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Results of 1996 research surveys of sea scallop abundance in areas near Grand Manan Island and Cape Spencer, Bay of Fundy

by

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ABSTRACT

Pilot-scale research surveys of sea scallop (*Placopecten magellanicus*) abundance and distribution were conducted in the Bay of Fundy near Cape Spencer (May) and Grand Manan Island (September) during 1996. The last surveys in either area were done in 1991. The mean number per tow in the Cape Spencer area was 7-times lower than observed in 1989 and individuals < 80 mm in shell height were uncommon in the survey area. This apparent lack of younger age-classes suggests that there will be no increase in the fishable resource near Cape Spencer in the short term. The mean number per tow near Grand Manan Island was lower than the peak observed in 1987 but similar to abundances observed in 1988 and 1989. The age-distribution was dominated by animals <age-8, which is characteristic of fully-exploited populations. The occurrence of relatively high concentrations of scallops near the boundaries of the survey area for both surveys is an indication that the distributions of the scallop populations were not adequately covered. The ideal solution to this problem would be to conduct a single survey covering all potential scallop habitat in the Bay of Fundy.

RÉSUMÉ

Des campagnes d'échantillonnage à petite échelle ont été effectuées en 1996 afin d'estimer l'abondance et la distribution du pétoncle géant (*Placopecten magellanicus*) dans la Baie de Fundy, près de Cap Spencer (mai) et de l'Île de Grand Manan (septembre). Les dernières campagnes ayant été effectuées dans ces deux régions remontaient à 1991. Le nombre moyen par trait dans la région de Cap Spencer était sept fois inférieures à la valeur observée en 1989. De plus, les individus ayant une hauteur de coquille < 80 mm étaient rares dans la région étudiée. Ce manque apparent de jeunes groupes d'âge permet de suggérer qu'il n'y aura pas d'augmentation à cours terme de la ressource exploitable dans la région de Cape Spencer. Le nombre moyen par trait près de l'Île de Grand Manan était inférieur à la valeur élevée qui avait été observée en 1987 mais était similaire aux abondances observées en 1988 et 1989. La distribution de fréquences d'âges était dominée par des animaux < 8 ans, ce qui est une caractéristique des populations entièrement exploitées. La présence de concentrations relativement élevées près des pourtours de l'aire d'échantillonnage des deux campagnes est une indication que les distributions de populations de pétoncles n'ont pas été couvertes adéquatement. La solution idéale à ce problème serait d'effectuer une campagne d'échantillonnage unique couvrant tous les habitats potentiels du pétoncle de la Baie de Fundy

INTRODUCTION

Fisheries independent surveys can provide an unbiased index of sea scallop (*Placopecten magellanicus*) populations. The Bay of Fundy supports an important sea scallop fishery yet there has never been a comprehensive survey of the abundance and distribution of sea scallops for the entire Bay. Indeed, some areas in the upper bay have never been surveyed yet are fished commercially or support recreational fisheries. Stock assessments are required for the Bay of Fundy but most of the effort (including research surveys) focuses on beds located near the Nova Scotia land mass. Information on the status of the population(s) located near the New Brunswick land mass has been collected sporadically. Research surveys have not been conducted in the western part of the Bay of Fundy (near Grand Manan Island and offshore from Cape Spencer) since 1991. This document reports the results of the two exploratory research surveys conducted near Cape Spencer during May 1996 and near Grand Manan Island during September 1996.

MATERIALS AND METHODS

Survey methods

Both research surveys were conducted on the *J. L. Hart* and used the same 4-gang scallop dredge (Kenchington et al. MS1996) and towing protocols. Two buckets were lined with a 38 mm stretched, diamond-shape, mesh liner and the other two buckets fished with 75 mm inside diameter steel rings. The estimates of abundance of scallops < 80 mm shell height were based on the two lined buckets. The estimates of abundance of scallops ≥ 80 mm shell height were based on the two unlined buckets. The counts per tow (two buckets) were multiplied by 3.5 to represent catches by a 7-gang dredge. Each tow was 8-min. long but were standardized to an 800 m long tow. Thus the area covered by the tow was 4256 m^2. To convert to SI units, I multiplied estimates/standard tow by 2.349 to yield estimates per hectare. Note: the estimates were not corrected for catchability to the dredge, i.e., they are indices and not true abundance estimates. All lobster captured were measured (carapace length in mm), sex determined , and presence of eggs recorded.

Cape Spencer. A pilot survey was conducted 8-15 May 1996 and covered much the same area as surveyed by Robinson and Chandler (MS1990) in 1989. The survey design was that of a fixed grid with evenly spaced stations. A rectangular grid consisting of eighty 2 X 2 nautical mile squares was overlaid on the area offshore from Cape Spencer and each grid was assigned a station number. The initial plan was to fish all 80 stations, however, poor weather only permitted fishing on 4 days; therefore, only 56 stations were fished. Once the catch was sorted from the debris, the shell height was measured to 5 mm. The average shell height distribution was then calculated (arithmetic mean number per tow for each 5-mm size-class). Too few samples (about 100 animals) were retained to permit calculation of the age-distribution or a meat weight on shell height relationship. Numbers per tow for scallops < 40 mm, 40-79.9 mm, and ≥80 mm were plotted as contours derived from ordinary kriging using beginning of tow latitudes and longitudes.

Grand Manan. This survey was conducted 5-8 September 1996. The survey design was arbitrary: some of the stations repeated those of a survey conducted during 1990 and 1991 (Robinson et al. MS1992) but other stations were assigned based on historical fishing grounds and current fishing activity. No strata were identified on the data sheets; therefore, the survey was treated as if it followed a random survey design. Sixty-five stations were fished. In most cases, meats were removed, placed in numbered bags, and weighed (to 0.1 g, wet weight) at the wharf. In addition, all shells were numbered (same number as the meat) and then transported to the laboratory to be measured and have ages determined. In the case of large sets, a subsample of shells were returned to the laboratory and the rest measured on the vessel. The height (mm) of every shell returned to the laboratory was measured and set-by-set size-distributions determined for 5-mm size-classes. A subsample of 28 sets were randomly chosen and the 1,186 shells from these sets had ages determined and shell height measured at the shell edge and last annulus. Arithmetic means (± 95% CI) shell heights at annulus and time of capture were calculated. An age-shell height key was used to convert the size-distributions to age-distributions on a set-by-set basis. A regression of meat weight on shell height was performed but the variation in meat weight about each shell height was very wide. To better accommodate this variation, a meat weight/shell height key was calculated to be applied to the 5-mm size-classes of the overall size-distribution. Numbers per tow for scallops of age-groups 1 to 10 and for size-classes < 40 mm, 40-79.9 mm, and ≥80 mm were plotted as contours derived from ordinary kriging using beginning of tow latitudes and longitudes.

RESULTS AND DISCUSSION

Cape Spencer Survey

The mean (± 95% CI) number per standard tow (n = 56) for all sizes of scallops was 82.7 ± 14.5 in 1996 (7-gang dredge) compared with and average of 324 age-2 and older per 4-gang dredge in 1989 (Robinson and Chandler 1990). When converted to comparable units, this represented 194 scallops/ha in the 1996 survey compared to 1,406/ha in 1989. Thus the survey area is capable of supporting a much higher abundance of scallops than is currently present.

