The Northern Shrimp Fisheries off Newfoundland-Labrador in 1988

by

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Abstract

Fishing effort for northern shrimp increased further in 1988, primarily due to successful exploratory fishing in NAFO Div. 0B, 2G and 3K. TAC's were taken in most of the traditional fishing areas and catch rates, although highly variable over the season and by area, remained high relative to the those prior to 1986. Total catches for the 1988/89 fishing season exceeded 22,000 t, compared to about 19,000 t in 1987/88. Approximately 7000 of the 22,000 t taken in 1988/89 resulted from exploratory fishing.

Two-phased research surveys were conducted in Hopedale, Cartwright and Hawke Channels in 1988. Biomass estimates obtained from the latter two were the highest ever obtained in those areas and the estimate for Hopedale Channel was higher than the level of the previous year and closer to the estimates of 1982 and 1986. Because the increases in the Cartwright Channel over the last two years occurred over all maturity stages, changes in availability seem likely. Bottom temperatures throughout the channels remain relatively warm (>2.5° C).

Research and commercial fishery data are reviewed for each area and advice on catch levels is provided where appropriate.

Résumé

L'effort de pêche de la crevette du nord a augmenté encore en 1988, principalement à cause de la réussite de la pêche exploratoire dans les divisions 0B, 2G et 3K de l'OPANO. Les TPA ont été capturés dans la plupart des zones de pêche traditionnelles et les taux de prise, quoique très variables selon le moment de la saison et la zone de pêche, sont demeurés élevés par rapport à ceux des années antérieures à 1986. Les prises totales de la saison de pêche 1988-1989 ont dépassé les 22 000 tonnes (elles étaient de 19 000 t en 1987-1988). Environ 7 000 tonnes de ces prises resultaient de la pêche exploratoire.

Des campagnes d'évaluation en deux phases ont été réalisées par des navires de recherche dans les chenaux Hopedale, Cartwright et Hawke en 1988. Les estimations de biomasse provenant de ces deux derniers étaient les plus élevées de toutes celles obtenues jusqu'ici à ces endroits, tandis que les estimations pour le chenal Hopedale étaient supérieures à celles de l'année antérieure et proches de celles de 1982 et 1986. Comme les augmentations de la biomasse du chenal Cartwright survenues au cours des deux dernières années touchaient tous les stades de maturité, il est propable que des changements se produiront dans la disponibilité. La température du fond de l'ensemble du chenal demeure relativement chaude (> 2,5 °C).

On examine les données de la recherche et de la pêche commerciale pour chaque zone, en fournissant, s'il y a lieu, des avis sur le niveaux des prises.

Introduction

The fishing plan for northern shrimp in 1988/89 remained essentially the same as in the previous year, as a continuation of the two-year experimental E.A. program. The fishing season opened on May 1 and will close on April 30, so some of the stock areas are still being fished. The number of licences remained at 16. As in 1987, TAC's recommended by CAFSAC were increased in many cases and, when combined with an allocation of 6120 t in Davis Strait, totalled 15,620 t. These increases were as follows: Hopedale Channel - 3700 to 4000 t; Cartwright Channel - 770 to 800 t; Hawke Channel - 1300 to 1500 t; St. Anthony Basin - 1200 to 1500 t; Ungava Bay and Eastern Hudson Strait - experimental fishery (1 or 2 vessels) to 200 and 1000 t, respectively. Also, the exploratory fishery initiated in 1987/88 in areas outside the traditionally fished zones was continued. This was intended to provide industry the opportunity to locate new concentrations for harvesting after the TAC's in other areas were taken or after vessel quotas expired.

The 1987/88 season was the first year of an experimental enterprise allocation system. Under this system, licencees were assigned 1000 t per licence, assuming a global TAC of about 16,000 t over the two-year trial period. As a means to optimize utilization of the resource, stocks were divided into the northern (2G and north) and southern (2HJ3K) grounds and participants were limited to no more than 500 t in each area. To ensure the resource was fully utilized, quota release dates were set at October 1 in the northern grounds and December 1 in the southern grounds. In the 1988/89 fishing plan, there were no quota release dates but specific allocations were applied in certain areas. Vessels were permitted no more than 380 t each in the Davis Strait fishery, leaving 120 t to be taken elsewhere in the northern zone (for a total of 500 t). The vessel quota in Hopedale Channel was limited to 250 t, with the remaining 250 t in the southern zone coming from the other areas within Div. 2J3K.

Most effort in the northern zone was expended in the Davis Strait where about 5900 t were taken by 14 vessels (9 domestic, 5 foreign). The TAC for P. montagui in eastern Hudson Strait (1000 t) was exceeded by 124 t (8 vessels) but no fishing was reported from Ungava Bay. High catch rates were obtained in Division 2G early in the season, the precautionary TAC of 500 t was exceeded by about 190 t and the area was closed on June 18, 1988. Later in the season, exploratory fishing was permitted north of 60° 40′ N and south of 60° N. Catches were reported only from the southern area, amounting to over 950 t by the middle of February. Also, in the late fall of 1988, a fishery developed off Cumberland Sound in Div. 0B. This was an exploratory fishery with no TAC or effort limitations on the shrimp fleet and the catch was estimated at more than 2800 t.

In the southern zone, most effort was expended in the Hopedale Channel where 15 vessels harvested about 4100 t. In addition to this amount, about 2500 t were taken in exploratory fishing east of the traditional fishing grounds but within the Channel. Total removals for the area exceeded 6500 t. The TAC in Cartwright Channel (800 t) was exceeded by 150 t in only one week (10 vessels) and the area was closed on May 7. Prior to May 1, (i.e. the 1987/88 season) about 600 t were taken from the northern end of the Channel in exploratory fishing and after May 7, another 20 t were taken. Therefore, in a period of just a few weeks, the catch totalled almost 1600 t. The 600 t exploratory catch must be considered as an overrun of the 1987/88 TAC. Fishing effort in Hawke Channel continued at a high level in 1988/89 with over 1600 t removed by 11 vessels up to June 18 when the area was closed. Eight vessels fished in Div. 3K (St. Anthony Basin) since May,

1988 with catches totalling 889 t up to March 1. Because this has been primarily a winter fishery and is continuing at this time, much of the data are not available for interpretion.

During the winter of 1988, two new areas were fished in Div. 2J and 3K. One was a small area east of St. Anthony Basin (Div. 2J3K) and the other was in Div. 3K on the east side of Notre Dame Channel. Catches for the 1987/88 season were estimated at roughly 2800 t for the two areas, combined. The data from the 1988/89 fishery are not fully available for consideration at this time, but the catch to February 22 is estimated at 439 t. The information on catch and effort summarized here is taken from Canadian Atlantic quota reports, vessel logs and from G. Brocklehurst (pers. comm.).

Hopedale Channel

1) Catch and CPUE

Catches of northern shrimp in Hopedale Channel increased from over 1200 t in 1977 to 4000 t in 1980 before declining to 700 t in 1984. Catch doubled in 1985 and has increased to over 6500 t in 1988 (Table 1). TAC's have been reached in 1980, 1986, 1987/88 and 1988/89. High proportions of Pandalus montagui, which occurred in the exploratory catches in November, 1987, were not a problem in 1988. The increased catches of the past three years are due primarily to an increase in effort in the area, especially in 1988 with the exploratory fishery.

Monthly CPUE estimates from 1977 to 1988 have shown extreme variation over time, both within and between years. This variation is due to a number of factors including vessel size, gear, effort levels, discarding and market requirements, none of which are quantifiable. Market demand for small shrimp remained strong in 1988 and high catch rates reflect, in part, those conditions in contrast to 1985 when there was much discarding of small shrimp. Gear improvements are continuing and a number of new vessels have entered the fishery.

CPUE in 1988 decreased from about 950 kg/hr in January and May to 343 kg/hr in October, then increased to 578 kg/hr in November (Table 1). Catch rates for the July - September period in 1988 were lower than those of the previous two years but remained much higher than the early 1980 levels. The annual CPUE value is the second highest in the unstandardized time series. The 1988 values are also influenced by the exploratory fishery which took place on the eastern side of the channel (see Introduction). When this effort is filtered out, the monthly CPUE is more comparable to previous years.

kg/hr	Jan	May	Jun	Jul	Aug	Sep	Oct	Nov
Total fishery	974	955	685	604	412	470	343	578
Traditional area	1041	541	632	574	567	477	343	578
New area	117	969	771	632	396	464		

The low value for May in the traditional area is not representative because it only represents six hours of fishing. Recalculated rates for June and July are slightly lower and August is considerably higher, but the initial comparison is not affected. Catch rates in the new area decreased steadily from May to August and compare favourably with those in the traditional grounds.

2) Shrimp Biomass

Results of the two-phase survey conducted in July, 1988 are detailed in Table 2. The survey area was increased in 1988 taking into account the southern part of the channel where some commercial fishing occurred in late 1987 and new bathymetric data for the northernmost parts. The changes have been incorporated into the time series and both old and new estimates are compared from 1979 to 1987. In addition, some nonproductive sets from peripheral areas in previous years were included in the revised calculations. Their inclusion does not alter the biomass estimates but makes the area surveyed more comparable between years.

Highest densities in 1988 were found in the northern zone (Fig. 1) in depths of 250 to 400 m. Densities were lower in the central zone but, because of the larger area, a significant biomass was estimated for the 350 to 400 m stratum. Typically, both low densities and biomass were found in the southern zone. Mean biomass estimates (t) using the old and new stratifications are given below.

	1979	1980	1981	1982	1983	1984	1985	1986	1987
Old	17,800	14,739	4,914	11,563	8,236	8,534	12,756	10,102	6,037
New	18,654	15,386	6,115	12,577	9,178	10,047	13,450	11,138	6,758

The biomass estimate of 9194 t is 36 % higher than the 1987 estimate of 6758 t but only 68 % of the value obtained in 1985 (Table 3). About 2000 t had been removed by the fishery at the time of the survey. The biomass estimate obtained, therefore, is closer to those of 1982 and 1986 (10,000-12,000 t). It is possible that the fishing activity in the area resulted in some dispersal of the concentrations or enhanced the vertical distribution of the shrimp outside the range of the research gear. In past assessments, a decrease in the proportion of biomass in the northern zone had been observed since 1979. This trend did not continue in 1987 with the proportion in zone 1 increasing from 26% in 1986 to 33%. In 1988, 66% of the biomass was estimated from that zone, similar to the levels observed in 1979 - 81. It appears, however, that the survey failed to detect the concentrations that sustained the exploratory fishery in shallow water (<350 m) over the saddle.

A separation of the biomass by maturity stages shows that 45% of the biomass were males, 19% primiparous females and 36% multiparous females. This compares to 41%, 26% and 33%, respectively for 1987 and 47%, 21% and 32% for 1986, if one assumes that most of the ovigerous females at the time belong to the primiparous group.

	Males	Primiparous	Multiparous	Total (t)
1986	5244	2301	3593	11138
1987	2735	1769	2254	6758
1988	4123	1716	3355	9194

Estimates of biomass increased for males and multiparous females between 1987 and 1988 while the estimate for the primiparous group was similar. This differs from the results of the previous year which showed decreases over all maturity stages. Mortality rates calculated for females from these data produce estimates of about 1.0 between 1986 and 1987 (catch 3500 t) and 0.2 between 1987 and 1988 (catch 4600 t). Such a wide discrepancy strongly suggests that the surveys are monitoring changes in availability but not necessarily changes in abundance.

3) Biomass of Predators

Estimates of biomass for Greenland halibut increased from about 10,000 t in 1981 to over 25,000 t in 1983, then decreased steadily to about 3000 t in 1987 (Table 4). The estimate of about 8500 t in 1988 ends the trend of declining biomass but is still well below the levels observed in the early 1980's. The highest estimate for cod was observed in 1982 (3149 t) but, in subsequent years, abundance apparently declined to the extremely low level of 20 t observed in 1987. The 1988 estimate of 116 t remains at a very low level compared to years prior to 1987. What little cod was available in the two most recent surveys was found at the same depths where shrimp were most abundant while most of the Greenland halibut biomass was found in deeper water.

4) Size Composition - Research

Length frequencies from the research survey in July, 1988 (Fig. 2) show the characteristic increase in mean size with depth in the northern zone. This is not apparent, however, in the central and southern zones where there is no trend in size with depth. The lack of trend has been apparent for the last several years in the central zone.

In depths where most biomass was found in the northern zone (250-400 m), there was a broad size range, similar to that observed in 1986 and 1987. The male modes were severely overlapped, although there were indications of modal groups at roughly 18, 20 and 22 mm CL, similar to the sizes observed previously. Large female shrimp were more prevalent in deeper water, except in the deepest stratum where males again dominated. Over the saddle where most biomass was found (350-400 m), the largest male size/age group and female shrimp were dominant in the samples, similar to the observations of 1987. In strata of lesser densities, either male or female groups tended to dominate, with no apparent relationship with depth. Although biomass was low in the southern zone, depths of highest densities showed dominance of males from 15-22 mm, similar to the previous year.

5) Size Composition - Commercial

Length frequencies from May to September (Fig. 3) from depths where most of the fishing activity occurred (generally from 200 m to 400 m) showed a broad range of sizes between about 18 and 26 mm CL. Large males around 22 mm dominated in May but the relative importance of females increased in later months. There appears to be at least three age groups of males occurring in the catches, although modes are severely overlapped, and a composite group of females. None of the modes are outstanding (except for the largest males in May), indicating no particularly strong year classes. This contrasts the findings of the previous two years which showed a predominance of large males and females in all depths fished in 1987 and high proportions of smaller males (18-19 mm) in the catches of 1986 (Parsons et al. 1988). The presence of a broad size range in 1988 shows that the concern for reduced recruitment based on the previous year's data was unfounded. Therefore, it appears that length frequency data has no value in making even qualitative predictions of recruitment. Nevertheless, such data must be examined each year in case of catastrophic events or the occurrence of unusually strong year classes.

6) By Catch and Shrimp Discards

Observer data for 1988 show that redfish was the main by-catch species from May to September, but comprised only 1.5 to 5.9% of the total observed catch (weight). Catch rates ranged from 9 to 19 kg/hr from May to July but increased to almost 30 kg/hr in August and September. Greenland halibut comprised less than 2% of the observed catch in each month and catch rates ranged from 5.5 to 12.6 kg/hr.

As usual, virtually no discards were reported from the vessel logs available for 1988 (<2 % in each month). These reports are corroborated by the observers (1-2%), reflecting the continuation of strong markets for shrimp of all sizes in 1988.

7) Temperature

After an anomalously cold year in 1985, temperatures increased throughout the channel in 1986 to values observed in 1979 and 1980. Temperatures in 1987 were slightly colder than in the previous year in the shallower strata (<300 m) but were comparable in the deeper depths (2-4°C) (Parsons et al. 1988). In 1988, temperatures in depths greater than 300 m also ranged from 2 to 4°C, even in the southern zone which has been, traditionally, a colder area.

The proportion of non-spawners appears to be related to temperature. In 1985, over 20 % of all females were not expected to spawn, based on maturity observations. The proportion of non-spawners in the sampling data decreased to 1.1% in 1986, 2.7% in 1987 and remained low in 1988 at 2.9%.

8) Discussion

Although the catch rate series for shrimp in Hopedale Channel is difficult to interpret in terms of stock abundance, the relatively high level of the July-September catch rates from 1986 to 1988 compared to those of the early 1980's might suggest a healthy stock. On the other hand, it might be more a reflection of the improved demand for small shrimp since 1986 and their acceptance in the catches. The biomass index, again, does not agree with the CPUE data. Although catch rates appeared to be lower in 1988 than in the previous two years, the biomass estimate in 1988 was higher than the 1987 value and similar to that of 1986. As none of the data sources appear to be predictive, either qualitatively or quantitatively, it is difficult to forecast what catch rates or biomass might be in 1989. The continuation of a broad range of sizes (ages) occurring in both the research and commercial catch data in 1988 and the apparent maintenance of the spawning stock support an optimistic view.

Environmental concerns are minimal. Both Greenland halibut and cod remain near the lowest levels observed in this area and temperatures are favourable as reflected in spawning success. Markets for small shrimp remain strong, resulting in reduced discards and, at the same time, posing no apparent problems in terms of yield per recruit (Parsons et al. 1988).

