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Archaeological excavations at the Station Bay pā, Motutapu Island, inner Hauraki Gulf, New Zealand

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ABSTRACT: Excavations at the Station Bay pā on Motutapu in 1970–71 revealed a complex sequence, from a relatively extensive open settlement to a more compact fortification between about AD 1500 and 1800. Charcoal analysis portrays a largely scrub-covered landscape with only a few trees. Food-storage pits and faunal remains reflect a subsistence economy based on kūmara (sweet potato) cultivation and the harvesting of marine resources: shellfish from the adjacent rocky shore and both protected and exposed sandy beaches, and fish, predominantly snapper, from fishing grounds nearby. The few items of material culture are typical of Māori assemblages of the time.

Results of two previous excavations of undefended settlements in the immediate vicinity help to expand a picture of a relatively stable and peaceful way of life, punctuated by periodic episodes of stress when the fortifications were built and rebuilt. External contacts are indicated by imported obsidian, mostly from nearby Great Barrier Island (Aotea Island).

The Station Bay excavations are discussed in the context of more than 50 years of archaeological research on Motutapu, which has a largely intact pre-European cultural landscape in close proximity to the large Auckland urban area, where many pre-European sites have been lost.

KEYWORDS: Motutapu Island, Station Bay, pā, settlement pattern, faunal analysis.

Introduction

Excavations were carried out at the pā at Station Bay in the northeast part of Motutapu Island in the summer of 1970–71. The results were briefly summarised shortly afterwards (Davidson 1972). A full report is presented here.

The site and its setting

Motutapu is a fertile, undulating island, about 1500 ha in area, lying just to the northeast of Auckland's youngest volcano, Rangitoto, in the inner Hauraki Gulf (Fig. 1). Its highest point is 121 m above sea-level, and much of the central part is above 90 m. The island is made up of two different geological formations. The northern and eastern parts, where Station Bay is situated, are formed of ancient greywacke of the Waipapa Formation; the west and south consist of the Lower Miocene Waitemata series (Mayer 1968). Almost the entire island was blanketed by volcanic ash erupted from Rangitoto at an early point in the Māori occupation of the Auckland region.

The island's geology made it attractive for Māori. The Waipapa greywacke and chert were important resources for tool manufacture for much of the period the island was occupied by Māori. In addition, soils developed on the Rangitoto ash seem to have been well suited to Māori horticulture.

Surprisingly, the vegetation history of the island is not well documented, although Esler (1980) provided a detailed description of the state of vegetation after more than a

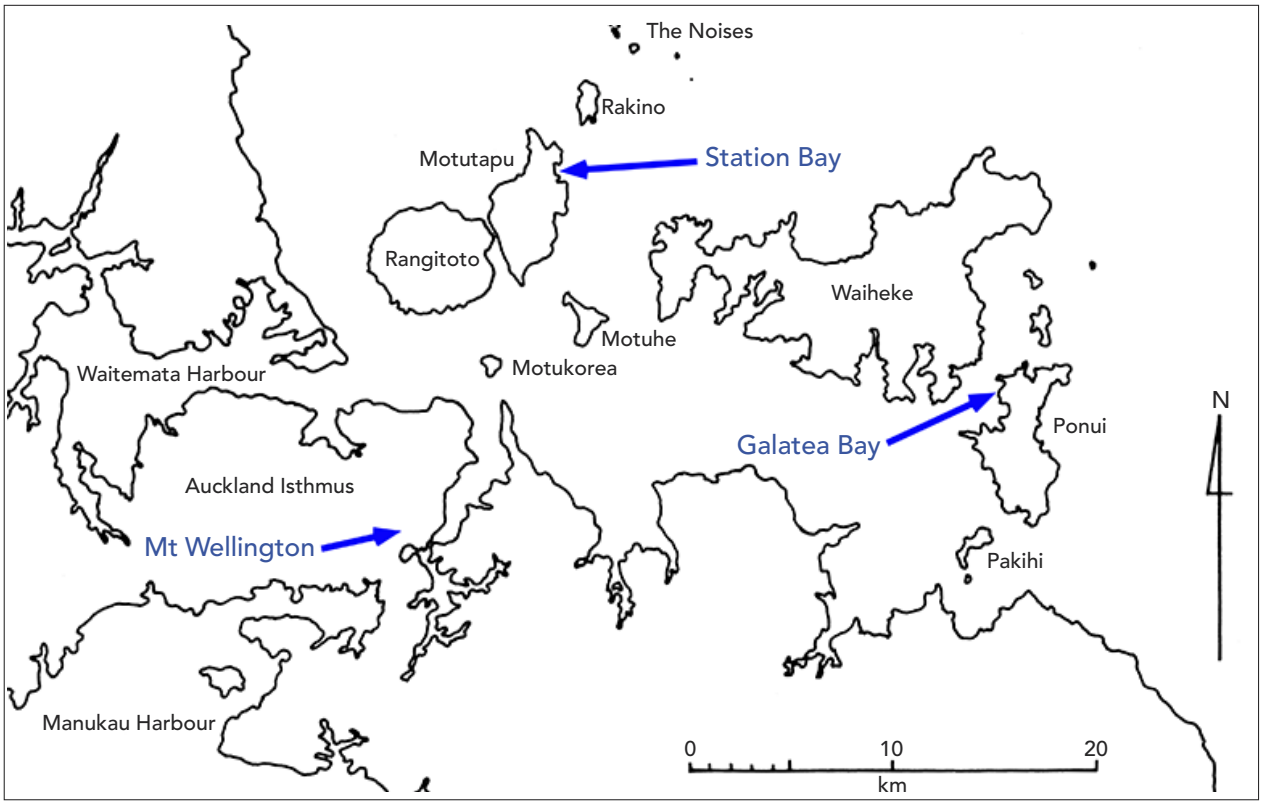

Fig. 1 The position of Motutapu in the inner Hauraki Gulf near Auckland. Sites in the area beyond the island, referred to in the text, are also shown.

century of farming, finding 139 native species compared with 207 exotics. Miller *et al.* (1994: 68) cited unpublished palynological data indicating that the island was once covered in mixed broadleaf/podocarp forest. Leaves of pōhutukawa (*Metrosideros excelsa*), karaka (*Corynocarpus laevigatus*) and kawakawa (*Macropiper excelsum*), common in northern coastal forests, were found preserved at the base of the Rangitoto ash at the Sunde archaeological site on the island (Cooper 1970).

An unpublished pollen study based on a core from near Billy Goat Point at the northern tip of the island found that the post-eruptive sequence was dominated by bracken (*Pteridium esculentum*) and mānuka (*Leptospermum ericoides* [now *scoparium*]) (Elliott & Neall 1995; V. Neall, pers. comm., 2011). This was interpreted as evidence that Māori gardening was preventing forest regeneration. In early European times, the island appears to have been largely covered in light scrub and native grasses, with small remnants of coastal forest, particularly on south-facing slopes in the east of the island. One early plan (Land Information New Zealand n.d.) indicates numerous dead trees in the gullies. Miller *et al.* (1994: 68) appear to have misinterpreted Smith's (1909) translation of D'Urville's account of his visit to the area in 1827. In both Smith's and Wright's (1950: 153) translations, it was Rangitoto rather than Motutapu that was covered in flourishing vegetation, in contrast to the 'bare land' on the mainland opposite.

The Station Bay pā (formerly N38/25, now R10/26) occupies a narrow, steep-sided peninsula on the east side of Station Bay (Figs 2, 3). Murdoch (1991: 6; pers. comm., 7 July 2011) gives its name as Ororopupu, meaning 'crushed brains', which he interprets as an attempt to deter enemies. Transverse ditches defend the central high point and surrounding flat area and terraces. A long, narrow tail with smaller flat areas and terraces tapers to the south. Three large visible pits lie just outside the defences to the north; the largest was investigated by Sullivan (1972) concurrently with the excavations reported here. In 1971, the main (northern) ditch still had vertical walls for part of its length (Fig. 4).

Motutapu and Rangitoto are closely intertwined in Māori history. Both have strong associations with the migratory canoes *Te Arawa* and *Tainui*, particularly the latter. These traditions are summarised by Murdoch (1991). Motutapu was named by Taikehu, a tohunga (priestly expert) on *Tainui*,

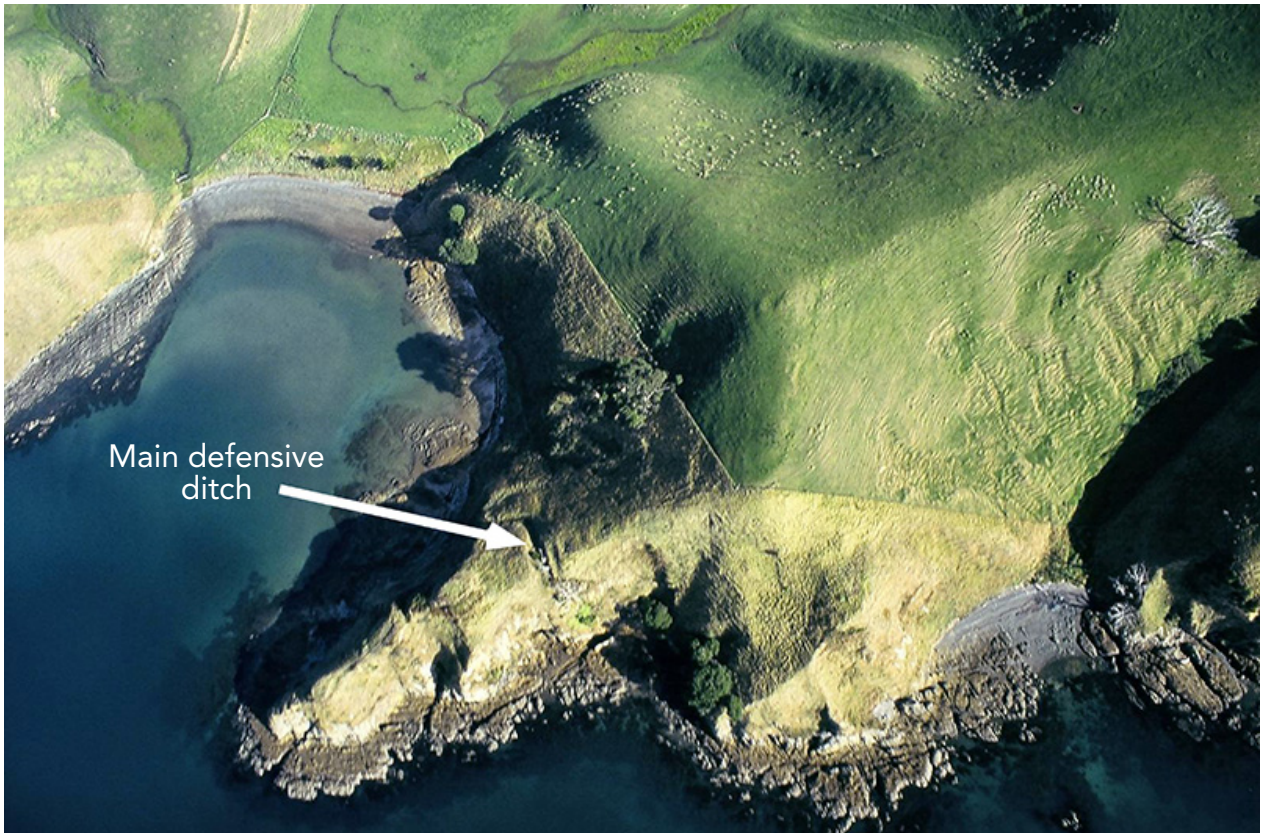

Fig. 2 Recent aerial view of the Station Bay pā. Note the rocky shore surrounding the site and the small shingle beach (photo: Kevin Jones).

Fig. 3 The Station Bay pā from the northwest in 1967, showing the principal defensive ditch, the tihi and the sheltered intertidal platform within the bay at the base of the pā (photo: Janet Davidson).

Fig. 4 The principal defensive ditch looking east in 1967. The sheer right-hand wall is immediately adjacent to Area B of the excavation (photo: Janet Davidson).

after a place in the homeland of Hawaiki, and was known to his descendants as Te Motu Tapu a Taikehu. It was occupied until the early nineteenth century by Ngāti Tai, whose name links back to various ancestors whose names could be shortened to Tai. The lives of the Ngāti Tai on Motutapu and elsewhere in the vicinity were seriously disrupted by incursions by Ngā Puhi war parties armed with muskets from 1821 onwards, although they were able to return to their lands by 1836. They then came under increasing pressure to sell land to Europeans.

In 1840, most of Motutapu was sold by Ngāti Tai leader Tara Te Irirangi and others to his son-in-law Thomas Maxwell. It was farmed privately, by several successive owners, until the Second World War, when it was acquired by the Crown. At the time of the Auckland Museum research on the island, it was a Lands and Survey Department farm. It became part of the Hauraki Gulf Maritime Park when that was established in 1967 and is now administered by the Department of Conservation.

Archaeological research on Motutapu

Motutapu has been the scene of considerable archaeological research for more than 50 years. This began with two seasons of excavation at the stratified beach site at Pig Bay (formerly N38/21, now R10/22) in 1958 and 1959 (Brothers & Golson 1959; Golson & Brothers 1959), and was followed by excavation of another stratified coastal site, the Sunde site (N38/24, now R10/25), in 1963 (Scott 1970) (see Fig. 28 for locations). In both of these excavations, the volcanic ash erupted from nearby Rangitoto was an important stratigraphic marker. An initial survey of the island was carried out by the Auckland University Archaeological Society early in 1963, resulting in what appeared to be a large number (~70) of sites (Davidson 1970a).

The Auckland Institute and Museum (Auckland Museum) research programme on Motutapu began in the summer of 1967–68 with the excavation of two 'undefended sites' at Station Bay: the Davidson undefended site (N38/37, now R10/38; Davidson 1970b) and the Leahy undefended site (N38/30, now R10/31; Leahy 1970). These excavations were designed to investigate the nature of the subsurface features that gave rise to the surface evidence found during the site survey and, indeed, to test whether some of the more amorphous surface evidence did actually represent archaeological features. The next stage of the research was the excavation of the Station Bay pā and a group of pits outside its defences (Davidson 1972; Sullivan 1972), and further excavation at the Leahy site (Leahy 1972). The results were reviewed in a short paper (Davidson 1978c) and incorporated in a broader review of the wider Auckland region (Davidson 1978b). The locations of the three excavated sites are shown in Fig. 5.

The aims of these excavations were to investigate the similarities and differences between the pā and the undefended sites, explore the nature of the defences, and obtain information about the layout of the site and its structures, samples of midden and an artefactual assemblage (Davidson 1972: 2).

In the course of the two excavation seasons it became apparent that there were still a lot of unrecorded sites on the island. An intensive resurvey was therefore begun in the summer of 1972–73 and finished in 1977 (Davidson 1987). At the same time, an apparent terrace on an undefended site at Pig Bay on the island's northwest coast (N38/140, now R10/137) was excavated (Leahy 1986). This marked the end of the Auckland Museum programme on Motutapu.

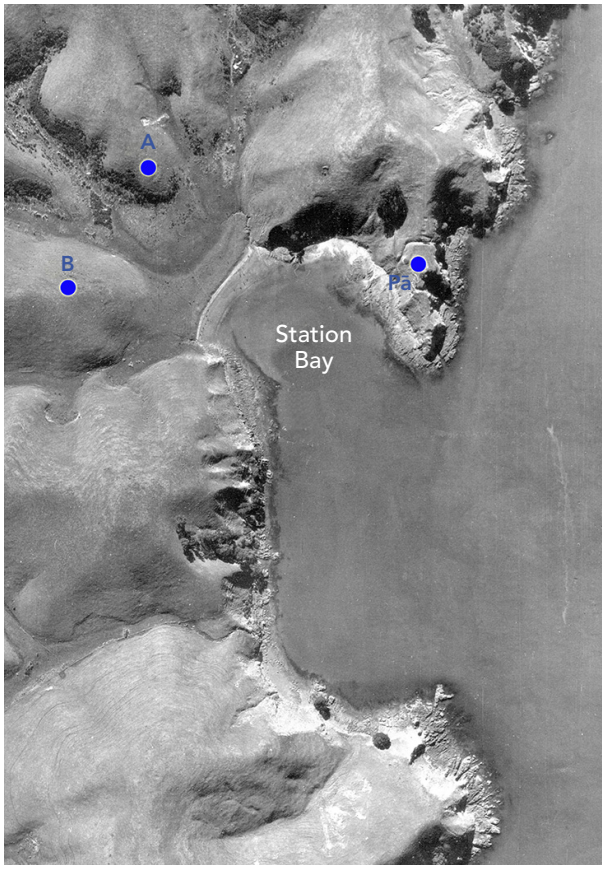

Fig. 5 Aerial view of Station Bay in 1963, showing the pā and the two previously excavated sites: A, Leahy undefended site, N38/30; B, Davidson undefended site, N38/37. Note the extent of the intertidal rocky shore in the vicinity of the bay (photo: New Zealand Aerial Mapping).

There has been considerable further research on the island since 1977. In 1981–82, Nichol (1988) carried out extensive work at the Sunde site. In 1994, Irwin, on behalf of the Anthropology Department, University of Auckland, contracted with the Department of Conservation to provide a greatly improved database, using geographic information systems (GIS) at a feature level to inform conservation management during the implementation of the Motutapu Restoration Plan (Irwin *et al.* 1996). This led to exploration of important issues such as site definition and the effects of splitting and lumping (Doherty 1996). During the course of the Auckland University programme, six undefended sites were investigated and Turner undertook limited further investigations at Pig Bay (Irwin *et al.* 1996; Szabó 1999; Watson 2004; Ladefoged & Wallace 2010; G.J. Irwin, pers. comm., 24 August 2012; M.T. Turner, pers. comm., 1995). Some aspects of this research are discussed below.

The excavation

The excavation at the Station Bay pā took place between 19 December 1970 and 26 January 1971. A varying number of volunteers participated. A baseline was laid out along the site and excavation units were aligned to it. One square was excavated on the highest point (the tihi, A on Fig. 6) and four on the relatively large flat immediately inside the northern defensive ditch (the central flat, B). Trenches were opened on the western end of a terrace between the tihi and the central flat (the internal terrace, C) and between the northern ditch and the large pit excavated by Sullivan (the external terrace, D) (Fig. 7).

Excavation was by hand trowel, following natural layers. Initially, the upper deposits on the main flat, which contained midden shell and bone, were excavated in blocks of 1 m^2 and sieved through 6.35 mm mesh. However, this proved difficult to manage and the deposits were later bagged variously according to 3 m squares, or specific features and patches within the squares. Sieving was limited to parts of the midden-bearing Layer 2. Shell and bone was retained from the sieving and hand-picked from other deposits. Because of the diffuse nature of the midden and the large amount of fire-cracked stone, only one large bulk sample was taken. This was a sieved sample from a patch of denser compacted midden at the base of Layer 2 in F4, Area A, which weighed a little over 6 kg. Unworked stone was weighed according to square and layer, and then discarded. These procedures were not unusual at the time, particularly where faunal analysis was not the primary objective.

The bedrock was hard clay that had developed on the underlying greywacke. Cultural layers included redeposited material from the digging of pits and other features into the underlying natural, and dark ashy soil and midden resulting from occupation.

Area A: the tihi

Four 2.5 m squares separated by 1 m baulks were set out on the tihi area, but only one (L4) could be excavated in the time available (Fig. 8). This square had no surface features apart from a slight depression towards the south side. Beneath the turf was a fairly thick soil layer (up to 25 cm deep) containing pebbles, other stones, charcoal fragments, minimal amounts of faunal material (including rat bone) and numerous small pieces of obsidian. Below this was a hard surface, which was at first thought to be natural, but was discovered to be the compacted surface of the fills of three pits that lay only partly within the square.