The size-distribution for Cape Spencer (Fig. 1) is of great concern because the distribution was dominated by a large peak at 110-120 mm with very few animals smaller than 80 mm. Furthermore, the size-distribution for the Cape Spencer area was truncated, few animals > 125 mm shell height were captured. Prospects for recruitment in the next few years seem poor. There appear to be small modes at 30-35 mm and 55-60 mm but they represented < 2 animals per standard tow. If these represent age-classes (no ages were available for this survey), then it could be as much as 5-6 years before another strong year-class enters this fishery, which means there will be no increase in the fishable resource in the short term.

The distributions by size-class near Cape Spencer showed a low abundance of small (<40 mm shell height) scallops over much of the area with the highest (relative) density near a survey boundary (Fig. 2a). Scallops 40-79 mm shell height were absent from but a single concentration in the survey area (Fig. 2b). The highest density of commercial sized scallops was located at the southeast boundary of the survey (Fig. 2c), which indicates the survey did not adequately cover the distribution. Commercial sized scallops were absent from a large part of the survey area and the small areas of relatively high abundance could be eliminated in a single fishing season.

Only one lobster, a berried female 127 mm carapace length (CL in mm), was captured in the Cape Spencer survey. This was not unexpected because most of the survey (47 of 56 sets) was conducted in water > 80 m deep. Furthermore, the bottom water temperatures were cool, they ranged between 3.5 and 4.9° C.

Grand Manan Island Survey

The mean (± 95% CI) number per standard tow (n = 65) of scallops of all sizes was 147.2± 54.3 scallop/tow or 346 animals/ha. Robinson et al. (MS1990) reported average numbers/tow for age-2 and older animals for research surveys conducted in 1987 to 1989. When estimates were converted to similar units (number/ha), the value for 1996 was substantially lower than that observed in 1987 but similar to the estimates for 1988 and 1989 (Table 1). The biggest difference between 1987 and the other three years was the very large number of 3 and 4 year-old scallops caught in 1987. The size-distribution for Grand Manan Island (Fig. 1) was polymodal, there were two strong peaks at 35-40 mm and between 75 and 85 mm, and animals up to 155 mm in shell height were captured. There was a small mode at 10-15 mm that may represent the 1995 year-class.

The shell-height-at-annulus curve for Grand Manan Island sea scallops indicated these animals did not reach an average size of 80 mm until age-5 (Fig. 3a). The variation in shell height at any annulus was, however, wide - the SD ranged between 6 and 11 mm. The ages should be interpreted with caution because it was not always clear whether the first annulus observed represented a true first annulus or was actually the second annulus. As expected, the difference between shell height at time of capture and shell height at annulus declined with age, e.g., 10 mm or greater for 1 to 3 year olds but < 2 mm for ages 11 and older (Fig. 3b). Both curves were shown to allow comparisons with growth curves for different periods or locations. Ideally, all studies would use shell height at annulus to facilitate inter-area comparisons.

The age-distribution (expressed as mean number/ha) showed the population to be dominated by animals < 8 years old but with relatively strong incoming year-classes (Fig. 4). The observation that the abundances of older age-classes are low is a characteristic of a fully exploited population.

Biomass distribution: The product landed for sea scallops is adductor muscle. The fishery catches animals by shell size not by age, therefore, all subsequent discussion is based on size-distributions. There was a strong relation between meat weight and shell height but the variation in meat weight for a given size is very wide (Fig. 5). Rather than apply the regression model, which masks much of the variation, a meat weight - shell height key was applied to the size-distributions on a tow by tow basis. Note: these calculations are not corrected for the catch efficiency of the dredge. If catchability is assumed to be 0.1, then estimates are multiplied by 10 to obtain a more realistic estimate of biomass available to the fishery. The weight of meats in 5-mm shell height catches per hectare suggests two peaks: 80 to 85 mm and 110 to 120 mm (Fig. 6). This distribution can be used to set catches by summing the weights greater than some minimum size, applying a range on catchability coefficients, and deciding what fraction can be caught annually. For example, let us assume: a catchability coefficient (q) of 0.1; a biomass of meats (B in kg/ha) for a minimum shell height of 80 mm (based on Fig. 6 = 1.893 kg/ha); a harvest rate (C in kg) of 15% annually; and a fishing zone (A) of 100,000 ha. The resulting allowable catch (TAC in kg) from the current biomass distribution would be:

$$TAC = 1/q \times B \times C \times A$$

which is

$$10 \times 1.893 \text{ kg/ha} \times 0.15 \times 100{,}000 \text{ ha} = 284{,}000 \text{ kg/yr (as meats)}.$$

Thus the TAC in this example would be set at 284 t, or some other number, depending on the management targets.

Geographic distribution: The 1996 survey was of limited geographic coverage; it did not cover the northern side of Grand Manan Island nor did it cover the full extent of the population. Nevertheless, some interesting patterns were observed. The distributions of most age-groups showed clear aggregations but some of the aggregations occurred in different areas (Fig. 7). The spatial distribution by age-group for Grand Manan Island showed small patches of relatively high densities of age-group 1 to 3 scallops either at the southern tip of the Island (age-1 and age-2) or at the east of the Island (age-3). Age-1 to -3 scallops were largely absent from the rest of the survey area (Fig. 7a, b, c). For ages 4 and 5, the spatial distribution was restricted to a single high density bed to the east of the Island (Fig. 7d, e). The distributions for older scallops illustrate one of the serious shortcomings of the survey - the highest densities for ages 7 and 9 occurred near the boundaries of the survey area, which suggests that an unknown portion of the population occurred outside of the survey area (Fig. 7f, g, h, i, j). Scallops of ages 1 to 5 were comparatively rare to the west of the Island. Low numbers of 8 and 10 year-old scallops were almost evenly distributed across the survey area.

The distributions by size-class near Grand Manan Island reflect the results of the age-based analyses, the < 40 mm (Fig. 8a) and 40-79 mm (Fig. 8b) animals were concentrated in single small clumps of high density and, in the case of 40-79 mm animals, the location near the survey boundary indicates all of the distribution was not sampled. Scallops of commercial size (≥ 80 mm) were more widely distributed but the two highest densities also corresponded with areas of high pre-recruit density (Fig. 8c).

While the depth distributions of scallops <40 mm and 40-79 mm in shell height were almost identical, that for scallops $\geq$ 80 mm shell height differed from the other two size-classes. The cumulative frequency plots show that scallops < 80 mm shell height were essentially only captured in water < 60 m deep (Fig. 9). In contrast, the depth distribution of scallops $\geq$ 80 mm more closely resembled the distribution of sets, i.e., they were more randomly distributed across depths. The scarcity of small scallops in water > 60 m deep is cause for concern. For example, scallops 40 to 79 mm shell height were only found to the east of Grand Manan Island (Fig. 8b). It is highly improbable that any of these animals will recruit to the area west of the island (or south for that matter) because this would require a directional migration of 10s of kilometers and there is no evidence that scallops are capable this type of extended , directed, migration. For the both of these areas, this means it is unlikely that there will be an increase in the fishable resource in the short term.

