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The Prehistoric Archaeology of Norfolk Island, Southwest Pacific

Edited by

Atholl Anderson and Peter White

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The Prehistoric Archaeology of Norfolk Island, Southwest Pacific

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VOLUME ABSTRACT. This *Supplement* documents the discovery, excavation and analysis of material of the Polynesian occupation of Norfolk Island about 600 years ago.

The main excavation, in the dunes of Emily Bay, revealed a probable house, with some posts in place, and an adjacent paved area, which we interpret as a possible *marae*. Some obsidian, mostly sourced to Raoul Island, was associated with the paving. Stone artefacts, including adzes, were made of local basalt. Shell and bone tools were also found. Both stone and shell tools retained residues and usewear. The nature and morphology of the artefacts suggest New Zealand or the Kermadec Islands as the most likely source of the settlement.

Faunal remains included a limited range of mammals and reptiles, along with fish, birds and shellfish. Some specialization in collection is evident in each of the three latter classes of remains. *Rattus exulans* is the only animal which was clearly introduced, and there is also pollen evidence for plant introductions.

Detailed analysis of the radiocarbon data establishes that the settlement was occupied between early thirteenth and early fifteenth centuries A.D., although the duration of occupation many have been considerably shorter. Reasons for abandonment of the island are discussed; extreme isolation may have been important.

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For assistance in assembling this volume we thank Mr Bob Cooper and staff of Coombs Photography and Mr Keith Mitchell and staff, especially Ms Kay Dancey, of the Cartography Unit, RSPAS. Ms Lyn Schmidt, Archaeology & Natural History, RSPAS provided tremendous assistance and support throughout the project. Reviewers of the whole volume were Drs Marshall Weisler and Harry Allen and their input was most helpful; the same is true of the specialist reviewers of many of the papers. Dr Val Attenbrow, Australian Museum, also reviewed the volume with great care and we record our extreme appreciation of her considerable effort. For the production we are grateful to the Australian Museum, particularly Associate Editors Dr Val Attenbrow, Dr Jeff Leis and Editor Dr Shane McEvey.

ATHOLL ANDERSON AND PETER WHITE
VOLUME EDITORS

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Approaching the Prehistory of Norfolk Island

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ABSTRACT. Norfolk Island, on the northeast edge of the Tasman Sea, is of volcanic origin and moderate height. A humid, forested subtropical landmass, it had a diverse range of natural resources, including some food plants such as *Cyathea*, forest birds such as pigeon and parrot species and substantial colonies of seabirds, notably boobies and procellariids. Its shoreline had few shellfish, but the coastal waters were rich in fish, of which Lethrinids were especially abundant.

The island had no inhabitants when discovered by Europeans in A.D. 1774. It was settled by them in A.D. 1788. From the eighteenth century discovery of feral bananas and then of stone adzes, knowledge of the prehistory of Norfolk Island has developed over a very long period. Collections of stone tools seemed predominantly East Polynesian in orientation, but Melanesian sources could not be ruled out. Research on fossil bone deposits established the antiquity of the human commensal *Rattus exulans* as about 800 B.P. but no prehistoric settlement site was known until one was discovered in 1995 at Emily Bay during the Norfolk Island Prehistory Project.

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The primary aim of the Norfolk Island Prehistory Project (NIPP), which began in 1995, was to determine the fact, extent and nature of pre-European settlement in the Norfolk Island archipelago, within the context of some wider questions of regional prehistory. Norfolk Island was of particular interest because of its status as one of the Polynesian "mystery" islands, its very isolated situation at the western extremity of Polynesian colonization, yet its proximity to Melanesia, and because of its history of tantalising evidence indicating former settlement.

That was not immediately apparent at European discovery. Ten days out from New Caledonia, on the 10th October 1774, HMS *Resolution* came upon a new island. A brief exploration suggested that it was uninhabited and Captain James Cook "took posission of this Isle… and named it *Norfolk Isle*, in honour of that noble family." (Beaglehole, 1961: 565). An absence of indigenous people was confirmed when extensive exploration and European settlement began in 1788, but at the same time evidence began to emerge of former habitation (below) and Norfolk Island became one of those "isolated, mystery islands" of Polynesia, "which have traces of prehistoric settlement, but which had no inhabitants at European contact." (Bellwood 1978: 352).

These islands occur in two main groups, equatorial atolls and sub-tropical high islands, of which Norfolk Island is the most westerly and was before our research perhaps the most enigmatic. Located almost equidistant between New Caledonia and New Zealand, it was open to settlement from either or both sources (if not others). New Caledonia and New Zealand represent the extremes of culture history in

Remote Oceania, the former occupied since the Lapita culture era about 3,000 years ago and the latter colonized by East Polynesians as late as 800–700 years ago (Anderson, 1991). In addition, the geographical potential was more than just theoretical, for artefacts of Melanesian and East Polynesian (including New Zealand) affinities had been recovered on Norfolk Island in quite substantial numbers from the time of first settlement until the twentieth century (Specht, 1984, 1993), all without any evidence recorded of a prehistoric settlement site. One of the first questions to be asked, therefore, was the source of the occupants and whether multiple origins had been involved. Linked to it were questions about settlement chronology, including whether there had been more than one phase of colonization.

The second question is the issue of the extent to which Norfolk Island was isolated during its prehistoric occupation. While some of the mystery islands, notably the Pitcairn group (Weisler, 1995), had evidently maintained external contacts for a time, others had no further contact with the outside world following initial colonization, e.g., the Auckland Islands (Anderson and O'Regan, 2000). Norfolk is one of the more isolated of Pacific islands, making links with any possible homeland difficult to maintain and if, as the surface collections suggested, the original colonists had come from within South Polynesia (Anderson, 2000), notably the Kermadecs and New Zealand, then isolation might have been compounded by relatively difficult voyaging conditions. In respect of this and the first question, clearly matters of chronology and the sourcing of archaeological materials would need to loom large in the project.

A third area of interest concerned human-environmental relationships. The significant impact of prehistoric colonists on the geomorphology, vegetation and faunas of Pacific islands, and reciprocal consequences for cultural behaviour, are now widely discussed (e.g., Kirch and Hunt, 1997). Norfolk Island is subtropical, with a relatively limited range of resources, and had, perhaps, a severely limited suite of cultigens in prehistory. These factors, in addition to isolation, may have rendered long-term habitation particularly difficult (Anderson, in press). Palaeoenvironmental investigations of sedimentary samples containing potential indications of a human presence were an integral part of the project. From pollen spectra especially, a record of vegetation change extending to either side of the period of human occupation was sought. Complementary data on fauna were anticipated from archaeological excavations, and to a lesser extent from investigation of natural bone deposits (Anderson, 1996) and landsnails (Neuweger, White and Ponder, this vol.).

The results of the NIPP are reported in this volume. Before turning to the specific evidence, however, it is useful to present an overview of the environment within which prehistoric habitation occurred and of the unusually long road by which a cultural prehistory of Norfolk Island has eventually been reached.

The natural history of Norfolk Island

The Norfolk Island archipelago consists of three islands: Norfolk Island (3,455 ha), and the much smaller Phillip Island and Nepean Island (Fig. 1). Situated at 29°2'S and 167°56'E (coordinates for Norfolk Island), the archipelago is equably sub-tropical with average monthly maximum temperatures of 19–25°C, and minimums of 13–19°C. The climate is mild and humid with average rainfall of 1313 mm.

Prior to any human occupation the islands were probably entirely forested. The first observations of the northern shore in Duncombe Bay, by Captain Cook, noted the similarity of the vegetation to that in New Zealand:

> we found… the Flax plant, many other Plants and Trees common to that country was found here but the chief produce of the isle is Spruce Pines which grow here in vast abundance and to a vast size… Here are the same sorts of Pigions, Parrots and Parrokeets as in New Zealand, Rails and some small birds… (Beaglehole, 1961: 565, see also Hoare, 1974).

Johann Forster (Hoare, 1982: 668–670), another in the landing party, observed the abundance of fish and seabirds, especially boobies and shearwaters, while William Wales, who also went ashore (Beaglehole, 1961: 869), noted the coastal growth of flax (*Phormium tenax*) and the "cabbage tree" (which was clearly the Norfolk palm, *Rhopalostylis baueri*), and collected "wood-sorrel", "sow-thistle" and "samphire" from along the shore. Beaglehole (1961: 869) identifies these respectively as *Oxalis* sp. (*O. corniculata* according to Forster, below), *Sonchus oleraceus* and *Apium prostratum*.

Lieutenant King landed on the north coast of Norfolk Island in March 1788 and set about exploring. He found that the forest, heavily entangled with supplejack, was without any clearings and almost impenetrable, but had no ground cover. The birds were exceedingly tame, able to be knocked down with a stick. Pigeons, parrots and parrokeets were numerous. Soon after, he landed at what was to become Sydney Bay (Kingston), noting that "the shore, close to the beach, was covered with a long kind of iris [flax] within which was an impenetrable forest." (King cited in Hunter, 1793: 300). Turtle were soon discovered on the eastern beach (Turtle Bay, later Emily Bay), although there was no evidence of their nesting there. Rats (probably *Rattus exulans*) appeared, nibbling the shoots of maize in the first gardens on Kingston Common and, soon after, grub-worms which attacked the potatoes, and later caterpillars of army-worm which infested the wheat. The edibility (and suitability as pig-food) of the *Cyathea* tree-fern pith was established ("it tastes like a bad turnip") and "thick clusters" of fruiting "plantain or bananas" were described in the small valley which became Arthur's Vale (Hunter, 1793: 306–313).

On 19th March 1790, the *Sirius* supply vessel was wrecked in Sydney Bay. Its convict and military passengers, and its crew, brought the Norfolk Island settlement unexpectedly up to more than 500 people. Reduced rations were ordered. The people began to catch the nesting "Bird of Providence" (Providence petrel, *Pterodroma solandri*), found on Mount Pitt in large numbers. According to Captain John Hunter (1793: 182):

> They were, at the end of May, as plentiful as if none had been caught, although for two months before had been not less taken than from two to three thousand birds every night; most of the females taken in May were with egg…

However, neither fowling generally, nor fishing, were as productive as had been hoped. The latter was frequently frustrated by continually heavy seas at the landing place: Hunter's records (1793: 199), showing that in the year

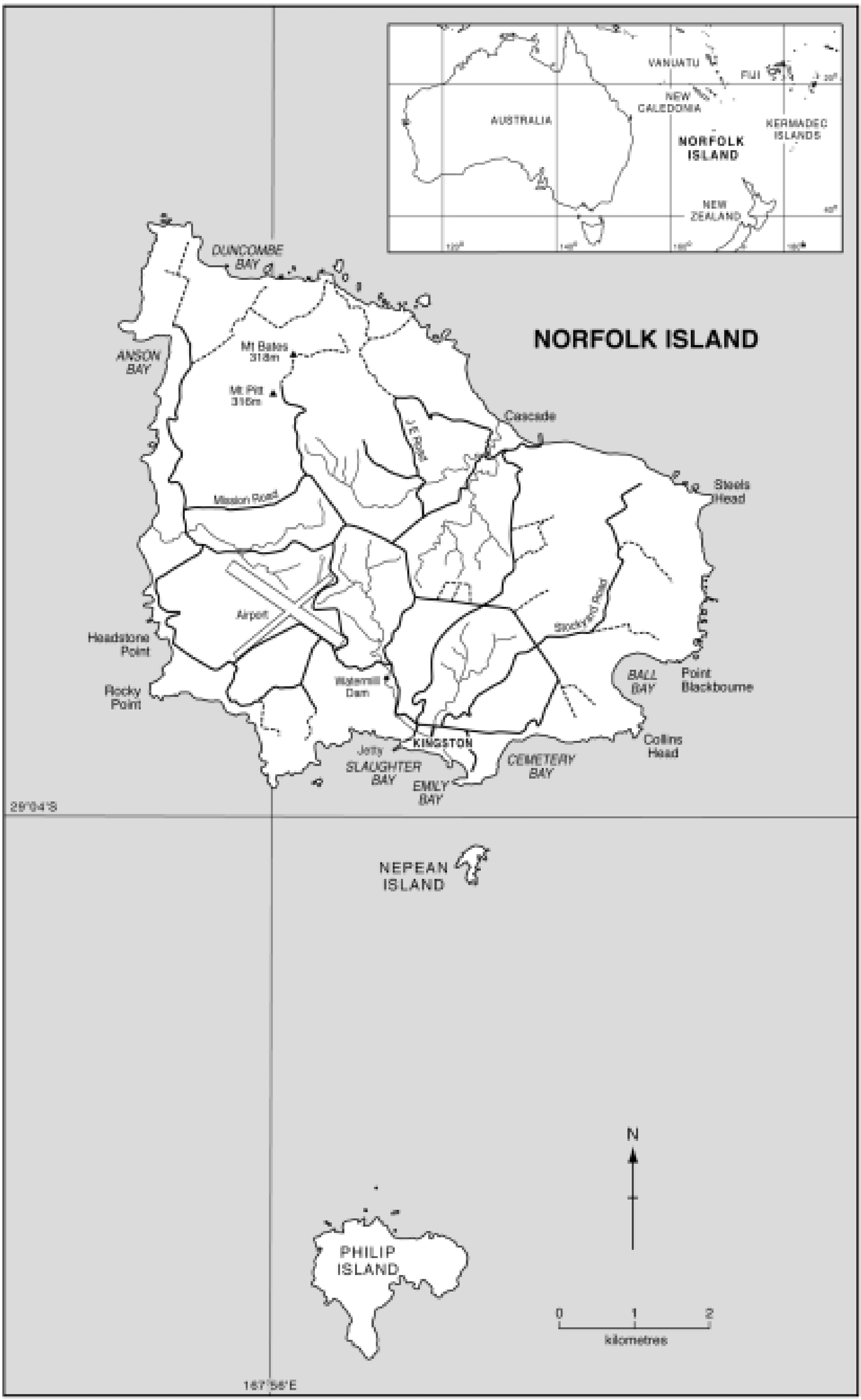

Figure 1. Norfolk, Nepean and Philip Islands.

March 1790–February 1791, landings and launchings of boats were possible on only 178 days (54%), with longer records (1788–1791) indicating an average of 64% (Hicks, 1988: 162).

Leaving the island in March 1790, Lieutenant King summarized his observations. It was very heavily forested, the soil was deep and fertile, the streams contained fine eels (these were both long-finned and short-finned *Anguilla* spp., according to Christian, 1985), cabbage palm and flax were abundant, and the seas abounded with fish, notably "snapper" weighing four to eight pounds.

Out of these early records, and later investigations, it is possible to describe the general basis of the Norfolk Island archipelago's natural history considered largely from the point of view of its interest to prehistoric settlers.

Although described as high islands in the cultural sense, the topography of the three islands is not so spectacular as that of many other volcanic islands of East Polynesia. Nepean Island is low, but the others are hilly, rising to about 320 m in Mounts Pitt and Bates on Norfolk Island (Fig. 2), these being the remnants of former volcanic vents, 2.3 to 3 million years old. Norfolk Island is composed primarily of basaltic lava, often deeply-weathered, amongst which are flows of fine-grained material which is very suitable for flaking into implements. Phillip Island rises to 280 m and consists equally of basaltic lavas and tuffs. On the southern side of Norfolk Island, and forming Nepean Island, are thick deposits of calcarenite, a cemented, cross-bedded, aeolianite which arose from windblown calcareous material during the lowered sea levels of the late Pleistocene. Upon it are developed dunes of carbonate sands (Veevers, 1976; Jones and McDougall, 1973).

On fertile, alkaline clay soils which occur everywhere except upon the calcarenite and sand at Kingston (Hutton and Stephens, 1956) were distributed several forest communities. On the lower ground and ridges was Norfolk pine (*Araucaria heterophylla*) forest rising above mixed hardwood forest and shrubs. On the higher areas was mixed hardwood forest, including Maple (*Elaeodendron curtipendulum*), Ironwood (*Nestigis apetala*), Beech (*Rapanea crassifolia*) and Bloodwood (*Baloghia inophyllum*), with *Cyathea* spp. ferns, Pepper tree (*Macropiper excelsium*) and other shrubs beneath, all tangled with climbers and vines, some prickly. In some hardwood forests, the Norfolk palm (*Rhopalostylis baueri* [Hook f.]) was dominant, and along gullies it occurred in association with tree ferns, *Cyathea brownii* and *C. australis*. Flax often formed a coastal fringe. There were 200 Norfolk pines on Nepean Island, and about 150 amongst *Cyperus lucidus* reeds and low forest on Philip Island (Hicks, 1988).

The vegetation of Norfolk Island contained a number of useful plants. Of food sources, in addition to the shoreline herbs (above), there was the Norfolk palm with its edible "heart" of leaves, the rhizomes of the King fern (*Marattia salicina*) (Jurd, 1987), the pith of *Cyathea* spp. palms, roots of the Norfolk Island ti (*Cordyline obtecta*), and *Hibiscus* sp., and a number of fruits (Pepper-tree and Mountain rush, *Freycinetia baueriana*, amongst others). The flax especially, but some other plants, such as Kurrajong (*Wickstroemia australis*), provided valuable fibres for cordage and rope, and the *Cyperus* rush was used historically for making baskets (Hicks, 1988).

Norfolk Island was and is a seasonal destination or way station for many migratory birds, including ducks, egrets, coots, and numerous taxa of shore and wading birds. Of its endemic species or subspecies, the larger kinds noted by early Europeans have become extinct (Schodde *et al.*, 1983). These were the Norfolk Island Ground Dove (*Gallicolumba norfolciensis*), the parrot or Norfolk Island Kaka (*Nestor productus*) and the Norfolk Island subspecies of the New Zealand Pigeon (*Hemiphaga novaeseelandiae spadicea*). Other native land birds which became extinct in the European era are the Long-tailed Triller (*Lalage leucopyga leucopyga*) and Norfolk Island Starling (*Aplonis fusca fusca*). Surviving, although rare, are the Boobook Owl (*Ninox undulata*), two species of White-eye (*Zosterops* spp.), Red-fronted Parakeet (*Cyanoramphus novaezelandiae cookii*), Grey-headed Blackbird (*Turdus poliocephalus poliocephalus*), Scarlet Robin (*Petroica multicolor multicolor*), Golden Whistler (*Pachycephala pectoralis xanthoprota*), Grey Fantail (*Rhipidura fuliginosa pelzelni*), and Grey Gerygone (*Gerygone igata modesta*). There were other land birds breeding on the island, at least in the late eighteenth century, including the Shining bronze-Cuckoo (*Chrysococcyx lucidus lucidus*), Sacred Kingfisher (*Halcyon sancta norfolkiensis*) and a "hawk", which was probably the Australian Kestrel (*Falco cenchroides cenchroides*).

In addition to birds, there were very few terrestrial vertebrates (Hicks, 1988). These included two bats (Norfolk Island free-tail bat, *Tadarida norfolkensis*; Gould's wattled bat, *Chalinolobus gouldii*), a gecko (*Phyllodactylus guentheri*) and a skink (*Leiolopisma lichenigerum*). The small Pacific rat, *Rattus exulans*, had clearly been introduced by about 800 years ago (Rich *et al.*, 1983).

Of the seabirds, the Providence Petrel (above) became locally extinct under European hunting which, in the winter of 1790 alone, took more than 172,000 birds, many of them females in egg (Hicks, 1988: 168); the species was no longer viable as a resource by 1792 (Fletcher, 1975: 196). Other seabirds which may have become locally extinct (Meredith, 1991) are Pycroft's Petrel (*Pterodroma pycrofti*) and the White-faced Storm Petrel (*Pterodroma marina*), but the systematic status of *Sula tasmani* is doubtful. However, most breeding or probable breeding species survived and they include: Masked Booby (*Sula dactylatra personata*), Australasian Gannet (*Morus serrator*), Black-winged Petrel (*Pterodroma nigripennis*), Wedge-tailed Shearwater (*Puffinus pacificus*), Little Shearwater (*Puffinus assimilis*), Red-tailed Tropicbird (*Phaethon rubricauda roseotincta*), Sooty Tern (*Sterna fuscata serrata*), Common Noddy (*Anous stolidus pileatus*), Black Noddy (*Anous minutus minutus*), Grey Ternlet (*Procelsterna albivittata albivittata*), and White Tern (Gygis *alba royana*) (Rich *et al.*, 1983).

In the marine environment, the early European reports of numerous whales, dolphins and turtles hint at the former richness of the potential resources. The turtle was probably the Green Turtle (*Chelonia mydas*), still seen in local waters, which was found in Emily Bay and which still occurred as large shoals from time to time into the nineteenth century, as reported by Ensign Best in 1839 (Taylor, 1966: 201).

The Norfolk Island fish are, by diversity, largely tropical, but by abundance largely subtropical, especially amongst the inshore taxa. Survey of the Kingston lagoon (Ivanovici, 1988) and other records (Francis, 1993) show that amongst the more abundant species are the Orange Wrasse

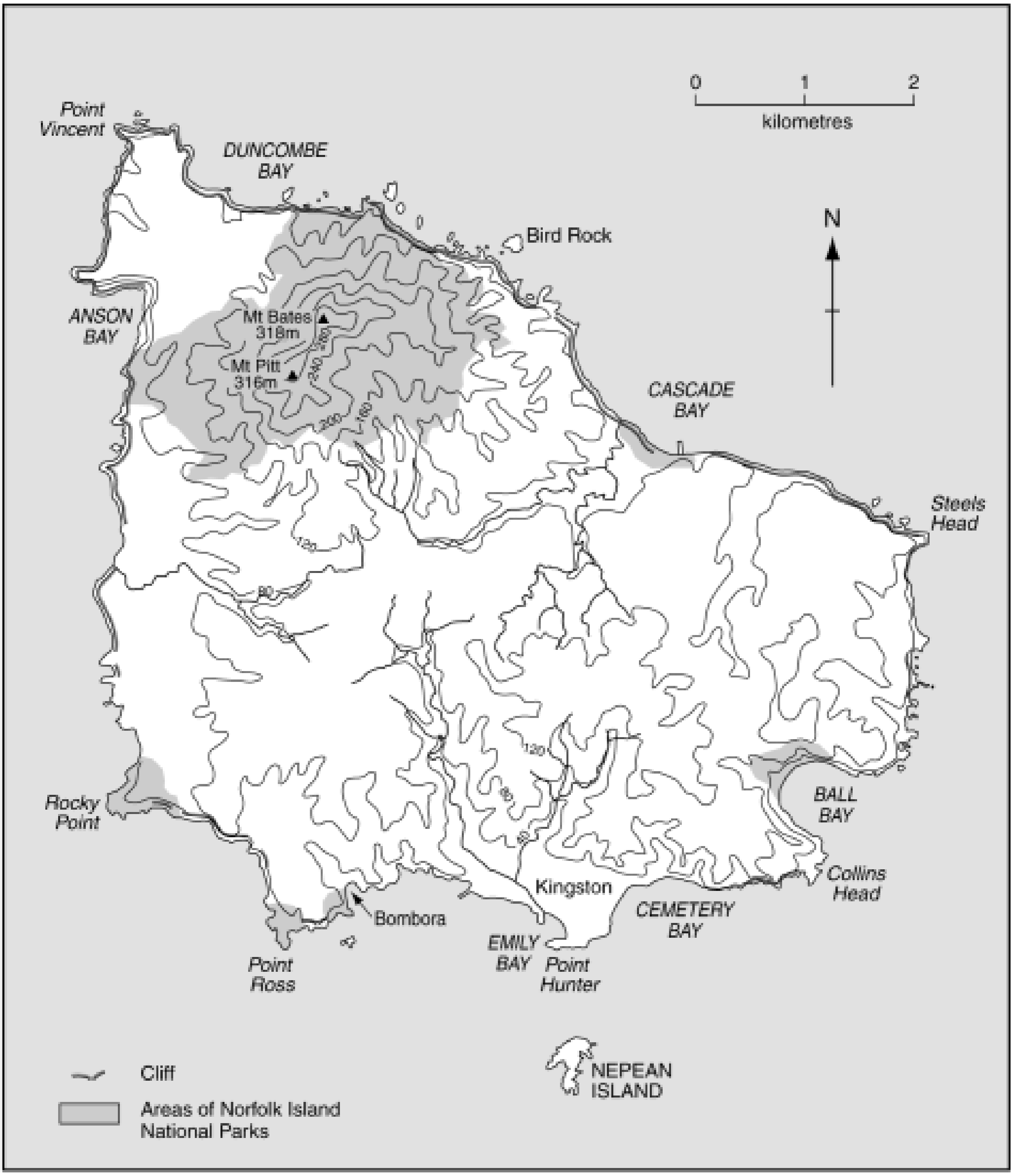

Figure 2. Norfolk Island, showing major peaks and coastal features.

(*Pseudolabrus lutescens*), Red Snapper (*Trachypoma macracanthus*), Demoiselle (*Chromis dispilus*), Nanwhi (*Kyphosus* spp.) and One-spot Puller (*Chromis hypsilepsis*). These, however, are small fish (12–30 cm maximum length), so the main target species were more likely to be those sought in recent times, of which the Trumpeter or Sweetlip (*Lethrinus miniatus*, or *L. chrysostomus*) is among the largest, most prized and heavily fished (Hicks, 1988). Others are the various Serranids, including the Black-tipped Rock Cod (*Epinephelus fasciatus*) and Groper or Black rock cod (*Epinephelus damelii*), the Silver Bream (*Chrysophrys auratus*), Trevally (*Pseudocaranx* spp.) and Yellowtail kingfish (*Seriola lalandi*). In addition, there are various large species which, though less sought after today, were probably caught regularly and consumed by Polynesians: the Doubleheader (*Coris bulbifrons*), Painted Morwong (*Cheilodactylus ephippium*), Girdled rock cod (*Acanthistius cinctus*), Bucket fish (Scorpaenids) and various rays and sharks of which the Galapagos shark (*Carcharhinus galapagensis*) is one of the more common (Ivanovici, 1988; Coleman, 1991).

There are large shore crabs, notably *Leptograpsus variegatus*, and one crayfish, the Shovel-nosed cray (*Scyllarides* sp.). Various species of sea-urchins are abundant, especially *Heliocidaris tuberculata* in pools and shallows (Coleman, 1991). Of shellfish in the edible size range, Norfolk Island is noticeably deficient. Pelecypods are scarce and the only common gastropod species is the small upper-shore Hi-hi, *Nerita atramentosa*.

From the perspective of prehistoric colonists the Norfolk Island archipelago offered substantial resources of fish and seabirds, but it was otherwise rather deficient in subsistence items which might have been expected by tropical discoverers. The slim array of indigenous food plants contained neither pandanus nor coconut, there were few forest birds and no land crabs of economic size, and shellfish which generally formed a staple item of Pacific island diets were particularly scarce.

Discovery of prehistoric habitation

William Wales had concluded of Norfolk Island in 1774 that, “we saw no Inhabitants nor the least reason to believe it had ever been trod by Human feet before.” (Beaglehole, 1961: 869). Yet his own plant collection possibly held a clue to earlier habitation: *Sonchus oleraceus*, the sow thistle, was found abundantly in New Zealand by Cook’s first expedition in 1769–1771, as also was *Apium prostratum*, or Maori celery, both eaten by Maori and valued by Cook as soup and salad plants and as antiscorbutics (Crowe, 1981). Amongst these, and other weeds and succulents recorded by Forster, there may be some plants which arrived with prehistoric settlers.

The early European settlers did not draw any implication of prior habitation from the existence of small rats which attacked their crops, but they saw immediately the significance of finding bananas growing wild. Collins, writing in 1798 (Fletcher, 1975: 153), says that King had thought they suggested earlier habitation, from their occurring “in regular rows”, although King does not make this remark in his journal, and the fact of their existence was in any case sufficient. Later, Maiden (1904: 723–724), the Government Botanist of New South Wales, doubted the identification of plantain as banana and suggested that it was actually taro, but the description seems sufficiently clear and King was more than once at pains to distinguish his introduced “Brazil” or “Rio Janeiro” plantains from the discovered variety (e.g., Hunter 1793: 317).

Even so, the existence of bananas planted in Arthur’s Vale (Fig. 3) before the arrival of the European colonists, does not unequivocally support the inference of prehistoric settlement. It is possible that the bananas had been introduced to Norfolk Island by Pacific voyagers between 1774 and 1788, in which case the various accounts of canoe wreckage found on Norfolk Island could be more significant than is generally assumed. In September 1788, King (Hunter, 1793: 331) linked catching a turtle with a puncture wound in its back to the finding in Ball Bay of some canoe wreckage which included a wooden image of human form and a fresh coconut, and surmised the existence of undiscovered land close to the eastward. Communicated to Governor Phillip, this news was passed on (Phillip to Sydney, 28 September, 16 November 1788, in Britton, 1892: 187, 211) initially as “two canoes… on the rocks, probably driven there from New Zealand” and later as “remains of two or three canoes” and, not necessarily associated with these, a piece of wood which appeared to have been not long in the water and was “said to resemble the handle of a flyflap” as made in Tonga. Later description (Phillip to Sydney 12 February 1790, in Britton, 1892: 296), separated the coconut from “parts of two canoes, which answer the description given of the canoes of New Zealand… and a wooden figure (very rudely carved)” of a kind found in Tonga. King also found a fresh coconut and remains of a canoe in Anson Bay (Hunter, 1793: 345). Whether any of these finds had been originally associated is uncertain, but it is possible that part of the canoe wreckage was the remains of a late eighteenth century landfall during which bananas were planted but then abandoned as the people died or managed to depart.

In any event, if the coastal finds including the bananas were suggestive of earlier contact, it seems to have been the period of major expansion inland, under the energetic direction of Major Ross, who had charge of the colony March 1790 to November 1791 in Commandant King’s absence, which turned up the first direct evidence. Notice of this arrived in letters brought to Sydney by the *Salamander* in October 1791, and from which it seems King advised Joseph Banks, that “Some Stone Axes, Chizzles and other tools have been found under ground some depth in the interior part of Norfolk Island.” (King to Banks 25th October 1791 in Specht, 1984: 12). The original letters are discussed by Collins (Fletcher, 1975: 153), who notes that the artefacts were “found in turning up some ground in the interior”. It is an intriguing possibility that the ground in question was a 100 acre pre-European opening in the forest (the only one ever found), overgrown with vines, which Ross named Charlottefield and began preparing for cultivation in June 1790 (Ross, 1791). This area to the west of Mount Pitt was, possibly, the site of a prehistoric clearing. Development of it continued through 1790 and 1791 with the construction of a new village, Queenborough (Wright, 1988: 114).

The whereabouts of the stone tools reported by King are unknown, but it is possibly one of them, a handsome example of a tanged, quadrangular cross-sectioned adze of typical early East Polynesian form, which was painted

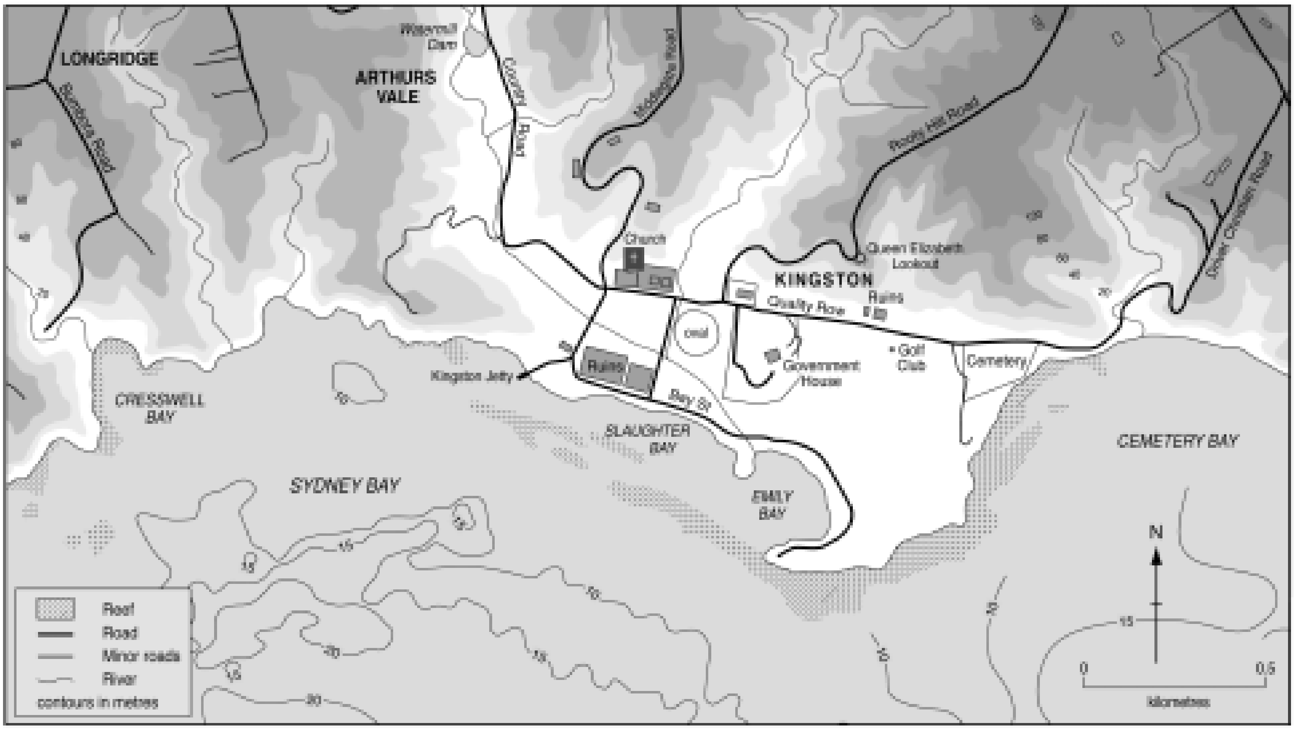

Figure 3. Arthur's Vale and Kingston areas.

between 1792 and 1794 in Sydney by Thomas Watling (Nobbs, 1988: vii, Specht, 1993: 147). At least one of the adzes was kept by King and shown to the two Northland Maori (Tuki and Huru) who had been brought to Norfolk Island to teach the working of flax; "they recognized it with extreme joy for an *etoki* [adze] of Eaheinomawe [E he ika no Maui, the fish of Maui, a traditional name for the North Island of New Zealand]." King then summarized his evidence; "[is] not this circumstance with that of the banana trees and canoe, a feasible proof of the island having been formerly inhabited or having made a part of New Zealand… " (King, 24th May 1793, in McCarthy, 1934: 267).

There is no known record of further discoveries of artefacts or of any other potentially prehistoric remains between the late eighteenth and early twentieth centuries, although it is almost inconceivable that none were made. The modern record begins with Thorpe's (1929) description of an adze found at Emily Bay by Harold Rabone whose recovery of material was described later by McCarthy (1934). He says that Rabone found in the sand dunes "a number of small adzes in process of being fashioned. With them were several hundred flakes that had been chipped off in the shaping of the adzes." The New Zealand ethnologist, Skinner, reviewed the material given to McCarthy and declared it to be characteristically Polynesian.

The history of later finds is described and analysed in detail by Specht (1984, 1993). He examined all the accessible material in museum (except Norfolk Island Museum) and private collections, combining stylistic with selected material analyses based upon petrological examination. He divided the implements into four groups. Group I consisted of two Australian tools, to which can be added one from the wreck of the *Sirius* (McBryde and Watchman, 1993; Stanbury, 1994). Group II consisted of two axe blades of Melanesian type (Specht, 1984), to which can be added a fragment of *Trochus* shell armband from the lagoon at Slaughter Bay and a large *Tridacna* shell blade found in sand at Cemetery Bay (Specht, 1993 and see Anderson, 1996). There are other probable Melanesian artefacts in the Norfolk Island Museum collection (uncatalogued when recorded and drawn by Anderson in 1995). Leaving aside a large triangular blade, donated by a Mr Watt, whose collection was gathered from around the Pacific, there is another donated lenticular cross-sectioned blade, and a pearl shell lure shank of Melanesian form found on the surface near the wharf in 1993 by Mr George Anderson. One possible source of Melanesian artefacts is the students from several Melanesian islands brought for training to the Melanesian Mission school on Norfolk Island. When it opened in 1866, indigenous artefacts were still commonly used, so the existence of such material on Norfolk Island need not necessarily be attributed to prehistoric visitors.

Groups III and IV comprised 30 pieces of Polynesian type, 25 of them in basalt and the remainder of volcanic or metamorphic silt and sandstones (Specht, 1984: 28). To them can be added six adzes described by Specht (1993), nine more basalt adzes and preforms in the Norfolk Island collection, all from Emily Bay or Slaughter Bay, a Duff, 1977 Type 2a basalt adze recovered in 1995 by Nicolai (below), and a Duff, 1977 Type 3 basalt adze found by Bob Tofts at Slaughter Bay in March 1996. The later finds add weight to Specht's (1984) original conclusions about the East Polynesian origin of this material, its particular similarity to the Raoul Island collections, and its associations with the Emily and Slaughter Bay area. The non-basalt pieces (Group IV) were mainly of Duff, 1977 Type 2b form and in materials indicative of South Island New Zealand origin. They do not come from the Kingston beaches and may have either a late prehistoric origin separate to the

Group III material or be European-era introductions.

Specht (1978, 1984) led an Australian Museum archaeological expedition to Norfolk Island in 1976. This surveyed the entire coastline and parts of the interior for archaeological sites. One mound and five other places inland were test-pitted, without uncovering anything of prehistoric archaeological interest (Specht, 1984: 10–11). On the coast, three test pits were excavated at Cascade without result. At Slaughter Bay a test square (1 m^2 Specht [1978: 220] says two test pits at this point) was excavated to 2.8 m depth on the beach side of the seawall but it encountered no material of pre-European provenance. At Emily Bay, "several test pits were excavated at the western edge of the quarry cuttings into the dune" (Specht, 1984: 9), again without result and Specht (1978: 220) suggested that the Rabone adze had possibly come from Slaughter Bay. The test pits must have been very close to the edge of the prehistoric site which, as we now know it, lies in older dunes immediately beside the former sand quarry.

Attention then became focussed upon the fossil bone and landsnail deposits in the Kingston dunes. The Royal Australian Ornithological Union held its annual congress on the island in 1978, during which Davidson and Rich, following up some earlier explorations by Davidson, excavated on Nepean Island and at Slaughter Bay, Emily Bay and particularly Cemetery Bay (Rich *et al*., 1983). This research, continued by Orth (1980) and then Meredith (1985, 1991; Meredith *et al*., 1985), produced some results with archaeologically interesting implications. At Cemetery Bay and Emily Bay there were layers which contained fossil bird bones but also rat (*Rattus exulans*) bone and considerable charcoal, the latter dated at Cemetery Bay to the period 715–450 B.P. (Anderson, Higham and Wallace, this vol., see also Meredith *et al*., 1985: 306). Excavations of historical remains in the Pier area at Kingston also encountered lower deposits of charcoal and bird bone which Varman (1993: 15) suggests may be of prehistoric origin.

When sand mining operations expanded at Cemetery Bay in 1989, it therefore made sense to the Norfolk Island Government to have these deposits appraised by archaeologists, and several reports were commissioned. Varman's (1990) observations suggested that the charcoal-enriched level at Cemetery Bay had resulted from a single major event, such as forest clearance, with ash and charcoal then becoming swept or carried into bird burrows and rootholes. There were also heat-affected bird bones, perhaps of chicks or others caught in the fire, and a piece of basalt which Varman (1990: 14) took to be part of an adze, but which Specht (1993: 150) inspected and regards as dubious. Monitoring sand mining in the same area, Packard (1990) recorded further outcrops of the charcoal-enriched horizon, including remains of a burnt tree stump. The large shell adze referred to above and found in the same area is not clearly associated with any pre-European level (Anderson, 1996). To summarize, we suggest the Cemetery Bay evidence reflects less direct habitation than early forest clearance associated with it, but there might have been a settlement in the near vicinity.

The long record of artefactual discoveries, the stratigraphic evidence of a charcoal-enriched layer dated to about 800–700 B.P. at Cemetery Bay, and the association of it with introduced rat bones, all added up to a fairly convincing suggestion of prehistoric settlement. All that was missing to confirm the case was a settlement site, and this finally came to light in December 1995. The investigations of it are described by Anderson, Smith and White (this vol.) and it provided most of the material on which the remainder of this volume is based.

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Archaeological Fieldwork on Norfolk Island

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ABSTRACT. Exploratory excavations in Cemetery, Emily and Slaughter Bays in search of a prehistoric settlement site are outlined, along with small scale researches elsewhere on Norfolk Island and on adjacent islands. The archaeological excavations at the settlement site discovered in Emily Bay are described in detail and the taphonomy of the site discussed.

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The Norfolk Island Prehistory Project (NIPP) programme was divided into four field seasons. These were in December 1995 (directed by Atholl Anderson and Geoff Hope), in April 1996 (directed by Atholl Anderson and Ian Smith), in November 1997 (directed by Atholl Anderson and Peter White) and in February 1999 (directed by Peter White). It is convenient to describe the fieldwork and the characteristics of the sites investigated in this framework.

Fieldwork in 1995

Cemetery Bay. The first focus of fieldwork on Norfolk Island was upon the fauna-rich localities previously recorded in Cemetery Bay. It was considered that further investigation of these might divulge clues to a greater cultural influence in the evidence than was then known, essentially the existence of rat bone and charcoal. Local resident Jack Anderson took us to a place located 78 m south of the southern end of the Cemetery Bay sand beach ("Jack's site"). There are similar exposures, many disclosing faunal material, to either side, but this one had the deepest stratigraphy. At the top of the low cliffs (about 5 m above high tide level) were two sedimentary units resting in holes and crevices of the underlying calcarenite basement. The upper consisted of about 0.5 m of coarse yellow-brown sand, containing scattered pebbles, calcarenite rubble, landsnails and bones, while the lower consisted of up to 0.5 m of compacted brown sand and clay, full of calcarenite rubble, and with very little bone. Most of the bone came from a band 0.1–0.5 m below the surface. A small excavation of the exposed face and of material slumped from it was carried out, and the faunal remains retained for analysis. There was nothing about them to suggest a cultural origin.

Trench CB95:01. The "Old Quarry" site ("Area 1" of Varman, 1990) at Cemetery Bay was chosen for investigation because it was the locality in which unit C4 (a band of charcoal enriched sand, and bird, fish and rat bones) had been most extensively investigated (Anderson and White, *Approaching the Prehistory*, this vol.). A large shell adze had been found in the northwest corner of the "Old Quarry" during sand mining. A 3 m^2 trench (CB95:01) was excavated in undisturbed ground near the edge of the quarry, some 5–8 m away from where the adze had been picked up (Fig. 1, further details in Anderson, 1996).

The stratigraphy at this site consisted of layers of carbonate sand interleaved with layers of sand or silt-enriched clay (Fig. 2). The upper of these latter formed part of the current soil horizon (included for archaeological recording purposes in layer 1), and the others were designated layers 2, 4 and 6. The important point to note about these layers is that they are not palaeosols. There is no evidence of soil development. Rather the material appears to have been washed into the site where it makes a sharp contact with the sand beneath (except for some subsequent worm activity, especially at the base of layer 6), and lifts away from it cleanly. In each case, the clay and silt has also carried pumice, which is found particularly in the upper parts, and on top of, each clay layer. The probable source of the clay is slope wash from the nearby hills.

The discovery of a concentration of rusted iron nails in layer 4 indicates that the top 0.65 m of the site, including the upper three clay layers at least, are European. The sand in layer 7 contained an irregular depression in the upper surface, filled with layer 6 clay, which might be an old root

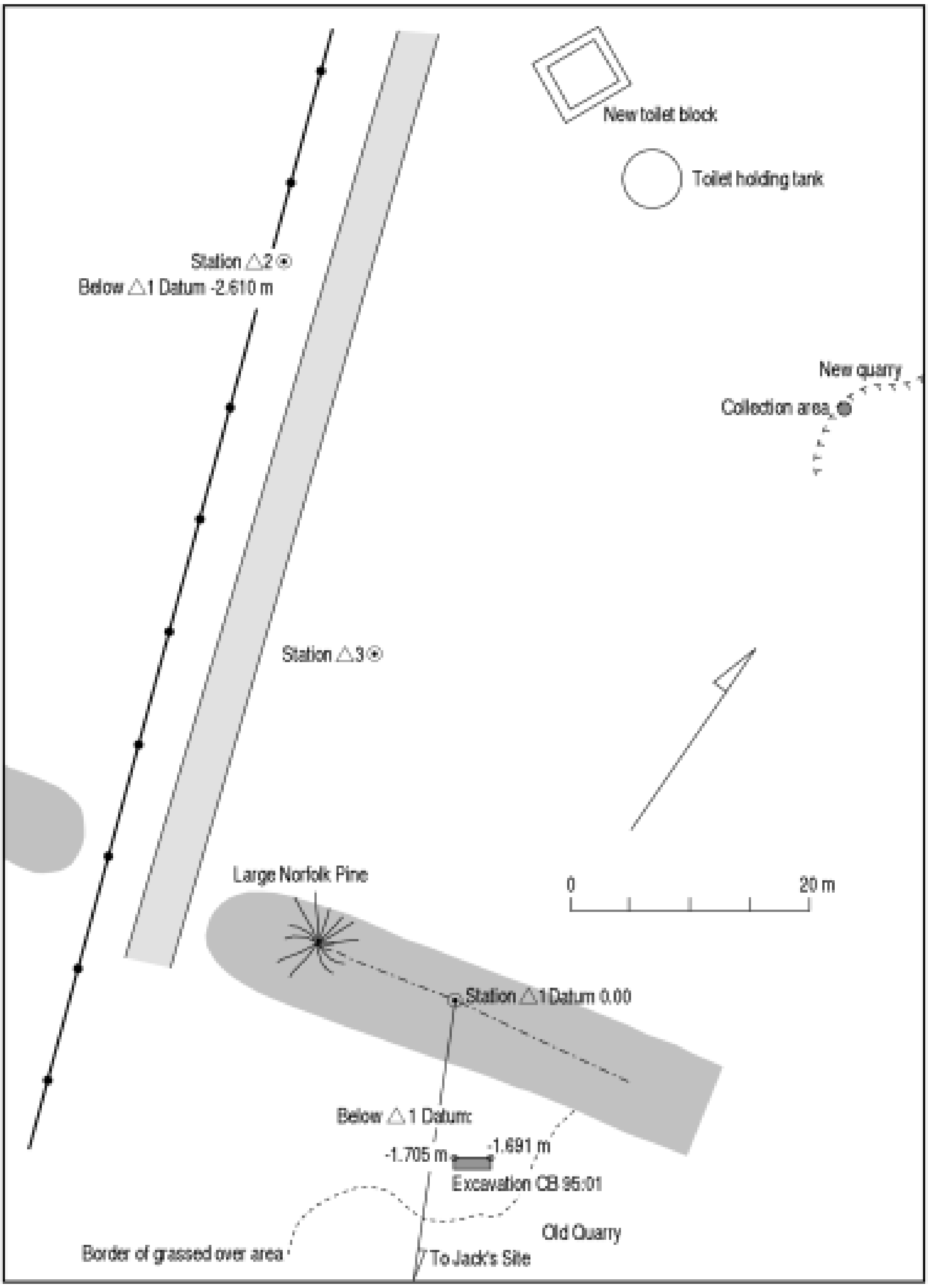

Figure 1. Location of trench CB95:01 in Cemetery Bay.

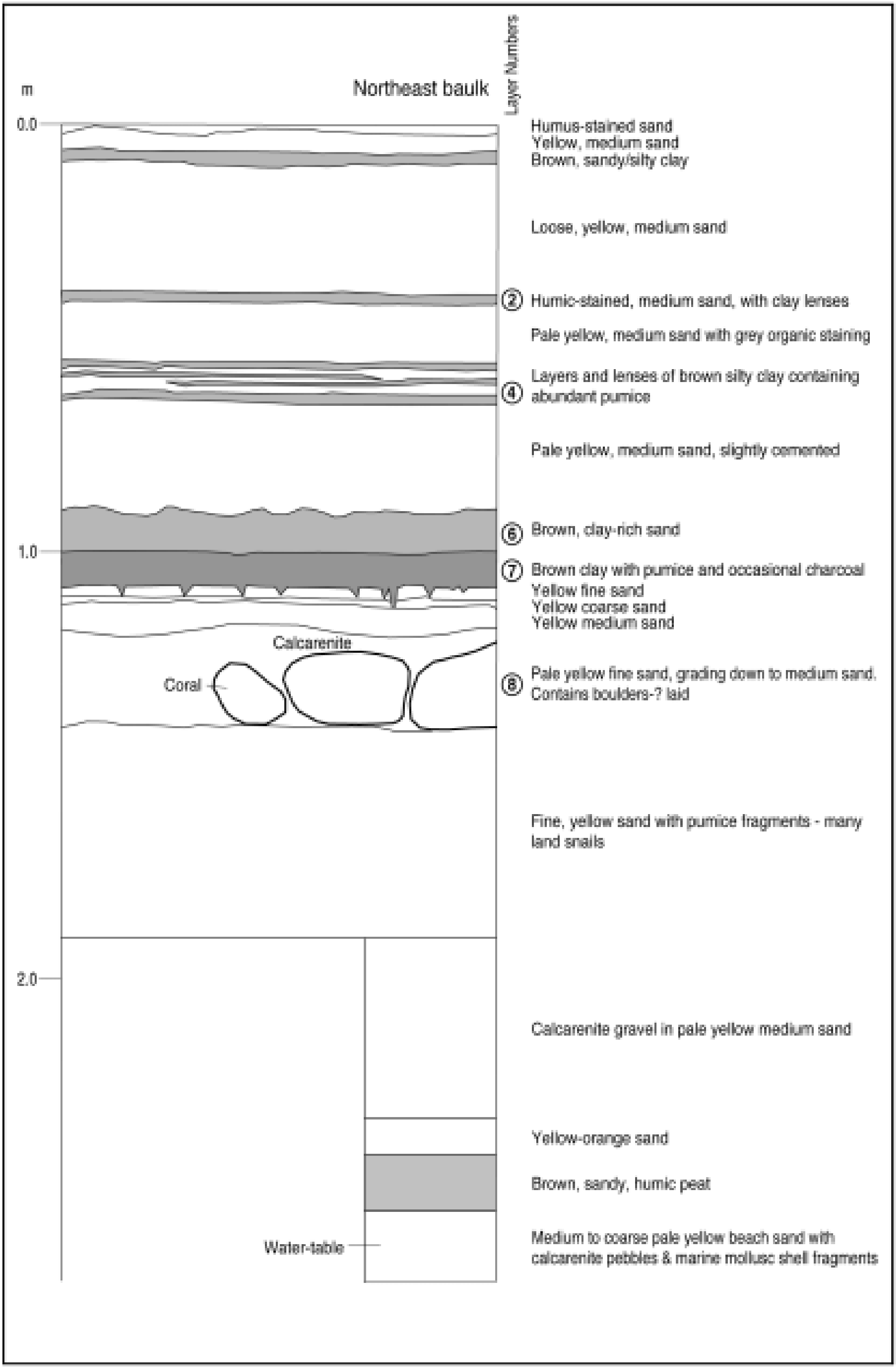

Figure 2. Stratigraphy of trench CB95:01 in Cemetery Bay.

channel, or possibly a procellariid burrow, but neither need be prehistoric. There was a noticeable increase in the abundance of charcoal and fish, bird and rat bones in layer 7, which appears in this respect, and in depth, to correspond with unit C4 (Meredith *et al.*, 1985), but the layer of calcarenite and coral boulders in layer 8 seems to have been laid by hand. It may form the edge of a coastal road known to have run through Cemetery Bay during the convict era. In that case, all of the stratigraphy down to at least 1.40 m is European in age.

This has important implications for the discovery of an adze nearby, "… the only artefact found on Norfolk for which a sub-surface context has been proposed" (Specht, 1993: 153). The adze, of *Tridacna gigas* shell, does not appear to be of Polynesian provenance and might have been imported from Melanesia, possibly in the nineteenth century, after the establishment of the Melanesian Mission in 1866. It was associated with a beer-barrel conch shell, a local species, when found by Ted Clampett and Matti Nola in December 1984. Information in the Norfolk Island Museum (Bag with conch shell, labelled ARNI 7), indicates that the findspot was 1.5 m below the surface (Specht, 1993: 150, quotes Varman as indicating a depth of 1.25–1.5 m), in clean yellow, sand. This would put it in the upper part of our layer 8 which is possibly very late prehistoric or European in age. It would then follow that the stratigraphy in our trench and its vicinity, possibly through European disturbance, is not the same as that which Meredith *et al.* (1985), excavated approximately 100 m away and dated to 800–700 B.P.

A sample of *Rattus exulans* bone collected by Charles Meredith from 140–155 cm in unit C4 was provided by the Museum of Victoria and we submitted it to the Oxford Radiocarbon Accelerator Unit. A sample of *Rattus exulans* bone from 130–150 cm depth in CB95:01 was submitted for radiocarbon dating at the Rafter Laboratory, Institute of Geological and Nuclear Sciences, Lower Hutt. The results, respectively OxA5781 and NZA6635, are presented in Anderson, Higham and Wallace, this vol., Table 8.

Trench CB95:02. At the request of the Kingston and Arthur's Vale Heritage Association and the Norfolk Island Administration, the excavation of a pit, about 5 m in diameter, for the toilet holding tank at Cemetery Bay was monitored and faunal material recovered as it became exposed by hand digging. The stratigraphy was as follows: 1.0 m of buff dune sand, then 0.45 m of medium-coarse, yellow-brown calcareous sand, containing an occasional bird bone. Below this was 0.7 m of brown sandy clay containing some bird bones and fragments of pumice, overlying 0.3 m of a coarse pale-yellow to white sand. This graded down into a white sand with many lumps of calcarenite, water-rolled marine shells and some fossil wood. Left to stand, the pit filled with fresh water to the top of the pale-yellow sand.

Cemetery Bay Stratigraphy. The previous excavations in this area leave little doubt that at least some of the material has a cultural origin (Anderson and White, *Approaching the prehistory…*, this vol.). While our research did not uncover any more conclusive evidence than that already established, we think that the wide distribution of charcoal, including a burnt stump, and its stratigraphic correspondence with *Rattus exulans* bone, define an horizon which is essentially cultural. Quite probably it is either on the periphery of a settlement site or it was an area of forest clearance.

Emily Bay. Attention turned to Emily Bay because it has produced a quantity of adzes and waste flakes over the years (Anderson and White, *Approaching the prehistory…*, this vol.) and it is inherently more suitable for prehistoric settlement than anywhere else on Norfolk Island. It provides the most sheltered anchorage for small craft and the best beach from which to launch and recover canoes. It is at the centre of the broad band of intertidal reef which runs from Cemetery Bay to Slaughter Bay, and at the broadest end of the lagoon, providing unparalleled access to inshore marine resources. Small vessels, including canoes, can cross the reef at high tide and, prior to the construction of the Kingston jetty, it was possible to sail into the western end of the lagoon and along to Emily Bay (Figs. 3, 4).

Figure 3. Emily Bay sheltered by a Norfolk pine plantation, with Slaughter Bay to the right. The main excavations occurred towards the right hand end of the main plantation of Norfolk pines. Nepean and Philip Islands in the background.

Figure 4. The reef in Slaughter Bay at low tide. Emily Bay is in the background, behind the limekiln chimney.

Search procedure. After inspecting the exposures in the drain and road cuttings, some auger holes were drilled and two road sections cleaned down in the Eastern end of Emily Bay, without discovering any archaeological remains. It was then decided to employ a small mechanical digger to explore the sand dune stratigraphy in greater depth. The first trench (EB95:01) was dug 115 m east of the toilet block and 5 m south (i.e. seaward) of the present road. It was located 8 m east of the exposed remains of an historical (A.D. 1835) road. A trench of 1.5×1 m, narrowing to about 1.0×0.5 m at the bottom (2.5 m, about the level of the modern road surface) was taken out in approximately 0.2 m spits. The stratigraphy consisted of medium to fine, yellow, carbonate sand, slightly compacted. There were occasional pieces of water-rolled pumice, but none in bands. (All sands in this and other trenches were described by ANU geomorphologist, Prof. G. Hope). No sign of cultural material was noted.

Directly inland across the road, there is a sand quarry area which has been scraped down to the level of the road surface. It is now partly used as a gravel dump and parking area. In this area, 13 m north of Trench EB95:01 a second trench (Trench EB95:02), was dug in the same way and of the same dimensions. At the top of it was a 0.15 m thick brown clay packed with road gravel, and evidently the edge of the modern road base. Beneath it, was a 0.7 m deep unit of yellow carbonate sand as in Trench EB95:01, lying above 0.1 m of bright yellow-orange sand and then fine white sand saturated with fresh water. The water table stood at the junction of the latter two units and along it was found matted roots of *Araucaria*. No sign of cultural material was noted. Another trench (EB95:03) was dug approximately 36 m northeast of Trench EB95:02. This disclosed the same stratigraphy as in Trench EB95:01, that is medium to fine yellow carbonate sands containing occasional small pieces of water-rolled pumice. No cultural material was noted.

The digger was then moved to the western end of Emily Bay within a fenced-in Norfolk pine plantation (Figs. 3, 5). Local historians believe that there may be some early historical burials in this general area, and particular attention was paid to any signs of those (none were observed, and some evidence suggests that the burial area was seaward of the present road (Specht, 1984: 32)). An auger hole revealed no cultural material, and the digger was employed. In order to get a shallower scrape of 0.1 m per time, a trench 2.5×1.0 m at the top, narrowing to 1.8×0.7 m on a sloping base (Trench EB95:04), was excavated. The sand below the pine duff was as in Trench EB95:01, but with occasional brown mottles. At 0.7 m, in the western end of the trench a sand of the same type, but light grey in colour appeared. A surface of grey sand was then exposed by trowel, the sterile overburden being cleared periodically by the digger. The surface proved to slope steeply to the east and was discontinuous in plan (Fig. 6). Excavation of part of this feature by trowel disclosed a broken cobble of basalt, several small fragments of charcoal and two large fish spines. This was taken as being the remains of an Oceanic type of cooking area and thus *prima facie* evidence of a prehistoric settlement site.

Nicolai records. Our discovery prompted local resident and archaeologist Mr Bevan Nicolai to produce a sample of bone collected from West Emily Bay in which some material appeared to be of cultural origin (remains of large fish, broken bones of large birds, a dog mandible). It is apparent, in fact, that Mr Nicolai (n.d.) had come very close to deducing the existence of a prehistoric site in Emily Bay. In November 1986 the Norfolk Island Administration dug a longdrop toilet hole (subsequently unused) just outside the seaward plantation fence in Emily Bay, about 15 m west of the gate. This produced the material noted above, plus some rat bones and basalt flakes. In his field notes (26 November 1986) Mr Nicolai observed that the fish bone was too big to have been washed up or brought by birds and he was curious about the dog bone. He concluded that only some radiocarbon determinations might solve the puzzle.

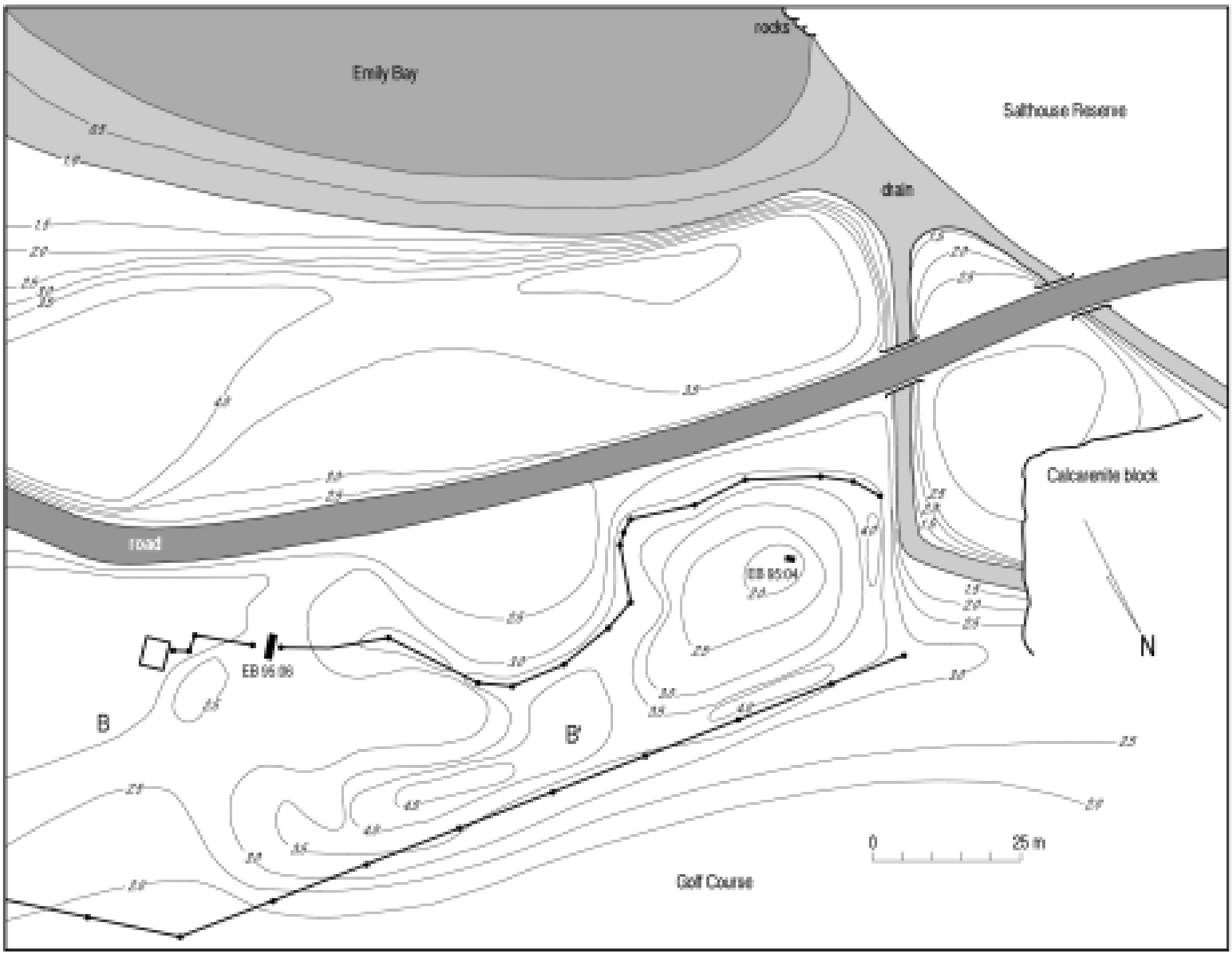

Figure 5. Location of Trenches EB95:04 and EB95:06 (incorporating EB95:05) at Emily Bay in 1995.

Similarly, in April 1987, Mr Nicolai (n.d.) recorded the existence of bird, rat and fish bones eroding from the sand face under the old convict road at the extreme eastern corner of Slaughter Bay, noting again that the fish bone must have come from individuals too large to have been carried by birds. He excavated about 0.5 m into the face and collected some faunal material. In 1995, he found an adze in the sand near this place.

While inspecting the ground surface in the vicinity of the Emily Bay toilet block, bird bone fragments and some fish bones were noted around the base of fence posts near the gate, at the gate posts, and on the sand road surface near the toilets. An auger hole near the fence (Fig. 8, Auger hole 3) encountered a brown clay soil at about 0.7 m and then some grey sand. No faunal or cultural remains were recovered, but the sand looked like that in EB95:04, so it was decided to concentrate attention in the vicinity. A test-pit of 0.4×0.4 m (Trench EB95:05) was then excavated, which disclosed cultural stratigraphy (Fig. 7), a broken and apparently burnt piece of a basalt cobble and a struck basalt flake. Some bird, fish and rat bone was recovered, along with small pieces of charcoal.

Trench E95:05 was then enlarged to an excavation of 4.0×1.0 m (Figs. 8, 9), called Trench EB95:06, which was set out across the gate opening. The digger was employed to remove loose dune sand and roots from above the clay—the latter, tough and sticky, was chipped off by hand. Underneath the clay was a surface of dark grey sand. Excavation showed that this dark grey sand formed a single layer and the material was taken out in four spits. All material was passed through 4 mm sieves. Initially we tried 2 mm mesh but found that it collected too much extraneous material, even when washed through, particularly rootlets which were abundant in the sand. Collection of material passing through the 4 mm mesh showed that some small pieces of broken bone and small landsnail shells (very common in all sand deposits on the island) were being lost, but not identifiable material of cultural origin (this was checked regularly by palaeontologist, Richard Holdaway, who took samples).

Two earth ovens were found, each consisting of a shallow scoop in which were packed burnt and broken fragments of basalt cobbles, charcoal pieces and bird, rat and fish bones, often broken and some burnt. One oven lay somewhat higher than the other in the same layer, and some material had spilled from each into the surrounding area. Six flakes of struck basalt were recovered, several of them of distinctive forms created in the fashioning of adze preforms. No other structures or artefacts were noted. The stratigraphy suggests a single cultural phase, probably of limited duration (Anderson, 1996).

Judging by our auger holes (Fig. 8, Auger holes 1–4), there is one edge of the Emily Bay site between the gateway and the northern wall of the toilet block, although the recovery of bones during the digging of the toilet pit indicates that the site extends that far. The stratigraphy in

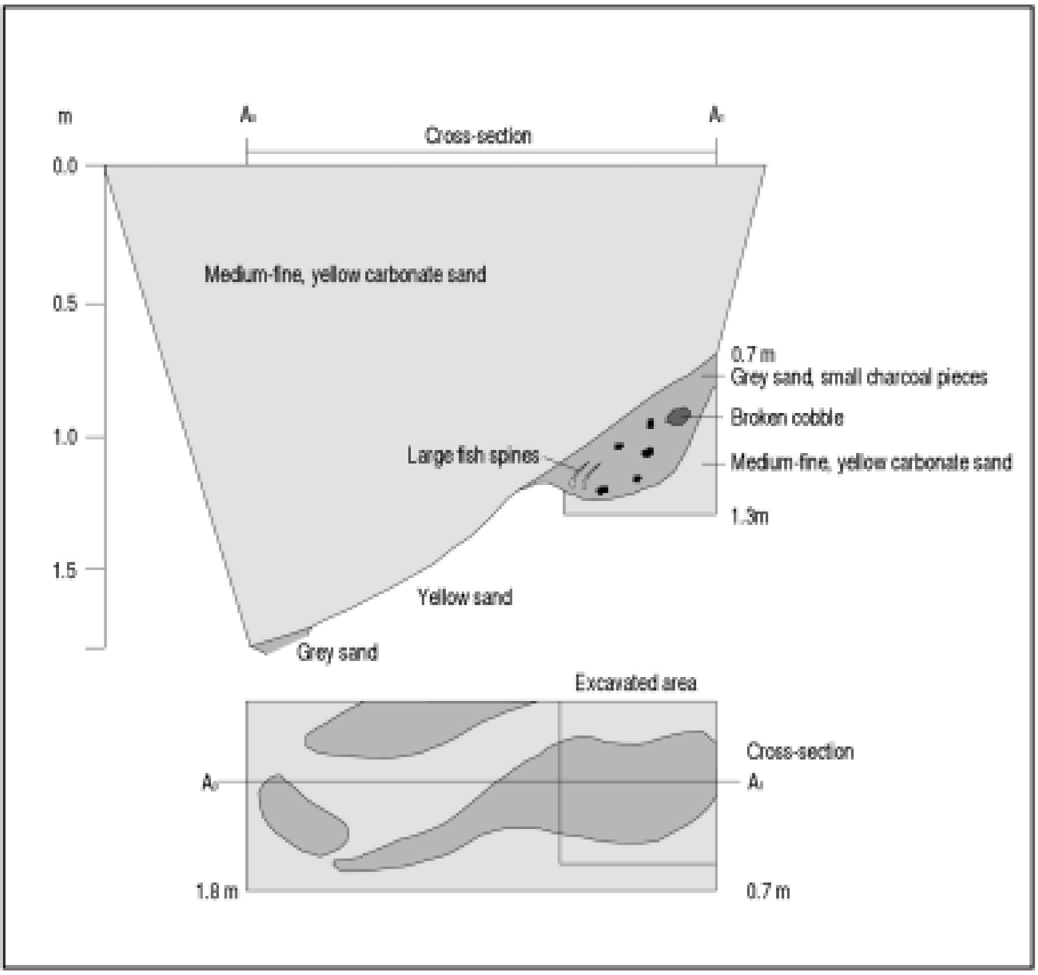

Figure 6. Stratigraphy and cross-section of Trench EB95:04.

Trench EB95:06 shallows towards the south, possibly indicating that there is another margin to the site between the gateway and the sealed road.

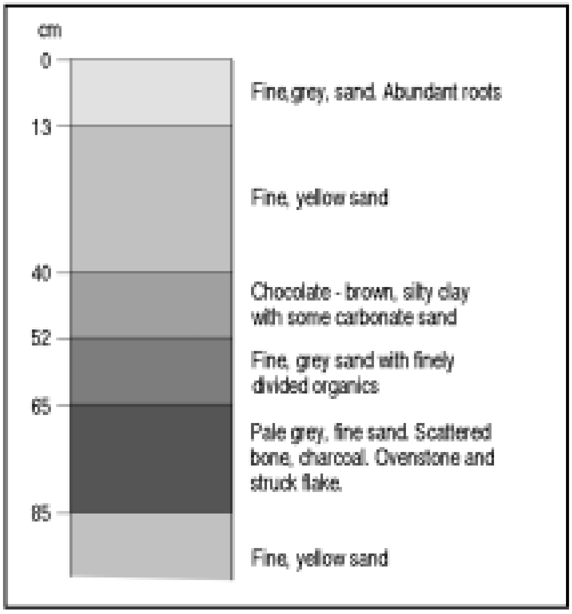

Figure 7. Stratigraphy of Trench EB95:05.

Fieldwork in 1996

Slaughter Bay. Investigations were confined to the eastern end of the bay, on the assumption that, since this was the end nearest to the known site in Emily Bay, and also the locality in which most of the adzes and adze pieces of Polynesian type had been found (Specht, 1984), it was the most likely area to produce prehistoric archaeological stratigraphy.

Search procedure. A series of holes was drilled with the sand auger along the northern side of the road at about 15 m intervals between the calcarenite massif and the western end of the stand of pines, and then north–south between the drain and the sea wall. Many of these holes bottomed out at 30–60 cm on coral rubble and were thus inconclusive. Those which disclosed greater depth and diversity of stratigraphy were noted for further reference and are shown in Fig. 10 (Auger holes a–e).

Test-pits were dug by spade at SB96:01 and SB96:02, but these also encountered difficulty in shifting calcarenite and coral rubble. Consequently, the backhoe was employed to excavate four small trenches: SB96:03 (which incorporated test-pit SB96:01), SB96:04, SB96:05 (which incorporated test-pit SB96:02) and SB96:06. Each trench was approximately 1.5×0.8 m in area at the top, narrowing to about 0.7×0.5 m at the bottom of the reach on the hydraulic arm. The sand auger was used in the base of three trenches to investigate the lower sediments. In trench

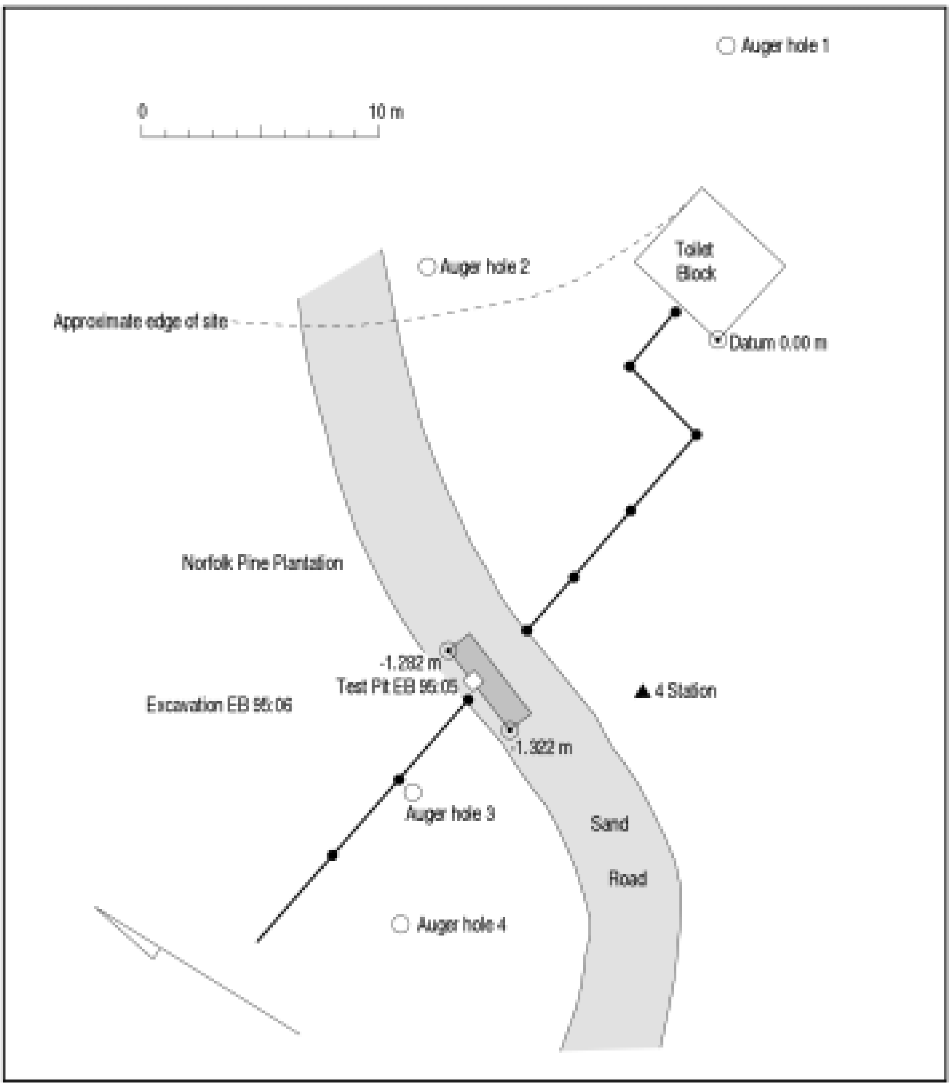

Figure 8. Location of auger holes (labelled 95/1–4 in Fig. 13) and Trenches EB95:05 and EB95:06.

SB96:04, the density of rubble prevented the back hoe from reaching below 1.4 m, and it was not possible to operate the auger. Sections were cleaned down by trowel and the stratigraphy measured and drawn (Fig. 11).

Test Trenches SB96:03–06. No significant cultural remains were revealed, either in structures or artefacts, and no charcoal-enriched levels were recorded. No structures of placed rock or other indications of settlement features of pre-European provenance were observed, except in SB96:06, and possibly SB96:05.

In SB96:03, a broken basalt cobble was found immediately below the brown sandy clay and rock layer, and a small, struck basalt flake, picked out of the sand scoop, seems to have been associated with it. It is possible that both are of historical age and caused incidentally in the course of activities other than adze manufacture. However, it is also possible that the yellow medium calcareous sand and rock unit in which these occurred, along with some pieces of marine gastropod shell and coral is, in fact, the prehistoric settlement level in Slaughter Bay. There was nothing beneath that level of archaeological interest all the way down to the water table at 3.0 m.

Trench SB96:04 was on the top of the ridge near the road. Below a series of thin sand layers of differing characteristics, and a brown, sandy, clay was yellow calcareous sand which, as the trench deepened, proved to contain increasing quantities of calcarenite rubble. This was of all sizes and shapes, in pieces up to 0.8 m long, with sand between. It has the appearance of a storm beach layer and may lie immediately above solid calcarenite bedrock.