In 1987, CAFSAC suggested that TAC's for some shrimp stocks should be fixed for two to three years, rather than changed annually by including the most recent estimate of biomass. That approach seems reasonable in this case, given the difficulty in interpreting biomass estimates as they relate to changes in abundance, distribution and availability. There are no relationships between

factors such as CPUE versus effort and catch in one year versus biomass in the next. Also, catch increases in a linear fashion with effort. Although the lack of a standard for effort might affect the shape of these relationships, there is little to suggest that past fishing practice has adversely affected the stock. Catch levels in the past two years, however, have exceeded the 4000 t TAC's as a result of exploratory fishing. No real exploratory fishing has ever taken place near the Hopedale Channel and the catch represents additional pressure on the stock. It is too early to tell whether or not the 6500 t taken in 1988 will adversely affect the resource but measures should be taken to ensure that the exploratory fishery in this area is discontinued.

The 1988 TAC of 4000 t was 300 t greater than advised by CAFSAC. The former, however, represents the highest annual catches taken in this channel over the years, excluding 1988. The northern shrimp fishery is, essentially, beginning again after experiencing hard economic times in the early 1980's. It might be appropriate to continue the catch level of 4000 t for a number of years to see how and if the stock reacts to sustained exploitation at this level. Any detrimental effects of the 6500 t catch in 1988 may not become obvious for a number of years.

Cartwright Channel

1) Catch and CPUE

Catches of shrimp in Cartwright Channel decreased from about 1500 t in 1978 to 1000 t in 1979. This was followed by a period of low and sporadic effort from 1980 to 1985 when catches ranged between 2 and 300 t (Table 5). Effort in 1986 increased substantially after the closure of the Hopedale Channel with removals in the order of 1400 t. Fishing continued into January of 1987 with catches of approximately 160 t in that month. The 1987/88 fishing season produced catches approaching 1500 t which includes almost 600 t caught in the exploratory fishery in the spring of 1988. About 970 t were taken during the 1988/89 season.

Catch rates decreased from 1977 to 1979 but the effort levels from 1980 to 1985 were so low that no comparisons can be made. Effort increased substantially late in 1986 when catch rates were among the highest ever recorded in this area. The very high 1988 catch rates in April and May (1.8 and 1.1 t/hr, respectively) cannot be compared to previous years because fishing never before occurred in those months. Most of the fishing activity was located on the norteastern part of the saddle.

The same problems that affect the interpretation of catch rates in Hopedale Channel apply to Cartwright, as well. Therefore, little can be said about levels of abundance. However, because the TAC in 1988/89 was taken in so little time at extremely high catch rates suggests that the stock in this area remains healthy.

2) Shrimp Biomass

The results of the two-phase survey conducted in this area are given in Table 6. As for the Hopedale Channel, some nonproductive sets from peripheral areas were included which did not affect the biomass estimates for shrimp but made the area surveyed more comparable between years. Their inclusion, however, did change slightly the estimates for cod but not to the extent to affect any observations made previously. It is noted that new charts are now available for

this area, requiring a restratification, particularly in the northernmost parts where much of the fishery and biomass has been located in the past year. A lack of information on these areas in the past has resulted in an underestimation of biomass since the stratified area was first expanded in 1983 but is particularly important in 1984 and 1988 when densities in the shallow water were high relative to other years.

Highest densities in 1988 were found in the northern part of the channel in depths of 300 - 400 m (Fig. 4, Table 6). This is somewhat similar to the pattern of the previous year except that high densities extended into the 250 - 300 m stratum where, in 1987, shrimp were scarce. The 1988 results are very different from 1986 when most shrimp were found well inside the channel in 450 - 550 m (Parsons et al. 1988). The 1988 biomass is 1.6 times the 1987 estimate, 4 times that of 1986 and is, by far, the highest estimated for the area (Table 7). Given that the bathymetric data for the shallow, northern areas are incomplete and that the commercial catch in April and May totalled almost 1600 t, the biomass estimate for 1988 likely exceeds 10,000 t! In the summer of 1986, biomass before the fishery took place was estimated at 1800 t. About 1400 t were removed in November and December and an additional 160 t in January, 1987. Then after another 900 t were removed from May to July, there remained a biomass of over 4500 t. Similarly, following the spring of 1988 when 1600 were removed, the biomass estimated was the highest ever recorded in the area. This cannot be explained entirely by increased recruitment as the following analysis indicates.

A breakdown of the biomass by maturity stages shows that 42% were males, 25% primiparous females and 33% multiparous females. This compares to 37%, 44% and 19%, respectively for 1986 and 41%, 31% and 28% for 1987.

	Males	Primiparous	Multiparous	Total (t)
1986	670	789	343	1802
1987	1880	1433	1263	4576
1988	3059	1827	2373	7258

Biomass increased substantially over all maturity stages which suggests changes in availability. As negative mortality rates are impossible (1986-87) and the value between 1987 and 1988 is very low (about 0.1), this situation can only be explained by a dramatic change in the availability of shrimp to the research gear and/or immigration from areas outside the channel. Given the high abundance over the saddle in 1987 and especially 1988, the latter seems likely.

3) Biomass of Predators

Biomass estimates for Greenland halibut have varied considerably over the period 1979 to 1988 (Table 8). The estimate of 3900 t in 1988 represents an increase of almost 25% over the 1987 value and suggests a gradual increase from 1986. Cod biomass was estimated at 356 t which is one of the lowest estimates of abundance observed since 1979. As in the Hopedale Channel, the distribution of Greenland halibut in 1988 was not closely related to the distribution of shrimp.

4) Size Composition - Research

Length frequencies from the research survey in July, 1988 again show a strong representation of male groups throughout the channel (Fig. 5). There appears to be some increase in size with depth but females are also abundant in some of the

shallower strata. In the deeper water, about 50% of the females were ovigerous, whereas the percentage was much lower in depths less than 450 m. In the northern part of the channel, where highest concentrations were found in 250-450 m, three or four size/age groups of males were abundant, ranging in length from about 15 to 21 mm. Modes were evident at roughly 16, 17.5, 19 and 20 mm CL, which corresponds to observations made in previous years. In shallower water (<350 m) in the southern part of the channel, three size groups of males were present; a smaller group at 13 mm, and the modes at 16 and 18 mm.

The length distributions for both 1987 and 1988 were similar to those of 1984 in that the male size/age groups were dominant in the depths where most biomass was found. It was in 1984 when a high biomass estimate was obtained in the northern part of the channel, as well. In 1985 and 1986, when biomass appeared to be lower, the proportions of larger males and females were greater in the depths where the highest concentrations were located.

5) Size Composition - Commercial

Length frequencies from the exploratory fishery in April, 1988 showed a predominance of large ovigerous females occurring in the catches (Fig. 6). Highest catch rates occurred in shallower water (200-300 m), suggesting a preference for the shallower water by ovigerous females at this time of year. The brief fishery in May occurred in deeper water with lower catch rates and proportionately more smaller males. Compared to the previous year, there appears to have been lower proportions of small shrimp occurring in the catches, but this probably relates more to the timing and location of the fishery rather than reflecting changes in abundance.

6) By Catch and Shrimp Discards

Observer data for the Cartwright Channel were only available for the month of May, 1988. By catches of finfish were low, comprising less than 1% of the total catch of all species, and consisted mainly of Greenland halibut, plaice, skate species and cod. Pandalus montagui comprised 5% of the total observed catch weight in May at a catch rate of 55 kg/hr. The occurrence of the latter likely reflects the relatively shallow areas where the fishery was concentrated.

Shrimp discards in Cartwright Channel reported in vessel logs were 2.7% of the total shrimp catch in April and 1.8% in May. The observer estimate for May was 3.9% but only covered 14 hours of fishing. These rates are, however, higher than the less than 1% rates reported in 1987.

7) Temperature

Bottom temperatures in the Cartwright Channel in 1986 were much warmer than those of the previous four years, returning to the levels observed in 1979 and 1981. In 1987, temperatures in depths greater than 400 m were as warm as or slightly warmer than in 1986 (2.8-3.0°C) while in shallower water it was slightly colder (1.1-2.3°C) (Parsons et al. 1988). Data from the 1988 survey suggest that relatively warm water (> 2.5°C) was present throughout the Channel, even in depths less than 300 m, and that in some of the deeper parts of the Channel, temperatures exceeded 3.0°C.

The proportion of non-spawning females has reflected the changes in temperature observed in recent years. In 1981, one of the warmest years, only 5% of females were unlikely to spawn. Adjacent cold years of 1980 and 1982 resulted in increased proportions of non-spawners at 16% and 20%, respectively. The coldest year in the series, 1985, showed a further increase to 33%, followed by major decreases to 19% and 5% and in the much warmer years of 1986 and 1987, respectively. Although 1988 appeared to be a relatively warm year, the proportion of nonspawners was high, about 22%. The reasons for this are unclear but might be related to the occurrence of female shrimp in the shallower, colder water. A breakdown of the females into multiparous and primiparous groups shows that the apparent spawning failure was associated with the former. Only 0.1% of primiparous females were not expected to spawn, whereas 41% of multiparous females showed no developing head roe. These observations are not without precedent as in 1984 it was noted that about 70% of older females were not expected to spawn. At that time, however, the phenomenon was associated with a switch to biennial spawning under cold conditions (Parsons and Veitch 1985).

8) Discussion

Both the commercial fishery and research survey data show that in 1988 the shrimp stock in this channel was at the highest level ever observed. Prior to this, surveys had shown a decrease in biomass from 1984 to 1986 in the virtual absence of a fishery. Yet, after heavy fishing late in 1986, in the summer of 1987 and the spring of 1988, the stock still appears to be increasing. The data suggest that such changes might be more related to availability than abundance and that immigration from areas outside the channel might be a factor, as well. Under such conditions, it is impossible at this time to forecast what the stock size will be in 1989. Predator abundance does not appear to be a problem and temperatures within the channel remain favourable. The implications of the apparent spawning failure for a large proportion of older females are uncertain but no adverse effects from the 1984 situation have been observed since then.

In past assessments, it has been suggested that TAC's under such variable conditions are inappropriate but, despite this, they have been maintained. Several years ago, CAFSAC agreed to provide for midseason updates of the TAC based on the biomass estimate for the current year. This stategy allowed for increases in the catch levels if the current biomass were greater than the average to which the 35% exploitation was previously applied. If it were lower, no changes would be made. In 1987, however, this system was considered unworkable and was essentially discontinued. The TAC's advised for 1987 and 1988 (770 t) were based on 35% of the average of all available biomass estimates. It was also suggested that this catch level be continued for two to three years.

The relationship between the fishing effort and stock size for this channel is even more uncertain than that for Hopedale. The fishery was virtually non-existant in the mid 1980's, yet biomass estimates were highly variable. The stock appeared to be in decline with declining bottom temperatures, then increased threefold during the coldest year on record. There was another apparent decrease from 1984 to 1986, followed by a substantial increase from 1986 to 1988. Obviously, removals of 1400 t in 1986, over 1000 t in 1987 and 1600 t in the spring of 1988 have had very little impact on the stock in this area. Catches of about 1500 t have been taken in early years of the fishery and represent the highest catch levels achieved over the time series. Although TAC's might still be inappropriate, it is possible that 16 vessels could severely damage the stock if no upper level of

catch were provided. Therefore, a catch limit of about 1500 t might be considered for a few years to see how the stock responds to that level of exploitation, after which further increases might be warranted.

Hawke Channel

1) Catch and CPUE

Fishing effort in Hawke Channel had been very low since the beginning of the northern shrimp fishery in the late 1970's to 1986, with negligible catches over that period. In January, 1987, a winter fishery was carried out with catches of about 800 t. The TAC of 1500 t was exceeded by about 250 t in 1987/88 and 130 t in 1988/89.

Previous CPUE data indicated that there was a seasonal concentration of shrimp in this area in winter. The catch rate for January, 1987 exceeded 1000 kg/hr compared to rates of about 200 to 300 kg/hr in other months of the year. In January, 1988, however, catch rates improved markedly to 612 kg/hr. Because the fishery was closed in late January of both years, it was uncertain whether or not these concentrations existed during the February-April period. The results of the 1988/89 fishery show that shrimp were still highly concentrated in May and June when the fishery took place. Although seasonality might still be a factor, it appears that abundance in the channel has also increased over the previous year, as evidenced in the catch rates.

kg/hr	Jan	May	Jun	Oct	Nov	Dec	Jan
1987/88	1049		268	306	242	165	612
1988/89		1052	857				

2) Biomass

An estimate of available biomass was obtained for the Hawke Channel for the first time since 1979. Research fishing in intervening years produced catches that were so low that a calculation was not necessary. After the success of the fishery in winter - spring of 1987 and 1988, a complete survey was scheduled for 1988 to establish whether or not there was a seasonal concentration or if the biomass level had changed. Since the late 1970's, new information on bathymetry has become available, facilitating a new stratification of the area (Fig. 7). Results of previous surveys have not been recalculated according to the new scheme. Results of the two-phase survey carried out in July, 1988 are given in Table 9. Highest densities were found in depths of 400-500 m but substantial catches were taken throughout the 350-550 m range. The biomass estimate of 11,497 t was the highest of the three areas surveyed in 1988. Although not directly comparable with the estimates of the mid to late 1970's, it is more than twice the 1975 estimate (5000 t) and 4.6 times the 1979 value (2500 t). Also, the fishery, which closed on June 18, removed an additional 1600 t for a total of about 13,000 t.

A separation of biomass by maturity stage, shows that 41% of the estimated biomass consisted of males, 23% primiparous females and 36% multiparous females. These per centages are similar to the breakdowns for other areas.

The biomass estimate for Greenland halibut in the Channel was slightly higher than shrimp at 13,379 t (95% C.I. 11,595-15,163 t) and the depths of highest concentration were greater than 500 m, somewhat deeper than optimal depths for shrimp. Cod catches were highly variable and the biomass estimate of 4621 t has a negative lower confidence interval. Best catches tended to occur in the shallower water.

3) Size Composition - Research

The increase in size of shrimp with increasing depth is clearly seen in the length frequency data from the 1988 survey. Modes around 12 and 16 mm CL are evident in the shallow strata (Fig. 8) and are gradually replaced by larger males and females in the deeper water. There appears to be additional modes of males at 18, 20 and possibly 22 mm, but the overlap is extreme in many cases. The female mode occurs around 24 mm, consistently over all depths.

In depths where most biomass was found (350-550 m), there was a broad range of sizes (13-26 mm). Males dominated in the 300-400 m range but, between 400 and 500 m, females were most prominent. Given the size range found during the survey, it appears that six or seven year classes are abundant in the area which only three years earlier produced very low catches of shrimp.

4) Size Composition - Commercial

Length frequency data from May, 1988, when most of the fishing took place, showed a high proportion of female shrimp, particularly in the shallower depths (Fig. 9). At least two, possibly three, age groups of males are present but modes are severely overlapped. In 1987, it was noted that sex ratios changed between depth and months but the size range and modes within that range were similar (Parsons et al. 1988). Similar modes and size range are present in the 1988 data.

5) By Catch and Shrimp Discards

The catches of other species in the shrimp fishery in Hawke Channel varied from month to month. In March, American plaice comprised over 8% of the total observed catch weight followed by skates at 3% and redfish and Greenland halibut at 2%. Caplin was the major species in April but only accounted for 1.4% of the observed catch. By catches of cod were particularly high in May at a rate of 121 kg/hr and the incidence of plaice and Greenland halibut also was relatively high. All observed by catch was discarded.

Estimates of shrimp discards from vessel logs were virtually zero in each month for which there were data. Observers reported discards of about 0.5% in March and April, increasing to 2.8% in May.

6) Discussion

In 1982, it was felt that a TAC for this area was unnecessary given the low biomass as determined from research surveys and lack of success by the fleet in finding suitable concentrations. The Subcommittee agreed that the area should be left open to take advantage of any seasonal concentrations. CAFSAC generally agreed with this assessment but indicated that managers might wish to retain a TAC for other reasons. A TAC of 850 t, based on the 1979 estimate of biomass, was

retained until 1987 when CAFSAC advised an increase to 1300 t based on the average of the 1975 and 1979 biomass estimates. This was increased to 1500 t and the catch was about 1700 t, most of which was taken in January, 1988. CAFSAC advice for the 1988/89 season was again 1300 t and the effective TAC of 1500 t was taken by mid June.

