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## **Reaching the Potential: The Archaeological Evidence for Late Holocene Change and Variability**

The primary objective here has been to examine and explain the occurrence of coastal shell middens and mounds on the Point Blane Peninsula within a context of significant, broader environmental change and re-structuring of the regional resource base. Following from this, and given the archaeological evidence for economic reorganisation on the Point Blane Peninsula, this research has also aimed to characterise the nature and variability of this regional coastal economy. In fact, spatial and temporal variability defines human economic activity in this area during the late Holocene. Research conducted in other areas also provides an indication that this level of inter and intra-regional variation is a common feature of the archaeological record of coastal northern Australia. That said, the degree or extent of change and variability in human economic behaviour has often been underestimated in northern coastal Australia, particularly given the use of ethnographic data to interpret archaeological material. In comparison, here the interpretive framework for the variability observed in the coastal foraging economies of northern Australia is provided via the nature and timing of broader environmental, climatic and ecological changes. Within this framework, the archaeological evidence indicates that human/environmental interactions during this period were fluid in nature and complex, and in some respects of a magnitude greater than has previously been interpreted for other coastal regions.

### **Characterising late Holocene economic activity on the Point Blane Peninsula**

The archaeological record of the Point Blane Peninsula is characterised by a high level of variability through space and time, particularly in the intensity of resource exploitation, and in the use of a range of molluscan resources and habitat areas. Through time, much of this variability appears to relate to changes in the structure of the coastal environment, tied strongly to long-term processes of climatic and environmental alterations that were in operation throughout the Holocene (Faulkner 2011). As the study area is a peninsula, the dominant resources, particularly prior to the formation of the wetland areas via ongoing progradation and sedimentary infilling, were located within the coastal zone. Shell mounds and middens are located in the landscape in those areas where there would have been easy access to abundant and varied resources, often differentially available along the coastline (Bailey 1975a, 1983; McNiven 1992:498–9). Variability in the distribution of shell mounds and middens are apparent, mainly the contrast between the lower, horizontally spread midden sites found in Myaoola Bay, and the mounded shell deposits that

dominate the Grindall Bay landscape. This pattern relates to a number of factors. Firstly, it is a function of sea level regression and differential landscape changes in these areas, with processes of successive beach-ridge development and seaward sedimentation on the largely unprotected coast of Myaoola Bay, and the gradual progradation of the large sheltered embayment in Grindall Bay and subsequent wetland formation. Secondly, this pattern reflects behavioural factors relating to the density of resources within different localities, the intensity of resource use, and the pattern of refuse discard.

The distribution of sites combined with the available radiocarbon age determinations across the peninsula indicates that the sites documented in the area fall broadly within an age range between 2953 cal BP and the present. Within this age range, there appears to have been limited or low level use of this area prior to approximately 2500 BP, although this may relate to factors of site visibility and/or post-depositional destruction of archaeological material. Between 2287 and 526 cal BP, there was a phase of intensive occupation on the margin of Grindall Bay corresponding with a large number of mounded shell deposits. Within this period, there appears to be a decrease in the intensity of exploitation of *A. granosa*, and potentially a decrease in the level of occupation and site formation between 1009 to 584 cal BP. In addition to this, between 1310 and 1009 cal BP there appears to be a period of rebound or recovery in *A. granosa* populations with a subsequent decline. Evidence for occupation Myaoola Bay during this period is relatively limited until approximately 1115 cal BP. With the cessation of mound accumulation occurring around 526 cal BP, there was an increase in the evidence for occupation and resource use on the more exposed coastal margin of the peninsula (see also discussions in Bourke *et al.* 2007; Faulkner 2008, 2011, in press). Due to the abundance of surface and sub-surface water on the Point Blane Peninsula, at least on a seasonal basis, approximately 80% of sites in the area are located within 200m of freshwater, and all sites on the peninsula are located within a maximum 2km of water. Given that water was apparently readily accessible across the study area, therefore, other factors are more influential in determining site location and morphology, such as changes in the structure of the shoreline from maximum sea level highstand to the present, and the effect of this process on the dispersal of suitable habitats containing exploitable food resources. It is possible, however, that some of the variability in the use of the peninsula may relate to the differential availability of water through time (e.g. during drought conditions), in combination with other resources. Overall, the archaeological data from this area, particularly in combination with the environmental and climatic processes acting on the northern Australian coastline more broadly during the mid-to-late Holocene, suggests that there was an ongoing process of economic reorganisation relative to the abundance and availability of resources.

### **Chronological variation in mollusc and habitat exploitation**

Interpretations of coastal environmental or cultural change have been successfully derived from midden analysis, particularly relating to their influence on strategies of resource procurement, social organisation and population demography. These interpretations have been primarily based on perceptible changes in the relative frequency of molluscan taxa or rates of shell discard through time (e.g. Schrire 1982:233–4; O'Connor and Sullivan 1994:24; Allen and Barton n.d.:88, 104–6). Across the Point Blane Peninsula, the exploitation of molluscan resources varies both spatially and temporally to a considerable degree (Faulkner 2011). Variations in the pattern of molluscan species and habitat exploitation here relate to micro- and macro-environmental changes, with a definite contrast in the use of specific resources and habitats through time. This is evident in the high degree of species composition variability within the Myaoola Bay midden sites. Although a number of taxa were consistently exploited through time, such as *Marcia hiantina*, *Septifer bilocularis* and *Gafrarium* sp., differences in the relative abundance of these species within and between the sites on this margin of the peninsula appear to relate to the variable distribution and dominance of near-shore shallow water and mangrove habitats. Changes to

the environment are reflected in both species composition and the intensity of species exploitation, due to the fact that changing environmental conditions would undoubtedly have affected the range and density of species available for exploitation.

