The spatial distribution of pā in Tōtaranui/Queen Charlotte Sound, New Zealand

A thesis submitted for the degree of Master of Arts, University of Otago, Dunedin, New Zealand

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Abstract

The distribution of pā sites in the central New Zealand region of Tōtaranui/Queen Charlotte Sound is investigated to determine the relationship between pā and other Māori archaeological sites, and the influence of maritime and introduced terrestrial resources. Particular aims of research are to investigate the role of visibility as a measure of defensibility in the distribution of Tōtaranui pā, and whether this distribution is influenced by the distribution of garden sites and karaka stands, two important introduced resources often considered to influence pā distribution at national levels. Additionally, evidence for gardening activity is ambiguous in Tōtaranui, for which there is a number of archaeologically recorded garden sites but a noted absence of gardening activity in the earliest historical records.

Investigation into the distribution of pā is done by comparing proximity and intervisibility of pā sites to a range of Māori archaeological site types (garden sites, karaka stands, midden sites, oven sites, other pā sites, pit sites, and terrace sites). Proximity of pā to other archaeological sites is quantitatively measured by way of cost distance analysis, and intervisibility of sites measured by way of viewshed analysis within Geographical Information Systems (GIS). Cost distances and frequency of intervisibility of pā to other archaeological sites is recorded and compared against a dataset of random points.

Based on the methodology used in the analysis, neither maritime nor introduced terrestrial resources had a significant influence on the distribution of Tōtaranui pā. A desire for high levels of visibility as a measure of defence was not found among these pā, as they did not have significantly larger viewsheds than random points. Pā were however, found to occupy spatially and visually central positions in Tōtaranui settlement systems, as cost distances from pā to other archaeological site types were significantly lower than cost distances from random points, and the frequency of intervisibility with other archaeological sites was higher among pā than among random points. Cost distance and viewshed analysis are shown to produce meaningful results in New Zealand archaeological contexts, and concerns are raised regarding the application of models based on distribution at national scales to individual regions, particularly those in areas considered marginal.

Keywords: landscape archaeology, Geographic Information Systems, visibility, viewshed analysis, cost distance analysis, pā, Tōtaranui/Queen Charlotte Sound, New Zealand
Acknowledgements

This research would not have been possible without the supervision, advice, and mentorship provided by Dr Ian Barber and Dr Mark McCoy.

Much of the data and technical support that this thesis required was provided by the University of Otago Department of Anthropology and Archaeology, and particular thanks must be given to Heather Sadler in this respect.

I am forever indebted to the New Zealand archaeological community for providing data and advice and I would to thank Rick McGovern-Wilson and Nicola Molloy for providing access to ArchSite and answering my questions, and to regional filekeepers Steve Bagley and Reg Nichol for their knowledge of my study area. The Marlborough District Council provided a range of information and support during this thesis, and particular thanks need to be given to Val Wadsworth, Mike Eade and Pete Hammill. Thank you also to the always friendly iwi of Tōtaranui, particularly Judith MacDonald of Rangitane ki Wairau, and Sue Buchanan and Vanessa Eade of Te Ātiawa o Te Waka-A-Maui.

I am grateful to James Robinson and Moira Jackson for many interesting discussions and their support in matters of Geographical Information Systems, and letting me compare notes. Thanks to all those within the department who provided frank and interesting discussion on a range of topics, and I would like to thank all those within the department, particularly Alex Bell, Ben Teele, Kirsty Potts, and Chelsea Dickson for commenting on drafts of this work, and Chris Jennings, Andy Brown and Matt Carter for their sage wisdom.

Thanks to all of my friends and family for their support, encouragement and patience. Chur.
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Naming conventions

Binary place names are common in Aotearoa/New Zealand, reflecting its combined Māori and colonial histories. In some cases these binary place names are official, such as in the case of this thesis’ Tōtaranui/Queen Charlotte Sound study area, and others are more informal such as the use of the traditional Māori name of Te Tau Ihu for New Zealand’s South Island, which is also known traditionally as Te Waipounamu. This thesis uses both Māori and English names interchangeably, with the former taking precedence. Words from Te Reo Māori are used frequently within the text, with long vowels indicated by use of macrons, and Māori words are not italicized. The study area of Tōtaranui is also referred to more colloquially as “the sound” in some places in the text, particularly where it was considered a relevant means of imparting a conceptual image of the geography of the area.
Chapter 1

Introduction

The pā is a style of fortification that was a common and important aspect of Māori settlement systems in Aotearoa/New Zealand from the 16th century into the 19th century AD, and is a common focus of archaeological studies of settlement (Schmidt 1996). Considerations of prehistoric settlement patterns in New Zealand frequently emphasise their flexible nature and the relationship between Māori settlement and seasonal mobility in relation to subsistence activity (Campbell and Phillips 2004; Davidson 1984, 31–2; Groube 1965; Walter, Smith, and Jacomb 2006). The nature of settlement varied temporally and regionally, and the distribution of pā is one aspect that exhibits considerable regional variation. The majority of pā are located towards the north of the country, with a tiny minority found in New Zealand’s far south. Explanatory models for this unequal distribution have noted a general correlation with population density, which was heavily weighted towards the north, and the viable range of horticultural activity (Groube 1970; Walton 2001). The theoretical background for these observations is that a surplus – in this case provided by horticultural activity – is necessary to fuel the labour costs associated with public works like pā (Trigger 1990), thus limiting their distribution to areas with sufficient population density and resource surplus. Spatial relationships between pā and horticultural activity have also been argued to exist in northern regions of New Zealand (M. W. Allen 1996; Cassels 1972) but little quantitative analysis of these relationships has been conducted at regional scales, particularly in areas where horticulture is considered to have been marginal in prehistory. The study area of this research – Tōtaranui/Queen Charlotte Sound – is located in central New Zealand, an area typically considered horticulturally marginal (e.g. Davidson and Leach 2002, 258; Davidson et al. 2007; Furey 2006), and a study area where little archaeological research has been conducted (Challis 1991). It is not clear to what degree prehistoric settlement patterns in the area correspond to models from other parts of the country and this thesis aims to investigate settlement patterns in Tōtaranui associated with pā, and determine to what degree generalisations about settlement made at national levels apply to this area.
Figure 1-1: Tōtaranui's location in the north of New Zealand's South Island

Figure 1-2: The modern landscape of Tōtaranui
1.1. Regional variation and the importance of local studies in New Zealand

There is considerable need for archaeological studies conducted at regional scales, not only because it makes the variation and abundance of data from national contexts manageable for analysis, but because it takes into account regional variation and the local context within which human behaviour occurs (Kowalewski 2008). This is one of the concepts associated with the sub-field of time perspectivism (Bailey 1981), which states that the many cultural and natural processes influencing human behaviour and the creation of the archaeological record occur in differing scales – temporal and spatial – and that analysis at different scales bring into focus different processes, requiring differing explanatory principles. Settlement pattern studies in New Zealand are frequently conducted at regional scales, and Nigel Prickett’s (1982) *The First Thousand Years: Regional Perspectives in New Zealand Archaeology* is an early attempt to collate archaeological knowledge of New Zealand regions. However, some New Zealand regions have been a greater focus of archaeological research than others; partially due to the presence of local universities, museums, and other organisations that fund research. Archaeological models are typically based on research in these core regions and due to a lack of comparative investigation, other areas are simply assumed to fit these models. Tōtaranui, part of the Marlborough Sounds of the northern South Island (an area known to Māori as Te Tau Ihu) is a region where archaeological research has been limited, with Aidan Challis (1991, 101) commenting that “site recording is far from comprehensive and detailed investigations have been few”. This research will contribute to the archaeological understanding of this part of the country through its focus on settlement in Tōtaranui.

The environmental variation in New Zealand meant unequal distribution of resources across the country, including sources of stone and timber, and wild and cultivated foodstuffs. Māori economies, subsistence behaviours and patterns of settlement varied as a result. The far north of New Zealand was a place of dense population, where the warmer, sub-tropical climate allowed the cultivation of kūmara (*Ipomoea batatas*) – typically considered the most important of the introduced Polynesian crops (Furey 2006), and where pā were constructed in considerable numbers (Walton 2001). Kūmara horticulture was not
viable in the cooler climate of southern New Zealand, and Māori subsistence in these regions relied more heavily on the exploitation of wild resources, like the native bracken fern (*Pteridium esculentum*). Populations in southern New Zealand tended to be smaller and more mobile, though often clustered around significant resource bases (A. Anderson and Smith 1996; A. Anderson 1998). The chosen study area of Tōtaranui lies between two systems of settlement and subsistence in New Zealand: the densely occupied far north with its horticultural economies and many pā, and the far south, with low population densities of hunter-gatherer-fisher groups and almost no pā. This research will assess to what degree settlement in this central New Zealand region corresponds to models from others, particularly in relation to the role of pā.

1.2. Research aims and objectives

The major aim of this thesis was to investigate factors influencing the spatial distribution of pā in Tōtaranui, particularly in relation to the use of kūmara gardens and karaka stands, two resources introduced to the area and considered to have a spatial relationship with pā at a national level. This involves using quantitative measures to assess the relationships between pā and other archaeological site types (gardens, midden, karaka stands, terrace sites, pit sites, and oven sites) through two major measures of spatial association commonly used in archaeological settlement pattern studies: proximity and visibility. Proximity provides evidence of a physical relationship between places, with the assumption that the factors which influence the distribution of settlements and other site types is apparent in their proximity i.e. settlements are typically located in close proximity to important subsistence resources, allowing ease of access and a measure of physical control (e.g. A. Anderson and Smith 1996; Hunt 1992; Trigger 1968; Vita-Finzi and Higgs 1970). Visibility and a direct line-of-sight from one place to another is also assumed to represent a deliberate relationship between places (e.g. Lake, Woodman, and Mithen 1998; Lake and Woodman 2003; Wheatley 1995), with the consideration that the visibility of places of importance are intentionally prioritised, and that intervisibility of sites implies a form of inter-site relationship and communication. These measures will determine what role in the distribution of pā was played by a desire to have visual and physical access between pā and components of surrounding settlement systems. The specific questions being asked are:
1) What is the relationship between pā and other Māori archaeological sites? Are the pā of Tōtaranui found more commonly within close proximity to archaeological sites than expected by random distribution?

2) What influence does visibility have on the distribution of pā?:
   a. Does the observed location of pā in Tōtaranui allow greater visibility over the surrounding landscape than would be expected by random placement?
   b. Is visibility over areas of either land or sea prioritised in pā distribution?
   c. Are archaeological sites found more commonly within view of pā than would be expected by random distribution?

3) What influences did the distribution of marine and introduced terrestrial resources have on the distribution of pā? Are the areas in which these resources are exploited more commonly within proximity or view of pā?

Analysis is conducted in a quantitative manner, using Geographic Information Systems (GIS), and the results of investigation regarding pā are compared against a dataset representing essentially randomized distribution of pā. It is assumed that if the distribution of pā was influenced by particular factors (such as the distribution of horticultural sites) these results would differ from those of the randomised dataset. The visual and spatial relationships between pā and common archaeological site types (garden sites, karaka stands, midden sites, oven sites, pit sites, and terrace sites) will be quantified and compared against a random dataset, and archaeological sites with only historical/European features are not included in analysis. Although earlier studies of settlement and pā in Tōtaranui have been conducted (Brailsford 1981; Brooks 1999; Trotter 1987), none have quantitatively investigated the spatial relationships that influenced the distribution of pā. Likewise, although visibility has been studied as an influence on site distribution across the globe (Lake and Woodman 2003) and pā have been considered monumental structures designed to be highly visible (Barber 1996; Sutton, Furey, and Marshall 2003), no published archaeological research has quantitatively tested aspects of visual relationships with regard to pā. Quantitative analysis will determine what role visual and physical relationships between pā and other surrounding archaeological sites played in settlement systems in Tōtaranui and contribute to archaeological understanding of this little-studied region.
1.3. The organisation of this thesis

Chapter 2 will discuss settlement pattern and landscape archaeology and how cultural and environmental factors influence the distribution of components of settlement. Potential models of settlement in Tōtaranui are proposed, with reference to archaeological models of New Zealand settlement.

Chapter 3 will describe the study area of Tōtaranui within the general context of New Zealand during the period of pā occupation, drawing upon archaeological, traditional and historical evidence. Because of the central importance of subsistence behaviour associated with resource production, this will include a discussion of the nature of subsistence in Tōtaranui, and the problem of ambiguity in evidence for cultivation in the area. Traditional evidence will be investigated to determine the general pattern of settlement in Tōtaranui within the greater New Zealand context, with a particular focus on the role of pā in prehistory.

Chapter 4 will outline the methodology used, including a restatement and refinement of the research questions, and a discussion of Geographic Information Systems, the form of software used to carry out the spatial analyses. The datasets forming the basis of analysis will be outlined, along with the methods taken to produce digital models of the Tōtaranui landscape for the study of maritime movement. The two main forms of analysis – viewshed analysis and site catchment analysis – will be described in detail.

Chapter 5 will present the results of the analysis and Chapter 6 will discuss the implications of these results. The models of pā distribution in relation to maritime and introduced terrestrial resources are assessed in relation to the visual and spatial relationships between sites. Intervisibility of pā sites and viewshed area will be discussed in terms of defensibility and the nature of local political systems. Spatial relationships between pā and other site types are discussed in relation to historical and traditional records, and the overall pattern of settlement in Tōtaranui will be described.
Chapter 7 presents the conclusions of research, reassessing the aims of the work and the steps taken to meet them. The implications of the interpretations made will be considered in relation to archaeological understanding of prehistory both in Tōtaranui and New Zealand, as well as potential avenues for future research.
Chapter 2

Settlement patterns and models of landscape use

The nature of settlement has been a major focus of archaeological research in New Zealand (see Campbell and Phillips 2004) and many of the issues that concern this thesis are questions found in archaeology both in New Zealand and world-wide: themes of landscape use, settlement ecology, and the role of food production in settlement patterns and social organisation. This chapter will look at the general nature of settlement pattern studies and the related field of landscape archaeology, and discuss how a range of factors influence patterns of settlement. Three settlement models of Tōtaranui pā distribution in relation to resource distribution are presented for testing.

2.1. Settlement pattern and landscape archaeology

Settlement pattern analysis had its genesis as a commonplace and coherent form of archaeological study in the twentieth century, with the pioneering work of Gordon Willey in South America (Willey 1953; Willey 1956; Willey et al. 1965). The earliest settlement pattern approaches emerged from detailed regional studies which used the archaeological site, rather than the artefact, as the primary unit of spatial analysis (Chang 1968). These approaches seek to identify how these spatial relationships are influenced by both environmental factors and human cultural behaviour.

Landscape archaeology can be considered a related field of inquiry to settlement pattern analysis in that both tend to investigate spatial relationships and focus on the site as the primary unit of analysis. The term ‘landscape archaeology’ has no universally applied definition but in a broad sense represents the study of past human interaction with, perception, and construction of their environment (Anschuetz, Wilshusen, and Scheick 2001; Gosden and Head 1994). Practitioners of landscape archaeology have been influenced by both processual and post-processual developments in archaeological theory and practice, and the variety of landscape approaches reflect this, ranging from the
quantitative to the experiential (e.g. Anschuetz, Wilshusen, and Scheick 2001; Fleming 2006; Tilley 1994; Tilley 2004). ‘Landscape’ in archaeology does not refer merely to the physical environment but incorporates cultural components: the elements of symbolism and meaning that humans ascribe to features of the landscape as well as their perception of, and participation in their surroundings. Landscape archaeologists recognise that human action has a considerable impact on their surroundings and that landscape is created through the interplay of human action and environmental effects (Anschuetz, Wilshusen, and Scheick 2001). Landscapes are dynamic, changing both physically and in the ways they are perceived culturally. Settlement pattern and landscape archaeology can be seen as related, complementary fields with a goal of investigating human activity within the greater archaeological contexts of their natural and cultural surroundings.

2.1.1. Defining settlement patterns: Intra-site and inter-site analysis

The term ‘settlement’ refers to the local context wherein a community resides and engages in everyday activity, and settlement can act as a spatial proxy for the community being studied (Chang 1968). Archaeologists study the remnants of community in abstract form via archaeological sites, typically the primary level of analysis for settlement pattern archaeology. Although the ‘settlement’ is the primary locus of everyday domestic activity, human behaviour extends beyond it, and archaeologists must consider components of activity beyond the base settlement (Green and Shawcross 1962; Groube 1965). Chang (1968) divided settlement pattern analysis into two levels:

1) *micro-settlement*, regarding the internal order and arrangement of a singular settlement; and

2) *macro-settlement*, representing the interaction and distribution of multiple settlements.

Other divisions of settlement patterns have also been proffered. Trigger’s (1968) work on the determinants of settlement patterns divided up the subject into three levels of organisation:

1) that of the individual building or *habitation*;

2) the *community*, including the layout of structures and activity areas within a site; and
3) **zonal patterns**, identified by Trigger at the level of society. This level includes the overall distribution of human population and activity.

A similar scheme of settlement organisation was proposed specifically for New Zealand’s prehistory by Groube (1965), consisting of three levels:

1) the **domestic** level, relating to the individual structure of household;
2) the **communal** level, relating to the relationship of structures and activity areas within a site; and
3) two interacting levels of inter-site organisation consisting of two levels:
   i) the **economic** level, influenced by and representing the subsistence concerns of people, but also includes the exploitation of resources for construction and technology, and the movement of goods and resources through trade and exchange; and
   ii) the **political** level, representing the socio-political interaction of independent groups.

Groube’s approach is particularly valuable in its recognition of economic and political organisation as two major, interacting influences on settlement distribution, and important avenues of study.

All three of these settlement pattern approaches are concerned with similar divisions, the most common being a basic distinction between intra-site and inter-site scales, the latter being represented in the models outlined above by Chang’s *macro-settlement*, Trigger’s *zonal patterns*, and Groube’s interacting *economic* and *political* levels. However, archaeologists should be cautious about simplifying a direct community-settlement-site relationship; a single community may utilise a number of settlements and a range of activity areas (H. Allen 1996; Chang 1968; Green and Shawcross 1962, 215). The factors that influence the formation of these inter-site patterns of settlement can include both environmental and cultural factors (Trigger 1968), varying between regions, cultural groups, and over time.

The foundation of New Zealand settlement pattern studies was provided by Les Groube (1965) and followed by a number of regional studies (see Campbell and Phillips 2004). The approaches used in this thesis are strongly influenced by these earlier settlement
pattern studies, and attempts to reflect Groube’s (1965) division of inter-site settlement patterns into interacting economic and political spheres through the factors being investigated and the methodologies used. Economic influences on site distribution are investigated through analysis of the distribution of pā in relation to horticulture using cost surface analysis, and political influences on site distribution through the relative proximity and intervisibility of pā sites using viewshed analysis.

2.1.2. Settlement systems: Components and influencing factors

A primary goal of both settlement pattern and landscape archaeology is identifying the factors that influence the decisions people make regarding settlement. The nature and distribution of resources and procurement activities in turn influences the nature and distribution of settlements and the archaeological sites that remain as evidence of behaviour (Trigger 1968). Seasonal or otherwise limited exploitation of resources is associated with high levels of mobility, with regular movement from resource to resource as a strategy of avoiding localised shortfalls (Halstead and O’Shea 1989; Rowley-Conwy and Zvelebil 1989). In turn, large, stable resources tend to encourage population aggregation and sedentism, even in hunter-gatherer societies (A. Anderson and Smith 1996). As a result, there is a tendency for settlements to be located in close proximity to important resources. This is essentially the central tenet of Optimal Foraging Theory (MacArthur and Pianka 1966), which utilises a principle of least cost in the explanation of subsistence behaviour. Social groups can only effectively utilise resources within a certain distance of settlements or camps; there is a threshold at which the energy expended in reaching and procuring resources becomes no longer cost-effective. Optimal Foraging Theory assumes optimised subsistence behaviour, attempting to conserve energy and seek the greatest reward for the lowest cost. In animals, this conservation of energy is a behavioural construct, but in humans it can be an active calculation, although based more on a subjective perception of costs and benefits which may not be actualised (Roper 1979). Archaeologists have utilised Optimal Foraging Theory to investigate past human subsistence practices, particularly resource depression of prey species (c.f. Nagaoka 2002), but it has its limitations: it can reduce human diet to a function of biological requirements and immediate availability of resources, ignoring cultural inputs to dietary selection such as taste, prestige value, and other localised cultural factors (c.f. H. M. Leach 2003; M. L. Smith 2006; van der Veen 2003). While Optimal Foraging Theory is a fairly effective
predictor of behaviour in mobile, socially independent hunter-gatherer groups, it is not as readily applicable to more politically complex sedentary societies; with increasing socio-political complexity, trade-offs are made between economic efficiency and socio-political expediency (Maschner 1996). In general though, limits of foraging or other economic activity can be observed (Hunt 1992), and settlements should ideally be located as close to resources as practically possible (Stone 1991). Binford (1982) divided the economic ranges of hunter-gatherer groups into two classes: 1) foraging radii, the immediate area within which day-to-day subsistence activity was carried out, and; 2) logistical radii, an extended area exploited by task groups travelling outside the base settlement for more than a day. In hunter-gatherer societies this kind of subsistence-based mobility is generally more common and more extensive than among horticultural or agricultural societies. Cultivations represent long-term investments with delayed returns and regular upkeep, and as a result encourage sedentism, and close proximity of settlement (G. Jones 2005). Although storage of foodstuffs is not unique to food-producing societies, it is a common practice among them, and also encourages increased sedentism (Halstead and O'Shea 1989; Testart 1982). The influences of these aspects of subsistence can be seen in patterns of settlement, and the zones of resource exploitation utilised by particular societies. For example, ethnographically observed economic ranges among hunter-gatherer societies can be up to 10 km in radius, while those of horticulturalists are more restricted and around 1.5 km in radius (Hunt 1992). Attempts by archaeologists to recreate these economic ranges, in order to investigate aspects of economic and political organisation are termed ‘site catchments’. The term ‘site catchment’ refers to a defined area around a settlement or archaeological site within which the inhabitants of that site limit the majority of their activity (Vita-Finzi and Higgs 1970). The geographic extent of a variety of social and economic behaviours can be represented and investigated in this way, but subsistence activity is the most common subject of analysis. Optimal Foraging Theory and the limitations of cost-effective foraging and other subsistence activity is often considered as a partial influence on site the limits of site catchments. Site catchment analysis has proved a valuable tool for archaeologists and has been used to study diverse subjects such as political organisation (e.g. M. W. Allen 1996; Hare 2004; Hunt 1992; Steponaitis 1981), the ecological impacts of human activity (e.g. Ullah 2011), and population mobility (Grove 2009).
Most of the spatial relationships discussed so far involve relationships between settlements and other non-settlement sites associated with subsistence activity. These relationships are typically intra-community, centred on a single base settlement with a dispersed population involved in subsistence activity, but inter-community and inter-settlement relationships are equally important. One of the ways in which archaeologists study the relationships and hierarchies present between sites in settlements is via central place theory, an attempt to explain the distribution of settlements as part of an economic system. Central place theory suggests that on a uniform landscape, settlement would have a regular distribution, characterised by an idealised equidistant pattern of settlement – a pattern which in reality is warped by environmental variability (Inomata and Aoyama 1996). Central place theory is characterised by a hierarchy of settlement, with major settlements distributed at a distance from each other and surrounded by smaller settlements under their influence, with goods and services moving between the centre and the outskirts. A range of hierarchies can exist, with a group of settlements of the same order acting as central places to smaller settlements, and having a larger central place of their own. Like optimal foraging theory, central place theory can be associated with ideas of conservation of energy, in this case minimising cost of travel and transport (Inomata and Aoyama 1996). Despite its origins as an economic model, central place theory and similar models have been used in archaeology to investigate political relationships and predict territorial units (e.g. Hare 2004; Steponaitis 1981).

Even in societies without hierarchical economic or political systems, the notion of centrality can still be of use. As suggested by concepts of home-ranges and foraging radii (Hunt 1992) a central place, however temporary, can be found among even highly mobile subsistence systems. Increased sedentism only adds to the permanence and importance of some form of central place. Setting aside the strict distributional notions of central place theory, multiple places of centrality can be theorised to have been used simultaneously by a single social group, possibly including separate economic, political, or spiritual centres within a single settlement system. This is certainly the case with many pre-urban societies, where spiritual centres are formal constructions separate from settlements, such as the monuments created by Neolithic societies from Polynesia to Europe (Kirch 1990; Sherratt 1990). Neolithic monuments have been considered to act as ‘village surrogates’, acting as spiritual centres for a dispersed community whose use of monuments reinforced social relationships (Sherratt 1990). The referential meanings given to monuments can be
circular: monuments are centrally located because they organise the surrounding population, and dispersed settlements cluster around monuments because they are used as central places (Bernardini 2004).

2.2. Potential settlement models for Tōtaranui pā

This thesis aims to test three potential models of settlement for Tōtaranui. These are based roughly on models of settlement from both northern and southern regions of New Zealand. The intent is to compare patterns of settlement in Tōtaranui with those of other regions and place the study area within the greater New Zealand context.

The major point of division between these models is the manner in which pā distribution was influenced by marine or introduced terrestrial aspects of the Tōtaranui landscape. Tōtaranui Māori engaged with and exploited resources from both areas of the landscape on a daily basis, but analysis is limited to those resources for which detailed spatial information is available, and general divisions of visibility over areas of land and sea. Two measures are used in this thesis to quantify the relationships between and among sites and environmental features: proximity (measured by way of cost distance analysis); and visibility (measured using viewshed analysis). Physical proximity can be understood to represent the desire to locate pā with easy access to resources, whereas visibility signifies a desire to maintain visual control over resources and important areas. The exact methodology related to these measures is described in Chapter 4. The expectation is that results will confirm one of these models, with pā distributed in close relation to marine or introduced terrestrial resources, or to both.

2.2.1. Model A: Pā location in Tōtaranui is influenced by the distribution of introduced terrestrial resources and protecting/signifying occupation of land

This model assumes that introduced terrestrial subsistence resources were the primary influence on the distribution of pā in Tōtaranui. The terrestrial resources specifically being studied in this thesis are cultivations of the introduced kūmara, and stands of transplanted karaka.
In archaeological and ethnographic contexts cultivations are typically located near settlements, with the proximity of the two typically higher in cases of intensified use of cultivated resources (Stone 1991). Storage of resources, as is the case with kūmara, also encourages sedentism (Halstead and O’Shea 1989; Rowley-Conwy and Zvelebil 1989; Testart 1982). The distribution of pā can be seen to roughly correspond at a national level to the limits of viable kūmara horticulture (Figure 2-1). Kūmara was the most important crop in New Zealand prehistory – as it was the only introduced Polynesian cultivar that could be grown with widespread success – but its cultivation was limited in the South Island to coastal areas north from Banks Peninsula (Barber 2004; Furey 2006; Trotter and McCulloch 1999). In certain northern regions access to viable horticultural soils has been considered to influence the distribution of settlements and pā and the nature of socio-political organisation (M. W. Allen 1996; 2008; Cassels 1972). Elsewhere in the Pacific some Fijian fortifications were situated so as to maintain visibility over gardening areas (C. Smith and Cochrane 2011), a situation that may have been repeated in New Zealand.
Figure 2-1: Distribution of New Zealand pa and the approximate limit of kumara horticulture
Part of the Māori adaptation of the tropical, perennial kūmara to an annual crop cycle in temperate New Zealand involved the storage of harvested tubers over winter in subterranean or semi-subterranean pits for planting the next season (Davidson et al. 2007; Furey 2006; Yen 1961). Storage is related to increasing sedentism, and is a buffering strategy against seasonal variability in resource availability (Rowley-Conwy and Zvelebil 1989; Testart 1982). The nature and distribution of stored materials can be related to social structures and the nature of settlement. Groups engaging in high levels of seasonal mobility tend to utilise a number of dispersed stores, and clustered stores are associated with periods of increased sedentism (Morgan 2008). Centralised communal stores have been associated with chiefly power and the redistribution of wealth, whereas concealed dispersed store may be evidence of resistance to centralised power (DeBoer 1988; Wesson 1999). Visible storage systems have been interpreted as deliberate means of advertising community wealth in Central America (Ogburn 2006), and a similar interpretation has been suggested for the storage structures of New Zealand Māori (Law 2000; Law and Green 1972). Although storage sites were essential aspects of the Māori garden systems, the distribution of pit sites does not necessarily equate to the distribution of horticultural resources. A study undertaken in northern New Zealand showed that the factors that influenced pit and garden site distribution were not necessarily identical, and that pit sites cannot be taken as an immediate proxy for gardening (Jorgensen 2009). For this reason, Tōtaranui pit sites were not considered as a terrestrial resource denoting kūmara horticulture in analysis.

