Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 91/32

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 91/ 32

Relative Selectivity of Four Sampling Methods Using Traps and Trawls for Male Snow Crabs (*Chionoecetes opilio*)

by

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Abstract

Catch rate and catch composition of male snow crabs were compared for four sampling methods. These methods were: (1) large-meshed commercial traps, (2) small-meshed traps, (3) bottom trawl deployed during the day, and (4) bottom trawl deployed at night. Catches were characterized in terms of crab body sizes, shell conditions, and claw allometry. We concluded that: 1) mean and modal size of crabs captured in large-meshed traps was larger than those captured in small-meshed traps which, in turn, were larger than those caught in the trawl; the size of crabs caught in the trawl at night was larger than those caught during the day; 2) large-clawed crabs predominated in the catches from traps whereas small-clawed animals predominated in the trawl catches; 3) soft-shell crabs were more common in trawl than in trap catches whereas old-shell crabs were more common in trap than in trawl catches; 4) mean size of the crabs caught increased with depth for all sampling methods, but especially so for traps; and 5) catch per unit effort for both large- and small-clawed crabs increased with depth for all sampling methods.

Résumé

On a comparé les taux de prises et la composition de crabes des neiges mâles prélevés au moyen des quatre méthodes d'échantillonnage suivantes : 1) casiers commerciaux à grosses mailles, 2) casiers à petites mailles, 3) chaluts de fond mouillés durant le jour et 4) chaluts de fond mouillés durant la nuit. On a déterminé la taille du corps, la condition de la carapace et l'allométrie des pinces des crabes capturés. Il s'est avéré que: 1) la taille modale et moyenne des crabes pêches dans les casiers à grosses mailles était supérieure à celle des crabes provenant des casiers à petits mailles, celle-ci étant toutefois supérieure à la taille des crabes pêches au chalut; en outre, les crabes capturés au chalut la nuit était plus gros que ceux capturés au chalut de jour; 2) les crabes à grosses pinces prédominaient dans les prises provenant des casiers, tandis que les spécimens à petites pinces étaient plus nombreux dans les prises au chalut; 3) les crabes à carapace molle étaient plus nombreux dans les prises au casier et les crabes à carapace plus vieille prédominaient dans les prises au chalut; 4) la taille moyenne des crabes capturés augmentait avec la profondeur dans le cas des quatre méthodes d'échantillonnage, quoique de manière encore plus prononcée parmi les captures au casier et 5) les prises par unité d'effort des crabes à grosses pinces ou à petites pinces augmentaient avec la profondeur dans tous les cas.

The fisheries for male snow crab (*Chionoecetes opilio*) in Atlantic Canada are prosecuted exclusively with baited traps. Traps are of various designs and are regulated in size of mesh to allow escapement of both sublegal-sized males less than 95 mm carapace width (cw) and of females which never attain the legal size for males. Conical traps, with a minimum mesh size of 13.3 cm, are used in Newfoundland. In some regions of Atlantic Canada, assessment of snow crab stocks is made on the basis of surveys conducted with commercial-type traps and with special, small-meshed traps. The rationale for this is that the large-meshed, commercial-style traps provide an index of abundance of recruited biomass while the small-meshed traps provide an index of pre-recruits. In other regions, the stock assessments are made on the basis of trawl surveys which provide estimates of minimum trawlable biomass.

The importance of understanding the size selectivity of fishing gear used in any fishery regulated by size is obvious. For snow crab fisheries, there are three other reasons for needing information on gear selectivity. First, if trawl data are to be useful for predicting conditions in the commercial fishery, the relative catchability of the commercial traps and the trawl must be understood. Second, recently molted crabs are considered to be of inferior quality and are often discarded; thus, harvesting gear that is selective against newly molted crabs would be beneficial for conservation purposes. Third, some researchers believe that male snow crabs undergo a terminal molt in concert with the development of large chelae (see Dawe et al. 1990 for a review of this question). The terminal molt theory leads to the conclusion that, in terms of yield per recruit, there is no reason to leave any hard-shelled, large-clawed males in the water whereas some small-clawed males should be left to grow. It would thus be of interest to know the true proportion of large-clawed and small-clawed crabs in the population and to determine if gear can be designed to fish selectively for large-clawed males.

This paper presents a comprehensive study of the relative selectivity of four types of sampling procedures with respect to the body size, shell condition and claw allometry of the crabs, as well as with respect to the depth of the water. The sampling procedures are: 1) commercial-type (large-meshed) traps, 2) small-meshed traps, 3) bottom trawl deployed during the day, and 4) bottom trawl deployed at night. Previous studies have shown that catch rate and size composition of snow crabs from traps are affected by mesh size, trap size and shape, and water depth (see Miller and O'Keefe 1981 and Moriyasu et al. 1990 for reviews). No study has considered the interaction of the biological characteristics listed above, the time of day, and the method of sampling.

Materials and Methods

All samples were collected within Conception Bay, Newfoundland during April 26 - May 4, 1988 or May 12 - May 22, 1989. Four sampling methods were used as follows: 1) commercial-type, top entry, steel-framed, conical traps of 122 cm diameter base, with stretched mesh-size of 13.3 cm and baited with squid, 2) small-meshed baited traps similar to those described above but with mesh-size of 2.5 cm, 3) Western II A bottom trawl with codend liner of 2.9 cm mesh, deployed during the day in sets of 30 min duration (effective fishing time), 4) the same bottom trawl, deployed as above, but used during the night. All four sampling methods were used in 1988 whereas only the two methods based on bottom trawling were utilized in 1989.

The two types of traps were fished together in fleets of twelve traps separated by 37 m. Typically, three to four small-meshed traps were spaced uniformly among the commercial-type traps. Soak time (duration of immersion) was approximately 24 hours.

Trawl stations were selected randomly within three strata which were defined by water depth. Stratum 1 comprised water 38 to 92 m depth; stratum 2, 93 - 184 m; stratum 3, greater than 184 m. Maximum water depth in the Bay is 294 m. At some trawl stations traps were fished for comparative purposes.

The maximum carapace width of each male examined was measured to the nearest millimeter with vernier calipers. Shell condition was judged according to the criteria of Taylor et al. (1990) and assigned to one of the following three categories: 1) soft-shelled animals which molted within the past three months, 2) new hard-shelled animals which molted more than three months ago but within the last molting season, and 3) old-shelled animals (skip-molters) which did not molt within the past year. The maximum height of the right chela, if present, was determined to the nearest 0.1 mm using vernier calipers.

Each specimen was assigned to one of the two groups "large-clawed" and "small-clawed" based on chela allometry. Specimens were partitioned between these groups based on whether the coordinates for chela height and carapace width fell above or below an arbitrary line which divides the more or less distinct clouds of points evident in Figures 1-4. The dividing line was obtained from an earlier study of snow crabs in Conception Bay in 1987 (Dawe et al. in review). Animals less than 50 mm cw are assumed to be small-clawed because the two clouds of points are indistinguishable below this size.

To minimize any confounding effects of depth in the analyses of relative selectivity of sampling methods, analyses were conducted separately for the three depth strata. Data from stratum 1 were not sufficient for use in the study of relative selectivity of methods by body size, shell condition, and chela category. However, they were used in the analysis of depth distribution.

