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The Horizontal Distribution of Larval Sea Scallops (*Placopecten magellanicus*) in the Bay of Fundy, on the Scotian Shelf and on Georges Bank

by

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ABSTRACT

Larval sea scallops were sampled for the first time in the Bay of Fundy (September, October, and November 1984 and October 1985) and on the Scotian Shelf and Georges Bank (October 1985). Within the Bay of Fundy, the distribution of larvae was compared with the distribution of potential spawners (commercial sea scallop landings). Together with larval length frequency data, this comparison indicates that there was transport of larvae within the Bay of Fundy via the residual currents but that most larvae either remained in or were returned to the area of major spawning. In October 1985, the Bay of Fundy and Georges Bank areas were similar with regard to larval concentrations and size range. On the Scotian Shelf larval concentrations were lower and large larvae were completely lacking. There was no evidence of exchange between Georges Bank and the Scotian Shelf.

INTRODUCTION

Major commercial concentrations of sea scallops are found in the Bay of Fundy, the Scotian Shelf and on Georges Bank (Fig. 1). Although persistent, recruitment to these areas fluctuates highly from year to year (Sinclair et al. 1985). An important step in considering recruitment variability in scallops is an evaluation of the source of recruitment. Both Dickie (1955) and Caddy (1979) have suggested that there is a link between larval supply and recruitment to the scallop fishery.

The only published account of larval sea scallop distribution that we are aware of is a short communication dealing with bivalve larval abundance in the nearshore region off New Hampshire (Savage 1980). As recently as 1979 Serchuk et al. (citing Bourne 1964) stated that *P. magellanicus* larvae had never been positively identified in plankton collections. As a result of close comparison with cultured *P. magellanicus* larvae, the identification of larval sea scallops from the plankton is now ongoing (Tremblay et al. in prep.).

The generalized residual circulation for the Bay of Fundy, Scotian Shelf and Georges Bank is depicted in Figure 2. The distribution of the larval stage of the sea scallop has been inferred in a general way from residual current patterns (Serchuk et al. 1979) and long distance transport of larvae has been postulated (Posgay 1979). These postulates on the transport of scallop larvae are based on the assumption that scallop larvae behave as inanimate objects which are at the mercy of residual circulation. Any vertical migrations which do occur are assumed to have no effect on the ultimate horizontal position of the larvae.

The present contribution describes larval sea scallop distribution in the Bay of Fundy and surrounding area in 1984 and 1985 in

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relation to adult concentrations and residual circulation. Larval scallops of all sizes were most concentrated in areas of commercial scallop concentrations. Dispersal beyond these areas was evident but large scale exchange between commercial concentrations was not.

METHODS

Sample collection and processing - Scallop larvae were collected during three periods in 1984 (Sept. 6 - 13, Oct. 10 - 15, and Nov. 3 - 14) and one period in 1985 (Oct. 10 - 15). In 1984 sampling was restricted to the Bay of Fundy, while in 1985 it included the Scotian Shelf and part of Georges Bank (Fig. 3). Larvae were sampled with three gear types: (i) plankton nets fitted with flowmeters; (ii) a pumping system which allowed discrete depth intervals to be sampled; and (iii) a hyperbenthic sled which obtained samples 0.5 m and 2.0 m off the bottom. The results of the plankton net samples will be the focus of the present paper.

The plankton nets were lowered to within 5 m of the bottom (or to 200 m) and towed to the surface at a speed of approximately 45 m per minute. In 1984 the plankton nets were 50 cm in diameter and were fitted with 120 um mesh. In 1985 the mouth diameter was reduced to 40 cm and the mesh size was decreased to 85 um. These modifications were made to decrease the volume sampled and to better sample the smallest scallop larvae.

Sea scallop larvae were preserved in 4% formalin buffered with sodium borate. The physical separation and taxonomic identification of the scallop larvae is described in Tremblay et al. (in prep.) All length measurements were made along the longest axis parallel to the hinge.

Source and abundance of scallop larvae - The potential source of scallop larvae in the areas sampled is depicted in a generalized manner in Figure 1. For the Bay of Fundy only (statistics on landings by the fishery are most complete for this area - G. Robert, Fisheries Research Branch, Halifax, N.S., pers. comm.) we utilized the 1984 and 1985 fishery data to obtain a more accurate representation of the distribution of adult scallops. Although some of the commercial catch is not reported, that which is utilized here is thought to accurately reflect the trends of the whole fleet ("Class 1 data"). The underlying assumption that all significant sources of scallops are exploited is reasonable for this fishery.

To compare the larval distribution in the Bay of Fundy with that of their potential source, the number of larvae and commercial catch of scallops was determined for three arbitrarily defined parts of the Bay of Fundy: Outer, Middle and Inner (Fig. 4). Total larval number for each part was estimated by multiplying the mean number of larvae per square meter by the area in square meters. Total scallop catch for each area was simply the sum of commercial landings in kilograms.

