Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 88/9

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 88/9

A Review of the Northern Shrimp Fisheries and Status of the Stocks off Newfoundland-Labrador in 1987

by

D. G. Parsons, P. J. Veitch, and V L. Mercer
Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland A1C 5X1

[1] This series documents the scientific basis for fisheries management advice in Atlantic Canada. As such, it addresses the issues of the day in the time frames required and the Research Documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research Documents are produced in the official language in which they are provided to the Secretariat by the author.

[1] Cette série documente les bases scientifiques des conseils de gestion des pêches sur la côte atlantique du Canada. Comme telle, elle couvre les problèmes actuels selon les échéanciers voulus et les Documents de recherche qu'elle contient ne doivent pas être considérés comme des énoncés finals sur les sujets traités mais plutôt comme des rapports d'étape sur les études en cours.

Les Documents de recherche sont publiés dans la langue officielle utilisée par les auteurs dans le manuscrit envoyé au secrétariat.

Abstract

Fishing effort for northern shrimp in 1987 increased substantially due to the expansion of the fleet and greater utilization of the available resources. TAC's were taken in Hudson Strait, Hopedale, Cartwright and Hawke Channels. Catch rates varied over the season and by area but were as high as or higher than those obtained in previous years. The high catch rates reflect, to some extent, improvements in gear as well as the acceptibility of small shrimp in the market. Quantification of these factors was not possible, however.

Research surveys were conducted in both the Hopedale and Cartwright Channels in 1987, utilizing a two-phase survey design. The estimate of just over 6000 t in the former was 40 % lower than the 1986 estimate and less than half the 1985 value. Biomass in the Cartwright Channel, on the other hand, was the highest estimated for that area and was 2.5 times the 1986 value. As the increase in the latter was observed over all maturity stages, it was assumed that changes in availability and/or immigration must have occurred.

Stock status is reviewed for each area fished in 1987 based on the available research and commercial data. Advice on TAC's is provided where appropriate.

Résumé

L'effort de pêche à la crevette nordique a fortement augmenté en 1987 à cause de l'expansion de la flottille et d'une exploitation plus importante des ressources existantes. Les TPA ont été atteints dans le détroit d'Hudson et les chenaux Hopedale, Cartwright et Hawke. Les taux de capture ont varié pendant la saison et d'une zone à l'autre mais étaient au moins aussi hauts que ceux des années précédentes. Ces forts taux de capture s'expliquent dans une certaine mesure par des améliorations apportées aux engins mais aussi par le meilleur accueil fait par le marché aux crevettes de petite taille. Il n'a toutefois pas été possible de quantifier ces facteurs.

Des campagnes de recherche ont été menées en 1987 dans les chenaux Hopedale et Cartwright, les relevés comportant deux phases. Dans le premier chenal, l'estimation d'à peine plus de 6000 t est inférieure de 40 % à celle de 1986, et égale à moins de la moitié de celle de 1985. Dans le chenal Cartwright, par contre, la biomasse était au niveau le plus haut jamais relevé dans la région et l'estimation correspondait à 2,5 fois celle de 1986. Etant donné que cette augmentation se manifestait à tous les stades de maturité, on pense qu'il s'est produit des changements dans la disponibilité et/ou un phenomène d'immigration.

L'étude examine l'état des stocks pour chaque zone exploitée en 1987, à partir des données scientifiques et commerciales existantes. Des avis sur les TPA sont donnés le cas échéant.

Introduction

The fishery for northern shrimp in 1987 experienced a number of changes over previous years. The fishing season was changed from the calendar year to an opening date of May 1 and closing on April 30, appparently at the request of industry. The number of licenses also increased from 12 to 16, assuming that approximately 1000 t per license would be adequate. 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 - 1500 t; St. Anthony Basin 1200 - 1500 t; Ungava Bay and Eastern Hudson Strait - experimental fishery (1 or 2 vessels) to 200 and 1000 t, respectively. Finally, an "exploratory" fishery was permitted late in the year in areas outside the traditionally fished zones. This was to provide industry the opportunity to locate "new" concentrations for harvesting after the TAC's in other areas had been taken.

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 required to harvest 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 at December 1 in the southern grounds. Participation after the quota release dates depended on whether or not the vessel was Canadian flag and if the allocated 500 t had been taken.

Effort in the northern zone was concentrated in the Davis Strait where 99 % of the 6120 t TAC was taken by 15 vessels (10 domestic, 5 foreign). The area was closed to fishing on October 31. The TAC for P. montagui in eastern Hudson Strait (1000 t) was exceeded by 63 t (5 vessels) and the fishery was closed on September 9. Fishing was not so successful in Ungava Bay and Division 2G where only 12 and 68 t were caught, respectively. In the southern zone, most effort was expended in the Hopedale Channel where 14 vessels harvested 4021 t and the area was closed on September 20. The area was essentially reopened on November 4 when the exploratory fishery was authorized and over 500 t were taken in the southernmost part of the channel. The TAC in Cartwright Channel (800 t) was taken primarily in June (7 vessels) and the area was closed July 4 with a total catch of 904 t. An additional 157 t from the channel were taken during January, 1987. Fishing effort in Hawke Channel increased substantially in 1987 with 793 t taken in January. Since the new season starting May 1, 1709 t have been taken by twelve vessels, resulting in the area being closed on January 29, 1988. Ten vessels fished in Division 3K (St. Anthony Basin) since May, 1987 with catches of about 200 t. Roughly 50 t were removed from this area in January, 1987, as well. Other than the cathes reported late in 1987 in the southern Hopedale Channel, the exploratory fishery was unsuccessful in areas adjacent to the Cartwright and Hawke Channels and St. Anthony Basin. In late February - early March, however, good concentrations were located within a limited area on Belle Isle Bank (52° 20′ N, 52° 28′ W) which produced catch rates of over 20 t per day. 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 4000 t in 1987 (Table 1). TAC's have been reached in 1980, 1986 and 1987. The total catch of Pandalus borealis is difficult to estimate for 1987/88 due to the exploratory fishery. Although there is no doubt that these removals were from Hopedale Channel, it appears that a substantial proportion of the catch consisted of P. montagui. A rough estimate of the total catch would be about 4500 t. The increased catches in the past two years are due primarily to increased effort in the area.

Monthly CPUE estimates from 1977 to 1987 have shown extreme variation over time, both within and between years. This variartion is due to a number of factors including season, vessel size, gear, effort levels and market requirements, none of which are quantifiable. Market demand for small shrimp remained strong in 1987 and high catch rates reflect those conditions in contrast to 1985, for example, when there were high discards of small shrimp. Gear improvements are continuing. Nets with vertical openings as high as 30 m have been reported and the use of a third warp to increase the vertical opening at night is another innovation.

CPUE in 1987 decreased from about 660 kg/hr in July and August to 564 kg/hr in September when the area was closed (Table 1). The exploratory fishery, conducted in November and December, produced catch rates in the range of 300 to 400 kg/hr but, as noted previously, a significant portion of the catch consisted of P. montagui. Catch rates for the July - September period in 1987 compare favourably with those of the previous year and the annual CPUE value is the highest in the unstandardized time series.

2) Shrimp Biomass

Results of the two-phase survey conducted in July, 1987 are detailed in the report by Parsons (1988). Highest densities were found in the northern zone in 300 - 350 m (Fig. 1). Lower densities but more biomass was estimated for the central zone within the same depth interval. Typically, both low densities and biomass were found in the southern zone, but best catches in this area occurred in the southernmost parts. The biomass estimate of 6037 t is 40 % lower than the 1986 estimate of 10,100 t and less than half the value obtained in 1985 (Table 2). The fishery in July, 1987 was intensive and about 1500 t had been removed at the time of the survey. The biomass estimate obtained, therefore, is closer to the estimates of 1983 and 1984 (about 8000 t). It is possible that the fishing activity in the area resulted in some dispersal of the concentrations in the northern zone to areas not covered in the survey (i.e. western side of channel) 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 has been observed since 1979. This trend did not continue in 1987 with the proportion in zone 1 increasing from 26 % in 1986 to 33 %.

A separation of the biomass by maturity stages shows that 38 % of the biomass were males, 28 % primiparous females and 34 % multiparous females. This compares to 45 %, 21 % and 34 %, respectively 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	4534	2163	3406	10103
1987	2322	1668	2045	6035

Estimates of biomass decreased for all maturity stages from 1986 to 1987 which might suggest a change in availability between years as well as a decrease in abundance. It is noted, however, that while the overall biomass decreased by about 40 %, males decreased by 49 % and primiparous females by only 23 %. The comparatively low decrease for the latter follows from the high abundance of males in the previous year, while the decrease for males might indicate some decline in recruitment. We are presently attempting to separate the biomass by maturity stages over as many years as possible to determine if some trends in abundance emerge from the time series.