There was a relatively consistent use of the taxa recovered from the midden sites located in Myaoola Bay, with no one species being exploited at a level greater than 50% within these sites. In turn, chronological variations in the intensity of exploitation of taxa from different habitat zones are also explained by contrasting landscape structures. These differences reflect larger-scale environmental changes and landscape alteration on the exposed coastal margin of Myaoola Bay through time. For example, while there is only a minor decrease in the exploitation of species from the sand and mud flat areas, there is a marked overall decrease in the use of species from the hard-substrate, shallow water zone. The decline in species abundance from these habitats corresponds with an increase in mangrove species, particularly the exploitation of *Isognomon isognomon* in the more recent past. In contrast, the shell mound sites located on the margin of Grindall Bay exhibit much less variability in the relative abundance of both the dominant and sub-dominant species. The taxonomic composition from the mounds indicates a more intensive focus on one habitat zone and one particular species. While other species were exploited to varying degrees during the overall period of site formation in Grindall Bay, *Anadara granosa* is the most abundant species in all three of the shell mound sites investigated in detail, followed by *Mactra abbreviata* and *Marcia hiantina*, all three of which inhabit sand and mud flat areas. The other sub-dominant species present, the mangrove bivalve *Placuna placenta*, is found only within BMB/029 near the top of the sequence.

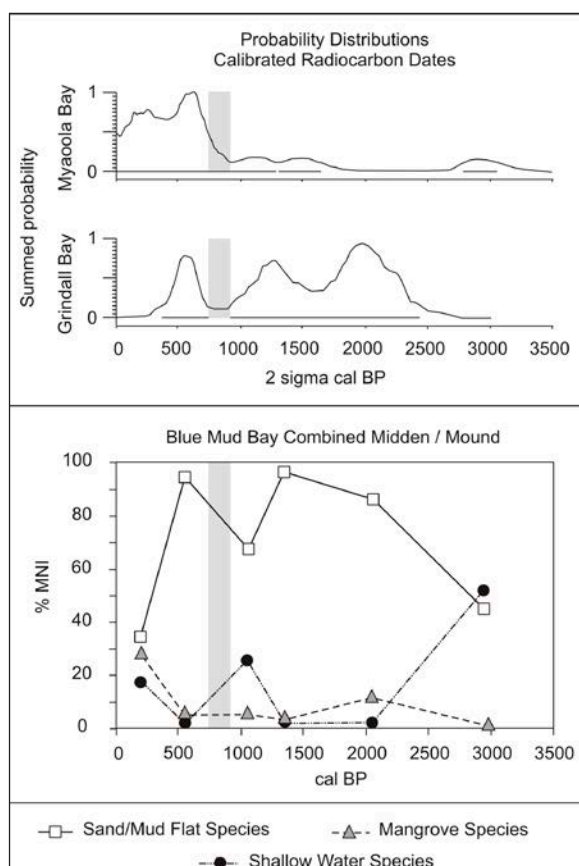


Figure 7.1: Chronological variation in the exploitation of mollusc species by habitat, with calibrated radiocarbon age summed probability plots for Myaoola and Grindall Bays (grey shading indicates phase of significant *A. granosa* size recovery in the Grindall Bay sites).

Source: Redrawn from Bourke *et al.* 2007; Faulkner 2011, in press.

The overall pattern of molluscan resource and habitat use on the Point Blane peninsula is as follows (Bourke *et al.* 2007:96; Faulkner 2011:147): prior to approximately 2500 BP there was a greater focus on the shallow water, near shore zone in conjunction with the sand and mud flats (Figure 7.1). Between approximately 2500 and 500 BP, and associated with the period of mound formation in the study area, there was an increasingly heavy reliance on species from the sand and mud flats relative to a decline in the relative abundance of species from the harder substrate, near shore areas. Depending on site location during this period there was a degree of variability in the use of species from the mangroves through time. Around 1000 BP there is a decline in sand/mudflat species with an associated increase in shallow water molluscs; however, this is more a reflection of the Myaoola Bay sites than the shell mounds of Grindall Bay. There was an increase in the use of mangrove species after approximately 500 BP, corresponding with a slight decline in exploitation of the sand and mud flats. In the Grindall Bay area in particular, these variations in habitat exploitation relate to the ongoing process of progradation, and the gradual establishment and proliferation of the sand/mud flat zone, often at the expense of exploitation within the mangroves. This pattern slowly changed as the process of progradation reached its limit within the area close to 500 years ago, with a slight decrease in sand/mud flat species corresponding with a slight increase in mangrove species. This final phase is likely to represent the relative stabilisation of the mangrove distribution close to its present extent at the mouth of Grindall Bay following long-term sedimentary infilling within the area. As such, the composition of the molluscan assemblages within the sites on the Point Blane Peninsula represents the long-term, average structure of mollusc communities in the area during the known period of occupation (see also Mowat 1995:153; Claassen 1998:134; Hiscock 1999:96; Bourke 2000:146).

Related to environmental changes linked to stabilisation and establishment of the coast following sea level rise, and patterns of progradation and sedimentary infill of shallow embayments across the Point Blane Peninsula, variability in molluscan exploitation through time is a reflection of the dynamic and changing nature of this coastline throughout the late Holocene (Bourke *et al.* 2007:96; Faulkner 2011:147). This illustrates the flexible nature of foraging behaviour on the coastal margins of this area, providing further support for the interpretation that people actively changed their foraging strategies to incorporate increasingly abundant or newly available species (Mowat 1995:163; Bourke *et al.* 2007). Similar patterns of shifting resource and habitat use relative to environmental changes have been observed between 1000 and 700 BP in other areas of northern Australia. In the Darwin region between approximately 2000 to 500 BP, midden and mound composition indicates that coastal foraging was focussed primarily on sand and mud flat habitats, with only minor exploitation of the mangroves. One hypothesis proposed for the cessation of mound formation in the area around 700 to 500 years ago is that it is associated with environmental change in shoreline characteristics at that time (Hiscock 1997, 1999). Hiscock (1997:447–9) has suggested that this particular economic system ceased approximately 700 years ago due to rapid environmental change, where mangroves expanded at the expense of other habitats, eventually leading to the disappearance of the productive *A. granosa* shell beds (Hiscock 1997:447–8, 1999:99). Further detailed research in the area by Bourke (2000, 2005) has reinforced this interpretation. Similar evidence for economic shifts relative to environmental change is also provided from the Blyth River region of northern central Arnhem Land via analysis of material excavated from the Ji-bena earth mound. Based on the available radiocarbon estimates, the period of deposition for this site spans the period between approximately 1000 and 500 BP (Brockwell *et al.* 2005:86). This site presently borders the large freshwater swamp of Balpilja near the mouth of the Blyth River, and based on geomorphological research undertaken in the area, this site is located on a prograded landscape that is no older than 2000 BP (Brockwell *et al.* 2005). Analysis of the Ji-bena earth mound material indicates that the dominant molluscan taxa exploited within the earlier phases of occupation within the Ji-bena earth mound were *Dosinia* sp. and *Mactra* sp.,

