ABSTRACT

East Polynesia is a vast region encompassing the 150 million km$^2$ of ocean and scattered islands between Hawai‘i, Rapa Nui and New Zealand. The societies in this region share common ancestry but distinct social and environmental conditions on different islands have shaped the emergence of unique cultures. In New Zealand, understanding of the pattern and process of change from the ancestral East Polynesian culture to the distinctive Māori culture has been undermined by a series of developments. In particular, a large-scale review of early radiocarbon dates (Anderson 1991) has reduced the established length of Māori occupation of New Zealand before European contact from around 1000 years to 500, halving the time in which change could occur. Despite these developments, no attempt has been made to integrate archaeological data with this new temporal framework. This research addresses this issue by re-evaluating patterns of change in material culture and population within a Darwinian framework. Classification and frequency seriation of material culture assemblages is used to develop diachronic sequences of change, which are tested against a null explanatory model of random drift. Both traditions show significant variation from this model suggesting other processes, such as selection, are more likely causes of change. Comparison of the diachronic sequences of change with the available radiocarbon dates also suggests that many characteristics linked with the later period in New Zealand emerged very rapidly, consistent with the idea of rapid adaptation to the new environment. The influence of population size and growth on culture change is also considered in this research. Summed probability distributions from collated radiocarbon dates show a variety of regional population trajectories, which can be linked to the patterns of change observed in the material culture. This is clearest in the southern region where large-scale population collapse may well be a major cause of stasis in the development of material culture. The comparison between the regional patterns in New Zealand and other East Polynesian islands reveals both similarities and key differences in the establishment and emergence of culture in the region.
ACKNOWLEDGEMENTS

Ehara taku toa, i te toa takitahi ēngari he toa takimano
Mine is not the strength of one, but the strength of many

This research is fundamentally about understanding the processes that shape artefacts. As such, it is difficult not to view this thesis through the same lens as I have tried to view artefacts. That is, as the result of the mixture of old ideas and new, random events and carefully made decisions and the influence of a huge range of people.

Firstly I wish to thank Stephen Shennan and Andy Bevan for their interest, insight and advice for which this research was greatly improved. In particular, thanks for pushing me to expand my archaeological horizons through both critique and conversation and for advice and feedback on academic matters outside my PhD.

This thesis profited greatly from discussions with Enrico Crema, Kevan Edinborough, Adrian Timpson and Pascale Gerbault who provided advice and ideas throughout the course of this research for which I am extremely grateful.

Collection of data was greatly aided by the knowledge and friendly assistance of staff from museums throughout New Zealand including: Louise Furey (Auckland War Memorial Museum), Kelvin Day, Glenn Skipper, Andrew Moffat and Elspeth Hocking (Puke Ariki Museum), Moana Parata (Te Papa Tongarewa) and Roger Fyffe and Hatesa Seumanutafa (Canterbury Museum) and Scott Reeves and Jamie Metzger (Otago Museum).

Thanks to Danielle Trilford, Chris Nichol, Shona Geary and Heather and Doug Townsend for housing me during the fieldwork phase of this research. Your generosity made this research possible.
I would like to acknowledge the UCL Graduate Research Scholarship, the Puke Ariki Trust Scholarship and the Royal Society of New Zealand Skinner Fund for supporting this research.

On a more personal note, I wish to thank the members of the Institute of Archaeology for their friendship and support over the last few years, particularly past and present members of G7B including: Oli Boles, Sirio Canós Donnay, Beatrijs De Groot, Jonny Gardner, Nik Gestrich, Barney Harris, Ahmed Mekawy, Tina Paphitis, Emma Payne, Paul Tourle, Sanja Vucetic and honorary member Kate Jarvis. Also, a big thanks to Andrew Reynolds, Mike Parker-Pearson, Gabe Moshenska and Leah Acheson-Roberts for the chats and fun over the last few years.

Mike Parker-Pearson, Kate Welham and Colin Richards have provided valuable fieldwork opportunities that have kept me sane throughout this process. A special thanks to Kate for her generosity and kindness over the last few years.

Many friends and colleagues from New Zealand and London deserve special mention for their support and engagement with my research over the years. Chris Jacomb has influenced me in more ways than I can count. Chris Jennings, Danielle Trilford, Matt Carter, Emma St Pierre, Gemma Dickson, Emma Clifford, Thomas Bromell, Andy Gillespie and Kim and Stephen Inglese have provided insightful and fun discussions about archaeology and life. Rosie Geary Nichol contributed to these discussions and provided valuable feedback on drafts. Thank you all very much.

I simply would not be here without the help and unwavering support of my family. To Murray, Judy, Marie, Mel, Rob, Sophie and Riley thank you for your love and support. You are touchstones to which I constantly return for inspiration and resolve.

Finally, thanks to Aimee for being a source of advice, affirmation, support and happiness without which I couldn’t have got this far.
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Introduction: the pattern and process of culture change

“…little progress has been made in developing theoretical frameworks to guide the study of New Zealand prehistory to the end of the century and beyond” (Davidson 1993: 153)

1.1 Problem Statement

This thesis examines the pattern and process of culture change in New Zealand through the lens of material culture and population history. Using an explicitly diachronic framework in combination with comparative methods, it seeks to understand the processes – both internal and external – that have driven the development of Maori culture in New Zealand from its East Polynesian roots.

East Polynesia consists of thousands of islands that lie within the expanse of ocean between Hawai‘i, Rapa Nui and New Zealand. The societies in this vast region share a common genetic and cultural ancestry arising from a shared origin in the West Polynesian islands of Samoa and Tonga. Beginning around AD 1000, the colonisation of East Polynesia proceeded rapidly with most habitable islands settled by AD 1300 (Wilmshurst et al. 2011). This rapid colonisation, together with ancestral cultural relationships and on-going contact amongst all but the most isolated islands, led to a fairly homogenous expression of culture in early East Polynesian sites (Walter 2004). Such consistency in expression is remarkable given the variety of island types (e.g. atolls, high volcanic islands, and near continental-
scale landmasses) located between latitude 20°N and 50°S and representing a diverse range of environments from tropical to sub-Antarctic (Kirch 1984).

Over time, increasing isolation and a variety of unique social and environmental conditions led to cultural divergence within islands and the development of distinct culture histories (Kirch 1984). In many East Polynesian islands the pattern and process of culture change is well established. Key aspects in these sequences include initial focus on wild resources, successful introduction of domesticated plants and animals, and growth of population and social complexity (Kirch 2000). However, while some of these aspects can be inferred in New Zealand, the exact nature of the sequence remains unresolved. Indeed, as Kirch (1982: 71) noted, “nowhere in Polynesia has there been more debate concerning culture sequence models than New Zealand”. While over thirty years have elapsed since this statement was made, the lack of clarity on the sequence in New Zealand remains.

Explaination of the material difference between the Maori culture ‘caught alive’ by the arrival of Europeans and the East Polynesian culture that settled the country is an important aspect of New Zealand archaeology. The opposition between early and late has generally manifested itself in the construction of schemes involving at least two discrete cultural ‘stages’ (e.g. Duff 1956; Golson 1959). New Zealand archaeologists have typically focussed on the description of such units (phases or periods) and have represented culture change, attributed to diffusionary forces (Buck 1950; Duff 1956) and, more recently, responses to the availability of economic resources (Anderson 1982a; Barber 1996), as the movement from one phase to the next.

Traditional objections to these models have focussed on their unitary view of change in prehistory and the emphasis on defining communities at the beginning and end of the sequence at the expense of attempting to understand change over time (Davidson 1984; Barber 1994). The frameworks can also be critiqued for their reliance on anecdotal evidence and the presence of layered assumptions about the past (discussed more in Chapter 2). In recent decades inertia has developed around the discussion of sequence models in New Zealand; however, during this same period a significant amount of evidence has emerged suggesting a pattern of rapid,
dynamic, and episodic change into which existing models of gradual evolutionary change do not fit (Holdaway 2004).

This evidence is derived from across the archaeological discipline, including the areas of chronology, economy, ecology, and demography. Amongst this evidence, revision of chronology has had the greatest impact on existing archaeological frameworks in New Zealand. Anderson’s (1991) review of early radiocarbon dates significantly revised the arrival time of Maori to New Zealand from c. AD 800 to c. AD 1300. As a result, change that was previously supposed to have occurred over 1000 years was limited to a period of less than 500 years. Palaeo-zoological studies have also shown that many big game resources central to the economy of the early period went extinct more rapidly than initially thought (Holdaway and Jacomb 2000; Smith 2005; Holdaway et al. 2014). This pattern is mirrored in forest clearance, particularly in the South Island where a swift decline following Polynesian settlement has been noted (McWethy et al. 2014). Finally, a handful of ancient DNA analyses and voyaging simulations tantalisingly suggest that the colonisation of New Zealand involved hundreds, not dozens, of people (Irwin 1991; Whyte et al. 2005). The conflict between new data and old models significantly undermines our current understanding of how and why the unique Maori culture emerged. It is therefore imperative that a substantial re-evaluation of available cultural data is carried out.

1.2 New Perspectives

This research is built on the belief that recycling existing cultural frameworks will not produce the results required to fill the current gaps in our knowledge of culture change in New Zealand. Instead, a new theoretical position is required that is explicitly concerned with understanding patterns of change and the generative processes behind these patterns.

In recent years Darwinian archaeology has emerged as a productive and versatile theoretical framework, which suits the requirements of this thesis. At its core, Darwinian archaeology views culture not as commonly recurring groups of artefacts (e.g. Childe 1956; Golson 1959) but as a body of inherited beliefs,
practices, and knowledge that influence behaviour and thus the archaeological record (Boyd and Richerson 1985). Crucially, the Darwinian perspective views culture as an inheritance system passed on via social learning and influenced by a range of factors, which lead to the ‘descent with modification’ of culture through time.

Archaeological applications of this perspective rely on the analysis of cultural traditions. Cultural traditions are aspects of culture associated with specific bodies of behaviour and skills, including those connected with subsistence, material culture, and language (Eerkens and Lipo 2007; Tehrani and Riede 2008). Traditions are dynamic and may be recognised as the outcome of interaction between the past and the conditions and people of the present (Pauketat 2001). Variation of traditions may occur over time as existing structures are modified or, more rarely, new traits are invented (O’Brien et al. 2002). Clearly, if aspects of traditions were copied with absolute fidelity, observed variation through time would not exist (Shennan 2002). Therefore, any variation must be the result of factors such as innovation, copying error, differential transmission pathways, and selection mechanisms and biases operating over short time scales (Shennan 2002; Richerson and Boyd 2005; Hosfield 2009; Shennan 2011). These factors and other aspects of Darwinian archaeology are discussed further in Chapter 3.

An important question to answer at this junction is: what advantages does a Darwinian perspective offer to New Zealand archaeology? The first and major advantage of a Darwinian perspective is that it uses structures (e.g. traditions and lineages) that enable a diachronic perspective of the archaeological record to be developed. Rather than applying units to discrete stages (i.e. cultures or phases) this approach views traditions through time, noting both change and persistence of the selected unit or attribute (Lightfoot 2001). The removal of synchronic categories allows for clearer understanding of change and also removes some of the problems inherent in existing cultural frameworks in New Zealand (discussed further in Chapter 2).

Secondly, a tradition represents a subset of an archaeological culture with its own history. Certain traditions may be inherently tied to others in ‘packages’, for
example a hunting tradition may be closely tied to that of arrow making, or they may be independent (Shennan 2002). This effectively disentangles culture into smaller units (e.g. the fishhook tradition explored in Chapter 7) allowing all its aspects to be viewed independently and allowing a clearer understanding of the nature and mechanisms of culture change (Lightfoot 2001).

Drawing upon the ideas presented above, this research argues that the construction and analysis of cultural traditions provides the best means to develop greater understanding of New Zealand’s archaeological sequence. Employing the tradition concept provides an opportunity for diachronic analysis across different facets of culture. Developing trajectories of change for the adze and fishhook tradition allows for a better understanding of similar and unique processes driving their change and, the comparative analysis of these processes. As such, traditions allow a finer-grained understanding of the process and tempo of change in New Zealand.

Alongside the more theoretical elements, this thesis also adopts a clear comparative perspective. The pattern of Polynesian dispersal shows that Maori society had its roots in central East Polynesia where a number of fundamental components of culture were developed (Walter 2004). In recent decades New Zealand archaeology has been studied largely in isolation from other Pacific Islands, to the exclusion for example of ideas regarding the processes driving culture change in related societies. In this thesis I take the view offered by Walter (2004) that any study of culture change in New Zealand must necessarily consider how these components operated in the homeland societies from which the first settlers of New Zealand originated. To that end, this thesis carries out an extensive review of the culture in the time and place from which New Zealand was settled to provide a baseline for further study of change in New Zealand (Chapter 4). Of equal importance is the comparison of the change observed in New Zealand with that seen in other East Polynesian islands. This comparison is seen as a means of determining if patterns of culture change and their presumed cause in New Zealand are consistent in other areas and, if not, what factors specific to New Zealand may be influencing change. Such comparison occurs throughout this thesis.
1.3 Research Questions

This study will attempt to understand the pattern and process of culture change by re-evaluating two strands of data: (i) material culture (adzes and fishhooks) and (ii) population history. Via these strands, it will focus on the following questions:

1. To the extent that we can recognise them via indirect lines of evidence, what are the population histories exhibited by different regions of New Zealand and how does these demographic trajectories impact upon wider cultural patterns?

2. What are the spatial and temporal patterns of variation in the material culture traditions of New Zealand? What are the possible explanations for any such variation?

3. How do the observed patterns in New Zealand compare with other Polynesian island groups?

1.4 Objectives

The first research question focuses on past population, something that cannot be directly observed in the archaeological record. Therefore, in this thesis past population is addressed through simulation. This simulation is drawn from similar methods employed in Europe and elsewhere, which use available radiocarbon dates to develop proxies for population size and history (Shennan and Edinborough 2007; Shennan et al. 2013; Manning and Timpson 2014). Such methods are novel in New Zealand archaeology and provide a first empirical indication of regional population histories. These patterns have important implications for many facets of New Zealand archaeology. Crucially, as outlined in Chapter 3 of this thesis, population size and density has an influence on processes of cultural change. Thus, demographic analysis (Chapter 5) will provide valuable information, which may be integrated into the analyses of material culture change.

The second research questions will be addressed through the analysis of adzes and fishhooks. The first objective in this process is to understand the culture that arrived in New Zealand to provide a baseline for further analysis. To achieve this a review of early period (c. AD 1000-1300) material culture from sites in East
Polynesia will be carried out and a synthetic picture developed of the probable artefact suite that arrived in New Zealand. The second objective is to construct sequences of change over time for both fishhooks and adzes in New Zealand, from which generative processes can be inferred. Developing the pattern of change over time will be based on data collected using qualitative classification of artefact traits, for which a series of statistics will then be applied to formalise sequences of change over time. This method will also be applied to sites from within specific regions to develop regional sequences of change. Finally, the information developed in the first two stages of this research will be used to infer the generative processes that led to the pattern seen in the archaeological record of New Zealand. Expectations of artefact change through drift will be developed using simulations and the patterns of change through time compared to these simulations and the expectations of culture change under different cultural selection mechanisms.

Finally, the fourth research question will be addressed by comparing the patterns observed in this thesis with published accounts from across East Polynesia. Well-researched archipelagos such as Hawai‘i, the Marquesas and Society Islands will be a particular focus of this comparison.

### 1.5 Scope and Limits

This research focuses on cultural change during the pre-European period of New Zealand history. New Zealand’s archaeological and ethnographic collections are rich; however, very little of the material recovered during the last one hundred plus years of digging and collecting can be firmly placed in any context. Therefore, despite the presence of material, such as the rich ornamental tradition, this research limits its scope to those material culture classes that are both abundant and frequently found in secure contexts. Further consideration of this point is discussed in Chapter 6.

In order to sensibly approach the questions asked above this research is necessarily focussed on several different scales. The impracticality of collecting and analysing material culture from sites throughout East Polynesia constrained this research to the use of published information to develop a synthetic picture of early East
Polynesian culture and in the comparison of diachronic patterns observed in New Zealand with other societies. At the national or regional scale in New Zealand a more in-depth analysis was possible.

Lastly, a growing number of New Zealand archaeologists recognize the division between the prehistoric and historic period as arbitrary. Proto-historic accounts clearly show that many aspects of Maori tradition did continue unabated into the historic period; however, while recognizing the potential interest in studying traditions up to and beyond the introduction of new technologies, it is felt that the focus on pre-European culture change provides a much clearer set of parameters for this research. Furthermore, the lack of sites with suitable numbers of artefacts from the period after 1769 means that little would be gained, even if this period were to be included.

1.6 Thesis Outline

Chapter 2 provides an outline of the major aspects of New Zealand archaeology, including colonisation, subsistence, and economic evidence. The history of different cultural frameworks and their implications for the understanding of archaeological evidence, outlined briefly above, is more fully discussed in this chapter. This justifies my assertion that there is need for novel theoretical frameworks in New Zealand archaeology and provides the foundation for later analyses. Drawing on the shortcomings of previous research presented in Chapter 2, Chapter 3 introduces the theoretical position taken up by this thesis. In particular, it focuses on introducing the structures and processes of change recognized by Darwinian archaeology. Chapter 4 is concerned with providing a starting point for the consideration of New Zealand prehistory. It reviews the archaeology of East Polynesian islands, providing context for later discussions but, crucially, it also develops a picture of the culture that arrived in New Zealand from East Polynesia. This synthesis particularly focuses on the adze and fishing kits transported to New Zealand. Chapter 5 introduces the method used for the development of population models, followed by the presentation of the results of the simulations. This chapter will allow the second research question to be answered, as well as providing valuable information for the drift simulations introduced in Chapter 6 and discussed in relation to fishhooks and adzes in
Chapters 7 and 8. The next group of chapters (Chapters 6-8) deals exclusively with material culture in New Zealand. Chapter 6 outlines the methods used in the analysis of material culture (adzes and fishhooks) while Chapter 7 presents the results of analysis of fishhooks and Chapter 8 the results of the analysis of adzes. These chapters will allow the first and third research questions to be answered and will provide the most important information for the comparative assessment required to answer the fourth and last research question. The final chapter (Chapter 9) will discuss the outcomes of this research and the prospects and future directions for both this type of research and this theoretical perspective in New Zealand and East Polynesia.

With this overall structure in mind, I now turn to considering the state of New Zealand archaeology. Both in terms of its current and former theoretical frameworks and what we know archaeologically about Maori culture in New Zealand.
From Moa-hunters to Fish-eaters: Research Frameworks and Agendas in New Zealand Archaeology

“...nowhere in Polynesia has there been more debate concerning culture sequence models than in New Zealand.” (Kirch 1982: 71)

2.1 Introduction

The previous chapter briefly outlined the current conflict between old models and new data in New Zealand archaeology, citing this as a key reason for conducting the current research. The following chapter expands this discussion by presenting a critical review of cultural frameworks into which archaeological data has been placed to explain cultural variation in space and time in New Zealand. This discussion proceeds chronologically in order to show the progression of thought in New Zealand archaeology, as well as the adherence to a system that has its origins in the 19th century. Following this review this chapter presents an up-to-date synopsis of aspects of New Zealand archaeology, including reviews of settlement, economy, and exchange networks. This review presents valuable contextual information relevant to the chapters that follow. Material culture and demography, the central aspects of this thesis, are discussed briefly but considered in greater depth in later chapters. However, before discussing New Zealand archaeology, an introduction to New Zealand itself is provided to further contextualise this research. This discussion focusses on the physical environment and climatic variations present throughout the country.
2.2 New Zealand: Geography, Environment and Climate

New Zealand is a continental landmass in the southwest corner of the Polynesian triangle. The country is relatively isolated, lying approximately 3,200 km from the Cook Islands, the nearest major island group. Relative to the rest of Polynesia New Zealand is at a low latitude (34° to 47° south) and spans the sub-tropical, temperate, and sub-Antarctic environmental zones (Figure 2.1). The landmass is the largest in Polynesia at approximately 265,000 km² in size (Walter and Jacomb 2007). The South Island (150,437 km²) and the North Island (113,729 km²) comprise the majority of this area, with around 700 off-shore islands making up the remainder (Walrond 2015). Due to its size, elevation, and latitudinal range, New Zealand has a range of environments and climates (Figure 2.2). The following section discusses these in turn, drawing on the [New Zealand] National Institute of Water and Atmospheric Research’s regional climate overviews housed at niwa.co.nz.

Figure 2.1 Map of the South Pacific showing the location of New Zealand and climatic zones.
The topography of the North Island is typically rolling, although it often becomes steep further inland or in the many ranges that cross the island. The central North Island is volcanically active and rises to a central plateau that has an alpine climate. Northern New Zealand is the region most similar to central East Polynesia, having a sub-tropical climate with warm summers (22°C to 26°C) and mild (12°C to 17°C), unsettled winters. The region has a relatively rough western coastline and sheltered bays on the east coast. The central and lower regions of the North Island have a mean annual temperature a couple of degrees lower than northern New Zealand, with the exception of the central high country, which is much cooler. Weather systems largely arrive from the west, therefore western areas are typically wetter and more exposed, while eastern areas (sheltered behind the high country) have a drier, more settled climate with higher summer temperatures. Both regions are subject to winter frosts, although these are more frequent in the south and west. The west coast of the North Island is characterised by rough seas and high cliffs, passable only at stream or river mouths.

The South Island’s climate and topography is dominated by the Southern Alps, a chain of mountains running nearly the length of the island. The west coast is exposed to weather systems and has very high rainfall, the region has mild summers (17°C to 22°C) and cool winters (10°C to 14°C), which commonly begin with frosts. Northern and eastern areas of the South Island fall within the rain shadow of the Southern Alps and are therefore drier and more settled. Summer temperatures range between 18°C and 26°C with occasional temperature peaks. In the northeast South Island winter temperatures range between 10°C and 15°C and annual sunshine hours are the greatest in New Zealand. The eastern South Island consists of alpine topography in the west, which gives way to large plains nearer the coast. Winters are cold (7°C to 14°C) and frosts are frequent.

Southern New Zealand is made up of two zones. The inland zone contains the Southern Alps in the west, which gradually give way to flat-topped mountains and rolling hills in its eastern and southern reaches (McGlone et al. 1995). This topography creates multiple localised micro-climates although generally the climate is dry with temperate summers and extremely cold winters characterised by frosts and snow drifts. The coastal topography of southern New Zealand generally consists of basins and ranges toward the interior with rolling hills and plains also
Figure 2.2 Climatic zones of the New Zealand, adapted from www.niwa.co.nz.

present. The climate is driven by oceanic events, which bring mild summers (16°C to 23°C), cold winters (8°C to 12°C), and wetter conditions than the inland region. Broadly, the modern climate pattern in New Zealand was established by around 550 BC (Salinger and McGlone 1990), well before the arrival of the first people.
Therefore, contemporary climate records are useful in establishing the broad relative climate differences between regions. However, palaeoclimate reconstructions using speleothems and tree rings show marked (albeit still modest by wider Pleistocene-Holocene standards) temperature variation within the period of human occupation. Specifically, it appears that humans arrived in a relatively warm period before a drop in temperature after AD 1300, which reached a low around AD 1500 - 1600 (Cook et al. 2002; Palmer and Xiong 2004; Williams et al. 2015). Based on the Oroko tree-ring data (Cook et al. 2002), the mean summer temperature before AD 1300 was similar to current temperatures, while in the trough it may have been as much as 1.5°C lower.

The climatic and geographic variability exhibited in New Zealand has influenced human activity in the country. Differential use of interior and coastal regions is apparent from the review of archaeological data from prehistoric New Zealand (particularly the distribution of pa, discussed below Figure 2.8). However, the most significant variation is the graded temperature drop from north to south noted above. This drop contributes to differential levels of horticultural production: northern areas are generally better suited to grow tropically adapted Polynesian cultigens, central areas are marginal and the lower half of the South Island does not support any horticultural species (Figure 2.2; Leach 1984; Bassett et al. 2004). It should be noted that the evidence of the southern extent of horticulture (and the line marking the approximate ‘optimal’ horticultural zone) does not exactly match the broad climatic zones outlined above. This is due to two things: first, the existence of local micro-climates within these broader environmental zones that presented better or worse conditions for horticulture with respect to other areas in the zone; second, the temperature variation based on altitude and latitude that can cause variation within climatic regions. Horticulture is viewed as a key component in the economy of later Maori society (Davidson 1984), therefore this and other constraints are important to consider during the review of New Zealand archaeology to follow.
2.3 Frameworks in New Zealand Archaeology

This section details the development of cultural frameworks, which have been the primary tools used to understand and explain spatio-temporal variation in the archaeological record of New Zealand. A major theme of the following sections is the attempt to define the differences between early Maori culture and that which was ‘caught alive’ by European explorers. As we shall see, while temporal and regional differences in Maori culture may have been defined, the processes underlying these variations are less clear (Holdaway 2004). The following section begins by briefly discussing the earliest models of culture change, which introduced the dichotomy between early and late culture in New Zealand, before proceeding forward in time to the present day.

2.3.1 Early Models

The separation of the New Zealand sequence into two units has its roots in the earliest research into prehistory. In the 1870s Julius von Haast proposed a discontinuous sequence consisting of an early moa-hunting culture, probably Polynesian in origin, who possessed Palaeolithic technology, and later Neolithic Maori groups (Haast 1871). The antiquity of the Moa-hunters was established by their association with moa remains in strata identified by Haast as quaternary. Haast reasoned that there was discontinuity between the moa-hunters and Maori on the basis of oral tradition:

“that the natives, who have reliable traditions extending back over several hundred years, and of many minor occurrences, should have no account of one of the most important events which could happen to a race of hunters, namely the extinction of their principle means of existence,” suggested that, “the forefathers of the Maoris not only have neither hunted or exterminated the moa, but that they know nothing about it” (Haast 1871; 71 and 74).

Haast’s excavations at Moa Bone Point Cave revealed a sterile layer between the top (Maori), and bottom (Moa-hunter) layers, which he argued supported the idea of discontinuity (Haast 1875). Alexander McKay, having excavated at Moa Bone Point Cave with Haast, noted that polished stone tools and fishing nets were present in layers associated with the (supposed Palaeolithic) Moa-hunters (McKay 1874). McKay recognised that Moa Bone Point Cave represented a discontinuous
sequence but suggested there was clear affinity between the layers. Indeed, McKay (1874: 23) noted that if a site were found that revealed continual occupation a “gradual progression of the Moa-hunter to the fish-eater” would be seen.

2.3.2 Museums and Ethnography

The early half of the twentieth century was characterised by the rise of evolutionary ideas, which involved the development of different levels of society and, with respect to change, discounted internal cultural dynamism in favour of models involving the introduction of superior migrant populations (Barber 1995). The earliest proponents of such models were the ethnographers S. Percy Smith and Elsdon Best. Smith and Best drew on oral traditions of the Maori to construct their culture history, which also suggested New Zealand was inhabited by two discrete cultures. Smith and Best (Smith 1913a, 1913b; Best 1916, 1924), proposed that the earliest inhabitants of New Zealand were accidentally swept from Melanesia. The initial inhabitants were called Maruiwi and were regarded as an inferior, non-horticultural society who, upon arrival of the superior Polynesians, were replaced or driven to the Chatham Islands (Best 1924). To establish an event chronology, Smith (1910) reviewed recorded whakapapa (lineages) from the west coast of the North Island. Using generation spans of 25 years, Smith (1910) developed the first ‘absolute’ chronology for New Zealand (below). This model was considered the authentic chronology of New Zealand for many years (Sorrenson 1979) and was important in establishing the idea of migration as a key catalyst of culture change.

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discovery by Kupe</td>
<td>A. D. 925</td>
</tr>
<tr>
<td>Arrival of Toi</td>
<td>A. D. 1150</td>
</tr>
<tr>
<td>Moriori to Chathams</td>
<td>A. D. 1175</td>
</tr>
<tr>
<td>Arrival of the Fleet</td>
<td>A. D. 1350</td>
</tr>
</tbody>
</table>

The influence of Smith and Best is present in Peter Buck’s (Te Rangi Hiroa) *The Coming of the Maori* (1950), which also focused on migration as a key stimulus for change. However, Buck’s sequence differed from Smith’s by omitting the Moriori (Maruiwi) departure and attributing the arrival of agriculture to the secondary settlement by the great fleet rather than the first Maori arrival (Buck 1950).
Skinner’s (1921) systematic analysis of artefacts from museum collections challenged many of the views held by Smith and Best. Skinner questioned the Melanesian origin of early New Zealanders and asserted that the majority of cultural differentiation in New Zealand was spatial rather than temporal. Using museum collections Skinner (1921) identified two principal cultures, Northern and Southern, and eight sub-culture areas in New Zealand. He noted similarities between the southern sub-culture area and the Chatham Island sub-culture and linked these regions most closely to East Polynesia not Melanesia (Skinner 1923). Skinner’s identification of Polynesia as the origin of the earliest New Zealanders was an important step that was largely accepted by scholars. The development of formalised sub-culture areas did not persist; however, the idea that regions might have distinct cultural expression has become an important component of New Zealand archaeology.

The late 1940s and early 1950s were a period of change in the understanding of New Zealand prehistory. Traditional Maori accounts were beginning to be questioned by archaeological enquiry although interest in these accounts remained strong (Groube 1993). Roger Duff’s *The Moa-hunter Period of Maori Prehistory* (1956) reflected this transition, containing a huge amount of archaeological data, but still relying heavily on traditional information to supplement holes in the archaeological record.

Duff’s excavation of Wairau Bar provided a rich array of artefact types in association with moa bone, which he used to define the Moa-hunter period (Duff 1956, 1977). The lack of any direct stratigraphic relationship between Moa-hunter and later Maori layers required Duff to rely on oral tradition to establish the relative antiquity of his periods (Allen 1987). Following Haast, Duff reasoned that the lack of traditions regarding the moa suggested that any cultural material associated with moa remains were likely to be of greater age (Duff 1947). Furthermore, Duff employed an age area hypothesis in his analysis of adzes. He reasoned that the first people to leave would carry the complete range of specialised adzes from the cultural epicentre. Although the core culture continued to develop its adze kit, generally simplifying its range and style, the marginal populations would be more conservative, even static, and continue to make a
wider range of adzes, such as those associated with the Moa-hunter populations (Duff 1977). Duff suggested the relatively simple 2B adze (rounded quadrangular cross section, un-tanged), most commonly associated with the northern Maori culture, was a later development within a new ‘cultural centre’ in the North Island.

In describing the mechanisms of change, Duff used an eclectic range of models. Regarding the North Island, Duff stated that change toward the simple adze form arose “from the Moa-hunter variety” (Duff 1977: 144), suggesting he believed change from the Moa-hunter to Maori period occurred in some, but not all, places. Barber (1994) asserted Duff saw such change as being evolutionary. However, in the true sense of evolutionary models (i.e. progression from simple to complex) Duff’s ideas cannot be considered evolutionary (Groube 1967). Indeed, early in his monograph Duff states that:

“…human cultures obey much the same laws as human lives in that to persist they must be transmitted and change is inherent in the transmission” (Duff 1956: 2)

From this statement Groube (1967: 9) argued that Duff viewed change as a process analogous to drift rather than true evolution. Duff also invoked outside stimuli from waves of new immigrants, which ceased after the great fleet (c. A.D. 1500). The introduction of taro, yam, gourd, and kumara, spurred on by favourable environmental conditions in the North, was the catalyst for regional cultural change, which saw the Moa-hunter become Maori (Duff 1962). The South Island, however, was in a marginal position for horticulture and remained away from the main migration stream. Here the driver for change was regarded as internal migrations from the north.

2.3.3 Archaic and Classic

As the first professional archaeologist in New Zealand, Jack Golson brought a material culture focus and gave little attention to oral traditions, which he viewed as dealing with a different realm of culture than archaeology (Golson 1960: 380). Following Childe (1956), Golson argued that the basic level of archaeological study – the culture – should be defined by recurrent assemblages of archaeological types (e.g. artefacts, house plans, mortuary practices), which represented the recoverable
remains of communities. Golson’s focus was to place the archaeologically observed patterns into “their correct geographical and chronological positions and study their developments and interrelationships” (Golson 1959: 30).

Golson’s (1959) paper *Culture Change in Prehistoric New Zealand* is arguably the most influential paper in New Zealand archaeology. The paper introduced a formal framework for archaeological material consisting of three facets: culture, phase, and aspect. Golson viewed New Zealand prehistory as belonging to one culture, the New Zealand East Polynesian Culture. Within this culture chronological variants were termed ‘phases’, defined as “significant associations of material” (Golson 1959: 33). This included both presence and frequencies of types in an assemblage, with significant differences between assemblages deciding inclusion in a given phase. Regional variation was also included in Golson’s scheme; change brought about by local developments unique to an area was termed an ‘aspect’ of a phase. Therefore, the phase represented “the chronological variant of a culture and the aspect the regional variant of the phase” (Golson 1959: 33).

Golson argued New Zealand prehistory consisted of a single culture, thus the phase became the focus of Golson’s culture change model. Golson included two phases in his scheme: an early phase, the Archaic Phase of New Zealand East Polynesian Culture (Archaic), and a later phase called the Classic Phase of New Zealand East Polynesian Culture (Classic). A third, transitional phase was also discussed although this was theoretical rather than empirical (Golson 1959). The term Archaic was offered by Golson as an alternative for the Moa-hunter period due to perceived ambiguity in the original term. In particular, Golson noted that an assemblage could be included in the Moa-hunter period if artefact types matching East Polynesian types were present. Therefore, it was possible that the inhabitants of a site could be termed Moa-hunter despite never having hunted moa. For Golson, the term Archaic had a single connotation as a relative cultural phase (Golson 1959: 36) and lacked connections to change related purely to economic or subsistence behaviours. By precluding such things, Golson was able to develop an artefact-based cultural assemblage (Figures 2.3 and 2.4) without the implications that the two phases were separated by economic change (Allen 1987).
Figure 2.3 Artefacts associated with Golson’s Archaic phase in New Zealand.
Figure 2.4 Artefacts associated with Golson’s Classic phase in New Zealand.
Selected assemblages used to define the Archaic Phase included the South Island sites of Kings Rock, Papatowai, Little Papanui, Shag River Mouth, and Wairau Bar. While in the North Island sites from the Horowhenua coast, Motutapu Island, Sarah’s Gully, and Opito Bay were used. Broadly, the artefacts that defined the Archaic Phase (Figure 2.3) resembled East Polynesian forms, with large gripped adzes, bone or ivory necklaces, and one-piece and trolling lure hooks (Golson 1959: 39).

In defining his ‘Classic Phase’ Golson noted that the arrival of Europeans to New Zealand “caught prehistory alive” (Golson 1959: 47), therefore much was known about the later phase. However, the abundance of ethnographic and traditional accounts surrounding the phase had minimised the impetus for archaeological enquiry, meaning little solid archaeological information about the later phase was at hand (Golson 1959). Therefore, much of his Classic phase material (Figure 2.4) was merely a prediction of types expected to appear archaeologically based on descriptions in European sources, which were often patchy and incomplete (Golson 1959). These included simple, un-gripped, quadrangular adzes made of nephrite and poorer quality local stones, and two-piece composite fishhooks and pendants predominantly made of nephrite. The Classic phase was also noted for the emergence of weapons, most notably the *patu* (clubs) group (Golson 1959: 47-65). In considering the process of culture change, Golson favoured an evolutionary model in which the Archaic phase developed into the Classic. He suggested that the complete evolutionary series of change would probably be found in the North Island where Classic culture was said to have developed.

The scheme proposed by Golson has been discussed and criticised for many reasons since its inception, Golson himself noted his framework was not necessarily inclusive of all available evidence (Golson 1986). However, Groube’s (1967) critique is perhaps the most prescient. Groube criticised Golson’s focus on periods of conservatism (Golson’s Archaic and Classic), rather than the peaks of change between them (Golson’s Transitional). He argued this showed only that culture changed, with little concern for tempo (Groube 1967: 24). As an alternative, Groube suggested a move away from using essentialist stages in favour of a ‘strophic’ model, which recognised peaks of change in the archaeological
record. Groube proposed four strophic models (Figure 2.5), with each having some support from the archaeological record. Unfortunately, the tendency of New Zealand archaeologists to favour essentialist schemes has meant Groube’s (1967) models have not been given the consideration they deserve.

![Figure 2.5 Four variants of Groube’s (1967) strophic model. A – constant rate of change model; B – Two strophic model with the first stroph representing initial adaptation and the second a ‘late efflorescence; C – Exponential model where change accelerated with population growth and expansion of subsistence activities; D – One-stroph model where change is driven by cultural intrusion.](image)

More recent criticism of the Golson model has focussed on its tendency to polarise archaeological remains toward early and late, making it altogether unhelpful for understanding culture change (Davidson 1984; Furey 2004). Golson himself noted that the structure of his model contains flaws, but arguably it is one of the perceived strengths of the model – its flexibility - that currently causes the greatest problem. While Golson developed his model using material culture alone, the flexibility of the model allowed phases to be reloaded with associated information such as settlement pattern and economic data. This serves to strengthen the idea of Golson’s phases as ‘real’ and useful entities for the explanation of change. However, the refitting has not been carried out in empirical fashion, therefore the phases have become very generalised units with little analytical value. Despite the misgivings of many archaeologists (see Holdaway and Furey 2004), the Archaic/Classic model remains the most widely used model in contemporary New Zealand archaeology.

### 2.3.4 Multi-stage Approaches

Working within the broad framework of Archaic and Classic, Roger Green’s *Review of the Prehistoric Sequence of the Auckland Province* (1964) adapted and challenged aspects of Golson’s scheme. Green proposed multiple phases within two distinct
cultures (an early and a late roughly equivalent to the Archaic and Classic) based on economy, ecology and settlement type. The holistic approach employed by Green placed little to no importance on portable artefacts due to their relative scarcity in the North Island, preferring to apply them to broad temporal units (Furey 2004).

Green’s view of culture change was more explicitly evolutionary than previous scholars. For example, Green suggested that Maori settlements changed from temporary encampments toward structured nucleated settlement (Green 1964). Assessing his own work, Green (1975) suggested some of his phases had proved unviable, however, he continued to support the division of the Archaic phase into early and late (Barber 1994). More notably, Green eventually abandoned his evolutionary view in favour of a more dynamic and sometimes cyclical process of change (Walter et al. 2006).

Janet Davidson (1984) developed the last national model of culture change. To counter what she saw as the polarising force of Golson’s model, Davidson (1984) proposed a three stage model involving settlement (colonisation to AD 1200), expansion and rapid change (1200 – 1500) and traditional (1500 – ) periods very similar to models proposed in East Polynesia. Her settlement period saw the large-scale exploration of New Zealand and exploitation of all suitable resources. Subsistence patterns were established and adapted to local environments and material culture continued to have strong affinity with East Polynesia (Davidson 1984: 223). This was followed by a period characterised by expansion and rapid change. Here population grew significantly, leading to developments such as pa and stringent ritual rules. In some areas the decline of the moa facilitated economic change, generally toward agriculture. Artefacts that disappeared were believed to do so gradually as later forms replaced them. The traditional period contained most of the characteristics found at European contact. The period was marked by slower change and development in certain artefact types (such as Maori combs, discussed above). In a similar manner to those before her, Davidson placed much of the emphasis of change within a dynamic middle period. This model, despite its generalist nature was never readily applied to New Zealand archaeology, possibly because of the similarity with past models of change.
However, the elevation and effectiveness of economic, ecological, and settlement data in proving variation and change through time in Green and Davidson’s models gave rise to a much broader focus in New Zealand archaeology. As a result, the comparative study of artefacts as cultural and chronological indicators, which were central to earlier sequences, was generally discouraged (Barber 1994).

2.3.5 Summary

In the 30 years since the publication of Davidson’s (1984) cultural model the archaeological sequence has had little consideration. As Allen (1987) noted, the result of this archaeological inertia is an understanding of New Zealand culture little advanced from Duff’s (1956) model, something that remains true today. Indeed, reviewing the development of archaeological sequences in New Zealand one may argue the contemporary archaeologist still follows the rationale of Haast or McKay who note an early population which (somehow) developed into later Maori. Barber (1994) has suggested that existing sequence models are advantageous for the interpretation and description of archaeological data as well as providing testable hypotheses about prehistory. However, Barber cautions that integrative sequence models have too often become inflexible schemes into which new data is fitted, rather than hypotheses tested by new data. In these circumstances sequence models become obstructive to the understanding of archaeological questions (Barber 1994). This observation is perhaps the most pertinent criticism of the cultural models discussed above.

This section has provided a detailed review of cultural models in New Zealand from the 19th century to the present day. The following sections provide more context for the current research by detailing the current state of knowledge in key areas of New Zealand archaeology, such as settlement and subsistence.

2.4 New Zealand Archaeology in Context.

Human colonisation of the Pacific Islands began during the Pleistocene, some 40,000 – 50,000 years BP, with the movement of people into Papua New Guinea and the northern Solomon Islands (Walter et al. 2010). Much later, between 3,500
and 3,300 BP, a second phase of immigrants arrived in this area from Island South East Asia. The subsequent interaction between established populations and newcomers gave rise to the cultural complex known as ‘Lapita’ (Summerhayes 2000). The Lapita Cultural Complex is characterised by intricately decorated pottery, mixed subsistence involving domesticated cultigens and animals (pig \([\text{Sus scrofa}]\), dog \([\text{Canis familiaris}]\), and chicken \([\text{Gallus gallus}]\) and wild resources, and large-scale interaction networks that maintained social and economic contacts over large distances (Kirch 1997). Technological innovations were also part of the Lapita Cultural Complex. In particular, new sailing technology allowed the Lapita people to cross the barrier between Near Oceania, with its closely spaced, intervisible islands, and the previously uninhabited Remote Oceania, where islands were both sparse and generally smaller. The Lapita diaspora occurred rapidly, reaching its eastern extent in Samoa by around 2900 BP (Green 1991; Kirch 2010).

Figure 2.6 The Pacific Islands showing the sub-regions of Polynesia as discussed in this research.

It is from the Western Polynesian islands of Samoa and Tonga that East Polynesia was settled, beginning with the colonisation of the Society Islands by at least 1000
BP (Wilmshurst et al. 2011) or perhaps a few hundred years earlier (Kahn 2014). Radiocarbon dates from early phase sites in East Polynesia suggest that the process of colonisation was rapid. This rapid colonisation, together with ancestral relationships and on-going contact in the form of interisland voyaging spheres (Weisler 1998; with the exception of some remote Polynesian islands that were isolated after colonisation), led to a fairly homogenous expression of culture in early East Polynesian sites (Walter 2004). The consistency of expression is remarkable given the variety of island types (i.e. atolls, high volcanic islands, and near continental-scale landmasses) located between latitude 20°N and 50°S and representing a diverse range of environments from tropical to sub-Antarctic (Kirch 1984). Understanding the East Polynesian cultural suite that arrived in New Zealand is crucial to this thesis, therefore East Polynesian archaeology is considered in greater depth in a later chapter (Chapter 4).

### 2.5 New Zealand Archaeology

New Zealand was colonized from central East Polynesia as part of the last wave of Austronesian expansion in the Pacific (Walter et al. 2010). The colonists brought with them a typically East Polynesian culture including tools, subsistence practices, and selected cultigens (Davidson 1984; outlined further in Chapter 4). In addition, lived experiences, ideology, and practical knowledge were 'transported' throughout East Polynesia via the colonists themselves (Thomas 2008). As we have seen, the expression of the East Polynesian Cultural Complex in New Zealand and, importantly, its change into a recognizably Maori culture has been the focus of intense archaeological investigation. The following section reviews selected aspects of New Zealand archaeology relevant to the current research.

#### 2.5.1.1 Colonisation

The colonisation date of New Zealand, as elsewhere in Polynesia (Chapter 4), has been the focus of a significant amount of revision and debate in the last two decades. Prior to the development of radiocarbon dating the use of whakapapa or generational counts, was applied to establish New Zealand’s discovery at around AD 900 and settlement around two hundred years later (Smith 1913a, 1913b; Best 1924). This approximate chronology remained in place and was largely supported
by early radiocarbon dates suggesting settlement between AD 800-900. Thus, the orthodox chronological model was established, suggesting New Zealand’s prehistoric sequence was approximately 1000 years in length (AD 800 – 1769; Higham and Jones 2004).

The first major critique of this model was stimulated by a deconstruction of the orthodox settlement scenario in Polynesia (Kirch 1986; discussed further in Chapter 4). Sutton (1987) re-interpreted palynological evidence arguing that there was evidence of forest clearance much earlier than the settlement dates supposed by Davidson (1984) and that a date of as early as AD 250 was possible. Subsequent analysis of forest clearance has overturned this suggestion. In particular, evidence for large-scale anthropogenic firing (known as the ‘initial burning period’) is now fixed to the period following AD 1300 (McWethy et al. 2014).

Dating of commensal animals, particularly the Pacific Rat (*Rattus exulans*), also suggested a relatively long chronology. The early results from rat bone dates suggested the commensal species might have been present in New Zealand between c. BC 50 – AD 150 (Holdaway 1996). Holdaway (1996) suggested this was most likely the result of transient visitations to New Zealand rather than colonisation. However, such an early landfall makes the likelihood of an earlier colonisation much higher. Holdaway’s results have been challenged on the grounds of insecure context, methodological concerns, and the lack of corroboration from repeat sampling of the sites (Higham and Jones 2004). A recent and substantive analysis of rat bone and rat-gnawed seed data from New Zealand has suggested that the commensal species was likely introduced in around AD 1280 (Wilmshurst et al. 2008).

Anderson’s (1991) analysis of radiocarbon dates from early New Zealand was diametrically opposed to Sutton’s model and dramatically shortened the supposed length of New Zealand’s prehistory. Anderson’s ‘chronometric hygiene’ approach assessed radiocarbon determinations according to material dated, security of archaeological context, the presence of at least two dates from the same context, and consistency of a series of dates from a single context (Anderson 1991). By
culling all questionable dates, Anderson identified a colonisation date of not earlier than AD 1100.

The ‘short-chronology’, predominantly based on the work of Anderson (1991), is now the dominant paradigm in New Zealand archaeology. Although Anderson initially suggested a colonisation date of around AD 1100, subsequent analysis of radiocarbon determinations by the Waikato radiocarbon unit (Higham and Hogg 1997) showed that no secure dates could be found prior to AD 1250. Indeed, in a review of dating procedures in New Zealand, Higham and Jones (2004) argued that archaeologists may be confident that humans arrived in New Zealand between AD 1250 – 1300, a loss of around 500 years (or half) of the original sequence length. Despite the significance of this result, archaeologists have so far failed to reconsider evidence within this new framework (discussed below).