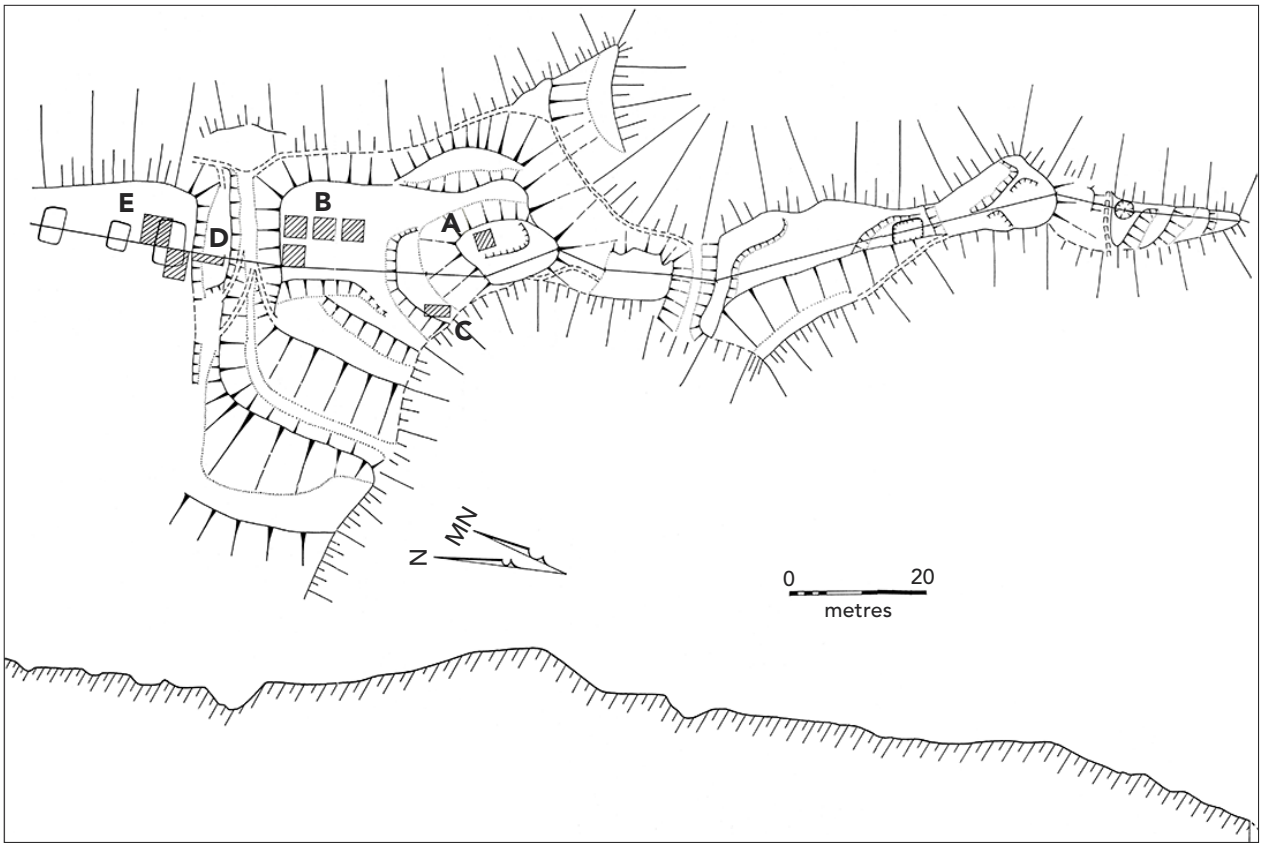

Fig. 6 Plan of the Station Bay pā, showing the excavated areas. A–D are described in this paper; E is the group of external pits, the largest of which was excavated by Sullivan in 1972.

Fig. 7 View from the tihi (Area A) of excavations in progress in Area B in January 1971, with Sullivan's excavation of a large external pit in the background beyond the defensive ditch. Square G4 is in the foreground, with F4 beyond it and E4 and E5 nearer the pōhutukawa trees growing in the defensive ditch (photo: Janet Davidson).

Pit 1 on the northern side of the square measured more than 230 × 110 cm in area, with a maximum depth below surface at its western end of 60 cm. The probable orientation was east–west. Its western end abutted a shallower feature, which was either a step down into the pit, or an earlier truncated feature. The surface of the pit fill included compacted clay lumps to the west and a scatter of pebbles, almost like a paving, to the east. The fill was undifferentiated redeposited clay except for a thick burnt layer almost on the bottom, which petered out over some clay lumps in the west. Charcoal from the burnt layer was identified by Jean Goulding of the Auckland Museum (pers. comm., 10 August 1971) as consisting entirely of bracken fronds – pieces of stalk (stipes), the midrib of leaflets (rachis) and leaflets (pinnae). Some of this material was used for a radiocarbon sample (NZ4349).

Pit 2, of which only a small part was exposed in the southwest corner of the square, had been truncated by a later pit (3). The fill of Pit 2 consisted of an upper layer of clay lumps, overlying a softer fill, which contained a thin burnt lens towards the bottom. Pit 3, which was of a similar depth to Pit 2, had an undifferentiated mixed fill. There was a buttress, asymmetrically placed in the northern wall, closer to the western than the eastern corner. Between the western corner

Fig. 8 Square L4 in Area A, looking east. Pit 1 is on the left, pit 3 on the right, and the vestige of Pit 2 in the bottom right-hand corner (photo: Janet Davidson).

and the buttress was a scooped area of charcoal, apparently a fire feature of some kind. Two human bodies had been placed together on the floor of the pit, face to face and with their heads towards the buttress; only the heads, arms and most of the torsos lay within the area of the excavation.

In view of their similar alignment and the presence of burnt bracken near the base of both their fills, pits 1 and 2 were probably contemporary. They were abandoned long enough for a little fill to accumulate naturally and bracken to grow, before being deliberately filled to ground level immediately after the bracken was burnt. Pit 3 was constructed on a slightly different alignment. The bodies were placed on the floor of the pit, which was then filled to the same level as pits 1 and 2. Pebbles were deliberately laid on the surface but there appear to have been no structures substantial enough for posts or stakes to penetrate the pit fills or the remains of the natural surface between the pits. Activities at this time involved the use and discard of obsidian.

It is unlikely that Pit 3 was dug as a burial pit. There was no indication during excavation or in the south section of the square that a grave had been dug through the pit fill. It appeared that the bodies were placed on the clean floor of the pit before any natural fill had accumulated following abandonment. The pit was then deliberately filled. Such a burial is most unusual, and is further discussed below.

The two individuals buried in Area A were studied by Houghton (1977), together with two single burials from the two undefended sites in Station Bay. He identified the two from the pā as a male of estimated age 30–35 and height 5 ft 6.6 in (1693 mm) and a female of estimated age 28 and height 5 ft 2 in (1576 mm). Cause of death was not apparent and neither individual showed signs of pathology or arthrosis. No Harris lines were present. Both showed evidence of tooth wear, including 'fern root planes', periapical abscesses and pre-mortem loss of some molars. There was no evidence of violence or trauma in the parts of the skeletons exposed.

Area B: the central flat

The flat area immediately inside the northern defensive ditch proved to have been used intensively, initially probably only for pit construction, and later for surface structures and defensive features. At some point between our first season at Station Bay in the summer of 1967–68 and the end of 1969, someone, presumably looking for artefacts, dug a trench across this area. Fortunately, this was shallow (and presumably unproductive). It is shown as 'recent disturbance' in the sections of F4 in Fig. 9.

Three main layers were identified in the four squares excavated in this area (Fig. 9):

Layer 1 Topsoil.
Layer 2 Dark, often ashy soil containing fire-cracked stone and faunal material, associated with, and often filling, a large number of postholes of varying sizes.
Layer 3 A yellower, more clay-like layer containing small amounts of faunal material and occasional burnt or ashy lenses, associated with, and filling, a number of pits and postholes.

Both Layer 2 and Layer 3 clearly reflected repeated activities, resulting in intercutting and residual features. Although there were variations in the texture of Layer 3, from finer, softer material to hard clay lumps, these did not correspond to different feature fills and it was usually difficult or impossible to trace the edges and floors of intercutting features.

Layer 2 features
(Fig. 10)
Although cooking was apparently a major activity during the Layer 2 occupation, reflected by large amounts of charcoal and fire-cracked stone, only one definite cooking feature was identified: a small, shallow oval hollow in the surface of Layer 3 in G4, lined with small stones and covered with charcoal. Ashy patches and lenses were common in E4 and E5; some of the better defined examples are shown in Fig. 10.

Unworked stone in Layer 2, assumed to be debris from cooking, was weighed according to square as follows: E5, 96 kg; E4, 68 kg; F4, 70 kg; G4, 10 kg.

The principal features associated with Layer 2 were postholes, ranging from very large holes (assumed to be for

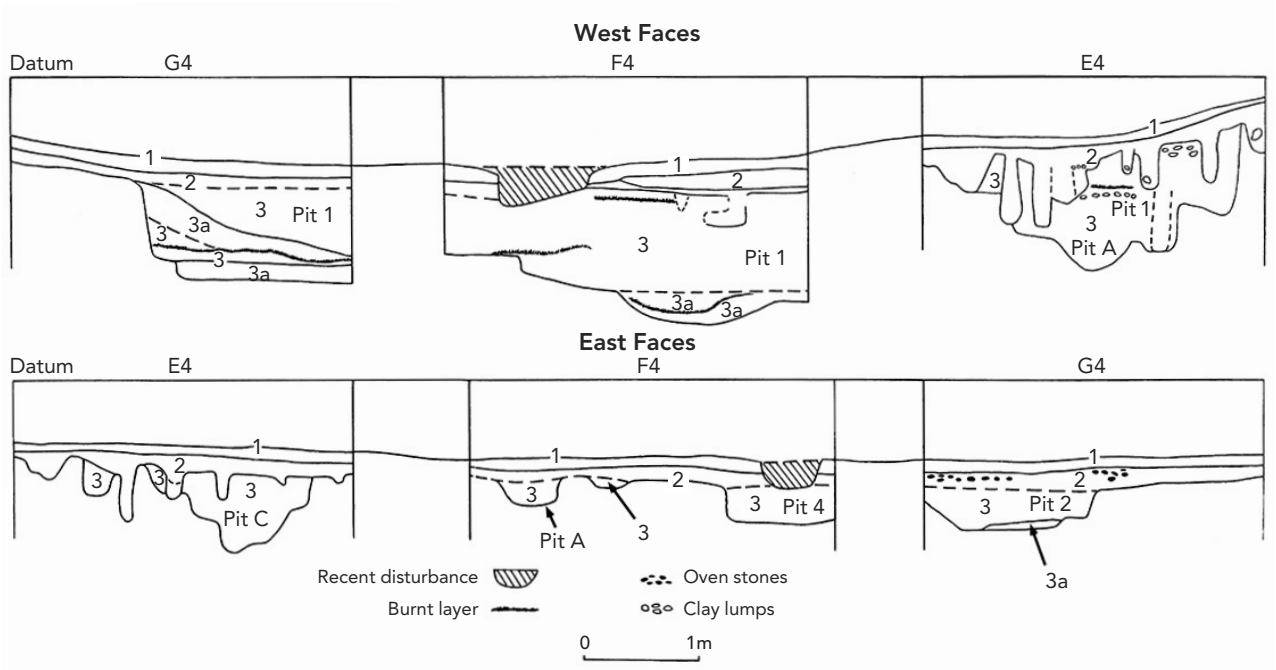

Fig. 9 East and west sections of squares E4, F4 and G4 in Area B.

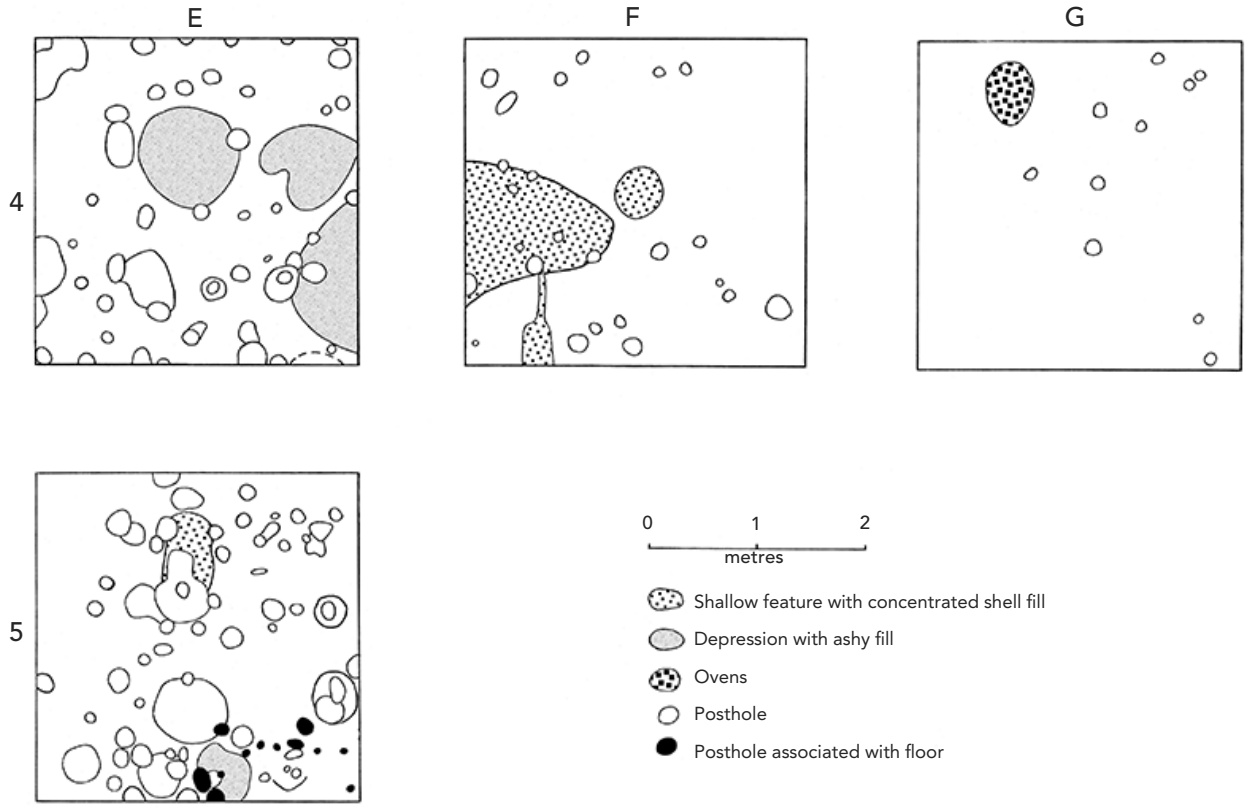

Fig. 10 Layer 2 features in Area B.

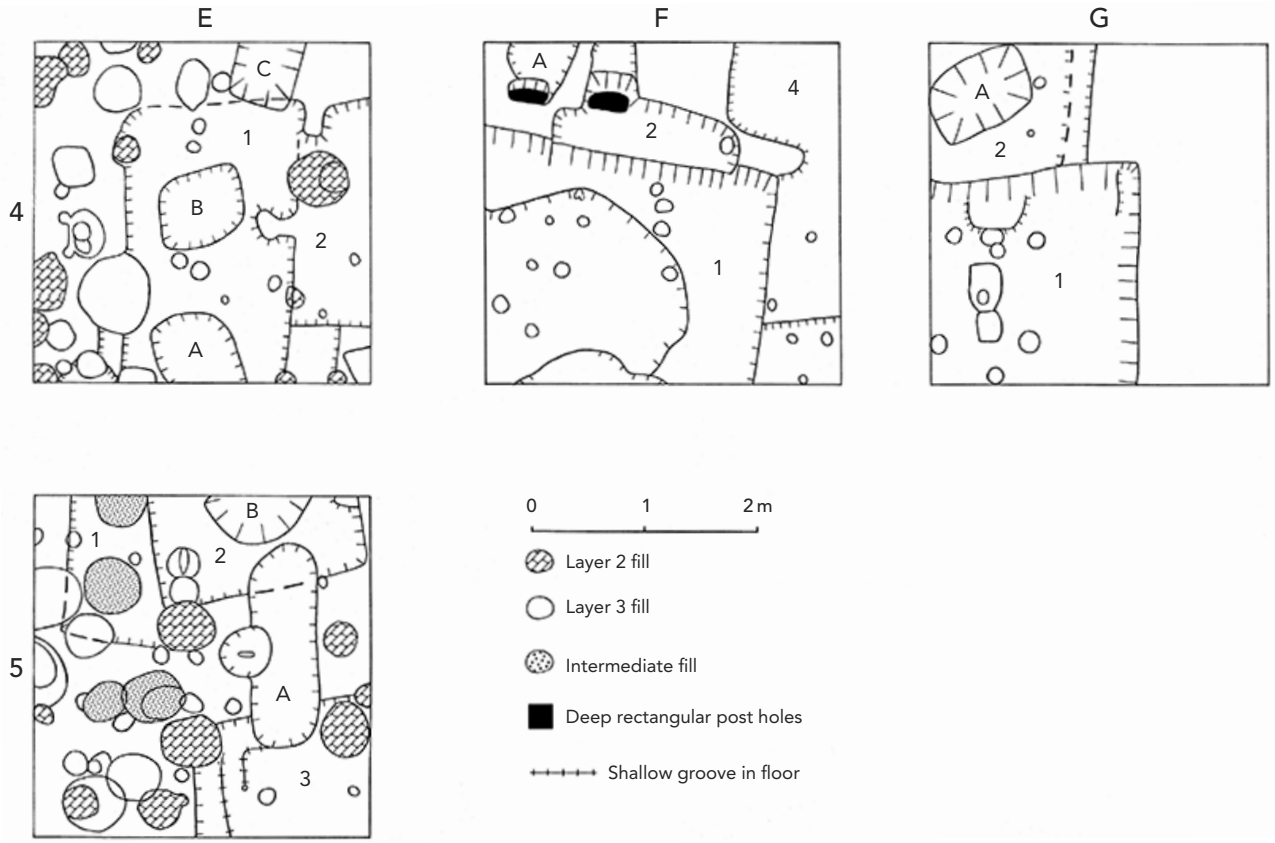

Fig. 11 Layer 3 features in Area B. In each square, the larger rectangular pits are numbered according to the apparent sequence from bottom to top, and the smaller pits similarly listed by letter.

palisade posts) in E4 and E5, to tiny stake-holes in all four squares. Recognising and defining the smaller holes was difficult, and there were probably many more than are illustrated. They were identified at different levels within the layer and some were capped with clay over a Layer 2 fill. One trampled surface associated with several small post- and stake-holes was identified in the southwest corner of E5. Large postholes with Layer 2 fill, which penetrated deep into the natural clay, were interpreted as palisade holes. They are clearly marked on Fig. 11, as they were not all identified during the excavation of Layer 2.

The large holes appear to represent defensive structures set slightly back from the edge of the ditch. Contrary to expectations, the slope upwards towards the ditch in E4 and E5 was found to be the natural slope through which the ditch had been dug and not a low inner bank. The large postholes ranged in depth below surface from about 135 cm to 200 cm.

Trotter (2009) has recently presented several examples from South Island pā in which palisade posts were set not on the top of the defensive inner bank or the immediately inner edge of ditch, but back behind the bank. Although the Station Bay situation is different in that there is no artificial bank, only a slight natural slope up to the edge of the vertically sheer ditch, the position of at least some of the presumed palisade posts is not unlike the examples illustrated by Trotter. These South Island examples all date to the nineteenth century and the period of musket warfare. No items of European material culture have been found at the Station Bay pā, but an early nineteenth-century age for the final occupation is not impossible.