Trench SB96:05 disclosed a thin layer of partly burnt packed calcarenite rubble lying above a thicker layer of calcarenite rubble and sand. Since the trench was dug beyond the known boundary of the convict road, it is assumed that these features may be discarded material from the nearby lime kilns.

In SB96:06, at 2.3 m depth near the base of the back hoe excavation, we encountered a thin, brown, sandy-clay layer which contained damp, rotted sandstone, some charcoal smears and cut pieces of cattle bone (identified by Ian Smith, a specialist in mammal bone). This find indicates that the overlying calcareous sands, and the layer of brown sandy-clay, are of historical age and have been blown and pushed over levels at which there was discard of European rubbish.

It is difficult to interpret the Slaughter Bay sedimentary sequence and determine the level or levels within it at which prehistoric remains could occur. At the sea wall in the extreme eastern corner of the beach, fish and bird bone

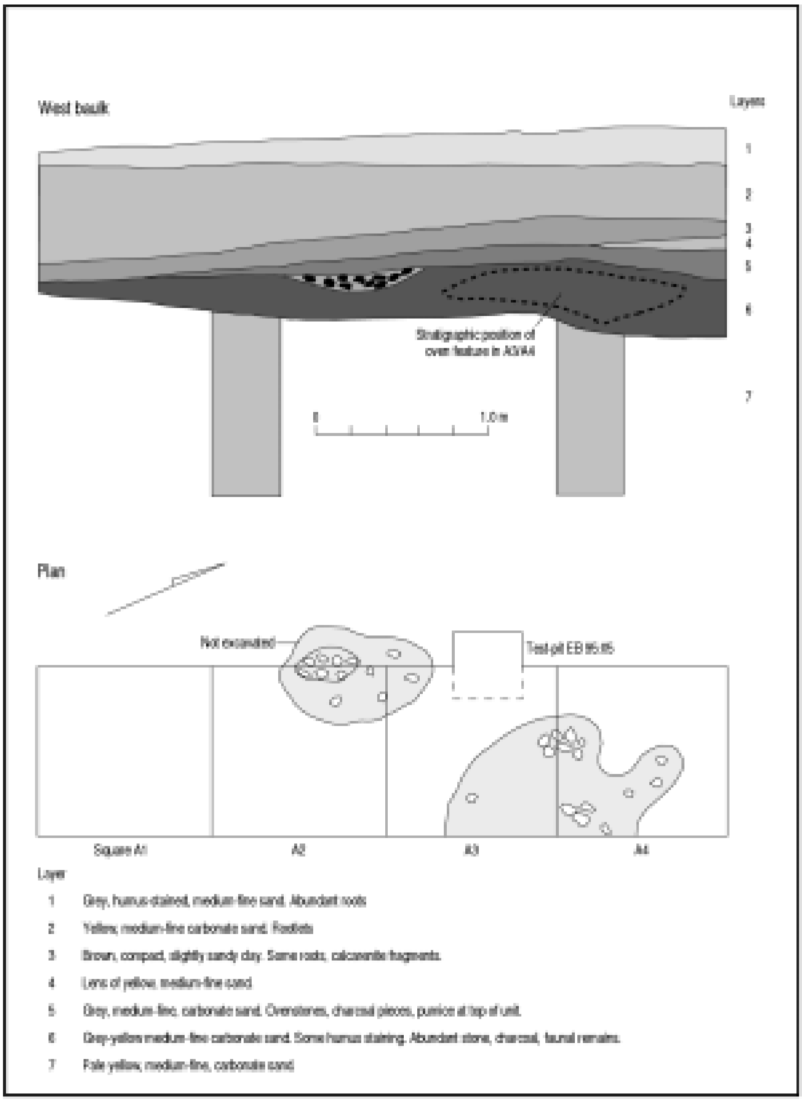

Figure 9. Stratigraphy and plan of Trench EB95:06.

together with an adze were recovered by Bevan Nicolai (above). There is no further sign of occupational debris there, and it seems that what remained was probably destroyed by the recent construction of the sea wall.

Where any depth of deposit is encountered in the eastern end of Slaughter Bay, the common sequence is: modern turf, calcareous sand (usually yellow, but also buff or containing humus-stained lenses), a layer of brown, sandy or silty clay which is compact and tough to penetrate, going down on to yellow calcareous sand beneath. The possible indication of prehistoric remains in SB96:03 occurred at the top of the last unit.

Since these sands would be highly mobile when exposed, it is quite possible that they were blown inland during the European era over the margins of the swamp, into which some butchery remains had been discarded previously (SB96:06). However, the brown clay is not mobile and it is difficult to see what could have shifted it over the dunes between the road and the swamp other than labour or machine. It is known that substantial dumps of “fill” (mostly clay and stone) were deposited and spread immediately to the west of the clump of pines in recent times and it seems very likely that this practice also occurred further east. If that was the case, then the stratigraphy above the yellow medium sand and rock is all comparatively recent and no prehistoric material will be encountered within it, at any rate *in situ*.

While these initial investigations suggest that prehistoric remains are not abundant in eastern Slaughter Bay—and the absence of charcoal-stained layers is particularly indicative of low density or absence—it will still be necessary to continue looking. Several test trenches closer to the base of the calcarenite massif, and further augering in the central and western parts of the bay may be warranted. There is, however, nothing to show that the Emily Bay site continued into Slaughter Bay. The area between has been heavily disturbed by public works over the last two centuries which might have destroyed some of the evidence, but the stratigraphy on the western side of the Emily Bay site indicates that it did not reach the present drainage ditch. Consequently, it seems almost certain there was a pre-European settlement site in Slaughter Bay, the erosion of which has left numerous adzes and basalt flakes along the eastern part of the beach.

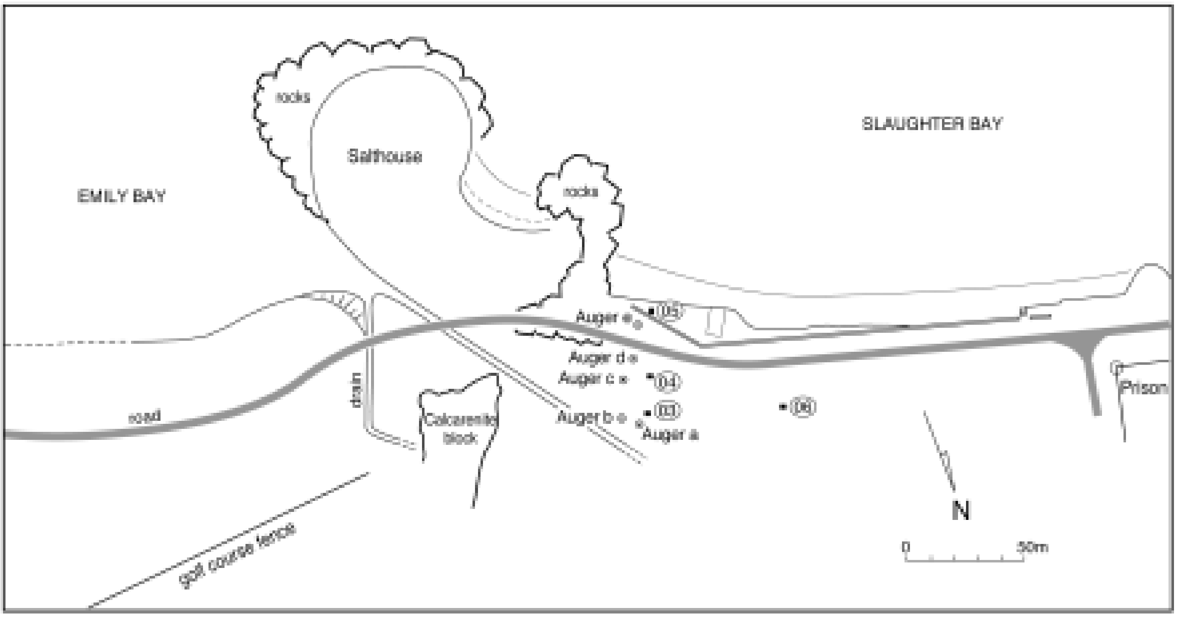

Figure 10. Auger holes and trenches in Slaughter Bay. SB96:03 incorporates SB96:01 and SB96:05 incorporates SB96:02.

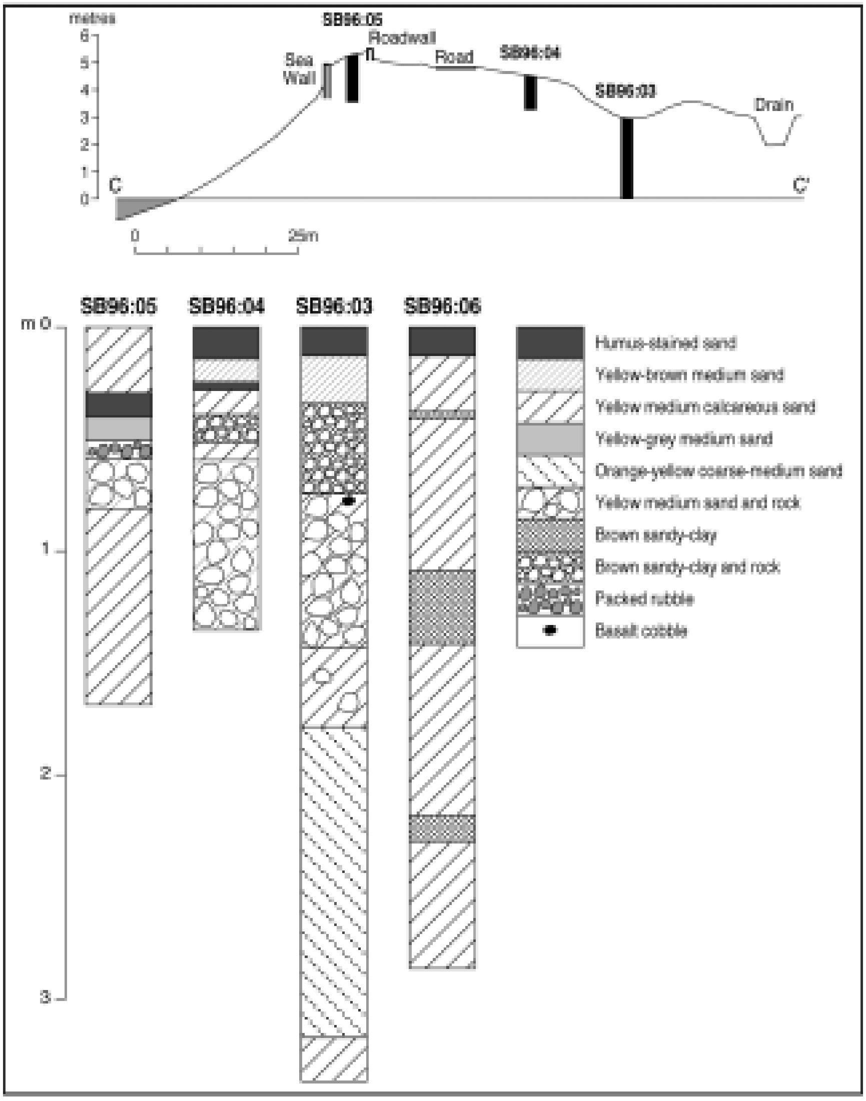

Figure 11. Stratigraphy of trenches in Slaughter Bay.

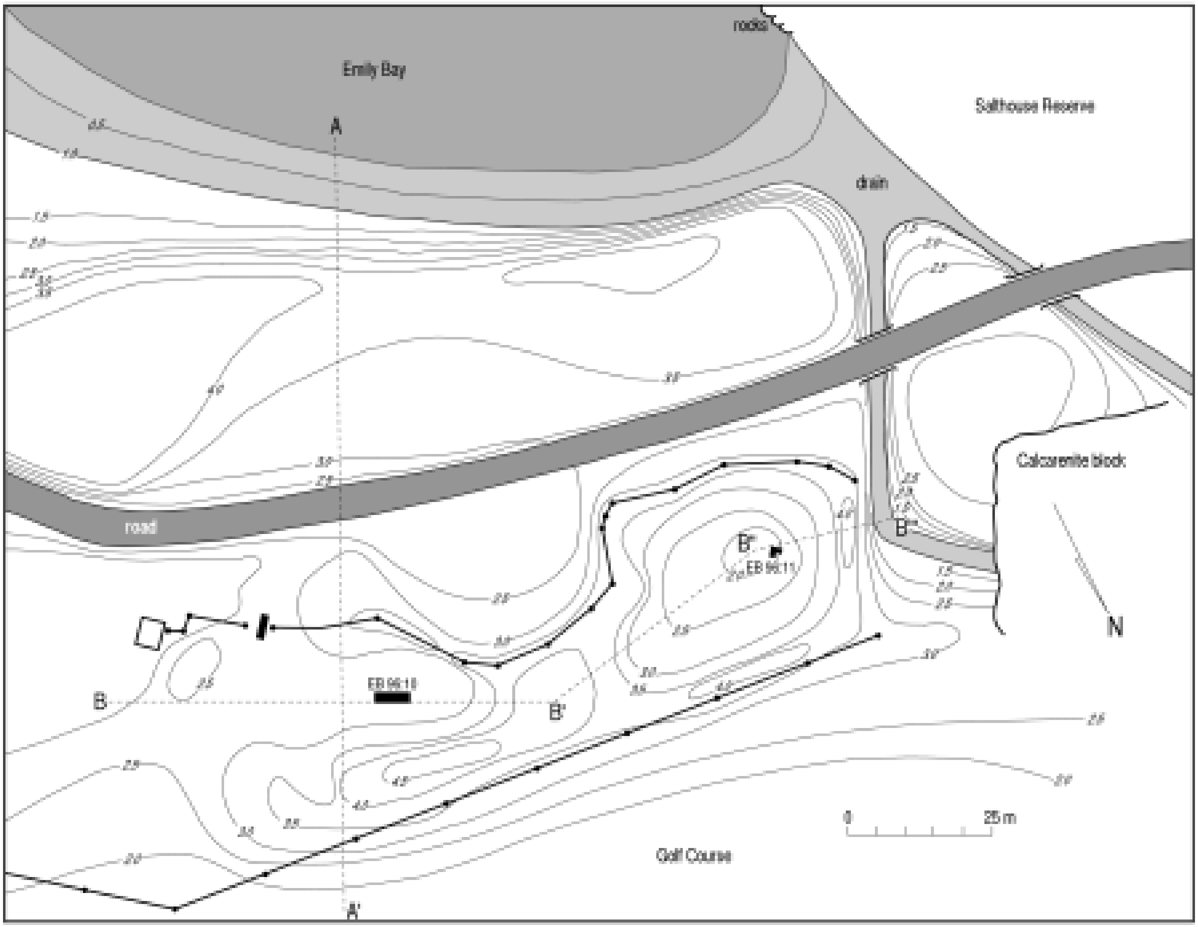

Figure 12. Location of trenches at Emily Bay in 1996, showing transect lines for stratigraphic analysis (Figs. 14, 15).

Emily Bay. The tasks at Emily Bay were to continue defining the extent of the site—areally and stratigraphically—and to expand the very small sample of it which was exposed in December 1995. The site was mapped and a contour plan drawn of the present land surface. Excavations were undertaken in each of the two main swales in which the site occurs (Fig. 12).

Extent of site. Thirty-six auger holes were drilled in order to define the boundaries of the site and its main stratigraphic pattern (Fig. 13). The details of each hole were recorded and then selected holes used to draw the stratigraphy along two axes of the site (Figs. 14, 15). As can be seen from these, the site is laid on a level to slightly undulating surface, but there are more substantial dunes deposited above it. These comprise a sinuous line along which runs the seaward fence of the pine plantation, and a second line inside the golf course fence. There are cross-dunes at the drain and through the centre of the site area. The effect of these is to create two large swales in which the archaeological remains are more accessible than elsewhere. It is in these swales that excavations have occurred: in the large eastern swale and its run-out area in December (Trenches EB95:05, EB95:06) and April (EB96:10), and in the smaller western swale in December (EB95:04) and April (EB96:11).

The auger holes showed that the site extends north–south for approximately the width of the plantation. It is possible that this coincidence results from protection of remains under the dunes, while former parts of the site were deflated or destroyed by earthmoving. However, the stratigraphy, indicating a thinning of the cultural layer at each extremity, suggests that the current site boundaries might define the original extent along this axis. Along the east-west axis, there appear to be gaps in the distribution. The main part of the site lies under the eastern swale, but does not extend further east than the sand road. The prehistoric cultural layer thins towards the central cross-dune and does not appear immediately on the western side of it. In the western swale, there is a discontinuous distribution of cultural stratigraphy.

Trench EB96:10. Auger holes showed that in this area the stratigraphy was very similar to that encountered in EB95:05 and EB95:06, but that the cultural layer was blacker in colour, indicating a cooking area, or possibly domestic hearths. The backhoe was used to scrape the overlying sand off an area 6.3×1.7 m, down to the brown clay. This was then chipped off by hand and an excavation area of 6.0×1.5 m was set out (Fig. 16).

Excavation disclosed a single cultural layer, varying in thickness from 0.15 m to 0.40 m (Fig. 17). It was directly overlain by the brown clay and underlain by medium-fine, yellow calcareous sand. The cultural layer was excavated in 0.10 m spits. It appeared as a compact grey-brown sand, grading to dark grey and black at the eastern end of the excavation. In that area, were numerous ovenstones and the pits of three scoop ovens, one apparent in spit 1 and the others in spit 2. Other possible structural features were investigated in spits 2–3. Several appeared, initially, to be post-holes, but all proved upon further excavation to be the remains of root holes. In spit 2, extending into spit 3, at the

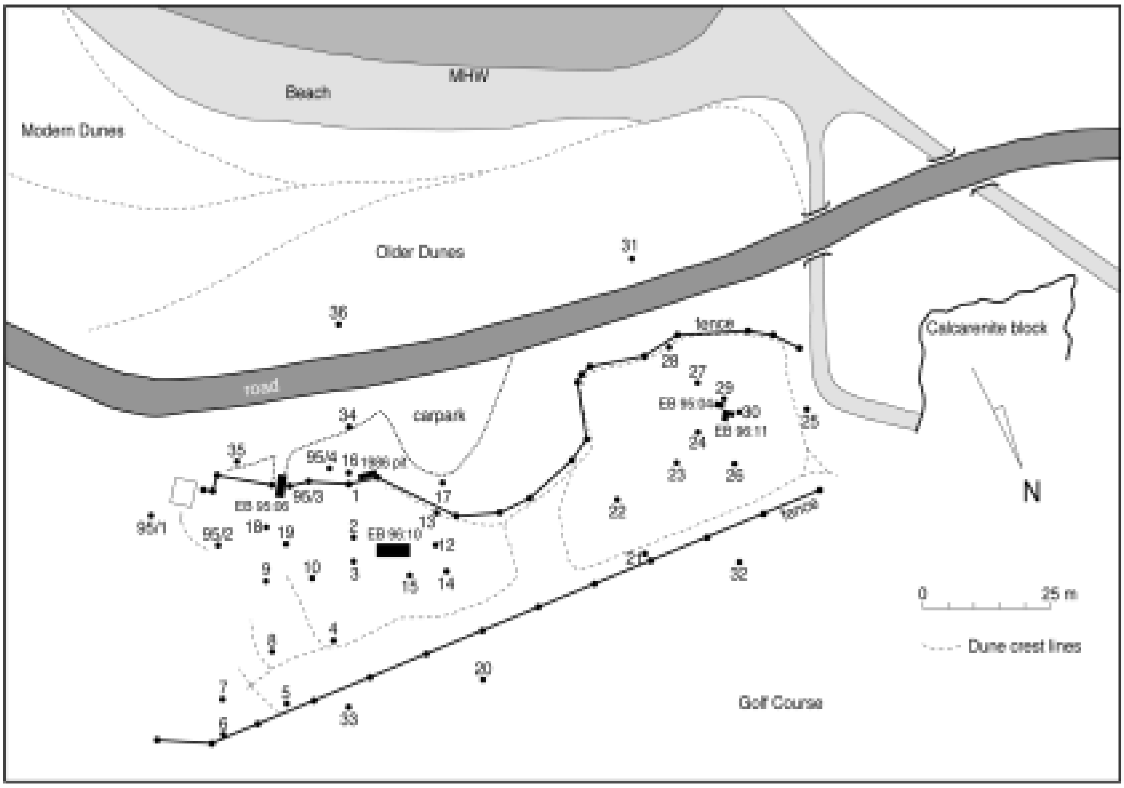

Figure 13. Location of auger holes excavated in 1996 at Emily Bay.

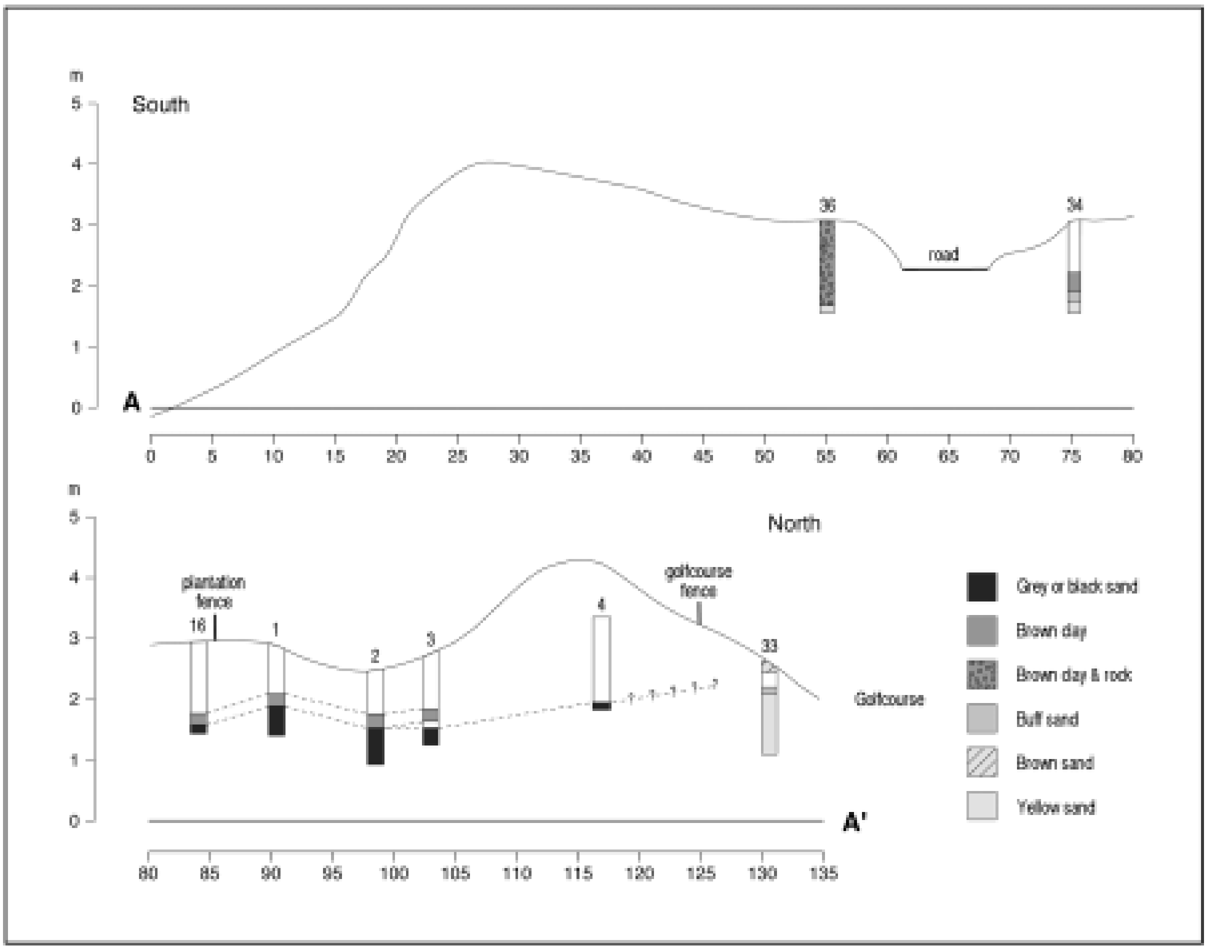

Figure 14. Stratigraphy in A transect at Emily Bay.

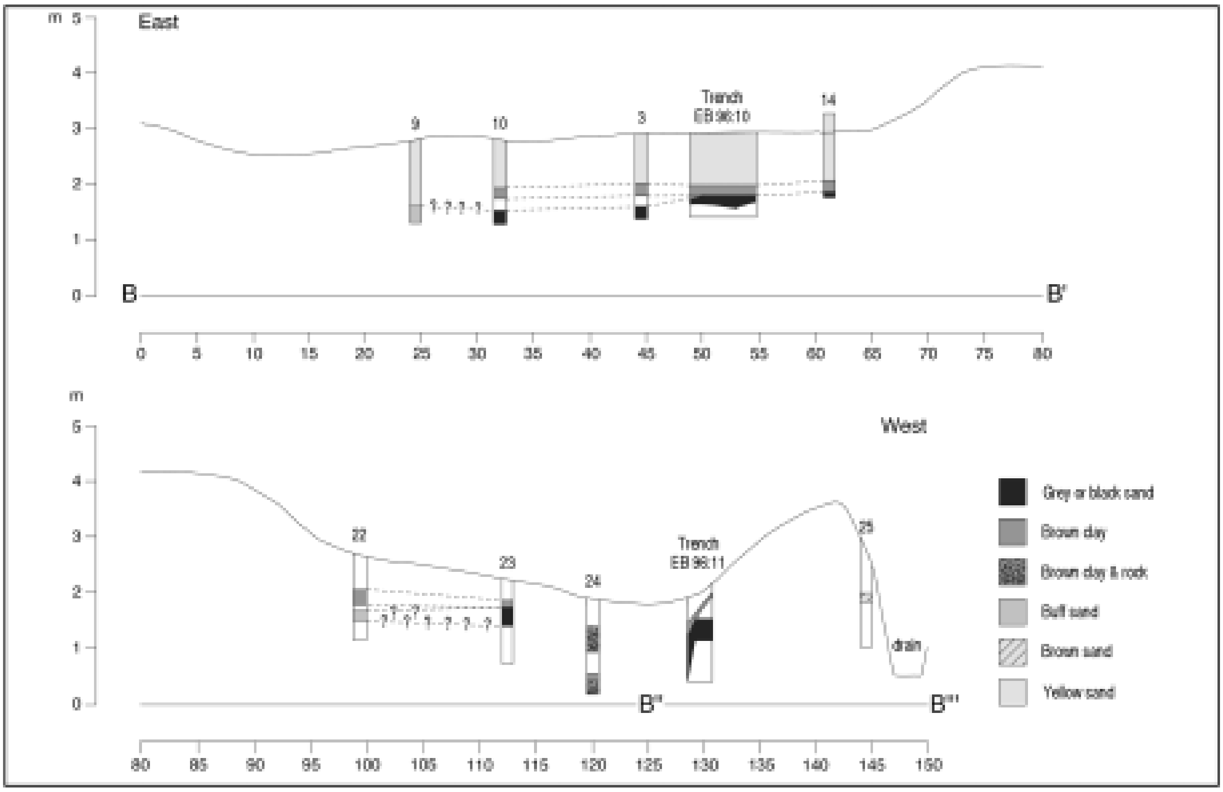

Figure 15. Stratigraphy in B transect at Emily Bay.

western end of the excavation was a rubbish pit, filled with fish and bird bone (Fig. 18). Midden remains were otherwise less abundant than in Trench EB95:06, but there were some different materials, including turtle bone (most of a scapula in one place) and the worked pieces of a large pelecypod. Basalt flakes from adze manufacture were fairly common, but no other lithics were discovered. In this excavation and also in EB96:11, all material was sieved through 4 mm mesh and the residue retained for laboratory analysis.

Trench EB96:11. A 3 m^2 excavation was opened in the western swale. The undamaged stratigraphy proved to be much as it is elsewhere in the site, with a cultural layer evidenced by 0.4 m of black sand grading down to 0.3 m of grey sand (at a total of 0.7 m, the thickest part of the cultural layer in the site), overlain by a brown clay—separated from it by some yellow sand in places—and underlain by yellow sand (Fig. 19).

In the eastern part of the excavation, the even deposition of layers terminates in ragged, slumped lenses. Some agency has cut away the site and left a steep edge, down which lenses of the various stratigraphic units—black sand, grey sand, yellow sand and brown clay—have tumbled and interleaved (Fig. 19). The damage extends through the area of Trench EB95:04. Further east, in the centre of the western swale, there is no evidence of the site, and it can be assumed that the same event or events were responsible for removal of it. The most probable explanation is that we have uncovered the edge of a cutting through which ran a road. The auger hole (Fig. 15, Auger hole 24) which was then expanded into a small pit in the centre of the swale disclosed two levels of hard-packed brown clay and rock which could only be penetrated with a crowbar. These are probably surfaces of a road in this area (apparently of Second Settlement age) which began at the junction of Bligh Street

Figure 16. Excavation of Trench EB96:10, showing hearth pits. Kirsten Anderson and Rosanne Anderson excavating.

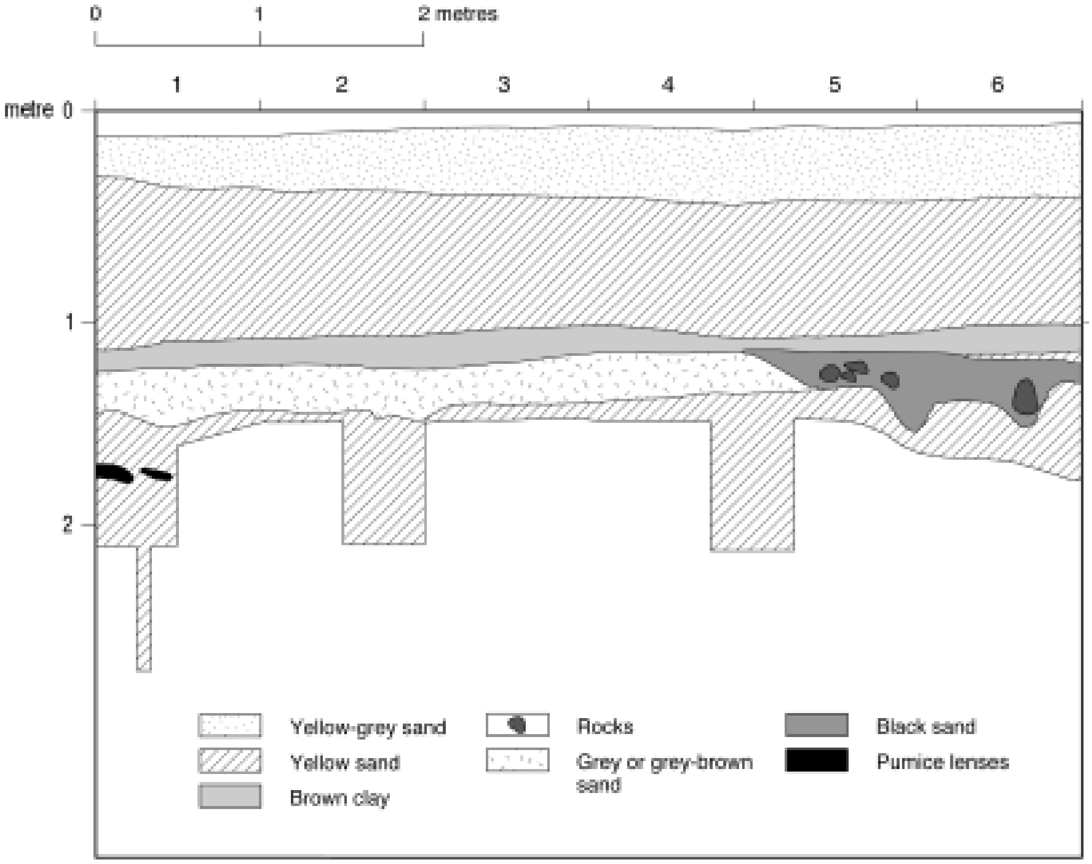

Figure 17. Stratigraphy of northern baulk of Trench EB96:10.

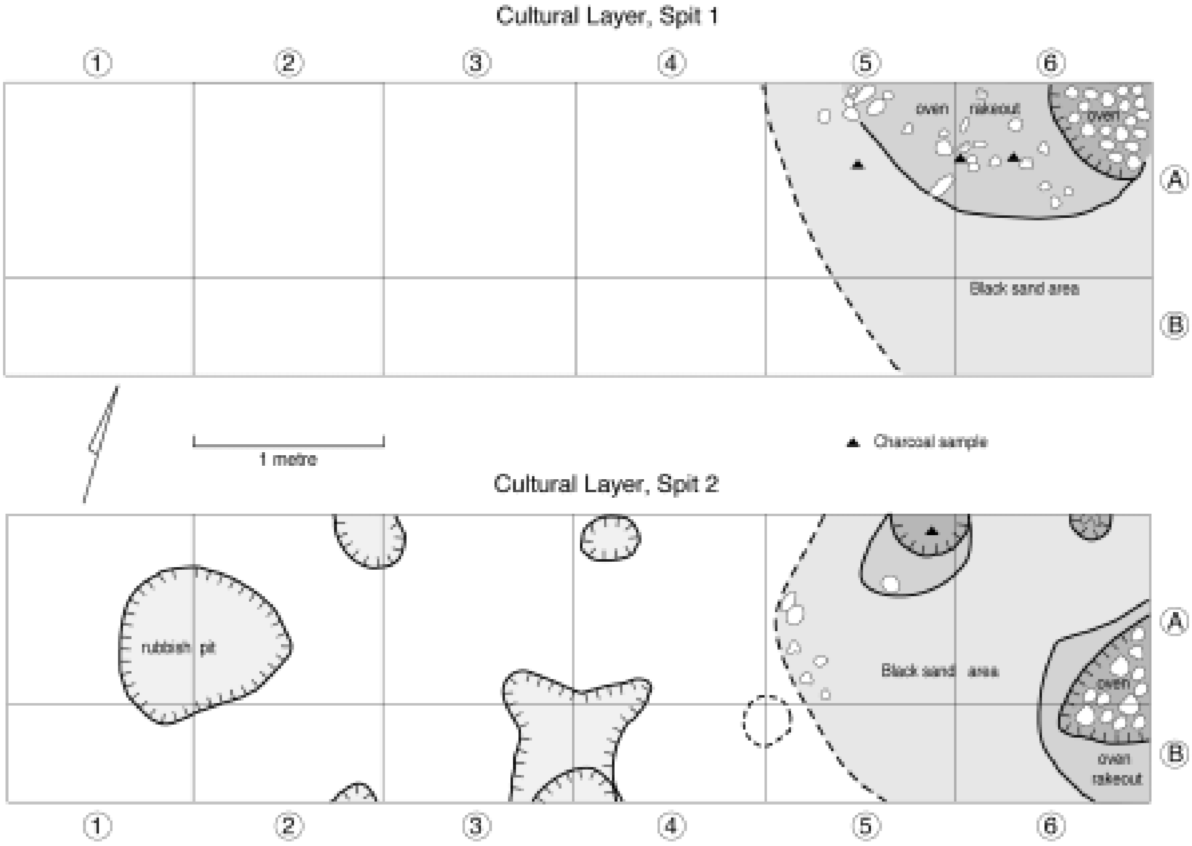

Figure 18. Plan of Trench EB96:10.

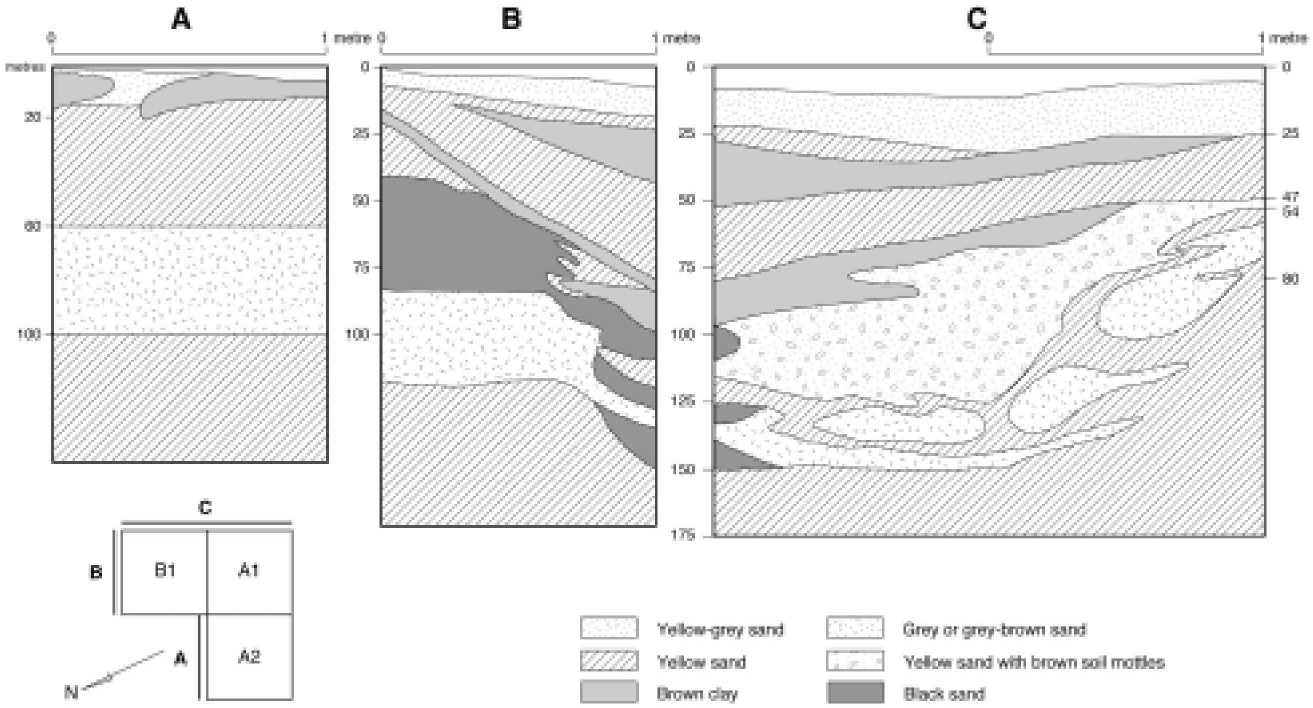

Figure 19. Stratigraphy of Trench EB96:11.

and Bay Street, ran across the drain, curved through the area of the western swale and terminated in a limestone quarry east of Government House.

The material recovered from this excavation was rather different from that obtained in the trenches in the eastern swale. A broken head of a rotating harpoon made from turtle bone and a blade of obsidian were found. There were numerous basalt flakes, some of which had come from polished adzes, a large, unifacially-retouched basalt blade and the butt of a trilaterally-flaked adze preform. This material looks like the debris that might be expected in a domestic area, compared to that which was recovered in the eastern area. Midden remains mainly comprised fish bone, with much less bird bone than was apparent in earlier excavations. A burnt and broken dog carnassial tooth was recovered and also a shark tooth.

These discoveries, including the evidence of greater diversity than previously documented in the archaeological materials, and most particularly the obsidian blade with its promise of sourcing the origin of the prehistoric settlers, encouraged planning for a third field season.

Fieldwork in 1997

Emily Bay. The nature of the evidence in 1996 indicated that a substantial open-area excavation in the western swale would repay the effort. The area had to be selected quite carefully because an original request to the Australian Heritage Commission for permission to excavate up to 150 m^2 was negotiated down to a total excavation area of 45 m^2, about 3% of the area of the swale. In the event, the discovery of stone paving required a special application from the field to KAVHA and the AHC for additional excavation area, resulting in permission for a further 10 m^2. The 1997 excavation areas are shown in Fig. 20. All excavated material was sieved to at least 4 or 5 mm mesh size (it became necessary to borrow an older sieve with 5 mm mesh from the Norfolk Island Museum). Where small stone flakes or faunal remains occurred, the excavated material was washed through 2 mm sieves. The residue was bagged and later sundried and sorted into major components (shell, bone, stone, charcoal etc.), re-bagged and retained for laboratory analysis. Whole samples of approximately two litres each were also taken from each square, sundried, sieved to remove sand and re-bagged for laboratory analysis.

In planning the main areas to open up, the information of the 1996 auger holes and EB95:04 and EB96:11 excavations was supplemented by two test-pits (Fig. 21).

Trench EB97:21. An excavation of 1.5 m^2, on the western slope of the swale, cut through yellow carbonate sand containing a sloping layer of brown clay mixed with sand and calcarenite, to reach the level surface of the cultural layer at 0.83 m (Fig. 22). This proved to be 20 cm thick, with one small, deeper depression in it. At 5 cm below its surface in square Z1 there was a fine example of a basalt adze preform, triangular in cross-section (Turner, Anderson and Fullagar, this vol.).

Trench EB97:22. A 1 m^2 excavation on the eastern slope of the swale encountered a similar stratigraphy to EB97:21, with the surface of the cultural layer reached at 0.7 m depth. In it, at 5–10 cm, there was a number of calcarenite slabs, laid flat, and in the northeast corner, at 10 cm depth, a small group of upright stones set above a hammerstone (Anderson and Green, this vol.). Burnt, broken cobbles were found in the southern part of the square. In due course, this excavation became incorporated into EB97:24 as square Z5.

Trenches EB97:23, EB97:24. These were the major excavations at Emily Bay. As such they constitute the subject of most of the chapters in this volume, and are described only briefly here. Both excavations were situated in the western swale, although the topography was different at the time of site occupancy. It is apparent that the Emily

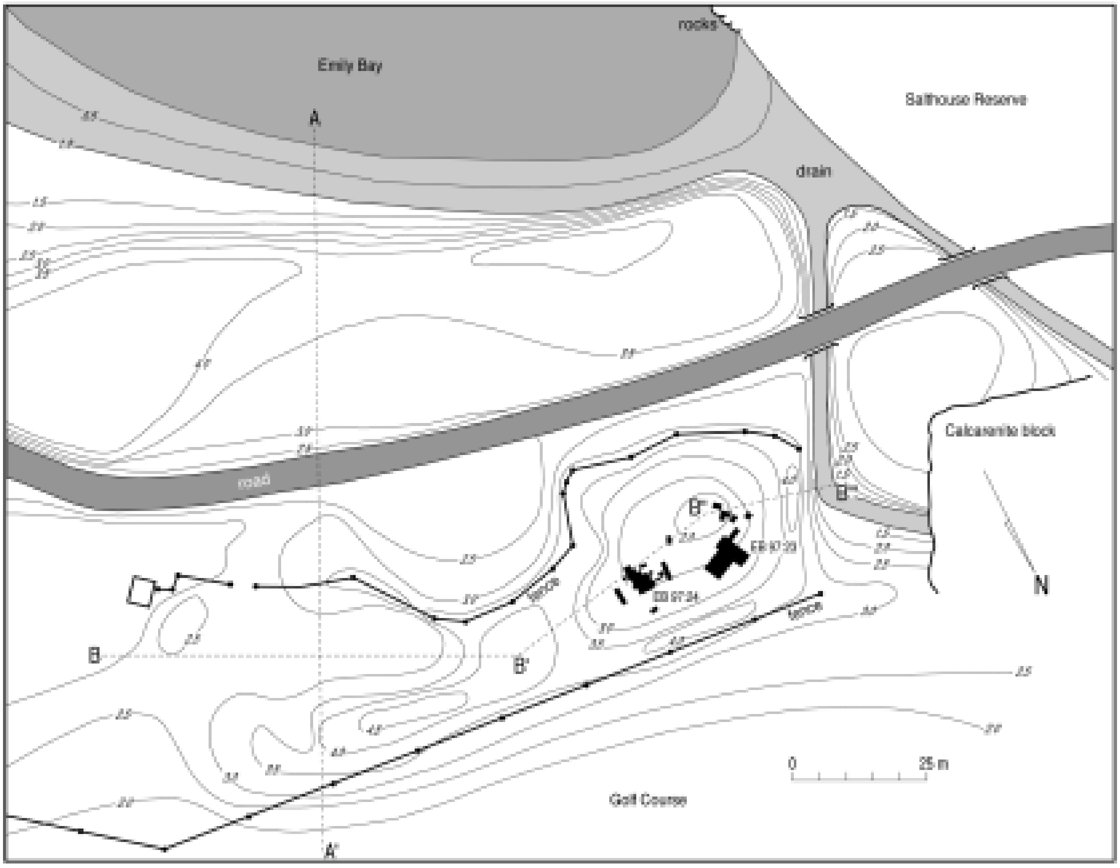

Figure 20. Location of trenches at Emily Bay in 1997.

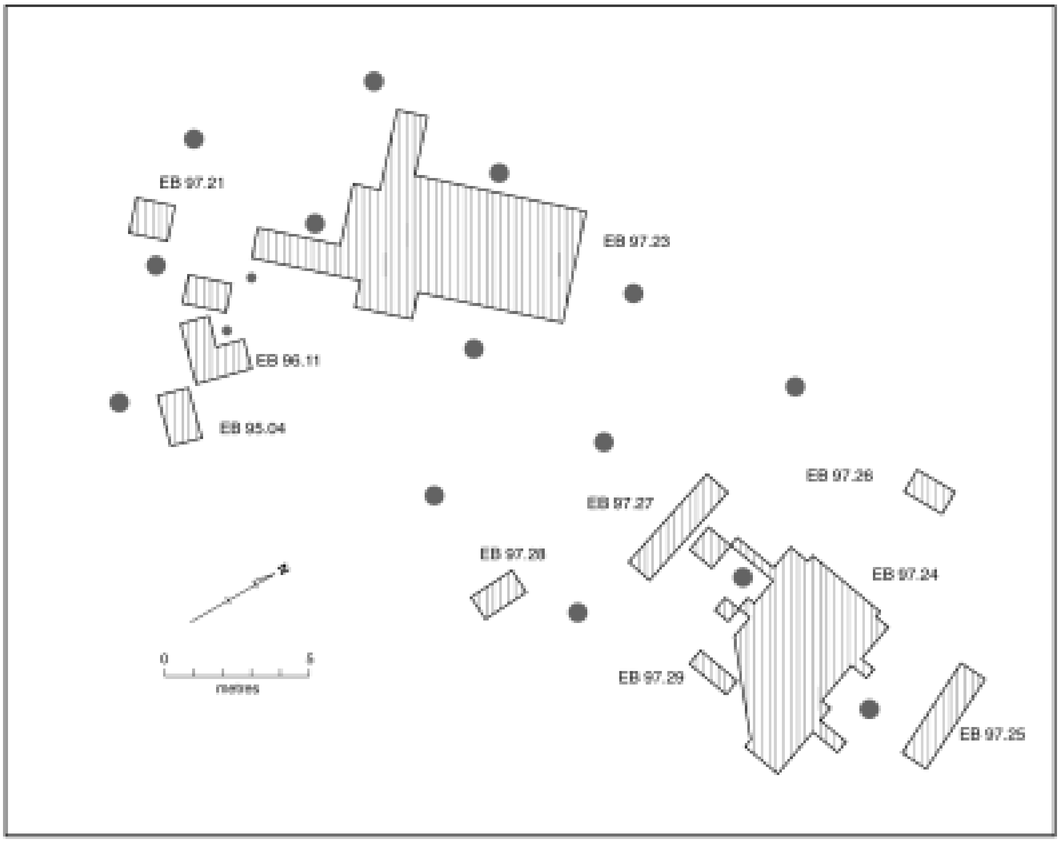

Figure 21. Plan of excavated and cleared areas at Emily Bay, 1997—shaded circles indicate tree boles. Note that EB97:23 includes adjacent unlabelled small trench to the south.

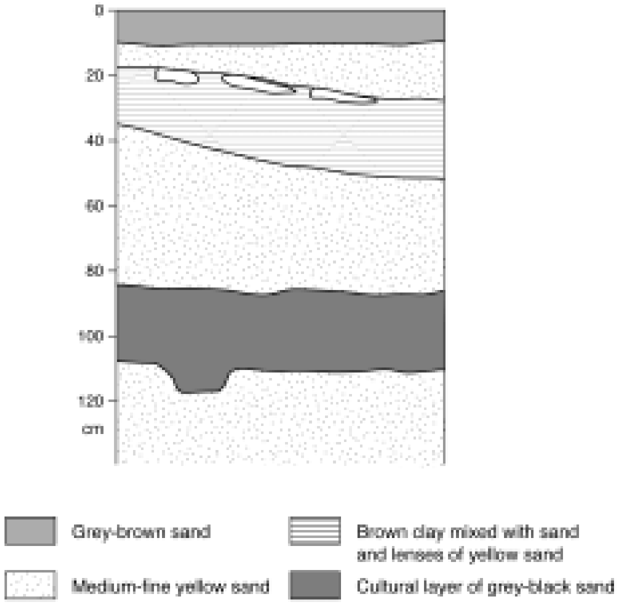

Figure 22. Stratigraphy of northern baulk of Trench EB97:21.

Figure 23. Excavation of EB97:23, seen from north. Note the heavily disturbed central squares of the excavation inside the postholes. Penny Crook and John Anderson excavating.

Bay site in general was located initially upon a surface which, while not flat, did not have the topography of the modern dunes. There is carbonate sand for 0.7–1.2 m under the cultural layer in the eastern swale, but beneath it in the western swale is mixed sand and water-rolled gravel and cobbles; material which has the appearance of a former beach or wind deflation area. It is possible that there were no active dunes in Emily Bay at the time of initial pre-European colonization and that the settlement was placed upon a more or less flat surface situated about 1.0 m above the high tide level (our survey indicated that the base of the cultural layer, where it was undisturbed, was about 1.3 m above high tide level in the eastern swale and 1.0 m above in the western swale).

On the basis of the test-pits, a 39 m^2 excavation (Figs. 23, 24) was undertaken in the northwest quadrant of the swale (EB97:23). The stratigraphy is generally straightforward. Under the pine duff is a layer of pale yellow carbonate sand of varying thickness and, running through it, following a former dune surface, is a thin (8–15 cm) band of brown soil, a fairly recent palaeosol. Beneath is a thick layer (0.6–1.0 m) of the same pale yellow sand which, over most of the excavation, covers the almost level surface of the cultural layer, observed as a grey-brown sand with black patches in it. In squares A–B 6–8, and E–F 6–8, lenses of stiff brown clay lay directly upon the cultural layer (below).

The cultural layer in EB97:23 is generally about 0.3 m thick and grey-brown in colour, and we excavated about 11.7 m^3 of it. Except in small patches, mostly near the postholes, and within and around the large oven in A–B 7, charcoal is scarce. Similarly, there was very little shell midden, and it consisted only of small patches of *Nerita* sp. (Campbell and Schmidt, this vol.). Bird bone was much more common. Most of it is broken, and some burnt, which is characteristic of midden, but some will also be from mutton birds which died naturally on the site (Holdaway and Anderson, this vol.). Fish remains (Walter and Anderson, this vol.) were sparsely scattered, and there were several pieces of turtle and mammal bone (Smith, Clark and White, this vol.). Basalt flakes were distributed about the site, in no apparent pattern and one flake of translucent obsidian was recovered from square E12, spit 4 (Turner, Anderson and Fullagar, this vol.).

The excavation of Trench EB97:22 had located some flat slabs which appeared to be paving. Additional excavation in this area (Fig. 25) uncovered a paving structure, discussed by Anderson and Green (this vol.). Nineteen square metres of this were excavated as Trench EB97:24. This part of the site was covered by up to 0.6 m of medium-fine yellow carbonate sand above a 10–15 cm thick layer of brown clay enriched with sand and fragments of calcarenite. Beneath was 5–10 cm of yellow carbonate sand overlying the cultural layer (Fig. 26). The latter, 15–25 cm thick, with slabs embedded within it, lay upon coarse brown sand containing abundant water-rolled gravel, which also occurred in the interstices between the paving. The brown clay layer dips steeply along the southwest edge of the paving to flatten out at about 1.2 m below the paving level, indicating that the loss of a paving edge along that side occurred prior to the formation of the brown clay, although the latter is almost certainly a European feature (see later).

It was not possible to excavate out to the limits of paving

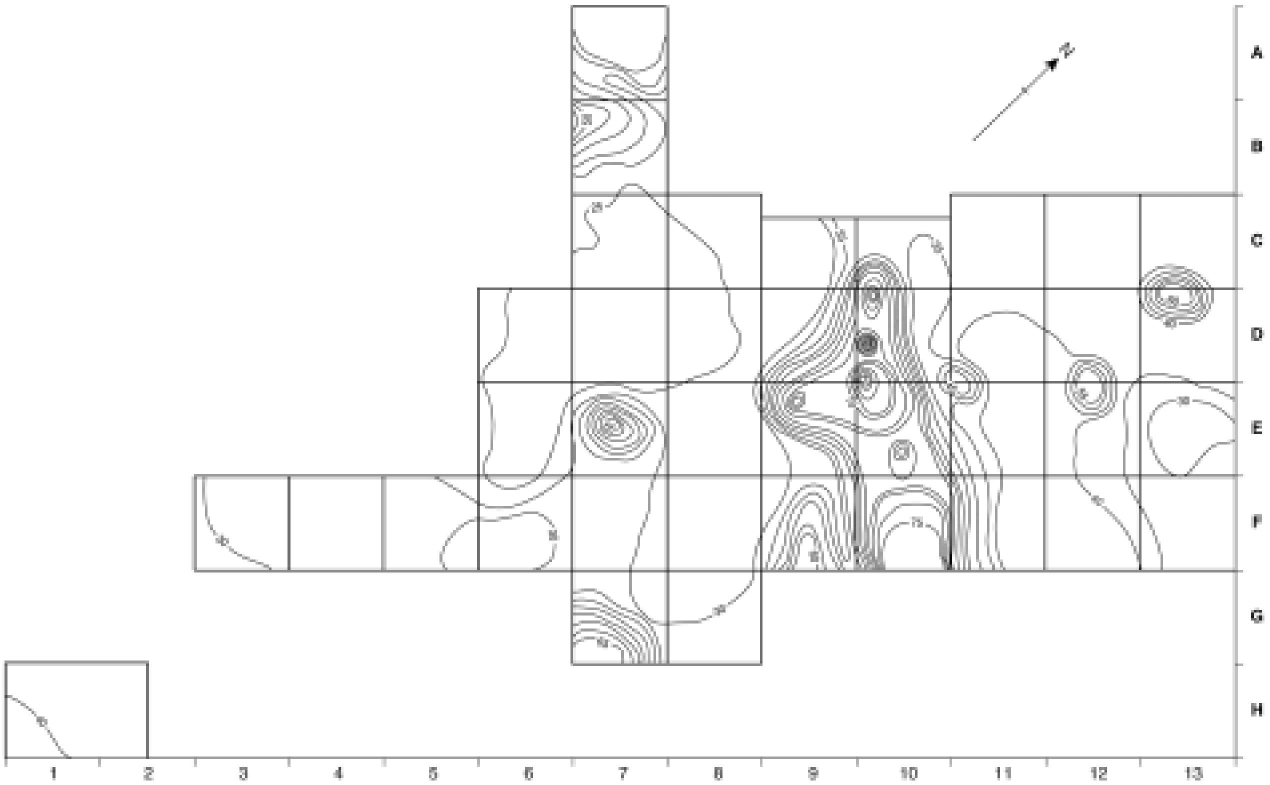

Figure 24. Contour plan of the depth of the cultural layer in Trench EB97:23.

stones along the west side, because of restrictions on permitted excavation area, and it would have been desirable to excavate further to the east as well. However, extensive probing in these areas, and a series of trenches (EB97:25, 26, 27, 28, 29) cleared down to the surface of the cultural layer, which was not excavated, showed that the exposed paving constituted the full feature, as it presently survives. The paved area is discussed at length by Anderson and Green (this vol.). These trenches also indicated that the disturbed deposit at the southwest edge of EB97:24 continued through the southern half of EB97:27 and that EB97:28 exhibited brown, rubble-filled clay in the northern half of the square, perhaps a further indication of the historical roadworking which runs through the centre of the western swale. Mention of that feature raises the more general question of the degree to which the Emily Bay site has been exposed to post-depositional disturbances of any kind.

Site Taphonomy. The Emily Bay site appeared initially to have been protected from post-depositional disturbance in the areas excavated in 1995 and 1996 in the eastern swale area by the tough brown clay layer over it. However, this layer is discontinuous at best in the western swale and there is evidence of at least four agencies of site disturbance there. First, within the historical era a roadway had been constructed through the centre of the western swale, and that seems to be evidenced in several auger holes. Further signs of historical disturbance reaching to the prehistoric cultural layer are evident in Trench EB97:23, squares A–B, 6–8 (the 6 and 8 rows in A–B were cleaned down to the top of the cultural horizon but only row 7 was excavated). A large oven feature containing many basalt cobbles was situated within the cultural layer and, almost immediately above it like a mirror image, was a low mound of calcarenite slabs (Fig. 27). The mound was sitting upon a thin layer of stiff brown clay packed with clasts of basalt and calcarenite which, in turn, lay directly upon the surface of the cultural layer. A piece of European china in the brown clay indicates that it, and the mound, are of European age, so the situation of these features together can only be coincidental.

Second, either as a result of a road cutting, or by natural agencies, the site is badly slumped along the eastern edge of excavation EB96:11. That at least some of this is probably natural (wave damage is suspected), is indicated by similar ragged slumping of the edge of the site in a curved “bite” along the SW edge of excavation EB97:24 which had caused that edge of the paved feature to collapse. Since the site is quite close to high tide level (below), and was probably closer to the shore before the formation of the modern dunes south of the road, it was vulnerable to storm damage. In both Emily and Slaughter Bay, in fact, there is a history of wave erosion which has uncovered burials and washed out numerous adzes, basalt flakes and other material (Specht, 1984). The current seaward boundary of the site is therefore probably an artefact of natural processes.

Third, in a process which is continuing today in the western swale, muttonbird burrowing into and through the cultural layer is redistributing material from above the archaeological horizon, into and below it. There is some evidence of this in the distribution of landsnails (Neuweger, White and Ponder, this vol.). The burrowing, which is most apparent as a deep disturbance across the centre of the EB97:23 excavation (Figs. 24, 28), has carried material to 0.9 m below the cultural surface.

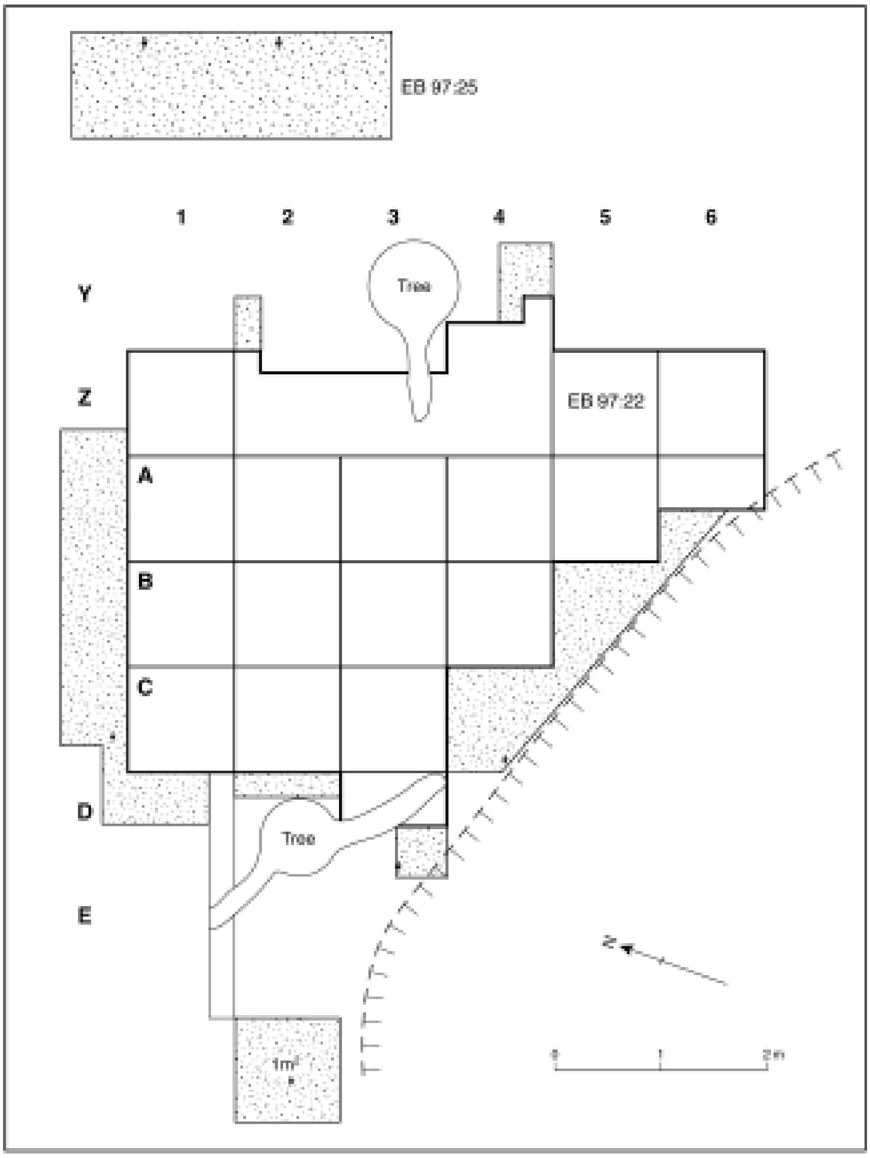

Figure 25. Plan of the excavated area of Trench EB97:24. Stippled areas were cleared of sand but the cultural layer was not excavated.

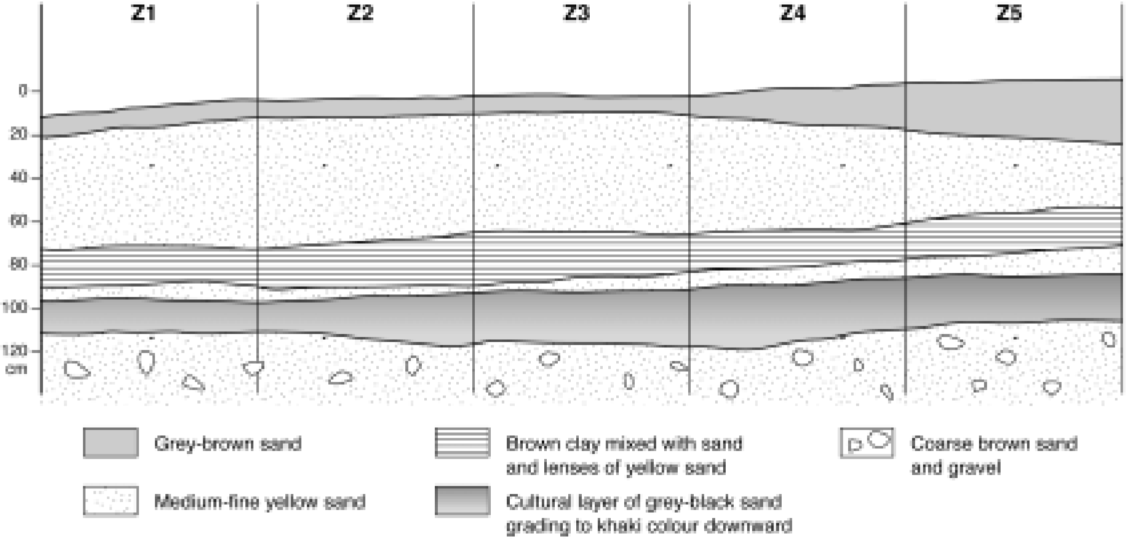

Figure 26. Stratigraphy of the east baulk of row Z in Trench EB97:24.

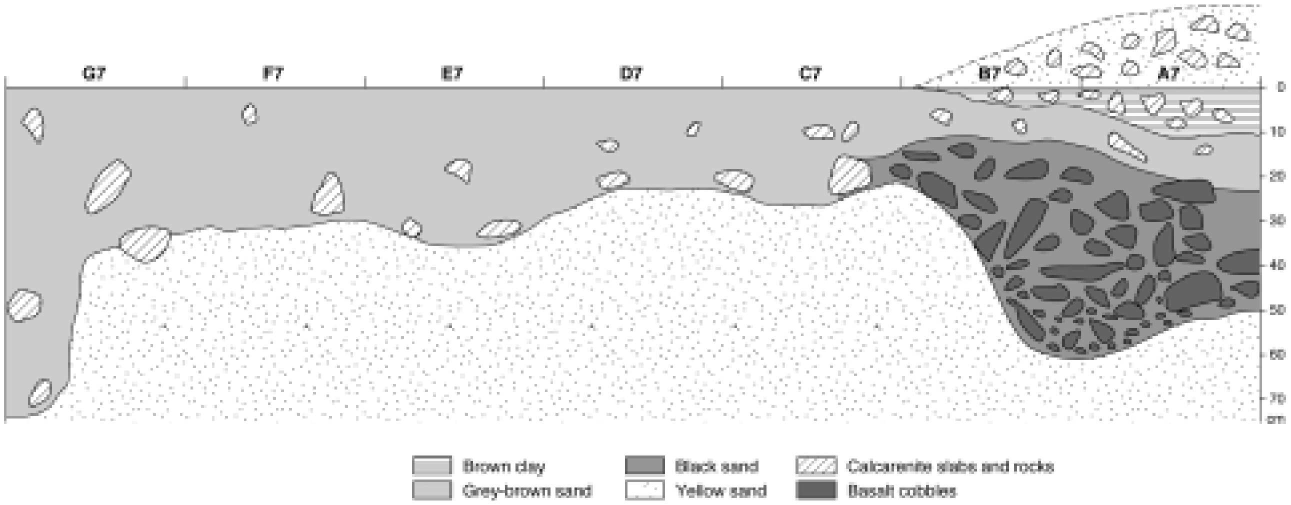

Figure 27. Stratigraphy of the west baulk of row 7 in Trench EB97:23.

Fourth, the virtually level surface of the cultural layer, everywhere that it is encountered, suggests not only that it is in that respect quite typical of a living surface, but perhaps also that it has undergone some natural planation. The remarks in McCarthy (1934: 268) that Mr Rabone found at Emily Bay, "a number of small adzes in process of being fashioned. With them were several hundred flakes that had been chipped off in the shaping of the adzes," suggest that some part of the site was open at that time. Since the Emily Bay dunes were largely unvegetated prior to the establishment of the current plantation, as shown in numerous photos taken from the 1930s onward (S. Quintal collection), it is very probable that wind deflation had periodically exposed parts of the site and planed the surface. It is probably this process which allowed a piece of European ceramic to almost reach the surface of the cultural layer in EB97:24 (square Z2), and which enabled a piece of modern pig mandible to reach the top of the cultural stratigraphy in EB97:23 (see also Anderson, Higham and Wallace, this vol.).

Fieldwork in 1999

During the 1997 fieldwork we observed considerable numbers of landsnails in all levels of the trenches. Grab samples were taken from the sands above and below the grey sandy cultural level and appeared to show considerable changes. In an attempt to analyse the human impact on the local environment, further samples were taken by 10cm sand auger in February 1999. Two sets, each of four samples, were taken adjacent to Trench EB97:23 and another set near EB96:10 (Figs. 13, 20). Two other sets were begun but encountered European disturbance and were abandoned. Two sets of two samples each were taken at Cemetery Bay, one inside and one adjacent to the new quarry. A comparative sample of the modern landsnail fauna was collected from six environmental zones by Dr Winston Ponder, Australian Museum. The analysis of this material is described by Neuweger, White and Ponder, (this vol.).

Additional investigations

The existence of prehistoric archaeological remains at Kingston, and the recovery of various artefacts, mostly adzes, from elsewhere on Norfolk Island, encourages the view that there may be additional prehistoric sites to be found. Some initial explorations were conducted during the 1997 fieldwork season.

Bomboras Bay. Two small test-pits (0.3×0.3 m) were dug 20 m and 30 m respectively to the north of the creek mouth on a small shelf of fairly level land about 2 m back from the high tide mark. The first disclosed only 0.5 m of stiff

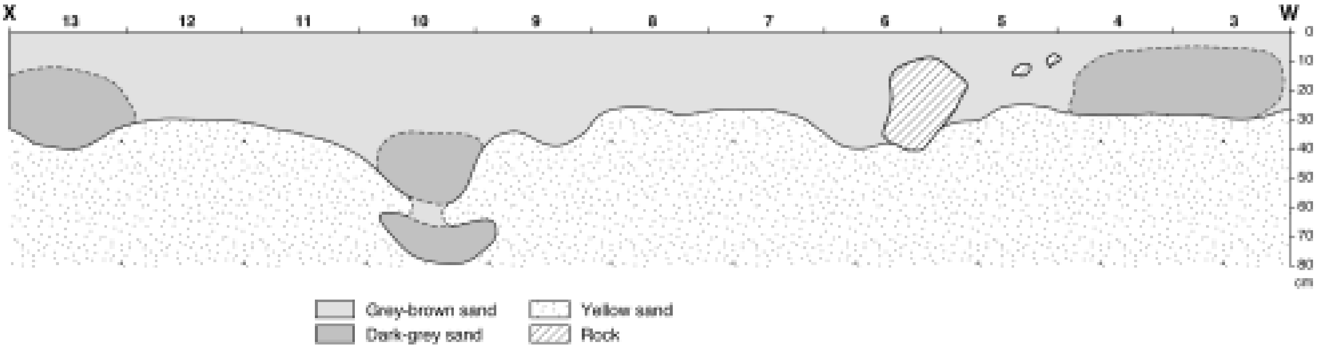

Figure 28. Stratigraphy of the south baulk of row F in Trench EB97:23. Transect WX shown in Anderson and Green (this vol., their fig. 2).

brown clay above bedrock. The second had 0.3 m of the same clay above 0.3 m of orange-yellow calcareous sand resting upon water-rolled boulders. No cultural material was observed.

Ball Bay. There are hearsay accounts of adzes being found at Ball Bay, notably along the eastern side of the bay near the "Melky" trees (Nicolai, pers. comm.). At the main patch of these, located around the coast about 210 m SE of the oil depot, a test-pit (0.3×0.3 m) disclosed 0.45 m of brown, hard-packed clay lying upon basalt bedrock. A second test-pit, a further 22 m to the east, cut through 0.55 m of hard-packed clay and clasts of weathered basalt, especially towards the bottom, to encounter 0.37 m of stone-free, brown clay-loam (probably an old soil horizon) resting upon heavily-weathered basalt boulders. The area on which this test-pit was located is a gently-sloping shelf of ground about 30×10 m lying immediately behind the boulder beach. The existence of this deeply buried horizon of good soil suitable for settlement should encourage more extensive investigation in future, despite the absence of cultural material in our excavations.

Phillip and Nepean Island. A brief surface inspection of the deeply-eroded surface of Phillip Island produced nothing of archaeological interest. Nepean Island, heavily wooded at European contact, is now under deep grass with occasional wind-sheared white oaks. The ground has been extensively disturbed by muttonbird burrowing. A test-pit (0.3×0.3 m) was dug on the saddle of the island. It found 0.5 m of friable, sandy loam resting on calcarenite bedrock. Muttonbird bones occurred, but nothing of cultural origin. A second test-pit was dug on a natural terrace about 15 m above sea level in the large cove and sand-beach on the NW coast of the island, a reasonably sheltered position. There was 0.6 m of yellow carbonate sand above calcarenite. Occasional bird and lizard bone appeared natural and there was one small cowrie shell, but nothing which appeared to be of cultural origin.

Conclusions

The fieldwork of the NIPP has located an extensive prehistoric site in Emily Bay, and shown that, so far at least, this is the only such site of any significance remaining on Norfolk Island. Excavations during 1995–1999 (Fig. 29) show that the Emily Bay site has a single cultural layer containing various features, notably a paved structure, and numerous ovens, with associated midden remains and quantities of flaked basalt.

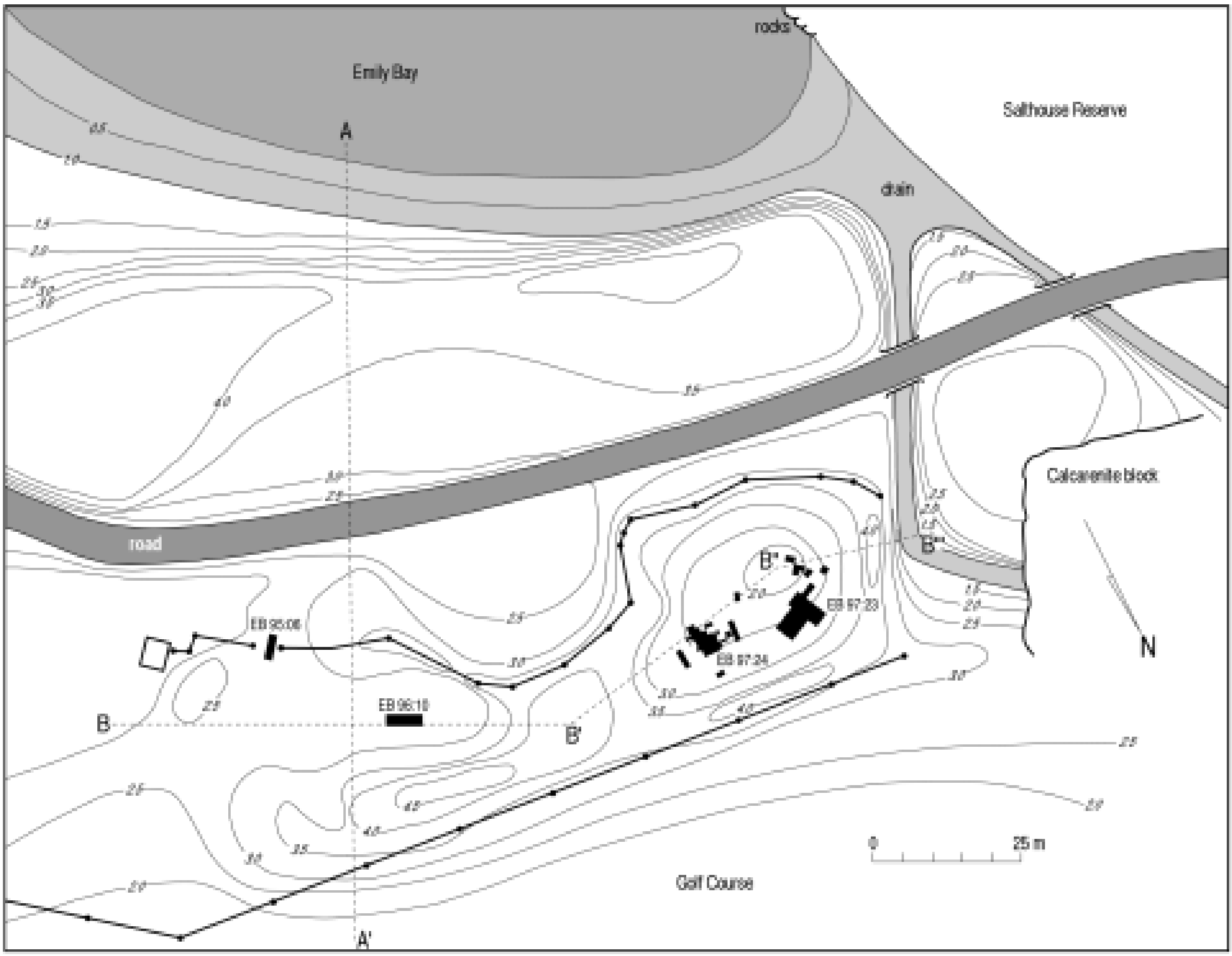

Figure 29. Map of all NIPP excavations at Emily Bay.