Evidence for horticulture in Tōtaranui is somewhat mixed; although there are a number of recorded archaeological garden sites the ethnohistorical records from James Cook’s voyages of the late 18th century show no evidence for gardens in the area, strongly suggesting that horticulture had been abandoned by this stage. The abandonment or localised restriction of horticultural activity has been observed in other areas of central New Zealand – Palliser Bay, Tasman Bay, Clarence River mouth – suggesting a general pattern in this area (Barber 1994; 2010; H. M. Leach and Leach 1979). The analysis of the spatial relationship between pā and archaeologically recorded garden sites in Tōtaranui was intended to provide a greater understanding of the nature of horticultural activity in the region. Unfortunately, garden sites are likely to be under-represented in the recorded sites database, as garden soils are typically less conspicuous archaeological features than terraces, ditches, and pits. Areas potentially suitable for gardening could be identified by
analysis of the variables (soil type, hydrology, temperature, aspect, etc.) appropriate for growth. Preliminary analysis of this type was carried out, but was unable to find sufficient variation in rainfall, soil type and temperature within the available data. Further analysis of this kind was considered to essentially reduce suitable garden locations to functions of slope and aspect, and this was believed to homogenise large areas of the study area. As such, it was decided to focus on the direct analysis of known garden sites.

Another terrestrial resource that has been shown to have a spatial association with archaeological sites – specifically pā – is karaka (Corynocarpus laevigatus) (H. M. Leach and Stowe 2005; Stowe 2003). Karaka is a tree endemic to northern parts of New Zealand that produces fruit with edible flesh and a toxic seed that is also edible when correctly prepared. Māori developed a means of detoxifying the seeds by baking them in in umu (earth ovens), and immersing them in water for long periods, and karaka was a major wild food resource. Karaka trees are now found throughout New Zealand, having been transplanted in prehistory well beyond their natural range in northern portions of the country. In the South Island the tree is not particularly naturalised, meaning that stands of karaka are likely the remnants of, or very near to transplantations made in prehistory. Studies have found a spatial relationship between karaka stands and archaeological sites – particularly pā – at a national level (H. M. Leach and Stowe 2005; Stowe 2003), and this research aims to test this relationship at a regional level in Tōtaranui.

If introduced terrestrial resources were a significant influence on the distribution of pā in Tōtaranui, spatial analysis could be assumed to return certain results:

1) **Garden sites would be found in close proximity to pā.** A general spatial relationship exists between pā and the limits of kūmara horticulture at a national level in New Zealand, and regional studies have suggested spatial associations between horticultural areas and pā at regional levels (M. W. Allen 1996; Cassels 1972).

2) **Karaka stands will be found in close proximity to pā.** In Tōtaranui, extant stands of karaka are likely the remnants, or very close to prehistoric transplantations, and a spatial association between the distribution of karaka stands and pā has been identified at a national level (H. M. Leach and Stowe 2005).

3) **The importance of introduced terrestrial resources will be reflected in expansive views from pā over areas of land, and the aforementioned**
Introduced terrestrial resource sites (gardens and karaka stands) will also be found more commonly within view of pā. Intervisibility is used as a secondary measure of indicating relationships between sites, and a desire to maintain visual control over important resources.

Unfortunately, analysis does not include the resource that ethnohistorical accounts suggest was the most important terrestrial contributor to Māori diet in Tōtaranui, and possibly also New Zealand in general: the rhizome of bracken fern (Brooks 1999; H. M. Leach 1980; McGlone, Wilmshurst, and Leach 2005; Shawcross 1967). Unlike karaka stands and kūmara gardens, no detailed spatial information for the prehistoric distribution of fern land in Tōtaranui was found beyond early historical references suggesting that it commonly grew on hilltops (Parkinson 1984, 115; Wakefield 1845, 31). No distinct fern ‘gardens’ are mentioned in the early historical accounts, which may suggest that bracken, and areas suitable for its growth were fairly ubiquitous. Future investigations could incorporate the influence of bracken fern on the distribution of pā, based on the conditions appropriate for its growth (i.e. soil type and temperature, aspect, and slope), but such analysis is beyond the scope of this thesis. While investigation could not incorporate all terrestrial resources, kūmara and karaka stands are the two most important resources introduced to Tōtaranui by Māori, and the major focus of analysis was on determining the relationship between the regional distribution of pā in the area and these resources, both of which have close spatial relationships with pā at national levels.

2.2.2. Model B: Pā location in Tōtaranui is influenced by the distribution of marine resources and protecting/signifying ownerships of areas of sea

This model assumes that marine resources, rather than terrestrial ones, were the primary influence on the distribution of pā in Tōtaranui. Marine resources were important throughout prehistory in New Zealand, with fish being the major supplier of protein to the Māori diet (I. Smith 2004). In the far south of New Zealand fishing tended to be specialised, targeting certain species (ibid.). During the early prehistoric sequence in southern New Zealand, the presence of large coastal/marine resources in the form of fur seal (*Arctocephalus forsterii*) colonies was associated with ‘transient villages’, large, permanent settlements with fluctuating populations (A. Anderson and Smith 1996).
Localised extirpation and depletion of resources by the 15th century AD (I. Smith 2005) removed the essential resource base these villages depended on, resulting in their disappearance from the archaeological record and more mobile settlement until the later sequence (A. Anderson and Smith 1996). Fishing grounds were one of the traditional food gathering areas covered by mahinga kai, a formalised system of resource ownership and access among South Island Māori based primarily on genealogical descent (A. Anderson 1996). Ethnographic accounts relate that visual landmarks were used to identify the boundaries of traditional fishing grounds (Barber 2003; Best 1977). Current evidence does not provide detailed spatial information regarding the distribution of maritime resource areas in prehistory (i.e. shellfish beds, fishing areas), and analysis relies primarily on testing whether visibility over areas of sea were prioritised.

If marine resources were a significant influence on the distribution of pā in Tōtaranui, spatial analysis could be assumed to return certain results:

1) **Midden sites may be found located within close proximity to pā.** Marine resources – fish, shellfish and marine mammals – tend to dominate midden assemblages in central New Zealand, with marine mammals disappearing part-way through the sequence, and fish being the dominant resource by late prehistory (F. Leach 2006; I. Smith 2004). Central New Zealand fishing practices also appear to have been specialised, focussing on one or more species. Though little analysis of Marlborough Sounds middens has been carried out (Challis 1991), historical records imply that fish was a staple food source of Tōtaranui Māori and middens in the study area are likely dominated by the remains of marine resources. If these sites are located more commonly at close distances to pā, it may suggest that pā were deliberately constructed in proximity to significant marine resources.

2) **The importance of the sea in day-to-day life is reflected in more expansive viewsheds over areas of water from pā.** Visual landmarks are known to have been used in identifying traditional Māori fishing grounds, and visibility over expansive areas of sea was a determinant in the placement of monumental cairns in northern Scotland and the Orkney isles (Fisher et al. 1997; T. Phillips 2004). Unfortunately, due to difficulty in identifying areas of traditional marine resource use, this will be the primary signifier of the importance of marine resources.
2.2.3. **Model C: Pā location in Tōtaranui reflects the influence of both terrestrial and marine resources, and a concern for both portions of the landscape**

This model assumes that neither marine nor introduced terrestrial resources were dominant over the other in terms of the influence they had on pā distribution. Subsistence behaviour in this situation is diversified, utilising a range of resources without any holding particular social importance. If this is the case, the results of spatial analysis would demonstrate a mixture of the results of the previous two models (i.e. expansive viewsheds over areas of sea, but close proximity of introduced terrestrial resources), or no particularly strong influences toward either model.

2.3. **Summary**

This thesis takes a landscape approach to investigate the pā of Tōtaranui, considering sites within their natural and cultural contexts, and can also be considered a settlement pattern study with a primary focus on the spatial relationships between sites. In an attempt to investigate both economic and political aspects of settlement, this thesis will attempt to recreate the economic interaction of Tōtaranui Māori with the environment in the form of both marine and introduced terrestrial resources, and the political interaction of groups within the settlement system with each other. Three models of settlement will be tested against the results of cost distance and viewshed analysis, the methodology of which will be described in the following chapter.
Chapter 3

Tōtaranui/Queen Charlotte Sound: The study area

Tōtaranui/Queen Charlotte Sound is one of a number of drowned river valleys that make up the Marlborough Sounds in the north of New Zealand’s South Island. It is a maritime landscape, its geography defined by the many bays, coves and islands that act as transitional areas from the waters of the sound to its sloping hillsides, headlands and promontories. An introduction to the prehistory of Tōtaranui is presented here, utilising evidence from archaeological, historical and ethnographic sources. The focus of this chapter is primarily on those aspects of prehistoric Māori culture that are of relevance to the landscape-oriented settlement pattern approach of this thesis, specifically the nature of settlement, social organisation, and subsistence behaviour, and the organisation of space with regards to these subjects. In order to present the greater archaeological context, this regional study will also describe general patterns of settlement and subsistence in New Zealand. This is done with an aim of inter-regional or regional-to-national comparison, in order to express where Tōtaranui both corresponds with and deviates from the wider New Zealand context.
Figure 3-1: Tōtaranui, with place names mentioned in the text

The phase of settlement under investigation in this thesis corresponds to the period of pā construction from around 1500 AD onwards in prehistory (Schmidt 1996) until the eventual abandonment of pā as a traditional form of fortification and settlement in the 19th century. This roughly correlates with the ‘Classic’ period of Māori culture as defined by Jack Golson (1959) as part of his binary model of cultural phases in New Zealand prehistory. Early historic and ethnographic accounts are used frequently, particularly those originating from the voyages of explorer James Cook in the 1770s. Both traditional and historical sources are treated cautiously and must be critically compared against archaeological data, rather than taken verbatim (Golson 1960).
3.1. The nature of social organisation in Tōtaranui

Prehistoric Māori social organisation is typically divided into three levels, based on both shared descent and territory:

1) Whanau, typically associated with the notion of extended family;
2) Hapū, ‘sub-tribe’, a larger descent group that was an agglomeration of whanau. However, descent is not simply a linear construction and individuals could belong to more than one hapū through various lines of descent; and
3) Iwi, typically associated with a European notion of tribe, as agglomerations of hapū. Like hapū, iwi often trace their origins to an ancestor, for whom the iwi is named. Iwi are sometimes grouped based on a shared connection to a waka (canoe) from the ancestral homeland of Hawaiki.

Groube associated these social divisions with his divisions of settlement outlined in the previous chapter: whanau/domestic, communal/hapū, and iwi/political (Groube 1965). Groube believed whanau to be the fundamental unit of organisation in prehistory, with the majority of movement and subsistence activity occurring at this level. The relationship between whanau, hapū and iwi should not be taken as a simple hierarchical one; organisation at the iwi level and the exertion of authority on affiliated hapū could only be achieved by charismatic leadership, and division among related hapū was as common as unity (H. Allen 1996).
Tōtaranui was not an isolated entity in a social or political sense. The area is generally taken to be part of a larger geographic region encompassing areas bordering
Raukawamoana/Cook Strait including the southern North Island, and Te Tau Ihu, the northern South Island. This region is characterised by considerable shared genealogy among the groups that inhabited it and also by successive immigration of groups from the north (Davidson and Leach 2002; Mitchell and Mitchell 2004; O’Regan 1987). As a result of this shared genealogy tribal ascription in the region can be a complicated matter, and both individuals and groups could be affiliated with multiple hapū and/or iwi. Amalgamated groups are mentioned occasionally in the traditional record (O’Regan 1987, 142-6) and these groups may have had different iwi ascriptions at different times, based on changing political circumstance. In New Zealand prehistory intermarriage between resident and immigrating or invading groups was common, and acted as a means of amalgamating both descent-based and conquest-based land rights (A. Anderson 1998, 57).

Traditional records suggest that Tōtaranui was often occupied by several autonomous and often competing social groups. Conflict was a common aspect of inter-group relations in New Zealand: a means of solving disputes, rectifying insults, and gaining access to territory or resources (Ballara 1976; 2003; Vayda 1960). Similarly, traditional accounts provide examples of the fluctuating political relationships of Te Tau Ihu. One such occurred following Ngāti Kuri’s move from Tōtaranui to neighbouring Te Whanganui/Port Underwood and the Wairau River following conflict with Ngāi Tara. There they then came into conflict with Ngāti Mamoe and Rangitāne, but during a period of relative peace following several battles Ngāti Kuri and Ngāti Mamoe were allied by a series of strategic intermarriages. These groups proceeded to launch attacks on communities of Ngāi Tara in Tōtaranui and Rangitāne in Te Whanganui/Port Underwood and the Wairau Valley, but Ngāti Mamoe and Ngāti Kuri would later come into conflict again (Mitchell and Mitchell 2004, 76–84; O’Regan 1987).

The early historical accounts of James Cook’s visits to Tōtaranui give a similar impression of a region populated by several independent groups with fluctuating political relationships. Within days of their first arrival on January 15th 1770 Cook and crew found the body of a woman floating in a cove near Mereto/Ship Cove and they shortly came across a group of her relations who had recently fought and killed a group of enemies that had come into their bay (Banks 2006, 214–5). The same day Cook witnessed a woman scarified about the arms and legs by way of mourning for her husband who had been killed somewhere to the east (Edwards 2003, 102). A few days later Joseph Banks (2006, 215)
noted that the people of Hippah Island pā (Q26/9) were quieter than usual and not engaging in their normal activities, for the reason that they were expecting an attack from their enemies as an act of retribution for the earlier killings. This conflict was already ongoing at the arrival of the Europeans but further fighting was precipitated by the opportunities for trade they provided. During Cook’s second voyage, a group of Māori who had taken up residence near Meretoto conducted a raid into Admiralty Bay, seemingly as a means to secure items to trade to the Europeans (Edwards 2003, 319–20; Forster 1777a, 511–2).

A formal confrontation between two groups occurred during Cook’s second voyage. A family of Māori that had spent some time with Cook and his crew were on board one morning when the approach of a canoe from the north was sighted:

“Our friends on board very earnestly told us they would be our enemies, and persisted to fire at them; nay Towahanga, the head of the family jumped on the arm chest... and taking hold of a stick, made a number of warlike motions with it, and soon after spoke to them very violently, but with some degree of solemnity” (Forster 1777b, 223).

At the same time, the rest of ‘Towahanga’s’ group left in their canoes, possibly to protect their possessions, women and children (Edwards 2003, 273–4). A chief among the newcomers gave a speech and after Cook welcomed them on board a formal peace was established between the two groups by way of a hongi (a traditional Māori greeting involving the pressing together of noses and forehead). The newcomer Te Ratu and his group came from Te Rawhiti, the southern cape of the North Island, and would return to Tōtaranui during Cook’s later visits in order to trade with the Europeans (Mitchell and Mitchell 2004, 192).
When Cook’s third voyage saw him return to Tōtaranui for the last time in February 1777 he met the chief Kahoura, who was present for the ‘Grass Cove Massacre’ four years earlier. This was an incident involving the killing of a small group of the Resolution’s crew by local Māori: a disagreement over a theft or unequal trade escalated when Lieutenant John Rowe fired on the Māori. The ten Resolution crewmembers were swiftly overpowered and killed and the incident was not discovered until the following day, when another small boat was sent out to find them and came across their cutter and soon found their dismembered remains, which had been set for ceremonial consumption (Barber 1999). The chief Kahoura had admitted to killing Rowe himself (Mitchell and Mitchell 2004, 182) and several times Cook was encouraged by both his crew and local Māori to take revenge and kill Kahoura, but Cook refused. Although they expected Cook to enact retribution for the deaths of his men, an act in line with the Māori concept of utu (Metge 2002), Cook also seemed to believe that there might have been additional political motivations for the death of Kahoura:
“he seemed to be a man more feared than beloved by them: many of them said he was a very bad man and importuned me to kill him, and I beleive they were not a little surprised that I did not, for accord[ing] to their ideas of equity this ought to have been done. But if I had followed the advice of all our pretended friends, I might have extirpated the whole race, for the people of each Hamlet or village by turns applied to me to distroy the other, a very striking proof of the divided state in which they live.” [sic] (Edwards 2003, 452–3).

This account and other traditional and historical accounts imply the divided nature of the political landscape of Tōtaranui and the presence of multiple independent groups – both resident and visiting. During Cook’s first visit in January and February of 1770, two occupied pā were noted: Hippah Island Pā (Q26/9) presided over by the chef Topaa, and Hippah Rocks Pā (Q27/3). Anne Salmond (1991, 253; 1997, 66) considered these “the citadels of two opposing federations of kin-groups”, equating them to the Rangitāne and Ngāti Apa iwi. During the visit, at least one of Topaa’s people had been killed somewhere to the east (Edwards 2003, 102), suggesting political tensions between groups in different parts of the sound. During the four visits of the Adventure and Resolution during 1773 and 1774, the Europeans explored more of the area and became familiar with more of the local Māori. By this stage the pā at Hippah Island was abandoned and there is no account of what had become of Topaa (Forster 1777b, 198; Mitchell and Mitchell 2004, 187). One group with whom the Europeans had a number of interactions during the second and third voyages was the family of ‘Towahanga’ who visited the Europeans almost daily. It is this group that Simmons (1987) identifies as Southland Ngāi Tahu, believing that the individual called ‘Khollakh’ is the same as the later southern chief Korako. The 71 year gap between ‘Khollakh’ in 1773 and the venerable Korako alive and well in 1844 has caused this interpretation to be disputed by John and Hilary Mitchell (2004, 180–1) and Atholl Anderson (1998, 72–5). Mitchell and Mitchell interpret Khollakh as the father of the 12-14 year old boy ‘Taywaherua’, requiring Khollakh to be an adult of 30 or so years in 1773 and making him unlikely to be alive 71 years later. Anne Salmond (1997, 537) however, considers the proposed father-son relationship a misinterpretation and suggested Khollakh could still have been quite young at the time of Cook’s visits. However, it seems unusual that Forster (1777b, 209), when describing the group, would refer to Taywaherua as a young boy, but not Khollakh, and Khollakh may also have been killed sometime between 1774 and 1777 (Mitchell and Mitchell 2004, 180–1). Atholl Anderson (1998, 72–
likewise questions the identification of Khollakh with Korako, pointing out the difficulties and inconsistencies in European attempts to record Māori names, and dismissing supposed material evidence for the connection between Cook’s visit to Tōtaranui and southern South Island Māori. Taywaherua’s family seem to have been resident locally in Tōtaranui for a long time: when they were first noted by Forster on the 23rd of May 1773, they arrived in “two small canoes” suggesting they had not come far (Forster 1777b, 204–9). Members of Taywaherua’s group were present again in 1777 (Mitchell and Mitchell 2004, 188), during Cook’s final voyage, an unlikely occurrence if they were transient visitors to the area.

Some of the Māori in Tōtaranui during Cook’s visits were certainly temporary visitors, drawn by the valuable trading opportunities the Europeans provided. The chief Te Ratu came from Te Rawhiti across Raukawamoana/Cook Strait, and the initial political tension between Towahanga, likely a resident of Tōtaranui and these North Island visitors is clear (Forster 1777b, 223–5). Simmons identifies another group led by ‘Tringo-Waya’ as originating from the Wanganui-Taranaki coast or Horowhenua based on an interpretation of the material culture forms collected and observed during Cook’s visits (Simmons 1987, 42). However, Tringo-Waya’s group came in several canoes of varying sizes – some of which had sails – and after trading with the Europeans ‘returned to the upper part of the sound from whence they came” (Forster 1777b, 217–221). Burney’s account (Burney 1975, 55) corroborates Forster’s, making it clear that this group came from further up the sound, i.e. to the southwest, making them more likely to be Tōtaranui locals, rather than North Island visitors. John and Hilary Mitchell (2004, 182) likewise disagree with Simmons’ interpretation, considering it likely that Tringo-Waya was from Te Tau Ihu, and provide genealogies affiliating him with Ngāti Apa, Ngāti Kuia and Rangitāne.

On the 5th of November 1774, Cook made his furthest journey up Tōtaranui, traversing Kura Te Au/Tory Channel to find where it terminated into Cook Strait. The channel was noted as being highly populated, and Cook and Forster noted at least two major settlements: a settlement in a ‘most spacious bay’ where they met the aged, but lively chief ‘Tringho-Boohee’, and a pā on the northern shore, likely one of the recorded pā at Whakenui Bay or Okukari Bay (Q27/56 and Q27/217) (Edwards 2003, 395–6; Forster 1777c, 471–5). Curiously, the former settlement, which apparently lay on the southern shore of Kura te Au at least ‘three leagues’ (around 20 km) west of the pā, is referred to as
'Ko-Haghee-nooee’ by Forster (1777c, 474), which both Salmond (1997, 112–3) and Simmons (1987, 42) understandably associate with Whekenui. However, the accounts make it clear that the settlement and pā are different places:

“Having advanced about three leagues from Tringho-Boohee’s settlement, which the natives call Ko-Haghee-nooee, we began to see many shags…A few moments afterwards, we also saw breakers at the farther end of the inlet…On the left, or at the back of Grass Cove, we saw a hippah, built on a high rock” (Forster 1777c, 474).

According to this Tringho-Boohee’s settlement is some three leagues (i.e. around 20 km) from the pā at Whekenui Bay. If ‘Ko-Haghee-nooee’ is indeed a transliteration of Whekenui, it is likely that a misunderstanding occurred during the conversation with Tringo-Boohee, and what Forster took for the name of the settlement further down Kura te Au was Tringho-Boohee providing the name of the pā – perhaps the place he considered his home or the centre of settlement in the vicinity.

Overall, the traditional and historical records suggest a picture of transience in the political landscape of Tōtaranui. Tensions or outright conflicts between groups are mentioned on several occasions, though the case of Te Ratu and Towahanga (Edwards 2003, 273–4; Forster 1777b, 223–5) shows that fighting was not inevitable, with formal means of establishing peace. There is little evidence in terms of hierarchy or established authority, but a number of chiefs or eminent figures are mentioned. Many of these named figures were elder statesmen, and the Europeans believed that Māori leaders were distinguished by age or natural talent (Mitchell and Mitchell 2004, 186–7). Several disappear in the periods between visits; such as Topaa and Tringho-Boohee, the latter of which was said to have been killed in conflict (Mitchell and Mitchell 2004, 187, 191). The disappearance of these leaders within such a short span may be further evidence for the conflict or mobility within this fluctuating political landscape.
Figure 3-4: Central New Zealand with place names mentioned in the text
3.2. Subsistence behaviour in New Zealand and Tōtaranui

Prehistoric Māori subsistence utilised a range of resources; wild and cultivated, native and introduced, terrestrial and marine. Subsistence behaviour varied both spatially and temporally in relation to varying availability of resources. This section will describe the general nature of subsistence in New Zealand with a focus on cultivated resources and wild plant foods.

Horticulture

New Zealand’s East Polynesian colonists brought with them the kiore (Polynesian rat, *Rattus exulans*) and kūri (Polynesian dog, *Canis familiaris*), along with a whole suite of cultigens. Although Polynesians transplanted and cultivated a range of tree and plant crops across the Pacific (Kirch 1991; Whistler 1991), few imported Polynesian cultigens could be grown successfully in the temperate climate of New Zealand and only six were grown at the time of European arrival: kūmara (sweet potato, *Ipomoea batatas*), taro (*Colocasia esculenta*), yam (*Dioscorea* spp.), hue (gourd, *Lagenaria siceraria*), ti pōre (*Cordyline fruticosa*) and aute (paper mulberry, *Broussonetia papyrifera*) (Furey 2006, 10–16).

The temperate climate of New Zealand limited the successful introduction of Polynesian cultigens: of those that were established, only kūmara could be grown extensively across the country and as a result gained importance as the staple crop of New Zealand Māori (Barber 2004; Furey 2006). A number of changes in cultivation practice – likely supplemented by genetic changes associated with selective pressures – allowed the adaptation of kūmara gardening to the colder, temperate New Zealand environment. In the wider Pacific, kūmara was a perennial crop cultivated by stem cutting, but Māori horticultural adaptations changed the way the tuber was grown. In New Zealand, kūmara was an annual crop propagated by directly planting the root and harvested tubers were stored over winter in semi-subterranean pits for planting next season (Davidson et al. 2007; Furey 2006, 10–12; Yen 1961). Further adaptation involved the improvement of the temperature, porosity and drainage of gardening soils by the addition of gravel or coarse sand, and the spread of lithic mulches on the surface around plants to protect against mud and dampness (Barber 2004; 2010; 2013; Furey 2006). Despite these adaptations kūmara gardening remained environmentally limited and in the South Island could only be grown in coastal areas as far south as the area around Banks Peninsula (Furey 2006; Trotter and
McCulloch 1999). The South Island generally and Tōtaranui specifically have been considered marginal for cultivation (e.g. Davidson and Leach 2002, 258; Davidson et al. 2007; Furey 2006) and it has even been suggested that the cultivation of kūmara in any significant volume and its use as a staple was limited to optimal zones in the Bay of Islands, Auckland and the Bay of Plenty (Walter, Smith, and Jacomb 2006, 278). As a result, there would have been increasing exploitation of wild plant food sources roughly proportionate with increasing latitude.

Early models associated the introduction of Polynesian cultigens with later phases of settlement and successive waves of colonisation, but more recent studies show that horticultural activity is clearly associated with the earliest phases of settlement in New Zealand (Barber 2004; Davidson 1984, 116–8; H. M. Leach 1979). Several phases of gardening activity were proposed by Helen Leach (1979):

1) *Introduction*: the phase of initial introduction of Polynesian cultivars and gardening techniques;

2) *Experimentation*: in which the introduced plants and methods were adapted to suit the New Zealand climate. Methods of storage were developed that allowed crops like kūmara and taro to survive temperate winters, allowing expansion of gardening practices into more marginal areas, such as Palliser Bay in the southern North Island;

3) *Regional consolidation*: this phase included secondary expansion from regional centres, elaboration of storage facilities, and the development of distinct regional varieties of kūmara; and

4) *Retrenchment*: during which gardens in marginal areas such as the Wairarapa coast and the Marlborough Sounds were abandoned, likely as the result of climatic variation and lower temperatures in the 17th century.

The timing of these phases is not precisely known, likely varied regionally, and not all phases necessarily occurred in all areas. Retrenchment may have been restricted to areas in central New Zealand that were already marginal for kūmara cultivation, because of the greater effect environmental variation may have had in these regions.

The early historical period saw a phase of horticultural resurgence alongside the introduction and incorporation of both European crops and imported varieties of the
traditional Polynesian cultivars into the Māori diet and economy. Some of these crops – particularly the potato (*Solanum tuberosum*) – were well suited to New Zealand’s temperate climate and allowed horticulture to flourish in such areas as the far south where kūmara cultivation had been previously impossible. A new market for surplus agricultural production developed as Māori traded pigs, potatoes, and traditional material culture for desirable European goods. The musket was a major item of trade, spurring an intensification of production that was closely linked with the inter-iwi warfare of the 1820s and 1830s (Ballara 2003; Crosby 1999)

**Wild plant foods**

The Māori diet included a range of native plants and animals in addition to introduced food sources. Initial colonists hunted the endemic moa (several species of large, flightless birds) and human predation was a leading factor in their extinction within perhaps 150 years of settlement, as well as the extinction of many other bird species (A. Anderson 1989; Holdaway and Jacomb 2000; Worthy 1999). Colonies of marine mammals were also important subsistence resources, but by ca. 1500 AD there had been regional extirpation of marine mammal colonies throughout the north of New Zealand (I. Smith 2005). Fish were always a major protein source for Māori, supplemented by shellfish, birds, kiore, kurī, and marine mammals where available (I. Smith 2004). In addition, the Māori diet included a range of plant species, chief among them aruhe, the rhizome of the native bracken fern (*Pteridium esculentum*). Bracken fern was ubiquitous, easily harvested and processed, and dried fern could be stored for years. This made it the most important wild plant food source and – although kūmara likely maintained greater social importance – may have matched or even outstripped kūmara in dietary importance even where the former was available (H. M. Leach 1980; 2001; Shawcross 1967).

