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## Recruitment to the macrobenthos of *Macomona liliana* (Bivalvia: Tellinidae) in Manukau Harbour, New Zealand

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**Abstract** The population biology of the wedge shell *Macomona liliana* (Iredale, 1915) was studied at six sites on intertidal sandflats in Manukau Harbour over 2 years. Differences were found in the densities of bivalves between sites, and at each site large seasonal fluctuations in densities were also observed. Within-site density fluctuations were mainly the result of changes in the numbers of juveniles (< 5 mm long). Length-frequency distributions were dominated by a single mode associated with new recruits. The only major inter-site difference was the scarcity of large bivalves at one site. Recruitment to the macrobenthos occurred over an extended period (summer to late winter or spring), but with markedly different levels of recruitment in the two successive years. Length-frequency plots indicated that growth in the first year was 2–3 mm. The possible involvement of hydrodynamics, inter- and intraspecific interactions, and pollution on recruitment, and the importance of mortality and migration to post-settlement survival are discussed.

**Keywords** *Macomona liliana*; macrobenthos; Manukau Harbour; marine mollusc; recruitment

### INTRODUCTION

Tellinid bivalve molluscs are common and often important components of estuarine and coastal benthos around the world. Their presence can have marked effects on community structure (e.g., Reise 1985) and they have been shown to make a major contribution to secondary production (e.g., Knox 1986). The wedge shell *Macomona liliana* (Iredale, 1915) is a tellinid bivalve found in estuaries and sheltered coastal waters throughout New Zealand. *Macomona liliana* has been referred to as *Tellina liliana* in the past (e.g., Powell 1979), however, Beu & Maxwell (1990) recognise *Macomona* as a valid genus.

Morton & Miller (1968) described the tidal distribution of *M. liliana* as being on the lower shore, down to ELWS, but it has also been reported as occurring in the subtidal benthos (Grange 1979; Davidson 1989; Roper 1990). Although *M. liliana* often forms a major component (both numerically and in terms of biomass) of the coastal benthos in New Zealand (Morton & Miller 1968; Pridmore et al. 1990b), no previous study has been made of its population biology. This paper describes the population structure and recruitment patterns of *M. liliana* from intertidal sandflats within Manukau Harbour (37°02'S, 174°45'E), a large (344 km<sup>2</sup>) tidally dominated inlet on the west coast of the North Island. Macrobenthic community structure at these same sites has been described previously by Pridmore et al. (1990a). This work established the numerical importance of *M. liliana* and highlighted differences in the density of the species between sites. Thrush et al. (1989), utilising data collected at the same six sites, have described spatial distribution patterns of several common invertebrates, including *M. liliana*.

### METHODS

*Macomona liliana* were sampled at six sites within Manukau Harbour (Fig. 1) on 12 occasions between October 1987 and December 1989. The interval between samplings was 2 months, apart from one

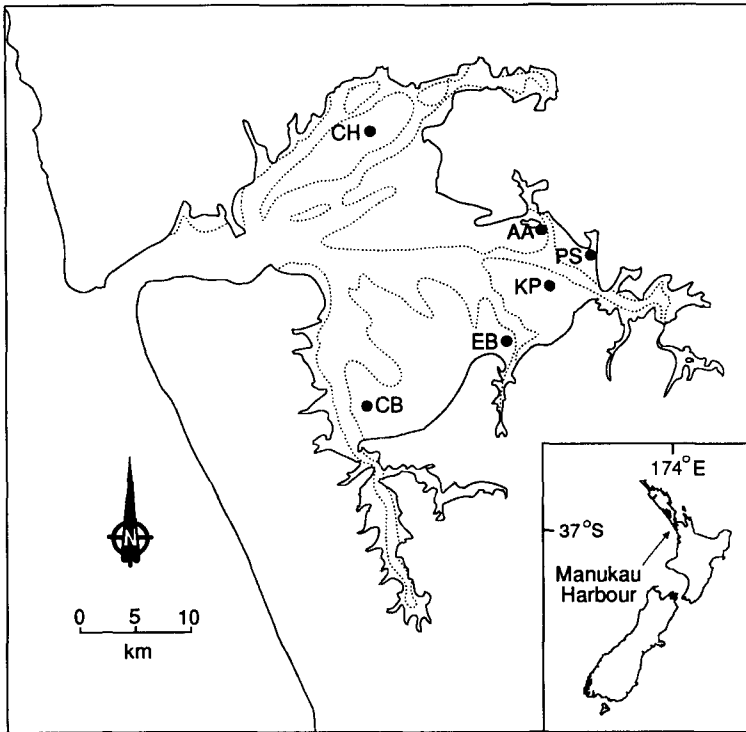


Fig. 1 Location map showing sampling sites within Manukau Harbour, North Island, New Zealand.

