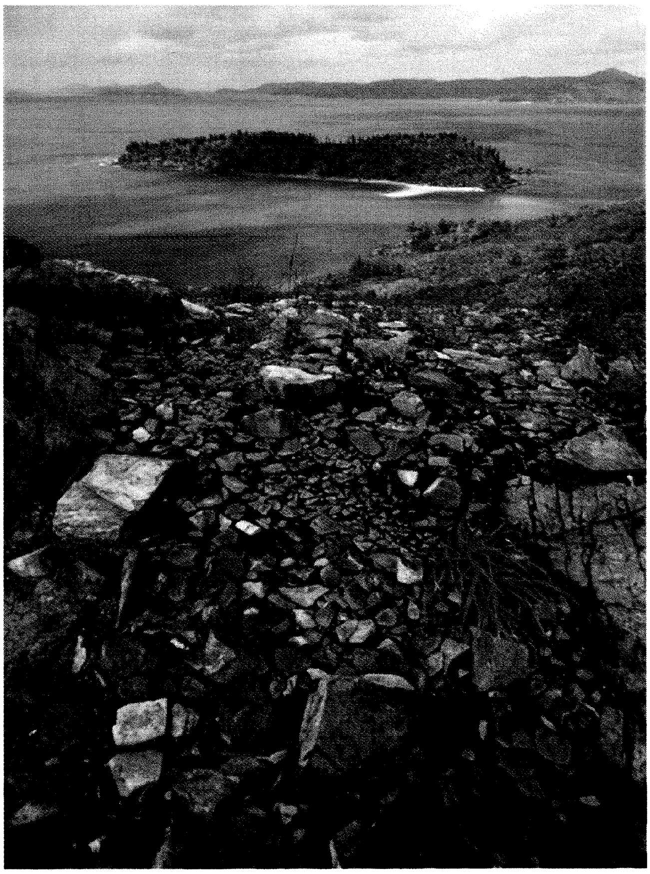
ROCK OF AGES

Use of the South Molle Island Quarry, Whitsunday Islands, and the Implications for Holocene Technological Change in Australia



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Lara

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ABSTRACT

There is evidence to suggest that the South Molle Island stone quarry, in the Whitsunday Islands, central Queensland coast, has been used by the indigenous inhabitants of the region from at least 9,000 BP to the present. Distribution of stone from the quarry extends for at least 170km along the coast, from Abbott Point in the north to the Repulse Islands in the south. A comprehensive technological characterisation of the quarry has demonstrated that a range of manufacturing behaviours was conducted on-site, including the initial extraction of the raw material, through to the final stages of artefact retouch. The systematic production of backed artefacts is included among this suite of technological practice. This research has demonstrated that the antiquity of backed artefacts and the timing of high production rates of backed artefact manufacture occurs earlier in the Whitsunday region than elsewhere in southern Australia. In the Whitsunday Islands backed artefact production has been shown to be present from the start of the Holocene and to have been a key technological element in the early Holocene. A new understanding of backing technologies in Australia can be developed in light of this recognition of regional variation. A risk-oriented model of Holocene technological change in the Whitsunday region is presented here, as well as a discussion of the implications for wider coastal and island technological systems throughout the Holocene.

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CHAPTER 1 INTRODUCTION

INTRODUCTION

The Whitsunday region presents a unique environment in which to analyse stone artefact provisioning, manufacture and use. The Aboriginal quarry on South Molle Island (South Molle Island Quarry, or SMIQ) was the predominant source of stone utilised over a period of at least 9,000 years, according to the evidence of several stratified rockshelter sites in the region (Barker 2004). These rockshelter sites contain stone from the quarry, in varying densities and varying discard rates for the duration of the Holocene, which also saw a widely changing landscape due to the rise of sea levels in the region. This altered landscape meant that the quarry on South Molle Island went from being a part of the mainland, to being contained on an island some 2km from the mainland. Not only was the quarry separated from the mainland, but the sites with signs of habitation also were modified in terms of place in the landscape. This changing environment had implications for access to the important source of stone on the SMIQ. Other changes that were occurring in the region were related to restructuring of the population around the landscape (demographic changes) during the mid to late Holocene. These changes had implications for social relationships and how people viewed themselves in relation to each other and the landscape, including resources contained within that landscape (Barker 2004).

The main objective of this thesis is to examination the pattern of stone artefact discard, as well as changing technologies through time, and determine whether they correlate with the environmental and social changes that were occurring in the region during the Holocene. By way of seeking an explanation for changes observed in the stone artefact assemblage, this thesis will attempt to find connections between the stone assemblage and the changing social and physical environment during the Holocene period in the Whitsunday region (Figure 1.1).

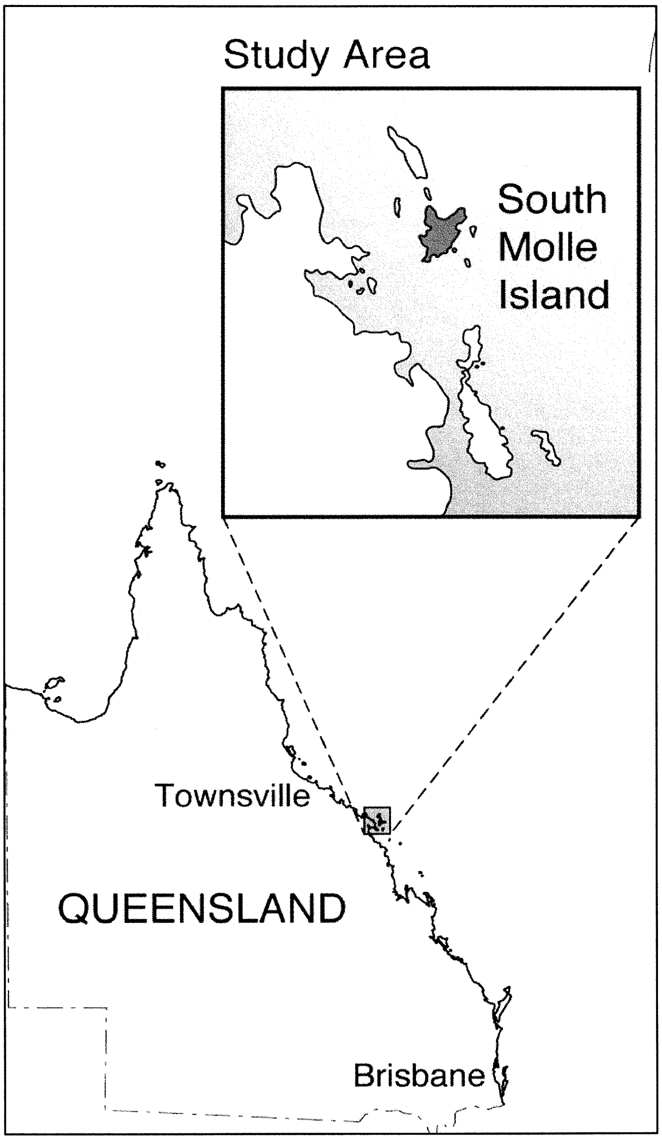

Figure 1.1 Study region.

AIMS

There are three general aims of this thesis:

1 It aims to achieve a technological characterisation of the quarry, examining extraction technology, raw material preferences, manufacturing systems, the extent of a standardised industry. This can be broken down into three main areas:

a) to determine the nature of the South Molle Island raw material. For example, how is it being procured? What is the morphology of the extant, unworked material? Which nodules of raw material are being selected for reduction?

b) to determine how people worked the stone. For example, how are the cores being reduced? How does this compare with extant, unutilised materials? What can this tell us about raw material availability? How are hammerstones used?

c) to determine what is being produced? For example, which flakes are selected for retouch? What is the variety of retouch that occurs on the SMIQ? How are flakes retouched? What is the range of backed artefact morphologies?

A series of collections undertaken by Barker (1995) between 1990 and 1995 brought to light a sample of backed artefacts from the South Molle Island Quarry (SMIQ) and South Repulse Island. Although all specimens in the sample were indeed backed, the degree of morphological variation was high, and a study was undertaken to determine the degree of technological similarity in manufacturing methods, despite these morphological differences (for preliminary results see Lamb 1996). At the commencement of the fieldwork component of this project, greater numbers of backed artefacts were discovered, and it was determined that an investigation should proceed as to the extent of backed artefact manufacture on the SMIQ, as part of the wider study.

The possibility of a standardised industry occurring on the SMIQ brought to light the importance of several other key issues. Principally, the importance of the SMIQ in a national context (see Chapter 2). It is the only known quarry site in Australia where the entire reduction process of backed artefacts takes place; from initial procurement and extraction, to final stages of retouch. Thus the entire sequence, or sequences may be observed. This provided an unparalleled opportunity to study related aspects of the industry, such as preference of raw materials, how the preferred material was extracted, how it occurs *in situ*, how it was reduced, preference of materials and so forth.

Thus, survey work was undertaken in order to determine what proportion of retouch occurring on artefacts could be classed as backing; that is, what proportion of retouched artefacts were backed artefacts. To this end, a technological analysis was undertaken on all retouched artefacts located on the quarry (see chapter 7). Furthermore, an analysis of the manufacturing debris was conducted. These data were then able to be applied to two distinct lines of questioning. Firstly, it evaluated the standardised nature of retouching on backed artefacts; secondly, it allowed the debris to be characterised, and thus for similar assemblages to be identified in temporal sequences (see below).

Clearly, an important part of the technological characterisation of the South Molle Island Quarry will entail the description of the reduction sequence of backed artefacts. As discussed above, an important part of this is the characterisation of the retouch, or final stages of reduction. However, an equally important component of the study involves the characterisation of early stages of reduction. This will involve determining the raw material preferences of the knappers (the size of the blanks selected and the identification of the main core size classes that were being produced), a characterisation of the reduction of the cores (which produces flake blanks on which backed artefacts are produced), and the characterisation of accompanying reduction technology (such as hammerstones). Once these technological processes have been described, it should be possible to determine the proportion of the quarry assemblage that could potentially be utilised for the purpose of backed artefact manufacture, and the proportion of the quarry that is the by-product of backed artefact manufacture, thus clarifying the extent of the backed artefact industry on the SMIQ.

2 To achieve a characterisation of stone artefact assemblages through time, documenting any changes in extraction and manufacturing technology. This can be broken down into two main areas:

a) to determine the temporal range of production,

b) to examine how the unique and changing island geography influences the patterns of stone artefact discard

There are several stratified rockshelter sites in the study area, all containing stone from the South Molle Island Quarry (Barker 2004). The two sites analysed in the context of this study were Nara Inlet 1 and Border Island 1. These sites have been previously excavated and the lithic component isolated by Bryce Barker of the University of Southern Queensland. Preliminary work (Barker 2004) has revealed distinct early/late Holocene patterns of stone use, with a definite reduction in the mid-to-late Holocene of stone material in the stratified rockshelter assemblages. Certain components of extraction and manufacturing behaviour relating to the quarry will be inferred by a detailed technological analysis of these assemblages, such as the extent of reduction prior to removal from the quarry, the amount of stone being removed, what percentage of the total quarry assemblage it represents and so on. Further, the characterisation of the reduction processes of backed artefact manufacture on the quarry (mentioned earlier), will assist in identifying similar late reduction assemblages within the stratified assemblages, thus dating the manufacture of backed artefacts in the Whitsunday region.

3 Finally, I wish to evaluate the applicability of theories of change that have previously been proposed for the region. Theories regarding changing use of stone in Australia have taken several directions. One, with a predominantly environmental bent, is that changing patterns of use corresponded with the stabilising sea levels at c6,000B.P. This conceivably altered the landscape to a degree that people had to adjust their methods of provisioning and use. The South Molle Island Quarry provides an optimal opportunity for observing a technologically controlled situation. This is in part due to it being a unique and identifiable source of raw material, and also because it is the principal source of raw material in the Whitsunday region. Thus it has the potential to enable a determination of the precise nature of technological change in the region. Additionally, there is temporal control for this change within the stratified rockshelter deposits.

Through the analysis of several sequences from stratified rockshelters in the region, I can refine the timing of this reduction of stone use to determine if there were any environmental correlates. Principally, Nara Inlet 1 and Border Island 1, which have basal dates of c.9,000 B.P and c.7,000 B.P. respectively. If there are no environmental correlates, the issue of access needs to be explored outside the realm of environmental determinism. As environmental models seem to form the backbone of the more dominant explanations for lithic analyses at this time, they will be explored initially, to determine whether they can explain changing patterns of stone artefact production in the Whitsunday region.

Structure of the Thesis

This thesis is structured into three parts: introduction, analysis and finally modeling. Each part is described as follows.

Firstly, there is an introduction to a range of broad theoretical concepts which have shaped stone artefact studies in an international context, followed by an examination of the aims and objectives of the thesis. The context of this study is refined by an outline of the models of Holocene change in Australia in which I draw upon the archaeological studies of offshore islands in Queensland; thus the theoretical and physical context of this project is set. This is followed by an examination of the methodologies associated with the project's aims and a chapter detailing the physical environment and palaeoenvironment of the study region (Chapters 1, 2, 3 and 4). Chapter One presents an introduction to the thesis, including a brief background to the objectives of this study, a presentation of the aims of the thesis and a theory/literature review which places this study in the broad field of stone analysis. Chapter Two situates the current study in the context of previous studies which relate specifically to the Whitsunday region and the questions asked of the stone assemblage. Chapter Three presents a discussion of the methodology associated with the aims of this project. Chapter Four presents a description of the physical environment, geology and palaeo-environment of the Whitsunday region.

Secondly , I present the results of the technological analyses which were undertaken to address the questions outlined in the aims and objectives of the thesis (Chapters 5, 6, 7 and 8). Chapters Five, Six and Seven detail the results of the technological examination incorporating the nature of the SMIQ material, how people are working the stone and what kind of artefacts that are being manufactured. Chapter Eight outlines the temporal and geographic range of production.

Thirdly, I discuss the previous models for the region in light of these technological analyses and model the use of the South Molle Island Quarry according to data outlined in the results chapters; this is followed by the conclusion to the thesis (Chapters 9, 10 and 11). Chapter Nine examines how the temporal trends relate to previous modeling for the region. Chapter Ten presents a model of use for the South Molle Island Quarry. Chapter Eleven concludes the thesis.

Background

As a response to a perceived lack of theory in archaeology, the last decade has seen various scholars devising theoretical frameworks at different levels (Preucel and Hodder 1996:8-9), within which a wide range of behavioural patterns can be observed and explained in relation to one another. In stone artefact studies, this was largely initiated in such terms by Torrence (1989), who devised the concept of using "optimisation theory" (Torrence 1989:2) to investigate stone tool technologies in the archaeological record. Optimising theory sets out to provide a set of rules that can be applied to explain various aspects of human behaviour under the same theory umbrella:

> ...the assumption [is] that tool using, as for many other forms of behaviour, was carried out in such a way as to optimise the expenditure of time and energy. Since tools are created and employed to satisfy a perceived need and to accomplish tasks which would themselves be susceptible to selective pressures, then an optimal technology would be favoured and would persist (Torrence 1989b:2).

The benefits of this approach are that it allows many different human behavioural systems to be investigated "in the same way" (Torrence 1989:2) and behavioural systems can be investigated using a common theoretical approach, a common set of 'rules', interpretive, predictive and explanatory guidelines - something that, previously, archaeologists had been unable (or unwilling) to do. Thus, using optimising theory, the study of stone tools can be "incorporated into a broader view of behaviour, and studied alongside and in the same way as subsistence, settlement and social organisation

(Torrence 1989:2).

Prior to Torrence's formative work with optimisation theory in lithic studies, and in the decades proceeding the `Man the Hunter Conference' (Lee and DeVore 1968), there was a significant body of literature developed, that looked at human adaptive systems, particularly organisation of technology, mobility/settlement patterns and population dynamics, in relation to regional environmental conditions (e.g. Cohen 1977; Dean et al. 1994). This ecosystems approach is marked clearly in history by Binford's (1979) influential analysis of mobility patterns of the Inuit peoples of north-central Alaska. This paper was at the forefront of a movement in archaeology away from culture histories, and into processual archaeology. Archaeologists began to ask questions about the reasons for change in the archaeological record, about the functional relationships between systems rather than simply documenting and categorising that change into typological culture histories (Trigger 1989:294). This data was collected with the purpose of acquiring knowledge, to be expressed in general statements, about how culture is shaped by a population's adaptation to specific environmental conditions (Earle and Preucel 1987).

During this time, archaeologists enjoyed the freedom to explore a range of dynamic relationships between people and the ecological contexts in which they existed; in Preucel and Hodder's (1996:7) words, they "...stressed the centrality of process - the relationships between variables in adaptive systems". The generalised outcome of this was that theories of process abounded and the discipline of archaeology was subdivided into a broad spectrum of specialist areas. Not only was there great diversity in different variables within adaptive systems, all viewed in relative isolation from one another, but there was also the plethora of regional ecosystems, all exhibiting variation throughout the late Pleistocene and into the Holocene. As a result of this emphasis on process, and a basically infinite amount of ecological/geographical variance, a great amount of theory was developed regarding different human systems as adaptive responses to the environment.

A major underlying tenet of the ecosystems approach is the realisation of "carrying capacity" (Preucel and Hodder 1996:25-26), the driving force of which is seen to be population dynamics. The understanding is that sufficient population increase in a specific environment will impact negatively on available resources, causing a reorganisation of mobility/settlement patterns and/or mode of production/procurement. Examples of this method of inquiry are many and varied, covering a wide range of human endeavour. The transition from hunting and gathering to agriculture for example, was examined from an ecosystems approach (e.g. Cohen 1977; Dolukhanov 1971; Ammerman and Cavalli-Sforza 1971). This transition saw both a widespread change in settlement/mobility patterns and mode of production, the latter affecting not only dietary production, but production of craft and utilitarian goods, as well as production related to ritual and ceremonial activities. The observation that these aspects of human activity, firstly, have all undergone change; that they, secondly, are all affected by population dynamics, and finally, that they are all ultimately defined within a specific environmental context, is to apply an explicitly inductive method of reasoning. The archaeological signatures of behaviour are observed individually before (or rather than) its patterns of change are predicted.

This pattern of inquiry is replicated with other forms of hunter gatherer cultural change, albeit, sometimes it has tended to incorporate a more deductive method into its analytical framework (e.g. Hiscock 1994). A plausible reason for this is that the archaeological signatures of change relating to, and existing within, a hunter gatherer economy are commonly less visible than those relating to an agricultural economy, and a certain amount of theoretical framework must exist to fully recognise this change from within a Western archaeological discourse (for a discussion see Preucel and Hodder 1996:667-677). It is worth noting at this point that the boundaries between theoretical perspectives pertaining to cultural economics (e.g. Hiscock 1994; see also Halstead and O'Shea 1989a) and the ecosystems approach (distinctions defined by Preucel and Hodder 1996) can be seen to overlap somewhat, the former often being defined by the latter.

Lithic analyses play a role in examining hunter gatherer change as both an analytical tool and an explanatory tool, from within an ecosystems framework. Hunter gatherer settlement/mobility patterns, for example, are generally examined with the basic underlying tenet of natural resource distribution being the causal force. Lithic analysis can be used as a means of determining the extent and pattern of changes to settlement/mobility patterns (e.g. Sullivan and Rozen 1985; Kuhn 1995; Ricklis and Cox 1993; Bamforth 1986; Bettinger 1977, 1979, but see Munday and Lincoln 1979;

Bamforth 1990, 1991; Rolland 1981; McNiven 1994; Odell 1980, 1996; Thacker 1996), as well being viewed as one of a variety of natural resources that people pattern their movements around (e.g. Binford 1979, but see Seeman 1994; Jochim 1976, 1981; Clark 1983; Rowley-Conwy 1983; Bahn 1983; Bailey and Sheridan 1981:1; Halstead and O'Shea 1989b:1; Minc and Smith 1989; Legge 1989; Halstead and O'Shea 1989c:123). The role of lithic studies within these two frameworks is often flexible and interchangeable (e.g. Kuhn 1995), fluctuating between analytical tool and ecological determinate.

Choices determining settlement/mobility and demographic patterns are seen largely in response to perceived economic needs and wants of a society, the success and patterning of which are determined by ecological conditions (Jochim 1976:4). The changing configuration of settlement/mobility patterns, therefore, is often closely associated with changing subsistence practices, including lithic procurement and production. Because of the enduring and highly visible nature of the lithic component of the archaeological record, questions regarding changing subsistence practices often begin with the observation of technological variation within and between lithic assemblages themselves (e.g. in addition to references listed above, Kelly and Todd 1988; Kelly 1988; Shott 1986; Nelson and Lippmeier 1993; Svoboda 1994; Byrne 1980; Newman 1994; Hiscock 1988, 1994).

The powerful interrelationships between settlement/mobility patterns, subsistence practices and technological variation in artefact assemblages were demonstrated concisely in Binford's (1979) investigations into technological organisation among the Nunamiut peoples, and the debate which followed the publication of this study. In this study it was proposed, through a series of ethnographic observations, that the procurement of stone was a strategy "embedded" within other economically orientated activities. Thus, distance from source was maintained to be an irrelevant variable when examining formal artefact variation (utility), as these distances "would have been traveled anyway" as part of the regular, planned "basic subsistence schedule" (Binford 1979:259; but see Gould and Saggers 1985). The portrayal of all lithic procurement as opportunistic prompted a response from some lithic analysts, who believed it could be demonstrated that lithic procurement was (contrary to Binford 1979) a specialised activity, one which was often conditioned as such by distance to the source (e.g. Bamforth 1986; Seeman 1994; Shott 1986).

In seeking to determine the precise nature of lithic procurement in varying cultural contexts, lithic analysts began to focus attention on detailed, controlled examinations of technological factors directly relating to lithic procurement and use (Gould and Saggers 1985:118; Seeman 1994). This line of investigation necessitates consideration of the sources of raw material themselves. The general underlying impetus of most quarry studies is that the extraction and reduction techniques/patterns observed can inform the analyst about aspects of behaviour both directly and indirectly related to lithic procurement and use (e.g. Rudebeck 1987; Mercer 1987; Miller 1987; Healan et al. 1983; Biagi and Cremaschi 1991; Weisgerber 1987).

While theory relating to the "embedded" or "specialised" nature of lithic procurement (Seeman 1994, cf. Binford 1979) tended to be derived from analysis of materials that had been removed from procurement sites, the issue was also being approached from another direction, by examining the quarries themselves (Shafer and Hester 1983, but see Mallory 1986; Bradley and Ford 1986; Cleghorn 1986). For example, matters of access relating to direct or indirect procurement were being investigated, the former being synonymous with nonspecialised activity, and the latter with specialised activity (Fladmark 1984; McAnany 1989; Torrence 1984, 1986:169,214; Gramly 1984). Both separate modes of access leave distinct archaeological signatures that can be interpreted through detailed technological analysis of quarry and reduction sites. Tied in with concepts of specialisation are questions of demand. By documenting the degree of intensity of stone procurement and production at a quarry site, the scale of demand in the surrounding economy/landscape can be estimated (Luedtke 1984), which in turn has implications for questions of manufacture for trade.

Specialised activity pertaining to quarry use is commonly extrapolated to considerations of trade and exchange (Burton 1987; Earl and Ericson 1977; Ericson and Earl 1982; Soles 1983; Sherratt 1987; Hatch and Miller 1985), frequently from within an economic or ecological framework (although, see McBryde 1978, 1984). In this context, the tracing of exchange/stone mobility patterns is frequently carried out via extensive petrographic/chemical/trace element comparisons between stone sources and artefacts in the surrounding landscape (e.g. Luedtke 1979; Hoard et al. 1993; Shackley 1988; Takacs-Biro 1986; Bush and Sueveking 1986; Briggs 1986; Spence et al. 1984; Stocker and Cobean 1984).

Both macroscopic and microscopic techniques have been used to trace artefacts to quarry sites, not only to document trade routes, but also to document movements of populations around the landscape (Singer 1984; Hiscock 1988; McBryde 1984). The nature of such movement (e.g. degree of mobility or sedentism) has been extensively explored through the study of the technological behaviour of people at and around the source itself. For example, distinctions between expedient or curative technologies have been utilised in a number of contexts to distinguish between different mobility patterns of hunter gatherer groups, as they move between economic resources (Bamforth 1986; Shot 1986, see Shott 1996 for an important discussion on the concept of "curation").

One of the key objections that was raised regarding the application of 'processual' theory was not that it was predominantly environmentally causal driven (although see Barker 1995; Jochim 1989), but that it was difficult to view different processes of change in relation to one another, under a strictly uniform theoretical approach (Torrence 1989). The research philosophy of most Processual archaeologists is that culture is a behavioural system composed of interrelated subsystems, each of which warrants individual investigation (Clark 1972). Additionally, such behaviour is perceived as directly aimed at improving group adaptation to a diverse range of external pressures, resulting in the varied material components of culture. Given the above, it could be said that the processual emphasis on process has produced a fragmented, albeit extensive set of theories regarding culture change. It was this perception that contributed to the development of theory that was seen to encompass many facets of human behaviour together, as discerned from the archaeological record (see below).

As a body of theory, evolutionary ecology (also termed evolutionary archaeology or Darwinian archaeology) is concerned with the design and application of theories of general sets, or general theories, as opposed to limited theories. To quote Bettinger (1991:vi) "such theories are constructed of fundamental principles that are meant to apply to widely divergent phenomena". Evolutionary ecology has its roots in Darwinian theory in the sense that, ultimately, human behaviour can be understood in terms of "fitness". Artefacts are commonly seen as an extension of the human phenotype, thus "the fitness of an artefact can be measured by its replication and spread through space and time" (Maschner and Mithen 1996:6). This aspect of evolutionary ecology is commonly referred to as cultural selection or the selectionist approach and is the most predominant form of Darwinian archaeology currently being applied (Maschner and Mithen 1996:6).

In selectionist approaches to evolutionary theory (unlike Processual archaeology), technology is viewed as a set of variants, randomly generated, which may have *differential* consequences for people (groups or individuals), thus their own replication. Adaptations are only identified *after* it has been demonstrated that natural selection has taken place (Abbott et al. 1996:35). A point of contention that exists within the selectionist approach to evolutionary ecology regards the unit of analysis required to formulate credible statements about human behaviour and cultural change. The three main alternatives view selection and adaptation at the level of the individual, the group or the cultural trait itself (Maschner and Mithen 1996:9). Recent theoretical developments in the study of changing lithic technologies have been formulated within an evolutionary ecology framework, specifically from a selectionist perspective which views items of material culture as the main unit of analysis.

Another direction of theory which views stone tool technology particularly as having differential consequences is that of optimising theory, of which Torrence (1983, 1989a, 1989b) was a major innovator in the context of stone tool procurement, manufacture and discard. Torrence (1983, 1989b) views the concept of risk, as relating to *time stress*, as a factor integral to the composition, diversity and complexity of the hunter gatherer stone tool assemblage. Composition is studied in terms of "the degree to which tools are effective at reducing the time spent in a task" (Torrence 1983:13) while diversity and complexity were seen to have inverse relationships with the amount of time available to conduct a task (Torrence 1983). Thus, the stone tool assemblage has the potential to reflect the optimal use of time, and in this way (assuming that it can lead to increased reproductive fitness) it can be considered 'adaptive' in the neo-Darwinian sense. It should be noted here that theory revolving around risk mitigation and optimisation (Bamforth and Bleed 1997; Hiscock 1994, 2004; Torrence 1983) differs on some fundamental levels to those proposed by the cultural selectionists.

While cultural selectionists attribute variation to random processes akin to *mutation* in the biological sense, researchers that propose risk mitigation as the cause for technological variation are more open as to the original cause of the variation (Rindos

1996:161). Fitzhugh (2001:126) states "[w]hile humans may invent new tools and techniques to solve perceived problems, the persistence and spread of the innovation among members of the population will depend on the selection after the invention was created, not when it was inspired". So there appears to be an uneasy connection between the two approaches: while risk proponents utilise the method of transmission proposed by selectionists (*selection*), they maintain independence from the selectionists by acknowledging that *directed* invention/innovation may be responsible for the initial appearance a given trait.

While approaching the notion of *risk* from a much broader standpoint, Hiscock (1994, 2002) proposes that the composition of the Australian stone toolkit is affected by manufacturing behaviour aimed at risk reduction. This is demonstrated for the mid-late Holocene Australian context in conjunction with other risk minimising strategies such as high mobility, colonisation of new landscapes and rapid environmental change (Hiscock 1994:278-283). Hiscock's risk mitigation theory is important in the context of this study and will be discussed in more detail in Chapter 2.

CHAPTER 2 HOLOCENE ECONOMICS, SETTLEMENT AND TECHNOLOGY

Initial occupation of the Whitsunday Islands occurred at a time of great pan-continental change. The late Pleistocene was characterised by a changing environment which manifested in higher temperatures than previously, rising sea levels and a suite of associated environmental changes. These changes preceded changes to demographic, settlement and technological patterns which were expressed archaeologically in the form of a greater number of sites being occupied, specialisation and intensification of resources, and technological change. This was particularly manifest in the mid-late Holocene.

The Whitsunday Islands were first occupied at approximately 10,000 BP during a time of rising sea levels and a changing local environment which affected the range and availability of resources (Barker 2004). Throughout the Holocene, a stone source on South Molle Island was being utilised to supply stone for the production of artefacts (see Figures 2.1 and 2.1). There are stratified sequences in several rockshelters in the region which document the temporal component of quarry use. Throughout the Holocene changes in discard rates of stone artefacts are observed, with implications for our interpretation of quarry use. In this chapter I examine these changes in light of dominant paradigms for change in coastal Australia, including social theory, risk mitigation and the slowly altering environment.

Thus the purpose of this chapter is to explore settlement patterns and resource use in coastal eastern Australia in the Holocene. I will examine archaeological patterns of change and theories seeking to explain these changes, with a view to modelling changing use of stone artefacts in the Whitsunday Islands throughout the Holocene period.

Figure 2.1 South Molle Island Quarry

Figure 2.2 South Molle Island Quarry

AUSTRALIA IN THE HOLOCENE: SETTLEMENT AND TECHNOLOGY

Use of the coast in early Holocene Australia has generally taken the form of a seasonal coastal/hinterland pattern of exploitation, with a land based terrestrial and estuarine diet being supplemented with more specialised seasonal marine resources (e.g. Draper 1978; Jones 1971; Lilley 1978; Poiner 1976; Vanderwal 1978). While environmental change in the form of rising sea levels and altering micro environments was occurring throughout the Holocene, there were few significant changes to settlement patterns until the mid-late Holocene. This is the case for mainland coastal and island settings. With the exception of islands in the Whitsundays (Barker 2004), all island occupation considerably post-dated the stabilisation of sea levels (see below).

The mid-to late-Holocene saw changes which were part of a continental wide phenomenon. There was a steady increase in the numbers of sites utilised on the coast as well as an apparent increase in the use of existing sites particularly after about 3,500 BP (e.g. Attenbrow 1982; Barker 1991; Beaton 1985; David 1994; Hall and Hiscock 1988; Hughes and Lampert 1982; Ross 1985). There was also a change in the types of environments utilised with the increased use of the more peripheral environments such as rain forests (Horsfall 1987), arid areas (Smith 1989; Veth 1989), highlands (Morwood 1992) and off shore islands (e.g.. Barker 1991; Beaton 1985; Hall 1982; O'Connor 1982, 1992).

The resource base also underwent significant change with the introduction of a wide range of previously little utilised foods into the regional dietary base, such as fern root (McNiven 1985, 1991), grass seeds (Smith 1988), and large marine mammals and reptiles (Barker 1991, 1999, 2004). This was accompanied by a change in technology, which was also part of a larger, continent-wide phenomenon. Such changes included the increased visibility of a range of stone tools, once known as the 'Small Tool Tradition' (STT) (Gould 1969) as well as other tools suited to the procurement and processing of the new suite of resources. These include, for example, the seed grinding implements of the arid zone of Australia that Smith (1986:36) refers to as "distinctive seedgrinding implements [indicative of] a late Holocene development and may be associated with other widespread changes in assemblages at this time" (however see Goreki et al. 1997 regarding the general antiquity of seed grinding implements).

Evidence for the existence of the purported Small Tool Tradition was initially gathered during excavations by McCarthy (1948, 1964) and subsequently affirmed by Mulvaney (1969) and Mulvaney and Joyce (1965) at Fromm's Landing in South Australia and in Kenniff Cave in south western Queensland. Since then, the Small Tool Tradition has become a chronological marker for many undated assemblages and late Holocene stone artefact assemblages. In general terms, the STT was claimed to incorporate the production of blades, points, geometric microliths and other forms of controlled artefact manufacture such as core preparation (Johnson 1979; Hiscock 1994) and most commonly, backed artefact production.

Reconstructions of the spatial distribution of backed artefacts in Australia have consistently drawn a line demarcating an 'absence' of backed artefacts in northern Australia (e.g. Mulvaney 1975; White and O'Connell 1979). The positioning and very existence of this line however, remains in a state of flux, with the continuing discovery of backed artefacts in the northern part of the continent (e.g. Bowdler and O'Connor 1991; Brayshaw 1977; Hiscock and Hughes 1980; Lamb 1996). Other factors centred around how sampling and typological distinctions (Hiscock and Attenbrow 1996) affect the known spatial distribution of backed artefacts, although Smith and Cundy's (1985) review would suggest that there are pockets within the north where backed artefacts appear genuinely absent (but see Hiscock 2001 for an alternative model). Temporal control of the emergence of backed artefacts in Australia has previously relied on a model which places them initially in the mid/late Holocene, or not before c4,500 BP (Beaton 1982:57; Bowdler 1981; Bowdler and O'Connor 1991; Johnson 1979; Morwood 1979, 1981:43-45; White and O'Connell 1982). Termed the 'sudden appearance model' (Hiscock and Attenbrow 1998:49) it proposed that the backing technology which produced artefacts belonging to the 'Small Tool Tradition', was not developed until after c4,500 BP. Indeed, this model has been used to date open sites containing backed specimens, where there were no other dating options available (e.g. Ross 1981).

The existence of the STT and the timing of various components of the tool kit has since been questioned (Hiscock 1994; Hiscock and Attenbrow 1998; McNiven 2000), particularly the aspect known as 'backing'. Backing is a technological method used in the production of several implement types: microliths, geometric microliths, and backed 'blades' commonly known as eloueras and juan knives, but more conveniently known collectively as 'backed artefacts' (Hiscock and Attenbrow 1996). The timing of the first appearance of backed artefacts has been found to be earlier than previously thought; contrary to the 'sudden appearance model' which places them at approximately 4,500 BP (Hiscock and Attenbrow 1998, 2004;

McNiven 2000; cf Johnson 1979; Morwood 1981). Hiscock and Attenbrow (1998), for example, apply a rigorous methodology aimed at establishing taphonomic integrity, which confirms backed artefacts in layers older than 5,370±60 BP at Mussel Shelter and layers older than 8,000 BP in Loggers Shelter in the Upper Mangrove Creek catchment area. McNiven (2000) argues that backing was part of the manufacturing process for 'thumbnail scrapers' in Bone Cave, southwest Tasmania, and has been a part of the 'technological repertoire' for 30,000 years. There is an undeniable flowering of the use of this manufacturing method in the Holocene onwards, however it is clearly not as temporally bounded as once thought.

Off-shore islands of Queensland

Use of offshore islands in northern Australia predominantly occurred in the late Holocene, considerably after the stabilisation of sea levels (Chapter 4). One notable exception to this pattern is the islands of the Whitsundays (Barker 2004). Varying degrees of marine resource utilisation can be observed in several island systems in northern Australia (Barker 2004; Hall and Hiscock 1988; O'Connor 1992; Rowland 1982). These range from seasonal coastal/hinterland patterns of use to intensive marine specialisation. The Moreton region of southeast Queensland for example, appears to have relied on a less clearly defined pattern of seasonal use than systems to the south (e.g.. Draper 1978), but present none the less. The emphasis in the Moreton region appears to be on coastal, shore based estuarine environments with a seasonal exploitation of islands and hinterland areas (Hall 1982; Hall and Hiscock 1988; Lilley 1978).

The nature of pre contact Aboriginal marine exploitation further north around the Tropic of Capricorn (Keppel Islands) and further to the Whitsundays was significantly different to that on the southern islands. The subsistence economy in the Keppels for example was oriented solely around marine resources, with no terrestrial component whatever and was exploited by a permanent population (Rowland 1982). The Whitsunday Islands demonstrate a similar marine specialisation with the procurement of large marine mammals and reptiles after approximately 3,000 BP (Barker 1989, 1996, 1999, 2004) and an associated marine specialised technology consisting of bone points, fish hooks and detachable harpoons (Barker 1996:36; and see also O'Connor 1992). Fish also figures significantly in the archaeological record, as does shellfish (although see Barker 2004:6-7 for a discussion on the relative significance of shellfish).

It is argued by Barker (2004) that people of the Whitsunday Islands were 'always' coastal. That is to say, they moved with the coast as the sea levels rose, thus inhabiting Nara Inlet 1 at the time of the sea's arrival at the 10,000 year old coastline. The implication of this model is that the Holocene peoples of the Whitsunday region were adapted to the coast, possessed watercraft and were adept at moving between the islands and the mainland. This method of movement between sites is unique to island contexts and has implications for stone artefact distance/decay models and associated archaeological signatures.

Distance/decay models are traditionally viewed as an inverse relationship between distance from source and amount of stone artefact discard (e.g. Newman 1994). The basis for this is that people attempt to ration or preserve the amount of stone in their possession, the further they move from the source of its procurement. The applicability of this model it seems, varies from context to context, depending on factors such as transport options and targeted production of particular types of artefacts (Close 1999). Distance decay models may work best on unretouched flakes rather than implement types (Hofman 1991, cited in Close 1999:24). When looking at implement size, intended use has been seen to be more important than distance from source (Newman 1994; Peterson et al. 1997:200, cited in Close 1999:24).

Another factor uniting amount of discard and distance is that of processing at the source. Models regarding central place foraging hold that as distance between central place and resource increases, field processing of materials becomes more cost effective, and thus degree of processing at the procurement site increases (Barlow and Metcalfe 1996; Bettenger et al. 1997; Metclafe and Barlow 1992; O'Connell et al. 1988; Beck et al. 2002). The degree of cost-effectiveness is determined by the time it takes to process the resource and the cost of transporting the unprocessed resource from the procurement site to the 'central place'. When the ratio between elements of resource non-utility and utility are high, cost effectiveness of field processing is increased when distances to be travelled are great. However, when distances are smaller, it may be more cost effective to transport the resource intact, rather than spend the time processing it in the field (Bettenger et al. 1997:888; Beck et al. 2002:486).

This model of cost effectiveness is particularly applicable in the Whitsundays where several resources that were procured as part of the specialised marine economy had demonstrably high ratios between their non utility and utility aspects. For example the exploitation of dugong and sea turtle, documented though it is, left few traces in the archaeological record. Cribb and Minnegal (1989) while examining dugong exploitation in Princess Charlotte Bay, north Queensland, demonstrated that field processing of the dugong carcass was commonplace, and that very little dugong bone found its way back to the residential sites. A similar explanation is invoked by Barker (2004) for the absence of dugong bone in the Whitsunday rockshelter sites, despite the historical record documenting dugong use in the region (Dalrymple 1860:29, cited in Barker 2004:40). There is a high proportion of non-utility resource in dugong (that being the dense, and thus heavy bone) and processing of the resource took place at the procurement site (Barker 2004:40).

Models for differential size of artefacts across the landscape are designed to explain assemblage variation. Thus, this variation is the expression of factors such as distance from source. While this type of model explains change insofar as it acknowledges changing visitation and provisioning patterns, it does not attempt to explain *why* such change occurs. These models are the subject of the following section.

Models of Coastal Holocene Change

Although the focus of this thesis is clearly on the stone artefact component of the archaeological record, the models outlined here focus on generalised change, which incorporates an expanding resource base, increased number of sites used, and increased use of individual sites. Technological change is usually discussed as being associated and inferred by these other, broader changes to entire systems (e.g. Rowland 1987). There are several notable exceptions to this, where technological change is explained by models that specifically target the technological components of the economic system (e.g. Hiscock 1994). These will also be addressed in the following section.

Published models for late Holocene change in Australia can generally be divided into five broad areas, with common areas of overlap: these centre around *environment*, *population increase*, *post-depositional factors, social factors* and *technology*.

Environmental models

The main protagonists for environmental models affecting Holocene change on the Queensland coast are Rowland (1983), Beaton (1985) and Walters (1989), who invoke a changing environment as the principal determinant in wide ranging systemic change for coastal peoples. Both Walters (1989) and Beaton (1985) link the late Holocene occupation of the coast with the altered range and distribution of marine biota, citing a 'lag' between sea level stabilisation and the establishment of coastal resources.

In his wide ranging discussion of climatic impacts on human populations, Rowland (1983) discusses several transitional periods in Holocene climatic conditions. These periods were marked by a transition from warmer and wetter conditions that prevailed at 5,500 BP to somewhat cooler and dryer conditions extending from approximately 3,500 BP to 2,000 BP (Rowland 1983:71). Associated fluctuating sea levels, it is argued, would have ensured a period of resource instability, and thus human populations widened their geographic and resource range as an adaptive measure (Rowland 1983:71).

Four specific adaptive strategies are identified by Rowland (1983:72): the development of a set of generalised techniques for maximising resource procurement, both for consumption and exchange; the development of a range of economic strategies such as the incorporation of the 'Small Tool Tradition' into the toolkit, while retaining elements of previously utilised strategies; the cultivation of "knowledge of the fullest expanse of resource alternatives" within a given territorial area, as well as expanding social and political networks for maximum economic gain; and the stockpiling of surplus resources.

More recent examinations of cultural change have emphasised the complex nature of human/environmental interactions and have made attempts to integrate internal socio/cultural processes with late Holocene environmental change (e.g. Rowland 1999). As environmental data are refined (Nicholls 1993) and the connection between specific environmental events and the archaeological record are established, models that invoke the environment as an agent of change, by nature of their scale, appear to have considerable merit (Bird 1995). This however, needs to be viewed at a regionally specific level, as the connection between cultural change and environmental variability is not always there (see Genever et al. 2003).

Population models

The habitation of off-shore islands in Queensland, as one of the more ephemeral environments in the late Holocene, has been explained by several researchers as the product of a 'slow, intrinsic population increase' that began at around the time of sea level stabilisation (Hiscock and Hall 1988:14; see also Beaton 1985). In an examination of the complex patterns of population dynamics, Beaton (1985:25) states that without an understanding of these dynamics "the interaction between population and culture change is difficult, if not impossible, to build into analyses and interpretations'. By invoking a link between the 'carrying capacity' of regional resources and limitations placed on population growth, Beaton (1985) concludes that the nature of resource distribution did, until the late Holocene, restrict populations. And while acknowledging the complexity of the relationship between the archaeological record and population number, he interprets changes to the record as indicative of population growth (Beaton 1985).

