NIWA

Taihoro Nukurangi

Cockles in Pauatahanui Inlet: results of the 1998 sampling programme.

NIWA Client Report: NEL90401/3
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Ken Grange
Tammy Crocker

prepared for

Guardians of Pauatahanui Inlet
P.O. Box 57034
Mana
PORIRUA CITY

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National Institute of Water & Atmospheric Research Ltd
PO Box 893, Nelson
New Zealand
Tel: 03 548 1715
Fax: 03 548 1716

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Reviewed by: *Approved for release by:*

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Executive Summary

An Inlet-wide survey of the cockle populations was undertaken by community volunteers during November 1998. This represents the fourth survey of the same sites since 1976.

The results show that cockles throughout the Inlet are distributed in similar patterns as found previously, with the greatest densities along the southern shores. Fewer cockles were recorded along the northern shore, consistent with previous surveys. Increasing densities of cockles occurred down the shore, as expected.

The major differences between the 1998 survey and those undertaken in 1992 and 1995 was the significant increase in the numbers of juvenile cockles recorded at almost all sites. The larger numbers of juveniles caused the total estimated population to increase as well, reducing the downward trend shown in previous surveys. The total estimated population of cockles in the Inlet, based on the 1998 survey, was around 257 million, up from 180 million in 1995.

It is possible that the increased numbers of juveniles may be due to the fact that samples were sieved in 1998, whereas in previous surveys, cockles were sorted by hand and small juveniles may have been overlooked. This is regarded as unlikely because a smaller survey in 1997 also sieved all samples, and few juveniles were recorded.

It is not known the reason for the apparent increase in recruitment shown by the 1998 survey. The increase in numbers of juveniles will eventually lead to an increase in the adult cockle population, if they survive. Monitoring of the juveniles is suggested.

1. INTRODUCTION

The Guardians of Pauatahanui Inlet is a community group of residents concerned about the ecological health of the Inlet. As part of that concern, they have arranged, in collaboration with NIWA, several surveys of the cockle (*Austrovenus stutchburyi*) population throughout the Inlet.

The first systematic sampling of the cockles in the Inlet was undertaken in 1976 by the then New Zealand Oceanographic Institute, DSIR, as part of the wider Pauatahanui Environmental Programme (Healy 1980). These results were published by Richardson *et al* (1979). A second survey, using most of the same sites as the 1976 survey, was undertaken in 1992, this time with the assistance of community volunteers, and overseen by NIWA (Grange 1993). That survey showed a significant decrease in the numbers of cockles in the Inlet since 1976, and indicated fewer recruits (juveniles $\leq$10 mm shell length) in the population. The most pronounced decreases were around the south-eastern shores on the Inlet. A third survey, undertaken in November 1995, resampled the same sites using the same methodology as the 1992 survey, and aimed to further document any changes in the population. Those results showed that the population decline had continued (Grange *et al* 1996).

The total population of cockles in Pauatahanui Inlet was estimated at each sampling period as having declined from 438-608 million individuals in 1976, to 187-257 million in 1992, and to 146-214 million in 1995 (Grange *et al* 1996), representing slightly more than one-third of the 1976 population. The 1995 survey, however, recorded a greater overall abundance of juveniles compared with the 1992 survey and Grange *et al* (1996) suggested that this could indicate that the population decline may reverse over the following few years.

It has not been possible to isolate the principle ecological or human-induced processes that have caused this decline in the cockle population. Potential causes have been identified, including sediment inundation from catchment clearing and modification (Grange 1980; 1993); poor or intermittent recruitment (Grange *et al* 1996); and recent increased harvesting pressure (Guardians of Pauatahanui Inlet, *pers. comm.*). Better management of the surrounding catchments has been recognised as being important by the Wellington Regional Council in their "Management of Pauatahanui Inlet Discussion Document" (Rosier 1993) and Regional Plan.

The present survey was undertaken on 2 and 21 November 1998, at the same sites as the previous two surveys (see Appendix 1).

2. METHODS

Community volunteers were each provided with a series of sheets that explained the sample sites, method of measurement, placing of quadrats, and recording sheets (Appendix 2). Three randomly placed, replicate quadrats of 0.1 m^2 were sampled from each of 4 tidal heights along each transect, as in previous surveys. Each cockle collected was measured to the nearest 1 mm and returned to the substrate. The only difference between this survey and previous ones was that all samples in 1998 were sieved to remove small individuals. Previous surveys had sorted by hand (1992) or sieved only one of the three replicates (1995). Sieve mesh sizes varied with volunteer, but most were reported to be 4-5 mm (Neil Bellingham, *pers. comm.*).

Densities for each site were calculated from the mean numbers recorded in each quadrat from all transects within a locality. Mean densities at each tidal height were also calculated and comparisons made with the 1976, 1992, and 1995 surveys.

Shell length measurements from each of the 3 replicate quadrats at each site were combined to produce an estimate of population size structure and allowed histograms to be produced to compare sites and tidal heights. The numbers of recruits (defined as individuals $\leq$10 mm, based on Larcombe 1971 and Richardson *et al* 1979) were also analysed to compare with previous surveys.

In August/October 1997, an independent survey of 9 of the 30 transects was completed. The results of this survey have been made available for inclusion in this report. The 9 transects corresponded to one from each major locality:

1 Equivalent to # 2, Mana

2 Equivalent to # 5, Browns Bay

3 Equivalent to # 8, Duck Creek

4 Equivalent to # 11, Bromley

5 Equivalent to # 15, Pauatahanui

6 Equivalent to # 18, Motukaraka

7 Equivalent to # 21, West Motukaraka

8 Equivalent to # 24, Kahao

9 Equivalent to # 28, Cambourne

These samples were collected using the same methodology, were sieved through a 4 mm mesh and all specimens retained measured to the nearest 1 mm.

3. RESULTS

3.1. Cockle Densities

The densities of cockles recorded in each quadrat ranged from zero, to a maximum of 273 per $0.1m^2$ (at lower mid tide, Browns Bay). The mean numbers of cockles recorded at each site are shown in Figure 1. The maximum mean density at any one site (mean of the 3 quadrats) was also recorded at LMT, Browns Bay (151 per $0.1m^2$). The highest mean densities were recorded at Browns Bay, Pauatahanui, and Mana Beach transects. However, at each of these localities, densities varied considerably among transects. Localities that supported low mean densities of cockles occurred at Cambourne, Duck Creek, and Motukaraka. These are the same general trends as recorded in previous surveys.

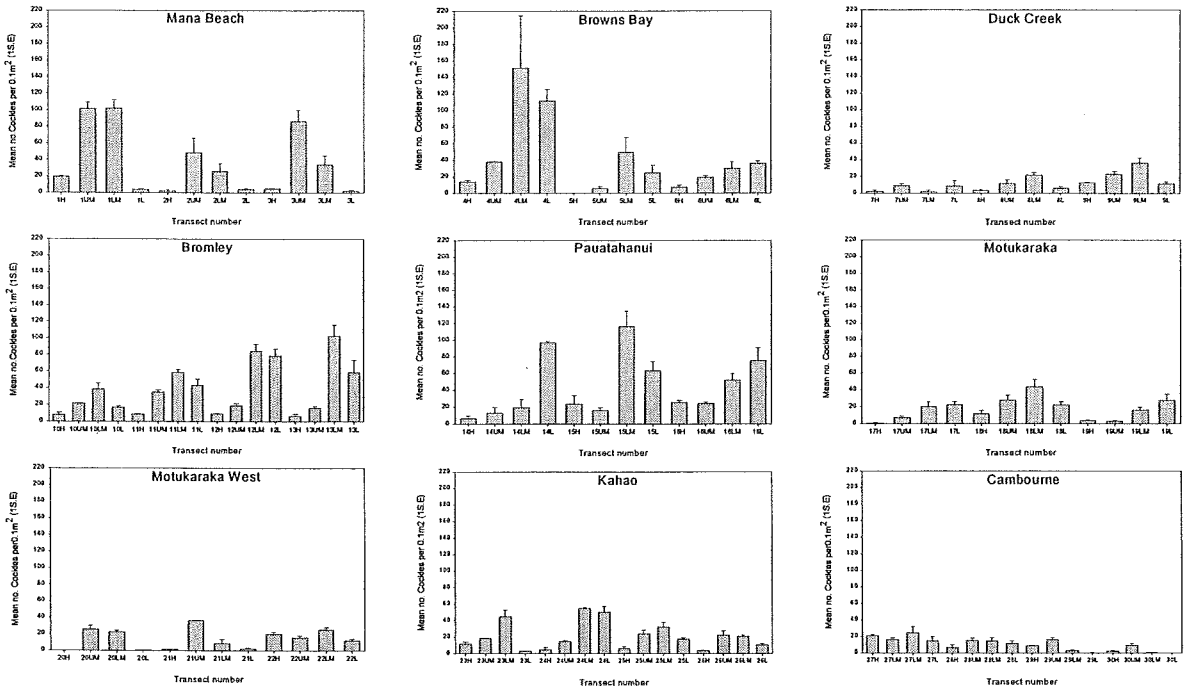

Figure 1. Mean densities of cockles recorded from each transect at each locality, 1998. Transect numbers correspond to those shown in Appendix 1. H = High Tide; UM = Upper Mid-tide; LM = Lower Mid-tide; L = Low Tide.

The total numbers of cockles collected at each transect show a similar trend to the mean numbers per quadrat (Fig. 2). Bromley and Pauatahanui transects had the

greatest total numbers of cockles, as did Mana, but there was greater variability among transects at Mana, with transect 2 supporting significantly fewer cockles that the other two transects. Cambourne transects supported the lowest total population.

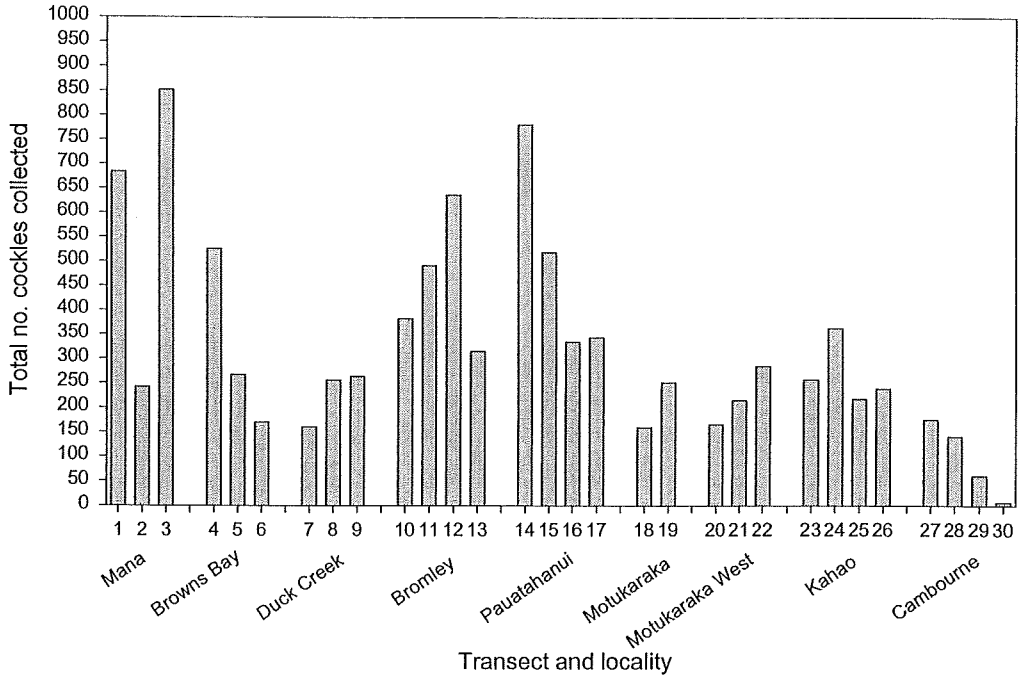

Figure 2. Total numbers of cockles collected down each transect at each locality, November 1998.

Generally, the densities of cockles increased down the shore, with most sites supporting more cockles at lower mid-tide and low tide quadrats. When all results are combined, however, the maximum densities of cockles occurred at lower mid-tidal sites (approximately 44 per $0.1.m^2$). High tidal sites supported a mean of only 10 cockles per 0.1 m^2. This was not unexpected, and reflects similar trends to previous surveys, although maximum densities were recorded at low tidal sites in 1995.