interval of 6 months in the middle of the sampling programme. All sites were situated on large, exposed sandflats, at about the mid-tide level. Details of sediment composition are given in Pridmore et al. (1990b). Each site covered an area of 9000 m<sup>2</sup>, (either 90 x 100 or 50 x 180 m configuration) and was divided into 12 equal sectors (30 x 25 m). Sample locations within each sector were obtained from randomly derived cartesian coordinates and, to ensure a more uniform coverage, the same number of samples was taken from each of the 12 sectors. Coordinates were redrawn if the selected location fell within a 5 m radius of a previously sampled area to preclude any localised modification of the sediment or resident populations. On the first sampling occasion (October 1987 for all sites except CB, which was first sampled in December 1987), 36 sediment cores (133 cm<sup>2</sup> x 15 cm deep) were collected from each site (3 from each sector) to establish the optimum sampling intensity for future visits. On all subsequent occasions 12 cores were collected from each site (1 from each sector). After collection, sediment cores were sieved (500 µm mesh) and the residue fixed in 5% formalin and 0.1% Rose Bengal in sea water. Specimens of *M. liliانا* were sorted from the samples, counted,

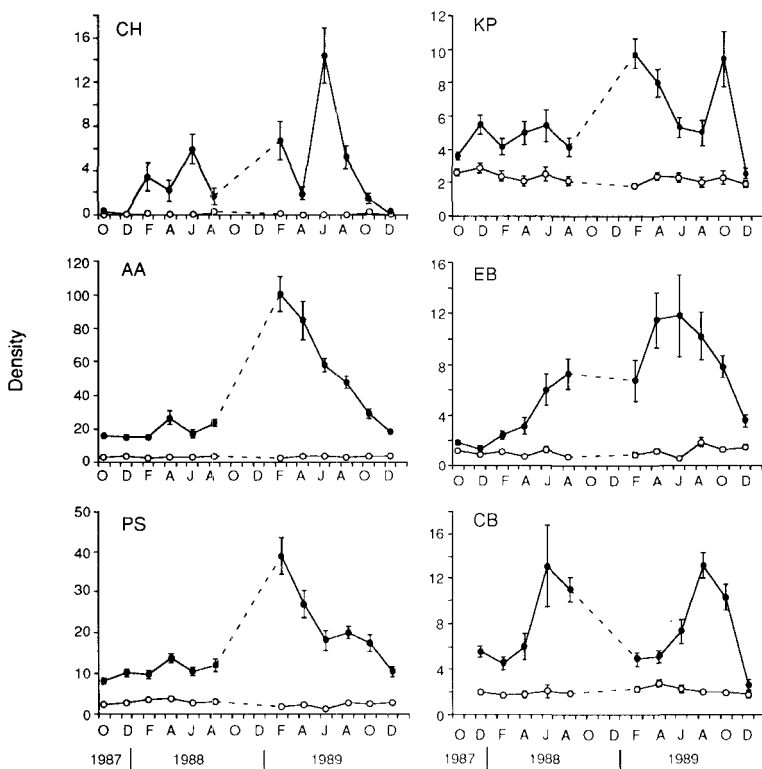
and their shell lengths measured to the nearest 0.1 mm using a microscope eye-piece micrometer or Vernier calipers.

## RESULTS

Temporal fluctuations in the density of *M. liliانا* occurred at all sites, with the average density and magnitude of fluctuation varying between sites (Fig. 2). The two extremes were displayed at Sites CH and AA. At CH, mean densities of less than 1 individual per core (133 cm<sup>2</sup>) were recorded on three occasions, and the largest mean density recorded was 14.4 (SD = 8.6) individuals per core. At AA, mean densities never fell below 15.1 (SD = 5.57) and the highest recorded was 100.4 (SD = 37.1).

