3

Spatial and Chronological Patterns of Landscape Use and Resource Exploitation

Based on the broadly known climatic and environmental parameters for northern Australia and the Indo-Pacific region outlined earlier, and the implications these patterns have for variability in human economic behaviour, it is pertinent to examine the distribution, morphology and content of sites from survey data in order to assess human-environmental interactions. Of particular interest is the identification of those environmental factors that can determine the focal points for occupation and use of resources, and how this has been reflected in broad economic patterns across the study area. This analysis is separated into several sections that investigate the chronological and spatial patterning of the shell-dominated midden and mound deposits, and the distribution of stone artefacts across the Point Blane Peninsula. Assessing the distribution, morphology and content of archaeological sites in this way enables the identification of a higher level of behavioural variability than would be possible with one form of evidence alone. Combining these lines of evidence provides a relatively coarse-grained picture of economic activity in the area, and highlights those localities that merited further investigation in greater detail.

Field methodology

Survey design and implementation

Archaeological fieldwork was undertaken in the study area during 2000 (June to November), 2001 (July to October) and 2002 (July to October). The initial fieldwork strategy was one of guidance through the process of negotiation, consultation, and the familiarisation of the Yolngu living in the Yilpara community with the process of archaeological research. In keeping with the community-based nature of the research, a purposefully directed systematic sampling strategy, whereby survey units were selected based on community direction and personal judgement, was deemed most appropriate for investigating the unknown abundance, characteristics and visibility of the archaeological record in this area (Clarke 1994, 2002; Mitchell 1994a:174). Purposeful sampling is an effective step in defining previously unknown archaeological features of a region, is relatively cost-effective in contrast with random sampling strategies, and facilitates the discovery of highly clustered, small or uncommon elements within the landscape (Schiffer *et al.* 1978:5; Rhoads 1980:147; Redman 1987:251; Banning 2002:133). Given the relative environmental homogeneity of the study area, this survey strategy was considered appropriate given the research questions it was designed to address. A purposeful survey in this context provides an adequate sample for the identification of spatial and temporal trends in the distribution of archaeological material for the purposes of investigating the nature and variability of a regional *coastal* economy (e.g. Mitchell 1994a).

Long, thin survey units, or transects, were selected due to the ease of locating these units within the landscape, increasing the chance of site discovery, and enabling an investigation of site variability and density estimates in combination with ecological observations (Judge *et al.* 1975:88; Plog *et al.* 1978:401; Schiffer *et al.* 1978:11–2; Sundstrom 1993:93; Banning 2002:133, 154). Initial surveys were conducted on the margins of the peninsula through the direction of community members, with transects walked along approximately 22km of coastline in Myaoola Bay and 13km along the edges of the freshwater wetlands of the Durabudboi River in the Grindall Bay area. In order to gain an efficient estimation of non-clustered archaeological elements, bush tracks and roads were used to systematically survey across the peninsula, with a further 46km of transects surveyed in these areas (Figure 3.1). Tracks were used as survey transects as they enabled an example of all landscape zones within the study area to be inspected and, although highly variable, afforded higher ground surface visibility than would have normally been expected through more heavily vegetated areas (Schiffer *et al.* 1978:7). No graded or heavily eroded roads were surveyed, with all tracks surveyed having been formed by vehicle movement, with wheel rutting reaching a maximum depth of 5cm. Vegetation on tracks was generally low and sparse, with approximate ground surface visibility of 80 to 100% on the track itself. This level of visibility dropped to around 20 to 40% outside of the tyre tracks. These surveys covered the vehicle tracks themselves, as well as approximately 10m either side of the wheel ruts. Where possible, surveys were also conducted in recently burnt areas to take advantage of the increased visibility.

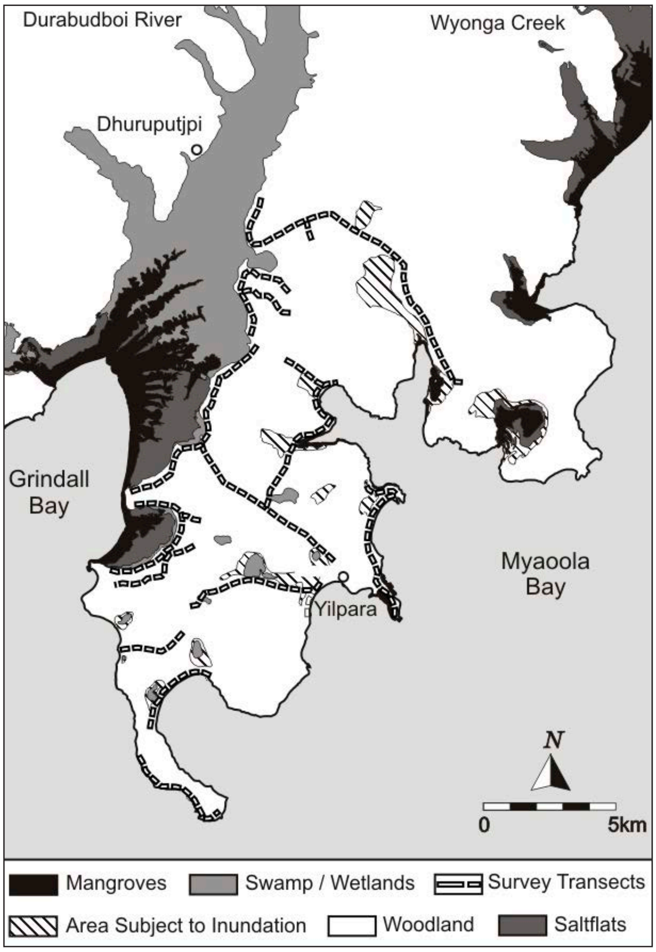

Figure 3.1: Survey transects locations on the Point Blane Peninsula.

Source: Based on Baniyala 1:50 000 Topographic Map.

Site definitions and recording

Sites are defined here by distinguishing those relatively dense, discrete concentrations of archaeological material from the sparsely distributed background or surrounding materials (Plog *et al.* 1978:389; Binford 1982:5). Concentrations of archaeological material that had merged, or where distinct site boundaries could not be identified (such as in large, composite mound sites), were classed as a single site (after Cribb 1996:160). For stone artefacts, it was decided that a single artefact should form the basis for the minimum recording unit (Thomas 1975; Foley 1981a; Dunnell and Dancey 1983:272; Holdaway *et al.* 1998).

Sites are classified following previous archaeological research in northern Australia (e.g. Clarke 1994; Mitchell 1994a; Bourke 2000) as:

- Shell Middens and Mounds: contain more than an estimated 50% weight or more of humanly deposited marine or freshwater molluscs. Middens often take the form of varying layers of shell over, or just below, the land surface. These deposits may also form as unstratified surface scatters, or as a thick mound of shell. In this case, shell deposits are classified as shell mounds if they were estimated to be greater than 30cm deep (Bowdler 1983:135; Sullivan 1989:49; Bourke 2000:60; see also variations proposed by Alexander 2009:74 and Morrison 2010:135).

- Stone Artefact Scatters and Quarries: contain flaked or ground stone artefacts (Hiscock and Mitchell 1993:27). Artefact scatters may occur as primarily surface scatters of material or as stratified deposits. No minimum number or density value of stone artefacts was set as the basis for recording according to the approach described above, with stone artefacts recorded across the study area either as isolated occurrences or in clusters. Following Hiscock and Mitchell (1993:21–22), quarries are defined as the location of a stone source, with or without evidence of procurement activities or extensive stoneworking (see also Ross *et al.* 2003).

- Macassan Site: refers mainly to Macassan Trepang processing sites, often located close to freshwater sources in sheltered bay areas. These sites characteristically contain stone lines for boiling the trepang, evidence of wells and smoke houses, Macassan pottery, glass, metal, shell (*Syrinx aruanus* and *Melo* species) and tamarind trees. Subsets of these features may occur within any given site (Macknight 1976:48–60; also Clarke 1994, 2000b; Mitchell 1994a, 1995, 1996).

The recording process included obtaining grid references with a hand-held Global Positioning System (GPS), taking the maximum and minimum dimensions of the site with a tape measure, noting the surrounding environmental features and landform associations, and characterising the types of cultural material present. An approximate percentage of ground surface visibility for the immediate area and the types of disturbance processes in operation were also noted (Sullivan 1989:51). A photographic record was made where possible, and where appropriate, the sites were mapped using a combination of dumpy level and tape and compass procedures (see Hobbs 1984; Sullivan 1984). All of the mound sites were mapped and cross-section measurements taken at the short (width) and long (length) axes using the dumpy level. Molluscan taxa were noted to identify the level of species richness and habitat selection across the study area, allowing for quantification and description of the variability in the dominant molluscan species exploited by people across time and space within the landscape.

Survey results

A total of 141 archaeological sites were recorded across the study area. The number and rank order of the different site types across the study area are shown in Table 3.1, with the distribution of sites by site type shown in Figure 3.2. Differences in the rank ordering of site types between the Myaoola and Grindall Bay areas suggests differences in the way in which these localities were occupied and variability in the intensity of resource exploitation. Of particular interest here is the dominance of larger shell mounds on Grindall Bay as opposed to the prevalence of lower lying-surface middens on Myaoola Bay. Chi-square results indicate that the Myaoola and Grindall Bay areas are significantly different in terms of the distribution of site types between the two bay areas ($\chi^2 = 55.44$, *d.f.* = 4, $p < 0.001$), suggesting that this is not a random pattern. Cramer's V, which indicates the strength of the association between the two variables, is 0.632.

Table 3.1: Number and rank order of site types within the study area.

Site Type	Total		Myaoola Bay		Grindall Bay	
	No.	Rank Order	No.	Rank Order	No.	Rank Order
Shell Mound	60	1	1	4	59	1
Shell Midden	56	2	31	1	25	2
Isolated Artefacts	14	3	1	4	13	3
Artefact Scatter	6	4	3	2	3	4
Shell Midden/Artefact Scatter	3	5	2	3	1	5
Macassan Site / Well	2	6	2	3	--	--
Total	**141**		**40**		**101**	

Very little archaeological material was recorded across the interior of the peninsula, and as such, the types of sites recorded are evidence of a pattern of landscape utilisation predominantly orientated towards the use of coastal resources. As the study area is a peninsula, the dominant resources, particularly in the past before the formation of the wetland areas, were located within the coastal zone. Shell mounds and middens are generally located in the landscape in areas where there are abundant and varied resources available along the coastline (Meehan 1982; Bailey 1993). Therefore, in the past, people would have primarily focussed on coastal and marine resources, a pattern similar to those found in other north Australian localities, like the Darwin region (Burns 1994, 1999; Bourke 2000:77). In these locations the dominant coastal site types are shell deposits, followed by smaller numbers of surface stone artefact scatters or isolated occurrences of artefacts. In fact, 85.6% of the sites recorded on the Point Blane Peninsula are deposits of marine shell, followed by artefact scatters and isolated artefacts, which make up 14.4%. Of the 139 sites presented above (excluding the Macassan site and the historic well), 38 are situated on the present-day coastline (27.3%), and 101 are located on the edges of the Dhuruputjpi freshwater wetland (an infilled former embayment) or significant seasonal swamps (72.7%).

The information presented in Table 3.1 also emphasises that, while shell deposits are the dominant archaeological site type regardless of location, variation does occur with the differential distribution of shell mounds and middens. When the middens and mounds are combined, they make up 84.2% of the Myaoola Bay and 83.2% of the Grindall Bay sites. With differentiation between shell mounds and middens, however, the mound sites dominate the margin of Grindall Bay at 58.4%, and only make up 2.6% of the sites located on the Myaoola Bay coastline. In comparison, the lower lying shell middens make up 24.8% of the Grindall Bay sites and 81.6% of the sites on Myaoola Bay respectively. This possibly reflects behavioural factors related to resource density

within these different locations, the intensity of resource use and patterns of refuse discard. These apparent differences are drawn out to a greater extent in viewing the relationship between the chronological patterns, site distributions and the environmental features of the study area.