Layer 3 features

(Fig. 11)

The majority of features associated with Layer 3 were rectangular pits; there were also smaller, usually deep, basin-like pits and, in E4 and E5, large postholes that again were assumed to be for defensive structures. The rectangular pits are numbered in each square from earliest to latest, except that E5/2 and E5/3 share the same alignment and were probably contemporary. Examples of the complex structures uncovered are illustrated in Figs 12–15.

Fig. 12

Fig. 13

Fig. 14

Fig. 15

Fig. 12 Square E5 looking north. Pits A and B are towards the front. The ranging pole marks a large Layer 3 posthole exposed in section (photo: Janet Davidson).

Fig. 13 Square E4 looking north. Pits A and B are in the foreground left and centre (photo: Janet Davidson).

Fig. 14 Square F4 looking north. The distinction between Layer 2 and Layer 3 is very clear. Part of one of two large rectangular postholes is at centre right (see also Fig. 29) (photo: Janet Davidson).

Fig. 15 Square G4 looking north. Part of the very hard fill of Pit A, centre right, remains unexcavated (photo: Janet Davidson).

No rectangular pits were completely exposed. They varied slightly in orientation and considerably in depth. A few had buttresses; none had floor drains or sumps, despite the impermeable nature of the bedrock. Both single and paired alignments of postholes were identified. Most pits had straight sides, but Pit 2 in G4 had sloping sides, and may have been functionally different from the others. The marks of digging sticks were visible in the walls of some of the earlier, deeper pits, particularly G4/1. The approximate depths below surface of pits not shown in Fig. 9 were as follows: E5/1, 60 cm; E5/2, 80 cm; E5/3, 80 cm; E4/2 60 cm.

The curious oval pit E5/A and the small, deep, rounded rectangular pits E4/A–C and E5/B (Fig. 11) were thought during excavation to be the earliest features in these squares. The oval pit was apparently abandoned unfinished. Although the others bear some resemblance to the bin pits found by Sullivan in the floor of her large pit to the north of the ditch (Sullivan 1972: 32, 40–43), they are deeper and more rounded. G4/A was not fully excavated. It had an extremely hard fill, similar to that in part of E5/A.

The two largest pits, F4/1 and G4/1, both had multiple floors; there also appeared to be a third smaller pit within F4/1, visible in the north section, although not detected during excavation of the Layer 3 fill.

Postholes with Layer 3 fill were mostly either in the floors of pits or very large holes in E4 and E5, and likely to be for palisade posts. However, two deep rectangular holes in the northeast of F4 (Fig. 29) appeared to represent a quite different kind of structure, perhaps of vertical slabs, of which no further traces were found. This is the only evidence in the excavated area of what might have been a significant surface building.

There was some cooking stone in patches in Layer 3. Stone from Layer 3 in F4 amounted to 37 kg. Stone from Layer 3 in the other squares was not weighed.

Area C: internal terrace

The internal terrace at the base of the northern slope of the tihi area overlooks the main flat and the larger terraces above and below the western arm of the main defensive ditch. No surface features were apparent. A 3.5 × 2 m trench (J7)[1] was excavated at its western end. It was hoped that the terrace might prove to have been the site of a house.

The trench revealed part of a well-preserved rectangular pit (J7/1) aligned along the terrace. It was 180 cm wide by more than 220 cm long and 70 cm deep, with an end buttress and a single central posthole in the area exposed. It appeared to have been cut through a grey and, in places, ashy soil overlying hard clay bedrock. The grey soil itself was overlain by a yellower clayey deposit that was probably derived partly from construction on the terrace and partly from activities on the tihi above. This in turn was covered by thin topsoil.

The pit fill consisted of a hard layer of flecked clay at the bottom, an ashy central layer and an upper layer of hard clay lumps. The top of this upper fill was level with the point at which the pit had been cut into the bedrock and had obviously been open to the air for a while, as there were patches of dark soil and a slight hollow containing burnt material in its surface. Above this surface was a thick layer of soil, flecked with clay in its lower part, presumably partly derived from activities on Area A above. Eleven small pieces of obsidian and one identifiable fish bone (a snapper maxilla) were found in this area.

Area D: external terrace

A 4.8 × 1 m trench was excavated along the baseline between the large external pit investigated by Sullivan and the top of the transverse ditch to the north of the central flat, to see whether this apparent terrace represented an earlier defensive ditch (Fig. 16). From the northern edge, the trench followed what appeared to be a natural downward slope for a short distance. There was then a clearly artificial scarp of about 60 cm leading down to a slightly dished flat about 2 m wide. The natural surface then rose gradually again. A lumpy clay fill, thickest at the edge of the scarp, extended across the flat and merged into a thinner clay layer capped with lumps. These clay layers were overlain by a thick soil deposit against the artificial scarp, which, like the underlying clay layers, thinned towards the south. No cultural material was found in this trench apart from a cluster of fire-cracked stones equivalent to a basketful, dumped in the fill against the northern scarp.

Fig. 16 The external trench in Area D, looking north towards the scarp leading up to the large external pit. The rectangular hole at centre right is a test pit (photo: Janet Davidson).

The purpose of the scarp and dished flat was not clear. If they were the remains of an earlier ditch it would have been wide and shallow, symbolic rather than an effective defence.

The occupation sequence

The most intensively occupied area uncovered by the excavations was Area B. A sequence from undefended pits through defended pits to a final dense occupation deposit without pits inside renewed defences was long ago argued for sites such as Ongari Point (particularly the eastern and central areas) in the Bay of Plenty (Shawcross 1964, 1966) and Waioneke on the southwest of the Kaipara Harbour

(McKinlay 1971), and more recently for Anatere in the Bay of Plenty (Phillips & Allen 1996). The central flat of the Station Bay pā repeats this sequence.

The Layer 3 features clearly include several different episodes of pit construction. Patches of burning within the layer appear to indicate periods of at least brief abandonment, for example the burning of vegetation that had grown in pits abandoned long enough for some fill to accumulate, or on surfaces that were subsequently covered with spoil from renewed pit digging activity. Several such lenses can be seen in the west faces of the Area B squares (Fig. 9).

The abundance of small postholes associated with Layer 2 suggests a number of relatively flimsy buildings and/or racks, again constructed on a number of occasions, but there is no evidence of substantial buildings other than the two large rectangular postholes in F4 (Figs 14 and 29). The main large structures appear to be defences. Repeated brief occupations, rather than any sustained or permanent occupation, are indicated.

As some of the large postholes in the central area have Layer 3 or 'intermediate' fills, it seems likely that the later, mostly smaller, rectangular pits in the central area were constructed inside what had now become a defended site. The large postholes in E4 and E5 appear to represent several phases of construction of a palisade and perhaps (in E5) a fighting stage.

It is impossible to estimate the number of separate construction episodes. Some may have been minor and local. For example, pits E5/2 and E5/3 are on a similar alignment and may therefore have been constructed at the same time, but whereas E5/2 was apparently deliberately filled immediately after use, E5/3 had a very weathered floor, which must have been left open to the elements after the superstructure was demolished or removed.

By contrast, there appear to have been only three stages of occupation of Area A: two phases of pit-building and a final occupation without pits, midden or, in the single square excavated, structures. Area C had only two clear stages: terrace and pit construction, followed by pit-filling and transient use of the new surface.

It is not easy to correlate the three areas excavated inside the pā. Area A can be argued to share at least part of the sequence in Area B, with two phases of pit construction followed by a flat working area of some kind with no pits. Area C, with one pit, very limited signs of later occupation in the excavated area and later slope debris derived from activities further up could be a still paler reflection of part of this sequence, but equally could stand alone, relating to any point in the sequence in the other areas before the final modifications of the tihi.

One of the aims of the excavation was to establish the relationship between the three large pits visible on the surface of the ridge outside the pā to the north and the pā itself. It seems most likely that the external pits pre-date the construction of the pā. Pits F4/1 and G4/1 are the earliest in their respective squares and the largest uncovered in Area B, comparable in size to the external pits. They could therefore easily belong to a period of undefended pit construction over the wider area of the headland, which Sullivan (1972: 60) described as 'extensive', rather than 'constricted, concentrated and intensive'. In support of this view, Sullivan also identified what she considered spoil from ditch construction in the fill of her large external pit after its main use had ceased (1972: 48, 59).

Although the large external pit was never completely filled in, a smaller adjacent pit was. This feature (Pit E) was rectangular, with an end buttress, and was comparable to the pit in Area C. Sullivan considered Pit E to be contemporary with the use of the large pit and argued that it was deliberately filled to provide a subsequently well-used path along the east edge of the ridge to the pā. She also identified the earliest feature in the area she investigated as a probable small terrace (Structure W) just to the southwest of her large pit, arguing that it pre-dated the large pit by a definite time gap (Sullivan 1972: 33). This small terrace is not shown on the site plan.

A sequence can therefore be suggested as follows:

1. Initial use of the area represented only by Structure W, probably a small living terrace.
2. Use of the ridge top, both inside and outside what would become the pā area, for the construction of kūmara (sweet potato, *Ipomoea batatas*) storage pits, both large and small rectangular pits, and smaller ovoid and rounded rectangular pits.
3. Initial ditch construction with continued construction of mainly smaller pits.
4. Final refortification without pits, at least in the areas excavated.

This sequence depends on the assumptions that the earliest pits inside the pā were probably roughly contemporary with the pits outside, and that use of the pā area continued after the latter were abandoned. The presumed Layer 3 palisade holes in squares E4 and E5 are very close indeed to the early pits in those squares and in some cases are dug partly through their fill. Fortification of the Layer 3 pits inside

Table 1 Radiocarbon dates for the three excavated sites at Station Bay.

Site	Lab#	Context	Material	$\delta^{13}C$	CRA
Pā	NZ4349	Burnt bracken in pit, Area A	Charcoal	–23.6 ± 0.1	35 ± 66
	WK35391	Midden at base of L2, Area B	Shell	0.9 ± 0.2	630 ± 30
	NZ8128	Fire feature in external pit, Area D	Charcoal	–27.3	377 ± 41
	NZ4348	Burial, Area A	Human bone	–25.0 ± 0.1	367 ± 41
	WK35392	Burnt bracken on surface within L3, Area B	Charcoal	–23.8 ± 0.2	442 ± 25
Leahy site	NZ8129	Pit 2	Charcoal	–26.0	323 ± 35
	NZ4347	Burial	Human bone	–18.2 ± 0.1	630 ± 30
Davidson site	NZ1168	Hāngī 1	Charcoal	–27.0	189 ± 86
	NZ4346	Burial	Human bone	–15.0 ± 0.1	451 ± 45

the pā would have been possible only if the ambiguous feature in Area D was, in fact, an earlier ditch.

It is tempting to consider that the various burnt surfaces in Areas A, B and D represent a site-wide event – either a landscape fire when the site was unoccupied, or a deliberate fire on the site in preparation for reoccupation. This could assist in linking the various areas and establishing a chronology. On balance, however, it seems unlikely. The fire feature in Area E was interpreted by Sullivan (1972: 43–46) as a deliberate fire, localised within the pit, fairly soon after it fell into disuse. The burnt bracken in the partly filled pits in Area A was probably the result of deliberate burning some time after the pits had been abandoned. The various burnt patches in Layer 3 in Area B were small and localised, and unlikely to be connected to each other or to fires in other areas.

Although information was collected about structures, faunal remains and material culture for comparison with the Station Bay undefended sites and sites elsewhere on the island, little was learnt about the fortifications, or about how the site actually functioned as a fortified pā. The northern ditch, with its sheer walls backed by substantial palisading, was clearly a serious defensive device, requiring considerable labour to construct. How it related to the terraces above and below it, and to the southern ditch, could not be established in the time available.

Chronology

Radiocarbon dates from Station Bay provide a good example of why radiocarbon dating is often not very helpful in establishing a clear chronology for pre-European sites in New Zealand. The extent of the probability ranges and multiple intercepts on the calibration curves make interpretation difficult. It has also become apparent that on Motutapu, charcoal from immediately beneath the Rangitoto ash can readily be incorporated into cultural deposits.

Nine radiocarbon dates for the three Station Bay sites have previously been published (Davidson 1972: 5–6; 1978a: 15). Three of the published dates from the Davidson undefended site were from non-cultural contexts beneath the Rangitoto ash. One from an apparent cultural context (NZ1164) was of similar age; this sample is assumed to have been pre-ash charcoal redeposited in pit fill. A further previously unpublished charcoal date, NZ8130, returned a conventional radiocarbon age (CRA) result of 656 ± 31 BP ($\delta^{13}C$-27.4) and was evidently also pre-ash charcoal. These dates are not considered further here.

The remaining five published dates and four additional ones are listed in Table 1. Slight differences between Table 1 and previously published results are due to recalculation at the Rafter Radiocarbon Laboratory. The age ranges corrected for marine reservoir and secular effects in years Cal BP are presented in Fig. 17.

Houghton (1977: 40) used nitrogen levels in the bones of the burials from Station Bay to estimate the site ages as follows: Leahy site, AD 1400; Davidson site, late 1700s; and the pā, early 1700s. The burials provided the samples for the radiocarbon dates NZ4346, NZ4347 and NZ4348. The human bone dates are consistently earlier than the charcoal dates from similar contexts; in the case of the pā, the burial is thought to be stratigraphically more recent than the bracken sample (NZ4349) from the adjacent pit in Area A. The possibility that a major contribution of seafood to the

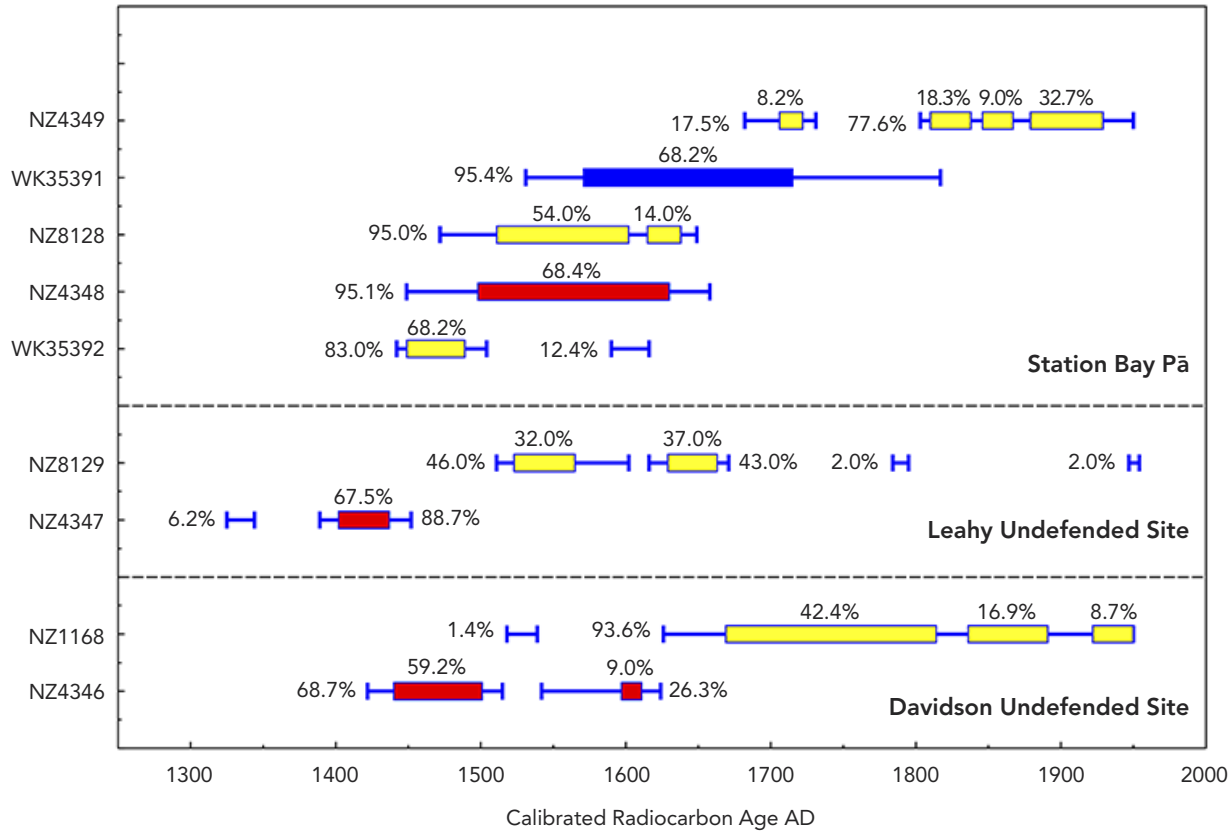

Fig. 17 Radiocarbon dates from the three Station Bay sites in years Cal AD after secular correction and calibration by the laboratories using southern hemisphere atmospheric data from McCormac *et al.* (2004) and, for the shell sample, marine data from Reimer *et al.* (2009). Yellow, charcoal dates; red, human bone dates; blue, shell date.

diet of these people has influenced the bone dates does not appear to be supported by the $\delta^{13}C$ values.

The results suggest that the site on the headland, including the external pits as well as the pā, was periodically occupied over a period of up to three centuries, with the final occupation probably close to the end of the eighteenth century or early in the nineteenth century. Of the two undefended sites, the Leahy site is earlier, perhaps close to the initial use of the headland for pits, and the Davidson site, in its final use at least, is later, perhaps close to the final occupation of the pā.

Material culture

Very few items of material culture were recovered from the excavations. A stone adze and a small selection of worked bone and shell came from Area B. Most items were from Layer 2 but some were from Layer 3 or from the sometimes confused junction between the two. Obsidian was quite differently distributed, as described below.

Bone and shell items

Worked bone was examined by Ian Smith and Sheryl McPherson but in most cases the material could not be determined.

Two points of composite fishhooks are round-sectioned pieces of bone with minimal modification. One, from E5, Layer 3, has a slight but definite barb (Fig. 18C). The foot and lashing ridges seem to suggest that the barb was intended to be on the outer surface, but the base may have been damaged and repaired to produce this unusual effect. The material is possibly moa bone. The other point, from G4, Layer 2 (Fig. 18B), is smaller and simpler with no barb, a clearly defined face for attachment to the shank, and five tiny grooves to assist lashing. The material is possibly whale bone.

Two pieces of worked shell that may be parts of fishhooks were found in the bulk faunal sample from F4, Layer 2. A worked piece of what appears to be Cook's turban *Cookia sulcata* shell with a single tiny notch at one end is probably

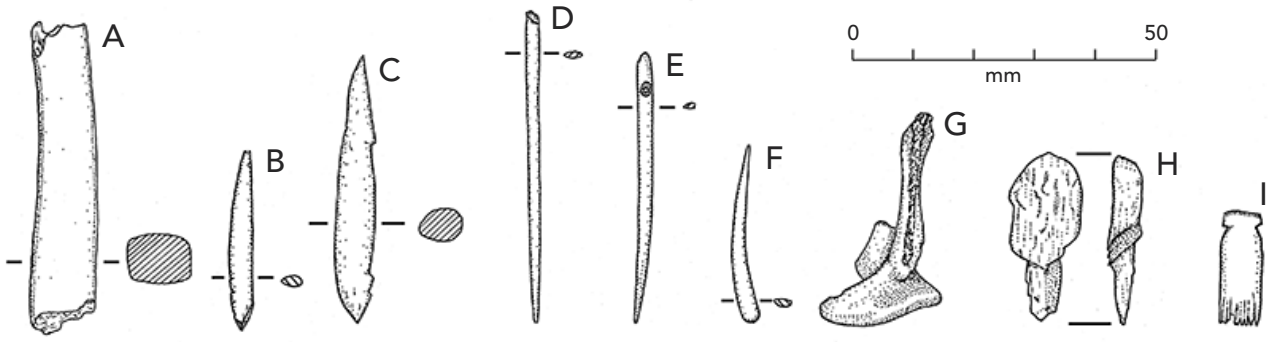

Fig. 18 Bone artefacts and worked bone. See text for contexts and descriptions.