Capture of Lobster: Seventy-one lobsters (35 males; 36 females) were caught in the Grand Manan Island survey -- an average ($\pm$ SE) of 1.8 $\pm$ 0.40 lobster per standard tow. The Grand Manan Island survey covered a wider depth range (16-145 m) than the Cape Spencer survey and 50% of the stations were in water > 40 m deep. Lobster catches were divided into 10 m depth zones and the cumulative frequency plotted with the cumulative frequency of sets (Fig. 10). The lobster were primarily (95%) found in water < 80 m deep, which represented where 82% of the sets were made. The average ($\pm$ SE) carapace length of the lobster was 66.6 $\pm$ 1.84 mm. The carapace length distribution ranged between 32 and 97 mm (Fig. 11) with peaks at 55-59 and 70-74 mm.

GENERAL DISCUSSION

The apparent seven-fold decline in sea scallop abundance between 1989 and 1996 in the Cape Spencer area is cause for great concern. Furthermore, the very low abundance of pre-recruits adds to the problem; it will be at least four or five years before any incoming strong year-class enters this fishery. The remaining scallops are tightly concentrated, which means they could be largely eliminated in a single fishing season.

The Grand Manan Island population is in better shape because there clearly is strong incoming recruitment. The 1996 abundance estimate was much lower than that for 1988 and age-distribution of this population is severely truncated, which indicates the population is fully exploited and dependent upon incoming recruitment. Furthermore, the distribution of commercial-sized scallops is highly clumped and largely limited to a two small areas to the east of the Island and to one small area on the southwest boundary of the survey area. These small areas could be depleted rapidly. Finally, the distributions of recruiting age-groups are also highly clumped and they are absent for much of the survey area. Any fishing activity on these small scallops could lead to their destruction through the physical action of the dredges (Langton and Robinson 1990; Robinson et al. MS1992). Great caution is required if fishing activity is to be permitted in this survey area.

One clear result on methodology is that a standard survey protocol is required. Even the concept of what comprises a standard tow varies with time (e.g., 4-gang vs 7-gang); however, this can be eliminated by expressing population measures in terms of standard units (e.g., number/ha). A more serious problem is the occurrence of concentrations of scallops at the boundaries of the survey area, which shows the entire population is not being covered by the survey. Furthermore, this phenomenon is also apparent in the contour plots for the 1995 surveys near Digby (Kenchington et al. MS1996) and Brier Island and Lurcher shoals (Kenchington and Lundy MS1996). Ideally, there would be a single research survey, conducted annually, designed to cover all possible scallop habitat in the Bay of Fundy. This comprehensive survey would provide a better description of the resource abundance and distribution within a year, permit detection of annual variation in abundance and spatial distribution of the resource, and allow managers to evaluate how well the fishing zones match the actual distribution of the resource.

ACKNOWLEDGMENTS

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REFERENCES

Kenchington, E., and Lundy, M. J. MS1996. 1995 Bay of Fundy scallop stock assessments: Briar Island and Lurcher Shoal. DFO Atlantic Fisheries Res. Doc. 96/15. 31 p.

Kenchington, E., Roddick, D. L., and Lundy, M. J. MS1996. 1995 Bay of Fundy scallop stock assessments: Digby and 1995 landings by statistical district for the Bay of Fundy. DFO Atlantic Fisheries Res. Doc. 96/14. 69 p.

Langton, R. W., and Robinson, W. E. 1990. Faunal associations on scallop grounds in the western Gulf of Maine. J. Exp. Mar. Biol. Ecol. 144: 157-171.

Robinson, S. M. C., and Chandler, R. A. MS1990. The Grand Manan scallop stock assessment 1988-1989. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 90/81. 26 p.

Robinson, S. M. C., Martin, J. D., and Chandler, R. A. MS1992. Assessment of a large mortality event of scallops in the Bay of Fundy. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 92/80. 13 p.

Table 1. Mean number/ha of various ages of sea scallop captured in research surveys near Grand Manan Island in 1987 to 1989 (Robinson et al. MS1990) and 1996 (this study). A similar dredge and liner was used for all four surveys.

	Year			
Age	1987	1988	1989	1996
2	69.9	86.3	16.4	73.8
3	148.9	24.7	37.0	40.2
4	156.2	82.2	53.4	60.6
5	102.8	41.1	74.0	40.0
6	41.1	16.4	49.3	31.2
7	16.4	4.1	12.3	20.0
8	12.3	4.1	8.2	9.6
9	12.3	4.1	8.2	6.1
10+	45.2	16.4	41.1	40.4
sum 2+	604.3	279.5	300.1	321.6
sum 4+	374.0	168.4	246.5	207.9
sum 5+	217.8	86.2	193.1	147.3

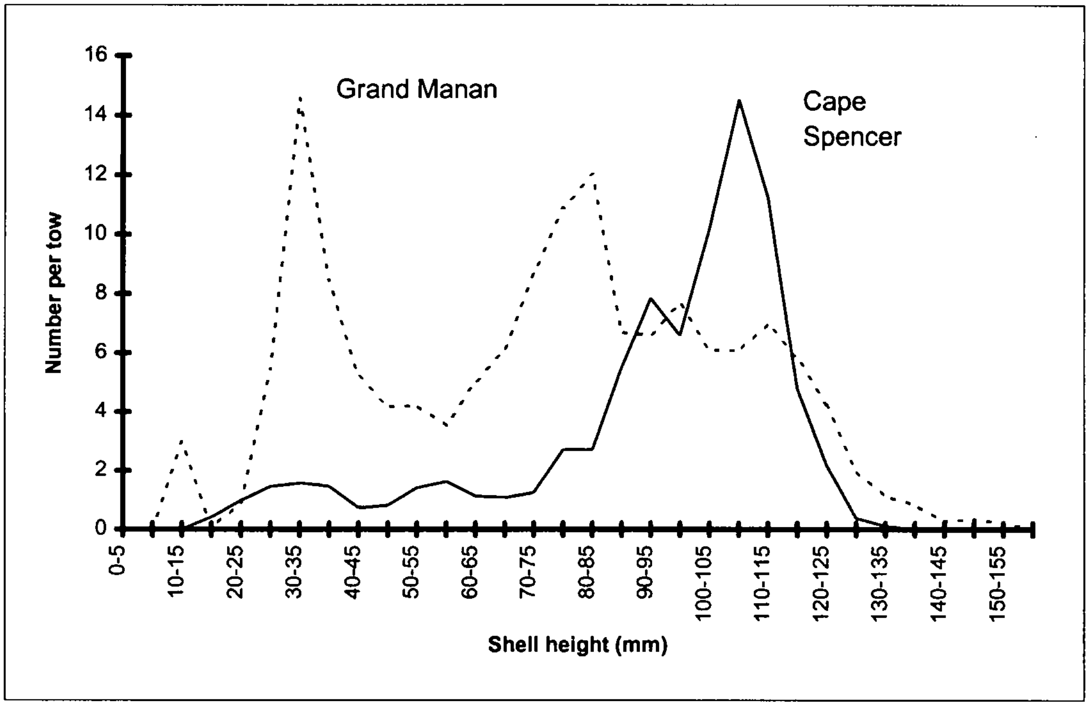

Figure 1. Shell height distributions for sea scallops captured near Grand Manan Island and Cape Spencer, 1996.

