'Unshelling the Past' – An Archaeological Study of Shellfish Assemblages from Caution Bay, Papua New Guinea

A dissertation submitted by

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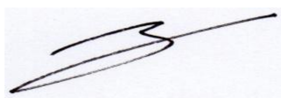
Abstract

The recent discovery of Lapita pottery at Caution Bay, on the southern coast of Papua New Guinea (PNG) has transformed our understanding of the Lapita culture complex by confirming the migration of Lapita peoples into the southern coast of mainland PNG from around 2900 cal BP where they encountered an extant population who had occupied the Caution Bay area from around 5000 years ago (David *et al.* completed ms; McNiven *et al.* 2011). Although Lapita peoples have been traditionally characterised as 'marine specialists', relatively little is known about their shellfish subsistence economies in comparison to their distinctive ceramic traditions. This thesis primarily focuses on understanding temporal and spatial changes in how shellfish were exploited throughout the antiquity of human occupation at Caution Bay, especially in relation to before, during and after contact with Lapita peoples.

Results have revealed significant changes in distribution, availability and exploitation of shellfish species over time. Trends are particularly prevalent before, during and after periods of 'contact' when the established indigenous population met and interacted with Lapita 'foreigners'. This is supported by the archaeological evidence with an intensification of shellfish resources and site use and extension of human predation pressures coinciding with the introduction of new material culture (i.e. pottery). Subsequent trends also correlate with wider socio-cultural events during post-Lapita occupation with both decreases and increases in site use intensity and shellfish exploitation. In addition, local peoples were most likely also restructuring their subsistence economy with a greater focus on agriculture. While, natural environmental changes have in the past been used to explain shellfish variability in sites, the strong evidence for anthropogenic modifications to the local landscape at Caution Bay suggests that people may have practiced a complex subsistence strategy. This complexity is further evident in the diversity of gathered shellfish from a range of habitats. Certain continuities in shellfish subsistence strategies before and during changes to the local landscape means that natural environmental factors probably did not significantly alter shellfish exploitation. Instead, local occupants at Caution Bay had a complex and diverse shellfish economy, and their activities were mainly dictated by the wider socio-cultural landscape.

Certification of Thesis

The work contained in the thesis is the bonafide work of the candidate, and has not been previously submitted for an award, and that, to the best of the candidate's knowledge and belief, the thesis contains no material previously published or written by another person except where due acknowledgement and reference is made in this thesis to that work.



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Professor Bryce Barker

Cover Photo: Completion of second phase of Bogi 1 archaeological excavations facing southwest with Squares C and D in centre (McNiven *et al.* 2010a:8).

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Definition of Terms

In general, the term 'shellfish' can be used to refer to molluscs, crustaceans and echinoderms. For the purpose of this study, this term relates specially to various species of marine and freshwater molluscs (bivalves and gastropods). Both 'shellfish' and 'molluscs' will be used interchangeably throughout this study.

In addition, the following definitions of shellfish are used in this thesis. Cultural / economic represents molluscan taxa that have been intentionally targeted and exploited by humans regardless of the end purpose, including use in subsistence, trade as raw material and artefact manufacture for both utilitarian (e.g. fishhooks) and non-utilitarian (e.g. for personal adornment) purposes. Non-economic is characterised by mollusc taxa not exploited by people and thereby brought into a site by accident or from natural processes such as predation by other fauna (e.g. birds of prey, Crustacea) and adverse environmental events (e.g. cyclones) (see pp:112-119 for detailed discussions of identifying human exploitation of shellfish in assemblages).

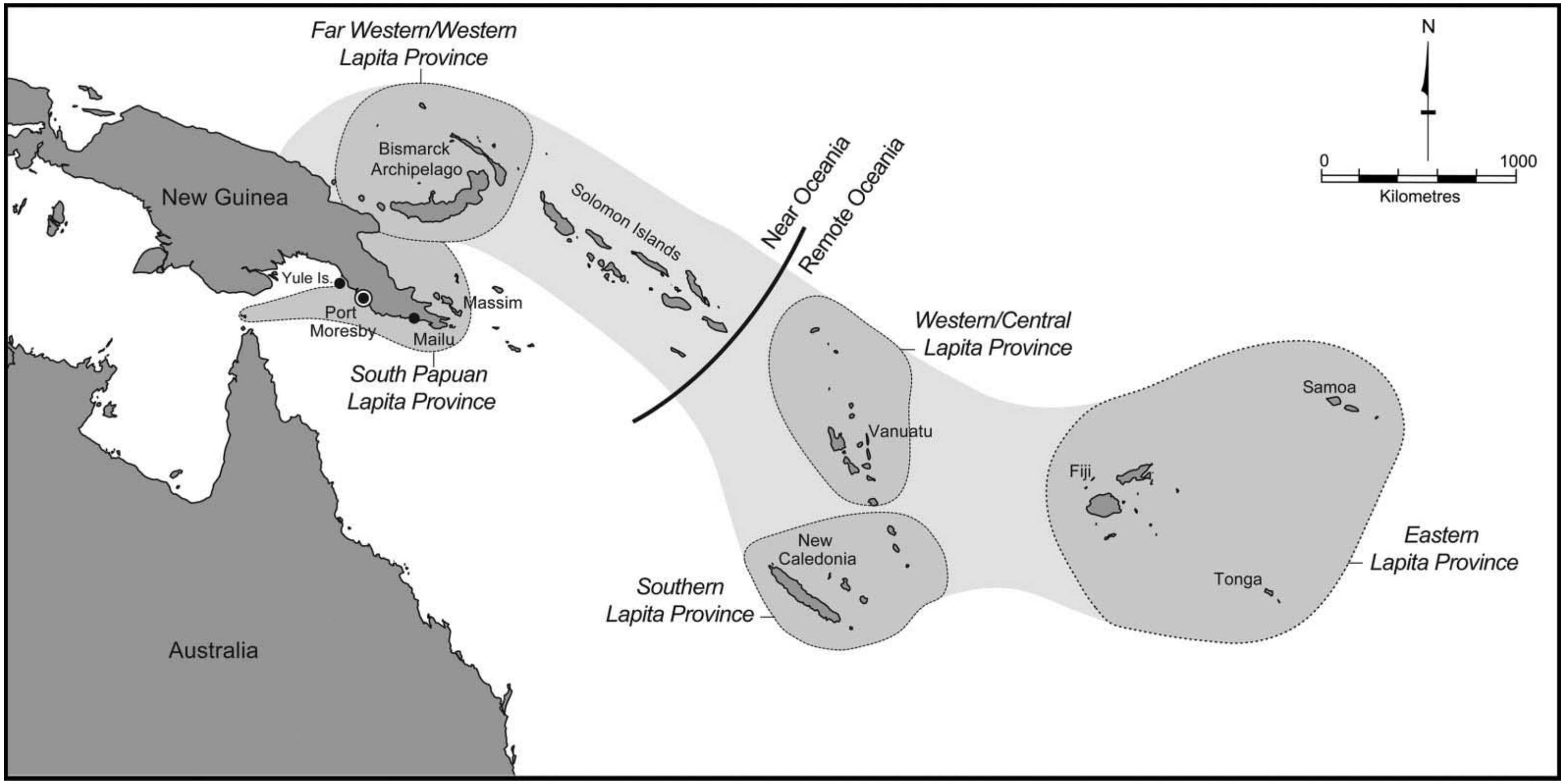

Figure 1.1. Spatial distribution of Lapita Cultural Complex, including the newly identified Lapita migration at Caution Bay, southern Papua New Guinea (David *et al.* 2011:578).

Chapter 1 – The Research Question

Introduction

Archaeological discoveries in Papua New Guinea (PNG) have had a significant impact in our understanding of the pre-European history of the Australasian region, from evidence of the Pleistocene colonisation of Sahul to the development of some of the earliest evidence of agriculture (Denham *et al* 2004; Hiscock 2008). The recent unearthing of sites containing highly distinctive Lapita ceramics on the southern coast of PNG has greatly altered our understanding of past cultural chronologies in the western Pacific region (McNiven *et al.* 2011). Although it had been postulated that Lapita peoples had not ventured onto mainland PNG (Lilley 2008:79), excavations of several highly significant sites with evidence of Lapita material culture at Caution Bay, on the southern coast of PNG (Figure 1.1), have forced a re-evaluation of previously held notions of the Lapita cultural complex (see Chapter 4).

Existing models explaining change at different localities have focused on Lapita colonisation, and by extension, subsequent changes in cultural practices, particularly in ceramic conventions and subsistence economies over time. At nearly all Lapita sites found in most geographic areas except for the Bismarck Archipelago, the landmass from which the origins and earliest archaeological evidence of the Lapita culture complex had been recorded, Lapita peoples were the initial colonisers who carried with them and introduced a wide range of new cultural practices (see Chapter 4). In contrast, the temporal sequence at Caution Bay extends back to 5000 years BP (David *et al.* completed ms.) prior to the arrival of Lapita peoples at 2900 years BP (McNiven *et al.* 2011), providing evidence of a unique contact situation whereby an established indigenous population interacts with an incoming ‘foreign’ culture. This situation is unique to Caution Bay since other instances of Lapita colonisation elsewhere in Melanesia and the western Pacific were somewhat different with Lapita arrival signalling the start of human occupation (see Chapter 4). Therefore, this scenario has the potential for understanding whether new cultural practices introduced to Caution Bay by Lapita peoples (e.g. pottery manufacture) and a possible change in social conditions resulted in changes to established marine subsistence economies. At

Caution Bay, three distinct occupational phases have been identified (David *et al.* completed ms; McNiven *et al.* 2011):

- Pre-Ceramic/Lapita phase dating from 5,000 to 2,900 cal BP, representative of indigenous occupation before contact.
- Lapita phase dating to between 2,900 and 2,600 cal BP, indicative of the arrival of foreign Lapita peoples culminating in a substantial period of interaction with local populations and the introduction of ceramics.
- Post-Lapita phase dating to after 2,600 cal BP, marked by changes in ceramic conventions.

With this in mind, I will be specifically looking at the Caution Bay shellfish assemblages together with an analysis of other important trends in ceramics, stone artefacts and non-molluscan fauna where available for each individual site. The decision to focus on marine and freshwater molluscs from this region was made following the unearthing of highly dense shell midden deposits covering all identified occupational phases. Both archaeologically and ethnographically, it has been well-established that shellfish not only represent an important dietary resource for coastal communities, but were targeted for other non-subsistence purposes (see Chapters 5 and 6). The coastal peoples of Caution Bay and the Lapita culture complex were marine specialists with considerable evidence depicting a preference for marine resource use (see Chapter 4). Therefore, shellfish are an important economic resource within such a context, with archaeological midden assemblages providing a unique opportunity to understand past social, economic and political systems. Furthermore, given the fact that previous studies on molluscs on the southern coast of PNG have not been undertaken on this scale, this research was considered important, especially when research on Lapita culture elsewhere have most often focused on understanding colonisation and stylistic changes in ceramic decorations over time and space (see Chapter 4). Overall, by doing so and in describing research from shellfish assemblages, this thesis will aim to provide an enhanced understanding of the spatial patterns and cultural chronologies of contact at this location and its implications on a local and regional scale for marine resource use. Thus, the main aim of this thesis is to examine changes in shellfish subsistence practices over time in the context of pre-Lapita, Lapita and post-Lapita events.

Aims of Research

The focus of this research is to analyse the archaeological shell assemblages from 3 sites at Caution Bay to:

- Ascertain whether there are changes in shellfish exploitation through time and space.
- To determine whether any changes (if present) are linked to the three phases of human occupation
- To interpret what these changes (if any) may be related to (e.g. predation pressures or other external factors such as environmental change).
- Document any correlating trends between the intensity of mollusc exploitation and identified stylistic changes in ceramic conventions.
- Determine the cultural component of the assemblage and what component of it represents non-cultural species (natural or incidental inclusions) from cultural taxa (food, artefacts) – i.e. what component of it reflects human activity and what were those species used for.
- Develop an archaeological model for understanding marine shell and resource use on the southern coast of PNG and its wider temporal and spatial implications, especially in relation to local and regional (e.g. Lapita) cultural chronologies.

Analysis of sites will incorporate spatial and temporal components, with sites specifically selected from different landform areas of Caution Bay that includes Bogi 1 and Tanamu 1 from near the beachfront and JA24 situated 2.3 km further inland. The overarching objective of this research then, is to broaden our understanding of the Austronesian colonisation of the Papuan mainland as well as to ascertain trends in intensities of regional occupation by Lapita marine specialists and resource exploitation during the pre-Lapita, Lapita and post-Lapita periods.

Thesis Structure

Chapter 1 - The Research Question provides an introduction to the research by stating the contextual framework, the primary objectives of the study and the thesis structure.

Chapter 2 – Theoretical Perspective and A Model for Change examines explanatory models for change and the theoretical perspective utilised in this study.

Chapter 3 – Understanding Contact explores the issue of contact since this study essentially explores the impact of Lapita migration into mainland PNG and its social, political and economic implications as evidenced from shellfish assemblages.

Chapter 4 – Caution Bay, Lapita and the Regional Problem discusses the archaeology of Caution Bay, and the south coast of PNG. Important themes in Lapita archaeology are also examined and the regional research problems are stated. The aim of this chapter is to provide an overview of previous research to provide context for the current study.

Chapter 5 – Molluscs in Ethnographic Research reviews existing ethnographic literature on shellfish so as to address key issues in mollusc research by illustrating how recent studies on shellfish procurement can provide an insight into the past.

Chapter 6 – Archaeology of Coastal Occupation explores important issues in coastal archaeology by identifying key aspects of coastal occupation in the Australasian region. By doing so, this Chapter will provide an archaeological framework for understanding shellfish exploitation at Caution Bay.

Chapter 7 – Palaeoenvironment provides an analysis of the palaeoenvironmental landscape at Caution Bay by discussing all significant changes and its implications for understanding mollusc exploitation and key research questions.

Chapter 8– Caution Bay Molluscs and Methodology provides an overview of the Caution Bay shellfish assemblage. Methodological approaches (e.g. fieldwork, laboratory) employed in this study are stated together with why such methods were selected and the expected outcomes of using these methods.

Chapter 9 – Tanamu 1, Chapter 10 – Bogi 1 and Chapter 11 – JA24 present the results from the analysis of shellfish assemblages at each site. The overall context of each site in relation to this study, and important spatial and temporal changes seen in the shell assemblages are analysed and discussed.

Chapter 12 – Shellfish Exploitation and Change at Caution Bay: A Synthesis addresses key changes over space and time between all three sites as observed in the archaeological record. The implications of these patterns for understanding ‘contact’ and past subsistence systems are discussed in this chapter.

Chapter 13 – Caution Bay Molluscs: A Regional Model examines overall results and its application on a regional scale. This chapter concludes by providing a local and regional model for shellfish exploitation along the southern coast of PNG and by extension, costal occupation and ‘contact’.

Chapter 2: Theoretical Perspective and a Model for Change

Theoretical Perspective

In this study, I will be analysing the archaeological data from a post-processual/social perspective using complimentary anthropological methods in conjunction with the acknowledged role that environment plays in shaping behaviour, which can enhance the interpretation of the material past. The south coast of PNG has a long and rich ethnographic record, which encompasses long oral traditions and contemporary traditional modes of living. In adopting a social approach which I argue provides a more holistic picture of the human past by addressing key social and cultural changes, including past social, political and economic system I do not mean to imply that environmental factors are not important in our understanding of socio-cultural change at Caution Bay, but see it as just one part of the complex interaction between culture and environment.

Within the Australasian region, the idea of a social stimulus for change was first proposed by Lourandos (1983) to account for changes which occurred during the late-Holocene in Australia. Changes, as argued by Lourandos, were due to internalised social processes, particularly a reorganisation of social relations leading to an intensification of local economy and production to feed growing demands (Barker 2004:18). This in turn resulted in an increase in sedentary lifestyle, population numbers, economic growth, and in the complexity of social relations (Barker 2004:18; Lourandos 1983:81). A feature of this model, is that environmental processes are taken into account within the overall scheme of events. When occupying marginal environmental landscapes where there can be stresses imposed on people at certain times, inherent social processes allowed for access to an extended array of services and resources (Barker 2004:18). This was possible through a sustainable system of reciprocity with delayed economic and social returns, essentially developed from complex kinship networks (Barker 2004:18). This system became increasingly complex over time, which created the need to intensify economic production (Barker 2004:18). As well, greater levels of inequalities in status, power and prestige emerged within and between groups of people, with extended kinship relationships leading to control of more territory (Barker 2004:18). Groups of people therefore became more competitive and complex, and inter-group relationships required greater social and economic demands which were supplemented by trade, ceremony and inter-group meetings (Barker 2004:19; Lourandos 1983:90). The basic premise of a social approach is that stimulus for change was not necessarily directly a consequence of environmental change, but rather a result of a complex set of inter-related social processes.

While this model was developed from anthropological literature on the social structures of Aboriginal Australians in response to environmental frameworks and to provide an alternative view on human behavioural changes in relation to marine resource use and occupation in Australia, other researchers have also successfully employed a socially orientated approach in nearby Torres Strait and PNG. Investigations on numerous coastal sites in both localities have revealed the level of complexity in how people were not just occupying the landscape, but the significance of such adaptation to their social, political and economic structures. In Torres Strait, dense shell middens appear during the late-Holocene at 2,800 years BP, but these middens were not just remnants of food remains but were in fact highly ritualised features that helped to maintain identity, cohesion and socialisation with the community (David *et al*. 2005; David and Badulgal 2006; McNiven 2013). By incorporating marine resources into their social system, people were using these resources in rituals, and internal social ceremonies to shape their worldview and even transform the sea into customary spiritscapes and seascapes. Exploiting marine resources for use in rituals, and inter-group dynamics also sees the appearance of constructed shell arrangements which were part of the political agenda for headhunting as seen during the ethnographic period (David *et al.* 2005). Similar results using archaeological and ethnographic data has also been borne out by research in PNG (Thangavelu *et al.* 2011) where the intensive exploitation of marine resources during the late-Holocene was due to wider socio-political reasons (see Chapters 5 and 6).

In providing some brief examples (see Chapters 5 and 6 for detailed discussion), my point here is that social models can be applicable to certain contexts and provide a more holistic reconstruction of past events. Given the ‘contact’ scenario at Caution Bay, and the extensive record of complex social-political systems as evident through the ethnographic record, I believe social models present the most viable method for explaining change in the local archaeological record since the Caution Bay archaeological sequence is representative of a complex set of social processes that were in place before, during and after contact with Lapita people (see Chapter 4). From other known examples from PNG, we know that highly complex social structures were in place, especially in regards to how people responded to the arrival of foreigners or how they interacted with other communities. As seen ethnographically, social responses to change and interaction normally involved the use of ceremonies, rituals and reciprocity of material items (e.g. shell artefacts) for political or economic outcomes. Some documented outcomes are extension of kinship, marriage ties and greater social and political status of an individual or group (see Chapter 3).

While such practices are known to have happened in the recent historical past, and continue to be part of contemporary social spheres in PNG, people may have responded to the arrival of Lapita peoples in a similar manner in the past, especially when we know that many current practices are performed by descendants of pre-European communities. With the introduction of pottery, a technology that was not local to the southern coast of PNG, together with the need to interact with outsiders, internal social practices may have been relied upon to both cope and enhance the success of this ongoing relationship. Increased reciprocity, and the development of a complex kinship and/or kinship network, and the ritualisation of material items may have led to an increased need to intensify economic production in order to also perhaps accommodate increased population densities. If it was indeed a social response to change, then evidence I believe should also be seen in the archaeological record from Caution Bay. The signatures of late-Holocene intensification, normally characterised by greater site numbers, increase and diversification of resource use and proliferation of new technology can in turn be accessed to determine how people responded to change. Whether or not the environment was the stimulus for change needs to be carefully examined in light of palaeoenvironmental reconstructions, to see if any sort of change was natural or anthropogenic (see Chapter 7). When done, and from applying known ethnographic and ethnohistoric data, whether internal social factors were likely to have dictated human behavioural change, as evident through trends in marine shellfish exploitation will be discussed in Chapter 12.

Chapter 3: Understanding Contact

Introduction

The purpose of this chapter is two-fold. Firstly, with the contact setting at Caution Bay, examples of contact need to be discussed to provide a research context. In doing so, how a 'contact' scenario may be represented by the material remains of the past and the archaeological implications for this phenomenon needs to be clearly understood. Investigations into contact between indigenous and 'foreign' societies have been undertaken in various locations globally, with contrasting differences in degree of contact, environmental landscapes, natural resources and in the cultural practices of indigenous communities (see Gosden 2004; Torrence and Clarke 2000b for case studies.). Examples range from the settlement of islands to the numerous historical accounts of European colonisations of various landmasses. The majority of research has been carried out on European sites through an analysis of historical records and excavation of sites. Documented European accounts of contact can provide an insight into the past, and at the same time present valuable information that may be used to complement archaeological data from pre-European sites where applicable. However, before proceeding, the term 'contact' first needs to be addressed and clearly defined.

Contact

The term 'contact' can be used to characterise a number of events, with the most common examples being contact between indigenes and foreigners through colonialism, cross-cultural contact among neighbouring communities/islands, and contact for the purposes of economic benefits or political power. Normally, 'contact' or 'first contact' is often representative of the events that transpired following the arrival of Europeans at previously unexplored locations with an established indigenous population (Torrence and Clarke 2000a:12). At its core, is a notion reminiscent of one-sided behaviour in which an indigenous community that is 'less capable' is passive to the dominance of foreigners and their cultural practices (Torrence and Clarke 2000a:12). The implications of such a meeting, is the perception that the eventual outcome is linear and inevitable (Torrence and Clarke 2000a:13). This idea is however problematic because it presumes that indigenous communities were static, succumbed to external pressures and lacked the ability to engage in intercultural exchange (Torrence and Clarke 2000a:13). I argue that this is not the case, and as I discuss below, people in PNG were in fact able to engage in intercultural exchange with European colonisers with mutual benefits for all parties involved. But perhaps, a more common problem with using 'contact' is that the term has often been used freely to not just characterise initial contact and its manifestations, but to also describe continued interactions without a proper definition of time and space (Torrence and Clarke 2000a:13). Additionally, as highlighted by Torrence and Clarke (2000a:13) using the term is problematic, 'since it folds a complex and continuing set of social processes into a concentrated moment of historical time'. This period of time, in turn, needs to be clearly defined since in most cases, the reasons as to why 'contact' ended or transpired into something else is not addressed (Torrence and Clarke 2000a:14). Additionally, it is normally perceived that when the 'dominant' party asserts its control over an indigenous population, then 'meaningful' interaction has ceased (Torrence and Clarke 2000a:14). Using contact to represent a definite time period, is seen as negating the continuity of intercultural interaction (Torrence and Clarke 2000a:14).

Another term used to describe cross-cultural relationships in Oceania is 'encounter' (Torrence and Clarke 2000a:15). Proposed by Dening (1980, 1992) the term encounter 'is important because it enfolds not only the individual and collective events of contact but also the processes set in train by prolonged encounter (Torrence and Clarke 2000a:15). This process sees the transformation of both parties involved with foreigners becoming socialised within the indigenous system (Torrence and Clarke 2000a:15). The problem with 'encounter' is that it implies meeting between two parties with a hostile purpose and thus the shortcomings of not being able to develop a middle ground (Torrence and Clarke 2000a:15). While agency is given to both parties, more importantly, this term is more suited to characterising a one-off event and not prolonged interaction (Torrence and Clarke 2000a:15). According to Torrence and Clarke (2000a:16), 'engagements' best suits the study of cross-cultural interaction between groups of people because it 'stresses the active involvement of both sides, it is not necessarily a once-only event, and it can refer to a process'. As well, this term also means that all involved groups 'made a conscious decision to be involved' (Torrence and Clarke 2000a:16).

Even though I agree with the sentiments of Torrence and Clarke (2000a) on the meanings, advantages and disadvantages of using all three terms, I argue that given the research context at Caution Bay, all three terms are applicable throughout different stages. The initial meeting between Lapita peoples and the indigenous community can best be described as perhaps 'first contact' or an 'encounter'. The subsequent and ongoing relationship between both parties, I believe should be looked as an 'engagement' or prolonged 'contact' While there are some negative aspects to using 'contact', this term can be justifiably used as long as there is a clear understanding of what it represents within the archaeological sequence at Caution Bay so as to erase any ambiguity associated with this term. Firstly, contact in this research is used to specifically relate to cultural interactions during the Lapita phase spanning some 300 years and the later interactions among communities in the area (Hiri trade). Engagement can also be used interchangeably because by contact, I am specifically referring to a pre-European scenario devoid of any negativity such as an indigenous population being static and succumbing to external pressures, leading to forced cultural changes. Here, both contact and engagement personify a mutual cross-cultural interaction with negotiated outcomes in which all parties had agency and were actively involved in a complex social, political and economic system. By properly defining the temporal and spatial range, I believe that both 'contact' and 'engagement' are appropriate terms as long as Eurocentric views are not applied.

Although applied to the notion of European colonisalism, Gosden's (2004:2), argument that whenever a 'metropolitan power' seeks to establish a colony, new features such as language, material culture (e.g. artefacts), customs, genes and burial customs are introduced to native populations is applicable to all new encounters between peoples. In archaeological terms, the introduction of such new features and how it differs from the pre-existing material culture of people in the new location can provide clues as to whether a colony was established (Gosden 2004:2). In the past, existing evidence demonstrates that certain major state systems (e.g. Uruk, Athens, Rome) had attempted to expand their territory by sending people to distant places that were different culturally (Gosden 2004:2). While Lapita peoples were known to colonise new areas, they were never a metropolitan power and cannot be classified as a state system. However, an important question here is whether the 'contact' made with the indigenous population at Caution Bay was an attempt to colonise the area or simply an activity that was undertaken for economic, political or social reasons given the rich resource base evident at this locality. Or perhaps, initial ‘contact’ might have even been accidental, but such a hypothesis can be difficult to test in this instance. Even so, given the primary reasons for which new colonies are established, such as trade, acquiring local resources, gaining military advantage or to support population increase (Gosden 2004:2), it might still be the case that ‘contact’ at Caution Bay may represent an event that occurred for economic, social or political reasons. In the case of economic benefits, Gosden (2004:4) states that colonialism is mainly about consumption, more so than exchange or production. As well, there is a link between colonialism and material culture with changes to values occurring between incoming peoples and native inhabitants (Gosden 2004:4). Such values play an integral role as they ‘set up a circulation system of people, ideas and artefacts which change all concerned and which have multiple sources’ (Gosden 2004:4). This process of circulation not only affects the native population, but also has an impact on the colonising party (Gosden 2004:4).

While there are varying approaches to understanding colonialism, ranging from world systems literature to post-colonial theory, Gosden (2004) explores the intrinsic relationship between PNG and a middle ground approach. This approach centres on ‘the creation of a working relationship between incomers and locals that formed a new way of living deriving from the cultural logics that all parties brought to the encounters’ (Gosden 2004:82). This view differs greatly from existing notions whereby there is only one of either the cessation of physical and cultural practices following contact, or acculturation of physical and cultural practices (Gosden 2004:82). Hence, in a middle ground approach, all involved parties had agency, with material culture often being a significant component for negotiations since items were of certain values (Gosden 2004:82-83). In PNG, there are notable differences in cultural practices with numerous communities occupying various landscapes, religious beliefs and rituals personifying well-being among these communities, thus presenting a vital component of contact since it is linked to materialism (Gosden 2004:92-93). Certain items such as pigs and pearl shells were of high value and were exchanged for ‘intellectual property rights to make and perform certain ceremonies’ (Gosden 2004:93). European contact in PNG had a similar effect with the introduction of new material culture leading to the development of various ritualistic practices, such as cargo cults (Gosden 2004:95). As well, trade activity increased as early Europeans sought highly prized items that were unique to the region. Such items were sometimes purposely manufactured to cater to the preferences of Europeans, especially in decoration and form of objects (e.g. obsidian spears and daggers) and were also used for sale (Gosden 2004:97). The introduction of new material culture altered existing cultural practices and had a cosmological significance for both parties. The exchange of goods not only presented an economic advantage, but allowed for the collection of mementoes belonging to two quite different cultures (Melanesian against European) from another place and time, therefore representing a cosmological meaning in this regard (Gosden 2004:96). Hence such items were of historical, social and cosmological significance and unlike elsewhere, there was a joint colonial culture where differences in cultural practices actually fostered a mutually beneficial relationship in some areas (Gosden 2004:96).

Contact through colonialism in PNG brought economic benefits to Europeans through activities such as mining, and for indigenous communities increased access to valuable resources that altered existing cultural practices. For instance, among the Tungei community in the PNG highlands, axes were an important part of local wealth economy and were used in marriage payments which could then be used for exchange with other distant communities (Gosden 2004:100). However, upon arriving in 1934, the first gold miners recognised the significance of marine shells as an item of local material wealth, which was then brought in and used as payment for workers (Gosden 2004:100). By doing so, axes were replaced by shells, which in turn reorganised exchange networks in the Highlands with the wealth status of shells illustrated by its increasing use for marriage ceremonies (Gosden 2004:100). Shells were eventually replaced by money and other consumer items, but this example clearly demonstrates that the disappearance of a particular item was a result of changes in wealth economy following contact and not from material constraints (Gosden 2004:100).

Prior to European contact in the central Highlands where there is archaeological evidence for long occupational antiquity, the development of intensive agricultural systems was a means for exchange and not for providing more subsistence (Gosden 2004:99). Here, increased productivity translated to success in exchange networks (Gosden 2004:99). Evidence from oral history of the Enga people shows that following the introduction of a new crop (sweet potato), perhaps signalling some form of contact with a ‘foreign’ population, led to significant increases in population density and intensity of agricultural practice over time (Gosden 2004:99). The subsequent implications of such change was not only the rise of new leaders who presided over agricultural production and exchange networks through leadership, ritual and knowledge of the region, but also made Engan and other Highland peoples more amenable to change that was to take place following European contact (Gosden 2004:99). Gosden (2004:99-100), states that ‘colonial changes and reorganisations came against a background of long-lived social flux, which necessitated the incorporation of new ideas and exchange media’.

Meanwhile, for PNG coastal regions which were quite different from the Highlands, European items that were mass-produced were not incorporated into local exchange ceremonies (Gosden 2004:101). Archaeologically, the ancient PNG coast boasts one of the oldest, ongoing practices of sea travel globally, and the onset of Lapita at 3300 BP connected parts of PNG to other distant islands (Gosden 2004:101). This connection provided opportunities for marine exchange of goods such as pottery and artefacts, and Gosden (2004:101) argues that it represents ‘one super-community stretching over much of the western Pacific’. As well, using sea travel, communities were linked together and when changes occurred at one location, similar cultural changes happened elsewhere (see Chapter 2). The end of the Lapita lifestyle led to changes, and from 1000 years ago, in New Britain, communities were set up with a defensive orientation and only after 500 years was there a more localised trading system that spanned a much shorter spatial range when compared with Lapita (Gosden 2004:101). The important difference between the Highlands and the coast was the lack of intensive food production, but control of knowledge and information was still very important (Gosden 2004:101). Therefore, in places like New Britain, even though there was a proliferation of exchange networks because of regional variations in production, substantial ceremonial exchanges as noted in the Highlands were not practiced (Gosden 2004:101). Therefore, people were not as amenable to change brought forth by European contact, as the incorporation of western goods used in exchange systems for social events would have had an impact on existing ways of life (Gosden 2004:102). These impacts would have weakened ‘regional differences in production and exchange, thus eroding the real basis for social links and competition’ (Gosden 2004:102). Likewise, ritual systems incorporating dances and exchanges were again vital since they allowed communities to cope with any significant change, especially in key areas such as initiation, marriage, birth and death (Gosden 2004:102). And while changes were noted, with the eventual use of European items in daily activities, these were not permitted into exchange or ritual systems so as to preserve fundamental cultural practices through the use of traditional items that had intrinsic values (Gosden 2004:102). Unlike in the Highlands where people were innovative, competitive and were willing to incorporate new objects brought about by colonialism, these communities preferred to adhere to existing practices in order to cope with the arrival of outsiders.

The advent of colonialism and its subsequent contact with native inhabitants in PNG had contrasting scenarios with communities attempting to find varying ways in which to deal with this contact. While some incorporated and interacted with the 'foreigners' through material culture, hereby presenting a middle ground, others chose to solve this problem through ritual. Nonetheless, contact through colonialism provides some key clues as to what may have happened during contact between Lapita peoples and the indigenous population at Caution Bay 2900 years BP. As much of the evidence will be discussed in further detail in subsequent chapters, an important point here is the introduction of new material culture (pottery) following contact, the subsequent proliferation of pottery manufacture and use in exchanges with other local communities (Motu Hiri trade) after Lapita occupation. It does seem that the indigenous population at this location recognised the social, political and economic benefits of pottery manufacture (see Chapter 4), but whether any further changes occurred other than the arrival of pottery needs to be examined. As discussed, other changes may be evident in subsistence practices, population dynamics, and increased social activities following contact, steps that may have been taken in order to cope with an influx of foreigners. While it may well be that such interaction may have provided a wealth economy, it is again difficult to ascertain if the people of Caution Bay turned to ritual to cope with this event. But, given the ethnographic and ethno-historical evidence for the prevalence of rituals, a trend that has transcended space and time as evident by the presence of contemporary descendants who continue to undertake traditional practices, such a hypothesis may be applicable. Overall, the implications from contact through colonial expansion are changes to the internal structure of a society following exchange of material culture. Even though it can be argued that external pressures from a colonising party and material constraints may have led to change, the examples in the case of PNG clearly demonstrate socio-economic/cultural change within a particular community in which people had the option to either increase their political status and economic wealth, or choose to not get involved substantially following contact. Either way, contact does not just represent trade or economic activities but has wider social, political and economic implications

Cross-Cultural Contact

The extent to which contact has an effect on human behaviour and cultural practices can be further exemplified by examining other cross-cultural engagements in Oceania. Many examples exist from European involvement to localised interaction between different islands. As I have discussed in the example above and will examine others in subsequent Chapters, this section will focus briefly on key elements of cross-cultural engagements. Material culture is an important tool often used in the study of cultural interactions as they can be used to determine how and why interaction was taking place (Torrence and Clarke 2000a:18-19). It is important to note that even though foreign material culture may not be present in some cases, that does not mean that contact did not take place (Torrence and Clarke 2000a:19). Likewise, the introduction of new material culture does not necessarily lead to changes in human behaviour (Torrence and Clarke 2000a:19). But in most instances, the introduction of new items had certain social, political and economic consequences. As pointed out by Hodder (1982), material culture has important implications to social action. People incorporated new material culture into their pre-existing social spheres and were both creative and innovative in how such items were utilised (Torrence and Clarke 2000a:19). As I have discussed above, such items can even be ritualised, and used as a means to cope with an influx of foreigners.

Another prime feature of interactions seen in many localities is intensification in landscape use. With intensification, there are distinctive changes in occupational patterns, and a ‘gravitational pull’ occurs whereby people were attracted to centres of contact with camps being set up (Torrence and Clarke 2000a:21). With a more sedentary lifestyle, foods that were readily available locally were exploited and according to Schrire (1972), food remains reflect if people were living more permanently at regional centres following contact. Hence, with a larger population density, local resources are also most likely to have been intensively exploited. In general, there are two types of 'gravitational pull', with the first drawing indigenous people to readily available food sources which increased social relations while reducing their movement to particular areas (Torrence and Clarke 2000a:23). Secondly, an entirely different scenario eventuates with the advent of contact pushing people further away, so as to allow for continuation of traditional practices such as ceremonies and to maintain their connection to their country (Torrence and Clarke 2000a:23).

A fundamental component of contact, is that there is no clear simple pattern of change since there is often negotiation between groups (Torrence and Clarke 2000a:23). This negotiation may be centred upon economic or political outcomes with each contact scenario resulting in a unique outcome (Torrence and Clarke 2000a:23). Some negotiations may be brief while others can be more extensive, regardless both parties experience some form of change that can significantly alter existing practices and lifestyles. For instance, the introduction of diseases had severe consequences in parts of Oceania following the arrival of Europeans (Torrence and Clarke 2000a:23). On the contrary, negotiations can also have a positive outcome, and there can be continuity despite significant changes (Torrence and Clarke 2000a:24).

Therefore, the primary question here is whether the introduction of Lapita material cultural and the ongoing inter-cultural engagement at Caution Bay which lasted for 300 years had any significant impact to existing political, economic and social systems in regards to shellfish exploitation. As I am principally focussing on the molluscan assemblage in this thesis, this question is examined in light of the archaeological evidence to determine if any trends in changes to shellfish subsistence practices occurred before and after contact (e.g. changes in discard of shellfish over time, evidence of predation pressure in the form of temporal changes to overall size and changes to species present etc.). When investigated, the results (see Chapter 12) will hopefully go some way to demonstrating the degree to which 'contact' took place at Caution Bay and provide an insight into how people engaged and responded to such change.

Chapter 4 – The Research Setting: Caution Bay, Lapita Peoples and The Regional Problem

Introduction

Following the excavation of sites demonstrating the presence of Lapita settlements on the mainland coast of PNG, Caution Bay has become key in the investigation of local and regional cultural histories in the western Pacific region. As previously discussed, existing archaeological chronologies from the wider region need to be addressed in order to provide an overarching context for this research. In this chapter, the role Caution Bay plays within a regional context will be looked at from an examination of previous temporal and spatial archaeological trends in human occupation and resource use, especially in relation to major ceramic phases. As well, the Lapita culture complex represents a crucial component of pre-European occupation in the western Pacific region and key elements of this cultural entity will be explored. This chapter will mainly focus on models of occupation and in doing so, will seek to demonstrate how Caution Bay 'fits' into the overall scheme of events that had transpired in the past and the research problems that need to be investigated on a regional scale over time and space using shellfish remains.

Caution Bay and Archaeology of the Papuan Coast

Caution Bay is situated approximately 20km northwest of Port Moresby, capital city of PNG along the southern coast. Within the large surface area extending 6.5km along the coast and 1.75km inland, over 100 archaeological sites were identified with research still being undertaken on excavated material (McNiven *et al.* 2011:2). While analysis of some sites is in progress, certain cultural elements from major sites have been completely analysed with the outcomes drawing an intriguing picture of pre-European occupation of this landscape. In previous years, archaeological work on the southern coast had revealed the antiquity of human occupation for this area to be c.2000 cal BP, a date often used to represent the earliest evidence for the appearance of pottery in mainland PNG (Summerhayes and Allen 2007). The stylistic features of this ceramic tradition, referred to as Early Papuan Pottery (EPP) became the centrepiece for investigating past cultural chronologies for this region. However, the discovery of Caution Bay has forced a re-evaluation of all existing archaeological chronologies since it not only confirms the mid-Holocene antiquity of human occupation in this region as evident from earlier research conducted at Kukuba Cave by Vanderwal (1973), but the presence of pre-EPP ceramic evidence in the form of Lapita pottery, has had significant implications on previously held notions on human occupation and behaviours from both a local and regional (Lapita) perspective.

From over 50 years of research, it has been clearly demonstrated that Lapita peoples had colonised vast areas of the Pacific after leaving the Bismarck Archipelago, northeastern PNG, the location at which this cultural entity first emerged with its highly distinctive style of pottery around 3350 years BP (Summerhayes 2007). Subsequent colonised areas include the Reef/Santa Cruz Islands at c.3200 cal BP (Green *et al.* 2008), Fiji, New Caledonia and Vanuatu at c.3000 cal BP (Bedford *et al.* 2006; Clarke and Anderson 2009), Tonga at c.2900 cal BP (Burley and Connaughton 2007) and lastly Samoa at c.2700 cal BP (Rieth *et al.* 2008). But, even with such an extensive colonisation event taking place over a vast distance of 4500km, it has often been assumed that mainland New Guinea was never part of the Lapita cultural complex since no Lapita sites had been discovered on the mainland coast until the Caution Bay research (Lilley 2008:79; McNiven *et al.* 2011:1). Recent archaeological investigations have however unearthed a number of Lapita sites at Caution Bay which revealed, ‘the largest contiguous Lapita landscape found anywhere in the Pacific’ (McNiven *et al.* 2011:2). A pre-2000 cal BP ceramic sequence not only has important implications in regards to Lapita archaeology, but also in relation to the pre-existing chronologies along the southern coast and other significant areas.

While my focus is on marine resources, in particular how shellfish were being exploited, analysis of shellfish assemblages needs to be undertaken in conjunction with the wider research context. Therefore, having a sound understanding of the major ceramic phases and how people occupied the landscape, their main cultural and subsistence practices together with the way social interactions took place between groups of people in this region needs to be taken into consideration. A discussion of how molluscan remains can inform us about the past will be the main focus of the next two chapters. Here, I will instead discuss the archaeology of the southern PNG coast and the Lapita cultural complex. Therefore the primary questions that need to be addressed here are:

- How Caution Bay represent a significant contribution to local and regional cultural chronologies.
- What are some of the major implications of Lapita settlement at this location.
- How does this area 'fit' into existing models for coastal occupation and Lapita colonisation.

Southern Papua New Guinea Post-2000 cal BP

Archaeological investigations on the southern Papuan coast have centred on understanding the dynamics of inter-community social and economic interactions through the study of major ceramic traditions (e.g. David 2008; David *et al.* 2010). While there is a paucity of detailed research on shellfish exploitation for this region, apart from sites situated in the Gulf of Papua following recent field research programmes initiated by David (e.g. David *et al*. 2008, Thangavelu *et al.* 2011), results from previous research on ceramic production and exchange has often been used as a proxy to model cultural interaction within the landscape. Historically, the majority of research conducted at different localities within the southern PNG coast can be grouped into two major periods of intensive fieldwork carried out by a number of archaeologists. The first major field research programme began during the mid-1960s when Peter White excavated coastal sites for his PhD (Skelly 2014:36). Soon after, a number of other excavations were undertaken by various researchers that included Ron Lampert (1968), Sue Bulmer (1975), Jim Allen (1972), Pamela Swadling (1980), Ron Vanderwal (1973), Sandra Bowdler (Bulmer 1975), Jim Rhoads (1980), Geoff Irwin (1985) and David Frankel (Frankel and Vanderwal 1985) (Skelly 2014:36-37) (Figure 4.1). Whilst a detailed discussion of results may be warranted, I will instead examine key outcomes and methodological limitations of these research endeavours since more in-depth analysis of this matter has been presented elsewhere (David 2008; Skelly 2014).

Outcomes from these early research agendas have revealed the presence of a complex system of pottery production and by extension, varying occupational strategies of the coastal landscape. Based on chronological sequences from excavations of multiple sites including Nebira 2, Nebira 4, Taurama and Eriama in the

Port Moresby region (Allen 1972; Bulmer 1978, 1999), Oposisi in Yule Island (Allen 2010; Vanderwal 1973), Collingwood Bay and the Massim (Bickler 1997; Egloff 1979; Negishi and Ono 2009), and Oraido 1, Mailu 3 and Selai from the Mailu region (Irwin 1985), the earliest use of pottery on the southern Papuan coast was deemed to have occurred at around 2000 BP while evidence for earlier mid-Holocene occupation was determined at Kukuba cave (David *et al.* 2011:580; Skelly 2014:35-38; Vanderwal 1973) (Figure 4.2). While evidence of Lapita pottery was non-existent when this idea was first proposed, the general consensus among researchers was that ‘each area studied contains strong Lapita influence’ (David *et al.* 2011:580). Hence, the broader colonising event starting from around 2000 BP was hypothesised to have been undertaken ‘by Austronesian-speaking bearers of post-Lapita wares who themselves were descendants of Lapita peoples’ (David *et al.* 2011:580).

In each of the archaeological investigations, individual researchers proposed similar models for occupation of the southern coast and the Papuan Gulf. One example is by Irwin (1991), who integrated existing evidence from Amazon Bay-Mailu and other previously excavated sites, leading him to propose the Early Papuan Ware (EPW) model for coastal pre-European occupation in which four major periods were identified and these comprise of:

- Colonisation (2000 to 1600 years ago) – Indicative of the occurrence of human settlements in the southern PNG coast with EPW ceramics.
- Deepening Regional Isolation (1600 to 1000 years ago) – Changes seen among coastal communities with the development of localised pottery styles. Further evidence for regionalisation is seen at Amazon Bay-Mailu where pottery remains were different when compared with the Yule-Island Hall Sound and Port Moresby regions.
- A Pottery Style Transformation (1200 to 800 years ago) – New ceramic traditions appear suddenly and are identical. However, when compared with earlier occupational phases, there is a reduction in uniformity within coastal areas.
- Interaction, Specialisation and Exchange (800 to 200 years ago) – Period of local integration in the south coast. Occurred at a time when coastal communication and exchange relationships varied spatially.

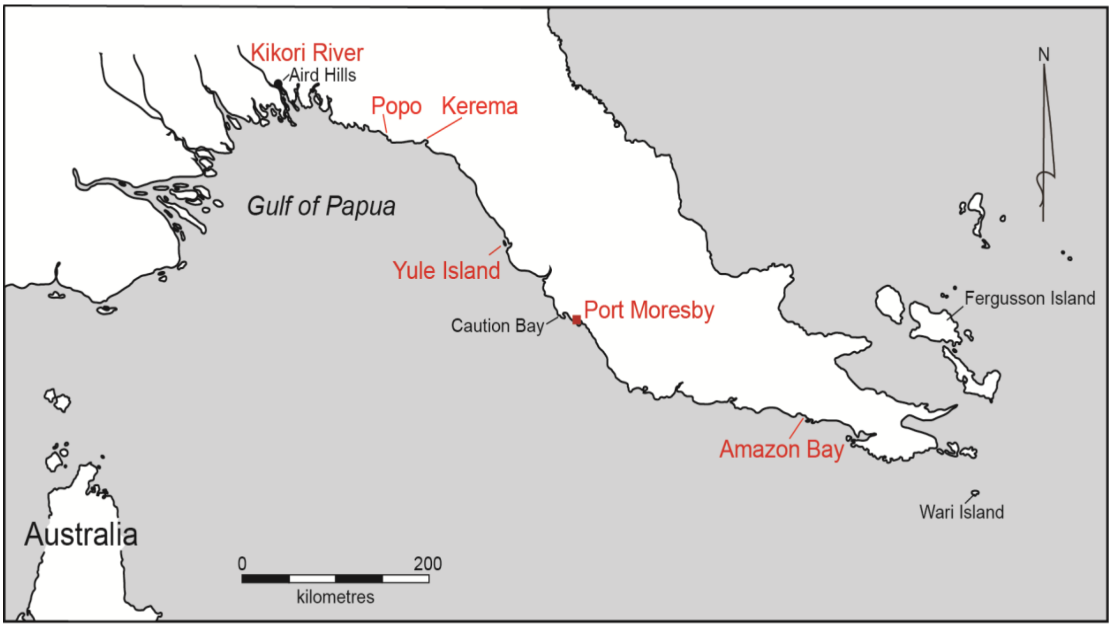

Figure 4.1. Locations where major archaeological research was undertaken from 1960s to early 1980s (Skelly 2014:38).

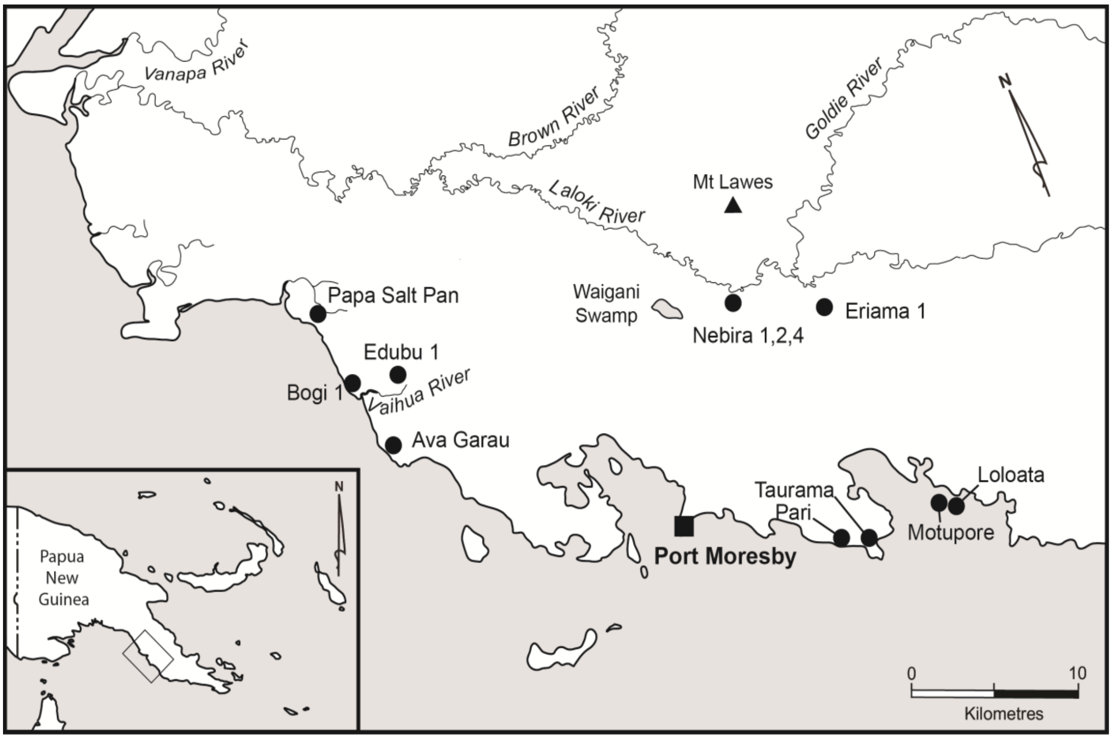

Figure 4.2. Location of major archaeological sites in the Port Moresby region (David *et al.* 2012; Skelly 2014:41).

This influential idea was consistent with earlier notions for pre-European occupation as stated by Allen who postulated that (Allen 1977a:391; David *et al.* 2011:580):

> The earliest known pottery using and producing communities appear on the south coast of Papua around 2000 years ago....Culturally the people concerned are viewed as a back migration of Austronesian speakers presumably from somewhere in island Melanesia although an exact derivation is yet to be suggested. Significantly the earliest levels of these sites contain pottery similar and presumably generically related to Lapita.

In a review of existing cultural chronologies, Summerhayes and Allen (2007) re-examined the ideas proposed by Irwin and Allen for a broader coastal 2000 year old colonisation event. In light of new evidence from the Massim, and in attempting to amalgamate various existing models on cultural traditions, Summerhayes and Allen (2007) proposed an overarching model termed 'Early Papuan Pottery (EPP)' (David *et al.*:580-581). By primarily using Irwin's EPW model and the earliest documented evidence for pottery at *c*.2000 cal BP, the EPP model was used to address cultural chronologies for the entire south Papuan coast especially when other pottery-bearing sites dating to this time period had been identified throughout the region except for the two western-most sites OAC and Kikiniu (Summerhayes and Allen 2007). Additionally, it is also important to note that stylistic changes occurred simultaneously across the region throughout the duration of the EPP (Skelly 2014:66). Furthermore, it was argued that pottery production during the EPP had an extensive impact on existing social systems throughout most of the entirety of the southern Papuan coast (Skelly 2014:66).

Whilst the use of EPP as a cultural marker for understanding human occupational strategies seemed plausible especially when evidence for sites containing ceramics older than 2000 BP had not been unearthed when this model was proposed, the discovery of the Caution Bay Lapita sites has led to a recent re-evaluation of the EPP (David *et al.* 2012). As researchers during the early stages of archaeological investigations attempted to answer fundamental questions on past human activities in this region, it was increasingly difficult to obtain secure chronologies because of inherent limitations with radiocarbon dating at this time (Skelly 2014:38-39). Since the development of AMS radiocarbon dating which only requires at least 0.005g of charcoal was to occur at a much later time, greater amounts of charcoal (at least 7g) were required in order to acquire radiocarbon dates (Skelly 2014:38-39). As the same time, cultural chronologies were also based on a limited number of radiocarbon dates from each site (Skelly 2014:39). Using a low number of radiocarbon dates with many being in reverse chronostratigraphic order, early researchers in the southern coast combined results from each site with other sites which led to the development of a broadly based model (Skelly 2014:39). In addition to problems associated with radiocarbon dates, developing a broader model based on inter-site datasets meant that differences in methods between each archaeologist, and chronostratigraphic differences of each site were not particularly taken into consideration (Skelly 2014:39). Hence, these early researchers did not endeavour to address these problems in relation to ceramic analysis, the cultural element relied upon to develop this model (Skelly 2014:39). Most importantly, given the lumping of radiocarbon dates, the EPP model has been criticised by David *et al.* (2012) for combining all trends that occurred before 1200 BP into a single phase even though there was clear variation in pottery traditions within the single analytical unit. Taking into consideration the limitations in regards to the available radiocarbon dating methods, the EPP was still important at the time when it was first proposed because this model was used to address key cultural changes for the southern PNG coast.

Caution Bay Lapita

The need for a re-evaluation of the EPP model was required following the unearthing of pre-2000 BP ceramic assemblages at Caution Bay. From excavations of over 100 sites, nine sites were identified with Lapita ceramic remains corresponding to a Lapita phase dated to between 2900 and 2600 cal BP (Bogi 1, Tanamu 1, RS63, Moiapu 1, Edubu 1, JA1, JD10, JD14 and JD17) (McNiven *et al*. 2011:2) (Figure 4.3). This discovery not only has significant implications for pre-European occupation on the southern coast, but has also reaffirmed earlier propositions made by pioneering researchers that the oldest ceramic remains found in the vicinity had connections to Lapita culture (Allen 1972, 1977a; Bulmer 1971, 1999; Egloff 1979; Irwin 1991; Skelly 2014:49; Vanderwal 1973). This hypothesis was advanced further by Bulmer (1999:573) who postulated that the oldest ceramic remains dating back to *c*. 2000 years ago were likely to have materialised from local Lapita occupation (Skelly 2014:49). With new Lapita sites at Caution Bay such as Tanamu 1 and Bogi 1 dating to 5000 cal BP and *c.* 4500 cal BP respectively, trends in human occupational patterns on the southern Papuan coast can therefore no longer be associated with an 'EPP' model (David *et al.* 2012; McNiven *et al.* 2011; Skelly 2014:67). However, the cessation of Lapita occupation and the subsequent continued transformation of the cultural landscape into a number of post-Lapita practices and pottery traditions meant that pre-existing cultural chronologies need to be evaluated in relation to this Lapita to post-Lapita event (David *et al.* 2012; Skelly 2014:50-51).

By incorporating the new Caution Bay Lapita and post-Lapita sequences, David *et al.* (2012) have argued that EPP should no longer be used and have instead proposed a five stage sequence for pottery traditions for the wider southern Papuan coast. This new sequence consists of (David *et al.* 2012):

- Lapita (*c.* 2900 to 2600 cal BP) – Characterised by Lapita pottery with dentate-stamped decorations.
- Post Lapita Transformative Tradition (*c.* 2500 to 2150 cal BP) – Stylistic features on pottery remains 'went through a process of simplification in design, transforming into recognisably similar but structurally more simple linear, geometric dentate-stamped decorations' (David *et al*. 2012:74).
- Linear Shell Edge-Impressed Tradition (*c.* 2150 to 2100 cal BP) – Highly standardised stylistic conventions. Designs made using 'distal dorsal edges of *Anadara* shell valves' (David *et al.* 2012:75). A finger groove under the lip together with shell-impressed design on the vessel body were present. Similar stylistic conventions were also noted for remains from Nebira 2 and Nebira 4, therefore pointing to the possibility that these sites may have a longer antiquity than formerly conceived (David *et al.* 2012).
- Umbo-Bordered Shell Back-Impressed Tradition (*c.* 2100 to 1650 cal BP) – Ceramic conventions are represented by umbo-bordered designs with impressions made using shell valves. This convention was found in sites Nebira 4 and Oposisi and while not present at Caution Bay, the similarity of this design with the Linear Shell Edge-Impressed Tradition, this phase may be representative of a late transformation of the previous sequence discussed above (David *et al.* 2012).

- Varied Incised Tradition (*c*. 1650 to 1000 cal BP) – Contains red-slipped/painted pottery with incised designs. Found at Caution Bay and is similar to pottery remains excavated from Nebira 4 and Oposisi (David *et al.* 2012).

This new model for occupation of the southern coast demonstrates two important points. Firstly, by identifying key differences in ceramic conventions as opposed to lumping different sequences into a single analytical unit, and the overall transition from one stylistic phase to another, the ancient cultural scenario at Caution Bay was probably much more complex than previously thought, especially with the intrusion of Lapita peoples. Consequently, the introduction and subsequent change in decorations may also signal new or altered directions in human occupational patterns and cultural practices. The other point this model eludes to is that ceramics became an important cultural commodity following its introduction, as pottery was not present during early stages of human occupation from 5000 to 2900 cal BP at Caution Bay. This is exemplified by pottery making traditions during the later ethnohistoric period and the important role of ceramics in exchange systems such as the well-documented ancestral *Motu-Hiri* trade system. Thus, while ceramics may have been an identifiable cultural marker, changes in human behaviour (e.g. settlement patterns, subsistence) need to be investigated both together and independently in relation to transformations in pottery decorations since linking relatively small changes in ceramic designs during the post-Lapita period to broader cultural change may possibly be problematic.

A further implication of this new Lapita Horizon is the connection that has been established with other significant finds in nearby Torres Strait. The earliest evidence for pottery from nearby Torres Strait, in the form of a red-slipped style, was firmly dated to c.2500 cal BP (McNiven *et al.* 2006). The manufacture of pottery in this instance had been considered to have been undertaken by local people who had 'ancestral connections' with pottery making communities from the Papuan Gulf (McNiven *et al.* 2006; McNiven *et al.* 2011:1). If so, it was postulated that a ceramic sequence dating back to at least 500 years earlier than the previously assumed 2000 cal BP date needs to be present along the southern Papuan coast (McNiven *et al.* 2011:1). Evidence from Caution Bay not only supports this hypothesis to a certain extent, it also presents the possibility that cultural connections between communities extended much further than previously assumed. The new Lapita Horizon at Caution

Bay nonetheless demonstrates that this location was part of the 'exploration and colonization' strategy undertaken by Lapita peoples (David *et al.* 2011:586). With the introduction of ceramics during this period, together with extended Lapita settlements appearing over time, explanatory models postulating for an incoming migration of pottery-making peoples during the later post-Lapita pottery phases can now be disregarded (David *et al.* 2011; McNiven *et al.* 2012b). Hence, the presence of pre-Ceramic settlements at Caution Bay long before the subsequent interaction following in-migration of the Lapita cultural complex means that any modelling of the southern Papuan coast for shellfish subsistence needs to be undertaken within this framework.

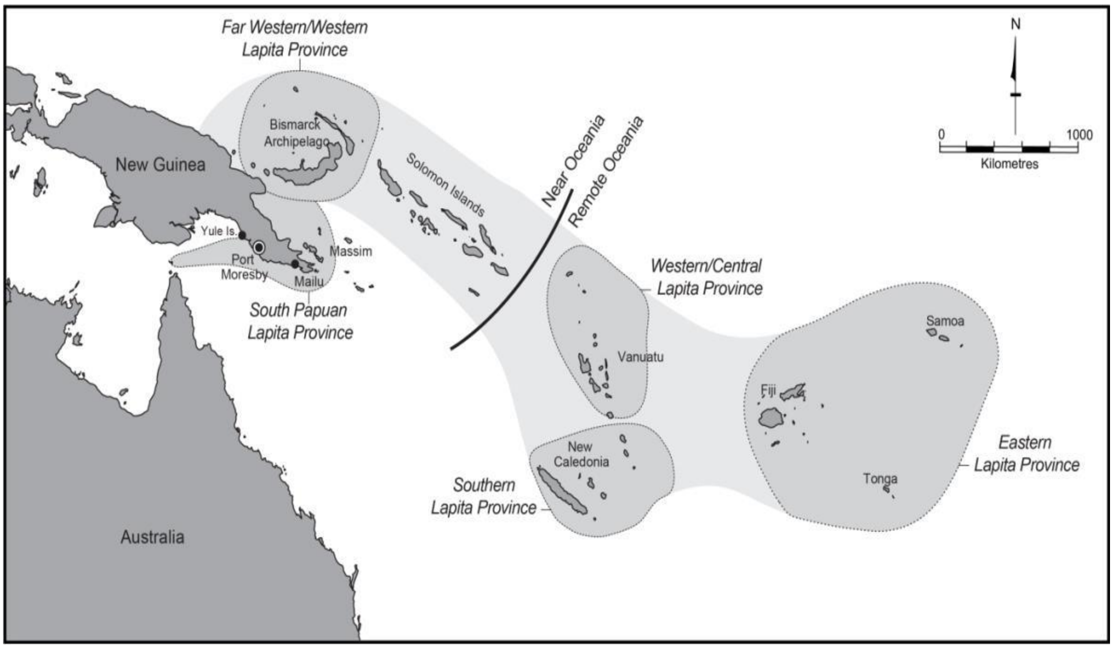

Figure 4.3. Spatial distribution of the Lapita culture complex in relation to the newly identified South Papuan Lapita Province (David *et al.* 2011:578).

Ceramic Hiccup

Notwithstanding the archaeological evidence for major transformations between the ceramic phases, significant changes in settlement patterns have also been documented during the post-Lapita period from *c*.1200 to 700 years ago (Skelly 2014:505). Initially coined as the 'Papuan Hiccup' by Rhoads (1982:146) and subsequently the 'Ceramic Hiccup' by Irwin (1991:507), the reduction in archaeological evidence for ceramics and human occupation during this period has led to the notion that major changes in cultural practices were occurring at this time. In areas along the southern Papuan coast, encompassing Port Moresby, Amazon Bay-Mailu and Yule Island-Hall Sound, more regionalisation of ceramic practices were noted while no evidence for ceramics were found from sites located in the nearby Papuan Gulf (Allen 1977a; David 2008; Irwin 1991; Skelly 2014:505; Vanderwal 1973). This change in trends to regionalisation and the disappearance of pottery has been interpreted to have occurred as a result of a reduction in communication and cultural exchange between different regional communities (Irwin 1991; Rhoads 1982).

Hence, within the vicinity of Port Moresby, communities were likely to have interacted less with others from both the east and west before regionalisation occurred with pottery no longer appearing at the Papuan Gulf after 950 cal BP (David 2008:469; Skelly 2014:506). More importantly, during this time, there is an abandonment of certain sites in Port Moresby (e.g. Nebira 4) but this hiatus in human occupation did not occur at sites in the Amazon Bay-Mailu area to the east with pottery still found within the assemblages (Skelly 2014:506). Unlike in the Port Moresby region, communities further east (Amazon-Bay Mailu and Massim) continued their local-distance exchange networks but social interactions had nonetheless decreased during this time (Irwin 1991:504). In interpreting this change in the archaeological record, White and O'Connell (1982:206) for example argue that local reasons instead of in-migrations by new communities may have led to cessation of existing practices. On the other hand, a possible decline in long-distance exchange networks, according to Rhoads (1982:142-143) who used evidence from the Papuan Gulf, may have resulted in site abandonment, reduction in pottery availability with coastal communities relocating to inland locations. Meanwhile Irwin (1991:507; Skelly 2014:506) suggests that external causal factors were responsible for change as ‘the response was local in that every regional instance was individual’. In contrast, Allen (2010) incites environmental change in which climate was affected by the El Nino-Southern Oscillation (ENSO) cycle which in turn may have had an impact on subsistence resources. Consequently, changes in occupational patterns and settlement systems were seen along the southern PNG coast (Skelly 2014:506).

While invoking environmental change may seem plausible, Skelly (2014:506-507) points out that with human settlements occurring in different habitats, varying subsistence resources would have been available, thus not all communities may have been ‘uniformly affected by regionally changing environmental conditions’. According to Skelly (2014:507), the Ceramic Hiccup signifies a change in the existing social system in which communities had previously moved to defensive locations just before the Ceramic Hiccup therefore implying that a rise in social tensions between communities resulted in withdrawals in inter-regional networks which were nearby pottery sources. Consequently, with a rise in conflict between communities (ceramic source and/or recipient), some groups continued to occupy certain locations (e.g. Amazon Bay-Mailu) but reduced or stopped long-distance travel whereas in locations further west, cultural interactions between communities was either drastically reduced or stopped (Skelly 2014:507). Overall, the Ceramic Hiccup as a period is important since drastic changes in occupation, social conditions and cultural exchange was demonstrated during this time and can be considered as a ‘regional period of re-adjustment’ (Skelly 2014:506).

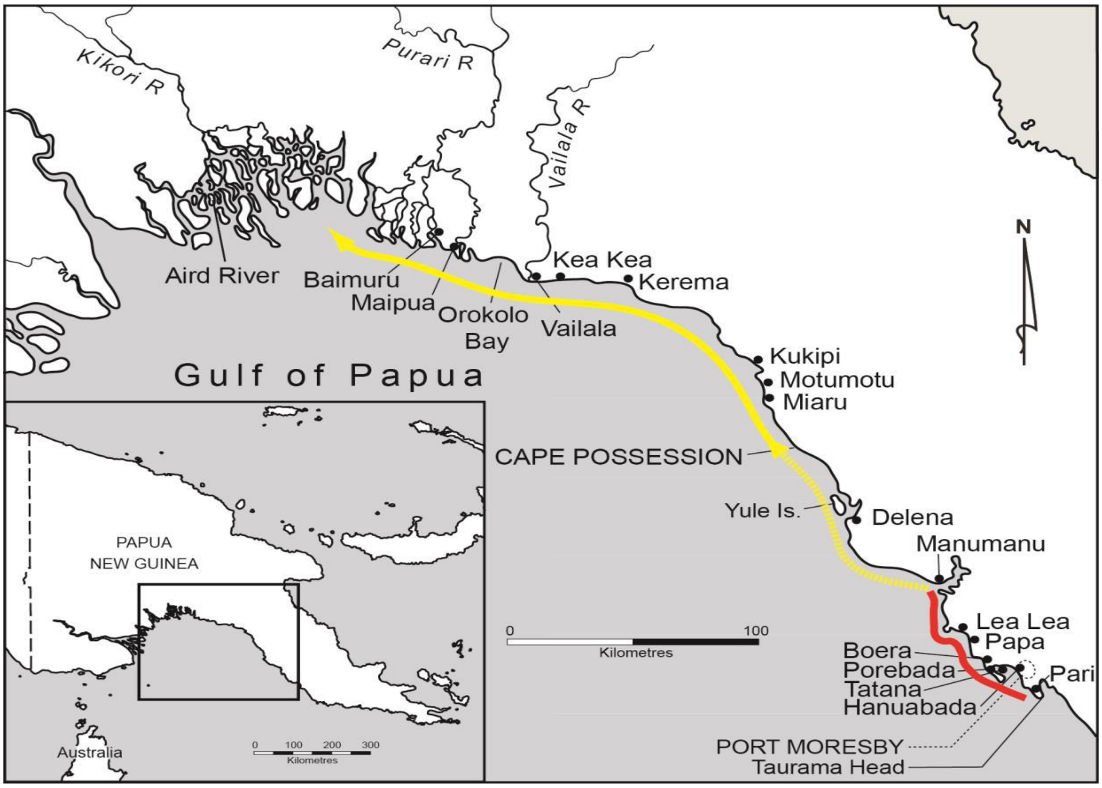

Figure 4.4. Route of the *hiri* trade system with source villages between Pari and Manumamu (red line) and destinations in the Gulf of Papua along Cape Possession (yellow line) (David *et al.* 2009; Skelly 2014:71).

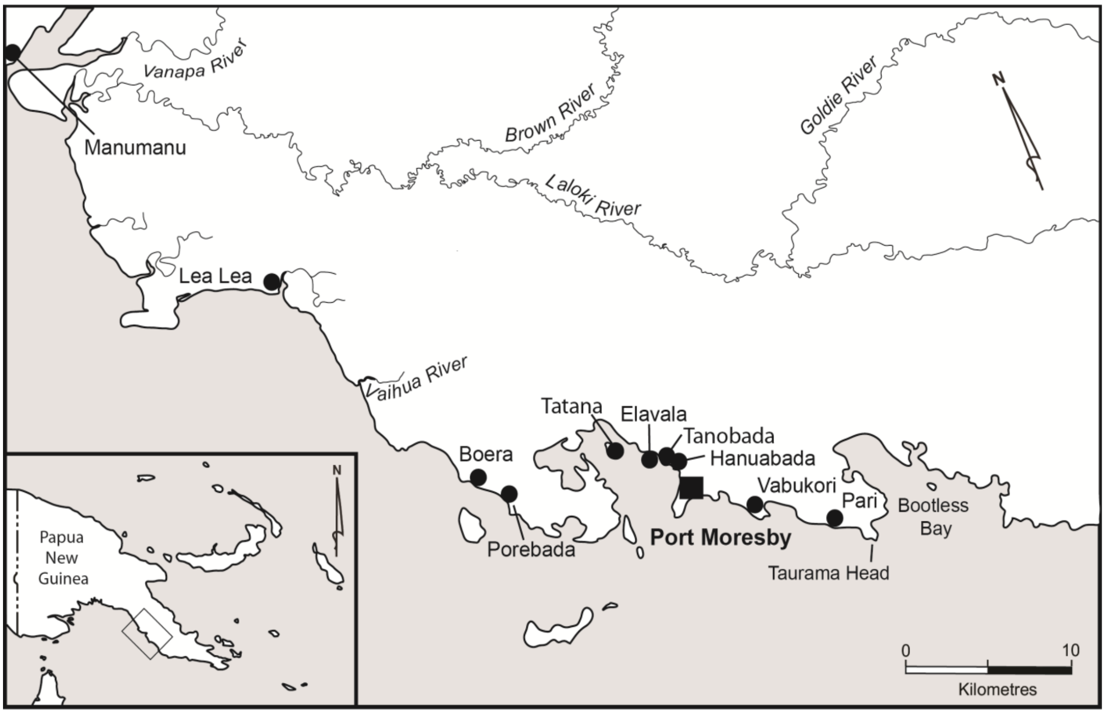

Figure 4.5. Location of Motu villages that participated in the *hiri* trade, in close proximity to Caution Bay (Skelly 2014:13).

Post Ceramic Hiccup

During the ensuing post-Ceramic Hiccup period from after around 700 cal BP, archaeological evidence shows a re-emergence of cultural activity along the southern PNG coast (Skelly 2014:508-510). Characterised by localised ceramic conventions in the Port Moresby, Yule-Island Sound and Amazon Bay-Mailu regions, this period signalled a new era of cultural interaction (Allen 1977b:449-450; Irwin 1985:87, 166; Skelly 2014:508; Vanderwal 1973:197-198). With growing evidence for ceramic use in the Papuan Gulf, cultural interaction between communities also increased after *c.* 500 cal BP and was similar 'to the geographic range of the ethnographic *hiri*' (Skelly 2014:508). Using ceramic evidence from the Kouri lowlands, Skelly (2014:509) suggests that increased cultural activity 'likely coincided with the development of relationships that ultimately led to the ethnographic *hiri*'. The *hiri* exchange system was first documented during the ethnographic period which involved pottery manufacturing Motu communities from the Port Moresby area and communities from the Gulf of Papua (Barton 1910; Chester 1878; Chalmers 1895; David 2008:466) (Figure 4.4). The main commodities exchanged during such trips were ceramic pots and shell artefacts from the Port Moresby region in return for sago and canoe hulls produced in the Papuan Gulf (David 2008:466). Trade expeditions were large with estimates ranging from 20,000 pots being exchanged for 150 tons of sago (Fort 1886:15) or even up to 500 to 600 tons of sago (Allen 1977c; David 2008:466). Trade voyages were regularly undertaken by Motu peoples with recipient villages acting as redistribution centres for other inland villages in the Gulf region (David 2008:466).

Understanding the late cultural traditions and exchange systems such as the *hiri* along the southern coast is particularly important for two reasons. Firstly, at present, Motu and Koita communities occupy the Caution Bay landscape, whose ancestors participated in the *hiri* trade system (Figure 4.5). This therefore means that communities along the southern coast were connected culturally, and this interaction may have dictated how the landscape and its resources were utilised. More importantly, the sites investigated in this study (e.g. Tanamu 1) have long-lived occupational sequences lasting up to the recent ethnohistoric period (see Chapter 9). Whether the role of an exchange system and ceramic production had any impact on shellfish subsistence therefore needs to be investigated. Nevertheless, it is evident that many of the changes seen in human activities reveal a picture of sophisticated cultural interaction along the southern coast with ceramics playing a major role in dictating how communities functioned.

Regional Trends in Marine Shellfish Use

In relation to human occupation along the southern coast, past archaeological investigations have also examined the role shellfish resources played in local subsistence economies. From examining the faunal remains from Nebira 4, Allen (1972:123) postulated that the subsistence economy of early settlers in the Port Moresby region was 'based on mixed hunting, agriculture and fishing'. However within such a broad subsistence economy at Nebira 4, more marine resources were exploited during the early stages of site occupation with 'a predominantly maritime economy, with enormous quantities of fish, sea mammals and shell fish consumed' (Bulmer 1971:57). This strategy to target greater numbers of marine resources was evident with early settlers as 'the subsistence patterns of these early migrants was oriented much towards the sea and the exploitation of sea resources, but that land hunting also contributed to the diet' (Allen 1977c, cited in McNiven *et al.* 2012a:145).

In line with these early observations, Swadling (1976) examined the contributions made by shellfish resources to local diet at the archaeological sites of Taurama and Motupore situated near Port Moresby. Taurama is a well-known site with pottery sequences occurring from around 2000 to 200 years ago whereas the occupational history at Motupore lasted from 800 to 200 years ago (Swadling 1976:156). Swadling (1976:156) envisioned that the shellfish assemblages from 'both sites should give some idea of the pattern of exploitation characteristic of an important coastal food supplement and famine sustainer during the time the *hiri* or Motuan trading expedition to the Papuan Gulf would have developed'. Results from an analysis of shellfish size and morphology showed that the first settlers at both sites 'were dependent on famine foods' relying heavily on natural resources with molluscs exploited in large numbers (Swadling 1976:161). Characterising shellfish as 'famine foods' is however problematic since such resources in certain locations were highly preferred and an economically viable option, a point which I discuss in subsequent chapters. Nevertheless, Swadling (1976:161) also demonstrates that at Motupore, evidence for predation pressures exerted on the gastropod taxa *Conomurex luhuanus* was present as the size-structure of this taxa was smaller than that of a natural non-exploited population. This trend consequently signalled no site abandonment, thus correlating with changes in pottery styles throughout the history of site occupation (Swadling 1976:161).

In contrast, at Taurama, while shellfish were an important economic resource that was heavily exploited during initial occupation by the earliest pottery makers, molluscs were still targeted in considerable numbers as site occupation continued but the level of exploitation started to decrease (Swadling 1976:161). This change according to Swadling (1976:161) was a result of the start of an exchange system in which ceramics, shell artefacts, chert and seafoods were traded for garden produce. While the later community at Taurama still exploited shellfish but at a lower intensity, it was postulated that late Taurama peoples may have incorporated new subsistence practices from their contact with other communities who produced garden surplus (Swadling 1976:161). A continued increase in trade activities within this region may have in turn resulted in the Motu exchange system or the ethnographically documeneted *hiri* (Swadling 1976:161). As well, at the time when the idea of a southern-coast Red Slip pottery tradition dating to around 2000 years ago and the subsequent change in stylistic conventions after 1000 A.D. was proposed, and found in other sites such as Eriama and Boera, it was assumed that changes in pottery making industries were representative of local occupation by successive communities (Swadling 1977:301). Makers of the Red Slip tradition occupied the area for over 1000 years, and according to Swadling (1977:301), 'were favoured by the environment and who departed only when it deteriorated, perhaps due to their own interference, or when competition drove them out'. After which, local settlements were seen as being alike before Motu peoples started a working economy in which a focus was placed on imported food (Bulmer 1971:81). Species such as *Strombus luhuanus* and *Anadara antiquata* were constantly exploited along the Pari to Taurama coastline where human occupation was continuous though people may not have always lived at just the same site since other sites were present in the vicinity (Swadling 1977:301-302). While the Red Slip tradition can no longer be accepted as an occupational marker (see above), Swadling (1976, 1977) demonstrates that shellfish were nonetheless an important subsistence option for local peoples throughout the antiquity of site occupation.

Swadling (1977) further explores the cultural importance of shellfish to local economies by examining the relative importance of certain taxa and their role in exchange systems. Given the variety of habitats and the prevalence of certain species in each habitat type, shellfish were traded for subsistence and as artefacts (Swadling 1977:294-295). Artefacts such as cone shell ornaments were highly valuable items because of their aesthetic value together with the difficulty in finding larger individuals of this taxa (Swadling 1977:294). Observations made during the historic period also emphasised the importance of shell ornaments such as the *toea*, armshells manufactured using large cone shells (Swadling 1977:295). Originating from the Milne Bay Province, these shells eventually reached communities in the Port Moresby area following trade exchanges (Swadling 1977:295). Together with artefacts locally manufactured by Motu peoples using shells derived from local reefs, such commodities were used in transactions for bride price, or more importantly, as exchange goods in the *hiri* trade system (Swadling 1977:295). The importance of shell artefacts can be exemplified by their value in trade exchanges with a *toea* worth 110-350 kg of sago while a large pot was only worth 40 kg of sago (Barton 1910:115). Other than for artefacts, shellfish were also traded for subsistence purposes as seen from archaeological evidence (Swadling 1977:295). For instance, the presence of certain taxa from mangrove and coralline or rocky shores within the deposit at the inland Obu site attests to the trade of edible shellfish species (Swadling 1977:295). This practice has been documented in contemporary PNG, with species such as *Gelonia coaxans* being traded by Delena villagers for agricultural produce and lime with the inland Mekeo peoples (Swadling 1977:295).

While the hypotheses proposed by Swadling (1976, 1977) needs to be investigated further, the main point here is that shellfish were often targeted in large numbers by ancient communities in the Port Moresby region. While Swadling had undoubtedly made major contributions on understanding shellfish use in this region, the problem with many of the interpretations made by early researchers such as Swadling and Allen, is that changes in subsistence were linked to human settlement patterns determined by pottery traditions and exchange networks. With the recent re-evaluation of the EPP (see above), a re-modelling of shellfish subsistence has to be undertaken in relation to new cultural chronologies identified for the southern Papuan coast. Furthermore, even though these early pioneers sought to answer key questions on subsistence economies of past peoples, another problem here is the paucity of detailed descriptions for shellfish subsistence in relation to updated palaeoenvironmental records for Caution Bay. Rather than mere descriptive accounts of data, a more in-depth analysis of shellfish exploitation is thus required.

In recent times, research programmes initiated by David (e.g. David *et al*. 2010) have shed more light on past subsistence economies following fine-grained excavations of several sites along the southern coast, therefore allowing for better documentation of chrono-stratigraphic trends in cultural practices. Results from these investigations (e.g. David *et al.* 2010) have not only revealed a mixed subsistence economy, but also the importance of shellfish to local diet in the past. For example, at the Emo site (Samoa) in the Kikori River Delta of the Gulf of Papua, a larger number of shellfish remains were excavated and according to David *et al.* (2010:46) were representative of 'constant and reliable if not voluminous contributions to the diet'. Essentially, the reliance and heavy exploitation of shellfish for subsistence during site occupation was further supported from evidence of predation pressures being exerted by local peoples in relation to the wider social setting (Thangavelu *et al.* 2011).

Further east at Edubu 1, a terminal Lapita site situated inland within the Caution Bay area, analysis of the faunal assemblage shows that the subsistence economy of people at this location included both terrestrial and marine resources, hereby corresponding with previous claims made by Allen (1977b) (McNiven *et al.* 2012a:145). Since Lapita peoples have often been characterised as 'marine specialists', evidence from Edubu 1 demonstrates that people during the terminal Lapita period had a more mixed subsistence economy than other nearby shore-line sites such as Bogi 1 where more marine resources were targeted (McNiven *et al.* 2011, 2012a). The choice to have a mixed subsistence economy in this instance may be a result of the site's location which was 1 km inland from the shoreline (McNiven *et al*. 2012a:146). However, as Edubu 1 dates to ca. 2600-2650 cal BP (terminal Lapita), and is within the broader identified Lapita phase at Caution Bay (2900-2600 cal BP), a degree of variation in subsistence practices ranging from a mixed to more marine based economy between sites demonstrates that 'a complex and diverse subsistence pattern existed for terminal-Lapita pottery-using peoples, whereby the ratio of terrestrial to marine foods in diets varied depending on context and site location' (McNiven *et al.* 2012a:146).