The site is approximately 100 m long and 30 m wide on average (3000 m^2), but it is now almost certainly rather smaller than it was originally, having been eroded along the seaward side and quite probably also to the east where the dunes are much younger and appear to have filled an area which had been heavily eroded by wind and water. Various agencies of post-depositional disturbance have also compromised the integrity of the cultural layer in many areas. Nevertheless, enough of the site remains in sufficiently original condition to obtain a clear view of the nature of the occupation that it represents.

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The Radiocarbon Chronology of the Norfolk Island Archaeological Sites

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ABSTRACT. Radiocarbon determinations were obtained for archaeological sites at Cemetery Bay and Emily Bay, Norfolk Island. Sample materials were rat bone gelatin, marine shell and wood charcoal. Ages on bone gelatin are contradictory and suggest a laboratory problem, while ages on marine shell appear to include an old-carbon offset of 500–600 years: dates on these samples are consistent with those on charcoal when appropriate corrections are made. Ages on charcoal were divided according to the expected inbuilt age of the sample taxa. The samples with lowest inbuilt age were subjected to Bayesian analysis which concluded that the main archaeological site, at Emily Bay, had been occupied from the early thirteenth to the early fifteenth centuries A.D. The Norfolk Island settlement occurs within the same age range as other Polynesian settlements of southern islands.

ANDERSON, ATHOLL, TOM HIGHAM AND ROD WALLACE, 2001. The radiocarbon chronology of the Norfolk Island archaeological sites. In *The Prehistoric Archaeology of Norfolk Island, Southwest Pacific*, ed. Atholl Anderson and Peter White, pp. 33–42. *Records of the Australian Museum, Supplement* 27. Sydney: Australian Museum.

Radiocarbon determinations have been obtained from two archaeological sites on Norfolk Island: Cemetery Bay and Emily Bay. In both cases, multiple sample types were dated. Each type of sample is associated with different issues of processing and interpretation so we consider them first in these categories. Following that, we discuss the chronologies in their stratigraphic and spatial contexts and then consider the age of prehistoric settlement on Norfolk Island generally and in relation to the prehistoric chronologies of archipelagos which might have contributed colonists.

Charcoal identification

The first results from Norfolk Island (Rich *et al*., 1983: 17) were on unidentified charcoal (I-11019, I-11303, Table 6) from excavations at Cemetery Bay. Additional excavations there by Meredith (1985: 22) added two samples (Beta-6821, Beta-6822) comprising pieces from "small branches" (3–4 cm diameter) of gymnosperm, almost certainly Norfolk pine (*Araucaria heterophylla*). It is not clear how branchwood was identified (deduction from the curvature of growth rings is open to alternative interpretations), and there are other reasons (below) that recommend caution, so the assumption that these results are good estimates of the age of the Cemetery Bay deposit remains open to question, for reasons outlined below.

The first four samples from the Norfolk Island Prehistory Project (NIPP) 1995 excavations (ANU-10157 to ANU-10160, Table 6) were identified no more certainly. Two were of *Araucaria* sp., and two of other but unidentified wood. From the NIPP 1996 season, it was possible to isolate material which was entirely of broadleaf taxa. In the NIPP 1997 season, Wallace (1998) made a collection of comparative material from all 33 indigenous woody plants on Norfolk Island (Orchard and Thompson, 1999) from which he was able to identify charcoal samples to species.

The wood samples were made into thin sections showing each of the three planes of each sample, and from those were made photomicrographs which allowed identification to the species level. Charcoal samples were snapped across the grain and cloven along it, and the faces observed under incident illumination using a compound microscope at magnifications of 50–500 diameters. Identifications were made by comparing the cell patterns with the samples from the comparative collection.

Wallace (1998) examined 99 bags of charcoal (about 2.5 kg) from the 1997 trenches, two from EB97:21, one from EB97:22, 78 from EB97:23 and 18 from EB97:24. In general, about 75% of the charcoal in each bag could be identified, the remainder being of pieces too small to process. The objective was to obtain samples of identified broadleaf material weighing a minimum of 6 g to enable high precision Liquid Scintillation radiocarbon dating. This was achieved relatively rarely. Broadleaf charcoal samples of 6 g or more were found once in EB97:21, in 38 of the 78 bags from EB97:23 and in none of the EB97:21 or EB97:24 bags. In the latter trench, only 12.5 g of broadleaf charcoal was obtained from the entire collection.

The most striking aspect of the assemblage is that 95% of the charcoal by weight was from Norfolk pine. Even if that was the dominant emergent tree, as it was historically in the Kingston area, it probably would not have provided 95% of the available firewood, except if the inhabitants chose to ignore material from other kinds of trees, which seems improbable. It is more likely that much of the charcoal in the site is from burnt-down structures, such as houses or cooking sheds, which had been built from the long, straight branches of Norfolk pine. Certainly, the postbutts left in EB97:23 were all of Norfolk pine branches (Wallace 1998).

Unfortunately, this is a poor material for accurate radiocarbon dating because its mode of growth presents a high probability of significant inbuilt age (i.e. the wood was dead, and stored in the trunk or branches, for a long time before it was used as firewood—McFadgen, 1982). Norfolk pine grows quickly to form massive, cylindrical trunks with regular radial outgrowths of branches which persist during the life of the tree and expand only very slowly in diameter. Consequently, not only is trunkwood likely to be several hundred years old or more, but so is branchwood. Measurements on carbonized branchwood disclose up to two annual growth rings per mm, so that even quite small branches can have significant inbuilt age.

The identification of *Metrosideros* sp. (pohutukawa) is interesting, because it is not native to Norfolk Island (Wallace, 1998). It is possible that some charcoal from recently-introduced *Metrosideros excelsa* has managed to get into the site, but it was found in two excavation areas and it may indicate either the former existence of a native *Metrosideros* sp. on Norfolk Island (it is a prominent native on Raoul Island and Lord Howe Island), or the prehistoric introduction of the genus. The charcoal could have come as *Metrosideros* timber in prehistoric artefacts, such as canoe components, or *Metrosideros* sp. may have been brought as seeds. Wallace (1998) points out that *Metrosideros kermadecensis* is dominant on Raoul Island, existing as an almost pure forest over the Low Flat site (Anderson, 1980); any soil around plants carried from Raoul would probably contain *Metrosideros* seed, which is highly abundant, and seed would have ended up in any canoe pulled up on the Low Flat foreshore. *Metrosideros* might have grown at Kingston around the Polynesian settlement, perhaps then dying out as the Norfolk pine forest reclaimed the abandoned site.

The distribution of the charcoal samples amongst broadleaved taxa (Table 1) shows that 20 of the 33 woody plants native to Norfolk Island occur in the Emily Bay charcoals. These indicate the existence of a mixed coastal forest of trees and shrubs. The main species in the charcoals (with common name and maximum height) were *Nestegis apetala* (Ironwood, 6 m), *Rapanea ralstoniae* (Beech, 6 m), *Elaeodendron curtipendulum* (Maple, 13 m), *Ungeria floribunda* (Bastard oak, 15 m) and *Baloghia inophylla* (Bloodwood, 7 m). Bastard oak is quite rare today, whereas white oak (*Lagunaria patersonia*) which is common today and grows under the Norfolk pine forest at Emily Bay, is fairly rare in the charcoal samples.

On the basis of the taxonomic identifications it is possible to divide the charcoal samples used for radiocarbon determination into three groups. Group A comprises samples

Table 1. Distribution of charcoal samples and pieces by identified broadleaf taxa at Emily Bay.

broadleaf taxa	number of charcoal samples	number of charcoal pieces
Rapanea ralstoniae	18	87
Elaeodendron curtipendulum	15	78
Ungeria floribunda	14	50
Baloghia inophylla	14	49
Nestegis apetala	13	123
Dodonaea viscosa	7	18
Myoporum obscurum	6	29
Lagunaria patersonia	5	13
Melicytus ramiflorus	4	16
Dysoxylum bijugum	3	28
Pennantia endlicheri	2	2
Excoecaria agallocha	2	3
Streblus pendulinus	2	3
Sarcomelicope simplicifolia	2	2
Celtis paniculata	1	3
Melicytus latifolius	1	1
Pittosporum bracteolatum	1	2
Melicope littoralis	1	1
Coprosma pilosa	1	1
Rhopalostylis baueri	1	1
Metrosideros sp.	4	20

in which the charcoal is all from broadleaved taxa and derived predominantly from small tree or shrub species, plus shoots of Norfolk pine twigs (Table 2). Group B samples are of broadleaved taxa which are either unidentified to genera or are identified as being from larger tree species (Table 2). Group C samples are of Norfolk pine or unidentified charcoal.

Radiocarbon determinations on charcoal samples

Over the past decade there have been significant developments in radiocarbon age calibration, culminating in the publication of the 1998 INTCAL calibration curves (Stuiver *et al.*, 1998) which enable calibration from 0–24,000 cal B.P. In addition, there has been a growing awareness of the importance of careful sample selection in archaeological dating and the combination of radiocarbon determinations with prior archaeological knowledge, in the form of stratigraphic and contextual information (Buck *et al.*, 1996). In the dating of the Norfolk Island contexts, we were interested particularly in issues of occupation span and the evidence for earliest human occupation at the excavated site at Emily Bay.

We used the BCal calibration programme (Buck *et al.*, 1999) to help us to answer these questions of chronology in more detail. BCal enables relative archaeological *a priori* information (relative stratigraphy and archaeological provenance) to be used in association with radiocarbon determinations, within a Bayesian statistical paradigm (Buck *et al.*, 1996).

We developed a calibration model (see Figs. 1, 5) in BCal to evaluate the chronology at the Emily Bay EB97:23 and EB97:24 trenches. These two trenches yielded the majority of the Group A samples. In the model, certain mathematical symbols are used to describe the stratigraphic phases and boundaries at the site. α_n and β_n represent the beginning and ending dates of phase n. α_1 therefore represents the period preceding human occupation, while the late phase boundary of Spit 2 is represented by β_4 (Fig. 1).

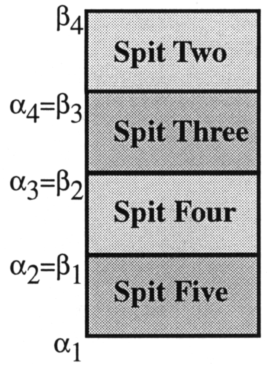

Figure 1. Calibration model for Trench EB97:23 at Emily Bay, Norfolk Island.

The calendar dates associated with individual radiocarbon determinations (termed $\theta_1 \ldots \theta_n$) (Table 3) from Trench EB97:23 were modelled within the constraints imposed by four stratigraphic phases, or spits. Spits 2, 3, 4 and 5 were modelled in BCal as abutting phases of shallow depth. Within each single spit, the radiocarbon determinations were assumed to be contemporary. The calibration model was run three times with a Markhov Chain Monte Carlo (MCMC) sampler of 50,000 iterations collected at a sampling interval of 50 (Buck *et al.*, 1996).

Table 2. Charcoal composition of Group A and Group B samples from Emily Bay.

laboratory number	ANU-11037	ANU-11041	ANU-11042	ANU-11043	ANU-11046	ANU-11047	ANU-11050	ANU-11051	WK-6901	WK-6902	WK-6903	WK-6904	ANU-11035	ANU-11036	WK-6905
charcoal Group	A	A	A	A	A	A	A	A	A	A	A	A	B	B	B
broadleaf taxa															
Ungeria floribunda	—	—	2	—	—	—	3	6	—	5	3	3	2	2	7
Lagunaria patersonia	—	—	—	3	2	—	—	—	3	—	3	—	2	—	—
Elaeodendron curtipendulum	—	—	3	2	9	4	—	—	2	6	4	—	12	11	—
Pennantia endlicheri	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Celtis paniculata	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—
Metrosideros sp.	—	—	—	—	—	—	—	—	—	—	—	—	6	5	3
Baloghia inophylla	6	—	5	1	2	7	—	6	—	—	3	2	7	1	—
Nestegis apetala	3	1	—	20	—	—	—	—	30	25	12	—	3	—	3
Dodonaea viscosa	—	—	—	—	—	—	—	—	—	7	1	—	2	—	—
Myoporum obscurum	—	15	—	2	5	—	2	3	—	—	—	—	—	—	—
Rapanea ralstoniae	1	4	10	3	15	6	—	—	—	—	3	—	—	—	3
Melicytus latifolius	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Dysoxylum bijugum	—	—	—	—	—	—	—	—	—	—	—	25	—	—	—
Streblus pendulinus	—	—	—	—	—	—	—	3	—	—	—	—	—	—	1
Pittosporum bracteolatum	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—
Coprosma pilosa	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Melicope littoralis	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Rhopalostylis baueri (seed)	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Norfolk pine twig	—	—	—	—	—	—	—	4	—	—	—	3	—	—	—

Table 3. Individual posterior date calendar distributions for each determination from EB97:23, as simulated in BCal. The HPD regions given are at 95% probability and are rounded to five years.

calendar date	laboratory number	HPD region
θ_1	ANU-11043	A.D. 1065–1080, 1125–1135, 1160–1295
θ_2	Wk-6902	A.D. 1240–1315
θ_3	Wk-6903	A.D. 1245–1320
θ_4	ANU-11037	A.D. 1275–1335, A.D. 1340–1380
θ_5	Wk-6901	A.D. 1275–1330, A.D. 1345–1385
θ_6	ANU-11042	A.D. 1295–1330, A.D. 1340–1400
θ_7	ANU-11041	A.D. 1300–1415
θ_8	ANU-11051	A.D. 1300–1435
θ_9	ANU-11046	A.D. 1300–1445

Prior to the analysis of the radiocarbon determinations, we hypothesized that the variation in Norfolk Island radiocarbon determinations upon charcoal samples might be related to inbuilt age. We therefore applied an outlier analysis to the Group A radiocarbon dataset at EB97:23 at Emily Bay to consider whether there were grounds for considering some determinations as affected by inbuilt age. We ascribed a prior outlier probability of 10% to each radiocarbon determination. With the exception of ANU-11042 (780±70 B.P.) which produced an posterior probability of 12%, the determinations were less than the 10% prior outlier applied. We concluded therefore that there are no outliers of significance.

The Group A results for EB97:23 span 790–530 B.P. (Table 4). We examined the group boundary parameters (early and late) for the determinations from each of the four stratigraphic components in this trench. These parameters represent the calibrated ages for the start and end of the groups. The posterior probability density for the earliest date of human occupation at this area of the site is represented by α_1. The most likely calendar date range (or ranges) for each parameter outlined in Fig. 1 are represented by highest posterior density (HPD) regions. The HPD region for α_1 at 95% is 1520 B.C. to A.D. 1295, with a modal value of A.D. 1220 (see Fig. 2). The modal value is the calendar age associated with the highest probability value. The terminus of occupation at the site is represented by β_4. The range for this parameter is A.D. 1300–1540 with a modal value of A.D. 1410 (Fig. 3). The overall range for occupation inferred for the EB97:23 area at 95% is 55–3,000 years, with 200 years yielding the highest probability (Fig. 4).

There are four Group A radiocarbon determinations from Trench EB97:24 (Table 4). The calibration model for these is shown in Fig. 5. The individual conventional radiocarbon ages support an occupation dating to the late thirteenth to fourteenth centuries A.D. A Bayesian analysis suggests a total elapsed occupation span of 10–2,740 years, with the highest probability (modal value) at 100 years (Fig. 6). The range for α_1 was 1350 B.C. to A.D. 1390 with a modal value of A.D. 1300. This represents the earliest likely date for human occupation given the present data. Taken together, the analysis supports an occupation which began after A.D. 1300 and lasted for about a century. Confidence in this interpretation is reduced by the small number of dated samples from this area.

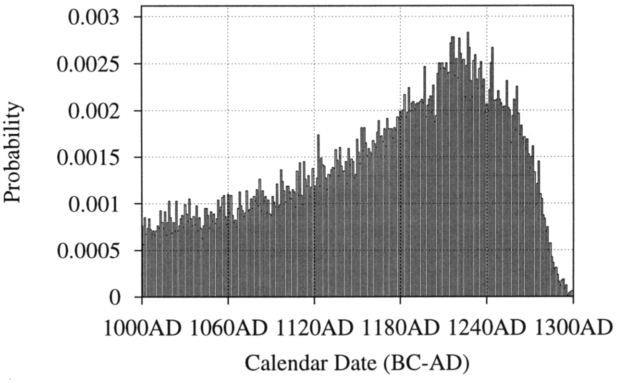

Figure 2. Posterior probability distribution for α_1 at EB97:23.

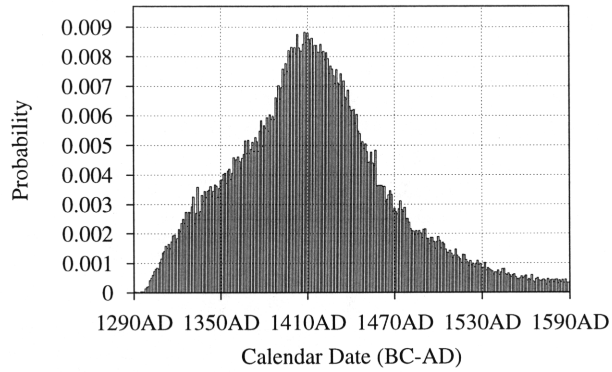

Figure 3. Posterior probability distribution region for β_4.

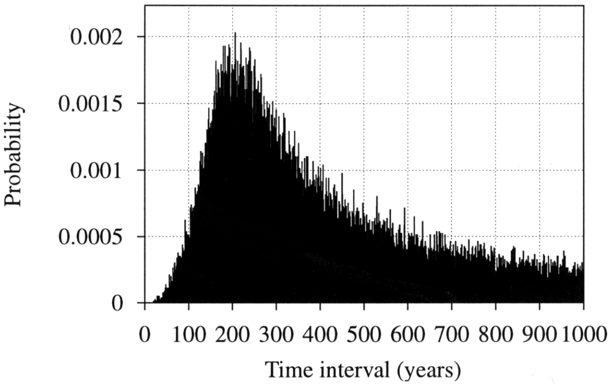

Figure 4. Total elapsed occupation span for cultural horizons at EB97:23, α_1–β_4.

Group B results from several trenches at the Emily Bay site are on material which could contain a higher inbuilt age. They are more variable, with the conventional radiocarbon ages spanning 400 radiocarbon years, three of them older than 800 B.P. (Table 5). Group C results are on material from Cemetery Bay and Emily Bay which, at least where it is identified as Norfolk pine, is likely to be significantly in error by reason of inbuilt age. They are the most variable of results, with conventional ages spanning 650 radiocarbon years, six of them older than 800 B.P. and three younger than 500 B.P. (Table 6). The young determinations remain enigmatic. They are too old to be

Table 4. Group A radiocarbon determinations from Emily Bay.

lab number	trench	square/spit	CRA (B.P.)	$\delta^{13}C$	calibrated 1SD (A.D.)
ANU-11037	EB97:23	Square B7 Spit 3	790±120	-24±2	1162–1300
ANU-11042	EB97:23	Square C7 Spit 2	780±70	-24±2	1217–1290
ANU-11041	EB97:23	Square D6 Spit 2	670±80	-24±2	1281–1398
ANU-11046	EB97:23	Square E7 Spit 2	530±70	-24±2	1327–1333, 1395–1441
ANU-11043	EB97:23	Square E10 Spit 5	760±70	-24±2	1225–1295
WK-6902	EB97:23	Square E12 Spit 4	750±45	-26.0±0.2	1255–1292
WK-6901	EB97:23	Square F10 Spit 3	720±45	-26.2±0.2	1277–1299
WK-6903	EB97:23	Square F10 Spit 4	710±45	-24.6±0.2	1280–1301
ANU-11051	EB97:23	Square A1 Spit 2	570±70	-24±2	1307–1361, 1378–1431
OxA-9629	EB97:24	Square A5 Spit 2	621±31	-26.6±0.3	1304–1370, 1370–1398
ANU-11050	EB97:24	Square A6 firepit/posthole	540±90	-24±2	1310–1354, 1385–1444
ANU-11047	EB97:24	Squares B1 & B2 Spit 3	590±110	-24±2	1293–1436
WK-6904	EB97:24	Square B4 Spit 2	740±55	-24.3±0.2	1256–1297

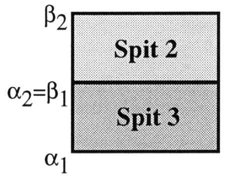

Figure 5. Calibration model for Trench EB97:24 at Emily Bay, Norfolk Island.

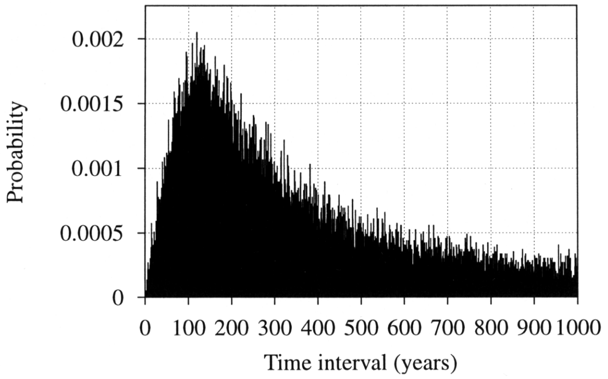

Figure 6. Total elapsed occupation span for cultural horizons at EB97:24; α_1–β_2.

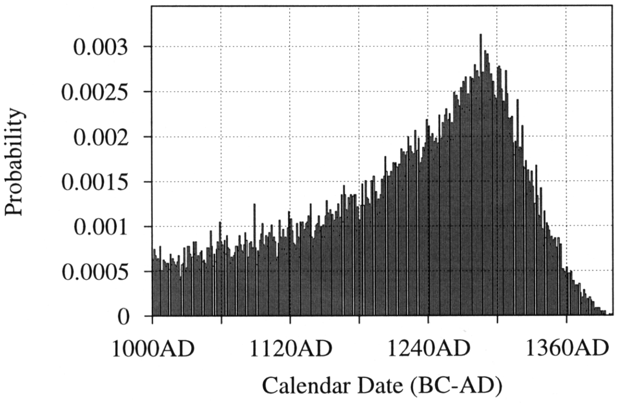

Figure 7. Posterior probability distribution of α_1 from EB97:24.

from European settlement and inbuilt age cannot be a significant variable in their measured ages since this influences radiocarbon determinations to be older, rather than younger. Whether they represent the last flickerings of the main prehistoric occupation, some later-arrived settlers, or are derived naturally from post-occupational forest fires, cannot be determined with confidence.

Neither Group B nor Group C samples were calibrated with BCal because of the sample constituent problems and the small numbers of dated samples from stratigraphically defined features. We conclude that the radiocarbon results for Group A samples from Trench EB97:23 are the most reliable since they are the largest and best identified assemblages of radiocarbon determinations for the excavation at Emily Bay. They provide support for an occupation which began in the thirteenth century A.D. The nature of the site suggests a brief period of occupancy, but this is not supported by the radiocarbon determinations which span 790–530 B.P., and suggest the highest probability associated with a period of c. 200 years of occupation from first settlement. This may imply that inbuilt age, even amongst the Group A samples, is still a significant influence in spreading the ages determined. Alternatively, it may suggest a more extensive span of occupation in prehistory than expected.

Radiocarbon determinations on marine shell

Determinations on marine shell samples are listed in Table 7. All of the determinations were from *Nerita atramentosa*, the most common shell species in the Emily Bay site. *Nerita* is an herbivorous grazing gastropod of the upper tidal zone, probably taken in largest numbers from the calcreted sandstone shore rock and tidal reef at Emily Bay. One question which arises regarding the marine shell series from Norfolk Island is the size of the marine reservoir offset. Radiocarbon assays of marine shell may be calibrated using the marine calibration curve which uses a box diffusion model based on the atmospheric ^{14}C record to determine an average world ocean curve (which incorporates a 400 year reservoir), from which local offsets (ΔR) can then be applied (Stuiver *et al*., 1998). In the absence of samples of known-age shell from Norfolk Island, the value for ΔR must be set to 0±0 yr, which assumes that the reservoir of surface ocean

Table 5. Group B radiocarbon determinations from Emily Bay.

lab number	trench	Square/Spit	CRA (B.P.)	$\delta^{13}C$	calibrated 1 SD (A.D.)
ANU-10701	EB96:10	Square A5 Spit 1	830±60	-24±2	1168–1278
ANU-10702	EB96:10	Square A5 Spit 2	730±70	-24±2	1251–1303
ANU-10703	EB96:10	Square B1 Spit 1	710±70	-24±2	1276–1377
ANU-10704	EB96:11	Square A1 Spit 1	1,010±110	-24±2	898–907, 961–1165
ANU-10705	EB96:11	Square A1 Spit 2	610±70	-24±2	1298–1409
ANU-11035	EB97:21	Square Z2 Spit 1	800±70	-24±2	1192–1286
ANU-11036	EB97:21	Square Z2 Spit 2	760±70	-24±2	1225–1295
WK-6905	EB97:24	Square C3 Spit 2	830±75	-25.6±0.2	1163–1281

waters in this region is typical of the average world ocean. Calibrating marine shell under these circumstances might involve a degree of error, because the local reservoir may be significantly different from the average world ocean value due to upwelling effects, for instance. One means of testing this is to radiocarbon date samples of known-age shell from the pre-bomb (earlier than A.D. 1950) reservoir and ascertain the size of the offset. In the absence of known-age shell, an alternative is to date stratigraphically identical marine and terrestrial samples, and determine the offset between them. In this instance, radiocarbon determinations of charcoal and *Nerita* shell from similar contexts produced ages at odds with that expected, with *Nerita* older by up to about 600 years. Why?

Marine and estuarine shellfish construct calcium carbonate within a small gap between the shell mantle and the body of the organism. Calcium and bicarbonate (HCO_3) are taken up by the organism from external sources, with the HCO_3 usually dominated by dissolved inorganic carbon (DIC) in the ocean water, as well as metabolic carbon from ingested marine microorganisms or algae. $CaCO_3$ is deposited from within the extrapillial fluid in the inner shell mantle. Determining the source, or sources, of carbon for shell carbonate precipitation is important in determining whether a marine shell is likely to prove reliable for routine radiocarbon assay.

One source of uncertainty in the dating of shell from Norfolk Island is the presence of calcareous rock substrates (that are radioactively dead), which may be an influence on shell radiocarbon concentrations if there is dissolution of the rock in the spray zone into a form which could be taken up by a living shellfish, such as the bicarbonate ion.

There is also the question of post-depositional contamination. The principal contaminant is likely to be dissolved carbonate which recrystallizes onto the surface of archaeological shell within a site. If that dissolved carbonate is of significantly different age then the radiocarbon age will be affected. One test for this contamination is to use powder X-Ray Diffractometry (XRD) to determine the crystallinity of the prehistoric samples. Since carbonate from post-depositional environments precipitates in the form of calcite, the presence of calcite in a naturally secreting aragonitic organism is a good test of recrystallization.

We collected modern samples of *Nerita atramentosa* and analysed their shell carbonate structures using XRD to determine their natural crystallinity. The samples were both calcite and aragonite, as were the prehistoric examples. This presents problems for determining isotopic exchange post-depositionally for the reasons outlined above.

There is some information in the literature regarding calcareous substrates and their influence on radiocarbon dating samples of archaeological marine and estuarine shell. Dye (1994), for instance, obtained radiocarbon determinations which yielded considerable variation between species of shell of known-age collected from the Hawaiian Islands. Some of the dated shells are of the same genus (*Nerita* sp.) as those from Norfolk Island, and just as common amongst

Table 6. Group C radiocarbon determinations from Emily Bay and Cemetery Bay.

lab number	Site/Trench	Square/Spit/Unit	CRA (B.P.)	$\delta^{13}C$	calibrated 1 SD (A.D.)
I-11019	Cemetery Bay	Unit C4	715±75	—	1261–1307, 1360–1379
I-11303	Cemetery Bay	Unit C4	840±160	—	1022–1298
Beta-6821	Cemetery Bay	Unit C4	850±50	—	1165–1255
Beta-6822	Cemetery Bay	Unit C4	800±50	—	1217–1282
ANU-10160	EB95:06	Square A2 Spit 1	390±70	-24±2	1443–1634
ANU-10159	EB95:06	Square A3 Spit 2	880±60	-24±2	1049–1228
ANU-10157	EB95:06	Square A4 Spit 2	480±70	-24±2	1396–1614
ANU-10158	EB95:06	Square A4 Spit 3	810±70	-24±2	1185–1284
WK-6900	EB97:23	Square E12 Spit 2	320±45	-21.5±0.2	1489–1605, 1613–1649
ANU-11195	EB97:24	Square A1 Spit 3	700±60	-24±2	1279–1307, 1360–1379
WK-7821	EB97:24	Square A5 Spit 3[a]	810±45	-24.3±0.2	1215–1280
ANU-11170	EB97:24	Square A5 Spit 2[b]	690±60	-24.2±2	1281–1310, 1353–1386
ANU-11171	EB97:24	Square B4 Spit 2[a]	970±60	-24±2	1013–1162

[a] under paving
[b] posthole in SE corner

Table 7. Radiocarbon determinations on shell samples from Emily Bay.

lab number	Site/Trench	location	CRA (B.P.)	δ^{13}C	calibrated 1 SD (A.D.)
WK-7299	Pt Ross	basaltic substrate	112.8±0.6% M	1.2±0.2	
WK-7298	Cemetery Bay	calcareous substrate	105±0.5% M	3.4±0.2	
WK-6898	EB96:10	Square A2 Spit 1	1,380±50	3.5±0.2	640–677
WK-6897	EB96:10	Square A4 Spit 1	1,440±45	3.7±0.2	601–656
WK-6894	EB97:23	Square D10 Spit 5	1,510±45	3.9±0.2	539–616
WK-6899	EB97:23	Square F12 Spit 3	1,480±50	4.2±0.2	547–641
WK-6896	EB97:24	Square A3 Spit 1	1,420±45	4.1±0.2	612–662
WK-6895	EB97:24	Square A5 Spit 2	1,560±45	4.0±0.2	424–560

prehistoric midden contexts. Dated *Nerita* samples yielded apparent ages up to 1740 years older than paired charcoal samples. Dye (1994) suggested that the most important variable in determining apparent ages was the substrate of the shell samples because freshwater inputs were negligible in their influence. Older shell determinations were consistently from locations with limestone substrates and younger determinations were from sites with volcanic substrates. Dye (1994) concluded that old carbon from limestone sources was making its way either indirectly into the organism's carbonate through consuming algae which ingested the limestone, or directly by the molluscs scraping and dissolving the limestone as they browse.

Goodfriend and Hood (1983) have examined ^{14}C uptake in landsnails in Jamaica and the United States. They showed that limestone was a source for shell carbonate in these species and that limestone contributed to carbon building in this organism, along with terrestrial plant carbon and atmospheric CO_2. Inputs from limestone-derived carbon occur through dissolution by secretions in the foot of the organism and subsequent metabolic uptake. In addition, limestone nodules may be stored in landsnails in the digestive gland and foot, and dissolved in the gut with subsequent diffusion into the hemolymph where it may then be incorporated into the shell of the organism. The δ^{13}C value for land snail is c. 9–10‰, so the uptake of limestone-derived carbon may be identified from an analysis of the change in δ^{13}C. Marine gastropods are very different organisms, but it seems reasonable to hypothesize that the mechanism for uptake in *Nerita* might involve the weathering of $CaCO_3$ from limestone into calcium bicarbonate under localized conditions through foot secretions, with subsequent incorporation into the shell.

We tested this hypothesis by dating post-bomb samples of *Nerita* of known-age, collected in 1999 from two different substrates; calcareous sandstone and basalt. The results were 105±0.5 pMC[1] for the calcareous substrate sample (Wk-7298) and 112.8±0.6 pMC (Wk-7299) for the basalt substrate. The results are clearly different, with the calcareous substrate sample yielding a lower pMC result and a δ^{13}C which mirrors those of the prehistoric samples. It is difficult to determine precisely the size of the offset from "true" age if the pre-bomb *Nerita* samples are taking up dead carbon from the calcreted sandstone substrate. If we estimate that there is a 7% contribution from the ^{14}C-free source, as the modern determinations imply, and we assume that the reservoir effect for Norfolk Island is the same as the average for the world ocean, then as a first approximation the net reservoir effect locally could amount to 800–1000 years. We think there is a possibility, then, that the older than expected ages might be caused by uptake of carbon from the local ^{14}C-free source based on the evidence to hand. The shell determinations of *Nerita* therefore appear to represent apparent ages too old by between 500 and 600 years. These conclusions might have implications for dating this species in other Pacific contexts, particularly where there is evidence for calcareous rock formations within the environs of the site. The application of a correction to these determinations would be premature and will remain so until additional data are obtained which tests the reliability of our estimated age offset in the *Nerita* samples. The shell determinations in Table 7 are therefore shown as uncorrected conventional radiocarbon ages (CRA) B.P.

Radiocarbon determinations on bone samples

Radiocarbon determinations on bone samples are listed in Table 8. The human bone sample was reported by Specht (1993: 152). Two fractions were dated as follows: ANU-7651A (apatite) 460±160 B.P. and ANU-7651B (collagen) 380±60 B.P. This sample is from burial 608 at Emily Bay, one of several burials exposed by high seas in 1936 (Specht, 1984: 32). Bulbeck and Groves (1984: 62) concluded that the morphology of the remains "eludes a straight racial identification [and] may well suggest a European×Oceanic hybrid status" of which they thought Polynesian characters the more prominent. However, the radiocarbon determination, even at two sigma (cal A.D. 1430–1654) is still comfortably older than European discovery. Perhaps this was a Polynesian burial.

There is a degree of uncertainty as well about the interpretation of the AMS determination, OxA-8749, upon the dog mandible (Smith, Clark and White, this vol.), which crosses the prehistoric/historical boundary. The sample was recovered by workmen digging a toilet pit outside the site and although other material collected then appears to be midden, the provenance is insecure. However, since a dog carnassial tooth was found in Trench EB96:11 within the site, the existence of dog prehistorically is probable. The pig mandible (OxA-8750, Smith, Clark and White, this vol.) is certainly modern. It came from the surface spit (1) of the cultural layer of Trench EB97:23 and it suggests, as does

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[1] pMC is percent modern carbon, a ratio of the activity of the modern standard and the unknown sample activity as a percentage. 0 pMC is A.D. 1950.

Table 8. Radiocarbon determinations on bone samples from Emily Bay.

lab number	Site/Trench	location	material	CRA (B.P.)	$\delta^{13}C$	calibrated 1SD (A.D.)
ANU-7651	Emily Bay	eroded shore	human bone	380±60		1446–1635
OxA-8749	West Emily Bay	0.8 m below surface	canine mandible	205±40	-12.7	1658–1682, 1747–1805, 1935–1954
OxA-8750	EB97:23	Spit 1	pig mandible	50±35	-20.9	1900–1900, 1955
OxA-5781	Cemetery Bay	Unit C4	rat mandible	495±55	-19.2	1320–1460
NZA-6635	CB95:01	Layer 7	rat femur	1,077±79	-19.1	883–1067
OZC-697	CB95:01	Layer 7	rat femur	795±50	-18.3	1219–1283
OZC-699	EB95:06	Square A4 Spit 3	rat tibia	540±50	-20	1398–1434
NZA-6634	EB95:06	Square A4 Spit 1	rat tibia	1,206±94	-19.8	716–957
NZA-6631	EB95:06	Square A4 Spit 3	rat femur	1,142±86	-19.3	812–992
NZA-6630	EB95:06	Square A4 Spit 4	rat mandible	874±84	-19.3	1047–1244
OZD-833	EB95:06	Square A3 Spit 2	rat femur	600±50	-20.5	1305–1408
OZD-834	EB95:06	Square A1 Spit 2	rat femur	605±45	-17.9	1305–1405
NZA-8039	EB96:10	Cultural layer Spit 1	rat bone powder	552±50	-18.5	1326–1430
OxA-7953	EB96:10	Cultural layer Spit 1	rat bone powder	565±45	-18.7	1321–1421
OZD-105	EB96:10	Cultural layer Spit 1	rat bone powder	990±60	-20	1004–1156
OZD-975	EB96:10	Cultural layer Spit 1	rat bone powder	560±60	-18.9	1315–1431
Ua-14267	EB97:23	Square F7 Spit 1	rat femur	485±60	-19.7	1408–1451
OxA-8331	EB97:23	Square H1 Spit 1	rat femur	790±35	-18.3	1227–1282
Ua-14268	EB97:24	Square B3 Spit 3	rat femur	485±60	-19.7	1408–1451

some other material, that parts of the site had been exposed in the historical period.

All the remaining results are AMS determinations on whole or powdered bone from *Rattus exulans*. Radiocarbon dating of *Rattus exulans* bone, including of the Norfolk Island samples (Holdaway and Anderson, 1998) processed by the Rafter Laboratory in Lower Hutt, New Zealand (the NZA series), has been the subject of considerable debate (e.g., Anderson, 1996, 1997, 1998, 2000a; Smith and Anderson, 1998; Holdaway, 1996, 1999; Holdaway and Beavan, 1999) which need not be detailed here. Suffice it to say that the latest review of the data (Anderson, 2000a), argues that there is a strong correlation between unusually old radiocarbon determinations and the period of processing at the Rafter Laboratory. The Norfolk Island results (NZA-6630, 6631, 6634, 6635, Table 8) were processed in 1995–1996, during which all the anomalously old determinations on *Rattus exulans* samples from New Zealand were also produced. Consequently, they should not be regarded as reliable estimates of age.

Part of the process of testing radiocarbon ages on *Rattus exulans* samples involved inter-laboratory dating of aliquots from the same bone powder samples. The results NZA-8039, OxA-7953, OZD-105 and OZD-975 (all Table 8) are from this project. The first was processed at the Rafter Laboratory in 1997–1998 at a time when all rat bone samples produced ages consistent with archaeological expectations (Anderson, 2000a). Sample OZD-105 is one of several anomalously old results from early processing of *Rattus exulans* samples at the ANSTO Laboratory (Lucas Heights, NSW; series OZC, OZD). A second aliquot subsequently produced the result OZD-975 and the former result is regarded by ANSTO as unreliable. When the unreliable results are discarded it can be seen the remaining determinations from all laboratories are consistent with ages on other material types at about 600 years.

Distribution of radiocarbon determinations

The radiocarbon determinations do not indicate any differentiation in occupation age between trenches. The Bayesian analysis suggested that Trench EB97:23 area was most probably occupied A.D. 1220–1410 and EB97:24 area for about a century beginning soon after A.D. 1300. On Group B samples and other results, EB97:24 looks to be somewhat earlier, probably occupied in the thirteenth century A.D. Certainly, the distribution of Raoul Island obsidian through Trenches EB97:23 and EB97:24 indicates their general contemporaneity (Turner, Anderson and Fullagar, this vol.). The other main excavation, Trench EB96:10, produced determinations indicative of thirteenth century occupation, and while determinations are few and variable for other parts of the Emily Bay site, they do not contradict the proposition that habitation began in the thirteenth century A.D.

From the first results, referring to Trench EB95:06, it was apparent that there is no significant relationship of age determination with stratigraphy. The Emily Bay site is consistently shallow and disturbed, both by cultural activity at the time of occupation and by subsequent bioturbation, if not other factors as well. It is therefore impossible to test stratigraphically the occupation spans suggested by the Bayesian analyses, and alternative explanations cannot be ranked. Within the 100–200 year occupations suggested, sources of radiocarbon dating variability, not least in inbuilt age of materials, constitute a sufficient explanation, and certainly the low density and shallow depth of material everywhere in the site does not suggest that people were living at Emily Bay for more than a few decades at most. However, we must not lose sight of the fact that occupation on a similar scale to Emily Bay had probably once existed in Slaughter Bay, judging by the continuing recovery of adzes in the intertidal zone there, and that some occupation may have extended to, or occurred in, Cemetery Bay, not to mention other places where artefacts have been discovered on Norfolk Island. So, it is quite possible that Emily Bay, while not occupied continuously for 200 years, was frequently visited over a longer period than that in which it was inhabited most intensively.

The determinations from Cemetery Bay are fewer and none are on Group A or B charcoals, so they may have quite significant inbuilt age. Taking that possibility into account, an occupation span beginning in or about the thirteenth century A.D. (c. 800 years B.P.) seems probable. In summary, the prehistoric habitation of Norfolk Island probably began in the early thirteenth century A.D. and may have persisted until the fifteenth century (c. 600 years B.P.) or even later, as some results that are potentially of cultural origin suggest the sixteenth and early seventeenth centuries.

The Norfolk Island chronology in Pacific perspective

The Norfolk Island archaeological chronology is strikingly similar to that from elsewhere in the south Polynesian region (Anderson, 2000b). Assemblages of radiocarbon determinations have shown, contrary to some earlier evidence and conjecture, that the earliest-known archaeological sites in New Zealand were inhabited from the thirteenth century A.D., as notably at Papatowai (Anderson and Smith, 1992), Houhora (Anderson and Wallace, 1993) and Wairau Bar (Higham *et al.*, 1999). Extensive radiocarbon databases compiled by the Rafter Radiocarbon Laboratory (Anderson, 1991) and the Waikato Radiocarbon Laboratory (Higham, 1993; Higham and Hogg, 1997), as well as a wide-ranging study of the calibrated ages (McFadgen *et al.*, 1994), agree that there is no evidence of human habitation of New Zealand before 800–600 B.P.

An extensive colonization site on Raoul Island in the Kermadecs, discovered in 1979 (Anderson, 1980), has radiocarbon dates extending back to 1,000 B.P., but probably because the first set of charcoal samples were exclusively on charcoal from the long-lived pohutukawa tree, *Metrosideros* sp. Later research, using different sample materials, indicated that 650–600 B.P. was a better estimate of the advent of habitation (Higham and Johnson, 1996). A similar age, 800–600 B.P., is indicated on relatively short life span charcoals (*Phyllocladus* sp.) from a fireplace and associated midden at Sandy Bay, on Enderby Island in the New Zealand subantarctic region. In short, south Polynesia was settled at virtually the same time and very probably from within the same colonizing population out of central East Polynesia. The Norfolk Island chronology fits precisely into this pattern.

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Domestic and Religious Structures in the Emily Bay Settlement Site, Norfolk Island

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ABSTRACT. At Emily Bay, domestic structures include earth ovens, scoop hearths and a possible rectangular house inferred from posts and postholes. An area of stone paving nearby is argued to be a religious structure, or *marae*. Made of naturally available stone, it lies slightly below the surface of the darker sand cultural layer. Obsidian flakes were found above it and postholes beneath. Several edging blocks of various shapes are noted. Radiocarbon dated to c. 700–600 B.P., this platform fits within the known parameters of other East Polynesian *marae* of similar age.

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Some clues to the nature of domestic and social life in the Emily Bay settlement are afforded by structural remains, and the existence of a religious construction is of considerable significance for Polynesian prehistory more broadly. Most of the relevant remains consisted of infilled holes and hollows of shapes characteristic of particular structures, such as postholes and earth ovens. The identification of these, however, varied across the site and their recorded distribution may not describe all those which once existed within the stratigraphic contexts which we excavated. There has been significant post-depositional disturbance of the site. The upper surface of the cultural layer, observed everywhere as smooth and almost level, almost certainly represents a period of wind planation, and possibly water planation, following the cessation of site occupancy and prior to the advent of the modern dunes over the site. In contrast, the lower margin of the cultural layer was very uneven, as might be expected from human activities in dune sand but, in addition, the burrowing of procellariids (petrels and shearwaters), which still nest on the margins of the site, has completely obliterated the internal structure of the cultural layer in some places and carried cultural material up to 0.8 m below the normal depth in a complex of hollows and lenses. Consequently, while the existence of stone paving protected a number of postholes in Trench EB97:24, it was often difficult in Trench EB97:23 to distinguish holes and hollows that might have been constructed deliberately from those representing casual impact or non-cultural activity.

Domestic structures

The most common domestic feature throughout the Emily Bay site is the heated stone earth oven or umu (PPN and PEP **gumu*[1]). Outside the main excavations examples occurred in Trenches EB95:06 and EB96:10, in each case comprising shallow scoops filled with broken, fired basalt cobbles mixed with charcoal and midden (see Anderson, Smith and White, this vol., fig. 16). In Trench EB97:23 there was a larger and deeper oven complex in squares A7–B7 (see Anderson, Smith and White, this vol., fig. 27). This seems to comprise at least three oven pits dug to differing depths and in slightly different positions. Across the remainder of Trench EB97:23 there are various small depressions, generally less than 1 m in diameter and 0.2 m to 0.6 m deep, which might have been oven scoops (see Anderson, Smith and White, this vol., fig. 24). However, these did not contain concentrations of ovenstone and charcoal and may simply be scoop fireplaces. Some of them contained richer deposits of midden than were apparent elsewhere and these might be rubbish holes (PPN and PEP **lua* (Green and Pawley, 1998: 60)), as one depression in Trench EB96:10 also appears to be. Alternatively, they are simply collapsed mutton bird burrows in which domestic debris accumulated naturally. In Trench EB97:24 Square Z6 there is a large oven at the southern edge of the paving, which contained the bones of an elephant seal (Fig. 1).

Postholes occurred in both of the larger excavations. In Trench EB97:23 posthole D contained a large Norfolk pine post-butt, the remains of an unshaped branch (R. Wallace, pers. comm.) (Fig. 2). There were substantial charred wood remains (all Norfolk pine) immediately adjacent to features J, K, and L, although several of these are uncertain postholes, being difficult to discern clearly by colour changes in the sand. The postholes were perceived only from the top of the cultural layer and they pass through it into the yellow sand beneath in most cases, which indicates that the posts burnt down at the end of the occupation.

In Fig. 2, the more convincing postholes can be seen to form an approximately rectangular outline about 5.0×2.5 m in size. There is nothing else in the stratigraphy or contents of the site to indicate what this feature represents, but its size and shape and its proximity to a large and repeatedly-used oven suggests that it was a small house, and that Trench EB97:23 excavation has uncovered part of a typical Polynesian domestic unit. Rectangular houses exhibiting such posthole arrangements, frequently with the floor perimeters outlined in curbstones, and with exterior ovens adjacent, are features to be expected in East Polynesian settlements (Green, 1996: 220–221; Oakes, 1994; Walter, 1998: 32–33,36). The evidence here, except for the lack of stone curbing demarcating the perimeter of the structure, is therefore entirely comparable to the ordinary Polynesian domestic structure.

There were also postholes in Trench EB97:24. These are, if anything, even more enigmatic. Since they underlie what seems to be a religious feature, they may be associated with its construction and are discussed in that connection.

Religious structures

The excavation of EB97:24 uncovered an area of paving which is almost certainly a religious structure, or *marae* as these are known collectively in Polynesia. When first encountered, it was thought that the paving might represent an historical road surface, since it is known that in the mid-nineteenth century a road was constructed from the stone bridge, through the western swale of Emily Bay and running approximately north–south towards a limestone quarry to the east of Government House. However, this initial interpretation was shown to be invalid on several grounds.

First, the position of the historical road appears to be documented in another place. The steep face in Trench EB96:11 (Anderson, Smith and White, this vol., fig. 19) may be a road cutting and it is adjacent to what seem to be several formed surfaces immediately to the east of it, in the lowest part of the swale. In Auger hole 24 (Anderson, Smith and White, this vol., figs. 13, 15), there are two heavily compacted surfaces, one above the other, of brown clay packed with rock and large sandstone slabs, each 0.3–0.5 m deep—plausibly, successive road surfaces. This material could be penetrated only by smashing through it with a heavy crowbar. There is no sign of the prehistoric cultural horizon in this area, but by Auger hole 23, a further 6 m to the east, the standard stratigraphy resumes. Trench EB97:24 lies 8 m, approximately, to the east again where the dark cultural layer of Auger hole 23 appears to gradually lighten in colour towards the buff-coloured horizon in Auger hole 22 (Anderson, Smith and White, this vol., fig. 15), which was immediately east of Trench EB97:24 (Anderson, Smith and White, this vol., fig. 29).

Second, the stratigraphy of EB97:24 shows that the paving is enclosed within, and is not set upon, the distinctive grey-brown to black layer which is the prehistoric cultural horizon throughout Emily Bay. In addition, the cultural layer is darkest through charcoal enrichment towards the top, above the paving, and lighter underneath, a circumstance that could not have persisted if the paving had been set in its position after the cessation of prehistoric occupation. Above the cultural layer is the widespread layer of brown clay, separated from the cultural layer by a thin layer of yellow sand. The brown clay contains some lenses of yellow sand, however, and may have been disturbed in places because a fragment of clear bottle glass was found almost on the surface of the cultural layer in square Z3 (although it might have tumbled in from higher up during our fieldwork, since the walls of the trench were highest in this area and suffered occasional minor slumping as they dried out).

A third important indication of the prehistoric origin of the paving is the fact that 24 obsidian artefacts were scattered above it. The position of these within squares was not recorded, and is shown schematically in Fig. 1, but it was noted that artefacts occurred directly on top of the paving (Spit 1) and within interstices between slabs (Spit 2), but were never found beneath slabs. In other words, the distribution of obsidian is a post-paving event.

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[1] PPN stands for Proto Polynesian and PEP for Proto Eastern Polynesian. This is the widely distributed Polynesian word for the even older Proto-Oceanic **gumun* or oven made with hot stones (Green and Pawley, 1998: 59)

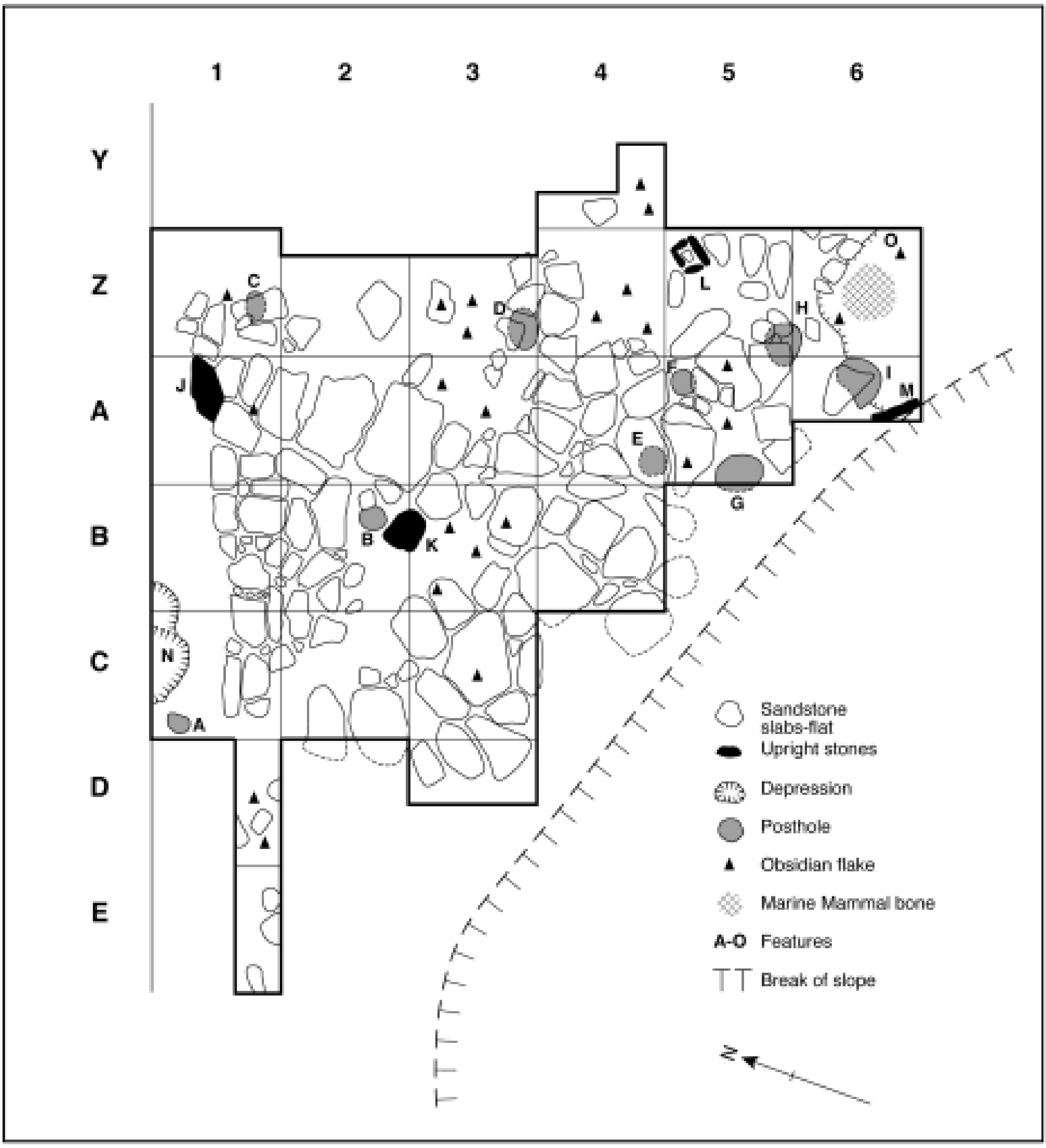

Figure 1. Features in Trench EB97:24.

Lastly, it was established that the paving is a discrete feature. Its extent along the southwest edge cannot be established because of the break of slope in that area, but strenuous efforts were made to test the possibility that paving continued in any other direction, both by extending the excavation boundaries up to the limit allowed by our excavation permit and, beyond that, by excavating a series of trenches around EB97:24, cleaning them down to the grey-brown surface and probing those surfaces to locate any stones or paving. Trenches, and cleaned-down surfaces around the perimeter of Trench EB97:24, were probed systematically at 0.10 m intervals, using a 0.33 m long metal probe, pushed in to 0.30 m in each case. This would have located all of the slabs in the excavated area, indeed penetrated well below the cultural layer. When stones were encountered, the probing interval was shortened to determine their size and shape.

This exercise had the following results (location of trenches in Anderson, Smith and White, this vol.: fig. 20). The only paving stones located were those shown in Fig. 1. No paving stones were found in the area immediately surrounding Trench EB97:24, or in contiguous trenches. In Trench EB97:25 no stones were found. In Trench EB97:26, one stone was located in the southeast corner. In Trench EB97:27 there were no stones. The stratigraphy of Trench EB97:28 was disturbed—it is close to both the historical road and the large area of apparent washout which reached the southwest edge of the paved area—and it contained several large stones and some rubble. Excavation of EB97:29 showed that the brown clay layer follows down the steep slope of the eroded area to flatten out about 1 m below the level of the paving, indicating that the washout or blowout area existed prior to the development of the modern dune system which overlies both the brown layer and the prehistoric stratigraphy which remains beneath it in other places.

The probing exercise showed, therefore, that while there was an occasional stone beyond the paved area, as there is throughout the Emily Bay site, there was definitely no additional or continued paving anywhere in the vicinity of the paved feature—nor is there any such paving indicated elsewhere in Emily Bay.

The paved feature. The paved feature (Figs. 3, 4), assumed to be a *marae* for reasons discussed below, is more complex than it appears at first sight. There are several events recorded in the stratigraphy. The feature was built on an almost level coarse-sand surface, which at the time must have appeared as a low sand ridge or knoll lying about 20 m east of the domestic structures in EB97:23 and approximately 1.0 m above the surface on which they lie. At least some postholes were dug into the surface before the paving was laid, assuming that it has not been shifted subsequently. Since none of them were noticed at the top of the cultural layer, unlike those in EB97:23, it seems probable that all of them pre-date the paving. The postholes in Squares Z 5–6 (Features H), A 6 (Feature I) and A 4–5 (Features E, F, G) appear to form a cluster of wooden poles which might have served some function later superseded by the paved site (Fig. 5, Table 1).

The cultural layer which was formed above the postholes is composed of the paving which is set in sand heavily-enriched with water-rolled, fine, gravel which also occurs between the paving and scattered thinly above it. The paving slabs are 3–8 cm thick, natural slabs of local sandstone. They are usually eroded around the edges, suggesting that they were gathered loose from the shoreline, for example in Slaughter Bay where they can still be found, rather than quarried.

The placing of the slabs forms no clear shape and there is nothing in the stratigraphy to suggest more than one phase of construction. However, their placement encourages some conjecture along that line. There is an area, half-round to triangular in shape, constructed from relatively small slabs which lies at the northern edge of the paving (Fig. 1), plus a block set on end reaching 0.24 m above the paving level (Feature K). The remainder of the paving, which contains larger slabs, appears as a northwest-southeast trending band with a northeast-southwest extension to the northern edge of the paving, where it terminates in an upright slab, protruding 0.10 m above the level of the paving (Feature J). At the southern end of the paving (Square A 6) is a slab set on its side, but hardly reaching above the paving level (Feature M), and on the eastern side of the paving a quadrangular group of small upright slabs (Feature L), which enclosed a basalt hammer stone.

Feature L is possibly related to the third event on the site, the flaking and distribution of obsidian, all of it of Raoul Island material and quite possibly from the same block, although they could not be re-fitted. The artefacts tend to occur in squares surrounding Z5, in which Feature L is located. There are also basalt flakes scattered on the paving and between the slabs, but these occur throughout the site and there is nothing apparently different in the

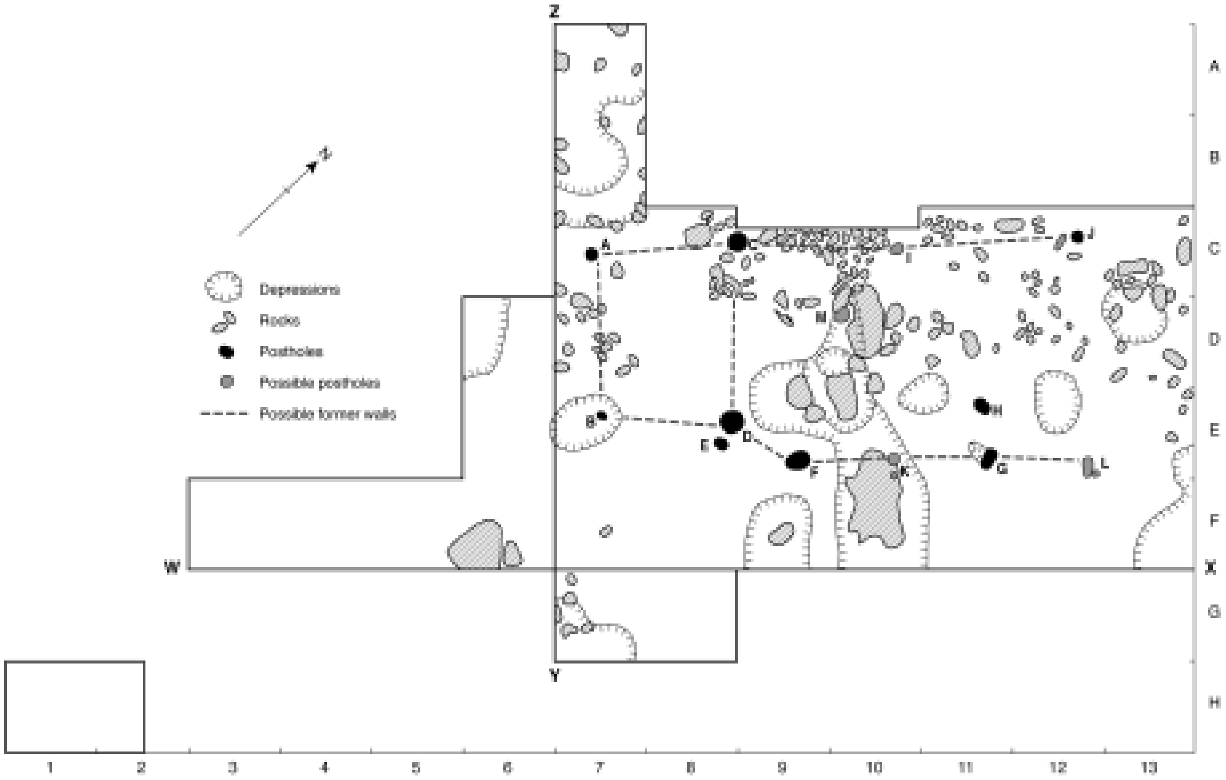

Figure 2. Features in Trench EB97:23.

Figure 3. Paved area in Trench EB97:24, taken from northwest.

Figure 4. Paved area in Trench EB97:24, looking southwest over EB97:23.

EB97:24 material. Following the obsidian flaking, the site was covered by grey to black sand, generally to a depth of 8–10 cm above the paving. The colour variation seems to be related to the construction of the shallow oven area in Square Z 6, which contained elephant seal bones. Charcoal, evidently from this feature, became distributed in the sand above the paving, staining it black in Squares Z 5, Z 6, A 6 and the southern half of A 5. Elsewhere the sand above the paving is grey to grey-brown. Since the black sand goes down to the level of the paving, but not below it, or between the slabs, the oven is later than the paving and the obsidian flaking.

Age of *marae* construction. Charcoal samples were selected and processed as described by Anderson, Higham and Wallace (this vol.). The first set of results (ANU-11047: 590±110 B.P.; ANU-11050: 540±90 B.P.), both on broadleaf samples, came from beneath the half-round area of paving

Figure 5. Postholes E, F, G, H, I at northern end of the paved area in Trench EB97:24.

and posthole I respectively, suggesting that the structure dated to about 550 B.P. However, the next set of results (ANU-11051: 570±70 B.P.; Wk-6904: 740±55 B.P.; Wk-6905: 830±75 B.P.), also on broadleaf samples, all came from spit 2 (the same level as the slabs) and covered such a wide span that attempts were made to test whether this was related to the different phases of construction (above) or to variation in the samples. That involved dating some more samples from under the paving and in the covered postholes. Of necessity, these were charcoals from Norfolk pine which, given the probability of significant inbuilt age could provide only a *terminus post quem*—that is, if the ages came back as similar to or younger than previously established determinations then they would confirm the general age estimate of construction, but older ages could not indicate an earlier phase of construction. These dates (ANU-11195: 700±60 B.P.; Wk-7821: 810±45 B.P.; ANU-11171: 970±60 B.P.) are predictably spread, but they run up to the range of other samples from under the paving.

Table 1. Features and their dimensions in Trench EB97:24.

postholes	top dimensions (cm)	depth (cm)
A	15 × 10	12
B	17 × 14	20
C	25 × 15	51
D	30 × 24	54
E	27 × 25	47
F	22 × 22	42
G	45 × 29	57
H	30 × 25	80
I	28 × 22	75
upright slabs	**height above paving (cm)**	
J	10	
K	24	
L	0	
M	5	
depressions	**maximum depth (cm)**	
N	24 (10 cm in eastern part)	
O	30	

When the dates are divided by sample group (Anderson, Higham and Wallace, this vol.), it can be seen that the preferred group A estimates (ANU-11047; 11050; 11051 and Wk-6904) indicate that the *marae* was constructed approximately 700–600 B.P.

The Emily Bay *marae* in Polynesian perspective

There are two components of a Polynesian perspective within which an interpretation of a 700 year old religious structure at Emily Bay on Norfolk Island can be addressed. One is what the initial form of ritual architecture and spaces were at the ancestral stage of Polynesian culture. The second is what forms to date have been seen as the foundation for the later and better known *marae-ahu* and *heiau* complexes of Eastern Polynesia, which took on a range of monumental shapes within the last 800 years or less in that region (Green, 1993: 10–11), but not in New Zealand (Davidson, 1984: 171) or in Western Polynesia. Consideration of the first component allows one to define the major architectural features which make up the religious structures in Polynesia and are reflected in the Norfolk Island evidence. This is followed by discussion of the second component, where the Norfolk Island *marae* is deemed to conform to the expected physical configuration predicted from earlier studies by Emory (1933, 1943, 1970), based on the 1925 Papeno'o Valley, Tahiti survey results. His view then was that he could identify the basic elements of Eastern

Polynesian *marae* (the courtyard, platform, and upright slabs) and had discovered a new tool for tracing Polynesian wanderings, the places where they had worshipped (Krauss, 1988: 140). So Emory had; it has just taken time to trace these developments more fully from the archaeological record.

The concept of a specially designed open space in a settlement, Proto Oceanic **m(a,e)laqi*, has a 3000 year antiquity among the Austronesian speaking societies of the Pacific (Green and Pawley, 1998: 63–64). Its continuation in Polynesia as PPN **malaqe* was interpreted by Biggs (1993) in his POLLEX linguistic reconstruction as referring to an open, cleared space used as a meeting place or ceremonial space.

Recently Kirch and Green (in press) have considered the probable ritual spaces of Ancestral Polynesian culture and its societies by drawing not only on linguistic, but also ethnographic and archaeological information. They point out that the essential components of ritual architecture present throughout all three main subregions of Polynesia (the Outliers, West Polynesia and central East Polynesia) are (1) an open space, variously elaborated into a formal courtyard, and almost everywhere designated by the term *malae* or *marae*; (2) some form of god house (*fale* or *fale*—adjective) attached or adjacent to the court, sometimes associated with ancestral burials; (3) either posts or uprights stones (often under the term *pou*) serving as symbolic representations and/or manifestations of deities, situated either around the perimeter or at one end of the court, or at times within the god house itself; and (4) present only in central Eastern Polynesia, a raised platform or altar called the *ahu* situated at one end of the court.

On the basis of the ethnographic, archaeological, and lexical evidence Ancestral Polynesian ritual spaces are argued by Kirch and Green to have been architecturally simple affairs, consisting of an open, cleared space (PPN**malaqe*) lying seaward of a sacred house (PPN**fale—{qatua}*), the latter constructed upon a base foundation (PPN**qafu*). Thus approached from the ancestral perspective, the Emily Bay structure possesses the elements of a formally defined courtyard space, in this case paved, and the associated upright stones. Whether there was a structure identifiable as a god house adjacent to the paved courtyard cannot be determined from the available evidence, while the absence in this case of any *ahu* platform, present in the later central Eastern Polynesian *marae*, and those of Easter Island, Pitcairn and Mangareva, is probably significant (see below).

Turning to the Eastern Polynesian literature, the Norfolk Island structure fits in well within the long predicted early or simple *marae* (or shrine) form. That form, based principally on later examples from Hawaii and Tahiti, but known in the Tuamotus as well (Emory, 1933, 1947, 1970, 1979: 205–207), has a rectangular court (often a stone pavement) frequently with three uprights at one end. In the development of religious structures in Hawaii, it is a descendant of that form which Kolb (1994: 423 and fig. 5) illustrates as the ancestral type dating to c. A.D. 1200 from which the increasingly more complex *heiau* forms in that island group evolved. Really solid dated archaeological evidence for his illustrated reconstruction, however, is weak. In the Marquesas, Suggs (1961: 63 and fig. 21) reported on some similar evidence (to that of the postulated ancestral type of East Polynesian shrine or the remains on Norfolk Island) for the Ha'atuatua site on Nukuhiva. This consisted of a partial pavement and an associated stone upright over a burial, all interpreted as forming a temple feature. The evidence, initially attributed to a much earlier settlement period, would now be dated to c. A.D. 1300–1650 (Anderson *et al*., 1994; Rolett and Conte, 1995; Rolett, 1998: 52–57; Sinoto, 1966: 303). Monumental forms of religious architecture in the Marquesas are argued by Rolett (1998: 255) to all date after A.D. 1300.

In the Society Islands, Wallin's recent study (1993) of *marae* structures indicates that Type 1 of his classification is the earliest form. Simple variants of Type 1 (the pavement and uprights at one end, sometimes with *ahu* platform), are judged to be the early and typical family *marae*, from which all later forms evolved (Wallin, 1993: 121 and fig. 84). Although the oldest actual archaeological date for a Society Island *marae* on his analysis of the current literature suggests approximately A.D. 1500, Wallin (1993: 78,127,130) is willing to consider the possibility of early forms in fact extending back to A.D. 1200. Sinoto (1996: 551 and fig. 6) too has the demarcated court and three uprights as his basic Windward Islands type from which later types evolved, and has a simple upright alone or with surrounding stones (as in the twelfth to thirteenth century Vaito'otia site) as the initial Leeward Islands form.

Easter Island *ahu* platform religious sites are extensively dealt with by Martinsson-Wallin (1994). Their earliest certain appearance in monumental form is c. A.D. 1100–1200 (Martinsson-Wallin, 1994: 77–82; see also Skjølsvold, 1996: 106), although A.D. 1000 remains a possible beginning date. In this case it is the *ahu* platform which is being dated, as most religious structures of the Mangarevan, Pitcairn, Rapanui type lack stone uprights, having raised *ahu* platforms fronting an open and sometimes partially paved courtyard. Later *ahu* platforms supported images in the Pitcairn and Rapanui cases, and they may well be a replacement for earlier forms with stone uprights (McCoy, 1976; Van Tilburg, 1994: 76, 83) at present unknown for this part of Eastern Polynesia. Certainly no images or uprights occur on the raised *ahu* platforms of Mangarevan *marae*. It is worth adding that in the Society Islands and Easter Island, small stone slab-outlined cists called *avata* occur in the courtyards of religious structures: Feature L on the paved court of the Norfolk Island *marae* may be a related feature of the same kind.

Currently we have no in-depth study of religious structures in the Cook Island group which outlines a possible sequence for their development, and little in the way of their dating. This is unfortunate. Certainly a *marae* form consisting of a step-terrace platform with uprights is present on Rarotonga (Bellwood, 1978), and Green has personally observed a *marae* type of shrine (in a modern garden setting) consisting of a flat stone pavement with uprights at one end preserved on that island. More interesting is the Mangaia Island case (Hiroa, 1934: 172–177; Bellwood, 1978), where these religious structures are relatively simple in their features, form a fairly homogeneous architectural set, and may be more recent but stylistically retentive examples of what was a little changing type. Thus they consist simply of rectangular courts paved with gravel and at times defined on their perimeters with stone edgings or curbings. Upright stones, representing deities, are often present at one end of a *marae* (Kirch and Green, in press).

The above review of the Eastern Polynesian literature is sufficient to contextualize the Emily Bay example. It becomes simply a well dated example of the ancestral central East Polynesian and Hawaiian *marae* type from which more complex monumental architectural shapes are deemed to have developed in the last 500 to 600 years. Some East Polynesian *marae* forms consisting of uprights on open cleared spaces, as in the Cook Islands, seem to have persisted as types throughout the sequence (Bellwood, 1978). Others, composed of simply defined and sometimes paved courts with uprights at one end, also had long typological and temporal runs, and yet others of much later periods developed elaborate stepped *ahu* and stone wall enclosed structures of monumental form as in the Tuamotus and Tahiti. Few of the later developments seemingly reached New Zealand. Davidson (1984: 171) neatly summarizes the situation there. Linguistically retained in Maori is the concept of *tuahu* or shrine. This is better documented ethnographically than archaeologically and, as in the Cook Islands, consists of the simplest form of a shrine—a sacred place marked by one or more uprights of stone or wood (Davidson, 1984: 171).

On the basis of the above evidence, it is usually argued that the architecturally more developed forms of the *marae-ahu* complex spread through East Polynesia after the departure of the settlers for New Zealand, an event currently dated by most to no more than 850 years ago (Anderson, 1991; Spriggs and Anderson, 1993). The Norfolk Island *marae* evidence further suggests this inference may be a quite reasonable deduction both typologically and temporally. Thus, after the settlement of the southern zone (Kermadec, Norfolk, New Zealand including the Chathams, described as South Polynesia by Anderson, 2000), that part of Polynesia thereafter remained rather isolated from the kinds of on-going contact which continued to characterize central Polynesia, Hawaii, and southeastern Polynesia (Anderson, 2000). When this southern zone was settled, only the linguistic *tuahu* concept and the architectural form of the simple *marae* or shrine was brought to it from central Eastern Polynesia. Moreover the dating of a good example of this simple shrine form in Norfolk Island, consistent with twelfth to thirteenth century estimates for similar complexes from the rest of Eastern Polynesia, furnishes most helpful support of its probable widespread existence at that time. Therefore, a typological argument initially dependent largely on a wide later distribution of this simple shrine form in tropical Eastern Polynesia takes on a more robust shape through archaeological excavations of dated examples in the Marquesas and Norfolk Island.

What did not diffuse to the southern zone was the concept and construction of a raised *ahu* platform as the central feature of a *marae* complex, something which current evidence indicates first appears in southeastern tropical Polynesia at about the same time as the Norfolk Island *marae*. As Kirch and Green (in press) suggest, in PPN **qafu* referred to the foundation of an earthen house mound or possibly a stone platform which supported a shrine or god house. In central Eastern Polynesia, the god house became miniaturized or abandoned within temple architecture, but the PPN **qafu* foundation remained to become elaborated as an altar, the most sacred part of the temple. The focus of that early development on current evidence lies in the southeastern part of Polynesia, but did not ever reach a southwestern zone of Polynesia below latitude 30°S.

The implications for mainland New Zealand archaeology are simple: archaeologists must re-examine early sites for signs of simple stone pavements or prepared gravel-surfaced courts associated with what once may have been stone or wooden uprights. In the South Island, the Heaphy River site (Wilkes and Scarlett, 1967) comes to mind as an example of what might be sought, as does the Dart Bridge site (Anderson and Ritchie, 1986). These two sites certainly have their problems of interpretation as they presently stand, but they are an indication of the kind of evidence upon which early religious structures in New Zealand might be identified. Additional excavations at several New Zealand sites, based on a large-scale areal approach to define the whole settlement, might also reveal such features of presumed ritual spaces.

Conclusions

The structural evidence from the Emily Bay site is consistent with a typical East Polynesian settlement of hamlet or village type. In EB97:23 there is one rectangular structure of about 5×2 m outlined by postholes. It is oriented northeast-southwest and may have had a porch facing to the sea. Adjacent to the seaward end of it is a large and repeatedly-used oven area. This looks like a typical East Polynesian type of domestic unit of house and cooking area. Smaller excavations elsewhere on the site uncovered more ovens and several postholes which possibly represent part of the same domestic complex.

In Trench EB97:24, about 15 m east of the probable house, and on higher ground, is situated a paved area which has been interpreted as a *marae*. This interesting feature, which dates to about 700–600 B.P., discloses the predictable elements of early East Polynesian *marae* and is a clear indication that, contrary to conventional wisdom, constructed *marae* of this type were introduced into the temperate southern zone of East Polynesia with the early settlers. The Emily Bay discovery raises questions for further research about why such *marae* forms are not more evident in New Zealand or the outlying archipelagoes to the north and east (Kermadecs, Chathams), or whether, in fact, we need to revisit some older evidence that they did exist there.

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Stone Artefacts from the Emily Bay Settlement Site, Norfolk Island

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ABSTRACT. The lithic material from the Emily Bay site consists principally of basalt flakes, blades, preforms and adzes. There are also a small number of obsidian artefacts. The basalt assemblage has been analysed primarily to describe the technology of adze manufacture, which occurred along with reworking of broken preforms and finished adzes. The pattern of adze production is very similar to that found in New Zealand sites. No complete finished adzes were recovered, but the flake material indicates that Duff (1977) Types 1, 2, 3 and 4 were being made. Sourcing studies show that the basalt is local. Sourcing of obsidian shows that nearly all came from Raoul Island (Kermadecs) while one piece may be from New Zealand. Use wear and residues, notably starch grains, were found on many of the sample of 10 basalt and five obsidian artefacts analysed and the range of activities represented is congruent with a permanent or semi-permanent village rather than a temporary camp.

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The major component of the stone artefact assemblage consists of basalt adzes and the flakes produced in making them. Some of these flakes were also used as tools and residues and usewear on a sample of these was analysed, along with some of the exotic obsidian. Our joint authorship of this paper is the result of an amalgamation of Turner's work on basalt artefacts, Anderson's on source characterization of stone and Fullagar's on usewear and residue analysis.