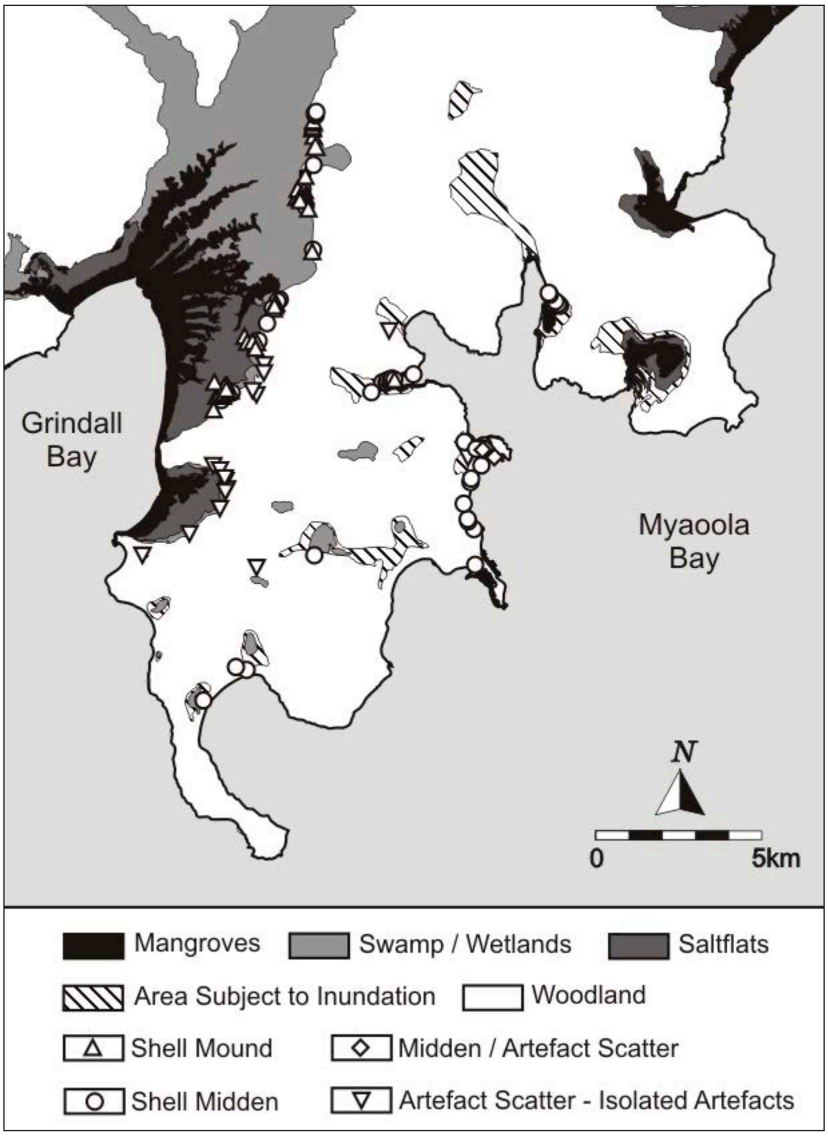

Figure 3.2: The distribution of sites on the Point Blane Peninsula by site type.

Source: Based on Baniyala 1:50 000 Topographic Map.

Chronology and changes in sea level

All of the radiocarbon dates from the midden and mounds sites in the study area were obtained from marine shell samples. All conventional radiocarbon ages were converted to calendar years using the CALIB (v6.1.1) calibration program (Stuiver and Reimer 1993). Those samples greater than 448 BP were calibrated using the marine04.14c calibration curve dataset (Hughen *et al.* 2004) with a ΔR correction value of 55±98 recommended for the Gulf of Carpentaria (Ulm 2006b). Following Telford *et al.* (2004) and Ulm *et al.* (2010b), median calibrated ages are presented here as they represent a central best-point estimate of the probability distribution for each calibrated date. Fifteen radiocarbon dates obtained from the surface of sites in the study area are listed in chronological order in Table 3.2.

Table 3.2: Surface radiocarbon age estimate ranges for sites across the Point Blane Peninsula.

Site Code	Site Type	Square	Excavation Unit	Depth (cm)	Lab Code	Sample	δ^{13}C (*estimate)	^{14}C Age (years BP)	1σ cal Age BP (68.3% probability)	2σ cal Age BP (95.4% probability)	Cal Age BP Median
BMB/084	Midden	Test Pit 1	1	0 - 1	ANU-11911	*M. hiantina*	0.0 ± 2.0*	122.3% ± 1.0%	Modern	Modern	--
BMB/116	Midden	Test Pit 1	1	0 - 1	ANU-12019	*A. antiquata*	0.0 ± 2.0*	650 ± 60	77–333	1#–426	225
BMB/003	Midden	Test Pit 1	1	0 - 5	ANU-11501	*M. hiantina*	0.2 ± 0.1	900 ± 50	336–549	274–640	461
BMB/036	Mound	N/A	--	Surface	ANU-12018	*A. granosa*	0.0 ± 2.0*	980 ± 130	389–667	239–847	526
BMB/045	Mound	Test Pit 1	1	0 - 2	ANU-11717	*A. granosa*	3.5 ± 0.2	990 ± 60	461–637	314–708	539
BMB/067b	Midden	Test Pit 1	1	0 - 2	Wk-17745	*A. granosa*	2.2 ± 0.2	1063 ± 35	511–661	433–773	592
BMB/061	Midden	Test Pit 1	1	0 - 4	ANU-11720	*A. granosa*	4.6 ± 0.2	1510 ± 50	900–1137	776–1243	1009
BMB/067a	Midden	Test Pit 1	1	1 - 5	ANU-11715	*A. granosa*	3.0 ± 0.2	1620 ± 80	992–1247	856–1367	1115
BMB/071	Mound	Test Pit 1	1	0 - 3	ANU-11722	*A. granosa*	2.9 ± 0.2	1700 ± 60	1067–1299	936–1412	1192
BMB/052	Mound	N/A	--	Surface	Wk-17744	*A. granosa*	-3.3 ± 0.2	1763 ± 37	1152–1367	1039–1496	1258
BMB/101	Mound	N/A	--	Surface	ANU-11894	*A. granosa*	0.0 ± 2.0*	2010 ± 80	1369–1657	1269–1809	1518
BMB/093	Mound	N/A	--	Surface	ANU-11893	*A. granosa*	0.0 ± 2.0*	2240 ± 80	1617–1924	1485–2101	1779
BMB/082	Mound	N/A	--	Surface	ANU-11892	*A. granosa*	0.0 ± 2.0*	2340 ± 70	1747–2047	1591–2210	1900
BMB/029	Mound	Test Pit 1	1	0 - 3	ANU-11496	*A. granosa*	-3.4 ± 0.1	2410 ± 50	1850–2120	1728–2279	1985
BMB/033	Mound	N/A	--	Surface	ANU-12017	*A. granosa*	0.0 ± 2.0*	2540 ± 60	2010–2290	1853–2420	2140

Note: # are suspect due to impingement on the end of the calibration data set.

Source: Calibration data from CALIB 6.1.1, marine04.14c (Hughen *et al*. 2004), ΔR = 55±98 (Ulm 2006b).

The distribution of the 15 sites from which these radiocarbon determinations have been obtained from surface samples is shown in Figure 3.3, and the one and two sigma calibrated radiocarbon ages graphed in Figure 3.4. These dates demonstrate a late Holocene sequence of occupation within the study area, ranging from 2140 cal BP to the present for the surface samples. This range of dates conforms well to the patterning of radiocarbon dates established from other coastal areas of northern Australia (for example Beaton 1985; Roberts 1991; Mitchell 1993, 1994a; Bourke 2000), where the occupation of open sites rarely extends beyond approximately 3000 BP. This chronological pattern also relates strongly to discussions regarding the potential for a time lag between sea level rise and stabilisation and the appearance of open coastal sites (for example Beaton 1985; Bourke 2000, 2003). The sea level data for the Gulf of Carpentaria region presented in Figure 2.10 indicates that sea level rise was relatively rapid throughout the early to mid Holocene. The reconstruction of past shorelines, although speculative in nature and associated with a degree of error, has proved to be a useful tool in assessing the use of coastal areas relative to sea levels and associated changes in the physical landscape (e.g. Shackleton and van Andel 1986; Shackleton 1988; Bailey and Craighead 2003). While such studies have focussed on long occupation sequences in caves or rockshelters relative to late-Pleistocene sea level patterns, the same approach may be applied here.

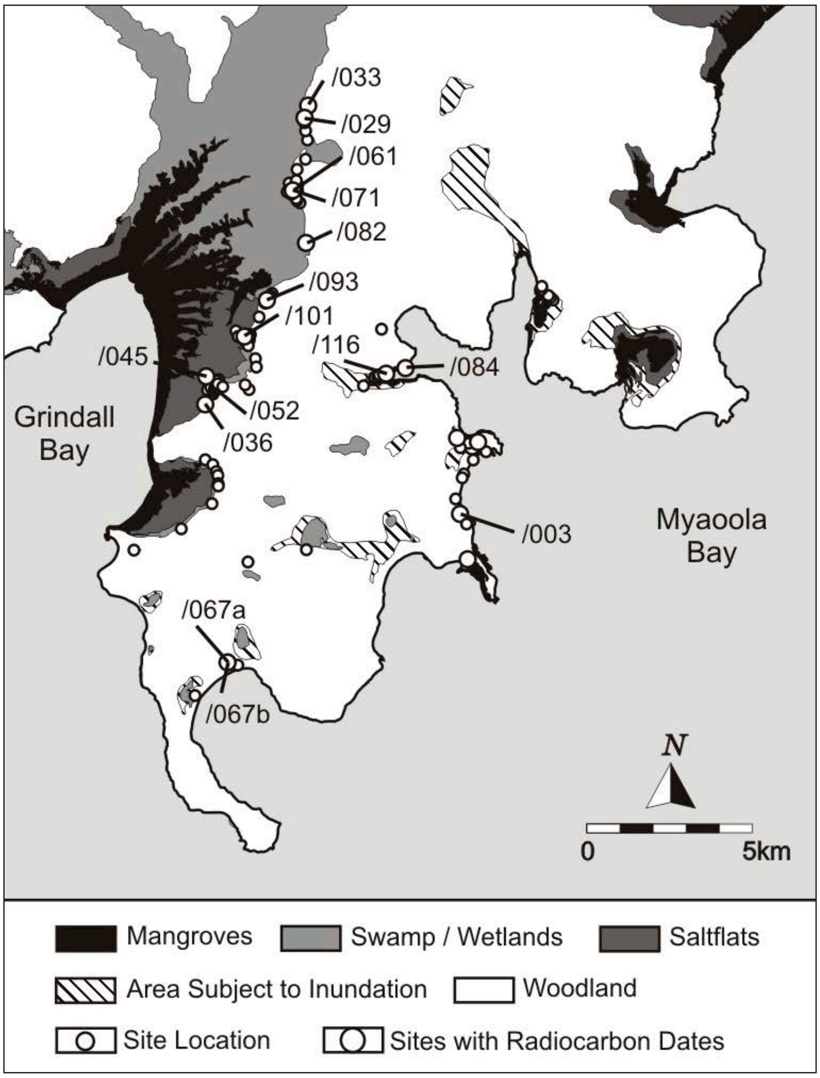

Figure 3.3: Location of sites on the Point Blane Peninsula with radiocarbon determinations obtained from surface samples.

Source: Based on Baniyala 1:50 000 Topographic Map.