Archaeological Implications

Archaeological sequences along the southern Papuan coast depict a highly complex ancient scenario where a mosaic of activities revolved around cultural interaction and ceramic production. Recent finds indicative of a new Lapita Horizon has not only extended the ages of pottery traditions but has also led to a re-modelling of previously held ideas on ceramic production and exchange. At the same time, the antiquity of human occupation has more than doubled with evidence from certain sites such as Bogi 1 and Tanamu 1 clearly demonstrating the presence of coastal human settlements long before the in-migration of pottery-making Lapita peoples at 2900 years ago. This is further supported by evidence from Kukuba cave for mid-Holocene human occupation in the region (Vanderwal 1973). This extended cultural chronology for the southern Papuan coast means that there is 'considerable scope to understand changes in landscape engagements and transformations associated with the arrival of Lapita colonists 2900 years ago' (McNiven *et al.* 2012a:150). Since Lapita peoples were often the first colonists in other areas within Remote Oceania, the process of interaction and its manifestations in the archaeological record at Caution Bay needs to be examined as human settlements had already previously transformed this landscape (McNiven *et al.* 2012a:150). Hence, engagement and emergence of Lapita settlements at Caution Bay according to McNiven *et al.* (2012a:150-151) 'was a more complex, negotiated process compared with Remote Oceania, as it involved interactions with existing social and environmental landscapes'. As different communities had their own cultural practices, the manner in which interaction between locals and immigrants took place needs to be investigated.

Examination of trends in subsistence practices along the southern coast not only highlights the importance of shellfish, but also the variability in practices between communities. While it can be assumed that shellfish consumption may have been an integral part of local subsistence strategies for coastal communities, it is also important to acknowledge the role other non-marine food resources may have had, especially in relation to settlement location (e.g. inland), and exchange networks (e.g. garden produce). Thus, when analysing shellfish assemblages, factors such as proximity of marine resources, distribution and the availability of non-marine foods needs to be taken into consideration so as to better understand the transformative processes (e.g. Lapita to Post-Lapita) that may have eventuated over time. Since shellfish assemblages from two coastal and one inland site will be analysed for this study, the points raised above will be addressed in the discussion chapter. Another primary feature of many of these early studies is the association between ceramic traditions, and by extension their perceived influence on local occupational patterns with subsistence practices. Even though it has been well-demonstrated that shellfish remains have been used as a proxy to better understand human settlement and exchange, this issue will be explored further throughout this thesis.

Archaeology of Lapita

The archaeology of the Western Pacific has been of foremost interest in the last 60 years, as research has brought to light the dynamic nature of sea voyaging and island settlement by marine specialists during the prehistoric era. Coined as Lapita following excavations by E.W. Gifford of a beach site which was locally referred to as 'Lapita' by native inhabitants from the Koné Peninsula of New Caledonia, the Lapita cultural phenomenon spanned an area from as far east as Polynesia to as far west as Melanesia and Micronesia (Kirch 1997:8). As there is new conclusive evidence for in-migration of Lapita peoples into a Caution Bay landscape that had already been occupied, models for Lapita colonisation needs to be addressed to provide a framework for understanding this cultural 'contact' event. While Lapita ceramics undeniably represent the major focus of many past investigations, my aim here is to instead provide a brief discussion of colonisation models and key aspects of Lapita settlement and subsistence patterns. By doing so, it is envisioned that this section will provide a framework for understanding 'contact' and subsequent transformative processes at Caution Bay in relation to the shellfish analysis that will be undertaken in this study.

Models for Lapita Origins and Colonisation

Originating from the northeastern edge of PNG, in the Bismarck Archipelago, archaeological evidence has established the *c.*3350 cal BP antiquity of the Lapita cultural complex (Anderson 2001; Anderson *et al.* 2001; Bedford and Sand 2007; Carson *et al.* 2013; Kirch 1997; Lilley 2000; McNiven *et al*. 2011; Pawley 2007; Specht and Goden 1997; Spiggs 1997; Summerhayes 2000, 2001) (Figure 2.1). As sites in the Bismarck Archipelago represent the earliest known evidence of Lapita, this area has also been referred to as the 'homeland' of Lapita, from which a complex culture expanded east to colonise the Western Pacific region (Kirch 1997; Spriggs 1997). The colonisation of the region encompassing Melanesia, Micronesia and Polynesia was a rapid event and by *c*.3000 cal BP, even islands extending as far as Tonga and Samoa in the far reaches of the Western Pacific, were inhabited by Lapita peoples (Kirch 1997; Spriggs 1997). Yet, even though evidence from the archaeological record has established the Bismarck Archipelago as the 'homeland' of Lapita, the emergence of Lapita in the Bismarcks, eventually spread to other locations and interaction in Oceania has been widely debated with arguments being articulated around models of either internal or external causes (Kirch 1997:48; Spriggs 1997).

Proponents of models framed around internal origins of Lapita, otherwise referred to as 'indigenists' by Spriggs (1997:72) have hypothesised the idea that Lapita culture was a phenomenon that developed internally within the Bismarck Archipelago (Spriggs 1997:72). Additionally, external factors outside of the Bismarck Archipelago, primarily from Southeast Asia, did not provide any contribution to the development process (Spriggs 1997:72). As mentioned by indigenists Peter White, Jim Allen and Jim Specht (White *et al.* 1988:416 cited in Spriggs 1997:72),

> It is now clear that the basic developments that lay behind the Lapita cultures occurred within the Bismarck Archipelago . . . There is, indeed, no need to believe in migrations at all: pottery technology may just as well been acquired by Bismarck inhabitants in the course of their voyaging in the Western Pacific 4,000 years ago.

One of the central points of argument in the indigenous model also highlights that prior to the production of Lapita pottery, shell and bone technology, domestic plants and animals, watercraft and voyaging were already available within the Bismarck Archipelago thus allowing for future *in situ* development of Lapita culture (Allen and White 1989:141, Spriggs 1997:72). However, more importantly, indigenists rejected the combined use of human biological and linguistic evidence with archaeological data to understand the origins of Lapita, therefore providing a limitation to their model (Spriggs 1997: 72).

On the contrary, proponents of different external or exogenous models have discussed the role of intrusion and the link with Southeast Asia in contributing to the development of the Lapita culture complex (Spriggs 1997:72). Labelled as the Fast

Train, Slow Train and Triple I, these models were based on the general notion revolving around emigration by peoples from island Southeast Asia into the Bismarck Archipelago but with some notable differences (Skelly 2014:496). The first is the Fast Train model in which Austronesian-speaking Southeast Asian peoples in possession of Lapita material culture travelled to the Bismarck Archipelago where they settled before continuing to quickly move east into other parts of the Western Pacific (Kirch and Hunt 1988:165). Using radiocarbon estimates, it was envisioned that first settlement at the Bismarcks was just before the occupation of Fiji some 3000 km east and therefore this quick Lapita colonisation event was seen as archaeologically instantaneous (Kirch *et al.* 1987; Kirch and Hunt 1988; Summerhayes 2000:111). While this model explains the similarity in material culture found throughout the western Pacific, other aspects of Lapita material culture (e.g. domestication, Austronesian languages) were hypothesised to have originated from Southeast Asia (Summerhayes 2000:111). Additionally, isolation of populations was seen as the contributing factor to changes in ceramic conventions (Summerhayes 2000:111). Therefore, following colonisation of different localities, Lapita colonists started 'to fragment into smaller regional entities with local patterns of communication and interaction between settlements' (Summerhayes 2000:111). Evidence for this pattern comes from the colonisation of Fiji, Tonga and Samoa where after colonising, the sea gap between these islands and Vanuatu acted as a barrier which in turn led to two-way travel becoming less regular (Green 1979; Summerhayes 2000:111). Using this barrier, ceramic conventions between the regions were differentiated from one another (Eastern and Western styles) as isolation meant that communication was reduced (Green 1978:11). While similarities in early stylistic conventions were indicative of interaction between communities, subsequent changes were due to 'isolation and local stylistic divergence' (Kirch 1988:105 cited in Summerhayes 2000:111).

The main difference with the Slow Train model was that even though Southeast Asian peoples ventured into the Bismarcks, an extended temporal settlement of some 300 years allowed for the development of Lapita culture traits in the Bismarcks before moving out to other parts of Remote Oceania (Summerhayes 2000:112). Using the basic premise of this model, Green (1991) proposed an alternative with a Triple I model comprising of three distinct stages: Intrusion, Innovation and Integration. Intrusion accounts for the movement of Austronesian speaking Southeast Asian peoples and their material culture into the Bismarck Archipelago (Green 1991; Skelly 2014:496; Summerhayes 2000:112-113). After which, new developments occurred with Innovations and from Integrating with indigenous peoples, Lapita material culture developed following interactions during the course of movements east into Remote Oceania (Summerhayes 2000:113). According to this model, Southeast Asian peoples may have incorporated certain aspects of local material culture while stopping in the Bismarcks and may have tried 'to adapt to an area with a complex continental island environment, which possessed a wide range of resources' (Green 1979:45 cited in Summerhayes 2000:113).

Another model proposed by Groube (1971:312) was that the eastward expansion of Lapita culture can best be described as 'strandloopers' because of the reliance on littoral resources for subsistence. Using settlement patterns which were restricted to beach fronting areas and the large amounts of shellfish remains recovered from archaeological sites, this idea was proposed for colonisation and expansion (Groube 1971; Skelly 2014:496). While the exogenous models for Lapita colonisation and expansion suggest a 'wave- or waves-of-advance' event (Skelly 2014:496), Lapita expansion could instead be classified as a 'leapfrog' in which 'Lapita peoples leapfrogged occupied and unoccupied areas' by chance or accident and this event was not systematic (Sheppard 2011:799, 818). Of all the models, the Triple I model is the most commonly accepted by researchers (Pawley 2007:19; Skelly 2014:497). The development of Lapita can best be summarised by Bedford and Sand (2007:3):

> ... the Lapita phenomenon was likely to have involved a myriad of complex contact and interaction situations over centuries, with varying and changing outcomes depending on the place and the time, as is the case with all migratory events that arrive on the shores of already occupied beaches.

The above discussion of models for Lapita development and colonisation provides an interesting dimension to what may have occurred at Caution Bay in regards to shellfish subsistence. As the temporal range for Lapita settlement (2900 to 2600 cal BP) indicates a prolonged settlement event taking place, with numerous beach-fronting sites (e.g. Bogi 1, Tanamu1) appearing, a scenario in line with a Slow Train or Triple I model may have eventuated, especially when an indigenous population was already present. How this complex contact, or mutually negotiated process may have eventuated will be explored in relation to the discussed models and shellfish results in Chapter 12.

Settlement Patterns and Subsistence

A reoccurring pattern in Lapita settlements across the Western Pacific is the preference seen for occupying beach-fronting locations. According to Kirch (1997:163), approximately '80 percent of all known Lapita sites are situated on geomorphologically similar environments: beach terraces constructed of unconsolidated calcareous sand and coral reef debris'. Even though some of these sites are now situated further inland, it was noted that sites were in fact located much closer to the sea in the past when there were higher sea levels (Kirch 1997:163). Increase in sea levels occurred during the Holocene from 10,000 years ago to around 4,000 years ago where it reached the high stand mark and remained stable before decreasing around 2,000 years ago (Kirch 1997:163). It is during this high sea level phase (4,000 to 2000 years ago) that Lapita sites appear in the archaeological record following dispersal from the Bismarck Archipelago (Kirch 1997:164). While a few rockshelter sites were recorded, some situated further inland, at the time of occupation these sites were on the coast (Kirch 1997:165). In addition to beach-fronting locations, a number of other common trends were evident with Lapita settlement patterns. All sites were located in areas that faced passages in the reef, which in turn would have allowed for canoe travel (Kirch 1997:165). As well, a large number of sites were in areas where either a lagoon or a broad fringing reef and barrier reef, or a combination of both were present (Kirch 1997:165). Even though settlement patterns may have been dictated by marine resources, another primary resource found in close proximity in most contexts was freshwater (Kirch 1997:165-166). Settlements varied in size, and while it may be archaeologically difficult to extrapolate the full size of each settlement at a particular location, it is important to note that there was much variation. From analysing 36 sites, Kirch (1997:167) states that Lapita settlement size can be divided into three main clusters. While large sites measuring at least 82,000 m^2 are few, two-thirds of sites were smaller than 5,000 m^2 while the remaining eight sites were between 9,000 and 15,000 m^2 (Kirch 1997:167). In turn, from using ethnographic descriptions of houses in Oceania, it is likely that smaller Lapita settlements were represented by 1 to approximately 10 houses with an open space for other structures (e.g. canoe sheds, cookhouses) (Kirch 1997:167). This figure is minute in contrast to medium-sized settlements where 15 to 30 dwellings which may be classified as a village whereas in the large settlements, as many as 150 or more dwelling may have been present (Kirch 1997:167). Therefore, while Lapita settlements may have varied in size, the important point here is that beach terraces were the preferred location for settlement.

By choosing to occupy elevated beach terraces, Lapita peoples were adequately placed to exploit a rich diversity of marine resources, particularly fish and shellfish (Kirch 1997:164). With changes in the environment, it also meant that more resource zones (i.e. habitats) became available (Kirch 1997:165). In assessing the importance of marine resources, extensive evidence shows that both fish and shellfish were targeted with deposits from most sites containing considerable amounts of shellfish, sea urchin, crab, turtle, shark and fish remains corresponding to a wide diversity of habitat types (Kirch 1997:197). While diversity in marine resources was demonstrated, only a few species dominated an assemblage (Kirch 1997:197). Resources such as shellfish were particularly important because they were exploited for food and as raw material for artefact production (Kirch 1997:199). Particular examples of Lapita artefacts made out of shellfish include *Trochus* fishhooks together with ornaments and exchange goods made out of large cone shells and *Spondylus* bivalves (Kirch 1997:199). Even though substantial quantities of shellfish were found in Lapita faunal assemblages, Kirch (1997:199) states that 'their contribution to the Lapita diet was probably relatively low. Rather, it was the abundant fish stocks of the inshore reef and lagoons that seem to have provided the greater share of meat and protein'. While Kirch (1997:199) cites that 'coral reefs are great biological "factories"' with inshore fish species being the main contributors to daily diet, the idea that shellfish were perhaps not a significant part of daily dietary requirement is a proposition that needs to be tested. This is further warranted following evidence for human predation effects on molluscs elsewhere at the Tongatapu site (Spennemann 1987). Nonetheless, as 'marine specialists', Lapita peoples relied heavily on the sea for a range of resources that would become an integral part of their subsistence strategy. Because the aim of my thesis is to analysis shellfish remains, I will not be discussing other aspects of Lapita subsistence in great detail, but other than a focus on marine resources, it is important to note that the Lapita subsistence repertoire also consisted of terrestrial fauna and gardening activities (Kirch 1997:203).

The Regional Problem

Long-lived cultural chronologies along the southern Papuan coast evident by the presence of pre-Lapita, Lapita and post-Lapita sequences present a unique opportunity to explore changes in shellfish subsistence across all three phases. A re-evaluation of previously held ideas on occupation and cultural exchange across the region means that a re-modelling of shellfish subsistence is required. Past archaeological investigations have brought to light the ongoing cultural interactions that took place over an extended period of time together with distinct changes in ceramic traditions, all of which demonstrate the presence of a complex social system in place. Therefore, if cultural interaction and transformative changes in ceramic traditions are the main archaeological markers, then the question here is how can such changes in social circumstances, pottery and occupational patterns be examined using shellfish remains. Crucially, during the identified periods of change (see above), the following problems need to be addressed:

- How did Lapita people interact with local populations following contact and did this change alter existing patterns for occupation and shellfish consumption (e.g. population increase)?
- Were there any significant changes in mollusc exploitation following the end of Lapita occupation (post-Lapita) and the subsequent transformative phases, especially during the *Ceramic Hiccup* phase.

Additionally, these problems need to be addressed in relation to models for Lapita colonisation and expansion, and the newly proposed post-EPP chronological sequences. Likewise, as the peoples of the southern coast and the Lapita cultural complex were probably ‘marine specialists’ thus focusing their subsistence economy on marine resources (e.g. fish and shellfish), the contribution of shellfish to local diet needs to be determined. This is particularly important since, in some cases, terrestrial fauna and gardening activities were seen to also be a significant component of a mixed subsistence economy. With phrases such as ‘famine foods’ and ‘relatively low’ contribution to local diet, the importance of shellfish consumption needs to examined. Moreover, while early researchers focused on pottery traditions and addressed shellfish subsistence in relation to these traditions, these archaeological investigations did not provide an in-depth detailed analysis of shellfish assemblages, particularly when interpretations were based on models with significant methodological limitations. Likewise, with refined chronologies and more recent excavations, Caution Bay holds the potential to reassess major patterns for human land and resource use. By analysing the shellfish assemblages from three sites, this thesis will seek to address the key problems discussed above and also provide a much needed re-modelling for shellfish subsistence in relation to Lapita and subsequent occupational phases along the southern Papuan coast.

Chapter 5 – Molluscs in Ethnographic Research

Introduction

Shellfish are amongst the most common and well preserved material remains found in coastal archaeological sites. Thus researchers have attempted to address specific questions relating to shellfish that range from alterations in human behaviour in relation to wider environmental changes during the Holocene (e.g. Barker 2004; Beaton 1985; Faulkner 2013) to the importance of shellfish as a raw material for artefact production and use in various cultural activities (e.g. Szabó 2010). The significance of shellfish, especially in regard to its importance to the subsistence economy of coastal peoples has been a point of contention in coastal archaeology (Msemwa 1994:1). While one camp considers shellfish gathering to be a minor fallback resource representative of a human population experiencing protein stress and therefore a source of sustenance that is inferior when compared with other types of food (Bailey 1975; Msemwa 1994; Osborn 1977), others have advocated a different view in which molluscs are seen as an easy and reliable resource that is readily available within certain environments (Erlandson 2001; Jerardino 2012; Jerardino and Marean 2010; Meehan 1982; Msemwa 1994; Yesner 1987).

The views of the former can be attested to in some studies whereby other resources may have been a more economical choice when compared to molluscs in terms of total meat weight to raw numbers ratio (Bailey 1975; Msemwa 1994). For instance, a single large resource (e.g. Dugong) would have provided much more meat and been a more efficient subsistence target in contrast to gathering hundreds of shellfish which could require more investment of time and labour to collect but can be reduced to some degree by mass-harvesting (Barker pers. comm. 2013; Braje and Erlandson 2009; Jerardino 2012; Whitaker 2008). Even though this may be true in some instances, the incorporation of molluscs into subsistence strategies may be equally efficient in areas where they are readily available and highly predictable even during seasonal climatic cycles (e.g. Meehan 1982; Mesemwa 1994). As well as this, shellfish can be used as a raw material for tool/artefact production which can then be utilised in various activities (e.g. fishhooks, scrapers). Other benefits of molluscs range from ceremonial use, manufacture of ornamentation, to use in trade activities/bride price etc. Shellfish are therefore a multi-faceted resource with potential benefits and high levels of molluscs exploitation may possibly have been due to their predictability, availability and multiple purposes for which they can be used. While the order of preference placed between economic shellfish taxa needs to be assessed with caution, especially when exploitation of certain species may yield higher returns in relation to meat weights, the point here is that mollusc resources were potentially important for more than just subsistence reasons. Thus, it is clear that the study of shellfish from coastal sites can provide a significant scholarly contribution to archaeological research. Given the focus of this study is to examine specific questions relating to cultural change at Caution Bay (see Chapter 1), this chapter will review previous ethnographic research on molluscs that relate to this study in order to understand:

- How and why shellfish were exploited in the ethnographic present.
- The way environmental changes may impact mollusc collection behaviour among humans.
- The multiple purposes for which shellfish can be used.
- How shell middens can inform us about the human past.
- Shellfish variability in the archaeological record.
- The significance of molluscs to humans.

Regional Ethnographic Observations

Ethnographic and ethnoarchaeological approaches to mollusc exploitation have shed light on key points that are of interest to this study. As such approaches have been applied to geographic areas that exhibit varying cultural and environmental patterns, attention needs to be paid to regional rather than global examples. Focus will be directed at research from the western Pacific region in relatively close proximity to Caution Bay since these areas are more similar in environmental, ecological and climatic conditions and in the taxa of shellfish that inhabit these landscapes. While an ethnographic study of shellfish exploitation at Caution Bay was not undertaken for this research, I will attempt to incorporate those ethnographic sources derived from areas of close proximity to the study area during analysis of the archaeological datasets so as to better understand variability in mollusc remains and past subsistence strategies at this location. This research will aim to use such evidence to better understand mollusc variability and richness for making holistic predictions about the social, economic and political spheres of human behaviour at Caution Bay, particularly when shellfish may have been used for both subsistence and non-subsistence purposes (e.g. economic transactions, trade, artefact production) (see Chapter 3) . Even though applying a similar approach needs to be handled with caution since there is no direct ethnographic data of shellfish exploitation at Caution Bay, it is still theoretically possible for such an undertaking (Bird *et al.* 2004:195; Stiner *et al.* 2000).

Northern Australia

One of the most extensive studies on shellfish gathering was undertaken in northern Australia by Betty Meehan during the 1970s. Working with the Gidjingali language speaking people, in particular the Anbarra, in Arnhem Land, Northern Territory of Australia, Meenhan's classic ethnographic study of the role of shellfish within the subsistence economy of local peoples revealed several important patterns associated with molluscs exploitation (Meehan 1982) (Figure 5.1). The typical climate in Arnhem Land can best be described as an Asiatic monsoon system with wet (transition months of October and November to April) and dry (June to October or November) seasons occurring at different times within a calendar year (Meehan 1982:22). During the course of fieldwork, slight changes from the ordinary climatic cycle were recorded with an extended wet season that lasted to June (Meehan 1982:25). While it might be expected that such weather patterns (similar to Caution Bay) may have impacted natural shellfish beds through natural events such as cyclones and therefore have subsequent implications for exploitation of these resources (see Meehan 1982 re- implications), local people continued to incorporate molluscs into their subsistence practices.

Occupying the landscape through home bases, and other sites referred to as 'dinner-time camps', local inhabitants exploited a wide range of molluscan taxa from three major environmental zones comprising rocky coasts, mangroves, open-sea beaches of sand and mud flats (Meehan 1982:26-59). Patterns of predation were selective and focused on multiple bivalve and gastropod species corresponding to a total of 30 taxa (Meehan 1982:59) (Table 5.1). Gathering of these taxa took place during both dry and wet seasons with 44% and 67% of days respectively from a total of 194 days of gathering (Meehan 1982:64). Peaks in gathering were a result of the occurrence of king tides which allowed for large quantities of collection from open-sea beds (Meehan 1982:67). The patterns of exploitation associated with both seasons paint a contrasting picture on the reliance of shellfish. Of particular interest is the wet season during which more time and focus is directed at molluscs together with relatively high levels of exploitation (% weight per month) (Meehan 1982:68). While patterns of predation differed between seasons, Meehan notes that mollusc beds, in particular bivalves, can be affected by major environmental events such as a cyclone which can wipe out an important shellfish resource (1982:163). In such scenarios, local people focused on other food sources but were confident that the mollusc beds would recover since such events had taken place previously and molluscs were able to re-colonise (Meehan 1982:164). Consequently, these trends demonstrated that mollusc exploitation was a reliable and constant activity even during seasonal cycles and adverse environmental events, thus representing a staple food source for local peoples (Meehan 1982:68).

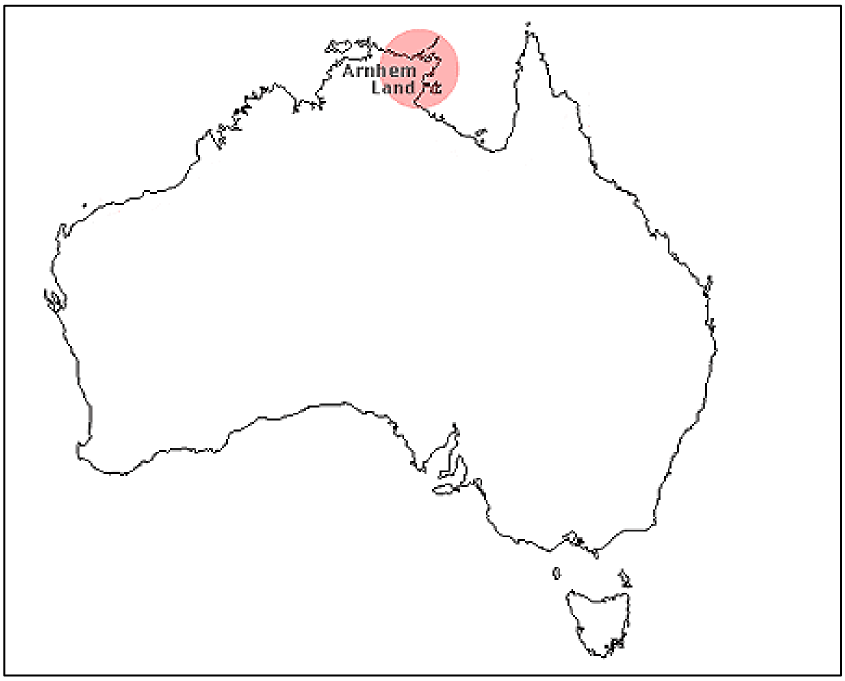

Figure 5.1. Map of Arnhem Land, Northern Territory, Australia (iDiDj Australia).

In addition to seasonality, two other main inter-related factors affected shellfish gathering, these being distance between mollusc beds and home bases, and ceremonial commitments (Meehan 1982:66). From observations, it was well-demonstrated that distance may have been a key factor. For instance, in camps which were as far as 12 km away from the shell beds, approximately 10% of foraging days were allocated for molluscs when compared with 70.5% at another camp that was 1 km away from coastal beds (Meehan 1982:66). Ceremonial commitments played a significant role in foraging strategies as evidenced at Ngalidjibama (1 km from the sea and 3 km from primary shellfish source) where during 86.5% of the days observed, shellfish were gathered to accommodate a ceremonial event even during the non-favourable dry seasonal cycle (Meehan 1982:66). According to Meehan, this foraging strategy was needed in order to account for population increase and the task was undertaken by women since men were in secret camps and were busy with ritual preparations (Meehan 1982:66). Division of labour and responsibilities was therefore clearly evident within the community as women were not only tasked with the duty for providing sustenance for an entire community but were also willing to travel the distance required to collect shellfish so as to meet their obligations during the Kunapipi ceremony, thus deviating from normal activities associated with mollusc harvesting (Meehan 1982:66-7). However, it must be noted that distance was not always a determining factor since molluscs were also important at another location where rich mussel and oyster beds were at least 5 km away (Meehan 1982:66). Additionally, more shellfish were collected at Ngalidjibama which was at least 3 km away from the shell beds compared to Lalarr-gadjirripa which was within 1 km of molluscs resources (Meehan 1982:66).

As well, bivalves were favoured over gastropods (98% vs 2%), with most gathering activities focusing on bivalves and gastropods collected in small numbers during such trips (Meehan 1982:69). Gathering of bivalves was selective and focused, with only one species targeted on most days (Meehan 1982:70). These were gathered using different methods that varied according to species and environmental conditions, with the molluscs placed in traditional containers (Meehan 1982:71). Likewise, when focusing on a specific species (e.g. *Marcia hiantina*), only larger individuals were targeted and any smaller shells were discarded (Meehan 1982:133). Hence, collected samples during a trip were mostly of the same size based on a collection strategy focusing on larger shells and from gathering within a particular shell bed (Meehan 1982:133). This trend in shellfish size-selectively is however not restricted to the Anbarra as it has also been noted at other locations (Bailey 1993; Bourke 2002). Furthermore, in another example, Meehan noted that larger shellfish were collected from an area that was not previously exploited as a result of tidal changes (Meehan 1982:134). Shellfish gathering as an overall activity was efficient when compared to other foraging strategies such as goanna catching and yam digging, because it did not require much physical strength, skill or use of energy (Meehan 1982:159). Likewise, the duration of time allocated to mollusc gathering was only about two hours each time from which a skilled woman was able to collect approximately 2000 kcal worth of shellfish since such resources were ‘there for the taking, like the food on a supermarket shelf’ (Meehan 1982:159-60). However, rather than attributing to size selection, Meehan argues that larger shellfish instead reflect the degree of resource availability in the environment (1982:135). While Meehan goes into specific details of collection between taxa, there were three overall patterns that emerged from her study (1982:80),

- The wide range of mollusc taxa, while present, were not particularly targeted in large numbers because only a few species were favoured and selected.
- Other species with low weights seem not to have played an important role in the diet but were nonetheless still a minor dietary component as they were collected as tidbits to provide variety in diet. For instance, before a main course of bivalves, some gastropods were consumed. In addition, these were also collected when ideal conditions occur.
- The gathering of molluscs corresponds to lunar and annual climatic cycles, and in relation to availability of certain taxa and changes in tidal conditions.

After collection, molluscs were then prepared for consumption either back at home bases or dinnertime camps (Meehan 1982:86). Cooking normally involves the use of fire with shellfish carefully stacked against each other and only cooked for a short period of time (Meehan 1982:87). Some other species were instead cooked in boiling water (Meehan 1982:87). Other than cooking, shellfish, especially larger gastropods were also used for other purposes, such as water containers (Meehan 1982:106). Disposal patterns are of particular interest to this project because of the nature in which archaeological shell middens are formed. With the Anbarra, Meehan (1982:112) noted that mollusc shells were disposed of after consumption and were associated with three types of sites, dinnertime camps, home bases and processing sites. Dinnertime camps were located under trees on or in close proximity to beaches around the river mouth, were adjacent to shell beds, with some being used only once while others were used multiple times (Meehan 1982:112-4). These sites had a simple structure, were in most times only occupied once mainly comprising of a cleared area with one or two hearths and discrete amounts of mollusc and other remains on the edges of the camp (Meehan 1982:114). Molluscs remains associated with dinnertime camps are of those from adjacent beds (Meehan 1982:114). On the other hand, home bases were used repeatedly over a period of time that lasted months or years, thus illustrating continued occupation or use of the site (Meehan 1982:114). Just like dinnertime camps, remains are deposited on the edges of each hearth complex (Meehan 1982:114). Food is cooked on one of the hearth complexes and left there for a period of time before being moved and dumped in different areas on the margins of the hearth complex, with this activity leading to an accumulation of debris over time (Meehan 1982:114). Meanwhile, at processing sites, the gathered shellfish were cooked at the location from which they were collected, with only the flesh being transported back to the home base in most instances while the shells were discarded locally (Meehan 1982:117). A typical feature of such sites is the prevalence of a single taxa (Meehan 1982:117). Hence, shell remains found at home bases only represent a minute fraction of all shells that were consumed (Meehan 1982:117).

The importance of molluscs to the Gidjingali people was well-known, however, shellfish only represented a part of a dynamic overall diet which included fish, crustacean, reptiles, birds, mammals, nuts, fruit, vegetables, honey and bought European foods (Meehan 1982:147). Having such a wide dietary range was needed to regulate an individual’s health, in particular to meet daily requirements of protein, vegetable, fat and so forth (Meehan 1982:140). Again, even with such a variety of food choices, shellfish were still very important because they were dependable and stable, while the other food sources were less predictable and in the case of meat (e.g. Dugong, turtle) could only be consumed for a short period of time since no storage technology was present, thus rendering the meat not fresh after a few days (Meehan 1982:140). On the contrary, if analysis of meat weight and energy contributions were considered, molluscs were no more than a supplementary source of food (Meehan 1982:159). Yet, they were consistently available when needed as evident from the number of days devoted to collecting them. Shellfish harvesting was similar to fishing with both activities being more common than any other type of foraging or hunting activity (Meehan 1982:159). Molluscs exploitation was also a much easier activity compared to hunting and was hence much more efficient in terms of quantities that could be gathered (Meehan 1982:159). Relative importance of shellfish was exemplified by the strategic placement of base and dinnertime camps close to shell beds (Meehan 1982:159). Other than edible flesh, vegetable foods were more dependable and constituted a major component of local diet even though they were seasonally constrained in terms of availability and abundance (Meehan 1982:151). In terms of nutritional contributions, even though molluscs only contributed 17% of the total energy intake, they were continuously collected and were a constant source of protein and as stated by Meehan 'at no time during the year were shellfish more than a supplementary food in the diet' (1982:159-60). While a game animal would have provided much more meat, protein and energy, these resources were not readily available in contrast to the availability of molluscs (Meehan 1982:160).

Meehan's study on mollusc exploitation has shed light on some very important points on not just the economic role of shellfish within the diet but also on its cultural significance. The following points about hunter-gatherer subsistence will be considered in relation to the archaeological datasets used in this research:

- In-depth knowledge of climatic cycles and environmental changes and their intrinsic relationship with shellfish resources aiding foraging activities (i.e. predictability even during adverse climatic conditions).
- Understanding the precise location of molluscs and methods that were developed to exploit them (i.e. availability)
- Strategic occupation of landscape in relation to occurrence of resources.
- The cultural role of molluscs, especially its importance in ceremonial activities and various other anthropogenic uses.
- The dependability on shellfish as a consistent source of sustenance in addition to other resources.
- A focused and efficient foraging strategy which targeted larger shells with more meat and more favourable taxa from a wide range that was available.
- Standardised methods for processing and cooking of different taxa.
- Consistent pattern of discarding exploited shells.

Overall, I agree with Meehan that shellfish are an important economic resource because of their predictability, availability and additional tasks for which they can be utilised. In addition, the above discussion demonstrates the complexity of shellfish foraging and by extension the dynamic behaviour of hunter-gatherer subsistence and landscape occupation.

Torres Strait

Torres Strait comprises of eighteen island and two Northern Peninsula communities spanning an area of $48,000^2$ km and is situated between the tip of Cape York, Australia to the borders of Papua New Guinea and Indonesia (Torres Strait Regional Authority 2012) (Figure 5.2). All of these islands are scattered across Torres Strait and from its northern most point is only approximately 4kms away from the PNG mainland (Torres Strait Regional Authority 2012). Extensive archaeological research has been undertaken in this area with dozens of sites recorded. Of particular attention is the work done by Bird *et al.* (2004) who looked at the ethnographic and ethnoarchaeological representations of shellfish subsistence. On the island of Mer, within the Eastern Torres Strait Meriam Islands, daily shellfish subsistence strategies were documented and subsequent data used in ethnoarchaeological investigation of mollusc remains (Bird *et al.* 2004). The main aim of the research was to assess the assumptions associated with foraging theory models in behavioural ecology in relation to the molluscan taxa gathered and the probability of remains being added to the makeup of shell midden assemblages (Bird *et al.* 2004:183). Additionally, understanding prehistoric subsistence strategies and variability in shell midden assemblages in relation to held assumptions on the economics of prey choice were central questions of enquiry (Bird *et al.* 2004:184). Defining ethnoarchaeology as 'the study of human 'archaeological action' in contemporary human contexts' (Bird *et al.* 2004:183), the authors argue that such an approach can help to evaluate any hypothesis which is theoretically informed on what dictates past human action from observable situations. As such, factors which influence patterned variability in resource exploitation within particular socio-ecological settings were looked at (Bird *et al.* 2004:184). Focus was directed at mollusc exploitation which was seen as a salient type of archaeological action, thus permitting observation and analysis of different stages from behaviour to archaeology, in particular 'patch selection, time allocation, prey choice, processing, transport, to deposition, patterned contemporary accumulation, and prehistoric remains' (Bird *et al.* 2004:184).

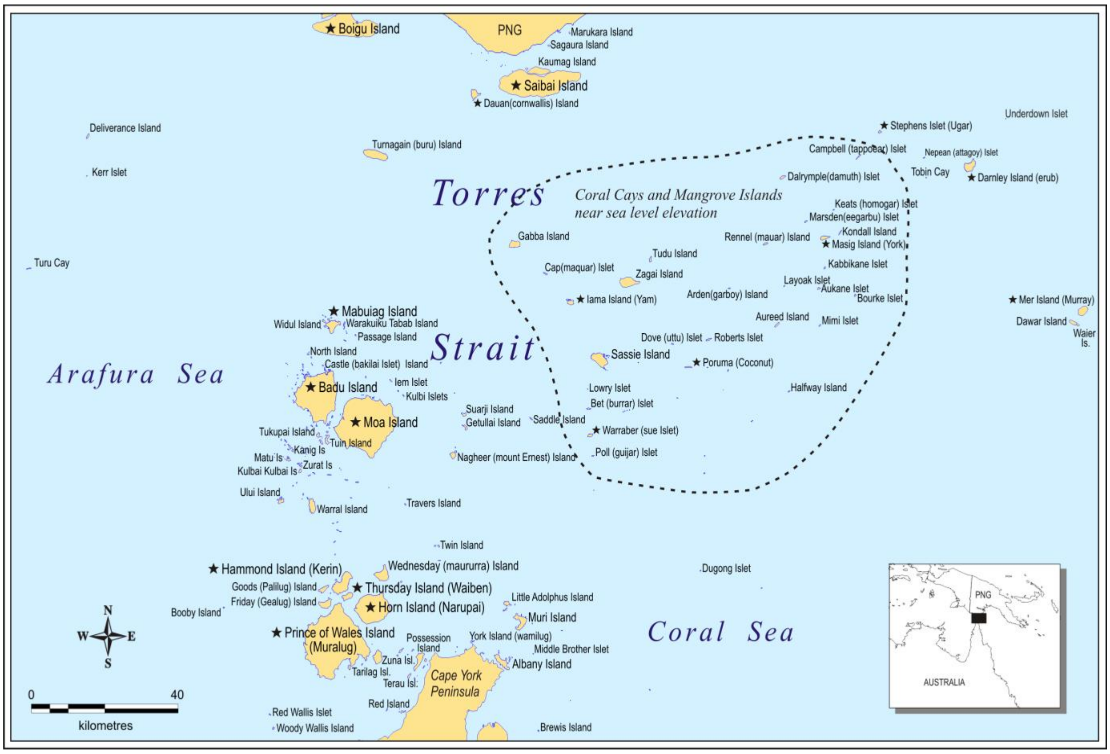

Figure 5.2. Map of Torres Strait (The Torres Strait).

Ethnographic observations of shellfish gathering and other forms of marine subsistence (e.g. turtle hunting) were undertaken for 27 months (Bird *et al.* 2004:184). While shellfish only represented a small portion of the daily required sustenance, they were still consumed as a primary subsistence option two to three times within a week (Bird *et al.* 2004:184). Altogether 13 shellfish taxa were exploited totalling 144.3kg of meat (Bird *et al.* 2004:185). The two main habitats from which these taxa were exploited were reef flats and rocky shores in the intertidal zone (Bird *et al.* 2004:186-87). Within reef flats, exploitation focused on three taxa (*Lambis lambis*, *Hippopus hippopus* and *Tridacna maxima*/*squamosa*) which made up 94% of all mollusc meat even though a variety of other species were present (Bird *et al.* 2004:186). The strategy used to gather shellfish in this habitat involved the use of a bucket while walking along the shoreline after 'a low spring tide exposes a significant portion of the fringing reef's mid-littoral' (Bird *et al.* 2004:186). Distributions of molluscs were normally sparse and upon collection were processed in the field for their meat (Bird *et al.* 2004:186). The meat was then cooked, in most instances stewed except for any whole *Lambis* shells that were brought back home and these were roasted over an open fire (Bird *et al.* 2004:186). Collecting shellfish was a common dry reef activity and similar to Meehan's study, most of the time spent on this activity was carried out by women (Bird *et al.* 2004:186). Gathering of molluscs in reef flats took place between April and September in line with the dry south-easterly wind season, when lowest spring tides occur, thus increasing the visibility of shellfish (Bird *et al.* 2004:187). Even though the quantity of food represented by shellfish was small, the abundance and reliability in which molluscs were found made shellfishing an important subsistence activity (Bird *et al.* 2004:187). This was further exemplified by the presence of strong offshore winds which makes fishing comparatively very difficult (Bird *et al.* 2004:187).

Unlike reef flats, mollusc exploitation on rocky shores were less frequent since only 4% of all gathering time was devoted to this habitat zone (Bird *et al.* 2004:187). Two shellfish taxa, bivalve *Asaphis violascens* and gastropod *Nerita* spp. were targeted and gathered using a knife or scoop (Bird *et al.* 2004:187). Collection took place at known locations and by overturning rocks for *A. violascens* buried in sand, while *Nerita* spp. were normally found close to *A. violascens* and also gathered during a single trip (Bird *et al.* 2004:187). With *Nerita* spp., only larger individuals were collected even though smaller choices were available (Bird *et al.* 2004:187). Again, gathering was primarily done by women, and processing of both taxa was done at home (Bird *et al.* 2004:188). Meat was extracted from *Nerita* spp. after boiling, while processing of *A. violascens* was much more time consuming as the valves had to be opened and meat was then separated from the flesh and silty stomach contents had to be removed before being stewed (Bird *et al.* 2004:188). A different method of roasting was also used for processing but this was rarely undertaken (Bird *et al.* 2004:188).

To compare any differences in mollusc subsistence strategies between ethnographic and archaeological contexts, the observed data was applied to develop an intertidal prey choice model and its archaeological manifestations following the main elements of the encounter contingent prey choice model (Bird *et al.* 2004:188; see Stephens and Krebs 1986 for discussion of encounter contingent prey choice model). Results from the application showed that the model was able to determine the predictability of certain taxa of mollusc that should be collected and should therefore also be reflected in archaeological sites according to levels at which contemporary people were finding them during shellfishing (Bird *et al*. 2004:188). However, results were in fact contrary to the predictions of the model for two reasons. Comparing mollusc data from archaeological sites in the Meriam Islands, some taxa such as *Nerita* spp., *Conomurex luhuanus*, and small *Trochus* spp. according to the predictions of the model should not have been found in the middens but in terms of MNI (1st, 2nd and 4th), these were clearly present within the archaeological assemblages (Bird *et al.* 2004:189). Likewise, taxa such as *Hippopus hippopus* and *Tridacna maxima/squamosa* that were highly profitable, increased collection efficiency when gathered and were focused on during ethnographic observations were found in lower quantities in the middens and were ranked 7th and 10th in terms of MNI from a total of 10 taxa (Bird *et al*. 2004:189). The inconsistencies between ethnographic and archaeological data in relation to the prey choice model were analysed, with several factors highlighted as contributing to this degree of difference.

One important factor as to why high ranked resources were not abundant in middens was due to differences in field processing techniques as the prey choice model was not able to predict the frequency of different mollusc taxa found in the archaeological assemblages (Bird *et al.* 2004:189). Bird *et al.* (2004:195) argue that the bivalve shell was normally discarded before the meat was transported back home which is both predictable and increases the utility of a load of individuals in quick time from processing them in the field. For lower ranked/preferred taxa such as *A. violascens* and *Nerita* spp., people were not able to walk greater distances from a central location which would not make field processing of these taxa justifiable (Bird *et al.* 2004:195). Hence, this may have contributed to the increased occurrence of these taxa within midden deposits since they were processed at home. However, if lower ranked taxa were represented more in middens, then why were adults focusing on such resources which would have decreased the energetic return rates in reef flat collecting (Bird *et al.* 2004:195)? Differences in utilisation of various intertidal areas and age of collectors were analysed to better understand this trend (Bird *et al.* 2004:195). For reef flats, it was argued that the collection return rate for children would have been a more efficient foraging strategy if a wider range of mollusc taxa were targeted (Bird *et al.* 2004:195). While both adults and children will probably focus on higher ranked shellfish taxa in the mid-sub littoral, it was clearly evident that children always collected lower ranked prey such as *Conomurex* and small *Trochus* when they came across these species (Bird *et al.* 2004:195). In rare instances, lower ranked taxa were also gathered by adults when rocky shore habitats were exploited rather than the higher yielding reef flats, but this only occurred when tidal conditions were not ideal for forgaing in the mid-littoral zone, or when shellfish collection was undertaken by women with accompanied children (Bird *et al*. 2004:195). These two main factors of patch choice (i.e. reef flats or rocky shore) and forager age (i.e. adults and children) would have had a significant impact on how shellfish taxa were processed, which species were collected and if they were brought back to a residential area (Bird *et al.* 2004:195). In turn, such differences in subsistence strategies would have resulted in differences in the composition of the archaeological shell middens of that area.

The use of and comparison between ethnographic and archaeological mollusc datasets raises important points on discussion and reconstruction of past marine subsistence activities and for addressing variability in the archaeological record (Bird *et al.* 2004:195). As demonstrated by Bird *et al.* (2004:195), 'variability in intertidal prey choice is reflected archaeologically only through a filter of differential field processing and transport, the constraints on age-linked foraging efficiency, and patch utilisation'. Yet, while this study shows that caution has to be applied when attempting to reconstruct past human activities such as trying to extrapolate dietary patterns directly from discarded shells, it also shows that to an extent, basic foraging models can be evaluated from ethnographic datasets which can then be used 'to evaluate their archaeological potential and demonstrate circumstances where their assumptions are warranted' (Bird *et al.* 2004:195). In areas where the values of different foraging variables can be approximated, such data can provide a starting point from which archaeological models and variability in shellfish assemblages can be better understood (Bird *et al*. 2004:195).

Papua New Guinea and rest of Melanesia

Apart from Australia and Torres Strait, ethnographic observations of shellfish exploitation have also been noted in other nearby surrounding landscapes. However, qualitative descriptions in these regions are not in-depth in contrast, and therefore a detailed ethnographic study focusing solely on mollusc is yet to be undertaken. Nevertheless, more generalised ethnographic descriptions about different groups of people from these locations do provide valuable information on how/why shellfish were exploited. Many of these coastal communities were essentially sea people who incorporated fishing and shellfish gathering into their diet along with hunting native terrestrial fauna and practising agriculture. In south western Papua (Figure 5.3), Landtman (1933) observed the traditional practices and material culture of the Kiwai people where his observations attest to similarities in the highly complex subsistence strategies as seen elsewhere in the Pacific. The Kiwai are such an example since they were efficient at not only growing their own staple crops, but were also both competent at hunting terrestrial fauna while reaping the riches of the ocean using a highly sophisticated technology (Landtman 1933). Even though a broad subsistence base was noted among the Kiwai, shellfish collecting was still an activity that was pursued since molluscs were used for other purposes (Landtman 1933). The methods that were used for shellfish exploitation are strikingly similar when compared with northern Australia and Torres Strait since the task was undertaken by women who gathered molluscs at the beach during low tide or in the marshes (mangroves) (Landtman 1933:31). As well, shellfish were only brought back home sometimes along with different taxa of fish and other small animals such as crabs and crocodiles for processing (Landtman 1933:31). Landtman (1933:31) notes that shellfish were sometimes kept alive for an extended period of time by being placed in baskets covered in mud before being processed. While this brief account does correlate with the earlier discussed descriptions of mollusc exploitation, an additional crucial element of shellfish exploitation within this community was its non-subsistence importance.

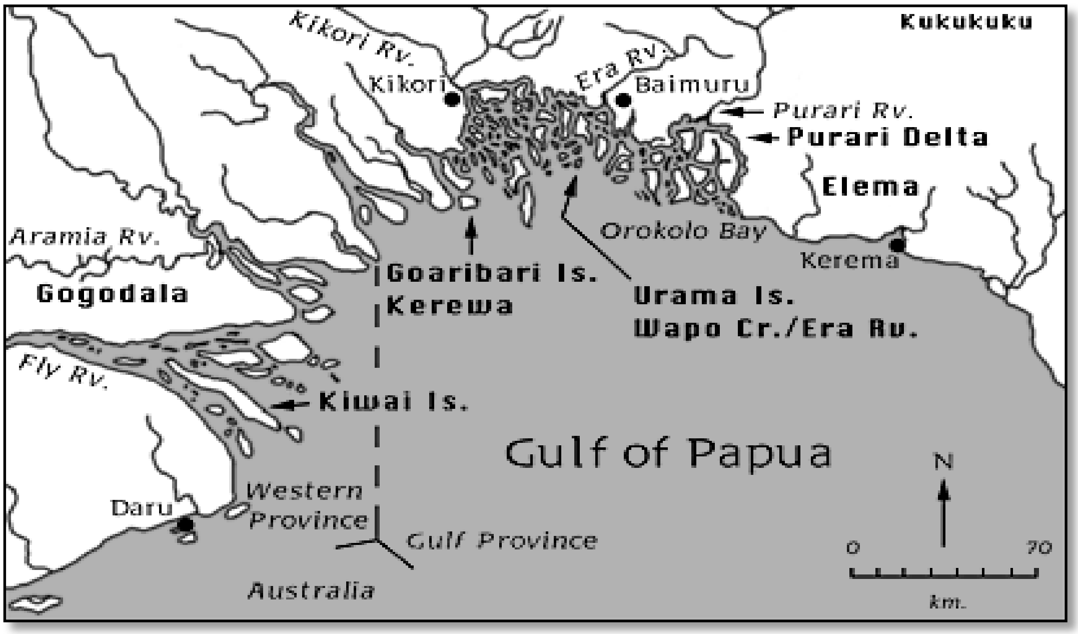

Figure 5.3. Map of Gulf of Papua, with location of Kiwai at mouth of the Fly River (Oceanic New Guinea Art 2015).

The material culture of the Kiwai consisted of a wide array of tools and ornamentation which were made for varying purposes. The Kiwai utilised molluscan resources beyond their caloric contribution to manufacture various items that were important in two main categories (Landtman 1933). The first category is the manufacture of shell tools/artefacts for utilitarian purposes such as a shell-hoe which was made by wedging a shell onto a hole in a stick, with the hole itself cut using shell (Landtman 1933:23). As well, shells were used for scraping, carving, sharpening (e.g. bamboo knives), producing sound (e.g. beating time during a dance) and even for curing illness such as to ease fever by making deep cuts to a shaven head to relieve the individual by bleeding (Landtman 1933:58). *Corbicula* sp. shell was the preferred choice but other taxa were also used at different times (Landtman 1933:58). The other category which was more prevalent was using mollusc for personal adornment and ornamentation (Landtman 1933). Distinctive differences in clothing were seen between men, women and children, with each using a variety of mollusc for personal adornment and as ornaments (Landtman 1933). Examples of commonly used items manufactured using a range of bivalves and gastropods include groin-shells, arm shells, frontlet comprising of small shells, crescent shaped chest shells, different types of necklaces using various mollusc taxa either whole or cut (Landtman 1933). To the Kiwai people, shellfish were culturally significant beyond their contribution to local diet and the range of uses exemplifies the complexity of their social system.

In a more extensive review, Pernetta and Hill (1981) discuss the many facets of marine resource exploitation on a broader scale across different coastal regions in Papua. Three broad ecological zones comprising of coral reefs and lagoons in two areas and mangrove swamps in the other region corresponding to the Western Province, Central Province and Milne Bay, and Gulf Province regions respectively, were part of the review (Pernetta and Hill 1981:175). Differences were noted within each location that led to a mosaic habitat pattern (Pernetta and Hill 1981:175). For example, the Western Province was made up of many large patch reefs that had widespread sea grass beds, while fringing reefs were more prevalent in the Central and Milne Bay region with a thin layer of mangroves accompanied by sea grass beds and off shore muddy substrates featuring prominently in the river mouths and bays (Pernetta and Hill 1981:176). In contrast, the Gulf Province was dominated by mangroves with a very thick swamp forest bordering the coast (Pernetta and Hill

1981:176). Since there were differences in marine substrates that ranged from rocky shores to sandy beaches, the prevalence and availability of different taxa of marine resources was different within each region, such as the range of shellfish species being greater in fringing reefs with sea grass beds compared with mangroves (e.g. 30 taxa compared to 16 taxa) (Pernetta and Hill 1981:176; Swadling 1977).

Pernetta and Hill (1981:178) discuss the multi-faceted significance of molluscs, and point out their importance to local subsistence strategies. The relative importance of shellfish varied between different habitats with *Conomurex luhuanus* being the main targeted taxa for subsistence in sandy sea grass areas zones (Pernetta and Hill 1981:178). Yet again, women and children were mainly responsible for collecting shellfish (Pernetta and Hill 1981:186). The different major taxa exploited in each habitat are listed below (Pernetta and Hill 1981:178) (Table 5.1). In addition to the major taxa that were important to people occupying different environmental landscapes, Pernetta and Hill (1981:182-5) discuss why shellfish were a significant cultural commodity and provide a detailed summary of the different types of artefacts molluscs were used in the manufacture of within the region. Table 5.2 demonstrates that production of shell artefacts was widespread within the region with many different types of products made. Despite the fact that the utilitarian function of shell artefacts was obvious (e.g. scraper), a reoccurring theme was the preference for using shells as a raw material in the manufacture of ornamentation and other locally-specific products (Pernetta and Hill 1981:186). An interesting example was the production of betel nut chewing lime using *Polymesoda erosa* (Pernetta and Hill 1981:186). In an elaborate process, Koiari people travelled to the coast to collect these shells before travelling 20 miles back inland to manufacture lime by burning *P. erosa* to powder form and once completed traded the commodity to coastal Motu villages (Pernetta and Hill 1981:186). Hence, people were either prepared to travel in order to collect certain mollusc taxa or trade for them (Penetta and Hill 1981:186). Evidently, in order to manufacture arm shells, *Conus* spp. shells of a specific size range were required and these were traded from the Massim islands into southern PNG because the taxa was not commonly found within the Moresby area and the mainland coastal region (Pernetta and Hill 1981:186). Furthermore, certain taxa (i.e. *Conus* spp., *Trochus* spp. and *Pinctada* spp.) were prized commodities for making artefacts as demonstrated by the number and type of artefacts they were used to manufacture (Pernetta and Hill

1981:186). More evidence of trade is also seen involving another type of *Conus* spp. arm shells originating in Torres Strait and moving to communities in the Western Province (Pernetta and Hill 1981:186).

Trade involving molluscs presents an interesting scenario as it demonstrates that shellfish were not than just a subsistence target but were in fact objects of prestige and represent an element of symbolism that helped foster an elaborate exchange network. Trubitt (2003:244) examined the manufacture and exchange of shell prestige items between various communities globally in extensive detail and proposed three conclusions:

- Mollusc were used to produce artefacts that were in fact ‘prestige goods’ which were either displayed, worn, exchanged or passed on as gifts. Shell artefacts may have been considered as being ‘attractive’, hence portraying health, success and status (Hayden 1998:12-3). They were material symbols of contact between people.
- Shell artefacts were utilised for different purposes within or outside of a community. This can be attested to in multiple ethnographic descriptions of the complexities of functions and symbolism attached to mollusc artefacts.
- Shell artefacts were frequently transported between communities and were distributed over an extensive time period.

Table 5.1. Major shellfish species of the coastal regions in Papau according to Pernetta and Hill (1981), species highlighted in purple font are represented in archaeological shell assemblages at Caution Bay.

Habitat	Major Shellfish Species or Family
Reefs	Arcidae, Strombidae, Tridacnidae, Trochidae, Turbinidae and Conidae
Rocky Shores	Neritidae and Cerithidae
Mangroves	Neritidae, Cerithidea and *Gelonia coaxans*
Soft Silt or Muddy Substrates	*Pinctada margaritifera*, *Charma spp.* (substituted by *Spondylus spp.* in sandy areas).

Table 5.2. Range of artefacts manufactured using each shellfish taxa according to Pernetta and Hill (1981), species highlighted in purple font colour are represented in archaeological shell assemblages at Caution Bay.

Shellfish Taxa	Type of Artefact	Location	Source
Anadara spp.	Net weights	Nebira	Bulmer 1979
Charma pacifica Cassis	Beads	Central Province	Seligman 1910
Conch	Trumpet	Western Province, Kiwai Western Province	Austin 1948, Chalmers 1903
Conus millipunctatus	Arm shells	Motu, Central Province	Seligman 1910
Conus spp.	Arm shells, adzes, tablet, ornament ring, top discs	Yule Island, Nebira, Mailu, Motupore, Taurama, Torres Strait	Vanderwal 1973, Allen 1982, Irwin 1977, Groube/Pernetta, Edge-Partington 1890-98, Bulmer 1979
Cymbium (=Melo)	Hoe blade, ‘kettle’, ‘saucepan’, ‘groin shield’	Kiwai Western Province, Torres Strait	Edge-Partington 1890-98, Haddon 1935, Landtman 1933
Cypraea spp.	Beads, scrapers	Taurama	Bulmer 1979

Nassa callospira	Discs (beads)	Central Province	Seligman 1910
Nautilus	Groin shield	Torres Strait	Edge-Partington 1890-98
Ostreidae	Tablet	Mailu	Irwin 1977
Olives	Drilled as bead, head band	Torres Strait, Port Moresby	Edge-Partington 1890-98
Ovula ovum	Whole on arm/leg bands, charm on mast of Hiri canoe	Yule Island, Central Province	Edge-Partington 1890-98, Seligman 1910
Pinctada	Scrapers, 'tablet', pendant crescent, neck-ornament	Taurama, Yule Island, Motu areas, Southeast Papua, Torres Strait	Bulmer 1979, Vanderwal 1973, Seligman 1910, Edge-Partington 1890-98
Spondylus	Disc (beads)	Nebira	Allen 1972
Tridacna	Axe, scraper, arm shell, nose stick, vessel, ear-ring pendant, breast-ornament (ring), neck ornament, concheilin mass and pearls, discs (beads)	Torres Strait, Yule Island, Massim, Southeast Papua, Koita charm, Taurama	Haddon 1935, Vanderwal 1973, Edge-Partington 1890-98, Seligman 1910, Bulmer 1979
Trochus	Arm shells, 'unit', pendant in shape of 2 pig tusks	Yule Island, Motupore, Taurama,	Vanderwal 1973, Groube/Pernetta, Bulmer 1979,

		Torres Strait	Edge-Partington 1890-98
Unidentified Molluscs	Net sinkers, surgical instrument, platform for spinning tops, discs (beads), discs (beads) on ear-ring, discs	Nebira, Taoripi, Torres Strait, Southeast Papua, Nebira, Tatana	Allen 1972, Chalmers 1898, Edge-Partington 1890-98, Seligman 1910

Figure 5.4. Crescent-shaped necklaces made using pearl shell from Gulf of Papua (Courtesy of Bryce Barker).

Figure 5.5. Crescent-shaped necklaces made using pearl shell from Gulf of Papua (Courtesy of Bryce Barker).

Figures 5.6 and 5.7. Groin shell made using Melo sp. and Conus sp. arm shell from Gulf of Papua (Courtesy of Bryce Barker).

Figures 5.8 and 5.9. Shell scraper/artefact made using Cypraeidae sp. from Gulf of Papua (Courtesy of Bryce Barker).

Figure 5.10 and 5.11. Conus sp. (left) and Turbo sp. (right) shell beads from Gulf of Papua (Courtesy of Bryce Barker).

Other researchers have also argued that mollusc were a unique resource since their utility extended much further beyond subsistence needs as evident in numerous locations worldwide (e.g. Andrews 1969; Di Peso 1974; Luer *et al.* 1986; Reese 1985; Stiner 1999; Swadling 1994; Szabó 2010; Szabó *et al.* 2007). These artefacts reflect the presence of a highly complex 'production system' in which several key aspects (i.e. artisans, means of production, organisation and social relationships of production, objects, relationships of distribution, consumers) are interconnected (Costin 2001). Analysing shell artefacts and their distribution is a key concern for reconstructing the past since despite the wide distribution range, shell artefacts can be sourced back to their origin and can inform us about past economic, social and political interactions between people (Trubitt 2003:244). This then allows for the development of archaeological based models of contact, production, use and exchange (Trubitt 2003:44).

At Caution Bay, the presence of highly distinctive shell artefacts associated with both pre-Lapita and Lapita occupational phases (see Chapter 9), allows for an in-depth investigation into the social, political and economic interactions between local inhabitants and the incoming migration of 'foreign' Lapita peoples. Building an archaeological model incorporating shell artefacts can be beneficial for not only the reasons discussed above, but also for understanding technological and social complexity within a group of people. A well-known example from within the region that attests to the conclusions made by Trubitt (2003) on key aspects of shell artefact production, exchange of symbolic prestige items and its implications for understanding the social, political and economic spheres of 'contact' is the *kula* ceremonial exchange system. In his influential book, *Argonauts of the Western Pacific* (1922), Malinowski's study of the Trobriand Islands of PNG revealed the presence of a highly complex and organised system of exchange between different islands (Trubitt 2003). Individuals, both men and women, manufactured artefacts from marine shell and these were exchanged with partners from different islands in a systematic manner (Trubitt 2003:246) (Figure 5.12).

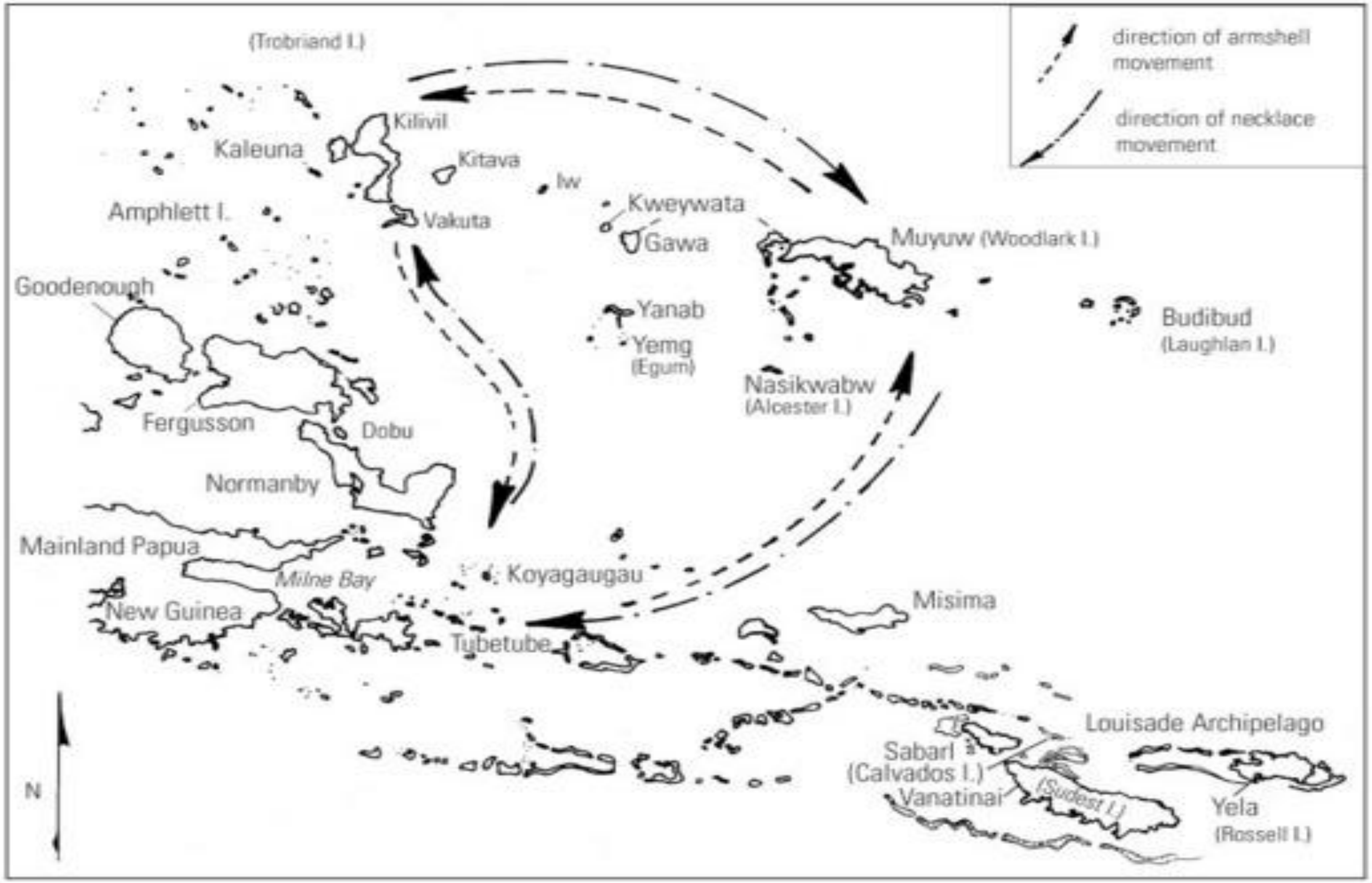

Figure 5.12. Map showing distribution network of *Kula* exchange system (Cairn. info).

Figure 5.13. *Kula* shell long necklace and jewellery (courtesy of Joke Sels 2014).

Figure 5.14. *Conus* sp. *Kula* arm shell (courtesy of Pitt Rivers Museum 2002).

Shell artefacts were highly prized products and the typical production items were *Chama* spp. or red *Spondylus* shell bead necklaces which were traded for white *Conus* spp. arm shells (Trubitt 2003:246; Weiner 1988) (Figures 5.13 and 5.14). These items were manufactured in several different islands within Massim (e.g. northeastern, northwestern and southern) and features such as age, size, history and colour determined their value and rank (Trubitt 2003:246; Leach 1983:23). Exchange within the *kula* system occurred over vast distances in the Massim region among men from different islands (Trubitt 2003:246; Weiner 1988). Essentially, the *kula* exchange system was reciprocal with both given and received shell artefacts being of similar value (Trubitt 2003:246). Exchanges were also often postponed so as to ensure that the process had a lengthy duration (Trubitt 2003:246).

According to Leach (1983), the *kula* exchange system occurred for a few reasons. Firstly, it allowed for trade of other resources and helped to ensure peace. Next, exchanges enabled men to vie for prestige, and lastly the exchange network materialised the social networks of people that preserve order within the society. However, differences were noted in the extent to which men participated in this system, and artefacts may have been used for exchange within a community while the symbolism attached to items (e.g. link between armshells with men or women) differed in some areas of the region (Leach 1983; Trubitt 2003). Nevertheless, shell artefacts were still a prized commodity within all those communities and the exchange of these goods paved the way for men to foster relationships with men from other communities (Trubitt 2003:246). As such, the *kula* exchange system clearly allowed anthropologists an avenue from which the social, political and economic implications of 'contact' between groups of people could be better understood. In line with this approach, analysing the artefactual remains of shell working from the archaeological assemblages at Caution Bay will provide valuable data that can be cross-examined with ethnographic descriptions of shell exchange to understand not just how people were consuming shellfish but perhaps how their social, political and economic systems functioned in the past. However, while the aim of this section was the demonstrate the multi-faceted use of shellfish, more than just a subsistence resource, the main focus of this study is to examine shellfish subsistence at Caution Bay and an analysis of the shell artefact assemblage will not be undertaken. Specialist analysis of the Caution Bay worked shell is still in progress and will be reported in the future.

Discussion

Review of the ethnographic literature on shellfish exploitation has clearly demonstrated that people were targeting mollusc resources for the following reasons:

- Shellfish were ubiquitous within the environment.
- Despite adverse environmental conditions, shellfish were able to withstand natural and cultural pressures and were still predictable as a resource.
- Gathering was relatively less demanding physically and could be undertaken by women and children while men were busy fishing and hunting.
- Shellfish were the preferred choice of food in some communities, with preference for certain species and size (small sized taxa were also targeted).
- Importance of molluscs as a raw material for manufacturing artefacts.
- Shellfish were symbolic and were items of prestige that were used for personal ornamentation, in ceremonies and trade.
- The trade of molluscs allowed for exchange of other resources with social, political and economic implications.

Building an archaeological model for the mollusc remains from Caution Bay can be undertaken by taking the main points from the contemporary qualitative descriptions into consideration in conjunction with the archaeological and palaeoenvironmental datasets. This would in turn help to address variability in the archaeological record to some extent as well as understand changes in economic and technological strategies. At the same time, the social, political and economic manifestations of 'contact' can be analysed and incorporated into a regional archaeological model. Some researchers have however often cautioned the use of wider ethnographic analogies for directly interpreting the archaeological past (e.g. Faulkner 2013; Hiscock 2008). Debate over the use of ethnographic data has centred around the notion that using such a method to infer past human activities in relation to evidence from the archaeological record may not paint an accurate picture since there is no plausible case for connecting each other, and it can therefore be seen as problematic and as a lesser methodological approach when compared with others (Barker 2004:25). However, research has shown that changes in the archaeological record can be documented using ethnographic data, especially when addressing continuity and discontinuity in past human activities (David *et al.* 2004a). As well, the negative stigma often associated with using ethnographies revolves around how such data is used, and interpreted in the archaeological record (Barker 2004). Such ideas are erroneous because as Barker (2004:25) states 'all interpretation of the archaeological record in terms of human behaviour involves some form of analogy and inference, which is set within a contemporary cultural contextual framework'.

I believe that qualitative ethnographic information should be used on a case by case basis and the usefulness of using such a method in archaeological research has been well demonstrated in some areas (e.g. Barker 2004; Binford 2001; David *et al.* 1994). Using ethnographies should be seen as a mechanism which provides an additional source of data that can assist in understanding the archaeological record but not solely frame the entire interpretation of a site. Likewise, evidence from the ethnographic record needs to be carefully assessed before being used. In the case of this study, the Caution Bay landscape is representative of both past and present living cultures of people who have occupied the area from throughout its antiquity to present-day descendants whose subsistence practices continue to incorporate shellfish, thereby persisting with some of the past traditions (Barker pers. comm. 2014). However, given the fact that some molluscs taxa are no longer present within the Caution Bay catchment (e.g. *Anadara granosa*) together with the notion that perhaps exploitation strategies may have changed with wider environmental changes (see Chapter 4) or over a temporal sequence that goes back to approximately 5000 years BP, inferring past scenarios from qualitative datasets must be tested. Drawing on important observations from the above discussed ethnographies which are from areas of close proximity to Caution Bay with very similar environmental niches, qualitative data will hence be carefully applied in conjunction with archaeological datasets and the results of this approach will be discussed further in later chapters.

Chapter 6: Archaeology of Coastal Occupation

Introduction

Extensive archaeological investigations on shell assemblages, and by extension the occupation of coastal areas by humans, have been undertaken on a global scale, with different explanations being provided by researchers for any spatial and temporal changes in relation to procurement strategies and behaviours of past human populations. These studies have shed light on key aspects of subsistence and cultural strategies while also addressing molluscan variability in the archaeological record. Given the unique 'contact' situation at Caution Bay that has unearthed a highly variable shell assemblage (see Chapter 3), I will review the archaeomalacological literature to provide:

- An archaeological context to understanding coastal sites and shell middens at Caution Bay.
- Comprehend why/how molluscs were exploited by people in the past and the implications for understanding human behaviour.
- Models on shellfish subsistence practices.
- Methods that have been proposed for tackling 'problems' in midden analysis, especially the fundamental question of differentiating which taxa were cultural (i.e. exploited by humans) from species brought naturally into a site.

Global Perspectives on Coastal Sites and Marine Shellfish Assemblages

Throughout the history of archaeological research on human antiquity, coastal sites and islands have often not received much attention when compared with research on human evolution, agriculture and major civilisations (Erlandson and Fitzpatrick 2006:6). Largely seen as only contributing to the human story in its latter stages (e.g. Yesner 1987), some archaeologists have advocated that human occupation of coastal and marine environments was not advantageous and resources from such habitats only became the primary focus of exploitation once terrestrial resources were exhausted (Cohen 1977; Osborn 1977). According to Erlandson and Fitzpatrick (2006:6), such views on the human occupation of marine habitats has become part of anthropological theory and an example concerns optimal foraging models where exploiting smaller marine resources (e.g. shellfish) was deemed less productive than hunting large terrestrial fauna (Erlandson and Fitzpatrick 2006:6). These ideas essentially revolved around the notion 'that archaeological sites on land are fully representative of past human behaviour' (Erlandson and Fitzpatrick 2006:6), and especially the notion that mollusc and other small-bodied resources were secondary fallback resources rather than being critical dietary components. Hence, such small-sized resources only became staple food items when forced by factors such as population increase, economic and/or social intensification.

Some archaeologists have in fact questioned this idea (e.g. Erlandson 1994; Glassow and Wilcoxon 1988; Moseley 1975; Yesner 1980) and extensive evidence has been used to illustrate the point that occupation of marine habitats has a much longer antiquity than first thought and exploitation of marine resources can be advantageous (Erlandson and Fitzpatrick 2006). The earliest form of evidence for use of marine landscapes comes from the occupation of coastlines by *Homo erectus* and archaic *Homo sapiens* who most likely exploited shellfish along with other marine resources (Erlandson 2001; Erlandson and Fitzpatrick 2006; Stiner 1994). Further concrete evidence of early exploitation of molluscs comes from the Middle Stone Age shell midden sites in southern Africa associated with early humans and has a minimum age of 125,000 years (Erlandson and Fitzpatrick 2006; Jerardino and Marean 2010; Klein 1999; Marean 2010; Parkington 2004). As well, the expansion of early modern humans throughout the world, in particular, through south-east Asia and Australia would have required maritime voyaging technology and this trend is also seen with later expansions such as that of the Pacific (Allen *et al.* 1989; Codding *et al.* 2014; Kirch 1997; O'Connell and Allen 2012; Torrence *et al.* 2004). Having the ability to undertake extensive journeys meant that humans were therefore occupying coastal environments, in some instances were marine specialists and would have no doubt come across marine resources such as shellfish. However, given the nature of preservation of some early Pleistocene sites exhibiting evidence of anthropogenic maritime specialisation together with the selective methodologies used by early researchers and other factors, there is a lack of evidence that depicts how intensively or extensively marine resources and landscapes were being utilised and further research is required (Erlandson and Fitzpatrick 2006:8). Nonetheless, as Erlandson and Fitzpatrick (2006:7) note 'the tide has turned on several decades of marginalization for coastal and island archaeology. This "sea change" places island and coastal archaeology at the forefront of many current issues in anthropology, archaeology, history, and historical ecology'.

Inhabiting coastal environments in comparison to terrestrial locations poses the question of whether occupying such habitats was economically productive and advantageous. Ethnographically, it has been well-demonstrated that coastal occupation was economically viable, however, within archaeological research, contrasting views have been put forth. Some generalisations about coastal occupation have characterised productivity as low (Osborn 1977), while others (Yesner 1980, 1987) argue 'that coastlines and marine resources were often extremely productive and highly attractive to human foragers' (cited in Erlandson and Fitzpatrick 2006:9). Increase in productivity was perhaps more pronounced following the Pleistocene epoch and the subsequent rise in sea levels (Erlandson and Fitzpatrick 2006:9; Yesner 1980, 1987). However, since there has been minimal research done on Pleistocene marine resource use apart from extensive research in South Africa (e.g. Jerardino and Marean 2010; Marean 2010), characterising marine resource exploitation as less productive in comparison to during the Holocene can be problematic (Erlandson and Fitzpatrick 2006:9). Hence, while there can be generalised ideas of coastal occupation that transcends over space and time clearly demonstrating the economic importance of such adaptations, more attention needs to be directed on a local and regional scale (Erlandson and Fitzpatrick 2006:9; see Ulm 2006b for discussion on regional example for Australia). When accessing the economic productivity of regional coastal adaptation, factors such as diversity and seasonality of resources, and environmental patterns need to be taken into consideration since these factors can not only be interrelated but can also impact subsistence strategies on a local scale (Erlandson and Fitzpatrick 2006:9; Erlandson *et al.* 2008; Glassow and Wilcoxon 1988; Jerardino 2012; Milner *et al.* 2007; Rick and Erlandson 2008; Thompson and Worth 2007).

Addressing marine habitat use on a regional scale can provide a clearer picture of resource variability in the archaeological record. For instance, Erlandson and Fitzpatrick (2006:10) point to the Chumash Indians of California who as complex hunter-gatherers occupied a range of environments and differences were seen between terrestrial and coastal adaptation within this group with the range of resources being exploited and these differences were a result of environmental factors and unique cultural histories. Variations in shellfish and marine resource procurement can therefore vary between and across different regional landscapes because of the unique cultural histories experienced by past human populations. Cultural responses to isolation, insularity and circumscription are an inherent part of coastal and island occupation by past societies because in many instances communities occupied either the periphery of an island or continent, or a small island surrounded by water (Erlandson and Fitzpatrick 2006:14). While it can be argued that coastal communities may have been isolated, such adaptation was not always disadvantageous as occupying an area close to the sea allowed for interaction with outsiders and travel (Erlandson and Fitzpatrick 2006:14; Finnery 1976; Irwin 1992; Moss 2004). At the same time, rather than depending exclusively on terrestrial fauna for subsistence, coastal occupation provided a range of economically viable marine resources (e.g. fish, shellfish) that could be accessed in conjunction with terrestrial and riverine resources. Choosing to settle in a coastal environment is therefore more of a cultural decision which can at times be influenced by environmental conditions (Erlandson and Fitzpatrick 2006:14).

As discussed in Chapter 4, the expansion of Lapita peoples is one example in which a community of people with a unique cultural history as evident from their material culture, travelled vast distances across the ocean to inhabit different islands with contrasting environmental landscapes. Undertaking such a journey would have no doubt been a cultural decision that allowed for interaction with other human populations at Caution Bay and an adaptation to the coast allowed for the manufacture of required technology and accumulation of knowledge which would have been a mandatory requirement for sea travel. As well, in some cases, colonisation of some islands following sea voyages also involved the introduction of domesticated plants and animals since these islands were isolated and had minimal native terrestrial fauna (White 2004). On the other hand, rather than arriving at a location devoid of human presence in all instances, evidence from the archaeological record reveals evidence of incoming migratory populations establishing cultural contact with native inhabitants in certain locations around the world (see Chapters 3 and 4). Population movement and cross-cultural contact between maritime specialists not only allowed for an increase in social activities, but provided the impetus for the rise of economic relations, in particular exchange systems (Erlandson and Fitzpatrick 2006). This interaction in the form of an exchange system of prized commodities needs to be taken into consideration when accessing complexity in coastal and island communities (Erlandson and Fitzpatrick 2006; Green 1996; Hage and Harary 1991; Kirch 1990). Archaeologists have analysed goods used in exchange systems and have argued that trade and exchange of items has both economic and social benefits such as expansion of kin and social relations (Erlandson and Fitzpatrick 2006; Hunt and Graves 1990; Kirch 1990). Additionally, Erlandson and Fitzpatrick (2006:17) point out that analysis of exchange goods 'can be an effective means for determining the timing, direction, and extent of prehistoric cultural contacts, the economics of raw-material acquisition, manufacturing, and exchange, and the sociopolitical processes behind group interaction'.

As coastal occupation requires some form of maritime specialisation, and use of marine resources, a commonly used raw-material for exchange seen in both pre-European sites and ethnographic descriptions is marine shell. Numerous examples exist on a global scale from the previously discussed *kula* shell exchange system, to cowrie shells from Africa (Gregory 1996), and in North America the shell bead wampum (Ceci 1982; Erlandson and Fitzpatrick 2006:617; Smith 1983). A common element of shell exchange systems is that items were highly prized, were manufactured into artefacts, were commonly exchanged and were socially and economically significant for creating wealth and status (Erlandson and Fitzpatrick 200:617). Because of its implications for understanding past social, economic and political systems of coastal human populations, together with remains of shell artefacts being well-preserved and visible in the archaeological record, it has often been the focus of analysis in many global studies (Erlandson and Fitzpatrick 2006). While this 'contact' scenario between two coastal communities provides a unique opportunity to undertake a technological analysis of the Caution Bay shell assemblages, this analysis will not be undertaken for this study since my focus is on shellfish subsistence. Further discussions of shell technology from Caution Bay will be presented in the future.

While shell technology can provide vital clues, the primary purpose for marine shell exploitation among coastal and island communities was for subsistence. Even though this may be well-known, certain factors such as mollusc availability, distribution and diversity along with human demographics, population size, environmental changes, economic importance and social circumstances can alter the ways in which shellfish may have been exploited in the past and the possible impact on aquatic ecosystems. It is important to remember that archaeologically, in most coastal communities, molluscs alone did not contribute to the entire diet even though some taxa may have been highly preferred because other marine resources (e.g. turtle, fish) may have been readily available within the landscape (e.g. Barker 2004). Even so, shellfish as a resource presented people with a dependable source of nutrients and could be reliably exploited, as seen in the ethnographic record (Erlandson 2001). In a recent issue of *The Journal of Island and Coastal Archaeology* (2014), a range of topics relating to molluscs exploitation were discussed. Codding *et al.* (2014:146) note that while there were economic, political and ecological differences between regions which resulted in significant variations in the ways molluscs were exploited within each area, many similar patterns were yet seen. Focusing on research from a range of localities including Africa, Central America, Micronesia, Pacific, North America and Australia (Rosendahl *et al.* 2014; Smith *et al.* 2014; H. Thomas 2014; R. Thomas 2014; Whitaker and Byrd 2014), Codding *et al.* (2014:146) reflect on how many researchers had used models of human behavioural ecology to understand shellfish exploitation.

The purpose of behavioural ecology models is to provide an avenue in which testable hypotheses can be framed to better understand any spatial and temporal variability in mollusc exploitation across different environments (Bird and O'Connell 2006). This is achieved 'by deriving specific predictions from models supported by a general theory of behaviour and linking those predictions to their expected material outcome' (Codding *et al.* 2014:146). In order to apply behavioural ecology models, experimental or ethnographic data is however required and when combined with raw archaeological data, has been argued that it can provide a better understanding of past human subsistence activities (Bird *et al.* 2002; Thomas 2007). As well, this approach provides insights into past human-environmental interactions, in particular whether over-exploitation, environmental change, and any evidence of resource management or conservation had resulted in varying patterns of mollusc exploitation (Codding *et al.* 2014:146). Many researchers have often used such models in conjunction with archaeological evidence to provide an explanation for human behavioural change (e.g. Bird and O'Connell 2006; Bird *et al.* 2002; Codding *et al.* 2014; O'Connell 1995;

Thomas 2007). The predications made by these common models, including prey choice, central place foraging and patch choice models, focus on the choices made by foragers on what prey to hunt when encountered, the areas (patch) that should be searched for prey and which prey choices should be brought back home (e.g. Bird and O'Connell 2006; Bird *et al.* 2002; Codding *et al.* 2014:146; O'Connell 1995; Thomas 2007). The authors (Codding *et al.* 2014:146) point out that predications on resource exploitation are not always accurate because of social, political and environmental reasons but argue that this 'systematic approach allows us to learn a great deal about the dynamic interactions between humans and their environments', by explaining any variability in relation to spatial and temporal changes in human-environmental interactions.