2.5.1.2 Settlement and Economy

Initial settlement in New Zealand occurred in coastal zones predominantly associated with river mouths, estuarine environments, and sheltered bays (Walter et al. 2006). These locations provided access to a variety of local perennial resources and may also have been situated for easy access to the interior where both food and lithic resources could be found (Anderson 1982a). Many early sites also appear in locations where access to both widely dispersed moa (Aves: Dinornithiformes) populations and more localised seal (Arctocephalus forsteri) colonies overlapped (Anderson and Smith 1996; Walter et al. 2006). The basic settlement in the early period was a small village or hamlet (Anderson and Smith 1996a). These villages typically had butchery areas, which, taken together, are suggestive of settlement permanence (Anderson 1982b; Anderson and Smith 1996). Village size appears to have been dictated by resource abundance, thus the largest village sites are located on the east coast of the South Island where game resources were the greatest (Anderson 1989). The location of early New Zealand sites is consistent with contemporary sites in East Polynesia, which are typically located on the leeward coast of islands and/or near reef passages where access to a variety of resources was maximised (Walter 2004). The intra-settlement structure, particularly defined activity zones, is also consistent with village sites such as Anai’o in central East Polynesia (Walter 1996).
This suggests that, while there is evidence of a nucleated community (perhaps a hapu or sub-tribe), the most basic and perhaps functional unit of organisation was probably the whanau (family or household).
In southern New Zealand villages are said to have formed the core of an overall landscape exploitation strategy (Anderson and Smith 1996; Smith 1999). Villages were staging points for big game hunting, fishing, and birding activities, but also provided a fixed base for the community to operate. Smaller, single-purpose sites existed in conjunction with villages to enable exploitation of the wider regional environment. Specialist fishing camps, such as Kings Rock, have been noted in southern New Zealand (Lockerbie 1940), as have inland sites such as Hawksburn and Coal Creek. These inland sites are probably specialised Moa-hunting camps used by expeditions into the interior to hunt and butcher moa (Anderson 1983). Importantly, Anderson and Smith (1996) suggest that villages may have been home for only a proportion of the population of the region at any one time.

Larger villages appear to have been occupied for between 20 and 50 years (Anderson and Smith 1996), while other village sites may have only lasted a few years and single purpose sites were likely occupied on multiple occasions for very short periods (Sutton and Marshall 1980; Walter et al. 2006). The eventual abandonment of village sites appears to have been driven by localised resource depression and smaller returns for foragers, at which point settlements were relocated to the next high quality resource zone (Anderson and Smith 1996; Nagaoka 2001, 2002). Walter et al. (2006) have recently argued that core elements of the transient village model, developed in southern New Zealand, can also be applied to other regions of New Zealand (Walter et al. 2006). In the North Island evidence of a range of activities occurring at Houhora has led Furey (2002) to argue that the site fits the criteria for a village, and the small river mouth site of Kaupokanui may also be a candidate (Walter et al. 2006). While these sites are similar to their South Island equivalents, they are smaller and show a different subsistence focus (fishing, supplemented with moa and seal at Houhora and just moa at Kaupokanui; Allen 2012). Evidence suggests that big game species were unequally dispersed and far less abundant in the North Island (McGlone et al. 1994; Holdaway and Jacomb 2000), which may be a factor in the relatively small size and variable subsistence base present in early settlements. The discrepancy between the north and south provides an interesting insight into social structures in the early period. On the basis of the large village sites in the South Island it can
be assumed that, where possible, small groups would coalesce. However, the presence of single-function sites and smaller villages in the North Island suggests that these large groupings were not crucial, and that the major social unit was the *whanaua* (household), consistent with the household-scale organisation observed in the ancestral regions of East Polynesia (Kirch and Green 2001).

In the south, change in settlement is thought to have occurred as a result of declining availability of big game resources and climatic deterioration (Lockerbie 1959; Anderson 1983). Moa species became extinct across New Zealand within 100 years and probably much quicker in some areas (Holdaway and Jacomb 2000; Holdaway et al. 2014). Fur seals were reduced to isolated locations within 200 years (Smith 2005). A decline in temperature between c. AD 1300 and 1600 (see above) may have meant previously marginal areas for the growth of tropical cultigens became unsuitable. The combination of these factors led to an increase in importance of offshore fishing and exploitation of shellfish (Anderson 1983). Hunting of small game and the exploitation of resources in the interior also became important and may have promoted movement to a more dispersed and mobile settlement pattern (Jacomb 1995; Anderson and Smith 1996), perhaps more akin to early sites in the North Island. The idea that southern New Zealand was largely abandoned following the decline of moa is also common (Lockerbie 1959; Simmons 1969; Hamel 1977, 1982). Around the Foveaux Strait, Jacomb et al. (2010) noted that sites were generally very small with little evidence of repeated occupation. Moreover, they demonstrated that radiocarbon data showed no evidence of occupation in the period between moa decline and European contact. Excavations on Codfish Island (*Whenua Hou*), also suggested a similar bi-modal pattern of early Archaic and early contact settlement (Smith and Anderson 2008). To accommodate this information Jacomb et al. (2010) argued that this area was abandoned until the very late prehistoric phase while northern areas of the non-horticultural zone likely experienced a reduction in population. This view seems to be supported by the general decrease in size and complexity of sites in the non-horticultural regions until very late prehistory or the early historical phase (Anderson 1982a; Anderson and Smith 1996).

In horticultural areas, particularly in the North Island, population is argued to have increased rapidly as horticulture developed; however, only in optimal horticultural
areas (Figure 2.7) for crops such as *kumara* or sweet potato (*Ipomoea batatas*) did the reliance on horticulture surpass hunted or gathered resources (Walter *et al.* 2006). Walter *et al.* (2006) argued that settlement patterns showed continuity with the settlement structures in early New Zealand. In particular, the authors suggested that the settlements noted by early European explorers typically consisted of a cluster of huts being occupied by an extended family (*hapu*) group – perhaps twenty people – that exploited a region within a greater tribal territory. These sites were both ‘open’ or undefended sites and defended sites (*pa*) consisting of storage pits and living terraces. *Pa* are the most distinctive site type in New Zealand. They emerged in the period after c. AD 1500 (Schmidt 1996), are most commonly found in defensible positions, and generally consist of a series of ditches, banks, and palisades, although their forms differ greatly. *Pa* are most abundant in northern areas where population density was greatest, with a gradual drop in numbers toward to the non-horticultural south (Figure 2.8). While some *pa* were likely to have been occupied year round, many may simply have been used as places of refuge during warfare (Irwin 1985).

Walter *et al.* (2006) argued that settlement patterns exhibit a degree of continuity through time, with *pa* fulfilling a similar role as villages in the early period and fission and fusion of groups common. In particular, smaller groups may have split away from larger groups to tend crops or forage for wild resources. Rapid nutrient loss in New Zealand soils and localised depression of bracken fern probably encouraged settlement movement around the landscape (Allen 2012; Allen 1996; Phillips 2000). Smaller *whanau* or *hapu* groups coalesced to share food and to pool labour for the construction of *pa* (Allen 1996; Walter *et al.* 2006).

*Pa* are often connected with increased social complexity in later New Zealand. *Pa* are seen as the focus of settlement (and authority) and/or monumental displays of power (Irwin 1985; Barber 1996). Irwin’s (1985) analysis of settlement on the Pouto peninsula, Northland, found that *pa* were distributed equidistant across the landscape suggesting they were placed relative to each other, while undefended sites were placed in relation to resources. Irwin (1985) argued that three types of *pa* exist in Pouto: small *pa* that acted as independent units, small *pa* that appear to
have had some influence over other small *pa* near them, and large *pa* that were used by the wider community, perhaps when faced with outside threats.

Figure 2.8 New Zealand showing the distribution of *pa* sites and the southern limit of horticulture.
The largest pa in New Zealand are approximately 25 hectares in size (Marshall 2004; Walter et al. 2006); however, many show little evidence of sustained occupation. Moreover, large-scale excavations of large pa have indicated that only small parts were occupied at a given point in time (Sutton et al. 2003; Walter et al. 2006). This supports the notion that large settlements were not common in New Zealand and that small village and specialist sites remain the key settlement types during the late period (Walter et al. 2006).

2.5.2 Trade, Exchange and Mobility

The majority of prehistoric settlements throughout the New Zealand sequence were coastal; however, occupants of the coast also exploited resources from other locales within their kin territory and beyond. The early occupants of New Zealand quickly located sources of high-grade, flakeable stones such as Tahanga basalt, Nelson argillite, and Mayor Island obsidian (Davidson 1984). Adze-making stones such as basalt and argillite spread many hundreds of kilometres beyond their source area (Figure 2.9) while Mayor Island obsidian (used for simple blades and scrapers) is present in almost all early sites from the sub-Antarctic islands to the Kermadec Islands north of New Zealand (Sheppard 2004).

The exact nature of the exchange/procurement of the stones remains ambiguous. Sites with both large amounts of debitage and sites with no debitage have been excavated, suggesting both exchange of materials and direct procurement operated. In later prehistory high-grade stones, ubiquitous in the early period, became largely restricted to local exploitation (Davidson 1984). In their stead, the use of nephrite (jade) increased for both adzes and ornaments and local, poorer quality, cherts, and quartzites replaced obsidian for simple cutting and scraping tools (Walter et al. 2010).

A similar pattern is noted in other areas of the Pacific, particularly the areas associated with the expansion of Lapita into Near Oceania (Irwin 1991; Sheppard 1993; Specht 2002). In these, and other, areas the initial period of long distance
exchange of goods is linked to the maintenance of communication networks with the homeland. These connections were vehicles for economic and social

Figure 2.9 Map of New Zealand showing the major lithic resources used in New Zealand prehistory and their distributions in space.
transactions, which were important both for pragmatic and communal reasons (Green and Green 2007). Walter et al. (2010) argued that a similar process occurred in New Zealand; however, because it was difficult to maintain contacts with the true homeland, early Maori focused on maintaining relationships with the many dispersed communities around the archipelago. In their model the breakdown of the initial exchange network occurs when population increased to a sufficient level that regional trade networks presented similar positive outcomes without the need for extensive voyaging (Walter et al. 2010). Either increased territoriality around the resource or resource depletion has been suggested as alternative explanations for the decreased circulation of high-grade stone, such as Nelson argillite (Barber 1996).

The presence of nephrite, which predominantly occurs on the West Coast and in inland southern New Zealand, shows that some trade did continue into the later period. It is likely that this trade was much broader than nephrite, including perishable items such as woven flax mats. Walter et al. (2010) suggested that later trade was based on the perceived value of the nephrite as a tool and for ornamentation and may not have had the same drivers as early trade systems.

2.5.3 Material Culture in New Zealand Archaeology

Material culture is the major source of data for this thesis. In particular, this research focuses on adzes and fishhooks, which are the focus of more in depth discussions in Chapter 7 and 8. This section gives a general overview of material culture studies in New Zealand, focussing on those that have tried to develop an understanding of change over time.

In New Zealand material culture has served as a means to understand, among other things, trade and exchange, technological change, and site function (Pickett 1982). However, the most common use of formal artefacts has been to infer regional, cultural, or temporal patterns of change (Furey 2004). Many studies have argued that material culture in New Zealand has undergone vast changes from the early to late periods (Golson 1959). The following discussion focuses on studies
concerned with the description of formal portable artefacts and the assessment of
patterns of change in these kits through time.

From the late nineteenth to mid-twentieth century the interest in Maori ‘curios’ led
to widespread informal digging at archaeological sites and the collection of
material culture (Samson 2003). In the South Island large artefact-bearing sites
were continuously targeted whereas, in the North Island, single artefacts were
generally serendipitously collected. In both cases the eventual centralisation of
these collections led to a great interest in the description of artefacts. In the South
Island this description took the form of typological studies, which were then used
to develop sequences of change (e.g. Duff 1956; Hjarno 1967). The relatively large
amount of material culture found in the South Island has led to a correspondingly
large amount of studies with material culture at their core. The absence of firm
archaeological contexts for many North Island artefacts meant that studies
necessarily focussed on the functional use of different artefacts (e.g. Crosby 1966;
Turner 2000), as such studies required neither large numbers of artefacts from a
single site nor solid archaeological context.

The advent of stratigraphic excavation provided the means to understand change
in material culture through time by recording the stratigraphic position of artefacts
relative to each other. Lockerbie’s (1940) excavation at Kings Rock recognised the
changing proportions of fishhooks in layers within the site. Lockerbie focused on
the presence of barbs, which had previously been considered a later development
in New Zealand, and noted their common presence throughout all layers of Kings
Rock. He was also able to detect differences, such as the presence of un-barbed
points with projections exclusively within the lower layers, which he linked with
the changing economy of South Otago.

Subsequent material culture studies supported Lockerbie’s descriptions of
changing frequency of artefact types through time. Michael Trotter (1965)
reviewed fishhooks from North Otago sites and ordered them based on the
frequency of artefact types, faunal remains, and limited radiocarbon dates. Trotter
showed a decrease in un-barbed one-piece hooks and a corresponding
proliferation of barbed two-piece hooks (Trotter 1965). Evaluating Trotter’s
results is difficult as no data is presented to reinforce his judgement of site order.
Trotter himself also noted the small sample size from two of his sites (Ototara and Waimataitai) is problematic (Trotter 1965: 354). Despite this, he argues for an increase in two-piece fishhooks and a corresponding decrease in one-piece forms.

Using his typology in combination with available radiocarbon dates, Hjarno (1967) showed gradual change in fishhook types over time with those types associated with extinct fauna being replaced by those observed at European contact. Hjarno reviewed sites based on midden content, specifically the amount of moa compared with fish and shellfish. This revealed a strong association between early, moa-bearing middens and one-piece fishhooks, with a gradual decline in both moa remains and one-piece fishhooks through time. From this, Hjarno developed a site order with high percentages of one-piece hooks placed at the early end of the sequence and lesser frequencies placed later (Hjarno 1967: 37, graph 1). Analysis of other fishhook types, in particular the emergence of serrated hooks in the later period, as well as associated radiocarbon dates, appears to support his one-piece seriation.

Simmons’s *Suggested Periods in South Island Prehistory* (1973) attempted to define change in material culture and relate this to research on economic change in the South Island. Due to their continuous spatial and temporal distribution, adzes, fishhooks, and flake tools were selected for analysis (Simmons 1973). Using the relative frequencies of different types Simmons developed three independent site seriations, which he then cross-referenced to ensure consistency. Simmons noted a high agreement of site order and argued that sites grouped in a manner consistent with a four phase cultural framework (Simmons 1973).

Simmons’ work is problematic for a number of reasons, including mathematical error and methodological inconsistency (Jacomb 1995). For example, when explaining the method of grouping sites into four phases, Simmons vaguely explains that groupings “became evident during analysis” (Simmons 1973: 13). This ambiguity casts doubt over the chronological ordering of sites and, indeed, any phase designation, therefore this work must be regarded with extreme caution.

The most recent temporal analysis of artefacts was Jacomb’s (1995) work on northeast South Island sites. Jacomb identified two unique artefact assemblages
that ‘anchored’ the early and late ends of his artefact sequence (Jacomb 1995). Jacomb’s early anchor consisted of burials 1-7 from Wairau Bar, which, based on the work of Anderson (1989), were regarded as containing the earliest material. In the absence of any clear late period site, Jacomb employed Cook-era accounts from Queen Charlotte Sound, which he reasoned was the most reliable indicator available for the late time period.

Based on the composition of the anchor assemblages, Jacomb ascribed particular artefacts as being exclusively early or late, mostly early or late and continuously present. He then classified sites according to the percentage of artefacts belonging to these groups. Those sites consisting mostly of exclusively early forms were placed nearest to the early anchor assemblage, Wairau Bar. Jacomb identified three temporal groupings: early, middle, and late. Very little commonality was noted between each end of the sequence, which Jacomb (following Groube 1969) suggested was a result of relatively rapid change from early to late (Jacomb 1995: 202). The middle period did not conform to the material culture or settlement patterns of either the early or late periods, which Jacomb reasoned was because these sites represented a transitional period in New Zealand.

The only major consideration of material culture change through time in the North Island was the stylistic percentage stratigraphy analysis (see Lyman et al. 1997) of Maori combs found at the Kauri Point Swamp by Wilfred Shawcross (1964). Shawcross excavated an area rich in combs, each sealed within discrete horizons suggesting multiple depositional events. Applying the law of superposition, Shawcross constructed a directional series of comb styles. He found a strong inverse relationship between his type A (rounded top) and type B (flat and flat notched tops) with the latter being of greater age (Shawcross 1964: 391). Though these changes could not be linked to specific times, the study remains important as the only research to demonstrate, using stratigraphy, unequivocal evolutionary change in portable artefact forms (Shawcross 1964).

The previous attempts at understanding change through time and constructing models using material culture have had mixed success. In many cases these models have been closely tied to other lines of evidence, particularly economic, and have
not been formulated as independent hypotheses for testing models or to be tested themselves. Many early studies have been guided by poor or poorly explained methodology, which has led to doubts about the validity of finer elements of these schemes. However, despite the inherent problems in many of the previous models, at a gross level most have been able to demonstrate a level of systematic change in material culture.

In New Zealand, as in the rest of the world, the use of seriation-based studies generally fell out of favour with the introduction of processual archaeology. In the past two decades theoretical developments have led internationally to a renewed focus on portable artefacts and seriation as legitimate lines of inquiry (e.g. Lipo et al. 1997). Many of these ideas, such as the archaeological tradition, have yet to be applied to a New Zealand context despite their potential for understanding culture change. This is one of the aims of the current research.

Further to the region-specific studies reviewed here, material culture has also been used in frameworks of culture change at a national level. These studies (discussed below), together with the research discussed above and a number of smaller-scale studies, have contributed to a general understanding of the pattern of change in New Zealand as a whole. While this thesis contends that the finer points of this pattern and the processes that drive such change require revision, a summary of the patterns of material culture change shown by these studies is provided below.

Early assemblages in New Zealand are associated with material culture found in East Polynesia (discussed further in Chapter 4). In particular, early assemblages usually include large flaked stone adzes made from high quality stone. These adzes take a variety of forms but most notably have quadrangular or triangular cross sections (Duff 1977). Fishhooks are commonly fashioned out of one piece of bone – often moa – while shell is present but less common. Composite lures are also present (Davidson 1984). Other utilitarian items, such as harpoons, are almost exclusively found in early contexts, while awls, needles, and birdspear points are ubiquitous throughout the sequence. Early ornaments generally consist of whale tooth pendants or imitations fashioned from stone. Reel ornaments, so
called because of their resemblance to cotton reels, and drilled porpoise teeth are also associated with early sites (Golson 1959).

Later sites, particularly in the North Island, yield a smaller amount of material culture. Adzes from this period are smaller and fashioned from locally sourced stone or nephrite. The formal properties of adzes decrease in complexity and a simple rounded quadrangular form comes to dominate (Golson 1959). Two-piece fishhooks replace one-piece forms, points are made of bone, and shanks are fashioned from either wood or bone. Ornamentation undergoes the biggest change from early to late. Most ornaments from the early period cease to be produced, replaced by dropped pendants or ear pendants made of nephrite. Whale tooth pendants, in an adapted form, do persist into late prehistory (Golson 1959).

2.5.4 Demography

Explicit consideration of population in prehistoric New Zealand is rare. When it did occur it commonly focussed on absolute population size at the beginning and end of the prehistoric sequence (Pool 1991; Whyte et al. 2005). While a small group of studies have considered the pattern of population growth, closer examination of these studies reveals very little empirical foundation. Given this, an in-depth consideration of past population in New Zealand is required, which is outside the summary remit of the current chapter. Therefore, a review of demographic studies in New Zealand is provided at the beginning of Chapter 5, which focuses on the demographic analysis conducted in this research.

2.6 Conclusion

This chapter has provided a brief overview of patterns in New Zealand archaeology. It has also shown that the understanding of cultural change in New Zealand has centred on evolutionary ideas and the effects of migrations. Population increase, pressure on economic resources, and adaptation to the New Zealand environment also feature to a lesser extent (Davidson 1984). The lack of recent developments in the understanding of culture change appears to be the result of an over-reliance on the development of essentialist phases or periods,
which, as Groube (1967) suggested, provide little information about the timing or processes underlying change. Like Groube, Holdaway (2004) has argued that any re-evaluation of culture change would benefit from consideration of evidence from a more materialist perspective rather than the usual reliance on discrete phases. Moreover, a consideration of differential rates of change in artefact lineages and in different regions is also likely to be profitable.

I agree strongly with Holdaway and argue that the consideration of culture change through a new lens is necessitated by the accumulation of new data over the past 20 years. Perhaps most significantly, the revised starting point of the New Zealand sequence from around AD 900 to the late thirteenth century has removed entire phases from some models, contracting the period in which change is supposed to have occurred from over one thousand years to less than five hundred. Such a change renders the gradual change proposed in many earlier models untenable, yet so far the response of New Zealand archaeologists has been to force existing models into the restricted timeframe. The alternative is to reassess the archaeological record using theory and method specifically designed to address change through time. The following chapter introduces the Darwinian archaeological theory at the core of this research and the methods that will be used in the analysis of material culture.
3

New Directions: Theoretical Perspectives on
Population and Culture

“Chronology emerges from the search for changing spatial patterns through time, not from the imposition of a phase structure imposed before analysis begins.” (Holdaway 2004: 25)

3.1 Introduction

Chapter two of this thesis presented a review of New Zealand archaeological data and many of the frameworks into which this data has traditionally been placed. It revealed a number of problems with these organisational frameworks and, in so doing, emphasised the necessity of applying new theoretical perspectives to New Zealand archaeology. This chapter introduces Darwinian archaeology as such a perspective and outlines its key concepts. Following this, the chapter discusses the importance of comparative analysis in aiding our interpretation of New Zealand data.

3.2 Key Gaps in Current Theoretical Perspectives in New Zealand

In the previous chapter I argued that when it comes to change over time most cultural models in New Zealand have acted as descriptive mechanisms rather than as models to explain the timing of, and generative processes behind, culture change. Critique of such models has primarily focussed on the problems with ‘stagal’ models (Groube 1967) and the continued re-packaging of such models at the expense of new approaches (see Chapter 2; Groube 1967; Allen 1987; Barber 1994).
While the critique of cultural frameworks is important, other, more veiled, aspects of the discussion of culture change are equally significant. In the last several decades New Zealand archaeology has tended toward approaches that favour adaptationist explanations of change. In particular, the non-tropical and variable nature of the New Zealand environment is commonly seen as a major factor in the emergence of a Maori culture from its tropical Polynesian antecedent (Walter 2004). Thus, the role of selection in the process of change is taken as a default position. In combination with predominantly dual-stage models, the adaptationist perspective has contributed to a relatively simple view of culture change in New Zealand that involves two phases: the early (or Archaic), representing localised adaptation of the central East Polynesian Archaic to New Zealand conditions; and the late (or Classic) phase, representing a large-scale adaptation to new endogenous and exogenous factors that emerged in New Zealand around two centuries after settlement (e.g. Davidson 1984). This account places limited emphasis on the role of neutral or stylistic change, which, in contemporary archaeology, is now recognised as an important explanatory variable (Shennan 2002).

Furthermore, little consideration has hitherto been given to the potentially negative influence of the culture concept on which most cultural frameworks are based. Here, I contend that the definition of culture in terms of regularly recurring types (e.g. Childe 1956; Golson 1959), while a useful descriptive method, is unhelpful when considering culture change through time in New Zealand. To address this and the other shortcomings briefly reiterated above, a new theoretical position is required, which views culture as a more dynamic entity. The following sections present a theoretical alternative to the traditional use of synchronic ‘stages’, focussing instead on change over time in cultural traditions.

3.3 New Directions

Understanding the pattern and processes that underlie continuity and change in the material record is among the most important concerns of archaeology. To address the questions that develop from such a concern requires a theoretical perspective specifically developed for the purpose. Therefore, this thesis employs a
Darwinian archaeological perspective, which is built upon theory and method from the likes of behavioural ecology and, more importantly for this research, dual inheritance theory (DIT; Boyd and Richerson 1985). Dual inheritance theory, also known as gene-culture coevolution, recognises both genes and culture as important components of human evolution. DIT is based on a description of culture vastly different than that currently applied in New Zealand archaeology. The developers of DIT, anthropologists Richerson and Boyd, explain culture as:

“...information capable of affecting individuals’ behaviour that they acquire from other members of their species through teaching, imitation, and other forms of social transmission.” (Richerson and Boyd 2005: 5).

A key aspect of this description is the idea that culture is passed on through transmission and, therefore, heritable links exist between aspects of culture through time (Mesoudi 2009). Due to the heritable nature of culture, explicit parallels can be drawn with biological ‘descent with modification’ through mechanisms such as reproduction, mutation and selection and cultural evolution (Shennan 2002; 2009). However, whereas in biological evolution genetic information is passed on through reproduction, in cultural evolution information is transmitted between and within generations via social learning (Steele et al. 2010). This different inheritance mechanism requires its own set of ideas, nomenclature and predictions to define the processes that generate continuity and diversity in cultural evolution; this set of ideas is the basis of DIT.

Richerson and Boyd (2005) outline a range of factors that contribute to cultural descent with modification. These factors fall into either random or non-random (decision-based) forces. The major random mechanism in cultural evolution is drift, or neutral evolution, which is heavily influenced by population size (discussed below). Non-random factors include ‘guided variation’, the process by which novel traits are developed through trial and error and, both direct and indirect transmission ‘biases’. Direct biases are those that lead to the retention of a trait or behaviour because of the perceived success or usefulness to people. On the other hand, indirect biases are those that promote uptake of cultural traits or behaviours irrespective of their quality or success. For example, a particular trait
may be ‘taken up’ if it is used by a person within the social group who has prestige despite offering no real benefit to the user. Each of these broad categories contains a number of specific factors for which the following section provides a more in-depth discussion.

3.4 Mechanisms of Change

In addition to the division between decision-based and random processes of change (above), there is also a clear distinction between processes that lead to the growth or decline of certain cultural traits and those that lead to the introduction of ‘new’ traits into a particular tradition. The following section considers both of these types beginning with a consideration of how and why novel traits come to develop.

3.4.1 Novel Traits: Copying Error, Invention, and Innovation

Accepting that cultural information is transmitted between individuals, one of the clearest means of developing ‘new’ traits or behaviours is copying error or ‘cultural mutation’ (Kempe et al. 2012). In a master-apprentice scenario, it is relatively easy to see that cultural mutations may result from a simple, unintentional change brought about by misinterpretation of (explicit or gestural) instructions by the novice. However, copying error is also present amongst craftspeople who attempt to imitate particular artefact forms. Gandon et al. (2014) asked skilled potters from three communities (2 in India, 1 in France) to produce vessels of four different shapes. The authors found that copying error occurred in all communities and that error increased with the complexity of the task. Interestingly, Gandon et al. (2014) also found that ‘complexity’ was culturally mediated: Indian potters were more familiar with bowl shapes, whereas French potters were more familiar with cylinder shapes. This familiarity, which shaped what was or was not a complex task within each group, was developed in the specific learning environment of each group and through the current activities of the potters.

Biological constraints also play a part in the development of unintentional error. In particular, our ability to accurately perceive differences between objects is limited
by the capacity of the human eye. The point at which difference cannot be perceived is not set; rather it is always relative to the size of the objects being compared (Kempe et al. 2012). This kind of copying error does not affect the overall shape of an artefact; however, the cumulative affect of such error may lead to the change in things like the length or width of artefacts (Eerkens and Lipo 2005; Kempe et al. 2012).

3.4.1.1 Invention and Innovation

Innovation and invention are distinct concepts in human cultural evolution, therefore it is important to outline the specific nomenclature used in the literature and in this thesis. Following Fitzhugh’s (2001: 128) definition, invention refers to the development of a novel or untested device or behaviour, with inventiveness being the tendency to produce these novelties. Conversely, innovation is the process by which inventions are put into practice and spread, with innovativeness being the tendency to experiment and use new strategies or traits. Invention and inventiveness are discussed below and innovation is discussed in the following section.

3.4.1.2 Invention

Inventiveness is a widely discussed and highly regarded aspect of human society. Because of this, inventors are often seen as “singular heroic geniuses” (Henrich 2010; 107), or individuals who break the mould and invent entirely new and useful things. However, in reality, the kind of punctuated advancement this implies seldom occurs. Rather, inventions most often result from incremental changes to existing structures or the integration of traits and ideas from one tradition into another (Richerson and Boyd 2005). One of the most famous examples of this is James Watt’s ‘invention’ of the steam engine. While the Boulton-Watt engine was novel and a technological step forward, it was nevertheless an improvement on an earlier engine type and not invented from scratch (Henrich 2010).

The causes or generative forces behind invention are also commonly considered. The popular cause is succinctly expressed in the saying ‘necessity is the mother of all invention’. Indeed, this idea is also present in archaeology, particularly
processual archaeology, which suggests that most inventions were welfare-enhancing adaptations to external challenges (Fitzhugh and Trusler 2009). The idea that necessity may drive inventiveness has been revived and formalised, albeit with revisions, in the risk-innovation model (Fitzhugh 2001). The key aspect of this model is that inventiveness (and innovation) is costly. Those engaging in inventions do so at the expense of making or carrying out tried and tested behaviours. Therefore, in order for people to be more inventive, experimental, and receptive to new ideas, the payoff for the old ideas must be sufficiently low to make the risk of novel items or behaviours worthwhile. For example, during times of prolonged subsistence crises new behaviours may be favoured if they are perceived to offer greater returns than traditional methods (Fitzhugh 2001). It is important to point out that these inventions may or may not prove adaptively advantageous; the key thing is that they are perceived to be. In this way, both adaptive and maladaptive inventions should increase when risk-prone behaviour is supported (Fitzhugh and Trusler 2009).

While accepting the idea that some inventions are driven by necessity, Henrich (2010) argued that the influence of necessity is overstated and may have serious flaws in both logic and in supporting evidence. Addressing the logic of the risk-innovation model, Henrich pointed out that learners are not omnipotent and cannot accurately assess the invention cost associated with a technology they have yet to conceive, let alone the potential benefits it may bring. Secondly, he suggested that in times of stress, for example, when subsistence practices are bringing lower returns, people may actually have less time to devote to experimentation.

Henrich’s second argument involved an assessment of evidence for what generally happens when populations are placed under stress. Using a range of examples he suggested that while inventions may result from things such as population pressure or environmental shifts, more often these factors lead to emigration or death. The limited experimental literature on this topic is also drawn upon to counter the necessity argument. Summarising a set of laboratory results, Henrich (2010) suggested that when faced with uncertainty, participants move away from
experience-based solutions towards social learning. In other words, they copied more and invented less.

These evidence-based arguments are compelling, particularly the argument that technological improvement can derive from small-scale developments not born from any necessity but simply from a desire or a lucky coincidence that improves technology (e.g. the cotton gin; Henrich 2010). Indeed, the main point of Henrich’s article - that there is more to inventiveness than simple necessity – is well supported by this discussion. However, Henrich (2010) did mischaracterise aspects of the Fitzhugh (2001) argument, with his discussion of omnipotence providing a good example. Here, Henrich (2010) argued that in real world scenarios people cannot accurately assess the costs of an invention and the benefits it will return before they have even conceived of the invention itself. However, Fitzhugh (2001: 139) stated that risk-prone behaviour occurs based on the idea that an individual has enough reserves to meet the anticipated cost of invention, which, importantly, are assumed to be similar to the costs of maintaining current (low yield) behaviours. Therefore, while people may not know the true costs of invention, Fitzhugh argued that they make their decision based on the risk of continuing what they are doing. In other words, people will invent when they look at their situation and decide ‘it can’t be any worse’. In this way, the Fitzhugh model is about a person’s exposure to risk rather than a true cost-benefit assessment.

3.4.2 Mechanisms Influencing Adoption and Change in Trait Frequency

3.4.2.1 Innovation

As outlined above, innovation is the process by which inventions are integrated into a population (Henrich 2010). The simplest model for invention uptake involves the recognition that a given invention will be more beneficial than its predecessor. While the thoughtful, deliberate selection of useful inventions does occur it is by no means the only explanation (O’Brien and Shennan 2010 and references therein). For example, functionally beneficial objects are often understood to be beneficial only after their invention and often spread as a result of their status as prestige items (Fitzhugh and Trusler 2009).
As well as influencing invention, Fitzhugh’s (2001) model suggests that people may be more open to adopting new ideas in changeable environments where adherence to existing behaviours may not be as beneficial as experimentation. As in the discussion of invention, this seems to be a likely component of innovativeness but not the only factor. Based on the idea that many inventions occur slowly through the combination of previously distinct aspects of cultural traditions, Henrich (2010) argued that the degree of connection between individuals in a culture (cultural connectedness) and population size are primary drivers of population ‘innovativeness’. Like the arguments about necessity, this model is intuitive since greater population size means there will simply be more minds focussing on invention and thus more opportunity to ‘take up’ novelties. Equally, innovation rate does not necessarily need to be coupled with invention. Indeed, a population with a high cultural connectedness will share information and inventions far more efficiently than a disjointed group. Therefore, connectedness may serve to amplify innovations and, in turn, the presence of innovations may lead to a greater presence in the next generation (Henrich 2010).

3.4.2.2 Non-random Change - Natural Selection

Natural selection, referring to the process by which adaptive advantages favour the survival of certain individuals over others, ultimately leading to the proliferation of the survivor’s genes, is a well-known aspect of biology. In a cultural context natural selection operates on the basis that certain cultural attributes may promote survival of those in possession of them above other members of a community and, as a result, leads to a greater presence of a given cultural attribute (Rogers and Ehrlich 2008).

3.4.2.3 Non-random Change - Cultural Selection

Cultural selection operates independently of reproductive outcomes and is affected by a range of factors (or ‘biases’) without genetic equivalents. These biases may influence what information is passed on through social learning and who passes it on (Shennan 2011). For example ‘results bias’ refers to a particular behaviour or belief that is selected by an individual because of a perceived advantage it offers (Richerson and Boyd 2005). Shennan (2011: 1071) also outlines other biases,
including ‘content bias’ which refers to a situation where the nature or content of information makes it either more or less likely to be transmitted; ‘prestige bias’, where the prestige of an individual leads others to replicate a given behaviour (i.e. the celebrity endorsement in contemporary society); and ‘conformist bias’, where information is copied simply to ‘fit in’ with the majority. Mesoudi (2015) argues that these biases may be divided into those that deliver individual payoffs (e.g. results and prestige bias) and those that require conformity. Summarising the experimental literature, Mesoudi (2015) notes that both biases affect behaviour, although in most situations information that delivers perceived payoffs to an individual will tend to be favoured over information that promotes conformity. With the exception of ‘results bias’, it is useful to note that other biases may lead to the proliferation of certain behaviour despite the fact that they are not reproductively advantageous and may actually be maladaptive (Shennan 2011).

3.4.2.4 Random Processes – Drift and Population Size

As outlined at the beginning of this chapter the processes that shape cultural evolution can be based both on conscious decisions and random processes. In the case of random change, frequencies of artefacts may change according to drift (chance events), rate of innovation, and the frequency of traits in the previous generation (Nieman 1995; Shennan 2002). Biological population size influences all these factors to a greater or lesser extent (Shennan 2000).

In smaller populations the retention or loss of cultural traits is far more impacted by random processes (Shennan 2000, 2002). By way of explanation we can consider a simplified, fictional example using two groups: a small extended family of approximately 20 individuals, one of whom is an expert in adze manufacture versus a multiple family group of 100 people with five adze manufacturing experts. For the purposes of simplicity we will say that these groups operate in isolation and cannot be influenced by outside groups. In the smaller group, if the adze expert dies before passing on their knowledge the outcome could be as bad as the complete loss of the tradition; however, the loss is more likely to result in a reduction of technological complexity because, while others may copy existing designs, they will do so with a lesser degree of skill (Boyd and Richerson 2005).
However, if the same were to occur in the larger group, the presence of other experts may ensure that technological complexity remains in the population. In effect, in smaller populations the influence of random processes in culture change is amplified.

The above model shows how a single chance event can shape the distribution of particular cultural traits through time. The accumulation of such events is known as ‘drift’. In cultural terms, drift results in the changing frequency of things, such as artefacts, in the absence of any selection pressure. Figure 3.1 presents a simulation of random drift, which illustrates how artefact frequencies may change and the influence of population size. From an initial frequency of 30%, the five individual simulations in a population of 100 individuals show marked variation in the frequency after 100 generations. In one simulation the trait becomes ‘fixed’ (represented by the line reaching 1.0), in another it becomes extinct (0.0), and in the other three the end frequency after 100 generations is incredibly varied. Conversely, in a population of 1000 individuals all five simulations are relatively stable; no traits become extinct and the range of frequency variation is small.

Drift can have negative influence on the average fitness of populations. The frequency of optimal behaviours or cultural objects may decrease through drift and deleterious traits may be present in higher proportions (Shennan 2011). This ‘drift
‘load’ is particularly influential in smaller populations, where the effect of drift is the most pronounced (Whitlock and Davis 2011).

In addition to increasing the influence of drift, smaller population size has a number of other effects on culture. Larger population size has already been discussed with respect to its influence in increasing the amount of innovation (see above; Henrich 2010). There is also evidence that both population size and intra and inter-group contact affect the complexity of toolkits in places such as Tasmania (Henrich 2004) and the Pacific (Kline and Boyd 2010). This is essentially because ‘learners’ in larger populations have access to more experts, which means the chances of cumulative improvement are greater (Kline and Boyd 2010).

A key footnote to this discussion is that a difference exists between the absolute population size and the ‘effective’ population size – the number of people who contribute to the transmission of cultural information. In many craft traditions transmission occurs primarily between members of the same sex (Shennan and Steele 1999), thus, the effective population for the transmission of these traditions is approximately half that of the absolute population size. This number can be further reduced based on the population structure. For example, if the population consists of 50% sub-adults then only the remaining 50% of adults will contribute information to the next generation. Taken together, this means that within craft traditions the effective population size may be around 25% of the overall population (Shennan 2002). While this example suggests that effective population size will be relative to absolute population size, this may not necessarily be the case. In cases where information may be more restricted, for example ritual knowledge, the effective population may be very low – perhaps just a single person may hold the ritual knowledge.

3.5 Routes of Transmission

Just as in biological evolution where sexual and asexual reproduction influences how genetic information is passed on, in cultural evolution the pathway of transmission is important. Various modes of transmission such as parent to child (vertical transmission), non-parent of older generation to child (oblique), and
between peers or contemporaries (horizontal) affect the way in which culture changes, based on differential rates of innovation, borrowing, and faithful replication inherent within each mode (Shennan 2002; Hosfield 2009).

Vertical transmission, particularly between parents and children of the same sex, is the most common pathway of social learning due to the inherent costs involved in teaching and transmitting ideas, which mean those with little connection to a person are unlikely to invest in teaching them (Shennan and Steele 1999). Vertical/oblique transmission is commonly associated with conservative rates of change, normally bought about when the next generation experiments with existing structures. Despite experimentation, the general adherence to taught behaviours results in the development of a number of distinct ‘ways of doing’ developing within populations (Shennan 2002; Hosfield 2009). Conversely, the transmission of information between peers, either within or between groups (horizontal transmission) is dynamic and usually associated with high rates of change (Shennan 2002; Hosfield 2009). While it is natural to assume that the widespread exchange of ideas may lead to a homogenisation of in-group variation (in direct opposition to vertical transmission), this may not be the case. Instead, the effect of horizontal transmission seems likely to be largely contingent on population size (see above).

3.6 Mechanisms of Change and Archaeology

The processes and mechanisms outlined above are well attested in anthropology but their application in archaeology is more difficult. Many of the processes that shape change are subtle and take place over short time scales that may be difficult to detect in the archaeological record (Cochrane 2009; Shennan 2011). Indeed the patterns that are present may suffer from issues of equifinality. In practice, it may be difficult to differentiate between a pattern that develops because of one mechanism and that driven by another (Shennan 2011). Moreover, some patterns may not be cultural, but instead may be the result of other factors such as environmental oscillation. Despite the challenges, archaeologists have developed units of analysis that allow the application of DIT and the study of the long-term change.
3.7 Units of Inheritance in Archaeology

The previous discussion of cultural evolution referred to the transmission of ‘traits’ (either behavioural or material). In this sense cultural traits are the basic unit of transmission that, if they persist, create cultural traditions or “patterned ways of doing things that exist” (O’Brien et al. 2010: 3797, discussed below). Richerson and Boyd’s (2005: 5) culture definition suggests that culture is “information”; therefore, units of transmission cannot themselves be seen in the archaeological record. Rather, they are manifest in traits or features of things like tools or architecture that make up the archaeological record, although their exact manifestation can also be influenced by things such a raw material (O’Brien et al. 2010). In reality, archaeologists rarely deal with individual traits but rather trait clusters represented in an artefact. Tracking change using artefacts involves the characterisation of variation, usually through classification and seriation (outlined in greater detail below) – the process of ordering sites based on similarity. If our ordering is found to correspond to chronological order we can imply that there is continuity and, therefore, that the artefact variation represents the remains of a cultural tradition.

3.8 Cultural Traditions

The basic units used by archaeologists to understand the pattern and processes of change are cultural traditions. Cultural traditions are aspects of culture associated with specific bodies of behavior and skills, including those connected with subsistence, material culture, and language (Eerkens and Lipo 2005; Tehrani and Riede 2008; O’Brien et al. 2010). Mainstream usage of the word ‘tradition’ or ‘traditional’ is connected with a sense of continuity and persistence of particular practices, often with negative connotations. However, here the term is used to describe a dynamic sub-set of culture influenced by an interaction between the past and both the conditions and people of the present (Pauketat 2001). Change over time within traditions occurs as existing structures are modified or, more rarely, new traits are invented (O’Brien et al. 2002). Clearly if aspects of traditions were copied with absolute fidelity observed variation through time would not exist
Material culture traditions are a useful and productive basic unit for archaeology (and this research) for a number of reasons. Firstly, they represent observable strands of a culture affected by different constraints and influences. For example, a hunting tradition will be shaped by ideas and stimuli different from the house-building tradition. Thus, the analysis of traditions allows the study of individual trajectories of change, providing a more comprehensive understanding of change through time. Secondly, traditions are fundamentally diachronic units, concerned with patterns of long-term change and the generative processes behind these patterns. In the case of this research, this means that the study of material culture is not constrained by existing essentialist phases. Furthermore, they are not constrained to selectionist (or in New Zealand’s case, adaptationist) explanations, which, as O’Brien and Shennan (2010) point out, have frequently been regarded as the key component of change to the exclusion of other possible factors. Lastly, traditions can be investigated through the analysis of the material culture remains – material culture lineages – which may then be linked back to the expected outcomes discussed in DIT. Therefore, traditions provide a link between material and theory.

3.9 The Comparative Perspective in New Zealand archaeology

Alongside its more overt theoretical elements this thesis also adopts a comparative approach. In particular, diachronic patterns from East Polynesian societies - historically linked to New Zealand Maori - are compared to those seen in the current research. Comparative analysis within the Pacific Islands was a crucial part of ethnological analysis in the early to mid-twentieth century (e.g. Skinner 1924, 1942), but has since declined heavily in New Zealand. Ironically this pattern in investigative priorities amongst indigenous New Zealand archaeologists mimics the interaction patterns observed in prehistory, when small, far-flung communities maintained contacts initially but, following population infilling, these connections reduced. Early scholars were relatively small in number and therefore necessarily
engaged with a wider Pacific scholarship. Today, the high number of research and cultural resource management archaeologists mean that the New Zealand archaeological community is self-sustaining and relatively inward looking. Moreover, as Drennan et al. (2012) note, it is also the case that archaeology now has a much greater focus on obtaining highest quality data from excavated sites, necessitating detailed description and analysis, often at the expense of comparison.

Maori society had its roots in central East Polynesia where a number of fundamental cultural components were developed. Richard Walter and colleagues (Walter 2004; Walter et al. 2006) convincingly argued that to further the study of culture change in New Zealand archaeologists must consider the homeland societies from which the first settlers of New Zealand were drawn. New Zealand archaeologists have typically considered the homeland only implicitly, within models discussing the adaptation from tropical conditions to those presented by New Zealand (Walter et al. 2006; Walter et al. 2010). However, the only way to truly identify regularities and variation between early New Zealand culture and the culture in East Polynesia is to collect information from traditions key to the research question (in this case material culture and demography) and directly compare the presence or absence of different traits. For example, Walter et al. (2006; 2010) used intensive regional comparison between the Cook Islands and New Zealand to establish baseline information for early settlement, socio-political organisation, and mobility in New Zealand.

As well as understanding the culture that arrived in New Zealand, comparison with neighbouring societies also affords an opportunity to understand the influence of different cultural and environmental conditions on historically related traditions (Kirch and Green 1987; 2001). Again, this is achieved by intensive comparison of the diachronic patterns of traditions from different islands. This research uses the literature-based comparisons to establish both the early material culture that arrived in New Zealand and to carry out regional comparisons between the patterns of change in New Zealand and other islands.
3.10 Conclusion

This chapter has introduced the key principles of Darwinian archaeology. Of particular interest to the current research is the revised definition of culture that allows archaeology to move away from defining synchronic units, which have proved unhelpful in the pursuit of understanding culture change. Furthermore, Darwinian archaeology’s focus on cultural traditions, entities that are by their very nature diachronic, provides a more advanced tool to address the key aims of this thesis.

This chapter and those that preceded it have focussed on outlining the context in which this research is being conducted and the theoretical perspective used to address the key aims. The following chapters move beyond background information and begin the analytical portion of this thesis. The following chapter begins this process by synthesising information from East Polynesia to provide a baseline for analysis carried out in Chapter 5-8.
Origins: The East Polynesian Cultural Complex

“Polynesians called it Hawaiki, the distantly remembered homeland, source of their ancestors, mythical site of the creation of culture, and spirit realm to which their own souls would voyage after death.”
(Kirch and Green 2001: 1)

4.1 Introduction

The settlement of Polynesia involved the colonisation of pristine island environments. In this context, colonisation can be understood at two levels. Viewed through the lens of an individual island or island group, it is an event – a beginning – where colonists represent the start of the human (and archaeological) sequence. Taking a broader perspective, colonisation is a process whereby cultural landscapes and ideology are transported from old environments to new (Thomas 2001). The two perspectives are not mutually exclusive, but each emphasises different functions of colonisation – one as a new start, the other as a continuance.

In New Zealand archaeology colonisation has typically been viewed as a starting point, which reflects the isolation of New Zealand archaeological thought from its broader Polynesian context. While the notion of the founding culture with links to East Polynesia is implicit in most cultural frameworks (e.g. Golson 1959; Davidson 1984; Green 1963), it is generally only discussed with reference to the changes the culture undergoes as a result of the challenges presented by the New Zealand environment (Walter 2004; Walter et al. 2006). In a synthesis of New Zealand archaeology and its connections to Polynesia, Walter (2004) has argued that a sound understanding of the ‘homeland society’ offers an advantage to contemporary New Zealand archaeology, in that it provides a useful baseline from
which can be drawn an understanding of the pattern and process of change in New Zealand.