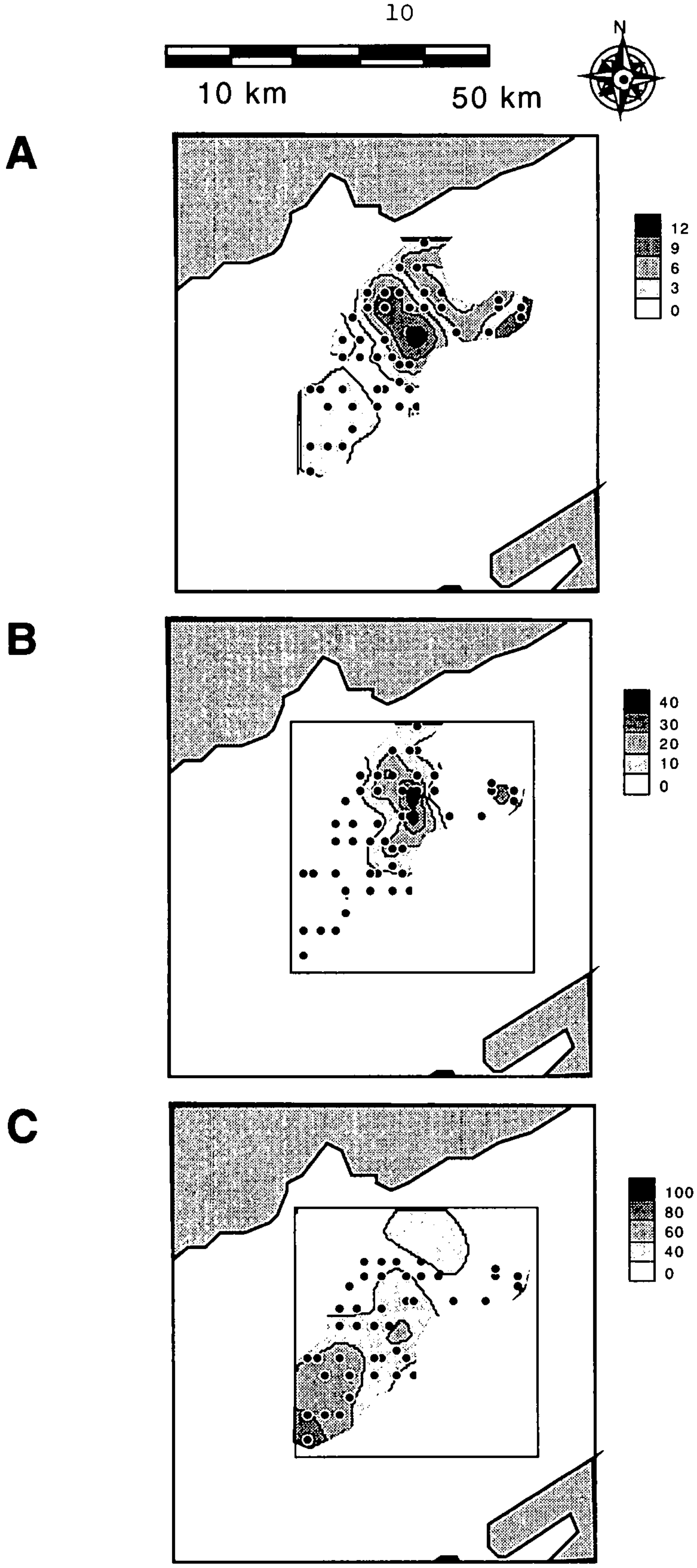

Fig 2. Distribution of sea scallops: (A) < 40 mm; (B) 40 79 mm; and (C) > 80 mm shell height in the Cape Spencer area, May 1996. Contouring was performed by means of ordinary kriging.

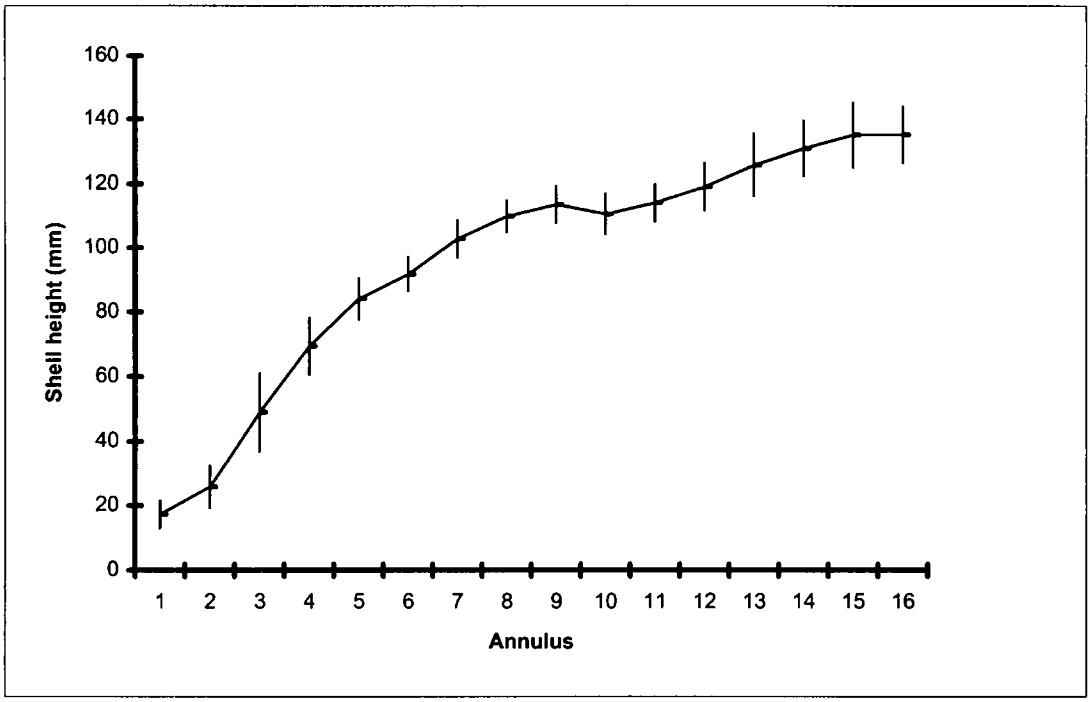

Figure 3a. Mean shell height at annulus (+ SD) for sea scallops captured near Grand Manan Island, September 1996.