Hughes and Lampert (1982) synthesise a range of data specifically relating to number of sites and intensity of site use in coastal New South Wales over the last 5,000 years. They conclude that there was a two to three-fold increase in numbers of sites used and a six to ten-fold increase in intensity of site use. This was apparent across the suite of site types: rockshelters, open sites, those in estuarine environments, in protected and exposed coastal conditions (Hughes and Lampert 1982:20). In advocating that population increase was the agent of this change to settlement and subsistence patterns, Hughes and Lampert (1982) argue against the implementation of other models of change, including that of environmental change for the late Holocene cultural patterns: "... cannot be explained in terms of environmental change as the coastline had essentially taken on its present configuration by that time".

Post depositional models

Site preservation factors have been used in varying contexts, to explain both the paucity of coastal sites in the terminal Pleistocene/early Holocene period, and the increase in the number of sites in the late Holocene (Head 1984; 1986; O'Connor and Sullivan 1994; Rowland 1989). Post depositional factors include cyclonic events, coastal and estuarine erosion and fluctuating sea levels. However, it appears that the expression of trends, which are interpreted as late Holocene cultural change, are replicated in a sufficient number of contexts as to discount post depositional factors as a pan-continental or island-specific agent of perceived change (e.g. Barker 2004; David 1994; Lourandos 1983; McNiven 1988; Morwood 1987).

Technological models

In the coastal/island setting, technological models have been utilised to explain the initial and increasing use of these somewhat more ephemeral environments. Thus, both Sullivan (1982) and Vanderwal (1978) explain the late Holocene use of offshore islands by suggesting that it was enabled by the development/acquisition and improvement of watercraft technology (see also Rowland 1987). The Whitsunday region was initially occupied in the early Holocene, at which time the islands in question were still a part of the mainland (Barker 2004). However, because of certain provisioning patterns that were in place at the time, particularly procurement of the stone source on South Molle island, it can be concluded that watercraft were already in use in the early Holocene in this region. Thus, models of technological innovation which have been posited to explain the late Holocene use of off-shore islands are of little relevance to the current study.

Social models of change

Lourandos' (1983) model of social change for the late Holocene phenomenon was the first of its kind. The concept of 'intensification' was being discussed in the international literature regarding cultural change (e.g. Bender 1981) but Lourandos (1983) was the first to identify it as a systematic and consistent pattern in the Australian assemblages, via an analysis of material from south west Victoria. Lourandos (1993:82) identified four main traits of the archaeological record which would indicate that economic intensification was occurring: a more intensive use of individual sites; increased establishment of new sites, an increased use of ephemeral environments; and an "increased complexity of site economy (i.e. resource management strategy)".

Lourandos (1983:88-90) drew upon ethnographic data to establish some characteristics of Aboriginal social and political alliances. He then identified a range of systems within society, upon which social relations have an impact: economy, resources, services, goods and knowledge. Production and productivity, Lourandos (1983:90) argues, "are in this way affected for incentives exist (due to the dynamic nature of the social relations) for their manipulation".

Subsequently, social models for change have been used in varying contexts (David 1994; McNiven 1991). Importantly for the purpose of this study, Barker (1996, 2004) constructs social models to depict and explain changes in the Whitsunday region and argues that the timing of environmental change is incongruent with the change in the archaeological record of the Whitsunday region. His studies of the economic systems in the region lead him to argue that the pattern of change observed in the late Holocene marks a transition from ephemeral coastal exploitation to a specialised marine economy (Barker 1996, 2004). The archaeological signatures of this change are: an increased number of sites utilised in the late Holocene; more intensive use of existing sites; a wider range of resources incorporated into the diet; and a specialised technology specifically related to the procurement of marine resources. Socially, Barker (1996:37, 2004) argues, this indicates a restructured demography from that of an open, "generalised coastal-hinterland system where boundaries, cultural demarcation and access to resources were less rigidly structured" (see also Barker 1991).

The transition to a more bounded system (Barker 1991, 1996, 2004) occurred in the late Holocene after approximately 3,000 BP. Barker (1996:38) states:

> "The boundedness of these systems intensified regional social interactions by formalising them. This can be viewed in terms of increasing 'complexity' of sociocultural relationships, and possibly as the outcome of a population increase."

There are several indications of regional social interactions between the people of the Whitsundays, and coastal peoples to the north. Barker (1996:38) observes common items of material culture, which include turtle shell and shell fish hooks, outrigger canoes (observed historically and see also Rowland 1987) and decorated broad-bladed canoe paddles. Additionally, there is evidence for the transportation of South Molle Island Quarry stone further along the north coast of Queensland, some 140km distance (Barker and Schon 1994).

There appear to be two distinct threads to Barker's social model for change in the Whitsunday region (Barker 1996, 2004). There are the ethnographic and historic observations which note material culture items suggestive of contact with coastal peoples to the north. There is also the notion of an archaeologically observable bounded cultural system, which is inclusive of a specialised marine economy, marine oriented technology and intensive use of the region and its resources. These factors in combination are used by Barker (1996, 2004) to argue for a significant demographic and social reorganisation of people across the landscape after 3,000 BP. The socio-demographic results of such change are heightened social interactions and an increased expression of territoriality which are inferred by elements of the archaeological record indicative of a specialised economy and technology and a more intensive use of the region.

These factors are expressed in the archaeological assemblage in a variety of ways. Firstly, there are two rockshelter sites in the region that were occupied for the first time in the late Holocene (Barker 2004:91-103 & 117-127). These are Hill Inlet 1 and Nara Inlet Art site (2,770 cal. BP and 2,350 cal. BP respectively). They contain a variety of terrestrial and marine based resources that are not present in the early Holocene layers of other sites (Border Island 1 and Nara Inlet 1; 6,900 cal. BP and 8,990 cal. BP respectively). This is despite the broad climatic pattern being in place throughout the Holocene (Genever et al. 2003) which supports the notion that the "macrophytic communities were in place throughout the period of occupation [thus] the species that appear only in the archaeological record after 3,000 BP were nonetheless available well before that time" (Barker 2004:143).

The specialised marine economy that Barker (2004) posits for the region, particularly in the late Holocene is inferred by a number of factors. Primarily among these is the appearance of three new marine shellfish species *Gelonia coaxons*, *Pinctada fucata*, and *Asaphis deflorata* in Nara Inlet 1. Additionally, there is evidence of predation pressure on the shellfish species *Nerita undata* in Nara Inlet 1, and on *Saccostrea cucullata* at Hill Inlet Rockshelter 1 (Barker 2004:146). There is also an increase in the discard rates of other cultural materials including fish bone, shell, marine reptile bone particularly the green sea turtle, and the presence of pilot whale in Nara Inlet 1 (Barker 2004:146).

Accompanying these dietary changes was a corresponding shift in the technology of the region. This included a decrease in the amount of stone discarded in the rockshelter sites in the late Holocene period of occupation and the incorporation of a range of tools made from marine products and/or geared toward the hunting of marine animals (Barker 2004:83-85). For example there is worked turtle shell in xu 23 of Nara Inlet 1. Barker (2004:83) suggests that it may be a by product of turtle shell fish hook manufacture, as observed in the historical record. Also recovered from Nara Inlet 1 was a wooden point covered in resin which may have been a barb or point end of a spear (Barker 2004:83). Other non-lithic components of the tool kit include bone points (Hill Inlet Rockshelter 1, xu 10; Nara Inlet 1 xu 19, 22 and 29), shell scrapers (three in Nara Inlet Art Site, xu 10; one Nara Inlet 1 xu 19 and 20 and four in Hill Inlet Rockshelter 1, xu 2, 6, 8 and 13) and knotted string/netting (Nara Inlet 1 xu 1). Cut shell pieces (of the genus A*nadara* in addition to *Gelonia coaxons*) also occur in Nara Inlet 1 (xu 19 and 20) and Hill Inlet Rockshelter 1 (xu 21).

Barker (2004:151) concludes that

> "the post-3,000 BP period marks the *beginning* of the process leading to the socio-cultural system described historically, in which the peoples of the Whitsunday Islands eventually became identified as the Ngaro, a 'tribal' entity described as the 'sea people', who were clearly distinguished from mainland populations".

Modelling technological change

The models outlined above deal with broad scale change to whole economic, social and demographic systems. Stone tool technology is frequently treated as an associative trait within these systems, and explanation for changing technologies tends to be inferred from explanations for wider systemic change. There are few models that relate directly to the changes in technological systems, that were observed in the mid-late Holocene. It is the purpose of this section to present theories that deal explicitly with change to the stone artefact component of the Australian archaeological record.

I touched briefly on Torrence's (1983) theory of optimisation as being one of the first models to examine change to various aspects of the archaeological record under a united body of theory (Chapter 1). Her argument was that people adopt various technological strategies to mitigate risk expressed as *time stress*, which has links to other foraging strategies. I presented this approach as differing from the body of processual theory in that processual theory examines change as it occurs to interrelated subsystems, each of which warrants individual investigation (Clark 1972) using disparate and often unrelated theory.

Related to Torrence's model for optimisation relative to risk as *time stress*, Hiscock (1994) approached risk from a broader perspective. In the Australian context, Hiscock (1994) proposed that the composition of the Australian stone toolkit is affected by manufacturing behaviour aimed at risk reduction. This is demonstrated for the mid-late Holocene in Australia in high "failure probability" contexts such as high mobility, colonisation of new landscapes and rapid environmental change (Hiscock 1994:278-283, 2001). The nature of the environmental change which could have triggered these changes to the Australian toolkit has been under subsequent review however (Hiscock 2001). Rather than focusing on "continuous and rapid environmental change... More likely the conditions evoking this response involved an increase in the level of environmental *variability*" (my italics; Hiscock 2001:169).

While the impetus is clearly placed on environmental perimeters, Hiscock (1994, 2001:169) acknowledges the role of social forces in mitigating and even inducing risk. However, he queries the link between the emergence of the late Holocene "compartmentalized cultural landscapes" (Hiscock 2001:169) and the spread of backed artefacts because the timing of the purported late Holocene compartmentalizing 'event' is several thousand years after the proliferation of backed artefacts. Hiscock (2001:169) offers the following model instead:

During a time of increasingly dry conditions between 4,000 BP and 5,000 BP, when populations were at least steady but possibly increasing, a preexisting implement form (the backed artefact) began to be manufactured in much higher numbers. This was a response to a shifting of resources across the landscape, not only in terms of availability, but also in terms of predictability. Risk was heightened in these conditions because "at least some human groups were moving into new landscapes" (Hiscock 2001:171) and the ongoing effects of a rising sea level continued to be felt. Hiscock (1994) argued that backed artefacts form part of a response to risk because they are versatile, reliable and are able to be readily maintained. Thus, in periods of greater risk they give a group using them an advantage and are therefore selected as a strategy, and proliferate. The extent to which backed artefacts are used across time and space depends on the following three factors: "the level and nature of foraging risk", "the cost-benefit of this technological response relative to other available technological strategies" and "the relationship between stone working technology and the other risk-response adjustments being made" (Hiscock 1994:171). The very fact that backed artefact numbers decline in the archaeological record after about 2,000 BP, when precipitation levels rose abruptly, appears to confirm the link between resource stress and uncertainty, and the proliferation of backed artefacts (Hiscock 1994:171).

A goal of this thesis is to characterise the temporal trends of artefact production in the Whitsunday region, with a view to establishing these patterns of production as they relate to the palaeoenvironmental data outlined in chapter four. Coupled with this is the goal of characterising artefact production on the quarry. These two factors together will enable me to determine not only the range of technological strategies practiced throughout the Holocene, but whether backed artefacts were incorporated into the tool kit as a response to aspects of 'foraging risk', principally that of environmental variability. The methods associated with the aims of this thesis are outlined in the following chapter.

CHAPTER 3 AIMS AND METHODOLOGY

This chapter presents methodologies associated with the two field-based aims of the thesis, which were explored in detail in Chapter 1. It should be noted here that the raw data for this project are not included as an appendix, as it amounts to several thousand pages. They are however, available upon request from the author.

FIRST AIM: TECHNOLOGICAL CHARACTERISATION OF THE QUARRY

The first aim of this research is a technological characterisation of the quarry, examining extraction technology, raw material preferences, manufacturing systems and the extent of retouch variability.

Field Methodologies

To examination of factors relating to the above, the quarry was divided into eight survey areas (described below), based on stone artefact visibility and densities (Figure 3.1). The areas selected were all areas of high visibility, with minimal obstruction by the dense tropical grasses that are a feature of the quarry. They were also all areas of high artefact density, typically numbering in the hundreds of artefacts per square metre. While these areas are not spatially representative of the quarry, this was deemed an appropriate survey strategy as it had the potential to yield the largest and therefore most comprehensive sample for the purposes of this project.

Area 1 is approximately 30m long by 15m wide and extends along the ridge top in a southerly direction, between the north east peg and excavation square N1 (Figure 3.2).

Figure 3.2 Study Area one on the South Molle Island Quarry

Area 2 is located south of the excavation square N1. It extends along the ridge top for approximately 30m and is only 15m wide, thus it is confined largely to the level ground of the ridge top.

Area 3 occupies the area east of excavation square S1. It extends down slope for approximately 10m and is 15m in width (Figure 3.3).

Figure 3.3 Study Area 3

Area 3a and *3a/1* are located to the east and further downslope from Area 3. Area 3a/1 is approximately 5m by 5m in dimension (being somewhat hampered by dense shrub) while 3a/1 is 5m by 12m

Area 4 extends to the north and west of excavation square N1. It is approximately 8m by 15m extending down the western slope of the ridge top (Figure 3.4).

Figure 3.4 Study Area 4

Area 5 occupies a dense artefact scatter located at the northern end of the quarry, some 60m north west of the north east marker peg.

Area 6 consists of the beach located to the north of the quarry, flanking the base of the ridge (Figure 3.6). Artefact densities on the beach are not as great as those on the quarry itself, but this area was included for analysis based on the fact that it was spatially distinct from the ridge top, and there was previously a quantity of retouched flakes recovered from that location which were analysed for a related study (Lamb 1996).

Figure 3.5 Study Area 6

Area 7 is approximately 90m to the north of excavation square N1 and occupies a portion of the western slope of the quarry (Figure 3.7). This area consists of a steep and mobile artefact scree-slope, punctuated by fern and shrubs, and bordered further to the west by a relatively level area.

Figure 3.6 Study Area 7

Area 8 consists of the most northerly artefact scatter that was mapped for the purposes of this project (Figure 3.8).

Figure 3.7 Study Area 8

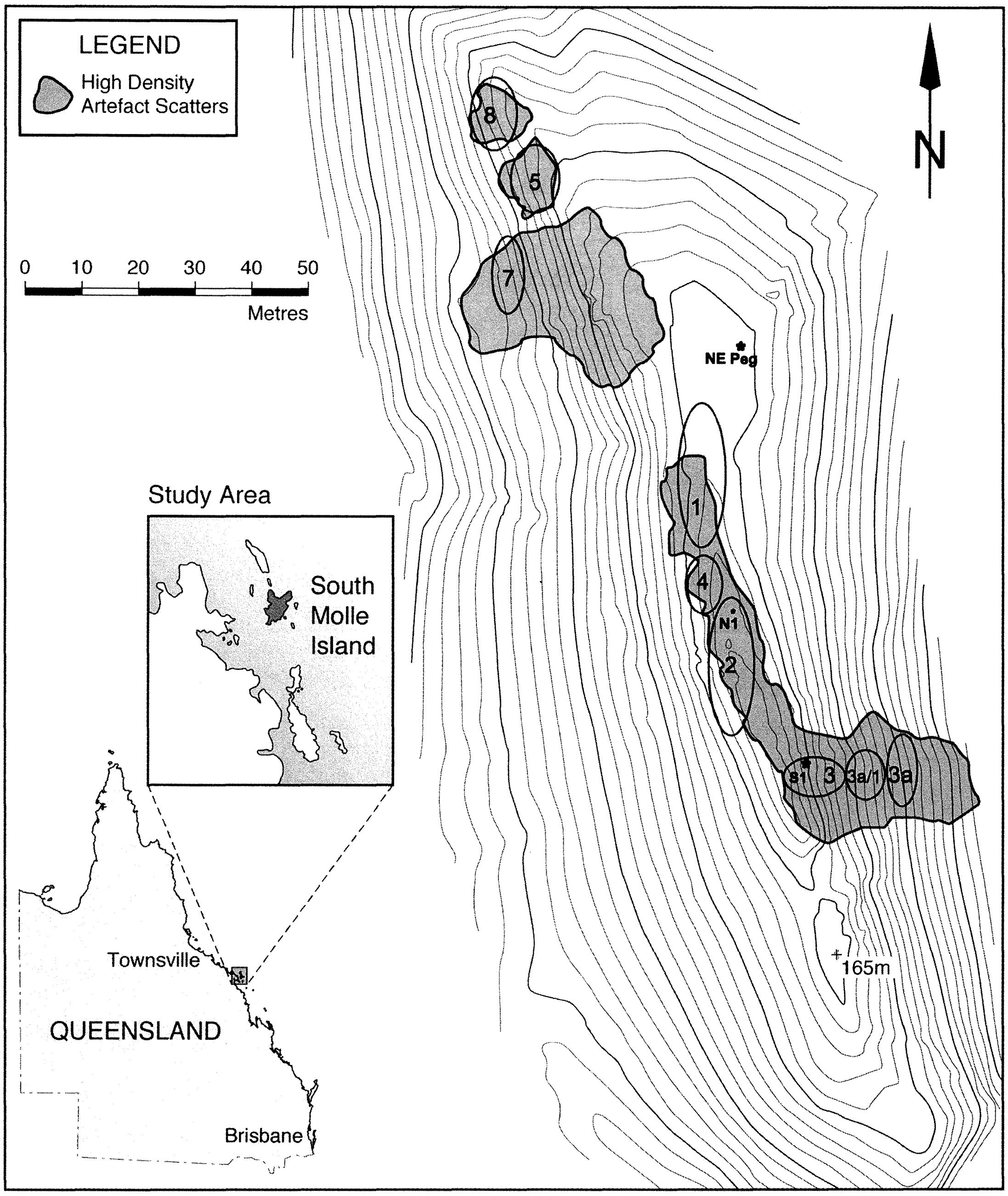

Figure 3.1 Map of the study areas on the South Molle Island Quarry

Unworked nodules

The objective of collecting data on unworked nodules was to enable a comparison to be made between properties of material utilised and properties of material that had not been utilised. This comparison will enable statements to be made regarding properties that affected choice of raw materials, and thus will assist in the explanation of spatial patterns of use observed on the SMIQ.

Data on a sample of 177 unworked nodules were collected from survey areas 2, 3 and 3a-I, as densities were greatest in these areas. The set of attributes selected for analysis was designed around illustrating the overall shape and dimensions of the unworked nodules, for the purposes of comparison with the sample of cores. To this end, 14 attributes were analysed on the unworked nodules (see Table 3.1). The analysis was conducted in the field with the aid of a set of Mitutoyo digital callipers to 0.1mm and A&D digital scales with a measurement capacity of 1g to 12kg. The data were recorded onto forms generated in Microsoft Exel, then transferred for the purpose of storage, into a Lotus Approach data base. The data were then analysed in SPSS.

Table 3.1 List of variables and variable explanations for Unworked Nodules

Variable	Explanation
Length	The maximum dimension. Measured in mm.
Width 1	At 90 degrees and approx. 1/3 of the way along the length. Measured in mm.
Width 2	At 90 degrees and approx ½ way along the length. Measured in mm.
Width3	At 90 degrees and approx 2/3 of the way along the length. Measured in mm.
Thickness	The measurement taken at right angles to the intersection of the length and width 2. Measured in mm.
Weight	Measured in g.
Distance and angle	Distance and compass readings taken from a reference point for mapping purposes.
Heat shattered	Presence/absence variable defined as alteration to the nodule brought about by natural heating.

Reduced outcrops

The rationale for collecting data on the reduced outcrops is that, technologically they can be classified as cores because knappers have utilised them as a source of raw material by flaking material from them. Thus the information gained from this analysis contributed to a more comprehensive understanding of core use on the SMIQ. The distinguishing feature of reduced outcrops is that they are masses of stone which remain embedded in the soil matrix. To this end, data on a sample of 22 reduced outcrops were collected. The large (and unwieldy) size of these cores determined that a different set of attributes had to be designed for practical purposes of analysis (see Table 3.2). As with the core attributes, these were designed around characterising overall size and dimension, the number and nature of flakes removed, platform morphology and stage of reduction. Analysis was undertaken *in situ*, with the aid of a set of Mitutoyo digital callipers which measured dimensions to a precision of 0.1mm and a tape measure. Data were recorded onto hand-drawn forms, then transferred for the purpose of storage, into a Lotus Approach data base. The data were then analysed in SPSS.

Table 3.2. List of general variables and variable explanations for Reduced Outcrops

Variable	Explanation
General variables	
Length	The dimension orientated along the percussion direction of the first platform utilised. Measured in mm.
Width	Dimension at 90 degrees and half way along the length. Measured in mm.
Thickness	Dimension at right angles to the intersection of length and width. Measured in mm.
Total number of flake scars	Numeric variable.
Number of platforms	Numeric variable.
Total number of each termination type	Numeric variable, where types include feather, hinge, step and outrepasse terminations.
Platform variables	
Outcrop number	Identifies the flaked outcrop.
Platform number	Identifies the platform specific to each outcrop.
Platform angle	The angle between the platform surface and the outcrop face (where the face has been created by the removal of flakes from that platform).
Platform type	Where types are identified as having cortex, 1-2 flake scars, 3 or more flake scars or faceting.
Number of negative flake scars originating from each platform	Numeric variable.
Average length of negative flake scars	Measured in mm.
Minimum length of negative flake scars	Measured in mm.
Maximum length of negative flake scars	Measured in mm.
Average width of negative flake scars	Measured in mm.
Minimum length of negative flake scars	Measured in mm.
Maximum length of negative flake scars	Measured in mm.
Number of each negative termination type	Numeric variable, where types include feather, hinge, step and outrepasse terminations.

Cores

As noted above, one of the objectives of this thesis was to determine which properties of stone were formative in decisions regarding choice of raw materials.

To this end, a sample of cores was analysed for the purpose of quantifying the characteristics of the raw materials utilised and as a means to understanding the process of core reduction. The attributes selected for analysis were designed around determining overall shape and dimensions of the cores, the number and nature of flakes removed, platform morphology, stage of reduction, degree of core rotation, grain size and extent of weathering (see Table 3.3). All cores were located within the survey areas 1, 2, 3, 4, 5 and 7. Analysis took place with the aid of a General Tools (NY) Goniometer No. 17 which measured angles to a precision of 1 degree; a set of Mitutoyo digital callipers which measured dimensions to a precision of 0.1mm; A&D digital scales with a measurement capacity of 0.01g to 120g and 1g to 12kg; and a revised edition (1967) Munsell Colour Chart. The data were recorded on forms generated in Microsoft Exel, then transferred for the purpose of storage, onto a Lotus Approach data base. The data were then analysed in SPSS. The total number of cores analysed was 424.

Table 3.3 Core variables and variable explanations

Variable	Explanation
General variables	
Length	The dimension orientated along the percussion direction of the first platform utilised. Measured in mm.
Width 1	At 90 degrees and approx. 1/3 of the way along the length. Measured in mm.
Width 2	At 90 degrees and approx ½ way along the length. Measured in mm.
Width 3	At 90 degrees and approx 2/3 of the way along the length. Measured in mm.
Thickness	Dimension at right angles to the intersection of length and width 2. Measured in mm.
Weight	Measured in g.
Total number of negative flake scars	Numeric variable.
Number of platforms	Numeric variable.
Percentage cortex	Measured as a proportion of the core's surface area.
Distance and angle	Distance and compass readings taken from a

	reference point.
Heat spalling	Presence/absence variable defined as alteration to the nodule brought about by natural heating.
Internal flaw	Presence/ absence variable defined as a fracture on the core's surface that follows the line of a natural internal flaw.
Total number of each negative termination type	Numeric variable, where types include feather, hinge, step and outrepasse terminations.
Platform variables	
Platform number	Identifies the platform specific to each core.
Number of negative flake scars	A numeric variable which identifies the number of flake scars originating from each platform.
Platform angle	The angle between the platform surface and the core face (where the core face has been created by the removal of flakes from that platform).
Bipolar	Presence/absence variable where bipolarity is identified by crushing on the opposite end of the core to the platform.
Number of each negative termination type	Numeric variable, where types include feather, hinge, step and outrepasse terminations, on flake scars originating from that platform.
Average length of flake scars	Measured in mm.
Minimum length of flake scars	Measured in mm.
Maximum length of flake scars	Measured in mm.
Platform type	Where types are identified as being cortex or partial cortex, 1-2 flake scars, 3 or more flake scars or faceting.
Platform orientation	Identified in relation to the first platform utilised. Eight positions are identified (see chapter 6 for a complete explanation).
Flake scar variables	
Core/outcrop number	Identifies the core/outcrop.
Platform number	Identifies the platform specific to each core.
Scar number	Identifies the flake scar specific to each platform.
Length	Distance between flake scar initiation and the termination.
Width	Measured half way along and perpendicular to the length.
Truncated	Presence/absence variable.
Termination type	Where types include feather, hinge, step and outrepasse terminations.
Munsell colour	Specific to the revised edition (1967) Munsell

	Colour Chart.
Patination type	Where types include no patination; smooth colour change (colour change as a result of weathering without visible texture change); course-hard granulated change (colour change accompanied by texture change as a result of weathering); course-chalky granulated (colour change accompanied by extreme texture change where the patina breaks down as a result of weathering).

Hammerstones

Data on a sample of 304 hammerstones were collected from survey areas 1-5 and 7, with the objective of quantifying size classes and their relationship to different stages of reduction observed across the quarry. To this end, a set of 17 attributes was designed (see Table 3.4), the principal emphasis of which was to examine overall dimensions, extent of use and raw material type. Analysis was undertaken in the field with the aid of a set of Mitutoyo digital callipers which measured dimensions to a precision of 0.1mm and A&D digital scales with a measurement capacity of 1g to 12kg. The data were recorded onto forms generated in Microsoft Exel, then transferred for the purpose of storage, into a Lotus Approach data base. The data were then analysed in SPSS.

Table 3.4 Hammerstone variables and variable explanations

Variable	Explanation
Length	The maximum dimension of the cobble. Measured in mm.
Width	Half way along and perpendicular to the length. Measured in mm.
Thickness	Dimension at right angles to the intersection of length and width.
Weight	Measured in g.
Split	Presence/absence variable defined as damaged resulting in loss amounting to between one quarter and one half of the surface area of the cobble.

Worked one end	Presence/absence variable where working is identified as pitting or other damage brought about by the striking of the cobble against another hard surface.
Worked both ends	Presence/absence variable defined as above.
Worked margin	Presence/absence variable defined as above.
Material	Identified as either 'rough', 'smooth' or 'tuff'.
Distance and angle	Distance and compass readings taken from a reference point.
Fragment	Presence/absence variable, defined as damage resulting a radius which is less than half of its original diameter.

Retouched flakes

As a means to characterising the range of retouch occurring on the quarry, a survey was undertaken for any evidence that artefacts were being reduced beyond initial procurement and reduction. To this end, the quarry was surveyed within the eight defined areas, for flakes exhibiting secondary retouch. For each retouched artefact, the distance and angle from a predetermined and constant point was recorded, for the purpose of mapping. Then, depending on time constraints, the artefact was analysed in the field or collected for analysis in the laboratory.

Analysis took the form of a set of 97 attributes designed to provide a detailed morphological characterisation, and to illuminate manufacturing technique (Table 3.5). Data resulting from the field analysis were recorded on forms generated in Microsoft Exel, and then transferred onto forms generated in Lotus Approach in the laboratory. These data were then analysed in SPSS. The total number of retouched flakes identified and analysed was 435.

Table 3.5 Retouched flake variables and variable explanations

Variable	Explanation
General variables	
Artefact number	Identifies the retouched artefact.
Weight	Measured in g.

Distance and angle	Distance and compass readings taken from a reference point for the purpose of mapping.
Heat alteration	Presence/absence variable defined as alteration to the nodule brought about by natural heating.
Snapped	Presence/absence variable to denote whether the retouched artefact is broken.
Portion remaining	A presence/absence variable with the options of right lateral, left lateral, proximal, distal, medial and indeterminate portion remaining.
Retouch variables	
Backing	Presence absence variable where backing is defined as steep retouch occurring on one lateral margin.
Juan	Presence absence variable of a prescribed typological category.
Unifacial retouch	Presence absence variable where unifacial is defined as retouch occurring on one face of the artefact.
Bifacial retouch	Presence absence variable where bifacial is defined as retouch occurring on both faces of the artefact (both ventral and dorsal).
Bidirectional retouch	Presence absence variable where bidirectional is defined as retouch originating from both the dorsal and ventral surface. This is further refined into 'dorsal first' and 'ventral first' categories.
From ventral surface only	Presence absence variable denoting retouch occurring from the ventral surface only.
From dorsal surface only	Presence absence variable denoting retouch occurring from the dorsal surface only.
Retouch location	This variable includes the categories right lateral, left lateral, proximal, distal and platform retouch, as well as retouch location indeterminate.
Morphology variables	
Ringcrack	Presence/absence variable.
Bulb	Presence/absence variable.
Ripples	Presence/absence variable.
Fissures	Presence/absence variable.
Erailure scar	Presence/absence variable.
No diagnostic indicators	Presence/absence variable.
Combination including ringcrack	Presence/absence variable.
Combination excluding ringcrack	Presence/absence variable.
Primary reduction	Presence/absence variable defined as the dorsal surface being comprised entirely of cortex.
Secondary reduction	Presence/absence variable defined as the

	dorsal surface comprised partially of cortex.
Tertiary reduction	Presence/absence variable defined as the dorsal surface having no cortex.
Microflaking	Presence/absence variable, further noted to be indiscriminate or localised.
Edge snapping	Presence/absence variable denoting edge damage.
Crushing	Presence/absence variable denoting edge damage, diagnostic of anvilling.
Dorsal ridge	Presence/absence variable.
Ventral weathering pattern	Where types of weathering include no patination; smooth colour change (colour change as a result of weathering without visible texture change); course-hard granulated change (colour change accompanied by texture change as a result of weathering); course-chalky granulated (colour change accompanied by extreme texture change where the patina breaks down as a result of weathering).
Dorsal weathering pattern	Where types of weathering include no patination; smooth colour change (colour change as a result of weathering without visible texture change); course-hard granulated change (colour change accompanied by texture change as a result of weathering); course-chalky granulated (colour change accompanied by extreme texture change where the patina breaks down as a result of weathering).
Platform variables	
Platform width	Measures the distance between each margin between the points where the margin connects with the platform.
Platform thickness	Perpendicular to the width, aligned from the ringcrack to the dorsal aspect of the platform.
Platform cortex	Presence/absence variable.
1-2 flake scars	Presence/absence variable.
3 or more flake scars	Presence/absence variable.
Platform facetted	Presence/absence variable.
No platform	Presence/absence variable.
Metric variables	
Length of backing scars (mode)	From the negative point of impact to the distal end of the flake scar, along the line of percussion.
Length of backing scars (maximum)	From the negative point of impact to the distal end of the flake scar, along the line of percussion.

Maximum length	Measured on the ventral surface, parallel to the cord on the retouched margin.
Percussion length	Distance across ventral surface, from ringcrack to termination (follows percussion axis).
Maximum width	greatest distance from one lateral margin to the other, at 90° to the maximum length.
Percussion width	distance from one lateral margin to the other, half way along, and at 90° to, the orientated length.
Maximum thickness	Greatest distance between the ventral and dorsal surfaces.
Assumed length, width, thickness	These measurements are recorded in situations where there are no diagnostic features from which to orientate percussion measurements.
Length of retouch	length of the longest continuous series of retouch scars, measured on the ventral surface as a straight line.
Thickness of retouch	distance ventral to dorsal over which retouch is distributed.
Midline thickness	distance between ventral and dorsal surface (at 90° to the ventral surface), midway along the maximum length.
Cord length	a straight-line measurement on the ventral plane of the longest unretouched margin.
Edge angle	ventral/dorsal angle of the chord, taken half way along the chord length.
Ventral retouch angle	angle between the negative retouch scar of a flake and the ventral surface, taken midway along the maximum length.
Dorsal retouch angle	angel between the negative retouch scar of a flake and the dorsal surface, taken midway along the maximum length.
Ventral platform angle	angle between the platform and the ventral surface, taken at the ringcrack.
Dorsal platform angle	angle between the platform and the dorsal surface, taken at the ringcrack.
Average Kuhn Index	This measures the extent of reduction by establishing a ratio of retouch height to artefact thickness. The Kuhn index is calculated at three points along the length of the artefact, from which an average is taken (see chapter 7 for a more detailed explanation). It is measured on a scale of 0 (no reduction) to 1 (complete reduction).
Index of retouch curvature	Determined by dividing the depth of retouch by the retouch span. A negative value indicates a concave edge while a value of >0 indicates a convex edge.

Backed artefact manufacturing debris

For the purpose of characterising the backed artefact manufacturing debris, two 1x1m squares were identified for collection (N1 and S1). These squares were selected on the basis of several factors: they were situated in places of high artefact density (>300/m^2); they were situated in areas of relative stability, where taphonomic processes such as down slope movement would have had minimal impact; visibility was not hampered by the dense tropical grasses typical of the region; most significantly, there was obvious clustering of small sized artefacts within these squares, indicative of late-stage reduction. Added to this was the fact that there were five and two backed artefacts laying on the surface of N1 and S1 respectively, seemingly in the middle of their manufacturing debris. In association with this debris, were 3 hammerstones on the surface of S1, and 3 on the surface of N1. Thus, these surfaces were interpreted as relatively intact knapping floors.

The two squares (N1 and S1) were excavated using arbitrary 3-5cm excavation units. Individual finds and start/end levels were plotted using XYZ coordinates and each excavation unit was weighed and recorded on conventional excavation forms. The soil matrix was sieved using a 3mm sieve fraction, and the remainder was bagged, labelled and transported back to the laboratory for further analysis.

Macroscopic and microscopic analysis took place using a set of problem-orientated variables (Table 3.6), centred around morphology and retouch. These were quantified in the laboratory with the use of a General Tools (NY) Goniometer No. 17 which measures precision to 1 degree, a set of Mitutoyo digital callipers which measures precision to 0.1mm, A&D digital scales with a measurement capacity of

0.01g to 120g and a similar set with a measurement capacity of 1g to 12kg, a Nikon microscope obj. x2 and x4 and a revised edition (1967) Munsell Colour Chart. All data were recorded onto forms contained in several Lotus Approach data bases. Data were then analysed in SPSS. The total number of artefacts analysed from squares N1 and S1 was 5,238.

Table 3.6 Quarry excavated materials (N1 and S1) variables and variable explanations

Variable	Explanation
General variables	
Artefact identification number	
Excavation unit	
Weight	
Fracture type	This is broken down into flake, flaked piece, retouched flake, potlid, hammerstone, core.
No snap	Presence/absence variable.
Lateral snap	Presence/absence variable where the snap is aligned to the direction of a lateral margin.
Transverse snap	Presence/absence variable where the snap is aligned at 90^0 to the lateral margins.
Other snap	Presence/absence variable.
Portion remaining	This variable is broken down into the categories of proximal, distal, lateral, left lateral, right lateral, medial and other portion remaining.
Morphology variables	
Crushing	Presence/absence variable denoting edge damage.
Snap fracturing	Presence/absence variable denoting edge damage.
Microflaking	Presence/absence variable denoting edge damage.
Cortex	Presence/absence variable.
Primary reduction	Presence/absence variable defined as the dorsal surface being comprised entirely of cortex.
Secondary reduction	Presence/absence variable defined as the dorsal surface comprised partially of cortex.
Tertiary reduction	Presence/absence variable defined as the dorsal surface having no cortex.
Thermal alteration	Presence/absence variable includes the categories of greasy lustre, colour change, potliding and crazing.
Initiation type	Includes the categories of hertzian and

	bending initiation.
Erailure scar	Presence/absence variable.
Erailure termination type	Includes the categories of feather, hinge, step terminations.
Termination type	Where types include feather, hinge, step and outrepasse terminations.
Bipolar	Presence/absence variable, diagnosed by the presence of distal crushing or step fracturing.
Dorsal scars	Presence/absence variable.
Dorsal scar orientation	Broken down into categories of proximal, distal, right lateral and left lateral.
Number of dorsal flake scars	Numeric variable denoting the number of scars on the dorsal surface.
Dorsal weathering pattern	Where types of weathering include no patination; smooth colour change (colour change as a result of weathering without visible texture change); course-hard granulated change (colour change accompanied by texture change as a result of weathering); course-chalky granulated (colour change accompanied by extreme texture change where the patina breaks down as a result of weathering).
Ventral weathering pattern	Where types of weathering include no patination; smooth colour change (colour change as a result of weathering without visible texture change); course-hard granulated change (colour change accompanied by texture change as a result of weathering); course-chalky granulated (colour change accompanied by extreme texture change where the patina breaks down as a result of weathering).
Dorsal munsell colour	Specific to the revised edition (1967) Munsell Colour Chart.
Ventral munsell colour	Specific to the revised edition (1967) Munsell Colour Chart.
Metric variables	
Erailure scar length	Oriented along the direction of ringcrack to termination.
Erailure scar width	Measured at 90 degrees and half way along the length.
Maximum dimension	Measured in mm as the maximum dimension across the dorsal surface.
Percussion length	Measured in mm orientated from the ringcrack to the termination.
Percussion width	Measured in mm at 90 degrees to the percussion axis.
Percussion thickness	Measured in mm as the distance between

	ventral and dorsal surface measure at the intersection of the percussion length and width.
Assumed length, width and thickness	Measure in mm, these measurements are recorded in situations where there are no diagnostic features from which to orientate percussion measurements.
Platform variables	
Platform width	Measures the distance between each margin from the points where the margin connects with the platform.
Platform thickness	Perpendicular to the width, running from the ringcrack to the dorsal surface.
Platform angle	angle between the platform and the dorsal surface taken at the ringcrack.
Platform type	Presence/absence variable broken down into the categories of 1-2 flake scars, 3 or more flake scars, facetted and cortex.

Sampling Within the Squares

It should be noted here that there is very little soil matrix throughout the depth of each square. Artefacts were deposited in such numbers and at such a rate that there was no opportunity for the build up of soil to occur, as it does in other contexts such as rockshelter habitation sites. Therefore it must be assumed that without the supporting matrix of soil, there has been significant downward movement of artefacts. Thus the two squares were treated as 'collections' rather than excavations, the assumption being that there are no useful relative age/depth relationships within the squares. Accordingly, the analysis took place by sampling the collection rather than analysing the entire depth of the square as one would in an excavation.

The sampling procedure was based on obtaining a representative sample of each square. Due to the downward movement of artefacts, the assumption was made that artefacts were distributed throughout the depth of the square in a pattern that did not conform to the laws of stratigraphy. Predicting the extent of movement is problematic, but the lack of soil matrix suggests that it was at least possible that artefacts originally from the surface layers had come to rest in basal layers at the time of excavation. Thus, the surface and basal excavation units of N1 and S1 were analysed (Table 3.7). In addition to this, two middle units in square S1 were analysed, to provide a comparative measure for the representativeness of the method employed in square N1 (analysing the surface and basal units only).

Table 3.7 Squares N1 and S1, units analysed

Square	Excavation Units Analysed
N1	1, 2, 13
S1	1,4(c), 6(c), 14

Fracture type squares

The concept of 'fracture type' squares was developed with the aim of gaining a representative sample of fracture types that occurred across the quarry. For the purpose of this study, the term 'fracture type' is used to denote the type of artefact produced through the flaking process (core, flake, flaked piece *etcetera*). Identifying proportions of fracture types as they occurred in relation to one another, within these squares, enabled me to allocate a percentage value to the quarry assemblage as a whole, that could potentially be used for backed artefact manufacture. Seven fracture type squares were identified for analysis on the basis that they were placed in areas of high artefact density and that they were in areas of relative stability; that is, they were on relatively level ground, not subjected to gravitational taphonomic processes in the form of down slope movement. Analysis of the fracture type squares took place *in situ* and was centred around a potential set of 48 attributes specifically designed to describe fracture type, metric data, and morphology, which could then be related to similar properties observed on backed artefacts (Table 3.8). The aim of this analysis is to document the percentage of the quarry assemblage that could potentially be utilised for backed artefact manufacture. Thus, fracture type and metric data will be emphasised in the results. Analysis was accomplished with the aid of a General Tools (NY) Goniometer No. 17 which measures precision to 1 degree, a set of Mitutoyo digital callipers which measures precision to 0.1mm, A&D digital scales which measures precision from 0.01g to 120g and from 1g to 12kg and a revised edition (1967) Munsell Colour Chart. The data were recorded onto forms generated in Microsoft Exel, then transferred into a Lotus Approach data base. SPSS was used for the analysis of the data. A total of 1001 artefacts from seven sample squares was analysed.

Table 3.8 Fracture type square variables and variable explanations

Variable	Explanation
General variables	
Identification number	Identifies each artefact specific to the square.
Munsell colour	Specific to the revised edition (1967) Munsell Colour Chart.
Core	Presence/absence variable.
Complete flake	Presence/absence variable.
Longitudinal break	Further divided into categories of left lateral piece, right lateral piece.
Transverse break	Further divided into categories of proximal piece, distal piece, medial piece.
Other break	Presence/absence variable.
Flaked piece	Presence/absence variable.
Hammerstone	Presence/absence variable.
Potlid	Presence/absence variable.
Retouch variables	
Backed	Presence/absence variable.
Bifacial retouch	Presence absence variable where bifacial is defined as retouch occurring on both faces of the artefact (both ventral and dorsal).

Unifacial retouch	Presence absence variable where unifacial is defined as retouch occurring on one face of the artefact.
Other retouch	
Metric variables	
Weight	Measured in g.
Minimum edge angle	Measured with a view to making comparisons with angles on other retouched flakes and with the cord on backed artefacts.
Maximum dimension	Measured in mm.
Percussion length	Measured in mm along the percussion axis, from the ringcrack to the termination.
Percussion width	Measured in mm at 90 degrees and half way along the length.
Percussion thickness	The distance between the ventral and dorsal surface, measured in mm at the intersection of the percussion length and width.
Assumed length, width and thickness	Measured in mm, these measurements are recorded in situations where there are no diagnostic features from which to orientate percussion measurements.
Morphological variables	
Primary reduction	Presence/absence variable defined as the dorsal surface being comprised entirely of cortex.
Secondary reduction	Presence/absence variable defined as the dorsal surface comprised partially of cortex.
Tertiary reduction	Presence/absence variable defined as the dorsal surface having no cortex.
Percentage cortex	Measured as a proportion of the artefact's surface area.
Microflaking	Presence/absence variable denoting edge damage.
Edge snapping	Presence/absence variable denoting edge damage.
Termination type	Where types include feather, hinge, step and outrepasse.
Weathering pattern	Where types of weathering include no patination; smooth colour change (colour change as a result of weathering without visible texture change); course-hard granulated change (colour change accompanied by texture change as a result of weathering); course-chalky granulated (colour change accompanied by extreme texture change where the patina breaks down as a result of weathering).