both of which inhabit sand and mud flats. During the last 1000 years, the relative abundance estimates of these species are greatly reduced, a decline that corresponds with the appearance and increasing abundance of freshwater turtle. In contrast with the patterns outlined for both Blue Mud Bay and Darwin Harbour, mangrove species were continually exploited throughout the history of the site, albeit to a reduced level within the upper excavation units. These changes have been related to the transition from estuarine to freshwater conditions in the area, marked by a possible reorganisation in foraging behaviour relative to the structure of the resource base (Brockwell *et al.* 2005).

### Mounding behaviour: social and environmental interpretations

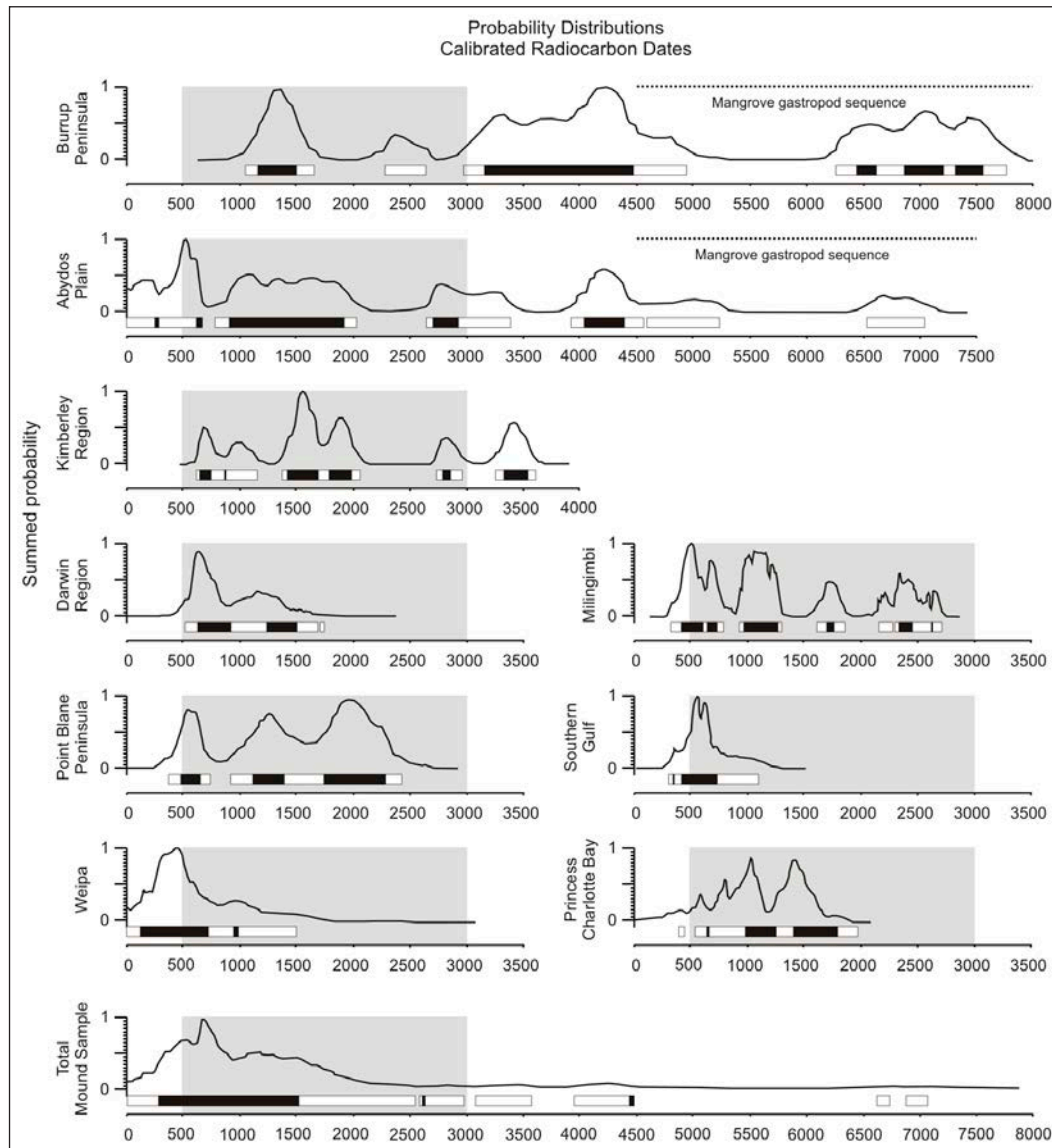


Figure 7.2: Comparison of the calibrated radiocarbon summed probability distributions (BP) from *Anadara granosa* dominated mound deposits in coastal regions across northern Australia (grey shading indicates principal phase of mound formation).

