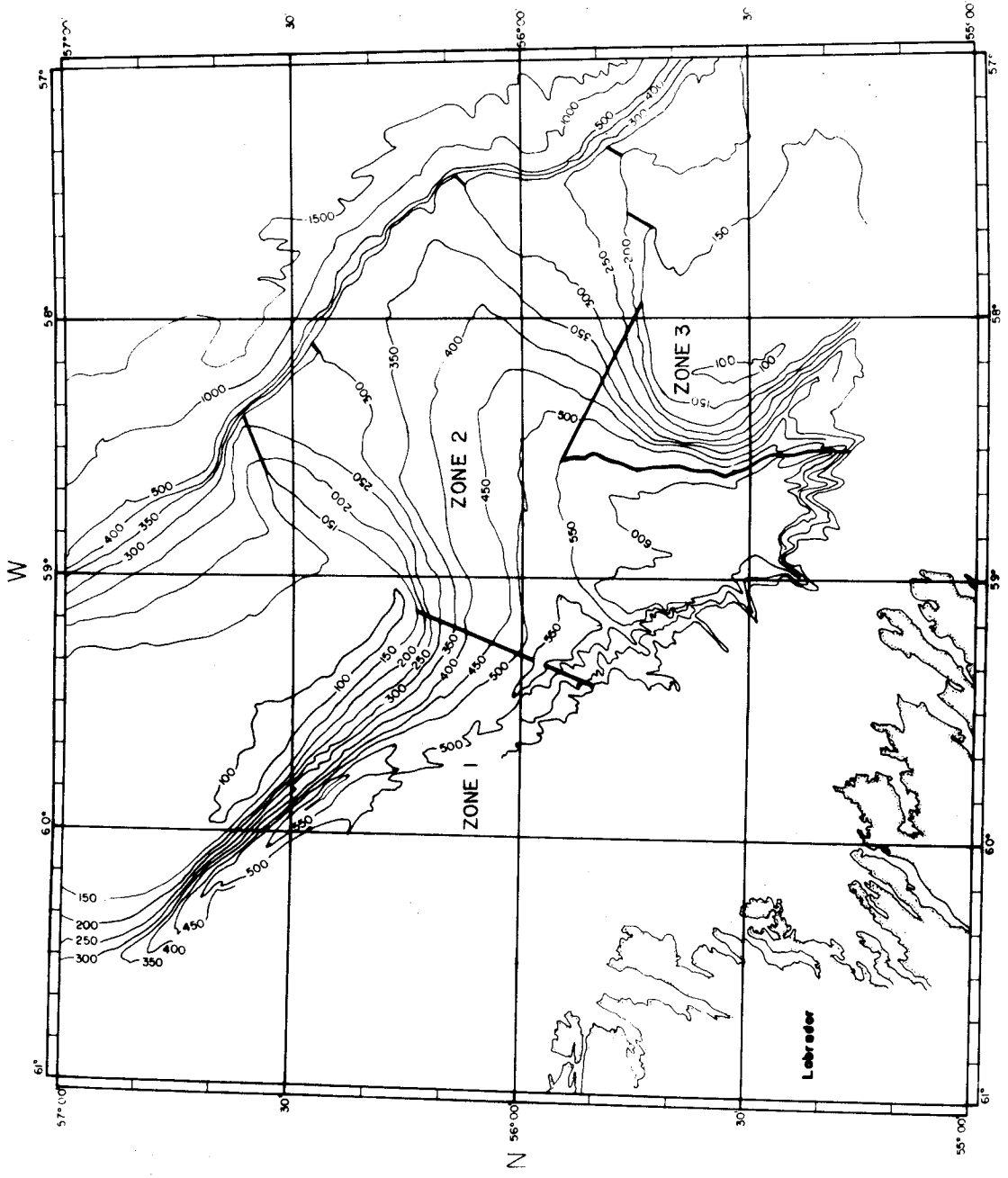

Fig. 1. Stratification of the Hopedale Channel for northern shrimp surveys.