3) Biomass of Predators

Estimates of biomass for Greenland halibut increased from about 9000 t in 1981 to over 24,000 t in 1983, then decreased steadily to about 2800 t in 1987 (Table 3). The highest estimate for cod was observed in 1982 (2655 t), but in each year since then, abundance has apparently declined to the extremely low level of 16 t observed in 1987. What little cod was available in the most recent survey 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, 1987 (Fig. 2) show the characteristic increase in mean size with depth in the northern and southern zones. This is not apparent, however, in the central zone where male and female size groups were well represented in all depths greater than 300 m. In this respect, the distributions were similar to those of 1986.

In depths where most biomass was found in the northern zone (300 - 350 m), there was a broad size range, similar to that observed in 1986. Three modes of males were present at 17.5, 19 and 21 mm CL, possibly corresponding to the 1983, 1982 and 1981 year classes. Between 350 and 450 m, smaller males (< 20 mm) were scarce and, in depths greater than 450 m, males were virtually absent. This is in contrast to the previous year when males were plentiful throughout. Over the saddle where most biomass was found (300 - 450 m), the largest male size/age group and female shrimp were dominant in the samples whereas, in 1986, smaller males were also present. Although biomass was low in the southern zone, depths of highest densities showed dominance of males from 15 - 18 mm (1984 and 1983 year classes?) in 300 - 400 m, and larger males and females in 400 - 450 m. Overall, it appears that some of the reduction in biomass in 1987 results from a decrease in the abundance or availability of smaller/younger males (< 20 mm, < 6 years).

5) Size Composition - Commercial

Length frequencies from July to September (Fig. 3) show a predominance of large males (about 20 - 22 mm) and females (> 22 mm) in all depths fished. This contrasts the results of the 1986 fishery which showed a high proportion of smaller males around 18 - 19 mm occurring in the catches. The smaller size/age group was poorly represented in the 1987 data in July and August but was present in the September samples, albeit, at much lower catch rates. These data support those of the research cruise which also showed a scarcity of smaller males and suggest the possibility of reduced recruitment for 1988. It is noted, however, that similar predictions in the past have not materialized and that the scarcity may be a question of availability rather than abundance.

Data from the exploratory fishery in November and December are somewhat supportive of the latter in that the samples show a high proportion of the smaller males less than 20 mm at good catch rates. It is possible that the smaller sizes were not available to the main fishery farther north in earlier months. On the other hand, the research survey failed to detect any major concentrations of shrimp in the southern zone in July.

6) By Catch and Shrimp Discards

Observer data for 1987 show that redfish was the main by-catch species from July to September, but comprised only 2 - 3 % of the the total observed catch weight. Total by catch of all species for these months ranged from 5 to 10 % of the total catch weight. Turbot, lanternfish and cod were the other major species occurring in the catches. During the exploratory fishery, by catch of cod increased substantially in November to over 12 % of the total observed catch (42 kg/hr) and P. montagui to 10 % (34 kg/hr). The latter amounted to 13 % of the total catch of shrimp. In December, turbot was the major finfish species, but only comprised 1.2 % of the total observed catch. P. montagui amounted to 16 % of the total catch of shrimp.

As usual, virtually no discards were reported from the vessel logs available for 1987 (< 1 %). These reports are corroborated for July to September, by the observers (1 - 2 %), reflecting the strong markets for shrimp of all sizes in 1987. During the early stages of the exploratory fishing, shrimp discards were high in November, increasing to 7 %, but subsequently declined to 1 % in December.

7) Temperature

After an anomalously cold year in 1985, temperatures increased throughout the channel in 1986 to values observed in 1979 and 1980 (Parsons et al., 1987). 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). In depths of highest concentration (301 - 350 m), temperatures ranged from 2.1°C in the north to 3.0°C over the saddle. 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 1986 sampling data decreased to 1.1 % and in 1987 was only 2.7 %.

8) Yield Per Recruit

Concerns over loss in yield per recruit due to the shift in 1986 and 1987 towards smaller animals (around 18 mm) were addressed using a Thompson and Bell (1934) analysis. Preliminary length-at-age data were used to derive mean weight at age, natural mortality was set at 0.35 and 0.50 and recruitment was assumed to be knife-edge.

Age	1	2	3	4	5	6	7	8+
CL (mm)	7.7	13.3	15.5	17.4	19.0	20.9	23.4	24.8
Wt (g)	0.28	1.53	2.45	3.49	4.58	6.13	8.68	10.38

The results suggest that there is no loss in yield per recruit under this practice and, in fact, yield might be optimal at even younger ages (Fig. 4), especially at higher values of M. Results obtained assuming that the selectivity of a 40 mm mesh trawl reflected recruitment were similar to those assuming a knife-edge pattern. Interpretation of the model in terms of fishing mortality was not practical because of the high Fmax and F0.1 (> 0.5) values indicated at the optimal ages of recruitment.

9) Discussion

Although the catch rate series for shrimp in Hopedale Channel is difficult to interpret in terms of stock abundance, the similarity between the July - September catch rates in 1986 and 1987 might suggest at least some stability in the stock. Even when the less productive months of the exploratory fishery are included, the annual CPUE value is the highest in the series. The biomass index, however, does not agree with the CPUE data and indicates a substantial reduction in abundance or change in availability from 1985 to 1987. Part of this change appears to be due to a decrease in the amount of smaller/younger males in 1987. Data from both research and commercial sources are supportive, in this respect. Although we must be concerned about these observations, predicting recruitment of shrimp from length frequency data has not been reliable in the past. Size groups that appear lacking in one year, show up in high numbers the next and what might appear to be a strong year class turns out to be average. Also, in the late season fishery in the southernmost part of the channel, the size/age groups lacking earlier in the year helped support good catch rates.

Environmental concerns are minimal. Both Greenland halibut and cod are at the lowest levels observed in this area and temperatures appear 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.

Past practice of applying the 35 % exploitation rate to a series of biomass estimates to arrive at a catch level would result in a lower TAC than advised for 1987. However, 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 and distribution. There are no relationships between such factors 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.

The 1987 TAC of 4000 t is 300 t greater than advised by CAFSAC. This level, however, represents the highest annual catches taken in this channel over the years. The northern shrimp fishery is, essentially, beginning again after experiencing hard economic times in the early 1980's. It might be appropriate to set an upper catch level of 4000 t for a number of years to see how and if the stock reacts to sustained exploitation at this level.

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 4). Effort in 1986 increased substantially after the closure of the Hopedale Channel with removals in the order of 1200 t. Fishing continued into January of 1987 with catches of approximately 160 t in that month. The fishing plan for 1987 changed the season, as described above, but the 160 t were not counted against the new TAC (800 t). The available fishery data indicate that removals between May 1 and July 4 were roughly 900 t.

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 1987 catch rates decreased from 1000 kg/hr in January to 700 kg/hr in June and 500 kg/hr in July. The 1987 CPUE is greater than the 1986 value but the fishery was conducted at an entirely different time of year.

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. The results of the 1987 fishery show that catch rates were as high as the best rates obtained in any previous year, even back to 1977 when the fishery began, suggesting that the stock is healthy.

2) Shrimp Biomass

The results of the two-phase survey conducted in this area are given in the report by Parsons (1988). Highest densities were found in the northern part of the channel in 350 to 400 m (Fig. 5). This contrasts the findings of the previous year when most shrimp were found well within the channel in 450 to 550 m (Parsons et al. 1987). The 1987 biomass estimate of 4578 t is 2.5 times the 1986 estimate and represents an abrupt end to a declining trend observed between 1984 and 1986 (Table 5). Adding the 1987 catch brings the biomass closer to 6000 t, by far the highest level of abundance ever observed in this area. In the summer of 1986, biomass before the fishery took place was estimated at 1800 t. About 1200 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. This cannot be explained by increased recruitment as the following analysis indicates.

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

	Males	Primiparous	Multiparous	Total (t)
1986	670	789	343	1802
1987	1880	1433	1263	4576

Biomass increased substantially over all maturity stages which suggests changes in availability. The overall increase in biomass was 154 % between the two years, male biomass by 181 %, primiparous females by 82 % and multiparous females by 268 %. As negative mortality rates are impossible, 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, the latter seems likely.

3) Biomass of Predators

Biomass estimates for Greenland halibut have varied considerably over the period 1979 to 1987 (Table 6). The estimate of 3100 t in 1987 represents an increase of almost 40 % over the 1986 value and is close to the long-term average. Cod biomass was estimated at only 30 t which is by far the lowest level of abundance observed since 1979. As in the Hopedale Channel, the distribution of Greenland halibut was not closely related to the distribution of shrimp, whereas most of the cod biomass occurred where shrimp were most plentiful.

4) Size Composition - Research

Length frequencies from the research survey in July, 1987 show the strong representation of male size/age groups throughout the channel (Fig. 6). In the northern part of the channel, where highest concentrations were found in 300 - 400 m, a wide size range was represented. Males about 16 - 18 mm CL were particularly abundant and these sizes likely represent the 1984 and 1983 year classes. Sizes were similar in the same depth range in the southern parts of the channel where abundance was much lower. In shallower water (< 300 m), three size groups were present; a smaller male group at 12.5 mm (1985 year class), the 16 - 18 mm males, and females around 23 mm. In depths greater than 400 m, larger males about 19 - 22 mm (1981 and 1982 year classes?) were more prominent in the catches, as were the female age groups.