Regardless of the benefits as perceived by numerous researchers, the above discussion of behavioural ecology, a variant of ecologically based models can be problematic since they can be environmentally deterministic in certain contexts (e.g. Bird and O'Connell 2006; Bird *et al.* 2002) with any apparent changes in the archaeological record being attributed as human adaptation to environmental changes (see Chapter 2). While I agree that addressing environmental changes is important, and that ethnographic information can provide vital clues, I do not contend with the notion that people were merely changing their subsistence strategies because of changes in the environment. I argue that this view is too simplistic because it proposes the idea that cultural change was just an adaptive response to external circumstances (see Chapter 2). Yet, this is a proposition that should be a testable hypothesis based on a range of archaeological and ethnographic datasets, as it is possible that either or both processes (social, environmental) may be in operation, potentially in very complex and diverse ways through time and space. Similarly, with shellfish exploitation, I believe that the process was more complex and socio-cultural factors may have influenced exploitation strategies in the past. For instance, the review of ethnographic literature clearly demonstrates that where people had a variety of terrestrial and marine resources to exploit, it was a cultural decision to target molluscs in some instances. At the same time, exploiting molluscs for production of artefacts such as ornamentation for personal adornment and trade cannot be explained logically as an adaptive response to environmental change. Rather, manufacturing these items, especially those without a utilitarian purpose, was most likely a socio-cultural choice.

To further emphasise my point, I will draw on regional ethnographic descriptions in conjunction with the archaeological data to test if models of behavioural ecology for shellfish exploitation at Caution Bay address key elements of cultural change. Understanding mollusc exploitation and occupation of coastal sites on a regional spatial and temporal scale is therefore of great significance since key aspects of research results will provide a better context for analysing the Caution Bay shell assemblages.

Regional Investigations on Coastal Sites

Previous regional and local studies on coastal occupation and marine resource use in the Australasian region encompassing PNG, Australia and the Western Pacific have provided valuable insights into past human social, political and economic activities. In Australia and Papua New Guinea, archaeological evidence of coastal occupation extends back to the latter stages of the Pleistocene epoch with numerous sites exhibiting signs of human presence. Some notable sites include Koolan Island, west Kimberly, Australia, dated to 27,300 ± 1100 BP (O'Connor 1989:102), Mandu Mandu Creek shelter, North West Cape Western Australia dated to 25,000 ± 250 BP (Morse 1988:84) and Matenkupkum cave in the Bismarck Archipelago, Papua New Guinea with basal dates from between 31,350 ± 550 BP and 33,300 ± 950 BP (Allen *et al.* 1989). This evidence clearly demonstrates that coastal occupation has an antiquity which extends back long before the onset of the Holocene epoch. Meanwhile, the Holocene archaeological record for coastal occupation is presented by numerous sites, especially from the mid to late Holocene. Since the temporal focus of this research is on changes which occur during this time scale, focus will be directed at chronological changes in relation to human behaviour during this time period. As a result of better preservation and increased chronological resolution, a large number of sites have been recorded on the coastal margins of the Australian continent, with research often directed at understanding temporal changes in human behaviour and cultural strategies in relation to wider environmental changes during this period, especially the effects of sea-level rise following the arrival of the Holocene epoch and its subsequent stabilisation approximately 6000 BP (Barker 2004:49). The three time scales often used to characterise the Holocene epoch are early (10,000 to 6,000 BP), mid (6,000 to 3,000 BP) and late (3,000 BP to present). During this period, many sites have been used to explore the concept of economic reconfiguration among past human societies, particularly as an adaptive mechanism in relation to social or natural causes (Hiscock 2008:162). Aspects such as changes in subsistence strategies and technologies, variations in landscape use and social engagements have often been the focus of research on coastal occupation (Hiscock 2008:162). Much of the research on this matter have ended up in attributing changes in human behaviour to either social factors or to changes in the natural environment. Understanding changes in resource use and human behaviour in this context is particularly important since PNG was part of the Australian landmass prior to the Holocene with changes in sea-level and the environment also evident at Caution Bay (see Chapter 4). Here, I will review the literature from northern Australia and Torres Strait since the archaeology of coastal adaptation for PNG was discussed in the previous Chapter.

At Princess Charlotte Bay, situated in the Cape York Peninsula of northern Australia, early research was conducted by Beaton (1985) who looked to provide an explanatory framework for understanding the emergence of coastal adaptations during the late Holocene. The sites excavated by Beaton (1985) revealed the antiquity of human occupation to be approximately 5,480 years BP for the Walaemini Shelter shell midden site while the earliest evidence for island occupation in that area was from the Endaen rock shelter site located on Stanley Island and dated to 2,350 years BP. Evidence from these sites showed that people were consuming molluscs during the mid to late Holocene and local diet was supplemented by kangaroo and marine turtle. This economic strategy was also evident on the mud flats, with shell mounds appearing after 2,000 BP. In explaining his results, Beaton proposed the ‘Coastal lag time’ model in which he argued that occupational strategies of coastal areas were a direct result of changes in the environment (Beaton 1985). The evidence used to argue for such a case, was the fact that people only started to occupy the landscape some 1,500 years after sea level stabilised and that early foragers did not focus on exploiting marine resources (Beaton 1985). Additionally, according to Beaton, marine resources were not readily available when people first appeared at this location, and the subsequent use of such resources was a long-term development with intensive exploitation of marine shell culminating in the appearance of shell mounds significantly after first occupation (Beaton 1985). Because of rising sea-levels, marine ecosystems were not economical, non-productive and therefore unstable, with marine subsistence options unable to accommodate a large human population. Intense marine resource exploitation (e.g. shell mounds) was a much later development which Beaton (1985) argued was a result of population increase. ‘Coastal time lag’ was also seen as occurring elsewhere since sea-level changes were deemed to be extremely disruptive and people were only able to occupy coastal areas after the environment stabilised (Beaton 1985). This model is however problematic because there is concrete evidence that humans were occupying coastal environments long before any changes in sea-level as demonstrated by the Pleistocene archaeological record of coastal adaptation (Bailey 1993, 1994; Ulm 2011). As well, a ‘universal’ ecological model is not indicative of coastal occupation at other locations because of the unique cultural and environmental histories of each area.

An example of the problems associated with using Beaton’s model was further exemplified by research from the Whitsunday Islands in the central Queensland coast. Research conducted by Barker (1991, 2004) on several islands provided the earliest evidence of human coastal occupation on the east coast of Australia with the oldest site, the rock shelter Nara Inlet 1 on Hook Island dating to approximately 10,000 years BP. At that time, the site was still part of mainland Australia before being separated sometime between about 8000 and 6500 years ago during sea-level rise (Barker 2004). The change in sea-levels also created a chain of islands and by 7,500 years BP, the rock shelter on Hook Island was completely separated from the mainland by a distance of 20km (Barker 2004). Despite such significant changes in landscape, and unlike the observations made by Beaton, occupation of Nara Inlet 1 continued up until the late Holocene, therefore clearly exhibiting that environmental changes were not an obstacle to coastal occupation. As well, the exploitation of marine resources continued throughout site occupation with changes in subsistence strategies occurring in relation to location and abundance of resources. During the rise of sea-levels, a range of marine resources were exploited including marine animals (e.g. fish), crabs, shellfish and marine mammals (Barker 2004). In order to successfully exploit marine resources, technology such as stone artefacts and watercraft was used (Barker 2004). Evidence of watercraft use in the Whitsundays comes from the presence of stone artefacts at Nara Inlet 1, made out of a distinctive raw material that was only available at a quarry in South Molle Island which was separated from Nara Inlet 1 during the early stages of sea-level rise and is approximately 2km away (Barker 2004; Lamb 2005). The late Holocene archaeological record for the Whitsunday Islands was however quite different as there was increased diversity in the way resources were being exploited with more focus being directed at obtaining marine food such as crabs and shellfish (Barker 2004). According to Barker (2004), the evidence from the late Holocene, 4,000 to 2,000 years BP, indicates an increasing dependence on marine specialisation with more emphasis on fishing and hunting in the open seas compared with being coastal generalists targeting shore-based resources during initial occupation. The greater emphasis on marine specialisation was also evident in the intensity at which some shellfish taxa were exploited in the late Holocene, with changes seen in size, hence pointing to which taxa may have been the preferred choice (Barker 2004). The changes seen in the Whitsunday Islands, especially the manner in which the landscape was occupied and marine resources were exploited can best be attributed to changes in social dynamics as there was no compelling evidence for environmental changes shaping economic activities. Both studies (Beaton 1985 and Barker 2004) conducted on coastal occupation provide an interesting comparison since changes seen in the coastal archaeological record for each area have been explained quite differently. A single theme that stands out in both, however, is the increase in economic activity during the late Holocene as evidenced through the remains of material culture and dietary components such as molluscs and is of similar temporal scale to the Caution Bay shellfish assemblages.

Within this late Holocene temporal scale, another notable behavioural feature that attests to the notion of economic change was reoccurring patterns of large shell mound construction from the Kimberley region to Cape York Peninsula in northern Australia (Hiscock 2008:175). Shell mounds are highly concentrated conical deposits of shell that are of at least 5cm in height, with some larger examples being 10m tall and 100m long (Hiscock 2008:175). Within these deposits, a range of taxa and other cultural material (e.g. artefacts, ash, faunal remains) can be found but a single species is normally most prevalent (Hiscock 2008:175-6). In some instances, *Anadara granosa* represents the single most dominant taxa found in shell mounds, hence such sites have been referred to as *Anadara* mounds. Additionally, shell mounds are so dense that bigger mounds have been estimated to have 10,000 tons of mollusc remains originating from the exploitation of more than 10 million individuals (Bailey 1994, 1999). The location of most mounds are further inland following coastal progradation, on features such as cheniers or slopes (Bailey 1994, 1999; Faulkner and Clarke 2004; Hiscock and Faulkner 2006). The appearance of highly dense shell mounds has been analysed so as to understand the causes behind their construction.

The earliest mounds have been dated to 3,000 years BP with cessation of mound building occurring between 800 and 600 years BP (Hiscock 2008:176). For *Anadara* dominated mounds, Hiscock and Faulkner (2006) have argued that between this period of time, people were exploiting the species in high numbers and stopped building mounds because the open silty beaches where natural beds of *A. granosa* were found had disappeared as a result of environmental changes. Cribb (1996) interpreted shell mound building as providing an adaptive advantage once fully constructed since living on top of mounds shielded people from flooding and insect bites while also providing a suitable location for harvesting fruit-bearing plants. However, mound construction was a long process that probably lasted several hundred years over a series of occupations, therefore the benefits proposed by Cribb (1996) could not have been fully obtained. Bailey (1999) on the contrary proposed in his 'self-selecting' model that shells were discarded on purpose at slightly elevated areas over a series of occupations, thus making mounds a visual marker which people could then revisit and camp. Using qualitative information from the historical period together with archaeological data, Morrison (2003, 2013) also argued that shell mounds near Weipa, Cape York Peninsula represent an area of symbolic importance to people in the past, especially with a need to support 'social gatherings'. Mounds were therefore constructed from intermittent high level intensities of mollusc exploitation by large groups of people and this activity was made possible by the presence of dense natural beds of shellfish.

On the contrary, Faulkner (2006) in an analysis of *Anadara* mounds in Grindall Bay, eastern Arnhem Land used shell size as a means for understating mound construction. Dated to between 3,000 and 600 years BP with a period of cessation between 1,000 and 600 years BP, Faulkner (2006) states that evidence from shell size analysis points to focused, consistent and intense exploitation of *Anadara* by people who were more sedentary. Decrease in shell size, thereby correlating with reduction in numbers of adult shells and an increase in juveniles in the later middens reveals an impact on the *Anadara* population. This impact on the population structure was time-averaged over a period during which there were higher levels of exploitation but these trends were seen as not relating the ‘classic’ over-exploitation model driving populations to localised extinction (Faulkner pers. comm. 2015). The subsequent mound building phase at 600 years BP occurred in conjunction with the recovery of the resource since human predation had ceased for a period of time (Faulkner 2013). In a recent study on shell mounds in the Yiinkan Embayment in northern Australia, Rosendahl *et al.* (2014) document significant changes in shell procurement strategies over the past 3,500 years. Firstly, shell mounds appear at 2,700 years BP together with shell scatters and this trend continues into the historical period. However, an interesting observation is the distinctive spatial patterns in the distribution of the dominant taxa *A. granosa* within the mound deposits at 1,200 years BP with no evidence of cessation of building (Rosendahl *et al.* 2014:264). Here, population increase with a long-term exploitation strategy of *Anadara* along with other mangrove species (*Terebralia* spp., *Telescopium telescopium*) points to continued use of the landscape with slow increase in site numbers (Rosendahl *et al.* 2014:264). With no significant environmental change occurring and the fact that *Anadara* beds had been present from approximately 3,500 years BP before being intensively exploited, Rosendahl *et al.* (2014:265) and others (Bourke 2005; Morrison 2001) attribute this change to cultural contact with Macassan traders. Hence, after contact, a shift in local economy with a reorganisation from subsistence to exchange production has been used to explain changes in midden composition at this location during the late Holocene (Rosendahl *et al.* 2014:265).

The mid to late Holocene record of coastal occupation in tropical northern Australia provides many valuable clues as to why people in the past reorganised their economic strategies. Regardless of the theoretical models being articulated around social or environmental causal factors, the important theme seen here is a drastic change in the ways people were living, and this may be attributed to a multitude of factors. Similarly, archaeological investigations in the Torres Strait also point to the importance of certain resources, economic reorganisation and the manner in which islands were occupied. Previous archaeological research has shown that people first occupied Torres Strait around 9,000 years BP but only exploited marine resources some time later, from between 7,000 and 6,000 years BP (Crouch *et al.* 2007; David *et al.* 2004b; Wright 2011). 2,500 years BP marks the first evidence of ceramics (McNiven *et al.* 2006) and complex social systems such as those seen ethnographically emerged 800 to 600 years BP (David *et al.* 2005; McNiven *et al.* 2009). Focusing on chronological changes during the mid to late Holocene, Wright (2011) notes the presence of two distinctive occupational phases on the island of Mabuyag situated in central-western Torres Strait. Here, cultural material obtained from excavations at the site Dabangai have been dated to 7180 to 4960 cal BP (Phase 1) and 230 BP to present (Phase 2) (Wright 2011:26). During the first phase of mid Holocene occupation, people were producing stone artefacts, undertook significant burning regimes and were marine specialists with a variety of resources being targeted (e.g. fish, turtle, dugong) (Wright 2011:26). Unlike the other islands, the settlement pattern at Mabuyag was quite different because high levels of human activity was taking place during the marine transgression and sea-level change 7180 to 4960 cal BP, after which there is reduction in activity for approximately 5,000 years (Wright 2011:26). In turn, greater levels in human activity only occurs in the last 230 years (Phase 2) with a rise in marine subsistence activities (e.g. fishing, shellfishing, turtle and dugong hunting). As certain small areas of the environment (reefs, beaches, sea-grass beds) were able withstand the effects brought about by the marine transgression, Wright (2011:26) argues that people were adequately prepared for any new ecological constraints. Hence, according to Wright (2011:26) the marine transgression led to the emergence of new subsistence strategies and technologies among local people living in the Torres Strait.

In contrast, on the islet of Berberass located in western Torres Strait, archaeological investigations of the Badu 19 midden site have shown that people were present at 4,000 BP (Crouch *et al.* 2007:49). From 4,000 to 2,600 years (Phase 1), people were targeting marine resources such as turtle, dugong, and shellfish (Crouch *et al.* 2007:58). A shift in local economy is then seen during Phase 2 (2,600 to 2,500 years BP) where human activity increases dramatically as evident in dugong hunting, shellfishing, fishing, stone tool production and ochre use (Crouch *et al.* 2007:60). Exploitation of certain resources ceased (e.g. Cardiidae, *Paphies striata*, *Soletellina tumens*) while other food items were targeted more (e.g. *Turbo* spp.) (Crouch *et al.* 2007:60). As a whole, more emphasis was placed on larger marine animals, and shellfish were exploited in lesser numbers. These changes in site use were significant as they correlate with the idea proposed by Barham (2000) of 'a 2500 BP event horizon for western Torres Strait' (Crouch *et al.* 2007:61). Crouch *et al.* (2007) argue that there is a marked rise in anthropogenic activity within the wider landscape around 2,600 years ago which according to McNiven *et al.* (2006a) was due to the arrival of people, likely from the Trans-Fly-Papuan Gulf region. The trends seen at Badu 19 were similar to those at Mask Cave (3,800 to 2,900 BP), whereby intensities in site use were also low (Crouch *et al.* 2007:62). Hence, before 2,600 years BP, there is a regional trend of low-level site use before dramatic economic reconfiguration occurs. In addition, environmental changes did take place at Badu, but palaeoenvironmental reconstruction has revealed that much of the changes, also in other areas within the region, were a result of anthropogenic modification to terrestrial and marine ecosystems by Islanders (Crouch *et al.* 2007:62; McNiven and Hitchcock 2004:123). Within the broader archaeological context of Australasia, these studies again demonstrate significant changes in site use during the late Holocene with a continued dependence on marine resources.

Similar to ethnographic accounts on mollusc exploitation, evidence from the archaeological record clearly demonstrates that shellfish were more than just contributing to the dietary requirements in certain Torres Strait islands. Extensive research (David *et al*. 2005; David and Badulgal 2006; McNiven 2013) has emphasised the crucial role played by shellfish in contributing to local ritual practices, spirituality and worldviews. Most of these sites have been dated to the late Holocene, and while it is well-demonstrated from earlier discussions that shellfish exploitation during this time was largely due to subsistence and technological requirements, studies from Torres Strait have shown that mollusc exploitation does serve a different purpose. Torres Strait Islanders as maritime specialists occupied different islands and exploited a variety of marine resources such as dugong, turtle, fish and shellfish (McNiven 2013:563). As discussed earlier, the late Holocene archaeological record at Torres Strait sees the emergence of dense midden deposits dated to 2,800 years BP with the material composition comprising of shellfish and a range of bones from fish, dugong and marine turtle remains (McNiven 2013:565). The feature that stands out, is the way in which shell middens were perceived by people who transformed middens into ritualised features and also began creating ritualised dugong mounds comprised of dugong bones some 500 to 400 years BP (McNiven 2013:565). McNiven (2013:552) states that 'ritualized middening was part of a broader social process of maintaining the biographical status of midden materials as a dimension of community socialization, identity and cohesion'. Referring to the repeated conceptualisation of midden formation in the archaeological record as inherently a result of simplistic ideas relating to food procurement and consumption, McNiven (2013:581) argues that middens in certain contexts were ritualised into 'special cultural features with ongoing roles within societies'. To illustrate this view, excavations of middens were undertaken at Goemu village in Mabuyag, Torres Strait, together with an analysis of the composition of midden material. Results indicate that midden deposits have been present from around 1,000 years ago, and the presence of certain remains which were of little economic value (e.g. Dugong bones) along with the manner in which middens were intentionally constructed points to middens becoming 'highly observable, conspicuous, monumentalized structures within the village precinct' (McNiven 2013:572-5). As well, midden 'material was the product of shared, gendered activities' since they were curated to represent complex social systems and were hence symbolic (McNiven 2013:576).

The study conducted by McNiven (2013) can be further supplemented by other accounts of ritualising resources. The ritualistic use of *Syrinx aruanus* or referred to as *Bu*, within the the Torres Strait is one such example (David *et al*. 2005:71). In a study conducted on the *Bu* shell arrangements on the island of Badu in western Torres Strait, David *et al*. (2005) looked to address the archaeology of customary spiritscapes to understand why people were engaging in the spirit world using shell arrangements. Following excavations of various sites on the island, and an analysis of the systematic shell arrangements, David *et al*. (2005:87) argue that the shell arrangements were 'ritual manifestations of worldviews that focus on the sea'. As Torres Strait islanders were essentially sea people, and had been so for a long time, the construction of *Bu* shell arrangements 500 to 400 years ago points to a way in which rituals could be observed with socio-political implications (David *et al*. 2005:88). The socio-politics of *Bu* arrangements, noted ethnographically, played a role in inter-group dynamics across the region, especially in violent exchanges as seen in the ethnographic record such as headhunting raids associated with *Bu* shells (David *et al*. 2005:88). The research conducted on the marine resource exploitation in the Torres Strait provides another dimension to the story of past peoples. While most archaeologists have often provided simplistic ecological models, McNiven and David illustrate that people in the past were part of complex social, political and economic systems who exploited marine resources for reasons other than just food. Human societies are inherently complex, and such explanations backed up by evidence from the archaeological and ethnographic record, exemplifies the need for an in-depth investigation of past societies.

Discussion

Review of the archaeological literature on coastal occupation has provided valuable insights into the social, political and economic systems of past peoples. A reoccurring theme is the manner in which sites were being occupied during the late Holocene and the ecological or social models that have been proposed to explain chronological changes. Regardless, the following points on coastal occupation are of concern to this study and will be explored in relation to Caution Bay sites in Chapter 12:

- Coastal occupation is economically productive with a host of resources available for exploitation.
- Marine specialists were part of complex social, political and economic systems.
- Changes in the environment occurred during the Holocene, especially in sea-levels but evidence from some localities demonstrate that such changes were not necessarily the driving force behind economic change.
- A regional trend is evident during the late Holocene (3,000 years to present) with greater intensities in site and resource use.
- Shellfish were an important resource, dependable and predictable.
- Marine resources were not just contributing to local subsistence, but were also of symbolic importance as well as for use in trade and in artefact manufacture.

In attempting to understand how and why shellfish were being exploited in the past, and how coastal peoples were living, this chapter has provided a review of the archaeological literature that relates to this topic. In doing so, it is clearly evident that shellfish represent a significant resource for many communities and were reliable, and predictable. As well, compared to other resources, molluscs are not a lesser source of food and were in fact in some cases preferred because of the number of purposes for which they can be used. Taking into consideration the key points highlighted throughout this chapter, I will look to address key chronological changes in the

Caution Bay shellfish assemblages. The next chapter provides an in-depth analysis of the Caution Bay palaeoenvironment.

Chapter 7 – Palaeoenvironment

Introduction

The purpose of this research is to document spatial and temporal chronologies of cultural change within the Caution Bay landscape through an analysis of shellfish assemblages. While mollusc analysis may provide an insight into past human activities, both natural and/or anthropogenic-induced changes in the environmental record over time needs to be documented in order to understand both diversity and variability in shellfish assemblages. This is particularly important especially when certain shellfish taxa may have possibly been impacted in different ways by changes to the natural environment (e.g. availability, size, loss of habitat). Since the environment is important, and provides the starting point for documenting change in the archaeological record, this chapter will examine the palaeoenvironmental record at Caution Bay. It is envisioned that this will then provide a framework which will in turn help to tease out the complex interaction of environmental and social factors and how this may have impacted shellfish exploitation. As well as this, with the 'contact' scenario at Caution Bay between an 'indigenous' population and 'external' (Lapita) peoples (see Chapter 3), palaeoenvironmental changes need to be analysed together with mollusc data together since any possible anthropogenic induced or natural environmental change may have conversely resulted in an increase in resource use and site numbers, and an overall change in subsistence focus.

Palaeoenvironment

Palaeoenvironmental reconstructions at Caution Bay have revealed significant changes that have taken place over time. Presently, the environment comprises mainly of a mangrove-fringed embayment that is connected to the Lea Lea River while the Viahua River borders the area (Tomkins *et al.* completed ms:12) (Figure 7.1). Within this landscape, there are various environmental zones and habitat types which include seagrass beds, coral reefs, subtidal and intertidal muddy and sandy substrates, and intertidal mangroves (Coffey Natural Systems 2009). Mangrove areas are represented by two mangroves communities (Rowe *et al.* 2013:1131). Towards the sea, an almost pure, tall and dense canopied *Rhizophora* forest is present (Rowe *et al.* 2013:1131). The inland mangrove community comprises mainly of *Avicennia* in a location with higher tides 'forming an irregular to low-height open canopy woodland' (Rowe *et al.* 2013:1131).

Seagrass is found in large areas, on the flat sandy seafloor that exists between the fringing reef and mangroves (Coffey Natural Systems 2009:13.3.2). Meanwhile, most of the near-shore coral reefs seem to be degraded with low quantities of fish and coral now available (Coffey Natural Systems 2009:13.3.2). Small areas of sandy beaches are also found along the coast in regions that do not support mangroves (Coffey Natural Systems 2009:13.3.1). Similarly, as summarised by Rowe *et al.* (2013:1131), 'environmental zones run parallel to the shoreline', and 'in succession inland a littoral plains complex, alluvial plain, coastal lowland and coastal hill-ridge formation comprise the Caution Bay catchment (and corresponding to the Papa, Boroka and Fairfax land-systems mapped by Mabbutt *et al.* 1965)'. In turn, environments can be differentiated by characteristics such as 'geology, pattern of topography, soils and vegetation' (Rowe *et al.* 2013:1131). The climatic condition in the region of the Caution Bay embayment is Tropical Savanna with seasonal changes in wind direction, humidity, temperature and rainfall (Rowe *et al.* 2013:1131). Rainfall is centred around a northwest monsoonal system that takes shape between December and April bringing with it consistent and considerable amounts of rain that is accompanied by warm weather with high humidity, while a dry and cooler weather pattern is associated with southeasterly trade winds that occur between June and October (Rowe *et al.* 2013:1131). The average annual rainfall is 1000mm and seasonal temperatures are between 28 to 32°C (Rowe *et al.* 2013:1131). Although the sites used for this study are distributed spatially (Bogi 1 on sand dune, Tanamu 1 on the edge of sand dune and JA24 further inland), there were significant changes to the overall environment in the past affecting all three sites.

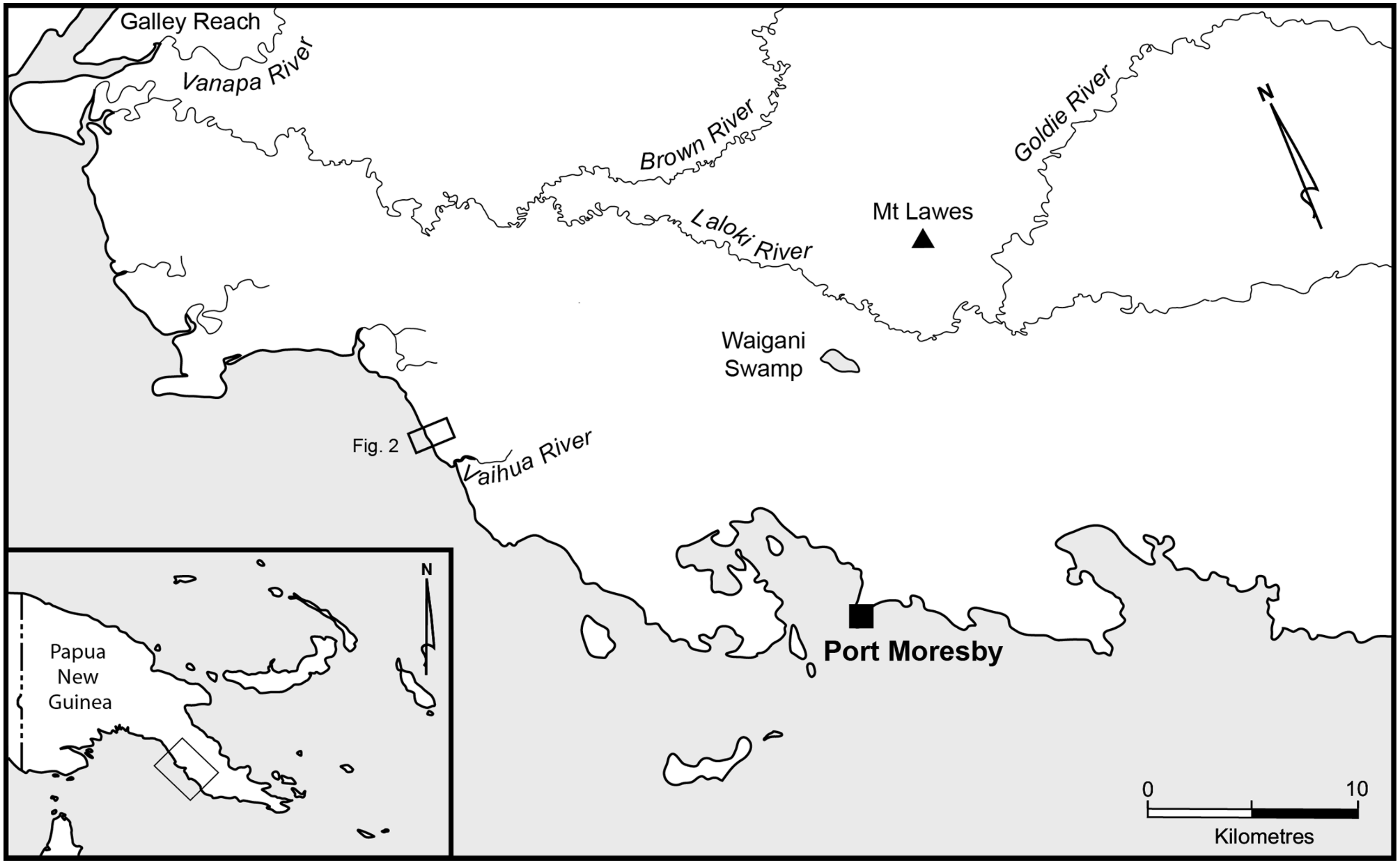

Figure 8.1. Main river systems in southern Papaua New Guinea (Rowe *et al.* 2013:1131).

Initial research on the environment was conducted by Pain and Swadling (1980) who argued that the Vaihua Inlet had been evolving over the past 120,000 years. Changes with the Vaihua Inlet which extends inland for 3km, are linked with three sandspit (linear dunes) complexes where sites such as Bogi 1 are found (McNiven *et al*. 2010a:1). The oldest complex, situated midway up the inlet was formed when sea levels were 5 or 6 metres higher than present times and relates to the Last Interglacial approximately 120,000 years ago (McNiven *et al*. 2010a:1; Pain and Swadling 1980:59). On the other hand, the second sandspit where site Bogi 1 is located is associated with a much later sea level elevation at 5000 to 6000 years ago (McNiven *et al*. 2010a: 1; Pain and Swadling 1980: 62). Lastly, the final sandspit which is also the smallest is situated a few hundred metres from the open sea and within the mangrove system (McNiven *et al.* 2010a:1). The discussed sandspit developed as sand bars in relation to the mangroves when sea levels were a little higher (McNiven *et al*. 2010a:1; Pain and Swadling 1980:59). Pain and Swadling (1980:59) argue that these areas were probably 'abandoned as sea level and the mangroves advanced seawards'. Extrapolating from the data, McNiven *et al*. (2010a:1) point out that the Bogi 1 site was 'probably active and forming prior to the development of extensive mangrove forests that currently occur on the seaward site of the sandspit. In this sense, the Bogi 1 sandspit is a relict of a period in the past when open sea and not mangroves fronted the site'. Environmental changes, in particular to the coastline, therefore accelerated after the sea-level highstand at 6000 BP and continued on to the late Holocene (Pain and Swadling 1980; Tomkins *et al.* completed ms:12).

Significant changes occurred to the shoreline and mangrove development during the Holocene from the deposition of terrestrial sediments in the intertidal zone and were probably a result of inland erosion through anthropogenic use of land (McNiven *et al.* 2012a:150). Between 3300 and 1000 cal BP, the mangrove community at Caution Bay was well-established alongside the coastline as evidenced from the palynological record (Petchey *et al.* 2012:77; Tomkins *et al.* completed ms:13). Changes also took place further inland where there is a transition from a coastal thicket and forest landscape to coastal scrub and reduction in tree cover after 2000 cal BP (Petchey *et al.* 2013:77; Tomkins *et al.* completed ms:13). Evidence from charcoal remains also points to increased burning activity between ~2000 and 1400 cal BP (Petchey *et al.* 2013:77;

Tomkins *et al.* completed ms:13). Rowe *et al.* (2013:1139), raise some important points with burning. Firstly, unlike other types of vegetation, mangroves do not normally burn and the closed canopies of mangroves may not have allowed for charcoal remains to enter trunk spaces and therefore may not provide an accurate representation of records. To provide a better understanding of possible burning regimes, charcoal remains from Bogi 1 were examined because of the site's spatial location 'above the mudflat and on the coastal foredune' (Rowe *et al.* 2013:1139). Results show peaks in charcoal concentrations with the peaks occurring at 300 to 750 cal BP, c. 1500 year, c. 1740 cal BP, c. 2050 cal BP (Rowe *et al.* 2013:1139) (Figure 8.2). The results correlate with the evidence for burning between 2000 to 1400 cal BP.

In addition, regional climatic cycles have shown an overall drying trend from mid-to-late Holocene in Greater Australia and the Pacific rim (Rowe *et al.* 2013:1139). During this time, periods of higher precipitation have been recorded and this is also evident in the Port Moresby region where wetter conditions first occur at c. 2500 BP and further increasing between 1700 and 1200 BP (Rowe *et al.* 2013:1139). Drier weather patterns may have been linked with 'large- scale sinking, dry southeasterly trade flows over the Greater Australian tropics' and identical to atmospheric flows commonly related with the El Niño-Southern Oscillation (ENSO) cycle which according to Haberle *et al.* (2001) was pronounced after c. 5000 cal BP (Rowe *et al.* 2013:1139). Rather, even with wet-dry conditions, the evidence at Caution Bay with both high precipitation and charcoal remains is representative of a local fire regime that was used by people to control local plant biomass which had increased with more moist conditions (Rowe *et al.* 2013:1139). Hence, the shift from coastal thicket and scrub to coastal woodland-grassland at c. 1740 to 1300 cal BP is consistent with repeated drier conditions and use of fire (Rowe *et al.* 2013:1139).

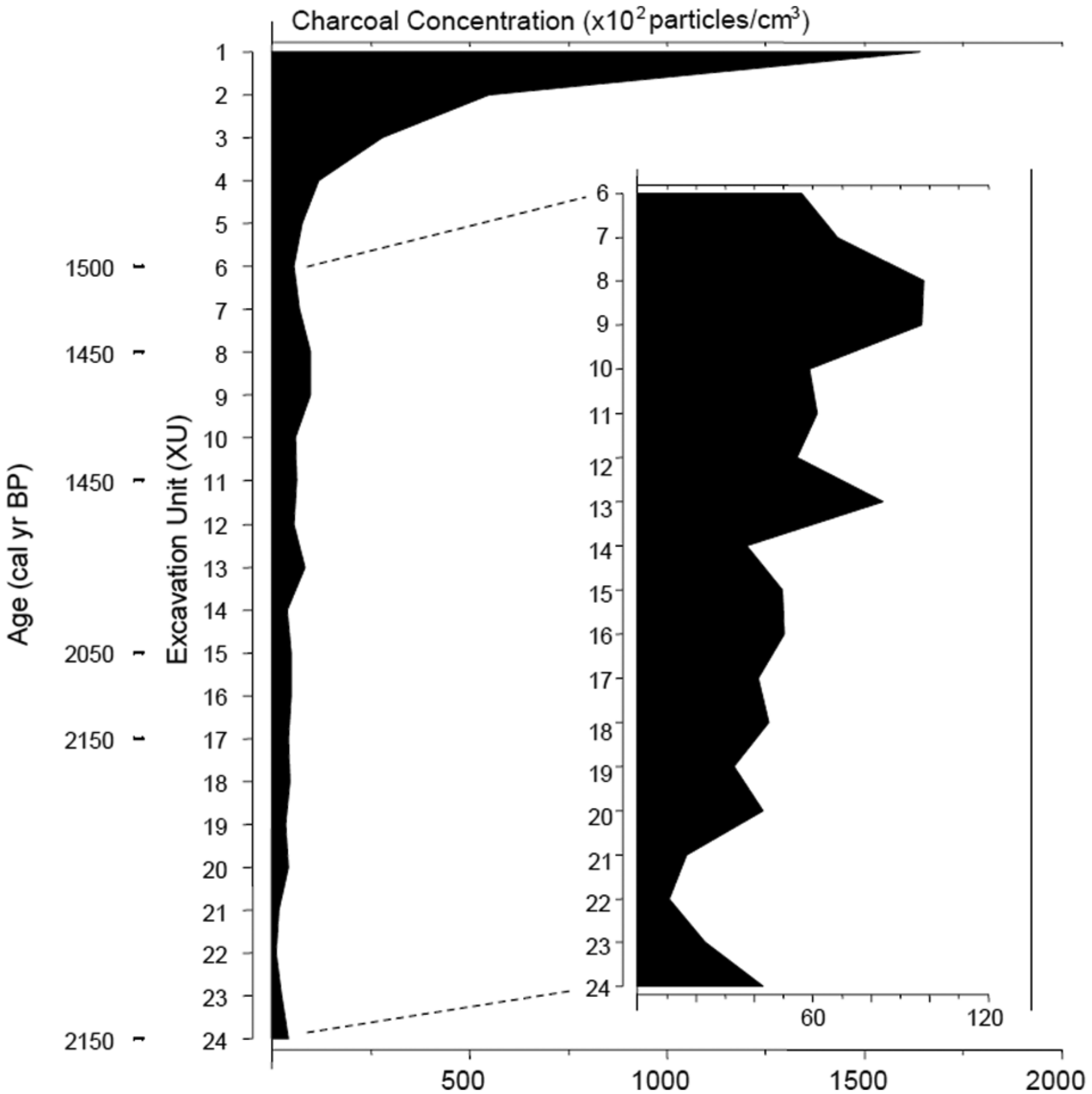

Figure 8.2. Microcharcoal concentration per excavation unit (XU), with magnified insert showing values between XU6-24, Square C, Bogi 1, Caution Bay (McNiven *et al*. 2011; Rowe *et al.* 2013:1139)

As well as this, increases in sedimentation after 1000 cal BP led to a decrease in tidal inundation frequency resulting in a change in mangrove composition and the appearance of a saltmarsh and unvegetated mudflat (Petchey *et al.* 2013:77; Rowe *et al.* 2013). Analysis of mangrove sediments and geomorphology has revealed rapid siltation and coastal progradation having occurred at Caution Bay (Ellison 2005). While this may have had significant implications, research by Rowe *et al.* (2013) on the correlations between the palaecoecological and archaeological records have demonstrated the degree of complexity in human-environment interactions at Caution Bay. Research at Caution Bay has revealed that the landscape was first occupied within the coastasl areas at around 5000 years BP, while occupation on the nearby lowland areas has been determined to be 6000 cal BP (Rowe *et al.* 2013:1139). Within this occupational sequence, at sites such as Bogi 1 where Lapita occupation has been recorded at 2900 cal BP (David *et al.* 2012; McNiven *et al.* 2011), evidence of pre-ceramic and post-Lapita occupation has also been unearthed. The timing of the major post-Lapita phase (2000 to 2150 cal BP) with dense midden concentrations is of particular interest here since mangrove development occurs at about the same time (Rowe *et al.* 2013:1139). It is important to note that similar changes in vegetation composition have been found in nearby Western Highland Provinces and West New Britain from anthropogenic control of plants accompanied by decrease in settlement patterns after c. 2000 cal BP, and has been attributed to a reorganisation of the subsistence economy with a greater focus on the production of plant food (Denham and Haberle 2008; Lentfer *et al.* 2010; Rowe *et al.* 2013:1139).

The development and expansion of mangroves (*Rhizophora*) would have eventually resulted in a physical obstacle hindering access to the shoreline, mobility of people (e.g. less use of watercraft) and land access (Rowe *et al.* 2013:1139). Similarly, changes in sea-level may have affected sea-travel since tidal direction and strength would have been less predictable (Rowe *et al.* 2013:1139-40). Reduction in resource types available for human exploitation within the mangrove *Rhizophora* forest would hence have reduced the occupational preference of such an environment (Rowe *et al.* 2013:1140). The implications of reduced occupational preference is seen at Caution Bay with archaeological evidence demonstrating cessation of most settlements around 2000 cal BP and intermittent pulses of occupation at around 1700 cal BP (Rowe *et al.* 2013:1140). Subsequent evidence of occupation is found at Boera district to the southeast by 1200 cal BP where mangroves are less prevalent, thereby presenting the possibility that the establishment of dense mangroves at Caution Bay may have led to changes in settlement patterns (Rowe *et al.* 2013:1140).

Discussion

The palaeoenvironmental record in relation to the Lapita cultural complex has been examined at other locations in the Pacific and these have demonstrated changes in island transformations especially in vegetation and sediment composition and loss of faunal taxa correlating with population increase after colonisation (Enright and Gosden 1992; Rowe *et al.* 2013:1140; Sand 1997; Stevenson 1999). This is however not evident at Caution Bay because people were already present and established for a significant period of time before Lapita peoples arrive (Rowe *et al.* 2013:1140). Hence, any anthropogenic alterations to the environment may have been undertaken by an existing pre-Lapita population (Rowe *et al.* 2013:1140). According to McNiven *et al.* (2012a), the subsequent changes that have been discussed represent a complexly negotiated scenario in relation to environmental and social landscapes that were in place. Overall, of the changes seen in the environmental record at Caution Bay, the following key points are of significance to this study:

- Change in sea-levels and habitat types before and after the arrival of Lapita peoples and the correlation of this event with mollusc exploitation.
- Deliberate modification of landscape (e.g. burning regimes) and its impact on resources and site occupation strategies during the last major midden phase between 2000-1400 cal BP.
- Coastal scrub and reduction in tree cover after 2000 cal BP and is implications as evidenced from shellfish remains for understanding the post-Lapita and 'ceramic hiccup' phases (see Chapter 4) phase.
- Timing of onset of mangrove communities and its effects on land and resource use strategies.

As a result of these significant environmental changes (e.g. habitats and environment) over a temporal sequence of 5000 years, mainly due to human land-use activity, the natural range and distribution of molluscs would have been impacted, and by extension this effect may have led to changes in local shell subsistence strategies (McNiven *et al.* 2012a:150; Tomkins *et al.* completed ms:13). Mollusc data from this study, in conjunction with environmental chronologies, will provide an insight on this matter.

Chapter 8: Caution Bay Molluscs and Methodology

Introduction

This chapter discusses field and laboratory methods utilised in this study to derive the data necessary to understand those key questions on past human trends in mollusc procurement outlined in Chapter 1. The methods employed in this research comprise primarily laboratory based techniques. All of the cultural material from Caution Bay had previously been excavated by a team of archaeologists prior to this study, and although field survey and excavations were not part of my research strategy, a description of field and dating techniques is nonetheless essential. An outline of the analytical techniques and a justification of their use in this thesis will provide the framework for later discussion of data and results from each individual site chapter. An overview of the Caution Bay molluscan assemblages will allow for further analysis in relation to previously discussed palaeoenvironmental trends (see Chapter 7).

Fieldwork: Survey and Excavation

Fieldwork at Caution Bay began in late 2009 as part of a large-scale salvage excavation programme prior to the construction of facilities for a liquefied natural gas (LNG) project in the area (McNiven *et al.* 2010a:1). Salvage of archaeological sites of cultural heritage significance was required in order to conform to the legislative requirements of the PNG government. Previous geomorphological research by Pain and Swadling (1980) who surveyed and documented the landscape, established the presence of archaeological sites in the area. This was further evident with the discovery of site Tanamu 1 by consultant Jeremy Ash during archaeological surveys of the area in 2008 (David *et al.* completed ms:4). The entire salvage operation was directed and managed by archaeologists from Monash University, in particular Dr Bruno David, and the project was undertaken with a focus on providing a community-based archaeological outcome. Fieldwork therefore proceeded in conjunction and in cooperation with individuals from the local Motu and Koita communities of Porebada, Boera, Papa and Lealea.

The Caution Bay landscape, which has a surface area that extends 6.5km along the coast and up to 1.75km inland, was thoroughly surveyed with over 100 archaeological sites identified (McNiven *et al.* 2011:2). Since the project had to be completed within a short period of time, multiple teams were tasked with the excavation of different sites under the supervision of a field director. An overall excavation strategy was implemented, with fine-grained excavation of main squares at a site proceeding in arbitrary Excavation Units (XUs) following the stratigraphy, with each XU averaging approximately 2 to 3cm in thickness (e.g. David *et al.* 2012; McNiven *et al.* 2011). The small thickness of each XU was part of a methodological approach which would allow for finer chronostratigraphic analysis of each site. At the same time, in order to conform to safety protocols, larger sites were excavated with shored stepping-out squares which allowed for greater depth in the excavation of main squares (David *et al.* completed ms:7; McNiven, *et al.* 2010). Cultural material from stepping-out squares were not passed through a sieve, however, any material that was unearthed such as pottery and artefacts were plotted and bagged (David *et al.* completed ms:7). This excavation strategy provided additional time to fully excavate the main squares at a site, thus ensuring that important cultural material was not affected by impending construction works (David *et al.* completed ms:7; McNiven *et al.* 2010a). Although a broad and consistent excavation strategy was implemented, there were some minor differences in excavation techniques between sites. Since this study only focuses on 3 sites from over 100 that were excavated as a part of the broader project, more in-depth details of excavations of each site will be discussed in individual site chapters.

During the course of excavations, selected charcoal samples and any artefacts more than 3cm in length were plotted in three-dimensions (3-D) (David *et al.* completed ms:7). Photographs of the wall profiles and the XU were also taken after the excavation of each XU was completed. A field sieving station and laboratory were set up and used to wet-sieve any sediment matter through a 2.1mm mesh, with the residue then air-dried and sorted at a preliminary level (David *et al.* completed ms:27). All of the material was sent to Monash University where individual XUs were sorted into each cultural category (e.g. bone, pottery, shell, shell artefacts). Each category of cultural material was subsequently sent to individual specialists where final sorting and analysis was undertaken (see David *et al.* completed ms for description of laboratory methods used to quantify and analyse each category). For this research, shell assemblages from two of the sites (Bogi 1 and JA24) were sent to the University of Southern Queensland (USQ) laboratory for sorting and analysis. Tanamu 1, the other site used in this study had already been sorted and analysed by Helene Tomkins from James Cook University (JCU), with these data forming a component of the analyses presented here, and only size analysis of selected species undertaken at USQ.

Radiocarbon Dates

Conventional radiocarbon dating techniques were applied to single fragments of selected marine shell or wood charcoal at The University of Waikato Radiocarbon Dating Laboratory in New Zealand (David *et al.* completed ms:35; McNiven *et al.* 2010a:17). All dates were accelerator mass spectrometry (AMS) dates. The calibration programme OxCal 10.4.1 (charcoal calibrations: IntCal09 curve selection; shell calibrations: MARINE09 curve selection) was used for determination of radiocarbon dates into calendar years (Reimer *et al.* 2009; Stuiver and Reimer 1993). Radiocarbon dates are conversely represented by either 'cal BP' or 'years ago' and relate to calendar years before 1950 (McNiven *et al.* 2010a:17).

Marine Reservoir Effect

While marine reservoir effect is not the focus of this study, a brief explanation is needed so as to understand and ensure the validity of the shell dates incorporated into the analyses. Though Marine09 dataset was initially used with ΔR correction value of 1 ± 69 to calibrate marine shell, and was deemed to be locally applicable for site Bogi 1 (McNiven *et al.* 2010a:17), a further comprehensive study of marine ΔR (marine calibration curve) values of each shell species selected for dating was undertaken to provide a more robust chronology of the area (Petchey *et al.* 2012). Such a study is needed because any dating of material that had inhabited a marine environment will reveal inaccurate, older radiocarbon ages as a result of uptake of carbon that had been subjected to radioactive decay following prolonged occupation in deep ocean (Ulm 2006a:57; Ulm *et al.* 2009:160). Radioactive carbon (^{14}C) in marine environments can also vary not just because of atmospheric activity, but also on a range of other local and regional factors like tidal flushing, terrestrial water input and hinterland geology (Ulm 2006a:57; Ulm *et al.* 2009:160). The negative effects of this can result in unreliable radiocarbon ages with up to several hundred years difference than actual dates (Ulm 2006a:57; Ulm *et al.* 2009:160). The Caution Bay

ΔR programme targeted the following species from site Bogi 1: *Anadara granosa*, *Anadara antiquata*, *Gafrarium tumidum*, *Gafrarium pectinatum*, *Polymesoda erosa*, *Batissa violacea* and Echinoidea (Petchey *et al.* 2012:70). While methods will not be discussed here (see Petchey *et al.* 2012 for further discussion), overall results point to a species-specific ΔR values for each taxa with recommendations made to not use *Polymesoda* or *Batissa* species for dating archaeological sites because of potential ^{14}C offsets (Petchey *et al.* 2012:78-9). The updated ΔR values for the Caution Bay region is 53±16 ^{14}C years for *G. pectinatum*, 67±16 ^{14}C years for *G. tumidum*, 11±17 ^{14}C years for Echinoidea, -71±15 ^{14}C years for *A. granosa* and -1±16 ^{14}C years for *A. antiquata* (Petchey *et al.* 2013:78). Radiocarbon chronology for Caution Bay sites from shell were therefore derived from the above updated ΔR values. Dates for each site will be presented in further detail in subsequent chapters.

Laboratory Techniques

Since the aim of this study is to document cultural change over time, a number of laboratory quantification methods in line with the shell quantification protocols for the Caution Bay project (see Tomkins *et al.* completed ms) were used. Throughout the sorting phase, shell from each XU were sorted and identified to the lowest possible taxonomic level that could be supported by diagnostic features, including mollusc fragments regardless of their size. This included entire shell remains of an XU, including fragments regardless of their size. Individual shell species were identified using published reference books (Abbot and Dance 1982; Carpenter and Niem 1998; Coleman 2003; Hinton 1972; Lamprell and Healy 1998; Lamprell and Whitehead 1992), primarily through photographs and descriptions, and an archaeological shell reference collection which was initially set up by Brit Asmussen and subsequently added to by Helene Tomkins, with any new species later added to the collection when found. It must be noted that scientific names of some mollusc species are subject to change, but for the purposes of this research existing nomenclature that were accepted at the time of analysis according to the World Register of Marine Species (WoRMS) will be used to maintain consistency. Although identification of all shell fragments was attempted, the lack of diagnostic features and morphological similarities between multiple species resulted in some fragments not being identifiable. Tomkins *et al.* (completed ms) separated unidentifiable fragments into broader categories comprising of ‘unidentified shells’, ‘unidentified bivalves’, ‘unidentified gastropods’ or to family (e.g. *Strombus* sp.). According to Tomkins *et al.* (completed ms), this procedure was undertaken in order to ensure that all taxa and fragments were identified accurately and to avoid numerical misrepresentation of a species. As mollusc data from one of the study sites (Tanamu 1) had already been collected (Tomkins *et al.* completed ms) and made available for inclusion in this study, the use of three main unidentifiable mollusc categories is only applicable to datasets for Tanamu 1. Since analysis of mollusc assemblages from the remaining sites (Bogi 1 and JA24) was undertaken by myself, the decision to incorporate all three unidentifiable categories into a single 'unidentified shell' category was made for these two sites. The justification for this specific methodological change was that the presence of a large diversity of taxa (over 100) meant that in certain cases it was not possible to distinguish fragments of unidentified bivalves from unidentified gastropods especially in combination with the differential effects of weathering and fragmentation on preservation of diagnostic features. Additionally, since all unidentified categories were only quantified by weight, it is envisioned that combining all three categories into a single analytical 'unidentified shell' category would not provide a significant overall alteration to site interpretations.

After an XU was sorted, four quantification methods were used to collect the shell data. These methods in shell quantification have been well-documented and discussed in many global archaeological studies (Claassen 2000; Giovas 2009; Glassow 2000; Mason *et al.* 1998, 2000; Nichol and Williams 1981; Szabó 2009). Minimum Number of Elements (MNE) was first used to record data from diagnostic features that are only present once in every complete shell (Non-Repetitive Elements) (Tomkins *et al.* completed ms:3). The MNE number for any bivalve species was based on counts of two main diagnostic features, left or right umbo from fragmented shells, and articulated individuals (Tomkins *et al.* completed ms:3) (Figure 8.1). For gastropods, five diagnostic elements were used for MNE counts and these were the aperture, apex/spire, siphonal canal, columellar deck and the whole shell (Tomkins *et al.* completed ms:3) (Figure 8.2). MNI counts were based on the presence of diagnostic features that were greater than 50% (Tomkins *et al.* completed ms:3).

Minimum number of individual (MNI) counts were calculated using the MNE data with the highest MNE count of each taxon in each XU recorded as the MNI for that unit, except for gastropods where the MNI was calculated by adding the number of whole shells with the highest numbered element based on the MNE diagnostic features (Tomkins *et al.* completed ms:3). In addition, in devising a standardised methodology for quantifying each taxa for all of the Caution Bay sites, Tomkins *et al.* (completed ms:4) used the highest occurring diagnostic feature from the entire assemblage to determine the MNI count for each taxa per XU. For instance, if the overall MNE count for left valves of a bivalve taxa was higher than that of right valves in an entire Square, then left valves were used to represent the MNI in each XU. This method according to Tomkins *et al.* (completed ms:4) would result in MNI counts being 'slightly lower than they would be if recorded by single excavation unit, but it does not significantly alter the relative representation of taxa in this instance'. A further justification made for incorporating such a method was that it helps to not only prevent over-estimation of a species when a combination of diagnostic elements are used, but also 'alleviates the problem of 'division in aggregates' that occurs when each XU is treated as a distinct temporal unit (Grayson 1984:29-49)' (Tomkins *et al.* completed ms:4).

Since the Tanamu 1 site and all of its cultural elements are in process of being published, the mollusc data provided by the project directors conformed to the above discussed method of MNI calculation for Tanamu 1. Therefore all shell analyses for Tanamu 1 based on relative abundance data is in accordance with that particular method. However, as data collection for Bogi 1 and JA24 was done by myself for this study, MNI data was instead determined from using the highest occurring MNE counts of diagnostic features for each taxa in each XU, Stratigraphic Unit (SU) and cultural phase. For example, if more left valves of a bivalve were present in the first XU, then MNE counts for left valves was used to determine the MNI for that XU rather than choosing the highest overall counts (MNE) of that bivalve taxa for an entire Square. As well, there would be reduced MNI numbers if the MNI count was recorded by SU or site or if the same diagnostic feature (e.g. siphonal canal for gastropods) was used for each species in every XU (Tomkins *et al.* completed ms:3). The difference between both methods is that for the Tanamu 1 shell assemblage the data will be under-estimated whereas for Bogi 1 and JA24, the data will slightly over-estimate. While quantifying shell by each XU as an individual temporal unit rather than SU or an entire site can result in the problem of 'division in aggregates' (Grayson 1984:29-49) with inflated numbers of approximately 15% more than using

MNI for an entire site for veterbrate remains, the decision to use this method allowed for documenting any fine-grained chronostratigraphic changes. MNI of each taxon will therefore be derived from MNE counts for each XU rather than SU and all diagnostic elements will be used (e.g. apex, aperture, columellar deck, siphonal canal) for this research.

The justification for the use of this method is two-fold. Firstly, the use of MNI per XU does not significantly change the relative representation of a species as there are comparatively fewer diagnostic elements incorporated into calculating MNI for mollusc in comparison to vertebrate fauna, thus aggregation effects are far less pronounced (Szabó 2009:186-7). In addition, as all XUs are consistent in size with similar thickness, the problem of overestimation of a species is not significant since the MNE and MNI methodology used here is consistent throughout the other two sites and aggregation is not significantly different. As well, in the Australasian region, many previous researchers have also employed a similar quantification method in which mollusc MNI was determined by XU (see Ash *et al.* 2013; Barker 2004; Crouch *et al.* 2007; Faulkner 2011; Ulm 2006b). Overall, it is likely that the MNI data from all 3 sites are broadly comparable even with the slight difference in method.

Number of identified specimens (NISP) counts were also taken as diagnostic elements were non-existent on some specimens, as well as providing an indication of the degree of fragmentation within and between species (Tomkins *et al.* completed ms:3). Understanding fragmentation is important since there are differences in robustness between shell species (Faulkner 2010). Fragmentation can also provide vital information into taphonomic processes (e.g. chemical and mechanical processes of degradation) and on the use of shellfish by past peoples in areas of meat extraction and shell artefact production (Mowat 1995; Tomkins *et al.* completed ms:3; Szabó 2009:186). However, it must be acknowledged that using NISP to interpret the number of shells represented within an XU can be problematic as a result of differential fragmentation between taxa for the reasons discussed above. Hence, NISP data will only be used to understand degrees of fragmentation and on areas as mentioned above (e.g. taphonomy, meat extraction, shell working). This method will not be used to estimate overall numbers of each taxon.

The last quantification method discussed here is the use of shell weight. Problems inherent with this method include unreliability for the purpose of calculating shell numbers because of chemical degradation (e.g. leaching, burning and acidic soil) thus possibly leading to a reduction in original weight (Stein 1992:150; Sullivan 1993:3; Tomkins *et al.* completed ms:4). In addition, despite a difference in size-structure, meat yields can also vary between different taxa as some robust heavier species may not have much meat in them while other smaller taxa may contribute more meat from higher levels of exploitation. Therefore, using shell weight of a larger taxa as a comparative tool in relation to MNI does not necessarily demonstrate the contribution of that species to local diet. For instance, some of the main taxa at Caution Bay by MNI have both a lower contribution per individual shell (<1g meat) to the diet and are small-sized. Even though such taxa may have higher overall MNI numbers and possibly yielded more meat, it is important to note that they may still weigh lesser than a more robust species with much lower MNI (Tomkins *et al.* completed ms:4). This therefore creates a problematic situation when trying to measure the absolute or relative frequency of a species. Yet, the use of shell weight can be useful in understanding the relative contribution of each species to shell densities in every XU and SU (Tomkins *et al.* completed ms:4). Using weight with MNI can be beneficial as weight can offer an additional source of information about contributions of individual species to activities of past peoples. Even though there has been considerable debate on the merits of using weight vs MNI (cf. Claassen 2000; Giovas 2009; Glassow 2000; Mason *et al.* 1998, 2000;), shell weight will nonetheless be used in conjunction with MNI and NISP in this study where applicable as it provides a balanced dataset given the advantages and disadvantages of each method.

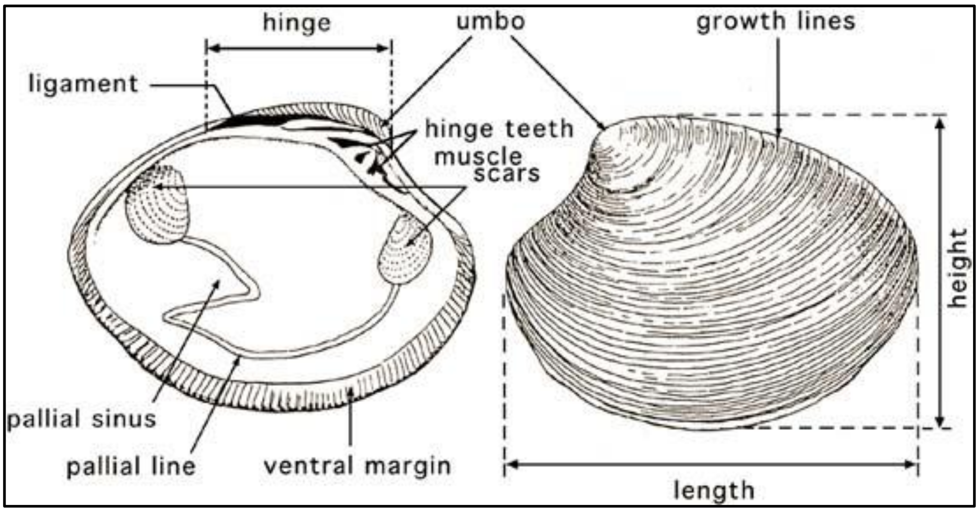

Figure 8.1. Morphology of a bivalve with MNE localities (umbo) (Fisheries and Agricultures Department of the United Nations 2013).

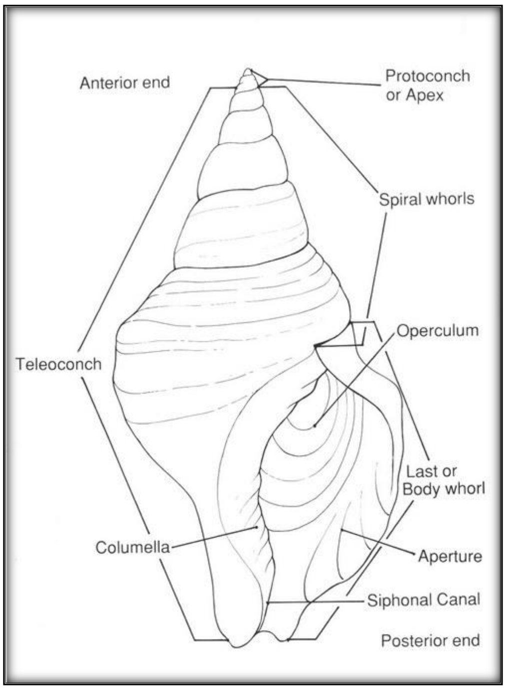

Figure 8.2. Morphology of gastropods with MNE localities (apex, siphonal canal, aperture) (Conchylinet 2015).

All of the above mentioned methods were applied to all three assemblages and analysed to investigate rates of discard and vital trends in taxonomic representation between each XU and cultural phase. Any sub-XUs were combined for analytical purposes, and the uniformity in XU volume and thickness means that weights and MNI will not be affected and correction does not need to be applied. Other studies (e.g. Barker 2004; Bailey and Craighead 2003) for example have undertaken volume corrections due to variability in depth/volume of each analytical unit. Volume per 100 years or cultural unit will however not be used here and is not required as the problem of differential XU size is not present. It would have however been problematic if XUs varied in size (e.g. XU1 = 5cm vs XU2 = 10cm) as there would have been an inaccurate representation of a species and volume. In addition to thickness of XUs, each excavated pit from all three study sites measured 1 m^2 in size. Since pits were consistently excavated in 1 m^2 squares, volume is not a problem as a change in pit size at any stage of excavation would have affected volume. Discard rates of shell for every 100 years and cultural phase will be used here to investigate trends in relation to taxonomic exploitation and occupation of the landscape (see Barker 2004). In addition, SPSS version.23 will be used for any statistical analysis that may be required. Overall, the outcomes of these methods will be presented and discussed in further detail in each site chapter.

Overview of Caution Bay Molluscs

Over 100 species of shellfish have been identified from within the sites at Caution Bay. The range of taxa consists predominantly of marine bivalves and marine gastropods with a lesser range of freshwater bivalve and gastropod species (Tomkins *et al.* completed ms:4). Polyplacophora (chiton), Vermetidae (wormtube) and Maxillopoda (barnacle) are also present within the assemblages but in small quantities (Tomkins *et al.* completed ms:4). Though distribution, prevalence and raw numbers will vary between sites (to be discussed in more detail in each site chapter), an overview of the common taxa and their favoured environmental zones as outlined by Tomkins *et al.* (completed ms:13-4) are as follows:

Intertidal Rocky Substrates

Common species from the assemblages that are found in intertidal rocky shore environmental zones are the Ostreidae (different taxa of oysters), *Turbo cinereus* and *Nerita* spp. (multiple taxa of nerites).

Shallow Sandy Habitats and Seagrass Meadows

Within this habitat, *Gafrarium* spp., *Anadara antiquata*, *Conomurex luhuanus* are the dominant taxa. *A. antiquata* favours sandy gravels and shallow lagoon bottoms and is a poor burrower. *C. luhuanus* is found in muddy-sand habitats and in seagrass beds (Carpenter and Niem 1998:475; Coleman 2003). *Gafrarium* spp. favours seagrass meadows of the high intertidal zone and shallow, sandy areas.

Muddy Tidal Flats and Mangroves

Anadara granosa, *Polymesoda erosa*, *Telescopium telescopium* and *Austriella corrugata* represent dominant taxa found in this habitat type and occupy the muddy bottoms of mangroves and tidal flats. *Isognomon* spp. are also found in this type of environment in dense population groups attached to trees or rocks and other hard surfaces in mangroves and muddy estuaries (Carpenter and Niem 1998:190)

Coral Reefs

Chama spp. (jewel box shell), *Pinctada* spp. (pearl oyster), Tridacnidae (giant-clam shell) and *Tectus niloticus* (top-shell) are readily found in this zone. While *Chama* spp. and *Pinctada* spp. are normally attached to rock and coral reefs in the sublittoral and littoral zones, the other two species are collected from clear shallow waters of coral reefs. Some conch shells (*Strombus* sp. and *Lambis* spp.) are also found in reef flats and coral rubble bottoms in subtidal and intertidal zones (Carpenter and Niem 1998:467)

Freshwater

The main freshwater species are *Batissa violacea* and some small Neritina gastropods (Lamprell and Healy 1998:180-82).

The wide range of species represented by different environmental zones points to a comprehensive subsistence strategy that was utilised by past inhabitants at Caution Bay (Tomkins *et al.* completed ms). Although some of the dominant taxa and their preferred environments have been mentioned, the diversity of species found presents a unique situation in regards to distinguishing which taxa were economic (e.g. food, artefacts) and non-economic (e.g. naturally brought/occurring into a site) because shellfish assemblages in a large number of coastal sites in the Austronesian region are represented by lesser number of taxa (e.g. Barker 2004). Addressing this problem of economic vs non-economic can be ambiguous at certain sites since a large variety of shellfish species representing the full faunal range of a particular habitat are found (see below). Furthermore, using size as a proxy for determining the economic status of a species can be unreliable as some taxa with a small size-structure may have still been exploited in larger numbers (e.g. used for soups) (Rowland 1994; Szabó pers. comm. 2013). Another example is the presence of small Nerite species (*Nerita undata*) in coastal rockshelter sites in the Whitsundays with an average meat weight of only 1.2g (Barker 2004). Analysing the meat weight range at site Tanamu 1, Tomkins *et al.* (completed ms:9) have pointed out that even with considerable differences in meat weight between the common taxa (>1g for *A. striata* against 35g for *Lambis lambis*), many of the taxa (e.g. *Cerithidea largillierti*, *Calliostoma* spp., *Clypeomorus batillariaeformis*) with an estimated 1g of meat or less were of economic importance as a source of food since they are found in large numbers during periods of human occupation. While finding large numbers of small taxa does not necessarily mean that they were cultural, in this instance, the discard of other known cultural material together during major occupational phases may have allowed for determining such small taxa with small meat weights as representing an economic resource. Additionally, according to Tomkins *et al.* (completed ms:9) other even smaller taxa measuring less than 10mm in size have been regarded as non-economic (e.g. Cerithiidae, Ellobiidae) at Tanamu 1 because they were associated with periods of minimal cultural activity, and are interpreted as being either accidentally or naturally brought into the site (Tomkins *et al.* completed ms:9). In this scenario, context dependant assessment and interpretation of shellfish taxa is therefore important.

Even though the data collected in this thesis is mainly quantitative in nature, it was initially envisioned that qualitative data could also provide an insight into shell exploitation and help to address the above problem. However, as a result of time and funding restrictions, ethnoarchaeological fieldwork was not undertaken for this project. Thus previously recorded oral histories and ethnographic observations of subsistence practices in nearby locations (see Chapter 5) will be discussed in conjunction with quantitative data to address this problem. Qualitative data can be important and may provide a better understanding of cultural practices involving molluscs, such as which species are used as food, artefacts or in rituals. For instance, recent communication with elders from Kerewo village in the Papuan Gulf Province has brought to light the use of various shells for the production of white paint for use in ceremonies and artefacts (Korokai pers. comm. 2012). Thus, in some scenarios, size cannot be used as a proxy for determining the use of a specific taxon, as multiple species regardless of their size may have still been exploited depending on their intended use, availability, abundance and shellbed location within the landscape. Once the cultural status of a taxon has been determined (see below for definition of cultural and non-cultural), there can however be an analysis on the level of economic importance of that species using size and raw numbers. This may again vary depending on a few factors (e.g. abundance, availability, and environment) and preference among people that were occupying the area. Nonetheless, determining the economic or non-economic status of a taxon can be problematic, but can be addressed through the use of a criteria incorporating qualitative, quantitative and environmental data (see below).

Identifying Human Exploitation of Molluscs

Fundamental to interpretations of shell remains within archaeological contexts is the ability to distinguish which mollusc species represent cultural/economic activities of humans from those that had likely been deposited by natural events (i.e. non-cultural/non-economic). Addressing this problem is essential since it can significantly alter our understanding of the past and not present an accurate story of pre-European human activities, especially considering that a prominent archaeological signature of most coastal sites are molluscan remains.

Researchers have devised different methodologies to address the problem of determining exploited shellfish taxa from those that were natural. From using shell size to analysing palaeoenvironmental conditions, a robust criteria that adequately considers all aspects is required in order to safely determine if a species was targeted by humans. For the purposes of this research, the following definitions will be used:

- Cultural / Economic – Molluscan taxa that have been intentionally targeted and exploited by humans regardless of the end purpose, including use in subsistence, trade as raw material and artefact manufacture for both utilitarian (e.g. fishhooks) and non-utilitarian (e.g. for personal adornment) purposes.
- Non-economic – Mollusc taxa not exploited by people and thereby brought into a site by accident or from natural processes such as predation by other fauna (e.g. birds of prey, Crustacea) and adverse environmental events (e.g. cyclones).

In the past, a range of criteria have been proposed to tackle this problem (e.g. Chadbourne 1859; Gill 1951; Hughes and Sullivan 1974; Moore 1892; Morlot 1861), however, much ambiguity still remains on this issue (Esposito 2005:1). This is further evident in some examples where both cultural and natural deposits can be similar in structure and/or mixed together (Bailey 1994; O'Connor and Sullivan 1994; Esposito 2005:1-2; Robins *et al.* 1998; Trigger 1986). Historically, the first attempts made to identify cultural deposits from those that were natural, were undertaken by the a committee organised in 1848 by the Royal Academy of Copenhagen following the discovery of shell deposits in Denmark (Daniel 1975; Esposito 2005:20). In turn, North American and European researchers proposed criteria that was used to differentiate natural remains from a cultural deposit (Baird 1882; Chadbourne 1859; Espositio 2005:20-21; Gifford 1916; Morlot 1861; Rau 1865). This criteria used to identify cultural deposits included:

- The presence of mature shells.
- Differentiating molluscs belonging to different habitat types.
- Presence of more focused range of taxa with higher numbers of a single species.
- Consistent trends in shell fragmentation.
- Combinations of fragmented shells and sand, perhaps indicative of camping sites.
- Occurrence of shell artefacts.
- Discard of charcoal and other faunal remains.
- Location of sites in relation to fresh water source.

At the same time, these early researchers proposed the idea that natural deposits would contain a mixture of shells of all ages and size, with only littoral fauna and water lain stratification (Esposito 2005:21). However, a primary problem with these early criteria, was the supposition that there was no stratification present in sites with cultural shell since addressing stratification was a later development in archaeological research (Esposito 2005:21; Willey and Sabloff 1980). Researchers began using stratigraphic data, and documented changes in the distribution of dominant mollusc taxa in conjunction with detailed information of each strata that had ash, sediment and broken shells (Esposito 2005:21; Uhle 1907). These changes within the stratigraphy were interpreted as being related to cultural changes, resulting in the appearance of regional chronological sequences (Willey and Sabloff 1980). Yet, a problematic feature of such early interpretations was that cultural and natural shells could not occur together within a deposit, hence shell matrix sites could only be either cultural or natural (Esposito 2005:21). In 1951, an updated criteria was proposed by Gill after an analysis of cultural shell deposits in Australia (Gill 1951:249-51) and this has been used by others in the field (Bailey 1977).

For cultural deposits, there should be:

- Use of fire as evident from burnt wood, charcoal and blackened shells.
- Occurrence of artefactual material.
- Rough stratification of charcoal and shell.
- Presence of limited number of taxa.
- Occurrence of edible taxa together with evidence for size selectivity.
- Taxa from different habitats from around the deposit.
- Surface of shells not affected by water.
- Consistent trends in shell breakage.
- Remains of marine and terrestrial fauna.

Whereas for natural deposits:

- No evidence of artefacts, use of fire, bones.
- Taxa worn out by water transport.
- An extensive range of taxa and sizes.
- Sedimentary features produced by water.

- Occurrence of other non-subsistence remains such as corals and worm tubes.

There have been some shortcomings of these proposed criteria because while a midden may contain mostly exploited shells, it does not mean that other remains such as smaller shells, coral or pumice might not be found (Esposito 2005:22; Hughes and Sullivan 1974:9). Size is also not a strong indicator because examples of smaller species being targeted do exist (see Chapter 4). Additionally, site formation and post-depositional factors require consideration even with the successful application of these criteria. For instance, natural weather patterns (e.g. cyclones, storms) may impact the makeup of shell-bearing sites by depositing other non-cultural material from wind, tidal surges and water transport as well as possibly removing/redepositing an actual shellfish specimen (Bird 1992; Hughes and Sullivan 1974; Nott and Hayne 2001; Przywolnik 2002; Rosendahl 2012:80; Woodroffe and Grime 1999). Likewise, other factors that need to be considered include bioturbation of the deposit from natural vegetation root system intrusion and burrowing by small animals, such as reptiles, mammals and invertebrates (Bocek 1986; Esposito 2005; Rosendahl 2012:79-80; Specht 1985; Stein 1983; Waselkov 1987). Cultural activities of people leading to changes in sites and formation, such as types of materials discarded, appearance of new or foreign materials, maintenance of campsites, and the impact of extensive site occupation leading to scuffage and treadage are factors that also need to be considered (Claassen 1998; Rosendahl 2012:80; Waselkov 1987). Adding to the picture, many evaluations of the proposed criteria have been made throughout the years. Lilley *et al.* (1999) for example argue that shell deposits should be analysed to determine if foraminifera are present, since these are mostly associated with natural deposits. Henderson *et al.* (2002) have also argued that cultural and natural shell deposits have varying formation processes with distinctive differences in taxonomy, stratigraphy and taphonomy (Esposito 2005:23). To test this proposition, shell deposits in North America (Henderson *et al.* 2002) and Australia (Bailey *et al.* 1994; O'Connor and Sullivan 1994) were analysed and their results indicated that within a cultural deposit, there were limited number of larger species present together with charcoal, artefacts, vertebrate remains and a non-stratified deposit (Esposito 2005:23).

Further debate surrounding this issue has taken place among many researchers, with concerns raised over the ambiguity of using a criteria (Attenbrow 1992: Claassen 1998; Esposito 2005; Rosendahl 2012; Sullivan 1983; Sullivan *et al.*

2011; Waselkov 1987). Predation of natural mollusc by other animals has often been used in this ongoing debate. According to Bowdler (1983), the remains of shellfish predation by seals and gulls in the Bass Strait had led to the formation of shell deposits with features indicative of cultural deposits as they contained unworn molluscs that were of adequate size for human consumption together with animal bones. Therefore, the only cultural indicators available in such a scenario are the presence of artefacts or charcoal especially when animals and birds were capable of creating a shell deposit (Bowdler 1983:137; Esposito 2005). In contrast, Attenbrow (1992) states that the presence of charcoal is not a firm indicator because charcoal remains can be found in cultural and natural deposits. According to Attenbrow (1992:19-20), an analysis of the proportion of juveniles and small shells (less than 15mm) along with the locality of a deposit within the wider context presents the most reliable criteria (Esposito 2005:24). Implying the idea that anything below 15mm in size is not cultural is however problematic as there are numerous examples where people may have exploited smaller shells for use in artefact manufacture and even in subsistence (e.g. in soups) (Rowland 1994; Szabó pers. comm. 2013).

In another example, Stone (1989) proposed the notion that all large shell mounds found in Weipa, northern Australia were formed by the orange-footed scrub fowl *Megapodius reinwardt* which are known to gather material from the environment to incubate their eggs. Furthermore, according to Stone (1992:158 cited in Esposito 2005:24), any shell deposits that was below a metre in height were ‘small shell cheniers’ and most commonly used criteria could also be applicable to natural shell deposits. While it is well-known that animals and birds do predate on molluscs or make use of the shell for nest construction, the ideas proposed by Stone created much debate and forced a re-examination of the existing criteria (Esposito 2005:24). Bailey (1993:9), for instance, acknowledged the ambiguity within established criteria but points out the most frequently used criteria was shell size, taxonomic diversity, occurrence of artefacts and other faunal remains, ash and features within stratigraphic units exhibiting evidence for human occupation. Moreover, the prevalence of a single mollusc taxa and shell size may also be indicative of choice and not availability (Bailey 1993:9). The solution to this problem, as proposed by Bailey (1994), is a comparison between the makeup of both cultural and natural deposits within a given region in order to ascertain their origin, since the presence of juvenile shells, sand, shell gravel, bauxite pisolites and a large variety of species would be more indicative of a natural deposit.

In a recent study, Esposito (2005) also looked to address this issue by using the existing criteria from Gill (1951) together with the other additions to the list of criteria as discussed above. These criteria were examined and applied to datasets from an archaeological site in Blue Mud Bay, northern Arnhem Land, Australia, and this site was selected since the deposit was known to be made up of both natural and cultural shell (Esposito 2005). By applying the criteria to each individual spit and comparing the results, Esposito (2005:73) was able to determine which taxa were cultural from those that were probably natural. This method was more accurate when compared with attempting to categorise all cultural shell from an entire site (Esposito 2005:73). From the existing criteria, it was noted that shell size, in particular the quantity of taxa larger than 15mm in size, the prevalence of taxa bigger than 15mm in size in terms of MNI and weight and a lower quantity of juvenile shell for each taxa together with the quantity of charcoal were reliable (Esposito 2005:73). Using variety of taxa present within a deposit was however the least applicable of the criteria for that site (Esposito 2005:73). As well, it was recommended that the entire criteria be applied so as to not just identify the cultural component but also add further description to the site, for instance in terms of site formation processes (Esposito 2005:73). Esposito (2005:73) does however highlight that the applicability of any criteria will vary between different sites. For instance, universal application of criteria does not necessarily account for localised climatic and environmental processes since these are variable traits between regions and can play a part in shell deposition and weathering processes (Esposito 2005:73). Hence, in order to safely assess whether a taxon was cultural or natural, the set of criteria needs to be applied to each individual spit or XU. As well, a researcher needs to determine which criteria are most applicable for that site by examining trends within the deposit (Esposito 2005:73-4). As Esposito (2005:75) states, ‘consistent identification of cultural material, at a spit level, by a robust combination of independent criteria may negate the ambiguity of those criteria’.

Given the environmental changes at Caution Bay, along with the wide diversity of taxa present within the assemblages (see Chapter 4), using a robust criteria for each spit as demonstrated by Esposito (2005) will be preferable in order to ascertain which taxa may have been cultural. As suggested by others (Bailey 1983; Esposito 2005; Rosendahl 2012; Rowland 1994; Sullivan *et al.* 2011), using multiple criteria increases the probability of identifying cultural deposits. While the criteria (Table 8.1) used by Rosendahl (2012) and others can be applicable to the assemblages at Caution Bay, with slight variations, this criteria requires data of other cultural elements before it can be applied. As interpretations of the Tanamu 1 shellfish assemblage were undertaken by Helene Tomkins with permission to adjust data not provided as a result of impending publication of results, the economic and non-economic determinations of shellfish remains from that site will not be undertaken by myself. However, I will address this problem for both other sites used in this study (Bogi 1 and JA24), but given that analysis of much of the other cultural remains is still in progress, I will utilise additional information from archaeological, ethnographic and malecological literature which I envision will be adequate. Overall, it is clearly evident that shell deposits can be created by multiple factors, including environmental conditions, animal and bird predation, animal burrowing, other changes in natural vegetation, and human exploitation of molluscs. Another factor which I argue can also lead to the presence of natural shellfish in cultural deposits is accidental/incidental gathering of taxa during foraging of other targeted species (Szabo 2009:186). Nonetheless, the review of literature on the problems associated with shell deposit identification, processes of formation and solutions to determining cultural from naturally deposited shells has provided a framework from which this 'problem' may possibly be addressed in this study.

Table 8.1. Criteria list used for determining cultural from natural deposits as outlined by Rosendahl (2012:79-80) and others (Attenbrow 1992:4; Gill *et al.* 1991:335; McNiven 1996; Rosendahl *et al.* 2007; Ulm 2006a).