Mapping

A topographic map was constructed with the aim of illustrating the position of the excavation squares, artefact type squares, and various artefact classes (cores, retouched flakes and hammerstones). Also featured on the map are several high density artefact areas, the major rocky outcrops and the largest visible boulders, all for the purposes of refining spatial identification of the features listed above. The map was constructed using a geodometre laser dumpy and two Computer Assisted Drawing programs: LisCAD and AutoCAD. A surveying student assisted me in the field with the operation of the laser dumpy.

SECOND AIM: TEMPORAL CHANGE IN QUARRY USE

The second aim of the research is a characterisation of the South Molle Island quarry through time, documenting any changes in extraction and manufacturing technology.

Field Methodologies

Nara Inlet 1 and Border Island 1 yielded basal dates of 8,990 BP and 6,990 BP respectively. Both sites have continuous Holocene sequences with stone artefacts made on South Molle Island stone present throughout, in varying densities. Given the fact that Border Island 1 and Nara Inlet 1 are both stratigraphically intact (see Chapter 8), span much of the Holocene and contain South Molle Island Quarry stone, they were selected for inclusion into this analysis because they provided an opportunity to examine changing technological behaviour in the study region.

The analysis of the stone artefact assemblage of each site was achieved through the use of a predetermined set of variables targeted towards quantifying changing technologies

(Table 3.9). It was undertaken in a controlled laboratory setting with the aid of a General Tools (NY) Goniometer No. 17 which measures precision to 1 degree, a set of Mitutoyo digital callipers which measures precision to 0.1mm, A&D digital scales with a measurement capacity of 0.01g to 120g and a revised edition (1967) of the Munsell Colour Chart. The data was stored in Lotus Approach, and analysed in SPSS. The sample size from the two combined assemblages numbered 718 artefacts.

Table 3.9 Nara Inlet 1 and Border Island 1 assemblage variables and variable explanations

Variable	Explanation
Artefact identification number	Identifies the artefact specific to the excavation unit.
Excavation unit	Identifies excavation unit.
Core	Presence/absence variable.
Flake	Presence/absence variable.
Broken flake	Presence/absence variable.
Longitudinal snap	Further divided into left lateral remaining, right lateral remaining.
Transverse snap	Further divided into proximal remaining, distal remaining.
Flaked piece	Presence/absence variable.
Potlid	Presence/absence variable.
Hammerstone	Presence/absence variable.
Core	Presence/absence variable.
Retouched	Further divided into backed, unifacial, bifacial and other.
Morphology variables	
Crushing	Presence/absence variable denoting edge damage.
Edge snapping	Presence/absence variable denoting edge damage.
Microflaking	Presence/absence variable denoting edge damage.
Cortex	Presence/absence variable.
Primary reduction	Presence/absence variable defined as the dorsal surface being comprised entirely of cortex.
Secondary reduction	Presence/absence variable defined as the dorsal surface comprised partially of cortex.
Tertiary reduction	Presence/absence variable defined as the dorsal surface having no cortex.
Heat alteration	Further divided into greasy lustre, colour change, crenation, potliding and crazing.

Initiation type	Where types include hertizian and bending initiations.
Erailure scar	Presence/absence variable.
Erailure length	Oriented along the direction of ringcrack to termination.
Erailure width	Measured at 90 degrees and half way along the length.
Erailure termination type	Includes feather, hinge and step terminations.
Termination type	Includes feather, hinge, step and outrepasse terminations.
Dorsal scars	Presence/absence variable.
Dorsal scar metrics	Length and width measurements taken. The length was aligned from the initiation point to the termination and the width aligned at 90 degrees and half way along the length.
Dorsal step fracturing	Presence/absence variable.
Dorsal weathering pattern	Where types of weathering include no patination; smooth colour change (colour change as a result of weathering without visible texture change); course-hard granulated change (colour change accompanied by texture change as a result of weathering); course-chalky granulated (colour change accompanied by extreme texture change where the patina breaks down as a result of weathering).
Ventral weathering pattern	Where types of weathering include no patination; smooth colour change (colour change as a result of weathering without visible texture change); course-hard granulated change (colour change accompanied by texture change as a result of weathering); course-chalky granulated (colour change accompanied by extreme texture change where the patina breaks down as a result of weathering).
Munsell colour	Specific to the revised edition (1967) Munsell Colour Chart.
Metric variables	
Maximum dimension	Maximum dimension measured in mm.
Percussion length	Measured in mm along the percussion axis, from the ringcrack to the termination.
Percussion width	Measured in mm at 90 degrees and half way along the length.
Percussion thickness	The distance between the ventral and dorsal surface, measured in mm at the intersection of the percussion length and width.
Assumed length, width and thickness	Measured in mm, these measurements are recorded in situations where there are no

	diagnostic features from which to orientate percussion measurements.
Platform variables	
Platform width	Measures the distance between each margin from the points where the margin connects with the platform.
Platform thickness	Perpendicular to the width, running from the ringcrack to the dorsal surface.
Platform angle	angle between the platform and the dorsal surface taken at the ringcrack.
Platform type	Includes 1-2 flake scars, 3 or more flake scars and faceting.
Platform crushed	Presence/absence variable.
Cortex	Presence/absence variable.
Partial cortex	Presence/absence variable.

CONCLUSION

Overall, a technological characterisation of the quarry will accomplish several things: it will provide a comprehensive description of a quarry site, something not yet done in Australia. It will also provide a characterisation of backed artefacts; one of (if not the) most common tool type in eastern Australia. It will also provide data to determine the degree of variation in the manufacturing behaviour. Analysis of technological change as investigated through the stratified rockshelter assemblages will direct the temporal framework of the theoretical discussion. Timing of this change will direct the nature of causal modelling for change and will establish patterns of use of the quarry through time.

CHAPTER 4 REGIONAL ENVIRONMENT, GEOLOGY AND PALAEOENVIRONMENT

INTRODUCTION

The goal of this chapter is to describe the physical environment of the Whitsunday region, with particular attention to the geology of the region, and particularly that of South Molle Island. Palaeoenvironment and sea level reconstructions are also described in this chapter.

For the purposes of this study the study region is defined as the central group of the Cumberland chain of islands, also known as 'the Whitsunday Islands'. These are inclusive of the Molle group (North, Mid and South Molle Islands), Hayman, Hook, Border, Whitsunday, Hamilton, Long, Haselwood, Dent, Pentecost, Lindeman, Little Lindeman and Shaw Islands. Additional to these are several minor or satellite islands such as Daydream Island, Goat, Planton and Denman Islands (off South Molle Island), Pine Island (off Long Island), Teague, Lupton, Worthington and Edward Islands (off Whitsunday Island) and Doloraine Island (off Border Island) (Figure 4.1).

REGIONAL ENVIRONMENT

South Molle Island is the largest island in the Molle Group (also included in this group are North Molle, Mid Molle and West Molle or Daydream Island). The Molle Group of Islands is contained within the Whitsunday Group, which, itself, is a sub-group of the Cumberland Islands, lying off the central Queensland coast (Figure. 4.2). The study region lies between 20 and 21 degrees south, approximately 300 km within the Tropic of Capricorn, and can therefore be classified a having a tropical climate. Seasonal variation is marked by hot, wet summers and moderate, dry winters. Annual rainfall totals for the Whitsunday region range from 1500 to 2000 mm, the majority of which falls between the months of December and March.

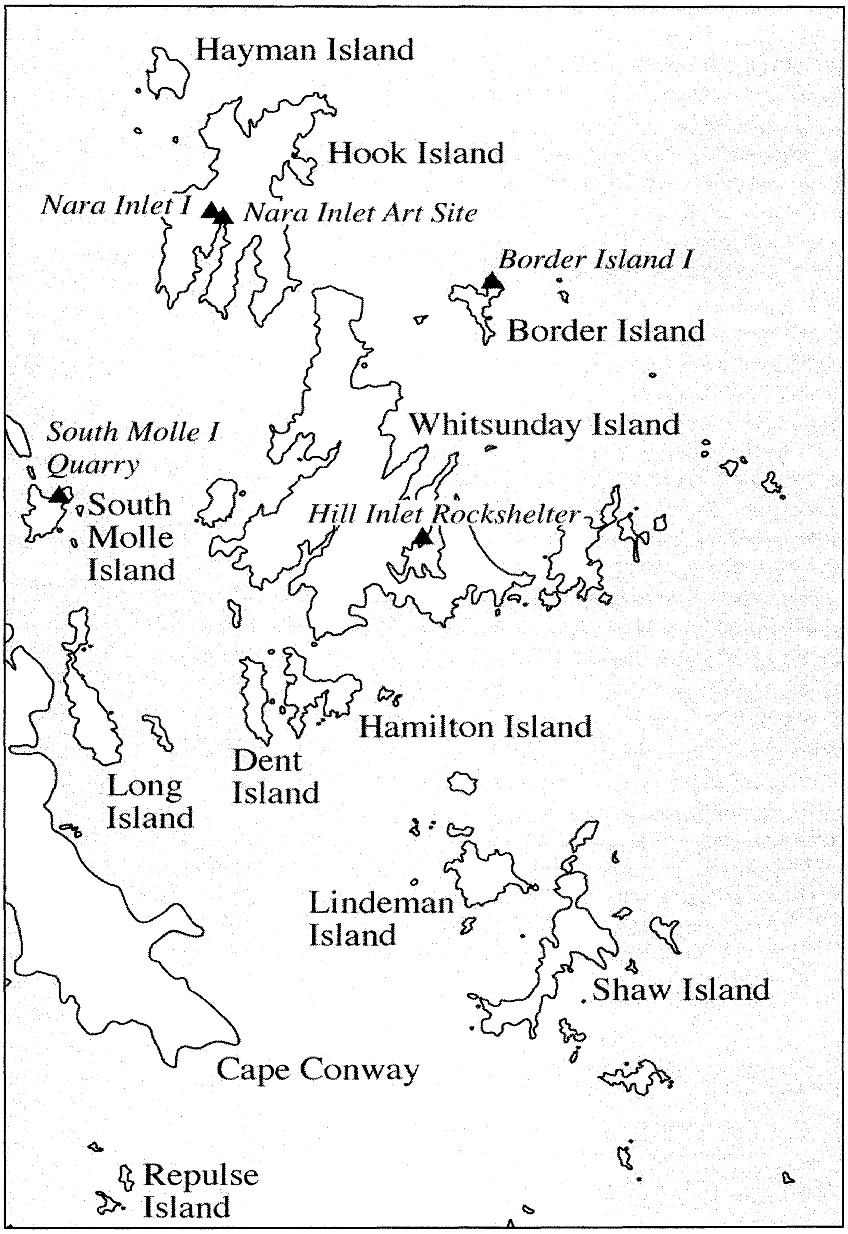

Figure 4.1 The main islands of the Whitsundays (from Barker 2004)

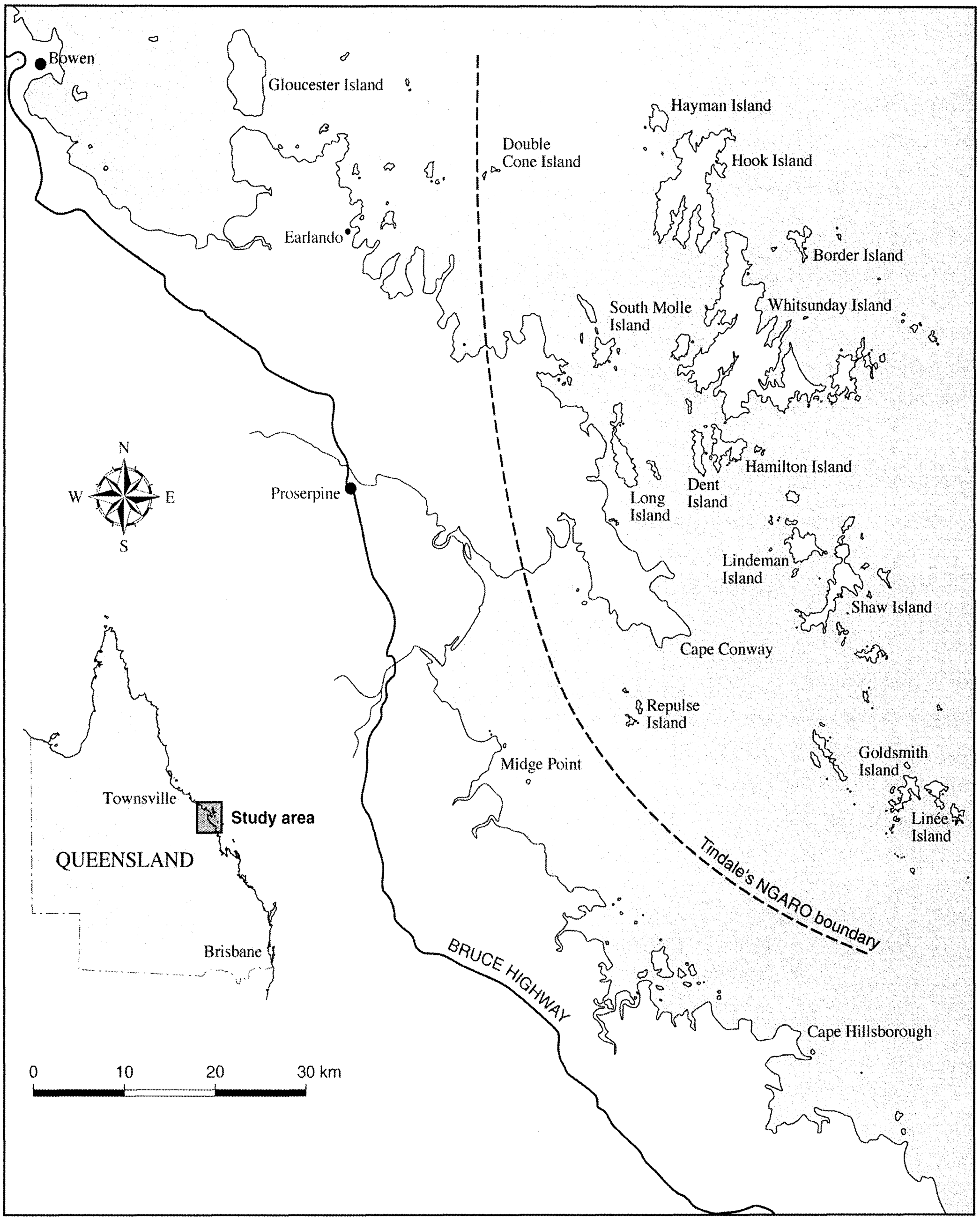

Figure 4.2 Whitsunday Islands, central Queensland coast (from Barker 2004)

As a result of the high annual precipitation totals, vegetation in the Whitsunday region is prolific and varied. Typical vegetation types include vine thickets (*Timonius timon*, *Mallotus*, *Ficus*, *Melia*, *Jagera* and *Albizia*), grassy, open forest (*Eucalyptus tereticornis*, *E. tessellaris*, *E. alba*, *Entermedia* and *Acacia* sp.), grassland and shrub land (*Timonius timon*, *Mallotus*, *Macaranga*) and low, closed forest (*Pisonia grandis* predominates). The topography of the islands ranges from rolling hills to steep, rocky crags ranging up to 300m and beyond. Shorelines are generally rocky and steep, although there are a few exceptions where sand or coral form a shoreline of gentle gradient.

Land based birds occurring in the Whitsunday region include the Asiatic common tern *Sterna hirundo,* bar-tailed godwit *Limosa lapponica*, black tern *Chlidonias niger*, Black-naped tern *Sterna sumatrana*, Black-tailed godwit *Limosa limosa*, Bridled tern *Sterna anaethetus*, Brown booby *Sula leucogaster,* Caspian Plover *Charadrius asiaticus,* Caspian tern *Sterna caspia*, Cattle egret *Ardea ibi*s, Common noddy *Anous* stolidus, Common sandpiper *Actitus hypoleucos,* Crested tern *Sterna bergii*, Curlew sandpiper *Calidris ferruginea*, Eastern curlew *Numenius madagascariensis*, Eastern reef egret *Egretta sacra*, Fleshy-footed shearwater *Puffinus carneipes*, Glossy ibis *Plegadis falcinellus*, Great egret *Ardea alba*, Great knot *Calidris tenuirostris*, Greater frigatebird *Fregata minor*, Greater sand dotterel *Charadrius leschenaultii*, Greenshank *Tringa nebularia*, Grey plover *Pluvialis squatarola*, Grey-tailed tattler *Heteroscelus brevipes*, Lesser crested tern *Sterna bengalensis*, Lesser frigatebird *Fregata ariel*, Lesser golden plover *Pluvialis dominica*, Oriental cuckoo *Cuculus saturatus*, Pin-tailed snipe

Gallinago stenura, Wedge-tailed shearwater *Puffinus pacificus*, Wilson's storm petrel *Oceanites oceanicus* and the Wood sandpiper *Tringa glareola* (see Stokes and Dobbs 2001 for a comprehensive list).

Marine reptiles in the Whitsunday region include the flatback turtle *Natator depressus*, green turtle *Chelonia mydas*, hawksbill turtle *Eretmochelys imbricata*, leatherback turtle *Dermochelys coriacea*, loggerhead turtle *Caretta carett* and the olive ridley turtle *Lepidochelys olivacea.* Seabirds in the Whitsundays include the grey-headed albatross *Diomedea chrysostoma* and the wandering albatross *Diomedea exulans* (see Stokes and Dobbs 2001). Marine Mammals include the dugong *Dugong dugon*, bottlenose dolphin *Tursiops truncatus*, Bryde's whale *Balaenoptera edeni*, Cuvier's beaked whale *Ziphius cavirostris*, dense-beaked whale *Mesoplodon densirostris*, fin whale *Balaenoptera physalus*, Fraser's dolphin *Lagenodelphis hosei*, humpback whale *Megaptera novaeangliae*, Indo-pacific hump-backed dolphin *Sousa chinensis*, Irrawaddy dolphin *Orcaella brevirostris*, killer whale (Orca) *Orcinus orca*, Longman's beaked whale *Mesoplodon pacificus*, minke whale *Balaenoptera acutorostrata*, pantropical spotted dolphin *Stenella attenuata*, pygmy killer whale *Feresa attenuata*, Risso's dolphin *Grampus* griseus, rough-toothed dolphin *Steno bredanensis*, sei whale *Balaenoptera borealis*, short-finned pilot whale *Globicephala macrorhynchus*, sperm whale *Physeter macrocephalus*, spinner dolphin *Stenella longirostris*, strap-toothed beaked whale *Mesoplodon layardii*, and the striped dolphin *Stenella coeruleoalba* (Stokes and Dobbs 2001).

Common fish species in the Whitsunday region include those of the family Scaridea and Labridae, which incorporate parrot fish, rainbow fish and wrasses. Shellfish species occurring commonly off the shore of many islands in the region include various species of *Nerites*, *Monodonto labio* and *Acanthopleura gemmata*. Common crab species in the region include *Scylla serrata* and *Thalamita sima*.

South Molle Island

South Molle Island lies between Shute Harbour on the mainland and Whitsunday Island, the largest of the Whitsunday Group. It is 420.5 hectares in size and forms part of the Great Barrier Reef Marine Park. The topography of South Molle Island consists of steeply rising peaks with an average slope of 1:3, but often reaching 1:2. The highest point on the island is 194 m above sea-level. All sides of South Molle Island are dissected by gullies, although these are not steeply embayed.

Predominant vegetation types on South Molle Island consist of:

Low microphyll vine forests (10%) plus *Araucaria cunninghamii* (hoop pine). The vine forests are usually restricted to the gullies and steep, exposed hill sides, while hoop pine clusters are found on the eastern or windward side of the island.

Open forests with a grassy understorey (70%) consisting of *Eucalyptus tereticornis*, *E. tessellaris*, *E. alba* & *E. intermedia* with *Acacia* sp. The stands of Eucalypt species are found mostly on hillsides of a gentler gradient than those on which the vine forests are to be found.

Open grassland and shrubland (20%) consisting of *Themeda*, *Imperata cylindrica*, *Xanthorroea*, *Lantana* and *Timonius*. South Molle Island was heavily grazed in the early half of the 20th century. To facilitate the grazing environment, over half of the island was cleared of forest. It was this process, combined with heavy grazing, that brought about the grassland environment that is so typical of the island today. The grasses can reach over 1.5m in height, especially in the centre and on sheltered parts of the island.

The European constructed features on the island include a resort, jetty, water supply dam, rubbish dump, helicopter pad, golf course, houses, sheds, sewerage treatment plant, roads, walking tracks and cleared areas. Aboriginal places include the South Molle Island Quarry and South Molle Island Rockshelter 1.

REGIONAL GEOLOGY

In the Early Cretaceous there were two major simultaneous volcanic events that took place to form a large part of the regional exposed geology of the study area. These events are termed the Proserpine and Whitsunday Volcanics (Clarke et al. 1971; Bryan 1991), the timing of which fell between about 112mya and 96mya (Clarke et al. 1971:72). A basic distinction between the Proserpine Volcanics and the Whitsunday Volcanics is the conditions in which the sediments were deposited. The Proserpine Volcanics were probably erupted upon to a stable terrestrial block, while the Whitsunday Volcanics are characterised as a "series of waterlaid pyroclastics" which were deposited in a land-locked basin to the east of the present day coastline (Clarke et al.1971:72). Both events however, are considered to form the same volcanic province (Bryan 1991:14).

The following characterisation of the Whitsunday and Proserpine Volcanics is referenced to Clarke et al. (1971:35-47) unless otherwise indicated. The Whitsunday Volcanics is formed by a series of Pyroclastics and minor laval flows, which form most of the islands east of Long Island (refer to Figure 4.1, and see Figure 4.3). Many outcrops in this region consist of massive green, grey or brown rocks, ranging in size from small fragments to boulder size. These are all generally set within a fine tuffaceous matrix. The tuffs are composed of a fine devitrified ash (0.25mm - 0.005mm) and many are slightly recrystallised. Corrosion by sea water commonly weathers this finer material away, to leave the coarser rock exposed in sharp projections. Horizontal strata are rare in the Whitsunday Volcanics, with moderately steep, dipping beds alternating with gently undulating strata. The thickness of the strata is largely unknown, but they are speculated to be more than 1000m thick.

The Proserpine Volcanics are a sequence of minor pyroclastics, rhyolite and andesite, and are regarded as the `terrestrial equivalent' of the Whitsunday Volcanics. As with the Whitsunday Volcanics, the Proserpine Volcanics are difficult to interpret due to faulting, but it is estimated that they are roughly 1000m thick.

The geological strata that were the result of these volcanic events are divided into `blocks' along several natural fault lines (these blocks also contain sub-strata from earlier geological episodes). There are two blocks that are relevant to this study: the Airlie Block and the Whitsunday Block. The Molle Group of islands is situated on the eastern boundary of the Airlie Block (Bryan 1991). The rest of the islands in the Whitsunday Group are contained within the Whitsunday Block, with the exception of Long and Pine Islands (refer to Figure 4.1 and see Figure 4.3). The following characterisation of the Airlie and Whitsunday Blocks are referenced to Clarke et al. (1971:69-71) unless otherwise indicated.

The Airlie Block consists of the Edgecumbe Beds, the Airlie Volcanics and the Proserpine Volcanics, all of which are the result of volcanic events that took place between the Lower Carboniferous and the Lower Cretaceous. The Airlie Block is defined as a horst, formed as a result of Cretaceous or Tertiary earth movements, and its boundaries are defined by fault lines. Geological strata in the Airlie Block are nowhere horizontal, the majority having a north-northeast or south-southwest trend. The Whitsunday Block consists largely of Whitsunday Volcanics. The pattern of folding is obscure and gradients are of variable direction. No definite trends have been recognised.

Clarke et al. (1971) place the Molle Group of islands on the western boundary of the Whitsunday Block. However, more recent studies have called this placement into question, and have modified the location of the Molle Group to the eastern boundary of the

Airlie Block (Bryan 1991). This revision is based largely on the system of major and minor fault lines that occur in the region. In earlier studies the Molle Fault has been interpreted as a major boundary fault (Clarke et al. 1971), while the Whitsunday Fault was considered a fault of secondary bounding significance between the Airlie and Whitsunday Blocks. However, aeromagnetic data for the Proserpine 1:250,000 map sheet area has revealed that the Molle Fault has little or no magnetic signature, while the Whitsunday Fault shows up as a major magnetic anomaly (Figure 4.4) (Bryan 1991:13; Bryan et al. 2000). On the basis of this, the Whitsunday Fault is now considered to form the boundary between the Airlie and Whitsunday Blocks, thus placing the Molle Group of islands on the eastern boundary of the Airlie Block (Figure 4.4).

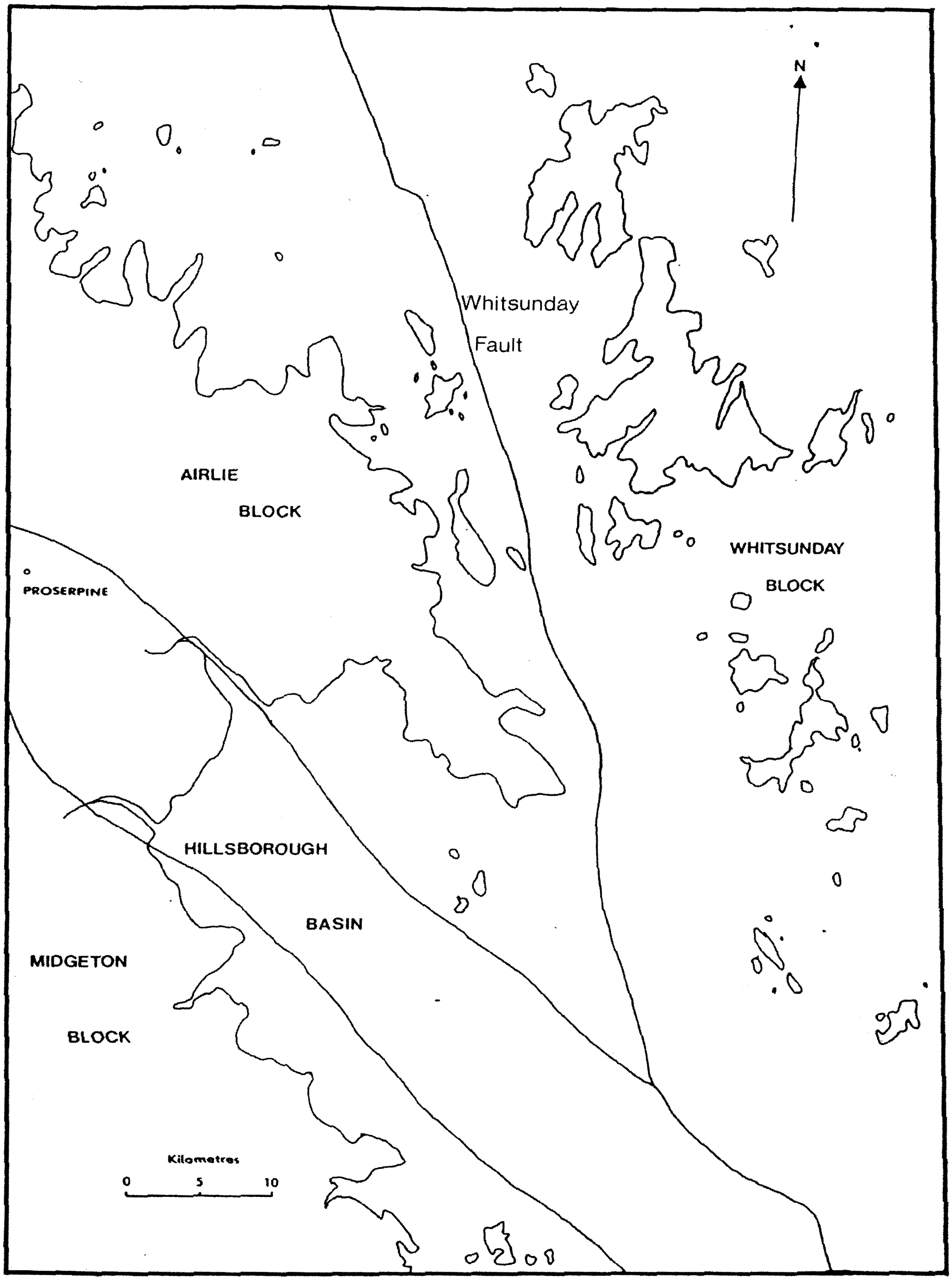

Figure 4.3 Whitsunday and Airlie Blocks (from Bryan 1991:12)

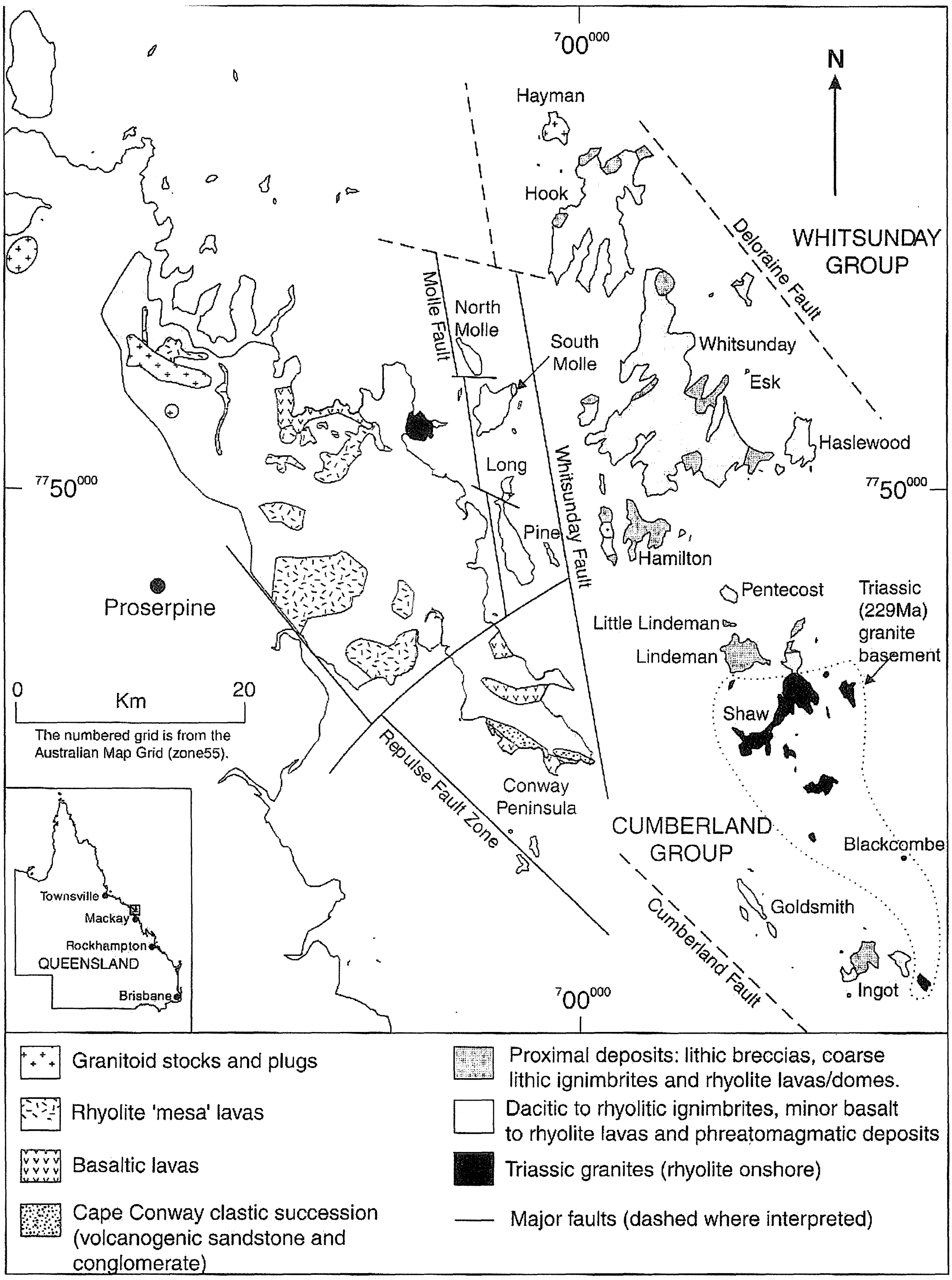

Figure 4.4 Geological fault lines, Whitsunday region (from Bryan et al. 2000:58)

South Molle Island

The following characterisation of the geological sequence of South Molle Island is referenced to Bryan (1991:20-60) and Bryan et al. (2000) unless otherwise indicated. The volcanics in the Molle Group are considered to be part of a steeply dipping section of the Proserpine Volcanics. The lower levels of the sequence have been characterised as consisting dominantly of Pyroclastic fall and flow deposits, while the upper levels are predominantly lavas. Listed below is the sequence of volcanic deposits for the northern end of South Molle Island, starting from the oldest and proceeding to the youngest:

1) Pyroclastic Fall: finely bedded units of crystal rich deposits. Pyroclastic Flow: a hot, fluidised, gas rich, high particle concentration of pyroclastic debris.
2) Basaltic lava interbeded with pyroclastic flows: lavas with a silica content of less than 56%, with much textural variation.
3) Silica lava flow: variable deposits with high silica content.
4) Pyroclastic surges interbedded with minor lava flows and sediments: unidirectional beds of turbulent, highly expanded, low particle concentration flows.
5) Intermediate and basaltic lava flows: lavas with medium to low concentrations of silica.
6) Rhyolite flow/dome complex: rhyolite lavas of fine to medium grain size.

South Molle Island Quarry

The geology of the South Molle Island Quarry material has been broadly characterised by Bryan (1991:49,56) as being part of a pyroclastic base surge deposit, exhibiting secondary silicification. Surge deposits are formed by the lateral movement of pyroclasts as "expanded, turbulent, low concentration gas/solid dispersions" (Wright et al. 1980:318). These dispersions can mantle topography, but tend more to concentrate in depressions (subsequent uplifting has obliterated this characteristic on South Molle Island). Unidirectional sedimentary bedforms are a common feature of pyroclastic base surge deposits, and this is clearly in evidence on the South Molle Island Quarry (Figure 4.5).

Figure 4.5 Vertically bedded nodules

Other Islands in the Study Region

To date, there are no studies relating specifically to the geology of other islands in the region. Indeed, regional characterisations, and characterisations of islands other than the Molle group, rely on focusing on the "well exposed and tilted volcanic sequences of the Molle group of islands (Bryan et al. 2000:56). There are statements that can be made regarding the geology of islands such as Hook and Border Islands, however they are restricted to generalised statements, the parameters of which are set by the regional constraints of studies further to the south on the mainland (Parianos 1993 cited in Bryan et al. 2000:56). It can be stated that both Hook and Border Islands are dominated by rhyolitic ignimbrites and minor basalt lavas with individual units up to 300m thick on Whitsunday Island (Finnis 1999). Resting atop these ignimbrites are the proximal deposits of lithic breccias, course lithic ignimbrites and rhyolite domes (Bryan et al. 2000:58). These can be observed in small pockets on South Molle Island, Hook Island and Border Island, as well as on other islands peripheral to this study such as Whitsunday, Hamilton and Lindeman Islands (refer to Figure. 4.1) (Bryan et al. 2000:58).

PALEOENVIRONMENT RECONSTRUCTIONS

Paleoclimatic reconstructions for the study region rely largely on data obtained for northern Australia, from palynological evidence (Kershaw 1970, 1971, 1975, 1983; Chen 1988; Goodfield 1983), chenier research (Lees and Clements 1987; Chapell and Grindrod 1984; Cook and Polach 1973; Rhodes 1982), coastal and ocean sediment cores (Chapell et al. 1983; Harris et al. 1990; Genever et al. 2003) and from research into geomorphic evolution of land forms (Hopley 1974, 1975). Various bio-indicators have also been examined with specific reference to the study region, in Barker's (2004) investigations into coastal economies for the Whitsunday region. As a thorough and comprehensive climatic reconstruction for the study region has already been undertaken (Barker 2004), I will limit this discussion to an overview of this reconstruction. As Barker (2004:499) has already stated, there have been criticisms leveled at the broad application of certain localised climatic evidence. However, recent archaeological studies have demonstrated that the environmental conditions outlined by Kershaw (1970, 1971, 1975, 1983) may have broader applicability (Barker 2004:49).

A combination of data pertaining to late Pleistocene climatic conditions led to the following paleoclimatic reconstruction for the study region (Barker 2004:45-54). Palynological evidence from Lynch's Crater indicates that between 50,000 and 38,000 years ago low araucarian vine forests were the predominant vegetation type, signifying that the mean average rainfall ranged between 900mm and 1,000mm. There was a shift to sclerophyll woodland between 38,000 and 26,000 years ago, perhaps a combined result of reduced rainfall levels and cultural firing of the landscape. Between 26,000 and 15,000 years ago sclerophyll woodland continued to dominate and precipitation and temperature levels were lower than they had been in the past 50,000 years. Temperature and precipitation levels rose between 15,000 years ago and the beginning of the Holocene, while sclerophyll woodland continued to dominate (Kershaw 1981).

Palynological data from Lake Euramoo and Quincan Crater spans the Holocene and reveals significant vegetation changes, which are indicative of changes in mean temperature levels and possibly (although not necessarily) precipitation levels (Kershaw 1970, 1971). The period between 9,700 and 7,600 BP saw a shift from dry to wet sclerophyll species (i.e. *Eucalyptus* to *Casuarina*). This was followed by a further shift after 7,600 BP to warm temperate rainforests, and then to dry, subtropical rainforests. Rainforest species remained dominant until 2,000 BP until a decrease in temperature and possibly precipitation levels encouraged the reemergence of sclerophyll woodland (Kershaw 1970, 1971). Further palynological evidence from Bromfield Swamp (Kershaw 1975) and various northern Australia Holocene mangrove swamps (Crowley et al. 1990, Grindrod 1985, 1988, Grindrod and Rhodes 1984, Woodroffe et al. 1985) are in general agreement with the Atherton sequence outlined above (Barker 2004:47).

An important source of data pertaining directly to the study area comes from Genever et al. (2003) which details a palynological study of Whitehaven Swamp, Whitsunday Island. Drawing upon interpretations of this data, which present a local swamp vegetation succession (and an extra-local or regional fire history and dry land vegetation history since the early Holocene on Whitsunday Island), the following reconstruction is presented (Genever et al. 2003). Just prior to 7,000 years ago, freshwater swamp conditions were initiated on Whitsunday Island. This was indicated initially by the presence of Ceratopteris "an aquatic fern of ephemeral freshwater environments" (Genever et al. 2003:149), suggestive of initially unstable swamp conditions, followed by the rapid and sequential colonisation of *Melaleuca*, *Cyperaceae* and *Leptocarpus*, indicative of permanent freshwater swamp conditions from 6957 BP (Genever et al. 2003:149). This trend continues uninterrupted until close to the top of the palynological sequence, at which time the presence of *Leptocarpus* declines, marking the "recent return to ephemeral swamp conditions" (Genever et al. (2003:149). At the time of swamp initiation around 7,000 years ago, the marine transgression was complete and the configuration of the Whitsunday Islands was established (see below).

Evidence from chenier research into paleoclimatic reconstructions is more equivocal than that from palynological research. There seems to be dissention between camps as to the cause of differing frequencies of chenier construction through time. As Barker (2004:48) states:

> There seems little doubt that chenier construction occurred in the late Holocene; but whether this is linked to periods of increased aridity in the late Holocene as suggested by Cook and Polach (1973), Lees (1987), Lees and Clements (1987) and Rhodes (1980), or to other factors such as geometry of sedimentation conditions (Chapell and Grindrod (1984) specific to local conditions is, as yet, unclear.

Work by Hopley (1973) on the geomorphological evolution of paleo-landforms, yielded the conclusion that arid to dry conditions were in place from 15,000 BP and that present-day patterns were in place around 10,000 BP. A recent study by Lees (1992), incorporating data from cheniers, dune fields and lake deposits, refines the climatic pattern of the late Holocene. To summarise:

> the evidence....demonstrates a pattern of greatly increased climatic instability in the last 5,000 years which continues to the present day: the drying trend began at 5,000 BP, was interrupted between 3,500 and 2,800 BP and began again between 2,100 BP and 1,600 BP, and probably numerous times over the last 1,000 years (Barker 2004:48).

Data for continued climatic fluctuations over the last 250 years comes from core drilling of coral bommies near the Burdekin River (Australian Institute of Marine Science). This evidence is in the form of humic compounds between growth bands of coral skeletons, which occurred as a result of increased fluvial run off (Barker 2004:49). The emergent pattern is as follows: from 1785 to 1801 there was a period of normal precipitation levels. From 1801 to 1901 conditions were, on average, drier than the preceding period, with drought periods interspersed with the occasional good wet season. Between 1901 to the present there were fluctuating wet and dry phases, usually lasting for 10 year periods (Isdale 1988).

Summary

It can be summarised from the above overview that a tropical environment was in place between *c* 10,000 and 7,000 BP. Certainly for the Whitsunday region the bioindicators point to such a climate being established by 7,000 BP (Genever et al. 2003). It must be noted however, that the timing and placement of this generally early Holocene phenomena is subject to many regional variables which make it difficult to apply the pattern generally. A tropical climate appears to have predominated throughout the mid Holocene and into the late Holocene when, at *c* 2,000 BP, lowered precipitation levels and higher temperatures saw the partial return of a temperate climate. Note here also that the timing of this late Holocene change varies between data sets and regions.

SEA-LEVEL RECONSTRUCTIONS

A detailed early Holocene sea-level reconstruction has previously been undertaken by Barker (2004:49-52) for the Whitsunday region of the Great Barrier Reef Marine Park (see also Lourandos 1997). While acknowledging the great regional diversity that can exist on the north east coast of Australia (Barker 2004:50), Barker (2004) draws upon primary geomorphic studies for the central and northern Queensland coast and presents a carefully constructed sea-level profile for the study area, inclusive of Bowen in the north and Midge Point to the south. I will limit this discussion to an overview of Barker's (2004) sea levels profile.

By calculating periodic mean sea-levels from compatible data obtained for north eastern Australia (Thom and Roy 1983; Grindrod and Rhodes 1984; Belperio 1979; Carter and Johnson 1986; Peltier 1988, although see Barker 2004:52; Nakada and Lambeck 1989; Hopley 1983), Barker (2004:49-52) postulates that sea-levels for 10,000 BP were at 30m below present mean low-water spring tide levels (MLWS), for 9,000BP were at 15.3m below present MLWS and for 8,000BP were at 9.2m below present MLWS. However, upon excluding Peltier's data which Barker (2004:52) treats as anomalous, the following mean sea-levels are calculated: 10,000BP at 30m below present MLWS, 9,000BP at 18.6m below present MLWS (Figure 4.5) and 8,000BP at 11m below present MLWS (Figure 4.7) (Barker 2004:49-52). Barker (1995:117) argues that a high degree of confidence can be placed in these calculations, as they conform closely to Hopley's data obtained from local reef core-samples taken off Hayman Island.