The length distributions for 1987 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 for January, 1987 (Fig. 7) were similar to those observed in the latter months of 1986, except that the occurrence of shrimp smaller than 19 mm was reduced in the former. This likely relates to the depths fished rather than changes in abundance (deeper in 1987). In June and July, the proportions of the smaller sizes occurring in the catches increased substantially, especially in depths of 300 to 400 m where most of the fishing was concentrated. These data support the findings of the research survey in that abundance of the smaller sizes appears to be high at similar depths and the 16 and 18 mm size/age groups (1984 and 1983 year classes) are evident.

6) By Catch and Shrimp Discards

Observer data for the Cartwright Channel were only available for the month of January, 1987. By catches were low, comprising less than 5 % of the total catch of all species, and consisted mainly of Greenland halibut (3 %) and cod (1 %).

Shrimp discards in Cartwright Channel reported in vessel logs were also very low in 1987 (< 1 %). The January estimate from observers supports the log data with a discard rate of only 1 % of the total catch of shrimp.

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 (Parsons et al., 1987). In 1987, temperatures in depths greater than 400 m were as warm or slightly warmer than in 1986 (2.8 - 3.0°C) while in shallower water it was slightly colder (1.1 - 2.3°C). Highest shrimp densities in 1987 were found in the northern part of the channel in the 350 to 400 m range where the temperatures averaged 2.7°C. Water in the same depth range farther south was colder, averaging 1.4°C. Most females were found in the deeper strata where the temperatures were warm. The proportion of non-spawning females reflects 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 % in the much warmer years of 1986 and 1987, respectively.

8) Discussion

Both the commercial fishery and research survey data show that in 1987 the shrimp stock in this channel was at the highest level observed since the late 1970's. 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 and again in the summer of 1987, the estimate of biomass was the highest in the series dating back to 1979. 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 1988. Predator abundance does not appear to be a problem and temperatures within the channel were much higher than they were in 1985, as reflected in the high proportion of spawning females. Because the growth rate in this area appears to be similar to that in the Hopedale Channel, growth overfishing under present fishing practice appears to be no problem.

In past assessments, it has been suggested that TAC's under such variable conditions are inappropriate but, despite this, they have been maintained. A couple of 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 advised for 1987 (770 t) was based on 35 % of the average of all available biomass estimates. It was also suggested that this catch level be continued for 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 nonexistant 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. Catches of over 1000 t were taken in the early years of the fishery and have been around that level for the past two years. 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 1000 t might be considered for a number of years to see how the stock responds to that level of exploitation.

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 cathes over that period. In January, 1987, a winter fishery was carried out with catches of about 800 t. The total catch in the 1987/88 season exceeded the TAC of 1500 t by roughly 200 t.

CPUE data indicate that there is a seasonal concentration of shrimp in this area in winter. The catch rate for January, 1987 exceeded 900 kg/hr compared to rates of 200 to 400 kg/hr in other months of the year.

Month	Jan	May	Jun	Sep	Oct	Nov	Dec
kg/hr	920	434	384	0	306	222	215

In January, 1988, however, catch rates improved markedly to 763 kg/hr. Because the fishery was closed in late January of both years, it is uncertain whether or not these concentrations exist during the February - April period.

2) Size Composition - Commercial

The high catches of January, 1987 were composed of ovigerous females about 24 mm CL and a number of male size/age groups ranging from about 17 to 22 mm in a 1 to 1 ratio (Fig. 8). The catch rates for the balance of the year were much lower but the size compositions remained much the same. Sex ratios changed between depths and months but the size range and modes within that range were similar. No commercial data are available from previous years for comparisons and data from the fishery in early 1988 have not yet been processed.

3) By Catch and Shrimp Discards

The catches of other species in the shrimp fishery in Hawke Channel varied substantially over the year. In January, by catches amounted to less than 4 % and consisted primarily of cod (1 %) and Greenland halibut (1 %). Very little fishing was observed until October when over 20 % of the catch was cod. This increased to over 50 % in November and dropped to 36 % in December. The November observed catch rate of cod (321 kg/hr) was actually higher than that of shrimp (243 kg/hr). Most of this cod (over 75 % - 150 t) was discarded.

Estimates of shrimp discards from vessel logs were very low, ranging from 0 to 0.6 %. These reports are supported by the observers who estimated discards in the order of 1 - 3 % over the year.

4) Discussion

In 1982, it was felt that a TAC for this area was unnecessary given the low biomass as estimated 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.

Basing current TAC's on biomass estimates that are 9 and 13 years old is not much 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. The effective 1987 TAC of 1500 t can serve as an upper catch level for a few years to see if the winter concentrations can be maintained at that rate.

The by catches of cod late in 1987 were excessive and in some cases became the main species in the catch. Data on the by catches are routinely available on a timely basis from vessel logs and observers, and such by catches and subsequent discarding can be minimized.

St. Anthony Basin

1) Catch and CPUE

The shrimp fishery began in this area in January, 1987 with a catch of about 50 t up to February 5 when it was closed. The 1987/88 season began in May and catches to date have amounted to about 200 t. Catch rate data suggest that this area, as well, might be characterized by seasonal concentrations.

Month	Jan	May	Sep	Nov
kg/hr	627	165	119	165

Although commercial catch rates were high in January, it is worth noting that research catches have also been high in the July - August period.

2) Size Composition - Commercial

The high January catches consisted primarily of male shrimp in the range of 15 to 21 mm (Fig. 9). Higher densities and a higher proportion of ovigerous females were found in the shallower water. Effort and catch rates in the remaining months of 1987 were very low and composition of the catches varied considerably over that period. No commercial data are available from previous years for comparison and the 1988 data have not yet been processed.

3) By Catch and Shrimp Discards

Similar to the Hawke Channel, by catches in the St. Anthony Basin were quite variable over the year. In January, less than 7 % of the observed catch consisted of other species, mainly Greenland halibut (2.7 %) and the pelagic "glass" shrimp, Pasiphaea multidentata (1.7 %). In September and October, effort was very low but catches showed increasing proportions of cod, Greenland halibut and capelin. Over 35 % of the observed catch in November was cod and the catch rate of 160 kg/hr was almost as high as that of shrimp (169 kg/hr). Proportions of redfish, American plaice and Greenland halibut were also high in that month, reducing the proportion of shrimp to only 37 % of the observed catch.

As for the other northern shrimp grounds, discards of shrimp in this area from logbook records were less than 1 % in all months. These low levels are supported by observer data which show discards in the range of 1 - 2 % in January and September. There was, however, a slight increase in November to 4 %.

4) Yield Per Recruit

Because growth in this area appears to differ from that interpreted for the Hopedale Channel, a yield-per-recruit analysis was conducted to determine the optimal age at recruitment.

Age	2	3	4	5	6	7+
CL (mm)	13.4	16.2	18.7	20.0	22.6	24.2
Wt (g)	1.56	2.80	4.36	5.28	7.80	9.63

Based on the results obtained, it seems that optimal yield occurs around ages 3 or 4 (Fig. 10), depending on the value of M, and that current fishing practice of harvesting animals at about 16 to 18 mm CL (3 to 4 years old) is acceptable from this perspective. Again, the fishing mortalities implied were too high for practical application of this aspect of the model ($F_{0.1} > 0.6$).

5) 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 and 1987. This was increased to an effective TAC of 1500 t in 1987 of which only about 200 t have been taken to date. Fishery data suggest that this area, as well, experiences seasonal concentrations of shrimp and problems with by catch species. High proportions of small shrimp also pose a potential problem.

Given the continued low level of interest in the St. Anthony Basin, there remains sufficient room for expansion 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.

Eastern Hudson Strait and Ungava Bay

1) Catch and CPUE

Vessel logs for 1986 show 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 1063 t caught in the former area were taken in late August and early September at catch rates of 1.2 and 1.9 t/hr. One vessel made a two-hour tow in December and obtained a catch of 25.6 t! By contrast, only 12 t were taken in Ungava Bay in November, 1987 and catch rates were extremely low (< 50 kg/hr).

2) Shrimp Discards

Discards from vessel logs were as high as 7.4 % in eastern Hudson Strait in August but fell to 2.5 % in September. These values are high compared to the low rate of 0.6 % recorded in October of the previous year. There are no observer data available for 1987 to substantiate these reports.

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 of 1987 provides very little information regarding the seasonality of the concentrations in that area. Also, the situation in Ungava Bay is uncertain given the poor results obtained in November. The drop in catch rates in the former area between 1986 and 1987 might only reflect seasonal differences in shrimp concentrations rather than a decrease in abundance (the 1986 fishery occurred in October). Given the extremely high catch rate obtained in December, this seems highly probable. Therefore, there is no basis to change the advice given in 1987 and, even if that advice were accepted, such an experimental fishery would have to be continued and monitored for a number of years.