This chapter focuses on developing such a baseline for further analysis of material culture change in New Zealand. Here I draw together the information from archaeological sites occupied from the earliest settlement of East Polynesia to the period when New Zealand was first settled (c. AD 1000-1300). The first section focuses on defining the so-called ‘homeland’. The development of this concept is charted and a contemporary definition is offered, which recognises the homeland not as one particular land *per se*, but rather a group of island societies who share common ancestry and remain in contact with each other. This shared ancestry and continued contact led to a relatively homogenous expression of culture in the region. The second section carries out a survey of available radiocarbon dates from across East Polynesia to identify sites considered to belong to this homeland society and from the remains of which we may glean something about the society itself. The last section compares the remains found in each of these sites to develop a synthesis of the East Polynesian cultural complex to be used as a baseline for the assessment of change in New Zealand.

### 4.2 The East Polynesian Homeland

The historical relationship and cultural similarity between Polynesian societies is a well-attested characteristic of the region. However, intra-regional patterns suggest that Polynesia may be sub-divided into smaller groups (*e.g.* Burrows 1938; Larson 2011). The distinction between West and East Polynesia is apparent from the earliest phase of settlement in East Polynesia, where material culture exhibits marked variation from contemporary sites in Western Polynesia (Kirch 1986; Bollt 2008). This division is commonly explained by invoking a ‘homeland hypothesis’ in which an early homeland develops in central East Polynesia that is the core of linguistic and cultural innovations. The eastern variant of Polynesian culture is then transported throughout the remaining islands, solidifying the distinction between East and West Polynesia (Rolett 1998).
The definition of the East Polynesian homeland has taken a number of forms throughout the history of Polynesian scholarship. Buck’s (1938, 1944) model of Polynesian settlement (Figure 4.1), based on ethnographic comparison, genealogies, and oral traditions, argued that the Society Islands were the core of East Polynesia from which diffusion to other islands occurred.

In the decades following Buck’s proposal the advent of stratigraphic excavation in many corners of Polynesia changed the view of regional settlement (Kirch 1986). A major development involved the Marquesas Islands becoming the central focus of a regional settlement model. Retained in this new model was the concept of a ‘homeland’ necessarily based in a single island group because inter-archipelago sailing distances were considered too great for substantial contacts to be maintained (Emory 1979). This ‘homeland’ represented the place where distinct East Polynesian traits emerged and spread throughout the region (Rolett 1998).

Figure 4.1 Buck’s depiction of Polynesian settlement history.
The relatively large amount of archaeology conducted in the Marquesas (e.g. Suggs 1961; Sinoto 1966, 1970, 1979) revealed a number of sites bearing material culture with some affinity to West Polynesia. Most notably, this included a small amount of ceramic later sourced to Fiji (Dickinson and Shutler 1974; Allen et al. 2012). The Marquesas sites also provided a series of early radiocarbon determinations. The large coastal sites of Ha’atuatua and Hane produced date ranges between 150 BC and AD 300 (Suggs 1961; Sinoto 1979) with the later end of that range becoming the favoured settlement date (Sinoto 1979). At the time this date range placed the Marquesas toward the beginning of East Polynesian settlement, further suggesting the islands were the first to be settled.

At this stage a model was developed using the radiocarbon dates then available, together with a historical stylistic relationship between artefact types from island groups (Sinoto 1968, 1970; Figure 4.2). The model, considered ‘orthodox’ at the time, was summarised by Kirch (1986: 17) in six elements:

1. The Marquesas were settled from West Polynesia around AD 300.
2. The ‘Archaic East Polynesian Culture’ developed in the Marquesas over the course of a few hundred years before being spread elsewhere. This culture was characterised by artefacts such as untanged adzes, shaped whale-tooth pendants, trolling lures, toggle-head harpoons, and compound-shank fishhooks. Pottery was quickly dropped from the Archaic East Polynesian assemblage.
3. The Society Islands were colonised from the Marquesas.
4. The Hawaiian Islands were colonised from the Marquesas around AD 750 and again in AD 1200 from the Society Islands.
5. The south-eastern islands (Mangareva, Pitcairn, and Rapa Nui) were colonised from the Marquesas between AD 600 – 1300.
6. New Zealand was colonised from the Society Islands about AD 1000.

This model remained the dominant strand of thought in the Pacific until Patrick Kirch’s seminal paper (Kirch 1986), which challenged this orthodoxy. In 1986 Kirch synthesised and enlarged on previous criticisms of the Sinoto framework, focussing on both theoretical and practical issues with the model. Kirch’s key
objections to the model involved sampling issues, chronological anomalies, and issues with material culture. These topics are considered in turn below.

Figure 4.2 The ‘orthodox model’ of Polynesian settlement (after Jennings 1979).

Drawing on Bellwood’s (1970) criticisms, Kirch (1986) pointed out the large geographic gaps in the archaeological record caused by differential sampling and geomorphological conditions. This bias served to amplify the Marquesan evidence disproportionately and led to the placement of the islands at the centre of the model. Interestingly, while many of these gaps have since been filled (e.g. Gambier – Kirch et al. 2010; Austral Islands – Bollt 2008) early sites remain poorly represented in the Society Islands (Kirch 2010; Kahn 2014), which were specifically mentioned by Kirch as a likely central point in the Polynesian diaspora (1986: 18).

Kirch (1986) also highlighted the contradiction between Hawaiian chronology and the established Marquesan sequence. This critique is perhaps the most prescient,
due to the large-scale and dramatic revision of prehistoric sequences that has taken place in Polynesia over the last two decades (e.g. Spriggs and Anderson 1993). Kirch outlined a series of objections based on chronometric information available in 1986, which, due to advancements in dating technology and additional dating data, is now largely out-dated. Therefore, the specifics of Kirch’s argument are not considered here beyond noting that radiometric evidence at the time, as well as that which has emerged since, does not support the traditional localised homeland within the Marquesas. This is due to an insufficient time depth in the Marquesas before settlement of other islands, suggesting it is unlikely that the East Polynesian Culture developed over a couple of centuries before spreading elsewhere.

In a third and final criticism, Kirch (1986) focused on the anomalous material culture record. His compelling argument suggested that, despite some similarities, the earliest East Polynesian sites demonstrated significant change from West Polynesian sites, which is inconsistent with them being settled directly from the west (Kirch 1986). This implied that the sites where East Polynesian forms developed were missing from the archaeological record. Thus, the early Marquesan sites were unlikely to represent primary settlement as suggested by Sinoto (1970). Kirch also presented two arguments that, with the benefit of hindsight, are less compelling. First, he noted that some elements of the diagnostically ‘Archaic’ artefact suite were not present in the early layers of the Hane site and instead may have derived from an intermediate phase of localised Marquesan development (Kirch 1986). Recently Conte and Molle (2014) have re-evaluated the Hane site, arguing that the early layers represent multiple, brief occupations. Under these circumstances diagnostic artefacts may have been present early, but were less likely to enter the archaeological record during brief occupations. This observation serves to undermine Kirch’s second critique but reinforces the objection (above) that the Marquesas was not a place of primary settlement. Secondly, Kirch observed that many early Hawaiian sites lack diagnostically ‘Archaic’ artefacts despite close temporal and geographic proximity to the Marquesas. Kirch (1986) dismissed Sinoto’s argument that the artefacts simply were not transported to Hawai‘i or that Hawai‘i was settled from the southern Marquesas (where no such

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1 The term ‘Archaic’ or ‘Archaic East Polynesian’ is a synonym for the homeland culture, before individual island cultures had diverged.
material had been uncovered). Instead, Kirch favoured a model in which Hawai'i was settled before the development of ‘Archaic’ forms in the Marquesas. This model required the settlement of the Marquesas to occur earlier than the supposed AD 300 date, perhaps in the mid-first millennium BC (Kirch 1986). The chronology of Polynesian settlement will be discussed in more detail in the following section; for now, it is worth noting that the settlement date for the Marquesas (and the rest of Polynesia) is now considered much later than previously thought, which does not support Kirch’s suggestion. Furthermore, considering both ‘conservative’ (based on short-lived materials) and ‘synthetic’ (based on radiocarbon dates and other proxies) models of Marquesan and Hawaiian settlement (Allen 2014) it is clear that there was no substantial period of time between the settlement of each island group. Again, this undermines Kirch’s explanation for the lack of key artefacts in Hawai'i.

Since the publication of Kirch’s “trenchant criticism” (Anderson 1995: 110) of the orthodox model, there has been a growing trend toward the decentralisation of the East Polynesian homeland. In its stead, a wider ‘regional homeland’ hypothesis has developed drawing support from new developments in the areas of chronology, voyaging, geochemical sourcing, and material culture. The following section briefly reviews each of these areas in turn.

### 4.3 The Regional Homeland Model

In broad terms, the regional homeland model describes a highly connected set of societies in central East Polynesia from which peripheral islands were settled. The high level of connectivity implies a high degree of cultural, genetic and linguistic similarity was retained in this region during the early years. Thus, while the exact origin of the first colonists to New Zealand and other peripheral East Polynesian islands is not known, a survey of sites within the homeland should yield a reasonable picture of the cultural package brought to New Zealand.

#### 4.3.1 Chronology

Overall, the human sequence in East Polynesia has been dramatically reduced in time depth since the sequences proposed in the 1960s. The Marquesas offers an
extreme example: here the sequence has been revised from a suggested beginning around 150 BC (Suggs 1961) to one as late as c. AD 1200 (Wilmshurst et al. 2011). Although this revisionism is less extreme in other island groups, the trend toward reducing sequence lengths is generally present. While consensus exists around shorter archaeological sequences on most islands, opinion remains divided about the exact timing of colonisation. Two major perspectives pervade, the division largely driven by differences in dating philosophy and analytical scope. The first strictly adheres to principles of chronometric hygiene (e.g. Anderson 1991; Spriggs and Anderson 1993; Wilmshurst et al. 2011). Radiocarbon dates are preferred if they are clearly linked to cultural activity, are taken from material that provides the lowest amount of potential error, and provide a calibrated range that is precise enough to inform the question being asked (Wilmshurst et al. 2011: 1815).

Typically, strict adherence to these principles is coupled with analysis of a large corpus of radiocarbon dates where more subjective intra-site analysis is impractical. This may be at a regional (Spriggs and Anderson 1993; Wilmshurst et al. 2011) or, less often, a national scale (Anderson 1991). These papers are also linked by an underlying philosophy, which argues that chronometric hygiene produces a ‘conservative’ colonisation date by focussing on established settlement rather than ephemeral or ‘archaeologically invisible’ early phase occupation (Mulrooney et al. 2011).

Increased scrutiny of radiocarbon dating, particularly around sample selection and avoidance of in-built age, is clearly beneficial. However, the application of chronometric hygiene principles can also be overly rigorous. In particular, Wilmshurst et al. (2011: 1819) applied a standard to dates whereby measurement error must be less than 10% of a given radiocarbon age range (BP). This criterion was put in place to reduce ‘spread’ and refine the colonisation date, yet it led to the culling of dates that, on other grounds (well provenanced, identified material), were accurate (Mulrooney et al. 2011). This is, in a sense, radical culling of dates in the pursuit of conservatism.

Conversely, Allen (2004, 2010, 2014; Allen and Wallace 2007; Allen and McAlister 2013) presented a second strand of thought that is sympathetic to chronometric
hygiene while also employing a range of site- and island-specific considerations. At the Moturakau site in the Cook Islands, Allen and Morrison (2013) carried out a stratigraphically informed analysis of radiocarbon dates. The analysis employed identified and unidentified sample materials (Allen and Morrison 2013: their Tables 3 & 4) and used stratigraphic position and outlier analysis to inform the chronological sequence. The nature and provenance of radiocarbon samples was important in Allen and Morrison's analysis; however, their analysis also provided a useful model of how dates that would be discarded under strict chronometric hygiene can be integrated into chronological frameworks.

The second aspect of Allen's chronometric approach involved island specific considerations. In the Marquesas, Allen (2014) argued that, at many sites, there was evidence of ephemeral activity before the more intensive occupation from which most radiocarbon dates were sourced. Furthermore, many early sites did not appear in optimal positions (large, well-watered valleys) and few had evidence of the exploitation of vulnerable species, such as turtles, which are consistently found in early sites throughout Polynesia (Anderson 2001). Lastly, Allen (2004) suggested that, based on analysis of material culture, many early sites reflect communities familiar with local resources both at an island and archipelago level. Taken as a whole, Allen argued that the Marquesan archipelago might have been initially colonised over one hundred years before evidence of large-scale settlement, an argument that could be extended to other islands.

As I suggested earlier, the difference in these approaches stems largely from variation in research scope. Wilmshurst et al. (2011) correctly noted that their 'top down' approach is not conducive to a more relaxed consideration of the chronological data. Equally, a site- or island-scale focus does allow dates to be considered in context and used with greater flexibility (e.g. Allen and Morrison 2013) but requires more intensive investment. As it stands, proponents of both methods would agree with the sentiments of Kahn (2014) that more robust chronologies are needed for most island groups.

With respect to homeland models, both viewpoints suggest that colonisation of East Polynesia occurred much later than was supposed two decades ago and that,
once begun, the process was rapid and widespread (Allen and Kahn 2010; Wilmshurst et al. 2011). The rapid spread of people across many island groups suggests the idea of a discrete East Polynesian homeland (sensu Emory and Sinoto 1965; Sinoto 1970; Emory 1979) is unlikely. Instead, the observation that the homeland, the centre of innovations distinct to East Polynesia, may be conceived as a region seems to better suit the data (Kirch 1986; Walter 1996; Rolett 1998).

4.3.2 Voyaging

Reflecting on the possibility of a ‘joint homeland’, Emory (1979) asserted that the Marquesas and Society Islands were too far apart to support such an idea. Research and modelling of sailing technology have since significantly improved our understanding of voyaging capabilities, suggesting that Polynesians were capable of long distance two-way voyages (Irwin 1991; Finney 1994). More recently, Anderson (2008) has contested what he calls the ‘traditional’ view of Polynesian sailing capability, arguing instead that, rather than possessing the technology to sail upwind, Polynesians harnessed anomalous climatic events to sail downwind to places like New Zealand and Rapa Nui (Goodwin et al. 2014), something also discussed by Finney (1994). However, while some debate still persists about this subject (Anderson 2008) it seems clear that, either through technology or knowledge of climate, it was possible to commute between islands in East Polynesia. By extension we can conclude that sailing distances in central East Polynesia were not prohibitive and a joint homeland is possible.

4.3.3 Trade and Exchange Networks

Geochemical sourcing provides harder evidence for the regional homeland model. Sourcing, primarily of stone but occasionally also of pottery (e.g. Walter and Dickinson 1989; Allen et al. 2012), has revealed an extensive network of inter-island interaction spheres that operated until approximately AD 1450 (Weisler 2008). Figure 4.3 presents a coarse-grained overview of these networks in Central East Polynesia². These networks are based on high-grade stone suitable for adze manufacture (Weisler 1998) and ceramic remains. Pearl shell for manufacture of

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² The New Zealand/Kermadec/Norfolk Island trade network (Anderson 2000) is excluded from this image, as is the link between the Marquesas and Hawai‘i reported by Collerson and Weisler (2007) based on an artefact of insecure provenance.
fishhooks was also transported between islands and it is likely that organic materials, not visible in the archaeological record, were also traded.

East Polynesia is primarily an aceramic region and the pottery sherds analysed represent isolated early finds. Petrographic analysis places the origin of the Ma’uke (Cook Islands) ceramic sherd in Tonga (Walter and Dickinson 1989), while a Fijian origin is indicated for the Marquesan sherds (Allen et al. 2012). As mentioned earlier, the presence of ceramic sherds in the Marquesas was originally linked to models of direct contact with West Polynesia (Sinoto 1968; 1970). However, it now seems far more likely that the ceramics were transported into East Polynesia via a series of intermediate steps (Anderson et al. 1994; Allen et al. 2012). Nevertheless, this evidence shows the capacity of East Polynesians to move material ‘down the line’ over large distances.

The basalt trading networks exhibit variable patterns of exchange. The high quality basalt from Eiao in the northern Marquesas Islands is a significant quarried source. In the Marquesas up to 25% of all adzes are constructed from the material and it is dispersed over great distances throughout much of East Polynesia (Weisler 1998, see his Figure 1, Networks C, D & E; Di Piazza and Peartree 2001; Rolett et al. 2015). Conversely, in the Cook Islands a number of dispersed sources are used although some high quality stone is imported. This suggests casual, low intensity procurement and exploitation of stone was also occurring within archipelagos (Rolett 2015).

In New Zealand, where similar large-scale trade networks operated, Walter et al. (2010) asked what drives the development of such networks:

“Is it something to do with the perceived value (utilitarian or otherwise) of the materials that were transported, or is the movement of raw material ancillary to the social act of long-distance interaction itself?” (Walter et al. 2010: 509-510).
The reality is that the utilitarian and social motivations behind long-distance trade are difficult to disentangle. In East Polynesia differential resource availability is certainly a component of inter-island trade. However, it is equally likely that trade networks provided crucial connections to ‘parent’ populations during establishment of new communities (Kirch 1988; Green and Kirch 1997). Maintenance of these connections in the post-settlement phase would ensure both demographic stability and continuing social contacts that would lead to preservation of social structures and traditions (Rolett 1993; Walter et al. 2010).

The period of on-going interactions in central East Polynesia following initial rapid settlement supports the idea that early island societies were not socially isolated but were integrated into a regional sphere. Like the chronological and voyaging
evidence, the geochemical evidence also lends support for a regional homeland within central East Polynesia.

4.3.4 Material Culture

A key challenge to the original homeland model (Emory and Sinoto 1965; Sinoto 1970) was the inconsistent expression of ‘Archaic East Polynesian’ material culture across the region (Kirch 1986, discussed above). Walter (1996) took this criticism further, questioning the existence of the ‘Archaic East Polynesian’ assemblage altogether. Walter focussed on identifying sets of types that regularly co-occurred and the distribution in time and space of any such types (Walter 1996). Employing a large-scale comparative analysis of early site material culture, he concluded that the sites surveyed did have types in common across a variety of material culture spheres (e.g. ornamentation and fishing gear). However, he also observed that the large temporal spread of sites, together with the presence of certain artefacts outside the geographic and temporal range suggested that the ‘Archaic’ assemblage could not be said to hold anything other than “trivial cultural meaning” (Walter 1996: 525). Instead, Walter placed less emphasis on the idea of a discrete assemblage, arguing that ‘Archaic East Polynesia’ is better represented as a period of widespread inter-island contact leading to shared ideas and innovations, which gave rise to a degree of homogeneity across the region.

Like Walter, many early studies of Polynesian material culture relied on descriptive and comparative analysis to infer cultural relationships between islands. In the last decade a range of analytical tools have been developed, which allow the assessment of relationships between assemblages and possible explanations for the observed patterns. To this end, phylogenetic analysis has recently been applied to three sets of data from Polynesia: ethnographic records of canoes, the barkcloth tradition, and ritual architecture.

Rogers et al. (2009) applied phylogenetic analysis to functional and stylistic canoe traits originally recorded by Haddon and Hornell (1936-1938). The authors found a correlation between geographic and cultural distance and noted a divide between West and East Polynesia consistent with earlier observations of material difference.
Most importantly, Rogers et al. (2009) noted the lack of support for a strictly ‘tree-like’ pattern in their data and cite a large degree of horizontal transmission amongst societies as a likely cause. Larsen’s (2011) analysis of Polynesian barkcloth showed similar patterns to those observed by Rogers et al. A clear distinction between West and East Polynesia was apparent and support for a ‘branching’ pattern within East Polynesia was very limited (Larsen 2011, their Fig. 4). However, a reasonable level of support was present for a Cook, Society and Austral Island grouping away from geographically marginal island groups. The most recent analysis was carried out on Polynesian ritual architecture. Cochrane (2015) found little evidence for specific architectural lineages. Cochrane suggested procedural issues, such as classification choices, may have affected the result but also argued that high rates of horizontal transmission or innovation could also be behind his results.

While limited in number, studies based on material remains suggest there was “frequent cultural sharing across islands and archipelagos” (Cochrane 2015: 39). These results are consistent with a more complicated picture of Polynesian settlement than previously thought, one in which islands were settled rapidly and maintained contact, leading to a degree of cultural continuity within the region during the early period.

4.3.5 Summary

Based on the developments of the last twenty years, a new ‘orthodox scenario’ for Polynesian settlement has emerged that directly relates to the conception of the ‘homeland’. This model retains aspects of the old, as well as a number of new ideas. It can be summarised in four broad points:

1. East Polynesia was settled following a prolonged pause in eastward colonisation during which the Ancestral East Polynesian society developed in West Polynesia before spreading east.
2. Rapid settlement of central East Polynesia.
3. Long-distance contacts were maintained between central East Polynesian islands for both utilitarian and social reasons, promoting a broadly homogenous ‘Archaic’ cultural expression in the region.
4. Relative isolation of marginal islands such as New Zealand and Hawaii from the central islands following settlement.

Despite not being able to locate the homeland of early New Zealanders, this model suggests it is possible to draw on a range of behaviour from central East Polynesia to provide a baseline for further analysis of culture change in New Zealand. To that end, the following section carries out a synthesis of settlement, subsistence, and material culture information from early East Polynesian sites.

4.4 Synthesis of Early East Polynesian Culture

In order to develop a synthesis of the regional homeland an extensive review of literature from central East Polynesia was conducted. My purpose was to identify those sites that were occupied from the initial settlement of East Polynesia through to the approximate time that New Zealand was settled (c. AD 1300; Higham and Jones 2004). By comparing these sites I will develop an understanding of the culture from which early New Zealanders derived. In so doing I apply a terminus ad quem to sites of approximately AD 1300. In cases where the radiocarbon range spans the time before and after AD 1300 I include the site but note its later temporal position. Appendix IV contains the calibrated radiocarbon dates from the sites selected for further analysis. Unidentified dates are included in the plots; however, the conservative colonisation range (Wilmshurst et al. 2011) is also shown for comparison. The following section briefly introduces the island groups and sites used in this analysis (Figure 4.4).

4.4.1 Marquesas Islands

The Marquesas Islands lie in the eastern margins of Polynesia (Figure 4.4), 1370 km northeast of the Society Islands and 480 km from their nearest neighbour, the Tuamotu Islands (Allen 2004). The archipelago consists of ten volcanic high islands the largest of which, Nuku Hiva, is approximately 380 km² (Allen et al. 2012). The islands are rugged and mountainous with deep valleys giving way to small, flat coastal plains offering little room for settlement. The topography is such that inter-valley communication and movement would have been difficult and costly for early settlers and their descendants (Thomas 1990; Allen 2004).
The marine environment also presented challenges to early colonists. Coral reefs are uncommon, leaving the windward coasts exposed, and marine biodiversity, in terms of both fish and shellfish, is relatively low (Rolett 1998).

Southeast trade winds bring precipitation that is caught on the windward side of the steep terrain, limiting rainfall elsewhere. This creates marked spatial variation in rainfall (Allen 2010). In particular, the south and eastern regions are well watered compared to the arid areas in the north and west (Allen 2010). Seasonal rainfall variation is minimal; however, there is considerable variation in inter-annual rainfall. Drought conditions are severe and often persist for several years (Rolett 1998; Allen 2010). Such was the severity and consistency of these events that some acquired names, such as the seven-year famine *Ivi omo* (‘to suck bones’). These conditions would have made management of agricultural resources difficult and, coupled with the geographic restrictions placed upon society, were the main drivers of the development of the unique Marquesan culture and society present at European contact (Allen 2010).

The Marquesas Islands contain the largest number of early East Polynesian sites. This analysis comprises a number of sites recently discovered by Allen and colleagues. These sites include Pahumano-o-te-tai and Teavau'ua, located in sheltered bays on the northern coast of Nuku Hiva. Other sites from Nuku Hiva are Ho’oumi and the large and important site of Ha’atuatua. Further sites include Hanatekua, a rockshelter site on Hiva Oa, and the large and extensively researched sites of Hane, Ua Huka, and Hanamiai, Tahuata.
Figure 4.4 The East Polynesian island groups and sites discussed in text.
4.4.2 Society Islands

The Society Islands are positioned near the middle of central East Polynesia. The Societies form a chain of volcanic islands and atolls divided into leeward islands and the geologically younger and larger windward islands (Kahn et al. 2015). With a tropical climate, relatively large landmass containing permanent streams, and lagoon systems providing easy access to marine resources, the Society Islands presented a rich landscape for early Polynesian settlements (Kahn 2014). However, unlike the Marquesas Islands, early sites from the Societies are scarce. The archipelago is now one of the most well-studied in French Polynesia; however, island subsidence and deposition of colluvium make the identification of early sites difficult (Kahn et al. 2015). Two sites from the Societies are used in this analysis; both come from the leeward Society Islands. The first is a burial ground located on Motu Paeo, a reef motu associated with Maupiti Island. Recent dating by Anderson et al. (1999) suggest this site may be slightly later than the AD 1300 cut off date; however, due to the date range beginning before the cut off, the site is included here. The second site is Fa’aahia/Vaito’otia, a large wet-site with well-preserved evidence of a range of prehistoric activity. This site is located on the leeward coast of Huahine.

4.4.3 Southern Cook Islands

The Southern Cook Islands lay in the so-called ‘gateway’ between East and West Polynesia (Allen and Wallace 2007). The Southern Cooks are made up of a range of volcanic, makatea (upraised coral islands), and atolls. This variation creates a range of environments, for example Aitutaki consists of a central lagoon with surrounding islets while Ma’uke has only a fringing reef (Walter 1998; Allen and Wallace 2007). Clearly this variation impacts on availability of resources. The Southern Cook Islands provides five sites for this analysis. Two sites are from Aitutaki: Moturakau, a rock shelter site, and Uriea, a village site. Two other village sites are also used: Ngati Tiare, from Rarotonga, and Anai’o, from Ma’uke. The last site is Tangatatatau rock shelter from Mangaia.
4.4.4 Austral Islands

The Austral Islands consist of five high islands near the southern boundary of East Polynesia (Bollt 2008). The position of the islands means they have strong cultural affinity with the Southern Cook Islands and Society Islands, yet are sufficiently removed to present a unique cultural expression (Bollt 2008). The climate of the Austral Islands is sub-tropical and is therefore wetter and cooler than other island groups in the region. The landmass is relatively small but lagoon systems provide access to rich marine resources (Kahn 2014). The Austral Islands remain relatively underexplored by archaeologists. Nevertheless, two sites are available for this analysis: the Peva site from Rurutu and the Atiahara site from Tubuai. Both of these sites represent occupation sites similar to those from the Southern Cook Islands (Bollt 2008).

4.4.5 Characterising Hawaiki

Drawing on information from the 18 sites identified above, the following section characterises the material culture kit that was present in the homeland around the time of New Zealand settlement. In particular, this section focuses on characterising the adze and fishhook traditions.

4.4.5.1 Material Culture

Material culture information was gathered from a range of published sources. The previous collation of material culture information by Walter (1996) was used as a starting point. Since the publication of this work a great deal of archaeological work has been undertaken in East Polynesia. While this has, in general, not contributed large new material culture assemblages, two factors require aspects of Walter’s Table 1 to be revised. Firstly, some of the sites discussed in Walter (1996) have been re-excavated (e.g. Ha’atuatua – Rolett and Conte 1995) and small amounts of material culture have been added. Secondly, the chronology of sites has changed or become much clearer. This means that some of the divisions (based on site phase) can be reconsidered. An exception to this is the Austral Islands that, since the publication of Walter’s (1996) work, have contributed two new sites of the correct age.
Different levels of reporting and separate classificatory systems complicate the collation of material culture information. In this section a balance was sought between collecting information from the greatest number of sites and collecting the best possible information. Initially, frequency information was sought; however, this could not be achieved across enough sites and therefore an occurrence method was applied. Following Walter (1996), fishhooks are defined using the non-classificatory arrangement of Rolett (1998; adapted from Suggs 1961). Adzes are defined as by their cross-section and modification to the poll (tanged/untanged), as these are two components mentioned in most texts. Ornaments are defined using simple and widely used descriptive terms.

4.4.5.2 Fishing Gear

In the broader Polynesian context, early East Polynesian sites are remarkable for the number and diversity of shell fishhooks. Allen (1992: 185) described the change between West and East Polynesia as a “virtual explosion of shell hook technology”. This proliferation of angling hooks may have been permitted by the greater availability of pearl shell (*Pinctata margaritifera*), a material that is more workable and robust than commonly available materials in West Polynesia (Allen 1992). While acknowledging the growth in fishhook variety, Walter (1996) argued that little technological innovation occurred. Instead, existing technology was adapted and grew in importance in response to non-lagoon environments common in East Polynesia. Ethnographic observation in West Polynesia supports this idea. Here seine netting at ebb tides and night spearing optimise the catch within reef-flat or reef-edge environments common in the region (Kirch and Dye 1979). The success of these techniques likely marginalised angling within the Polynesian fishing tradition until environments were encountered in East Polynesia that required a shift toward angling.

Table 4.1 shows that a large number of one-piece fishhook varieties (Figure 4.5) were present at sites in Archaic East Polynesia. Variation is particularly apparent
in the Marquesas. There, Kirch (1980) has argued that the lack of reef or lagoon systems led to a period of early experimentation in angling hooks. Variation elsewhere is less marked, perhaps reflecting a reduced need for experimentation in environments similar to West Polynesia where the technology evolved. Nevertheless, the increased frequency of one-piece forms relative to West Polynesia probably reflects the shift from a reef to inshore fishing focus as evidenced in the faunal record.

Trolling occurred in open water and is evidenced throughout the Marquesas and at Fa’aahia/Vaito’otia in the Society Islands by the presence of lure shanks (Table 4.2). Trolling is also in evidence at Anai’o on Ma’uke in the Cook Islands. Ma’uke has a fringing reef but not a large lagoon system; therefore, the inhabitants may have been required to exploit the open sea for their marine subsistence. Evidence of subsistence will be discussed in greater detail in a later section; however, faunal data from throughout East Polynesia suggest a predominantly inshore focus. Therefore, although some material culture evidence of trolling is present, such as the types shown in Figure 4.6, it is likely they were minor components of the overall marine exploitation strategy.
An interesting departure from the typical pattern is the Peva site from Rurutu, Austral Islands. Few angling or trolling hooks (or any fishing gear in general) was found. Bollt (2008) argues that the developed reef/lagoon system on Rurutu probably led to the continuation of West Polynesian fishing strategies, such as netting or spearing, which leave little evidence in the archaeological record.

The fishing gear found at these sites, in combination with faunal data supports the idea of a predominantly inshore focus in the East Polynesian regional homeland. More importantly, the fishing gear suggests a fishing tradition that was diverse and consisted of a range of strategies. One-piece forms exhibit significant diversity, particularly in potentially difficult environments, suggesting the tradition was not conservative but given to innovation and adaptation when required.

4.4.5.3 Adzes

The adze tradition in Archaic East Polynesia shows clear continuity with West Polynesia, particularly with the presence of quadrangular, triangular and trapezoidal forms (Walter 1996; Figure 4.7). New forms, including reverse triangular and thick quadrangular cross-sectioned adzes, and the reduction of the butt (tang), emerged in East Polynesia (Cleghorn 1984; Walter 1996; Bollt 2008). Bollt (2008) suggested that the Archaic East Polynesian adze kit was the product of greater innovation and diversity than its relatively conservative West Polynesian equivalent. Unfortunately, although some attempts have been made to quantify the function of types (Best 1977; Turner 2000), little convincing information is available. Therefore, it is impossible to equate the efflorescence of adze types in East Polynesia or inter-island diversity with functional variations. Table 4.3 shows few clear patterns, although once again it could be
argued that the Marquesas Islands display the greatest variation. Despite this, many of the types present in those islands are also present elsewhere, suggesting that the adze tradition may not display the same innovation pattern present in one-piece fishhooks. The large site of Fa’ahia/Vaito’otia also shows a large range of adzes; together with the evidence from the Marquesas this may suggest that the relatively high diversity is the result of sampling within the region.

Figure 4.7 Examples of adzes found in early East Polynesian sites (adapted from Buck 1950).
Table 4.1 One-piece hooks from East Polynesian sites.

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<tr>
<th></th>
<th>Marquesas</th>
<th>Societies</th>
<th>Cooks</th>
<th>Australs</th>
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<tr>
<td></td>
<td>Hane</td>
<td>Ha'atutu</td>
<td>Hanamiai</td>
<td>Hanatekua</td>
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<td>Acute recurved point</td>
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<td>Angular Shank</td>
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<tr>
<td>Barrel Shank jabbing</td>
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<tr>
<td>Bent upper Shank</td>
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<tr>
<td>Circular Shank</td>
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<tr>
<td>Curved Shank</td>
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<tr>
<td>Heavy Shank</td>
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<tr>
<td>Jabbing</td>
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<tr>
<td>Narrow curved Shank</td>
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<td>Obtuse recurved point</td>
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<td>Open jabbing hook</td>
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<tr>
<td>Rotating</td>
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<tr>
<td>V-Bend jabbing</td>
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<tr>
<td>Wiggly Shank</td>
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<tr>
<td>Y-Bend</td>
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<tr>
<td>Pearshell Hook Blank</td>
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<td>Unspecified one-piece hooks</td>
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Table 4.2 Two-piece and lure fishhook types from East Polynesian sites.

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<th>Marquesas</th>
<th>Societies</th>
<th>Cooks</th>
<th>Australs</th>
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</thead>
<tbody>
<tr>
<td>Hane V-VII</td>
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<tr>
<td>Ha'aturua II</td>
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<tr>
<td>Hanamai G-H</td>
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<tr>
<td>Hanatekua</td>
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<tr>
<td>Ho'oumi</td>
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<tr>
<td>Faahia/Vaito'o'oa</td>
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<tr>
<td>Maupiti</td>
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<tr>
<td>Ana'o IV</td>
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<tr>
<td>Tangatau</td>
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<td>Ureia</td>
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<td>Moturakau</td>
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<td>Ngati Tiare</td>
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<tr>
<td>Peva</td>
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<tr>
<td>Atiahara</td>
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<tr>
<td>Two-piece hooks</td>
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<tr>
<td>Trolling lure shanks</td>
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<td>Biflanged lure points</td>
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<tr>
<td>Proximal base projecting points</td>
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<td>L shaped lure points</td>
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<td>Coffee bean octopus sinkers</td>
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<tr>
<td>Conical octopus sinkers</td>
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<td>Octopus lure cowries</td>
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<td>Octopus lure points</td>
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<tr>
<td>Octopus lure flappers</td>
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<tr>
<td>Turtle lures</td>
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<tr>
<td>Compound shank hooks</td>
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<tr>
<td>Harpoon heads</td>
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</table>

* Indicates presence of type, ? indicates evidence of presence.
Table 4.3 Adzes forms from East Polynesia.

<table>
<thead>
<tr>
<th></th>
<th>Marquesas</th>
<th>Societies</th>
<th>Cooks</th>
<th>Australs</th>
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<tbody>
<tr>
<td></td>
<td>Hane V-VII</td>
<td>Ha’amaratu I</td>
<td>Hanamau G-H</td>
<td>Hanarouns</td>
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<tr>
<td>Ovular</td>
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<tr>
<td>Lenticular</td>
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<td>Plano-convex</td>
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<td>Quadrangular</td>
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<td>Quadrangular incipient tang</td>
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<td>Quadrangular tanged</td>
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<tr>
<td>Reverse trapezoidal</td>
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<td>Reverse trapezoidal tanged</td>
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<tr>
<td>Trapezoidal</td>
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<tr>
<td>Reverse triangular tanged</td>
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<tr>
<td>Triangular</td>
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<tr>
<td>Triangular tanged</td>
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<tr>
<td>Chisel</td>
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<tr>
<td>Shell Adzes</td>
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<tr>
<td>Bone Adzes</td>
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4.5 The Likely Composition of Early New Zealand sites

The sections above have outlined the different forms of artefacts present in the so-called homeland. By assessing the different levels of occurrence it is possible to infer the likely composition of the artefact kit that arrived in New Zealand. Based on the relative abundance of one-piece hooks and lure points (Walter 1996), it is highly likely that one-piece hooks should dominate early New Zealand assemblages. Of the one-piece hook varieties noted above, acute recurved and simple rotating and jabbing hooks are present in at least three of the archipelagos surveyed, suggesting these forms were common and were likely to be transported to New Zealand. Lures are less abundant in the sites surveyed, with the ‘proximal base extension’ forms (see Figure 4.6) clearly the most widespread type in the region and would be expected to be the dominant form in early New Zealand sites. With respect to adzes, no types appear to be consistently present. Rather, the major characteristic of this period in East Polynesia is a large degree of morphological variation, both in cross section and tang. Therefore, if sites are large enough that sampling bias is sufficiently reduced, we should expect early sites from New Zealand to display a large variety of forms, something that is evident at the early site of Wairau Bar.

4.6 Conclusion

This chapter offered a synthesis of the archaeological evidence from Archaic East Polynesia, the homeland of the Maori culture. It suggested that, while the first New Zealanders must have set off from a single island, this island was part of trade networks that carried materials and ideas across large areas of East Polynesia. These connections ensured a close affinity between many of the societies within central East Polynesia and suggest the homeland is better conceived as a home region. Within this region a number of sites provide us with a picture of the Archaic East Polynesian culture that arrived in New Zealand. Material culture from these sites was highly variable, although, at least in the case of fishhooks, the likely presence of certain types could be deduced. The following chapter presents the first true analysis of this thesis and focuses on the
pattern of population growth in New Zealand. Following this, Chapters 7 and 8 return to the consideration of material culture, this time in the context of change through time in New Zealand.
The Demographic Factor in Prehistoric New Zealand

“Unfortunately, this [demography] is a field in which speculation flourishes, but very little can be said with certainty.” (Davidson 1984: 56)

5.1 Introduction

This chapter focusses on demographic patterns in New Zealand prehistory. The chapter begins by setting the scene of the analysis, first with a broad discussion of the relationship between population and culture change and then by discussing previous considerations of population in New Zealand capable of informing this analysis. The method used for the simulation of population proxies (summed probability distribution) is outlined followed by a consideration of the key aspects and assumptions inherent in these approaches. Finally, new results derived from summed radiocarbon probability are presented.

5.2 Population and Culture

Connections between cultural patterns and population are both common sense and more theoretical. In the case of the former, it is intuitive to suggest that the expansion or movement of people leads to a corresponding movement of cultural material, which may be tracked in the archaeological record. Perhaps even more intuitive and prescient in the current global environment, is the idea that growing population places pressure on societies. The popular notion that there are environmental limits on population size has been developed in academic research, and has been widely applied in the Pacific Islands (e.g. Kirch and Rallu 2007 and
references therein). Here, the pressure (either perceived or real) on resources has been linked to variation in the timing and pattern of settlement between regions and technological innovations, which unlocked new levels of productivity and allowed population to grow until absolute limits were reached.

Population size and the pattern of growth or decline also have endogenous effects on society and culture. With regard to small foraging groups, ‘scalar stress’ may result in decreasing consensus and quality of decision-making within groups. While group fission is one possible action, another is the development of some kind of incipient hierarchy, which may develop into a more traditional hierarchy in time (Kelly 2013: 249). Rapid population growth may also increase the number of people aspiring for higher social positions, something that may lead to the development of competitive aggrandizement and potentially conflict (Turchin 2005; Kelly 2013).

A further consideration is the role that population size plays in cultural transmission. In smaller populations the retention or loss of cultural traits is far more impacted by random processes such as death of experts or transmission errors (Shennan 2000, 2002). Furthermore, traits themselves also go out of use far more quickly in small populations (Neiman 1995) and complexity of manufacture may also suffer (Henrich 2004; Richerson and Boyd 2005). In larger populations the potential for comparing outcomes of techniques and practices is greater and selection becomes a more important mechanism (Shennan 2000).

5.3 Demography in East Polynesia

Past population size and growth has received a lot of attention in East Polynesia (e.g. Kirch 1985; Dye and Komori 1991; Kirch and Rallu 2007). Kirch (1985) presented a range of possible models for the region (Figure 5.1) but argued that the most likely pattern of growth was some kind of logistic pattern. Tuljapurkar et al. (2007: 35) succinctly described the logistic pattern as follows:

“Founding immigrants begin a period of exponential numerical increase in time and of spatial spread; then follows a confrontation with Malthusian...”
limits [carrying capacity] that is manifest in expansion into marginal areas and in the slowing or cessation of population increase; the latter period is marked by the evolution of sociocultural hierarchies in the form of chiefdoms.”

Kirch (2000: 311) suggested this pattern was a “necessary condition” of many aspects of Polynesian cultural development. Initial rapid growth increased survivability of colonists by allowing populations to attain a critical mass quickly, while a levelling off of population is an outcome of populations reaching the limits of finite island resources. As Prentiss et al. (2014) discussed, carrying capacity \((K)\) can be defined in a number of ways, including the optimal population level for the production of surplus and the optimum population for surplus without environmental degradation. However, in Polynesia the term is not as nuanced, usually described as the maximum population capacity of an environment given available resources (Kirch and Rallu 2007, and references therein).

5.3.1 Initial Growth Phase

A period of rapid growth following island colonisation is a likely scenario for a small population entering a pristine environment that offered few constraints to growth. The initial occupation of East Polynesia seems to have adhered to an ideal free distribution model (Kennett et al. 2005) whereby early settlements were established in richly resourced zones. These zones varied between island groups. In Hawai‘i early settlements such as the Bellow’s Dune site were located on the windward coast near permanent water sources (Kirch 1984) and in the Cook and Society Islands early villages were located near reef passages, normally on the sheltered leeward side of islands (Walter 1996; Kahn 2014). Anderson (2002) suggested that from these optimally positioned bases the exploitation of wild resources, such as marine mammals and reptiles, fish, shellfish, and ground-nesting seabirds, would have driven rapid demographic expansion. Cultigens and domestic animals were differentially transported to islands as part of a transported cultural inventory. The successful establishment of agricultural or horticultural economies continued to drive population growth and expansion following the collapse of wild faunal resources (Anderson 2002).
Figure 5.1 Population models proposed for Polynesia by Kirch (1984).
At the archipelago level the rapid growth phase took place below carrying capacity and it is often assumed that this phase was a period of plenty. However, while the upper carrying limits of an archipelago may not have been reached, at a local scale some restriction on growth may have occurred as production met the basic limits of the immediate environment around settlements. Overcoming these restrictions was likely achieved by expansion of the current food production infrastructure or intensification of production through increased inputs (Ladefoged and Graves 2007). Kirch (1984) argued that, in Hawaii, this process led to the expansion of food production from the windward areas to the more marginal production zones on the leeward side of islands. Where agriculture had yet to be established, local carrying capacities produced a different pattern of behaviour. Here, reaching the population carrying capacity of the environment led to the depletion of local wild resources and ultimately the abandonment of sites in favour of pristine areas offering greater resources; essentially, subsistence-driven mobility.
5.3.2 Zero Growth Phase

The transition to a reduced growth phase is said to have occurred as populations reached a threshold defined by available resources (Diamond 2005). Approaching these limits elicited a density-dependent response. Kirch (1984) suggested that, in the absence of infectious disease in Polynesia, these responses were likely to have been primarily social. Cultural regulation of population, in the form of sexual taboos or celibacy, infanticide, abortion, or lactation-induced amenorrhea, has been noted elsewhere as a factor limiting population growth (Kelly 2013) and is also invoked by Kirch. In particular, Kirch (1984: 116-120) cites the Polynesian outlier of Tikopia as a society that actively managed its population to maintain a level at which a specific subsistence standard could be met. This population management consisted of preventative and reactive measures. Cultural values implying that the ideal family consisted of parents and two children were reinforced through religious ceremonies and may have caused a kind of peer pressure, which guided individual reproductive behaviour. Reactive measures such as infanticide and abortion also contributed to the maintenance of population levels. In addition, factors operating beyond local regulations would also have impacted upon population. Warfare – present to a greater or lesser degree on most Polynesian islands – is likely to have provided punctuated change in the number of people in a population (Kirch 1984).

The rationale behind Kirch’s interpretation of Tikopia requires two, somewhat dubious, assertions: (1) that past societies operated only for the good of the group and (2) socio-cultural controls operate only at or near population threshold levels. However, Shennan (2002) has argued that altruistic models are open to exploitation by opportunistic individuals and therefore are not an optimal, or particularly likely, strategy. Instead, responses such as a drop in birth rate may be the result of individual responses to maximise prospects of reproductive success. In the case of Tikopia, families may have had fewer children to allow greater female involvement in subsistence activities while also maintaining investment in those children to ensure greater survival. The mechanisms of this behaviour may be both behavioural (e.g. celibacy during nursing) and biological (e.g. suppression of the

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3 Of course this statement ignores the potentially negative impacts on health and nutrition that population pressure and greater population density may produce (e.g. Cohen and Armelagos 1984, but see Wood 1998 for alternative perspective).
female reproductive system under resource stress). In other words, under this model it was not necessary for human populations in East Polynesia to actively manage group size; instead, zero growth may have been achieved by a series of individual decisions.

Kirch (1984) has argued that the logistic growth pattern is a useful basic model for population growth in Polynesia. However, equally, Kirch (1984; 2007) suggests the pattern of population growth and expansion involves feedback between ecological, demographic and cultural factors. Therefore, individual islands and island groups will exhibit unique patterns of change. The following section introduces past attempts to understand patterns, such as the initial population size and pattern of growth, in New Zealand to provide key background information and parameters for the analysis conducted below.

5.4 Demography in New Zealand

Many early culture histories of New Zealand emphasised the importance of secondary waves of migrants as stimuli for cultural (and presumably demographic) change following initial colonisation (Smith 1913a; Best 1924; Buck 1950). However, archaeological research has provided no evidence of on-going contact with, or subsequent ‘great fleet’ migrations from, East Polynesia following initial settlement. Therefore, the population history of New Zealand is now considered to be one of in situ development of the population within the confines of the New Zealand environment. Like most Polynesian islands inhabited at European contact, it is clear that population growth did occur in New Zealand. Such growth would have had an impact on both people and culture. Therefore, reflections on population are relatively common in the archaeological literature of New Zealand. Considerations generally follow two lines: the absolute population size (usually at colonisation or contact) or the pattern of population growth through time. While these two issues are intimately linked, each will be considered in turn in the following section.
Initial population size is a figure that, until recently, has been considered ‘unknowable’ (Davidson 1984), although some estimates have been produced. One line of thought involved how many people could reasonably be transported to New Zealand in different settlement scenarios (accidental drift versus deliberate voyaging). Irwin’s (1991) modelling of voyaging suggested that the Pacific Islands were settled in a systematic and deliberate manner. This result confirmed that the initial population of New Zealand was not drawn from the crew of a shipwrecked fishing canoe but rather a group of mariners in a double-hulled voyaging canoe thought to have held 40 – 60 people (Irwin 1991). Within this deliberate voyaging framework, McGlone et al. (1994) suggested an initial population figure somewhere in the vicinity of 500 people, based on the number of early settlements and number of people required to fill them and maintain traditions. In both cases the exact means used to arrive at these figures is deeply unclear, thus these estimates must be regarded with extreme caution.