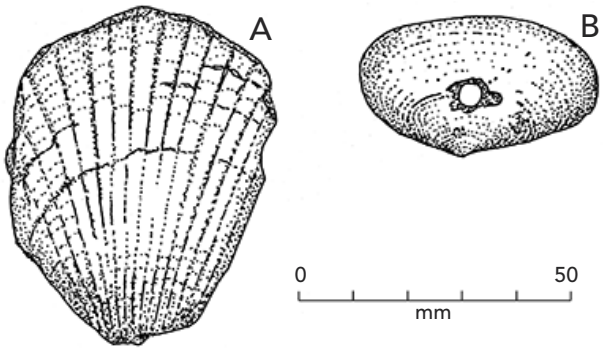

Fig. 19 Worked shell. See text for details.

part of the shank of a baited hook. A flat tapering piece of green mussel shell (*Perna canaliculus*) with a slight knob at the end could be from a trolling lure shank, or could be part of a pendant.

A complete needle (Fig. 18E) came from Layer 1 in G4, and what is probably the point of another from Layer 2 in E4 (Fig. 18D). The complete needle is slightly curved, following the shape of the original bone. It has a drilled hole with what appears to be an attempt at another hole partly drilled just above it on the convex back surface. An item from Layer 2 in E4 is just a rounded piece of bone tapering to a fine point (Fig. 18F). The other end is blunt and the item appears to be complete. Its function is uncertain.

The only object relating to adornment is a small tattooing chisel (Fig. 18I) from Layer 2 in F4. It has 11 uneven teeth.

A broken piece of bone, possibly moa, worked to a square section (Fig. 18A) came from E5, Layer 3, the same context as the fishhook point that was also identified as possibly moa bone. Two examples of cut dog mandibles, one of which is illustrated in Fig. 18G, were found in Layer 2 in F4 and G4. They are presumably by-products of the manufacture of needles or fishhook points. Elsewhere in the Auckland area, worked dog jaws were found at Taylor's Hill (Leahy 1991: 54). A puzzling small fragment of a well-made bone object of some kind from Layer 2 in G4 is possibly whale bone (Fig. 18H). A tilly bone from Layer 3 in G4, probably from a snapper, appears to have been slightly modified. A fragment of a long bone shaft, probably dog bone, from the fill of a Layer 2 posthole in F4 has been sawn transversely.

Worked shell includes a pipi (*Paphies australis*) valve with a central perforation from E5 (Fig. 19B), and a dog cockle (*Glycymeris*) shell from Layer 2 in F4, chipped all round the edges (Fig. 19A). Nichol (1988: 392, fig. 9.13E) figures a fragment of a similarly chipped shell, which he describes as a scraper, from the Sunde site. However, Furey (1986) has described pendants made from dog cockle shells from a variety of North Island locations and it is possible that the Station Bay shell was the first stage of pendant preparation.

Stone tools

The sole stone adze blade, from Layer 2 in F4, is a small, untanged, typically 'Classic Māori' adze, in a fine-grained black stone (Fig. 20). All surfaces, including the poll, are well ground. It is heavily chipped along about two-thirds of the cutting edge and may have been deemed not worth repairing. Similar small adze blades were found at Oruarangi, for instance, although those examples had a clearly defined bevel shoulder (Furey 1996: 108, 110). This adze is different from the adzes found in the two undefended sites in Station Bay (Davidson 1970b: 49; Leahy 1970: 69, 71).

Also from F4, but from the Layer 3 fill at the base of Pit 3, was a hōanga (grinding stone) of fairly coarse sandstone. It is roughly rectangular, 60 × 65 cm, with a maximum thickness of 22 cm. Two edges are flat and rough, while the other two are tapered. One flat surface and one tapered edge appear to have been particularly used as abraders.

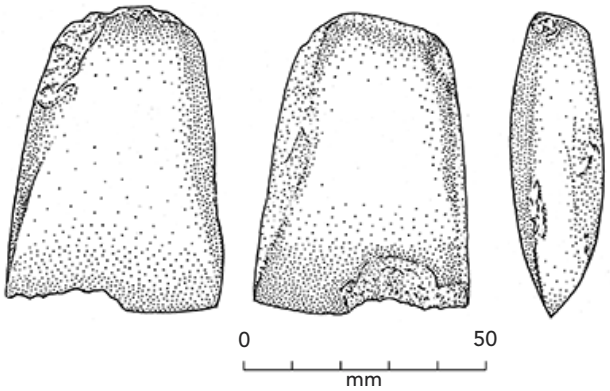

Fig. 20 Stone adze blade from Square F4, Layer 2.

A smooth round pebble weighing 442 g from Layer 3 in G4 is possibly an autoru, or stone for grinding kōkōwai (iron oxide), although there are now no obvious traces of pigment on it. The largest flat surface is faintly dished and abraded.

Two pieces of beach cobbles, found in Layer 2 in F4, appear to show opportunistic use. One is a flake-like spall, possibly used as a rough scraper. The other is a significant part of an oval cobble, one end of which, forming a natural bevel, appears to have been used as a rough, probably hand-held, chopper. A similar object from R10/497, a more recently excavated undefended site on Motutapu, was described by Watson (2004: 100) as a heavy pounder or hammer stone.

A number of other chips, spalls and fractured pieces of greywacke, collected during the excavation, appear to have been broken accidentally and left unused. There is no sign of the deliberate flaking of local greywacke and chert, as was seen in the two undefended sites, particularly the Leahy site, where 868 flakes were recovered from the small area excavated during the first season (Leahy 1970: 74). However, only one greywacke flake was found during the subsequent excavation (Leahy 1972: 20), showing that a flaking area can be very localised within a site. The absence of greywacke flakes from the excavated areas does not necessarily mean that this kind of activity was not carried out anywhere on the pā.

Obsidian items

One hundred and seventy-one pieces of obsidian were recovered from the excavation. Many are tiny chips and there are few large items. The distribution of obsidian is very different from that of faunal remains or, indeed, the small number of other artefacts described above, which all came from Area B. More than 70% of the obsidian pieces came from Area A: 115 from Layer 2 and seven from the pit fills. There are 11 pieces from the otherwise largely sterile soil above the infilled pit in Area C. Within Area B, most of the obsidian came from G4: 13 pieces from just under the top-soil, nine from Layer 2 and seven from Layer 3. In contrast, there were only 10 pieces from all layers in E4, E5 and F4 combined. It appears that obsidian is largely associated with areas where there is little or no midden. It is possible that some tiny chips of obsidian escaped notice during excavation of the midden deposits in Area B, but this should not be enough to alter the overall picture of the distribution.

The obsidian assemblage largely consists of detritus or chunks, much of which would have resulted from chipping larger pieces and discarding scraps, but there are also larger pieces that show signs of use. Every piece, regardless of size, was examined under low-power binocular microscope for signs of use-wear and secondary working. Experimental research (e.g. Egeland 2003) has shown that even a tiny piece of obsidian or chert is very effective in butchering a large animal, since the edges can be extremely sharp, easily severing sinews and removing joints of meat. However, the paucity of obsidian in Area B suggests it was not being used in this way.

Although obsidian can be fashioned into such sharp tools or used simply as a flake, it is very brittle, so it is best suited to cutting and scraping softer materials. It can be used for working wood, bone and shell, but acute-angled edges do not last long, and steep angles are more effective. It is therefore not surprising that amongst the obsidian collection quite a few steep-angled tools were found. The term 'tool' is used here not in the formal sense of a specific shape being manufactured before use, but in the sense that a piece of obsidian was used as a tool, taking advantage of high-angled edges. There are also some tools in the collection with more acute-angled edges. Some of these show use marks along concave edges, and qualify as notch-scrapers, sometimes referred to as spokeshaves. Some of the more notable tools are described below:

Area A, Layer 2

AR3598.41 This small tool shows bi-directional micro-flaking along a nose-shaped part of a chunk-shaped piece. Such use-wear results from rotating a tool backwards and forwards by hand while drilling a hole. The tool could have been used to ream out a hole in a piece of shell.

AR3598.34 This small flake terminates in a hinge fracture with a 15° cutting edge to the front surface. Along this edge there is extremely fine micro-flaking. It was probably used as a small knife.

AR3596.20 A tiny flake with a cutting edge of about 5° angle showing extremely fine micro-flaking. It was probably used as a small knife.

Area A, Layer 3

AR3597a This is one of the largest pieces of obsidian: 55 mm wide, 22 mm long and 6 mm thick. It is a wide, short flake with cortex on the outer surface. The flake terminates in a hinge fracture. The top of the flake, where the bulb of percussion would have been, has been snapped off. This snapped edge has one sharper edge of about 20° angle and is 35 mm long. There is very fine micro-flaking along this edge, suggesting use as a knife on some relatively soft material.

Area C

AR3594e A flake that has been snapped into more than two pieces. The original flake terminates in a hinge fracture. One of the two snapped faces has two 90° edges, and both of these show considerable use-wear in the form of micro-flaking. Given the high angle of the edges, a scraping function is suggested, such as scutching flax or scraping wood.

Area B, Layers 1 and 2

AR3588d (Square G4) This small flake has acute-angled edges on both sides, and each displays pronounced micro-flaking. Most of the chipping is unidirectional. This type of use-wear results from a scraping action. The flake would have been used on a harder material, perhaps bone or wood.

AR3574 (Square E5) This small flake has been broken or flaked at the striking platform end, leaving a concave edge that is covered in unidirectional micro-flaking. It has been used as a small spokeshave on some round-sectioned object such as a spear handle.

AR3571 (Square E4) This is a small chunk with a nose-shaped edge at one end. There is unidirectional micro-flaking along this edge. This type of use-wear results from scraping in a groove. The tool could have been used during woodcarving.

Area B, Layer 3

AR3592 (Square G4) This is very similar to item AR3594e from Area C, described above, in that a snapped flake has been used that has two 90° edges, both of which show considerable use-wear in the form of micro-flaking. This is also a scraping tool.

AR3590a (Square G4) This is best described as a chunk rather than a flake. One snapped edge has micro-flaking along one of the 60° edges. This could be a knife for some harder material such as wood.

Discussion

This small artefact assemblage is compatible with assemblages from other Māori sites in the northern North Island that date to the middle and late parts of the prehistoric sequence. Activities on the site probably included fibre-working, limited woodworking, and the repair and maintenance of tools, as well as food processing and, at least occasionally, tattooing. However, the small size of the assemblage could imply brief periods of occupation, rather than more settled residence. The possible use of artefacts made from moa and whale bone is intriguing and may suggest links to the Pig Bay site, where such items were found (Davidson 1978b: 11),

Faunal remains

The main objective in studying the faunal remains was to document the shellfish, fish, bird and mammal foods of the occupants of the site and to explore variability within and between the two main layers in Area B. The great bulk of protein food came from marine environments, and it is therefore worth considering what these might have been.

Allo, who studied the faunal remains from the two undefended sites at Station Bay, described five types of marine environment: 1, the Station Bay beach, which at that time (late 1960s) was stony and exposed to wave action (Fig. 21); 2, the rocky headlands at either end of the beach and along the adjacent coastline; 3, the sheltered and rather muddy beaches on the east and southeast of the island, a rich source of bivalves such as pipi and cockle (*Austrovenus stutchburyi*);[2] 4, the more exposed sandy beaches in the north of the island, where she believed tuatua (*Paphies subtriangulata*) could be found; and 5, the offshore fishing ground (Allo 1970: 83).

In February 2012, Hayward & Morley (2012) carried out a survey of intertidal biota at Station Bay. They reported 113 species of mollusc and eight species of echinoderms, as well as other invertebrates, listing them as abundant, common,

Fig. 21 The Station Bay beach in January 1968, with the pā in the background (photo: Janet Davidson).

frequent, occasional, rare or dead specimens only. The similarities and differences between their survey and the contents of the midden are discussed below.

Midden deposits in the Station Bay pā were largely confined to Area B. Six identifiable fish bones (snapper and elasmobranch) were recovered from Area A. A few very weathered pieces of shell from the same context amounted to about seven pipi, four cat's eyes (*Lunella smaragdus*), and a few possible fragments of mussel (*Perna/Mytilus*) and pāua (*Haliotis* spp.). A single identifiable fish bone was found in Area C, and there was no faunal material in Area D.

The deposits in Area B were different from the more concentrated shell middens, consisting largely of cockles, found on the volcanic cones of Auckland such as Maungarei (Mt Wellington) (Davidson 2011: 62). At the Station Bay pā, faunal remains were scattered through the soil, with concentrations in occasional patches and in the fills of some features.

Methodology

About half the material was processed in Auckland in the early 1970s. In 2012, the remainder (the remaining part of Square F4 and all of E5) was sorted and the previously analysed material checked and mostly rebagged. Bivalves were sorted according to side and all complete hinges counted. A decision was taken at the start to count the umbo of gastropods; in hindsight that was unwise, as some species proved more easily identifiable from the aperture. Rarer species, usually represented only by other fragments, were noted as present and given a minimum number of individuals (MNI) value of 1 in each sample in which they were present. Species such as scallops (*Pecten novaezelandiae*) and pāua may therefore be overrepresented, while some gastropods, notably *Diloma* spp. and *Cominella* spp., are underrepresented. However, in the overall scheme of things, these differences are unlikely to be important.

Fish bones extracted during the first sorting in the 1970s were identified by Leach according to his established methodology (Leach 1986) and included in his reviews of pre-European Māori fishing (Leach & Boocock 1993; Leach 2006). The remaining fish bones were identified by the same procedure in 2011, using the comparative collection in the Archaeozoology Laboratory at the Museum of New Zealand Te Papa Tongarewa (Te Papa). The combined data sets are presented here.

Bird and mammal bones were identified by Ian Smith and Sheryl McPherson (see Appendix 1).

Shellfish

The relatively large bulk sample from near the base of Layer 2 in Square F4 (AM448) provided the starting point for the present study (Table 2). This yielded most of the species represented in the deposits on the site and was large enough to give an indication of relative abundance. It was apparent that the occupants of the pā were gathering shellfish from the nearby rocky shore but also from both protected, and to a lesser extent open, beaches (in the terms of Morton & Miller 1968: 445). The bulk sample also contained some fish bones and otoliths, discussed below, and 151 g of small pieces of unworked stone.

Table 3 compares the relative abundance of all shells recovered from the midden with their relative abundance in the bulk sample AM448 and their representation in the survey by Hayward & Morley (2012).

In several cases, specimens of one genus from similar habitat have not been identified to species. Thus limpets of the genus *Cellana* probably include both *C. radians* and *C. ornata*; the thaids of the genus *Cominella* include *C. maculosa*, *C. virgata* and probably a few examples of *C. adspersa*; the topshells of the genus *Diloma* are predominantly *D. aethiops* but probably also include *D. arida*. All of these molluscs are likely to have been collected from the rocky shore in the vicinity of the pā.

Every attempt was made to distinguish between the blue mussel (*Mytilus*) and the green mussel (*Perna*), using difference in hinge form and/or colour when preserved, but this was not always possible. In summarising relative abundance, all mussels have been grouped together. Neither the large horse mussel *Atrina* nor the smaller mussel *Modiolus* has been identified in the midden, but either or both may be present in very small numbers among the fragile fragments.

The small oysters in the bulk sample AM448 were identified by Bruce Marshall (Te Papa) as *Ostrea capsa*. Most of the oysters from the site appear to be of this species, although examples of the northern rock oyster (*Saccostrea cucullata glomerata*) are also present.

The rocky shore component of the midden centres on the cat's eye, which is the most abundant species in all contexts except the small and aberrant sample from G4 (Tables 4 and 5). Other consistently appearing species are its predators, including *Cominella* spp., the rock shells *Dicathais orbita* and *Haustrum haustorium*, and fellow browsers *Diloma* spp. The mussels and rock oysters also come from this

Table 2 Relative abundance of shells in the bulk sample AM448 from Station Bay pā.

Taxon	Element	No.	MNI	%
Lunella smaragdus	Umbo	577		
	Operculum	744	744	36.7
Austrovenus stutchburyi	L valve	532	532	26.2
	R valve	489		
Mytilus edulis galloprovincialis	L valve	145		
	R valve	134		
Perna canaliculus	L valve	23		
	R valve	23		
Perna/Mytilus spp.	L valve	10		
	R valve	8		
Total mussel	L valve		178	8.8
Diloma aethiops	Umbo	139	139	6.5
Nerita (Lisanerita) melanotragus	Umbo	72	72	3.6
Prototthaca crassicosta	L valve	54	54	2.7
	R valve	45		
Paphies australis	L valve	35		
	R valve	37	37	1.8
Gari stangeri	L valve	34		
	R valve	37	37	1.8
Cominella spp.	Umbo	9	9	<1.0
Dicathais orbita	Umbo	8	8	<1.0
Haustrum haustorium	Umbo	6	6	<1.0
Paphies subtriangulata	R valve	3	3	<1.0
Dosina zelandica	R valve	2		
	L valve	2	2	<1.0
Paphirus largillierti		1	1	<1.0
Cookia sulcata	Fragment	1	1	<1.0
Total edible			**1823**	**89.9**
Maoricrypta monoxyla	Whole shell	157	157	7.7
Ostrea capsa	Upper valve	36	36	1.8
Haustrum scobina	Whole shell	6	6	<1.0
Patelloida corticata	Whole shell	1	1	<1.0
Paratrophon quoyi	Whole shell	1	1	<1.0
Coelotrochus viridis	Whole shell	1	1	<1.0
Eudoxochiton nobilis	Plate	1	1	<1.0
Echinocardium cordatum	Fragment	1	1	<1.0
Novastoa lamellosa	Cluster		1	<1.0
Total inedible			**205**	**10.1**
Total MNI			**2028**	

Table 3 Relative abundance (per cent) of shells in the bulk sample and total collection from the Station Bay pā, compared with the modern survey of the bay by Hayward & Morley (2012) (abbreviations: **a**, abundant; **c**, common; **f**, frequent; **o**, occasional; **r**, rare; **d**, dead; **x**, not present).

	Modern sample	AM 448	Total collection
Gastropods			
Alcithoe spp.	d	—	<1
Calliostoma (Maurea) punctulata	x	—	<1
Cellana spp.	f, o	—	<1
Coelotrochus viridis	d	<1	<1
Cominella spp.	c, d, o	<1	<1
Cookia sulcata	x	<1	<1
Dicathais orbita	x	<1	<1
Diloma aethiops	c, f	6.5	5.6
Haliotis iris	x	—	<1
Haustrum haustorium	o	<1	<1
Haustrum scobina	o	<1	<1
Lunella smaragdus	a	36.7	37.3
Maoricolpus roseus	d	—	<1
Maoricrypta costata	f, o	—	<1
Maoricrypta monoxyla	a	7.7	4.3
Nerita (Lisanerita) melanotragus	a	3.6	1.4
Paratrophon quoyi	x	<1	<1
Patelloidea corticata	x	<1	<1
Penion spp.	d	—	<1
Sigapatella novaezelandiae	c	—	<1
Struthiolaria spp.	x	—	<1
Unidentified		—	<1
Vermetidae	x	<1	<1
Bivalves			
Austrovenus stutchburyi	f	26.2	16.9
Dosina zelandica	d	<1	<1
Gari stangeri	d	1.8	<1
Mytilus edulis galloprovincialis	o	7.1	10.1
Mytilus/Perna	n/a	0.5	1.3
Nucula hartvigiana	x	—	<1
Ostrea capsa	Not listed	1.8	1.3
Paphies australis	o	1.8	9.5
Paphies subtriangulata	x	<1	1.8
Paphirus largillierti	d	<1	<1
Pecten novaezelandiae	d	-	<1
Perna canaliculus	o	1.1	3.2
Protothaca crassicosta	d	2.7	<1
Saccostrea glomerata cucullata	a	—	<1
Tucetona laticostata	x	—	<1
Echinoderms			
Echinocardium cordatum	d	<1	<1
Evechinus chloroticus	f	—	<1
Chitons			
Eudoxochiton nobilis	x	<1	<1
Total MNI		**2028**	**13775**

environment, as do the very rare examples of *Coelotrochus viridis* and *Maurea punctulata.* Also from rocky environments are *Cellana* spp., *Nerita (Lisanerita) melanotragus*, *Penion* spp. (probably *P. sulcatus*, identified only from columella and whorl fragments), the heart urchin *Echinocardium cordatum*, the common sea egg or kina (*Evechinus chloroticus*), and the chitons.