References

Parsons, D.G. 1988. Two-Phased Survey Design For Shrimp Off Labrador. CAFSAC Res. Doc. in preparation.

Parsons, D.G., P.J. Veitch and V.L. Mercer. 1987. Assessment of the Northern Shrimp (Pandalus borealis) Resources in Hopedale and Cartwright Channels, 1986. CAFSAC Res. Doc. 87/20: 29p.

Thompson, W.F. and F.H. Bell. 1934. Biological statistics of the Pacific halibut fishery. 2. Effect of changes in intensity upon total yield and yield per unit of gear. Rep. Int. Fish. (Pacific Halibut) Comm. 8: 49p.

Table 1. Catch (t) and catch per hour fished, 1977 - 1987, Hopedale Channel.

	1977		1978		1979		1980		1981		1982		1983		1984		1985		1986		1987	
Month	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE
May									5	.201												
Jun					197	.902	29	.812	408	.454	171	.396	167	.366					10	.298		
Jul			132	.735	965	.594	737	.596	361	.300	303	.351	253	.297	40	.453	80	.245	173	.563	1807	.659
Aug	94	.532	86	.506	887	.314	589	.397	474	.329	219	.348	2	.191	35	.238	453	.310	417	.731	1008	.657
Sep	206	.638	69	.328	111	.263	606	.292	555	.360	68	.192	2	.123	50	.201	182	.148	823	.506	918	.564
Oct	331	.316	585	.477			390	.334	406	.380	246	.367			335	.309	404	.202	736	.494		
Nov	642	.696	470	.432			163	.536	469	.363	471	.491	370	.311	100	.350	370	.252	309	.458	12	.300
Dec									168	.524	113	.336	71	.198	56	.261	30	.330			90	.391
Total[1]	1272	.516	1340	.467	2160	.424	2514	.399	2848	.365	1591	.375	865	.299	616	.298	1520	.231	2468	.525	3834	.622
Total[2]	1203		2109		2693		3938		3382		1708		1014		712		1539		3483[3]		4615[3]	
TAC			4500		3200		4000		4000		4000		4000		3500		2800		3400		4000	

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

Table 2. Biomass estimates (t) and 95% confidence intervals for shrimp in Hopedale Channel, 1979 - 1987.

Year	Mean	Upper	Lower	Area (sq. n. mi.)	No. Sets
1979	17800	33642	1958	2302	56
1980	14739	23220	6258	2802	84
1981	4914	7015	2813	2724	56
1982	11563	15370	7757	2724	76
1983	8236	9688	6784	2778	87
1984	8534	12238	4830	2456	60
1985	12756	20372	5140	3385	69
1986	10102	14951	5254	3198	78
1987	6037	8788	3287	3198	74

Table 3. Biomass estimates (t) and 95% confidence intervals for Greenland halibut and cod in Hopedale Channel, 1979 - 1987.

	Greenland halibut			Cod		
Year	Mean	Upper	Lower	Mean	Upper	Lower
1979	4785	6563	3007	649	3341	-
1980	23621	27876	19365	2043	2642	1443
1981	9105	13363	4848	788	2093	-
1982	12239	14049	10430	2655	4123	1187
1983	24018	27434	20602	1622	2367	878
1984	18602	21759	15445	1435	2488	383
1985	11746	18354	5138	897	1356	437
1986	5000	8915	1084	688	972	403
1987	2780	5016	543	16	30	3

Table 4. Catch (t) and catch per hour fished, 1977 – 1987, Cartwright Channel.

	1977		1978		1979		1980		1981		1982		1983		1984		1985		1986		1987	
Month	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE
Jan																					64	.993
Jun							23	.187			114	.340	3	.111					1	.156	729	.702
Jul	312	.813	156	.479	147	.658	12	.453	7	.255					51	.301					166	.504
Aug	515	.624	400	.633	148	.264	22	.292	5	.155	1	.255			38	.343	1	.131				
Sep	234	.454	638	.395	422	.217	56	.264	1	.202			>1	.053	143	.313	1	.049				
Oct	14	.181	45	.190			>1	.058							19	.224						
Nov	74	.691					4	.107							7	.157			81	.591		
Dec	10	.449									29	.370			>1	.023			1126	.593		
Total[1]	1158	.600	1239	.441	718	.263	117	.245	13	.200	143	.345	3	.105	258	.297	2	.064	1208	.592	958	.670
Total[2]	1414		1521		1034		170		67		167		3		312		–		1248[3]		1061[3]	
TAC			800		800		800		800		800		800		700		770		1000		800	

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

Table 5. Biomass estimates (t) and 955 confidence intervals for shrimp in Cartwright Channel, 1979 - 1987.

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[1]	1111	1446	775	713	56
1984	3113	4863	1362	880	47
1985	2574	3523	1625	633	45
1986	1803	2494	1111	881	45
1987	4578	5662	3494	881	43

[1] Expanded stratified area from 1983 to 1987.

Table 6. Biomass estimates (t) and 95% confidence intervals for Greenland halibut and cod in Cartwright Channel, 1979 - 1987.

	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
1987	3133	3698	2569	30	77	-

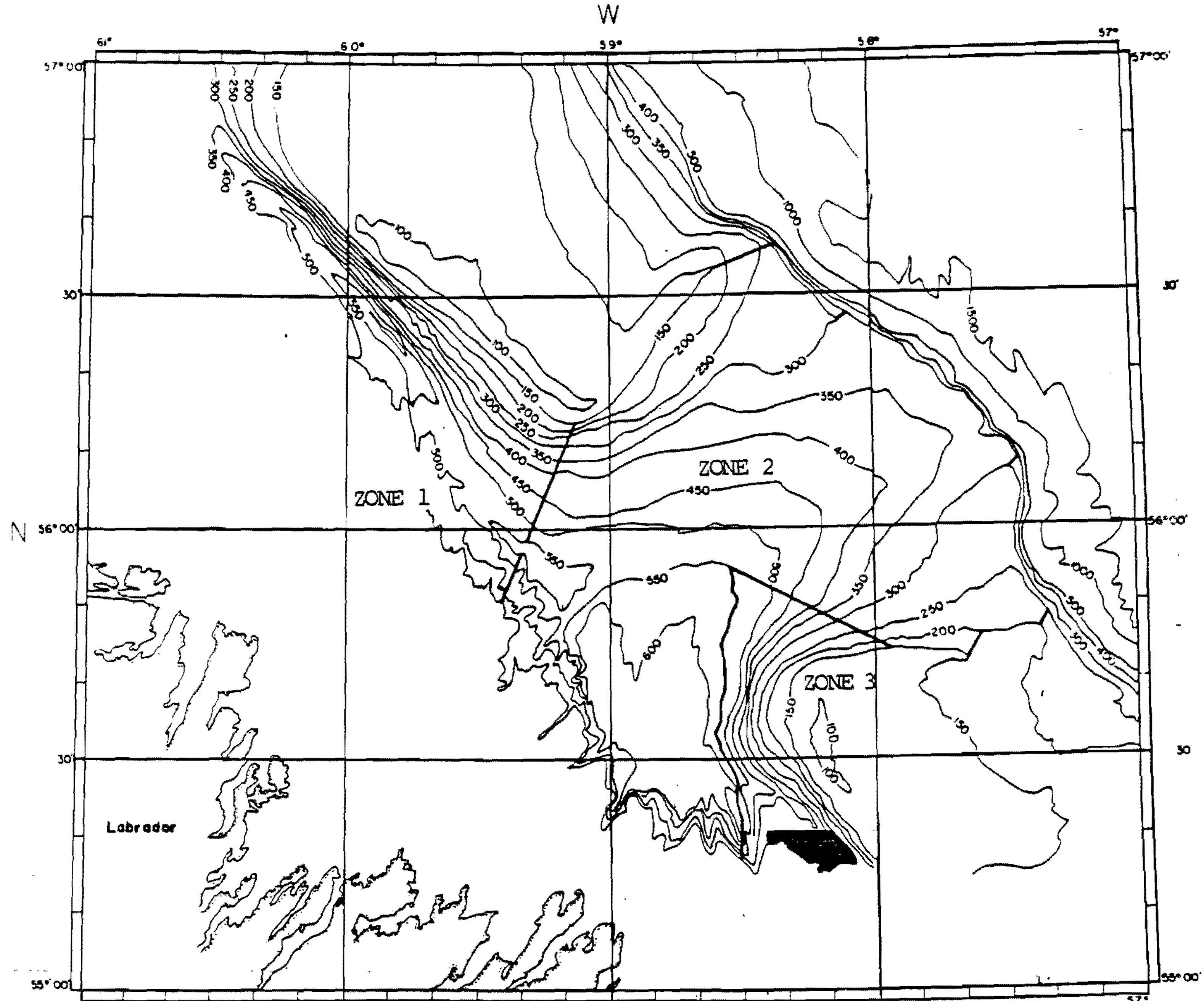

Fig. 1. Stratification of the Hopedale Channel for northern shrimp surveys. Darkened area - - exploratory fishing.