Perhaps second in importance to Māori in terms of wild plant food sources was the fruit and seeds of the karaka tree (*Corynocarpus laevigatus*). The flesh of karaka berries is edible and though the seed is toxic, Māori developed a preparative method to make it safe for consumption by cooking the seeds in an earth oven, followed by immersion in running water (Klinac, Benton, and Rentoul 2009; Skey 1871). Karaka was among the most important endemic plant foods, and was considered a staple of Māori diet, though not as common or nutritionally important as bracken fern (H. M. Leach and Stowe 2005). The
species’ natural range is limited to the very northern parts of New Zealand, but the modern nation-wide distribution of the plant is the result of deliberate translocation by prehistoric Māori. At a national scale karaka is found in association with archaeological sites, and a particular spatial relationship between karaka stands and pā has been observed at this level (H. M. Leach and Stowe 2005; Stowe 2003, 48). In the South Island karaka is not particularly naturalised, and it is likely that extant stands of karaka are the remains of – or at least very near to – original prehistoric plantings (H. M. Leach and Stowe 2005; Stowe 2003).

**Subsistence models**

In terms of subsistence models and their impact on patterns of settlement, it is generally considered that Māori utilised a range of resources and that subsistence strategies included considerable mobility in pursuit of these resources (Walter, Smith, and Jacomb 2006). In some regions, cultivations likely militated against mobility, as it encouraged investment in an area, and a greater degree of territoriality (A. Anderson 1996). Formalised ownership of specific resources by particular groups is implied in the stone and earthen rows that separate garden plots in addition to serving other functions (Barber 2004), and a formalised system of resource and land access rights based on descent was used by Ngāi Tahu in southern New Zealand (A. Anderson 1996). Evidence suggests hereditary ownership of stands of karaka: some associated with burials were tapu to all but descendants of the deceased and the wealth of some families was associated with ownership of a productive grove (Klinac, Benton, and Rentoul 2009, 4–5). Formal fishing grounds identified by the alignment of terrestrial landmarks also existed, with access rights determined by descent (Barber 2003). Particular resources may have been communal or exclusive, but access to exclusive areas could be negotiated (H. Allen 1996). Religious and ritual activity was bound up in the use of resources, and regulation of resources was carried out, possibly in association with risk-aversion strategies or in the wake of resource depletion (Barber 1996; 2003).

**3.2.1. Subsistence in Tōtaranui**

The nature of subsistence in Tōtaranui in prehistory can currently be best understood from the ethnohistoric sources, due to the current absence of Tōtaranui-specific faunal studies.
Archaeological studies of Tōtaranui are generally based on limited excavated material or conflate this small area within greater regions – either the Te Tau Ihu region of Nelson-Marlborough or a central New Zealand region of the areas bordering Raukawamoana/Cook Strait – possibly masking intra-regional variation (c.f. Challis 1991; F. Leach 2006). Brooks (1999) presents the best study to date of subsistence behaviour in Tōtaranui, synthesising both historical and archaeological evidence from the early contact period with a particular focus on seasonality of subsistence behaviour. For the most part subsistence in Tōtaranui matches the general pattern in New Zealand, with a few deviations.

Tōtaranui Māori exploited a range of both terrestrial and marine resources. Fish made up a major portion of their diet but other marine sources of food included shellfish, crayfish, squid, and the occasional marine mammal (Brooks 1999; Challis 1991). Terrestrial sources of food included a variety of avifauna, kiore, kurī, and various plant foods. Historical records show that Tōtaranui Māori consumed tawa (*Beilschmiedia tawa*), mamaku (*Cyathea medullaris*), and karaka, but bracken fern was the most common plant food (Brooks 1999). The reliance on fish and bracken fern is neatly stated by Cook in his
journals: “They live dispers’d along the Shore in search of their daily bread, which is fish and firn roots, for they Cultivate no part of the lands [sic]” (Beaglehole 1955, 247). These two food sources appear to have been plentiful. Although the hills of Tōtaranui were heavily wooded, fern grew readily on the hilltops (Forster 1777b, 207; Parkinson 1984, 115). European explorers also marvelled at the ubiquity of fish in Tōtaranui and the ease with which Māori caught them, supplying them in great quantities to the European crews (Banks 2006, 215–6; Edwards 2003, 106), and a local chief despaired at one point that they would buy up his people’s entire supply (Banks 2006, 219). The major species supplied to the Europeans are related by Brooks (1999, 19–25) including tawatawa (blue mackerel/’pinfish’, Scomber australasicus), ngōiro (southern conger eel, Conger verrauxi), tarakihi (Nemodactylus macropterus), moki (Latridopsis ciliarsis) and kōura (crayfish, Jasus edwardsii). The major role of both fish and bracken fern in the diet of Tōtaranui Māori as recorded by early European explorers suggest significant exploitation of both marine and terrestrial resources but cultivations do not seem to have played a significant role at the time, as discussed below.

Kūmara cultivation

The current evidence for prehistoric kūmara horticulture in Tōtaranui is mixed, with archaeological evidence for gardening at unknown periods and historical evidence for both the absence and presence of gardening in the sound at different times. A number of sites in the study area with horticultural features have been recorded as part of the New Zealand Archaeological Association (NZAA) Site Recording Scheme (Figure 8). These garden features come in the form of both ‘made soil’ – natural soils with additives of sand or gravel to improve drainage – and stone or earth rows and mounds – the remnants of clearing areas for gardening, demarcating garden plots, and possibly acting as windbreaks, or along which plants were grown (Barber 2004; Furey 2006; Walton 1999, 59–61, 66–67). While the presence of these sites is evidence for horticultural activity at some point in Tōtaranui’s past, it is currently unknown whether the use of these gardens was contemporaneous with pā. As of yet there has been no dating of garden sites in Tōtaranui, nor microbotanical plant studies as conducted elsewhere in New Zealand (e.g. Horrocks 2004; Horrocks and Barber 2005; Horrocks, Campbell, and Gumbley 2007; Horrocks et al. 2004; Horrocks et al. 2008). It is possible that some of these recorded sites are the result of early contact period cultivations; historical records from the first half of the 19th century
record gardens of potatoes, kūmara, taro, and wheat associated with Māori settlement in various places in the sound, including nearby areas of recorded archaeological garden sites and evidence for these is summarised in Appendix A. No evidence of gardening was present in Tōtaranui during the many visits made by James Cook and his crew during the 1770s even though they had seen Māori gardens in other parts of New Zealand (e.g. Beaglehole 1962, 409, 417, 433). It is unlikely that the Europeans simply missed evidence of gardening by being in the wrong parts of Tōtaranui or visiting at the wrong time of year; Cook made forays deep into the sound and into Kura te Au/Tory Channel (Edwards 2003, 395–6) past the location of several recorded archaeological garden sites, and visited the area throughout all seasons, including April 1773 – during the kūmara harvest season – and late October 1774 – around which time planting should have been taking place (Brooks 1999; Davidson et al. 2007, 28–40). Nor is it the case that gardens were present but the explorer’s neglected to mention it, for Banks explicitly stated “Our friends here do not seem to feel the want of such places as we have not yet seen the least appearance of cultivation” (Banks 2006, 210; Beaglehole 1962). Archaeological evidence from other central New Zealand regions including Palliser Bay, Clarence and Tasman Bay suggest a phase of abandonment or restriction of horticultural activity in response to the “Little Ice Age”, a period of climate change which had a glacial maximum in New Zealand in the mid-18th century (Barber 2004; Barber 2010; H. M. Leach and Leach 1979; Palmer and Xiong 2004; Winkler 2000; 2004). Ian Barber (2013) suggests that a late-sequence addition of shell mulch to Triangle Flat garden areas may also have been a localised development in response to changing environmental conditions. By the early 19th century, gardening had undergone a revival in Tōtaranui alongside the introduction of European crops and descriptions of settlements at this time often mention associated cultivations of various crops including potatoes, kūmara, taro, and wheat, which was traded to sailors and local whalers (Dieffenbach 1843, 25, 30, 41, 55, 58, 119–120; Mitchell and Mitchell 2004; 2007). The spatial research carried out in this thesis may help to shed light on the relationship between pā and horticulture in Tōtaranui.
Karaka arboriculture in Tōtaranui

Eighteen extant karaka stands have been recorded within Tōtaranui. The plant is not native to nor highly naturalised in the South Island and it is likely that existing karaka stands are the result of transplantation during prehistory (H. M. Leach and Stowe 2005; Stowe 2003). Unlike kūmara, karaka was one of a number of plant foods observed by the earliest European explorers (Brooks 1999, 24). There is no evidence that karaka held a particular cultural or dietary importance for Tōtaranui Māori, or that arboriculture required more labour than the harvesting of existing stands of transplanted trees; if such activity or importance did exist, the early European explorers took no notice of it.
3.3. Settlement in Tōtaranui

In New Zealand, many recorded sites lack evidence for the domestic structures that might identify a settlement and are classified primarily on the presence of surface or exposed subsurface features. The New Zealand Archaeological Association manages a site recording system in which sites are recorded and classified based on artefacts and features including middens, ovens, terraces, pits, defences, and garden features (Walton 1999). These features make up the archaeological components of settlement systems (Green and Shawcross 1962, 215), and sites can be found with multiple associated features. Because little excavation has been carried out in Tōtaranui (Challis 1991), earlier studies of settlement (Brailsford 1981; Brooks 1999; Trotter 1987) tend to draw heavily on early historical accounts, and this study follows that pattern. Terminology regarding the nature of settlement used in these early European records is often ambiguous; for example, pā are frequently referred to by some variation of ‘Hippah’ but are almost as often simply called ‘towns’ (c.f. Banks 2006, 213, 217–8; Edwards 2003, 104–5) and the distinction made by
archaeologists between defended and undefended settlements was not among the concerns of those writing the accounts.

Pā

Pā are the most visible form of settlement in New Zealand, defensive sites characterised by earthwork defences, palisades, and naturally defensible locations (Walton 2001). Pā construction in New Zealand began ca. 1500 AD and there is no evidence for either a specific region of innovation or the various forms of pā (c.f. Groube 1970; Fox 1976) being part of an evolutionary sequence (Schmidt 1996). Occupation of pā continued into the mid-19th century AD, a time of considerable socio-political upheaval in New Zealand involving the inter-iwi conflict known as the ‘Musket Wars’, and the ‘Land Wars’ or ‘New Zealand Wars’ of the 1840s to 1870s – a series of regional conflicts in which different Māori iwi fought both for and against the British Crown and colonial troops over issues of sovereignty and land ownership (Ballara 2003; Belich 1998; Crosby 1999).

While the defining aspect of pā – the presence of artificial defences – implies a universal concern for defence (Walton 2001), beyond this the role of pā within New Zealand settlement patterns is a complex subject. One of the primary notions that has been borne out by a range of investigations is that the role and function of pā varied both regionally and individually (Davidson 1987, 15–6). Although pā have been argued to have been permanently occupied fortified settlements in other regions (Fox 1983; Kennedy 1969), some have been argued to have been unoccupied defended stores (Law and Green 1972), and pā may have come in a variety of forms ranging from temporary crisis-associated occupation to permanent settlements, and the occupation history of individual pā may have fluctuated over time (Groube 1965). Excavation of particular pā have shown that complicated sequences of occupation, with abandonment, refortification, and recycling of fortified areas may have been a commonplace occurrence in the biographies of pā (Sutton, Furey, and Marshall 2003). In addition, pā have been argued to have been symbolic constructions as well as functional ones, conspicuously advertising community and social ownership of the land (Barber 1996) and have been associated with chiefdom-level organisation (M. W. Allen 1996; 2008).
Twenty-one pā have been recorded in Tōtaranui, primarily located on headlands and small islands (Appendix A). This is a larger number than expected for a South Island region and archaeological investigation of pā in the area has tended to focus on those for which ethnographic or historical data exists (e.g. Brailsford 1981). The explorers of the 1770s were of the opinion that the Māori of Tōtaranui lived dispersed along the shore and only retired to pā en masse in times of stress and conflict (Trotter 1987, 115), suggesting that the pā of the area were temporarily occupied defensive refuges with fluctuating populations. Later observations imply the same use of pā was continued into the 19th century; in 1840, James Crawford noted that the people occupying Tōtaranui at the time were expecting an attack from across Raukawamoana/Cook Strait and had stationed watches on hills overlooking the strait and repaired several pā “on the various island in the sound which might form rallying points for all the different settlements to concentrate their forces [sic]” (Crawford 1880 in Trotter 1987, 123). Despite this conflict occurring at a
time when the application of the musket to Māori warfare had caused considerable changes (c.f. Ballara 2003; Crosby 1999), the use of pā in Tōtaranui as refuges in times of stress is continuous with their use in prehistory as recorded by the early European explorers.

Figure 3-9: A scene from Hippah Island pā (Q26/9), with Motuara Island in the background, a drawing by John Webber, February 1777 (Alexander Turnbull Library, Wellington). Webber took artistic licence with this image, exaggerating the width of the settlement and adding Māori inhabitants to the pā, which was unoccupied at the time (Trotter 1987; Mitchell and Mitchell 2004).

The traditional and historical records also imply temporally fluctuating occupation histories of pā, as several case studies show. The site known today as Hippah Island pā (Q26/9) was first identified as a pā by Cook during his first visit to the sound in the summer of 1770. Māori were observed fleeing to the pā at the arrival of the Europeans, though they soon dispersed. Parkinson noted 32 houses and 200 inhabitants at the site at the time (Trotter 1987, 114), and artificial defences were present in the form of a palisade and fighting stage, though Banks considered the island’s steep sides were sufficient to thwart assaults (Beaglehole 1962, 458). During Cook’s subsequent visits to Tōtaranui in 1773, 1774, and 1777 the pā was unoccupied but had perhaps been occupied at some point in the intervening periods; in 1777 the houses were noted as having been recently rebuilt and were in good condition. The pā was noted as being unoccupied by the crew of the 1820 Russian expedition of the Vostok and Mirnyi, and again in 1839 by the passengers
Dieffenbach and Jerningham of the Tory (Trotter 1987). Karaka Point pā (P27/133) in the western portions of Tōtaranui has a similar biography of occupation, conflict, abandonment and reoccupation. According to oral tradition, the pā – named Te Rae O Karaka after the Ngāti Mamoe chief Te Karaka – was successfully attacked by Ngāi Tahu resulting in the death of Te Karaka and Ngāti Mamoe’s flight to the Wairau. The site was tapu for the Ngāi Tahu victors because the remains of one of their people had been made into fishhooks there and remained unoccupied in the aftermath of the battle (Elvy 1927). In the early 19th century the pā was again occupied as a refuge for Rangitāne and Ngāti Apa, but was overcome by an attacking force of Te Ātiawa (Crosby 1999, 201–4). Overall, the traditional and documentary records suggest that the pā of Tōtaranui were occupied in periods of stress and often abandoned and reoccupied.

Undeﬁended settlements

Undeﬁended settlements were also noted in the early historic records. Richard Pickersgill’s 1770 map of the mouth of Tōtaranui (Figure 3-10) shows signs of housing in a number of coves, in addition to ‘hippah’ on several islands. According to the historic records small clusters of houses were present in many bays surrounding Meretoto/Ship Cove (Trotter 1987) and Tobias Furneaux commented that “there is a number of Huts in every Cove you meet with” [sic] (Beaglehole 1961, 738). The general nature of these settlements appears to have been impermanent (Trotter 1987) and uninhabited structures were frequently seen by the Europeans (Banks 2006, 217; Edwards 2003, 104). These were attributed by the explorers not to depopulation but to the regular movement of people about the sound (Edwards 2003, 275). In general, the undeﬁended settlements in the earliest historical records appear small: the only large undeﬁended settlement noted in the earliest European records is one in Little Waikawa Bay in 1820; the site of two houses in 1770, and uninhabited by 1839 when Cannibal Cove was the local centre of settlement (Trotter 1987).
Figure 3-10: Richard Pickersgill’s Map of Tōtaranui/Queen Charlotte Sound, 1770 (from Brailsford 1981, 21)
The nature of settlement in Tōtaranui

The nature of settlement in Tōtaranui is characterised by transient settlement and highly mobile populations (Brailsford 1981; Brooks 1999; Trotter 1987) but interpretations regarding the cause of this transience have differed. The region has a complicated traditional history characterised by repeated immigration, emigration, and invasion of groups from the North Island and Salmond (1991, 255) considered that the mobile settlement pattern was catalysed by conflict, with movement particularly related to the use of pā as refuges in times of stress. Brooks (1999, 56), on the other hand, identified elements of seasonality within the patterns of movement and considered subsistence practices to be the predominant factor influencing levels of mobility.

The generally transient nature of occupation in Tōtaranui seems to fit models of settlement which emphasise high levels of mobility, seasonality, and fluctuating populations within base settlements (A. Anderson and Smith 1996; Walter, Smith, and Jacomb 2006). The pā of Tōtaranui – with impermanent biographies including abandonment and reoccupation – appear to have acted as refuges in time of stress and seem to have been the largest agglomerations of settlement in the area in late prehistory (Trotter 1987). Whether the assumptions based on historical records match the results of the spatial analyses carried out in this thesis will be considered later.

3.4. The distribution and role of pā in New Zealand settlement patterns

A spatial relationship between pā and food resources has been suggested at national and regional levels, particularly for horticultural resources (M. W. Allen 1996; Cassels 1972; Furey 2006, 119; Groube 1970; Walton 2006) but these relationships have not been universally established by investigation at regional levels. Walter et al. (2006, 285) considered that a settlement pattern with high levels of logistical movement in association with subsistence activity would leave those away from central settlements exposed to attack, and in addition to larger fortifications near residential bases, small ‘satellite’ pā would have been constructed near specialised resources as a defensive mechanism. Small pā argued to have acted as subservient satellites to other pā were observed by Geoff Irwin
(1985) on the Pouto Peninsula in addition to large pā constructed with a concern for greater aggregation of population for regional defence. Irwin believed the spatial distribution of pā to be strongly related to the nature of Māori social organisation, and that the hapū was the primary unit of organisation. Competition and conflict was believed to occur mostly between hapū groups and that the majority of pā were constructed at this level. As a result, pā were deliberately located at a distance from each other, and political territories could be reconstructed based on the distribution of pā. Pā that were of considerable size and located in positions of potential importance for regional defence were thought by Irwin (1985) to be signs of political organisation at the iwi level to defend against external threats. Pā located with a similar purpose of regional defence have been suggested for hilltop pā overlooking entrances to the Waihou River valley system (C. Phillips 2000).

There is precedent in New Zealand for treating pā as political centres in settlement pattern systems (c.f. M. W. Allen 1996; Irwin 1985). Irwin’s (1985) expansive study of the pā of Pouto attempted to recreate political territories centred on pā and determine the relationship between pā and other site types. This study suggested that spatially, pā acted within systems in a manner dissimilar to that of large open settlements, suggesting a role beyond that of a fortified habitation. In a similar treatment, Allen’s (1996) study of the Hawke’s Bay region reconstructed political units based around clusters of pā, and treated pā as the centre of economic catchments associated with horticulture. While the ‘transient village’ model of settlement in New Zealand (A. Anderson and Smith 1996; Walter, Smith, and Jacomb 2006), treats large, permanently occupied but short-lived open settlements as centres of settlement and subsistence-related mobility, it is possible that in some contexts pā filled the role of the ‘transient village’. This concept is similar to that posited by Janet Davidson’s *The prehistory of New Zealand* (1984, 150–71) of a seasonally mobile settlement pattern centred on a base settlement. Political circumstance determined whether this base settlement was a fortified pā or undefended.
3.5. Summarizing the pattern of settlement in Tōtaranui

The early historic records present a consistent pattern of settlement and subsistence in late Tōtaranui. Settlement in the area is considered to be one of high mobility associated with subsistence and seasonality (Brooks 1999) or as a result of conflict and political instability (Salmond 1991). Pā are considered to be centres of settlement in these patterns (Trotter 1987), perhaps filling the role that the ‘transient village’ did elsewhere (Walter, Smith, and Jacomb 2006). Several independent and sometimes conflicting social groups appear to have been resident in the area in late prehistory. In terms of subsistence, the major staples of diet were fish and bracken fern rhizome. Karaka consumption was mentioned offhand, and gardening was not practiced during this late period of occupation (Brooks 1999). These historic observations cannot be assumed to represent the entirety of the prehistoric sequence, and require archaeological investigation. This thesis aims to test the assumptions of the proximity of pā to kūmara horticulture and karaka arboriculture by investigating the spatial relationships that influence the distribution of pā in Tōtaranui at a regional level.
Chapter 4

Methodology

This chapter outlines the methodology used in this thesis to investigate the spatial relationships between Tōtaranui pā and other archaeological sites, determine whether the distribution of marine and introduced terrestrial resources played a significant role in the distribution of pā, and test the observed distribution of archaeological sites in Tōtaranui against the three proposed models of settlement outlined in Chapter 2. The specific research questions being addressed in this thesis are presented again here:

1) What is the relationship between pā and other Māori archaeological sites? Are the pā of Tōtaranui found more commonly within close proximity to archaeological sites than expected by random distribution?

2) What influence does visibility have on the distribution of pā?:
   a. Does the observed location of pā in Tōtaranui allow greater visibility over the surrounding landscape than would be expected by random placement?
   b. Is visibility over areas of either land or sea prioritised in pā distribution?
   c. Are archaeological sites found more commonly within view of pā than would be expected by random distribution?

3) What influences did the distribution of marine and introduced terrestrial resources have on the distribution of pā? Are the areas in which these resources are exploited more commonly within proximity or view of pā?

Two methods were used to test spatial relationships in Tōtaranui: cost distance and visibility. Tōtaranui pā were compared against a dataset of randomly generated points representing an essentially random distribution of pā. Results of cost distance and viewshed analysis were compared between these two datasets, and an influence on the distribution of pā was considered to exist where the results of analysis conducted on pā were found to diverge significantly from the same analysis conducted on random points.
Cost distance is a measure of physical proximity expressed in terms of hours of travel time from one point to another, taking into account the effect of terrain on the energetic cost of movement. It was expected that important resources or components of settlement would be found more commonly within close proximity to pā and the cost distances from pā to these places and sites would be lesser than the same measures from randomly generated points.

Viewshed analysis was also conducted to quantitatively test several expectations related to the role of visibility among pā. Firstly, if pā locations were selected for greater visibility over their surroundings as a form of defensibility, the viewshed area of pā would be larger than those of random points. Secondly, if the pā of Tōtaranui were part of a coordinated regional polity, this would be reflected in high levels of intervisibility among pā, and the frequency of intervisible pā would be higher than the frequency of intervisible random points. Finally, as with cost distances, important resources or settlement components were assumed to be found more significantly within view of pā than of random points.

This chapter will go on to describe the methodology of these investigations. Section 1 describes how Geographic Information Systems were used as the primary analytical tool and outlines the baseline data used in the analysis, including the construction of a Digital Elevation Model of the Tōtaranui landscape. Section 2 relates the methodology used to create cost surfaces and determine cost distances between sites. The viewshed analysis methodology used in this thesis is outlined in Section 3, including the determination of site intervisibility and the construction of viewsheds. The methodology associated with the GIS processes are presented briefly here, and covered in greater detail in Appendix C.
4.1. Baseline spatial data and Geographic Information Systems

Geographical Information Systems (GIS) is a catchall term for a range of computer software (e.g. GRASS, ArcGIS, etc.) that provide essentially the same function: the digital storage, visualisation and manipulation of spatial information. GIS are valuable tools for studies in which spatial information is of specific importance, and have applications ranging from simple visualisation through to complex modelling. Landscape archaeology and settlement pattern approaches often make use of GIS, and studies of this kind have covered scales of analysis ranging from artefact distribution within a single site to colonisation movement on a continental scale (c.f. D. G. Anderson and Gillam 2000; Fanning et al. 2009).

The data involved in this thesis was stored and analysed primarily using ArcGIS 9.3 (ESRI, Redlands, California, USA). The baseline data was selected to facilitate specific forms of analysis (cost surfaces and viewsheds) in relation to particular archaeological site types (pā and sites of horticulture or arboriculture). Environmental data – primarily elevation – was used to construct a Digital Elevation Model (DEM) that would act as the backdrop on which the analysis of the archaeological data would be conducted. Accurate landscape models are necessary for the application of cost surface and viewshed analysis, and the DEM used in this thesis was specifically constructed with these particular forms of analysis in mind.
4.1.1. Digitally modelling the Tōtaranui landscape

Digital Elevation Models are digital representations of terrain based on elevation data. Though two-dimensional in design and functionality, elevation data can be stored as an attribute of point, line or polygon features, and from this data GIS can construct three-dimensional models of landscape for visualisation and analysis. An elevation matrix is a common form of elevation model used in GIS, consisting of a raster of equal-sized cells each carrying an elevation value, and this was the form of DEM selected for this thesis. DEM accuracy is partially a factor of cell resolution and values between known elevations can be constructed through interpolation (Wheatley and Gillings 2002, 113–4). The real value of DEMs for archaeologists is not simply the visual reconstruction of the landscape in digital form, but their use in investigating relationships between the physical and cultural landscape.

The creation of the DEM used in this research had a series of requirements; some general, and some particularly associated with the forms of analysis being carried out. An accurate DEM is essential for the two forms of analyses utilised in this thesis: Cost Surface Analysis and Viewshed Analysis. The study area and its geographic features are relatively small, making a high resolution DEM an accessible goal limited primarily by computer processing capabilities and the base data from which the DEM is constructed. Another goal was to distinguish between areas of land and sea for the purposes of viewshed analysis. One of the goals of the viewshed analysis was to see if pā were deliberately situated to prioritise visibility over areas of either land or sea, so it was important to be able to distinguish between these and measure the visible area of each. Although preliminary analysis involved attempts to model maritime movement within Tōtaranui, little work of this sort has been done specific to Māori watercraft and it was deemed that a precise model of the comparative efficiency of pedestrian and maritime transport could not be achieved based on current evidence. Although movement by waka (the general Māori term for a variety of wooden canoes) was most likely more efficient than pedestrian travel (Best 1976; c.f. Blair 2010; Howey 2007), for the sake of simplicity the cost surface models used in this thesis treated maritime movement as equivalent to pedestrian movement.
4.1.2. DEM Methodology

The Digital Elevation Model constructed for use in this research was an elevation matrix with a cell resolution of 20 m. Cell resolution was determined by computer processing power and the resolution of the available elevation data: a digitised NZMS 260 contour map with contours at 20 masl intervals. Unfortunately the contour data did not distinguish between land close to sea level and the sea itself and preliminary attempts at DEM construction either resulted in DEMs completely absent areas of water, DEMs that ‘washed out’ low-lying land areas making them indistinguishable from areas of sea, or DEMs that interpolated values between opposite shores and created vast canyons in place of the waters of the sound. To solve this problem a coastline feature with elevation values was added to the contour data. This was done by initially converting a polygon shapefile of New Zealand’s coastline into a polyline shapefile and merging the line features. The coastline features in this shapefile were given an extra attribute field with a ‘fake elevation’ value of 10 masl. This value was chosen as a halfway point between sea level and the lowest contour elevation of 20 masl and produced what was deemed to be a reasonably accurate representation of the coastline. Tests of higher or lower values tended to either overemphasise the steepness of hill slopes from the shoreline or wash out low-lying areas. The elevation data from both the regular NZMS contour and the ‘fake elevation’ was converted into a raster DEM through the `topo to raster` tool in arctoolbox (ArcGIS 9.3), with a cell size of 20 m by 20 m. In addition, a polygon shapefile representing the waters of the sound was incorporated into the `topo to raster` process as a ‘lake’ feature. This resulted in the creation of a DEM that incorporated both land and sea area, and was appropriate for the creation of viewsheds.
4.1.3. Baseline archaeological data

The primary source of archaeological information for this thesis came from ArchSite, a constantly updating digital database of archaeological sites maintained by the New Zealand Archaeological Association (NZAA). ArchSite is a digital version of the NZAA’s site recording scheme and the successor to the earlier Central Index of New Zealand Archaeological Sites (CINZAS). Spatial data for the archaeological sites in the Marlborough region was extracted as a shapefile from the ArchSite GIS by ArchSite Staff in 2011 and sent to the author digitally, but the data was recognised to be missing a considerable number of sites due to an unforeseen and unresolved difficulty. Although accessible in the digital version of ArchSite, the sites were missing from the data of the extracted shapefile. To overcome this problem the data was merged in ArcGIS with a static digitised CINZAS dataset dating from March 2008. The combination of these two data sources was deemed to produce a sufficiently accurate database of archaeological sites within the study area.
Archaeological sites in New Zealand are identified and classified according to protocols set by the NZAA. In the past the NZAA site recording scheme used a morphological classification system that included both site descriptors and a two-letter coding system based on the primary archaeological features present (Walton 1999). The two-letter coding system was abandoned with recent updates to the site recording system, and ArchSite is a more descriptive system that outlines the major features present. Regardless of the classification system, the presence of multiple archaeological features within a site often forces recorders to prioritise when categorising sites. For example, a site recorded simply as an ‘occupation’ site may include several features, including ovens, terraces, pits or stone working areas. The presence of modified garden soil in particular are often not related in initial site classification and only mentioned in the broader descriptions of sites. Because of this, an inclusive approach was taken to site classification in this thesis. Sites were initially categorised by the two-letter classification from *Archaeological Site Recording in New Zealand* (Walton 1999) and further sites were added to each class based on analysis of the site records and the descriptions within. Historical European sites were not included within analysis, but those with a combination of Māori and European features were, as for...
the most part the age of the Māori components of these sites is unknown, and it is possible that Māori and European components were not cotemporaneous. In addition, the coordinates of several karaka stands were taken from Chris Stowe’s (2003) Master’s thesis – *The ecology and ethnobotany of karaka (Corynocarpus laevigatus)*, as these sites are not consistently recorded by archaeologists; CINZAS yielded records for 84 karaka stands in New Zealand, and a single record (Q27/264) for Tōtaranui, compared to the 805 karaka stands recorded for New Zealand – 18 of those in Tōtaranui – by Stowe (2003). The spatial coordinates for the 18 karaka stands were imported into ArcGIS as an excel spreadsheet and converted into a point-data shapefile. One karaka stand within the area unfortunately could not be included in analysis, as the coordinates were incorrect. The positions of some sites were relocated within the DEM where they were obviously incorrect due to a Global Positioning System or similar error. Most of these changes were minor, and involved shifting site points from offshore locations to an appropriate onshore position, and the details of these changes can be found within Appendix C. The archaeological site types used in analysis are presented in Table 4-1.