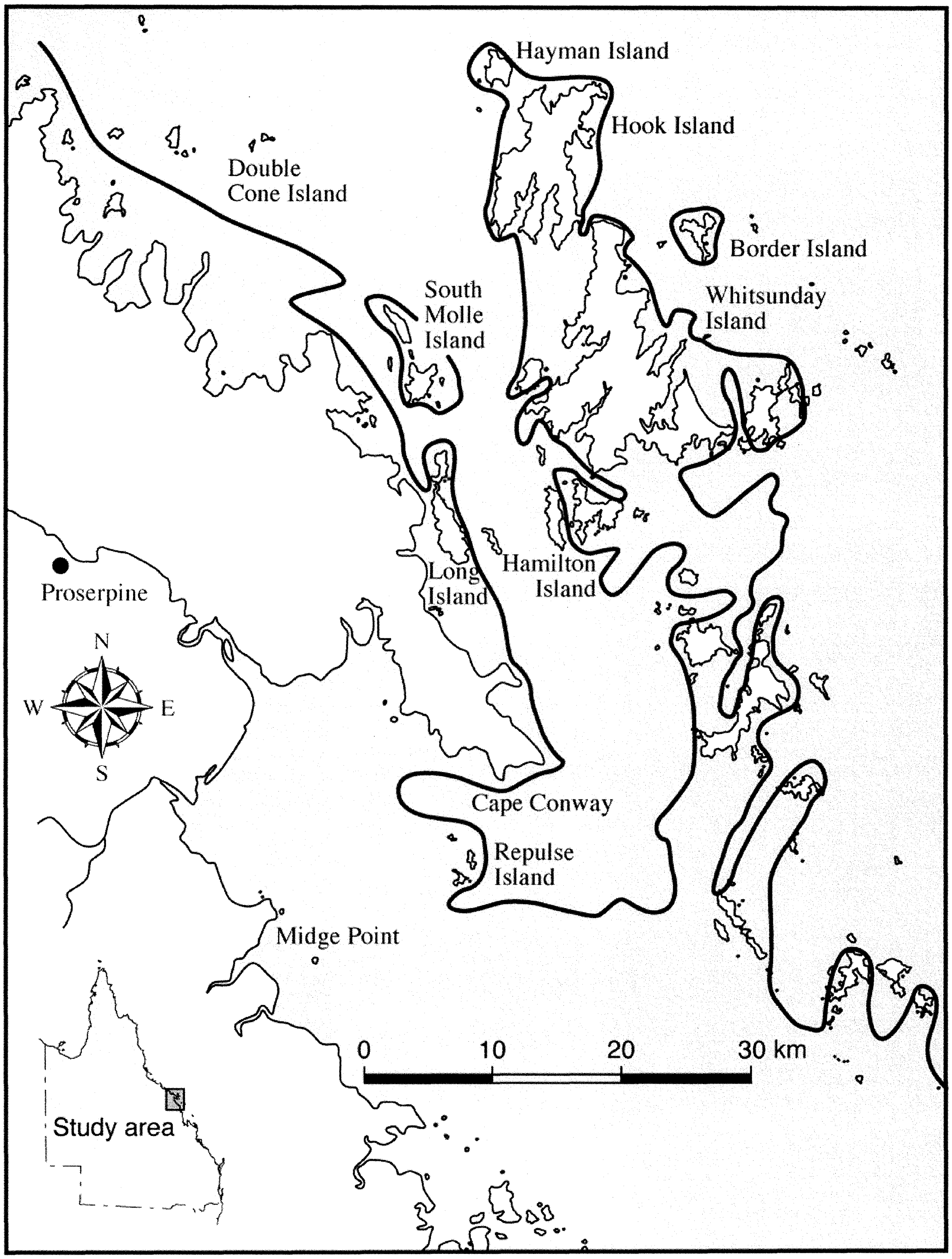

Figure 4.6 Whitsunday region: coastline at 9,000 BP (Cumberland Islands and Whitsunday Passage Hydrographic Chart, 1:100,000 (from Barker 2004)

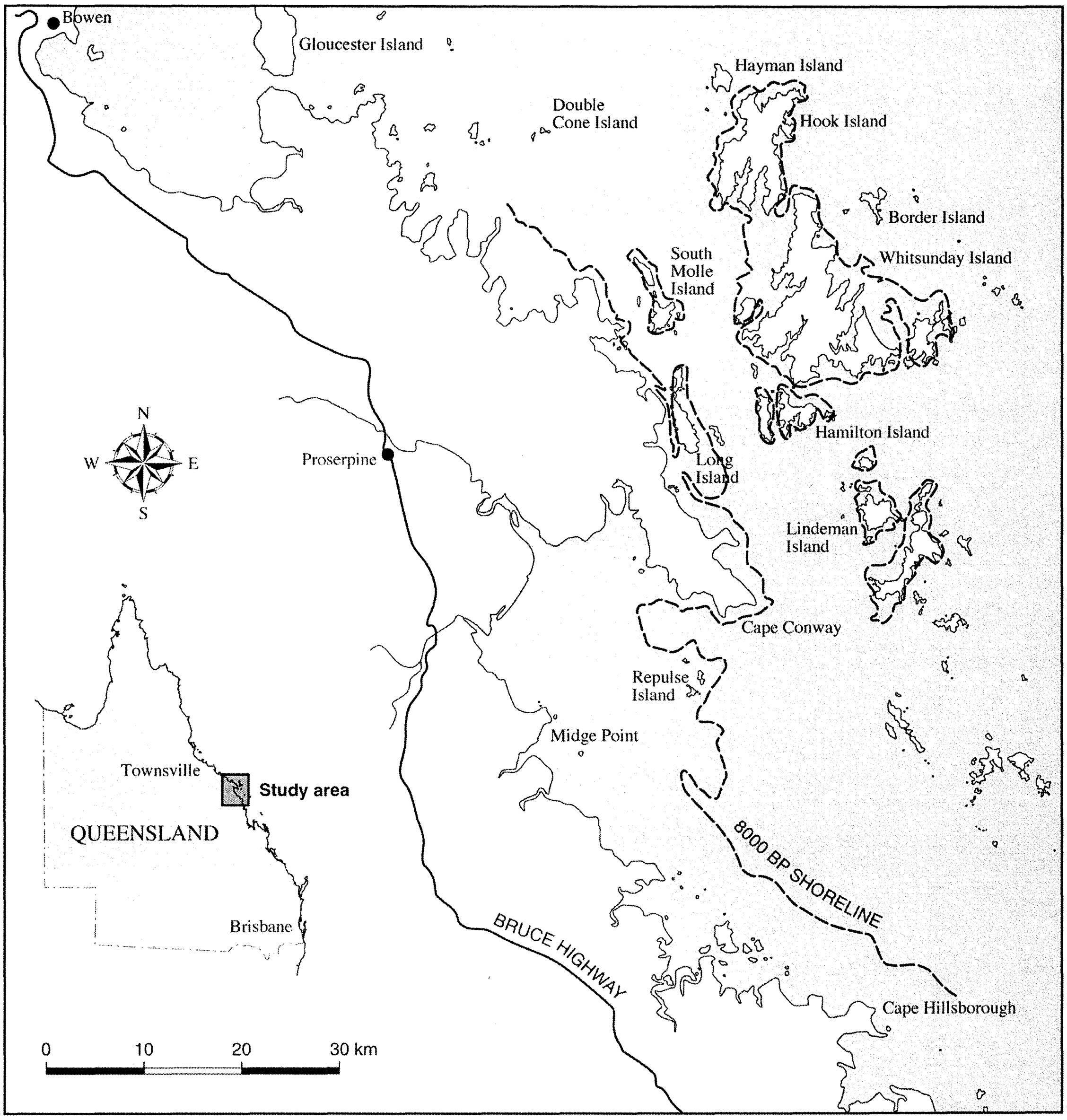

Figure 4.7 Whitsunday region: coastline at 8,000 BP, - 12 m contour (Cumberland Islands and Whitsunday Passage Hydrographic Chart, 1:100,000 (from Barker 2004)

When applying sea level reconstructions to the Whitsunday region settlement patterns, Barker (2004:53-54) is able to make the following statements: at 9,000 years ago when people initially occupied Nara Inlet 1, the sea level was approximately 20m below present levels and the island geography was significantly different. The Whitsunday Passage was a drowned valley, which separated a peninsula formed of the larger islands of the Whitsunday group, from the mainland (Barker 2004:53). Significantly, at this time the Molle group of islands (South, North and Mid Molle Islands) were already separated from the mainland, and formed one larger island. Nara Inlet 1, which was situated in a deeply cut river valley as part of the Hook catchment, would have been within 1km of the 9,000 coastline. Between 9,000 and 7,000 years ago, the peninsula would have been separated from the coastline due to rising sea levels, and thus the islands were established with some degree of variation to the present day formation. Hook, Whitsunday, Haselwood and Cid Islands were part of a single landmass, and Long Island may still have been part of the mainland (Barker 2004:54). Initial occupation of Border Island at 6,900 BP would have corresponded with stabilisaiton. Distances between the Molle group and the mainland and other islands would have increased, although the difference is probably negligible.

Stone provisioning strategies would have been affected to some degree, by changing sea levels and changing regional topography throughout the Holocene. The timing of technological changes in the stone artefact assemblage are assessed in chapter eight, and sea level reconstructions are revisited in chapter nine as part of modeling changing provisioning strategies and use of the South Molle Island Quarry.

CHAPTER 5 A CHARACTERISATION OF THE RAW MATERIAL SOURCE AND PROCUREMENT ON THE SOUTH MOLLE ISLAND QUARRY

THE SOURCE

As discussed in chapter 4, the South Molle Island stone is characterised as a pyroclastic surge deposit of a base surge type, and is referred to as a siliceous volcanic tuff (Barker and Schon 1994:5). These surges typically produce unidirectional bedforms which can include dune forms, low angle cross stratification, pitch and swell structures and wavy lamination. Unweathered, base surges range in colour from gray to black, and demonstrate a 'flint-like' habit which is the result of secondary silicification (Brian 1991:55-56).

The quarry stone occurs in several different physical forms, and the procurement techniques differ accordingly as will be outlined below. The two main distinguishable forms of raw material are the vertically bedded nodules (Figure 5.1) and the much larger, horizontally bedded slabs (Figure 5.2). The former occur primarily towards the southern end of the quarry. They tend to be rectangular in shape, and roughly as thick as they are wide, thus 'blocky' as opposed to tabular and range from 1.2m to 15.8cm in length. Many of these vertically bedded nodules are still in their original geological context. That is, they are embedded in a soil matrix, with the top portion visible. There are also several incidences where the nodules have been worked loose from the soil matrix, however it is unclear whether this is a result of natural weathering forces, or by the knappers' design.

Figure 5.1 Vertical nodules (flaked)

Figure 5.2 Horizontal bedrock

The horizontally bedded slabs tend to occur most frequently on the extreme northern end of the quarry where it begins a steep decent down to the beach, and on the beach itself. They differ from the vertically bedded nodules both in terms of size and the manner in which they occur in the soil matrix. Ranging from 2.8m to 1.3 m in length, and 1.1m to 3.2m in thickness, there are no obvious signs of systematic directional orientation within the soil. Further, due to the fact that they occur on a particularly steep slope on the northern end of the quarry, it is possible that they have shifted from their original positions as soil erosion occurs around them.

Grain size, colour, and texture of the SMIQ raw material varies substantially across the site. This is in keeping with the overall characteristics of pyroclastic base surge deposits, which due to differing cooling rates, are typically finer grained further away from the source (Fisher 1999:http://magic.geol.ucsb.edu/~fisher/hydro.htm). Colours observed on unweathered rock were recorded for flake scars on cores, and on artefacts within the 'fracture type sample squares', and are discussed in the following section (see Table 5.1). These samples form the largest taken across the quarry (batches of 5,786 and 1,003 respectively). Unweathered colour patterns were identified based on visual assessments of rock that had been freshly fractured through the process of heat spalling.

Table 5.1 Munsell colours on unweathered artefacts

		Percent		Frequency	
Munsell	**Description**	**Unweathered Flake Scars on Cores**	**Unweathered Artefact Type Data**	**Unweathered Flake Scars**	**Unweathered Artefact Type Data**
N2/0	Black	3.8	2.0	20	5
N3/0	Dark gray	60.1	42.6	314	84
N4/0	Grey	26.8	39.1	140	77
N5/0	Grey	4.0	1.5	21	3
10Y4/1	Grey		0.5		1
10Y5/1	Grey		6.1		12
5GY4/1	Dark olive gray	0.6	0.5	3	1
5GY5/1	Olive Grey	2.9	6.1	15	12
5GY6/1	Olive Gray	0.6		3	
5BG6/1	Bluish Gray	0.2		1	
10BG4/1	Dark bluish Gray	0.2	0.5	1	1
5G5/1	Greenish Gray	0.2		1	
10GY5/1	Greenish Gray	0.6		3	
Total		100	*98.9		

* munsell values are missing for several unweathered artefact specimens

Table 5.1 demonstrates that the colour of the SMIQ source ranges from black, through dark gray, gray and olive gray, and finally at the other end of the spectrum, greenish gray. The further from black the colour, the larger the grain size of the stone (this value is unquantified and based on *in situ* visual assessments alone). Thus, it can also be said that (based on the observed trend between distance from source and grain size) the further from the volcanic source, the darker the stone. This extends in a clear north/south orientation in line with the quarry ridge top. The black, fine grained material occurs at the northern or beach end of the quarry, and grades into gray, courser grained material at the southern end.

WEATHERING PATTERNS

The degree of weathering on an artefact was characterised using the presence/absence of several variables: *colour-change*, and *texture plus colour-change* - texture change being an indicator of greater weathering than colour change alone. These data were obtained from three samples on the quarry: flake scars on cores, retouched artefacts and the fracture type sample squares which collectively represent a quarry-wide sample (Table 5.2).

Table 5.2 Differential weathering patterns on the SMIQ

	No weathering % (N)	Colour change (moderate weathering) % (N)	Colour + texture change (heavy weathering) % (N)
Flake scars on cores	10% (522)	66% (3532)	24% (1279)
Fracture-type squares	25% (198)	73% (576)	1% (10)
Retouched artefacts	26% (18)	64% (45)	10% (7)

The dominant weathering pattern in all three samples is that of colour change alone, which implies that most of the quarry assemblage has been affected by moderate weathering as opposed to heavy weathering or no weathering at all (Table 5.2). Thus the quarry can be divided into three general components: not weathered, moderately weathered and heavily weathered. The possibility that differential weathering patterns were a product of microclimate variations or material variations was explored by comparing weathering patterns between individual fracture-type squares. These squares range in location from the northern tip of the quarry as it slopes down to the beach, to the southern end of the ridge top. Thus an examination of weathering patterns in relation to both microclimate variations and raw material type (grain size) variations can be achieved.

Seven fracture type squares were analysed, covering four general study areas on the quarry (Figure 5.3). Generally, these study areas corresponded with areas of particularly high density artefact scatter). Within each study area, the pattern is similar to that observed on core flake scars, retouched artefacts and the collective sample of fracture type squares (Table 5.3). Moderate weathering identified by the presence of a colour change to the rock repeatedly presents as the dominant weathering pattern, followed by that of no patenation and lastly the heavily weathered pattern. Expressed as individual samples, the pattern within each fracture type square is similar, with moderate weathering forming the bulk of each sample square, with some proportional variations between them (Table 5.4).

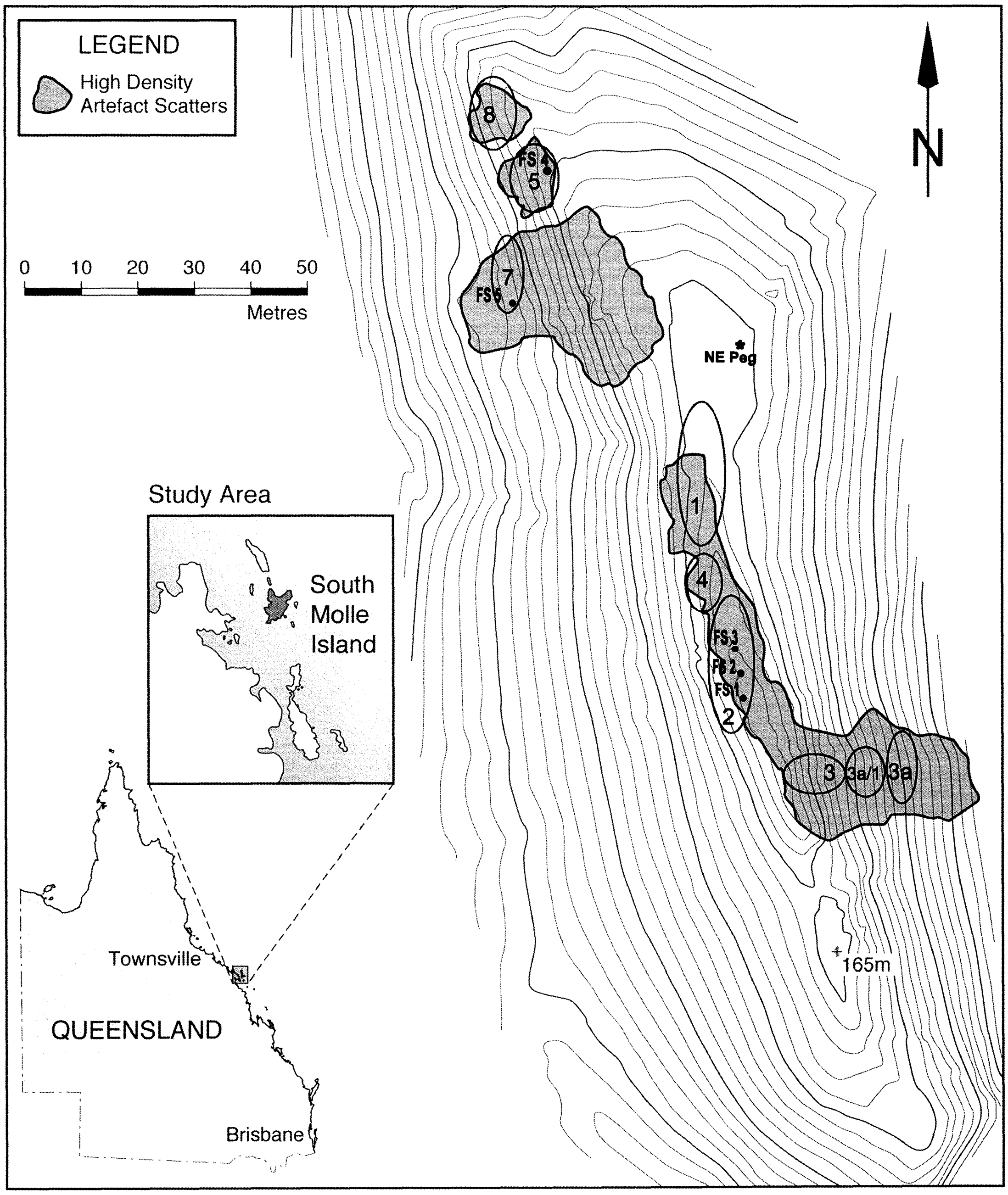

Figure 5.3 Fracture type square locations on SMIQ

Table 5.3 Weathering patterns across the quarry, according to study area

	Area 2	Area 5	Area 6	Area 7
No Patenation	26% (116)	12% (18)	21% (58)	4.5% (6)
Smooth Colour Change (moderate weathering)	59% (261)	56% (83)	44% (121)	82% (110)
Colour + Texture change (heavy weathering)	2% (7)	-	.5% (1)	.5% (1)

Table 5.4 Weathering patterns across the quarry, according to fracture type squares

	Square 1 (area 2)	Square 2 (area 2)	Square 3 (area 2)	Square 4 (area 5)	Square 5 (area 7)	Square 6 (area 6)	Square 7 (area 6)
No Patenation	36% (38)	31% (27)	20% (51)	12% (18)	4% (6)	26% (50)	10% (8)
Smooth Colour Change (moderate weathering)	36% (38)	37% (32)	75% (191)	56% (83)	82% (110)	36% (70)	61% (50)
Colour + Texture Change (heavy weathering)	5% (5)	2% (2)	-	-	1% (2)	-	1% (1)

The argument can be made that the pattern of moderate weathering that dominates across the quarry, mitigates the variation that can occur due to raw material variation and microclimate variation. Thus, a case can be made for differential weathering of flaked stone across the quarry, indicating varying lengths of exposure time, as opposed to variation between microclimates. This suggests that a relative chronology for periods of quarry use can be established. Although these differential weathering patterns can not be calibrated, we can say that most of the assemblage was flaked after one component and before the other. The implications of the relative chronology for quarry use are that there are multiple periods of use and further, that one period (the period represented by the moderately weathered artefacts) is a more intensive period of use than that preceding and proceeding it.

EXTANT, UNWORKED MATERIAL

Unworked raw material on the SMIQ takes the form of nodules, originally bedded in a unidirectional manner and having once formed the ridge top of what is now the SMIQ (Cook unpublished report and 1998 pers. comm.). Data were recorded on unworked nodules from Areas 2, 3, and 3a/1. Most samples (84%) analysed exhibit a mantle of thick, course cortex with the exception of those shattered through thermal alteration (spalling) or other non-cultural means (16%). The mean nodule weight is 3478gm. Length-to-width-to-thickness comparisons indicate that the majority of nodules are elongated and tabular in shape. This is further supported by the consistent width measurements. Three measurements for width were recorded at three equidistant points along the length of each nodule. The means for each width measurement are all within 30.2mm with remarkably similar standard deviations (Table 5.5). The implication of this pattern is that the nodules are consistently wide along the three points selected for measurement, which indicates that they are tabular in shape (see also Figure 5.4).

It is also important to note here that the mantel of cortex appears uniform in thickness both between specimens and on individual specimens of unworked nodules. Thus, knappers are not selecting nodules determined by the differential nature of the cortex, but rather determined by shape. A comparison of unworked nodule attributes and core attributes will be discussed below in an attempt to illustrate what type of raw material is being selected for reduction.

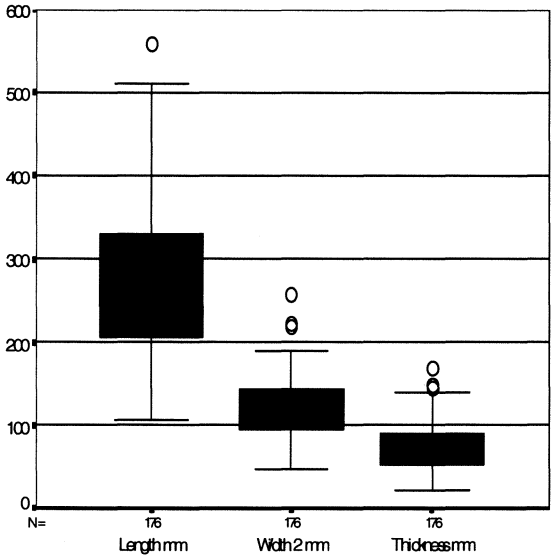

Figure 5.4 Length/width/thickness relationships for unworked nodules

Table 5.5 Descriptive Statistics for unworked nodules

	N	Minimum	Maximum	Mean	Std. Dev.
Weight gm	176	507	12000	3478.2	2312.2
Length mm	176	107	560	265	89.9
Width 1 mm	176	30	230	101.5	34.7
Width 2 mm	176	48	260	120	37.4
Width 3 mm	176	22	195	98.8	37.3
Thickness mm	176	21	1527	71.5	112.8

PROCUREMENT

The use of the vertically bedded nodules is extensive and there appear to be several methods of procurement. The first I surmise, based on a set of assumptions regarding what we know about the source and how it outcrops. Base surge deposits result from a ground-level, horizontal surge of pyroclastic materials, mixed with water vapour and ash. These are frequently interspersed or overlain by pyroclastic fall deposits (Brian 1991:55). In these instances, cross bedding can occur, with one type of material overlaying another. With differing capacity to withstand weathering, one material weathers faster than another, leaving discrete, unidirectionally bedded nodules. These vary in size from several centimetres to several metres, and remain bedded in the soil matrix of the local sedimentary environment. Whether they are exposed or not, depends on local erosional conditions.

Thus, the model is that procurement was a process of either selecting nodules for reduction *in situ* off the surface of the quarry ridge top, or obtaining nodules from just below the surface. There is evidence for both methods being employed on the SMIQ. Firstly, data from 22 *in situ* flaked outcrops (embedded raw material) was obtained which indicate that source material was selected from, and in these cases worked in, their original location. These data were recorded from Areas 2, 3, 6 and 7. While all outcrops are of the typical siliceous volcanic tuff they vary considerably in size. The exposed portion of these outcrops ranged from 158mm to 2800mm in length, 105mm to 5100mm in width, and 135mm to 3200mm in thickness (Table 5.6). All outcrops examined had evidence of *in situ* flaking activity, with the average number of flake scars being 22 (maximum 127 and minimum 1).

Table 5.6 Descriptive statistics of flaked outcrop dimensions

	N	Minimum (mm)	Maximum (mm)	Mean (mm)	Std. Dev.
Length	22	158	2800	758	691
Width	22	105	5103	1163	1273
Thickness	22	135	3200	693	717

Secondly, a series of one square and three circular ‘extraction pits’ are situated on the ridgeline of the SMIQ, in Area 2. These pits are fashioned downward into the nodule bedforms, to a depth of up to 1.5m, and varying from 1.2m to 2m in diameter. In one case, the base of the extraction pit reaches bedrock. It appears that the knappers were retrieving stone from beneath the surface of the secondary artefact scatters, in an effort to either supplement depleted surface materials, or access materials of a better quality. The presence of slightly raised mounds of rock beside the pits suggest that people were not transporting the material far once it was retrieved. In fact, it seems likely that the material was reduced *in situ*, adjacent to the pits, given that they are located in one of the areas of particularly high artefact density along the quarry ridge top.

Cores Selected for Reduction

The general morphology of discarded cores on SMIQ, when compared with the extant, unreduced raw material, tends to be considerably more 'cubic' than 'tabular'. For example, the variance between average length and width of discarded cores remains consistently within 40mm of each other. A similar comparison between average length, width and thickness of unworked nodules demonstrates a much higher degree of variance, with differences between them reaching 194mm (see Figure 5.5).

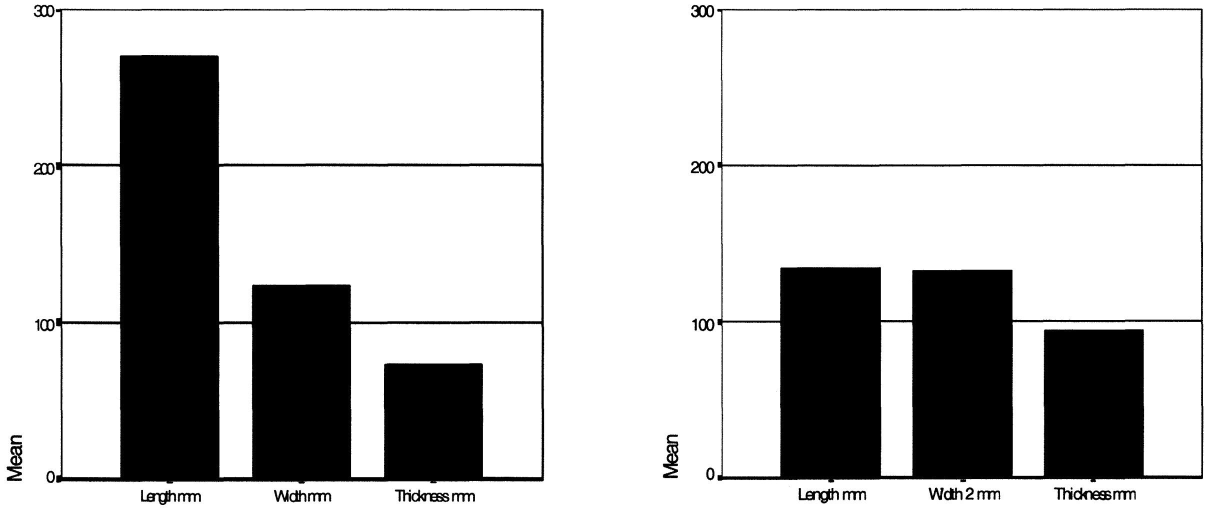

Figure 5.5 Mean length, width and thickness for unworked nodules (left) and cores (right)

However, the possibility that the cubic shapes of cores selected for reduction are a product of the flaking process must be acknowledged. What is needed is an insight into the original size and shape of cores. In order to extrapolate the original size and shape of cores, I compare a sample of cores with the least amount of working (one platform worked only), with the unworked raw material (Table 5.7). This gives us the closest approximation possible of the original size and shape of material selected for reduction.

Table 5.7 Dimensions of unworked nodules and single platform cores

	Length (mm)	**Width 1 (mm)**	**Width 2 (mm)**	**Width 3 (mm)**	**Thickness (mm)**
Single Platform Cores (N=92)	128 ±45	124 ±45	135 ±46	108 ±42	91 ±32
Unworked Nodules (N=176)	269 ±90	101 ±35	123 ±37	98 ±37	73 ±27
T value	-17.05	4.273	2.163	1.92	4.606
d.f.	265	149	153	165	159
Probability	<.001	<.001	0.032	0.055	<.001

As Table 5.7 demonstrates, the mean length of the unworked material is more than twice that of the cores, while width measurements one and two and the thickness measurement are consistently higher. Thus on the basis of this simple test, it can be claimed that material selected for reduction is likely to be of a size and shape markedly different to the unworked material that remains on the quarry.

On cores that have a greater degree of reduction in the form of more platforms used, we see a similar pattern (Table 5.8 and see Table 5.9 for significance tests). The mean *length* of unworked nodules is consistently higher than that of all cores, regardless of the number of platforms. T tests reveal that these means vary *significantly* between unworked nodules and cores with two, three, four and six platforms. All mean width and thickness measurements on cores are also higher than the mean width and thickness measurements on unworked nodules, although they are closer to one another than the mean lengths and not all of the differences are significant.

Width one varies significantly between unworked nodules and cores with one, two and three platforms. There are no significant differences when comparing width two, between unworked nodules and cores (Table 5.8). *Width three* on the other hand varies significantly between unworked nodules and cores with one and six platforms (although the latter is drawing on a very small sample size). Thickness varies significantly between unworked nodules and cores with one, two, three and four platforms. Overall, when comparing dimensions between unworked nodules and cores, we see significant differences being limited to cores that have been reduced the least amount. As one could expect, this difference is lost as cores are worked more extensively. This comparison leads me to conclude that the material selected for reduction tends to be considerably wider and thicker than the extant unworked material that was sampled from the quarry.

Represented as a series of length/width2/thickness ratios, the pattern revealed by the comparisons of means suggests that the cores with two or more platforms worked are closer in length and width than are the unworked nodules (Table 5.10). It is also apparent that in most cases (apart from cores with six platforms) the thickness and width are closer than they are in the unworked sample. One possible interpretation of these data is that cores selected for reduction are more cubic in shape than the unworked material sampled.

Table 5.8 Mean length, width and thickness of cores with multiple platforms

Number of platforms	Measurement	Number	Minimum	Maximum	Mean	Std. dev.
2	Length	169	52	104	136.7	81.9
	Width 1	169	20	350	114.2	43.3
	Width 2	169	23	360	130.7	50.1
	Width 3	169	18	330	108.0	48.9
	Thickness	169	26	250	94.3	38.1
3	Length	106	14	260	129.4	45.8
	Width 1	106	20	270	114.3	44.5
	Width 2	106	45	244	131.3	45.3
	Width 3	106	29	210	101.8	41.8
	Thickness	106	34	225	95.7	36.5
4	Length	36	42	280	131.8	48.3
	Width 1	36	53	240	126.5	43.1
	Width 2	36	47	250	133.5	44.6
	Width 3	36	38	200	99.5	36.5
	Thickness	36	40	186	90.7	30.6
5	Length	13	73	622	186.3	139.9
	Width 1	13	48	210	128.2	46.9
	Width 2	13	52	225	137.8	53.5
	Width 3	13	51	190	98.9	42.2
	Thickness	13	45	166	95.2	34.6
6	Length	5	87	185	121.9	40.9
	Width 1	5	53	175	120.3	45.5
	Width 2	5	78	240	167.3	67.6
	Width 3	5	79	195	163.2	48.1
	Thickness	5	42	120	83.5	29.6
7	Length	3	67	195	138.3	65.2
	Width 1	3	72	138	112.0	35.2
	Width 2	3	81	173	135.7	48.4
	Width 3	3	102	127	113.0	12.8
	Thickness	3	79	130	96.3	29.2

Table 5.9 T tests for comparison of dimensions between unworked nodules and cores

Unworked nodules	Two platforms	Three platforms	Four platforms	Five platforms	Six Platforms	Seven platforms
Length	T=11.679 d.f.=172 p=<.001	T=13.482 d.f.=130 p=<.001	T=11.098 d.f.=113 p=<.001	T=2.072 d.f.=13 p=0.0529	T=7.156 d.f.=6 p=.000	T=3.369 d.f.=2 p=.0.086
Width 1	T=-8.778 d.f.=322 p=<.001	T=-2.626 d.f.=182 p=0.009	T=-3.332 d.f.=44 p=0.002	T=-2.049 d.f.=13 p=0.061	T=-0.941 d.f.=4 p=0.407	T=-0.537 d.f.=2 p=0.650
Width 2	T=-1.619 d.f.=308 p=0.107	T=-1.593 d.f.=188 p=0.113	T=-1.323 d.f.=45 p=0.189	T=-0.98 d.f.=12 p=0.342	T=-1.459 d.f.=4 p=0.221	T=-0.452 d.f.=2 p=0.698
Width 3	T=-2.136 d.f.=312 p=0.033	T=-0.771 d.f.=200 p=0.442	T=-0.224 d.f.=50 p=0.823	T=-0.075 d.f.=13 p=0.940	T=-3.006 d.f.=4 p=0.041	T=-1.899 d.f.=2 p=0.238
Thickness	T=-5.97 d.f.=301 p=<.001	T=-5.553 d.f.=174 p=<.001	T=-3.223 d.f.=46 p=0.002	T=-2.263 d.f.=13 p=0.042	T=-0.784 d.f.=4 p=0.486	T=-1.372 d.f.=2 p=0.309

Table 5.10 Length/Width2/Thickness ratios for cores and unworked nodules

	Unworked	Two platforms	Three platforms	Four platforms	Five platforms	Six platforms	Seven platforms
L:W2	3.7/1.	1.4/1.4	1.3/1.4	1.4/1.5	1.9/1.4	1.5/2	1.4/1.4
W2:T	1.7/1	1.4/1	1.4/1	1.5/1	1.4/1	2/1	1.4/1

It appears from the discussion above that core selection was based on size and shape of available raw material, as evidenced by the contrast between the size and shape of 177 unworked nodules and a sample of 424 cores from the South Molle Island Quarry. The following chapter will explore core reduction further, and in combination with the model for core selection presented here, will examine raw material availability on the South Molle Island Quarry.

CHAPTER 6 CHARACTERISATION OF CORE REDUCTION SYSTEMS

INTRODUCTION

The first section of this chapter (*Core Rotation*) aims to characterise core reduction on the South Molle Island Quarry. In doing this I will examine the extent and nature of core rotation including the number of platforms and the sequence in which they are used. I also examine flake scar morphology throughout the sequence of core rotation, in addition to platform angle and frequency of flake removal. Characterising these latter three aspects of core reduction will benefit the study in two ways: firstly, they will help to characterise changes in the reductive process as core rotation proceeds; thus certain inferences are enabled regarding rationale for the nature of the rotational sequence. Secondly it assists in the characterisation of the cores at the point of their discard. The second half of this chapter (*Raw Material Availability*) examines the availability of raw material on the South Molle Island Quarry by examining the viability of cores that remain on the quarry. This is achieved through a closer look at the interrelationship between core rotation and flake scar morphology.

Core rotation is measured by the number and positioning of platforms upon the core. Multiple platforms in combination with flake scar frequency indicates greater core reduction (see below). Platform angle and flake scar morphology are indicative of the continued viability of the fracture plane orientated to a given platform. When the extent of rotation and the viability of fracture planes is assessed, statements regarding future viability of the core are enabled. It is this analytical approach which allows me to assess the raw material availability on the South Molle Island Quarry, at the time of cessation of use.

As noted in the previous chapter, knappers tended to select raw material that existed in a cubic form, over that in tabular form, the likely reason for which is that they provide a greater number of viable fracture planes from which to generate large flakes. Supporting this, is the clear evidence of core rotation on most cores. Eight platform positions were identified on the sample of cores analysed for this project. The platform positions were identified according to the position of the flake scars' point of origin, not the direction of the fracture plane. Therefore, a given platform position may produce flakes along multiple fracture planes (for example, Figure 6.1)

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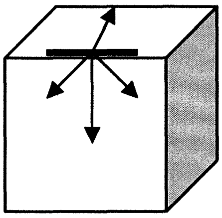


Figure 6.1 One platform generating multiple fracture planes

For the sake of consistency, each platform position is orientated to the first platform used. An *adjacent proximal* platform is on the adjacent face of the core to the first platform, at the proximal end (Figure 6.2a); an opposite proximal platform is on the opposite face of the core to the first platform, at the proximal end (Figure 6.2b).

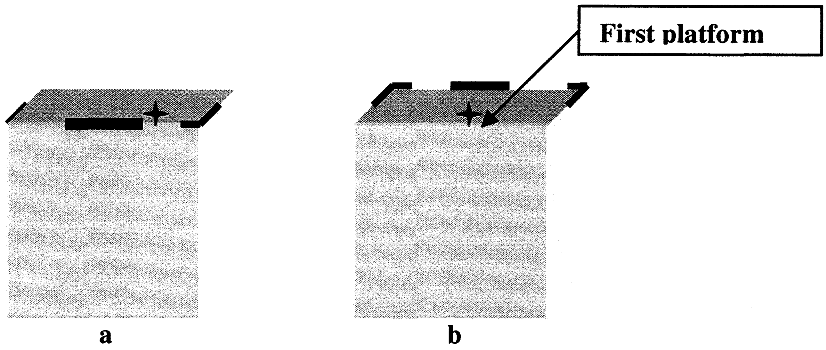


Figure 6.2 a and b. Adjacent and opposite proximal platform positions

An *adjacent distal* platform is on the adjacent face of the core to the first platform, at the distal end (Figure 6.3a); an *opposite distal* platform is on the opposite face of the core to the first platform, at the distal end (Figure 6.3b).

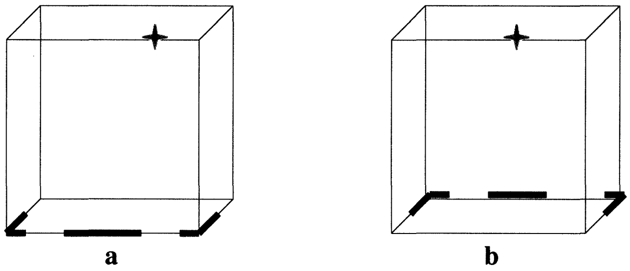


Figure 6.3 a and b. Adjacent and opposite distal platform positions

An *adjacent left lateral* platform is on the adjacent face of the core to the first platform, on the left lateral side (Figure 6.4a); an *opposite left lateral* platform is on the opposite face of the core to the first platform, on the left lateral side (Figure 6.4b).

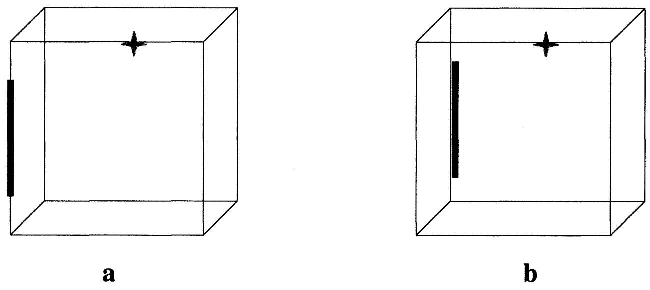


Figure 6.4 a and b. Adjacent and opposite left lateral platform positions

An *adjacent right lateral* platform is on the adjacent face of the core to the first platform, on the right lateral side (Figure 6.5a); an *opposite right lateral* platform is on the opposite face of the core to the first platform, on the right lateral side (Figure 6.5b).

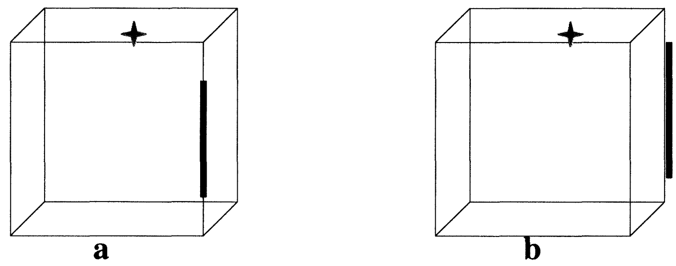


Figure 6.5 a and b. Adjacent and opposite right lateral platform positions

It is important to note here that the patterns outlined below are the result of observations made on the *observable* reduction characteristics of cores. While in many cases the 'first platforms' utilised are not actually the first in the entire sequence (as these are no longer visible due to subsequent flake removal), however they are the first utilised in the *observable* sequence. Thus the observations made regarding sequence and order remain valid.

CORE ROTATION

Seventy eight percent of cores analysed had multiple platforms. Of those, cores with two platforms counted for 51 percent, cores with 3 platforms counted for 32%, those with 4 platforms counted for 11%, those with 5 counted for 4%, those with 6 platforms counted for 1.5% and those with 7 platforms counted for 1% (Figure 6.6).

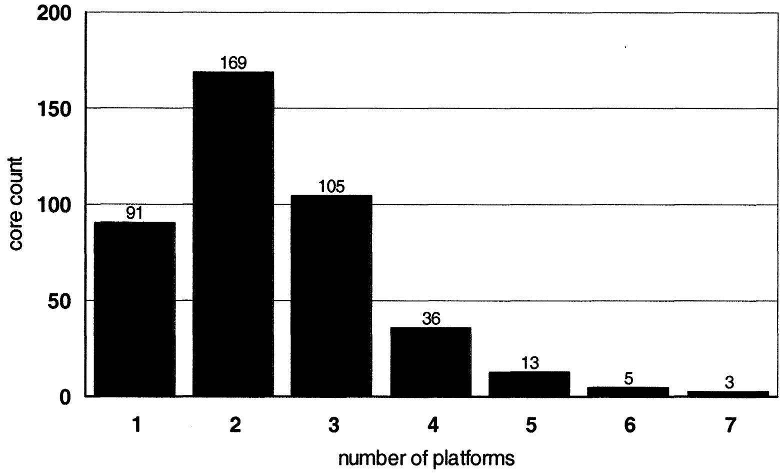


Figure 6.6 Cores with multiple platforms

Analysis of platforms took place in the order in which they were used; first through to last. Upon analysis, a pattern emerged which indicated that knappers had a definite preference for rotating the core along the adjacent face when selecting their second platform. Adjacent platform positions accounted for 68% of all second platforms selected.