Basalt artefacts

The basalt assemblage from the Emily Bay site comprised primarily flakes, with a small number of adzes and preforms. These have been analysed as if all were produced during the manufacture of adzes, giving an overall impression of the lithic technology and manufacturing sequences. We recognize that some flakes were probably made for other uses, but the overwhelming evidence of the technology is that adze production was primary.

Because nearly all adzes and flakes from Norfolk Island were similar to those found in New Zealand, the flakes recovered from the Emily Bay site were analysed according to a flake typology developed from an extensive programme of adze replication experiments by skilled stone-adze maker Dante Bonica (New Zealand), in conjunction with analysis of several New Zealand basalt archaeological flake assemblages. The adze replication flakes were made from Tahanga basalt, the major adze stone used in the North Island of New Zealand. It is a tough fine-grained basalt very similar to the Norfolk Island material.

The development of this typology is discussed fully by Turner (1992) and Turner and Bonica (1994). It divides flakes into four categories according to size (measured by weight), dorsal surface characteristics (cortex and scarring), shape (including the type of flake termination) and a fourth descriptive category "special flake types", based on other attributes of morphology.

Adze manufacture can be viewed as a reduction process during which smaller flakes will normally be produced as manufacture advances. Cortical flakes will be removed during the initial stages of manufacture whereas flakes with multiple scarring on their dorsal surfaces will be removed later. The manufacturing process can be reconstructed from these basic assumptions. Flake shape and termination can provide information on success in shaping, which is an indirect measure of skill. To describe the Emily Bay assemblage it is necessary to outline the typology in some detail.

Adze flake typology

Category One: size. Size 1 (over 300 g) and Size 2 (201–300 g) flakes are produced in experimental breaking of boulders and roughing-out of blanks over 2,500 g. Only 10% of total boulder weight is produced as debitage; most flakes are produced during adze making. At Tahanga, most blank production occurred at areas where raw material was concentrated, whereas flaking of blanks occurred in areas where there was less clutter. Large flakes result mainly from the reduction of large blanks.

Size 3 (101–200 g) flakes are produced during the initial roughing out of flake blanks over 2,000 g, while Size 4 (51–100 g) flakes are usually produced during the initial rouging out of flake blanks under 2,000 g. They also might result from the later stages of production of larger adzes. The amount of dorsal cortex and scarring (Category 2) indicates whether they were produced in the primary roughing out of small preforms or the secondary working of larger preforms.

Size 5 (21–50 g) and 6 (3–20 g) flakes are most commonly produced in the shaping of preforms of all sizes. They are generally the largest flakes produced from the working of blanks under 1000g. Size 7 (less than 3 g) flakes are numerically dominant and their frequency increases as manufacture advances. Size 7 flakes made up 85% of the experimental flake total. They are the most frequently produced flakes at all stages of manufacture, but especially during fine trimming. During blank production and initial roughing out, Size 7 flakes commonly resulted from shattering and breakage of distal flake ends. Size 7 flakes were uncommon on the surface of the Tahanga working floors, as they became lost between larger flakes (Turner, 1992; Kronqvist, 1991). They are equally rare in surface collections and excavated assemblages because sampling procedures generally have not ensured that these flakes are retained; the Emily Bay case is an exception and it reflects sieving to a small mesh size (4 mm), especially at Trenches EB97:23 and EB97:24.

Category Two: dorsal surface characteristics. Flakes retaining cortex and no scarring (CO) represent primary roughing out of blanks. The roughing-out of large cobble blanks produces the highest frequency of these primary flakes especially in Sizes 1–3. Preparation of small cortical flake blanks also produces CO flakes, typically of Sizes 4 and 5. There was, however, a greater number of Size 6 CO flakes produced overall due to small flakes shearing from the dorsal surfaces of large blanks upon hammer impact.

Flakes retaining cortex and with primary scarring (CP) represent secondary roughing out of preforms. These flakes have one or two flake scars on the dorsal surface. The majority is produced during the roughing out stage. Cobble blanks require more extensive roughing-out and, being more cortical, produce the highest frequency of CP flakes.

Flakes retaining cortex and with secondary scarring (CS) represent later stages of roughing-out and fine trimming. These flakes have more than two flake scars on the dorsal surface. They are the rarest category because little cortex generally remained after roughing-out, while secondary scarring mainly occurs during fine trimming and edge straightening. These flakes are produced more frequently in the later stages of roughing-out and in the fine trimming of large cobble preforms.

Flakes with no cortex and no scarring (OO) are uncommon, but result from two distinct processes. First, during blank production and heavy roughing-out of large cobble blanks a thin sliver, shaped like a potato chip, occasionally sheared off the bulb of percussion on hammer impact. Second, a similar flake is produced during trimming of the ventral surface of flake and split cobble blanks after some side trimming.

Flakes with no cortex and primary scarring (OP) represent adze shaping. This is the commonest class of flake, and it occurs most frequently at the later stages of roughing-out (shaping the preform), particularly during reduction of flake blanks. The initial shaping of boulder cores also produces many of these flakes.

Flakes with no cortex and secondary scarring (OS) represent adze shaping. These are predominantly fine trimming and edge straightening flakes produced at an advanced stage of manufacture where the intention is to refine the adze shape in preparation for hammer-dressing and grinding.

Category Three: shape and termination. Category A flakes have step and hinge terminations. They are flakes that failed to follow through the desired distance across the side of the preform and broke off short. Shaping problems resulting from adjacent step and hinge fractures often produced unsightly protuberances and smashed striking platforms. When this could not be fixed the preform is rejected. Flaws and inclusions of poor quality material often cause this to occur. Another practice which also caused high levels of Category A flakes was the reworking of preforms and adzes. The modification of flakes into other types of tools, or the process of using the flake as a tool again resulted in high numbers of flakes with broken or damaged distal margins.

Category B flakes are generally thin, longer than they are wide and have feather terminations. They usually followed through across the surface being flaked. Therefore, lumps are unlikely to develop. Skill is required to produce these flakes consistently, although stone quality was also important.

Category C flakes are chunky, blocky pieces. They are generally the thick central pieces from broken flakes where distal and lateral margins and other diagnostic features had been snapped off. In experiments they are most commonly produced during blank production and the roughing out of large blanks where the degree of force caused frequent shattering of the flakes. They are also produced when end-shock occurred or when pieces broke off as a consequence of hitting a flaw. Flake modification also produces high percentages of C flakes.

Category D flakes are thin small slivers or splinters without a striking platform or bulb of percussion. Therefore, like Category C specimens, they cannot be classified as true flakes. These slivers and chips resulted from flakes shattering on impact during manufacture and flake modification into other tools. Where C flakes are the central pieces, D flakes are often the snapped off lateral and distal margins. Generally they prevailed in the smaller flake classes (Sizes 6 and 7).

Category E flakes have thick, abrupt ends, sometimes known as "plunging" terminations (Cotterell and Kamminga, 1987). They often have prominent bulbs of percussion and are most frequently produced in experiments when a hard hammerstone is used with considerable force. They occur most commonly in larger flake sizes and during the early stages of production where hard hammers are often needed, particularly with large blanks. These flakes are also produced in the reduction of thin flake blanks where the flake travelled the thickness of the blank. This form of fracture is frequently produced when reworking broken preforms and adzes (discussed in greater detail below).

Category F flakes are wider than they are long, with feather terminations. They are more frequent in the later, fine-trimming stage after the preform has been thinned down considerably, but are also prevalent at all stages with thin flake blanks, and common in small size classes.

Category Four: special flake types. Category Four comprises a number of special types. At Norfolk Island this fourth category consisted of reworked preform flakes, reworked adze flakes and modified flakes.

Preform reworking flakes. Reworking broken preforms into smaller adzes produced distinctive "reworking flakes". These can be identified in archaeological assemblages. Preform pieces, which result from unintended transverse fractures, require different shaping strategies than those applied to primary blanks. The width and depth of the broken preform are usually too great for its length. Therefore, reworking involves substantial narrowing of sides and faces. The flat surface created by the transverse fracture serves as an effective striking platform that is rarely available on primary blanks. Striking from this surface frequently produced long blade-like flakes, which are uncommon in primary adze manufacture. When struck down a corner they often resemble triangular "hogback" (Duff, 1977, Type 4) beaks. For this reason, identification of hogback manufacture can be difficult in assemblages containing a high percentage of reworking flakes. The presence of "hogback" flakes in the Riverton assemblage (Leach and Leach, 1980) indicated the production of Type 4 adzes although no preforms were found. During experiments their production was one of the last steps undertaken before hammer dressing. Therefore, their presence in the site provides information on the stages of manufacture represented at a site. However, as explained above, the high number of reworked adze flakes in the assemblage makes their identification problematical. Consequently all flakes that might be hogback flakes are classified as adze reworking flakes.

Adze Reworking flakes. Adze flakes have hammer dressed and ground surfaces produced from the repair and reshaping of finished adzes. Their presence and frequency indicate the degree to which these activities have taken place at a site. However, not all flakes from reworking adzes will have a ground and/or hammer dressed surface. In adze reworking experiments 50% of flakes resembled those of adze manufacture.

Modified flakes. In New Zealand collections, discarded adze flakes were modified to form a range of flake tools including various points and flake tools which have edge damage indicative of use wear. Experiments are currently being conducted to ascertain the functions of these tools (Turner and Bonica, in prep).

Flake analysis results. A total of 3,178 basalt flakes was recovered from the Emily Bay site. Of these, 2,606 flakes were of the smallest size category, Size 7—these are so small that the identification of diagnostic features is difficult and time-consuming. They were excluded from the analysis below. However, they indicate that there was comprehensive recovery of lithic remains which suggests that all remains have been recovered in other categories and, therefore, this is an excellent assemblage upon which to deduce the stages of adze manufacture and its products.

The 572 flakes of Sizes 3–6 indicate that the following manufacturing stages were present in the Emily Bay assemblage: adze manufacture accounted for 63.2% of the flakes, adze preform working was 18.8%, and adze reworking accounts for the final 17.9%. Table 1 shows the manufacturing stages that were occurring at Emily Bay. The results for Emily Bay are shown together with Bonica's experimental data sets and some of the New Zealand archaeological assemblages. These provide a comparison and aid in identifying the processes represented in the Emily Bay assemblage.

Adze manufacture. There are three major stages in the production of adzes. These are the primary manufacture of adzes, followed by the distinctive preform reworking flakes and adze reworking flakes (Table 1). Distinguishing between the different stages of adze manufacture is achieved by a combination of the three basic categories mentioned earlier: size (based on weight), dorsal surface characteristics and termination type. Characteristics used to identify stages of adze manufacture that took place at each site are given in Tables 2 and 3.

In the Tahanga basalt adze production complex in New Zealand, all blank production and most of the initial blank shaping (or roughing-out) took place at the quarry while most of the fine trimming took place at villages elsewhere (Turner, 1992). The fact that there are very low proportions of the larger size classes (Table 2) or of cortex on the dorsal surfaces (Table 3) in the Norfolk Island assemblage compared to our experimental data suggest that this practice

Table 1. Adjusted breakdown of processes indicated by flake data from Emily Bay and selected New Zealand archaeological sites.

site	number	adze manufacture (%)	RWPF (%)	RWadze (%)	modified (%)
Emily Bay NI	572	63.2	18.8	17.9	19.4
Tahanga Quarry NZ	4706	100.0	0	0	0
Whitianga NZ[a]	24597	62.7	33.0	4.2	25.6
Hot Water Beach NZ[a]	909	67.3	17.0	15.6	2.8
Hahei NZ[a]	5022	63.0	25.8	11.0	4.0
Whitipirorua NZ[a]	3435	58.7	30.4	10.8	10.5
Opoutere NZ[a]	1309	48.2	39.1	12.6	36.2
Bowentown NZ[b]	4186	39.5	41.8	19.7	18.1
Mt Camel NZ[c]	918	8.4	5.6	83.6	4.3
Toke/toke NZ[d]	933	0	0	100	14.6

[a] Coromandel Peninsula [b] Bay of Plenty [c] Northland [d] East Bay of Plenty

was followed on Norfolk Island also. Both flake size and dorsal surface characteristics for Emily Bay are more similar to the fine trimming experimental data and the Coromandel settlement sites data than they are to the roughing out experimental data and the Tahanga quarry data. This indicates, in turn, the existence of a quarry or quarries on Norfolk Island which have yet to be located.

These results are consistent with the basic strategy that underpins an adze technology based on the flaking of fine-grained materials. As outlined in detail by Turner and Bonica (1994), the strategy is based on reworking. Low adze production rates characterize a technology based on the flaking technique largely because of the high risk of breakage, which increases with adze size and the extent of flaking. Therefore time at the quarry has to be used carefully. Roughing out is fast and reduces the weight of the blank by up to 70%, but fine trimming requires greater care and time. By maximising the size of preforms at the quarry, adze makers could remove them before the high-risk fine trimming stage knowing many would break during this stage of manufacture but safe in the knowledge that from one large broken preform, several smaller ones could be made. In experiments, preform reworking had a higher success rate than primary adze manufacture. At all the New Zealand sites where adze production took place, reworking of broken preforms was a feature regardless of stone availability. Reworking was, instead, aimed at managing costs of time and effort. The presence of the distinctive preform reworking flakes and adze reworking flakes at Emily Bay provide additional evidence that this strategy was also in operation on Norfolk Island.

The frequencies of A, C and D flakes in the Emily Bay assemblage show the influence of reworking and flake modification, and are unlikely to indicate any deficiency in stone quality or flaking ability (Table 4). As can be seen in the experimental data for flake modification and reworking, these activities increase the frequency of these flake types probably due to a high incidence of flake breakage.

Table 2. Size categories of flakes (%) produced by experiments and from sites in Emily Bay and New Zealand.

		size categories				
	number	1+2	3	4	5	6
experiments						
roughing out	621	12.6	12.4	13.0	22.2	39.7
flake preform fine trimming	432	0	1.3	2.6	21.7	74.3
cobble preform fine trim	2677	0.1	0.5	1.1	13.4	84.7
edge straightening	50	0	0	0	7.0	93.0
reworking preforms	798	0.7	2.3	5.0	12.0	79.6
reworking adzes	66	0	0	0	0	100.0
sites						
Emily Bay NI	572	0	1.2	2.4	13.3	83.0
Tahanga Quarry NZ	4706	9.3	8.9	16.3	25.4	40.0
Whitianga NZ	24597	0.2	0.2	1.0	17.4	81.1
Hot Water Beach NZ	909	0	0.4	4.7	22.4	72.3
Hahei NZ	5022	0	0	0.6	8.1	91.2
Whitipirorua NZ	3435	0	0.3	1.1	17.1	81.0
Opoutere NZ	1309	0	1.1	3.0	14.0	81.7
Bowentown NZ	4186	0	0.5	1.1	17.4	80.8

Table 3. Dorsal surface characteristics (%) produced by experiments and from sites in Emily Bay and New Zealand. For number, see Table 2.

	CO	CP	CS	all cortex	OO	OP	OS
experiments							
flake roughing out	24.9	33.4	6.3	64.6	0	31.2	3.9
cobble roughing out	33.3	40.0	4.8	78.1	0	17.6	4.2
flake fine trimming	6.1	14.7	9.4	30.2	5.0	39.2	25.4
cobble fine trimming	1.6	4.6	7.9	14.1	0.8	16.7	68.1
edge straightening	1.0	6.0	3.0	10.0	0	21.0	69.0
reworking preforms	0	2.5	6.2	8.7	0.3	15.9	74.9
reworking adzes	0	0	0	0	0	30.2	69.7
sites							
Emily Bay NI	0.4	4.2	5.8	10.5	1.6	22.2	65.6
Tahanga Quarry NZ	23.0	23.3	2.1	48.4	10.2	32.3	9.0
Whitianga NZ	1.4	5.2	5.1	11.7	1.0	17.0	69.0
Hot Water Beach NZ	1.2	5.9	6.1	13.2	1.0	17.0	69.0
Hahei NZ	1.3	6.0	7.4	14.7	1.5	13.4	70.0
Whitipirorua NZ	2.4	6.2	7.1	15.7	2.2	15.6	66.2
Opoutere NZ	3.4	9.8	8.2	21.4	0.3	14.4	63.7
Bowentown NZ	1.2	5.1	9.8	16.1	0.7	10.3	72.6

Reworked preform flakes. There were eight reworked preform flakes in the Emily Bay assemblage of the "truncated blade" type indicating detachment from quadrangular Duff (1977) Type 1 adzes. In addition there were three "beaks" that may have been detached to form the bevel and blade of Duff (1977) Type 4A adzes. This evidence suggests a wider range of adze forms were made at Emily Bay than the preform/adze assemblage itself indicates. The range varies also by size. Other Duff (1977) types that are suggested by the preform pieces are Type 2 and possibly Type 3. All of these adze types, except Type 4 occur amongst the Norfolk Island surface finds of Polynesian type, which Specht (1984) labelled Group III (Anderson, Smith and White, this vol.).

Table 4. Distribution of flakes by category of shape and termination (%) produced by experiments and from sites in Emily Bay and New Zealand. For N, see Table 2. For category definitions, see text.

	A	B	C	D	E	F
experiments						
flake roughing out	21.3	31.3	2.1	3.5	16.7	25.0
cobble roughing out	22.6	37.3	10.1	3.4	9.2	17.3
flake fine trimming	14.6	49.1	2.1	1.5	11.0	21.6
cobble fine trimming	22.1	36.1	1.7	16.9	6.6	16.2
edge straightening	13.0	71.0	0	0	2.0	13.0
reworking preforms	30.9	30.0	6.3	5.4	18.1	10.1
reworking adzes	12.0	50.0	0	0	20.0	18.0
flake modification	27.9	18.3	11.4	14.6	18.8	8.7
sites						
Emily Bay NI	27.0	19.4	8.3	15.5	10.8	18.8
Tahanga Quarry NZ	13.2	44.6	14.1	4.4	7.8	15.8
Whitianga NZ	38.4	24.8	6.7	18.7	6.2	5.0
Hot Water Beach NZ	16.3	46.6	8.2	11.1	10.7	7.0
Hahei NZ	18.5	31.6	8.6	19.4	9.7	11.9
Whitipirorua NZ	22.7	53.4	0.6	1.2	12.2	9.8
Opoutere NZ	38.3	19.4	4.6	18.5	8.4	10.4
Bowentown NZ	39.5	21.7	7.5	11.0	9.5	10.5

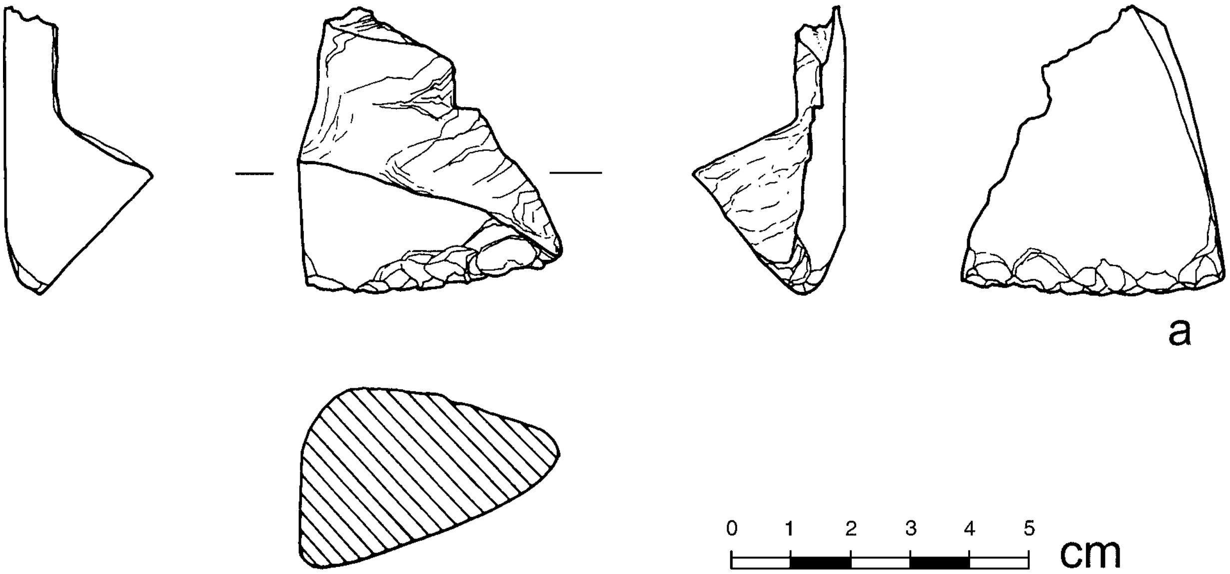

Figure 1. Blade and bevel section of broken adze; left, top, right view. a = base. NIPP 736.

Reworked adze flakes. Among the reworked adze flakes there were five flake pieces from finished adze blades that could be assigned to adze typology. These are more likely to be the product of reworking or blade rejuvenation than the result of damage during use. Two (NIPP 684 and 514) blade corners were from back-wider-than-front forms; one (NIPP 514) possibly from a hogback or Duff (1977) Type 4A adze, the other (NIPP 684) possibly from a Duff (1977) Type 2C adze. Another blade corner (NIPP 613) came from a front-wider-than-back form, possibly Type 1 or Type 2A. A large blade and bevel piece (NIPP 736, Fig. 1) from a Type 2A adze, displays a type of fracture that can occur during blade repair.

Modified flakes. Of the 572 flakes, 19.4% showed definite signs of modification for a range of different functions which included a variety of point tools, high-and low-angled edge use (e.g., NIPP 708, Fig. 2.5), saws and possible bruising and hammering implements (Table 5). One drillpoint was also identified. As in assemblages from New Zealand and elsewhere, flakes proved valuable for opportunistic use at Emily Bay. The toughness and sharpness of the basalt was useful when fine sharp edges were required for boring or pecking points. Most of the modified flakes are, however, broken or badly damaged, making precise identification of function difficult.

Table 5. Numbers of modified flakes from Emily Bay.

drillpoint	1
other points	36
high angled edge damage	19
low angled edge damage	17
saw	1
bruising/chopping damage	21
broken tool pieces	16
total	111

Adzes and preform analysis. There were five adze and nine preform pieces (Table 6). All but one were in a broken state. Among the adze pieces were two small "scrappy flake adzes" (SFA; e.g., NIPP 508, Fig. 2.4). These represent the only expedient adze form thus far known in Polynesian adze technology. That is, they were opportunistically made from a waste flake, and probably discarded after a short period of use. Unlike other adze forms, therefore, they can directly indicate that adze use took place on the site. The curated or unfinished nature of other forms can rarely indicate this.

There are three other pieces from finished adzes. All have seen reworking attempts that failed. One is a butt portion, which may have been rejected after failure to form a new bevel (NIPP 639, Fig. 3.1). Another piece from the bevel section of a quadrangular adze (Fig. 3.3) may have initially broken during blade repair—a very risky operation that can cause transverse fracture. Following this, the piece may have been reflaked for use as a hand-held tool. Reflaking down from the broken transverse fracture plane is evident on the broken gouge section; probably to thin it out for hafting, but this process had not been completed for some reason. NIPP 137 (Fig. 3.2) has been reflaked into a gouge.

Of the nine adze preforms, four (Fig. 4: NIPP 556, 757B, 641, 527) had been rejected, evidently after a reworking attempt that failed, although one was modified into a sturdy point and was probably used before final rejection. Another piece was used as a hammer. Four other pieces were probably too small and ill-shaped to rework (NIPP 757A, 507, 154: Fig. 2.1, 2.2, 2.3). Unusually for an assemblage of reject material, there is also one complete and quite well formed hogback gouge preform (NIPP 1001, Fig. 5). There is no obvious reason why it has not been finished. One possibility—a problem experienced in experimental adze making sessions—is that it may have been accidentally lost among the debitage.

Most of the preforms were derived from flake blanks and tended to be small to medium in size. A range of cross-section shapes is evident with bilateral and trilateral flaking observed. With reject preform pieces it is generally difficult to identify the type of adzes intended, especially when they have been further reshaped in a reworking attempt. It is

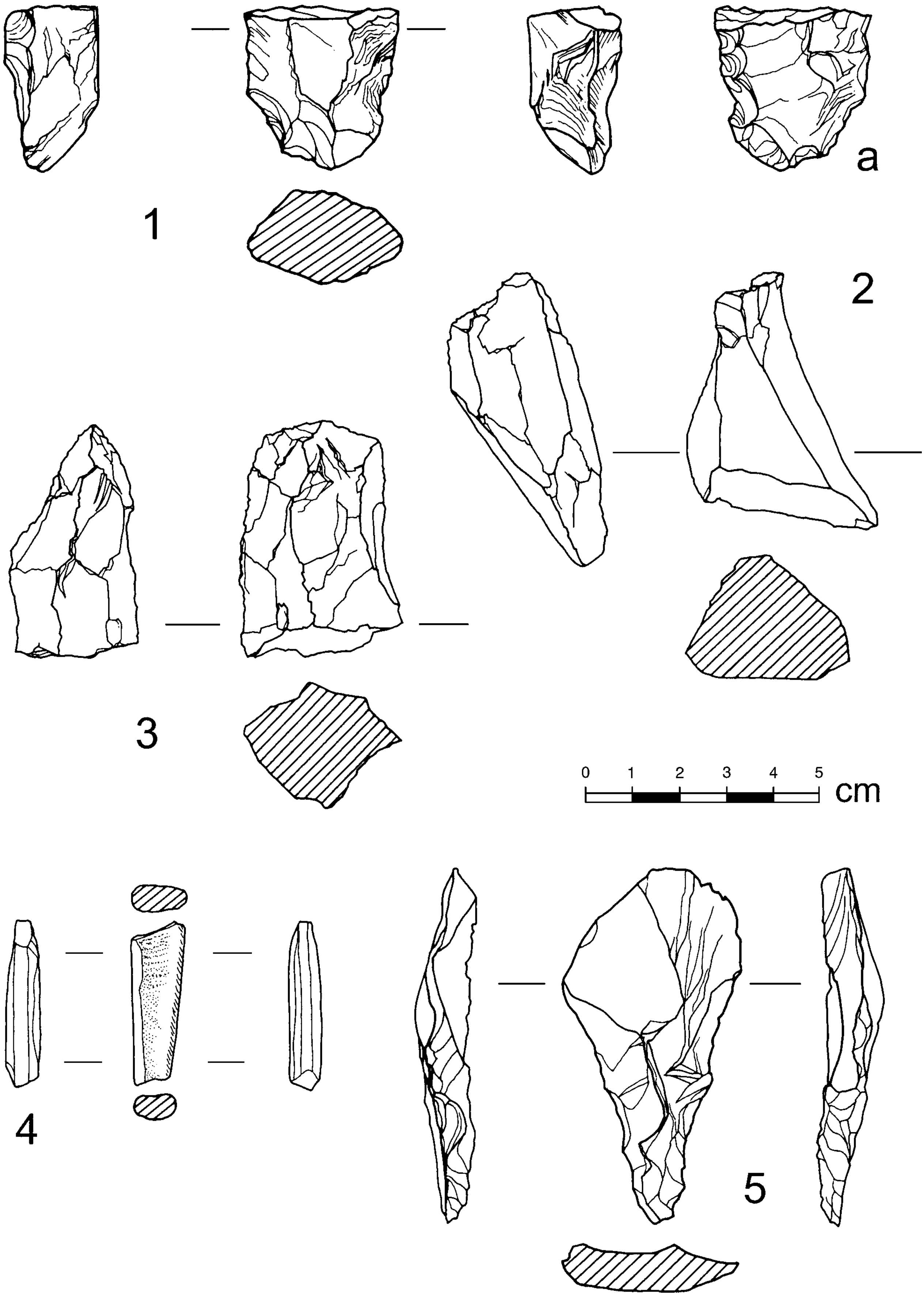

Figure 2. 1. Broken adze preform, butt end. Left, top, right views; a = base. NIPP 757A. 2. Broken adze preform, bevel end. NIPP 507. 3. Broken adze preform, bevel end. NIPP 154. 4. Ground basalt artefact, possibly trolling lure or pendant. NIPP 508. 5. Modified flake. NIPP 708.

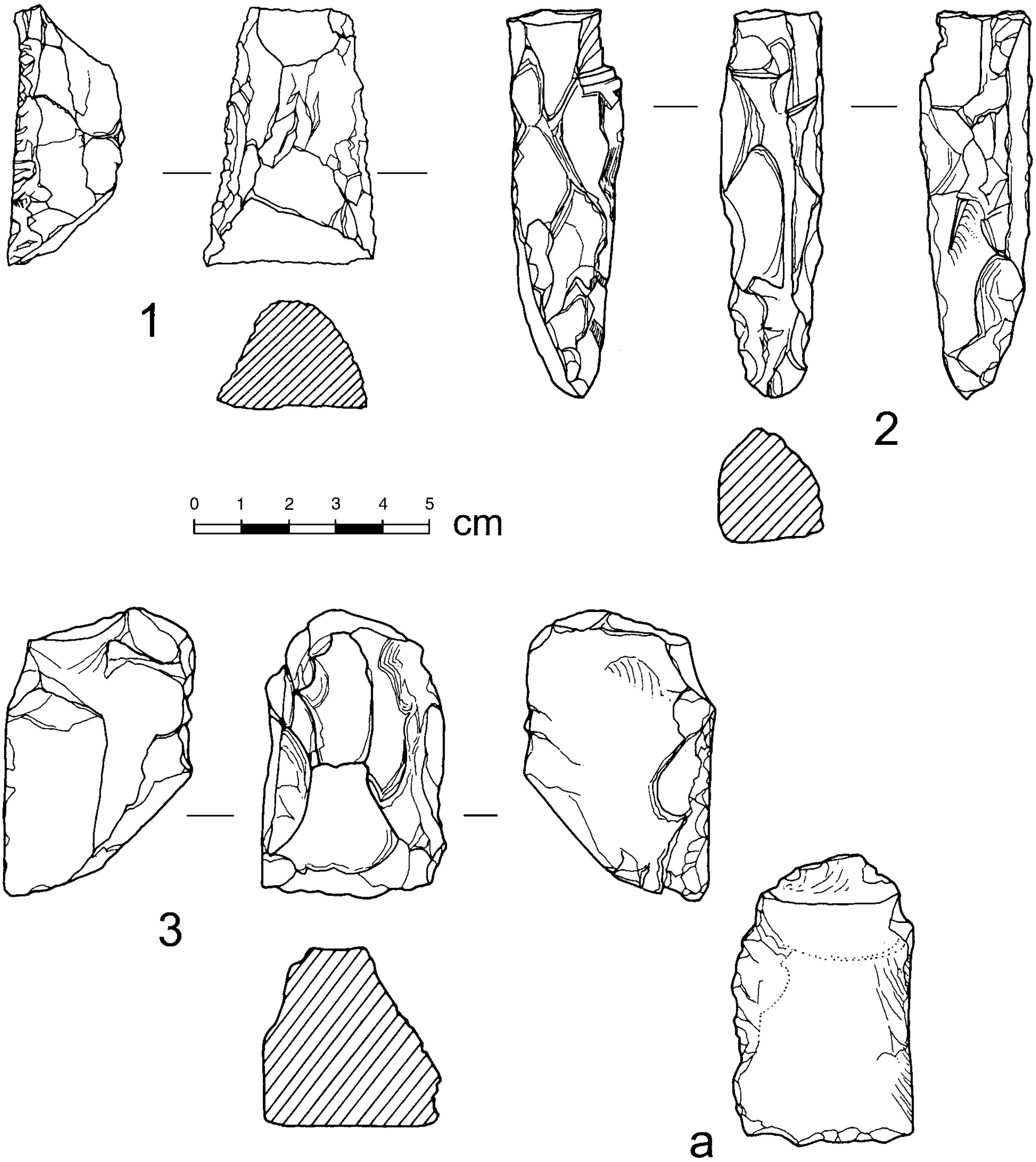

Figure 3. 1. Reworked adze. NIPP 639. 2. Bevel end of adze reflaked into gouge. NIPP 137. 3. Reworked adze, bevel end. a = base.

therefore to the adze flakes (above) that we must look for indications of the type of adzes that may have been successfully made and removed.

Spatial distribution. The majority of the material in this assemblage came from Trench EB97:23—61.3% of diagnostic flakes (Size 3–6) and 71% of the adzes and preforms (see Tables 6 and 7). A further 13.9% of diagnostic flakes and 14.2% of adzes and preforms came from Trench EB97:24. 12.4% of flakes came from Trench EB96:10 and 9.0% from Trench EB96:11. The remaining 1.3% of flakes came from Trenches EB95:01, EB95:02 and EB97:22 (N=18 diagnostic flakes—too small to be considered as separate samples in Table 7). Two other preforms came from Trench EB96:11 and EB97:21 respectively (see Table 6).

It is clear from Table 7 that all adze related processes were occurring in each of the four trenches. While there are no major differences, preform and adze reworking, as well as flake modification were more common activities in Trench EB96:11, as indicated by higher frequencies of “OS” and Size 7 and 6 flakes. Trench EB97:24 also has a slightly higher frequency of preform reworking again accompanied by higher frequencies of “OS” and Size 7 flakes.

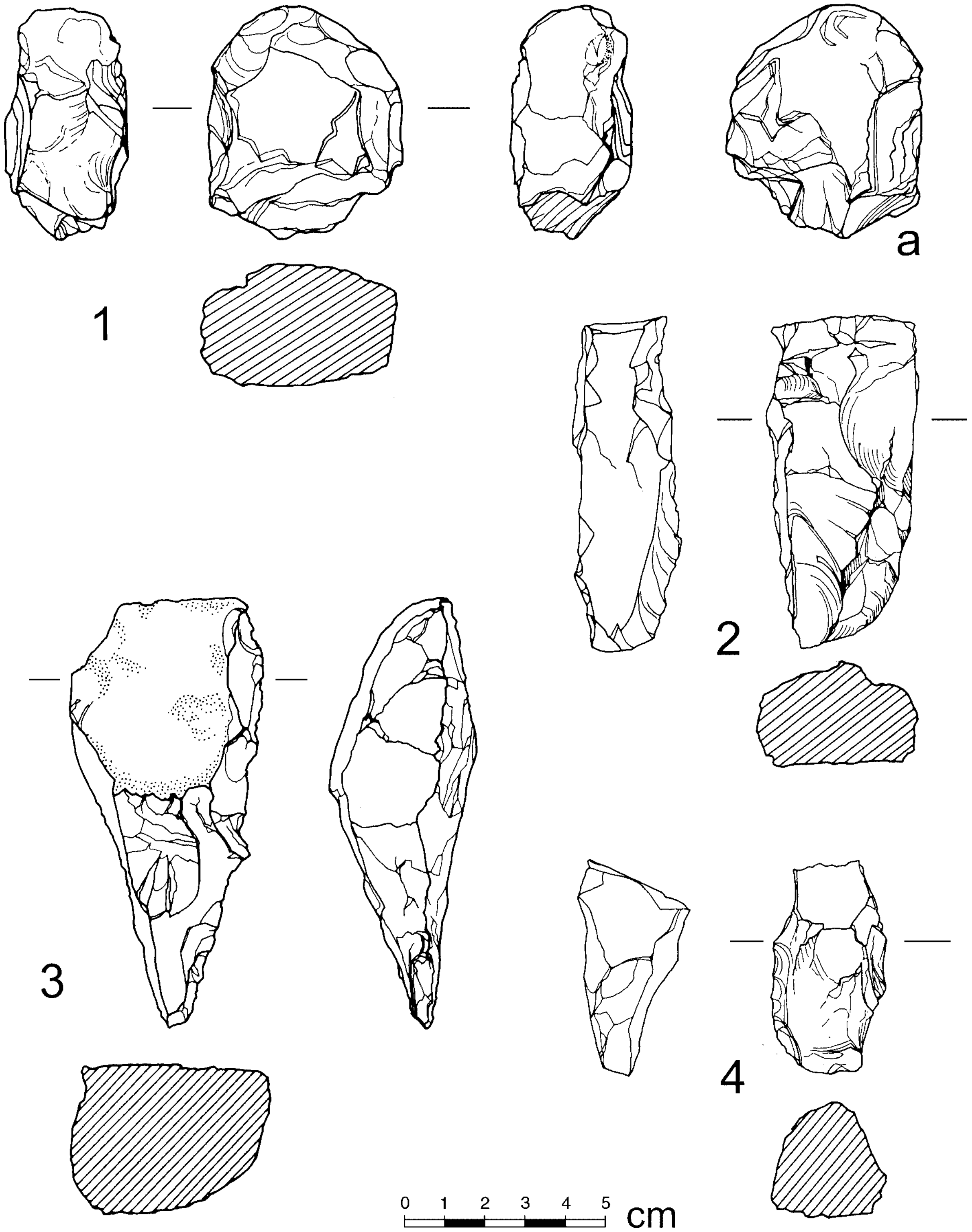

Figure 4. 1. Reworked preform. Left, top, right views; a = base. NIPP757B. 2. Reworked preform. NIPP 641. 3. Reworked preform. NIPP 556 (also used subsequently, see Usewear section). 4. Reworked preform. NIPP 527.

Other material. A single ground basalt artefact (NIPP 508) was recovered from Trench EB97:23, Square B7, spit 3. It was possibly part of a pendant, or perhaps a shank from a trolling lure. It measures 5.4 mm. long, 11.6 mm. wide and 5.5 mm broad. The piece tapers from one end and has been shaped by grinding (Fig. 2.4).

There were numerous pieces from water-rolled andesitic pebbles found among the flake material, but on close inspection, there was no evidence that any of these had been used as hammerstones. Rather the fire damage identified on many pieces suggests their use as oven stones. Two small pieces of sandstone (NIPP 553 and 568) may have come from larger stones used to grind adzes and other items. One piece (NIPP 568) had a ground concave surface.

Table 6. Preforms and adzes from Emily Bay. diag: diagonal; Gr rem: grinding remnant; ND: not identifiable; PF: preform; quad: quadrangular (close to square in section); rec: rectangular (sides < half width); RWA: reworked adze; RWPF: reworked preform; SFA: scrappy flake adzes; TF: transverse fracture; tri: triangular. All lengths in millimetres, all weights in grams.

NIPP	trench	sq.	layer/ spit	artefact	state	cross-section	wgt	lgth	blade max.	width min.	thick	blank type	other data	Fig.
672	EB97:23	H2	Sp 2	SFA	damaged	rec	20	57	18	12	12	flake	chipped blade	
154	EB96:11	A2	L2/Sp3	PF	bevel end	tri	50	47	30	25	26	ND	“gouge, trilat flaking”	2.3
1001	EB97:21	Z1	Sp 1	4A PF	complete	tri	240	165	30	13	37	flake	“cortex, trilat flaking”	5
507	EB97:23	B7	Sp 2	PF	part bevel	rec	40	49	38	6	24	flake	“cortex, diag TF”	2.2
556	EB97:23	D11	Sp 2	RWPF	bevel end	quad	180	105	45	7	35	flake?	“cortex, mod point”	4.3
527	EB97:23	C13	Sp 1	RWPF	bevel end	irregular	40	50	24	21	26	ND	“gouge, trilat flaking”	4.4
508	EB97:23	B7	Sp 3	SFA	mid-sec	round rec	5	35	10	8	6	flake?	chisel? v.small	2.4
641	EB97:23	F10	Sp 7	RWPF	butt end	rec	100	81	35	22	24	flake?	rough reflaking	4.2
555	EB97:23	D11	Sp 1	PF	butt end	lenticular	55	39	41	31	35	ND	Type 3?	
639	EB97:23	F10	Sp 5	RWA?	butt end	sub-tri	50	54	35	24	22	flake	“rough, new bevel?”	3.1
137	EB97:23	B7	Sp 3	RWA	bevel end	tri	56	80	20	11	23	ND	reflaked gouge	3.2
0	EB97:23	D12	Sp 1	RWA	bevel end	quad	131	60	37	32	39	ND	reflaked	3.3
757A	EB97:24	Z4	Sp 1	PF	butt end	lenticular	25	34	32	23	19	ND	poss RW?—Gr rem	2.1
757B	EB97:24	Z4	Sp 1	RWPF	butt end	rec	113	55	47	31	29	ND	reuse as hammer	4.1

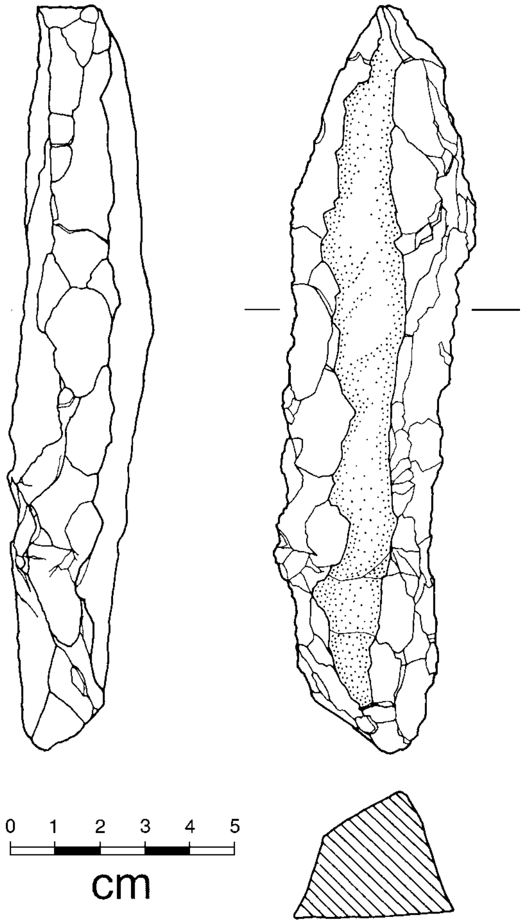

Figure 5. Gouge preform. NIPP 1001.

Table 7. Spatial distribution of basalt flake characteristics in Emily Bay trenches studied. Number (N) as indicated, otherwise data given as percentage.

	all	EB96:10	EB96:11	EB97:23	EB97:24
N	3178	282	527	1408	925
N (size 3–6 only)	572	71	52	351	80
stages					
adze manufacture	63.2	63.5	54	64.5	60.0
preform reworking	18.8	22.5	23	18.3	25.0
adze reworking	17.9	14.0	23	17.2	15.0
modifications					
modified flakes	19.4	12.6	25.0	19.2	20.2
OS fine trimming	65.6	58.4	76.6	65.5	78.0
cortical flakes	10.5	9.1	8.5	10.9	3.7
size category					
7	78.2	74.8	90.1	75.2	86.4
size 3–6 only					
6	83.0	85.9	88.4	82.2	82.5
5	13.3	14.0	9.6	13.5	15.0
3+4	3.6	0	1.9	4.3	2.5
flake category					
A	27.0	32.3	20.7	26.8	19.0
B	19.4	15.4	16.9	20.4	25.3
C	8.3	8.4	7.5	8.6	8.8
D	15.5	11.2	11.3	17.0	15.1
E	10.8	14.1	13.2	9.5	17.7
F	18.8	18.3	30.1	17.5	13.9

Conclusions. Analysis of the basalt assemblage from the Emily Bay archaeological site shows that it was primarily being used for adze manufacture. Flake analysis shows that adze stone was quarried elsewhere and roughing out did not occur on site. Preforms were brought to the site and finishing off occurred there. The flakes, preforms and broken adzes show that Duff (1977) Types 1, 2, 3 and 4 were all made on site. Unique to Polynesia are two small adzes, expediently made on waste flakes. Some broken pieces and preforms have been re-worked into other artefacts, demonstrating further expedient use of the material.

Source characterization of stone

As described in Anderson *et al*. (1997) a sample of the basalt flakes was subjected to non-destructive, energy-dispersive XRF analysis which indicates that there was local adze production, not merely refurbishment, on Norfolk Island. This suggests the quarry and reduction sites might yet be discovered. A collection of obsidian flakes, including one blade section from Trench EB96:11, was made during excavations at Emily Bay. Twenty-four were recovered from the paving feature in Trench EB97:24 (Anderson, Smith and White, this vol.). Distinctive characteristics were visible in hand specimen, confirmed by analysis of major element oxides plus PIXE/PIGME analysis of trace elements (Anderson *et al*., 1997), all but one of the specimens (N = 26) are from Raoul Island. The non-Raoul Island piece, from Spit 4 of Square E12 in Trench EB97:23 was in a high-quality, translucent green obsidian which has a specific gravity and major elements profile consistent with the Mayor Island source (New Zealand), according to Ambrose (pers. comm.). However, the trace element analysis by PIXE/PIGME and NAA contains some anomalous data, and the origin of this piece remains in question (F. Leach, pers. comm.).

Usewear and residue analyses

The excavators selected 15 artefacts (10 basalt and 5 obsidian) from the Emily Bay settlement site for the study of functional traces. They were selected because they appeared to have macroscopic indications of use. The methods and results of a microscopic analysis are described here. Macroscopic and microscopic forms of usewear and residues were recorded. General aspects of lithic technology are also discussed.

Methods and laboratory procedures. Artefacts were handled during excavation, and gloves were not worn in the laboratory. However, adhering sediment protected surfaces and residues and the artefact edges appear to be in good condition, with few contaminant fibres and rare traces of metal.

All artefacts came from sandy dune deposits and some fine-grained sediment remains attached to the artefacts. Artefacts were not cleaned because residues could have survived in the adhering sediment which may provide an opportunity for future quantitative study of certain plant structures (eg phytoliths and starch grains). Evidence presented elsewhere (Anderson, Smith and White, this vol.) indicates that the cultural layer from which these artefacts came is not greatly disturbed.

Two kinds of microscope were used: a stereomicroscope with external oblique lighting (Zeiss model, with a magnification range of ×10 to ×100); and a metallographic microscope with vertical incident lighting, bright-field, dark-field, cross polarising attachments (Olympus model, with a magnification range of ×100, ×200, ×500, ×1,000).

Analysis of the artefacts is based on recognition of the following main forms of usewear: scars, striations, rounding, polishes, and bevels. The length and termination (step, feather, hinge, bending) of scars were noted. The direction and location of striations were recorded. Rounding was recorded in terms of qualitative assessment (low, medium and high) based on my replicative experiments for similar raw materials. Polish was categorized within five stages of development and surface features, which can be distinctive of particular materials given other traces of use (Fullagar, 1991). Bevels or asymmetrical, level bands of smoothing along edges were not observed in this collection.

Other variables recorded were (see Table 8): NIPP No.: unique identification number, assigned by excavators; trench, square and spit number within cultural layer, assigned by excavators; stone: class of stone material, assigned by excavators; weight (g): measured on electronic balance, by RF; type: a technological category, assigned by RF to include core, flake, fragment or morphological type (eg adze); grinding: manufacturing traces of grinding caused by stone rubbing on stone; use status: derived from study of main forms of usewear (see above); cortex: percentage of weathered surfaces (% dorsal flake surface or % whole surface of a flaked piece (a fragment which could not be oriented) or an implement type such as an adze); BL mm: (block length) maximum length of smallest rectangle into which piece could fit; BW mm: (block width) maximum width of smallest rectangle into which piece could fit; BTH mm: (block thickness) maximum thickness; block length×block width×block thickness provides a rough estimate of the volume of the flaked piece. Block length×block width provides an estimate of surface area for ventral or dorsal surfaces; platform: indicates the presence of a measurable striking platform; AL mm: (axial length) maximum length from point of impact to distal end of flake on ventral surface; AW mm: (axial width) maximum width of flake at right angles to axial length; ATH mm: (axial thickness) maximum thickness of flake at right angle to axial length and width; PL mm: platform length; PW mm: platform width from point of impact to dorsal surface at right angles to ventral surface.

The above descriptive technological features were recorded in order to provide a basis for comparing the nature of flake production with other archaeological collections, although no such comparison is attempted here.

Results. Results are given in Table 8 and four representative artefacts are illustrated in Fig. 6. All but one (NIPP 166ii) of the 10 basalt artefacts had clear traces of use. One artefact (NIPP 672) had been ground on various surfaces to produce a small implement with clearly developed polish at the wider end, and impacted fibres from woodworking. Rounding on high ridges which were not ground, and the distribution of less developed polish suggest the implement was hafted in a wooden handle. Eight other basalt pieces had traces of use. Polish on the edge of NIPP 556 can be seen in Fig. 7. Artefact NIPP 588 is almost entirely pecked and ground on the dorsal surface, and the concave cortex surface indicates that it was probably struck from an adze with a raised back. The distal end shows traces of subsequent use in the form of scarring, although the material worked in this instance could not be determined.

Grinding as an edge sharpening technique occurs on three utilized flakes (NIPP 70, 153, 642). Usewear is also present in the form of scars and polish, not well developed but distinct from stone grinding. Artefact NIPP 70 has a small patch of grinding in the centre of the ventral surface, and

Table 8. Basalt and obsidian artefacts from the Emily Bay archaeological site analysed for usewear and residues. For definitions of column headings, see text.

NIPP no.	trench	square	spit	weight (g)	type	grinding	use status	cortex (%)	BL (mm)	BW (mm)	BTH	AL	AW	platform	PL	PW
basalt																
68	EB95:06	square A2	spit 2	42.2	flake	absent	used	0	64	44	21	64	44	P	21	12
69	EB95:06	square A4	spit 2	67.3	broken flake	absent	used	10	71	44	18	25	59	P	51	11
70	EB95:06	square A4	spit 3	75.9	split flake	present	used	10	65	61	20	61	65	—	—	—
153	EB96:11	square B1	slumped	56.6	flake	present	used	0	113	46	15	113	46	P	8	crush
166i	EB96:11	square B1	spit 3	51.6	flake	absent	used	40	69	57	13	49	56	P	22	10
166ii	EB96:11	square B1	spit 3	33.1	flake	absent	not used	50	60	38	12	38	60	P	32	7
556	EB97:23	square D11	spit 2	37.9	?biface frag/ split flake	absent	used	0	60	36	18	—	—	A	—	—
588	EB97:23	square E10	spit 4	67.9	flake	present/ recycled adze	prob	0	106	41	13	38	106	P	18	5
642	EB97:23	square F11	spit 1	164.7	split flake	present	used	0	118	58	22	—	—	P	35	19
672	EB97:23	square H2	spit 2	24.1	adze	present	used	0	58	22	12	—	—	A	—	—
obsidian																
595	EB96:11	square A1	spit 3	7.1	flake	absent	poss	0	38	23	11	31	23	P	22	11
701	EB97:24	square A5	spit 2	10.1	flake	absent	poss	0	37	27	13	37	27	P	8	9
723	EB97:24	square B3	spit 2	4.2	fragment	absent	prob	0	25	22	10	—	—	A	—	—
761i		T24:Z6:3		1.9	flake	absent	not used	0	24	13	6	13	24	P	6	5
761ii		T24:Z6:3		0.2	fragment	absent	not used	0	13	8	4	—	—	A	—	—

pitting which may be a result of earlier use as a hammerstone, before this flake was struck off. The other two artefacts (NIPP 642, 153) with ground edges are large blade-like flakes.

Although the precise materials worked could not be identified, plant tissues in association with usewear is common. Starch grains are present on basalt artefacts NIPP 68, 69 (see Fig. 8), 556 and on obsidian artefact NIPP 723. All starch grains observed are small, about one micron and less in diameter. The adhering sediment probably obscures starch grains on these and other artefacts. Further analyses of starch grains by quantitative methods (e.g., Loy, 1994; Loy *et al*., 1992; Therin, 1998) is justified. The origin of the starch grains and the identification of the species of plants that were processed may be further assessed by removal and more detailed study of residues in conjunction with usewear on cleaned artefact surfaces (e.g., Kealhofer *et al*., 1999).

Three obsidian flakes and a fragment (flaked piece that could not be oriented: no distinct ventral surface or direction of blow) were bagged separately. One of the flakes (NIPP 761) had broken in the bag, making an extra, fifth, fragment which was also examined. So, altogether five pieces were examined, and none had clear retouch or other evidence of deliberate edge modification, or formal design.

Artefact NIPP 761 and the broken fragment in the same bag had no traces of use. Artefact NIPP 595 had traces of use (scarring, slight rounding and plant fibres) indicating possible use on soft non-siliceous, plant tissue and artefact NIPP 701 had scarring on a relatively unstable edge indicative of possible use on some soft material. Artefact NIPP 723 had traces (scarring, rounding and starch grain residues) indicating probable use on soft, non-siliceous, starchy plant tissue.

Discussion and conclusions

I presume that the relatively high frequency of use in this small collection of basalt and obsidian artefacts is a consequence of prior selection with a view to picking artefacts with likely macroscopic indications of use.

The study of 10 basalt artefacts from the Norfolk Island excavations indicates that their main function was to process wood and other plant materials. Utilized edges of the basalt artefacts also indicate light-duty wood or other plant processing. There is no evidence of processing animal tissue.

Some edges were sharpened by hard hammer retouch, and others by partial edge grinding. The partial grinding of some flake margins to create a suitably sharp edge may have been a deliberate strategy, employed in preference to hard hammer flaking (which could have been wasteful of scarce stone and unsuitable for the tasks at hand). On the other hand, flaking invariably produces a sharper edge than grinding, suggesting that the Norfolk Island ground flake edges were produced for some kind of plant processing which did not necessarily need such a sharp edge. One possibility is an implement, perhaps hafted, for the processing of plant material for basketry or clothing, a possible function of at least some polished flakes from northern Australia (heavily rounded but not ground) which also explains their usewear and residues (see Akerman, 1998). The possibly introduced flax on Norfolk Island may have been involved (Macphail, Hope and Anderson, this vol.) but further research would be required to test this.

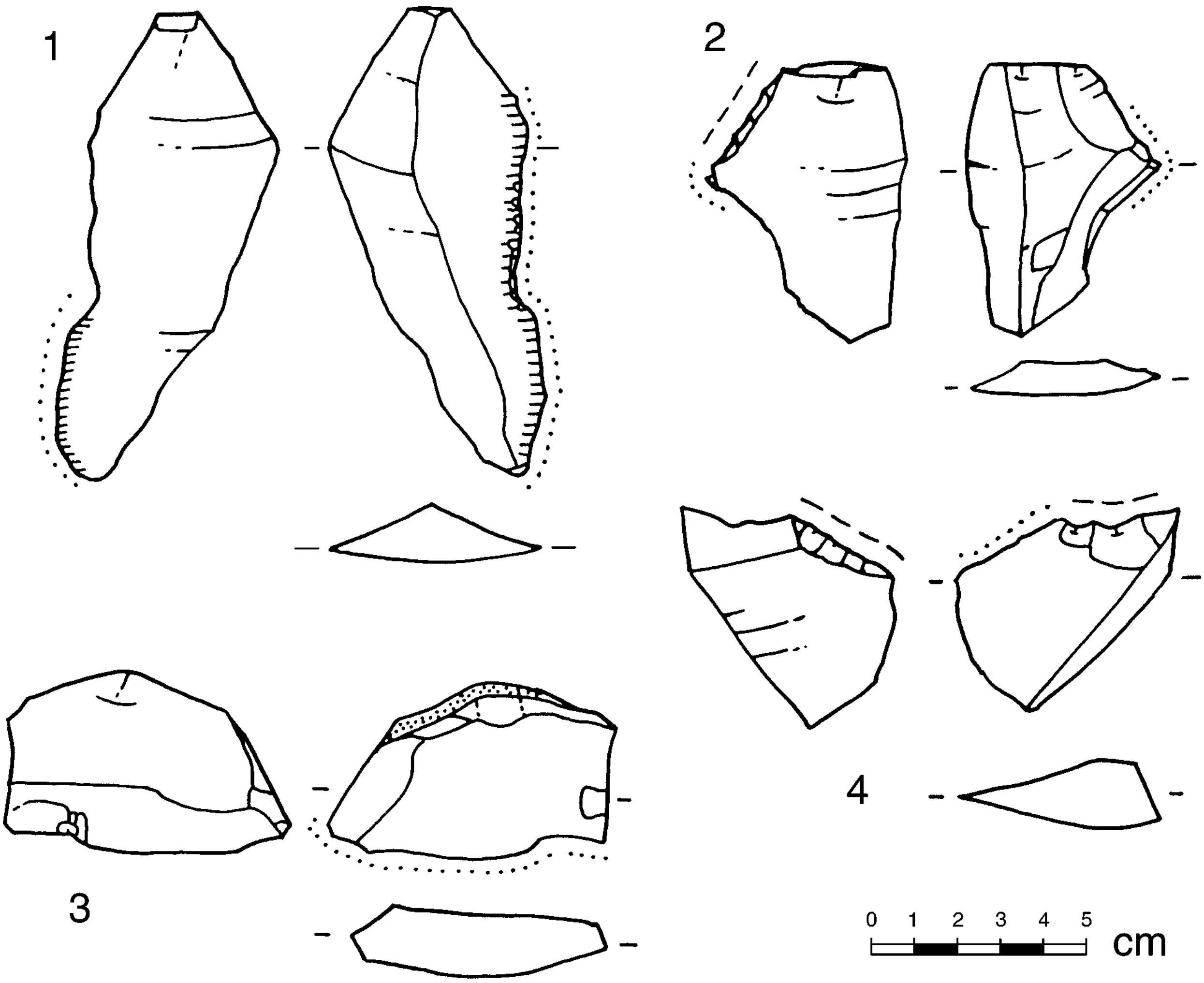

Figure 6. Artefacts with usewear. 1: NIPP 68; 2: NIPP 153; 3: NIPP 69; 4: NIPP 556. Dashed line indicates retouch (68, 556), dotted line indicates polish (all), close short lines at right angle to edge show striations (153). Dotted area of artefact indicates cortex. Scale bar 10 mm.

The excavated assemblage contained one small complete adze (NIPP 672) while the large flake NIPP 588 came from an adze. Design features and wear traces suggest basalt adzes were hafted while other flake implements were probably hand-held.

Indications of conservation of raw material include recycling of a hammerstone (NIPP 70) and adze (NIPP 588) into new tools. Further study of the whole assemblage may shed more light on technological strategies.

Basalt flakes include several decortication flakes (NIPP 69, 166i, 166ii, 642), some from cores more than 10 cm diameter. It is possible that these and others (NIPP 68, 556) are by-products of large adze production, and were selected for use from the adze production locality (if it were not at Emily Bay itself).

The study of five obsidian artefacts from Norfolk Island has provided little detail of function other than to identify that a few were probably used. There are no obsidian cores in the analysed collection and no flakes or fragments that show any signs of intensive use, in contrast with the more developed wear patterns on basalt artefacts. This probably relates in part to functional differences in the utilization of basalt and obsidian implements, as a consequence of the vastly different properties (hardness and fracture toughness) of these raw materials. However, there are too few pieces of obsidian to reliably reconstruct flaking strategies. In fact, all pieces may have come from a single small amorphous core or other implement.

The absence of distinctive animal tissue on any of the artefacts may simply be a consequence of the particular taphonomic conditions in open, exposed, sandy deposits. On the other hand, the absence may be real. Other studies have demonstrated differences in obsidian technology for various regions of the western Pacific. For example, ethnography in the West New Britain area (Specht, 1981) suggests the recent use of flaked obsidian was for surgery and other activities related to the human body. Barton and White (1993) in New Ireland as well as Specht and Fullagar (1988) suggested yams and other tubers were also often processed with obsidian, but that manufactured glass may have replaced it for this task since initial European contact (Fullagar *et al.*, 1998). Other research also indicates that flaked stone was used differently in prehistoric and more recent times (Brass, 1998).

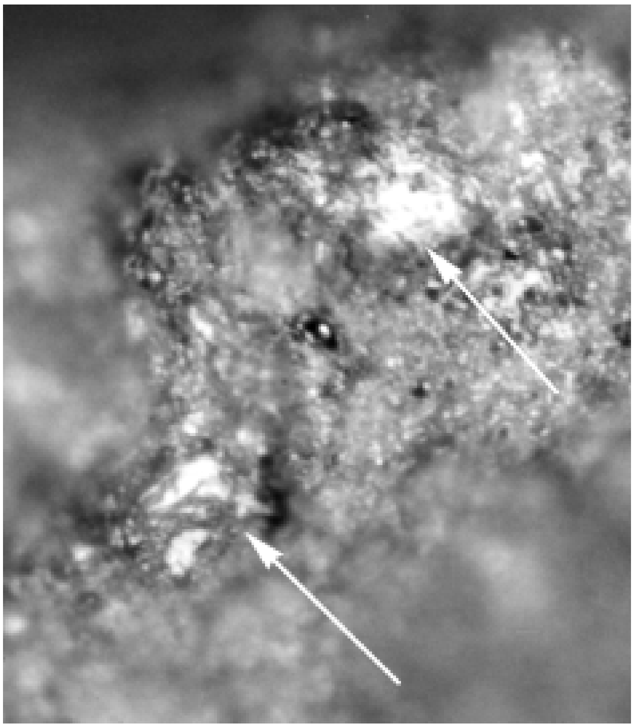

Figure 7. NIPP 556. Patches of smooth polished surface (arrowed white areas). Objective magnification ×50. Photo width 0.1 mm.

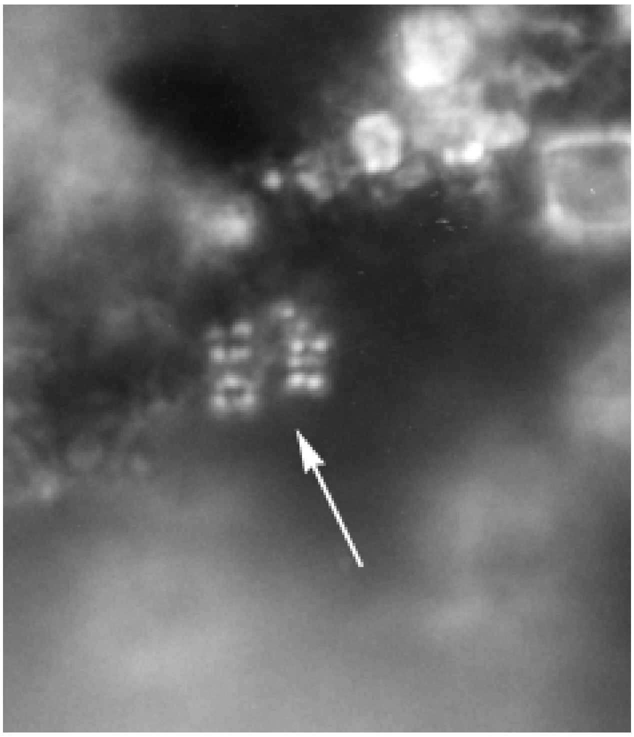

Figure 8. NIPP 69. Cluster of starch granules with dark extinction crosses under polarised light on a pointed end of the artefact. Objective magnification ×80. Starch granule diameter c. 2.5 µm.

ACKNOWLEDGMENTS. Judith Field took the digital photographs. Peter White authorized use of the Archaeological Materials Laboratory, University of Sydney. Dan Witter discussed aspects of ground edges on flaked implements, and their occurrence in Australia and New Zealand.

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Shell and Bone Artefacts from the Emily Bay Settlement Site, Norfolk Island

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ABSTRACT. Amongst molluscan shell from the Emily Bay site were 40 specimens of fragmented bivalves, especially of *Gari livida*, which were examined for evidence of their use as artefacts. Experiments using modern specimens of the same taxa showed that it was impossible to define deliberate breakage sufficiently clearly to define shell tools on that criterion. Analysis of usewear by microscopic inspection of edges was the main discriminant adopted. In addition vegetable residues were identified on several edges. These means identified 19 pieces as tools, which had been used mainly for scraping soft materials. Two other tools were identified by morphology. A small assemblage of bone and marine ivory artefacts was also recovered from Emily Bay. Most were pieces of fishing gear.

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Shell artefacts

The shell artefacts referred to here are not of the formal kinds found throughout Oceania (Poulsen, 1970), but rather informal, flaked shell pieces. Fragments of worked shell appear in Pacific sites from early Lapita in the west (Spriggs, 1991; Kirch, 1987) to late sites in the east (Kirch, 1989), thus possessing a very wide geographic and temporal distribution. However, they have been considered to yield no information about cultural sequences and so little time has been devoted to their analysis. They have been described variously as worked shell, shell fragments, shell scrapers or shell knife fragments. Smith (1999: 284) notes that no direct relationship between usewear and residues has been established for any of these artefacts. This paper attempts to address this issue by an examination of usewear and residues on the worked edges. No signs of deliberate modification or use were observed on any gastropod shell recovered from the site at Emily Bay. In contrast, all of the bivalve shell (40 pieces) was highly fragmented, often in ways which suggested deliberate human modification. In order to cast some light on the processes which might have been involved in shell modification at the site, experimental breakage was conducted with material from the same molluscan species, and the archaeological specimens were examined microscopically for edge wear and residues.

Shell breakage experiments. Breakage pattern experiments were carried out on modern specimens of the main bivalves in the Emily Bay assemblage, *Gari livida*, *Pinctada maculata* and *Mactra rufescens*. The experiments aimed to simulate the two main processes other than deliberate modification likely to have affected the shells. These are impact breaks and trampling. Impact breaks may have been caused either by meat extraction or shell discard processes, or by subsequent natural forces, such as storm damage. Secondly, there is the post-depositional effect of trampling over the site. Twenty bivalves were included in the breakage experiments (dropping shells onto a hard floor) and in experimental trampling. An additional five shells were snapped between thumb and forefinger to replicate deliberate breakage to form a clean working edge.

These experiments produced breakage patterns similar to those in the Emily Bay assemblage. Deliberate snapping between thumb and forefinger resulted in fracturing that could not be differentiated from that caused by discard throws (impact) or smashing to extract meat. Both snapping and impact forms of modification resulted in a segment retaining some portion of the original valve edge with a sharp internal edge (Fig. 1). Edges were very angular and sharp in *G. livida* and *M. rufescens* due to the tendency in these species for the material to split along cleavage planes in the shell structure. Without any further modification a very sharp working edge is thereby obtained. Previous shell flaking experiments (Cleghorn, 1977) had demonstrated that initial breakage of shell produced pieces that exhibited sharp cutting edges needing no further modification, and that flake removals were unpredictable according to planes of weakness within the shell matrix. Both these findings were confirmed in our study.

Application of weight by crushing or trampling resulted either in shells with the valve intact but flakes removed along the margins, or a clean, lateral break separating the inferior and superior portions of the valve. These distinctive patterns are also illustrated in Fig. 1.

While these experiments produced all of the shell modification features apparent in the archaeological assemblage, it was not possible to distinguish clearly between the agencies in any particular case. Sharp working edges result from all agencies and it is not possible to demonstrate that deliberate breakage aimed at producing a working edge was responsible in most cases. Abrasion along edges is also not diagnostic as it might occur through the action of wind or water and sand. The only valves that can definitely be classed as tools are those that contain retouch and/or usewear other than slight abrasion along their margins. These experimental results conform with those found in earlier work (Spennemann, 1993: 80) on *Anadara* shell when the different strength of the shell structure for the species involved is taken into consideration.

Usewear analysis. Usewear on shell artefacts has been studied on a number of occasions (Attenbrow *et al*., 1998; Barton and White, 1993; Cleghorn, 1977; Cooper, 1988; Fullagar, 1986; Fullagar *et al*., 1992; Kamminga, 1982;

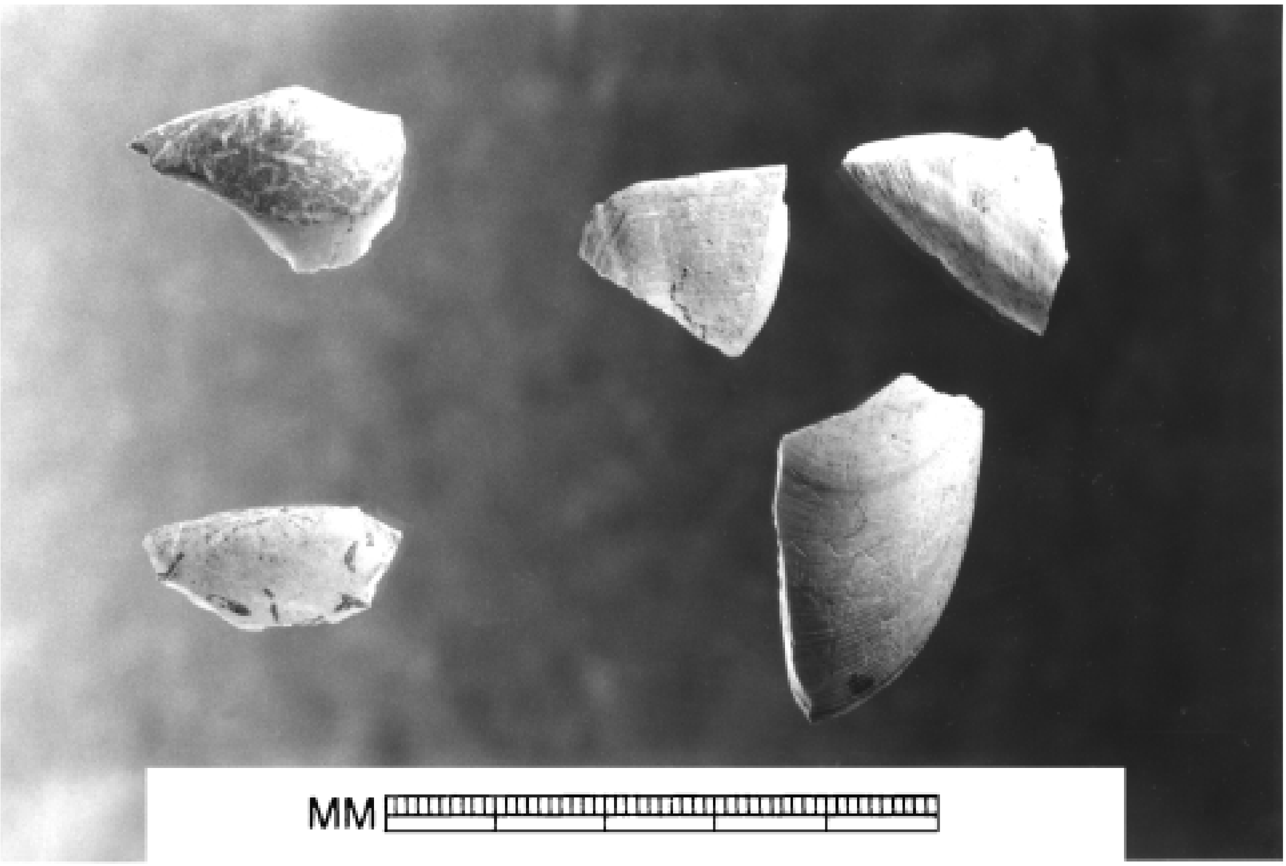

Figure 1. Shell breakage patterns. Examples (left) show typical damage from trampling in which the hinge remains intact and flakes are removed around much of the periphery. Examples (right) show typical snap patterns in which there are long, clean breaks and a portion of the valve edge remaining.

Spennemann, 1993; Toth and Woods, 1989). However, there has been relatively little systematic experimentation with shell and the interpretation of wear patterns can only be tentative until a more extensive range of studies is undertaken. In addition it is rare in archaeological reports for small, informal shell tool types to be recorded (Janetski, 1976; Lima *et al*., 1986; Reiger, 1981; Schrire, 1982). In reports where these tools are pictured they appear similar to the modified shell pieces recovered from Norfolk Island (e.g., Lima *et al*., 1986).

A search for both macroscopic and microscopic usewear was carried out on the shell artefacts from the Emily Bay site. Wear was defined as consisting of edge fracturing, striations and edge dulling or rounding, as defined by Kamminga (1982). These criteria were used to establish use, along with deliberate modification by flaking of an edge. Barton and White (1993) found that fractures on a shell matrix did not possess the clear characteristics of feather, snap and step fractures found on stone. A further complication results from the findings that edge rounding and striations have also been found to be the result of wave action (Spennemann, 1993; Claasen, 1998; Toth and Woods, 1989).

Analysis of the archaeological assemblage. All of the 40 pieces which appeared to have been artefacts were examined macroscopically and in magnifications up to about ×50 using a Zeiss stereomicroscope. Since it is not possible to distinguish deliberate from natural processes in breakage, the presence of usewear or retouch were required to class a specimen as a shell tool. Three artefacts had been formed by quite deliberate flaking and grinding irrespective of additional evidence of use. These atypical artefacts are pictured in Fig. 2.

Any artefacts that exhibited usewear traces were then examined at magnifications up to ×500, using an Olympus metallographic microscope with vertical incident light. Sketches and observations of usewear were recorded for each shell. A combination of diagnostic use traces is necessary to distinguish usewear because of the impact of weathering on shell, which is more vulnerable than stone. Interpretations of shell artefacts as utilized tools have been classified into four levels of confidence dependent on the incidence of diagnostic traces and their combination with unstable thin edges which are prone to incidental damage:

0 possible use: shaping but no wear traces
1 possible use: rounding and scarring in combination with weathered or unstable edges
2 probable use: rounding and scarring
3 definite use: clear distinctive usewear

Following the usewear analysis, edges that showed use traces were examined for residue analysis. Survival of residues is uncommon in the archaeological assemblage. Films and fragments of unidentified plant tissue are present and starch grains were identified on two of the shell edges.

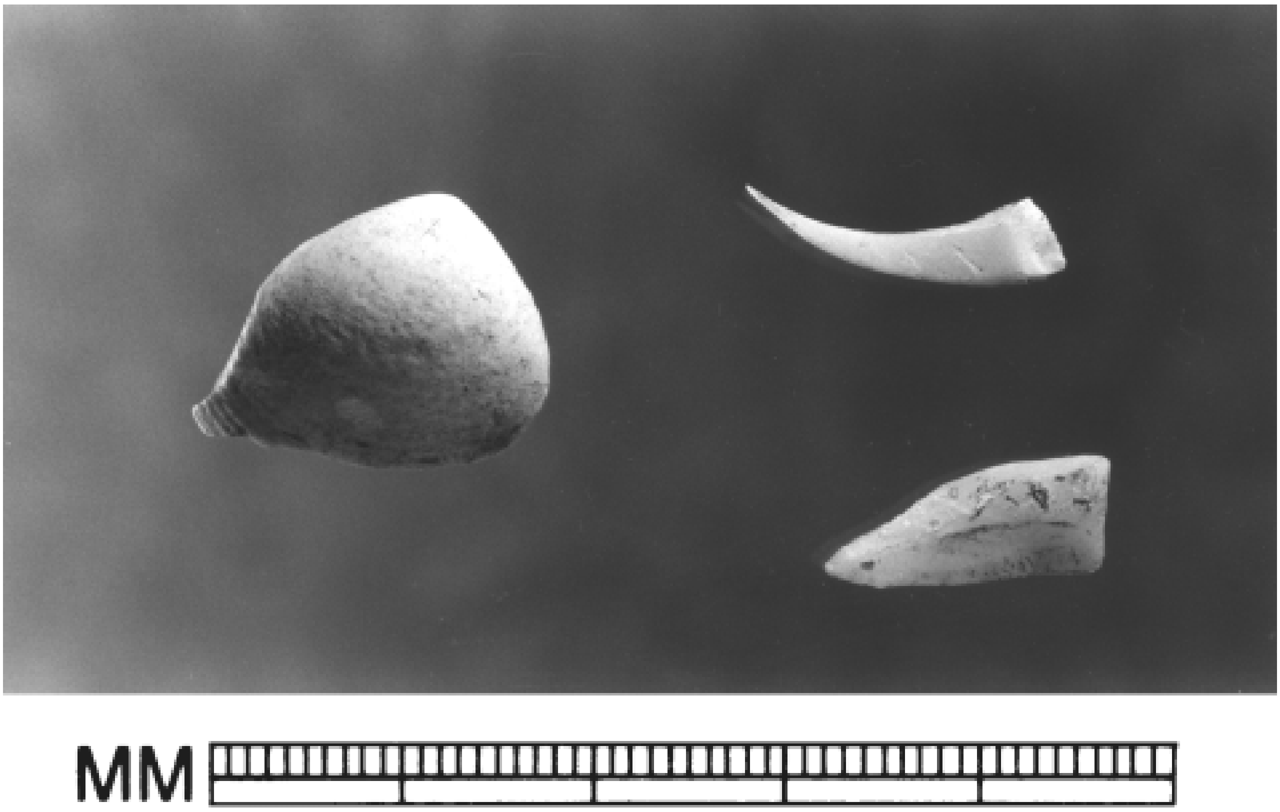

Figure 2. Atypical shell artefacts.