Feature	Cultural	Natural	Disturbance
Charcoal	✓		
Artefacts	✓		
Hearth stones	✓		
Animal bones	✓		
Exoskeletons of edible Crustacea	✓		

Burnt shell and/or Crustacea	✓		
Burnt bone	✓		
Edible shell predominant	✓		
Size selection of edible shells	✓		
Species selection	✓		
Regular shell fracture patterns	✓		
Consistent radiocarbon dates	✓		
Minimal foraminifera	✓		
Articulated bivalves	✓	✓	✓
Full range of shell sizes		✓	✓
Non-edible shell species		✓	✓
No evidence for species selection		✓	✓
Coral		✓	✓
Shellfish with predation boring		✓	✓
Worn shells		✓	✓
Pumice and marine shell grit		✓	✓
Abundant foraminifera		✓	✓
Inconsistent sediment size distribution		✓	✓

Shell Size and Morphometric Analysis

When attempting to address questions related to cultural change, and by extension an investigation into temporal and spatial changes in resource use, established quantification methods can provide vital sets of data. However, since there are dozens of species present within the molluscan assemblages at Caution Bay, analysis of changes in shell size over time can provide an additional source of data that can potentially highlight any changes in levels of exploitation or in the environment. Past research into similar human/environment impacts on a natural shellfish population using shell size have been carried out in different regions around the world (Ash *et al.* 2013; Barker 2004; Claassen 1998; Ebbestad and Stott 2008; Faulkner 2009, 2010, 2013; Klein *et al.* 2004; Mannino and Thomas 2002; Poiner and Catterall 1988; Pombo and Escofet 1996; Spennemann 1987; Thangavelu *et al.* 2011; Yamazaki and Oda 2009). The results of these studies have revealed that impacts on shellfish populations can be due to anthropogenic or environmental mechanisms. Furthermore, while some species are able to withstand high levels of exploitation, evidence shows that other molluscs are susceptible to predation pressures exerted on them by humans (Botkin 1980; Claassen 1998; Roberts and Hawkins 1999; Spennemann 19987; Thangavelu *et al.* 2011; Yesner 1984, 1987). The exploitation of molluscs by humans has been primarily attributed to being a source of food and to a lesser extent for use in artefact production or trade. As a result, within some societies, the multiple advantages (e.g. food, artefact) of gathering shellfish may lead to over-exploitation of a species which has been demonstrated by some studies to be represented by a reduction in the size structure of a species over time (Ambrose 1967; Anderson 1979, 1981; Faulkner 2009; Mellars 1980; Spennemann 1987; Swadling 1976; Thangavelu *et al.* 2011). Where predation pressures are evident, considerable differences in the relative abundance of higher-ranked resources may also be seen (Faulkner 2009:822).

To further investigate levels of intensity in exploitation, evidence from the archaeological record such as occupational trends and discard rates of other cultural elements should be used in conjunction with the following criteria to ascertain how intensively a shellfish species was targeted in the past (Barker 2004; Botkin 1980:135; Claassen 1998:45; Faulkner 2009; Mannino and Thomas 2002:458; Thangavelu *et al.* 2011:69):

- The absolute abundance of preferred species will decrease over time.
- Mean shell size of a species recovered from an archaeological site will be significantly smaller than individuals from a natural, non-exploited population.
- Temporal decrease in mean shell size from bottom to top of deposit.
- Increase in numbers of less easily procured species over time.

Hence, in addition to relative abundance and discard rates, analysing possible over-exploitation and intensities of predation pressures can help to not only reconstruct past subsistence practices but also provide a picture of how sites were being occupied in relation to available resources and social conditions. For example, from reconstructing the size structure of the freshwater bivalve *Batissa violacea* at the Emo site in the Gulf Province of PNG, changes in temporal occupational trends were identified from instances where predation pressures were evident, therefore signalling the presence of people while recovery in shell size was attributed to abandonment due to social factors (Thangavelu *et al.* 2011). However, it must be noted that in certain scenarios intensive or higher predation does not necessarily lead to over-exploitation, and conversely be a result of different processes with varying effects. For instance, Poiner and Catterall (1988:197) demonstrate that despite being under stress from predation pressures, the gastropod species *Conomurex luhuanus* was able to withstand human predation at Bootless Inlet, southern Papua New Guinea. An analysis of the modern *C. luhuanus* population revealed no significant change to the density and distribution of the species (Poiner and Catterall 1988:197). *C. luhuanus* was able to thrive because traditional gatherers seldom exploited individuals that were buried or below 30mm in shell length (Poiner and Catterall 1988:197). Thus, while juveniles who were less than 30mm in shell length were rejected, other juveniles measuring more than 30mm were also able to protect themselves with the biological trait of burying (Poiner and Catterall 1988:197-8). The gathering practice of local peoples also shed light on the available size distribution of the *C. luhuanus* population (Poiner and Catterall 1988:198). Hence, *C. luhuanus* had the biological capability to continue its recruitment cycle, and attain maximum size through subtidal distribution and burying together with the survival of a population bed that was not targeted by people (Poiner and Catterall 1988:198). The gathering practices of the traditional community were therefore not able to exert predation pressure on *C. luhuanus* because the species possessed biological characteristics that made it resilient to human predation (Poiner and Catterall 1988:197-8)

Nevertheless, when applying the above discussed method and set of criteria, researchers in the past have tended to measure each complete individual of an exploited species from an assemblage (Barker 2004; Claassen 1998; Faulkner 2009; Spennemann 1987). The problem with this approach is that it may be biased, for example where larger individuals of a species were preferentially selected over smaller individuals, thus leading to a larger mean size from an unbiased population sample (Claassen 1998:107). Basically, irrespective of whether people size-select or harvest all available individuals of a taxa, flow-on effects are present in relation to recruitment of cohorts, mean size and population structure if levels of exploitation are high and larger/mature individuals are consistently removed. This approach in selecting larger shellfish is therefore relative as with focused selection of larger individuals, the exertion of predation pressures on those shells will lead to a decrease in size over time as an entire population (Claassen 1998:107). Likewise, another issue with addressing predation pressures is the likelihood that samples from multiple populations of a single species may have been mixed together at a site (Claassen 1998:107). If this is the case, this combination of individuals from different populations can result in a significant difference in size with a smaller mean size than a population that has larger specimens, even though there may have been minimal variation in size within a single population. However, as postulated by Mannino and Thomas (2001), this problem can be negated by the time-averaged nature of archaeological deposits.

In line with size analysis, the most common technique is to measure the maximum length of whole individuals of a selected species (Antczak *et al.* 2008; Baez and Jackson 2008; Bailey and Milner 2008; Bailey *et al.* 2008; Barker 2004; Claassen 1998; Faulkner 2009; Jerardino 1997; Jerardino *et al.* 2008; Mannino and Thomas 2001, 2002; Milner *et al.* 2007; Poiner and Catterall 1988; Pombo and Escofet 1996; Spennemann 1987; Swadling 1976, 1977; Thangavelu *et al.* 2011). This method can however be problematic since only complete, intact shells of a given species are incorporated into the analysis of the assemblage, whereas in many cases shell is susceptible to fragmentation from a range of factors (e.g. meat extraction, shell working, taphonomic), thus making it extremely difficult to attain any sort of measurements (Claassen 1998:111; Faulkner 2010:1942; Thangavelu *et al.* 2011; Yamazaki and Oda 2009:2008). Although some species tend to have more intact shells because of their morphology and degree of robustness, using only complete specimens can nonetheless lead to skewed results due to differential size preservation and create a level of bias in the observation of any size trends, potentially inaccurately reflecting that either larger or smaller individuals of a species were preferred (Faulkner 2010:1942; Jerardino and Navarro 2008:1024; Thangavelu *et al.* 2011). In this instance, the measurable sample may not be representative of the actual size-structure of the species.

Morphometric analysis on the other hand provides a means to address this issue. The use of morphometric analysis on molluscs assemblages has been well-documented in many archaeological studies (Ash *et al.* 2013; Cabral and da Silva 2003; Faulkner 2010, 2013; Gardner and Thompson 1999; Jerardino 2014; Jerardino and Navarro 2008; Marelli and Arnold 2001; Peacock and Mistak 2008; Peacock and Seitzer 2008; Thangavelu *et al.* 2011; Ulm 2006b; Whitaker 2008; Yamazaki and Oda 2009). Morphometric analyses have been used extensively where the measurement of well-preserved identifiable features from fragmented shells are used to estimate maximum shell size using regression equations (Ash *et al.* 2013; Cabral and da Silva 2003; Faulkner 2010; Gardner and Thompson 1999; Jerardino and Navarro 2008; Marelli and Arnold 2001; Peacock and Mistak 2008; Peacock and Seitzer 2008; Thangavelu *et al.* 2011; Ulm 2006b; Whitaker 2008; Yamazaki and Oda 2009). An example of such an application was undertaken by Thangavelu *et al*. (2011) where the complete shell size of the bivalve *B. violacea* was calculated from measurements of an identifiable feature, posterior cardinal tooth, using morphometric equations. Using this method increased the sample size to more than 80% compared to less than 20% based on complete shells, and therefore provided a more accurate picture of human predation pressure, shellfish exploitation and occupational patterns at the site (Thangavelu *et al*. 2011).

From the Caution Bay mollusc remains, four species comprising two gastropods (*Conomurex luhuanus* and *Polinices mammilla*) and two bivalves (*Atactodea striata* and *Anadara antiquata*) were selected for size and morphometric analysis. These four taxa were selected based on the following devised criteria:

- Enough individuals present to measure in terms of MNI and found within major cultural horizons, thus allowing for an analysis and documentation of any change between major occupational periods;
- Varying levels of discard from high (*A. antiquata*) to low (*P. mammilla*) together with sudden appearance (*C. luhuanus*), allows for determining economic importance;
- Taxa with fragmented individuals, therefore providing an opportunity to develop and use morphometric analysis;
- Identified as economic species within the literature.

All four species were also selected due to a marked difference in size between larger (*C. luhuanus* and *A. antiquata*) and smaller (*P. mammilla* and *A. striata*) species and associated differential meat weights. All measurements (in millimetres, mm) were taken using a precision Starrett electronic digital caliper (model: 798B Series) with an accuracy range of ± 0.02mm for up to 100mm sized measurements and ± 0.03mm for > 100mm measurements. Since morphometric analysis relies on using measurements of an intact well-preserved feature and linear regression equations to estimate original size, the formulation of equations had to be established using measurements from an independent population prior to the application to archaeological molluscan deposits. Apart from *A. striata*, which had previously been investigated in Torres Strait archaeological deposits (Ash *et al.* 2013), measurements of *A. antiquata* and *P. mammilla* samples housed in the Queensland Museum collection were obtained, with assistance provided by Dr John Healy and Darryl Potter. For *C. luhuanus*, only measurements of maximum shell size were recorded from the archaeological assemblages. In line with other archaeological analyses, linear regression equations represent the most suitable method for examining correlation between datasets with any R^2 values of above 0.75 accepted as a robust correlation (e.g. Faulkner 2010; Jerardino and Navarro 2008; Thangavelu *et al.* 2011). The measurement techniques and biological information for each species are as follow:

Conomurex luhuanus

C. luhuanus (Linne 1758) is a marine gastropod that lives in warm water conditions with an abundant distribution range that spans from Japan to Melanesia, Polynesia and Australia (Carpenter and Niem 1998:475). This species is found in abundant quantities within the coastal ecological niches of PNG. The habitats *C. luhuanus* is comprised of coastal bays, lagoons where the bottom is devoid of mud, and sandy bottoms of coral reef areas, among coral rubble and sea grass (Carpenter and Niem 1998:475). *C. luhuanus* is typically located in intertidal and shallow sublittoral zones to a depth of approximately 20m (Carpenter and Niem 1998:475). The maximum shell length is 8cm but most individuals attain 5cm in length (Carpenter and Niem:475). Measurements were taken for Maximum Height (MH) of *C. luhuanus* from the tip of the apex to the siphonal canal (Figure 8.3). Morphometric analysis was not applied because of strong sexual dimorphism that is present within this species (Faulkner pers. comm. 2013; Kuwamura *et al.* 1983) and fragmentation was minimal since this taxa is extremely robust. While I acknowledge that problems exist with using only MH measurements, especially when sexual dimorphism and age-size representations are important issues that need to be taken into consideration in metric analysis (e.g. Giovas *et al.* 2010), the decision to take MH measurements was made in order to represent the size-structure of *C. luhuanus* as an entire population, thus accounting for the strong sexual dimorphism. While recent developments of morphometric equations for this taxa using lip thickness to determine size and age-at-death will be published in the future (Aird pers. comm. 2014), it is envisioned that analysis of size as an entire population for *C. luhuanus* presents an adequate solution.

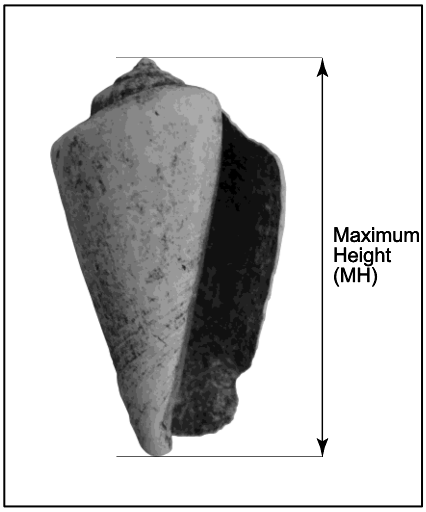

Figure 8.3. *Conomurex luhuanus* showing measurement of Maximum Height (MH).

Polinices mammilla

The marine gastropod *P. mammilla* has a widespread distribution range from South and East Africa to the Indo-West Pacific, eastern Polynesia, Japan, Hawaii and Australia (Carpenter and Niem 1998:519). This species is abundant on sandy bottoms and is commonly found in coral reefs (Carpenter and Niem:519). *P. mammilla* is an intertidal and sublittoral species and can be found in the low tide zone to a depth of around 20m (Carpenter and Niem:519). Exploitation is common and in large quantities for subsistence or for use in production of artefacts (Carpenter and Niem:519). Maximum size recorded is 6cm but is more commonly 5cm (Carpenter and Niem:519). Morphometric analysis was used because of the highly fragmented nature of this species within the archaeological assemblage. Measurements were taken for Maximum Height (MH), Aperture Width (AW) and Aperture Height (AH) from the Queensland Museum controlled independent sample size of 60 individuals, most of which (44 individuals) were collected from coastal areas in Queensland, Australia (Figure 8.4). The mean MH of samples from QM were 24.89 mm. While the samples were not from PNG, the datasets should be broadly applicable to other assemblages in nearby coastal margins of PNG. Regression analysis was established between measurements with robust correlation coefficients between all three diagnostic features (Figures 8.5 and 8.6). For MH vs AH, the R^2 value was 0.972 with equation (MH = 1.512 (AH) – 1.0055). R^2 value of 0.9804 for MH vs AW with equation (MH = 2.5944 (AW) – 0.6322). As a result of the strong correlation, AH measurements of the archaeological shells were taken and used as a proxy to estimate the mean overall size of shell in each XU and cultural unit because they were the most-well preserved attribute. AW measurements were taken where available but were not used because of the prevalence of AH feature. The AH was well preserved and was therefore the primary measurement taken.

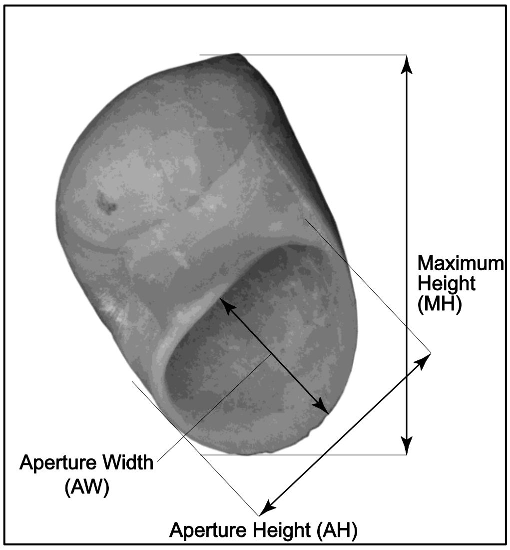

Figure 8.4. *Polinices* mammilla showing measurement of Maximum Height (MH), Aperture Width (AW), Aperture Height (AH).

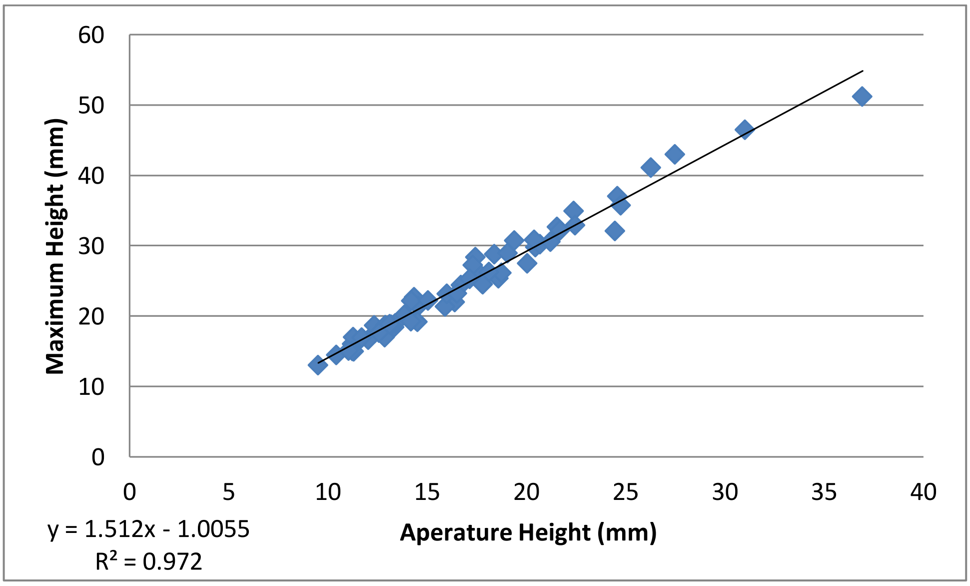

Figure 8.5. Queensland Museum Polinices *mammilla* maximum height vs. aperture height, with formulated linear regression equation of y = 1.512x – 1.0055, R^2 = 0.972.

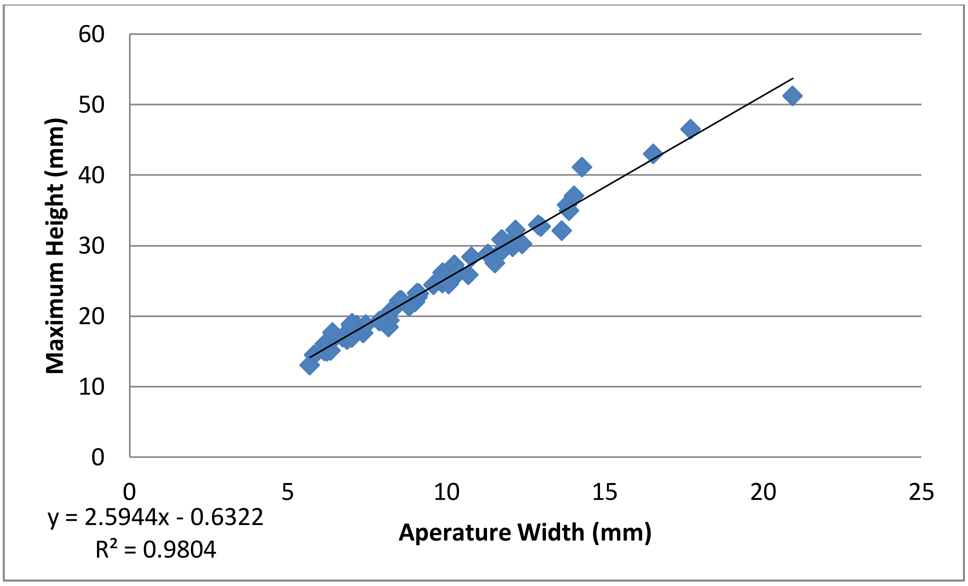

Figure 8.6. Queensland Museum *Polinices mammilla* maximum height vs. aperture width, with formulated linear regression equation of y = 2.5944x – 0.6322, R^2 = 0.9804.

Atactodea striata

The marine bivalve *A. striata* is found in many sandy beach localities including Polynesia, Australia, Japan, East Africa and India (Carpenter and Niem 1998:283). This species is exploited as a source of food in abundant numbers throughout the sub-tropical and tropical areas regardless of its small size (Ash *et al.* 2013:5; Carpenter and Niem 1998:283; Paulay 2000; Tan and Kastoro 2004). As a result, *A. striata* has been found in many archaeological sites from different regions (Ash *et al*. 2013: 5; Clarke and Wright 2010; Morrison and Addison 2008; Swadling and Chowning 1981; Thomas *et al.* 2007). Inter-tidal sandy substrates within sandy beaches that have low to medium water circulation is the typical environment associated with this species (Ash *et al.* 2013:6). Maximum shell length is 4cm with the common size being 2.5cm (Carpenter and Niem 1998:283). As fragmentation of this taxon is common within the archaeological deposits investigated here, morphometric analysis was applied following the morphometric reconstruction undertaken by Ash *et al*. (2013). While the equations were derived from Torres Strait samples, they should still be broadly applicable to *A. striata* assemblages from neighbouring PNG coast. The mean overall size of *A. striata* in each XU was calculated using previously established linear regression equations (see Ash *et al.* 2013) from measurements of the greatest extent between lateral teeth (ELT) and Valve Length (VL) (Figure 8.7). For left valves, R^2 value was 0.84 with an equation of VL = -0.409 + 2.341 (ELT) (Ash *et al.* 2013). R^2 for right valves was 0.78 with equation of VL = 2.020 + 2.864 (ELT) (Ash *et al.* 2013) Only ELT measurements were taken as the ELT was the most intact feature in the archaeological assemblage. However, as Ash *et al.* (2013:5-6) note, 'the species is opisthogyrate, whereby the umbones curve toward the posterior rather than the anterior margin of the valve, thereby reversing the usual mode of identification for left and right valve'. Unlike the identification process utilised by Ash *et al.* (2013), the quantification of left and right valves were undertaken in the usual mode. Therefore the linear regression equations developed by Ash *et al.* (2013) had to be reversed as different equations were used for different sides of valves. For instance, the equation used by Ash *et al.* (2013) for calculating the size of left valves was used for right valves in this study.

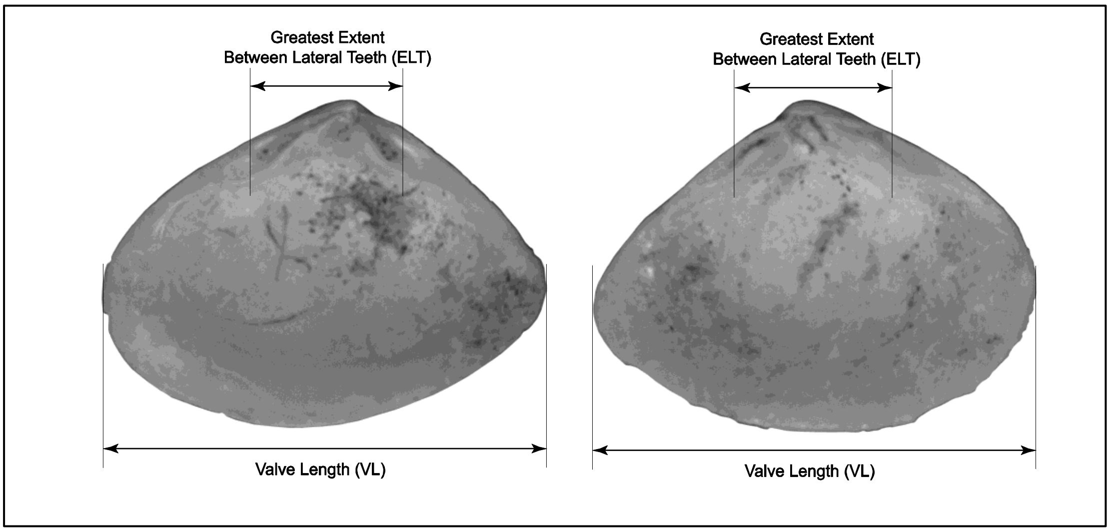

Figure 8.7. ***Atactodea striata*** **showing Valve Length (VL) and Greatest Extent between Lateral Teeth (ELT) measurements of both valves following Ash** ***et al.*** **(2013).**

Anadara antiquata

A. antiquata is a marine bivalve that is widespread in the Indo-West region, East Africa, Polynesia, Japan and Hawaii (Carpenter and Niem 1998:146). The species is found on muddy bottoms, is intertidal and sublittoral to a depth of 25m (Carpenter and Niem 1998:146). *A. antiquata* is a common food source in many areas (Carpenter and Niem 1998:146). Maximum length is 10.5cm but 7cm is a more common indication of size. Like *P. mammilla*, morphometric analysis for this species was performed with linear regression analysis based on measurements of a controlled independent sample from the Queensland Museum. This sample consisted mainly of specimens collected from coastal margins of Queensland, Australia and because of the close proximity to PNG, derived equations would be broadly applicable to this region.

Altogether 37 individuals were measured for Maximum Valve Length (MVL), Valve Height (VH) and Hinge Length (HL) with subsequent regression analysis demonstrating strong correlations between all three measurements (Figures 8.8, 8.9, 8.10 and 8.11). The R^2 value of 0.99 was derived for MVL vs VL measurements with an equation of MVL = 1.1434 (VH) + 4.643. R^2 value for VH vs HL was 0.96 with equation of VH = 1.3473 (HL) + 1.0652. MVL vs HL R^2 value was 0.96 with an equation of MVL = 1.5432 (HL) + 5.7727. The mean size recorded within the QM assemblage was 55.66 mm. Since the hinge was the most intact feature within the fragmented *A. antiquata* in the archaeological assemblage, HL measurements were taken and the mean size was estimated using the calculated equations. As this species is equivalve (Carpenter and Niem 1998:146), with both valves being similar, the equations can be applied to HL measurements regardless of valve side.

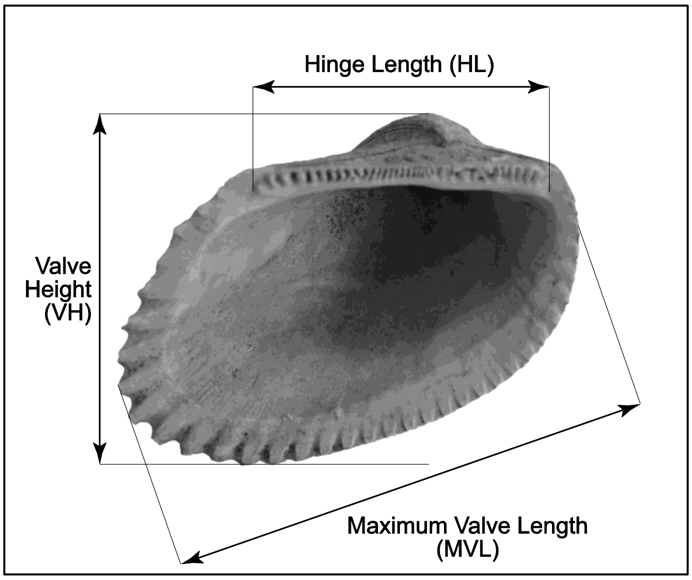

Figure 8.8. ***Anadara antiquata*** **showing measurements of Maximum Valve Length (MVL), Valve Height (VH) and Hinge Length (HL).**

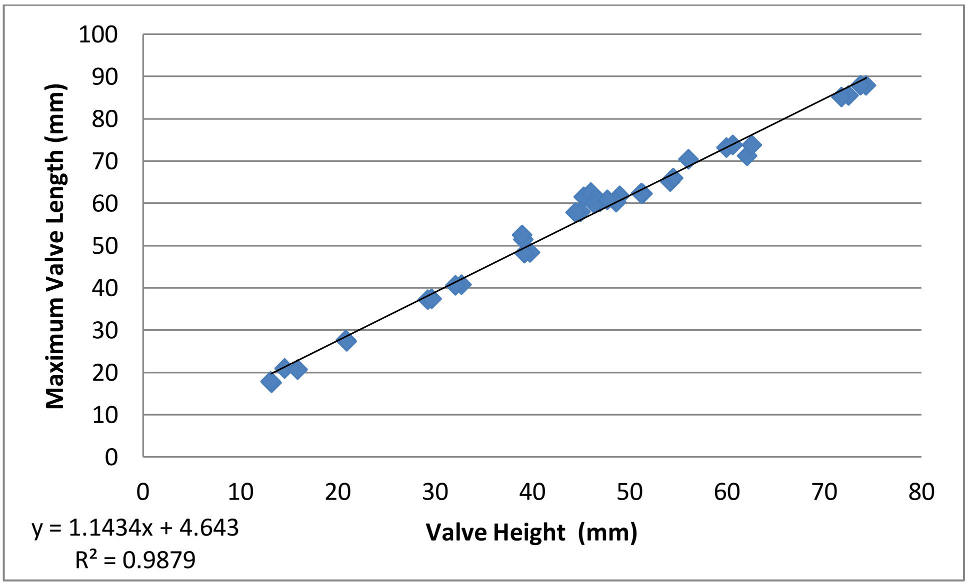

Figure 8.9. Queensland Museum *Anadara antiquata* maximum valve length vs valve height, with formulated linear regression equation, y = 1.1434x + 4.643, R^2 = 0.9879.

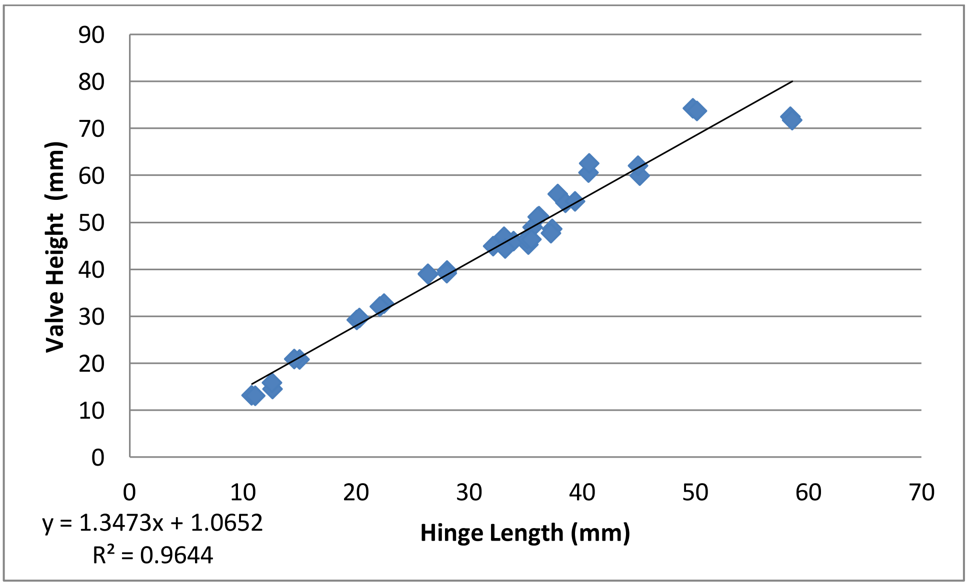

Figure 8.10. Queensland Museum *Anadara antiquata* valve height vs hinge length, with formulated linear regression equation, y = 1.3473x + 1.0652, R^2 = 0.9644.

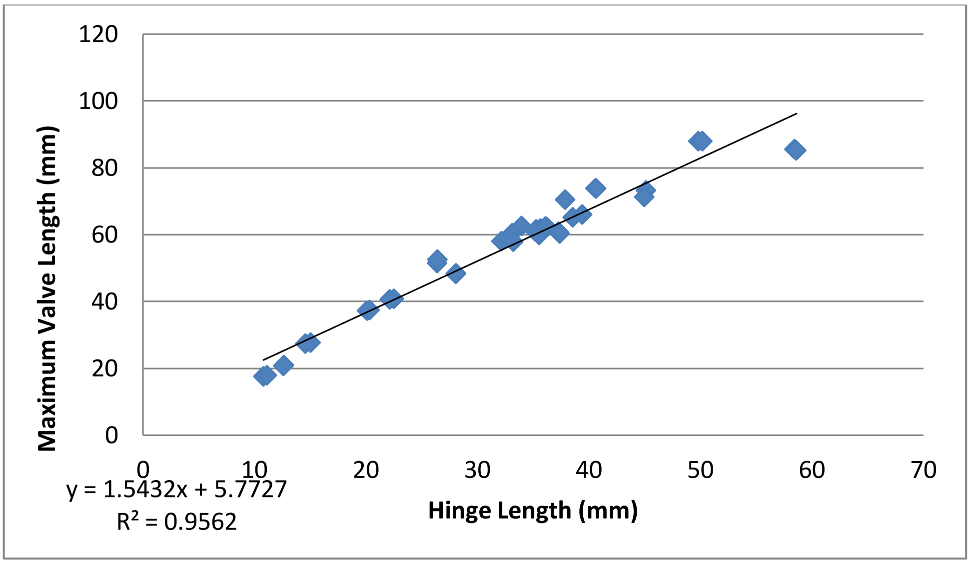

Figure 8.11. Queensland Museum *Anadara antiquata* maximum valve length vs hinge length, with formulated linear regression equation, y = 1.5432x + 5.7727, R^2 = 0.9562.

With such robust correlations, this technique was applied to remains of the four species from each site, if available. Understanding the biology and ecology of each species is equally important. This is due to the effects environmental conditions can have on certain species. For shell size, factors such as salinity, water temperature, currents, sediment type, population density, nutrition and availability of calcium carbonate can all play a part in altering growth rates (Claassen 1998:25-26; Spennemann 1987:87; Thangavelu *et al.* 2011:69). For instance, water temperatures can stop and slow growth while salinity levels can have an impact on the survival of a species (Spennemann 1987:88; Thangavelu *et al.* 2011:69). Hence, the biology and ecology of the above four species selected for size analysis was discussed so as to allow for further comparison with the palaeoenvironmental record. It must however be noted that even though age is often used to identify growth, size can be a good substitute because shell mortality is more dependent on size than age (Claassen 1998:107-8). Some other factors that should be considered when analysing a species include reproduction process, disease, demographics, sexuality and eggs, dispersal of adults, larvae and eggs (Claassen 1998:25-33). Where applicable, shell size analysis will therefore need to be analysed in conjunction with the palaeoenvironmental record to ascertain any temporal changes in size and if the trend was either due to human predation or environmental change, or a combination of both. The discussion of methods and Caution Bay mollusc assemblages allows for the application of techniques to shell remains from each site. The results of this analysis will be shown and discussed in subsequent site chapters.

Table 8.2. Parameters of morphometric equations for estimation of overall size for each taxa, y = a(x) +/- b following Jeradino and Navarro (2008).

y variable	a	X variable	+/-	b	r^2
P. mammilla Maximum Height (MH)	1.512 2.5944	Aperture Width (AW) Aperture Height (AH)	- -	-1.0055 0.6322	0.97 0.98
A. striata Valve Length (VL) for left valve *A. striata* Valve Length (VL) for right *valve	2.864 2.341	Greatest Extent Between Lateral Teeth (ELT) Greatest Extent Between Lateral Teeth (ELT)	+ +	2.020 - 0.409	0.78 0.84
A. antiquata Maximum Valve Length (MVL) *A. antiquata* Valve Height (VH)	1.1434 1.5432 1.3473	Valve Height (VH) Hinge Length (HL) Hinge Length (HL)	+ + +	4.643 +5.7727 1.065	0.99 0.96 0.96

Discussion

In attempting to understand how and why shellfish were being exploited at Caution Bay, this chapter has provided a comprehensive discussion of the methods employed in this study. These standard methods in mollusc quantification provide the adequate tools needed to attain the required datasets needed to address the key research questions. Methods used to derive a combination of datasets comprising of MNI, NISP, shell weight, and morphometric analysis will provide for a robust analysis by allowing for cross-comparison across shellfish taxa and cultural phases. This is especially important because of the complexities associated with trying to address taxonomic richness present within the molluscan assemblages at Caution Bay. By being able to address species variability and richness over time, it is also envisioned that the methods utilised in this study will allow for a better understanding of cultural change in relation to shellfish subsistence over the major phases of occupation. Results of the application of these techniques are discussed in subsequent site chapters.

Chapter 9 – Tanamu 1

Regional Context

The archaeological site of Tanamu 1 was recorded during systematic surveys along the southern coast of PNG in 2008 (David *et al.* completed ms:4). Tanamu 1 is situated 140m southeast from the other major Lapita site Bogi 1 (see Chapter 10) and is located on part of the same exposed coastal sand dune (David *et al.* completed ms:4). With similarities in cultural horizons that reveal three distinct occupational sequences together with the presence of a middle Lapita phase, Tanamu 1 is both highly significant and particularly important in understanding cultural chronologies from local and regional perspectives. This is especially the case given the nearby presence of numerous sites dating to the post-Lapita era, allowing for an in-depth analysis of the transformation processes between the identified cultural horizons (David *et al.* completed ms:3). The purpose of this Chapter is to present the results of research into the shellfish assemblages at Tanamu 1, and provide a comprehensive discussion on key trends and how they relate to changes in the environment and anthropogenic activities.

Site Description

Tanamu 1 is positioned on the rim of an exposed coastal sand dune part of a low northwest to southeast-trending peninsula (David *et al.* completed ms:1). The site is situated on top of a littoral complex where the fore-dunes slope to merge with the alluvial plain (David *et al.* completed ms:1) (Figure 9.1). In line with the coastal lowlands and hill-ridge zones, increases in landform elevations are evident at around 5km and 7.2km further inland from Tanamu 1 (David *et al.* completed ms:1). As well, this site is bordered by an extensive inter-tidal mangrove forest to the west, open tidal mudflats to the east and the entire littoral zone is 800m wide in closest proximity to Tanamu 1 (David *et al.* completed ms:1) (Figures 9.2 and 9.3). Additionally, Tanamu 1 is located 5m above the present high tide and 25m east of the high water mark found close to the inland margins of mangroves (David *et al.* completed ms:1). *Themeda* grassland is the primary niche on which Tanamu 1 is situated, but sparse distributions of *Eucalyptus*, *Acacia* and *Pandanus* are found in close proximity (David *et al.* completed ms:1).

Figure 9.1. Tanamu 1 excavation site, excavation in progress with surrounding landscape (David *et al.* completed ms:3).

Figure 9.2. Mud flats and mangroves to the immediate southwest of Tanamu 1, low tide (David *et al.* completed ms:4).

Figure 9.3. Mud flats and mangroves to the immediate southwest of Tanamu 1, high tide (David *et al.* completed ms:4).

Excavations

Upon discovery, Tanamu 1 was identified as medium-sized with a low density surface scatter of pottery sherds, stone artefacts and shell (David *et al.* completed ms:4). At 20m x 13m in size, it was envisioned that this site had good potential for the presence of stratified sub-surface cultural deposits (David *et al.* completed ms:4) (Figure 9.4). Two contiguous squares (A and B), representing the main squares, measuring 1 x 1m were then excavated to determine the type of sub-surface cultural deposits that were present (David *et al.* completed ms:4). The trench was orientated in a north-south/east-west position (David *et al.* completed ms:4). Each square was then excavated in arbitrary Excavation Units (XUs) in line with the stratigraphic profiles (David *et al.* completed ms:4). As mentioned in Chapter 8, the excavation methodology was standardised across all sites, and in the case of Tanamu 1, the average thickness of each XU was 2.1±0.5 cm in both Squares (David *et al.* completed ms:4).

In addition, 28 squares measuring 1 x 1m forming a double-ring around the main Squares A and B were excavated (David *et al.* completed ms:9) (Figures 9.5 to 9.10). The excavation of these stepping-out squares was required in order to allow for the continuation of excavation to deeper levels in Squares A and B and to also conform to safety protocols and the short time period in which the excavations had to be completed (David *et al.* completed ms:9). Squares C-L, representing the inner ring of the stepping-out squares were excavated to a maximum depth of 2.15m (21 XUs per square) with mean thickness of each XU being 9.9 ± 1.1 cm (David *et al.* completed ms:9). The second outer ring (Squares M-Z and AA-AD) was dug using a shovel before excavation of each square commenced, proceeding to a maximum depth of 1.03 m (four additional XUs) with average XU thickness of 12.1 ± 4.3 cm (David *et al.* completed ms:9). After the wall profiles for Squares A and B were drawn and photographed, stepping-out squares were excavated quickly without sieving with selected artefacts and visible decorated pottery plotted and collected (David *et al.* completed ms:9-10). This excavation strategy was employed because of impending heavy machinery construction works, thus allowing sufficient time for deeper excavation of main Squares A and B to reveal Lapita and pre-Lapita levels and saving the remainder of the site from destruction (David *et al.* completed ms:10). As this study focuses on shellfish remains from Square A, with identical material culture unearthed from Square B, I will be discussing key excavation results from Square A for the rest of this Chapter.

Figure 9.4. Tanamu 1 site map showing location of excavation trench. Contours in 10cm intervals (David *et al.* completed ms:6).

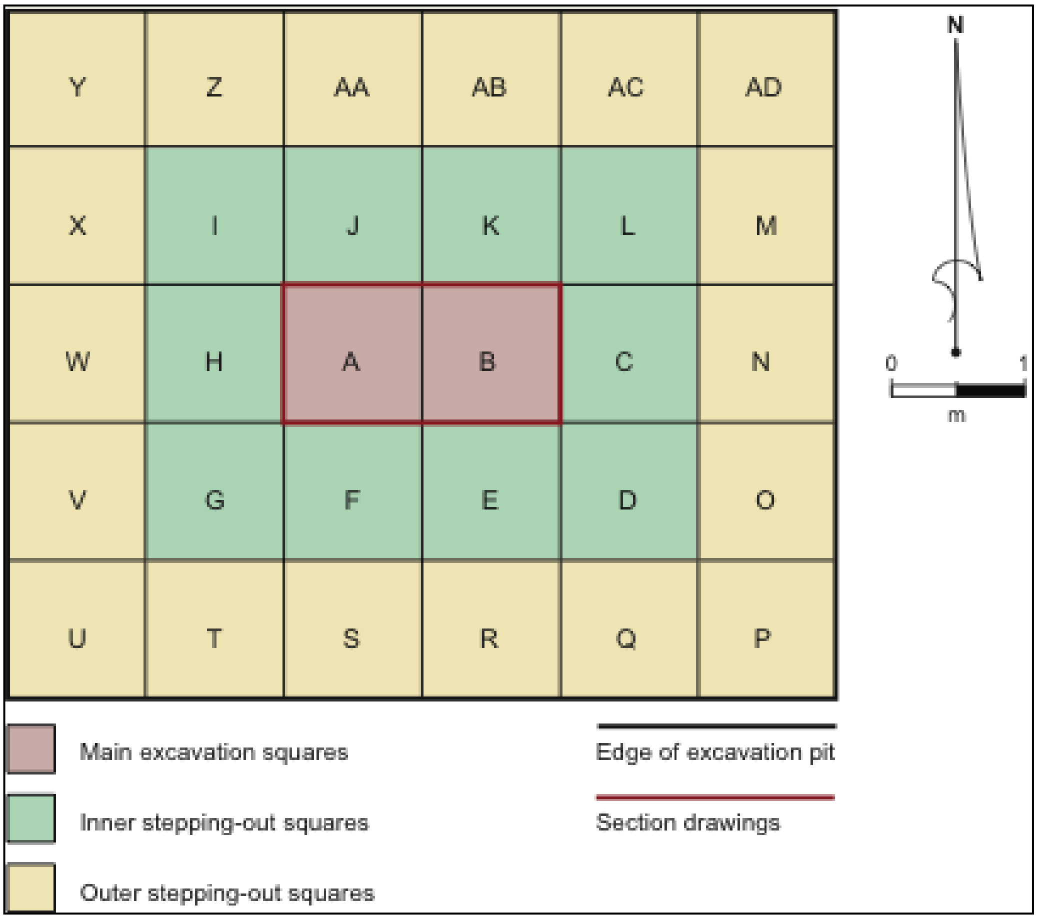

Figure 9.5. Map of Tanamu 1 trench showing location of each excavation square (David *et al.* completed ms:7).

Figure 9.6. Laying out of Tanamu 1 Squares A and B excavation trench showing density of surface cultural materials (David *et* al. completed ms:8).

Figure 9.7. Squares A and B and inner stepping-out squares facing southwest, early stages of excavation in progress (David *et al.* completed ms:8).

Figure 9.8. Shoring of the outer ring of excavation squares, Tanamu 1. The central trench (Squares A and B) is covered by a wooden lid (David *et al.* completed ms:11).

Figure 9.9. Re-stringing of Squares A and B to continue excavation after shoring of the outer stepping-out squares, Tanamu 1 (David *et al.* completed ms:12).

Figure 9.10. Excavation of the outer stepping-out squares in progress, Tanamu 1 (David *et al.* completed ms:9).

Stratigrapic Description: Square A

Excavations of the main squares to a maximum depth of 2.84 m revealed seven major stratigraphic units (SUs), each continuous across both squares (David *et al.* completed ms:28) (Figures 9.11 to 9.16). Excavations did not reach basal clays or bedrock, but the deepest deposits from SU7 consisted of non-cultural sandy concretions in sandy sediments with small amounts of charcoal only found in the upper XUs of SU7, linking up with SU6 (David *et al.* completed ms:28). Charcoal, pumice and foraminifera were found within sands located immediately above in SU6, thus revealing an ancient environmental landscape comprising of low dune/or beach-line (SU6) and beach-line and/or inter-tidal (SU7) conditions (David *et al.* completed ms:28). Additionally, some SUs comprised of separate features or lenses with each of these recorded as a sub-SU (David *et al.* completed ms:28). Apart from SU6 and SU7, all other SUs were clearly separated from underlying and overlying SUs with interfaces between SUs highly visible and up to few centimetres thick (David *et al.* completed ms:28) (Table 9.1).

Overall, all SUs were sandy which enabled excavations to proceed smoothly and most layers were moderately to well secured and compact (David *et al.* completed ms:28). Dense cultural material was found in the uppermost SUs (SU1, SU3 and SU5) and were separated by culturally less rich SUs (SU2 and SU4) and basal SUs (SU6 and SU7) (David *et al.* completed ms:28). Evidence of geochemical alteration of sediments linked to root staining from the discovery of numerous linear sub-vertical but diffuse white sediment stains in SU4 and SU6 points to the existence of very old land surfaces at the bottom of SU3 and SU5 (David *et al.* completed ms:28). The basal layer (SU7) was made up of abundant concreted sand from increased humidity (David *et al.* completed ms:29). While cultural material was found in all SUs, these were much less visible in SU7 (David *et al.* completed ms:29).

On the whole, for a dune deposit, this site has relatively good chrono-stratigraphic integrity (David *et al.* completed ms:29). Interfaces between SUs are around 5cm thick, less commonly increasing to approximately 10cm (David *et al.* completed ms:29). Radiocarbon dates have revealed no significant reversals between cultural phases except for Wk-32535 (2971 ± 30 BP) derived from shell (XU8) at the base of SU1 Square B where radiocarbon determinations are more recent than 700 cal

BP (David *et al.* completed ms:29). As a date obtained from a shell sample 14-16 cm below surface, separated by 4 cm from the broad phase of similar ages below it, this date reflects an age reversal over a depth of only 4 cm (David *et al.* completed ms:29). Overall, Tanamu 1 displayed relatively good chrono-stratigraphic integrity regardless of the type of sample (charcoal, shell) used for dating (David *et al.* completed ms:29).

Figure 9.11. Excavation in progress within the dense Middle Horizon of SU3 (Lapita horizon), Square A after excavation of XU29 (David *et al.* completed ms:32).

Figure 9.12. Excavation in progress within the dense Lower Horizon of SU5 (preceramic horizon), Squares A and B after excavation of XU66 (David *et al.* completed ms:34).

Figure 9.13. Excavation in progress in SU6 immediately below the Lower Horizon, Squares A and B after excavation of XU77 (David *et al.* completed ms:34).

Figure 9.14. Excavation in progress in the culturally-poor SU4 below the Middle Horizon, Square A after completion of XU41. The distinctive localised white band of SU1a is clearly visible, as are the sub-vertical root stains in SU4 below the Middle Horizon (David *et al.* completed ms:33).

Figure 9.15. Excavation after completion of XU94 (mid levels of SU6) in Squares A and B, showing diffuse charcoal-rich patches on the north wall (David *et al.* completed ms:35).

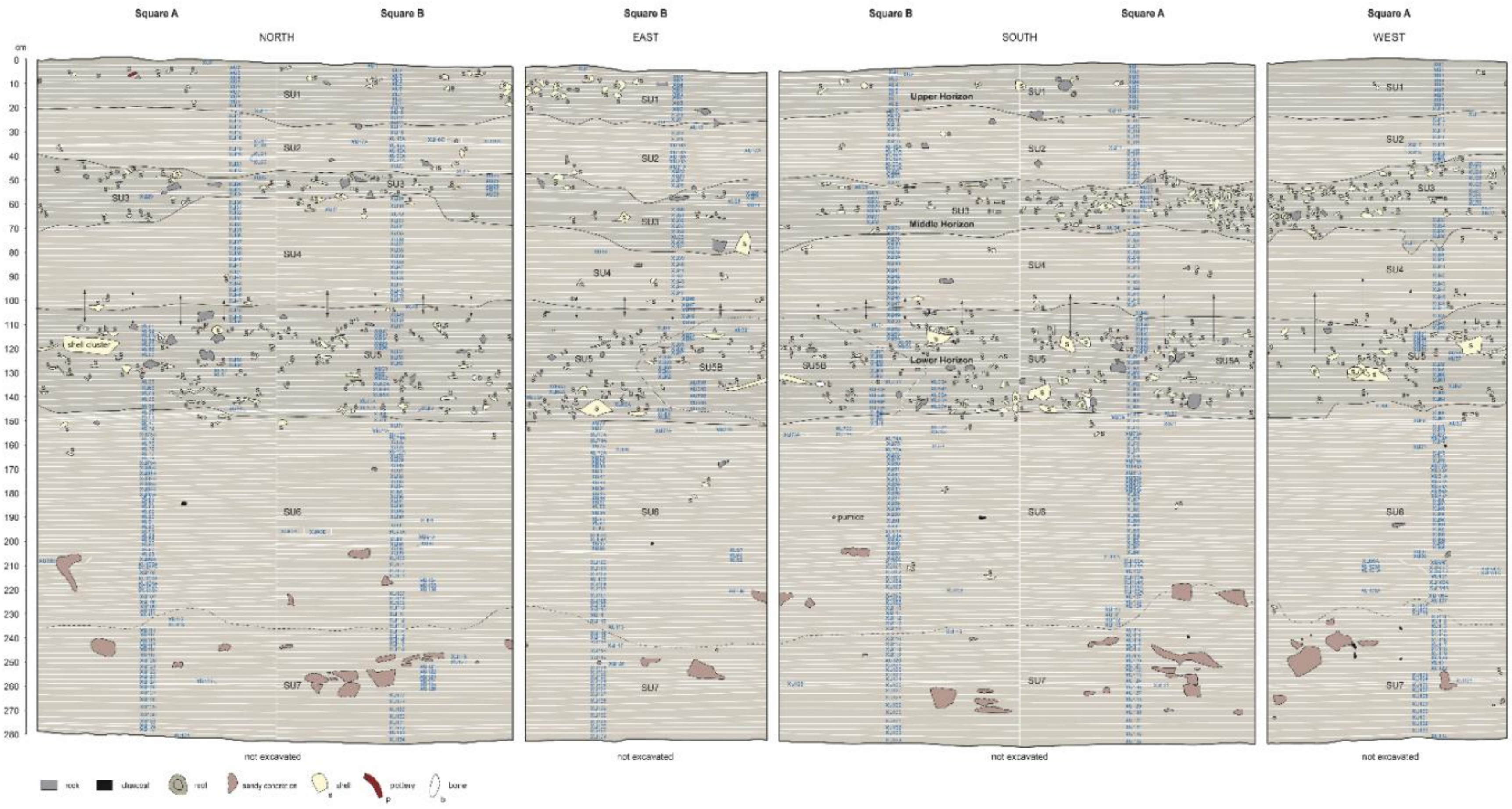

Figure 9.16. Section drawings, Tanamu 1 Squares A and B showing backplotted XUs (David *et al.* completed ms:30).

Table 9.1. Stratigraphic Units, Tanamu 1 (David *et al.* completed ms:35-39).

SU	Typical depth below ground (cm)	Description
1	0-20	This SU contains the culturally dense Upper Horizon concentrated especially in the SU's upper half. Soft, humic, dark grey aeolian sand with dense shell, stone artefact and pottery concentration in the NE part of Square B. Grass rootlets are abundant. The dark grey colouring is probably due in part at least to organic decomposition and staining as typical of local topsoil development. Fairly compact. SU1a (Figure 17) is a localised white horizontal band of indeterminate ash or shell carbonate at the base of SU1 along and into the very edge of the south wall of Square A and, to a much lesser extent, Square B only, where it delimits the base of SU1. As only the very edge of this sub-XU was exposed without significantly sampling SU1a in the excavation itself, we are not certain whether it represents a hearth or a shell lens. SU1a represents a very distinct boundary with the underlying SU2. Elsewhere SU1 typically grades into SU2 over a thickness of *c*.5cm.
2	20-50	Culturally sparse, soft, grey aeolian sand, lighter in colour than SU1, with some whole shells noted *in situ*. Boundary with underlying SU3 is fairly distinct, typically grading over a thickness of *c*.5cm. SU2a: Towards the base of SU2 in Square B, isolated as XU16b-XU21b and XU16c-XU17c, and measuring a maximum *c*.50cm x 20cm in size, is a well-defined area of loose and similar-coloured but slightly darker sand than the rest of the square. It is located just northeast of the centre of the square (it does not feature in the section drawings as it does not cross into any of the square's walls). It is likely to be an infilled animal burrow. No cultural materials were seen within this feature during excavation, and it is restricted to SU2.

3	50-70	Middle Horizon. Rich, compact but relatively unconsolidated cultural layer composed of dark aeolian sand and high quantities of whole and fragmented shell, pottery sherds and stone artefacts. Boundary with underlying SU4 is distinct, in the main grading over a thickness of *c*.5cm.
4	70-110	Soft, grey aeolian sand with high quantities of comminuted shell and some whole shells. Boundary with underlying SU5 is diffuse, typically grading over a thickness of *c*.10cm but sometimes more. SU4 contains numerous sub-vertical patches or pockets of light-coloured sandy sediments that are more compact than surrounding sediments reminiscent of root staining. The SU4/5 interface consists of brown-grey aeolian sand with occasional whole shell in its upper sections, grading down to a darker brown-grey loamy sand. Small amounts of small, degraded pottery sherds occur in this underlying level.
5	110-150	Lower Horizon. SU5 is a light brown-grey loamy sand with compact, lighter-coloured patches and copious amounts of larger-sized shell (whole and broken), animal bone and stone artefacts. The high density and high diversity of shell stands it apart as a distinct cultural horizon. Sediments are compact, with shell fragments often tending to cement together. Charcoal is present. Pumice, coral and rock are also present in moderate quantities. Some small roots also occur. Sediments are easy to excavate. SU5's lower boundary is distinct, in the main grading with SU6 over a thickness of *c*.5cm. SU5a is a poorly-defined patch of light brown-grey aeolian sand with small quantities of fragmented shell. It is soft and homogeneous in color and texture, and appears to be a local variation of SU5. SU5b is a dark-brown loamy sand with some ash, burned shell (whole and broken), animal bone, coral, pumice, charcoal and stone artefacts. The shell in particular is burned. Sediment is compact and homogenous in colour and texture. SU5b is similar to SU5 in terms of contents but different in colour, texture and general appearance. It is interpreted as a hearth or oven. It occurs in the southeast parts of Square B in XU49-XU70, where it was only isolated during excavation in its lower levels, at XUs 63b-XU67b and XU72b-XU74b.
6	150-240	SU6 is a light grey-brown sand with a hint of yellow. Cultural materials are sparse but continue to occur in most XUs.

		Small charcoal fragments occur throughout. The sparse comminuted shell fragments are typically 2-4mm long with sub-rounded edges. Pumice and foraminifera are present throughout. SU6 contains numerous compact, light brownish-pink clayey sand patches or vertical pockets reminiscent of the marks of roots/rootlets. The boundary with SU7 is indistinct. SU6a is a small, localised but diffuse patch of hard, light-coloured sediment with *in situ* charcoal restricted to within SU6. It is *c*.40cm x 30cm in size. It occurs near the northeast corner of Square A but does not feature in any of the section walls. It was isolated during excavation as XU79c-XU85c and may be the remnants of a hearth. SU6b is a localised but diffuse patch of hard, dark brown-black sediment with *in situ* charcoal. It is *c*.30cm x 30cm in size and continues into the west wall of Square A. It is present in XU96-XU101 of Square A, where it was only isolated *in situ* in XU99e-XU101e. It is likely to be the remnants of a hearth. Other charcoal-rich patches of similar contents occur elsewhere in Squares A and B at this stratigraphic level but have not been demarcated on the section drawings because they are diffuse (Figure 18).
7	>240	SU7 is a moist, soft, fine light-brown/yellow sand. Sediments are compact, and coral fragments and concreted sand and shell are present. Coral fragments vary in length from 2-10cm. Some small fragments of crustacean and shell (broken and whole) occur but are not abundant. Patches or vertical pockets of compact, lighter brown-pink clayey sand occur within the upper levels of SU7. Dried roots were found within some of these patches/pockets. Although some small charcoal fragments are evident at the SU6-SU7 interface; SU7 contains sparse cultural materials.

Chronology

A total of fifty-nine radiocarbon dates were derived from Squares A and B (David *et al.* completed ms:39) (Table 9.2). Out of the fifty-nine AMS radiocarbon dates, 34 dates were obtained from individual pieces of charcoal while the remaining 25 dates were from marine shell (David *et al.* completed ms:39). Pieces of charcoal were millimetre-scale in length with a mean weight of 0.1 ± 0.1 g (David *et al.* completed ms:40). Shell samples used for dating were flat, long shell valves or valve fragments with average weight of 5.7 ± 5.2 g (David *et al.* completed ms:40).

Radiocarbon dates from Tanamu 1 have revealed the antiquity of the site to be approximately 5000 cal BP, a date associated with the accumulation of sediments in basal layer SU7 (David *et al.* completed ms:40). In the next layer SU6, the ~90cm-thick sediments started to accumulate at approximately 60cm/100yrs from 4700 to 4450 cal BP (David *et al.* completed ms:40). While shell dates seem to be slightly younger than charcoal age determinations, this was most likely a result of inbuilt old wood ages for the charcoal (David *et al.* completed ms:40). Therefore, SU6 is considered to be of similar age to the lower levels of SU5 (ca. 4300 cal BP) and signifies the peak stage of dune-building at Tanamu 1 (David *et al.* completed ms:40). The site was hence an open landscape during this period as shielding mangroves that acted as a barrier by separating the beach from the land were non-existent and thus conditions were conducive to the aeolian buildup of beach-bordering sand dunes (David *et al.* completed ms:40).

SU5 (4350 to 4050 cal BP) marks the first of three dense cultural layers (Lower Horizon) during which some 40cm of cultural material built up over a 300 year time span (David *et al.* completed ms:41). Stratigraphic evidence reveals no abandonment of the site, pointing to the presence of a semi-permanent or permanent settlement over this prolonged period (David *et al.* completed ms:41). But an increase in radiocarbon dates and age from ca. 4100 to ca. 4300-4350 cal BP in SU5 over a shallow area around XU60 could be due to missing dates, thus meaning that the upper and lower sections of SU5 (ca. 4100 and ca. 4300-4350 cal BP respectively) and SU6 are part of a continued occupational pattern lasting over ca. 300 years (David *et al.* completed ms:41). Furthermore, there is no proof of temporal divisions within the sections (David *et al.* completed ms:41). As there is only minor variation in shell dates until SU7, the implication here is that there is most likely some minor inbuilt ages in radiocarbon determinations derived from charcoal (David *et al.* completed ms:41).

Immediately after settlement abandonment in SU5, a slow accumulation of dune sands (approximately 40cm, average of 3 cm/100 years) was seen in SU4, dated to between 4050 and 2800 cal BP (David *et al.* completed ms:41). SU4 is culturally more sparse and any cultural material found in this SU was interpreted to more likely have been post-depositional intrusions and not in situ material culture (David *et al.* completed ms:41).

The next major occupational phase representing the Lapita period or Middle Horizon was identified in SU3 (ca. 2800 to 2750 cal BP) (David *et al.* completed ms:41). Around 20cm of rich cultural deposits were accumulated in SU3 (rate of ~40 cm/100 years) above the pre-existent sand dune which was 1.7 m high (David *et al.* completed ms:41). SU3 represents the first evidence for the arrival of pottery-manufacturing peoples at Tanamu 1 with chrono-stratigraphic analysis demonstrating the presence of a permanent settlement and no site abandonment during this rich Middle Horizon period (David *et al.* completed ms:41).

Stratigraphic evidence found between SU3 and SU2 indicates that Tanamu 1 was abandoned by Lapita peoples but evidence of Lapita pottery in the later and more culturally sparse SU2 (2750 to 700 cal BP) indicates that Lapita peoples were present within the landscape (David *et al.* completed ms:41). This is further evident from evidence gathered at the nearby site Bogi 1 (140m to the northwest) where Lapita occupation continued until 2600 cal BP thus correlating with ceramic evidence dating to post-2750 cal BP in SU2, Tanamu 1(David *et al.* completed ms:41; McNiven *et al.* 2012). The ~30cm thick sands of SU2 had built up slowly at an average of 1 cm/100 years, which demonstrates that dune building had stopped following the end of the Lapita/Middle Horizon (David *et al.* completed ms:41). The discovery of a Linear Shell Edge-Impressed sherd two-thirds below SU2 in Square B XU19 lends further support the cessation of dune building at Tanamu 1 as this ceramic type was firmly dated to 2150-2100 cal BP at Bogi 1 after which more recent pottery was found in above XUs (David *et* al. 2012; David *et al.* completed ms:42).

The period lasting from 2750 to 700 cal BP was relatively stable but evidence for cultural activity is minimal (David *et al.* completed ms:41). Mixture of sediments at the interface of SU2 and SU1 as a result of post-depositional factors however made it hard to determine cultural remains within this interceding period (David *et al.* completed ms:41). Nonetheless, in SU1, sediment accumulation after 700 cal BP first consisted of culturally sparse sediments from 700 to ca. 200 cal BP, after which a dense Upper Horizon occurs from ca. 200 cal BP to the ethnographic period (late 1800s AD) (David *et al.* completed ms:41). The ~20 cm thick SU1 from between 700 and ca. 100 cal BP was built up at an average of ~3 cm/100 years (David *et al.* completed ms:41).

Overall, analysis of radiocarbon determinations and density of cultural material has revealed three major occupational periods at Tanamu 1, with intervening levels containing sparse cultural sediments (David *et al.* completed ms:52). Thus the major cultural phases in Tanamu 1 can be characterised as thus:

Upper Horizon (ca. 200 to 100 cal BP) (SU1) – Presence of undecorated pottery with rich material culture found from XU2 to XU5 in the upper sections of SU1.

Lapita/Middle Horizon (2800 to 2750 cal BP) (SU3) - Dense cultural layer containing Lapita pottery from XU43 to XU24. Lapita pottery was also found throughout the later culturally sparse SU2 layer.

Pre-Lapita/Lower Horizon (4350 to 4050 cal BP) (SU5) – Rich pre-Lapita/pre-Ceramic phase with abundant amounts of shell remains.

Table 9.2. Radiocarbon determinations, Tanamu 1. All ^{14}C ages are AMS. Calibrations undertaken using OxCal 10.4.1 (charcoal calibrations: INTCAL09 curve selection; shell calibrations: MARINE09 curve selection, *Anadara antiquata* ΔR = -1±16; *Gafrarium tumidum* ΔR = 67±16) (Petchey *et al.* submitted; Reimer *et al.* 2009; Stuiver and Reimer 1993) (David *et al.* completed ms:43-50).

Square	XU	SU	Depth (cm)	Wk-Laboratory Code	Material Dated	$\delta^{13}C$‰	% Modern	^{14}C Age (years BP)	Calibrated Age BP (68.2% probability)	Calibrated Age BP (95.4% probability)	Median Calibrated Age BP
B	2	1	2.8	29957	charcoal	-24.7±0.2	98.6±0.3	117±30	270-220 150-60 50-20	270-180 150-10	120
A	4	1	4.2	29966	charcoal	-25.1±0.2	98.5±0.4	123±30	270-210 150-60 40-20	280-170 160-10	120
B	3	1	3.1-5.4	32532	*Anadara antiquata* shell	-2.4±0.2	92.9±0.3	593±25	290-220 210-190 170-140	300-130	240
B	4	1	5.4-7.2	32533	*Anadara antiquata* shell	-2.2±0.2	93.1±0.3	575±25	270-180 170-140	290-120	210
A	4	1	7.3	27504	charcoal	-26.5±0.2	97.6±0.2	193±30	290-260 220-140 20--10	310-250 230-130 30--10	180
B	5	1	7.2-9.2	32534	*Anadara antiquata* shell	-2.7±0.2	93.5±0.3	538±25	240-130	270-60	180
A	5	1	8.8	29967	charcoal	-25.5±0.2	98.6±0.4	117±30	270-220 150-60 50-20	270-180 150-10	120
A	7	1	12.5	29968	charcoal	-24.5±0.2	90.9±0.3	769±30	730-670	740-660	700
B	8	1	13.9-16.0	32535	*Anadara antiquata* shell	0.6±0.2	69.1±0.3	2971±30	2780-2710	2830-2680	2750
B	9	1	16.7	29958	charcoal	-26.1±0.2	99.2±0.4	66±33	260-220 140-110 80-30	260-220 150-20	100
A	9	1	17.4	27505	charcoal	-24.4±0.2	90.2±0.1	826±30	770-690	790-680	730
B	10	1-2	20.0	29959	charcoal	-27.1±0.2	98.1±0.4	158±30	290-250 230-130	290-60 40- -10	170

									30-0		
B	11	1-2	19.7-21.5	32536	*Gafrarium tumidum* shell	1.3±0.2	68.5±0.2	3042±26	2780-2710	2830-2690	2750
B	15	2	27.9-30.3	32537	*Anadara antiquata* shell	-0.7±0.2	68.4±0.2	3053±28	2860-2760	2920-2740	2820
B	22	2-3	41.6-43.6	32538	*Anadara antiquata* shell	0.8±0.2	68.2±0.3	3080±31	2900-2780	2950-2750	2850
B	25	2-3	47.3-49.9	32540	*Gafrarium tumidum* shell	0.5±0.2	68.9±0.3	2990±31	2750-2680	2790-2590	2710
B	25	2-3	47.3-49.9	32539	*Anadara antiquata* shell	0.4±0.2	68.9±0.3	2993±31	2800-2720	2850-2700	2760
B	28	2-3-4	53.6-55.3	32541	*Anadara antiquata* shell	1.1±0.2	68.8±0.2	3000±27	2810-2730	2850-2710	2770
B	31	3-4	60.4-62.0	32542	*Anadara antiquata* shell	0.5±0.2	68.2±0.2	3078±26	2890-2780	2940-2750	2840
B	34	3-4	66.8-69.6	32543	*Anadara antiquata* shell	0.1±0.2	68.6±0.2	3024±26	2830-2740	2870-2720	2790
A	35	3-4	70.5	27506	charcoal	-26.7±0.2	70.2±0.2	2842±30	3000-2920 2910-2880	3070-2860	2950
B	37	3-4	73.7-75.9	32544	*Anadara antiquata* shell	0.4±0.2	68.4±0.2	3055±27	2860-2760	2920-2740	2820
B	40	4	81.1-83.4	32545	*Anadara antiquata* shell	0.1±0.2	68.5±0.2	3035±28	2840-2750	2890-2720	2800
B	43	4	87.7-90.3	32546	*Anadara antiquata* shell	0.8±0.2	68.6±0.2	3024±29	2830-2740	2880-2720	2790
B	46	4-5	95.4-97.3	32547	*Anadara antiquata* shell	0.5±0.2	65.9±0.2	3350±26	3280-3160	3330-3100	3220
B	49	4-5	102.5-104.7	32548	*Anadara antiquata* shell	0.1±0.2	60.2±0.2	4076±27	4180-4060	4230-3990	4120
B	53	5	110.4-112.3	32549	*Anadara antiquata* shell	-0.2±0.2	60.5±0.2	4032±29	4110-3980	4170-3920	4050
A	53	4-5	115.8	27508	charcoal	-25.2±0.2	62.8±0.1	3734±30	4150-4070 4040-3990	4220-4200 4160-3980	4090
B	58	5	122.1	29961	charcoal	-26.3±0.2	63.0±0.2	3715±30	4150-4120 4100-4060 4050-3980	4150-3970	4050

B	60	5	124.6	29962	charcoal	-26.0±0.2	62.1±0.2	3829±30	4290-4270 4260-4150	4410-4310 4300-4140 4120-4100	4230
A	59	5	125.1	29969	charcoal	-26.2±0.2	61.9±0.2	3858±32	4410-4320 4300-4230 4200-4180	4420-4220 4210-4150	4290
B	65b	5	135.1	29963	charcoal	-24.1±0.2	61.8±0.2	3864±32	4410-4320 4300-4230	4420-4220 4210-4150	4300
A	66	5-6	144.9	27714	charcoal	-25.6±0.2	61.4±0.2	3919±30	4420-4350 4340-4290	4430-4240	4360
A	75	6	159.1	27643	charcoal	-26.3±0.2	61.6±0.2	3895±30	4410-4290	4420-4240	4340
A	80a	6	167.7	29970	charcoal	-26.0±0.2	61.0±0.2	3968±31	4520-4470 4450-4410	4530-4380 4370-4350 4330-4290	4440
A	81a	6	172.6	27644	charcoal	-24.8±0.2	61.2±0.2	3941±30	4440-4380 4370-4350 4330-4290	4520-4470 4450-4280 4270-4250	4390
A	83c	6	174.4	29341	charcoal	-24.5±0.2	61.0±0.3	3968±39	4520-4460 4450-4400	4530-4290	4440
A	83a	6	175.8	29340	charcoal	-26.7±0.2	60.4±0.2	4053±30	4580-4510 4490-4440	4790-4760 4620-4420	4530
A	85a	6	177.3	28805	charcoal	-23.4±0.2	60.6±0.3	4021±33	4530-4430	4570-4410	4480
B	87	6	178.7-180.9	31008	*Anadara antiquata* shell	0.0±0.2	58.8±0.2	4268±25	4440-4320	4500-4270	4380
B	87	6	178.7-180.9	31007	*Gafrarium tumidum* shell	0.8±0.2	58.7±0.2	4285±25	4390-4270	4420-4210	4320
B	87	6	178.7-180.9	31009	*Anadara antiquata* shell	-0.3±0.2	58.5±0.2	4313±25	4500-4400	4540-4340	4440
A	89	6	186.2	27645	charcoal	-24.5±0.2	60.5±0.2	4042±30	4570-4440	4790-4760 4610-4600 4590-4420	4500
A	90	6	188.1	27646	charcoal	-26.0±0.2	60.7±0.2	4012±30	4520-4430	4570-4550 4530-4410	4480
A	93	6	198.1	27647	charcoal	-26.5±0.2	60.5±0.2	4037±30	4570-4560 4530-4430	4780-4760 4580-4420	4490

A	97	6	202.3	29971	charcoal	-25.9±0.2	61.0±0.2	3969±32	4520-4470 4450-4410	4530-4380 4370-4350 4330-4290	4440
A	102	6	212.1	29977	charcoal	-25.0±0.2	61.2±0.2	3949±30	4520-4480 4450-4400 4370-4350 4330-4300	4520-4460 4450-4290	4420
A	103a	6	214.1	29972	charcoal	-26.3±0.2	60.9±0.2	3978±31	4520-4470 4450-4410	4530-4400 4370-4350 4330-4300	4470
A	106a	6-7	220.0	29978	charcoal	-25.7±0.2	61.0±0.2	3965±32	4520-4470 4450-4410	4530-4350 4330-4290	4440
B	111	6-7	225.7-228.2	32550	*Gafrarium tumidum* shell	1.1±0.2	58.4±0.3	4318±37	4420-4290	4490-4230	4360
A	109	6-7	227.3	28604	charcoal	-24.9±0.2	60.2±0.2	4071±30	4790-4760 4610-4510 4470-4440	4810-4760 4700-4670 4650-4510 4490-4440	4560
B	113	6-7	229.7-232.3	32551	*Anadara antiquata* shell	0.2±0.2	60.6±0.2	4029±27	4100-3970	4160-3920	4050
A	111	6-7	231.2	29974	charcoal	-30.8±0.2	61.2±0.2	3949±30	4520-4480 4450-4400 4370-4350 4330-4300	4520-4460 4450-4290	4420
A	112	6-7	232.3	29984	charcoal	-26.0±0.2	59.6±0.2	4154±27	4820-4780 4770-4750 4730-4620	4830-4780 4770-4580	4700
B	114	6-7	232.9	29964	charcoal	-24.5±0.2	61.0±0.2	3971±30	4520-4480 4450-4410	4530-4400 4370-4350 4330-4290	4450
B	116	6-7	238.8	29965	charcoal	-25.5±0.2	60.1±0.2	4093±30	4790-4760 4630-4520	4810-4750 4710-4510 4470-4440	4600
A	118	7	244.8	29212	charcoal	-24.5±0.2	60.1±0.3	4091±35	4790-4760 4630-4520	4820-4750 4710-4510 4490-4440	4600
B	127	7	258.0-	32552	*Anadara antiquata*	0.2±0.2	55.2±0.2	4766±30	5120-5090	5200-4880	5020

			260.7		shell				5080-4940		
B	130	7	266.6-269.6	32553	*Gafrarium tumidum* shell	0.0±0.2	55.5±0.2	4727±30	4920-4820	4990-4800	4880

Shellfish Assemblage

Since the main focus of this thesis is on understanding shellfish exploitation in relation to previously discussed research questions (see Chapters 1 to 4) within the Caution Bay landscape, this section will provide a comprehensive discussion of key trends from Square A, Tanamu 1 focussing on shellfish. In addition, results derived from analysis of other cultural elements (e.g. ceramics, stone artefacts) will be incorporated into the discussion section below in support of key trends in shellfish use. Aspects of the analysis and discussion of the Tanamu 1 shellfish assemblage was recently undertaken by Tomkins *et al.* (completed ms) and datasets from this analysis were made available to be incorporated into this study. While data collection and analysis of the other sites to be presented in subsequent chapters (Bogi 1 and JA24) were carried out by myself, the nature of being part of a large multi-disciplinary team meant that my role in the analysis of the Tanamu 1 shellfish assemblage was confined to undertaking the morphometric analysis. In order to maintain consistency especially with upcoming publication of shellfish analysis results in the Tanamu 1 site monograph, I will therefore be incorporating the main results, datasets and figures utilised by Tomkins *et al.* (completed ms) in this chapter. However, additional data graphs together with results from morphometric analysis of certain taxa will be added to the overall discussion. While I am limited to using the datasets gathered by Tomkins *et al.* (completed ms), overall interpretations of molluscan remains will be my own. As a clarification, the methods used by Tomkins *et al.* (completed ms) for calculating shellfish MNI for a square differs from that which was employed for this PhD (see Chapter 8 for detailed discussion), but given the limitations on not being able to alter any MNI data because of the impending monograph publication, I am required to present the existing dataset. It is envisioned that the slight difference in methods will not significantly alter overall site interpretations, and an investigation on shellfish methodologies in archaeological contexts will be presented in a future publication.

Square A Results

A total of 111 species of shellfish were present within the Square A assemblage comprising of 67 marine gastropods, 40 marine bivalves, 3 freshwater gastropods and 1 freshwater bivalve (Tomkins *et al.* completed ms:5). By weight, 83% of all molluscs were identified to either Family, Genus or species with bivalves representing 36,012.4g (58%) while gastropods accounted for 15,609.9g (25%) of the assemblage (Tomkins *et al.* completed ms:5). 17% (10,344.2g) of molluscs could not be identified because of high extent of breakage and/or weathering (Tomkins *et al.* completed ms:5). Discard rates of shellfish varied between XUs ranging from 2.1g in XU17 to 2684.8g in XU66 (Tomkins *et al.* completed ms:5). Other than molluscs, small numbers of Maxillopoda (barnacle, 57.2g), Vermetidae (wormtude, 11.1g), Polyplacophera (chiton, 8.7g), Subulinidae and Camaenidae (landsnails, 1.3g) were also present within the assemblage (Tomkins *et al.* completed ms:5).

In terms of weight, 75% of the entire assemblage was represented by 25 taxa, thus demonstrating the relative importance of these taxa (Tomkins *et al.* completed ms:5).Out of the 25 taxa, the top 10 taxa representing 71% of the assemblage were *Anadara antiquata* (7289.2g, 14%), Ostreidae (5864.0g, 11%), *Chama* spp. (4430.5g, 9%), *Gafrarium tumidum* (4173.0g, 8%), *Lambis* spp. (3664.7g, 7%), *Conomurex luhuanus* (3613.1g, 7%), *Lambis lambis* (3070.5g, 6%), *Gafrarium* spp. (1687.3g, 3%), *Isognomon* spp. (1654.1g, 3%) and *Austriella corrugata* (1494.4g, 3%) (Tomkins *et al.* completed ms:5).

In terms of MNI, 4323 bivalves and 2201 gastropods totalling 6524 MNI was present in Square A with results demonstrating a clear preference for bivalves (Tomkins *et al.* completed ms:7). In order of MNI, the top 10 species make up 58% of the entire assemblage and these were *Gafrarium tumidum*, (MNI 599, 9%), *Isognomon* spp. (MNI 535, 8%), *Anadara antiquata* (MNI 504, 8%), *Atactodea striata* (MNI 377, 6%), *Conomurex luhuanus* (MNI 330, 5%), *Gafrarium* spp. (MNI 267, 4%), Cerithidea largillierti (MNI 195, 3%), *Tellina* spp. (MNI 192, 3%) and *Chama* spp. (MNI 157, 2%) (Tomkins *et al.* completed ms:7). Figures 9.17 and 9.18 highlight the most prevalent taxa in terms of both weight and MNI (Tomkins *et al.* completed ms:6).

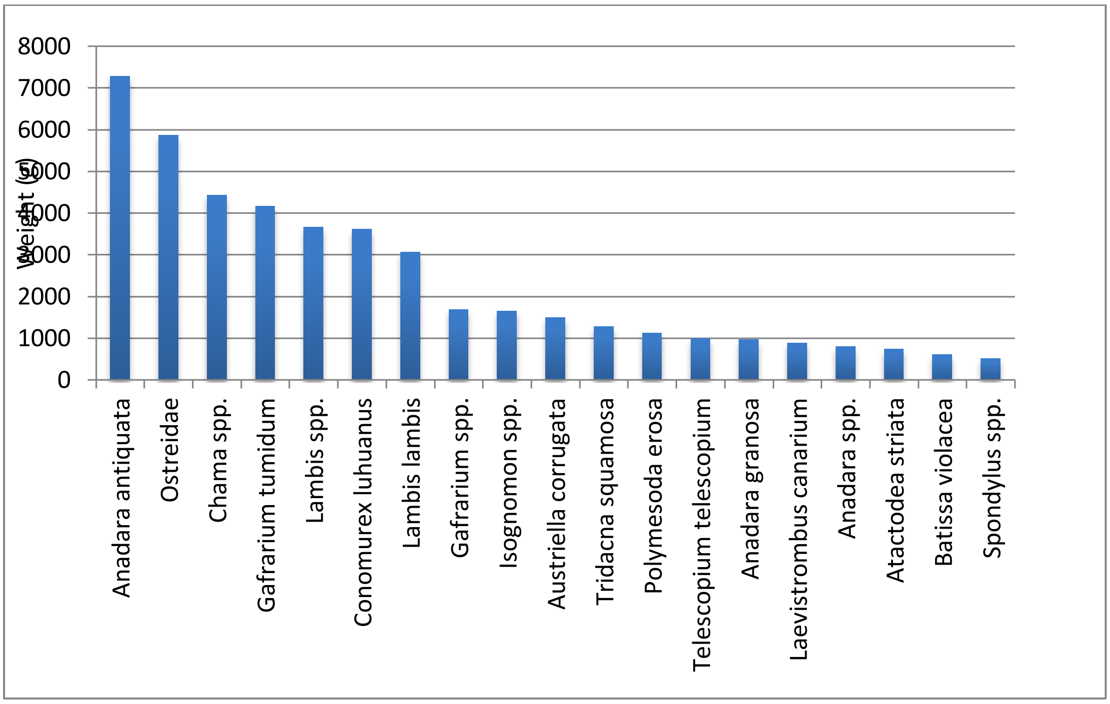

Figure 9.17. Ranking of shellfish taxa from Square A by weight ≥500g (Tomkins et al. completed ms:6).