However, the further the cores were rotated (with a greater number of platforms being utilised), the more the knappers elected to move from the adjacent platform positions, to the opposite platform positions. For example, those cores with six platforms exhibited the reverse trend to those with only two , with 87% of sixth platforms being located on opposite platform positions. It is clear that as the cores became more extensively used, the knappers would rotate the cores along the adjacent (and closest) face initially, and then move to the opposite face when the adjacent platform positions were exhausted (Figure 6.7; Table 6.1).

Table 6.1 Platform positions relative to degree of core rotation

	Adjacent face	Opposite face
Second platform	68%	31%
Third platform	49%	51%
Fourth platform	55%	45%
Fifth platform	39%	61%
Sixth platform	13%	87%
Seventh platform	NA	NA

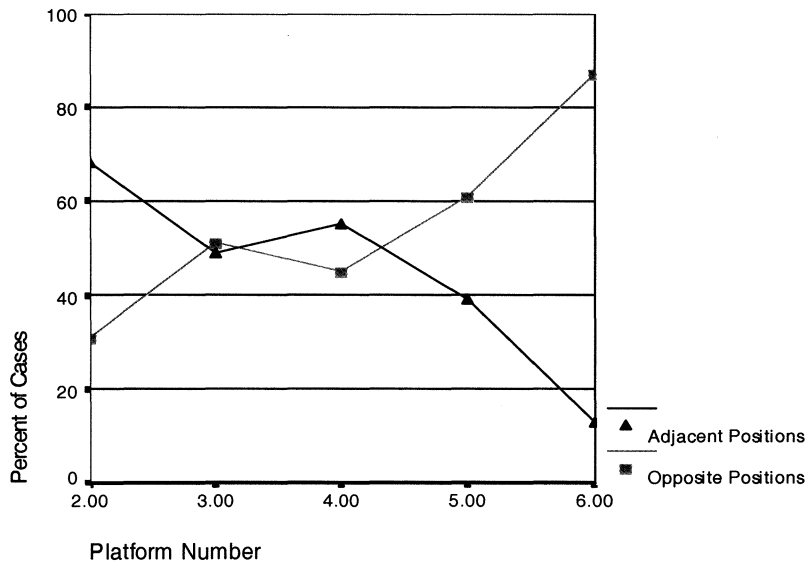


Figure 6.7 Platform positions relative to degree of core rotation

Size of Flakes Removed

An examination of the data from a sample of 2,286 complete flake scars with recorded length and width, demonstrates that as the core was rotated from the fourth to the fifth platform, and from the fifth to the sixth platform (in 61% and 87% of cases respectively, this meant rotating the core onto the opposite face, see Table 6.7), both the flake scar mean length and width increase marginally. Mean length and width of flakes detached from platform 4 was 44.8mm and 47.4mm respectively. This increased to 51.8mm and 50.6mm respectively from platform 5, and further to 55.0mm and 52.5mm respectively from platform 6 (Figure 6.8; Table 6.2). Although not statistically significant when analysed with a t-test, this overall increase of 10.2mm in mean length and 5.1mm in mean width could support the idea knappers were benefiting by rotating the core from the adjacent to the opposite face, because in doing so, they were able to detach flakes of greater size. Additionally, it can be demonstrated that cores with a higher number of platforms yielded a greater number of flakes overall (Figure 6.9).

Table 6.2 Comparison of flake scar length and width on platforms in the rotational sequence

Flake scar	**Platform one**	**Platform Two**	**Platform three**	**Platform four**	**Platform five**	**Platform six**	**Platform seven**
Mean length (mm)	55.7±27.2 N=1068	47.4±30.8 N=676	46.6±29.9 N=318	44.8±34.3 N=151	51.8±40.1 N=47	55.0±27.2 N=26	52.6±33.4 N=28
Mean width (mm)	51.7±30.1 N=666	48.3±28.1 N=421	44.7±26.9 N=212	47.4±28.7 N=94	50.5±38.4 N=36	52.5±32.3 N=21	60.9±52.3 N=20

T=-1.694, d.f.=40, p=0.098 (comparison of mean length of flake scars between platform 4 and 6)
T=-0.667, d.f.=27, p=0.506 (comparison of mean width of flake scars between platform 4 and 6)

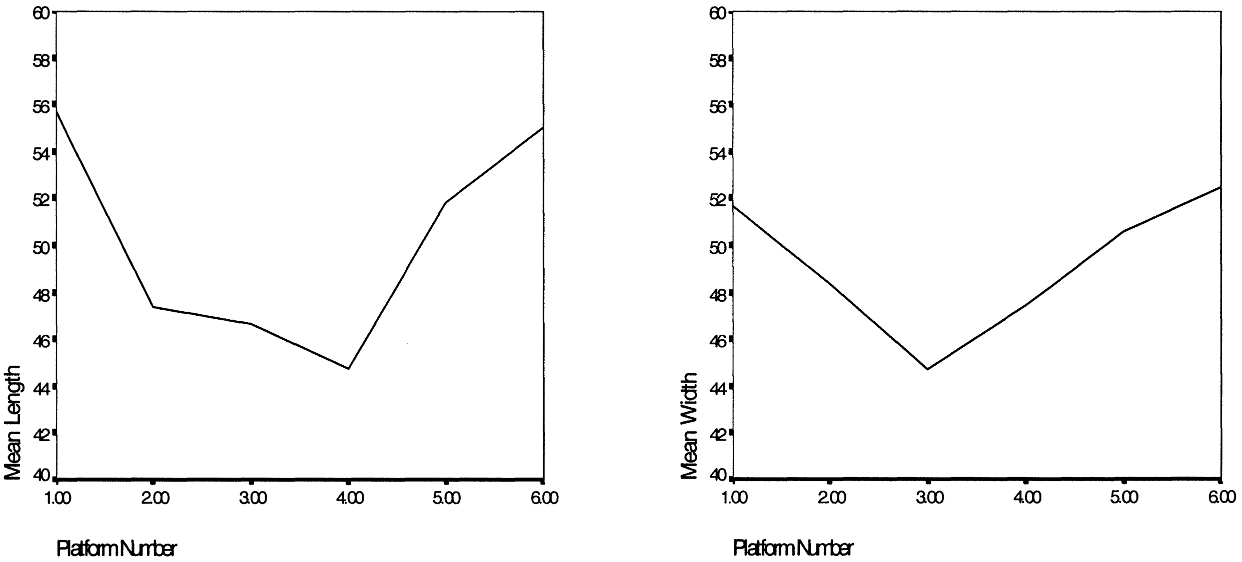


Figure 6.8 Mean length and width by platform number

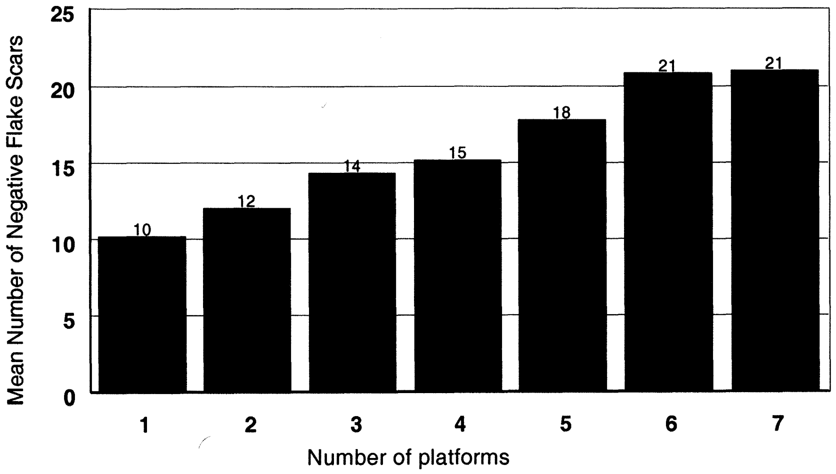


Figure 6.9 Number of platforms and average number of flake scars, per core

Platform Angle and Frequency of Flake Removal

In a sample of 1,007 platforms, and 5,426 flake scars, the average number of flake scars preserved on each platform in the sequence was minimally varied from 2.5 (first platform) to 1.3 (sixth platform) (Table 6.3). There is a relationship between where the platform is located in the rotational sequence, the average platform angle and the average number of flake scars removed from each sequential platform. The further along the platform is in the rotation sequence, the higher the average angle, and the fewer average number of flake scars originate from it.

Table 6.3 Average platform angles and number of flake scars removed

	Platform 1	Platform 2	Platform 3	Platform 4	Platform 5	Platform 6
Mean number of flakes	2.5±1.9	2.1±1.5	1.9±1.3	2.4±2.0	1.4±0.5	1.3±0.7
Mean platform angle	83±14.3	83±12.8	86±15.3	86±18.9	89±19.6	96±28.6

As we are looking at platform angles at the time of *discard*, this indicates the point at which knappers were willing to cease work on a platform. It appears that in an effort to further reduce the cores, knappers were more willing to continue working platforms with higher angles, as core rotation progressed. As the earlier discussion of flake length and core rotation illustrates, this practice aided the knappers in the removal not only of a greater number of flakes overall, but also of longer flakes after the core was rotated to the fourth platform.

Summary

Several general statements can be made regarding the nature of core reduction on the South Molle Island Quarry: 1) core rotation was practiced extensively, with 78% of cores analysed worked from multiple platforms; 2) there was a general preference for utilising the adjacent face of the core for the location of the second and third platforms; this preference shifted to the opposite face for the fifth and sixth platforms. The following changes to the reduction process indicate that people were rotating cores to achieve maximum flake removal: 1) there was an overall increase of 10.2mm in mean length and 5.1mm in mean width as knapper rotated the cores from the adjacent to the opposite face; 2) there was an exponential increase in the number of flakes detached from cores on which a greater number of platforms were utilised; and 4) there was an apparent willingness of the knapper to work with stone that became progressively untenable in terms of platform angles, as core rotation increased. Whether the cores were exhausted at the point of discard, and thus the implied availability of raw material across the quarry, is explored in the following section.

RAW MATERIAL AVAILABILITY

It has been suggested that knappers were selecting raw material for reduction, based on metrical dimensions that significantly exceeded those of the extant, unworked raw material on the SMIQ, and whose relative cubic proportions offered the benefit of being able to detach large flakes off a greater number of fracture planes (see chapter 5). This section aims to explore the question of continued availability of raw material that fits these requirements, firstly by way of examining the sample of unworked nodules, and secondly by examining the potential of cores already worked, for further reduction.

Unworked Nodules

Within the sample of unworked nodules, which forms the quota of available (unworked) raw material, there are no cases which equal or exceed the length or projected mean width and thickness of material selected for reduction (Figure 6.10). Thus, on the basis of this sample it could be argued that raw material availability is limited to that which was deemed undesirable on the basis of size and potential for detaching an implied 'adequate' number of large flakes.

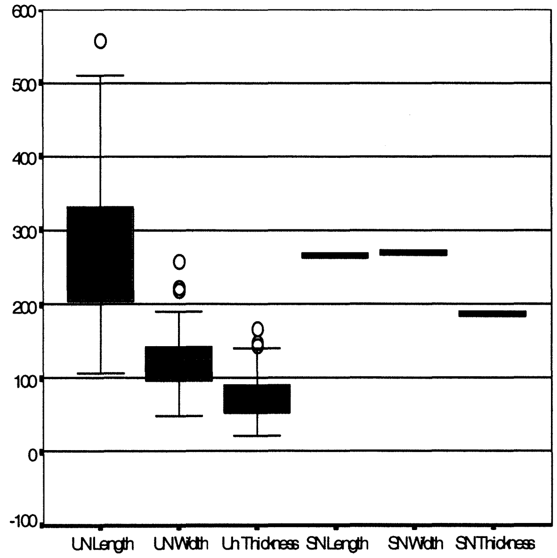


Figure 6.10 Comparison of means including outliers and extremes.
UN = Unworked Nodule; SN = Selected Nodule

Cores

As is illustrated in Table 6.3, mean platform angles range from 83^0 to 96^0. While the former is not particularly high, an unobstructed fracture plane would still be required in order to detach flakes that equal the length of the plane. Step and hinge terminations on the fracture plane, resulting from previous flaking attempts, have the potential to interrupt the progress of the force of a blow as it travels through the core. When the presence of step and hinge terminations become so prevalent as to prevent any flakes being detached, then the core can be considered 'exhausted'; that is, the core's potential for producing flakes is severely limited. Three factors (discussed below) suggest that the sample of cores from the SMIQ were near to exhaustion, or exhausted.

Firstly, as a means to measuring the viability of existing cores on the SMIQ, the relative proportions of termination types per platform were quantified. The high proportion of hinge and step terminations suggest that a significant number of fracture planes were no longer viable: as Table 6.4 demonstrates, when the data are broken down according to platform number, hinge and step terminations *combined* make up between 57% and 65% of terminations. As a subtotal of *all* terminations recorded, regardless of platform number, they make up 60.2% (Table 6.6). A definite increase in the proportion of step terminations is also observable, the further the core is rotated (Table 6.6). This is suggestive of platforms becoming increasingly unusable as rotation progressed. Factors to do with individual core and platform morphology could be responsible for this, which is illustrative of the sequence of platform preference being based on a perceived idea of which platforms were likely to be most profitable.

When we look at the proportion of hinge and step terminations according to platform number, where the platform is the *last platform used*, the pattern is similar, with hinge and step terminations combined, making up between 50 and 69 percent of termination recorded on all last platforms used (Table 6.5). The percentage of hinge and step terminations, as a total percentage taken from all last platforms used, regardless of platform number is 57.2 percent.

Table 6.4 Termination types according to platform number.

	Plat angle	Feather		Hinge		Step		Outrepasse	
		#	%	#	%	#	%	#	%
Plats 1	83±14.3	402	39.2	367	35.8	248	24.2	8	0.8
Plats 2	83±12.8	256	38.4	232	34.8	172	25.8	6	0.9
Plats 3	86±15.3	136	43	100	31.6	80	25.3	0	0
Plats 4	86±18.9	50	34	54	36.7	42	28.6	1	0.7
Plats 5	89±19.6	18	38.3	11	23.4	18	38.3	0	0
Plats 6	96±28.6	13	50	1	3.8	12	46.1	0	0
Plats 7	Na	7	25	8	28.6	13	46.4	0	0

Table 6.5 Termination types according to platform number, where platform number = the last platform used.

	Plat angle	Feather		Hinge		Step		Outrepasse	
		#	%	#	%	#	%	#	%
Plat 1	83	105	43	80	33	56	23	4	2
Plat 2	82	132	41	104	32	85	26	2	1
Plat 3	84	65	46	40	28	36	26	0	0
Plat 4	82	13	32	17	42	10	25	0	0
Plat 5	97	4	31	6	46	3	23	0	0
Plat 6	112	3	50	1	17	2	33	0	0
Plat 7	Na	Na	Na	na	na	Na	na	na	na

Table 6.6 Breakdown of termination data for all platforms, in all core classes

	N	Cores with hinges (N, %)	Cores with steps (N, %)	Cores with hinge and step terminations (N, %)
Single Platform Cores	91	25 (27)	11 (12)	25 (27)
Cores with 2 Platforms	169			
1st platform		85 (50)	55 (32)	32 (19)
2nd platform		81 (48)	61 (36)	31 (18)
both platforms		49 (29)	20 (12)	8 (7)
Cores with 3 Platforms	106			
1st platform		57 (54)	26 (24)	15 (14)
2nd platform		50 (47)	27 (26)	13 (12)
3rd platform		38 (36)	32 (30)	12 (12)
All platforms		9 (8)	4 (4)	1 (1)
Cores with 4 Platforms	36			
1st platform		17 (47)	12 (33)	5 (14)
2nd platform		18 (50)	7 (19)	3 (8)
3rd platform		20 (55)	12 (33)	5 (14)
4th platform		15 (42)	11 (30)	4 (11)
All platforms		4 (11)	0 (0)	0 (0)
Cores with 5 platforms	13			
1st platform		5 (38)	3 (23)	2 (15)
2nd platform		8 (61)	1 (8)	1 (8)
3rd platform		5 (38)	4 (31)	1 (8)
4th platform		7 (54)	4 (31)	1 (8)
5th platform		6 (46)	2 (15)	0 (0)
All platforms		1 (8)	0 (0)	0 (0)
Cores with 6 Platforms	5			
1st platform		2 (40)	0 (0)	0 (0)
2nd platform		0 (0)	2 (40)	0 (0)
3rd platform		1 (20)	2 (40)	0 (0)
4th platform		2 (40)	4 (80)	1 (20)
5th platform		1 (20)	0 (0)	0 (0)
6th platform		1 (20)	1 (20)	1 (20)
All platforms		0 (0)	0 (0)	0 (0)

Secondly, I documented the percentage of all platforms (N=1,007) which generated multiple flake scars with either hinge or step terminations. While this is not directly analogous with an exhausted platform, it does suggest an impediment to the further production of flakes of similar size, from the same fracture plane; and in combination with the points outlined below, it does suggest that such terminations were indeed a contributing factor. From a population of 1,007 *platforms* analysed for this study (on 423) cores, a sample of 797 or 79% of platforms had *one or more* flake scars terminating in either a hinge or a step (471 or 46.8% had *multiple* scars terminating in a hinge or a step). Of these, 484 or 48.1% of platforms had *one or more* flake scars terminating in a hinge (284 or 28.2% had *multiple* scars terminating in a hinge) and 313 or 31.1% of platforms had *one or more* flake scars terminating in a step (196 or 19.5% had *multiple* scars terminating in a step).

These data can also be looked at another way: broken down according to the number of platforms per core, I documented the percentage of *cores* that had fracture planes which were 'interrupted' by either hinge or step terminations. The purpose of this was to gain an understanding of the relative percentages as they related to degrees of core rotation. As Table 6.7 demonstrates, there is a direct coefficient between cores with a greater degree of rotation, and a higher percentage of multiple fracture planes 'interrupted' by hinge or step terminations. For example, 61% of cores with three platforms had multiple fracture planes interrupted by step or hinge terminations. This suggests that knappers were rotating the core as a result of the interruption of fracture planes. Thus, fracture planes with flake scars terminated by hinges or steps could be considered exhausted, as evidenced by the continued rotation of these cores.

Table 6.7 Relationship between cores by number of platforms and cores with multiple platforms interrupted by hinge or step terminations

	Cores with **multiple platforms** terminated by hinge or step terminations	
	#	%
Single Platform Cores (N=91)	31	34
Two Platforms (N=169)	81	48
Three Platforms (N=106)	65	61
Four Platforms (N=30)	30	83
Five Platforms (N=13)	13	100
Six Platforms (N=5)	3	60
Seven Platforms (N=3)	3	100

Thirdly, an examination of metrical measurements according to termination type (Figure 6.11), demonstrates that blows to the core which result in step or hinge terminations tended to produce shorter flakes than those terminating in a feather. Thus, these flake scars not only interrupt the fracture planes, but disable the further production of large, elongated flakes from those fracture planes. These metrics are consistent between all platforms within core classes (cores with 2 platforms, cores with 3 platforms *etc*) (See Table 6.8 for a breakdown of these data according to last platform used). Thus, the relatively high proportion of step and hinge terminations across all platforms, regardless of their place in the rotational sequence, is associated with the production of flakes less than 60mm in length, which prohibits the further production of flakes larger than 60mm long.

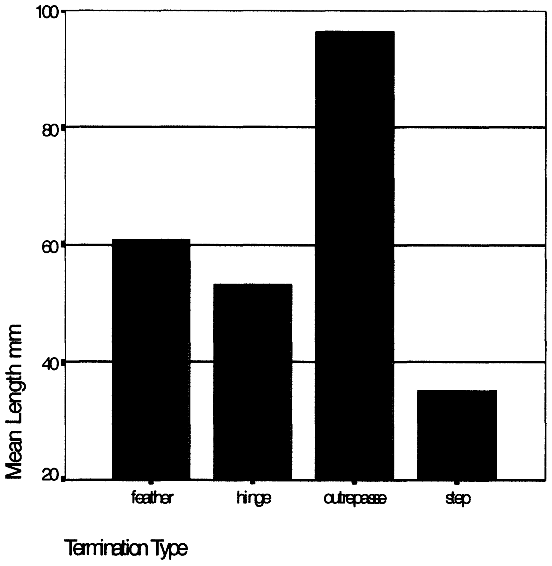


Figure 6.11 Relationship between Mean length and termination type

Table 6.8 Breakdown of termination/metrical data for all and last platforms in all core classes

Number of platforms	**# scars with any recorded termination**	**Mean Length mm**	**(N) & Std. Dev.**	**Mean Width mm**	**(N) & Std. Dev.**
One	539				
Feather	186	78	(105) 38	67	(62) 35
Hinge	238	55	(76) 31	48	(54) 23
Step	105	30	(56) 21	35	(47) 22
Outrepasse	10	116	(3) 47	110	(2) 73
Two					
All platforms	1296				
Feather	463	59	(298) 33	50	(187) 27
Hinge	522	55	(249) 32	56	(156) 31
Step	303	28	(195) 19	33	(127) 18
Outrepasse	8	105	(4) 36	83	(1) -
2nd Platform	335				
Feather	130	57	(127) 32	51	(74) 28
Hinge	109	51	(107) 32	54	(67) 31
Step	95	27	(95) 17	33	(61) 18
Outrepasse	1	122	(1) 122	-	(0) -
Three					
All platforms	1012				
Feather	364	60	(249) 34	48	(186) 28
Hinge	440	50	(211) 27	51	(137) 26
Step	202	27	(122) 17	37	(94) 20
Outrepasse	6	88	(3) 19	97	(1) -
3rd platform	165				
Feather	81	56	(80) 32	46	(61) 28

Table 6.8 Breakdown of termination/metrical data for all and last platforms in all core classes cont.

Hinge	45	45	(44) 24	46	(28) 22
Step	39	29	(38) 19	39	(28) 24
Outrepasse	0	-	(0) -	-	(0) -
Four					
All Platforms	367				
Feather	122	57	(89) 32	48	(52) 28
Hinge	161	43	(109) 27	41	(68) 25
Step	80	27	(57) 15	40	(42) 20
Outrepasse	4	65	(3) 22	33	(1) -
4th platform	60				
Feather	23	61	(23) 41	48	(15) 27
Hinge	24	31	(23) 20	35	(14) 23
Step	12	21	(12) 11	35	(6) 11
Outrepasse	1	79	(1) -	-	(0) -
Five					
All platforms	149				
Feather	58	57	(43) 39	51	(33) 24
Hinge	63	50	(39) 32	48	(29) 29
Step	28	33	(21) 30	40	(12) 25
Outrepasse	0	-	(0) -	-	(0) -
5th platform	16				
Feather	6	61	(6) 63	31	(4) 14
Hinge	7	55	(7) 52	55	(5) 47
Step	3	23	(3) 10	27	(2) 6
Outrepasse	0	-	(0) -	-	(0) -
Six					
All platforms	72				
Feather	34	50	(31) 25	38	(23) 24
Hinge	19	53	(12) 34	61	(6) 15
Step	19	32	(18) 22	32	(14) 13
Outrepasse	0	-	(0) -	-	(0) -
6th platform	8				
Feather	5	36	(5) 18	26	(5) 11
Hinge	1	17	(1) -	-	(0) -
Step	2	57	(2) 1	40	(1) -
Outrepasse	0	-	(0) -	-	(0) -

SUMMARY

Based on the above data, I present the following model for raw material availability on the South Molle Island Quarry. In combination, data relating to the sample of unworked nodules, and the sample of cores on SMIQ, suggest that at the time the quarry ceased to be used, unworked raw material was not available in the form and quantity it was when the sample of cores studied was selected for reduction.

Furthermore, the majority of cores that remained on the South Molle Island Quarry were not generally viable for future reduction. This is based on several factors which are summarised in point form below.

- The size of the cores selected for reduction significantly exceeded that the existing unworked material.
- There is a high proportion of step and hinge terminations, which interrupt the production of flakes along any given fracture plane: these were documented in the following ways:
    - as a percentage of terminations, on a per-platform basis according to where it (the platform) was in the rotational sequence;
    - as a percentage of terminations on a per-platform basis when the platform is the final platform used in the rotational sequence;
    - the percentage of all platforms which had *multiple* negative flake scars with either hinge or step terminations were also documented;
    - the percentage of cores in each rotational class (one platform, two platforms, three platforms *etc*) that had platforms which were interrupted by either hinge or step terminations;
- An examination of metrical measurements according to termination type revealed that negative flake scars terminating in either a hinge or a step did not, on average, produce flakes longer than 60mm in length. The significance of this final point will be illustrated in the following chapter when I examine the patterns of retouch occurring on the SMIQ.

HAMMERSTONES IN THE REDUCTION PROCESS

As an essential component of the toolkit in the process of core reduction and artefact manufacture, hammerstones are frequently neglected in otherwise comprehensive technological characterisations of quarry and reduction sites. Hammerstones are a very visible aspect of the South Molle Island Quarry and a study of them was devised in order to determine which material was selected for hammerstone use, how the hammerstones were used in the process of reduction, and their place in the reduction sequence determined by overall metrics (size being an indication of their utility). A sample of 304 hammerstones was analysed for this study.

Hammerstone Damage

Hammerstone 'damage', not inclusive of impact pitting was assessed using two variables; that of 'split' and 'fragment'. A hammerstone was considered split, if it was damaged to the extent of loss amounting to between one quarter and one half (contiguous) of the surface area (Figure 6.12 a and b). A hammerstone fragment was identified if the piece was less than a 'half round'; that is if its radius was less than half of its original diameter (Figure 6.12c).

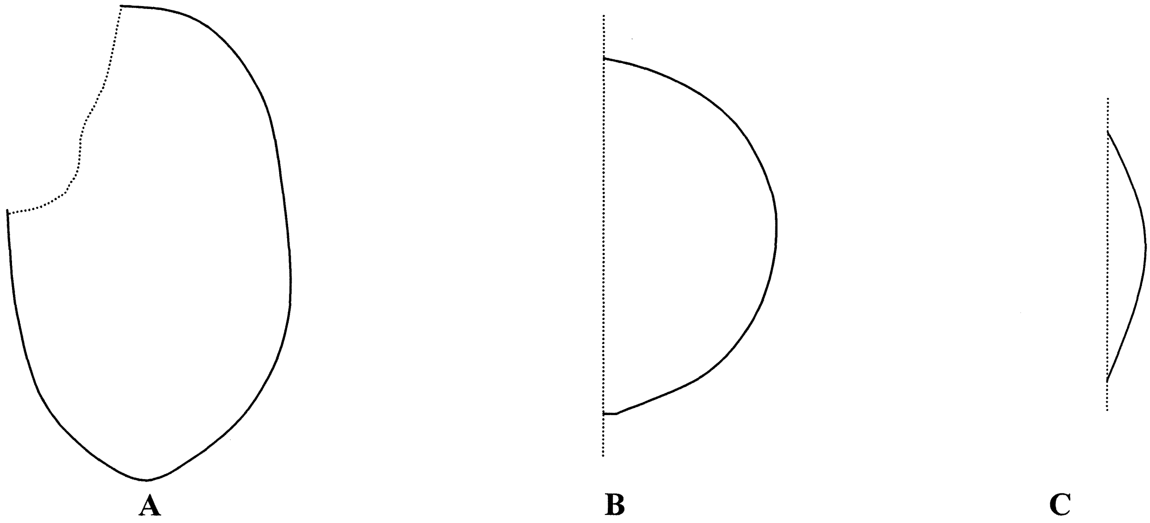


Figure 6.12 Illustration of a broken hammerstone (A), a split hammerstone (B) and a hammerstone fragment (C).

Hammerstone Material

Raw material type was recorded for 301 out of the 304 hammerstones (Table 6.9). The prevalent material was classified as a 'rough' ignimbrite which accounted for 52 percent of all hammerstones. The other prevalent material was a 'smooth' ignimbrite. Both materials were naturally rounded beach cobbles, the origin of which was presumably a portion of South Molle Island shoreline, the closest point to the quarry being approximately 100m to the north. The third raw material type was the siliceous volcanic tuff itself. This raw material type accounted for 6 of the total hammerstone sample. As this material is highly brittle and fractures easily, it was not a suitable material for heavy use and thus was not selected frequently.

Table 6.9 Hammerstone raw material types and mean weight (gm) on unbroken specimens

Material	Count	Percent	Mean Weight gm (St Dev)
Smooth	136	45	420 (423)
Rough	159	52	872 (633)
Smooth (tuff)	6	2	472 (276)
Total	301	99	

Hammerstone Use

Hammerstone use was analysed using three variables: 'pitted one end', 'pitted both ends' and 'pitted margin'. The assumption here, is that hammerstones with multiple worked ends (margins included) had a heavier use-life than those worked on single ends only. The term 'heavier use-life' is used to indicate *prolonged* use (indicated by hammerstone rotation). These variables were examined (in combination with each other, and in isolation) in relationship to material type and weight, with a view to making statements regarding raw material selection for particular types of reduction activity.

Of the total sample, a population of 68 hammerstones (22%) exhibit pitting on one end, 48 (16%) exhibit pitting on both ends, 35 (11%) exhibit pitting on one end and the margin, while 89 (29%) exhibit pitting on both ends and the margin. These four use categories are explored below, and some very interesting trends are illuminated. (When I introduce the weight and dimensions of hammerstones into the discussion, I draw on data for unbroken specimens only.)

Pitted on One End

In total, there are 20 unbroken hammerstones (17% of 118 in total) which are pitted on one end only. When mean weights are compared between material types for this use-class, there is no significant difference between the smooth and the rough ignimbrite (Table 6.10). As the rough ignimbrite tends to be, on average, heavier than the smooth, this similarity is noteworthy. If limited working on the hammerstone (indicated by pitting on one end only) is indicative of either work of a short duration, or work that takes place late in the reduction sequence (for example retouch), then it is reasonable to conclude that the knappers did not select robust hammerstones for such work.

Table 6.10 Mean weight of unbroken hammerstones, according to extent of use and material.

Use	**One End**			**Both Ends**			**One End + Margin**			**Both End + Margin**		
%	**17%**			**17%**			**7%**			**34%**		
	Material			**Material**			**Material**			**Material**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
N	17	3	-	4	15	1	4	4	-	11	26	3
Mean weight	240	283	-	248	799	226	242	799	-	545	993	554
St Dev	142	73	-	128	869	-	88	516	-	525	488	272
Mean length	79	90	-	71	96	100	76	123	-	91	106	95
St Dev	17	19	-	15	25	-	9	38	-	26	22	12
Mean width	52	54	-	54	81	46	55	75	-	66	92	81
St Dev	12	7	-	10	26	-	13	18	-	19	16	5
Mean thick	38	35	-	38	60	34	38	53	-	49	68	56
St Dev	10	8	-	11	21	-	8	8	-	16	13	21

Material 1=smooth ignimbrite; 2=rough ignimbrite; 3=tuff

Pitted on Both Ends

There are 20 (17%) unbroken hammerstones in this use-class also. However, unlike those worked on one end only, this sample of hammerstones shows a significant weight disparity between raw material types which can not be accounted for by the dimensions (Table 6.10). Mean weight of hammerstones made on rough ignimbrite within this use-class is 3.22 times heavier than those of smooth ignimbrite. This is suggestive of rough ignimbrite being selected in preference to smooth (as evidenced by the frequencies of each – 75% and 20% respectively) for hammerstones that undergo a heavier use-life.

Pitted on One End + the Margin

This use class is composed of 8 specimens only and the weight disparity between rough and smooth ignimbrite is almost identical to that of the previous use-class. Unlike the previous use-class however, there is a 47mm difference between mean lengths of rough and smooth ignimbrite, which could explain the weight disparity. Because of the particularly small sample, and the degree of variance between raw material mean lengths, I am not modeling any preference for raw material within this use class, based on weight.

Pitted on Both Ends + the Margin

Comprised of 40 unbroken specimens, this use-class forms the largest in the sample of hammerstones (34%). There are two interesting observations to be made about the hammerstones in this class: firstly, that the weight disparity between smooth and rough ignimbrite is to be found here, as in the other two classes; this remains constant. Secondly, that the sample of smooth ignimbrite hammerstones in this class are heavier than those in the other use-classes (Table 6.10). This second point is particularly suggestive of knappers selecting heavier hammerstones for work that involves prolonged use.

Summary

Four use-classes were identified among the sample of hammerstones from the SMIQ: *pitted on one end*, *pitted on both ends*, *pitted on one end and the margin*, *pitted on both ends and the margin*. These classes represent a progressively heavier use-life in the form of prolonged use, as evidenced by hammerstone rotation. A clear connection exists between hammerstone rotation and the selection of larger, heavier cobbles for this type of prolonged use. This selection of heavier cobbles is largely restricted to the use of rough ignimbrite, except for the use-class which represents the most prolonged use – that of *pitted on both ends* + *the margin*, when heavier cobbles of smooth ignimbrite are also selected.

CHAPTER 7 RETOUCHED ARTEFACT PRODUCTION ON THE SOUTH MOLLE ISLAND QUARRY

In the previous two chapters I examined the nature of raw material on the South Molle Island quarry, including the form in which it occurred, the morphology of the unworked material, and I examined which cores were being selected for reduction. In combination with an examination of how the cores were being reduced, I was able to make certain predictions about raw material availability. The focus of this chapter is to investigate the next stage of reduction; that is, retouch of flakes.

A CHARACTERISATION OF RETOUCH ON THE SOUTH MOLLE ISLAND QUARRY

As outlined in Chapter 3, a systematic survey for retouched flakes was undertaken with the aim of characterising the range of retouch on the South Molle Island Quarry. The sample of retouched artefacts contained two preliminarily identified classes: backed (N=329) (see Figure 7.1) and non-backed (N=117) artefacts. The aim of the analysis contained in this section is to comprehensively characterise the retouch technology occurring on the quarry. This is achieved through both metric and non-metric tests which determine both variability and extent of retouch. The tests will determine *retouch direction*, *retouch location*, *percentage of length retouched*, *extent of retouching* and *size of retouched artefacts*.

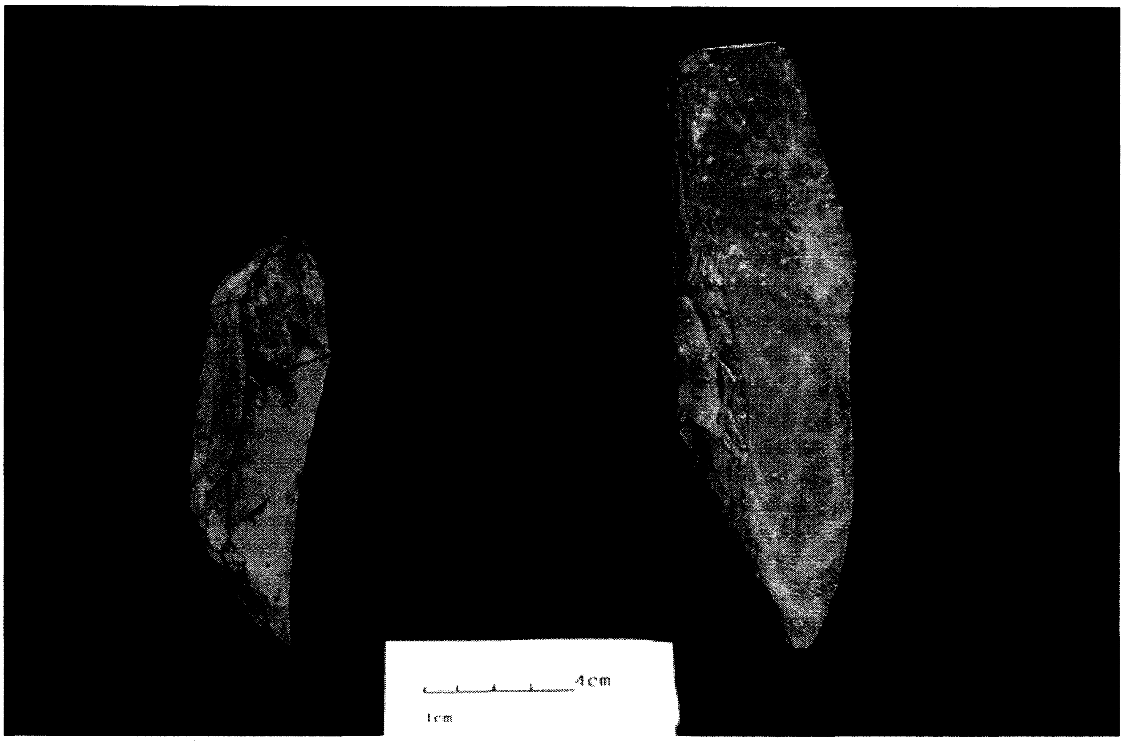


Figure 7.1 Backed artefacts from the south Molle Island Quarry

Retouch Direction

The aim of the category *retouch* direction is to determine from which side of a flake the retouch originates. Thus, the concept of retouch direction relies on the satisfactory identification of the dorsal and the ventral surfaces of a flake. During analysis, two directional categories were identified in order to determine retouch direction: bi-directional and unidirectional. *Bidirectional* denotes that the retouch originates from both the ventral and the dorsal surface of the flake, while *unidirectional* denotes the origin of the retouch as being either the ventral or the dorsal surface. In order to refine the nature of the data gathered, the two categories were further broken down into the subsets of: *unidirectional from dorsal surface only* and *unidirectional from ventral surface only*). Table 7.1 illustrates a polarity between backed artefacts and non-backed artefacts in terms of retouch direction, with the majority of backed artefacts exhibiting bi-directional retouch, while the opposite is true of non-backed artefacts. The differences in the proportion of bi-directional retouch between categories also prove significant (X^2= 100.771; P=<.0005). This result is of particular note and will be discussed in more detail below.

Table 7.1 Direction of retouch on all retouched artefacts.

	Bi-directional	Unidirectional	
Backed Artefacts (N=146)	90 (62%)	53 (36%)	
		From dorsal only	From ventral only
		12 (8%)	41 (28%)
Other Retouch (N=63)	17 (27%)	46 (73%)	
		From dorsal only	From ventral only
		22 (35%)	21 (33%)

***Note: a small portion of retouch was categorised as 'indeterminate' in regards to direction.**

Retouch Location

The location of retouch was recorded as right, left, proximal or distal margins, oriented according to the ventral surface. Adjacent margins are defined as distinct from one another according to the orientation of the retouch to its opposite margin (right being opposite to left, and proximal being opposite to distal). For example, if a line extending out perpendicular to the proximal margin locates retouch on the opposite margin, then that retouch is said to be located on the distal end. If a line extending out perpendicular to the left margin also encounters the retouch, then it would be classed as occupying two margins: distal and right.

Generally, the majority of retouched flakes were retouched on one margin only (this is in keeping with the generally low curvature index for backed artefacts – see below). However, of note is the fact that non-backed artefacts exhibit significantly higher rates of retouch on *multiple* margins than do backed artefacts (Chi Square = 100.771; P=<.0005). This is suggestive of a sub-grouping exhibiting generalised retouch on a range of margins, and not exclusively devoted to early-stage backing of a single margin (Table 7.2). However, the retouching of multiple margins could instead suggest that this group represents the reworking of backed artefacts. If this were the case, we might expect to see similar if not lower mean weights for such a 'reworked' (non-backed) sample. In fact, the opposite is observed (Table 7.3). A *t*-test indicates that non-backed artefacts are significantly heavier than backed artefacts (Table 7.3).

Table 7.2 number of margins retouched.

	1 Retouched Margin	2 Retouched Margins	3 Retouched Margins	4 Retouched Margins	Missing Data
Backed (N=146)	103 (71%)	17 (12%)	2 (1%)	-	24 (16%)
Non-backed (N=63)	35 (56%)	15 (24%)	7 (11%)	1 (1.5%)	5 (8%)

Table 7.3 average weight of artefacts, according to number of margins retouched

	1 Retouched Margin	2 Retouched Margins	3 Retouched Margins	4 Retouched Margins
Backed Mean Weight (N=146)	160g	214g	136g	-
Non-backed Mean Weight (N=63)	724g	1111g	1527g	3259g
t-test	p=.001	p=.004	p=.006	-

Percentage of Maximum Length Retouched

For the purposes of this analysis, *maximum retouch length* is defined as the length of the longest section of retouch, measured from two extreme points of impact. Table 7.4 illustrates that on average, the percentage of the maximum length retouched on backed artefacts is 20% greater than that of non-backed artefacts (*t*-test, p = <.0005). Standard deviation is also 8.2% less than for non-backed artefacts, and the interquartile range of the backed group occupies the top fifth of the non-backed ('other retouched') range (Figure 7.2). Essentially, this indicates that in many instances backed artefacts are retouched along most, if not all, of the margin selected for retouching and when compared to the non-backed category, they are retouched along greater proportions of their margin lengths overall. Although there does exist a degree of overlap within the top of the range of the 'non-backed' category that is equivalent to the range within the backed artefact category (discussed below) (Figure 7.2).