Survey and recording of archaeological sites in Tōtaranui has not been comprehensive, and there are areas where little or no recording has been conducted. Additionally, the area has seen limited archaeological excavation (Challis 1991) and the majority of sites have been identified and classified based on surface features and exposed sub-surface material. As a result, there is often disparity between the features recorded within the site records and those mentioned in early accounts of historically occupied sites, a particular issue for historically occupied pā. Some historically occupied pā, such as Hippah Island Pā (Q26/9), lacks the defensive surface features (ditches, banks, steep scarps) typically used to define a pā and is recorded in ArchSite as a Terrace/Midden site. The site is well documented as a pā in the traditional and historical records – its modern name a transliteration of the Māori ‘he pā’ by early European explorers – and the islands steep sides were surmounted by a palisade and fighting stage in the 1770s (Brailsford 1981, 19–20; Trotter 1987). It is a curiosity of the New Zealand site recording system that some sites for which there is historical or traditional evidence of defences are included in the archaeological category of pā while others like Hippah Island Pā are excluded (see Potts and McCoy 2012). This thesis took an holistic approach regarding the identification of pā and used a combination of archaeological, historical and traditional evidence, including sites like Hippah Island pā which are not recorded as pā but have been treated as pā in past archaeological studies.
Brailsford 1981, 19–20). The 21 sites identified as pā for this thesis are presented in Appendix A, along with the criteria for their inclusion. One site, Moioio Island appeared to have been given two site record numbers (Q27/6 and Q27/233), so only one of these was included within the thesis, under the site record number Q27/6. Although Māori adapted the defensive structures of pā to the musket and cannon warfare of the 19th century (Ballara 2003; Belich 1998), the use of these sites is thought to be consistent with their use in prehistory (Ballara 1979). In any case, no Tōtaranui sites are recorded as ‘musket pā’ or known to have these adaptations, so no distinctions needed to be made in analysis between these pā.

Previous GIS studies have made great use of analysis of areas with the greatest potential for horticultural growth, based on such factors as soil type, rainfall, soil temperature and pH, slope, and aspect (Ladefoged et al. 2009). Unfortunately, high-resolution data of this type was unavailable for the study area, and preliminary analysis failed to find variation in rainfall, soil type and temperature that was considered sufficient for further analysis. Rather than simply reduce suitable garden locations to a function of slope and aspect, and homogenise large areas of the study area, it was decided to focus solely on the direct analysis of known garden sites.
### Table 4-1: Primary site types used in this thesis

<table>
<thead>
<tr>
<th>Site type</th>
<th>No. of sites</th>
<th>Identifying features</th>
<th>CINZAS codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garden sites</td>
<td>25</td>
<td>Made soil, stone or earth rows and mounds</td>
<td>BG, BH, BL, BT, CN</td>
</tr>
<tr>
<td>Karaka stands</td>
<td>18</td>
<td>Presence of karaka trees</td>
<td>BF</td>
</tr>
<tr>
<td>Midden sites</td>
<td>134</td>
<td>Midden</td>
<td>AA, AV, AY, CG, CH, CJ, EJ, EK, GM</td>
</tr>
<tr>
<td>Oven sites</td>
<td>49</td>
<td>Blackened soil, oven stones</td>
<td>AC, AI, AV, AY, CI, CS</td>
</tr>
<tr>
<td>Pā sites</td>
<td>21</td>
<td>Ditches, banks, palisades, defensive scarps</td>
<td>AD, CB, CC, CD, EI</td>
</tr>
<tr>
<td>Pit sites</td>
<td>70</td>
<td>Pits</td>
<td>AM, AO, BI, CF, CG, CH, CO, CP, CS, EJ</td>
</tr>
<tr>
<td>Terrace sites</td>
<td>52</td>
<td>Cultural terraces</td>
<td>AO, AP, AY, BQ, CU, CV, EJ, EK, GO</td>
</tr>
<tr>
<td>All archaeological sites</td>
<td>343</td>
<td>Any prehistoric/Māori</td>
<td>Any prehistoric/Māori</td>
</tr>
</tbody>
</table>
4.1.4. Constructed random datasets

Following previous spatial studies (Fisher et al. 1997; Maschner 1996; C. Smith and Cochrane 2011) a random dataset was constructed to act as a control against which to test the results of analysis. These datasets were designed to represent an effectively random pattern of site distribution, absent environmental and cultural influences. This form of control in research design allows the construction of null hypotheses: if the distribution of pā is effectively random, the results of analysis conducted on pā should not differ significantly from the results of the same analysis conducted on randomly distributed points.

Twenty-one random points were created using the create random points tool in ArcGIS 9.3 – matching the number of pā being investigated – and each point was given a unique numeric identifier. In order to match the most basic distribution of pā in Tōtaranui the random points were constrained to areas within 350 m of the coastline, the approximate
maximum distance observed between any pā and the shore. Because not much was known prior to this thesis about what factors influenced pā placement in Tōtaranui, no further attempt was made to match the placement of pā and the random points.

![Figure 4-4: Distribution of random points (RP) in Tōtaranui (n=21)](image)

4.2. Measuring spatial relationships in Tōtaranui

The first stage of analysis focussed on investigating the spatial relationships between pā and archaeological sites in Tōtaranui. Although a range of archaeological sites were included, a major focus was investigating relationships between pā and both introduced terrestrial and marine resources. Spatial relationships were tested using measures of cost distance – the effort or ‘cost’ involved in travelling from one point to another – and a spatial relationship between sites was considered to exist if cost distances were shorter than would be expected from random distribution. Cost distances from random points were used as the dataset of expected results against which to statistically test those observed.

Measures of proximity, as described above, are often used to investigate how settlement systems are spatially organised. As discussed in Chapter 2, settlement distribution is often
influenced by a desire to locate settlements near important places and this is reflected in the proximity of sites to each other and to such environmental features as major resource zones. The first stage of this analysis was aimed at investigating the spatial relationships between pā and other archaeological sites within Tōtaranui. In particular, one of the major goals of this thesis was investigating the relationship between pā and horticulture in Tōtaranui, and the disparity between the historical and archaeological evidence described in previous chapters. Analysis required available and accurate spatial information, and so some subsistence resources utilised in prehistory by Tōtaranui Māori could not be investigated, or could only be investigated by proxy using recorded archaeological sites.

4.2.1. Cost surface analysis

Measures of spatial proximity are typically based on simple Cartesian distance but these measures do not reflect how geography diverts or restrains movement; a featureless flat plain is more easily travelled than steep mountainous terrain, and a simple line drawn from one point to another on a map rarely offers a direct route in reality. Cost surfaces are landscape models that attempt to take into account the effect of terrain and other restrictive factors on movement and represent landscape not by Cartesian distance but by a measure of the effort required to traverse it (Wheatley and Gillings 2002, 151–9). The most common form of cost surface uses a Digital Elevation Model and calculations of slope to determine the cost involved in movement. In archaeology, cost surfaces are primarily used in two ways:

1) To model ‘least-cost paths’, which reconstruct the fastest route from one point to another in terms of cost. This has often been used for studying movement associated with trade and colonisation, recreating the routes taken by people involved in migration, trade or resource acquisition (D. G. Anderson and Gillam 2000; Howey 2007; McCoy et al. 2011; Scott 2008; Taliaferro, Schriever, and Shackley 2010; Whitley and Hicks 2003); and

2) In the construction of site catchments, the area surrounding a settlement from which its occupants gather subsistence resources, based on the concept of optimal foraging theory (MacArthur and Pianka 1966; Wheatley and Gillings 2002, 160). Site catchments are limited by the cost of gathering resources in relation to their
benefits, and typically represent the distance in all directions from a site that can be covered in a single day with a return trip, and have been used to investigate such subjects as resource production, environmental degradation, and political boundaries (Arroyo 2009; Hare 2004; Morgan 2008; Ullah 2011). Site catchments using cost surfaces are unique for the point of origin based on local terrain, and can change in shape and extent depending on the variable of effort used.

These approaches have the same theoretical basis and utilise the same data, but differ slightly in application. Least-cost paths estimate one- or two-way movement between pre-established points and the creation of linear paths, whereas site catchments model movement in all directions outwards from a single point creating a continuous territory. The forms of movement they model also tend to be dissimilar; least-cost paths are typically used for long-distance movement with set destinations (such as migration or trade journeys), whereas site catchments represent short distance, daily return trips where the point of origin is also the destination. The focus of this thesis is similar to site catchment analysis in its investigation of relationships within a settlement system, but rather than define an arbitrary site catchment for Tōtaranui pā, this study aimed to quantify the nature of spatial relationships between sites. Cost surfaces were used to create measures of cost distance (hours of travel time) between sites, in an attempt to accurately model the role of Tōtaranui’s unique environment on site distribution and patterns of settlement.

Cost surface models are typically created by applying a function that represents pedestrian movement such as the Tobler hiking function (Tobler 1993) to a DEM of the area of interest. Tobler’s function mathematically calculates the effect of slope on movement: movement across a level plane is less difficult than movement up-slope and movement down-slope is less difficult again, to a point where a downwards slope becomes too steep, and difficulty in movement increases again. Cost surface models can be isotropic (treating cost of movement from one cell to another the same regardless of direction) or anisotropic (accounting for the direction of movement in attributing cost) (Wheatley and Gillings 2002, 151–9). The latter form of cost surface models can be considered more accurate, as movement up, across, and down a slope are very different in terms of the effort required. In addition to elevation, other factors limiting movement such as vegetation can be incorporated into cost surfaces, and though more difficult, cultural factors such as sacred spaces, rival territories, and even scenic routes could also be translated into notions of
relative cost. The difficulty in modelling cultural factors lies in establishing what cultural factors would have influenced movement and quantifying them in an appropriate manner. As a result, most cost surface analysis tends to focus on environmental influences on movement, but the application of cultural influences to cost surface models should be a growing direction for these studies.

4.2.2. Cost distance methodology

Cost surfaces were constructed in ArcGIS 9.3 for each pā following a method used by McCoy et al. (McCoy et al. 2011). The path distance tool was used to construct cost surfaces for each pā site. This tool applied the Tobler hiking function (Tobler 1993) in the form of a table (ToblerAway.txt from Mapaspects.org) to the DEM of Tōtaranui. As mentioned earlier, maritime movement was considered equivalent to pedestrian movement for the sake of simplicity and because of the absence of accurate models of maritime movement in New Zealand. Cost surfaces were also constructed for random points using the same process. This process resulted in cost surfaces with raster cell values equivalent to hours of travel time from the point of origin. The raster files were symbolised to emphasise this, using a classification of equal interval breaks (1, 2, 3 etc.).

Cost distances between sites were recorded, using the extract value to points tool on the cost surface of each pā, with point data for each site type (gardens, karaka stands, pits etc.) as the input. This produced point files with a value of cost distance from each pā to each site. These cost distance values, in hours of travel time, were recorded for the closest site in each category, and means calculated. The same process was repeated with the random points replacing pā, and the two sets of results – pā and random points – were tested against each other by means of a two-tailed, homostochastic student t-test. Relationships were judged to be significant when p-values of these tests were equal to or less than 0.05.
4.3. Visibility and pā

In addition to proximity, visibility has been used to infer relationships between archaeological sites, and a second goal of this thesis was investigating the influence of visibility on the distribution of Tōtaranui pā. This involved answering a set of specific questions in a quantifiable manner:

1) What influence does visibility have on the distribution of pā?:
   a. Does the observed location of pā in Tōtaranui allow greater visibility over the surrounding landscape than would be expected by random placement?
   b. Is visibility over areas of either land or sea prioritised in pā distribution?
   c. Are archaeological sites found more commonly within view of pā than would be expected by random distribution?

4.3.1. Visibility in landscape studies

Archaeologists have long considered visibility to be an important factor in how past peoples experienced and constructed their landscapes, and have made efforts to study the nature of visibility in settlement systems. Sight is the dominant means of human sensory experience of the world and visibility studies are considered a means of exploring experiential and cognitive aspects of human culture (Gaffney and van Leusen 1995; Gaffney, Stancic, and Watson 1996). Conspicuous visibility is often a deliberate goal of human construction (Llobera 2007), and monumental architecture is believed to have been intentionally constructed to advertise symbolic, religious or ideological authority. As a result, visibility studies tend to focus less commonly on settlements (c.f. E. E. Jones 2006; 2010), and more commonly on monumental or symbolic constructions, such as cairns (Fisher et al. 1997; Gaffney, Stancic, and Watson 1996; T. Phillips 2004), megaliths (Lake and Woodman 2003), stores of communal wealth (Ogburn 2006), and fortifications (Martindale and Supernant 2009; C. Smith and Cochrane 2011). In addition to acting as intentional advertisement of military power, conspicuous visibility and expansive views is an important aspect of the defensibility of fortifications, allowing forewarning of approaching threats, prioritising view over certain areas for strategic purposes, or to better ensure the protection of nearby resources (E. E. Jones 2006; 2010; Martindale and Supernant 2009). Conversely, fortifications can be located so as to minimise their visibility
from surrounding areas, providing an alternate form of defensibility by hiding them and their occupants from external threats (C. Smith and Cochrane 2011).

The content of fields-of-view, in addition to their size, is also of relevance. Sites can be located to take advantage of views of specific natural or cultural features of the landscape, or to be viewed from them. Examples include Orkney and Northern Scotland, where chambered cairns were sited to be visible from the sea (T. Phillips 2004), the Isle of Mull, where visibility over areas of the sea was an influence on the distribution of Bronze Age cairns (Fisher et al. 1997), and Rapa Nui, where cooking areas were found more commonly within view of ahu (ceremonial stone structures) (Simpson 2009). Intervisibility has been suggested to represent visual communication between sites, connecting them within a mutual settlement system (Gaffney, Stancic, and Watson 1996; E. E. Jon es 2006). A strong and deliberate spatial association can be tested for by comparing the level of observed intervisibility between pā in comparison to that of random points, representing essentially random distribution. This thesis further tested the association of pā and horticultural production by investigating whether pā maintained a greater degree of visibility over areas of production (garden sites) and resource storage (pit sites) than would be expected by random placement. This may be of particular importance with regard to kūmara storage pits, as these structures may have been constructed to advertise the wealth of a community (Law and Green 1972; Law 2000) and international examples exist of similar storage structures placed with a deliberate aim of conspicuous advertisement of community wealth (Ogburn 2006).

4.3.2. Viewshed analysis and GIS

GIS has allowed archaeologists to model and quantify the role of visibility in past settlement systems through the use of viewshed analysis. The term ‘viewshed’ refers to the area visible from a single point in the landscape, as limited by line-of-sight (Gaffney, Stancic, and Watson 1996; Llobera 2007; Wheatley and Gillings 2002, Chapter 10). Through the application of a line-of-sight function, GIS tools can determine the visibility of every cell in a raster DEM within a certain range. If line-of-sight to a cell is not blocked by an intervening cell with a higher elevation it is visible but intervening cells with higher elevations block line-of-sight. Developments in viewshed analysis allow cumulative calculation of which raster cells are intervisible, speeding up data processing and allowing
statistical testing on significance of intervisibility (Lake, Woodman, and Mithen 1998). The simplest viewsheds create a binary visible/not visible division of the landscape but more complex viewsheds can take into account a greater range of factors affecting visibility such as size and contrast of viewed objects, falloff in visibility due to limitations in human sight, and the curvature of the earth (Ogburn 2006; Wheatley and Gillings 2002, 201–216). Visibility studies have origins that predate the use of GIS, and trends in GIS-based studies can be seen to recapitulate developments in visibility studies in general: developing from informal studies to those with a greater concern for statistical rigour, followed by a humanistic development of studies rejecting functionalist approaches and focussing on issues of perception and cognition (Lake and Woodman 2003). While this latter approach mirrors post-processual landscape approaches like phenomenology (Tilley 1994), many visibility studies can be viewed as extensions of cognitive-processual approaches, and retain such features as hypothesis testing and a concern for statistical rigour (Lake and Woodman 2003).

It is important to be mindful of the shortcomings and criticisms of visibility studies. Like many landscape approaches, visibility studies tend to prioritise the spatial and are limited by a lack of temporal data, assuming a level of contemporaneity among sites that may not be realistic (Llobera 2007). Criticisms of a lack of comparative testing in visibility studies have also been expressed; a problem which can and has been partially remedied through the application of statistical analysis and comparison with randomly created datasets (Fisher et al. 1997; Lake and Woodman 2003; Wheatley 1995). There is also the concern that viewshed suffers the general problem of GIS that Lake and Woodman (2003, 690) call ‘methodological determinism’- that the methodological possibilities of GIS, and not archaeological theory, drive its application. Further criticism lies with the prioritisation of the visual sense over others, and the tendency of visibility studies to ignore the other senses through which people interact with the landscape (Dawson et al. 2007). In response, Marcos Llobera (2007) notes that humans primarily understand and alter their surroundings visually, that this is the primary method of providing spatial information, and that these studies focus on a legitimate aspect of human behaviour. Further development in the field of the archaeology of sense and perception has included archaeoacoustic studies and the investigation of past ‘soundscapes’ (e.g. Díaz-Andreu and García Benito 2012; Goldhahn 2002).
Viewshed analysis of the pā of Tōtaranui was designed to test the role of visibility in site distribution. To this end, viewsheds were created in ArcGIS 9.3 for each pā using the *viewshed* tool and the DEM of Tōtaranui as the input raster dataset. This process was repeated for the randomly generated points and all resultant raster viewsheds were converted into polygon shapefiles using the *raster to polygon* tool for more effective manipulation. These polygon files were then edited, merging the polygons representing visible area, and deleting those representing non-visible areas. A cumulative viewshed representing the overlapping visible areas of the pā of Tōtaranui was constructed by merging those polygon files using the *merge* tool. It was not deemed necessary to model deteriorating visibility with distance or to impose limits on viewshed extent (c.f. Ogburn 2006; C. Smith and Cochran 2011) because of the small size of the study area. Likewise no attempt was made to model vegetation and its effect on visibility in Tōtaranui; it is likely that for the most part the area was densely wooded in prehistory (Parkinson 1984, 115) but insufficient data exists at present to model prehistoric variation in vegetation.

In order to compare total visible area between the viewsheds of pā and random points the *area* tool was used on each viewshed polygon shapefile, providing viewshed area in m². If extensive visibility was a significant factor influencing the location of pā sites, it would be expected that the viewshed areas of pā would differ from those of random points. These two datasets were then compared by way of a Student’s T-test. To test the further question of whether a preference for visibility over areas of land or sea was an influencing factor on pā placement, the viewshed polygons were divided into separate viewsheds of land and sea. This was done by using the *clip* tool in conjunction with polygons representing either land or sea, and recording the areas of each. These areas were then compared between the datasets of pā and random points using the same method as was used for the total viewsheds.

Testing the degree of intervisibility of sites was straightforward; sites were considered intervisible if they fell within each other’s viewshed. The number of intervisible pā or random points were tallied and compared via student t-test. It was expected that if the pā of Tōtaranui were part of a coordinated polity there would be a higher frequency of
intervisibility among pā sites than among random points. Similarly, if garden sites, pit sites and karaka stands represented significant resources over which pā stood guard, they would be found more commonly within the viewsheds of pā than those of random points, and would be more likely to be within view than other archaeological sites. To test this assumption, the number of each archaeological site type (e.g. garden sites, pit sites, karaka stands, etc.) within view of each pā or random point was recorded, and the results compared using Student’s T-test. Relationships were judged to be significant when p-values of these tests were equal to or less than 0.05. The same methodology was used for a dataset comprising all archaeological sites in the study area, to compare against the results of analysis on the individual site types.

4.4. Summary

Relationships between pā and other archaeological sites were investigated in ArcGIS 9.3 by way of cost distance and viewshed analysis. The results of these analyses were compared against the same measures from random points by have of Student’s T-test. The results of analysis are presented in the following chapter.
Chapter 5

Results

The results of the analyses establish certain facts regarding the spatial distribution of pā which will be elaborated on in this chapter. Viewshed area did not vary significantly between pā and random points. In general, archaeological sites were found more frequently within the viewsheds of pā than those of random points, and cost distances from pā to archaeological sites were generally lower than cost distances from random points. Some site types (including garden and pit sites) were found more frequently within view and proximity of pā than others.

5.1. Cost distance results

The following section presents the results of the cost distance analysis conducted as part of this research. Cost distances from each Tōtaranui pā to the closest site of each type are presented in Table 5-1, and cost distances from each random point to the closest site of each type are presented in Table 5-2. The results of statistical comparison of these values between the pā and random point datasets by way of Student’s T-tests are presented in Table 5-3.
Table 5-1: Cost distances (hrs.) from pā to nearest recorded site of each type

<table>
<thead>
<tr>
<th></th>
<th>Garden sites</th>
<th>Karaka stands</th>
<th>Midden Sites</th>
<th>Oven sites</th>
<th>Pā sites</th>
<th>Pit sites</th>
<th>Terrace sites</th>
<th>All archaeological sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>P27/132</td>
<td>1.2</td>
<td>1.1</td>
<td>0.19</td>
<td>1.2</td>
<td>1.7</td>
<td>0.79</td>
<td>1.5</td>
<td>0.0066</td>
</tr>
<tr>
<td>P27/133</td>
<td>0.18</td>
<td>0.052</td>
<td>0.18</td>
<td>0.45</td>
<td>0.72</td>
<td>0.23</td>
<td>0.27</td>
<td>0.022</td>
</tr>
<tr>
<td>P27/216</td>
<td>0.54</td>
<td>0.40</td>
<td>0.22</td>
<td>0.48</td>
<td>0.71</td>
<td>0.30</td>
<td>0.30</td>
<td>0.042</td>
</tr>
<tr>
<td>P27/235</td>
<td>0.15</td>
<td>1.1</td>
<td>0.15</td>
<td>0.67</td>
<td>1.5</td>
<td>0.015</td>
<td>0.67</td>
<td>0.0019</td>
</tr>
<tr>
<td>P27/268</td>
<td>0.32</td>
<td>1.5</td>
<td>0.28</td>
<td>0.19</td>
<td>0.81</td>
<td>0.54</td>
<td>0.22</td>
<td>0.0023</td>
</tr>
<tr>
<td>P27/337</td>
<td>0.41</td>
<td>1.4</td>
<td>0.19</td>
<td>0.38</td>
<td>0.80</td>
<td>0.33</td>
<td>0.46</td>
<td>0.0011</td>
</tr>
<tr>
<td>Q26/9</td>
<td>0.23</td>
<td>0.25</td>
<td>0.21</td>
<td>0.83</td>
<td>1.4</td>
<td>0.19</td>
<td>0.19</td>
<td>0.19</td>
</tr>
<tr>
<td>Q27/1</td>
<td>0.22</td>
<td>1.3</td>
<td>0.27</td>
<td>0.27</td>
<td>0.36</td>
<td>0.83</td>
<td>0.52</td>
<td>0.22</td>
</tr>
<tr>
<td>Q27/2</td>
<td>0.33</td>
<td>0.66</td>
<td>0.065</td>
<td>0.47</td>
<td>0.086</td>
<td>0.080</td>
<td>0.080</td>
<td>0.065</td>
</tr>
<tr>
<td>Q27/3</td>
<td>0.94</td>
<td>0.98</td>
<td>0.12</td>
<td>0.12</td>
<td>0.76</td>
<td>0.26</td>
<td>0.85</td>
<td>0.12</td>
</tr>
<tr>
<td>Q27/5</td>
<td>0.85</td>
<td>0.80</td>
<td>0.85</td>
<td>0.88</td>
<td>1.1</td>
<td>1.0</td>
<td>1.1</td>
<td>0.69</td>
</tr>
<tr>
<td>Q27/6</td>
<td>0.33</td>
<td>0.63</td>
<td>0.11</td>
<td>0.46</td>
<td>0.088</td>
<td>0.12</td>
<td>0.12</td>
<td>0.11</td>
</tr>
<tr>
<td>Q27/7</td>
<td>0.81</td>
<td>2.0</td>
<td>0.050</td>
<td>0.050</td>
<td>0.52</td>
<td>0.054</td>
<td>0.81</td>
<td>0.050</td>
</tr>
<tr>
<td>Q27/11</td>
<td>0.12</td>
<td>1.1</td>
<td>0.072</td>
<td>0.34</td>
<td>0.35</td>
<td>0.50</td>
<td>0.42</td>
<td>0.072</td>
</tr>
<tr>
<td>Q27/19</td>
<td>0.82</td>
<td>0.58</td>
<td>0.0018</td>
<td>0.39</td>
<td>0.71</td>
<td>0.42</td>
<td>0.56</td>
<td>0.0018</td>
</tr>
<tr>
<td>Q27/56</td>
<td>0.040</td>
<td>1.4</td>
<td>0.17</td>
<td>0.23</td>
<td>0.20</td>
<td>0.045</td>
<td>0.045</td>
<td>0.024</td>
</tr>
<tr>
<td>Q27/57</td>
<td>0.58</td>
<td>0.43</td>
<td>0.58</td>
<td>0.18</td>
<td>0.59</td>
<td>0.086</td>
<td>0.086</td>
<td>0.086</td>
</tr>
<tr>
<td>Q27/76</td>
<td>0.29</td>
<td>1.4</td>
<td>0.021</td>
<td>0.36</td>
<td>0.61</td>
<td>0.021</td>
<td>0.29</td>
<td>0.021</td>
</tr>
<tr>
<td>Q27/159</td>
<td>1.2</td>
<td>0.28</td>
<td>0.58</td>
<td>0.53</td>
<td>0.58</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Q27/217</td>
<td>0.042</td>
<td>1.5</td>
<td>0.083</td>
<td>0.35</td>
<td>0.18</td>
<td>0.031</td>
<td>0.068</td>
<td>0.027</td>
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<tr>
<td>Mean</td>
<td>0.48</td>
<td>0.97</td>
<td>0.22</td>
<td>0.44</td>
<td>0.67</td>
<td>0.31</td>
<td>0.44</td>
<td>0.11</td>
</tr>
</tbody>
</table>
Table 5-2: Cost distances (hrs.) from random points to nearest recorded site of each type