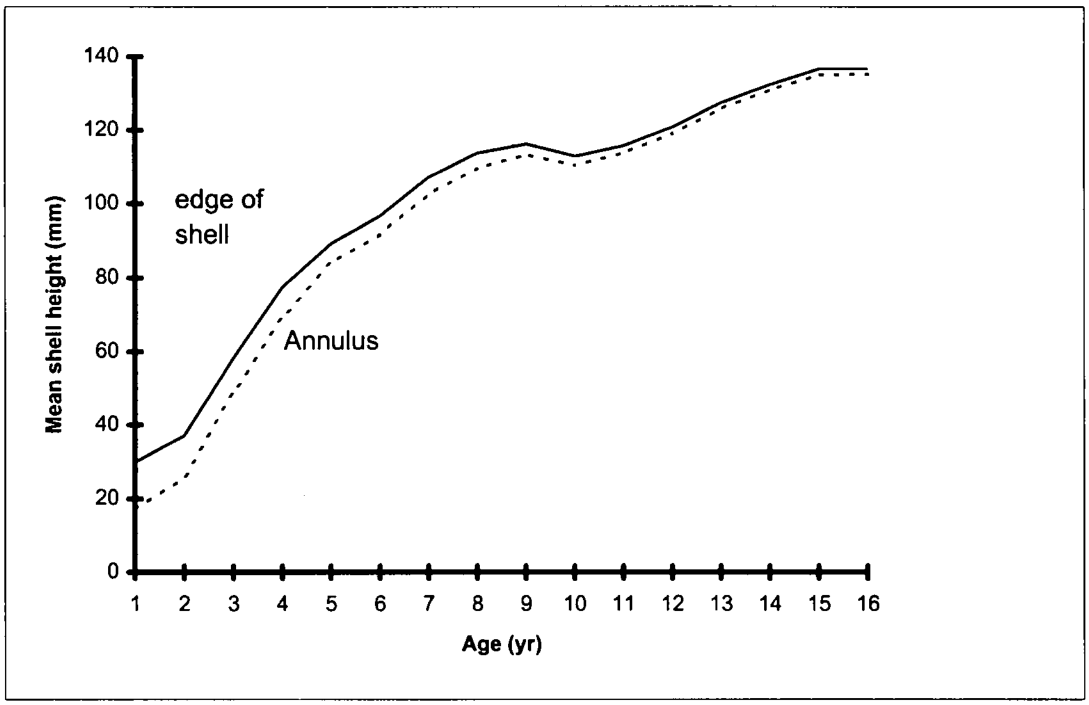

Figure 3b. Shell height at annulus and at time of capture of sea scallops captured near Grand Manan Island, September 1996.

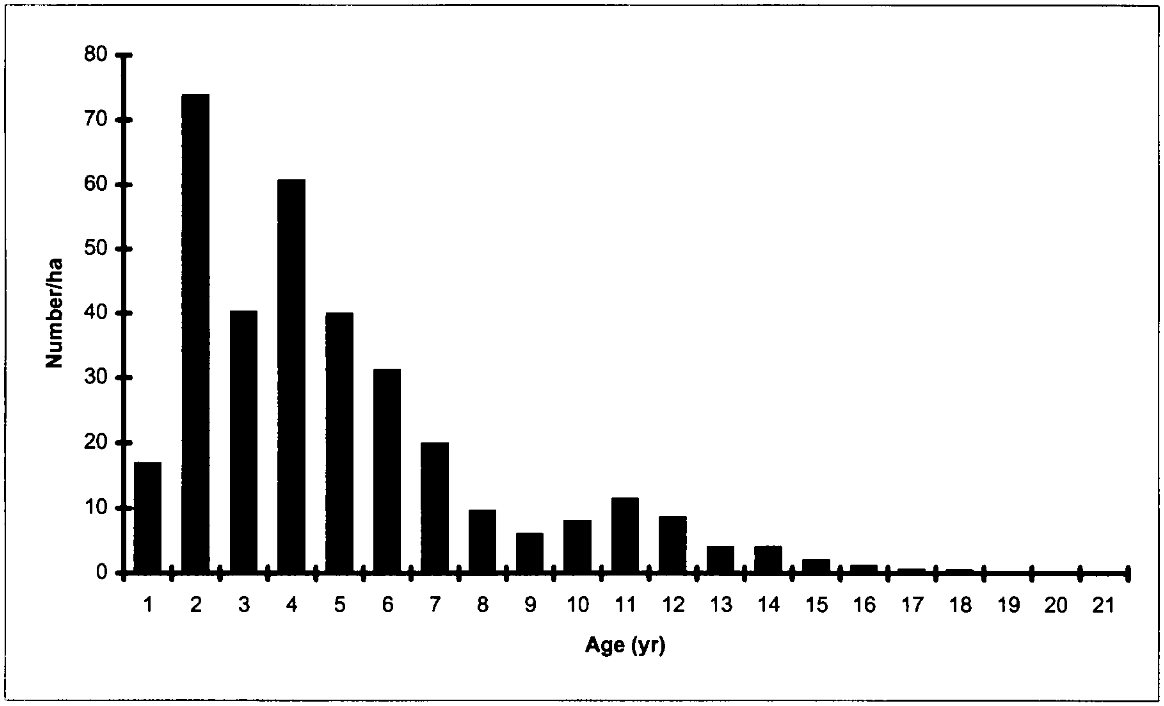

Figure 4. Mean number per hectare of various age-classes of sea scallops captured near Grand Manan Island, September 1996.

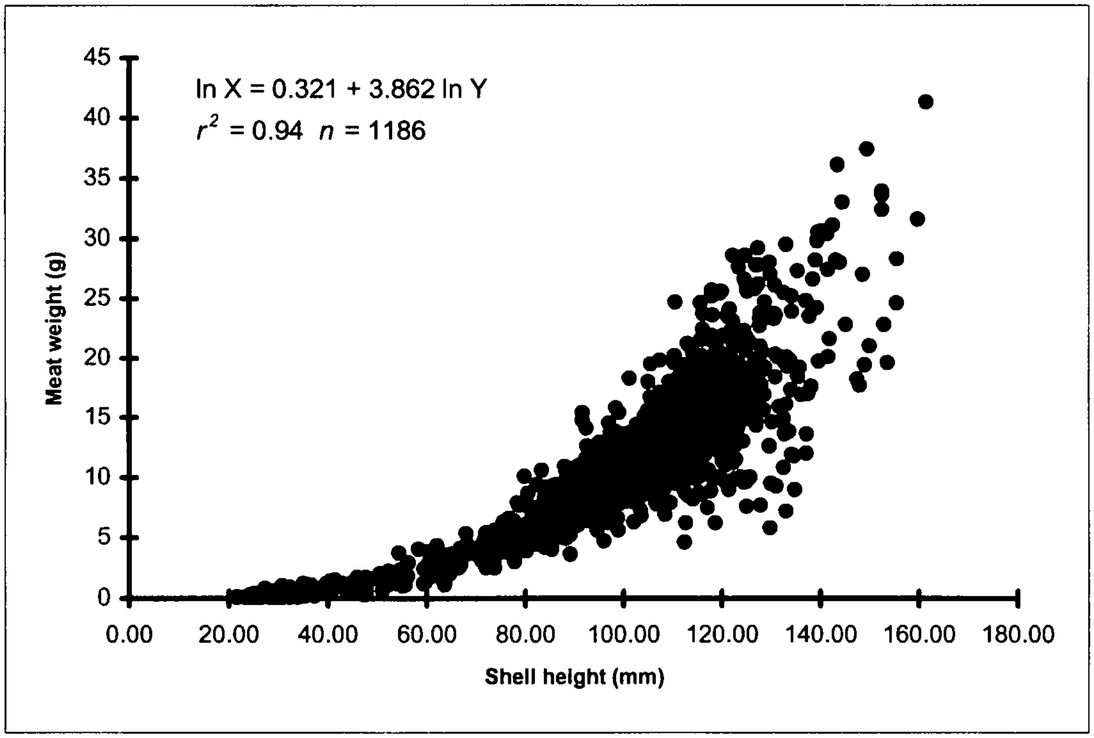

Figure 5. Meat weight - shell height regression for sea scallops collected near Grand Manan Island, September 1996.