RESULTS

Within the Bay of Fundy - In 1984, scallop larvae were present in much of the Bay of Fundy in each of the sampling periods between September and mid November (Fig. 5). Larvae ranging in length from 144 um to 300 um were sampled by the 120 um mesh nets (Fig. 6). Since cultured larvae range from 105 um to 290 um (Culliney 1974), larvae less than about 150 um were evidently undersampled. In October of 1985, larvae were again widespread in the Bay of Fundy (Fig. 7) and the 85 um mesh nets sampled larvae as small as 115 um (Fig. 8).

In 1984 and 1985 78% or more of the total commercial scallop catch in the three areas depicted in Fig. 4 was obtained in the Outer Bay (Table 1). The percentage of Bay of Fundy larvae found in the Outer Bay ranged from 85% in October 1985 to 35% in November 1984 (Table 2).

The larval length frequency distributions (Figs. 6 and 8) show that larvae greater than 230 um in length, which are metamorphically competent (Culliney 1974), were relatively more important in the Inner Bay. For Oct. 1985 (Fig. 8), when a complete size range of larvae was sampled, the percentage of competent larvae in the three areas was:

Outer Bay (3.9%), Middle Bay (6.4%) and Inner Bay (9.5%). The length frequency distribution of larvae from the New Brunswick side of the Inner Bay is particularly noteworthy because it is much less skewed towards the smaller sizes than any of the other areas of the Bay (Fig. 8). Metamorphically competent larvae were always most abundant in the Outer Bay however, because of the higher larval abundance there (Table 2).

In 1984, the approaches to the Bay of Fundy registered generally lower concentrations than in the the Outer Bay (Fig. 5) while in 1985 larvae were as abundant there as in the Outer Bay (Fig. 7). Grand Manan and the surrounding area always had concentrations as high or higher than the Outer Bay, with the exception of November 1984.

Georges Bank and the Scotian Shelf - Larval concentrations on Georges Bank were similar to the Bay of Fundy but much greater than those on the Scotian Shelf. Inside the 200 m contour on Georges Bank six of 15 stations sampled had larval concentrations greater than 1000 per square meter and three of the six registered concentrations greater than 5000 per square meter. In the Outer Bay of Fundy larval concentrations reached 1000 per square meter or more at 12/22 stations. On the Scotian Shelf only two of some 62 stations reached this concentration. Taking the Scotian Shelf and Georges Bank areas together, larvae were reduced or absent in areas deeper than 200 m, including the Northeast Channel.

As with larval concentrations, the length frequency distribution of larvae on Georges Bank was more similar to that of the Bay of Fundy than the Scotian Shelf (Fig. 9). On Georges, larvae greater than 230 um in length comprised more than 8 % of the total sampled (Fig. 9). On the entire Scotian Shelf there were no larvae greater than 230 um in length and very few greater than 200 um.

DISCUSSION

Large differences in larval scallop number and length frequency distribution were found within the Bay of Fundy and between the Bay of Fundy as a whole, the Scotian Shelf and Georges Bank. These differences could be the result of: (i) larval exchange between areas (i.e. larvae are produced in one area, are transported to another area and in the process decrease in number and increase in length); (ii) differences in spawning times between areas (i.e. larval lengths differ between two areas only because the larvae did not originate at the same time); (iii) differences in growth or surival between areas. These possibilities are discussed below.

Within the Bay of Fundy - There is strong evidence that a proportion of the larvae which are spawned in the Outer Bay are transported downstream with the residual currents. First, the percentage of Bay of Fundy larvae found in the Inner Bay is much greater than would be expected based on the commercial catch that is taken there. Second, the greater proportion of large larvae in the Middle and Inner Bay areas (particularly the New Brunswick side) is consistent with transport via residual currents up the Bay of Fundy on the Nova Scotia side and out the Bay of Fundy on the New Brunswick side (Fig. 2). In this way some larvae which are 'lost' from the Outer Bay may actually be returned via the residual currents.

The percentage of Bay of Fundy larvae found in the Inner Bay was higher than expected during each of the sampling periods in September, October and November. Since nearly all scallop spawning in the Bay of Fundy occurs during these months, with a peak in August or September, (Dickie 1955, Robert 1985), it is unlikely that a difference in spawning times between the Outer and Inner Bay areas could explain higher than expected larval numbers in the Inner Bay. Better survival in the Inner Bay is also unlikely since the rate would have to be at least double that of the Outer Bay. We conclude that a substantial portion of the larvae in the Inner Bay originated in the Outer Bay.

