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SALVAGE EXCAVATION AND ANALYSIS OF FAUNAL MATERIAL FROM AN ARCHAEOLOGICAL SITE (R27/24) AT PAUATAHANUI INLET NEAR WELLINGTON

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B.F. Leach[1], J.M. Davidson[1], K.J. Miller[1], K. Greig[1] and R. Wallace[2]

ABSTRACT

A small excavation was conducted by the New Zealand Historic Places Trust in an archaeological site (R27/24) scheduled for destruction at Henderson's Bend, Pauatahanui Inlet. Five bulk midden samples from four areas of the site were analysed at the Archaeozoology Laboratory of the Museum of New Zealand Te Papa Tongarewa.

The samples were mainly composed of shell, with 74 percent cockle (*Austrovenus stutchburyi*), which is by far the dominant inshore animal in today's inlet ecosystem. Mud snail (*Amphibola crenata*) at 18.4 percent and mussel (*Mytilus galloprovincialis*) at 2.8 percent are the next most numerous species. Most of the other shells are commonly found in the inlet, but some prefer a rocky shore or ocean beach environment. This suggests that the occupants of the site were also exploiting environments outside the inlet.

The samples contained only small amounts of bone. Minimum numbers of 14 fish from 7 families, 14 birds of 8 species, 8 rats, and 1 dog were identified. The birds are predominantly forest dwelling species, with one duck and one sea bird. The rat is the Pacific rat, introduced to New Zealand in pre-European times.

Charcoal analysis showed that the vegetation in the vicinity of the site during occupation consisted of coastal scrub dominated by kānuka (*Kunzea ericoides*), suggesting regeneration after earlier clearance of forest by fire.

Five artefacts were found. Radiocarbon dates suggest occupation between the fifteenth and sixteenth centuries AD.

Measurement of intact cockle valves showed some variation in mean cockle size between the areas sampled. However, these variations are very slight compared with the marked difference in size between the archaeological samples and the cockles studied in a series of modern surveys in the inlet between 1976 and 1998. The archaeological samples are much larger.

Three possible explanations for this difference are considered: different selective harvesting strategies; sustained human predation over a long period; and environmental changes such as turbidity associated with high levels of suspended sediment, salinity, and water temperature, which affect shell recruitment and growth rate. The first explanation is rejected. Pre-European gatherers may have selected for large shells, but they had access to far more larger shells than were present in the modern surveys. The other two possibilities await the result of further research. Analysis of archaeological samples from later prehistoric and nineteenth century middens around the inlet (dating both before and after the 1855 earthquake) and bulk shell $\delta^{18}O/\delta^{16}O$ analysis of archaeological and modern shells could help to resolve the issue.

Keywords: ARCHAEOLOGY, ARCHAEOZOOLOGY, SHELLFISH, FISH, BIRDS, VEGETATION, NEW ZEALAND, PAUATAHANUI.

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INTRODUCTION

Site R27/24 is located on the southern side of Pauatahanui Inlet, in the southwest North Island (Figs 1 and 2). It was first recorded in 1959, as shell midden exposed in a coastal road cutting. In 2000, a proposal to widen the existing road (State Highway 58) threatened the surviving remnant of the site, prompting an archaeological salvage excavation. This was carried out by Karen Greig, then of the New Zealand Historic Places Trust, in September 2000. Road widening began in November 2000 and destroyed what remained of the site. Bulk midden samples, taken from several parts of the site during the salvage excavation, were analysed in the Archaeozoology Laboratory of the Museum of New Zealand. This report describes the background to the study and the results of the analysis.

THE ENVIRONMENTAL SETTING

The Pauatahanui Inlet is the eastern arm of the Porirua Harbour (Sheehan 1988:1). During the final stage of the last ice age (around 17,000 years ago) Pauatahanui was a steep river valley. Rising sea levels after this last glaciation flooded the valley. Sediments eroding off the surrounding hills have filled the old valley and formed the mud flats of today (Bellingham 1998: 1.8). The inlet's sedimentation rate has been calculated at 2.9 mm per year (Healy 1980). The inlet has long been recognised for its natural beauty and importance as a wildlife habitat; the eastern third was designated a Wildlife Reserve in 1956.

Pollen cores from the Pauatahanui Inlet indicated the presence of podocarp forest and typically coastal vegetation until about 500 to 600 years ago, when the forest was burned (Mildenhall 1979). Accounts of the vegetation around the Porirua Harbour in the mid

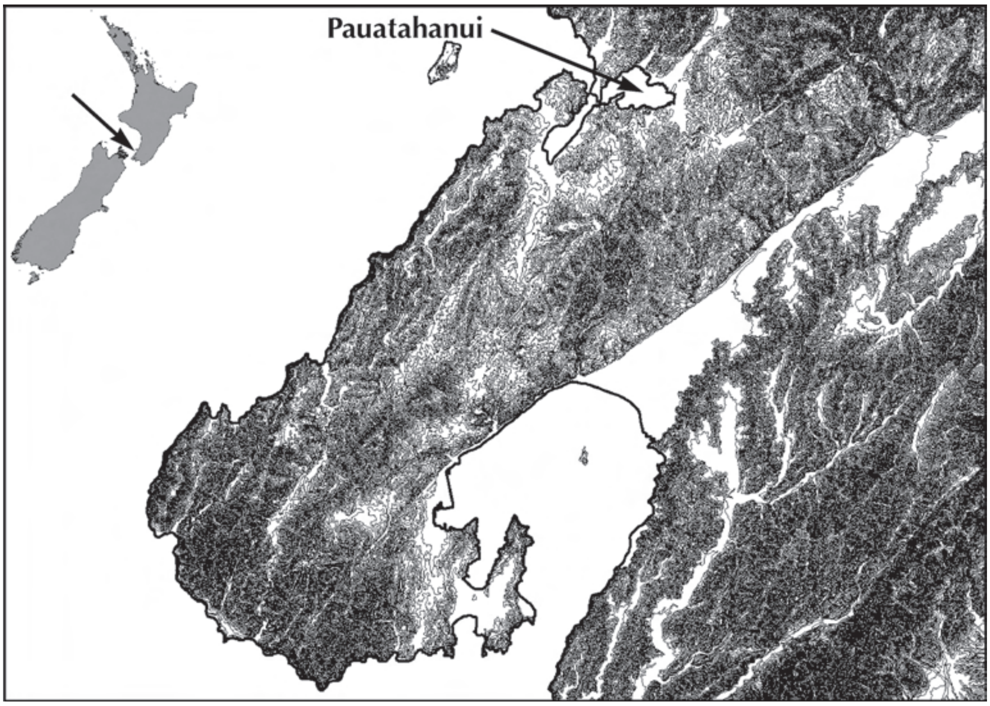

Figure 1. The southwest part of the North Island showing the location of Pauatahanui Inlet.

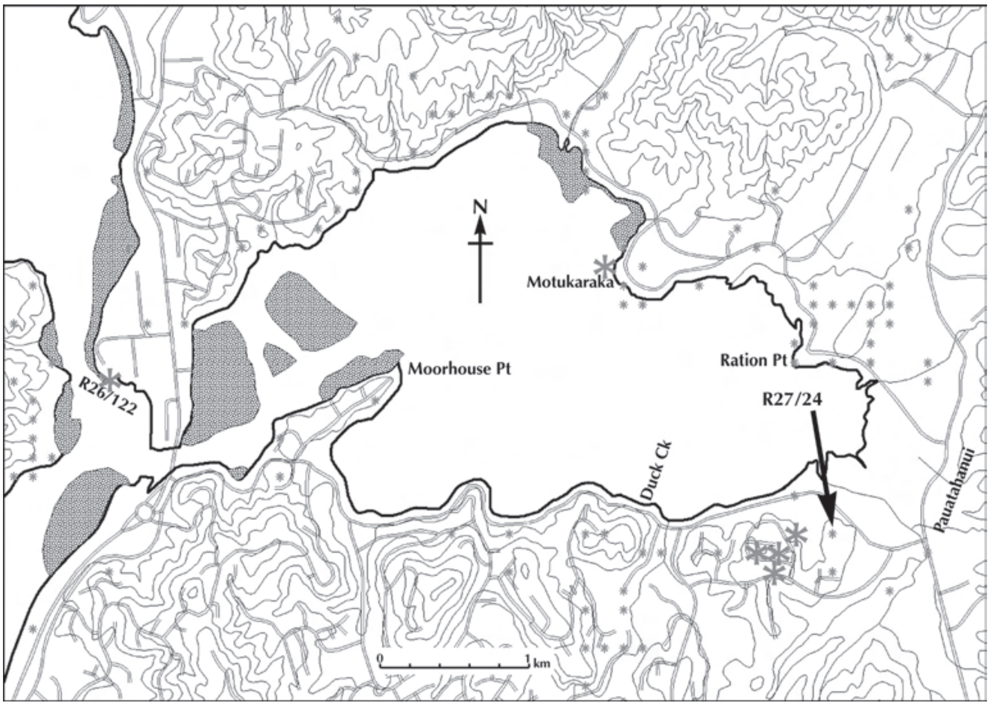

Figure 2. Pauatahanui Inlet, showing the position of archaeological site R27/24. Recorded archaeological sites are shown as dots; large asterisks are sites with radiocarbon dates.

nineteenth century are conflicting. Brees (1849: 9) described the general area as "thickly wooded", which suggests regeneration after initial Maori clearance. An 1841 account of a journey by a surveying party from Wellington to Paremata and over what is now Hayward's Hill to the Hutt Valley described vegetation along the way in more detail, noting that "the hills on the southern side [of the Pauatahanui Inlet] here and there were bare, shewing signs of a clayey soil; the trees near these places were generally manukou [mānuka], which is generally an indication of poor soil, but the northern side had a better appearance generally…" (*New Zealand Gazette and Wellington Spectator* 1841). However, valleys around the inlet seemed to be well wooded.

Housing development in the 1960s and 1970s led to concerns from local residents about the acceleration of sedimentation in the inlet. Silt deposition in Browns Bay became a concern for long-term community members and led to the formation of the Pauatahanui Environmental Programme, a three year study (1975–1977) designed to understand the ecology of the inlet, particularly as it related to the needs of city planners (Healy 1980). This programme led to a census of the population of cockles (*Austrovenus stutchburyi*) in 1976, and subsequent surveys in the 1990s. The results of these surveys are discussed below.

MAORI HISTORY

According to Best (1914), the Ngāi Tara were the first known iwi to occupy the Wellington and Porirua area. They are supposed to have been pushed out of the region and over Cook Strait by the Ngāti Ira and Ngāti Rangi (Rangitāne) people. Best records a battle between the Ngāti Ira, who had pushed their northern boundary as far as Pukerua Bay, and the Ngāti Rangi, who were feeling threatened by this. The battle took place on the track between Pauatahanui and Horokiri.

