NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

ARCHAEOLOGY IN NEW ZEALAND

THE ARCHAEOLOGY OF KAKAHI (*HYRIDELLA MENZIESI*)

Matthew Campbell
Anthropology Department, University of Auckland

The kakahi or freshwater mussel (*Hyridella menziesi*) is a bivalve of the family Hyriidae (order Unionoida, the naiades), which has a Gondwanan distribution, being widespread in, but restricted to, the Southern Hemisphere. New Zealand has two other Hyriid species: *H. aucklandica* and *Cucumerunio websteri*, both of which are restricted to the northern North Island and little known (Walker *et al.* 2000). *H. menziesi* can be found in any fresh water, from swift-flowing streams to lakes (Walker *et al.* 2000: 10). It is generally believed to be declining in many environments, though this has not been quantified (McDowal 2002). It demonstrates considerable morphological variation, but this is believed to be more due to environmental factors than genetic (McMichael 1958: 428; Walker *et al.* 2000: 11). Certainly there are no longer considered to be separate species or sub-species other than *H. aucklandica* (cf., Dell 1953; Powell 1979: 384). Reported densities for modern kakahi populations average 6 m^2, but range up to 814 m^2 locally (Walker *et al.* 2000: 16). Most Unionoida are filter feeders, and, when populations are healthy, may play a major role in keeping lakes clean of algal growth (Walker *et al.* 2000: 21).

One unusual feature of Unionoida ecology is that it has a glochidial larva, that is they are parasitic on freshwater fish. Kakahi glochidia have been recorded on eels (*Anguilla* sp.) (Hine 1978), koaro (*Galaxias brevipennis*), giant bullies (*Gobiomorphus gobioides*) and common bullies (*G. cotidianus*) (Walker *et al.* 2000: 16), and even "reported" (McMichael 1958: 430) on introduced trout in the South Island. While some Unionoida are quite host specific, this does not seem to be the case for kakahi.

A kakahi midden, site U15/9, was recently excavated at Hamurana on the north shore of Lake Rotorua (U15/9 was an extensive occupation site (Campbell and Phillips 2005): the midden was only one feature of it). This shell was quite unlike the shell usually found in coastal middens. Pipi (*Paphies australis*) or cockle (*Austrovenus stutchburyi*) retain their shape and hardness and are generally only destroyed by active weathering (within the short time frame of New Zealand prehistory), while paua (*Haliotis iris*) or Cook's turban (*Cookia sulcata*) are often rapidly destroyed by delamination of the shell. The taphonomy of kakahi would seem to be quite different—it crumbles to a powder, and the shell becomes soft and, to a degree, pliable. This breakdown of kakahi shell would seem to be quite rapid and it is generally considered not to survive well in archaeological contexts. This paper is concerned with examining the archaeology of kakahi, its taphonomy, how best to excavate and analyse it, and what sort of information might be gained from kakahi middens.

The archaeology of the Unionoida worldwide

New Zealand

Despite the quantity of coastal shell middens constantly excavated in New Zealand, information of inland middens is sparse at best. Almost all information on archaeological kakahi that I have been able to find is associated with rockshelters, which limits its usefulness somewhat for comparison with the open site at Hamurana.

Three of these rockshelters are in the Taupo region. Trotter (1978) reported three small (25 cm^2) testpits in the floor of the Rua Hoata rockshelter, a rock art site near Aratiatia on the Waikato river. These revealed a 10–100 mm thick prehistoric cultural layer containing kakahi shell as well as charcoal and red pigment. Leahy (1976) reported the excavation of Whakamoenga Cave, where four occupation periods were recognised. Kakahi numbers rose from an MNI of six in the earliest period to 120 in the latest (Leahy 1976: 45). Given the areal extent of the excavation these numbers are very low, but Leahy was able to conclude that kakahi became more important over time. She also described a "considerable number of broken pieces of shell in all layers" (Leahy 1976: 51), but none of the layers are specifically described as midden. One kakahi shell had some evidence of use as a tool. At Waihora Bay only ten valves were found, but five of these were heavily coated in kokowai (Hosking and Leahy 1982: 87). Williams and Walton (2003: 21), in summarising the relevant ethnographic and archaeological literature, conclude that there is no evidence that kakahi were ever an important food resource in the Taupo region.