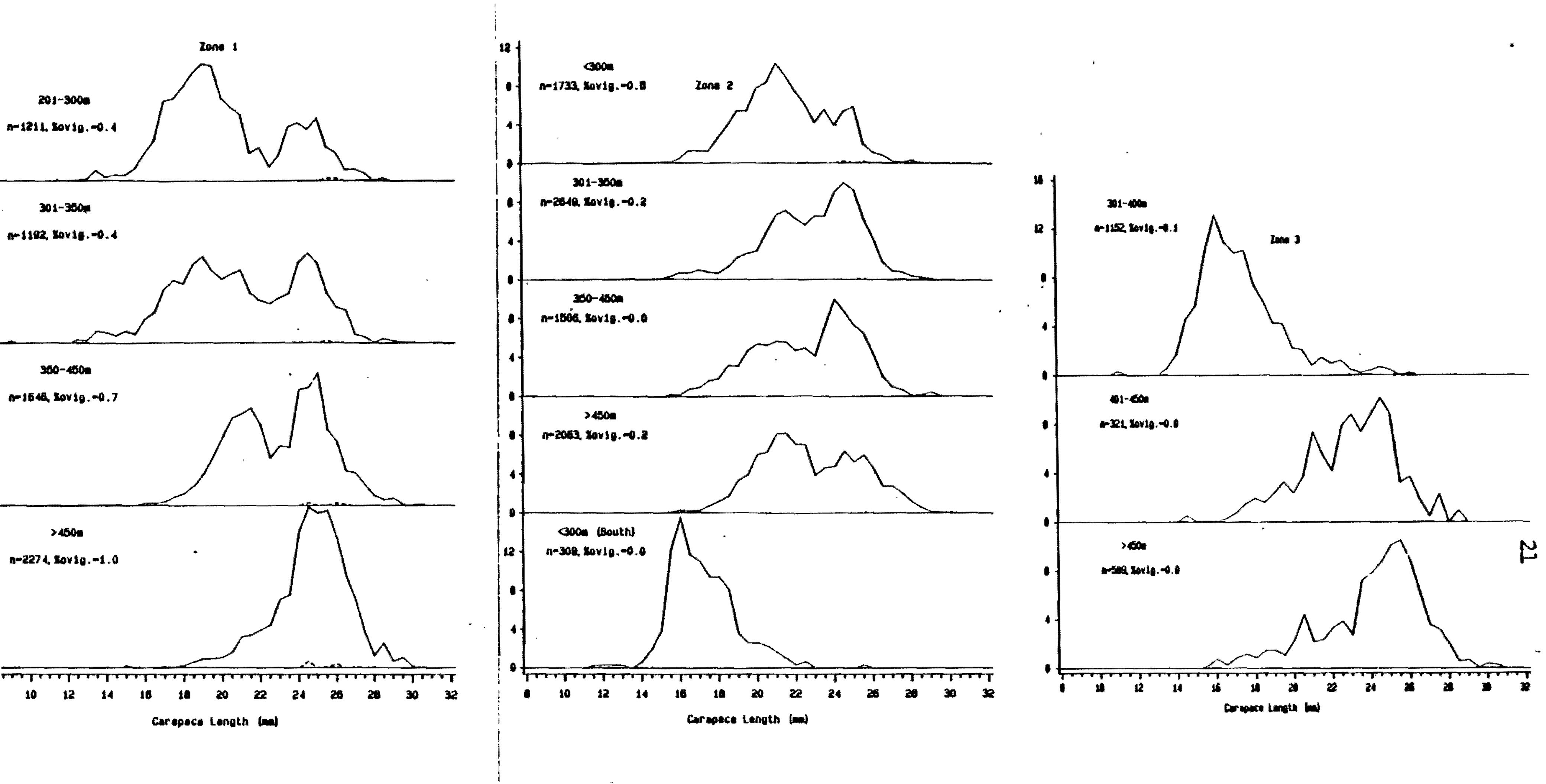

Fig. 2. Size distributions of shrimp in Hopedale Channel from the July 1987 research survey. (Broken line = ovigerous)

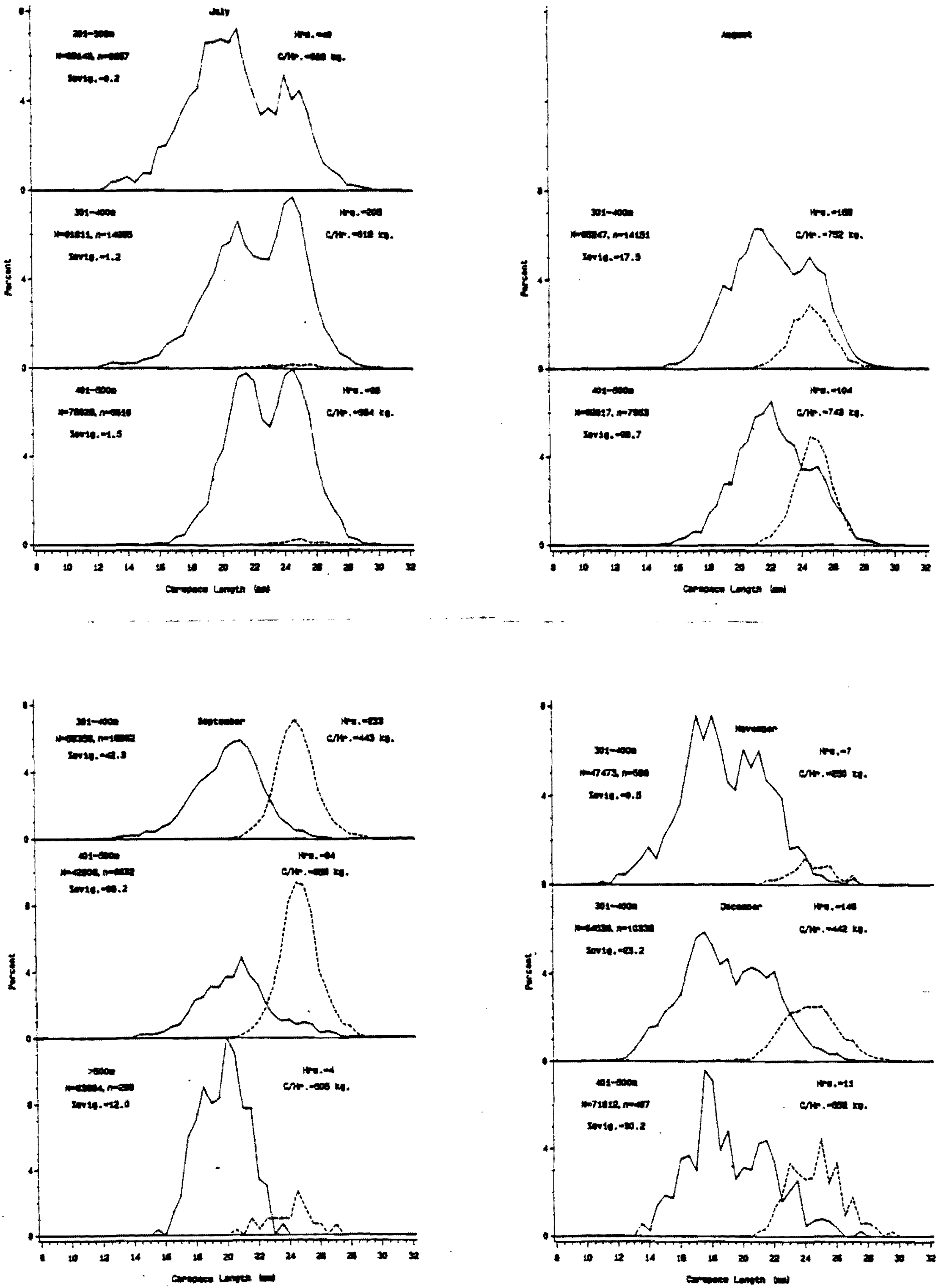

Fig. 3 Commercial length frequencies of shrimp taken from the fishery in Hopedale Channel,1987.
N=number caught per hour, n=number measured, broken line=ovigerous.