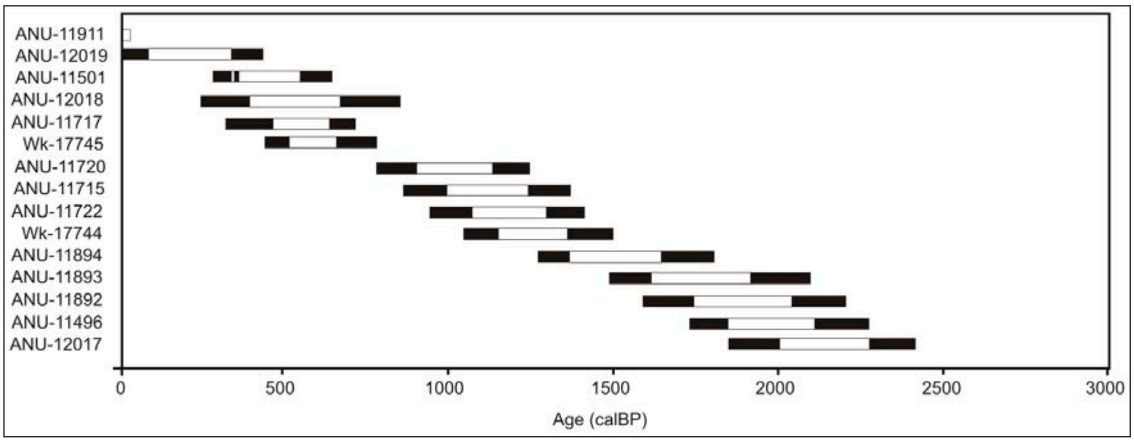

Figure 3.4: Calibrated radiocarbon age estimates (1 and 2σ) from surface samples across the Point Blane Peninsula.

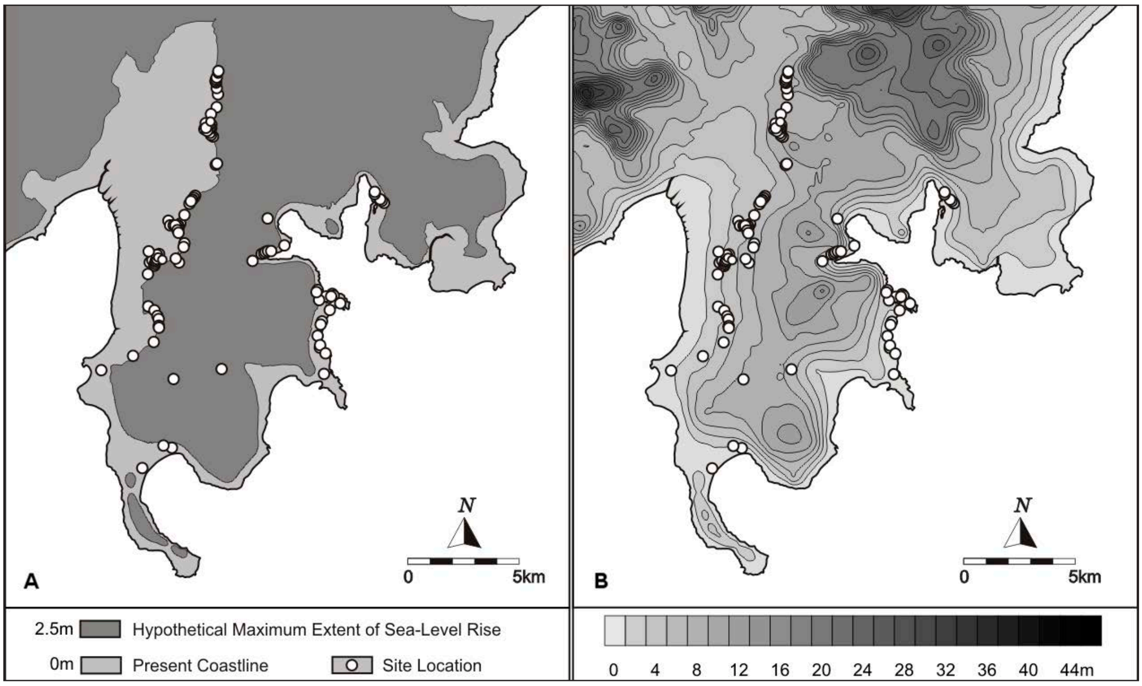

Figure 3.5: (A) Site location relative to the present and hypothetical maximum extent of sea levels; (B) Site location plotted against height above present sea level (2m contour interval) and present coastline (0m).

Source: Based on Baniyala 1:50 000 Topographic Map.

The hypothetical maximum extent of sea level for the Point Blane Peninsula at 2.5m above present, although theoretical in nature, has been calculated based on the sea level curve for the Gulf of Carpentaria, relative to contour height data across the study area and the distribution of older and/or more stable land surfaces. This highlights the distribution of sites relative to the position of the coastline over time, as well as associated landscape alterations. It is apparent that sea level rise would have dramatically affected the physical characteristics of the coastline. An example of this is the prograded Dhuruputjpi wetlands system, which approximately 5000 years ago was a sheltered, shallow embayment. Figure 3.5A presents the distribution of sites relative to present sea level and an approximate maximum sea level height above present. This demonstrates that, with the exception of two sites located within the southern-central area of the peninsula, all of the sites in the study area fall along or below the hypothetical shoreline at the maximum sea level highstand of 2.5m above present. This distribution, combined with the calibrated radiocarbon age range across the peninsula, suggests that the open sites recorded in the area began to be deposited as sea levels were probably receding in conjunction with changes to the landscape via progradation and beach ridge formation, some 2000 years after maximum sea levels were reached (Cotter 1996:200).

To evaluate general processes associated with late Holocene coastal landscape alteration relative to the chronological pattern discussed above, height above sea level and distance to present coastline are used to assess the total distribution of sites by Myaoola or Grindall Bay locality. Height above sea level has been measured according to the nearest 0.5m contour, and the sites grouped within 2m contour intervals for comparison. Distance to coastline has been measured as the shortest straight-line distance between the site and the shoreline. In this case, the sites have been grouped according to 2km distance intervals. The distribution of sites plotted against the 2m contour intervals and relative to present shoreline is mapped in Figure 3.5B. The number and percentage of sites by the 2km distance to present coastline units is presented in Table 3.3. The

data are ordered by the total number of sites across the peninsula, as well as being separated by site location into the Grindall and Myaoola Bay areas. In these two areas, the frequency of sites by distance unit is expressed as a percentage of the total number of sites across the peninsula.

Table 3.3: The number and percentage of sites by distance to present coastline relative to all sites.

Distance to	Total		Myaoola Bay		Grindall Bay	
Present Coastline	**No. Sites**	**%**	**No. Sites**	**%**	**No. Sites**	**%**
0 to 2 kilometres	68	48.92	38	27.34	30	21.58
2 to 4 kilometres	32	23.02	0	0.00	32	23.02
4 to 6 kilometres	28	20.14	0	0.00	28	20.14
6 to 8 kilometres	11	7.91	0	0.00	11	7.91
Total	**139**		**38**		**101**	

The site to coastline distance for all sites ranges from 0 to 8km, with 48.9% of sites falling within 2km of the present shoreline, and 71.9 and 92.1% within 4km and 6km respectively. Although a pattern of sites clustering closer to the present coastline would be expected of an archaeological record dominated by shell deposits, the pattern varies dramatically when separated by broad locality. All of the Myaoola Bay sites are situated within 2km of the present shoreline. This contrasts sharply with the Grindall Bay sites, with little difference in percentages between the 2km, 4km and 6km distance intervals. The frequency of sites only tails off between 6 and 8km from the coast. Again, this reflects differential landscape processes between the two peninsula localities. This is also reflected in a comparison of site location relative to height above sea level, with this data presented in Table 3.4. The data are ordered in a similar fashion, by the total number of sites across the peninsula, and by the sites situated in Myaoola and Grindall Bays. In this case, 2m height intervals are used to group the sites.

Table 3.4: The number and percentage of sites by height above sea level interval relative to all sites.

Relative Height	Total		Myaoola Bay		Grindall Bay	
Above Sea level	**No. Sites**	**%**	**No. Sites**	**%**	**No. Sites**	**%**
0 to 2 metres	29	20.86	28	20.14	1	0.72
2 to 4 metres	26	18.71	8	5.76	18	12.95
4 to 6 metres	38	27.34	1	0.72	37	26.62
6 to 10 metres	46	33.09	1	0.72	45	32.37
Totals	**139**		**38**		**101**	

All of the sites fall within a height of 10m above present sea level. Unlike the distance to shoreline data, there is no clear patterning in the frequency of total sites within these height intervals. These data only begin to make sense when comparing the frequency of sites within these height intervals between the Myaoola and Grindall Bay. To investigate whether the Myaoola and Grindall Bay areas differ in the number of sites by height above sea level interval, a chi-square statistic was used. The results indicate that these areas are significantly different in terms of the distribution of sites by height above sea level ($\chi^2 = 97.74$, *d.f.* = 3, $p < 0.001$), suggesting that this is not a random pattern. Cramer's V (0.839) indicates a very strong association between the two variables. The Myaoola Bay sites follow the type of pattern that would be expected in this area given the sea level data and chronological patterns. That is, sites are densely clustered within 2m height above sea level (approximately 75%), then decrease rapidly in number with increasing height. No sites in this area occur beyond 8m above sea level. In contrast, there appears to be little patterning in

the frequency of sites per height above sea level interval along Grindall Bay, although the majority of sites in this area are more densely clustered within the 4 to 6m and 8 to 10m height intervals. These contrasting patterns in site location relative to the present coastline and topography across the peninsula suggest differential processes of landscape changes acting within each broad locality. In order to draw this pattern out more fully, however, the strength of the relationship between distance to coastline and height above sea level within these two areas must also be investigated. This enables the relationship between the general topography of the area to be evaluated relative to changes in sea level.

Figure 3.6A presents a scatterplot of the distance to present coastline (km) by height above sea level for all sites located on Myaoola Bay. This suggests that in this area the overall trend is for distance to coast to increase with height above sea level, with the relationship between these variables being moderately strong (Pearson's $r = 0.634$, $r^2 = 0.402$, $p < 0.01$, $n = 38$). It is expected for these site and environmental variables to relate reasonably strongly in this context, as sea levels dropped and physical changes occurred to the coastline with time, older sites would be located higher and further from the present day coastline. The significance of this relationship is, however, only moderate, as evidenced by the r^2 value of 0.402, which indicates a high degree of data dispersion. This pattern may relate to the physical characteristics of this part of the coast, as topographically this area shows significant changes within short distances from the shoreline. The vast majority of Myaoola Bay sites fall within 500m of the shoreline, and within this distance, height above sea level varies between 0.5m and 4m for all but two of the sites. While height above sea level may not correspond significantly with the age of sites in this area, largely due to processes of beach ridge development relative to the variable topography of the coastline, distance from shore is a significant factor relative to the chronological patterns. As a comparison, the scatterplot presented in Figure 3.6B shows distance to coastline plotted against height above sea level for the Grindall Bay sites. In this case the trend for distance to coast to increase with height above sea level stronger. The correlation coefficients (Pearson's $r = 0.920$, $r^2 = 0.846$, $p < 0.001$, $n = 101$) suggest that the relationship between these variables is both strong and significant.