Table 1. Shell artefacts from Emily Bay settlement site.

Trench/Square/ Spit	species	use class	type of usewear and modification	weight (g)	length (mm)
EB96:10 A2/1	*G. livida*	1	All margins removed to get semi crescentic shape.	0.1	15.2
EB96:10 A2/2	*M. rufescens*	2	Slight rounding and denticulate edge on 7.3 mm length.	0.9	19.8
EB96:10 A2/2	*M. rufescens*	3	Section of usewear along lateral shell edge 13.4 mm length with scarring and rounding of edge.	2.2	31.6
EB96:10 A2/4	?	3	Section of usewear along lateral shell edge 24.5 mm length with striations and rounding of margins.	2.7	30.4
EB96:10 A3/1	*G. livida*	1	14.6 mm section of usewear on one edge consisting of bending fractures, striations and edge dulling (not yet rounding) 5.3 mm notch in process of formation as result of use.	0.6	17.7
EB96:10 A5/1	*G. livida*	2	18 mm section of usewear on right lateral edge consisting of fractures, striations and edge dulling on ventral face. Starch grains present.	1.1	30.9
EB96:10 A5/1	*G. livida*	1	One margin has section of usewear 16.7 mm long with striations, one step fracture and edge dulling on ventral face.	0.5	17.4
EB96:10 A5/1	*G. livida*	1	Striations and edge dulling on one margin 10.5 mm length on ventral face.	0.9	20.9
EB96:10 A6/1	*M. rufescens*	1	Section of usewear on left lateral margin consisting of three step fractures, striations and edge dulling for a length of 10 mm on dorsal face.	0.6	16.3
EB96:10 B5/1	*G. livida*	1	Denticulate edge on two sides of segment.	1.2	26.5
EB97:23 D9/6	*G. livida*	3	All sides show use fractures, striations and edge rounding on ventral face. Residues present consist of plant fibres, roots and starch grains.	2.6	30.7
EB97:23 D10/3	*G. livida*	2	On ventral face on left lateral margin are unifacial step fractures, striations and edge dulling along a 24.5 mm length.	2.0	29.3
EB97:23 D11/3	*G. livida*	1	Rounding and scarring on lateral margins.	0.7	22.8
EB97:23 D12/1	*G. livida*	1	Lateral edge has striations and edge rounding for a length of 21.9 mm on ventral face.	2.7	33.7
EB97:23 D13/4	*Anapella cycladea*?	0	Atypical. Umbo intact but all margins have been shaped (probably by flaking and then smoothing) to form a sharp protrusion.	1.1	17.9
EB97:23 E12/3	*G. livida*	2	Right lateral margin has bifacial striations and the left lateral margin has five step fractures from use on the ventral face.	1.03	25.5
EB97:23 E12/3	*G. livida*	0	Atypical. Segment with no valve edge shatter removals leaving central triangular tab section. Smoothing and shaping have occurred on all margins to form pointed shape. Then segment has been snapped. Suggest distal point of larger artefact.	0.2	14.7
EB97:23 F13/3	*G. livida*	2	Segment with no valve edge remaining with three shatter removals leaving central triangular tab section. Outer edges have been smoothed and three flakes removed on butt. Usewear is evident on right lateral margin with step fractures and edge rounding. A notch 6.14 mm wide is forming from use on this margin.	1.1	26.7
EB97:24 A5/2	*G. livida*	1	Rounding on one margin on ventral face.	0.4	14.4
EB97:23 G8/3	*G. livida*	1	Rounding.	0.5	22.0
EB97:24 B3/1	*G. livida*	1	Rounding.	0.4	23.0

Results and discussion. Of the 40 shell pieces, 19 exhibited signs of usewear. The results of the usewear study along with residue results, are listed in Table 1. Two other artefacts shaped by deliberate flaking and grinding were highly weathered making identification of use impossible; in Table 1 they have been classed as exhibiting no usewear traces (Use class 0), but due to their unnatural shape remain classed as artefactual.

The patterns of usewear observed would be produced mainly by scraping (Fullagar, 1986; Kamminga, 1982). In the modification of the valves, the dorsal or ventral edge of one lateral margin on the inferior portion of the valve appeared to be the preferred working edge with the umbo or hinge area of the valve being completely removed with two or more breaks leaving a segment with a sharp working edge for use. All the artefacts result from the opportunistic use of fractured material and, as discussed previously, this material could have been deliberately fractured, or removed from a midden where it had been fractured by natural processes such as trampling or midden deflation. Due to the shell microstructure of *Gari livida*, the most common species for artefact construction, fracturing occurs along horizontal planes of weakness within the shell matrix, resulting in sharp working edges with acute edge angles that need no further modification. This species seems to have been deliberately sought as a raw material, possibly for that reason. These artefacts are pictured in Fig. 3.

Small, opportunistically-made shell artefacts are seldom reported in the archaeological literature (apart from their presence), so the study of this artefact class is limited. Lima *et al.* (1986) found that the majority of artefacts at Ilha de Santana were broken valves with sharp edges. They found by experiment that these artefacts were highly efficient for scaling fish, but no usewear or residue studies were carried out on the archaeological assemblage. Fish scaling is a possibility for the Norfolk Island assemblage as the small size of the artefacts and the light degree of fracturing on their margins indicates that no hard materials were worked with them. Reiger (1981) describes shell artefacts from South Florida which also functioned as cutting and scraping implements. As stated previously these artefacts are commonly reported for the Pacific (Best, 1984; Kirch, 1987, 1989, 1993; Poulsen, 1967; Smith, 1999) where they are usually ascribed to food preparation. The working of tubers

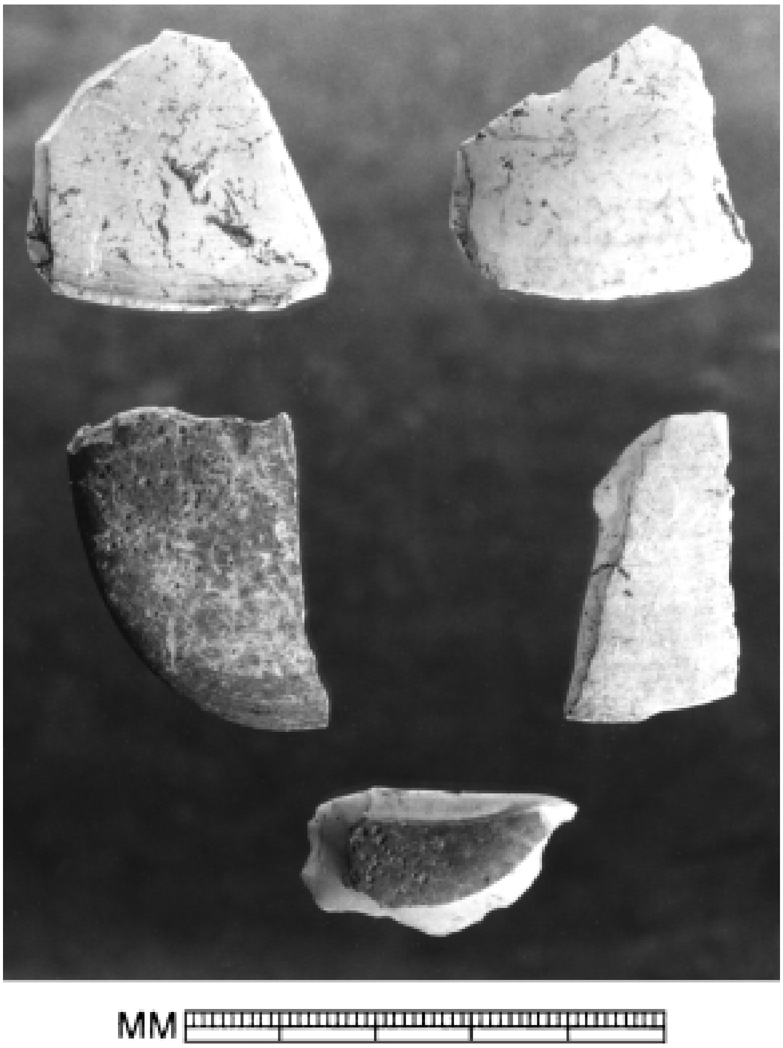

Figure 3. Typical shell artefacts, shown in dorsal view.

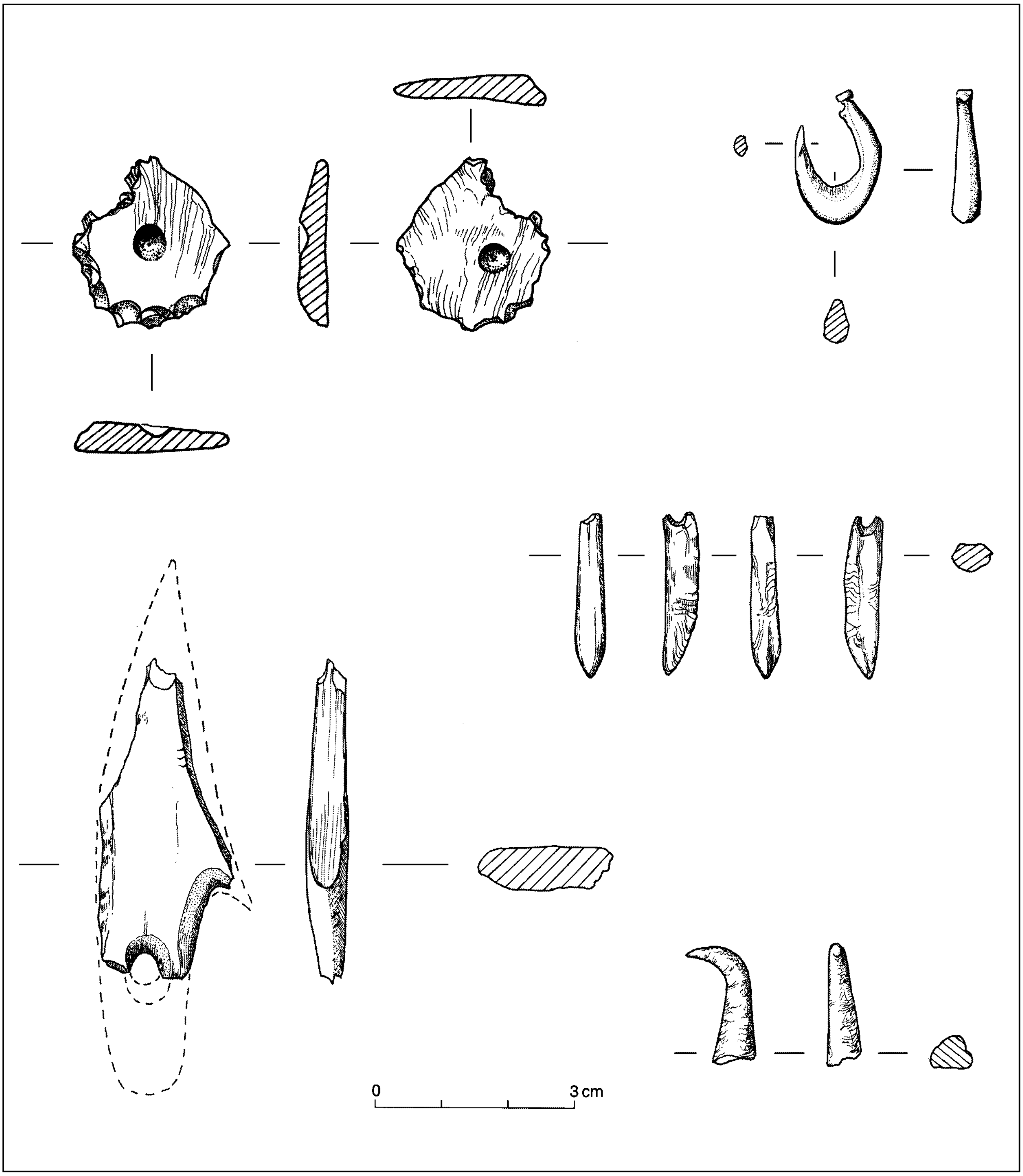

Figure 4. The bone artefacts from Norfolk Island (clockwise from top left): the fishhook tab, the ivory rotating hook, the drilled awl or pendant, the broken hook point, the broken harpoon.

or other soft vegetable products is another possibility for the Emily Bay assemblage and the presence of starch residues on two of the working edges of artefacts lends support to this suggestion. Unfortunately, it was not possible to identify the starch grains to a particular taxon.

The 19 shell pieces which exhibited use traces were found in Trenches EB96:10, EB97:23 and EB97:24. The majority of the artefacts were located in EB96:10, especially in the uppermost spit (Table 2), where they appear to be associated mainly with the oven feature in Squares A5-A6-B5 and the rubbish pit feature in Square A2. In EB97:23 shell artefacts were located mainly in the central part of the excavation, where deeper cultural stratigraphy suggests high levels of discard. The general distribution of shell tools near ovens and rubbish dumps suggests discard after use. The relatively high concentration in EB96:10 might represent a particular activity area in the site.

Table 2. Shell tool distribution in Emily Bay settlement site.

	trench				
spit	EB96:10	EB97:23	EB97:24	total	percent
1	7	1	1	9	42.9
2	2	—	1	3	14.3
3	—	6	—	6	28.6
4	1	1	—	2	9.6
5	—	—	—	—	—
6	—	1	—	1	4.8
total	10	9	2	21	
percent	47.6	42.9	9.5		

Bone and ivory artefacts

Four of the five bone artefacts recovered from the Norfolk Island excavation are components of a typical Polynesian fishing kit. These are, a complete one piece fishhook in marine ivory, a partially worked fishhook tab, a broken hook point, and a harpoon point. The fifth bone artefact is a bone awl or pendant. Artefacts are shown in Fig. 4.

The complete one piece fishhook from Trench EB97:23 (C13 Spit 1) has been made from marine ivory, exhibiting enamel traces on the outer surface of both point and shank. It is therefore from a tooth smaller than any in a large whale, such as Sperm whale, and resembles in form and size the two seal ivory fish hooks recovered from Sandy Bay, in the Auckland Islands (Anderson and O'Regan, 1999). The most probable source of the material is a tooth from the elephant seal skull found, fragmented, in EB97:24.

The hook is a Type D one-piece hook in the New Zealand classification of Hjarno (1967; see also Anderson and Gumbley, 1996), with a sub-circular form, incurving tip and typical knobbed head. Such hooks have a rotating action and are typical of bait fishing in relatively deep water (Reinman, 1970; Allen, 1996). However the point incurve is relatively slight and the hook would not fit into the rotating class in the Sinoto (1991) classification of Hawaiian hooks, in which the line of point curvature intersects the shank. Measurements of the shank length (18.5 mm), and point length (15.4 mm), both taken at right angles to the base, and the width (13.0 mm) taken from the outer edge of the shank to the outer edge of the point parallel to the base at the widest part of the hook, also show that it falls outside the rotating hook ratios for Marquesas and Societies assemblages, established by Sinoto (1967: 354). It is more typical of Cook Islands and New Zealand forms.

The bone fishhook tab from Trench EB96:11 (Square A2 Spit 2) shows drilling around the perimeter, by which the tab was cut from a larger piece of bone, and an initial drill hole in the centre. Had the process continued, the centre would have been drilled out and a single, probably sub-circular hook, then formed by filing. This is a very typical style of hook manufacture in East Polynesian sites, especially in New Zealand. The bone has not been positively identified, but it may be from the elephant seal remains.

The point from Trench EB97:24 (Square Y1 Spit 2) is difficult to interpret definitively. It could be either the incurved tip of a point leg from a large one-piece or compound bait hook, or a trolling lure point similar to those in barracouta lures (Anderson, 1981). The latter seems less likely from the expansion of the basal part of the point. This is more probably indicative of a bait hook, suggesting that some large hooks had also been used at Norfolk Island.

The bone harpoon point from EB96:11 (Square A1 Spit 2), is almost complete from the distal point to midway through the eye through which a line would have been attached. The artefact has a well formed barb and measures 19.3 mm across at that point. It is 45.5 mm in length. The harpoon point is constructed from turtle bone. It is a toggling form, intended to rotate once it had struck fast and detached from the shaft. Toggling harpoons are typical items of early East Polynesian material culture (Sinoto, 1970: 116–117).

There is a bone awl, or possibly a pendant, from EB97:24 (Square Y1 Spit 1). It is broken through the eye-hole. Bone awls are a common East Polynesian artefact type. The material has not been identified, but appears to be mammalian.

Conclusions

From the Emily Bay site on Norfolk Island a small assemblage of shell and bone artefacts was recovered. Shell tools were defined here by the presence of usewear traces, rather than the morphology of the shell pieces alone, as experiments suggested that sharp shell pieces suitable as tools could be created accidentally as well as deliberately. Of 40 shell pieces that might have been tools, 19 were confirmed by usewear and two were suggested by shape. The usewear suggests mainly scraping, but of what is difficult to tell. Fish scaling and vegetable scraping are possibilities, the latter function also suggested by starch residues left on the working edges of two pieces. The relative prominence of flaked shell tools at Emily Bay may reflect the scarcity of other materials needed to carry a sharp edge, such as quartz, chert or obsidian, none of which occur locally. There are basalt flake and blade tools, but shell was evidently preferred for some tasks.

The bone artefacts include a marine ivory one-piece fish hook, possibly made from an elephant seal tooth, a turtle bone harpoon point and several other pieces, including a fish hook tab. The assemblage is typical of early East Polynesian material and particularly reminiscent of items found in New Zealand.

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Mammalian and Reptilian Fauna from Emily and Cemetery Bays, Norfolk Island

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ABSTRACT. Large mammal remains described from the prehistoric settlement at Emily Bay consist of elephant seal and turtle. *Rattus exulans* remains similar to those elsewhere in Polynesia were the only rodent remains found throughout excavations at Emily and Cemetery Bays: there is no evidence that this animal was eaten. A partial dog mandible from Emily Bay is described: it may be prehistoric but neither its date nor osteometry are definitive. An intrusive recent pig is noted.

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Mammal and reptile remains were scarce in the excavations at Emily and Cemetery Bays. Identification of all bone recovered was taken to the lowest possible taxonomic level for two reasons: first, to see what animals had been brought by people to the island and second, to see what native animals were available for exploitation.

Our joint authorship of this paper is the result of an amalgamation of Smith's work on large mammals and reptiles, White's on rodents from Emily and Cemetery Bays, and Clark's on a *Canis familiaris* mandible from Emily Bay.

Large mammals and reptiles

All large mammalian and reptilian remains recovered in the excavations are summarized in Table 1. These consisted of 95 bone fragments and one piece of tooth. The latter was the crown and part of the root of a human maxillary incisor from a depth of 72 cm at Cemetery Bay. The bones were mostly in a dry, friable and fragmentary state that made species identification impossible. Identifications were made by comparison with reference specimens in the Otago Archaeological Laboratories (OAL).

Nearly three-quarters of the number of bones were from Spit 3 in one square of Trench EB97:24 at Emily Bay, and came from the cranium of a Southern Elephant Seal (*Mirounga leonina*). These included the left frontal bone, right tympanic bulla and numerous unsided fragments from the occipital, parietal, frontal and nasal regions. In size they are closely similar to a sub adult male in the OAL collection.

This identification constitutes the northern-most (29°S) documented occurrence of elephant seal in the Pacific Ocean. The modern distribution of this species is confined largely to subantarctic waters south of c. 40°S (Jefferson *et al*., 1993: 287), although they formerly occurred as far north

Table 1. Large mammal and reptile bones from Emily Bay (EB), West Emily Bay (WEB), Cemetery Bay (CB) and Limekiln.

NIPP no.	site	trench	sq.	cultural layer	other provenance	taxon	element	side	portion	NISP	notes
1	Limekiln	outcrop	—	—	—	turtle	carapace	—	fragment	1	appears to be cut at one end
15	WEB	new toilet	—	—	c. 1.3 m b.s.	turtle	fibula	—	fragment	1	not sure of element identification
50	CB	CB95:01	A3	—	72 cm b.s.	*Homo sapiens*	I'	right	crown and part root	1	—
65	EB	EB95:02	A1	Spit 3	17/12/95	mammal or turtle	—	—	fragments	3	—
109	EB	EB96:10	B4	Spit 2	9/4/96	turtle	pelvis	—	fragments	2	not sure of element identification
125	EB	EB96:10	A5	Spit 1	8/4/96	turtle	vertebra	—	fragments	3	—
128	EB	EB96:10	B1	Spit 1	9/4/96	turtle	vertebra-cervical		centrum	1	—
141	EB	EB96:10	A2	Spit 4	8/4/96	mammal or turtle	—	—	fragments	2	—
150	EB	EB96:10	B3	Spit 4	10/4/96	turtle	vertebra-cervical	—	complete	1	—
156	EB	EB96:11	A2	Spit 3	12/4/96	turtle	vertebra-cervical	—	neural arch	1	—
162	EB	EB96:11	A2	Spit 2	12/4/96	turtle	carapace	—	fragment	1	—
162	EB	EB96:11	A2	Spit 2	12/4/96	mammal or turtle	—	—	fragment	1	—
606	EB	EB97:23	E13	Spit 3	—	turtle	carapace	—	fragments	2	—
630	EB	EB97:23	F9	Spit 4	—	turtle	carapace	—	fragments	4	—
632	EB	EB97:23	F9	Spit 5	—	turtle	carapace	—	fragments	3	—
15	EB	EB97:23	E7	Spit 1	—	pig	mandible	right	tooth row fragment	1	modern
762	EB	EB97:24	Z6	Spit 3	bag 1	elephant seal	cranium	left	frontal	1	—
762	EB	EB97:24	Z6	Spit 3	bag 1	elephant seal	cranium	right	tympanic bulla	1	—
762	EB	EB97:24	Z6	Spit 3	bag 2	elephant seal	cranium	—	occipital and frontal fragments	30	—
762	EB	EB97:24	Z6	Spit 3	bag 3	elephant seal	cranium	—	parietal and nasal fragments	37	—

as 16°S at St Helena in the Atlantic Ocean (King, 1990: 264). In the Pacific the northernmost modern records are from the Bay of Islands New Zealand (King, 1990: 265), and archaeologically they have previously been recorded as far north as c. 35°S at Houhora, New Zealand (Smith, 1989: 85–86). The modern records from New Zealand are predominantly of occasional individuals hauling out to moult or rest, and it is likely that this was the case for the Norfolk Island example.

This is the third recent case of seal remains found in an early archaeological context in the southwest Pacific. They occurred in a probable fourteenth century A.D. context at the Low Flat site, Raoul Island (Anderson, 1980). A New Zealand fur seal in a fourteenth century A.D. site in the Cook Islands was interpreted as an isolated vagrant, wandering northward from a breeding range that then included the northern tip of New Zealand (Walter and Smith, 1998). The extension of the pelagic range of the elephant seal to Norfolk Island may indicate that before European arrival in the Pacific Ocean this species was also breeding further north than it does today.

Turtle remains were present in four of the Emily Bay trenches, although never in great abundance. No turtle remains occurred close to the *marae*, although this might have been expected given the high status of this structure in many parts of Polynesia. Eleven pieces were fragments of carapace, and another six were parts of at least three vertebrae. Fragments of a pelvis and fibula were also probably present. None of these could be identified to species. The Green Turtle (*Chelonia mydas*) is the most common species in the southwest Pacific, but the Hawksbill (*Eretmochelys imbricata*), Leatherback (*Dermochelys coriacea*) and Loggerhead (*Caretta caretta*) are also present (South Pacific Commission, 1979). It is of interest to note that Emily Bay was formerly known as Turtle Bay, because of the abundance of breeding turtles there (Hunter, 1793: 317).

The only other large mammal represented was the pig (*Sus scrofa*), by part of the tooth row of a right mandible. Although this specimen appeared to be in a secure prehistoric context, in the top spit of the cultural level, Trench EB97:23, a radiocarbon date of 50±35 (OxA8750) on it shows that it must be from the historic period.

Table 2. Number and type of rodent bones by trench.

Trench	n	mandible	maxilla	femur	tibia	innominate	humerus	other
EB95:02	60	13	9	10	14	9	4	1
EB96:10	29	8	2	5	4	7	2	1
EB96:11	21	1	2	7	5	4	0	2
EB97:21	1	0	0	0	0	0	1	0
EB97:22	1	1	0	0	0	0	0	0
EB97:23	369	86	12	103	51	67	46	4
EB97:24	88	19	3	30	14	10	12	0
Cemetary Bay	13	1	2	4	2	3	1	0
total	582	129	30	159	90	100	66	8

Rodents in the Emily and Cemetery Bay excavations

A total of 569 identified rodent bones were recovered from all excavations in Emily Bay and 13 from Cemetery Bay. Their distribution by trench is given in Table 2.

The bones were studied for three reasons. First, how many species were represented? It could be predicted that *Rattus exulans*, the “Polynesian rat” was present, as this has been found on all other Pacific islands reached by Polynesian voyagers (Roberts, 1991). Were there others?

Second, did these species differ from those found in the potential source region of the Norfolk Island settlement, New Zealand (as determined by other archaeological evidence)?

Third, were the animals eaten, as was common elsewhere in Polynesia, notably New Zealand (Roberts, 1991)?

The rodent bones consisted almost entirely of mandibles, maxillas and the four most robust and readily identifiable post-cranial bones—femur, tibia, innominate and humerus. All mandibles and maxillas were identified as *Rattus exulans* on the basis of comparative material from New Ireland and Vanuatu in the Archaeology Laboratory, University of Sydney. The post-cranial bones were compared with already identified material in terms of length, robustness and morphology (White *et al*., 2000). No anomalies were noted, confirming that the material is all from the same species.

Measurements taken were on M_{1-3} lengths. For these the material was divided into mandibles with at least M_1 and M_3 present, so that measures could be taken on actual teeth, (n=27) and those for which measurements had to be made on the alveoli (n=81). Results are given in Table 3. As has been demonstrated elsewhere (White *et al*., 2000), the alveoli results are slightly larger than measurements made directly on teeth, but both fall comfortably within the range of modern *R. exulans*. The Norfolk Island animals are similar in size to animals from Vanuatu, but somewhat smaller overall than those from elsewhere in Polynesia (White *et al*., 2000), including New Zealand (Matisoo-Smith and Allen, in press). This runs counter to the current pattern where sub-tropical *R. exulans*, without competition from other rodents, are larger (Atkinson and Moller, 1998). Comparison with a clearly contemporary data set from New Zealand would be of interest.

Table 3. M_{1-3} lengths (mm) from Norfolk Island compared with other Pacific *Rattus exulans*. “Polynesian” and Vanuatu data from White *et al*. (2000), New Zealand data from Matisoo-Smith and Allen (in press).

	n	mean	s.d.	median	max	min
NI, on teeth	27	5.26	0.18	5.27	5.58	4.81
NI, on alveoli	81	5.70	0.24	5.69	6.37	5.21
“Polynesian”	178	6.0	0.5	—	7.2	4.9
Vanuatu	76	5.3	0.3	—	5.9	4.5
New Zealand	42	6.22	0.51	—	7.3	5.35

In terms of distribution over the site the only noticeable concentration of material was in the upper spits of squares D9 and D10 of Trench EB97:23 (Table 4). These two squares contained one-third of the total specimens (n=123) in the 37 square metre trench. Trench EB97:23 showed a greater concentration of rat bones overall (10/m^2) than the rest of the site, notably Trench EB97:24 (5.5/m^2). This suggests a rodent focus on the “house” rather than the “platform” area. This is to be expected given the commensal nature of *R. exulans* and may thus provide support to this interpretation of these features. However, bones from the site showed no evidence of burning and were largely unbroken, suggesting natural death. Unlike New Zealand, there is no evidence that people were eating these animals (and even in New Zealand the evidence is ethnographic rather than archaeological).

Table 4. Rodent bones (NISP) in Trench EB97:23, squares D9 and D10 (n = 123).

Spit	1	2	3	4	5	6	7
D9	1	28	14	10	0	5	1
D10	10	8	19	8	10	9	0

Finally, I note that *R. exulans* is still present on the island, and was noted as common by the first European settlers in 1788, providing evidence of continuity. While the radiocarbon determinations on rat bone are in some respects contradictory, and therefore unreliable, the weight of data confirm the stratigraphic interpretation that *Rattus exulans* was introduced in the Polynesian settlement era (see Anderson, Higham and Wallace, this vol.).

A *Canis familiaris* mandible from Emily Bay

A dog mandible thought to be associated with the prehistoric Polynesian settlement site on Norfolk Island was recovered by Bevan Nicolai at a depth of approximately 80 cm during the digging of a toilet hole, subsequently unused, at Emily Bay in 1986. The hole lay just on the southern edge of the site within 10 m of excavation Trench EB95:06. A broken *Canis* carnassial tooth identified by A. Anderson and I. Smith during excavation of the cultural layer at Trench EB96:10 at Emily Bay has not been relocated in the material returned to the ANU.

This note describes the mandible and attempts to clarify its cultural affinity. Contextual details for the mandible recorded on the plastic bag containing the bone were: "West Emily Bay, New toilet, Nov. 86, Brown earthy layer, B.N., NIPP 15 [number allocated to this collection of specimens]".

The mandible was dated by the AMS method to 205±40 years (OxA-8749). At one standard deviation the calibrated date's lower distribution is pre-European (cal A.D. 1658–1682, 1747–1805, 1935–1954), and a Polynesian origin, while unlikely, cannot be ruled out, although it does not have the same stratigraphic associations as the dog tooth from Trench EB96:10. The date is younger by several hundred years than most reliable determinations from the Emily Bay site.

The left demi-mandible weighs 8.50 g and is light yellow in colour. No teeth remain in the alveoli. Post-depositional damage is suggested by sharp edged and unweathered breaks across the anterior infradentale and posterior ramus. Light microscopy showed pale yellow sand grains trapped in the alveoli and this, along with the bone colour, suggests that the mandible was interred in a loose yellow-brown sand rather than a "Brown earthy layer". This is significant as the site is capped by a layer of yellow-brown hummocky dune sand that overlies the thin grey prehistoric occupation horizon. The lower layer is distinguished from the upper by its dark-grey colour caused by charcoal staining, and its faunal and artefactual content. Thus, while the mandible cannot be confidently assigned either to the pre-European or European period deposits, the good bone preservation and colour of the trapped sand grains suggest interment in the latter.

It is not possible to establish whether the bone belongs to a male or female dog but it is reasonable to assume that it came from a small-to-medium sized adult using as a guide the size of the mandible, the development of the condyle process, and the degree of mineralization observed on the bone surface. No dental abnormalities in the alveoli were noted except for the possibility that P_1 was impacted into P_2.

As the mandible's stratigraphic association and origin were in doubt, five measurements from it were compared with the same dimensions from the Polynesian dog of New Zealand and Hawaii (Clark, 1997a,b) to determine whether or not the specimen was potentially of Polynesian origin. Because of selective breeding the dog is the most morphologically varied animal on earth today (Wayne, 1986: 382), and a comparison with heterogeneous European dog populations will tell us little about the affinities of a particular specimen, and begs the question of what form a comparative sample of "European dogs" should take given the degree of phenotypic variation. An alternative approach to examine specimen affiliation is to compare its dimensions with the osteometric parameters of suspected source populations and this method is followed here (Clark, 1997a: 115, 1998). If the Norfolk Island specimen falls outside the known population dimensions of Polynesian dogs then a European origin or non-regional derivation must be suspected. Mandibular measurements (mean, minimum and maximum) for the samples are listed in Table 5 and a bivariate plot of tooth row length (M_3-P_1 Length) versus the height of the corpus at M_1 (Corpus M_1 Height) is shown in Fig. 1.

A univariate comparison of the Norfolk Island dog mandible shows that most measurements fit comfortably within the metric parameters of the prehistoric dog of Hawaii

Table 5. Mandibular measurements (mm) of the Norfolk Island dog mandible, Polynesian dog (*kuri*) from New Zealand (n = 117–118) and Hawaii (n = 71–83).

sample	M_3-P_1 length	corpus M_1 height	corpus P_2 height	premolar length	molar length
NIPP 15	62.6	16.8	14.6	28.9	31.9
NZ—mean	64.2	22.8	18.5	35.1	29.7
NZ—min	56.3	17.4	14.6	24.8	23.0
NZ—max	72.5	28.2	27.7	53.7	35.4
Haw—mean	60.3	18.6	16.0	31.8	30.0
Haw—min	53.1	13.6	12.6	27.0	26.2
Haw—max	67.0	22.8	19.1	37.7	33.7

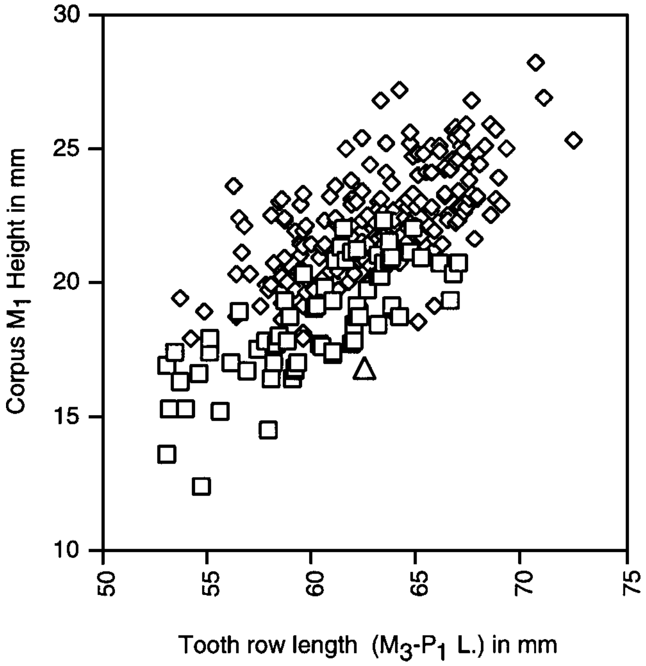

Figure 1. Bivariate plot of mandibular measurements of the Norfolk Island dog (triangle), New Zealand *kuri* (diamonds) and Hawaiian dog (squares).

and New Zealand. The exceptions are the mandible height variables (Corpus M_1 and P_2 Height) which are less than, or the same as, those from the smallest New Zealand dogs (Table 5). However, the plot of the mandibular dimensions of the Norfolk Island dog indicates that it is not especially "Polynesian like" (Fig. 1) and plots of other dimensions produced a similar result, placing NIPP 15 on the plot periphery closest to Hawaiian dogs and away from the New Zealand *kuri* (e.g., premolar length × P_2 Height). The measurement comparison does not therefore rule out a Polynesian origin. However, the specimen's marginal position in bivariate plots lends further support to its European derivation.

To summarize, both the radiocarbon date and the metrical comparison are ambiguous in relation to the mandible's origin. If it is pre-European, it would represent the only direct evidence of Polynesians bringing a domestic animal to Norfolk Island.

As part of the domestic landscape, dogs were seldom mentioned in early accounts of European life on Norfolk Island and it is not known when they were first introduced. That they were present is shown by the abandonment of about a dozen male and female dogs at the end of the First Settlement in 1814 (Nobbs, 1988: 164–165). It is possible that a similar event occurred at the end of Polynesian occupation leaving a resident population that rapidly reverted to a feral state. The existence of such a population could have been tied to the seasonal availability of ground-nesting seabirds and hunting of the introduced Pacific rat (*Rattus exulans*), but long-term survival would seem unlikely.

The prehistoric distribution of domestic and commensal animals in the Pacific provides a valuable insight into the subsistence strategy, maritime ability and approach to island settlement by colonizing groups. It is therefore important to carefully examine the remains of introduced species and to differentiate prehistoric Polynesian from European introductions—particularly bones from the pig, dog and chicken that were transported through the Pacific in the past by Oceanic peoples and more recently by Europeans. The provenance and age of the Emily Bay dog mandible does not provide a strong link to the East Polynesian settlement deposits. Additionally, five measurements were used to further explore its affinities to Polynesian dogs from Hawaii and New Zealand and these suggest that a New Zealand derivation is unlikely. The mandible has greater similarity to the Hawaiian dog sample but a definitive Polynesian origin cannot be determined. Unless the missing carnassial tooth is relocated or new *in situ* dog remains from prehistoric contexts are recovered, there must remain some doubt as to whether Polynesians transported the dog, along with the ubiquitous commensal *Rattus exulans*, to Norfolk Island.

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Genetic Variation in Archaeological *Rattus exulans* Remains from the Emily Bay Settlement Site, Norfolk Island

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ABSTRACT. Analyses of mitochondrial DNA variation in archaeological samples of *Rattus exulans* obtained during the 1997 excavations at Emily Bay, Norfolk Island suggest a high degree of variation in the prehistoric populations on the island. The ten samples sequenced produced five unique haplotypes. This result is consistent with a scenario of multiple introductions of the species to the island. There are clear affiliations with East Polynesian and New Zealand samples, however other lineages also appear to be present on Norfolk Island. Three haplotypes that had previously not been identified in tropical East Polynesia appear on Norfolk. One of these has also been identified in an archaeological sample from New Zealand. The other two haplotypes have yet to be identified elsewhere.

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It has been argued that patterns of genetic variation in Pacific populations of the Pacific rat, *Rattus exulans*, serve as a model for prehistoric human movement in the region. Specifically they have been valuable for identifying points of origin for voyages of exploration, colonization and later contact (Matisoo-Smith *et al*., 1998). More recently, analyses of degrees of genetic variation in archaeological and modern samples of *R. exulans* have been used to assess the degree of contact with and isolation of particular island groups within Polynesia (Matisoo-Smith *et al*., 1999). Both of these approaches are applied here to archaeological samples collected during the 1997 Emily Bay excavations on Norfolk Island (see Anderson, Smith and White, this vol.).

Materials and methods

A total of 33 *Rattus exulans* bone samples were provided for analysis. From this material, 13 samples were considered to be large enough and in good enough condition for ancient DNA extraction. We were able to obtain enough DNA from 10 of these samples to amplify, using the Polymerase Chain Reaction (PCR), and directly sequence a 175 base-pair (bp)

Table 1. Bone samples processed. MRL = mandibular alveolar length (MRL) as described in Matisoo-Smith and Allen (2001).

sample	trench	square, spit	skeletal element	weight (g)	MRL (mm) mandibles	maximum length femur (mm)	sequence obtained?
NIPP 574A	EB97:23	E6, spit3	mandible/L	0.09	6.63	—	N
NIPP 574B	EB97:23	E6, spit3	mandible/L	0.10	5.59	—	Y
NIPP 635A	EB97:23	F10, spit3	mandible/R	0.10	6.36	—	Y
NIPP 641	EB97:23	F10, spit7	mandible/L	0.10	6.56	—	Y
NIPP 740A	EB97:24	C3, spit3	mandible/L	0.13	5.89	—	Y
NIPP 575A	EB97:24	E6, spit4	femur/L	0.11	—	incomplete	Y
NIPP 635B	EB97:24	F10, spit3	femur/L	0.13	—	26.99	Y
NIPP 692	EB97:24	A2, spit1	femur/L	0.22	—	29.15	Y
NIPP 699	EB97:24	A4, spit2	femur/R	0.11	—	23.43	N
NIPP 740B	EB97:24	C3, spit3	femur/L	0.14	—	incomplete	Y
NIPP 739	EB97:24	C3, spit2	femur/R	0.12	—	incomplete	Y
NIPP 573	EB97:23	E6, spit2	femur/R	0.11	—	incomplete	N
NIPP 575B	EB97:23	E6, spit4	femur/L	0.13	—	24.37	Y

fragment of a hypervariable region of the mtDNA d-loop. The sample identification numbers, location, morphological measurements and other information are shown in Table 1. The Emily Bay settlement site has been interpreted as representing a single-phase occupation dating to the thirteenth to fifteenth centuries A.D. (see Anderson, Higham and Wallace, this vol.).

Extraction, amplification and sequencing methods are as described previously with all ancient DNA work carried out with strict precautions to avoid and identify contamination (Matisoo-Smith *et al*., 1999). PCR primers EGL 8 (L5'GGACATACCTGTGTTATCA 3') and EGL 9 (H5' CCCTGAAGTAAGAACCAGA 3') were used for amplification and sequencing, providing sequence data of approximately 175 base pairs for each sample (bases 15594–15765 in Gadaleta *et al*., 1989). Gene diversity (h) was calculated using Nei's (1987) equation, where x = haplotype frequency and n = number of haplotypes sampled:

$$h = (1 - \Sigma x^2)\, n / (n - 1)$$

All sequences were compared with those derived from *R. rattus*, *R. norvegicus* and *R. praetor* material and were confirmed as belonging to *R. exulans*. Distance analyses were performed using MEGA, version 1.01 (Kumar *et al*., 1993) and a phylogeny was constructed using the neighbor-joining method. One thousand bootstrap replicates were performed and values are shown on the phylogenetic tree in Fig. 1.

Results

Morphology and bone quality. In terms of maximum length (ML) for femora, and mandibular alveolar length (MRL), the material from Emily Bay overall appears relatively large, but fits well within the normal range for *Rattus exulans* from around the Pacific Islands (20.5–30.3 mm for ML and 4.79–7.3 mm for MRL). However, sample NIPP 692 approaches the maximum size recorded for archaeological *R. exulans* material (Matisoo-Smith and Allen, 2001). All material appeared to be well preserved, with most femora and mandibles weighing more than 0.1 g, as is typical of *R. exulans* material of good quality. None of the bones appeared to be burned or have any other distinguishing features.

Genetic variation. We had a particularly high success rate for amplification and sequencing of the material, with only three of 13 samples not providing DNA of sufficient quality for direct sequencing. From the 10 samples analysed, five unique sequences and six phylogenetically informative sites were identified, which produced a gene diversity value for Norfolk Island rats of 0.80. These five sequences were compared to all existing sequences for *Rattus exulans* (Matisoo-Smith *et al*., 1998 [GenBank accession numbers AF104120–104211] and unpublished data). The phylogenetically informative sites were identified and are shown

Table 2. Phylogenetically informative sites for 175 bp of *Rattus exulans* mtDNA sequence. Variable sites 1–6 refer to sites 255, 257, 272, 293, 317, and 332 in Matisoo-Smith (1996). East Polynesian consensus sequence is from Matisoo-Smith (1996). All NIPP samples are archaeological samples from Emily Bay, Norfolk Island; all AI samples are from archaeological sites in New Zealand (AI 536, 537, and 539 from the Washpool Midden site, and AI 552 from Paremata) and were provided by the Archaeozoology Laboratory, Museum of New Zealand. A, T, C, and G represent the bases adenine, thymine and cytosine and guanine—which make up DNA.

variable site	1	2	3	4	5	6
East Polynesian consensus	C	T	C	C	C	G
AI537	C	T	C	C	C	G
AI552	C	T	C	C	C	G
NIPP 574B	C	T	C	C	C	G
NIPP 641	C	T	C	C	C	G
NIPP 739	C	T	C	C	C	G
NIPP 740B	C	T	C	C	C	G
NIPP 575A	C	T	C	C	C	A
NIPP 575B	C	T	T	T	T	G
NIPP 635A	C	T	T	T	A	G
NIPP 635B	C	T	T	T	A	G
NIPP 692	C	T	T	T	A	G
NIPP 740A	A	C	T	T	A	G
AI536	A	C	T	T	A	G
AI539	C	T	T	C	A	G

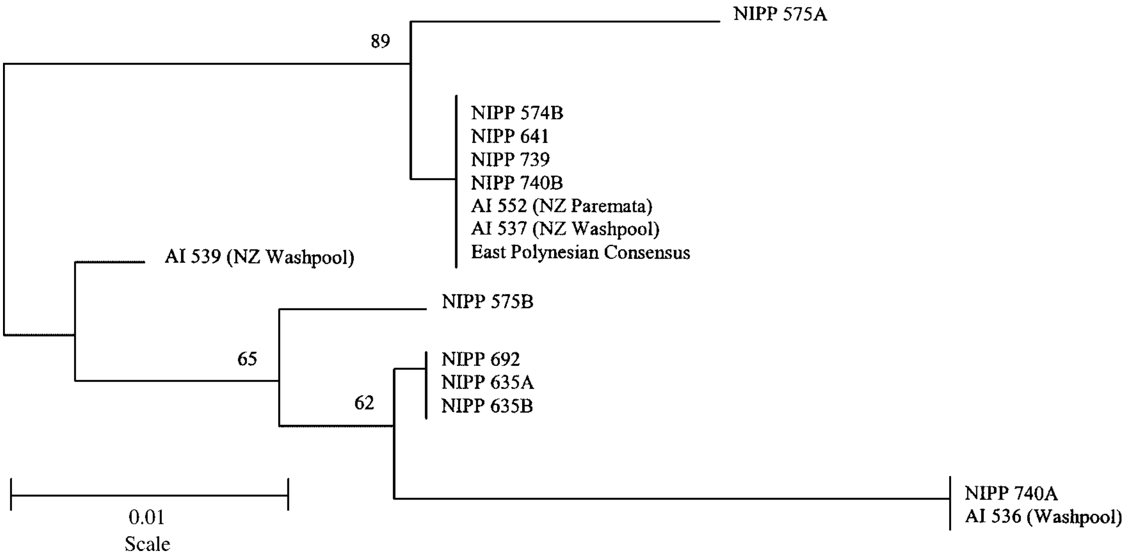

Figure 1. Neighbor Joining Tree for 175 bp of mtDNA d-loop sequence. NIPP samples from Emily Bay settlement site, Norfolk Island.

in Table 2. In addition to the Norfolk Island samples, sequences from archaeological samples from New Zealand, and an East Polynesian consensus sequence from modern *R. exulans* (from the Southern Cook Islands, the Society Islands, Raoul Island, the Marquesas Islands, the Hawaiian Islands and New Zealand) are also shown for comparison.

Four of the samples (NIPP 574B, 641, 739 and 740B) were identical to the East Polynesian sequence and to two archaeological samples from New Zealand, AI 552 and AI 537. Sample NIPP 575A was identical to these four samples with the exception of a single point mutation (a transition, G to A, identified as variable site 6 in Table 2). Sample NIPP 740A is unique amongst the Norfolk Island sequences and similar only to one other sample sequenced so far, an archaeological sample (AI 536) from the earliest layer from the Washpool Midden site (N168/22), located in Palliser Bay in the south of the North Island of New Zealand (Leach, 1979). These two samples differ from all others at variable sites 1 (C to A) and 2 (T to C) shown in Table 2. Three samples, NIPP 635A, 635B, and 692, were identical to one another, and unlike any East Polynesian samples, though they differ from a New Zealand sample (AI 539) at only one site (C to T at site 4, Table 2). Sample NIPP 575B is unique, but differs from the NIPP 635A, 635B and 692 by one point mutation (A to T at variable site 5, Table 2).

Discussion

Genetic variation as an indicator of contact. Irwin (1992) classes Norfolk Island with the Kermadecs in his discussion of prehistoric voyaging, suggesting that both may have served as stepping stone islands for voyages to and from New Zealand, and as such "they could show signs of multiple contacts, from New Zealand and elsewhere in East Polynesia" (1992: 111). The Kermadecs, lying between New Zealand and tropical East Polynesia, would probably have been contacted more frequently than Norfolk Island, but less frequently than the Chatham Islands which are particularly isolated and unlikely to have had regular prehistoric contact after initial occupation.

Tajima (1990) suggests that genetic diversity is likely to be high where migration rates are high and low where migration rates are low. Given this as an assumption, together with the commensal relationship between *Rattus exulans* and prehistoric Pacific Islanders, then the degree of genetic diversity in an island population of this rat could be an indicator of the degree of human contact with that island (Matisoo-Smith *et al*., 1998). It is, of course, also possible that genetic diversity varied within transported populations.

Gene diversity (h), as calculated by Nei (1987: 179), is an indicator of genetic diversity within species. If each haplotype scored is unique, then the maximum value of h equals (n+1)/n, where n is the number of haplotypes scored. An h value of 0 denotes a population with no haplotype variation. The Norfolk Island h value of 0.80 suggests a relatively variable *Rattus exulans* population. A phylogenetic analysis of these samples (Fig. 1) shows not only the variability, but the fact that these are quite divergent sequences, suggesting that they are not closely related.

Previously (Matisoo-Smith *et al*., 1999), gene diversity was calculated for an archaeological population of *R. exulans* from Chatham Island, and modern samples from New Zealand, and Raoul Island in the Kermadec group. As predicted, given suggestions of isolation, the Chatham Island value was relatively low, 0.54. In contrast, the New Zealand and Raoul values were much higher, with h equal to 0.985 and 0.90 respectively. For the 175 bp region of the genome analysed in this study, the Raoul Island value was the same, 0.90, with four unique sequences from seven samples. The Chatham Island samples, however, showed no variation in this region of the genome, and therefore had an h value of 0. The intermediate Norfolk Island value is consistent with a level of prehistoric contact between those of the Chathams and the Kermadecs.

Origins of Norfolk Island *Rattus exulans*. Four of the Norfolk Island *R. exulans* sequences (NIPP 574B, 641, 739 and 740B) were identical to the consensus sequence for East Polynesian extant *R. exulans*. This sequence was also identified in two archaeological rat bones from the Washpool Midden and Paremata sites in New Zealand (samples AI 537 and 552). Sample NIPP 575A differs from this typical East Polynesian sequence by only one point mutation. These results are thoroughly consistent with other archaeological evidence suggesting East Polynesian influence in Norfolk Island and ties between Norfolk Island and New Zealand (Specht, 1984).

A third haplotype also suggests a connection between Norfolk Island and New Zealand—that haplotype shared between NIPP 740A and AI 536. This New Zealand sample (AI 536) is also from the Washpool Midden site (N168/22). It is associated with Level 1, lens B, which is part of the earliest phase of occupation of the site, dated to about A.D. 1180 (Leach, 1979). What is particularly interesting is that this sequence has not been identified elsewhere in East Polynesia, nor have the fourth haplotype, a sequence shared by three other Norfolk Island samples, NIPP 635A, 635B and 692, and the fifth haplotype (NIPP 575B) which differs from these three by a single point mutation.

While the common haplotype found between NIPP 740A and AI536 strongly suggests a Norfolk-New Zealand connection, it is impossible to say which direction this represents—from Norfolk Island to New Zealand or from New Zealand to Norfolk. It could, of course, merely represent a common source for both samples, and not necessarily a direct connection between the locations. As yet the source of this haplotype and the other two that are closely related has not been identified, despite analysis of more than 200 *R. exulans* sequences from East Polynesia, both archaeological and modern. It is possible that this sequence therefore represents either a very rare and/or extinct East Polynesian lineage, or a non-East Polynesian source for Norfolk Island and/or some New Zealand *R. exulans* populations. Alternatively, there may have been a highly variable source population for the Norfolk Island rats. We are currently collecting and analysing samples from West Polynesia (Tonga, Niue and Fiji) and from more westerly locations such as New Caledonia, Vanuatu, and sites in Near Oceania, in addition to studying archaeological samples from additional East Polynesian sites. Only through continued genetic analyses of *R. exulans* remains from a range of archaeological sites throughout the Pacific Ocean will we potentially identify the source of these mystery sequences.

In conclusion, results of analyses of genetic variation in *R. exulans* remains from Emily Bay, Norfolk Island are consistent with other archaeological evidence suggesting links between Norfolk, New Zealand and East Polynesia. However, several samples have mtDNA sequences that have not yet been identified in East Polynesian populations. This may suggest a link between Norfolk, New Zealand and a third region that we have not yet been able to identify.

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Avifauna from the Emily Bay Settlement Site, Norfolk Island: A Preliminary Account

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ABSTRACT. The avifauna of the Emily Bay settlement site, Norfolk Island, southwest Pacific, is described. Most of the remains, which consisted of nearly 10,000 identifiable bones (mostly fragmentary) and several thousand unidentifiable elements and fragments, were of several species of petrel and shearwater (Procellariiformes) and boobies (Sulidae), but some land birds were also represented in small numbers. Two species of migratory wading bird (Charadriiformes) were identified in the deposits, but no terns, which are dominant members of the present avifauna. The taphonomy of the remains indicates intensive use of birds as food, but some material of other than cultural origin was also present. Remains were not distributed evenly throughout the excavated parts of the site, and were concentrated in areas where other evidence such as post holes and fires scoops indicated points of occupation. Some species that are present on the island and palatable were not represented in the collections: possible reasons for their absence are canvassed. An estimate of the biomass is presented, with the proviso that the variation in density of deposition made extrapolation to the remainder of the site problematic. The size of the sample, the preservation of elements such as vertebrae of small petrels, and the good condition of material of apparent natural (non-cultural) origin indicate that the collection represents a good sample of the avifauna used as food by the Polynesian inhabitants of Emily Bay.

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Norfolk Island is one of the "mystery islands" of the South Pacific that has evidence of former human occupation, but which had been abandoned by its Polynesian inhabitants before European discovery (Kirch, 1988). Even the most apparently pristine of these islands usually has evidence of the use of natural resources such as birds, and often of the extinction of a range of bird species (Steadman and Olson, 1985). The ability of such islands to sustain a human population in the long term has been questioned (Kirch, 1988; Anderson, in press), because of the probable scarcity of food resources. Faunal remains in archaeological sites on the islands can reveal much about the interaction of people and pristine environments.

Norfolk Island is at the southern edge of the sub-tropics. The nearest substantial land masses are Lord Howe Island (900 km to the southwest), New Caledonia (700 km to the north), New Zealand (800 km to the southeast), and the Kermadecs (1300 km to the east): Australia is 1300 km to the west. The Norfolk Island group is so placed that it has an avifauna with links to all the surrounding faunal regions, the Australian, New Zealand, and Pacific faunas (Holdaway *et al*., 2001). In particular, the seabirds breeding on the group are a mixture of species from the sub-tropical and tropical Pacific and from the cooler waters around the northern part of New Zealand. The Norfolk Island group is the only available nesting ground for seabirds over a substantial area of ocean.

Seabirds (petrels, sulids, and terns) are the most conspicuous component of the present-day avifauna. There are, however, no gulls or cormorants and most littoral birds are migratory visitors or rare vagrants. There was little open land and no large permanent areas of fresh water before Europeans dammed two small streams at Kingston and The Cascades. A large area of swamp behind the beach at Slaughter Bay was recorded as being open land by the first Europeans to land on that side of the island in 1788. Temporary pools of water and wet grassland on Kingston Common provide the largest area of habitat for wading birds on the island today (Wakelin, 1968; Schodde *et al*., 1983).

In contrast to the marine species, most of which bred over large areas of the South Pacific and beyond, the few Norfolk Island land birds are mostly endemic (Holdaway *et al*., 2001). Norfolk Island is remote enough from adjacent sources of terrestrial birds to have received only occasional successful colonizations of terrestrial birds. As the islands are about 3 million years old, there has been sufficient time for distinctive species to evolve in several groups, including rails, pigeons, parrots, and passerines.

The present fauna is relict, following the extinction of some taxa (such as *Pterodroma pycrofti*) after Polynesian settlement, and further losses (such as *Nestor productus* and *Lalage leucopyga*) in the nineteenth and twentieth centuries after the establishment of a series of European settlements. Fossil deposits of late Quaternary age containing bird remains are known from both natural and archaeological contexts in the Kingston area, on the southern side of Norfolk Island itself, and on Nepean Island about 1 km off the southern coast (Meredith, 1985, 1991; Anderson, 1996).

Bird remains have been found in archaeological deposits of two ages: a Polynesian site at Emily Bay (Anderson, 1996), and in a First (European) Settlement site dating from the late 1790s. The First Settlement site contained many petrel bones (Meredith, 1985). Some of those which were retained in the Commissariat Museum at Kingston, Norfolk Island, were examined in December 1995. During a famine arising from the wreck of the supply ship HMS *Sirius* at the island in March 1790, the convicts, military, and free settler population relied on the birds for sustenance until supplies could be obtained from the host colony at Sydney (Hoare, 1987).

The present analysis is based on bird fossils collected during archaeological investigations of the Polynesian site at Emily Bay. This was discovered in December 1995 (Anderson, 1996), and further, more extensive, excavations took place in the same area in 1996 and 1997, resulting in the retrieval of the large amount of mainly fragmentary avian material that is discussed here. The analysis deals with collections from Trenches EB96:10, EB96:11, EB97:21, EB97:22, EB97:23, and EB97:24 in Emily Bay. Distribution of material is presented for the largest collection, that from Trench EB97:23. The composition of the archaeological avifauna is reported and discussed both in the contexts of the past and present avifauna of the island and of the resource that the birds represented to the Polynesian population.

People are part of an island ecosystem but they also interact with the ecosystem in different ways than other species, especially on islands with no history of human occupation. A point of major consequence for faunal analysis of archaeological deposits is that people interact with living birds and whole avifaunas, not with the bones that remain as evidence of the interaction. Hence, this preliminary analysis of the avifaunal remains associated with the archaeological deposit at Emily Bay, Norfolk Island goes some way beyond simple lists of bones and species. The differences in composition between an archaeological fauna and that of the total avifauna of the island can provide information such as the fowling strategy of the people, their food preferences (Worthy, 1998), and the time of year that the site was occupied. To that end, some attention is paid here to the breeding season of the species that are best represented in the deposits, and of the likely season of passage or residence of migrants.

Before the archaeological avifauna can be compared with the original avifauna, the composition of that original fauna must be known. For Norfolk Island, determining which species bred there at the time of Polynesian contact is made more difficult by extinctions that occurred both before and after the first written records were made in the late eighteenth century. To provide a basis for the inclusion or exclusion of species from the avifaunal list, problems of identification of fossil material and background information on the identification of species known from early European records are dealt with in some detail in the Appendix to this paper.

The Appendix also discusses the present distributions of species, which can also provide clues as to the identification of species. Breeding distributions that enclose but do not include Norfolk Island suggest that some species might have been part of the Norfolk Island fauna, whereas others whose distributions are marginal might be less likely to have bred there in the past.

Extinctions are important because they indicate the possible effects of human impact on the Norfolk Island environment, and also have a major bearing on the identification of the species in fossil deposits. Extinctions are part of the process of human interactions with the environment throughout the history of the Pacific (Steadman, 1997) and so the loss of species that people used for food, and those that went extinct in the same period but for which there is no archaeological record of human exploitation, are also discussed.

Methods

The excavation and collection techniques are described in Anderson (1996), and Anderson, Smith and White (this vol.). Material was identified to species using morphological characters if preserved, otherwise the material was taken to the lowest taxonomic rank that could be supported (e.g., *Pterodroma* petrel, or “other petrel” which included petrels such as *P. neglecta* and *P. solandri* which are larger than *P. pycrofti* as well as *Puffinus assimilis*—see below), or left as unidentified. Minimum numbers of individuals (MNI) were determined for each taxon in each spit of each square, using the maximum number of ipsilateral examples of the commonest element. Crude estimates of biomass were developed from the total numbers of individuals of each species or taxonomic group, to give an order of magnitude assessment of the resource represented in each excavated area. Note that this calculation gives the greatest MNI and biomass; quantification by layer or trench would reduce the numbers considerably (cf. Table 1; Fig. 2, *above*).

Comparative material. Identifications were made with reference to voucher specimens in the Museum of New Zealand Te Papa Tongarewa (MNZ: Wellington, New Zealand) and the Canterbury Museum (CM: Christchurch, New Zealand). There is little skeletal material for some of the most significant species of petrel expected in the Norfolk Island deposits. In particular, only three specimens of *Pterodroma solandri* (MNZ S23504; and two unregistered individuals in MNZ, and three of *Pterodroma neglecta* (MNZ S23720, CM Av 5201 and Av 27263 were available. The paucity of material contributed to the difficulty of identification of petrel remains. A full study of natural material from the island in conjunction with a satisfactory comparative collection will be necessary before the present group taxon "other petrels" can be re-analysed with confidence. Meredith (1985, 1991) has provided a useful baseline but present knowledge of the South Pacific petrel fauna is insufficient to justify confidence in identification of the medium-sized petrels of the group.

Material consulted included representatives of all relevant species held in MNZ, and the following specimens from CM: *Puffinus bulleri* (Av36803), *Puffinus gavia* (Av12158), *Gallirallus philippensis* (Av36805), *Gallirallus australis* (Av5187), *Porphyrio porphyrio* (Av22392), *Coenocorypha huegeli* (Av5200), *Limosa lapponica* (Av36583), *Cyanoramphus novaezelandiae* (Av5163), *Cyanoramphus auriceps* (Av5194), *Nestor meridionalis* (Av9956), *Ninox novaeseelandiae* (Av22387), and *Eudynamys taitensis* (Av14854). The archaeological material from Emily Bay will be accessed to the collections of the Norfolk Island Museum.

Biomass. Body masses cited are from Heather and Robertson (1996) or Marchant and Higgins (1990). For large petrels, a mean body mass of 500 g was assumed, the normal mass of the three largest species. As most of the animal appears to have been consumed, including much of the bone (and presumably the viscera), the total meat mass was taken to be the normal body mass. The estimate is therefore high by an unknown amount. The total amount of avian biomass represented in the excavations was calculated and extrapolated to the whole Emily Bay site.

"Natural" versus "archaeological" deposits. The distinction is made between "natural" and "archaeological" deposits, as a convenient shorthand to describe the taphonomic processes involved in the development of the deposit. While there is clearly a case for considering humans to be a natural part of the environment, the distinction is useful not least because non-archaeological ("natural") deposits can be formed by several different processes. Not all of these are immediately obvious, and each involves its own biases. "Natural" deposits are formed regardless of human presence. For example, much of the "natural" fossil material on Norfolk Island appears to have been accumulated beneath feeding stations of the one or more species of *Accipiter* that once lived there (RNH, unpubl. data). It is therefore biased by the time of hunting, maximum and minimum prey size, agility of prey, and probably other factors including preferences of individual predators. Other bones were preserved as a result of mortality unrelated to predation, such as burrow collapse or pathology. In contrast to the variety of possible origins of the "natural" fossil avifauna, the "archaeological" material was assembled as a result of by a single process, the collection of birds by people for food or other resources. That material yields information on the choices of prey by people, and other factors, such as seasonality, which are useful in reconstructing human associations with the environment.

The term "petrel" is used for brevity in the broad sense of all Procellariiformes and includes shearwaters, species of *Pterodroma*, and other genera that may have been present in the past. As well as the unknown range of species that may be involved and the paucity of comparative material for many, and the fragmentary nature of almost all the petrel (and other) material from the archaeological deposit, the catch-all headings serve the purpose of archaeological analysis while not conveying a false sense of exactitude in identification. Only *P. pycrofti* was determined to species, on the basis of size for small fragments. The term "other petrel" indicates all the other species of petrel that bred on Norfolk Island, which were known to be present in the archaeological fauna, but which could not be positively identified regularly enough for quantitative analysis. Sufficient elements of these other petrels could be identified to species with greater or lesser confidence, to support their inclusion in the list of species counted as present in the deposit.

Results

General. A total of 8699 bones and bone fragments was identified to taxon (20 fragments of *Sula dactylatra* were not included in the determination of MNI and are not included in tabulated values); at least that number again of unidentified fragments and small elements such as vertebrae was also examined. For example, in Square E12 in Trench EB97:23, there were 155 identifiable elements, representing a minimum of 27 individuals, but there were 145 elements such as quadrates, vertebrae, and fragments that could not be certainly assigned to taxon within the constraints of the present study. The bird bone collection also contained material of the Pacific rat *Rattus exulans*, and fish, which had been hidden among the bulk of the fragmentary bird bones.

Preservation/taphonomy. The presence of large numbers of small, fragile elements, and the occasional cranium or other fragile elements demonstrated that the preservation conditions were optimal for small bird bones. Most of the damage to material that caused difficulties of identification resulted from modification by human activities such as heating, burning, breakage during dismemberment of the carcass, and chewing. Immature bones were more affected than adult bones. Some avian material, particularly in Trench EB97:24, was clearly of natural origin and showed no sign of human handling. Some of the "natural" material was recorded as having been deposited in posthole features or burrows and appears to post-date Polynesian occupation of the site. Some elements showed signs of damage by an avian predator (either the owl *Ninox novaeseelandiae* or goshawk *Accipiter* cf. *A. fasciatus*), on the basis that the damage was similar to that characteristic of butchering by accipitrid hawks, as observed in material from natural sites in New Zealand whose accumulation has been attributed to the extinct harrier *Circus eylesi* (RNH, unpubl. data).

Complete bones, particularly long bones, were rare. Most individuals were represented by proximal humeri, fragmentary coracoids, anterior sterna, furcular symphyses, proximal scapulae, or distal tibiotarsi or tarsometatarsi. Most MNI were based on the proximal humeri and coracoids for *Pterodroma pycrofti* and on coracoids and fragments of coracoids for the other petrels. The waders were best represented by coracoids (*Pluvialis fulva*) and distal tarsometatarsi (*Limosa lapponica*). Of the two largest common terrestrial species, the most common distinguishing elements were the coracoid and distal tibiotarsus for the large parrot *Nestor productus* and the coracoid for the pigeon *Hemiphaga spadicea*. Two taxa that differed from the pattern were *Sula dactylatra* and *Accipiter* cf. *A. fasciatus*: the first was best represented by fragments and vertebrae, and most hawk elements were pedal phalanges, fibulae, and distal tibiotarsi. These remains made estimates of numbers of individuals suspect as the smaller, more numerous bones in the body may have been widely spread through the site.

Emily Bay bird sample. The number of identifiable elements and minimum numbers of individuals (MNI) of taxa represented in the archaeological collections from Trenches EB96:10, EB96:11, EB97:21, EB97:22, EB97:23, and EB97:24 at Emily Bay, Norfolk Island are shown in Table 1. The 14 taxa or group taxa (e.g., “other petrels”) differed in their proportions in the samples (Table 2). “Other petrels”, *Pterodroma pycrofti* and the Norfolk Island pigeon (*Hemiphaga spadicea*) contributed most individuals (Table 1) and elements (Table 3). Their representation in the smallest sample (Trench EB97:21) was skewed in comparison to those in the larger samples and reflects the heterogeneity of the distribution of material throughout the site. The heterogeneity within a large part of the area (Trench EB97:23) was marked, both in terms of elements (Fig. 1) and individuals (Fig. 2). Most squares in Trench EB97:23 had fewer than 100 elements (Fig. 3, above) and fewer than 20 individuals (Fig. 3, below). Squares D10, D13, and E10 in Trench EB97:23 contained the greatest concentration of bones (Fig. 1, below).

The concentrations of material appear to coincide with the location of post-holes and a fire scoop (Anderson, Smith and White, this vol.). Six of the 42 squares contained most of the elements, and three, most of the individuals. The heterogeneity of the distribution within Trench EB97:23 shows that estimates of concentration over the whole Emily Bay area must take into account the clumping of dense deposits amid a much lower density of material over most of the site. Squares D10, D13, and E10 in Trench EB97:23 contained the greatest numbers of identifiable individual birds (Fig. 1, above).

Table 1. Minimum number of individuals (*above*) and number of identified bones (*below*) for each taxon or group of taxa in each excavation in Emily Bay. Totals in parentheses are MNI calculated on representation in all trenches combined (every element potentially from same bird regardless of position in excavated area).

	trench						
	EB96:10	**EB96:11**	**EB97:21**	**EB97:22**	**EB97:23**	**EB97:24**	**totals**
Pterodroma pycrofti	8	3	3	3	108	25	150 (141)
	79	19	9	17	980	276	1380
other petrels and shearwaters	47	6	1	9	663	89	815 (807)
	356	52	2	42	5599	544	6595
Limosa lapponica	2	2	—	—	12	8	24 (23)
	13	8	—	—	112	59	192
Pluvialis fulva	1	2	1	1	8	5	18 (13)
	1	8	2	3	41	47	102
Nestor productus	2	2	—	—	2	1	7 (3)
	3	3	—	—	9	6	21
Hemiphaga spadicea	5	2	—	1	28	12	48 (46)
	19	4	—	2	136	40	201
Sula dactylatra	2	2	—	1	16	5	26 (25)
	4	7	—	2	82	18	113
Gallirallus Norfolk	—	—	—	1	3	—	4 (3)
	—	—	—	1	6	—	7
Cyanoramphus novaezelandiae	—	1	1	—	4	2	8 (5)
	—	3	1	—	12	4	20
passerines	1	1	—	—	2	2	6 (3)
	1	1	—	—	9	10	21
Gallirallus cf. *G. philippensis*	1	—	—	—	2	1	4 (3)
	2	—	—	—	6	1	9
Accipiter cf. *A. fasciatus*	—	—	—	1	1	—	2 (1)
	—	—	—	1	8	—	9
Gallicolumba cf. *G. norfolciensis*	—	—	—	—	1	—	1 (1)
	—	—	—	—	2	—	2
Porphyrio sp.	—	—	—	—	2	—	2 (2)
	—	—	—	—	7	—	7
total	69	21	6	17	852	150	1115
	478	105	14	68	7009	1005	8679

Table 2. Percentage of individuals in each excavation represented by each taxon or group of taxa.

	trench						
	EB96:10	**EB96:11**	**EB97:21**	**EB97:22**	**EB97:23**	**EB97:24**	**total**
Pterodroma pycrofti	11.6	14.3	50.0	17.6	12.7	16.7	13.5
other petrels	68.1	28.6	16.7	52.9	77.8	59.3	73.1
Limosa lapponica	2.9	9.5	0	0	1.4	5.3	2.2
Pluvialis fulva	1.4	9.5	16.7	5.9	0.9	3.3	1.6
Nestor productus	2.9	9.5	0	0	0.2	0.7	0.6
Hemiphaga spadicea	7.2	9.5	0	5.9	3.3	8.0	4.3
Sula dactylatra	7.2	9.5	0	5.9	1.9	3.3	2.6
Gallirallus Norfolk	0	0	0	5.9	0.4	0	0.3
Cyanoramphus novaezelandiae	0	4.8	16.7	0	0.5	1.3	0.7
passerines	1.4	4.8	0	0	0.2	1.3	0.5
Gallirallus cf. *G. philippensis*	1.4	0	0	0	0.2	0.7	0.4
Accipiter cf. *A. fasciatus*	0	0	0	5.9	0.5	0	0.2
Gallicolumba cf. *G. norfolciensis*	0	0	0	0	0.1	0	0.01
Porphyrio sp.	0	0	0	0	0.2	0	0.02

Patterns of representation of taxa within the site. *Pterodroma pycrofti* was found in 76 (87.4%) of the squares; other species of petrel were found in 78 squares (89.7%). Least common were the Norfolk Island Ground Dove (*Gallicolumba* cf. *G. norfolciensis*) and Swamphen (*Porphyrio* species), elements of which were found in three squares only.

Squares contained up to 11 taxa, with the mode at seven (Fig. 4). The bimodality of the distribution results from the greater abundance of material in squares in Trench EB97:23, and the greater chance of finding more species in a larger sample; the lower tail of the distribution reflects the small number of species in the poorer parts of the deposit.

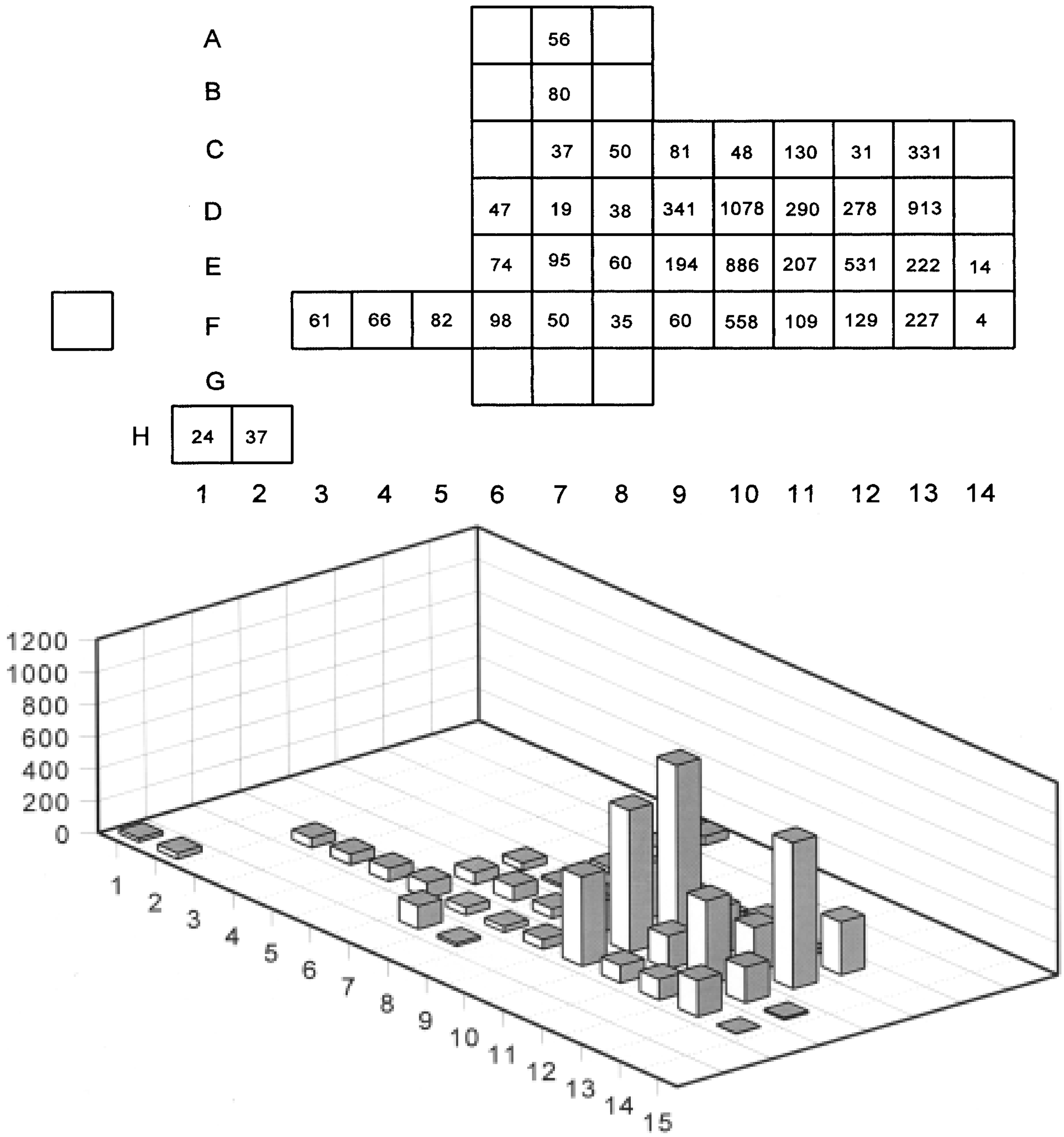
Biomass. Calculations of body mass represented by the individuals of the different taxa are given in Table 4, percentages of total biomass by trench in Table 5. By far the greatest contribution to biomass was by the petrels, over 80% when *Pterodroma pycrofti* are pooled with "other petrels". The Booby *Sula dactylatra* (Sulidae) contributed significantly to the total biomass because of its greater individual mass, although it was difficult to assess the total numbers concerned because many examples were juvenile and hence more poorly preserved.