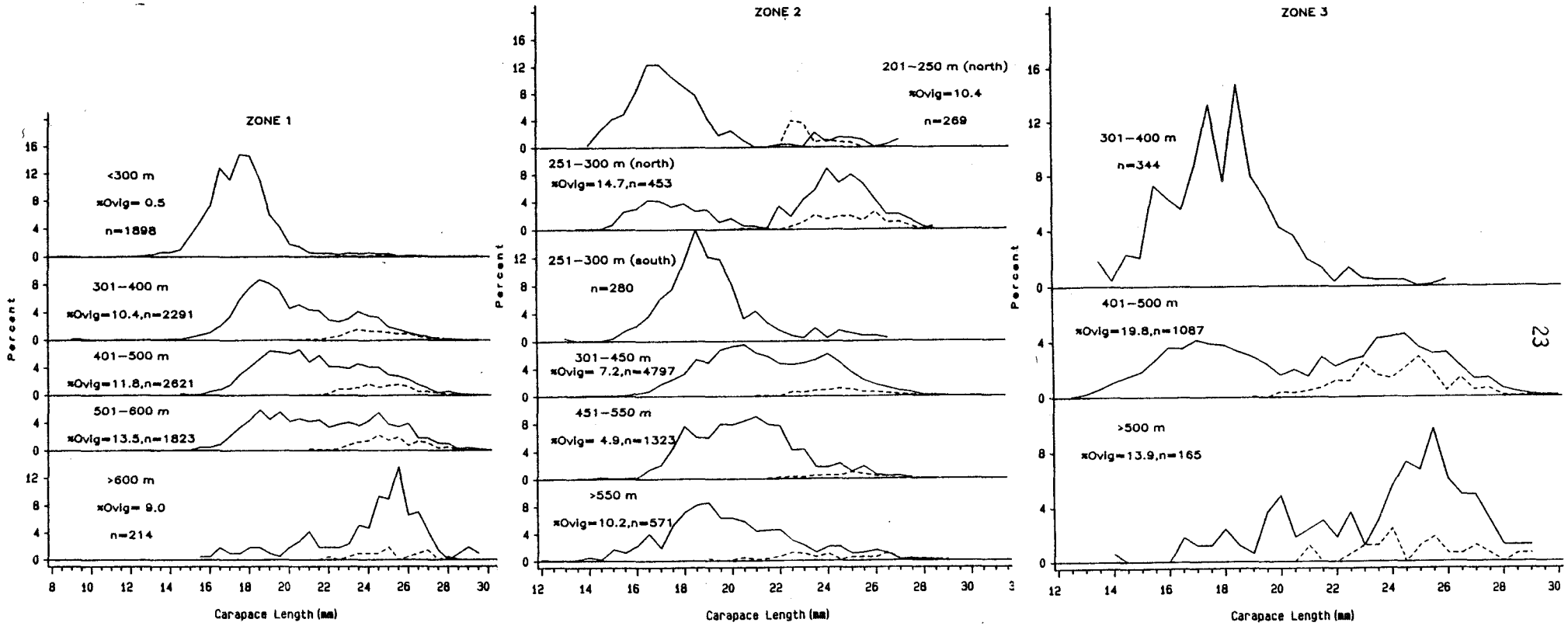

Fig.2 Size distributions of shrimp in Hopedale Channel from the August,1986 research survey. (Broken line = ovigerous)