In 1819, war parties from Northland, accompanied by Ngāti Toa chiefs Te Rauparaha and Te Rangihaeata and their followers, harassed the local tribes before returning to the north. Over the next few years, Ngāti Toa from Kawhia, with their relatives Ngāti Raukawa and some Te Āti Awa from Taranaki, returned and took possession of the Porirua and Wellington districts, driving most of Ngāti Ira to the Wairarapa. Ngāti Toa settled at Kapiti, Mana and Porirua, including the Pauatahanui Inlet, and still live in the district today.

Ngāti Ira were said to have had at least two pā in the inlet; Motukaraka on the point of the same name and Te Ewe o Whanake on Ration Point (Sheehan 1988: 2). Te Rangihaeata occupied Motukaraka briefly, then built a new pā on the hill at Pauatahanui where the present St Albans church stands (Healy 1982: 12–15; Bellingham 1998: 1.10–1.11).

PREVIOUS ARCHAEOLOGICAL RESEARCH

Best (1914: 13) reported several shell middens around the shores of the inlet. He saw middens along the ridge of a point to which he gave three names — Point Russel, Long Point and Rapa-a-te-whai. He was probably referring to what is today known as Moorhouse Point, in the southwestern area of the inlet. He also reported middens at Duck Creek, between there and Pauatahanui (one of which may have been R27/24), and at Motukaraka (where adzes had also been found). He made special mention of large middens at Paremata and Plimmerton (Best 1918).

The first formal records of sites in the area were submitted to the New Zealand Archaeological Association's newly established Site Recording Scheme in 1959. By 2000, 91 sites had been recorded around the shores of the inlet; many of these had been destroyed. Most are listed as middens. Figure 2 shows the distribution of these sites.

In 1962, preliminary bulldozing for the establishment of the Mana Cruising Club at Paremata, on the northern side of the mouth of the inlet, revealed extensive midden remains, including moa bones. Salvage excavations established that the site (R26/122, formerly N160/50) had first been occupied by people who hunted moa and other extinct birds (Davidson 1978). This strategically important location was then successively occupied by a later but still pre-European Maori group and by Ngāti Toa, who established Paremata Pā adjacent to Thom's whaling station in the 1830s. Paremata Pā was occupied into the early 1840s, but as relations between Maori and settlers deteriorated, it was abandoned. A brief British military occupation, including a two-storey stone barracks and other less durable buildings, commenced in 1846 (Davidson 1978: 207; Burnett 1963). The remains of the barracks (which partially collapsed when a canon was fired at and missed a passing canoe) can still be seen.

In 1978, Sheppard and McFadgen (n.d.) investigated four midden sites comprising eight separate midden deposits on hill sides on the south-eastern side of the inlet. Four were less than 140 m from the shore and the others were between 220 and 280 m inland. The sites were scheduled to be destroyed during housing development. There are nine radiocarbon dates on shells from these sites, eight on *Austrovenus stutchburyi* and one on *Haliotis iris* (McFadgen 1997: 33–34). McFadgen (1980) also dated a sample of *Austrovenus stutchburyi* shells from a midden overlying a plaggen soil, exposed in a road cutting on the northern side of the inlet.

Figure 3. Clearance of Site R27/24 in preparation for excavation.

Figure 4. Excavation in progress, looking east towards Area D.

Beyond the inlet, excavations on Mana Island revealed a sequence somewhat similar to that at Paremata, with a documented historic Ngāti Toa occupation from the nineteenth century overlying earlier fourteenth century occupation (Horwood 1991; Horwood *et al*. 1998).

Both Paremata and Mana appear to have been substantial settlements of some duration, in contrast to the majority of middens around the inlet, which reflect briefer, more transient occupation.

THE EXCAVATION AT R27/24

The road section was cleaned down and examined and relevant parts photographed. The small remnant of the site between the road and the hill slope was then cleared of vegetation by hand and weed eater (Fig. 3) and the exposed surface examined. No surface features were visible.

A mechanical excavator was used the dig 50-cm-wide trenches through the remnant of the site (Figs 4 and 5). A 17-m-long trench (EW Trench) was dug parallel to the road and a datum point established at its eastern end. Figure 4 shows how narrow the remnant of the site was. A shorter trench (NS Trench) was dug at right angles from near the centre of the EW Trench to the inland edge of the site at the base of the slope. The trench sections were cleaned down and inspected and areas selected for sampling or further investigation. A second short trench (NS Lower Trench) was subsequently dug by spade from the EW Trench to the edge of the road. One rectangle (Area D) was set out on the inland side of the EW Trench and excavated by hand trowel.

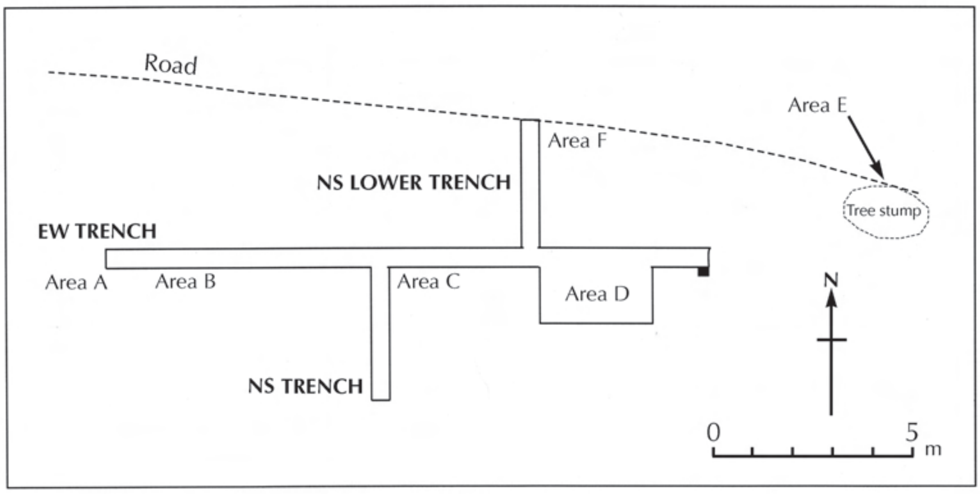

Figure 5. Plan of the areas investigated and sampled at R27/24.

Area A, at the western at the western end of EW Trench, consisted of a dense layer of shell with many unbroken cockle valves, other shell, ash, charcoal and fire-cracked rock (Fig. 6). Three rubbish bags (45 kg) of this material were collected for analysis. The samples were sieved through 6 mm mesh in the field.

Area B, on the inner edge of the EW Trench east of Area A, was divided stratigraphically into B Top and B Base (Fig. 7). It was unclear whether the lenses of shell represented one or two phases of midden deposition. B Base was exposed in the EW Trench itself, while B Top (Fig.

Figure 6. The western end of EW Trench, showing Area A.

8) was up the slope of the hill above it. The material was very similar in composition to the midden in Area A, but was not sieved in the field. Three bags (45 kg) were delivered to the laboratory from B Top and two (40 kg) from B Base.

Area C was at the junction of the NS and EW Trenches. The shells were fragmentary and the matrix high in charcoal. Unsieved material from this area filled one rubbish bag (5 kg) and two 20 litre polypails. These samples were retained for possible future analysis.

Area D was the 1.5 x 3 m rectangle on the southern side of the EW Trench. The shell material was relatively fragmentary and was scattered through the dark soil (Fig. 9). Two rubbish bags (35 kg) of sieved midden were taken and the material that passed through the sieves was also retained in a polypail. This area contained a feature identified as a possible hearth or cooking structure (Fig. 10). A sample of its contents (10 kg) was taken in a rubbish bag.

Area E was an area of midden overlying a layer of dark soil and concentrations of oven stones exposed under a tree trunk at the roadside. A small sample was taken.

Figure 7. EW Trench, looking east. In the foreground can be seen the stratigraphically divided Areas B Top and B Base.

Figure 8. The loose cockle shells of Area B Top.

Figure 9. The west face of Area D.

Figure 10. Area D, showing a possible hearth feature.

Area F was at the northern end of the NS Lower Trench, where it came out on to the road. The material was far more fragmentary and dispersed than the shells from Areas A and B. Two bags (40 kg) of bulk midden material were taken.

Area G refers to the entire NS Lower Trench. Some bones were collected from the topsoil in this area during excavation, but no bulk samples were taken apart from those of Area F.

There appeared to be a difference between the deposits in Areas A and B, and those in other areas sampled. Areas A and B contained loose, often intact, shells with little matrix, but interspersed with lenses of yellow clay. Remaining areas contained more fragmentary shell in an often charcoal-rich matrix of dark soil (Fig. 10). It seemed likely that the deposits in Areas A and B represented midden thrown down from an occupation area on the high ground above, whereas the more eastern deposits were probably the result of occupation on the flat itself. A brief inspection of the area at the top of the hill above Area A confirmed that there had also been activity there. Shells, predominantly cockles, were visible around a large macrocarpa tree and the foundations of a garage and were eroding from exposed patches at the top of the cliff. The overburden of yellow clay above the midden in Areas A and B may have resulted from Maori or later European activities on the hill top. These hypotheses were further evaluated during monitoring of site destruction.

MONITORING OF SITE DESTRUCTION

Removal of the archaeological deposits in preparation for road widening began on November 8, 2000, and was monitored by Kate Miller and Jim Samson.

A mechanical digger with a toothed bucket was made available. The driver was shown the stratigraphic profile still visible in the EW Trench at the eastern end of the site and asked to remove the midden layer in shallow scrapes (Fig. 11) until the basal natural deposit was visible. The driver did this over an area of 15 by 4 m. The deposit appeared to be a single undifferentiated layer. The soil was dark and charcoal rich and the shells were fragmentary, very similar to the samples collected from Areas D and F during the excavation. No features were observed in the midden while it was being removed.

The surface of the soil beneath the midden was thoroughly inspected. The basal layer was densely packed yellow-brown earth, which was not easily penetrated with a spade. No features were identified on the top of this natural layer. The midden thinned towards the south and terminated against the hillside.

The concentrated shell deposits at the western end of the site proved to extend west up the slope of the hill and north towards the existing road, where a thin layer was visible. All midden uncovered here looked similar in composition to samples from Areas A and B, which had already been analysed in the laboratory (Fig. 12). It was hard to identify distinct midden areas in this part of the site during this type of rapid mechanical excavation. It was difficult to ascertain the thickness of the midden deposit, as it rapidly crumbled from the loose soil of the hillside. Such observations as could be made under the circumstances support the view that the midden deposits in the west part of the site were dumped over the side of the hill in the course of pre-European Maori activities above.

Figure 11. The ground surface after a shallow digger scrape. The light area is the trench from the September excavation.

Figure 12. Midden exposed by a digger at the west end of site.

CURATORIAL DETAILS

The excavated samples arrived at the Archaeozoology Laboratory in black plastic rubbish bags within paper rubbish bags. Archaeological provenance information was written on these paper bags. Each bag was assigned an Archaeozoology Laboratory catalogue number. This number was entered into a computer database together with all the original information written on the bag. Each bag was weighed and the contents were dried on plastic sheeting before being passed through ¼ and $^{1}/_{16}$ inch nested sieves. The material caught in the $^{1}/_{16}$ inch mesh and the material which passed through it were retained for future analysis in clip-seal plastic bags. Only material from the ¼ inch mesh is analysed in this report, excluding the sample from Area C and one bag from Area D. The single bag from Area C and the unanalysed bag from Area D were from suspected oven areas and contained large amounts of charcoal; they were retained for future analysis.