All other taxa combined contributed less than 10% of the biomass represented in the site. Of the terrestrial species, only the Norfolk Island Pigeon *Hemiphaga spadicea* was important in the diet. Apparently vulnerable and palatable species such as the flightless Norfolk Island Rail and the Norfolk Island Kaka contributed less than the more common of the two migrant wading birds (*Limosa lapponica*). The smaller species contributed negligible amounts to the total biomass and were not favoured prey. The rarity or absence of some palatable species (such as snipe and rails) and of other species that might have been used for ornament, if not for food, is noteworthy. In view of the common presence of strongly flying species such as the two migrant waders, the absence of snipe, for example, begs the question of availability during the period of occupation.

The absence of terns from the sample might be explained by the very small meat content of the species present, and the fact that all but the Sooty Tern (*Sterna fuscata*) nest in trees. Sooty Terns breed on beaches or open ground, and lack of open areas in Polynesian times except for the beaches in the Kingston area (which were subject to disturbance by people), suggests that Sooty Terns might not have bred in

Table 3. Percentage of elements in each excavation represented by each taxon or group of taxa.

	trench						
	EB96:10	**EB96:11**	**EB97:21**	**EB97:22**	**EB97:23**	**EB97:24**	**total**
Pterodroma pycrofti	16.5	18.1	64.3	25.0	14.0	27.5	15.9
other petrels	74.5	49.5	14.3	61.8	79.9	54.1	76.0
Limosa lapponica	2.7	7.6	0	0	1.6	5.9	2.2
Pluvialis fulva	0.2	7.6	14.3	4.4	0.6	4.7	1.2
Nestor productus	0.6	2.9	0	0	0.2	0.6	0.2
Hemiphaga spadicea	4.0	3.8	0	2.9	1.9	4.0	2.3
Sula dactylatra	1.9	6.7	0	2.9	1.3	2.2	1.3
Gallirallus Norfolk	0	0	0	1.5	0.1	0	0.1
Cyanoramphus novaezelandiae	0	2.9	7.1	0	0.2	0.4	0.2
passerines	0.2	1.0	0	0	0.1	1.0	0.2
Gallirallus cf. *G. philippensis*	0.4	0	0	0	0.1	0.1	0.1
Accipiter cf. *A. fasciatus*	0	0	0	1.5	0.1	0	0.1
Gallicolumba cf. *G. norfolciensis*	0	0	0	0	<0.1	0	<0.1
Porphyrio sp.	0	0	0	0	0.1	0	0.1



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A							56							
B							80							
C							37	50	81	48	130	31	331	
D						47	19	38	341	1078	290	278	913	
E						74	95	60	194	886	207	531	222	14
F			61	66	82	98	50	35	60	558	109	129	227	4
G														
H	24	37												

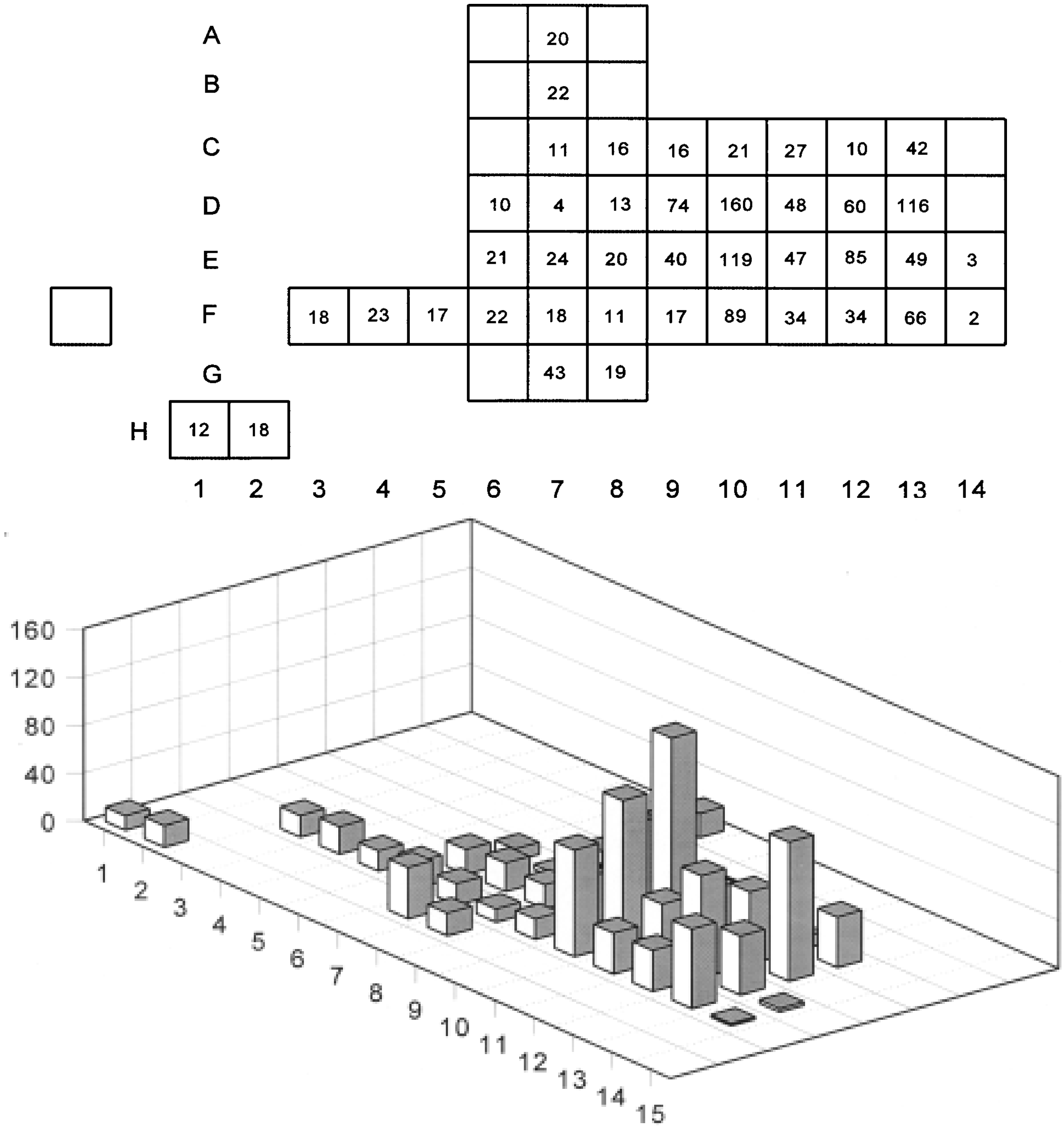
Figure 1. Plan of excavated squares in Trench EB97:23, Emily Bay, Norfolk Island, showing number of bird elements identifiable to taxon or taxon group, all spits in each square pooled (*above*). Isometric representation of number of identifiable bird elements in Trench EB97:23, Emily Bay, Norfolk Island, showing concentration of material in a few squares centred on D10–13 to F10–13 (*below*).

numbers on the main island in the past. In any event, larger species that were easier to catch were abundant in and near the occupation site. The archaeological sample is a subset of the breeding bird fauna: many species, particularly terns and tropicbirds, are not represented at all (Table 6).

Seasonality. Some impression of the time of year that the site was inhabited can be obtained from the composition of the faunal remains, most of which represent seabirds whose abundance on the island fluctuates greatly with the seasons. Many, including the most important taxa, were absent for at least half the year while on non-breeding migration to the Northern Hemisphere or elsewhere in the Pacific. Different taxa can be defined as summer- or winter-breeding. Two of the terrestrial species were also migratory, being present in the southern summer. The present status and usual breeding season of Norfolk Island birds are given in Table 6.

Systematic list of species represented in the Emily Bay settlement site

The following descriptions provide the mean individual body weight of live birds, the proportional distribution of remains in the excavations and pertinent zoological and behavioural information.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A							20							
B							22							
C							11	16	16	21	27	10	42	
D						10	4	13	74	160	48	60	116	
E						21	24	20	40	119	47	85	49	3
F			18	23	17	22	18	11	17	89	34	34	66	2
G							43	19						
H	12	18												

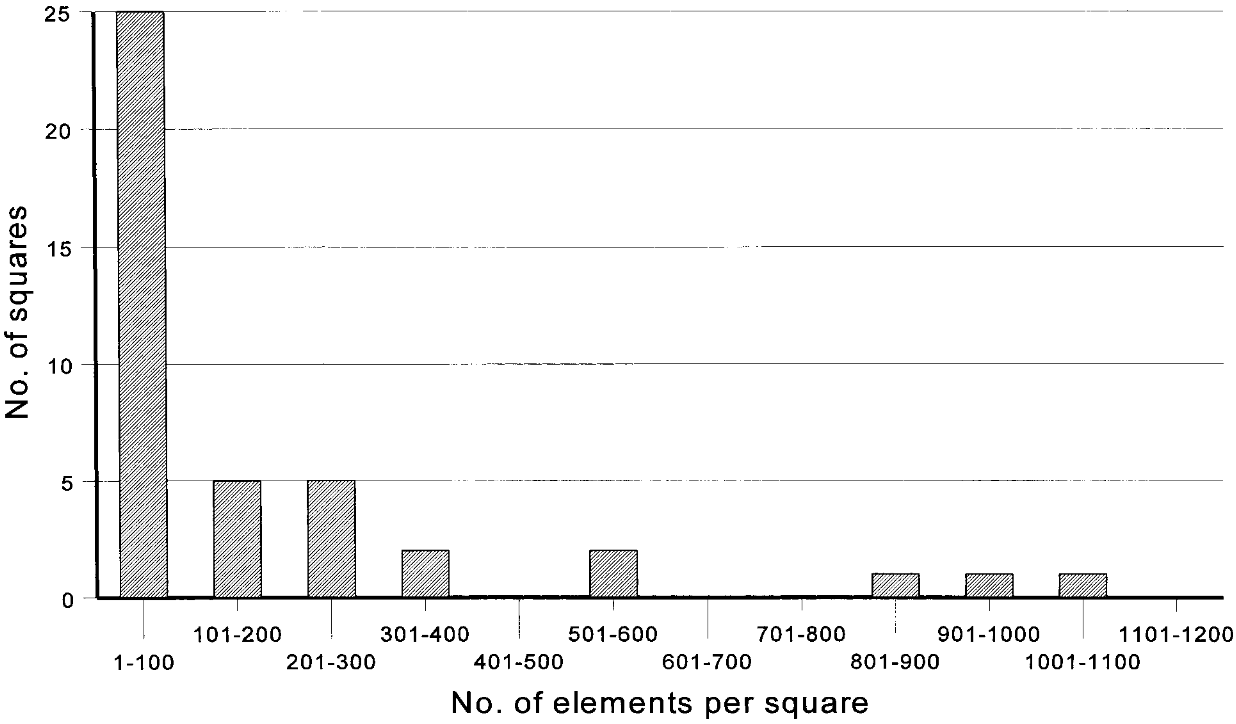
Figure 2. Plan of excavated squares in Trench EB97:23, Emily Bay, Norfolk Island, showing the minimum number of individuals represented by identifiable bones, all spits in each square pooled (*above*). Isometric representation of minimum number of individuals represented by identifiable bones in Trench EB97:23, Emily Bay, Norfolk Island, all spits in each square pooled. Individuals were also concentrated in one section of the excavation (*below*).

PROCELLARIIDAE—PETRELS AND SHEARWATERS (89.7% OF SQUARES)

Pterodroma pycrofti Pycroft's Petrel 160 g (87.4% of squares). The smallest petrel breeding in significant numbers on Norfolk Island. The history of its discovery is discussed in the Appendix.

Pterodroma solandri Providence Petrel or Solander's Petrel 500 g. These and the other petrels cannot be assigned a representation by square, because their records were necessarily pooled (see Methods and Appendix). At the time of European settlement, *P. solandri* seems to have been largely, if not entirely, confined to the forest on Mt Pitt and Mt Bates. Petrel bones of the size range of *P. solandri* are abundant in the archaeological collections from Emily Bay. Either the species had a wider geographical range on the island before Europeans arrived, or the Polynesians collected birds from farther afield on that island than the environs of the Kingston flat. *Pterodroma* petrels can be attracted to the ground from flight by making various loud sounds (Tennyson and Taylor, 1990) so it is impossible to tell from the presence of *P. solandri* in the Emily Bay site, just where the birds were nesting and being hunted in Polynesian times.

Pterodroma neglecta Kermadec Petrel 500 g. The Kermadec Petrel has not been recognized from Norfolk Island fossil deposits before, although it has now been recorded breeding on Philip Island (Moore, 1999). A



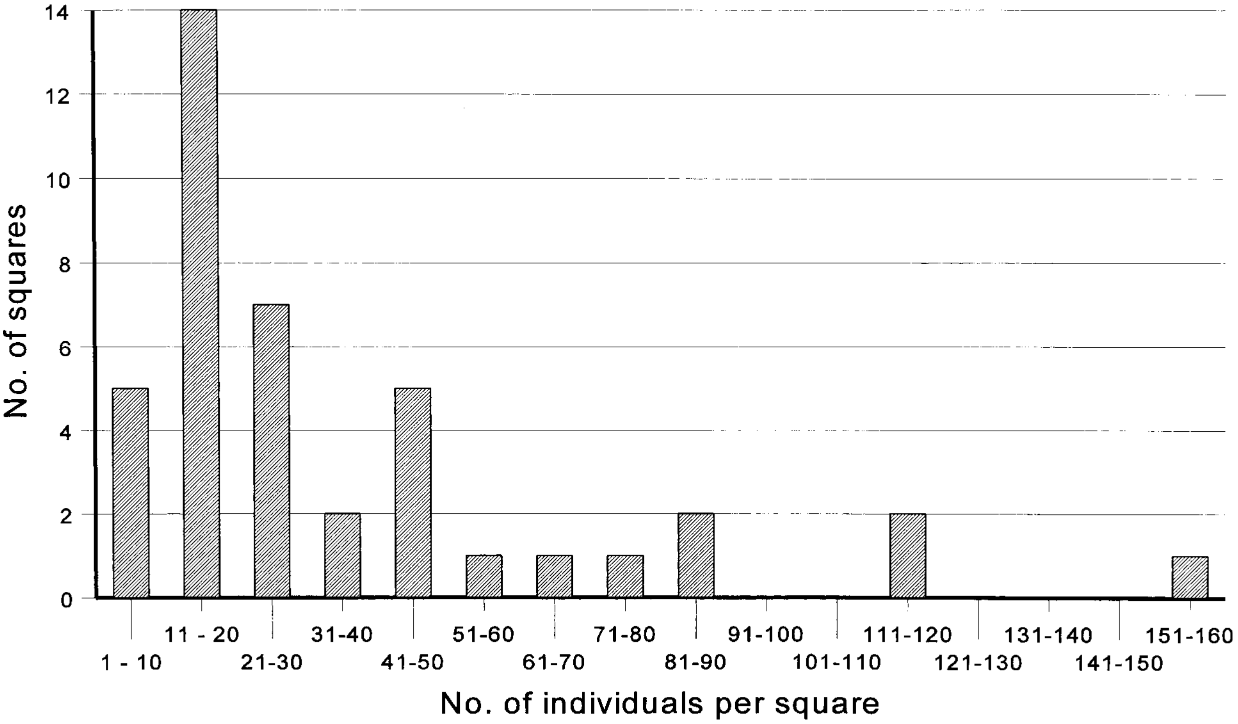


Figure 3. Pattern of distribution of identifiable elements per square in Trench EB97:23, Emily Bay, Norfolk Island (*above*). Pattern of distribution of individuals represented of identifiable elements per square in Trench EB97:23, Emily Bay, Norfolk Island (*below*).

summary of the reasons for including *P. neglecta* in the avifauna of Norfolk Island is given in the Appendix. The absence of reports of ground-nesting petrels in the notes and diaries of the first European settlers may result from the rarity of the species as a result of predation by Pacific rats, or because *P. neglecta* on Norfolk Island used different nest sites to those in other populations. Kermadec Petrels nest on the surface at the present colonies (Heather and Robertson, 1996), but at none of these sites are the birds hunted by diurnal birds of prey. On Norfolk Island at least one large raptor was capable of killing *P. neglecta*; a petrel population there would have had many thousands of years to adopt a burrowing habit.

Puffinus pacificus Wedge-tailed Shearwater 450 g. This is the common summer-breeding large petrel surviving on Norfolk Island. It still attempts to breed on headlands on the main island, but cats take many birds, and the population is probably declining. Although they could not be quantified, both adult and juvenile bones of *P. pacificus* were obviously abundant in the remains, supporting the view established

Table 4. Biomass (kg) represented by minimum number of individuals in each excavation at Emily Bay, based on normal body masses given in text.

	trench						
	EB96:10	**EB96:11**	**EB97:21**	**EB97:22**	**EB97:23**	**EB97:24**	**total**
Pterodroma pycrofti	1.28	0.48	0.48	0.48	17.28	4.0	24.0
other petrels	21.15	2.70	0.45	4.05	298.35	40.05	36.75
Limosa lapponica	0.6	0.6	0	0	3.6	2.4	7.2
Pluvialis fulva	0.13	0.26	0.13	0.13	1.04	0.65	2.34
Nestor productus	1.0	1.0	0	0	1.0	0.5	3.5
Hemiphaga spadicea	2.5	1.0	0	0.5	14.0	6.0	24.0
Sula dactylatra	3.4	3.4	0	1.7	27.2	8.5	44.2
Gallirallus Norfolk	0	0	0	0.25	0.75	0	1.0
Cyanoramphus novaezelandiae	0	0.075	0.075	0	0.3	0.15	0.6
passerines	0.09	0.09	0	0	0.18	0.18	0.54
Gallirallus cf. *G. philippensis*	0.17	0	0	0	0.34	0.17	0.68
Accipiter cf. *A. fasciatus*	0	0	0	0.5	0.5	0	1.0
Gallicolumba cf. *G. norfolciensis*	0	0	0	0	0.2	0	0.2
Porphyrio sp.	0	0	0	0	1.6	0	1.6
total	30.32	9.61	1.14	7.61	366.34	62.6	477.61
biomass m^{-2}	2.76	3.2	0.19	7.61	8.76	2.72	5.55

by the presence of migratory wading birds that part of the deposit was laid down in summer. *Puffinus pacificus* is migratory in the opposite sense to the Bar-tailed Godwit and Golden Plover, breeding on the islands and migrating to the North Pacific in the southern winter. They are large and aggressive petrels and are not known to be attracted to strange noises so must have been collected at the breeding colonies.

Puffinus assimilis Norfolk Island Little Shearwater 200 g. Holdaway *et al*. (2001) recognize the Norfolk Island form of little shearwater as a separate species from others at the Kermadecs, northern New Zealand, and the New Zealand subantarctic. On this view, *P. assimilis* is a rare and endangered species, as most breeding attempts on the main island are thwarted by cats and rats. Only the population breeding on Philip Island has both the space and freedom from predation to be sure of survival in the medium to long term. Although this species is not abundant in the archaeological samples, *P. assimilis* was certainly part of the diet of the Emily Bay people. Both *P. assimilis* and the similar-sized *P. auricularis newelli* may have bred on the island formerly (Appendix). Their size makes both species vulnerable to predation by Pacific rats (Booth *et al*., 1996) and hence they may have suffered more from rat predation than from human exploitation when there were larger species to concentrate on.

SULIDAE—GANNETS AND BOOBIES

Sula dactylatra Masked Booby 1700 g (73.6% of squares). Boobies were the largest terrestrial prey available on the Norfolk Island group. It is not surprising that they were relatively common in the deposit (26 individuals; 2.6% of total birds; 9.25% total body mass). At about four times the mass of a large petrel, the boobies would have been attractive and easy prey. At first contact, it is likely that *S. dactylatra* nested on open, flat areas such as the tops of stacks (to which they are largely confined today by human persecution) and on the sandy beaches so would have been extremely vulnerable. It is unlikely that beach colonies of *S. dactylatra* could have survived the first year of human occupation of Norfolk Island. Masked Boobies elsewhere

Table 5. Percentage of biomass contributed by each taxon or group of taxa in the excavations at Emily Bay.

	trench						
	EB96:10	**EB96:11**	**EB97:21**	**EB97:22**	**EB97:23**	**EB97:24**	**total**
Pterodroma pycrofti	4.22	5.00	42.29	6.31	4.72	6.39	5.03
other petrels	69.76	28.11	39.65	53.22	81.44	63.98	76.79
Limosa lapponica	1.98	6.25	0	0	0.98	3.83	1.51
Pluvialis fulva	0.43	2.71	11.45	1.71	0.28	1.04	0.49
Nestor productus	3.30	10.41	0	0	0.27	0.80	0.73
Hemiphaga spadicea	8.25	10.41	0	6.57	3.82	9.58	5.03
Sula dactylatra	11.21	35.40	0	22.34	7.42	13.58	9.25
Gallirallus Norfolk	0	0	0	3.29	0.20	0	0.21
Cyanoramphus novaezelandiae	0	0.78	6.61	0	0.08	0.24	0.13
passerines	0.30	0.94	0	0	0.05	0.29	0.11
Gallirallus cf. *G. philippensis*	0.56	0	0	0	0.09	0.27	0.14
Accipiter cf. *A. fasciatus*	0	0	0	6.57	0.14	0	0.21
Gallicolumba cf. *G. norfolciensis*	0	0	0	0	0.05	0	0.04
Porphyrio sp.	0	0	0	0	0.44	0	0.34

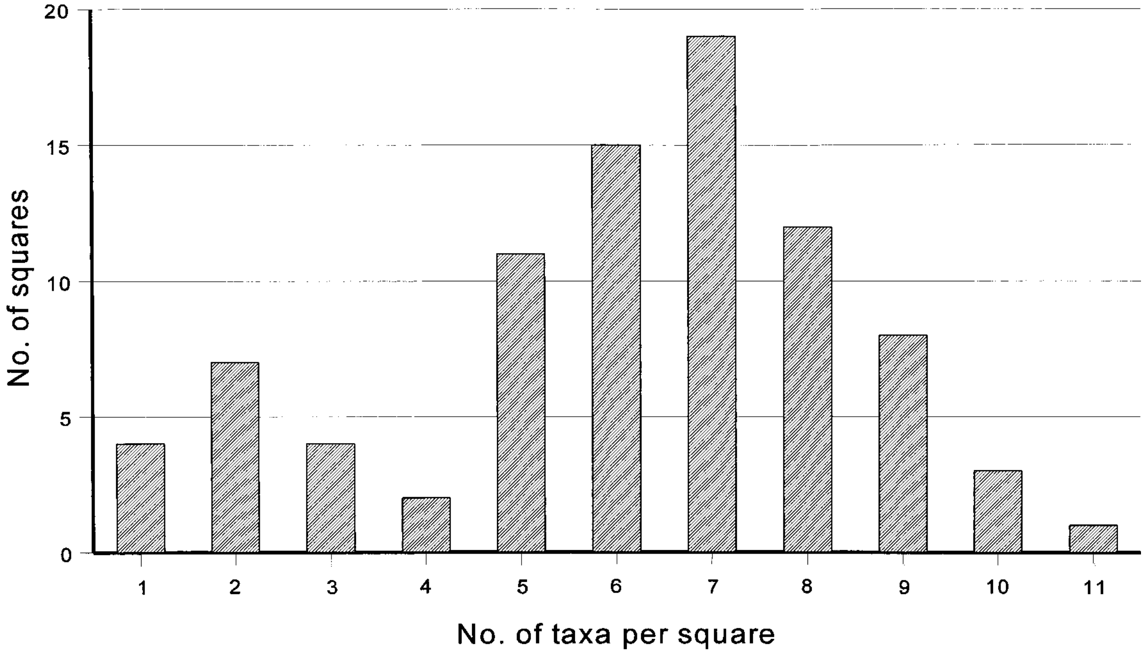


Figure 4. Distribution of taxa in squares in Trenches EB96:10, EB96:11, EB97:21, EB97:22, EB97:23, and EB97:24, Emily Bay, Norfolk Island.

nest mainly on low islands and amid dunes (Serventy *et al.*, 1971). A larger species described from the island is not accepted here (Appendix).

PHAETHONTIDAE—TROPICBIRDS

Only *Phaethon rubricauda*, the Red-tailed Tropicbird at 900–1,000 g approached the mass of a Masked Booby. At twice the mass of a large petrel, and in relative abundance around the islands, it is surprising that Red-tailed Tropicbirds do not figure in the food remains. Their tails are highly prized elsewhere in Polynesia (Steadman, 1997) and it might have been expected that some birds would have been taken for that purpose, but if so their remains were not found at the Emily Bay site.

ACCIPITRIDAE—HAWKS AND EAGLES

Accipiter cf. *A. fasciatus* Brown Goshawk 350–500 g (9.2% of squares). Remains of the goshawk were rare in the site, but most had clearly been cooked and eaten. Remains of harriers (*Circus* species) are occasionally found in Polynesian sites in New Zealand and appear to have been eaten there as well.

RALLIDAE—RAILS

Gallirallus philippensis Banded Rail 170 g (9.2% of squares). The status of the Banded Rail on Norfolk Island has been the subject of debate (e.g., Schodde *et al.*, 1983), but fossil remains reported by Meredith (1985, 1991) and in this paper show that it was present in pre-European times in sufficient numbers for it to be available as a resource for the Polynesian inhabitants. It was therefore sympatric with the undescribed endemic flightless species of *Gallirallus* and was possibly a relatively recent arrival.

Gallirallus new species ?250 g (5.7% of squares). Meredith (1985, 1991) reported the presence of a rail larger than *Gallirallus philippensis* in fossil collections from Norfolk Island, but did not describe or name it. He referred it to *Gallirallus* and suggested that it was flightless. A rail painted during the first European settlement of Norfolk Island (no. 79 in the "Sydney" series, Hindwood, 1965) has been identified as *G. philippensis* but could equally be this species.

Porphyrio species Swamphen 800 g (3.4% of squares). Races of *Porphyrio porphyrio* and other species of *Porphyrio* are widespread in the Pacific (Ripley, 1977; Steadman, 1988). Ramsay (1888) was the first to record Swamphens (*Porphyrio porphyrio*) on Norfolk Island in historic times. By 1978 the species was still regarded as an "uncommon, restricted self-introduced resident" (Schodde *et al.*, 1983). Meredith (1985, 1991) did not record fossil material of *Porphyrio*. A few bones of a small *Porphyrio* found in Trench EB97:23 constitute the only evidence for the former presence of Swamphens on the island. Unfortunately, there is insufficient material for a statistical analysis, but comparison with an individual of the New Zealand population suggests that the Norfolk Island *Porphyrio* were smaller than New Zealand birds and perhaps more similar to the small races of the islands to the north than to the Australian and New Zealand forms. The presence of more than one individual of *Porphyrio* at the Emily Bay site indicates the presence of a population and hence that suitable habitat for the species was present during the Polynesian occupation.

Norfolk Island had at least four species of rail, a high diversity of rails for its area. Besides the three discussed here, the Spotless Crake (*Porzana tabuensis*) was also present (Meredith, 1991, and Appendix).

SCOLOPACIDAE—SNIPE AND GODWIT

Limosa lapponica Bar-tailed Godwit 300 g (65.5% of squares). *Limosa lapponica* migrates each year from the breeding area on the Siberian tundra to wintering grounds that include the estuaries of New Zealand. They occur on Norfolk Island from September to March (Schodde *et al.*, 1983). The number of individuals in the Emily Bay deposit

Table 6. The late Holocene avifauna of Norfolk Island, with representative body mass (g), present status at Norfolk Island, representation in the Emily Bay archaeological site, and breeding season. EB, present in the Emily Bay fauna; *E*, now extinct as a breeding species.

		mass	**status**	**EB**	**season**
Procellariidae (petrels and shearwaters)					
Pterodroma neglecta	Kermadec Petrel	500	recolonizing	Y	all year
Pterodroma solandri	Providence Petrel	500	recolonizing	Y	Winter
Pterodroma pycrofti	Pycroft's Petrel	160	extinct	Y	Summer
?*Pterodroma nigripennis*	Black-winged Petrel	175	?recolonizing		Summer
Puffinus pacificus	Wedge-tailed Shearwater	450	breeding	Y	Summer
Puffinus assimilis	Norfolk Island Little Shearwater	200	breeding		Winter
Hydrobatidae (storm petrels)					
Pelagodroma albiclunis	Kermadec Storm Petrel	45	extinct		Summer
?*Fregetta grallaria*	White-bellied Storm Petrel	50	?extinct		late Summer
Sulidae (gannets and boobies)					
Sula dactylatra	Masked Booby	1700	breeding	Y	all year
Phaethontidae (tropicbirds)					
Phaethon rubricauda	Red-tailed Tropic Bird	c. 900	breeding		Summer
Accipitridae (hawks and eagles)					
Accipiter cf. *A. fasciatus*	?Brown Goshawk	500	extinct	Y	?
Rallidae (rails)					
Gallirallus undescribed sp.	Norfolk Island Rail	250?	extinct	Y	?
Gallirallus philippensis	Banded Rail	170	vagrant	Y	Summer
Porzana tabuensis	Spotless Crake	45	*E*, vagrant		Summer
Porphyrio sp.	Swamphen	800	extinct	Y	Spring–Summer
Scolopacidae (snipe and godwits)					
Coenocorypha undescribed sp.	Norfolk Island Snipe	100	extinct		Summer
Limosa lapponica	Bar-tailed Godwit	300	migrant	Y	Summer
Numenius phaeopus	Whimbrel	450	migrant		Summer
Charadriidae (dotterels and plovers)					
Pluvialis fulva	Pacific Golden Plover	130	migrant	Y	Summer
Laridae (gulls and terns)					
Sterna fuscata	Sooty Tern	210	breeding		Spring–Summer
Anous stolidus	Common Noddy	200	breeding		Spring–Summer
Anous minutus	Black Noddy	100	breeding		Spring
Procelsterna cerulea	Grey Ternlet	75	breeding		Spring
Gygis alba	White Tern	110	breeding		Spring
Columbidae (pigeons and doves)					
Hemiphaga spadicea	Norfolk Island Pigeon	650	extinct	Y	all year?
Gallicolumba cf. *G. norfolciensis*	Norfolk Island Ground Dove	200?	extinct	Y	?
Psittacidae (parrots and parakeets)					
Cyanoramphus novaezelandiae cookii	Norfolk Island Green Parrot	75	endangered	Y	Spring–Summer
Nestor productus	Norfolk Island Kaka	400	extinct	Y	Summer
Cuculidae (cuckoos)					
Eudynamys taitensis	Long-tailed Cuckoo	125	migrant		Summer
Strigidae (typical owls)					
Ninox novaeseelandiae	Southern Boobook	175	endangered		Summer
Alcedinidae (kingfishers)					
Halcyon sancta	Sacred Kingfisher	65	breeding		Summer
Songbirds					
Campephagidae (trillers)					
Lalage leucopyga	Long-tailed Triller	50?	extinct		?
Muscicapidae (northern flycatchers)					
Turdus poliocephalus	Grey-headed Blackbird	90?	extinct		Spring?
Pachycephalidae (thickheads)					
Pachycephala pectoralis	Golden Whistler	50?	breeding		Spring?
Acanthizidae (flyeaters)					
Gerygone modesta	Norfolk Island Gerygone	6.5	breeding		Spring?
Monarchidae (monarch flycatchers)					
Rhipidura fuliginosa	Grey Fantail	8	breeding		Spring?
Petroicidae (southern robins)					
Petroica multicolor	Pacific Robin	11	breeding		Spring?
Zosteropidae (silvereyes)					
Zosterops tenuirostris	Slender-billed White-eye	15	breeding		Spring?
Zosterops albogularis	White-chested White-eye	16	breeding		Spring?
Sturnidae (starlings)					
Aplonis fusca	Norfolk Island Starling	80?	extinct		Spring?

suggests that *L. lapponica* was taken from migrating flocks, as relatively few birds would have been resident on the island when it was still mainly forested.

CHARADRIIDAE—PLOVERS

Pluvialis fulva Pacific Golden Plover 130 g (48.3% of squares). Less common than the godwit in the samples, *Pluvialis fulva* was nevertheless more abundant than resident land birds such as the parrot and parakeet. Because this species is a strong-flying migrant, the degree of representation is rather anomalous, even though the birds are much tamer on smaller islands than they are on the New Zealand mainland (Heather and Robertson, 1996) and might therefore have been easier to catch. The identification is based on the likelihood of occurrence of the two species of golden plover in the Pacific. The species is listed in older literature as *Pluvialis dominica*, but that is now regarded as a separate species with allopatric non-breeding distributions (Connors, 1983).

COLUMBIDAE

Hemiphaga spadicea Norfolk Island Pigeon 650 g (73.6% of squares). The Norfolk Island Pigeon was very similar to *Hemiphaga novaeseelandiae*, the New Zealand Pigeon, of which it has been regarded as a subspecies by some authors (Schodde *et al*., 1983). The New Zealand bird was a regular item in the diet of Polynesians there (Oliver, 1955). *Hemiphaga spadicea* survived on Norfolk Island into the early nineteenth century. It is the most abundant of the terrestrial birds in the archaeological avifauna, in which young birds as well as adults were represented.

Gallicolumba cf. *G. norfolciensis* Norfolk Island Ground Dove 200 g (3.4% of squares). The status of the small doves on Norfolk Island has yet to be resolved. Whether *Chalcophaps indica* was resident before habitat destruction became important in the European era is not known. Although fossils have been found (Meredith, 1991), none has been dated. The presence of a species of *Gallicolumba* was confirmed by Meredith (1985, 1991). It is probably this species which was mentioned in the diaries of the first European settlers and is the subject of a painting done before 1800 (no. 89, “Sydney” series, Hindwood, 1965). Bones of a dove-sized pigeon, apparently this species, were rare in the archaeological fauna. The fragmentary material did not allow complete certainty of the identification.

PSITTACIDAE

Nestor productus Norfolk Island, or Long-billed, Kaka 400 g (18.4% of squares). Although *Nestor productus* was apparently common when Europeans reached the island and therefore was likely to have been a prominent component of the avifauna exploited by Polynesians, surprisingly few were represented in the archaeological deposits. The New Zealand species *N. meridionalis* was a favoured item in the diet of Maori from settlement to historic times, and its feathers were used in cloak manufacture (Oliver, 1955): *N. productus* was even more colourful so Polynesians may have caught it for its feathers as well as the meat.

Cyanoramphus novaezelandiae cooki Norfolk Island Green Parrot; Norfolk Island Red-crowned Parakeet 75 g (21.8% of squares). Green Parrots are rare in the archaeological record and constituted only a minor and opportunistic food source.

PASSERINES (20.7% OF SQUARES)

The Grey-headed Blackbird *Turdus poliocephalus* (?90 g) and other species such as the Norfolk Island Starling *Aplonis fuscus* represented a tiny percentage of the total biomass in the deposits. Their presence is important mainly as an indication of the eclectic diet of the inhabitants, which again parallels that observed in New Zealand sites where even *Petroica*s (New Zealand Robins) were consumed.

Discussion

The faunal remains in the archaeological site at Emily Bay are confined mainly to birds, fish, and introduced Pacific rats. The dominance of seabirds is understandable, because the species were very abundant, easy to catch, and mostly large enough to constitute worthwhile additions to the diet. It appears that the larger petrels were, indeed, a staple food for the early Polynesian inhabitants of the island, as one species was for Europeans for a short period in the early part of their occupation. Other marine species, and most of the land birds, appear to have been included in the diet only as adjuncts, probably when they could be caught with little or no effort. As most of the *Pterodroma* petrels can be called from the sky during the breeding season, food gathering on Norfolk Island—while the petrel populations survived—would have been remarkably easy; but the diet might have been rather monotonous.

Taphonomy, butchering, and consumption. Patterns of survival of elements confirmed that most of the deposit accumulated as debris from human occupation. The pattern of bone breakage and survival was typical of a large predator that could process and remove as much of the available nutrients from each carcass as possible. For the major long bones, such as tibiotarsus, humerus, and ulna, only one end (often the proximal) is well represented, indicating that the sections holding the most meat have been removed, and probably consumed along with the meat. Interestingly, the pattern of archaeological bone survival is quite similar to that found in deposits accumulated by the large extinct harrier *Circus eylesi* in New Zealand (RNH, unpubl. data) in which the larger long bones and most bones from the body are not present, and peripheral, even tiny, elements are well-represented in the sample.

The taphonomic processes contributed to the difficulty of assigning most petrel material to species, apart from the very small *P. pycrofti*, exacerbating the already difficult task of separating closely similar species with inadequate reference material. However, the lumping of petrel taxa into two groups should not have altered the main conclusion of the study, that petrels were the main item of diet of the people who lived at the site.

Limited avifauna as part of a limited natural food supply. Polynesians living on Norfolk Island had a much smaller choice of natural foods than they did on other island groups elsewhere in the Pacific. In particular, most of the coastline consists of steep slopes above a rocky shore or vertical cliffs. There are few beaches (Anson Bay, Cemetery Bay, Emily Bay, Slaughter Bay), and the littoral zone has very few species of (small) mollusc and echinoderms. The small area of reef at Slaughter Bay meant that only fishing in deep water was likely to be productive enough to support a human population. That in turn meant that the birds would have been proportionately more important than on most other islands. Their importance is reflected in their relative abundance in the food remains at Emily Bay. Although the avifauna was limited in variety, some species, including two or three petrels, were extremely abundant. Others, including all the terns that are such a feature of the present avifauna, were, for whatever reason, virtually ignored for food.

Choice versus availability of food. The biases in the avian remains from the archaeological excavations could indicate either that the people actively selected a limited range of species from those available on the island, or took by default those species that were most abundant and easy to catch. In general, most species in the deposits could have been collected within 500 m of the site. The two most abundant species were both *Pterodroma* petrels that could be harvested from the surface or from burrows in the neighbourhood of Emily Bay, and which could also have been called down from the sky by shouting or hand-clapping (Tennyson and Taylor, 1990).

Meredith (1985) reported that both *P. pycrofti* and his *Pterodroma* new species were rare in the First Settlement deposits that he examined. As the former, which is the smaller of the two, is well within the size range for predation on adults, eggs, and young by Pacific rats (Holdaway, 1999), its rarity by the late eighteenth century is not surprising. The apparently low abundance of the larger, *Pterodroma* new species (probably *P. neglecta*) at European contact is more difficult to explain. *Pterodroma neglecta* survived in the presence of Pacific rats on Raoul Island from about 650 years ago (Anderson, 1980) into the early twentieth century, so apparently can cope with some predation even though its egg is just within the ability of Pacific rats to open (Holdaway, 1999). High numbers of rats maintained by the year-round availability of animal and vegetable food might have created conditions that allowed rat predation to be more severe than it might have been otherwise. Another possible factor in the rarity of *P. neglecta* in the First Settlement deposits was the degree to which it might have been taken as a preferred food by the Polynesians. Unfortunately, identification problems for the petrels made quantification of their relative representation impossible.

Seasonality. It is apparent that food was harvested throughout the year at Emily Bay: *P. pycrofti*, a summer breeder (Heather and Robertson, 1996), is a major part of the sample, as is *P. solandri*, which breeds in the southern winter. The young of *P. pycrofti* would be available up to the time of their fledging in late summer and autumn. Again, although *P. neglecta* has been recorded nesting at most times of the year in various parts of its huge breeding range, birds in the remaining colonies usually lay their eggs from October to March, so that species and *Puffinus pacificus* would have supplemented the supply of *P. pycrofti*, which as a smaller bird would provide less meat per animal.

A greater variety of birds would be available in summer, with the presence of the migrant waders and several species of petrel. In winter, the people would have had to depend on *P. solandri* and *Puffinus assimilis*. That dependence, at a time of greater frequency of storms and hence lower availability of fish, may have limited the human population that could be supported on the island over a period of years. The population of *P. solandri* on the higher areas of the island could not sustain predation by the few hundred people of the First Settlement for more than a few years.

Species representation and extinction. There were substantially fewer species represented in the Emily Bay archaeological site than were available in the local environment. To some extent, the comparison is unequal, because the natural bone deposits from which the composition of the late Holocene avifauna of Norfolk Island has been established (Meredith, 1985, 1991) accumulated over thousands of years, whereas the archaeological site may have existed for less than 200 years and, in addition, only about 3.5% of it was excavated. While it is unlikely that the avifauna found by the first Polynesian settlers differed greatly from that reported by the earliest European inhabitants—plus the known extinct species—it is difficult to tell whether the archaeological absence of the more than half of the late Holocene avifauna (excluding songbirds) can be explained by sampling biases during the prehistoric fowling or during archaeological recovery, or by other factors.

The rarity of terrestrial species in the deposit is noteworthy. Contrary to Meredith (1985), it is likely that *Rattus exulans* was responsible for the extinction of several of the smaller, terrestrial birds on Norfolk Island. No other environmental factors are known which could have affected small species, and terrestrial as well as oceanic species. In fact, the extinctions of small vertebrates on Norfolk Island parallels the far more extensive extinctions attributed to the Pacific rat in New Zealand (Holdaway, 1999). Species lacking from the archaeological collection but known from natural fossil deposits at Cemetery Bay and elsewhere include a prion (*Pachyptila* species), a storm petrel (*Pelagodroma* species, presumably *P. albiclunis*, the Kermadec Storm petrel), and a southern snipe (*Coenocorypha* new species), all of which were palatable to both humans and rats.

The absence of Norfolk Island Snipe (*Coenocorypha* new species) from the archaeological deposits is particularly noticeable as there are remains of two shorebirds (*Pluvialis fulva*, *Limosa lapponica*) that should have been harder to catch. *Coenocorypha* new species and *P. fulva* had roughly the same body mass (105 g vs 130 g). The former is unlikely to have been missed in recovery of material, because passerine bones were recovered and many elements smaller than snipe bones were common in the collection. Given the size of the sample, it is unlikely that *Coenocorypha* new species was present when the archaeological deposits were formed. Why this should be, when other wading birds were eaten regularly, is unknown, although the Pacific rat and snipe of the genus *Coenocorypha* have been unable to coexist elsewhere (Holdaway, 1999). If the rat population rose to and was sustained at a high level by abundant petrels, as it would have been on Norfolk Island, then extinctions could have occurred extremely rapidly, as occurred when *Rattus rattus* reached the Big South Cape Islands off southern New Zealand in the early 1960s (Bell, 1978).

Various scenarios are possible in relation to the absence of snipe and other taxa in the archaeological assemblage. The lack of terns, which are the most obvious seabirds on Norfolk Island today, may be related to the cost and benefits of harvesting. Some species, such as the Sooty Tern, may have been more limited in numbers on the island in the past. Tropicbirds are used by Pacific peoples for ornamentation as well as for food, so the absence of this presently common species from the archaeological avifauna is rather surprising. It is unfortunate that the archaeology of Norfolk Island does not, so far, offer later prehistoric settlement sites with bird bone middens in which to test some of the propositions suggested here. The only comparisons possible at present are with the records made by the first European settlers (Meredith, 1985) and the material in the deposits of that date.

Conclusions

In terms of body mass, and therefore available meat value, the archaeological avifauna from Emily Bay discloses a strong predominance of petrels and boobies, as might be predicted from the relative body mass and probable abundance of these taxa in the local environment. Larger forest birds are relatively scarce, especially the rails, Norfolk Island Kaka, and Norfolk Island Ground Dove. Some small terrestrial taxa are absent and either were not sought or may have become extinct so rapidly (probably as a result of predation by the Pacific rat, *Rattus exulans*) that they were not incorporated in the Emily Bay deposits. The archaeological fauna of Norfolk Island includes species such as Pycroft's Petrel (*Pterodroma pycrofti*) that were either locally extinct, or at least very rare, when Europeans reached the island. It is apparent, therefore, that Norfolk Island fits the pattern of other Pacific Islands, where early contact by Polynesian settlers resulted in the extinction of the more vulnerable of the resident bird species (Steadman, 1997).

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Appendix

Problems of identification, reasons for inclusion or exclusion of taxa from the Norfolk Island avifauna, and comments on the time of some extinctions.

Petrels. There have long been problems in identifying the species of petrel that originally bred on Norfolk Island, notwithstanding the copious fossil remains and the existence of paintings from the early period of European occupation. All the *Pterodroma* petrels are difficult to separate on fragmentary material such as is normal in middens. It is usually necessary to examine crania of species that are closely similar in post-cranial dimensions.

Meredith (1991) recorded three species of *Pterodroma*—*Pterodroma solandri*, *P. pycrofti*, and an undescribed species—from Norfolk Island. *P. solandri* and *P. pycrofti* are now extinct on Norfolk Island itself. *Pterodroma solandri* breeds at Lord Howe Island 900 km to the west, and a small breeding population has recently been found on Philip Island (Hermes *et al.*, 1986). It is not known whether the Philip Island colony represents a recolonization of the Norfolk Island group from the Lord Howe population or is a remnant of the population that was otherwise extirpated on the Norfolk Island group during the early years of European settlement.

The only large *Pterodroma* to be recorded as definitely breeding on Norfolk Island is *Pterodroma solandri*, the Bird of Providence, Providence Petrel, or Solander's Petrel. Meredith (1985, 1991) recorded this species as being common in fossil deposits on Norfolk Island. He also recorded an unnamed *Pterodroma* of intermediate size (*Pterodroma* new species), but listed mainly leg elements; wing elements from other collections were referred. In the present study, it became apparent that, although all *Pterodroma* humeri larger than those of *P. pycrofti* were of a size range consistent with specimens of *P. solandri*, there were two size classes in the leg elements. The longer femora, tibiotarsi, and tarsometatarsi were long enough to be of *P. solandri* but others were more comparable to elements of *Pterodroma inexpectata* and therefore were at first attributed to *Pterodroma* new species of Meredith (1985, 1991). The absence of wing bones in the intermediate size range was problematic, and other possibilities were explored.

Two other species of *Pterodroma* in the Pacific have humeri of about the same length as that of *Pterodroma solandri*, but shorter, thinner legs. These are *P. neglecta* (Kermadec Petrel) and *P. arminjoniana* (Herald Petrel). The Pacific populations of Herald Petrel have been recognized as a separate species (*P. heraldica*) and Brooke and Rowe (1996) split that species into white-bellied (*P. heraldica*) and dark-plumaged birds (*P. atrata*). The presence of any of these species would explain the anomalous pattern of smaller leg elements but larger humeri and ulnae. Measurements of leg elements of both these species (T.H. Worthy, pers. comm.) are similar to those in the collection considered here. The material is referred to *P. neglecta* on the basis of present breeding range. Harrison (1983) gave the breeding range of *P. arminjoniana* (*P. heraldica*) in the Pacific as including Chesterfield Reef, Tonga, Marquesas, Tuamotus, Gambier Islands, Pitcairn group, and Easter Island. The putative *P. atrata* is confined to the Pitcairn Islands. These islands are all either north of, or are very close to, the Tropic of Capricorn: none of those in the western South Pacific is south of 23°S. The range of *P. neglecta* includes Lord Howe, Kermadecs, Austral, Pitcairn, and Easter groups, and islands off Chile. In the southwestern Pacific its range is well south of that of *P. arminjoniana* (*P. heraldica*) (Lord Howe is at 32°S, and Raoul Island is at 28°S, roughly the same as Norfolk Island). As Norfolk Island lies between two of the present breeding stations of the Kermadec Petrel, it is reasonable to suspect that *P. neglecta* formerly bred there. Hindwood (1940) pointed out that two specimens taken by Dr P.H. Metcalfe in the 1880s referred to *P. solandri* by North (1890) were in turn referred by Mathews (1912) to *P. neglecta*, which, if correct, would constitute the first record of that species from Norfolk Island, and add weight to the conclusion that bones referred to an "intermediate" *Pterodroma* (Meredith, 1991) are actually of *P. neglecta*.

A further point that may aid in distinguishing between the two species in old accounts is that *Pterodroma neglecta* usually nests on the surface and does not burrow like *P. solandri* (Bartle *et al.*, 1993). Records of surface-nesting petrels in early accounts are likely to refer to *P. neglecta*. A confounding factor may be the former presence on the islands of at least one species of *Accipiter*, whose predation could conceivably have forced *P. neglecta* to nest under cover.

The identity of the small species of *Pterodroma* that formerly bred in large numbers on Norfolk Island has been especially problematic. Until Meredith (1985, 1991) established that the small *Pterodroma* bones from the island represented a previously unknown and very large population of *P. pycrofti*, it was thought that *P. nigripennis* was probably present at the time of European settlement. *Pterodroma pycrofti* is now absent from the Norfolk Island group: it breeds on small islands off the northeastern coast of the North Island of New Zealand (Heather and Robertson, 1996). There are too few *P. pycrofti* on the present breeding islands (1500+ pairs, Heather and Robertson, 1996) for there to be any pressure for young birds to find new breeding sites.

Part of the reason for suspecting the former presence of *P. nigripennis* was that, by analogy with the present small population of *P. solandri*, the *P. nigripennis* presently breeding on Philip Island and attempting to breed on Norfolk Island have been taken to be a recolonization after extermination in the 1790s (Schodde *et al.*, 1983). In fact, *P. nigripennis* was first identified on Norfolk Island in 1965 (Serventy *et al.*, 1971). It has not been identified among the fossils in either natural or archaeological contexts (Meredith, 1985, 1991; this study), so it is likely to be instead a recent colonist, as it is in northern New Zealand and the Chatham Islands (Tennyson, 1991) where there also no records of former breeding.

The present populations on Lord Howe Island and Balls Pyramid cannot be used as evidence of a former more extensive breeding range of *P. nigripennis*, as can be proposed for *P. neglecta*. The breeding colonies of *P. nigripennis* (Philip Island, Lord Howe Island, Balls Pyramid) are part of the recent and on-going south and southwestward expansion (Marchant and Higgins, 1990). The source is probably the large population (2–3 million pairs, Heather and Robertson, 1996) on Macauley Island in the Kermadecs, 1300 km to the east. *Pterodroma nigripennis* is not mentioned by Hindwood (1940) as being part of the Lord Howe Island fauna, although he records two skins of *Cookilaria* [=*Pterodroma*] *cookii* (under the common name "Blue-footed Petrel"), citing a breeding range that includes the Kermadecs, where *P. cookii* does not breed. The 1965 specimen of *P. nigripennis* on Norfolk Island had blue instead of the typical fleshy pink legs (Serventy *et al.*, 1971). A small proportion of *P. nigripennis* individuals has blue legs (Serventy *et al.*, 1971) so it is possible that the birds seen by Hindwood were of this form rather than *P. cookii*. The specimens should be re-examined.

The identity of the small *Pterodroma* petrel portrayed in a coloured drawing done at the time of the First Settlement (no. 96 in the "Sydney" collection, Hindwood, 1965) remains an enigma. Whitley (1938) described it as a new species *Cookilaria hindwoodi*. The discovery of a specimen of *P. nigripennis* on Norfolk led Hindwood (1965: 90) to suggest that the "Norfolk Island Dove-Petrel [had] been re-discovered". Earlier, Hindwood and Serventy (1943) considered that the bird "differs from all known species of *Cookilaria* in the brown colour of the upper parts" and considered it to be *incertae sedis*. As painted, the bird appears to lack the "powdering of grey… from the nape down the sides of the upper breast" (Serventy *et al*., 1971) that is characteristic of *P. nigripennis* and the dimensions (if the bird was indeed painted life size) fit with those of *P. pycrofti* (Oliver, 1955). It is possible, contra Serventy *et al*. (1971: 103), that the bird in the painting was *P. pycrofti*. In favour of this interpretation are the dimensions taken by G.M. Mathews from the painting (Hindwood and Serventy, 1943), which are all within the ranges for *P. pycrofti*. In addition, the colour pattern is similar to that species, although the colour itself apparently differs in having a brown back, which could be an artefact of the paint used. The reference in Heather and Robertson (1996) to a "huge" colony of *P. nigripennis* on Norfolk Island being destroyed by cats and rats ignores the fact that the birds were not known to breed there before 1965 and have not been identified in the large fossil collections (Meredith, 1991, and see above). The simplest view, and the one adopted here, is that the late Holocene avifauna of Norfolk Island included one species of small *Pterodroma* petrel, *P. pycrofti*, which became extinct shortly after European settlement, and whose place is now being taken—for whatever reason, and in the absence of a large source population of *P. pycrofti*—by immigrant *P. nigripennis* from the thriving populations on the southern Kermadec Islands.

A recent summary of birds reported from the Norfolk Island group (Moore, 1999) includes references to several other petrels that may well have been part of the original avifauna. These include the Flesh-footed Shearwater (*Puffinus carneipes*: in a burrow on Philip Island), Newells Shearwater (*Puffinus auricularis newelli*: captured, photographed and released on Philip Island), Tahiti Petrel (*Pseudobulweria rostrata*: at sea within 15 km of the island, breeds in the South Pacific), Goulds Petrel (*Pterodroma leucoptera*: one race of which breeds on New Caledonia), White-necked Petrel (*Pterodroma cervicalis*: breeding in large numbers on Macauley Island in the Kermadec group, 1200 km east of Norfolk, and a nesting pair found on Philip Island in 1992), and Kermadec Petrel (*Pterodroma neglecta*: breeding on islets off Raoul Island, Kermadecs, and at Lord Howe Island, found nesting on Philip Island in 1992). Other species, such as the Cape Petrel (*Daption capense*), have been seen near the islands, but their breeding grounds are in the subantarctic and it is highly unlikely that there were breeding populations of these species in the Norfolk Island area at any time in the past.

There appear to be previous records of the occurrence of two of these species on the island. A specimen of *Puffinus carneipes* taken on Norfolk Island by E.H. Saunders (Saunders and Salvin, 1896) is apparently the first record from the island. Meredith (1991) did not list *P. carneipes* in the fossil fauna while Schodde *et al*. (1983) recorded it only as a vagrant before the recent breeding record (Moore, 1999). The breeding distribution of the species includes Lord Howe Island as well as islands off northern New Zealand and many around Australia (Hindwood, 1940; Serventy *et al*., 1971). Hence, as with *P. neglecta*, it is likely on the grounds of a gap in an otherwise continuous distribution that the species once bred at Norfolk Island. For this reason, and as the measurements of *P. carneipes* overlap with those of *P. pacificus* (Oliver, 1955; Serventy *et al*., 1971), it is possible that material of *P. carneipes* exists unrecognized in the fossil collections. If so, it is included here in the unresolved "other petrel" category.

In addition to the petrels dealt with above, it is possible that at least one other subtropical petrel may have had a breeding population in the group: four individuals of the Phoenix Petrel (*Pterodroma alba*) were found ashore on Raoul Island in 1913 (Oliver, 1955), and it is likely that the species bred there before rats and cats were introduced (Holdaway *et al*., 2001). That some of the subtropical species have now been found breeding, or attempting to breed, on Philip Island is evidence that they could have included the group in their breeding range in the past. The possibility of their former presence adds complexity to an already difficult identification problem.

Sulids. The sulid presently breeding in the Norfolk Island group is the Masked Booby *Sula dactylatra*. An apparently extinct species of booby (*Sula tasmani*) has been described from fossil remains collected on Norfolk and Lord Howe Islands (van Tets *et al*., 1988). The material in the present collection is attributed to *S. dactylatra* because the mensural differences listed by van Tets *et al*. (1988) are not sufficient to support recognition of a separate taxon and instead represent the upper size range of *S. dactylatra* (Holdaway and Anderson, unpubl. data).

Other differences proposed included choice of nesting habitat, *S. tasmani* apparently differing from *S. dactylatra* in nesting on sand beaches where they were vulnerable to predation by humans (van Tets *et al*., 1988). When undisturbed by humans, even Australasian Gannets (*Morus serrator*), which typically nest on or above high sea cliffs, nest on sand dunes at sea level (Hawkins, 1988).

Waders. Although several species of charadriiform have been identified from the island, all are vagrants or regular migrants. Only two species, the Bar-tailed Godwit (*Limosa lapponica*) and Pacific Golden Plover (*Pluvialis fulva*) are regular in numbers on the island. Although Whimbrels (races of *Numenius phaeopus*) have been reported live and as fossil from Norfolk Island, none was recorded in the archaeological collection.

Hawks. The only predatory bird on the island today is the Australian Kestrel (Falconidae: *Falco cenchroides*), which became established as a breeding species in the 1970s (Schodde *et al*., 1983). Reports of the presence of "hawks" in the 1790s were confirmed by the discovery of remains of an *Accipiter* very closely related to, if not identical to, the Brown Goshawk *Accipiter fasciatus* of Australia and some islands to the north of Norfolk Island, including New Caledonia (Meredith, 1985, 1991). It has been thought that hawks died out on Norfolk Island very soon after Europeans arrived or were vagrants (Schodde *et al*., 1983), but Gurney (1854) referred to a report by F. Strange that hawks were on Philip Island some time before 1853, presumably during the residence of Strange's informant on Norfolk Island, which may mean that the goshawk survived on Philip Island for several decades after its demise on the main island. Philip Island was still vegetated at that time, and Strange records having met the man "who exterminated the *Nestor productus* of Philip Island". After describing the way that the large parrot used its bill in climbing, Strange reports that "He likewise informed me that there was a large species of hawk that used to commit great havoc amongst them [the parrots], but what species it was he could not tell me."

Rails. The flightless endemic *Gallirallus* new species discovered by Meredith (1985) may have survived into the European period. A rail painted on Norfolk Island in the 1790s (no. 79 in the "Sydney" series, Hindwood, 1965) has a plumage pattern similar to that of *G. philippensis*, but it may represent *Gallirallus* new species rather than the extant *Gallirallus philippensis* as has been assumed. Ripley (1977) identified *Rallus tenebrosus* (Gray, 1862), a small rail described from Norfolk Island in 1824, as the Spotless Crake (*Porzana tabuensis*), which is widespread in Australia and the South Pacific. At present, both *P. tabuensis* and *G. philippensis* are vagrants on Norfolk Island, rarely breed there, and their former status has been uncertain (Schodde *et al*., 1983).

Parrots. *Nestor productus* survived until the late 1840s on Philip Island (Strange, in Gurney, 1854) after being extirpated on the main island in the early 1800s. By late 1853 the species was known only from Philip Island. No mention of its former presence on the main island is made, although it figures prominently in the collections of paintings made during the first convict settlement. Strange's informant said that "they rarely made use of their wings, except when closely pressed" and that when he went to the island to shoot them, he "would invariably find them on the ground". Such habits are not unusual in species confined to uninhabited islands without mammalian predators and would have made the birds easy prey for people.

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Fishbone from the Emily Bay Settlement Site, Norfolk Island

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ABSTRACT. Fishbone from the settlement site at Emily Bay and excavations in West Emily Bay was identified on the basis of five mouth parts, checked against eight paired bones and some multiple and unique bones. The number of specimens (NISP) was counted and the Minimum Number of Individuals (MNI) calculated to display relative abundance of families. Lethrinidae dominate all assemblages, with Carangidae, Labridae and Serranidae as significant secondaries. Many specimens are large examples of the species. The domination of benthic feeders implies baited hooks, used over submerged reefs close to shore, were probably the most common technology. There are no deep water species present. Norfolk Island fishing appears to be very like that of prehistoric New Zealand.

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Norfolk Island is one of a band of widely dispersed subtropical Pacific islands stretching from Australia to South America (Francis, 1993: 136). The three easternmost of these islands, Lord Howe, Norfolk Island and the Kermadecs, lie on the fringes of southwest Polynesia (SWP) near the southern limit of the tropical convergence zone. These SWP islands exhibit features of both temperate and tropical Pacific ecologies and share a number of common features of archaeology and biogeography.

In archaeological terms, the Kermadecs and Norfolk are both “mystery islands” (Kirch, 1988; Irwin, 1992; Weisler, 1996) and Lord Howe might well fall into the same category if archaeological remains exist there. The first two of these small, isolated islands were settled during the Polynesian expansion in East Polynesia, but were abandoned some time before European arrival. The reasons for abandonment appear to have been partly ecological and partly to do with the social and economic problems of isolation. The SWP islands all lie in proximity to larger, continental landmasses and this fact also may have affected the course of their prehistories.

In terms of marine biogeography, it is difficult to define a separate province for the SWP islands but they do share general features in common, and are unique from other Polynesian islands. The most characteristic of these is the mixing of tropical and temperate fish faunas and the maintenance of biogeographic links with their continental neighbours: Norfolk and Lord Howe Islands with Australia, and the Kermadecs with New Zealand (Francis, 1993: 148). They also maintain biogeographic links with one another and all three display low rates of marine vertebrate endemism. In several features of fish diversity, Norfolk Island falls into a position mid-way between Lord Howe and the Kermadecs (Table 1).

Table 1. Comparison of fish diversity, Kermadecs, Lord Howe and Norfolk Island (based on Francis, 1993).

	Kermadecs	Norfolk Island	Lord Howe
number of fish species	145	254	433
tropical species (%)	41	55	67

This combination of archaeological and biogeographic factors, plus the unique environmental status of the SWP islands as small, isolated and sub-tropical suggests that their prehistoric inhabitants may have developed a distinctive set of adaptive strategies. This paper intends to address this problem by examining the fishing adaptation of Norfolk Island, as understood though the excavations of the Norfolk Island Prehistory Project (NIPP).

The fishbone assemblages reported on below were collected from excavations at Cemetery Bay, Emily Bay, and Slaughter Bay during NIPP fieldwork in 1995, 1996 and 1997 (Anderson, 1996; Anderson, Smith and White, this vol.). The Cemetery Bay excavations were carried out in December 1995 following earlier reports that Polynesian cultural deposits might be present in the Bay area (Anderson, 1996). These horizons failed to eventuate, although some late prehistoric or early historic material was recovered. A more promising site was located at Emily Bay, where surface finds of adzes had been reported, and which was seen as a potentially attractive place to early Polynesian settlers. At Emily Bay cultural material, including ovens and basalt adze manufacturing flakes, were found in several localities and the site was targeted for more intensive excavation in April 1996 and November 1997. During these excavations, components of a Polynesian settlement were exposed and a number of artefacts and a large quantity of midden were collected. Specht (1984) had also identified Slaughter Bay as a potentially promising site for locating early cultural horizons and some testing was carried out there during the April 1996 field season. The Slaughter Bay excavations produced a small quantity of midden, but the site did not contain the rich cultural material that was anticipated.

Fishbone was recovered from the three Norfolk Island sites, primary sorting was carried out at Australian National University (ANU) and the material was sent on to the Otago Archaeology Laboratories (OAL) at the University of Otago, Dunedin, New Zealand where it was analysed using a methodology outlined below. The analysis had two aims. First, as one of the regional outposts of the Polynesian culture area the midden bone was seen as contributing to defining the full scope of Polynesian maritime subsistence adaptation. Second, the fishbone was analysed with a view to addressing the issue of local and SWP ecological adaptation.

Polynesian fishing. Polynesian fishing systems share many common elements across the full range of island ecologies, but within this broad universe of shared practices local fishing practices are finely targeted according to factors such as local habitat, technology and cultural preference. Thus common target families such as Scaridae will be caught using different technologies according to the type of marine ecosystems accessible to local fishing parties. On the raised reef islands of the southern Cooks for example, scarids are generally speared, or caught in small numbers in dip nets placed across the surge channels in the reef (Walter, 1992, 1998: 72). On Aitutaki, another island in the southern Cooks but one with a deep lagoon and extensive areas of sheltered coral reef, scarids are caught in larger numbers, using seine nets (Allen, 1995). Other factors which influence fishing strategies include cultural issues, such as prohibitions or special symbolic values, age structure and aggregating behaviours of target species and seasonal environmental conditions.

Polynesian fishing systems developed in the tropics but were successfully adapted to the temperate waters of New Zealand. Norfolk Island's intermediate position helps to extend the range of known Polynesian habitats and increases our understanding of Polynesian adaptive strategies. This theoretical interest is not confined to fishing, but is one of the central research themes of the Norfolk Island project. However because fishing leaves such well defined archaeological traces it is the subsistence practice which is most easily defined archaeologically.

The analysis of prehistoric Polynesian fishing systems involves the study of fishing technologies, as represented by fishing related artefacts, and the identification of targeted taxa from fishbones collected from prehistoric middens. Additional information might include a consideration of the size range of specimens. These data must be interpreted within the context of coastal geomorphology and ecology.

Methods

The general aims of the fishbone analysis were outlined above. The specific aims were to identify species targeted by Norfolk Island fishers and to determine their relative abundance within the different assemblages. The ability to compare fishbone assemblages and to build up a comparative model of Polynesian fishing practices requires archaeologists to use standard sets of analytical procedures in both the field and laboratory. This follows from the observation that the structure of an assemblage can be strongly influenced by such variables as screen size and other aspects of collection strategy, and by quantification methods and the selection of elements used for identification (Grayson, 1984; Nagaoka, 1993). In practice, total standardization is neither possible nor necessarily desirable, but a reasonable minimum requirement is that reports contain basic information on recovery technique, and on laboratory sorting, identification, quantification and storage procedures. This provides other researchers with enough information to enable comparative analysis to be carried out, whereas straight NISP (Number of Identified Specimens) or MNI (Minimum Number of Individuals) counts do not.

Field techniques for the recovery of midden during the Norfolk Island excavations varied slightly during the project. All archaeological material was recovered by normal excavation techniques and sieved. In 1995 the Cemetery Bay material was sieved to 2 mm, but at the EB95:06 excavation the density of extraneous material in 2 mm sieves, notably of rootlets, in relation to the scarcity of small cultural components, particularly of midden, led eventually to the use of 4 mm sieves. This practice continued, for the same reason, in the 1996 excavations, although in all cases the potential loss of material was carefully monitored by occasional fine sieving and judged to be insignificant. In the 1997 excavations, all material was sieved to at least 4 mm or 5 mm (the difference reflects use of sieves based on metric and imperial mesh sizes).

The output of residues was monitored regularly for materials of cultural origin. For most of these excavations, inspection failed to identify a significant quantity of cultural material passing through the larger screens. Nevertheless, where patches of midden were encountered—it was generally scarce in this part of the site—all material was wet-sieved to 2 mm and whole samples were taken. The fact that screening retained more than 150 teleost teeth, which are amongst the smallest specimens identified in fishbone middens, suggests that the collection strategies were adequate for identifying the major catch taxa and their relative abundance.

All material was bagged in the field and the contents of each bag were then dried and sorted into each of the main classes of bone and other materials before transport to the ANU laboratories, and consignment to specialists.

The methods used for processing the fishbone were based on standard protocols developed in the OAL (Walter *et al*., 1996). The basic principle involves the creation of analytical units through a two stage sorting process. In the first stage, the bones are all sorted to primary anatomical unit which is defined as the sided element. In the second stage, sets of these units are selected, and identified to the lowest possible taxonomic level. These are the analytical units which are later used for quantification purposes. The decision about which set of anatomical units should be used for identification purposes depends on the nature of the particular research question. The fish skeleton contains approximately 70 unique bones. Of these, it is common practice in Pacific archaeology to use the five paired mouth bones (maxilla, premaxilla, dentary, articular, quadrate) plus a range of multiple and unique bones commonly known as "specials", for identification purposes (Leach, 1986; Nagaoka, 1993). Recent experience in the OAL, however, suggests that a much wider range of paired elements than the jaw bones are identifiable to family level, and that some of these may be of greater potential use than some of the jaw elements (Walter, 1998: 65). Selecting which set of elements to use in a fishbone analysis involves a compromise. By electing to use a minimum number of bones certain levels of bias can be eliminated in relative abundance studies. This bias arises when some elements are very distinctive in a small number of fishes, but are either absent or equivocal in others. Appropriate bones to choose from in this case are those which are present in all (or most) fish, have good preservation qualities and occur either as single or paired elements, thus allowing reliable quantification. The five mouth parts fulfil these requirements well and have proven to be a particularly useful set (Anderson, 1973; Leach, 1986). The disadvantage of restricting the analysis to a small set of bones is that a number of fish taxa will be missed, or significantly under-represented. For example, Acanthuridae, Exocoetidae and Mullidae rank very highly in many present day Polynesian subsistence fisheries but are extremely rare in Pacific midden collections. Weisler *et al*. (1999) have also documented the effect that changing the range of identified elements can have on the composition of New Zealand fishbone assemblages. On the other hand, increasing the range of elements identified introduces the law of diminishing returns in relative abundance studies, and it has been shown that the use of just one or two of the most abundant paired bones (dentary for example) can be effective in these types of analysis (Anderson *et al*., 1996; Rolett, 1998; Walter, 1998: 65).

In this study, identification was made on the basis of the maximum number of paired bones and "specials". In addition to the five mouth parts the paired bones: ceratohyal, cleithrum, epihyal, hyomandibular, palatine, post-temporal, scapular, and supracleithrum were used along with a number of multiple and unique bones (Table 2). Use of these non-standard bones did not expand the range of identified specimens produced using paired mouth bones, nor did it provide a more effective measure of relative abundance which was the main interest of the analysis.

Table 2. Anatomical units and Minimum Number of elements used in the fishbone analysis. The top four ranked units, plus pterygiophore, cannot normally be identified to taxon using OAL collections and methods.

element	total
vertebra	3,479
unidentified	2,755
miscellaneous spines & rays	1,230
dorsal spines	648
premaxilla	239
dentary	213
pterygiophore	213
quadrate	168
tooth	160
maxilla	159
articular	121
palatine	84
hypural	76
hyomandibular	64
ceratohyal	51
opercule	48
inferior pharangyal plate	44
supracleithrum	41
post-temporal	41
scapular	41
pharangeal plate	30
epihyal	27
vomer	20
otolith	18
superior pharangyal plate	15
preopercule	15
scale	12
urohyal	8
cleithrum	5
branchiostegal rays	3
basiptergium	2
subopercule	1
grand total	10,031

Taxonomic identifications were made by Walter using the OAL Pacific and New Zealand fishbone reference collections which contain approximately 520 specimens of tropical and temperate water Indo-Pacific fish falling into 100 genera and 70 families. The nomenclature used here follows Randall *et al*. (1990). There are few Norfolk Island specimens in the OAL collections and thus few bones were identified below family level. However, identification below the level of family is not usually carried out in Pacific fishbone analysis as identification to family provides sufficient information to identify targeted ecologies and derive reasonable inferences about fishing strategies (Walter, 1998: 68).

Once the identifications were complete, the bones were bagged and labelled according to standard OAL procedures (Walter *et al*., 1996). The units created during the sorting and identification process were retained and each analytical unit was bagged and labelled with a unique three part laboratory number.

Prefix	NIPP.
ID No.	The original field bag number which encodes all the field information, such as provenance, that was assigned by the excavator.
Suffix	A unique number for each analytical unit. This encodes all the laboratory information such as quantity, element, side, taxa.

In addition to the laboratory number, the full element and taxonomic identification was written on each bag, and sets from each provenance unit were placed in an outer bag on which all the provenance information was written. The results of the analysis were entered into the OAL computer database which can be searched according to the unique three part lab number. For example, NIPP-167-7 is the seventh sample processed from field bag 167 which was collected from Emily Bay, Trench 11, Area A1, Layer 2, Spit 2. It contains two left dentaries of the family Lethrinidae.

There is some debate in the archaeological literature as to which quantification method is appropriate in faunal analysis (Grayson, 1984). In New Zealand, MNI is commonly used (Leach and Boocock, 1993) but most tropical Pacific archaeologists use NISP, a method which eliminates the aggregation problems associated with MNI (Grayson, 1984), and which is, in any case, the necessary choice for tropical fish bones which can seldom be identified to species, unlike New Zealand taxa (Anderson, 1997). However in relative abundance analysis NISP can potentially introduce a bias in favour of species which have large numbers of particular identifiable elements (Grayson, 1984; Klein and Cruz-Uribe, 1984: 25; Nagaoka, 1993: 193). The best solution is to select a quantification method appropriate to the analysis in question but to provide as much raw data as possible so that the appropriateness of any derived unit can be independently assessed. In this study both NISP and MNI values are provided.

Results

The largest assemblage of fishbone was from Emily Bay and it provides the basis for a useful working model of prehistoric Norfolk Island fishing practices. The other assemblages are described below, but they are too small to provide any really useful information on subsistence or fishing practices.

Emily Bay. The Emily Bay excavations consisted of a number of test-pits and trenches spread out over about 100 m behind the main foredunes of Emily Bay (Anderson, Smith and White, this vol.). The stratigraphy was disturbed in many places, especially by bioturbation, and it varied in detail across the excavation units. However, it all seems to refer to a single occupational horizon. To document any stratigraphic variation that did exist, excavation of the cultural layer was carried out in spits of 10 cm depth. The following discussion assumes that the fishbone derives from a single occupation although the finer stratigraphic resolution is preserved in Table 3.

The fishbone analysis is based on eight provenance units for Emily Bay. These are the seven trenches plus the West Emily Bay (WEB) assemblage (collected during earlier government excavations for a toilet pit, see Anderson, Smith and White, this vol.). NISP counts for each spit in each unit are given, but MNI values are based on the assumption that the spits all fall within the same cultural layer. Table 3 shows NISP values for the Emily Bay fishbone generated using all elements. Lethrinidae dominate by a wide margin but there may be a bias towards this family based on size, and the presence of a wider range of identifiable elements (especially teeth). In Table 4 paired mouth bones are listed and these data are used to produce the MNI values shown in Table 5. By using only mouth parts much of the bias is eliminated although Lethrinidae still dominate the assemblage, with the Carangidae, Labridae and Serranidae families showing as significant secondary catch components (Fig. 1).

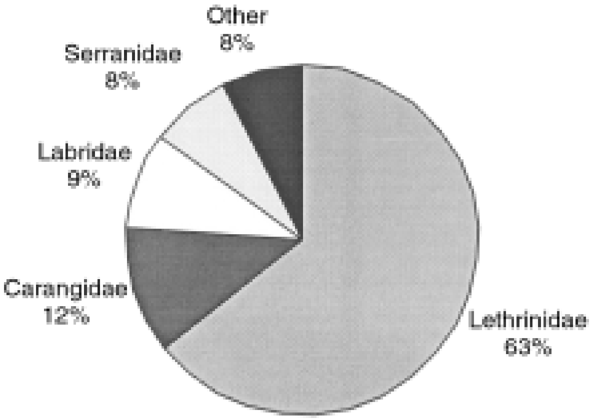

Figure 1. Emily Bay. Relative abundance, as measured by MNI, of identified fish families.

Cemetery Bay and Slaughter Bay. Although considerable reconnaissance work and subsurface testing was carried out in both these locations, very little cultural material was recovered. At Cemetery Bay a 3 m^2 trench was excavated close to the NW corner of the quarry approximately 5–8 m from where a shell adze was thought to have been found during sand mining activities many years earlier (Anderson, Smith and White, this vol.). The stratigraphy consisted of carbonate sands interspersed with silt enriched clays which are interpreted as slope-wash deposits. Layer 7 contained a small quantity of faunal material which the excavators considered may be of late prehistoric or historic origin. There are only rat bone gelatin radiocarbon ages for this horizon, and they are dubious (Anderson, Higham and Wallace, this vol.). A small quantity of fishbone was recovered from Layer 7 but only one specimen (Serranidae) could be identified to family level (Table 6). The Slaughter Bay excavations failed to identify any clearly defined prehistoric horizon. However, there was a remnant of an occupation layer, from which a basalt adze had been recovered (Nicolai, pers. comm.) exposed in the steep beach-front bank at the extreme eastern end of the bay. This contained some midden which is undated but probably of prehistoric age (Table 6).