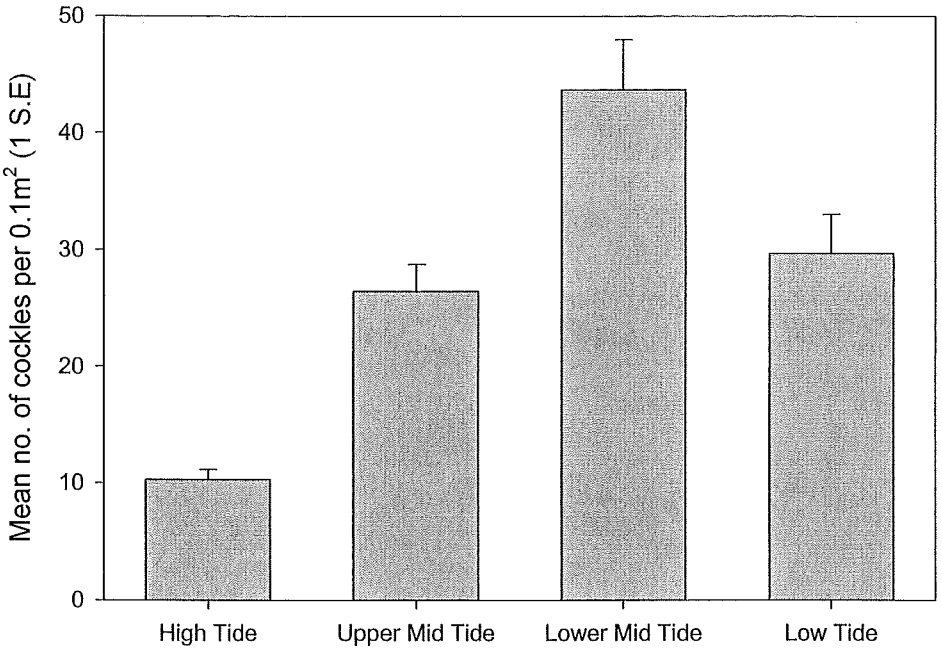

Figure 3. Distribution of cockles at each tidal height, all localities combined, November 1998.

An estimate of the total cockle population in the Inlet has been calculated from the mean densities of cockles in each quadrat (Table 1), as in previous surveys, assuming a total intertidal area of 1 km^2 (Healy 1980).

Table 1. Densities of cockles in Pauatahanui Inlet and total population estimate, 1975-1998.

	1976	1992	1995	1998
Max number per quadrat	280	168	191	273
Total counted	15,633	7,976	6,484	9,264
Mean number per quadrat	52.3	22.2	18.0	25.7
99% CL on mean	43.8-60.8	18.7-25.7	14.6-21.4	21.5-29.9
Total population estimate (millions)	438-608	187-257	146-214	215-299

The maximum number of cockles recorded per quadrat (273) was a large increase compared with the two previous surveys, and very close to that recorded in 1975.

Similarly, the total numbers of cockles counted during the survey and the mean number per quadrat were greater than in 1992 and 1995.

The 1998 results indicate a reversal of the recent downward trend in the total population of cockles in the Inlet (Fig. 4).

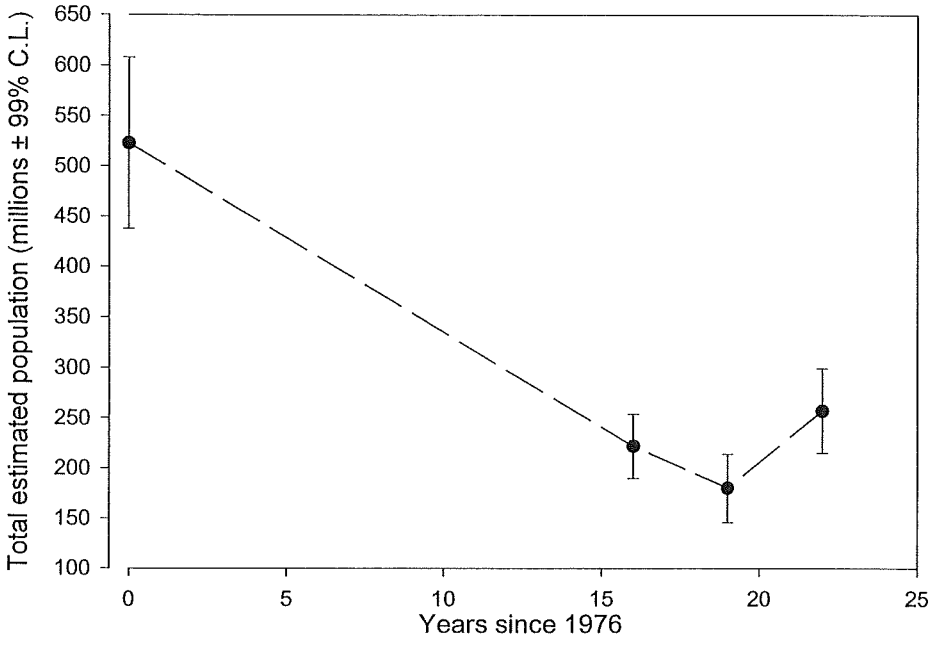

Figure 4. Trend in total cockle population within Pauatahanui Inlet, 1975-1998.

Previous surveys indicated that there had been pronounced decreases in cockle densities along the eastern and south-eastern shores between 1976 and 1995. In particular, transects 7-20 showed consistent decreases over time, as did the Cambourne sites (Grange *et al* 1996; Fig. 4). Those results also showed that 23 of the 30 transects had fewer cockles in 1995 than in 1992. To examine whether these trends have continued, or whether the increase in total population shown by these present results are due to large increases at only a few sites or a general estuary-wide increase, the mean numbers of cockles recorded from all transects over time have been plotted in Figure 5. Overall, the same pattern exists, with those sites that have previously supported more cockles continuing to do so. However, there appears to have been considerably more cockles collected at most sites during 1998. There were fewer cockles counted in 1998 than in 1995 at only 7 of the 30 sites. The 7 sites that

supported fewer cockles were two transects at Mana, one at Duck Creek, both transects at Motukaraka, and two at Cambourne.

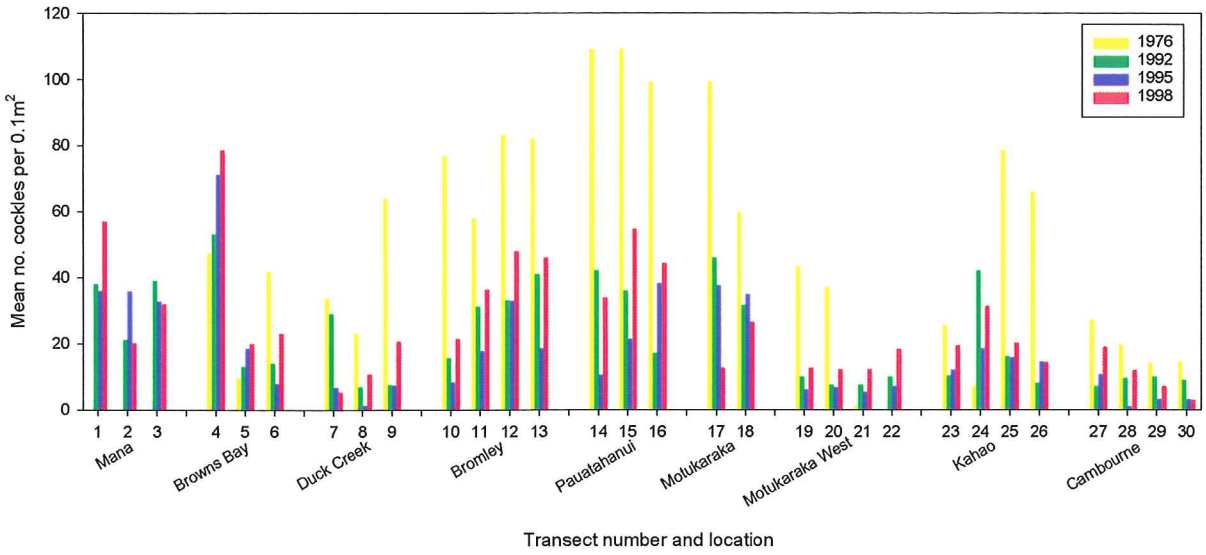

Figure 5. Mean number of cockles recorded at each site over the four surveys, 1975-1998.

Transects 25 and 26, at Kahao showed the largest decrease in populations between 1976 and 1992, but have remained relatively stable since then. Previous surveys have shown the only locality to show a consistent increase in population over time was at two transects in Browns Bay. That trend has continued for the 1998 survey.

3.2. Cockle Size Frequencies

Histograms of the size frequencies of cockles at all sites are presented in figures 6 (high tidal sites), 7 (upper mid-tidal sites), 8 (lower mid-tidal sites) and 9 (low tidal sites).

Most high tidal localities showed a unimodal size frequency distribution (Fig. 6), with modes between 15-20 or 20-25 mm. At two localities, Duck Creek and Bromley, there appears to be a second mode with adults cockles at around 35-45 mm, but the numbers are too small to be certain that these are significant. In contrast to previous surveys, juvenile cockles, those less than 10 mm shell length, were recorded at all high tidal sites. The largest individuals were recorded at Duck Creek and Bromley.

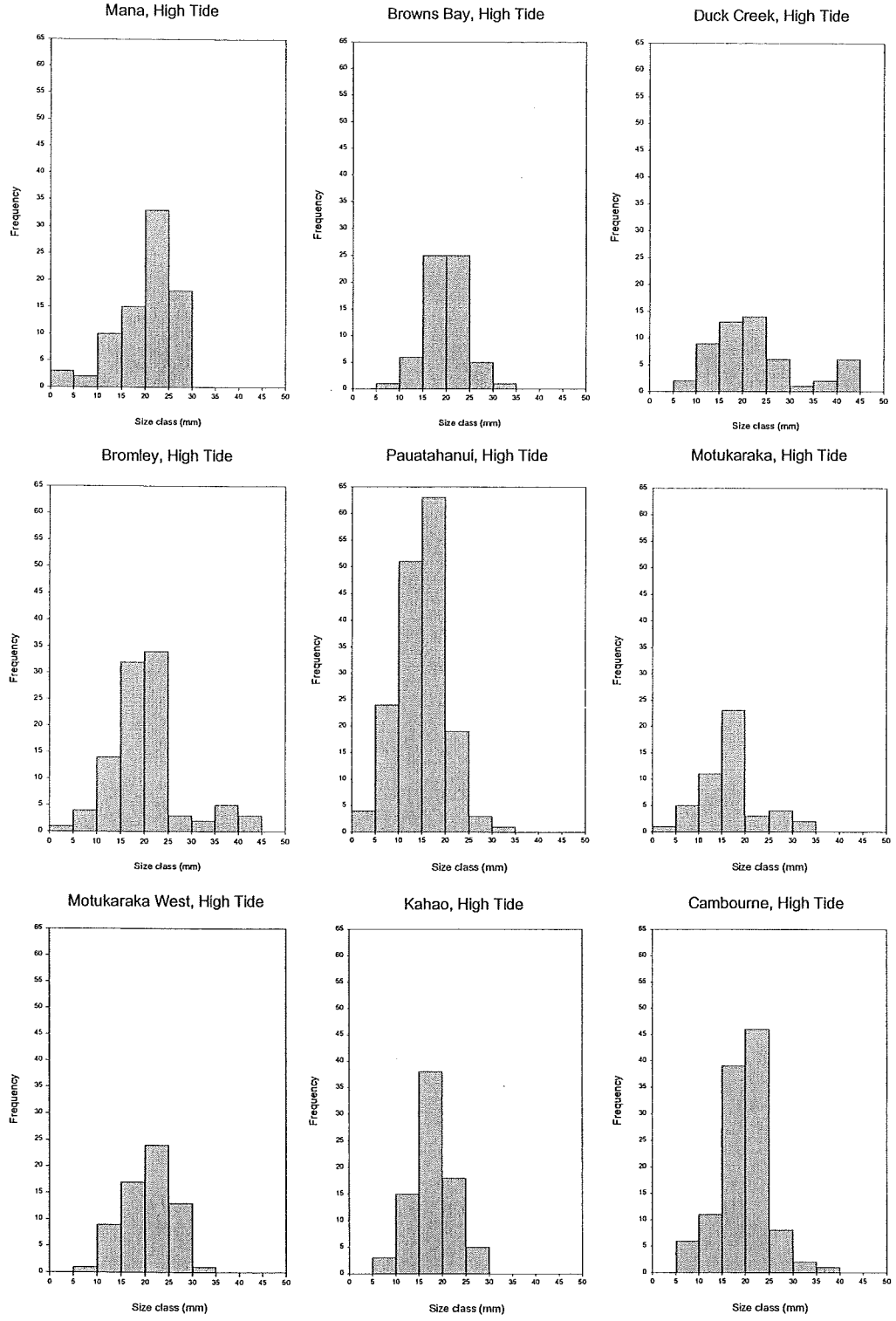

Figure 6. Size frequencies of cockles from high-tidal localities, Pauatahanui Inlet, November 1998.