<table>
<thead>
<tr>
<th>Cost distance from random point to nearest site type (hrs.)</th>
<th>Garden sites</th>
<th>Karaka stands</th>
<th>Midden Sites</th>
<th>Oven sites</th>
<th>Random points</th>
<th>Pit sites</th>
<th>Terrace sites</th>
<th>All archaeological sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>RP_1</td>
<td>1.7</td>
<td>0.12</td>
<td>0.045</td>
<td>0.045</td>
<td>0.10</td>
<td>0.17</td>
<td>1.3</td>
<td>0.045</td>
</tr>
<tr>
<td>RP_2</td>
<td>0.34</td>
<td>0.13</td>
<td>0.13</td>
<td>0.24</td>
<td>1.1</td>
<td>0.61</td>
<td>0.34</td>
<td>0.13</td>
</tr>
<tr>
<td>RP_3</td>
<td>0.70</td>
<td>0.97</td>
<td>0.67</td>
<td>0.75</td>
<td>1.2</td>
<td>0.91</td>
<td>0.91</td>
<td>0.75</td>
</tr>
<tr>
<td>RP_4</td>
<td>0.41</td>
<td>1.0</td>
<td>0.15</td>
<td>0.15</td>
<td>0.72</td>
<td>0.20</td>
<td>0.27</td>
<td>0.20</td>
</tr>
<tr>
<td>RP_5</td>
<td>0.19</td>
<td>1.5</td>
<td>0.15</td>
<td>0.44</td>
<td>0.32</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>RP_6</td>
<td>0.53</td>
<td>1.2</td>
<td>0.35</td>
<td>0.51</td>
<td>0.63</td>
<td>0.35</td>
<td>0.73</td>
<td>0.35</td>
</tr>
<tr>
<td>RP_7</td>
<td>0.66</td>
<td>2.0</td>
<td>0.63</td>
<td>1.3</td>
<td>1.7</td>
<td>0.63</td>
<td>0.66</td>
<td>0.63</td>
</tr>
<tr>
<td>RP_8</td>
<td>0.70</td>
<td>1.0</td>
<td>0.65</td>
<td>0.98</td>
<td>0.83</td>
<td>0.60</td>
<td>0.60</td>
<td>0.098</td>
</tr>
<tr>
<td>RP_9</td>
<td>0.55</td>
<td>1.1</td>
<td>0.20</td>
<td>0.39</td>
<td>0.74</td>
<td>0.40</td>
<td>0.36</td>
<td>0.20</td>
</tr>
<tr>
<td>RP_10</td>
<td>0.12</td>
<td>1.3</td>
<td>0.12</td>
<td>0.71</td>
<td>0.66</td>
<td>0.29</td>
<td>0.71</td>
<td>0.12</td>
</tr>
<tr>
<td>RP_11</td>
<td>0.29</td>
<td>1.4</td>
<td>0.33</td>
<td>0.27</td>
<td>1.1</td>
<td>0.81</td>
<td>0.50</td>
<td>0.078</td>
</tr>
<tr>
<td>RP_12</td>
<td>0.099</td>
<td>1.3</td>
<td>0.21</td>
<td>0.33</td>
<td>0.24</td>
<td>0.067</td>
<td>0.067</td>
<td>0.085</td>
</tr>
<tr>
<td>RP_13</td>
<td>0.072</td>
<td>0.58</td>
<td>0.46</td>
<td>0.29</td>
<td>0.84</td>
<td>0.46</td>
<td>0.46</td>
<td>0.21</td>
</tr>
<tr>
<td>RP_14</td>
<td>2.1</td>
<td>0.76</td>
<td>0.064</td>
<td>0.49</td>
<td>0.75</td>
<td>0.67</td>
<td>0.53</td>
<td>0.49</td>
</tr>
<tr>
<td>RP_15</td>
<td>0.79</td>
<td>1.2</td>
<td>0.31</td>
<td>0.41</td>
<td>0.62</td>
<td>0.48</td>
<td>0.68</td>
<td>0.24</td>
</tr>
<tr>
<td>RP_16</td>
<td>0.12</td>
<td>1.5</td>
<td>0.25</td>
<td>0.12</td>
<td>0.24</td>
<td>0.083</td>
<td>0.083</td>
<td>0.083</td>
</tr>
<tr>
<td>RP_17</td>
<td>0.52</td>
<td>0.66</td>
<td>0.25</td>
<td>0.39</td>
<td>0.65</td>
<td>0.39</td>
<td>0.67</td>
<td>0.17</td>
</tr>
<tr>
<td>RP_18</td>
<td>1.5</td>
<td>0.28</td>
<td>0.13</td>
<td>1.2</td>
<td>1.2</td>
<td>0.24</td>
<td>1.2</td>
<td>0.24</td>
</tr>
<tr>
<td>RP_19</td>
<td>1.6</td>
<td>0.20</td>
<td>0.12</td>
<td>0.11</td>
<td>0.10</td>
<td>0.14</td>
<td>1.3</td>
<td>0.031</td>
</tr>
<tr>
<td>RP_20</td>
<td>0.71</td>
<td>0.37</td>
<td>0.70</td>
<td>0.84</td>
<td>1.2</td>
<td>0.69</td>
<td>0.69</td>
<td>0.69</td>
</tr>
<tr>
<td>RP_21</td>
<td>0.59</td>
<td>1.0</td>
<td>0.068</td>
<td>0.18</td>
<td>0.77</td>
<td>0.54</td>
<td>0.59</td>
<td>0.59</td>
</tr>
<tr>
<td>Mean</td>
<td>0.68</td>
<td>0.93</td>
<td>0.29</td>
<td>0.44</td>
<td>0.75</td>
<td>0.42</td>
<td>0.61</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Table 5-3: P-value results (2 s.f.) of statistical comparison (homoscedastic, 2-tailed Student t-test) between cost distances to closest sites of each type from pā and random points

<table>
<thead>
<tr>
<th>Site type</th>
<th>Garden sites</th>
<th>Karaka stands</th>
<th>Midden Sites</th>
<th>Oven sites</th>
<th>Pā/Random points</th>
<th>Pit sites</th>
<th>Terrace sites</th>
<th>All archaeological sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-value</td>
<td>0.19</td>
<td>0.81</td>
<td>0.36</td>
<td>0.96</td>
<td>0.56</td>
<td>0.17</td>
<td>0.14</td>
<td>0.013</td>
</tr>
</tbody>
</table>
Figure 5-1: Mean cost distance (hrs.) to the closest archaeological site of each type from both pā and random points versus number of sites of each type in Tōtaranui.

Figure 5-2: Box plots of cost distance values (hrs.) from pā and random points to closest archaeological site.

Figure 5-3: Box plots of cost distance values (hrs.) from pā and random points to closest garden site.
Overall, the more ubiquitous the archaeological feature, the higher the probability of a site with this feature being found in close proximity to any pā site - e.g. midden is the site feature found most frequently in Tōtaranui, and is also the site type with the lowest mean cost distance from pā (Figure 5-1). In general, archaeological sites are found in close proximity to pā, and cost distances from pā to the nearest archaeological site are generally
lower than the same measure from random points. However, in few cases is the difference between the pā and random point datasets statistically significant, and results vary by site type. The relationships between pā and certain site types (karaka stands and oven sites) is essentially the same as the relationships between random points and the same site types. Pā are also found in closer proximity to certain site types (garden sites, pit sites, and terrace sites) than random points and though this result tends towards statistical significance, these results are not significant. The only significant difference between the pā and random point datasets was in the case of archaeological sites as a general category. Cost distances from pā to the closest archaeological site of any kind are lower than cost distances from random points to the closest archaeological site. This result is statistically significant, meaning that there is strong spatial relationship between the distribution of pā and the distribution of other archaeological sites in general in Tōtaranui.

5.2. Results of viewshed analysis

There is considerable variation in viewshed areas for the pā in Tōtaranui. Example viewsheds are presented in Figure 5-10. Figure 5-11 and Figure 5-12 present cumulative viewsheds of the pā and random point datasets that show areas of overlapping visibility in these viewsheds.

![Figure 5-10: Example viewsheds of a selection of pā](image-url)
The areas of overlap in viewshed differ substantially between pā and random points. Three general areas of overlap exist in the cumulative viewshed of pā within Tōtaranui: western Tōtaranui in the vicinity of Allports Island, the general area of East Bay and between
Oruawairua/Blumine Island and Long Island, and within Tory Channel/Kura Te Au, roughly centred on Moioio Island. Another area of overlap occurs beyond the mouth of Tōtaranui, where the viewsheds of Q26/9 and Q27/254 overlook Cook Strait.

5.2.1. Visible area in viewsheds

Table 5-4 presents the visible area within the viewshed of each pā, including the area of land or sea within those viewsheds. Table 5-5 presents the same figures for the random points. For most pā viewsheds, visible land area is lower than visible sea area, as expected based on the geography of Tōtaranui.

<table>
<thead>
<tr>
<th></th>
<th>Visible land area (km²)</th>
<th>Visible sea area (km²)</th>
<th>Total visible area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P27/132</td>
<td>20.84</td>
<td>40.04</td>
<td>60.88</td>
</tr>
<tr>
<td>P27/133</td>
<td>21.38</td>
<td>41.09</td>
<td>62.48</td>
</tr>
<tr>
<td>P27/216</td>
<td>17.37</td>
<td>24.94</td>
<td>42.31</td>
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<td>P27/235</td>
<td>8.05</td>
<td>5.91</td>
<td>13.97</td>
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<tr>
<td>P27/268</td>
<td>4.45</td>
<td>4.53</td>
<td>8.98</td>
</tr>
<tr>
<td>P27/337</td>
<td>4.62</td>
<td>2.16</td>
<td>6.77</td>
</tr>
<tr>
<td>Q26/9</td>
<td>22.77</td>
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<tr>
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<td>4.49</td>
<td>6.10</td>
<td>10.59</td>
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<td>9.05</td>
<td>8.86</td>
<td>17.90</td>
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<td>9.56</td>
<td>19.09</td>
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<td>24.98</td>
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<td>26.82</td>
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<td>0.05</td>
<td>1.76</td>
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<td>52.99</td>
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<tr>
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<td>9.35</td>
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<td>86.22</td>
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<td>5.98</td>
<td>7.01</td>
<td>13.00</td>
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<td>Q27/254</td>
<td>24.51</td>
<td>133.01</td>
<td>157.52</td>
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<tr>
<td>Mean</td>
<td>13.02</td>
<td>29.67</td>
<td>42.70</td>
</tr>
</tbody>
</table>
Table 5-5: Viewshed area of random points

<table>
<thead>
<tr>
<th></th>
<th>Visible land area (km²)</th>
<th>Visible sea area (km²)</th>
<th>Total visible area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RP_1</td>
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<td>16.23</td>
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<td>RP_2</td>
<td>7.90</td>
<td>9.68</td>
<td>17.58</td>
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<tr>
<td>RP_3</td>
<td>35.34</td>
<td>58.99</td>
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<td>11.67</td>
<td>29.73</td>
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<td>7.95</td>
<td>77.10</td>
<td>85.05</td>
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<td>10.02</td>
<td>4.24</td>
<td>14.26</td>
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<td>RP_7</td>
<td>0.23</td>
<td>66.60</td>
<td>66.83</td>
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<td>RP_8</td>
<td>14.75</td>
<td>36.06</td>
<td>50.81</td>
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<td>RP_9</td>
<td>9.59</td>
<td>12.17</td>
<td>21.76</td>
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<td>4.87</td>
<td>11.28</td>
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<tr>
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<td>6.20</td>
<td>7.81</td>
<td>14.01</td>
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<td>34.76</td>
<td>37.18</td>
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<td>RP_13</td>
<td>5.87</td>
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<td>9.05</td>
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<td>10.57</td>
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<td>6.86</td>
<td>68.94</td>
<td>75.80</td>
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<td>9.88</td>
<td>10.60</td>
<td>20.48</td>
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<td>RP_18</td>
<td>24.02</td>
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<td>44.67</td>
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<tr>
<td>Mean</td>
<td>10.81</td>
<td>22.97</td>
<td>33.78</td>
</tr>
</tbody>
</table>

Figure 5-13 presents mean viewshed area for both pā sites and random points. Statistical comparison of viewshed area between the pā and random point datasets by way of Student’s t-test is presented in Table 5-6. Overall, pā have more extensive viewsheds than random points and mean visible sea area is higher among pā. However, statistical comparison of the two datasets of visible area shows no significant differences, as shown in Table 5-6.
Table 5-6: p-value results (2 s.f.) of statistical testing of visible area from pā vs. random points

<table>
<thead>
<tr>
<th></th>
<th>Visible Land Area</th>
<th>Visible Sea Area</th>
<th>Total Visible Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>p-value</td>
<td>0.37</td>
<td>0.54</td>
<td>0.46</td>
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</tbody>
</table>

5.2.2. Intervisibility and frequency of archaeological sites within viewsheds

Table 5-7 presents the number of archaeological sites within the viewsheds of individual pā, divided by site type, and Table 5-8 presents the same information for random points. The site of origin for each viewshed is not included within these tallies.
Table 5-7: Number of archaeological sites found within the viewsheds of pā

<table>
<thead>
<tr>
<th></th>
<th>Garden sites</th>
<th>Karaka stands</th>
<th>Midden sites</th>
<th>Oven sites</th>
<th>Pā sites</th>
<th>Pit sites</th>
<th>Terrace sites</th>
<th>All archaeological sites</th>
</tr>
</thead>
<tbody>
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<td>12</td>
</tr>
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<td>P27/133</td>
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<td>3</td>
<td>7</td>
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<td>9</td>
<td>9</td>
<td>24</td>
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<tr>
<td>P27/216</td>
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<td>2</td>
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<td>25</td>
</tr>
<tr>
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</tr>
<tr>
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</tr>
<tr>
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<tr>
<td>Q27/2</td>
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<td>1</td>
<td>0</td>
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<td>4</td>
<td>14</td>
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80
Table 5-8: Number of archaeological sites found within viewsheds of random points (RP)

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<th>Oven sites</th>
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<th>Pit sites</th>
<th>Terrace sites</th>
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</tr>
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<td>3</td>
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<td>0</td>
<td>1</td>
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</tr>
<tr>
<td>RP_20</td>
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<td>1</td>
<td>3</td>
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<td>2</td>
<td>1</td>
<td>6</td>
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<tr>
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<td>2.29</td>
<td>0.86</td>
<td>0.48</td>
<td>1.29</td>
<td>1.33</td>
<td>6.57</td>
</tr>
</tbody>
</table>
In general, more archaeological sites are found within the viewsheds of pā than those of random points. The results of statistical comparison of the number of archaeological sites within these two datasets are presented in Table 5-9.

Table 5-9: p-value results (2 s.f.) of statistical testing on number of sites within the viewsheds of pā vs. random points

<table>
<thead>
<tr>
<th></th>
<th>Garden sites</th>
<th>Karaka stands</th>
<th>Midden sites</th>
<th>Oven sites</th>
<th>Pā/Random Points</th>
<th>Pit sites</th>
<th>Terrace sites</th>
<th>All archaeological sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>p-value</td>
<td>0.071</td>
<td>0.21</td>
<td>0.24</td>
<td>0.065</td>
<td>0.25</td>
<td>0.048</td>
<td>0.14</td>
<td>0.011</td>
</tr>
</tbody>
</table>

Of the archaeological site types investigated in this thesis, those with garden, oven and terrace features trend towards statistical significance in relation to visibility from pā, and those with pit features were found more significantly within view of pā (p-value=0.048). Overall, the total number of archaeological sites found within the viewsheds of pā was significantly higher than the number within the viewsheds of random points (p=0.011).
5.3. Summary of results

Comparing the results of the site catchment and viewshed analyses conducted on pā and random points, a number of results stand out:

1) In general, cost distances between pā and the closest archaeological site are lower than the same measures from random points, but this result is not statistically significant in most cases. Cost distances from pā to the closest archaeological site of any kind are lower than cost distances from random points to the closest archaeological site. This result is statistically significant, meaning that there is strong spatial relationship between the distribution of pā and the distribution of other archaeological sites in general in Tōtaranui.

2) The viewsheds of pā are slightly larger than those of random points, but statistical comparison of the two datasets showed no statistical difference between them.

3) Although the viewsheds of pā show no significant difference to those of random points in area, significant differences exist in their content: archaeological sites are found more commonly within the viewsheds of pā than those of random points, particularly those sites with garden, oven and pit features.

4) Distinct areas of overlapping pā viewsheds are found in three areas in Tōtaranui, in association with intervisibility of pā sites. These areas of overlap are in western Tōtaranui, Tory Channel/Kura Te Au, and around East Bay.
Chapter 6
Discussion

This chapter discusses the implications of the results outlined in the previous chapter in relation to the nature of settlement in Tōtaranui. The questions asked in Chapter 1 regarding the general distribution of Tōtaranui pā will be addressed in relation to the results of analysis. The three models of pā distribution in relation to resources are assessed in detail based on the results of spatial analysis, and all are found to be unsupported by these results. With these models dismissed, the following section will attempt to relate how the results correspond to the traditional and early historical records, and what these sources of information together imply about the nature of settlement and socio-political organisation in relation to pā and their distribution in the study area.

6.1. Addressing questions of settlement in Tōtaranui

Chapter 1 proposed a series of questions related to the spatial distribution of archaeological sites in Tōtaranui, and each will be addressed in turn in relation to the results of the previous chapter.

1) What is the relationship between pā and other Māori archaeological sites? Are the pā of Tōtaranui found more commonly within close proximity to Māori archaeological sites than expected by random distribution?

Pā are found generally found within closer proximity to archaeological sites than would be expected from random distribution, as cost distances from pā to the closest archaeological site of any type are significantly lower than the same cost distances from random points. Archaeological sites as a general category were found significantly more often in proximity to pā than in proximity to random points, but no particular site type (gardens, ovens, pits etc.) showed a significant difference in cost distance to pā or random points. This is interpreted as a general spatial relationship between pā and the other archaeological sites (as a general group) that make up patterns of settlement in Tōtaranui.
2) What influence does visibility have on the distribution of pā?:

a. Does the observed location of pā in Tōtaranui allow greater visibility over the surrounding landscape than would be expected by random placement?

b. Is visibility over areas of either land or sea prioritised in pā distribution?

c. Are archaeological sites found more commonly within view of pā than would be expected by random distribution?

Tōtaranui pā were not found to have a greater degree of visibility over the surrounding area than expected by random distribution, as the viewshed areas of pā were not found to differ significantly from those of random points. Similarly, pā were not found to have significantly greater areas of land or sea within their viewsheds in comparison to random points, showing no prioritisation of visibility over either of these areas. However, pā were found to have greater visibility over archaeological sites than would be expected by random distribution. Archaeological sites as a general category are found significantly more commonly within the viewsheds of pā than the viewsheds of random points, suggesting an intentional visible relationship between pā and their surrounding settlement systems that somewhat mirrors the spatial relationship described above. There is a trend towards certain site types (gardens, ovens, and pits in particular) being found significantly more often within view of pā compared to random points, but of these, only pits were found significantly more often within view of pā.

3) What influences did the distribution of marine and introduced terrestrial resources have on the distribution of pā? Are the areas in which these resources are exploited more commonly within proximity or view of pā?

These questions will be covered in greater detail in the following section, in relation to the proposed models of landscape use presented in Chapter 2.
6.2. Assessing potential models of settlement in relation to terrestrial and maritime aspects of landscape

Three models of pā distribution in relation to resources were proposed at the beginning of this work. These models are briefly presented below:

1) Model A: Pā location in Tōtaranui is influenced by the distribution of introduced terrestrial resources and protecting/signifying occupation of land
2) Model B: Pā location in Tōtaranui is influenced by the distribution of marine resources and protecting/signifying ownerships of areas of sea
3) Model C: Pā location in Tōtaranui reflects the influence of both terrestrial and marine resources, and a concern for both portions of the landscape

These models were assessed based on the results presented in the previous chapter, including the following general observations:

1) Land areas visible from pā are not significantly different from those of random points.
2) Sea areas visible from pā are larger on average than those of random points, but this result is not statistically significant.
3) There are no apparent spatial or visual relationships between the distribution of pā and midden sites. No significant difference exists between cost distances from pā to midden sites and cost distances from random points to midden sites, and neither are midden sites found more or less frequently within the viewsheds of pā compared to random points.
4) There are no apparent spatial or visual relationships between pā and karaka stands. No significant difference exists between cost distances from pā to karaka stands and cost distances from random points to karaka stands, and neither are karaka stands found more or less frequently within the viewsheds of pā compared to random points.
5) Pā sites tend to have lower cost distances to garden sites than random points, and tend to be found more commonly within view of pā than random points. However, this trend was not found to be statistically significant.
Model A

In assessing Model A, the focus was largely on the extent of areas of land within viewsheds, and on the distribution of pā in relation to the distribution of garden sites and karaka stands. These two terrestrial resources have both been associated with pā at either regional or national levels by previous studies (M. W. Allen 1996; Cassels 1972; H. M. Leach and Stowe 2005), and each will be discussed in turn.

There is no apparent spatial relationship between Tōtaranui pā and stands of karaka, and the two were not found to be intentionally intervisible. These results differ from observations made at a national level by Helen Leach and Chris Stowe (2005; Stowe 2003) in which a spatial relationship was found between the distribution of karaka stands and archaeological sites, particularly pā. Stowe and Leach considered a relationship between archaeological sites and stands of karaka to be “cultural” if the distance between them was less than 500 m and found that the association of karaka stands with pā was over-represented in relation to the frequency of pā within the New Zealand archaeological site database. The research presented here did not investigate the relationship between karaka stands and archaeological sites as a general category, but found no apparent spatial relationship between pā and karaka stands in Tōtaranui. It is unlikely that this discrepancy is the result of differing methodologies; mean cost distances from pā to the nearest karaka stand is 0.97 hrs. (approx. 58 mins) and based on Tobler’s (1993) average walking speed of 5.037 km/h, the average distance from pā to the closest karaka stand (approx. 4.9 km) is well beyond Leach and Stowe’s 500 m measure of spatial association. Only one pā site, Karaka Point Pā (P27/133), falls within 500m of a karaka stand, the name of which coincidentally comes from the chief Te Karaka who lived and was killed there (Elvy 1927).

The discrepancy between these results shows that spatial relationships are not necessarily maintained with changes in scale. The cultural and natural processes that influence human behaviour and the nature of the archaeological record unfold at different temporal and spatial scales, and as a result, investigation at different scales are suited for bringing into focus different processes (Bailey 1981; Bailey 1983; Bailey 1987). It may be the case that the national distribution of karaka largely represents the effect of environmental processes that limit the tree’s successful transplantation; the tree is moderately frost tender, making
transplantation in southern regions difficult (Klinac, Benton, and Rentoul 2009). This may explain the similar distribution of karaka to that of kūmara horticulture (H. M. Leach and Stowe 2005, 18–20). The distribution of karaka within Tōtaranui has potential for further investigation, but may be the result of smaller micro-climatic factors – soil temperature and composition, sheltered or north-facing aspects, low susceptibility to frosts, and similar factors – or may also be influenced by significant socio-political factors. It is commonly believed that important resources encourage close proximity of settlement, and greater proximity is related to more intensive use of said resource (G. Jones 2005; Stone 1991; Trigger 1968), but while karaka has been viewed as a staple or prestige food (H. M. Leach and Stowe 2005, 18) it does not appear to have been intensively exploited or required much upkeep beyond initial planting and annual harvest. It is possible that the low maintenance involved in upkeep of karaka stands would not necessarily have encouraged close proximity of settlement, or yield may have been too limited, and other considerations would have taken precedence in the distribution of pā. Alternatively, the lack of association could be explained by the manner in which these resources were socially organised or maintained. Ownership of a good grove of karaka was considered a sign of wealth among some Māori families (Klinac, Benton, and Rentoul 2009, 4), which may suggest that ownership or access to karaka stands may have been organised at the level of whanau/family. If this was the case, and assuming that pā represent more aggregated organisation of population at the hapū or iwi levels, individual or whanau ownership of karaka would be unlikely to significantly influence pā distribution.

There is a greater difference between pā and random points in terms of their relationship to garden sites. Pā and garden sites were often found to be either intervisible or in close proximity but there was no significant difference between pā and random points in this respect. As with karaka stands, spatial associations between the distribution of pā and kūmara horticulture have been observed at a national level – and also at regional levels in northern New Zealand (M. W. Allen 1996; Cassels 1972; K. L. Jones 1986) – and the lack of spatial association between the two in Tōtaranui can be seen as a divergence from this model.

This result questions the importance of kūmara in the southern limits of its distribution, and supports the idea that kūmara was largely a supplemental aspect of a diet heavily reliant on wild food sources (particularly bracken fern rhizome) throughout most of New
Zealand (H. M. Leach 2001; McGlone, Wilmhurst, and Leach 2005; Shawcross 1967; Walter, Smith, and Jacomb 2006, 278). The results must also be considered in relation to the observed absence of gardening in Tōtaranui in the late 18th century and the related climatic variability around this time (Brooks 1999, 20; H. M. Leach and Leach 1979; Palmer and Xiong 2004; Winkler 2000; Winkler 2004). In this context the abandonment of gardening for an unknown, but possibly substantial part of the Tōtaranui sequence of occupation could largely explain the lack of a spatial association between garden sites and pā. This result is a generalisation regarding Tōtaranui pā as a group, and individual sites with close relationships to gardens are outliers to this general pattern. It is currently unknown whether horticultural activity predated pā construction in Tōtaranui – though it is certainly possible, based on early evidence for gardening in nearby regions (c.f. Barber 1994; H. M. Leach 1979) – and was subsequently abandoned due to climatic variability, but there are historical examples of pā occupied in the early 19th century with associated cultivations of traditional and introduced European crops (Dieffenbach 1843, 25, 30, 41, 55, 58, 119–120; Mitchell and Mitchell 2004; 2007), some of which return the lowest cost distances between pā and garden sites (e.g. Q27/56 and Q27/217). The recorded garden sites in Tōtaranui could potentially all be the remains of historical gardens, but further investigation is required to establish the precise chronology of gardening in the area, and the contemporaneity of pā and gardens.

As mentioned in Chapter 2, while this model focuses on two resources – kūmara and karaka – which have apparent spatial relationships with pā at national levels, it was unable to investigate all terrestrial resources, including the major dietary staple of bracken fern. This was due to the constraints of analysis and the lack of accurate spatial information for other resources, but with more detailed information these results could be overturned, and specific terrestrial resources like bracken could be shown to have been a significant influence on pā distribution. On current evidence however, the results show a marked lack of clear spatial relationships between pā and the terrestrial resources investigated in this thesis, as well as an absence of prioritisation of visibility over land areas. As a result, Model A must be dismissed.
Model B

Model B, proposing that maritime resources influenced the distribution of Tōtaranui pā, was assessed based on the relationship of pā with midden sites and whether pā were placed so as to prioritise visibility over areas of sea for the purpose of maintaining visual control over the maritime resources of the inner sound. Although pā tend to have larger sea views than random points this result was not found to be statistically significant, suggesting that the prioritisation of sea views did not substantially influence pā distribution. Midden sites, largely the remains of the exploitation of marine resources, were not found significantly closer to pā than to random points or significantly more frequently within the viewsheds of pā in comparison to random points. Although historical sources relate that fish was a major staple in the study area, they also suggest that Tōtaranui Māori were skilled fishermen able to make good catches without difficulty (Brooks 1999), and marine resources may have been too ubiquitous to influence the distribution of pā.

As above, the analysis of this model was limited by the availability of detailed spatial information. Future analysis could make use of more detailed data regarding the distribution of maritime resources, and could overturn the results of this thesis. However, based on current evidence, and the nature of the results of this thesis, marine resources do not appear to have been a significant influence on the distribution of pā in Tōtaranui, and Model B must also be dismissed.

Model C

Model C proposed that maritime and terrestrial resources both influenced the distribution of pā distribution in Tōtaranui. As stated above, the results of the cost distance and viewshed analysis found no strong spatial relationships between pā and either terrestrial or maritime resources, and as a result Model C can also be dismissed.

None of the three proposed models fit the observed results of analysis. Contrary to expectations, neither maritime nor introduced terrestrial resources appear to have had a significant influence on the distribution of Tōtaranui pā. These models were based on the assumption that the distribution of subsistence resources – in large part determined by environmental factors – was a major influence on the distribution of pā in Tōtaranui, but
there may have been a range of contributing factors. With the three proposed models summarily dismissed, this chapter will go on to describe the nature of the distribution of pā in the study area as revealed by the analyses.