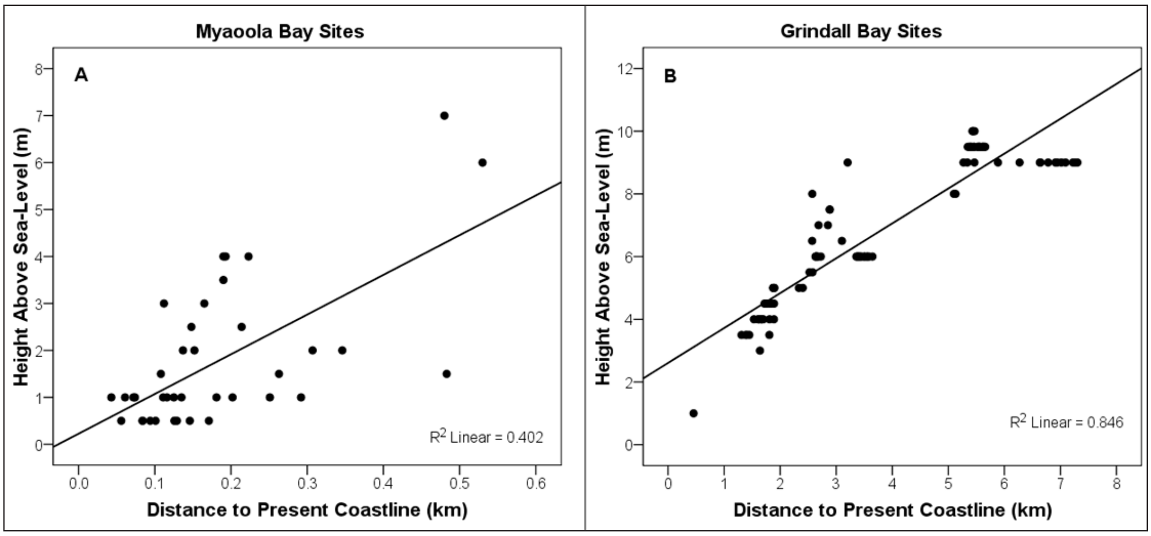

Figure 3.6: Distance to present coastline plotted against height above present sea level for (A) Myaoola Bay and (B) Grindall Bay.

This pattern again relates to the topography of this particular area relative to sea level rise and the stability of the dominant land-surfaces. With increasing distance from the coastline, the landscape rises quickly as it moves away from the relatively low-lying coastal plain. The fact that

this relationship is stronger in Grindall Bay compared with Myaoola Bay suggests that different processes have affected site location relative to these variables. This pattern again relates to the physical characteristics of this area, with the majority of the Grindall Bay sites being situated along the laterite ridge that forms the rough extent of maximum sea level rise in this area. The height of this ridge above the wetlands or saltflats varies with distance away from the modern coastline, but in general terms, height above sea level increases as the ridge extends northwards away from the coast (see Figure 3.5A). Over time, as sea levels gradually retreated and sedimentation increased in this embayment, the general trend was for occupation to follow the retreating resource base corresponding to progradation in the bay. The main differences in the location of sites in the study area lie between the eastern and western bays. This is primarily a function of slow sea level regression and differential landscape changes in these areas. This is most likely related to processes of successive beach-ridge development and seaward sedimentation on the largely unprotected coast of Myaoola Bay in the east, and the gradual progradation and wetland formation within the large sheltered embayment on the western margin.

Resource exploitation

Distance to sources of freshwater

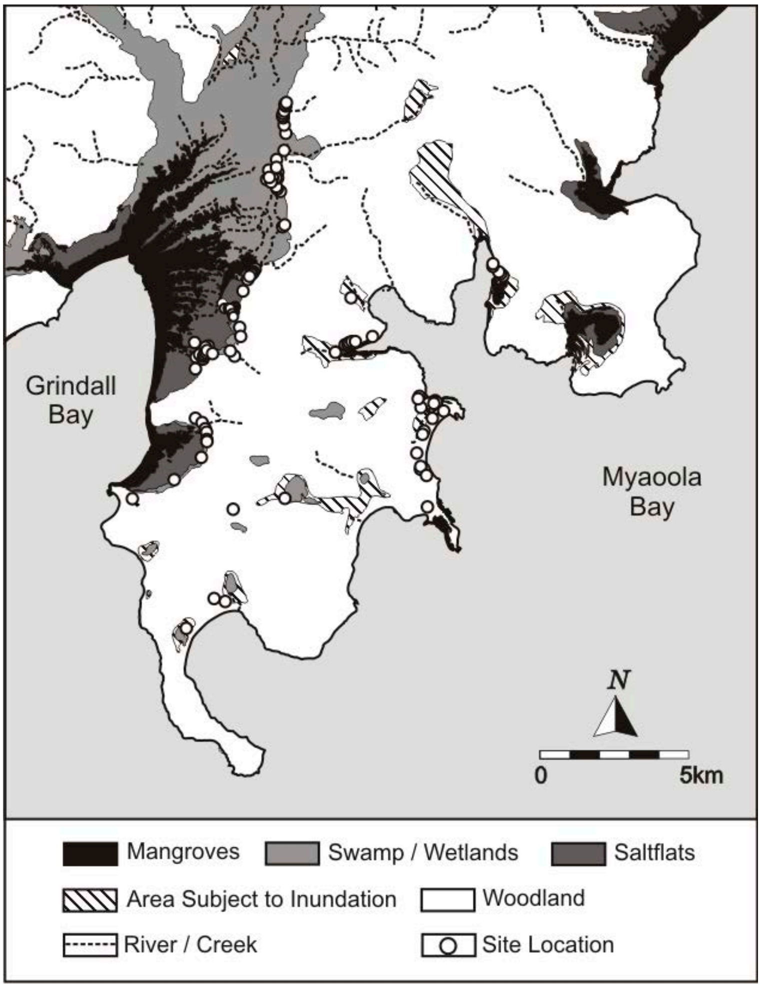

Figure 3.7: The distribution of all sites relative to sources of freshwater.

Source: Based on Baniyala 1:50 000 Topographic Map and Water Resources of North Eastern Arnhem Land Mapsheet.

Sources of reliable, seasonal freshwater are well distributed across the Point Blane Peninsula. Rivers and creeks, such as the Durabudboi River and Wyonga Creek, feed into the many freshwater wetlands, smaller swamps and billabongs in the area. Both watercourses have large catchment areas, resulting in larger amounts of rainfall runoff and river flow over the wet season (Haines *et al.* 1999:1–2, Zaar *et al.* 1999:19–20), with a correlation between the amount of annual wet season rainfall and the availability of both surface and sub-surface water sources throughout the year. Higher rainfall results in higher water table levels and greater spring flows. Even taking into account annual wet season variation in rainfall, this area is a seasonally well-watered landscape. This is apparent in Figure 3.7, which shows the distribution of sites in relation to sources of freshwater.

While the large freshwater wetlands serve as a relatively reliable source of seasonal freshwater at present, this would not have always been the case as they formed subsequent to sea level rise, coastline stabilisation and ongoing processes of progradation. To gain an idea of the location of sites relative to freshwater sources, those creek-lines draining the interior of the peninsula and the lower-lying areas subject to higher levels of inundation have been used. The shortest distance in kilometres from these areas to each site has been taken as the minimum distance to freshwater. The sites have then been grouped according to 200m distance intervals as an indication of occupation density relative to these water sources. The number and percentage of sites within these distance intervals is shown in Table 3.5, and the percentages graphed in Figure 3.8.

Table 3.5: The number and percentage of sites by minimum distance to water interval.

Minimum Distance to Water	No. of Sites	% of Sites
0.0 to 0.2 kilometres	111	79.86
0.2 to 0.4 kilometres	20	14.39
0.4 to 0.6 kilometres	3	2.16
0.6 to 0.8 kilometres	0	0.00
0.8 to 1.0 kilometres	1	0.72
1.0 to 1.2 kilometres	1	0.72
1.2 to 1.4 kilometres	2	1.44
1.4 to 1.6 kilometres	1	0.72
Total Sites	**139**	

While this pattern would at first appear to be significant, with approximately 80% of sites located within 200m of freshwater, all sites on the peninsula are located within 2km of a water source. These site density estimates, combined with Figure 3.7, suggests that water may not be an overriding factor in site location. Although undoubtedly an important and necessary resource in this environment, on the margins of the peninsula freshwater was relatively easily accessible from every location surveyed. As the distribution of sites in the area suggests a higher concentration of activity within embayments (Figure 3.7), in economic terms the distribution of sites may relate more to other factors, such as shoreline changes from maximum sea levels to the present, and the effect of this process on the dispersal of suitable habitats containing exploitable food resources.

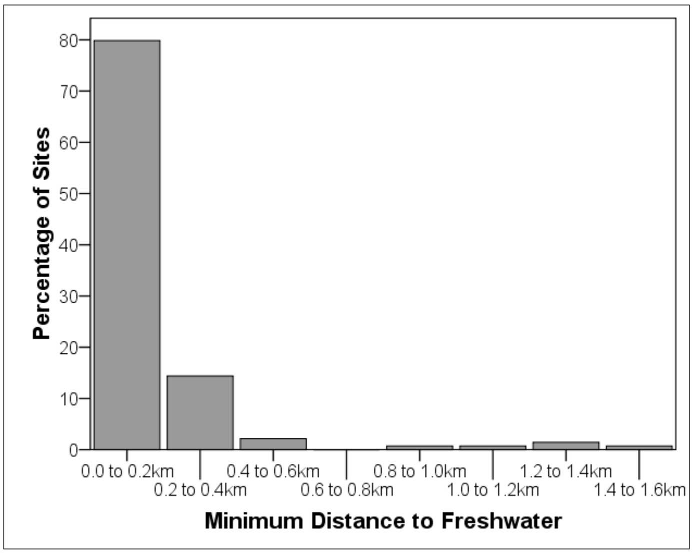

Figure 3.8: The percentage of sites by minimum distance to water interval.

Molluscan species and habitat exploitation

As noted by Bailey and Craighead (2003:176), sea level rise to maximum and subsequent slow regression to present would have had an effect on the nature of the available near-shore habitats, and therefore the differential availability and abundance of molluscan taxa. As a result, the range of taxa and habitats exploited across the peninsula should vary relative to the sea level rise and landscape alteration processes described above. Table 3.6 lists the 30 molluscan species identified on the surface of all sites across the peninsula by family, taxon and their respective habitats. In terms of the available species and habitats exploited within the study area, this list should be viewed as the minimum range, as this relies on the identification of macro remains under trying field conditions. Those species currently exploited (as listed in Chapter 2), albeit in very low numbers at present, are also indicated. Contemporary patterns of molluscan exploitation indicate a limited focus on this resource, where the harvesting of molluscs is limited to only six taxa (Barber 2002, 2005). In comparison, the range of molluscan taxa identified from the archaeological sites in the area suggests that the intensity and diversity of molluscan exploitation was much greater in the past. The number and percentage of sites containing the relevant molluscan species detailed in Table 3.6 is presented in Table 3.7. The taxa have been rank ordered according to the percentages of the total number of sites. This allows for an easy comparison with the percentages of sites in the Myaoola and Grindall Bay locations.

Table 3.6: Molluscan species identified on the surface of the sites and their habitat.

Family	Taxon	Habitat
Arcidae	*Barbatia* sp.	Rock/Debris in Littoral Area, Coral Reefs
	Anadara granosa	Littoral Sand and Mud (Intertidal/marginally subtidal)
	*Anadara antiquata**	Littoral Sand and Mud (Intertidal/marginally subtidal)
Chamidae	*Chama* sp.	Coral, Rock, or Shell Debris
Chitonidae	Chitonidae f.	Upper Intertidal to Shallow Sub-tidal
Corbiculidae	*Polymesoda (Geloina) coaxans**	Coastal Rivers, Streams and Estuaries
Ellobiidea	*Cassidula angulata*	Mangroves (*Rhizophora, Bruguiera*) / Mud
Isognomonidae	*Isognomon isognomon**	Mangroves to Under rocks in Shallow Water
Mactridae	*Mactra abbreviata*	Littoral Sand
Melongenidae	*Syrinx aruanus*	Sand and Mud in Shallow Water
	Volema cochlidium	Sand and Mud in Shallow Water
Mytilidae	*Modiolus* sp.	Sand and Mud in Shallow Water – Estuaries
	Septifer bilocularis	Attached to Rocks or Debris
Neritidae	*Nerita* sp.	Mangrove Roots / Rocks
Ostreidae	Ostreidae f.*	Mangrove Roots / Rock / Debris in Sub-tidal Areas
Pinnidae	*Pinna bicolor*	Littoral Sand / Seagrass Beds
Placunidae	*Placuna placenta*	Surface of Mud / Mangroves
Potamididae	*Cerithidea* sp.	Shallow Mud / Mangroves Roots (*Avicennia, Bruguiera*)
	Terebralia sp.*	Mangroves (*Avicennia, Bruguiera*, Ceriops)
	*Telescopium telescopium**	Mangroves (*Rhizophora*)
Pteriidae	*Pinctada* sp.	Attached to Substrate in Intertidal / Sub-tidal Areas
Tellinidae	*Tellina* sp.	Littoral Sand and Muds
Trochidae	*Monodonta labio*	Shallow Water
	Tectus pyramis	Shallow Water
Turbinidae	*Turbo cinereus*	Shallow Water
Veneridae	*Gafrarium tumidum*	Littoral Muddy Sand
	Marcia hiantina	Littoral Sand
	Dosinia mira	Littoral Sand
	Placamen calophyllum	Littoral Sand
Volutidae	*Melo amphora*	Lower Intertidal and Sub-tidal Sand / Mud

Note: * indicates those species currently exploited in the study area.