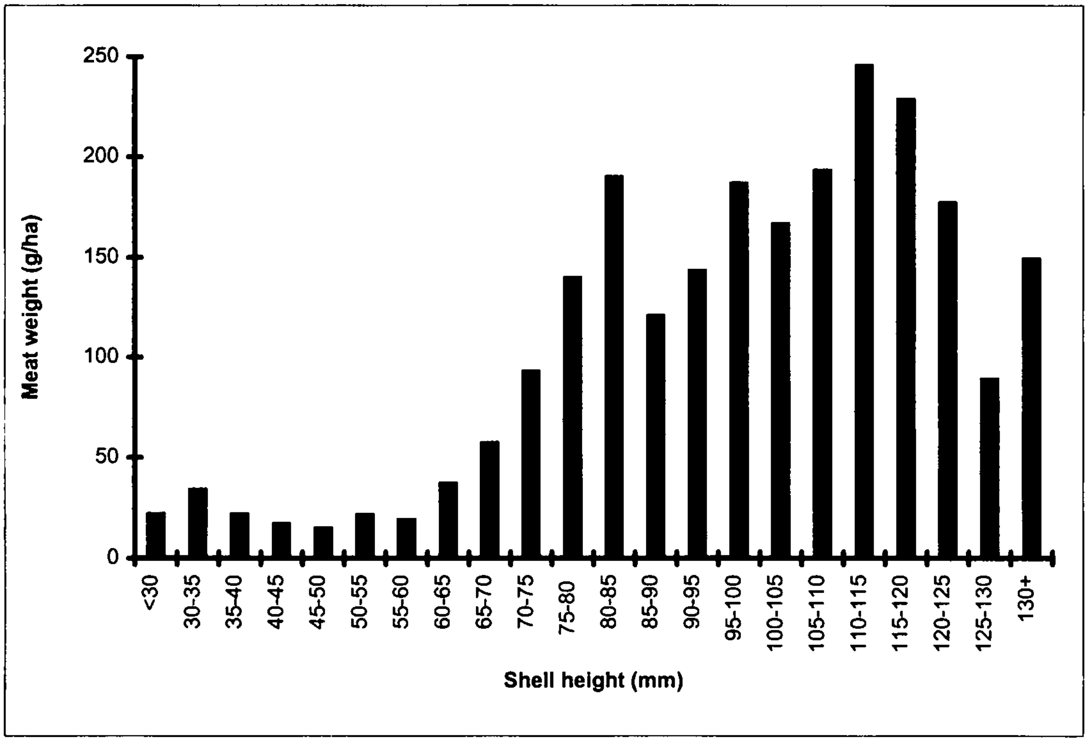

Figure 6. Meat weight distribution of sea scallops captured near Grand Manan Island, September 1996.

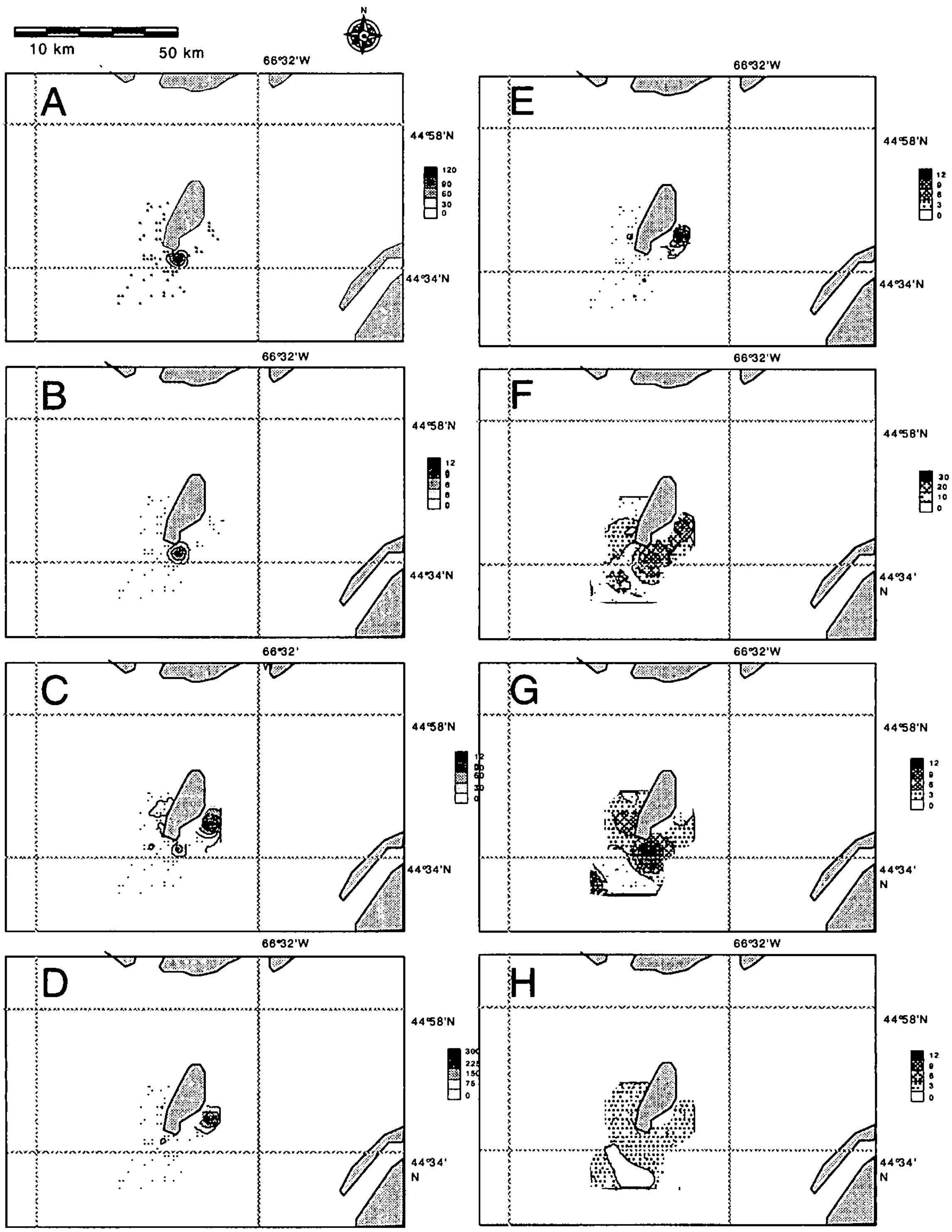

Fig 7. Distribution of sea scallops in the Grand Manan Island area, September 1996: (A) age 1; (B) age 2; (C) age 3; (D) age 4; (E) age 5; (F) age 6; (G) age 7; (H) age 8; (I) age 9; and (J) age 10. Contouring was performed by means of ordinary kriging.