Basing current TAC's on biomass estimates that are 10 and 14 years old is not more than setting an arbitrary catch level. However, because the potential to damage the stock with 16 active and efficient vessels exists, some upper level of removals would seem appropriate. The Hawke Channel covers a large area, and even at low densities could support a large biomass. Setting a TAC on the 1988 biomass alone might not be appropriate because it is uncertain at this point if and how these stocks in the southern area (2J+3K) interact. There is, for example, a physical connection between Hawke Channel and the St. Anthony Basin but it is not known what interchange between the two areas occurs. If all biomass estimates since 1975 are included in an average, a TAC of 2400 t is implied using the 35% rule. This approach is in line with the position taken by the Subcommittee in 1988. The catch level could remain in effect for a number of years to see if and how the stock reacts to this level of removal.

St. Anthony Basin

1) Catch and CPUE

The shrimp fishery in St. Anthony Basin began in January, 1987 with a catch of about 50 t up to February 5 when the area was closed. The 1987/88 season began in May and catches exceeded 900 t. The 1988/89 season is ongoing and the catches to date total 889 t. Catch rate data suggest that this area, as well, might be characterized by seasonal concentrations, although there appears to be no consistency in the seasonality.

kg/hr	Jan	May	Jun	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1987/88	627	165		119		175	184	165	267	135	608
1988/89		321	954		58	634					

2) Size Composition - Commercial

Length composition data are available from March, April, October and December, 1988 (Fig. 10) and show a broad range of sizes occurring in most months. Ovigerous female shrimp were dominant in April when the catch rates were highest. The high catches of January, 1987 consisted primarily of male shrimp in the range of 15-21 mm (Parsons et al. 1988). Effort and catch rates in the remaining months of 1987 were very low and composition of the catches varied considerably over that period. The 1989 data have not yet been processed.

3) By Catch and Shrimp Discards

By-catch data from the St. Anthony Basin were only available for April and October. In the former, caplin, Greenland halibut, plaice and cod were the main fish species occurring in the catches but comprised less than 8% of the total observed weight. It was also reported that over 100 kg of Pasiphaea spp. were caught and kept. Less than 30 hours were observed in October and shrimp comprised

less than 50% of the total catch whereas Greenland halibut and cod accounted for over 30%.

Discards of shrimp reported from vessel logs were less than 2% in all months except October when 12% was reported. The low effort levels expended in this month do not reflect typical discarding practices in the area, however. The observer estimate for April corroborates the estimate given in the vessel logs for the same month (0.6%)

4) Discussion

CAFSAC advice for this area was based on the average of biomass estimates from 1984 and 1985 surveys resulting in an advised TAC of 1200 t for 1986, 1987 and 1988. This was increased to an effective TAC of 1500 t in 1987 and 1988. Catches were about 900 t in 1987/88 and are approaching that level this season. Fishery data suggest that this area experiences seasonal concentrations of shrimp with inconsistency in the seasonality. Problems with by-catch species also occur and high proportions of small shrimp pose a potential problem.

Given the increasing interest for shrimp fishing in the St. Anthony Basin, there remains room for increased catches at either the 1200 or 1500 t level. As in the Hawke Channel, fishing activity should be monitored closely to ensure that by catches are not excessive.

Div. 3K (new areas)

1) Catch and CPUE

A fishery for northern shrimp began in the Notre Dame Channel (Fig. 11) in January, 1988 as part of the exploratory fishing program. A small area east of the St. Anthony Basin was also fished, beginning in February, and catches from both areas during the 1987/88 season totalled 2858 t. No breakdown of the total catch by area is currently available. Data for the 1988/89 season are incomplete but the catch as of February 22 for both areas is estimated at 439 t.

CPUE data for both areas spanning two fishing seasons (1988 calendar year) are given below.

	1987/88				1988/89		
kg/hr	Jan	Feb	Mar	Apr	May	Jul	Oct
Notre Dame Channel	241	362	555	396		66	137
N.E. St. Anthony		1484	520	350	1010	282	7

Catch rates from the larger channel increased from January to March, declined to about the February level in April and were lower in July and October. Data from observers in December suggest some increase in CPUE in that month, but no vessel logs are available for direct comparison. In the smaller area east of the St. Anthony Basin, catch rates were very high in February, declined in March and April and increased again in May. The small amount of effort expended in later months produced much lower catch rates.

2) Size Composition - Research

During the 1988 research survey, two sets were made in each of the above areas to obtain samples for comparison with adjacent channels. Although the combined length frequencies might not be representative of the resource in each area, they are presented for comparison (Fig. 12). Samples from the Notre Dame Channel show a broad range of sizes with modes at 14, 18, 20, 22 and 25 mm. It is uncertain whether or not these modes represent age groups because of a high degree of overlap. In the area northeast of St. Anthony Basin, only the mode at 14 mm was evident. Other size/age groups were virtually absent. One station sampled in St. Anthony Basin produced a length distribution which was very similar.

3) Size Composition - Commercial

Length frequencies from commercial vessels are available from the Notre Dame Channel for the months of February to April, October and December (Fig. 13). The higher catches obtained in the early months consisted of a broad size range of male and female shrimp, except in the shallower depths in February which were dominated by ovigerous females. Three or four modal groups of males are present in most of the samples which occur in the range of 16 to 22 mm. Three modes of males were typically present later in the year when catch rates were much lower.

By contrast, catches in the small depression east of the St. Anthony Basin consisted primarily of large ovigerous shrimp, especially in February (Fig. 14). The subsequent decrease in CPUE appears to be associated with a decrease in the availability or abundance of this group. The number of modal groups of males is not clear from the available samples.

4) By Catch and Shrimp Discards

Cod by catch was high in the Notre Dame Channel in March with catch rates approaching 100 kg/hr. Catches of plaice were also significant. In October, with catch rates of shrimp very low, lanternfish, redfish, cod and Greenland halibut accounted for almost 40% of the observed catch. East of St. Anthony Basin in March, American plaice, Greenland sharks, skates, redfish and turbot were the major by-catch species reported.

Shrimp discards from the channel reported in vessel logs were less than 0.5% from January to April, rising only to 1.1% in October. Observer data for the latter show discards of 7.7% but from only 70 hours fished compared to 242 from logs. In the small area east of the Basin, shrimp discards from logs ranged from 1.5 to 5.4% from February to May. Observer data from March show a discard rate of only 0.5% compared to 1.5% from logs.

5) Discussion

The provision of advice on catch levels in these new areas is uncertain, given that they are very close to the traditional grounds in the Hawke Channel and St. Anthony Basin and the possible relationships between the concentrations are unknown. For the small area east of the Basin which overlaps Div.s 2J and 3K, a precautionary TAC of 500 t might be appropriate. This would encourage some fishing each year to determine whether or not the concentrations recur and, at the same time, recognize the possible linkage with the St. Anthony Basin as might be inferred from the length frequency data (see above). The potential shrimp grounds

within the Notre Dame Channel are extensive but the resource only may be sufficiently concentrated in spring to warrant a fishery. A TAC of 1000 t would, on the one hand, recognize the large geographic area while, on the other, take into account the uncertainty about the resource.

Div. 2G

1) Catch and CPUE

Fishing for shrimp in the northern 2G area (Fig. 15) began in June, 1988 and the 500 t precautionary TAC was exceeded by almost 200 t in just a few weeks, resulting in closure of the area on June 18. Later in the year, fishing occurred south of 60° N as part of the exploratory fishery (see Introduction) resulting in an additional catch of just over 950 t. Catch rates in both areas were high - 1853 kg/hr in the northern area in June and 2037 kg/hr in the southern area in December.

2) Size Composition - Commercial

Catches in June consisted primarily of large female shrimp forming an obvious mode at 26 mm (Fig. 16). The proportion of males was reduced in deeper water and modes were not distinct. Fishing resumed farther south in December and although catch rates were high, catches were dominated by male shrimp ranging in size from about 18-24 mm. The proportion of ovigerous females was higher in the deeper water.

3) By Catches and Shrimp Discards

The major by catch species in June was redfish accounting for 5.7% of the observed catch and a rate of 157 kg/hr. Other species of lesser importance included Greenland sharks, turbot and skates. In December, incidence of sharks was higher but catch rates of redfish were reduced. Similar species mix was obtained in both months.

Vessel logs showed shrimp discards in both June and December at less than 1%. Observer reports confirm the low levels in December (1.6%) but estimate the discards in June at 15.2%. The high rate is unusual, given the dominance of larger animals in the catch at that time.

4) Discussion

There are very little data, from both research and commercial sources, to provide advice on TAC in this area but it is clear that some controls on catch/effort are advisable to guard against overexploitation, given the capacity of the northern shrimp fleet. If it is wished to maintain an exploratory fishery in this Division, then an upper limit of catch for the area north of 60° N which would not be overly restrictive to the fleet could be set at 1000 t. An additional 1000 t could also be permitted within the Div. south of 60° N. Proposals for further exploratory fishing can be evaluated on an ad hoc basis, if the proposed areas are remote from those already exploited.

Div. 0B

1) Catch and CPUE

Although the occurrence of shrimp off Cumberland sound in the Davis Strait has been known for some time, the resource was never fished with any intensity until late 1988. Vessels began fishing in the area in October and continued through to late December (Fig. 17), resulting in a total catch of just over 2800 t. Catch rates were low during October and November (288 and 180 kg/hr, respectively) and vessels likely remained in the area because of the very large sizes of shrimp occurring in the catches. Early in December, catches increased substantially and the catch rate for the month increased to 1003 kg/hr. Ice moving into the area apparently forced the vessels out late in December.

2) Size Composition - Commercial

The low catches of October and November consisted of male and female shrimp ranging in size from about 20 to 30 mm (Fig. 18). The substantial increase in catch rates in December is associated with an apparently sudden increase in the availability of large ovigerous females, forming the dominant mode at roughly 27 mm. These large sizes are similar to those encountered off east Greenland in the Denmark Strait. It is worth noting that these catches resulted in a new size category for processing, 50 to 70 per kilogram.

3) By Catch and Shrimp Discards

The most important by-catch species occurring in the catches in this area were Greenland shark, redfish, plaice and turbot. Catch rates of sharks increased from October to December while those of plaice decreased. The occurrence of redfish and turbot remained relatively stable over the period. Catches of shark are the only concern from a fisheries perspective as their presence generally causes damage to the catch, often resulting in higher shrimp discards.

Discards of shrimp as estimated from logs were 0.6%, 0.5% and 1.2% of the total shrimp catch from October through December, respectively. The data from observers corresponding to the same months were 1.7%, 1.5% and 2.1%. It is assumed that these low figures are representative because of the large sizes of shrimp found in the area.

4) Discussion

The sudden change in catch rates experienced in this area in December of 1988 is difficult to interpret without an indepth analysis of the catch and effort data. It is certain that most of the catch taken during the period of high catch rates comprised ovigerous females and that heavy fishing on this component might cause some concerns for recruitment overfishing. It is also known that water temperatures in this area are cold (<2°C) compared to the more southern zones (Parsons and Tucker 1986) and that under such conditions, overall productivity is likely reduced while longevity increases. Therefore, recovery of catch rates after an initial decline from virgin levels might be a lengthy process. It might be advisable, under these conditions, to limit the catch in Div. 0B to 2800 t, the catch obtained during the 1988/89 fishery.

Eastern Hudson Strait and Ungava Bay (Pandalus montagui)

1) Catch and CPUE

Vessel logs for 1986 showed total catches of 373 t and 109 t and catch rates of 8.3 and 5.4 t/hr for eastern Hudson Strait and Ungava Bay, respectively. All catches were taken in October. In 1987, the 1057 t caught in the former area were taken in late August and early September at catch rates of 1.8 and 1.7 t/hr. By contrast, only 12 t were taken in Ungava Bay in November, 1987 and catch rates were extremely low (<50 kg/hr). The 1988 fishery occurred in the Eastern Hudson Strait only, resulting in a total catch of 1124 t from August to October. Catch rates in these three months were 1.8, 1.2 and 1.9 t/hr, respectively.

2) Size Composition - Commercial

The size composition of the catches in the 1988 fishery varied according to depth and month (Fig. 19). In August, ovigerous females dominated in depths between 200 and 300 m while large males were more prevalent in the deeper water. Ovigerous females comprised about 50% of the sampled catches in shallow water in September but increased to over 60% in depths between 300 and 400 m.

3) By Catches and Shrimp Discards

By catches do not appear to present a problem in this area because of the low abundances, aside from the main species sought. In August and September, observers estimated that about 96 to 98% of the catches were shrimp and that no by-catch species exceeded 1% of the total observed catch. The only species which occurred in any amount were Arctic cod, redfish, turbot and skates.

Shrimp discards from vessel logs were highest in September at 3.4% of the total shrimp catch. This compares to 7.6% for the same month from observer reports. This indicates that the 7.4% reported from logs in August, 1987 might have been substantially higher and suggests that the situation should be monitored closely.

3) Discussion

In 1987, CAFSAC recognized that the characteristics of the shrimp concentrations in these areas suggest "a highly variable resource for which the concept of sustainable yield may not be appropriate". It was agreed that more information was needed in order to predict the response of the population to fishing pressure and that an appropriate means of collecting the information would be to allow an experimental fishery by one or two vessels, subjected to detailed monitoring. The brief fishery in eastern Hudson Strait in the summer and fall of 1988 provides very little information regarding the seasonality of the concentrations in that area. The difference in catch rates between 1986 and those obtained in 1987 and 1988 might only reflect seasonal differences in shrimp concentrations rather than a decrease in abundance. Therefore, there is no basis to change the advice given in 1988 and, even if that advice were accepted, such an experimental fishery would have to be continued and monitored for a number of years.

References

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Table 1. Catch (t) and catch per hour fished, 1979 - 1988, Hopedale Channel.

	1979		1980		1981		1982		1983		1984		1985		1986		1987		1988	
	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE
Jan																			189	.974
May					5	.201													182	.955
Jun	197	.902	29	.812	408	.454	171	.396	167	.366					10	.298			1008	.685
Jul	965	.594	737	.596	361	.300	303	.351	253	.297	40	.453	80	.245	173	.563	1948	.656	1487	.604
Aug	887	.314	589	.397	474	.329	219	.348	2	.191	35	.238	453	.310	417	.731	1008	.657	669	.412
Sep	111	.263	606	.292	555	.360	68	.192	2	.123	50	.201	182	.148	823	.506	918	.564	722	.470
Oct			390	.334	406	.380	246	.367			335	.309	404	.202	736	.494			228	.343
Nov			163	.536	469	.363	471	.491	370	.311	100	.350	370	.252	309	.458	14	.220	70	.578
Dec					168	.524	113	.336	71	.198	56	.261	30	.330			310	.494		
Tot[1]	2160	.424	2514	.399	2848	.365	1591	.375	865	.299	616	.298	1520	.231	2468	.525	4198	.615	4555	.551
Tot[2]	2693		3938		3382		1707		1014		712		1539		3498		4538[3]		6584[3]	
TAC	3200		4000		4000		4000		4000		3500		2800		3400		4000		4000	

[1] Catches reported in vessel logs
[2] Statistics from landings
[3] Preliminary

Table 2. Minimum trawlable shrimp biomass (kg) - 1988 - Hopedale Channel

STRATUM	DEPTH (M)	NO. SETS	TOTAL	AV./SET	AREA (N MI²)	TOTAL NO	VAR.
102	200-250	2	152.42	76.21	146	624675.	10889.93
103	250-300	3	948.84	316.28	75	1331749.	46552.45
104	300-350	2	643.23	321.61	56	1011146.	14694.12
105	350-400	8	2865.97	358.25	66	1327440.	61521.27
106	400-450	3	519.84	173.28	60	583699.	8339.34
107	450-500	3	307.18	102.39	66	379407.	7864.26
108	500-550	5	279.10	55.82	177	554690.	9128.03
109	550-600	3	387.65	129.22	38	275671.	9206.63
202	201-250	2	1.26	0.63	84	2971.	0.18
203	250-300	3	91.27	30.42	174	297198.	1111.26
204	300-350	4	54.36	13.59	398	303663.	611.77
205	350-400	8	794.86	99.36	319	1779429.	15424.54
206	400-450	4	92.51	23.13	304	394722.	179.26
207	450-500	2	12.53	6.27	173	60849.	25.13
208	500-550	2	4.03	2.02	182	20589.	0.13
209	550-600	2	0.57	0.28	185	2960.	0.02
210	600-650	2	1.53	0.77	305	13099.	0.19
214	>550	2	8.38	4.19	42	9880.	5.78
B	250-300	2	0.43	0.22	230	2792.	0.08
304	300-350	2	29.02	14.51	61	49692.	243.76
A	350-450	3	2.60	0.87	103	5012.	0.53
307	450-500	2	133.31	66.65	43	160913.	3555.77
308	500-550	2	0.93	0.47	73	1906.	0.41

TOTAL	TOTAL UPPER	TOTAL LOWER	AVERAGE MEAN	AVERAGE UPPER	AVERAGE LOWER
9194155.	12121590.	6266720.	48.74	64.26	33.22

EFFECTIVE DEGREES OF FREEDOM= 13
STUDENTS T-VALUE= 2.16 ALPHA=0.05

Table 3. Biomass estimates (t) and 95% confidence intervals for shrimp in Hopedale Channel, 1979 - 1988.