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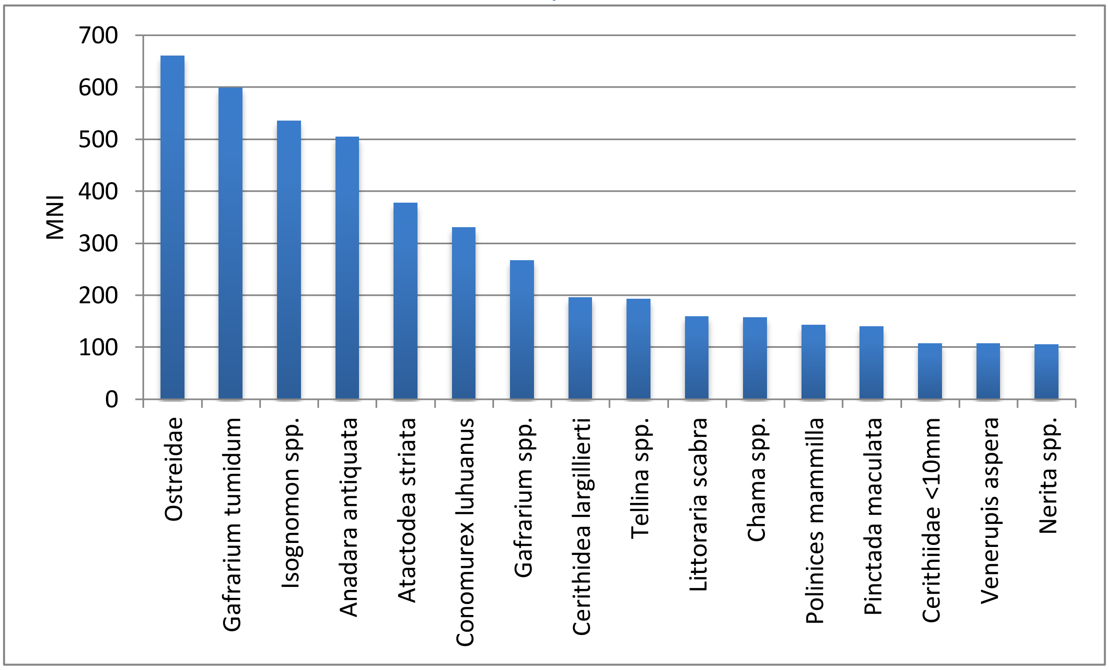

Figure 9.18. Ranking of shellfish taxa from Square A by MNI ≥100 MNI (Tomkins et al. completed ms:6).

Relative Importance of Mollusc Taxa for both Squares

With the wide diversity of shellfish taxa being exploited as evidenced by weight and MNI figures, size and meat weights differed greatly between individual species (Tomkins *et al.* completed ms:9). For instance, *Lambis spp.* has an average meat weight of 35g compared with ≥1g for the bivalve *Atactodea striata* (Tomkins *et al.* completed ms:9). The taxa with the highest MNI count Ostreidae has an average meat weight range of 6-15g whereas *Conomurex luhuanus* has a mean meat weight of approximately 2g (Tomkins *et al.* completed ms:9). Hence shell size is not indicative of meat weight as taxa such as *Conomurex luhuanus* and Ostreidae (depending on size) are larger than some of the other species but their meat weight contributions can still be relatively small. Likewise, prevalence of small-sized taxa (*Atactodea striata*) with low meat weight would most likely not have provided a significant dietary contribution unless exploited in larger numbers. Similar occurrence of other small-sized taxa containing low meat weights of approximately 1g or less (e.g. *Cerithidea largillierti, Nerita* spp. *and Calliostoma* sp.) also represent a food source in the Middle and Lower Horizons because they were present in large numbers (Tomkins *et al.* completed ms:10). Based on the large quantities of discard, certain taxa are in this instance considered to be economic even though their size-structure may be small in comparison to other larger species. Meanwhile a minor part of the assemblage equalling 4% (n=594) has been interpreted to be non-economic (Tomkins *et al.* completed ms:10). According to Tomkins *et al.* (completed ms:10), taxa such as Ellobiidae and *Hemitoma* spp. which are smaller than 10mm long were considered to have been naturally or accidentally brought into the site, for instance attached to larger molluscs. The fact that such taxa occur in smaller numbers throughout the deposit even in culturally sparse sections indicative of lesser anthropogenic activity (minor phases, e.g. SU6-7) together with their extremely small size-structure and low meat weight (mostly less than 10mm in size) reaffirms their non-economic role within the assemblage.

Shell Artfefacts

A number of worked shells were identified within the assemblage. Certain preferred taxa for artefact manufacture (e.g. giant clams – Tridacnidae, cone shells – *Conus* spp., top-shells – *Tectus niloticus*, cowries – *Cypraea* spp., and pearl oysters – *Pinctada* spp.) by Pacific shell-workers were likely to have been available at Caution

Bay (Szabó 2010:116; Tomkins *et al.* completed ms:10). Additionally, these taxa were also present in all three major cultural horizons (SU1, SU3 and SU5) (Tomkins *et al.* completed ms:10). Results of the shell artefact assemblage is still in progress, but so far has revealed a number of artefacts present at Tanamu 1 dating to pre-Lapita times (David *et al.* completed ms:58). The shell artefact assemblage from Square B consists of a shell bead (XU75) and a shell adze (XU89) from pre-Lapita levels dating to 4339-4410 cal BP and 4424-4581 cal BP respectively (David *et al.* completed ms:58). Further details of the entire shell artefact assemblage will be presented at a later date but these significant finds nonetheless demonstrate that contrary to the notion that perhaps Lapita peoples may have introduced worked shell to Caution Bay, pre-Lapita peoples had already engaged in producing such items well before Lapita peoples arrived.

Trends in Shellfish Exploitation Between Major Horizons in Both Squares

Mollusc exploitation at Tanamu varied between the three major horizons. For the post-Lapita/Upper Horizon (SU1, XU3-6), the range of targeted taxa (<20 species) and discard was much less than as documented during the Lapita Horizon (SU3, XU24-35) and pre-Lapita/Lower Horizon (SU5, XU48-69) with >60 species and >90 taxa respectively (Tomkins *et al.* completed ms:11). Most of the shellfish remains in SU1 (XU3-6) are accounted for by *Conomurex luhuanus*, Ostreidae, *Lambis spp.* and *Polymesoda erosa* (Tomkins *et al.* completed ms:11) (Figure 9.19).

In contrast to SU1, a much wider spectrum and density of mollusc were exploited during Lapita occupation (SU3, XU24-35) and before the arrival of Lapita peoples (SU5, XU48-69) (Tomkins *et al.* completed ms:11) (Figures 9.20 and 9.21). The predominant taxa during both phases were *Atactodea striata*, *Anadara antiquata*, *Gafrarium* spp., *Chama* spp., Ostreidae and *Isognomon* spp. (Tomkins *et al.* completed ms:11). Taxa diversity points to similar choice of targeted species between both horizons (Tomkins *et al.* completed ms:11). Some key differences were however also noted. Even though *Anadara antiquata* discard during the Lapita phase (SU3) was higher (MNI), total weight of this species only accounted for half of the taxa weight in the Lower Horizon (Tomkins *et al.* completed ms:13). This trend can be attributed to the smaller size-structure of this species during Lapita occupation than those found in SU5, perhaps indicative of predation pressures or environmental changes (Tomkins *et al.* completed ms:13). Morphometric analysis of this species is presented below. The prevalence of larger individuals in SU5 than in SU3 was also noted for all other *Anadara* species (Tomkins *et al*. completed ms:13).

Another important difference in shellfish procurement between pre-Lapita and Lapita times, is a greater focus on larger gastropods and other bivalve taxa such as *Conomurex luhuanus*, *Gibberulus gibberulus*, *Laevistrombus canarium*, *Lambis* spp. for gastropods and for bivalves *Tellina* and *Gafrarium* (Tomkins *et al*. completed ms:13). *Conomurex luhuanus* which accounts for much of the deposit (by MNI and weight) thereby demonstrating its economic importance was not present between SU5 and SU7, with vast numbers only found from XU1 to XU47 which indicates either a shift in subsistence focus or the environment (Tomkins *et al*. completed ms:13-14). Although certain taxa including smaller-sized species were either exploited in larger numbers or incorporated into local subsistence strategies during Lapita occupation, some other species had a higher density of discard in SU5 (pre-Lapita Horizon) (Tomkins *et al*. completed ms:14) (Table 9.3).

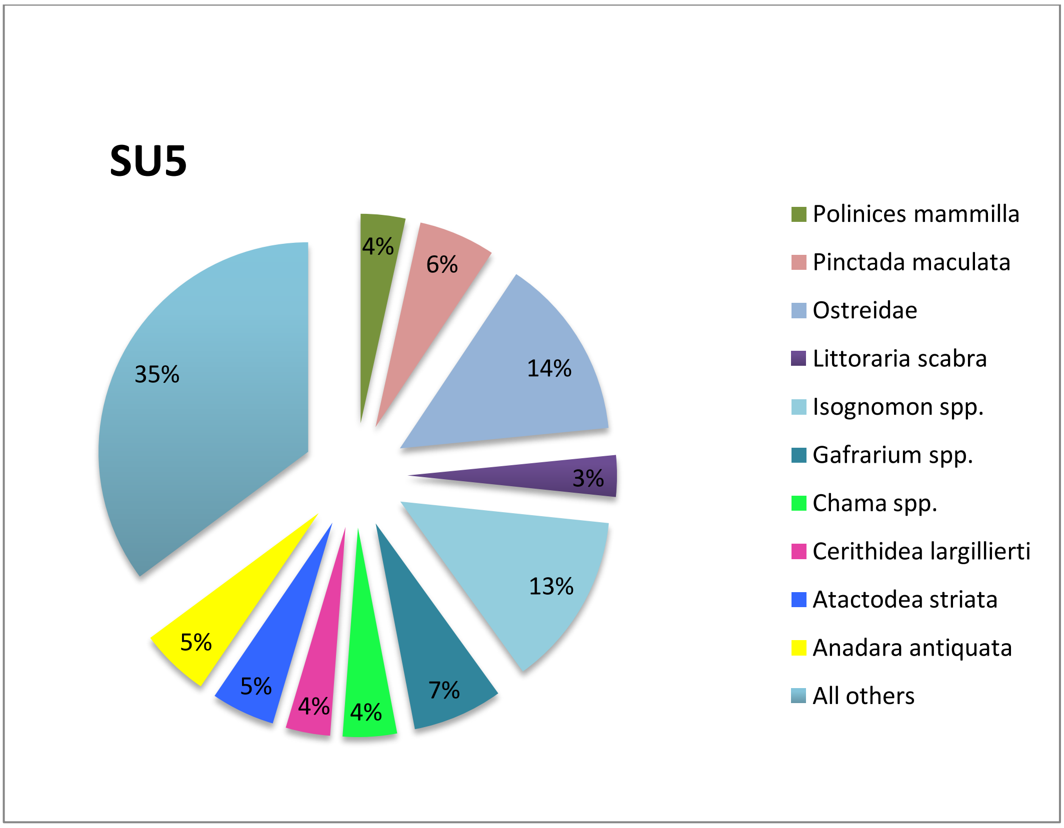

Figure 9.19. Main shellfish species in pre-Lapita/Lower Horizon (Tomkins *et al.* completed ms:13).

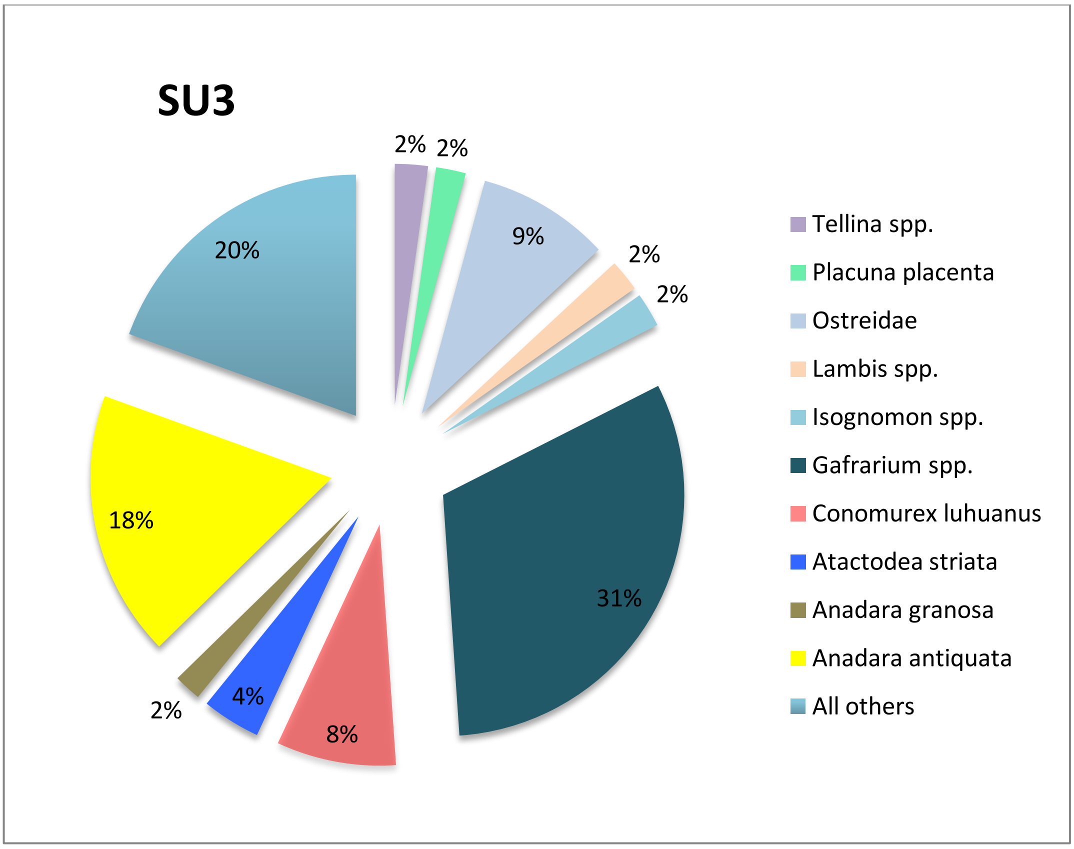

Figure 9.20. Main shellfish species in Lapita/Middle Horizon (Tomkins *et al.* completed ms:12).

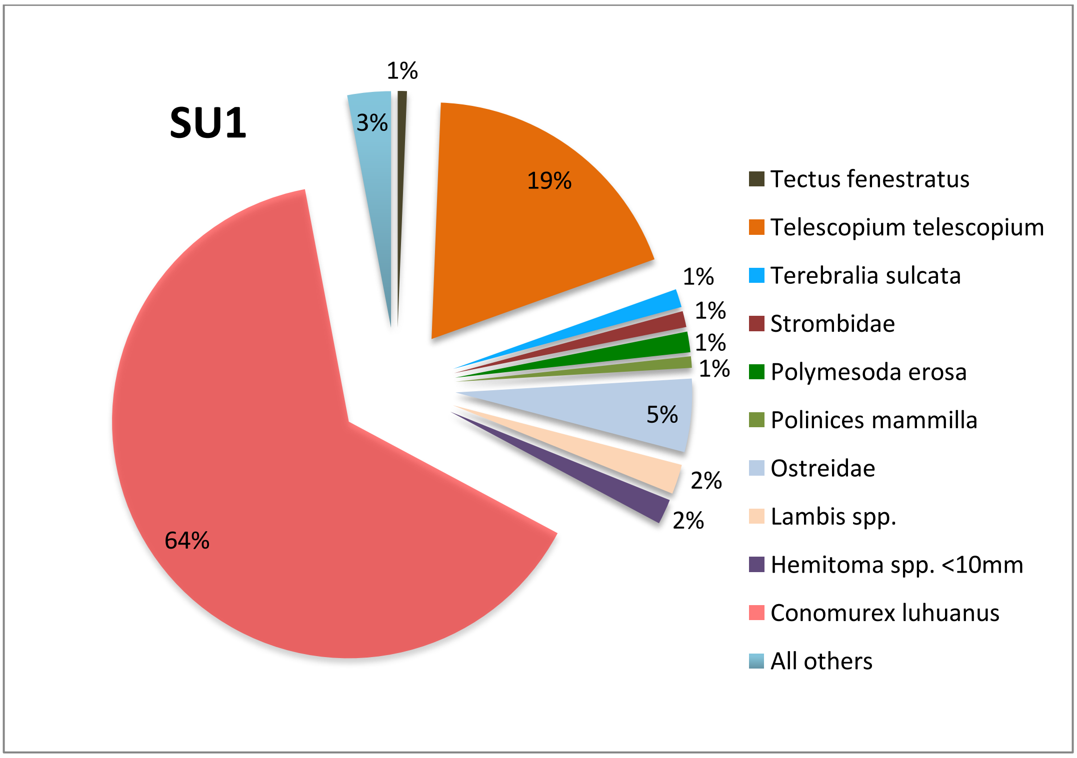

Figure 9.21. Main shellfish species in post-Lapita/Upper Horizon (Tomkins *et al.* completed ms:12).

Table 9.3. Example of taxa more prevalent in SU5 (pre-Lapita Horizon) than SU3 (Lapita Horizon) (Tomkins *et al.* completed ms:14).

Bivalves	*Batissa violacea*, *Polymesoda erosa*, *Chama* spp., *Venerupis aspera*, Ostreidae, *Isognomon* spp., *Pinctada maculata*
Gastropods	*Chicoreus* spp., *Terebralia sulcata*, *Conus* spp., *Cypraea* spp.
Small-sized taxa	*Nerita* spp., *Calliostoma* spp., *Oliva* spp., *Littoraria* spp., *Nassarius* spp., *Cerithidea largillierti*

In addition to the dense shellfish deposits in SU1, SU3 and SU5, much smaller amounts of molluscan remains were unearthed in all other SUs. For SU2 (XU10-XU23), Tomkins *et al*. (completed ms:14) have postulated for a 'c.2000-year hiatus following site abandonment by Lapita peoples around 2750 cal BP and prior to renewed settlement by post-Lapita peoples sometime after c.700 cal BP'. Even though the limited quantity of shell found has led to this conclusion, I believe that this is not an adequate explanation especially when other sites nearby dating to this post-Lapita period has been found with evidence for shellfish exploitation (see Chapters 10 and 11). Further discussions on this matter will be presented in subsequent chapters. In relation to SU2, SU4 contains more shellfish but the likelihood here is that this layer is made up of shells from Lapita and pre-Lapita periods as a results of post-depositional factors (Tomkins *et al.* completed ms:14). Species diversity is similar except for certain robust taxa such as Tridacnidae (giant clam) and *Lambis* spp. (large conch shell) which were not present (Tomkins *et al.* completed ms:14). Lastly, in the lowest sections of SU6 and SU7 (XU70 to XU134), a number of common species such as *Anadara antiquata*, *Atactodea striata*, *Gafrarium*, Ostreidae, *Polymesoda erosa*, *Tellina* spp., *Nerita* spp., *Telescopium telescopium*, and *Cerithidea largillierti* were present, indicative of a focus on multiple habitats (Tomkins *et al.* completed ms:14). As well, with some shellfish remains having been found in SU6, the evidence points to use of the local landscape by ancient peoples from at least 4700 years ago (Tomkins *et al.* completed ms:14).

Differences in Habitat Use for both Squares

In Chapter 8, an overview of shellfish habitats for common species found in the Tanamu 1 assemblage suggests that people were targeting a wide range of tidal habitats. Over time, this practice continued to be utilised but to varying degrees. Figure 9.22 demonstrates differences in chronostratigraphic use of habitats and a summary of key trends for each SU are provided below.

In the lowest stratigraphic section (SU7) (c.5000 to 4500 cal BP), species such as Ostreidae, *Calliostoma* spp. and *Nerita* spp. belonging to rocky and sandy intertidal habitats were found (Tomkins *et al.* completed ms:18). Approximately half of the individuals had evidence for water-rolling representing intermittent submergence below high tide (Tomkins *et al.* completed ms:18). Evidence for storm surge events or intertidal sediments is also seen with the presence of taxa smaller than 10mm in size (e.g. Cerithiidae and *Fragum* spp.) (Tomkins *et al.* completed ms:18). Most of the shellfish remains from this SU are deemed to be non-economic and when considered with topographic and stratigraphic evidence to be partially of natural beachline sediments (Tomkins *et al.* completed ms:18).

Mangrove, rocky shore, intertidal sand and mud flat species constitute the bulk of mollusc remains in SU6 (c.4500 to 4350 cal BP) (Tomkins *et al.* completed ms:20). 44% of the assemblage consists of sandy substrate bivalves such as *Atactodea striata* and *Gafrarium spp.* while a blend of bivalve and gastropod species from muddy substrates of intertidal flats and mangroves (e.g. *Polymesoda erosa* and *Austriella corrugata*) account for 31% of all molluscs in SU6 (Tomkins *et al.* completed ms:20-21). Smaller-sized individuals in SU6 are represented by turbo snails (*Lunella cinera*), nerites and rock oysters (Ostreidae) from rocky substrate habitat (Tomkins *et al.* completed ms:21).

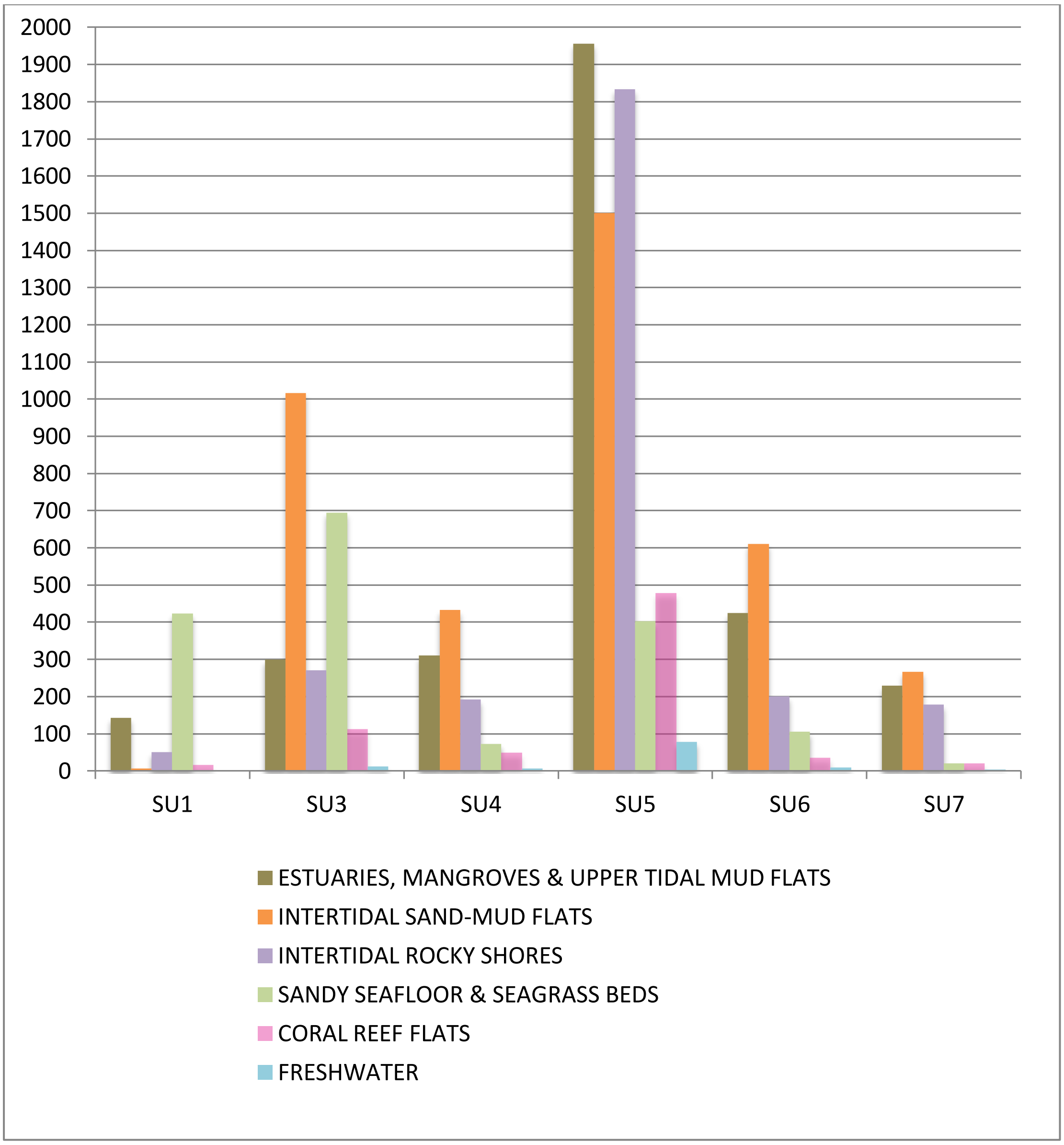

Figure 9.22. MNI of shellfish taxa by SU for each habitat (Tomkins *et al.* completed ms:18).

In the SU5 Lower Horizon (Pre-ceramic, c.4350 to 4050 cal BP), inshore environments (e.g. mangroves, intertidal sand and mudflats) were targeted the most by people before the intrusion of Lapita peoples (Tomkins *et al.* completed ms:21). 88% of the all mollusc remains from this SU are from species belonging to inshore environments (Tomkins *et al.* completed ms:21). In addition, taxa from seagrass beds, reef flats and freshwater environments were also targeted (Tomkins *et al.* completed ms:21). Species that continued to be exploited include *Atactodea striata*, *Venerupis aspera*, and *Asaphis violescens* from sandy flats, and oysters, *Chama spp.* (jewel-box shell) and nerites from rocky shore habitats (Tomkins *et al.* completed ms:21). For muddy substrates, *Austriella corrugata*, *Polymesoda erosa*, *Terebralia* spp. and *Cerithidea largillerti* were gathered in large quantities (Tomkins *et al.* completed ms:21). Effort was also made to collect shellfish from more distant rock and reef platforms as indicated by *Chicoreus* spp. (murex shells), *Conus* spp. (cone shells) and *Cypraea* sp. (cowrie shell) remains in the assemblage (Tomkins *et al.* completed ms:21). Coral reef systems were also targeted with a minimal number of *Tectus niloticus* (top-shell) and Tridacnidae (giant-clam shell) also present (Tomkins *et al.* completed ms:21). Other than these habitats, fresh/brackish water environments are also represented by abundant remains of the bivalve *Batissa violacea* (Tomkins *et al.* completed ms:21).

Even though inshore habitats were still being targeted, a change in focus to targeting taxa from sandy substrates is demonstrated in SU4 (c.4050 to 2800 cal BP) (Tomkins *et al.* completed ms:21). During this time, 41% of all targeted species were from sandy substrates, with a decrease in mollusc numbers from rocky shore (18%) and muddy mangroves (29%) (Tomkins *et al.* completed ms:21). At the same time, more evidence for reef flat resources was also noted (Tomkins *et al.* completed ms:21). The sandy substrates and intertidal-seagrass meadows species *Conomurex luhuanus* appears for the first time at Tanamu 1 (XU47) and was previously not present in earlier deposits from SU6, SU7 and the dense midden layer SU5 (Tomkins *et al.* completed ms:21-22).

The subsequent Lapita Horizon (c.2800-2750 cal BP, SU3) was considerably different in the manner habitats were being targeted when compared with the earlier major Lower Horizon (Tomkins *et al.* completed ms:22). Whether a product of environmental change or shift in habitat focus, greater numbers of certain species were seen (Tomkins *et al.* completed ms:22). This includes *Gibberulus gibberulus* (sandy reef flats), *Laevistrombus canarium* (muddy-sand bottoms and seagrass meadows) and *Conomurex luhuanus* (sandy substrates and seagrass meadows) (Tomkins *et al.* completed ms:22). Species from clean coral reef habitats were also present in larger numbers in SU3 than SU5 (Tomkins *et al.* completed ms:22). Apart from SU5, a similar trend to SU4 is seen with the highest number of targeted species coming from intertidal sand and mud flats (SU4 = 41% of MNI, SU3 = 42% of MNI) (Tomkins *et al.* completed ms:22). Dominant intertidal sand and mud flats species comprise of *Anadara antiquata*, *Gafrarium pectinatum*, *Gafrarium tumidum*, *Tellina* spp. and *Atactodea striata* (Tomkins *et al.* completed ms:22). While species from rocky substrates such as *Chama* spp. and Ostreidae occur in SU3, small nerites and *Isognomon* spp. were present in lesser quantities compared to SU5 (Tomkins *et al.* completed ms:22). These changes in subsistence focus between SU5 and SU3 points to a proportional shift in focus of habitats as the range of targeted environments did not alter (Tomkins *et al.* completed ms:22). For instance, there is an increased focus on exploiting molluscs from intertidal sand and mud flats, and reef environments during Lapita occupation at 2800 cal BP or to some extent sometime earlier (upper sections of SU4) which probably dates to around 2900 cal BP, the earliest evidence for Lapita arrival at Caution Bay demonstrated at site Bogi 1 approximately 140m away (Tomkins *et al.* completed ms:22).

As SU2 (c.2750 to 700 cal BP) has low amounts of shell thus making it difficult to ascertain the habitats from which mollusc were exploited during this period in time, the SU1 Upper Horizon (c.700 to 100 cal BP) molluscan assemblage again demonstrates a significant change in shellfish procurement strategies (Tomkins *et al.* completed ms:23). The most significant difference between SU1 and the other major horizons is a major decrease in the diversity of exploited shellfish. Here, evidence points to a more intensive subsistence strategy targeting the sandy substrates and intertidal seagrass beds species *Conomurex luhuanus*, and *Lambis lambis* which is found in reef flats and coral-rubble bottoms (Tomkins *et al.* completed ms:23). Continuity is seen with the exploitation of certain mangrove species (*Polymesoda erosa*, *Terebralia sulcata* and *Telescopium telescopium*) and rock oysters (Tomkins *et al.* completed ms:23).

Overall, analysis of chronostratigraphic trends in molluscs gathering by habitat demonstrates that people were mainly exploiting shellfish from a number of littoral habitats with different substrates (e.g. sand, rock, coral reef, mud and mangrove trees) (Tomkins *et al.* completed ms:23). An additional source of sustenance was derived from gathering shellfish found in intertidal seagrass meadows, reef flats and freshwater habitats (Tomkins *et al.* completed ms:23). While I will explore the possible reasons for variation in focus on different habitats in Chapter 12 following a discussion of shellfish assemblages from the other two sites, the main points as summarised by Tomkins *et al.* (completed ms:23) for habitat use between identified horizons at Tanamu 1 are:

- Lower/pre-Lapita Horizon (SU5) – Mollusc were gathered in identical quantities from a number of intertidal habitats. People at this time had also started to exploit offshore habitats for some prized resources such as the infrequent giant-clam shell and nacreous top-shell.
- Middle/Lapita Horizon (SU3) – Increased focus on sandy and rock intertidal species instead of mangroves. As well, prevalence of clean coral reef habitat taxa indicates more time spent offshore.
- Upper/post-Lapita Horizon (SU1) – A greater focus (>50% of assemblage) on a specific taxa (*Conomurex luhuanus*) exploited from sandy substrates and intertidal seagrass beds.

Intensity of Mollusc Exploitation

The vast array of mollusc taxa, together with the rich density of discard in each of the major cultural horizons has clearly demonstrated that shellfish resources were of economic importance to local inhabitants at Tanamu 1. Yet, the descriptive accounts of key chronological changes on shellfish procurement by Tomkins *et al.* (completed ms) can be investigated further from an analysis of discard rates in each cultural phase. Figures 9.23 and 9.24 reveal that apart from post-Lapita levels, bivalves were clearly preferred over gastropods in both pre-Lapita and Lapita Horizons. In contrast, the dominance of gastropods over bivalves (231 MNI vs 17 MNI) during the Upper Horizon may be a result of increased dependence on certain species such as *Conomurex luhuanus*. This is further substantiated by similar MNI figures for gastropod discard in both Lapita (MNI 339) and post-Lapita Horizons (MNI 231) during which *Conomurex luhuanus* appears in the archaeological record for the first time. On the contrary, major reduction in gastropod exploitation occurs between pre-Lapita (MNI 828) and Lapita (MNI 339) phases. For bivalves, drastic decreases seemed to occur between all three phases with the difference between Lapita (MNI 1348) and post-Lapita (MNI 17) periods the most noticeable, and therefore suggestive of a major reorganisation of subsistence strategies with varying intensities in resource use.

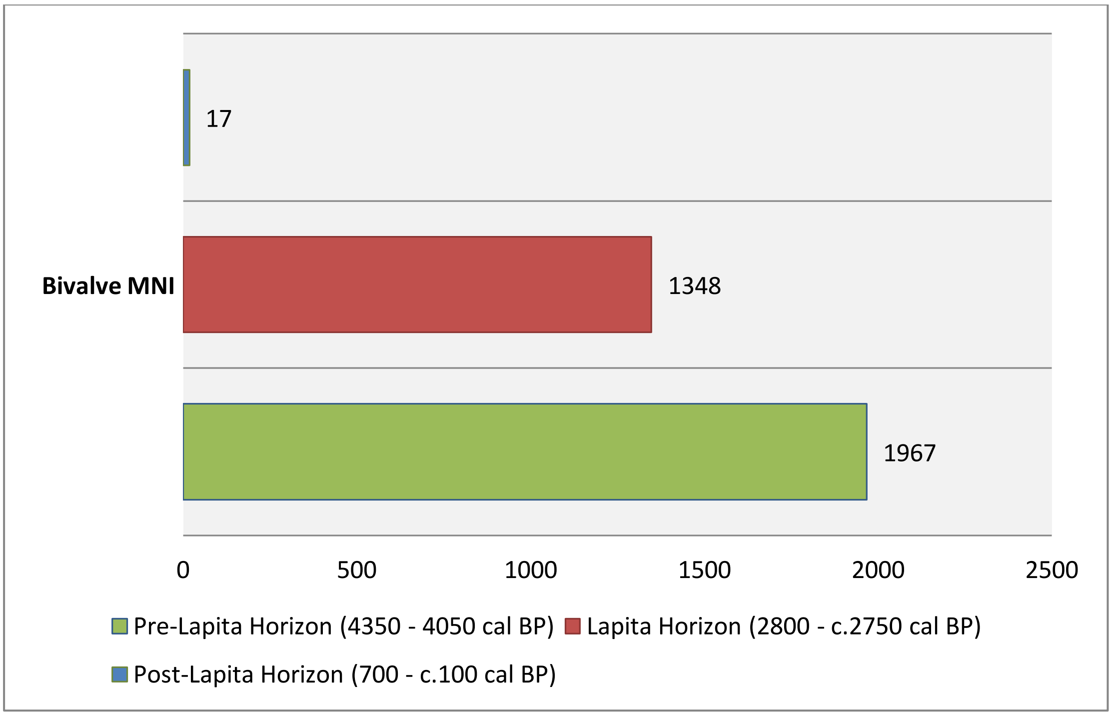

Figure 9.23. Total MNI for bivalves per major cultural horizon.

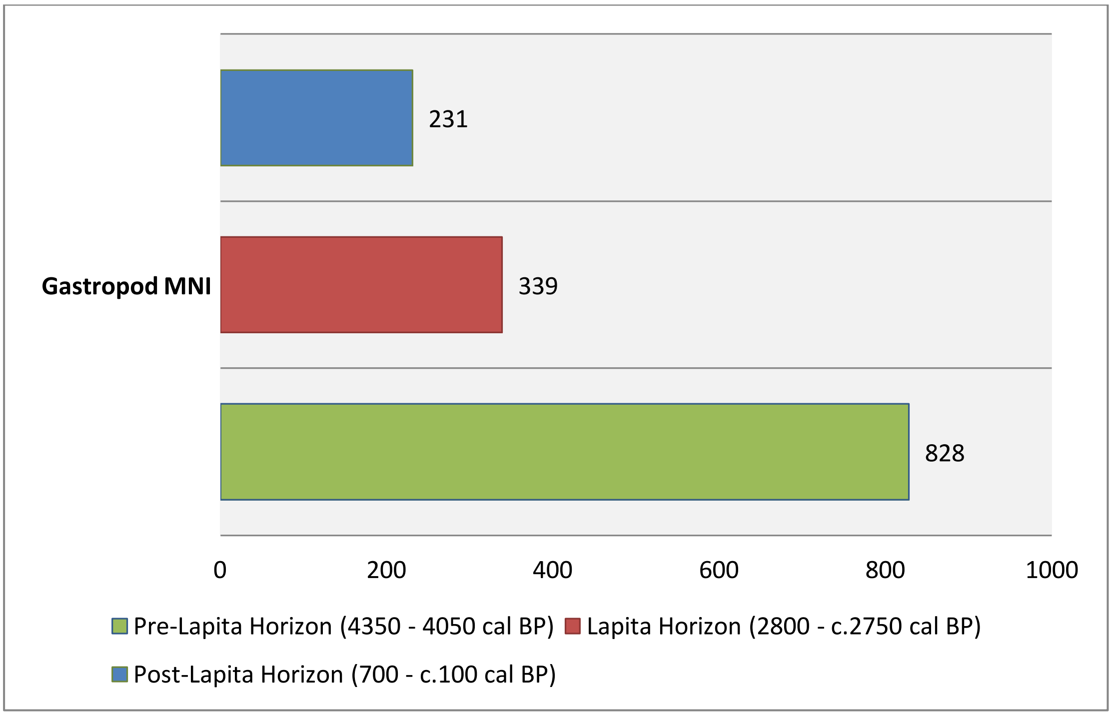

Figure 9.24. Total MNI for gastropods per major cultural horizon.

Overall MNI of shellfish remains in Square A is also indicative of its importance as a subsistence resource in each of the major cultural horizons (Figure 9.25). With discard rates of 2795 MNI in pre-Lapita (Upper), 1687 MNI for Lapita (Middle) and 248 MNI during post-Lapita (Upper) horizons, it can be argued that shellfish exploitation was at its greatest during the earliest Upper Horizon phase. However, analysis of total discard for each phase as an arbitrary analytical unit does not provide a clear picture of the intensities in which people were targeting natural shellfish populations. This is particularly the case when the temporal range of occupation in each phase is considerably different from one another. When examined further, the pre-Lapita/Lower Horizon dating to between 4350 and 4050 cal BP demonstrates a 300 year occupational phase whereas for the Lapita/Middle Horizon dated to 2800 and c.2750 cal BP, occupation only lasted for approximately 50 years. The post-Lapita/Upper Horizon, 700 to c.100 cal BP has a longer occupational sequence of about 600 years. In order to ascertain levels of intensity in site and resource use according to the temporal range of each occupational sequence, analysis of shellfish discard for every 100 years was undertaken.

Figures 9.26 and 9.27 paint a contrasting picture when compared with mere MNI discard of shellfish in each horizon. By taking into consideration the different temporal scales for each horizon and quantifying shellfish MNI accordingly (MNI per 100 years), results clearly depict the degree to which mollusc resources were exploited. During pre-Lapita/Upper Horizon (SU5), shellfish were being exploited at an estimated rate of 932 MNI per 100 years. Whilst this figure suggests a focus on such resources at that time, the arrival of Lapita peoples and the subsequent occupation at Tanamu 1 resulted in intensification of mollusc exploitation (3374 MNI per 100 years). Within a period of 50 years, local peoples at Caution Bay heavily targeted shellfish, more so than in the previous phase or subsequent post-Lapita Horizon (41 MNI per 100 years). In relation to overall shellfish exploitation levels (MNI per 100 years), post-Lapita and pre-Lapita peoples only contributed 1% and 21% respectively while the majority and most intense period of mollusc exploitation (78%) was accounted for by people during Lapita occupation. Discussions on why this trend may have occurred will be presented in Chapter 12.

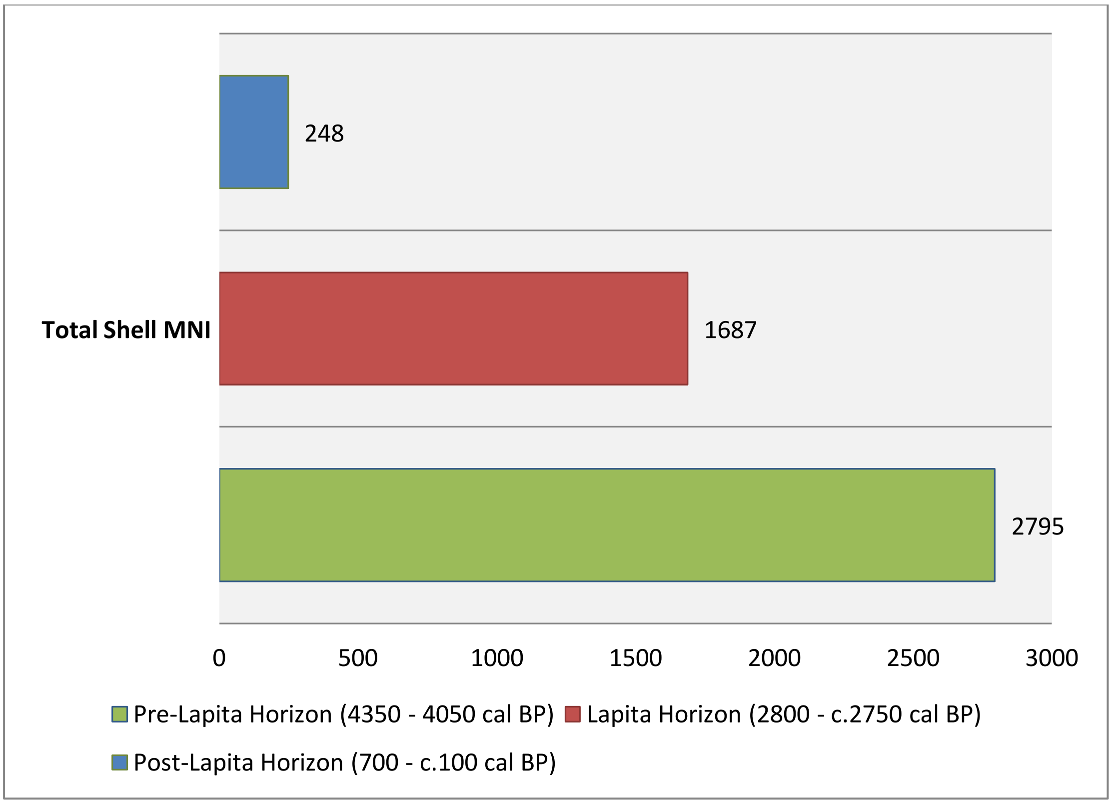

Figure 9.25. Total MNI for shell per major cultural horizon.

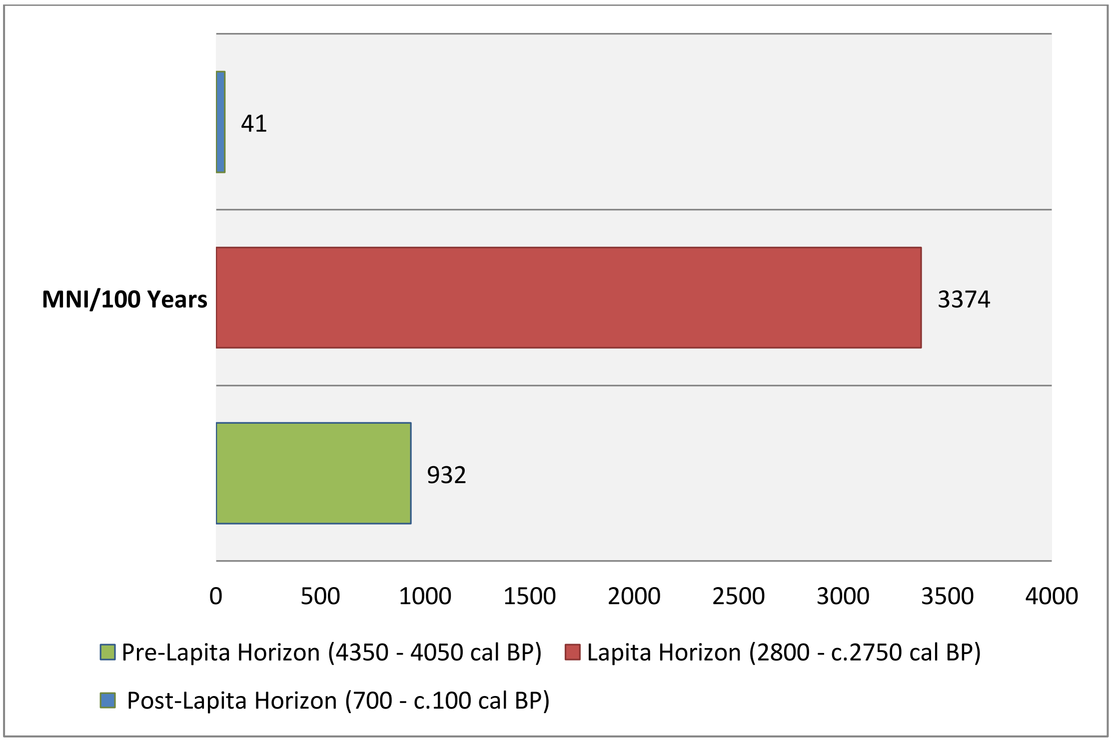

Figure 9.26. Total shell discard by MNI per 100 years between major cultural horizons.

Morphometric Analysis

Application of morphometric analysis (see Chapter 8) to taxa to ascertain whether predation pressures were applied by peoples from over-exploitation of mollusc has also revealed varying intensities in resource use. The use of morphometrics and measurements of identified intact features of three species allowed for most individuals to be measured (Table 9.4). This is evident as >85% of each of the species was measurable, providing a much more complete dataset in comparison to only measuring complete shells. Since morphometic analysis was not applied to *C. luhuanus*, only maximum height (MH) measurements were taken for this taxa. Although there are three major occupational levels, all data from before the Middle Horizon (Lower Horizon SU5 and culturally sparse SUs 6 and 7) has been combined as one. This step was undertaken so as to analyse the mean size of a species from the beginning of site occupation before the arrival of Lapita, thus allowing for a comparison of mean size of a species before, during and after Lapita occupation. From an analysis of the data, there are clear patterns of change in the size-structure of all four taxa over time.

Table 9.4. Proportion of measured shells by MNI for each taxa.

Species	MNI	Measured	Not measured
Conomurex luhuanus	330	280 (85.15%)	50 (14.85%)
Polinices mammilla	141	124 (87.94%)	17 (12.06%)
Atactodea striata	464	436 (93.97%)	28 (6.03%)
Anadara antiquata	584	532 (91.10%)	52 (8.90%)

Unlike the other three taxa, *C. luhuanus* only appears in the archaeological record at Tanamu 1 during Lapita occupation and a small change in size is evident between both the Middle and Upper Horizons (44.00mm vs 43.28mm) (Figure 9.27). This change in size is further supported by the MNI per 100 years discard (Figure 9.28) in both Horizons with high MNI in the Middle Horizon (MNI = 268) and a larger mean shell size compared with the Upper Horizon where there is an decrease in MNI per 100 years (MNI = 32) and a decrease in mean size by 0.72mm. Independent Samples T-Test ($F = 9.837$, df = 271, $p = 0.002$) suggests a significant variability in shell size. Hence, with the arrival of the Lapita occupational phase, there is evidence for a change in subsistence strategy with the exploitation of a new resource, and the continued exploitation of *C. luhuanus* in increased numbers may possibly point to human predation pressures exerted on the species, thus resulting in the size range seen during the Upper Horizon/post-Lapita period. The size trends derived for *C. luhuanus* at Tanamu 1 is also below the recorded mean size range of 50mm for a natural population (see Chapter 8). The sudden appearance of this taxa within the assemblage, together with the overall change in shell size suggests that *C. luhuanus* was not only of subsistence importance, but may have been targeted in greater numbers.

Exploitation of the gastropod *Polinices mammilla* occurred much earlier and there are significant changes within the size-structure of this species (Figure 9.29). The high MNI count per 100 years (MNI = 39) during the Lower/pre-Lapita period is accompanied by bigger mean size of 16.77mm (Figure 9.30). However, during the subsequent Middle/Lapita Horizon, there are both major changes to MNI per 100 years numbers (MNI = 28) and shell size (14.50mm). Although predation pressures are normally accompanied by a reduction in size and an increase in exploitation levels, in this case, the natural *P. mammilla* population had possibly already been exposed to significant levels of predation pressures exerted by people as evidenced by the high MNI per 100 years discard (MNI = 39) present during the Lower Horizon. As a result, possible reductions in the mean size and availability of this taxa occurred within the local landscape which accounts for the decrease in discard per 100 years (MNI = 28) during the Lapita occupational phase. Consequently, it is postulated that with a decrease in availability, the natural *P. mammilla* population was probably either no longer exploited or was targeted as a supplementary resource for subsistence over a period of time. This is evident during the Upper Horizon as the species may have recovered from past predation pressures, demonstrated by size re-growth (17.38mm) to almost identical size recorded during the Lower Horizon. Since *P. mammilla* was only represented in XU5 (MNI = 2) of the Upper Horizon, perhaps accidental/experimental gathering was taking place especially with more XUs containing this taxa in each of the previous major occupational phases. As well, the mean size range for this taxa at Tanamu 1 was smaller than mean size of a natural population 24.89mm, from the Queensland Museum (QM). While the size difference may seem minimal (e.g. 2.22mm to 2.88mm), one-way ANOVA tests demonstrate significant variability in shell size between all three phases (ANOVA F = 3.304, df =

2 , *p* = 0.040). Further post-hoc comparisons using Turkey HSD test reveals mean size for *P. mammilla* between pre-Lapita and Lapita levels were significantly different at 0.05 level (*p* = 0.036).

For the bivalve *Atactodea striata*, the size and MNI pattern points to a decrease in importance of this species to local subsistence following the arrival of Lapita peoples (Figure 9.31). High numbers of this species per 100 years (MNI = 118) were exploited during the Lower Horizon, but following the arrival of Lapita occupation, there appears to be a major increase in gathering intensity of this species (MNI = 224) (Figure 9.32). This trend is not reflected in the mean size with smaller size-structure (23.27mm) occurring during high levels of exploitation and a subsequent slight increase in size (24.91mm) when greater numbers of this species (MNI = 224) were gathered. In turn, predation pressures may have accounted for smaller size during the Lower Horizon and a possible slight reduction in predation pressures together with a shift in subsistence focus to other species may have allowed for the slight recovery/increase in size despite the increase in discard rates. However, it must be noted that the sizes are almost identical and this may perhaps just be a reflection of a species that had previously been exposed to human predation and/or environmental change. The natural size range of this species according to Carpenter and Niem (1998:283), was maximum shell length of 40mm, but commonly occurring to 25mm. Despite a mean difference of 1.64mm, a significant change in size variability was evident for this taxa between both major horizons from Independent Samples T-Test (F = 4.077, df = 434, p = < 0.001) and one-way ANOVA test (ANOVA F = 12.555, df = 1, p = < 0.001) results.

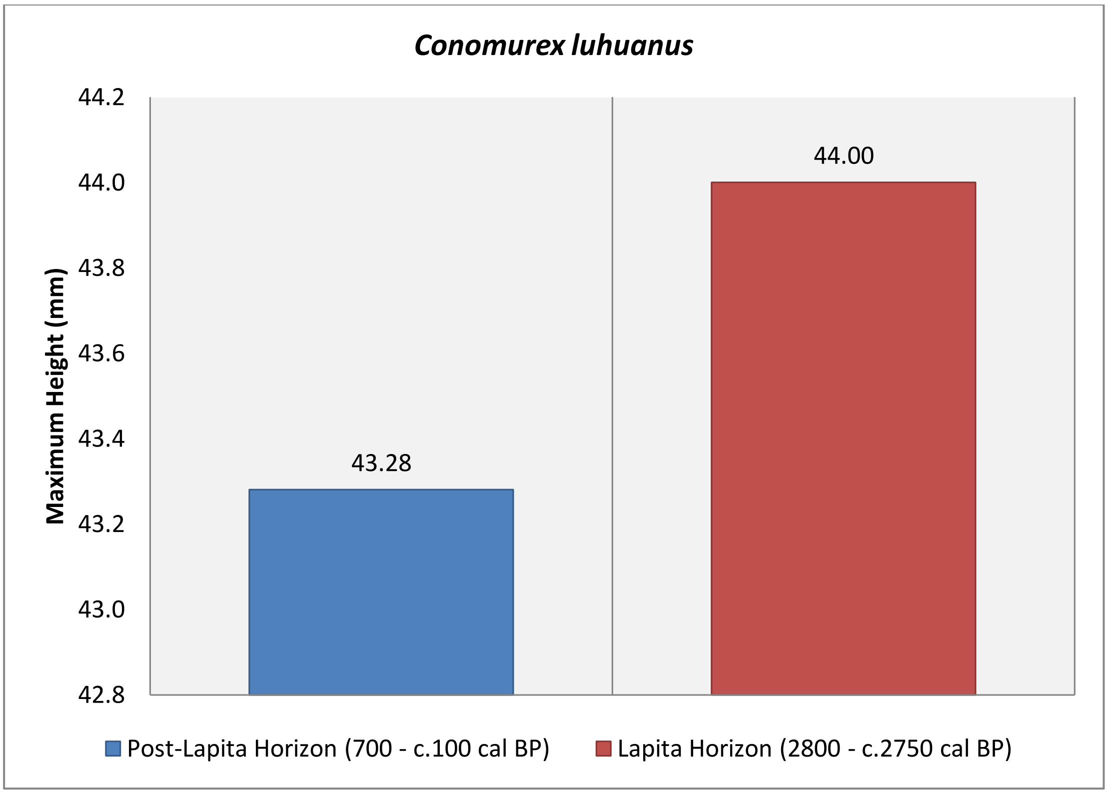

Figure 9.27. Mean overall size of *Conomurex luhuanus* between major cultural horizons.

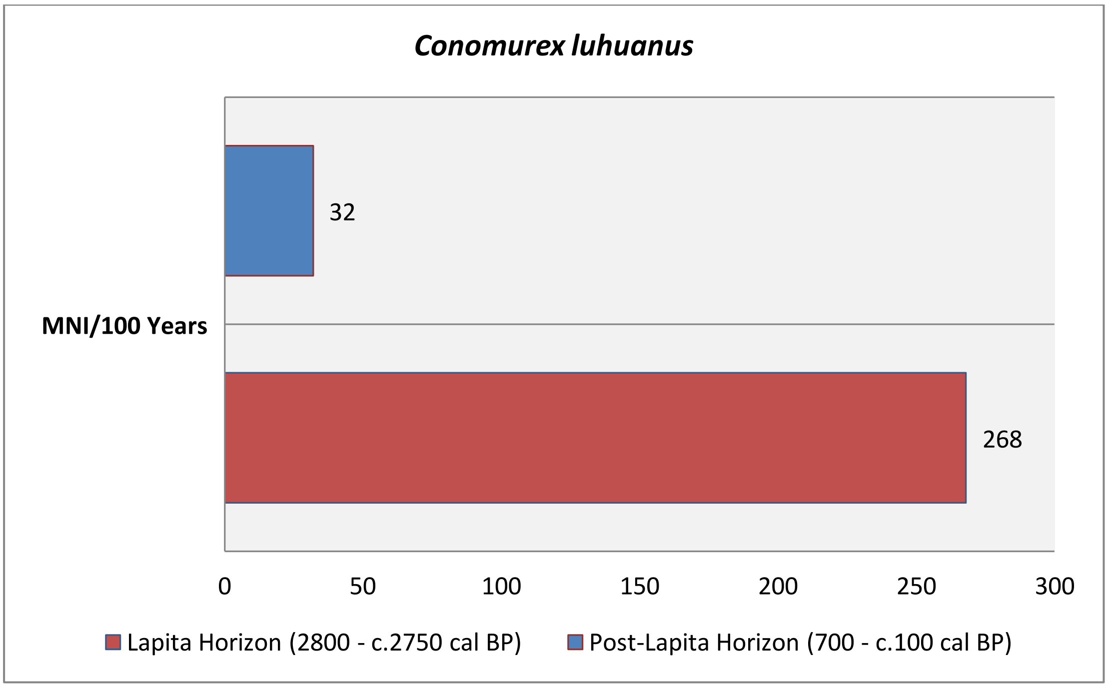

Figure 9.28. Conomurex *luhuanus* discard per 100 years between major cultural horizons.

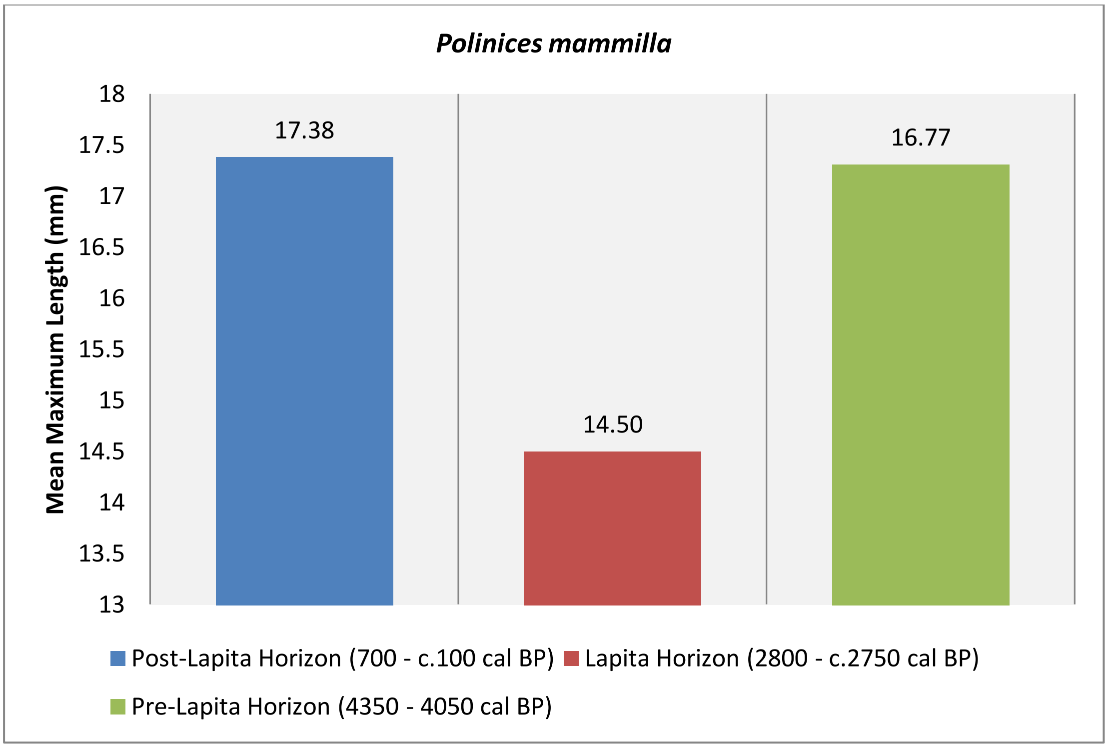

Figure 9.29. Mean overall size of *Polinices mammilla* between major cultural horizons.

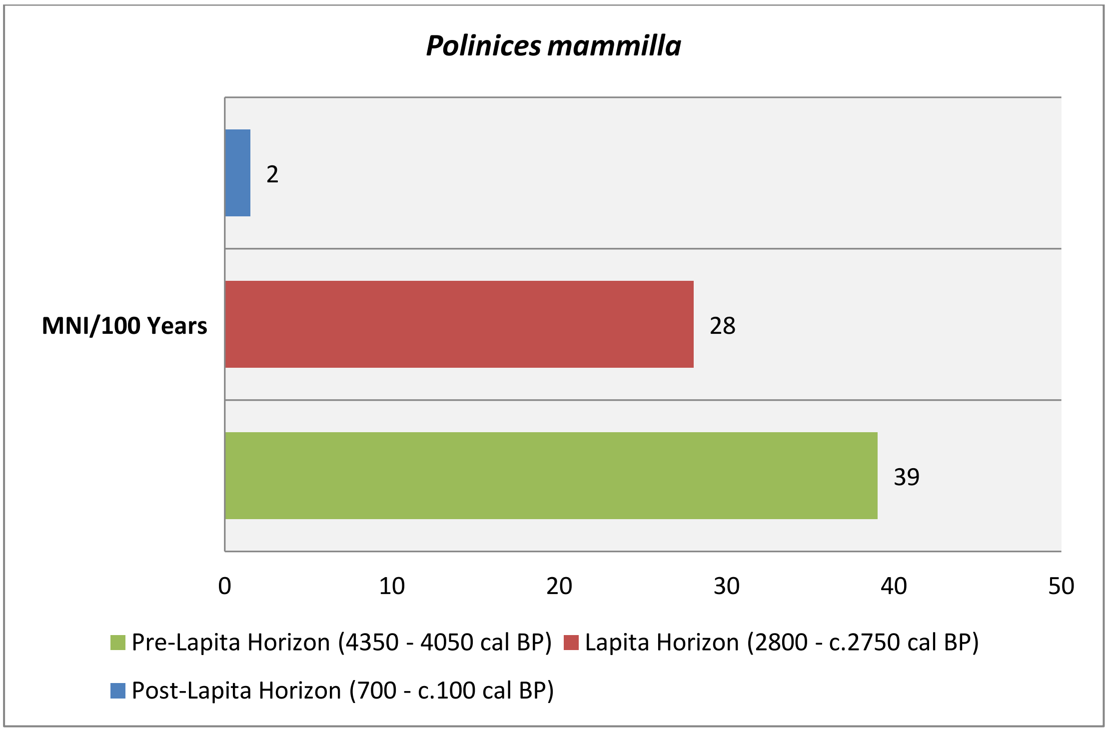

Figure 9.30. *Polinices mammilla* discard per 100 years between major cultural horizons.

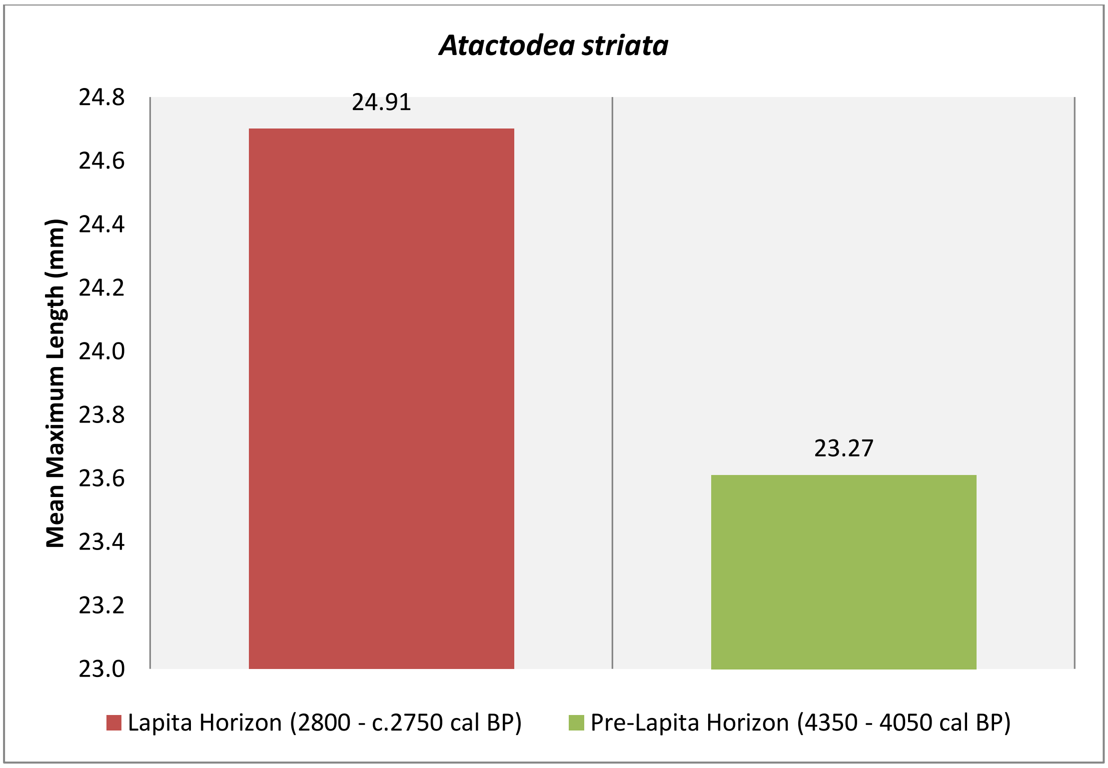

Figure 9.31. Mean valve length of *Atactodea striata* between major cultural horizons.

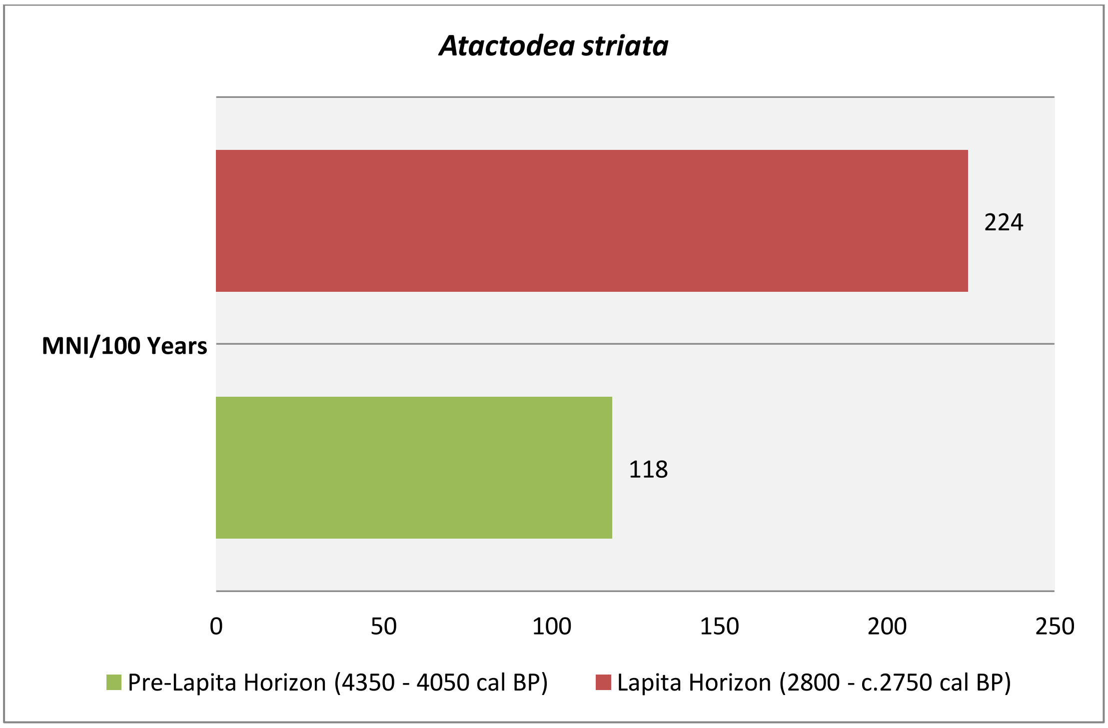

Figure 9.32. Atactodea *striata* discard per 100 years between major cultural horizon

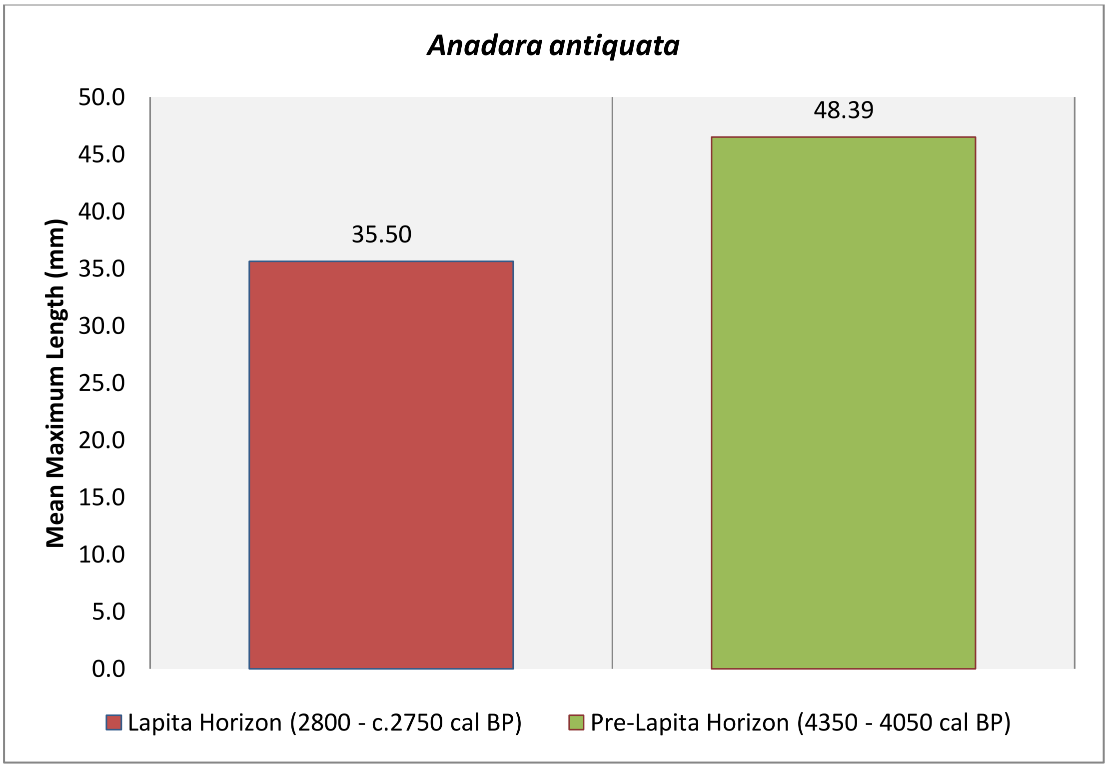

Figure 9.33. Mean maximum valve length of *Anadara antiquata* between major cultural horizons.

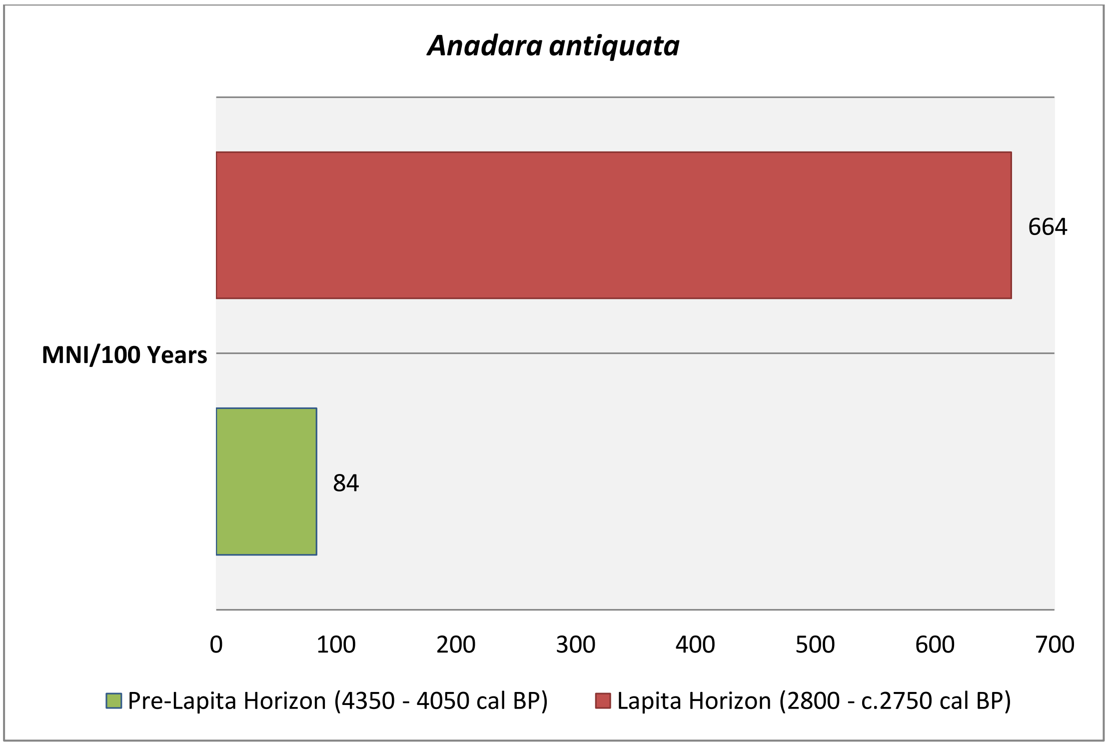

Figure 9.34. *Anadara* antiquata discard per 100 years between major cultural horizons.

Predation pressure was also possibly experienced by the Tanamu 1 *Anadara antiquata* population, with trends in size change pointing to a higher level of exploitation of this taxa than the previous two species (Figure 9.33). With a decrease of 12.89mm between the Lower (48.39mm) and Middle (35.50mm) Horizons, and a marked increase in MNI per 100 years discard during Lapita occupation (Lower Horizon MNI = 84, Middle Horizon MNI = 664), *A. antiquata* was clearly of economic importance as a species (Figure 9.34). Both Independent Samples T-Test ($F = 105.828$, df = 530 , $p = < 0.001$) and one-way ANOVA test (ANOVA $F = 395.524$, df = 1 , $p = < 0.001$) reveal a significant change in size in Square A. This significant decrease in size and the increase in exploitation levels suggests that high levels of predation pressures may have been exerted on local *A. antiquata* populations which may have led to either localised extinction since none were exploited during the Upper Horizon or a shift in local subsistence strategies. Moreover, analysis of a non-predated natural population from the QM with a larger mean size of 55.66mm again reaffirms that this taxa was either heavily exploited and/or affected by changes to local environmental conditions.

Discussion

As analysis of Tanamu 1 is now complete with individual elements having been examined by specialists from their respective fields, a discussion of key results from each category will provide complimentary information that can be used in conjunction with shellfish data that has been discussed above. These additional categories of cultural material include ceramics, stone artefacts, and non-molluscan fauna. Detailed discussions of each category will be presented elsewhere in future monograph publications as part of the Caution Bay archaeological research programme. The highly rich cultural deposit spanning the three major cultural horizons and the density of discard has been quantified using Table 9.5 by XU and Figure 9.36 using the Tilia-Tiliagraph program suite for diagrammatic presentation of data (Grimm 1991) and zone borders are in line with the stratigraphically-constrained classification sub-routine CONISS dendogram part of the Tilia program (David *et al.* completed ms:52). Categories of cultural material in Figure 9.36 were utilised as input into CONISS (David *et al.* completed ms:52).

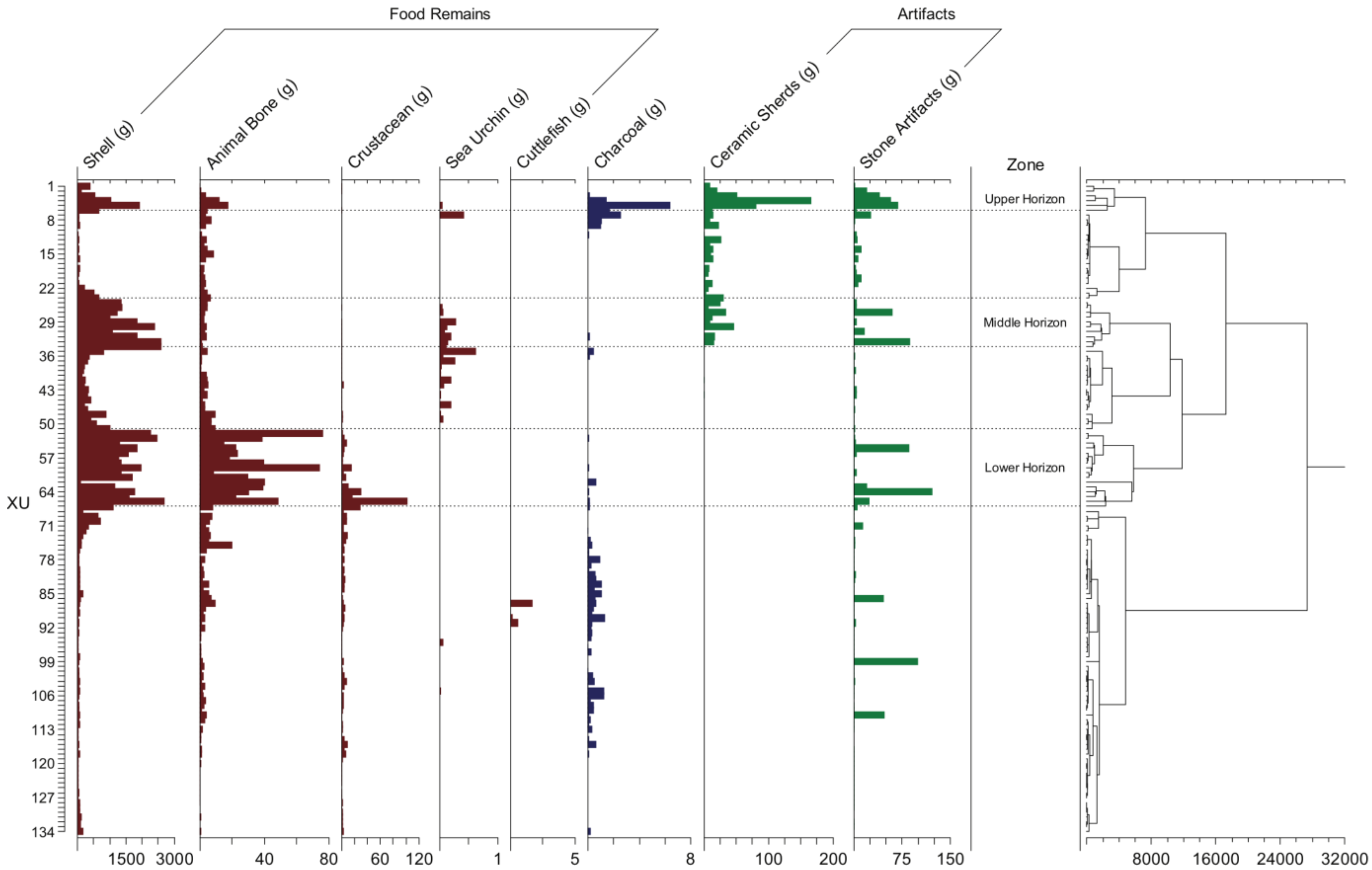

Figure 9.35. Distribution of cultural materials Tanamu 1 Squares A by XU (David *et al.* completed ms:53).

Table 9.5. Details of excavated materials Tanamu 1 Square A by XU (David *et al.* completed ms:63-67).