What proportion of larvae which originate in the Outer Bay are transported downstream is difficult to assess. Few larvae were ever present on the New Brunswick side of the Upper Bay (Figs. 5 and 7), and there is no evidence that transport through this area is faster than other parts of the Bay (Godin 1968). Thus it is unlikely that large numbers of the metamorphically competent larvae found in the Outer Bay during each sampling period (Table 2) had completed a 'round trip' of the Bay of Fundy via the counterclockwise circulation. A percentage of larvae which are produced in the Outer Bay must remain there throughout the pelagic stage, perhaps by the gyre present there, perhaps by some active vertical migration by the larvae.

The Scotian Shelf and Georges Bank - Major features of larval sea scallop distribution in these areas are the high concentrations of larvae on Georges Bank, the reduced numbers of larvae in the Northeast Channel, and the strong differences in the length frequency distribution of larvae from Georges versus the Scotian Shelf.

High larval abundance on Georges must be related to the large spawning biomass there compared to the Scotian Shelf. Landings on Georges are usually more than an order of magnitude greater than those from the Scotian Shelf or the Bay of Fundy (Sinclair et al. 1985). Similar concentrations of larvae in the Bay of Fundy in October 1985 indicate either (i) larval numbers had not yet reached a peak on Georges Bank or (ii) the larger spawning biomass on Georges is reflected in the total number of larvae there (which cannot be assessed here), rather than the concentration.

The low numbers of larvae in the Northeast Channel during October 1985 indicate that larval exchange between Georges and Browns Bank was insignificant at this time. If the lack of larval exchange between major scallop concentrations is a general phenomenon, than recruitment overfishing in single areas may be possible. Isolation of larval concentrations on Georges Bank from those on the Scotian Shelf is the case for other animals, including larval herring (Lough et al. 1985) and larval haddock (Smith and Morse 1985). Whether this retention of larvae on Georges is due to circulation alone or whether larval behavior (i.e. vertical migration) is involved requires further study.

The lack of any large scallop larvae on the Scotian Shelf contrasts with the large numbers found on Georges Bank and in the Bay of Fundy. Transport of larvae by the residual currents along the Scotian Shelf into the Bay of Fundy is not likely since there is no increase in length of larvae between the Browns Bank area (Fig. 9b) and that part of the Scotian Shelf to the north (Fig. 9a). We suggest that the lack of larvae greater than 200 um long on the Scotian Shelf is the result of either depressed larval growth rates or markedly later spawning times there. If growth rates are significantly lower on the Scotian Shelf, larval survival in this area is also likely to be lower. These possibilities will be investigated in the near future.

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Table 1. Commercial catch of scallops from the Bay of Fundy (Class 1 data only) in 1984 and 1985 with percentages from each area in Figure 4.

		Percentage of total by area		
Year	Catch (kg)	Outer	Middle	Inner
1984	$5.41 * 10^{5}$	78.0	18.9	3.1
1985	$4.64 * 10^{5}$	90.4	7.3	2.3

Table 2. Larval numbers in the Bay of Fundy with percentages from Outer, Middle and Inner Bay areas.

			Percentage of total by area		
Date	Size (um)	Total Number	Outer	Middle	Inner
Sept 84	150 - 199	$2.22 * 10^{12}$	54.5	20.9	24.9
	200 - 229	$7.39 * 10^{11}$	53.6	18.9	27.5
	230 - 299	$6.77 * 10^{11}$	52.6	21.1	26.2
	150 - 299	$3.64 * 10^{12}$	53.2	20.7	26.0
Oct 84	155 - 199	$6.92 * 10^{11}$	72.3	12.6	15.2
	200 - 229	$7.04 * 10^{11}$	69.3	13.7	16.9
	230 - 299	$3.60 * 10^{11}$	66.9	13.7	19.3
	155 - 299	$1.76 * 10^{12}$	70.0	13.3	16.8
Nov 84	150 - 199	$3.01 * 10^{11}$	31.0	11.2	57.8
	200 - 229	$1.42 * 10^{11}$	38.0	12.4	49.6
	230 - 276	$7.51 * 10^{9}$	76.6	23.4	0.0
	150 - 276	$4.50 * 10^{11}$	34.5	12.0	53.5
Oct '85	109 - 199	$6.02 * 10^{12}$	86.3	5.3	8.3
	200 - 229	$4.56 * 10^{11}$	70.0	8.7	21.3
	230 - 288	$3.10 * 10^{11}$	71.9	7.9	20.2
	109 - 288	$6.78 * 10^{12}$	84.6	5.7	9.8