Year	Mean	Upper	Lower	Area (sq. n. mi.)	No. Sets
1979	18654	34535	2774	2582	56
1980	15386	23890	6881	2991	84
1981	6115	8706	3523	3050	57
1982	12577	16437	8717	3050	77
1983	9178	10756	7601	3359	89
1984	10047	13555	6538	2829	61
1985	13450	21184	5716	3636	65
1986	11138	16020	6257	3494	76
1987	6758	9577	3940	3494	74
1988	9194	12122	6267	3360	71

Table 4. Biomass estimates (t) and 95% confidence intervals for Greenland halibut and cod in Hopedale Channel, 1979 - 1988.

	Greenland halibut			Cod		
Year	Mean	Upper	Lower	Mean	Upper	Lower
1979	5197	6824	3569	831	1846	-
1980	25232	29521	20942	2411	3073	1749
1981	9663	13970	5356	1460	11200	-
1982	12926	14769	11084	3149	4780	1519
1983	25017	28457	21578	1844	2608	1080
1984	19416	22639	16192	1864	3060	668
1985	12103	18739	5467	1158	2095	222
1986	5406	7399	3413	779	1111	447
1987	3034	5334	734	20	41	-
1988	8458	10305	6612	116	256	-

Table 5. Catch (t) and catch per hour fished, 1979 – 1988, Cartwright Channel.

	1979		1980		1981		1982		1983		1984		1985		1986		1987		1988	
	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE
Jan																	177	.736		
Apr																			582	1.845
May																	179	.434	564	1.097
Jun			23	.187			114	.340	3	.111					1	.156	874	.624		
Jul	147	.658	12	.453	7	.255					51	.301					199	.502		
Aug	148	.264	22	.292	5	.155	1	.255			38	.343	1	.131						
Sep	422	.217	56	.264	1	.202			>1	.053	143	.313	1	.049						
Oct			>1	.058							19	.224								
Nov			4	.107							7	.157			81	.591				
Dec							29	.370			>1	.023			1126	.593				
Tot[1]	718	.263	117	.245	13	.200	143	.345	3	.105	258	.297	2	.064	1208	.592	1429	.583	1146	1.381
Tot[2]	1034		170		67		167		3		312		–		1368		1045[3]		1557[3]	
TAC	800		800		800		800		800		700		770		1000		800		800	

[1] Catches reported in vessel logs
[2] Statistics from landings
[3] Preliminary

Table 6. Minimum trawlable shrimp biomass (kg) - 1988 - Cartwright Channel.

STRATUM	DEPTH (M)	NO.SETS	TOTAL	AV./SET	AREA (N MI²)	TOTAL NO	VAR.
701	250-300	2	192.36	96.18	58	313186.	14829.86
702	300-350	2	4.29	2.14	90	10829.	0.04
A	251-300	2	0.28	0.14	49	390.	0.04
B	300-400	3	107.48	35.83	82	164934.	997.29
708	400-450	4	551.65	137.91	45	348422.	34412.69
709	450-500	3	480.84	160.28	54	485914.	21225.58
711	450-500	2	150.08	75.04	16	67408.	1080.35
712	>550	4	622.41	155.60	41	358168.	27491.14
801	250-300	2	379.25	189.63	79	841031.	4742.41
806	300-350	4	1254.90	313.73	78	1373831.	3312.75
807	350-400	3	1054.44	351.48	67	1322102.	11610.63
808	400-450	4	1157.90	289.48	47	763833.	22419.02
809	450-500	3	711.71	237.24	37	492803.	34042.73
C	500-550	5	656.59	131.32	97	715134.	7581.59

TOTAL	TOTAL UPPER	TOTAL LOWER	AVERAGE MEAN	AVERAGE UPPER	AVERAGE LOWER
7257984.	8753350.	5762618.	153.90	185.61	122.19

EFFECTIVE DEGREES OF FREEDOM= 15
STUDENTS T-VALUE= 2.13 ALPHA=0.05

Table 7. Biomass estimates (t) and 955 confidence intervals for shrimp in Cartwright Channel, 1979 - 1988.

Year	Mean	Upper	Lower	Area (sq. n. mi.)	No. Sets
1979	1886	2871	902	354	24
1980	2783	3413	2152	476	39
1981	2361	3371	1351	563	51
1982	1916	2867	965	505	43
1983[1]	1111	1446	775	871	56
1984	3113	4863	1362	881	47
1985	2574	3524	1625	744	46
1986	1803	2494	1111	878	45
1987	4578	5662	3494	878	43
1988	7258	8753	5763	840	43

[1] Expanded stratified area from 1983 to 1988.

Table 8. Biomass estimates (t) and 95% confidence intervals for Greenland halibut and cod in Cartwright Channel, 1979 - 1988.

	Greenland halibut			Cod		
Year	Mean	Upper	Lower	Mean	Upper	Lower
1979	1734	2677	790	244	426	62
1980	5338	6192	4483	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	5523	7606	3441	1628	3020	237
1986	2255	2872	1639	954	1565	343
1987	3133	3698	2569	30	77	-
1988	3862	4825	2898	356	984	-

Table 9. Minimum trawlable shrimp biomass (kg) - 1988 - Hawke Channel.

STRATUM	DEPTH (M)	NO.SETS	TOTAL	AV./SET	AREA (N MI²)	TOTAL WT	VAR.
101	250-300	2	13.88	6.94	343	133642.	23.26
102	300-350	2	27.67	13.84	248	192628.	29.41
103	350-400	5	435.97	87.19	457	2237136.	1673.07
104	400-450	6	789.08	131.51	250	1845862.	10352.69
105	450-500	10	1455.95	145.60	163	1332366.	21674.68
106	500-550	4	390.86	97.72	176	965525.	6043.15
107	>550	2	58.32	29.16	150	245566.	384.20
108	>300	2	102.14	51.07	44	126156.	1733.43
201	250-300	2	31.51	15.76	441	390074.	1.20
202	300-350	2	32.23	16.11	361	326608.	42.41
203	350-400	2	61.25	30.63	175	300887.	1476.96
204	400-450	5	391.91	78.38	278	1223334.	4268.66
205	450-500	5	308.76	61.75	340	1178744.	2470.22
206	500-550	5	364.28	72.86	244	998032.	4292.06

TOTAL	TOTAL UPPER	TOTAL LOWER	AVERAGE MEAN	AVERAGE UPPER	AVERAGE LOWER
11496560.	14030909.	8962212.	55.80	68.10	43.50

EFFECTIVE DEGREES OF FREEDOM= 31
STUDENTS T-VALUE= 2.04 ALPHA=0.05

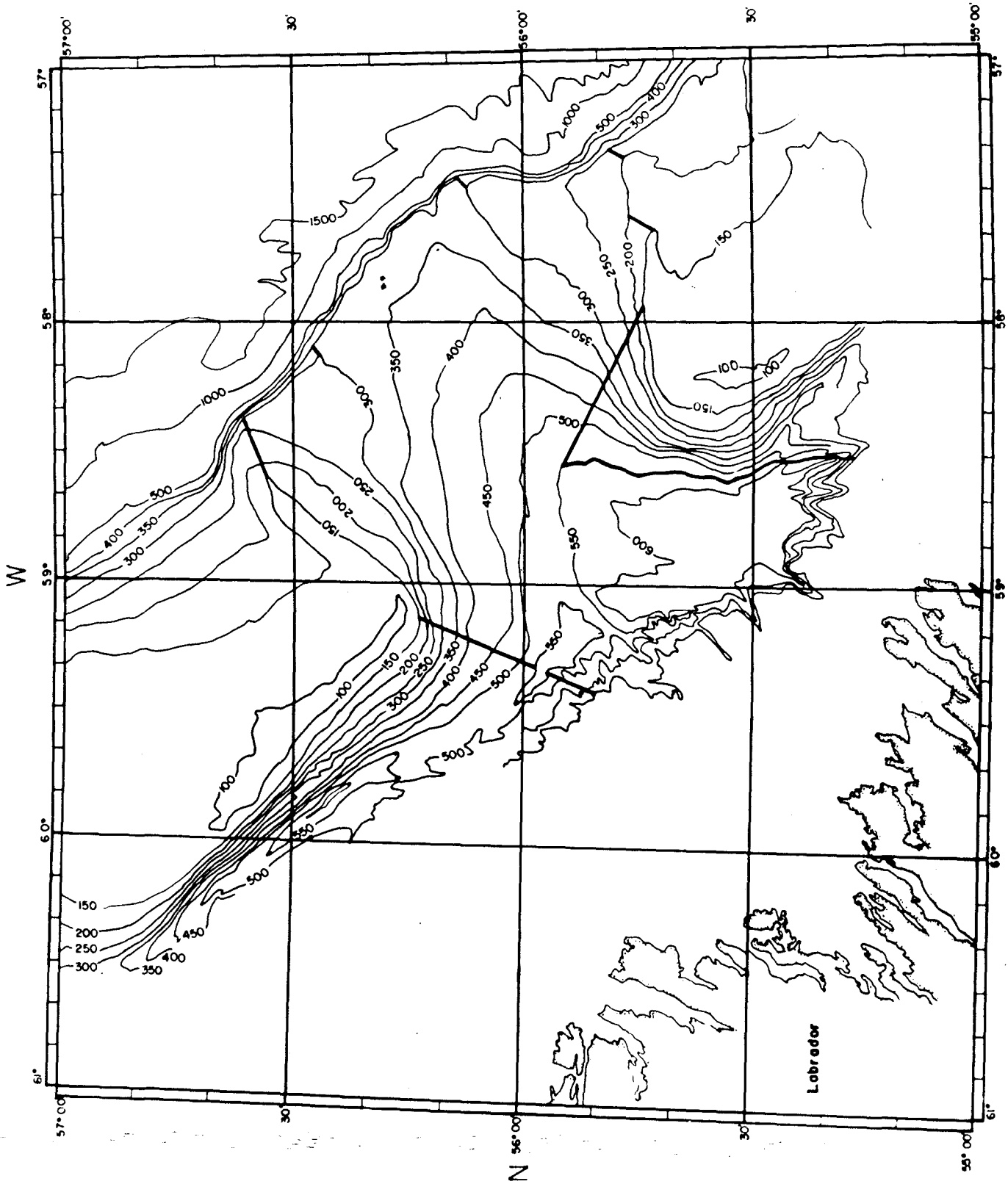

Fig. 1. Stratification of the Hopedale Channel for northern shrimp surveys.

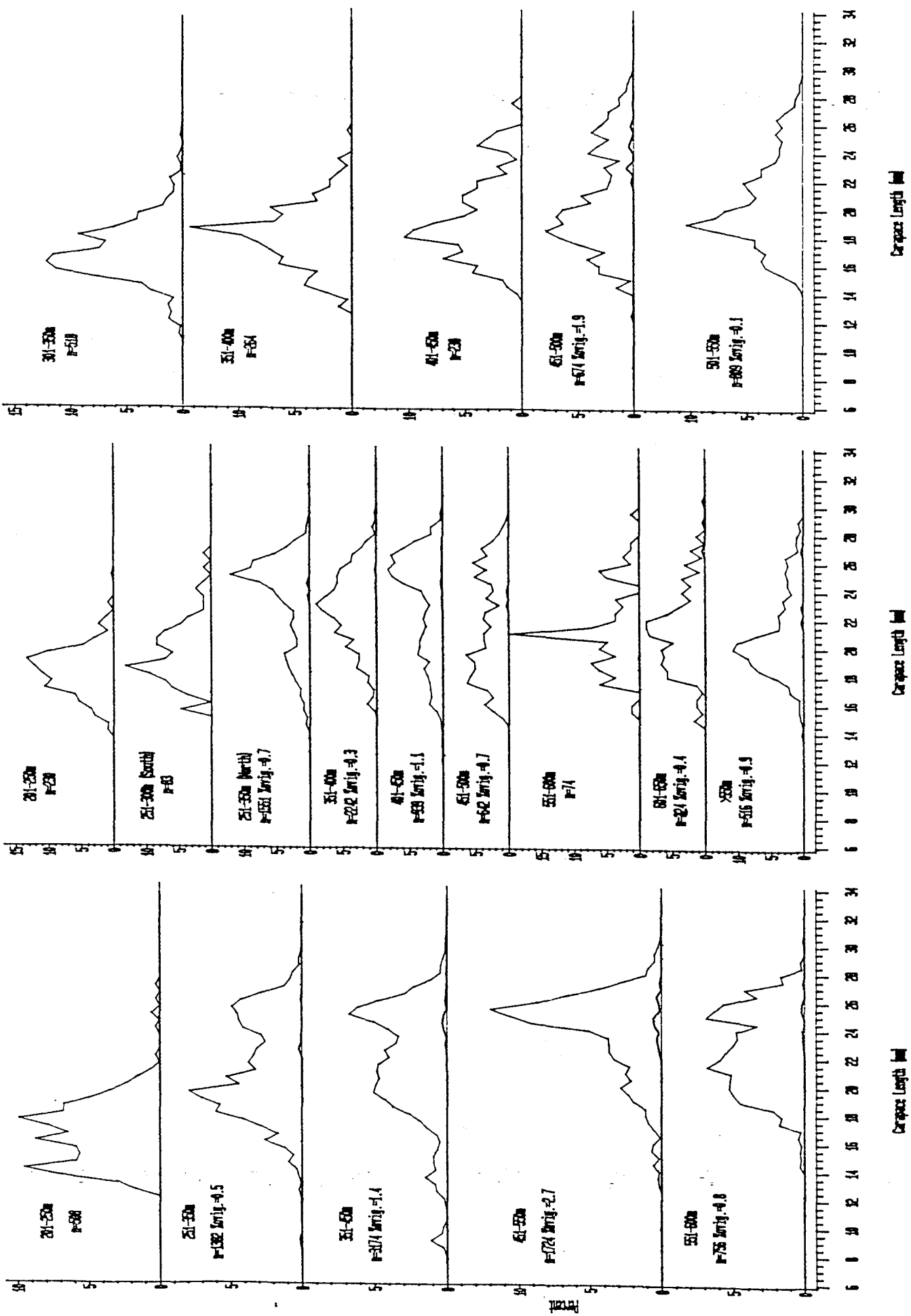

Fig. 2. Size distributions of shrimp in Hopedale Channel from the July 1988 research survey. (Broken line = ovigerous)