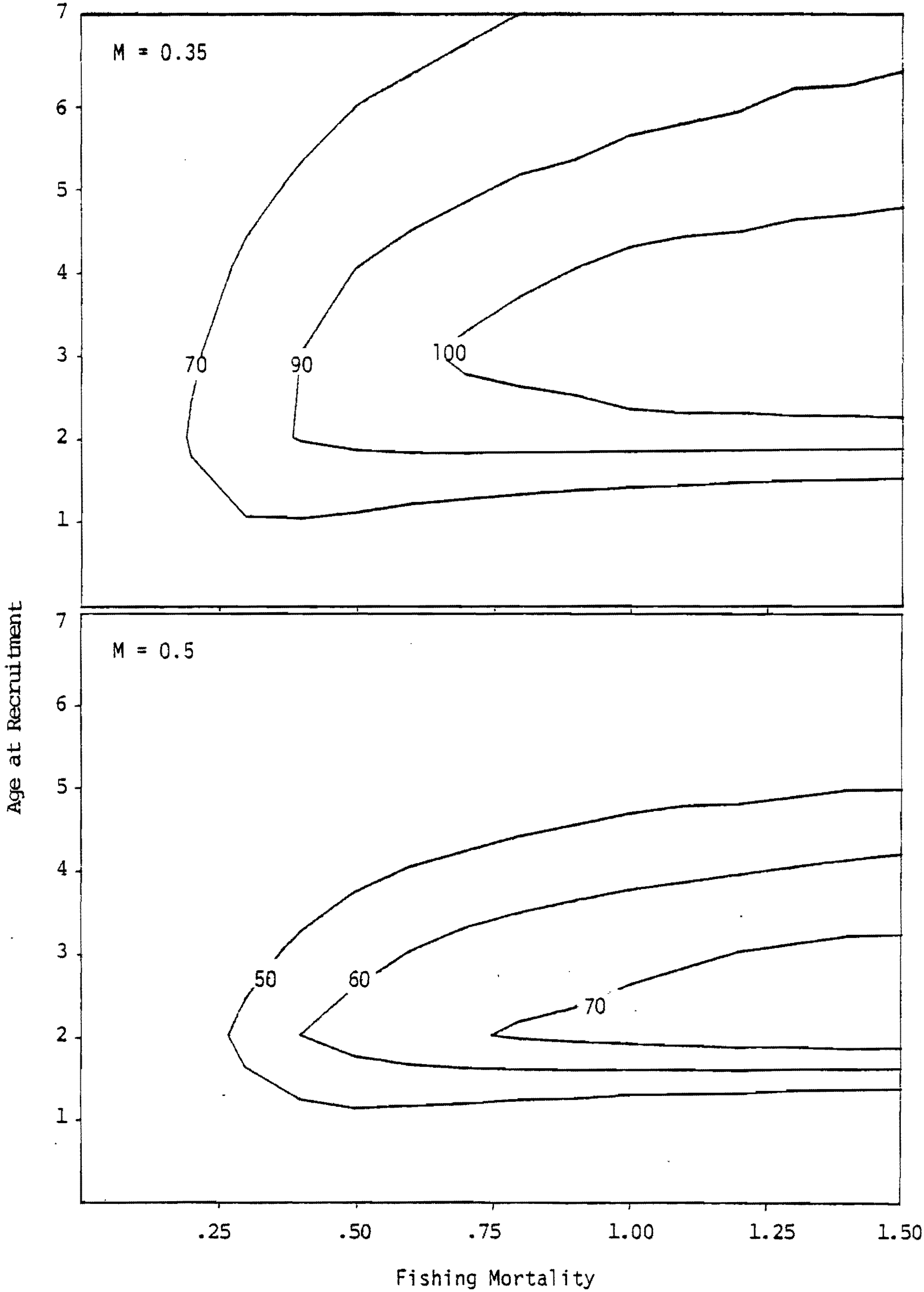

Fig. 4. Yield per 100 recruits at two levels of natural mortality for shrimp in Hopedale Channel.

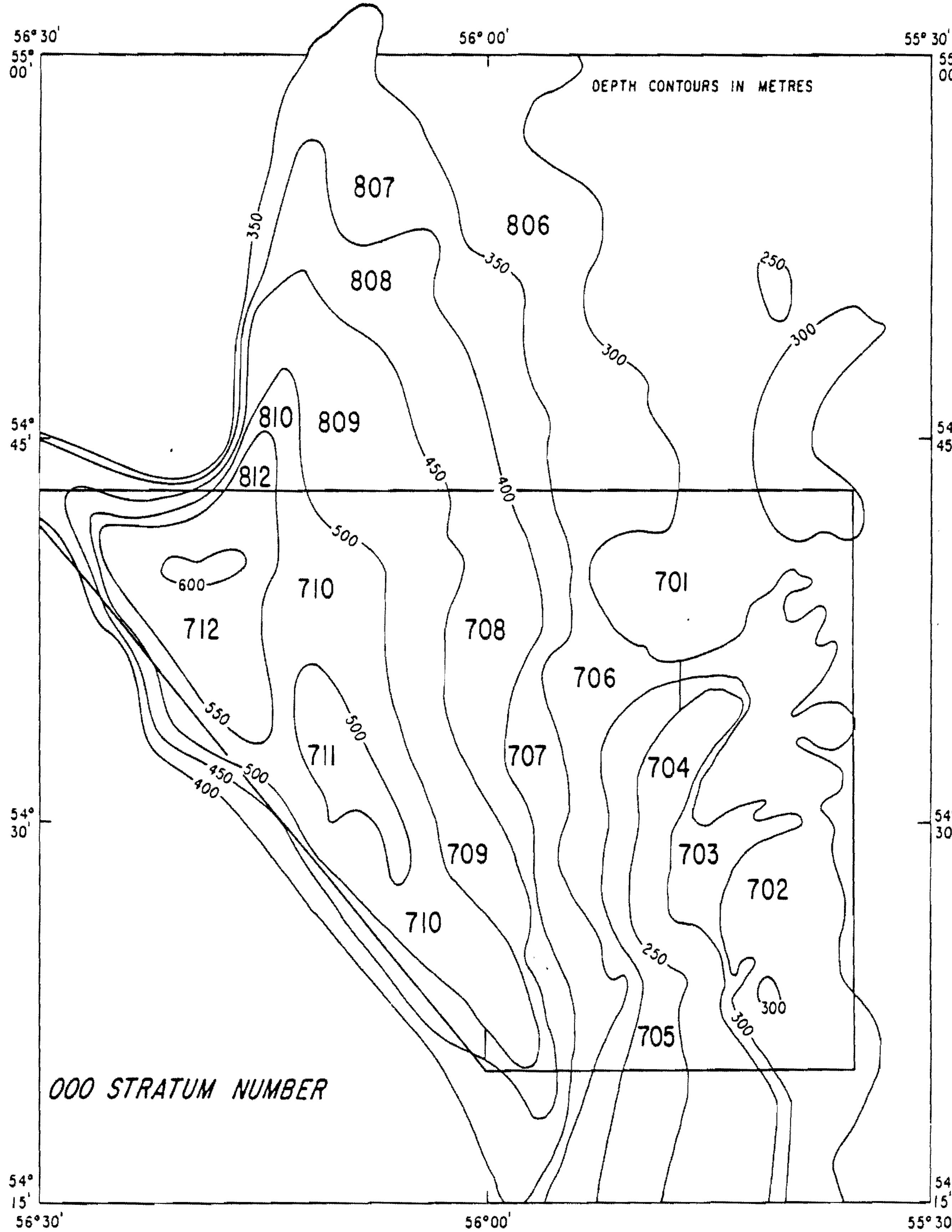

Fig. 5. Stratification of the Cartwright Channel.

