Living on Pipi (*Paphies australis*): Specialised Shellfish Harvest in a Marginal Environment at Karamea, West Coast, New Zealand

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ABSTRACT

A large, single-species shell midden on the South Island's West Coast is investigated. The deposit is remarkable both for its size in an otherwise sparse and resource-poor archaeological landscape and its composition. Because of its single-species nature and apparent lack of stratigraphic variability several methods of analysis were required for its investigation. In addition to standard archaeofaunal identification these included measurement of bivalve size as well as examination of chronological patterns. The results demonstrate a continuity of use of the site over several centuries that followed a change in economic strategy from broad-spectrum multi-species exploitation to a highly specialised mono-species harvest. More significantly, they show that this change happened suddenly, near the end of the fourteenth century AD, within only about one hundred years of Polynesian settlement in New Zealand.

Keywords: Shell midden, chronology, West Coast, economic change, *Paphies australis*.

INTRODUCTION

This paper describes the excavation and analysis of a shell midden site (L27/4) from Karamea, on the northern West Coast of the South Island (Figure 1). Shell middens are one of the most common archaeological site types in New Zealand and are an important component of archaeological landscapes, particularly in northern New Zealand. In such landscapes there are likely to be shell middens of varying sizes dotted along the coastlines, and scatters of shell or denser midden patches found with living terraces and other habitation zones. In those contexts archaeologists usually see middens as being able to provide information on species selection, diet, settlement pattern or seasonality and it is usual to treat them collectively, as part of a local settlement complex. It is less usual for archaeologists to expect a single shell midden to make a significant contribution to the construction of a regional sequence.

Broadly speaking, prehistoric regional economic sequences in New Zealand follow a generalised pattern of early reliance on a wide range of marine (sea mammal, fish and shellfish) and terrestrial (bird) resources, supported by horticulture where tropical Polynesian crops could be grown, followed by a focus in the later period on a restricted range of marine species (mainly soft shore shellfish) and bracken fern root (*Pteridium esculentum*) – again supported to an unknown extent by tropical cultigens. Archaeological sites of the early period can be found over most of the country although they are most densely concentrated in places where moa and seal populations were highest – the east coast of the South Island. Later sites, which include several thousand fortifications (pa), are concentrated in the northern parts of New Zealand where the climate was both more equable and better suited to horticulture, and where the largest and richest estuaries were situated (see McGlone *et al.* 1994). The nature and timing of the change, including regional aspects, are poorly understood.

The Karamea midden site is situated in a part of New Zealand that, while not technically outside the bounds of the zone within which horticulture was possible, does not contain any recorded garden soils or storage pits typical of that zone. It is also not situated within a favourable zone for early settlement as the West Coast only appears to have supported a restricted range of moa species and in relatively small numbers (Holdaway R., pers. comm. 23 February 2008). Forest birds would have been available as well as seals (*Arctocephalus forsterii*), at least during the early period. However, the windward West Coast of the South Island was almost completely covered in dense rainforest which, in New Zealand, was 'virtually barren of economically obtainable [food] resources' (Anderson 1997).

The Karamea midden stands out as a very large, uniform, single species deposit in an otherwise sparse and isolated archaeological landscape. The few other recorded middens in the area contain hundreds, or perhaps a few

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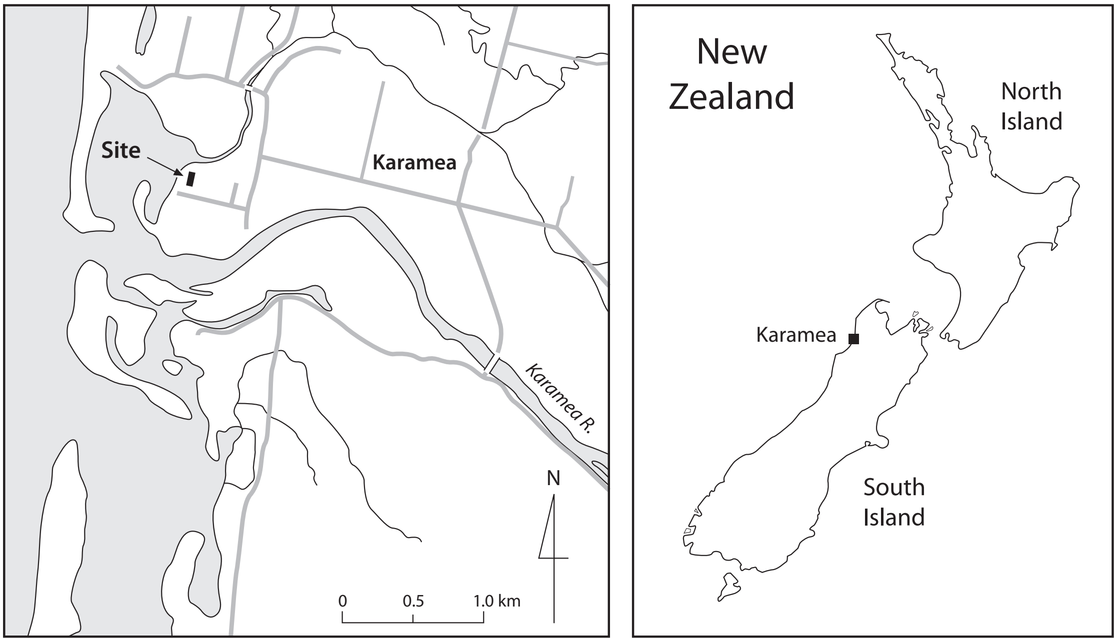

Figure 1. Location of Karamea midden site L27/4

thousand shells, which is consistent with the broad pattern to which reference is made above. The Karamea midden probably contained tens of millions of shells and this indicates quite different sets of activities and demographics than those usually assumed for this part of the country (e.g.one person per 80 sq. km in the early historic period) (Anderson 1982a). Apart from the question of why this large, monospecies midden is present at this West Coast location, this paper explores higher level questions of the process and timing of economic change in New Zealand, in particular that involving resource scarcity or depression.

Investigation of the impact of human predation on faunal resources has come to the fore in zooarchaeological studies in the last several decades (e.g. Grayson 2001). The impact of prehistoric human harvesting on shellfish populations has been documented on several occasions in New Zealand (e.g. Swadling 1976; Nichol 1988;) and foraging theory models drawn from behavioural ecology have been used widely in the Pacific and elsewhere to explain the relationship between predator and prey and the consequences of this relationship on animal populations including shellfish (e.g. Anderson 1979, 1981b; Lightfoot, Cerrato & Wallace 1993; Mannino & Thomas 2001, 2002; Nagaoka 2002a, b; Allen 2003; Morrison & Hunt 2007; Morrison & Addison 2008; Morrison & Cochrane 2008). In New Zealand, foraging theory models have been employed most systematically at Black Rocks peninsula (Anderson 1981b) and Shag River Mouth (Nagaoka 2002a, b). These models generally characterise resource depression through a decrease in the amount of large prey, a diversification of species targeted to include previously overlooked or less desirable taxa and a decrease in the mean overall size of the prey. What makes the New Zealand situation particularly interesting is the speed at which the shift to new resources had to occur following the extinction of the moa (Anderson 1989; Holdaway & Jacomb 2000) and large-scale extirpation of seal populations (Smith 1989).

The excavation of a site the size and nature of the Karamea midden posed a number of methodological problems. From the surface it appeared to be simply a very large deposit of shell of only a single species. In terms of economic studies, there would be little additional information to be gained by its excavation. The potential of the site lay more in its general chronology and history of deposition and for this reason several analytical techniques were used. The deposit was treated more in the manner of an item of material culture than as a faunal record. This required a thorough understanding of both the morphology of the site and of any internal structure, as well as its time of deposition and span of use.