Kakahi have also been reported from two rockshelter sites in the lower South Island. Anderson *et al.* (1991) describe two rockshelters on Lee Island, Lake Te Anau, where excavation yielded MNIs for kakahi of 17 and 26 respectively, which are again low. There were also fragments of kakahi, but by weight this accounted for less than half the shell. They conclude that kakahi were "taken casually for variety in the food supply" (Anderson *et al.* 1991: 59) but were not an important food source. Ritchie (1982: 25) also excavated about 20 kakahi valves from the Italian Creek rockshelter in Central Otago.

Sutton *et al*. (2003: 157) record the only open site kakahi midden that I have been able to track down, on Pouerua Pa in Northland. The describe "a thin but very compact midden lens … it was impossible to identify any but the dominant species due to the poor state of preservation." A sample of this shell was submitted for radiocarbon dating, and yielded a conventional radiocarbon age of 1179 ± 55 BP, somewhat older than any other dates for Pouerua. This highlights one thing that kakahi cannot be used for; due to possible environmental contamination by old carbon they are an unsuitable material for dating. Hardwater effects in freshwater shells are normally only a few hundred years, though errors of several thousands of years are possible depending on environmental conditions, such as limestone, artesian springs, volcanic emissions etc. (Fiona Petchey pers. comm. 2004). Claasen (1998: 94) reports errors of up to 3000 years. Given that the amount of old carbon will vary with environmental conditions an appropriate reservoir effect would have to be calculated for each body of freshwater, hardly a sensible proposition.

In summary, the archaeology of kakahi is not at all well known in this country and consequently the role of kakahi in subsistence economies is not well understood.

Australia

Further afield in both time and space Unionoida shells have been found at the Lake Mungo site in Australia, clearly in cultural context, and dated to 32,750 ± 1250 B.P. (Bowler *et al.* 1970: 42). Like most material found at Mungo they were encrusted with soil carbonates. Mungo is located in western New South Wales with a mean annual rainfall of around 250 mm, in other words, this is the arid zone, which helps explain the long term survival of the shell. Soil conditions also would probably have played a role. These shells were *Velesunio ambiguus* and so their taphonomy may differ from kakahi.

Little if any faunal analysis has been carried out on Australian Unionoida. Their main use seems to have been for dating, despite the inbuilt age problems noted above. Clark and Hope (1985) give shell dates for several burial sites along the Murray River that generally fall into the 13,000–10,000 BP range, while charcoal dates range from 9000–6000 BP. Their explanations for this discrepancy are environmental and social, particularly that the association of fire with burials may be a late practice. Gillespie (1998) accepts the freshwater mussel and freshwater fish otolith dates for the Willandra Lakes (of which Mungo is one), but again the pattern of freshwater faunal dates and charcoal dates is notably different. Given a general lack of datable material in the arid zone this may be a difficult problem for Australian archaeology, but reinforces the fact that kakahi are not a suitable dating material in New Zealand.

North America

The Unionoida are far more important in the archaeology of North America (where they have such lovely names as fatmucket, threehorn wartyback or pink heelsplitter) than they have been in New Zealand or Australia. In the Mississippi River and its tributaries prehistoric villages are often identified as shell mounds, indicating how extensively they were exploited as part of the daily subsistence of the palaeo-Native Americans. Shell counts of over 33,000 have been reported from sites in Illinois (Parmalee and Klippel 1974: 422). Parmalee and Bogan (1986: 34) record 48 taxa, in 18 genera, at the Clinch River Breeder Research Plant site in Tennessee, though other sites may yield only one or two species. Parmalee and Klippel (1974) compared the nutritional value of freshwater mussels with a variety of North American mammals, birds and fish. They found that they were low in calories and particularly low in protein and fat, though they may have been a useful source of trace elements. They were less important in the diet than casual observation of the large shell mounds would suggest and were probably "exploited as a supplement, rather than a staple" (Parmalee and Klippel 1974: 432). They go on to invoke optimal foraging and diet breadth models to account for their continued presence in prehistoric sites.