There was a difference in the levels of recruitment of *M. liliانا* into the macrofauna between 1988 and 1989, with generally lower numbers of individuals in 1988, compared with the relatively higher total densities seen at most sites in 1989. Timing of the 1989 recruitment varied between sites so that maximum densities were recorded from February (at AA, KP, and PS) through to August (at CB). During 1989, a secondary peak of abundance was seen at KP

**Fig. 2** Densities (means  $\pm$  1 standard error) of all ( $\bullet$ ) and  $>$  5.0 mm long ( $\circ$ ) *Macomona liliana* at the six sites in Manukau Harbour, between October 1987 and December 1989 (based on 36 cores for the first sample and 12 thereafter). Where error bars are absent standard errors were small and within the area of the symbol.



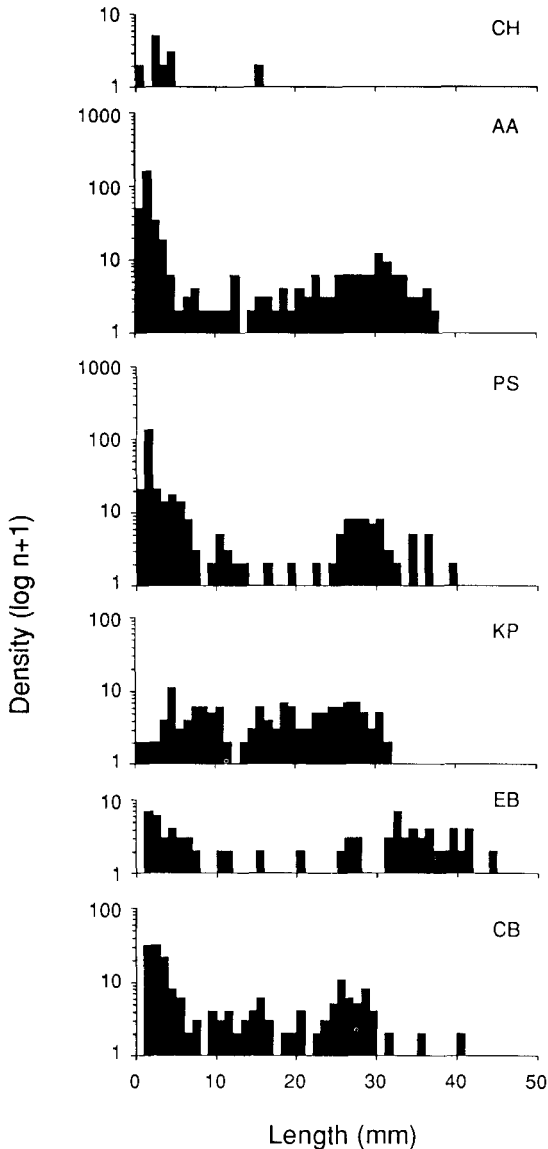
in October. After the high recruitment in 1989, total densities tended to decline to their 1988 baseline at most sites. At CB, similar cyclical changes in numbers were displayed during 1988 and 1989, with peak densities being recorded during winter in both years.

Examination of density changes with size showed that at all sites the large fluctuations over the sampling period resulted mainly from changes in numbers of animals  $\leq$  5.0 mm long (Fig. 2). Densities of individuals  $>$  5.0 mm were quite consistent throughout the sampling period.

Plots of length-frequency distributions revealed some differences between the sites. For example, Fig. 3 shows length-frequency distributions at the time of the first sampling (October 1987 at all sites except CB which was first sampled in December 1987). No large animals were found at CH, although on other occasions small numbers of larger individuals were taken. A 54.9 mm long specimen collected at CH was the largest *M. liliana* collected during the study. Newly recruited animals resulted in a major peak in the distributions, especially at AA, PS, and CB. Secondary peaks were evident between 25 and 30 mm at AA, PS, and KP, and between 30 and

35 mm at EB. Over time these distributions were relatively stable.