Current estimates are based on ancient DNA analysis, which has seen a rapid growth in application in the study of Polynesian prehistory (e.g. Matisoo-Smith and Robins 2004; Storey et al. 2007). Mitochondrial DNA analysis has shown that genetic diversity is limited in modern East Polynesian populations. This lack of variety may reflect limited variation in founding populations owing to successive bottlenecks in the colonisation process or a net loss of diversity when populations were exposed to disease following European contact (Knapp et al. 2012).

Modern diversity of Maori and East Polynesian haplotypes has been used to predict the number of females who settled New Zealand. The simulation method, first used by Murray-McIntosh et al. (1998) on 54 DNA sequences, has four basic steps. First, the diversity of mitochondrial haplotypes in the East Polynesia was mapped and assumed to be the population from which Maori haplotypes were derived. Second, haplotypes were randomly selected, representing those taken to New Zealand in the colonising population. The number of selections varied based on the number of females assumed to be present in the founding population (values between four and two hundred and fifty females were simulated). The female population in New Zealand was allowed to grow exponentially to a
population of 50,000 (equivalent to 100,000 people) and then the genetic diversity present in 54 randomly sampled sequences was tested to determine the number of females in the initial population that most closely represented the four known haplotype variations in the current Maori population. Based on the evidence available at the time, Murray-McIntosh and colleagues (1998) suggested that a population between 50 and 100 females was sufficient to produce the genetic diversity of modern populations.

Whyte et al. (2005) employed a similar method on an expanded data set. Whyte et al. found nine unique haplotypes in the mitochondrial control region of the modern Maori population and noted that any increase in genetic diversity in New Zealand would lead to a necessary increase in the estimates of initial population (Whyte et al. 2005: 169). Their analysis suggested an initial female population of 170-230 people was most likely given the current diversity in modern Maori populations. Knapp et al. (2012) presented a complete mitochondrial analysis of individuals from the earliest known archaeological site in New Zealand, Wairau Bar. Here Knapp et al. found three distinct lineages in a relatively small (n=4) sample, suggesting further research may show greater initial diversity in New Zealand than previously thought. Furthermore, three of the four individuals showed no sign of recent genetic relationships, suggesting that the effect or existence of bottlenecks may be overstated in previous studies and that the founding individuals were unlikely to be derived from a single matrilocal population (Knapp et al. 2012)

5.4.2 Terminal Population Size

For many years, terminal population size (Maori population size at the time of European contact) has provided the closest ‘real number’ estimate that archaeologists could use. The earliest recorded figure of Maori population size is attributed to Captain James Cook on his eighteenth century voyages to New Zealand. Using his observations of different population size and density around New Zealand, Cook arrived at 100,000 people (Pool 1977). Europeans following Cook made other estimates; however, these were often extrapolated from very localised visitations. For example, in 1817 Nicholas estimated New Zealand’s
population at around 150,000 people based on his experience in the densely populated Bay of Islands (Pool 1977). It is Cook’s estimate that has received the most critique and revision by scholars. Buck (1924) suggested that large tracts of New Zealand were unknown to Cook and, therefore, his estimate was likely an under-representation. He suggested a fairer estimate lay somewhere between 200,000 and 500,000 people. Adhering to a similar argument, Lewthwaite (1950) contradicted Cook’s claim that large areas of the West Coast were unpopulated, stating that, in fact, some areas supported dense populations. This would suggest Cook underestimated Maori population. Later, Lewthwaite (1999) further undermined Cook’s figure by arguing that in other islands around the Pacific he had consistently estimated poorly. Lewthwaite’s own estimate was more conservative than Buck, although he suggested that Cook’s estimate should still be doubled to 200,000 people, half of which was lost by 1840 due to disease and warfare. At the other end of the spectrum, H.D. Skinner took the view that Cook had overly relied on his experience of densely populated areas in the north. Applying similar logic, although with the inverse argument, Skinner (1933) suggested that accounting for lower population in the Otago/Canterbury area meant Cook’s estimate had to be lowered. Skinner went further, suggesting that the introduction of European crops and animals had in fact acted to augment the population in the South Island – and perhaps all districts – following contact. Applying this assumption to the later population data, Skinner argued Cook’s estimate was probably too high.

The first recognised census of the Maori population in New Zealand was made in 1856. This revealed a total population of 56,049. However, given the use of estimates and the avoidance of dangerous areas, it is likely that this census was highly inaccurate and under-represented the population at that time (Pool 1977). While Skinner (1933) argued that population may have grown following European contact this is not a widely held view. Instead, the introduction of venereal and other infectious diseases is seen as a check on population growth as mortality rose rapidly. This, coupled with loses in warfare estimated at between 30,000 and 40,000 people, is suggestive of a period of net population loss in the first fifty or sixty years following prolonged European contact (Pool 1977).
In reaction to what he saw as a caution-less use of the records of explorers who “…had not the least idea of what New Zealand was like outside their landing places…” (Shawcross 1970: 290), Wilfred Shawcross (1970) attempted a quantitative reconstruction of population based on potential carrying capacity. Shawcross focussed on shellfish exploitation within the Whangateau harbour, Northland, and used a range of values to arrive at a population estimate. These included:

- Forager efficiency (or cropping rate) of 14% of the available resource. At such a rate it is argued that there may be limited damage to the viability of the population.
- Average forager take of 105 kg per tide. Both this value and the cropping rate were drawn from non-mechanised commercial shellfisheries in the United Kingdom.
- Seasonal exploitation of the available resource of around 120 days.
- Female-Male-Adolescent ration of 1:1:1.5 based on the ratio observed by Cook in Queen Charlotte sound during his voyages in the eighteenth century.

Using these figures, together with a total biomass of shells, Shawcross estimated that the harbour could support 57 active foragers. Given the assumed population structure, this was extended to around two hundred people in a given season. The modal value was then extrapolated to the whole of the North Island by using biomass and the area of harbours to work out capacity. The figure arrived at was 71,000 people (± 13,000), with another 35,200 (± 9,000) people attributed to areas outside northern New Zealand but in favourable environmental zones. The latter figure is based on approximations of population in given environmental zones of northern New Zealand. Other estimates include 11,000 people (± 3,000) in open shore environments and 5,300 people (± 1,300) in forested areas, bringing the total estimate to 122,300 people (± 26,300).

I agree with Pool (1991) that neither the early voyager nor the later scholarly estimates can be regarded as particularly accurate. The critiques of the likes of Cook’s estimates by Buck (1950) and Lewthwaite (1964) are fair; however, their solution of simply scaling unreliable data is highly problematic. Indeed it now
seems that terminal population size, once considered a more reliable figure than colonising population, must be considered with much more caution.

5.4.3 Diachronic Population Models

Regardless of the true size of the Maori population at European contact, logic suggests that the number is many times larger than the initial number of settlers. As discussed earlier in this chapter, such growth likely had an effect on both the people and their culture. However, despite the potential impact of population dynamics on culture change, most considerations of population remain ‘conceptual’ rather than evidentially based. Typically, references to population growth are made either in passing or as part of a wider archaeological model (e.g. Hamel 1977; Davidson 1984; McGlone et al. 1994; Anderson and Smith 1996; Jacomb et al. 2010). Most often these models assume a pattern of logistic growth analogous with other areas in East Polynesia, the notable exception being those dealing with the non-horticultural areas of the South Islands, (e.g. Jacomb et al. 2010) which, on the basis of limited evidence for later sites, often argue for some kind of collapse scenario.

An example of the consideration of population in relation to other forms of evidence is Groube’s (1970) discussion of population in relation to the development of pa in New Zealand. Groube followed the simple logic that growth in fortifications was related to the rise in warfare or conflict over resources, and the catalyst for such conflict was the growth of population. While population is a secondary concern in the article, Groube offered the opinion that the likely pattern of growth was logistic in shape with a maximum population growth rate not exceeding 1.5 per cent a year. Groube also considered the maximum Maori population of New Zealand in terms of its potential to drive greater conflict. Here, he suggested a population of between 100,000 and 200,000 people was far too small to cause pressure on resources given the large land size of New Zealand. Instead, Groube suggested the competition might have developed around naturally cleared areas or those areas where capital investment in horticulture had already been made and thus the land was of higher value. Although impossible to verify, such an explanation is plausible and such circumstances may have lead to the
perception that resources were becoming limited, which had the same effect on Maori population in New Zealand (population growth levelling off) as environmental limits did elsewhere in Polynesia.

Law (1977) drew upon recorded life tables to model the potential of early Maori population growth, stating that the lowest rate possible to explain Maori population at European contact was 0.6 per cent. While Law presented models of growth to a population level of 200,000 people, these were based on initial population sizes of between two and thirty-two people. Therefore, given current understanding of much larger initial population size, these models are of little use.

The major contribution to the area of population modelling through time is the analysis of osteological material by Brewis et al. (1990). This work builds on earlier work involving estimation of demographic factors, such as fertility, from skeletal remains (e.g. Houghton 1980; Phillips 1980; Sutton 1986; Brewis 1988) and is often cited as confirmation of a logistic growth pattern in New Zealand prehistory. It is for this reason that it is considered in detail in the following section.

Brewis et al. (1990) analysed skeletal data from 172 individuals from which sex and age at death could be estimated. Samples were taken from across the spatio-temporal spectrum of New Zealand prehistory because of the small number of available skeletons. Maori age-specific mortality was measured and plotted against a model population (West 2 Male). Brewis et al. highlighted two differences between the samples in the resulting plot (reproduced as Figure 5.3). The first was the extremely low levels of child mortality and the second was a steep line suggesting a short life expectancy. These variances from model population led the authors to develop a model Maori life table by scaling their results in relation to other Polynesian samples.

Detailed comparison with other skeletal samples from the Pacific suggested the child (0-4 years) mortality rate of the Maori sample (0.095) falls at the extreme lower end of Polynesian samples (see Brewis et al. 1990: 347, Table 4). The low value was argued to be the result of recovery bias rather than any cultural phenomenon unique to Maori, and therefore this value was later scaled.
Dismissing extremely large values from Pu’a Ali’i (0.631) and ‘Atele (0.424), Brewis and colleagues calculated an average childhood mortality value from the remaining sites (0.180, rounded to 0.150), which they suggested is the lower limit of childhood mortality in Polynesia (the upper limit is set as 0.300, double the low value). These revised figures are used in the scaling of the original data into the model life tables.

The adult age-specific life expectancy values for Maori showed a short life expectancy and a very ‘jagged’ pattern with peaks and troughs appearing when compared with the model (West 2 Male) population. When compared to an average life expectancy from the Polynesian samples the Maori values were comparable, leading to their retention by the authors, however, the jagged features of the plot were smoothed until they “more closely resembled standard life table form” (Brewis et al. 1990: 346).

The resulting adjusted age-specific values and completed fertility rates were then compared to the intrinsic growth rate of the Maori population. Fertility rates were measured by ‘counting’ the extent of modification to the innominate bone where greater modification is understood to indicate greater number of pregnancies. Earlier analysis of a small number of Maori skeletal materials using this method suggested that females who had completed their reproductive lives had an average of 3.4 parturitions (Phillips 1980, cited in Brewis et al. 1990). This figure was adopted as a starting point for modelling population growth by Brewis et al. (1990).

Using the supposed founder population size (fifty individuals), the reported population at European contact (150,000 people, based on the mid-point of Pool 1977) and prehistory starting at AD 850 and ending at 1769, Brewis et al. suggested a growth rate of 0.00875 (around 0.8% growth a year) would be required. This figure is in keeping with expectations of modest growth around 1 per cent (Davidson 1984); however, it requires reworking of some of the adjusted life table values. In particular, that level of intrinsic growth requires either a higher level of completed fertility or much greater female survivability during reproductive periods than is accommodated in the adjusted life tables (see Brewis et al. 1990: 353, Table 9).
In considering this discrepancy, Brewis et al. (1990) suggested four possible interpretations:

1. The skeletal evidence of mortality is inaccurate.
2. The level of fertility is underestimated.
3. Growth rate might not be constant.
4. The period of human history in New Zealand might have commenced before AD 850.

The authors dismissed the first two of these interpretations on the basis that similarity between the Maori and other Polynesian values supported the Maori data as a good approximation. This is an interesting position given the manipulation of the New Zealand data to more closely match the Polynesian samples. Furthermore, as noted by Bocquet-Appel and Masset (1982) and Jackes (1994), age
at death distribution is influenced by both the techniques used to arrive at age and the age at death distribution of the sample used to develop the technique. Therefore, any consistency in technique used to establish age in Polynesian samples may, in some way, account for similarities.

The use of the comparison by Brewis et al., while intuitive, does require further consideration. In their Appendix A, Brewis et al. discuss the context of each skeletal collection. It is clear from their summary that the cemeteries come from different periods in the history of an island. For example, Hane is an early site while Namu is considered to be late prehistoric. If, as Kirch (1984) asserts, most Polynesian societies underwent some kind of logistic growth, then it follows that very different demographic processes were operating between sites of different ages. Thus, any attempt to average samples, or indeed to compare the temporally ill-defined Maori remains with cemetery populations, lacks credibility.

The second consideration, incorrectly dismissed by Brewis et al. (1990), is that completed fertility rates in the Maori sample may be underestimated. Brewis et al. noted that, by their estimation, Maori fertility is low. However, in considering the question of underestimation they simply emphasised that the observed completed fertility values would have to increase (from 3.4 to 4.5 births), seemingly suggesting such a rise was unlikely. Despite noting that measures of fertility based on skeletal remains could be problematic, the authors concluded by stating that the “…estimation of fertility offered above on the basis of bony impact evidence is unlikely to be completely misleading” (Brewis et al. 1990: 353). This statement is incorrect, as evidence that alterations to the skeleton during pregnancy are useful in systematic analysis is currently lacking (Ubelaker and De La Paz 2012).

To explain their results, Brewis et al. favoured a combination of a logistic growth pattern and extended prehistory. The latter interpretation can be rejected based on current evidence, which shows the New Zealand sequence is, in fact, shorter than believed when Brewis et al. were writing (Higham and Jones 2004). The former interpretation is possible given current evidence; however, it is important to show that positive identification of the sigmoid growth curve was never presented by
Brewis et al. Rather, the sigmoid curve is used as an explanation for the contradictions in their results.

5.4.4 Summary

Estimates of Maori population at the beginning and end of the prehistoric sequence differ greatly in their reliability. Estimates of the founding population size have become more robust with the development of DNA approaches in archaeology. The current estimate of around 500 initial colonists, while subject to on-going revision, seems in line with a deliberate and organised voyage of colonisation. The range of estimates available for Maori population at European contact demonstrate the difficulty and subjectivity involved in making such projections. As such, it would seem that despite the amount of time dedicated to this topic, more work is required before any particular number may be used with confidence.

Patterns of population growth are of particular interest to archaeologists. Drawing upon analogues from other islands in East Polynesia, local osteological evidence (Brewis et al. 1990), and the disparity between early and late phase population numbers, a logistic growth pattern is logically applied to New Zealand. However, closer inspection of the palaeodemographic analysis from Brewis et al. (1990) reveals a series of problems and no firm evidence for a sigmoid growth pattern. The combination of limited empirical evidence with the emergence of a more complicated pattern of population growth in East Polynesia (Kirch and Rallu 2007) suggests that the next logical step is to test the assumptions that pervade much of the discussion of population in New Zealand archaeology.

5.5 Materials and Methods

Previous sections of this chapter provided introductory and background information. The remainder of this chapter presents the data, method, and results used in the analysis of population in New Zealand.
5.5.1 Data

This analysis was carried out using a large body of radiocarbon dates sourced from the online New Zealand Radiocarbon database as well as published and grey literature. Dates were separated into two reliability classes based on selected criteria discussed by Anderson (1991) and Wilmshurst et al. (2011). Class one dates were derived from species considered reliable for dating and deemed to have minimal in-built age (Anderson 1991; McFadgen et al. 1994; Petchey 1997; Schmidt 2000). Dates were required to have secure archaeological context; however, unlike other studies, single dates from sites were retained for the purposes of this research. Class two dates were those where the context was questionable or the date was derived from a sample with a high chance of in-built age (based on McFadgen et al. 1994) or regarded as being problematic for dating. The analysis presented below was carried out on Class 1 dates exclusively, as Class 2 dates, particularly those from the earlier end of the sequence, were likely to influence the overall shape of the probability distribution.

The majority of dates were collected from the northern region, although Class 2 dates were reasonably evenly collected across all three regions. The lower number of Class 2 dates relative to Class 1 in the north may reflect the large amount of Cultural Resource Management archaeology conducted in that region in recent years when greater attention has been paid to the quality of radiocarbon sampling. Table 5.1 presents the raw numbers of dates collected from across the three regions; however, it should be noted that some well-researched sites have contributed significantly to these counts as evidenced by the unique site count. This attainment or wealth bias is discussed further below.

<table>
<thead>
<tr>
<th>Region</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Unique Sites (class 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>893</td>
<td>258</td>
<td>447</td>
</tr>
<tr>
<td>Central</td>
<td>291</td>
<td>152</td>
<td>129</td>
</tr>
<tr>
<td>Southern</td>
<td>256</td>
<td>207</td>
<td>83</td>
</tr>
<tr>
<td>Total</td>
<td>1440</td>
<td>617</td>
<td>659</td>
</tr>
</tbody>
</table>
5.5.2 Method - Developing Regions

As outlined in Chapter 2, New Zealand consists of a range of environments that have contributed to variation in the development of regional trajectories in Maori culture (Prickett 1982). The environment is particularly influential in the economies of different regions, with respect to the suitability of horticulture. Indeed, despite widespread discord about population number, most sources agree that there is a huge disparity in the distribution of population with northern zones, better suited for horticulture, having far higher populations than less suitable areas (Davidson 1984). To address the possible difference in population histories the radiocarbon database was split into three sub-regions (Figure 5.3). The division between the southern and central regions marks the southern extent of horticulture inferred by the presence of related features (e.g. storage pits) north of this line and their absence south (Basset et al. 2004; Walter et al. 2010). With horticulture present throughout the North Island, the separation of optimal and sub-optimal regions was more arbitrary. This is particularly true because of the evidence of small-scale microclimates highly favourable to horticulture amongst otherwise poor zones (see Chapter 2). Nevertheless, Waltons’s (2006) division of the North Island according to mean July temperature (i.e. mean winter temperature) was taken as a proxy for where this division should be drawn. In general, the zone above this line (northern region) is warmer with fewer frosts during the year to disrupt crops, whereas the temperate area below this line (central region) is cooler, more susceptible to frosts and presented harsher conditions for tropically adapted cultigens.

While not perfect, the regional divisions provide reasonable – if coarse – proxies for the influence of environment on economic activity. While it may be preferable to account for such factors at a smaller scale, the resulting fall in sample size would undermine the resulting population curves. One positive element of this type of analysis is that it is both repeatable and able to be adapted as more radiocarbon information becomes available, or perhaps if other regional boundaries are deemed more appropriate.
Figure 5.4 The regions of New Zealand used in this research with the sites from which radiocarbon dates were taken shown with black dots.

5.5.3 Method - Deriving Population Curves

This thesis uses the summed probability distribution (SPD) of radiocarbon dates to develop population proxies for the three regions outlined above. The basis of this method is the assumption that a relationship exists between the number of radiocarbon dates from a particular period and the population density of that period (Rick 1987; Collard et al. 2010; Shennan et al. 2013). The SPD approach began with the assessment of un-calibrated dates (Rick 1987), but has since developed more toward the analysis of calibrated dates and quantitative assessment results using a hypothesis testing approach (e.g. Shennan et al. 2013 and Timpson et al. 2014)
The method used here employs a simple qualitative assessment of regional population models and a more complex hypothesis testing approach. In the first instance both marine and terrestrial radiocarbon dates are calibrated using the southern hemisphere 13 and marine curve respectively. A local delta-R offset of -7 ± 45 years (Petchey, Pers. Com.) was also applied to marine dates. If multiple dates are drawn from the same archaeological context the dates are pooled to reduce the impact of ‘wealth bias’ where single sites contribute a greater proportion of dates, skewing the resulting SPD. Following the calibration process dates, or aggregated dates (so-called ‘bins’), are split into regional sets and a SPD is generated.

The next step involves a qualitative assessment of the shape of the SPDs to ascertain if any population curve (e.g. logistic growth curve) could reasonably have caused the observed pattern. However, such a comparison is not straightforward. As Williams (2012) discussed, the calibration curve can have an influence on the relative distribution of dates. Ambiguous zones or ‘wiggles’ in the calibration curve may result in a recruitment of dates within a particular range into a centralised date, causing peaks in the distribution that do not truly reflect the density of dates. McFadgen and colleagues (1994) argued that two such zones (one around AD 1400 and another at 1550) create peaks in radiocarbon dates in New Zealand. To assess the possible effect of the ambiguous zone the present analysis follows that of Mulrooney (2013). Four artificial datasets were generated consisting of uncalibrated radiocarbon dates covering the same temporal span of prehistoric New Zealand. Each dataset was developed with different distributions of dates to reflect a range of population scenarios in New Zealand including: static population, logistic growth, exponential growth, and collapse. Dates were then randomly selected from this distribution and an SPD produced. This process was repeated 1000 times to produce a 95% confidence envelope. To test the influence of sample size this process was repeated with a varied number of dates selected from each artificial dataset (200, 500 and 1000 dates). Finally the SPDs derived from known date distributions were compared with the observed regional SPDs to assess what, if any, growth pattern may account for the shape of the observed SPD.
The second set of analyses is more advanced and follows a hypothesis testing approach that allows for quantitative comparison of two or more SPDs. The initial stages of this analysis are the same as those outlined above, with dates calibrated and aggregated if required. Once this is complete the dates that derive from a specific region are summed to generate the observed SPD from the region.

In the second stage of this analysis all dates and binned dates were placed into a single pool representing data from throughout New Zealand. Then, based on the number of dates (or bins) from an individual region, the same number of dates was randomly selected from the national pool of dates and an SPD was generated. This process was repeated 1000 times. Using the 1000 iterations, a 95% upper and lower confidence interval (or envelope) was computed. For the sake of clarity we can consider a toy example where 1000 dates and bins from throughout New Zealand represent the national pool of dates. We count the number of these that are found from the southern region and find there are 250. We then randomly select 250 dates from the national pool and produce an SPD, the dates are placed back into the national pool of dates, and the process is repeated until a confidence interval can be produced.

The observed SPD from each region was then overlaid onto the confidence interval envelope derived from the simulation of the dates from the national data pool. The portions of the observed regional SPD that fall outside the confidence envelope are said to be statistically significant local deviations from the null model, represented by the national dataset. Based on the methods outlined by Timpson et al. (2014) a significance value was then calculated by calculating the area outside the 95% confidence range for both the observed data and each simulated SPD. The proportion of simulations which had a summary statistic as or more extreme than the observed data provided the $p$-value for each region.

Ultimately, this analysis is based on differences in shape between two SPDs. Therefore, a drop or rise in a particular SPD implies a drop in population, given the particular factors unique to that region, relative to the other data. In other
words, the focus of this analysis is on identifying different regional variations from the national pattern of population.

5.5.4 Discussion of Method

The methods used in this chapter represent both qualitative and quantitative solutions to the question of what past populations looked like. However, they rely on the assumption that SPDs represent a fair population proxy and, at a deeper level, that the density of radiocarbon dates does represent density of population. The following section considers this last point in greater detail, focusing on factors that may introduce bias.

Taphonomic processes have a large influence on the methods used in this thesis. In particular, if there is a positive correlation between the age of a site and the likelihood of destruction by taphonomic processes, it follows that the density of later sites may be inflated. This is particularly problematic as the length of the sequence increases and the degree to which survivability of deposits diverges between early and late sites. The relatively short New Zealand sequence is likely to reduce the degree to which taphonomic factors bias the dataset, although clearly some bias will still be present.

The major taphonomic factor in New Zealand is coastal erosion. Most early sites in New Zealand have been found in association with river mouths or estuarine environments (Davidson 1984; Walter et al. 2006) very close to, or on, the coast, and are highly likely to have been negatively affected in high erosion zones. While such a trend suggests these sites are less likely to survive in the archaeological record, it is also true that erosion increases the visibility and recovery of archaeological material from these sites. This is true of other contexts in New Zealand; sites in inland zones can be less affected by taphonomy, meaning they will survive in the record, but are also far less visible. Clearly then, there can be no straight line drawn between taphonomic effects and collection bias, which makes accounting for taphonomy in a systematic fashion difficult.
Williams (2012) argued that sites of different ages might be subject to differential collection biases as well as taphonomic biases. If particular periods are of greater interest to archaeologists, for example the colonisation of islands in the Pacific, it is possible that date density around these periods will be inflated. In New Zealand’s case the research agenda remains, ostensibly at least, focussed on developing regional sequences of change. Theoretically this involves an understanding of sites from across the temporal spectrum, suggesting a lack of systematic research bias. In practice some skew is inevitable but its form (i.e. skew toward early or late) is difficult to predict. One region where systematic bias may exist is southern New Zealand, where the early period has been a major focus of archaeological enquiry (e.g. Anderson 1982, 1989; Anderson and Smith 1996). However, it is possible that this bias is actually driven by the archaeological record itself. Jacomb et al. (2010) suggested that areas of southern New Zealand were abandoned after the first 200 years of settlement. Their assertion is based on a large-scale survey of the south coast of the South Island, which recorded all coastal sites and, together with a programme of radiocarbon dating, identified very few sites occupied after the first 200 years of human settlement of the region. This small example shows that it can sometimes be difficult to disentangle patterns assumed to be the result of bias from those that reflect the true nature of the record.

The lack of precision provided by relative dating also impacts on sampling. Relative dating measures in New Zealand are based around the dual-phased cultural model: the presence of artefacts and features, or the landscape context of sites, leads to the label of ‘early’ or ‘late’. While providing some relative measure of site age within the sequence, archaeological remains cannot provide further precision. Therefore, to develop an understanding of when sites were occupied within the broader cultural phases, radiocarbon dating is equally likely to be deployed across all sites. A further consideration is the impact of the growing contribution of cultural resource management (CRM) archaeology to the corpus of radiocarbon dates. In New Zealand CRM proceeds ad hoc in terms of location and has no centrally driven research aims. It follows that it is unlikely to contribute dates with a systematic bias toward a particular timeframe.
5.5.5 Summary

From the preceding discussion it is quite clear that the influence of factors with the potential to bias these results is not easily predicted. Potentially destructive forces, such as erosion, eliminate sites from the record but may actually increase the likelihood that a site will be sampled for radiocarbon because of the need for mitigating excavation. Ultimately the lack of clarity around how these processes influence the record makes it difficult to systematically account for them in this analysis. Despite this, I take that view that the analysis conducted here is suitably robust against known factors, such as wealth bias, to warrant its application in New Zealand. Given its repeatability, it is always possible that information developed regarding taphonomic bias in New Zealand can be integrated at a later stage.

5.6 Results

5.6.1 Assessing Bias – regional spread of dates and the influence of the calibration curve

5.6.1.1 Regional Spread

Comparison of early census data, archaeological authorities (required for any kind of excavation in New Zealand), and the radiocarbon data (Table 5.2) inform understanding of how accurate the spatial distribution of dates in this chapter may reflect spatial spread of population. As discussed earlier, the 1856 census data was collected in an ad hoc fashion and is not without problems; so too the authority information, which lacks data from the South Island. Nevertheless, if we compare the Class 1 dates with the census data we see the northern and central regions are not too dissimilar, although southern New Zealand is apparently over-represented by radiocarbon dates. Perhaps a more pertinent comparison is between the authority data and Class 1 dates. Given the lack of data from the southern region it is clear that direct comparisons will be skewed. However, by omitting the southern region entirely we end up with 75% of radiocarbon dates from the northern region and 24% from the central region, closely matching the relative frequencies of authorities. This correlation suggests archaeological focus does introduce some bias between regions.
Table 5.2 Comparison of census data, recorded number of excavations undertaken in each region 2000 - 2015, and number of radiocarbon dates used in this analysis.

<table>
<thead>
<tr>
<th>Region</th>
<th>1856 Census</th>
<th>1856 % of pop.</th>
<th>Authorities</th>
<th>% of Authorities</th>
<th>C14 dates</th>
<th>% of C14 dates</th>
<th>Class 1 dates</th>
<th>% of Class 1 dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>38,269</td>
<td>69</td>
<td>1750</td>
<td>77</td>
<td>1151</td>
<td>56</td>
<td>893</td>
<td>62</td>
</tr>
<tr>
<td>Central</td>
<td>15,907</td>
<td>28</td>
<td>516</td>
<td>23</td>
<td>443</td>
<td>21</td>
<td>291</td>
<td>20</td>
</tr>
<tr>
<td>Southern</td>
<td>1,163</td>
<td>3</td>
<td>No data</td>
<td>No data</td>
<td>463</td>
<td>22</td>
<td>256</td>
<td>18</td>
</tr>
</tbody>
</table>

5.6.1.2 Calibration Curve

The southern hemisphere calibration curve for New Zealand’s prehistoric period possesses some features which influence the reliability of calibrated date ranges. McFadgen et al. (1994) note two ambiguous zones, or so-called ‘wiggles’, in the calibration curve at 400 and 550 BP respectively, which are said to recruit dates and create ‘peaks’ in the distribution of dates. Figure 5.4 shows the results of calibrating a known, and in this case uniform, distribution of uncalibrated dates. Here, the ‘peaks’ discussed by McFadgen et al. are very clear; however, another equally influential peak is also apparent slightly earlier at around 625 BP, although the 100 year rolling mean does appear to be relatively flat. This result emphasises the fact that many finer scale peaks and troughs in the SPDs are purely the result of calibration and should not be treated as ‘real’ patterns.

The effect of the calibration curve can also be seen in other scenarios of population growth. Figures 5.5 – 5.8 show SPDs based on uncalibrated date distributions including exponential growth, logistic growth, and exponential growth followed by collapse. Figure 5.6 shows the simulated SPD from an uncalibrated date distribution based on exponential growth. Here, the peaks seen in Figure 5.5 are present, while the rolling mean shows a gradual increase followed by a small decline, which could possibly be interpreted as a logistic pattern. This pattern may be caused by the recruitment of dates from the last 100 years into the
peak between 400 and 300 BP, which is also seen to a much greater extent in the other simulations. Edge effects may also account for some of this decline.

Figure 5.5 Summed probability distributions based on an underlying uniform distribution of uncalibrated dates.

Figure 5.6 Summed probability distributions based on an underlying exponential distribution of uncalibrated dates.
Figure 5.7 Summed probability distributions based on an underlying logistic distribution of uncalibrated dates.

Figure 5.8 Summed probability distributions based on an underlying collapse distribution of uncalibrated dates.
Figure 5.7, based on a logistic growth model, demonstrates that simulated dates, before and after calibration, exhibit a marked difference at the later end of the chronological spectrum. As above, the simulated data exhibits a large-scale drop-off, which was not present before calibration. In fact, with the exception of the size of the first ‘peak’ at around 625 BP, the logistic model (including the rolling mean) shows a remarkable likeness to the uniform simulation.

The other scenario drawn from New Zealand’s archaeological literature is population collapse. When compared to the simulated collapse dataset prior to calibration, the SPD has a broadly similar population peak but has a much steeper decline (Figure 5.8). Like the other SPDs, it is difficult to connect the observed shape with the underlying date distribution. Overall, this exercise has shown the clear and obstructive influence of the population curve on the shape of SPDs. The similarity between the logistic and uniform distributions also shows the potential for equifinality in this data.

5.6.2 Pattern of Population Change

The results of the previous analysis show the difficulties in inferring underlying patterns of data from SPDs. Nevertheless, this section does attempt some qualitative comparison, albeit with a note of caution attached to the results. Figure 5.9 shows the results of the summed frequency of Class 1 radiocarbon dates from the three sub-regions of New Zealand. One consistent pattern across the regional SPDs is the presence of relatively rapid growth, although this appears to be slightly later in the northern region. To some extent this rapid rise may be the result of the peaks noted in the discussion of the uniform distribution SPD; however, the evidence from the rolling means, which discounts the extremes in the data, supports the idea that growth is rapid. This pattern is important as it suggests that the idea that population growth following initial settlement of New Zealand was rapid and probably exponential (McGlone et al. 1994) does appear to be supported to some extent by these data.
Figure 5.9 Summed probability distributions from the northern, central, and southern regions of New Zealand.
Based solely on the 200 year rolling means of the SPDs, it could possibly be argued that population in the northern and central region underwent a broadly logistic growth pattern, in that after the first \( \approx \) 200 years population growth levelled off. Conversely, the southern region appears to decline during this later period. This decline may also be an artefact of the calibration process discussed above. However, the decline seems to occur to a much greater extent than either the regional SPDs or the models presented above. It is also noteworthy that this decline appears to begin at around 500 BP, which is well before the decline, assumed to be the result of calibration, in other plots.

### 5.6.3 Quantitative comparison of regional SPDs

The quantitative assessment of regional data shows the variation of regional SPDs from the null model consisting of all dates from New Zealand. Figure 5.10 presents the results of the analysis of only terrestrial dates, while Figure 5.11 presents the combined results of terrestrial and marine dates. Broadly speaking, both figures reveal the same patterns and therefore are considered together in the following section.

Beginning with the northern region we see two significant \( (p=0.0001) \) deviations from the null model. The first is the undershoot of the northern SPD between 700 and 500 BP (i.e. approximately the first 200 years of settlement), suggesting population growth was significantly slower in the northern region. The second pattern is a large overshoot of the northern SPD during the later half of the sequence. This pattern suggests that the major focus of population in the northern region occurred later in prehistory and that this population was greater than predicted by the null model. This is entirely consistent with the archaeological evidence and census data that suggests this region was the focal point of later Maori population.
Figure 5.10 Regional terrestrial SPDs compared with the null model (grey envelope) derived from all New Zealand dates.
Figure 5.11 Regional SPDs based on marine and terrestrial dates compared with the null model (grey envelope) derived from all New Zealand dates.
The central region is generally consistent with the null model, although the SPD does fall below its expected position between 400 and 200 BP (this is significant using terrestrial data \( p=0.025 \) but not using both marine and terrestrial \( p=0.05389 \)). This pattern suggests the central region is a middle ground between the early focus on southern New Zealand and the later focus on northern New Zealand, probably reflecting its literal middle ground status, straddling the horticultural zone and the rich big game hunting grounds of the South Island.

Finally, the southern region shows a significant \( (p=0.0001) \) overshoot during the first two centuries following human settlement of New Zealand, when compared to the null model. This rise is consistent with archaeological models, which suggest rapid population growth occurred in regions with large numbers of big game resources, such as southern New Zealand. The region also shows significant undershoot in the last three to four centuries of prehistory. Again, this is consistent with the early census data, which suggests this region was only sparsely populated, and with archaeological models that predict some kind of population collapse or large-scale migration from the region following the decline of big game resources (generally said to have occurred by the point the SPD declines) due to the inability to establish horticulture in the region.

5.7 Conclusion

The qualitative analysis of simulated summed probability distributions shows the influence of the calibration curve and the difficulty with assigning observed patterns to specific growth curves. However, despite this, some patterns, such as that which appears to be some kind of exponential growth at the beginning of all regional SPDs, provides useful information about patterns of population growth. This information will be used for analysis later in this thesis.

Quantitative assessment of SPDs largely confirmed the conceptions of population history that are implicit in many aspects of archaeological research in New Zealand. Figures 5.10 and 5.11 show a clear difference in population within the three regions. The greatest difference is exhibited between the southern region and the remaining regions. In particular, the southern population grew more
rapidly than other regions, almost certainly on the back of the abundant wild resources that were voraciously harvested by early communities. Population growth was slower in the other regions, probably reflecting the slower returns offered by subsistence based around horticulture. However, once wild resources became scarce in the southern region (c. 100 years after first settlement), population in the southern region appears to have collapsed.

In the northern and central regions, favourable conditions for cultigens led to the development of a horticulture-based economy. Once established, this economy encouraged increased sedentism, higher population, and probably more complex socio-political organisation as well as greater competition for resources. In many ways these zones (particularly the northern zone) represent the areas of New Zealand most like the related populations and culture in East Polynesia. However, the still marginal conditions of the region meant that the population density achieved elsewhere in the Pacific, for example the 120 people per km$^2$ in the Hawaiian Islands and 66 ppkm$^2$ in Rapa Nui) was not replicated in New Zealand, which had a peak density of approximately 11 ppkm$^2$ (c. 20 ppkm$^2$ excluding the South Island). The other regions reflect even lower population density and indeed evidence of large-scale population decline. Such population patterns probably reflect the position of these zones on the very margins of Polynesian technology. In the central region available knowledge and technology could sustain population whereas, in the south the inability to establish horticultural crops, a major part of the East Polynesia inventory, meant population was not sustainable.

While many of the patterns discussed in this chapter are similar to those previously assumed; this analysis has successfully developed these models from an independent empirical base. These models may now contribute to wider discussions of culture change in New Zealand, including those surrounding material culture and settlement patterns.
Material Culture Methods

6.1 Introduction

The previous chapter presented the results of demographic analysis, the first key methodological thread in this research. In the next three chapters a second avenue of analysis – material culture – is considered in greater detail. The current chapter provides an introduction to this set of chapters by outlining the methodology used for characterising the material culture variation in adzes and fishhooks and for developing an understanding of change over time. The results of these analyses are presented in Chapters 7 (fishhooks) and 8 (adzes).

6.2 Classification

The documentation of material culture lineages involves a number of steps, the first of which is the classification of material culture variation. Artefacts have a range of characteristics (traits), which may be classified. Cultural information that is the basis for these traits is transferred between individuals leading to both continuity and change in the traits themselves. Therefore, by assessing the variation of material culture we may begin to develop an understanding of the processes that led to change through time in the artefact tradition.

Classification is a practical technique enabling large collections or assemblages to be assessed (O’Brien and Lyman 2000; Read 2007). Although archaeologists frequently deal with empirical differences, which are easily defined without associated theory (e.g. the empirical difference between adzes and fishhooks), classification involves the development of classes using ideational units, that is,
units that cannot be seen or felt, such as a unit of measurement (O’Brien and Lyman 2000; O’Brien et al. 2010). As classification is an important part of this thesis, its underlying theory and nomenclature are outlined below.

Dunnell (1971: 51) differentiated the terms ‘group’ and ‘class’. ‘Groups’ were recognised as empirical collections based on a basic conceptual understanding (e.g. a group of apples v. a group of oranges), while ‘classes’ were intentionally developed (Dunnell 1971: 200-201). Intentionally developing a class usually involves assessment of an empirical thing (e.g. an artefact) using ideational units either through measurement or description of a different attribute state (O’Brien and Lyman 2000). This research focuses on ‘types’ (a class defined by a range of attributes) and the attributes themselves. Dunnell (1971: 200) defined attributes as the smallest distinct unit in a given investigation. In this thesis ‘trait’ is used to describe a specific phenotype of an artefact (e.g. blue, red, green) and a class of attributes is termed a variable (e.g. colour). Figure 6.1 shows the relationship of these concepts; here an artefact is classified based on the variable colour, which has four possible traits: yellow, blue, red, and green. The last term to be discussed is ‘type’, which Dunnell (1971: 158) described as:

“(C)lasses whose significata consist of sets of modes (variables) stating the necessary and sufficient conditions of membership”.

Essentially then, types are defined by the unique expression of attributes across a selection of variables (e.g. colour and shape).

In cases where a variable displays continuous variation artificial divisions may be imposed using prior knowledge. For example, O’Brien et al. (2010) showed that the continuous variable ‘notch angle’ on projectile-points could be divided (1-30°, 31-60° and 61-90°) based on the functional distinction of points falling within these ranges. As Bettinger and Eerkens (1999: 231) note, types are useful tools to:

“identify consistently recurring combinations of attributes, suggesting the presence of evolutionary forces that cause these combinations to be maintained more or less across space and time”
One of the key reasons for outlining the nomenclature used in this thesis is to differentiate empirical and ideational units. Understanding that classifications are ideational constructs, which should be developed with specific investigative purposes in mind is crucial when developing typological schemes (Brew 1946). The decline in studies with a focus on portable material culture in New Zealand has led to a corresponding decline in the appreciation of this fact. For example, in her discussion of previous New Zealand adze studies, Turner (2000) criticised the lack of typological focus on the primary purpose of adzes – their functional attributes. Turner argued that function-dictates-form and her examination and experimental work on adzes allows the development of a typology using factors “relevant to the people who originally produced these artefacts” (Turner 2000: 1). Turner indicated that experiments showed certain adze traits had little functionality and criticised their use in other typologies (Turner 2000). In her discussion it is clear that Turner viewed her types as empirical realities and did not recognise the worth of typologies developed using other criteria. This singular example demonstrates how New Zealand archaeologists have often been insufficiently inclusive of typology building based on research agendas that are not in sync with their own. In this case, classification is carried out with the goal of characterising change over time, for which functional traits may or may not be useful.
6.2.1 Methods of Classification

Two classification techniques are prevalent within archaeology: taxonomic and paradigmatic. Taxonomic classification involves the creation of types through ordered and hierarchical division of artefacts based on differentially weighted characteristics (Dunnell 1971; O’Brien and Lyman 2000). Paradigmatic classifications are built using un-weighted variables of interest to a specific question, thus removing the need to estimate the relative importance of each variable. Each variable may have multiple attributes determined by the researcher before the application of the system to an assemblage (Dunnell 1971). This has the effect of creating categories, which should cover the variability of forms within an assemblage while not being defined by any one trait in particular. This system allows any attribute to combine with any other attributes selected by the researcher, although this may not occur in reality (O’Brien et al. 2002). Traits are selected for an analytical purpose and not tied to extensional constructions based on specific assemblages, which, as Allen (1996: 102) noted, gives paradigms an ahistorical quality allowing them to be applied to new assemblages. In the development of classes paradigmatic classification allows greater flexibility. If, for example, a variable is assessed and found to be unhelpful for analytical purposes it may be removed with no effect to the overall scheme.

While existing typologies of fishhook and adzes in the Pacific were available for use in the current research (e.g. Duff 1956; Emory et al. 1959; Hjarno 1967; Turner 2000), these suffer from being extensionally defined (Dunnell 1986) and hierarchical in nature, thus certain aspects are judged to be of greater significance than others. Both situations present problems; therefore, it was decided to employ paradigmatic classification, which uses un-weighted taxonomic classification (Dunnell 1971; O’Brien and Lyman 2000).

The fishing gear tradition in New Zealand consists of three lineages: (1) one-piece angling hooks; (2) two-piece angling hooks; and (3) trolling lures. Each group has a different range of characters; therefore three separate paradigmatic classifications were developed. The classification of adzes involved a single paradigmatic scheme. Characters were included based on observation of variability in state and the
expectation that they would exhibit some kind of structured change. The specific traits assessed are outlined in Chapters 7 and 8.

6.2.2 Selection of Functional v. Stylistic Variables

One of the key concerns in the analysis of material culture has traditionally been whether traits are functional or stylistic (Allen 1996). The concepts of style and function were described by Dunnell (1978) as fundamentally dichotomous. ‘Style’ denotes forms that are not under selection, while ‘function’ suggests forms that are selected for their functional value (Dunnell 1978). Therefore, functional variables may correlate more closely with the activity they perform than with any temporal or cultural relationship. Conversely, the lack of selective forces acting on stylistic features means they evolve through drift, independent of environmental or output driven factors, suggesting that similarities are homologous and based on relatedness (temporal or spatial) or interaction (Nieman 1995; Dunnell 2001).

Given the supposed superiority of stylistic variables in chronological studies, differentiating them from functional variables is important. Dunnell (1978) argued that stylistic or neutral variables could be identified prior to analysis as variables with equal cost across all attributes. Put simply, in cases where the cost of creating attributes remained constant through time any variation may be identified as the result of stylistic preference (Jordan and Shennan 2009). More recently, the concept of designating variables as ‘functional’ or ‘stylistic’ using Dunnell’s (1978) dichotomy hypothesis has been criticised. Instead, function and style have been viewed as the ends of a spectrum encompassing pure drift (style) through to strong selection (Shennan and Wilkinson 2001). Based on evidence from European Neolithic pottery, Shennan and Wilkinson (2001) suggested supposedly stylistic variables may exhibit selection-driven change as well as pure drift. However, at the functional or heavily selected end of the spectrum evidence of cultural transmission was blurred, consistent with the assertion of Dunnell. This is not always the case. Shennan and Wilkinson (2001) suggested there is evidence for strong descent signals within cultural variables such as subsistence, which would usually be considered under heavy selection pressures.
In East Polynesia Allen (1996) noted a similar phenomenon in her work with onepiece fishhook heads from Aitutaki, Cook Islands. Regarding style and function she noted fishhook heads have an:

“…important functional role [however] the particular morphologies of these line-lashing devices have proven to be good chronological indicators, consistent with the definition of style used here” (Allen 1996: 103).

In other words, Allen identified that the lashing or ‘head shape’ of a one-piece fishhook, which may be presumed to have a functional component, behaved, in practice, like a stylistic variable in regards to change of attributes through time. As the boundaries between these mechanisms are unknown and the possibility exists that the variables assumed to behave in a particular manner (e.g. stylistically) may not, the selection of variables based on a priori assumptions of what is stylistic and functional is unwise. Instead, this thesis takes an inductive approach to choosing variables for analysis. Firstly, those variables, such as one-piece hooks heads, that have previously shown evidence of structured change are included in analysis on the basis of their past efficacy. Secondly, because of the use of photographs, artefacts could be examined thoroughly to determine what variables appeared to show deliberate variation. These variables were then included in this analysis.

6.3 Seriation

The seriation technique involves the ordering of archaeological units along a single dimension based on similarities in material culture (Marquardt 1978; O’Brien and Lyman 2000). The underlying assumption of this ordering “is that propinquity in formal properties denotes propinquity in time” (O’Brien and Lyman 2000: 273). Put simply, within a homologous artefact lineage those artefacts which are similar in form are likely to possess similarities because they have had less time to diverge or change. Therefore, in an ordering system like seriation they may be placed closer together relative to other, less similar, artefacts.

Perhaps the most important aspect of seriation is that it is the product of ordering based solely on the formal properties of artefacts (Lyman et al. 1997). Independent
factors, such as chronometric data or stratigraphic position, are irrelevant to the order (Dunnell 1970). Instead, any chronological pattern must be inferred from the ordering itself. Once completed, however, such an order may be corroborated with independent techniques such as radiocarbon dating (Teltscher 1995).

The conditions of seriation have been the focus of a great deal of discussion since the culture history period (Rowe 1961; Ford 1962; Rouse 1967; Dunnell 1970; Cowgill 1972; Marquardt 1978; O’Brien and Lyman 2000). O’Brien and Lyman (2000) summarize this work by presenting four key requirements:

- Seriated assemblages must be of similar duration. This negates the possibility that observed change is the result of greater or lesser time depth and strengthens the chance that change is related to chronology. The most favourable site is one with a small time depth as this provides a ‘snapshot’ of the artefacts within the site before they have the chance to be modified.