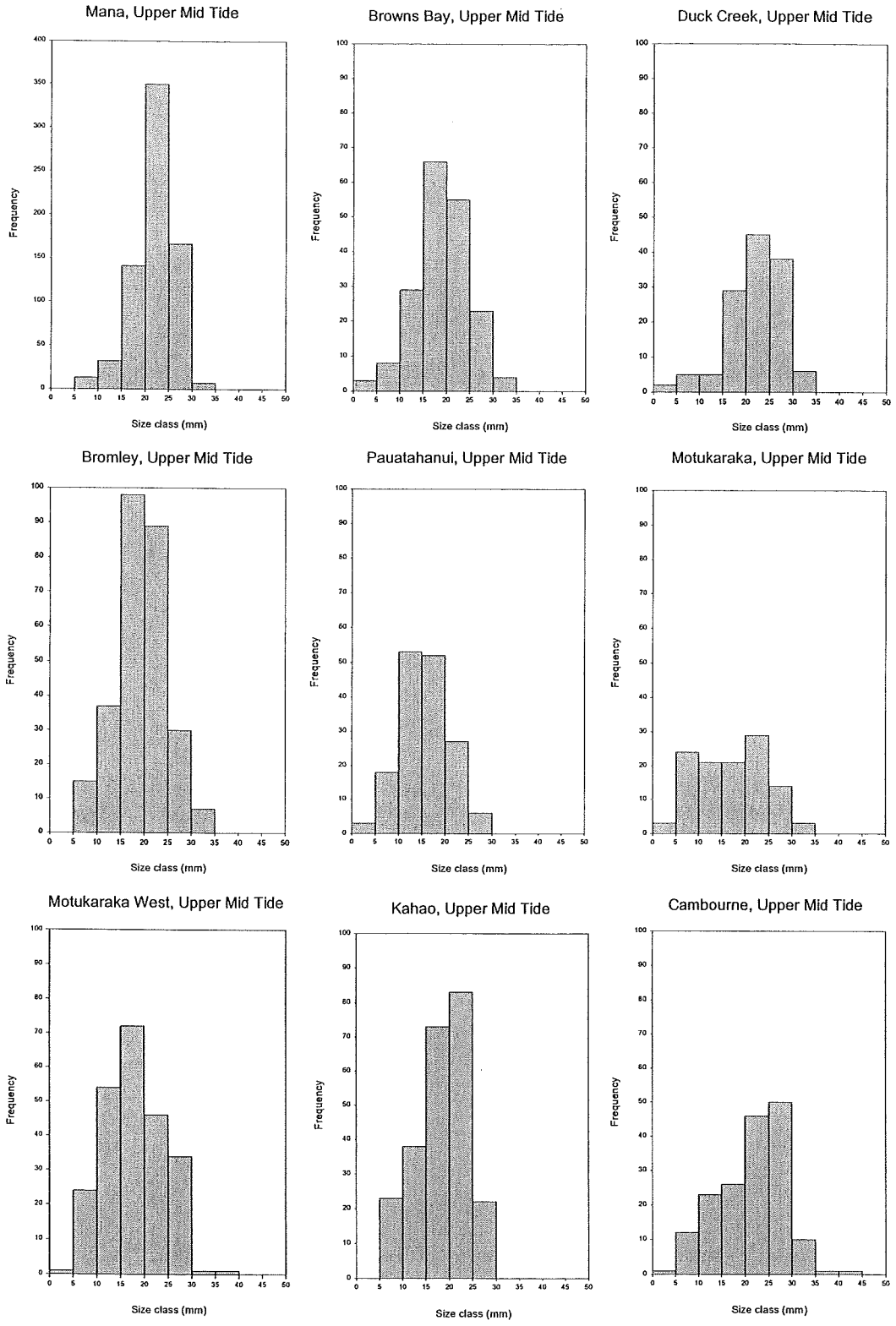

Figure 7. Size frequencies of cockles from upper mid-tidal localities, Pauatahanui Inlet, November 1998. Note different scale on y-axis at Mana.

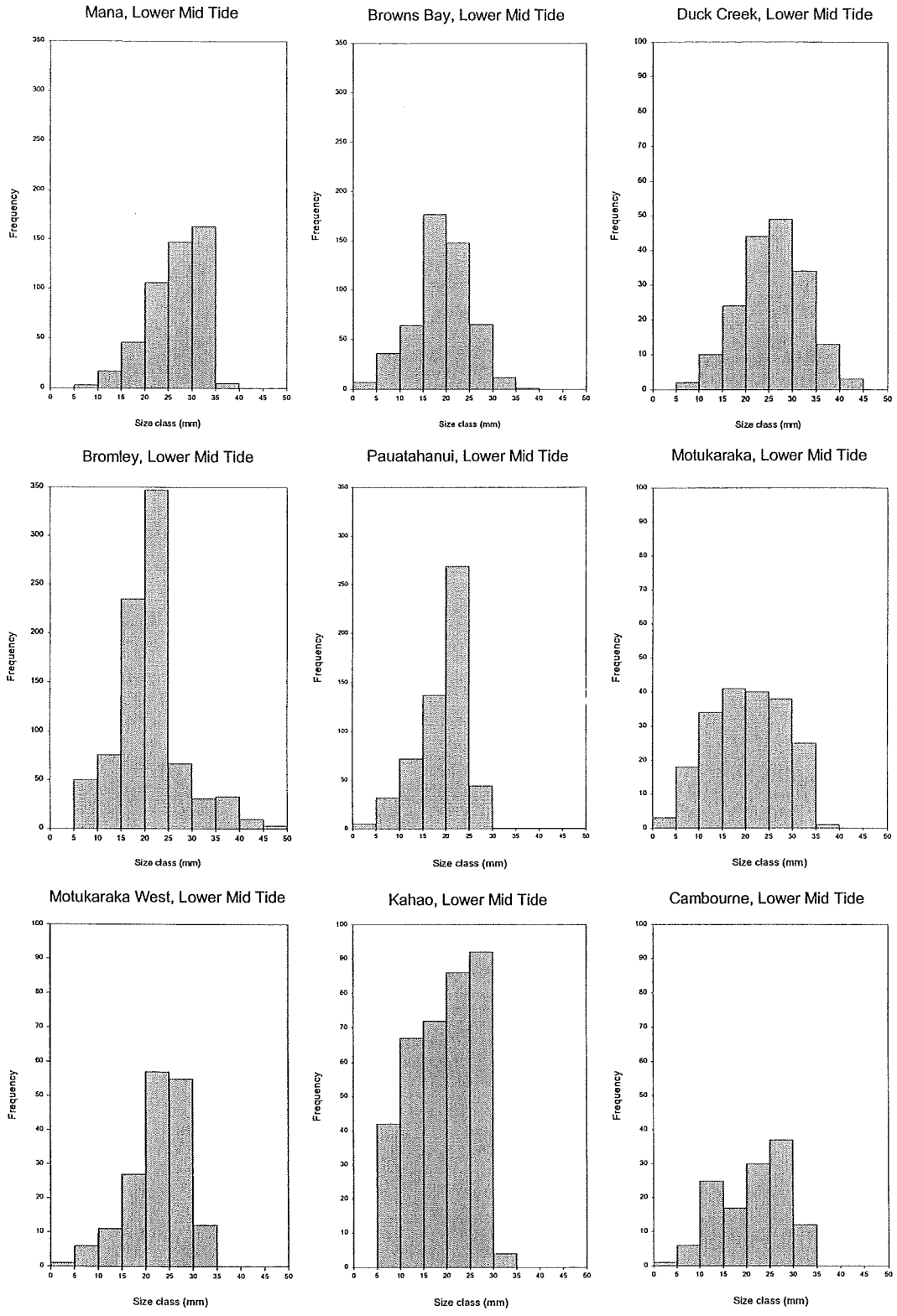

Figure 8. Size frequencies of cockles from lower mid-tidal localities, Pauatahanui Inlet, November 1998. Note different y axes at some localities.

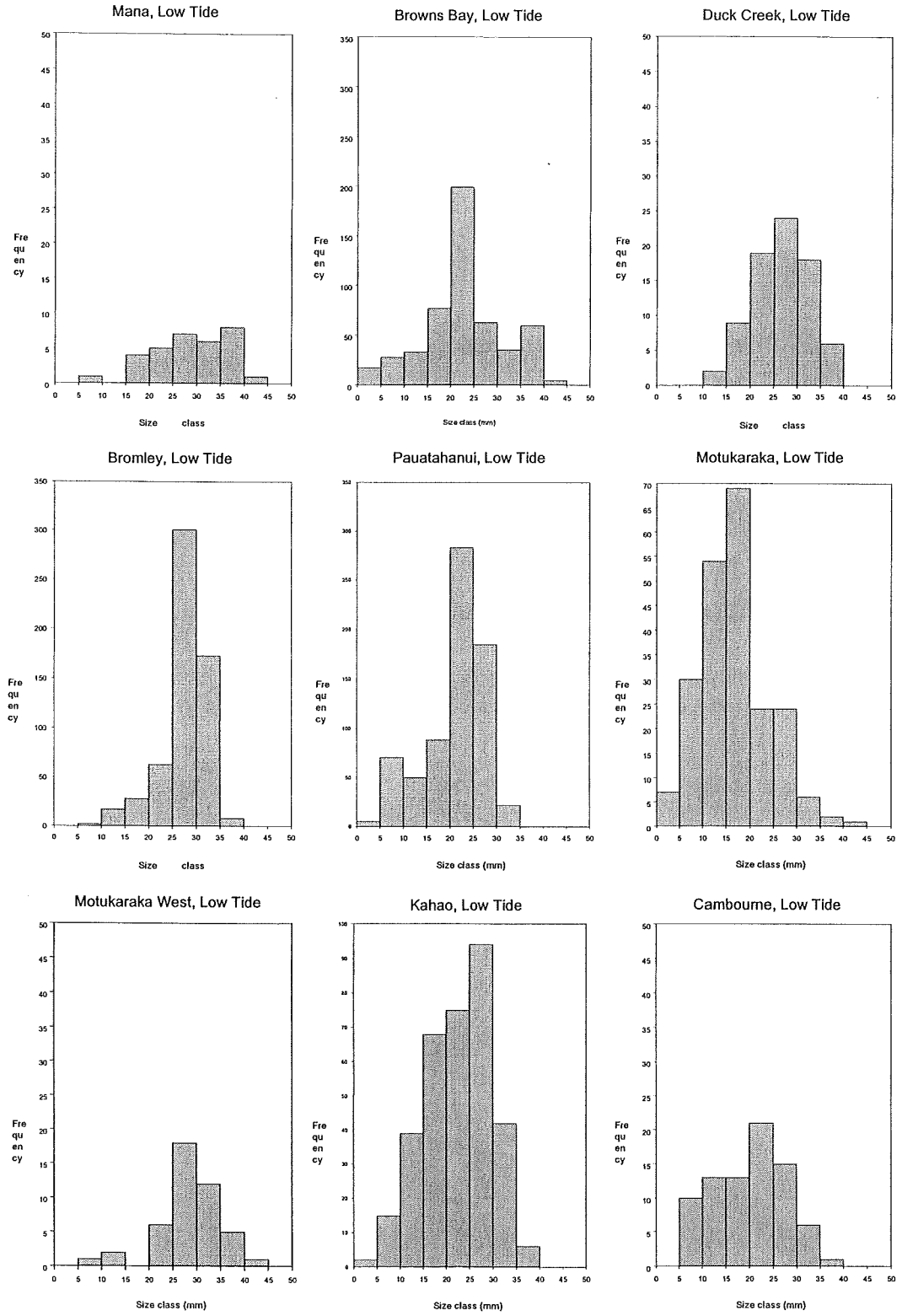

Figure 9. Size frequencies of cockles from low tidal localities, Pauatahanui Inlet, November 1998. Note different y axes at some localities.

At the upper mid-tidal sites (Fig. 7), far more cockles were recorded at Mana than at other locations. Modes occurred at all localities between 15-20 or 20-25 mm size class, except at Pauatahanui where the mode occurred at 10-15 mm. Juveniles occurred at all localities and very small individuals, less than 5 mm shell length, occurred at 6 of the 9 localities. This 5 mm size class was recorded in the 1995 survey at only one locality (Pauatahanui). Large cockles, greater than 35 mm shell length, occurred at only Motukaraka West and Cambourne, whereas cockles between 30-35 mm were recorded at all sites except Pauatahanui and Kahao.

At the lower mid-tidal sites (Fig. 8), juveniles were also recorded at all localities, and a few very large individuals (> 40 mm) were recorded at Bromley. This was also the case in the 1995 survey. Modes in the size frequencies were most common in the 25-35 mm range. Generally, all sites showed similar size frequency distributions.

At low tidal sites (Fig. 9), there was a suggestion of a recruitment cohort producing a bimodal distribution at Mana and Motukaraka. The most commonly occurring size range was 25-30 mm. All sites, except Pauatahanui, had reasonable numbers of large (> 35 mm) cockles.

The mean sizes of all cockles recorded at each locality and tidal height are presented in Table 2. Within each locality, the largest individuals occurred at the low tidal level at all sites, except Motukaraka (where the largest mean individuals were at lower mid-tide), and Cambourne, where they occurred at upper mid-tide. Conversely, the mean sizes were smallest at high tide or upper mid-tide sites. The sites with the largest mean sizes were Mana (low tide) and Motukaraka West (low tide). The values in Table 2 are very similar to those given in Table 3 of Grange *et al* (1996), summarising the 1995 survey data, and there are no significant differences in mean sizes between each tidal height or site.

Table 2. Mean sizes (mm) of cockles for each shore height at each locality, November 1998.

	High tide	Upper mid-tide	Lower mid-tide	Low tide
Mana	20.9	22.6	27.2	29.4
Browns Bay	20.8	19.5	19.8	23.4
Duck Creek	23.6	22.9	26.9	27.7
Bromley	20.9	20.1	21.7	28.2
Pauatahanui	16.4	16.4	19.6	21.3
Motukaraka	18.0	19.4	22.3	18.4
Motukaraka West	21.2	19.8	23.3	29.3
Kahao	18.8	19.1	20.1	23.2
Cambourne	20.3	22.2	22.0	20.9

The mean sizes of cockles measured at each locality and tidal height are also presented in graphic form in Figure 10. No clear trends are evident, with most sites supporting cockles of very similar sizes. Overall, though, mean sizes tend to be larger at the low tide sites.