Source: After Meehan 1982; Short and Potter 1987; Wells and Bryce 1988; Lamprell and Whitehead 1992; Lamprell and Healy 1998.

Table 3.7: The number and percentage of sites containing molluscan species by broad locality.

	Total		Myaoola Bay		Grindall Bay	
Molluscan Taxa	**# Sites**	**%**	**# Sites**	**%**	**# Sites**	**%**
Anadara granosa	96	80.67	15	44.12	81	95.29
Polymesoda (Geloina) coaxans	61	51.26	20	58.82	41	48.24
Marcia hiantina	61	51.26	31	91.18	30	35.29
Mactra abbreviata	56	47.06	0	0.00	56	65.88
Telescopium telescopium	51	42.86	9	26.47	42	49.41
Ostreidae f.	47	39.50	17	50.00	30	35.29
Placuna placenta	44	36.97	0	0.00	44	51.76
Terebralia sp.	33	27.73	25	73.53	8	9.41
Isognomon isognomon	27	22.69	23	67.65	4	4.71
Nerita sp.	22	18.49	14	41.18	8	9.41
Cerithidea sp.	21	17.65	10	29.41	11	12.94
Anadara antiquata	21	17.65	15	44.12	6	7.06
Septifer bilocularis	21	17.65	20	58.82	1	1.18
Gafrarium tumidum	19	15.97	17	50.00	2	2.35
Cassidula angulata	15	12.61	0	0.00	15	17.65
Dosinia mira	10	8.40	6	17.65	4	4.71
Pinctada sp.	10	8.40	8	23.53	2	2.35
Syrinx aruanus	9	7.56	7	20.59	2	2.35
Modiolus sp.	6	5.04	4	11.76	2	2.35
Volema cochlidium	5	4.20	3	8.82	2	2.35
Melo amphora	4	3.36	1	2.94	3	3.53
Monodonta labio	4	3.36	2	5.88	2	2.35
Tellina sp.	4	3.36	3	8.82	1	1.18
Barbatia sp.	3	2.52	3	8.82	0	0.00
Pinna bicolor	3	2.52	3	8.82	0	0.00
Tectus pyramis	3	2.52	3	8.82	0	0.00
Turbo cinereus	3	2.52	3	8.82	0	0.00
Chitonidae f.	2	1.68	2	5.88	0	0.00
Placamen calophyllum	1	0.84	0	0.00	1	1.18
Chama sp.	1	0.84	1	2.94	0	0.00

These data show that molluscan species distribution is quite variable between these landscape categories. As this table is reasonably complex to interpret, site percentages for the three categories have been graphed in Figure 3.9. This shows that, depending on the species, the observed differences in the frequency of sites containing various species relates to the distribution of the resource base across the study area. The differential availability of resources across the study area reflects the diversity of environmental conditions and the differential distribution of molluscan habitats, as well as the processes of climatic and landscape alteration of the mid-to-late Holocene. Therefore, some species may have been more abundant, and by extension more heavily exploited, on Myaoola Bay, such as *Anadara antiquata*, *Gafrarium tumidum*, *Marcia hiantina*, *Polymesoda (Geloina) coaxans*, *Septifer bilocularis*, *Isognomon isognomon*, Ostreidae species and *Terebralia palustris*. Other species, such as *Anadara granosa*, *Mactra abbreviata*, *Placuna placenta* and *Telescopium telescopium*, by contrast, are more abundant in those sites concentrated on the margins of Grindall Bay.

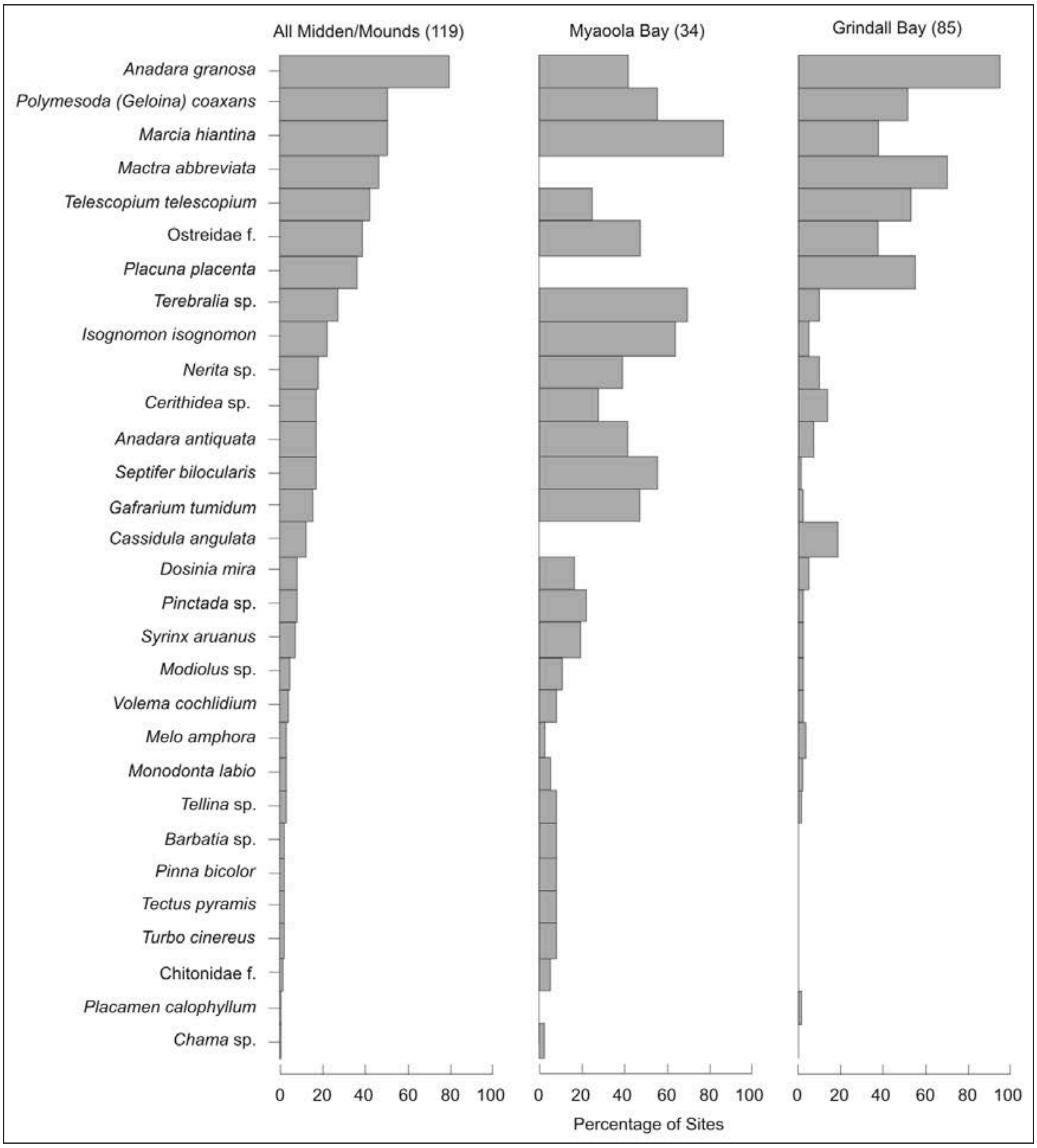

Figure 3.9: The percentage of sites containing molluscan species by the total number of sites and broad locality.

These data also suggest that the Myaoola Bay sites reflect a higher level of species richness compared to the Grindall Bay sites. This is investigated further by comparing the number of molluscan taxa as an indicator of species richness within each site across the peninsula (e.g. Magurran 1988; Broughton and Grayson 1993). Figure 3.10 maps the number of taxa per site across the Point Blane Peninsula, with an extrapolated contour interval of two molluscan species. This provides a general indication of the way that species richness varies between the sites on the margins of the peninsula. It further emphasises the earlier point that embayments, or currently infilled former embayments, were focal points for economic activity in the study area, possibly related to the density of molluscan resources. While it is difficult to draw out specific patterning in species richness from this figure, it does show that the number of species contained within the sites on the western margin is reasonably consistent. The Myaoola Bay sites show quite a different pattern, one where species richness appears to be generally greater and where there are

concentrated patches of higher species richness in particular areas. This contrasting pattern of species richness is further investigated below, with descriptive statistics presented in Table 3.8 for the Myaoola and Grindall Bay sites.

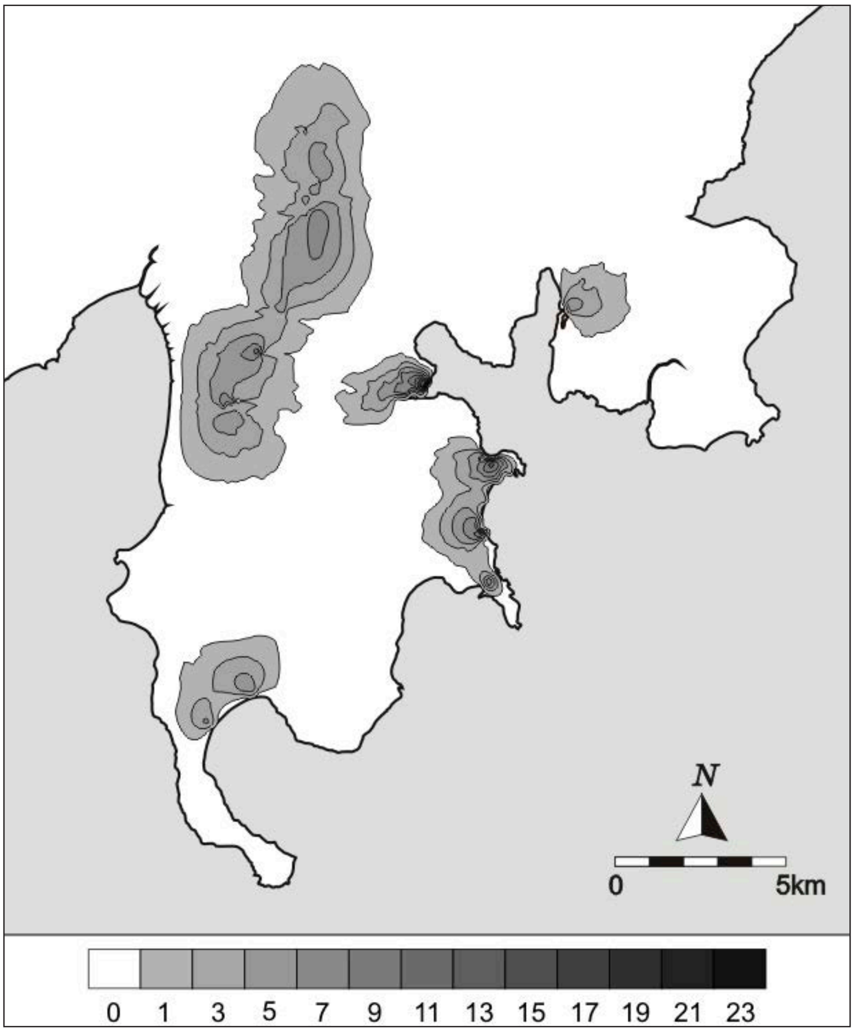

Figure 3.10: Density map of the number of molluscan taxa per site across the study area (contour interval = two species exploited).