- Assemblages must derive from the same geographic area. Like the first requirement, this ensures that change is more likely to be related to chronological variation. Importantly, the conception of ‘the same geographic area’ is different in an island environment compared with the continental scale. However, while New Zealand’s spatial scale is limited, it is important to consider environmental diversity, which may result in variation based on functional requirements. As a generalised woodworking tool, adzes were probably used for similar purposes, although raw material may have influenced shape. Conversely, fishing gear may have been influenced more by different prey species in regions than by raw material. Therefore, while New Zealand is small, geographic variation remains an important consideration.

- Seriated assemblages must belong to the same cultural tradition. As O’Brien and Lyman (2000) suggested, generally meeting the second requirement will often mean the third is also met. The shared cultural origin of New Zealand culture, together with the lack of later migrations, means this condition is easily met.

- Assemblages must conform to a minimum sample size. As discussed above, the size of a sample assemblage can have a large effect on
frequencies as well as presence and absence data. O’Brien and Lyman (2000) suggested a minimum threshold of one hundred artefacts (in their case ceramic sherds) is desirable. However, smaller samples may be used where appropriate. This condition as it relates to the current research is considered further below.

If the conditions of seriation are met the technique is a powerful tool for understanding change through time and measuring homologous similarity in material culture lineages.

6.3.1 Seriation Method

The abundance of types constructed through paradigmatic classification in this thesis necessitates the use of more sophisticated, rapid means of seriating assemblages than frequency graphs (e.g. Ford 1962). In this research assemblages are seriated using correspondence analysis. Correspondence analysis (CA) is a method that reduces complex, multiple dimensional data down to workable levels to allow greater understanding of underlying pattern (Shennan 1997). CA uses count data to assess the relative $x^2$ distances of sites from the overall mean and reduces this data into many dimensions, any one of which may be plotted against another. Generally the first dimension accounts for the most variation and is regarded as best for use in seriation (Shennan 1997). Therefore, for ease of interpretation, this thesis presents ‘battleship’ plots showing the seriation of sites based on their position along dimension 1 and the relative frequency of a trait. This allows for a clear assessment of the patterns of change over time.

It is important to point out that, as with all seriations, the plots produced by the CA merely show the relation of sites to each other along a particular axis. This order does not necessarily have to be the result of propinquity in time. Instead it may represent geographical or environmental similarities of particular sites. It also does not suggest which end of the sequence represents early or late (Shennan 1997). Rooting one end of the sequence must be carried out using markers such as historical record of site occupation, presence of extinct species, or radiocarbon dating (Jacomb 1995; Shennan 1997). Frequency seriation presents a hypothetical
sequence; therefore, strong seriations will be supported by others constructed using different variables, or in a different fashion. In this thesis frequency seriation is carried out independently on adzes and fishhooks to allow comparison. These seriations are also tested against available radiocarbon determinations to ensure the dimension along which assemblages are ordered relates to temporal variation.

Sites within three broad regions (southern South Island, northern South Island and North Island) are also isolated. Following the same methods as are outlined above allows regional seriations to be developed that inform the understanding of different patterns and tempo of change between different regions.

6.3.2 Testing CA and Seriation Accuracy

CA is an exploratory technique designed to discover patterns in data; therefore the strength of the result is difficult to ascertain. In particular, the relative sample sizes of different sites are likely to influence the observed frequency of a particular trait and overall trait diversity. In effect, this means that it may be difficult to have confidence in the relative positions of sites (in a CA plot and resulting seriation) if sample size is low, thus the result is undermined. One means of testing the robusticity of CA results has recently been developed for archaeozoological data (Gerbault et al. in prep). This method develops point clouds representing the uncertainty of the position of a site in a CA plot. The point cloud is derived from \( n \) random grabs taken from a dirichlet distribution (a multinomial version of the beta distribution; Frigyik et al. 2010). The precision of these grabs (i.e. the spread or clustered nature of the distribution derived for an individual site) is based on the relative sample size of each site. Thus, in sites with large sample sizes the dirichlet point cloud will be tightly clustered. The inverse is true of sites with low sample sizes. Following the selection of \( n \) dirichlet deviates the 95% confidence interval is produced based on these points, which represents the uncertainty range for each site in the CA plot (Figure 6.2)

Figure 6.2 provides an example of this process. Sites A-E are analysed using CA and plotted to show their relative positions. Then, based on the position of each site, dirichlet deviates are drawn from an underlying dirichlet distribution. The
distributions parameters (e.g. how spread the distribution is) are determined by the sites themselves. In this example we can see that the deviates derived from Site A are tightly clustered while those from Site E are spread. This is because Site A has a high sample size (and therefore has a more constrained distribution) while Site E has a relatively small sample size accounting for the greater spread of points.

The other important aspect of the example below (Figure 6.2) is the overlap of some sites (Site B and C) and not others. Based on the lower plot, showing the 95% confidence interval polygons for the position of sites, we can argue the Sites A, D and E can reasonably be considered distinct from all other sites and their relative position in the CA plot and resulting seriations can be regarded with confidence. However, Sites B and C, while being distinct from the remaining sites, overlap with each other. This suggests that the ordering of these two sites should be viewed with some caution. An important point of clarification in this matter is that the position of these sites relative to the other sites remains firm. This point is best represented by the inferred sequence (Figure 6.2) taken from the position of sites along Dimension 1. Here we can see that, while the position of sites B and C may change (each site may be either second or third in the sequence) the lack of overlap with other sites means these sites can reliably be placed in those positions in the sequence.

In this thesis the uncertainty range, based on 1000 dirichlet deviates (1000 deviates represents the highest number that was possible given computational power available), is only established for those trait seriations that appear to relate to temporal change in trait frequency. The decision to exclude traits without any obvious change relating to time was taken due to the fact that the analysis of these traits was deemed to add little information to the consideration of culture change. The dirichlet simulations are also carried out prior to the drift simulations (detailed below) in order to understand the uncertainty between those sites used for that analysis.
6.4 Processes of Change - Drift

Developing patterns of change over time is the first step in the analysis of material culture. The second step involves an attempt to identify what evolutionary process caused the distribution of through-time patterns identified in the previous step of analysis. Despite the preoccupation with adaptive change in New Zealand archaeology, other forces, such as neutral trait evolution (drift), may also account for change. In this thesis the potential influence of drift is assessed via simulations in combination with real-world archaeological data. As discussed in earlier chapters, drift is heavily influenced by population size and growth rate; therefore these factors are also accounted for in the method.

To explain the simulation method let us consider an example where an artefact trait is present at a frequency of 50% in a dated early period site. A random drift model (without mutations) is run 1000 times (grey lines, Figure 6.3 – 6.5) using this initial trait frequency, this is repeated but for each set of 1000 simulations a
different initial population size (between 5 and 500 people) and differing population growth rates are applied (1%, 1.5% and 2% per annum). Figures 6.3 – 6.5 show an example of these simulations.

The resulting simulations are then used to extract a mean and two standard deviation range for each combination of starting population and population growth rates. The mean values nearly always remain constant at, or near, the starting frequency and are therefore not shown in the resulting graphs. However, the 2σ range, showing the range in which 95% of simulations fell, is shown (red lines in Figure 6.3 – 6.5). Other lines shown on the figure are the mean frequency through time of surviving simulations (i.e. those that have not fixed at 1 or 0: blue line, Figure 6.3 – 6.5) and the survivability curve (black line Figure 6.3 – 6.5) showing the number of surviving simulations through time as a percentage of the original 1000.

The second stage of the analysis involves overlaying trait frequency data from other dated sites onto the plots produced in stage one (Figure 6.9). Sites were placed along the X-axis of the graphs according to their absolute chronological position (taken as the mid-point in their 2σ radiocarbon range) and the Y-axis according to the frequency of a given trait in the assemblage. To ensure that trait frequency variation between sites is significant and not the result of sampling, the dirichlet method (outlined above) is carried out on the sites prior to this step of analysis. This results in a CA plot showing dirichlet polygons (Figure 6.9) derived from the sites that overlay the simulation (black squares, Figure 6.9). We can have high confidence that the observed trait frequencies are a fair test of the simulations if no overlap in the 95% ranges produced from dirichlet analysis is apparent between sites.

Finally, the observed archaeological data is qualitatively compared with the simulated data to ascertain whether drift seems a likely cause of through-time change. Figure 6.9 shows this process using an example dataset where the initial trait frequency is 15% and where three different trait trajectories are shown (squares represent the frequency of this trait at a site, see previous paragraph). If the observed pattern falls outside the 2σ range, represented by the red lines, we
can say that it is unlikely that drift could account for the change. In Figure 6.9 trajectory ‘A’ would be considered unlikely to arise due to drift, while trajectory ‘B’ would also be considered unlikely although perhaps with less certainty. If the change falls inside this range (trajectory ‘C’) we cannot reject the idea that drift could be a cause but nor can we confirm it because other factors, such as various cultural selection biases, may also account for the pattern.

The measure of standard deviation used above can be influenced by the number of simulations that go extinct or become fixed. Therefore, this measure is recognised as an imperfect measure of the range in which most simulations fall, particularly in cases where the initial trait frequency is very large or very small (e.g. close to the fix or extinction point). However, in combination with the other measures (survivability and mean of surviving simulations) it is argued that a reasonable qualitative assessment of the drift hypothesis can be made.

An important component of this assessment is the consideration of the relative volatility of the simulations (i.e. how much change is likely to occur to a trait frequency under drift at a given point of time). To address this, a volatility index was created using the observed inter-generational trait frequency changes across the 1000 simulations. Specifically, for each generational shift the change in trait frequency in each simulation was recorded. For example, if in generation 1 of a single simulation the trait frequency is 50% and in generation 2 it is 53% the increase is recorded as 3%. By recording the mean and standard deviation of inter-generational change across all simulations we can ascertain the volatility. Figures 6.6 – 6.8 shows that, in traits present from the outset in New Zealand, large changes in frequency (± 40%) occur only in very small populations, and even when effective population size is around 25 people change will most likely not exceed (± 20%).
Figure 6.3 Example of the drift simulation plots with a starting trait frequency of 50% and differing population growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 6.4 Example of the drift simulation plots with a starting trait frequency of 50% and differing population growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 6.5 Example of the drift simulation plots with a starting trait frequency of 50% and differing population growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 6.6 Volatility index for the above simulations showing the degree of change in simulations with different initial population size and growth rates.
Figure 6.7 Volatility index for the above simulations showing the degree of change in simulations with different initial population size and growth rates.
Figure 6.8 Volatility index for the above simulations showing the degree of change in simulations with different initial population size and growth rates.
Most importantly, the volatility index shows that after c. 50 and 100 years, the influence of drift on traits present at the outset is negligible. However, if new traits develop through invention after the point at which population growth has levelled off (c. AD 1500; this can also be seen in Figure 6.9) a more traditional pattern of gradual divergence from the initial frequency is likely to occur.

![Graph showing drift data](image)

**Figure 6.9** Example of the drift data derived using simulation overlaid with archaeological data. Black squares represent sites and are placed along the X axis according to the date of each site and along the Y axis according to the frequency of a given trait in time. Letters A, B and C (discussed in text) represent different trait trajectories over time. Lower figure shows the dirichlet confidence intervals of each site, lack of overlap suggests the frequency differences between sites can be regarded with a high level of certainty.

### 6.5 Process of Change – Cultural Selection

Following the assessment of drift it is also necessary to consider what other factors may account for the observed patterns of change. To achieve this the changing pattern of trait frequency within a given variable (e.g. changing frequency of traits
such as ‘external barb’ or ‘internal barb’ of the variable ‘fishhook barb’) is assessed against the expectations of different cultural selection biases. Figure 6.10 shows idealised models of three such biases including results bias (assuming direct learning scenarios and social learning), conformist bias, and anti-conformist bias. The first of these is a so-called ‘pay-off based strategy’ because the frequency of the trait changes according to a perceived value of the trait to an agent (Mesoudi 2015; Richerson and Boyd 2005). This sort of selection can result in very rapid, r-shaped uptake of a particular trait if people are learning directly from the environment or a slower s-shaped curve if biased cultural transmission is the major factor in trait spread (Henrich 2001; Steele 2009; Figure 6.10).

The remaining biases are known as ‘frequency-dependent biases’ because the frequency of a trait influences the adoption of traits in the next generation. This can operate in two ways: (1) less common traits are disproportionately adopted (anti-conformist bias) or, (2) more common traits have an increased probability of adoption compared with the neutral model (Richerson and Boyd 2005; Crema et al. 2014). Figure 6.10 shows the possible outcomes of these processes, demonstrating that conformist bias ultimately leads to fewer traits with a clear dominance by a single trait. Henrich (2001) suggests the increased frequency of the main trait should occur slowly therefore, in practice, it might be difficult to disentangle the pattern of conformist bias from results bias based on social learning. Conversely, anti-conformist bias should ultimately lead to equal representation of traits with no clear dominant trait (Figure 6.10).

As discussed in Chapter 3, inferring processes of change from the patterns they produce is a difficult task (Shennan 2011). Observed patterns can result from a variety of processes, introducing the problem of equifinality to any analysis (Premo 2010; Crema et al. 2014). Moreover, uncertainty and patchiness in archaeological data also adds complexity. Therefore, while this thesis suggests what processes may account for the observed patterns in the data this is done tentatively and with the understanding that such questions require a more in-depth analysis to be addressed appropriately (see Future directions, Chapter 9).
Figure 6.10 Idealised models of the change in trait frequencies through time based on the influence of different cultural biases.

6.6 Occurrence Data

Up until this point, this chapter has focussed on methods designed to understand changing frequencies of traits over time. However, another key aspect of the current conception of change in New Zealand is that early and late assemblages can be disentangled based on the presence or absence of artefact types, not simply their frequency (Golson 1959). Therefore, the following sections outline the analyses used to investigate if change, both through time and across space, can be identified based solely on the occurrence of artefact types.
6.6.1 NeighborNet

Phylogenetic analysis is traditionally used for the reconstruction and assessment of biological lineages in order to understand the development of traits through time and the relationship between species (Kitching et al. 1998). Its recent application to archaeological data has focussed on material culture lineages, where trees are produced showing the development and diversification of these lineages (O’Brien and Lyman 2003). Commonly, phylogenetic analysis is applied in areas with large prehistoric time depth in which a kind of ‘cultural speciation’, where new artefact forms develop from a single ancestral type, can be detected. In the American southeast such methods were successfully applied to understand the nature of projectile point development and the relationship between forms over a 1500 year period from c. 11,500 – 10,000 BP (O’Brien et al. 2002). Kirch and Green (2001) also used related phylogenetic methods as part of their ‘triangulation’ approach, which reconstructed the Ancestral Polynesian Culture that developed in West Polynesia after 2800 BP. By contrast, New Zealand’s c. 500 year prehistory presents extremely different circumstances, where the time available for artefact change was much less and the phylogenetic signal between sites is absent or diluted. This situation (discovered during the early stages of this research) necessitates an alternative approach to phylogenetic analysis in New Zealand.

In recent years quantitative phylogenetic techniques have shown promise in the investigation of patterns of material culture diversity in the Pacific (Cochrane and Lipo 2010, Larsen 2011, Rogers and Ehrlich 2009). Of the range of available methods, network based analyses provide a simple means of examining datasets without the imposition of a priori models (Bryant et al. 2005). The NeighborNet technique uses occurrence data to produce a dissimilarity matrix. The resulting network shows groupings and the degree of difference represented by branch length (Bryant et al. 2005). The shape of the overall network is derived from the data: if it is tree-like this should be reflected in the network and vice versa. Often the split between two nodes, say nodes A and C, may be in conflict with the split between nodes C and E (Figure 6.11). In these cases the NeighborNet plot will produce ‘boxes’ in the middle of the graph, which reflect these conflicts.
Following a method similar to Jordan and Shennan (2009), sites are set as the analytical unit for NeighborNet analysis in this research. Sites are chosen on the basis that their contents represent the composition of artefact traditions at different times and places. Non-metric traits from adzes and fishing gear are used separately to analyse the relationships between material culture lineages at each site in regard to each tradition. The coding of data follows a model similar to that used in the paradigmatic classification of artefacts. Each site is assessed according to the presence (1) or absence (0) of non-metric attributes. Table 6.1 shows the Shag River Mouth site hypothetically coded according to the presence or absence of attributes associated with the variable barb, where external barbs are not present at the site. This process is repeated for all non-metric variables and all sites within this analysis. Sites were therefore made up of a string of binary code representing the presence or absence of attributes within the adze or fishhook assemblages.

Table 6.1 A hypothetical coding of the Shag River Mouth site, according to the occurrence of attributes from the variable 'barb'.

<table>
<thead>
<tr>
<th>Site</th>
<th>Variable</th>
<th>Trait</th>
<th>Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shag River Mouth</td>
<td>Barb</td>
<td>Internal</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>External</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal and External</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Absent</td>
<td>1</td>
</tr>
</tbody>
</table>
The assessment of binary presence/absence data was carried out using Splitstree version 4.10 (Huson and Bryant 2006), a programme that organises data using the assumption of maximum parsimony. The resulting phylogenetic networks are analysed using bootstrap analysis, a method commonly applied to this type of data to assess the level of support for each branch on the tree and therefore the accuracy of the tree structure (Jordan and Shennan 2009). In this context, bootstrapping involves re-running the original data multiple times and assessing the strength of the different branches in the original tree according the proportion of bootstrapped networks with that branch present (Efron et al. 1996). If bootstrapping reveals that the branches produced in the original tree are seen in over fifty percent of bootstrapped samples, this branch is said to be well supported (Baxter 2003) and not the result of differential weights placed on variables during computation of trees. The result of this analysis is the production of networks, which show the relationships between sites according the Jaccard distance. Like seriation the networks produced using cladistics do not necessarily relate to chronological proximity, and may infer environmental or perhaps functional similarities of sites. For this reason the networks are qualitatively assessed for patterned clustering either as a result of temporal or geographic propinquity between sites.

6.7 Regional Variation in type occurrence – object deviation linkages

The final analysis conducted on the two material culture traditions specifically focuses on the idea of geographic proximity influencing the occurrence of artefact types. The method used here is called object deviation analysis (Clark 2013), which compares the expected difference between sites with the observed difference. The expected or independent variable is based on geographic distance between sites (in this case straight-line distance) while the dependent variable is derived from Jaccard distance between sites, based on occurrence data. In essence, object deviation analysis carries out a similar function to a Mantel test but focuses on the relationship between individual data points, not the aggregate of values in a matrix.
The methods used here follow Clarke (2013). Both sets of data are first placed into separate distance matrices, which are then standardised and the mean and standard deviation of the independent matrix (based on distance) is taken. Values from the dependent matrix (based on Jaccard scores) are then compared to the corresponding values in the independent matrix. Those values that fall within $1\sigma$ of the predicted value are coded ‘0’, those that fall between $1\sigma$ and $2\sigma$ are coded ‘1’ and those that fall outside $2\sigma$ are coded ‘2’. A further notation is made based on whether these numbers fall below or above the expected value (i.e. -1 or 1).

The resulting values form the basis of a network model (Figure 6.12). Sites are placed in their approximate geographic position (some movement occurs to aid the clarity of the network) and lines are drawn between sites based on whether sites are either more or less similar than predicted by their geographic distance. The degree of difference is represented by the thickness of lines linking sites.

![Figure 6.12 Example of the networks produced from the object deviation analysis.](image)

In the above example (Figure 6.12) we can see that sites A, B and C are all more similar to each other than predicted by distance (represented in the ‘positive linkage’ plot), whereas sites E and D are more dissimilar to sites A, B and C than distance predicts. The thicker lines between Site B and Site C suggest these sites were much more similar (more than $2\sigma$ above the predicted value) with the inverse true of Site B and Site E. The lack of line between Site E and Site D suggests that geographic distance accurately predicts the Jaccard distance between the two sites.
A potential interpretation of this toy example is that regionality does exist in this island with two possible territories: one on the west coast, and one based on the east coast of the island.

6.7 Discussion of Method

The methods used in this thesis have been designed to characterise variation in material culture lineages and develop an understanding of the patterns and processes of culture change. Although effort has been made to construct this methodology within the framework of sound methodological and theoretical practice, certain aspects require further discussion.

6.7.1 Selection of Fishhooks and Adzes

The analysis of cultural ‘lineages’ allows cultures to be broken down into specific traditions, which exist and change through time. This thesis involves the investigation of two of these: adzes and fishing gear. The selection of fishhooks and adzes and the exclusion of other traditions (e.g. ornaments) is based on two factors: (1) adzes and fishhooks were sufficiently abundant in a range of sites to allow meaningful analysis of change through time, and (2) both fishhooks and adzes are sufficiently complex to have a range of traits that are consistently present in assemblages and appear to show change through time. By comparison other traditions such as flake tools, while abundant, show little evidence of consistent forms (besides blades) beyond those associated with manufacture and the presence of a usable sharp edge (Brown 2007). It is, therefore, difficult to use such a tradition in this analysis because there is unlikely to be any transmission signal. Conversely, ornaments, while exhibiting consistent forms and evidence for change through time, are not abundant and often lack accurate information rendering them of little use in this study.

6.7.2 The Sample

As with all scientific studies the careful consideration and selection of the sample is of utmost importance (Orton 2000). In this thesis assemblages were selected
based on three criteria: availability, occupation length, and sample size. All assemblages were housed in museums in New Zealand; however, limited time and funds meant smaller, provincial museums were difficult to visit. Therefore, this study is limited to assemblages housed in the major museums of New Zealand: Auckland War Memorial (16 collections), Puke Ariki (1 collection), Te Papa (2 collections, not used in final thesis due to context problems), Canterbury (17 collections), and Otago Museums (23 collections). Two samples were also analysed in the University of Otago laboratories.

Without a comprehensive register of artefacts in all New Zealand museums it is difficult to categorically state that the sampling strategy used in this thesis does not result in some bias. However, based on advice from other archaeologists and personal experience, I believe that the omission of smaller regional museums made little difference to the quality of information collected for this research. Very few regional museums, particularly in the North Island, have large collections of artefacts that can be provenanced to a single site. Instead, the bulk of material is collected randomly and subsequently deposited in museums. This is less true of the South Island where more targeted and sustained collections at single sites has taken place historically. However, a great majority of the material recovered from the South Island is housed in the museums visited in this research, meaning little bias is likely to be introduced.

The type of occupation at sites is an important component, which may influence the outcome of analysis. For example, if not accounted for, the presence of multiple occupations will lead to the conflation of layers that may be separated by many years, thus any chronological signal will be lost. In the first instance sites were selected based on evidence of single occupations. Where multiple occupations were evident, clear stratigraphic association for each artefact was sought before it could be included. Thus, multiple layered sites contributed artefacts from a single occupation context only.

Finally, sites were required to have a minimum \( n \) value of 10 fishhooks or 10 adzes to be considered in this research. As discussed above, sample size has an important impact on the results of frequency seriation, with a high minimum \( n \).
value (around n=100) preferred for seriation of ceramic assemblages (O’Brien and Lyman 2000). It is important to point out that this value is based on the idea that one pot may contribute many sherds to an assemblage, thus conflating the values of particular stylistic variables. In such studies the minimum n value of an assemblage must be high to increase the likelihood that multiple vessels are contributing to analysis. The current study requires artefacts for analysis, which are, at a minimum, nearly complete. As such, each artefact may only contribute one set of data to the analysis of change over time, avoiding problems of conflation inherent in ceramic analysis. This allows the minimum n value of an assemblage to decrease and allows a greater number of sites to be analysed in this research. Moreover, the use of dirichlet analysis provides a further measure of how much sample size may be influencing results. Thus, it is possible to interpret patterns from sites in light of different confidence levels provided by the dirichlet analysis and account for any negative influences introduced by sites with small sample sizes.

The issue of site function is also worth brief consideration. Variation in site function is noted in both the early (Anderson and Smith 1996) and late (Anderson 1998) periods, although it is difficult to infer in all but a few well-excavated sites (e.g. Shag River Mouth). The functional variation of sites may well influence the material culture content, however, the analysis of traditions together with a minimum artefact number goes some way to remove this bias. Traditions (e.g. the fishhook tradition) were used for the same purpose across all sites, therefore, if they are present in sufficient numbers it is unlikely that vastly different behaviours were being carried out that would affect the material culture remains.

6.7.3 Collections and Assemblages

New Zealand, particularly the South Island, has a history of prolific ‘curio’ hunting during the late nineteenth and early twentieth century (Leach 1972; Samson 2003). These activities lead to the deposition of large amounts of artefacts in the Otago and Canterbury Museum, which may at best be provenanced to a particular site, but often only to region with no supporting information. These collections typically only contain the best quality artefacts, with broken or less attractive
artefacts largely discarded. Conversely, an archaeological assemblage represents the excavated component of the material within each site and collects both artefacts considered interesting or attractive and those with less appeal (Samson 2003). The differential nature of collections and assemblages used introduces the possibility of bias in this analysis.

In reality this problem is difficult to overcome methodologically. In this thesis collections that were not excavated according to current standards were only included if a clear context could be established. New Zealand researchers of material culture find themselves facing difficult questions, particularly: should one use collections with adequate sample size but of questionable origin, or assemblages with adequate provenance but relatively small sample size? This latter question is foremost, because few systematically excavated sites have yielded enough artefacts to allow meaningful analysis. In this thesis the view is taken that the use of both collections and assemblages, while not ideal, provides a more meaningful contribution to our understanding of prehistory than the alternative.

6.7.4 Discussion of methods for understanding change

Several aspects of this experimental method require further discussion, particularly initial population size, target period for drift modelling, and duration of generations. The initial population sizes used in this thesis are based on the work of Whyte et al. (2005) who suggested initial population size in New Zealand was around 500 people, the upper value population used here. The lower values were chosen as incremental decreases from this figure. The use of these values was necessary for two reasons. First, while the overall population may have been as much as 500 people, the effective population size, that is, the number of people who were likely to have been involved in the transmission of particular cultural information, may be only 25% of the entire population (c. 125 people). This figure is based on the idea that the majority of transmission occurs vertically, or between same-sex relations from different generations, and that age specific factors may also reduce the number of people involved in the learning and transmission of specific information (Steele and Shennan 2009).
The second reason for the use of incrementally lower numbers (of initial population size) is the current lack of clarity around whether the communities in New Zealand formed a panmictic population in terms of cultural transmission, and therefore what the effective population may actually have been. Evidence of trade and exchange (outlined in Chapter 2) suggests communities, particularly early communities, were in contact, although it is difficult to be sure on what scale this occurred. For example, did fishhook makers from a single site retain contacts with immediately adjacent communities, between communities in the same region or, indeed, across New Zealand. The absence of clarity on this issue is the reason this thesis presents simulations with incrementally smaller initial population sizes with the lowest value set at five. The figure of five is arrived at on the basis that an extended family of perhaps 20 people was likely the primary unit of organisation in New Zealand (Walter et al. 2006) and, given the 25% figure, five seems a suitable, although perhaps unlikely, lower limit.

The second question regarding this method is, which period should the drift modelling focus on? The answer relates to the discussion above, specifically the discussion of the relationship between communities. The method discussed here sometimes relies on the ability to reasonably compare frequencies of artefacts from sites many kilometres distant, based on the fact that these sites could derive from a panmictic population. As discussed in Chapter 2 the increasing territoriality present in the later period makes such an assumption impossible and, therefore, any comparisons in traits would be restricted to within specific regions. Other reasons to focus on the early period (c. AD 1300 – 1500) include: a higher number of dated sites, the presence of most traits from the early stages of the New Zealand sequence, and, most importantly, a recognition that the early period was a time when many formative changes were made. Therefore, it is important to understand the processes underlying this change.

The final consideration is the length of time allotted to a transmission generation. In genetics generational difference is clearly defined; however, in archaeology this is less clear. In the current research generational blocks of 20 years were tried; however, over such a short period there was insufficient time for patterns to develop. Moreover, frequency change is unlikely to be limited to periods after one
generation succeeds another. The turnover of artefacts (fishhooks in particular) was relatively rapid; therefore it seems much more likely that drift was operating year to year. In this thesis an arbitrary period of one year was set for the turnover of fishhooks based on the lack of evidence of reuse, suggesting used artefacts were discarded and new ones made during this time. The period for adzes was increased to 5 years, again representing an arbitrary figure based on the fact that adzes were often reused before discard.

6.8 Conclusion

This chapter has outlined a series of analytical methods that will now be used to consider two key classes of New Zealand material culture. The two chapters to follow discuss the results of the application of these methods to fishhooks (Chapter 7) and adzes (Chapter 8).
Fishing Gear

“The Maori was assuredly a very expert fisherman; long-continued practice made him so; hence it rendered him expert in the manufacture of fishing implements, and gave him much knowledge of the habits and movements of many species of fish.” (Best 1986: 8)

7.1 Introduction

This chapter introduces the fishing tradition in prehistoric New Zealand and presents analyses of three material culture lineages within that tradition. The chapter begins with a discussion of fishing in prehistoric New Zealand, focusing on the major species of fish caught by Maori as well as regional and chronological variation in those catches. This is followed by a discussion of the technological aspects of three lineages of fishhook used by Maori. The second section outlines the sites that provided artefacts for analysis and discusses the traits used to characterise the variation present in each of the fishhook lineages through paradigmatic classification. Lastly, the results of the lineage analyses are presented.

7.2 Fishing and fishing gear in New Zealand

To traditional Polynesian societies, the ocean was many things. In New Zealand, as with elsewhere in central East Polynesia, it provided a fast and efficient means of transporting materials and ideas over large distances, thus connecting local communities to a wider economic region (Sheppard 2004; Walter et al. 2010; Rollett et al. 2015). It was also a crucial part of local economies throughout the prehistoric sequence in New Zealand, providing a key food resource in the form of marine mammals, fish, and shellfish (Anderson 1983; Smith 2011). The
following section provides a brief overview of the fishing activities using archaeological and ethnographic accounts.

7.2.1 Archaeological Evidence of Fishing

New Zealand’s marine biodiversity is, in a comparative global sense, high; however, Maori targeted a relatively narrow range of species across both time and space. Leach (2006) noted that six species made up around 85% of the fish present in archaeological midden: barracouta (*Thyrsites atun*), blue cod (*Parapercis colias*), snapper (*Pagrus auratus*), spotty (*Notolabrus celidotus*), red cod (*Pseudophycis bachus*), and greenbone (*Odax syanoalix*). Anderson (1997) suggested that this pattern was consistent with the targeting of species abundant within in-shore environments and of a size that was within the mechanical limits of available harvesting technology, and not species such as Hapuku (*Polyprion oxygeneios*), which are much larger. Despite the widespread focus on these species, their frequency in different regions varies drastically.

Regional differences in fish catch was, and is still, driven by the natural availability of fish species across different regions (see Figure 7.1). As discussed in Chapter 2, New Zealand has a graded, but marked, temperature change from north to south, which is also manifest in sea temperatures. The effect of this is twofold. Firstly, it limits the range of some species like snapper (*Pagrus auratus*), which are not found in any great numbers below the Cook Strait (Leach 2006). Secondly, the seasonal changes, particularly the presence of very cold seas in the South Island, drive seasonal migration in some fish species to warmer northern waters (*e.g.* Barracouta; Francis 2001; Walrond 2012). In both cases these factors limit the availability of particular species either entirely or on a seasonal basis.

South Island middens are characterised by a dominance of barracouta and red cod (Leach and Boocock 1993; Leach 2006; Smith 2011). These species were caught using trolling and angling methods respectively (these methods are expanded on below). Smith (2011) noted that within his Otago/Catlins study area (Figure 7.1) there was significant variation in minor taxa in different sites and that through time the variety of species being caught seemed to have diminished. This is perhaps indicative of initial experimentation followed by the targeting of specific
species. Snapper dominate the middens in the North Island and the upper South Island, perhaps because of their abundance (Leach 2006; Smith 2011). Snapper are a warm water fish and infrequently found south of the Cook Strait (the body of water separating the North and South Islands), accounting for their absence in most South Island areas. Barracouta summer in the fisheries in the North Island and, while present in middens, are generally well under 20% of the species present perhaps suggesting a preference for Snapper in the North Island (Leach 2006). The abundance of both barracouta and other minor species varies at different sites, consistent with the pattern observed in the South Island. In his Hauraki/Coromandel region Smith (2011) noted that in his three chronological periods after around AD 1500 the number of midden sites without fish bone varied between 12% and 24%. Smith argued that this reflected a change in settlement pattern relating to the rise in horticultural production, which also involved a rise of single purpose sites including shellfishing camps. This pattern of increased specialisation was not present in the non-horticultural South Island where fish bone is ubiquitous. As Smith (2011) noted, this pattern was also consistent with a more dispersed settlement pattern in the south, where small foraging groups conducted a full range of activities at their camps.

To summarise, the range of species targeted by Maori was relatively small. At a broad regional scale Snapper were the preferred catch in the North Island and the top of the South Island and Barracouta and Red Cod were most commonly targeted in the remainder of the South Island. Despite some evidence of broader scale species targeting in at least one early site, it seems that once identified the favoured fish species (either because of preference as an eating fish or perhaps because of ease of capture) were consistently the focus of fishing activities. Along with variation in fish catch, one other spatio-temporal difference is the presence of fish bone in midden. As much as 24% of later period midden sites contained no fishbone at all (i.e. were simply shell middens), whereas in Southern sites all sites contained evidence of fishing. This pattern shows the clear connection between fishing activity and broader regional economies.
Figure 7.1 Snapper grounds and the relative proportion of Barracouta and Red Cod in the North and South Islands as they relate to the sites analysed in this chapter (adapted from Barber 2004).
7.2.2 Fishing Gear in New Zealand

Polynesian fishers used a range of techniques, including: netting, spearing, trapping, angling, trolling, and poisoning (Leach 2006). Most of these techniques were in evidence when Europeans arrived in New Zealand. Nineteenth century accounts suggest netting was a diverse and well-developed activity in both marine and riverine environments. Few nets have been preserved archaeologically, although netting has been inferred at one early site in Opito Bay in the Coromandel on the basis of faunal remains (Mann 2009). Stone fish-traps, which work by trapping fish as the tide recedes, are also found in New Zealand although they are not as large or extensive as those found in other areas of Polynesia. Spearing is common in reef environments but was largely impossible in New Zealand where such environments are not present and sea visibility is low due to rough seas that stir the sands (Leach 2006). Aside from middens, the most frequently observed remains of fishing practices are fishhooks. These come in three broad forms: one-piece, two-piece, and lures (Figure 7.2). One-piece and two-piece hooks were used for angling whereas lures were used to troll for surface-dwelling, carnivorous fish. These forms (discussed below) are the focus of the analysis in this chapter.

7.2.2.1 Angling

Angling is the major method employed by modern sport fishing. Leach (2006) outlined two major techniques. The first involved waiting for a fish to nibble the hook and then abruptly pulling on the line to hook the fish. The second commonly used bait or other methods of attraction and relied on the fish swallowing the hook, allowing it to become embedded in its mouth. The first method is usually associated with a ‘J’ shape hook (known archaeologically as a ‘jabbing’ hook; Figure 7.3). These forms are also similar to the traditional European angling hooks. The second method involves the ‘C’ shaped hook (known as the ‘rotating’ hook). This type of hook is the most common archaeologically and was also noted by early European explorers.
Figure 7.2 Angling hooks (one-piece and two-piece) and trolling lures from New Zealand.
These hooks characteristically demonstrate a smaller gap between the barb and the shank (Figure 7.3), something that confounded Europeans from earliest contact. Best (1986: 43) noted:

“The shape of the nature-made fishhooks often surprises observers, in that the point is so close to the shank; but old natives have assured me that such hooks were the most effective and decidedly superior to the wide mouthed ones for taking certain fish.”

Leach (2006) noted that, given the lack of reef and the difficulty in feeling nibbles when traditional flax cordage is used, the rotating hook was probably superior for Maori fishermen. Angling hooks are made in either one piece or two. One-piece hooks are typically made of bone, although shell and occasionally stone are also used. Two-piece forms normally have a bone point lashed to a wooden or bone shank. The general shape is consistent although embellishments (e.g. extra barbs) are common.

Figure 7.3 Different shaped one-piece hooks and the methods associated with their use (after Leach 2006). A – Rotating hook. A hook is left on a slack line, fish swallows hook and bait and swims away, the hook rotates in the mouth of the fish and gets lodged. B – Jabbing hook. A hook is attached to a taut line, when a fish nibbles the line is rapidly pulled, hooking the fish.
7.2.2.2  Trolling

Best (1986) discussed two uses of lures. In the first instance they were used at river mouths to target the carnivorous Kahawai (*Arripis trutta*). When the Kahawai began to run canoes were paddled up and down the river towing a series of lures along the surface of the water to attract fish, consistent with the contemporary understanding of ‘trolling’. The second method targeted barracouta, a shoaling and veracious fish. In this method a canoe was put to sea and, when a shoal of barracouta were located, a single person began to fish. Fishing was carried out using a rod of between one and two metres, with a length of line approximately the same length with a lure attached at the end. The rod was used to pull the lure back and forth in the water until a fish struck, at which point the fisherman simply swung the fish into the canoe using centrifugal force. Best (1986: 52) recounted a story of a European fisherman employing the Maori technique to great effect, saying that the fisherman “…caught upwards of a dozen fine fish in a few minutes while the shoal remained near us.” This story is consistent with other ethnographic accounts attesting to the efficiency of the technique.

The lures used in these techniques are composite forms with a point and a shank (Figure 7.2). The point of the lure is commonly made from bird bones, mammal teeth, or dog mandibles. The lure shank is constructed of wood or stone. The stone used in shank construction is typically glossy or with mica content, a feature that attracts voracious, photic zone feeding fish species. In some cases the lustrous *pana* (or abalone [*Haliotis iris*]) shell is inlayed in a shank to produce the same effect. Lures used for barracouta are typically made or wood and are more robust than other forms owing to the harsh strike of the fish (Figure 7.3).

7.3  Sites used in this analysis

As outlined in Chapter 4, data was collected from sites containing 10 or more fishhooks. The sites (Figure. 7.1) were predominantly found in the South Island and in the northern North Island. Of the sites from which data were collected, nine had associated radiocarbon dates and another (Whareakeake) is noted in the historical record as a site occupied in late prehistory and the very early historic period (Figure 7.4). While data was collected from all these sites, for inclusion in
the analysis of individual lineages (e.g. one-piece hooks) sites had to contain 10 or more of that particular class of artefact.

Figure 7.4 Pooled dates from fishhook sites with available radiocarbon dates.

7.4 Data Collection and Trait Characterisation

The previous chapter outlined the criteria by which sites were selected for analysis in this thesis. Once selected, fishhooks from each site were photographed and these photographs were then used to record relevant traits. The selection of traits for use in the classification was based primarily on a review of traits used in published fishhook research in East Polynesia (particularly New Zealand). Each trait contained at least two different attributes, which were assigned a number. Types were then formed by combining the set of numbers derived from assessing the range of traits (e.g. 1211). In the event that an artefact had suffered breakage the visible traits were recorded, although broken artefacts were not used in the
analysis of types. The following section outlines the traits recorded in the three lineages of fishing gear.

7.4.1 One-Piece Hooks

As discussed above, one-piece fishhooks often suffer breakage at the bend; therefore, archaeological recovery of entire hooks is relatively limited. As recourse to this, and to allow the study of these hooks, both Allen (1996) in the Cook Islands and Furey (2002) in northern New Zealand, have suggested the analysis of fishhook head forms. As the part attached to the line, this part of the hook is most often found in archaeological sites. Allen’s (1996) analysis of fishhook heads suggested that, despite the functionality of the hook head, they do not necessarily behave in the traditional ‘functional’ manner and may be a useful tool to understand change over time. Furey (2004) did not discuss temporal variation but did argue that fishhook heads varied between regions in New Zealand, suggesting they are useful tool in understanding patterns of change over time and space.

Consistent with Allen (1996) and Furey (2002), one-piece fishhooks are characterised by the form of three variables: inner, outer and upper. Figure 7.5 shows how each of these variables was demarcated on a range of fishhook heads, the most lateral points on the head are the major markers defining the extent of the area that was assessed. The traits used for classification are presented below (Figure 7.6).

![Figure 7.5 Method of demarcating inner, upper and outer surfaces in this research.](image-url)
Figure 7.6 Character states of the three traits used in classification of one-piece fishhook heads.

*Internal Head* – This variable is analysed by placing the fishhook in profile and viewing the morphology of the margin closest to the barb. Eight traits were used to classify variation: (1) plain, (2) shallow/long grip, (3) short grip, (4) stepped, (5) barbed, (6) notched, and (7) upward projecting knob (Figure 7.6).
Upper Head - This variable is analysed by placing the fishhook in profile and viewing the top of the shank end. Six attributes were selected: (1) flat/angled, (2) pointed, (3) angled-triangular, (4) notched small projection, (5) notched large projection, and (6) double projection (Figure 7.6).

External Head - This variable is analysed by placing the fishhook in profile and viewing the margin furthest from the barb. Seven attributes were selected: (1) small projection, (2) large projection, (3) plain, (4) angled notch, (5) knobbed, (6) upward projection, and (7) notched (Figure 7.6).

7.4.2 Two-piece Fishhook points

Two-piece hooks are the second lineage in the angling tradition. Two-piece hooks consist of a shank and bend, most often made of wood or bone, and a sharp point that is lashed to the shank (Figure 7.2). Two-piece points are commonly recovered in archaeological sites in Hawai‘i and New Zealand (but rarely in Central East Polynesia), where they have been included in a number of analyses (Emory et al. 1959; Hjarno 1967; Jacomb 1995). In New Zealand, two-piece forms show the greatest diversity of form compared to other fishhook lineages, necessitating a consideration of broad morphological variation (e.g. shape) as well as finer grained variation (such as decorative features). Five traits were used in the classification of two-piece hook points. These are outlined below.

Articulation surface – This trait refers to the presence or absence of a flattened surface that articulated with the shank of the two-piece hook (see Figure 7.2). Two attribute states were recorded for this variable: (1) Present and (2) Absent (Figure 7.7).
Figure 7.7 The two character states recorded for the trait ‘articulation surface’.

Point Shape – This trait was classified by assessing the point at which the point articulates with the shank. The angle of this articulation is placed against a vertical line and the shape is then assessed. Four shapes were selected for classification: (1) U bend, (2) V bend, (3) Straight, and (4) Straight-incurved point (Figure 7.8).

Figure 7.8 The four character states recorded for the trait ‘point shape’.
Barb – The presence or absence of barb is a commonly used variable in fishhook classification. Four attributes of the trait barb were selected for this analysis: (1) External, (2) Internal, (3) Multiple, and (4) Absent (Fig. 7.9).

![Figure 7.9 The four character states recorded for the trait 'barb'.](image)

Base form – Base form refers to the morphological variation associated with the lashing of the fishhook points to the shank. This has not previously been considered an important variable of the classification of two-piece points in New Zealand, although it is discussed elsewhere in Polynesia (e.g. Emory et al. 1959). The principle that lashing morphology is an important variable in one-piece hooks should be transferable to the two-piece forms. The variable of base form was analysed with six attributes: (1) Gripped, (2) Notched, (3) Serrated, (4) Perforated, (5) Absent, and (6) Projected (Figure 7.10).

![Figure 7.10 The six character states recorded for the trait ‘base form’.](image)
Decoration – This variable focuses on decorative serrations placed on the fishhook’s lateral surface(s). For decoration to be noted as present on the external facet of the point it had to either extend the entire external margin or be present at the distal end of the fishhook. This allowed a distinction between serration associated with the lashing of the point and that may have been stylistic or non-functional. Four states were recorded for this trait: (1) External, (2) Internal, (3) External and Internal, and (4) Absent (Figure 7.11).

![Figure 7.11 The four character states recorded for the trait 'decoration'. Differences are apparent on the lateral margins of the hooks.](image)

7.4.3 Lure Points

Lure points have received relatively little attention compared with other hook forms. Lure points are most abundant in southern New Zealand where they frequently represent over half of the fishhook assemblage. It is here that previous work on lure forms (Hjarno 1967) has taken place. The lure point lineage consists of two major forms: one that is inserted into the shank and another that is lashed directly to the shank. This key trait and three others were used to classify lure points in this research.

Lashing device – Lashing device is a landmark feature, which enables the differentiation of minnow lures (lure points that are lashed to the surface of a shank) and barracouta lures (lure points that are inserted through a hole in the shank). Five attributes for lashing device were recorded: (1) Inserted, (2) perforated, (3) perforated distal projection, (4) lashed, and (5) inserted/perforated (Figure 7.12).
Barb – The presence or absence of a barb is a commonly used variable in previous fishhook classifications. While rare on lure points, four attributes were recorded here: (1) External, (2) Internal, (3) External and Internal, and (4) Absent (Figure 7.13). The internal aspect of the point is defined as the curve with the shortest distance from tip to base.

Serrations – Serration was discussed by Hjarno (1967) as a feature which proliferates in the later period of New Zealand prehistory; however, it is not exclusively used to define a type. In this thesis it is deemed important enough to be used as an independent variable suitable for analysis. Four attributes were recorded in this study: (1) External, (2) Internal, (3) External and Internal, and (4)
Absent. (Figure 7.14). The internal aspect of the point is defined as the curve with the shortest distance from tip to base.

![Figure 7.14](image)

Figure 7.14 The four character states recorded for the trait ‘serration’ in the analysis of fishhook lure points.

*Mid shaft lug projection* – Four attributes of mid-shaft lug were recorded in this thesis: (1) Angled, (2) Present, (3) Present/elaborated, and (4) Absent (Figure 7.15). This trait was determined by placing the artefact in the position it would have been in relation to the shank (see Figure 7.2). ‘Angled’ forms continue straight before abruptly turning toward the tip. ‘Present’ forms continue straight but have a clear projection going in the opposite direction from the tip. If this projection has been notched or carved it is said to be ‘elaborated’. Forms that have a gradual curve are said to be ‘absent’ of a lug.