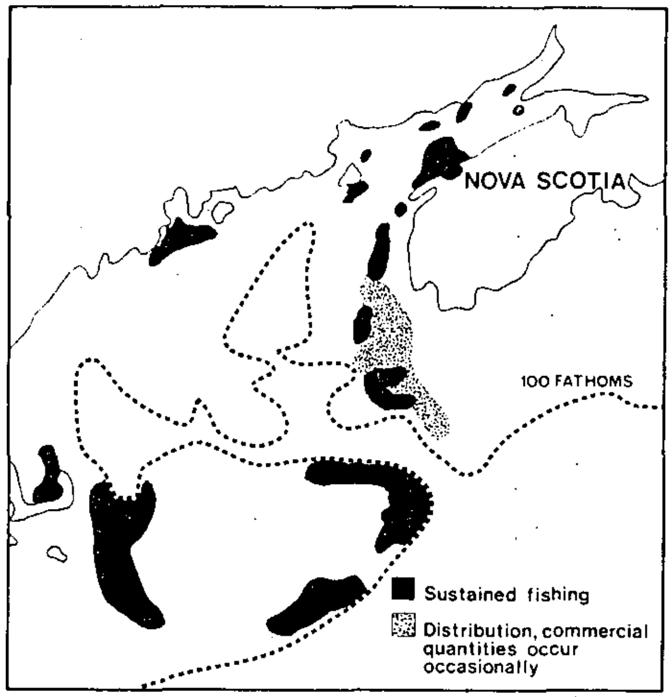

Figure 1. The distribution of Placopecten magellanicus fishing areas (modified from Sinclair et al. 1985).

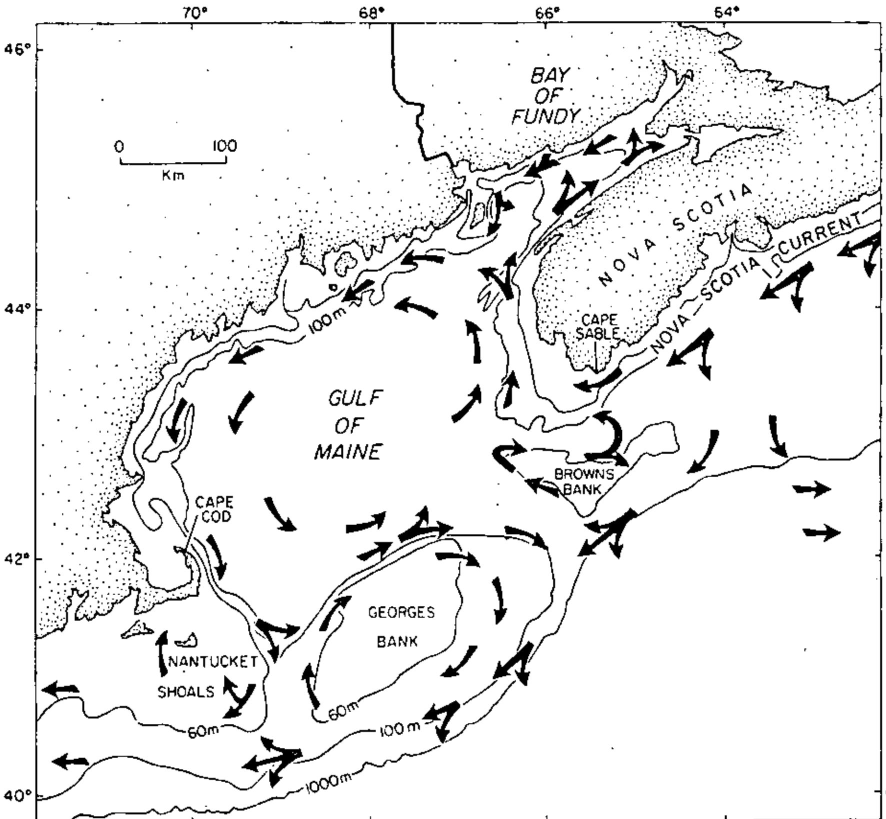

Figure 2. Residual circulation of the Gulf of Maine area (as drawn by R. Trites, Marine Ecology Laboratory, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada.