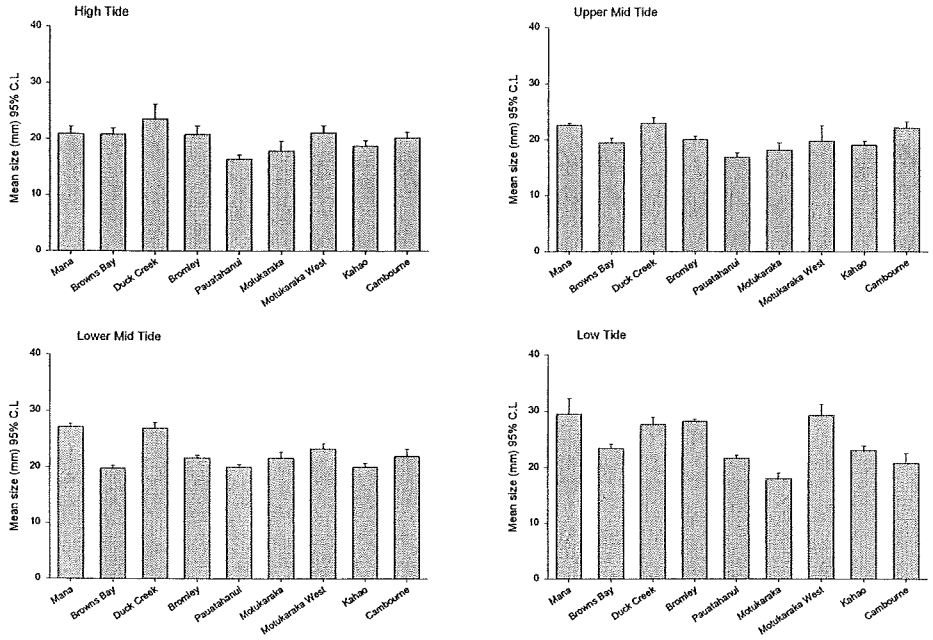

Figure 10. Mean sizes (mm ± 95% Confidence Limits) of cockles at each locality and tidal height, November 1998.

The size frequency histograms show that juvenile cockles were recorded at most sites during the present survey, in contrast to previous surveys when juveniles were scarse. There is also an indication from Figure 4 that the total population of cockles in the Inlet has increased since 1995.

Figure 11 presents the numbers of adult cockles (> 10 mm shell length) that were recorded at each locality in 1998, compared to 1995 and 1992. Few trends to suggest an overall increase in the population are evident. At most sites, adult numbers of cockles are very similar to previous surveys. Slight increases may be apparent at Mana and Browns Bay, and an obvious decrease has occurred at Motukaraka.

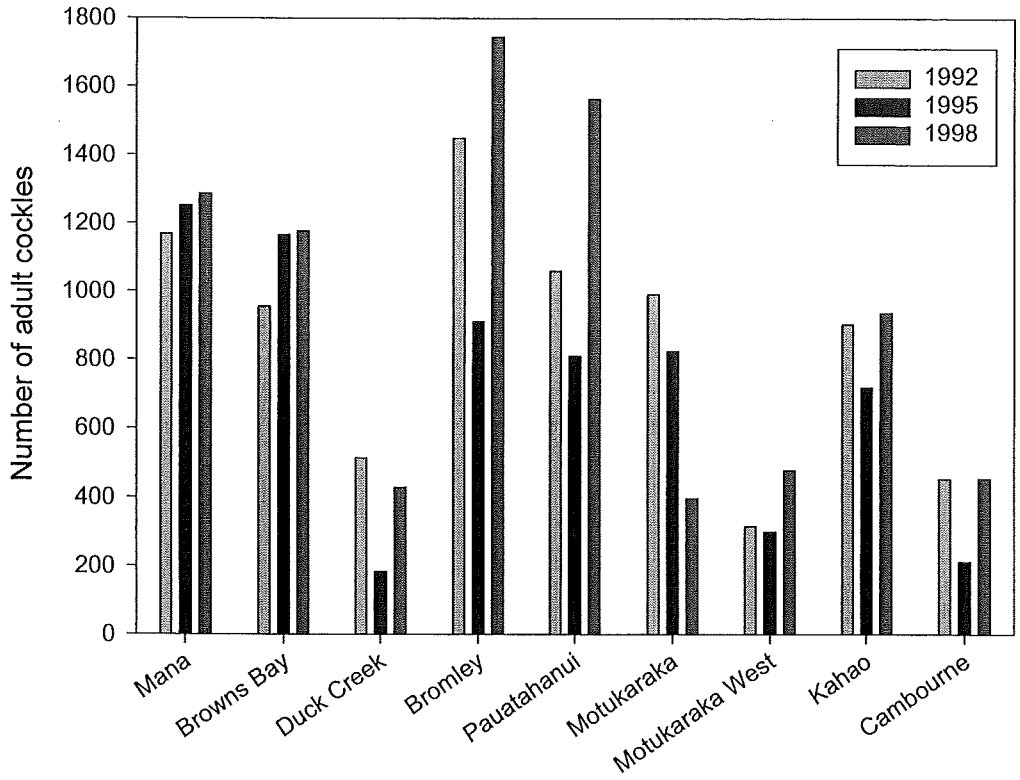

Figure 11. Total number of adult cockles (> 10 mm) collected at each site, 1992-1998.

Figure 12 presents the numbers of juveniles recorded at all localities from 1992-1998. In 1995, increased numbers of juveniles were recorded at a few sites compared to 1992, but in the 1998 survey, more juveniles were recorded at every locality. Large increases occurred at Browns Bay, Bromley, Pauatahanui, and Kahao. For instance, at Pauatahanui, 16 juveniles were recorded in 1992, 29 in 1995, and 172 in 1998. In 1992, the survey recorded a total of 83 juveniles from all quadrats. This had increased to 118 in 1995, but there was a further substantial increase in the 1998 survey, to a total of 623 juveniles.

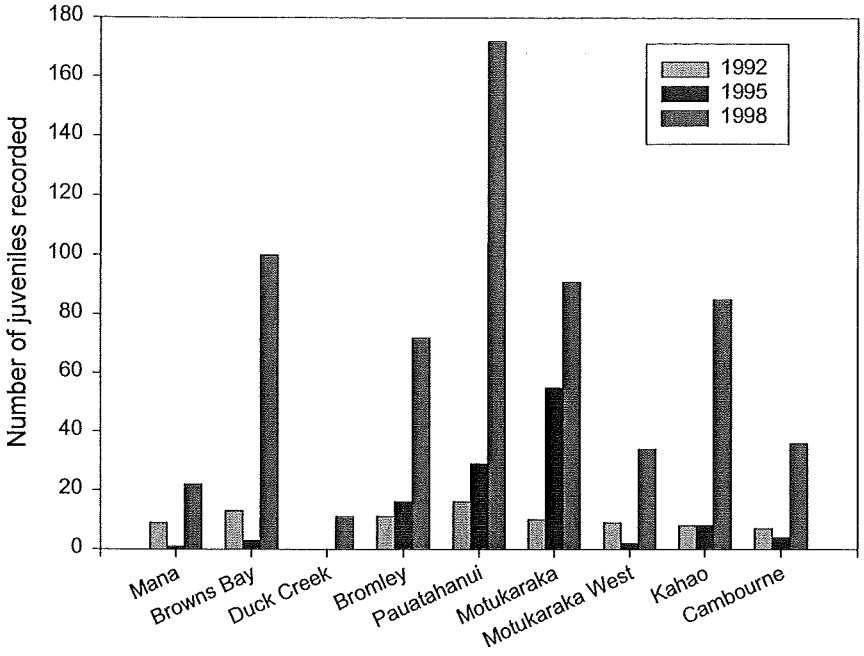

Figure 12. Numbers of juvenile cockles (< 100 mm shell length) recorded at all localities, 1992-1998.

The increase in abundance of juveniles, coupled with a lack of associated increase in adults at most sites means that the proportion of juveniles in the total population within Pauatahanui Inlet has increased from around 1% in 1992, to almost 7% in 1998 (Fig. 13).

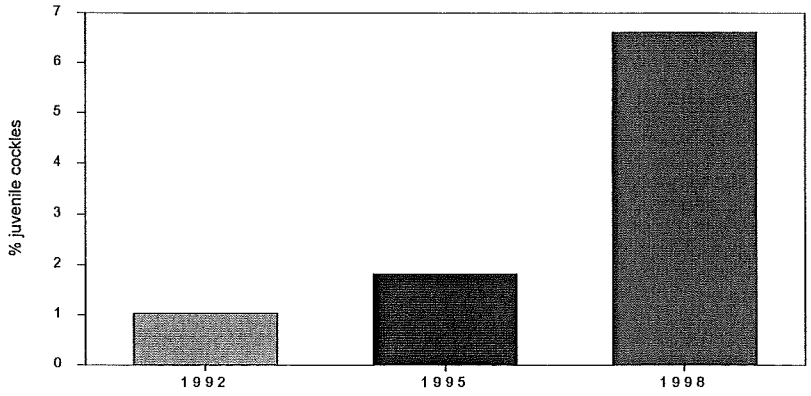

Figure 13. Juveniles as a percentage of total cockle population, 1992-1998.

3.3. Independent Survey, 1997.

During August-October 1997, another survey of the cockle population was undertaken by Mr Vladislav Sedouch. While the results may not be directly comparable to the other surveys since it was completed at a different time of year and sampled only some of the transects, the methodology used was the same. The results are included in this report for completeness.

The mean numbers of cockles collected at each transect sampled are presented in Figure 14. Generally, the trends are similar to those recorded from other surveys, with high densities at Browns Bay, Bromley and Pauatahanui, and low densities at Motukaraka, Motukaraka West, and Cambourne.

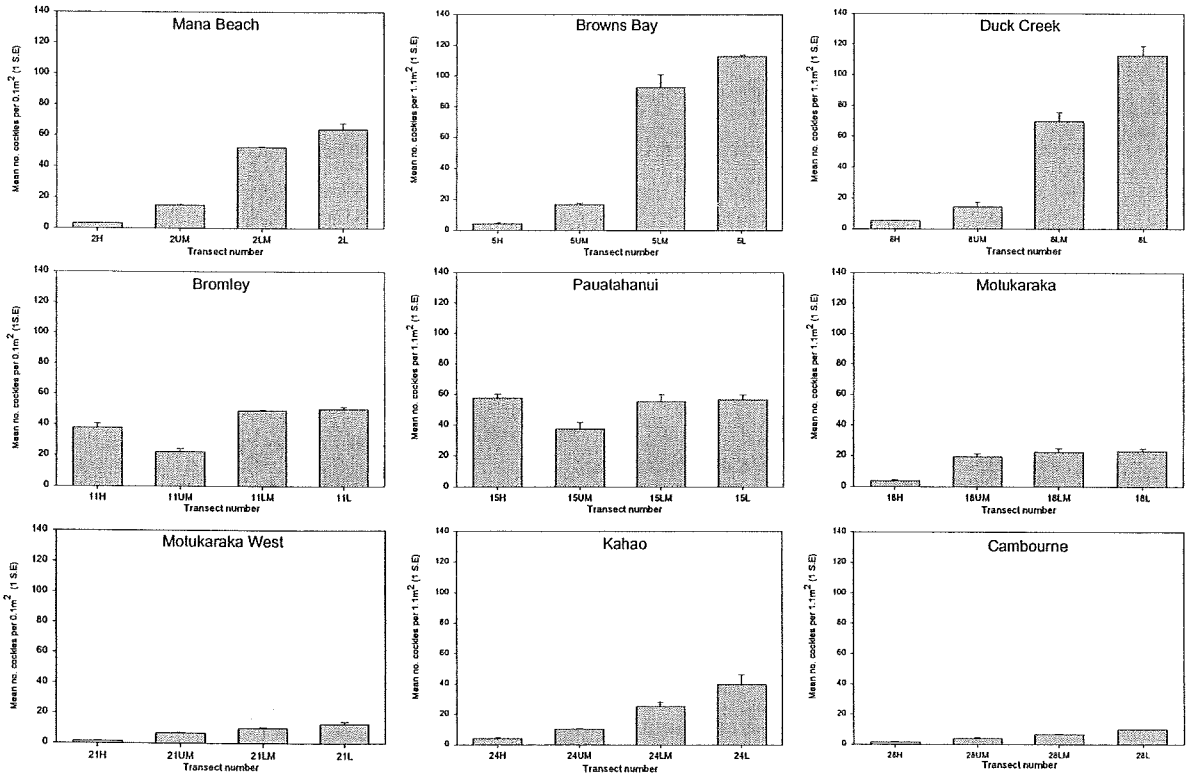

Figure 14. Mean densities of cockles, Pauatahanui Inlet, 1997.

The distribution of cockles down the shore showed the same pattern as in previous surveys, with the greatest densities at low tide (Fig 15). The densities are similar to those recorded in the 1998 survey (see Fig. 3).