Results

Relative Selectivity by Body Size

There was much variability among sampling methods in relative selectivity by body size. Size distributions in 1988 showed that in both depth strata large-meshed (commercial-type) traps selected larger crabs than did small-meshed traps (Figures 1 and 2). The large-meshed traps caught predominantly commercial-sized (≥ 95 mm cw) crabs in stratum 3 (the deep stratum) whereas they caught mostly sub-legal (< 95 mm cw) crabs at the lesser depths of stratum 2 (Figures 1 and 2). Both trawling methods collected much smaller crabs in general than did the small-meshed traps in 1988 within both depth strata. That difference was most pronounced in stratum 2 where the modal size interval was 51-55 mm cw for each trawling method, whereas the modal size was 61-65 mm for small-meshed traps and 86-90 mm for large-meshed traps (Figure 1). Mean body size of crab trawled during the night was greater than that of those trawled during the day for both strata in 1988 (Figures 1 and 2) but especially in the deeper stratum (Figure 2).

Our results from bottom trawling in 1989 were similar to those in 1988 but diel effects on the trawl catches were less pronounced for both depth strata (Figures 3 and 4). This was probably related to the overall smaller sizes of crabs collected in 1989 than during the preceding year.

Relative Selectivity by Chela Allometry

Relative selectivity with respect to chela allometry was striking in depth stratum 2 in 1988 (Figure 1). Traps of both types captured predominantly large-clawed crabs. This is especially true of large-meshed traps, from which 96% of the crabs caught were large-clawed. In contrast, the trawl caught more small-clawed than large-clawed crabs with the proportion of small-clawed crabs being greater in the day (79%) than at night (68%).

Selectivity by chela allometry and body size are obviously related since the largest crabs have large chelae and the smallest crabs have small chelae (Figure 1). However, that both types of traps collected mostly large-clawed crabs at body sizes as small as 51-55 mm cw (Figure 1) indicates that strong selectivity for large-clawed crabs was taking place.

Patterns of relative selectivity for chela allometry in depth stratum 3 in 1988 were similar to those in stratum 2 but even more pronounced (Figure 2). That was at least partly because, for all four methods, body sizes were larger at the greater depths of stratum 3 than in stratum 2 and chela allometry is related to body size.

Relative Selectivity with Respect to Shell Condition

In both depth strata in 1988, soft-shelled (recently molted) crabs were virtually absent from trap catches but were well represented in trawl catches, accounting for between 18 and 59 % of the crabs caught (Figures 5 and 6). The carapaces of most of these trawled, very recently molted crabs were not yet brittle and were probably too soft to provide skeletal support. Later in the year, trap catches contain recently molted, soft-shelled crabs whose carapaces have attained an easily-shattered brittleness. Peak catches of soft-shelled crabs in traps occurred in June in 1978 in Conception Bay but may occur between July and September in other areas of Newfoundland (Miller and O'Keefe 1981).

The occurrence of soft-shell crabs was much lower in 1989 than in 1988 in the trawl catches (Figures 7 and 8). However, the size compositions of the soft-shell crabs were grossly similar in the two years.

Trends in Catch Numbers and Size Composition with Depth

Catch rate increased with depth for all four sampling methods (Figures 9 and 10). The catch rate for small-mesh traps was larger than for large-mesh traps at all depths.

Mean size of crabs increased with depth for all sampling methods in both years (Figures 11 and 12). This trend was most notable for traps, where mean size increased progressively to the maximum depth sampled.

Discussion

It is difficult to design experiments that will clearly demonstrate the differences in fishing performance of various sampling gears. This is because fishing gear can only catch what is in the water; thus for example, if there are no very large crabs in the area then one will not observe differences in catch rates for this size group. Our study noted that trawls caught considerable numbers of soft shell crabs whereas traps did not. If we had conducted our study later in the year when there were almost no more soft shell crabs left, then we would have missed noting this difference. We noted that differences in catch composition among sampling gears was not always consistent from depth stratum to depth stratum. This could be explainable by the fact that the populations being sampled in the two strata were different in composition. Similarly, populations can vary from year to year. It was for these reasons that we analyzed our data separately by depth stratum and year to minimize confounding relative catchability with availability.

Our study shows significant, consistent differences in relative selectivity of sampling gears. In particular, large-meshed traps seem ideally suited for selective harvesting of non-soft shell, large-clawed males. This may be an important consideration since it has been suggested that harvest be limited to such animals.

If trawl surveys are to be used to predict biomass available to the commercial fishery, it seems essential to characterize the catch in terms of body size, claw type, and shell condition since these factors affect availability to the commercial fishing gear. It must also be recognized that at present we have no way of knowing how the catch compositions obtained from the various sampling methods compare to the actual composition of the population. However it seems to us that the trawl, deployed at night, provides the most representative picture of the population. This is because the trawl captures the broadest size range, including some very large animals, it samples all shell conditions, and it catches predominately small-clawed males. In an exploited population, such as in Conception Bay, we would not expect to find a large accumulation of old crabs with large claws. Rather, one would expect a large proportion of the population to be younger animals with small claws.