Table 3. Emily Bay NISP values based on all identified elements (see also Table 2). Acan., Acanthuridae; Cara., Carangidae; Elas., Elasmobranchi; Holo., Holocentridae; Kyph., Kyphosidae; Labr., Labridae; Leth., Lethrinidae; Lutj., Lutjanidae; Mura., Muraenidae; Serr., Serranidae.

trench	spit	Acan.	Cara.	Elas.	Holo.	Kyph.	Labr.	Leth.	Lutj.	Mura.	Serr.	unident.	total
EB95:02	1	—	—	—	—	—	—	—	—	—	—	25	25
	2	1	—	—	—	—	—	4	1	—	1	151	158
	3	—	—	—	—	—	—	12	—	—	—	106	118
	total	1	—	—	—	—	—	16	1	—	1	282	301
EB96:10	1	—	2	—	—	—	13	109	1	—	11	1186	1322
	2	—	1	—	—	—	1	16	—	—	—	218	236
	3	—	—	—	—	—	1	36	—	—	—	195	232
	4	—	1	—	—	—	—	159	—	—	—	1596	1756
	total	—	4	—	—	—	15	320	1	—	11	3195	3546
EB96:11	1	—	—	—	—	—	—	—	—	—	—	30	30
	2	—	—	—	—	—	—	9	—	—	—	70	79
	3	—	—	—	—	—	—	1	—	—	—	67	68
	4	—	—	—	—	—	—	—	—	—	—	11	11
	total	—	—	—	—	—	—	10	—	—	—	178	188
EB97:21	1	—	—	—	—	—	—	—	—	—	—	4	4
	2	—	—	—	—	—	—	—	—	—	—	13	13
	total	—	—	—	—	—	—	—	—	—	—	17	17
EB97:22	1	—	—	—	—	—	—	—	—	—	—	2	2
	2	—	—	—	—	—	2	—	—	—	—	8	10
	3	—	—	—	—	—	—	2	—	—	—	26	28
	total	—	—	—	—	—	2	2	—	—	—	36	40
EB97:23	1	—	4	1	—	—	3	90	1	—	—	515	614
	2	—	12	9	—	1	19	123	1	—	2	861	1028
	3	—	11	—	1	5	12	212	—	1	5	1213	1460
	4	—	13	—	—	3	4	129	—	—	3	911	1063
	5	—	11	1	—	—	—	26	—	—	3	379	420
	6	—	5	—	—	1	11	70	—	—	3	298	388
	7	—	2	—	—	—	3	13	—	—	—	80	98
	8	—	—	—	—	—	—	4	—	—	—	23	27
	9	—	—	—	—	—	—	7	—	—	—	54	61
	total	—	58	11	1	10	52	674	2	1	16	4334	5159
EB97:24	1	—	—	—	—	—	3	14	1	—	1	129	148
	2	—	2	1	—	—	2	16	—	—	—	113	134
	3	—	1	—	—	—	1	5	1	—	—	77	85
	4	—	—	—	—	—	—	—	—	—	—	1	1
	6	—	—	—	—	—	—	—	—	—	—	6	6
	total	—	3	1	—	—	6	35	2	—	1	326	374
WEB	total	—	1	—	—	—	3	4	4	—	1	393	406
	total	1	66	12	1	10	78	1061	10	1	30	8761	10031

Discussion

Before offering an interpretation of the assemblage in terms of fishing practices, some cautions need to be raised. As discussed above, recovery strategy and the set of elements used for taxonomic identification purposes can have a major effect on the final composition of a fishbone assemblage. The Emily Bay material is dominated by very large specimens and arises from a field programme in which several sieving strategies were adopted. This might be reflected in the difference between the Trench EB96:10 data, obtained by screening through 4 mm mesh and the Trench EB97:23 and EB97:24 data obtained by screening most of the material through 2 mm mesh. However, those data could also reflect different sample sizes and, in any case, they do not suggest that finer screening would produce a very different fish bone assemblage. Screen residues were monitored during excavation and no evidence of retention problems was noted. Even if very small catch specimens are under-represented in the identifications, there would have to be an improbably large number of these to substantially alter the interpretation of fishing practices offered here. Further analysis of bulk samples is desirable nevertheless.

The MNI values for Emily Bay seem low with a total of only 153 fish, but the density of faunal remains from a site depends on the functions represented by the excavated components. Many New Zealand sites display much higher fishbone densities, but these are often substantial midden deposits. At the Anai'o site in the Southern Cook Islands a total MNI value of only 73 was reported from a 200 m^2 exposure of a fourteenth century A.D. layer (Walter, 1998). The material was taken from the living surface of a small village and no discrete midden dump was identified. If the Emily Bay site was a village or hamlet, it is likely that most of the faunal material was disposed outside the living zone

Table 4. Paired mouth parts and shark teeth from trenches EB95:02, EB96:10, EB96:11, EB97:22, EB97:23, EB97:24 at Emily Bay and West Emily Bay (these data used to generate MNI values shown in Table 5).

family	element	side	EB95:02	EB96:10	EB96:11	EB97:22	EB97:23	EB97:24	WEB	total
Acanthuridae	dentary	L	1	—	—	—	—	—	—	1
Carangidae	articular	L	—	—	—	—	1	—	—	1
		R	—	—	—	—	2	1	—	3
	dentary	L	—	—	—	—	7	—	—	7
		R	—	—	—	—	9	—	—	9
	maxilla	L	—	—	—	—	2	2	1	5
		R	—	—	—	—	5	—	—	5
	premaxilla	L	—	—	—	—	8	—	—	8
		R	—	—	—	—	4	—	—	4
	quadrate	L	—	3	—	—	8	—	—	11
		R	—	1	—	—	12	—	—	13
Elasmobranchi	tooth	—	—	—	—	—	11	1	—	12
Kyphosidae	dentary	L	—	—	—	—	1	—	—	1
		R	—	—	—	—	2	—	—	2
	maxilla	R	—	—	—	—	1	—	—	1
	premaxilla	L	—	—	—	—	3	—	—	3
		R	—	—	—	—	3	—	—	3
Labridae	articular	L	—	1	—	—	6	—	—	7
		R	—	1	—	—	3	—	—	4
	dentary	L	—	—	—	—	—	—	1	1
		R	—	—	—	—	—	—	1	1
	maxilla	L	—	—	—	—	1	—	—	1
		R	—	—	—	—	5	—	—	5
	premaxilla	L	—	3	—	—	8	2	1	14
		R	—	3	—	—	7	—	—	10
	quadrate	L	—	—	—	—	1	2	—	3
		R	—	—	—	—	3	—	—	3
Lethrinidae	articular	L	—	10	—	—	25	2	—	37
		R	1	15	—	—	36	2	—	54
	dentary	L	2	12	2	—	50	—	—	66
		R	1	22	—	—	50	—	—	73
	maxilla	L	2	7	1	—	24	4	—	38
		R	1	10	—	—	42	2	1	56
	premaxilla	L	2	19	—	—	59	5	2	87
		R	2	12	3	2	50	4	2	75
	quadrate	L	1	21	2	—	40	1	—	65
		R	—	17	—	—	27	6	—	50
Lutjanidae	articular	R	1	—	—	—	—	—	—	1
	maxilla	L	—	1	—	—	1	1	—	3
		R	—	—	—	—	1	1	1	3
	quadrate	L	—	—	—	—	—	—	2	2
		R	—	—	—	—	—	—	1	1
Muraenidae	dentary	R	—	—	—	—	1	—	—	1
Serranidae	dentary	R	—	1	—	—	—	—	—	1
	maxilla	L	—	—	—	—	4	—	—	4
		R	—	—	—	—	3	—	—	3
	premaxilla	L	—	4	—	—	2	—	1	7
		R	1	5	—	—	4	1	—	11
	total		15	168	8	2	532	37	14	776

and that portion of the site may fall beyond the excavation area.

The Emily Bay assemblage is dominated by benthic feeders with special emphasis on the "emperor" family, Lethrinidae. Although identification was not carried out below the level of family, the Lethrinidae specimens appear to be of a single species, probably *Lethrinus miniatus*. The Lethrinidae assemblage was dominated by large specimens. Although no estimate is presented here of live fish sizes, the mouth parts were significantly larger than any equivalent bones contained in the OAL collections. For example, the mean length of complete Lethrinidae maxilla in the assemblage is 50 mm (n = 28) (see Leach *et al*., 1996). The largest *Lethrinus* maxilla in the OAL collection measures 28 mm from a *Lethrinus olivaceus* specimen with a live tail length of 260 mm.

Lethrinus miniatus are amongst the largest species in the family and are the most commonly caught Lethrinid on Norfolk Island today. *Lethrinus miniatus* inhabit coral reefs during the day and forage more widely over sandy bottoms at night (Randall *et al*., 1990: 201). They can be caught on hooks over submerged reefs and are an important catch in

Table 5. Emily Bay. MNI values based on paired mouth parts and shark teeth as listed in Table 4.

family	EB95:02	EB96:10	EB96:11	trench EB97:22	EB97:23	EB97:24	WEB	total
Acanthuridae	1	—	—	—	—	—	—	1
Carangidae	—	3	—	—	12	2	1	18
Elasmobranchi	—	—	—	—	1	1	—	2
Kyphosidae	—	—	—	—	3	—	—	3
Labridae	—	3	—	—	8	2	1	14
Lethrinidae	2	22	3	2	59	6	2	96
Lutjanidae	1	1	—	—	1	1	2	6
Muraenidae	—	—	—	—	1	—	—	1
Serranidae	1	5	—	—	4	1	1	12
grand total	5	34	3	2	89	13	7	153

the contemporary inshore recreational fishery of Norfolk Island. The argument that the Emily Bay fishers were specifically targeting Lethrinidae is supported by the low representation of the families Carangidae, Labridae, Lutjanidae and Serranidae which rank next after Lethrinidae. If the Emily Bay fishers had a more generalized fishing system we might expect greater numbers of these families since they occupy similar habitats, and are usually caught using the same technology as Lethrinidae. Instead, it would appear that the Norfolk Island fishers were using a technology which selected the large Lethrinids from the available stock. The means by which that was achieved is unclear to us via the archaeological data, but is very likely to have involved a particular combination of hook form, bait and rigging.

In terms of MNI Lethrinidae represent 63% of the identified specimens with Carangidae ranking second at only 12% (Fig. 1). Since the assemblage is dominated by benthic feeders, it seems most likely that the Norfolk Island fishers relied on baited hooks which they used from canoes stationed over the submerged reefs. In fact, there is little evidence in the fishbone assemblage for the use of any technologies other than hook fishing. There is no pearlshell on Norfolk Island for hook manufacture but hooks could be made in bone or more perishable materials. A very typical East Polynesian form of a small one-piece hook was recovered in 1997 along with the point shank of another and evidence of hook manufacture in bone. There was also a broken harpoon (Schmidt, Anderson and Fullagar, this vol.). The one-piece hooks are precisely the types expected in relation to the catch.

Only one Acanthuridae specimen was present, probably *Prionurus maculatus* or another member of the Prionuninae sub-family. Fish of the family Acanthuridae are some of the most common caught on tropical reefs (although admittedly they are relatively uncommon in archaeological assemblages) and they are normally taken on spears and in nets. If netting was being practiced at Emily Bay a higher proportion of Acanthurids and other smaller specimens such as the schooling species (juvenile Carangidae, Mullidae, Mugilidae etc.) would be expected. Similarly, if the Norfolk Island fishers were practicing a more generalized foraging strategy we might expect to see Diodontidae represented in the assemblage. These fish produce very high NISP values in Pacific assemblages because they can be identified on the basis of their numerous dermal spines. Although rare, these fish are present in Norfolk Island waters but absent from the Emily Bay midden. Finally, only a small quantity of shark elements was identified and there were no examples of deep water pelagic species, such as those in the family Scombridae, which might indicate an offshore fishing regime. In summary, the Emily Bay fishing system was narrowly focussed in terms of target ecology and taxa. The community specialized in the exploitation of Lethrinidae which they probably caught using baited hooks over submerged coral heads within the lagoon and on the broken ground and reefs which lie in relatively shallow water between Emily Bay and Nepean Island.

Having speculated on the nature of the Emily Bay fishing system on the basis of fishbone analysis, it remains to comment on Norfolk Island within the wider structure of Polynesian fishing adaptations. The most important question stems from the environmental and biogeographic position of the island as falling mid way between tropical and temperate Polynesian settings. Although there are insufficient data to make any quantitative assessments at this point, the Norfolk Island data (as represented by Emily Bay) point strongly to a Polynesian fishing adaptation more

Table 6. Cemetery Bay and Slaughter Bay fishbone, NISP/MNI values.

site	location	element	Carangidae	Labridae	Lethrinidae	Lutjanidae	Serranidae	unidentified
Cemetery Bay (Layer 7)	Trench CB95:01	unidentified	—	—	—	—	—	21/1
		quadrate	—	—	—	—	1/1	—
Slaughter Bay	Lime Kiln	dentary	—	—	1/1	—	—	—
		quadrate	—	—	—	—	1/1	—
		unidentified	—	—	—	—	—	5/1

similar to that of New Zealand than to the tropics. Specifically, Norfolk Island fishing appears very close to that of northern New Zealand.

In common with Polynesia as a whole, the Norfolk Island assemblage is dominated by benthic feeders. Such fish are usually caught on bait hooks, which seems also to have been the case in Norfolk Island. In common with many northern New Zealand assemblages, there was a wide margin (as measured by both NISP and MNI) between the first ranked and next ranked taxon in the Emily Bay catch. Like many northern New Zealand middens, the Emily Bay midden was dominated by a single family, and it seems clear that these particular taxa were being specifically targeted (see Anderson, 1997 for an overview of northern New Zealand fishing). In tropical assemblages the numeric differences between the first few ranked taxa is usually lower and there is rarely any indication of mono-species targeting (at least in the benthic component). In northern New Zealand, the target species was usually Snapper (*Pagrus auratus*) (Anderson, 1997; Leach and Boocock, 1993) and the Emperor (Lethrinidae) seems to have filled this niche in the Norfolk Island fishing system. Interestingly, Emperors and Snapper have very similar habitats and feeding behaviour and are taken using similar capture technologies, as the Emily Bay hooks also suggest.

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Molluscs and Echinoderms from the Emily Bay Settlement Site, Norfolk Island

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ABSTRACT. The Emily Bay archaeological molluscan fauna as an ensemble is almost entirely intertidal in its natural occurrence, with seven species preferring sand or mud substrates and 13 species preferring hard substrates. The only exceptions are the pelagic cephalopods *Nautilus* and *Spirula*. The gastropod species *Nerita atramentosa* is dominant in both numbers and by weight.

The rocky intertidal platform was the focus of mollusc collecting. The four most common species derive from this zone and habitually cluster in colonies, which would have made them a preferred prey.

Among the many factors that may have contributed to eventual abandonment of Norfolk Island, a scarcity of easily harvestable coastal marine resources would probably have been significant.

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It is assumed that those food resources on Norfolk Island that could be collected by people immediately on arrival would have been of great importance to Polynesian settlers. The availability and ease of collection of shellfish would have been an important factor, therefore, in the initial viability of settlement on Norfolk Island.

The molluscs that appear in the archaeological material reflect the natural environment of Norfolk Island, which is notable for its restricted range of suitable molluscan habitats (Anderson and White, *Approaching the Prehistory*… , this vol.). The greatest density of species occurs in the intertidal zone, but on Norfolk Island soft shore intertidal areas are restricted largely to the Kingston lagoon and only rocky shores are extensive.

Shellfish collection

The year-round abundance of mollusc resources is their greatest asset for people, and in times of scarcity of other resources they assume a greater significance in the diet (Higham, 1996; Meehan, 1982; Meighan, 1969; Swadling and Chowning, 1981). Shellfish therefore represent a stabilising factor in food procurement. In addition to their food value, mollusc shells can be raw material for artefacts.

Claasen (1998) working with the fishermen of San Salvador Island in the Bahamas reports on the important role of shellfish, including *Nerita* sp. as bait (Claasen, 1998: 10).

Site taphonomy

As discussed in this volume (Anderson, Smith and White) the stratigraphy for Trenches EB97:23 and EB97:24 reveals a cultural layer that was generally sealed by overlying sediments since its deposition. However, there is some evidence that it was exposed to both wind and wave action before the formation of the modern dune system. There is a history of cultural material being washed out of Emily Bay (Specht, 1984) and it is highly probable that the cultural layer was affected. In addition the cultural layer has itself suffered disturbance in the form of mutton bird nesting hollows.

The abundance of shell diminishes with depth in both trenches, although less so in Trench EB97:23. There is only a single occupation level, but bioturbation has been significant in moving material as much as 90cm below the surface of the cultural layer.

Methodology

The molluscan assemblage from Norfolk Island was identified by Dr Colin Campbell at the Department of Archaeology & Natural History (ANU). A small taxonomic reference collection was abstracted from the archaeological sample. Of the eight trenches excavated at Emily Bay, Trenches EB97:23 and EB97:24 were the most productive in terms of faunal remains and therefore the best suited for intensive analysis, the goal being to investigate prehistoric molluscan collection and use strategies.

The material recovered by excavation was sieved through 2 mm or 4 mm screens (Anderson, Smith and White, this vol.). The shell was then cleaned and all taxa were identified to species in the ANU laboratories. The left and right valves of bivalves were identified and counted, location of damage to valves noted, all shells weighed, and all fragments counted, weighed and taxonomically assigned as far as possible.

Minimum numbers of individuals (MNI) were calculated by counting whole shells, and in the case of bivalves by comparing right and left pairs. In the case of fragmented shells, hinges in bivalves and apices in gastropods were used to signify an individual. The common gastropod species *Nerita atramentosa* is represented by abundant whole specimens and fragments. MNIs from fragments were estimated by calculating the mean weight for whole *N. atramentosa* shells in each spit and dividing the total weight of fragments by that value.

Results of molluscan analysis

Trench EB97:24. Nineteen one metre squares were excavated from the cultural layer in this trench, each to a depth of 30 cm, producing a total of 5.7 m^3 of sediment. The total shell weight from this volume was 2.02 kg, producing a density of 0.35 kg/m^3.

Eighteen species of molluscs were present (Table 1), with four of those species having one occurrence only and with another five species appearing less than five times. *Nerita atramentosa* alone accounts for 65% by number and 86% by weight of the entire assemblage. The next three most common species, *Bembicium flavescens, Hinea brasiliana* and *Capulus* sp. account for 28% by number and 11% by weight, with the remaining 15 species therefore being responsible for only 7% by number and 3% by weight of the assemblage. The absolute predominance of *N. atramentosa* is clear, and is a consequence, presumably, of their natural abundance on the rock platform and the ease of their collection.

Table 1. Trench EB97:24 molluscs by species showing their weight and MNI counts.

species	MNI (no.)	MNI (%)	weight (g)	weight (%)
GASTROPODA				
Nerita atramentosa	755	65	1734.9	85.9
Bembicium flavescens	124	10.7	114.4	5.7
Hinea brasiliana	102	8.8	52.7	2.6
Capulus sp.	95	8.2	44.1	2.2
Gastropod sp.	20	1.7	10.7	0.5
Nassarius sp.	14	1.2	11.6	0.6
Tonna variegata	7	0.6	4.7	0.2
Siphonaria cf. *diemenensis*	6	0.5	0.7	0.0
Strombus labiatus	4	0.3	8.1	0.4
Morula sp.	4	0.3	3.6	0.2
Cypraea caputserpentis	2	0.2	2.1	0.1
Thais orbita	1	0.1	1.8	0.1
BIVALVIA				
Gari cf. *livida*	19	1.6	27.3	1.4
Pinctada maculata	2	0.2	0.3	0.0
Mactra rufescens	1	0.1	0.7	0.0
Saccostrea cucullata	1	0.1	0.7	0.0
Anapella cycladea	1	0.1	0.5	0.0
CEPHALOPODA				
Spirula spirula	3	0.3	0.7	0.0
totals	1161	100.0	2019.6	100

Remarkably, one of the four most common taxa, *Capulus* sp., is most unlikely to have been a food species. It is a very small mollusc, generally less than 8 mm in diameter, and lives attached to other shells. Its presence in the midden is almost certainly adventitious, as a rider on other shells, or possibly rocks. There are no recorded instances of this species being consumed.

Trench EB97:23. Thirty-nine one metre squares were excavated from the cultural layer in this trench, an average depth of 30 cm. This excavation resulted in a volume of 11.70 m^3 of sediment. The total shell weight from this volume was 6.54 kg, a density of 0.56 kg/m^3.

At least 20 species of mollusc are present (Table 2). Three of these are represented by single occurrences, another three are present less than five times, and a further five present between five and ten times. Here *N. atramentosa* is even more dominant, accounting for 87% by number and 95% by weight of the local assemblage. The next three most common species, *Siphonaria* sp., *Capulus* sp. and *Anapella cycladea* contribute 6.5% by number and 1.2% by weight, with the remaining 16 species contributing only 6.5% by number and 3.8% by weight.

Table 2. Trench EB97:23 molluscs by species showing weight and MNI counts.

species	MNI (no.)	MNI (%)	weight (g)	weight (%)
GASTROPODA				
Nerita atramentosa	2448	87.2	6206.4	95
Siphonaria cf. *diemenensis*	75	2.7	10.1	0.2
Capulus sp.	59	2.1	16.4	0.3
Hinea brasiliana	36	1.3	17.0	0.3
Tonna variegata	30	1.1	63.8	1.0
Thais orbita	11	0.4	79.8	1.2
Bembicium flavescens	9	0.3	3.9	0.1
Nassarius sp.	7	0.2	0.6	0.0
Serpulorbis sp.	1	0.0	1.3	0.0
Bulla sp.	1	0.0	0.5	0.0
Cypraea caputserpentis	1	0.0	11.1	0.2
BIVALVIA				
Anapella cycladea	48	1.7	54.2	0.8
Gari cf. *livida*	24	0.9	22.6	0.3
Cardita tasmanica	23	0.8	5.8	0.1
Mactra rufescens	9	0.3	31.4	0.5
Barbatia squamosa	8	0.3	2.5	0.0
bivalve sp.	7	0.2	2.3	0.0
Pinctada maculata	4	0.1	3.0	0.0
Saccostrea cucullata	3	0.1	1.4	0.0
CEPHALOPODA				
Nautilus repertus	4	0.1	1.8	0.0
totals	2808	100.0	6535.9	100.0

Molluscan ecology

The habitat preferences of the species identified in the Emily Bay site range vertically from the upper intertidal to the subtidal zone (Dakin *et al*., 1980). The substrates that the species prefer range from sandy intertidal through rocky intertidal to shallow subtidal rocks. The known ecological attributes of the 24 identified species from the Emily Bay site are listed in Table 3, while the percentage of species that occupy each substrate zone is shown in Fig. 1.

Figure 1 illustrates by number of species the difference between the habitat zones. MNI and shell weight counts show consistently that the four species most commonly represented in the samples all inhabit rocky substrates of the intertidal zone. This result is further supported and illustrated in Fig. 2 which shows that, when measured by weight, the rocky intertidal zone was the main focus of collecting activity. The species representation and the inferred collection strategy may both be regarded as natural consequences of the intertidal geography of Norfolk Island in which rocky shores are predominant.

The collected molluscs

Most abundant species. Analysis of Trenches EB97:23 and EB97:24 reveals that *Nerita atramentosa* is dominant in the assemblage. In addition to *N. atramentosa*, two other species (*Bembicium flavescens* and *Hinea brasiliana*) were commonly collected. The adventitious occurrence of *Capulus* is excluded from this discussion. All three preferred species are similar in their ecology and in the possession of gregarious behaviour, clustering in easily collected colonies. All preferentially occupy the rocky intertidal zone, and are therefore easily collected at low tide.

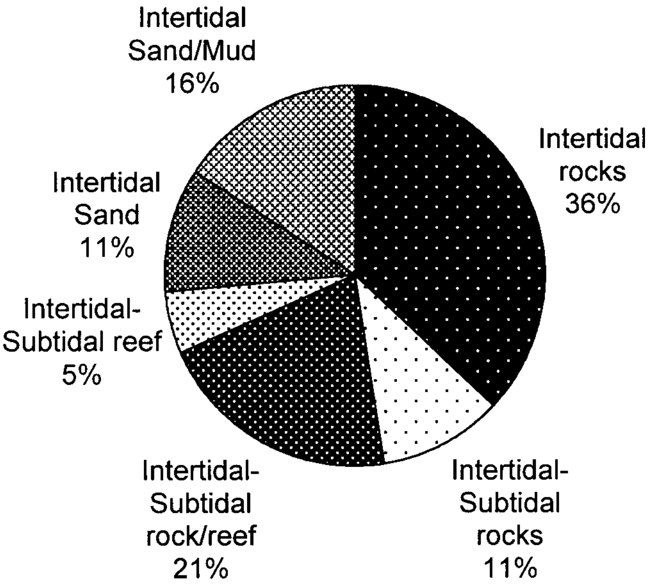

Figure 1. Percentage of Mollusc Species occupying Substrate Types at Emily Bay.

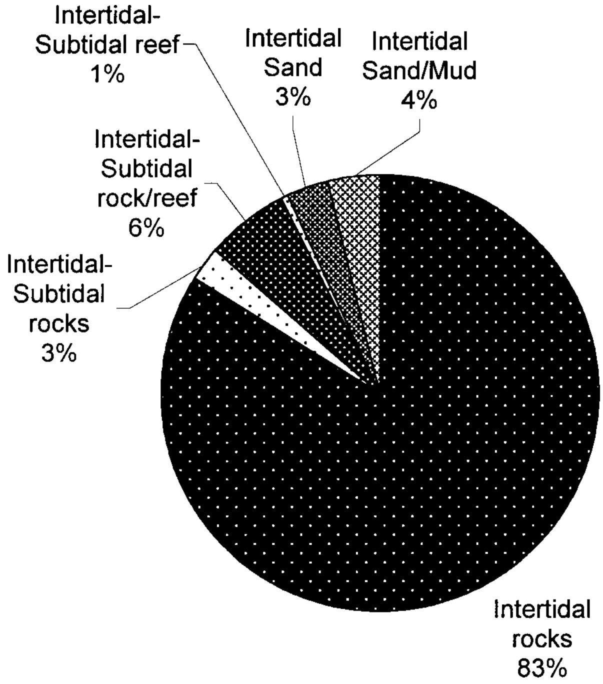

Figure 2. Molluscan substrate representation by percentage of shell weight recovered at Emily Bay.

Nerita atramentosa, Bembicium flavescens and *Hinea brasiliana* are all herbivorous grazing gastropods of the upper intertidal zone. None are particularly large, and in an area including mudflats with bivalves they would probably have been ignored as they require more effort to collect and process. However, on Norfolk Island, soft shore habitats are very limited, and there is little doubt that these three species were collected most often precisely because they

Table 3. Ecological preferences of the Norfolk Island archaeological molluscan fauna. Constructed with reference to Wilson (1993, 1994), Shepherd and Thomas (1989), Dakin *et al*. (1980) and Allen (1959).

taxon	**depth**	**substrate**
GASTROPODA		
Buccinidae (dog whelks)		
Nassarius sp.	intertidal	sand to mud
Bullidae (bubble shells)		
Bulla cf. *quoyii*	intertidal	silty sand near seagrass beds
Capulidae (cap shells)		
Capulus sp.	shallow subtidal to intertidal	attached to other molluscs or stones
Cypraeidae (cowries)		
Cypraea caputserpentis	intertidal and shallow subtidal	coral reef or rock
Epitoniidae (wentle traps)		
Epitonium sp.	shallow subtidal	rock or coral
Littorinidae (periwinkles)		
Bembicium flavescens	intertidal	rock
Muricidae		
Morula sp.	intertidal to shallow subtidal	rock and coral reefs
Thais orbita	intertidal to subtidal	coral and rock
Naticidae (moon snails)		
Polinices sp.	intertidal	sand bars and beaches
Neritidae		
Nerita atramentosa	uppermost intertidal	rock—often exposed for long periods
Planaxidae (clusterwinks)		
Hinea brasiliana	upper intertidal	wave exposed rock and rubble
Siphonariidae (siphons)		
Siphonaria diemenensis	intertidal	rocks
Strombidae		
Strombus labiatus	intertidal	sand
Tonnidae (tun shells)		
Tonna variegata	intertidal	sand
Vermetidae (worm shells)		
Serpulorbis sipho	shallow subtidal to intertidal	attached and zonally distributed on rocky shores
BIVALVIA		
Arcidae (ark shells)		
Barbatia pistachia	subtidal to shallow intertidal	under stones; medium to high energy coasts or currents
Carditidae		
Cardita tasmanica	intertidal	under reef rocks
Mactridae		
Mactra rufescens	intertidal	sand and mud
Mesodesmatidae		
Anapella cycladea	intertidal	rocks or coral
Ostreidae (oysters)		
Saccostrea cucullata	exposed to sheltered intertidal	rocks
Psammobiidae		
Gari cf. *livida*	intertidal	sand to gravelly mud
Pteriidae		
Pinctada maculata	intertidal	
CEPHALOPODA		
Nautilidae		
Nautilus repertus	oceanic	pelagic
Spirulidae		
Spirula spirula	oceanic	pelagic

were the most abundant and accessible in the area. *Nerita atramentosa* in particular far exceeds any other species in both shell weight and MNI count.

The minor species. Although approximately 30% of the species present have soft substrate preferences they are, as noted, very little represented in both MNI and weight counts. This is almost certainly due to the scarcity of suitable habitat. Those few species present in the midden which are large and meaty (e.g., *Tonna variegata* and *Gari livida*) are derived from this soft substrate habitat. All the *T. variegata* fragments, for example, could probably have come from one or two individuals. *Gari livida*, which inhabits sand or gravelly mud in the intertidal zone, is notable for the fact that the small amount of shell present often appears to have been worked to produce a cutting edge (Schmidt, Anderson and Fullagar, this vol.).

Echinoderms

Apart from the molluscan resources it is important to note that almost every spit excavated contained fragments of the test or spines of one or two species of sea urchin (phylum Echinodermata), which would have significantly supplemented the food value of the accompanying molluscs. In both of the analysed trenches the echinoid fragments were second only to *N. atramentosa* in weight, therefore representing a substantial resource (363g in Trench EB97:24 and 1,368 g in Trench EB97:23). Sea urchins are an easily collected resource.

Echinoids are considered a valuable food resource in the Pacific, particularly in Maori culture where they are considered a delicacy and are one of the most numerous taxa found in middens (Best, 1929: 70–71). Sea urchins are not molluscs and their presence in the midden does not affect the results of the molluscan analysis in regards to collection strategies but rather is supplemental to it. The harvesting of sea urchins may well have mitigated the effect of meagre shellfish beds by supplying a store of easily accessed protein although a major reliance on the species may well have resulted in overexploitation and stock collapses.

Due to their poor preservational qualities, the quantities of sea urchin collected at Norfolk Island in prehistory remain difficult to quantify with only highly fragmented remains occurring. Currently these remains are not amenable to further analysis in regards to measuring size or number of individuals. As a result their role in the resource strategy must remain speculative.

Discussion

A number of studies considering Polynesian methods of shellfish collecting have been conducted over the past three decades (e.g., Spennemann, 1987; Kirch, 1979; Kirch and Dye, 1979; Swadling and Chowning, 1981; Anderson, 1979, 1981; Szabó, 1999). As well as these Pacific examples, Meehan's (1982) seminal study among the Gidjingali of Australia is also pertinent.

Meehan (1982) and Anderson (1979, 1981) offer the most comprehensive studies of shellfish gathering strategies. Meehan's study concludes that particular species are targeted by gatherers, though other desirable species encountered fortuitously may also be collected (Meehan, 1982: 69). Anderson (1979, 1981) deduced that prehistoric inhabitants of Black Rocks, Palliser Bay, were collecting the largest individuals regardless of species. It follows, however, that some species attain a larger size than others, and are thus more desirable and more frequently collected (Anderson, 1981: 114). The difference in conclusions between these two studies can be seen as a consequence of the respective areas of study; Meehan's (1982) study focuses on the soft shore, which contains fewer species of generally high biomass, while Anderson's (1979, 1981) study revolves entirely around the rocky shore, which in general harbours a greater variety of species with each species being of significantly lower biomass. Hence, logically, it is easier and more productive to focus on the collection of certain species when gathering from the soft shore, and upon large individuals from the rocky shore. Given that shellfishing strategies and, hence, archaeological midden deposits, reflect the ecology of the area being exploited, it would appear that both Meehan (1982) and Anderson (1979, 1981) describe optimal strategies for different niches.

The Emily Bay deposits can be seen to follow both the pattern of exploiting the largest individuals, and certain species which tend to offer the largest individuals. *Nerita atramentosa, Bembicium flavescens* and *Hinea brasiliana* are the largest of the common intertidal molluscs inhabiting the rocky reef at Emily Bay. Where other desirable individuals of larger species were encountered, they too were collected. This tactic is represented by *Tonna variegata* and *Saccostrea cucullata*. It is difficult to say whether *Nerita atramentosa* individuals were being targeted due to their size, taste, visibility, convenient location or colonial tendencies—mostly likely it was a combination of some or all of these factors.

Conclusions

The aim of this analysis was to investigate shellfish collection strategies on Norfolk Island. The presence of 24 molluscan species when a mere four provide more than 90% of the discarded shells suggests a harvesting strategy concentrated on the gastropod *Nerita atramentosa*, but which involved the collection of any other shellfish encountered during collecting forays. This is a common resource procurement strategy for shellfish, one which allows for some taste variability in the diet without the necessity of expanding the collection effort (Meehan, 1982: 80). Some species like *Capulus* sp. were most likely gathered incidentally as attachments to the larger shells. The small size of *Nerita atramentosa*, the main gastropod collected, and the scarcity of shellfish habitat, would have imposed an intractable protein limit for molluscs as a food source. The relatively low abundance of shell in the site supports the view that molluscs represented a marginal food resource to the human group. The overall strategy displays efficiency in maximising the available molluscan resources by concentrating on the most numerous species, but at the same time including any mollusc that was large enough regardless of species, and supplementing this collection strategy with the inclusion of sea urchins.

Another explanation for the shellfish collection on Norfolk Island would be that *N. atramentosa* was used as bait for the important task of fishing on the protein-limited Norfolk Island. In this view the shellfish did not constitute only a food resource but a vital ingredient in the procurement of other marine resources. The lack of large quantities of shellfish resources on Norfolk Island would have placed a greater emphasis on the role of other resources for protein procurement. Norfolk Island has a rich biota of fish and marine turtles (Walter and Anderson, this vol.) that could have compensated to some extent for a meagre shellfish resource. However this alternative explanation is not supported by the archaeological evidence. The location of the *N. atramentosa* remains, within the food midden and close to earth ovens in the site points to the species being used as a food resource rather than as a bait resource. The use of nerites as bait usually results in the dispersal of the shell overboard or on the spot where the fishing is being carried out, as live mollusc bait is preferentially used. Whilst feasible as bait, the occurrence of the *N. atramentosa* shell in the midden leads to the conclusion that they were being harvested as a food resource for the human inhabitants of Norfolk Island.

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Land Snails from Norfolk Island Sites

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ABSTRACT. Fourteen sequences of land snails were sampled by corer from the Emily Bay settlement site and four from Cemetery Bay. Thirty-nine samples of modern land snails were collected from six environmental zones on Norfolk Island. The modern fauna is depauperate compared to the prehistoric one, with loss occurring mostly among the larger species. We suggest this is due first to predation by *Rattus exulans* introduced by prehistoric Polynesians and later to habitat loss following European settlement. We consider we cannot use the land snail data to make any interpretation of direct human impact on the Norfolk Island environment. We note however that the density and diversity of snails is high in the prehistoric cultural layer and below it, showing that the settlement area probably provided a more vegetated and wetter environment for the earliest settlers than is now present.

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The aim of this research was to use the land snail fauna to investigate the effects of the Polynesian settlement at Emily Bay on the local environment. We reasoned that a settlement of the extent revealed by the excavations was likely to have caused at least local changes through brush clearance, tree felling, burning, building, gardening, refuse disposal and the like. These changes would, perhaps, have had their greatest effects amongst animals of low mobility, some species of which might also be assumed to be restricted environmentally. Land snails seemed to be appropriate.

Methods

The research was carried out in three stages. Bulk samples of landsnails from Trench EB96:10 were submitted to WP in 1996. At the end of fieldwork in 1997 DN and PW took six grab samples of sand, each of c. 1 kg, from various trenches of the Emily Bay excavations. Three samples came from sands above the cultural layer and three from the fine yellow sand below. The samples were wet sieved through 2 and 1 mm sieves at the Archaeological Materials Laboratory (AML), University of Sydney and dried. The land snails were sorted into apparent species, the results being checked by Stephanie Clark of Invertebrate Identifications Australasia. Final results are in Table 1, which shows that only three of the 12 identified species are common to levels above and below the prehistoric occupation. Seven species are found only below the cultural layer and two only above it. One species (*Omphalotropis albocarinata* Mousson, 1873) dominates, providing more than three-quarters of the total number.

Despite the dramatic nature of these results, we considered that they might be flawed in several ways. First, since they were grab samples, sample sizes were only approximately similar. Next, our initial processing methods were experimental and certainly resulted in the loss or

Table 1. Emily Bay, 1997 samples, counts of each species.

species	upper sand EB97:23 **South**	 EB97:23 **West**	 EB97:25	lower sand EB97:23 **Sq. E7**	 EB97:23 **Sq. E13**	 EB97:24	total
Advena campbellii (Gray, 1834)	—	—	—	—	1	—	1
Allenoconcha basispiralis Preston, 1913	—	2	—	—	—	—	2
Fanulena insculpta (Pfeiffer, 1846)	—	—	—	1	57	7	65
Fanulena perrugosa Iredale, 1945	—	—	—	3	—	—	3
Greenwoodoconcha nux (Sykes, 1900)	—	—	—	—	6	1	7
Mathewsoconcha belli Preston, 1913	—	—	—	3	33	15	51
Mathewsoconcha suteri (Sykes, 1900)	—	—	—	—	4	—	4
new genus, new species	—	—	—	—	1	—	1
Omphalotropis albocarinata Mousson, 1873	58	64	67	29	317	183	718
Palmatina sp. Iredale, 1944	2	—	—	—	—	1	3
Succinea (Succinea) norfolkensis Sykes, 1900	7	11	1	1	19	12	51
Vallonia pulchella (Muller, 1774)	18	5	2	—	—	—	25
total	85	82	70	37	438	219	931

crushing of a few shells. Third, the considerable variation between samples may be real or simply an artefact of their small number. Fourth, no comparative samples were collected from sand bodies away from the site. And finally because little was known of the ecology of many species, environmental interpretation, such as whether the variation was due to the effects of human settlement, could not be made with confidence.

As a result we expanded the research in two directions. This stage of research aimed (a) to sample the current land snail fauna of Norfolk Island in sufficient environmental detail so that we could assess the extent to which prehistoric environments might be determinable by their faunas, and (b) to determine, if possible, the nature of the environment of Emily Bay before, during and after the first human occupation and in particular to test the reality of the radical differences observed a year earlier.

To carry out (*a*) 39 samples of the modern snail fauna were taken from six environmental zones we identified on Norfolk Island. To carry out (*b*) 14 samples were taken by corer from areas of the Emily Bay prehistoric settlement, supplemented by four samples from Cemetery Bay. Since both areas lay within the same environmental zone of beach and dunes, they should display similar patterns of change in land snails over time. While specific methods of analysis are described below, we note here that each species in all samples, both modern and prehistoric, was given an arbitrary alphabetical label pending final species determination. The total range of species identified in this study is given in Table 2; the taxonomy largely follows Iredale's (1945) review of the fauna, with Smith's (1992) modifications.

The modern sample

Despite extensive European use of the island during the last two centuries, a range of environments can be seen on Norfolk Island, especially within different parts of the Norfolk Island National Park, and in a few private properties which have been less subject to cattle grazing. Based on discussions with National Parks officers and Ponder's previous experience of Norfolk Island, our survey divided the island into eight environmental zones: open grassland, flax growth, beach and dunes, pine forest, mixed pines, mixed forest, palm forest and rainforest. The first two of these zones, open grassland and flax growth, proved to be devoid of snails and are thus not included in this analysis. Table 3 lists the stations and the number of samples taken from each environmental zone, while Fig. 1 shows their locations. Samples from stations 12 and 14 were not processed for this analysis.

Table 2. Land snail species recorded in this study.

species	**archaeological samples**	**modern samples**
Advena campbellii (Gray, 1834)	✓	✓
Allenoconcha basispiralis Preston, 1913	✓	
Allenoconcha sp. Preston, 1913		✓
Cryptocharopa exagitans (Cox, 1870)		✓
Fanulena insculpta (Pfeiffer, 1846)	✓	✓
Fanulena new species	✓	
Fanulena perrugosa Iredale, 1945	✓	
Greenwoodoconcha nux (Sykes, 1900)	✓	✓
Hawaiia miniscula (Binney, 1840)	✓	
Helix aspersa Muller, 1774		✓
Johannesoconcha multivolva Preston, 1913		✓
Lutilodix imitatrix (Sykes, 1900)	✓	✓
Mathewsoconcha belli Preston, 1913	✓	✓
Mathewsoconcha suteri (Sykes, 1900)	✓	✓
Nancibella quintalae (Cox, 1870)		✓
Neospuparia norfolkensis (Sykes, 1906)	✓	✓
new genus, new species	✓	
Norfolcioconcha norfolkensis (Hedley, 1899)	✓	
Norfolcioconcha sp. Preston, 1913		✓
Omphalotropis albocarinata Mousson, 1873	✓	✓
Pacificella norfolkensis (Preston, 1913)	✓	✓
Palmatina quintali Iredale, 1945	✓	✓
Palmatina sp. Iredale, 1944	✓	✓
Paraloma duncombei Iredale, 1945	✓	✓
Penescosta mathewsi (Preston, 1913)		✓
Pittoconcha concinna Preston, 1913		✓
Pittoconcha sp. Preston, 1913		✓
Quintalia stoddartii (Gray, 1834)		✓
Roybellia depressa Preston, 1913		✓
Succinea (Succinea) norfolkensis Sykes, 1900	✓	✓
Vallonia pulchella (Muller, 1774)	✓	✓
Zonitoides arboreus (Say, 1817)		✓

Our sampling followed methods generally used by malacologists. Within the six selected environmental zones we collected several samples at one to three specific locations, called here stations. Each sample consisted of bags of surface litter collected from haphazardly selected 1×1 m squares. Each bag weighed 1–2 kg. Samples were soaked in methylated spirit before transport to Australia. There, samples were dried and sieved through nested 3, 2, 1 and 0.5 mm sieves in the AML by DN. The sieve residue was also checked for specimens.

Specimens were sorted into species. Most species were represented by less than 20 individuals per sample; where frequency was higher, this was estimated. Twenty-six species were found. These were identified using comparative collections in the Malacology Section, Australian Museum, with the assistance of Stephanie Clark. Table 4 gives the species found in each environment and their approximate numbers in our samples. This table shows that a few species are ubiquitous, being present in all areas; these are also found in most samples.

The only clear overall trend in these data is that wetter areas contain rather more species than drier ones. More specifically, there are a few species which seem to be environmentally restricted. Four species (*Palmatina quintali* Iredale, 1945, *Lutilodix imitatrix* (Sykes, 1900), *Johannesoconcha multivolva* Preston, 1913 and *Nancibella quintalae* (Cox, 1870)) are found only in the rainforest. Some species such as *Roybellia depressa* Preston, 1913 and "*Norfolcioconcha* sp." (Preston, 1913) seem to be restricted to wetter areas, such as rainforest and palm forest. Four species [*Mathewsoconcha suteri* (Sykes, 1900), *Mathewsoconcha belli* Preston, 1913, *Advena campbellii* (Gray, 1834) and

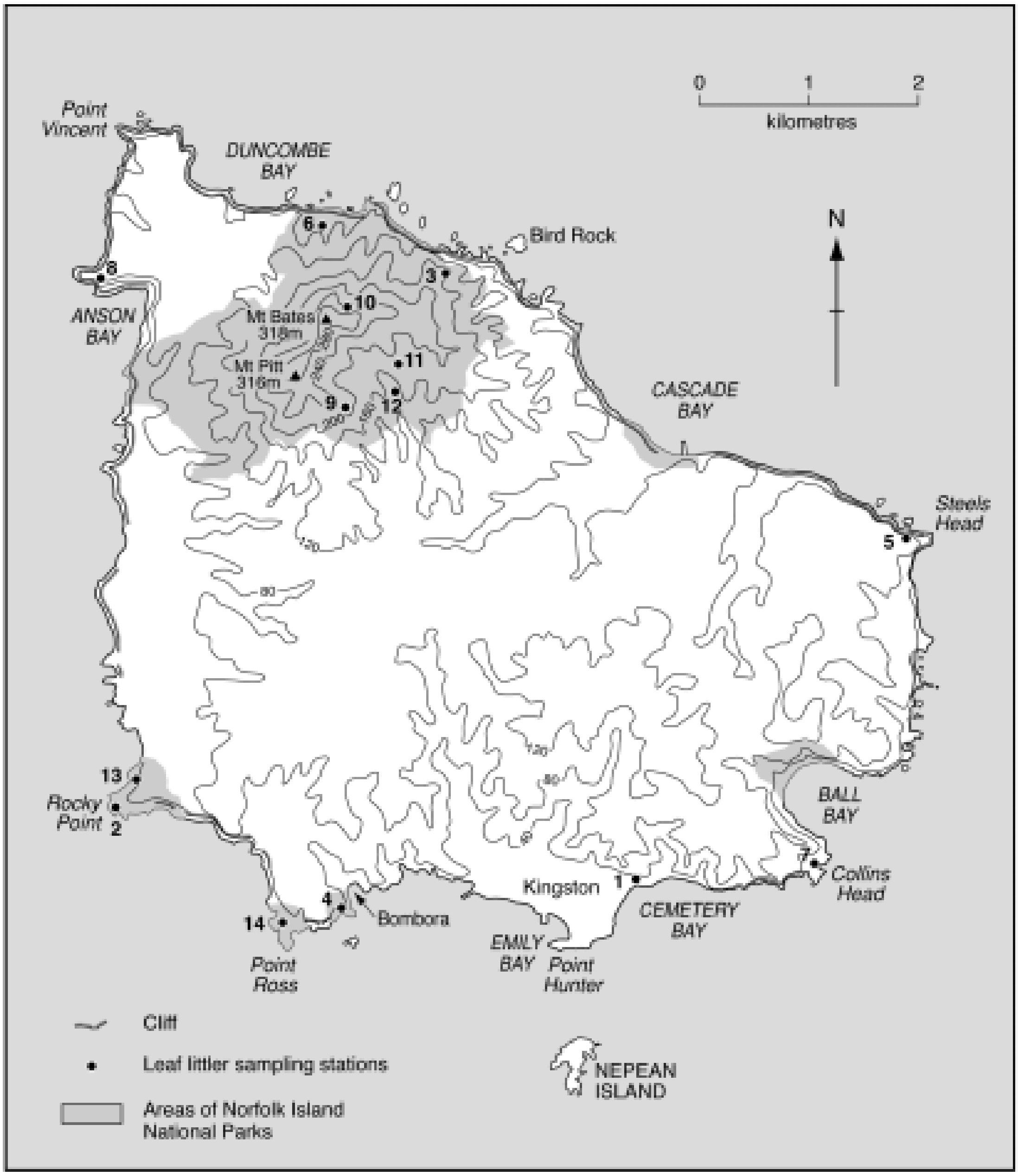

Figure 1. Norfolk Island showing approximate locations of sampling stations for both modern and archaeological samples. For modern sample environments, see Table 3.

Table 3. Modern sample: environment, location, station number and number of samples taken. Stations 2, 3, 4, 6, 9, 10, 11 and 13 are within the Norfolk Island National Park. Stations 12 and 14 were not used in this analysis.

environmental zone	location	station number	total number of samples
beach and dunes	Cemetery Bay	1	6
flax growth	Anson Bay	8	0
pine forest	Rocky Point	2	2
pine forest	Rocky Point	13	2
mixed forest	Anson Bay	6	5
mixed pines	Mt Pitt	3	5
mixed pines	Bumbora	4	3
mixed pines	Collins Head	7	4
palm forest	Mt Bates	10	2
palm forest	Mt Bates	11	3
rain forest	Mt Pitt	9	4
rain forest	Steeles Point	5	3

Vallonia pulchella (Muller, 1774)] are found only in the beach and dunes.

We conclude that the presence or absence of some species may be used to indicate the relative wetness of the local environment of the Emily Bay settlement site, which is in the beach and dune zone. However, even if clearly indicative numbers of these species are not present the diversity of the fauna may be helpful as an environmental indicator.

It should be noted here that, as Brook and Goulstone (1999, see also Brook, 1999a,b) found in similar environments in New Zealand, present diversity is likely to be less than in the pre-human past. This is due to the activities of the predators *Rattus exulans* and, more recently, *R. rattus*, introduced by Polynesians and Europeans respectively, as well as to anthropogenically induced environmental change. We note that three introduced specimens occur in these samples, namely *Helix aspersa* Muller, 1774, *Vallonia pulchella* (Muller, 1774) and *Zonitoides arboreus* (Say, 1817).

The archaeological sample

Fourteen cores were taken from the Emily Bay site area in 1999. Our initial plan was to take cores in two transects across the site, but the layout of the archaeological excavations and previous disturbances made this impossible, so sets of four cores were taken from three areas. Two sets (2, 3) were taken near the southeast and northeast ends of Trench EB97:23. Set 4 was taken 75 m east of this, near Trench EB96:10 (Anderson, Smith and White, this vol., fig. 29). Sets 1 and 5 each consisted of one core which showed disturbance and were therefore abandoned. They are not included in our analysis.

Four cores were taken from Cemetery Bay in two sets each of two cores. Set 6 was taken from within a small sand quarry, which had removed sand from above a clay layer, while Set 7, 16 m away, started at the current sandy ground surface, about 1 m higher.

Table 4. Modern sample: approximate number of individuals of each species per environmental zone and number of species per zone.

species	rain forest	mixed forest	palm forest	beach and dunes	mixed pines	pine forest
Advena campbellii (Gray, 1834)	—	—	—	1	—	—
Allenoconcha sp. Preston, 1913	63	26	19	10	4	2
Cryptocharopa exagitans (Cox, 1870)	16	110	16	—	10	—
Fanulena insculpta (Pfeiffer, 1846)	18	0.2	6	15	9	4
Greenwoodoconcha nux (Sykes, 1900)	75	34	74	—	107	—
Helix aspersa Muller, 1774	1	—	1	3	—	—
Johannesoconcha multivolva Preston, 1913	1	—	—	—	—	—
Lutilodix imitatrix (Sykes, 1900)	1	—	—	—	—	—
Mathewsoconcha belli Preston, 1913	—	—	—	10	—	—
Mathewsoconcha suteri (Sykes, 1900)	—	—	—	80	—	—
Nancibella quintalae (Cox, 1870)	21	—	—	—	—	—
Neospuparia norfolkensis (Sykes, 1906)	1	5	5	—	—	1
Norfolcioconcha sp. Preston, 1913	1	—	1	—	—	—
Omphalotropis albocarinata Mousson, 1873	133	105	160	381	205	280
Pacificella norfolkensis (Preston, 1913)	38	29	15	445	69	190
Palmatina quintali Iredale, 1945	10	—	—	—	—	—
Palmatina sp. Iredale, 1944	150	10	55	1	—	—
Paralaoma duncombei Iredale, 1945	—	—	1	—	—	1
Penescosta mathewsi (Preston, 1913)	2	5	—	—	—	—
Pittoconcha concinna Preston, 1913	—	—	6	—	—	—
Pittoconcha sp. Preston, 1913	—	—	1	—	—	—
Quintalia stoddartii (Gray, 1834)	15	—	—	—	8	4
Roybellia depressa Preston, 1913	61	90	1	—	10	—
Succinea (Succinea) norfolkensis Sykes, 1900	12	20	15	12	40	30
Vallonia pulchella (Muller, 1774)	—	—	—	235	—	—
Zonitoides arboreus (Say, 1817)	73	—	1	15	1	1
number of species per environmental zone	19	10	16	12	10	9

Cores were taken with a 10 cm diameter sand corer which extracted samples 10 cm in depth, thus providing samples of equal volume (785 cm^3). Cores were not of equal depth in either area, since the depth of each stratigraphic layer varied, while some cores were halted by obstructive stones. In general, the advent of a new layer could be detected by feel or could be predicted within each set once the first core was taken. In order to keep the core samples from each layer as separate as possible, not every sample was exactly 10 cm in depth. This variation has been taken into account in the averaging of data. Table 5 shows the number of core samples taken from each stratigraphic layer by each analysed core.

Table 5. Emily Bay and Cemetery Bay: number of core samples in each layer for each core.

core and set number	upper sand layer	clay layer	cultural layer	lower sand layer
EB2, Set 3	4	1	6	8
EB3, Set 3	3	2	4	6
EB4, Set 2	3	—	5	12
EB5, Set 2	2	2	4	—
EB6, Set 2	3	—	5	10
EB7, Set 4	9	2	5	15
EB8, Set 3	4	2	3	3
EB9, Set 4	9	1	5	15
EB10, Set 4	9	1	5	15
EB12, Set 2	4	—	5	8
EB13, Set 3	3	2	3	2
EB14, Set 4	8	2	5	15
total, Emily Bay	61	15	55	109
CB1, Set 7	8	1	—	5
CB2, Set 6	—	1	—	7
CB3, Set 6	—	1	—	7
CB4, Set 7	7	1	—	7
total, Cemetery Bay	15	4	—	26
total, both areas	76	19	55	135

As discussed elsewhere (Anderson, Smith and White, this vol.), the stratigraphy of the site area at Emily Bay is divisible into four main layers. These form the analytical framework of our analysis.

1 Wind-blown dunes of yellow-brown sand with considerable surface configuration on which grow a plantation of Norfolk pines. It is called here the Upper Sand layer.
2 A stiff, chocolate brown Clay layer, which slopes lightly from northeast to southwest and varies in thickness from 3 to 20 cm. The contents of this include European period material suggesting it derives from the historic period. This layer is sometimes underlain by a very thin layer of yellow sand: our analyses include this with the Clay layer.
3 Grey-brown sand, containing a considerable component of cultural material including bird and fish bone, basalt flakes and the remains of structures. This Cultural layer also slopes slightly northeast to southwest. It is sometimes up to 60 cm thick, though generally rather less. Our analyses attributed material to the Cultural layer only when clearly within a grey-brown sandy matrix. We note that very small amounts of cultural and midden material were pushed down into the fine yellow sand below, but decided that the possible contamination of our snail samples was likely to be insignificant.
4 Clean yellow sand, which continues down to the water table in all cases. Called here the Lower Sand layer, it is of variable thickness.

The stratigraphy of the Cemetery Bay cores was similar to Emily Bay, but layer 3, the Cultural layer, was absent. Following Anderson, Smith and White (this vol.), we have divided our core samples into Upper Sand (cf. Trench CB95:01, Layers 1–5), Clay (Layers 6–7) and Lower Sand (all layers below 7).

We believe that the stratigraphic integrity of the cores was fairly high but not total, based on the evidence of two introduced species. *Hawaiia miniscula* is found in many parts of the world (Cowie, 1997). In the Emily Bay cores, it is found in the Clay and Cultural layers, with one specimen in the Lower Sand layer. Six specimens occur in the Lower Sand layer of the Cemetery Bay cores. *Vallonia pulchella* is a small (2 mm diameter) snail of European origin. Sixty six specimens (18%) occur in the Cultural layer and ten (3%) in the Lower Sand layer from a total of 359 at Emily Bay, clearly indicating some movement of material. Similar movement is found in the Cemetery Bay cores. There are two possible reasons for this movement. First, both areas are long-term nesting sites for burrowing mutton birds (*Puffinus pacificus*) whose bones are found throughout the layers, and second, dune movement will have inevitably re-sorted some of the snail shells. These examples show that it would be unwise to rely on single species or small numbers in any interpretation.

Sample processing. Processing procedures were similar to those used elsewhere in Pacific archaeology (refs in Neuweger, 1999). In the field each core sample was bagged and labelled with its core number and depth. Each was then wet sieved through 2 and 1 mm geological sieves, oven-dried, and stone and other large objects such as roots discarded before return to Sydney. Samples were sorted with the aid of a magnifying lens and shells extracted were allocated arbitrary alphabetical labels pending final species identification. Species were identified using comparative collections in the Malacology Section, Australian Museum and with the assistance of Stephanie Clark.

In calculating minimum number of individuals (MNI), broken shells were also allocated to species as follows. Any shell which was only slightly damaged (e.g., apex removed) could be identified by features such as edge angle or spire size and counted along with whole shells. With more heavily broken shells numbers of individuals were calculated either from the number of particular elements present (e.g., apertures) or from assessment of broken pieces within a specific depth unit. Broken shell numbers form 12% of the total. However, breakage was not the same for all shells but varied directly with size as Table 6 shows.

A total of 9376 individual land snails were identified from the studied cores, 4601 from Emily Bay and 4775 from Cemetery Bay.

Results

Emily Bay. Table 7 gives the species count by stratigraphic layer for the Emily Bay cores and Table 8 presents the

Table 6. Emily Bay, archaeological sample. Left side: percent of broken shell numbers, by species. Right side: mean size of the adult of each species. Abbreviations: L = long, W = wide.

species	broken (%)	species	mean size of adult (mm)
Advena campbellii (Gray, 1834)	45.5	*Advena campbellii* (Gray, 1834)	22 diameter
Greenwoodoconcha nux (Sykes, 1900)	39.1	*Succinea (Succinea) norfolkensis* (Sykes, 1900)	L 12, W 6
Fanulena insculpta (Pfeiffer, 1846)	28.2	*Mathewsoconcha suteri* (Sykes, 1900)	10 diameter
Mathewsoconcha suteri (Sykes, 1900)	23.1	*Mathewsoconcha belli* Preston, 1913	10 diameter
Succinea (Succinea) norfolkensis (Sykes, 1900)	19.6	*Fanulena insculpta* (Pfeiffer, 1846)	7 diameter
Omphalotropis albocarinata Mousson, 1873	15.6	*Greenwoodoconcha nux* (Sykes, 1900)	4 diameter
Fanulena new species	11.6	*Omphalotropis albocarinata* Mousson, 1873	L 4, W 3
Hawaiia miniscula (Binney, 1840)	9.5	*Fanulena perrugosa* Iredale, 1945	L 4, W 3
Mathewsoconcha belli Preston, 1913	9.0	*Fanulena* new species	L 4, W 3
Pacificella norfolkensis (Preston, 1913)	3.1	*Neospuparia norfolkensis* (Sykes, 1906)	L 4, W 3
Norfolcioconcha norfolkensis (Hedley, 1899)	3.1	*Gastrocopta insignifica*	L 4, W 2
Palmatina sp. Iredale, 1944	2.8	*Allenoconcha basispiralis* Preston, 1913	4 diameter
Vallonia pulchella (Muller, 1774)	1.7	*Palmatina* sp. Iredale, 1944	L 3, W 1.5
Paralaoma duncombei Iredale, 1945	0.6	*Pacificella norfolkensis* (Preston, 1913)	L 2, W 1
Neospuparia norfolkensis (Sykes, 1906)	0.0	*Vallonia pulchella* (Muller, 1774)	2 diameter
Gastrocopta insignifica	0.0	*Paraloma duncombei* Iredale, 1945	2 diameter
Fanulena perrugosa Iredale, 1945	0.0	*Norfolcioconcha norfolkensis* Hedley, 1899	2 diameter
Allenoconcha basispiralis Preston, 1913	0.0	*Palmatina quintali* Iredale, 1945	2 diameter
new genus, new species	0.0	*Hawaiia miniscula* (Binney, 1840)	2 diameter
Palmatina quintali Iredale, 1945	0.0	new genus, new species	1 diameter
total	12.7		

percentage distribution of each species within each layer. Four points are immediately apparent. First, almost two-thirds of the total number of specimens comes from the Cultural layer even though this is volumetrically much smaller than Upper Sand or the Lower Sand layers. Second, there are notable changes in the proportional representations of four species. *Omphalotropis albocarinata* Mousson, 1873 and *Succinea (Succinea) norfolkensis* Sykes, 1900 both show marked declines in the Upper Sand and Clay layers, while *Pacificella norfolkensis* (Preston, 1913) and *Vallonia pulchella* (Muller, 1774) show considerable rises. The two latter species are particularly common in the modern samples drawn from the beach and dune zone. Third, *Mathewsoconcha suteri* (Sykes, 1900), *Mathewsoconcha belli* Preston, 1913, *Greenwoodoconcha nux* (Sykes, 1900) and *Advena campbellii* (Gray, 1834) are missing from the Upper Sand and Clay layers as they were in the 1997 results (the two specimens of *M. belli* Preston, 1913 in the Clay come from the interface with the Cultural layer). However, in contrast to our second point, above, three of these species,

Table 7. Emily Bay core samples: minimum number of individuals by species for each analytical unit.

species	upper sand	clay	cultural	lower sand	total
Advena campbellii (Gray, 1834)	—	—	8	4	12
Allenoconcha basispiralis Preston, 1913	1	—	—	1	2
Fanulena insculpta (Pfeiffer, 1846)	11	1	108	51	171
Fanulena perrugosa Iredale, 1945	—	1	4	—	5
Greenwoodoconcha nux (Sykes, 1900)	—	—	36	9	45
Hawaiia miniscula (Binney, 1840)	—	2	3	1	6
Mathewsoconcha belli Preston, 1913	—	2	149	28	179
Mathewsoconcha suteri (Sykes, 1900)	—	—	10	2	12
Neospuparia norfolkensis (Sykes, 1906)	—	—	2	2	4
new genus, new species	—	2	4	2	8
Norfolcioconcha norfolkensis (Hedley, 1899)	3	—	5	5	13
Omphalotropis albocarinata Mousson, 1873	162	52	2114	620	2948
Pacificella norfolkensis (Preston, 1913)	170	3	35	20	228
Palmatina quintali Iredale, 1945	1	—	1	—	2
Palmatina sp. Iredale, 1944	27	8	157	32	224
Paralaoma duncombei Iredale, 1945	59	—	120	98	277
Succinea (Succinea) norfolkensis Sykes, 1900	2	2	81	21	106
Vallonia pulchella (Muller, 1774)	157	126	66	10	359
total	593	199	2903	906	4601

Table 8. Emily Bay: percentage of each species per core sample in each analytical unit, using the minimum number of individuals as the counting basis.

species	**upper sand**	**clay**	**cultural**	**lower sand**	**total**
Advena campbellii (Gray, 1834)	—	—	0.3	0.4	0.3
Allenoconcha basispiralis Preston, 1913	0.2	—	—	0.1	0.04
Fanulena insculpta (Pfeiffer, 1846)	1.9	0.5	3.7	5.6	3.7
Fanulena perrugosa Iredale, 1945	—	0.5	0.1	—	0.1
Greenwoodoconcha nux (Sykes, 1900)	—	—	1.2	1.0	1.0
Hawaiia miniscula (Binney, 1840)	—	0.5	0.1	0.1	0.1
Mathewsoconcha belli Preston, 1913	—	0.5	5.1	3.1	3.9
Mathewsoconcha suteri (Sykes, 1900)	—	—	0.3	0.2	0.3
Neospuparia norfolkensis (Sykes, 1906)	0.5	—	0.2	0.6	0.3
new genus, new species	—	0.5	0.1	0.2	0.2
Norfolcioconcha norfolkensis (Hedley, 1899)	—	—	0.1	0.6	0.2
Omphalotropis albocarinata Mousson, 1873	27.3	26.1	72.8	68.4	64.0
Pacificella norfolkensis (Preston, 1913)	28.7	1.5	1.2	2.2	5.0
Palmatina quintali Iredale, 1945	0.2	—	0.03	—	0.04
Palmatina sp. Iredale, 1944	4.6	4.0	5.4	3.5	4.9
Paralaoma duncombei Iredale, 1945	9.9	—	4.1	10.8	6.0
Succinea (Succinea) norfolkensis Sykes, 1900	0.3	0.5	3.7	2.3	2.3
Vallonia pulchella (Muller, 1774)	26.5	63.3	2.3	1.1	7.8
mean number per core sample	9.7	13.2	52.8	8.4	19.2

namely *A. campbellii*, *M. belli* and *M. suteri* are only found in the beach and dune zone in the modern sample. Fourth, there are no species that appear only in the European period Clay and Upper Sand layers, unlike the 1997 results.

Cemetery Bay. Analysis of the Cemetery Bay material is set out in Table 9. This shows that there is a high degree of overlap with the Emily Bay data in the species represented and that there are similar numbers of species in the pre-human Lower Sand layer and the Clay layer. There are many fewer species in the Upper Sand layer, but the three represented are those most common at Emily Bay. The similarity in overall pattern to the Emily Bay data supports its reality.

In terms of absolute numbers there are considerable differences between the two areas, with many more shells per unit volume in the pre-human layer at Cemetery Bay compared to Emily Bay, while the reverse is true of the Upper Sand layer. We presume that the differences relate both to minor environmental differences resulting in different snail population densities at the times of accumulation and to local taphonomic processes.

Table 9. Cemetery Bay core samples: minimum numbers of individuals of each species.

species	**upper sand**	**clay**	**lower sand**	**total**
Advena campbellii (Gray, 1834)	—	1	8	9
Allenoconcha basispiralis Preston, 1913	—	—	1	1
Fanulena insculpta (Pfeiffer, 1846)	—	4	96	100
Fanulena new species	—	—	1	1
Greenwoodoconcha nux (Sykes, 1900)	—	2	11	13
Hawaiia miniscula (Binney, 1840)	—	—	6	6
Lutilodix imitatrix (Sykes, 1900)	—	—	1	1
Mathewsoconcha belli Preston, 1913	—	4	263	267
Mathewsoconcha suteri (Sykes, 1900)	—	3	53	56
new genus, new species	—	—	1	1
Norfolcioconcha norfolkensis (Hedley, 1899)	—	—	10	10
Omphalotropis albocarinata Mousson, 1873	8	81	3683	3772
Pacificella norfolkensis (Preston, 1913)	1	—	6	7
Palmatina sp. Iredale, 1944	—	3	218	221
Paraloma duncombei Iredale, 1945	—	1	7	8
Succinea (Succinea) norfolkensis Sykes, 1900	—	—	57	57
Vallonia pulchella (Muller, 1774)	28	169	48	245
total	37	268	4470	4775
mean number per core sample	2.5	67.0	171.9	106.1

Discussion and implications

We start by noting that our modern samples suggest that land snails may be indicative of environments in two ways. First, some species appear to be restricted to certain environments and second, wetter environments, that is those with more permanent moisture, host a greater diversity of species.

Snail diversity is high in both the Lower Sand and Cultural layers. The number of species in both layers is comparable to that of wet environments such as rainforest and palm forest in our modern sample. This may suggest a damper environment with more vegetation in the Emily Bay area in the past. However, these layers do not contain those species which are found only in wetter forest areas today, so we do not think that the difference was particularly great.

Diversity in the fauna is lower in layers attributable to the European period, both in the Clay layer which dates to an early European time and the dunes of the Upper Sand layer. The dominant species are those found in the beach and dune zone today, confirming that the environment has remained much the same throughout this period.

There are, however, three other variables to be taken into account.

First, high density and diversity of the snail fauna in the Cultural layer may be directly attributable to human activity. Humans generally increase the floral diversity of a site by transporting a variety of plants to it: snails may come accidentally with these plants. Food refuse also attracts snails and an increase in this is the common result of human occupation. Our results are clearly similar to those of Brook and Goulstone (1999: 125) who have demonstrated that diversity in the land snail fauna in sand dune areas on several islands in New Zealand increases within the Maori occupation period.

Second, human settlers almost certainly increased the level of fire in the landscape and this would have affected the snail population. To what extent the vegetation of Norfolk Island was modified in pre-European times is not clear from the limited palaeoenvironmental studies so far carried out (see Macphail, Hope and Anderson, this vol.).

Third, the decline in diversity in both the Clay and Upper Sand layers may be the consequence of predation on snails by *Rattus exulans*. We note that it is the larger among the common beach and dune zone species that have declined or disappeared (Table 6). *Rattus exulans* had arrived on the island before the Europeans—probably introduced by the Polynesian settlers—and had reached pest proportions when the Europeans arrived. It is an eclectic omnivore, and we presume that the larger snails would be a more attractive prey and therefore under greater threat of extinction. By the time the Clay layer was deposited, early in the European period, our data suggest that many species were already in decline (Table 7). The large scale loss of vegetation cover and diversity through cattle grazing and other land use in the European period may have played some part in the final extinction, as demonstrated by our data for the Upper Sand layer.

The pattern of faunal change we present here is highly comparable with that demonstrated in greater detail by Brook and Goulstone (1999, see also Brook, 1999a,b) for similar environments dating to a similar time period in New Zealand. But, as Brook (1999b: 136) says, the relative contributions of rat predation and habitat modification "will probably never be disentangled".

Conclusion

We conclude that the environmental impact of the Polynesian settlement of Norfolk Island can be seen in changes in the land snail fauna. This was probably not a direct impact but likely through the introduction of *Rattus exulans*. The decline in species in the Emily Bay area in the European period is probably attributable to local clearance and rodent predation.

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Polynesian Plant Introductions in the Southwest Pacific: Initial Pollen Evidence from Norfolk Island

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ABSTRACT. Thick organic swamp sediments, buried under land fill on Kingston Common, preserves evidence of the Norfolk Island flora and vegetation back to the middle Holocene and probably much earlier times in the Late Quaternary. These sediments provide (1) a bench mark against which the impact of humans on the flora and vegetation of a long-isolated island can be assessed and (2) a means of determining whether particular plant genera and species are introduced or native to the island. Although sediments contemporary with Polynesian occupation about 800 years ago were destroyed by European draining and cultivation of the swamp during the early nineteenth century, the pollen data indicate that New Zealand flax (*Phormium tenax*) was introduced to Norfolk Island by Polynesians. Other putative exotics such as Ti (*Cordyline*), a bull-rush (*Typha orientalis*) and, less certain, herbs such as the sow thistle (*Sonchus oleraceus*), were part of the native flora long before the earliest recorded Polynesian settlement. Wildfires have been part of the landscape ecology of Norfolk Island since at least the middle Holocene.

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Like Europeans, Polynesians have been responsible for the spread of exotic plants into the southwest Pacific. Obvious examples are food species such as bananas (*Musa paradisica*), coconuts (*Cocos nucifera*) and sweet potato (*Ipomoea batatas*). Less clear-cut examples are the New Zealand flax (*Phormium tenax*), Ti (*Cordyline*) and the sow thistle *Sonchus oleraceus*. European commensals found include dandelion (*Taraxacum officinale*) and plantain (*Plantago lanceolata, P. major*).

Norfolk Island (29°02'S 167°56'E) lies too far south for coconuts to survive (see Hoare, 1988: 18). However, when first visited by Europeans in A.D. 1774 (James Cook) and A.D. 1788 (Phillip King), large numbers of banana trees were found growing along a freshwater stream flowing from Arthur's Vale into the Kingston Swamp on the south coast (Fig. 1). New Zealand flax covered rocky outcrops and sea cliffs in the same area (references in Hoare, 1988). Hoare (1988: 19) lists *Sonchus oleraceus*, palm hearts (*Rhopalo-*

stylis baueri) and the fruits of the Screw Palm (*Freycinetia*) as a food plant available to Polynesian colonists. *Sonchus* was amongst the edible species collected by Cook's crew in 1774 (Hoare cited in Hicks, 1988: 165). Other suggested early introductions include one of the more common *Hibiscus* species on Norfolk Island (*H. diversifolius*), *Persicaria decipiens* (no common name) and a bull-rush (*Typha orientalis*) (Wilson, 1994).

Clearing and other forms of landscape disturbance have allowed many European exotics and some native shrubs to become invasive (Green, 1994: 2–5). Examples of the latter are the Chaff-flower (*Achyranthes aspera*) and probably the Shrubby Creeper (*Muehlenbeckia australis*). Native trees are suggested to have formed three major forest types in 1788 (Gillman and Helman cited in Green, 1994: 5). These are: (1) *Rhopalostylis baueri–Cyathea* Palm Forest lining narrower gullies and steeper moist slopes; (2) Broadleaf Hardwood Forest growing on less steep slopes and shaded areas (species suggested to have been particularly abundant (Hicks, 1991) are *Elaeodendron curtipendulum* (Maple), *Nestigis apetala* (Ironwood), *Rapanea ralstoniae* (Beech) and *Baloghia inophylla* (Bloodwood)); and (3) Gymnosperm Forest, dominated by *Araucaria heterophylla* (Norfolk Island Pine) growing on the drier and more exposed/infertile sites.

Most of these plants produce distinctive pollen grains and the presence of cultigens and commensals provides a complementary method to archaeology for detecting the presence of early human settlement on Norfolk Island. One site which preserves a long-term pollen record of the Norfolk Island flora and vegetation is Kingston Swamp (Fig. 1) where thick peats and organic silts have accumulated behind calcarenite dunes lining the foreshore of Slaughter Bay. Importantly, the swamp is located less than 0.5 km west of Emily Bay where archaeological excavation has uncovered c. 800 year old remains of a Polynesian settlement (Anderson, 1996a,b).

This study describes fossil pollen and spores recovered from the top 2.9 m of a 5 m long core (Borehole KCA) of sediments from the edge of Kingston Swamp, now buried under landfill (Anderson and Hope, 1996). Other boreholes demonstrate that the organic sedimentary infill further away from the margins is at least 7 m thick (Borehole KCB) and possibly up to 21 m thick (Borehole 197). Boreholes KCB, KCD and 197 were not analysed for this study, but contain very little material suitable for analysis. If correct, the swamp preserves a uniquely detailed record for small islands in the southwest Pacific (Macphail and Neale, 1996).

Human settlement

Because of encircling reefs and steep volcanic terrain, human settlement of Norfolk Island has been centred around the Kingston-Arthur's Vale area on the south coast, the only extensive coastal plain and the only part of the island accessible from the sea. This area was occupied on at least three separate occasions before permanent settlement of the island began in 1856 (references in Nobbs, 1988, 1991; Wilson and McLaren, 1994; Anderson, 1996b):

1 Polynesian settlement (c. A.D. 1200). Radiocarbon dates for the Polynesian settlement at Emily Bay are clustered within 800–600 B.P. The remains of a canoe, found in A.D. 1788 (King cited in Hoare, 1988: 19) may be

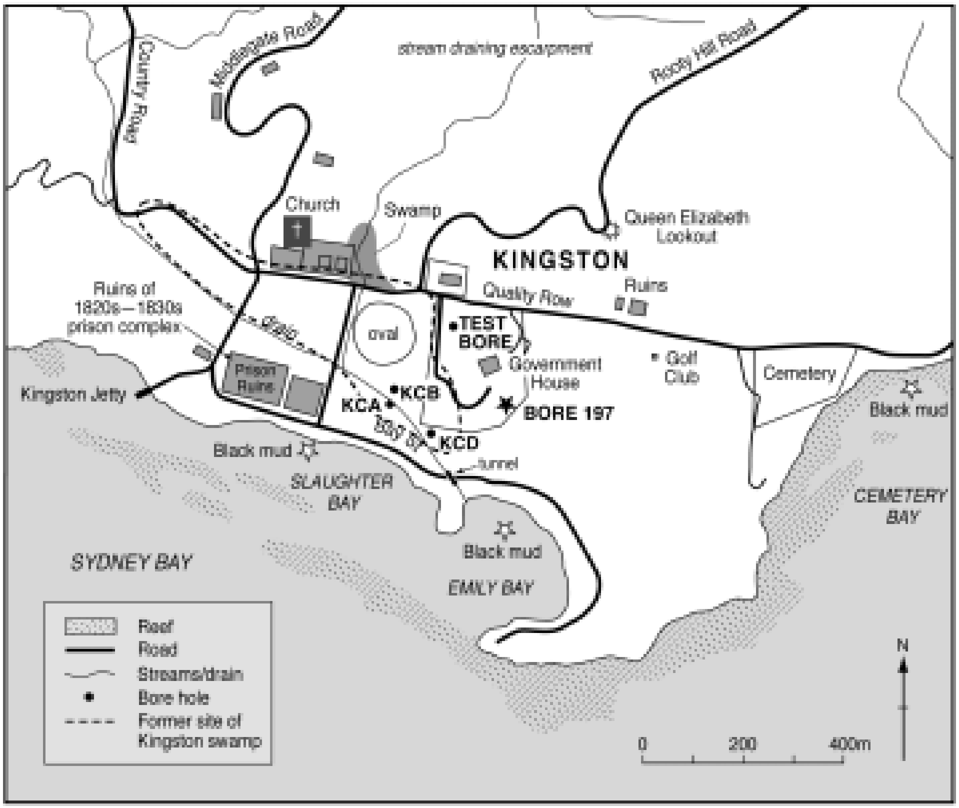

Figure 1. Kingston area showing location of Boreholes KCA, KCB, KCD and 197.

evidence of subsequent visits up to the eighteenth century. At the time of first European settlement in A.D. 1788, the island was covered in thick forest with dense vine thickets in the understorey. The plants growing in the Kingston Swamp were not recorded but King (cited in Hunter, 1793: 306) observed that the banana trees were interlaced with "small aquatic shrubs" and a "bear-bind" (= *Muehlenbeckia australis*?). The only naturally treeless areas were the *Phormium tenax*-covered sea cliffs. Rats, presumed to be the Polynesian species *Rattus exulans*, are listed during the first days of European settlement in 1788 as being very numerous and destructive (King cited in Hunter, 1793: 311–312; Green, 1994: 7).