We begin with a description of the site. We then describe the sampling strategies used for the field investigation and laboratory analysis and follow this with a discussion of the results. We discuss the results in terms of their implications for understanding the rate of culture change in this part of New Zealand, particularly that involving economic adaptation to scarcity. We conclude with an interpretation of the results in those terms.

BACKGROUND

The Prehistoric Archaeology of the West Coast

Within a few decades of New Zealand colonisation, which occurred around the end of the thirteenth century AD, settlements were established at many of the large river mouths of the West Coast. Faunal studies of these sites are limited but those of contemporary east coast South Island sites show that the economy was strongly focussed on moa and sea mammals, although a wide range of other species was targeted. The marine environment also posed some limitations. There are few estuaries of any size from which to gather shellfish, and fishing was risky and dangerous from both shore and canoe. In fact the rough seas of the West Coast limited the use of canoes to no more than one day in ten (Anderson 1981a) rendering anything but estuarine or inshore fish difficult to exploit. Nevertheless, early sites such as those at the Heaphy (Wilkes & Scarlett 1967; Walter *et al.* n.d.a) and Buller River mouths (Jacomb *et al.* 2004) were relatively large and supported populations whose subsistence practices included estuarine and river-mouth fishing and the hunting of sea mammals, moa, and other marine and forest bird species. The material from which their artefacts were manufactured included most of the major stone types associated with the earliest phase of New Zealand settlement and compare closely with those from Wairau Bar (Duff 1950). Whether or not horticulture was also practiced on the West Coast has not been determined, but it is certainly possible as the northern West Coast lies within the potential horticultural zone of many of the crops brought to New Zealand from tropical Polynesia. Along the coast the individual sites of this time were widely dispersed, although each contained an abundance of stone material from distant geological sources in both the North and South Islands.

Within a century or two, all of the large river-mouth villages were abandoned and population levels appear to have dropped over most of the South Island. This may have been associated with the extinction of the moa, which also occurred within this timeframe (Holdaway & Jacomb 2000), although the low density of moa on the West Coast may have meant that they were never of great importance in the early West Coast economies. In fact, the abandonment may have had more to do with the loss of moa near more permanent centres of population elsewhere, in relation to which sites on the West Coast were likely satellite settlements in a wider 'resource network' as has been argued for the South Island's south coast and Foveaux Strait (Walter *et al.* n.d.b). If the same model applies to the West Coast, then occupation would have been most readily sustainable during the early period, when the area was part of a wider resource network based outside the region (where West Coast nephrite sources were the attractor) and then later with the advent of European trade networks (nephrite was an important trade item during this time) and the introduction of the potato and other crops.

The archaeological record from the time following the abandonment of the large river-mouth sites is ephemeral and consists mainly of small, scattered shell midden deposits attesting to short-term and probably shifting occupation. Ironically, this change occurred at the same time as the West Coast may have been gaining an increased importance within wider New Zealand exchange networks. Artefacts made from West Coast nephrite (pounamu) became increasingly valued by Maori for both their technological and symbolic properties late in the prehistoric period.

The earliest European explorers of the West Coast (e.g. Charles Heaphy and Thomas Brunner) reported seeing small Maori settlements that relied upon the exploitation of eels and forest bird species. Drawing largely on reports of these visits, Anderson inferred early nineteenth century settlement patterns as comprising small, but more or less permanently occupied, villages near the mouths of major rivers in which people congregated during the winter, and seasonal camps at fishing and fowling stations elsewhere to which most of the population dispersed during summer (Anderson 1982a: 109). In the early nineteenth century pounamu procurement strategies changed as did the trade in finished products although the material itself remained valuable, or even increased in value, within both the indigenous and expanding Maori-European trade networks. At this time seasonal processing of dogfish was recorded at Potikohua (Fox River) in summer where it was dried for consumption during winter months (Anderson 1998: 161). The degree to which the ethnographic record reflects prehistoric settlement and economy is not known.

THE SITE

The midden site is situated on the north side of the Karamea River estuary. It was first described in 1966 by Owen Wilkes (New Zealand Archaeological Association Site Record Form) as a 'midden deposit which was formerly 'quarried' and crushed for agricultural lime, so is probably less extensive than formerly. It is now protected by gorse'. Wilkes recorded the site as covering about 300 m^2 and as being composed mainly of pipi (*Paphies australis*) shell. Wilkes also noted local claims that adzes had been found at the site in the past.

Since Wilkes's visit the gorse has been removed and the site now lies on cleared pasture land. It is much larger than Wilkes believed – covering about ten times his estimate – making it by far the largest shell midden recorded on the West Coast. The site consists of a deposit of shell which lies directly beneath the turf, and includes several shell mounds that rise up to 2 m above the surrounding, level ground. Some shell is exposed on the surface, especially on the northern slopes of the mounds. The mounds are apparently all that is left of a much larger deposit after decades of quarrying for agricultural lime. Interviews with local people suggest that shell was quarried at this site intermittently from the 1920s through to the 1950s. The machine used for crushing the shell is still present at the site, bolted to its concrete foundation.

Large middens are not particularly unusual in the North Island but no comparable examples are known from the West Coast and, even in the North Island, middens of this size are not common. Furthermore, in the North Island, large midden sites are rarely found as isolated features. Instead they form part of a wider archaeological landscape that typically includes storage pits, house terraces and other signs of human activity such as defended pa. Indeed they appear to be an integral component of settlement patterns based around horticultural production. The Karamea site stands alone in the coastal landscape with no obvious indication of its having been part of a larger local settlement system. The only other sites recorded in the vicinity of the Karamea valley are two small shell middens, an oven site and two artefact findspots. Finally, it is unusual to find a midden of any size that is composed of only a single species. The Karamea midden (see analysis, below) is effectively a monospecies deposit. It is, therefore, strikingly anomalous in the archaeological landscape and yet difficult to analyse because of its apparent homogeneity.

Investigations were carried out at Karamea by the authors in 2004. The purpose of the work was to integrate the site into a wider programme of research into the coastal archaeology of the West Coast of the South Island (e.g., Jacomb *et al.* 2004; Jacomb *et al.* n.d.b.). The Karamea site was targeted because it was believed likely to fall within the poorly understood period of West Coast prehistory which followed the loss of moa hunting and the decline of the large, early river-mouth settlements that date to about 1300–1400 AD. Of some interest, therefore, is the time of occupation of the site, and what this might reveal about the chronology of change in subsistence patterns in this part of New Zealand. The specific aims of the investigation were to determine whether there was any internal structure to the site that could be used to explain its depositional history and to establish the period during which the midden shell was laid down.

To achieve these aims the specific objectives of the excavation were to map the area and depth of the site; to obtain information on stratigraphy including an understanding of the basic deposition sequence; to obtain absolute age estimates for the period and duration of occupation; to obtain a representative sample of fauna from the midden for archaeofanual analysis, and to identify any patterning in the structure of the deposit.

FIELD METHODS

Single-species midden sites such as L27/4 pose particular problems for archaeological study and in order to address the research objectives it was necessary to devise a systematic sampling and recording strategy. There are many ways of approaching a midden (e.g. Ambrose 1967; Anderson 1981b; Stein 1992). Most previous midden studies in New Zealand follow the 'economic archaeology' approach (Allen & Nagaoka 2004) and focus on issues such as population modelling, meat weights and diet (Anderson & Smith 1992; Nichol 1988; Shawcross 1967, 1972), foraging strategies (Anderson 1981b; Brooks 2002; Nagaoka 2002a, b; Szabo 1999), nutrition (Leach *et al.* 2001), seasonality (Higham 1990, 1996; Samson 1995), and the environmental impact of human exploitation practices (Anderson 1979, 1981; Barber 1994). These are essentially 'compositional approaches' that focus on the content of the sites – the faunal remains themselves. Other studies take a landscape or settlement pattern view in which the distribution of middens in relation to other sites and environmental features is an indicator of wider socio-political or economic realities (Campbell *et al.* 2004). We are interested in a middle area where the midden site itself is the focus of analysis. In other words, the site is considered and examined in much the same way as would be an artefact. This approach considers factors like the overall morphology of the midden, and variability both horizontally and vertically through the midden in faunal content, shell size, fragmentation, matrix and so on. A specific set of methodologies was employed to investigate these aspects of the site.