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1988 STRATUM 2

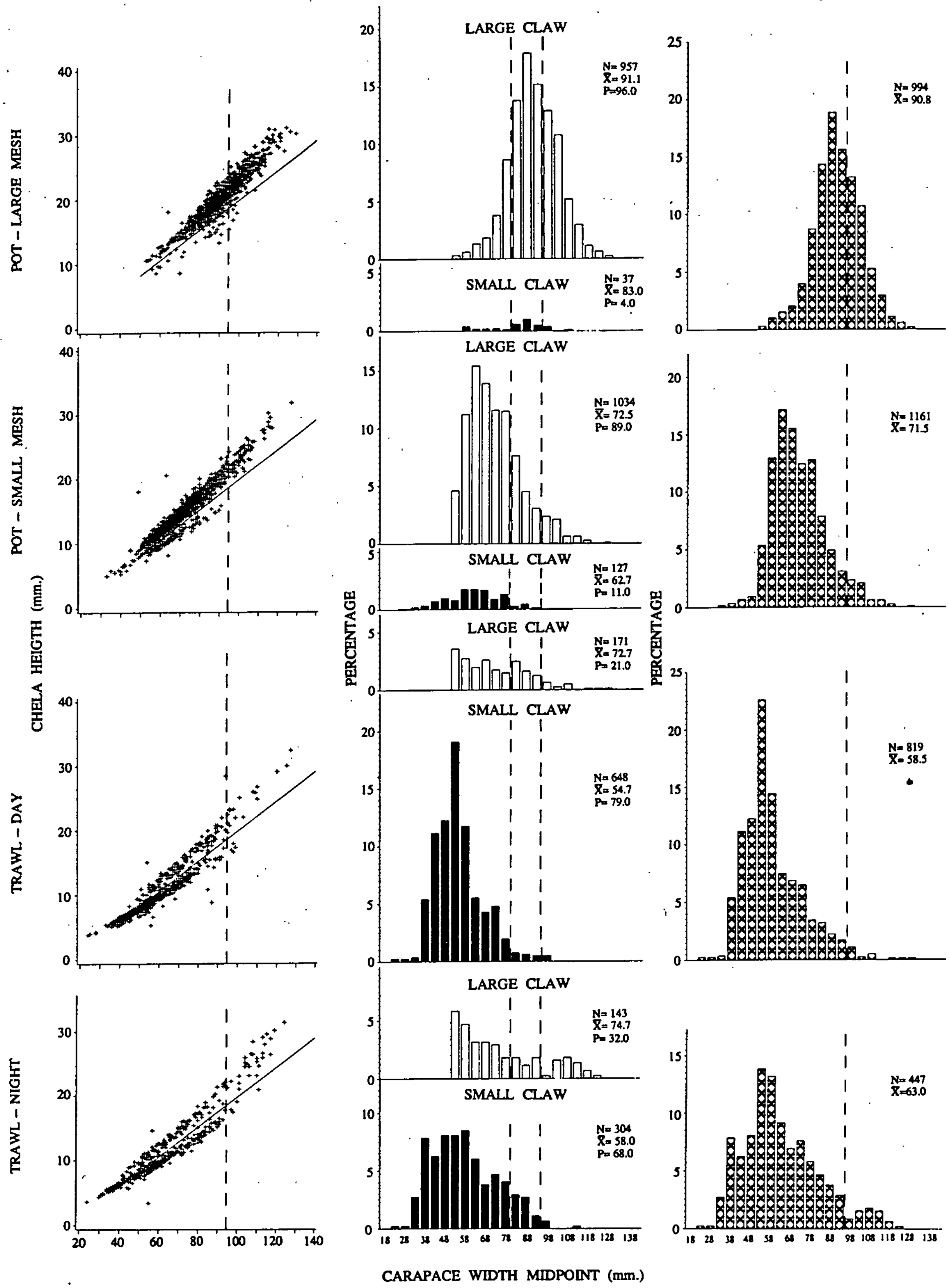

Fig. 1. Comparison of four sampling methods with respect to male snow crab chela allometry - body size relationships (left and centre), and overall body size distribution (right) for depth stratum 2 in 1988.

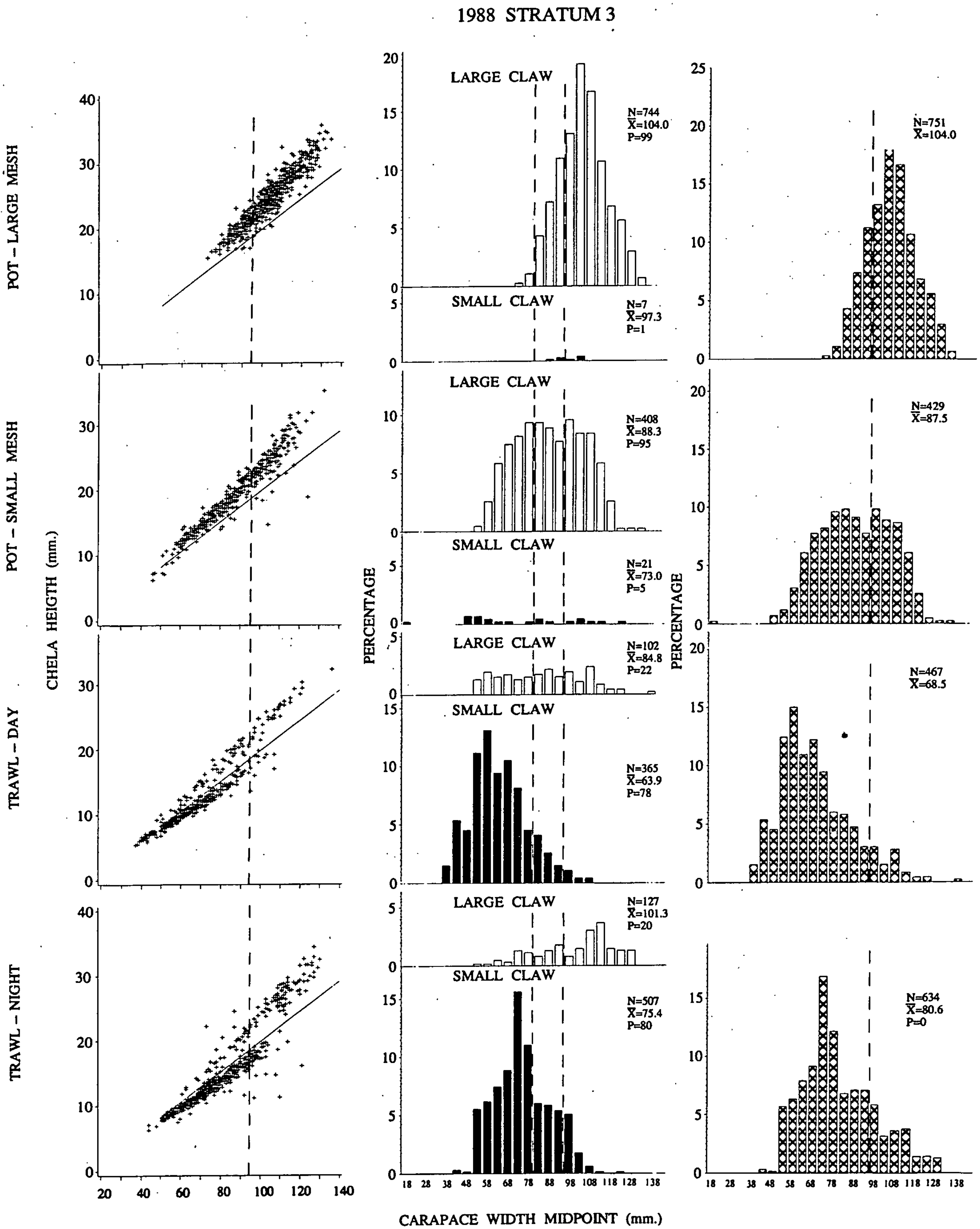

Fig. 2. Comparison of four sampling methods with respect to male snow crab chela allometry - body size relationships (left and centre), and overall body size distribution (right) for depth stratum 3 in 1988.