In explaining long-term economic change, and particularly where the aim is to gain an insight into *A. granosa* mound formation, the focus of research needs to be placed on the analysis of trends in prehistoric resource exploitation through time. What is required in an archaeological study of



this type, therefore, is the analysis of relative changes in patterns of resource exploitation and their relationship to environmental factors (Bailey 1981a:13). While ideally this should be based on localised changes in the environment, in the absence of detailed local palaeoenvironmental data, information from the broader north Australian and Indo-Pacific region is used to contextualise regional variation in the nature and timing of resource exploitation. It has been suggested that the main period of *A. granosa* dominated shell mound formation across northern Australia is chronologically confined to the period between approximately 3000–2000 BP and 800–500 BP (Hiscock and Faulkner 2006; Hiscock 2008; Brockwell *et al.* 2009; Faulkner 2009). A sample of 223 radiocarbon determinations from 121 shell mound sites situated in various locations across northern Australia (see Figure 7.2) are presented here to further investigate this chronological patterning, particularly relative to broadly known environmental changes during the mid-to-late Holocene. All the radiocarbon determinations are from *A. granosa* dominated shell mounds, and have been calibrated using CALIB 6.1.1 in order to ensure a robust comparison across broad regions. The currently available subregional  $\Delta R$  values for these north Australian areas have been applied in calibration, with a value of  $12 \pm 7$  for Princess Charlotte Bay (Ulm 2006b),  $74 \pm 78$  for Weipa and the Southern Gulf (Ulm *et al.* 2010a),  $55 \pm 98$  for Blue Mud Bay (Ulm 2006b),  $65 \pm 24$  for Milngimbi and the Darwin Region (Brockwell *et al.* 2009),  $58 \pm 17$  for the Kimberley (O'Connor *et al.* 2010), and  $70 \pm 70$  for the Pilbara (Ulm 2006b). The probabilities for each location have been ranked and summed to find the  $1\sigma$  (68.3%) and  $2\sigma$  (95.4%) confidence intervals and the relative areas under the probability curve, with the total area under the probability curve normalised to one (e.g. Brockwell *et al.* 2009).

The patterns presented here, with regional chronological variability, confirm that the dominant phase of *A. granosa* shell mound formation across much of northern Australia occurs largely within the 3000 to 500 cal BP period. The chronological patterns currently available from the Darwin region, Milngimbi and Blue Mud Bay all fall neatly within this time period. From the southern coast of the Gulf of Carpentaria, specifically the Barbara Cove Mound on the Edward Pellew Islands and Bayley Point Mound on the mainland near Doomadgee (Robins *et al.* 1998; Sim and Wallis 2008), and Princess Charlotte Bay in north Queensland (Beaton 1985; Ulm and Reid 2000) there is some evidence from age determinations for mound formation after approximately 500 cal BP, although this is minor in terms of the overall distribution from both areas in addition to inherent error ranges in radiocarbon calibration. The sequences from Western Australia (the Burrup, Abydos Plain and Kimberley regions) demonstrate longer sequences, although the greater antiquity in these sites generally reflects the transition within the same sites from the mangrove gastropod *Terebralia* or *Telescopium* spp. dominated assemblages of the early Holocene (8000 to 6000 cal BP) to overlying *A. granosa* mounded deposits of the mid-to-late Holocene (after 4500 cal BP) (Clune and Harrison 2009). For Western Australia, O'Connor (1999) has highlighted a shifting chronological pattern, whereby a gradation in dates for the *A. granosa* dominated portions of the deposits move north along the coast, with a decline in mound formation around 1000 cal BP (O'Connor 1999; Clune 2002). Recently, Harrison (2009) has argued that mounds on the Abydos Plain near Port Hedland continued to be formed into the more recent past; however the anthropogenic origin of these deposits is ambiguous (see Sullivan *et al.* 2011). As noted above, the appearance of *A. granosa* mounds in the mid-to-late Holocene appears to relate to environmental change, with a shift in diet relative to habitat formation and/or replacement from mangrove-dominated shorelines (Burns 1994:10; O'Connor 1999; although see Veitch 1999a for a contrasting social argument). The Weipa area presents a markedly different chronological pattern in comparison with the other north Australian coastal regions (Morrison 2010). There is a major peak centred on 500 cal BP, with a significant proportion of the calibrated age ranges extending into the last 500 years. It has previously been argued that the cessation of shell mound formation across the north of Australia occurred between 800 and 500 years

ago due to changing environmental and ecological conditions becoming less favourable for *A. granosa* (Hiscock and Faulkner 2006; Hiscock 2008; Brockwell *et al.* 2009; Faulkner 2009). In response, it has been suggested that this generalised explanation is less applicable when focussing on specific regions across north Australia, with particular reference to the patterns seen within the Weipa area (Shiner and Morrison 2009:53–54; Morrison 2010; Ulm 2011). This is undoubtedly the case given the recent chronological evidence provided by Morrison's (2010) research. The localised persistence of habitats suitable for *A. granosa* within the Weipa area may go some way to explaining this distinct chronological pattern.