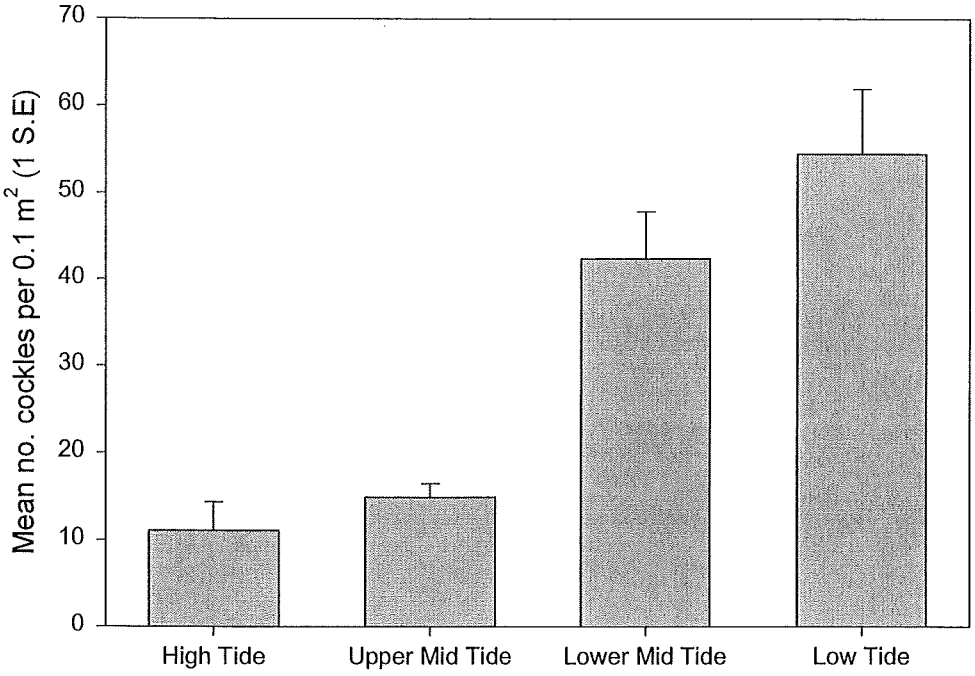

Figure 15. Distribution of cockles at each tidal height, all localities combined, 1997.

A comparison of the 1997 results for mean numbers of cockles at each transect location with results from all other surveys shows that while the overall trend is similar, with higher densities at Bromley, Pauatahanui and Motukaraka, the 1997 survey recorded much greater numbers at transects 5 (Browns Bay) and 8 (Duck Creek) (Fig. 16). These high densities were not recorded during the 1998 survey, so the reason for this is unknown.

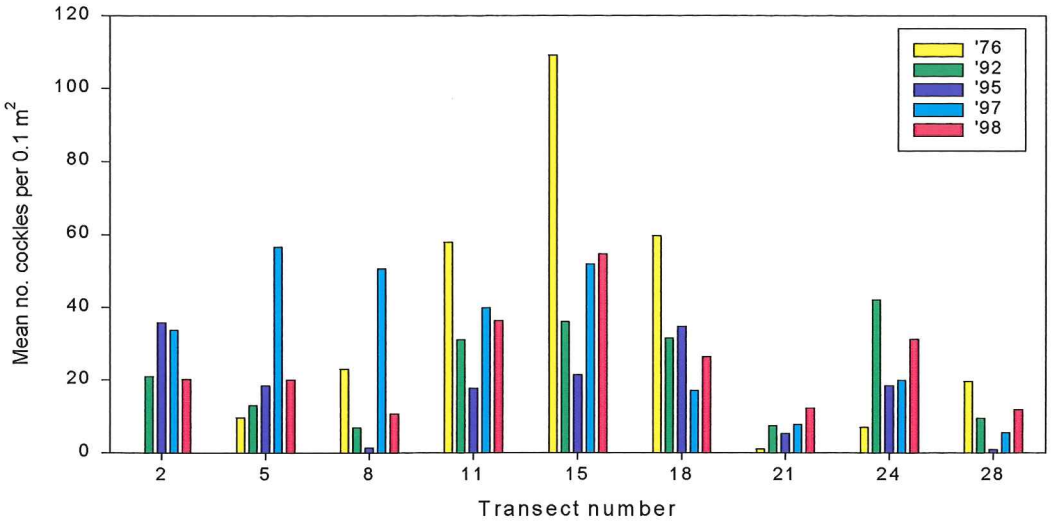

Figure 16. Comparison of cockle densities at those sites sampled in 1997 with surveys in 1976, 1992, 1995, and 1998.

The size-frequency data from the 1997 survey is presented in Appendix 3. For most of these data, the numbers are too small to give accurate estimates. This is because fewer samples were collected. However, the modes occur at very similar size ranges as those analysed from other surveys. One obvious difference between these results and the 1998 results presented above is the lack of recruits at high tide sites and all except one of the UMT sites. Recruits were recorded at most LMT and LT sites.

4. DISCUSSION

The results from the 1998 survey both confirm previous survey results and indicate a potentially important difference. Overall, the patterns of distribution both down the shore and geographically are very similar to previous surveys. The areas of greatest densities are Mana, Bromley, Pauatahanui, and Motukaraka, and densities increase towards low tide at most localities. The mean sizes of the cockles throughout the Inlet show no significant differences to previous surveys, although there are some small differences at particular sites.

The results of greatest interest are those that indicate the population of cockles may be starting to recover after the decline that has occurred over the past 20 years. The total population estimate from the 1998 survey is around 257 million cockles, up from 180 million in 1995. Only 7 of the 30 transects supported fewer cockles than in 1995,

whereas in 1995, 23 of the 30 transects had fewer numbers than in 1992. While the adult cockle population has not increased significantly at most sites, the 1998 survey recorded far greater numbers of juveniles and this has caused the apparent increase in the overall population. Juvenile cockles were widespread in the samples, not just confined to some localities, and were recorded at all tidal levels.

There is a possibility that the increased numbers of juveniles in the samples is due to a change in the sampling methodology. During the 1998 survey, all samples were sieved and cockles measured, whereas in previous surveys the cockles were removed from the sediment by hand. It is possible that the sieve method is more efficient than hand picking, leading to a far greater retention of juveniles. This possibility cannot be ruled out, but the August-October 1997 survey also used a 4-mm sieve to retain cockles. That survey methodology should therefore be directly comparable to the 1998 survey. There were very few juveniles recorded in the 1997 survey, and almost none at the high tidal sites sampled. It is therefore possible that the 1997 survey, in August-October, sampled the Inlet before a major spawning/recruitment event. There is some anecdotal evidence that many shellfish, including tuatua and cockles, experienced a very successful recruitment year in 1997/98 (NIWA, *unpub. obs.*) in many parts of New Zealand.

If the 1998 survey results do indicate a major spawning event then it will lead to resurgence in the cockle population only if the recruits grow through to adults. At this stage it is not known how fast these juveniles may grow or whether the ecological processes within Inlet will allow them to survive in large numbers. It is therefore recommended that the Guardians consult about the feasibility of tagging a large number of the juveniles. This could be done as a community-based project and would involve tagging juvenile cockles with small numbers, measuring each, and releasing them on the shores. Intensive sampling would then the undertaken at specified periods in an attempt to relocate the tagged individuals so they can be re-measured and released once again. Such a study would provide information vital to the speed of recovery and its longer-term viability.

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APPENDIX 1. COCKLE SAMPLING SITES, PAUATAHANUI INLET

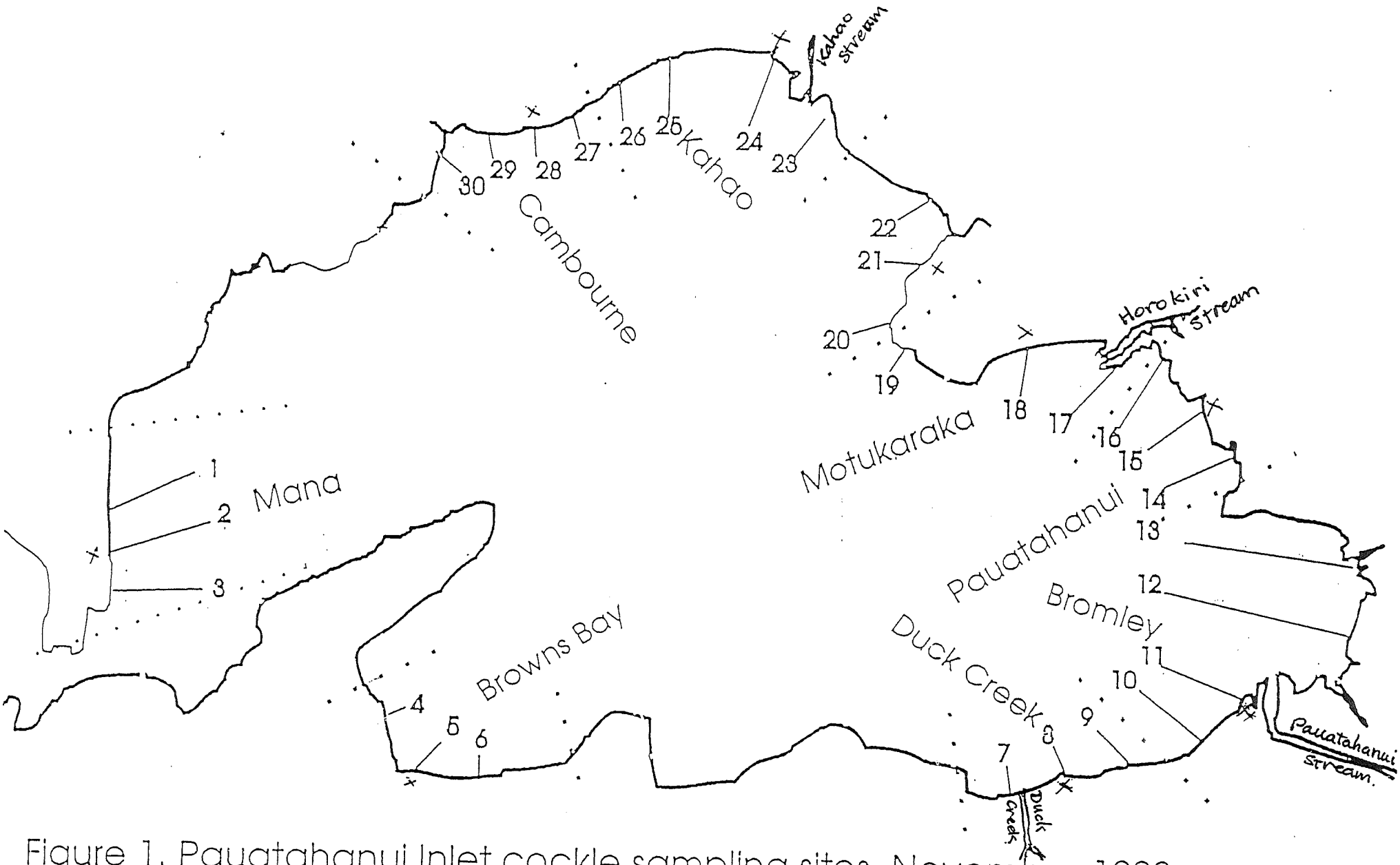
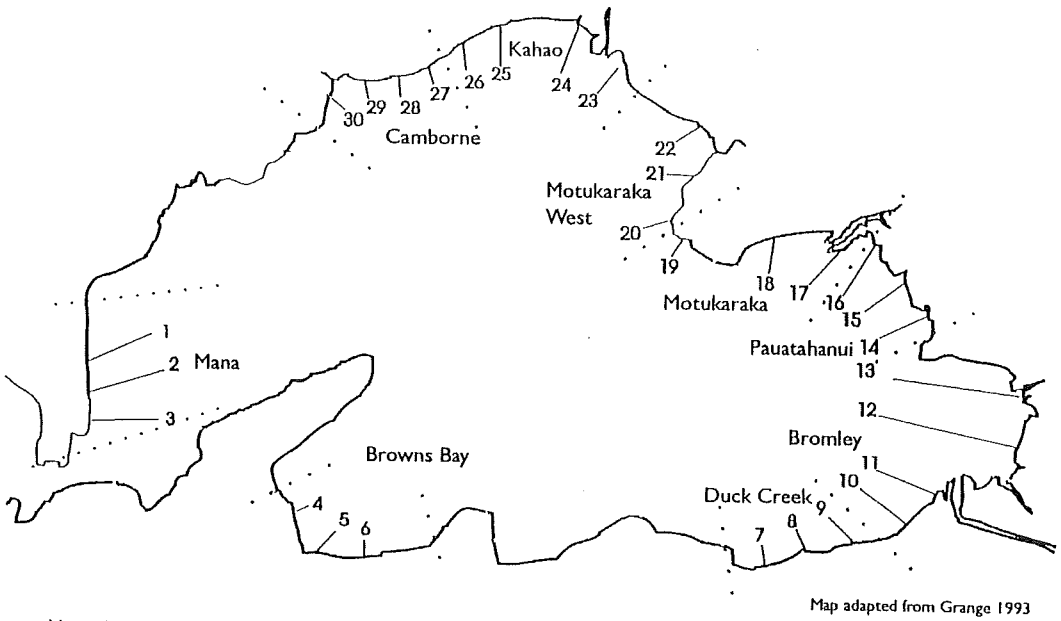


Figure 1. Pauatahanui Inlet cockle sampling sites, November 1992

APPENDIX 2. SAMPLING SHEETS AND INSTRUCTIONS

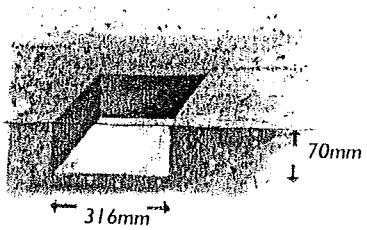
Cockle sampling sites

A map to help identify soft shore study sites

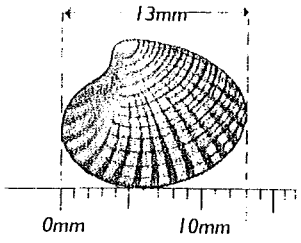


Map adapted from Grange 1993

Note: The area to the west of Motukaraka Point was mis-named Ration Point in the 1976 cockle survey. We have more accurately called it Motukaraka West. The true Ration Point is between sampling sites 13 and 14.