6.3. The distribution of pā within Tōtaranui systems of settlement

Although the testing of the models above failed to identify any influence on pā distribution associated with a desire to be close to maritime or introduced terrestrial resources, it has established that some factors – such as the distribution of garden sites and karaka stands – did not influence this distribution, and has quantitatively established the existence of spatial and visual relationships between pā and the archaeological sites that make up the surrounding patterns of settlement. Furthermore, a brief analysis of extraneous factors associated with analysis – such as the role of visibility and defensibility in pā construction, and the nature of pā as part of systems of settlement – may provide a greater understanding of the nature and distribution of Tōtaranui pā.

Visibility and defensibility

Extensive visibility has been considered a measure of defensibility in fortifications, not only acting as a conspicuous advertisement of military power but also allowing forewarning of approaching threats (E. E. Jones 2006; E. E. Jones 2010; Maschner 1996; Trigger 1990, 121–2). In contrast, small viewsheds have been argued to have been a function of defence among some Fijian fortifications, deliberately hiding them from invaders in areas that are not easily visible (C. Smith and Cochrane 2011). Neither of these scenarios apply to the pā of Tōtaranui, as the results of viewshed analysis did not find pā viewsheds to be significantly larger or smaller than expected by random distribution. These results are somewhat unexpected, as the pā of Tōtaranui are typically located atop projecting headlands, promontories, and islands which intuitively appear to produce impressive views of the surrounding waters and bays. However these locations are not significantly better situated in terms of field of view than randomly distributed points, and it must be considered that the Tōtaranui landscape, composed of open waters with surrounding sloping hillsides, provides ample elevated, coastal positions with equally impressive views. This is not to suggest that Tōtaranui pā sites were not selected with a concern for defensibility – the majority have limited approaches and some degree of
natural defensibility – but does bring into question the value of visibility as a sole measure of defensibility in hilly landscapes like Tōtaranui.

**Settlement patterns and socio-political organisation**

Although the models of pā distribution in relation to resource distribution have been rejected, the results of analysis allow some inferences to be made regarding the distribution of pā in Tōtaranui and the nature of settlement and socio-political organisation in the area.

Although no strong spatial relationships were identified between pā and any particular site type, archaeological sites as a general category were found significantly more commonly in close proximity to pā than to random points. Additionally, greater numbers of archaeological sites were found within the viewsheds of pā in comparison to random points. These trends of intervisibility and proximity show that archaeological sites tend to be clustered around pā, a spatial arrangement found also in the Pouto and Waihou regions of northern New Zealand (Irwin 1985; C. Phillips 2000). The proximity of these sites to pā would have allowed the groups that were affiliated with them to rapidly seek shelter within in times of conflict, and the use of Tōtaranui pā as refuges for dispersed populations is well documented in early historical accounts (Brooks 1999; Groube 1965; Trotter 1987). In addition, these results imply a common theme of spatial and visual centrality for pā in the region. Recent models of settlement organisation in New Zealand relate that settlement was centred on the ‘transient village’ – a large semi-permanent settlement with a fluctuating population located in proximity to large, stable resources. The populations of these settlements were aggregates of smaller groups who spent much of their time dispersed throughout surrounding areas and engaged in logistical subsistence behaviour, periodically returning to the central settlement in association with seasonal changes in resource availability (A. Anderson and Smith 1996; Walter, Smith, and Jacomb 2006). Earlier models of settlement in New Zealand suggested conceptually similar base settlements, which may or may not have been fortified depending on political circumstance (Davidson 1984, 166–70). The nature of socio-political organisation in Tōtaranui – as known from traditional and historical records and supported by the results of this spatial analysis – suggest a fluctuating political climate in which centralised fortifications would have been desirable, if not necessary.
The traditional and historical records of the study area show that Tōtaranui was often home to several independent and competing political groups, that settlement was characterised by successive immigration of groups from the North Island, and that conflict between migrant and extant groups was common (Davidson and Leach 2002; Mitchell and Mitchell 2004; O’Regan 1987). Intervisibility of archaeological sites has been considered an identifier of organisation of settlement (c.f. Gaffney, Stancic, and Watson 1996; Simpson 2009) but intervisibility of Tōtaranui pā is no more common than would be expected from random distribution, reflecting the independent nature of these sites and their occupying groups, and a general absence of overarching political structure. It is impossible to tell based on current evidence if the handful of intervisible pā were occupied contemporaneously, but there are two known historical cases of intervisible pā that were simultaneously occupied. Okukari Bay (Q27/217) and Whekenui Bay (Q27/56) were occupied simultaneously by groups of Te Ātiawa in the early 19th century, and the contemporary Kaihinu Point (Q27/2) and Moioio Island (Q27/6) were home to chief Hurihenua of the Ngāti Rahiri hapū of Te Ātiawa (Mitchell and Mitchell 2007, 28–9, 439–40). In both these cases the intervisible pā were located in very close proximity – in either one or adjoining bays – and were occupied by groups that were either closely related or shared a single group identity. In contrast is the earlier occupation of Kaihinu and Moioio by two different groups: Ngāi Tara and Ngāti Kurī. Traditional records relate that when Ngāti Kurī migrate from the North Island and settled Moioio Island, Ngāi Tara were already occupying the adjacent Kaihinu Point (Elvy 1957, 39–43; Mitchell and Mitchell 2004, 82–3) although alternative accounts related by O’Regan (1987, 148–153) and Anderson (A. Anderson 1998, 30–2) suggest that Ngāti Kurī were the sole occupants of Kaihinu Bay and instead place Ngāi Tara in the western portions of the sound. Regardless of this particular contradiction in the accounts, if Ngāi Tara and Ngāti Kurī were living in such close proximity on Moioio and Kaihinu, this state did not last long and Ngāti Kurī abandoned Moioio and Tōtaranui within a generation. The few areas of Tōtaranui in which pā are intervisible are also associated with areas of overlapping viewshed, particularly in Kura Te Au/Tory Channel, East Bay, and the western portion of the sound centred on Allports Island (Figure 6-1). This pattern is not necessarily an inevitable function of the geography of Tōtaranui, as it is not repeated in the cumulative viewsheds of random points. Although the idea of an organised social system encompassing all of Tōtaranui has been dismissed, assuming the contemporaneity of intervisible pā, these areas of overlap
may represent small autonomous settlement systems, with intervisible archaeological sites associated with dispersed settlement around one or more central pā.

Figure 6-1: Cumulative viewshed of pā in Tōtaranui (a), and areas of overlapping viewshed and intervisible pā (b)

There are a few vague examples of large undefended villages in the early historical records, but occupation appears to have consisted largely of scattered temporary habitations of no more than a few structures occupied by small whanau groups. In times of stress, these dispersed groups would seek refuge within local pā that were likely associated with their aggregate hapū (Brooks 1999; Groube 1965; Trotter 1987). Here, pā seem to
have acted as the centre of settlement, necessarily fortified due to the autonomous and competing nature of the socio-political climate of Tōtaranui.

Interestingly, pits are found significantly more often within the viewsheds of pā than of random points. While this could suggest that pā site locations were specifically located so as to maintain visibility over storage areas, it may instead suggest a high degree of visibility among Tōtaranui pit sites independent of a relationship with pā. Kūmara storage pits and similar storage structures elsewhere have been argued to have been constructed so as be deliberately visible, in order to advertise community wealth (Law 2000; Law and Green 1972; Ogburn 2006). The high degree of visibility between pā and pit sites is as likely to be related to the distribution of pit sites as intentionally conspicuous stores of community wealth as it is related to the distribution of pā, and further study of this sort is necessary to determine the exact nature of this relationship.

6.4. Summary

The results of spatial analysis in Tōtaranui mirror evidence from the traditional and historical records of a region occupied by multiple autonomous groups, as seen in the lack of intervisibility of pā and their general distribution at a distance from each other. Pā appear to have been located so as to remain in close proximity and intervisibility with other archaeological sites, implying a deliberate centrality to these sites. This centrality would have been of value in the use of pā as refuges, allowing dispersed populations to rapidly retreat when threatened. However, while the results of spatial analysis can explain the patterns of pā distribution, the question of why Tōtaranui pā are in their exact locations remain unanswered. Although proximity to resources – particularly kūmara gardens – has been considered a determinant of pā distribution at national and regional levels, no significant spatial relationship was found between the distribution of Tōtaranui pā and the distribution of the terrestrial or maritime resources investigated in this thesis.
Chapter 7

Conclusion

This thesis has quantitatively investigated spatial relationships between archaeological sites in order to gain a better understanding of the factors that influence the distribution of pā in Tōtaranui. Cost surface and viewshed analyses were used to investigate the relationships between pā and other archaeological sites, with a focus on the influence of maritime and introduced terrestrial resources – particularly the cultivation and exploitation of kūmara and karaka. Tōtaranui pā are argued to have been centrally located within dispersed settlement systems based on observed spatial and visual relationships between them and archaeological sites as a general category. Models proposing that the distribution of pā was influenced by a desire to maintain visibility and proximity to either introduced terrestrial resources, maritime resources, or both were not found to be supported by the results of analysis and were dismissed. Although this thesis was not able to establish precisely what factors were involved in determining the distribution of pā in the study area, the analyses were able to show that these particular factors were not a significant influence, which is a result in itself. The distribution of pā in Tōtaranui deviates from models which show spatial relationships between pā and both kūmara horticulture and karaka stands at a national level, and studies from northern regions which suggest a close spatial association between pā and gardening at regional levels (c.f. M. W. Allen 1996; Cassels 1972; K. L. Jones 1986; H. M. Leach and Stowe 2005). This should not be taken to suggest that either result is incorrect, but instead reinforces the importance of multi-scalar approaches, and shows that the many factors that influence human behaviour and site distribution operate at different temporal or spatial scales (Bailey 2007). At national levels, processes like climate that operate at large scales may be a primary influence on the distribution of pā and garden sites, but in small, horticulturally marginal regions like Tōtaranui, these factors are of lesser influence and other (as yet unknown) factors take precedence in determining inter-site relationships. With this in mind, it is clear that the processes that influence the distribution of pā and kūmara horticulture/karaka at national levels in New Zealand and create the apparent spatial relationship between them, are
different from the processes that govern the same distribution at higher resolution spatial scales in smaller areas. The importance of these results is to show that relationships observed at national scales are not necessarily repeated at regional scales, and to re-establish the importance of regional studies, both in New Zealand archaeology – which has a long and significant history of regional studies – and elsewhere. Although they provide important and necessary starting points, models based on observations at national levels or on limited regional observations should ideally be tested quantitatively before being accepted at different scales or in different regions.

7.1. Future research directions

One of the aims of this research was to contribute to the understanding of Tōtaranui and the greater Marlborough Sounds. Archaeological study – especially excavation – has been limited in this area (Challis 1991) and there are many avenues for further research, particularly regarding the chronology of pā occupation and horticultural activity. Due to the lack of temporal control, this study had to assume contemporaneity of the sites being investigated, and greater temporal control could affirm or refute the conclusions made here.

The techniques used in this thesis – cost distance and viewshed analysis – have been shown to produce meaningful results in New Zealand archaeological contexts, and there is considerable room for further studies of this nature. The maritime landscape of Tōtaranui provided a particular problem of how to model the relative cost of maritime transport in relation to pedestrian travel. For the sake of brevity this research was treated maritime travel as equivalent to pedestrian travel, but it is likely that in most cases maritime movement was the more efficient option, particularly in the case of movement of bulk materials (Best, 1976; Blair, 2010; Howey, 2007; Parker, 2001, 27). Cost surface analysis of maritime landscapes in New Zealand could benefit from more detailed reconstructions of the relative cost of maritime movement in relation to pedestrian movement.

There is room for further investigation into the factors that influence pā distribution in Tōtaranui. This thesis was limited to studying spatial relationship between pā and archaeological sites and resources for which detailed spatial information existed, but future study could potentially benefit from greater data resolution, or from accurate spatial data.
detailing the location of other resources like traditional fishing areas or shellfish beds. Perhaps most significantly, this study was unable to incorporate the influence of the dietary staple bracken fern on site distribution, and this remains an avenue for future analysis. These resources were significant contributors to Māori diet, and may have influenced archaeological site distribution, but data of this sort was not available for this study. Although the results of this thesis dismissed the influence of introduced terrestrial and maritime resources on the distribution of pā, further research into the aforementioned (or other) resources could overturn these results.

7.2. Summary

This thesis has established the value of cost surface and viewshed techniques in producing meaningful results regarding the spatial distribution of New Zealand archaeological sites. The results of these spatial analyses have been shown to correspond to a dispersed system of settlement described in both early ethnohistoric accounts and archaeological models of settlement in New Zealand (Groube 1965; Trotter 1987). Tōtaranui pā are argued to have occupied a central place in these settlement systems, and were located so as to be both close and intervisible with the archaeological sites comprising this surrounding system of settlement. The reason for pā acting as these central places as opposed to the semi-permanent open settlements occupying similar positions in southern New Zealand (A. Anderson and Smith 1996) is likely based on the nature of the political systems of the study area: Tōtaranui was typically the home of several related, but autonomous and competing social groups often in conflict with one another (Mitchell and Mitchell 2004; O’Regan 1987), and in this fluctuating political climate pā were an important aspect of settlement. Visual and spatial centrality of pā would have been of value in their role as fortified refuges, allowing dispersed populations to rapidly seek refuge when under threat.

The distribution of pā was not found to be significantly influenced by a desire to place them in areas of proximity to or visibility over either maritime or introduced terrestrial resources, specifically horticultural sites or karaka stands. This can be seen to diverge from national observations, in which spatial associations have been suggested between pā and both kūmara horticulture and karaka stands. Tōtaranui’s divergence from these models show that different processes influenced the distribution of pā at a regional level in this area, and that national models do not necessarily apply at regional levels.
References


### Appendix A: The pā of Tōtaranui*

<table>
<thead>
<tr>
<th>NZAA ID</th>
<th>Site Name</th>
<th>Site Type</th>
<th>Features</th>
<th>ArchSite Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P27/132</td>
<td>Ngakuta Bay Pa</td>
<td>Pa</td>
<td>Unclassified</td>
<td>Pa Site</td>
</tr>
<tr>
<td>P27/133</td>
<td>Karaka Point Pa</td>
<td>Pa</td>
<td>Bank (earth), Ditch, Midden, Pit, Terrace</td>
<td>Pa site, with remaining evidence including pits, defensive ditch, terracing, banks and midden.</td>
</tr>
<tr>
<td>P27/216</td>
<td>Pihaka Point Pa</td>
<td>Pa</td>
<td>Unclassified</td>
<td>Probable pa with pits.</td>
</tr>
<tr>
<td>P27/235</td>
<td>Ratimera Point Pa</td>
<td>Pa</td>
<td>Unclassified</td>
<td>Pa with pits.</td>
</tr>
<tr>
<td>P27/268</td>
<td>Hitaua Bay Pa</td>
<td>Pa</td>
<td>Midden, Terrace</td>
<td>Pa site comprised of several terraces, which cover virtually all parts of the small headland. Three middens seen on the edges of the site comprise i) a few large pipi; ii) some scraps of pipi; iii) some scraps of cockles.</td>
</tr>
<tr>
<td>P27/337</td>
<td>Opua Bay Pa</td>
<td>Pa</td>
<td>Pit</td>
<td>Possible pa with pit.</td>
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<tr>
<td>Q26/9</td>
<td>Hippa Island Pit/Terrace</td>
<td>Unclassified</td>
<td>Terrace/Artefact</td>
<td></td>
</tr>
<tr>
<td>Q27/1</td>
<td>Te Rua Bay Pa</td>
<td>Ditch, Midden, Terrace</td>
<td>Ditch, 3 m wide. Midden, containing cockle, pipi and oyster. Possible lateral terrace recorded during 2006 Upgrade Project visit.</td>
<td></td>
</tr>
<tr>
<td>Q27/2</td>
<td>Kaihinu Point Pa</td>
<td>Midden</td>
<td>Pa site and midden.</td>
<td></td>
</tr>
<tr>
<td>Q27/3</td>
<td>Hippa Rocks Pa</td>
<td>Unclassified</td>
<td>Pa site, originally recorded as having sparse shell midden and burnt stones.</td>
<td></td>
</tr>
<tr>
<td>Site Name</td>
<td>Site Type</td>
<td>Features</td>
<td>ArchSite Description</td>
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</tr>
<tr>
<td>Amerikiwhati Island</td>
<td>Midden/Oven</td>
<td>Midden, Oven</td>
<td>Originally recorded as very sparse burnt stones, possible shell midden and possible surface modifications about the centre.</td>
<td></td>
</tr>
<tr>
<td>Moioio Island</td>
<td>Pa island/swamp</td>
<td>Midden, Pit</td>
<td>Island pa. Originally recorded as having two large fosses (holes) straddling the peninsula. Midden, with water-worn flakes and pieces of worked argillite, fire stones, black earth, shells, bones of seals, birds and fish.</td>
<td></td>
</tr>
<tr>
<td>Ruapara Bay</td>
<td>Pa</td>
<td>Bank (earth), Ditch, Midden, Mound</td>
<td>Pa site, originally recorded as a ditch and bank structure cutting off the small tongue of land, the other sides having steep natural banks. Blackened soil, shell midden and three mounds.</td>
<td></td>
</tr>
<tr>
<td>Motukina Point</td>
<td>Pa</td>
<td>Bank (earth), Depression, Ditch</td>
<td>Pa site with ditch, possible depressions (house sites etc.) and eroded bank. Midden was originally recorded but was not seen during 2006 Upgrade Project visit.</td>
<td></td>
</tr>
<tr>
<td>Wharehunga Bay</td>
<td>Pa</td>
<td>Ditch, Terrace</td>
<td>Pa site, originally recorded as a series of at least 12 terraces on the end of the spur, defended by a ditch and wall structure, with four terraces outside the ditch.</td>
<td></td>
</tr>
<tr>
<td>Whekenui Bay</td>
<td>Midden/Oven</td>
<td>Midden, Pit, Terrace</td>
<td>Pa site. A series of terraces, up to 50 metres long. Pits and midden originally recorded but not found during 2006 Upgrade Project visit.</td>
<td></td>
</tr>
<tr>
<td>Fitzgerald Bay</td>
<td>Pa</td>
<td>Artefact – stone flakes, Ditch, Pit, Terrace</td>
<td>Pa site, recorded as a series of pits and terraces on headland, ditch on inland end and flakes of argillite in rims of central pits.</td>
<td></td>
</tr>
<tr>
<td>Mokoike Bay</td>
<td>Pa</td>
<td>Bank (earth), Ditch, Midden, Pit, Terrace</td>
<td>Pa site, recorded as consisting of a series of ten terrace-pit features and two ditch and bank structures on top of headland. Blackened soil with shell midden on north eastern slope.</td>
<td></td>
</tr>
<tr>
<td>Matapara/Pickersgill Island</td>
<td>Pa</td>
<td>Unclassified</td>
<td>Terraces/?Pa</td>
<td></td>
</tr>
<tr>
<td>Okukari Bay</td>
<td>Pa</td>
<td>Unclassified</td>
<td>Pa site.</td>
<td></td>
</tr>
<tr>
<td>Umukorora Bay</td>
<td>Pa</td>
<td>Ditch – defensive, Terrace</td>
<td>Pa site.</td>
<td></td>
</tr>
</tbody>
</table>

* Information from ArchSite, the New Zealand Archaeological Association’s Site Recording Scheme website (Eagle Technology)
Figure A - 1: Recorded pā sites in western Tōtaranui, with place names mentioned in the text
Site Description: There are two bays named Ngakuta in Tōtaranui: one on the northern shore of East Bay, and one on the southern shore of western Tōtaranui. P27/132 is located in the western Ngakuta Bay, on a narrow ridgeline at the eastern end of the bay. The ridgeline is oriented almost north/south, and is connected to the mainland by a low, narrow spur. The ridgeline rises steeply from this spur, and terraces cover the narrow area at the top. Two defensive features, a ditch and a bank separated by around 40 m distance, run transverse to the ridgeline at the centre of the ridge. Several pit features are located within the site.

![Figure A - 2: Plan of P27/132, Ngakuta Bay, from site records (ArchSite 2012)](image)

Site History: A sketch by surveyor John Wallis Barnicoat dated to 1843 shows a Māori settlement in Ngakuta Bay (Figure A - 3). The point in the background of the sketch on which the pā site is located is covered with vegetation, with no evidence of contemporaneous or relict structures, suggesting that the site had been abandoned for a considerable period of time (Brailsford 1981, 40–41).
Figure A - 3: A sketch by John Wallis Barnicoat, 1843, showing a Māori settlement in Ngakuta Bay (image from Brailsford 1981, 40). The recorded pā (P27/132) is located on the peninsula at the left of the sketch, directly above the large war canoe.

P27/133 – Karaka Point Pā

**Site Description:** The site is located on Karaka Point, a headland between Waikawa and Whatamango Bays. A ditch and bank separates the mainland from further archaeological features on the headland beyond. Faint terraces and several pits are located within the defences. Pit features include both small rimless and large raised rim pits. Eroding midden features are found on the eastern slope of the headland.
Site History: The site of Karaka Point Pā is named for a Ngāti Mamoe chief, Te Karaka. Oral traditions recorded by Elvy (1927) state that the pā was attacked and taken by a Ngāi Tahu force led by the chiefs Tuahuriri and Te Kuri. Te Karaka was slain in the assault, and the Ngāti Mamoe are said to have ultimately fled Tōtaranui as a result. The pā was not reoccupied by either the attackers or defenders following the attack; it had been rendered tapu to Ngāi Tahu, as the remains of one of their people had been made into fishhooks.
there (the same fate as Te Aomariere of Ngāi Tara, see Q27/2), and for Ngāti Mamoe the place had lost its mana (Elvy 1927).

The pā was again occupied and attacked in the summer of 1829/1830, during the invasion of the northern South Island by a coalition of North Island iwi led by Te Rauparaha. The conquest of Tōtaranui was largely undertaken by Te Ātiawa, while other North Island tribes attacked Te Hoiere/Pelorus Sound and the regions to the west. Resident Rangitāne and Ngāti Apa sought refuge in Karaka Point Pā as their people were defeated by Te Ātiawa in eastern portions of Tōtaranui. The accounts of the attack on the pā suggest that the attacking force picked off individual chiefs and warriors among the defenders from surrounding high points, inducing a panic. When the defenders attempted to flee out the gate and up the hill, they were ambushed by hidden Te Ātiawa warriors and slaughtered (Crosby 1999, 201–203; Elvy 1957).

**P27/216 – Pihaka Point**

**Site Description:** Pihaka Point is located north-west of Allports Island and east of Torea Bay. The site records refer to the site as a “probable pa”, with a possible defensive ditch feature, and two small circular pits.

**Site History:** There are no currently known traditional or historical accounts relating to this site.
P27/235 – Ratimera Point

Site Description: Ratimera Point is located at the northern end of Ratimera Bay in western Tōtaranui. The site consists of a number of terrace and pit features, including raised rim pits. Although no ditch and bank features are mentioned in the site record, the record for nearby site P27/236 describes that site as a raised rim pit on the headland 35 m beyond the ditch of “Record 39”, likely referring to P27/235.

Site History: There are no currently known traditional or historical accounts relating to this site.
Figure A - 6: Recorded pā sites in western Kura Te Au/Tory Channel, with place names mentioned in the text
Site Description: The site occupies a headland in Hitaua Bay in Kura Te Au/Tory Channel, south of Otamango Point. The whole of the headland is covered by terracing, and is connected to the mainland by a narrow neck. Eroding midden features are recorded at the edges of the site. Although no distinct artificial defences are present, the headland is naturally defensible, and the recurving terrace features appear to be constructed in such a way as to prevent outflanking by attackers.

Figure A - 7: Plan of P27/268 from site records (ArchSite 2012)
Site History: On November 5th, 1774, Kura Te Au was navigated in a pinnace by James Cook and some of the crew of the Resolution, who noted the presence of Māori settlements:

“we steered into the eastern arm and soon discovered a most spacious bay in it, to the right of which the shores were every where lined with natives [sic]” (Forster 1777c, 471)

Here the Europeans stopped and traded with the chief Te Ringapuhi (“Tringho-Boohee”) and other local Māori, and George Forster recorded the name of the settlement as “Ko-haghee-nooee” (Forster 1777c, 470–5; Mitchell and Mitchell 2004). The second settlement observed by the Europeans was a pā on the northern shore of Kura Te Au, not far from the entrance to Raukawamoana/Cook Strait, but due to time constraints the Europeans did not stop there.

It is likely that there was some confusion related to Forster’s identification of the former settlement as “Ko-haghee-nooee”. Later historians have understandably associated this reference with Whekenui Bay – i.e. “Ko Whekenui” – at the mouth of Kura Te Au (Mitchell and Mitchell 2004, 169; Salmond 1997, 112), but Whekenui Bay more accurately fits Forster’s description of the location of the pā seen later that day, which his journal makes clear is a different site to the settlement he calls Ko-haghee-nooee:

“Having advanced about three leagues from Tringho-Boohee’s settlement, which the natives call Ko-Haghee-nooee, we began to see many shags…On the left, or at the back of Grass Cove, we saw a hippah built on a high rock which stood in a manner insulated, on a fine spot of level land…Having left it at some distance (for it lay in a kind of bay) we saw the outlet into Cook’s Strait” (Forster 1777c, 474).

Anne Salmond identifies Hitaua Bay as the location of the pā seen by Cook in 1774 (Salmond 1997, 113), but both Cook and Forster’s accounts make it clear that this fortification was a short way inside the mouth of Kura Te Au/Tory Channel on the northern shore, and about three leagues (16.7 km) from the settlement on the southern shore within the vicinity of Whekenui and Okukari Bays (Edwards 2003, 395–6; Forster 1777c, 470–5). It is possible that the name relayed by Forster for the settlement on the southern shore was the result of a misunderstanding, and that Forster was asking Māori
who were simply visiting from Whekenui the name of their home, or that although they were currently living in the bay, they were giving the name of the pā that was the local centre of settlement.

Unfortunately, the exact location of the settlement visited by Cook and Forster remains unclear. The vague details from Forster suggest that it was located on the southern shore of Kura Te Au/Tory Channel five to six leagues (27.8-33.3 km) from the ship and three leagues (16.7 km) from the pā seen on the north shore of the channel, placing it somewhere in the vicinity of Hitaua Bay, or the neighbouring Maretai and Onapua Bays. Although recorded pā are found in both Hitaua Bay (P27/268) and Onapua Bay (P27/337), it is not clear if the settlement noted by Cook refers to – or is associated with – either of these sites, as this settlement was not explicitly mentioned as a pā, unlike that mentioned on the northern shore.

**P27/337 – Opua Bay**

**Site Description:** The site is located on the southern shore of Onapua Bay. A steep, 1 m high scarp runs across the headland, interpreted as a defensive feature. The only other identified archaeological feature is a single pit further up the headland.

**Site History:** There are no currently known traditional or historical accounts relating to this site.
Q26/9 – Hippah Island Pā

**Site Description:** Q26/9 is located on a small islet named Hippah Island at the southeast of Motuara Island, separated only from the larger island by a small rocky terminus. The site consists of a series of earthwork features that incorporate the entirety of the summit of the islet. The major features of the pā are terraces, with some artificial scarps that may have served a defensive purpose.

![Figure A - 8: Plan of Q26/9 (image from Brailsford 1981, 20)](image)

**Site History:** The Hippah Island pā site was first documented by Europeans in the summer of 1770 during James Cook’s first visit to Tōtaranui. The pā appears to have been used as a refuge, as Māori were observed fleeing to the pā, though they dispersed in a matter of days.
The defensive nature of the site was obvious to Cook and his crew, and was referred to in the records of the time as the “hippah” – an obvious transliteration of the Māori “he pā” – which gives the islet and site its modern name. During Cook’s first voyage, the islet was surmounted by a palisade, with a fighting stage at one end supplementing the natural defensibility of the island’s steep sides (Banks 2006, 214). Parkinson noted the presence of 32 houses within the pā, and some 200 inhabitants (Trotter 1987, 114).