![Figure 7.15](image)

Figure 7.15 The four character states recorded for the trait ‘mid shaft lug projection’ in the analysis of fishhook lure points.
Table 7.1. Counts of one-piece fishhook head types (continued on next page)

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Table 7.2. Counts of one-piece fishhook head types from sites with less than ten hooks.

| Site              | 111 | 112 | 114 | 116 | 124 | 125 | 211 | 212 | 221 | 311 | 312 | 332 | 412 | 413 | 421 | 423 | 425 | 512 | 523 | 612 | 613 | 631 | Total |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Centre Island     | -   | -   | -   | -   | -   | -   | 1   | -   | -   | -   | 1   | 1   | -   | 1   | -   | -   | -   | 4   | -   | -   | -   | -   | -   | 4   |
| Cross Creek       | -   | -   | -   | -   | -   | -   | 2   | -   | 1   | 2   | 1   | -   | -   | -   | -   | -   | -   | -   | 6   | -   | -   | -   | -   | -   | 6   |
| Fishermans Bay    | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1   | -   | -   | -   | 1   | -   | -   | -   | -   | -   | 2   |
| Kings Rock        | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1   | -   | -   | 1   | -   | -   | -   | -   | -   | 3   |
| Matai Bay         | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1   | 1   | -   | -   | -   | -   | -   | 1   | -   | -   | -   | -   | -   | 2   |
| Opito N40/2       | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1   | -   | -   | -   | -   | 1   | -   | -   | -   | -   | -   | 3   |
| Oruarangi         | 1   | 1   | 1   | -   | 2   | 1   | -   | 1   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1   | -   | -   | -   | -   | 8   |
| Pahia             | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 3   | -   | 1   | -   | -   | -   | -   | -   | -   | -   | 4   |
| Panau             | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1   | -   | -   | -   | -   | 1   |
| Pipikaretu        | 1   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1   | -   | -   | -   | -   | 2   |
| Pounawea          | -   | -   | -   | -   | 2   | -   | -   | -   | 1   | 1   | -   | -   | -   | 2   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 6   |
| Purakaunui        | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 4   |
| Sleepy Bay        | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1   |
| Whareakeake       | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1   |
| **Total**         | 1   | 1   | 1   | 2   | 2   | 1   | 2   | 2   | 1   | 1   | 4   | 3   | 15  | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 48   |
7.5.2 Classification of two-piece hook points

Two-piece fishhook types were created using five variables: articulation surface, point shape, barb, lashing, and decoration. A total of 158 types were produced from 911 hooks (Table 7.3) of which 23 types were represented by ten or more examples (Table 7.4). Of the remaining 135 types that had fewer than ten real world examples a majority (74) were represented by only a single artefact (Table 7.3). The most common type was 23224 (Figure 7.16; Table 7.4), a straight, notched, internally barbed point with no decoration, which was much more common than all other types (12%). The next most common types were straight with incurved points (24124 & 24154) and were exclusively found at the site of Oruarangi. The remaining types making up the five most common at this site were 11224 and 12224, which are non-decorated, internally barbed points with U bend and jabbing shapes (Figure 7.17).

![Figure 7.17 Most common two-piece hook point types (ranked left to right, most to least common).](image-url)
Table 7.3. Counts of two-piece fishhook point types from sites with ten or more hooks (continued on following pages).

| Site | 11121 | 11124 | 11131 | 11134 | 11154 | 11214 | 11221 | 11222 | 11224 | 11234 | 11254 | 11264 | 11324 | 11353 | 11364 | 11421 | 11423 | 11424 | 11434 | 11451 | 11454 | 12124 | 12133 | 12134 | 12213 |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| CTI  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| CRB  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| FID  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| FMB  | 1     | 1     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| JBC  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| KHK  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| KGR  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| LFB  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       | 1     |
| ONP  | 1     | 1     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| ORR  | 1     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       | 3     |
| PHA  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| PNA  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| PAB  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| PPK  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| PUK  | 4     | 2     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| PRK  | 1     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| SFB  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| SRM  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| SLB  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| TWP  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| WAA  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Total| 2     | 8     | 2     | 1     | 2     | 1     | 3     | 1     | 50    | 5     | 14    | 3     | 10    | 1     | 1     | 2     | 1     | 13    | 4     | 1     | 2     | 5     | 1     | 4     | 1     |       |
| Site | 1214 | 1221 | 1222 | 1223 | 1224 | 1225 | 1226 | 1231 | 1232 | 1233 | 1234 | 1241 | 1242 | 1243 | 1311 | 1321 | 1322 | 1323 | 1324 | 1325 | 1326 | 1327 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| CTI  | -    | -    | 1    | 3    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    |
| CRB  | -    | -    | -    | 3    | 1    | -    | -    | -    | 1    | -    | -    | -    | 1    | -    | -    | -    | -    | -    | 1    | -    | -    |
| FID  | -    | 2    | -    | 7    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | -    | -    | 3    |
| FMB  | 1    | 1    | -    | 2    | -    | -    | -    | -    | -    | -    | 1    | -    | -    | -    | -    | 1    | -    | 1    | -    | -    |
| JBC  | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    |
| KHK  | -    | -    | 2    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    |
| KGR  | -    | -    | -    | -    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 2    | -    |
| LFB  | -    | 1    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | 2    | -    | -    | -    | -    | -    | -    | -    |
| ONP  | -    | -    | -    | -    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 2    | 5    | -    | -    | -    | 1    | -    |
| ORR  | 4    | 1    | 7    | 2    | 2    | 1    | -    | -    | 23   | 5    | 2    | -    | 2    | -    | -    | -    | -    | -    | -    | -    | -    |
| PHA  | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    |
| PNA  | 1    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    |
| PAB  | 1    | 1    | 1    | 2    | -    | 1    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | -    |
| PPK  | -    | -    | -    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    |
| PUK  | -    | -    | -    | -    | -    | -    | -    | -    | 2    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    |
| PRK  | -    | -    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | -    | -    | -    | -    | -    | -    | -    | 1    | -    |
| SFB  | -    | -    | 4    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | -    | -    | -    | -    | -    | -    | -    | 1    | -    |
| SRM  | -    | -    | -    | 1    | 1    | -    | -    | -    | -    | -    | -    | 1    | 7    | -    | -    | 1    | -    | -    | -    | -    |
| SLB  | -    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | -    | -    | -    | -    | -    | 1    | -    | -    | 1    | -    |
| TWP  | -    | -    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    |
| WAA  | -    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | -    | -    | -    | 1    | -    | -    | -    | -    | -    | -    |

<p>| Total | 1 | 11 | 3 | 34 | 8 | 1 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 25 | 5 | 2 | 6 | 17 | 1 | 1 | 1 | 1 | 10 | 2 | 1 | 1 | 1 |
| Site | 13324 | 13414 | 13421 | 13424 | 13434 | 13454 | 14124 | 14134 | 14164 | 14321 | 14324 | 21124 | 21154 | 21211 | 21221 | 21223 | 21224 | 21234 | 21254 | 21264 | 21323 | 21334 | 21414 | 21424 | 21431 | 21434 |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| CTI  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| CRB  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| FID  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| FMB  | 1     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| JBC  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| KHK  | 1     | 1     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| KGR  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| LFB  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| ONP  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| ORR  | 1     | 1     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| PHA  |       | 1     | 1     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| PNA  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| PAB  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| PPK  |       | 1     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| PUK  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| PRK  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| SFB  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| SRM  | 1     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| SLB  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| TWP  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| WAA  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Total| 2     | 2     | 1     | 3     | 1     | 1     | 9     | 1     | 2     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 2     | 19    | 1     | 1     | 2     | 1     | 1     | 1     | 1     | 16    | 1     | 3     |</p>
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Table 7.5. Counts of two-piece hook point types from sites with less than ten hooks.

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7.5.3 Classification of lure points

Lure point types were created using four variables: lashing, barb, decoration, and lug. A total of 36 types were produced from 585 lures (Tables 7.6 & 7.7). 50% of the artefacts studied were classified as a single type (1444), which is an unbarbed, inserted point with no decorative features (Figure 7.18). The remaining types (5412, 1412, 1414 & 1441) are represented by between 20 and 30 real world examples and are all inserted, barbless forms with different levels of elaboration (Table 7.6; Figure 7.18).

Figure 7.18 Most common lure point types (ranked left to right, most to least common).
Table 7.6 Counts of lure point types from sites with more than ten hooks.

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Total counts: 585

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### 7.6 Frequency Seriation

Following the classification of each of the fishing tradition lineages, correspondence analysis was applied to the raw count data. Correspondence analysis was used as a means of seriating sites according to the frequency of artefacts and was preferred over simple frequency table approaches because of its ability to deal with large amounts of data efficiently. The following section presents the results of correspondence analysis carried out on artefact traits (e.g. barb), artefact classes (e.g. one-piece hooks), and traditions (e.g. the angling tradition).

#### 7.6.1 One-piece fishhook heads

#### 7.6.1.1 One-piece fishhook head traits

The first step in this analysis involved assessing the traits (e.g. different attributes of upper fishhook head) to understand how they behave when applied to correspondence analysis. This process uses methods within the R packages ‘CAinterprTools’ (Alberti 2015) and ‘CAseriation’ (Alberti 2013). The count data of trait attributes from each site was applied to a correspondence analysis (Figures
sites were seriated using dimension 1 of the correspondence analysis (Figures 7.19A, 7.20A & 7.21A) and the relative contributions of types and sites in the determination of dimensions was assessed (Figures 7.19 C & D, 7.20 C & D and 7.21 C & D).

The correspondence analysis plots for each trait (Figure 7.19B, 7.20B & 7.21B) are highly variable when compared, suggesting no consistent or patterned relationship between sites. This is backed up by Figures 7.19A, 7.20A and 7.21A (battleship plots based on dimension 1), which show an inconsistency in the ordering of sites. Cross-referencing the correspondence analysis plots with available radiocarbon dates (Figure. 7.4) reveals that early sites, such as Shag River Mouth, Houhora and Wairau Bar, are present throughout the distribution of points. Therefore, no clear early or late end of this seriation is present. A great many of the sites with one-piece hooks appear to date to the earlier end of the prehistoric sequence (c. AD 1300 – 1500), although this range may be much more compressed. In this case, it is possible that the length of time being assessed using one-piece hooks is insufficient to show structured change.

Despite the lack of temporal pattern, it does appear that the correspondence analysis plots of one-piece head traits show some clustering based on geographic proximity. This is present at a low level across all plots, with some clustering of sites from the same region evident. However, the clearest case is present in the ‘inner’ correspondence analysis plot where North and South Island sites cluster at different ends of dimension 1 (Figure 7.19). Figure 7.19D shows that the attribute with the most influence on this dimension (represented by the presence of a point to the right of the dotted red line) was ‘3’ (short grip). Comparing the northern sites with their southern counterparts (Table 7.1) it seems that the major regional difference in this attribute is that northern sites are dominated by form ‘3’, whereas it is less common in southern sites, which also appear to have a broader range of forms.
Figure 7.19 Interpretations of the CA analysis of the trait ‘inner fishhook head’. A – Frequency seriation of based on inner traits, B – CA plot of sites according to inner traits, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 7.20 Interpretations of the CA analysis of the trait 'upper fishhook head'. A – Frequency seriation of based on upper traits, B – CA plot of sites according to upper traits, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 7.21 Interpretations of the CA analysis of the trait ‘outer fishhook head’. A – Frequency seriation of based on outer traits, B – CA plot of sites according to outer traits, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
7.6.1.2 One-piece fishhook types

The patterns hinted at in the analysis of single traits are amplified in the consideration of one-piece fishhook head types. The correspondence analysis of these types (Figure 7.22) reveals no robust pattern of sites according to dimension 1. Overlaying the CA plot with radiocarbon dates from sites at different points along dimension 1 it is clear the reason for this is the relatively narrow temporal range of sites (c. AD 1300 – 1500), which suggests strong temporal variation may not have had sufficient time to develop.

Of equal interest is the position of sites along dimension 2 (Figure 7.22). Here the geographic variation, hinted at in the analysis of single traits, is quite clear. The northern sites all fall below zero on the CA plot and are clearly separated from the South Island sites, which are all above the zero point. Figure 7.23 (lower) shows the influence of different types on the position of sites along dimension 2, with those types above the horizontal red line important in determining the position. Cross referencing the types shown above this line in this graph with Table 7.2 shows that, while both sets of sites have a similar number of types present the North Island sites have a far narrower range of types (e.g. 332). For example, both the Houhora (North Island) and Wairau Bar (South Island) sites have 20 types present yet the five most frequent types across all sites (311, 312, 332, 412 & 432) make up 66% of the Houhora assemblage and only 36% of Wairau Bar.

The narrower range of types present in the North Island may be the result of a number of factors. First, it may simply be the result of the relatively small (compared to the South Island) geographic area from which the sites are taken. This may limit any variation driven by different regional conditions. Second, it may reflect the relatively narrow temporal range of the sites. In this scenario the fishhook kit composition is similar to the ancestral kit from East Polynesia, and has not had sufficient time to develop. Lastly, it is possible that the narrower range in the North Island is due to the types in the ancestral kit being sufficient to catch fish, whereas the more challenging environments of the South Island drove much faster change in the fishing kit. These possibilities are discussed further in Chapter 9.
Figure 7.22 Correspondence Analysis of one-piece fishhook head types and the correspondence analysis overlaid with available radiocarbon dates.
Figure 7.23 Interpretation aids to the CA analysis of the onepiece head types. Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
7.6.2 Two-piece hook points

Before discussing the individual analyses it is important to note that there is a strong regional bias in the two-piece point dataset. Only three sites (Puketapu Cross Creek and Oruarangi) are from the North Island with the remaining 18 sites coming from the South Island. This regional variation is due to the lack of early sites containing two-piece points, which may relate to the regional variation in hook species. More specifically, in the South Island voracious fish may have driven the development of a more robust form. This is discussed in greater detail later in this thesis.

7.6.2.1 Traits

Four traits (barb, lashing, decoration, and shape) were assessed using correspondence analysis. The fifth trait, articulation platform, contained only two character states, meaning CA could not be applied to the data set. The CA plots generated from these traits show little evidence of any clear patterns, either temporal or spatial (Figures 7.24B – 7.27B). Frequency seriation graphs (Figures 7.24A – 7.27A) also show an inconsistent pattern of site orders according to dimension 1. The seriations derived from ‘lashing’ and ‘shape’ cannot be reliably linked to temporal changes through comparison with available absolute dates.

The seriation derived from the trait ‘barb’ (Figure 7.24A) does conform very broadly to independent dating. However, it is tenuous and is only really true because most of the late sites cluster at one end of the seriation. If this pattern does reflect changes over time it can be argued that internally barbed points are always common, although their presence slightly diminishes with time. Conversely, multiple barbed points and externally barbed points increase through time, although Oruarangi and Jacksons Bay Cave amplify the growth in popularity of externally barbed points. The seriation of the trait ‘decoration’ (Figure 7.25A) is also consistent with absolute dating with one caveat: Oruarangi appears in the upper middle of the plot when it would be expected toward the bottom (the later end according to absolute dates from these sites). Despite this issue, we can say that the general temporal trend in decoration is for a slow decline in plain artefacts and a growth in decorative serrations on the external margin only and on both the internal and external aspects of hook points.
Figure 7.24 Interpretations of the CA analysis of the trait 'barb'.

A – Frequency seriation of based on barb, B – CA plot based on barb, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 7.25 Interpretations of the CA analysis of the trait ‘decoration’. A – Frequency seriation of based on decoration, B – CA plot based on decoration, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 7.26 Interpretations of the CA analysis of the trait ‘lashing’. A – Frequency seriation of based on lashing, B – CA plot based on lashing traits, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 7.27 Interpretations of the CA analysis of the trait ‘shape’. A – Frequency seriation of based on shape, B – CA plot based on lashing shape, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 7.28 Upper: CA analysis of sites using the two-piece trait ‘barb’ with error ranges based on distribution of dirichlet deviates. Lower: Overlap of sites based on Dimension 1.
Figure 7.29 Upper: CA analysis of sites using the two-piece trait 'decoration' with error ranges based on distribution of dirichlet deviates. Lower: Overlap of sites based on Dimension 1.

The dirichlet analysis carried out on two-piece traits with evidence of chronologically related change (Figures 7.28 and 7.29) shows that, for two-piece barbs, there is significant overlap between sites. In particular, those dated to the early and middle period of the sequence, even those sites with large sample size, show significant overlap. This shows that while we can be confident that late sites are different, the exact order of earlier sites is very volatile.
Dirichlet analysis of the two-piece trait decoration shows more differentiation between points, although there is still overlap in the dirichlet-derived distributions. This result suggests we can have substantially more confidence in the result based on two-piece decoration.

7.6.2.2 Two-piece hook point types

The analysis of two-piece traits shows that, when a temporally related pattern was observed, Oruarangi and Jacksons Bay Cave were consistently found toward the later end of the sequence. These sites were characterised by the presence of a large number of straight-incurved hooks with external barbs, which were uncommon elsewhere. In the analysis of fishhook types the difference between these sites and others was immediately apparent in the CA plots. Figure 7.30B shows the initial CA analysis with all sites included. Here it is clear that Jacksons Bay Cave is a large outlier from the other sites, probably due to the restricted number of types present at the site. The inclusion of Jacksons Bay Cave compressed the other points into a small cluster where patterns could not be interrogated. This site was therefore removed from further analysis. Figure 7.30C shows the resulting plot, but here again an outlier (Oruarangi) reduced the ability to understand patterns. Therefore, this outlier was also removed resulting in Figure 7.30A, which is discussed further below.

The temporal changes noted in the analysis of two-piece hook point traits are also evident in the CA plot of types. The connection between temporal change and site order is well supported by the available absolute dates (Figure 7.32). Referring back to Table 7.4 and the earlier trait analysis it is clear that the major trend in two-piece hook points is toward more elaborate forms, which include external and multiple barbed forms as well as lateral serration.
Figure 7.30 CA plots of two-piece fishhook points. A – CA plot excluding the outliers, Jacksons Bay Cave and Oruarangi, B – CA plot with outliers included, C – CA plot with the biggest outlier (Jacksons Bay Cave) removed.
The clear regional clustering present in one-piece forms is not apparent in the hook point CA. Although it is worth noting that most of the early sites that included two-piece hooks were from the south of the South Island with very few early sites from elsewhere (Table 7.5), this suggests that this hook form may have developed first in the southern South Island, perhaps due to the different species present in the area, and then spread elsewhere.

Figure 7.31 Interpretation aids to the CA analysis of the two-piece fishhook points. A – Evaluation of the seriation structure in the data, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
7.6.3 The Angling Tradition

The previous sections have shown both temporal and spatial variation in fishhooks. As one-piece and two-piece forms were both used in angling it is worth considering these two forms together to understand how these two lineages interacted with each other through time and in different regions. In the following section the angling tradition is first considered as a whole and then at a regional level.

Figure 7.32 An overlay of the CA plot based on two-piece hook points and absolute dates.
The angling tradition was assessed by combining the information from one and two-piece hook forms. Following the methods used above, sites were required to have a minimum of ten artefacts for inclusion in this analysis. This minimum count was based on both one and two-piece forms. This meant that sites that were below the threshold when analysing a single artefact tradition could be included in the joint analysis.

Correspondence analysis of the angling tradition (Figure 7.33) produces a distribution of sites which, when cross-referenced with available absolute dates (Figure 7.34), shows that the distribution of sites along dimension one of the CA plot is consistent with a pattern driven by change over time. The large number of types makes examination of individuals very difficult. However, a graph based on the distribution of sites along dimension 1 of Figure 7.33 and showing the relative frequencies of one and two-piece hooks in each site (Figure 7.35) demonstrates that the CA is being driven by diminishing amounts of one-piece hooks through time and an associated rise of two-piece forms. This transition was largely complete by the time the Kahukura site (highlighted in Figure 7.35) was occupied between the mid 15th and early 16th centuries.

The regional variation evident in one-piece hooks remains clear in the angling tradition. Interestingly it seems that early sites in the North Island have relatively few two-piece forms compared with their southern counterparts. While this may reflect a temporal difference, it may also be regional variation driven by the rapid adoption of two-piece forms in the South Island.
Figure 7.33 Correspondence Analysis plot of the angling tradition (one-piece fishhook heads and two-piece hook points).
Figure 7.34. CA plot of the angling tradition with absolute dates overlaid
7.6.4 Lure Points

The sites that qualify for the analysis of lure points (i.e. contained ten or more lure points) are exclusively from the South Island. Table 7.7 shows that, while lures are present in the North Island, they are found in small numbers. While the small sample size means further analysis cannot be carried out it is interesting to note the the lure types found in the North Island closely match those identified as belonging to the fishing kit that arrived in New Zealand from East Polynesia (Chapter 4). This suggests that there was continuity in fishing gear in the North Island, unlike in the south (see below). The following section discusses the individual traits assessed in this analysis followed by the type data.
7.6.4.1 Lure point traits

Figure 7.36A shows that the ‘barb’ trait does not significantly vary across time or space. Indeed most sites exclusively contain points with the attribute ‘barb absent’ and only Centre Island and Whareakeake, from southern New Zealand have other forms present.

The trait ‘mid-shaft lug’ provides a much clearer pattern. The CA plot (Figure 7.37B) reveals a broadly ‘horseshoe’ shape and associated absolute dates support the idea that the distribution of sites along dimension 1 relates to temporal change. One clear exception to this is Purakaunui, which is placed later in the relative sequence than would be expected given its 14th century date. As Figure 7.37D shows, the frequency seriation of this data (Figure 7.37A) is largely being driven by the relative proportions of attribute ‘4’ (lug absent) and ‘2’ (lug present) with absent forms giving way to lugged forms through time.

The CA plot of lure point ‘lashing’ (Figure 7.38B) shows that Wairau Bar heavily influences the distribution. The high frequency of ‘lashed’ forms distinguishes Wairau Bar from the other sites, where ‘inserted’ forms dominate. While the relative order of sites cannot be seen in the CA plot due to the clustering of sites, the frequency seriation (Figure 7.38A) reveals a pattern generally consistent with absolute dates from sites. Again Purakaunui is an exception, as is Jacksons Bay Cave, which in other seriations frequently appears toward the more recent end of the sequence. The frequency seriation reveals a pattern of increased frequency of inserted form with a perforated base at the expense of plain inserted forms.

The CA plot of sites based on decoration shows a good correlation between dimension 1 and time. Figure 7.39D shows that the major influencing attribute was the presence of decorative serration (C1) on the external margin of the lures. This pattern is also matched in the frequency seriation (Figure 7.39A), which shows a trend away from undecorated (C4) and toward decorated forms.
Figure 7.36 Interpretations of the CA analysis of the trait ‘barb’. A – Suggested seriation according to popularity principle, B – CA plot based on counts of different traits, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 7.37 Interpretations of the CA analysis of the trait 'mid-shaft lug'. A – Suggested seriation according to popularity principle, B – CA plot based on counts of different traits, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 7.38 Interpretations of the CA analysis of the trait ‘lashing’. A – Suggested seriation according to popularity principle, B – CA plot based on counts of different traits, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 7.39 Interpretations of the CA analysis of the trait ‘decoration’. A – Suggested seriation according to popularity principle, B – CA plot based on counts of different traits, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 7.40 Upper: CA analysis of sites using the lure trait ‘mid-shaft lug’ with error ranges based on distribution of dirichlet deviates. Lower: Overlap of sites based on Dimension 1.
The dirichlet analysis on lure point traits reveals some interesting patterns. In the case of ‘mid-shaft lug’ the dirichlet analysis (Figure 7.40) shows that sites do overlap with those neighbouring them on the inferred sequence but no overlap is seen at the beginning and end of the sequence. Generally, it appears that this trait is a reliable source of sequence information. In the case of lashing type (Figure 7.41) Wairau Bar can be considered different from other sites with a good level of certainty, while the observed position of all other sites, with the possible exception of Papatowai, cannot be relied upon heavily. This is clearly because of the
dominance of ‘inserted’ or barracouta lures in South Island sites, with the exception of Wairau Bar, which retains a lot of ‘minnow forms’ much more consistent with East Polynesian sites. This result, while appearing to undermine the validity of the analysis, is actually positive. It reinforces the view that the rise of ‘inserted’ points was rapid and widespread, such that most South Island sites had a high proportion of them and therefore cannot be separated based on this trait.

7.6.4.2 Lure point types

The temporally related patterns observed in some lure traits are unsurprisingly present in the CA plot of lure types. As Figure 7.42 shows, there is a good level of agreement between site order and time with the exception of Purakaunui. The targeted layer of this site is radiocarbon dated to the 14th century yet it exhibits a pattern more consistent with a much later site; it is therefore possible that some mixture of material from different layers has occurred.

Figure 7.43B shows that the types ‘1444’, ‘1412’, and ‘5412’ were the most influential in the site ordering. These are all ‘inserted’ types (denoted by the ‘1’ at the start of the type number list) with forms denoted with a ‘5’ (e.g. ‘5412’) representing an inserted form with a perforation. Inserted forms are the dominant types in the sites analysed in this section; however, it is interesting to note that among the small number of lures from the North Island sites (not included in this analysis) these forms were uncommon and lashed forms (e.g. 2444) were the most frequent. This is more consistent with Wairau Bar, which is found at the early end of the sequence inferred from dimension 1 of Figure 7.38. This perhaps suggests that, despite the small numbers of lures, many of the North Island sites should also be considered ‘early’ in terms of their lure assemblage.
Figure 7.42 Top - Correspondence Analysis plot based on Lure point types. Bottom – CA plot overlaid with absolute dates.
7.7 Consideration of the Drift Hypothesis

Identification of change over time is an important first step in this analysis; however, it is also important to identify the possible processes driving change. One key hypothesis that required testing is whether change is occurring because of random processes (drift). Figures 7.44 - 7.46 focus on the rapid increase of ‘inserted’ lure points (Barracouta points) in southern New Zealand (see Figure 7.2,
lower left). The starting frequency of 0.01% is taken from the Wairau Bar assemblage (representing a very early assemblage), which contains only one such point. The other assemblages are Shag River Mouth and Papatowai where ‘inserted’ forms represent 92% and 77% of the total lure assemblage. In all simulations the observed data falls well outside of the 95% confidence interval predicted by the simulations. This is largely because so many of the simulations become extinct with such a small starting trait frequency (see black line in Figures 7.44 – 7.46). Although unlikely, based on the small number of simulations reaching these frequencies, the large amount of volatility present in the early stages of the sequence (as shown in Chapter 6) may account for the rapid frequency rise at low population levels. This is particularly true of the simulation with the starting effective population size of 10 whose average frequency of surviving simulations (blue lines) is reasonably similar to the observed data. However, it should be noted that while it is possible drift caused this level of change (representing a cumulative annual adoption rate of 10.34%) it is highly unlikely. In simulations with the initial effective population of greater than 100 no simulations reach the frequencies in the observed data. This indicates that at this level of population we can reasonably reject the drift hypothesis. Instead it seems reasonable to say that the change in this form reflects an ‘r-curve’ pattern associated with greater influence of direct or indirect biased transmission.

Figures 7.47 – 7.49 present the simulations based on an initial trait frequency of 99% consistent with the percentage of one-piece hooks in the angling tradition in the North Island site of Houhora. The results can be divided into three categories based on the initial effective population size: (1) 5 – 10, (2) 25 – 50 and (3) >100. In the first case (5-10) the results fall within the confidence range; however, the simulations suggest that if drift was driving change it would be much more rapid than seen in the observed data. Thus there appears to be little support for drift given these parameters. In the second group (25 – 50) the observed data falls outside the confidence range (again this is being influenced by the high number of simulations that fix at 100% frequency) and, although the mean of surviving simulations does show a similar pattern to the observed data, drift is therefore an unlikely cause of this change. Finally, simulations starting with populations of 100 or more show no support for drift at all. Overall these results suggest that the
change from the North Island angling tradition to that typical of the south was not influenced by drift.

Figures 7.50 – 7.52 present the same simulation as above but only involving those sites in southern New Zealand. Here the starting trait frequency is 72% based on the Papatowai site. Comparison with the observed data from a strictly regional context reveals a similar pattern as above in simulations based on low effective population size (5-10). The observed data falls within the 95% confidence range but the simulations show the change is much more drastic than is shown in the observed data. As with the previous example, this suggests that if effective population started at these levels drift is unlikely to have accounted for the change in frequency.

The remaining simulations depart from the patterns observed when including a North Island site. The observed data falls within the 95% range in simulations based on effective population sizes of between 25 and 50 and the mean frequency of non-fixed simulations broadly tracks the observed data in the first 100 years or so. After this time the simulations appear to settle around a particular frequency (as shown in the diversity index presented in Chapter 6). This suggests that the change in frequency between Shag River Mouth and Kahukura is unlikely to be accounted for by drift. Similar patterns are also present in the remaining simulation (100-500 initial effective population), which show Shag River Mouth falling within the 95% confidence interval but Kahukura falling outside. Again this appears to be because these simulations suggest large-scale changes in frequency after the first century of occupation are unlikely to be the result of drift. It is perhaps the case that there are two phases of change here. The first occurring, through random processes, in the first 50 years of settlement in southern New Zealand and the second a more deliberate selection of two-piece hooks later in prehistory. A further note to this analysis is that the dirichlet analysis of sites used as observed data for this analysis (see Appendix V) shows that sites can be generally regarded as distinct based on the frequency of traits. The only exception to this is that the frequency of barracouta points in Papatowai and Shag River mouth does show some overlap; however, this does not have a negative influence on the results above.
Figure 7.44 Drift simulations of 'inserted' lure points using differing initial population sizes and population growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 7.45 Drift simulations of ‘inserted’ lure points using differing initial population sizes and population growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 7.46 Drift simulations of 'inserted' lure points using differing initial population sizes and population growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 7.47 Drift simulations of one-piece hook decline using differing initial population sizes and population growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 7.48 Drift simulations of one-piece hook decline using differing initial population sizes and population growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 7.49 Drift simulations of one-piece hook decline using differing initial population sizes and population growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 7.50 Drift simulations of one-piece hook decline in the South Island using differing initial population sizes and population growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 7.51 Drift simulations of one-piece hook decline in the South Island using differing initial population sizes and population growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 7.52 Drift simulations of one-piece hook decline in the South Island using differing initial population sizes and population growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
7.8 Regional Variation in fishing gear

7.8.1 Comparison of temporal patterns in regional groups

The analysis of individual lineages pointed to broad regional differences in the presence and frequency of types. As such the regional variation of lineages is an important consideration. Figure 7.53 shows the distribution of the two lineages of the angling tradition (one and two-piece hooks) through time based on the CA plots presented earlier. Comparison of the regions suggests that the North Island and Canterbury region show abrupt change from early to late (although the broad trends remain the same in all regions). Rather than any radical change, it is more likely that this represents an interrupted sequence where middle sites are absent. Conversely southern sites, which absolute dates suggest span the entire prehistoric sequence, show a gradual shift towards two-piece forms. Comparing only the early sites from the regions it is apparent that the southern sites differ from the other regions (and most East Polynesian assemblages) in that two-piece hooks seem to have been a relatively important part of the tradition from the earliest periods. Indeed Table 7.8 shows that even in this early period two-piece hooks represent over 20% of the assemblage. This is a rapid and quite radical change in this region compared to elsewhere. The other pattern of note is the transition toward almost exclusive use of two-piece hooks by the time the Kahukura site is occupied, around the 15th century. Chronological ordering of sites according to the CA of lure points also presents considerable regional variation in the frequency of lures and their variation over time. Figure 7.53 shows that lures are present from the earliest period in southern New Zealand and are consistently represented throughout the sequence. This pattern is not seen in the other regions where two contrasting patterns are evident. In Canterbury early sites contain a small number of lures (c. 15%; see Table 7.9), which increases through time. Conversely the frequency of lure points is greatest in the early period in the North Island (although it is highly variable) with lures becoming absent by later prehistory (Figure 7.54). This contrast again suggests that a rapid change occurred in southern New Zealand away from the more traditional fishing kit found in central East Polynesia and the North Island. Although appearing to be more gradual, the increased importance of lures also occurred in Canterbury. This change, more than
likely, was driven by the functional requirements of catching Barracouta, which were more common in the southern waters.

Figure 7.53 Frequency distributions of one and two-piece hooks divided into three broad regional clusters.
Table 7.8 Frequency of one-piece hooks vs. two-piece hooks across three regions

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<td>Tarewai Point</td>
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<tr>
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Figure 7.54 Frequency distributions of angling forms and lures divided into three broad regional clusters.
Table 7.9 Frequency of angling hooks & lure points across three regions.

<table>
<thead>
<tr>
<th>Sites</th>
<th>Angling (%)</th>
<th>Lures (%)</th>
</tr>
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<tr>
<td>Jackson's Bay Cave</td>
<td>34</td>
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7.8.2 Regional Variation in type occurrence

7.8.2.1 NeighborNet Analysis

Together with the frequency of types it is also important to investigate patterns based on the occurrence of different types. As outlined in Chapter 2, the New Zealand archaeological record is frequently split into two phases based on the presence or absence of artefact types. This process is usually carried out on a site-by-site basis therefore the patterns based on occurrence across multiple sites is seldom considered. The following section uses the NeighborNet method in SplitsTree v4.0 (Huson and Bryant 2008) to assess inter-site patterns based on the presence/absence of artefacts. Figures 7.55 and 7.56 present the splits graphs of one-piece and two-piece hooks. Examination of the nodes of the one-piece graph (Figure 7.55) shows that northern and southern sites are mixed and therefore that the differentiation observed between regions in the frequency data is not present here. No temporal pattern is apparent in the graph, but as discussed earlier this is probably due to the close temporal proximity of all of the sites with large numbers of one-piece hooks.

Two-piece hook points (Figure 7.56) reveal a similarly radial pattern. Node positions shows no sign of clustering based on geographic proximity; however, there does appear to be some evidence that later sites from both the northern and southern South Island cluster at the bottom of the plot. This is almost certainly driven by the exclusive presence of some more elaborate forms of two-piece hook in these later sites. Again, no regional clustering is obvious.

Figure 7.57 presents the combined occurrence data of one and two-piece hooks (the angling tradition). This graph shows a much higher degree of differentiation, with two major groupings on the left and right. The right cluster is characterised by few two-piece hooks, while the inverse is true for the left cluster. This right grouping is also largely made up of North Island sites and South Island sites that are probably quite early (based on available radiocarbon dates). This cluster is likely to be the result of assemblages that closely resemble the profile of the East Polynesian fishing kit that first arrived in New Zealand, which was made up predominantly of one-piece hooks.
It is also interesting to note that the early southern site of Shag River Mouth does not comfortably fit in the right cluster. This may support the idea that change in the fishhook kit took place very early in southern New Zealand sites, perhaps driven by the quite different (and up-to-that point unfamiliar) environmental conditions in the south.

The occurrence data from lure points (Figure 7.58) produces a graph that appears to be primarily driven by chronological, rather than geographic, variation. Early sites are found on the left of the graph and later sites on the right. The exception, as with frequency data, is Purakaunui, which clusters more closely with later sites. It should be noted however, that no North Island sites could be included in this plot because none had the required number of lures. This in itself is a regional pattern, despite not being revealed by this plot (Figure 7.58).

Figure 7.55 Splits graph of Jaccard distance between sites, based on occurrence of one-piece types. Dark lines represent those with a bootstrap value over 50%. Sites are colour-coded by region: black – North Island, red – northern South Island and green – southern South Island.
Figure 7.56 Splits graph of Jaccard distance between sites, based on occurrence of two-piece types. Dark lines represent those with a bootstrap value over 50%. Sites are colour-coded by region: black – North Island, red – northern South Island and green – southern South Island.

Figure 7.57 Splits graph of Jaccard distance between sites, based on occurrence of angling types. Dark lines represent those with a bootstrap value over 50%. Sites are colour-coded by region: black – North Island, red – northern South Island and green – southern South Island.
7.8.2.2 Regional Variation of Types – object deviation linkages

Another means by which the influence of geographic distance on the composition of assemblages can be tested is object deviation analysis (Clark 2013). Here an independent variable (in this case geographic distance) can be used to predict the outcome of a dependent variable (Jaccard distance between sites based on the occurrence of fishhook types). The discrepancy between the predicted Jaccard distance between two sites and the predicted value (based on average distances across all sites) gives an indication of the influence of geographic distance of material culture similarity. In Figures 7.59 – 7.62 lines between sites correspond to values above one and two standard deviations above the mean. The absence of lines between sites suggests geographic distance predicts Jaccard distance between sites to within one standard deviation of the mean.

Figure 7.59 shows positive linkages, or those sites that are more similar to each other than would be predicted by geographic distance. What is clearly evident in this network is that the early period sites in the North Island are more similar to most of their South Island contemporaries than may be predicted by their spatial location. This is particularly true of the earliest sites, such as Papatowai, which suggests the connections between these early sites were quite strong and regionalism had yet to develop.
Among South Island sites there are relatively few positive linkages. Those that are present are between later period sites, suggesting that the southern and Canterbury sites from the late period are more similar than would be predicted by their geographic proximity. This may well support the idea that following population collapse much of the lower South Island was accessed by people hailing from elsewhere, perhaps even the north-east South Island (Jacomb et al. 2010).

Figure 7.60 shows the negative linkages between sites, which represent greater dissimilarity than would be predicted by space. The majority of these linkages are between late and early period sites. This reflects the fact that temporal change has operated on these assemblages rendering them different to an early period site in the same location may have been. However, it is interesting to note that some southern sites (Shag River Mouth, Purakaunui, Pipikaretu, Onepoto, and Sandfly Bay) are more dissimilar to some other early sites in the area than might be expected. This pattern may reflect the challenging conditions in southern New Zealand, which possibly drove experimentation in fishhook form and ultimately greater dissimilarity between sites than expected.

Given that temporal variation is clearly a large influence in the above figures (particularly Figure 7.60, which measured dissimilarity) further analysis is required. Despite the goal of this research being to get beyond ‘early’ and ‘late’, here such a division is necessary. Figure 7.61 shows linkage networks based solely on the angling tradition and with the data divided into presumed ‘early’ and ‘late’ sites, based on the CA analysis above. No sites, ‘early’ or ‘late’, were found to be more dissimilar than predicted by geographic distance. Figure 7.61 shows the early and late networks of higher than predicted similarity, which reveals that very early South Island sites (e.g. Wairau Bar, Papatowai) are much more similar to the North Island sites than distance would predict. This is consistent with the analysis of all fishhook types (Figure 7.60, above). The North Island sites themselves are also much more similar to each other than distance predicts. This is entirely consistent with a number of ideas about early settlement of New Zealand including: that the early colonists were extremely close culturally; that New Zealand was settled rapidly (such that material culture in the earliest sites across the country did not have the
Figure 7.62 shows three linkage networks based on the occurrence of lure types. ‘Late’ sites had no connections that were more dissimilar than expected and very few that were more similar, suggesting that in this period distance was a reasonable predictor of variation. This could reflect the rise of regional differences by the late period. Amongst ‘early’ sites we can see that most South Island sites are more dissimilar than those in the North Island. Connections based on greater similarity than would be predicted by distance are between South Island sites with no lures and North Island sites. This is in contrast to the angling tradition and is likely to reflect local adaptation to available fish species (barracouta) in the South.

7.9 Conclusion

This chapter has presented analytical results for angling hooks (one-piece and two-piece hooks) and lure points from New Zealand. It has shown that some qualitative traits exhibit structured change, which is clearly linked to chronological variation. In particular, so-called decorative traits (excess barbs, serrations) show gradual increase through time across all hook classes. Other aspects of the tradition show much more rapid change. The fastest change occurs in the lure tradition where barracouta lures quickly rise to prominence as the dominant form. The rapidity of uptake and the rapid spread of the barracouata lure in the South Island of New Zealand is almost certainly the result of the functional superiority of the form in these areas. Another marked change comes in the form of the change from one-piece to two-piece hooks, which was largely complete by the mid-point of the sequence (c. AD 1500). This change follows a more gradual S-shaped pattern of adoption and may have been driven by results bias with two-piece fishhooks seen as superior forms due to their greater strength. The remaining traits assessed across all lineages revealed little in the way of convincing patterns.
Regional analysis of fishhook change revealed marked contrasts. Southern New Zealand reveals a pattern of rapid divergence from the fishing kit that first arrived in New Zealand, while North Island sites show a high level of consistency. This is particularly true in regards to lure points, but also true of angling forms. Indeed, it appears that southern New Zealand may have been a centre of innovation perhaps because of its harsh conditions, which may have driven innovation and also because of its large population in the early period (see Chapter 5).

Assessment of the presence/absence of fishhook types showed a large degree of similarity between all sites, suggesting a core section of fishhook forms may be present across time and space in New Zealand. Regional variation was clear in two-piece forms and to a lesser extent in lures. It should be noted that the absence of lures in North Island sites is not picked up by this analysis and, if sites were included that did not reach the ten artefact threshold a pattern would be apparent. More specifically we would see a grouping of South Island sites, which have a large amount of lures and North Island sites that have very few forming two distinct groups. The angling tradition shows a marked difference between early sites with a predominance of one-piece forms and late sites with a predominance of two-piece. Ultimately these patterns suggest that the assessment of site age based on the presence or absence of individual types will provide poor results, with the exception of the different angling forms.

The following chapter replicates many of the analyses conducted in this chapter but applies them to the adze tradition of New Zealand.
8

Results: Adzes

“He panehe toki ka tut e tangitangi kai – A little adze well-used brings lots of food.” (Maori Proverb)

8.1 Introduction

This chapter presents the results of analyses of the adze tradition from prehistoric New Zealand. Like the fishhook tradition, adzes are present in large numbers in New Zealand, which is a key factor in their selection for analysis in this thesis. Adzes also present key contrasts to fishhooks; for instance, whereas fishhooks are made from locally available materials, adze stone was often sourced from highly localised sources. Thus, as well as providing key information about the intra-tradition processes of change, adzes can also provide valuable information about the influence of the wider economy (e.g. decreasing availability of stone) on cultural change. In this chapter the morphological, functional, and technological aspects of this tradition are discussed, as are the sources of stone used in adze production. The sites used in this analysis are then introduced and are followed by a consideration of the various traits used in the classification of adzes. Finally, the results of the analyses conducted on the adze tradition, including individual traits and types, are presented.

8.2 The Adze Tradition

The widespread presence of adzes in archaeological sites in Polynesia has ensured they have been, and remain, a well-studied artefact. Beginning in the early 20th century, when study of portable artefacts was at its peak, adze morphology across Polynesia was used to show the cultural association between far-flung island
societies (e.g. Skinner 1974; Duff 1977). Comparative analysis of adzes from sites in central East Polynesia (e.g. Maupiti, Society Islands) with sites in New Zealand (e.g. Wairau Bar) was also used to establish a relative chronological position for the latter, ‘early’ sites having similar adzes to Polynesian sites and ‘late’ sites showing marked differences.

This distinction was built around typological schemes based on excavated and museum collections (e.g. Skinner 1974; Duff 1977). These typological schemes provided a framework for describing change. In general, early adze types were considered to be larger, possessing a range of cross sections and some kind of reduction at the butt of adze to aid in hafting (Duff 1977). Conversely, late period adzes were considered to be smaller, generally quadrangular/rounded quadrangular in cross section, and without haft reduction (Duff 1977; Figure 8.1).

Despite providing a means to identify general trends in morphological variation, such typologies were intricately connected to larger binary cultural frameworks. Thus, types could only be seen as ‘early’ or ‘late’ with no provision for the identification of different patterns, processes, and rates of change. Indeed, the cause of morphological change in the adze tradition was considered either an outcome of broader cultural processes (see below) or a result of changing adze function (Best 1977; Turner 2000).

Stone adzes are present in great numbers throughout archaeological sites in Polynesia; however, their rapid replacement by metal tools following European contact means little ethnographic evidence is available to inform our understanding of the different uses of the tool (Turner 2000). Primarily, adzes are assumed to be a woodworking tools (Best 1977), yet the existence of adzes apparently too large for use, together with the presence of adzes in burial contexts, suggests some were connected with non-utilitarian functions (Turner 2000).
8.2.1 Adze function

The absence of ethnographic evidence means that the archaeological record is the only source of information regarding Maori use of adzes (more generally, there is very little ethnographic evidence anywhere in the Pacific for comparison). Functional variation in adzes was first addressed by Best (1977). Experimental analysis comparing the optimal attack angle for ‘early’ quadrangular forms with
that for the smaller, simpler, ‘late’ rounded quadrangular forms led Best to conclude that the ‘late’ adzes were better suited for land clearance and general purpose tasks. In contrast, the ‘early’ adze kit was thought to have been developed primarily for the construction of canoes and included a range of specialist tools. Best (1977) also argued that the choice of coarse, tough stone that was difficult to flake but could be pecked or ground into shape was more suitable for heavy tasks, leading to greater uptake of stone like gabbro and greywacke in the later end of the sequence.

In contrast to Best, Turner (2000, 2004) argued that variation in certain formal traits did not necessarily reflect changing functionality. Turner’s research involved observation of, and discussion with, people using traditional adze forms in the construction of a large, canoe-shaped kumete (trough or bowl). Turner (2000) found that the traits with major functional influence on the adze were bevel angle, edge curvature, edge width, and size. Most notably Turner argued that other formal variation, for example the shape of the cross section - a traditional focus of adze studies, had little bearing on the functioning of the adze. Instead, Turner argued that variation in such features might have been a reaction to the requirements of working various stone types into shape. For example, some materials might be difficult to flake and instead require pecking into shape, which is more likely to result in a rounded cross section when compared to flaked forms (Turner 2000, 2004). Encouragingly for this research, Turner (2000) suggested that some later adzes, although formally different, represent functional equivalents of earlier forms. This indicates that, despite the utilitarian nature of the adze, it is important to assess the descent of various traits to understand the processes that may operate to drive change.

8.2.2 Quarries and Changing Use of Material

Polynesian adzes were usually constructed of fine-grained basalts (Cleghorn 1984; Turner 2000). While local quarries were exploited, early colonists to East Polynesia went to great lengths to import adzes made of high-quality stone from exotic sources. The early distribution of Eiao basalt from the Marquesas (Chapter 4), which was exported to islands over 1000 miles distant, is clear evidence of this. In New Zealand this trend was retained, with material from high-quality flakeable
stone quarries, such as Tahanga basalt and the various Nelson argillite quarries (Figure 8.2), being exported to sites throughout New Zealand. Other high-quality stones, such as Mayor Island obsidian, (which is too brittle for adze manufacture) and South Island nephrite (which cannot be flaked but requires attrition sawing to shape into adzes) have similar distribution patterns (Davidson 1984; Walter et al. 2010).

An important general point is that the distribution of high-quality flakeable stone in New Zealand contracted over time. Only nephrite (a very hard but unflakeable stone), the sources of which are restricted to the western and southern areas of the South Island, continued to be transported throughout New Zealand (Davidson 1984; Turner 2000; Furey 2004; Walter et al. 2010). Walter et al. (2010) argued that the distribution decreased as the initial trade networks, set up to support the fledgling coloniser community, became defunct as overall population grew and localised populations became more self-sustaining.

The assessment of Walter et al. (2010) regarding the likely causes of early period exchange is compelling. However, their suggestion that a decreased need for outside connections over time resulted in a corresponding decrease in presence of high grade stone outside the immediate vicinity of quarrying seems dubious considering the widespread trade in nephrite. Walter et al. (2010) argue that nephrite trade represents a different mode of exchange. Even allowing this to be so, it is clear that lithic resources could be, and were, moved via these networks. Therefore, there is no reason to suspect that, if available, the same high-grade, flakeable stones common to the ‘early’ period were not transported along the same networks along which nephrite was traded. Instead, changes to quarrying, and adze production activities at quarries, are more likely drivers of changing availability in adze stone.