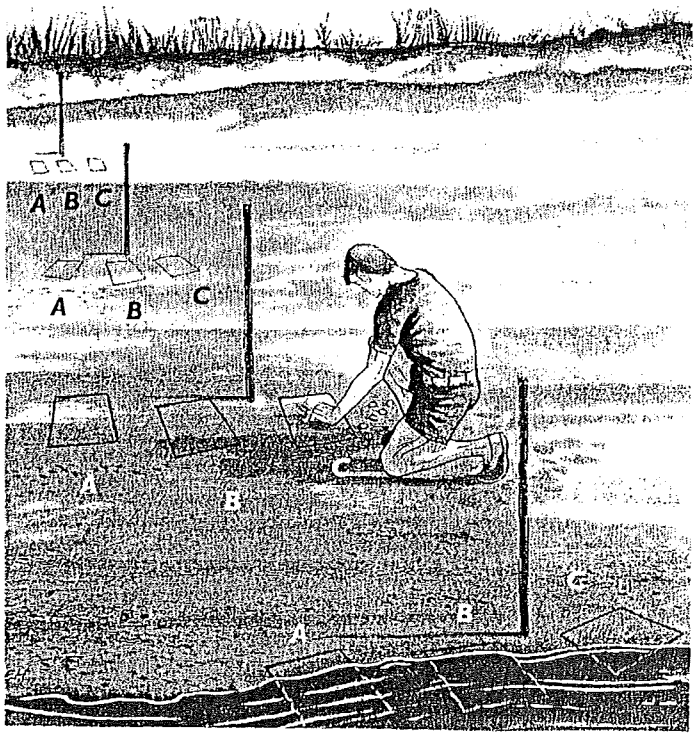
CUT AWAY VIEW OF EXCAVATED QUADRAT



MEASURING A COCKLE

Measure cockles to the nearest millimetre. Record each length on the record sheet. Record each quadrat separately.

Measure all cockles this way — hinge at the top.



LOW TIDE:

MON	4.04
TUES	4.24
WED	5.20
THUR	5.56
FRI	6.32
SAT	7.08

COCKLE COUNT COVER SHEET

TRANSECT NUMBER

LOCALITY _____

DISTANCE BETWEEN TIDAL LEVELS:

(Each pace is 90 cm or 1 yard)

Paces

Dig out three quadrats at four tide levels, making 12 quadrats in all:

1. High tide	Quadrats	**A**	**B**	**C** (circle when tally complete)
2. Upper mid tide		**A**	**B**	**C**
3. Lower mid tide		**A**	**B**	**C**
4. Low tide		**A**	**B**	**C**

INSTRUCTIONS

- Transects are marked with numbered paint marks or stakes. The direction is:

  _____

- The distance between tide levels at your transect is written in the square above. If it has not already been staked, pace down from high to low putting a marker at the appropriate levels
- Your team will need:
  - a digger
  - a cockle sorter
  - a measurer and caller
  - a recorder who calls back
- Choose which tide level to start digging at, so that you will be able to dig the low tide level at low tide time. (Tide times over page)
- Quadrats A, B, C at each level should be about 5 paces apart
- For each quadrat:
  1. Drop the quadrat frame without bias (don't choose good places)
  2. Dig out the mud and animals inside the frame to a depth of at least 7 cm, and put it into a bucket or large dish. (It saves time to throw out gravel and shell as you go). ~~Sieve quadrat B if possible~~.
  3. The sorter takes out every live cockle and puts it into an ice cream carton.
  4. The measurer measures each cockle to the nearest mm. and calls the measurement. (See picture over page) (Return cockles to the mud)
  5. The recorder puts a single tally dash (/) for each cockle beside the correct mm. size, and calls back the measurement.
  6. Tallies are marked in groups of 5 like this: "𝍸 //" = 7

PLEASE RETURN EVERYTHING TO THE LEADER AT YOUR LOCALITY

THANK YOU, your help is appreciated

COCKLE COUNT EQUIPMENT LIST

EACH LOCALITY

Signs

EACH TRANSECT

Clip board, pen pencil ruler, plastic bag, data sheets

High tide marker stake - wooden

3 intertidal markers

quadrat frame

sieve or colander

Bucket or large container

3 ice-cream cartons

spade or trowel

TIPS

Dig out three quadrats at four tide levels, making 12 quadrats in all:

Paces are 90 cm (1 yard).
Dig high tide quadrats 20 paces from the high water drift.
Then the stated number of paces between each tidal level.
Each team will need:

a digger and carrier of water
a siever and cockle sorter
a measurer and caller
a recorder who calls back

Choose the tide level to start digging at, so that the low tide level will be dug at low tide time. (Saturday tide about 7pm)

Quadrat frames dropped without bias

Depth of dig 7cm or to black anoxic layer, whichever is least.

We are sieving every quadrat, it is quicker.

Alan Bryant prize winning method of sieving. Use about half or one third of the mud in the quadrat. Swirl mud in half a bucket of water until all is completely liquid and suspended. Raise sieve (or colander) and pour liquid mud through, helping it with a swirl of the hand if necessary.

Ask the recorder to call back the measurement to the measurer. This is both a check that the recorder has heard correctly and gives the recorder time to record before the next measurement is called.

Tallies are marked in groups of 5 like this: "𝍸 //" = 7

Please get an address or telephone number from every helper, so that we can reward them with newsletters and honorary membership until next AGM.

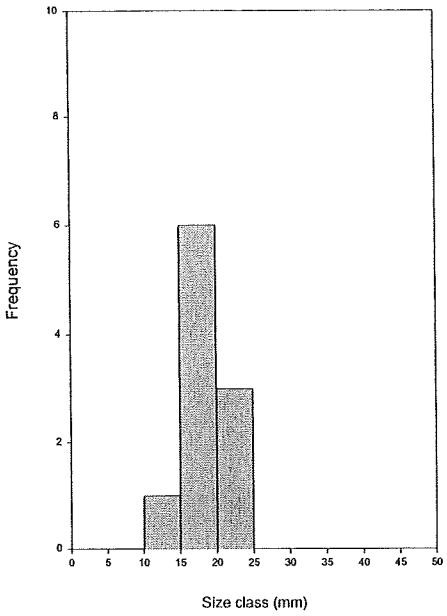
PLEASE COLLECT ALL GEAR AND RETURN TO STOUT COTTAGE

If a transect is not completed leave a marker to show the position.

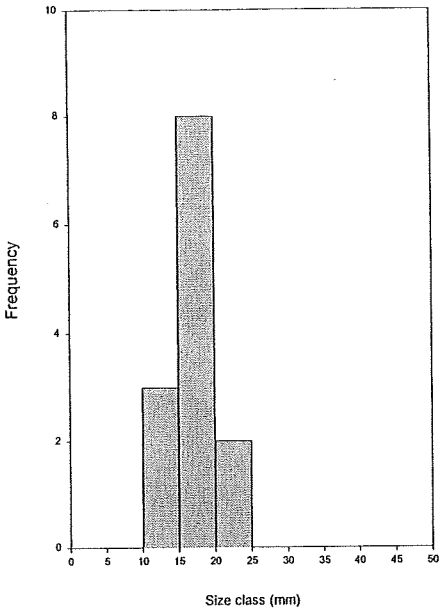
THANK YOU, your help is appreciated

APPENDIX 3. SIZE-FREQUENCY HISTOGRAMS FROM EACH SAMPLING SITE AND TIDAL HEIGHT, 1997.