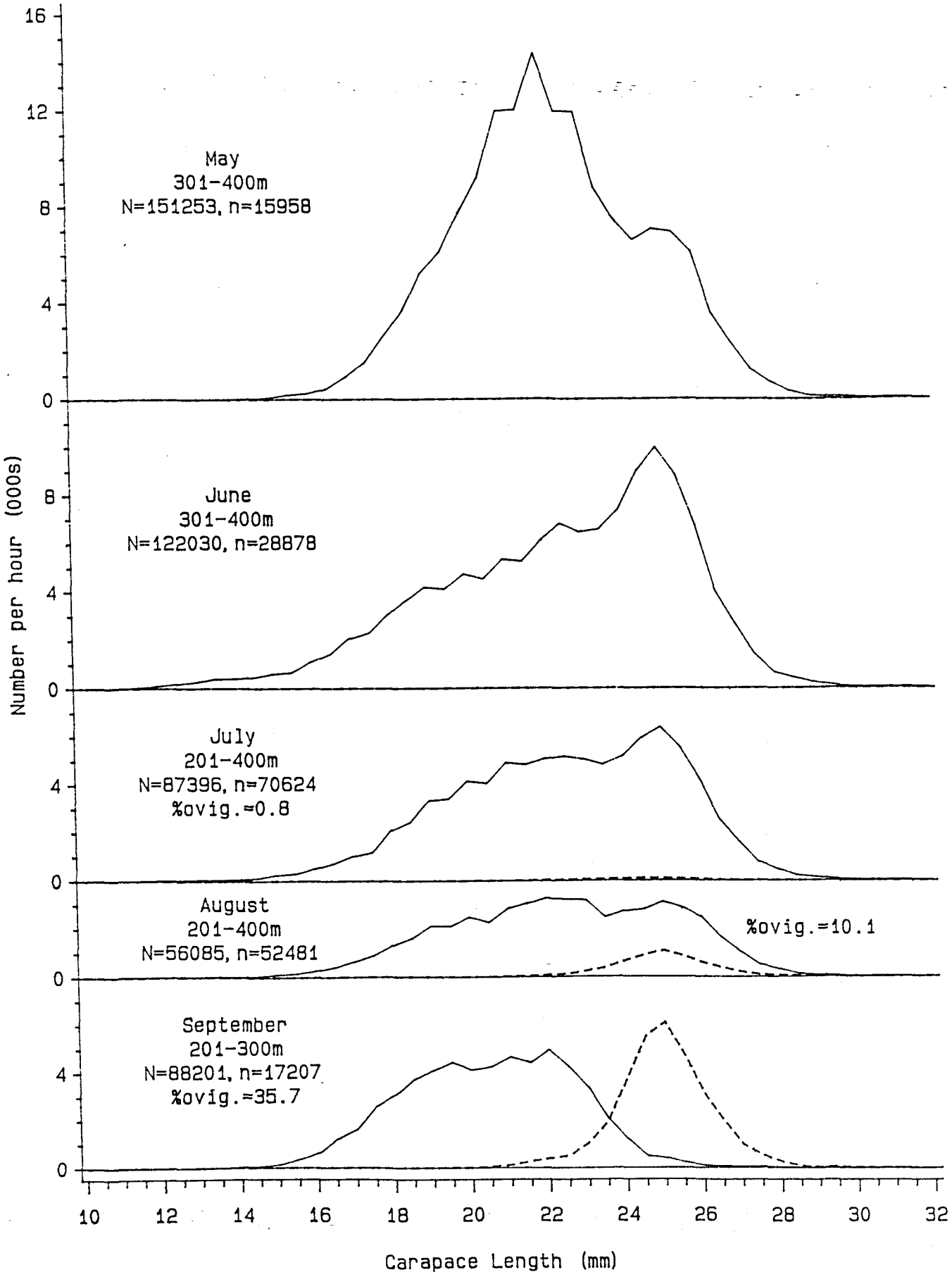

Fig. 3. Size distributions of shrimp in Hopedale Channel from the 1988 commercial fishery. (N = number caught per hour, n = number measured, broken line = ovigerous)

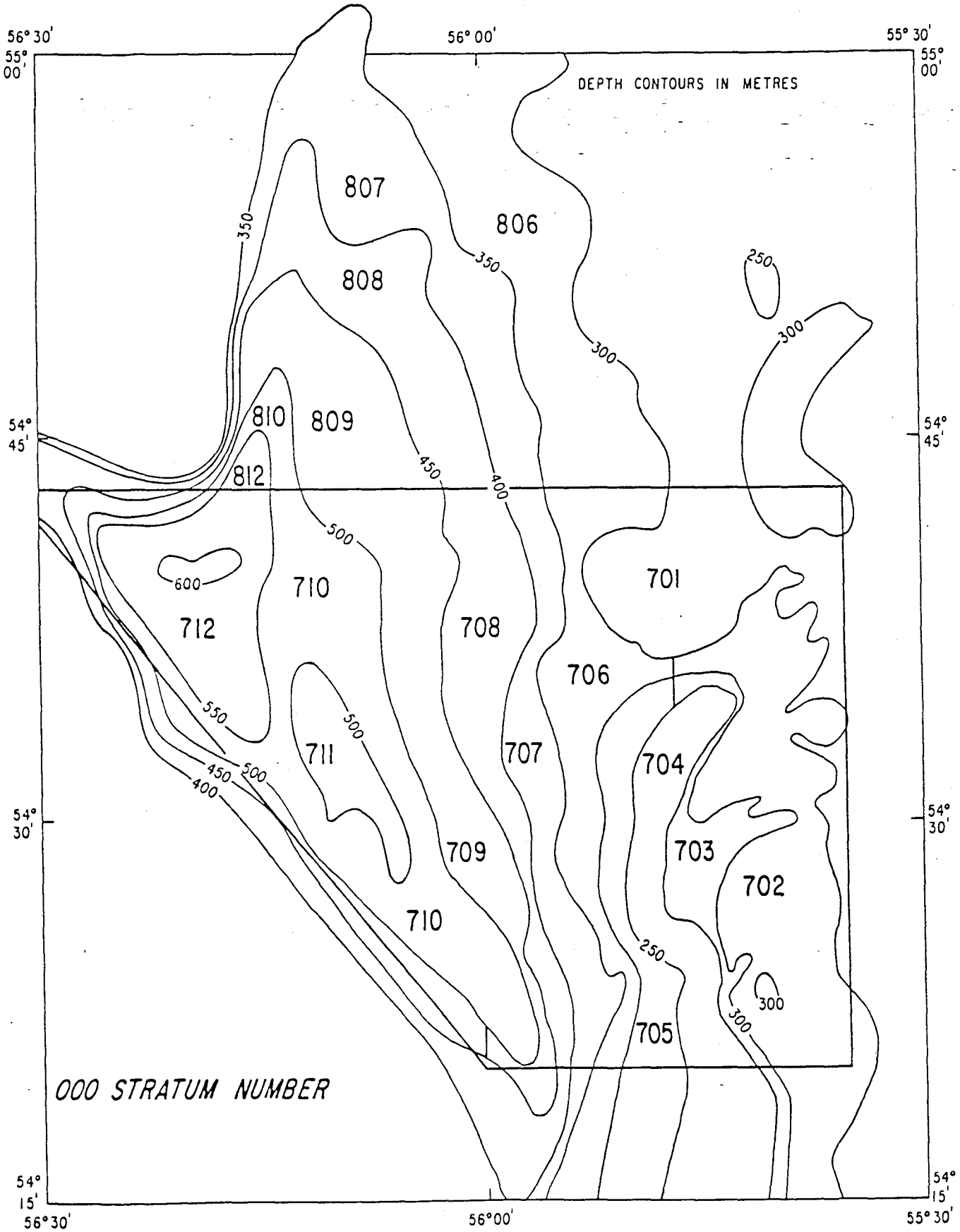

Fig. 4. Stratification of the Cartwright Channel for northern shrimp surveys.

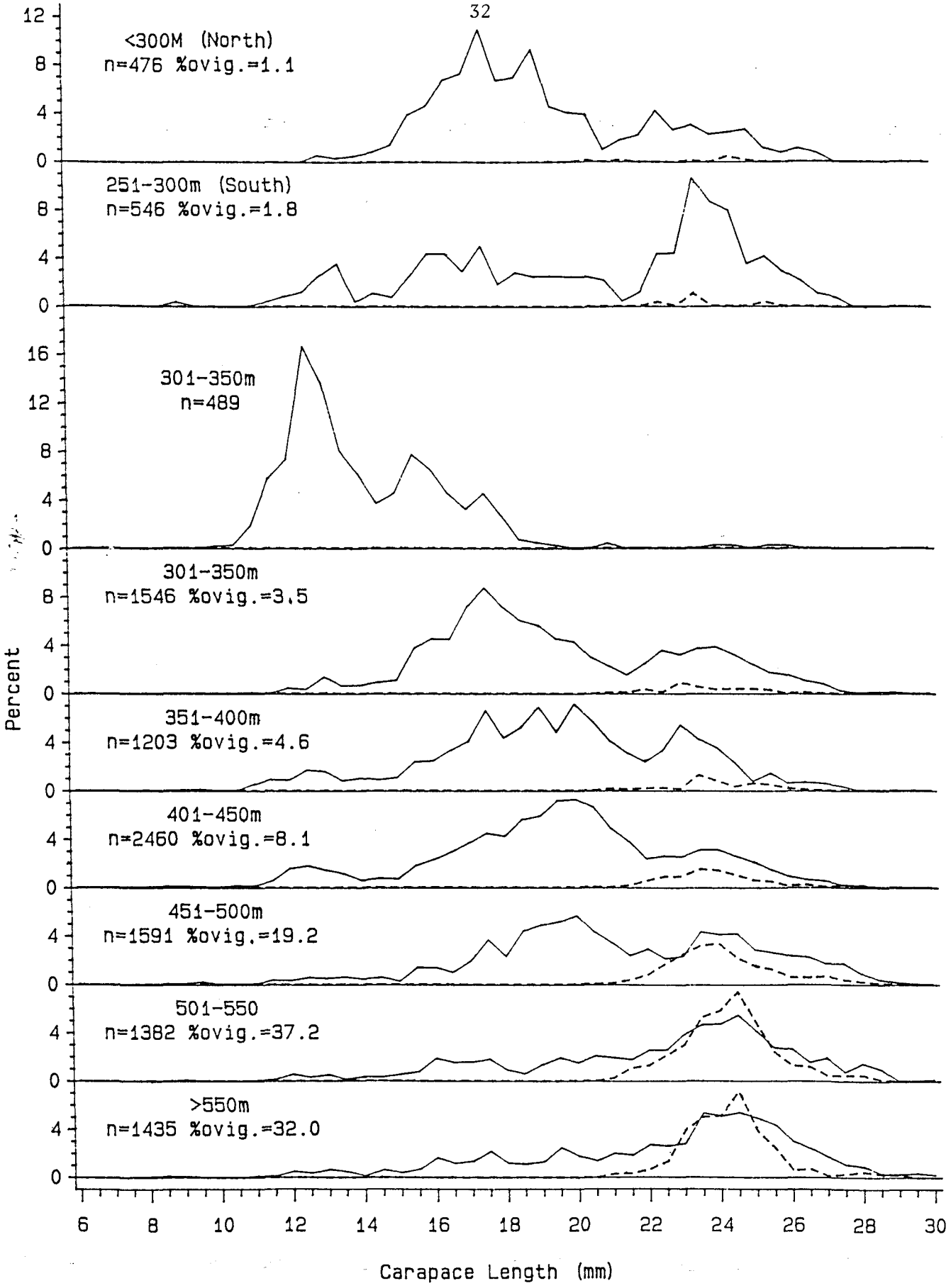

Fig. 5. Size distributions of shrimp in Cartwright Channel from the July 1988 research survey. (Broken line = ovigerous)

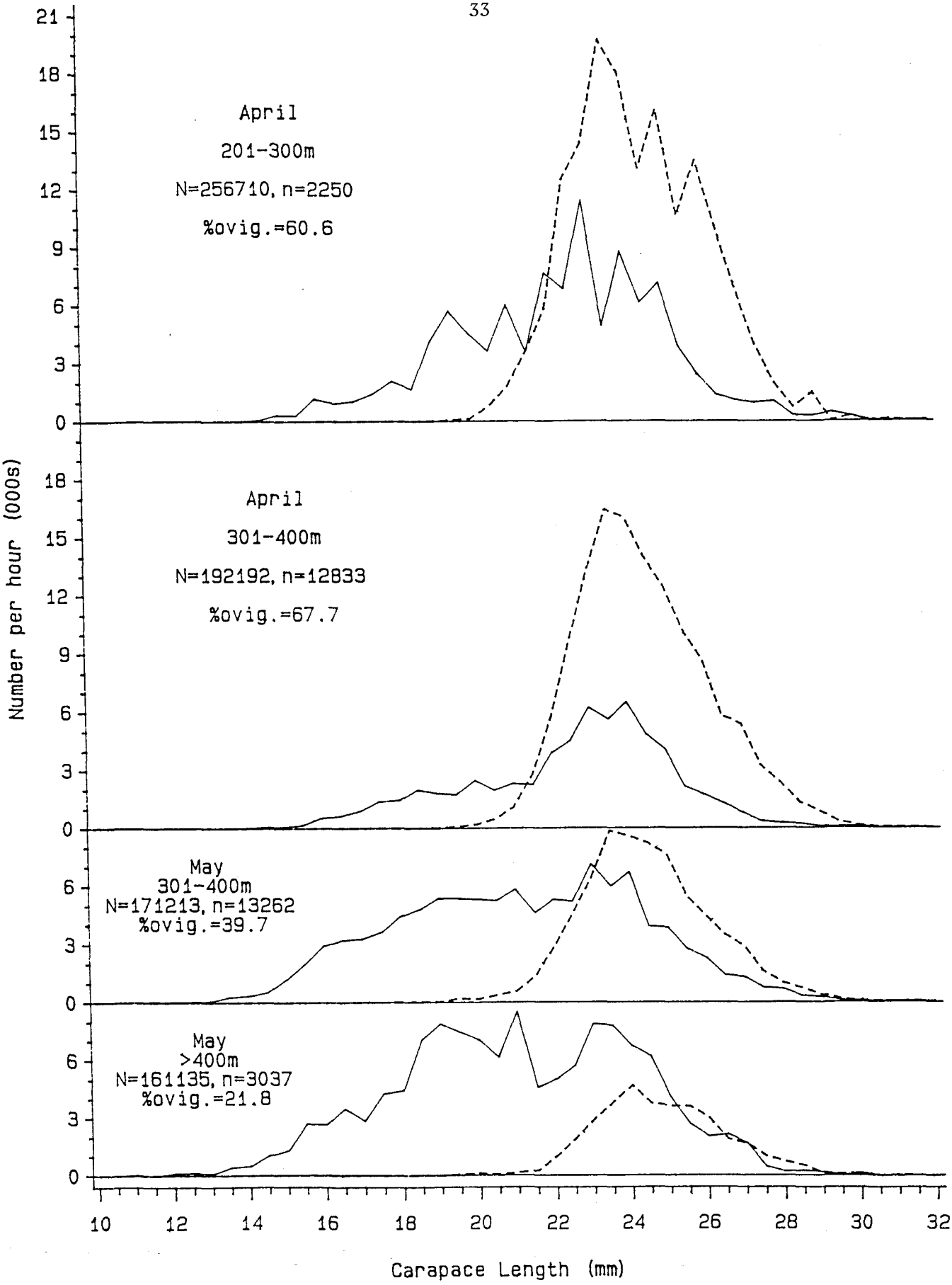

Fig. 6. Size distributions of shrimp in Cartwright Channel from the 1988 commercial fishery. (N = number caught per hour, n = number measured, broken line = ovigerous)

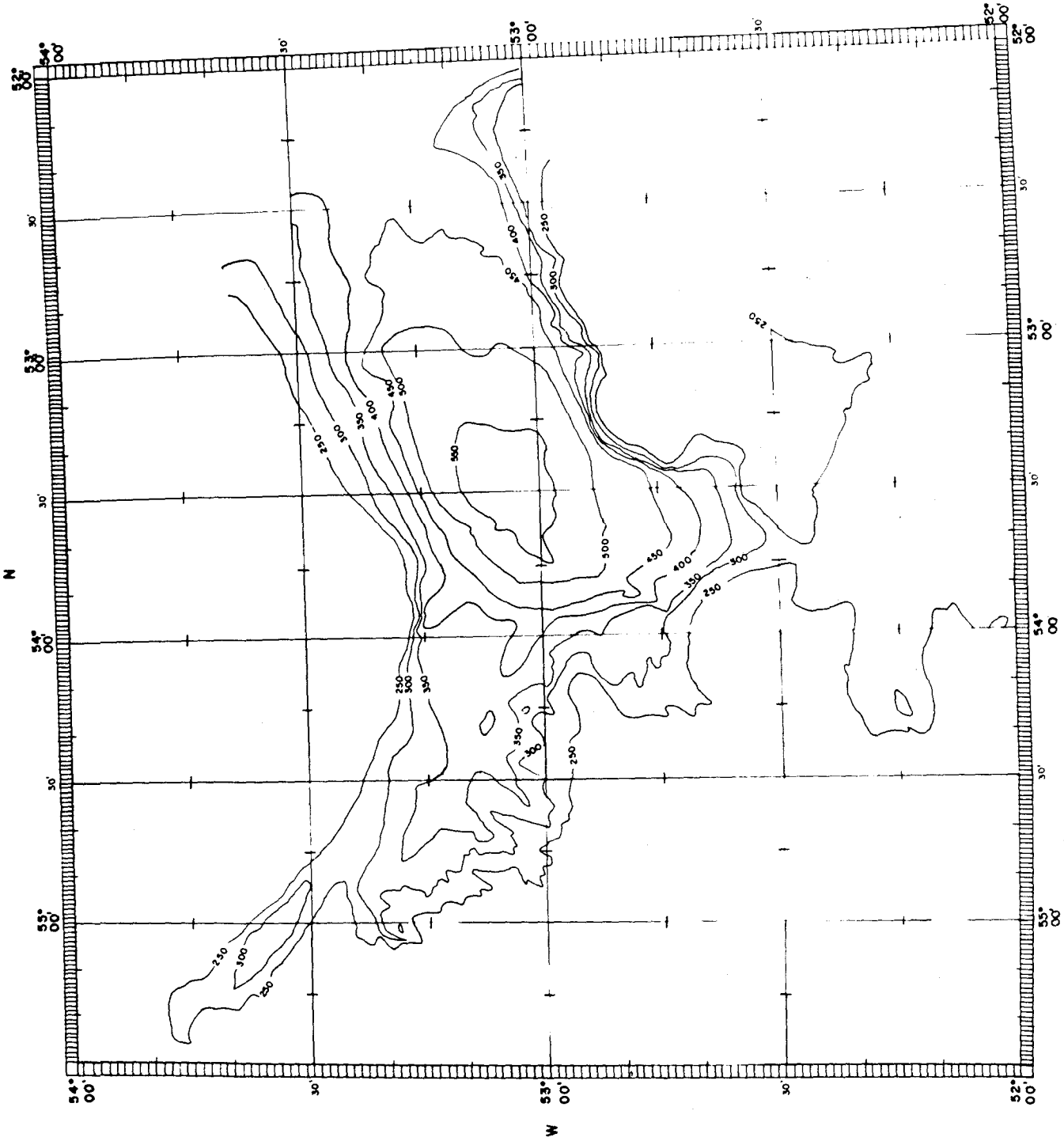

Fig. 7. Stratification of the Hawke Channel for northern shrimp surveys.