Four bulk samples of material (two total samples from Area C and two containing sieved residue from Area A) arrived in 20 litre polypails and these were also retained, after being assigned Archaeozoology Laboratory catalogue numbers. Small plastic bags of material collected during excavation were also given Archaeozoology Laboratory catalogue numbers.

In subsequent sorting and re-bagging, all bags were consistently labelled with the following information: Site name (Paua, short for Pauatahanui), Area (for example, A or D), any stratigraphic information, and the Archaeozoology Laboratory catalogue number of the original bag. Thus, a sample bag could be labelled: Paua, B, Top, AL110.

FAUNAL ANALYSIS

The material from each bag was sorted into a number of different categories: cockle, other shell, charcoal, stone, bone and miscellaneous. Each category was re-bagged separately.

SHELLFISH

Cockle valves were sorted into left and right valves. The left valves were discarded. The right valves were retained and counted (if more than half the hinge was present) in order to generate the MNI (Minimum Number of Individuals).

The other shells were separated according to species where possible, sometimes only to genus. Bruce Marshall, Collection Manager Mollusca at Te Papa, assisted in these identifications. All the protoconches of gastropod species were counted, provided they were more than half intact. *Turbo smaragdus* has an operculum which survives extremely well in archaeological contexts. Both the protoconches and the opercula were counted and the higher number in each case was taken as the MNI. For bivalves other than cockles, the procedure of only counting right valves was followed except where NISP (Number of Identified Specimens) was less than 20. In these cases, both left and right valves were counted and the larger number taken as the MNI. All valves were retained and bagged together. Mussel (*Mytilus galloprovincialis*) remains were fragmentary and proved difficult to side; therefore all hinges were counted and the total halved to give a minimum number.

The total MNI and percent MNI of shellfish species from all analysed provenances are given in Table 1 and Figure 13. Details according to sample and provenance are given in Appendix 1.

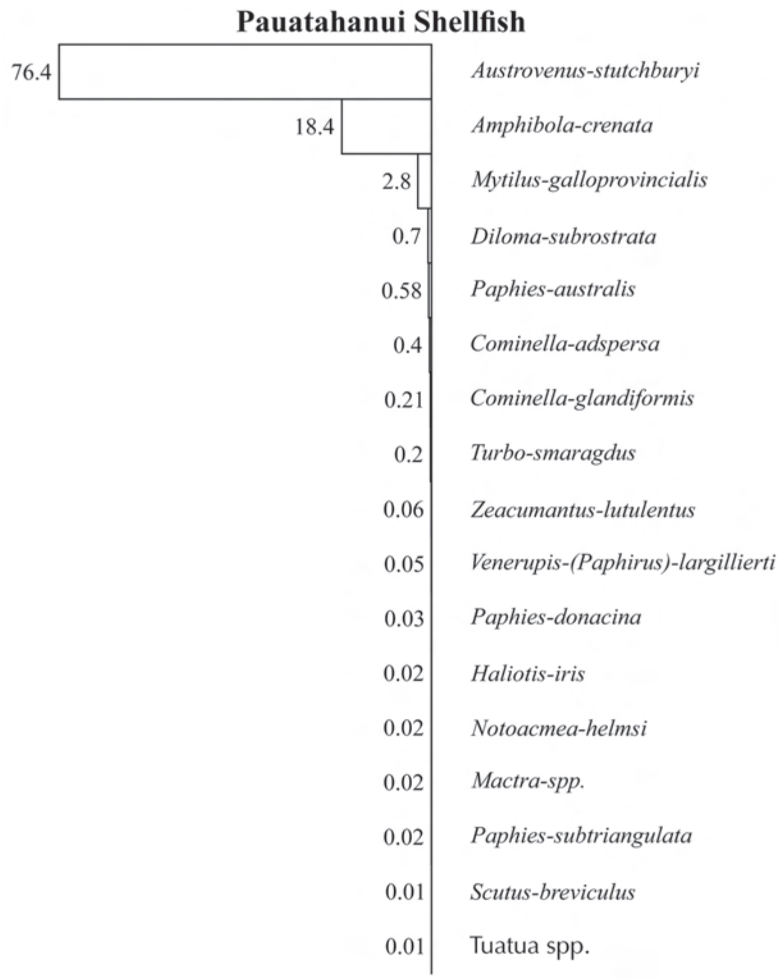

Figure 13. The relative abundance of shellfish from R27/24 by number from Areas A, B, D and F combined.

As expected, cockles (*Austrovenus stutchburyi*) make up by far the largest proportion of shellfish represented at the site. They are the most abundant shore animal in Pauatahanui Inlet (Bellingham 1998: 4.8) and have been favoured as a food by both prehistoric Maori and modern gatherers. Mudsnails (*Amphibola crenata*), which are numerous on the mudflats of the inlet, are also a significant component of the midden. Most of the shellfish represented are commonly found on the sands and mudflats of the inlet. *Cominella glandiformis*, for example, feeds on cockles, pipi (*Paphies australis*) and mudsnails. Exceptions include species such as blue mussels (*Mytilus galloprovincialis*), cat's eyes (*Turbo smaragdus*), and pāua (*Haliotis iris*), which would have come from an area of rocky shore, probably closer to the harbour mouth. Pipi can be found in the inlet waters, but tuatua (*Paphies subtriangulata, P. donacina*) are found on ocean beaches and are common on the exposed west coast beaches of the lower North Island. The presence of these non-estuarine species indicates that the people who made the midden deposits brought shellfish to the site from some distance. The mussels in particular are relatively abundant, suggesting gathering expeditions to the outer harbour during occupation of the site.

Table 1. Total MNI and percent MNI of shellfish from Pauatahanui, all provenances combined.

	Species	MNI	%MNI
1	*Austrovenus stutchburyi*	9653	76.4
2	*Amphibola crenata*	2331	18.4
3	*Mytilus galloprovincialis*	357	2.8
4	*Diloma subrostrata*	93	0.7
5	*Paphies australis*	73	0.6
6	*Cominella adspersa*	51	0.4
7	*Cominella glandiformis*	27	0.2
8	*Turbo smaragdus*	25	0.2
9	*Zeacumantus lutulentus*	7	0.1
10	*Venerupis (Paphirus) largillierti*	6	<0.1
11	*Paphies donacina*	4	<0.1
12	*Haliotis iris*	3	<0.1
13	*Notoacmea helmsi*	2	<0.1
14	*Mactra* spp.	2	<0.1
15	*Paphies subtriangulata*	2	<0.1
16	*Scutus breviculus*	1	<0.1
17	Tuatua spp.	1	<0.1
	Total	12,638	100.0

Figure 14 shows the percentage of total MNI of the three most numerous species (cockles, mudsnails and mussels) from the five provenances analysed. The histograms show a similar pattern. The main difference is the lack of mussel remains from Area D, where cockles reach over 90 percent of total MNI. The material from Area D is generally in a high state of fragmentation. This might explain the lack of fragile mussel, but not the low occurrence of mudsnail, which is fairly robust. The Area D midden may reflect a more selective collecting strategy that focused on cockles and/or collection from a single environment. Cockles live in sand and mud, mudsnails are most abundant on mud flats, and mussels are found on a rocky shore.

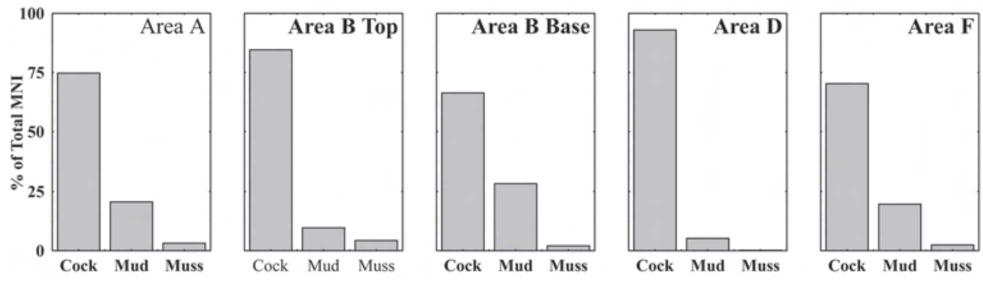

Figure 14. The relative abundant of the three main shell species in four areas at R27/24.

Cockle was the most abundant species of shellfish and the only bivalve with sufficient numbers for an analysis of valve size. All complete right valves were measured. No data were available to enable size to be estimated from hinge measurements, so fragments were not used. Valves were rotated within digital callipers to record maximum length. Measurements from the digital callipers were entered directly into a computer data base.

The measured valves came from the bulk samples originally in rubbish bags and give a picture of cockle size in five midden contexts: Area A, Area B Top, Area B Base, Area D and Area F. The statistics from this analysis are presented in Appendix 2. Size frequency histograms were also produced for each area (Appendix 3), the aim being to show any differences in cockle size between the five main contexts. Figure 15 shows mean cockle size and standard deviation for each sample. There are clear differences between areas D and F, which have the smallest sample sizes and a high occurrence of broken shells in the samples. There is a smaller but distinct difference between Areas B Top and B Base, which may indicate that they do represent different deposition events, as suspected during excavation. There is also a difference between Areas A and B.