Even given the variability in regional chronologies exhibited in the Western Australian and Weipa sites, the major period of mound formation across the northern coast occurs between 3000 and 500 years ago. With broadly similar patterns of foraging reorganisation occurring in widely separated geographic areas, it would appear that broader scale processes of environmental change were indeed one of the primary causes behind economic change on the coast of northern Australia during the late Holocene (see Figure 7.3). While there are regional differences in the timing and nature of late Holocene changes in the coastal foraging economy, this almost certainly relates to localised environmental conditions occurring within broader patterns of climatic and environmental change. In general, however, there appears to be a strong correlation between shifting patterns in human economic activity relative to overall Holocene climatic and environmental parameters across northern Australia (O'Connor 1999; Faulkner 2006; Bourke *et al.* 2007; Morrison 2010). The timing of mound deposition across much of northern Australia, with those exceptions noted here, varies to only a minor degree. This suggests that the timing and nature of sand and mud flat development, creating suitable habitats for the proliferation of molluscan species, in particular *A. granosa*, occurred in broadly similar ways. There are a number of optimal environmental conditions required for the establishment and proliferation of *Anadara granosa* shell beds (see also discussion in Bourke *et al.* 2007). This species naturally occurs in large estuarine mudflats that are bordered on the landward margin by mangrove forests. It thrives within the comparatively calm conditions afforded by shallow inlets or bays, particularly with a sub-stratum of fine, soft, flocculent mud (Pathansali and Soong 1958:27). The three most important factors for shell bed establishment are the nature of the substrate, salinity levels, and slope of bed. The optimal habitat for *A. granosa* needs to be protected from strong wave action, and situated outside the mouth of estuaries and tidal creeks, with a salinity range between 18 to 30 parts per thousand (Pathansali 1966:91). Following the marine transgression, more extensive mangrove forests developed on low relief shorelines bordering estuaries and tidal flats within broad shallow embayments (Woodroffe *et al.* 1986, 1988). Regardless of the timing and extent of this phase across northern Australia, the structure of environments within these embayments was broadly similar. While sedimentation continued throughout this phase, with the cessation of the large mangrove swamps and the transition into the sinuous phase of progradation along the river systems, the level of coastal progradation appears to have accelerated markedly between approximately 4000 and 2000 BP (Woodroffe *et al.* 1986). In combination with the slow pattern of sea level recession, continued fluvial and marine sedimentation within these former shallow embayments provided the intertidal mudflats suitable for *A. granosa* shell beds. On the Point Blane Peninsula, based on the radiocarbon estimates from the two sites located within the most northerly cluster of mounds closest to the mouth of the Dhuruputjpi River in Grindall Bay, the establishment of the appropriate habitats and of the *A. granosa* shell beds likely occurred at approximately 2500 BP. Significantly, this approximate age is the same as that proposed for the Darwin Region by Bourke (2000:325).

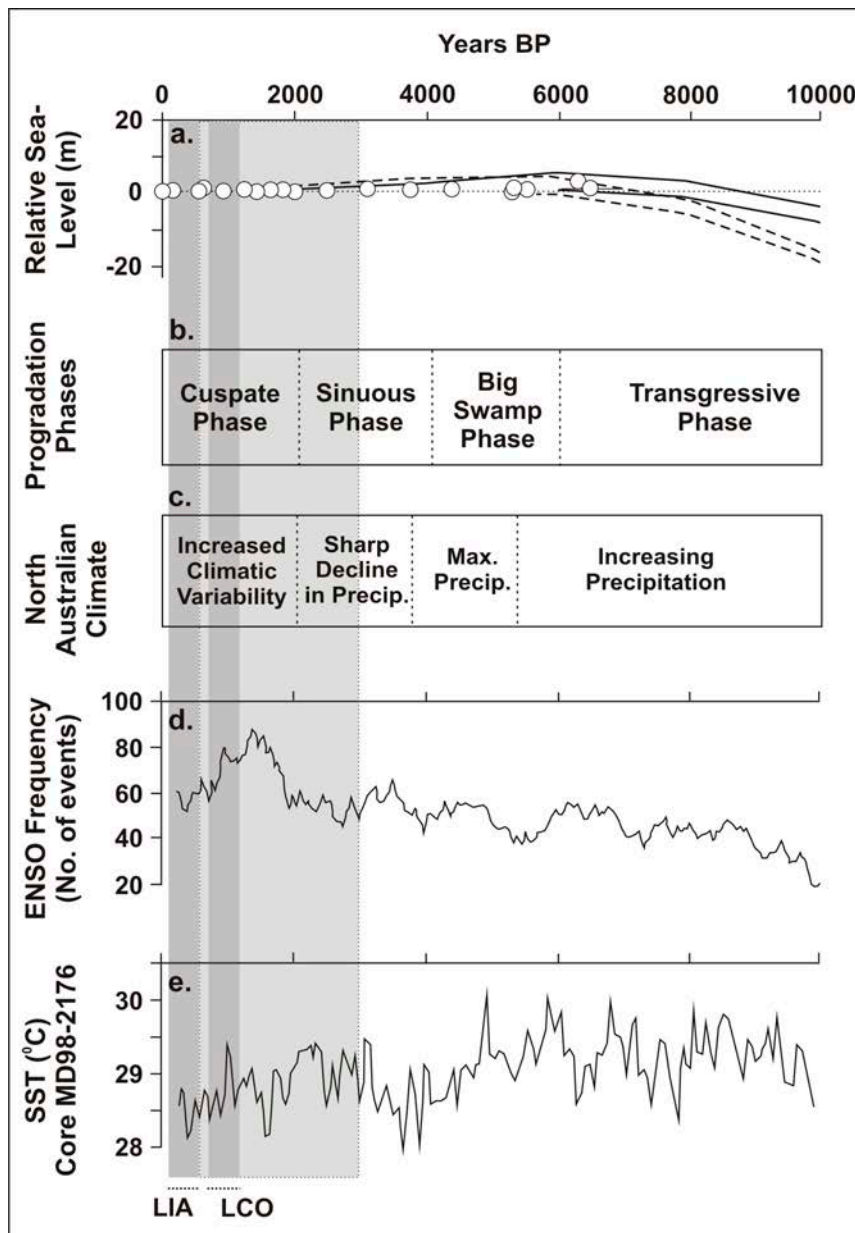


Figure 7.3: Holocene palaeoenvironmental patterns for Australasia and the Indo-Pacific contrasted with the major period of mound formation (3000 to 500 BP) across northern Australia; darker grey shading indicates Little Ice Age and Little Climatic Optimum.

Source: Data derived from: (a) Nakiboglu *et al.* 1983; (b) Woodroffe *et al.* 1986; (c) Shulmeister 1992, 1999; (d) Gagan *et al.* 2004; (e) Brijker *et al.* 2007.