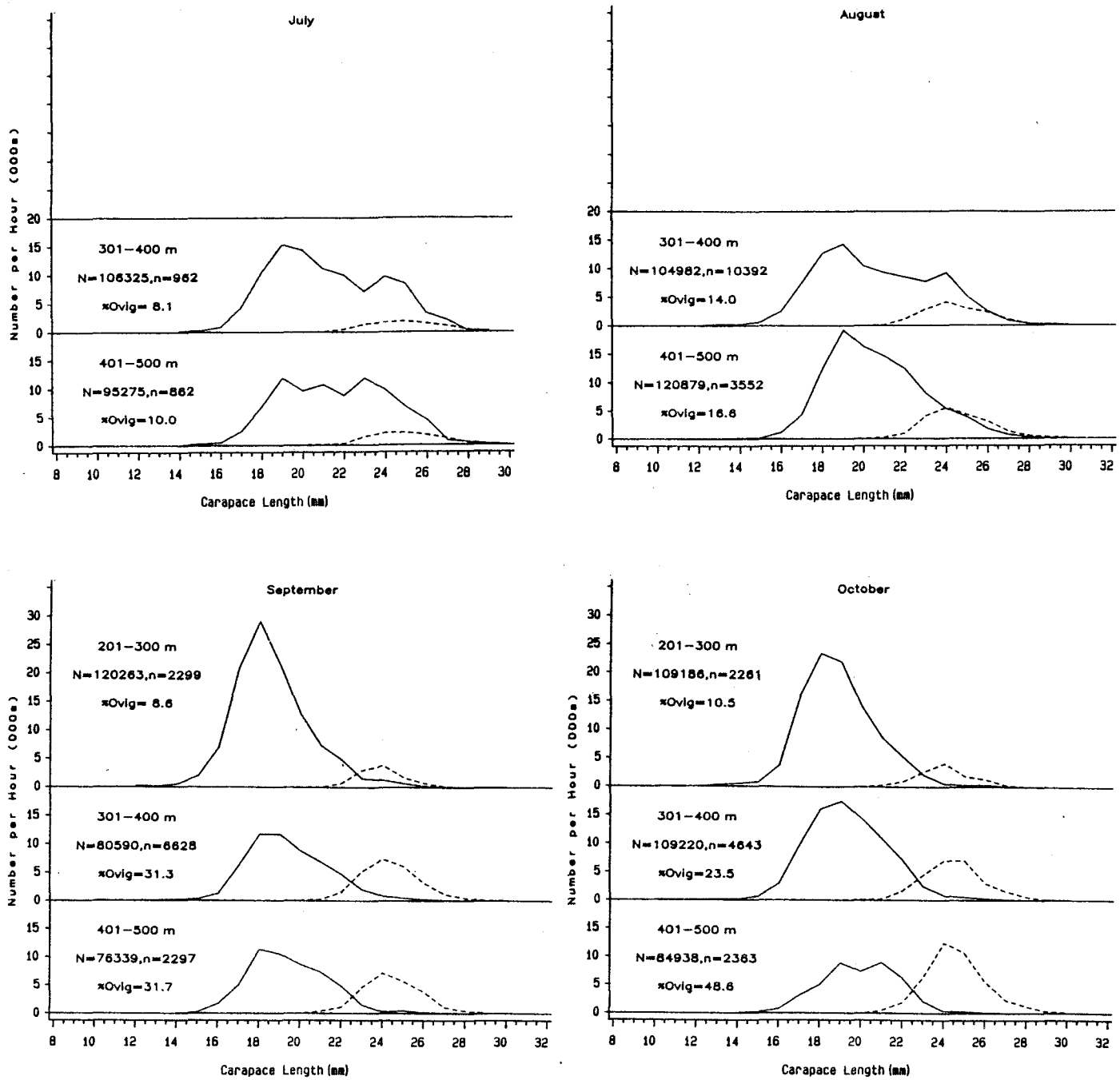

Fig.3. Commercial length frequencies of shrimp from the fishery in Hopedale Channel, 1986. (Broken line = ovigerous)