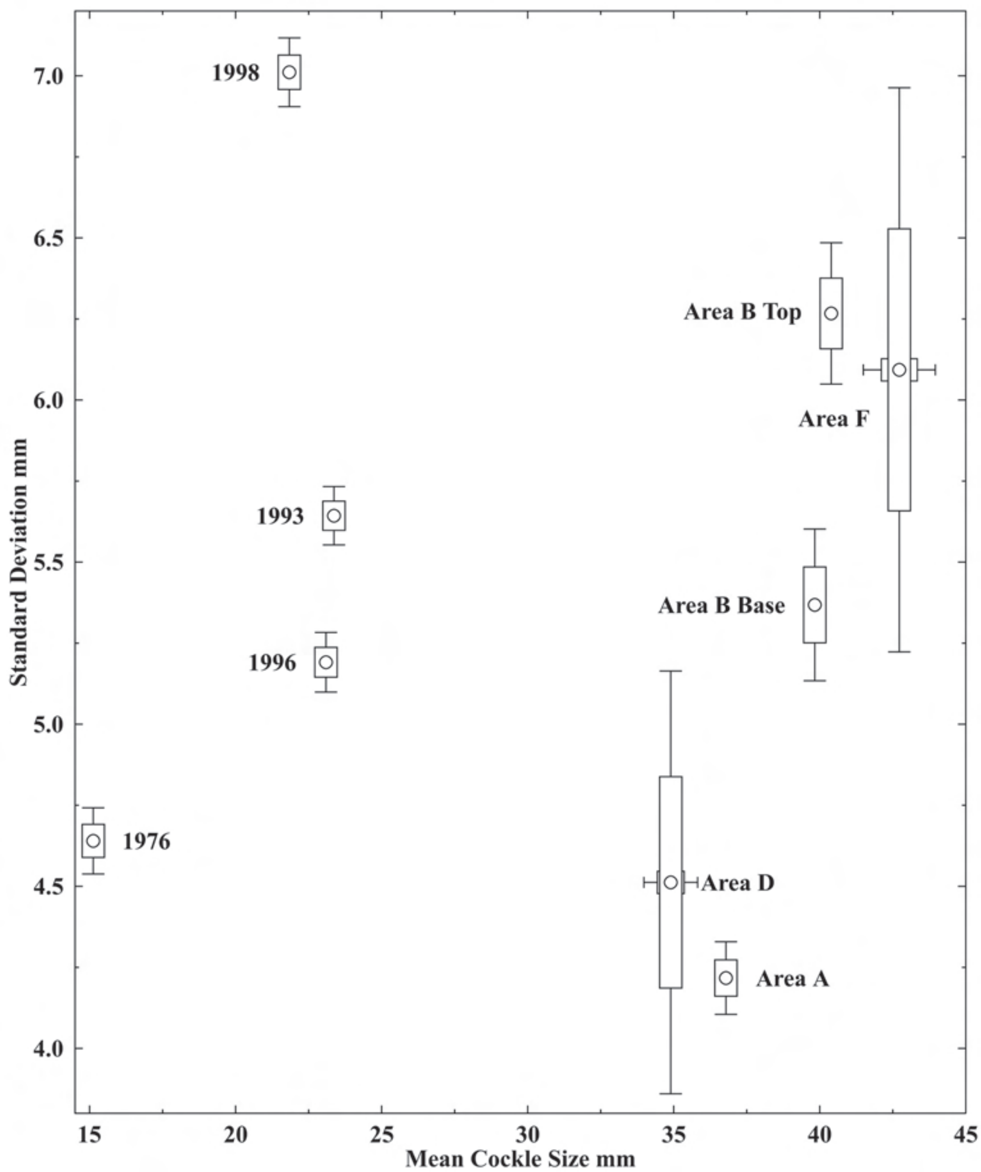

Figure 15. Mean sizes and standard deviations of archaeological cockle samples from R27/24 and cockles from modern surveys in the Pauatahanui Inlet.

The data can be compared with modern data on cockle size. As part of the Pauatahanui Environmental Programme, the New Zealand Oceanographic Institute made a census of the cockle population on 30 November 1976 (Richardson *et al*. 1979). They sampled 515 stations along 77 transects, although only 299 intertidal stations are included in their analysis of the results. They sampled at 20 m intervals along the transects, from the high tide to the low water mark. The samples were taken to a depth of 7 cm and were 0.1 m^2 in area. The entire contents of each sampled area were placed in a cheesecloth bag and analysed in the laboratory. Shells were counted and measured for maximum length. The results showed a mean density of 58 cockles per station. The total cockle population in the estuary (an area of 1 km^2) was estimated at 577 million. The study also showed an increase in the average size of adult specimens from high to low water due to the increased feeding time available to cockles with a longer period of immersion.

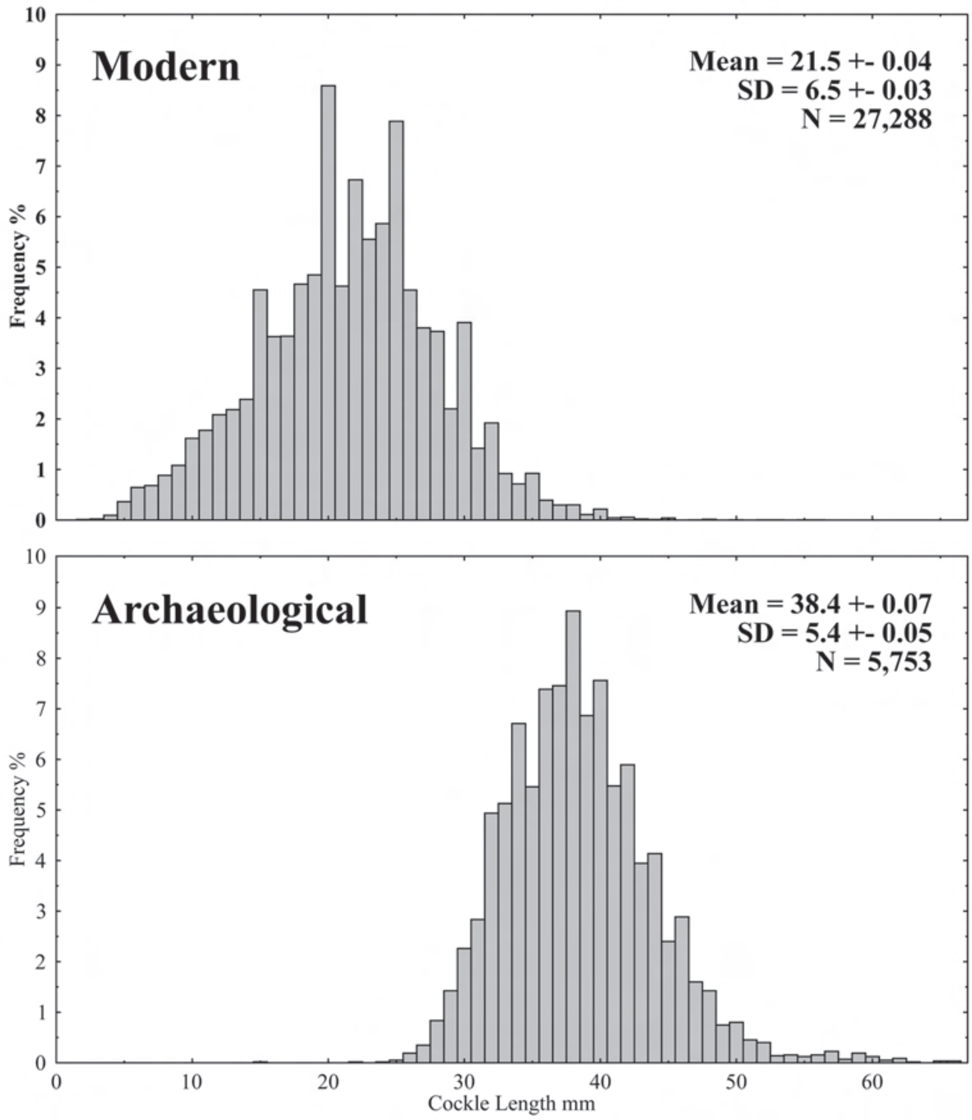

Figure 16. Size frequency distributions of all archaeological cockles from R27/24, compared with cockles from four modern surveys in the Pauatahanui Inlet.

Healy (1980: 116) estimates that cockles account for over 80 percent of the total living things in the inlet, excluding fish and birds. Cockles are filter-feeding bivalves; they burrow into the sand and inhale water containing suspended oxygen and plankton through one of their siphons and exhale water and wastes from another. The studies of cockle population density and size are intended to indicate the general ecological health of the inlet by inference from the health of the cockles. Cockles are numerous, sensitive to habitat change and easy to count and measure (Bellingham 1998: 3.22, 4.8)

In November 1992, the Guardians of the Pauatahanui Inlet in conjunction with NIWA organised another cockle survey, which aimed to give results comparable to those of the 1976 survey. There were further surveys in November 1995 and November 1998. These surveys were carried out by volunteers from the community and had a similar methodology to the 1976 survey. The inlet was divided into nine areas with three or four transects in each, making 30 transects in total. Four 0.1 m^2 quadrats were randomly placed at four tidal heights — high tide, upper mid-tide, lower mid-tide and low tide. Altogether, 360 samples were taken from 120 sites. Cockles were sorted by hand in 1992 and 1996 but sieved from the substrate in 1998. Specimens were measured to the nearest 1 mm then released back into their natural environment.

The reports from these studies (Grange 1993; Grange *et al*. 1996; Grange and Crocker 1999) focused on the population density of cockles in the inlet. The results showed a population decline between 1976 and 1992, which continued to 1995. The 1998 survey, however, showed some apparent recovery in the cockle population.

Shellfish size was also analysed. The researchers were particularly concerned to monitor the presence of juvenile cockles (under 10 mm) as a guide to the rejuvenation of the populations; juveniles also seemed to be increasing in 1998.

The archaeological cockle sample can tell us nothing about cockle biomass in the inlet at the time when the site was occupied. Nor is it possible to say which tide level zones were being exploited by the site's occupants. However, the size frequency distribution and mean size of the archaeological sample can be compared with the modern sample (Figs 15 and 16). It is immediately apparent that the archaeological cockles were much larger than the modern ones. This is not because the pre-European gatherers collected only large examples. Although they may have rejected or discarded juveniles, the majority of the shells they collected were larger than any of the shells found during the modern surveys. A number of factors may have contributed to this difference, including the water temperatures at the time the site was occupied, a lesser degree of silting up, and the extent and nature of previous exploitation during the pre-European period.

FISH BONE

The small amount of fish bone was sorted into commonly identified anatomical elements: dentary, premaxilla, maxilla, articular, quadrate and 'special' bones (following Leach 1986). Each bone was then identified to the lowest taxonomic level possible using the Archaeozoology Laboratory comparative collection and entered in a database. Unidentifiable fish bones were rebagged and retained.

A few fish bones were found in each of the five analysed bulk samples. The results according to family from all provenances combined are presented in Table 2 and Figure 17. Full details are given in Appendix 4. The small sample and method of calculating MNI mean that the relative abundances are not significant. Only NISP are given in Figure 17.

Table 2. Relative abundance of fish families at Pauatahanui.

Family	**NISP**	**MNI**
Condrichthyes (sharks, skates, rays)	10	4
Sparidae (snapper)	5	3
Mugiloididae (blue cod)	3	2
Gemphilidae (barracouta)	3	2
Anguillidae (eels)	1	1
Labridae (spotties, parrotfish)	1	1
Pleuronectidae (flounder and sole)	1	1
Total	24	14

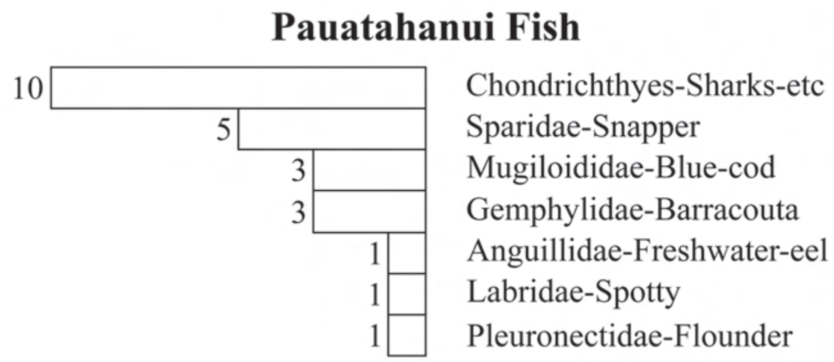

Figure 17. Relative abundance of fish from R27/24 by NISP.

These fish are all found in sites around Cook Strait, although snapper tend to be more common in earlier sites and eels are always relatively rare.