To study recruitment patterns in detail, length-frequency plots were made of  $<$  10 mm long individuals, using a 0.2 mm size class. This size range included about 88% of all individuals taken in sampling and no obvious modes were observed in plots of the full size range. Length-frequency plots of the  $<$  10 mm size range for every sampling occasion at AA are presented in Fig. 4. This site was chosen for presentation because of the high recruitment densities and the fact that population dynamics at this site appeared to be representative of other sites. During October 1987–August 1988, growth of individuals forming a mode at 1.1 mm in October apparently resulted in movement of this mode to 3.1 mm in August. During this same period, new recruits started to appear in February, and continued to be taken until August. During February–December 1989 recruitment seemed to continue throughout the period, at least until October. The continuous recruitment was countered by a high loss rate. This had the effect of masking any growth-related movement in this mode which remained at 1.0–1.2 mm until December, by



**Fig. 3** Length-frequency distributions of *Macomona liliiana* at the six sites in Manukau Harbour in October 1987 (except for CB which was sampled in December 1987). Densities are based on the total number of *M. liliiana* taken in 36 cores at each site. Because some shells were damaged and could not be accurately measured, total densities are in some instances slightly lower than those reported in Fig. 2.

which time most *M. liliiana* were 2.1 mm long. It was not possible to discern any obvious interruption between year classes (as in 1988). During both periods loss of small individuals was very high, resulting in

the addition of few animals to the > 5 mm size range (Fig. 2 and 4)).

## DISCUSSION

The population structure of *M. liliiana* is strongly influenced by the presence of small individuals. Densities of individuals > 5 mm long (and probably over 1 year old) were relatively stable over the study period whereas at all sites, large fluctuations in the total density of animals present resulted from changes in the abundance of newly recruited juveniles. The numerical importance of juveniles was also apparent at several sites from the length-frequency plots (Fig. 3). This is similar to *Tellina tenuis*, for which fluctuations in total densities result mainly from settlement of juvenile individuals, and size-frequencies are dominated by 1–2-year-olds (Evans & Tallmark 1976; Barnett & Watson 1986). Young individuals are also important for the tellinid bivalve *Macoma balthica*, with small animals (up to 2 years old) predominating in size-frequency distributions (Nichols & Thompson 1982; McGreer 1983).

Peaks in total densities (Fig. 2) indicate an extended recruitment period ranging from February (late summer) to August (late winter) in 1989. Recruitment may have occurred earlier than February, but sampling did not recommence until then. There is also evidence of secondary recruitment, with two density peaks during 1989 discernible at KP, and possibly PS and CH. It is not known how long the delay would be between spawning and juveniles appearing in benthic samples, settling out of the plankton, and then growing to a sufficiently large size to be retained on a 500  $\mu$ m mesh. However, it would appear from a visual inspection of sexual tissue, that spawning may be protracted, beginning in spring and extending into autumn. From the length-frequency plots, February 1988 was the earliest that new recruits were detected, with individuals 0.9 mm long appearing (Fig. 4). During 1989, new recruits less than 1.0 mm long were present through to October. *Macoma balthica* has been found to release gametes in both spring and autumn, resulting in the appearance of juveniles at both times of year (Nichols & Thompson 1982). Bachelet (1986), studying another *M. balthica* population, described a protracted spawning period from spring to autumn, giving 2 or 3 settlements per year.

There was a dramatic difference in the numbers of recruiting juveniles between 1988 and 1989. Similar annual fluctuations in recruitment have been observed