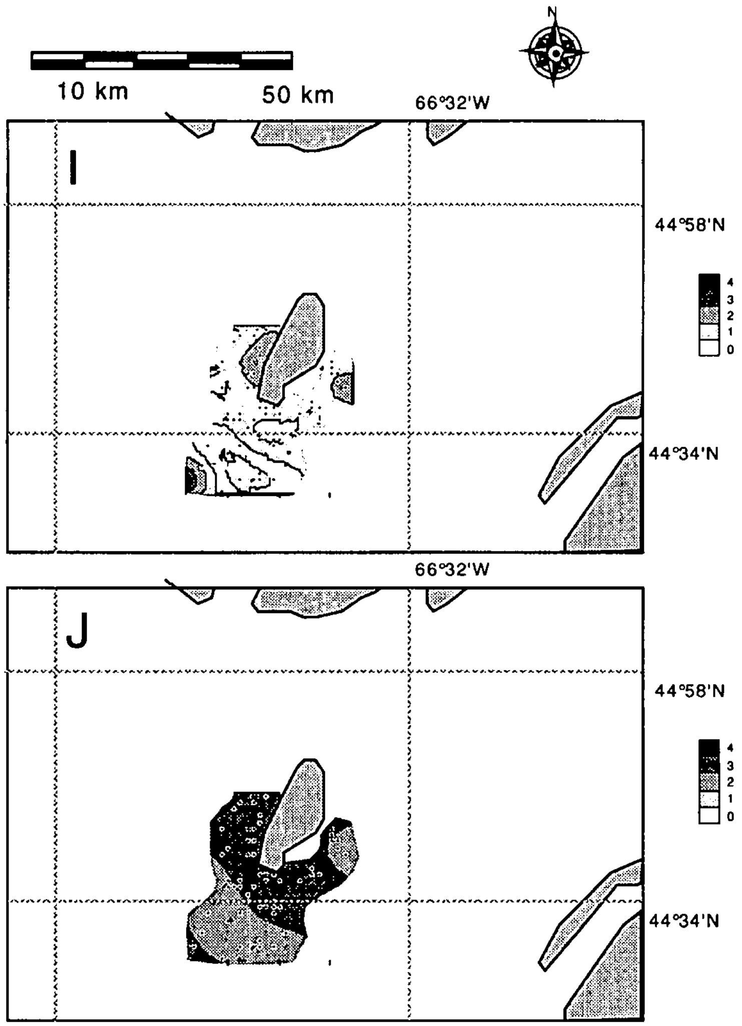

Fig 7. Continued

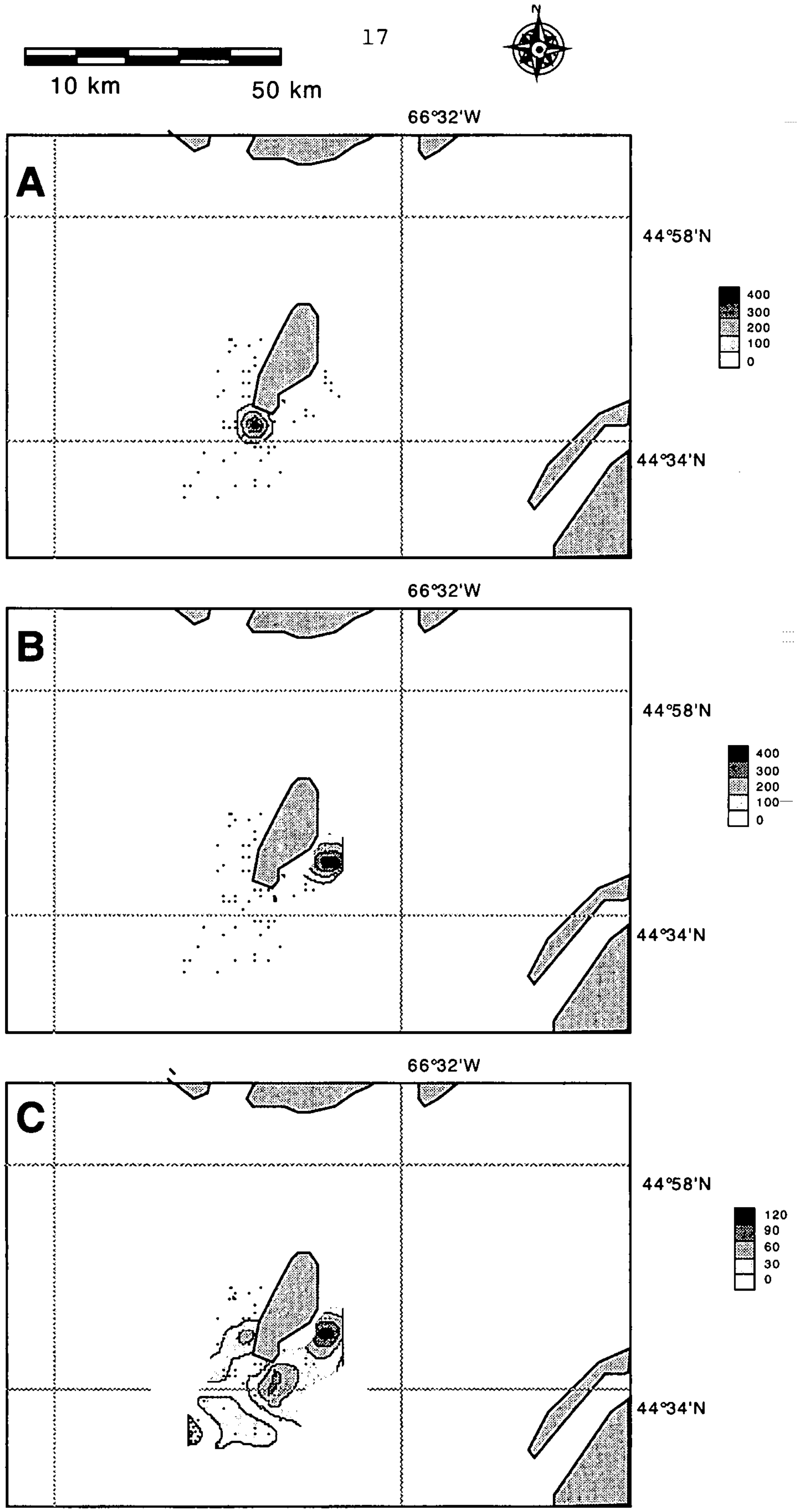

Fig 8. Distribution of sea scallops: (A) < 40 mm; (B) 40 79 mm; and (C) > 80 mm shell height in the Grand Manan Island area, September 1996. Contouring was performed by means of ordinary kriging.