Table 3.8: Descriptive statistics for the number of molluscan taxa by broad peninsula locality.

No. of Molluscan Taxa by Peninsula Locality	Myaoola Bay	Grindall Bay
Mean	7.25	5.06
Standard Deviation	4.17	3.01
Minimum	1	1
Maximum	23	23
Range	22	22
Number of Sites	34	85

The Myaoola Bay sites show a mean species richness of 7.25, compared with a mean of 5.06 for the Grindall Bay sites. This pattern suggests that there was a broader range of molluscan species exploited on the eastern margin of the peninsula compared with a limited range of species utilised, and possibly available, in the west. A Mann-Whitney *U* test revealed a significant difference in species richness between these two areas ($U = 899.5$, $z = -3.463$, $p = 0.001$, $r = 0.32$). In this case, species richness is a useful indicator of the diversity in resource exploitation within the area. Regardless of whether the number of taxa recorded during the surveys represents the average or the maximum diet breadth over a given length of time (Madsen 1993; Nagaoka 2000; Lyman 2003), it is apparent that different exploitation patterns were in operation relative to the broad area in which sites were located. This may be a reflection of the availability of particular resources, as well as choice in the exploitation of available resources. One way of teasing out differences in behavioural versus environmental reasons for the differences in the exploitation of various species may be to look at the number of habitats represented by the species identified in the area. Four broad habitat areas have been defined for the 30 taxa listed in Table 3.6. While it is acknowledged that there is a large degree of overlap within and between molluscan taxa in terms of their habitats, the following divisions provide a basis for analysing broad ecological trends. Following Kress (2000:301–4) and Morton (1983:101), these habitat areas are:

1. Shallow Water: this category contains species that inhabit the rocky, clear water areas in or just below the tidal zone, including parts of the reef and sandy/rocky areas close to the shore. Littoral and tide pool species are also included here;

2. Sand/Mud Flats: the brackish water habitat that encompasses the mud and sand flats that fringe the edge of most mangrove forests;

3. Mangroves: the mangal zone, situated within the mangroves proper, including those species found specifically in mangrove mud, as well as attached to the trees themselves;

4. Estuarine: encompassing coastal rivers, streams and estuaries.

The number and percentage of sites containing molluscan taxa representative of these different habitats is presented in Table 3.9. The species have been rank ordered according to the percentages of sites containing taxa from these four habitat divisions.

Table 3.9: The number and percentage of sites by molluscan habitat and broad locality.

Molluscan	**Total**			**Myaoola Bay**			**Grindall Bay**		
Habitat	**# Sites**	**%**	**Rank Order**	**# Sites**	**%**	**Rank Order**	**# Sites**	**%**	**Rank Order**
Shallow Water	64	53.78	3	30	88.24	3	34	40.00	4
Sand/Mud Flats	116	97.48	1	35	97.06	1	81	97.65	1
Mangroves	99	83.19	2	33	94.12	2	66	78.82	2
Estuarine	62	52.10	4	22	64.71	4	40	47.06	3
Total No. Sites	**119**			**34**			**85**		

Chi-square results indicate that Myaoola Bay and Grindall Bay are not significantly different in terms of the distribution of sites by habitat representation ($\chi^2 = 5.26$, $d.f. = 3$, $p > 0.1$). In terms of the number of sites in which species from different habitats occur, taxa from the mangrove-associated sand/mud flats areas dominate the study area as a whole, followed by taxa from the mangal zone proper. Hard substrate species (those that attach themselves to mangrove roots, rocks and shell debris), and taxa located in shallow waters appear to have been exploited to a greater extent on the exposed coastal margin in comparison with the Grindall Bay sites. Between 50 and 60% of sites in both areas contained taxa obtained from coastal rivers, streams or estuaries. The

slight variation in the rank ordering of habitats between the Myaoola and Grindall Bay areas therefore possibly relates to the distribution of resources within each given locality. In order to assess this pattern further, the level of species richness from each habitat is used as a measure of the intensity or focus of exploitation. A comparison of the mean number of taxa exploited per habitat is presented in Table 3.10. In many respects, the number of species exploited from each habitat reflects the previous pattern, with more species exploited from the mangrove-associated sand/mud flat areas relative to other habitat areas. There are, however, differences in the mean number of species exploited by habitat between the Myaoola and Grindall Bay sites, particularly within the shallow water and mangal zone proper habitats.

Table 3.10: Descriptive statistics for the number of molluscan species from the defined habitats by broad peninsula locality.

	Myaoola Bay			
Habitats	**Shallow Water**	**Sand/Mud Flats**	**Mangroves**	**Estuarine**
Mean	1.70	2.70	2.19	0.68
Median	1	3	2	1
Standard Deviation	1.58	1.53	1.47	0.63
Minimum	0	0	0	0
Maximum	8	7	6	2
Range	8	7	6	2
Total No. Sites	**34**	**34**	**34**	**34**
	Grindall Bay			
Habitats	**Shallow Water**	**Sand/Mud Flats**	**Mangroves**	**Estuarine**
Mean	0.43	2.26	1.61	0.51
Median	0	2	1	0
Standard Deviation	0.52	0.89	1.34	0.55
Minimum	0	0	0	0
Maximum	2	6	6	2
Range	2	6	6	2
Total No. Sites	**85**	**85**	**85**	**85**

Table 3.11: *t*-test results for the relationship between the mean number of molluscan taxa by habitat for the Myaoola and Grindall Bay sites.

Molluscan Habitats	Myaoola Bay No. Taxa	Grindall Bay No. Taxa	t	d.f.	p
Shallow Water	1.7027	0.4268	-4.799	40	< 0.001
Sand/Mud Flats	2.7027	2.2561	-1.659	47	> 0.1
Mangroves	2.1892	1.6098	-2.046	64	< 0.05
Estuarine	0.5122	0.6757	-1.368	62	> 0.1

Table 3.11 details the results of *t*-tests performed to determine the significance of the differences between the mean number of taxa exploited per habitat between the eastern and western margins of the peninsula. These results suggest that, whereas there is a certain level of consistency in the number of species exploited within sand/mud flat areas and estuarine environments between these two areas, the differences observed between shallow water and mangrove habitats are significant. If the level of species richness for these habitats accurately reflects the level of exploitation intensity, then species gathered from hard-substrate areas in the shallow water zone and from the mangrove forests were exploited to a greater degree on the exposed coastal margin of Myaoola Bay. This result combined with that of species richness indicates that the differences observed between the two areas are a product of resource availability linked to long-term changes in the

coastline. This strongly suggests that, although there is always a certain level of choice involved in the exploitation of resources, decisions are ultimately constrained by what is available in the immediate area.

Stone artefacts on the Point Blane Peninsula

Stone artefact recording

All stone artefacts were recorded in the field, and the methods used for the identification and recording of artefacts in the field follows that of Hiscock (1984, 1989), Hiscock and Hughes (1983) and Andrefsky (1998) (see also Clarkson 2004; Holdaway *et al.* 2004; Shiner 2004; Faulkner and Clarke 2009). The five features detailed below were selected as being appropriate for this research:

1. Stone artefact raw material type: predominantly five types of stone were noted. These were chert, quartz, quartzite, silcrete and volcanic. This feature was recorded to gain an understanding of raw material movement across the landscape and use in artefact production.

2. Artefact types (following Hiscock 1989:25–6) were recorded as Flaked pieces: an artefact that cannot be classified as a flake, core, retouched flake or implement (e.g. broken piece); Unretouched flakes: any primary piece of stone detached from a core or another flake, generally characterised by the presence of initiations and terminations and containing a bulb of force, ringcrack and eraillure scar; Retouched flakes: a flake which has subsequently been re-flaked, and where secondary flake scars extend onto either surface after the removal of the flake from the core; and Cores: a piece of flaked stone with one or more negative flake scars and no positive flake scars.

3. Breakage: for flakes it was noted whether the broken piece represented a proximal, medial or distal piece, or whether the piece had snapped laterally or longitudinally. The breakage position was recorded so that a minimum number of artefacts could be calculated for the overall assemblage. Following Hiscock (2002:254), the minimum number of artefacts (MNF) is calculated by MNF=C+T+L, where C is the number of complete flakes, T is the largest category of transverse fragments (excluding medial fragments) and L is the count of longitudinal fragments.

4. Cortex: measured in terms of Primary decortication: dorsal surface 100% covered; Secondary decortication: 1-99% of the dorsal surface covered; and Tertiary decortication: with no cortex present (0%). On non-bifacial cores, cortex is measured as Type one (primary): cortical platform and cortex on the flaking surface; Type two (secondary): cortex on the flaking surface but none on the platform; and Type three (tertiary): no cortex on the flaking face or the platform.

5. Artefact measurements: on flakes, the percussion length, or the distance along the ventral surface from the ringcrack to the flake termination (Hiscock 1988), was measured with width and thickness taken at the midpoint of the percussion length, and platform width and thickness were taken relative to the point of force on the platform. On cores, the length was taken as the percussion length and width of the largest negative scar, as well as the maximum platform thickness. The number of platforms and the number of negative scars were also recorded on cores as an indicator of core rotation and core use. Weight was recorded for all artefacts as another comparative size measure (Roth and Dibble 1998; Marks *et al.* 2001:24–26; Clarkson 2004:109–110; Holdaway *et al.* 2004:57; Braun *et al.* 2005).

Assemblage characteristics and raw material variation

Given the lack of stratigraphic context and the inability to assign a chronological framework to these sites (e.g. Holdaway *et al.* 2004:34), the study area is considered to be a single catchment area (see Vita-Finzi and Higgs 1970), and the artefacts analysed as a single assemblage. As surface stone artefact scatters are generally time-averaged deposits, and result from repeated activities rather than a single event (Holdaway and Wandsnider 2006:192–3), spatial patterning of artefactual material does not necessarily provide a strong temporal context. While the study area is analysed as a single catchment, the aim here is to understand the sum of those activities, and the variability that entails, at particular locations (e.g. Holdaway *et al.* 2004; Shiner 2004; Holdaway and Wandsnider 2006) rather than assume chronological similarity. This approach enables general trends in stone raw material use, artefact manufacture and spatial distribution to be analysed. A total of 250 stone artefacts were recorded during the course of the survey, and as with the distribution of the other sites in the study area, these sites are largely concentrated on the margins of the peninsula (Figure 3.11). In order to identify diversity within this assemblage, the frequency of the major artefact and raw material components of the assemblage are shown in Table 3.12.

Table 3.12: Number and type of stone artefacts per raw material.

	Raw Material						
Artefact Type	**Chert**	**Quartz**	**Quartzite**	**Silcrete**	**Volcanic**	**Total**	**%**
Core	--	1	11	--	--	12	4.84
Flaked Piece	--	--	40	4	--	44	17.74
Retouched Flake	--	--	6	4	--	10	4.03
Unretouched Flake	1	--	162	18	1	182	73.39
Total (MNF)	**1**	**1**	**219**	**26**	**1**	**248**	**100**
Percentage	0.40	0.40	88.31	10.48	0.40	100	

As noted by Hiscock (2001) and Grayson and Cole (1998:928), assemblage richness or diversity is largely dependent upon sample size. While this may hold true for the Point Blane Peninsula with small numbers of artefacts recorded across the study area, a number of useful points can still be addressed. The data presented in Table 3.12 suggests a very low level of assemblage diversity in both artefact type and raw materials utilised. Unretouched or unmodified flakes dominate the area at 73.4%, followed by flaked pieces at 17.7%. The latter may represent the by-products of manufacture and/or use of stone artefacts. Cores and retouched flakes represent minor components of the assemblage at 4.8% and 4.0% respectively, though they still provide information on the way in which stone was used within the area. Although an unmodified flake will provide a sharp, functional edge, retouched flakes can potentially serve as an indicator of stone raw material conservation, as this process enables a flake to remain in operation for a longer period of time. There are 10 retouched flakes (4 silcrete and 6 quartzite), comprising 4.0% of the assemblage. The unretouched flakes dominate the composition of the assemblage, with a 16:1 ratio of flakes to cores, and an 18.2:1 ratio of unretouched to retouched flakes (Faulkner and Clarke 2009:23). The following analysis will focus on raw material variability and distribution across the landscape, as differences in stone raw material abundance and quality may place constraints on the variability of the archaeological record (Dibble 1985:391–392; Bamforth 1986; Kuhn 1991:76–7; Andrefsky 1994a, 1994b; Hiscock 1996; Brantingham *et al.* 2000:256; Clarkson 2004:9; Orton 2008).