These broad environmental patterns help to define the reasons for the appearance of *A. granosa*, and by extension the appearance of mounds, across northern Australia. A similar line of evidence can be used to explain the variations in the use of the Point Blane Peninsula highlighted by the radiocarbon estimates, site morphology and distribution, and differential use of resources through time. The general climatic pattern suggests that following the period of maximum effective precipitation between approximately 5000 and 3500 BP, often referred to as the Holocene environmental optimum (Kershaw 1983, 1995; Gagan *et al.* 1994; Shulmeister 1999:83; Gagan and Chappell 2000:44), there was a period of reduced interannual variability and a sharp decline in effective precipitation, beginning around 3500 BP and ending somewhere between 2500 and 2000 BP (Chappell 2001:177). There is also a body of evidence in support of high variability in



late Holocene precipitation across north Australia (Clarke *et al.* 1979; Lees *et al.* 1990; Shulmeister 1992; Shulmeister and Lees 1992). Interestingly, the major period of mound building on the Point Blane Peninsula falls within the period of increased climatic variability between 2500 BP and the present, following the sharp reduction in effective precipitation. While perhaps not being a major reason for the intensive use of *A. granosa*, the mass collection of this resource may have helped to buffer coastal populations against climatic instability during this time. Within this late Holocene period of climatic variability, spanning the period from 2500–2000 BP to the present, there appear to be several punctuated phases of rapid climatic change, as well as higher levels of aridity in tropical areas (between approximately 1200 and 1000 BP, and 600 to 150 BP). This period of higher aridity is supported by a peak in ENSO activity between 1500 and 1000 BP (Gagan *et al.* 2004:135; Jones and Mann 2004). These two late Holocene phases of climate change correspond with several possible phases of behavioural change noted in the archaeological record on the Point Blane Peninsula (Bourke *et al.* 2007; Faulkner in press). There is evidence for a warm dry (relative to today) period about 1200 to 700 BP in low latitudes named the Little Climatic Optimum (or Medieval Warm Period), followed by a period of anomalously cold, dry conditions referred to as the Little Ice Age between approximately 600 to 100 BP (Nunn 2000:716). Following a phase of a higher climatic instability and aridity between 1200 and 1000 BP, the transition between the Little Climatic Optimum and the Little Ice Age was marked by rapid cooling and two stages of sea level fall throughout the Pacific Basin at approximately 650 BP and 500 BP (Nunn 1998, 2000). The changes noted in resource use and the potential decrease in occupation intensity in Grindall Bay occurs between approximately 1009 and 584 cal BP. Importantly, Hendy *et al.* (2002) have also suggested that conditions in the tropical southwest Pacific during the Little Ice Age were consistently more saline than present, largely between approximately 500 and 200 BP. There are a number of implications for this pattern relative to the evidence of *A. granosa* valve size and possible decrease in economic activity in Grindall Bay. Rapid climate change may well have adversely affected the *A. granosa* shell beds by altering the environmental parameters for optimal habitat conditions, which at best would have decreased their productivity and viability in conjunction with the patterns of long-term intensive exploitation previously outlined, and at worst destroyed the shell beds entirely. In addition, an increase in aridity may have affected the distribution and availability of freshwater within the study area, which may have contributed to the need for economic reorganisation during this phase.

Between 584 and 526 cal BP, there is a clear period of *A. granosa* population rebound/recovery and proliferation in the area, corresponding with a final phase of intensive exploitation and mound building. A similar argument to that presented above for the commencement of mound building across northern Australia is suggested here for the cessation of mound building on the Point Blane Peninsula. Changes in environmental and climatic conditions approximately 800 to 500 years ago, depending on regional variation in the timing of these changes, correlates with the cessation of mound building across several north Australian coastal areas. The termination of mounding on the Point Blane Peninsula relates to the effective removal of suitable habitats for *A. granosa*, a change that resulted in this species either disappearing entirely, or occurring in very low densities in northern Australia as seen at present (Bourke *et al.* 2007). There are a number of interrelated environmental and climatic factors that contributed to the disappearance of the habitats and conditions suitable for the *A. granosa* biomass at this time. As noted by Bourke *et al.* (2007:97) continuing processes of sedimentation would have gradually changed the gradient of the coastal plain, eventually reducing tidal inundation and freshwater input (Woodroffe *et al.* 1986), leading to changing conditions for *A. granosa* (see also Chappell and Grindrod 1984; Beaton 1985 and Bailey 1999 for similar arguments). A further factor that may explain the decline of *A. granosa* is the sustained accretion of the mudflats and subsequent colonisation by mangroves, increasing the elevation of the substratum and gradually isolating the shell beds

from tidal movement (Macintosh 1982:13). There also appear to have been changes in sea levels and salinity levels at this time that would have had a significant impact on the large *A. granosa* beds. The effects of these climatic changes do not appear to have been geographically limited, as distinct cultural changes have been observed across a number of other areas worldwide. These changes include variability in population growth, population dislocations and changes in settlement patterns, urban abandonment, state collapse, increasing conflict and the cessation of long-distance trade (e.g. Larson and Michaelsen 1990; Raab and Larson 1997; Jones *et al.* 1999; Nunn 2000, 2003; de Menocal 2001; Field 2004; Bourke *et al.* 2007). This evidence contradicts the idea that there is little significant correlation between environmental change and changes in the Holocene archaeological record (e.g. Barker 1999:120), and these examples reinforce the notion that there are significant implications of environmental and climatic change for human behaviour, particularly when viewed as an interactive process. These patterns of change through time also have implications for previous interpretations of the role of mounds in the structure of coastal economies, the intensity of molluscan resource exploitation, and potential variability in population size and levels of mobility.