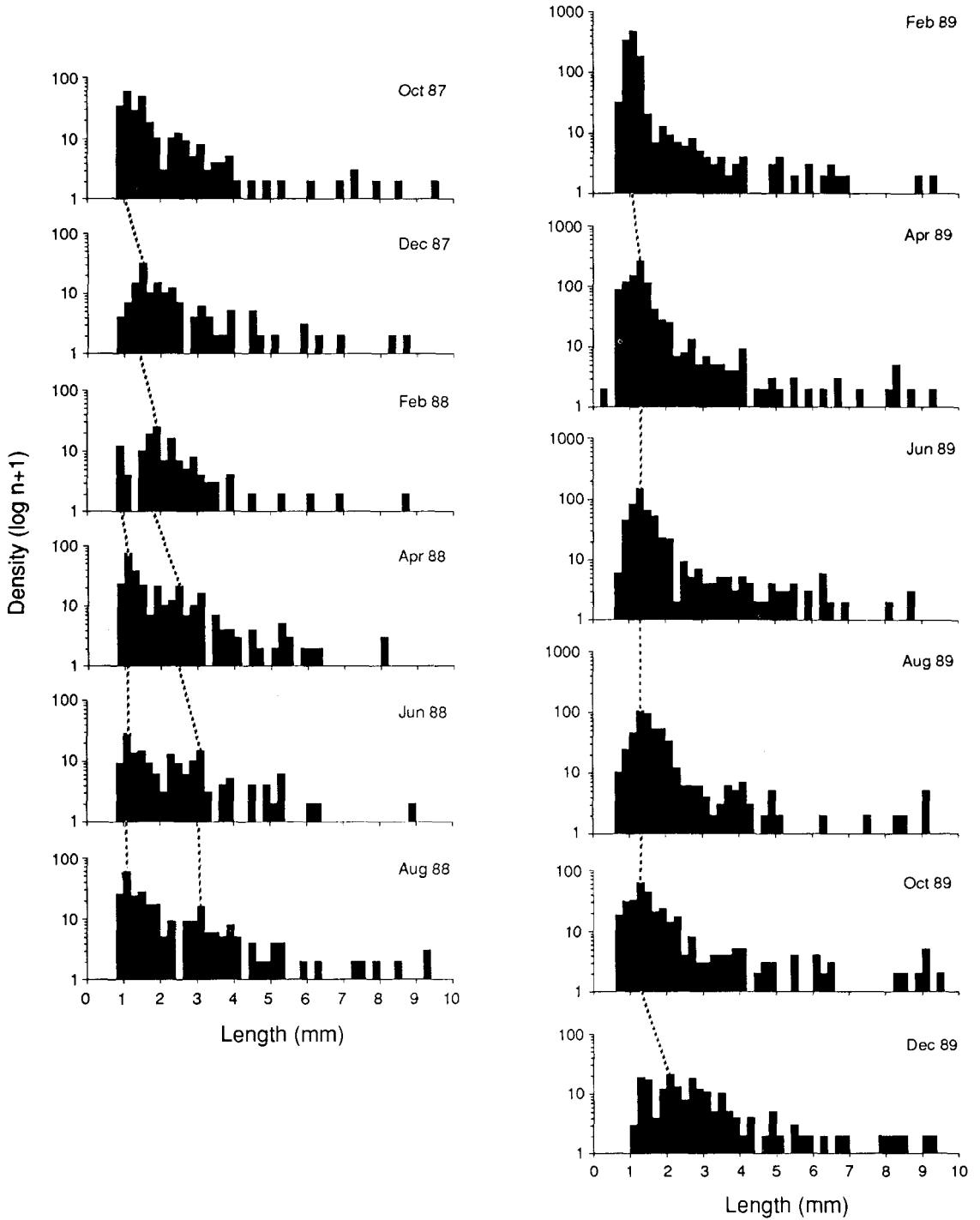


Fig. 4 Length-frequency distributions of *Macomona liliana* < 10 mm long at Site AA between October 1987 and December 1989. Lines linking possible recruitment modes have been fitted by eye. Densities are based on the total number of *M. liliana* taken in 36 cores in October 1987 and 12 cores at all other times.

in *Tellina tenuis* (McIntyre 1970; Barnett & Watson 1986) and *Macoma balthica* (Bachelet 1986). The reason for such fluctuations in densities is not known; however, Barnett & Watson (1986) concluded for *T. tenuis* that temperature conditions before, during, and after spawning were probably important factors in the long-term variability of that species.

The numbers of juveniles colonising a site seems to be related to the number of adults present. Highest recruitment occurred at AA where adult densities were highest. At CH, where adults were always scarce, recruitment was never high. This may indicate that some sites provide a better habitat for *M. liliana* even though the sites are similar in gross physical characteristics. Larval movement around the harbour may also be restricted, with young settling near spawning adults. Water flow within the harbour is mainly tidal and aligned along the major channels (Heath et al. 1977). The mixing of waters from the different channels occurs mostly near the entrance channel where exchange with the sea is greatest (B. L. Williams, Water Quality Centre, Hamilton, pers. comm.). Thus, the number of planktonic larvae travelling from one region of the harbour to another is likely to be greatly diminished by tidal exchange. It is also possible that wind-driven currents hold larvae in the vicinity of Sites PS and AA as the prevailing and strongest winds are south-westerlies. Adult *M. liliana* may also promote juvenile recruitment. For example, Thrush et al. (1992) have shown that the addition of adult *M. liliana* to defaunated sediment can increase the number of juvenile conspecifics. Experiments carried out with *Macoma balthica*, however, indicate that adults of that species either have no effect on juvenile recruitment (Gallagher et al. 1983; 'Olafsson 1989; Vincent et al. 1989) or hinder their colonisation (Hines et al. 1989). It is very likely that such adult/larval interactions will be density-dependent, with low adult densities facilitating recruitment and high densities inhibiting it (Zajac & Whitlatch 1985).