Flounder are likely to have been abundant in the inlet when the site was occupied; other species may have been caught there or further afield. It is only a short distance by canoe from the site to the reef at the harbour entrance or on to Mana Island. The few fish, like the rocky shore shellfish, may well have been brought to the site from the harbour entrance or beyond.

BIRD BONE

Bird bones were identified by Trevor Worthy. Forty-one fragments were not identifiable. Eighteen specimens provided identifications of eight species. The results are summarised in Table 3 and Figure 18. The full details are given in Appendix 5.

These results suggest that fowling, like fishing, was not the main activity of the people responsible for the midden. Occasional birds were captured to add variety to the diet. The individual identifications account for only eight birds in total, if it is assumed that the single tūī/kōkako bone is most likely to be part of the same kōkako that was positively identified in the Area A sample. It is unlikely, however, that the bones of a single tūī would be found in four separate samples some distance apart. It is more reasonable to calculate the minimum numbers for each sample, in which case the total MNI is 14 (again assuming the tūī/kōkako and kōkako bones from Area A derive from one bird).

Table 3. Birds from Pauatahanui (NISP).

Species	**A**	**B Top**	**B Base**	**D**	**F**
Cf. *Prosthemadera/Callaeas* (tūī/kōkako)	1	-	-	-	-
Prosthemadera novaeseelandiae (tūī)	-	1	1	1	3
Callaeas wilsoni (kōkako)	1	-	-	-	-
Phalacrocorax melanoleucos (little shag)	1	-	-	-	-
Gallirallus australis (weka)	1	-	1	-	-
Hemiphaga novaeseelandiae (pigeon)	-	-	2	1	-
Cyanoramphus sp. (parakeet)	-	-	-	1	1
Ninox novaeseelandiae (morepork)	-	-	-	-	1
Anas sp. (duck)	-	-	-	-	1

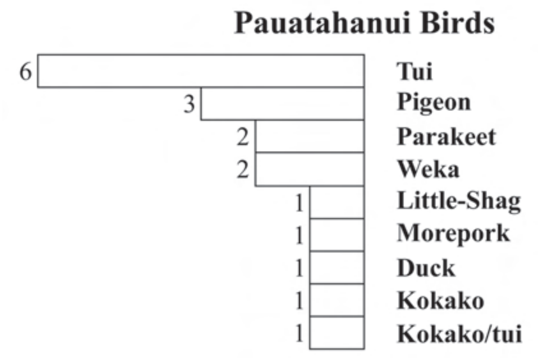

Figure 18. Relative abundance of birds from R27/24 (NISP).

The predominance of forest birds tends to support Brees' account (1849: 9) that the shores of the Porirua Harbour were "thickly wooded" when Europeans arrived in the area. A similar but larger range and quantity of birds was found in the late prehistoric and nineteenth century deposits at Paremata. As the charcoal results described below show, this was by no means a pristine forest, but an environment already much affected by human presence. The inlet is likely to have provided a major habitat for ducks and there would also have been many sea birds available in the general vicinity. However, hunting of such birds was evidently not a priority for the occupants of the site.The single duck and shag are likely to have been victims of opportunistic, rather than targeted, capture.

RAT BONE

Rat bones were found in several of the samples and identified in the Archaeozoology Laboratory. They are compatible in size with bones of *Rattus exulans*, the Pacific rat introduced to New Zealand in pre-European times. The bones represent an MNI of eight rats, three in Area D, two in both Area B base and Area B Top, and one in Area F. The detailed identifications are given in Appendix 6.

OTHER MAMMAL BONE

Other mammal bone was sent to Ian Smith of the Anthropology Department, University of Otago to be identified. The results are given in Table 4.

Table 4. Mammal bone from R27/24.

Provenance	Species	Element	Number
Area G, Topsoil	Cow	Rib	1
Area G, Top soil	Rabbit	Most of skeleton	1
Area F	Dog	Canine tooth	1
Area F	Dog	L. metacarpal 4	1
Area F	Indet.	Fragments	2
Area B, Base	Indet.	Fragments	1
Area D	Indet.	Fragments	2

The cow and rabbit remains, found in the topsoil, are clearly of European origin. The dog remains from the Area F sample, however, represent a dog belonging to the Maori occupants of the site. Nothing can be said about the indeterminate or unidentifiable fragments.

CHARCOAL

Fourteen charcoal samples were identified by Wallace. The individual determinations are given in Appendix 7 and summarised in Table 5.

The charcoal collected during the excavation is assumed to have been the residue of domestic fires. It is likely the prehistoric inhabitants collected firewood from the immediate vicinity of the site. In general, the species composition of these samples will indicate local vegetation at the times the site was occupied. It must be pointed out, however, that some of the firewood may have been driftwood collected from the local foreshore of the inlet and not have come from local vegetation. Secondly, certain species, mainly large conifers such as matai̅, produce massive trunks and stumps that can survive on land surfaces long after the trees died. Such dead wood is ideal for firewood but its possible presence complicates palaeo-environmental interpretation of a charcoal assemblage.

Forty-five percent of the current assemblage is kānuka (*Kunzea ericoides*), a species present in all 14 samples. This scrub species tends to dominate vegetation succession after forest clearance. Shrub or scrub species form 87 percent of the assemblage, with coprosmas, fivefinger, akeake, māhoe, hebes, ngaio and lancewood occurring in more than two of the samples. Only 13 percent of the assemblage consisted of tree species. Kōwhai grows along streams and shorelines, and tawa, tītoki and kohekohe are typical of coastal forest. Tawa was mentioned as prominent in the wider region in 1841 (*New Zealand Gazette and Wellington Spectator* 1841), although not specifically on the southern shore of the inlet. The only conifer present was matai̅; a large tree whose logs and stumps can survive on land surfaces long after forest clearance.

The charcoal assemblage indicates that the vegetation surrounding the site at the times it was occupied consisted of coastal scrub dominated by kānuka regenerating after the forest, represented by the presumed relict matai̅, had been cleared by fire.

Table 5. Charcoal identifications from R27/24.

Name	Species name	Type	#	%	Samples
Fern root	*Pteridium esculentum*	Fern	1	0.5	1
Shrub	Undetermined shrubs	Smaller	3	33.5	3
Hebe	*Hebe* sp.	shrubs	6		4
Coprosma	*Coprosma* sp.		12		9
Mānuka	*Leptospermum scoparium*		3		1
Patē	*Schefflera digitata*		4		2
Ramarama	*Myrtus bullata* spp.		5		2
Fivefinger	*Pseudopanax arboreus*		6		5
Lancewood	*Pseudopanax crassifolius*		8		3
Pittosporum	*Pittosporum* sp.		1		1
Akeake	*Dodonaea viscosa*		16		5
Mingimingi?	*Leucopogon fasciculata*		1		1
Olearia	*Olearia* sp.		1		1
Ngaio	*Myoporum laetum*		10		4
Kānuka	*Kunzea ericoides*	Kānuka	103	45.4	14
Putaputaweta	*Carpodetus serratus*	Larger	1	7.5	1
Porokaiwhiria	*Hedycarya arborea*	shrubs	3		1
Māhoe	*Melicytus ramiflorus*		10		5
Māpau	*Myrsine australis*		2		1
Vine rata?	*Metrosideros* sp.?		1		1
Tawa	*Beilschmedia tawa*	Broadleaf	9	8.4	2
Tītoki	*Alectryon excelsus*	trees	5		2
Kohekohe	*Dysoxylum spectabile*		4		1
Kōwhai	*Sophora microphylla*		1		1
Mataī	*Prumnopitys taxifolia*	conifers	11	4.8	9
Totals			227		

ARTEFACTS AND OTHER PORTABLE ITEMS

Two small stone adzes and an obsidian flake were collected from the road cutting. A broken bone toggle and a small obsidian chip were recovered from the bulk samples. A ceramic fragment, probably from a drain pipe, was found in the topsoil in Area G, where the cow and rabbit bones were recovered.

Before the investigation began, the bevel end of a stone adze blade was found in material eroding from the road cutting at the eastern end of the site, associated with apparently disturbed midden, charcoal and oven stone fragments. It is from a small adze of rectangular cross-section with a curved and slightly asymmetrical cutting edge, and has shattered transversely at the top of the bevel, possibly along a natural flaw. The surviving portion is fully ground. It is 40 mm wide at the cutting edge and 20 mm thick at the top of the bevel. The material appears to be dark grey metasomatised argillite.

A small adze-like tool was found in the road section west of the NS Lower Trench. It appears to have been formed by reworking a large flake from an existing adze by flaking around the sides. It is oval in outline, thickest towards the butt, and tapers towards a thin cutting edge with almost no bevel. The ground surfaces on back and front are slightly weathered, suggesting the possibility that the original fragment was picked up from the beach. Its maximum dimensions are 54 x 33 x 14 mm. The material appears to be dark grey to black metasomatised argillite.

A chip of obsidian, green in transmitted light, with possible retouch or use along one edge, was found in the road section midway between areas E and F. It has a maximum dimension of 26 mm.

A smaller chip of obsidian, grey in transmitted light, was found in the sample from Area F. It has a maximum dimension of 11 mm.

The toggle, found in the Area A sample, is a shaft segment, probably of sea bird bone, with a single central perforation. There is no notching or other decoration. It has split in half longitudinally and the pieces do not now join cleanly; the bone is somewhat weathered. It is 59 mm long, 14 mm wide and 9 mm thick.

A curiosity is a broken, roundish piece of pumice-like material with a highly glazed surface. It appears to be a glazed siliceous froth resembling pumice but with an apparent granular (sand?) content within a highly vesicular glass matrix and can be described as a natural glass of some sort. It could be derived from any activity involving intense heat, either deliberately or accidentally (H. Campbell, pers. comm. 20 June 2001). As it was found in the Area D sample, the most likely explanation is that it is an accidental by-product of a very hot cooking fire.

Fire-cracked rock in the bulk samples was separated from other items and retained but has not been examined further.

RADIOCARBON DATING

Four samples, each consisting of ten cockle (*Austrovenus stutchburyi*) valves, were dated by the Waikato Radiocarbon Dating Laboratory at the University of Waikato. Details of the samples are given in Table 6. The results are given in Table 7 and the calibrated ages are shown in Figure 19.

Table 6. Shell samples from Pauatahanui selected for radiocarbon dating.