The Cook's turban shell and pāua are rocky shore dwellers, although neither was recorded in Station Bay by Hayward & Morley (2012). Pāua are apparently not present in the Auckland region today (B. Hayward, pers. comm., 13 August 2012). Small turbans are often associated with cat's eyes, while larger ones are found under intertidal rocks (Morton & Miller 1968: 81). The iridescent shells of turbans and pāua were sometimes used for artefacts such as fishhooks and pendants, and it is possible that some of these shells were brought to the site at least partly for this purpose. However, the presence of the opercula of turbans may argue against this suggestion for that species.

A significant number of small shells in the midden (MNI 826, 6.3% of total MNI) are probably incidental by-products of gathering from this rocky shore. Particularly numerous are the slipper limpets *Maoricrypta monoxyla*. These, along with the rarer examples of other slippers *Maoricrypta costata* and *Sigapatella novaezelandiae*, would have arrived in the site attached to cat's eyes and mussels in particular. Other probable by-products are the small carnivores *Haustrum scobina* and *Paratrophon quoyi*, and the small limpet, *Patelloida corticata*. The small oysters, *Ostrea capsa*, also attach to shells; examples were noted on *Haustrum*, mussel and pāua shells, and 34 examples were counted on two large white rock shells (*Dicathais orbita*) from one context. The vermetid worm *Novastoa lamellosa* and some extremely small cat's eyes are probably also incidental.

The principal species not from the rocky shore are the cockles and pipi, both of which live on protected beaches. Both are present in Station Bay now, although small and infrequent, but were not seen at the time of the excavations, when it was assumed that those in the middens of the excavated sites had probably been brought from the extensive sheltered areas of Islington Bay and Gardiner Gap on the other side of the island, adjacent to Rangitoto. Haywood and Morley mention a sand ridge that now provides a sheltered habitat in Station Bay for these species. Whether this has come and gone over the years and was present at the time the pā was occupied unfortunately has not been determined.

One indication of its past existence may be the presence of *Gari stangeri* in the midden; this species is seldom reported from archaeological sites but is noted by Hayward & Morley (2012) as present today on the sandbank. Associated with cockles and pipi may have been the volute *Alcithoe*.

Almost certainly not from a protected environment is the tuatua, which lives on exposed sandy beaches. This shell is consistently present in small numbers in all contexts, but is relatively more important in Layer 3. The nearest definite source would have been the open beaches of Takapuna and Milford on the mainland. Allo (1970: 83) thought tuatua were present on beaches on the north of Motutapu, while Szabó (1999: 14), who studied faunal remains from sites closer to these beaches (see below), thought there were no tuatua there, but that they could be found on the eastern beaches. I am inclined to think that there were never any tuatua on Motutapu beaches. Possibly associated with tuatua would be *Dosina zelandica* and *Alcithoe* spp.

The source of the remaining non-rocky shore species is more difficult to pinpoint. Morton & Millar (1968: 566) mention *Gari stangeri*, *Maoricolpus roseus*, *Paphirus largillierti* and *Protothaca crassicosta* as dwellers in harbour channels (at what appear to be unsuitable locations for gathering), while *Protothaca* is also shown as a borer in the Waitemata sandstone that forms the southern and eastern parts of Motutapu Island (Morton & Millar 1968: 245). Since dead examples of all of these shells were found by Hayward & Morley (2012), it is possible that they were formerly available in or near Station Bay. In the 1970s, the bay provided what was probably a suitable environment for *Protothaca crassicosta*. *Gari stangeri* and *Paphirus largillierti* may have been associated with pipi. *Maoricolpus roseus* could be a by-product of this association.

There are both marked similarities and striking differences between the content of the midden and the biota present in the vicinity of Station Bay today. Of the principal species gathered, cat's eyes are 'abundant' and cockles 'frequent' today, while pipi and mussels are 'occasional', and tuatua are absent. Of the slippers, *Maoricrypta monoxyla* is abundant, as might be expected, while *M. costata* and *Sigapatella novaezelandiae* are, respectively, frequent and common, although a modern sample of cat's eyes collected from the bay in February 2012 by Hayward & Morley (2012) yielded only *M. monoxyla*.

Missing from Station Bay today on the basis of this one survey and therefore rare, if in fact present, are the significant rocky shore species turban, pāua and white rock shell, as well as some minor species. As noted above, turbans and pāua could have been collected as raw material, but the white rock shell was a consistent part of the rocky shore contribution to diet. The rock oyster is abundant in the bay today and the kina is frequent, and both are of edible size (B. Hayward, pers. comm., 13 August 2012). Both are, however, rare in the midden. This could suggest that these now prized food species had been largely eliminated locally by overgathering at the time the pā was occupied.

The data were examined for variations within and between layers, focusing on rocky shore and soft shore gathering. Tables 4 and 5 show the relative abundance of the most common species by square and layer (including subdivisions of Layer 2), and the proportions of rocky shore and soft shore species. It is interesting to note that the bulk sample AM448 has almost identical proportions of rocky to soft shore species as the total sample, although there is some variety in the actual species represented. There is enough variation between squares and between sub-samples to suggest that meal contents varied from day to day; it would be unwise to suggest any real chronological changes.

There have been several previous analyses of shells from sites of various ages on Motutapu. Allo (1970) studied the relatively small samples from the two undefended sites on the ridges on the western side of Station Bay. In both she found that soft shore shellfish dominated, although there was also a rocky shore component. Whereas pipi were most numerous at the Davidson site followed by cockle, tuatua dominated at the Leahy site, again followed by cockle. Allo tentatively suggested that this may have reflected different periods of occupation of the two sites. Based on the environmental conditions in Station Bay in the late 1960s, she assumed that the cockles and pipi did not come from there, but from the protected beaches on the western side of the island, and the tuatua from more open beaches on the north side of the island.

The pā midden is different again, with rocky shore species – headed by cat's eye and followed by mussels – dominating in almost all contexts. Cockles were more numerous than pipi, and tuatua much less significant. The exception is the small samples from Layer 2 and Layer 3 in G4, where pipi were the dominant species in both. As Layer 2 was very thin in G4, it is possible that most, if not all, of the shell collected from this square should have been assigned to Layer 3.

Elsewhere on Motutapu, Nichol (1988) carried out a major study of shell (and other faunal remains) at the Sunde site on the west of the island. The 'oyster lens' below the ash from the Rangitoto eruption was dominated by rock oysters,

Table 4 Relative abundance (per cent) of principal shell species and habitat at the Station Bay pā by square.

	AM448	F4	E4	E5	G4	Total
Lunella smaragdus	36.7	37.1	37.7	38.2	25.9	37.3
Austrovenus stutchburyi	26.2	12.4	18.3	15.0	2.6	16.9
Paphies australis	1.8	20.4	6.9	7.4	44.6	9.5
All mussels	8.8	8.5	16.3	16.9	7.5	14.6
Diloma spp.	6.9	5.4	3.9	7.0	0.5	5.6
All slipper shells	7.7	0.9	4.9	4.7	0.3	4.4
Paphies subtriangulata	0.1	5.7	0.9	1.3	6.5	1.8
Subtotal	88.2	90.4	88.9	90.5	87.9	90.1
All others	11.7	9.6	9.4	9.5	12	9.9
Total MNI	2028	2175	4252	4936	389	13780
% rocky shore species	67.2	58.8	72	74.3	42.2	67.5
% soft shore species	32.8	41.2	28	25.7	57.8	32.5

Table 5 Relative abundance (per cent) of principal shell species and habitat at the Station Bay pā by layer.

	L2 main*	L2 ashy	L2 other	L3	Total
Lunella smaragdus	34.5	46.1	32.9	37.4	37.3
Austrovenus stutchburyi	24.2	9.8	19.7	5.0	16.9
Paphies australis	7.8	3.2	6.2	25.3	9.5
All mussels	12.5	16.7	21.4	8.9	14.6
Diloma spp.	5.0	10.0	2.8	4.2	5.6
All slipper shells	4.4	6.1	4.1	1.2	4.4
Paphies subtriangulata	0.5	0.4	0.8	8.1	1.8
Subtotal	88.9	92.3	87.9	90.1	90.1
All others	11.1	7.7	12.1	9.9	9.9
Total MNI	5757	3062	2653	2308	13780
% rocky shore species	58.9	84	68	58.7	67.5
% soft shore species	41.1	16	32	41.3	32.5

*Includes bulk sample AM448.

with significant secondary components of mussels and kina (Nichol 1988: 233), while the apparently disturbed post-eruption deposits were dominated by pipi followed by cockles, with a very minor component of rock oysters and almost no mussels (Nichol 1988: 389).

Szabó (1999) explored the concept of optimal foraging through examination of three sites on Motutapu: the Sunde site as documented by Nichol, and two more recently excavated undefended sites in the northwest of the island, R10/494 and R10/497. In the relatively small assemblages from these two sites there were hardly any oysters, and mussels were fifth in rank order. At R10/494, cat's eyes were first, followed by pipi, tuatua and cockle in that order. At R10/497, the order was cockle, cat's eye, pipi and tuatua. There was variability in relative abundance within both these sites, and also an important difference in size of pipi between midden dumps (smaller) and fill of features (larger). Szabó attributed this to the gathering of smaller shells in the

immediate vicinity and larger ones from further afield, possibly during excursions for other activities.

It is unfortunate that the chronology of these sites on Motutapu is not well defined, so the possible effect of time cannot be gauged, except in the distinction between pre- and post-eruption deposits. The Sunde site stands out from the others in the remarkable content of the pre-eruption oyster lens. Never again could oysters, kina and mussels have been available in such abundance. Szabó (1999: 47) speculated that the ash fall may seriously have affected the oysters and kina, but it is likely that human impact was a factor in their failure to recover.

The post-eruption deposit at the Sunde site, studied by Nichol, also stands out in its complete dominance of pipi and cockle. This site is closer than the other five to the probable source of these shellfish in the protected shores created by the eruption in what are now Islington Bay and Gardiner Gap. In Szabó's 1999 study, both the pre- and post-eruption deposits met her criteria for optimal foraging.

The composition of the shell midden at the Station Bay pā and in-site variations in relative abundance in the other five sites suggest that people were gathering from several locations, perhaps taking advantage of trips to different parts of the island for other purposes to gather non-local shellfish. But as Szabó (1999: 54) pointed out, it is difficult to pursue such arguments very far, when our understanding of what may have been in the local environment at the time is derived from what is in the midden, rather than from independent evidence. The question of whether the cockles and pipi in the midden of the Station Bay pā were gathered locally or not may never be answerable. The variation within Layer 2 at the Station Bay pā is a further warning against basing conclusions about chronological change or optimal foraging on small samples.

Nichol (1986: 195; 1988: 99) suggested that the relative proportions of shells to opercula of cat's eyes in middens may indicate processing and removal of the meat with opercula still attached. This would require the more difficult removal of raw animals from their shells, as the operculum is easily detached by slight steaming. It is most probable that the shellfish brought to the Station Bay pā were eaten there rather than processed for preservation and later consumption elsewhere. Even so, it is worth considering the possibility of processing. The relative proportions of shells and opercula in the midden were highly variable. Overall, there were fewer opercula, but in some of the larger samples, particularly, opercula considerably outnumbered shells. Preservation as proposed by Nichol appears to be ruled out, although the differential distributions raise interesting questions about processing and dumping.

Shell size

Size-frequency distributions of shells from archaeological sites can provide information on gathering practices, suggest possible changes in natural populations and are used in calculations of the meat weight a particular species contributed to diet at a site or sites.

Nichol (1988: 400) measured shells of cockle and pipi from above the ash at the Sunde site, using the length of the resilium to estimate the maximum dimensions of broken shells. He measured other species from below the ash at the Sunde site and from other sites, including cat's eyes from sites in Northland and Coromandel, where he demonstrated a relationship between operculum length and shell length (Nichol 1988: 52, 101). His samples were relatively small and he graphed his results by 5 mm blocks.

Szabó (1999: 20) measured shells as part of her focus on gathering practices and selection in two undefended sites on Motutapu, avoiding links to human predation or any other causes of size variation. Like Nichol, she used resilium length to estimate sizes of pipi from fragments from both R10/494 and R10/497. She measured shells of cat's eyes from R10/494, using the dimension of shell height to investigate possible selection for or against juvenile specimens (which are recognisably different), but found that size appeared to be the main criterion for selection. She noted the presence of some very large shells.

Unfortunately, pipi from Station Bay pā are too few and too widely dispersed among a number of relatively small sub-samples to be worth measuring. Sub-samples of the two most abundant species, cat's eyes and cockles, were selected for measurement.

The shell of the cat's eye is not very dense, being rich in a protein known as conchiolin, and is frequently broken when found in middens. It is therefore not easy to measure. However, it has a dense calcareous operculum, which usually survives intact in archaeological deposits and is ideal for calculating MNI and estimating live animal size. Although Nichol (1988: 52) had previously demonstrated an allometric relationship between operculum size and shell size, his sample was small. A modern comparative collection was made for the present study. Live specimens were collected at various localities: Ngakuta Bay in the Marlborough Sounds (n = 49, mainly small), the northern (n = 51) and southern (n = 75) ends of Station Bay, Hobson Bay in

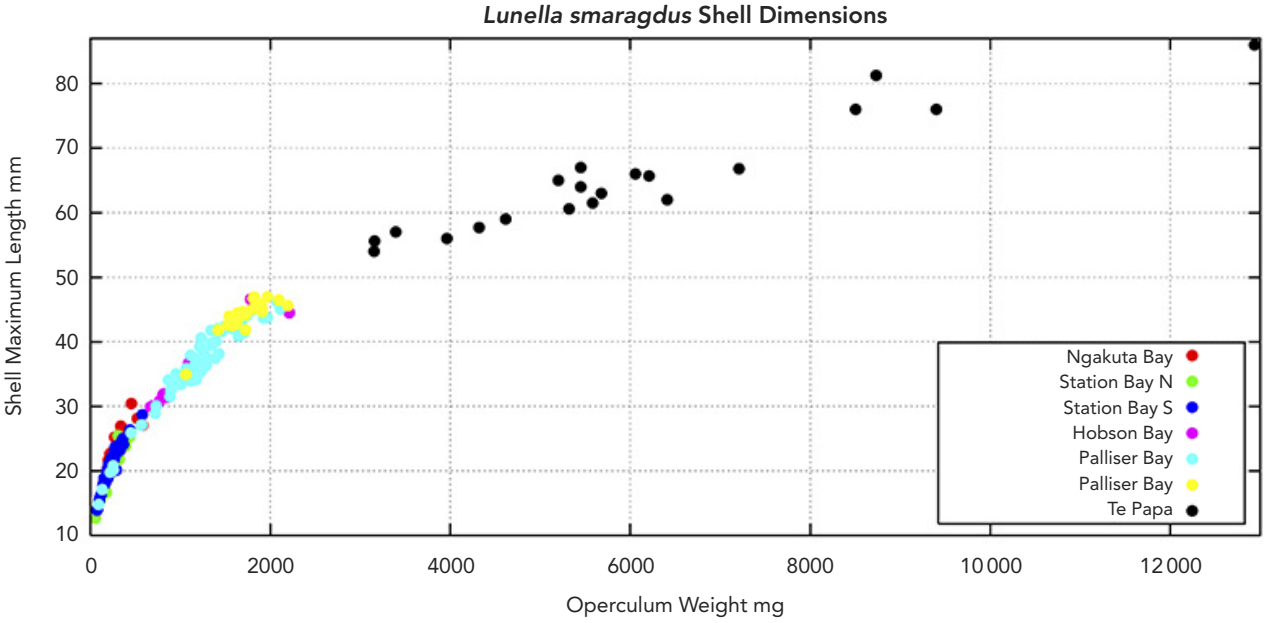

Fig. 22 The cubic relationship between operculum weight and shell size of cat's eyes (*Lunella smaragdus*).

Auckland (n = 9, mostly large), and Palliser Bay southeast of Ngawi Point (n = 64 and n = 21). A further 20 very large specimens in the gastropod collection at Te Papa, nearly all from the south of the South Island, were added to make a total sample of 289.

This comparative collection was measured and weighed as follows. The whole shell was placed on a flat surface and digital callipers were used to measure the maximum diameter in the plane of the flat surface (maximum length in millimetres recorded to two decimal places). The maximum length of the operculum was similarly obtained, and it was then weighed with a precision of 1 mg. The relationships between these two operculum dimensions and the live shell size are illustrated in Figs 22 and 23.

The range of dimensions in the comparative collection was: shell length 12.6–86.0 mm, operculum length 5.5–25.2 mm, and operculum weight 55–12,936 mg. This fairly represents the full range that could be found in archaeological sites. Least squares analysis was carried out between pairs of the three dimensions to provide suitable allometric equations that could be used to estimate live shell length from operculum measurements. The relationship between a linear dimension and weight requires a power curve fit, and analyses of real data invariably find a power within a margin of statistical variation ≈ 3.0. There are good theoretical reasons why this should be a cubic function, so a value of ≡ 3.0 is chosen here.

The linear regression equation is:

Shell length mm = 2.369 * operculum length mm + 0.792 ± 1.3 mm

Correlation coefficient = 0.995 (student's t = 174.6)

The cubic regression equation is:

Shell length mm = 3.718 * (operculum weight mg)$^{1/3}$ – 1.80 ± 1.4 mm

Correlation coefficient = 0.995 (student's t = 162.6)

In both cases, the correlation coefficient is very high and the standard error of the estimate is very low. Therefore, either of these equations could be used with excellent results when estimating original shell size from the operculum. A Sartorius top-loading balance, model BAS01S, with a precision of 1 mg was available, and was found to be much faster than digital callipers for measuring archaeological specimens of opercula.