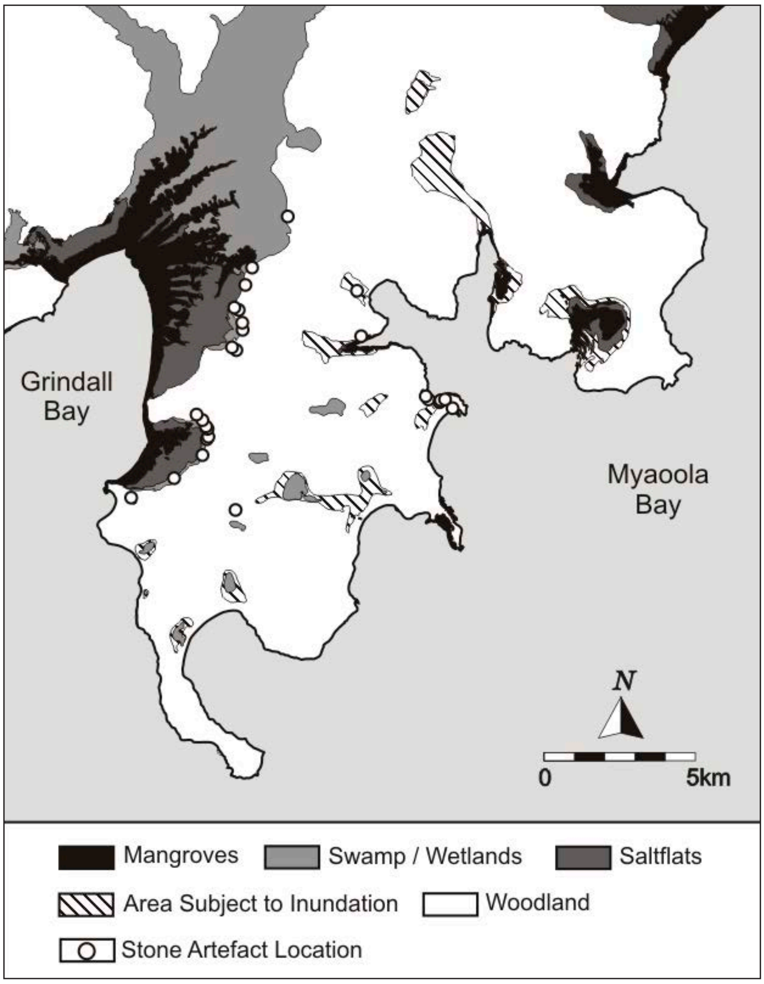

Figure 3.11: The distribution of sites containing stone artefacts on the Point Blane Peninsula.

Source: Based on Baniyala 1:50 000 Topographic Map.

Concentrating on the raw materials present in the study area, this shows that quartzite is the dominant stone raw material (88.4%), followed by silcrete occurring at a considerably lower frequency (10.4%). Given the dominance of quartzite and silcrete artefacts across the peninsula, and the fact that chert, quartz and volcanic artefacts form such a minor component of the assemblage at one artefact each, and a combined 0.4% of the raw materials represented, they are not included in this analysis due to sample size limitations. It is also important to understand the differences between the two main raw material types, as they can appear morphologically very similar, and these are described below (Haines et al. 1999:71–6):

1. Quartzite: a metamorphic rock, which is hard due to the fact that it is primarily made from interlocked quartz particles set in a cementing solution, or matrix, creating a sugary appearance.
2. Silcrete: is a silicified sediment, the quartz grains are usually set further apart within the cementing matrix, creating a peppery surface appearance.

The quartzite in this area varies considerably from relatively coarse-grained to fine-grained, and the silcrete generally occurs at the finer-grained end of the spectrum. This material typically fractures across the individual grains conchoidally, enabling a higher degree of control and predictability in knapping procedures (Andrefsky 1998:55–6).

In conjunction with the morphological characteristics of the various raw materials used in artefact production, the size and shape of the core are important considerations. These factors are directly related to the level of the force required for flake removal and the morphology of the flakes produced (Cotterell and Kamminga 1987:677–8; Kuhn 1995:32; Clarkson 2004:114; Webb and Domanski 2007; Orton 2008). There are 11 cores in the assemblage, comprising 4.8% of the artefactual material recorded. All of the cores on the Point Blane Peninsula are quartzite, the dominant raw material within the area. Table 3.13 presents the descriptive statistics for several variables recorded for the cores to assess the relative level of reduction. A mean weight of 15.91g, in conjunction with the low mean dimension values for cores, indicates a relatively small size for these artefacts. This is supported by the low range of core dimensions, at 10mm and 18mm difference between minimum and maximum measurements for length, width and thickness. Comparing the length and width measurements in Table 3.13 establishes the basic shape of the artefact. In this instance, length is divided by width to provide an elongation ratio. A mean elongation value of 1.11 indicates that, on average, the cores are relatively square. These dimension and shape attributes suggest a reasonable intensity of reduction for the cores from the assemblage, as the level of reduction should correlate with the low elongation value combined with the small, consistent length, width and thickness measurements.

Table 3.13: Descriptive statistics for quartzite core measurements.

	Descriptive Statistics	Weight (g)	Length (mm)	Width (mm)	Thickness (mm)
Quartzite Cores	Mean	15.91	21.36	22.42	18.12
	Median	13	19.35	21.82	15.14
	S.D.	7.78	3.74	9.64	7.77
	Min	7	18.02	10.14	10.1
	Max	31	28.2	45.62	29.35
	Range	24	10.18	35.48	19.25
	No.	11	11	11	11

Examining the number of core platforms and negative flake scarring also enables the intensity of use of this raw material to be examined. For example, once a platform angle becomes too high, or there are too many step-terminated flake scars, continued use of the artefact may only be possible with the creation of a new platform (Hiscock 1988; Clarkson 2004). The data presented in Table 3.14 indicate that variation in core rotation is minimal, ranging from no rotations (single platform) up to two rotations (three platforms), with the mean number of core platforms recorded at 2.18. Combined with the mean number of negative scars per core at 7.18, and the mean number of negative scars per platform at 3.55, these values indicate that these artefacts were worked consistently to a point where the removal of flakes no longer became viable, possibly due to the relatively small core size at the point of discard. This is supported by the percentage of remaining cortex on these cores. The amount of cortex on an artefact may be an indication of the level of reduction, where large amounts of cortex may be indicative of an early stage of reduction, and very little cortex may indicate a higher degree of reduction (Hiscock 1988:369; Clarkson 2004:114; Holdaway *et al.* 2004:50). All of the cores in this assemblage contained little to no cortex at all, with Type 2 (secondary) cortex on two cores, and Type 3 (tertiary) cortex on nine cores.

Table 3.14: Descriptive statistics for quartzite core platforms and negative scars.

	Descriptive Statistics	No. of Platforms	No. of Negative Scars	No. of Negative Scars per Platform
Quartzite Cores	Mean	2.18	7.18	3.55
	Median	2	7	3.33
	S.D.	0.6	2.64	1.97
	Min	1	3	1.5
	Max	3	12	9
	Range	2	9	7.5
	No.	11	11	11

Table 3.15: Descriptive statistics for quartzite and silcrete unretouched flakes.

		Weight (g)	Length (mm)	Width (mm)	Thickness (mm)	Elongation	Platform Area (mm²)	Platform Shape
Quartzite Unretouched	Mean	9.60	27.51	23.97	7.59	1.26	137.67	2.79
	Median	6.00	24.92	21.08	6.53	1.18	92.67	2.42
	S.D.	12.99	12.24	10.78	4.24	0.55	162.70	1.27
	Min	0.50	5.16	6.24	1.30	0.15	7.12	0.66
	Max	92.00	63.57	65.68	24.79	3.11	1229.45	7.49
	Range	91.50	58.41	59.44	23.49	2.97	1222.33	6.83
	Number	162	162	162	162	162	162	162
Silcrete Unretouched	Mean	10.22	28.77	25.35	7.19	1.17	120.76	3.83
	Median	7.50	24.36	25.03	5.76	1.04	93.54	3.29
	S.D.	6.89	14.63	7.70	3.98	0.48	108.99	1.80
	Min	2.00	14.95	11.08	2.38	0.63	6.21	1.84
	Max	24.00	78.25	40.92	16.09	2.51	355.84	8.68
	Range	22.00	63.30	29.84	13.71	1.88	349.63	6.84
	Number	18	18	18	18	18	18	18

Following on from the investigation of cores, the flakes in the area have been divided into unretouched and retouched categories. There are 182 unretouched flakes, comprising 73.4% of the assemblage (162 quartzite and 18 silcrete). The main attributes measured on the flakes from the assemblage give an indication of size and shape, with the addition of a platform shape index (platform length/platform width) (Table 3.15). Mean values for all dimensions and indices appear consistent between the two raw materials, enough so to suggest that although the number of quartzite artefacts outweighs the silcrete artefacts considerably, there are negligible differences in the intensity of reduction and the point of discard. As indicated by the mean dimension values, the size of the unretouched flakes are relatively small and square in shape, with low mean length, width and thickness measurements, and with the elongation and platform shape indices indicating a slightly longer than wide shape with a long and thin platform. As with the amount of cortex on cores, the majority of unretouched flakes contain very little to no cortex, with 99.4% of the assemblage containing either secondary or tertiary cortex. This pattern is consistent with that noted in the analysis of core reduction and rotation (Faulkner and Clarke 2009:23–4).

Regardless of the potential differences in the use of raw materials, the characterisation of the assemblage, the analysis and comparison of artefact sizes and raw materials suggests that while there was not a heavy reliance on stone artefacts, it does appear that the stone artefacts were reduced relatively intensively. In this area, where and when stone artefacts were required, the most important strategy appears to have involved keeping a supply of fresh edges where needed,

while at the same time extending the life of the raw material (Faulkner and Clarke 2009). This is a potentially important strategy as sources of reasonable quality stone are only available to a limited degree within the coastal plains of Blue Mud Bay.

Stone artefact distribution

The way that stone artefacts were distributed across the study area becomes important in terms of investigating past economic activity. This may indicate any differences in the focal point of raw material procurement relative to areas of artefact discard (for example Byrne 1980; Foley 1981a:11, 1981b; Isaac 1981; Hiscock 1984, 1994) as material can generally be expected to accumulate in those places that were used more often than locations used infrequently. Figure 3.12 shows the density of artefactual material across the study area with a contour interval of 10 artefacts, as well as the density of stone artefacts between two points across the Point Blane Peninsula (indicated as A and B) also graphed as another relative density measure. Disturbance or visibility factors aside, the higher artefact density on the eastern side of the Point Blane Peninsula is due to the central location of a quartzitic outcrop in this area. The density of material closer to the quartzite outcrop, therefore, illustrates the strong relationship between environmental features and the location of activities within the landscape (Hiscock 1989:22; Fanning and Holdaway 2001:669–70). Although there was no obvious stone working noted within the outcropping, combined with the fact that quartzite artefacts are dominant, this area is significant as it is the only source of flakeable stone located in the study area (Faulkner and Clarke 2009:24). As such, the fact that this exact location does not specifically contain evidence that it was used as a quarry may not be important (see for example Hiscock and Mitchell 1993:27; Ross *et al.* 2003). The distribution of artefacts within the study area is further analysed by testing the proposition that this outcrop was the central raw material procurement point for quartzite in the immediate area.