Peacock (1996) pointed out that most studies of freshwater mussels in North America have concentrated on environmental reconstruction, dietary analysis and seasonality. He suggests that other lines of research into freshwater mussel middens, and shell middens generally, may be equally revealing. These include studies of environmental change, as increased silt and sediment loads resulting from, for instance, land clearance for agriculture may be reflected in shell morphology; the frequency of occurrence of paired valves as a measure of post-depositional disturbance; whether differentials in shell size are a reflection of social status divisions (which may be more relevant to the Late Mississippian Culture than to New Zealand); and size distributions of valves as an indicator of collection techniques. Blakeslee (2000) argues that freshwater mussels are sensitive indicators of environment and seasonality, and can be used to analyse the length of occupation of sites associated with the shifting agriculturalist/hunters of the Great Plains. Dorsey (2000: 17) found that mussels were harvested at low frequencies throughout the period of occupation of Solomon River sites in Kansas, but that much larger harvests occurred at 4–5 yearly intervals, most probably as swidden plots became exhausted and local game depleted. One consequence of Unionoida having glochidial larvae is that population recruitment is in cohorts of greater than yearly frequency (Blakeslee 2000: 7), which has potential implications for the study of length of occupation of archaeological sites.

All these lines of research are applicable to the New Zealand situation of course, and could equally well be applied to coastal middens, but before they can be applied to freshwater mussel middens here we need a better idea of what a kakahi midden is composed of, what it represents at a most basic economic level, and how to go about excavating and analysing it.

U15/9

In January 2004 site U15/9, at Hamurana Road, Rotorua, was excavated prior to road works. This excavation is reported in full elsewhere (Campbell and Phillips 2005). Hamurana Road was an occupation site with evidence of a palisade or fence, kumara pits both rectangular and bell-shaped and at least one small house. These features occurred together in an area identified from traditional records by Stafford (1994) as a kainga called Paketuri. To the east of Paketuri a large, dense kakahi midden had been exposed in profile by road works in the early 1960s. Part of this midden, located on a slope was trenched during the 2004 excavation, and revealed at least four phases of activity: terraced gardened soils, shown by mixing and mottling and confirmed by the presence of kumara starch in soil samples (Horrocks in Campbell and Phillips 2005); deposition of a kakahi midden; a hiatus in occupation during which time a topsoil developed, followed by the levelling of the hill top above the midden; and a second deposition of kakahi midden. Four charcoal samples from the site, were dated all of which yielded modern dates. Charcoal from each layer of kakahi midden as dated: the lower midden (Wk16047, Sample 2) gave a date of 266 ± 49 BP, cal AD 1480–1960 at 95% probability, with multiple intercepts; the upper midden (Wk16046, Sample 1) gave a date of 160 ± 46 BP, cal AD 1660–1960 at 95 % probability. These were the oldest and youngest of the four dates respectively, so that the occupation of the entire site seems to be bracketed by gardening, followed by the first midden deposition, and the second midden.

The kakahi midden

Five approximately 6 litre samples were taken from the middens at U15/9. Three of these were from the same deposit, and two were used to test a variety of methods for preparing and analysing the samples. Not surprisingly, both wet and dry sieving were very destructive of the already fragile shell, and in the end the least destructive method seemed to be to air dry the three remaining samples unsieved, and sort them by hand. Any shell for which the hinge remained whole or nearly whole was counted. Left and right shells were not distinguished and MNIs were calculated by halving the count of all valves. The results are given in Table 1. Sample 6 was taken from a midden on the other side of the road, now greatly reduced by roadworks, which was the midden recorded in the original site record form in the early 1960s.