Adze manufacture commonly occurred at quarry sites in Polynesia. The most notable example of this is the Mauna Kea quarry, Hawaiʻi Island, Hawaiʻi, where the extraction and working of stone was carried out in a series of ‘workshops’ spread across a 12 km² area, which also contained a number of religious shrines (Bayman and Nakamura 2001).
Figure 8.2 Location of sites used in the analysis of the adze tradition and the major lithic sources in New Zealand.

This activity was almost certainly conducted by an organised and skilled workforce (Cleghorn 1984; 1986). While not at the same scale, similar in-quarry manufacture is also noted in New Zealand. For example, Jones’ (1984) assessment of selected argillite quarries showed a clear reduction sequence, from extraction of stone to
roughing out of adzes, was present at the sites. Likewise, Turner and Bonica (1994) asserted that, on the basis of comparison between experimental and archaeological adze flake assemblages, the initial stages of adze production occurred at quarries.

Leach (1993) has suggested that, as elsewhere in Polynesia, the quarrying and production of adzes at high-quality stone quarries was conducted by specialists who controlled the resource and exported adzes to other communities. Leach (1990) has drawn attention to the relatively high cost of producing adzes at often remote quarry sites, which was likely to have been passed to other consumers. Leach (1993) and Barber (1996) suggested that the exhaustion of easily won stone may have led to the cost of adzes from these key quarry sites becoming too great for other communities. Therefore, they began to turn to domestic production using low-skill techniques such as hammerdressing. These techniques were less risky and, although potentially more arduous, they initiated the exploitation of more local stone sources, which in turn led to the contraction in distribution of high-quality stones and a shift towards more localised production using a variety of local stone types (Leach 1990; Turner 2000).

8.2.3 Summary of Adze Tradition

The adze tradition in New Zealand is characterised by clear changes from adzes recovered from well-dated ‘early’ sites possessing particular characteristics (large in size, exhibiting some form of reduction to aid hafting and a range in cross-sections, and formed from high-grade flakeable stones from a narrow range of quarries), to the smaller, ‘simple’ forms made of localised stone sources. However, as Turner (2000) noted, the functional requirements of adzes throughout the New Zealand sequence was unlikely to change to the extent that variation in adze morphology solely relates to variation in activity. Indeed, it seems more likely that many later types, while taking different forms, may be functionally equivalent to earlier types (Turner 2000). While Turner (2000, 2004) suggested that some formal properties may change according to adze material another, currently unconfirmed, possibility is that the depression of stone resources instigated the collapse of economies reliant on specialist adze production, an increase in production of adzes...
using simpler methods such as pecking, and a decline in skilled knappers over time.

### 8.3 Sites Used in this Analysis

As outlined in Chapter 4, data was collected from sites containing 10 or more adzes. The sites (Figure 8.2) were predominantly found in the South Island, with four sites located in close proximity to each other in the North Island. Of those sites from which information was collected six had associated radiocarbon dates (Figure 8.3) and Whareakeake is noted as being occupied in the early historical record and probably the last prehistoric phase.

![Figure 8.3 Reliable radiocarbon dates associated with sites used in the analysis of adzes.](image)

### 8.4 Data Collection and Trait Characterisation

Chapter five outlined the criteria by which sites were included in this analysis. As with fishhooks, adzes from selected sites were photographed in fixed position. Photographs of the front, back, and side of each adze were used to analyse relevant traits. Notes on material and cross section were also recorded during photography. The selection of traits and trait characters was based on a review of
traits used in published research of adzes in East Polynesia with a particular focus on New Zealand (e.g. Duff 1956, Turner 2000). Each trait contained at least two different attributes, which were assigned a number. Types were formed by combining the set of numbers derived from assessing the range of traits (e.g. 1234). In the event that an artefact had suffered breakage the visible traits were recorded, although broken artefacts were not used in the analysis of types. The following section outlines the traits recorded on adzes.

![Image of adze morphology]

**Figure 8.4** Terminology associated with adze morphology.

### 8.4.1 Adze Traits

*Adze Grip* – This trait refers to the nature of modification at the butt of the adze, which presumably aided with the attachment of the adze blade to the haft. This trait was assessed by placing the adze on its back (*i.e.* bevel down) and observing reductions to the butt end. Seven attribute states were recorded for this variable: (1) Front, (2) Front with projections (often called ‘horns’), (3) Bilateral reduction
(spade shouldered), (4) Lateral asymmetrical reduction, (5) Pecked surface modification, (6) Absent, and (7) Loop tanged (Figure 8.5).

Figure 8.5 The seven attribute states recorded for the trait 'adze grip'.

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**Front shape** – Front shape refers to the shape of the adze when placed bevel down so the front of the adze is visible. Six attribute states were recorded: (1) Straight (lateral edges of the adze parallel), (2) Flared (wider at bevel that at poll), (3) Coffin (widest section neither at poll or bevel, lateral margin comes to a point), (4) Rounded (widest section neither at poll or bevel, lateral margin in rounded), (5) Sidehafted (straight lateral margin on one side with reduction on the other), and (6) Amorphous (Figure 8.6).

Figure 8.6 The six attribute states recorded for the trait ‘front shape’.
Cross section – Cross section refers to the shape of the adze at a point midway between the poll and bevel of the adze. Eight attribute states were recorded in this research: (1) Quadrangular, (2) Quadrangular front wider than back, (3) Rounded Quadrangular, (4) Triangular, (5) Reverse triangular, (6) Rounded, (7) Triangular lateral apex, and (8) Flat/Amorphous (Figure 8.7).

![Figure 8.7 The eight attribute states recorded for the trait 'cross section'.](image)

Material – Material type was included in the qualitative analysis of adzes, despite no intention to use this trait in the classification of adzes. The estimation of material origin was based on hand-specimen analysis. To increase the repeatability and validity of this process, only broad categories of stone were used in this analysis (e.g. ‘basalt’) rather than attempting to ascribe adzes to individual quarries. This process was conducted primarily in the field, as early field trials using photographs proved inaccurate when compared with ‘hands on’ estimates. The materials recorded were: (1) Basalt, (2) Nelson Argillite, (3) Southland Argillite, (4) Nephrite, (5) Greywacke, and (6) Other (see Figure 8.2 for reference to source locations).

Size – The last trait used in the classification of adzes was the length of the adze. Three categories were developed: (1) 0-5 cm, (2) 6-10 cm, and (3) >10 cm.

Side Profiles (front and back) – The front and back profiles of each adze were assessed by placing the adze on its side. The back profile was assessed from the chin to the poll (Figure 8.8) to remove the influence of the bevel. Four attribute states were
used for the classification of profiles: (1) Straight, (2) Concave, (3) Convex, and (4) Straight with lug (Figure 8.8).

Figure 8.8 Upper, the area assessed for front and back profile; lower, the four attribute states recorded for the traits ‘front profile’ and ‘back profile’.

8.5 Assessment of Adze Traits

Consistent with the analysis of fishhooks, the qualitative traits recorded for adzes were analysed using correspondence analysis (CA). As with fishhooks, adzes were analysed using the R packages ‘CAinterprTools’ (Alberti 2015) and ‘CAseriation’ (Alberti 2013). Frequency data of each trait attribute was used to carry out seriation (Figures 8.9 – 8.15A) and raw count data was inputted into correspondence analysis (Figure 8.9 – 8.15B). Relative contributions of sites and traits to the first two dimensions of the CA plot are presented in Figures 8.9 – 8.15C & D.

Comparison of both seriation and CA plots with available radiocarbon determinations shows some evidence of chronologically related variation. The traits ‘adze grip’, ‘cross section’, ‘front shape’, and ‘size’ all have dated ‘early’ sites at the opposite end of the order of sites (in the case of the CA plots this can be seen in relation to dimension one). This is particularly true in the case of ‘tang’ and
‘size’, which seem to show a clear shift in forms from ‘early’ to ‘late’. This clear shift can also be seen in the dirichlet analysis (Figure 8.16 and 8.17), which shows overlap between neighbouring sites along the sequence but clear separation between the beginning and end of the sequence. Thus we can be reasonably sure that sample size is not affecting the overall sequence of sites. For ‘tang’, Figure 8.9D shows the major driver of dimension 1 was the presence of front tangs, which appear in ‘early’ sites but reduce through time, although other grip forms do persist (Figure 8.9A). The analysis of size (Figure 8.12A) shows that larger adzes clearly become less frequent through time. Equally there appears to be a development of smaller adze tools (0-5 cm), which cannot have simply replaced the larger tools and must instead relate to the increase in other activities. However, in all cases a small number of ‘early’ or ‘late’ sites do appear out of sequence, for example, in the analysis of cross section (Figure 8.11), Pounawea appears at the wrong end of the sequence. Therefore, while there is a trend toward chronologically related change, this must be regarded as only weakly supported.

Two traits, ‘front profile’ and ‘back profile’, while having some variation between sites, proved to have no meaningful patterns. In both cases no coherent order could be made of sites based on chronology or regional variation. Based on the lack of patterns, and because these traits caused a large degree of fragmentation when developing types, it was decided to exclude them from further analysis. Finally, the analysis of material shows little pattern in the seriation (Figure 8.15A), but spatially related clustering is apparent in the CA plot. This is due to the clear bias in access to different sources. However, within regional analyses patterns in stone material choice may become apparent. To investigate this and other regional patterns the seriations of adze traits are considered at a regional scale in the next section.
Figure 8.9 Interpretation of CA analysis of the trait ‘adze grip’. A – Frequency seriation of sites, B – CA plot of sites according to dimensions 1 and 2, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 8.10 Interpretation of CA analysis of the trait ‘front shape’. A – Frequency seriation of sites, B – CA plot of sites according to dimensions 1 and 2, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 8.11 Interpretation of CA analysis of the trait ‘cross section’. A – Frequency seriation of sites, B – CA plot of sites according to dimensions 1 and 2, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 8.12 Interpretation of CA analysis of the trait ‘size’. A – Frequency seriation of sites, B – CA plot of sites according to dimensions 1 and 2, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 8.13 Interpretation of CA analysis of the trait ‘front profile’. A – Frequency seriation of sites, B – CA plot of sites according to dimensions 1 and 2, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 8.14 Interpretation of CA analysis of the trait ‘back profile’. A – Frequency seriation of sites, B – CA plot of sites according to dimensions 1 and 2, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 8.15 Interpretation of CA analysis of the trait ‘material’. A – Frequency seriation of sites, B – CA plot of sites according to dimensions 1 and 2, C & D – Evaluation of the influence of sites and types on the determination of dimension 1 and 2.
Figure 8.16 Upper: CA analysis of sites using the adze trait ‘grip’ with error ranges based on distribution of dirichlet deviates. Lower: Overlap of sites based on Dimension 1.
Figure 8.17 Upper: CA analysis of sites using the adze trait ‘size’ with error ranges based on distribution of dirichlet deviates. Lower: Overlap of sites based on Dimension 1.

8.6 Adze Seriation at a Regional Scale

The CA plots presented above hint at the influence of regional differences, therefore considering these trait trajectories within a regional context is important. The lack of any defineable pattern in either ‘front profile’ or ‘back profile’ means
they are excluded from this analysis; however, adze material estimations are included. Figure 8.18 shows the distribution of sites according to adze grip. These sequences appear to correspond with chronology in all regions with the trend being the reduction in frequency of adzes with grips, particularly front tangs, which suggests a simplification of adze technology through time. Southern New Zealand sites appear to have a lesser focus on ‘front tang’ with more traits being present in small frequencies than other regions. The seriations of ‘front shape’ (Figure 8.19) in the Canterbury and southern New Zealand sites appear to have little relationship to chronology, with ‘flared’ forms dominating throughout the sequence. The seriation of North Island sites is consistent with the order generated by ‘adze grip’ and shows a growing, although still relatively small, frequency of straight forms. Seriation based on ‘cross section’ (Figure 8.20) shows some marked regional differences. The seriation of North Island sites is consistent with chronology, with quadrangular forms dominating throughout and other traits, such as reverse triangular forms, dropping out of the record. The seriation of Canterbury sites also appears to fit well with chronology. However, in this region, while the quadrangular forms remain dominant, there is a clear rise in rounded forms and the flat/amorphous cross sections associated primarily with nephrite adzes. Interestingly, the clear relationship between seriation and chronology is not present in southern New Zealand sites. Conversely, the seriation of ‘size’ (Figure 8.21) presents a coherent pattern across all regions. Each regional seriation does appear to correspond with temporal variation (the notable exception is the placement of Whareakeake in the southern New Zealand seriation) and in all cases there is a clear trend away from larger adzes toward smaller varieties. Canterbury sites present a slightly different picture in that they show a large increase in very small chisel adzes (0-5cm), whereas these are rare elsewhere.

The last trait assessed here is material. This trait was not used in the classification of adzes. Nevertheless, changing choices of raw material in the adze tradition is of interest. The seriation of sites based on material frequency (Figure 8.22) does appear to show close relationships with time. The rise in frequency of nephrite adzes at the expense of local high-grade stone (such as basalt or Nelson argillite) is present across all regions to varying degrees. This is particularly apparent in the Canterbury sites. Another pattern of note is the lack of a clearly dominant stone
source in the early period in southern New Zealand. Instead, a range of stones is present at approximately equal frequencies across all sites.

Figure 8.18 Frequency seriation of ‘adze grip’ divided into regional groupings.
Figure 8.19 Frequency seriation of ‘front shape’ divided into regional groupings.
Figure 8.20 Frequency seriation of 'cross section' divided into regional groupings.

Key - Dated 'late' sites | Dated 'early' sites
Figure 8.21 Frequency seriation of ‘size’ divided into regional groupings.

KEY – Dated ‘late’ sites | Dated ‘early’ sites
As with the analysis of fishhooks, the influence of drift on the frequency of adze traits was also considered. The first step in this analysis was the identification of appropriate traits for testing, which involved identifying those trait attributes that show clear chronologically related change. Unfortunately few adze traits show this pattern unequivocally, with many exhibiting near consistent frequencies through.
time. This limited the scope of the drift simulations to a single trait, front tang, which was assessed according to the methodology outlined in the Chapter 6. Briefly, this involved the establishment of an artefact’s starting frequency based on the earliest dated archaeological site available. Based on this initial frequency a random drift model with no mutations was run with 1000 iterations. This was carried out a number of times with different starting populations and with differing rates of exponential population growth. Mean and 2 standard deviation range were extracted from each simulation to provide a confidence range to enable the assessment of the likelihood that drift accounts for changes in artefact frequency. Sites were plotted on the X axis according to their chronological position and the Y axis according to the frequency of a given trait. If these values fall within the 95% confidence interval we cannot reasonably reject the hypothesis that drift is a factor in changing artefact frequency.

Figures 8.23 - 8.25 show the simulations using the initial trait frequency of 40.6% from Wairau Bar against the decrease in frequency based on data from other sites. Interestingly, despite the drop from approximately 40% (Wairau Bar) to 11% (Purakaunui, representing a cumulative annual decrease of 1.76%) the trait frequency decrease falls within the 2 standard deviation range where we cannot discount drift as a factor in frequency change in all simulations. However, simulations with low initial effective population size show much more rapid change that leads to fixation or extinction in most cases. This pattern is unlike that seen in the observed data, therefore, at that (low) population level drift is unlikely to account for the pattern seen in the archaeological record.
Figure 8.23 Drift simulations of the trait ‘adze front tang’ with a starting frequency of 40.6% and differing initial population sizes and background growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 8.24 Drift simulations of the trait ‘adze front tang’ with a starting frequency of 40.6% and differing initial population sizes and background growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
Figure 8.25 Drift simulations of the trait ‘adze front tang’ with a starting frequency of 40.6% and differing initial population sizes and background growth rates. Red line shows the range in which 95% of simulations fall. Blue line shows the mean frequency of surviving simulations. Black line shows the percentage of surviving simulations.
8.8 Classification of Adzes

Adzes were initially classified using six traits: grip, front shape, cross section, front profile, back profile, and size. A total of 264 types were produced using paradigmatic classification; however, approximately 70% of these types were represented by only a single real world example. Therefore, upon reviewing the results of the analysis of single traits a decision was made to remove ‘front profile’ and ‘back profile’ for classificatory purposes. The construction of an adze typology according to only four traits produced 108 types (Table 8.1) of which twenty-four types were represented by ten or more artefacts (Table 8.2). Three types were clearly dominant (Figure 8.26):

- 6232 (untanged, flared, rounded quadrangular, 5-10cm in length)
- 6212 (untanged, flared, quadrangular, 5-10cm in length)
- 6213 (untanged, flared, quadrangular, >10cm in length)

These types represent relatively ‘simple’ forms without any type of reduction to aid hafting. The two most common types (6232 and 6212) are also between 5 and 10 cm in length, which is an interesting result because traditionally adze studies have focused on larger forms.
Figure 8.26 Most common adze types (ranked top to bottom).
Table 8.1 Raw counts of adze types from 24 sites across New Zealand. Table continued on following pages.

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Table 8.2 Types with raw counts of 10 and above.

|          | 1212 | 1213 | 1223 | 1453 | 5213 | 5232 | 6111 | 6112 | 6131 | 6132 | 6122 | 6213 | 6222 | 6223 | 6232 | 6282 | 6432 | 6461 | 6462 | Total |
|----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|
| Fishermans Bay | -    | -    | -    | -    | -    | 3    | 1    | 3    | 2    | 11   | 6    | 2    | 1    | 1    | 1    | 1    | 1    | 12   | 13    | 2    | 7    | 1    | 3    | 1    | 70    |
| Goughs Bay | -    | 1    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | 2    | 7    | 7    | 1    | 4    | -    | 2    | 12   | 2    | 1    | -    | 1    | -    | 42    |
| Heaphy River Mouth | -    | 1    | -    | -    | 4    | -    | -    | -    | -    | 1    | 2    | -    | 1    | 6    | -    | -    | -    | -    | -    | -    | 1    | -    | -    | -    | 16    |
| Kaka Point | -    | 2    | 3    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | -    | 1    | -    | -    | -    | 1    | 6    | -    | -    | -    | -    | -    | 15    |
| Kawatiri | -    | 1    | -    | -    | -    | -    | -    | -    | 1    | 6    | 4    | -    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 14    |
| Little Fishermans Bay | -    | -    | -    | -    | -    | 1    | 2    | -    | 4    | 8    | -    | -    | -    | 1    | 1    | 7    | -    | 1    | 1    | 4    | 2    | 3    | 33    |
| Long Bay | -    | -    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | 3    | -    | -    | 3    | -    | 1    | 1    | 1    | 4    | -    | 18    |
| Manukau South Head | 1    | -    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | 3    | -    | 6    | -    | 7    | 1    | -    | -    | -    | 20    |
| Moa Bone Point Cave | -    | -    | -    | -    | 1    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 4    | 2    | -    | -    | -    | 3    | -    | 1    | 1    | 1    | -    | 13    |
| Omihia | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 8    | 1    | -    | 2    | -    | 1    | 7    | 1    | 3    | -    | 1    | 1    | 25    |
| Onepoto | 1    | -    | 1    | -    | 1    | -    | 1    | -    | 1    | 1    | 10   | -    | 2    | -    | 4    | -    | 1    | -    | 2    | 25    |
| Oruarangi | -    | 1    | -    | 1    | -    | -    | 3    | 3    | 2    | 2    | 1    | 9    | 8    | 7    | 3    | 14   | 13   | 9    | 36   | 15   | -    | -    | -    | -    | 1    | 128   |
| Oue Pa | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | 1    | 1    | -    | 3    | -    | -    | 4    | -    | -    | -    | -    | 10    |
| Papatowai | 1    | -    | 1    | 3    | -    | -    | -    | -    | 1    | -    | 1    | -    | 3    | 3    | -    | -    | -    | -    | -    | -    | 1    | -    | -    | -    | -    | 14    |
| Paua Bay | -    | -    | -    | -    | -    | 1    | 1    | 2    | -    | 2    | 2    | 2    | -    | -    | -    | -    | 1    | 1    | 1    | 4    | 1    | 2    | -    | -    | -    | 20    |
| Pounawea | -    | 1    | 1    | 4    | -    | -    | -    | -    | -    | -    | -    | 3    | 1    | -    | 1    | -    | 1    | -    | 3    | -    | -    | -    | -    | -    | -    | 15    |
| Purakaunui | -    | 1    | 1    | 3    | 1    | 4    | 1    | 2    | 1    | -    | 1    | 2    | 8    | 2    | 1    | -    | 2    | -    | 1    | 2    | -    | 1    | 70    | 1    | 2    | -    | 46    |
| Shag River Mouth | 2    | 1    | 2    | 1    | 2    | 3    | 2    | -    | 4    | 1    | 4    | 1    | 1    | 11   | -    | -    | 1    | -    | -    | 12   | 1    | 1    | 2    | 1    | 2    | 54    |
| Sleepy Bay | -    | -    | -    | -    | -    | -    | 1    | -    | -    | -    | 1    | 2    | 1    | 3    | 2    | 1    | -    | 4    | 14   | 2    | -    | -    | -    | 2    | 32    |
| Tarewai Point | -    | -    | -    | -    | -    | 1    | 1    | 1    | -    | 2    | 11   | 2    | 1    | -    | -    | 1    | 9    | 1    | -    | 1    | 1    | 1    | 1    | 1    | 33    |
| Taylors Hill | -    | 2    | 3    | 3    | 2    | 1    | -    | -    | 4    | -    | 5    | 2    | -    | 1    | -    | 1    | 9    | 1    | -    | 1    | 1    | 1    | 1    | 1    | 41    |
| Tokata | 6    | 39   | 8    | -    | 29   | 3    | -    | 2    | -    | 3    | 26   | 36   | 1    | 3    | 6    | 1    | 9    | 5    | -    | -    | -    | -    | 1    | 78    |
| Whareakeake | -    | 2    | -    | 2    | 2    | -    | -    | 2    | 5    | 14   | 9    | 1    | 2    | 4    | 1    | 9    | 19   | 11   | -    | -    | 4    | 80    |
| **Total** | 11   | 52   | 22   | 18   | 40   | 15   | 11   | 12   | 16   | 15   | 21   | 45   | 151  | 91   | 11   | 39   | 37   | 34   | 189  | 56   | 20   | 10   | 16   | 18   | 950   |
8.9 Analysis of Adze Types

Correspondence analysis of adze types (developed using the four adze traits discussed above) shows a clear temporal pattern of variation based on the distribution of sites along dimension 1 (Figure 8.27). Most early sites are found to the right of the CA plot with later sites to the left. The wide temporal range presented by the radiocarbon date from Taylors Hill is unhelpful; however, the presence of two pa sites (Oue Pa, Tarewai Point), which are considered to be a later (post AD 1500) site type, provides a secondary line of evidence to support the interpretation of chronologically driven change. One anomalous site in this distribution is Moa Bone Point Cave, which is often associated with an early date (although the radiocarbon dates from this site are of poor quality).

Also of interest is an apparent trend toward regionally based distributions. All sites from the Canterbury region are present higher up dimension 2, while North Island sites all fall in the bottom left of the distribution. These are not distinct clusters but do hint at a degree of regional variation within the data. Figure 8.28 shows the contribution of both sites and types to the distribution of sites along dimension 1 and 2, with those types or sites either above or to the right of the dotted red line representing those which make a ‘significant’ contribution. In the case of sites, the relatively large size of the Wairau Bar assemblage is the major influence. Review of the type plot highlights some of the potential drivers of the regional variation. Cross referencing some of the influential types with Table 1 and 2 shows some interesting patterns. Type 1233 (front tanged, flared, rounded quadrangular, >10cm) is only present in the southern South Island sites. Types 6282 (no tang, flared, flat amorphous, 5-10cm) and 6461 (no tang, flared, rounded, 5-10cm) are present, particularly in northern South Island sites, rare in southern South Island sites and not present in the North Island. Lastly, types 1453 (front tang, rounded, reverse triangular, >10cm) and 1213 (front tang, flared, sidehafted, >10cm) are present in the South Island in low numbers but are very rare in the North Island sites investigated in this thesis. It is possible that the relatively small number of North Island sites may account for some of these differences. Nevertheless, it seems important to further investigate regional variation; therefore the following section looks at adze traits in a regional context.
Figure 8.27 Correspondence analysis of adze types (top) and CA plot overlaid with C14 dates (bottom).
8.10 Analysis of Type Occurrence

8.10.1 NeighborNet Analysis

As discussed in the previous chapter, the composition of assemblages in terms of the presence or absence of key types is often cited as a means of assessing the age of sites. In practice, the attribution of age to sites based on this method is seldom
tested. Here the NeighborNet method (in SplitsTree v4.0, Huson and Bryant 2006) is used to assess any patterns based on the presence/absence of adze types. Figure 8.29 shows the splits graph produced using Jaccard distance between sites based on occurrence of adze types. The graph is radial with no strong clusters although, based on the temporal order developed using frequency seriation, it could be argued that earlier sites tend to group on the left of the graph with later sites on the right. The other likely driver of variation is spatial proximity. Figure 8.29 colour codes sites according to their regional affiliation. Here we can see some relationship, for example the collection of five northern South Island sites (Little Fishermans Bay – Goughs Bay), but, like the temporal data, this pattern is not entirely coherent.

The lack of a clear regional or temporal pattern in Figure 8.29 is itself instructive. Traditionally New Zealand archaeologists have argued for large-scale changes in the formal composition of adze kits over time. Yet, while some types noted above do appear to be exclusively early, the result below also suggests the core of the adze tradition remains relatively similar over time and space.

Figure 8.29 Splits graph of Jaccard distance between sites, based on occurrence of adze types. Site colour-coded according to region. Black – North Island, Red – northern South Island, Green – southern South Island. Grey lines represent those with less than 50% bootstrap support.
8.10.2 Object Deviation Analysis

The occurrence data generated above may also be applied to object deviation analysis to assess if differences in geographic proximity predict the Jaccard distance between sites. As outlined in the previous chapter, the discrepancy between predicted difference between sites (based on geographic distance) and the observed Jaccard distance is represented by the networks below (Figures 8.30 and 8.31). In these networks, lines between sites correspond to values above either one or two standard deviations from the predicted value. The absence of lines suggests that geographic distance provides a good predictor for the relationship between sites.

Figure 8.30 shows the positive linkages, or those sites that are more similar to each other than would be predicted by geographic distance. Unlike the object deviation analysis conducted on fishhook sites, this network shows that, in some cases, the supposed later sites are more similar to early sites than geographic distance would predict despite the temporal distance. This is particularly true of the later South Island sites in Canterbury (e.g. Paua Bay, Goughs Bay etc.). While this is the case, the majority of connections in Figure 8.30 remain in-period (i.e. early to early or late to late), particularly in the case of late sites. This result is interesting considering the supposed growth of regionalism in the later period of New Zealand prehistory (Walter et al. 2010).

The second network (Figure 8.31) shows the negative linkages, or those sites that are less similar than would be predicted by geographic distance. This network is dominated by later period sites, such as Oruarangi, showing greater than predicted Jaccard distances from many of the early sites. This pattern is clearly driven by temporal, rather than geographic variation. Indeed few early period sites, with the notable exception of Onepoto, have any linkages to each other, suggesting geographic distance either accurately predicts Jaccard distance in early period sites or underestimates similarity.
Figure 8.30 Positive object deviation linkages based on geographic distance $f$. Jaccard distance of sites based on adze type.
Figure 8.31 Negative object deviation linkages based on geographic distance $r$. Jaccard distance of sites based on adze type.
8.11 Conclusion

This chapter has presented the results of the analysis of the adze tradition in New Zealand. It has shown that some qualitative traits recorded in this research show structured change, which appears to be the result of change over time. In particular, the morphology associated with hafting, and the size of adzes showed the clearest change over time. The major trend in terms of hafting is the decrease in adzes with a ‘front tang’ in favour of simple, unhafted forms. The adze tradition also exhibits a change toward smaller adzes (<10cm) from the larger forms commonly associated with the moa-hunter period in New Zealand (Duff 1956). Somewhat disappointingly, no clear generative mechanism for these changes could be conclusively found. The influence of drift could not be discounted in the case of ‘adze grip’. In the case of adze size, one may reasonably argue that the increased frequency of very small adzes may reflect a different function for some adzes in later prehistory. The remaining adze traits revealed little in the way of convincing patterns; however, adze material showed a strong relationship with the regional relationships between sites. This clearly relates to the variable accessibility to different materials, particularly basalt and Nelson argillite at the early end of the sequence and nephrite toward the end.

The analysis of type frequency using correspondence analysis heightened the ability to see the patterns hinted at by analysis of traits and showed that relatively ‘simple’ adzes predominate in the New Zealand record with an apparent decrease in type variation over time. Here again, the regional groupings were apparent, reflecting the influence of material in the final form of adzes. This regional association is evident in both sets of network analysis, where the collection of later sites from the northern South Island (e.g. Goughs Bay, Paua Bay, Fishermans Bay etc.) is particularly apparent. The lack of clear regional associations between early sites supports the idea regionality did not develop until the later end of the New Zealand sequence.

The following chapter discusses these findings, together with those of the population models from (Chapter 5) and fishhooks evidence from Chapter 7, relating them to the broader archaeological and theoretical context of this thesis.
Discussion and Conclusion

“The Prehistorian is concerned, fundamentally, with patterns of change.” (Groube 1967: 1)

9.1 Introduction

This thesis has sought to understand the pattern and process of culture change in New Zealand. To address this aim three key research questions were developed, and these were:

1. To the extent that we can recognise them via indirect lines of evidence, what are the population histories exhibited by different regions of New Zealand and how do these demographic trajectories impact upon wider cultural patterns?

2. What are the spatial and temporal patterns of variation in the material culture traditions of New Zealand? What are the possible explanations for any such variation?

3. How do the observed patterns in New Zealand compare with other Polynesian island groups?

This chapter draws together the various strands of thought and analyses presented in this thesis to address these questions. It first discusses the population history of the three New Zealand regions that were the focus of Chapter 5. These observed demographic patterns are considered against the backdrop of other well-known kinds of archaeological evidence, such as settlement patterns. The final part of this section compares the patterns seen in New Zealand with those of other East Polynesian islands. In the second section I turn to the discussion of material culture, focussing first on fishhooks and then adzes. In both sections, spatio-temporal patterns of variation are discussed followed by consideration of the
possible processes leading to these patterns. The latter part of this discussion is either directly informed or more informally influenced by the principles of Darwinian archaeology (Chapter 3). A comparison is then drawn between these patterns and those evident in East Polynesia in order to better inform the discussion of underlying processes of change. Finally, I conclude the chapter by considering the ways in which this research could be expanded and by presenting a synthesis of the results of this research.

### 9.2 Population History

#### 9.2.1 Regional Variation in Population History

The demographic modelling using radiocarbon dates as a proxy, presented in Chapter 5, has provided the first empirically derived models of regional population history in New Zealand. This section outlines the patterns and suggests possible causes of inter-regional variation in population history. The initial period of rapid growth is discussed first, followed by a discussion of patterns evident after this period of growth had ceased.

All regions (northern, central and southern) are characterised by a sharp upward growth phase following initial settlement; however, the rate of growth in the southern region appears higher than other zones. The cause of this rapid growth relative to other regions may well be differential availability of wild resources. Typically, settlements in early New Zealand prehistory were located in resource-rich zones where both marine and terrestrial resources could be exploited (Anderson and Smith 1996; Walter et al. 2006). The largest early villages were located in the eastern South Island (spanning both the southern and central regions in this analysis) where New Zealand fur seal (*Arctocephalus forsteri*) and moa (Aves: Dinornithiformes) were particularly abundant (Anderson 1989; Walter et al. 2006). The remains of these animals are present in almost all early sites (Smith 2011) and it is clear they were a major part of the early subsistence economy in the South Island (Anderson 1989; Anderson and Smith 1996; Smith 2004). Contemporary North Island sites (*e.g.* Kaupokanui and Houhora) are much smaller and, while they contain remains of big game animals, these species are not present in the same abundance as the South Island sites reflecting their lower availability in
the northern region (Anderson 1989). Anderson and Smith (1996) argue that large resource patches acted as pull factors for early settlement, and the population curve derived here supports this argument while also suggesting that these resource-rich patches were the bases for early, rapid population growth in the southern region.

While differential wild resource availability may account for the difference between northern and southern population curves, the cause of difference between central region and southern region curves is less clear (the northern region exhibits slower growth than the central region). While a substantial area (e.g. the lower North Island) of the central region had a relatively low concentration of big game resources, the southern margin of the central region is the area where moa-human interactions were the most intense (Anderson 1989; Holdaway et al. 2014). Under such circumstances it might be expected that this area also would have undergone rapid population growth within the high quality resource patches. Yet, relative to the southern region, the central region appears to have a slower rate of growth (although it is faster than the northern region). No clear explanation is apparent; however, it is possible that attempts to introduce crops in this area had some constraining influence on growth, perhaps through limiting the time available for hunting.

The exponential growth evident across all regions appears to peak between c. AD 1450-1550, perhaps indicating that Maori societies reached local carrying capacities during this time, which caused population growth to level off. As stated in Chapter 5, matching the shapes of SPDs with known growth models, such as the logistic curve, to prove such a theory is a highly inaccurate process. However, drawing on broader archaeological data can enlighten this point. A potential outcome of increased competition is increased inter-group conflict, present throughout East Polynesia in later prehistory (Davidson 1982; Kirch 2000; Kirch and Rallu 2007, and references therein). One possible sign of such conflict in New Zealand is the rise of a site type known as pa, which is a landesque-intensive site formed of a series of ditches, banks and palisades, often in highly defensible positions (Figure 9.1). Pa are most often considered defensive structures (Best 1927; Davidson 1982); however, more recent considerations also suggest that they may be
important as symbols of group identity and display (Barber 1996; Sutton et al. 2003). In both cases the presence of pa does suggest a degree of inter-group competition, either as a direct part of warfare or simply as a means of marking territory. On the basis of radiocarbon dates, Schmidt (1996) has argued that pa construction commenced around AD 1500. The emergence of pa construction at the same time as population growth appears to peak provides anecdotal support for the idea that population growth may have slowed as competition for resources increased.

Following the peak, all regional models show a period of population decline. In northern and central SPDs this decline occurs after what appears to be a levelling off of population and seems to be relatively gradual. Comparison of the northern and central models with known distributions of uncalibrated dates suggests that a logistic growth pattern is most similar to the observed data. The transported East Polynesian cultural inventory included cultigens, which, logic suggests, were planted upon arrival. While evidence of early horticulture in New Zealand is minimal it is considered to have taken place in some early northern sites such as Houhora and Sarah’s Gully (Davidson 1984; Walter et al. 2006). Walter et al. (2006) state that, within the optimal horticultural zone (roughly equivalent to the

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4 The evidence for this seems to be that these are the largest North Island sites, and therefore horticulture should have taken place at them. Direct evidence is absent.
northern region in the demographic analysis) communities maintained a horticulture-based economy. However, further south in the areas defined as the central region, crops such as the sweet potato (*Ipomoea batatas*) could not be grown in sufficient amounts and, instead, horticulture merely supplemented an economy based on wild foods. Therefore, while access to big game may have been limited in the northern and central regions, the establishment of horticulture allowed a more sustained period of population growth in these regions. Favourable conditions in the northern region, including higher temperatures, good rainfall and less frost days *per annum*, allowed population to grow to a much larger size, potentially reaching as much as 90% of the total population of New Zealand (McGlone *et al.* 1994). In other words, in these regions, population grew slower than the southern region but overall population size was larger and more sustainable. The interpretation of these patterns is complicated by the position of an ambiguous zone on the Southern Hemisphere calibration curve at the point of negative inflexion in the models. The ambiguous zone results in the recruitment of dates into two peaks around AD 1400 and 1550 (McFadgen *et al.* 1994) and a resulting loss of dates on either side of these points. Therefore, while it is tempting to suggest that population progressed through a boom and bust scenario or perhaps logistic growth, it is important to be cautious about how we describe the chronological shape of this change.

In the southern region, the ambiguous calibration zones may heighten the population peak and remove some dates from later in the curve, but despite this, it appears likely that population was trending downward. This interpretation is based on a much earlier and more pronounced decline than is evident in the other regions. While growth was fuelled by big game resources, over-exploitation led to the extinction of moa between 50-150 years after initial colonisation (Holdaway and Jacomb 2000) and extirpation of seals within 200 years (Smith 2005). Environmental conditions did not allow the successful establishment of tropical cultigens in the southern region (Anderson and Smith 1996; Basset *et al.* 2004). Therefore, populations could not supplement their diet with crops following the loss of big game resources. The pattern observed in the population model supports the idea of a large-scale decline in population following the loss of faunal resources (Anderson and Smith 1996; Jacomb *et al.* 2010).
9.3 New Zealand v. East Polynesia – a comparative perspective

As outlined in Chapter 5, the typical growth curve applied in East Polynesian archaeology is one of logistic growth. A range of analytical processes including house counts (Cordy 1981), frequency of sites within date ranges (Kirch 1984; Dye and Komori 1992), and intensification of subsistence infrastructure (Ladefoged and Graves 2007) have been used to show logistic growth in places, such as Western Hawaii and the Kohala field system (Figure 9.2); however, other patterns are also present in the region. For example, Kirch’s (2007a) analysis of radiocarbon-dated sites from the Kahikinui region, Maui shows continuing growth in the number of sites until European contact in 1778, with marked growth in the region beginning slightly later than the West Hawai‘i sample. Kirch (2007a) suggests that these patterns reflect Kahikinui’s marginality in terms of agriculture, which led to its settlement later in prehistory after more favourable regions. As a result, the population has less time to grow and to reach carrying capacity, which resulted in an exponential pattern.

Divergence from the logistic model is also observed in the ‘Opunohu Valley, Society Islands (Hamilton and Kahn 2007). Hamilton and Kahn (2007) use the frequency of calibrated dates within two-hundred-year bin ranges. The resulting graph (Figure 9.2F) reveals a pattern of growth that continued until European contact in 1767. The authors posit that this pattern of growth reflects a situation where carrying capacity has yet to be reached.

Lastly, a series of approximately twenty-five Polynesian islands, settled in antiquity but abandoned prior to the arrival of Europeans (Anderson 2002), represent a more radical departure from the logistic growth model. These ‘mystery islands’ (Bellwood 1978) represent marginal locations with relatively impoverished wild resources and where the establishment of agriculture/horticulture may have proved difficult. Anderson (2001) suggests that the inability to supplement diet with agricultural produce following the over-exploitation of wild resources led to the abandonment of islands or extinction of human populations. A less extreme
version of this scenario, and perhaps the widest cited example of Polynesian
demography, is the ‘collapse’ of population on Rapa Nui.

Figure 9.2 Population curves from East Polynesia, figure adapted from cited works. A - Summed probability distribution of Hawaiian radiocarbon dates (Dye and Komori 1992), B – Suggested population of the Leeward region of Hawai‘i Island (Hommon 1976), C – Suggested population of North Kona (Cordy 1981), D - Temporal frequency of radiocarbon dates from Kahikinui, Hawai‘I (Kirch 2007), E - Number of dated sites from West Hawai‘i (Kirch 1984), F - Temporal frequency of radiocarbon dates from Mo'orea, Society Islands (Hamilton and Kahn 2007), G - Summed probability distribution of Class 1 (high reliability) and Class 2 (medium reliability) radiocarbon dates from Rapa Nui (Multnooney 2013) and H – Southern and Northern hemisphere calibration curves.
Diamond (2005: 118) notes that Rapa Nui is “the clearest example of a society that destroyed itself by over-exploiting its own resources”, an interpretation also proposed by others (Bahn and Flenley 1992). However, more recently Mulrooney (2013) has carried out a summed radiocarbon analysis (similar to that conducted in this research) as part of a wider study of settlement. The resulting pattern (Figure 9.2 G) does not conform to the expectation of collapse, but instead suggests a continuous pattern of occupation. On the balance of evidence it seems that the pattern of population history in Rapa Nui is now conforming to the general logistic model present elsewhere in Polynesia.

Comparison between the population models from New Zealand and those of East Polynesia demonstrates some clear similarities. The northern and central models appear similar to models from Hawai‘i (above), interpreted as exhibiting logistic growth (Dye and Komori 1991; Ladefoged and Graves 2007). This comparison suggests population growth in these zones had, like Hawai‘i, levelled off. Following Kirch’s (1984) logic, this pattern may be due to the population in the northern and central zones reaching carrying capacity; however, the very low overall population density observed throughout New Zealand (Table 9.1) suggests that carrying capacity must have been far lower than other islands in East Polynesia.

<table>
<thead>
<tr>
<th>Island group</th>
<th>Total Pop.</th>
<th>Population of maximal political unit</th>
<th>Total land (km2)</th>
<th>Arable land (km2)</th>
<th>Pop Density (N/km2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawaiian Is.</td>
<td>200,000</td>
<td>30,000</td>
<td>16,633</td>
<td>1,663</td>
<td>120</td>
</tr>
<tr>
<td>Tonga Is.</td>
<td>40,000</td>
<td>40,000</td>
<td>696</td>
<td>487</td>
<td>82</td>
</tr>
<tr>
<td>Society Is.</td>
<td>45,000</td>
<td>9,000</td>
<td>1,535</td>
<td>460</td>
<td>98</td>
</tr>
<tr>
<td>Samoan Is.</td>
<td>80,000</td>
<td>25,000</td>
<td>2,829</td>
<td>810</td>
<td>99</td>
</tr>
<tr>
<td>Easter Is.</td>
<td>7,000</td>
<td>3,500</td>
<td>160</td>
<td>106</td>
<td>66</td>
</tr>
<tr>
<td>‘Uvea</td>
<td>4,000</td>
<td>4,000</td>
<td>59</td>
<td>40</td>
<td>68</td>
</tr>
<tr>
<td>Mangaia</td>
<td>3,000</td>
<td>3,000</td>
<td>70</td>
<td>40</td>
<td>75</td>
</tr>
<tr>
<td>Marquesas Is.</td>
<td>35,000</td>
<td>1,500</td>
<td>1,058</td>
<td>529</td>
<td>66</td>
</tr>
<tr>
<td>Futuna</td>
<td>2,000</td>
<td>2,000</td>
<td>62</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>New Zealand</td>
<td>125,000</td>
<td>3,500</td>
<td>265,146</td>
<td>10,000</td>
<td>11</td>
</tr>
</tbody>
</table>
Kirch (1984) argues that this is due to the difficult conditions for Polynesian crops presented by the New Zealand environment, which meant lower yields. Adding to this, Walter et al. (2006) have argued that the poor quality of New Zealand’s soil necessitated frequent movement of gardens, which reduced the available land area further limiting the productive capacity of New Zealand.

Despite these very plausible explanations, another possible explanation can be drawn from the Society Islands. Hamilton and Kahn (2007) argue that the inhabitants of the ‘Opunohu Valley, Society Islands, may have perceived a level of population pressure despite being nowhere near what the authors regard as the maximum number of people that can be supported by the local environment based on estimates of crop productivity. The authors suggest that local land tenure systems and socio-political boundaries restricted settlement and created dense pockets of occupation in the valley, mimicking the social and cultural conditions of a population at carrying capacity.

Taking the known distribution of pa sites in New Zealand as a proxy for general settlement (Figure 9.3) we can see that settlement distribution was reasonably dense, particularly in coastal areas of the North Island. Viewing this pattern from an emic perspective, it seems possible that the density of settlement may have caused a perception of population pressure, based on high settlement density in well-frequented parts of the island and/or socio-political actions such as claiming of territories. Under such circumstances, social responses (e.g. introduction of sexual taboos) may have kicked in to limit population growth (Kirch 1984). However, while this is possible, as I noted in Chapter 5, life-history theory predicts that behaviour aimed at maximising the reproductive success of the individual is a more likely cause of a drop in population growth than ‘for the good of the group’ models (Shennan 2002). In support of this, Winterhalder et al. (2015) have recently shown that households harvesting crops in temperate zones where yield may be unpredictable were likely to have over-produced in order to carry substantial surpluses, which mitigated risk of starvation. This is particularly likely in cases where groups relied heavily on a limited range of species because the impact of failure is much higher if other crops are not available as a fall back. Interestingly, and in support of the predictions of life-history theory, Winterhalder et al. (2015)
also suggest that decisions made by households to mitigate risk had population level consequences. This is particularly true where surplus is carrying forward into a new harvest cycle to lower the risk of inter-annual variation in yields, because setting aside some of the harvest reduces what can be consumed. Therefore, in circumstances where some harvest is retained, the number of people who can be supported will be less than is predicted by maximum productivity estimates.

Applying the general principals of life-history theory and those outlined by Winterhalder et al. (2015), I believe that a realistic model for why New Zealand population appears to level off at what appears to be a very low level involves and aggregation of the following factors: (1) reduced crop yield in New Zealand, (2) environmental conditions that increased risk and drove decisions to store crops, further reducing the number of people that could be supported, (3) a focus on a limited number of crop species (particularly sweet potato), which also increased risk of crop failure and, (4) probable competition for high-quality patches that may have produced conflict and despotism.

![Figure 9.3 Distribution of pa sites in New Zealand showing the large disparity between the North and South Islands.](image-url)
While such factors may account for some decrease in population density, the question remains: do the factors outlined above account for the enormous disparity in population density and size in New Zealand when compared to other East Polynesia islands? To this I would say that the jury remains out. What is required to address this point is more detailed analysis of productive capacities in different regions of New Zealand together with a major focus on the relationship between crop storage, settlement pattern and population in different regional contexts.

A comparative perspective is also useful when considering the pattern of regional settlement and population growth in New Zealand. Evidence from Kahikinui, Hawai‘i, suggests sub-optimal environments may have a different pattern of growth compared to the optimal zones (Kirch 2007a). The New Zealand evidence suggests regional differences in population growth, but does not entirely line up with the Hawaiian pattern. Kahikinui is regarded as a secondary settlement zone, colonised by people moving out of adjacent, higher-quality patches. Kirch (2007a) argues this is reflected in the population growth pattern, which still appears to be in the exponential phase associated with populations yet to meet local carrying capacities (Kirch 2007a). As I have previously said, comparing observed data with growth models is difficult, yet one of the clearest results from the comparisons (Chapter 5) was that observed SPDs in New Zealand were unlikely to result from an underlying exponential growth trend.

Accepting Kirch’s (2007a) model that exponential growth may suggest secondary settlement of certain regions, the lack of exponential growth in New Zealand suggests that there is little evidence for sequential settlement. While the southern region does appear to undergo more rapid growth than the other regions (Section 9.2.1), it is clear that all regions were at least initially occupied at the same time. That said, the larger scale of the regions analysed in this research clearly conflates patches of different quality which may show different population trajectories.

The pattern of population growth in the southern region has no analogues amongst East Polynesian societies from the time of European expansion into Polynesia. Indeed the closest comparison can be found in islands that were
abandoned at European contact, the so-called ‘Mystery Islands’. The traditional narrative for population history on these islands suggests that they were difficult places to settle, with limited wild resources and poor conditions for growing Polynesian crops (Anderson 2001). Such conditions ultimately led to the death or relocation of inhabitants. The southern region has similarities to this population history; however, it also has key differences. Large continuing quantities of wild resources allowed populations to grow and persist in the region for a much longer time than was possible on the ‘Mystery Islands’ and the relative ease of travel to the southern region from adjacent zones probably meant it could remain in use, albeit in a minor way, throughout prehistory (Anderson and Smith 1996).