While a number of hypotheses have been suggested to explain the construction of shell mounds across northern Australia, particularly contrasting arguments over low-level economic (Jones 1975:25; Bailey 1975a, 1983, 1994, 1999; Cribb 1996; Bourke 2000) or higher-intensity ceremonial causes for this behaviour (Bourke 2000, 2002, 2005; Morrison 2003; Clune and Harrison 2009), these explanations have largely been based on directly interpreting these sites with the use of ethnographies. Much of this work has used data on human behaviour derived from the ethnoarchaeological research of Meehan (1982) in northern-central Arnhem Land. This direct application of more recent observations of foraging behaviour can be problematic in this context, as *A. granosa*-dominated shell mounds do not correspond with any one of the midden types defined by Meehan (1982:168), a factor she herself noted in her discussion of the shell mounds in the Blyth River region. In addition, the interpretation of mound sites as reflecting ceremonial activity relies heavily on the ethnographic data for large-scale social gatherings in northern Australia drawn from a relatively wide area, as well as perceived differences in the cultural rules of discard (see for example Frazer 1937; Thomson 1949; Warner 1969; Elkin 1978). These arguments have drawn on historical and anthropological descriptions of Aboriginal peoples' perception of place and their connection to religious and political beliefs (Hiscock and Faulkner 2006). The analogous use of post-contact ethnographic records in this way heavily implies that there were several thousand years of cultural continuity across much of northern Australia, although it should be noted that based on Morrison's (2010) research, the Weipa patterns may suggest otherwise for that region. If this were true, then why is it that very few of the explanations offered by Indigenous people for these sites relate to ceremonial activity? Furthermore, if the construction of these sites was the result of widespread large-scale ceremonial activity, how can we account for the high degree of variability in the explanations that have been provided? In fact, the structure of the environment and differences in the availability and abundance of resources prior to this time may preclude the direct use of ethnographic analogy, particularly in many of the regions in which shell mounds occur. This is largely due to the fact that economic behaviours, as observed ethnographically, are based on the contemporary structure of the environment and climate, and particularly on recent patterns of seasonal resource density and availability.

Further to the issue regarding ceremonial arguments for shell mound formation, these kinds of interpretations often refer to the observations of Meehan (1982:66) and Warner (1969:463) regarding a relationship between intensified periods of mollusc harvesting and ceremonial activities. These observations have been cited by Bourke (2005), Clune and Harrison (2009). Morrison (2003) and Harrison (2009) in support of the interpretation of large, single species

shell mounds as sites associated with ceremonial gatherings. The lack of species diversity in the *A. granosa* mounds is used as evidence to support the suggestion that shell mound composition should be more variable, incorporating a wider range of marine and terrestrial resources, if occupation was longer-term in nature. This argument essentially hinges predominantly on the position that *A. granosa* was not seasonally available in large numbers. Therefore if mound formation occurred over longer periods of time, then taxonomic composition would be more variable due to seasonal changes in *A. granosa* availability in the local environment, in combination with associated shifts in exploitation strategies (Morrison 2003:2; Harrison 2009:73). It is important to note that while Meehan (1982) does indicate an increase in mollusc harvesting during ceremonial gatherings, she also makes the point that, even in the recent past in the Blyth River area, *A. granosa* continued to be collected throughout the year and served as a staple resource (Meehan 1982:77). With reference to the relative proportion of mollusc species and morphological differences between the more recent horizontally spread middens and prehistoric mounded deposits, Meehan (1982:117, 168) also suggests that the mounds actually reflect different foraging behaviours to those seen ethnographically. In some respects, these differences have also been highlighted by Bourke (2000:282) in noting that the absence of specific resources from mound sites, such as dugong, turtle and magpie geese, may be due to the unsuitability of local environmental conditions for these animals at the time that the mound deposits were formed.

Importantly, Todd (1991:232) has noted that differences in seasonal resource structures in the past may well have permitted systems of use by humans that were very different from those employed later and documented ethnographically. This also relates to changing environmental conditions, particularly long-term patterns of change. Based on the archaeological data obtained from the shell mounds on the Point Blane Peninsula, an alternative hypothesis can therefore be proposed, whereby coastal foragers operated within a distinctly different economic pattern during the period of *A. granosa* mound accumulation to that seen historically, with medium-sized groups of people regularly and intensively exploiting shell beds. This model is based on the inter- and intra-site chronological patterns, the observed differences in site density and morphology, and the focussed and intensive exploitation of *A. granosa* over a long period of time (e.g. Hiscock 2008; Faulkner 2009, in press). An alternative suggestion, therefore, is that the observable differences between shell mounds and ethnographically observed foraging behaviour, patterns of discard and site function, and the resultant patterning of cultural midden material within the landscape relates to variability in settlement strategies and resource exploitation, patterns of mobility and population size between the pre-contact and historic periods. These differences are masked to a certain degree where the ethnographies are relied upon to interpret mound deposits, and where it is assumed that patterns of settlement, resource exploitation, levels of mobility and population size have been constant through time. The archaeological evidence from the Point Blane Peninsula suggests that the shell mounds within the study area are not consistent with either continuous low-level harvesting or sporadic high intensity harvesting of *A. granosa*, but in drawing in the evidence from non-mounded shell deposits, are instead more indicative of long-term, focussed and intensive resource exploitation and occupation. More broadly, the variability across the peninsula suggests that the identified occupation phases may relate to the differential and localised availability of other resources in the area through time, particularly water and vegetable foods. This is particularly relevant given the increase in ENSO activity and associated variability in precipitation within the last 3000 years. These interpretations potentially indicate a more constant, intensive exploitation of this resource than observed in the recent past (as also suggested by Clune 2002 and more recently Morrison 2010).