Cat's eyes from four contexts in the Station Bay pā were studied and characterised according to stratigraphic position within the site: the top of Layer 2 in E5 (late), the ashy midden at the base of Layer 2 in E5 (middle 1), the bulk sample from the base of Layer 2 in F4 (middle 2), and the total number dispersed throughout Layer 3 in the four squares (early). These may be meaningfully examined to test for potential changes through time. The two middle samples are especially useful because they are both from the base of Layer 2 but spatially separate. They can therefore

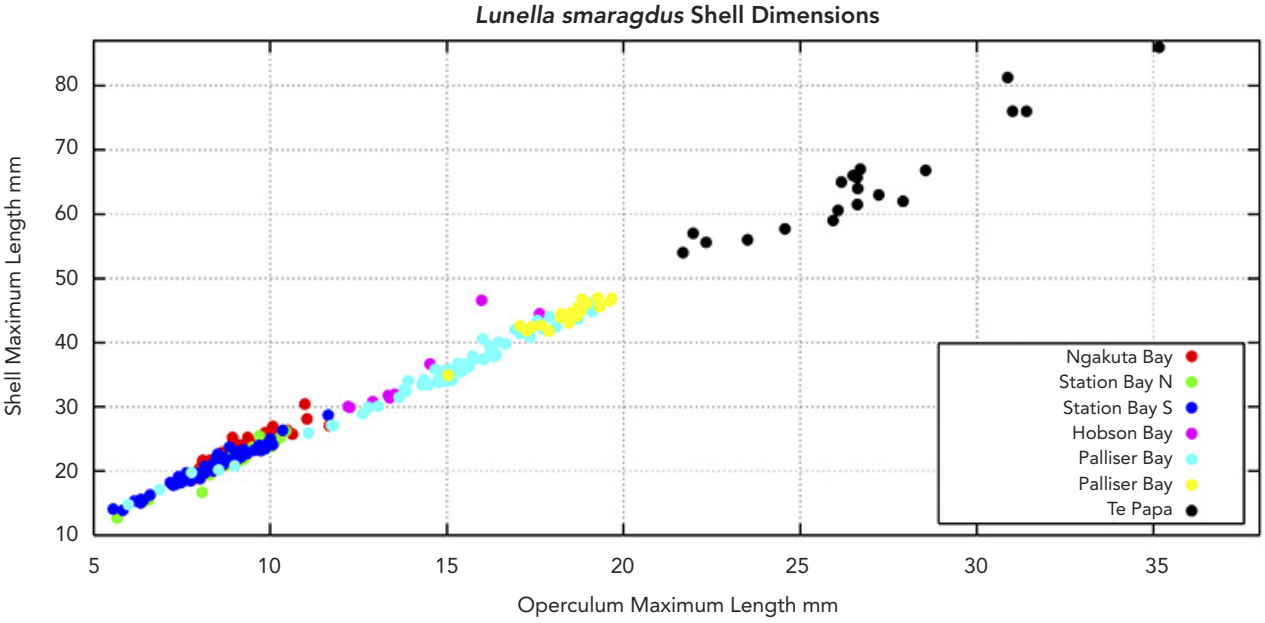

Fig. 23 The linear relationship between operculum length and shell size of cat's eyes (*Lunella smaragdus*).

Table 6 Dispersion statistics for modern and archaeological samples of *Lunella smaragdus*.

						Skewness	Kurtosis
Sample	No.	Range	Mean	SD	Coef. Var.	g1/w1	g2/w2
Modern	126	12.7–28.7	21.0 ± 0.2	2.7 ± 0.2	12.8 ± 0.8	-0.6/3.5	3.9/2.3
Late	544	13.1–48.7	28.3 ± 0.3	6.5 ± 0.2	23.0 ± 0.7	0.5/6.8	3.0/0.1
Middle 1	852	11.1–48.2	26.6 ± 0.2	5.6 ± 0.1	21.1 ± 0.5	0.8/10.5	3.8/4.6
Middle 2	741	16.4–41.7	24.6 ± 0.2	4.7 ± 0.1	19.1 ± 0.5	0.8/10.0	3.1/0.7
Middle all	1593	11.1–48.2	25.7 ± 0.1	5.3 ± 0.1	20.7 ± 0.4	0.8/15.0	3.8/6.2
Early	313	10.5–61.1	28.3 ± 0.4	7.3 ± 0.3	25.9 ± 1.0	0.7/6.0	4.2/4.4
Black Rocks	248	20.4–55.2	40.4 ± 0.4	6.8 ± 0.3	16.8 ± 0.8	0.6/4.9	2.8/0.6

help to define the range of variation that can be expected within a similar time period. This in turn helps to define a baseline against which to examine potential changes through time. The late sample was physically above the Middle 1 sample.

The opercula from these four samples were weighed and the equation above used to estimate original live shell size. The two middle samples were also combined for comparison with the others. The modern sample from Station Bay collected by Hayward & Morley (2012) and a grab sample from the archaeological site known as the Black Midden, BR3, at Black Rocks in Palliser Bay were included for comparison. After shell size was estimated from the opercula, the dispersion statistics were calculated and are presented in Table 6.

The student's *t*-test was carried out on all pairs of means of these samples. All values except one are highly significant ($p < 0.01$). The exception is the means of the late and early

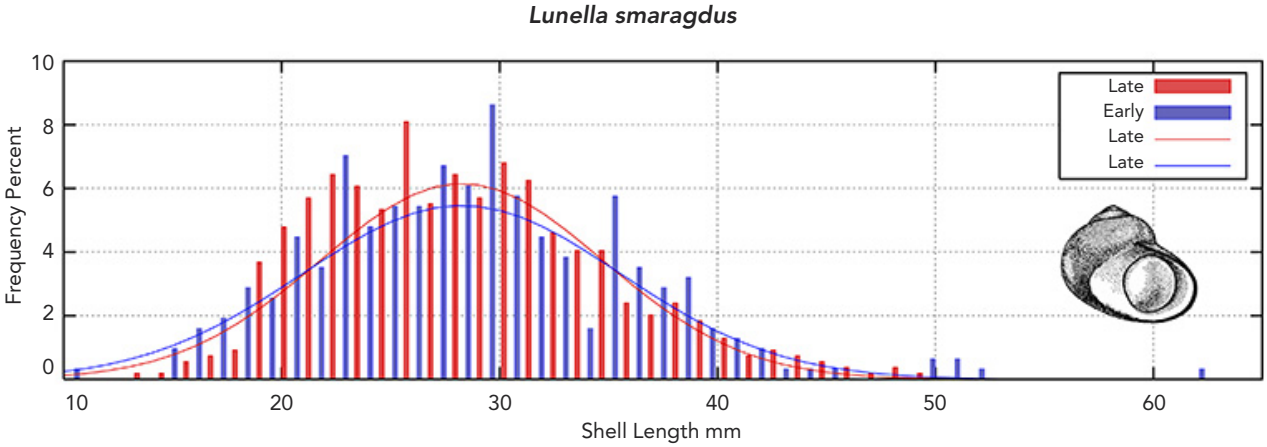

Fig. 24 Estimates of live shell size of cat's eyes (*Lunella smaragdus*) from the early and late horizons at the Station Bay pā, showing slight differences in size-frequency curves.

samples, which are not significantly different (p = 0.05). These results are most interesting and suggest that catches vary considerably in size over short periods and, in the case of the two middle samples, from one place to another in the same horizon. One would therefore have to observe a considerable difference in mean size between two samples to be sure that this indicated an effect on the biological population of this species, such as might result from human predation pressure. This is also reflected in the coefficients of variation, which are all high, varying from 19% to 26%. Two results do stand out, however: one is that specimens in the modern sample from Station Bay are certainly smaller than others, and the other that those from Black Rocks are by far the largest. With one exception, the normality statistics g1 and g2 are all significant at various levels (w1 and w2). This is typical of archaeological samples of shell, which seldom display normal size-frequency distributions. This is usually because humans preferentially harvest larger specimens wherever possible, which results in positive skewness (g1 > 0) and positive kurtosis (g2 > 3).

In spite of the identical mean values of the early and late samples, there are subtle differences, which are clearer when size-frequency curves are examined (Fig. 24).

The early sample shows a far wider distribution than the late one, with several shells larger than 50 mm and one that is 61 mm. Nothing approaching this size is present in the late sample or in the modern environment at Station Bay. Such shells are more comparable to the very large specimens in the gastropod collection at Te Papa. Another difference in these two curves is a greater central tendency in the early sample, reflected in significant leptokurtosis in Table 6. This is what results from selective harvesting by size. By contrast, the late sample has a mesokurtic shape. Overlain on this size-frequency graph are the two pure Gaussian curves that have the same means and standard deviations as the two archaeological samples, but have normal skewness and normal kurtosis.

Finally, a comment should be made about cat's eyes as food. The shells need to be only lightly steamed before the meat can easily and quickly be removed by piercing it with a sharp stick and rotating it from the shell. The flavour is quite strong and slightly bitter, and not popular with everyone.

There were insufficient cockles from the site to explore possible variations in cockle size through time. A combined sample from secure Layer 2 contexts was measured for comparison with cockle samples from the volcanic cone of Maungarei (Mt Wellington) in the east of the Tamaki Isthmus within sight of Motutapu (Fig. 1) and two other more distant sites in the North Island. Kauri Point is in the western Bay of Plenty north of Tauranga and Pauatahanui is an inlet of the Porirua Harbour north of Wellington. The Station Bay sample consisted of 574 left valves: 152 from the bulk sample AM448 and 422 from 15 smaller sub-samples taken from the ¼ in (6.35 mm) sieve from throughout Layer 2. Measurements were taken with digital callipers and captured electronically in a database. The measurement used was maximum shell length as defined by Williams *et al.* (2008).

Dispersion statistics were calculated and are presented in Table 7, together with similar results from three other archaeological sites for which comparable data are available. A two-tailed t-test was carried out on each pair of mean

Table 7 Maximum-length statistics for cockles (*Austrovenus stutchburyi*) from the Station Bay pā.

Site	No.	Range	Mean	SD	Coef. Var.	Skewness g1/w1	Kurtosis g2/w2
Maungarei	2049	10.3–43.0	20.0 ± 70.1	3.1 ± 0.0	15.1 ± 0.2	0.6/13.9**	1/19.2**
Kauri Point	1123	11.0–42.0	22.9 ± 0.1	4.8 ± 0.1	21.0 ± 0.4	0.5/9.4**	2.7/2.1*
Station Bay	574	11.9–37.4	24.2 ± 0.1	3.6 ± 0.1	15.1 ± 0.4	0.2/4.8**	3.4/1.8*
Pauatahanui	5753	15.1–66.0	38.4 ± 0.1	5.4 ± 0.1	14.2 ± 0.1	0.7/25.7**	4.4/21.6*

*Denotes significant at $p = 0.05$. ** Denotes significant at $p = 0.01$.

values. The *t* results are: 1/2 = 3.8, 1/3 = 21.2, 1/4 = 179.1, 2/3 = 6.3, 2/4 = 96.9, 3/4 = 85.4. The numbers 1/2 etc. refer to the numbers allocated to the sites in Table 7. Each of these is significantly different ($p = 0.01$). In spite of these individual differences, the most striking aspect of cockle size is just how small cockles from the three northern North Island archaeological sites are compared to those from Pauatahanui (Fig. 25). These northern sites date to the latter half of the pre-European period, so the small size may reflect a biological response of the species to a long period of sustained human predation. Unfortunately, it is not yet possible to test this hypothesis, since there are no archaeological samples from substantially earlier contexts in the same areas. It is hoped that future archaeological research will shed light on this.

It can be seen in Table 7 that each archaeological sample of cockles displays marked non-normal characteristics. That is, they all have both significant positive skewness and significant positive kurtosis. Positive kurtosis, also described as a leptokurtic shape, refers to a very strong central tendency, characteristic of a harvesting strategy that is strongly biased towards a certain size. In this case it is towards large specimens (strong positive skewness), deliberately rejecting smaller-sized specimens.

As noted above, it is not at present possible to say where the cockles in the Station Bay pā came from, although it seems most likely that they came from the other side of the island, from the extensive cockle beds at Islington Bay and Gardiner Gap. The small sample of cockles Nichol measured from the disturbed post-eruption layers he excavated at the Sunde site, very close to this resource (Nichol 1988: 400), shows a similar size range to the Station Bay sample, although the data are not directly comparable.

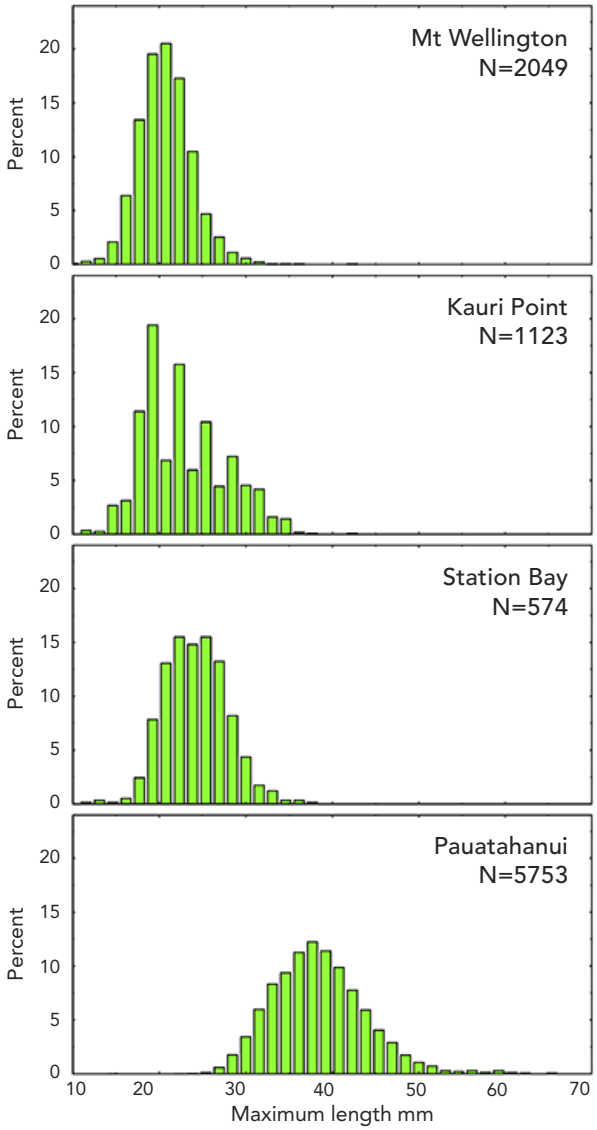

Fig. 25 Size-frequency distributions of cockles (*Austrovenus stutchburyi*) from the Station Bay pā and three other North Island archaeological sites.

Discussion

The above discussion has been primarily concerned with what shellfish the occupants of the Station Bay pā were gathering and where they were getting them from. However, shells as well as other fauna in archaeological sites have the potential to contribute knowledge to fields other than prehistory. Rowland's study of the limpet *Cellana denticulata* in Coromandel middens began as an investigation of whether this species might be a useful chronological marker for archaeologists, but led him to conclude as follows:

> It would not seem presumptuous to consider that archaeology can contribute to understanding the modern population dynamics of species from the information stored in prehistoric middens or that the archaeologist can assist the zoologist in studying past distribution of species. This study further emphasises the long-term and cumulative effects of human pressure on shellfish resources that must be taken account of by zoologists investigating current species' distributions. (Rowland 1976: 14)

More recently, Szabó (2001) suggested that the gastropod *Nerita (Lisanerita) melanotragus*, a species susceptible to changes in temperature, might provide evidence of climatic fluctuations: specifically, that its absence from the undefended site R10/497 on Motutapu Island, in contrast to known earlier and probably later sites, might be indicative of a period of cooler temperature.

Szabó's carefully framed argument was challenged by McFadgen & Goff, who concluded (2001: 316): 'This rare intertidal gastropod is erroneously used as an indicator of palaeoclimatic conditions and to provide "evidence" for prehistoric temperature fluctuations. A far more likely explanation is that regular indiscriminate shellfish gathering temporarily exhausted a scarce resource, although fluctuations of the EAUC [East Auckland Current] have undoubtedly played a role in the presence or absence of *N.[erita] atramentosa [now Nerita (Lisanerita) melanotragus]*.'

It is worth commenting that although *Nerita (Lisanerita) melanotragus* accounts for only 3.6% of the bulk sample AM448 at the Station Bay pā and a mere 1.5% of the total sample from the site, it is present in small numbers in almost all contexts and layers. This casts some doubt on the suggestion that 'regular indiscriminate shellfish gathering' might temporarily exhaust this supposedly scarce resource. It should also be noted that although, as McFadgen & Goff point out (2001: 315), *N. (L.) melanotragus* was present above the Rangitoto ash in Scott's excavation at the Sunde site, it was present only in the two most recent of the four layers above the ash, and not in the lower two, which might be expected to correspond to the time when Szabó suggests the species might have been very rare or absent in the vicinity. The possibility of significant fluctuations in the presence of *N. (L.) melanotragus* in the Auckland area should not be rejected out of hand.

Distinguishing between the effects of environmental change and human impact will not be easy, but there is no doubt that well-curated archaeological collections in long-term storage have great potential for further studies, including some not envisaged at the time the archaeological material was collected, as Rowland (1976: 14) implied.

Table 8 Relative abundance of fish from the Station Bay pā by family.

Family: common name	NISP	MNI	MNI %
Sparidae: snapper	899	236	68.41 ± 5.1
Triglidae: gurnard	65	35	10.14 ± 3.3
Chondrichthyes: sharks, etc.	53	24	6.96 ± 2.8
Gemphylidae: barracouta	24	16	4.64 ± 2.4
Arripidae: kahawai	13	10	2.90 ± 1.9
Carangidae: trevally, kingfish, mackerel	8	7	2.03 ± 1.6
Mugiloididae: blue cod	6	6	1.74 ± 1.5
Labridae: spotty, etc.	7	6	1.74 ± 1.5
Zeidae: John Dory	4	4	1.16 ± 1.3
Osteichthyes: ?species	1	1	0.29 ± 0.7
Totals	1080	345	100%

Fish

A minimum number of 345 fish were identified, suggesting that fish were the main contributor of protein to the diet of those who occupied the pā. The number of identified specimens (NISP) was 899. As might be expected in this part of New Zealand, snapper were by far the most common species, followed by gurnard (Table 8 and Fig. 26). Fish bones from the large bulk sample were inadvertently excluded from the analysis. Fourteen identifiable bones, all snapper, were present. An MNI of three fish was represented by three right pre-maxillas. Surprisingly, however, 14 otoliths were present in the sample; only one other otolith was recovered from the site. A small number of identifiable

Table 9 Anatomical parts identified for snapper (Sparidae).

Anatomy	NISP
Left dentary	125
Right dentary	107
Left articular	62
Right articular	53
Left quadrate	44
Right quadrate	51
Left pre-maxilla	123
Right pre-maxilla	149
Left maxilla	95
Right maxilla	90

fish bones were missorted as mammal bones. These, too, were not included in the analysis described below.

There is relatively little comparative information about fish remains from sites in the Auckland region. The pioneering study of Galatea Bay on Ponui Island produced an MNI of 108 snapper, eight other small fish and two stingrays (Shawcross 1967: 112). Motutapu has been reasonably well served, with a large number of identifications from the Sunde site, and smaller amounts from several undefended sites. Snapper is the predominant species in all these sites, but other species are always present in small numbers.

Allo's (1970) initial identifications of fish from the two undefended sites at Station Bay have been amended using a more comprehensive comparative collection (Leach 2006: appendix 1). The Davidson site yielded 39 snapper (72% of total MNI), seven barracouta, four sharks/rays, three gurnard and one John Dory. The Leahy site provided eight snapper (67%), three gurnard and one kahawai.

Of the more recently excavated undefended sites, R10/497 yielded 26 snapper, along with eight barracouta, four sharks/rays, three red gurnard, two spotted gurnard, and one each of kahawai, trevally, pōrae and sand flounder (Watson 2004: 154). This is an unusually low proportion of snapper. Ladefoged & Wallace (2010: 177, 180) report fish remains from R10/494 by NISP rather than MNI, with snapper as 79% of total NISP, followed by gurnard (15%) and small amounts of kingfish, trevally, jack mackerel and shark/ray.

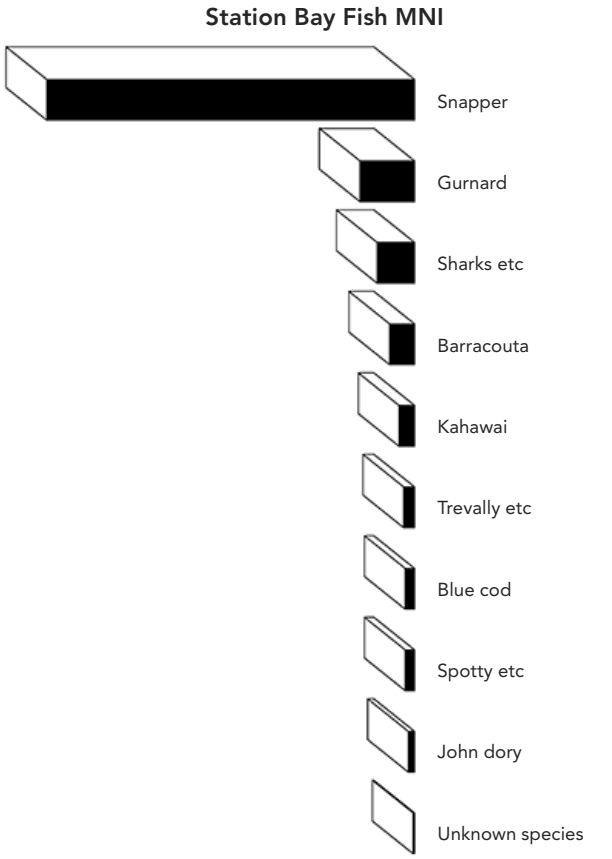

Fig. 26 The relative abundance of fish species at the Station Bay pā. The total MNI value is 345.