We adopted a five-step field strategy that involved mapping, coring, test-pitting and faunal sampling. An electronic total station was used to create a contour map of the site (Figure 2) and the deposit was then cored along transect lines using a 5 cm diameter auger. This provided information about basic distribution and depth of the deposit over a wide area. A series of test pits was excavated along a baseline transect for the purposes of recovering faunal samples, and for obtaining high-precision stratigraphic data to supplement the auger results. Bulk samples of material were taken from each stratigraphic unit within the test pit excavations for archaeofanual analysis in the Otago Archaeology Laboratories (OAL) at the University of Otago. Samples for radiocarbon dating were obtained from specific locations and from key stratigraphic units.

A north-south baseline was established across the site at 7 degrees E (magnetic) in alignment with the long axis of the site. The excavations were all located in relation to this baseline. Twenty test pits that measured 50 x 50 cm were laid out (nineteen along the baseline and one, TP 7, 50 m south of the main deposit) and excavated by natural stratigraphy. Within layers, excavation proceeded by 10 cm spits. Bulk samples were recovered from each excavation level (spit or layer) and retained for laboratory analysis. Transect lines were laid out across the site – some parallel and some at right angles to the baseline – and located so as to cut across the deeper mounds. Twenty-two auger cores were drilled at intervals along these and records made of the depth and composition of the recovered matrix (Table 1).

RESULTS

The site is aligned along a north-south axis, with the largest deposits of midden towards the north where the mound is both widest and deepest (Figure 2).

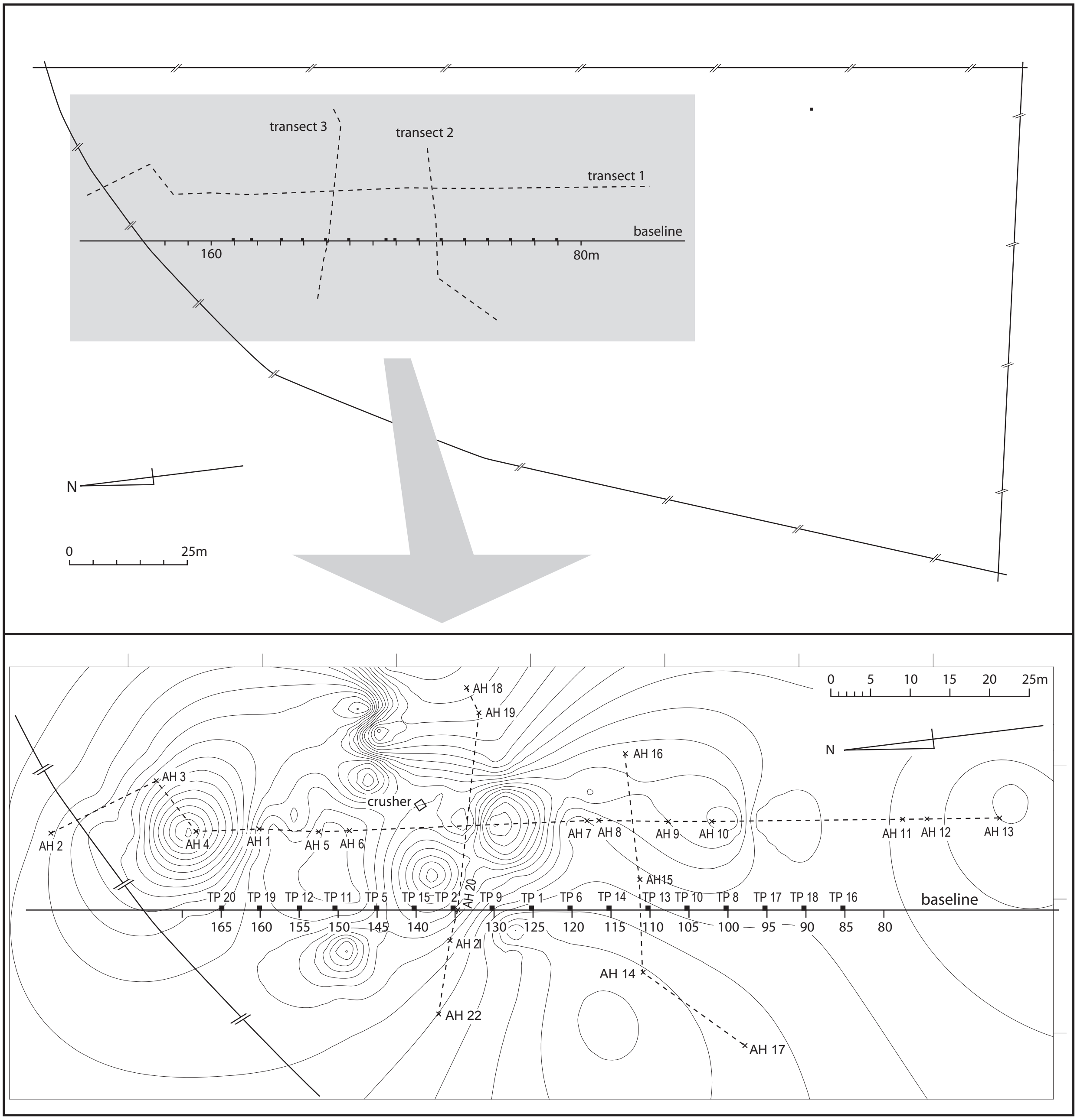

Figure 2. Site plan of Karamea midden site L27/4.

Stratigraphy

The stratigraphic profile was established both from the test pit and auger-hole data. The excavations took place over a distance of 90 m along the base line, with an additional test pit (TP 7) lying on its own about 50 m south-southeast of the main line of test pits . The results of the test pit and auger excavations were sufficiently consistent across the site to confirm a basic three-layer stratigraphy although there was some variation in the absolute and relative depths.

Layer 1. A thin lens of dark soil with a humus component and a low density of finely broken shell. This layer was found at 0–10 cm below the surface.

Layer 2. This is the shell midden component. In most places the shell is very dense and finely packed within a generally sparse, dark brown to black soil matrix. However, there are a few areas, especially Test Pits 7 and 19, where the deposit consists of a deep loosely packed matrix of solid shell with no significant soil component. The depth of this layer varied considerably across the site. In some areas (especially on the mounds), the midden layer was

Table 1. *Results of coring programme*
(note that in all cases the turf layer is consistently 5 cm or so in depth and the subsoil is clean sand).

Auger Hole	Contents
AH 1	Sterile sand
AH 2	0–80 cm shell midden
AH 3	0–205 cm shell midden
AH 4	0–65 cm shell midden and shelly soil
AH 5	0–120 cm shell midden
AH 6	0–10 cm shell midden with dense charcoal at base
AH 7	0–9 cm shell midden
AH 8	0–23 cm shell midden
AH 9	0–20 cm shell midden
AH 10	0–13 cm shell midden
AH 11	0–12 cm shell midden
AH 12	0–6 cm shell midden
AH 13	0–30 cm sparse shell in soil matrix
AH 14	Sterile
AH 15	0–17 cm crushed shell
AH 16	0–11 cm crushed shell
AH 17	Sterile
AH 18	Sterile
AH 19	0–5 cm shell midden
AH 20	Sterile
AH 21	0–60 cm shell midden
AH 22	Sterile

very deep. For example, the core sample point AH 1 (Auger Hole 1, Figure 2) extended through over two metres of shell. In other areas especially in the hollows, there was no shell midden at all, and Layer 1 rested directly on Layer 3.