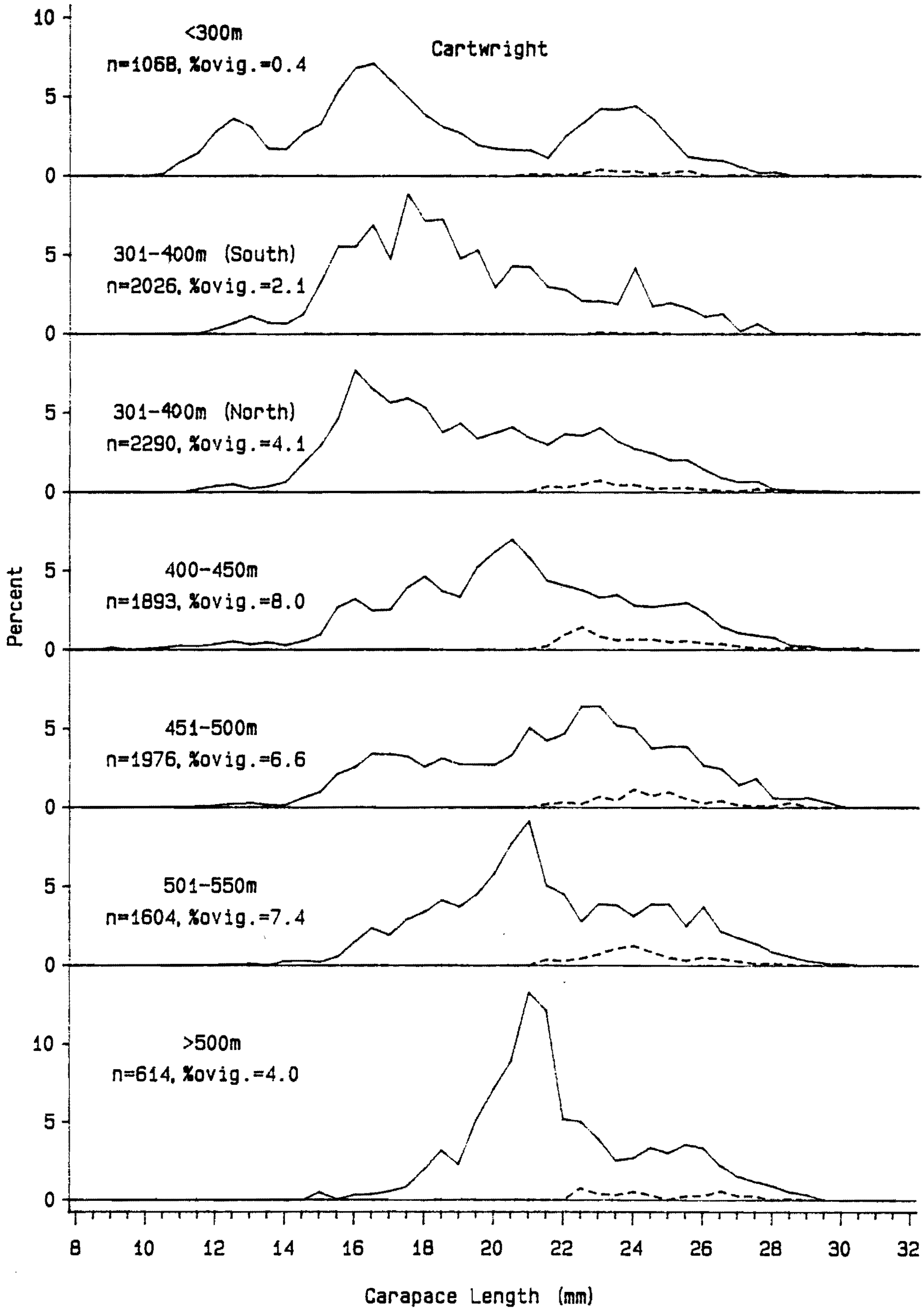

Fig. 6. Length distributions of shrimp taken from Cartwright Channel July, 1987 (research)
Solid line = non-ovigerous, broken = ovigerous, n = number measured.

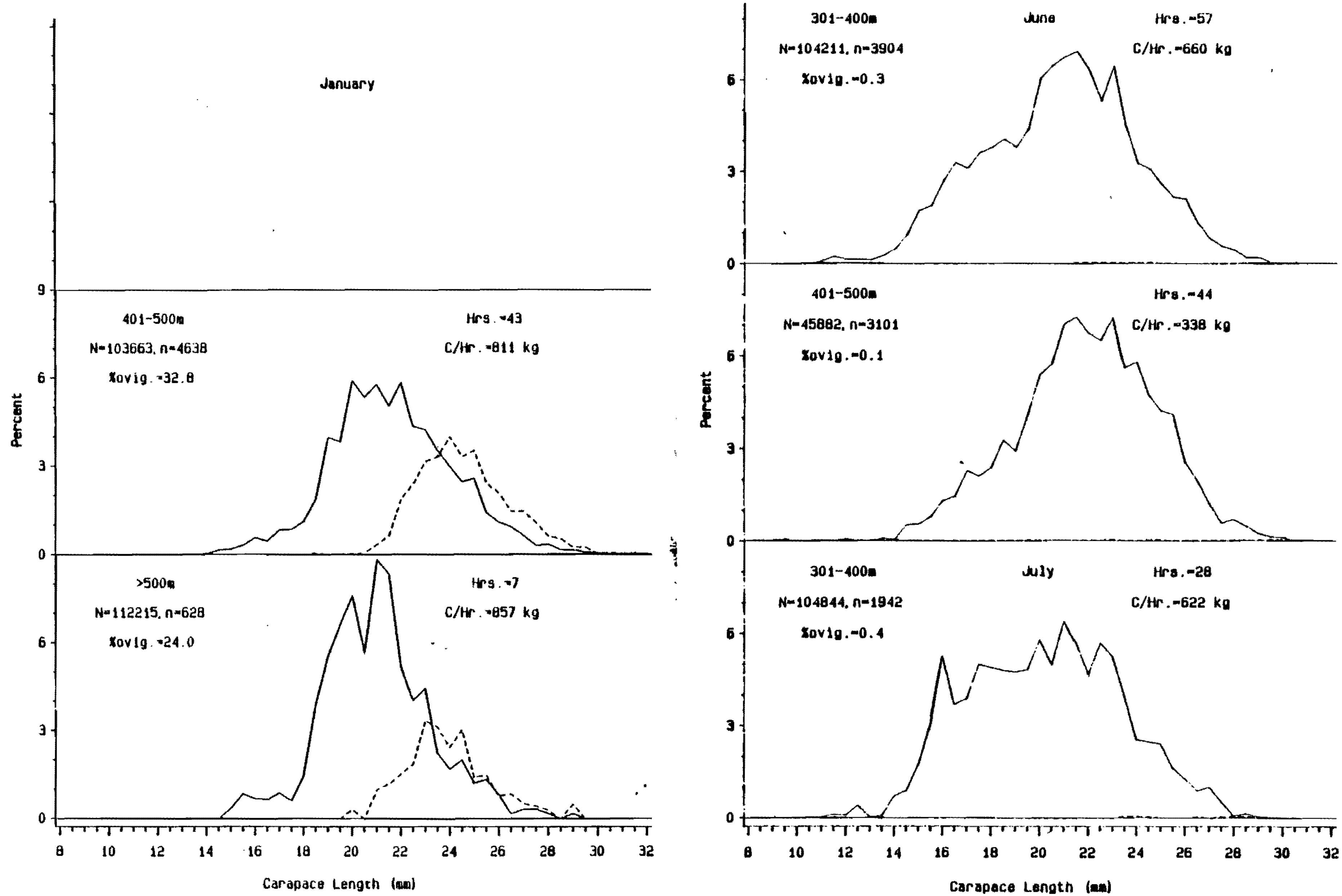

Fig. 7. Commercial length frequencies of shrimp taken from the fishery in Cartwright Channel, 1987.
N = number caught per hour, n = number measured, broken line = ovigerous.

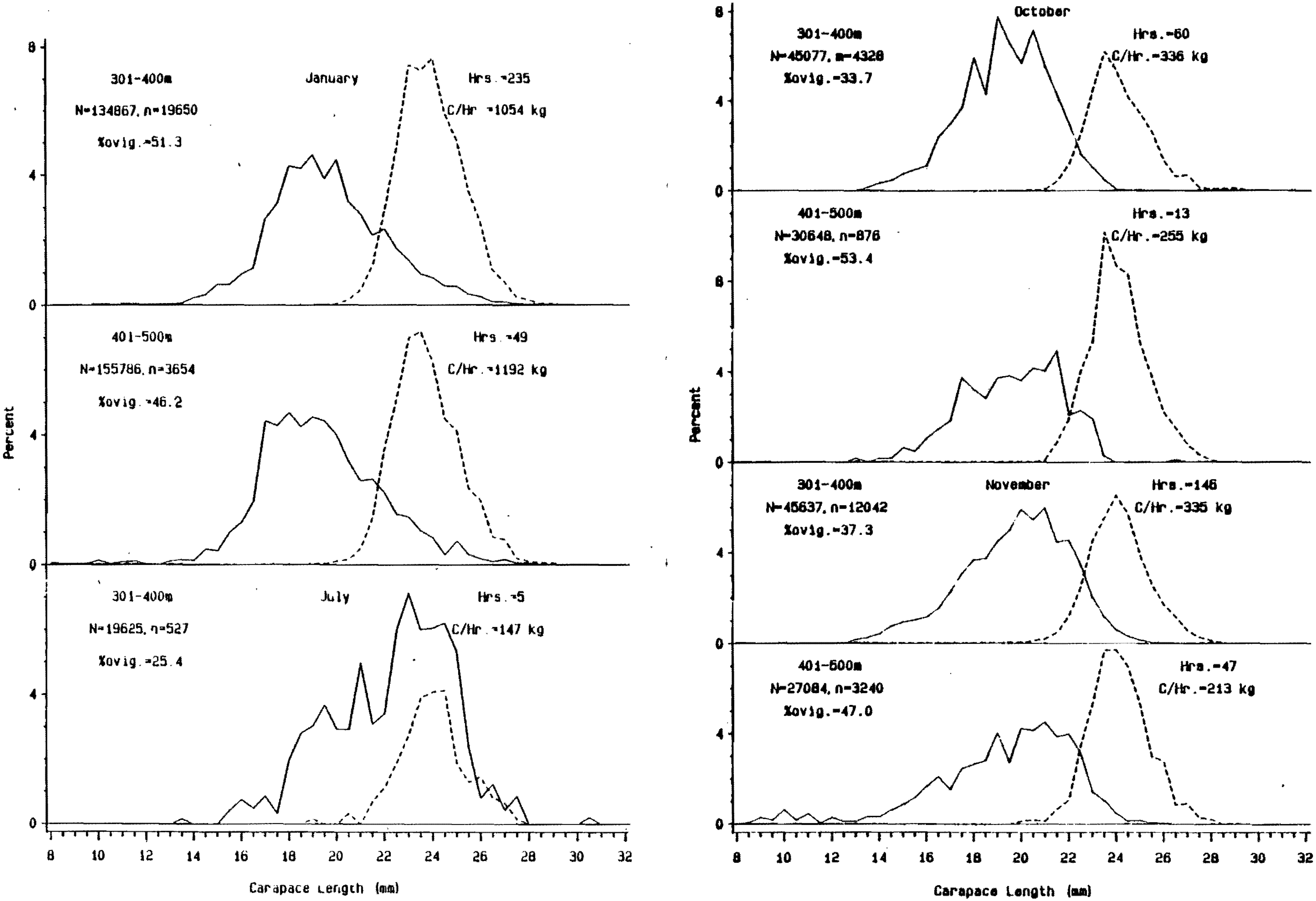

Fig. 8. Commercial length frequencies of shrimp taken from the fishery in Hawke Channel, 1987. N = number caught per hour, n = number measured, broken line = ovigerous.