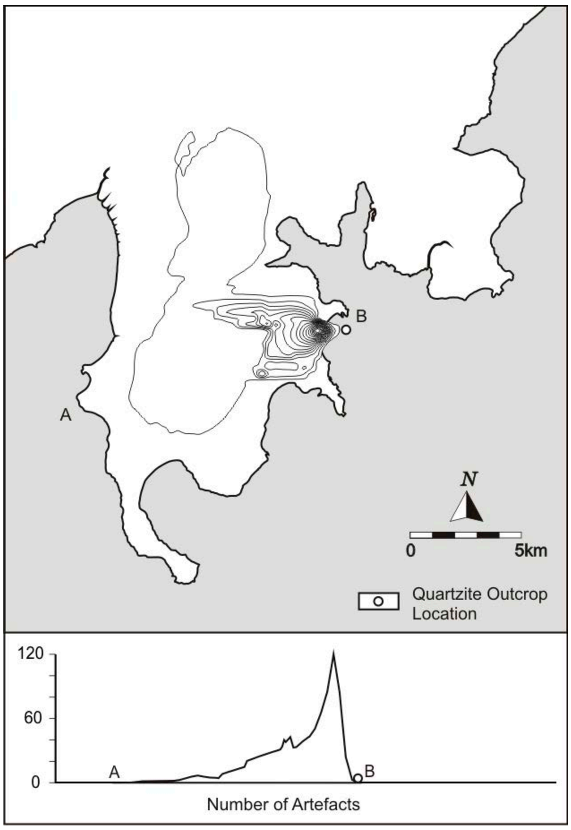

Figure 3.12: Stone artefact densities across the Point Blane Peninsula.

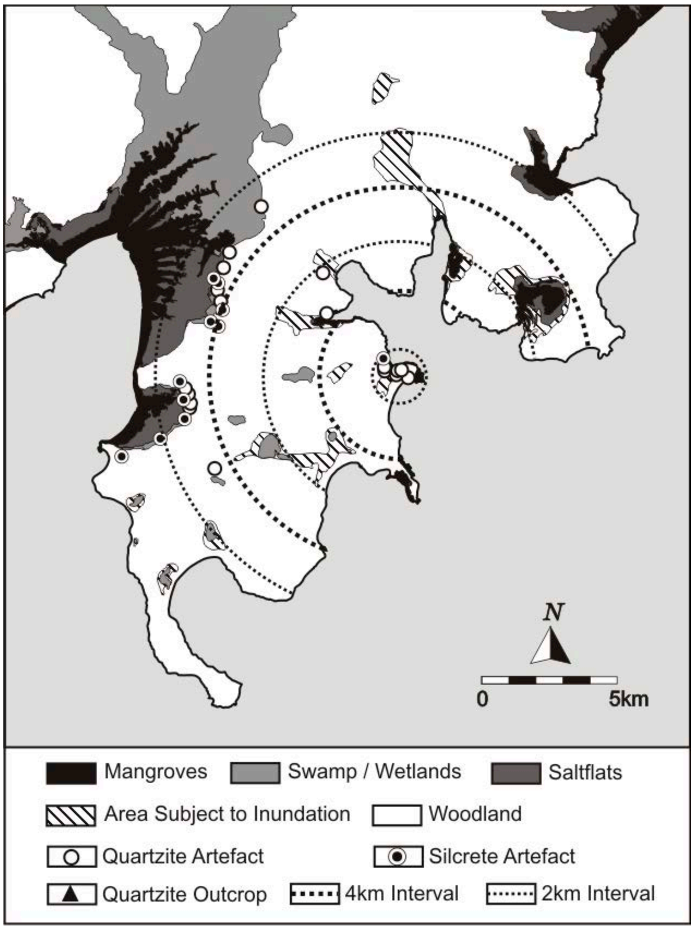

Figure 3.13: Location of quartzite and silcrete artefacts across the Point Blane Peninsula, with 2km (thin line) and 4km (thick line) intervals from quartzitic outcrop.

Source: Based on Baniyala 1:50 000 Topographic Map.

Figure 3.13 shows the location of quartzite and silcrete artefacts within 2 and 4km intervals from the quartzite outcrop, with Tables 3.16 and 3.17 detailing several site and artefact variables within these intervals for the quartzite and silcrete artefacts respectively. The number of quartzite artefacts per 2km interval shows a concentration of stone artefacts on the margins of the peninsula, particularly on the eastern side within the first 4km of the quartzite outcrop. All quartzite cores and retouched flakes occur within this area, with the only artefact classes occurring within all intervals being unretouched flakes and flaked pieces. This concentration of material within 4km of the outcrop does suggest that this area may have been a focal point for quartzite artefact manufacture and use. The dominance of unretouched flakes may indicate use of this raw material primarily at, or near to, the source as it was needed. This material was then transported across the study area away from the source location to much less of a degree (Faulkner and Clarke 2009:24–5).

Table 3.16: Quartzite artefact data at 4km intervals from quartzite outcrop.

Criteria	0 - 4km	4 - 8km	8 - 12km
No. of sites containing quartzite artefacts	6	2	10
No. of quartzite artefacts	197	2	20
No. of quartzite cores	11	--	--
No. of quartzite flaked pieces	37	--	3
No. of quartzite unretouched flakes	143	2	17
No. of quartzite retouched flakes	6	--	--

Table 3.17: Silcrete artefact data at 4km intervals from quartzite outcrop.

Criteria	0 - 4km	4 - 8km	8 - 12km
No. of sites containing silcrete artefacts	1	--	14
No. of silcrete artefacts	12	--	17
No. of silcrete cores	--	--	--
No. of silcrete flaked pieces	2	--	2
No. of silcrete unretouched flakes	9	--	9
No. of silcrete retouched flakes	1	--	3

Although occurring in considerably lower numbers, the silcrete artefacts present a similar distribution pattern to the quartzite unretouched flakes, with the material concentrated exclusively on the margins of the peninsula. In this case, silcrete artefacts occur only within 4km of the quartzite outcrop and at distances of 8km or greater. The same number of cores and unretouched flakes occur at both distances, with a single retouched flake within a 2km radius and three retouched flakes at 8km or greater. With similar numbers of silcrete artefacts occurring within the two areas, there does not appear to be preferential use of this material within any one area. To determine the significance of these distributional patterns, however, the size variables used previously per raw material for the unretouched flakes are assessed by distance from the outcropping. In this case, for comparative reasons the sites are grouped into 0 to 6km and 6 to 12km distance intervals. Due to the small sample size of silcrete unretouched flakes, only quartzite unretouched flakes have been included in this analysis. Descriptive statistics for size variables by raw material and 6km distance interval are listed in Table 3.18. Using length as an indication of artefact size, there is very little difference in mean dimensions between distance intervals, and as evidenced by the elongation ratios, little difference in the shape of the artefacts. Even though it has been shown that there are differences in the density of artefacts, it appears from the size and shape data that there is very little difference in the way the stone material was worked (Faulkner and Clarke 2009:25). That is, regardless of the distance from the source of the dominant raw material, the stone was worked intensively prior to discard.

Table 3.18: Descriptive statistics for quartzite unretouched flakes at 6km intervals from quartzite outcrop.

	Quartzite	Weight (g)	Length (mm)	Width (mm)	Thickness (mm)	Elongation	Platform Area (mm^2)	Platform Shape
0 - 6km	Mean	9.13	27.58	23.93	7.52	1.27	141.46	2.82
	Median	6.00	24.97	20.91	6.52	1.18	98.06	2.42
	S.D.	13.05	12.48	10.94	4.24	0.57	168.46	1.30
	Min	0.50	5.16	6.24	1.30	0.15	7.12	0.66
	Max	92.00	63.57	65.68	24.79	3.11	1229.45	7.49
	Range	91.50	58.41	59.44	23.49	2.97	1222.33	6.83
	No.	145	145	145	145	145	145	145
6 - 12km	Mean	11.41	26.65	22.62	7.50	1.21	95.05	2.52
	Median	7.00	22.33	20.84	6.08	1.12	66.02	2.21
	S.D.	11.51	10.97	8.77	4.05	0.30	87.54	1.03
	Min	1.00	13.45	10.78	2.74	0.74	10.24	1.32
	Max	42.00	49.75	36.98	15.39	1.83	352.94	5.38
	Range	41.00	36.30	26.20	12.65	1.09	342.70	4.06
	No.	17	17	17	17	17	17	17

The artefact assemblage in the study area is dominated by locally available raw materials, again indicating a focussed use of resources available within the immediate area. In addition, the size and shape of the artefacts, combined with little cortex being evident, suggests that people in this area were maximising or extending the use-life of stone due to its relative scarcity in the landscape (Dibble 1985; Bleed 1986; Kuhn 1992, 1995; Odell 1996; Brantingham *et al.* 2000:256–7; Bousman 2005:209; Faulkner and Clarke 2009:24–6). The interpretation of the artefactual assemblage in the study area only becomes significant when viewed as a part of the wider economic and settlement system (Binford 1980; Ugan *et al.* 2003:1325), particularly given the difficulty of deriving behavioural inferences from surface artefact scatters (Fanning and Holdaway 2001:669). With very little flakeable stone outcropping in this region of the coastal plain, the appropriate raw materials were intensively worked. This may be seen as an aspect of the 'maximising' strategy proposed above, with stone being worked in close proximity to the main source, and then distributed sparingly across the study area as required. Although a small sample, something that potentially reflects less of a need for stone artefacts in these kinds of coastal landscapes, this analysis provides an additional line of evidence for investigating past economic activity in this area. The area surrounding the quartzite outcrop north of the Yilpara community appears to have been the central procurement point for quartzite in the study area. Rather than the exposed outcrop being the specific source, it is this general locality that is of importance. It is possible that other outcrop locations have been exposed in the past, with the dynamic and changing nature of the coastline masking these locations. That is, other outcrops may have been worked in the past and covered with sand and sediment. The paucity of artefactual evidence within this region may also reflect a coastally oriented economy, particularly when viewed in conjunction with the distribution of shell material presented in the site section. The exploitation of near-shore resources such as shellfish and fish may not have required the intensive use of stone artefacts. This type of pattern has been noted in the past by Meehan (1982) and Bailey (1993:9), where relatively few or a limited range of stone artefacts may be discarded in localities where a limited range of economic activities may have been carried out, such as with shell-processing sites.

Conclusion

The nature of the north Australian coastline is fluid and dynamic, with elements of the archaeological record demonstrating that human behaviour was structured relative to these conditions. For example, maximum sea level is hypothesised to have occurred approximately 5000 years ago, following from which it has gradually subsided (with some variability through time), with stands of mangroves following in the wake of falling sea level, creating still, rich nearshore habitats that were suitable for colonisation by a range of molluscan taxa. The absence of archaeological evidence prior to 3000 BP in this area makes it difficult to accurately assess reasons for a possible time lag in occupation following sea level rise. There are, however, a number of possibilities for this pattern, including a lack of preservation of older sites in the area and/or a reorganisation of forager economies relative to changing marine environments during and after changes in sea level. Regardless of the reasons for the apparent lag in the visibility of archaeological evidence for occupation, the distribution and timing of shell mounds and middens in the study area virtually mirrors the process of the receding sea level and establishment of mangroves and shellbeds. At a broad level, they indicate a relatively long-term sequence of occupation and shellfish exploitation from 3000 years ago up to the present day. In combination with the midden sites, the stone artefact evidence suggests that resources were targeted and exploited in a highly localised and discrete pattern within the study area, across both time and space. Given these patterns, it is pertinent to investigate spatial and chronological patterns of resource exploitation in finer detail.