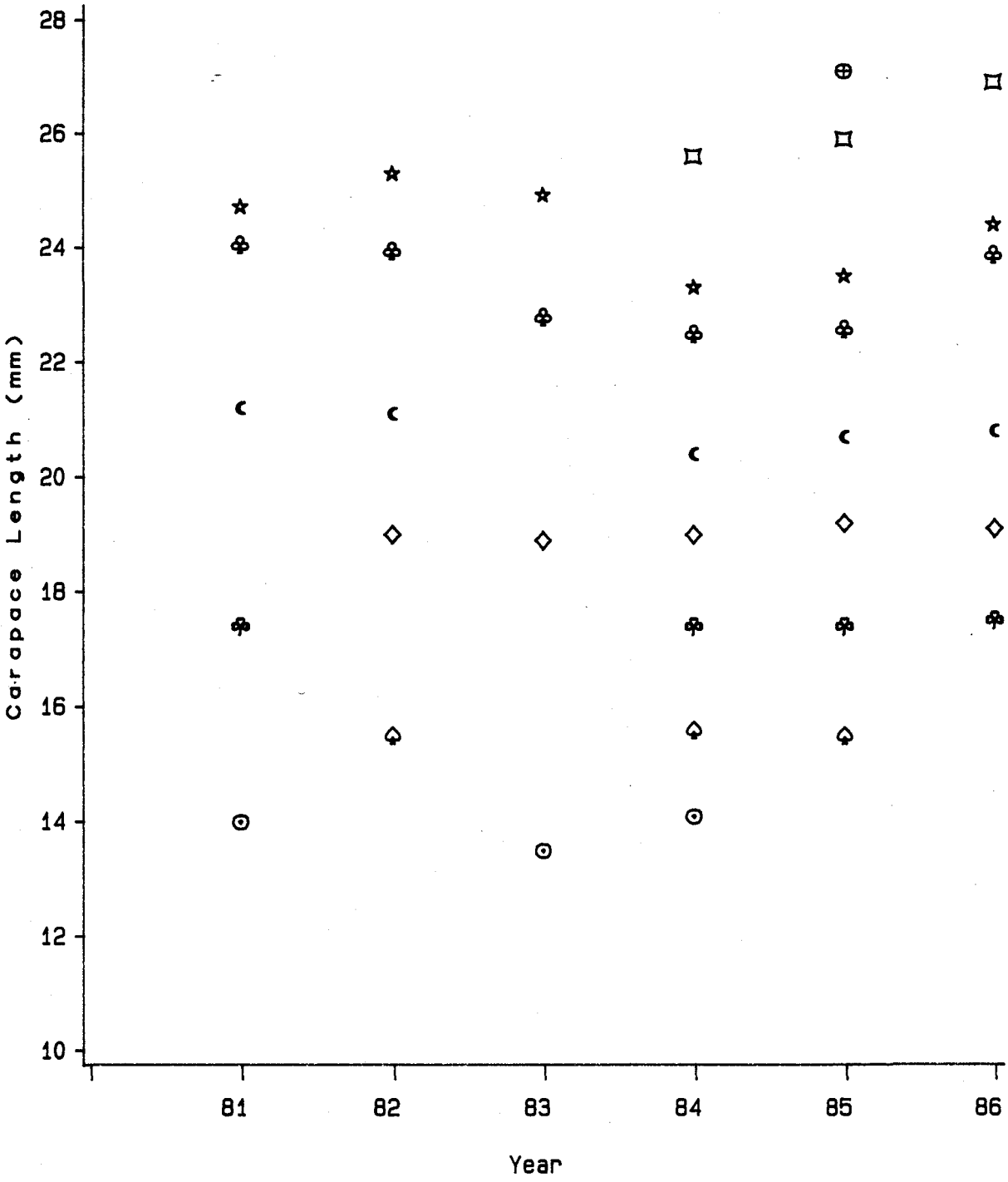

Fig.4 Mean length of sex and maturity stages, Hopedale Channel, 1981-86. (Symbols represent possible age groups).