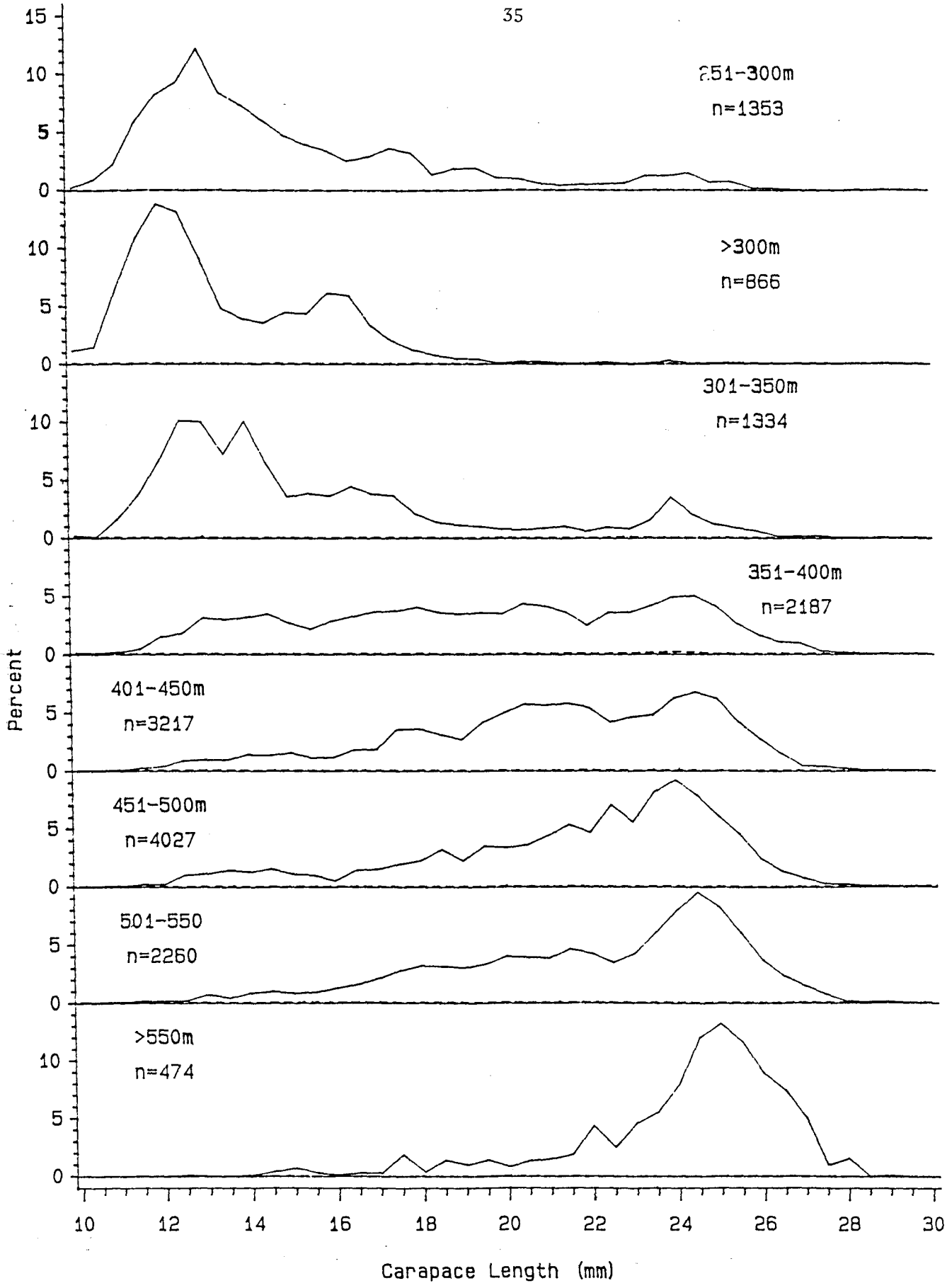

Fig. 8. Size distributions of shrimp in Hawke Channel from the July 1988 research survey. (Broken line = ovigerous)

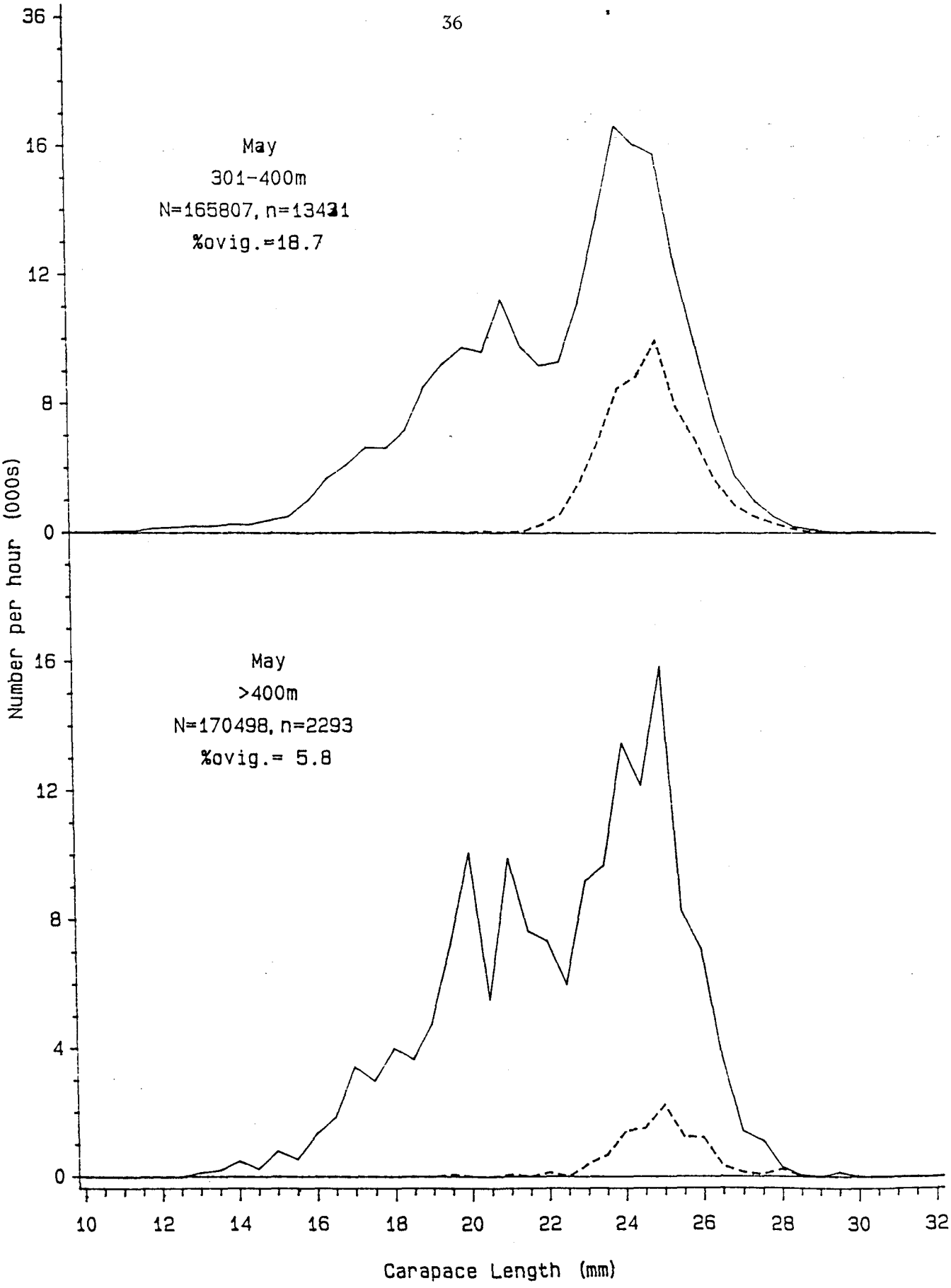

Fig. 9. Size distributions of shrimp in Hawke Channel from the 1988 commercial fishery. (N = number caught per hour, n = number measured, broken line = ovigerous)

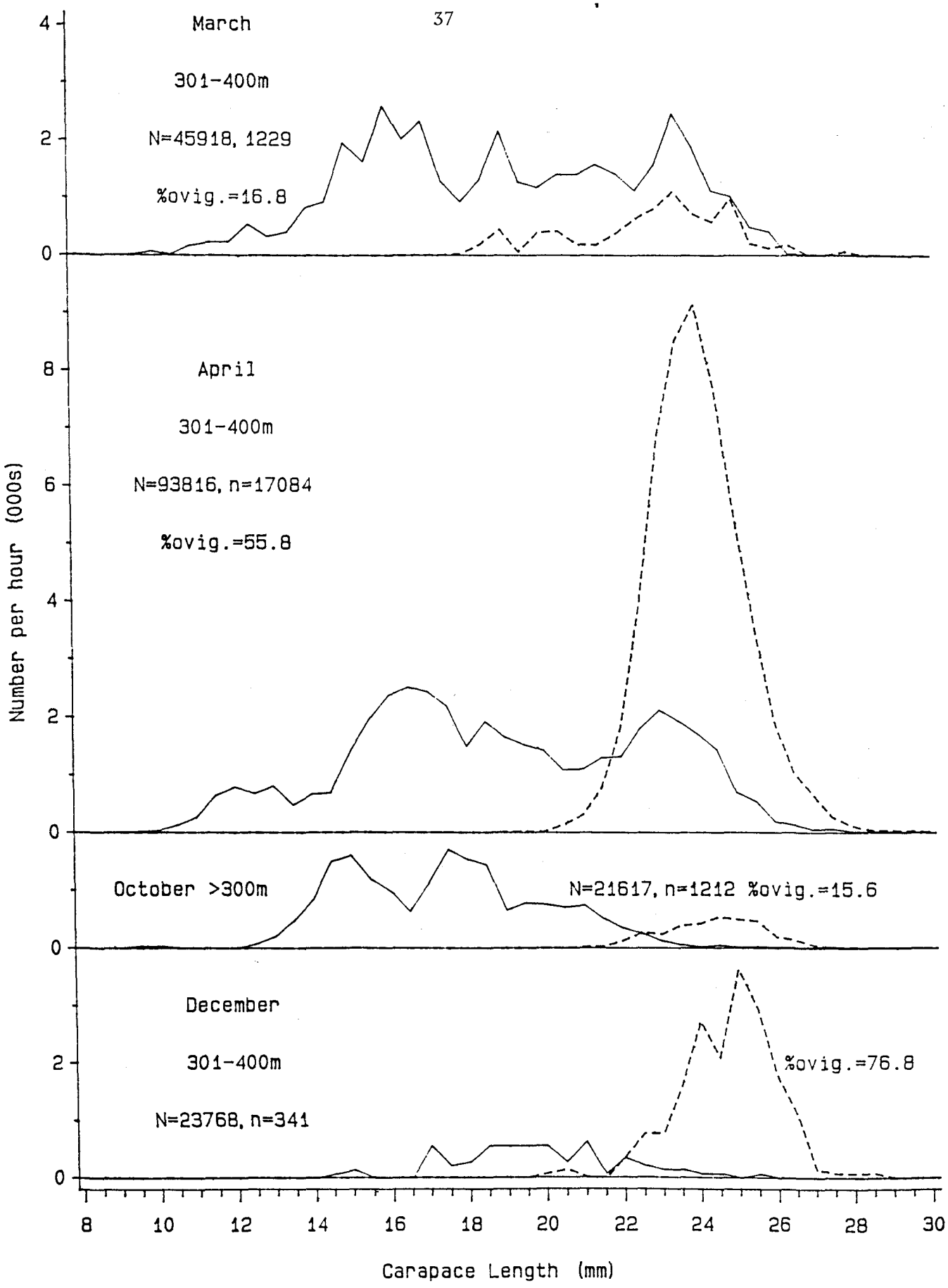

Fig. 10. Size distributions of shrimp in St. Anthony Basin from the 1988 commercial fishery. (N = number caught per hour, n = number measured, broken line = ovigerous)

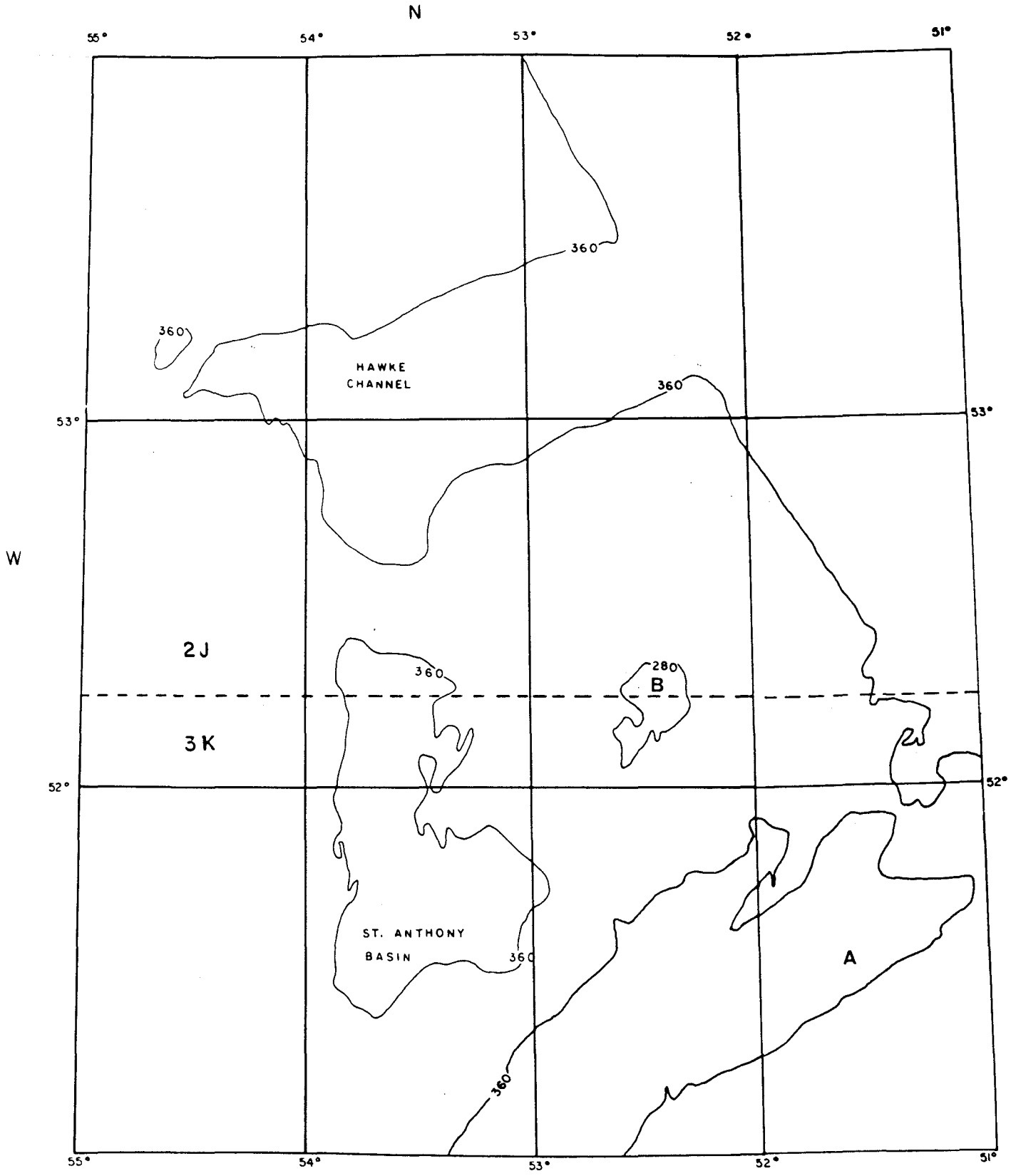

Fig. 11. New fishing areas in Division 3K, outside St. Anthony Basin.
A = Notre Dame Channel, B = Northeast St. Anthony Basin