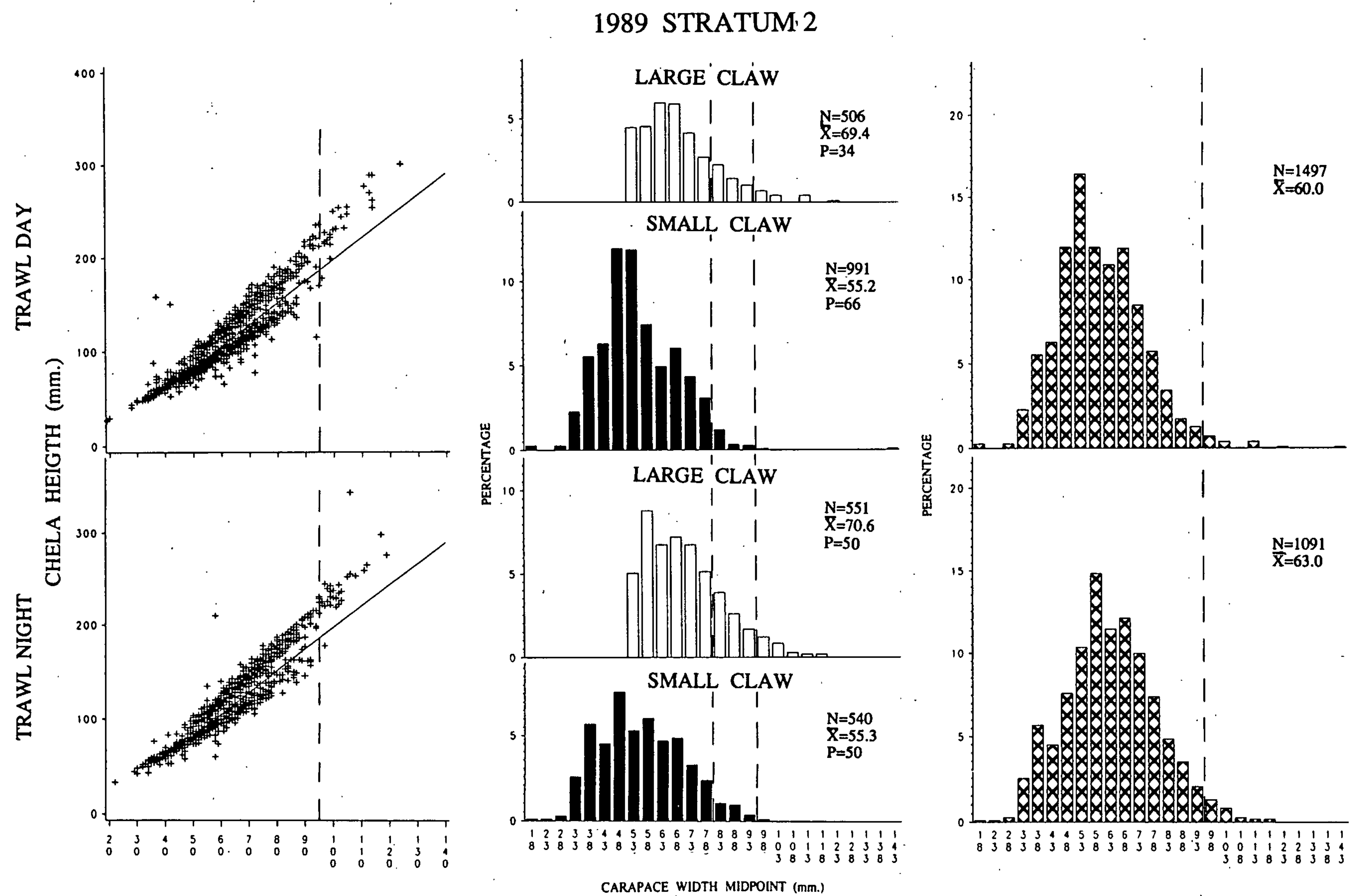

Fig. 3. Comparison of four sampling methods with respect to male snow crab chela allometry - body size relationships (left and centre), and overall body size distribution (right) for depth stratum 2 in 1989.

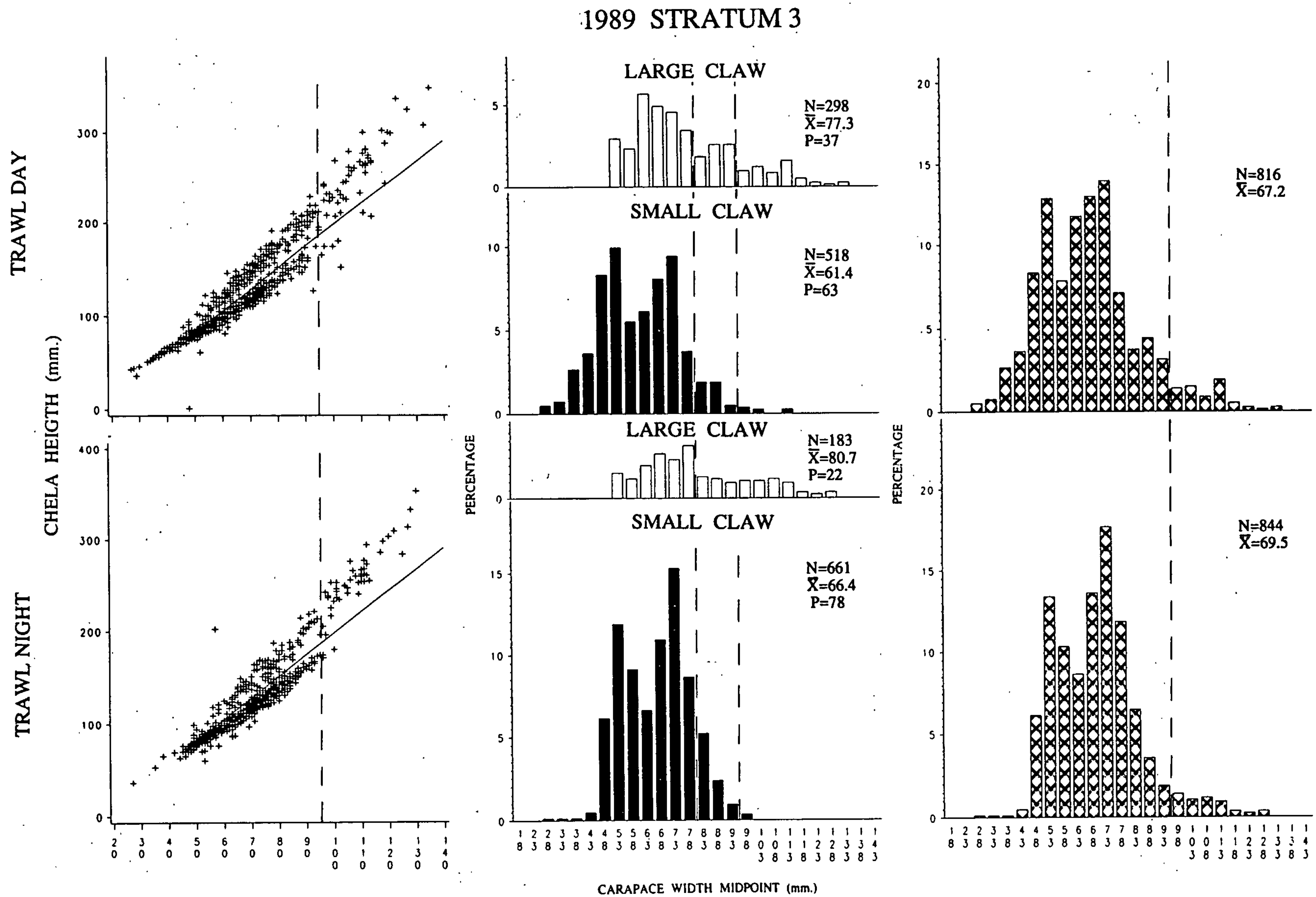

Fig. 4. Comparison of four sampling methods with respect to male snow crab chela allometry - body size relationships (left and centre), and overall body size distribution (right) for depth stratum 3 in 1989.