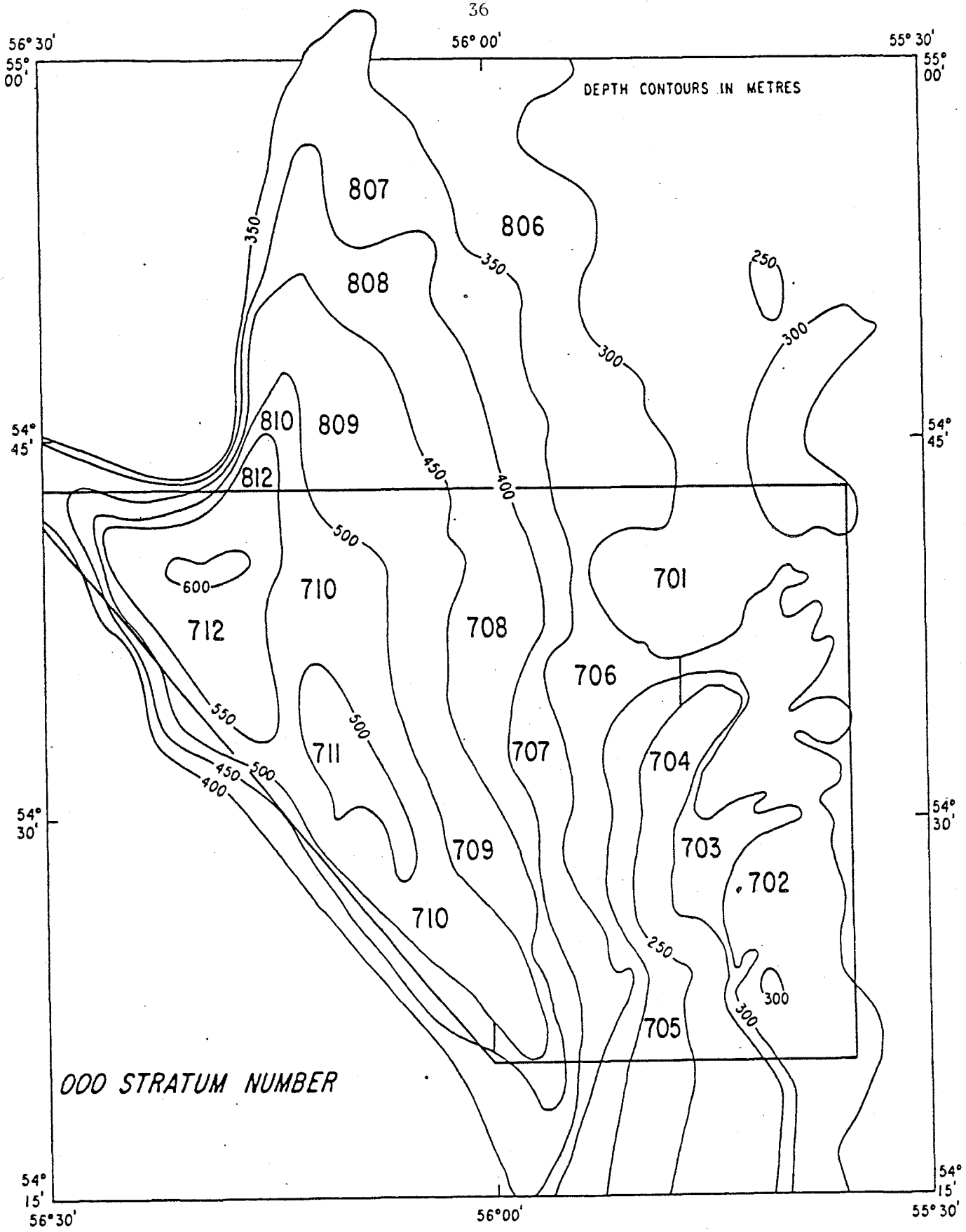

Fig. 5. Stratification of the Cartwright Channel.