2. First European settlement (A.D. 1788–1814). During the first phase of convict occupation, the native forest was cleared from about 30% of the island. Administration buildings were constructed along Quality Row at the foot of the volcanic escarpment behind Kingston Swamp and a channel was dug to regulate flooding and divert water through a tunnel excavated through the foreshore calcarenite ridge into Emily Bay. The drained swamp was used for grazing and the cultivation of crops, including vegetables and barley. Following abandonment of the settlement in A.D. 1814, the tunnel to Emily Bay became blocked, allowing the swamp to reform behind the foreshore ridges.
3. Second European settlement (A.D. 1825–1855). During the second phase of convict occupation, the top of the calcarenite ridge separating Kingston Swamp from Slaughter Bay was levelled for construction of the prison complex whilst the swamp was drained for a second time and converted into prisoners' gardens (Fig. 1). The gardened area was buried under clay landfill and reshaped as a "picturesque" landscape in the mid 1830s, and the channel straightened about A.D. 1847. The built-up section between this drain and Quality Row (now Kingston Common) has been converted to playing fields and the levelled foreshore ridge, now traversed by Bay St. (Fig. 1), is mostly covered by lawn and planted Norfolk Island Pines.

Kingston Swamp and surrounds

Kingston Swamp occupies a deep basin formed at the junction of two Late Pleistocene carbonate sand dune fields (now lithified into calcarenite ridges), one aligned E-W and moving inland from the direction of Slaughter Bay and the other aligned NE–SW and moving inland from the direction of Cemetery Bay. Natural drainage was by percolation though the calcarenite into Emily Bay and the swamp appears to have been subject to marked seasonal lateral expansion and contraction. Drilling (Anderson and Hope, 1996; Macphail and Neale, 1996; G. Duval, pers. comm.) has demonstrated that the sedimentary infill is greater than 7 m thick and possibly up to 21 m thick away from the margins. Organic deposits of middle Holocene age outcrop below low water mark in Slaughter and Cemetery Bays. Also present in Cemetery Bay are raised reefs, one of which preserves evidence of fire in the form of partially burnt lignites sandwiched between two limestone strata (Macphail and Neale, 1996). This lignite has yet to be radiocarbon dated but is likely to be early to mid Holocene based on radiocarbon dates of 8,310±90 B.P. (ANU-10661) for organic muds exposed below low water mark at the northern end of Cemetery Bay and 4,830±30 B.P. (ANU-10660) for black muds in the equivalent position in Slaughter Bay (Fig. 1, open star symbols).

Lithostratigraphy and age control

Borehole KCA is located on the southeastern margin of the former swamp close to the point where the organic infill is believed to have onlapped the calcarenite ridge behind Slaughter Bay (Fig. 1). Four distinctive lithological units were intersected below a 40 cm thick layer of recent sands forming the base of the present-day lawn (depths below present-day ground level in cm). Each is separated from its neighbour(s) by unconformity surfaces representing episodes of erosion or non-deposition at the borehole site:

Unit A 40–141 cm. Grey-brown clays and silts. This unit is interpreted as landfill dumped on the swamp after c. A.D. 1835.

Unit B 141–148 cm. Yellow-white horizontally bedded carbonate sand. This unit has been variably interpreted as sands deposited by a tidal wave in A.D. 1834 (Anderson and Hope, 1996) and as a slope-wash deposit accumulating on the swamp surface during levelling of the calcarenite ridge (Macphail and Neale, 1996). The sand thins inland to c. 1 cm thick in Borehole KCB (Macphail and Neale, 1996).

Unit C 148–167 cm. Black strongly humified silty peat. This unit is interpreted to be the oxidized remnants of the upper peat layers, caused by draining and cultivation of the swamp. Organic silt between 148 and 157 cm yielded an uncorrected/conventional radiocarbon date of 1,000±150 B.P. (ANU-10090).

Unit D 167–500 cm. Interbedded peats, organic muds, and yellow-brown to dark grey clays. This unit is interpreted as being undisturbed sediments accumulating before human settlement of the island. Samples from 226–235 cm and 315–325 cm yielded conventional radiocarbon dates of 2,580±250 B.P. (ANU-10091) and 5,450±180 B.P. (ANU-10091), respectively.

Exotic pollen types such as *Plantago lanceolata*-type, and abundant Liguliflorae (*Taraxacum officinale*?) and Poaceae pollen occur at 50 cm, and a single grain of a cereal species was found at 120 cm (Table 1). These records demonstrate that the upper 80 cm of Unit A was deposited after European settlement and, by extrapolation, the whole of Unit A post-dates the mid 1830s when the former swamp was buried under landfill (see below).

The low relative abundance of woody species other than *Cyathea* indicates the interval above 50 cm represents a time when almost all native forest had been cleared from the Kingston area. The interval could be as young as the early twentieth century, based on the widespread planting of Kikuyu Grass (*Pennisetum clandestinum*) as a pasture species across the island about this time. Conversely the interval below 120 cm may represent an early phase of European clearing before A.D. 1855, or the sediment came from an area retaining some native forest species. If

Table 1. Kingston Common relative abundance data of commonly occurring and other selected plant types in borehole KCA. Figures in section above dashed line are %, those below the line are counts and concentrations. ([a] this species belongs to Arecaceae).

unit	UNIT A			UNIT B		UNIT C		UNIT D								
depth from surface (cm)	50	120	135	143	147	153	163	175	185	195	205	210	225	235	255	285
plants introduced by Europeans?																
Brassica-type	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—
cereal Poaceae	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chenopodiaceae	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	—
Liguliflorae (*Taraxacum*?)	15	+	+	+	+	—	—	—	—	—	—	—	—	—	—	—
Plantago lanceolata-type	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
plants introduced by Polynesians?																
Cordyline obtecta	—	+	+	4	9	14	3	—	—	—	—	—	—	—	+	—
Hibiscus diversifolius-type	+	+	+	+	+	+	+	—	+	+	—	—	—	+	—	+
Liguliflorae (*Sonchus*?)	?	?	?	?	?	—	—	—	—	+	—	—	—	—	—	—
Persicaria decipiens	+	+	3	3	3	2	—	—	—	—	—	—	—	—	+	+
Typha orientalis	+	32	25	32	20	6	3	3	11	5	6	6	2	6	+	1
locally extinct? taxa																
cf. *Hedyscepe canterburyana*[a]	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—
Hibiscus sp.	—	—	+	+	3	2	+	—	+	—	—	—	—	—	—	—
native trees & shrubs																
Achyranthes spp.	—	—	—	—	—	—	+	3	1	+	+	1	2	1	2	+
Araucaria heterophylla	3	6	18	18	26	10	8	19	12	5	6	15	13	13	2	7
Celtis paniculata	—	—	—	—	+	3	—	—	+	+	—	1	30	4	3	6
Muehlenbeckia australis	+	33	24	28	20	19	55	32	52	74	62	51	23	13	8	7
Nestigis apetala	—	—	—	—	+	+	—	—	—	—	+	+	—	+	2	2
Pennantia endlicheri	—	—	—	—	+	—	—	+	+	+	+	1	+	+	3	8
Rapanea ralstoniae	—	—	+	—	+	+	—	+	+	—	+	—	+	—	2	1
Rhopalostylis baueri	+	+	—	+	+	—	—	+	+	—	+	—	5	3	2	2
native herbs																
Cyperaceae	31	14	50	39	74	+	+	2	2	1	+	+	+	1	1	2
Poaceae	9	+	+	—	+	—	—	+	—	+	—	—	—	—	—	—
native ferns & liverworts																
Cyathea australis/brownii	63	41	34	28	16	7	32	35	23	12	20	14	28	51	51	47
Marattia salicina	—	7	4	3	3	3	2	8	7	4	9	12	18	11	17	11
unidentified monolete ferns	3	5	6	9	16	20	+	2	2	1	2	1	4	2	3	4
unidentified trilete spores	2	4	6	5	6	1	—	—	—	—	—	—	—	—	—	—
dryland pollen count	253	304	253	257	254	243	432	443	443	675	723	572	370	474	484	539
total pollen count	332	433	441	439	538	330	459	464	491	713	770	613	381	497	493	545
pollen concentration (10^3)	51	212	391	206	418	111	1450	183	650	820	320	129	169	281	377	763
charcoal concentration (10^3)	408	114	365	171	266	114	100	13	31	36	2	5	990	1783	525	1544

correctly interpreted, the carbonate sand unit confirms that samples above 148 cm are younger than A.D. 1824–1834.

The radiocarbon date of c. 1,000 B.P. at 148–157 cm is considered imprecise for two reasons. (1) Unit C represents the remnants of an unknown thickness of peat. (2) Older soil charcoal may have washed into the swamp during First Settlement time. Nevertheless, in combination with the sedimentary evidence, the date of c. 1,000 B.P. strongly implies that swamp sediments deposited at the KCA site during the period(s) of Polynesian occupation have been destroyed by European activities. Whether this is true in other areas of the former swamp is uncertain but a similar sequence of lithologies, including a c. 60 cm thick unit of strongly oxidized peaty silts, was intersected in Borehole KCB drilled c. 30 m to the NNE of Borehole KCA.

Pollen analysis methods

Sixteen samples, representing all four lithological units down to a depth of 285 cm, were processed for fossil pollen, spores and other acid-resistant plant microfossils using standard techniques: addition of a known quantity of an exotic *Lycopodium* spore to each sample allowed numbers of fossil pollen, spores and charcoal particle to be estimated (see Moore *et al*., 1991: 41–54).

Fossil extracts were mounted on glass slides and a minimum of 330 identifiable fossil pollen and spores counted for each sample using a Zeiss Photomicroscope II fitted with oil immersions objectives capable of providing magnifications of up to ×2,000. The remainder of each mount was then scanned for additional rare taxa.

The relatively small size of the Norfolk Island flora has allowed many fossil pollen and spores to be identified to species or to groups of related genera or species. Examples in the first category are *Araucaria heterophylla, Muehlenbeckia australis, Phormium tenax*, and *Rhopalostylis baueri* (Norfolk Island Palm). Examples in the latter category are *Sonchus* and *Taraxacum* species which produce Liguliflorae-type pollen, and *Plantago lanceolata* and *P. major*, which are the only known sources of *Plantago lanceolata*-type pollen on Norfolk Island.

Most ferns are a special case in that their fossil spores can only be identified to species level when the outer wall layer (perispore) is preserved intact. Fern spores which can almost always be identified to species level include *Histiopteris incisa* (Bat Wing Fern), *Marattia salicina*, (King Fern) and the three species of *Pteris* (Brakefern). The *Cyathea* count comprises spores produced by two native tree-ferns, *Cyathea australis* (Rough Tree-fern) and *C. brownii* (Norfolk Island Tree-fern).

Results

Relative abundance data for selected commonly occurring and culturally significant plants, expressed as percentages of the total dryland pollen count, are given in Table 1. Figure 2 gives an overview of lithology, selected pollen spectra, a summary of the latter and charcoal concentration. A selection of the more distinctive fossil pollen and spore types are illustrated in Figs. 3–5, and the pollen and spore database listed in full in Appendix.

Preservation and yield. Apart from the fragmentation of very large pollen types such as *Hibiscus*, pollen preservation was uniformly excellent in all lithological units. Yields of fossil pollen and spores were high to very high, with concentration values ranging from 51×10^3 grains cc^{-1} in the clay landfill (Unit A) to a maximum of $1{,}450\times10^3$ grains cc^{-1}, in what may be a lag concentrate near the base of strongly oxidized peats (Unit C). Intermediate values are recorded in the other lithologies. Charcoal fragments with a minimum dimension of 8 µm are present in all samples but concentration values vary greatly, from 2 to $1{,}783\times10^3$ particles cc^{-1}. Minimum and maximum values occur within Unit D, at 175–210 cm and below 220 cm depth respectively.

Diversity. At least 60 distinctive fossil pollen and spore types are present, of which approximately 20 can be assigned to living species and about the same number to groups of two or three related species (Appendix).

The majority of these are native taxa and include some of the more important endemic trees and shrubs in the Norfolk Island flora, e.g., *Achyranthes* (Chaff-tree/Chaff-flower), *Araucaria heterophylla, Celtis paniculata* (Whitewood), *Lagunaria patersonia* (Sally Wood), *Pennantia endlicheri* (Pennantia), *Rapanea ralsoniae, Rhopalostylis baueri* and *Ungeria floribunda* (no common name). Herbs are poorly represented except for swamp plants such as the Cyperaceae (sedges) and *Typha orientalis*.

Only one confirmed cultigen pollen type was recorded—a cereal species at 120 cm within Unit A. It is possible that *Brassica*-type pollen at 135 cm and 143 cm depth represents crop species such as turnip or mustard (*Brassica* spp.). Pollen of other plants cultivated or utilized by Polynesians, e.g., banana, sweet potato and flax, were not recorded; nor were salt-water indicators such as the cysts of marine alga (dinoflagellates) found in any sample.

Twelve pollen types could not be matched with those produced by living plants in the Norfolk Island flora. Most of these are known to be transported by wind over long distances, e.g., Casuarinaceae, Myrtaceae and *Nothofagus* (cf. Salas, 1983). Pollen types, which include aquatic species, have been carried in mud on the feet of migrating birds, e.g., Apiaceae cf. *Hydrocotyle, Lemna*-type (Duckweed) and *Triglochin*. Two types are not known to be dispersed over long distances, and therefore are more likely to be sourced from plants growing on Norfolk Island in the past. These are (1) a palm type which resembles pollen produced by a species endemic to Lord Howe Island (*Hedyscepe canterburyana*) and (2) a Malvaceae which may represent a locally extinct *Hibiscus* species.

Dominance. With the exception of the highest assemblage (50 cm), the same small group of native taxa dominates all microfloras, irrespective of lithology. The majority of these are produced by genera that produce and disperse pollen or spores in large numbers by water and/or wind (well-represented taxa). The group includes *Cyathea, Araucaria heterophylla* and Poaceae. Other commonly occurring types are more likely to come from plants which grew locally around, in or upstream of the swamp (under-represented taxa). Examples are Liguliflorae, *Marattia salicina, Muehlenbeckia australis* and *Typha orientalis*. Most herbs, shrubs and hardwood trees are severely under-represented by pollen, and low to trace pollen percentages still are reliable evidence that the source plant(s) grew locally. Examples are *Persicaria decipiens, Freycinetia, Nestigis apetala* and *Zanthoxylum pinnatum* (Box Wood).

Interpretation and vegetation history

Unit A 40–141 cm inferred age: after A.D. 1834

This unit is represented by three samples, at 50 cm, 120 cm and 135 cm. The microflora at 50 cm is unique in that abundant *Cyathea* and Cyperaceae are associated with high values of Liguliflorae (15%) and Poaceae (9%). Both of the latter types are likely to represent introduced species, e.g., *Taraxacum officinale* and *Pennisetum clandestinum*. *Araucaria heterophylla* percentages are low (3%) relative to values recorded at 120–135 cm. *Muehlenbeckia australis* and *Typha orientalis* pollen occur in trace numbers only.

Microfloras at 120 cm and 135 cm are dominated by Cyperaceae, *Typha orientalis, Cyathea* and *Muehlenbeckia australis*, associated with frequent (4–7%) *Marattia salicina* and other monolete and trilete fern spores. Several possible exotic pollen types are present in trace numbers, e.g., Chenopodiaceae and Liguliflorae. Charcoal particle concentration values are low relative to the maximum values in the sequence but are sufficiently high to imply that fire was used as one method to clear land.

The data indicate that the upper 10 cm of Unit A either accumulated in a sedge swamp in which the water table usually was above ground level or the clays were sourced from a similar freshwater swamp elsewhere. *Cyathea* spores are dispersed in large numbers by water and the spore count

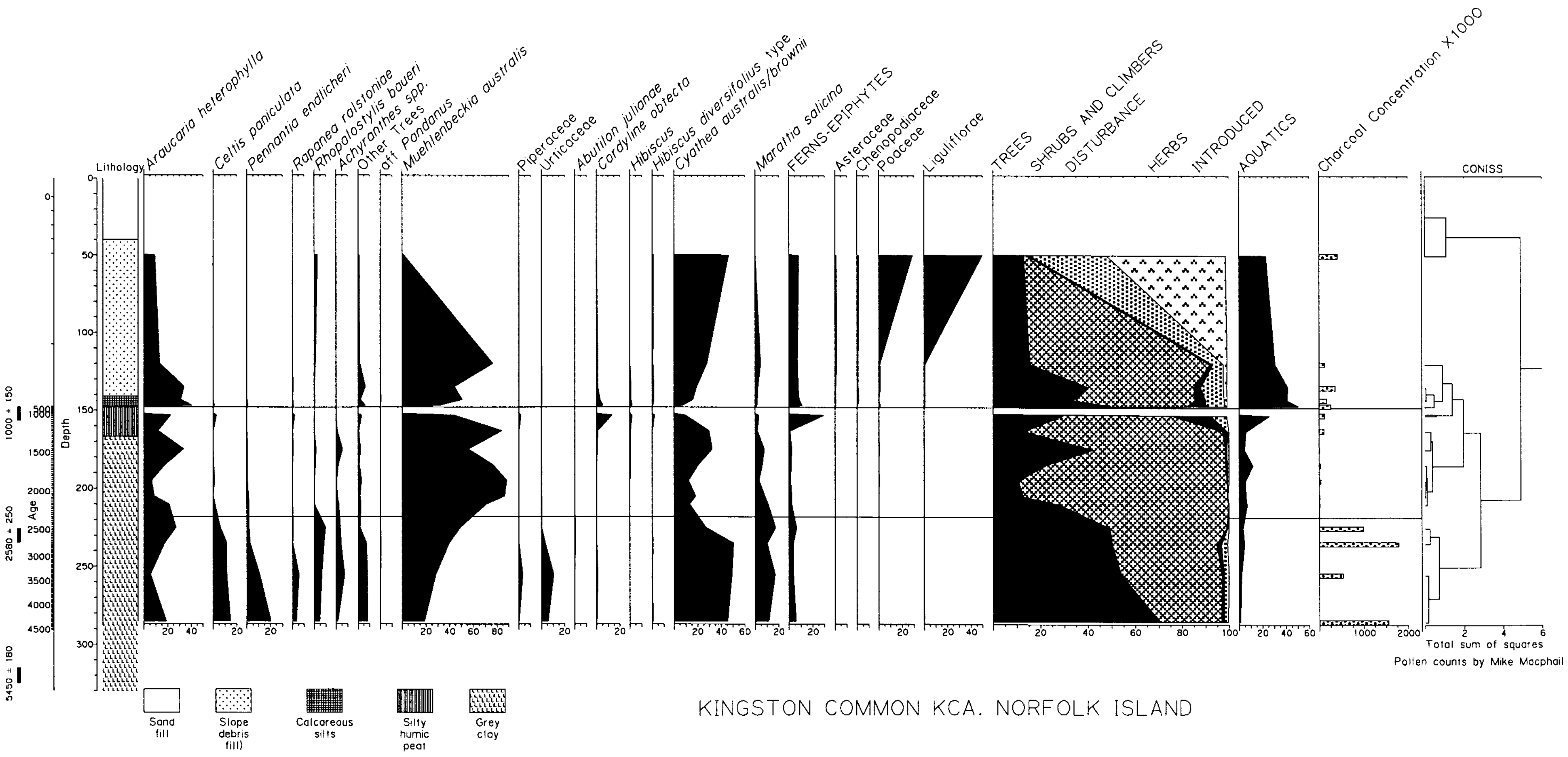

Figure 2. Stratigraphy, selected pollen spectra, pollen summary and charcoal concentration for Borehole KCA at Kingston Common.

almost certainly will have come from tree-ferns growing in gullies on the escarpment behind Quality Row, or from stands growing upstream in Arthur's Vale. In either case, the data are consistent with periodic flooding of the swamp during the early to middle nineteenth century A.D.

Pollen preserved in the basal 35 cm of Unit A and within Unit B (see below) are circumstantial evidence that *Muehlenbeckia australis* and *Typha orientalis* were two of the "wild vines and aquatic shrubs" growing along streams flowing into Kingston Swamp in 1788 (King cited in Hunter, 1793: 306). Forest communities growing on the adjacent foreshore ridge included a tall tree species, *Lagunaria patersonia*, that is now widespread on the island.

Unit B 141–147 cm inferred age: A.D. 1824–1834

The carbonate sand unit is represented by two samples, at 143 cm and 147 cm. Pollen dominance is similar to that recorded at the basal sample of Unit A (135 cm) although charcoal particle concentration values are slightly lower.

The chief distinguishing feature is that *Persicaria decipiens* and *Cordyline* pollen are frequent to common (3–9%). *Araucaria heterophylla* values (18–26%) are the highest recorded in the sequence, probably because a reduction in the local pollen influx (due to clearing or flooding of the swamp) has accentuated the representation of more distant, well-represented trees. Pollen of Arecaceae cf. *Hedyscepe canterburyana* and the possibly extinct *Hibiscus* sp. are best represented in this unit and the underlying organic silts (Unit C).

Persicaria is typically found in wet habitats and the inferred age of the sand is close to the date (A.D. 1835) when this herb was first collected on Norfolk Island (see Wilson, 1994: 99). The pollen type indicates that the carbonate sand was deposited on a damp surface, ie. the water table was below ground level. If the *Persicaria* pollen grains at 285 cm are *in situ* then the fossil data are against the species being an early introduction. *Cordyline* (presumed to be the endemic species *C. obtecta*) is now frequent only in Norfolk Island National Park centred around the volcanic peaks of Mt. Pitt (316 m elevation) and Mt. Bates (308 m elevation) in the northwest of the island. The pollen data are evidence that this small tree grew in the Kingston lowlands during the early nineteenth century and may have been a food resource if its roots and lower stems, like those of some other *Cordyline* species, are edible.

Unit C 147–167 cm c. 1,000 B.P.

Unit C is represented by two samples, at 153 cm and 163 cm. The sedimentary evidence, supported by the pollen concentration data, indicates that the interval is the residue of peats accumulating on the site between c. 1,000 B.P. and A.D. 1788. Microfloras from such deposits are difficult to interpret, not least because of biases caused by preferential destruction of less robust pollen types, the condensing of widely separated strata and/or mixing of microfloras of different ages.

Marked differences in the pollen concentration values (111×10^3 *vs* $1{,}450\times10^3$ grains cc^{-1}) and in the relative abundance of commonly occurring taxa such as *Muehlenbeckia australis* and fern spores indicate that the unit is a condensed sequence: (*a*) The assemblage at 153 cm is dominated by monolete fern spores (20%) and *Muehlenbeckia australis* (19%), associated with unusually high values of *Celtis paniculata* (3%), *Cordyline obtecta* (14%) and *Persicaria decipiens* (2%). Values of *Araucaria heterophylla* (10%) and *Typha orientalis* (6%) are low relative to those recorded in Unit B. (*b*) *Muehlenbeckia australis* (55%) and *Cyathea* (32%) wholly dominate the assemblage at 163 cm. Values of *Araucaria* (8%) and *Typha orientalis* and *Cordyline obtecta* (3%) are lower than at 153 cm whilst *Persicaria decipiens* is absent. Cyperaceae pollen occurs in trace numbers only in both assemblages.

How the fossil pollen data are interpreted depends on whether *Cyathea* spores were water-transported to, or sourced from tree-ferns growing on or near, the site. If the former occurred, then the swamp was repeatedly flooded during the time represented by the sample at 163 cm. *Muehlenbeckia australis* appears to have been established on the site itself. If the latter, then the water table in Kingston Swamp was below ground level, allowing tree-ferns as well as *Muehlenbeckia australis* to colonize the damp peat surface. Circumstantial evidence that the latter hypothesis is the more likely is provided by the low value of *Typha orientalis* at 163 cm and presence of *Persicaria decipiens* at 153 cm. During the period represented by this sample (153 cm), tree-ferns and *Muehlenbeckia australis* were less common whilst *Cordyline* almost certainly was part of the woody vegetation on the adjacent calcarenite ridge.

The low representation of long distance dispersed pollen types such as *Araucaria* (8–10%) is likely to reflect the high local pollen influx. It is noted that what are interpreted as relatively dry edaphic conditions would be expected to favour the local establishment of *Phormium tenax* (nowhere recorded in the sequence) had the species been present on the island in Unit C time.

Unit D 167–285+ cm between 2,580 and 1,000 B.P.

Unit D is represented by nine samples taken at 5–10 cm spacings between 175 and 285 cm depth. Unlike the overlying sedimentary units, there is little doubt that the microfloras predate the known settlement of Norfolk Island by humans.

All microfloras are dominated by one or more of *Cyathea, Marattia salicina, Muehlenbeckia australis* and *Araucaria heterophylla*. These are associated with low to frequent numbers of pollen of *Rhopalostylis baueri* and other palynologically under-represented trees, including some hitherto rare hardwood species, e.g., *Celtis, Nestigis*, and *Rapanea ralsoniae*. Values of *Typha orientalis* and *Muehlenbeckia australis* increase upwards within the unit whilst those of *Cyathea, Marattia salicina*, all hardwood trees and charcoal particles are most abundant below 220 cm depth. Rare pollen types include *Hibiscus diversifolius*-type at 185 cm, 195 cm, 235 cm and 285 cm, and Liguliflorae (*Sonchus*?) and the unknown *Hibiscus* sp. at 185 cm.

Since *Typha orientalis* pollen is a low (av. 4%) but persistent component of all microfloras; the data are unequivocal evidence that this species is native to Norfolk Island. Trends in its relative abundance suggest that relatively dry local conditions before c. 2,580 B.P. are behind the local establishment of hardwood trees such as *Celtis paniculata, Nestigis apetala* and *Rapanea ralstoniae,* as well as *Rhopalostylis baueri, Cyathea* and *Marattia salicina*.

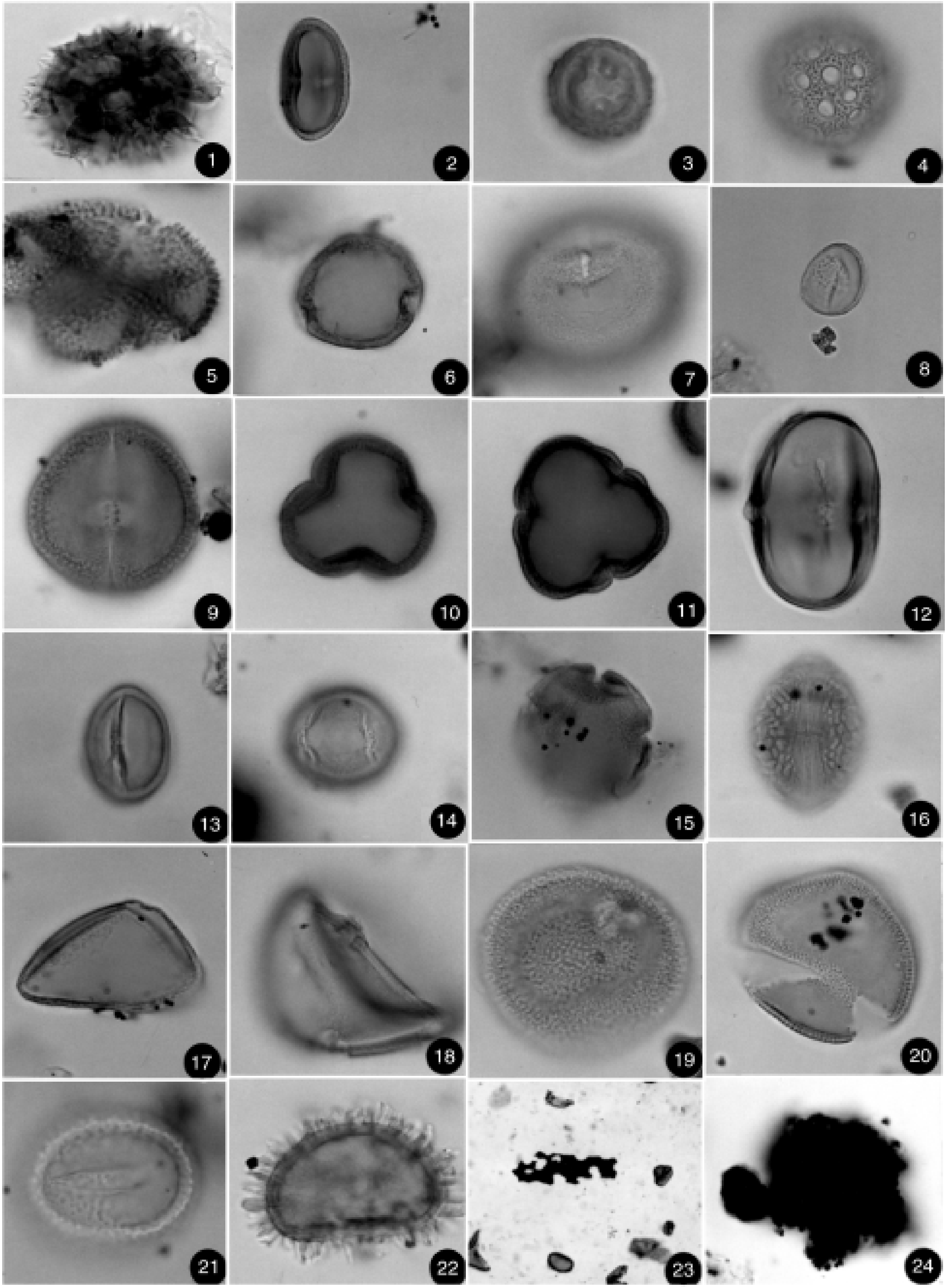

Figure 3. Photomicrographs taken at ×788 magnification (50 µm scale bar): 1, Liguliflorae (Asteraceae); 2, Apiaceae (*Hydrocotyle*-type); 3, *Plantago lanceolata*-type (Plantaginaceae); 4, *Achyranthes* (Amaranthaceae); 5, *Baloghia inophylla* (Euphorbiaceae); 6, *Celtis paniculata* (Ulmaceae); 7, *Coprosma baueri/pilosa* (Rubiaceae); 8, *Macropiper*-type (Piperaceae);

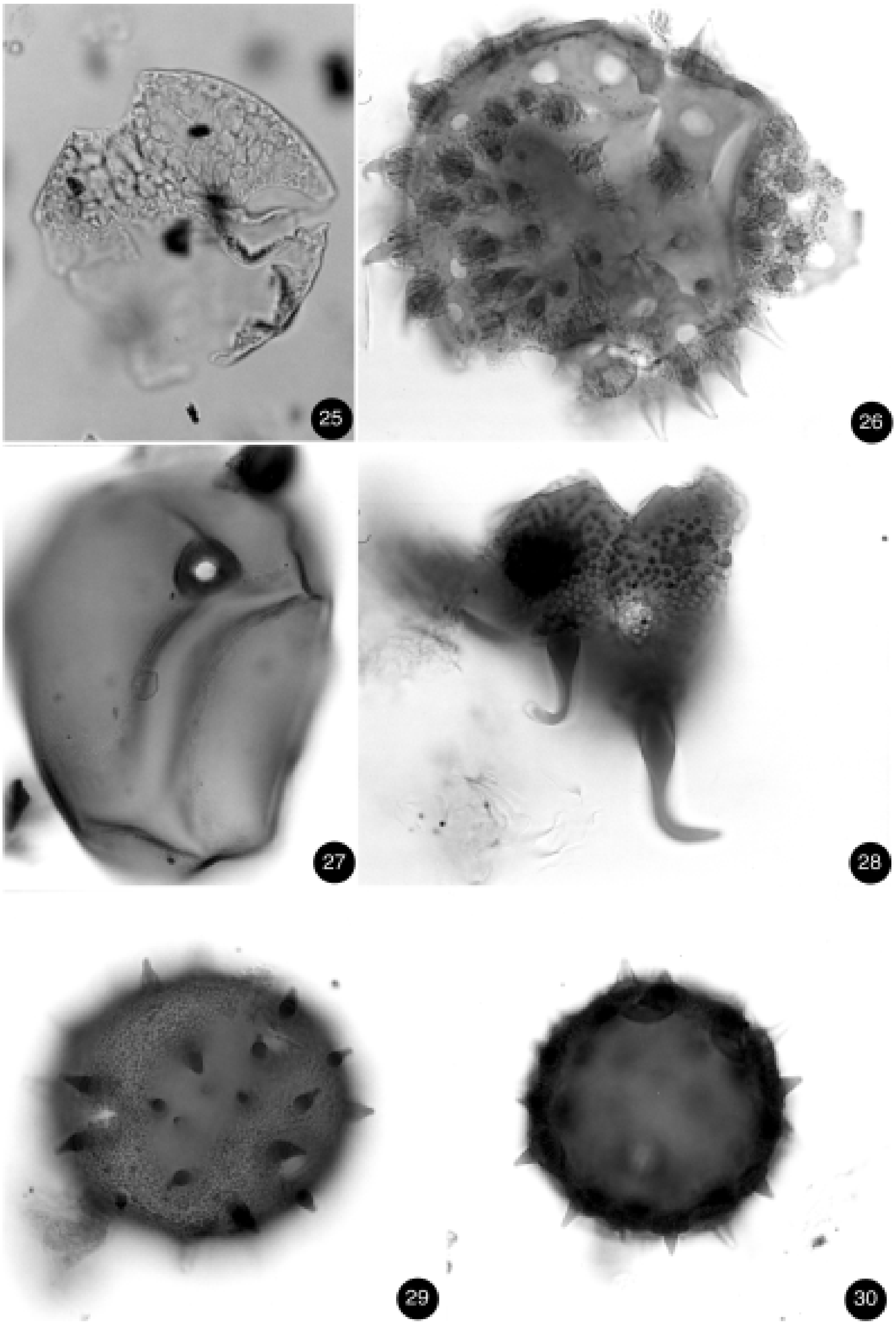

Figure 4. Photomicrographs taken at ×788 magnification (50 µm scale bar): 25, *Podocarpus-Prumnopitys* (Podocarpaceae); 26, unidentified *Hibiscus*-type (Malvaceae); 27, cereal (Poaceae); 28, fragment of *Hibiscus diversifolius*-type (Malvaceae); 29, *Lagunaria patersonia* (Malvaceae); 30, *Abutilon julianae* (Malvaceae). For scale bar see Fig. 5.

Figure 3 (continued). 9, *Muehlenbeckia australis* (Polygonaceae), equatorial view; 10, *Muehlenbeckia australis* (Polygonaceae), median polar view; 11, cf. *Exoecaria agallocha* (Euphorbiaceae), median polar view; 12, *Pouteria bracteolatum* (Sapotaceae); 13, *Pennantia endlicheri* (Icacinaceae); 14, *Rapanea ralstoniae* (Myrsinaceae); 15, *Ungeria floribunda* (Sterculiaceae); 16, *Zanthoxylum pinnatum* (Rutaceae); 17, *Cordyline obtecta* (Agavaceae); 18, Poaceae (native); 19, *Typha orientalis* (Typhaceae); 20, cf. *Frankenia* (Frankeniaceae); 21, *Marattia salicina* (Marattiaceae); 22, *Hypolepis* (Dennstaedtiaceae); 23, carbonized xylem, 0.50 m depth; 24, aggregates of fine carbon particles ("soot balls"), 2.35 m depth. For scale bar see Fig. 5.

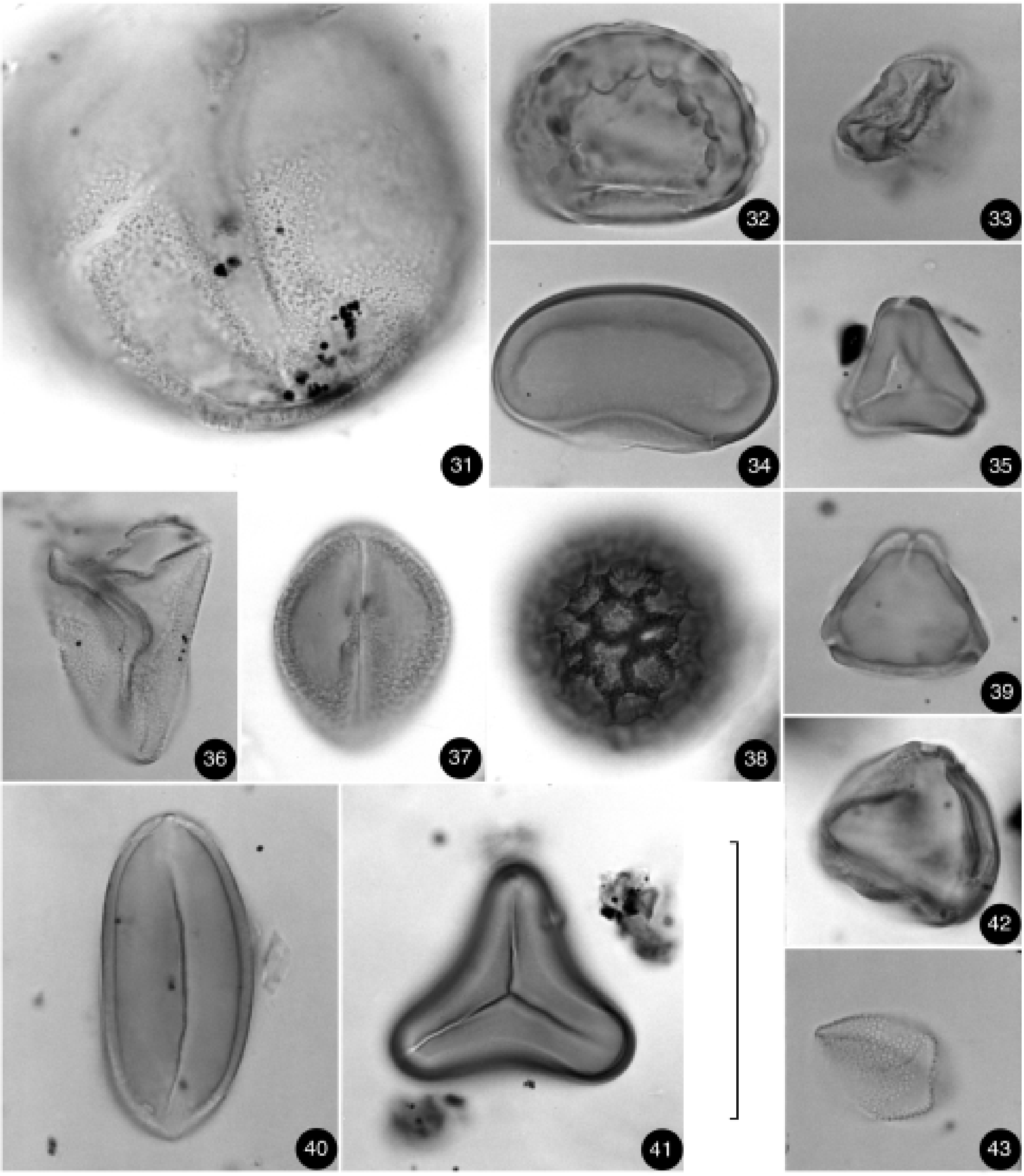

Figure 5. Photomicrographs taken at ×788 magnification (50 µm scale bar): 31, *Araucaria heterophylla* (Araucariaceae); 32, *Phymatosorus pustulatus* (Polypodiaceae); 33, *Nothofagus (Brassospora)* sp. (Fagaceae); 34, monolete spore cf. *Vittaria* (Vittariaceae); 35, *Metrosideros* (Myrtaceae); 36, cf. *Scirpus* (Cyperaceae); 37, *Muehlenbeckia australis* (Polygonaceae), equatorial view; 38, *Persicaria decipiens* (Polygonaceae); 39, *Eucalyptus gummifera*-type (Myrtaceae); 40, *Rhopalostylis baueri* (Arecaceae); 41, *Cyathea brownii*-type (Cyatheaceae); 42, Casuarinaceae; 43, *Triglochin* (Juncaginaceae).

Muehlenbeckia australis values indicate that this shrub-like creeper was uncommon at the site until after c. 2,580 B.P. (225 cm). Since charcoal particle values in the underlying sample at 235 cm are the highest in the sequence ($1{,}783\times10^3$ particles cc^{-1}) it is tempting to link the spread of *Muehlenbeckia* to one or more local wildfires as well as to increasingly wet conditions within the swamp indicated by increasing values of *Typha orientalis*. Circumstantial evidence that the expansion of *Muehlenbeckia australis* was stimulated by local disturbances is provided by maxima in the pollen curve of *Achyranthes* (presumed to be the only widespread species *A. aspera*) before c. 2,580 B.P. The apparent temporary reduction in *Araucaria heterophylla* and *Cyathea* populations almost certainly is a consequence of the increased influx of local pollen.

Charcoal particle values remain high down to the lowest sample analysed (285 cm) and seem to point to (*a*) a period characterized by relatively frequent wildfires and by inference if naturally ignited, (*b*) more strongly seasonal or drought-prone local climates. Whether the marked reduction in charcoal particle concentrations above 225 cm reflects a reduction in fuel loads near the site, a change in the hydrology of the site, and/or locally wetter climates, is unclear.

Discussion and conclusions

Islands ecosystems in the southwest Pacific remained undisturbed by humans until some 3500–800 years ago when a sophisticated maritime culture allowed Polynesians to locate and settle the majority of basalt-cored islands and coral atolls. Lord Howe is the only known example of a sizeable habitable island for which there is no archaeological or other evidence of humans prior to its discovery by Europeans two centuries ago. Norfolk Island also was unoccupied at the time of European discovery in A.D. 1774 but there is clear archaeological evidence for one or more Polynesian settlements in the last 800 years (Anderson, 1996b). Accordingly a comparison of their palaeoecology with long-settled islands such as Vanuatu and Fiji offers a rare opportunity to unravel the impact of human activity and climatic events. An example is the question of whether marked increases in the relative abundance of charcoal particles is reliable evidence for humans or whether the fires have other, non-anthropogenic causes.

Because of the potentially unique depth of organic sediments preserved in the former Kingston Swamp and the unusually high taxonomic resolution, the Norfolk Island pollen data are an important natural archive in two related arenas of island biogeography. They provide benchmark evidence against which the impact of humans on a long-isolated island flora and vegetation can be assessed in the longer-term and provide a means of determining whether particular plants were native to the island or introduced by humans.

1 The combined charcoal and pollen data confirm that wildfires were a naturally occurring event on Norfolk Island before c. 2,580 B.P., and probably before the middle Holocene based on burnt lignites preserved *in situ* at Cemetery Bay (Macphail and Neale, 1996). The extent to which the forest vegetation observed by Cook and King had already been shaped by wildfires (natural and human-lit) is uncertain but the KCA data point to a link between fire frequency and local climatic change during the Late Holocene (cf. Macphail, 1980). It is noted that charcoal particle concentration values similar to those recorded at 225–285 cm have been cited as evidence for early human occupation on other remote oceanic islands (Kirch and Ellison, 1994: Fig. 3; challenged by Anderson, 1994, 1996b). Pollen analysis of older/deeper samples is required before the same can be inferred for Norfolk Island.

2 The same data provide unequivocal evidence that putative exotics such as Ti (*Cordyline*), the bull-rushes (*Typha orientalis*) and, less certain herbs, such as the sow thistle (*Sonchus oleraceus*) and *Persicaria decipiens*, were present on the island long before the earliest known Polynesian settlement. Because sediments contemporary with this presence have been destroyed by European activities, evidence of Polynesian cultigens other than banana has been lost—and banana is known only from historical observations, not from pollen. Nevertheless, the complete absence of *Phormium tenax* (New Zealand Flax) pollen at a site known to have been within metres of a ridge described as being covered by this plant in A.D. 1774 is difficult to explain unless *Phormium* was introduced onto Norfolk Island by Polynesians sometime after c. 1200 and before A.D. 1774. The data greatly strengthen the case that occurrences of New Zealand Flax elsewhere on small Southwest Pacific islands such as Raoul will be due to Polynesian occupation.

Until an intensive coring programme of the Kingston Common and surrounding areas has been undertaken, it is premature to conclude that European settlement has destroyed a fossil pollen and spore record of the time(s) of Polynesian settlement. Equally important to understanding the complex relationship between climate, the biogeography of small volcanic islands and human colonization will be the recovery of a continuous core through the sedimentary infill in former Kingston Swamp down to the basalt basement.

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Prehistoric Settlement on Norfolk Island and its Oceanic Context

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ABSTRACT. The likelihood of Polynesian settlement of Norfolk Island was recognized in the eighteenth century, but archaeological remains of a settlement site were only discovered in 1995. The excavation history of the Emily Bay site is summarized, its date put at about the thirteenth to fourteenth century A.D. and its East Polynesian nature, especially its contacts with the Kermadecs and New Zealand, recognized through its artefacts. The faunal remains show a dominance of fish and birds, and low diversity within each. The reasons for ending the settlement are unknown but speculated upon and several future research priorities noted.

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There are two small archipelagos in the northern Tasman Sea. One of them, consisting of Lord Howe Island and Ball's Pyramid, has never produced any evidence of prehistoric human settlement, even by extensive test-pitting, coring and drilling (Anderson, 1996a, Macphail, 1996). In the other, consisting of Norfolk Island, Nepean Island and Phillip Island—the Norfolk Island archipelago—indications of earlier habitation were observed from the beginnings of European settlement. These were, and remained, enigmatic, namely, clusters of bananas growing in Arthur's Vale, the existence of small rats, pieces of wrecked canoes and other wooden artefacts which were ascribed variously to origins in Tonga or New Zealand, and from the interior of the island some stone adzes and chisels. By A.D. 1793 Commandant King, clearly influenced by the fact that two Maori taken to Norfolk Island had recognized the newly-discovered stone tools as Maori "toki" (adzes) from the North Island (New Zealand), concluded that the various pieces of evidence constituted "a feasible proof" of Norfolk Island having once been settled from New Zealand (King, 1793, cited in McCarthy, 1934: 267).

If this seems a prescient observation now, it was not one that the history of archaeological discovery subsequent to 1793 and prior to the current project would have easily allowed. Many stone adzes and flakes, recovered particularly from Emily Bay and adjacent areas, were of forms regarded as generically East Polynesian, but some Norfolk Island collections were found by Specht (1984) to contain many stone implements, and some of shell, in non-Polynesian forms and materials, Melanesian types especially. Further examples of non-Polynesian implements, not recorded by Specht, occur in the Norfolk Island Museum collection, where they were catalogued by Anderson (n.d.). Since New Caledonia is relatively close to the north and has been settled for 3000 years, the possibility that Norfolk Island had been reached from there thus seemed very plausible. Systematic field survey in 1976 (Specht, 1984) and subsequent palaeontological and archaeological salvage excavations in the Kingston area up until 1990 (Anderson and White, *Approaching the prehistory…*, this vol.) failed to resolve the issues of when and from where prehistoric occupation had occurred. No prehistoric habitation site was located. It was in this context that the Norfolk Island Prehistory Project began.

The Norfolk Island Prehistory Project (NIPP)

The NIPP had two consecutive phases. From November 1994 to May 1997 it was directed by Atholl Anderson as a project of the Australian Heritage Commission, while from November 1997 until publication of this volume it has been directed jointly by us as one of the case studies in the Australian Research Council project “Understanding the Prehistoric Colonisation of the Pacific” (White and Anderson), and the Royal Society of New Zealand project “Prehistoric Colonisation and Environmental Change in Remote Oceania” (Anderson, as James Cook Research Fellow).

Fieldwork was divided into four seasons. In 1995 the Emily Bay archaeological site was discovered and a small test-pit completed (Trench EB95:06). More extensive excavations occurred in 1996 (Trenches EB96:10 and EB96:11), and were followed by the major field season at Emily Bay in 1997 (focussed on Trenches EB97:23 and EB97:24). A small investigation recovered additional landsnail samples in 1999. Beyond Emily Bay, there were test excavations at Cemetery Bay in 1995 (Trench CB95:01, CB95:02), and in Slaughter Bay (Trenches SB96:01–06). Outside the Kingston area, we inspected and cored various inland localities where adzes had been picked up and other potential site locations at Anson Bay, Rocky Point and Cascade. We excavated small test-pits at Bomboras Bay, Ball Bay and Nepean Island and carried out a surface inspection of Phillip Island (Anderson, Smith and White, this vol.).

While archaeological investigations were proceeding, all swamps inland were investigated by Hope and found to be of historical origin. There were then two seasons of coring at the Kingston Swamp, in 1995 and 1996, aimed at obtaining a record of sedimentary and vegetational change extending to before and through the period of human settlement (Macphail, Hope and Anderson, this vol.). In addition, various natural localities of subfossil bone were sampled, especially in Cemetery Bay. Analytical research was concentrated at the Department of Archaeology & Natural History, ANU, where all material recovered from fieldwork was initially processed and accessioned. Components of it were then allocated to specialists, whose reports comprise the main part of this volume.

The Emily Bay site, structural remains and chronology

Our investigations have uncovered an archaeological site extending over approximately 3000 m^2 at Emily Bay. It lies at 0.5 m to 1.5 m below modern dune sands under a Norfolk pine (*Araucaria heterophylla*) plantation. Systematic coring over the full site area, and test excavations at the eastern edge of the site, within the eastern swale and throughout the western swale of the site area, show that the cultural stratigraphy is uniformly shallow, generally about 0.3 m thick, internally undifferentiated except by disturbance and for the most part sparsely packed with cultural remains. The site has been removed in the centre of the western swale, it seems by nineteenth century road construction, and the ragged and tumbled southern edge of it elsewhere in that area might also reflect storm-wave action. Bioturbation, largely by muttonbirds, is very common throughout the site, and both historical records of artefact collecting and the discovery of some European-era bone and artefacts in our excavations, indicate that at least part of the site surface has been exposed during the last 200 years.

Nevertheless, remains of some original structures could still be recorded. We found examples of typical Oceanic earth ovens and other small pits or depressions in which cultural debris had accumulated. Postholes in Trench EB97:23, some with *Araucaria heterophylla* branchwood postbutts remaining in them, suggested the former existence of at least one small house, possibly with a porch, facing toward the sea. Several metres to one side of it was a large oven, the structure of which suggested it had been used repeatedly. These features appear to constitute a typically Oceanic unit of house and separate cooking area. More extensive excavation of the site would perhaps disclose the repetition of this pattern as a small hamlet or village.

Approximately 20 m to the east of the domestic structures in Trench EB97:23, and set on a slightly higher sand knoll, was a pavement of calcarenite slabs, several set on edge at the margins and one small upright stone in the centre (Trench EB97:24). This interesting feature is almost certainly a Polynesian religious structure or *marae*. On its seaward edge were the buried remains of an elephant seal cranium, recalling the common association of whale bone with *marae* elsewhere in Polynesia, and scattered across the paving were numerous small flakes of obsidian.

Radiocarbon determinations indicate that the *marae* was constructed at least by the early fourteenth century and possibly somewhat earlier than that, but certainly within the period early thirteenth to early fifteenth centuries A.D. during which occupation had occurred throughout the Emily Bay site (Anderson, Higham and Wallace, this vol.). The wide occupation span, derived through Bayesian analysis of an assemblage of radiocarbon determinations on charcoal samples of short-lived broadleaf taxa, seems inconsistent with the low density of remains. Two propositions might explain this. Firstly, it is possible that variation in the radiocarbon determinations is merely reflecting variation in sources of inbuilt age in the charcoal samples. This might have occurred despite our grouping of the dated samples according to this likelihood (samples on larger broadleaved species were assigned to a second group, and on *Araucaria heterophylla* or unidentified material to a third, neither of which was used in the Bayesian analysis). Secondly, given that occupation occurred elsewhere on Norfolk Island, as we know that it did in Slaughter Bay at least, it is possible that the use of the Emily Bay site was extended but periodic. There is nothing in the stratigraphy or material remains to indicate this, but then neither might have varied sufficiently within 200 years to record such an eventuality.

Several substantial anomalies turned up in the radiocarbon data. One consisted of a set of unusually early results produced by the Rafter Radiocarbon Laboratory, on rat (*Rattus exulans*) bone gelatin. However, it is now apparent that this anomaly is common to results produced in 1995–1996 on that material by the Rafter Laboratory (Anderson, 2000a). Additional rat bone samples from Emily Bay and Cemetery Bay, dated later at the Rafter Laboratory, or in different laboratories, produced results consistent with those on group A charcoal samples. The other example consisted of some very early determinations by the Waikato Radiocarbon Laboratory on *Nerita* shell samples. Additional comparative research showed that these, too, were anomalous. Experimental data suggested that uptake of dead carbon, probably from the calcreted reef, made apparent ages of some specimens about 500–600 years too old.

Emily Bay artefacts

The most abundant artefactual remains in the Emily Bay site were basalt flakes. All of the basalt appears the same in hand specimen; sourcing studies on a series of samples show that it is local in origin. Since water-rolled cortex appears on some specimens it is probable that raw material was obtained from boulder beaches, at Ball Bay for example, or perhaps from the small boulder beach northeast of Cemetery Bay. Most of the flakes, cores and preforms can be classified as debris from adze manufacture, primarily, and to a lesser extent adze reworking. The predominance of flake types and sizes associated with trimming and other later stages of manufacture suggests that there are sites of the primary shaping of adze blanks yet to be discovered. A range of typical East Polynesian adze types (Duff, 1977) is represented amongst the Emily Bay site assemblage; Types 1, 2A and possibly 2C, probably Type 3 and certainly Type 4A. This assemblage thus helps to anchor the existing collections of unprovenanced East Polynesian adze types, many specimens of which appear to be fashioned from the same local basalt, in an original archaeological context. Many of them have come from the intertidal area at Slaughter Bay, suggesting habitation occurred at Slaughter Bay at the same time as at Emily Bay.

Some of the basalt and obsidian flakes were used as implements, and the former were re-sharpened by grinding. Wear, especially polish, and some traces of residues, show that flakes were used on soft, non-siliceous plant materials, possibly for basketry or clothing and perhaps including plant foods, although none could be specifically identified.

Of 26 pieces of obsidian, 25 were of a very distinctive material which in hand specimen was recognized during excavation as coming from Raoul Island in the Kermadecs, to which it was indeed sourced by PIXE/PIGME analysis. Most of these pieces were small flakes, but one mid-section of a large blade also occurred. Similar large blades, struck in basalt, are known from Raoul Island and New Zealand (Anderson, 1980). The remaining piece of obsidian cannot yet be sourced definitively. In appearance, specific gravity and major elements it fits the Mayor Island, New Zealand, range but some of the trace element data produced by PIXE/PIGME and NAA were anomalous.

Few remains of fishing gear were recovered. The best of them is a small one-piece hook of typical East Polynesian design, which had been fashioned in marine ivory, quite possibly a tooth from the elephant seal cranium buried beside the *marae*. A broken bone fish hook point has the incurved tip of other East Polynesian types, and there was one drilled tab, indicating the equally characteristic method of manufacture. Similarly typical of East Polynesian assemblages is a harpoon point, made from turtle bone.

Pelecypod shell is scarce in the Emily Bay site, and all of it was examined for evidence of artefactual use. Valves of *Gari livida*, in particular, had been broken and the pieces used as small scrapers, possibly for scaling fish or scraping roots; two of the pieces retained some unidentified starch residues.

Emily Bay faunal remains

Large mammal remains represented at Emily Bay were confined to the cranium of a sub-adult elephant seal, a human tooth and a burnt carnassial tooth of a dog, excluding here the enigmatic dog mandible recovered from the edge of the site prior to our investigations and a pig mandible from near the surface of the site which was radiocarbon dated as a modern specimen.

Bones of *Rattus exulans* were very common in the site, especially in the vicinity of the probable house. All were recovered within the cultural layer, or in holes and burrows which originated in or passed through it. No rat bones were found in test-pits dug in undisturbed sediments beneath the cultural layer. This adds to similar data from New Zealand indicating that rats were not dispersed prior to the period of demonstrable archaeological evidence (Anderson, 1996b, 2000a). Analysis of mtDNA from some specimens suggests that the rat population on Norfolk Island had diverse origins, though whether it became a population before it reached Norfolk Island, or did so as a result of multiple arrivals on the island, cannot be determined. Origins in central East Polynesia and New Zealand are indicated. Some data suggest additional but currently undetermined sources.

Turtle remains were fairly scarce, most of them pieces of carapace, and none could be identified to species. There were also difficulties in identifying the bird bone, mainly because so much of it consists of broken specimens from petrels, shearwaters and other taxa of Procellariiformes which are very difficult to distinguish osteologically. In addition, some of the bone is almost certainly from natural deposits arising from muttonbirds and other species burrowing through, or nesting on, the Emily Bay dunes.

The data indicate that about 1000 petrels and shearwaters are represented in the Emily Bay material, about 90% of all birds represented in the site. The only other species of much significance were the Norfolk Island Pigeon (*Hemiphaga spadicea*), Masked Booby (*Sula dactylatra*) and Bar-tailed Godwit (*Limosa lapponica*). No previously unknown taxa were discovered in the Emily Bay remains. It is unclear whether the absence in the archaeological avifauna of approximately half of the expected Norfolk Island taxa is a result of archaeological sampling bias, extinction events prior to the archaeologically-recorded habitation, selectivity by the prehistoric inhabitants or rapid reduction or disappearance of some taxa through rat predation contemporaneous with human settlement.

Fishing at Emily Bay concentrated upon Lethrinidae, which dominate all the fishbone assemblages. The species could not be identified but it appeared that all the lethrinid material belonged to one species. It may be surmised that this is *Lethrinus miniatus* (formerly *L. chrysostomus*), known variously as the Sweetlip Emperor, Trumpet Emperor or Red-throated Trumpeter, which is the most commonly-caught lethrinid on Norfolk Island today. It is a large species which congregates around coral heads and reefs by day in 5–30 m of water (Walter and Anderson, this vol.) and it could have been found, therefore, inside and immediately outside Emily Bay in the past. It is normally taken by baited hook, and the dominance of benthic feeders amongst the fish represented at Emily Bay indicates that this may have been the only method employed. It is notable that the settlement site specimens are considerably larger than those now caught.

A similarly narrow harvest is apparent amongst the molluscs. Intertidal rocky shore taxa are predominant and the small upper shore gastropod, *Nerita atramentosa*, accounts for 73% of the shellfish MNI. Echinoderm test and spine fragments were also quite common in the site, but as a whole intertidal rock platform fauna do not seem to have constituted a significant food category on Norfolk Island. This was almost certainly because of their general scarcity, rather than a matter of choice.

Pre-European Polynesian habitation on Norfolk Island

Now that we have presented the evidence of a Polynesian inhabitation of Norfolk Island in the thirteenth to fifteenth centuries A.D., we can consider some wider aspects.

Our interpretation of the data is that the Emily Bay settlement was a single event, or perhaps represents repeated occupations by the same population, and that the archaeological record encapsulates its entirety. In this interpretation we can write the following scenario.

The inhabitants of Norfolk Island arrived from Raoul Island in the Kermadecs, about 1300 km upwind to the east. They had probably arrived in a large double canoe, possibly more than one, and therefore might have numbered in the order of 20–50 people, plus at least one dog, and some small rats which had, no doubt, secreted themselves amongst sails and supplies. They brought a core or two of Raoul Island obsidian and probably some potted food plants, although only the banana seems to have survived until the European period. It is possible that they brought also the New Zealand flax, an exceedingly useful fibre plant, and perhaps the sugar-yielding *Cordyline*. It might have been the first arrivals who surprised a sub-adult elephant seal hauled out on the shore, or perhaps they had carried a cranium and teeth from the Kermadecs—such prizes would have been exceedingly rare in either place. The inventory of imported items is modest and no more than might have been expected, indeed perhaps less so in the case of plants and animals, in a canoe provisioned for the eventuality of discovery of a new homeland.

The appeal of the Kingston area above others was, we can imagine, readily apparent. It was the only area of lagoon in the archipelago, it had the best canoe access and it was the largest, almost the only, area of flat land close to the shore. It had a small swampy lake behind the beach which yielded eels and a constant supply of fresh water. Furthermore it was the closest point to the other two islands in the Norfolk Island archipelago. The prime spot in the area was Emily Bay, with its sheltered beach at the head of the widest stretch of lagoon.

Prior to the modern dune development, the Emily Bay beach seems to have sloped gradually from the shore into a gently undulating surface of sand a metre of so above high water. This was probably covered in a mixed coastal forest with emergent Norfolk pines increasing in density inland. Branches were cut from the pines to frame the first houses, and some canoe spars of *Metrosideros* may have been used as well. The first ovens were dug and basalt cobbles collected as ovenstones and tested for tool manufacture. Soon a small village would have been visible, and there were perhaps some houses also at Slaughter Bay. In the latter case, these must have stood on a high dune bank, now almost entirely eroded away, rather than on the calcarenite and sand ridge north of the present road. Alternatively, the eastern end of Slaughter Bay may have functioned largely as an adze manufacturing area. On grounds noted above, and also the current distribution of archaeological remains, it can be assumed that Emily Bay was the main habitation area, and there are suggestions (Specht, 1984) that a burial area had existed in part of its seaward dunes. In the centre of the Emily Bay settlement a shrine was constructed, its sanctity emphasized by a seal cranium burial.

The Kingston area habitation was established, almost certainly, in an area thickly strewn with muttonbird burrows and seabird nests. The ground-nesting birds were the primary target of human and rat predation alike and within a few years at most the local colonies would have been wiped out and some of the scarcer birds, such as snipe, driven into extinction. Fowling, fishing and shellfishing was doubtless accompanied by the development of gardens. Forest fires, clearing out the underbrush and bird colonies alike, seem to have extended rapidly over the Kingston flat into Cemetery Bay and probably also up the coastal valleys and hill slopes within less than a generation. Forest clearance, however, was probably neither as extensive nor as rapid as in the early European era, the latter marked by mobilization of hill-slope clays that washed out over the Kingston sands in several episodes. It is these clays, with their associated fragments of early European artefacts, which lie above, and in places directly upon, the prehistoric horizon, but never within or below it.

Sustained initially by reserves of easily-gathered resources—the ground-nesting sea birds, nesting turtles which came seasonally to the Kingston beaches, the local schools of sweetlip and the shellfish from lagoon and rocky shore—the Polynesian colony probably increased quite rapidly in numbers, and some families may have established themselves in Bomboras, Ball Bay, Anson Bay and perhaps parts of the interior, not to mention on the other two islands. Within a few generations, several hundred people may have lived in the Norfolk Island archipelago. Yet, the colony did not last and we can only speculate as to when it finally disappeared and why.

The timing is reasonably definable. If the Group A radiocarbon determinations are not substantially in error by inbuilt age, then settlement persisted on some scale in the Kingston area until the fifteenth century A.D. A few later determinations invite the conjecture that the last families, perhaps living somewhere else—possibly at inland plantations—visited Emily Bay at late as the seventeenth century. At any rate, the Norfolk pine forest had re-grown over the entire Kingston area by the late eighteenth century and this suggests that effective habitation had ceased in the primary settlement location on Norfolk Island several hundred years earlier.

Reasons for colony failure are as numerous as imagination allows, but some which seem more probable are these. Firstly, the simplicity and homogeneity of material culture suggests that there was only one landfall—all of the East Polynesian types from museum and private collections, together with those obtained by excavation on Norfolk Island, amount to less diversity than is apparent at many small, single, sites of early East Polynesian type elsewhere, including in the Kermadecs and throughout New Zealand. Further, since pre-European colonization seems to have failed fairly quickly on the source islands as well, the Kermadecs, the Norfolk Island community may have felt severe social isolation which, within a few generations if not earlier, prompted renewed voyaging in an attempt to re-establish contact with other communities. Secondly, the subsistence base was insubstantial and prone to failure. Shellfish could never form a staple on Norfolk Island; sea fishing, at least for the sweetlip, probably declined quite quickly inshore, as it has done again in historical times, and above all the populations of nesting seabirds were liable to crash disastrously in the face of sustained exploitation (Anderson, 1996c), as was also demonstrated in the eighteenth century. Banana cultivation is a very narrow horticultural base and vulnerable to periodic failure. Norfolk Island thus joins other subtropical islands in Remote Oceania which fell between the richness of tropical horticulture and the abundance of temperate faunas, as an unusually difficult location for long-term habitation by prehistoric Polynesians (Anderson, in press).

What happened at the end? There are a number of possibilities, but no evidence. As vigorous and experienced marine migrants, it is unlikely that the last Polynesian settlers simply faded away on Norfolk Island. Equally, they must have understood the grim fact of their location far to leeward of the Kermadecs. One possibility was that they tried to sail back east and were deflected southeast to reach New Zealand. However, it is just as likely that there was some oral history about New Zealand, since they, or people whom they met on Raoul Island, had already been there (Anderson, 1980). Another possibility is that they sailed north and found New Caledonia or Vanuatu where the Maori word for their only domestic animal (kuri = dog) is found. Finally, they may have sailed off to the west, as their ancestors had done before, missed the only other opportunity of an uninhabited island available to them, at Lord Howe, and fetched up in Australia.

Norfolk Island in Oceanic prehistory

Moving beyond the scenario of Norfolk Island prehistory suggested by the excavated data, there are some wider issues to consider. The first is whether Norfolk Island was settled only within the period of East Polynesian habitation, c. 1,000 B.P. onwards.

The NIPP research has not uncovered any evidence in support of the possibility that Norfolk Island was reached prior to this period or at any time in prehistory by non-Polynesians. We concede readily that this is negative evidence and that the possibility of it being overturned in future cannot be dismissed. However, it is a much lower possibility now than it was before our project. Our research concentrated on the area of Norfolk Island to which any prehistoric colonization would have been most attracted, as indeed were all historical phases of colonization, and it involved substantial coring, test-pitting and excavation in Slaughter Bay, Emily Bay and Cemetery Bay. These researches penetrated at many points the Holocene carbonate sands which underlie the modern dunes. The only prehistoric cultural remains to be discovered were from, or of the same age as, the East Polynesian colonization. Radiocarbon determinations of significantly earlier age, as on one series of rat bones and some shellfish, have more plausible explanations than cultural visits that are otherwise invisible in the evidence. It is also worth noting that the one non-Polynesian artefact with a reasonably explicit stratigraphic provenance, the shell adze from Cemetery Bay, seems on our investigations of the area to have come from an historical context (Anderson, 1996d). Evidence that some Melanesian artefacts reached Norfolk Island in Pacific collections taken there in European settlement times, along with the long tenure of the Melanesian Mission, and the virtual absence of any archaeological context for material of this kind, adds up to a strong argument against the casual assumption of prehistoric contact. Moreover, the absence of any of the critical artefacts of central Pacific prehistory, most notably pottery which, incidentally, could have been made quite easily on Norfolk Island, adds a further argument against that proposition. The positive evidence is that Norfolk Island was settled in prehistory from only one source area.

Its connections were clearly with other islands in South Polynesia. The particular evidence consists of the following points. First, the Emily Bay and associated material culture is of East Polynesian type. The collections had been recognized by Specht (1984, 1993) as particularly reminiscent of those in the Kermadecs and New Zealand and our excavated material has added to that conclusion. Second, nearly all the obsidian came from Raoul Island where the existence in the Low Flat archaeological site of some pieces from Mayor Island indicates that New Zealand had already been discovered (Anderson, 2000c). The Low Flat site is a contemporary of Emily Bay. It remains possible, too, that the single piece of translucent obsidian from Emily Bay has a New Zealand origin. Thirdly, the discovery of *Metrosideros* amongst the charcoal provides a further tie to the Kermadecs or New Zealand and the pre-1,000 B.P. absence of *Phormium tenax* indicates that flax, abundant at European contact, was taken to Norfolk Island in the prehistoric period, either directly from New Zealand or from the small stands of flax introduced to Raoul Island. Fourthly, while some uncertainty remains about the origin of all the haplotypes recognized amongst the *Rattus exulans* samples from Emily Bay, both a general East Polynesian sequence and one which is otherwise confined to New Zealand can be recognized. Together, these points suggest quite strongly that Norfolk Island was colonized from Raoul Island by people who had come from New Zealand or, if they came directly from somewhere else in East Polynesia, had lived on Raoul Island amongst people who had originated in or visited New Zealand.

The Norfolk Island archipelago, like the Kermadecs, the Chathams and the subantarctic Auckland Islands, was therefore one of the outlying groups discovered at almost the same time by those East Polynesians who also found the main islands of New Zealand during a phase of secondary colonization several hundred years or more after the discovery of central East Polynesia (Anderson, 2000b). The motivations behind this colonizing pulse are unclear, the more so since its specific origin is unknown but, like the earlier colonization episodes of Remote Oceania, it represents an impressive exploratory venture. In this case Polynesian sailors travelled well outside their normal tropical habitat to find an initial plethora of resources, in New Zealand of almost continental size and diversity. We might surmise that finding New Zealand encouraged a conviction that other equally profitable lands lay over the horizon, and that the discovery and settlement of Norfolk Island and the other outlying archipelagoes was the result. So far, at least, there is no evidence in mainland New Zealand archaeological sites that voyaging occurred in both directions. In the case of Norfolk Island it would have been very difficult to sail back against the prevailing winds to the Kermadecs.

Another important issue is whether colonization arrived as a single event, or over a long period, perhaps across centuries. Several sets of evidence bear upon this matter.

1. While only a single cultural layer can be recognized over most of the Emily Bay site, more complex stratigraphy was uncovered in Trench EB97:24, at the *marae* feature. Anderson and Green (this vol.) identify three successive events: posthole construction, paving which covers some postholes, and flaking of obsidian after the paving was in place. It is possible that these events were separated significantly, possibly representing multiple landfalls, but insofar as we were able to test that proposition, we could find nothing to support it. The postholes are stratigraphically associated with the elephant seal cranium, suggesting a ritual event on the same place as a *marae* was then constructed, and the obsidian flaking is also, plausibly, a ritual activity. In other words, it certainly appears as if all the events are connected to a single activity. Radiocarbon dating of the covered postholes, relative to samples from above the paving, was hindered somewhat by the necessity of using Norfolk pine samples from the postholes, but even so, the dates from above and below the paving are very similar.

2. The fact that our excavation produced almost no extinct birds could be used to argue that the earliest settlement was not found. Considerable reduction in bird species occurred on many Pacific islands following colonization, so the absence of evidence might suggest that an earlier phase of settlement occurred. Its remains could exist in a slightly different location from our excavations or they might have been destroyed by European disturbance. That conjecture aside, it is noticeable that Emily Bay is similar to other probable colonization-era sites throughout East Polynesia in its high proportion of seabirds (Steadman, 1995). In addition, Moniz (1997: 47) describes "early and heavy exploitation of more abundant seabirds, whose extirpation exposed land birds to predation pressures", implying that middens rich in seabird rather than landbird bone might constitute the more accurate signature of earliest occupation.

3. The diversity of *Rattus exulans* haplotypes might result from a high diversity within a single introduction, or from multiple introductions. The diversity of prehistoric Raoul Island *Rattus exulans* is unknown, but the modern population is highly diverse (Matisoo-Smith *et al*., 1999). Were that also the case in the past, then it is conceivable that a single introduction from there could account for the Norfolk Island diversity. The same would be true of an origin in New Zealand, where there is even greater genetic diversity in *R. exulans*. In either case the number of female rats needed to produce such diversity cannot be estimated realistically but it may have been considerable, suggesting both that multiple canoes were involved and that the process may not have been totally accidental (cf. White, in press). While it is currently impossible to pin this matter down any more precisely, it is worth noting that the Norfolk Island data demonstrate that end-of-the-line cases in Polynesian voyaging can have diverse genetic signatures as well as the restricted mtDNA signature found in *R. exulans* from the Chathams (Matisoo-Smith *et al*., 1999).

None of these considerations are definitive. We believe that we have found most of the major remains and that if there were multiple landfalls on Norfolk Island they occurred within the period represented by the Emily Bay settlement site and from the same sources. Compared to other "mystery" islands (those previously occupied but abandoned at the time of European discovery), Norfolk Island has produced a surprisingly small and homogeneous amount of archaeological material. Islands and atolls much smaller than Norfolk, and environmentally much more marginal, such as Henderson in the Pitcairn group (Weisler, 1995) or some of the Phoenix and Line Islands (Terrell, 1986: 92) have widespread evidence of intensive habitation. Pitcairn Island, quite similar environmentally to Norfolk, though smaller, also has more elaborate archaeological remains. It seems probable that both the relative isolation of Norfolk Island, at the western extremity of Polynesia, and the slim horticultural opportunity afforded its prehistoric inhabitants, created circumstances unfavourable to the elaboration of settlement patterns and ultimately inimical to long-term survival.

Further research

The NIPP investigations have opened a number of avenues of potential research in Remote Oceanic prehistory. There are, of course, some intriguing historical matters that are worth pursuing. One is whether any of the possible East Polynesian adzes that have been found on the east coast of Australia have a Norfolk Island origin, and the possibility of adze movement, as well as the implications of demonstrated obsidian transfer to Norfolk Island, invite further consideration through sourcing studies in the region around Norfolk Island, notably New Zealand, New Caledonia and southern Vanuatu (Anderson, 2000c).

The nature of prehistoric vegetation change on Norfolk Island is another intriguing issue. Our research was not as successful in capturing evidence from across the late Holocene as we wanted, but the Kingston swamp is extensive and that evidence will almost certainly still exist.

Further coring is essential. Amongst other things it offers a means of testing the archaeological conclusions about settlement history. It might also provide some additional data on the suite of prehistoric cultigens and on other plants which might have been introduced. Bananas are one of the few Pacific food crops which are distinguishable by phytoliths and their history of cultivation on the island, at least, may be accessible to study.

The lithic analysis indicates that sites of primary reduction of adze blanks ought to exist somewhere on Norfolk Island, and the intriguing eighteenth century discovery of an unforested, overgrown area in the interior, are other aspects of additional archaeological fieldwork which needs to be undertaken. A more extensive programme of test excavations and coring at Ball Bay, where adzes have been recovered, is worth consideration. The NIPP research has succeeded in creating a first prehistory for Norfolk Island, but there might yet be much to discover.

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