Table 1. Results of midden analysis, U15/9, Hamurana Road

Sample	Kakahi		Notes
	MNI	%	
Trench 1, Sample 1	43	100	Very crushed shell, dense, very little charcoal staining in matrix.
Trench 1, Sample 2	261	100	Less dense, more matrix, very little charcoal staining. 1 fish (*Scomber australasicus*?) vertebra, several land snails, some burnt shell.
Sample 6	363	100	Medium density, very little charcoal staining in matrix. Some shells still paired, several land snails.

Only a single fish bone was found, a vertebra in Sample 2. Fish vertebrae are not usually identified in New Zealand midden analysis, so the identification of this bone is not 100% positive, but it is almost certainly from a blue mackerel (*Scomber australasicus*). This is not a species often encountered in coastal middens, so it is something of a surprise to find it so far from the coast. It would seem to be a reasonable working assumption that it is from an individual preserved in some fashion at a coastal site and transported inland; it would therefore represent a much greater quantity of preserved fish that may have brought onto the site, but we can't say much more than that from a single bone.

The other thing we can't immediately say much about is the kakahi themselves. As the second and third columns show, the number of countable valves may vary, but the shell is 100% from a single species. The density of shell material in each sample was much the same, and the MNIs indicate that Sample 1 was the most disturbed, probably because the deposit was very close to the surface and was disturbed by historic period agricultural activities, including stock and machinery. It had also been damaged by heavy machinery removing nearby pines, an activity which had exposed it.

Foods of Lake Rotorua

Only two species were encountered during the midden analysis: kakahi and blue mackerel. As noted, there is very little we can conclude from the presence of a single fish bone, but what is surprising is that no freshwater fish bone was found. Hiroa (1921: 435) notes that "in pre-trout days [Lake Rotorua] teemed with food which to the Maori palate was far more appetizing than the introduced trout which has displaced so much of it." Evidence of these other food sources might be expected to be found in middens around Rotorua. Mair (quoted in Best 1977 [1929]: 103) records that Lake Rotorua was stocked with eels, but

Figure 1. A selection of reasonably whole kakahi shell from Sample 2

eel bone is notoriously invisible in New Zealand middens (Leach and Boocock 1993: 25), despite their historically recorded importance (Marshall 1987).

As noted above, most Unionoida have an unusual lifecycle, with a glochidial larval stage that is parasitic on fish. McDowal (2002: 8) records that in particular kakahi parasitise koaro (*Galaxias brevipennis*), but as noted they appear to be quite adaptable in respect to their host species. The presence of kakahi cannot, therefore, be taken as confirmation of the presence of koaro or any other particular species, but does imply the presence of freshwater fish in general. Mair (quoted in Best 1977 [1929]: 228) records that Lake Rotorua was stocked with koaro (*Galaxias brevipennis*), where it became very numerous. He witnessed it being netted in the Hamurana Stream in the 1860s, with a ton taken in a night's fishing. Interestingly, the decline of the koaro, due to competition from introduced trout, is implicated in the decline of the kakahi today. Kakahi and koaro share the same lake bed environmental niche, so while kakahi may be able to parasitise a wide range of species, they may not have access to mid- and surface-dwelling trout (McDowal 2002: 9).

The koura or freshwater crayfish (*Paranephrops planifrons*) was abundant only in places, but Best (1977 [1929]: 229) lists Rotorua, Rotoiti and Taupo as the main lakes from which it was taken. Presumably there are hard parts of koura, such as mandibles, that could survive in middens, as there are of salt-water crayfish, but whether or not they would be recognised by archaeologists during midden sorting is a different matter (Leach and Boocock 1993: 18).

Hiroa (1921) lists all these species as being important, even in the early twentieth century, and presumably they would have been much more so in pre-European times though no evidence of this was found during midden analysis.