When Cook returned to Tōtaranui in 1773 and 1774 during his second Pacific voyage, the pā was unoccupied. Anne Salmond believes this may have been due to Cook’s erection of a carved post on Motuara Island when he left the area; the Māori may have interpreted this as a rahui post, representing Cook’s claim to ownership of the area, and rendering the area tapu, placing a restriction on use of the island (Salmond 1991, 250–1; 1997, 68). However it is equally possible that Hippah Island was abandoned due to being rendered tapu by the death of an important figure – a common cause in Māori society for the abandonment of settlements (A. Anderson and Smith 1996, 368; Mitchell and Mitchell 2007), and the reason for the temporary abandonment of at least two Tōtaranui pā: Karaka Point (P27/133) and Moioio Island (Q27/6). During Cook’s first visit to Tōtaranui, they often met with “Topaa”, a chief of Hippah Island and the surrounding area, but in the later visits of 1773, 1774 and 1777, there is no mention of him (Mitchell and Mitchell 2004, 107). It is possible that the aged Topaa passed away between Cook’s voyages, and his death rendered Hippah Island tapu, causing it to be abandoned. There are numerous possible reasons for withdrawal from Hippah Island, including fluctuating political relationships or general mobility of settlement, and we can only speculate at influencing factors. In any case, if the abandonment of Hippah Island was the result of rahui or tapu, the observance of any restrictions did not last long. Te Ratu and his group from Te Rawhiti in the North Island set up temporary camp on Motuara when they came to visit the sound in July 1773 (Edwards 2003, 274–5), and although the pā was unoccupied during Cook’s third voyage in 1777, the houses and palisades had recently been rebuilt and were in good condition, suggesting that it had been occupied at some point in the intervening years (Trotter 1987, 114).
In 1820, Tōtaranui was visited by the crew of the Russian expedition of the *Vostok* and *Mirnyi*, who noted the pā as again being unoccupied, as it was again in 1839 during the passage of Dieffenbach and Jerningham of the *Tory* (Trotter 1987).

**Q27/1 – Te Rua Bay**

**Site Description:** The site is located on a peninsula on the eastern shore of Te Rua Bay. A ditch feature cuts across the peninsula approximately 100 m from the point, with a possible lateral terrace within the defence, and midden material eroding out of the sides of the peninsula.

**Site History:** There are no currently known traditional or historical accounts relating to this site.

**Q27/2 – Kaihinu Peninsula**

**Site Description:** The site occupies the whole of the Kaihinu Point, which separates Erie and Te Weuweu Bays. Two transverse ditches run across the peninsula, with eroding midden on the sides of the peninsula.

**Site History:** Around 200 m separates Kaihinu Point from Moioio Island (Q27/6), and the site records show the close connection between the two. Oral traditions recount that the Kaihinu Point and the surrounding area was occupied by Ngāi Tara when the Ngāti Kuri hapū immigrated to Tōtaranui and occupied Moioio Island. Conflict soon occurred between the two groups, and although recorded traditional accounts differ, they tend to follow a general pattern. The burial of Te Aomarire, a recently deceased Ngāi Tara chief, was disturbed by Ngāti Kuri, who made fishhooks from his bones. Ngāi Tara became aware of this, overhearing Ngāti Kuri joking about ‘how the old man nips’. Ngāi Tara retaliated, first by killing a party of Ngāti Kuri women, and then by ambushing and killing the aged Ngāti Kuri chief Puraho at his latrine on Moioio Island (Mitchell and Mitchell 2004, 82–3). Ultimately, as a result of this conflict with Ngāi Tara, and further fluctuating conflict also involving Rangitāne and Ngāti Mamoe, Ngāti Kuri left Tōtaranui and Te Tau Ihu altogether, with the northern boundary of their settlement set at the Clarence River on the Kaikoura coast (O’Regan 1987).
Earlier combined site records for the pā on Moioio Island (Q27/6) and Kaihinu Point (Q27/2), relate that the Kaihinu pā was the site visited by Cook on November 5th 1774 (see the entry for P27/268; Edwards 2003, 395–6; Forster 1777c, 470–5). However, neither Cook’s nor Forster’s descriptions of the “spacious bay” and associated settlement on the southern shore of Kura Te Au/Tory Channel make mention of an island within the bay, or a headland pā, making this association questionable. Similarly, if the distance given by Forster (1777c, 474) between the settlement on the southern shore of Kura Te Au and Whekenui Bay is correct – three leagues (approx. 16.7 km) – it is less likely to have been in this area.

The area around Kaihinu Point was occupied by the Ngāti Rahiri hapū of Te Ātiawa in the early 19th century. Pā were once again occupied on Moioio Island and Kaihinu Point in the 1830s (Mitchell and Mitchell 2007, 28). The area was under the leadership of the chief Huriwhenua, and when he died in 1843 his village – considered by John and Hilary Mitchell (2007, 439–40) to be the same site of the Ngāi Tara settlement 250 years earlier – was rendered tapu and the site abandoned.

Figure A - 9: Kaihinu Point and Moioio Island, Kura Te Au/Tory Channel
Figure A - 10: Recorded pā sites in northern Tōtaranui, with place names mentioned in the text
Q27/3 – Hippa Rocks Pā

**Site Description:** Q27/3 is located in Anatohia Bay in East Bay, on the largest of the rocky islets there. Remnants of terracing occupy the majority of the flat land at the summit of the islet. The islet’s steep slopes have exposed midden in places. The islet is also known locally as Cemetery Island, due to the presence of more recent burials.

![Plan of Q27/3](image from Brailsford 1981, 25)

**Site History:** Hippa Rocks Pā was one of the occupied pā seen and visited by James Cook and crew in the 1770s. The Europeans compared it to the pā on Hippah Island, noting the natural defensibility of its steep sides. At the time, the pā was surmounted by a palisade and a fighting stage, supplementing the natural defensibility of the island (Banks 2006, 213). Banks’ account records 80 to 100 houses within the pā, but Brailsford (1981, 25–7) considers this an overestimation based on the size of the islet.
Q27/5 – Amerikiwahati Island

Site Description: Amerikiwahati Island is a small island south of Blumine Island and north of Ahitarakihi Bay. The site of Q27/5 was investigated by Barry Brailsford (1981, 34–6) in his study of South Island pā, who recorded a series of terrace features encompassing the entire summit of the island, and the presence of both rectangular and circular pit features. The site is recorded in ArchSite as a Midden/Oven site, and is not officially recorded as a pā – likely due to the lack of distinct ditch and bank features – Brailsford considers it a pā and records three steep transverse scarps as defensive features. In addition to the features, Brailsford made several surface finds of artefacts, including an iron adze. While the adze suggests activity on the island during the historic period, without secure archaeological context, it is insufficient evidence to suggest historical occupation of this site.

Figure A - 12: Plan of Q27/5 (image from Brailsford 1981, 35)
Site History: Barry Brailsford (1981, 34–6) and Anne Salmond (1991, 247–8) associate Amerikiwhati Island with an account of a deserted “town” noted by John Magra, one of the *Endeavour’s* crewmembers in 1770. Magra relates that “on a small island, lying S. E. from the place where we anchored, was one of these deserted towns, most agreeably situated, and consisting of about eighteen houses, placed in a circular form; it was surrounded and defended by a wall curiously constructed” (Magra 1771, 97-8). A second fortification abandoned on a high hill is mentioned in the same account, “a short distance” from the aforementioned island, with another abandoned settlement below it.

While Brailsford and Salmond equate the Amerikiwhati pā with that seen by Magra, the account is vague, and there are inconsistencies between Magra’s description and the location of Amerikiwhati. For instance, Magra’s account has the small island south-east of Cook’s anchorage in Meretoto/Ship Cove, but Amerikiwhati lies distinctly to the south, and though Magra mentions a second fortification on a hill nearby, there are no recorded pā in the vicinity of Amerikiwhati. These inconsistencies could be due to Magra incorrectly estimating the direction of the pā from Meretoto, and there may be evidence for a pā nearby on Arapaoa that has not yet been identified and recorded. The pā on Matapara/Pickersgill Island (Q27/159) is an alternative location for that seen by Magra; the island lies south-southeast of Meretoto, although this island is considerably larger than Amerikiwhati, and may or may not match John Magra’s subjective, vague scale of “a small island”. Ultimately, the exact locations of the pā seen by Magra are unknown, but Amerikiwhati Island may be the small island pā he saw abandoned in 1770.
Q27/6 – Moioio Island Pā

Site Description: Moioio Island is located in Kura Te Au/Tory Channel, at the entrance to Erie Bay and a short distance west of Kaihinu Point. Due to confusion in recording this site and the associated Kaihinu Point pā (Q27/2), there are currently two ArchSite records for the Moioio Island pā site: Q27/6, and Q27/233. The site covers the entirety of Moioio Island, consisting of many terraces, with the summit of the island potentially artificially flattened. There are many pit features of various size, as well as scattered midden features.

Site History: The history of Moioio Island Pā is closely connected to that of Kaihinu Pā (Q27/2). The earliest mentions of Moioio Island in the traditional record refer to it as the home of Ngāti Kuri, with genealogically derived dates suggesting this occurred around the 17th century (Elvy 1957, 39–41; O’Regan 1987). Some accounts relate that the Ngāti Kuri hapū of Ngāi Tahu also inhabited the Kaihinu Point Pā and the surrounding bay (O’Regan 1987), while others relate that Kaihinu was occupied by a mixed community of Ngāi Tara and Ngāti Mamoe (Elvy 1957, 39–41; Mitchell and Mitchell 2004, 82–3). Ngāti Kuri abandoned Moioio Island following the death of the chief Puraho (see the entry for Q27/2), which had likely rendered the island tapu.

No explicit mention is made of Moioio Island in the voyages of James Cook and his crew; although they visited Tory Channel in the summer of 1774, and record the presence of a pā near the mouth of the channel, and a settlement in a spacious bay on the southern shore (Edwards 2003, 135–6; Forster 1777c, 471–5), there is no distinct mention of the island pā, suggesting it was unoccupied at the time. Following the invasion of Te Tau Ihu by North Island iwi during the ‘Musket Wars’ of the early 19th century, Moioio Island and Kaihinu were occupied by the Ngāti Rahiri hapū of Te Ātiawa, and the chief Huriwhenua (Dieffenbach 1843, 35; Mitchell and Mitchell 2007, 28).
Q27/7 – Ruapara Bay

**Site Description:** The site is located at the eastern end of Ruapara Bay, on the northern bank of a stream. A ditch and bank feature cuts off the pā, with the other two sides consisting of naturally steep banks. Additional features include blackened soil and midden exposed in the banks of the site. The site records mention the presence of three mound features and pit features outside the defences.

![Plan of Q27/7 from site records (ArchSite 2012)](image)

**Site History:** The early site records refer to a 1841 visit of German naturalist Ernst Dieffenbach to an East Bay village “on a spacious beach, surrounded by hills” called “Mokupeka” (Dieffenbach 1843, 120–1). However, it is more likely that this refers to Mokopeke Bay to the south (see the entry for Q27/76), and the confusion arises from Dieffenbach’s description of “Mokupeka” at the head of East Bay – it is possible that Dieffenbach was unaware of the northern arm of East Bay in which Ruapara Bay is found.
Figure A - 14: Recorded pā sites in eastern Kura Te Au/Tory Channel, with place names mentioned in the text
Q27/11 – Motukina Point

**Site Description:** Motukina Point is a westwards projecting point in Tory Channel, forming the north-eastern entrance of Oyster Bay. A ditch and bank feature cuts off the point from the mainland, with another possible ditch and midden features. Depressions observed within the defences may be the remnants of terrace or pit features.

![Figure A - 15: Plan of Q27/11 from site records (ArchSite 2012)](image)

**Site History:** There are no currently known traditional or historical accounts relating to this site.
Q27/19 – Wharehunga Bay Pā

**Site Description:** The site is located on a spur in Wharehunga Bay. A transverse ditch and bank feature cuts off the spur, with terraces both inside the defences and outside them, further up the spur. Site record forms mention a second, lateral ditch “at a higher level up the spur”. Brailsford (1981, 37–9) records the presence of pit features at the site, and exposed midden material.

![Plan of Q27/19](image)

*Figure A - 16: Plan of Q27/19 (Brailsford 1981, 38)*
Site History: Wharehunga Bay was called Grass Cove by the earliest European explorers, and in 1773 was the site of the deaths of ten crewmembers of the *Adventure*. The fight between local Māori and the Europeans was the result of a disagreement over trade, which was swiftly escalated when John Rowe fired on the Māori (Barber 1999). When James Burney went looking for the absent crewmen the next day, he discovered some of their possessions, along with dismembered body parts and cooked flesh on a beach adjoining Wharehunga Bay. Following the sign of a fire, Burney and his men took their launch into Wharehunga Bay, where they fired on “a great many people” who had gathered on “a small hill within a Ships length of the water side [sic]”, who retreated immediately (Burney 1975, 95–99). No explicit mention is made by Burney of any structures in the bay or immediate surroundings, and it is possible that Q27/19 is the remnants of a pā that was either not yet constructed or a site had been long abandoned and overgrown.

Q27/56 – Whekenui Bay Pā

Site Description: Q27/56 is located in Whekenui Bay, west of Okukari Bay in Kura Te Au. The site consists of a series of terraces on rising ground on the south side of the bay, in addition to pit and midden features. There are no recorded earthwork defences, and the site is likely recorded as a pā due to historical sources.

Site History: Whekenui Bay is named for a legendary giant octopus killed by Kupe in the area (Elvy 1957, 13). The earliest European reference to Whekenui comes from Cook’s second voyage, during which Cook charted Tory Channel. Along with a settlement on the southern shore of Tory Channel, where they were received by the chief Te Ringapuhi (“Tringho-Boohee”) (see the earlier description of Moioio Island), the Europeans noted the presence of a pā “built on a high rock which stood in a manner insulated on a fine spot of level land” (Forster 1777c, 474), but did not visit it. It is likely that this pā is one of the recorded sites in either Whekenui Bay (Q27/56) or Okukari Bay (Q27/217). Curiously Forster (1777c, 470–5) relates the name of the settlement on the southern shore of Tory Channel, at least 3 leagues (16.7 km) from the pā as “Ko-Haghee-nooe”, a very likely transliteration of Whekenui, and likely the result of a misunderstanding between Forster and Māori regarding local place names (see the entry for P27/268).
In the 19th century, Whakenui Bay was the site of a settlement called a pā by Edward Jerningham Wakefield (Wakefield 1845, 50–1), the inhabitants of which crewed a pair of whaleboats and sold on harpooned whales to the whalers of Te Awaiti.

**Q27/57 – Fitzgerald Bay**

**Site Description:** The site is located on the headland immediately east of Fitzgerald Bay, and east of the south-eastern point of Matapara/Pickersgill Island. The site covers almost the whole area of the headland, consisting of a series of pit and terrace features. A transverse ditch separates the site from the mainland.

![Figure A - 17: Plan of Q27/57 from site records (ArchSite 2012)](image)

**Site History:** There are no currently known traditional or historical accounts relating to this site.
Q27/76 – Mokopeke Bay

Site Description: Q27/76 is located on a headland on the western side of Mokopeke Bay. The pā runs parallel to the coastline, its western edge bounded by a cliff to the sea. Features include two transverse ditch and bank defences, and exposed midden. Pit-terrace features are found both inside and outside the defences.

Site History: As mentioned in the entry for Q27/7, a village called “Mokupeka” is mentioned in the travel journal of Ernst Dieffenbach (1843, 120–1) “at the head of East Bay”. Dieffenbach describes “a spacious beach, surrounded by hills” sheltered from the east and south winds, with nearby plantations of taro, potatoes, and wheat. The vague description does not make clear whether the recorded pā site in Mokopeke Bay – or other nearby recorded archaeological sites – is the same site as the village seen by Dieffenbach.
Q27/159 – Matapara/Pickersgill Island

**Site Description:** Q27/159 occupies the north-western point of Matapara/Pickersgill Island, a steeply scarped ridgeline with a few terraces. There is also a cut 150 m from the point of the ridge, which may be a natural feature that was used, and possibly modified for defensive purposes.

*Figure A - 19: Plan of Q27/159 from site records (ArchSite 2012)*

**Site History:** In 1770, John Magra (1771, 97–8) noted the presence of an abandoned “town” on a small island south-east of Meretoto/Ship Cove. The site was defended by a wall, with the remains of another fortification nearby “on a high hill, near a pleasant bay”.
A further abandoned settlement, not mentioned as being fortified, was located at the foot of this hill. The identification of these sites is speculative (see the entry for Amerikiwhati Island, Q27/5), with Matapara being one possible location for the first, lying roughly south-east of Meretoto.

If Matapara was the location of this first pā noted by Magra, a second fortification could be located nearby, either on the larger Arapaoa Island, or also on Matapara itself. Although a second recorded pā is located a short distance away on the headland east of Fitzgerald Bay (Q27/57), this small headland pā does not appear to match Magra’s description of the second pā, which was located on a high hill, and was seemingly large enough to contain two or three hundred houses, though it is not clear if Magra visited either site, or merely observed them from a distance.

**Q27/217 – Okukari Bay**

**Site Description:** This site is located in Okukari Bay, on the eastern side of the bay, on the south bank of a stream. There is a ditch feature on the uphill side of the site, and some associated pits.

**Site History:** Okukari Bay adjoins Whekenui Bay, and has a shared history (see the entry for Q27/56). When Cook navigated Tory Channel on November the 5th 1774, he noted the presence of a pā in the vicinity of Whekenui and Okukari Bays, on the northern shore just within the entrance of Tory Channel (Edwards 2003, 395–6). Descriptions of the pā record “a large Hippa or strong hold built on a rising ground” (Edwards 2003, 395), or “a hippah, built on a high rock, which stood in a manner insulated, on a fine spot of level land” (Forster 1777c, 474). It is not entirely clear whether this description refers to either of the archaeologically recorded pā sites in the area.

Traditional sources relate during the 1829/1830 invasion of Te Tau Ihu by the coalition of North Island iwi under Te Rauparaha, a considerable pā was located in Okukari Bay, with another pā on the southern side of the channel that was later used as a lookout by whalers. Several hundred local Māori took refuge at the pā on the south shore, and retreated to the headland at the mouth of the channel, but were overcome by the invaders (Elvy 1957, 60).
The area at the mouth of Tory Channel was subsequently occupied by members of Te Ātiawa, and was an important centre of settlement through the early 19th century. Settlements were present in both Whekenui and Okukari Bays, with the Okukari Bay pā described by Dieffenbach as mentions a “large native settlement” on “a fine flat of fertile earth about one square mile in extent” (Dieffenbach 1843, 56). These settlements had cultivations that supplied the nearby whaling station in Te Awaiti, and in addition to Māori serving as crew members on whaling boats, the European whalers often married prominent Māori women (Mitchell and Mitchell 2004, 238; Mitchell and Mitchell 2007). By the 1840s, Okukari was also an important centre of Christian mission activity (Mitchell and Mitchell 2007, 115).

Q27/254 – Umukorora Bay

**Site Description:** The site is located on a knoll overlooking the southern end of Umukorora Bay. Features at the site include two transverse ditches, with terraces and possible pits to the east of the site.

**Site History:** There are no currently known traditional or historical accounts relating to this site.
## Appendix B: Horticultural sites of Tōtaranui*

<table>
<thead>
<tr>
<th>NZAA ID</th>
<th>Site Name/ Location</th>
<th>Site Type</th>
<th>Features</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P27/156</td>
<td>Te Iro Bay</td>
<td>Maori horticulture</td>
<td>Soil - made</td>
<td>Modified soil. A deep friable brown loam, with good crumb structure and occasional examples of fine rolled gravel.</td>
</tr>
<tr>
<td>P27/158</td>
<td>Waikawa Bay</td>
<td>Maori horticulture</td>
<td>Stone mound heap/mound</td>
<td>Stone Mounds</td>
</tr>
<tr>
<td>P27/218</td>
<td>Kaipakirikiri Bay</td>
<td>Midden/Oven</td>
<td>Unclassified</td>
<td>Middens, terraces, made soil, flakes and oven remains.</td>
</tr>
<tr>
<td>P27/237</td>
<td>Ruakaka Bay</td>
<td>Midden/Oven</td>
<td>Unclassified</td>
<td>Midden and modified soil.</td>
</tr>
<tr>
<td>P27/246</td>
<td>Ruakaka Bay</td>
<td>Midden/Oven</td>
<td>Unclassified</td>
<td>Midden and modified soil.</td>
</tr>
<tr>
<td>P27/250</td>
<td>Bay of Many Coves</td>
<td>Midden/Oven</td>
<td>Unclassified</td>
<td>Worked stone, midden and modified soil.</td>
</tr>
<tr>
<td>P27/307</td>
<td>Summer Bay</td>
<td>Midden/Oven</td>
<td>Unclassified</td>
<td>Midden, flakes and modified soil.</td>
</tr>
<tr>
<td>P27/315</td>
<td>Titoki Bay</td>
<td>Midden/Oven</td>
<td>Unclassified</td>
<td>Midden and modified soil. Findspot for artefacts.</td>
</tr>
<tr>
<td>NZAA ID</td>
<td>Site Name/Location</td>
<td>Site Type</td>
<td>Features</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------</td>
<td>---------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Q26/11</td>
<td>Oamaru Bay</td>
<td>Pit/Terrace</td>
<td>Stone row, Terrace – stone faced</td>
<td>Site of a 19th century Maori/missionary settlement. Three dry-stoned faced terraces. One stone row of the Maori gardening type, 60 m long, 4 m wide and 0.7 m high.</td>
</tr>
<tr>
<td>Q26/18</td>
<td>Motuara Island</td>
<td>Pit/Terrace</td>
<td>Artefact - stone flakes, Pit - rectangular, Stone row and mound; pit and terrace features; also stone working.</td>
<td></td>
</tr>
<tr>
<td>Q26/21</td>
<td>Motuara Island</td>
<td>Maori horticulture</td>
<td>Stone heap/mound</td>
<td>Stone mound.</td>
</tr>
<tr>
<td>Q27/59</td>
<td>Otanerau Bay</td>
<td>Pit/Terrace</td>
<td>Artefact - stone flakes, Midden, Mound, Terrace</td>
<td>Recorded in 1978 as a series of broad terraces, low earthen walls, mounds and at least one midden. Argillite flakes noted along beach front in 2011.</td>
</tr>
<tr>
<td>Q27/150</td>
<td>Opua Bay</td>
<td>Midden/Oven</td>
<td>Artefact, Artefact - chert, Artefact - stone flakes,</td>
<td>Three midden areas, mostly cockle, with some pipi and small catseyes. Modified soil with a hammerstone, a splinter of dark caramel-coloured chert, flakes and a lump of argillite.</td>
</tr>
<tr>
<td>Q27/166</td>
<td>Erie Bay</td>
<td>Maori horticulture</td>
<td>Artefact - adze, Soil – made</td>
<td>Soil exposed as layer up to 150mm thick over distance c.30 m. Soil identifiable from abundant fine rolled beach gravel visible in section. Findspot for adze.</td>
</tr>
<tr>
<td>Q27/179</td>
<td>Ongonga Bay</td>
<td>Pit/Terrace</td>
<td>Unclassified</td>
<td>Pit/midden/soil.</td>
</tr>
<tr>
<td>Q27/188</td>
<td>Tory Channel/East of Te Iro Bay</td>
<td>Maori horticulture</td>
<td>Unclassified</td>
<td>Modified soil.</td>
</tr>
<tr>
<td>Q27/190</td>
<td>Ngaruru Bay</td>
<td>Midden/Oven</td>
<td>Unclassified</td>
<td>Midden and modified soil.</td>
</tr>
<tr>
<td>NZAA ID</td>
<td>Site Name/Location</td>
<td>Site Type</td>
<td>Features</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
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<td>-----------------</td>
<td>------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Q27/195</td>
<td>Ngaruru Bay</td>
<td>Artefact find</td>
<td>Unclassified</td>
<td>Modified soil. Findspot for artefacts.</td>
</tr>
<tr>
<td>Q27/204</td>
<td>Te Awaiti Bay</td>
<td>Working area</td>
<td>Unclassified</td>
<td>Modified soil and stone working area</td>
</tr>
<tr>
<td>Q27/208</td>
<td>Fisherman's Bay</td>
<td>Pit/Terrace</td>
<td>Unclassified</td>
<td>Terraces and modified soil.</td>
</tr>
<tr>
<td>Q27/210</td>
<td>Fisherman's Bay</td>
<td>Midden/Oven</td>
<td>Unclassified</td>
<td>Modified soil and oven.</td>
</tr>
<tr>
<td>Q27/214</td>
<td>Okukari Bay</td>
<td>Maori horticulture</td>
<td>Unclassified</td>
<td>Modified soil.</td>
</tr>
<tr>
<td>Q27/228</td>
<td>East of Motukina Point</td>
<td>Maori horticulture</td>
<td>Unclassified</td>
<td>Modified soil.</td>
</tr>
<tr>
<td>Q27/238</td>
<td>Erie Bay</td>
<td>Midden/Oven</td>
<td>Unclassified</td>
<td>Midden and modified soil. Stone working.</td>
</tr>
</tbody>
</table>

*Information from ArchSite, the New Zealand Archaeological Association’s Site Recording Scheme website (Eagle Technology)
B-1: Tōtaranui settlement and cultivation in the early historical period

The early 19th century saw a number of significant changes as Māori society adapted to take advantage of the presence of Europeans and introduced material culture. The introduction of European crops and domesticates contributed to changes in Māori economic behaviour, resulting in what has been termed a period of horticultural revival (H. M. Leach 1979). These changes were particularly significant in previously uncultivated southern regions (A. Anderson 1998). The introduced white potato (*Solanum tuberosum*) swiftly became a major crop, not just as part of the Māori diet, but as a trade item, exchanged alongside pigs for European goods. In Tōtaranui, there is substantial evidence for historical Māori exchange with sailing vessels and onshore whaling stations, and there are recorded accounts of cultivations within the sound.

In a general description of the bays and coves of Tōtaranui in 1839, Ernst Dieffenbach stated:

“In these places there are generally some native huts, inhabited chiefly at the fishing seasons; and here also the natives find the soil most suited for the cultivation of the kumera [sic], or sweet potato: for their other crops, however, they prefer the sides and ravines of the hills, where, after having burned the wood, they obtain for cultivation new and fertile soil, where the surrounding forest preserves a continual supply of moisture” (Dieffenbach 1843, 25–6)

The locations of particular cultivations are also referred to more specifically in accounts from this period, and will be outlined here. Archaeologically recorded garden sites will also be mentioned, in relation to how they correspond to historical gardens.

Northern Tōtaranui

Early 19th century accounts refer to settlements in the general vicinity of Meretoto, including nearby cultivations. The island of Motuara seems to have been unoccupied during the early 19th century, but was the location of plantations and a place where the people of the nearby village of Anaho kept pigs (Dieffenbach 1843, 30). Two recorded garden sites are located on Motuara (Q26/18 and Q26/21), perhaps the remains of these
historical cultivations, or even those planted on the island by James Cook in 1773 (Edwards 2003, 272; Forster 1777b, 216–7). Abandoned cultivations were observed by Dieffenbach (1843, 116–7) in “Naruawitu” or “West Bay” (Endeavour Inlet), which were believed to belong to Rangitane prior to the invasion of Tōtaranui by North Island iwi.

The only other garden site in this area is associated with an historical mission settlement in Oamaru Bay (Q26/11).

![Figure B - 1: Recorded garden sites in northern Tōtaranui and East Bay, with place names mentioned in the text](image)

**East Bay**

A number of settlements were located in East Bay in the early 19th century, typically in association with cultivations (Mitchell & Mitchell, 2007, p. 31). Plantations and habitations were observed in Otanerau Bay, associated with those living in Whekenui/Okukari a short distance over the hills on the southern side of Arapaoa (Dieffenbach 1843, 116–7). One recorded garden site is located in this area in Puriri Bay, the western arm of Otanerau (Q27/59).
Another settlement was noted at Mokopeke Bay, where there were cultivations of taro, potatoes, and even a field of wheat (Dieffenbach 1843, 119–20). The only other recorded garden site in East Bay is located at Onauku Bay (Q27/179), several bays south of Mokopeke.

**Kura Te Au/Tory Channel**

During the early 19th century, Kura Te Au/Tory Channel was a major area of settlement, with the establishment of whaling stations by Europeans encouraging Māori to settle in close proximity, and firm social, economic and familial relations rapidly being formed (Mitchell and Mitchell 2004, 233–41). Whaling stations were present in Te Awaiti and Jackson’s Bay, and Dieffenbach stated that the whalers lived dispersed through the sound during the summer. Some kept cultivations, but it is not entirely clear where (Dieffenbach 1843, 39–41). There are recorded garden sites in Te Awaiti (Q27/204) and Fisherman’s Bay (Q27/208, Q27/210) that could possibly be associated with historical whaling stations.