Cat.No.	Lab.No.	Weight (g)	Provenance
AL155	Wk-9034	96	Area B Base
AL156	Wk-9035	101	Area B Top
AL157	Wk-9036	73	Area D
AL158	Wk-9037	102	Area E

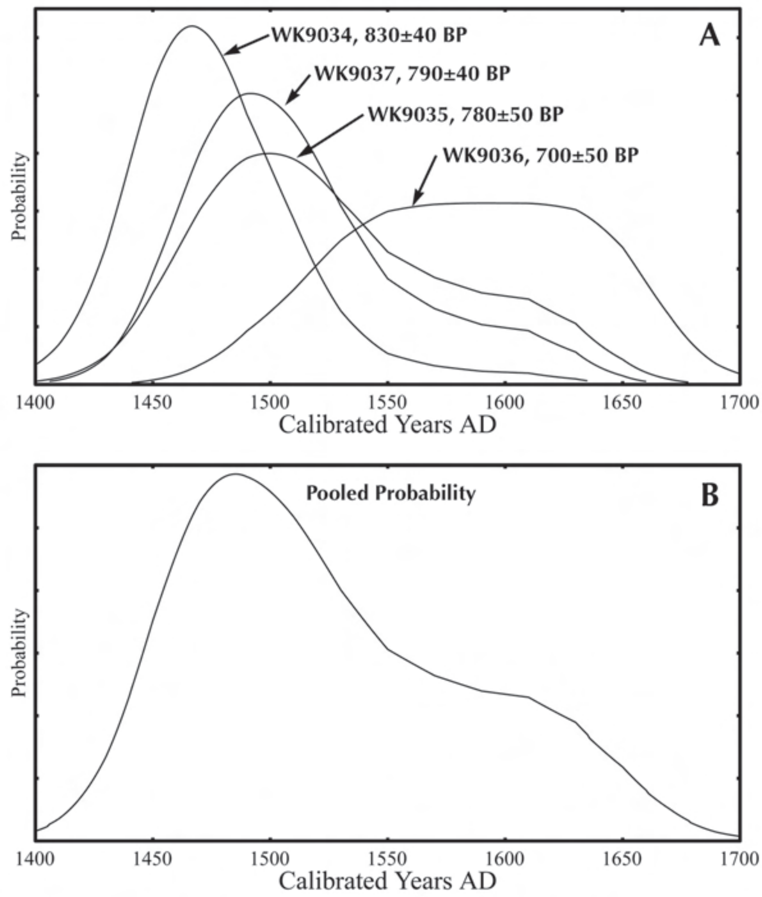

Figure 19. Probability curves for calibrated radiocarbon dates from R27/24.

Table 7. Radiocarbon results from Pauatahanui.

Cat. No.	**Lab. No.**	**$\delta^{13}C$**	**Conventional Radiocarbon Age BP**
AL155	Wk-9034	-0.3 ± 0.2	830 ± 40
AL156	Wk-9035	-0.6 ± 0.2	780 ± 50
AL157	Wk-9036	0.2 ± 0.2	700 ± 50
AL158	Wk-9037	0.4 ± 0.2	790 ± 40

The probability curves illustrated in Figure 19 suggest that the site was occupied at one or more times between about AD 1450 and 1650, with three of the samples having a high probability of falling between 1450 and 1550, or about 500 years ago.

These results are similar to those obtained from other midden sites (R27/35, 36, 37 and 45) on the southern side of the inlet close to site R27/24 (Sheppard and McFadgen n.d. Table 1; McFadgen 1997: 33–34). The Conventional Radiocarbon Ages for nine shell samples from the four sites are between 705 ± 33 BP and 883 ± 67 BP. These dates have recently been supplemented by a further six dates on *Rattus exulans* bones, which give a similar picture (Athfield *et al*. 1999). These results suggest quite extensive Maori use of this area during the period when R27/24 was occupied.

DISCUSSION AND CONCLUSIONS

Site R27/24 is only one of a large number of midden sites, many now destroyed, around the shores and hill sides of the inlet. The limited investigations undertaken at this site have enabled us to add significantly to our knowledge of past Maori life in the area and place the site in its wider context.

The full extent of the site cannot now be established, as most of it was destroyed when the road was first constructed. What was able to be investigated was only the back fragment at the base of the hill. Evidence of cooking and rubbish dumping was found here, but no traces of buildings or other structures, which were probably situated closer to the shore. The midden in Areas C, D and F appears to have been deposited *in situ* by people actually living on the site. The midden in Areas A and B, however, appears to derive from activity on the ridge above, where traces of midden, now much disturbed by post-European occupation, are still evident.

The site was occupied on one or more occasions between AD 1450 and 1650 by people who gathered shellfish from the inlet and occasionally from further afield, fished, and snared birds and rats. The principal shellfish gathered were cockles, which were significantly larger than those found in the inlet today (Fig. 20). By the time the site was occupied, forest had already been cleared from the vicinity and the immediate vegetation was regenerating scrub dominated by kānuka. Even so, a range of forest birds was available to the inhabitants.

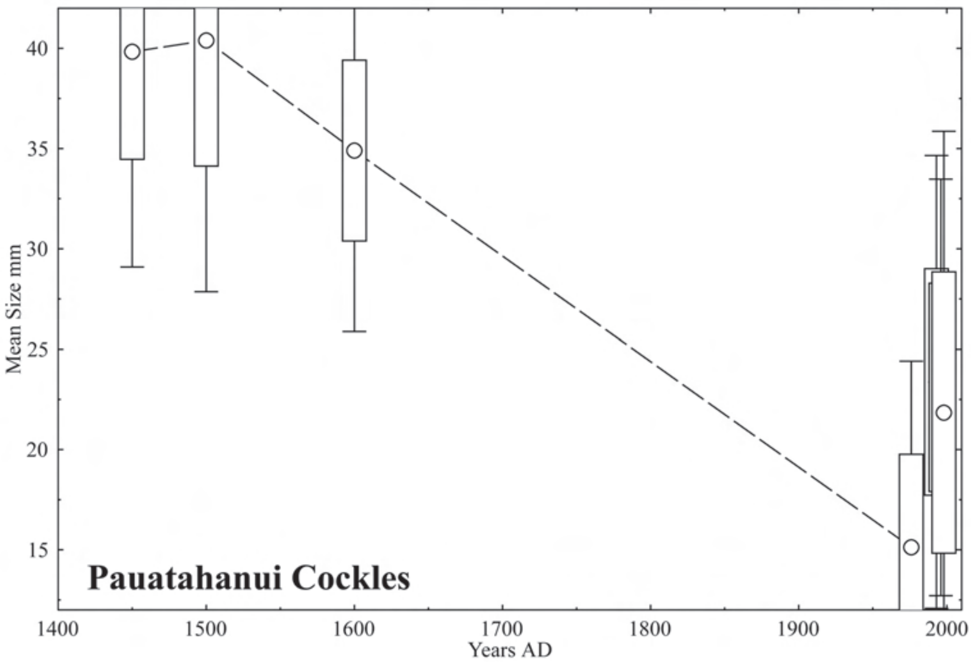

Figure 20. Changes in cockle sizes over time. On the left are the archaeological cockles from R27/24 and on the right cockles from modern surveys. The ranges shown for each point are one and two standard deviations, not standard errors which are much smaller.

The results of our analysis parallel those from an earlier study by Sheppard and McFadgen (n.d.) of eight separate smaller middens recorded as parts of four sites just to the west of

R27/24. One is on the shore, three others are less than 140 m from the shore and the remainder are between 220 and 280 m inland. These sites were of similar age to R27/24. Cockles were the dominant shellfish. Remains of kōkako, tūī, parakeet, red-billed gull and an unidentified wading bird, snapper, spotty and eagle ray were found, and a few bones of pilot whale and possibly dolphin. One dog was present. The remains of at least 25 rats were found in one of the middens, suggesting that these animals were being deliberately snared as food, and possibly preserved for later eating elsewhere. Charcoal and landsnail analysis suggested disturbed forest/scrub and scrub/grassland environments.

Although quite a lot is known about the exploitation of birds, fish and mammals for food, the vegetable component of the diet is poorly understood. McFadgen (1980: 9; 1997: 33) has reported a plaggen soil (agricultural soil) on the northern shore of the inlet, underlying a shell midden with a date in the same range as those discussed above (CRA 804 ± 57, NZ1878). This suggests that the initial forest clearance around the inlet may have been for gardens, although Sheppard and McFadgen (n.d.) found no evidence of cultivation in the vicinity of the middens near R27/24 that they investigated.

The earliest known archaeological site in the Porirua area is the site at the harbour entrance where the Mana Cruising Club is now situated. This site was occupied by people who hunted moa and other extinct birds, by a later prehistoric group and by Ngāti Toa, who established Paremata Pā there in the nineteenth century. Two radiocarbon dates give calibrated age ranges of AD 1260 to 1400 (WK-8543) for the initial occupation and AD 1460 to 1660 for the second occupation (WK-8542) (B.G. McFadgen pers. comm.). This second occupation is thus broadly contemporary with the dated middens around the inlet. There seems to have been a fairly rapid human impact soon after initial occupation, with some forest clearance and quite extensive human activity in the area some two hundred years later. The effects of this impact on the inlet itself are likely to have been considerable. There is much less evidence of human activity after about AD 1650 and it is possible that climatic deterioration (Leach 2006: 176 ff.) led to the virtual abandonment of the inlet until the arrival of Ngāti Toa in the region in the nineteenth century. By this time, pigs and potatoes were available to supplement the food resources of earlier times.

The dramatic difference in cockle size in the archaeological site compared to those available today is perhaps the most interesting feature of this small study (Fig. 16). There are basically three factors which could be proposed to explain this difference: different selective harvesting strategies, the effect of sustained predation over a long period, and natural environmental change. More than one of these could have occurred in concert with another.

The most obvious explanation is that the huge difference is simply a matter of sampling bias. That is, that the pre-European Māori selectively harvested the cockles, favouring large specimens, whereas the modern survey was effectively a catchall. Harvesting for food is bound to have been selective to some extent, because when using the hands to dig and gather these shells small ones certainly do escape through the fingers. On the other hand, there is ample evidence that Pre-European Māori harvested very tiny specimens of shellfish and other marine organisms, even when large specimens were abundant (Leach 2006: 293, 300). A related possibility is that the Māori were harvesting an area where larger cockles were found. The 1976 survey of the inlet showed that the average adult size of specimens in the high water zone was 18 mm compared to 26 mm from the lowest inter-tidal zone (Richardson *et al*. 1979: 2). Even the larger of these figures is tiny compared to most of the archaeological specimens. In the four modern surveys at Pauatahanui, only 116 shells of 27,288 specimens gathered were over 40 mm size (0.4%), whereas in the archaeological site, 2,040 out of 5,753 specimens (35.5%) measured over 40 mm. This difference in abundance is so great that selective harvesting could not account for the bulk of the observed difference. This hypothesis is therefore rejected.

The second possibility is that the small size of modern shellfish is the result of a long period of sustained human predation on these shellfish beds. Unfortunately little is known of the long term effects of selective harvesting of adults of this species. In the case of some fish species it has been shown that rapid genetic changes take place when only large or only small fish are selectively harvested from a population. Harvesting large specimens can drive down the mean size and lower the size at which recruitment occurs. Harvesting small specimens can have the opposite effect. Moreover, cessation of harvesting does not necessarily result in a return to the original population structure and biological aspects of recruitment (Leach 2006: 301 ff.). In a study of cockles at Snake Bank in the Whangarei Harbour it was found that recruitment of juvenile cockles can be reduced by the removal of a large proportion of adult cockles in a given area. Conversely, there did not seem to be heavy recruitment to the population during the years when adult biomass was high. This suggests that there is an optimal level of adult biomass to facilitate recruitment. Sexual maturity is reached at about 18 mm size. In addition, it has been found that there is a significant increase in growth rate of remaining individuals when an area has been thinned out by heavy harvesting (Annala *et al*. 2003: 110, 116). It is difficult to know what impact the pre-European Māori population might have had on the cockle beds at Pauatahanui. Modern estimates suggest a biomass of about 5,000 tonne in the inlet (ibid.), but this includes the shell. The available wet weight of edible meat in a cockle is only 11% of this total biomass[3], so the actual food in this inlet is therefore only 550 tonne. Vlieg's figures for proximate composition of cockle and several other species are provided in Table 8.