Kakahi were obtained with the use of dredge rakes called kapu or mangakino (Hiroa 1921: 445). These consisted of a triangular frame of manuka with a net with a 40 mm mesh about 1 m long trailing behind it. It was dragged from a canoe on a pole up to 10 m long. As Hiroa says, this would have been a very skilled task. Although kakahi are generally described as tasteless and rubbery[1] it was a very important food in pre-European times and much sought after (Hiroa 1921: 449); it was said to be very good for motherless infants and recuperating patients. It could be eaten raw or cooked.

Taphonomic considerations

Although some consideration has been given to the taphonomy of shells in general "our understanding of these processes is … most underdeveloped" (Claasen 1998: Chapter 3). Even so, understanding the taphonomy of a shell deposit helps us to understand how it was created, how it relates to the natural communities from which it was harvested, and how the deposit has been modified through artificial or natural processes since it was laid down. Clearly the latter is of considerable importance in the archaeology of kakahi, as most if not all deposits seem to be heavily modified and much of the shell poorly preserved, though with so little research carried out to date this is hard to quantify. In fact it may not be possible, or even desirable, to quantify the destruction of faunal remains through taphonomic processes, but an understanding of taphonomy ought at least to give us an understanding of the limits of archaeological analysis.

Certainly the shell from U15/9 was in poor condition: it was soft, often malleable when freshly exposed; it was very fragmented; and it appeared, though this is only an impression, to be have become *even more* fragmented by the

[1]The palatability of freshwater mussels seems generally to be not particularly high. Wood (1634, quoted in Parmalee and Bogan 1986: 35) says of the Native Americans of southwest New England that mussels were not a favoured food, and "their wives … trudge to the Clambankes when all other means faile", although Hildreth (1828, quoted in Parmalee and Bogan 1986: 35) claims that "some of the species are very fine eating, and much admired by the lovers of shell fish at the present day."

time it came to be sorted and counted. The reason for this poor preservation is not entirely clear: it could be due to cooking methods; it could be due to soil conditions, or the way in which the deposit was buried; but the most likely cause would seem to be related to the crystalline structure of the shell itself.

There are two crystalline forms of calcium carbonate in shells; calcite and aragonite. Most shells are composed of calcite, but the Unionoida are composed of aragonite, which is less hard, more dense and more soluble than calcite (Claasen 1998: 23). Paua, another shell that preserves poorly, is also composed of aragonite, but it is not the crystalline form that accounts for the poor preservation of these shells, it is the way in which the crystals are laid down in the shell matrix (Szabo 2004). Aragonite in these species is laid down in layers parallel to the surface, and in Unionoida at least seem to be designed to delaminate in fast moving streams, which is thought to provide greater long-term protection to the soft inner tissues than more homogenous shell structures (Claasen 1998: 23). This may go a long way towards accounting for the archaeological shell at U15/9 being in such poor condition. Examination of the structure, strength and response to a variety of simulated environmental conditions of kakahi shells in comparison to marine species would be a useful topic of research. That the Unionoida of the shell mounds of North America seem to preserve much better (at least, the literature I have accessed does not mention preservation problems of the sort encountered in New Zealand) also indicates that kakahi shell may be particularly vulnerable in this respect.

Local environmental conditions may also play a part. Most coastal middens are preserved in sand, which may be an ideal medium for shell preservation. Sand may blow over a shell dump soon after deposition, so preserving it from gross environmental conditions. Also, coastal shell middens would seem to create self-buffering conditions that result in an ideal pH balance for shell preservation. Perhaps kakahi does not do this—the inclusion of the thick leathery periostracum in the midden may mean that there is more than usual organic matter, resulting in a more acidic midden matrix. However, all these possibilities remain unexplored. What they do indicate is that the counts from the midden probably vastly underestimate the actual deposited number of shells.