XU	Shell	Non-Human Bone	Crab	Sea Urchin	Cuttlefish	Human Bone	Charcoal	Ceramic Sherds		Stone Artifacts		Worked Bone	Land Snail Shell	Foraminifera	Pumice	Termite Larvae Husks	Seeds (Other than Modern Grass)
	g	g	g	g	g	g	g	#	g	#	g	g	g	g	g	g	g
1	397.7	0.02	0.37					9	8.6	6	1.9					0.04	19.2[a]
2	127.5	0.5	0.01					22	19.7	24	20.0					0.38	
3	548.5	3.79					0.15	46	51.4	69	39.5					2.37	
4	1,034.9	12.1					1.40	76	166.4	68	57.4					10.58	
5	1,911.2	17.25		0.04			6.36	23	80.2	49	68.4		0.10			8.09	
6	670.0	4.57	0.01				1.65	15	12.2	31	4.7		<0.01				
7	50.4	3.81		0.41			2.55	4	14.0	20	27.0		<0.01			1.90	
8	51.6	6.93					1.03	11	9.1	23	1.6					0.38	
9+10	57.3	3.63					0.97	13	22.7	23	0.8					0.52	
11	22.7	1.25					0.09	1	0.4	24	4.1					0.05	
12	43.2	3.97						9	26.4	9	5.6					0.09	
13	14.5	2.86						12	8.7	12	0.5					0.01	
14	34.9	4.71						12	14.4	42	11.5						
15	26.9	8.5						11	10.3	23	2.2						
16	65.6	3.78						11	14.2	11	6.4						
17	2.1	0.28								5	0.5						
18	66.0	2.44						7	7.6	15	3.5						
19	35.9	1.97						12	6.4	32	4.1						
20	10.9	3.16						3	1.8	16	11.4						

21	36.0	3.63						8	12.6	13	7.3						
22	209.0	2.68						2	6.0	9	0.7						
23	511.8	4.72						4	2.7	12	1.0						
24	666.2	6.53						7	30.5	1	<0.1						
25	1,352.7	4.63						19	24.7	13	4.3						
26	1,376.4	4.61	0.02	0.05				11	6.1	9	3.8						
27	1,227.6	3.32		0.06				6	34.1	7	59.9						
28	998.4	2.76						1	13.0	5	0.8						
29	1,859.0	2.63	0.47	0.27				21	8.7	7	4.3		0.10				
30	2,388.0	4.1	0.34	0.12				12	46.2	10	0.3						
31	1,093.1	3	0.21	0.09						12	16.2						
32	1,850.1	3.99	0.02	0.20			0.14	1	16.8	6	0.7		0.01				
33	2,588.2	1.07	0.55	0.14				1	15.6	8	87.2		0.10				
34	2,593.9	1.46	0.61	0.11				1	0.2	3	0.8	0.09					
35	804.0	4.61	0.32	0.62			0.43						0.10				
36	367.0	0.95	0.81	0.06			0.11			11	1.2		0.04				
37	306.4	1.26	0.33	0.26						3	0.2		0.03				
38	224.9	0.5	0.22	0.03						4	0.9		0.03				
39	197.2	0.73	0.24	0.01						6	3.2		0.01				
40	145.4	4.23	0.32	0.01						8	0.9		0.05				
41	236.6	4.71	0.23	0.20				1	0.4	1	0.1		0.07				
42	213.4	4.97	2.85	0.07						3	0.1		0.04				
43	345.1	2.82	0.21							12	4.7		0.03				
44	315.3	4.64	0.27	0.02				1	0.2	11	4.4		<0.01				
45	425.9	1.75	0.14							12	0.3		0.02				
46	218.0	3.21	0.79	0.19						4	0.3		0.11				
47	308.6	3.22	0.16							6	1.2		<0.01				

48	886.1	9.33	1.78	0.01						5	0.2						
49	415.0	7.06	1.87	0.06						10	0.3						
50	588.0	7.02	0.68							10	0.4						
51	1,017.1	9.45	0.40							6	1.4				0.12		
52	2,259.6	76.16	1.73							12	0.7						
53	2,477.9	38.76	3.71				0.04			5	1.9		0.02		0.09		
54	1,299.0	15.18	8.25			0.60				5	3.2		<0.01		0.01		
55	1,857.4	22.5	3.95							13	86.0				6.08		
56	1,568.9	23.64	3.18							5	3.7		0.11				
57	1,280.3	18.39	1.15							13	0.9						
58	1,355.7	39.58	2.23							10	0.8		0.02				
59	1,979.1	74.56	15.43				0.09			10	0.8		<0.01				
60	1,352.8	8.44	3.25							8	4.6				0.29		
61	1,706.3	29.97	7.17							11	0.9				0.01		
62	87.5	40.4	0.25				0.59										
63	1,143.7	39.47	10.63							7	20.5						
64	1,780.2	30.52	30.51				0.07			10	121.0						
65	1,601.1	22.37	16.05							6	0.3				0.07		
66	2,684.8	48.57	101.43				0.10			11	23.4		0.01	0.01	0.06		
67	1,100.4	8.16	28.54				0.15			6	5.5		<0.01		0.05		
68	178.0	0.31	2.30							1	<0.1						
69	638.9	7.73	7.70							3	<0.1		0.12		1.85		
70	700.8	6.3	7.25							6	1.1		<0.01				
71	336.4	3.75	2.63							2	14.7		<0.01	0.05			

72	261.4	5.78	3.30				0.03			4	0.4			0.01			
73	159.9	6.77	8.85							6	0.4		0.01	0.01			
74	111.7	5.53	5.95				0.19			2	1.6						
75	115.9	20.15	3.24				0.28			7	1.8		0.01				
76	64.7	4.34	3.70				0.05			4	0.2				0.61		
77	53.6		2.18				0.04			3	0.3						
78	47.0	3.11	4.29				0.95			5	0.2			0.01	0.08		
79	41.3	1.09	2.16				0.22			6	0.8			0.01			
80	70.2	2.26	3.68				0.06			5	0.2				0.42		
81	68.1	2.65	3.35				0.56			3	2.6				0.76	0.01	
82	68.0	1.82	5.48				0.61			7	1.7			0.01	2.38		
83	74.8	5.86	3.68				1.03			3	0.7		<0.01	0.01	0.24	0.01	
84	56.5	2.28	4.15				0.52			1	0.2				0.34	0.01	
85	155.3	5.48	0.99				1.08			8	0.7				0.46		
86	81.5	6.94	1.41				0.55			2	46.8				0.65		
87	57.6	9.61	3.03		1.65		0.60			5	0.3			0.01			
88	37.4	3.44	5.02				0.41			2	0.1			0.03	0.91		
89	59.0	2.33	2.80				0.30			5	0.3			0.01	0.81		
90	26.3	3.39	4.21		0.11		1.28			3	0.1						
91	48.9	1.24	3.22		0.58		0.32			4	2.7		0.02	0.04	1.14		
92	27.1	3.18	2.14				0.24			1	0.2				1.42		
93	33.6	0.78	0.65				0.33			2	0.8		<0.01	0.05	0.16		
94	19.8	0.48	0.17				0.25			2	<0.1				0.18		
95	9.1	0.31	0.31	0.06						2	<0.1						
96	24.6	0.59	0.60				0.01			3	0.1						
97	13.3	0.89	0.06				0.25			5	0.2						

98	65.0	0.77	0.91							5	0.2				1.01		
99	48.7	1.79	3.14							9	99.7			0.01	0.73	0.01	
100	22.7	2.68	0.35							5	0.3			0.01	0.24		
101	49.3	1.40	1.40				0.03			2	0.5		<0.01	0.01	0.34		
102	56.2	2.24	4.53				0.36			6	0.9		0.02		0.01		
103	69.8	1.35	8.03				0.47			2	1.3			0.01	0.08		
104	49.8	3.22	4.01				0.01			3	0.3			0.01	1.31		
105	75.0	1.87	0.90	0.02			1.26			4	0.2			0.03	0.07		
106	35.7	1.99	2.99				1.23			2	0.2			0.15	0.27		
107	22.7	3.68	2.28				0.16							0.07	0.27		
108	48.8	2.61	2.25				0.41			1	0.1			0.08	0.01		
109	42.6	1.31	1.12				0.44			4	0.1			0.06			
110	78.6	4.03	0.53				0.08			4	47.3		0.01				
111	48.1	3.06	0.95				0.21			5	0.1		<0.01	0.09			
112	75.4	0.41	1.40				0.06			1	0.1			0.01			
113	31.5	1.55	2.06				0.29			2	0.7						
114	21.4	0.51	0.90										0.02				
115	21.4	0.53	4.00				0.04										
116	32.4	0.26	8.72				0.60						0.01	0.03	0.38		
117	31.5	1.13	4.64							3	1.0						
118	62.2	1.18	6.20				0.08			2	0.3			0.11			
119	12.3	0.16	1.18							1	<0.1						
120	19.1	0.58	0.19							1	0.1						
121	21.6	0.31	0.16							1	0.1		0.01				
122	30.3	0.07	0.39							1	0.1				0.03		
123	25.1	0.19	0.93							1	0.1		<0.01	0.01			
124	28.4	0.02	0.03							2	0.1						

125	19.8	0.01								1	<0.1						
126	35.5	0.25	0.31							3	<0.1				0.04		
127	29.5	0.05	0.74							1	<0.1						
128	70.8	0.08	1.27							1	0.1			0.11			
129	68.3		0.30							6	0.5						
130	65.9		1.01														
131	109.2	0.46	1.44											0.36			
132	84.8		1.29							3	0.3						
133	87.0		1.04							4	0.1			0.87			
134	159.0	0.53	2.74				0.16							1.01			

Both Figure 9.36 and Table 9.5 reveal varying levels of discard of other important cultural elements at Tanamu 1. However, an obvious trend here is that each of these cultural elements (except for ceramics in pre-Lapita Horizon) occurred in much greater numbers during major phases of site occupation. By incorporating these results into individual analytical units representing the major cultural horizons along with interpretations already made for each cultural element, the following overall trends can be ascertained in relation to shellfish exploitation:

Lower/pre-Lapita Horizon (4350-4050 cal BP)

While ceramics are yet to be introduced, increased production of stone artefacts occurs with 16% of the Square A assemblage discarded during this time (David *et al.* completed ms:56). This rise in production follows on from SU6 (4500-4350 cal BP) which marks the beginning of an increase in stone knapping (David *et al.* completed ms:56). Since the oldest artefacts (all cherts) from Tanamu 1 were found present in XU133 (276-278cm depth, base of SU7), it must therefore be noted that human occupation began around ca. 5000 cal BP despite their low numbers of discard (David *et al.* completed ms:56). Other than shellfish, exploitation efforts on non-molluscan fauna were concentrated around marine resources such as turtles, fish, reef crabs and the occasional dugong (David *et al.* completed ms:60). However, more focus was also directed at obtaining terrestrial fauna, such as hunting in rainforest and savannah habitats (David *et al.* completed ms:60). This was somewhat different in earlier periods (SU6 and SU7) where terrestrial fauna were not focused upon with marine resources relied upon more, mainly fish (also including dugong, turtle and reef crabs) coinciding with low intensity site use (David *et al.* completed ms:60).

In addition, shellfish exploitation during this phase also points to a primary focus on marine resources. Overall discard rate of 2795 MNI (Bivalve MNI = 1967, Gastropod MNI = 628) (932 MNI per 100 years) accounting for over 90 taxa meant that people at this time were concentrating their efforts on obtaining shellfish over a 300 year period of concentrated occupation. While certain taxa occur more in the assemblage at this time, the sheer number of targeted species clearly demonstrates that a comprehensive range of habitats were relied upon for subsistence, including intertidal and offshore habitats. Even though not all taxa were utilised in morphometric analysis, the heavy reliance on shellfish for subsistence is borne out by evidence for possible predation pressures on species such as *Polinices mammilla* and

Atacodea striata. By integrating key trends from each cultural element, evidence strongly suggests a semi-permanent/permanent settlement indicative of a reliance on marine resources including shellfish.

Middle/Lapita Horizon (2800-c.2750 cal BP)

The most conspicuous material culture in this period is the introduction of ceramics following the arrival of Lapita peoples. Peaks in pottery discard ((David and Jones-Amin completed ms:3) was accompanied by a substantial increase in stone artefact production with 35% of the entire Square A assemblage discarded during this period (David *et al.* completed ms:56). Changes to raw materials indicates territorial restructuring of resources and the appearance of piercing implements points to implementation of new activities (David *et al.* completed ms:57). A minor increase in targeting terrestrial resources over marine was also noted with crabs not frequently targeted (David *et al.* completed ms:60). As well, people persisted with hunting in savannah and rainforest environments but the possible occurrence of firing activities and land clearance for gardening sees the decline in rainforest habitats on a regional scale (David *et al.* completed ms:60). Pigs may have been introduced towards the end of Lapita occupation but whether this is a product of domestication or hunting of wild population is yet to be determined (David *et al.* completed ms:60).

Shellfish resources were exploited in much larger numbers during Lapita occupation with over 60 species targeted. Even though the total discard of mollusc (MNI = 1687) (Bivalve MNI = 1348, Gastropod MNI = 339) seems lower than pre-Lapita times, over a 50 year occupation period people in fact targeted much more shellfish as evidenced by a MNI per 100 years discard rate of 3374. Despite the lower number of taxa, people still continued to target multiple habitats but with key difference being more emphasis on targeting sandy and rock intertidal taxa instead of mangrove species. People also spent more time in offshore environments with clean coral reef habitat species occurring in greater numbers. As such, certain species occurred in greater numbers, with the appearance of *Conomurex luhuanus* in the assemblage for the first time. Such change in subsistence focus suggests a proportional change in exploitation and not in range of targeted habitats. Size analysis reaffirms the intensity in which shellfish were being exploited as a significant size reduction for the bivalve *Anadara antiquata* was most likely due to over-exploitation and predation pressures. Most importantly, results demonstrate a marked intensification of resources following Lapita intrusion. This in turn may possibly have been due to increases in population density and a more permanent and/or intensive settlement pattern following contact with local peoples at this location.

Upper/ post-Lapita Horizon (700-c.100 cal BP)

In this post-Lapita transformation phase, greater peaks in pottery discard was documented but with different stylistic conventions (David and Jones-Amin completed ms:55). As well, another intensive phase of stone artefact production was noted with 23% of the entire Square A assemblage discarded in this phase (David *et al.* completed ms:57). While thermal alteration was not as significant as documented during the previous Lapita phase, flakes were considerably larger with thicker platforms (David *et al.* completed ms:56-7). Non-molluscan faunal remains suggest more focus on terrestrial than marine resources and this trend is likely to have occurred in relation to an enlarged agricultural base with the rearing of domestic pigs (David *et al.* completed ms:60). Ethnographic evidence also shows the occurrence of seasonal hunting in savannah woodland together with anthropogenic firing activities to maintain the habitat (David *et al.* completed ms:60).

In contract to the earlier phases, a decrease in shellfish exploitation was seen with only a total of 248 MNI (Bivalve MNI = 17, Gastropod MNI = 231). Over approximately 600 years of occupation, people only gathered mollusc at 41 MNI per 100 years. This signals a significant shift in subsistence activities, perhaps a consequence of increase in agriculture and hunting. Another difference is that of gastropod discard, which during this time was significantly higher than bivalves, a trend that had previously not been evident. With <20 species targeted, signalling a drastic reduction in species diversity, people either chose to intensively focus on certain taxa or this trend may be a result of environmental factors. This is evident from the presence of sandy substrates and intertidal seagrass beds species *Conomurex luhuanus* which accounts for much of the assemblage at this time. Morphometric evidence from *Polinices mammilla* reiterates this point, as the species was most likely able to recover from past predation pressures since it was no longer being exploited. The Upper/post-Lapita Horizon evidence suggests a period of resource use that was not as intense as seen in previous phases with a lesser focus in marine shellfish and consequently a substantial shift in subsistence practices.

Conclusion

The primary feature of the archaeological sequence at Tanamu 1 along with other sites at Caution Bay, is the in-migration of the Lapita cultural complex and the impact of this arrival on existing cultural practices. The occurrence of this temporal event dating to between 2800 and c.2750 cal BP (Middle/Lapita Horizon), together with evidence for pre-existing local cultures and the subsequent transformation into a post-Lapita period, means that temporal analysis of material culture was undertaken within this context. While the introduction of new cultural material in the form of ceramics undoubtedly represents the most significant component, the wide range of cultural materials found within the assemblage has provided important insights into past anthropogenic activities at this location. Settlements patterns changed considerably following the arrival of Lapita peoples.

Archaeological evidence from mollusc remains strongly suggests intensification of shellfish exploitation following cultural contact at Tanamu 1. By having a broad subsistence economy, with a focus on marine resources from numerous habitats in both pre-Lapita and Lapita levels, the evidence demonstrates that people here were marine specialists. Evidence for intensified site and resource use is further substantiated by increased discard rates of other important cultural elements (e.g. ceramics, stone artefacts and non-molluscan fauna) during the major occupational phases at Tanamu 1. Whether the overall differences in shellfish procurement between phases was due to population increase, socio-cultural factors or changes in the environment, these possible scenarios will be addressed in Chapter 12 following discussions of other shellfish assemblages in Chapters 10 and 11.

Chapter 10 – Bogi 1

Regional Context

The archaeological site of Bogi 1 is located on an exposed sand dune 140m northwest of the Tanamu 1 Lapita site (David *et al.* completed ms:4). Bogi 1 is similar to Tanamu 1 with the presence of three major occupational phases (pre-Lapita, Lapita and post-Lapita). Because of its long temporal Lapita sequence (in terms of Caution Bay sites), Bogi 1 presents a unique opportunity to investigate the transformative processes in shellfish exploitation between all three major cultural phases. This is particularly important since only a small number of Lapita sites have been identified from over 100 excavated sites elsewhere at Caution Bay (see Chapter 4). This Chapter discusses results from an analysis of the Bogi 1 molluscan assemblage in order to reveal and explain trends in shellfish use over time. It must be noted that detailed analysis of other cultural elements relating to this site is still in progress by a range of specialists and therefore only limited information on various aspects of this site is available.

Site Description

Situated 20km northwest of Port Moresby, Bogi 1 is located halfway along a 2km linear dune facing the coast (McNiven *et al.* 2010a:1) (Figure 10.1). Surface scatter consisted of stone artefacts and marine shells covering a minimum area of 50 x 30m, with *Conomurex luhuanus* and *Telescopium telescopium* representing common mollusc taxa (McNiven *et al.* 2010a:1). By density, the largest surface concentration of molluscs occurred on the dune top situated 4m above the high water mark and 45m inland (McNiven *et al.* 2010a:1). The site is surrounded by scrub and emergent trees on its shoreline side and grassland on the inland side (McNiven *et al.* 2010a:1). The depth of the aeolian dune complex in which Bogi 1 is situated is at least 3.5m and probably extends to a depth of 4m (McNiven *et al.* 2010a:1). This dune is a linear dunes that occurs parallel to the shoreline (McNiven *et al.* 2010a:1).

Excavations

Excavation of Bogi 1 proceeded in three phases, sampling two spatially separated pits (McNiven *et al.* 2010a:4). The field strategy implemented for Bogi 1 was in line with the standardised excavation protocols for the Caution Bay programme (see Chapter 8) and was used in the excavation of both sets of pits (McNiven *et al.* 2010a:4). Pit 1 comprised two contiguous Squares, each measuring 1 x 1m (Squares A and B); it was excavated to a maximum depth of 130cm during the initial phase of fieldwork (McNiven *et al.* 2010a:4). However, as a result of damage caused to the lower sections of Pit 1 by goannas, the integrity of the lowermost deposits were deemed to be compromised (McNiven *et al.* 2010a:4). Thus a second pit (Pit 2) was subsequently excavated (McNiven *et al.* 2010a:4).

Pit 2, comprising of two main Squares (C and D) each measuring 1 x 1m, was excavated 4m east of Pit 1 (McNiven *et al.* 2010a:4). In order to allow for the continuation of excavation to deeper levels in accordance with the project's safety protocols, 59 Squares (E to QQQ), each measuring 1 x 1m, were excavated around the main central Squares C and D (McNiven *et al.* 2010a:4) (Figure 10.1). Elaborate shoring and varying excavation techniques were used in conjunction with stepping-out squares to accommodate time and safety constraints. Squares C and D were excavated in arbitrary XUs following the stratigraphy, with each XU averaging 2-3cm in thickness (McNiven *et al.* 2010a:10) (Figures 10.2 to 10.4). A total of 280 XUs (Square C – 140 XUs; Square D – 140 XUs) were excavated to a maximum depth of 331cm, with a further 50 x 50cm extension pit in the northeastern corner of Square C excavated to a depth of 346cm through the addition of seven further XUs (Square C XUs 141-147). Altogether, 7776.8 litres of deposit were excavated from both Squares (Square C – 3993.3 litres and Square D – 3783.5 litres).

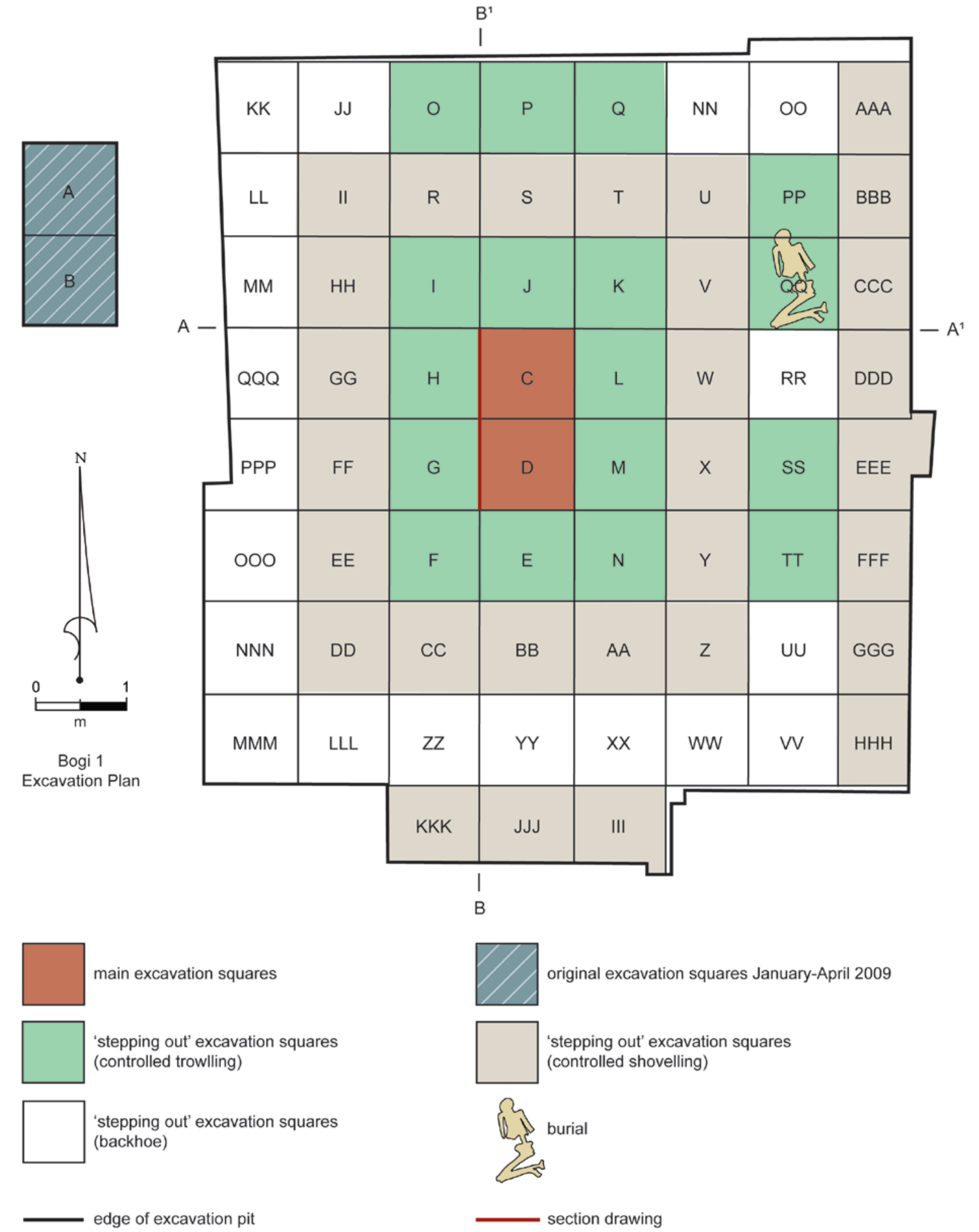

Figure 10.1. Excavation plan of Bogi 1 showing main and stepping out squares (McNiven *et al.* 2010a:5).

Figure 20.2. Early stages of excavation, Bogi 1 Squares C and D south and west sections (McNiven *et al.* 2010a:7).

Figure 10.3. Completion of second phase of Bogi 1 excavations facing southwest with Squares C and D in centre (McNiven *et al.* 2010a:8).

Figure 10.4. Completion of second phase of Bogi 1 excavations facing north with Squares C and D in centre (McNiven *et al.* 2010a:8).

Stratigrapic Description: Squares C and D

Eleven stratigraphic units (SUs) were identified during excavation with sediments consisting mainly of sand associated with the development of a dune feature which started to take shape over 4500 years ago (McNiven *et al.* 2010a:14) (Table 10.1). The majority of the sand is associated with beach sand movement by wind action in relation to the dune deposits (McNiven *et al.* 2010a:14). However, higher concentrations of coarser-grained sands and shell grit content at basal levels below 3m depth are consistent with beach deposits (McNiven *et al.* 2010a:14). The eleven SUs in Squares C and D have been interpreted as representing combinations of natural processes of sediment accumulation and anthropogenic activities over the past 4500 years and possibly slightly more (McNiven *et al.* 2010a:14). Post-depositional effects on sediments were demonstrated through increasing levels of calcium carbonate concretions below 2m depth (McNiven *et al.* 2010a:14). A major horizon of cemented sediment concretions is present between 3 and 3.3m depth (McNiven *et al.* 2010a:14). Hence, cultural materials found below 2m tend to be coated with varying amounts of calcium carbonate, a phenomenon that increases with depth (McNiven *et al.* 2010a:14). SUs were differentiated by sediment colour and texture together with densities of cultural materials including midden deposits (McNiven *et al.* 2011:2) (Figure 10.5). Squares C and D displayed high chrono-stratigraphic integrity, with cultural materials found in most SUs considered to be insitu except for the interfaces between major cultural phases which may represent evidence of some mixing of sediments as evidenced by inversions in radiocarbon dates (McNiven pers. comm. 2015).

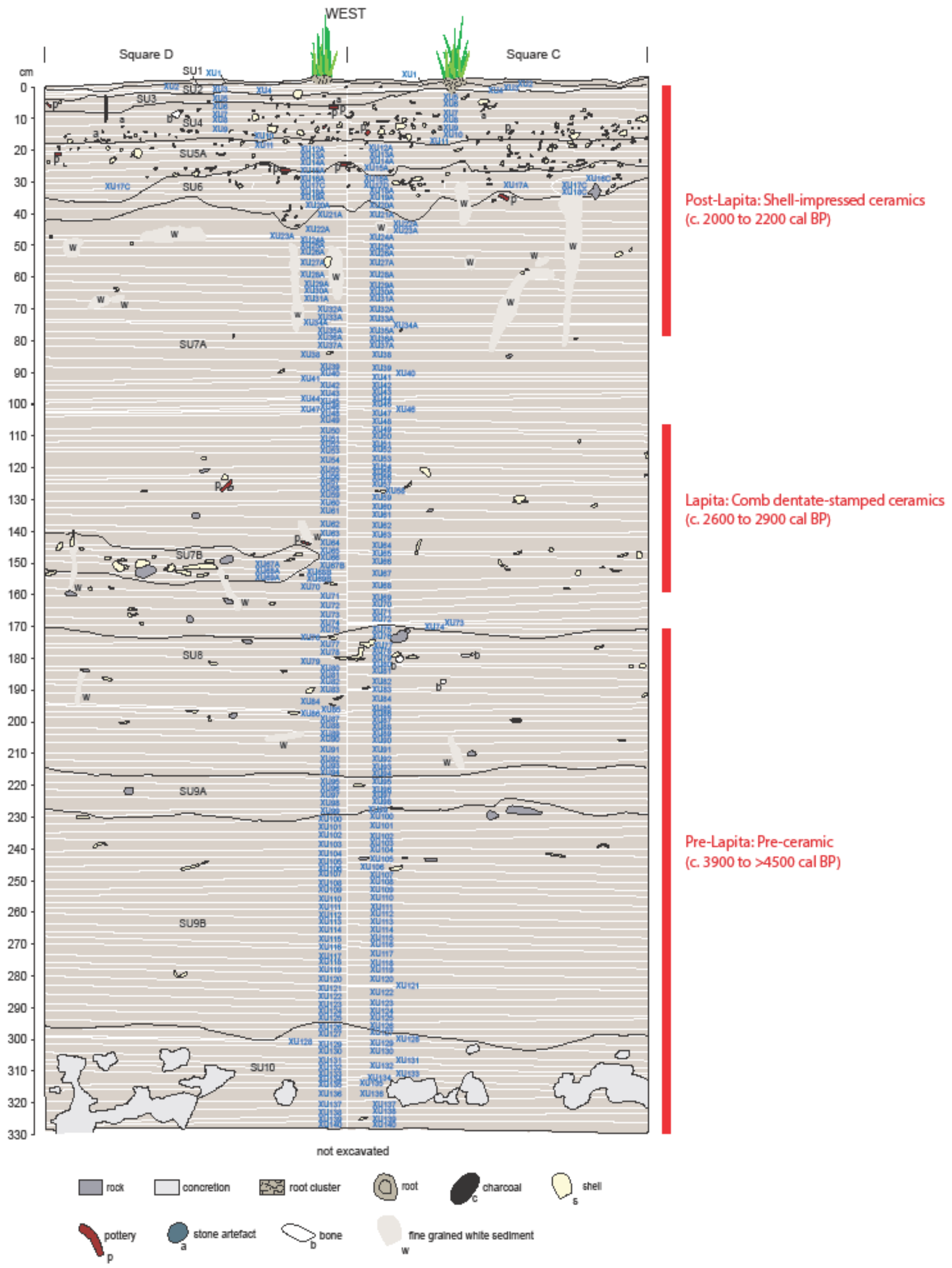

Figure 10.5. Sections drawings of west wall, Bogi 1 Squares C and D showing backplotted XUs and major cultural phases (Courtesy of Ian McNiven).

Table 10.1. Preliminary field details of stratigraphic units, Bogi 1 Squares C and D (McNiven *et al.* 2010a:15).

SU	Description
1	Loose grey-brown sand across the surface 1cm of pit. Contains grass and herbaceous plants and scattered cultural materials (e.g. shells).
2	Brown-grey sand that is slightly consolidated. It underlies SU1 across the pit and the interface with SU1 is distinct and sharp. It contains plant roots and scattered cultural materials (mostly shell).
3	Darker brown-grey sand that is partly consolidated. It underlies only parts of SU2. It contains plant roots and scattered cultural materials (mostly shell).
4	Brown-grey sand that is partly consolidated (but less consolidated and lighter in colour than SU3). Contains numerous fibrous roots. Interface with SU3 is reasonably distinct while the interface with SU5 is more diffuse (over 2cm depth in places) and often difficult to delineate.
5	Grey-brown sand that is partly consolidated (but less consolidated than XU2 to XU4). Definitely more grey in colour compared to SU4. Interface with SU6 reasonably distinct. SU5a is slightly more brown. SU5b is slightly more grey.
6	Darker grey-brown sand. SU6 is more patchy in colour with light grey sand running through the middle between gaps in darker coloured sand.
7	Grey-brown sand that grades with depth from lighter coloured grey and reasonably loose and unconsolidated sediment to slightly darker coloured grey-brown, more consolidated and compacted sediment. Interface with XU6 is reasonably distinct. Vertically-oriented linear features of white clay-rich consolidated sand occur across the upper sections of this unit. The lower sections of the unit feature a dense layer of midden (shells, rock fragments, bone and pottery sherds). Dense parts of this midden layer are associated with darker coloured organic-rich sediments (SU7b).
8	Grey-brown sand that is more consolidated and compacted than SU7 and

	has diffuse grey patches that contrast with overlying SU7 sediments. Interface with SU7 is highly diffuse and difficult to delineate. SU8 contained low density cultural materials (mostly marine shells, mammal bone and rock fragments). Density and size of charcoal fragments increases in this unit compared to SUs 1 to 7. Most shells, rocks and bones are coated with calcium carbonate.
9a	Grey-brown to grey, partly consolidated and compacted sand that is coarser-grained than SU8. Slight brown colouring derives from infiltration of SU8 sediments. Contains little cultural material. Interface with SU8 is diffuse. Interface with SU9b is more clear and textural and marked by a dramatic increase in carbonate concretion inclusions.
9b	Grey coarse-grained sand, partly consolidated and compacted, with a gravelly texture due to carbonate concretion inclusions. Concretions increase in density and size with depth. Sands include fine shell grit. Sediments contain higher concentrations of cultural materials (marine shells, rock fragments and bones) compared to SU9a. The occurrence of rock fragments decreases with depth and disappears in the lower sections of the unit.
10	Grey sand with fine texture that includes fine shell grit and large carbonate concretions. These concretions form an irregular layer of cemented sands. This SU contains scattered fragments and whole shells and appears to be culturally sterile. It continues below the base of the pit. Interface with SU9b is reasonably distinct.
11	Grey-brown coarse-grained sand with a higher fine shell grit content than XU10. It is mostly cemented by calcium carbonate. This SU appears to be culturally sterile and continues below the base of pit. Interface with XU10 is diffuse. Recorded only in the north section.

Chronology

A total of 142 calibrated AMS radiocarbon dates from marine shell and charcoal are available for Squares C and D (McNiven pers. comm. 2015). Because analysis of Bogi 1 is still in progress – unlike Tanamu 1 where it has been completed – detailed discussions on radiocarbon dates, chronology and stratigraphy will be presented by the excavation team elsewhere. This does not affect my overall analysis, since the trends identified within the shellfish assemblage for Square C are considered in relation to the already established major cultural phases each treated as a chronologically secure chronological block.

Overall, analysis of radiocarbon determinations has revealed three major occupational phases at Bogi 1, with intervening sections between phases interpreted as periods of slow sand accumulation that are sometimes inter-mixed, as demonstrated by the presence of radiocarbon dates contemporaneous with preceding and following cultural phases near those interfaces (McNiven pers. comm. 2015) (Figure 10.5). From earlier analysis of Bogi 1, the presence of cultural materials along with intervening radiocarbon dates was interpreted as representing occupational continuity, albeit very ephemeral between the upper two phases – Lapita and post-Lapita (McNiven *et al.* 2011:3). This was further supported by ceramic remains that suggest *in situ* temporal changes in pottery styles (McNiven *et al.* 2011:3). Similarly, it was also suggested that a possible occupational hiatus was present between the two lower phases – Lapita and pre-Lapita (McNiven *et al.* 2011:3). It must be noted that these interpretations were based on early analysis of Bogi 1 and analysis of various cultural elements is still in progress. Taking into consideration these early interpretations along with a recent update on Bogi 1's temporal sequence, the major cultural phases at Bogi 1 are as follows:

- Pre-Lapita (>4500 to c. 3900 cal BP) (upper SU8 to SU10) (XUs 74-147) – Pre-Ceramic phase with no evidence of pottery.
- Lapita (2900 to c. 2600 cal BP) (lower SU7A to SU7B) (XUs 48-69) – Dense cultural layer containing Lapita pottery.
- Post-Lapita (2200 to c. 2000 cal BP) (SU2 to upper 7A) (XUs 3-35) – Presence of shell-impressed ceramics with rich material culture in upper layers.

Analysis of shellfish assemblages will thus be undertaken in relation to the three major occupational phases/chronological blocks, each phase principally represented by a dense horizon of shell midden material. Shellfish remains from intervening periods will be addressed with caution as such material may belong to either neighbouring cultural phase, or to intervening times.

Cultural Materials

A wide range of cultural materials was excavated from Bogi 1, comprising ceramics, stone artefacts, shellfish, and a range of other food remains such as fish, crab, marine turtle and terrestrial fauna (McNiven *et al.* 2011:4). Ceramics include both Lapita and post-Lapita sherds together spanning the period from 2900 to 2000 cal BP; the Lapita versus post-Lapita ceramics are clearly separated chrono-stratigraphically (see McNiven *et al.* 2011 for a brief description of the Bogi 1 Lapita pottery). The Bogi 1 stone artefact assemblage includes chert and obsidian flakes, along with ground stone adzes that were likely to have been imported from the hinterland (McNiven *et al.* 2011:4). Obsidian may have been sourced from the island of West Fergusson situated 500km to the east, which represents the nearest available source for this raw material (McNiven *et al.* 2011:4). However, unlike typical Lapita stone artefact assemblages, the occurrence of obsidian at the end of the Lapita phase is similar to other assemblages found along the southern coast of Papua New Guinea dating to the post-Lapita period (McNiven *et al.* 2011:4). In addition, a human burial dating to pre-Lapita times (4200 to 2900 cal BP) was also found, representing 'the first complete human burial recovered from beneath Lapita levels in the Pacific' (McNiven *et al.* 2011:4) (Figure 10.6). The presence of two clusters of shell grave-goods, comprising of taxa such as *Pinctada* sp. and *Tridacna* sp. (McNiven *et al.* 2011:4), suggests that in addition to dietary factors and artefact manufacture, shellfish also had ritual and spiritual significance during pre-Lapita times. As various cultural elements of Bogi 1 are still being analysed by a multi-disciplinary team, this chapter will only discuss the results from analysis of the shellfish assemblage from Square C where discard rates of ceramic and stone artefacts are also available. The decision to focus on Square C was made because of time constraints.

Figure 10.6. Bogi 1 burial with shell grave goods on left and right of the body (McNiven *et al.* 2011:5).

Shellfish Remains

In contrast to Tanamu 1, most of the shellfish analysis of Bogi 1 Square C was undertaken by myself, with XUs 1 to 16 sorted and identified by Helene Tomkins. Shell data from sub-XUs were combined into single XUs (see Chapter 8). In addition, shellfish from XUs 2 and 105 were not present and therefore were not able to be included in this analysis. Results of this analysis have revealed important trends in shellfish exploitation, with a total of 183 shellfish species present within Square C. The assemblage comprises 108 marine gastropod taxa, 63 marine bivalve taxa, 1 freshwater bivalve and 11 unidentified taxa. In terms of weight, 81% (94,594.6g) of shellfish were identified to either Family, Genus or species with 18% (21866.0g) of remains not identified due to high levels of fragmentation, cemented sediment concretions on shell and weathering. Among the identified species, gastropods represent 60% (56,563.5g) of the assemblages while bivalves account for 40% (38,031.1g). The levels of discard also varied between XUs, ranging from 21.9g (XU124) to 5418.2g (XU11). Small quantities of landsnail (0.8g), Maxillpoda (barnacle) (28.5g), Crustacea (36.9g), Vermetidae (wormtube) (20.9g), and Sea urchin (18.9g) were also present in Square C. By weight, the assemblage is dominated by *Conomurex luhuanus* (18,187.0g), *Gibberulus gibberulus* (9491.4g), Ostreidae (7962.1g), *Calliostoma* spp. (6414.2g), *Anadara granosa* (5011.5g), *Anadara antiquata* (4585.2g) and *Gafrarium tumidum* (4177.4g), which collectively account for 59% of all taxa.

Figures 10.7 and 10.8 provide the order of taxonomic representation for the top 20 ranked species in relation to both weight and MNI. By weight, the top 10 most prevalent taxa in Square C are *Conomurex luhuanus* (18,187.0g, 15.9%), *Gibberulus gibberulus* (9491.4g, 8.1%), Ostreidae (7962.1g, 6.8%), *Calliostoma* spp. (6414.2g, 5.5%), *Anadara granosa* (5011.5g, 4.3%), *Anadara antiquata* (4585.2g, 4.0%), *Gafrarium tumidum* (4177.4g, 3.6%), Strombidae (3739.9g, 3.2%), *Isognomon* spp. (2984.3g, 2.6%) and *Cerithidea largillerti* (2965.0g, 2.5%).

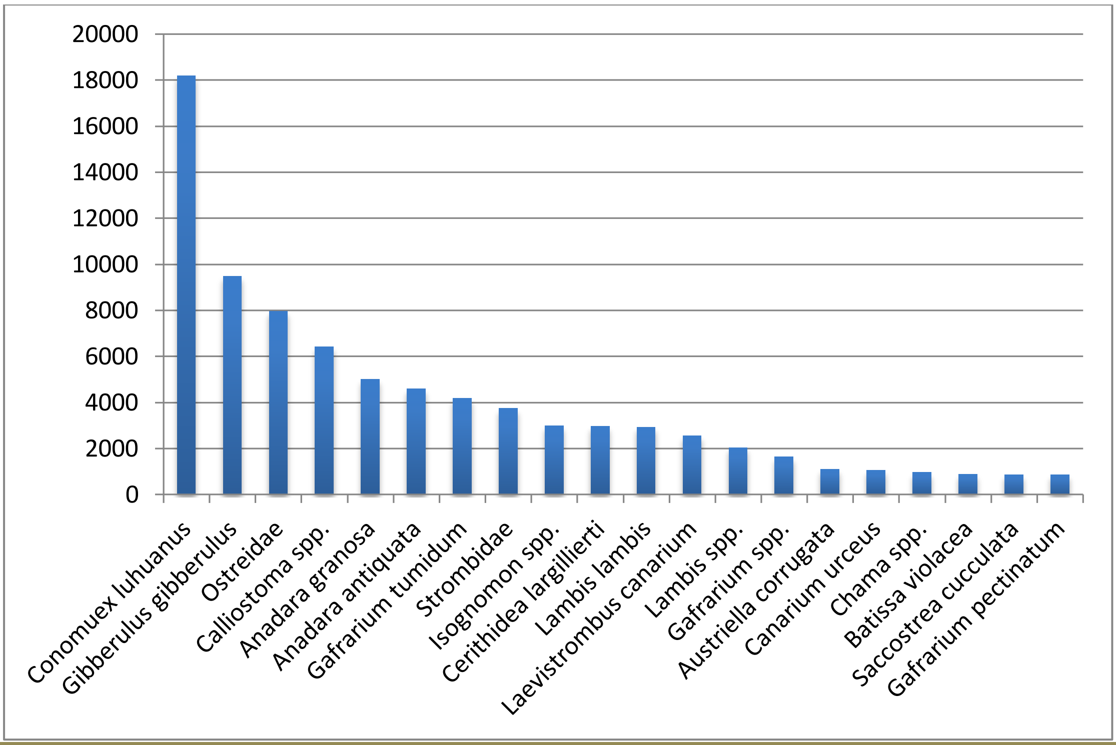

Figure 10.7. Ranking of shellfish taxa from Bogi 1 Square C by weight.

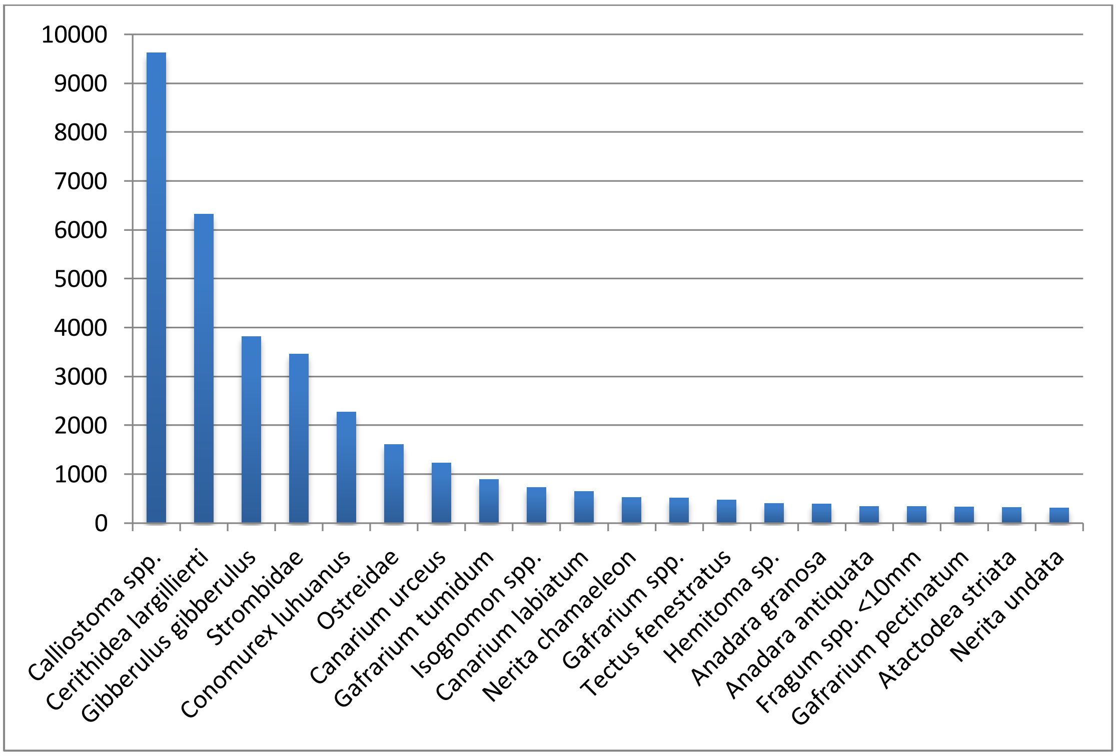

Figure 10.8. Ranking of shellfish taxa from Bogi 1 Square C by MNI.

By MNI, a total of 40,069 bivalves and gastropods (7836 = bivalves and 32,233 = gastropods) was counted for Square C, demonstrating the dominance of gastropods over bivalves. The top 10 ranked species by MNI for Square C are *Calliostoma* spp. (9624, 23%), *Cerithidea largillerti* (6324, 15.1%), *Gibberulus gibberulus* (3818, 9.1%), Strombidae (3458, 8.3%), *Conomurex luhuanus* (2269, 5.4%), Ostreidae (1608, 3.8%), *Canarium urceus* (1228, 2.9%), *Gafrarium tumidum* (892, 2.1%), *Isognomon* spp. (731, 1.7%) and *Canarium labiatum* (650, 1.6%). These taxa account for 76.4% by MNI of all bivalve and gastropod species.

Relative Importance of Mollusc Taxa

Both MNI and weight figures reveal that despite a diverse range of species, there is a clear preference for certain taxa compared to other species. While some of these taxa vary in size from larger (e.g. *Gibberulus gibberulus*) to smaller (e.g. *Calliostoma* spp. and *Cerithidea largillerti*) species, their high rates of discard clearly demonstrate that such taxa were of subsistence importance. Even with lower discard rates, the majority of species were most probably also economic, particularly those species occurring in all phases that have been identified within the shellfish literature to have either been targeted for subsistence or artefact production. For example, gastropods such as *Telescopium telescopium* (MNI = 72, 0.2%), *Lambis lambis* (MNI = 28, 0.07%), and *Oliva oliva* (MNI = 17, 0.04%), and bivalves such as *Austriella corrugata* (MNI = 49, 0.12%), *Chama pacifica* (MNI = 3, 0.007%), and *Tridacna maxima* (MNI = 1, 0.002%), have been documented in archaeological, ethnographic and malecological studies as representing species of economic or cultural significance.

The low discard rates of the majority of taxa within Bogi 1 most likely represents a scenario similar to Tanamu 1 where people intensively targeted a relatively small number of favoured taxa, while the majority of the taxa were less intensively targeted and not particularly important in terms of overall economic contribution. Furthermore, the lower occurrence of certain species may possibly be a result of incidental or secondary gathering, which may have occurred during a gathering trip for a preferred taxa at which time population beds of less dominant species may have been in close proximity (see Chapter 5 for discussion on ethnographic examples). Therefore, the decision to target certain species at a lower intensity may be due to environmental factors or cultural choices in relation to availability and/or distribution of these taxa. These possible scenarios will be examined further in Chapter 12. In addition, non-economic species (MNI = 2243, 0.05%) were also part of the assemblage and have been determined to be non-economic since they mostly had a small size-structure (<10mm) (e.g. Arciidae <10mm) which could have been added to the assemblage either by natural processes or by accident (see discussion in Chapter 3 re non-ecomonic shellfish).

Shell Artefacts

In addition to the presence of shell grave goods, shell artefacts were also identified during the laboratory sorting phase. Taxa identified to most likely be artefacts within Bogi 1 Square C in all three cultural phases include *Conus* spp., *Cypraea* spp. and *Tridacna* spp. The presence of shell artefacts in all phases provides the potential for an analysis of temporal change in production and use. As analysis of the worked shell by specialists is in progress and detailed descriptions of the Caution Bay shell working economy will be reported elsewhere in the future.

Trends in Shellfish Exploitation between Major Phases

Differences in shellfish exploitation are evident between all three major phases of human occupation at Bogi 1. During the pre-Lapita phase, a preference for bivalves over gastropods is evident (SU8 to SU10, XUs 74-147) (Figure 10.9). Another trend is seen in both the diversity and discard of the 128 taxa present within the assemblage. Apart from *Fragum* spp. (at <10mm) which was probably non-economic, a greater focus was placed on bivalves species with the predominant taxa being *Isognomon* spp., Ostreidae, *Gafrarium tumidum*, *Anadara antiquata* and *Atactodea striata*. A main difference between this phase and the subsequent Lapita occupation is seen in discard of certain species such as *Conomurex luhuanus* which not only accounts for much of the entire assemblage (by MNI and weight) but only starts to appear after XU81, closer to Lapita occupation. This trend is similar to Tanamu 1 where this species was only present from Lapita occupation onwards.

With the onset of Lapita occupation, both continuities and differences are seen in the preference and intensity of targeted species (lower SU7A to SU7B, XUs 48-69) (Figure 10.10) (Table 10.2). A total of 124 taxa are present in this phase, most of which also occur in the pre-Lapita phase. Out of the 124 species, only 4 taxa have over 100 MNI – three bivales (*Gafrarium tumidum*, Ostreidae, *Atactodea striata*) and one gastropod (*Conomurex luhuanus*). A change is seen with the greater occurrence of *Conomurex luhuanus*. The relatively high rates of discard of these higher-ranked taxa is significantly lower than the later post-Lapita phase. More importantly, the trend during Lapita occupation points to more focused targeting of bivalves than gastropods, a similar pattern to Tanamu 1. Species such as *Calliostoma* spp. and *Cerithidea largillerti* which were heavily exploited following the end of Lapita occupation were not exploited intensively as evident by a significantly lower density of discard. Therefore, people were targeting larger sized species, particularly bivalves (e.g. *Gafrarium tumidum*, Ostreidae, *Anadara granosa*, *Anadara antiquata*), to a greater extent during Lapita occupation.

Table 10.2. Example of taxa more prevalent in post-Lapita Phase than Lapita Phase in Bogi 1 Square C.

Bivalves	*Chama* spp., Ostreidae
Gastropods	*Gibberulus gibberulus, Conomurex luhuanus, Canarium urecus, Canarium labiatum, Tectus fenestratus*
Small-sized taxa	*Nerita chamaeleon, Nerita undata, Calliostoma* spp., *Cerithidea largillierti, Cerithidea cingulata*

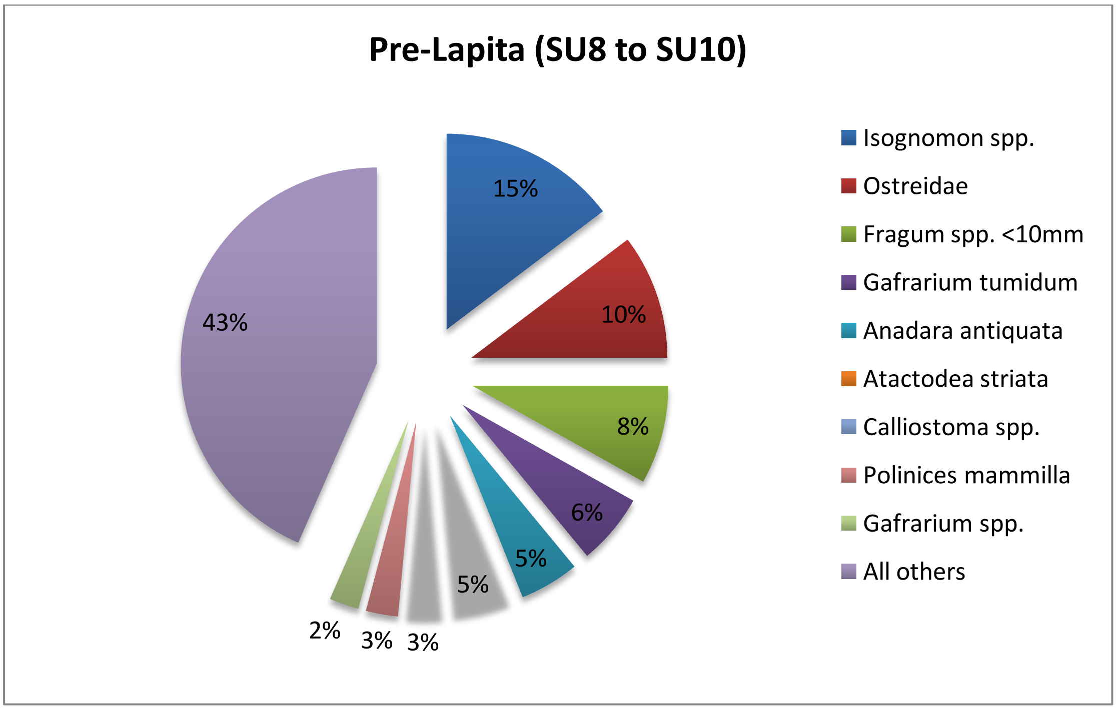

Figure 10.9. Main shellfish species in pre-Lapita Phase of Bogi 1 Square C.

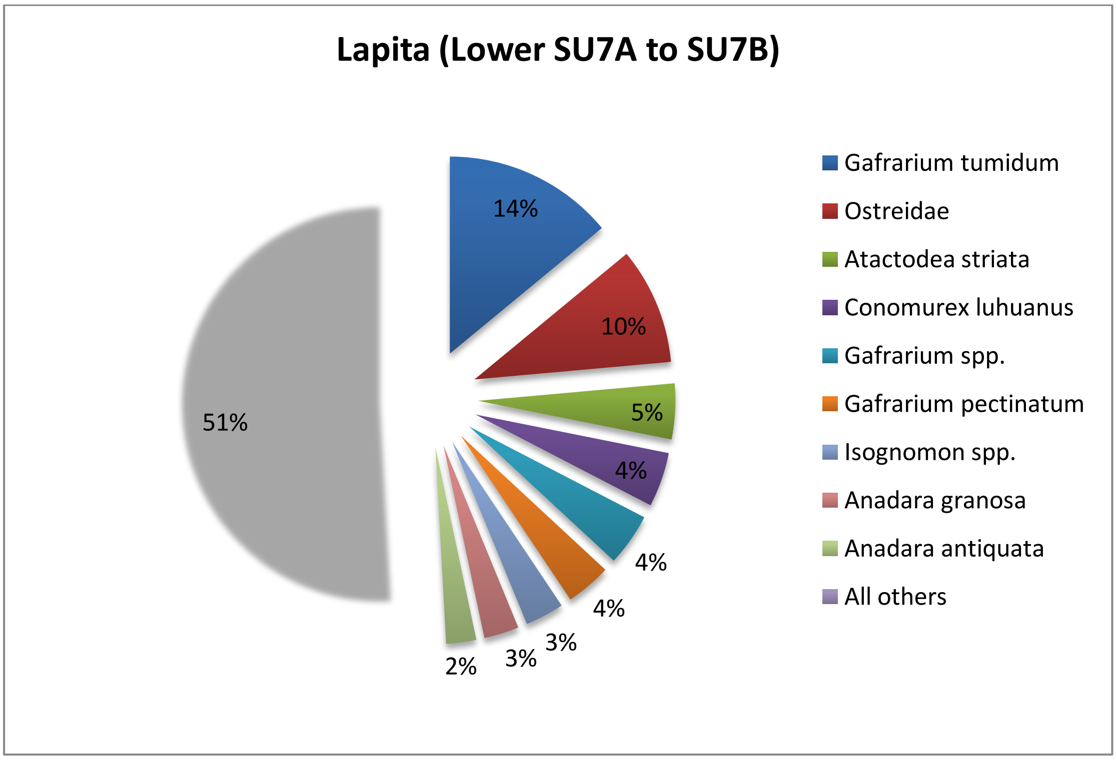

Figure 10.10. Main shellfish species in Lapita Phase in Bogi1 Square C.

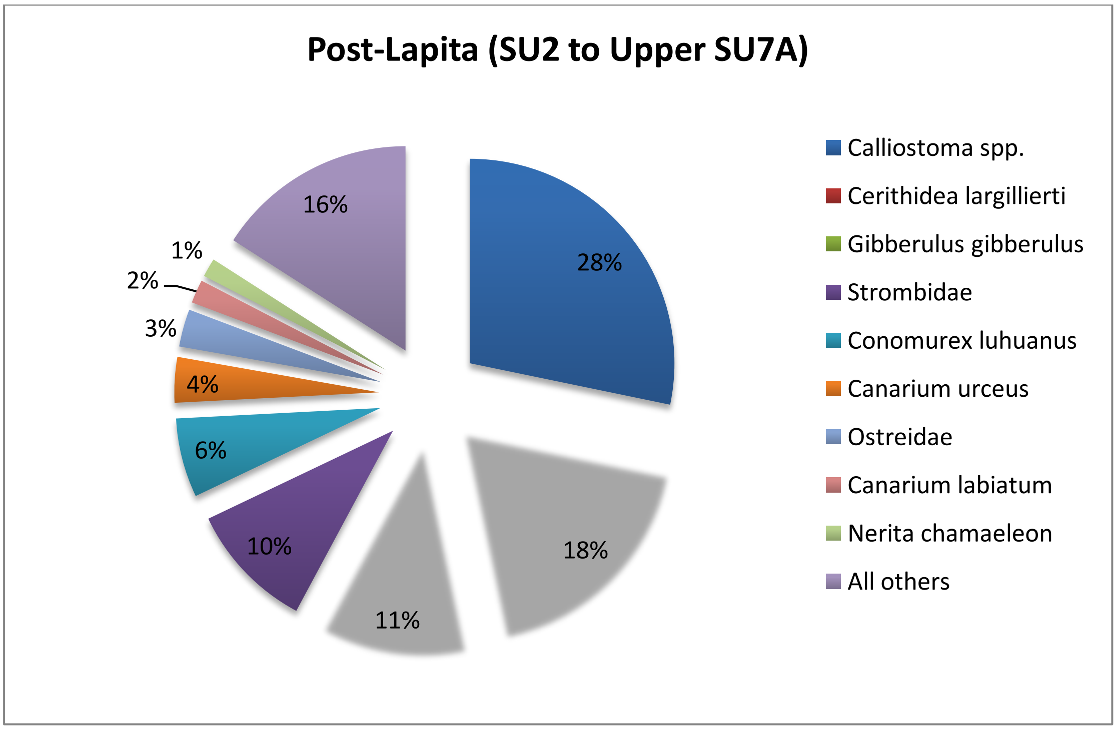

Figure 10.11. Main shellfish species in post-Lapita Phase in Bogi1 Square C.

Major changes in shellfish exploitation are seen during the post-Lapita occupation of Bogi 1 (SU2 to upper SU7A, XUs 3-35). A total of 157 species are present within the assemblage, but the most intensively targeted taxa (>100 MNI) are only represented by 24 taxa, mostly gastropods. These species include gastropods *Calliostoma* spp., *Cerithidea largillerti*, *Gibberulus gibberulus*, *Conomurex luhuanus*, and *Canarium urceus*, and the bivalve Ostreidae (Figure 10.11). This pattern demonstrates selective intensive gathering of certain species which were supplemented by a wide range of lesser-ranked taxa. Even though some of the higher-ranked taxa are relatively small in size when compared with a larger gastropod such as *Conomurex luhuanus*, the degree to which they were exploited reveals that they were desired. Major differences between this phase and the previous two phases include an increase in the diversity of species and an overall shift in subsistence strategy to exploiting a higher proportion of gastropods.

In addition to the rich deposits in all three phases, shellfish are also present in-between these phases, but with very low levels of discard. While interpreting these intervening periods may be problematic since they may represent mixed zones and an in-depth analysis of these layers are not presented here, the presence of at least some shellfish remains still presents the possibility that continued site occupation, albeit ephemeral occurred, especially between Lapita and post-Lapita phases but at a much lower intensity. Overall, the major chronological trends in shellfish exploitation show varying levels of shellfish exploitation between pre-Lapita, Lapita and post-Lapita levels with a shift towards gastropods and some smaller species after Lapita occupation.

Differences in Habitat Use

Similar to Tanamu 1, shellfish belonging to a wide range of habitats were targeted by people at Bogi 1. However, temporal changes are also evident between the major occupation phases. Figure 10.12 reveals differences in chrono-stratigraphic use of habitats, while a summary of important trends for each major occupation phase are provided below.

In the pre-Lapita phase (>4500 to c. 3900 cal BP) (SU8-SU10), species belonging to sandy intertidal, rocky intertidal, estuaries and mangroves such as *Gafrarium tumidum*, Ostreidae and *Isgonomon* spp. occur in greater numbers (75%). People were therefore targeting a few environments more intensively with a focus on bivalves. Other than marine species, species from fresh/brackish-water habitats were also gathered (e.g. *Batissa violacea*). Molluscs from lower sections of this phase also exhibit water-worn edges, thereby suggesting the presence of natural shellfish species within this layer. This is evident from the presence of smaller taxa such as *Fragum* spp. (<10mm) which suggests that storm surge events may have occurred. While environmental processes may have added certain non-economic species to this phase, especially within its lower sections, the occurrence of certain larger-sized taxa such as *Anadara antiquata* and Ostreidae (XU147) clearly demonstrates that Bogi 1 was occupied from at least 4500 years ago.

Sandy intertidal, rocky intertidal, estuaries and mangroves, reef flats intertidal and mud-flats intertidal species constitute the majority of shellfish remains during Lapita occupation (2900 to c. 2600 cal BP) (lower SU7A to SU7B). 91% of the assemblages is represented by species from these habitats with *Gafrarium tumudum* and *Atactodea striata* (sandy intertidal), Ostreidae (rocky intertidal) and *Conomurex luhuanus* (seagrass intertidal) accounting for 33% of species. Following pre-Lapita occupation, a number of other small species (e.g. nerites from rocky shore habitats) were still being exploited. While this trend of a preference for selective bivalve species is similar to the pre-Lapita phase, people were starting to gather more taxa from other habitats such as seagrass intertidal zones (e.g. *Conomurex luhuanus*). At the same time, people were also making the effort to gather species from more distant rock and reef platforms (e.g. *Conus* spp., *Cymatium* spp.). The presence of *Batissa violacea* demonstrates that people also exploited shellfish from freshwater/slightly brackish-water environments. Therefore, during Lapita occupation, people were again targeting a wide range of habitats with certain habitats clearly preferred over others.

A major difference in habitat preference is seen for the post-Lapita period (2200 to c. 2000 cal BP) (SU2 to upper 7A). Even though a wide variety of habitats were targeted, there is much greater emphasis on gastropod species with rocky intertidal, estuaries and mangroves, sandy intertidal, reef flats intertidal and seagrass intertidal species accounting for 97% of the total MNI (33302). This is demonstrated by individual taxa such as *Cerithidea largillerti* (86% of estuaries and mangroves), *Calliostoma* spp. (77% of rocky intertidal) and *Conomurex luhuanus* (76% of seagrass intertidal) representing the majority of discard (by MNI) for each of their respective habitats. Another major difference is the increase in species diversity with people making an increased effort to exploit new species (e.g. *Tridacna* spp.) from habitats such as coral reefs situated further away. Similarities with the earlier phases are also demonstrated with the continued gathering of many taxa such as nerites.

The overall analysis of chronostratigraphic trends in shellfish exploitation by habitat reveals that people were targeting molluscs from a range of littoral habitats with different substrates along with intertidal seagrass, reef flats and freshwater environments. While further discussions on habitat choice will be provided in Chapter 12, the main trends for each major phase are:

Pre-Lapita (>4500 to c. 3900 cal BP)) – Preference for bivalves belonging to certain habitats from among multiple targeted habitats.

Lapita (2900 to c. 2600 cal BP) – Wide range of habitats were targeted but people focused more on certain bivalve species from particular habitats. An increase in the exploitation of certain gastropod species which dominate the assemblage within the subsequent phase.

Post-Lapita (2200 to c. 2000 cal BP) – Major shift in focus to certain gastropod species (97% of assemblage within phase) while continuing to target multiple habitats. Exploitation of new species from existing habitats.

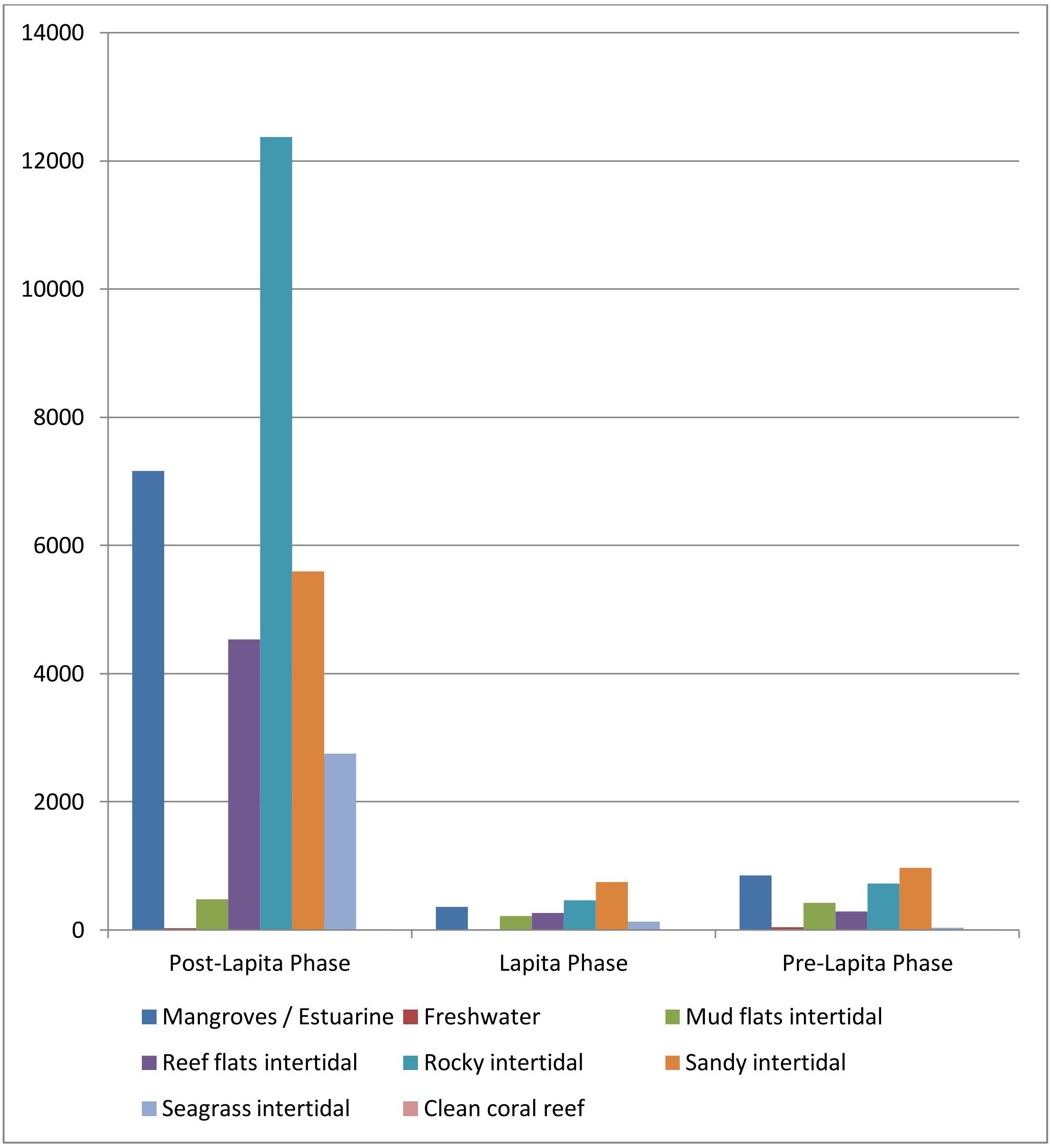

Figure 10.12. MNI of shellfish taxa by SU for each habitat in Bogi1 Square C.

Intensity of Mollusc Exploitation

The dense shellfish deposits together with a wide range of taxa in each of the major cultural phases demonstrates the importance of shellfish to the people at the Bogi 1 site. Figures 10.13 and 10.14 further substantiate the key trends discussed above. Apart from the post-Lapita phase, bivalves were preferred over gastropods during both pre-Lapita and Lapita occupation (2315 MNI vs 1049 MNI and 1327 MNI vs 908 MNI respectively).Gastropods clearly dominate bivalves during the post-Lapita phase (29602 MNI vs 3700 MNI). The dramatic shift towards increased reliance on gastropods from pre-Lapita (MNI 1049) and Lapita (MNI 908) levels to post-Lapita (29,602 MNI) levels suggests a major reorganisation of subsistence practices.

Figure 10.15 demonstrates the importance of shellfish resources between all major phases. Overall discard rates for pre-Lapita (MNI 3364), Lapita (MNI 2235) and post-Lapita (MNI 33,302) clearly show that an intensification of mollusc exploitation occurred during post-Lapita occupation at Bogi 1. As discussed in Chapter 9, overall discard rates for an occupational phase as an arbitrary analytical unit may not provide a clear understanding on rates of exploitation because of varying temporal scales between each phase. At Bogi 1, the pre-Lapita phase dating to between >4500 and c. 3900 cal BP equates to a minimal occupational phase of 600 years. In contrast, the Lapita phase dated to between 2900 and c. 2600 cal BP only lasted for approximately 300 years. The subsequent post-Lapita phase from 2200 to c. 200 cal BP was even shorter at around 200 years. With three different temporal scales, trends in shellfish exploitation can be explored further in terms of shellfish MNI per 100 years.

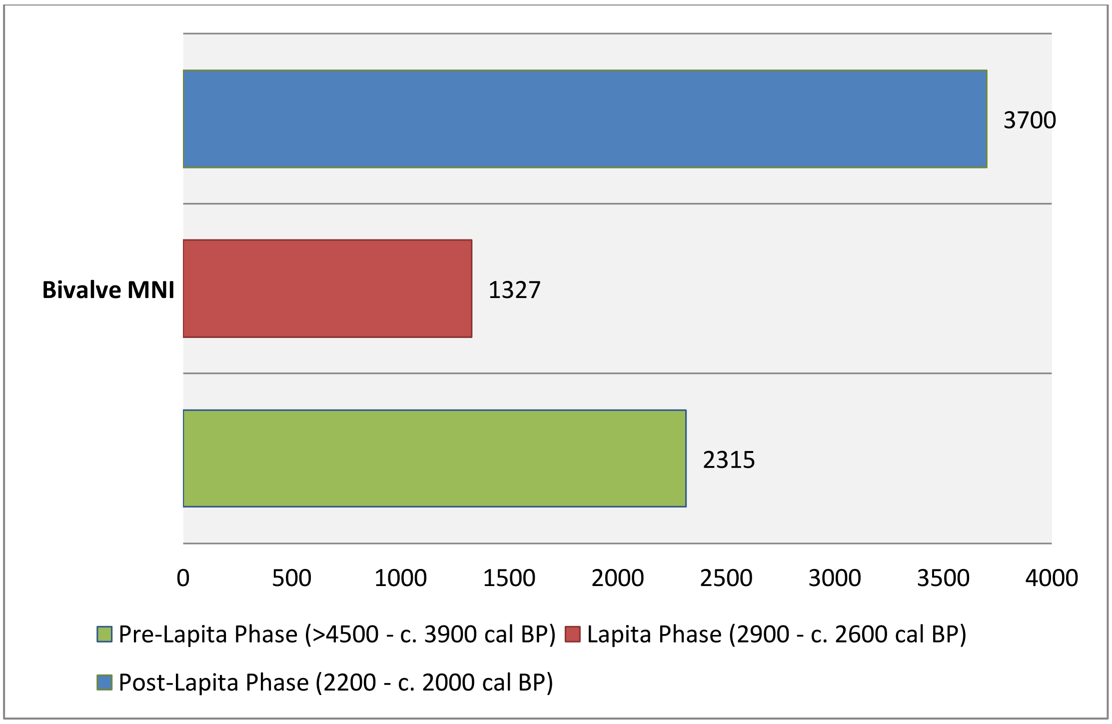

Figure 10.13. Total MNI for bivalves per major cultural phase in Bogi 1 Square C.

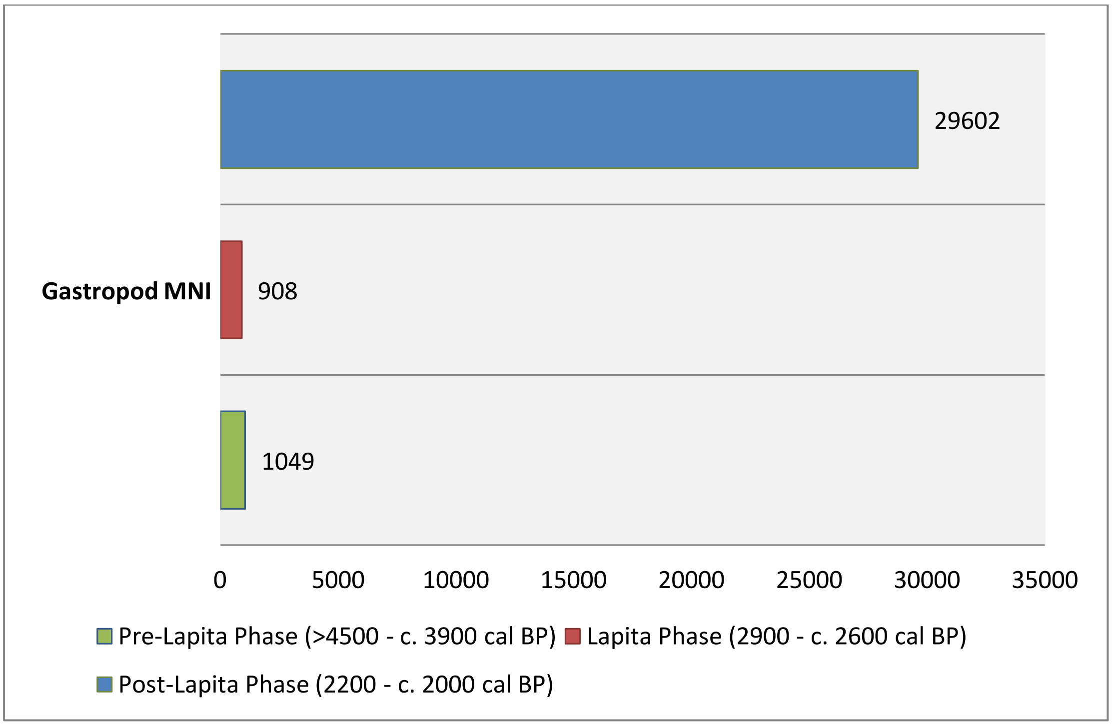

Figure 10.14. Total MNI for gastropods per major cultural phase in Bogi 1 Square C.

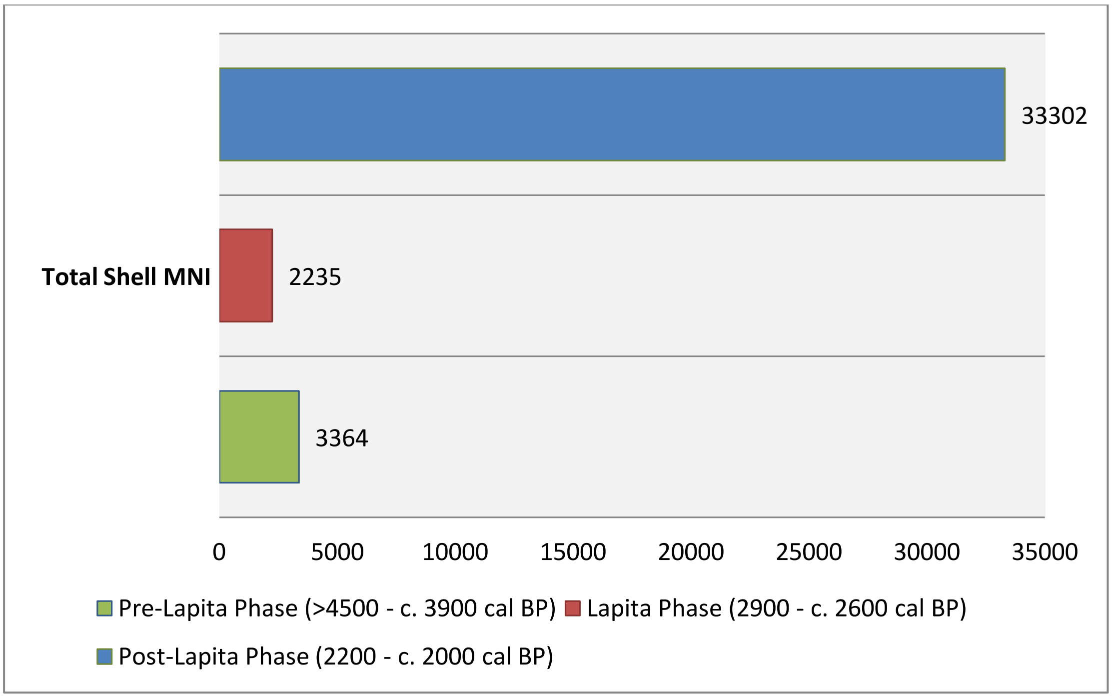

Figure 10.15. Total MNI for shellfish per major cultural phase in Bogi 1 Square C.

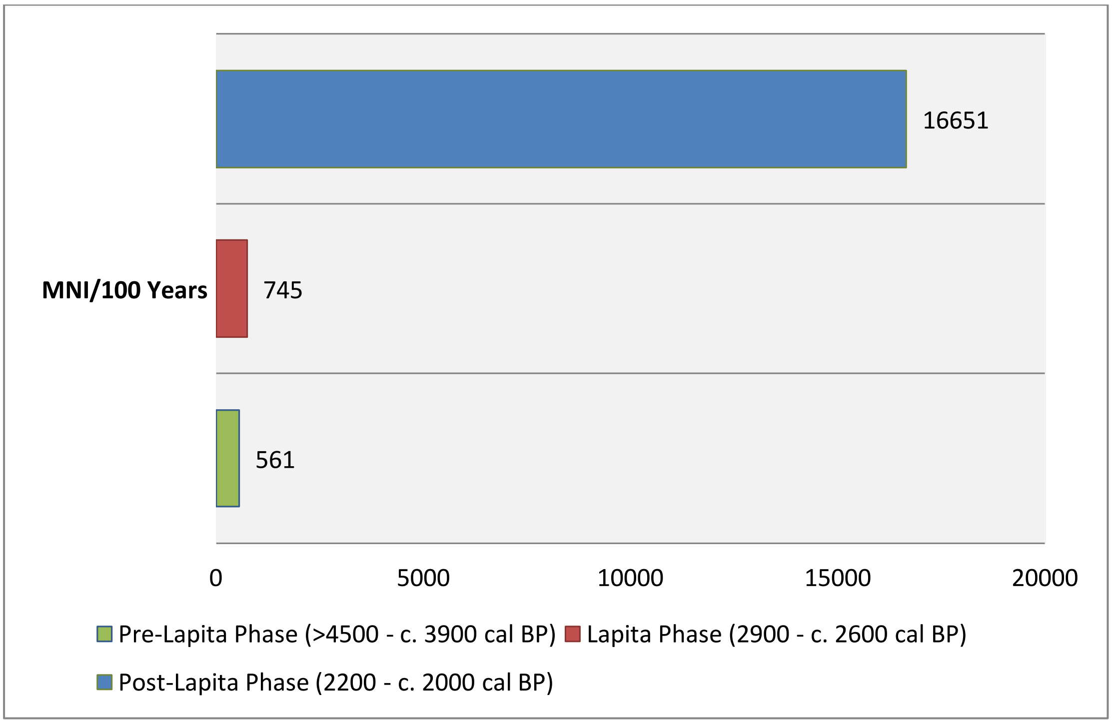

Figure 10.16. Total shellfish discard by MNI per 100 years between major cultural phases in Bogi 1 Square C.

Figure 10.16 provide a temporal analysis of MNI discard per 100 years and results clearly demonstrate the varying intensities at which shellfish were targeted throughout the occupational duration of Bogi 1. For the pre-Lapita phase, molluscs were exploited at an estimated rate of 561 MNI per 100 years. While the raw MNI for total shellfish discard is higher in post-Lapita levels compared to Lapita, there is in fact an increase in shellfish exploitation following the arrival of Lapita peoples with an estimated 745 MNI per 100 years discard. This trend however dramatically increases with 16,651 MNI per 100 years of discard during post-Lapita occupation. This evidence not only demonstrates that the greatest intensity at which shellfish were exploited occurred after Lapita occupation, but also reveals a more accurate representation of an increase in molluscs gathering following the arrival of Lapita peoples.

Shell Size Analysis

Morphometric analysis was applied to four taxa to examine possible predation pressures from high levels of exploitation. Table 10.3 shows the total number of individuals measured for each species with measurements taken for >65% of each taxa. Except for three of the taxa, morphometric analysis was not applied to *Conomurex luhuanus* (see Chapter 8) and instead measurements of maximum size were taken. All accumulated data in each major phase has been combined to reflect the overall mean size of a species as a chronological block, thus allowing for a comparison of results before, during and after Lapita occupation.

Table 10.3. Proportion of measured shells by MNI for each taxa in Bogi 1 Square C.

Species	MNI	Measured	Not measured
Conomurex luhuanus	2269	1613 (71.09%)	656 (28.91%)
Polinices mammilla	202	156 (77.23%)	46 (22.77%)
Atactodea striata	315	207 (65.71%)	108 (34.29%)
Anadara antiquata	340	236 (69.41%)	104 (30.59%)

In contrast to Tanamu 1, *C. luhuanus* does occur within the uppermost XUs (closer to Lapita) of the pre-Lapita phase. However, there were minimal individuals (by MNI) and this evidence is consistent with Tanamu 1 in which this species only appears within the assemblage after a considerable period of occupation. Analysis of the size-structure of this taxon shows both minor and major changes between phases (pre-Lapita 42.13mm, Lapita 47.01mm, post-Lapita 40.63) and discard rates per 100 years (pre-Lapita MNI = 4, Lapita MNI = 33, post-Lapita MNI = 1043). One-way ANOVA tests demonstrate significant variability in shell size between all three phases (ANOVA $F = 34.9$, df = 2 , $p = <0.001$). Further post-hoc comparisons using Turkey HSD test reveals mean size for *C. luhuanus* between pre-Lapita and Lapita levels ($p = <0.001$) and between Lapita and post-Lapita phases ($p = <0.001$) were significantly different at 0.05 level. Given that these measurements are below the recorded mean of 50mm for a natural population, it is likely that predation pressures were exerted on this species.