Layer 3. A compact golden brown sandy silt that formed the natural base to the excavations. This material was consistent in colour and texture across the site and contained no evidence of soil development. The depth of this layer varied across the site depending on the thickness of Layer 2. In some areas Layer 3 was found immediately below Layer 1. In other areas, it was found below a deep deposit of shell midden. Augering indicated that this material extended at least 60 cm below the base of the midden deposit.

Although the primary stratigraphic data were provided by the test pit excavations the coring programme provided useful supplementary information. The deepest core was AH 1 which was drilled into the top of the highest shell mound at the northern end of the site. In AH 1 the shell extended to a depth of 2.05 m which was the deepest deposit encountered on the site. In this north (main) area the base of Layer 2 appears quite flat and all the test pits are approximately level with the base of the shell horizon in AH 1. Thus it appears that the midden here was deposited over a relatively flat area of land. Test Pit 7, located some distance south of the main deposit, encountered a midden deposit that extended 90 cm into the ground from a level surface before the sterile substrate was found indicating that this midden was dumped into a hollow.

The matrix of Layer 2 varied across the site. In some test pits the shell component appeared to be almost exclusively pipi. In other areas there was slight variation in taxa with mud-snail (*Amphibola crenata*) being very sparsely present. Where mud-snail appeared in the test pits it tended to occur in tight lenses or deposits and was not evenly dispersed through the matrix. The midden contained very little in the way of vertebrate fauna. Fewer than 50 fish bones were recovered as well as a small number of bird bone fragments. The matrix of many of the test pits contained charcoal fragments and in the far north of the site some oven stones were found on the surface, and more appeared near the top of Layer 2 in some of the northern test pits. An auger hole close to AH 6 (approx 10 m south of AH 1) yielded evidence of a cooking feature in the form of dense, charcoal-stained soil and fragments of charcoal.

Laboratory Analysis

A total of 42 bulk samples was treated in the OAL according to the following sampling protocol. Each bulk sample was divided into two approximately equal-sized units using a sample splitter. One unit became an archive sample and consisted of a full soil column from each excavation unit. The archive sample was put into storage. The second sample became a laboratory sample. From this laboratory sample the Layer 2 midden was removed for further sorting and analysis. This fraction weighed about 33 kg and a 25 per cent random sample was taken for final analysis. This analytical sample was created by passing the material twice through the sample splitter until an approximately 25 per cent sample of the original material remained. The mean weight of the final samples was 210 g (σ = 82.9 g) which provided a total of just less than 9 kg of shell for analysis from Layer 2. The leftover fraction was bagged separately, labelled and stored alongside the archived bulk sample. During the analysis, observations were recorded about the sample condition, matrix and any inclusions (Table 2). Where there is more than one sample for a provenance unit in Table 2 this is because the test pits had been expanded and more than one sample bag was gathered. Since the aim was to analyse approximately 25 per cent of each excavated sample this meant that more midden was analysed from some units than from others, although the relative proportion analysed remained the same throughout.

Species identification and relative abundance

The shell was identified in the OAL using the New Zealand shell reference collection. A range of quantification

Table 2. *Layer 2 sample weights, provenance and observations on soil matrix and inclusions* (blank = absent, X = sparse, XX = common, H = high, M = medium, L = low, Ch S = charcoal stain, Ch F = charcoal fragments, FCR = fire cracked rock, FB = fish bone, LS = land snails, BB = bird bone).

	Unit	Wt (g)		Matrix		Inclusions				Fauna		
Lab No.	Test pit, layer, spit	Bulk	Sample	Soils	Density	Ch. S	Ch. F	FCR	Pebbles	FB	LS	BB
11	TP 1 1-ii	1099.78	280.97	Sandy silt	L	M		X	X	X		
48	TP 1 1-ii	980.69	262.39	Sandy silt	L	M			X			
12	TP 1 1-iii	580.29	185.26	Sand	L	L			X	X	X	
13	TP 1 1-iii	602.37	121.25	Sandy silt	L	L			X	X		
240	TP 1 1-iv	309.27	67.27	Sand	L							
249	TP 1 1-iv	696.69	165.87	Sand	L					X	X	
245	TP 2 2-ii	1011.86	209.75	Sand	L	L	X		X	X	X	
14	TP 6 2-i	1102.48	348.27	Sandy soil	H	H	X	X	X	X		X
6	TP 7 2-i	987.12	250.25	Sandy soil	L	M			X	X	X	
15	TP 7 2-ii	1022.70	265.53	Sandy silt	L	M	X				X	
855	TP 7 2-iii	521.34	123.26	Sand	L	L	X		X			
881	TP 7 2-iii	506.37	137.62				X					
884	TP 7 2-iv	609.40	182.36	Sand	L	L	X			X		
885	TP 7 2-iv	408.93	96.45	Sand	L	L	XX		X			
853	TP 7 2-ix	445.39	160.15				XX					
854	TP 7 2-ix	588.00	140.68				XX		X		X	
35	TP 7 2-v	452.57	98.21	Sand	L	L	X		X			
851	TP 7 2-v	557.52	135.73	Sand	L	L	X	X	X			
882	TP 7 2-vii	525.91	165.12				X		X	X		
883	TP 7 2-vii	471.44	117.08	Sand	L	L	X		X	X	X	
8	TP 7 2-viii	714.30	214.44	Sand	L	M	XX					
10	TP 7 2-viii	288.85	79.72				XX					
856	TP 7 2-x	557.69	134.46				XX			X		
857	TP 7 2-x	453.65	107.20				X		X	X	X	
858	TP 8 2-i	1023.03	263.52	Sand	L	L	X	X	X	X	X	X
861	TP 8 2-ii	1010.48	230.75									
860	TP 8 2-iii	1006.30	282.56									
873	TP 9 2-i	1009.74	338.28	Sandy silt	M	H	XX	XX	XX	X		
874	TP 9 2-ii	1029.45	255.36		M	H	XX	X	XX	X		
871	TP 9 2-iii	1011.68	300.65	Sandy silt	M	H	XX	XX	X	X		
868	TP 9 2-iv	1000.66	316.32									
867	TP 10 2-i	987.30	251.92	Sandy soil	M	M	X	X	X	X		
31	TP 11 2-i	977.70	238.18	Sandy soil	M	M			X			
32	TP 11 2-ii	1020.23	284.30	Sandy soil	M	M			X			
34	TP 15 2-ii	990.59	258.39	Sand	L	L	X	X	X			
33	TP 16 2-i	1023.95	370.16	Sandy soil	L	L		X	X	X		
864	TP 17 2-i	1007.69	329.54	Sandy silt	L	L	O	X	X	O	O	
870	TP 17 2-ii	1012.53	289.86	Sandy silt	L	M	X	X	X			
865	TP 17 2-iii	1031.68	267.21	Sand	L	L	X	X	X			
859	TP 18 2-i	1006.28	243.87	Sandy soil	L	M	X		X	X		
862	TP 18 2-ii	363.65	89.60	Sandy silt	L	M	XX			X		
863	TP 18 2-ii	675.94	165.55	Sandy silt	L	M	X		X	X	X	

methods is available in archaeozoology (Grayson 1984). In this analysis we used MNE (minimum number of elements) as a simple measure of quantity and relative abundance (Table 3). MNE values for bivalves were obtained by counting hinge sections. All broken hinge sections were counted and divided by two. The MNE for gastropods was obtained by counting whorls. Using the values in Table 3 MNI (minimum number of individuals) can be calculated