Table 8. Proximate Composition of common shellfish.
Proximate values are g/100 g wet weight, energy values are kcal/100 g wet weight. From Vlieg 1988: 47

Species	**Protein**	**Fat**	**Carbohydrate**	**Ash**	**Moisture**	**Gross Energy**
Cockle	8.2	0.9	0.6	2.5	87.8	43
Green mussel	11.9	2.1	3.4	1.7	80.9	79
Paua	20.8	1.0	0.9	1.6	75.7	99
Pipi	8.2	0.7	0.5	3.6	87.0	41
Tuatua	16.7	2.2	6.2	2.9	72.0	110

From this it will be seen that cockles are a very poor source of useful protein and fat, compared to most other common shellfish species. To put this into perspective, if cockles were the only source of food energy available to say 100 pre-European Māori living in the vicinity of this inlet, they would need approximately 200,000 kcal/day. The 550 tonne of cockle

[3] A sample of 15 live valves from Ngakuta Bay in the Marlborough Sounds were weighed and then opened and the animals extracted. These were lightly dabbed on paper towels following Vlieg's method (1988), and weighed. The mean percent of edible meat weight compared to the whole shell weight was found to be 11.00 ± 0.33, with a standard deviation of 1.28 ± 0.23. There was 190 g wet meat weight per kg of empty dry shells in this sample, which is a useful statistic for assessing food biomass from archaeological deposits of cockles.

meat available in the entire inlet would provide about 236.5 million kcal. This would keep this small population going for about 3.2 years. It would, of course be impossible for any group of people to be sustained entirely on cockles or any other kind of meat. By far the greatest nutritional requirements of humans must be derived from fat or carbohydrate and less than 30% from protein sources (Leach 2006: chapter 8). However, this calculation does show that cockles are a poor source of food, even compared with other shellfish species. Tuatua, for example, provide nearly three times the food energy of cockles (Leach *et al*. 2001). It is easy to see that even a relatively small group of Māori living along the shores of the Pauatahanui inlet could have a significant impact on the cockle beds there in a relatively short space of time. Whether the cockle beds may have recovered between AD 1650 and the arrival of Ngāti Toa in the nineteenth century is unknown. It would be very helpful to have some analyses done on cockles in nineteenth century middens to shed light on this. Until this is done this hypothesis for explaining the size disparity between archaeological and modern cockles remains untested.

The third possibility which would help to explain the disparity between archaeological and modern cockle size is that there has been significant environmental change at some stage since the archaeological site was occupied. A number of possible causes could be suggested. For example it is well known that increased turbidity associated with high levels of suspended sediment from land runoff results in a lowering of the feeding rate of cockles and decreased growth rate (Hewitt 2002). In addition, prolonged exposure to low salinity can also stress a population of cockles, resulting in a lower growth rate (Marsden 2004: 167). Finally, cockle growth rate is also positively correlated with rising low tide temperature (ibid.: 157, Table 4). With these factors in mind it is reasonable to suggest that some time after about AD 1600 and before the modern surveys commenced in 1976 the cockle population in the Pauatahanui inlet was subject to one or more environmental factors which greatly reduced their growth rate — for example, a sustained period of lower water temperature (such as Little Ice Age effects; Leach 2006: 176 ff.) or increased sedimentation from land runoff during forest clearance, or lower salinity from increased rainfall, or a reduction in overall depth of water in the estuary. This area was subjected to uplift of approximately 1 m during the 1855 earthquake and while this certainly reduced the depth of water in the inlet and changed the rate of sea water exchange during tidal movements, its effect on salinity is not known. The present-day maximum depth is about 2.4 m (Pickrill 1979: 59). Deciding which of these different effects may have had the greater influence here is not easy, but there is no doubt that during the time this site was occupied the cockle population was a great deal healthier than it is today. It would be useful to carry out bulk shell $\delta^{18}O/\delta^{16}O$ analysis to see if there were changes in mean annual sea water temperatures over time. Until some nineteenth century archaeological shellfish beds dating to both before and after 1855 are studied, putting forward a suggestion of natural environmental changes to explain the size disparity will continue to be only a hypothesis.

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APPENDIX 1: Shell MNI values for Pauatahanui

1 *Austrovenus stutchburyi*
2 *Amphibola crenata*
3 *Cominella adspersa*
4 *Mytilus galloprovincialis*
5 *Paphies australis*
6 *Scutus breviculus*
7 *Mactra* spp.
8 *Diloma subrostrata*
9 *Venerupis* (*Paphirus*) *largillierti*
10 *Cominella glandiformis*
11 *Zeacumantus lutulentus*
12 *Turbo smaragdus*
13 Tuatua spp.
14 *Paphies subtriangulata*
15 *Paphies donacina*
16 *Haliotis iris*
17 *Notoacmea helmsi*

Provenance		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	AL104	1254	351	3	33	13	0	0	3	0	3	2	0	0	0	0	0	0
A	AL105	1108	314	4	68	10	0	0	5	0	2	2	2	1	0	0	0	0
A	AL106	1265	334	2	52	9	0	1	3	0	3	1	0	0	0	0	0	1
A	AL128	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0
B Top	AL110	790	71	2	52	0	0	1	8	1	0	0	5	0	0	1	0	1
B Top	AL112	714	101	5	42	0	0	0	4	1	0	0	0	0	0	0	0	0
B Top	AL113	841	95	3	25	1	0	0	2	4	0	1	1	0	0	0	0	0
B Base	AL101	787	372	0	39	2	0	0	16	0	3	0	1	0	0	0	0	0
B Base	AL109	581	144	5	19	3	1	0	17	0	8	0	2	0	1	0	0	0
B Base	AL111	566	309	7	2	5	0	0	20	0	2	0	0	0	1	0	0	0
F	AL103	320	80	8	8	15	0	0	8	0	2	0	4	0	0	2	0	0
F	AL114	317	98	5	14	14	0	0	7	0	0	0	3	0	0	1	0	0
D	AL107	780	43	1	1	0	0	0	0	0	3	1	3	0	0	0	0	0
D	AL108	330	19	6	1	1	0	0	0	0	1	0	4	0	0	0	0	0

APPENDIX 2: Pauatahanui archaeological cockle measurement statistics according to sample area

```
Area A
N                        =  2857
Range of Values          =    15.110 to     56.770
Mean                     =    36.788 +-      0.079
Standard Deviation       =     4.217 +-      0.056
Coefficient of Variation =    11.462 +-      0.152
Skewness g1/w1           =     0.236 and    10.608
Kurtosis g2/w2           =     3.568 and     6.239

Area B Top
N                        =  1643
Range of Values          =    22.330 to     65.980
Mean                     =    40.393 +-      0.155
Standard Deviation       =     6.267 +-      0.109
Coefficient of Variation =    15.515 +-      0.271
Skewness g1/w1           =     0.819 and    15.004
Kurtosis g2/w2           =     4.282 and    10.688

Area B Base
N                        =  1059
Range of Values          =    26.170 to     59.490
Mean                     =    39.830 +-      0.165
Standard Deviation       =     5.368 +-      0.117
Coefficient of Variation =    13.477 +-      0.293
Skewness g1/w1           =    -0.144 and     5.064
Kurtosis g2/w2           =     2.602 and     2.624

Area D
N                        =    96
Range of Values          =    26.270 to     46.350
Mean                     =    34.899 +-      0.460
Standard Deviation       =     4.512 +-      0.326
Coefficient of Variation =    12.928 +-      0.933
Skewness g1/w1           =     0.301 and     2.263
Kurtosis g2/w2           =     2.615 and     0.699

Area F
N                        =    98
Range of Values          =    27.160 to     59.940
Mean                     =    42.724 +-      0.616
Standard Deviation       =     6.093 +-      0.435
Coefficient of Variation =    14.262 +-      1.019
Skewness g1/w1           =    -0.079 and     1.172
Kurtosis g2/w2           =     3.097 and     0.345
```

APPENDIX 3: Size frequency diagrams of cockles

Figure 21 gives the size-frequency diagrams for three of the modern surveys of Pauatahanui inlet for each of the four main total ranges sampled.

Figure 22 gives the size-frequency diagrams for four of the modern surveys with all data combined for the different sampling stations. Below these are the size-frequency diagrams for each of the five contexts analysed at R27/24. The consistent difference between modern and archaeological is evident.

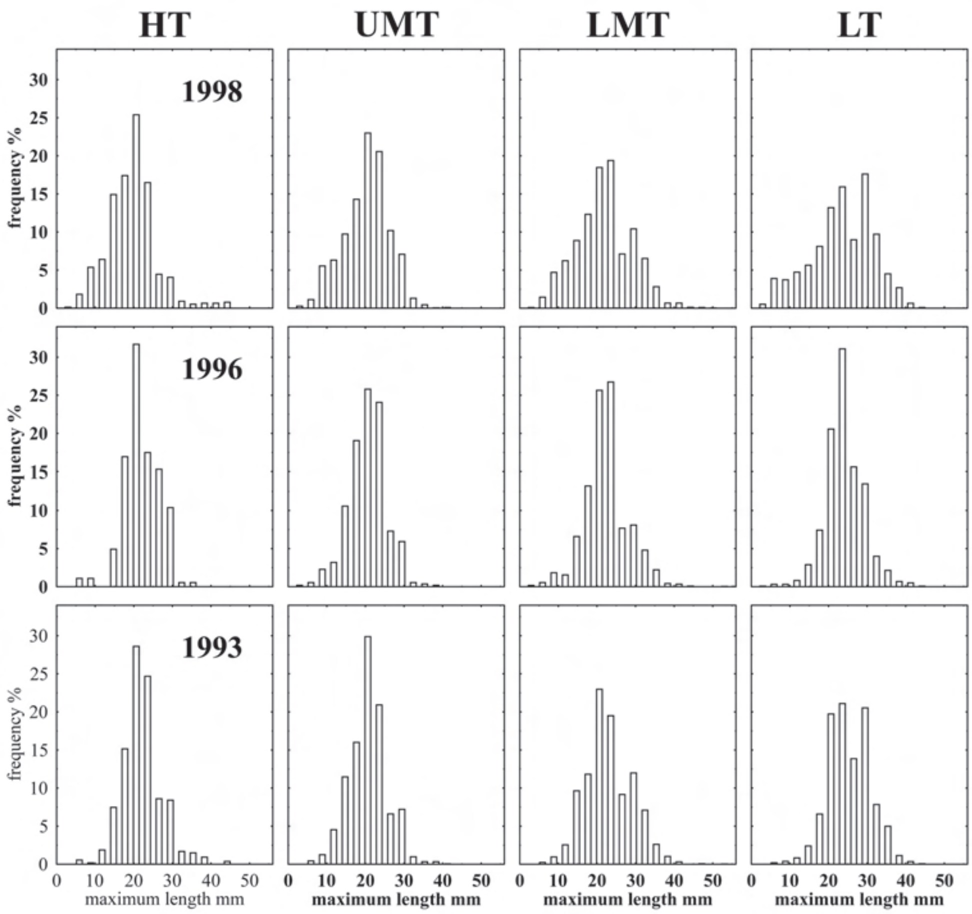

Figure 21. Size frequency diagrams of cockles from modern Pauatahanui inlet surveys. HT = high tide, UMT = upper mid-tide, LMT = lower mid-tide, LT = lowtide.