P. mammilla was targeted throughout site occupation, with discards occurring in lower levels of the pre-Lapita phase. Changes in size and discard are also evident between all three phases (Figure 10.19 and 10.20). Mean size ranged from 16.76mm (pre-Lapita) to 17.73mm (Lapita) and 17.67mm (post-Lapita) with varying discard rates per 100 years (pre-Lapita MNI = 15, Lapita MNI = 9, post-Lapita MNI = 37). This trend suggests that the natural *P. mammilla* population had possibly been under predation pressures exerted by people during pre-Lapita times as evidenced by both MNI and mean size. This taxa was possibly able to recover and attain a larger size during Lapita occupation, with a similar size trend within the population occurring in post-Lapita. As well, the size range recorded within the assemblage was smaller than that of the mean measured size of a natural population (24.89mm) sourced from the Queensland Museum. Significance tests using One-way ANOVA and Tukey HSD tests reveal no significance in size between all phases (ANOVA $F = 1.256$, df = 2 , $p = 0.288$). Statistical results suggest that considerable change in size did not occur for *P. mammilla*, but that it none the less appears to be smaller in size to a natural population. This difference in size will be explored further in Chapter 12.

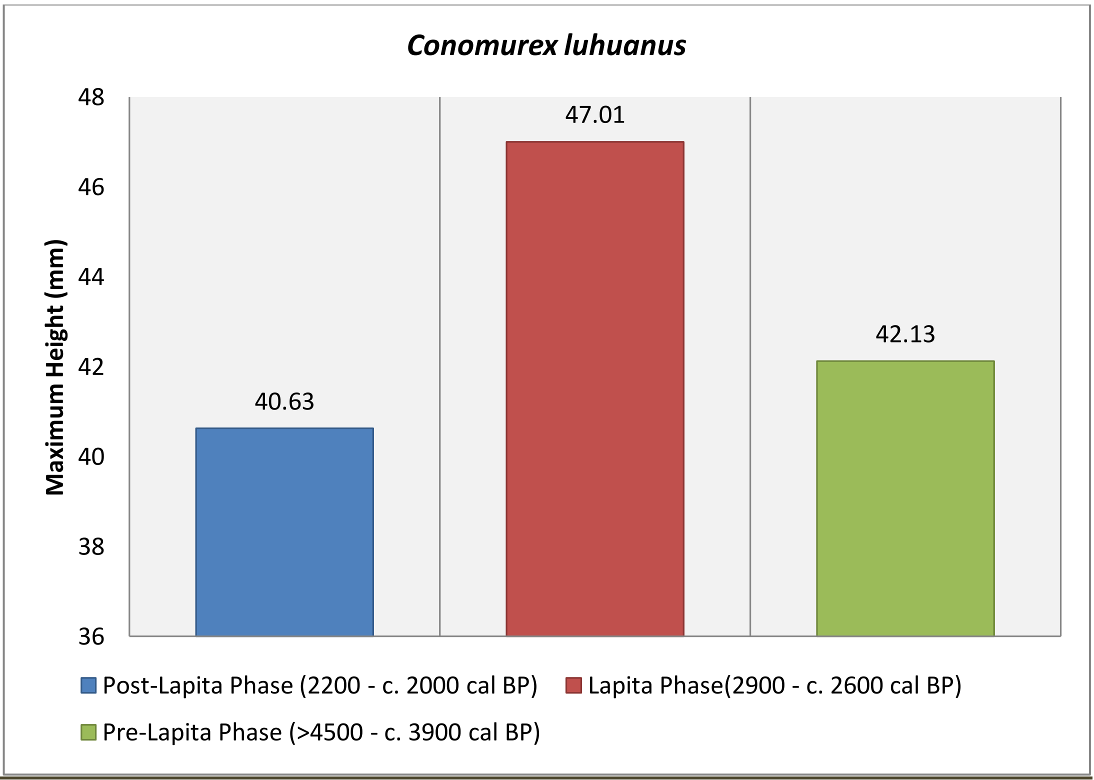

Figure 10.17. Mean overall size of *Conomurex luhuanus* between major cultural phases in Bogi1 Square C.

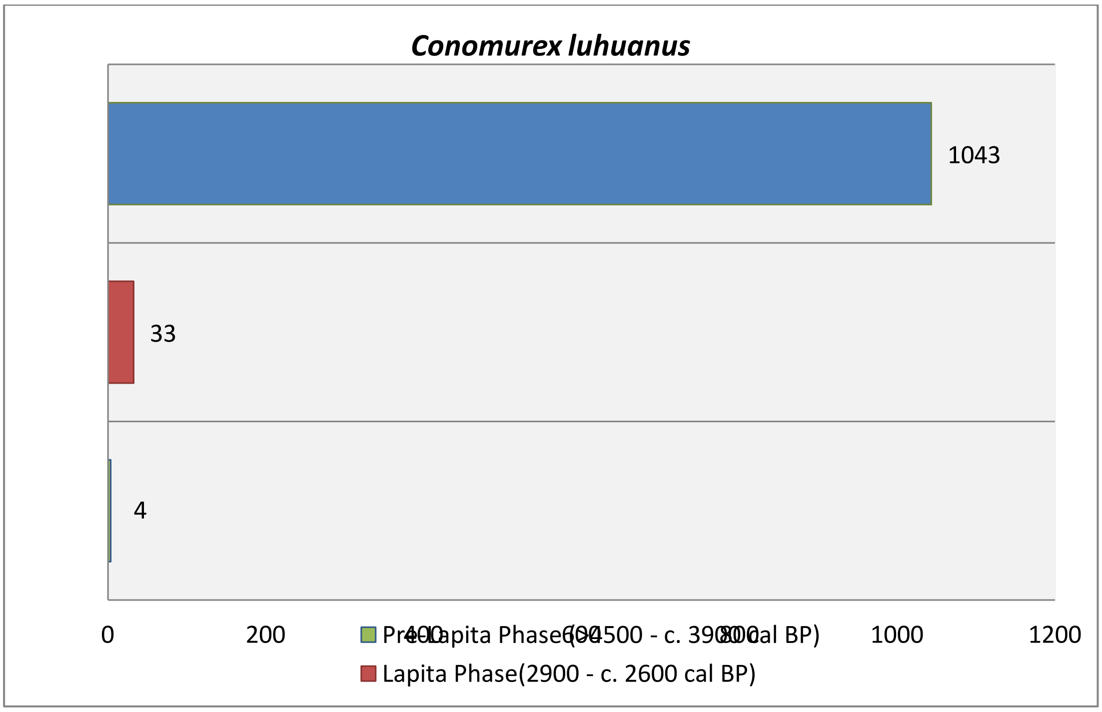

Figure 10.18. *Conomurex luhuanus* discard per 100 years between major cultural phases in Bogi1 Square C.

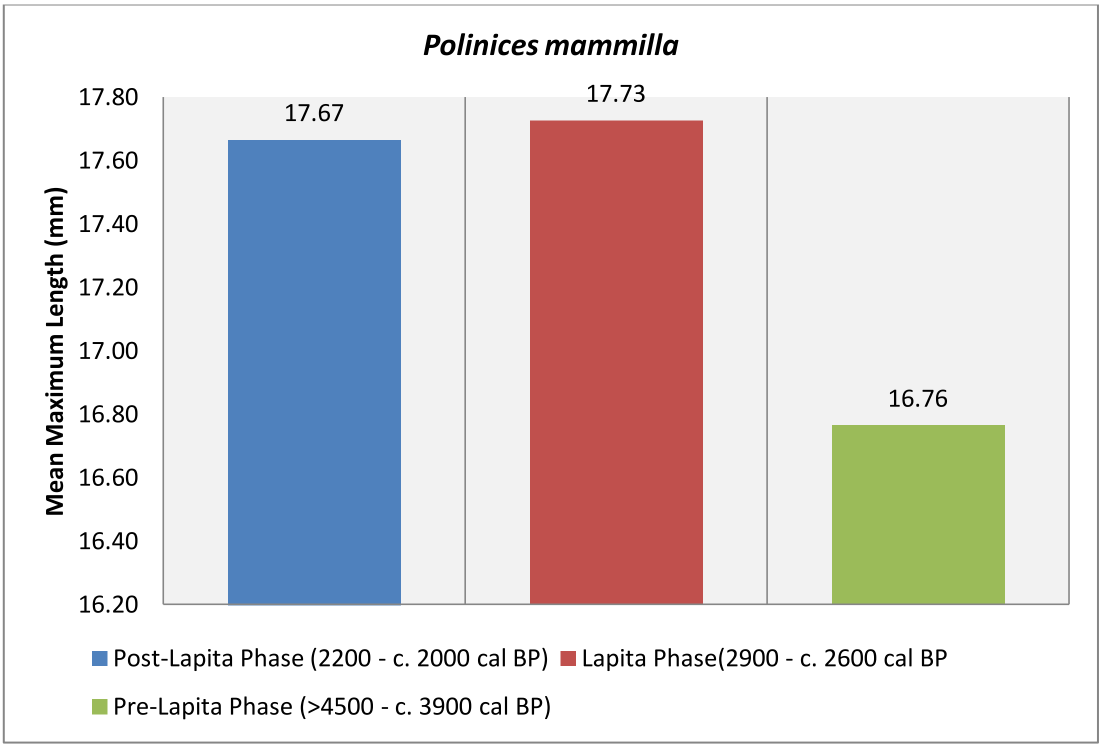

Figure 10.19. Mean overall size of Polinices *mammilla* between major cultural phases in Bogi1 Square C.

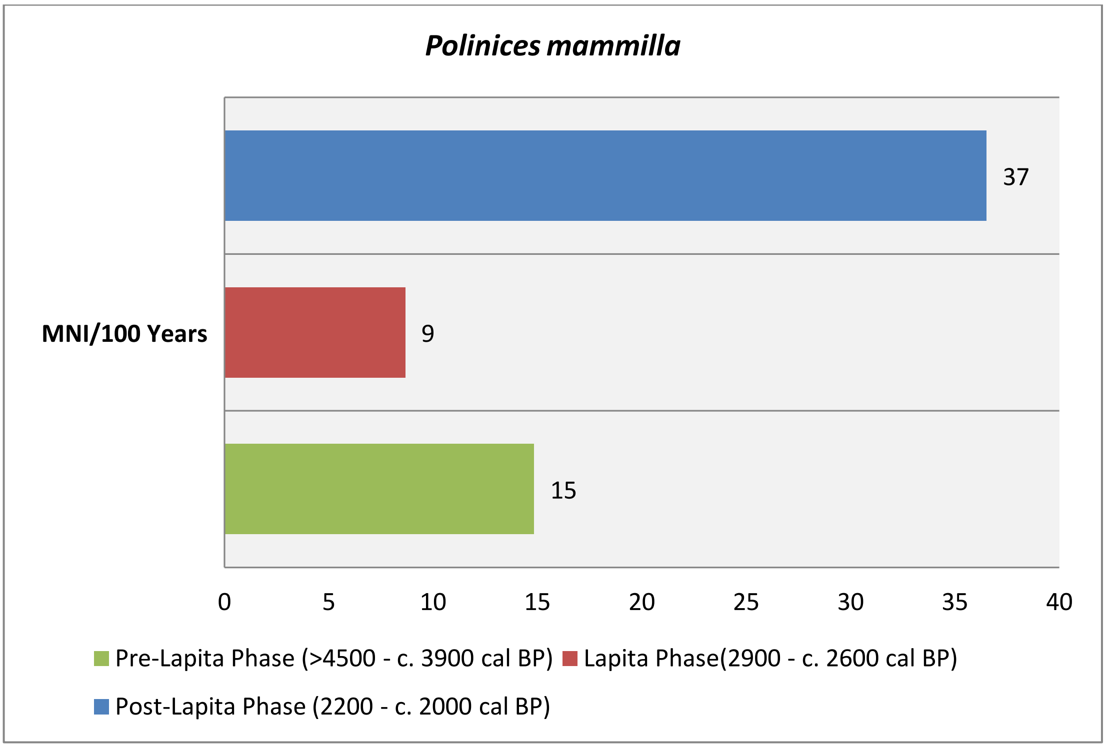

Figure 10.20. *Polinices mammilla* discard per 100 years between major cultural phases in Bogi1 Square C.

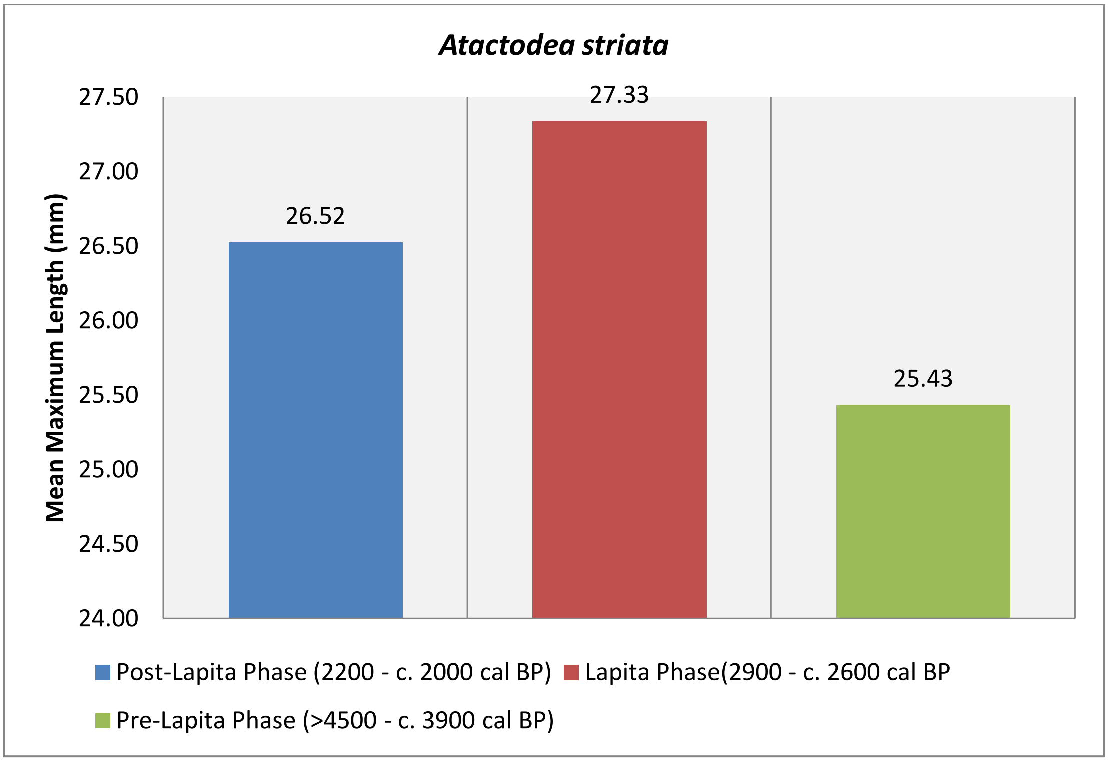

Figure 10.21. Mean overall size of *Atactodea striata* between major cultural phases in Bogi1 Square C.

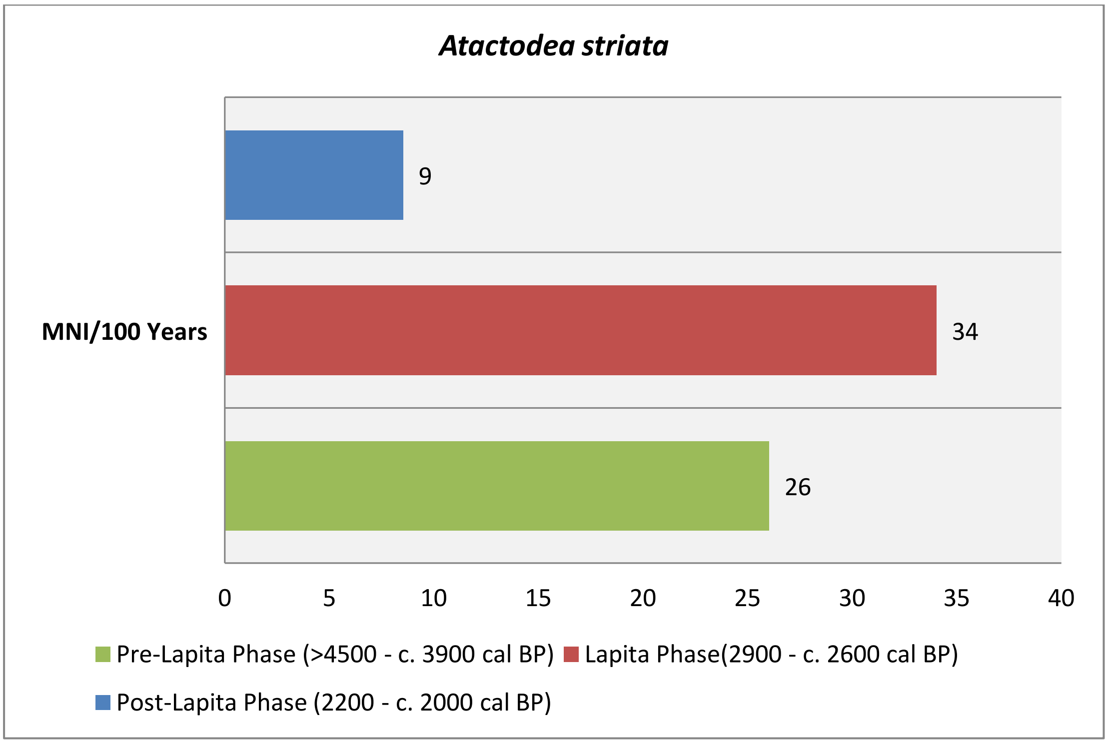

Figure 10.22. *Atactodea striata* discard per 100 years between major cultural phases in Bogi1 Square C.

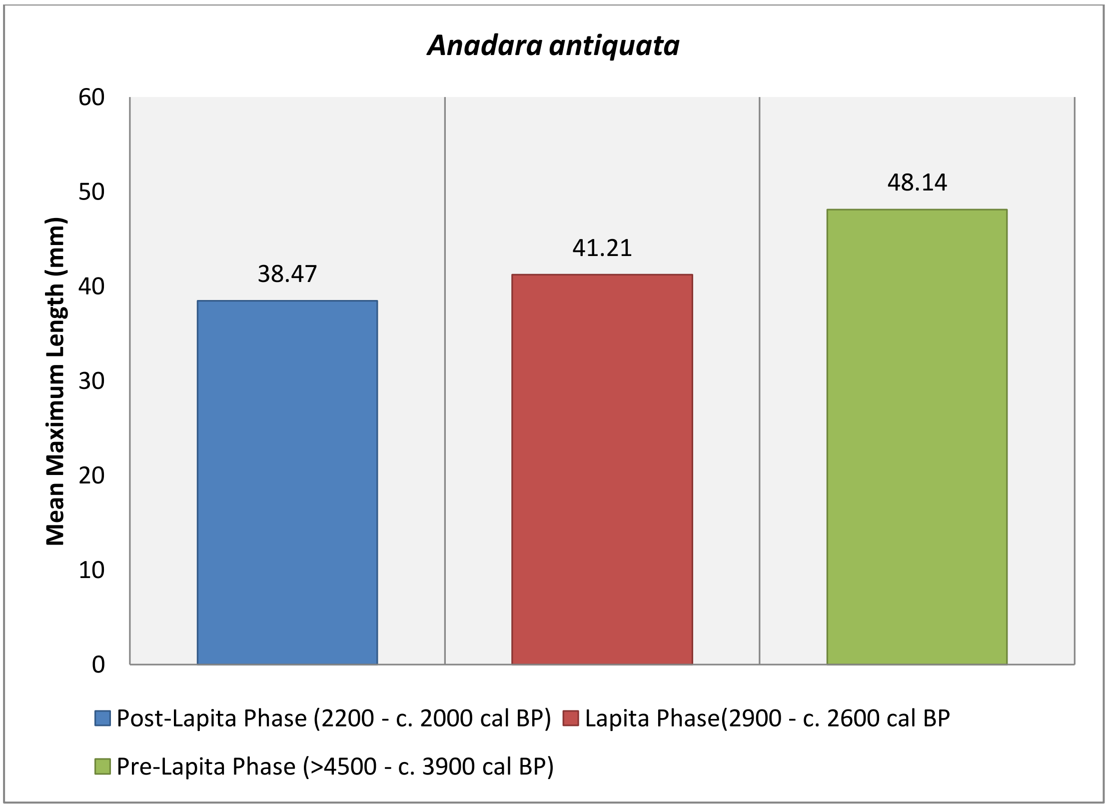

Figure 10.23. Mean overall size of *Anadara antiquata* between major cultural phases in Bogi1 Square C.

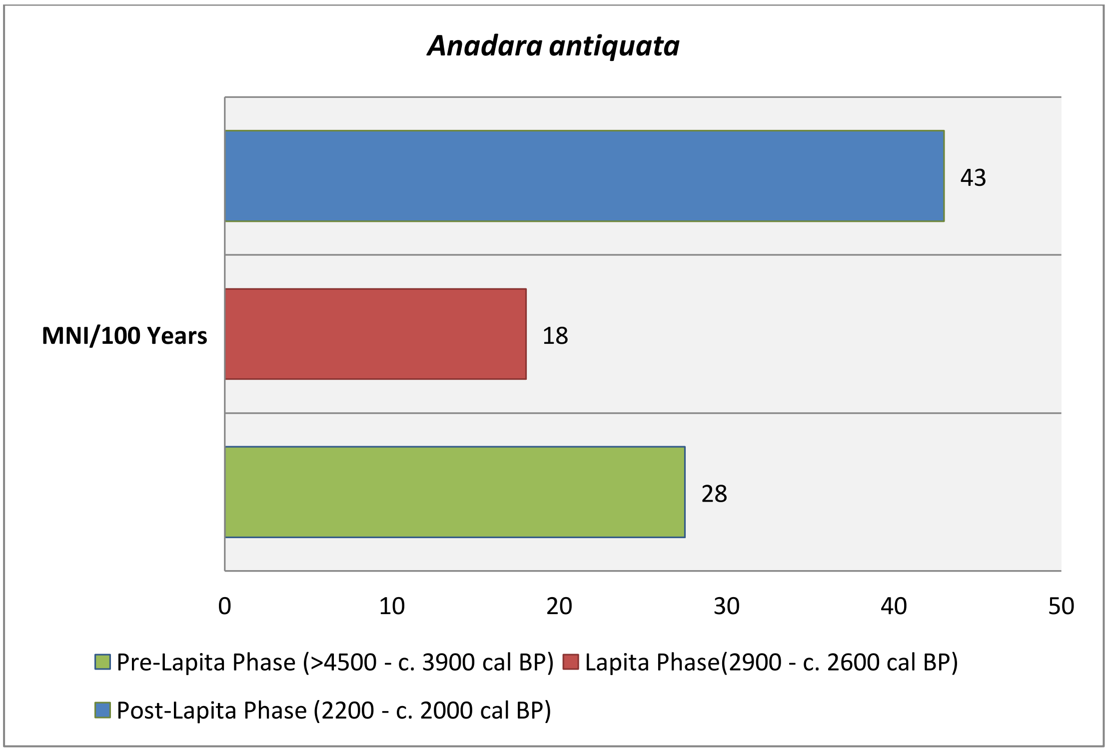

Figure 10.24. *Anadara* antiquata discard per 100 years between major cultural phases in Bogi1 Square C.

Changes in size and rates of discard for *A. striata* highlights the importance of this species to local inhabitants at Bogi 1 (Figures 10.21 and 10.22). In terms of MNI per 100 years, this species was exploited in greater numbers during both of the lower phases (pre-Lapita MNI = 26, Lapita MNI = 34, post-Lapita MNI = 9), however the increase in size from 25.43mm to 27.33mm during pre-Lapita to Lapita occupation is accompanied by an increase in MNI. With relatively minimal discard within the post-Lapita period, only a minor decrease is seen with the size structure of this species (26.52mm). Therefore, possible predation pressures before Lapita occupation may have accounted for a smaller size and because the sizes are almost identical in both the upper phases, this trend may instead represent a species that has recovered from prior human predation and/or environmental change since people preferred to target other larger bivalve species. This may be supported by the mean natural size for this taxa which is 25mm. One-way ANOVA tests does not demonstrate significant variability in shell size between all three phases (ANOVA $F = 2.856$, df = 2 , $p = 0.060$). However, further post-hoc comparisons using Turkey HSD test reveals mean size for *A. striata* between pre-Lapita and Lapita levels ($p = 0.047$) to be significantly different at 0.05 level.

In addition to *A. striata*, the *Anadara antiquata* assemblage at Bogi 1 also exhibits evidence for a change in size, possibly due to the environment and/or human predation. It was noticed visibly during the quantification process that individuals were considerably larger in lower levels of the site. This is supported by a decrease in size between pre-Lapita (48.14mm), Lapita (41.21mm) and post-Lapita (38.47mm). Furthermore, MNI discard per 100 years also reveal that higher numbers were exploited during pre-Lapita (MNI = 28) which followed a subsequent decrease in the Lapita phase (MNI = 18) before again increasing to MNI 43 (post-Lapita). Significant changes evident from One-way ANOVA tests are seen between all phases (ANOVA $F = 32.587$, df = 2 , $p = <0.001$) with Tukey HSD tests also revealing a significant difference between post-Lapita and the remaining phases ($p = <0.001$). These results are consistent with the evidence since people were focusing more on larger bivalves before and during Lapita occupation. Therefore, *A. antiquata* may have already been under predation pressures before Lapita people arrived, and the continued exploitation of this species meant that it was never able to fully recover to highest recorded size of 48.14mm in the pre-Lapita phase. Furthermore, with the mean size of the non-predated natural population from the QM measuring 55.66mm, this taxa was most likely under pressure either by the environment and/or by humans.

Discussion

Analysis of the Bogi 1 Square C shellfish assemblage has provided an insight into the cultural practices of past occupants of the site. Since only preliminary analysis of other cultural elements have been done, Table 10.4 provides details of pottery and stone artefact discard rates (by XU) which can be used alongside shellfish data to ascertain overall trends for each major phase.

Table 10.4. Details of excavated material from Bogi 1 Square C by XU (courtesy of Ian McNiven; David in prep; Mialanes in prep).

	Shell	Ceramic Sherds		Stone Artefacts	
XU	g	#	g	#	g
1	155.1	20	6.6	19	2.2
2				217	40.63
3	540.6	336	87.02	295	63.05
4	453	130	65.04	316	135.32
5	582.7	520	124.16	372	77.5
6	1019.9	412	133.14	457	93.87
7	2233.9	318	188.34	480	147.7
8	3174.7	498	169.96	314	139.85
9	3929.9	305	96.49	34	18.83
10	4939.4	107	63.69	86	76.2
11	5418.2	343	281.03	247	161.4
12	4922	534	478.57	234	101.16
13	4623.1	384	706.68	238	150.45
14	4000.3	228	179.17	249	226.41
15	3928.4	218	224.1	314	347.87
16	4746.9	328	188.65	310	188.57
17	5503.6	382	308.1	266	95.1
18	1845.4	312	165.4	117	59.5
19	2021.42	120	70.27	95	46.92
20	2154.1	98	103.75	111	47.76
21	1797.5	90	100.16	85	49.63
22	1456.7	99	36.64	67	36.65
23	1387.3	133	75.95	52	27.51
24	1188.5	92	39.45	48	13.07
25	1268.5	48	31.78	29	21.56
26	651.3	357	103.31	50	23.16
27	1402.5	35	17.82	46	41.45
28	911.4	62	43.47	38	17.41
29	1299.8	80	53.61	61	15.83

30	990.6	79	46.76	32	8.91
31	765.1	2	1.99	7	4.62
32	1382.4	71	42.26	43	5.3
33	723.4	87	41.01	23	3.19
34	711.2	98	60.71	20	10.24
35	435.5	58	36.33	10	4.94
36	472.7	60	25.48	18	3.11
37	450.4	33	34.39	20	4.25
38	343.2	28	10.9	17	0.88
39	314.4	25	11.67	10	1.5
40	243.2 (XU40+43)	37	23	12	0.96
41	252.9	45	19.67	13	0.35
42	331.4	19	8.73	19	1.96
43		50	22.76	13	2.68
44	291.4	17	37.15	3	0.07
45	374.9	62	23.43	10	0.33
46	303.7	31	18.14	6	0.45
47	309.1	60	24.77	10	0.72
48	322.8	48	36	20	2.15
49	128.8	6	3.96	0	0
50	399.8	45	40.27	8	0.42
51	353.6	29	19.69	11	0.86
52	379	91	59.4	4	3.81
53	432.6	24	16.09	9	5.06
54	386.3	74	32.61	6	0.24
55	476.7	53	48.71	14	10.15
56	334.4	43	24.13	4	0.49
57	323.9	17	21.79	7	0.62
58	722	27	29.78	11	0.6
59	683.5	72	14.72	16	12.91
60	507.1	34	22.67	12	0.33
61	904.7	36	16.05	13	2.21
62	1807.8	106	42.04	11	0.91
63	2030.9	62	12.61	7	0.88
64	3548	16	12.35	15	31.11
65	2246.39	2	0.46	21	3.96
66	635.1	1	0.51	12	3.48
67	484	1	3.21	13	1.29
68	309.6	5	1.44	4	0.07
69	377			18	1.11
70	340.4	1	2.92	16	6.82
71	388.1	4	1.91	7	0.22
72	403.54			4	0.25
73	395.55			9	0.43
74	449.27	4	0.5	5	0.1
75	401			4	1.91

76	580.12			6	1.01
77	717.67			5	0.55
78	774.9			4	2.54
79	654.44			6	4.41
80	888.3			7	0.69
81	899.9			10	17.3
82	757.5	2	0.54	5	0.31
83	538.8	3	2.2	1	5.4
84	1225	1	0.83	11	141.8
85	244.2			1	0.01
86	761.5	2	0.08	2	0
87	422.8			8	0.9
88	429			1	0.16
89	170.1			3	0.18
90	327.2			2	0.19
91	320.7			7	2.98
92	455.2			4	0.33
93	753.5			3	0.71
94	262.5			1	0
95	222.2			2	0.24
96	222.1			1	0.34
97	168.5			4	0.86
98	195			6	1.57
99	882.7			4	0.62
100	844.7			3	0.78
101	795.27			4	0.59
102	685.2			4	0.19
103	563.1			3	0.14
104	1343.1			0	0
105				0	0
106	122.6			0	0
107	127.7			1	0.51
108	64.1			2	0.03
109	59.1			0	0
110	118.4			1	0.02
111	197.4			1	0
112	199.9			2	0.1
113	154.6			2	0.34
114	126.1			0	0
115	110.6			0	0
116	136.5			0	0
117	64.7			0	0
118	30.6			0	0
119	29			0	0
120	17.7			0	0
121	39.7			0	0

122	32.1			1	0.24
123	45.7			0	0
124	21.9			0	0
125	25.1			0	0
126	32.3			0	0
127	32.6			0	0
128	11.6			0	0
129	2.6			1	0.18
130	35.8			0	0
131	43.9			0	0
132	25.3			0	0
133	4.3			0	0
134	11.5			0	0
135	9.5			0	0
136	39.7			0	0
137	43.8			0	0
138	78.2			3	0.02
139	113.1			0	0
140	62.6			1	0.03
141	32.9			5	0.23
142	41.4			0	0
143	74.4			4	0.16
144	36			2	4.42
145	87.1			3	0.15
146	91.6			3	0
147	115.2			3	0

Pre-Lapita Phase (>4500-c.3900 cal BP)

During the initial occupation of Bogi 1 before the arrival of Lapita peoples and the subsequent introduction of pottery, the complex cultural activities of local inhabitants is evident from the rich excavated archaeological deposit. While overall discard of stone artefacts both by weight and MNI is lower than subsequent phases, the presence of an axe/adze dating to at least 4200 years ago from Square HH (McNiven *et al.* 2010a:24-25), along with economic shellfish species in XU147, strongly suggests that site occupation began at least 4500 years ago. This complexity is further substantiated by the presence of a pre-Lapita burial with associated shell grave-goods, relating to ritual practice (McNiven *et al.* 2011:4). In addition, people were also targeting other non-molluscan resources as evident from fish, turtle, and other terrestrial faunal remains (e.g. wallaby) at this site (McNiven *et al.* 2010a:26).

Shellfish exploitation during this period clearly demonstrates that people were comprehensively utilising a marine environment. The total discard of 3364 MNI (Bivalve = 2315, Gastropod = 1049) (561 MNI per 100 years) along with targeting over 120 species of molluscs over a 600 year occupational period meant that shellfish represented a major part of the local subsistence economy. The diversity of species suggests a reliance on a wide variety of marine habitats, some of which may have required additional effort to gain access. At the time, people also had a clear preference for certain larger bivalve species while supplementing their diet with the vast variety of small and large shellfish. Evidence from morphometric analysis also suggests that certain species such as *Andara antiquata*, *Atactodea striata* and *Polinices mammilla* may have been under human predation pressure. Therefore, evidence from both smaller and larger species along with other key trends suggests the presence of a degree of early marine specialisation by pre-Lapita occupants of Bogi 1.

Lapita Phase (2900-c.2600 cal BP)

Lapita pottery remains are undoubtedly the most obvious cultural element during Lapita occupation. Following the arrival of Lapita peoples, peaks in both pottery and stone artefact discard are evident at Bogi 1 (Table 10.4). In addition to shellfish, the remains of fish, dugong and wallaby were also found in these layers following preliminary analysis (McNiven *et al.* 2010a:25-26). In contrast to the previous phase, shellfish resources were gathered in larger numbers with over 120 species from a comprehensive range of habitats targeted. Despite a lower overall MNI of 2235 (Bivalves = 1327, Gastropods = 908) when compared to the previous phase, a higher shellfish discard per 100 years (MNI = 745) clearly shows that people were exploiting more shellfish during Lapita occupation, a trend similar to Tanamu 1. In addition, even with a similar diversity of species, evidence points to a proportional shift in targeted species with certain taxa (e.g. *Conomurex luhuanus*) from coral reefs becoming more prevalent. Therefore, people were venturing out to a wider range of established habitats more frequently to gather certain species even though these taxa were not highly-ranked within the assemblage. The overall trend of species choice again shows greater preference for certain bivalve species but at the same time, slightly increased gathering of other taxa begins to take place. The evidence for a minor increase in shellfish subsistence activities is borne out by a reduction in size of the bivalve *Anadara antiquata*, a trend that began during pre-Lapita times with continued exploitation or environmental change possibly leading to a decrease in size. The increase in shellfish exploitation and discard of other cultural elements, along with a restructuring of shellfish choices, may reflect an increase in population density and more active settlements following contact and introduction of new material culture (i.e. pottery).

Post-Lapita Phase (2200-c.2000 cal BP)

The post-Lapita archaeological sequence at Bogi 1 comprises an extremely rich assemblage of shellfish together with marked increases in pottery and stone artefact discard (Table 10.4). While other non-molluscan fauna (e.g. fish, wallaby) and possible pig and dog remains have also been associated with this phase (McNiven *et al*. 2010a:25-6), the post-Lapita phase at Bogi 1 represents the most intensive period of shellfish exploitation. The total MNI of 33,302 (Bivalve MNI = 3700, Gastropod MNI = 29,602) is more than 10 times the levels of exploitation during Lapita occupation, a trend supported by MNI discard of 11,651 per 100 years. Therefore, people were targeting shellfish at a much greater intensity over approximately 200 years (Lapita Phase = 300 years). In addition, unlike the previous occupational phases, another major shift in subsistence focus is that of gastropod discard which drastically increased and dominates bivalves. This trend is probably not indicative of changes in habitat choice, but rather a proportional shift in numbers of targeted species such as *Calliostoma* spp., *Cerithidea largillerti* and *Conomurex luhuanus* which were also exploited during Lapita occupation. Even with this drastic change, people were still utilising a wide spectrum of habitats since there was an increase in species diversity (>150) found within the assemblage. The high intensity at which some of the higher-ranked shellfish taxa were being targeted is clearly demonstrated by a drastic reduction in the size of *Conomurex luhuanus* over time. The dramatic increase in discard of other cultural elements and shellfish, especially towards the upper sections of this phase, is indicative of the presence of a major settlement/s with a large population base following a transition from Lapita occupation.

Conclusion

The archaeological record at Bogi 1 is highly significant from both a local and regional context because it not only has the longest temporal Lapita phase, but also represents some of the earliest evidence for the emergence of pottery along the southern coast of Papua New Guinea. Equally significant is the presence of both pre-Lapita and post-Lapita occupational phases which have more than doubled the antiquity of human occupation in the region while also allowing for a unique opportunity to investigate any transformative processes in material culture use and production into subsequent phases (e.g. shellfish, pottery). Within this temporal framework, analysis of the rich Bogi 1 shellfish assemblage has provided important insights into the activities of marine specialists at this location.

The evidence outlined above clearly demonstrates the economic importance of shellfish and a degree of marine specialisation at the Bogi 1 site. A dramatic increase in molluscs discard (along with pottery and stone artefacts) and species use over time strongly suggests an intensification of shellfish resource use and site use particularly towards the end of site occupation. An in-depth discussion of overall differences in shellfish exploitation between all sites examined in this study will be presented in Chapter 12 in order to ascertain if there are possible anthropogenic or environmental factors behind these trends. Nonetheless, from an analysis of the Bogi 1 shellfish assemblage, this chapter clearly demonstrates the importance of shellfish resources.

Chapter 11 – JA24

Regional Context

This chapter will focus on the inland site JA24 which is considerably different from the previous sites examined in this study as it represents one of the many post-Lapita sites found within the Caution Bay landscape. While a Lapita Horizon has not been identified, abundant pottery remains together with a rich shellfish assemblage allows for an investigation into the transformative processes in mollusc exploitation following the cessation of Lapita occupation. This is particularly important since the occurrence of other post-Lapita sites dating to the previously held 'EPP' chronological framework as identified by earlier research means that JA24 has the potential to test existing notions on settlement patterns and shellfish subsistence in relation to ceramic traditions during post-Lapita occupation of the landscape.

Site Description

The archaeological site JA24 (Monash University field code; PNG National Museum and Art Gallery site code AAUG) is situated 2.3km east from the coast and 20km northwest of Port Moresby (Richards *et al.* in prep:1) (Figure 11.1). The site itself is located on a low rocky outcrop that at a higher elevation than the surrounding undulating open plain (Richards *et al.* in prep:1). Water sources are found nearby with the Ruisasi Creek situated 190m to the SSW while an unnamed tributary is located 160m to the NNW (Richards *et al.* in prep:1). The surrounding landscape consists of savannah 1.2km to the SE, mangroves 1.8km to the SW with the closest inter-tidal mudflats 1.6km to the SW (Richards *et al.* in prep:1). The site is deep in the derived grassland, typical of most of the landscape (Richards *et al.* in prep:1).

The rocky hill on which JA24 sits has an elevation of 26.5m above sea level (Richards *et al.* in prep:1; Figure 3).The surface of the hillock is littered with fossilised coral limestone with inconsistent grass cover and low bushes on the eastern side (Richards *et al.* in prep:1). This site was discovered following systematic archaeological surface surveys of the landscape by a Monash University field team (Richards *et al.* in prep:1). At that stage, it was noted that JA24 had the potential for stratified deposits with a low density, shell and large ceramic surface scatter (David *et al.* n.d.a; Richards *et al.* in prep:1). The overall area of marine shell and pottery sherds scatter was over an area measuring 75m long by 73m wide, equalling $5475m^2$ (Richards *et al.* in prep:1). This surface scatter was orientated on a WNW-ESE long axis on the crest, west and north facing upper slopes of the low hillock (Richards *et al.* in prep:1-2). Additional surface surveys prior to excavation revealed the presence of stone artefacts on the surface that included groundstone adze or axe blades (Richards *et al.* in prep:2).

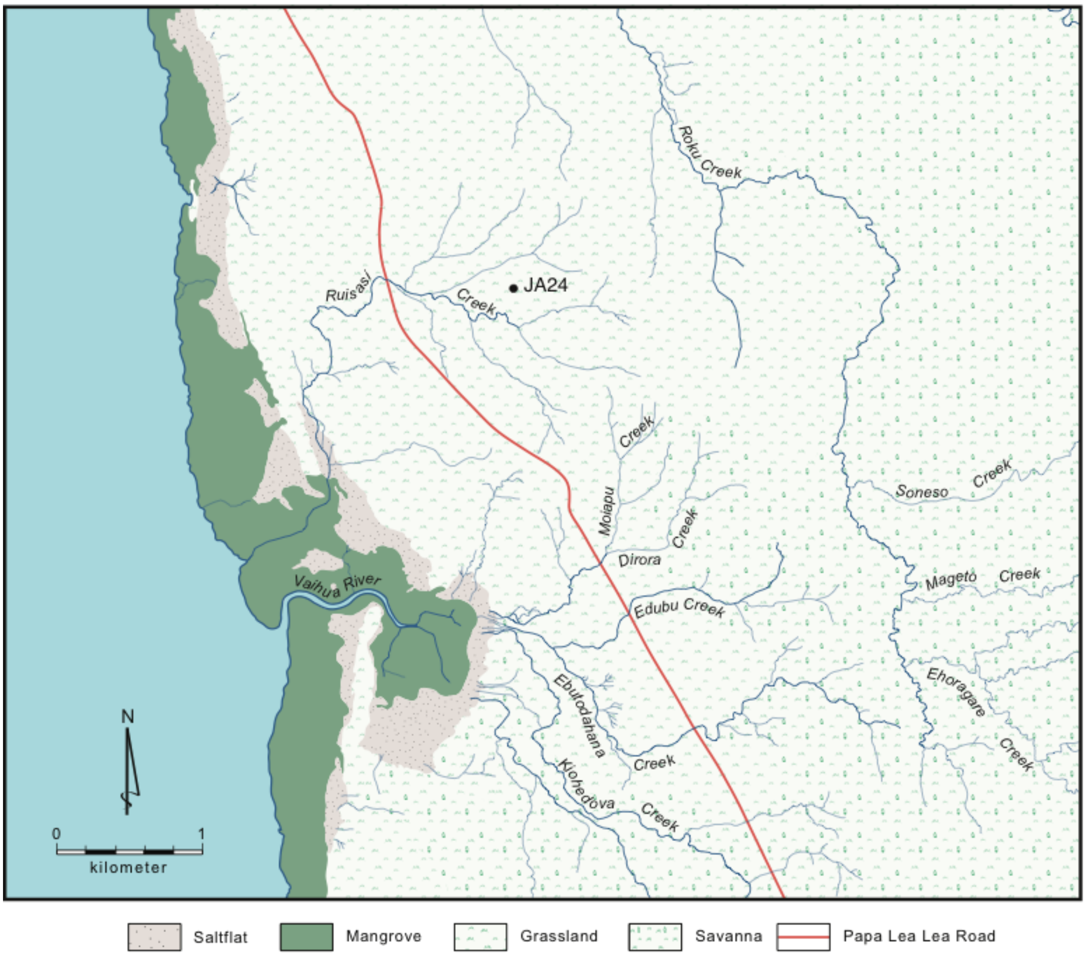

Figure 1. Location of site JA24 (black dot) in the Caution Bay study area (Richards *et al.* in prep:1).

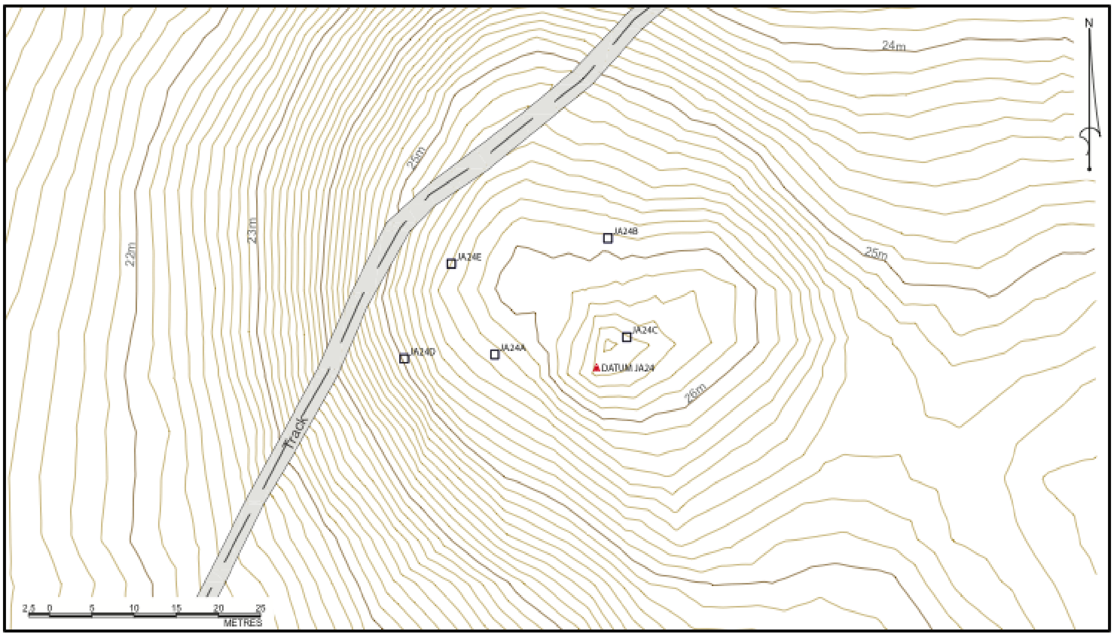

Figure 11.2. Plan of JA24, showing excavation squares A-E. Contour interval is .10 m (Richards *et al.* in prep:2).

Excavations

In line with the standardised field methodology discussed in Chapter 7, a total of five 1m x 1m squares were excavated from 25 October to 12 November 2009 (Figure 11.2). For the purposes of this study, only shellfish assemblages from Square A were analysed. Square A is situated 25.75m above sea level on the west-facing upper slope of the aforementioned hillock and was excavated under the directorship of Ceri Shipton (Richards *et al.* in prep:2). Excavation units averaged 2.2cm in thickness and were excavated to a depth of 49.1cm (Richards *et al.* in prep:2) (Figure 11.3). However excavation of the last four XUs in Square A (SU 4) were reduced in size to 0.50m x 0.50m (Richards *et al.* in prep:2).

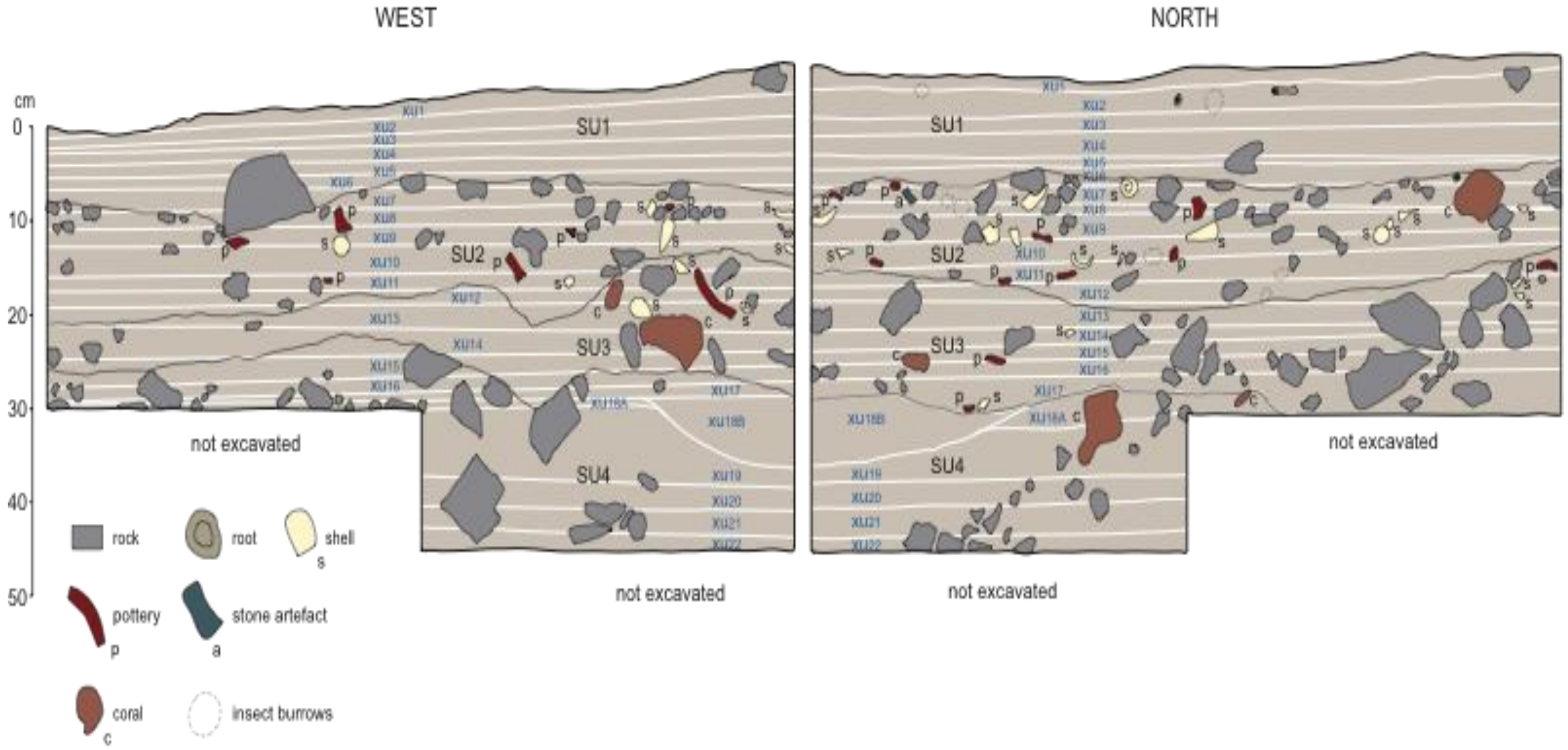

Figure 11.3. JA24, Square A west and north sections with XUs backplotted (Richards *et al.* in prep:3).

Stratigrapic Description: Square A

Four stratigraphic units (SU) were identified during excavation (Richards *et al.* in prep:2) (Table 11.1). SU1 was made up of greyish brown silty clay with presence of some cultural material. SU2 and SU3 is characterised by greyish brown silty clays with abundant gravel and larger rocks (Richards *et al.* in prep:2). Abundant cultural material was found within SU2 before decreasing in SU3 (Richards *et al.* in prep:2). No cultural material was present in SU4 except for downward movement of small material through cracks found in overlaying SU1 to SU3 (Richards *et al.* in prep:2). SU4 comprised of pale brownish grey clay (Richards *et al.* in prep:2).

Table 11.1. Stratigraphic Units, JA24, Square A (Richards *et al.* in prep:4).

SU	Description
1	Dark greyish brown silty clay with frequent rootlets, some small to large pieces of coral and occasional roots. Dry and compact, forms granules when loose. Occasional pottery, shell and lithics.
2	Dark brownish grey gravelly silty clay with frequent rootlets, some small to large pieces of coral and occasional roots. Gravel is composed of coral and limestone. Dry and compact, forms granules when loose. Frequent pottery, shell and lithics.
3	Mid brownish grey gravelly silty clay with large pieces of coral and occasional rootlets. Gravel is composed of coral and limestone. Dry and compact, forms granules when loose. Some pottery, shell and lithics.
4	Pale brownish grey clay, with frequent degrading limestone and sub-rounded pieces of limestone. Dry and compact. Culturally sterile.

Chronology

A total of nine AMS radiocarbon dates were derived from single pieces of marine shell for Square A (Richards *et al.* in prep:2) (Table 11.2). Three species from two shell genus were dated in accordance with ΔR values discussed in Chapter 7 (Richards *et al.* in prep:2-3). Using the 68.2% probability calibrations, seven age determinations from XU5 to XU17 were calibrated to an age range between 1916-

2331 cal BP, median age of 1977-2279 cal BP, thus demonstrating an occupation phase lasting approximately 400 years (Richards *et al.* in prep:3). Dates from the other two samples (XU9 and XU12) fall outside of the identified main occupation phase as these were calibrated to between 1270 and 1488 cal BP, median age of 1340 to 1384 cal BP, and therefore suggests a subsequent minor occupation phase (Richards *et al.* in prep:3). Additionally, both of these anomalous dates from XU9 and XU12 from single pieces of shell have been interpreted to have originated from XUs 1 and 2 (upper ~4cm of Square A) and most likely to have moved downwards from the upper portion of SU1 to lower sections of SU2 through cracks found in the clay (Richards *et al.* in prep:3-4).

Overall, the major occupation phase as determined from radiocarbon dates for Square A (and all of the other squares) at JA24 is between *ca.* 1950 cal BP and 2350 cal BP (Richards *et al.* in prep:3). Two minor occupation phases were also identified. The first minor occupation period as suggested by dates from Square A (and Square B) is from the period *ca.* 1300 to 1500 cal BP (Richards *et al.* in prep:3). While no evidence has been demonstrated from the Square A deposit, it is important to note that an earlier minor occupation phase of *ca* 2400 to 2600 cal BP was derived following radiocarbon determinations from Squares C and D (Richards *et al.* in prep:3). Occupational phases and their respective SUs and XUs are as follows:

- Late Minor Occupation Phase (*ca.* 1300-1500 cal BP) – SU1, XU 1 and 2. Determined by downward movement of shell through cracks in clay.
- Middle Major Occupation Phase (*ca.* 1950-2350 cal BP) – SUs 2 and 3, In situ cultural material is mainly concentrated from XU6 to 22 (~27cm of deposit). This has been interpreted as a middle phase since evidence from Squares C and D nearby suggests that JA24 had a minor early occupation period from *ca.* 2400-2600 cal BP.

Analysis of shellfish remains will therefore be undertaken in relation to both occupation phases. XUs 3, 4 and 5 which falls in-between both of the occupational phases will not be incorporated in this analysis since these XUs may have a mixture of materials from both late and middle phases (Richards *et al.* in prep:4).

Table 11.2. Radiocarbon determinations, JA24 Square A. All ^{14}C ages are AMS. OxCal v 4.2.3 (Bronk Ramsey 2013). (shell: MARINE13 curve selection) (Reimer et al. 2013). ΔR after Petchey et al., 2012, 2013: *Anadara granosa* ΔR = -71±15; *Anadara cf. granosa* ΔR = -39±22; Anadara antiquata ΔR = -1±16; Gafrarium tumidum ΔR = 67±16; Gafrarium sp. ΔR = 60±11) (Richards *et al.* in prep:5).

XU	Depth (cm)	SU	Wk- Lab Code	Material Dated	%Modern ($F^{14}C$ %)	$\delta^{13}C$‰ (IRMS)	^{14}C Age (years BP)	Unmodelled Calibrated Age BP (68.2% probability)	Unmodelled Calibrated Age BP (95.4% probability)	Median Calibrated Age BP
5	7.9-9.3	1	31109	*Anadara cf. granosa* shell	74.0±0.3	-4.1±0.2	2421±28	2037-2158	1992-2253	2108
6	9.3-11.3	1,2	31110	*Anadara granosa* shell	74.2±0.2	-4.6±0.2	2397±26	2054-2165	2012-2257	2119
7	11.3-13.7	1,2	31111	*Anadara granosa* shell	73.8±0.3	-4.5±0.2	2441±29	2130-2251	2085-2295	2187
8	13.7-15.8	1,2	27498	*Anadara granosa* shell	75.0±0.2	-6.7±0.2	2311±35	1950-2067	1900-2118	2011
9	15.8-17.6	1,2	31112	*Gafrarium tumidum* shell	78.8±0.3	-1.7±0.2	1911±29	1327-1426	1300-1488	1384
12	22.8-24.2	2,3	31113	*Gafrarium tumidum* shell	79.2±0.3	-2.2±0.2	1869±28	1299-1371	1270-1422	1340
15	28.3-31.7	3,4	31114	*Gafrarium sp.* shell	72.3±0.2	0.7±0.2	2607±27	2177-2283	2130-2306	2223
16	31.7-34.0	3,4	31115	*Anadara antiquata* shell	72.4±0.3	-3.0±0.2	2596±31	2209-2215 2240-2331	2152-2346	2279
17	34.0-36.0	3,4	27499	*Anadara granosa* shell	75.3±0.2	-5.2±0.2	2284±38	1916-2035	1870-2098	1977

Cultural Materials

A range of cultural material was unearthed from Square A from XU1-22 but only minimal discards of cultural material found after XU17 where SU3 joins SU4 (Richards *et al.* in prep:4). XU6-17 has the main concentration of material, with any remains found from XU18 onwards deemed to be representative of downward movement through cracks in the clay (Richards *et al.* in prep:4). No in situ material was discovered in SU4. In order of weight, marine shell dominates Square A, followed by ceramics and stone artefacts (Richards *et al.* in prep:4). XU9 (SU2) has the densest discard of cultural material (Richards *et al.* in prep:4). Apart from shellfish remains which are discussed below, other cultural materials (bone, ceramics and shell artefacts) are still being analysed and detailed results of this analysis will be available sometime in the future. A preliminary analysis of lithics has demonstrated the presence of obsidian in all JA24 squares with 22 flaked obsidian pieces (ongoing sourcing analysis) found in Square A (Richards *et al.* in prep:4). As this study is part of ongoing archaeological investigations at Caution Bay undertaken by a multi-disciplinary team, and given the time limitations for this thesis, I will only be discussing shellfish remains from JA24 Square A in conjunction with the limited available datasets on ceramics and stone artefact discard.

Shellfish Remains Square A

Unlike Tanamu 1, analysis of the JA24 Square A shellfish assemblage was undertaken by myself using a slight variation in methods (see Chapter 8), with the derived data revealing certain important trends in marine resource use. Altogether 84 shellfish species were present within Square A comprising of 55 marine gastropods, 28 marine bivalves and 1 freshwater bivalve. In terms of weight, 72% (6423.61g) of shellfish were identified to either Family, Genus or species with 28% (2505.65g) of remains not identified as a result of high levels of fragmentation and/or weathering. Of the identified components, gastropods accounted for 4741.9g (53%) of the assemblage while bivalves represented only 19% (1681.69g). Varying intensities of mollusc discard between XUs were also evident, ranging from 2.29g in XU2 to 1715.04g in XU9. Small quantities of Maxillpoda (barnacle, 9.5g), Vermetidae (wormtube, 1.1g) and Hemitoma (8.58g) were also present in Square A. By weight, four taxa (*Conomurex luhuanus*, Strombidae, Ostreidae and *Anadara granosa*) made up for 77% of the assemblage, clearly revealing the relative importance of certain species.

Figures 11.4 and 11.5 demonstrate the order of importance (taxonomic representation) in relation to both weight and MNI for the top 20 taxa. By weight, the species most prevalent in Square A (top 10) were *Conomurex luhuanus* (2915.55g, 45.39%), Strombidae (915.32g, 14.25%), Ostreidae (647.47g, 10.08%), *Anadara granosa* (481.54g, 7.5%), *Lambis* spp. (148.49g, 2.31%), *Calliostoma* spp. (146.79g, 2.29%), *Laevistrombus canarium* (144.13g, 2.24%), *Polymesoda erosa* (123.92g, 1.93%), *Batissa violacea* (102.69g, 1.6%), *Telescopium telescopium* (91.58g, 1.43%).

By MNI, a total of 1312 individuals was derived for Square A with 1007 gastropods and 305 bivalves. These results are in line with weight determinations as they reinforce the preference for gastropods over bivalves. *Conomurex luhuanus* (MNI 369, 28.13%), *Calliostoma* spp. (MNI 220, 16.77%) and Ostreidae (MNI 176, 13.41%) account for 58.31% of the assemblage by MNI. In addition, the following 7 taxa round out the top 10 species by MNI: *Cerithidea largillerti* (MNI 65, 4.95%), *Canarium urceus* (MNI 60, 4.57%), *Tectus fenestratus* (MNI 58, 4.42%), *Telescopium telescopium* (MNI 33, 2.52%), *Anadara granosa* (MNI 32, 2.44%), *Canarium labiatum* (MNI 26, 1.98%) and *Batissa violacea* (MNI 22, 1.68%).

Relative Importance of Mollusc Taxa

From both MNI and weight, it appears that while a wide variety of taxa are present, the subsistence economy of local peoples was focused on fewer shellfish species in comparison to the other sites analysed in this study. These few species may vary in size from larger (e.g. *Conomurex luhuanus*) to smaller (e.g. *Calliostoma* spp.) taxa but were nonetheless of economic importance as evidenced by their quantities of discard. A number of other taxa (e.g. *Cerithidea largillerti*, *Canarium urceus*, *Batissa violacea*) which occur in much lesser numbers are in this case also considered economic because they are only present in the Middle Major Occupation phase and are also known for their cultural use in southern PNG.

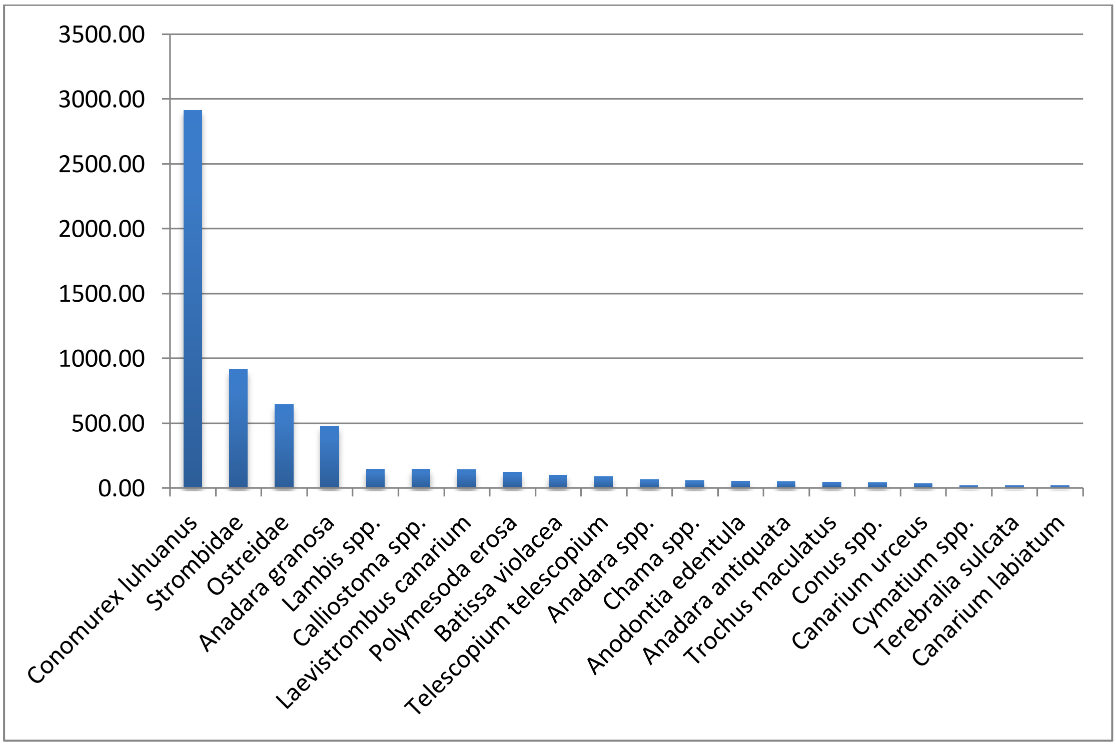

Figure 11.4. Ranking of shellfish taxa from Square A by weight.

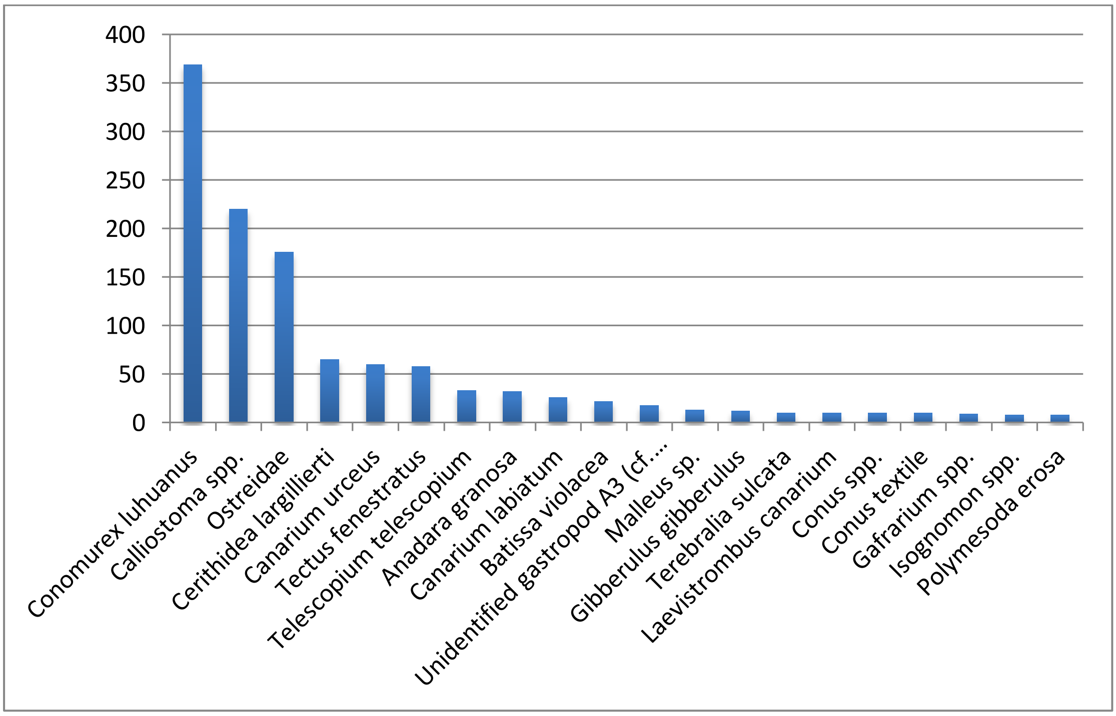

Figure 31.5. Ranking of shellfish taxa from Square A by MNI.

For instance, taxa such as *Nerita undata* (MNI 6, 0.46%), *Gafrarium tumidum* (MNI 5, 0.38%), *Anadara antiquata* (MNI 2, 0.15%) and *Conus arenatus* (MNI 1, 0.08%) occur in relatively fewer numbers at JA24 but are found in larger quantities at other Caution Bay sites and have been documented to be of cultural importance (food, artefact production) at other locations from past archaeological, ethnohistoric and ethnographic investigations. Rather than assigning such taxa as non-economic, the occurrence of these species in low quantities at JA24 instead presents a site-specific scenario relating to similar evidence seen at both Tanamu 1 and Bogi 1 during post-Lapita occupation where a greater emphasis was placed on a certain few taxa such as *Conomurex luhuanus*. Hence, local peoples at JA24 probably targeted a select few species in greater numbers while others were also exploited but to a much lesser degree. Whether this strategy was due to availability and/or distribution of certain species, hence correlating with low MNI for a majority of the taxa as a result of possible environmental or cultural processes will be discussed further in Chapter 12. In addition, a portion of the Square A assemblage was interpreted as likely being non-economic (MNI 29, 0.02%) since these were extremely small-sized (less than 10mm) and may have been brought into the site naturally or accidentally.

Shell Artefacts

As mentioned in previous site chapters for Tanamu 1 and Bogi 1, analysis of worked shells is currently being undertaken by specialists and will be reported at a later date. Similarly, worked shells from JA24 will also be analysed in the future as part of the multi-disciplinary research strategy for Caution Bay. While pre-Lapita phase shell artefacts have been identified for Tanamu 1, a number of worked shells were also noted during the laboratory sorting phase for JA24, represented by common taxa used for artefact manufacture (e.g. *Conus* spp. and *Cypraea* spp.). Dating to the post-Lapita period, these artefacts have the potential for documenting temporal changes in shell artefact technology at Caution Bay and results for the JA24 shell artefact assemblage will be reported elsewhere.

Trends in Shellfish Exploitation between Major and Minor Horizons

A number of significant differences are seen in shellfish exploitation between the minor and major horizons at JA24. Unlike SU1, a much larger range and number of shellfish were targeted during the Middle Major Occupation Phase (SU2-3), a period dating to post-Lapita times at Caution Bay. The main exploited taxa during this phase *Conomurex luhuanus, Calliostoma* spp. and Ostreidae were supplemented by a range of gastropod and bivalve species. An important difference between SU1 and SU2-3 is that apart from *Conomurex luhuanus* and *Telescopium telescopium* which occur in both phases, all other economic taxa are only represented within the Middle Major Occupation Phase (Table 11.3). This trend may be a product of environmental and/or cultural processes in relation to species availability and/or distribution within the Caution Bay landscape. Nonetheless, the predominance of gastropods, particularly Conomurex *luhuanus* aligns with trends seen at both Tanamu 1 and Bogi 1. As SU4 represents the basal layer with no in-situ material present, analysis of this SU is therefore not required.

During the Late Minor Occupation Phase (SU1, XU1-2), only a small range of taxa were targeted (2 species) with low discard rates when compared with the Middle Major Occupation Phase (SU2-3, XU6-22) in which more than 80 species are present. The majority of molluscan remains in SU1 (XU1-2) are represented by *Conomurex luhuanus* and *Telescopium telescopium*. While 53% of the assemblage in SU1 is accounted for by Unidentified gastropod A3 (cf. *Subulina octona*), this taxa is considered to have been naturally or accidentally brought into the site since it is an extremely small-sized species (less than 10mm) and thus would likely not have been an economic choice (Figure 11.6).

Table 11.3. Example of taxa only prevalent in SU2-3 (Middle Major Occupation Phase) than in SU1 (Late Minor Occupation Phase).

Bivalves	Ostreidae, *Anadara granosa*
Gastropods	*Canarium urecus, Tectus fenestratus, Canarium labiatum*
Small-sized taxa	*Calliostoma* spp., *Cerithidea largillerti*

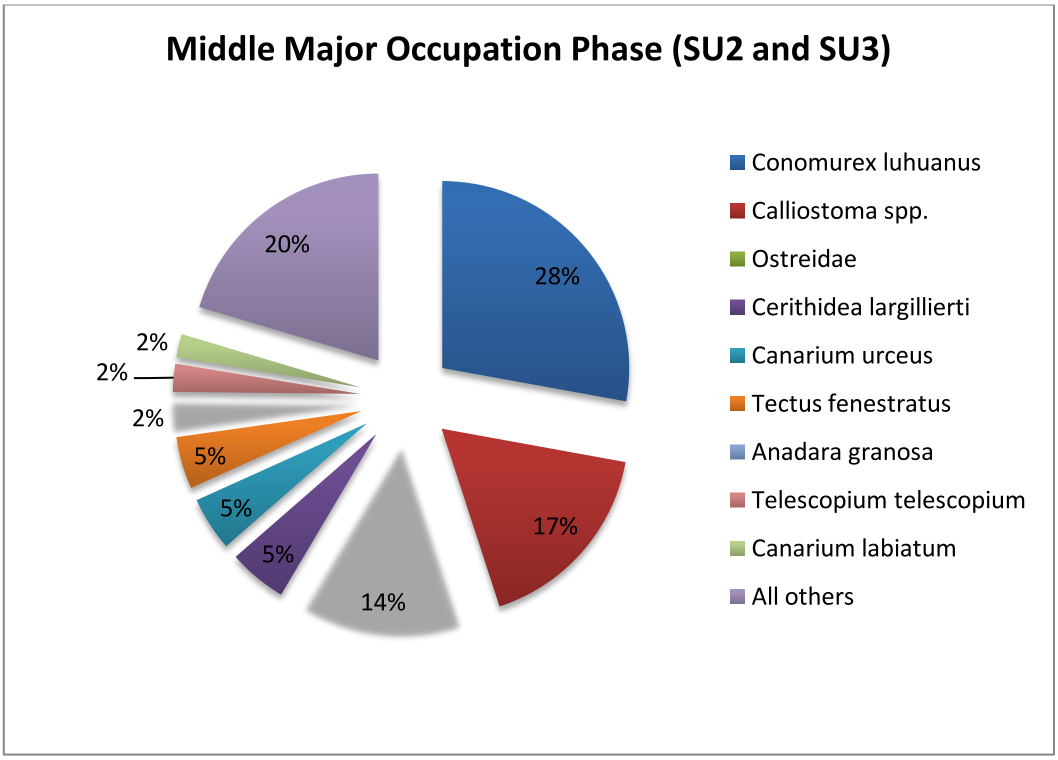

Figure 11.6. Main shellfish species in Middle Major Occupation Phase.

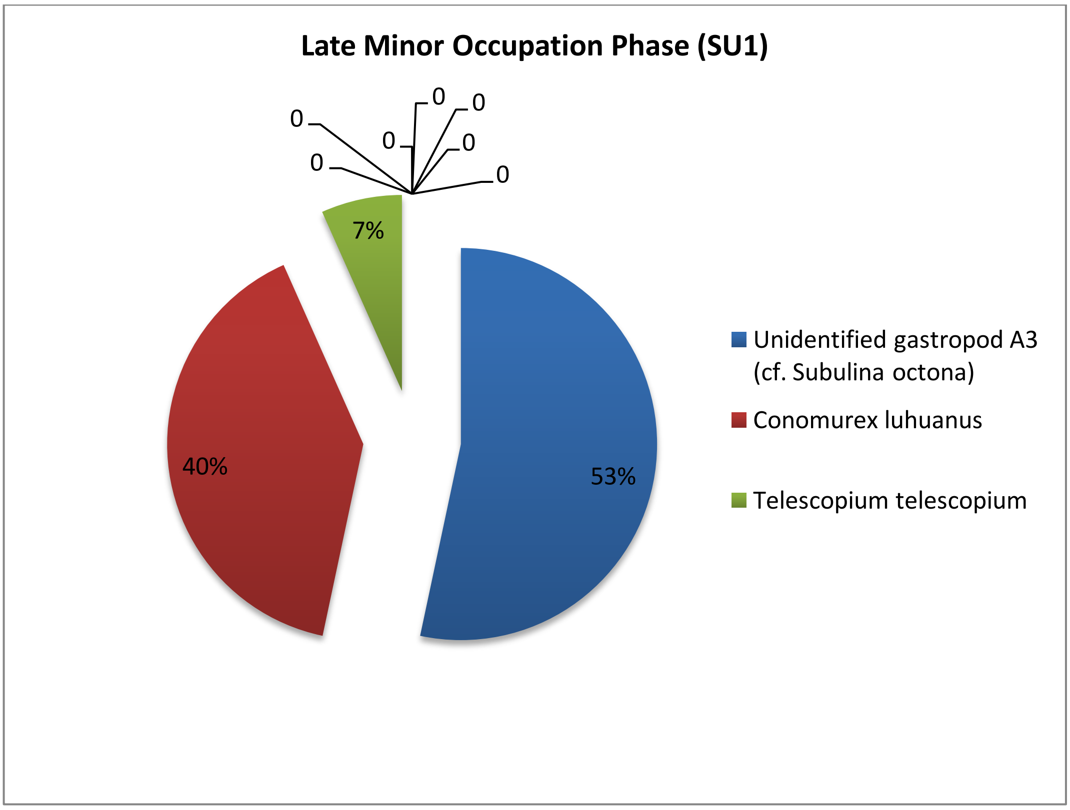

Figure 11.7. Main shellfish species in Late Minor Occupation Phase.

Differences in Habitat Use

Shellfish assemblages from both Tanamu 1 and Bogi 1 demonstrate a focus by past peoples on shellfish taxa belonging to a number of habitats. Habitat use by peoples at JA24 was however somewhat different since this site is further inland which may consequently have had an impact on access to different habitats. Because JA24 only has a post-Lapita horizon, trends in habitat use will be analysed in relation to other post-Lapita shellfish assemblages (see Chapter 12).

Within this post-Lapita occupation phase, Figure 11.8 demonstrates differences in chronostratigraphic use of habitats and a summary of key trends for both the Middle Major Occupation and Late Minor Occupation Phases. In SUs2-3 (Middle Major Occupation Phase), the wide variety of shellfish species found correspond to a number of habitats that were targeted. However, sandy substrates and seagrass meadows together with rocky and sandy intertidal habitats were heavily targeted as evidenced by discard rates (MNI %) of *Conomurex luhuanus* (28%), *Calliostoma* spp. (17%) and Ostreidae (14%). This top order of taxonomic representation is then followed by the muddy substrates taxa *Cerithidea largillerti* (5%), sandy intertidal species *Canarium urceus* (5%), rocky intertidal taxa *Tectus fenestratus* (5%) and the mangrove species *Anadara granosa* (2%) and *Telescopium telescopium* (2%). Most importantly, evidence points to a heavy reliance on 3 main taxa from fewer habitats and while many other species (total of 84 taxa) belonging to various habitats are present, the relatively low discard numbers of such taxa reaffirms that a focused shellfish subsistence strategy was employed. In comparison, only 2 economic species belonging to mangroves (*Telescopium telescopium*), sandy substrates and seagrass meadows (*Conomurex luhuanus*) are present in SU1 (Late Minor Occupation Phase). Thus, during this time, a distinct change in shellfish procurement is seen with much less of a focus on habitat diversity together with an overall decrease in shellfish subsistence strategies.

Overall, chronostratigraphic patterns of mollusc exploitation by habitat at JA24 shows that people chose to focus on a limited number of habitats with different substrates when compared with the sequences for Tanamu 1 and Bogi 1. While I will explore the possible reasons for a focused/smaller shellfish subsistence base in Chapter 12, the main points for habitat use are:

Major Middle Occupation Phase (SUs2-3) - Mollusc were collected from a wide variety of habitats but there was a greater focus on certain specific taxa (>50% of assemblage) (e.g. *Conomurex luhuanus*) from a particular habitat.

Late Minor Occupation Phase (SU1) – Much less emphasis on shellfish subsistence with only two taxa exploited from two habitats.

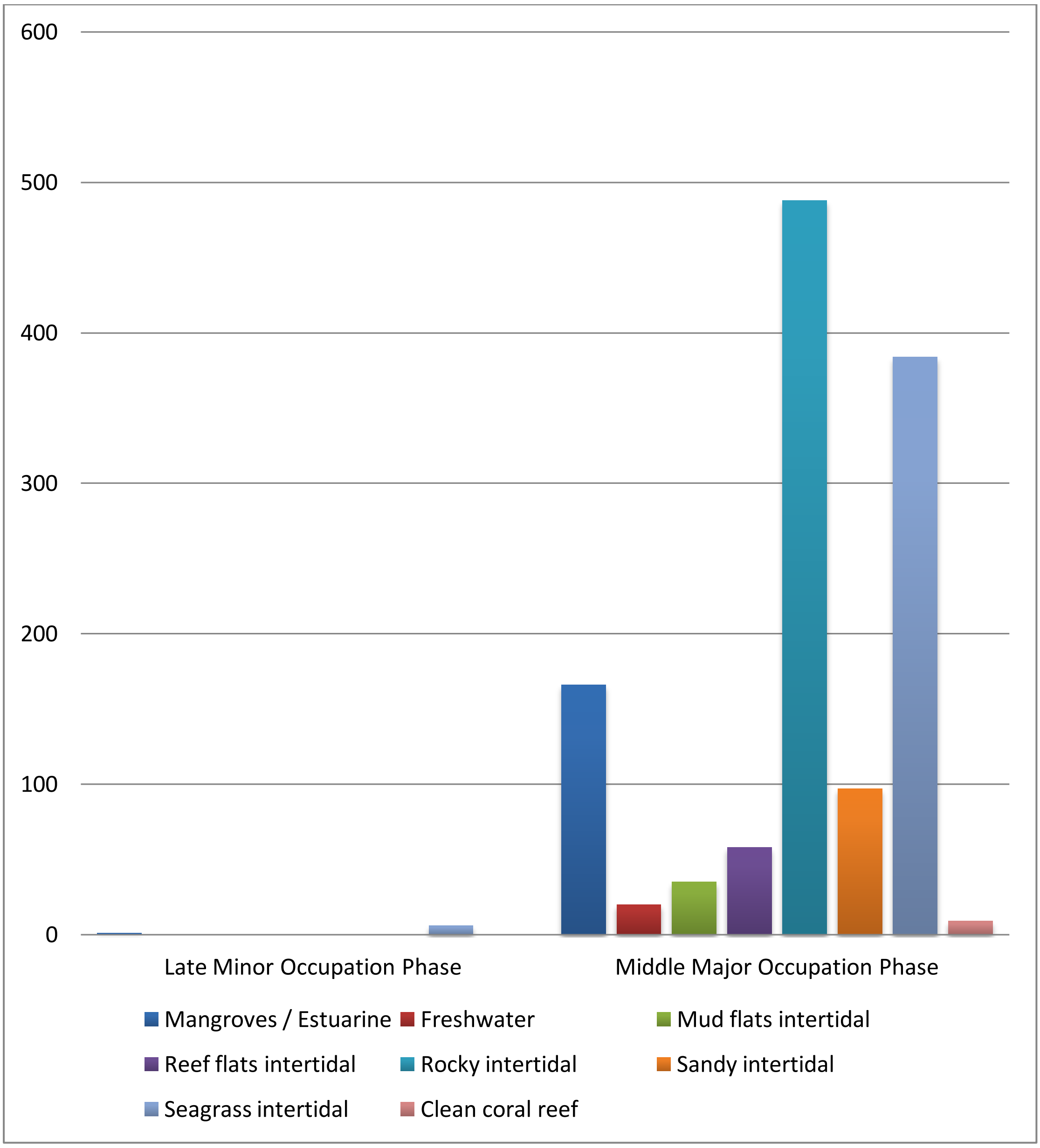

Figure 11.8. MNI of shellfish taxa by SU for each habitat.