Table 7.4: Mean percentage of length retouched on backed and non backed artefacts. T=5.318, d.f.=80, p=<.001

	N	Mean percent of maximum length retouched (mm)	Std. Dev.
Backed	146	89.55	17.7
Non-backed	59	70	25.9

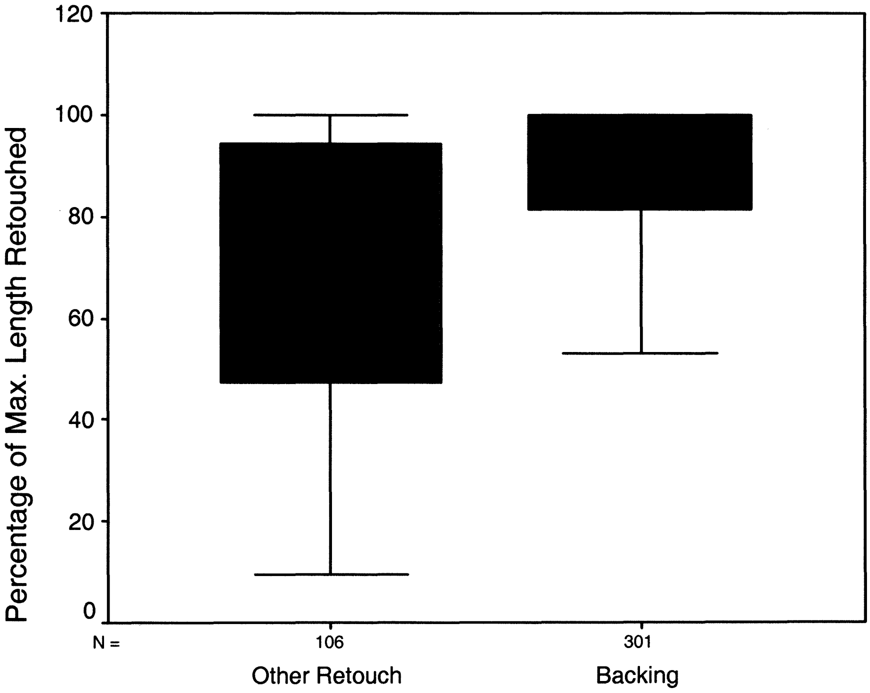


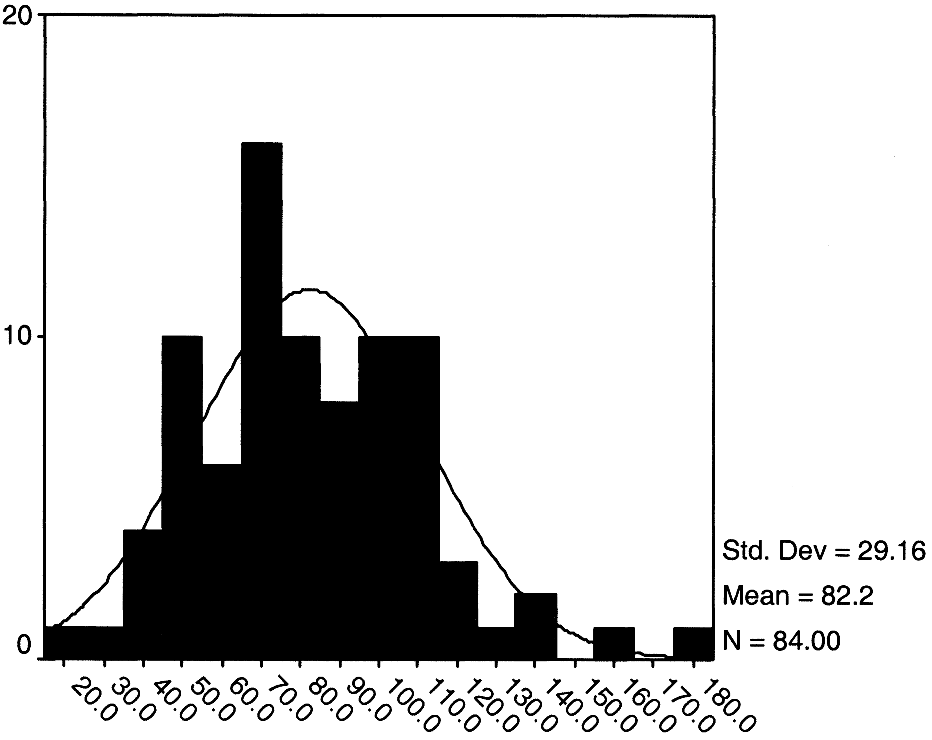
Figure 7.2 Percentage of maximum length retouched.

Extent of Retouching

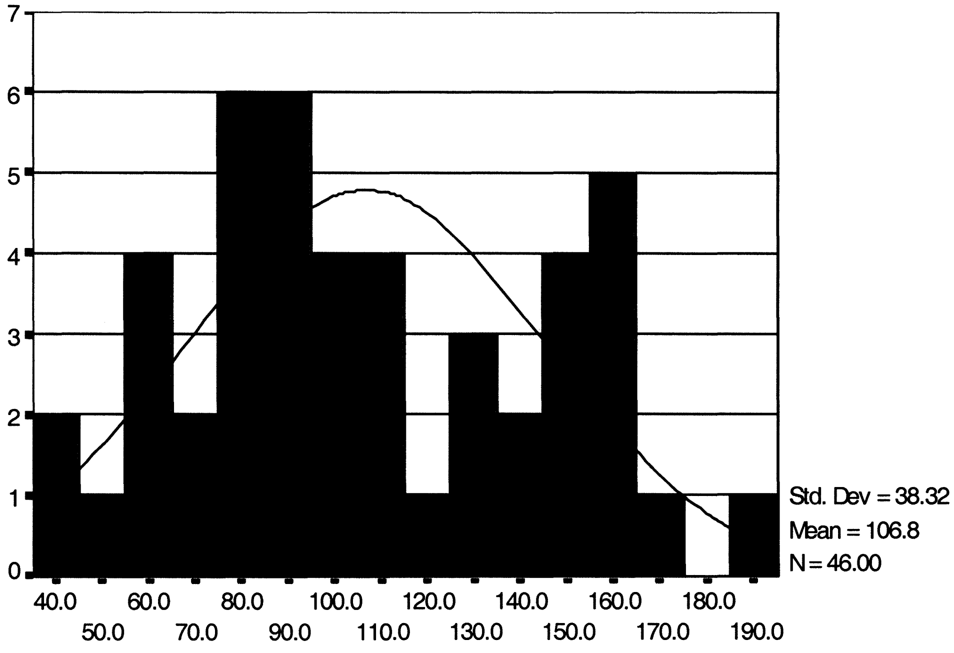
In order to determine extent of retouching, three tests were conducted on the South Molle Island Quarry sample: Kuhn's Reduction Index (Kuhn 1992), the Edge Curvature Index (Hiscock and Attenbrow 2002), and the measurement of retouch edge angle as an indicator of retouch intensity (e.g. Clarkson in press; Dibble 1995; Hiscock 1982) (Table 7.5). The use of the Kuhn Index as a tool for measuring reduction intensity has been discussed extensively by Clarkson and Hiscock (in press). Essentially the test provides a relative measure of reduction by establishing a ratio of retouch height to flake thickness. This is measured on a scale of 0 (no reduction) to 1 (complete reduction). The edge curvature index is determined by dividing the depth of retouch by the retouch span (Hiscock and Attenbrow (in press). A negative value indicates a concave edge, while a value of >0 indicates a convex edge. A higher positive value represents a greater convex edge.

Table 7.5 Kuhn's reduction index, curvature index and retouched edge angle

	N	Backed Artefacts	Non-backed Artefacts	T test
Kuhn Reduction Index (mean, std. dev.)	232	0.97±0.07	0.96±0.06	T=1.652, d.f.=451, p=0.099
Curvature Index (mean, std. dev.)	233	0.17±0.08	0.2±0.09	T=3.803, d.f.=457, p=<.001
Retouched Edge Angle (mean, std. dev.)	372	87.5±11.2	71.7±17.4	T=14.727, d.f.=633, p=<.001999



Backed Artefacts - Percussion Length (mm)



Non-backed Artefacts - Percussion Length (mm)

Figure 7.3 Percussion length of retouched artefacts, illustrating a bimodal pattern within the sample of non-backed artefacts

Two observations can be made from Table 7.5. Firstly, according to the Kuhn reduction index and the curvature index, the majority of implements in the sample are reduced to a uniform extent and exhibit no significant differences in shape between backed and non-backed categories. Secondly, there is a highly significant difference (*t*-test, p=.000) in retouched edge angle between the two retouch categories, with non-backed artefacts recording lower retouched edges than the remainder of the sample, while maintaining a near-maximum Kuhn reduction index.

Size of Retouched Artefacts

The majority (83.5%) of backed artefacts show a unimodal distribution for percussion length of between 50mm and 105mm, and centred on around 70mm (Figure 7.3). The non-backed artefacts on the other hand show a bi-modal distribution. The lower mode overlaps almost exactly with that of backed artefacts, but the upper mode (37% of non-backed specimens) indicates the existence of a group of much larger artefacts with a percussion length centred on around 160mm. These larger non-backed artefacts are also more often retouched on multiple margins (59%). Thus, while both backed and non-backed artefacts are common up to around 110mm, only non-backed artefacts retouched on multiple margins are common above this size.

Edge Angle and Scar Size

Both the Kuhn Reduction Index and the Curvature Index results indicate that the sample of retouched artefacts has been reduced to a reasonably uniform extent (refer to Table 7.5). Yet despite the fact that both groups show extensive retouching, there is a significant difference in the mean retouched edge angle of each group, with non-backed artefacts showing much lower edge angles than backed artefacts.

We might typically expect edge angles either to increase as unifacial reduction increases and step terminations build up, as found by Clarkson (in press), or to increase and then decrease as these areas of steeply retouched edge are removed by deep blows, as found by Hiscock and Attenbrow (in press). Which of these models best explains the differences in edge angles noted between the backed and non-backed implements found at the SMIQ might be investigated by considering the size of retouch flake scars themselves. Very large and invasive flake scars could conceivably succeed in producing very high Kuhn index values while also maintaining edges at fairly low angles. Figure 7.4 demonstrates that this in fact seems to be the case, and that a greater range and mean length of retouch scars is found for the non-backed category than for backed artefacts. The conclusion that can be drawn from this test is that some artefacts received relatively short, steep-edged retouch, while others had long flakes removed from their margins that did not overly increase edge angle.

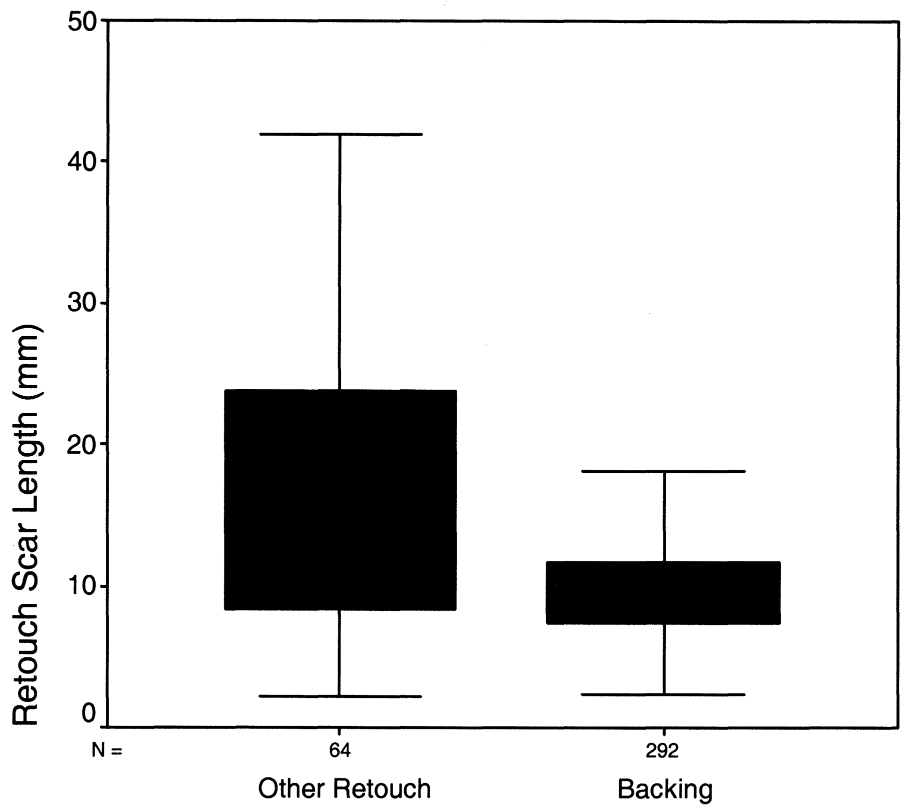


Figure 7.4 Mean length of retouch scars.

Discussion: The Nature of SMIQ Reduction Strategies

Together, the results of the tests presented here suggest that two quite distinctive reduction processes were in operation at the SMIQ in the past. The first focussed on the production of backed artefacts ranging in size up to around 110mm in length, that were steeply and bi-directionally retouched along a single margin. The second strategy was focussed on the production of flakes from numerous margins of large flakes (i.e. greater than 110mm in length). While the size distinction seems important in separating these two reduction processes, the overlap between backed artefact and the lower mode in non-backed artefact length is still to be explained. It is suggested here that the smaller mode may represent early-stage backed artefacts that had not yet progressed from single margin unidirectional retouching to the single margin bi-directional flaking that defines backing.

For example, in backing an edge it might be expected that the length of the edge might be unifacially flaked in its entirety before turning the artefact over and working it from the other side, giving it is bidirectional form. Thus, the higher rate of unidirectional retouch on smaller (i.e. <110mm), unimarginal, non-backed artefacts could indicate that many of these represent an early stage in the backing process. This smaller group is also characterised by a corresponding *percentage of length retouched* which falls within the range for backed artefacts (Figure 7.4).

In contrast, the differences in retouch location provide an indication that the larger grouping of artefacts within the non-backed category (i.e. >110mm) can be distinguished from both backed artefacts and early-stage backed artefacts. Artefacts within this group have multiple margins retouched - suggestive of a more generalised flaking around the perimeter of the flake. This sub-group also exhibits large flake scars and low edge angles indicative of a very different reduction strategy. I propose that this subgroup of non-backed retouched artefacts was used to produce flakes from their margins of comparable size to those produced from cores. To support this assertion, two further lines of evidence can be presented. Firstly, retouch scars found on the larger non-backed artefact group average 53.5mm in length, compared with an average of 21.4mm for those found on the smaller non-backed artefact group, and for the sample of *backed artefacts* longer than 120mm (*t*-test, p=.000). Secondly, the mean length for flake scars measured on a sample of 424 cores from the SMIQ, is 50.1mm. Thus the length of flake scars on the large non-backed artefact group compares very favourably with that of cores. There is therefore strong evidence to support the existence of two very different strategies of flake retouch having been practised at the SMIQ.

BACKED ARTEFACT REDUCTION

The purpose of this section is to characterise several variables linked to the manufacture process of backed artefacts on the SMIQ, with a view to the identification of similar variables within assemblages of flaking debris both on the quarry and within the stratified rockshelter assemblages in the Whitsunday region. The general aim of this exercise is to 1) determine whether the flaking debris on the quarry can be linked to the production of backed artefacts; this will lead onto the second aim of the exercise (Chapter 8) which is to 2) identify and date the production of backed artefacts in the surrounding area by dint of the rockshelter assemblages.

The selection of variables to use as comparative measures between *implied backing debris* and debris excavated on the quarry and in the stratified rockshelters, involved a process of determining variable differentiation between the two artefact classes (backed and non-backed). This process allowed me to firmly differentiate material resulting from the production of backed artefacts from that of the production of non-backed, retouched artefacts. Variables selected were length of retouch scar - being directly analogous with flake length, and angle of retouch - being indicative of the platform angle on the retouched flake. These variables were measured on the SMIQ sample of retouched artefacts (Table 7.6).

Table 7.6 Descriptive statistics for backed and non-backed artefacts
Retouch angle (dorsal) Significance t-test P=<.001
Retouch scar length Significance t-test P=<.001

	Backed artefacts	**Non-backed artefacts**
Average retouch angle (ventral surface)	87.5 St.Dev. 11.2	71.4 St Dev. 17.4
Average length retouch scar (mm)	10.3 St. Dev. 3.7	18.6 St. Dev. 13.9

Table 7.6 demonstrates that length of retouch scars and retouch angle vary significantly between retouched artefact classes. Because the debris produced from the backing process is easily distinguished using these two variables, it is reasonable to use these variables when attempting to characterise debris excavated on the SMIQ and the stratified rockshelter sites, as being the result of the backing process, or some other form of artefact retouch/reduction.

Squares N1 and S1: Characterising the Debris

Squares N1 and S1 were selected for excavation because they contained clear indications of backed artefact manufacture (Square S1 contained 6 backed artefacts while N1 contained 5 backed artefacts on the surface layer) (Figure 7.5). Upon initial assessment, both the small size of the surrounding flaking debris and the presence of hammerstones, indicated that the debris surrounding these backed artefacts was linked with their manufacture. The aim of the following analysis is to test whether this could indeed be the case by comparing the attributes of percussion length and platform angle on the dorsal surface with the analogous attributes on the sample of retouched artefacts (as discussed above, being directly analogous to the flake scar length and retouch angle recorded on retouched artefacts). The results of this analysis will then be compared to material from several stratified rockshelter sites in the region, in order to clarify the nature of technological activities being carried out in these sites (Chapter 8).

Figure 7.5 Square S1, before and after excavation

The analysed sample from excavated square N1 contained 2,428 artefacts. Of these, 774 were non-retouched flakes with recorded percussion lengths. The percussion length on 445 (57%) of these flakes fell within the range of length observed on backed artefact retouch scars (2.3 – 36.8mm). A similar sample was analysed from excavated square S1. The analysed sample contained 2,810 artefacts, 953 of which had recorded percussion lengths. Of these 717 (75%) fell within the of flake scar length observed on backed artefact retouch (2.3 – 36.8mm).

Thus I argue that it is reasonable to state that a portion of the assemblages from N1 and S1 (18% and 25% respectively) could have been the by-product of backed artefact manufacture, based on the comparison of percussion length between backed artefact retouch scars and flakes from the quarry assemblages (N1 and S1).

This argument can be further substantiated by examining the platform angle of artefacts in excavated squares N1 and S1 and determining how closely they reflect the retouch angles of backed artefacts. This test is conducted on the assemblage as a whole (Table 7.7_), and on the portion of the assemblage which fits the size range of backing scars (Table 7.8).

Table 7.7 Platform angles compared (whole assemblage)
Significance t-test P=<.001

Mean Plat Angle N1	Mean Plat Angle S1	Retouch Angle Backed Artefacts
67.4 (St.Dev. 16.3)	66.3 (St.Dev. 14.8)	87.5 (St.Dev. 11.2)

Table 7.8 Platform angles compared (backing scar size-range)
Significance t-test P=<.001

Mean Plat Angle N1 N=1090	Mean Plat Angle S1 N=200	Retouch Angle Backed Artefacts
62.7 (St.Dev. 16)	61.5 (St.Dev. 16)	87.5 (St.Dev. 11.2)

As Tables 7.7 and 7.8 demonstrate, there is a significant difference between the mean platform angles on the excavated squares' assemblages (N1 and S1) and the retouch angles on the backed artefact sample. This is to be expected if the assemblages represent all stages of the reduction process, as smaller angles are indicative of earlier stages of the backing process of reduction. (As the flake is retouched from the margin, the platform angles on the early retouch flakes will mirror the angle of the margin. As the retouch proceeds in from the margin toward the centre of the flake, and the retouch edge approaches 90 degrees to the ventral surface, the edge angle progressively increases - see previous section).

However, within N1 it can also be demonstrated that 81% (N=333) of flakes with recorded platform angles, that are within the size range of backing flake scars, are equivalent to the retouch angle range of backed artefacts (53-123°). Similarly, within S1 90% of flakes with recorded platform angles (N=672), that are within the size range of backing scars, are equivalent to the retouch angle range of backed artefacts. Expressed as a percentage of the total assemblage of N1 and S1, flakes with platform angles within the range for backed artefact retouch angles and within the range for size of backing flake scars comprise 14% and 24% respectively.

Thus, it can be stated that flakes in large quantities that have the features outlined above, indicate that backing has occurred. These features which typify the backing process include platform angles which are consistent to those observed on the retouched margin of backed artefacts; the other defining feature is length of flake. As demonstrated, mean backing scars cluster around 10mm in length with 3.7 standard deviations. Thus, it would be expected that flakes resulting from the backing process would demonstrate similar trends in regards to length. Implied by the process of retouch is that the majority of the assemblage resulting from backing should exhibit no cortex (tertiary reduction) on the dorsal surface.

CONCLUSION

The systematic survey of the South Molle Island Quarry identified a sample of 443 retouched artefacts, including 329 backed artefacts. This chapter has attempted to utilise technological tests to comprehensively characterise the nature of the retouch occurring on the quarry. Analysis of the sample as a whole has identified attributes which suggest that quarry production was aimed at the manufacture of backed artefacts (including early-stage backed artefacts) and larger retouched flakes that appear broadly similar to cores in terms of the size of flakes being removed.

In regards to the identified manufacturing debris, there are three lines of evidence which suggest that a portion of the South Molle Island Quarry artefact assemblage could be a by-product of backed artefact manufacture. Firstly, there is the presence of backed artefacts and hammerstones in the surface layers of the excavated squares N1 and S1. Secondly, as argued earlier in the chapter, the backing industry on the quarry is the only formal and consistent type of retouch. Thirdly there is consistency between length and platform angles of flakes and backed artefact retouch scars. The following chapter examines the stone artefact assemblages of Nara Inlet 1 and Border Island 1 in order to determine whether the assemblages resemble those from N1 and S1, and thus could be identified as the result of a backing technology practiced in locations other than the South Molle Island Quarry.

CHAPTER 8 SOUTH MOLLE ISLAND QUARRY STONE ARTEFACTS IN THE WHITSUNDAY ISLANDS

This chapter will outline the distribution of stone from the South Molle island Quarry throughout space and time, in the Whitsunday Island region. This will be achieved by exploring two lines of evidence. One source of evidence is available in the general geographic distribution of stone that has been located during field surveys in the region. A separate source of information comes from a detailed technological characterisation of stone artefacts in two stratified rockshelter sites that span the Holocene period.

REGIONAL DISTRIBUTION OF SOUTH MOLLE ISLAND STONE

The absence of known alternative sources, in addition to a limited petrographic study undertaken by Barker and Schon (1994) suggests that the South Molle Island Quarry is the only source of black, siliceous volcanic tuff in the Whitsunday region. On the basis of this evidence the following discussion will treat the quarry of South Molle Island as the 'epicentre' of distribution.

Several surveys conducted in the region have revealed the following pattern of stone artefact distribution (notably Barker 1992a, 1992b; Barker and Schon 1994; Lamb 1998). Surface scatters are commonplace on the islands, and on the adjoining mainland from Abbot Point 120km to the north of the quarry, to the southern tip of Cape Conway 50km to the south (Figure 8.1). There is no evidence that the distribution of volcanic tuff extends inland beyond the coastal fringe, consistent with the inferred source on south Molle Island. Islands on which volcanic tuff has been located include (from north to south) Hayman Island, Hook Island, Border Island, Whitsunday Island, North Molle Island, Daydream Island, South Molle Island, Long Island, Lindeman Island and South Repulse Island.

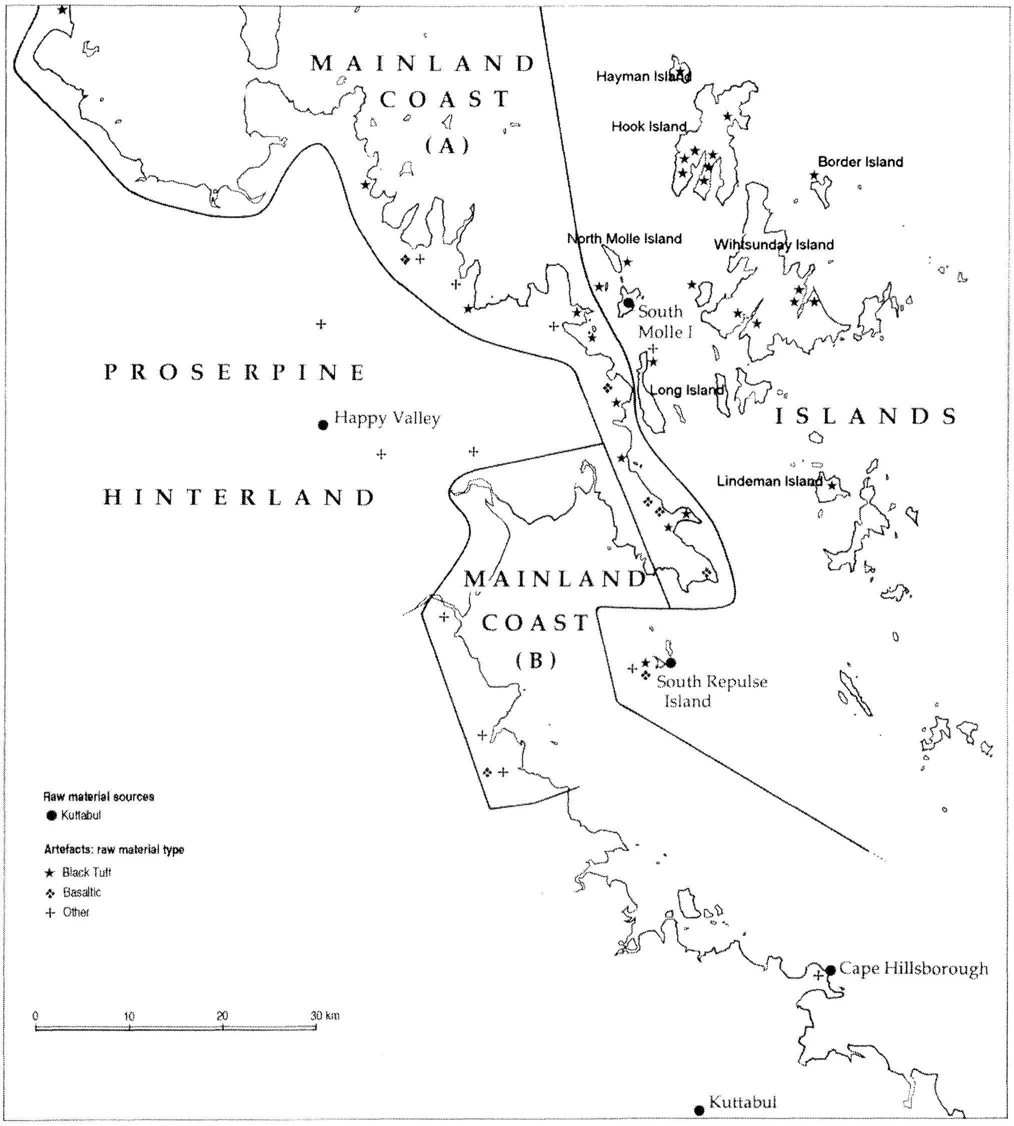


Figure 8.1 Regional Artefact distribution (from Barker and Schon 1996)

Analysis of artefacts for this study was conducted on the samples from the South Molle Island Quarry (Chapters 5-7) and on two stratified rockshelter sequences from Hook Island and Border Island.

STRATIFIED STONE ASSEMBLAGES

Several islands in the study region contain stratified cultural assemblages, a portion of which consist of stone artefacts. Hook Island, the sites of Nara Inlet 1, Nara Inlet Art Site, and Hook Island Rockshelter 1 all contain volcanic tuff assemblages. On Border Island the shelter called Border Island 1 also has volcanic tuff assemblages. For the purpose of this thesis and the questions I am asking regarding technological change throughout the Holocene (Chapter 3), I determined that the sequences from Nara Inlet 1 (Hook Island) and Border Island 1 (Border Island) would be most suitable for inclusion in the analysis (Figure 8.2). Nara Inlet 1 has the longest Holocene sequence of all sites excavated in the region, with a near-basal date of 8,990 cal. BP (see below). Border Island 1 yielded the second longest sequence with a basal date of 6,990 cal. BP. Both sites are stratigraphically intact (see descriptions under each site heading) and contain volcanic tuff throughout. The following sections provide site descriptions of each, including a technological analysis of the stone component of the stratified cultural assemblage.

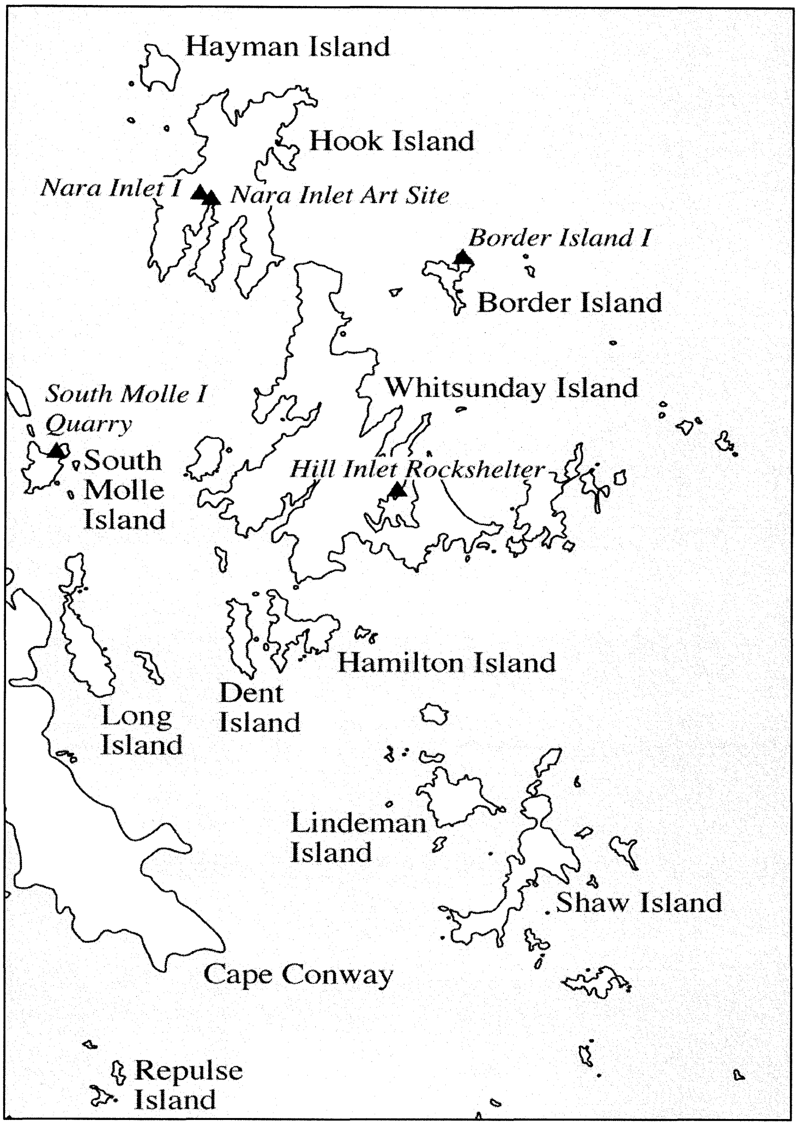


Figure 8.2 Islands of the study region (from Barker 2004).

Nara Inlet 1

Nara Inlet 1 is situated within Nara Inlet on Hook Island, the second largest of the islands within the Cumberland group (Figure 8.2). The inlet is situated in the south west of the island and is approximately 5 km long, with steep shores and little or no beach, which precludes the presence of flat habitation areas, other than rockshelters and a thin coastal fringe which appears at low tide. Dominant vegetation types include hoop pine (*Araucaria cunninghamii*), *xanthorrhoea*, *cycas* and *pandanas*, with vine forest throughout. Mangrove habitats are also present today in small quantities, located in Refuge Bay on the eastern side of the inlet, in a small bay on the western side, and at the head of the inlet. A 10m wide fringing reef surrounds the shoreline, parts of which are exposed during low tide. The rockshelter itself is located 20m above the high water mark, measures approximately 10mx7m and consists of two chambers which face east. The site was excavated in two seasons by Barker (2004). Squares G50 and H50 were excavated in 1988 and J50, J51, K50 and L50 in 1989 (Figure 8.3). Squares G50 and H50 are located in the west-south-west section of the shelter near the back wall, while the other four squares (J50, K50, L50 and J51) are located due east of G50 and H50 (see Figure 8.3).

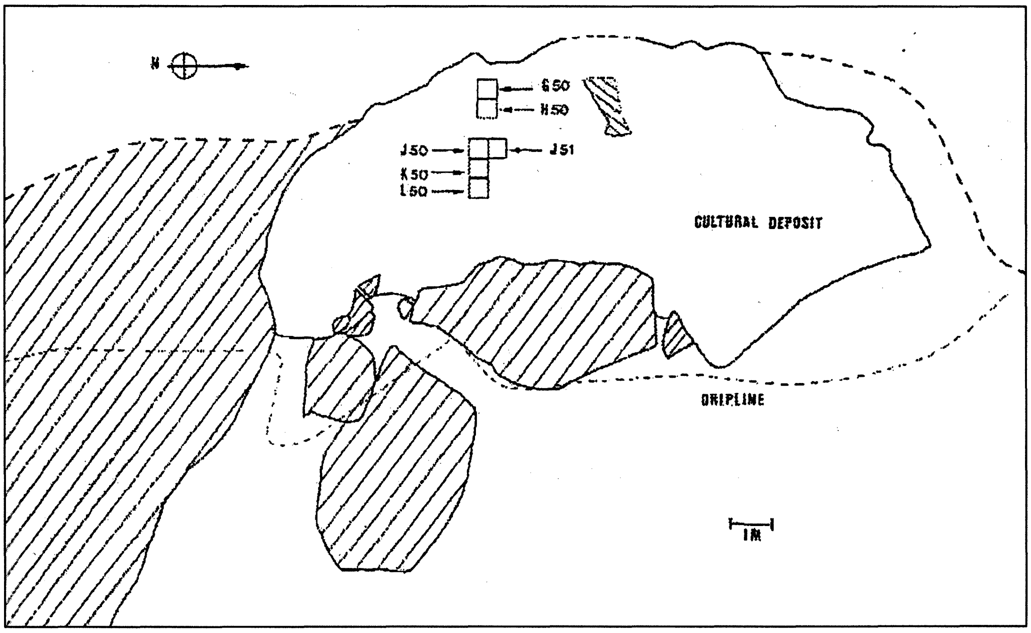


Figure 8.3 Nara Inlet 1 site map (from Barker 2004)

Stratigraphy

Barker (2004:67) identified four main stratigraphic units as follows (see Figure 8.4):

Stratigraphic Unit 1 (SU1) was approximately 10cm thick and was excavated in five spits. The unit consisted of extremely fine, loose, grey sediment, and contained diverse cultural material, including paperbark, nuts, seeds and fibre netting. It also showed evidence of post-European material; for example goat droppings were found to a depth of 8cm.

Stratigraphic Unit 2 (SU2) was a red-brown sediment, greasy in texture and more compact than SU1. It was excavated by spits 6-31. This unit was characterised by a number of lenses of white ash, abundant charcoal and a high density of cultural material in the form of shellfish, fish and plant remains.

Stratigraphic Unit 3 (SU3). This was a brown sediment with less abundant charcoal, fewer layers of ash, and a decrease in shellfish remains relative to SU2. The lowermost cultural unit, it was excavated by spits 32-45 inclusive, and began at a depth of 49cm below the ground surface at its highest point.

Stratigraphic Unit 4 (SU4) was a green gravel of the same material as the geological bedrock. It was excavated by spits 45-52 inclusive, began at 96cm below the ground surface at its highest point. This unit was without any cultural material and rested on top of bedrock.

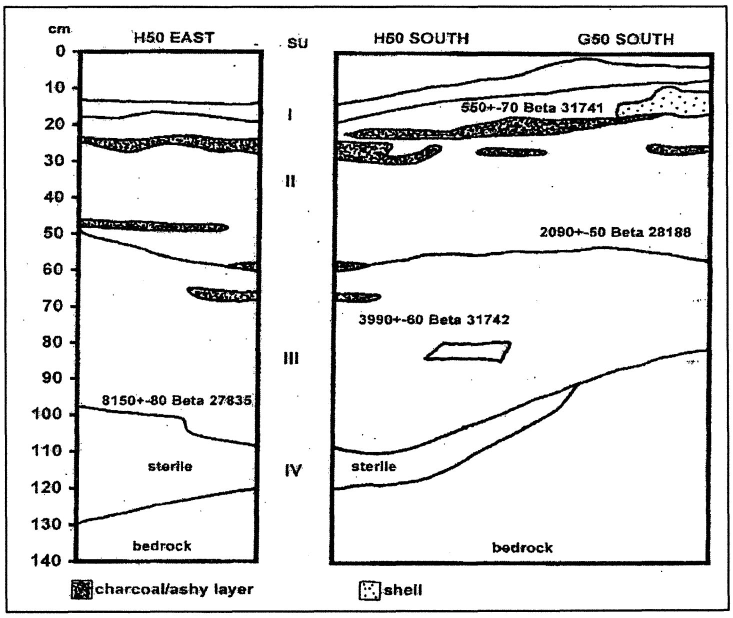


Figure 8.4 Nara Inlet 1 stratigraphic drawing with dates located (from Barker 2004)

Chronology

Five radiocarbon dates were obtained for Nara Inlet 1 (Table 8.1), all with the exception of ANU 11381 on charcoal. Beta 27835 and Beta 31741 are dates on *in situ* charcoal pieces which were plotted three dimensionally and bagged on site. The two other dates were on charcoal (Beta 28188 and Beta 31742) which was excavated from XU28 and XU35 and extracted from the sieves (Barker 2004:67). The sample of shell on which ANU 11381 was obtained was excavated from XU41 and extracted from the sieves. "Conventional radiocarbon ages were calibrated using CALIB (3.03c) computer program (Stuiver and Reimer 1993). Dates on charcoal samples were calibrated using the bi-decal atmospheric calibration curve with no laboratory error multiplier. 40 years was subtracted to correct for 14c variations between northern and southern hemispheres. Dates on shell were calibrated using the marine calibration model with a Δ R value of –5±35 (Stuiver and Braziunas 1993). The calibrated ages reported are rounded to the nearest 10 years" (Barker 2004:67).

Table 8.1 Radiocarbon dates from Nara Inlet 1.

Square	XU	Depth (cm)	Material	^{14}C Age	Lab No.	Calibrated Ages
G50	13	15	Charcoal	550 ±70	Beta-31741	650(520)340
G50	28	46-49	Charcoal	2090±50	Beta-28188	2130(1990)1880
H50	35	63-66	Charcoal	3990±60	Beta-31743	4530(4410)4160
H50	41	78-83	Shell	6700±60	ANU 11381	7320(7190)7040
G50	45	96	Charcoal	8150±80	Beta-27835	9250(8990)8670

Beta 27835 is a non-basal date for human occupation. It was obtained at 95cm in the eastern section of square H50, from a discrete concentration of charcoal in SU3, just above the interface with SU4. This is, however, 14cm above the lowest cultural material, which lays at the interface between SU3 (cultural) and SU4 (non-cultural) in the southern section of Square H50. Thus, based on an age/depth extrapolation (Barker 2004:53) the initial occupation of Nara Inlet 1 occurred at 9,890 cal. BP.

The sample ANU 11381 comes from XU41 (SU3) at a depth of 78-83cm. Beta 31743 comes from XU35 between 66-63cm, the top of which is 14cm below the interface of SU3 and SU2. Beta 28188 is from XU28 between 46 and 49cm, the bottom of which is 10cm above the interface of SU3 and SU2 in the southern section of Square G50. Beta 31741 dates a discrete concentration of charcoal at the top of SU2 at 15cm depth. All dates referred to throughout this chapter are calibrated.

The deposit contained various species of shell fish throughout, including the rock platform – dwelling gastropod *chiton* and numerous bivalve species. Among these were *Nerita undata*, *Monodonto labio*, *Acanthopleura gemmata*, *Saccrostrea cucullata*, *Trichomia hirsuta*, *Lunella cinerea*, *Thais kieneri*, *Melina ephippium*, *Pinctada fucata*, *Asaphis deflorata* and *Gelonia coaxans* (Barker 2004:69). The fish present were identified as the families *scaridae* (parrot fish), *labridae* (tusk fish), *lethrinidae* (emperors and sweetlip), *lutjanidae* (sea perch and mangrove jacks), *sparidae* (snapper, bream and tarwhine), and *atherinidae* (hardyheads). Crustaceans identified were *Scylla serrata* (mud crab) and *Portunus pelagicus* (sand crab). Other evidence of marine fauna included several teeth of the *odontoceti*, which is one of the smaller toothed whales (Barker 2004:76).

Terrestrial fauna identified in the assemblage of Nara Inlet 1 included 5 species of mammal. These were *Petrogale inornata* (the unadorned rock wallaby), *Trichosurus vulpecula* (possum), *Perameles nasuta* (bandicoot) and two species of rodent; *Melomys cervinipes* and *Rattus fuscipes coracius*. Present too were several species of terrestrial reptile; *veranidae* (goanna), *agamidae* (lizard) and *morelia* sp. (python) (Barker 2004:79).

Barker (2004:81) identified four edible plant species in the deposit of Nara Inlet 1. These were *Pleiogynuim timorense* (Burdekin plum seeds), *Bruguiera gymnorhiza* (orange mangrove flowers), *Planchonia careya* (cocky apple seeds) and *Cycas media* (cycad husks). There was also remains of the woody stem of *Xanthorrhoea* (grass tree) and sheets of paperbark from *Melaleuca* (Barker 2004:81).

Stone artefacts

When Barker (1991; 2004) excavated Nara Inlet 1, he inferred a pattern whereby stone artefact discard rates are higher in the early Holocene, with a significant decline in discard beginning at about 4,410 cal. BP. When the sequence of dates for the site was refined (Lamb and Barker 2001), it was revealed that artefact numbers began to decline earlier than previously thought, after the initial phase of occupation. However, as Figure 8.5 illustrates there is in fact, an increase in weight of artefacts discarded between the phases 7,190 cal. BP – 8,990 cal. BP and 4,410 cal. BP – 7,190 cal. BP, with a subsequent steep decline which is also reflected in declining numbers of artefacts. Deposition of stone artefacts increases both in terms of weight and numbers per 1,000 years in the in the final 500 years of occupation.

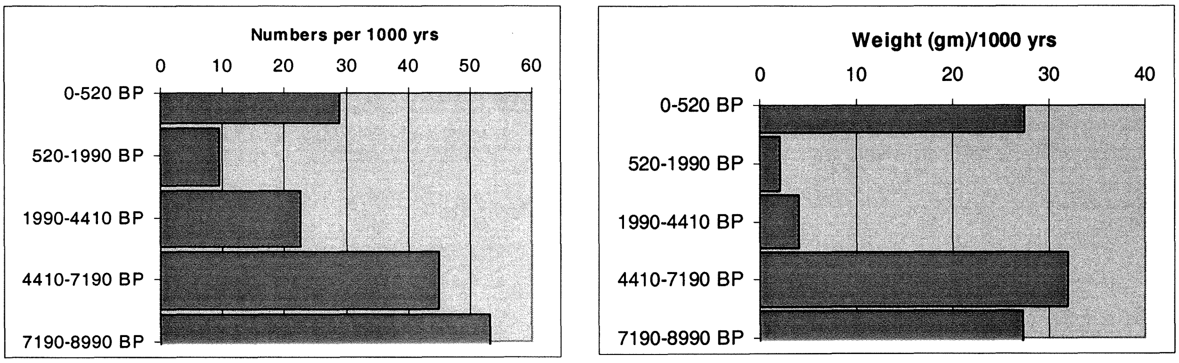


Figure 8.5 Rates of discard per one thousand years at Nara Inlet 1

The only two types of artefacts contained in Nara Inlet 1 are flakes and flaked pieces. The ratio of flakes to flaked pieces is similar throughout the temporal sequence (Table 8.2) with flakes dominating flaked pieces consistently. Flakes range from 72% to 86% of the assemblage when examined by dated phase, while flaked pieces range from 14% to 28% of the assemblage.