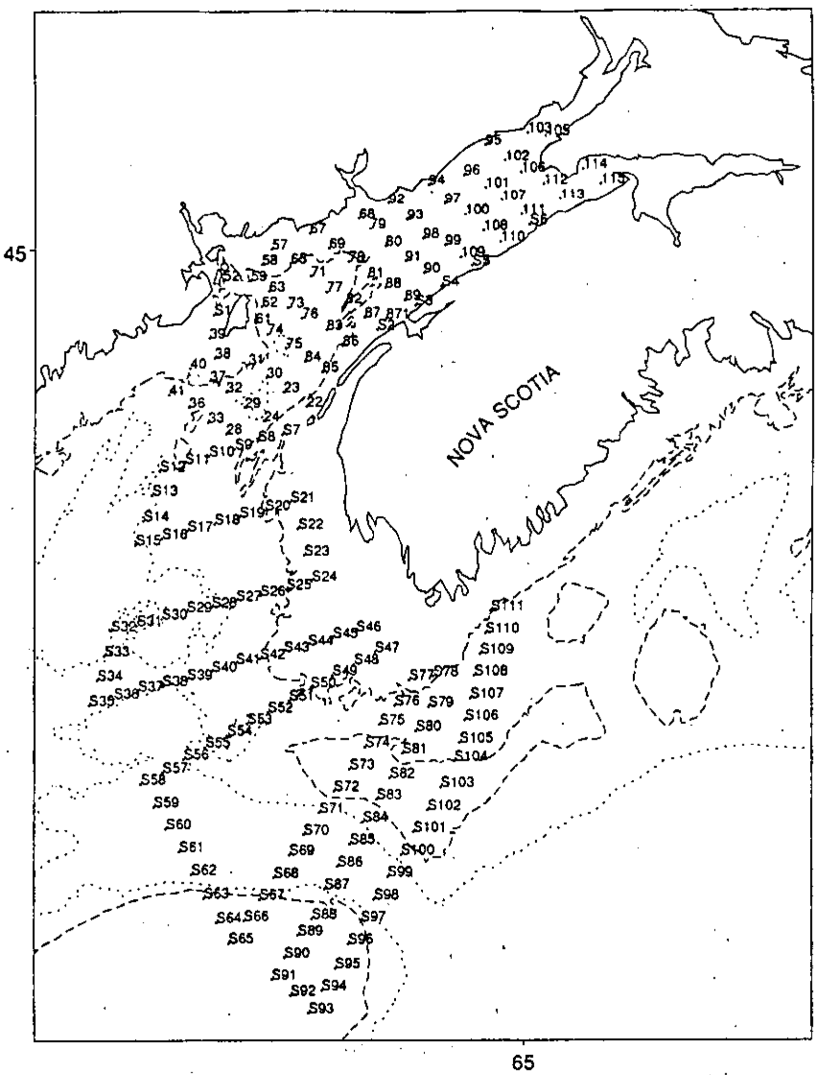

Figure 3. Stations sampled for larval scallops during at least one of the following periods: September 6 - 13 1984, October 10 - 15 1984, November 3 - 14 1984, October 10 - 15 1985.

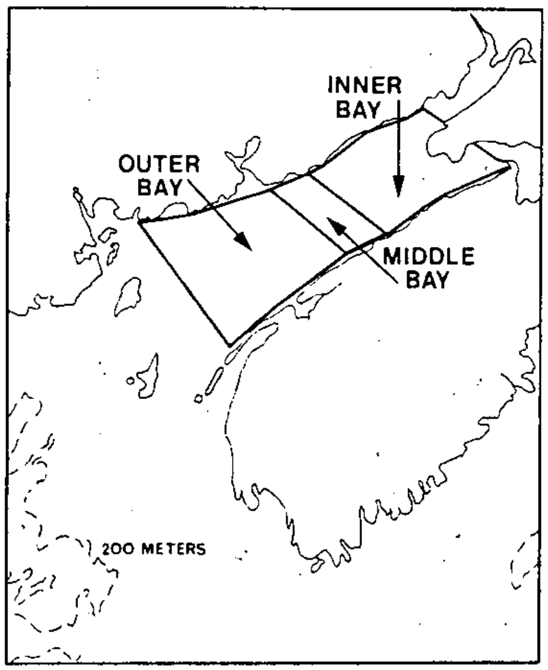

Figure 4. Areas of Bay of Fundy referred to in text.