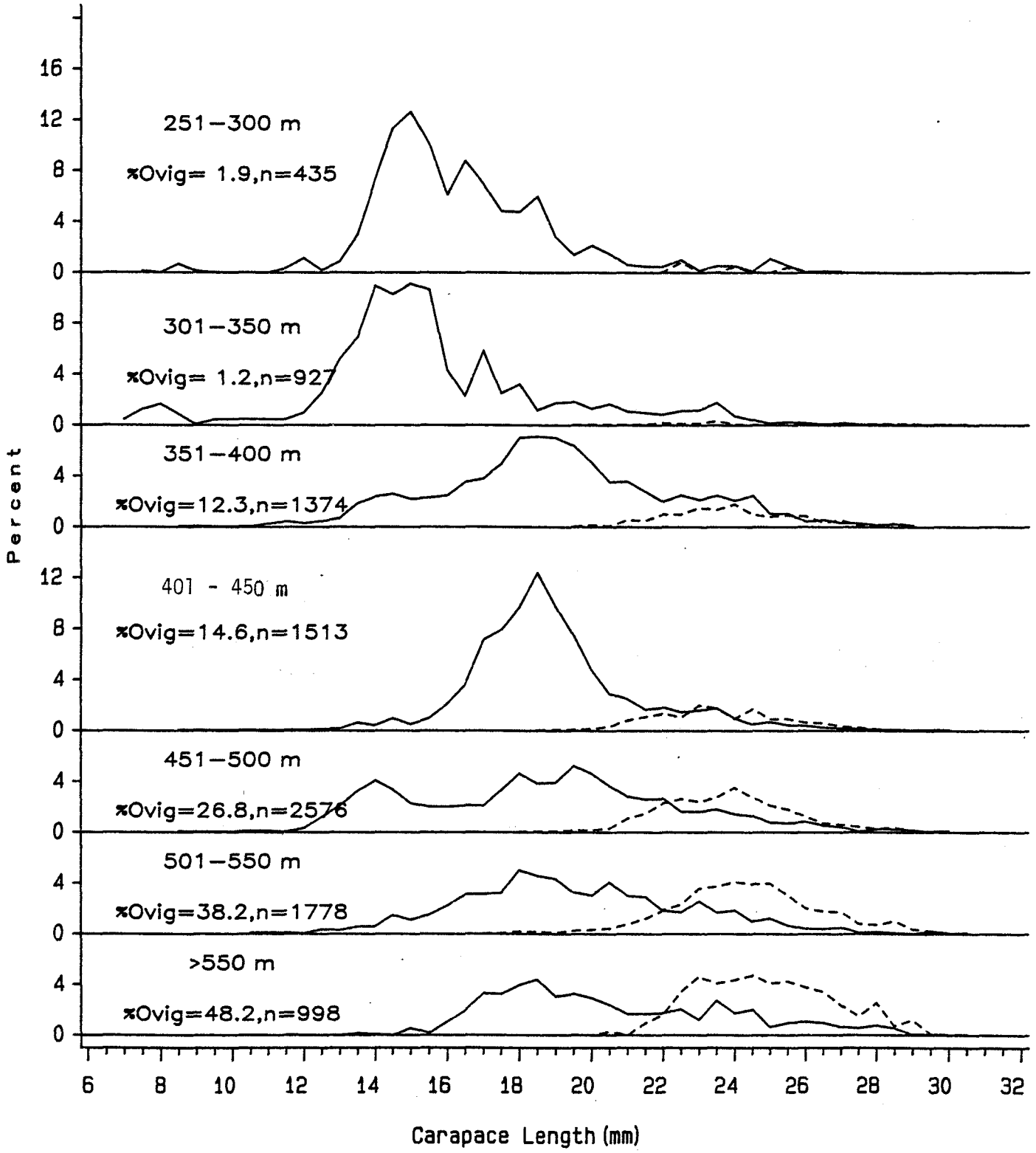

Fig.6 Length distributions of shrimp taken from Cartwright Channel August, 1986 (research). Solid line=non-ovigerous broken=ovigerous n=number measured.