McMichael (1958: 428) notes that some phenotypic variation in *H. menziesi* is probably due to calcium deficiency in the water. Dell (1953: 231) describes kakahi from places like sand dune lakes as having extremely thin shells, a form originally classified as *H. depauperatus*. This ecotype includes those from Lake Omapere, that were excavated at Pouerua (Sutton *et al.* 2003). Kakahi shell strength, which will depend on thickness and calcium content, will therefore vary from place to place, implying that taphonomic effects will vary similarly.

Little research, either experimental or in the field, has been specifically carried out into the taphonomy of the Unionoida. Peacock and Chapman (2001) compared species compositions from within and below the plough zone at a site on the Ouachita River, Louisiana. They found that thin shelled species were under-represented in the plough zone, and that in general the plough zone was less diverse in species composition—a not unsurprising conclusion perhaps, but seemingly the limit of research to date.

Possible solutions

Because the shell is so soft and fragile it seems that any bulk sampling and handling techniques will damage it. For instance, the three main samples were taken by trowelling the shell on to a coal shovel and tipping this into a plastic bag. Such a technique may be appropriate for pipi and cockle but not for kakahi. The most useful approach to kakahi midden would seem to be to carry out as much as possible of the analysis in the field, including counting and measuring the shell as well as assessing the density of the midden and the relative proportions of whole to broken shell. This may seem time consuming within the context of an excavation, with its limited budget of time as well as money, but would seem to be the only viable option. In essence, it replicates the laboratory analysis in a different context. Another possible avenue may lie in analysing the calcium content and pH of the midden matrix, comparing it with a non-midden control. This might yield some insights into how the shell is destroyed, and how much of it has been destroyed.

Conclusion

As things stand, the information to be gained from kakahi middens seems to be rather minimal. There are considerable difficulties with the archaeology of kakahi arising from the particular taphonomic problems associated with them. In the case of Hamurana Road it could be established that the shell was kakahi and that no other species were present, but this is a rather uninteresting conclusion. Given that there are good historical records of other freshwater faunal species being exploited from Rotorua the lack of fish bone is surprising. It may be a sampling error—the sample taken from the U15/9 midden was small and did not target anything but shell. On the other hand, freshwater fish bone may have its own taphonomic problems, and these too will require investigation.

Two questions must be answered regarding kakahi before any others can be addressed: these are, how do we maximise the information we obtain from kakahi middens (some possible solutions are outlined above); and, how do kakahi fit into the inland economy. Some inventive solutions may be required.

Acknowledgements

Ken Phillips, Stuart Hawkins, Jonno Carpenter, Warren Gumbley, Peter Caldwell and Jenny Spark assisted with the excavation of U15/9. My thanks especially to Evan Peacock for discussion and assistance, and to Jacqui Craig and Nigel Prickett for editorial assistance.

References

Anderson, A.J., R. McGovern-Wilson and S. Holdaway, 1991. Identification and analysis of faunal remains. In A. Anderson and R. McGovern-Wilson (eds) *Beech Forest Hunters: The Archaeology of Maori Rockshelter Sites on Lee Island, Lake Te Anau, in Southern New Zealand*. New Zealand Archaeological Association Monograph, 18: 56–66. Auckland.

Best, E., 1977 [1929]. *Fishing Devices and Methods of the Maori*. E.C. Keating, Government Printer, Wellington.

Blakeslee, D.J., 2000. Mussels, bison kills and pots: Clarity in the archaeological record. *Central Plains Archaeology*, 8(1): 5–12.

Bowler, J.M., R. Jones, H. Allen and A.G. Thorne, 1970. Pleistocene human remains from Australia: a living site and human cremation from Lake Mungo, Western New South Wales. *World Archaeology*, 2(1): 39–60.

Campbell, M. and K. Phillips, 2005. Archaeological investigations at site U15/9, Hamurana Road, Rotorua: final report. Unpublished report to Rotorua District Council.

Claasen, C., 1998. *Shells*. Cambridge Manuals in Archaeology. Cambridge University Press, Cambridge.