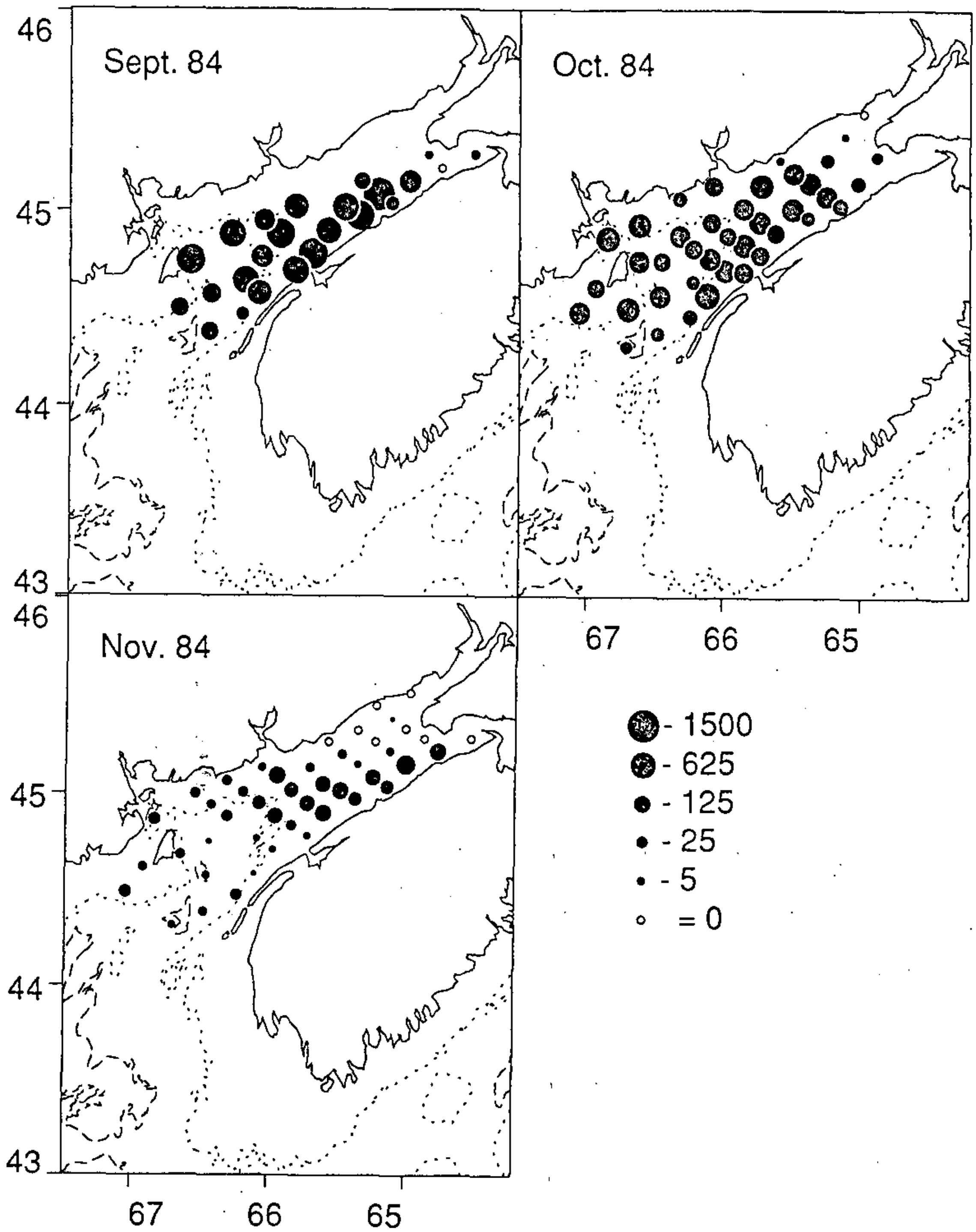

Figure 5. Distribution of larval scallops during 1984 sampling periods. (in number per square meter)