Whekenui and Okukari Bays, further out toward the mouth of Tory Channel both were the locations of pā/settlements, and Dieffenbach (Dieffenbach 1843, 56) notes that the settlement in Okukari was located “on a fine flat of fertile earth” perhaps alluding to the presence of cultivations. Garden soils are recorded in both Whekenui (Q27/211) and Okukari Bays (Q27/214) that could be associated with these settlements.

Potato cultivations were also noted by Dieffenbach further west in Tory Channel in the vicinity of a pā/settlement called “Toko Karoro” (which is currently unrecorded), located in recent clearings within the ravines (Dieffenbach 1843, 58). Two recorded garden sites are located in Ngaruru Bay (Q27/190 and Q27/195), immediately west of Tokokaroro Point, but these gardens do not definitively correspond to those mentioned by Dieffenbach. Two archaeological garden sites are recorded in Erie Bay (Q27/166 and Q27/238) south of the historically occupied Moioio Island (Q27/2) and Kaihinu Point (Q27/6), but there are no known references to gardens in this area.
Other recorded garden sites are located in Kura Te Au/Tory Channel east of Motukina Point (Q27/228), in Opua Bay (Q27/150), and on the northern shore of Tory Channel in the vicinity of Te Iro Bay (P27/156 and Q27/188).

Figure B - 2: Recorded garden sites in western Kura Te Au/Tory Channel, with place names mentioned in the text
Western Tōtaranui

Important pā were located in western Tōtaranui in the 19th century at Anakiwa and Waitohi/Picton. The New Zealand Company found Waitohi a desirable location for purchase and development, and endeavoured to strike a deal with Te Ātiawa, who occupied a large pā with extensive cultivations. Due to the ultimately imbalanced nature of the Waitohi Purchase signed in 1850, Te Ātiawa relocated to Waikawa, finding it unsuitable for cultivations, and planted cultivations elsewhere in the sound as a result (Te Ātiawa O Te Waka-a-Māui and Te Ātiawa O Te Waka-a-Māui Trust and The Crown: Deed of Settlement of Historical Claims 2012, 14–5; Mitchell and Mitchell 2004, 358–65). Although there are no recorded garden sites in Waitohi, there is one in Waikawa (P27/158), and two more in the nearby localities of Titoki Bay (P27/315) and Summer Bay (P27/307). Another recorded garden site is located on the northern shore of Tōtaranui opposite this area at Kaipakirikiri Bay (P27/218).
John Wallis Barnicoat noted the presence of gardens in the western arm of Tōtaranui (possibly in Momorangi), including extensive cultivations of potatoes, kūmara and corn behind the pā at Anakiwa (Mitchell and Mitchell 2007, 37).

Garden sites are located elsewhere in central Tōtaranui at Ruakaka Bay (P27/237 and P27/246) and in the Bay of Many Coves (P27/250).

Figure B - 4: Recorded garden sites in western Tōtaranui, with place names mentioned in the text
Appendix C: Metadata

This appendix provides metadata for the Geographic Information Systems processes involved in analysis. All GIS processes were carried out using ArcGIS 9.3 (ESRI, Redmonds, California). Files were projected using the New Zealand Transverse Mercator projection (NZGD_2000_New_Zealand_Transverse_Mercator). This required some of the original data to be projected to match. The basic environmental and archaeological metadata is presented here in the form of a glossary, with a description of the origins of the file where necessary, or a description of how the file was created using the GIS. File names are in bold, and ArcToolbox processes in italics.
Table C - 1: Environmental and derived datasets used in analysis

<table>
<thead>
<tr>
<th>File name</th>
<th>Type</th>
<th>Location</th>
<th>Projection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ_coastline.shp</td>
<td>Polygon shapefile</td>
<td>Metadata\Environmental\NZ</td>
<td>NZGD 2000 NZTM</td>
<td>Polygon features of the major islands of New Zealand</td>
</tr>
<tr>
<td>NZ_islands.shp</td>
<td>Polygon shapefile</td>
<td>Metadata\Environmental\NZ</td>
<td>NZGD 2000 NZTM</td>
<td>Polygon features of the smaller islands of New Zealand not included in NZ_coastline.shp</td>
</tr>
<tr>
<td>NZ_contours.shp</td>
<td>Vector shapefile</td>
<td>Metadata\Environmental\NZ</td>
<td>NZGD 2000 NZTM</td>
<td>20 m contour line features of New Zealand</td>
</tr>
<tr>
<td>NZ_Coast.shp</td>
<td>Vector shapefile</td>
<td>Metadata\Environmental\NZ</td>
<td>GCS_New_Zealand_1949</td>
<td>Line features depicting the New Zealand Coastline</td>
</tr>
<tr>
<td>NZ_coast</td>
<td>Vector feature class</td>
<td>Metadata\Environmental\NZ Data.gdb</td>
<td>NZGD 2000 NZTM</td>
<td>Line features depicting the New Zealand Coastline</td>
</tr>
<tr>
<td>NZ_islandscoastline_merge.shp</td>
<td>Polygon shapefile</td>
<td>Metadata\Environmental\NZ</td>
<td>NZGD 2000 NZTM</td>
<td>Polygon features of all islands of New Zealand</td>
</tr>
<tr>
<td>studyarea1</td>
<td>Polygon feature class</td>
<td>GIS Metadata\Study area delineations.gdb</td>
<td>NZGD 2000 NZTM</td>
<td>Polygon feature delineating the extent of all ArcGIS processes</td>
</tr>
<tr>
<td>File name</td>
<td>Type</td>
<td>Location</td>
<td>Projection</td>
<td>Description</td>
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<td>---------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Innersoundpolygon</td>
<td>Polygon feature class</td>
<td>GIS Metadata\Study delineations.gdb</td>
<td>NZGD 2000 NZTM</td>
<td>Polygon feature class delineating the boundaries of Tōtaranui, as defined by the tops of the surrounding hill ranges.</td>
</tr>
<tr>
<td>studyareacoastpoly</td>
<td>Polygon feature class</td>
<td>GIS Metadata\Study delineations.gdb</td>
<td>NZGD 2000 NZTM</td>
<td>Polygon features of the islands of the study area</td>
</tr>
<tr>
<td>studyareacoastline</td>
<td>Vector feature class</td>
<td>GIS Metadata\Study delineations.gdb</td>
<td>NZGD 2000 NZTM</td>
<td>Line features depicting the coastline of the study area</td>
</tr>
<tr>
<td>Landandseapoly</td>
<td>Polygon feature class</td>
<td>GIS Metadata\Study delineations.gdb</td>
<td>NZGD 2000 NZTM</td>
<td>Polygons for areas of both land and sea within Tōtaranui.</td>
</tr>
<tr>
<td>seapoly</td>
<td>Polygon feature class</td>
<td>GIS Metadata\Study delineations.gdb</td>
<td>NZGD 2000 NZTM</td>
<td>Polygon features of all areas of sea within the study area</td>
</tr>
<tr>
<td>QCSCoast</td>
<td>Vector feature class</td>
<td>GIS Metadata\Study delineations.gdb</td>
<td>NZGD 2000 NZTM</td>
<td>Line features presenting the inner coastline and islands of Tōtaranui</td>
</tr>
<tr>
<td>QCScontour_TM</td>
<td>Polygon feature class</td>
<td>GIS Metadata\Study delineations.gdb</td>
<td>NZGD 2000 NZTM</td>
<td>20 m contour line features of the study area</td>
</tr>
<tr>
<td>File name</td>
<td>Type</td>
<td>Location</td>
<td>Projection</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------</td>
<td>-----------------------------------</td>
<td>------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>QCScontourconstruct</td>
<td>Vector feature class</td>
<td>GIS Metadata\Study area delineations.gdb</td>
<td>NZGD 2000 NZTM</td>
<td>Collation of all contour data to be used in DEM construction</td>
</tr>
<tr>
<td>QCScoast_buffer350mclip</td>
<td>Polygon feature class</td>
<td>GIS Metadata\Study area delineations.gdb</td>
<td>NZGD 2000 NZTM</td>
<td>Polygon features representing the approximate area of Tōtaranui within which pā were found, 350 m from the coast</td>
</tr>
<tr>
<td>RandomPoint_21</td>
<td>Point feature class</td>
<td>GIS Metadata\Study area delineations.gdb</td>
<td>NZGD 2000 NZTM</td>
<td>Random points approximately representing a random distribution of pā distribution in Tōtaranui</td>
</tr>
<tr>
<td>Msdem_v6-2</td>
<td>Raster file</td>
<td>GIS Metadata\Environmental</td>
<td>NZGD 2000 NZTM</td>
<td>DEM of the study area</td>
</tr>
</tbody>
</table>
Environmental Data

NZ_coastline.shp: this is a basic polygon shapefile of the major islands of New Zealand. This data was supplied by the Department of Anthropology and Archaeology, University of Otago.

NZ_islands.shp: This polygon shapefile includes those smaller islands of New Zealand not included in NZ_coastline.shp. This data was supplied by the Department of Anthropology and Archaeology, University of Otago.

NZ_contours.shp: This vector shapefile contains 20m contours of the entirety of New Zealand. This data was supplied by the Department of Anthropology and Archaeology, University of Otago.

NZ_Coast.shp: this vector shapefile contains line features representing the New Zealand coastline. This data was supplied by the Department of Anthropology and Archaeology, University of Otago.

NZ_coast: this vector feature class depicted the coastline of New Zealand as line features. This file was constructed by projecting NZ_Coast.shp to match the NZGD_2000_New_Zealand_Transverse_Mercator projection used in the remainder of analysis using the project tool.

NZ_islandscoastline_merge.shp: this polygon shapefile was created by merging NZ_coastline.shp and NZ_islands.shp using the merge tool.

Studyarea1: this polygon feature class represents the limits within which the processes of this thesis would be carried out. This was done by drawing a rectangular graphic within the GIS, which bounded the limits of Tōtaranui. This graphic was then converted into a polygon feature class.

Innersoundpolygon: this polygon feature class depicted the limits of Tōtaranui within which archaeological sites would be selected. This was done by drawing a graphic
connecting the high points along the ridges of Tōtaranui, then converting this graphic to a polygon feature class.

**Studyareacoastpoly**: this polygon shapefile presents the general geography of the study area as polygon features. This was done by clipping NZ_islandscoastline_merge.shp by studyarea1 using the *clip* tool.

**Studyareacoastline**: this vector feature class presented the coastline of the study area as line features. This was done by clipping NZ_coast by studyarea1 using the *clip* tool. To facilitate later DEM creation, this file was given a new attribute field, named a1021 to match the elevation attribute field in the contour data. The features in this attribute field were given a value of 10m, halfway between sea level and the lowest contour interval of 20m.

**Landandseapoly**: this polygon feature class presents polygons for areas of both land and sea in Tōtaranui. This was done by using the *merge* tool on Studyareacoastpoly and studyarea1. All polygons that represented areas of land were merged in editing, and the same was done with polygons representing areas of sea.

**Seapoly**: This polygon feature class is a collection of polygon features representing areas of water within the study area, to distinguish between land and sea in analysis. This file was created the same way as Landseapoly, but the resultant shapefile was edited, deleting those polygon features representing land area, and the remaining sea polygon features merged.

**QCSCoast**: this vector feature class presents the coastline of Tōtaranui as line features. This was done by clipping NZ_Coast by studyarea1 using the *clip* tool, and then editing the resultant line features. Line features extending beyond Cape Jackson and West Point were eliminated by first using the *split* editing tool, then deleting the line features that extended beyond the points. All line features of the mainland coast were merged while editing, as were those for the islands within Tōtaranui. This resulted in line features that delineated the inner coastline and islands of Tōtaranui. The difference between QCSCoast and Studyareacoastline is that the latter delineates all coastline.
features within the study area limits, including those of Te Hoiere/Pelorus Sound and Port Underwood, while the former only delineates the inner area of Tōtaranui.

**QCScontour_TM:** This was a 20m contour of the Tōtaranui study area; created by clipping NZ_contours.shp by studyarea1 using the *clip* tool, to make a smaller file that would speed up processing.

**QCScontourconstruct:** This vector feature class was created by merging QCScontour_TM and Studyareacoastline using the *merge* tool. The QCScontourconstruct file presents all the contour data used in DEM construction.

**QCScoast_buffer350mclip:** This polygon feature class represents the basic area within which pā are found in Tōtaranui. Preliminary analysis of the distribution of pā found that they were located no further than 350m from the coast. Using the *buffer* tool, a 350 m buffer was given to QCSCoast. This was then clipped by studyareacaostpoly using the *clip* tool.

**RandomPoint_21:** This point feature class represents the random point dataset against to test the results of the pā analysis. This point feature class was constructed using the *create random points* tool, using QCScoast_buffer350mclip as the constraining feature class, and with 21 points. Each point in this layer was given a unique identifier: RP_n.

**Msdem_v6-2:** This raster file was created using the *topo to raster* file in ArcGIS. The QCScontourconstruct file and the ‘a1021’ field was used as the input contour data. Seapoly was added as a ‘Lake’ input. Output cell size was set to 20 and the smallest z value for interpolation set to 0. The output extent was set to be the same as studyarea1. Several preliminary attempts to construct DEMs influenced the eventual use of this method. QCScontour_TM and studyareacoastline were combined into a single contour file (QCScontourconstruct) because QCScontour_TM lacked elevation data below 20 masl, and low lying portions of the study area became indistinguishable from sea in earlier DEMs. The addition of seapoly as a ‘Lake’ input, and the smallest ‘z’ value were set to 0 because previous DEM constructions had caused curious interpolation results in inner portions of the sound. This method of DEM construction was believed to most accurately represent the Tōtaranui landscape.
Figure C - 1: Input parameters of topo to raster tool for construction of msdem_v6-2 (screenshot from ArcGIS 10.2.1, ESRI, Redlands, California)
<table>
<thead>
<tr>
<th>File name</th>
<th>Type</th>
<th>Location</th>
<th>Projection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marlborough_District</td>
<td>Point feature</td>
<td>GIS Metadata\Archaeological</td>
<td>NZGD 2000</td>
<td>Point data representing the distribution of recorded archaeological sites in Marlborough in ArchSite. Supplied by ArchSite.</td>
</tr>
<tr>
<td></td>
<td>class</td>
<td>data.gdb</td>
<td>NZTM</td>
<td></td>
</tr>
<tr>
<td>CINZAS_Mar_2008_Project.shp</td>
<td>Point shapefile</td>
<td>Metadata\Archaeological\CINZAS</td>
<td>NZGD 2000</td>
<td>Point data representing the distribution of recorded archaeological sites in New Zealand, from the Central Index of New Zealand Archaeological Sites extracted in March 2008. Supplied by the Department of Anthropology and Archaeology, University of Otago.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>March 2008</td>
<td>NZTM</td>
<td></td>
</tr>
<tr>
<td>Cinarchcollation</td>
<td>Point feature</td>
<td>GIS Metadata\Archaeological\CINZAS</td>
<td>NZGD 2000</td>
<td>Point data representing all recorded archaeological sites in Tōtaranui, from both ArchSite and CINZAS data sources</td>
</tr>
<tr>
<td></td>
<td>class</td>
<td>March 2008</td>
<td>NZTM</td>
<td></td>
</tr>
<tr>
<td>QCS_allsitesMaori</td>
<td>Point feature</td>
<td>GIS Metadata\Archaeological\CINZAS</td>
<td>NZGD 2000</td>
<td>Point data representing all recorded Māori archaeological sites in Tōtaranui, from both ArchSite and CINZAS data sources</td>
</tr>
<tr>
<td></td>
<td>class</td>
<td>March 2008</td>
<td>NZTM</td>
<td></td>
</tr>
<tr>
<td>QCS_karaka_Stowe</td>
<td>Point feature</td>
<td>GIS Metadata\Archaeological\CINZAS</td>
<td>NZGD 2000</td>
<td>Point data representing the distribution of karaka stands in Tōtaranui as recorded by Stowe (2003).</td>
</tr>
<tr>
<td></td>
<td>class</td>
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<td>NZTM</td>
<td></td>
</tr>
<tr>
<td>Q27_264_karaka</td>
<td>feature</td>
<td>GIS Metadata\Archaeological\CINZAS</td>
<td>NZGD 2000</td>
<td>Single point feature class represents the single Tōtaranui karaka stand (Q27/264) recorded in ArchSite.</td>
</tr>
<tr>
<td></td>
<td>class</td>
<td>March 2008</td>
<td>NZTM</td>
<td></td>
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<tr>
<td>File name</td>
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<td>Location</td>
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<td>Description</td>
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<td>--------------------</td>
<td>----------</td>
<td>------------------------</td>
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<td>----------------------------------------------------------------------------</td>
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<td>QCS_karaka_stands</td>
<td>feature</td>
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<td>NZGD 2000</td>
<td>Point data representing the distribution of all karaka stands in Tōtaranui</td>
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<td>class</td>
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<td>NZTM</td>
<td>from all data sources</td>
</tr>
<tr>
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<td>NZGD 2000</td>
<td>Point data representing the distribution of all pā in Tōtaranui</td>
</tr>
<tr>
<td></td>
<td>class</td>
<td>March 2008</td>
<td>NZTM</td>
<td>from all data sources</td>
</tr>
<tr>
<td>QCS_gardensites</td>
<td>feature</td>
<td>Metadata\Archaeological\CINZAS</td>
<td>NZGD 2000</td>
<td>Point data representing the distribution of garden sites in Tōtaranui</td>
</tr>
<tr>
<td></td>
<td>class</td>
<td>March 2008</td>
<td>NZTM</td>
<td></td>
</tr>
<tr>
<td>QCS_middensites</td>
<td>feature</td>
<td>Metadata\Archaeological\CINZAS</td>
<td>NZGD 2000</td>
<td>Point data representing the distribution of midden sites in Tōtaranui</td>
</tr>
<tr>
<td></td>
<td>class</td>
<td>March 2008</td>
<td>NZTM</td>
<td></td>
</tr>
<tr>
<td>QCS_ovensites</td>
<td>feature</td>
<td>Metadata\Archaeological\CINZAS</td>
<td>NZGD 2000</td>
<td>Point data representing the distribution of oven sites in Tōtaranui</td>
</tr>
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<td></td>
<td>class</td>
<td>March 2008</td>
<td>NZTM</td>
<td></td>
</tr>
<tr>
<td>QCS_pitsites</td>
<td>feature</td>
<td>Metadata\Archaeological\CINZAS</td>
<td>NZGD 2000</td>
<td>Point data representing the distribution of pit sites in Tōtaranui</td>
</tr>
<tr>
<td></td>
<td>class</td>
<td>March 2008</td>
<td>NZTM</td>
<td></td>
</tr>
<tr>
<td>QCS_terracsites</td>
<td>feature</td>
<td>Metadata\Archaeological\CINZAS</td>
<td>NZGD 2000</td>
<td>Point data representing the distribution of terrace sites in Tōtaranui</td>
</tr>
<tr>
<td></td>
<td>class</td>
<td>March 2008</td>
<td>NZTM</td>
<td></td>
</tr>
</tbody>
</table>
Archaeological data

**Marlborough_District**: This feature class was an extract of Marlborough archaeological point data supplied by ArchSite. It was observed that this extract was missing a number of sites that were present within the CINZAS data, and despite contact with ArchSite, this problem was not resolved.

**CINZAS_Mar_2008_Project.shp**: This point shapefile presented spatial data from the Central Index of New Zealand Archaeological Sites extracted in March 2008. This data was supplied by the Department of Anthropology and Archaeology, University of Otago.

**Cinarchcollation**: This point data feature class represented all archaeological sites within Tōtaranui. This was done by first using the *join and relate* function to join **Marlborough_District** and **CINZAS_Mar_2008_Project.shp** by the attribute field ‘NZAA_ID’. These files were then merged using the *merge* tool, and attribute fields that were deemed unnecessary were deleted. The results were limited to those within the inner area of Tōtaranui by clipping the results by *innersoundpolygon* using the *clip* tool.

**QCS_allsitesMaori**: This point data feature class represents all the likely Māori/prehistoric sites in the study area. Sites with only historic/European features were removed from **Cinarchcollation**, and the remainder of sites were exported into a new feature class (**QCS_allsitesMaori**).

**QCS_karaka_Stowe**: This feature class presented spatial information for the karaka stands recorded by Stowe (2003). Data for the18 karaka stands within Tōtaranui were transferred into an excel file, and then imported into ArcGIS as a feature class. One of these stands had incorrect coordinates and could not be included in analysis.

**Q27_264_karaka**: This single point feature class represents the single karaka stand recorded in Tōtaranui in ArchSite. This file was selected and exported from **Marlborough_District**.
QCS_karaka_stowe_Merge: This feature class represented spatial information for the 19 karaka stands within Tōtaranui. This was done by merging QCS_karaka_Stowe and Q27_264_karaka using the merge tool.

QCS_pa_dataset: This feature class presents the 21 possible pā in Tōtaranui. Pā were selected based on CINZAS classification codes (Walton 1999), the ArchSite site descriptors, and if they had previously been treated as pā in archaeological studies. Some changes were made to the spatial locations of pā within the GIS where the point data was recognised to be misleading or to match more recent ArchSite data. Typically this involved moving the points either from areas of ocean to the top of the point or island on which the site was known to be found. These changes in coordinates are related in the table below.

<table>
<thead>
<tr>
<th>NZAA ID</th>
<th>Movement Type</th>
<th>Old Coordinates</th>
<th>New Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Easting</td>
<td>Northing</td>
</tr>
<tr>
<td>P27/132</td>
<td>Moved to top of point</td>
<td>1680838</td>
<td>5431172</td>
</tr>
<tr>
<td>P27/216</td>
<td>Moved onto point</td>
<td>1687187</td>
<td>5435191</td>
</tr>
<tr>
<td>Q27/1</td>
<td>Moved onto point to match ArchSite</td>
<td>1706783</td>
<td>5433690</td>
</tr>
<tr>
<td>Q27/3</td>
<td>Moved onto island</td>
<td>1710883</td>
<td>5445288</td>
</tr>
<tr>
<td>Q27/5</td>
<td>Moved onto island</td>
<td>1703684</td>
<td>5438289</td>
</tr>
<tr>
<td>Q27/6 and Q27/233</td>
<td>Eliminated extra site record number, moved to centre of island</td>
<td>1701824</td>
<td>5433430</td>
</tr>
</tbody>
</table>
**QCS_gardensites:** This feature class presents the 25 horticultural sites in Tōtaranui. Sites were selected based on CINZAS classification codes (Walton 1999), and ArchSite site descriptors. One site, P27/154 was noted be 10km east of its supposed location of Waikawa Bay, and its coordinate were shifted within the GIS from 1696684E to 5430791N to 1686686E 5430792N. None of the 21 pā sites within **QCS_pa_dataset** were included within this feature class.

**QCS_middensites:** This feature class presents the 134 sites with midden features in Tōtaranui. Sites were selected based on CINZAS classification codes (Walton 1999), and ArchSite site descriptors. None of the 21 pā sites within **QCS_pa_dataset** were included within this feature class.

**QCS_ovensites:** This feature class presents the 49 sites with oven features in Tōtaranui. Sites were selected based on CINZAS classification codes (Walton 1999), and ArchSite site descriptors. None of the 21 pā sites within **QCS_pa_dataset** were included within this feature class.

**QCS_pitsites:** This feature class presents the 70 sites with pit features in Tōtaranui. Sites were selected based on CINZAS classification codes (Walton 1999), and ArchSite site descriptors. None of the 21 pā sites within **QCS_pa_dataset** were included within this feature class.

**QCS_terracesites:** This feature class presents the 52 sites with terrace features in Tōtaranui. Sites were selected based on CINZAS classification codes (Walton 1999), and ArchSite site descriptors. None of the 21 pā sites within **QCS_pa_dataset** were included within this feature class.
Cost surfaces

Cost surfaces were constructed for each pā site by selecting each individual pā in turn, and using the relevant QCS_pa_dataset file as the input feature source data for the path distance tool in ArcGIS.

Vertical factor parameters were set as follows: input vertical raster was set as MSdem_v6-2, the vertical factor set to ‘Table’, using ToblerAway.txt (from mapaspects.org) as the input table. Output files were named CostSurf followed by the NZAA ID of the point of origin, e.g. CostSurf_P27_132. The processing extent of these rasters was set as the same as studyarea1 within the environment settings. This produced a cost surface raster in which every cell had a value representing cost distance in hours from the point of origin, either a pā site.

This method was repeated for random points, with the only difference in method being that RandomPoint_21 used as the input source data, and each random point selected in turn. Output files were named CostSurf followed by the RP_ID of the point of origin, e.g. CostSurf_RP_1.
To extract the cost distances from each pā and random point to the nearest site of each type, the following method was used. The *extract values to points* was used, with the relevant point feature class for each site type (i.e. **QCS_gardensites** for garden sites, **QCS_karakastands** for karaka stands, etc.) as the input point features, and the relevant cost surface raster for each pā or random point (i.e. **CostSurf_P27_132** for P27/132, **CostSurf_RP_1** for RP_1, etc.) as the input raster. The tool was set to interpolate values at the point locations (rather than just use the central value for the cell it is within), and the output point feature was saved as a feature class named **Stan[Site type][NZAA_ID or RP_ID]Extr**. These point feature class contained the same features and attributes of the input point feature class, with the addition of the attribute field “RASTERVALU” which provides the cost distance from the point of origin of the cost surface in hours of travel time. For example, using **QCS_gardensites**
as the input point features and **CostSurf_P27_132** as the input raster would return a feature class named **StanGardensP27_132Extr**. This feature class contained point data for each garden site within Tōtaranui, and the “RASTERVALU” attribute field provides the cost distance in hours of travel time to each of those sites from P27/132 (see Figure C - 3, below).

The nearest site of each site type to each pā or random point (as presented respectively in Table 5-1 and Table 5-2) was taken from these value extract files. This was done simply by taking the site with the lowest positive cost distance (from the “RASTERVALU” attribute field) that was not the point of origin or another pā or random point.

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**Figure C - 3**: Example input parameters for *extract values to points* tool, returning cost distance in hours of travel time from P27/132 to all garden sites within the study area.
Cumulative viewsheds for all pā were created using the viewshed tool, with QCS_pa_dataset as the input feature, msdem_v6-2 as the input raster, and the extent set to match studyarea1. The resultant raster file was named pacumulview. This process was repeated for the random points using RandomPoints_21 as the input point data and the resultant raster file was named randomview_v1.

In addition to the cumulative viewsheds, individual viewsheds with each pā or random point as the origin point were created. This followed the previous method, with each individual pā or random point selected in turn as the sole point of origin for the viewshed. In order to measure viewshed area and distinguish between visibility over areas of land and sea, a model was created to convert viewshed rasters into polygons with measured areas.

Each pā and random point was selected individually and either QCS_pa_dataset or RandomPoints_21 was used as the input point feature for the viewshed tool. Msdem_v6-2 was set as the input raster, and the extent set to match studyarea1. The resultant viewshed rasters were then used as input rasters in the raster to polygon tool, and the simplify polygon option was turned off. The final stage of the model involved using the resultant polygon files as the input for the calculate areas tool in order to determine viewshed area. The final viewshed polygons were named [NZAA_ID or RP_ID]_area, e.g. P27_132_area.

Each viewshed polygon feature class was edited in turn. Polygon features representing non-visible portions of the landscape were deleted, and the remaining polygon features representing visible portions merged into one. A new attribute field was added to identify the polygon feature by the NZAA_ID or RP_ID of its origin point.

All pā viewshed polygon feature classes were then merged using the merge tool into a singular polygon feature class, totalpaview. The same was done for all random point viewsheds, creating totalRPview.
In order to distinguish sea area from land area, these cumulative viewshed polygon feature classes were separated by the coastline. A polygon feature class representing viewsheds over land area was created by using the *clip* tool on `totalpaview`, with `studyareacoastpoly` as the clipping feature, creating `palandview`. This process was repeated for sea views by clipping `totalpaview` by `seapoly`, creating `paseaview`. These two files now contained an attribute field containing total visible area from each pā over areas of only land or sea, allowing comparison of these attributes in analysis. These two processes were repeated again for random points, using `totalRP` as the input polygon feature class, creating `randviewland` and `randviewsea`.

![Diagram of viewshed calculation](image)

Figure C - 4: Example of model used to create viewshed polygons with calculated visible areas, using P27/132 as the point of origin (screenshot from ArcGIS 10.2.1, ESRI, Redlands, California)