Clark, P. and J. Hope, 1985. Aboriginal burials and shell middens at Snaggy Bend and other sites on the central Murray River. *Australian Archaeology*, 20: 68–89.

Dell, R.K., 1953. The fresh-water mollusca of New Zealand: Part 1 – the genus *Hyridella*. *Transactions of the Royal Society of New Zealand*, 81(2): 221–237.

Dorsey, R., 2000. Archaeological interpretation of freshwater mussel assemblages near the Solomon River, Kansas. *Central Plains Archaeology*, 8(1): 13–24.

Gillespie, R., 1998. Alternative timescales: a critical review of Wilandra Lakes dating. *Archaeology in Oceania*, 33(3): 169–182.

Hine, P.M., 1978. Distribution of some parasites of freshwater eels in New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 12(2): 179–187.

Hosking, T. and A. Leahy, 1982. Investigations at rock shelter N93/5 Waihora Bay, Taupo, New Zealand. *Records of the Auckland Institute and Museum*, 19: 81–99.

Leach, B.F. and A. Boocock, 1993. *Prehistoric Fish Catches in New Zealand*. BAR International Series, 584. Tempus Reparartum, Oxford.

Leahy, A., 1976. Whakamoenga Cave, Taupo, N94/7: a report on the ecology, economy and stratigraphy. *Records of the Auckland Institute and Museum*, 13: 29–75.

Marshall, Y., 1987. Maori mass capture of freshwater eels: An ethnoarchaeological reconstruction of prehistoric subsistence and social behaviour. *New Zealand Journal of Archaeology*, 9: 55–80.

McDowal, B., 2002. Decline of the kakahi – identifying cause and effect. *Water and Atmosphere*, 10(4): 8–9.

McMichael, D.F., 1958. The nature and origin of the New Zealand freshwater mussel fauna. *Transactions of the Royal Society of New Zealand*, 85(3): 427–432.

Parmalee, P.W. and A.E. Bogan, 1986. Molluscan remains from Aboriginal middens at the Clinch River Breeder Reactor Plant Site, Roane County, Tennessee. *American Malocological Bulletin*, 4(1): 25–37.

Parmalee, P.W. and W.E. Klippel, 1974. Freshwater mussels as a prehistoric food resource. *American Antiquity*, 39(3): 421–434.

Peacock, E., 1996. Future directions in the analysis of freshwater bivalves in archaeology. http://www.shef.ac.uk/assem/1/peacock.html. Accessed 10 March, 2004.

Peacock, E. and S. Chapman, 2001. Taphonomic and biogeographic data from a Plaquemine shell midden on the Ouachita River, Louisiana. *Southeastern Archaeology*, 20(1): 44–55.

Powell, A.W.B., 1979. *New Zealand Mollusca: Marine, Land and Freshwater Shells*. Collins, Auckland.

Ritchie, N.A., 1982. The prehistoric role of the Cromwell Gorge, New Zealand. *New Zealand Journal of Archaeology*, 4: 21–43.

Stafford, D.M., 1994. *Landmarks of Te Arawa, Volume 1: Rotorua*. Reed, Auckland.

Sutton, D., L. Furey and Y. Marshall, 2003. *The Archaeology of Pouerua*. Auckland University Press, Auckland.

Szabo, K., 2004. Technique and practice: Shell-working in the western Pacific and Island Southeast Asia. Unpublished PhD thesis, Australian National University.

Trotter, M.M., 1978. Rua Hoata: report of an inspection. Unpublished report to New Zealand Historic Places Trust.

Walker, K.F., M. Byrne, C.W. Hickey and D.S. Roper, 2000. Freshwater mussels (Hyriidae) of Australasia. In G. Bauer and K. Wächtler (eds) *Ecology and Evolution of the Freshwater Mussels Unionoida*. Ecological Studies, 145: 5–31. Springer, Berlin.

Williams, A. and T. Walton, 2003. *Early Landuse Patterns in the Lake Taupo Area*. Science for Conservation, 222. Department of Conservation, Wellington.