Intensity of Mollusc Exploitation

The large emphasis placed on mollusc gathering with high levels of discard in SUs2-3 clearly demonstrates that shellfish resources played an integral role in local subsistence economies at JA24. To further investigate the relative importance of shellfish, Figures 11.9 and 11.10 reveal that while bivalves were targeted in moderate numbers during the Middle Major Occupation Horizon, this practice was not evident in the subsequent Late Minor Occupation Horizon (MNI 300 vs MNI 0). On the contrary, gastropods were clearly targeted more intensively than bivalves within SUs2-3 (MNI 985 vs MNI 300) but there is again a drastic reduction in gastropod exploitation over time (MNI 985 vs MNI 15).

Overall MNI of shellfish remains in Square A also demonstrates the importance of mollusc as a subsistence resource (Figure 11.11). Discard rates of MNI 1285 during the Middle Major Occupation period shows that shellfish exploitation was at its greatest during this time before it drastically recedes during the subsequent Late Minor Occupation Phase. Because the temporal range for occupation differed for each cultural phase (400 years for Middle Major Occupation Phase vs 200 years for Late Minor Occupation Phase), analysis of total discard per phase as an arbitrary analytical unit needs to investigated further in order to ascertain this trend in intensity of shellfish exploitation. When analysed by using MNI discard per 100 years of occupation (Figures 11.12 and 11.13), results clearly depict the degree in which mollusc were targeted at JA24. During the Major Middle Occupation Horizon, mollusc were being exploited intensively at an estimated rate of 321 MNI per 100 years which in turn was significantly higher than the subsequent Late Minor Occupation Horizon where shellfish as a subsistence resource only represent approximately 8 MNI per 100 years. Therefore, in relation to levels of exploitation (MNI per 100 years), Late Minor Occupation Horizon peoples only contributed 2% while the period of shellfish exploitation at its greatest and most intense (98%) was accounted for by peoples during the Middle Major Occupation Phase.

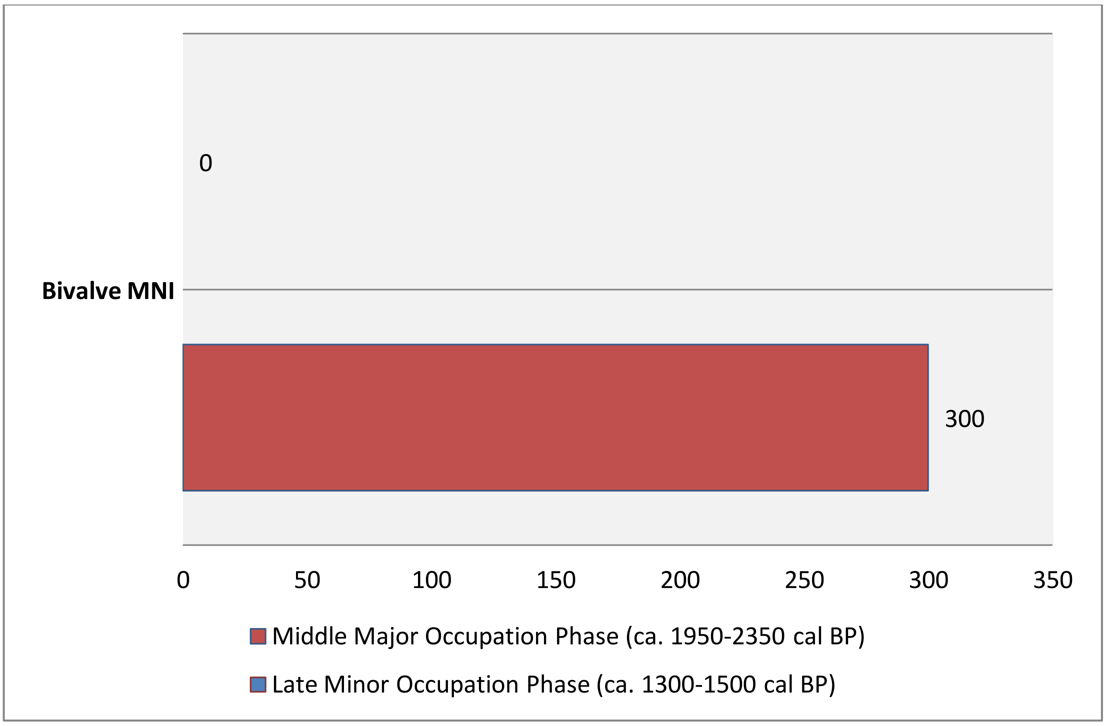

Figure 11.9. Total MNI for bivalves per cultural horizon.

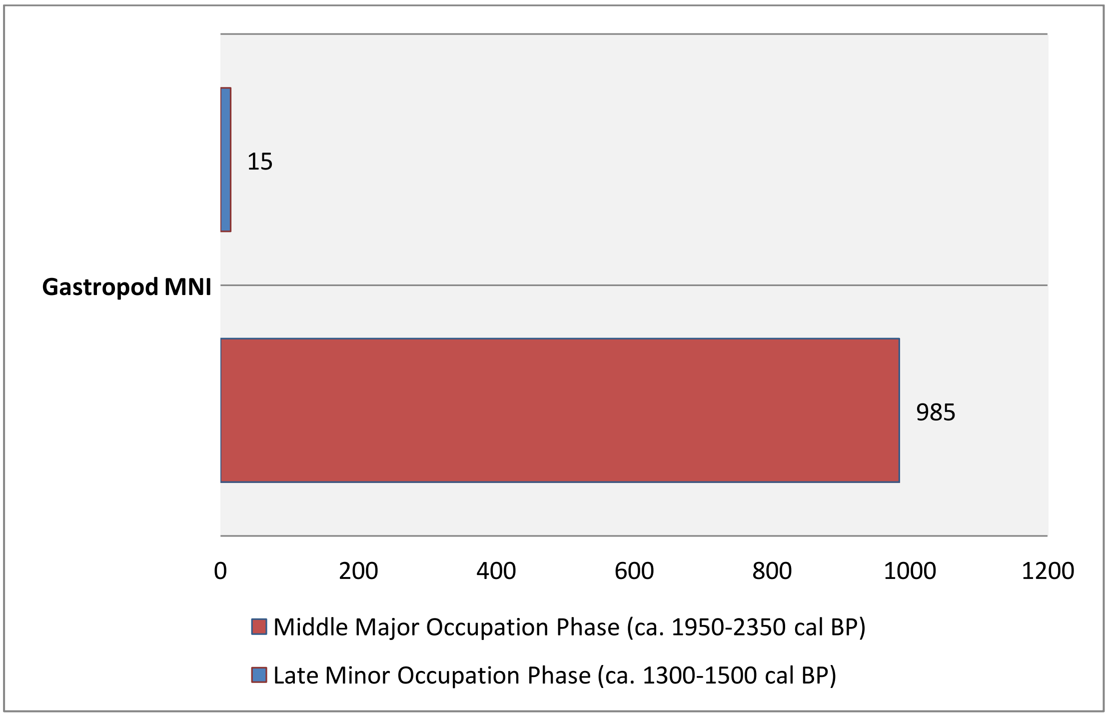

Figure 11.10. Total MNI for gastropods per cultural horizon.

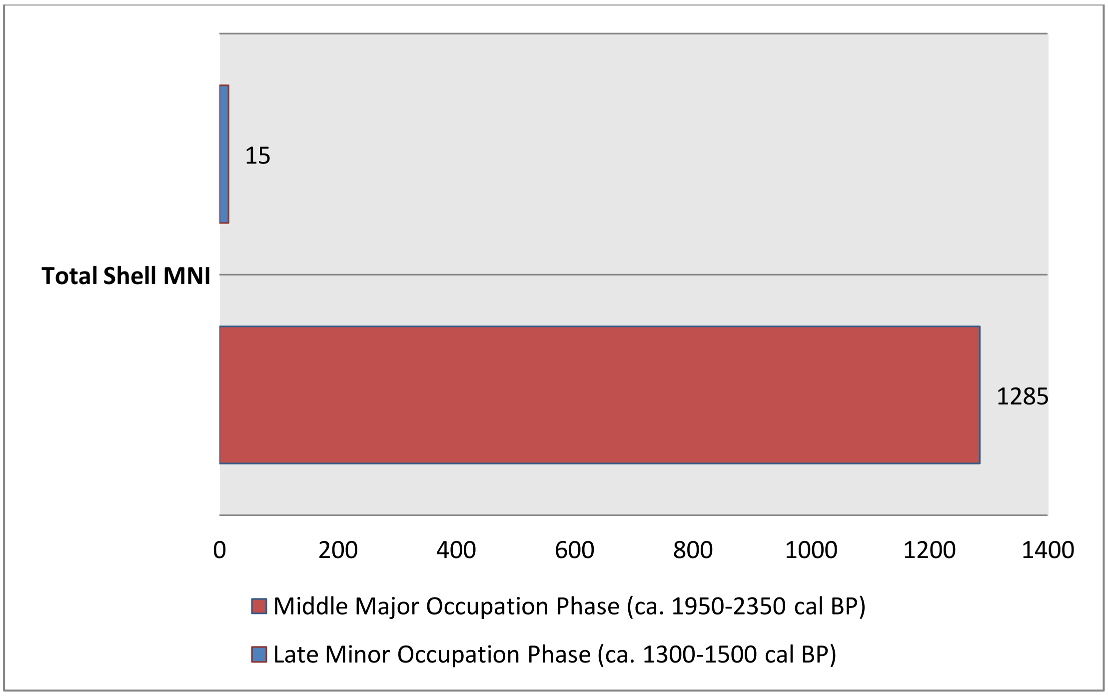

Figure 11.11. Total MNI for shellfish per cultural horizon.

Figure 11.12. Total shellfish discard by MNI per 100 years between cultural horizons.

Shell Size Analysis

Since the majority of the species incorporated in morphometric analysis in previous Chapter 9 and 10 were either not present or occurred in small numbers, only *C. luhuanus* was used for size analysis from the JA24 shellfish assemblage as it was the dominant taxa. While taxonomic representation of this species was evident for both major and minor phases, individuals present in the Late Minor Occupation Phase were too fragmented to allow for measurements of overall size of this taxa (see Chapter 8). Therefore, while results from this analysis are only available for one phase (Major Middle Occupation Phase), this data still provides an insight into any changes in size-structure of this taxa during post-Lapita occupation when compared with other results from both Tanamu 1 and Bogi 1 for the same temporal post-Lapita period. Discussion and comparisons of data will be presented in Chapter 12, but a brief description of the analysis for the JA24 *C. luhuanus* assemblage is provided here.

Table 11.4. Proportion of measured shells by MNI for *Conomurex luhuanus*.

Species	MNI	Measured	Not measured
Conomurex luhuanus	369	172 / 46.41%	197 / 53.59%

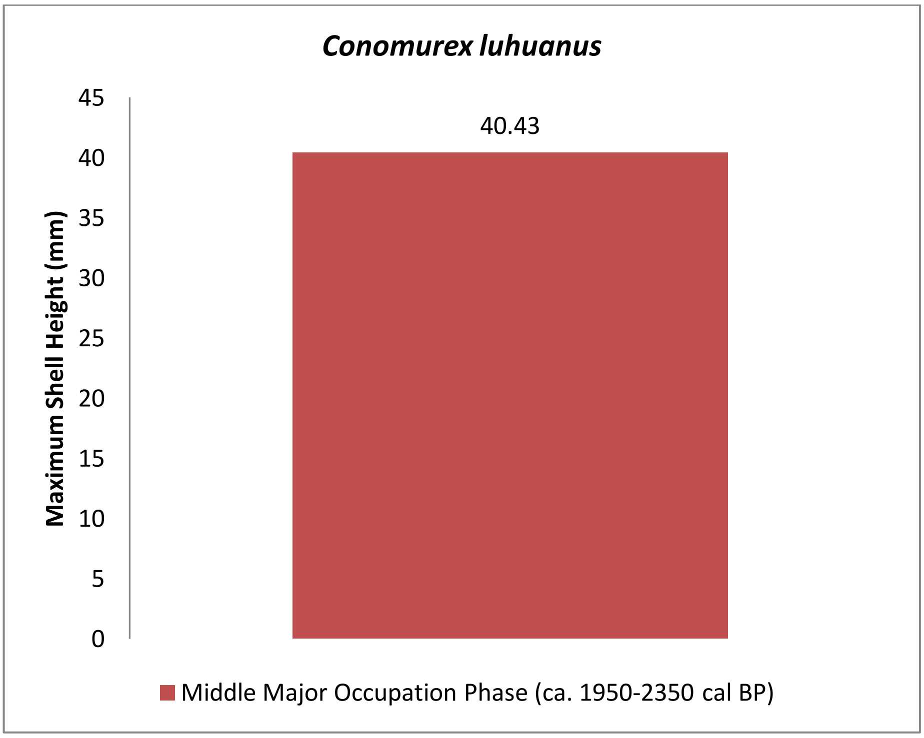

Figure 11.13. Mean overall size of Conomurex *luhuanus* in major cultural horizon.

A total of 172 (46.41%) out of 369 individuals were measured with 197 MNI (53.59%) not measured because of shell fragmentation. The mean maximum shell size in the Middle Major Occupation Phase was 40.43mm. When compared to ecological data, the JA24 *C. luhuanus* has a smaller overall size-structure as the natural population size record for this taxa is a maximum length of 80 mm with most individuals measuring 50 mm in length (see Chapter 8). Hence, there appears to be some pressures exerted on this taxa, and this may be a product of human predation and/or environmental change. Cross-comparison with both Tanamu 1 and Bogi 1 *C. luhuanus* assemblages will provide further insight into this trend.

Discussion

Investigations into the JA24 shellfish assemblage has revealed several distinct patterns on mollusc exploitation by past peoples at this site. The overall trends discussed thus far can be further summarised in relation to the discard of other cultural elements. Table 11.5 provides details for discard of major cultural categories that are available. Given analysis of these each cultural element is still ongoing, only weights and MNI were made available with results of completed analysis to be reported in the future.

Middle Major Occupation Phase (ca. 1950-2350 cal BP)

Ceramic remains undoubtedly represent the most distinct cultural element during this phase with high discard rates by both MNI and weight. This peak in discard is also accompanied by a substantial increase in artefact manufacture. Whether ceramic remains found during this phase exhibit stylistic features reminiscent of other post-Lapita sequences elsewhere is still uncertain. However, both peaks in ceramic and stone artefact discard do emphasise the importance of this site within the Caution Bay landscape as it was very likely that such large rates of discard may point to a scenario of resource intensification. While further analysis of other faunal remains may shed light on past subsistence economies at the location, the high discard rates for mollusc remains supports the possibility of increased occupational and resource use activity at this site. Shellfish resources were exploited intensively (MNI 1285) with a greater focus on a few select species and habitats. When analysed together with evidence for ceramics and stone artefacts, it clearly demonstrates intensive site use especially when the occupation only lasted for 400 years. Because there is no evidence for Lapita occupation at JA24, cross-comparisons of site use and intensities in resource procurement need to be undertaken together with both Tanamu 1 and Bog 1 post-Lapita sequences. Nonetheless, the evidence examined here is in line with other major sites whereby shellfish exploitation during the post-Lapita period is characterised by reduced taxa diversity with more dependence on certain species, especially gastropods. Whether this regional trend is a product of environmental and/or social processes will be discussed in the next chapter.

Late Minor Occupation Phase (ca. 1300-1500 cal BP)

While pottery and stone artefacts occur during this Late Minor Occupation Phase, there is a drastic reduction in rates of discard (MNI and weight) for both cultural elements despite the 200 year temporal occupational sequence. Molluscan remains also decrease dramatically in both overall discard and species diversity. While this pattern suggests a significant decrease in site and resource use, analysis of other faunal remains will provide an insight into whether there was a shift in subsistence focus since JA24 is situated further inland, in which distance may have reduced access to certain shellfish species. More importantly, as significant changes in settlement patterns occurred during the post-Lapita period from *c.* 1200 to 500 years ago along the southern Papuan coast, referred to as the 'Ceramic Hiccup' (see Chapter 4), it is more likely that this drastic reduction in site and resource use at JA24 marks a period leading into the 'Ceramic Hiccup'. As major changes to cultural practices, especially with reduction in cultural interaction, decreases and/or absence of ceramics together with new, regionalised social conditions and a re-adjustment to local social conditions were taking place, the Late Minor Occupation Phase was perhaps a precursor to the eventual broader Ceramic Hiccup. This I believe presents a plausible scenario since people were beginning to no longer occupy JA24 intensively nor exploit much shellfish or produce large number of ceramics, stone artefacts, all of which are indicative of impending cultural change within the wider region.

Table 11.5. General list of excavated materials by XU, JA24, Square A (Richards *et al.* in prep:6).

XU	SU	Shell	Bone	Crusta-cean	Sea Urchin	Char-coal	Ceramic Sherds		Stone Artefacts		Shell Artefacts
		g	g	g	g	g	#	g	#	g	g
1	1	23.71					21	26.59	39	53.97	
2	1	2.29					23	10.84	18	2.19	
3	1	3.93					5	1.35	5	0.25	
4	1	6.84					10	2.70	21	0.66	
5	1	19.13					8	9.30	14	4.25	
6	1,2	264.10					70	40.15	79	73.72	
7	1,2	759.26					520	187.59	156	161.71	
8	1,2	434.02					540	253.11	205	156.59	
9	1,2	1715.04					1494	348.36	216	270.55	
10	2,3	1674.06					892	333.02	201	160.50	
11	2,3	828.08					582	190.60	145	104.45	
12	2,3	976.17					424	129.09	92	61.18	
13	2,3	543.49					299	144.94	49	43.21	
14	3,4	286.51					189	46.10	27	9.92	
15	3,4	154.73					4	2.78	9	2.87	
16	3,4	83.23					5	6.08	5	4.03	
17	3,4	53.51					2	1.88	1	7.35	
18a	3,4	7.21					1	0.31	1	0.52	
18b	4	0					0	0	0	0	
19	4	0.17					0	0	0	0	
20	4	0					0	0	0	0	
21	4	0					0	0	0	0	
22	4	0					2	59.14	0	0	
Total		7835.48					5091	1793.93	1283	1117.92	

Conclusion

As an inland site with ceramic remains, JA24 presents a different scenario since there is no evidence for Lapita occupation. The appearance of this site following the cessation of the Lapita signature at other nearby sites suggests territorial expansion from the costal margins to further inland. Perhaps a result of population increase or greater cultural activity, it is clear that JA24 was occupied by a sedentary population to whom ceramics were of great significance. Archaeological evidence from shellfish remains strongly suggests intensive exploitation of mollusc during the major period of ceramic production and clearly shows that people were focusing on shellfish despite being situated further inland. However, clear choices were made on which shellfish and habitats were to be targeted at greater levels, thus following a post-Lapita trend discussed in previous chapters. This pattern may be attributed to environmental and/or socio-cultural scenarios. However, the distinct changes derived in the archaeological record for JA24 during the Late Minor Occupation Phase suggests that socio-cultural factors may have played an important role in leading to site abandonment because major changes to cultural practices were occurring on a regional scale, as evidenced by the subsequent Ceramic Hiccup phase. These scenarios will be discussed further in Chapter 12 following a discussion of mollusc results from all three sites.

Chapter 12 – Shellfish Exploitation and Change at Caution Bay: A Synthesis

Introduction

Evidence from the archaeological record for shellfish exploitation at Caution Bay has revealed different patterns between all three phases of occupation. However, a synthesis of overall trends needs to be undertaken in association with the environment, and socio-cultural factors that include 'contact' between local and Lapita culture, and major chronological sequences during the subsequent post-Lapita transformation (e.g. Ceramic Hiccup). In order to better understand how shellfish gathering may have transpired and what they represent in terms of a broader shellfish subsistence economy, this Chapter will provide a discussion of overall trends by taking into account all of the evidence procured from all three sites.

Sequences of Occupation

Temporal radiocarbon sequences for human occupation at Caution Bay consists of three major chronological blocks represented by pre-Lapita/pre-Ceramic, Lapita and post-Lapita/Ceramic phases. The earliest evidence for occupation, dating to approximately 5000 cal BP at Tanamu 1 demonstrates use of the Caution Bay landscape during the mid-Holocene. Similar evidence is also present from radiocarbon determinations for Bogi 1 where the pre-Lapita phase has been dated to >4500 cal BP. Thus, occupation at Bogi 1 may possibly also be close to 5000 cal BP since the minimum radiocarbon age for this site is 4500 cal BP. Likewise, another similarity is also seen with the timing of Lapita occupation as evidenced by ceramic remains, with this phase beginning at 2900 cal BP at Bogi 1 and ca. 2800 cal BP at Tanamu 1. Although the timing of initial occupation and date of the presence of Lapita pottery varies marginally between Bogi 1 and Tanamu 1, it is considered that both Bogi 1 and Tanamu 1 probably represent two distinct areas found within the same settlement. Bogi 1 and Tanamu 1 are only separated by 140m while also occurring on the same exposed sand dune close to the sea, a strategic location which would have given greater access to marine resources from different habitats. Therefore, in terms of a broader chronological sequence, both pre-Lapita and Lapita phases at Bogi 1 and Tanamu 1 are indicative of human occupation of a single larger settlement, with different levels of cultural activity possibly occurring in each area.

Post-Lapita occupational phases at Caution Bay are present in all three sites (Bogi 1 and Tanamu1) including the inland JA24 site where evidence for a Lapita phase was not present. The presence of varying levels of ceramic remains with different stylistic features within these deposits, nonetheless, reaffirms the notion that all three sites are perhaps representative of a mostly continuous occupational event that occurred during the broader post-Lapita transformative phase. In its entirety, the post-Lapita phase most likely occurred between 2600 and c. 100 cal BP at Caution Bay (Bogi 1 – 2200 to c. 2000 cal BP, JA24 – c. 2350 – 1950 cal BP and 1500 to c. 1300 cal BP, Tanamu 1 – 700 to c. 100 cal BP). However, this temporal sequence can be deconstructed further in relation to other major cultural chronologies of the southern coast of Papua New Guinea (see Chapter 4). Similarities in radiocarbon ages for post-Lapita occupation at Bogi 1 and JA24 (Middle Major Occupation Phase) means that analysis of broader shellfish trends can be applied to both sites to a certain extent. While it is likely that both sites were different, since JA24 is situated 2.3 km inland from the coast, they were probably still part of the broader Caution Bay settlement. With the appearance of numerous other archaeological sites at or after 2000 cal BP in nearby areas (see Chapter 4), it is important to consider both differences and similarities in shellfish exploitation in relation to spatial differences between both the coastal settlement and the inland site JA24.

The subsequent Late Minor Occupation Phase at JA24 dating to c. 1500 to 1300 cal BP, also demonstrates continued use of the Caution Bay landscape by local occupants. The paucity of radiocarbon determinations and material culture evidence from 1300 cal BP (JA24) to 700 cal BP (Tanamu 1) correlates to some extent with previously known archaeological evidence for a Ceramic Hiccup that occurred between c. 1200 and 500 years ago (see Chapter 4). This, in turn, needs to be taken into consideration in terms of a broader cultural trend during analysis of the shellfish assemblage from JA24's Late Minor Occupation Phase. Although there may seem to be a gap between 1300 and 700 cal BP, this does not represent a hiatus in occupation since a number of other post-Lapita sites have been found and following the completion of analysis will likely fill this gap (David *et al.* completed ms:74). In addition, radiocarbon evidence for occupation at Tanamu 1 from 700 to c. 100 cal BP occurs during a period that has been associated with an increase in cultural interactions around 700 cal BP after the Ceramic Hiccup and a subsequent increase in cultural interaction after c. 500 cal BP leading up to the ethnographic *hiri* period. Since the evidence as a whole clearly demonstrates a broader continued occupational event from pre-Lapita to Lapita and post-Lapita periods. Interpretation of overall shellfish trends from all three sites needs to be undertaken in relation to the following combined temporal sequences for Caution Bay:

- Pre-Lapita/pre-Ceramic Phase (c. 5000 to 2900 cal BP) (Sites Bogi 1 and Tanamu 1) - A period devoid of pottery but still occupied by a local population.
- Lapita Phase (2900 to c. 2600 cal BP) (Sites Bogi 1 and Tanamu 1) – Associated with the arrival and establishment of Lapita occupation and emergence of pottery.
- Post-Lapita Phase (2200 to c. 100 cal BP) (Sites Bogi 1, Tanamu 1 and JA23) - Associated with the end of the Lapita ceramic signature (post-Lapita Ceramic and cultural traditions), before and after the Ceramic Hiccup up to the ethnographic period.

It must also be noted that while there is an apparent gap in occupation from between c. 2600 and 2200 cal BP as evident from the Bogi 1 radiocarbon determinations, it is highly possible that there is no hiatus in occupation since some low levels of cultural material was found between the Lapita and post-Lapita phases at this site but was not analysed as it represents a section comprising of the interface between the 2 phases (McNiven *et al.* 2011:3; McNiven pers. comm. 2015). This is further supported by ceramic remains which suggest *in situ* temporal changes in pottery styles (McNiven *et al.* 2011:3). In addition, with other sites dating to the Lapita period also present at Caution Bay but not incorporated into this study, it is likely that further radiocarbon dating will reaffirm the notion that people continuously occupied Caution Bay during this time.

Landscape Change

Throughout the antiquity of human occupation, important changes to the local landscape occurred at Caution Bay. Environmental change, especially in regards to whether it was induced by natural or anthropogenic events, needs to be re-examined in light of new evidence from the shellfish assemblages analysed in this study. Palaeoenvironmental reconstructions of this landscape by McNiven *et al.* (2010; 2012) and Rowe *et al.* (2013) highlight significant chronological changes from the time of first occupation with the elevation of sea levels during the mid-Holocene 5000 to 6000 years ago. McNiven *et al.* (2010:1) point out that the Bogi 1 site was likely active and developing before the growth of extensive mangrove forests that are currently present on the seaward site of the sandspit in which Bogi 1 is situated. Therefore, this sandspit represents a period in time when open sea and not mangroves were in front of the site and the landscape people were occupying (McNiven *et al.* 2010a:1). Changes to sandspits at Caution Bay have been occurring for an extended period of time, with three sandspit (linear dunes) complexes present (McNiven *et al.* 2010a:1). While the oldest sandspit is linked to the Last Interglacial, the second sandspit correlates with the sea level elevation between 5000 and 6000 years ago while the third sandspit associated with Bogi 1 is located within the mangrove system, a few hundred metres away from the open sea. This in turn demonstrates that the sandspits developed as sand bars in association with the mangroves when sea levels were a little higher (McNiven *et al.* 2010a:1; Pain and Swadling 1980:59).

In addition, environmental changes accelerated from after the sea level highstand at 6000 cal BP to the late Holocene resulting in changes to the shoreline while also signalling the development of mangroves from deposition of terrestrial sediments in the intertidal zone due to inland erosion from anthropogenic factors (McNiven *et al.* 2012:150). Mangroves were therefore established alongside the coastline between 3300 and 1000 cal BP (Petchey *et al.* 2012:77; Tomkins *et al.* completed ms:13), thus demonstrating coastal progradation. However, development and expansion of mangroves can also be problematic since it would have become a physical barrier that may have reduced access to the coastline and land which according to Rowe *et al.* (2013:1140) may have had an affect on occupational preference since the number of major settlements around 2000 cal BP reduces and is followed by intermittent occupational pulses around 1700 cal BP. Hence, the point here is that there was still continuous occupation of the broader Caution Bay landscape but with changes in settlement patterns and site use intensity. Further anthropogenic induced changes were also seen with a reduction in tree cover and the emergence of coastal scrub from a coastal thicket and forest landscape after 2000 cal BP and increased burning activities between 2000 and 1400 cal BP (Rowe *et al.* 2013:1139). The overall evidence suggests the use of a local burning regime by occupants as a method for clearing and controlling local plant biomass which allowed for human production of plant food and more sedentary settlements, a trend that has also been noted for other areas (see Chapter 4). While natural changes to the landscape may have taken place, the overwhelming evidence suggests marked anthropogenic alteration of the environment beginning from just before the arrival of Lapita peoples.

In relation to these changes, the majority of the evidence from the shellfish assemblages of all three sites correlate with the broader overall environmental trends. The increased occurrence of mangrove and mud flats intertidal species (e.g. *Anadara granosa*, *Andara antiquata*, *Nassarius olivaceus*) in the upper levels of the pre-Lapita phase suggests greater use of this habitat type after its development and expansion. However, the drastic decrease in species diversity and discard during the post-Lapita phase at JA24, highlights a continued decline in intensity in site use from after 2000 cal BP to c. 1300 cal BP. This in turn, is in line with the assertion that an expansion of mangroves likely presented a physical barrier to coastal access at the location of Bogi 1 and Tanaumu 1 and intensive occupation largely ceased to exist there after around 2000 cal BP which was then replaced by intermittent pulses of occupation around 1700 cal BP. People may therefore have moved further inland or further to the south, because of this change since JA24 was situated 2.3km from the coastline. For instance, at the Boera district southeast of Caution Bay, where mangroves are less prevalent, people occupied the area by 1200 cal BP which points to changes in settlement locations following the onset of dense mangroves at Caution Bay (Rowe *et al.* 2013:1140). At Caution Bay (JA24), species diversity reduces from >100 in the post-Lapita phase of Bogi 1, to 84 taxa during 2350 to c. 1950 cal BP and 2 species from between 1500 to c. 1300 cal BP at JA24. Fewer species were therefore targeted during the major occupation at JA24, a period when mangroves had expanded significantly. The number of targeted habitats (n = 2, including mangroves) reduces even further during the late occupation phase. This evidence suggests that perhaps access to different habitats was reduced and people were targeting species such as *Conomurex luhuanus* from a particular habitat (seagrass meadows) at greater intensity (>50% of JA24 assemblage) possibly due to factors such as easier access to this particular habitat with presence of a large *C. luhuanus* natural population, or to fully take advantage of gathering trips since with the presence of a mangrove population, people may have had to travel around the mangroves to access shellfish habitats, and by gathering larger taxa, it would have been more beneficial in terms of meat weight contribution and made gathering trips more efficient.

Evidence procured from the post-Lapita shellfish assemblages is also consistent with other anthropogenic induced landscape modifications. The proliferation of burning regimes (2000 to 1400 cal BP) attributed to land clearing, with the reduction in tree cover and increased prevelance of coastal scrub (after 2000 cal BP) for human production of plant food (agricultural economy) suggests a reorganisation of the local subsistence economy. Since the emphasis on shellfish resources as a major subsistence item seems to gradually decline in importance from around or after 2000 to 1300 cal BP, as evidenced by decreases in species diversity and discard at the inland JA24 site, whereas Bogi 1 and Tanamu 1 have different post-Lapita temporal sequences (see above discussion on chronological sequence), people were most likely restructuring their subsistence base by adding a more intensive agricultural economy while also choosing to occupy areas further inland. In addition, mangroves usually occur in the intertidal zone and were probably not really subjected to burning regimes. Instead, the link between mangroves and more intensive burning regimes would have led to increased sedimentation resulting in progradation of the shoreline. By changing their occupational strategy and moving further inland, people were probably able to further diversify their non-molluscan subsistence economy. It must be noted that while shellfish remains along with the palaeoenvironmental record strongly suggests this scenario, ongoing analysis of plant remains will shed further light on this matter.

From 1000 cal BP onwards, a saltmarsh and unvegetated mudflat occurs along with changes in mangrove composition, and coastal progradation following a rise in sedimentation rates (Petchey *et al.* 2013:77; Rowe *et al.* 2013). While this change may have had an impact, people continued to intensively target shellfish taxa from seagrass (*Conomurex luhuanus*) and reef flats (*Lambis lambis*) habitats as seen at Tanamu 1 (700 to c. 100 cal BP). Mangrove taxa were also gathered (*Polymesoda erosa*, *Terebralia sulcata* and *Telescopium telescopium*). Apart from the period between c. 1300 to 700 cal BP, this trend is similar with the evidence procured from the JA24 post-Lapita sequence as a lower range of species were targeted, again highlighting a change in subsistence focus mostly likely due to an enlarged agricultural base following deliberate landscape modification to maintain the habitat, a practice that has been documented in ethnographic times (see Chapter 9).

Overall, shellfish evidence from the three phases reveal a broader trend that correlates with major changes to the local environment with a greater focus on molluscs even when the mangrove system was present but not at its densest. A gradual decline in shellfish exploitation in terms of diversity and discard is seen after 2000 cal BP following deliberate anthropogenic modification of the landscape and differing occupational strategies. While this strategy was most probably incorporated in order to accommodate agricultural production, major changes to the environment were mostly created by local peoples, thus highlighting the complex human-environment interaction at Caution Bay that was likely related to environmental and social landscapes that were in place.

Trends in Shellfish Exploitation

While the trends in shellfish exploitation discussed for each individual site reveal certain differences between the major occupational phases, these patterns need to be re-examined in association with synthesized chronological sequences in order to determine broader patterns within the Caution Bay area.

Pre-Lapita/Pre-Ceramic Phase (c. 5000 to 2900 cal BP)

Shellfish evidence from Bogi 1 and Tanamu 1 reveal a total MNI of 6159 (Bivalve MNI = 4282, Gastropod MNI = 1877). During this early phase of occupation, people were gathering a diverse range of taxa belonging to multiple habitats. A total of >120 species are present within the assemblage, and the most preferred habitats include rocky intertidal and inshore environments (sandy intertidal, estuaries and mangroves). In addition, sandy flats, muddy substrates, distant rock and reef platforms, coral reefs and freshwater/brackish habitats were also targeted. Common species that account for most of the assemblage are Ostreidae, *Atactodea* *striata*, *Gafrarium* spp., *Gafrarium tumidum* and *Isognomon* spp. Despite the environmental change that was occurring after the sea level highstand from the mid-Holocene with changes to the shoreline and the onset of mangroves during the latter stages, local occupants clearly had a diverse shellfish economy and were undoubtedly making the effort to procure valuable species such as *Cyprea* spp. and *Conus* spp. This is quite a significant trend because both species, among others, have been well-documented to be of non-subsistence cultural importance in the manufacture of shell artefacts within the Pacific region (see Chapter 5) with shell artefacts found in lower levels of this phase at Tanamu 1. Furthermore, the discovery of shell grave-goods (*Pinctada* sp. and *Tridacna* sp.) associated with a human burial at Bogi 1 suggests the incorporation of molluscs into the ritual and spiritual domain. This represents the earliest known evidence for the ritualistic/ceremonial use of shellfish on the southern coast when compared with other nearby examples (e.g. *Bu* shell arrangements in Torres Strait, see Chapter 6 for discussion). As an entire phase, bivalves predominate the assemblage but the overall evidence clearly demonstrates that even before Lapita people arrived, the shellfish economy of local occupants exhibit both complexity and diversity during a period when environmental change was occurring. The occurrence of other faunal remains, including fish, crab and terrestrial resources shows that while people may have had a mixed subsistence economy, marine resources played a major role and the strategic placement of the settlement close to the sea would have been highly beneficial. At the same time, as evidenced by overall shellfish remains, a single large settlement, with a low-mid level of intensity in use, was present at Bogi 1 and Tanamu 1.

Lapita Phase (2900 to c. 2600 cal BP)

In contrast, an intensification of shellfish exploitation coincides with the arrival of Lapita peoples. Although the total MNI of 3922 (Bivalve MNI = 2675, Gastropod MNI = 1247) is lower than that of the previous phase, a dramatic increase is seen in discard per 100 years of occupation (Lapita = 4119 vs pre-Lapita/pre-Ceramic = 1493) (Figure 12.1). This trend strongly suggests greater use of molluscan resources within a shorter temporal sequence of 300 years. In addition, while there is a similarity in the diversity of exploited species (>120), and the continued preference for bivalves (*Atactodea striata*, *Anadara antiquata*, *Gafrarium* spp., *Gafrarium tumidum*, *Chama* spp., Ostreidae and *Isognomon* spp.), greater emphasis (by weight and MNI) was placed on gathering larger gastropods (*Conomurex luhuanus*, *Gibberulus gibberulus*, *Laevistrombus canarium*, *Lambis* spp. and bivalves (*Tellina* and *Gafrarium*). This strategic choice to incorporate more of the larger taxa, particularly gastropods, would have provided greater meat yields which were supplemented by other smaller-sized species. Multiple habitats were again targeted, including intertidal sand and mud flats, rocky substrates, sandy reefs, seagrass meadows, coral reefs, mangroves and fresh/brackish-water habitats. While people continued to exploit a similar range of habitats, there is a proportional shift in focus with certain species (e.g. *Conomurex luhuanus*) gathered more. Despite this change, and the presence of mangroves (established 3300 years ago) which may have had an impact on access to certain resources, local occupants were most likely still making cultural choices to target offshore habitats situated further away even though other habitats were probably located closer to the settlement. Shell artefacts are an identifiable feature of the Lapita cultural repertoire, and the presence of taxa such as *Conus* spp., *Cypraea* spp., and *Tectus niloticus*, may indicate the deliberate harvesting of these species for artefact manufacture. The overall evidence demonstrates that in addition to other non-molluscan fauna (crab, terrestrial resources), shellfish were a crucial component of the local subsistence economy. Furthermore, people continued to employ a complex and diverse shellfish procurement strategy despite major changes in the environment.

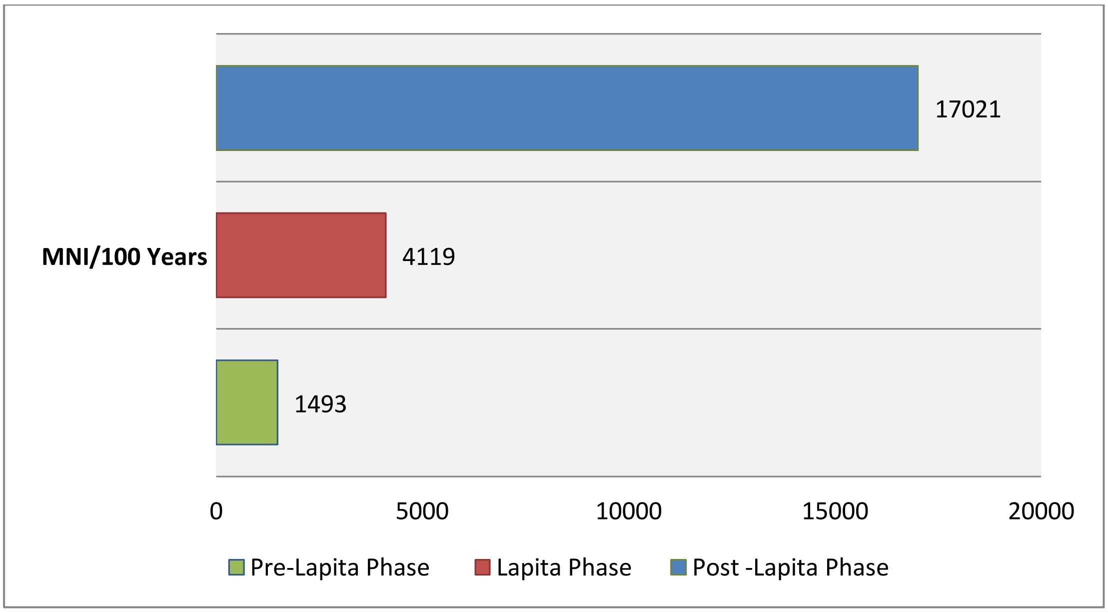

Figure 12.1. Combined MNI per 100 years discard of all shellfish for each major phase, Bogi 1 Square C, Tanamu 1 Square A and JA24 Square A.

More importantly, it is clearly evident that following contact with Lapita peoples and the continued engagement between both the established indigenous and foreign populations, shellfish resources were exploited at a much greater rate to provide greater meat yields. Intensification of shellfish of this magnitude suggests mid to high level intensity in site use with the presence of a larger more permanent settlement that was needed to support an increase in population density (both Lapita and Indigenous peoples). This is supported by further evidence from increasing rates of discard for pottery and stone artefacts during this time (Figure 9.36; Tables 9.5 and 10.4). Therefore, the arrival of Lapita peoples and the introduction of a highly-prized commodity such as pottery, most likely increased population density which had to be supported by exploiting more shellfish, an achievable task especially when this large settlement, situated along the sand dunes, was close to both the sea and a vast array of resources.

Post-Lapita Phase (2200 to c. 100 cal BP)

Although the total MNI of 34850 (Bivalve MNI = 4017, Gastropod MNI = 30833) along with a high discard per 100 years (n = 17021) is much greater than the Lapita Phase and lends support to further intensification of molluscs on a broader post-Lapita scale, an in-depth analysis of this broader trend is required. This is particularly important as the broader discard figures are representative of shellfish remains from three sites and results need to be interpreted in relation to other major cultural chronologies. It is however important to note that in a broader sense, this evidence still demonstrates human occupation of the Caution Bay landscape for the majority of the post-Lapita period.

Changes in shellfish exploitation by MNI and discard per 100 years reveal important trends over time. Since the post-Lapita phases at Bogi 1 and JA24 date to around the same time, trends from both sites need to be explored further because of their spatial distribution within the Caution Bay landscape. The highest level of shellfish exploitation by MNI and discard per 100 years throughout the antiquity of human occupation at Caution Bay occurs at Bogi 1 during the post-Lapita period following the transition from the Lapita phase. This site, along with Tanamu 1, are representative of a single larger settlement and the significant increase in shellfish subsistence activities are most likely to be representative of further resource intensification in comparison to the Lapita phase.

A total MNI of 33302 (Bivalve MNI = 3700, Gastropod MNI = 29602) and a high discard per 100 years (n = 16651) (Figure 12.2) demonstrate the importance of molluscan resources. Although there is an increase in species diversity (>150), the majority of food remains are only represented by 24 species, most of which are gastropods. Hence, the increased inclusion of larger gastropods (*Conomurex luhuanus*, *Gibberulus gibberulus*) in local subsistence practice during the preceding Lapita period not only continued, but accelerates during post-Lapita occupation. However, a major difference is the greater addition of smaller sized gastropods, especially *Calliostoma* spp. and *Cerithidea largillerti*. This trend again suggests that people were targeting large numbers of gastropods to provide greater meat yields.

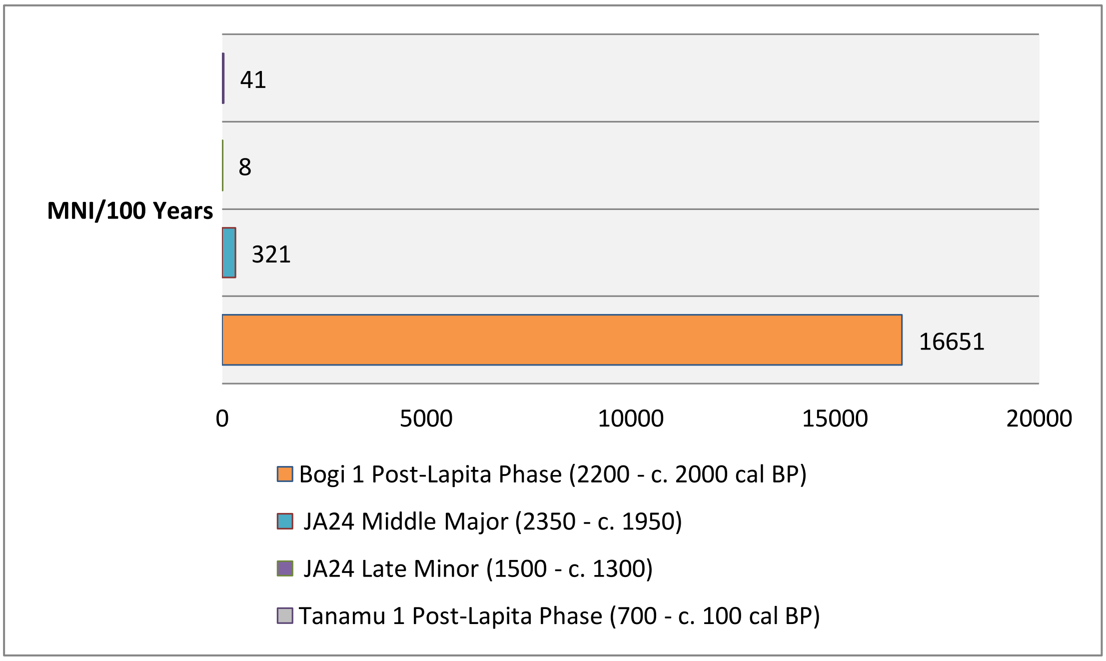

Figure 12.2. Shellfish MNI/100 years in each post-Lapita sequence, Bogi 1 Square C, Tanamu 1 Square A, JA24 Square A.

While it can be argued that smaller sized species may not have been a viable economic choice, both *Calliostoma* spp. and *Cerithidea largillerti* account for 46% by MNI during this period and thus may be considered as highly beneficial resources by local people and possibly targeted because they were readily available. In addition, shellfish were procured from multiple habitats which include rocky intertidal, estuaries and mangroves, sandy intertidal, reef flats intertidal, sea grass intertidal and coral reefs. Habitat choice suggests that even while the established mangrove system was expanding and getting thicker, local inhabitants were making an effort to gain access to other habitats. However, it must be noted that while there was diversity in targeted species and habitats, this trend was proportional since people focused more on certain gastropod species. The overall pattern demonstrates selective intensive gathering of certain species which were supplemented by a wide range of lesser-ranked taxa. Shell artefacts were also produced as demonstrated by a piece of worked shell dating to around 2100 years ago that was similar to the ethnographically documented *toia* shell valuables.

Overall trends in shellfish exploitation during the Bogi 1 post-Lapita phase demonstrate continued occupation from the Lapita period of a single large settlement. Dramatic increases in shellfish exploitation, along with ceramic and stone artefact discard suggests that this settlement was occupied intensively by a much larger population towards the end of its use. Therefore, population density and site use continued to accelerate from Lapita to post-Lapita times (2900 to c.2000 cal BP) before a re-organisation of occupational strategies around 2000 cal BP, a trend possibly associated with the more intensive practice of agriculture resulting in extensive anthropogenic landscape modification. Shellfish remains indicate a dynamic and multi-faceted use of molluscan resources that were most likely part of a wider economy comprising of other food items that were probably required to support a large population density.

JA24, situated 2.3km further inland and dating to between 2350 and ca. 1950 cal BP, thus synchronous with the much larger settlement located near the coastline, points to territorial expansion by local peoples. Yet, shellfish exploitation at this location was considerably lower and different. With a total MNI of 1285 (Bivalve MNI = 300, Gastropod MNI = 985) and a discard rate of 321 per 100 years, JA24 represents an inland settlement within the Caution Bay cultural landscape where people may have targeted lower number of molluscs because they were situated 2 km inland. Species diversity is also considerably lower (n = 84), and the assemblage is dominated by *Conomurex luhuanus*, *Calliostoma* spp. and Ostreidae. As a broader post-Lapita trend, gastropods were again targeted more and the main economic species were supplemented by other species. Although there is a diversity in the habitats exploited (sandy intertidal, seagrass meadows, rocky intertidal, mangroves), people relied heavily on 3 main species from fewer habitats. To a certain extent, this pattern is similar to the larger coastal settlement, especially with the preference for *Calliostom*a spp. and *Conomurex luhuanus*. However, the overall trend shows less of an emphasis on shellfish resources. This can perhaps be a product of reduced access to certain shellfish habitats following the onset of dense mangroves. Occupation of an inland area points to a strategic movement of people that coincides not only with a large settlement at the coast, but also with the evidence for anthropogenic landscape modification possibly related to an intensification of agriculture. Bearing in mind that ceramic remains are present within the JA24 assemblage together with the manufacture of stone artefacts, it is likely that despite territorial expansion, inland communities were still a part of the broader cultural landscape and were linked to the large coastal settlement that was present at that time. The common preference for certain shellfish species (*Conomurex luhuanus* and *Calliostoma* spp.) lends further support to this as people from the larger coastal and smaller inland settlement were in reality part of the same population, and had likely made a cultural decision as an entire community with collective knowledge on the distribution of these species that were deemed as being economically viable. Therefore, local occupants at Caution Bay were expanding their territory to inland areas, with a lower level of intensity in site use and shellfish exploitation at these sites while most probably also restructuring their subsistence economy, a trend that was occurring while a significantly larger settlement was present along the coastline.

Subsequent occupational trends after around 2000 cal BP during the post-Lapita period at Caution Bay were intermittent. The late phase at JA24 dating to between 1500 and ca. 1300 cal BP exhibits evidence for a continued reduction in site use intensity since discard of pottery, stone artefacts and molluscan remains was much lower. This is supported by a total of 15 MNI (Bivalve = 0, Gastropod = 15) and 8 MNI per 100 years discard for shellfish remains. At the same time, only 2 economic species (*Conomurex luhuanus* and *Telescopium telecopium*) from seagrass meadows and mangroves were exploited, thus demonstrating an overall decrease in shellfish and habitat exploitation. Local occupants may therefore not have intensively used the landscape. Although dense mangroves were present and human landscape modification was occurring, the continued exploitation of shellfish together with ceramic and stone artefact remains during the earlier period when environmental conditions were similar, means that other socio-cultural factors may have contributed to this reduction in site and landscape use. With the evidence for major chronological and cultural changes associated with the Ceramic Hiccup well-documented at other locations along the southern Papuan coast, and occurring between c. 1200 and 500 years ago (see Chapter 4), evidence from JA24 strongly suggests a similar event at Caution Bay. Further evidence for the gradual increase in occupational intensity after 700 cal BP (Tanamu 1) also coincides with this likely scenario. Therefore, after around 2000 cal BP, people were probably still occupying the Caution Bay landscape albeit at a reduced intensity, even during a major period in time when there was a reduction in communication and cultural exchange along the southern coast.

An increase in intensity in site use at Caution Bay occurs after the Ceramic Hiccup from after 700 to 100 cal BP, especially from ca. 200 to 100 cal BP, thus coinciding with archaeological evidence for a re-emergence of cultural activity along the southern Papuan coast associated with the Motu *hir*i trade (see Chapter 4). An increase is seen in shellfish exploitation, as evident by total MNI of 248 (Bivalve = 17, Gastropod = 231) and 41 MNI discard per 100 years. Although a low number of species (>20) from a few habitats (seagrass beds, reef flats, mangroves and rocky platforms) were targeted, this is still higher than the evidence procured for occupation just before the Ceramic Hiccup. The shellfish economy of local occupants was more focused on intensively exploiting gastropod species such as *Conomurex luhuanus* and *Lambis lambis*. Similar intensity in pottery discard with different stylistic conventions and stone artefact production along with greater emphasis on terrestrial resources were also noted. As domestic pigs were present, it is likely that there was an enlarged agricultural base, especially when anthropogenic burning regimes were documented in ethnographic times. The overall evidence points to a re-organisation of the local subsistence economy, with shellfish resources constituting a minor component among other food items.

More importantly, communities at Caution Bay exhibit increased cultural activity after the Ceramic Hiccup, in line with a period in time when localised ceramic conventions appeared along the southern PNG coast. While changes to mangrove composition may have impacted occupational patterns along the coastline at Caution Bay after 1000 cal BP, it is more likely that increased cultural interaction was the likely contributing factor for an increase in shellfish exploitation as people ultimately becoming part of the ethnographically documented *hiri* exchange system involving pottery manufacturing Motu communities from the Port Moresby area and communities from the Gulf of Papua. Evidence for ceramic remains, and the continued exploitation of shellfish from 700 to c. 100 cal BP, with peaks in site use intensity from ca. 200 cal BP to the ethnographic period at Tanamu 1 (David *et al.* completed ms:74) supports this interpretation since Motu communities whose ancestors participated in the *hiri* trade system currently occupy the Caution Bay landscape and continue to exploit shellfish.

Predation Pressures or Environmental Change

Analysis of temporal changes in shellfish size for 4 species has revealed certain overall trends in change over time at Caution Bay. Since results of statistical analysis in differences between mean size have been reported in each site chapter, details of these will not be presented here. Instead, discussions will be in line with overall chronological sequence for site occupation.

Mean size for *Conomurex luhuanus* differs between pre-Lapita (Bogi 1 = 42.13mm), Lapita (Bogi 1 = 47.01, Tanamu 1 = 44.0mm) and post-Lapita (Bogi 1 – 40.63mm, Tanamu 1 = 43.28mm, JA24 = 40.43mm). While the pre-Lapita *C. luhuanus* measurements were derived from a minimal discard of 4 MNI that occurs in the upper layers of Bogi 1, close to Lapita occupation, data from this phase need to be handled with caution especially due to the small sample size. Instead, intensive exploitation of this taxa coincides with Lapita occupation, and a statistically significant change occurs from 2900 to 2600 cal BP (Bogi 1 = 47.01mm and Tanamu 1 = 44.0mm) and from 2350 to ca. 1950 cal BP (Bogi 1 = 40.63mm and JA24 = 40.43mm). During the subsequent post-Lapita occupation between 700 to c. 100 cal BP, the species had a larger size structure (43.28mm). When examined closer, the decrease in shell size between Lapita and the initial post-Lapita period correlates with a much greater increase in levels of exploitation in terms of MNI per 100 years (Lapita = 301 vs post-Lapita >2000 cal BP = 1133). Furthermore, as occupational intensity at Caution Bay was at its greatest closer to 2000 cal BP as evidenced by the shellfish discard at Bogi 1, it is highly likely that *C. luhuanus*, as an entire population, was under predation pressure exerted by humans. Environmental change does occur and may have been a contributing factor, however, seagrass meadows/beds which this species occurs in, are a highly adaptable ecosystem and much of the documented landscape changes are primarily associated with mangroves. With a reduction in site use intensity before the latter post-Lapita Phase (700 to c. 100 cal BP), the natural population of this robust species was probably able to slightly recover from past human predation (43.28mm) but was never able to attain its mean maximum size (47.01mm) (modern population mean size = 50mm) since it was again exploited but at a lower rate (MNI per 100 years = 32).

Polinices mammilla was exploited for most of the antiquity of site occupation and morphometric analysis shows changes in size between pre-Lapita (Bogi 1 = 17.67mm, Tanamu 1 = 16.77mm), Lapita (Bogi 1 = 17.73mm, Tanamu 1 = 14.50mm), post-Lapita (Bogi 1 = 16.76mm, Tanamu 1 = 17.38mm) phases. Unlike *C.* luhuanus, discard per 100 years was however much lower (pre-Lapita = 54, Lapita = 37, post-Lapita>2000 cal BP = 37, post-Lapita 700 to c. 100 cal BP = 2). Even though predation pressures in most instances correlate with a reduction in size and an increase in exploitation levels, the natural *P. mammilla* population may perhaps have been exposed to low levels of predation pressures at Caution Bay during the pre-Lapita period and therefore having a smaller size structure during Lapita occupation. Subsequent recovery in size occurs during the late occupational phase (17.38mm) since this species was not targeted in large number and the mean size is similar to measurements recorded in pre-Lapita levels. While significance tests of the sizes recorded at Bogi 1 are not statistically significant, results from Tanamu 1 demonstrate a small but significant trend in size variability between all three phases despite the change in size being only around 2mm. Since a minimal variation, in terms of millimetres yielded a significant result, it is important to note that a mean size of 24.89mm was recorded from a modern population sample. Even though this sample is from Queensland, Australia, there is still a big disparity in size of over 6mm. This species occurs on sandy bottoms of coral reefs, and even though environmental factors may have contributed to a change in size, human exploitation may have inflicted low levels of predation pressure, a stark contrast to the evidence for *C. luhuanus*.

For the bivalve *Atactodea striata*, the size and MNI pattern demonstrate overall changes. Recorded mean sizes are pre-Lapita (Bogi 1 = 25.43mm, Tanamu 1 = 23.27mm), Lapita (Bogi 1 = 27.33mm, Tanamu 1 = 24.97mm) and post-Lapita (Bogi 1 = 26.52). An interesting pattern of the *A. striata* assemblage it that this species is not present after 2000 cal BP. Differences were also noted in terms of discard per 100 years for each major phase (pre-Lapita = 144, Lapita = 258, Post Lapita >2000 cal BP = 9). Therefore this species was targeted in larger numbers during Lapita occupation. Significant differences were evident in mean size between pre-Lapita and Lapita *A. striata* assemblages from both Bogi 1 and Tanamu 1. However, there are no significant mean changes between Lapita and post-Lapita at Bogi 1. As well, the natural mean size of this species is 25mm. While this species was important during pre-Lapita and Lapita occupation, the difference in size between these two phases is perhaps a reflection of environmental processes and possibly minor human predation. Since *A. striata* is found on sandy beaches, and changes to the shoreline were occurring with increased erosion and movement of sediments, it is highly likely that environmental factors more so than human predation may have had a minor impact as evident by relatively small size changes. Furthermore, archaeological evidence from both phases also point to greater preference for larger rather than smaller bivalves.

Unlike the evidence for *A. striata*, the *Anadara antiquata* assemblage at Caution Bay demonstrates evidence for highly significant size change over time. Evidence for decrease in mean sizes between pre-Lapita (Bogi 1 = 48.14mm, Tanamu 1 = 48.39mm), Lapita (Bogi 1 = 41.21mm, Tanamu 1 = 35.50mm) and post-Lapita>2000 cal BP (Bogi 1 = 38.47mm) is also supported by MNI discard per 100 years (pre-Lapita = 112, Lapita = 682, post-Lapita>2000 cal BP = 43). Therefore, this species was intensively targeted during Lapita occupation, a period when larger bivalves were generally preferred. In addition, *A. antiquata* does not occur after around 2000 cal BP at Caution Bay. Overall size variability between each phase was also statistically significant. Thus, the magnitude at which this species was targeted, especially during Lapita occupation likely points to the exertion of human predation pressures since size recovery does not seem to occur during the post-Lapita (2200 to c.2000 cal BP) phase. The mean size of this species at Caution Bay is also considerably smaller than that of a non-predated natural population from the QM measuring at 55.66mm. Furthermore, the drastic reduction in exploitation from Lapita to post-Lapita>2000 cal BP, also suggests a reduction in distribution of *A.* antiquata, and perhaps subsequent localised extinction, thus explaining why this species was not present at Caution Bay after c. 2000 cal BP. *A. antiquata* is a species found on muddy bottoms, in the intertidal and sublittoral zone, and within the tropical regions, muddy shores are mostly covered by mangroves. The greater exploitation of *A. antiquata* also seems to occur after the onset of mangroves and since changes in mangrove composition happened after 1000 cal BP, it may also be the case that while intensive exploitation during Lapita occupation may have already impacted the natural population, subsequent environmental change might have also contributed to localised extinction.

Discussion

Chronological analysis of the synthesized molluscs data has demonstrated trends in exploitation covering all major phases. In addition, the evidence shows that the wider Caution Bay landscape was occupied for the most part of its antiquity. In addition, shellfish resources played an important role in the subsistence economies of local peoples from around 5000 cal BP. A broader pre-Lapita trend in molluscs exploitation demonstrates that larger bivalve species were preferred and supplemented by other taxa. From c. 5000 to 2900 cal BP, a major settlement was situated along the coastline exhibiting low to mid level intensity of site and shellfish use. Following the arrival of Lapita peoples at 2900, site use intensifies with a much greater number of shellfish exploited which was probably required to support a higher population density. While larger bivalve species were still preferred, other mollusc taxa, particularly gastropods are increasingly targeted. Acceleration in intensity of site use then occurs and continues onto the post-Lapita period before ceasing at around 2000 cal BP. Evidence strongly suggests that the large settlement that had been present along the coastline had transformed into a major regional centre with a large population density that had to be supported by exploiting more resources. As the arrival of Lapita peoples also introduced new material culture (i.e. pottery) to this region, which became an important commodity (see Chapter 4), it is therefore likely that the transformation of this settlement into a regional centre was partly a consequence of the arrival of this new material culture. Shellfish exploitation was at its highest during this post-Lapita period, with a shift in exploitation towards gastropods. An intensification of shellfish resources is also supported by size evidence for increased human predation pressures on preferred species.

At the same time, smaller settlements associated with the regional centre emerge further inland for a number of possible reasons. Although a number of anthropogenic related environmental changes to the landscape were occurring, overall evidence suggests minimal impact on shellfish exploitation since a wide range of habitats were still targeted during early occupation from 2900 to c. 2000 cal BP. If environmental changes had an impact on shellfish resource beds and their respective habitats, then a decrease in targeted environments and species diversity would have occurred. On the contrary, local occupants were still targeting a large number of different taxa belonging to various habitats and this trend accelerates following the establishment of the regional centre at a time when mangroves were expanding. While mangroves may have impacted inland sites, the strategic location of a large settlement near the coast would have given local people access to multiple habitats. Thus, the manner in which people were targeting different habitats and species is indicative of cultural and economic choices, that may been made following contact with Lapita people and in relation to a population increase. It must however be noted that, while the volume of shellfish found within the sites might be large, especially in association with the major settlement, the occurrence of other faunal remains (e.g. fish, turtle, terrestrial) means that a complex and diverse economy was also present. Moreover, non-molluscan fauna would also provide a greater contribution in terms of meat weight, and this has to be taken into consideration.

After 2000 cal BP, a period when dense mangroves were present, along with the occurrence and deliberate land clearance, settlement of the Caution Bay landscape was at times sporadic as seen with the occupation of inland areas. Shellfish exploitation, in terms of diversity and discard reduces and this trend continues up to the Ceramic Hiccup from c. 1200 to 500 cal BP. Before a possible decrease in occupational intensity, it appears that a major shift in subsistence practices was occurring with the possible intensification of agricultural production. In addition, as communities were situated further inland, with dense mangroves possibly being an obstacle, lower numbers of shellfish were targeted, thus suggesting a combination of factors such as reduced access to habitats, and the incorporation of new subsistence items. Settlement at Caution Bay re-emerges at 700 cal BP after the Ceramic Hiccup, coinciding with the wider region and lasts up to around 100 cal BP. Shellfish remains re-appear in the archaeological record but unlike previous times, there is a decrease in overall focus on molluscan resources while people incorporated other fauna in greater numbers with perhaps a greater emphasis on agriculture. Nevertheless, overall evidence not only demonstrates continued occupation of Caution Bay for most of its antiquity, but also major differences in shellfish exploitation.

Conclusion

The archaeological record for shellfish exploitation at Caution Bay has demonstrated important trends, while also suggesting that shellfish, in addition to other marine and terrestrial foods, represent important resources to local peoples who were harvesting the sea often. The following trends discussed in this chapter, relating to overall aims of this thesis, are summarised:

- Caution Bay was continuously occupied at various levels of intensity from at least 5000 years ago.
- Shellfish for the most part were of importance to local communities, for both subsistence and artefact production.
- Major trends in shellfish exploitation are present and relate to major cultural events such as the arrival of the Lapita Culture Complex, Ceramic Hiccup and re-emergence of cultural interaction following the end of the Ceramic Hiccup.
- Intensified use of shellfish resources occurs at different stages of occupation.
- Intensity of site use and shellfish exploitation was dictated by anthropogenic factors as reflected by human predation pressures following high levels of exploitation
- Correlation between shellfish exploitation and discard of other cultural material (e.g. pottery, stone artefacts)
- Changes to the environment, induced by anthropogenic activities had an impact on shellfish exploitation and occupation.
- Other natural environmental changes did not seem to severely alter shellfish exploitation.

Chapter 13 – Caution Bay Molluscs: A Regional Model

Introduction

The activities of ancient peoples at Caution Bay have provided a unique opportunity to understand shellfish exploitation over time. Because the full extent of the cultural history of past peoples at Caution Bay was only uncovered in recent times, and is still being understood, this study has presented a much needed examination of the relationship between shellfish exploitation and use as a resource, and the complexity of interactions between human communities in relation to the broader environment. This chapter will present a broader model for shellfish use and occupation at Caution Bay and the southern coast of PNG.

Patterns of Change

Archaeological evidence seems to suggest that a largely marine resource orientated population first occupied the coastal fringes of Caution Bay during the mid-Holocene at around 5000 cal BP. Although occupation after this period was at times sporadic in terms of site use intensity, I argue that local settlements were still present for around 2100 years during which shellfish were exploited at varying levels of intensity, and therefore may only represent a small proportion of the overall diet since other marine fauna were also present within the assemblages. However, apart from dietary contributions, molluscs were also used to produce artefacts and incorporated into rituals, which reveals the presence of a culturally complex local population.

This general trend was mostly unchanged until the arrival of Lapita peoples at 2900 cal BP and the introduction of pottery, which correlates with a number of cultural changes. Shellfish resources were targeted at a much greater intensity, along with an increase in discard of other cultural elements. This, I believe, represents the establishment of a larger settlement along the coast with a higher population density which resulted in more complex socio-cultural relations. In addition to other food items, an intensification of shellfish resources would therefore have been necessary. Even after the cessation of the Lapita pottery signature, the major coastal settlement that was already present, continues to increase in population density as evidenced by a dramatic increase in shellfish exploitation. At the same time, local territorial expansion of settlement takes place and inland areas become occupied. This, I argue represents a change in demography, as a result of the wider socio-cultural implications following the introduction and increased manufacture of new material culture such as pottery.

Major changes to occupation reflected in shellfish exploitation takes place after 2000 cal BP, in line with documented evidence for anthropogenic alterations to the local habitat for possible agricultural production. There is evidence for a movement of people away from the coast at this time. As some communities shifted inland, access to the coast was reduced resulting in a reduction in shellfish exploitation. The reduction in shellfish numbers in the inland sites may also relate to taphonomic factors such as processing of the shellfish at the site as described ethnographically elsewhere (see Chapter 5) in which meat was removed from the shell at the site of extraction (Bird *et al.* 2004; Meehan 1982). Species such as *Conomurex luhuanus* which provide higher meat yields, would have been preferred more since after making the trip to the coast which would have required people to most likely negotiate their way around the dense mangroves, gathering larger species would have been a more efficient overall task.

Another important point from ethnographic evidence is that even though terrestrial and other marine fauna (e.g. fish, crab) were targeted, shellfish were still an important resource because they were consistently and reliably available and added an extra source of sustenance whereas other food items such as fish can comparatively be more difficult to harvest because of factors such as strong offshore winds and differences in tides (Bird *et al.* 2004; Meehan 1982). Likewise, this reliability makes shellfish an ideal food source and as a raw material for manufacturing artefacts that can be used in anthropogenic activities, with possible economic, social or political benefits such as seen with the *kula* trade (Trubitt 2003), as prestige goods (Gosden 2004; Hayden 1998), or for producing highly valuable lime for betel nut chewing in PNG (Pernetta and Hill 1981). Although shell artefact analysis is not the focus of this thesis, the presence of worked shell, particularly an example from mid levels of Bogi 1 that is similar to the ethnographically important *toia* armshells used in trade activities shows that past peoples may have engaged in some sort of social and economic activity using shellfish at Caution Bay. More importantly, in line with the ethnographic evidence, I also argue that with the occurrence of other food remains (e.g. fish, crab) and the continuous exploitation of shellfish, molluscs were likely a highly dependable and consistent source of sustenance throughout occupation at Caution Bay from around 5000 cal BP.

Occupational intensity reduces after 2000 cal BP before again increasing at 700 cal BP and continuing to c. 100 cal BP. During the majority of the post-Lapita period, from 2000 cal BP onwards, shellfish subsistence is less intense, and while this trend is linked to other broader trends, I believe that Caution Bay was still occupied, especially from between 1300 to 700 cal BP at a lower intensity after which from 700 to c. 100 cal BP increasing levels of occupation occurs as evidenced by the discard of shellfish and other remains. These changes in site occupation intensity and resource use, I argue are reflective of a regional trend associated with the Ceramic Hiccup. Dating to between c. 1200 and 500 years ago, the Ceramic Hiccup is representative of a period when major changes in settlement patterns and cultural practices took place in the southern region of PNG (David 2008; Irwin 1991; Rhoads 1982). David (2008:467) postulates that drastic changes in occupation and cultural exchange occurred during this time, ultimately leading to new, regionalised social conditions and a period of re-adjustment to local social conditions. The primary premise of the Ceramic Hiccup is therefore a change in the existing social system, which had been part of an inter-regional network in relation to the absence of pottery.

While researchers such as Rhoads (1982:142-143) used evidence from the Papuan Gulf, to argue that site abandonment occurred in relation to a reduction in pottery availability with coastal communities relocating to inland locations, I argue that for the Caution Bay area, total site abandonment did not take place. Firstly, apart from the Papuan Gulf, archaeological evidence demonstrates that people were still present along the southern region with more regionalisation of ceramic traditions occurring at Port Moresby (close to Caution Bay), Amazon Bay-Mailu and Yule Island-Hall Sound (Allen 1977c; David 2008; Irwin 1991; Vanderwal 1973). The more likely reason for this regional change, is that communities from the Port Moresby area may have had reduced interactions with other groups from the west and east before this regionalisation occurs (David 2008:469; Skelly 2014:506). While there is a hiatus in occupation at some sites (e.g. Nebira 4) in the Port Moresby area around 950 cal BP, people still continued to occupy other locations (Amazon Bay-Mailu and Massim) and long-distance exchange networks were still present (Skelly 2014:506).

At Caution Bay (site JA24), the evidence suggests a correlation between this regional change in socio-cultural relations, and a reduction in shellfish exploitation and occupation. While future archaeological investigations further south at Caution Bay will likely add to this picture, a number of other sites dating to the post-Lapita period are still present and according to David *et al.* (completed ms:74) fill the gap between 2750 and 700 cal BP in relation to the Tanamu 1 sequence. It is envisioned that these sites might reveal a similar occupational pattern highlighting continued occupation of Caution Bay even during the Ceramic Hiccup. Likewise, the reduction in shellfish exploitation, suggests more of a re-organisation of the subsistence economy with possibly increased agricultural production which was also likely linked with anthropogenic alterations of the landscape.

After around 700 cal BP, a regional increase in cultural activity and interaction is seen along the southern PNG coast, represented by localised ceramic conventions (David 2008; Irwin 1991; Rhoads 1982). Cultural interactions between communities then increases after around 500 cal BP and 'likely coincided with the development of relationships that ultimately led to the ethnographic *hiri*' (Skelly 2014:509). Shellfish evidence from Caution Bay correlates with this regional trend, and as the *hiri* exchange system involved Motu communities who produced and traded pottery from the Port Moresby region, occupational intensity and molluscs use at Caution Bay gradually increased from 700 cal BP onwards. However, although there was probably a shift towards practising more intensive agriculture, and a greater reliance on terrestrial fauna, I argue that people continued to exploit shellfish since they were a reliable resource and were strategically located close to the sea. The possible reason for this, is that Motu communities undertook trade voyages to the Papuan Gulf as part of the *hiri* exchange system, and occupation of the coastal fringes would thus have been beneficial. As I have argued earlier, the levels of intensity at which Caution Bay was occupied and shellfish resources were exploited seemed to change in relation to broader cultural events, and in association with the social-cultural implications of pottery during certain temporal phases.

Nonetheless, the evidence demonstrates that people were employing a diverse and complex shellfish exploitation strategy in relation to broader cultural changes. When interpreting evidence for shellfish remains, a number of explanatory models, within a largely broader marine subsistence economy have been applied to the region.

In a broader sense, these models often invoke environmentally deterministic or socially-orientated explanations for human cultural practices. For instance, environmental models often take into consideration factors such as prey choice, and distance between settlement camps and prey as, to an extent, dictating how people were exploiting resources. In contrast, the evidence at Caution Bay, clearly shows that despite being closer to certain habitats, people were making the effort to gather species from habitats situated further out. Moreover, many researchers (e.g. Bird and O'Connell 2006; Bird *et al.* 2002; Codding *et al.* 2014) have used behavioural ecological models, that utilise ethnographic and archaeological datasets to make predictions and explain changes in past human behaviours. As I have argued, such models can be environmentally deterministic in certain contexts and do not take wider social processes into account. Although these models may be applicable in certain contexts, changes in shellfish use and occupation at Caution Bay have shown a correlation to wider socio-cultural processes that have been documented from previous archaeological studies in the region.

From previous research on shellfish assemblages from archaeological sites near Port Moresby dating from around 2000 to 200 years ago, Swadling (1976:161) states that while people relied heavily on natural resources and molluscs were exploited in large numbers, shellfish were famine foods. Evidence from Caution Bay, however, clearly demonstrates that this is not the case, and that shellfish during the presence of the large settlement were intensively exploited for food because they were likely a reliable resource that was easier to target. Overall reductions in shell size as a result of significant levels of human predation pressures exerted on more preferred taxa supports the notion that shellfish were in fact not famine foods. Furthermore, people were most probably also making specific trips to gather shellfish despite the availability of other terrestrial or marine fauna.

The temporal and spatial trends in shellfish exploitation suggest that the Caution Bay landscape was occupied throughout its antiquity by people with a degree of marine specialisation with varying levels of intensity in site use. Varying degrees of shellfish exploitation occurs during this time, and reaches its peak during Lapita and early post-Lapita occupation. Regional decrease and increases in cultural interaction associated with before and after the Ceramic Hiccup seems to have also impacted Caution Bay since levels of shellfish exploitation and occupation varied.

Although the environment and landscape modification were factors, changes in shellfish exploitation, I argue, are also indicative of a re-organisation of the local subsistence economy. Nonetheless, marine resources were important, and shellfish were an important resource especially during Lapita occupation. The reasons as to why this may the case will be discussed in the next section.

Understanding Contact at Caution Bay

One of the main areas of enquiry in this thesis concerns the arrival of a foreign culture and its interaction with a pre-established indigenous population. At Caution Bay, this event is epitomised by the arrival of Lapita peoples at 2900 cal BP, and the introduction of highly identifiable Lapita pottery to the region, which over time changes in style, becoming an integral part of the local repertoire and cultural interactions between communities along the southern Papuan coast (see Chapter 4). While the introduction of pottery, without doubt, had significant broader socio-economic implications, the initial meeting or 'first contact/encounter' between Lapita peoples and local occupants who had occupied the coastal margins of Caution Bay from 5000 cal BP, also had an impact on how shellfish were exploited. In the first instance, a change to the overall strategy is the addition of certain larger gastropod species (e.g. *Conomurex luhuanus*, *Gibberulus gibberulus*), to the subsistence repetoire. This is a marked change, since larger gastropods were not a primary subsistence focus during pre-Lapita occupation, and the incorporation of these species, would have provided greater meat yields necessary to support an influx of people. The complexity of cross-cultural contact, subsequent knowledge exchange resulting in exploitation of new species are also plausible scenarios for why these new speices coincide with the arrival of the Lapita peoples since evidence for exploitation of similar species during Lapita occupation has been found elsewhere (Wolf 1999).

Following first contact, it is highly likely cross-cultural interactions continued, thus leading to a period of prolonged engagement at Caution Bay from 2900 to 2600 cal BP. The archaeological signature shows that during this period, people intensified the exploitation of shellfish resources. One of the features of cross-cultural interaction, is that distinctive changes in occupational patterns can take place with a 'gravitational pull' attracting more people to regional centres of contact (Torrence and Clarke 2002a:21). This leads to the establishment of more permanent settlement/s, hosting a larger human population with greater use of local resources. In line with this, I argue that a ‘gravitational pull’ did occur at Caution Bay, in which a large regional centre emerged following prolonged contact with Lapita peoples before expanding further in size over time. Evidence from the shellfish food remains clearly demonstrate this scenario as a dramatic rise in exploitation not only correlates with Lapita arrival but also with the introduction of pottery. Therefore, there was a major increase in population density and social complexity, and thus a regional centre emerged close to the sea, which was strategically placed and in close proximity to multiple habitats and resources, while also suggesting that people from the Lapita culture complex did not simply engage with the local indigenous population and leave, but more likely continuously interacted over a period of time. If transmission of pottery manufacturing ideas did occur, Lapita pottery with its highly complex styles would have required a highly specialised skillset to manufacture. Since pottery remains with Lapita styles occur up to 2600 cal BP, and shellfish resource intensification continued, the likely scenario is that Lapita people were integrated into the local population as evidenced by the continued occurrence of a ceramic tradition.

It is considered that the pattern of change at Caution Bay probably involved a negotiation/middle ground approach between both groups where all parties had agency. Evidence for this could be interpreted from the patterns of shellfish exploitation that had already been in place for an extended period of time continuing following contact with Lapita people (range of habitats and exploited species, and preference for bivalves). According to Gosden (2004:82), a middle ground approach represents ‘the creation of a working relationship between incomers and locals that formed a new way of living deriving from the cultural logics that all parties brought to the encounters’. This is evident from the remains of shellfish and other cultural material as while there is some continuity, new species were also being targeted in addition to the introduction of pottery. Although Lapita peoples can be considered as a colonising force in the Pacific, the presence of a well-established indigenous population meant that complex negotiations likely took place with mutual benefits for all involved parties. From ethno-historic literature, it is well-known that certain material culture belonging to Europeans were not only incorporated into local practices, but were also highly desirable in PNG (Gosden 2004). While using such analogies can be deemed problematic, the continued occupation of Caution Bay by descendants of Motu pottery making communities, together with the presence of shell artefacts closely resembling the ethnographically documented *toia* shells, means that there is some continuity of cultural practices, abeit with some differences. Therefore, when Lapita people introduced pottery, this new technology would have been highly desirable, and could perhaps only be attained through mutual negotiations with possible economic and social benefits for all involved parties. Therefore, in order for this to have eventuated, cross-cultural engagement had to occur, which corresponds with a larger population density, the establishment of a regional centre and an intensification in shellfish subsistence activities to accommodate the high population density and increased social complexity.

A model for Shellfish Exploitation in the Southern Papuan Coast

The overall evidence demonstrates that the people of Caution Bay had a degree of marine specialisation and were harvesting the sea. Among the exploited resources, shellfish were highly preferred because of their multi-faceted use, in diets and in other cultural activities. In addition, levels in which shellfish were exploited largely depended on the wider social-cultural setting and on the subsistence choices made by local occupants. Although the environment was changing at various points in time, people were still targeting shellfish and continued to do so until major changes to the cultural landscape occurred.

Green (1991a) proposed a Triple-I model for Lapita expansion and colonisation that comprised of three stages. Beginning with intrusion, Austronesian speaking Southeast Asian peoples moved into the Bismarck Archipelago and brought their own material culture. New developments then emerged with innovations and from integrating with local peoples. Subsequently, Lapita material culture developed after interactions, before and during expansion into other parts of Remote Oceania (Skelly 2014:496). A similar explanatory framework is the Slow Train model in which an extended period of temporal settlement (300 years) followed after Southeast Asian peoples ventured into the Bismarcks, and this allowed for the emergence of Lapita material culture before expansion to other parts of Remote Oceania (Summerhayes 2000:112). The evidence at Caution Bay certainly holds similarities with certain elements of both the Triple-I and Slow Train models.

As people were already present at Caution Bay, I argue that a phase of innovation and integration occurred during which shellfish were intensively exploited. Firstly, Lapita culture starts at around 3350 cal BP and only appears at Caution Bay about 450 years after its intial appearance in the Bismarks. While Lapita material culture, particularly pottery had already been developed previously, a period of innovation with the introduction of new technology to the landscape, and integration as evidenced by the increase in population density and changing social-cultural conditions occurred from 2900 to c. 2000 cal BP. This in turn, over time, transformed the large settlement into a regional centre, changing the social and cultural landscape, and because of an increase in population density and complexity of social relations, people started to expand their territory by moving further inland and intensifying their resource base including mollusc exploitation. This is also in line with the idea that a social stimulus for change occurred during the late Holocene (Barker 2004:18; Lourandos 1983). While this idea was proposed for hunter-gatherer occupation in Australia, some of the basic premises of this model are also applicable to Caution Bay since overall temporal changes in resource use and settlement patterns was largely a result of wider social processes at Caution Bay.

Changes to the shellfish economy of past peoples at Caution Bay were largely influenced by major socio-cultural events. Incorporation of new species and changes in order of preferred taxa demonstrate the shellfish economy was changing over time. Yet the manner in which people targeted different habitats, shows that the shellfish subsistence strategy was complex and diverse. Likewise the local population was dynamic and only altered their practices during major periods of social and cultural change. The overall model for shellfish exploitation at Caution Bay, postulates that shellfish were an important resource that were readily available and changes in exploitation of this resource was due to the wider socio-cultural landscape.

Conclusion

In summary, this research has demonstrated a clear pattern of shellfish exploitation that correlates with major socio-cultural events and anthropogenic landscape modification than with natural environmental change. This thesis also clearly demonstrates that, depending on the context, a number of factors can influence changes in marine resource use. Therefore, while environmental models can be applied in certain scenarios, it is recommended that before interpreting the archaeological record, archaeologists where possible, should take the wider social-cultural setting into consideration. More importantly, it is now clear that the peoples of Caution Bay were not only socially and economically complex, but were part of a larger regional socio-cultural setting that played an important role in their daily shellfish subsistence activities.

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Appendix