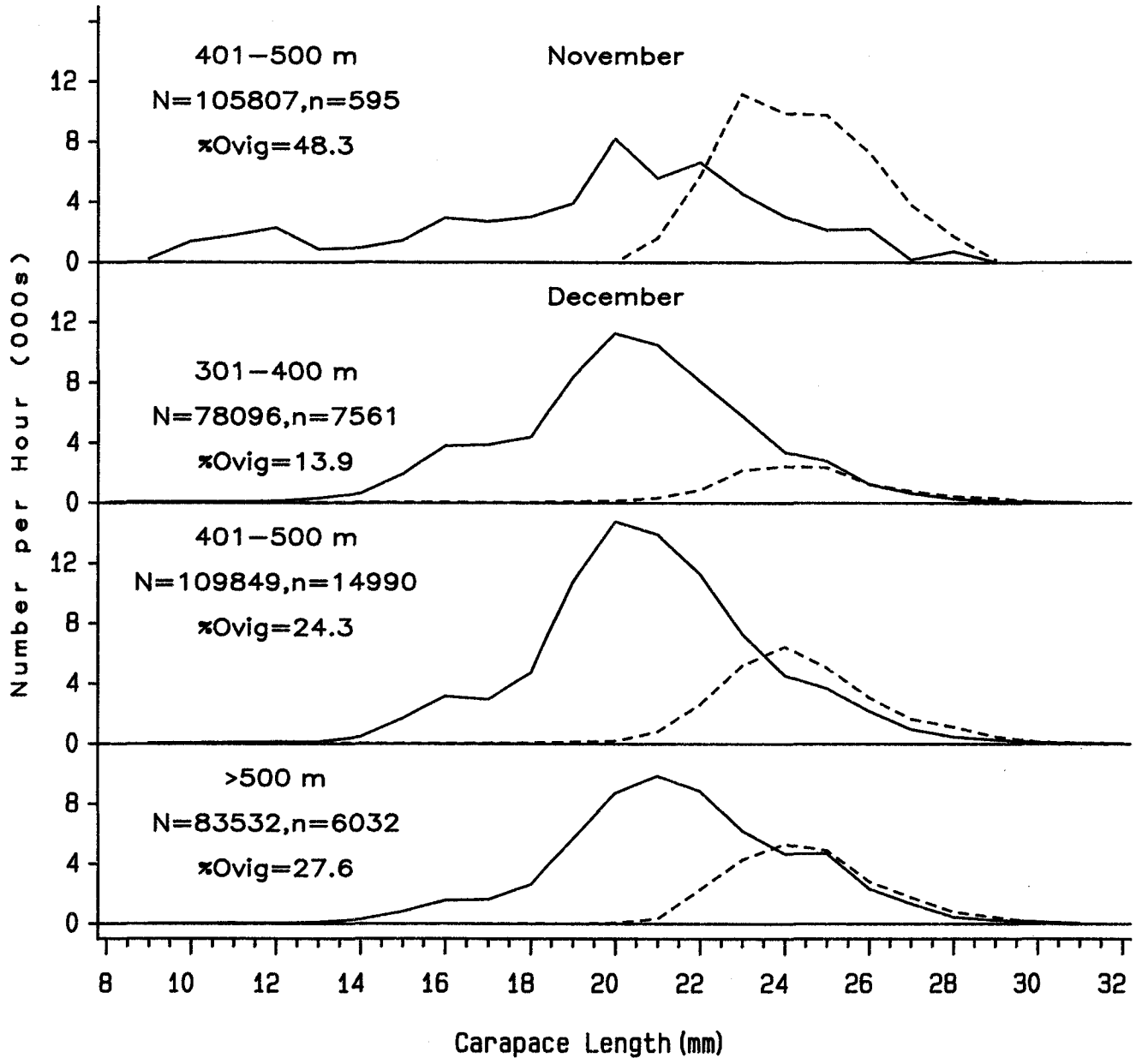

Fig.7 Length distributions of shrimp taken in Cartwright Channel in November and December, 1986 (commercial).
Solid line=non-ovigerous, broken=ovigerous , N=number caught
n=number measured.