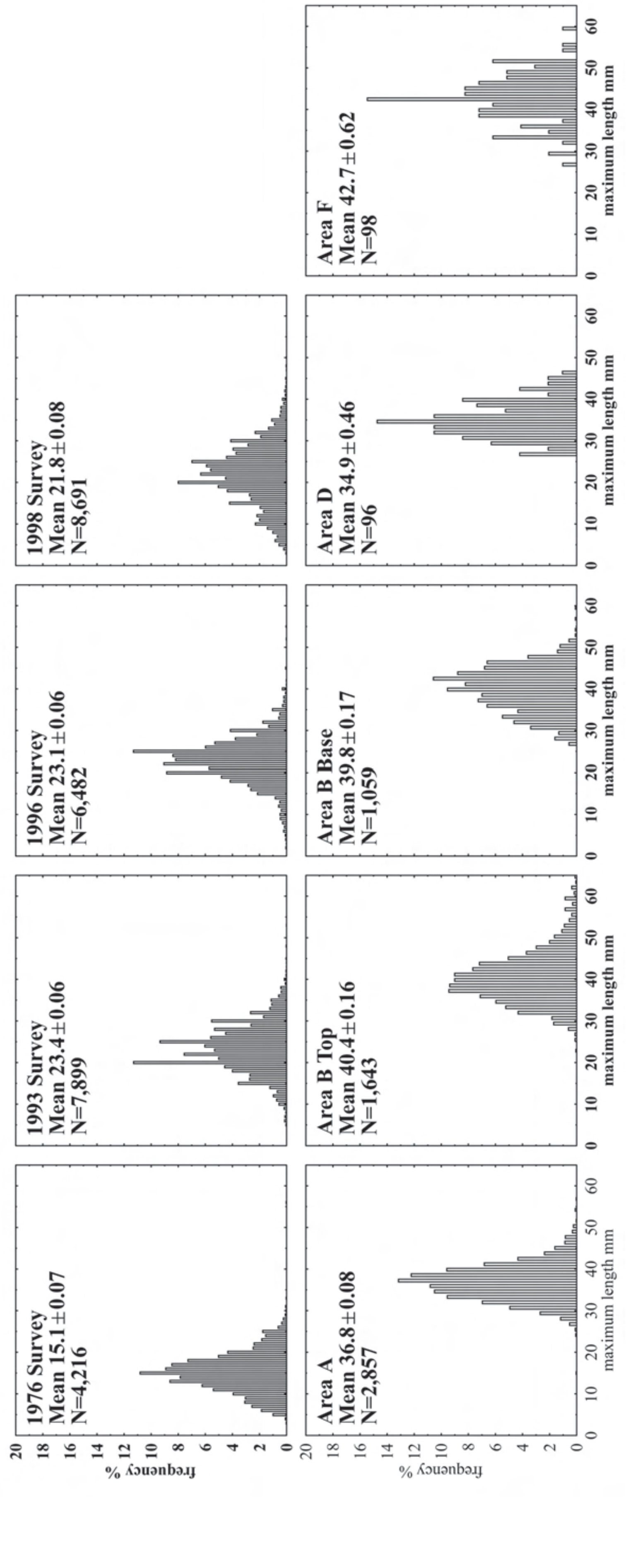

Figure 22. Size frequency diagrams of modern cockles from Pauatahanui inlet (upper) and archaeological cockles from R27/24 (lower).

APPENDIX 4: Fish bone identifications from R27/24

Area	Layer	NBones	Anatomy	Taxon	Bag No
Area D	All Layers	1	Right Dentary	Parapercis colias	1
Area B	Top	1	Right Quadrate	Thyrsites atun	2
Area B	Top	1	Right Quadrate	Thyrsites atun	3
Area B	Top	1	Left Quadrate	Parapercis colias	4
Area A	All Layers	1	Left Premaxilla	Rhombosolea sp.	5
Area B	Top	1	Right Premaxilla	Parapercis colias	6
Area F	All Layers	1	Left Premaxilla	Pagrus auratus	7
Area F	All Layers	1	Left Premaxilla	Pagrus auratus	8
Area B	Top	1	Right Maxilla	Thyrsites atun	9
Area B	Base	1	Left Maxilla	Pagrus auratus	10
Area F	All Layers	1	Right Maxilla	Pagrus auratus	11
Area F	All Layers	1	Right Maxilla	Pagrus auratus	12
Area A	All Layers	2	Vertebra	Elasmobranchii	13
Area A	All Layers	1	Vertebra	Elasmobranchii	14
Area B	Top	1	Inferior Pharyngeal	Pseudolabrus sp.	15
Area B	Top	1	Vertebra	Elasmobranchii	16
Area B	Top	2	Vertebra	Elasmobranchii	17
Area D	All Layers	3	Vertebra	Elasmobranchii	18
Area F	All Layers	1	Vomer	Anguilla australis	19
Area F	All Layers	1	Vertebra	Elasmobranchii	20

APPENDIX 5: Bird bone identifications from R27/24

Area	Cat. No.	Taxon	Element	Number
A	AL104	cf. *Prosthemadera/Callaeas*	ungual phalanx	1
	AL104	indet.	frag.	1
	AL105	indet.	frag.	1
	AL120	*Phalacrocorax melanoleucos*	distal part pelvis	1
	AL122	*Gallirallus australis*	sR humerus	1
	AL122	*Callaeas wilsoni*	dL tmt	1
	AL122	indet.	frag.	2
	AL128	indet.	frag.	1
B Top	AL110	*Prosthemadera novaeseelandiae*	dR tibia	1
	AL110	indet.	frag.	1
B Base	AL101	indet.	frag.	1
	AL109	*Prosthemadera novaeseelandiae*	R cmc	1
	AL109	*Hemiphaga novaeseelandiae*	dL radius	1
	AL109	indet.	frag.	2
	AL111	*Hemiphaga novaeseelandiae*	pL cor	1
	AL111	*Gallirallus australis*	sL tibia	1
	AL111	indet.	frag.	3
	AL123	indet.	frag.	1
D	AL107	*Cyanoramphus* sp.	pR cmc	1
	AL107	*Hemiphaga novaeseelandiae*	dL cmc	1
	AL107	indet.	frag.	2
	AL108	*Prosthemadera novaeseelandiae*	pL tibia	1
	AL108	indet.	frag.	4
F	AL103	*Prosthemadera novaeseelandiae*	dL cor	1
	AL103	*Cyanoramphus* sp.	ant sternum	1
	AL103	*Ninox novaeseelandiae*	dR tibia	1
	AL103	indet.	frag.	9
	AL114	*Prosthemadera novaeseelandiae*	pL tmt	1
	AL114	*Prosthemadera novaeseelandiae*	dL tt	1
	AL114	*Anas* sp.	dL tibia	1
	AL114	indet.	frag.	13

APPENDIX 6: Rat bone identifications from R27/24

Area	Cat. No.	Element
B Base	AL111	L femur
-	AL101	L mandible
-	AL 109	L femur
B Top	AL112	L+R mandible
-	AL110	R Mandible
F	AL114	R mandible, occipital, frontal cranium
D	AL107	R femur, 2L+R pelvis, 2R mandible, R ulna
-	AL108	L pelvis, L+R tibia

APPENDIX 7: Charcoal identifications from R27/24

Sample	Area	Cat No.	Taxon	Number
1	A	AL103	Patē	3
-	-	-	Lancewood	3
-	-	-	Pittosporum	1
-	-	-	Fivefinger	1
-	-	-	Ngaio	2
-	-	-	Kānuka	4
-	-	-	Māhoe	2
-	-	-	Mataī	1
2	A	AL106	Vine rata?	1
-	-	-	Hebe	1
-	-	-	Coprosma	1
-	-	-	Ramarama	1
-	-	-	Ngaio	3
-	-	-	Kānuka	2
-	-	-	Māhoe	2
-	-	-	Mataī	1
3	A	AL104	Fern root	1
-	-	-	Shrub	1
-	-	-	Coprosma	2
-	-	-	Fivefinger	1
-	-	-	Lancewood	4
-	-	-	Ngaio	4
-	-	-	Kānuka	4
-	-	-	Māhoe	2
-	-	-	Mataī	1
4	B Top	AL110	Coprosma	1
-	-	-	Akeake	4
-	-	-	Kānuka	6
-	-	-	Māpau	2
-	-	-	Tawa	4
5	B Top	AL113	Coprosma	2
-	-	-	Patē	1
-	-	-	Fivefinger	1
-	-	-	Māhoe	1
-	-	-	Kānuka	7
-	-	-	Tītoki	1
-	-	-	Tawa	5
-	-	-	Kōwhai	1
-	-	-	Mataī	1
6	B Base	AL109	Fivefinger	1
-	-	-	Putaputaweta	1
-	-	-	Kānuka	10
7	B Top	AL112	Shrub	1
-	-	-	Ramarama	4
-	-	-	Mingimingi?	1
-	-	-	Coprosma	1
-	-	-	Ngaio	1
-	-	-	Akeake	1
-	-	-	Kānuka	9
-	-	-	Māhoe	3
-	-	-	Mataī	1
8	B Base	AL101	Hebe	1
-	-	-	Fivefinger	2
-	-	-	Porokaiwhiria	3

-	-	-	Kānuka	4
9	B	AL111	Hebe	2
-	-	-	Kānuka	14
10	D Top	AL108	Coprosma	2
-	-	-	Olearia	1
-	-	-	Kānuka	10
-	-	-	Kohekohe	4
-	-	-	Tītoki	4
-	-	-	Mataī	1
11	D	AL107	Coprosma	1
-	-	-	Hebe	2
-	-	-	Akeake	5
-	-	-	Kānuka	10
-	-	-	Mataī	1
12	E	AL124	Coprosma	1
-	-	-	Akeake	2
-	-	-	Kānuka	4
-	-	-	Mataī	2
13	F	AL103	Shrub	1
-	-	-	Coprosma	1
-	-	-	Lancewood	1
-	-	-	Akeake	4
-	-	-	Kānuka	9
-	-	-	Mataī	4
14	F	AL114/109	Mānuka	3
-	-	-	Kānuka	10
-	-	-	Mataī	2