Table 3. *Identification of shellfish from excavation units (MNE). X = 'present'; blank = absent.*

Lab no.	Provenance	*Paphies australis*		*Amphibola crenata*	*Spisula aeqilateralis*	*Paphies subtriangulatum*	*Perna canaliculus*	*Austrovenus stutchburyi*
		Whole	Broken					
11	TP 1 1-i	247	239					X
48	TP 1 1-ii	222	176	1				
12	TP 1 1-iii	128	90					X
13	TP 1 1-iii	107	79					1, X
240	TP 1 1-iv	45	19					1, X
249	TP 1 1-iv	139	59					2, X
245	TP 2 2-ii	135	124	1, X				
14	TP 6 2-i	119	117	1				
6	TP 7 2-i	100	98		X			
15	TP 7 2-ii	96	56		1, X			
855	TP 7 2-iii	56	34	X				
881	TP 7 2-iii	60	40	X				
884	TP 7 2-iv	73	25				X	
885	TP 7 2-iv	44	16				X	
853	TP 7 2-ix	51	12			X		
854	TP 7 2-ix	53	17	X				
35	TP 7 2-v	35	11			1		
851	TP 7 2-v	66	20	X				
882	TP 7 2-vii	63	20	X				
883	TP 7 2-vii	45	16	2, X				
8	TP 7 2-viii	72	21		X			
10	TP 7 2-viii	34	8				X	
856	TP 7 2-x	53	8	X				
857	TP 7 2-x	37	13	X				
858	TP 8 2-i	154	153					X
861	TP 8 2-ii	161	147					X
860	TP 8 2-iii	173	135	1, X				
873	TP 9 2-i	125	123	X				
874	TP 9 2-ii	130	114					X
871	TP 9 2-iii	164	131					X
868	TP 9 2-iv	125	112					X
867	TP 10 2-i	166	157					1
31	TP 11 2-i	126	124	X				
32	TP 11 2-ii	146	144					X
34	TP 15 2-ii	155	151		X			
33	TP 16 2-i	225	223		X			
864	TP 17 2-i	158	155					X
870	TP 17 2-ii	188	180					X
865	TP 17 2-iii	149	144					X
859	TP 18 2-i	200	196	X				
862	TP 18 2-ii	87	80	X				
863	TP 18 2-ii	157	154	1, X				

for the bivalves by dividing the MNE counts by two, while the MNI and MNE counts remain the same for gastropods. Pipi shell fragments were present in each sample. In Table 3 an 'X' in a particular species column indicates that several fragments of that species were also present.

The Karamea midden displays extremely low species diversity (Table 3) and to all intents and purposes can be described as a single species pipi midden. Furthermore, there was no indication of differences in species diversity or relative abundance levels within or between the excavation units.

Radiocarbon results

Five marine shell samples, all of *Paphies australis*, were selected from locations within the site that would most economically provide an indication of chronological variation. The samples were submitted to the Waikato Radiocarbon Laboratory for dating. The radiocarbon ages (Table 4, Figure 3) were calibrated with OxCal 3.1, using the Southern Hemisphere marine calibration curve (McCormac *et al.* 2004) and ΔR set to -7 ± 45.

The age estimates span a range of approximately 350 years at 2 σ, from AD 1330 to AD 1680, although the medians suggest that the actual span of occupation was shorter, from about the late fourteenth to early seventeenth centuries AD or about 250 years.

Patterns of variation

One of the purposes of the analysis was to identify any patterns of variation within the site. In addition to looking at relative taxonomic abundance values we carried out a study of size range differences in the pipi shell of Layer 2. Given that site L27/4 is essentially a single-layer site we might assume fairly rapid deposition in which case variation in these values might not be time dependent. For this reason we were particularly interested in variation in horizontal space. During excavation some basic differences were noted. The midden was deeper in some places than others, but the base of the site was approximately level (with the exception of TP 7, which was excavated into a midden-filled hollow) and it is possible that depth variation might be related to quarrying activities and mound-

Table 4. *Radiocarbon dating results.*

Lab No.	Provenance	CRA (yr BP)	Calibrated Age AD	$\delta^{13}C$ (‰)
Wk 14791	Surface near AH1	707±33	1555–1650 (68.2%) 1510–1680 (95.4%)	1.5±0.2
Wk 24127	TP 7–2-x	946±32	1355–1450 (68.2%) 1330–1460 (95.4%)	0.7±0.2
Wk 24128	TP 18–2-i	796±33	1465–1540 (68.2%) 1450–1620 (95.4%)	0.8±0.2
Wk 24129	TP 11–2-i	718±33	1540–1640 (68.2%) 1500–1670 (95.4%)	1.4±0.2
Wk 24130	TP 1–1-iii	824±34	1455–1515 (68.2%) 1430–1570 (95.4%)	1.2±0.2

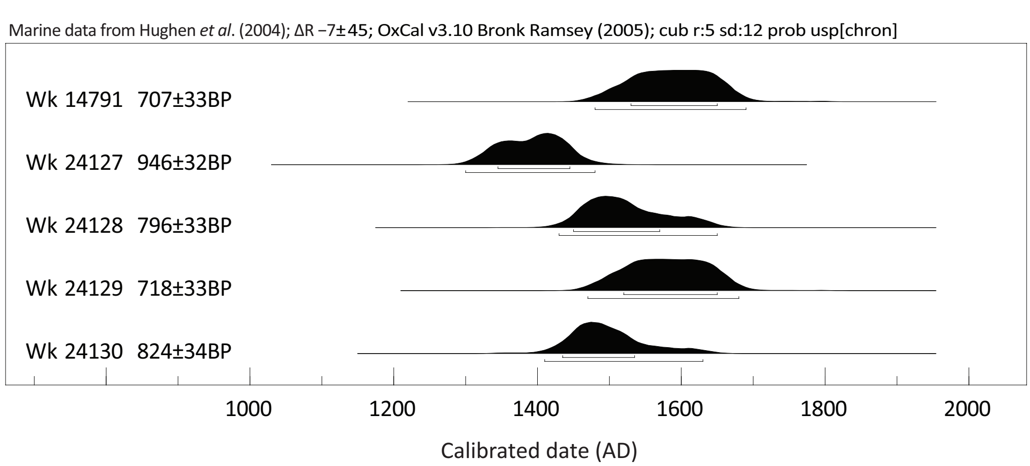

Figure 3. Plot of calibrated radiocarbon dating results with ΔR set to −7±45

ing. We also noted that in TP 7 the shell was looser and with a lower density soil matrix than the other units. Further differences between the test pits were revealed through the following analysis.

Shell size

Whole pipi shells were measured and the size range of shells compared within and between units. The measurement used was maximum length (measured along the greatest dimension) and the results are shown in Table 5. The distribution of mean length values is shown in Figure 4 where only those excavation units with two or more sample sets of sufficient size for comparison have been selected. Two important results of the size analysis can be seen here. First, there is almost no variation in the size range of the shellfish vertically in the midden deposit. Second, there is some variation in mean shell size between units.

To test for horizontal variation in shell size in the site, mean shell length was examined in relation to distance north of the southernmost test pit (TP 7). Unlike the previous analysis this did not require a number of stratigraphic samples and mean shell size was here calculated on the total sample in each test pit. Only those test pits with a minimum of 20 shells in their laboratory sample were used (test pits 1, 7, 8 and 9). The analysis demonstrated a clear trend of decreasing shell size with respect to distance from south to north (Figure 5).