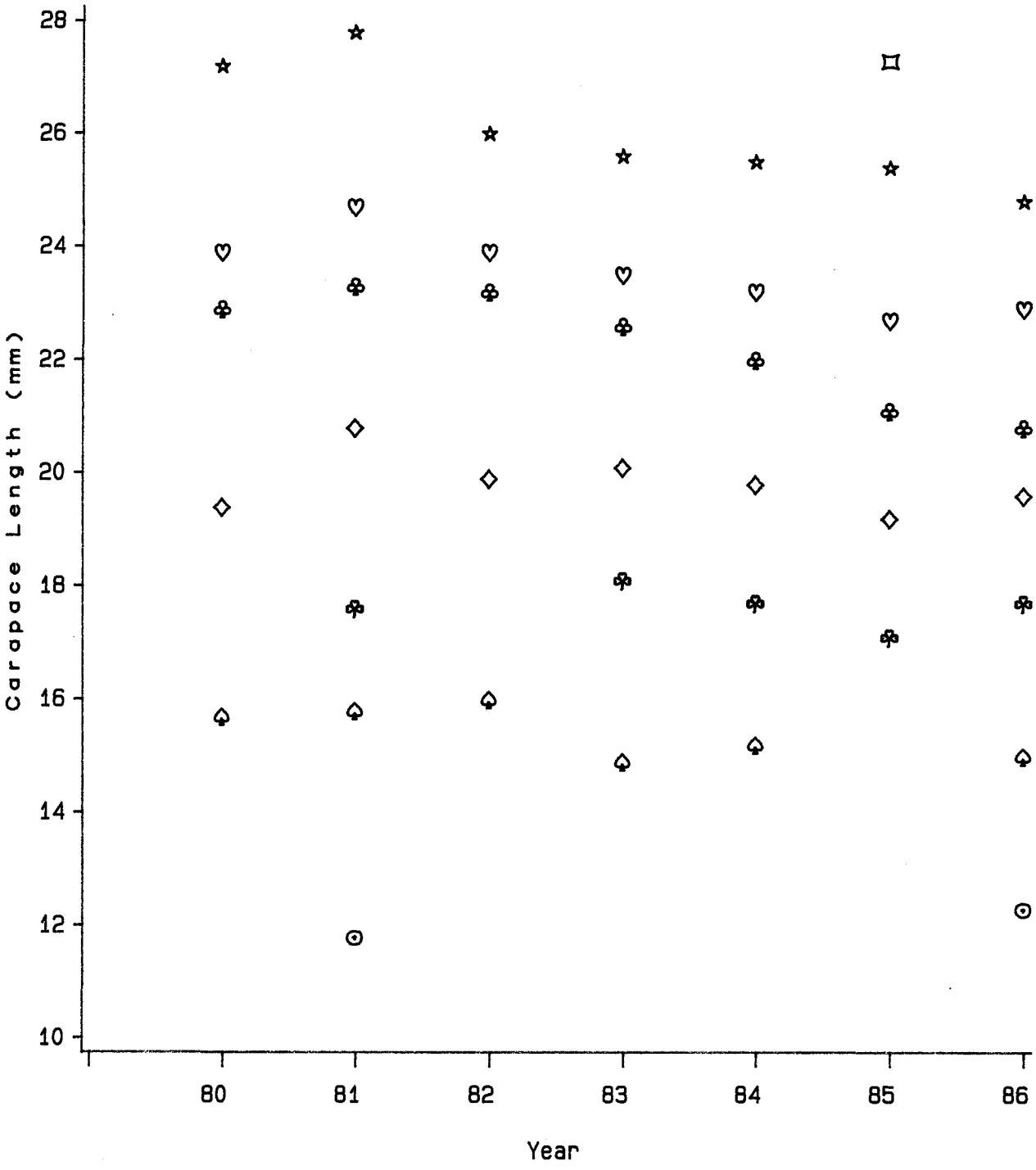

Fig.8 Mean length of sex and maturity stages, Cartwright Channel, 1980-86. (Symbols represent possible age groups).