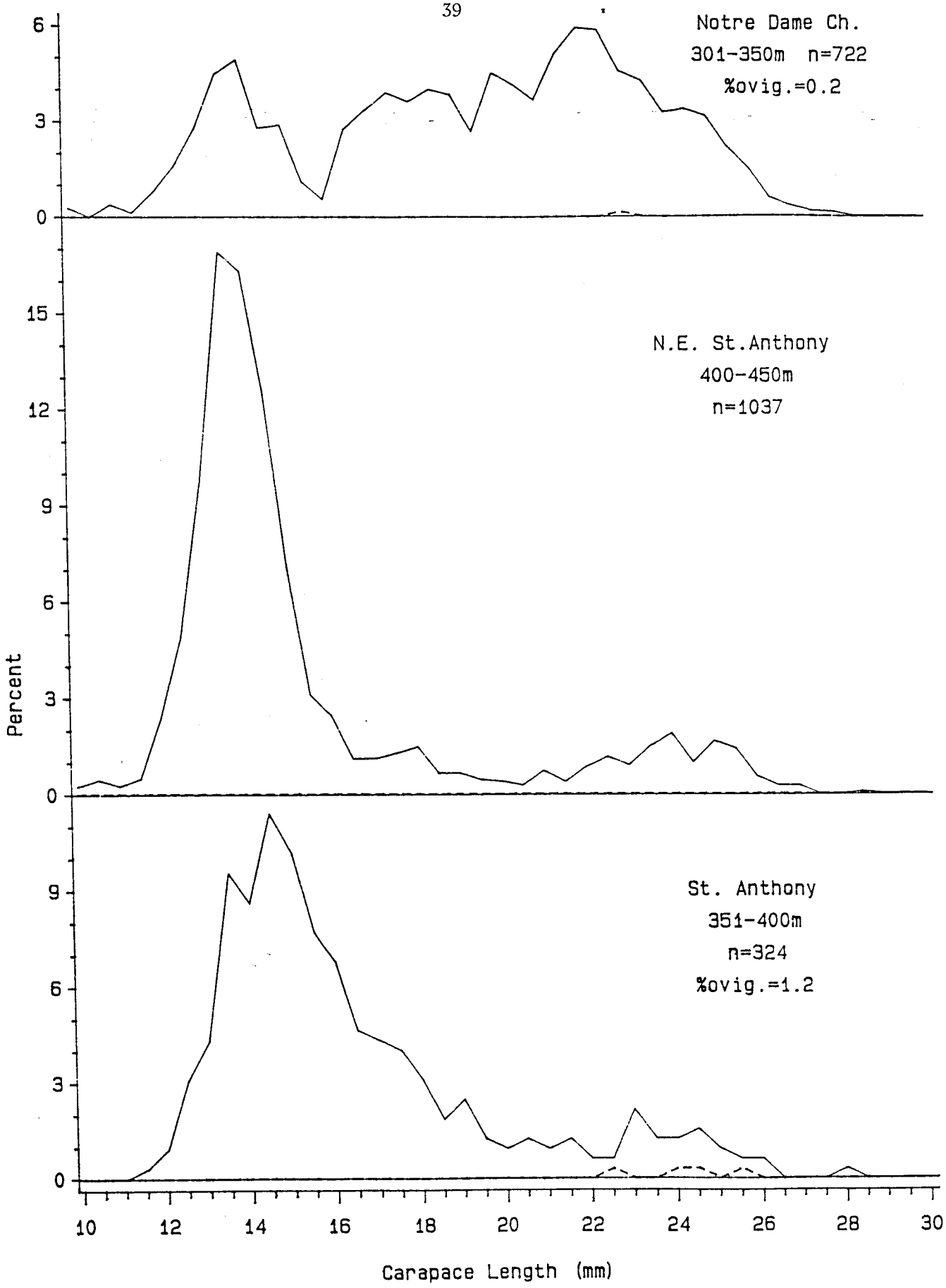

Fig. 12. Size distributions of shrimp in Notre Dame Channel, northeast of St. Anthony Basin and St. Anthony Basin from the July 1988 research survey. (Broken line = ovigerous)

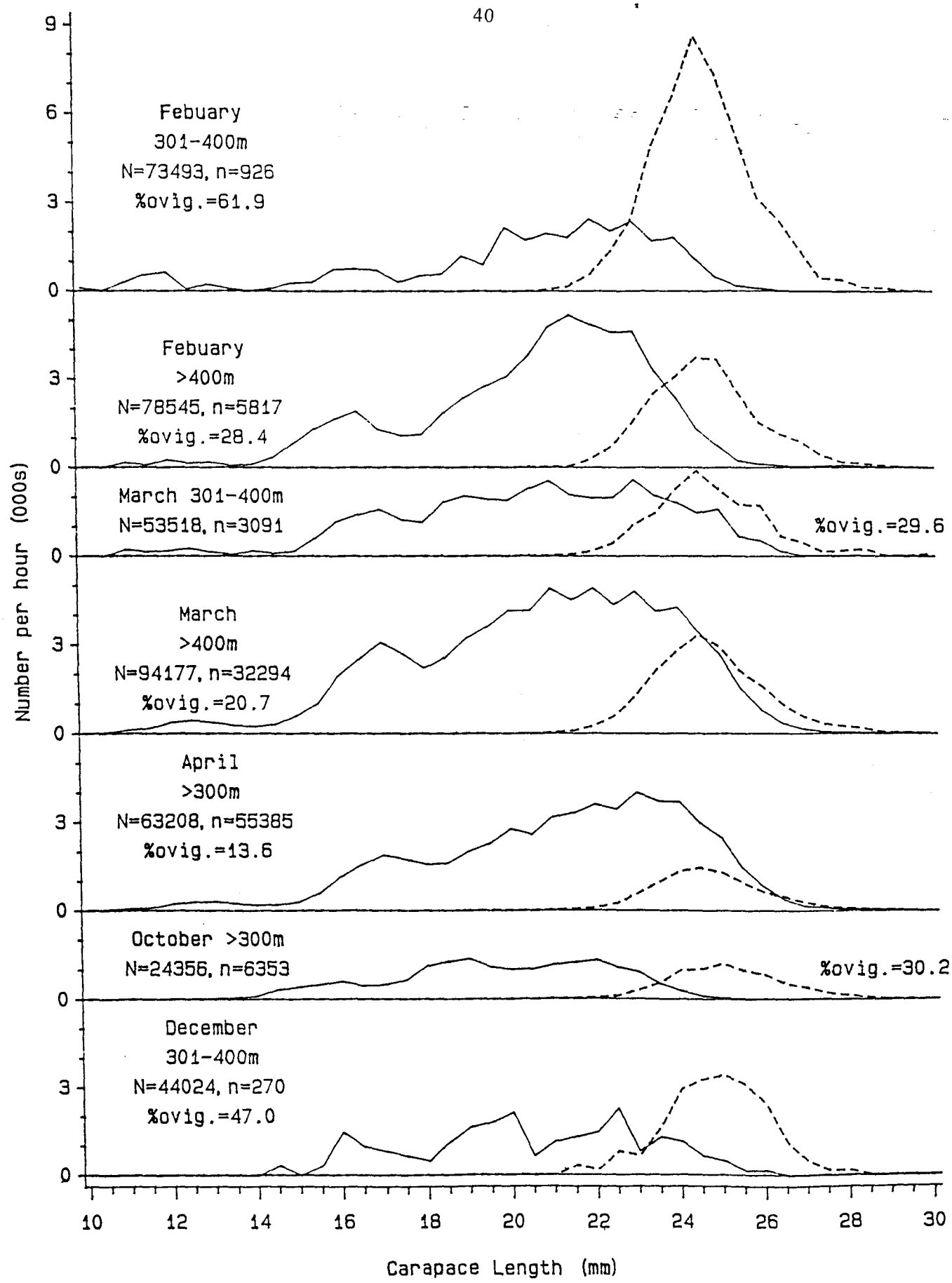

Fig. 13. Size distributions of shrimp in Notre Dame Channel from the 1988 commercial fishery. (N = number caught per hour, n = number measured, broken line = ovigerous)

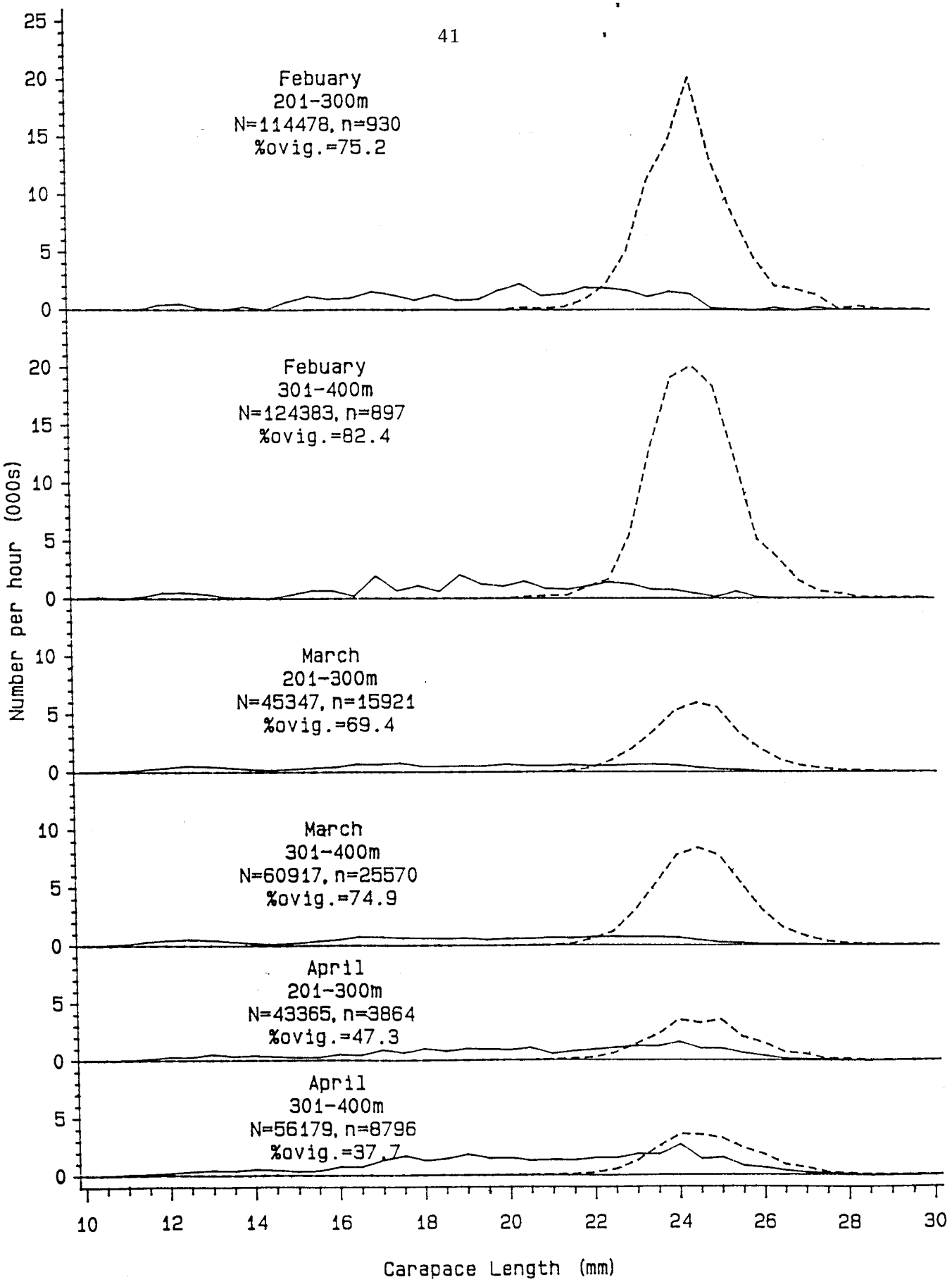

Fig. 14. Size distributions of shrimp east of the St. Anthony Basin from the 1988 commercial fishery. (N = number per hour, n = number measured, broken line = ovigerous)

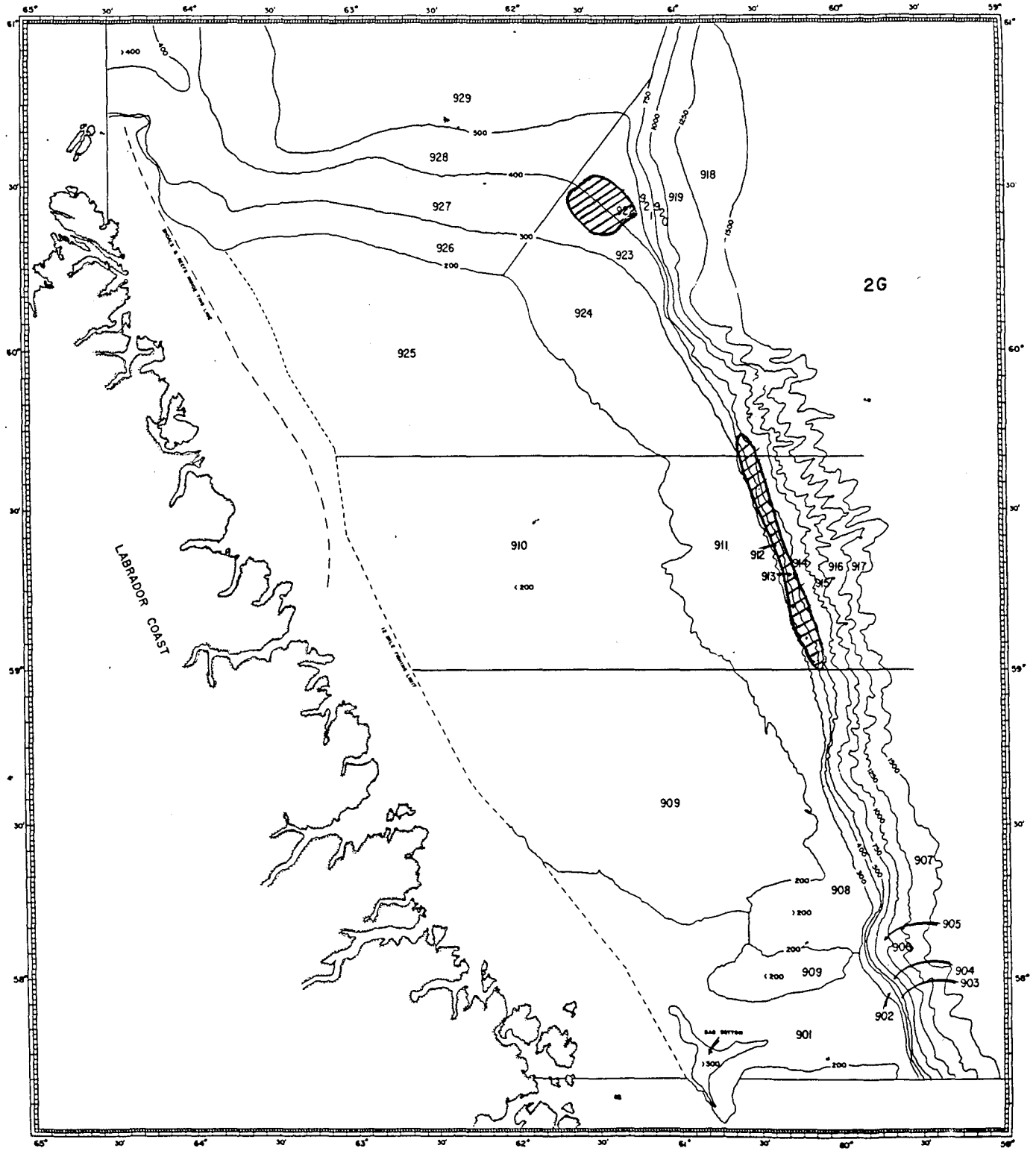

Fig. 15. Fishing areas in Division 2G, 1988.