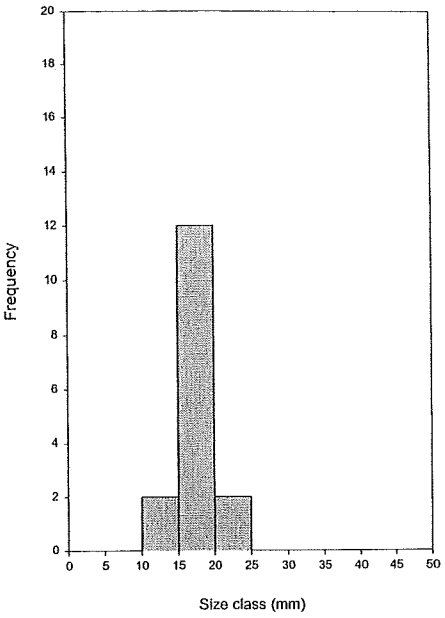
Mana, High Tide



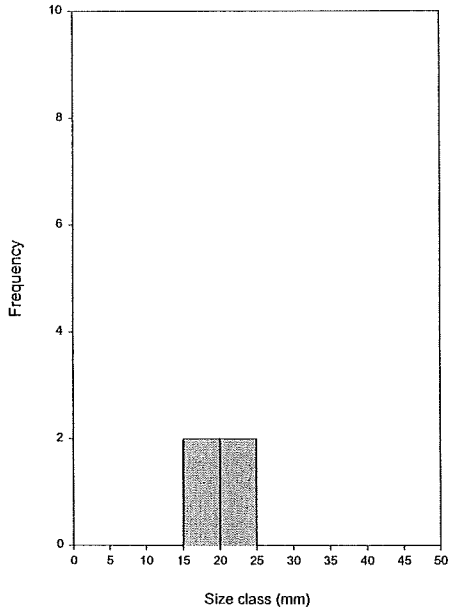
Browns Bay, High Tide



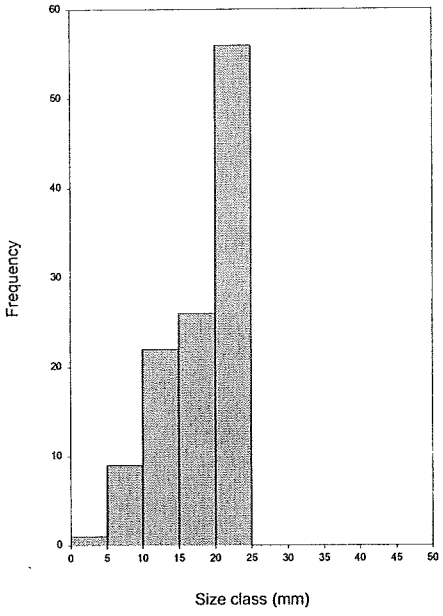
Duck Creek, High Tide



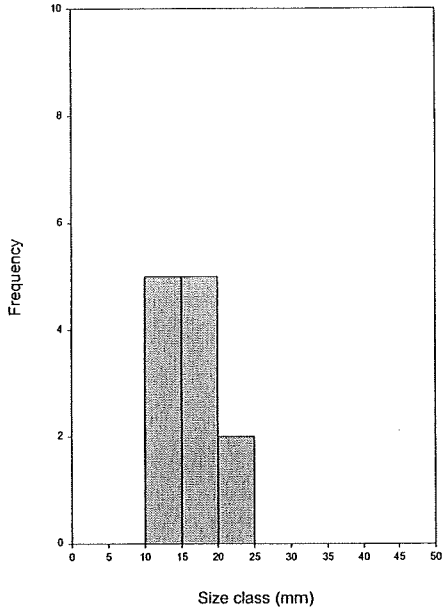
Bromley, High Tide



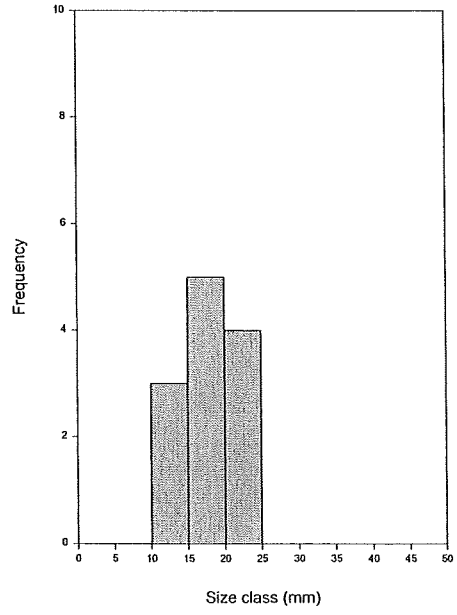
Pauatahanui, High Tide



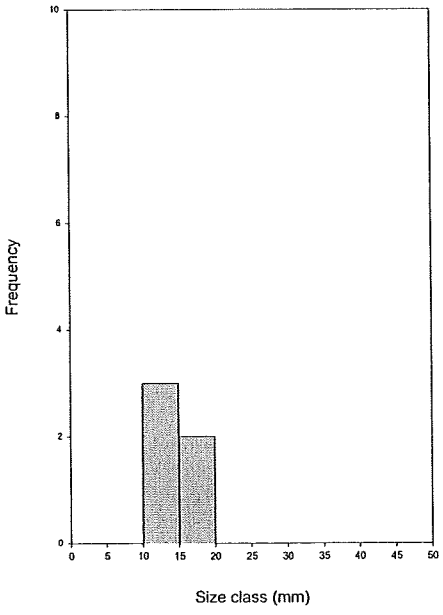
Motukaraka, High Tide



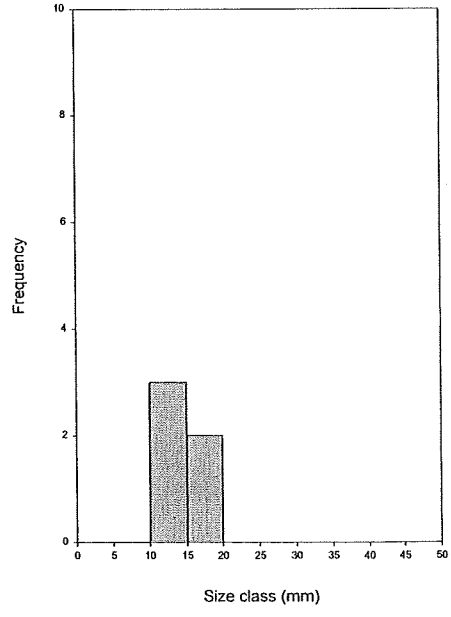
Motukaraka West, High Tide



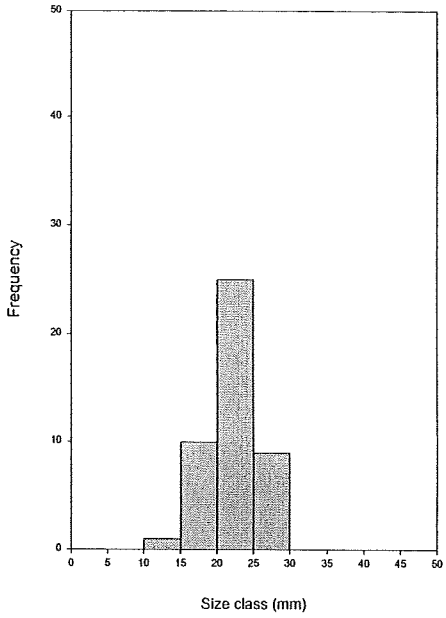
Kahao, High Tide



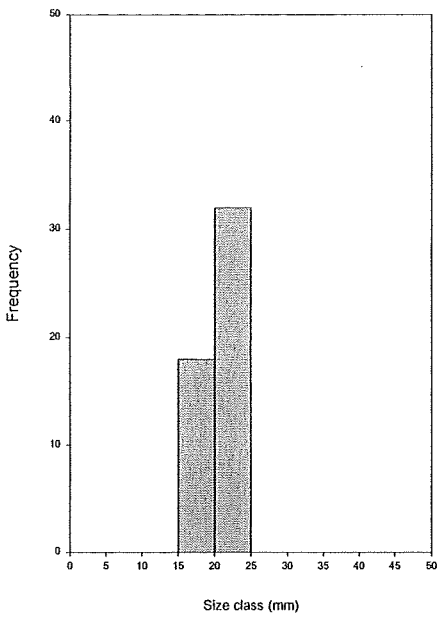
Cambourne, High Tide



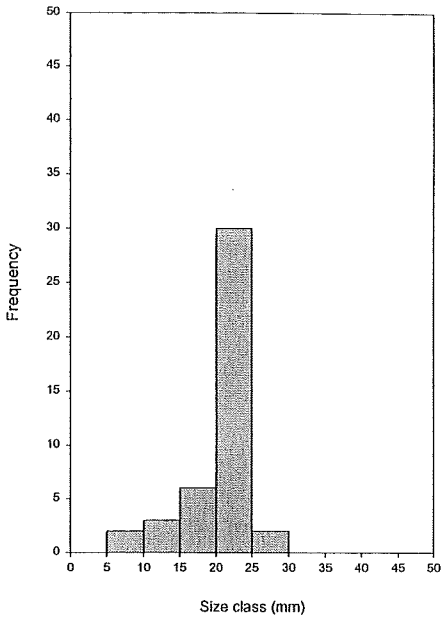
Mana, Upper Mid Tide



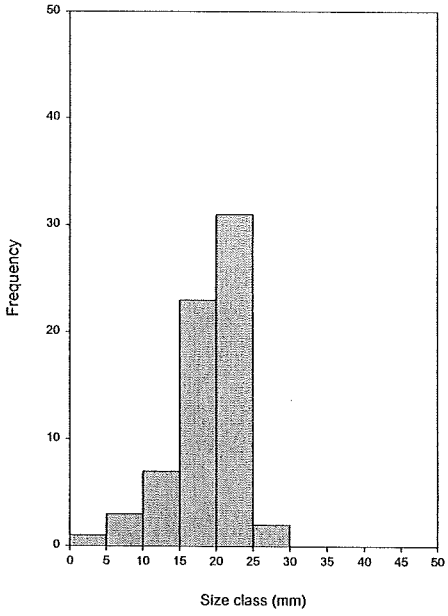
Browns Bay, Upper Mid Tide



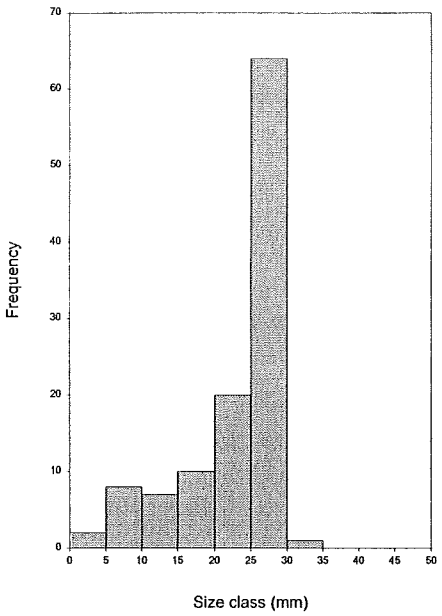
Duck Creek, Upper Mid Tide



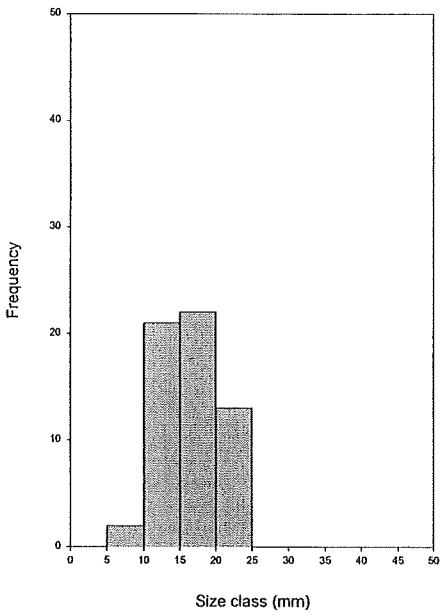
Bromley, Upper Mid Tide



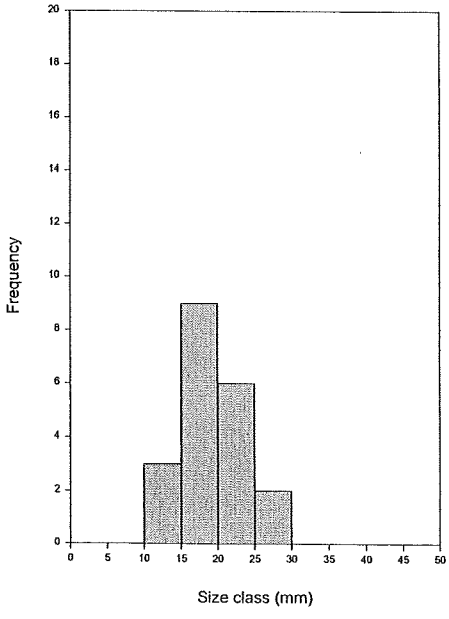
Pauatahanui, Upper Mid Tide



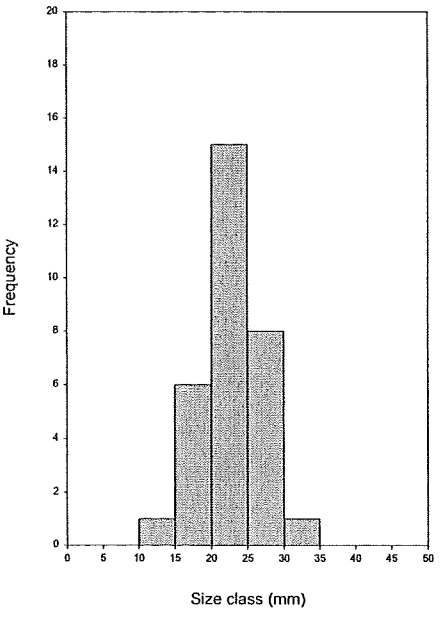
Motukaraka, Upper Mid Tide



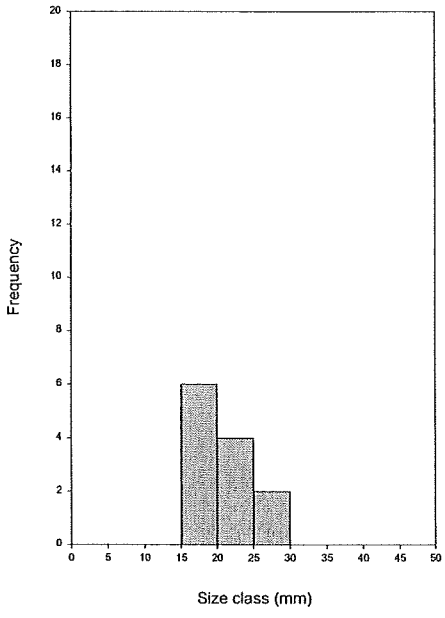
Motukaraka West, Upper Mid Tide



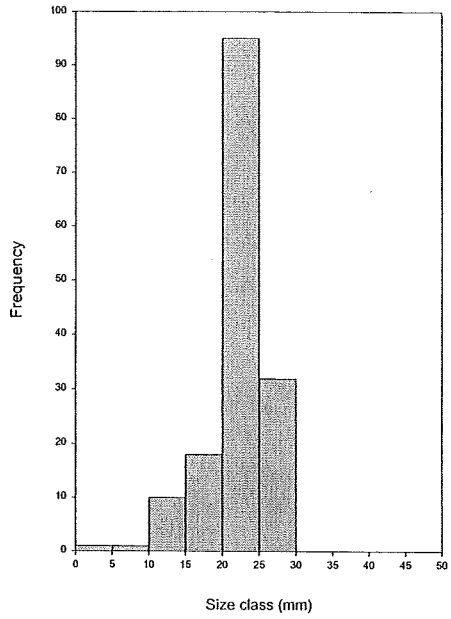
Kahao, Upper Mid Tide