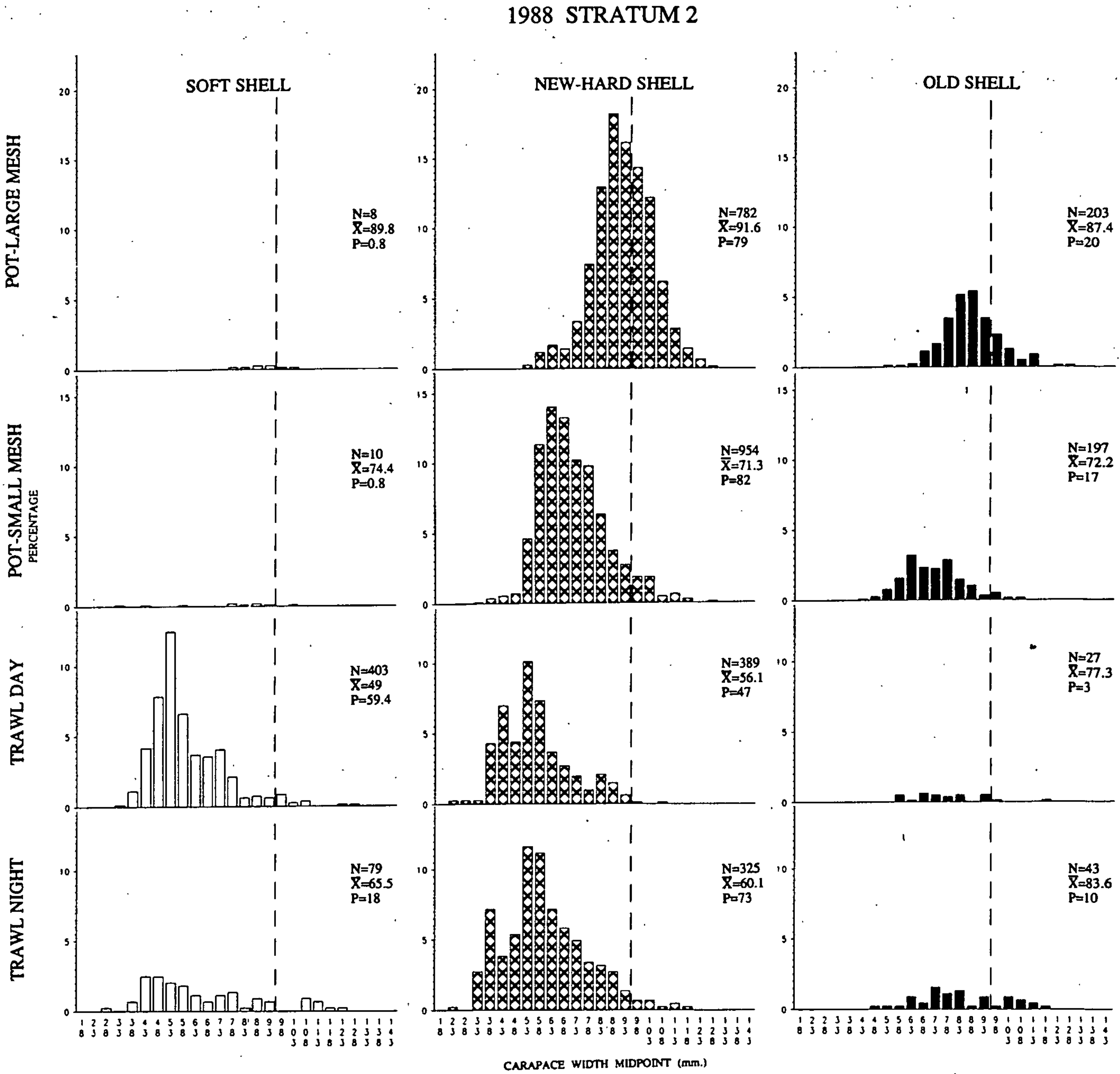

Fig. 5. Comparison of four sampling methods with respect to male snow crab shell (carapace) condition - body size relationships for depth stratum 2 in 1988.

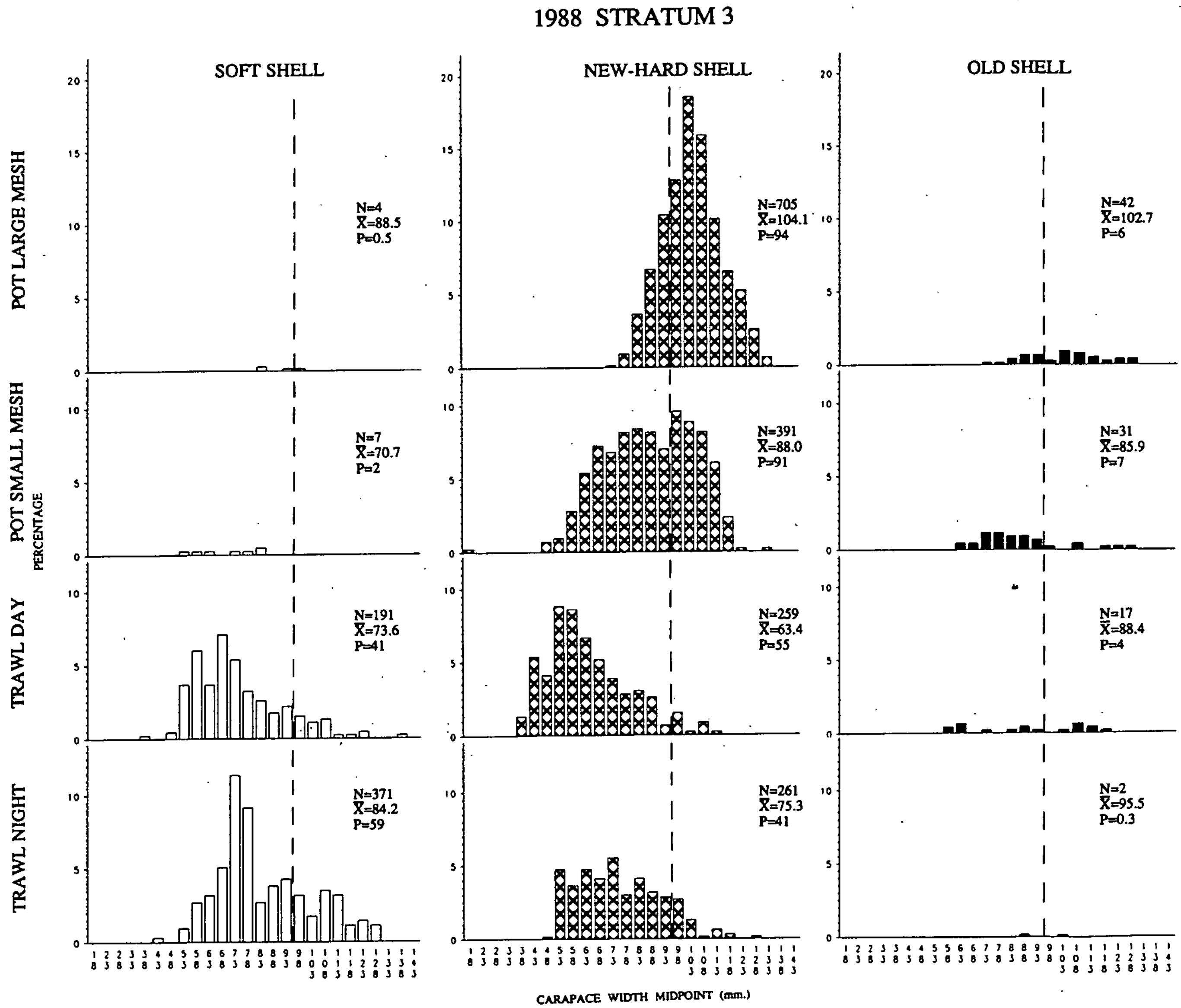

Fig. 6. Comparison of four sampling methods with respect to male snow crab shell (carapace) condition - body size relationships for depth stratum 3 in 1988.