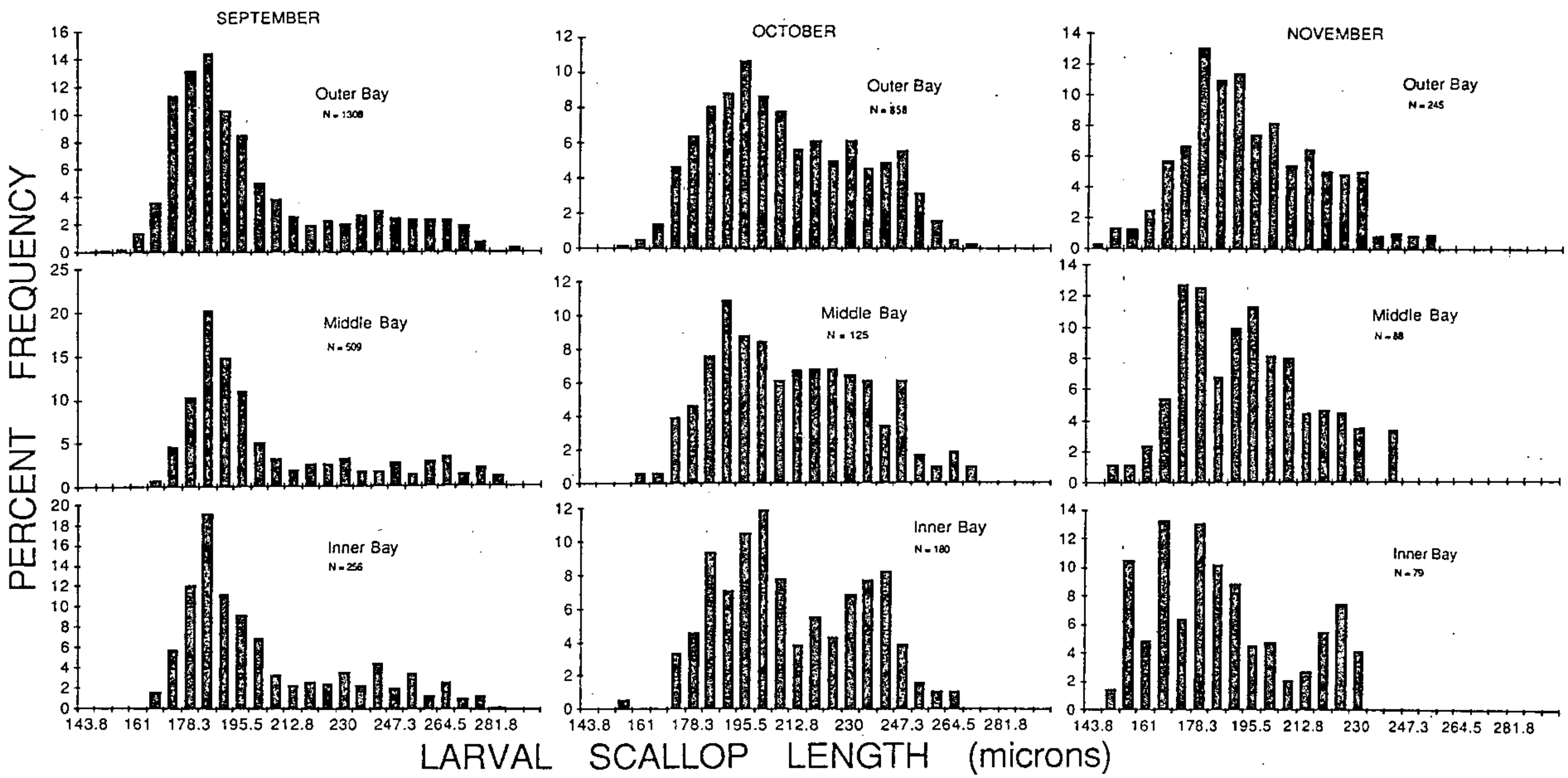

Figure 6. Length frequency distribution of larvae in different areas of the Bay of Fundy during 1984. N is the number of larvae measured.

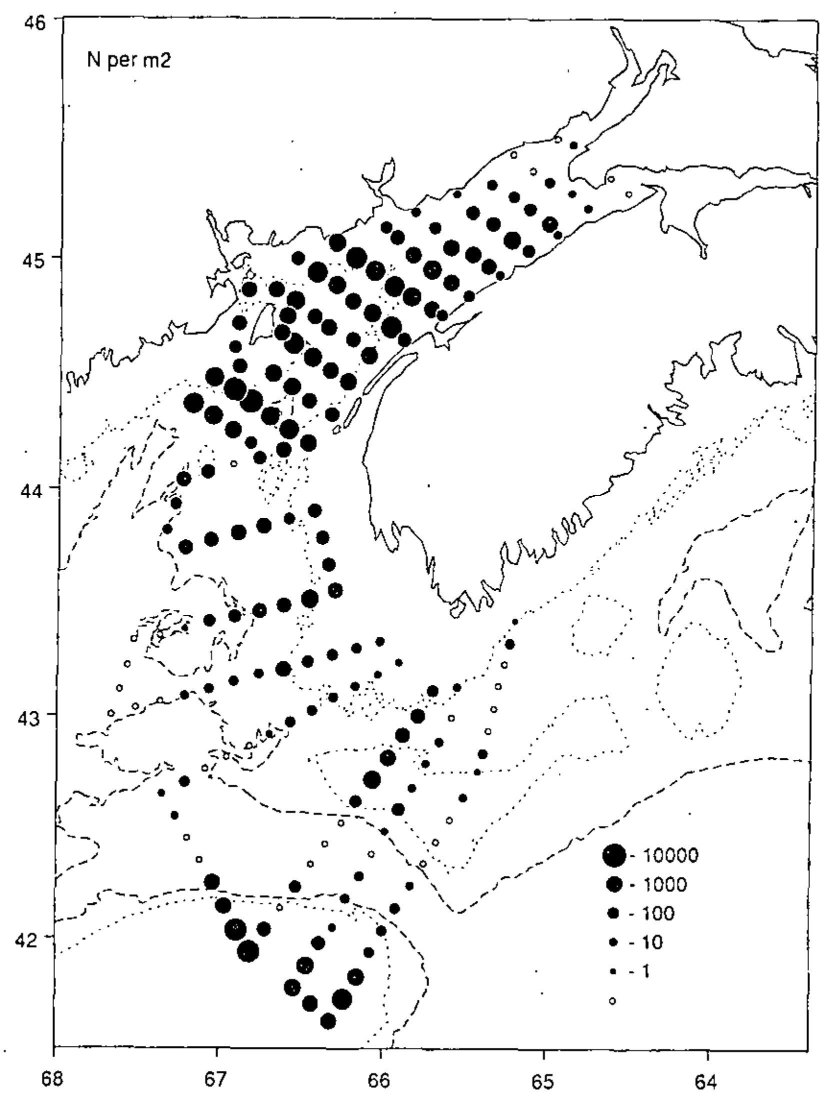

Figure 7. Distribution of larval scallops during October 1985 (in number per square meter)