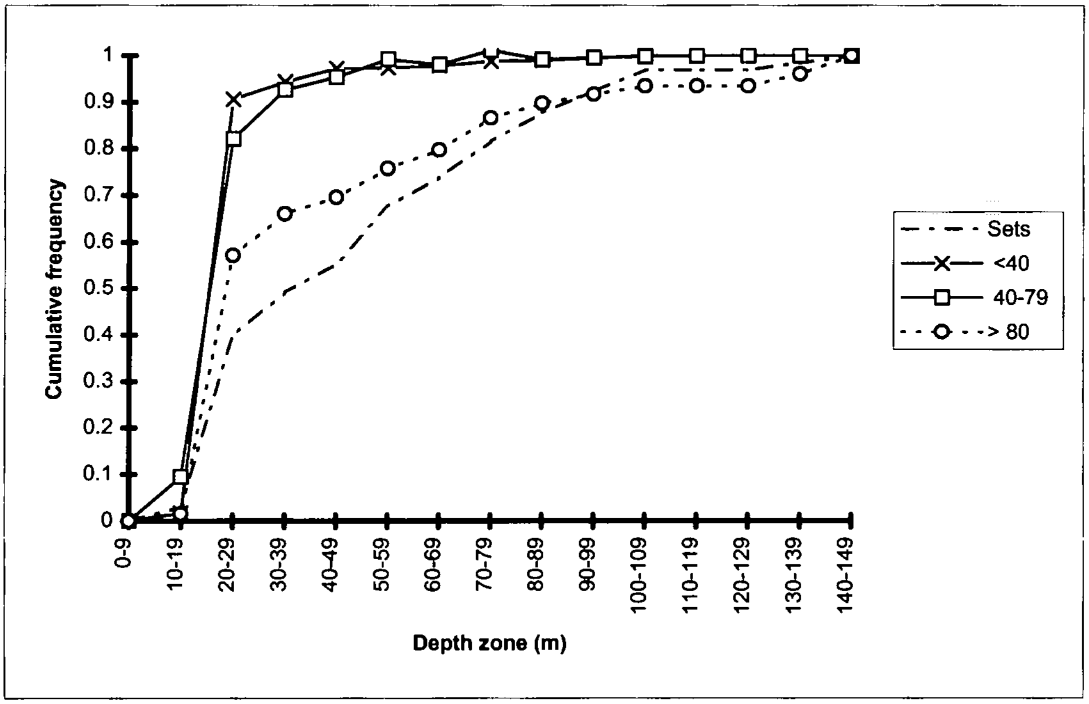

Figure 9. Depth distribution of sea scallops captured in research survey near Grand Manan Island, September 1996.

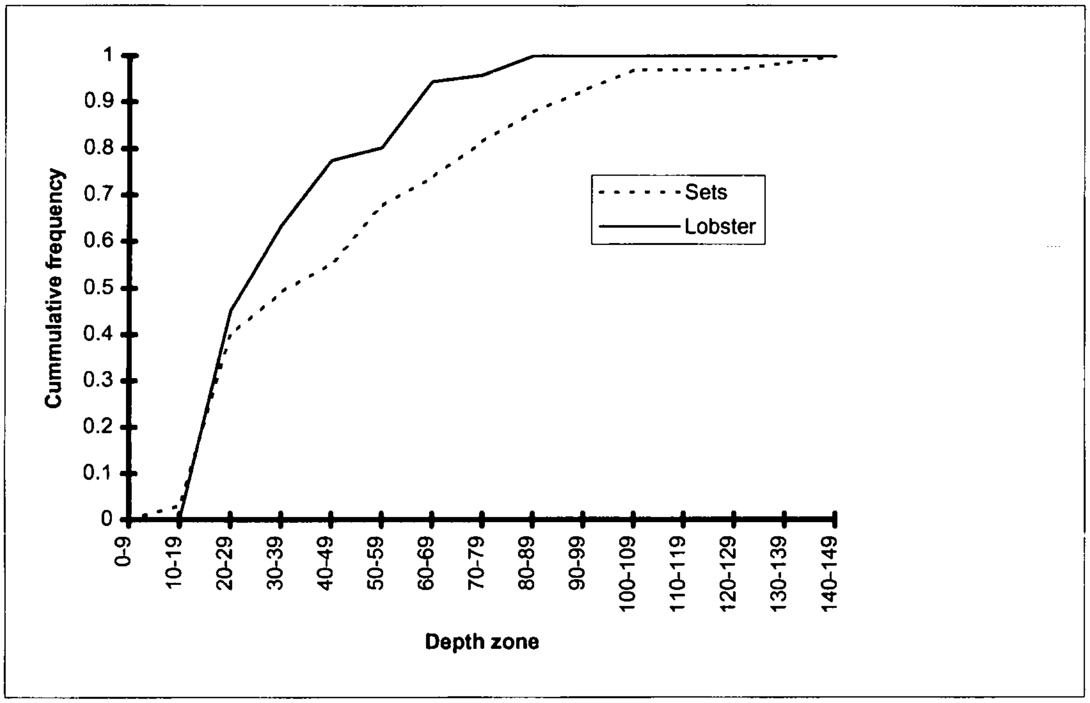

Figure 10. Depth distribution of lobster captured in scallop dredge during research survey near Grand Manan Island, September 1996.

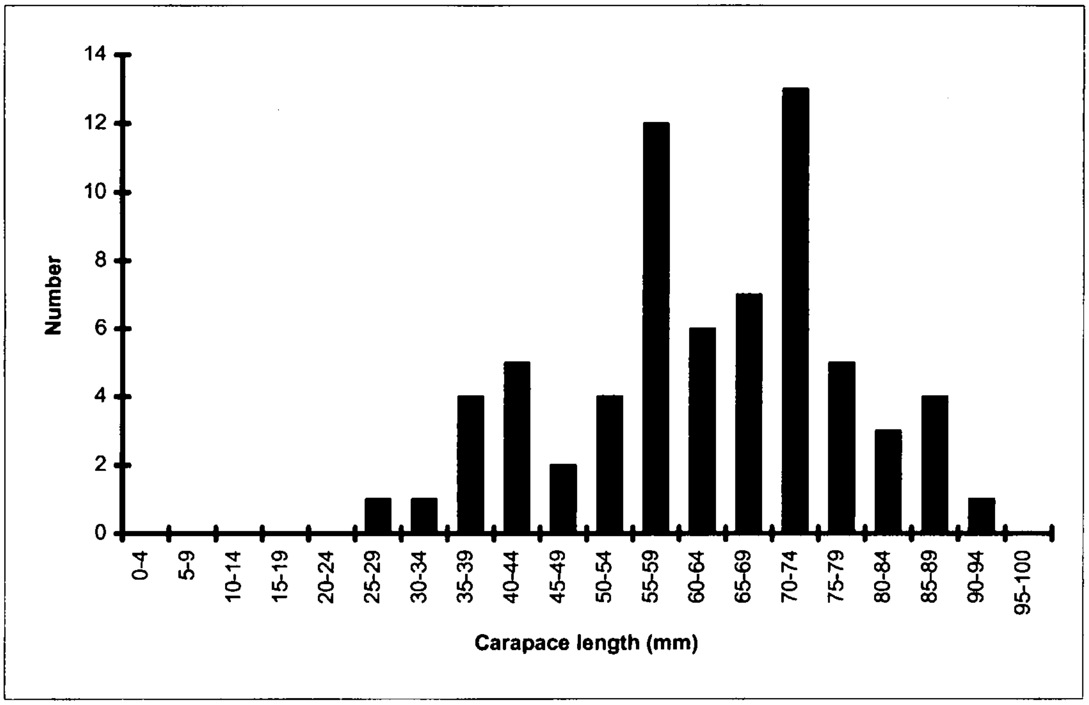

Figure 11. Size- distribution of lobster captured during sea scallop survey near Grand Manan Island, September 1996.