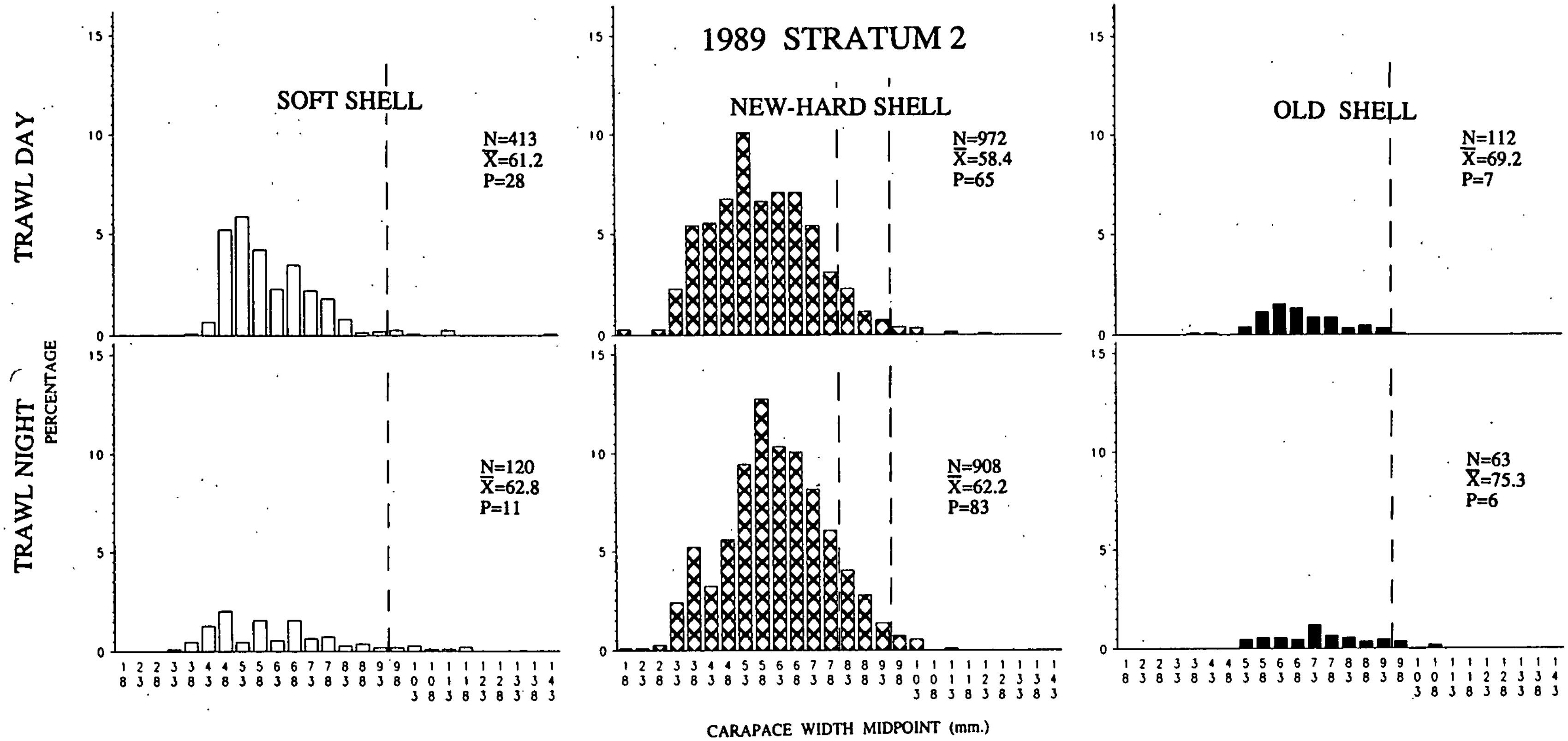

Fig. 7. Comparison of four sampling methods with respect to male snow crab shell (carapace) condition - body size relationships for depth stratum 2 in 1989.

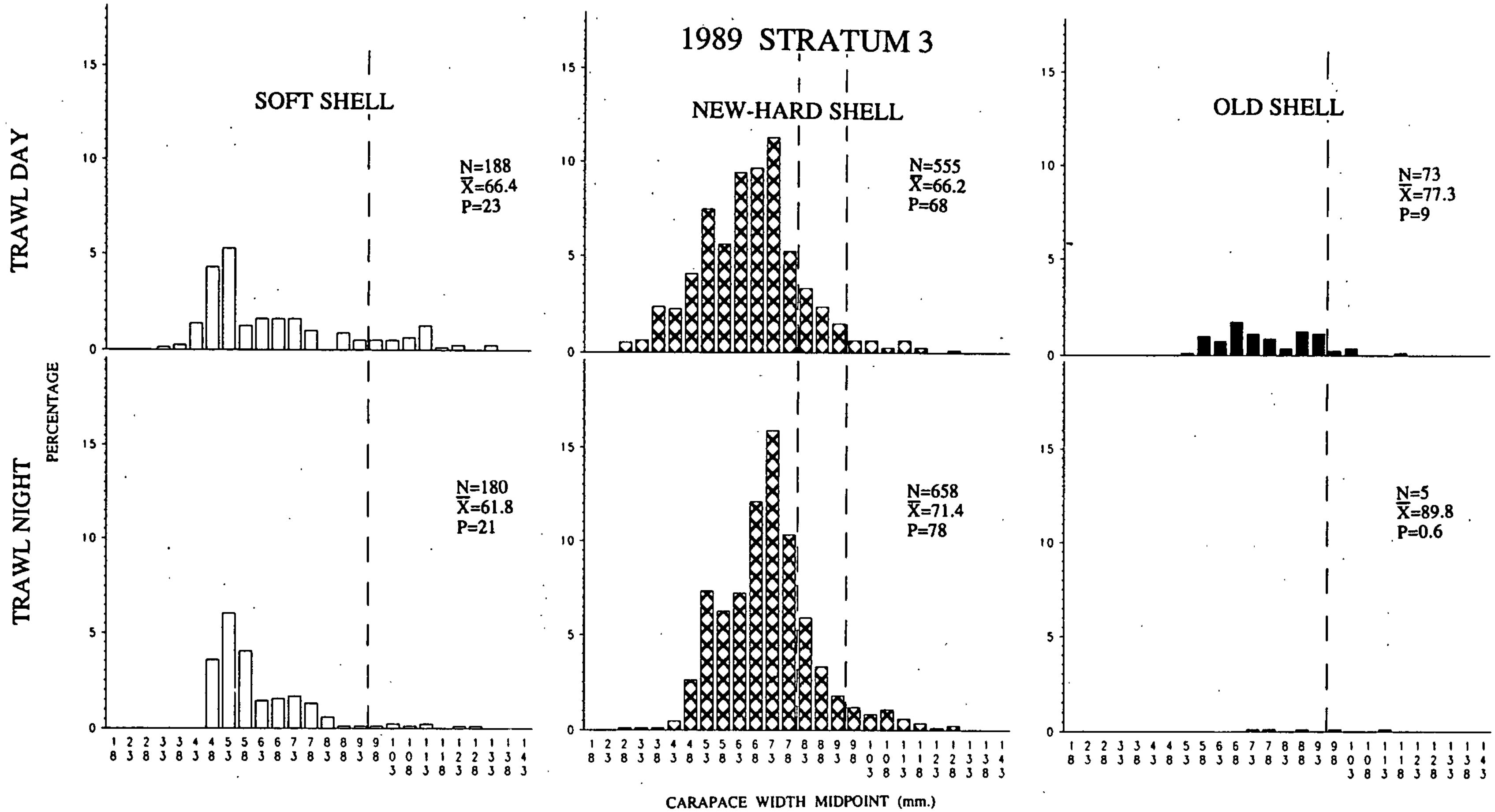

Fig. 8. Comparison of four sampling methods with respect to male snow crab shell (carapace) condition - body size relationships for depth stratum 3 in 1989.