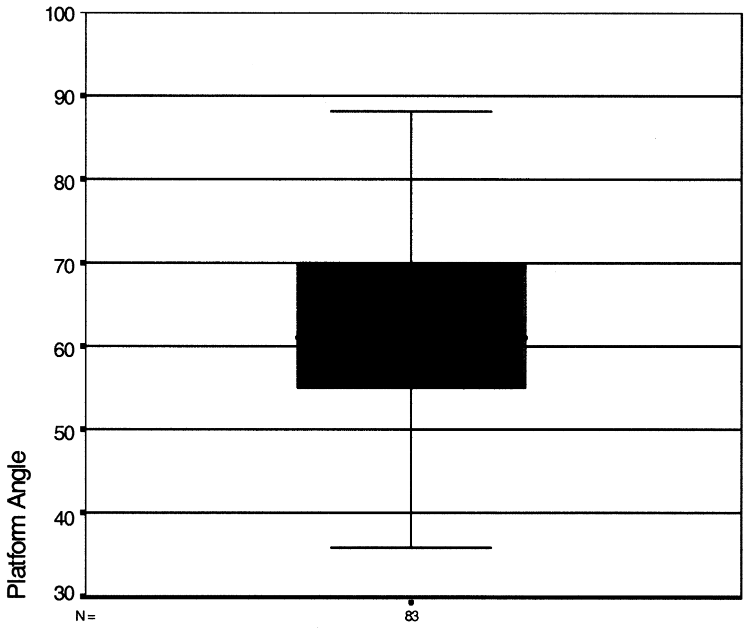


Figure 8.6 Range of platform angles in Nara Inlet 1

Table 8.2 Artefact types in Nara Inlet 1

Phase	% Flakes (N)	% Flaked Pieces (N)
0-520 cal. BP	80 (12)	20 (3)
520 – 1,990 cal. BP	86 (12)	14 (2)
1,990 – 4410 cal. BP	79 (42)	21 (11)
4,410 – 7,190 cal. BP	72 (88)	28 (35)
7,190 – 8,990 cal. BP	76 (72)	24 (23)

The stone artefacts in Nara Inlet 1 are small throughout the occupational sequence. Table 8.3 lists descriptive statistics for flakes. The mean length of artefacts remains within the 7.1 – 9.7mm range. Mean widths are between 6.8 – 11.2mm with the exception of the final phase (0-520 cal. BP) when the mean increases to 24.1mm. This increase in mean width corresponds with a higher mean weight for the phase 0 – 520 cal. BP of 0.9gm. Otherwise weight remains in the range of 0.7 – 0.2gm. Mean thickness ranges from 1.4 to 2.0 mm. Mean platform angles throughout the temporal sequence are reasonably acute, ranging from 59^0 to 64^0 (Table 8.3) (Figure 8.6). It is important to note that while the mean platform angles are thus, 100% of flakes in Nara Inlet 1 with recorded platform angles occupy the range of retouch edge angles on backed artefacts. This comprises 28% of the total stone artefact assemblage in Nara Inlet 1.

Table 8.3 Dimension and weight of complete flakes in Nara Inlet 1

Phase	Mean Length (St Dev)	Mean Width (St Dev)	Mean Thickness (St Dev)	Mean Weight (St Dev)	Mean Platform Angle (St Dev)
0-520 cal. BP	9.7 ±(7.2)	24.1 ±(11.6)	2.1 ±(2.0)	0.9 ±1.6)	59 ±18)
520 – 1,990 cal. BP	9.5 ± (-)	9.6 ±5.4)	1.4 ±0.9)	0.2 ±0.3)	64 ±19)
1,990 – 4410 cal. BP	7.1 ±3.8	6.8 ±6.1	1.4 ±0.9	0.2 ±0.6	64 ±9.6
4,410 – 7,190 cal. BP	9.3 ±6.4	11.2 ±8.4	2.0 ±1.7	0.7 ±1.9	62 ±11
7,190 – 8,990 cal. BP	9.3 ±5.7	9.0 ±7.6	1.6 ±1.3	0.5±1.2	61 ±10

The presence of one primary reduction flake in the assemblage dated from 520 cal. BP to 1,990 cal. BP is enough to imply that stone was transported from the quarry to Nara Inlet 1 in relatively early stages of reduction, at least early enough to still have cortex present. The same can be said of the primary flake in the assemblage dated from 4,410 cal. BP to 7,190 cal. BP. This phase of occupation also has the highest percentage of secondary reduction flakes (flakes with partial cortex on the dorsal surface) making up 18.4% of the assemblage (Table 8.4), as well as the highest weight of deposited stone artefacts (refer to Figure 8.5). These two factors could be related, considering that flakes detached during initial stages of reduction also tend to be the heaviest (Table 8.5). Overall, however, the stone artefact assemblage in Nara Inlet 1 is clearly dominated by tertiary flakes in all 4 phases.

Table 8.4 Relative proportions of reduction stage in Nara Inlet 1

Phase	**Primary reduction % (N)**	**Secondary reduction % (N)**	**Tertiary reduction % (N)**
0-520 cal. BP	-	-	100 (15)
520 – 1,990 cal. BP	7 (1)	7 (1)	86 (12)
1,990 – 4410 cal. BP		4 (2)	96 (51)
4,410 – 7,190 cal. BP	1 (1)	19 (23)	80 (96)
7,190 – 8,990 cal. BP		9 (8)	91 (86)

Table 8.5 Weight according to stage of reduction

	Mean weight	**St. Dev.**	**N**
Primary reduction	0.58	.13	2
Secondary reduction	0.90	1.5	34
Tertiary reduction	0.44	1.4	258

Fisher Exact analysis determines a probability value of <.001 for the comparison of mean weights between tertiary and secondary reduction artefacts.

Termination types are predominantly feather, followed in relative frequency by hinge and step terminations in all dated phases (Table 8.6). The most notable variation in the pattern in is the phase dated from 520-1,990 cal. BP when flakes terminating in feather and hinge terminations are of roughly equal proportions. Sample size is a likely issue here, and the variation will not be explored further.

Table 8.6 Relative proportions of termination type in Nara Inlet 1

Phase	**Feather** **% (N)**	**Hinge** **% (N)**	**Step** **% (N)**	**Outrepasse** **% (N)**
0-520 cal. BP	90 (9)	10 (1)	-	-
520 – 1,990 cal. BP	50 (5)	40 (4)	10 (1)	-
1,990 – 4410 cal. BP	73 (27)	24 (9)	3 (1)	-
4,410 – 7,190 cal. BP	66 (45)	20 (14)	12 (8)	2 (1)
7,190 – 8,990 cal. BP	63 (40)	27 (17)	10 (6)	-

Border Island 1

Border Island 1 is located in Cateran Bay on Border Island, some 4km to the east of Whitsunday Island (refer to Figure 8.2). The island topography consists of a steeply rising, rocky mass, with little soil and high precipitous cliffs. Vegetation on the island is dominated by low vine forest, scrub including acacias, *Tristania conferta*, *Casuarina littoralis*, and *Xanthorrhoea*, with some open forest consisting of *Eucalyptus alba* and *E. tereticornis* in the north eastern part of Cataran Bay. Cataran Bay has a precipitous coastline of approximately 2km in length, with several small beaches and the shoreline is surrounded by a fringing reef.

The Border Island 1 rockshelter is located 30m above the high water mark. It is 18m across the entrance, divided into two smaller entrances by a rocky pillar of 5m and 7m across (Figure 8.7). There is a distance of 17m from the drip line to the furthest extent of the back wall and the total floor area is approximately 25m^2, however cultural deposit only covers 12m^2. An alphanumeric grid was constructed over the site and two 50x50cm pits were excavated (C6 & D6). Of these, only D6 has been analysed. The pits were located at the southern end of the shelter, in the area of highest cultural deposit. Unfortunately no site plan exists for Border Island 1, as it was lost over the side of the boat in a accident of human error; there was no opportunity to repeat the drawing (Barker 2004:106).

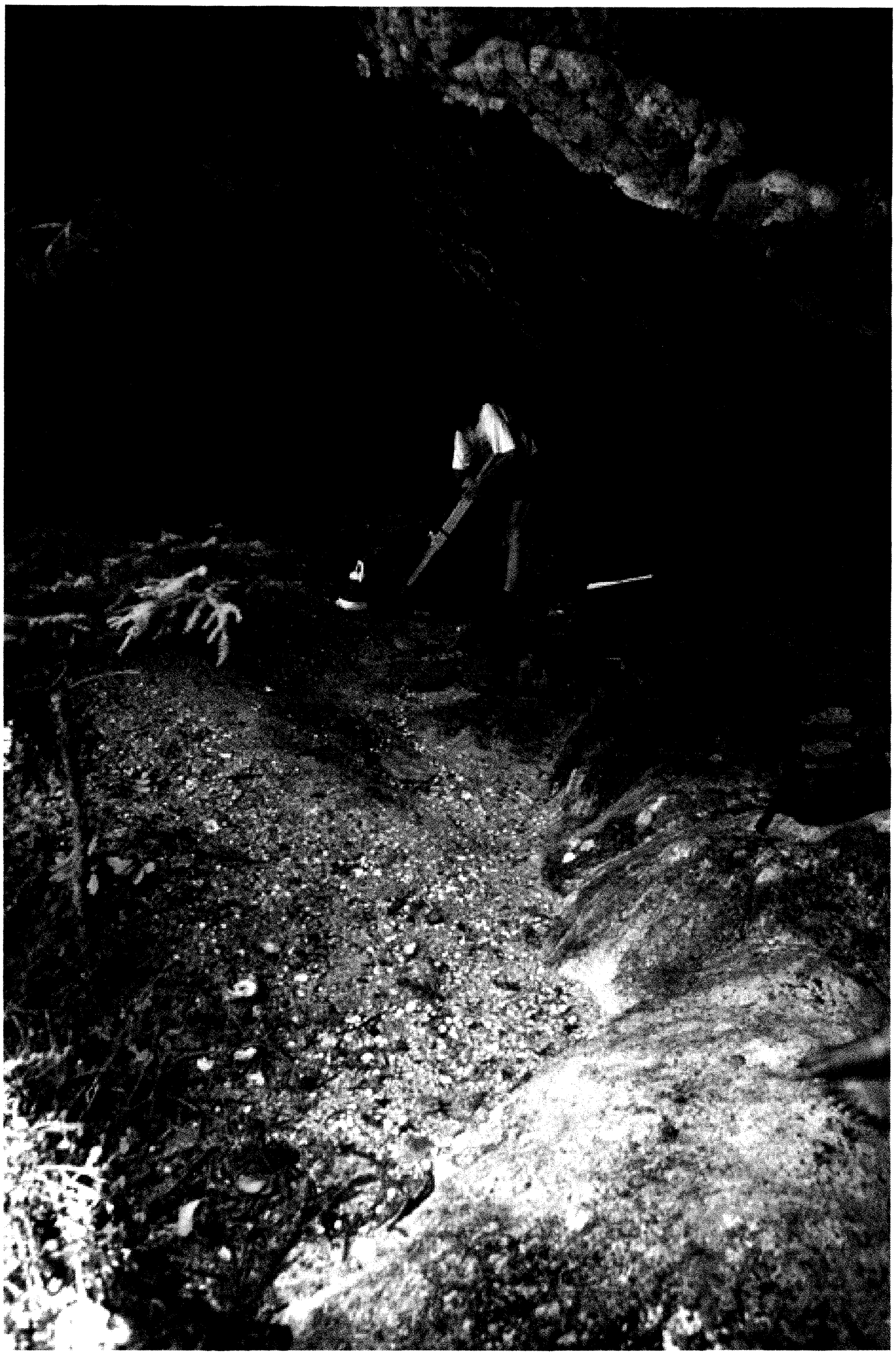


Figure 8.7 Border Island 1 Rockshelter

Stratigraphy

The two excavated pits contained six SUs as follows (see Figure 8.8):

Stratigraphic Unit 1 (SU1), is the top unit. It is comprised of a loose, gray powdery matrix (10YR32) with large amounts of cultural material. With a maximum thickness of 6.2cm, this unit extends to a depth of 9.5cm below the highest point in Square D6, incorporating Spit 1 and 2.

Stratigraphic Unit 2 (SU2), is a uniform compact, brown matrix (10YR82) with ashy mottling and charcoal throughout. This unit which has a maximum thickness of 9cm, incorporates Spit 3. This layer extends to 12cm below the ground surface.

Stratigraphic Unit 3 (SU3), includes two sub-units, SU3A and SU3B. SU3A is a loose, brown and compact gray ashy matrix (10YR33), with evidence of intensive burning in the form of calcined bone. SU3B is a discrete, highly compacted shell lens in Square D6, 21cm wide and 2.5cm thick, which rests immediately on top of SU4. SU3, which incorporates Spit 4, has a maximum thickness of 5cm in Square D6 extending to a maximum depth of 16cm below the surface.

Stratigraphic Unit 4 (SU4), is a uniform brown greasy matrix (10YR82) interspersed with charcoal pieces. It consists of two sub-units, 4A and 4B. SU4A extends through the entire excavated area, while SU4B is located in Square D6 only. "The difference between the two sub-units is a slight change in colour, almost imperceptible in section but apparent during excavation" (Barker 2004:107). This unit, within Spit 5, has a maximum thickness of 7cm in Square D6 and a total maximum depth of 20cm below the ground surface.

Stratigraphic Unit 5 (SU5), is gray/brown (10YR41) and fairly compact with intermittent greasy black sediment. It consists of five sub-units, termed 5A-5E. 5A extends across the entire excavation and makes up the bulk of the unit. SU5B and

5C occur in Squares C6 and D6 respectively and are differentiated from SU5A by their darker colour. However, they grade into SU5A with no clear boundary between them. SU5D and SU5E are discrete shell lenses in Square C6 and D6 respectively. SU5 is the thickest unit in the sequence, incorporating Spits 6 to 10. It measures 16cm thick and extends to a maximum of 36cm below the ground surface in the northern part of D6, and 30cm below ground surface in the southern section.

Stratigraphic Unit 6 (SU6), the lowermost unit, is completely uniform in texture and colour (10YR42). It consists of a loose, light gray matrix lacking any charcoal or ash. It has a maximum thickness of 12.5cm, incorporating Spits 11 to 14 and extends down to a maximum depth of 40.9cm below the ground surface, resting on bedrock.

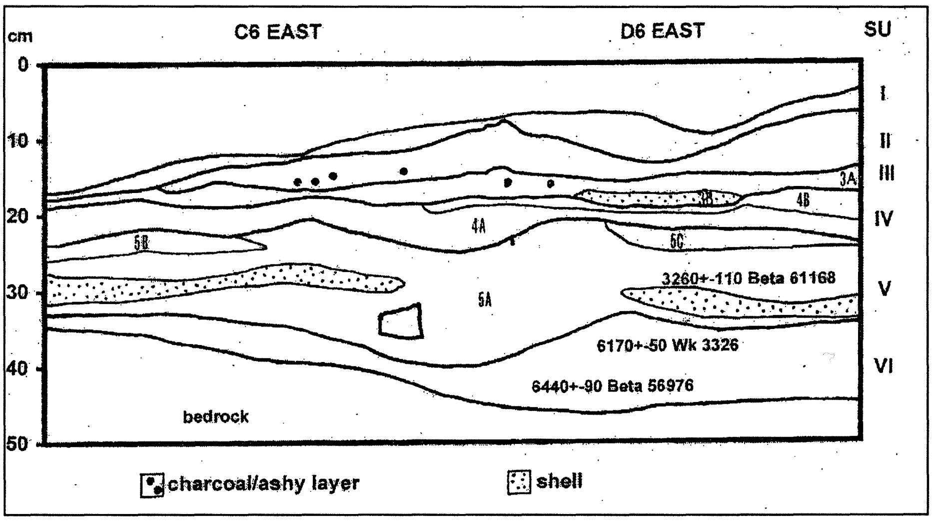


Figure 8.8 Border Island stratigraphic drawing with dates located (from Barker 2004)

Chronology

Three radiocarbon dates were obtained from Border Island 1 (Table 8.7). All dates were obtained on shell which was isolated during sorting and analysis. The selected shells were large. Thus the risk of dating fragments which could have fallen into the excavation undetected was minimized. The excavation extended for 14 Spits, reaching a maximum depth of 40.9cm. A near-basal date of 6,900 cal BP (Beta 56976) was obtained from XU13.

Wk 3326 was obtained from the top of Spit 11, 3cm below the stratigraphic change from SU6 to SU5. This dated a major drop in discard rates of cultural materials after Spit 11 (Barker 2004:108).

Discard rates increased sharply after XU8 (Barker 2004:108). This increase was dated on a sample collected 5 cm above the boundary between SU5 and 6 (3,080 cal BP Beta 61168).

8 cm of deposit separates Spit 14 at 6,900 cal. BP and Spit 11 at 6,620 cal. BP. Thus a period of some 280 years has a mean sedimentation rate of 2.8 cm/100 years. Therefore SU6 between Spit 14 and 11, represents a brief period of early occupation, known as Phase 1. It is possible that the relatively high cultural discard rates during this phase reflect a single event.

There are 8 cm of sediment between Spit 11 near the top of SU6 (6,620 cal. BP) and Spit 8 near the bottom of SU5 (3,080 cal. BP). This represents 3,540 years during which time there is a decline in the rate of sediment deposition to 0.23 cm/100 years from the previous 2.8 cm/100 years. Spits 10 and 9, which incorporate this period, are thus "an intermediate period representing either a hiatus in occupation or merely ephemeral visitation" (Barker 2004:108).

The increase in cultural deposition from Spit 8 to the top of the site constitutes Phase 2, beginning at 3,080 cal. BP.

Stuiver and Reimer 1993.
Table 8.7 Radiocarbon dates from Border Island

Lab number	SU	XU	Depth	C ^{14} BP	cal BP
Beta 61168	5	8	21-23	3260±110	3360(3080)2770
WK3326	6	11	32-34	6170±50	6740(6620)6450
Beta 56976	6	13	39-41	6440±90	7150(6900)6700

Shellfish are abundant in the cultural deposit of Border Island 1. Species include the rock platform – dwelling gastropod *chiton* and numerous bivalve species. Among these were *Nerita undata*, *Nerita lineata*, *Monodontio labio*, *Acanthopleura gemmata*, *Saccrostrea cucullata*, *Trichomia hirsuta*, *Lunella cinerea*, *Thais kieneri*, *Melina ephippium* and *Pinctada fucata* (Barker 2004:110). Six species of fish were also present: *lethrinidae* (emperors and sweetlip), *labridae* (wrasses and tusk fish), *sillaginidae* (whiting), *atherinidae* (hardyheads) and one unidentified species (Barker 2004:112). Crustaceans were present, however their remains were fragmented to such an extent that they remain unidentifiable. Marine turtle was present throughout the deposit of Border Island 1, in every Spit except Spit 4, in SU3. Evidence for terrestrial fauna included a vertebra of a small unidentified snake and a single dentary element of a lizard (*agamidae*). No plant remains were found with the exception of charcoal (Barker 2004:113).

Stone Artefacts

Deposition of stone artefacts in Border Island 1 decreases significantly between phase one (6,900 – 6,620 cal. BP) and phase two (6,620 – 3,080 cal. BP) (Figure

8.9). This is in keeping with the overall decline of cultural deposition during this phase (Barker 2004:108). However, stone artefact deposition continues to decline in the third phase of occupation (3,080 – present) (Figure 8.9), unlike the remaining component of the cultural assemblage, which undergoes a significant increase (Barker 2004:108). Stone artefacts are the only aspect of the cultural assemblage that decreases during this time (Barker 2004:108-109), a fact which Barker (2004) attributes to the changing economy, increasing marine specialisation and the corresponding change in the toolkit.

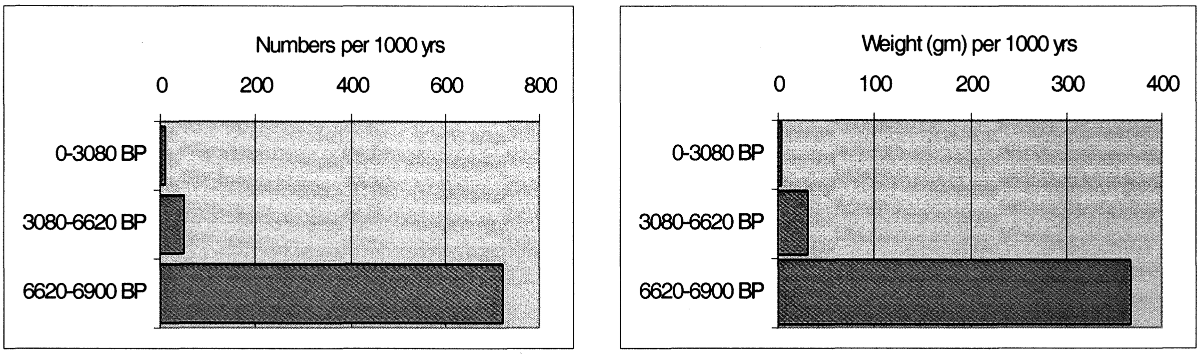


Figure 8.9 Rates of discard per one thousand years at Nara Inlet 1

The Border Island 1 stone artefact assemblage consists of flakes, flaked pieces, a tip of a backed artefact and a single core. There is also an incidental, non-cultural component consisting of potlids. Table 8.8 clearly demonstrates that in all phases of occupation, flakes dominate the assemblage, albeit in declining proportions in the final phase of reduction. The relatively high proportions of flaked pieces is likely due to the nature of the raw material. Being a highly siliceous volcanic tuff, the material is very brittle. This causes a high rate of shatter (personal observation) which produces artefacts without the diagnostic traits of flakes.

Table 8.8 Artefact types in Border Island 1

Phase	% Flakes (N)	% Flaked Pieces (N)	% Cores (N)	% Backed Artefacts (N)	% Potlids (N)
0 – 3,080 cal. BP	55 (16)	45 (13)	-	-	-
3,080 – 6,620 cal. BP	70 (118)	27 (45)	0.5 (1)	-	2.5 (5)
6,620 – 6,900 cal. BP	69 (135)	29 (57)	-	1 (1)	2 (2)

Artefacts in the two earlier phases of occupation of Border Island are of consistently small dimensions, with length, width and thickness clustering around 11mm, 9mm and 2mm respectively (Table 8.9). Of note, is that flakes in the final phase of occupation tend to be wider and shorter than those in other occupational phases (Figure 8.10). However, due to the small sample size, little significance can be attached to this trend.

Mean platform angles come in under 70^0 for all phases (Table 8.9). As with Nara Inlet 1, 100% of flakes with recorded platform angles occupy the range of retouched edge angles on backed artefacts. This comprises 35% of the entire stone artefact assemblage for Border Island 1.

Table 8.9 Descriptive statistics for length, width, thickness, weight and platform angle

Phase	Mean Length mm St. Dev. (N)	Mean Width mm St. Dev. (N)	Mean Thickness mm St. Dev. (N)	Mean Weight gm St. Dev. (N)	Mean Platform Angle St. Dev. (N)
0 – 3,080 cal. BP	7.2 ±4.0 (6)	11.0 ±5.5 (6)	1.4 ±0.8 (9)	0.4 ±0.5 (30)	57 ±13.1 (7)
3,080 – 6,620 cal. BP	11.0 ±6.1 (74)	9.4 ±3.9 (60)	2.1 ±1.6 (79)	0.6 ±1.6 (173)	66.6 ±12.2 (63)
6,620 – 6,900 cal. BP	11.2 ±6.9 (71)	9.4 ±3.7 (54)	2.1 ±1.9 (72)	0.5 ±1.1 (198)	69 ±13.4 (73)

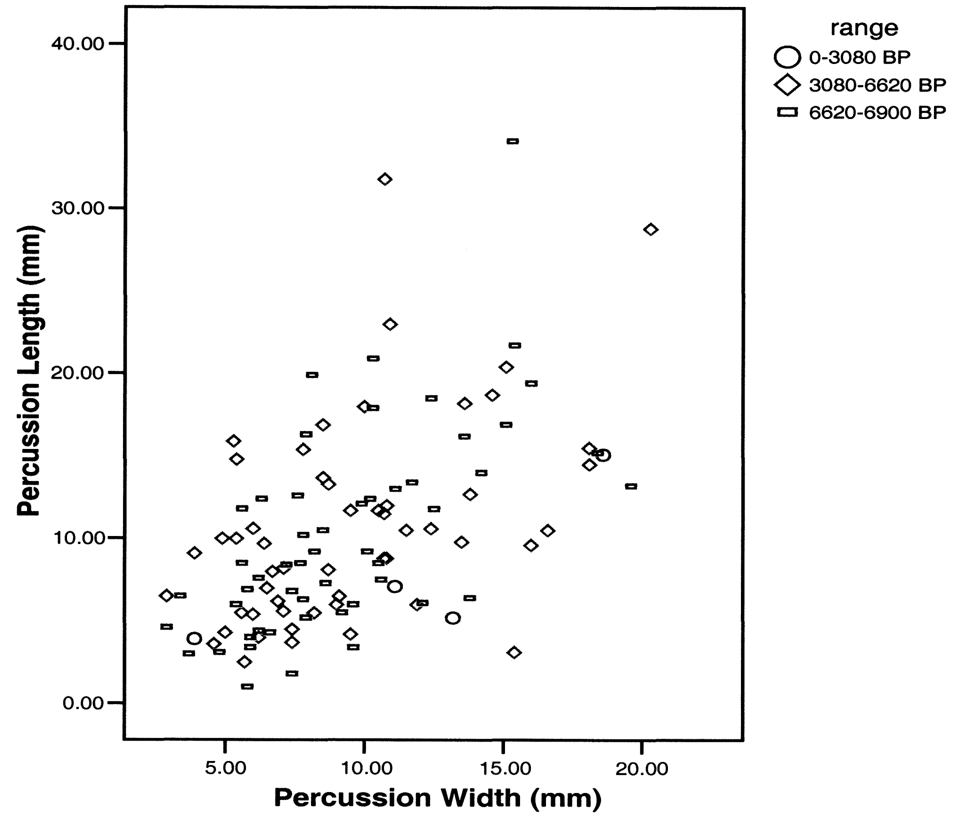


Figure 8.10 Percussion length and width for Border Island 1

The stone assemblage in Border Island 1 overwhelmingly consists of small flakes that are at the tertiary stage of reduction (Table 8.11). This is consistent in all three phases of occupation. As with Nara Inlet 1, there is a single primary reduction flake and small proportions of secondary flakes (Table 8.10). This indicates that people were transporting stone to the island that had been minimally reduced as evidence by the presence of cortex. Feather terminations dominate in the two early phases, while hinge terminations prevail in the final phase. In fact, sample size is an issue in regards to this pattern. Flakes terminating in feather and hinge terminations are actually of roughly equal proportions (N = 4 and 6 respectively). However, owing to the small sample size of artefacts in this final phase, I am prevented from drawing any conclusions regarding this trend.

Table 8.10 Relative proportions of termination type in Border Island 1

Phase	Feather % (N)	Hinge % (N)	Step % (N)	Outrepasse % (N)
0 – 3,080 cal. BP	40 (4)	60 (6)	-	-
3,080 – 6,620 cal. BP	63 (57)	23 (21)	14 (12)	-
6,620 – 6,900 cal. BP	55 (60)	15 (17)	27 (29)	3 (3)

Table 8.11 Relative proportions of reduction stage in Border Island 1

Phase	Primary reduction% (N)	Secondary reduction % (N)	Tertiary reduction % (N)
0 – 3,080 cal. BP		3.0 (1)	97.0 (29)
3,080 – 6,620 cal. BP	0.5 (1)	3.5 (6)	96.0 (160)
6,620 – 6,900 cal. BP		5.0 (10)	95.0 (184)

DISCUSSION

There are several general observations to be made regarding the trends observed through time in each site discussed above. Artefact dimensions in both sites remain consistent to within several millimetres through time, with the exception of an increased mean width in the upper phase of Nara Inlet 1. In this instance however, the population from which this mean is taken consists of three specimens, and thus can not be treated as a significant variation. Platform angles remain consistent through time, with the exception of a decline in the upper phase of both sites. Stage of reduction is consistent through time, revealing no significant patterns of change in the technological elements represented in the assemblage. Thus the following reduction models outlined below can be applied to each site as a whole, across all phases of occupation except where noted. In the following discussion I will evaluate four alternative scenarios capable of explaining the origin of Nara Inlet 1 and Border Island 1 stone artefact assemblages.

Model 1: Working of unretouched flakes.

This model is the transport of unretouched flakes from the quarry to these island sites. Following that transport, the unretouched flakes were then retouched into backed artefacts in the rockshelter sites. Consequently the assemblage could contain flakes removed during the backing process and resemble the assemblage identified as a by-product of backed artefact manufacture on the South Molle Island Quarry (see chapter 7).

For this model of manufacturing behaviour in Nara Inlet 1 and Border Island 1 to be applicable, we would expect to see an assemblage of flakes in each, that are of similar length to the retouch scars on the backed artefacts from the South Molle island Quarry (described in chapter 7). Furthermore, not only would we predict length would be the same as the backed scars, but platform angles should be comparable with the retouch angle on the backed edge of backed artefacts. Descriptive statistics for these lengths and angles are presented in Table 8.12.

Table 8.12 Descriptive stats for length and angle on backed artefacts and stratified assemblages

	Mean length & St. Dev. (N)	**Mean ventral and dorsal angle & St. Dev. (N)**
Backed artefacts	10.3 ±17.3 (292)	82 ±11.1 (292) 87 ±11.2 (227)
Nara Inlet 1	8.9 ±5.7 (120)	59.7 ±15.2 (86)
Border Island 1	10.9 ±6.4 (151)	67.5 ±13.1 (143)

T=-0.527, d.f.=409, p=0.598 (comparison of mean length between flakes in Border Island and flake scars on backed artefacts)
T=1.23, d.f.=397, p=0.219 (comparison of mean length between flakes in Nara Inlet 1 and flake scars on backed artefacts)
T=12.648, d.f.=112, p=<.001 (comparison of mean platform angle on flakes in Border Island 1 the mean retouched edge angle on backed artefacts)

While there is no significant difference between length of backed scars and length of flakes from the rockshelter sites, mean platform angles on flakes in Nara Inlet 1 and

Border Island 1 are significantly less than the retouch edge on backed artefacts. However, as noted in Chapter 7 when looking at the N1 and S1 quarry assemblages, this is consistent with backed artefact manufacture, when all stages of production, from the flake blank to final retouch are carried out. The backing process is typically initiated on a lateral margin, the mean edge angle of which is around 45^0. Thus, the first retouch flakes would be of particularly low platform angles and these would increase as retouch proceeded toward the thickest part of the flake, to finally reflect angles similar to the backed edge. However, because the initial retouch flakes are represented in the mean platform angles, and not simply the final retouch flakes, this mean is dragged lower than the mean for retouched edge angles.

Thus, the assemblages in Nara Inlet 1 and Border Island 1 could indeed be representative of the backing process. This is with the proviso, as indicated by the low mean platform angels, that reduction in the sites was inclusive of all retouch from the flake-blank stage, to the final retouch that produced the steep backed edge.

Model 2: **Backed artefact rejuvenation**. This model is one in which backed artefacts were being transported away from the South Molle Island Quarry, but were rejuvenated by repairing the backed edge when specimens snapped so that the backed form was maintained.

The most common form of backed artefact breakage pattern is the transverse snap, as evidenced by the sample of implements analysed from the South Molle Island Quarry where 56% of backed artefacts analysed were snapped in this manner. Thus, in these instances reworking would involve re-backing the proximal or distal end (or both) on the fresh surface created by the snap, depending on which piece was discarded. Transverse snapping typically occurs perpendicular to the original fracture plane, as this is the shortest distance between the two surfaces. Thus, the re-backing process would result in an assemblage of mostly small, tertiary flakes with platform angles consistently close to 90^0.

Flakes from Nara Inlet 1 and Border Island 1 are of a size to fit this model, however the platform angles of those flakes are significantly lower than would be produced by retouching a backed edge. Rather, these angles represent flaking from edges that have lower angles than the backed edges. Therefore, this model can not be applied with confidence to the stone assemblages from Nara Inlet 1 and Border Island 1.

Model 3: **Recycling artefacts (backed or non-backed)**. This model is that flakes, backed or non-backed, were being transported away from the South Molle Island Quarry and were being retouched in different ways in order to produce flakes. The result was the conversion of artefacts (backed or non-backed) into non-backed artefacts as flaked were removed from non-backed edges.

If people were reworking backed artefacts, they would probably do so most frequently from the chord or lateral margin, as this edge would have the most acute angle on the artefact (the retouched edges being on average 87.5^0). If the reworking was occurring on other non-backed flakes, then it is likely that the edges chosen for reworking would be those with the lowest edge angle, that is the lateral margins. As the chord of a backed artefact is usually the lateral margin, there is no need for the purpose of this test to differentiate between the two likely specimen types being reworked.

If retouch from the cord or lateral margin of a backed artefact or flake was occurring in Nara Inlet 1 and Border Island 1, the assemblages would be dominated by tertiary flakes, with mean platform angles that are less than those of the backed edge and more than the chord or edge angle. The reasoning for this is that once the initial flakes were struck off the edge, the subsequent platform angles would immediately be higher. This would reflect in a mean that was *higher* than the chord or edge angle. Table 8.13 demonstrates that this is indeed the composition of the Nara Inlet 1 and Border Island 1 stone artefact assemblages, with the mean platform angles clustering between the mean cord angle and the mean angle of the retouched edge on the backed artefacts.

Table 8.13 Mean angles on backed artefacts and stratified assemblages

Backed artefact chord angle	**Nara Inlet 1 platform angles**	**Border Island 1 Platform angles**	**Backed artefact Retouch angle ventral and dorsal**
46.0 ±10.0 (320)	59.8 ±15.2 (86)	67.5 ±13.0 (143)	82 ±11.1 (292) 87 ±11.2 (227)

T=-7.969, d.f.=105, p=<.001 (comparison between backed cord angle and Nara Inlet 1 Platform angles
T=-11.45, d.f.=246, p=<.001 (comparison between Border Island mean platform angles and mean retouch angle on backed artefacts)

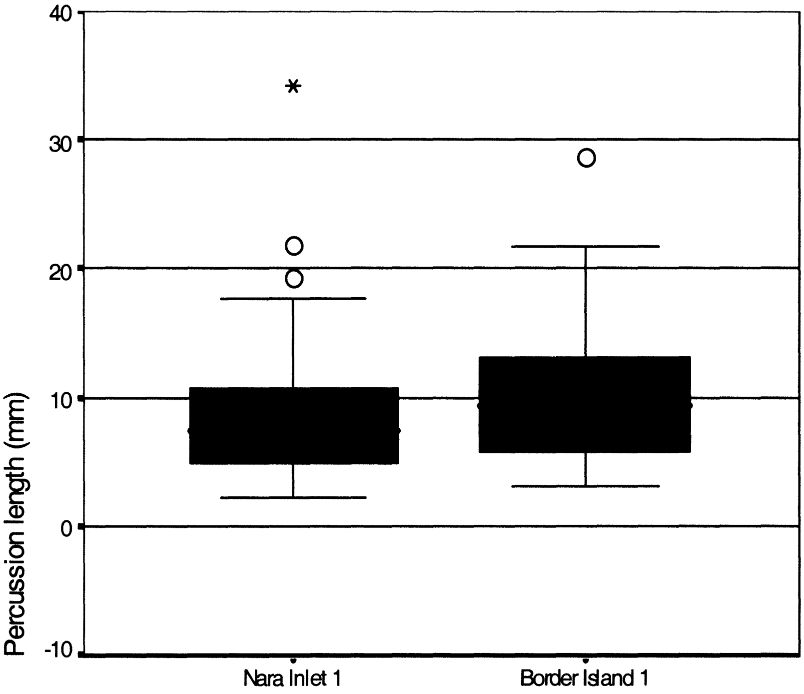


Figure 8.11 Box plots of flake percussion length for Nara Inlet 1 and Border Island 1

The factor that throws this model into some question is that of flake size in Nara Inlet 1 and Border Island 1. If flakes (backed or otherwise) were being reworked in the sites, we would expect to see a range of sizes represented. However, in Nara Inlet 1 and Border Island 1 respectively, 96% and 98% of flakes are under 25mm in length (Figure 8.11). One factor that could account for this uniform size of flakes is if the larger flakes were transported and used off-site. This being the case, the attribute of flake length is a less useful test of this model, and I am inclined to rely largely on the attribute of platform angle. Given the above discussion regarding platform angles and their relationship to chord and edge angles, I feel that there is some merit to this model as an explanation for the nature of the stone artefact assemblages in Nara Inlet 1 and Border Island 1, although Model 1 appears to fit the data most closely.

CONCLUSION

Three models for stone artefact production and discard in Nara Inlet 1 and Border Island 1 were presented in this chapter. These models covered three broad conceptual areas: that of production, rejuvenation and recycling occurring *in situ*. Examining attributes of flake/retouch scar length and edge/platform angle, I was able to conclude that two of the three models fit the available data. These were models one and three; production of backed artefacts and recycling of artefacts (backed or non-backed) in Nara Inlet 1 and Border Island 1. The following chapter integrates aspects of data presented here, particularly that of artefact discard through time, as a means to modelling quarry use throughout the Holocene.

CHAPTER 9 USE OF THE SOUTH MOLLE ISLAND QUARRY THROUGH TIME

Several models for the use of the South Molle Quarry through time are examined in this chapter. These models are built on the evidence already presented from the quarry itself, and the two stratified rockshelter sites Nara Inlet 1 and Border Island 1. These data are interpreted within a framework of palaeoenvironmental data for the region. Firstly I will summarise several aspects of these data, including the palaeoenvironmental material and observations from the South Molle Island Quarry and the stratified sequences. Then I will systematically describe each model in chronological order and evaluate its strengths and weaknesses in relation to the available data. At the end of the chapter I will discuss and compare the models and conclude which scenario(s) best explain the patterns observed.

PALAEOENVIRONMENT

The history of quarry exploitation can be understood within the context of the changing environment within the region. At the time of initial Nara Inlet 1's initial occupation at 10,000 years ago, sea levels were approximately 20m below today's levels. North, Mid and South Molle Islands were part of a single landmass, already separated from the mainland. Hook 'Island' was still part of the mainland, albeit situated on a peninsula which was bordered by what is now Whitsunday Passage to the west, and the open water to the east. Between 9,000 and 7,000 years ago, the peninsula would have been cut off from the mainland due to rising sea levels and by 7,000 years stabilisation of the sea levels had occurred (Barker 2004). This synthesis of sea level rise is supported by palynological studies in the study region (Genever et al 2003) which suggest that by 7,000 years ago, a tropical environment was established, and thus current climatic characteristics were in place. Thus we can say that at the time of Border Island 1's initial occupation at 7,000 years ago, the sea levels had stabilised and the island geography and climate resembled that of the present.

The result of sea level rise was that at 10,000 years ago the South Molle Island Quarry was located on an island, some 2km from the mainland. Border Island 1 was separated from the mainland and as yet, unoccupied as far as we know. Nara Inlet 1 was part of a peninsula, attached to the mainland some 55km to the south. Hence at that time the distance required to travel over land from Nara Inlet 1 to the South Molle Island Quarry at this time was at least 100km. The shortest single journey by sea would have been approximately 12km, and the shortest combination land/sea journey would have been 12km and 5km respectively.

DISCARD RATES THROUGH TIME

Initial occupation of Nara Inlet 1 was marked by higher discard rates of stone artefacts than any other period of occupation, at the rate of 53 artefacts/1,000 years during the period of 8,990 cal. BP to 7,190 cal. BP. Border Island 1 also demonstrated its highest discard rates during the first phase of occupation, at 721 artefacts/1,000 years. Rates of artefact discard declined significantly in both sites (see chapter 8) during the Holocene. This trend continued until the present in Border Island, despite increased discard rates of other cultural material. However, rates of discard in Nara Inlet 1 rose again in the final phase of occupation, from 9.5 artefacts/1,000 years (1,990 – 520 cal. BP) to 29 artefacts/1000 years (520 cal. BP - present).

Technology in the Rockshelters

The stone artefact assemblages from Nara Inlet 1 and Border Island 1 appear fairly homogenous through time. They are both dominated by small tertiary artefacts, with flakes prevalent in all phases of occupation. These factors in combination with data regarding platform angle and flake dimensions suggest that the assemblages in Nara Inlet 1 and Border Island 1 are either largely the product of backed artefact manufacture, or reworking implements/flakes. By implication, this activity also reflects the nature of activity occurring on the quarry, which takes the form of reduction of cores to produce flakes which are transported away from the quarry. In the following analysis, I equate increased or decreased rates of discard per 1,000 years with increased or decreased quarry use. Because I have eliminated any significant technological change which could account for differing rates of discard (chapter 8), I am confident that I can make this association.

TECHNOLOGY ON THE QUARRY

There is a range of technological activities occurring on the South Molle Island Quarry. These include raw material extraction, core reduction and flake retouching, plus associated activities such as the use of hammerstones in the manufacturing process. Previous chapters (chapters 5-7) have documented raw material properties and raw material procurement, core reduction systems and artefact production. There are several summary comments regarding technological systems on the quarry that it would be pertinent to make.

Firstly, it appears as though raw material availability on the South Molle Island Quarry was in decline throughout the Holocene. This conclusion was drawn as a result of a comparison between extant, unworked raw material and previously worked cores on the quarry. Secondly, backed artefact implement production occurred on the quarry, and this form of retouch is the only identifiable, systematic form of retouch practiced.

WEATHERING PATTERNS AND RELATIVE CHRONOLOGY

I suggest that weathering patterns on the quarry imply a relative chronology for use. There are three identified weathering states: not weathered (recent past), moderately weathered (mid-past) and heavily weathered (distant past). It is important to note here that I am not assuming that the rockshelter sites are as old as the quarry, because they came into use with the rising sea levels and it is possible that the quarry may already have been in use at that point. It is entirely feasible that the quarry was also being used prior to the arrival of the sea, when the now drowned landscapes were once expansive, open plains and river flats.

We can use the degree of weathering on stone artefacts to establish likely chronological links between assemblages at the South Molle Island Quarry and at those in the rockshelters. The rockshelter assemblages have few artefacts with weathering at any temporal phase (14% in Border Island 1 and 11% in Nara Inlet 1), possibly due to the extreme alkaline nature of the sediment (Barker 2004). The quarry is a completely different microclimate, being exposed to the elements. Because weathering on the quarry must, by virtue of the increased exposure, happen at a faster rate than in the rockshelters, the non weathered material on the quarry is likely to be of a more recent origin than the non weathered material in the rockshelter sites. Therefore, it could be argued that the non weathered material in the sites must at least equal the moderately weathered material on the quarry in terms of age. I can refine the temporal association further by looking at abundance. The most abundant period of artefact deposition in the rockshelter sites is in the early Holocene. The most abundant weathering pattern on the quarry is that of moderately weathered (66% of artefacts in the fracture-type squares [N=1003] and 73% of flake scars analysed on cores [N=5271] exhibited a colour change). By applying an association based on common measures of abundance, I suggest the portion of the quarry that is moderately weathered may be of the same antiquity as the period of high artefact discard in the rockshelter sites.