Internal chronology

To test for chronological variation across the site the dates were examined in relation to their position in the site along its N-S axis. Since the relative age only of the samples was important here the ΔR correction above was not applied to this second calibration. A clear pattern is evident in the resulting plot (Figure 6). The two dates at the top of the diagram are from two samples recovered from locations about 10 m apart from one another at the north end of the site (AH 1 and TP 11). They are effectively identical and are centred about the end of the 16th century. The next two dates are from samples recovered from locations 35 m apart from one another near the centre of the site (TP 1 and TP 18) and, again, are very similar, but centred around the end of the 15th century. The oldest date is from a sample recovered from TP 7, the southernmost test pit, and is centred on about the end of the 14th century. In other words, the radiocarbon dates indicate a trend of decreasing age with distance from the southern end of the site and the midden was laid down over a period of about 200 years.

DISCUSSION

The results of the excavations and analysis can be summarised in terms of the five specific objectives listed above.

Table 5. *Mean sizes of pipi shell in each excavation unit sample.*

TP	n =	mean	sd
TP 1 1-ii	8	35.33	7.13
TP 1 1-ii	46	34.17	7.85
TP 1 1-iii	38	34.36	7.07
TP 1 1-iii	28	31.79	8.50
TP 1 1-iv	26	35.87	6.47
TP 1 1-iv	80	32.73	7.45
TP 10 2-i	9	37.19	8.44
TP 11 2-i	2	40.59	3.08
TP 11 2-ii	2	48.99	3.93
TP 15 2-ii	4	40.99	8.08
TP 16 2-i	2	40.98	0.05
TP 17 2-i	3	41.34	4.77
TP 17 2-ii	8	38.65	4.93
TP 17 2-iii	5	41.58	5.17
TP 18 2-i	4	38.12	3.22
TP 18 2-ii	7	30.47	11.61
TP 18 2-ii	3	34.80	11.61
TP 2 2-ii	11	39.85	4.80
TP 6 2-i	2	42.41	9.23
TP 7 2-i	2	47.32	3.14
TP 7 2-ii	40	42.49	5.17
TP 7 2-iii	22	42.81	3.77
TP 7 2-iii	20	44.77	3.38
TP 7 2-iv	48	40.91	7.74
TP 7 2-iv	28	42.15	5.32
TP 7 2-ix	39	40.85	7.45
TP 7 2-ix	36	40.76	8.25
TP 7 2-v	24	40.20	5.93
TP 7 2-v	46	40.35	4.56
TP 7 2-vii	43	41.62	3.83
TP 7 2-vii	29	41.82	5.37
TP 7 2-viii	51	40.10	4.81
TP 7 2-viii	26	39.71	6.00
TP 7 2-x	45	40.88	4.73
TP 7 2-x	24	42.72	5.33
TP 8 2-ii	14	38.77	4.54
TP 8 2-iii	38	38.01	5.39
TP 9 2-i	2	38.23	4.03
TP 9 2-ii	16	32.50	6.91
TP 9 2-iii	33	35.49	6.91
TP 9 2-iv	13	32.53	5.52

Site area

The midden deposit covers an area of approximately 3000 m^2. The test pit and auger work allow for a rough estimate of the volume of the midden prior to the quarrying of a significant proportion of the shell matrix in the first half of the twentieth century. Without good historical records it is impossible to be certain what the site looked like before

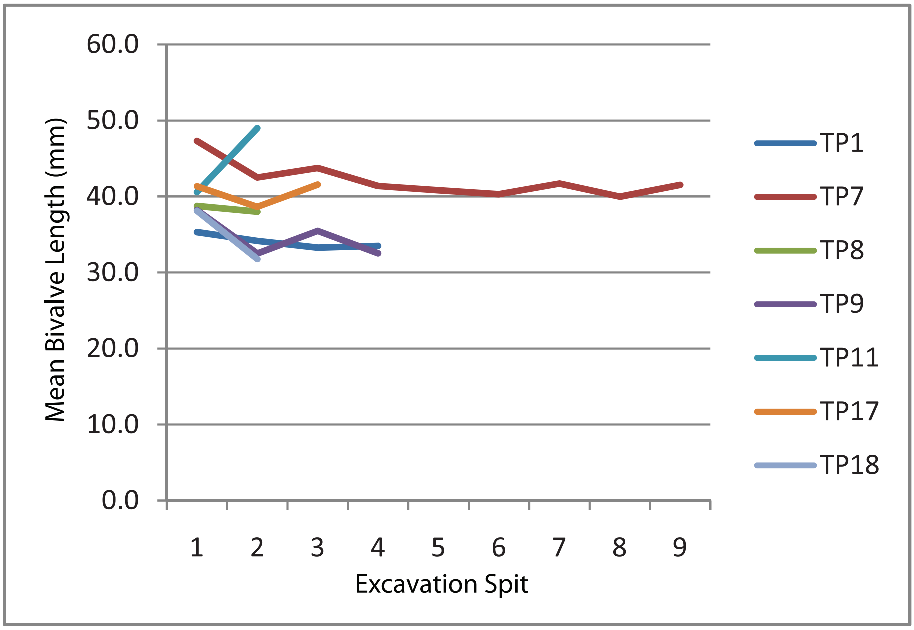

Figure 4. Distribution of mean shell length.

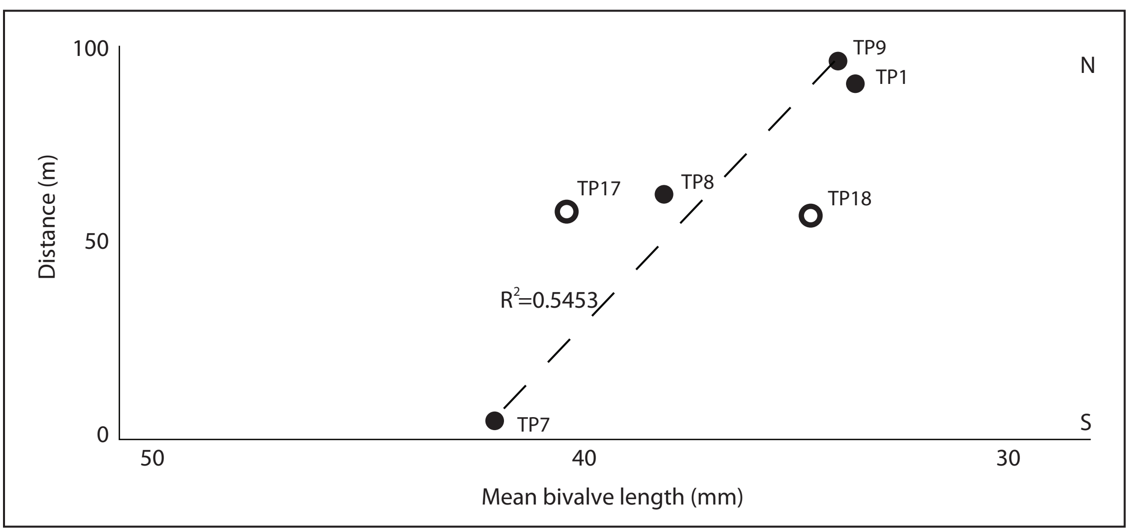

Figure 5. Plot of mean shell length from north to south.

this mining work commenced. However, the crusher in the north-central part of the midden is situated in a hollow around the edges of which the slope of the mound is steeper than elsewhere in the site. This suggests that quarrying was restricted to this part of the site and that the remainder of the midden is more-or-less in its original form. The test pits showed no signs of disturbance outside this steep-sided hollow. If we assume that the steep-sided hollow is the area of maximum disturbance and that the top of the larger mounds represents the original ground surface this would imply that a total of about 400 m^3 of midden had been removed from a deposit that originally contained up to 800 m^3 of shell.