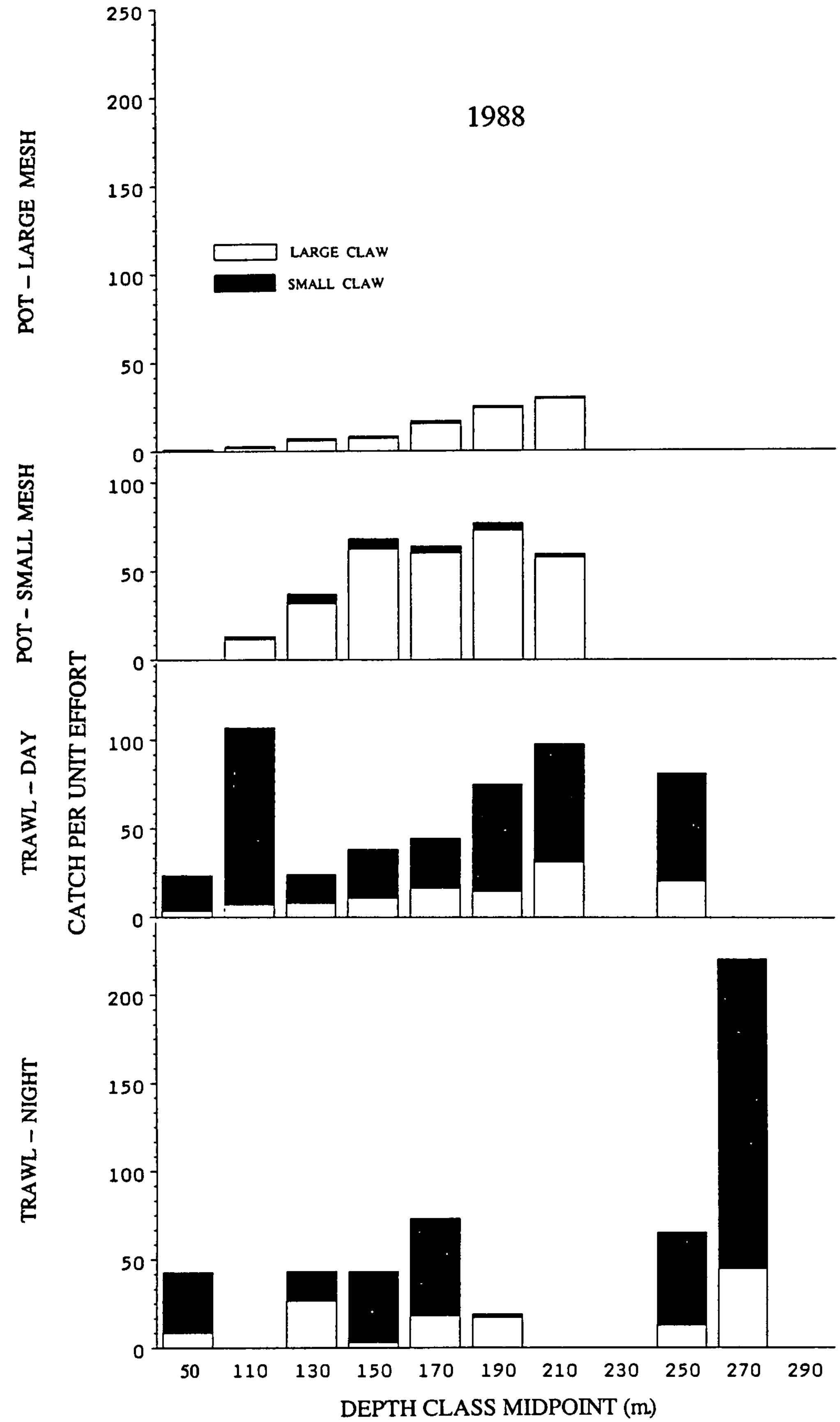

Fig. 9. Trends in catch per unit effort of male snow crabs by depth and chela allometry for each of four sampling methods in 1988.

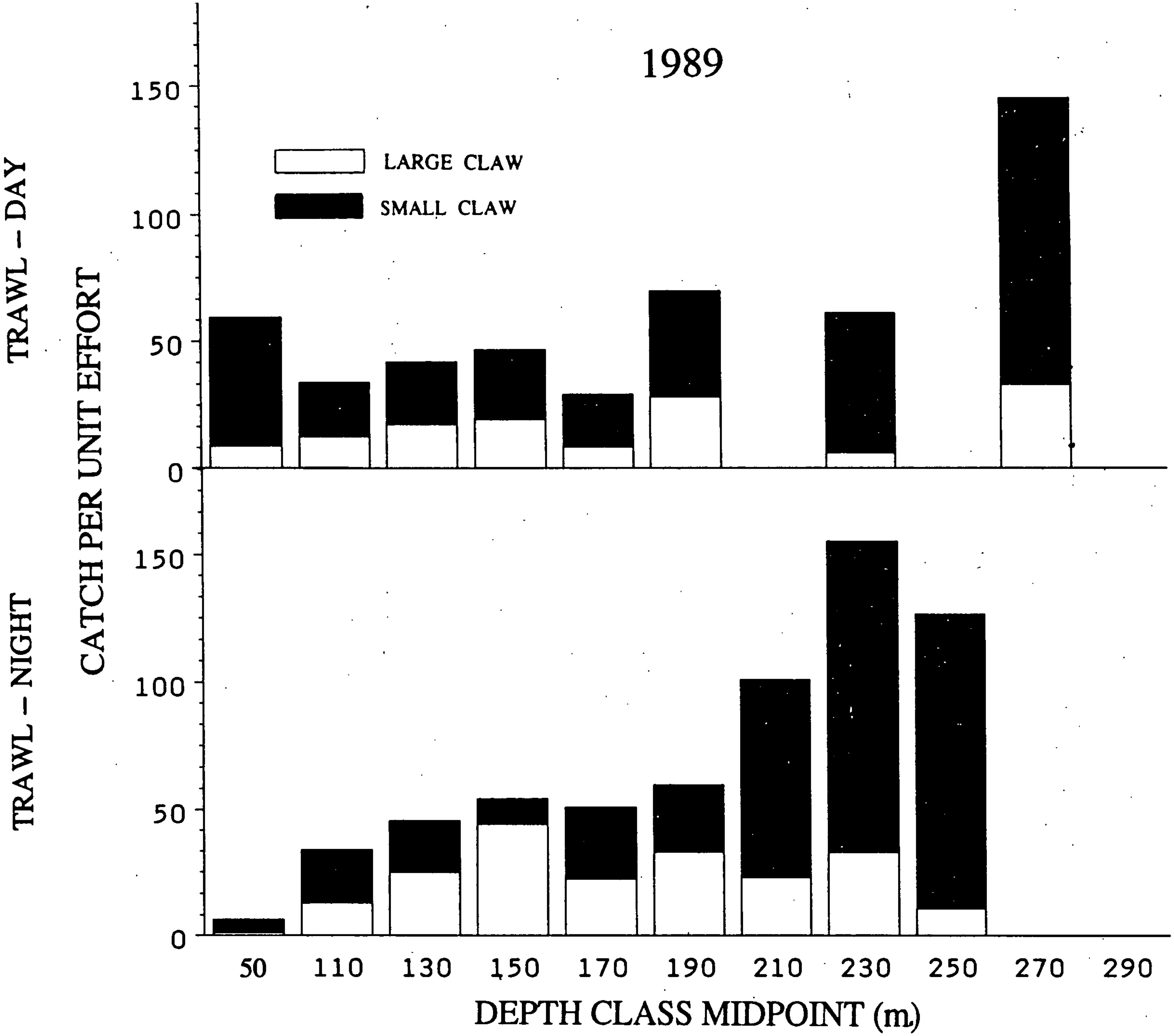

Fig. 10. Trends in catch per unit effort of male snow crabs by depth and chela allometry for each of two trawling methods in 1989.