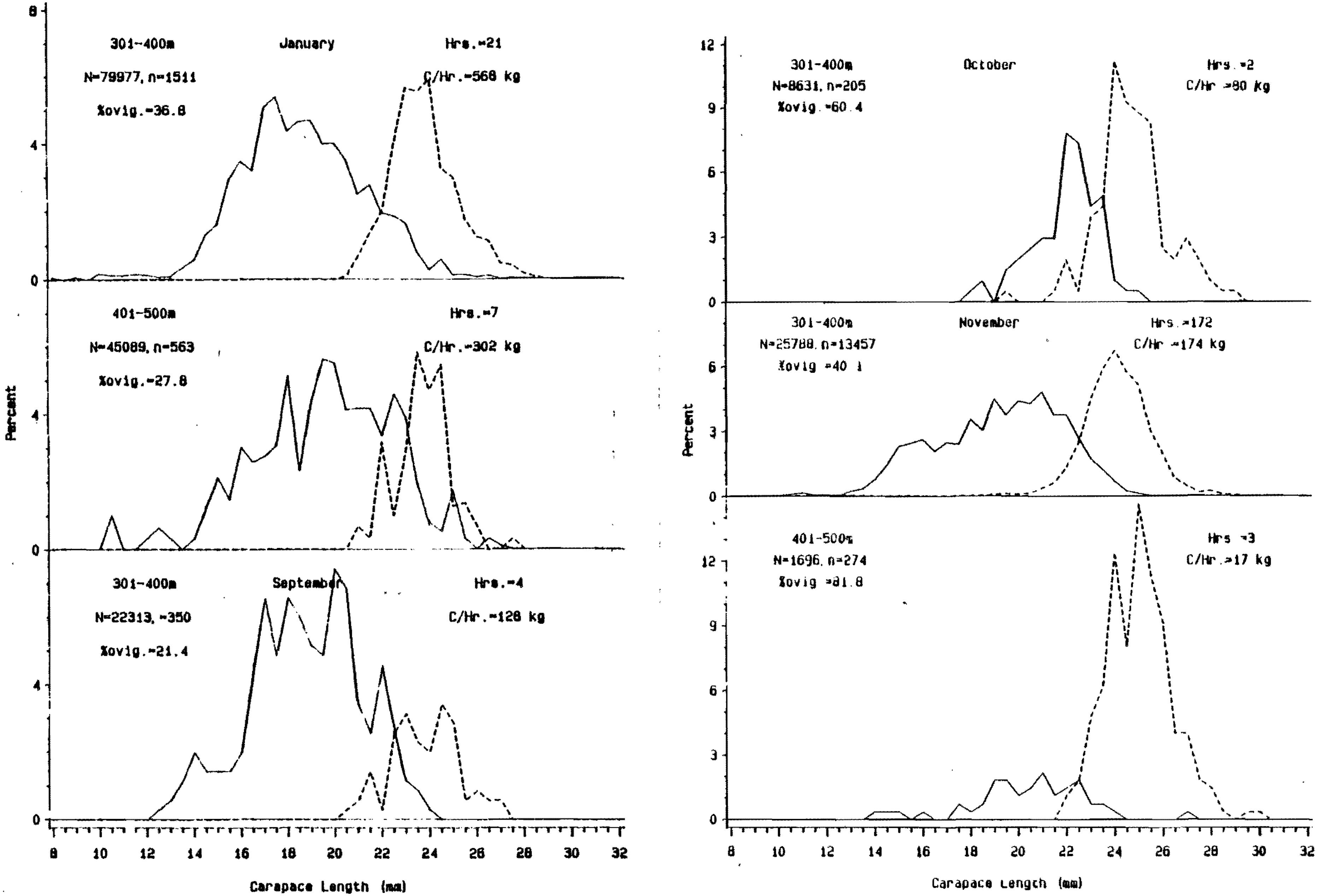

Fig. 9. Commercial length frequencies of shrimp taken from the fishery in St. Anthony Basin, 1987.
N = number caught per hour, n = number measured, broken line = ovigerous.

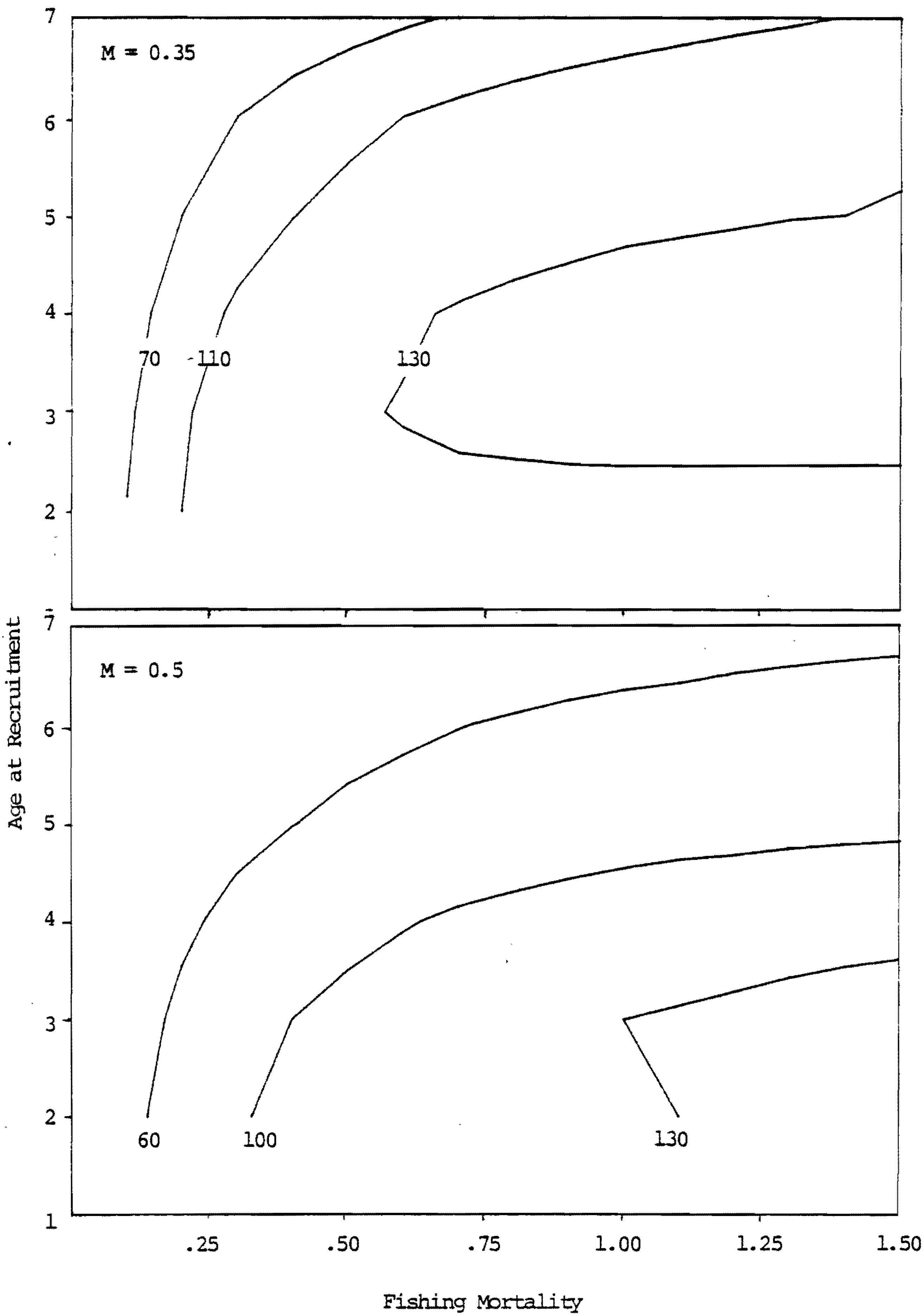

Fig. 10. Yield per 100 recruits at two levels of natural mortality for shrimp in the St. Anthony Basin.