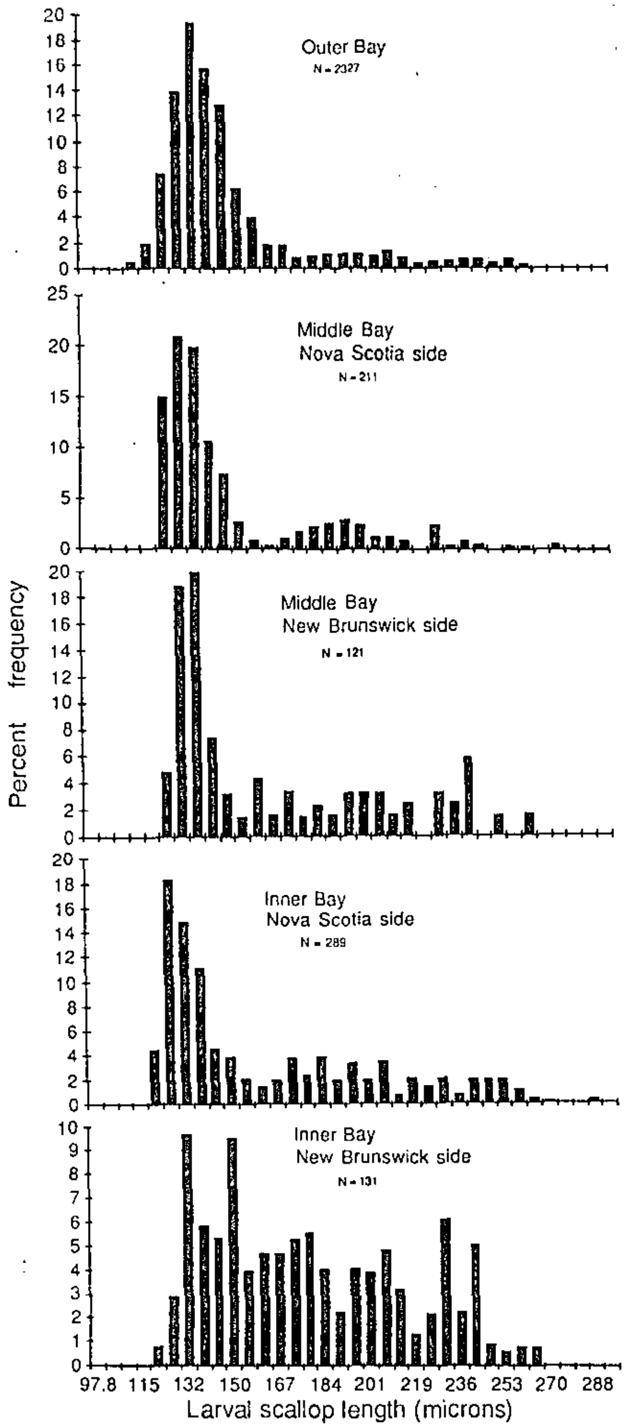

Figure 8. Length frequency distribution of larvae in different areas of the Bay of Fundy during October 1985. N is number of larvae measured.

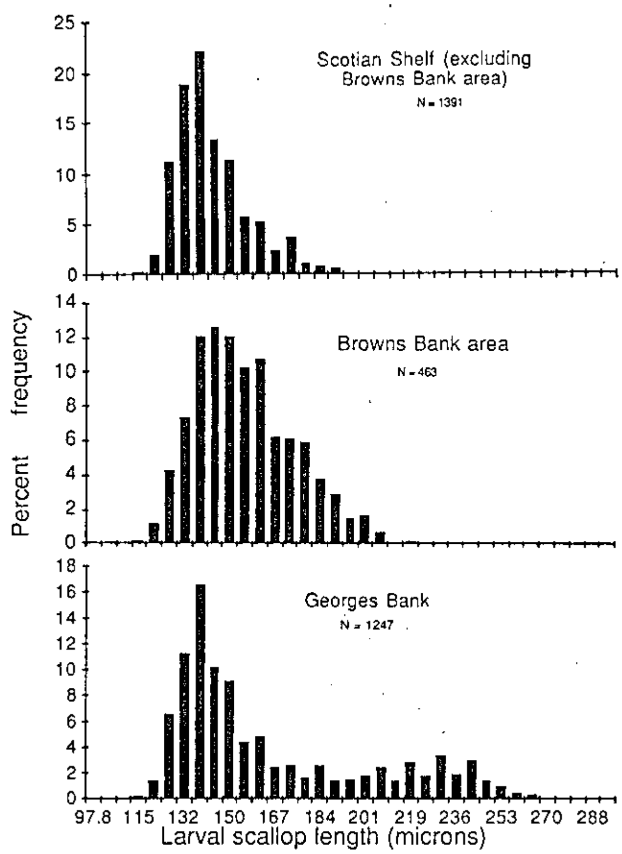

Figure 9. Length frequency distribution of larvae from the Scotian Shelf and Georges Bank. N is number of larvae measured.