The final point I wish to make involves how this analysis might feedback into palaeodemographic studies on other East Polynesian islands. As Chapter 5 showed, the usual method of qualitatively comparing observed data with idealised population growth curves is problematic. In the case of SPDs the calibration curve is a major concern, while the potential of high levels of equifinality is likely to be an issue across all methods. Thus, based on the evidence of this thesis, qualitative comparisons, which form the backbone of demographic analysis in East Polynesia, should be regarded with much more caution. The application of the quantitative method presented here would provide a more secure view of population across East Polynesia.

9.3.1 Summary

The application of the summed probability distribution method is novel in New Zealand archaeology and has produced a range of interesting results. These results support existing archaeological interpretations, such as the possibility of population collapse in southern New Zealand (Jacomb et al. 2010) and a concentration of population in the later period in the north (McGlone et al. 1994). The comparison of New Zealand data with that of East Polynesia has revealed strong parallels, particularly in terms of the evidence for populations growing rapidly in the early period before growth levels off as local environmental limits are reached. The cause of the low population levels in New Zealand remain unclear; however, a combination of poor yields, risk aversion strategies and
perhaps some degree of competition for high-quality horticultural land, rather than social controls (e.g. Kirch 1984) seems the most likely cause. The relationship between demography, horticulture, storage and conflict in northern New Zealand is an area of research that would be incredibly productive and useful in New Zealand archaeology.

The influence of population is also discussed occasionally in the following sections where, using the theoretical considerations discussed in earlier chapters (Chapter 3), the influence of changing population size on cultural drift is discussed.

9.4 Fishing Gear

This section discusses temporal and regional variation in New Zealand fishing gear and the processes that may have driven these changes. Both of these points are addressed with regards to the angling tradition (one-piece and two-piece hooks) and the lure tradition. Finally, these patterns are compared with neighbouring East Polynesian evidence to further inform our wider understanding of cultural change in the region.

9.4.1 Temporal and Regional Variation in the Angling Tradition

By way of introduction to this section it is worth recapping the significant changes to the angling tradition presented in Chapter 7. These variations represent two separate levels of change: the change in artefact trait morphology and the replacement of one form by another (e.g. one-piece by two-piece). Temporal variation in the morphology of one-piece hooks is limited. Instead, the major temporal trend observed for one-piece hooks is that their frequency in assemblages declined from nearly 100% in East Polynesian and early North Island sites to being infrequent and numerically inconsequential in later sites. Regional analysis suggests this trend began in the South Island, where the frequency of one-piece hooks in early sites (e.g. those dated to the first century of settlement) is much reduced compared to the aforementioned regions. The decline of one-piece hooks is in contrast to the increasing frequency of two-piece forms through time. However, unlike one-piece hook heads, two-piece hook points do exhibit some morphological variation over time. In particular, ‘decorative’ features, such as
lateral serrations and the presence of multiple barbs, increase over time. Regional variation in trait morphology and the pattern of trait change is limited. However, it should be noted that no early North Island sites consistently reached the minimum of ten artefacts for assessment, so data from this region is unavailable in the following discussion.

9.4.1.1 Changes to trait morphology

Within the angling tradition, meaningful temporal changes of individual traits are restricted to two-piece forms, specifically ‘barb’ and ‘decoration’ (Figure 9.4). Seriations presented in Chapter 7 show that, across all sites, elaborate forms with lateral serrations and/or multiple barb and external barb points steadily increase over time. Using Kahukura, a site securely dated to the middle of the sequence (AD 1440-1570), we can see that in both the traits ‘barb’ and ‘decoration’ the more elaborate trait state (i.e. multiple barbs or external serration) is present in increasing, though relatively small, frequencies. The major frequency increase in these forms occurs toward the more recent end of the sequence. This is quite different to the rapid frequency increase in ‘barracouta’ lures at the beginning of the sequence, which was probably associated with heavy selection pressure (discussed below) and suggests a different underlying cause for change. Perhaps the clearest examples of this are the rise of the ‘external barb’ in the North Island data and ‘multiple barb’ in the South Island data (Figure 9.4). The Kahukura site has an ‘external barb’ frequency of 0% compared with 59% at the epi-prehistoric site of Oruarangi (although it should be noted the Oruarangi site does have an unusually high frequency) and a ‘multiple barb’ frequency of 6% compared with 44% at the similarly late site of Whareakeake.
Existing explanations for trait level change are limited in New Zealand and East Polynesia and rely solely on anecdotal evidence. For example, following his regional study of fishhooks, Gumbley (1988) claimed that increased elaboration (e.g. lateral serration) might be detrimental to the action of the fishhook, particularly in terms of removing fish, therefore the development of decorative serrations was a ‘stylistic’ change. The ‘stylistic’ designation is also often applied to the growth in frequency of multiple-barbed hooks (e.g. Hjarno 1967; Davidson 1982; Furey 2004), although, again no explanation is provided. The lack of appropriate explanation is not helped by a dearth of experimental or ethnographic accounts that deal with the fishing tradition, and fishhooks, at the level of the trait.

While this thesis was interested in explaining patterns of change, a number of problems were encountered when it came to analysing patterns like those noted above that occurred after c. AD 1500. The first of these problems was that there were simply fewer sites from the late period that contained enough artefacts for
analysis. This meant that the pattern of change over the last c. 300 years of settlement was inferred from a small number of sites, increasing the likelihood of inaccurate patterns from this period. The second problem was that, of those good site samples that were available, few had an associated radiocarbon date, meaning sites could not be accurately placed within the last 300-years of the sequence. Lastly, the small number of sites from the North Island meant meaningful comparison with the northern sequence of change with the South Island data was difficult. Taken together these factors mean that the pattern of frequency change, and the tempo of this change were impossible to accurately identify in the last c. 300 years.

9.4.1.2 **Large Scale Artefact Change**

As discussed in Chapter 4, one-piece fishhooks are consistently the most abundant form of hook in many central East Polynesian sites with two-piece points noted only in the early site of Anai’o in the Cook Islands, where they are represented by only a single example (Walter 1996, 1998; Rolett 1998; Bollt 2008). Typically these sites also contain the remains of trolling lures, particularly forms where the lure point is lashed to the shank utilising holes in the point. Interestingly, like the South Island of New Zealand, two-piece hooks do appear in early sites from Hawai’i, such as Pu’u Ali’i and Bellows Dune (Emory et al. 1959; Kirch 1985), although it is not clear if this represents independent invention or a shared ancestral trait that developed only on the ‘edges’ of East Polynesia.

This composition of the East Polynesian fishing kit (one-piece hooks and trolling lures) is replicated in early New Zealand sites, such as Houhora and Wairau Bar and suggests these sites represent a continuity of behaviour between central East Polynesia and New Zealand. However, it remains unclear what the causes of change are in the angling tradition of New Zealand. Several ideas have been advanced on this point.

The most intuitive of these ideas is that the move from one-piece to two-piece hooks represents a change in fishing behaviour, specifically the targeting of different species over time. However, the support for this idea is relatively weak.
Anderson’s (1997) large-scale assessment of published faunal assemblages suggests there is little change in the composition of fish assemblages through time. Smith (2011) supports this assertion further pointing out that the major difference in economy is the absence of big game species in later prehistory (a point that will be returned to later).

Two further causes have been offered with regards to the demise of one-piece forms. Kirch (1985) suggests that presence of two-piece forms in Hawai‘i is driven by the use of bone for fishhooks in the absence of pearl shell, which is limited to some central East Polynesian archipelagos. Bone is much weaker than the cross-laminated pearl shell used in one-piece hook manufacture elsewhere. Thus, two-piece forms, being lashed at the bend, provided a superior functioning hook. However, Furey (1996) argues that a simple modification of the cross-section of the bend of bone hooks, toward a robust form seems a more likely scenario than widespread abandonment of one-piece types. As an alternative, Furey (1996) suggests that the change in hook represents a lack of large bones like those of moa (Smith 2011, above) from which the majority of early New Zealand one-piece hooks were made, suitable for fashioning into these forms.

Assessment of Furey’s (1996) model is relatively straightforward. If one-piece fishhook decline is a function of a lack of moa bone we should see the decline of one-piece forms occurring after moa extinction. The decline of moa is now suggested to have occurred within the first century of colonisation in New Zealand (Holdaway and Jacomb 2000). If we allow a nominal lag period where industrial bone may still have been available for around 50 years, we should see a decline occurring around AD 1400-1450. Yet, the decline of one-piece hooks observed in Chapter 7, begins instantly in the South Island where moa was the most abundant. In other words, the causal relationship between material availability and one-piece decline, at least at this regional scale, is not supported by the present data.

Kirch’s suggestion that one-piece hooks were rejected because of a perceived functional advantage in two-piece forms is intuitive but difficult to test. Having established that changing prey choice and material availability are unlikely causes, it is necessary to consider whether random processes could be the cause. The drift
models presented in Chapter 7 assessed the observed frequency of one-piece hooks against a simulated data series. The first model involved an assessment of frequency change given a starting frequency of 92% based on the data from the North Island site of Houhora. The results showed that the change in one-piece frequency using this initial frequency was unlikely to be caused by drift. The second model began with a starting frequency of 72% based on data from the early southern New Zealand site of Papatowai. In this case it was found that, starting at low levels of population (25 – 50), the decrease in one-piece forms could be explained by drift irrespective of population growth rate. Interestingly, at higher levels of population (100 – 500 people) the models revealed that the change in frequency from Papatowai to Shag River mouth (within the first several decades of occupation in southern New Zealand) falls inside the 95% confidence interval, within which most simulations fell. However, in these models the change in one-piece frequency from Shag River Mouth to Kahukura (probably occupied around 200 years after initial settlement of southern New Zealand) fell outside the range of most simulations. Thus, in these cases drift cannot be offered as a possible cause of change. Collating these results we can say that in the South Island, for models with the initial population size between 25 and 50, drift cannot be rejected as a cause of change. However, even in these cases, the vast majority of simulations did not lead to the observed pattern of fishhook decline.

One difficulty with this interpretation is that very little is known about group size in prehistoric New Zealand, particularly in the early phase. Based on the study of Maori DNA, Whyte et al. (2005) suggest that perhaps 170-230 females were part of the founding population. If we assume that females made up around 50% of the population the overall founding population can be placed between 340-460 people. However, the overall size of the population does not necessarily represent the number of people engaged with an activity like fishing and fishhook manufacture. Shennan and Steele (1999) show that most cultural transmission occurs between family members of the same sex. Moreover, age factors further reduce the pool of people engaged in a task (i.e. the very young may not take part in a task for adults). This means that the effective population engaged in an activity may be many times lower, perhaps only 25% of the overall population size (Shennan 2002).
Ethnographic accounts of Maori fishing suggest that gendered divisions of labour did exist; men carried out the majority of fishing, while women collected shellfish and processed the catch (Best 1986). Such a division supports the idea that cultural information about fishing, and probably fishhook manufacture, were transmitted vertically or obliquely (i.e. older family members to same-sex younger family members) and therefore that the effective population size in early Maori society was much lower than overall population. Using the approximate initial population size in New Zealand of 340-460, and the 25% figure, we can deduce that the effective population size for those engaged with fishhook manufacture may have only been between 85 and 115 people.

However, what we do not know is the structure and relationships between people in these settlements. Evidence from lithic exchange (Chapter 2) shows that the early dispersed communities in New Zealand were in contact across large distances; however, in the northern South Island, Anderson and McGovern-Wilson (1990) showed that there was no apparent pattern in site distribution and, therefore, that it was unlikely that areas were progressively settled in a kind of ‘branching off’ pattern from an original site by ‘daughter’ communities. Therefore, if transmission was restricted to vertical or oblique pathways, the effective population may have been very small, being limited to a small hapu (extended family) group, meaning drift may have had a significant influence.

On the other hand, it is possible that horizontal transmission did occur between groups inhabiting different sites. On the basis of simulation-based models, Powell et al. (2009) suggest that in low density, isolated populations cumulative adaptive evolution will never occur. Following this assertion, the rapid spread of some, seemingly adaptive, technologies when population density in New Zealand was very low suggests that contact between groups, and horizontal transmission, was probably occurring. As Walter et al. (2006, 2010) suggest, a large degree of contact and exchange between small populations was probably an important component of the settlement process in early East Polynesian islands where population was very low. If this was the case, as seems likely, then the effective population size of those engaged in fishhook manufacture was greater than single hapu groups.
Cultural selection mechanisms may also account for the change in one-piece and two-piece hooks. To address this, I first return to Kirch’s (1985) suggestion that two-piece hooks are functionally advantageous. As discussed earlier in this section, the selection of a trait because of a perceived advantage is termed ‘results bias’ (Richerson and Boyd 2005) and may result in a reasonably rapid uptake of a particular trait at the expense of others, if populations are not averse to adopting new traits. Comparing the observed change in frequency of one and two-piece hooks (Figure 7.33) with the outcome expected from results bias (Richerson and Boyd 2005) or functional selection (Dunnell 1971: presented in Chapter 6), it appears that it is reasonable to infer that this type of selection may have driven the observed artefact change.

The regional patterns of two-piece hook points is quite a compelling piece of additional evidence. As outlined in Chapter 7, very few early North Island sites in this analysis contain two-piece hooks (the later sites are dominated by them). However, early sites from the South Island show an almost immediate shift toward two-piece forms, which are common by the time Sandfly Bay was occupied (AD 1295-1395) and dominant by the occupation of Kahukura (AD 1440-1570). This represents a very rapid uptake of two-piece forms, which may relate to an underlying functional requirement, based on fish catch.

Chapter 7 outlined the variation in regional fish catch, which can be broadly characterised as follows: North Island middens contain a majority of Snapper (*Pagrus auratus*), a fish caught through angling, while the South Island is dominated by Red Cod (*Pseudophycis bachus*), caught through angling, and Barracouta (*Thyrsites atun*), caught through trolling. The upper South Island also contains a large frequency of Snapper. Concentrating on South Island sites and the species targeted by angling (with discussion of Barracouta in a following section), Leach (2006) states that both are mid-sized carnivorous fish, but specifically mentions that Red Cod are voracious feeders. Potentially then, it is the presence of these voracious feeders in South Island waters that drove a very rapid selection of two-piece forms, because of their supposed greater robusticity. Unfortunately, the quality of data, in terms of data points throughout the sequence, is not as high in the North
Island. Therefore, while we can say that the North Island sites do go from dominance of one-piece hooks in assemblages to near absence, we cannot confidently ascribe this pattern to any particular process.

### 9.4.1.3 Summary

In summary, the major change in the angling tradition is the movement from dominance by one-piece angling hooks, consistent with central East Polynesian sites, to two-piece forms, which appear almost exclusively in New Zealand and Hawai‘i (one is present in the Cook Islands, see Chapter 4). The likely cause of this pattern for both island groups is the lack of large pearl shell, or indeed any pearl shell in New Zealand, which required the use of different, more fragile materials. The transition to the more sturdy two-piece forms appear to have been driven by selection, which began rapidly after settlement, particularly in the South Island. Although, given the uncertainty about population numbers, drift cannot be ruled out altogether. The results of both the change from one-piece to two-piece hook forms and the changing frequency of two-piece traits, suggests that different forces may have acted on fishhooks after c. AD 1500 when it appears that trait selection began.

### 9.4.2 Temporal and Regional Variation in Lure Points

The lure point lineage contains the same sorts of change present in the two-piece and angling tradition. Changes in trait frequency, particularly decoration (lateral serrations) and increase in mid-shaft lugs, are both present. However, the most notable change is the increased frequency of inserted points, or ‘barracouta’ lures at the expense of forms lashed to the lure shank (‘minnow’ forms). Like the angling tradition, the changes observed at the trait level are difficult to ascribe to a particular underlying process. This is because, while they are present in the first centuries of the sequence, the major change in frequency happens in the later half of the sequence where information is of poor resolution; therefore, they are not considered further here.
9.4.2.1  Change in dominant types over time

The lure point lineage consists of two different forms commonly identified as ‘minnow’ (lashed and perforated) and ‘barracouta’ (inserted) forms (Hjarno 1967: Figure 9.3). Chapter 4 identified that ‘minnow’ forms were a typical feature of the homeland fishing kit, with only one possible ‘inserted’ form present in the Marquesas site of Hanatekua (Sinoto 1979; Rolett 1998; Walter 1996). Compared with sites in the South Island, lures occur at relatively low numbers in North Island sites across the sequence. In early North Island sites, lures are always of the ‘minnow’ class; however, from the earliest period in southern New Zealand there is a mixture of both ‘minnow’ and ‘barracouta’ points, with ‘barracouta’ forms dominant. Sites in the upper South Island are also mixed, although ‘barracouta’ forms represent less than 1% of the assemblage. The increased frequency of ‘barracouta’ forms in southern New Zealand is striking in terms of both the rapidity of change and because of the large variation in fishing behaviour compared with the homeland region it implies. This section will consider these factors in turn; however, since the caveats surrounding population size have been outlined above, this will not be discussed further here.

Figure 9.5 ‘Barracouta’ points (called ‘inserted’ in this research because the point is inserted into the shank) and ‘minnow’ (lashed/perforated) points.
The rapid uptake in the form allows a more unequivocal assessment of change than is possible with other traits and types. Firstly, it is clear from the drift models that random processes are highly unlikely to account for this change. The rapid dominance of a single form developing from an initially small frequency makes it logical that cultural selection through ‘results bias’ (Richerson and Boyd 2005: the cultural selection of a trait based on perceived advantageous results) led to this change. Other possibilities, such as conformist or anti-conformist bias can also be rejected. Given this result and the clear regional differences relating to the faster uptake of novel traits in the South Island, it is useful to consider what drove the regionally distinct patterns. In particular, the ‘risk-innovation model’ (Fitzhugh and Trusler 2009) is considered against the evidence observed in New Zealand.

9.4.2.2 Regional change: the risk-innovation model and connectedness model

As discussed in Chapter 3, the risk-innovation model argues that the propensity to invent or innovate is more common in unstable environments where adherence to the status quo may be less beneficial than experimenting with new technologies (Fitzhugh and Trusler 2009). Arguing against this model Henrich (2010) suggests that the degree of connectedness and the size of population are primary drivers of innovativeness and inventiveness and that, when faced with uncertainties, people are more likely to copy others than experiment for themselves. In order to consider these models in the New Zealand context we must explore some parameters important to each, including: difficulty of environment, population size and the degree of connectedness. Unfortunately, in each case we must rely on secondary lines of evidence or inference.

Relative to many other East Polynesian islands, New Zealand presented considerable challenges to sustained settlement based on traditional Polynesian life ways. New Zealand’s position in the sub-tropical to sub-Antarctic climate zones made traditional horticulture more difficult or, in the case of the southern South Island, impossible (Basset et al. 2004). The impossibility of establishing crops in the south necessitated a shift to a total focus on wild foods, a considerable adaptation to the life ways of settlers. Moreover, many of the species and environmental conditions in the region presented novel challenges to settlers that were likely to
be disruptive to the maintenance of traditional behaviours. Thus, while we can reasonably assume that the decades following colonisation of any island were difficult, this was particularly true of southern New Zealand.

Connectedness is a difficult pattern to discern but is perhaps best inferred from exchange networks. Evidence from lithic exchange (see Chapter 2) suggests communities were connected throughout the prehistoric period in New Zealand; however, the peak of trade was in the first century or two after settlement (Walter et al. 2010). In the years following c. AD 1500 the growth in fortifications (pā) and lower level of trade suggest an increased territoriality and, therefore, less connectedness throughout the country. However, intra-group connectedness would have remained high. With growing populations this may have meant that individuals were connected to a similar sized pool of people throughout prehistory.

Lastly, Chapter 5 showed that southern New Zealand's population increased rapidly and then fell away relative to the null model. Based on the correlation between population size and inventiveness (Henrich 2010), we can conclude that the early period in southern New Zealand (c. AD 1300 – 1500) should show the greatest amount of invention. Central and northern regions are more difficult to characterise, but it seems reasonable to argue that that population levels at least held reasonably steady after peaking around AD 1500. Thus, in terms of population alone, inventiveness should be relatively consistent after AD 1500 (but see earlier discussions [Section 9.2.1] about the uncertainty attached to this sort of inference).

Considering each of these factors in light of the competing models, we can make the following predictions. Based on the risk-innovation model, we should expect the highest number of novel behaviours in the early period when the communities were most strained because of the need to adapt to new conditions and low population numbers. Regionally, this should be the greatest in areas where horticulture wasn’t possible and where wild species presented a greater challenge to hunt, or perhaps were possessed of certain behaviours that forced a change in the traditional strategies, in other words, southern New Zealand. The population-
connectivity model predicts the greatest number of novel behaviours will occur after the first 100 – 200 years of settlement (in most areas) when population has grown to peak levels. In the case of New Zealand, population is probably the biggest driver of this model since connectivity can be argued to be relatively stable, in which case we may expect the later period northern sites to be the focus of inventiveness.

Reviewing the evidence outlined in Chapter 4 we can see that the typical East Polynesian fishing kit included one-piece angling hooks and, in lesser numbers, trolling lures of the ‘minnow’ form. In New Zealand, North Island sites conform closely to this fishing kit composition, whereas kits in the South Island sites rapidly become comprised of ‘barracouta’ lures and two-piece forms. As discussed in Chapter 7, the abundance of barracouta in the South Island is an obvious catalyst for this change in lure form (Hjarno 1967; Leach and Hamel 1981). Barracouta are present at low frequencies in North Island middens, very occasionally reaching 20% of the assemblage, but are often the most abundant species in South Island middens (particularly southern South Island; Leach 2006). Barrcoute are voracious feeders and almost certainly created a need for innovation toward robust forms that could handle the ferocity of their strike. It should also be noted that the connectedness model also predicts that, if inventions were to occur in the south, they should occur during this time. Thus, in southern New Zealand, it is difficult to confirm one model over the other. However, by taking a pan-regional perspective of the early phase we can see that it was southern New Zealand where change appears to have been greatest. This is despite evidence of similarly large settlements in the north-eastern South Island, which were probably more connected to other communities due to their position in the middle of New Zealand and close to an important stone source. Therefore, at this scale, the best model may well suggest necessity was the mother of invention.

If northern New Zealand represented a relatively easily environment for the establishment of culture from East Polynesia (based on its greater similarity to the conditions from whence the initial colonists came) and had a smaller population in

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5 Based on recovered archaeological material. It should be acknowledged that a number of other fishing tools, which are noted in ethnographic accounts (e.g. nets) are most often archaeologically invisible.
the early period (based on relatively slow growth in the northern regional SPD, Chapter 5) it follows that both models would predict conservative levels of change. Thus, in the early colonising period of this region it is difficult to disentangle both models. However, in the later period, the North Island is often cited as the centre of cultural innovation (Davidson 1984) and was clearly the densest populated area. Following the connectedness model, we would expect the two to be linked. Ultimately then, it is difficult to accept or reject either model as a cause of regionally specific variation. What seems likely is that the risk-innovation model is best applied to the early phase when people were entering new environments, and the connectedness model may, anecdotally at least, explain later inventions and innovation in domains such as food storage in the North Island.

9.5 The Adze Tradition

Adze variation has been a key contributor to archaeological enquiry in Polynesia. In particular, the study of adzes has contributed to an understanding of cultural affinity between Polynesian islands (see Cleghorn 1984) and the development of cultural sequence frameworks within islands (e.g. Duff 1956, Golson 1959). While less common, studies focussing on the likely causes of morphological variation have contributed a great deal to the understanding of adzes. This section follows the same format as those above in discussing the results of spatio-temporal analysis of the adze tradition followed by a comparison with East Polynesia data.

9.5.1 Temporal Variation in the Adze Tradition

A key aspect of the adze results presented in Chapter 8 is the large number of variables that show little evidence of structured change over time. One trait that did show such change was ‘adze grip’. When considered at a national scale, this trait showed a gradual pattern of change from tanged to untanged forms. This was also the case when regions were considered separately. Throughout this thesis, the first analytical step was to compare observed patterns with simulated examples of random drift to attempt to exclude neutral processes as factors driving change. As Chapter 8 showed, drift could not be rejected as the cause of the frequency change of ‘front tanged’ adzes or, indeed, the rise of ‘ungripped’ adzes. One further point
of relevance is that, on the evidence from dated sites, it appears that the greatest changes in trait frequency occur within the first few centuries of human settlement, thereafter becoming more gradual. As the volatility graphs from the drift models showed, this is not unexpected in cases where drift is the underlying cause of change. Other mechanisms of change, such as cultural selection via ‘results bias’ or ‘conformist/anti-conformist bias’ do not appear to be well supported.

In general, qualitative adze traits proved disappointing in terms of their robusticity and usefulness in determining the pattern and process of change over time. The lack of North Island sites with the minimum number of adzes required for analysis and associated dates also restricted the analysis largely to the South Island. However, even here the poor chronological resolution offered by sites that appeared later in the sequence made firm interpretation about the pattern and processes of change over time difficult.

Finally, a particularly interesting pattern in adze type occurrence, is that, irrespective of temporal (and spatial) difference, sites appear to have a number of the same types present. This is clearly evidenced by the NeighborNet analysis of presence/absence type data that shows a lack of clear differentiation between sites based on chronology. This does not negate the fact that key types of adze, such as large tanged forms made of high quality flaked stone, are clearly more dominant in the early period, but it does suggest that there is far more continuity in the adze tradition, at least in terms of the traits measured here, than is often acknowledged in the literature.

9.5.2 Regional Variation in the Adze Tradition

The clearest regional variation involves the materials for adze manufacture, which is predictable given differential access to stone. As discussed above, South Island sites show an early focus on high-grade flakeable stone (Nelson argillite), while North Island sites contain both Nelson argillite and the similarly high quality Tahanga basalt. In the South Island, argillite eventually gives way to nephrite as the dominant adze stone. This pattern is in keeping with the model of lithic exchange
proposed by Walter *et al.* (2010) and with the idea that early communities may have lacked the technology and knowledge to exploit nephrite, which cannot be flaked and was traditionally worked using attrition sawing in later prehistory (Beck *et al.* 2002). However, one early site where nephrite is frequently used for adzes is Kawatiri, which is located on the West Coast of the South Island, close to one source zone of nephrite. The evidence from Kawatiri (Walter *et al.* n.d.) demonstrates that, when available, early Maori did exploit nephrite, particularly poorer quality stone that could be split along fracture planes. This pattern is interesting because the other source zone of nephrite is in inland southern New Zealand and the relative frequency of nephrite adzes in this region is proportionally much larger than in early sites further north. Clearly, access to nephrite was crucial in developing skills to work with it and it seems that southern New Zealand may well have been an early centre of nephrite working.

In the North Island the initial focus on Tahanga basalt also decreased; however, while nephrite adzes were present, local, lower-quality stone became the dominant adze stone. The relative lack of nephrite in the North Island compared to the South Island probably represents the relative cost involved in transporting nephrite to the North Island.

The comparison between the northern and southern South Island sites is also interesting for the large range of materials present in the early end of the southern sequence *versus* the focus on a single material in northern South Island. In all probability the distance of southern sites from the major argillite quarries in the north, perhaps in association with the presence of other argillite materials on the south coast drove this pattern.

### 9.5.3 Comparative Perspectives in Material Culture Change

Producing a comparative picture of New Zealand and East Polynesian material culture change is more complicated than the comparison of population models (above). This is because East Polynesian archaeology has followed a similar pattern to New Zealand archaeology, which is to say there has been a declining focus on portable artefact studies. Effectively this means that mid-twentieth century ideas
about change, developed in very different chronological contexts still heavily pervade East Polynesian archaeology. Furthermore, such studies suffer from a very restricted number of dated assemblages, particularly in the late period, which has meant that ethnographically collected material is frequently used as an example of late period material culture (e.g. Emory 1978). Methodologically this is fine, but it does mean that material culture is assessed in terms of change from very early forms, to very late with no real understanding about finer-grained patterns of change. Given these issues, the comparison conducted here is necessarily broad, and it is important that we do regard some patterns with caution.

As already noted, the typical early East Polynesian line fishing kit includes one-piece shell (often pearshell) hooks and trolling lures. The evidence from New Zealand sites shows a clear transition from one-piece hooks to two-piece. As discussed earlier, evidence for such a change in East Polynesia is restricted to Hawai‘i and Rapa Nui, where the availability of pearl shell is limited. In these islands pearl shell was replaced with bone or sometimes stone (Allen 1992). Bone is more difficult to work than pearl shell and was probably more prone to breakage at the bend, meaning the development of two-piece forms may have been a functional adaptation to strengthen the hook (Tuggle 1978; Kirch 1985). The apparent independent invention of two-piece forms in the ‘corners’ of East Polynesia where pearl shell is very rare seems a compelling reason to support this idea. Indeed it is made more likely because other explanations, most notably the idea that materials required to make larger varieties of one-piece hooks decline over time, forcing a move to two-piece forms (Furey 2004) are not well supported in New Zealand.

Because of the compositional difference in fishhook assemblages between New Zealand and many islands of East Polynesia, smaller-scale trait changes are difficult to compare. Early work in Hawai‘i by Emory et al. (1959) revealed some change in the lashing forms of two-piece hooks from ‘notched’ to ‘knobbed’, which are not replicated in New Zealand. However, as Allen (1996) shows, this and other patterns are produced from highly questionable data, in particular, some of the frequencies appear to be drawn from horizons with multiple, rather than a single continuous, occupation. This combined with the tendency of East
Polynesian archaeologists to group morphologies based on unclear criteria means further discussion of fishhook change over time is impossible.

The study of adzes provides an exception to the trend of not studying portable material culture; however, recent studies tend to focus on using the adze to establish lithic exchange networks (e.g. Rolett 2002), and seldom consider morphology. Thus, comparison of New Zealand diachronic change with that of East Polynesia is restricted to very general patterns.

With respect to adzes, the greatest amount of data comes from Hawai‘i, the Marquesas and the Society Islands. Early adze assemblages in these islands are frequently discussed as being relatively variable compared to later period assemblages (e.g. Emory 1978 for the Society Islands). The early Marquesan adze assemblage is often discussed as having great affinity with West Polynesian assemblages, which generally contain no tang or reduction to the butt of the adze (Suggs 1961; Sinoto 1978). Tangs are typically considered an East Polynesian invention (Emory 1968), although in early sites including Vaito‘otia/Fa‘ahia and Maupiti (Emory and Sinoto 1964; Sinoto 1979) in the Society Islands and Hanamiai (Rolett 1998) in the Marquesas, there are a large number of incipient, rather than well-developed forms. Adzes without tangs also remain very common in early sites across these archipelagos (Emory and Sinoto 1964; Sinoto 1978). As we have seen, early New Zealand adze assemblages are in keeping with this pattern, although, as Davidson (1982, 1978) has observed, early sites like Wairau Bar appear remarkable in terms of degree of tang development.

The pattern of change discussed in East Polynesian island groups focuses on two major traits, cross-section and presence and absence of tang. Early assemblages are described as relatively variable in terms of forms, specifically in regard to the cross-sections of adzes. Multi-phase culture histories of the Marquesas formulated by Suggs (1961) and Sinoto (1978) suggest that the variation in adzes decreased to the point where Suggs’ ‘Koma’ adze (a reverse triangular, tanged adze Figure 9.4) was the dominant form. Despite a general lack of late period adzes from excavated contexts, Emory (1978) points out that this
Figure 9.6 The ‘Koma’ adze, common in central East Polynesia and the relatively simple adze form common in the late period of New Zealand.

general form is also the dominant type of adze from the c. 75 collected from the Society Islands by Captain Cook’s expedition at first contact with Europeans. Thus, Emory argues that the pattern of contraction and standardisation of forms is also present in the Societies. A similar pattern has also been shown in Hawai’i,
although here the trend is for a greater frequency of quadrangular, tanged forms in late prehistory (Emory 1968; Sinoto 1978; Kirch 1985). In the case of Hawai‘i, this change has been attributed to changing function of adzes, in a similar manner as discussed by Best (1977) in New Zealand with regards to the growth in importance of untanged, rounded quadrangular forms. Moreover, the presence of the large-scale adze quarry of Mauna Kea, has also raised the possibility that adze production became a specialist task and thus, forms became more standardised (Kirch 1985). While such a pattern may be supported in Hawai‘i, where socio-political organisation reached its peak in East Polynesia, this level of specialisation seems unlikely elsewhere. Not least because, within the Marquesas and New Zealand, the spread of high grade lithic resources (Eiao basalt in the Marquesas and Nelson argillite in New Zealand) begins to contract in the later periods (Rolett 2008; Walter et al. 2010) at the same time that simpler production methods (e.g. hammer dressing) and locally available stone began to increase. Thus, while groups may have had adze makers, this activity does not appear to have been part of a well-organised adze industry as in Hawai‘i.

The presence of tangs throughout the later period in East Polynesia (largely based on ethnographic material) contrasts sharply with the pattern in New Zealand, where tangs are prominent early but are almost entirely absent in the late period. One potential driver for this change in New Zealand was the development of a socketed adze handle, which may have performed some of the functions of the butt end of larger adze types (Turner 2000). If so, then we can conclude through comparison that this invention occurred only in New Zealand; however, the scarcity of adze handles (which are made from wood and do not survive in the archaeological record) makes this difficult to test with any degree of certainty.

A key critique of the supposed pattern in adze change has come from Cleghorn (1992) through a study of Hawaiian adzes. Cleghorn (1992) notes that very few Hawaiian adzes used for the development of diachronic sequences are from securely dated contexts rendering the resulting patterns dubious. Using only adzes from dated contexts, Cleghorn (1992) finds that, in terms of cross-section, quadrangular forms are consistently dominant, with other forms varying in frequency across time and space. This observation, while conflicting with earlier
accounts for Hawai‘i, is in keeping with the pattern observed in the analysis of adzes in this thesis. Under these circumstances, it is likely that a similar pattern may also be evident in other island groups were reanalysis carried out. Ultimately then, New Zealand’s pattern of dominance of key traits (such as rounded quadrangular cross-section) but continued existence of others is consistent with the only other securely defined adze sequence in East Polynesia. This supports the idea that adze studies have too often focussed on definitions of ‘early’ and ‘late’ assemblages based on the presence or absence of certain types at the expense of looking for continuity.

9.5.4 Other Considerations

Although slightly tangential to morphological changes, one of the interesting patterns that emerged from the comparative assessment of material culture from East Polynesia, was that there is a trend for the decrease in the frequency of artefacts from secure contexts through time. This is certainly true in New Zealand, and has been noted as one issue in conducting this type of research. But it is equally true elsewhere; for example in the Society Islands, Emory (1978) notes that only around 10 adzes from secure late contexts have been found compared with dozens from early contexts. The presence of this trend in other islands aside from New Zealand suggests it may be the result of processes occurring across East Polynesia. One such process is the expansion of settlement from coastal zones into inland areas as population grew (Walter et al. 2006). Clearly, the spread of settlement and economic activities means the process by which artefacts enter the archaeological record will be changed, from finite zones where deposition is high, to a more dispersed pattern of deposition. Anecdotally, the assessment of adze from museum collections in New Zealand suggests, particularly in the North Island, that isolated adzes are often found by chance on the ground surface, which supports the idea that settlement pattern is a major driver in this change.

9.5.5 Summary: shared patterns in East Polynesian Prehistory

The shared ancestry of East Polynesian communities leads to many societies sharing what Kirch (2000:302) refers to as “big structures and large processes”, or, more simply, cultural similarity, which undergo similar processes of change. The ‘large process’ of population growth revealed in this thesis shows a remarkable
consistency with other islands in East Polynesia. While caution must be exercised when assessing the shape of SPDs, New Zealand does appear to conform to the logistic pattern of growth present in many islands in East Polynesia and the collapse pattern present in the so-called mystery islands (those abandoned by Polynesians).

The ‘large process’ of material culture change is best seen through the unfortunately named process of human ‘conquest’ of East Polynesia (Kirch 2000). Material culture throughout East Polynesia changed either through selection pressures or sometimes drift. The evidence from New Zealand shows that many adaptive changes occurred very rapidly after settlement as part of a dynamic early period, which laid the foundation for incipient East Polynesian cultures and drastically changed the landscapes of all inhabited East Polynesian islands.

9.6 Evaluation and Future Directions

This research has used a mixture of established and novel methods in New Zealand archaeology. This section evaluates aspects of these methods and the data on which they are based; it first focuses on methods involving material culture and secondly on the methods used for the development of population models.

The methods used for the analysis of material culture (e.g. correspondence analysis) are well established among archaeologists. However, the effectiveness of these methods is heavily influenced by the materials used to derive data. The materials used in this analysis were collected from museums and represented both excavated assemblages and fossicked collections. The majority of collections used in this analysis were donated to museums by individuals who worked in specific areas of the country and, despite not conforming to the standards of today, recorded the location in which artefacts were found to a good degree of accuracy. Given the general lack of stratigraphy in New Zealand sites, a reasonable assumption can be made that artefacts recovered in this way came from a single occupation layer. Yet, despite this, samples may not only represent different collection strategies but also a different focus. Collections contain a greater proportion of pristine artefacts while assemblages supposedly represent a systematic sample of material from the
site (Samson 2003). Ideally, one would carry out this research on large, well-sampled and dated sites that span the chronological sequence. However, no such data exists in New Zealand and without the use of unsystematically collected assemblages, little analysis of change over time could be carried out.

A particular concern for this research is the completeness of material culture data. The lack of North Island sites suitable for analysis and the clear bias this causes toward the South Island data is a significant issue. During museum visits for this research it quickly became evident that adzes were not generally recovered in the same way across space, and to some extent, time. North Island adzes are generally recovered in isolated locations, often either by plough or sheer luck, whereas in the South Island multiple adzes are often found in single locations associated with sites. Where such adze-bearing sites are present they are most often categorised as ‘early’, with very few sites from the later end of the sequence. While it is certain that this difference is influenced by recovery bias, it is also possible that this represents an underlying pattern of archaeological deposition. Early settlement in New Zealand was centred on villages with satellite sites also forming part of the landscape exploitation strategy (Anderson and Smith 1996; Walter et al. 2006). In the later period a similar strategy was probably employed in the horticultural zones with the satellite communities operating as gardeners who moved location as soil quality degraded (Walter et al. 2006). In the non-horticultural zones, the communities were similarly small and scattered (Anderson and Smith 1996), which may account for the small amount of late period sites bearing adzes. If the pattern of adze recovery does represent, to some extent, the pattern of settlement, a detailed spatial analysis of material culture locations would be a useful step in understanding New Zealand prehistory. This idea is relatively simple, yet it remains to be carried out in New Zealand.

The second large hole in the data used in this research is material from the period post-AD 1500. While a number of sites from this period were identified for this research, the uncertainty about the dates of these sites meant that a detailed check of the sequence during this period was impossible. In some areas, such as southern New Zealand, population modelling and evidence for changing settlement patterns (Anderson and Smith 1996; Jacomb et al. 2010) suggest the lack of sites may in fact
represent a true picture of prehistory. Elsewhere further work is required to investigate the later and middle stages of New Zealand prehistory. However, given that many sites may relate to gardening (e.g. pit sites) it may be that, even if located, sites will not yield the number of artefacts necessary to allow this type of research. Although I recognise that radiocarbon dating is problematic in the later period of New Zealand, re-dating sites that have lost their chronological context through chronological hygiene would be helpful to determine more about the later period. However, perhaps the key contribution to this type of research would be the excavation (or re-dating) of those rare sites that have stratigraphic layers that would provide valuable evidence about change in New Zealand.

The trap of circular reasoning is ever-present in diachronic studies of material culture. In this thesis circularity was addressed by comparing site sequences with available radiocarbon dates or early historic references to site occupation. As mentioned above, one of the key considerations of this research was the lack of well-dated later sites, which ultimately meant the ordering of late sites could not be tested against independent evidence. However, a similar issue was present in dated sites, which have large age ranges that frequently overlap, meaning the exact order of sites cannot be conclusively identified. Perhaps more importantly, sites that may have been occupied at similar times can clearly possess very different frequencies of artefacts. Typically this difference is not major, yet it hints at possible issues of sampling bias across sites. This is well supported by the analysis of sites using dirichlet deviates. This novel technique shows that in many cases the observed artefact frequency of sites overlaps to a very large degree, particularly in sites with low sample sizes. This result is not surprising, yet it is novel in the context of New Zealand archaeology to specifically consider this factor. Ultimately, the blend of sites on chronological grounds, and in some cases type or trait frequency suggests the conclusions of this research must be treated with a degree of caution. However, in the absence of other lines of evidence or more secure dating, the methods used in this thesis must still be regarded as the best available.

The analysis of fishhooks and adzes has provided valuable information about two, largely utilitarian, traditions. The focus on these artefact classes was necessary because few other traditions or material culture classes are present in the numbers
or secure contexts required for this analysis. However, traditions such as ornaments shows a level of differentiation from early to late which is far more distinct than the traditions analysed here and could provide a different picture of change in non-utilitarian areas of Maori culture. Ornaments were not included in this analysis because of difficulties with museum access and a general lack of secure context. Nevertheless, a detailed study of ornaments within a different framework may be a fruitful line of enquiry that would run in parallel to the current results.

Finally, a brief consideration of the worth of the theoretical framework employed in this thesis is appropriate. The second chapter of this research outlined the different mechanisms though which prehistorians had viewed the development of Maori society in New Zealand. The major point of that discussion was to illustrate the theoretical quagmire in which New Zealand archaeology has fallen. More specifically, I outlined how, despite much discussion of the issues with the binary sequences models that pervade New Zealand archaeology, no progress had been made in advancing new methods or frameworks to overcome the problems with these models.

The analysis of artefact traditions as diachronic units, rather than synchronic phases has the potential to address key gaps in our knowledge of change in the past. The analysis carried out here shows that this is particularly true of the South Island where large assemblages from reasonably firm contexts exist. Within the South Island, the first 100 – 200 years of settlement provide the most robust data and it is here that the theory and method of Darwinian archaeology has been most applicable. The later period (after c. AD 1500), particularly in the North Island, presents challenges for the use of the tradition concept and for the generation of robust conclusions about the processes behind change. Nevertheless, in such regions other forms of data, such as settlement and economic information, are abundant and easily applied to other analytical streams of Darwinian archaeology, notably human behavioural ecology. Such an undertaking, while not a replacement for the study of artefact or craft traditions, would be a useful avenue of future research.
9.7 Conclusions

To conclude this thesis I wish to directly address each of the questions restated at the beginning of this chapter by drawing together the various strands of research in this thesis and broader archaeological context.

New Zealand was colonised from central East Polynesia around AD 1300 (Higham and Jones 2004). Early populations appeared to target patches rich in wild resources, particularly focusing on big game animals such as moa and fur seal (Anderson and Smith 1996; Walter et al. 2006). The abundance of wild resources and lack of disease likely contributed to rapid population growth (Davidson 1984; McGlone et al. 1994), particularly in the South Island where these resources were most concentrated (Anderson 1989; Smith 2011). In the North Island population growth appears to have been gradual, perhaps reflecting a reliance on Polynesian crops from which returns were slower but ultimately more sustainable than the wild resources elsewhere. This sustainability is reflected in the relatively high population in the northern zone compared with the southern region where population appears to have collapsed following the extinction of wild resources after c. 100 years of settlement (Holdaway and Jocomb 2000).

Combining the results of the population models and evidence of material culture change we can clearly say that the ‘settling in’ period following initial colonisation of New Zealand was a dynamic period of growth and change. Material culture appears to have undergone the greatest amount of change during the first 100 or so years after settlement. During this period random processes could have driven some large-scale change in artefact forms, but cultural selection in this early period was perhaps equally important. In particular, the selection of traits based on their perceived benefits seems to have been the major process behind the adoption of certain technologies like the barracouta lure or two-piece hooks. This appears to have been more rapid in the more challenging environment of southern New Zealand, suggesting necessity to overcome local conditions was an important catalyst for invention. Early settlers to New Zealand maintained contacts over large distances (Walter et al. 2010), which involved the exchange of materials and, perhaps, sharing of aspects of material culture traditions. This exchange led to the
rapid adoption of certain artefact forms across large areas of New Zealand, which enhanced the prospects of survival in the new land.

Following the initial period of rapid change, other aspects of artefact traditions developed. In the fishhook tradition these appear to be purely decorative and include the emergence of multiple barb hooks and lures and hooks with decorative lateral serrations. These forms emerged in the early period but became dominant later in prehistory. The adze tradition also continued to undergo change, leading to the dominance of relatively simple adzes (rounded quadrangular, no tang) in later prehistory, which were commonly made from nephrite, or, where nephrite was scarce, local stone. While the contraction of artefact variation suggests this was probably not related to drift (Eerkens and Lipo 2005) the paucity of data in the later period means little can be said with certainty about the processes leading to these and other changes.

Understanding of the patterns observed in New Zealand is greatly enhanced by the comparison with archaeological evidence from elsewhere in East Polynesia. Although it is unwise to ascribe a specific growth curve to the observed population in the three New Zealand regions, it is clear that the southern region differs greatly from the other regions. Indeed the boom and bust pattern inferred in this region connected with the availability of wild resources (Anderson and Smith 1996) most closely matches the ‘mystery islands’ of Polynesia, which were abandoned prior to European arrival in the Pacific. The calibration curve makes it difficult to definitively say what pattern the northern and central regional populations followed after around AD 1500, although it seems likely that population either continued to grow or levelled off. If levelling off did occur, it happened well short of the true carrying capacity of the New Zealand environment. However, as Hamilton and Kahn (2004) note in the Society Islands, populations may create an artificial carrying capacity based on the perception of resource stress given by high-density settlements.

The comparison of material culture from New Zealand with elsewhere in East Polynesia has also proved useful. The emergence of two-piece fishhooks in Hawai‘i, potentially as a result of a lack of quality material (Kirch 1985), provided a
useful model for the analogous development in New Zealand. This comparison was somewhere hampered by the similarity of biases in East Polynesian archaeology, notably the lack of large artefact collections from the later period.

This research represents an attempt to go beyond anecdotal evidence, so commonly used in New Zealand archaeology, and develop a robust diachronic understanding of prehistory. The consideration of material culture and population history outside of the usual dual-phase framework, using both novel and familiar methods, has shown promise in this regard. While the quality and characteristics of data has hampered some attempted analysis, further refinement of these methods has the potential to contribute a great deal to the understanding of New Zealand’s history.
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APPENDICES

APPENDIX I - CD

New Zealand Radiocarbon Dates

APPENDIX II - CD

Adze Data

APPENDIX III - CD

Fishhook Data

APPENDIX IV - CD

Radiocarbon Dates from East Polynesian ‘Homeland’ Sites

APPENDIX V - CD

Enlarged Drift Simulations