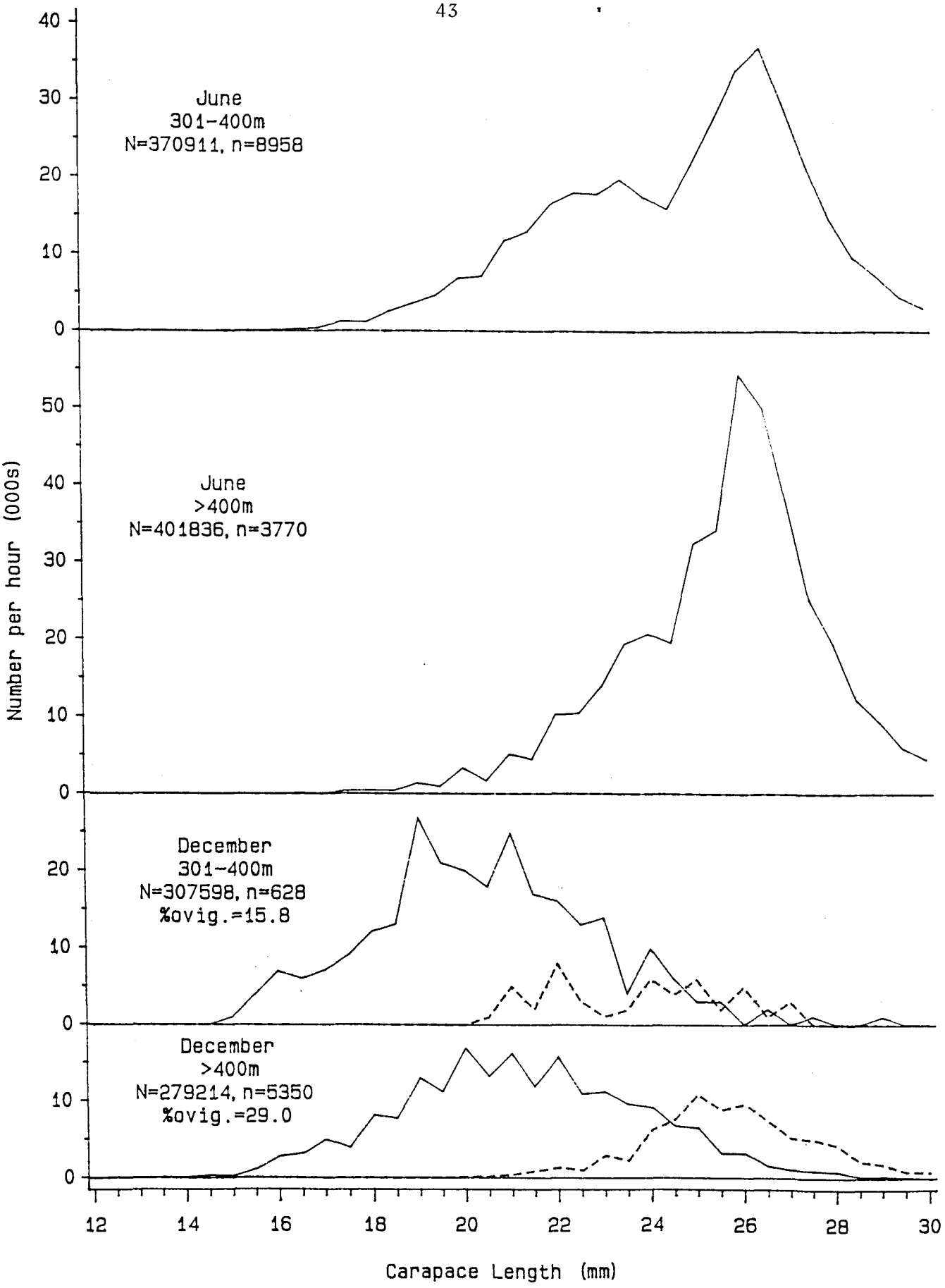

Fig. 16. Size distributions of shrimp in Division 2G from the 1988 commercial fishery. (N = number per hour, n = number measured, broken line = ovigerous)

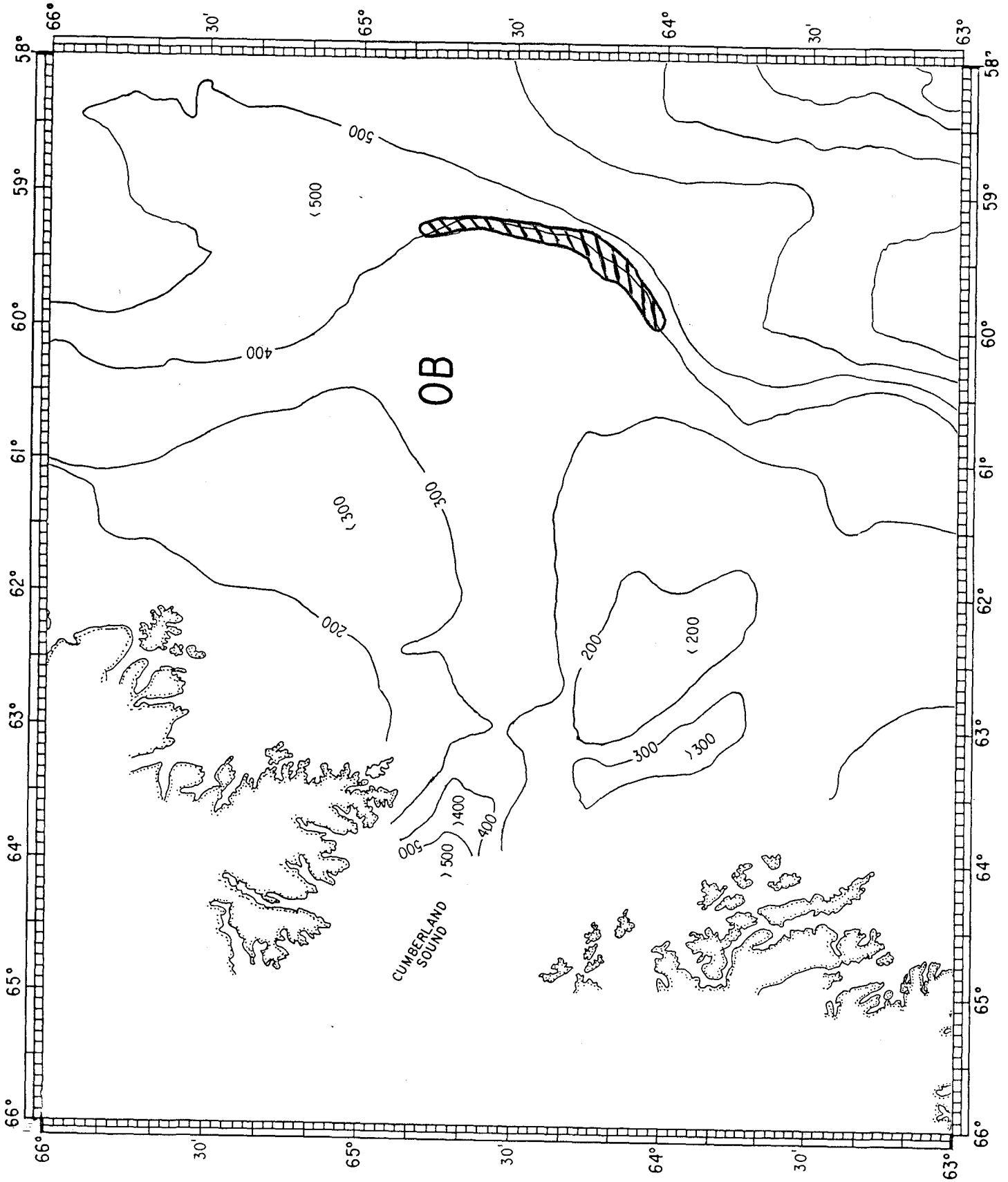

Fig. 17. Fishing area in Division OB, 1988.

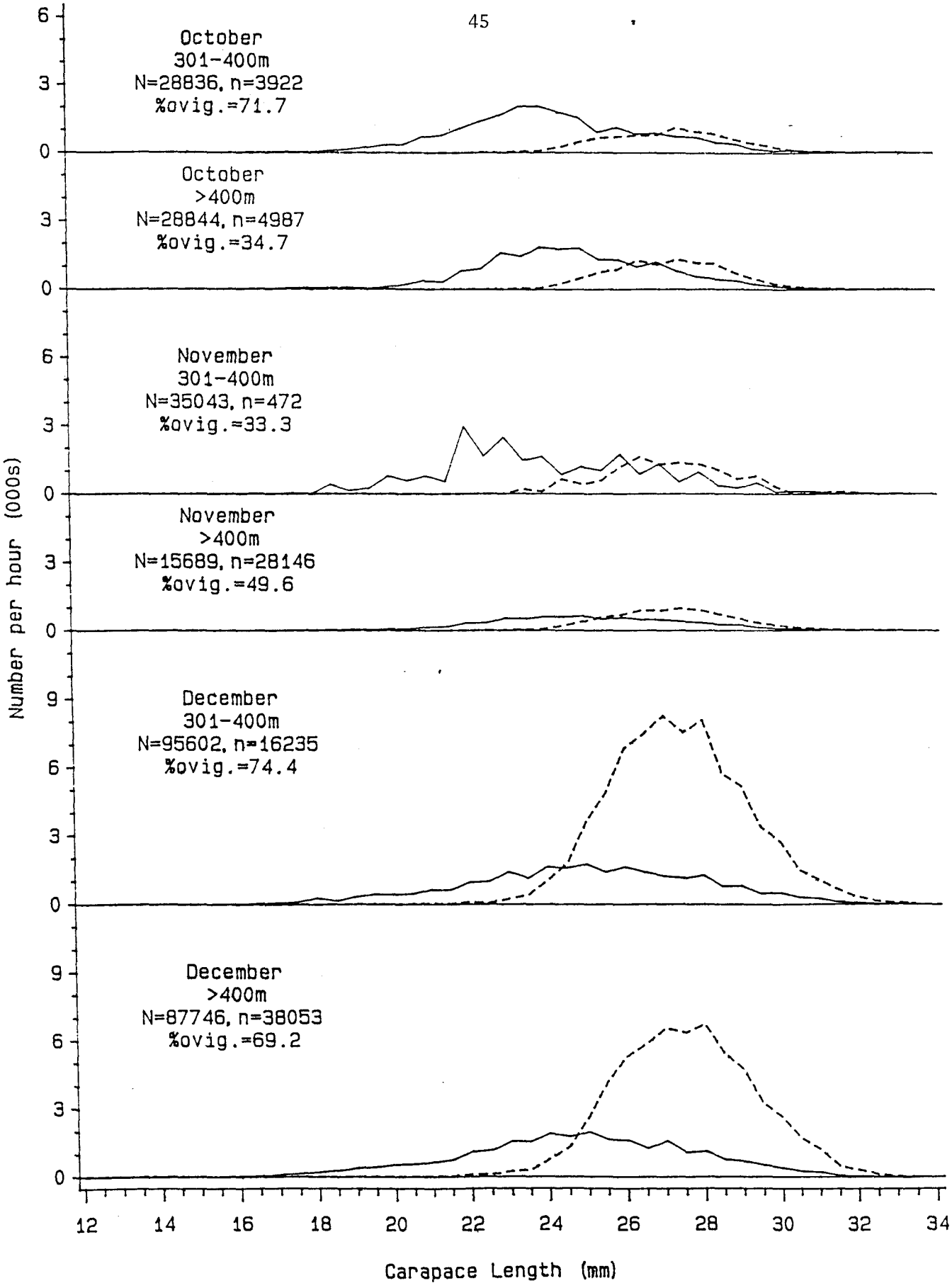

Fig. 18. Size distributions of shrimp in Division 0B from the 1988 commercial fishery. (N = number per hour, n = number measured, broken line = ovigerous)

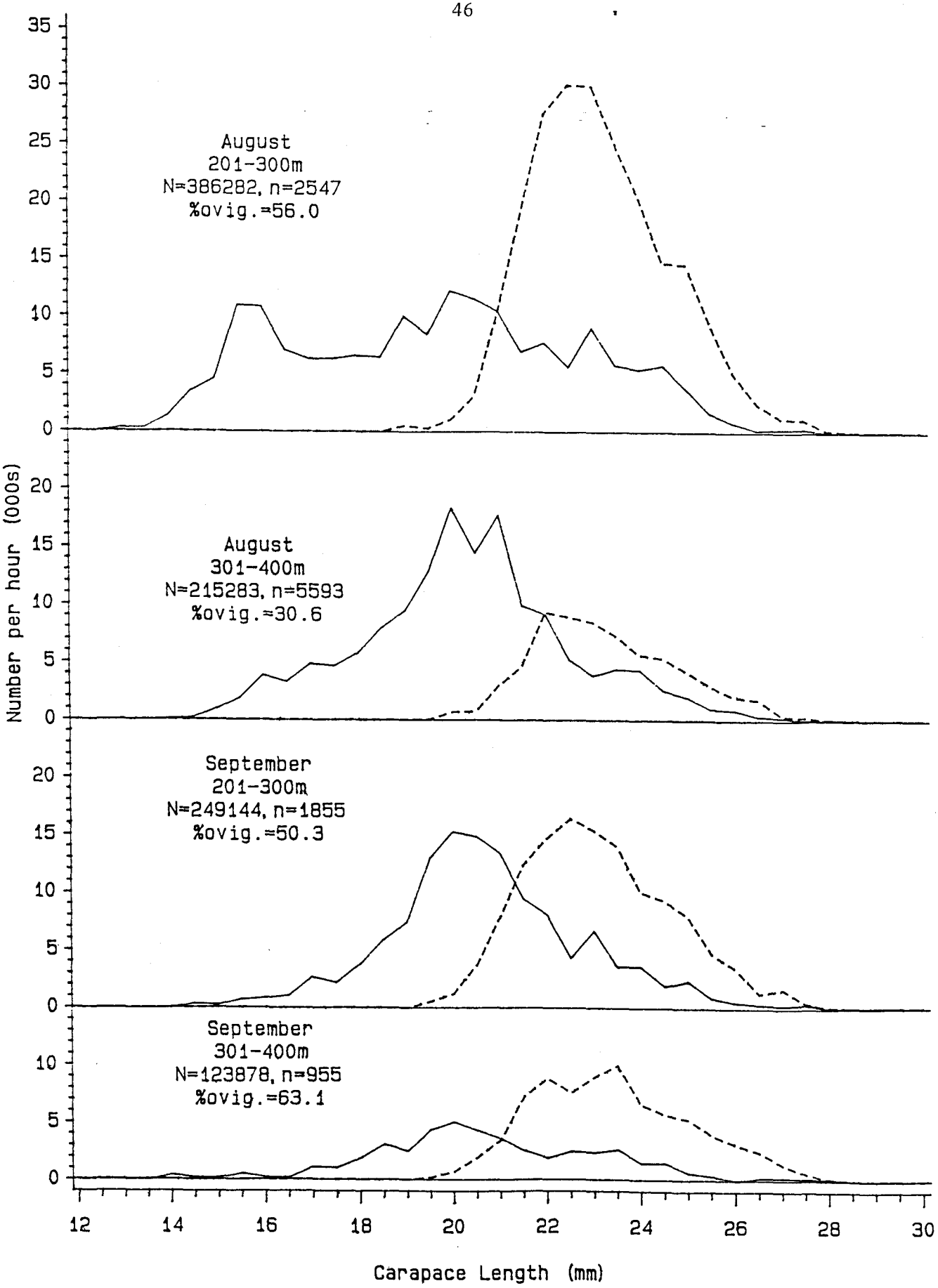

Fig. 19. Size distributions of shrimp (Pandalus montagui) in eastern Hudson Strait from the 1988 commercial fishery. (N = number per hour, n = number measured, broken line = ovigerous)