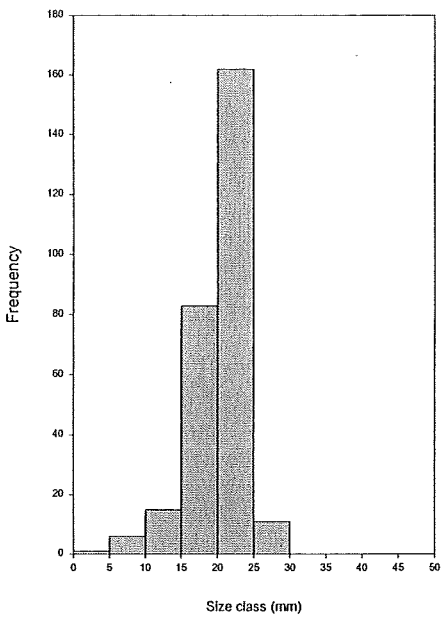
Cambourne, Upper Mid Tide



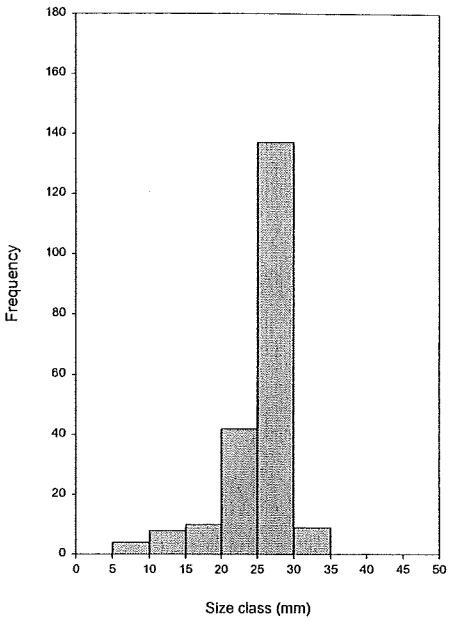
Mana, Lower Mid Tide



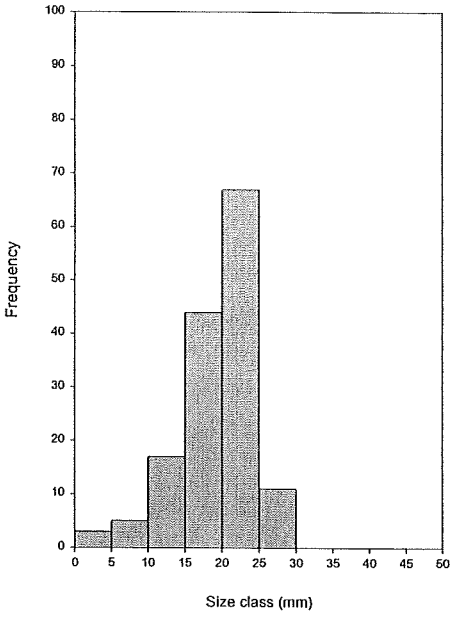
Browns Bay, Lower Mid Tide



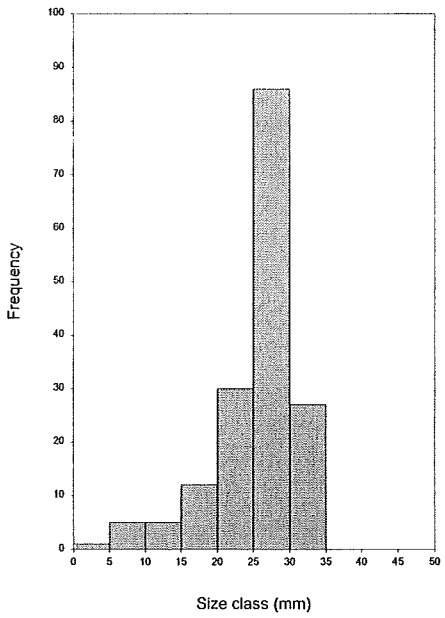
Duck Creek, Lower Mid Tide



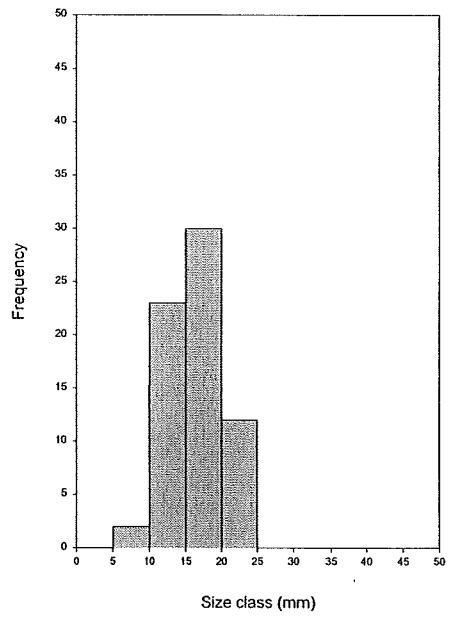
Bromley, Lower Mid Tide



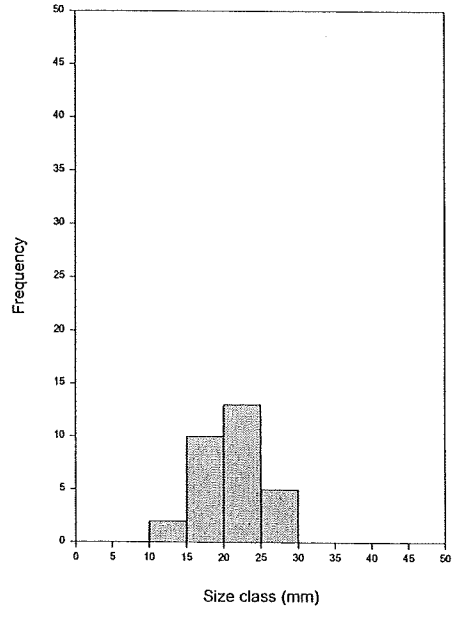
Pauatahanui, Lower Mid Tide



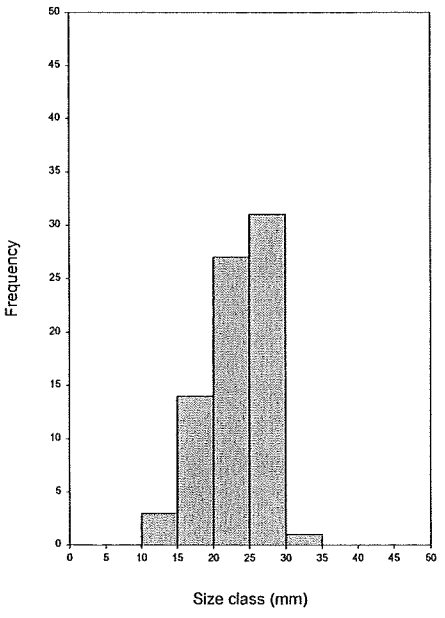
Motukaraka, Lower Mid Tide



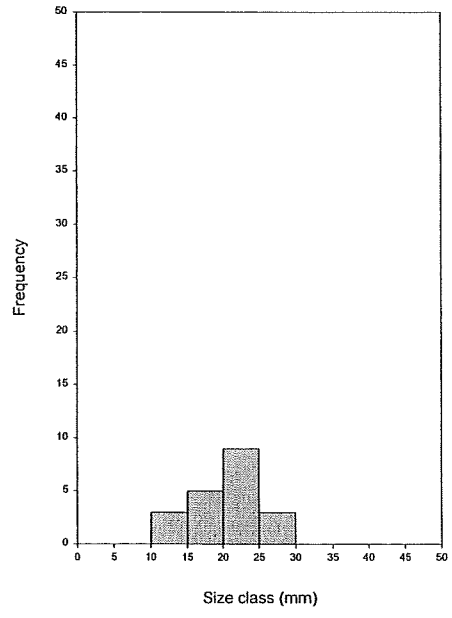
Motukaraka West, Lower Mid Tide



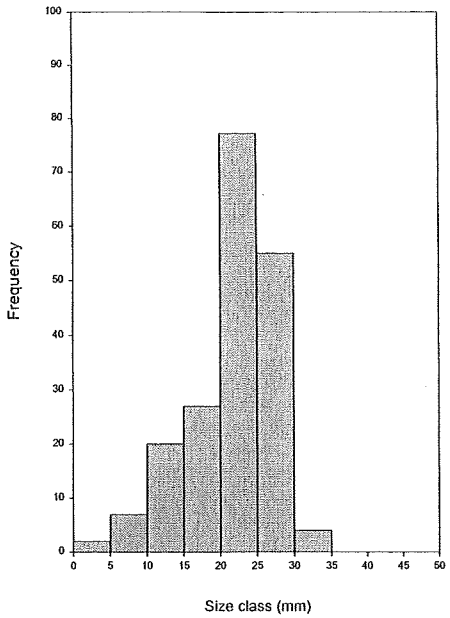
Kahao, Lower Mid Tide



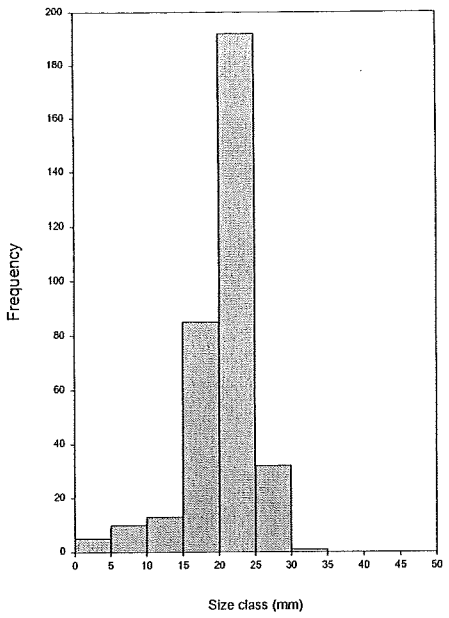
Cambourne, Lower Mid Tide



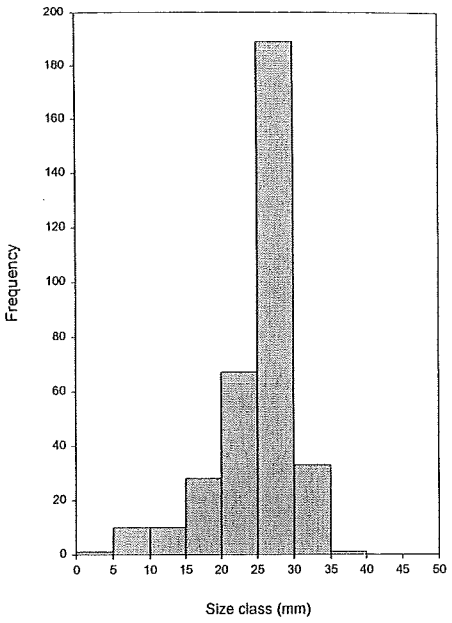
Mana, Low Tide



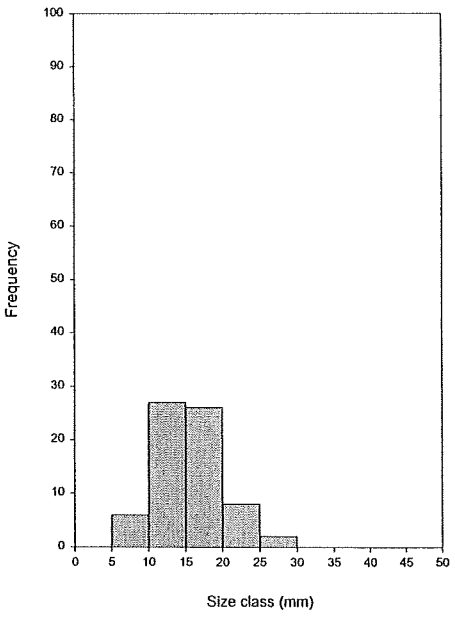
Browns Bay, Low Tide



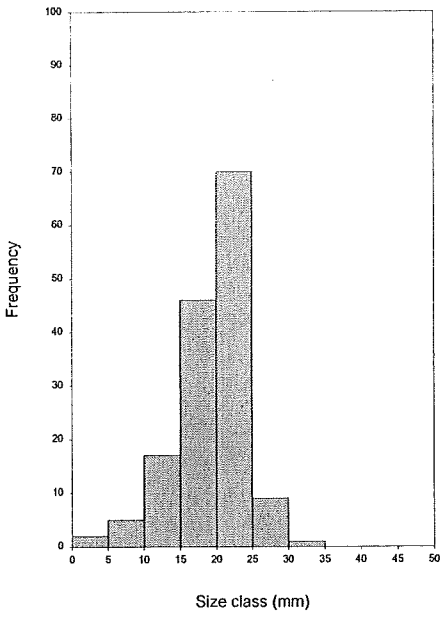
Duck Creek, Low Tide



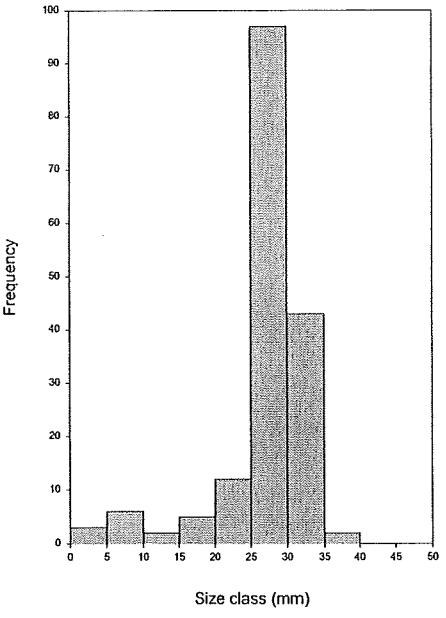
Bromley, Low Tide



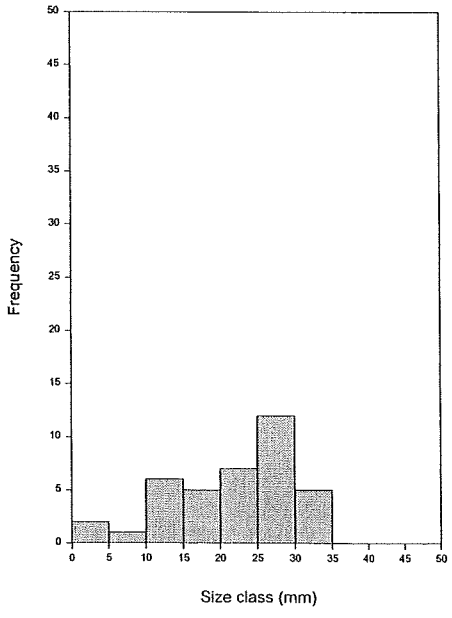
Pauatahanui, Low Tide



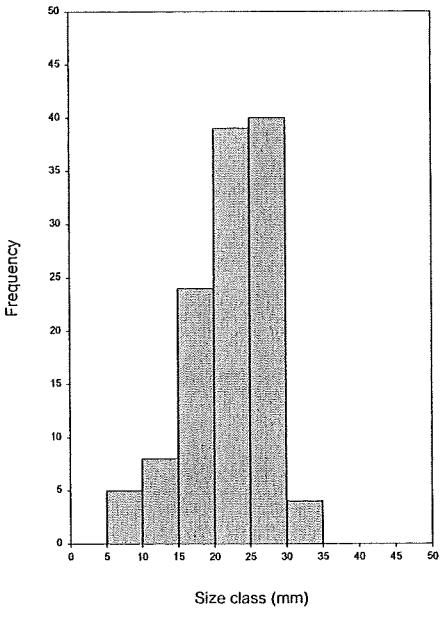
Motukaraka, Low Tide



Motukaraka West, Low Tide



Kahao, Low Tide



Cambourne, Low Tide