Snapper size

Cranial bones of snapper were measured with digital callipers and the data used to estimate the live fish size and weight using the method described by Leach & Boocock (1995). Statistical data are presented in Table 10 with data for eight other New Zealand sites for comparison. Size-frequency diagrams are given in Fig. 27.

There was a wide range of sizes in the catch. There can be little doubt that seine nets would have been used for taking the smallest of these fish and possibly many of the larger ones too. The two bone fishhook points from the site (Fig. 18) show that baited line fishing was used at least occasionally by the people who occupied the pā. Such hooks are not effective for catching small fish.

The smallest fish in the site (187 mm fork length) would have weighed only about 131 g, but the largest weighed 7.5 kg (732 mm fork length), which is a good size. The mean fork length and weight (436 mm and 1.9 kg) are at the smaller end of the size range of pre-European snapper catches and fairly typical of North Island archaeological

Table 10 Live fork-length statistics of snapper from Station Bay pā and a selection of other sites.

Site	No.	Range	Mean	SD	Coef. Var.	Skewness g1/w1	Kurtosis g2/w2
Station Bay	481	187	732	435.8 ± 4.5	98.2 ± 3.2	0.42/5.83	3.00/0.04
Mt Wellington	145	128	903	428.6 ± 13.3	160.6 ± 9.4	0.12/1.74	2.78/0.46
Houhora	8847	218	1010	490.5 ± 0.9	81.6 ± 0.6	0.33/22.07	3.79/15.28
Twilight	1914	176	994	532.0 ± 2.3	102.5 ± 1.7	0.37/10.85	3.64/5.73
Galatea Bay	212	246	799	464.2 ± 7. 1	103.2 ± 5.0	0.52/4.36	3.35/1.15
Cross Creek	997	146	782	400.0 ± 3.0	94.9 ± 2.1	0.28/6.86	3.2/1.80
Foxton	1080	239	953	471.5 ± 3.0	100.0 ± 2.2	0.48/9.32	3.4/3.04
Mana Island	527	266	939	463.7 ± 5.1	116.13 ± 0.6	0.70/7.92	3.17/0.84
Rotokura	824	138	870	575.0 ± 3.3	93.5 ± 2.3	-0.38/7.21	4.8/11.09

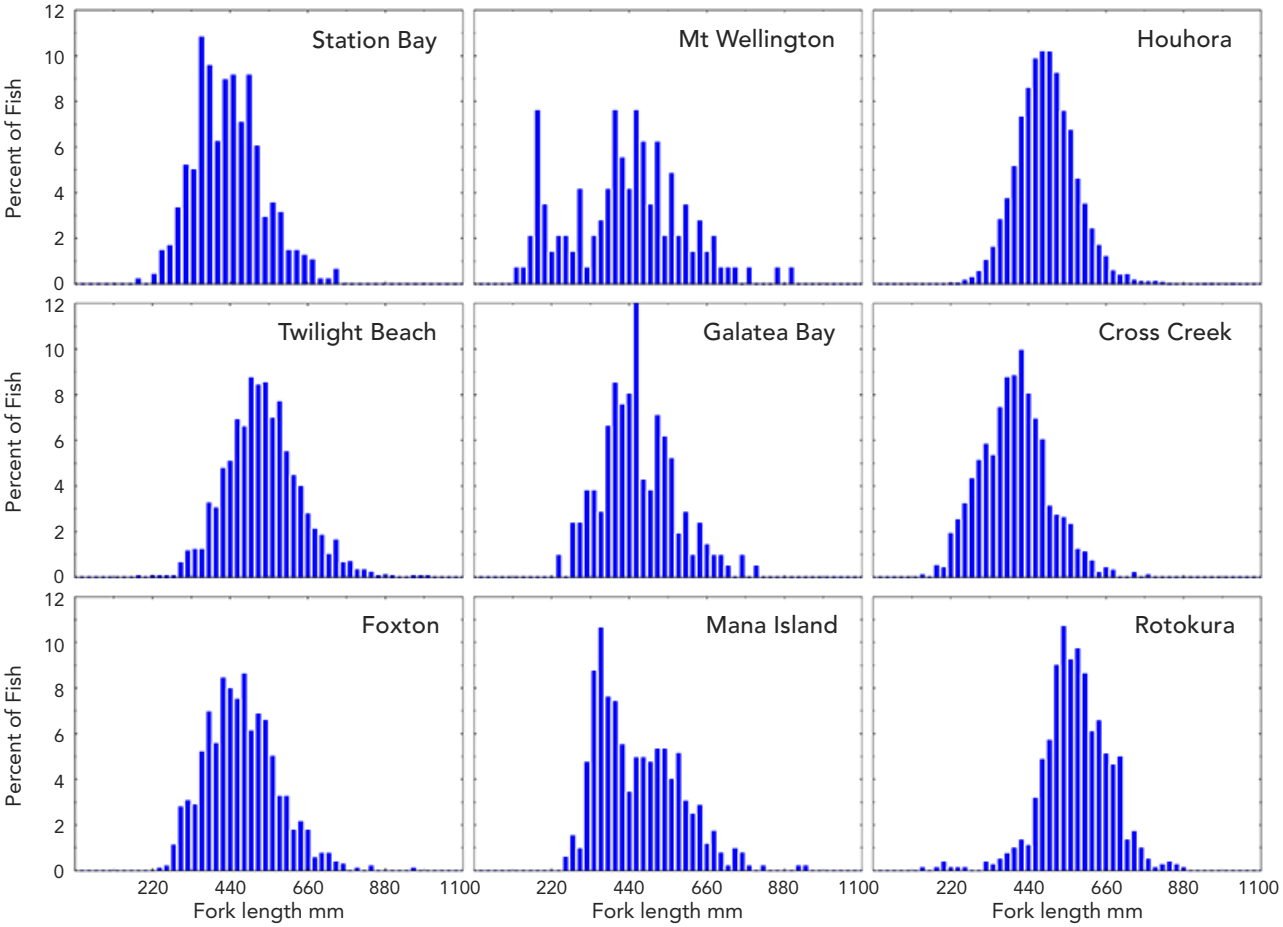

Fig. 27 Fork-length frequency distribution of snapper in the Station Bay site, with several other sites for comparison. See Table 10 for statistical data relating to these catches.

sites dating to the latter part of the prehistoric sequence. The total meat weight represented by the catch at Station Bay is estimated to have been 897 kg. Clearly, fish was an important source of protein for these people.

There are no signs of multi-nodality in the size-frequency distribution of the snapper catch, something that was observed at the nearby site of Maungarei (Mt Wellington). The normality statistics g1 and g2 show slight but significant positive skewness and normal kurtosis. In this respect the snapper catch here is similar to that of several other sites.

Allo (1970: 89) reconstructed the sizes of snapper from the Station Bay undefended sites, following the method of Shawcross (1967). Unfortunately, the very small samples gave only an indication of range: 19 fish of 9–23 in (*c.* 23–58 cm), with a single larger fish of 32 in (*c.* 81 cm) from the Davidson site; and a range of 7–21 in (*c.* 18–53 cm), with an outlier of 29 in (74 cm), for 11 fish from the Leahy site.

Nichol (1988: 280) produced size-frequency distributions from three successive parts of the oyster lens beneath the Rangitoto ash at the Sunde site and demonstrated a decline in size through time, although the largest sample at the top of the lens had a fish measuring over 80 cm long. Although not directly comparable, Nichol's three size-frequency diagrams, and particularly the earliest one, are quite similar to that resulting from finds at Station Bay pā.

Mammals and birds

Mammal and bird bones, identified by Ian Smith and Sheryl McPherson, are described in Appendix 1. This small assemblage stands in marked contrast to the amount of fish and shellfish recovered from the pā, and is fairly typical of mid- and later-period northern sites. Apart from relatively recent remains of rabbits and possums, which post-date occupation of the site, the principal mammal remains are from dogs and rats. There are no marine mammal remains, in contrast to the earlier Pig Bay site, where a few pilot whale bones were found (Smith 1981: 97). Smith and McPherson have treated the bird and mammal bone as a single assemblage, which means the minimum numbers are not comparable to those for fish, which were treated as a number of separate smaller assemblages.

The apparent difference in abundance of rats and dogs between Layer 2 and Layer 3 in Area B is intriguing and may reflect the fact that the site was not actually occupied very much during the earlier period of pit construction and use, compared with the perhaps briefer but more intensive Layer 2 occupation.

Charcoal analysis

Charcoal was not collected systematically. As noted above, despite the clear evidence of cooking activity provided by the large amounts of heat-fractured stone in Area B, only one definite fire feature was found, and that contained only tiny charcoal fragments. Charcoal was picked from concentrations in the layers and from the sieves. Thirty bags were submitted to Rod Wallace, who identified 291 pieces. The identifications are summarised in Table 11 and listed in more detail in Table 12. Most of the samples are from Area B. The Layer 3 samples are evenly divided among the four squares but the Layer 2 samples are predominantly from E5.

The abundant heat-fractured stone and midden from cooking activities suggests that much of the charcoal in the assemblage was from firewood. This is very likely to have been sourced locally by the inhabitants and to reflect vegetation in the immediate vicinity of the site at the time of occupation. The overwhelming dominance of smaller shrub species in the assemblage strongly suggests there was little in the way of mature woody vegetation in the vicinity of the site at this time.

Only two samples contained bracken charcoal, although it was found in patches throughout the layers of the site. This species is unlikely to have been used as firewood and the charcoal probably originated in landscape fires in bracken cover on the site during periods when it was not occupied or from deliberate burning in preparation for reoccupation. Wallace (2012) states that bracken charcoal in most site assemblages is usually accompanied by tutu (*Coriaria arborea*), *Hebe* spp. and *Coprosma* spp. This implies that some of the charcoal of these species in the site may have come from landscape fires rather than domestic activities. The fact that the bracken previously identified by Goulding (pers. comm., 10 August 1971) from low in the fill of Pit 1 in Area A appeared to have been burnt immediately before the remainder of the pit was deliberately filled suggests that in this instance vegetation on the site was burnt as a prelude to reoccupation.

On the basis of his review of charcoal samples from several sites on Motutapu, including the Station Bay pā, Wallace (2012) has concluded 'that most of the forests on the island were cleared by fire at the time of the Rangitoto eruption and that only limited areas of bush remained in the vicinity of the sites at the time they were occupied'. He suggests that the main woody vegetation present consisted of shrubs accompanied by pūriri (*Vitex lucens*) and

Table 11 Summary of charcoal identifications from the Station Bay pā.

Plant group	Species	No. of pieces	%
Ferns	Bracken (*Pteridium esculentum*) stems	20	8%
	Ponga (*Cyathea dealbata*)	3	
Shrubs and small trees	Tutu (*Coriaria arborea*)	12	71%
	Rangiora (*Brachyglottis repanda*)	6	
	Hebe spp.	13	
	Coprosma spp.	38	
	Pseudopanax spp.	94	
	Mānuka (*Leptospermum scoparium*)	26	
	Māhoe (*Melicytus ramniflorus*)	14	
	Pittosporum spp.	2	
	Olearia spp.	4	
	Ngaio (*Myoporum laetum*)	2	
	Ribbonwood (*Plagianthus regius*)	1	
Large broadleaf trees	Karaka (*Corynocarpus laevigatus*)	6	15%
	Beech (*Nothofagus* sp.)	1	
	Kohekohe/pūriri (*Dysoxylum spectabile/Vitex lucens*)	12	
	Pōhutukawa (*Metrosideros excelsa*)	24	
Conifers	Kauri (*Agathis australis*) branch wood	5	6%
	Kahikatea (*Dacrycarpus dacrydioides*)	4	
	Rimu (*Dacrydium cupressinum*)	8	
	Total	**291**	**100%**

pōhutukawa. Consequently, conifer timber for houses and pit superstructures may not have been obtained locally and may even have been imported to the island.

As can be seen in Table 12, there is little difference in the content of the samples from the two main layers in Area B or between the actual layers and the fills of features. There is very little evidence of structural timbers in Area B; the eight pieces of rimu (*Dacrydium cupressinum*) and 10 pieces of kohekohe/pūriri (*Dysoxylum spectabile*/*Vitex lucens*) from Layer 3 are each from a single sample. It appears that palisade posts and the timbers from pit superstructures were removed from the area excavated. Of the three pieces of ponga (tree fern, *Cyathea* sp.), which might have been used in pit lining, only one is associated with the base of a pit fill.

The widespread presence of pōhutukawa is not surprising. This tree still grows in the immediate vicinity of the site today and branches are readily accessible for firewood. The presence of karaka in Layer 2 is unusual; this tree was a food resource for Māori and was sometimes deliberately planted, both in gardens and in pā (Colenso 1881: 17). It was present on Motutapu before the Rangitoto eruption (Cooper 1970) but has not been recorded in other charcoal samples from the island studied by Wallace (2012). The single piece of beech may have originated from the palaeosol under the Rangitoto ash layer during occupation of the site. Wallace (2012) has found that this species dominates charcoal from that horizon.

Most of the charcoal from Area A is from Layer 2 there, probably contemporary with Layer 2 in Area B. However, the conifer pieces are from deliberate pit fill immediately preceding Layer 2, and may represent fragmentary remains of earlier structures. The few fragments from Area C are from a context following initial pit construction but preceding considerable renewed activity on the tihi above, and probably equate with a relatively early stage of pit construction in Area B nearby.

Table 12 Charcoal identifications by context.

Context	B, L2	B, L2 feature	B, L3	B, L3 feature	A, all contexts	C	Total
Number of bags	10	4	6	5	4	1	30
Bracken	—	—	10	10	—	—	20
Ponga	—	1	—	1	—	—	3
Tutu	8	2	3	—	—	—	12
Rangiora	—	6	—	—	—	—	6
Hebe	9	2	—	—	2	—	13
Coprosma	13	5	11	5	3	1	38
Pseudopanax	36	19	16	5	8	—	84
Mānuka	2	—	24	—	—	—	26
Māhoe	2	10	1	1	—	—	14
Pittosporum	—	—	—	—	2	—	3
Olearia	2	2	—	—	—	—	4
Ngaio	1	—	—	—	1	—	2
Ribbonwood	—	1	—	—	—	—	1
Māpou	2	—	1	—	1	—	4
Karaka	3	5	—	—	—	—	8
Beech	—	—	1	—	—	—	1
Kohekohe/pūriri	2	—	—	10	—	—	12
Pōhutukawa	2	2	2	9	8	1	24
Kauri branch wood	—	—	—	1	2	2	5
Kahikatea	—	—	—	—	3	1	4
Rimu	—	—	8	—	—	—	8
Total	**82**	**54**	**78**	**42**	**30**	**5**	**291**

Charcoal from the large pit outside the pā, identified by Wallace (2012), includes a relatively large amount from the trunks of ponga, which Wallace considers may have been from the lining of the pit when it was in use, as well as broadleaf and conifer trees, probably from the pit's structural timbers. Sullivan (1972: 43) interpreted much of the burnt material in the pit (which also included what she described as 'bracken … wrenched up by the roots') as the result of a deliberate fire, rather than a landscape fire. She argued that this fire was lit not long after the pit had fallen into disuse. One burnt kūmara tuber is consistent with the interpretation of the pit as a food-storage structure.

Discussion and conclusions

The Station Bay pā exists in the immediate context of other sites in and around Station Bay, including the two excavated undefended settlements, and the wider contexts of the island and adjoining regions.

As discussed above, the radiocarbon dates suggest repeated use of the pā headland and less intensive use of the two undefended settlements in Station Bay over several centuries in the latter half of the pre-European sequence in the region. Both of the undefended sites showed some evidence of reoccupation or modification, but much less intensity of use than the pā. The excavated terrace at the Leahy site is the lowest of a series extending up the ridge. The

extent to which these terraces were contemporary with each other is unknown.

The three sites have revealed an impressive range of pits and pit-like structures. Pits on the headland, both inside and outside the defences, include larger, deeper pits than those in the undefended settlements, as well as smaller and shallower rectangular pits and a range of small oval pits with rounded bottoms. It is noteworthy that there are no drains in any of the pits on the headland, whereas most of the pits and pit-like structures in the undefended sites have drains. End buttresses are present but relatively uncommon in all three sites, while what appear to be side or asymmetrical buttresses are found only in the pā. The days when it was believed that pit typology could provide chronological markers (e.g. Parker 1962) are long gone, but there is still scope to consider variations among pits in specific areas.

The pā is comparable in area to the larger of two defended high points on the summit of the volcanic cone of Maungarei (Mt Wellington), which is in the same general size category as defended areas on the volcanic cone of Pouerua in the inland Bay of Islands and non-volcanic cone pā such as the Kauri Point pā in the western Bay of Plenty (Davidson 2011: 80). Although the Station Bay landscape is visually much less striking than Maungarei or Pouerua, it reflects a similar settlement pattern: gardens and undefended settlements dispersed over the landscape, with a refuge nearby. At Maungarei and Pouerua, that refuge is on the summit of a prominent hill. At Station Bay it is on a steep headland, readily visible to potential enemies approaching by canoe. It is likely that similar-sized social groups used these geographically rather different landscapes in a very similar way.

The pā catchment is considerably bigger than the immediate vicinity of Station Bay. As many as 50 undefended settlements in this part of the island are closer to the Station Bay pā than to any other pā (Fig. 28). Station Bay and its pā would have been a focal point for the occupants of most or all of these sites.

Analysis of charcoal from the three Station Bay sites suggests a landscape predominantly covered in scrub, much of it probably on gardens in fallow, with a few trees, particularly pōhutukawa, which are still such a feature of the coastal margins.

The subsistence economy at all three sites was based on kūmara cultivation and the harvesting of fish and shellfish from nearby marine environments. Rats and dogs were represented in all the sites, but birds were virtually absent. A dietary contribution from other plant foods, such as bracken rhizomes and karaka berries, is likely but not confirmed, although Houghton's (1977) identification of so-called 'fern root planes' on the teeth of the two individuals from the pā and the one from the Davidson undefended site lends some support to this.

Analysis of shell shows that people were gathering from three different environments: the nearby rocky shore, protected beaches and unprotected beaches, with differing proportions in the different sites but also within the larger sample from the pā. Similar variation was found in the two other undefended sites on the island studied by Szabó (1999). Realistically, what was gathered from day to day probably depended on the state of weather and tides, other activities that were taking people to different locations where they could also gather shellfish, and even such factors as whether or not children were contributing to what was collected on a particular day.

A possible indicator of chronological change is provided by tuatua. Allo (1970) proposed that the preponderance of tuatua in the Leahy site compared with the Davidson site might indicate chronological difference. The radiocarbon dates suggest that the Leahy site is earlier than the Davidson site. There are clearly more tuatua in Layer 3 at the pā than in Layer 2, which might reflect a similar trend. However, the samples from the undefended sites are small and there are a few tuatua in almost all contexts in the pā. The fact that there are tuatua at all, given the question of where they came from, raises an interesting topic for future research.