Deposition sequence

The absence of evidence of soil development on the surface of the Layer 3 substrate suggests that the midden was deposited on a weathered, silty sand deposited by the adjacent Karamea River. The excavation units and test pits defined the stratigraphy of the site and demonstrated that the shell midden was deposited within a single stratigraphic level. There are variations in depth within Layer 2, but there is no banding, lensing or build-up of soil horizons to suggest discrete episodes of deposition. Two parts of the site produced deep samples of material that appear to be unaffected by these activities – the deep auger hole

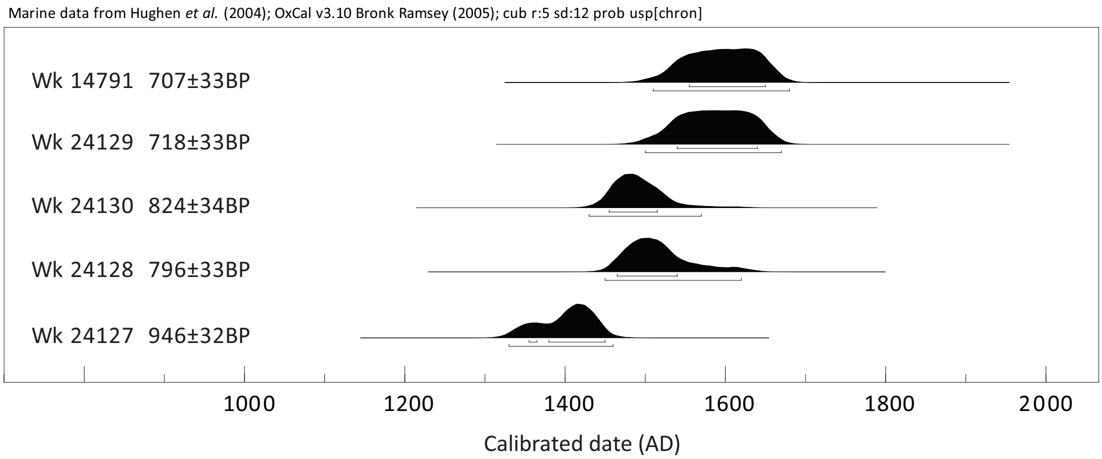

Figure 6. Plot of calibrated radiocarbon dates north-south with no ΔR correction

(AH 1) in the top of the northernmost mound, and TP 7 to the south. In those places the material recovered from below 15 cm consisted of loosely packed pipi shell in a very thin or absent soil matrix and with a low degree of fragmentation. It is very likely therefore, that this material is representative of much of the shell deposit prior to grazing and quarrying.

Vertical stratigraphical variation within the site was restricted to taphonomic effects (fragmentation in Layer 1) presumably caused by stock trampling. There was almost no variation in the content of Layer 2 across the site. The only significant patterns of variation were in the size differences in shell from south to north and the fact that the midden heap increases in volume from south to north.

There was little variation in the distribution of other fauna, in charcoal content or in other archaeological materials such as oven stones. Non-pipi components occurred at extremely low frequency and there was no discernible pattern to their distribution. No artefacts of any sort were recovered. The probable oven feature in Auger Hole 6 and the presence of charcoal fragments and scatters of ovenstones indicates that cooking activities were directly associated with the shell deposit.

Chronology

The radiocarbon results show that the site was used intermittently over a period of some two centuries. Most of the midden deposition occurred during the late fifteenth to early seventeenth centuries, with the outlying TP 7 date (Wk 24127) indicating first use about a century earlier, around the end of the 14th century. Although the number of dates is too small for conclusive inferences to be drawn, there is plausible evidence of a trend of decreasing age with distance north from the southernmost test pit.

Midden content. Although there are examples of other shell species scattered through the midden as well as a few bird and fish bones, the Karamea site is a very large, effectively single-species, pipi midden. This is an inshore species common in bays and estuaries throughout New Zealand (Morton & Miller 1968). It prefers a coarse, sandy substrate and the midden pipi are likely to have been gathered close to the site, probably in the adjacent river-mouth estuary. Pipi are thought to live for about ten years growing rapidly at first to reach a size of about 30 mm in 16–17 months. They reach sexual maturity at a shell length of about 40 mm and reach 50 mm in length at about three years. From this time their growth rate slows considerably although they can reach a maximum length of just over 80 mm. The shellfish in the Karamea midden had a mean shell length of 38.6 mm for all units dropping to 35.1 mm if the TP 7 sample is omitted. This is comparatively low for a harvested stock. Cole *et al.* (2000) for example report a bimodal size distribution for pipi on Centre Bank, Tauranga Harbour. The first modal peak is in the 5–10 mm range of juveniles with an adult mean falling between 70 and 72.5 mm at different seasons (Cole *et al.* 2000: 324, 325). The Karamea size distribution is unimodal as would be expected for a human-selected sample.

The small size of the shells is not easy to explain. Their size range in comparison with others from around New Zealand (e.g. Cole *et al.* 2000) suggests that they were all immature individuals, and by extension, that the population as a whole was immature. This could be explained for example by there having been a major flooding or seismic event that changed the estuary and resulted in the colonisation of this zone by pipi only 2–3 years before the site was occupied (e.g. see Goff & McFadgen 2003). However, the site was clearly occupied for around 200 years, and shell size is consistently small for the apparent duration of occupation. This reduces the likelihood that environmental change is the reason for the small shell size and suggests, instead, that this was simply a population of unusually small individuals – perhaps a subspecies or a population that was stunted due to nutritional limitations, possibly because too much fresh water was passing through the habitat.

Internal variation. The trend of decreasing shell size from south to north correlates directly with the age trend of the deposition sequence. Differences in the mean size of individuals of a given shell species within a midden, or between middens of different age in the same locality, are thought to be the result of predation impacts on shellfish populations. Anderson (1979: 60–62) found a similar pattern of mollusc shell size reduction over time at two sites, Black Midden and Crescent Midden, in Palliser Bay. The size reduction was greater at Palliser Bay where the shells dropped in size by approximately 50 per cent over a period of some 200 years. At Karamea the reduction in size was closer to 20 per cent although over a similar span of time.

CONCLUSIONS

There are three important aspects to this study. The first is methodological and relates to the problem of extracting useful information from a large and apparently uniform midden deposit. The second concerns the interpretation of the site in its local context and the third relates to the contribution of the site in improving understanding of the process of adaptation to resource depression in a New Zealand context.

Horizontal stratigraphy

Stratified sites – specifically those which involve superposition of culturally distinct phases of occupation – are extremely rare in New Zealand. In those few sites where several occupation layers are visible they generally prove, upon investigation, to represent either brief occupation events within a single cultural phase or to be simply lenses of charcoal-stained sand redeposited from elsewhere within the site by wind, as at Papatowai (Anderson and Smith 1992). This problem was first noted by Roger Duff in relation to the difficulty of 'dating' items found in New Zealand sites on stratigraphic grounds:

> New Zealand sites are essentially surface sites, and it is thus only possible to contrast extreme types – in the South Island for instance, Murdering Beach with Shag Point [Shag River Mouth], where it is known that the immigrant greenstone-working Ngai Tahu occupied the immediately pre-European decades of the former, while Moa-hunters (wherever from) occupied certainly the opening centuries or decades of the latter. Indeed, with the important exception of Moa-bone Point Cave, Sumner, this constituted the difficulty of all South Island investigations until the happy accident of the discovery of undoubted Moa-hunter burials at Wairau. (Duff 1950: 255)