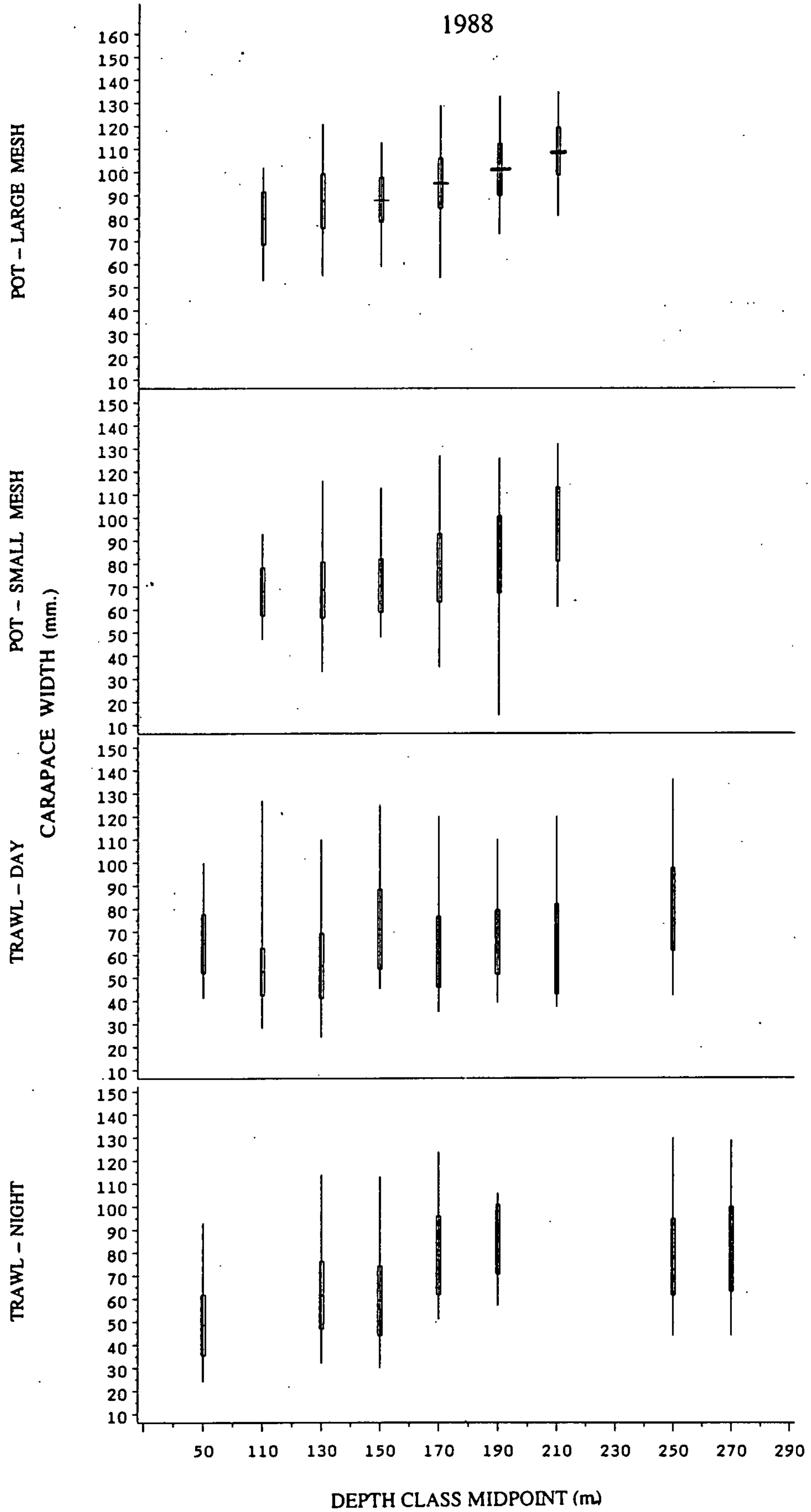

Fig. 11. Trends in male snow crab carapace width (mean, 2 sd, and range) by depth for four sampling methods in 1988.

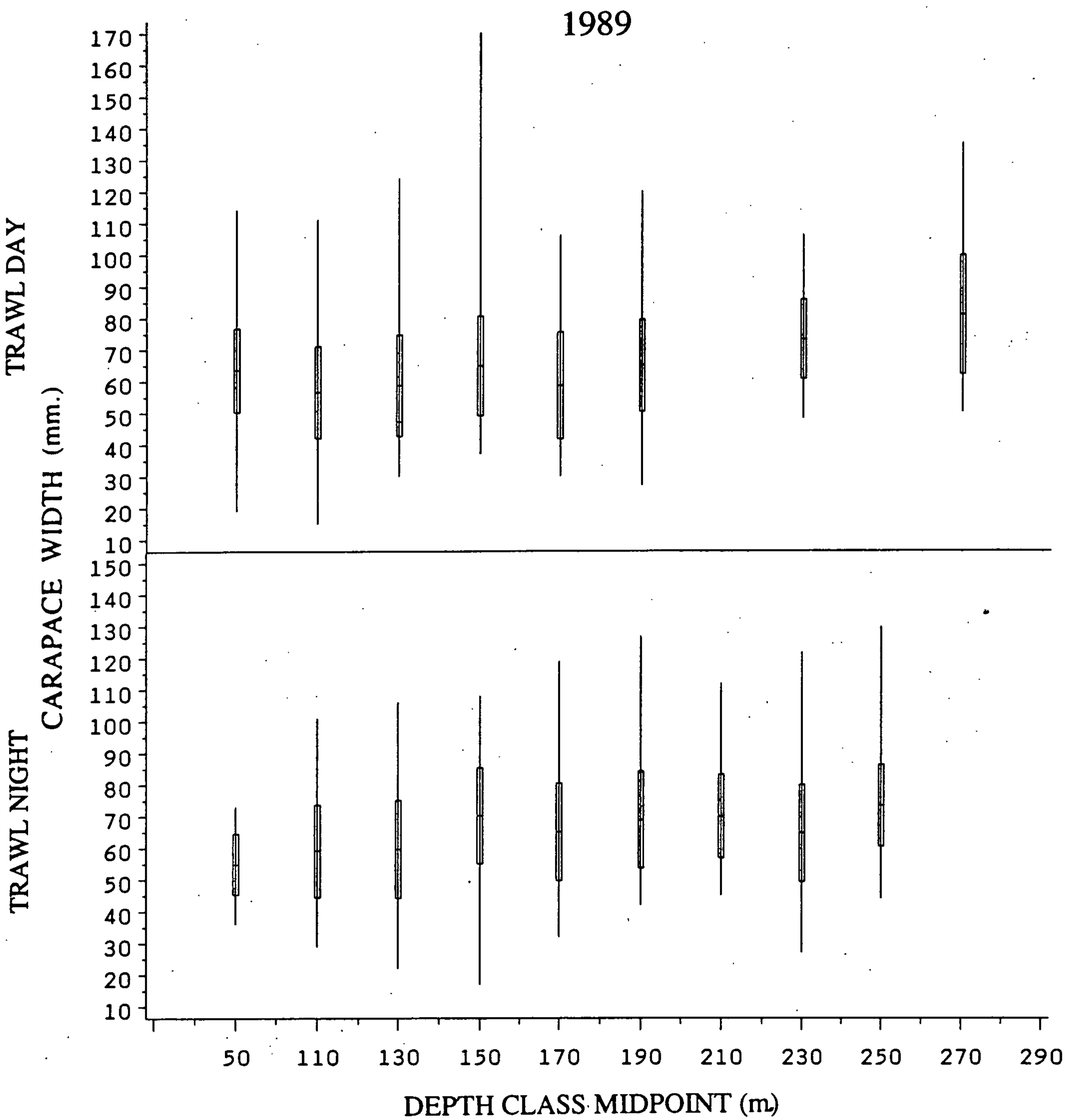

Fig. 12. Trends in male snow crab carapace width (mean, 1 sd, and range) by depth for two sampling methods in 1989.