MODELS OF QUARRY USE

The models discussed in this section outline the case for differential use of the quarry throughout the Holocene. Because there are no datable assemblages on the quarry itself, periods of quarry use are inferred from the abundance and nature of stone in the two stratified rockshelter sequences, as described above. Differential quarry use is associated with varying rates of stone artefact discard in these sites throughout the Holocene. The nature of this association is explored below under several chronological headings.

Use of the SMI Quarry From 9,000 – 7,000 Years Ago

Quarry use from 9,000 – 7,000 years ago is implied by deposition of SMIQ stone artefacts in Nara Inlet 1 between the dates of 8,990 cal. BP and 7,190 cal. BP. At this time, deposition rates of stone artefacts were 53 artefacts/1000 years, the highest in any phase of occupation at the site. As I have argued above, cores were being reduced on the quarry, and material taken from the quarry to Nara Inlet 1 where it was used in the manufacture of backed artefacts. This is evident from the nature of the stone artefact assemblage in Nara Inlet 1, which predominantly consists of small, tertiary flakes with platform angles indicative of the range of retouch from initial retouch to final backing (Chapter 8).

Use of the SMI Quarry From 7,000 Years Ago to 520 Years Ago

At 7,000 years ago Border Island 1 was occupied for the first time. As with Nara Inlet 1, the initial phase of occupation (6,900 – 6620 cal. BP) demonstrated the highest rate of stone artefact deposition at 721 artefacts/1000 years. The stone artefact assemblage in Border Island 1 resembles that of Nara Inlet 1 in that I have been able to argue it was the product of backed artefact manufacture.

Quarry use can be inferred from the nature of the Border Island 1 assemblage in a similar way as was enabled by data from Nara Inlet 1. That is, cores were being reduced on the quarry, and unretouched flakes taken from the quarry to Border Island 1, where the flakes were used largely in the manufacture of backed artefacts. On the basis of discarded quantities of artefacts I argue that there was a greater amount of material removed, and by implication, an increase in activity on the quarry between the end of the first phase of Nara Inlet 1 occupation and the end of the first phase of Border Island 1 (in all, from 7,190 years ago to 6,620 years ago) (Table 9.1).

Table 9.1 Discard rates in initial phases of occupation for Nara Inlet 1 and Border Island 1

	Artefacts/1000 years	Weight /1000 years (gm)
Nara Inlet 1 **8,990 – 7,190**	53	27
Border Island 1 **6,900 – 6,620**	721	368

The possibility that the higher rates of deposition in Border Island 1 represent a phase of *decreased or static* quarry use, and rather procurement by scavenging is explored below through an examination of weathering patterns on both stratified assemblages. Tables 9.2 and 9.3 clearly show that in both sites the dominant pattern of weathering on dorsal surfaces is that of 'no patination', which represents an *absence* of weathering in all phases. Thus it can be concluded that relatively little time elapsed between procurement of the material and the reworking of the material within the sites. Scavenging behaviour at this time is therefore considered unlikely.

Table 9.2 Dorsal weathering patterns in Nara Inlet 1

Nara Inlet 1	No patination % (N)	Colour change % (N)	Colour + texture change % (N)
8,990 – 7,190 cal. BP			
7,190 – 4,410 cal. BP	94 (83)	4.(4)	1 (1)
4,410 – 1,990 cal. BP	95 (40)	5 (2)	0 (0)
1,990 – 520 cal. BP	100 (12)	0 (0)	0 (0)
520 cal. BP to present	100 (12)	0 (0)	0 (0)

Table 9.3 Dorsal weathering patterns in Border Island 1

Border Island 1	No patination % (N)	Colour change % (N)	Colour + texture change % (N)
6,990 – 6,620 cal. BP	95 (128)	4 (5)	1 (1)
6,620 – 3,080 cal. BP	98 (114)	1.5 (3)	0.5 (1)
3,080 cal. BP to present	100 (17)	0 (0)	0 (0)

Stone artefact discard rates after 6,620 cal. BP in Border Island 1, reflect those of Nara Inlet 1 (Tables 9.4 and 9.5). It should be noted that these discard rates are calculated from a similar area for each rockshelter (i.e. 50 x 50 cm square) While dated phases overlap, the pattern is similar: thus from 7,190 – 4,410 cal. BP in Nara Inlet 1 stone artefact discard is 45 artefacts/1,000 years; in Border Island 1 from

6,620 – 3,080 cal. BP discard is 50 artefacts/1000 years. Discard in Nara Inlet 1 is 9.5 artefacts/1000 years from 1,990 – 520 cal. BP; and 9 artefacts/1,000 years in Border Island 1 from 3,080 cal. BP to the present.

Table 9.4 Discard rates in all phases of occupation for Nara Inlet 1

Nara Inlet 1	Artefacts/ 1000 years	Weight/1000 years (gm)
8,990 – 7,190 cal. BP	53	27
7,190 – 4,410 cal. BP	45	32*
4,410 – 1,990 cal. BP	23	4
1,990 – 520 cal. BP	9.5	2
520 cal. BP – present**	29	27

* increased mean weight in this phase due to a 17gm extreme outlier
** this phase is discussed in the following section

Table 9.5 Discard rates in all phases of occupation for Border Island 1

Border Island 1	Artefacts/ 1000 years	Weight/1000 years (gm)
6,900 – 6,620 cal. BP	721	368
6,620 – 3,080 cal. BP	50	31
3,080 cal. BP – present	9	3.5

Declining stone artefact discard throughout the Holocene is indicative of a decline in manufacturing behaviour in Nara Inlet 1 and Border Island 1. This could suggest that fewer flakes were being removed from the South Molle Island Quarry, and thus an indication of decreasing activity at the quarry. Alternatively, declining artefact discard in the stratified sites indicates that people were simply changing their patterns of visitation to Nara Inlet 1 and Border Island 1, and along with other economic activities, were reducing and using the stone elsewhere in the region. Apart from a very ephemeral presence in the sequence of two late Holocene stratified rockshelter sites (Nara Inlet Art Site and Hill Inlet Rockshelter 1 [Barker 2004]), the only stone artefacts that have been recorded in the region including the mainland (see chapter 8) have been surface scatters of varying density (Barker and Schon 1994; Lamb 1998). Thus, it is not possible on the basis of this evidence to apply a temporal framework to patterns of artefact discard in the region, nor to infer altered visitation patterns in Nara Inlet 1 and Border Island 1.

However, when Barker (2004) conducted his study of the Whitsunday region's prehistory he found that in both Nara Inlet 1 and Border Island 1, cultural material other than stone artefacts increased significantly in the late Holocene. The pattern of increased deposition was consistent throughout the Holocene in Nara Inlet 1, but was particularly marked after 1,990 cal. BP (Barker 2004:69-85). The pattern of cultural discard in Border Island 1 is somewhat different in the early Holocene, as there is a decline in all materials between 6,900 cal. BP and 3,080 cal. BP. After 3,080 cal. BP however cultural materials such as shell, fish bone, turtle bone and charcoal rose by several hundred percent (Barker 2004:108-114), reflecting the late Holocene patterns in Nara Inlet 1. It is therefore difficult to argue in light of the increased suite of cultural materials, that declining stone represents a decline in rockshelter visitation. In light of this, I interpret the declining discard of stone artefacts at this time to indicate a reduction in the amount of material being removed from the quarry. Whether or not it represents declining quarry use will be explored below.

It is feasible that while the amount of material removed from the quarry was reduced after 7,000 years ago, quarrying behaviour did not decrease. Rather, it is possible that people shifted the typical location of their implement production away from the rockshelter sites and to the quarry itself. Such a shift would involve a reduction in the rate of artefacts manufactured in the rockshelter sites and an increase in the proportion of specimens backed on the quarry.

As I outlined in chapter 7, a sample of 323 backed artefacts from the SMIQ were analysed. The timing of their manufacture is the key to exploring the possibility of a shift in manufacturing behaviour to the quarry. As there are no datable assemblages on the SMIQ, this line of enquiry relies on the relative chronology that the weathering patterns illuminate. At this stage, the relative chronology is speculative and thus neither the possibility that quarrying behaviour decreased, or that the focus of manufacture shifted to the quarry can be excluded.

Of the sample of backed artefacts for which weathering data was recorded (94), 87% exhibited moderate weathering (colour change only) while 13% exhibited no weathering at all. According to the hypothesized relative chronology for quarry use, this places the manufacture of these backed artefacts as contemporary with the material in the rockshelter sites (see previous section: *Weathering Patterns and Relative Chronology*). If the 10% of artefacts that exhibit no weathering are equated with a recent phase of activity, and I have argued they should be, then I can infer that the manufacture of backed artefacts with moderate weathering must fall some time between a recent phase of use, and the earliest use of the quarry.

It is possible that the manufacture of backed artefacts on the quarry represents a period of time during which people shifted the focus of their technological behaviour away from the rockshelter sites, to the quarry. At this time, they would have engaged in all phases of manufacture on the quarry, rather than simply the initial extraction and reduction of cores. If this phase of technological behaviour is linked with the period of declining stone artefact discard in Nara Inlet 1 and Border Island 1, it could be argued that after 7,000 BP stone artefacts continued to be an important economic resource, and that people continued to extract and manufacture flakes on the quarry, and extending this process to the manufacture of backed artefacts.

Use of the SMI Quarry From 520 Years Ago to the Present

While data from Border Island 1 suggest that stone artefact deposition continued to decline steadily throughout the late Holocene despite an increase in other cultural materials, Nara Inlet 1 demonstrates an increased rate of deposition in the final phase of occupation, beginning at 520 cal. BP. This calculated increase however, is to be treated with caution for two reasons: firstly, the sample from which this rate of deposition is calculated is quite small (N=15) and is contained in only 15cm of deposit. Secondly, this pattern is reflected in Nara Inlet 1 but not in Border Island 1. If I treat the pattern as real and not a product of sampling error, then I can present the following model for quarry use after 520 cal. BP.

An increase in stone artefact deposition in the late Holocene implies an increase in the amount of material to be removed from the SMIQ. People were removing large, tertiary flakes which were further reduced in Nara Inlet 1 and Border Island 1 in the manufacture of backed artefacts. Whether this late Holocene phase also represents an increase in activity on the quarry is a matter for further discussion.

Firstly, two factors lead me to conclude that the stone artefact assemblage in Nara Inlet 1 is in fact representative of quarry activity. The absence of weathering on material in the upper phase of Nara Inlet 1 suggests that people were not scavenging material (refer to Table 9.2). Further, there is a portion of the quarry assemblage that exhibits no weathering. A previous discussion on relative weathering chronologies identifies this portion of the assemblage as the latest in the sequence of quarry use. The existence of historical accounts of quarry use supports the association between this latest phase of use with the contact period (Barker 2004) which belongs to the phase bounded by the date of 520 cal. BP. An examination of relative proportions of weathering patterns on the quarry should throw some light on whether the late Holocene increase in stone artefact deposition rates in Nara Inlet 1 indicates an increase in quarry activity.

As stated earlier, the two comprehensive samples of weathering data were taken from a population of 5271 flake scars on cores and 1003 artefacts in the fracture-type sample squares. Of these populations, 9% (N=522) of flake scars on cores and 20% (N=198) of artefacts in sample squares are display no weathering characteristics. Thus, acknowledging that the relative chronology for quarry use is speculative at this stage, I propose that a greater amount of activity was occurring on the quarry prior to this late phase of activity, and by implication quarry activity actually declined in the period represented by the post-520 cal. BP stone artefact assemblage in Nara Inlet 1.

SYNTHESIS

Between 9,000 years ago and 7,000 years ago quarry activity is indicated by the presence of stone artefact discard in Nara Inlet 1. The discard rates per 1000 years during this phase are low (although relatively in the context of the site), but none the less demonstrate that material was being procured from the quarry and removed for further work in Nara Inlet.

Discard rates between the initial phases of Nara Inlet 1 and Border Island 1 rise steeply. At this time, when Border Island 1 is occupied for the first time, people appear to be working the stone in similar ways to Nara Inlet 1, but in much higher quantities, thus indicating an increase in material removed and by implication, an increase in quarry activity.

After approximately 6,620 cal. BP discard rates in Border Island 1 decline, to reflect a similar pattern in Nara Inlet 1, which had begun after 7,190 cal. BP. It is clear that there is a reduction in the amount of material being removed from the quarry - a trend which began in the early-mid Holocene. Associated with this is a contraction of backed artefact manufacturing activity in Nara Inlet 1 and Border Island 1, which, I have argued, becomes focused on the quarry. There is definite evidence of backed artefacts being manufactured on the quarry (Chapter 7), and the relative weathering chronology observed for this sample of backed artefacts is not inconsistent with this argument. Alternatively, if the relative chronology for the quarry is too speculative, it may the case that the declining stone artefact discard in Nara Inlet 1 and Border Island 1 simply represents a decline in the amount of material removed from the quarry, and by implication, a decline in associated quarry activities such as procurement and initial reduction of stone.

The period post 520 cal. BP in Nara Inlet 1 is characterised by an increase in stone artefact discard. The increase is, however, represented by a relatively small sample of 15 stone artefacts and thus should be treated with caution. If however the integrity of this increase is accepted, then it could be argued that there was a very late Holocene increase (post 520 cal. BP) in the amount of material removed from the quarry and by implication an increase in associated procurement and reduction activity.

CHAPTER 10 MODELLING STONE ARTEFACT USE IN THE WHITSUNDAY REGION

INTRODUCTION

The previous chapter (Chapter 9) outlined the models for use of the South Molle Island Quarry through time. Patterns of use were inferred by an examination of the stone artefact assemblages from two stratified rockshelter sites: Nara Inlet 1 on Hook Island, and Border Island 1 on Border Island. The island topography changed considerably throughout the period of use, with rising sea levels playing a major role in local environmental change (see Chapter 4), although previous modelling of Whitsunday prehistory has posited that environmental change had little effect on peoples' use of the region and its resources (Barker 1995, 1996, 2004). The following chapter assesses the applicability of various models for late Holocene change to the Whitsunday stone artefact record.

MODELLING HOLOCENE USE OF THE SMIQ

During the earliest phase of Nara Inlet 1's occupation (beginning at 8,990 cal. BP), Hook Island was part of the mainland. At the same time however, South Molle Island was an island, some 2km from the mainland at its closest point. Between what was Hook Island and South Molle Island there was approximately 12km of water. This is in contrast to a 100km journey over land to reach the adjacent mainland and then a 2km journey over water to South Molle Island (Figure 10.1). Whichever route was selected to access the raw material on South Molle Island, it is safe to conclude that at 9,000 BP the people occupying Nara Inlet 1 possessed watercraft. This is posited by Barker (2004:150-152) who argues that the people who occupied Nara

Inlet 1 had followed the coastline as it rose, and while they exploited the terrestrial environment, were pre-adapted to a marine environment. Therefore, the method of accessing South Molle Island by water probably posed little difficulty.

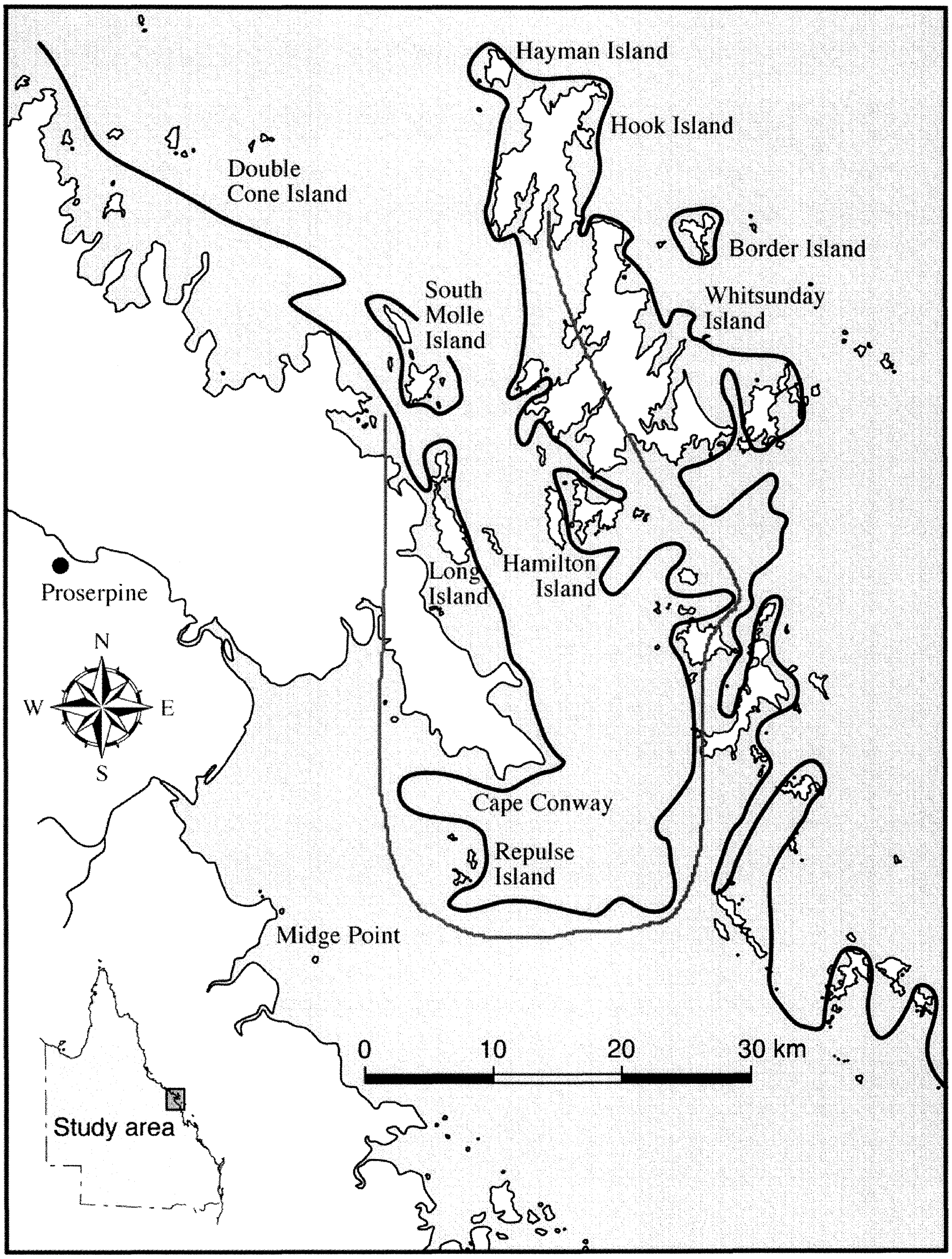


Figure 10.1 Map showing overland journey from Hook Island To mainland adjacent to South Molle Island

It has been argued (Chapter 8) that the stone artefact discard in both Nara Inlet 1 and Border Island 1 is largely a product of backed artefact manufacture. By implication, at 9,000 BP people were accessing the South Molle Island Quarry for raw material procurement, and removing stone away and onto the islands. The rate of stone artefact discard in the early phase of Border Island 1 occupation (6,900 cal. BP and 6,620 cal. BP) is significantly higher than in the early phase of Nara Inlet 1 (8,990 – 7,190 cal. BP). Thus at this time in Border Island 1, people were working more stone than they were in the previous 2,000 years in Nara Inlet 1. By implication, a greater number of backed artefacts were produced during the initial phase of occupation in Border Island 1, than in the early phase of Nara Inlet 1. After the early phase in each site, stone artefact discard, and by implication backed artefact manufacture, proceeds to decline throughout the Holocene. This chapter poses the question of why backed artefact manufacture was more intense in the early Holocene.

Risk in a Changing Landscape

In the explanation of technological change, the theory of risk mitigation as the catalyst for change has gained ground in recent archaeological literature. The concept underpinning risk theory is that of the cost of various provisioning strategies is weighed against the various risks associated with the possible disruption of the foraging strategies employed in an economic system. Certain technological strategies are therefore employed which minimise both the *provisioning cost* and the risk factors associated with procuring resources. In terms of the stone toolkit, it is proposed that technologies are adopted which emphasise ease of procurement and manufacture, thus reducing the failure probability (Hiscock in press:2), and that these technologies are emphasised within the economic system.

The dominant risk-response model for Australian stone artefacts in the Holocene was proposed by Hiscock (1994, 2002 and in press) who argued that the proliferation of backed artefacts constituted an adjustment by people to increasing uncertainty of resource distribution that meant resources were less easily predicted or ‘mapped’. However, because regional differences in “the nature and onset of risks and costs will be reflected in local differences in the nature and timing of change in technological strategies” it is unlikely that there will be a single, uniform technological trend evident across the entire Australian continent (Hiscock in press:17).

The Whitsunday region offers a perfect opportunity to explore the regionality of risk-response strategies. As I argue in Chapter 8, the evidence from the rockshelter sites suggests that the busiest period of quarry and manufacturing activity occurs in the early Holocene between approximately 9,000 BP and 6,620 cal. BP. It is during this time that two significant events occurred: the land mass that was the Whitsunday ‘Islands’ separated from the mainland, and Border Island was occupied for the first time. These events were part of an extreme geomorphic modification that took place in the early Holocene, and constituted not only landscape change, but also precipitated the colonisation of new landscapes (see Hiscock 1994, 2002 and in press). I argue that these two events constituted sufficient ‘risk’ in terms of access to the stone material, that during this time, people were using the pre existing backing technology more frequently in the Whitsundays.

It should be noted here that while I am arguing that the particular technological strategy under investigation here was adopted and utilised as a response to perceived instability, I am not crediting the selectionist model of change. I support the idea that the initial 'appearance' of cultural traits should be investigated as non-random responses to a situation ("non-random forces" [Fitzhugh 2001:127]), rather than as a random and undirected entity. Fitzhugh (2001:126) states:

> Darwinian mechanisms may in fact justify the traditional "mother of invention" model, but only if we are willing to consider the role of behaviour as a *mediator* [my italics] between environmental opportunities and constraints (the social and physical selective environment) and technological production".

Thus, the notion of a cultural trait being selected and propagated because it gives the user an 'advantage' is acceptable, but only if it is acknowledged that the trait was developed according to non-random bias (Fitzhugh 2001:127). It is in this context that I view the manufacture of backed artefacts in the Whitsunday Islands; as one response which optimised peoples' use of stone, to mitigate unpredictability of resources.

Risk responses on islands without stone

Although the period between 8,990 cal. BP and 7,190 cal. BP constitutes the most intensive period of artefact discard in Nara Inlet 1, there is a steady decline in discard from 8,990 cal. BP until 520 cal. BP. A similar pattern can be observed in Border Island 1. From initial occupation at 6,900 cal. BP, there is a decline in artefact discard until the present. The difference between the two sites lay in the fact that the amount of stone discard in Border Island upon initial occupation is so much greater than in Nara Inlet 1 in the early period of occupation (721 artefacts/1000 years compared to 53 artefacts/1000 years respectively).

I argue that the difference in discard between the two sites reflects a relatively more intensive backing activity in Border Island 1. This, I argue, is related to two factors which constitute an increased risk for the Border Island context: firstly, the distance to the source of raw material is far greater for people when they are inhabiting and exploiting Border Island 1 than when they are inhabiting Nara Inlet 1; secondly, at the time of initial occupation of Border Island 1, the Whitsunday Islands had recently separated from the mainland. Thus, during a period of fundamental bio-geographic change, a true regional island habitat/environment was established. Therefore, the occupation of Border Island 1 signified the habitation of an entirely new environmental niche. This, according to proponents of the risk models, constitutes sufficient risk to see the manufacture of high numbers of backed artefacts (Hiscock 1994, 2002 and in press), as their organisational properties reduce potential risk in foraging contexts. This trend is represented in the stone artefact assemblage of Border Island 1 between 6,900 cal. BP and 6,620 cal. BP.

Organisational properties such as reliability can be inferred of the backed artefact toolkit in the Whitsunday region. As Hiscock (in press) reminds us, backed artefacts vary in size and morphology across the eastern portion of the continent. The backed artefacts from the study region are typically large and asymmetric (Chapter 7). Bleed (1986:839) points out that among the characteristics that constitutes reliability are “strengthening and increasing the size of the components of the system”. The backed edge on the artefacts manufactured in the Whitsunday region is typically as thick as the flake's maximum thickness, providing a robust exterior surface of maximum surface area to either haft or hold by hand. Another aspect of the Whitsunday backed artefacts which emphasises optimal organisational properties is their potential for extended use. Extended or prolonged use reduces the frequency with which the raw material needs to be resupplied, and thus reduces the procurement costs (Hiscock in press). Prolonged use can take several forms, all of which could be applicable in this context; extended flaking, extended use, and resharpening.

While debris associated with backed artefact manufacture is to be found in Nara Inlet 1, the rate of discard is far less than in Border Island 1. Therefore, there is no evidence that backed artefacts were produced at the rate they were in Border Island 1, either at initial occupation, or even subsequently when the islands became separated from the mainland, as is seen at Border Island 1. I argue that this reflects the lower risk experienced by people in their utilisation of Nara Inlet 1 compared to the context of the first inhabitation of Border Island. The reasons for the different levels of risk in the two areas can be summarised as follows. First of all, when Hook Island became an island by 8,000 BP, people had already had at least 1,000 years of experience with procuring stone from South Molle Island, which involved water travel. Secondly, Nara Inlet 1 was only approximately 12km to 20km from South Molle Island, compared with a 40km to 70km journey from Border Island to South Molle Island, depending on the precise timing of the separation of the intervening landmass which made up Hook and Whitsunday Island (Figure 10.1). Thus, access to the raw material on South Molle Island constituted less risk for people when they were at Nara Inlet 1.

Evidence for the manufacture of backed artefacts in each rockshelter site declines throughout the Holocene. This happens markedly in Border Island 1 after 6,620 cal. BP and steadily in Nara Inlet 1 from 7,190 cal. BP. Barker (2004) attributes this decline to peoples' increasing marine specialisation which included of a technology made *from* marine products (shell, turtle shell, bone and so on) rather than stone. This, Barker (1996, 2004) argues was part of a social and demographic restructuring of territory and settlement patterns, culminating in a bounded, specialised and culturally distinct island population.

While I support Barker's (1996, 2004) hypothesis about the *nature* of the social and demographic changes that occurred in the late Holocene, I argue that declining stone artefact discard began prior to these social and demographic changes, and thus marked a transformation of a different nature. Hiscock (2002) argues that the proliferation of backed artefacts throughout southeastern portions of the continent was in direct correlation with declining effective precipitation (constituting environmental variability) and the colonisation, by some peoples, of new landscapes and habitats. I develop this model to suggest that the most prolific backed artefact production in the Whitsunday Islands corresponded with a time of greatest environmental variability in the form of sea level rises and the creation and habitation of an island habitat. How my model differs from Hiscock's (1994, 2002) is that both the timing of the effective environmental change and the period of prolific backed artefact manufacture occurs several thousand year earlier, in the early Holocene. I suggest that the nature and timing of this change is particularly unique to the off-shore island habitats and will explore this in greater detail in the next chapter (Chapter 11).

The period of declining stone artefact discard and by inference backed artefact production in the rockshelters, begins in the early-mid Holocene and extends into the mid and late Holocene. While this is also a period of decreasing precipitation, which in some contexts constitutes environmental variability, I argue that it in fact represents relatively greater environmental stability than previously; as it is at this time, sometime around 6,500 BP, that sea levels stabilised. Regardless of variability in temperature and effective precipitation, I would argue that in this island context sea level stability represents environmental stability to a degree, particularly in light of the palynological evidence for the region (Chapter 4). Hiscock (2002) invokes a reduced degree of risk as an explanation for the mid-late Holocene pattern of declining backed artefact production in other geographical contexts. I am reluctant to rely solely on this as an explanation for declining backed artefact productivity in the Whitsundays. Simply because the selective pressure of risk relating to environmental variability is removed or reduced, does not necessarily constitute the reduction in this technological trend. Rather, I argue that by this time, the technology would have been embedded in many different systems, not just that of enviro-economics. Thus its extrication from society is more complex than a simple reversal of the trend which ensured its entrenchment.

I propose that the reduction in backed artefact manufacture in the rockshelter sites had its roots in two causal factors that can be determined from the archaeological record. First, there is the reduction in manufacturing behaviour began at 6,620 cal. BP in Border Island and 7,190 cal. BP in Nara Inlet 1. This is just on the cusp of the period that is generally associated with the stabilisation of sea levels. This would have constituted a relatively stable and predictable situation with respect to access to the raw material source on South Molle Island, and in terms of the flux and change of other shore based resources. Also, at this stage, there had been several hundred years worth of habitation of a true off-shore island environment: 810 years in Nara Inlet 1 and 380 years in Border Island 1. Thus, the period that constituted the habitation of a *new* environment (Hiscock 1994, 2002) had possibly passed and people were moving across a landscape with which they had considerable history.

The continuing decline in rates of stone artefact discard throughout the mid-late Holocene in the rockshelter sites can also be associated with the concept of culturally bounded, marine specialisation proposed by Barker (2004). Barker (2004:150) argues for a pre-3,000 BP period that was characterised by ephemeral coastal and island occupation by a people whose diet consisted largely of littoral marine fauna, with a significant terrestrial based diet. Barker (2004:150) characterises this picture as

> "indicative of reasonably small and mobile groups whose settlement and subsistence patterns reflect 'classic' models of Australian coastal foragers who utilised a substantial coastal hinterland area but pursued a largely shore-based marine subsistence strategy".

The period post 3,000 BP sees a range of changes to settlement, subsistence and economy (Barker 2004:147). These changes include greater emphasis on open sea biota such as large marine mammals and turtle, a "change in technology reflective of the increased importance of the marine resource base", an increase in discard of organic cultural materials and an expansion of island habitation (Barker 2004:147).

It is argued by Barker (2004) that the diminishing use of stone reflects the increasing emphasis on marine oriented technologies which are made from marine resources.

I hypothesise that the use of stone does not necessarily decrease, and particularly not because of an increasing reliance on marine resources. The early phase of Border Island 1 occupation contains the highest densities of both stone artefact discard and turtle bone. I think that the link between the two is a manifestation of the methods required to butcher these large marine animals. Dismembering and de-fleshing a creature the size of a turtle or dugong would require not only an implement of considerable size and robusticity, but also one that was reliable and easily reshaped should it snap. Backed artefacts are such an implement type (Hiscock 2002). Thus, despite the declining discard in the rockshelter sites, I do not subscribe to the notion that increasing marine specialisation equates decreasing utilisation of stone artefacts.

I am inclined to agree with Barker (2004) however, that the cultural system marked by the post 3,000 BP changes was characterised by a certain boundedness in which territories "became more clearly defined and access to resource areas controlled or restricted" (Barker 2004:150). This pattern is observed across late Holocene Australia, particularly in well resourced, coastal or hinterland regions (David 1994; Lourandos 1983, 1985; McNiven 1999). The quarry on South Molle Island may well have constituted a very critical and important resource that was controlled in such a manner, throughout the mid-late Holocene. If the quarry did become controlled in such a manner, there may well have been specialists, or at least a designated knapper(s) responsible for the production and distribution of backed artefacts to people occupying other sites in the region.

If this was indeed the case, the declining rates of artefact discard in the rockshelters in the mid-late Holocene could be explained in the following manner: the more culturally bounded system that Barker (2004) documents for the mid-late Holocene was responsible for the continually declining rates of stone artefacts discarded in the rockshelter sites. This is due to the raw material source on South Molle Island being part of the culturally bounded system that controlled and restricted the quarry resource. That is, the backed artefact reduction process was undertaken on the quarry itself, possibly by specialised knappers, and the backed artefacts were distributed from the quarry rather than being produced in many varying locales.

The Role of the South Molle Island Quarry

Evidence from Border Island 1 and Nara Inlet 1 demonstrates that the South Molle Island Quarry has been used from 9,000 years ago to the archaeological present. The patterning of that use, across both space and time will be modelled here. There are several technological systems at work on the quarry. Raw material extraction is evident in several forms: the removal and working of nodules from the substrata and working the large bedrock-type outcrops. Analysis of retouched forms on the quarry indicated that retouch activity was directed at the production of backed artefacts as the only systematically produced implement form. Retouch also occurred on flakes, which in terms of material removed, resembled the sample of cores. Thus entire reduction sequences (*processes*) were carried out on the SMIQ, from initial extraction of raw material to final stages of retouch.

An analysis of cores and unworked nodules on the South Molle Island Quarry indicated that at the time of contact, raw material availability was declining. I draw this conclusion from two main lines of evidence: firstly, the remaining unworked nodules were not of the size and shape of the majority of the cores on the quarry. While the cores tended to be fairly cubic and 'blocky' in nature, the unworked nodules were more tabular in form, which limited the number of potential fracture planes. Secondly, an examination of fracture planes on cores revealed that there was a consistent pattern of 'interruption' caused by step and hinge terminations. This being the case, the potential for further removal of flakes is severely limited. These two factors in combination lead me to conclude that the raw material source on South Molle Island was under stress.

The early phases of occupation at Nara Inlet 1 and Border Island 1 indicate that stone was being procured and removed from the quarry, although not in large quantities. The near complete absence of cortex on artefacts in both sites indicates that most of the reduction was occurring on the quarry, including preparation of the flake-blank. I argue above that the declining rates of stone artefact discard in Nara Inlet 1 and Border Island 1 represent a period of decreasing backed artefact manufacture in regional locations away from the quarry. This is attributed to two factors. Firstly an increasing awareness and familiarity with the island habitat (reduced risk) in the early Holocene which is represented by the period after 7,190 cal. BP in Nara Inlet 1 and after 6,620 cal. BP in Border Island 1. This trend continues through to the late Holocene when the socio-demographic changes are picked up in the archaeological record. At this time, I argue, other factors contribute to the absence of stone in the sites. Noteworthy among them is the increasing control and restriction placed on resources as part of the increasing boundedness documented by Barker (2004) for the region.

During this time, I argue that the procurement, initial reduction, and late stages of reduction that contribute to the process of backed artefact manufacture were all being carried out on the South Molle Island Quarry, rather than occurring in other locations throughout the region. Stone artefact discard declining in the rockshelter sites, combined with the observed retouch patterns occurring on the quarry (Chapter 7), and other socio-demographic restructuring within the region, constitutes all the hallmarks of specialised knappers or possibly 'caretakers' maintaining control of a resource where procurement is indirect and restricted (eg. Fladmark 1884).

CHAPTER 11 THE SMIQ AND IMPLICATIONS FOR HOLOCENE CHANGE IN COASTAL AND ISLAND SYSTEMS

This research has added to the mounting evidence that the antiquity of backed artefacts and the timing of high production rates of backed artefact manufacture varies around Australia. In the Whitsunday Islands backed artefact production has been shown to be present from the start of the Holocene and to have been a key technological element in the early Holocene. A new understanding of backing technologies in Australia can be developed in light of this recognition of regional variation. In this chapter I present a model for Holocene technological change in the Whitsunday region, and a discussion of the implications for wider coastal and island technological systems throughout the Holocene.

I offer the following model for changing technological patterns in the Whitsunday Islands. In the early Holocene, the evidence from the rockshelter sites Nara Inlet 1 and Border Island 1 shows that between approximately 9,000 BP and 6,500 BP people were obtaining relatively large quantities of stone from South Molle Island and transporting it to various locations within the region including, importantly, rockshelter sites. The evidence from the stratified sites indicates that part of the technology at this time included the production of backed artefacts. This is interpreted here as comprising part of a strategy to reduce perceived risk at this time, related to the colonisation of a previously unexploited island landscape. For example, greater discard density in Border Island 1 in the early Holocene may reflect greater foraging risk owing to such factors as distance of the island from the source of stone. The further from the source people move, the less predictable is the provisioning of raw material, particularly in a newly exploited island landscape. However, unlike traditional distance-decay models, where distance from source correspond with lower discard and smaller artefacts, this particular situation may reflect peoples' increased requirements for reliable, maintainable implements. Thus, the manufacture of a greater number of backed artefacts in Border Island 1 accounts for the higher discard densities.

Stone artefact manufacture in the rockshelters declined steadily in Nara Inlet 1 from 7,190 cal. BP and markedly in Border Island 1 from 6,620 cal. BP. A possible explanation for this is that by this time people had a history of living in this habitat, and while it is difficult to be definitive about what constitutes a 'new' habitat, it is likely that perceived risk in that sense was reduced at this time. This, could be partially responsible for the decreased rate of stone artefact discard in Nara Inlet 1 and Border Island I in the early-mid Holocene. However, because the technology is embedded in various cultural systems, particularly after many generations of prolonged use, there could be a combination of factors at work which acted either in an overlapping fashion or in sequence to maintain this trend.

To elaborate on this, it has been argued (Barker 2004) that people in the region became culturally bounded and marine specialised after 3,000 BP. However, people were hunting turtle off Border Island as early as 6,900 cal. BP, which suggests that the process of specialisation could have been more prolonged and was initiated earlier than previously acknowledged (Barker 2004). If the process of marine specialisation is to be seen as intrinsically linked to other socio-cultural changes as Barker (2004) argues, then it is possible that the reduced rate of discard in the early-mid Holocene could also represent the early stages of the socio-demographic shift that Barker (2004) has identified in the late Holocene (this will be discussed in more detail below).

The pattern of declining stone artefact discard persists throughout the late Holocene. Owing to the likely importance of stone implements for butchering large marine mammals and reptiles, I am reluctant to subscribe to Barker's (2004) argument that stone became less important during the late Holocene. However, the notion of restricted and controlled resource access commonly associated with the late Holocene process of demographic change, supports the idea that the focus of stone artefact manufacture shifted onto the quarry. Because I have argued that the beginnings of this change occurred in the early-mid Holocene in the form of early marine specialisation, it is reasonable to suggest that other changes such as controlled resource access might also begin earlier than previously thought. Thus, the declining stone artefact discard in the early to mid Holocene be represent this earlier social and demographic change, which is usually attributed to the mid-late Holocene. In this context, the quarry would have become the epicentre of manufacturing and distribution of implements throughout the region.

The highest discard rates of stone artefacts in the rockshelter sites Nara Inlet 1 and Border Island 1 occurred between 8,990-7,190 cal. BP and 6,900-6,620 cal. BP respectively. An examination of the debris from backed artefact manufacture on SMIQ and attributes indicative of the backing process on the backed artefact sample from the quarry (Chapter 8), has demonstrated a strong correlation between the debris in the rockshelter sites and the process of backing. Thus, I feel it can reasonably be concluded that the most intensive period of backed artefact manufacture in Nara Inlet 1 and Border Island 1 occurred during the early to mid Holocene as indicated by the dates above. This pattern contrasts with that outlined by Hiscock (2002), in which he concluded that backed artefact proliferation on mainland Australia tended to be greatest between 4,500 BP and 3,500 BP (Hiscock 2002; Mulvaney 1975). It is proposed here that this should be seen as evidence relating to the pattern found in southeastern Australia and not directly applicable to the situation on the tropical Queensland coast.

While evidence for backed artefact technology is now evident from the early Holocene, its proliferation in mainland southeastern Australia has been largely associated with a period of environmental variability in the mid-late Holocene (Hiscock 2002). Research refining the patterns and effects of the El Niño Southern Oscillation (ENSO) event has determined that much of the Holocene was affected by this pattern of variability (Shulmeister and Lees 1995) which was expressed as low effective precipitation rates particularly between 5,000 BP and 4,000 BP. We can now understand the argument Hiscock (2002) made that this period of environmental variability corresponds with the proliferation of backed artefact manufacture and discard observed for mainland southeastern Australia. However, this temporal trend of backed artefact proliferation contrasts significantly with that observed in the Whitsunday region, which I have argued saw intensive backed artefact manufacture between 9,000 and 6,500 BP. I want to explore the possible causes for the earlier proliferation of backed artefacts in the Whitsunday Islands in light of the unique island habitat and environmental characteristics.

When compared with the mainland region at the same time (early to mid Holocene), I suggest that there are factors at work in the Whitsunday Islands that constitute a unique set of circumstances and that these circumstances were integral to early technological change in the form of backed artefact proliferation. We know that environmental variability throughout the Holocene brought about increasingly moist and warmer conditions on the south east coast of Australia until the mid late Holocene. This had a range of effects on the biogeography of eastern Australia. Among these effects was the formation of off-shore islands, as a result of rising sea levels. This constitutes the formation of completely new landscapes, as in the case of the Whitsunday Islands. On-shore, topography however, remains essentially the same despite a range of effects enacted on the flora and fauna, caused by warmer temperatures and increasing Effective Precipitation levels.

The proposed proliferation of backed artefacts on the Whitsunday off-shore islands, appears to be in contrast to the pattern on the mainland. I propose that it is the creation of a *new landscape* (the formation of islands) that constituted foraging risk in the Whitsunday region, rather than generalised *climatic variability* such as would have been experienced in mainland coastal regions in the early to mid Holocene. The fact that there are relatively fewer backed artefacts documented on the adjacent mainland during this time tends to support this argument.

Conclusion and Future Directions

It has been argued extensively in the Australian and international literature that curative technologies such as backing are particularly favoured in environments which constitute foraging risk. For the most part, the proliferation of this kind of technology in eastern Australia occurs in the mid-late Holocene and is frequently associated with other changes to the settlement subsistence system, which continued throughout the late Holocene. As I have hypothesized in this research, there appears to be a connection in Border Island 1 between backing technologies and turtle procurement, particularly between 7,000 and 6,500 BP. It has been proposed by Barker (2004) that the procurement of large marine reptiles and mammals, is part of a process of marine specialisation in the region. I suggest that the evidence for turtle exploitation in Border Island 1 signals the beginning of early marine specialisation in the Whitsunday region.

As sea level reconstruction data suggest, the sea levels had either not quite, or had just recently stabilised at this time. This suggests that for the Whitsunday region, there did not appear to be a 'lag effect' between stabilisation and the beginnings of marine specialisation, as proposed by Beaton (1985) to explain the delay between stabilisation and marine specialisation in coastal areas continent-wide. Accompanying these early signs of specialisation are signs that backed artefacts were being manufactured and used in higher densities than in any other time during the Holocene. I have argued here that the manufacture and use of these implements is a strategy related to the mitigation of foraging risk, which was brought about through the colonisation of new landscapes. It is also apparent that the Whitsunday region is unique in its timing of this particular risk mitigation strategy.

This study highlights the fact that risk, risk mitigation strategies, environment and social factors are all local conditions. The implication of this observation is that pan-continental models are losing their relevance as these local conditions are highlighted and incorporated into regional models of change. Thus, I feel that researchers need to systematically change the scale of their enquires in future, in order to further differentiate among the unique regional conditions that shape change in Holocene Australia.

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