Given the central importance of stratigraphy to archaeological method, a lack of stratified sites is a serious problem for any archaeologist who wishes to document change through time. However, occupation deposits are not only laid down vertically, they also have a horizontal dimension. In New Zealand this was first suggested for Tiwai Point by Park (1969) who explained the size of the site on the basis that it had been occupied serially across the landscape resulting in 'horizontal stratigraphy'. The concept of horizontal stratigraphy is probably very important in the New Zealand context but has not received much further attention. It was alluded to by Anderson (1982: 68 and fig. 5) where he refers to 'accretionary growth' of staging camps over time in southern New Zealand, and to spatial expansion of Waitaki Mouth (Anderson 1989: 132). Of course, all sites have some degree of horizontal stratigraphy, although it can be difficult to document if there is no obvious variation in the physical character of the deposit. For example, at Panau, Banks Peninsula, the evidence for horizontal stratigraphy was that the middle part of the site yielded the earliest radiocarbon dates while the intermediate and outer components of the site yielded increasingly younger age estimates (Jacomb 2000). This pattern was reflected in an artefact seriation (Jacomb 1995) in which the typologically earliest artefacts were provenanced to the central part of the site. At Karamea, standard techniques of archaeofaunal analysis were used to confirm the apparent single-species nature of the midden, but it was the use of shell size, volume and chronological variation that allowed the various aspects of horizontal stratigraphy to be identified.

Site function. Earlier in this paper we posed the question of why this large, monospecies midden was present in this location. We also noted the importance of determining the age and duration of its use. In terms of the former, the midden is highly specialised, and the absence of other recorded sites of any size in the Karamea River valley or, indeed, anywhere within at least 50 km, suggests that the site was not part of a local system. This shift in midden-forming behaviour may mark the beginning of an economic pattern similar to that inferred by Anderson (1982b) for the east coast of southern New Zealand, in which Maori communities compensated for local resource shortage by developing complex seasonal rounds of harvest from multiple widely separated resource zones. However, given the marginal nature of the West Coast environment for permanent settlement we do not believe that this model applies here. The only significant food resource that was being consumed was pipi. This species, closely followed by cockle (*Austrovenus stutchburyi*), has by far the lowest nutritional yield of any of the common fish and shellfish species exploited in prehistoric New Zealand (Vlieg 1988; Leach *et al.* 2001). It is difficult to believe that the pipi stocks on their own could have attracted people from anywhere distant.

It is more likely that the West Coast was part of a wider resource network, as we have suggested was the case for the early and historic periods and that it also involved nephrite. The West Coast has virtually all of New Zealand's supply of that resource. The use of Karamea as a staging point for people on the way south to the nephrite sources would make sense. The pipi beds could have provided a predictable, albeit not particularly nourishing, food supply for successive groups; and the estuary itself would have provided a suitable canoe harbour. Nephrite, although very important in the later prehistoric period, is only rarely found in archaeological sites of the early period generally but was certainly being used at the Buller River mouth site in the fourteenth century where fifteen per cent of the 77 adzes found were made of nephrite (Walter, Jacomb and Muth n.d.c). By the 16th and 17th centuries artefacts in this material had become increasingly important on the northern east coast of the South Island. For example, at Hohoupounamu just north of Banks Peninsula, a site roughly contemporary with the Karamea midden, nephrite forms a significant proportion of the material culture inventory (Challis 1995: 59; Jacomb n.d.). The volume of shells in the Karamea midden seems too large to have resulted from simple stopover visits, but could be explained if quantities were being preserved to sustain groups for extended periods seeking and processing nephrite further south, and again, perhaps to sustain them on the voyage back to their home. Ethnographic records say that the preservation of shellfish including pipi for later consumption was carried out by first cooking them in the shell and then stringing on a line for drying (Best 1929: 70, Beattie 1994: 326). Of course, we cannot completely discount the alternative possibility that the midden was a component of a local settlement complex of which no other components have been found, but arguments based on absence of evidence are less convincing than those that are based upon it.

In terms of the age and span of use of the midden, its earliest use was around the beginning of the fifteenth century and it was used regularly over a period of some 200 years. There was clear evidence of chronological patterning across the site. This 'horizontal stratigraphy' has three dimensions. First, the deposit increases in volume from south to north. Second, shell size reduces from south to north. Finally, the site becomes more recent from south to north. The results indicate that a local pipi population was deliberately targeted over a period of at least two hundred years, that the volume of shellfish harvested increased sharply towards the latter end of this time – about 400 years ago – and that generally smaller individuals were available over time until the site was eventually abandoned. Unlike many small, single species middens that can be passed off as the results of a single meal, perhaps, or a short visit, this represents a clear pattern of continuity of use over many generations. The fact that no other comparable middens are known from the vicinity suggests that this harvest strategy ceased locally at the time the site was abandoned. As to the reasons for its abandonment, and the apparent abandonment of the Karamea valley as a whole, around the early to mid seventeenth century, currently available data do not provide an answer. However, nephrite continued to increase in importance in other parts of New Zealand, especially in the northeast South Island where it was commonly used for tools, ornaments and weapons. It is possible that land transport routes directly over the Southern Alps were used in the later period in preference to sea transport by canoe.

The Karamea midden in a New Zealand context

The results of the study also bear on the subject of economic responses to resource loss in a wider context. New Zealand archaeology during the century before this site was occupied is characterised by middens that exhibit a generalised broad-spectrum vertebrate and invertebrate resource exploitation that included many large and high-value taxa. The Karamea midden, conversely, represents a highly specialised harvest regime that persisted for two centuries, which reflects the broad theme of resource depression for the country as a whole.

In fact, there are two dimensions to the process of resource depression in New Zealand. The first exemplifies the classic resource depression model in which an initial focus on a few high-value targets (e.g. moa, seal) broadens over time as those resources become depleted, as described for Shag River Mouth by Nagaoka (2002a, b). She assumed that this occurred gradually over a relatively long period of time (e.g. Nagaoka 2002b: 425), although chronological studies have demonstrated that Shag River Mouth (Anderson *et al.* 1996) and some other early sites such as Papatowai (Anderson & Smith 1992), and Houhora (Anderson & Wallace 1993) were occupied for only a matter of decades. The second is a dramatic refocusing onto a very reduced range of species to the extent that many middens of the late prehistoric period, even in the optimal northern parts of New Zealand, are almost exclusively made up of shellfish, mostly cockle and pipi (Anderson & McGlone 1992: 232). This phase has been shown, in some places, to exhibit an internal pattern of resource depression in the form of a reduction in animal size over time – as documented here at Karamea. What is important about this study is that it indicates that the new economic pattern had developed on the West Coast within about a century of the first evidence of Polynesian settlement in New Zealand. A similar pattern of rapid adaptation to resource loss has been described for the east coast of the South Island at Moncks Cave (Jacomb 2008) where the broad-spectrum exploitation typical of early period sites nearby such as Redcliffs (Trotter 1975; Jacomb n.d.) was replaced within a century or so by one that was almost exclusively reliant on one mollusc species, cockle. In a more local context, this pattern continued at the Karamea site for at least two centuries from the early fifteenth century and is visible in the Nelson region from at least as early as the late fifteenth century (Barber 1996; Brooks 2002).

Our investigation has yielded significant new information on a little-known phase of New Zealand prehistory, that immediately followed the extinction of the moa around the beginning of the fifteenth century, and in a region generally neglected by archaeology. Although much remains to be done on the course and rate of cultural and economic change in prehistoric New Zealand, a picture is emerging of sudden, early and widespread collapse of ecosystems following colonisation and of a necessarily rapid human response in cultural and economic terms. Middens with low species diversity are very common in New Zealand but have been examined rarely in any detail because of a perceived scarcity of returns in archaeological evidence. This study has shown, however, that there is valuable information to be gained from such deposits if a suitable methodology is used. The investigation of low-diversity shell middens in other areas is likely to be equally rewarding.

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