Differences in juvenile recruitment between sites may also be linked to the presence of other invertebrates through interference or predation. Nichols & Thompson (1985) suggested that amphipods may affect the settlement of *Macoma balthica*. Elmgren et al. (1986) showed experimentally that the survival of *M. balthica* spat was lowered as a result of physical damage inflicted by the amphipod *Pontoporeia affinis*. Romn et al. (1988) and 'Olafsson (1989) have demonstrated that the polychaete *Nereis diversicolor* can reduce the survival of juvenile *M. balthica*. Bachelet (1986) noted an inverse relation

between settlement of *M. balthica* and densities of the spionid polychaete *Streblospio shrubsolei*. The abundance of surface-burrowing crustaceans or large predatory polychaetes does not readily relate to the density of *Macomona liliana* at the six sites (Pridmore et al. 1990b). However, high densities of the tube building spionid polychaete *Boccardia syrtis* occur only at Site CH (Pridmore et al. 1990b). These tube mats may physically restrict burrowing and feeding activities of young bivalves, and competition for food or aggression by the worms may further reduce their survivorship.

Pollution is also known to affect the recruitment of tellinid bivalves. For example, Bonsdorff & Wenne (1989) found that recruits of *Macoma balthica* were negatively affected by hydrogen sulfide concentrations, so that juveniles were absent at polluted sites, compared with other sites where size-frequency distributions showed many age classes and a clear dominance of juveniles. High sediment metal concentrations have also been found to influence the settlement and survival of *M. balthica* (McGreer 1982). Site CH lies in a pollution gradient running along the northern channel of the harbour. Elevated concentrations of chlorinated organic compounds, metals, and microbiological contaminants along the northern shore of the harbour have been linked to loss of condition in oysters (Pridmore et al. 1990a). Contamination of the sandflats at CH may therefore be affecting the recruitment and survival of *M. liliana*.

At all sites, juvenile *M. liliana* numbers decreased steadily after initial recruitment. This high loss of small individuals was probably normal as the population structure at most sites had few adults compared with the numbers of recruits. However, high annual variability has been found in the survival of *M. balthica* recruits (Bachelet 1986). The possible role of predation by amphipods and polychaetes in reducing juvenile numbers has been discussed above. Larger predators, e.g., eagle rays (*Myliobatis tenuicaudatus*) and wading birds (i.e., knots, oystercatchers) feed in large numbers on the Manukau Harbour sandflats (Auckland Regional Water Board 1990; Thrush et al. 1991), and their feeding activity may also account for losses of *M. liliana*. Young *M. liliana* may also actively migrate from the mid-tidal level of the sandflats. Beukema & de Vlas (1989) have described the mechanism whereby postlarval *Macoma balthica* juveniles secrete hyaline threads to aid in their tidal transport away from the sandflats they first settle on. For this tellinid species, there are therefore two settlement phases. The first occurs when metamorphic larval individuals settle from the

plankton and adopt a benthic habitat, principally in the high intertidal areas. Then in the winter following primary settlement, the young shellfish use tidal transport to carry them from high tidal flats to lower flats, and subtidal and offshore areas. Although it has not been definitely established that *M. liliانا* undergoes some form of postlarval migration and secondary settlement, individuals up to 8 mm long have been taken in plankton samples (Pridmore et al. 1991), and hyaline threads similar to those described for *M. balthica* have been seen (pers. obs.). It is therefore quite possible that the variation in numbers of small *M. liliانا* observed at the mid-tide sites was partially the result of postlarval transport. As well as accounting for the observed losses of small individuals, this could also explain the increase, in December 1989, of the number of bivalves about 3 mm long at Site AA (Fig. 4).

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