It is no surprise that the predominant fish in the middens of all three sites was snapper, as the species predominates in almost all northern sites. Station Bay is well placed for access to the fishing grounds of the Hauraki Gulf.

The amount of durable fishing gear is disproportionate to the amount of fish bone. From the pā there are two bone two-piece fishhook points and a possible shank fragment made from shell. One dentary of a kahawai has a perforation commensurate with being taken on a lure. There is a single dog-tooth point from the Leahy site. It appears that most of the fishing was carried out with nets.

The few fishhooks are part of a small assemblage of artefacts from the three sites that is a pale reflection of Māori assemblages dating to the latter part of the pre-European sequence elsewhere in the North Island. Needles, pickers and tattooing chisels are typical of, but not confined to, relatively recent sites. A single pendant fragment of nephrite from the Leahy site is the only ornament recovered.

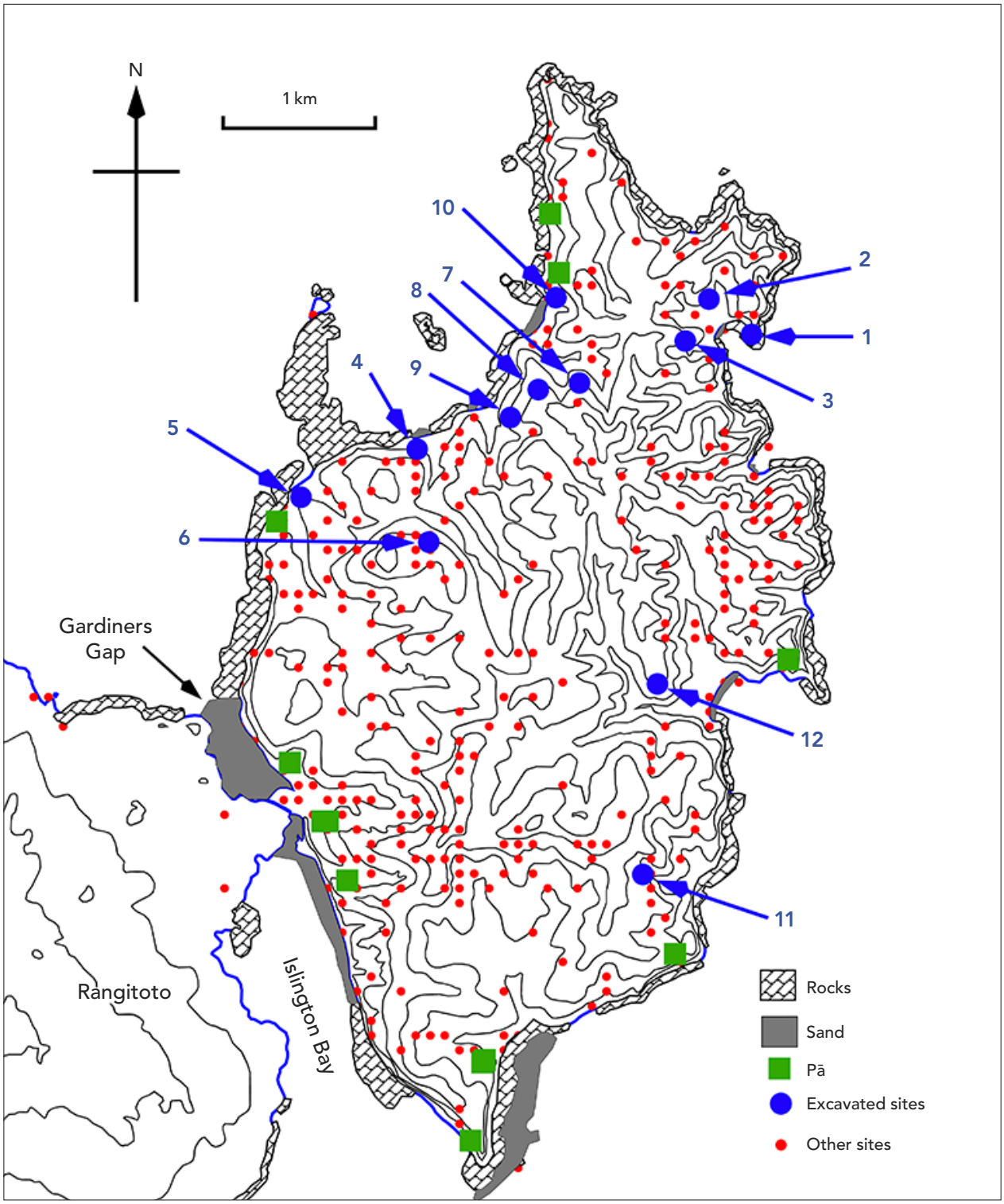

Fig. 28 Map of Motutapu, showing recorded and excavated sites. 1, Station Bay pā; 2, Leahy site; 3, Davidson site; 4, Pig Bay; 5, Sunde site; 6, Leahy N38/404; 7, R10/494; 8, R10/497; 9, R10/496; 11, R11/1277; 12, R10/557.

Stone tools and by-products from their manufacture are the main component of the assemblages. At the two undefended sites, local greywacke was still being worked into adzes as it had been at Pig Bay and the Sunde site, although the distinctive Archaic types found at Pig Bay were no longer present. The absence of any evidence of greywacke-working in the pā, apart from apparently opportunistic use of a beach cobble, may be an important difference between the pā and the undefended sites, but may simply be due to lack of an adequate areal sample of the pā.

The unusual burial of two individuals in a pit on the tihi of the pā has been described above. The pit had every appearance of being a food-storage pit and would therefore be noa, the antithesis of tapu. On the other hand, it is on the tihi or highest point on the site, which would have been ceremonially or ritually important. The fact that these two people were buried together at the same time suggests that they had died together, either in an accident, or as the result of violence. If they were of protohistoric age they could conceivably have died of an introduced illness. They appear to have been carefully placed rather than carelessly tossed into the pit, but burial in a food-storage pit does seem to suggest the scornful treatment of enemies or the sacrifice of low-status people rather than the respectful, ritual interment of members of the community.

A possible parallel can be found at Kauri Point in the Bay of Plenty, where partly dismembered bodies were found in two shallow pits, late in the sequence (Ambrose 1967: 15).

A single burial of a woman in a crouched position in a shallow grave, a more normal form of interment, was found in each of the other sites at Station Bay (Davidson 1970b: 43–44; Leahy 1970: 67). Houghton's measurement of nitrogen levels in the bones of these individuals suggested that the woman from the Leahy site was significantly earlier than the others (Houghton 1977: 40). He suggested that this woman had a better diet, which enabled her to grow taller and live longer than the later people. However, there is nothing in the archaeological evidence from the sites to confirm any difference in diet. Houghton also found evidence that the woman from the Leahy site and the man from the pā were habitual canoe paddlers – hardly surprising for these island people.

The picture that emerges from the three excavations is of a stable, established way of life on the island during the latter half of the pre-European sequence. It involved horticulture and the harvesting of marine resources, and was predominantly peaceful, but with periodic episodes of stress requiring the construction or reconstruction of defences and relatively brief occupations of the headland.

Contacts with the wider region are reflected in imported items, primarily obsidian. A tiny fragment of a nephrite pendant from the Leahy site is the only example of something from beyond the northern half of the North Island.

The sources of the obsidian found in the pā have not been determined. Most of the pieces are grey in transmitted light; only about 15% are green and therefore probably, although not certainly, from Mayor Island (Tuhua). Reeves (1972) attributed nine pieces from the Leahy site to Great Barrier Island (Aotea Island) and one to Whitianga on the Coromandel Peninsula; and two from the Davidson site to Great Barrier Island (Aotea Island) and Mayor Island (Tuhua). A further sample of 30 pieces from the Davidson site that were grey in transmitted light was submitted to Ward (1974), who was able to analyse 24. He attributed 17 to Te Ahumata and four to Awana, both on Great Barrier Island (Aotea Island), and three to Huruiki in Northland.

Recent research by Cruickshank (2011: 88) has shown that in the Auckland area during the latter part of the prehistoric sequence, Te Ahumata on Great Barrier Island (Aotea Island) was the most important source of obsidian, followed by Mayor Island (Tuhua), with less than 3% in the sites he studied coming from Northland and Coromandel sources. McCoy's recent study of obsidian from Maungarei (Mt Wellington) (Davidson 2011: 59) found that the majority of items sourced were from Te Ahumata, with a much smaller amount from Mayor Island (Tuhua) and smaller amounts still from Rotorua, Awana and two Coromandel sources.

The Station Bay undefended sites tend to fit this pattern, with Te Ahumata dominating, followed by Mayor Island (Tuhua). Cruickshank argued that only the Te Ahumata source on Great Barrier Island (Aotea Island) has high-quality obsidian for tools, and that the Awana source was probably not used by Māori (2011: 102). Moore (1982: 245) has noted the difficulty of distinguishing the material from the Northland source of Huruiki and that from Coromandel sources, a point also discussed by Cruickshank (2011: 81). Moore's most recent study shows Motutapu Island falling within the primary distribution area of Te Ahumata and secondary distribution areas of Huruiki and Cooks Beach/Hahei (2012: 23, 25). Moore's definitions of distribution areas are, of course, derived from obsidian in archaeological sites, and the Station Bay attributions (not included in Moore's study) conform to this pattern.

Fig. 29 Square F4 looking east, giving a clear view of one of two large rectangular postholes that suggest there may have been a substantial house in Area B. The second similar posthole is to the left (see Fig. 11 for details). Houses are difficult to identify in sites like this where there have been repeated episodes of occupation and the digging of storage pits (photo: Janet Davidson).

Cruikshank (2011: 88) included obsidian from Pig Bay and the Sunde site on Motutapu as Archaic (early) period sites in his study. They showed a dominance of Mayor Island (Tuhua) obsidian, followed by Cooks Beach/Hahei and Whangamata. His Classic (late) period sites are from the Auckland mainland. It is to be hoped that further sourcing studies of obsidian from Motutapu sites will expand on this apparent picture of changing access to this resource over time.

Twelve sites have been excavated on Motutapu to date: two beachfront settlements (Sunde and Pig Bay), nine undefended sites that are not immediately on the coast, and the pā that is the subject of this paper (Fig. 28). Not surprisingly, the beachfront settlements and the pā revealed more complicated histories of repeated occupation than the undefended settlements. The former are situated in particularly desirable locations: flats adjacent to stream mouths with canoe-landing beaches, and a naturally steep and relatively easily defended headland.

Five of the undefended sites (the Leahy site, R10/494, R10/496, R10/497, R10/557) have provided clear evidence of houses, usually associated with one or more roofed storage pits (Leahy 1970, 1972; Szabó 1999; Watson 2004; Ladefoged & Wallace 2010; G.J. Irwin, pers. comm., 24 August 2012). The pā, with its much more complex history of repeated occupations, provided only one tantalising glimpse of a possible substantial house, in the form of the two large rectangular postholes in F4 in Area B (Fig. 29). It is, of course, possible that houses might be found in other parts of the site, but our failure to find them in the areas investigated was disappointing.

Eleven pā are distributed around the coast of Motutapu;[3] there was probably one more at the northern tip of the island, destroyed by Second World War installations. There are at least 300 undefended sites, depending on how they are defined. These vary greatly in size. Some, such as R10/54, are comparable in area to pā or larger. Assuming that the inhabitants of the undefended sites retreated to pā during

periodic episodes of stress, it is likely that all the pā had histories at least as complex as that of the Station Bay pā.

The excavations at Pig Bay and the Sunde site provided information about the earlier centuries of the occupation sequence on the island. Clearly, there were dramatic changes in subsistence economy and less dramatic but still significant changes in material cultural (Davidson 1978b: 2). Important questions to be answered in future are just how quickly the way of life reflected in the three Station Bay sites came into being after the Rangitoto ash blanketed Motutapu, and how the Pig Bay sequence, in particular, relates to the Station Bay pā and the nine excavated undefended sites. One thread of continuity is the use of Motutapu greywacke and chert for tool manufacture in the more recent sites. An important indication of changing social relations may be the shift in obsidian procurement away from Mayor Island (Tuhua) and Coromandel sources to Great Barrier Island (Aotea Island).

Motutapu is exceptional in its preservation of a former cultural landscape in a reserve so close to a major conurbation. Overlying the evidence of centuries of Māori occupation are smaller areas relating to a more recent history of pastoral farming and defensive structures dating from the Second World War. The island presents magnificent opportunities for public interpretation of past ways of life. There is abundant scope for further archaeological research to build on the information that has already been obtained from more than 50 years of research on the island, and to explore in greater depth questions that have arisen from that research.

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Notes

1 Previously wrongly listed as I6.

2 The construction of the causeway linking Rangitoto and Motutapu during the Second World War must certainly have increased the shallow, sheltered area between the islands, but it has generally been assumed that this sheltered area formed soon after Rangitoto came into existence. Samuel Marsden is thought to have tried to sail through the passage from the north in November 1820, grounding his boat on a sandbank and having to be dragged off by local Māori. He described the northern approach as 'a narrow, shallow channel between two islands … where the surf broke with much violence' (Elder 1932: 310), but then passed into the sheltered area between the islands, where he ran aground.

3 There is no evidence that the large terraced site in the northwest of the island, R10/54, which was originally recorded as a pā, was actually a defended site.

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Appendix 1: Mammal and bird remains from the Station Bay pā

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Mammal and bird remains from Station Bay pā were analysed in the archaeological laboratories of the Department of Anthropology and Archaeology, University of Otago, using the faunal reference collections housed there. All specimens were identified to the most precise taxonomic class to which they could be assigned with confidence, and the anatomical element represented and portion present noted, along with any evidence of developmental age, taphonomic condition, and presence of cut marks or other notable features. The number of identified specimens (NISP) that each identification represented was recorded and two quantification measures were derived: the minimum number of anatomical elements (MNE) and the minimum number of individual animals (MNI). The latter were calculated treating all material from the site as a single assemblage.

A total of 270 mammalian specimens, 10 bird specimens and another five unidentifiable fragments were examined (Table A1.1). Almost 40% of these items must have entered the archaeological record after abandonment of the site. A cluster of bones from the brushtail possum (*Trichosurus*

Table A1.1 Mammalian and avian fauna (NISP) from N38/25.

Square	Layer	Possum	Rabbit	Rat	Dog	Human	Mammal ?sp	Shag	Gannet	Gull	Bird ?sp	Unident.	Total
E4	2	—	—	7	2	—	—	1	—	—	—	—	10
	3	—	—	5	3	—	—	—	—	—	—	—	8
E4 or 5	1	—	—	—	1	—	—	—	—	—	—	—	1
E5	1	48	—	1	1	—	—	1	—	—	—	—	51
	1 & 2	—	—	—	2	—	1	—	—	—	—	—	3
	2	1	—	—	2	3	1	1	—	1	—	—	9
	3	—	—	19	3	7	—	—	—	—	—	—	29
F4	1 & 2	—	49	—	2	—	1	—	—	—	—	1	53
	2	—	1	4	3	1	—	—	—	—	—	—	9
	3	—	—	8	1	—	—	—	—	—	3	—	12
G4	1	—	1	—	7	—	—	—	2	—	1	1	12
	2	—	—	1	4	—	1	—	—	—	—	—	6
	3	—	—	58	—	—	7	—	—	—	—	2	67
J7	1	—	11	—	—	—	—	—	—	—	—	—	11
L4	2	—	—	1	—	—	—	—	—	—	—	1	2
	3	—	—	2	—	—	—	—	—	—	—	—	2
Total		**49**	**62**	**106**	**31**	**11**	**11**	**3**	**2**	**1**	**4**	**5**	**285**

Table A1.2 Number of identified specimens (NISP), minimum number of anatomical elements (MNE) and minimum number of individuals (MNI) of presumed pre-European mammals and birds from the Station Bay pā.

	NISP	MNE	MNI
Mammals			
Rat	106	80	10
Dog	31	17	1
Human	11	10	1
Mammal ?sp	11	—	—
Subtotals	**159**	**107**	**12**
Birds			
Black shag	3	3	1
Australasian gannet	2	2	1
Southern black-backed gull	1	1	1
Bird ?sp	4	1	—
Subtotals	**10**	7	**3**
Totals	**169**	**124**	**15**

vulpecula) was found in Layer 1 of Square E5. These must post-date 1869, when the species was first introduced to the Auckland region at Kawau Island, but are more likely to have reached Motutapu after the 1931 liberation on Rangitoto Island (Pracy 1962: table 3). The rabbit (*Oryctolagus cuniculus*) bones in the upper layers of squares F4, G4 and J7 may date to the nineteenth century, as this species was reported as 'common on Motutapu before 1883' (Gibb & Williams 1990: 144). However, rabbits were still common on the island at the time of the excavations. These items, along with four unidentifiable fragments, have been excluded from further consideration here.

Among the remaining taxa, rat bones predominate, making up 63% of NISP (Table A1.2). These are all small specimens, making it almost certain that they are kiore, the Polynesian rat (*Rattus exulans*). Kurī, the Polynesian dog (*Canis lupus familiaris*) is the next most common, followed by human (*Homo sapiens*) remains. Bird bones were comparatively scarce, but three species were identified: Australasian gannet (*Morus serrator*), southern black-backed gull (*Larus dominicanus dominicanus*) and a cormorant, almost certainly the black shag (*Phalacrocorax carbo novaehollandiae*).

Rat bones were mostly in squares E4, E5, F4 and especially G4, where more than half of them were found. This cluster accounts for half of the total MNI of 10 animals. Both here, and elsewhere in the site, the rats were represented by skeletal elements from all parts of the body, indicating that they were deposited, or otherwise entered the site, as complete skeletons. The rat remains are strongly concentrated in the basal strata of the site, with 82% of NISP from Layer 3.

In contrast, 71% of the dog remains derive from Layers 1 and 2, also most prominently in squares E4, E5, F4 and G4. Given that there is probably a time difference between upper and lower strata, it is likely that there are multiple individual dogs represented, although when all the remains are considered together they amount to no more than one animal, with skeletal elements from most parts of its carcass.

The human remains are, like the rat remains, mostly found in Layer 3, with all but one item in Square E5. Most are small bones – five metacarpals, one metatarsal and one tarsal – although there are also two fragments of radius, one of ulna and one long bone shaft fragment. Such items may have been displaced from a burial, although it is notable that the radius fragment has what appears to be a dog-tooth puncture mark on its shaft, which might indicate scavenging of body parts from a recently deceased corpse.

The shag is represented by three bones from Layer 2 in squares E4 and E5 and Layer 1 in E5. They are almost certainly black shag, but the Otago reference material for this species is limited, and smaller than the Station Bay specimens. This species occurs widely throughout New Zealand (Tennyson 2010: 145). It is comparatively rare in well-dated middens from the northern North Island, but is known from early deposits at the Sunde site on Motutapu Island, as well as Port Jackson and Hot Water Beach on the Coromandel Peninsula (Smith & James-Lee 2010: appendix 4).

The two bone fragments from the Australasian gannet were both found in Layer 1 of Square G4, and could be from a post-occupational bird-wreck. This species is also widespread in New Zealand (Tennyson 2010: 139), again relatively rare in well-dated northern middens, but is represented at the Sunde site (Smith & James-Lee 2010: appendix 4). The southern black-backed gull is represented by a single bone. This is also a widespread species.

The Station Bay pā material is important, because there are relatively few published mammal and avian bone assemblages from northern sites dating after about AD 1500 (Smith 2013). Like those few others, it shows that bird

bones were scarce, and that the only mammals were rats, dogs and humans. What is interesting about the Station Bay pā assemblage is that it shows a shift in dominance from rats, earlier on, to dogs, later. Whether this is a product of sampling or rat nesting behaviour, or reflects a shift in economic conditions at the site and perhaps more generally, are questions that further publication of later prehistoric bone assemblages from the region could seek to address.

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