The various suggestions relating to mounding behaviour, particularly the contrasting interpretations of ceremonial activity, low-level economic or the suggestion made here of focussed

and intensive exploitation, can be assessed relative to the intensity of foraging and shell size variability. Unfortunately, other than research undertaken in the Darwin and Weipa regions, few detailed metrical studies on *A. granosa* from shell mound deposits are available to form a comparison with the data outlined here. Seasonal, low-intensity economic exploitation by small mobile groups and relatively sporadic, higher-intensity foraging by large groups for ceremonial purposes (although Harrison and Clune 2009 suggest annual harvesting) would place a certain amount of pressure on the natural *A. granosa* populations. The expectation would be that we would see indications of resource depression within single deposits, but not over the longer-term pattern as populations would be able to recover due to the high fecundity and recruitment rates characteristic of *A. granosa*. Patterns of intra-site valve size decrease in the Darwin region mounds have been interpreted by Bourke (2000, 2002) as reflecting predation pressure during individual site formation, although not to the point where there was a long-term impact on the shell beds. For the Kwamter mound site in Weipa, north Queensland, Bailey (1993:10) interprets the size frequency pattern as showing no evidence of sustained size decrease typical of over-exploitation, and therefore concludes that the archaeological samples are reflective of a mollusc population subjected to continuous, but not overly excessive, levels of human predation. The Kwamter data is based on a total site pattern, and while it indicates a population subject to human harvesting, size-frequency data presented at such a coarse scale does not allow for detailed evaluation of variability in valve size through time. For this particular species, the longer-term patterns are essential for assessing potential resource depression given high fecundity (see Faulkner 2009 and in press for this argument regarding longer-term analysis of *A. granosa* human predation). Data obtained from the base, middle and surface of the Hope Inlet mound deposits provides more information on valve size variability (Bourke 2000, 2002). When ordered chronologically, these data indicate a significant decline in mean valve length from 35 to 30mm during the earlier phase ( $t = 780.71$ ,  $d.f. = 2519$ ,  $p < 0.001$ ), followed by a period of relative stability with mean lengths of approximately 30mm. Following a period of possible population recovery, there is a subsequent significant decline in size to approximately 500 BP ( $t = -312.19$ ,  $d.f. = 1413$ ,  $p < 0.001$ ), when mounding appears to cease in the region. These patterns are similar in many respects to that seen on the Point Blane Peninsula, and would appear to indicate significant predation pressure throughout these sequences. The suggestion here is not that all regions containing *A. granosa*-dominated mounds will demonstrate the same patterns as presented in these analyses, but rather that metrical analyses need to be considered in detail as a possible way to disentangle aspects of human behaviour that may be related to variability in exploitation intensity.

### **The role of molluscs in coastal economies**

Following from the final point made above, one issue that has divided most researchers investigating coastal hunter-gatherer economies is the value of coastal resources and habitats to human populations, particularly the importance of molluscan resources in the diet. The vast quantities of shell that are sometimes found in archaeological deposits, in addition to apparent abundance and ease of collection of marine molluscs, have stimulated interest in the place of these resources in human economies. For example, in interpreting shell deposits in the archaeological record, some researchers proposed that coastal habitats were only rich on a seasonal basis, and that despite representing large volumes of material archaeologically, molluscan resources may only represent a minor, if regular and seasonally reliable, portion of the diet (Bailey 1975a, 1975b; Cohen 1977; Meehan 1977, 1982; Osborn 1977; Parkington 1981; Beaton 1985). Following this position, others (most notably Perlman 1980; Yesner 1980; Rowly-Conwy 1983; Erlandson



1988, 1994) have suggested that coastal resources, and particularly molluscs, played a highly significant dietary role, and may have been 'protein staples' when other meat was unavailable, predominantly in areas with carbohydrate-rich plant food.

There are a number of difficulties involved in assessing the role of molluscan resources in human diets. As noted by Newsome *et al.* (2004:1102), inherent sampling and preservational biases make it difficult to quantify past human diets, especially in coastal areas where people had access to a wide range of marine and terrestrial food sources. In many cases, only a small sample of the site is excavated, providing a relatively limited representation of the range and/or quantity of faunal material (Mannino and Thomas 2002:465). Based on preservational factors, it is also often assumed that the dominance of molluscs in midden deposits signifies a gross over-representation of their dietary importance, with other non-molluscan faunal material being substantially under-represented (Hobson and Collier 1984; Bourke 2000:256; and discussions in Collier and Hobson 1987). While it is difficult to estimate from the archaeological data the relative contribution of molluscan and non-molluscan resources, it is still possible to investigate patterns of resource use and suggest possible interpretations based on the data at hand. The relative absence of non-molluscan fauna recovered from the excavated sites on the Point Blane Peninsula has been interpreted in economic terms here as reflecting a foraging pattern focussed on the exploitation and discard of molluscs. While this pattern may be a product of differential preservation or issues of sample recovery, the comparative lack of fauna, particularly terrestrial fauna (other than reptile), on the Point Blane Peninsula, can also be explained as a product of differential landscape and resource structure. As the study area is a peninsula, the dominant resources, particularly prior to the formation of the wetland areas, were located within the coastal zone. Interpretations presented for the Darwin region contrast with this idea (Bourke 2000:251), however it must be noted that this region would have contained a greater variety of habitats, and by extension a greater variety of available faunal resources. Bourke (2000:256–7) also suggests that the presence and range of non-molluscan faunal remains in the Darwin region sites indicates that a wide range of resources were clearly exploited, albeit resources that are much less visible archaeologically. Further to this point, given the probable level of preservation and bone decay, she proposed that these data approximate the ethnographically recorded economies of northern Australia. Bourke suggested that the data does not support the notion that the function of these deposits solely reflects the gathering and cooking of molluscs, and that the range of faunal remains in each site suggests a home-base aspect, similar to that proposed by Meehan (1982, 1988a). While the range of non-molluscan fauna present in the Darwin Harbour mound sites are consistent with the type of resources exploited ethnographically, the relative quantities, or proportions, are not. The values reported for that region are similar to those reported for the sites on the Point Blane Peninsula (see Chapter 4).

Even given that vertebrate fauna may well be under-represented in midden and mound deposits, they do appear to form a particularly minor component of the excavated assemblages from the Point Blane Peninsula. As has been posited by a number of other researchers for Australian contexts (e.g. Walters *et al.* 1987:92; McNiven 1989:46; Morrison 2010:308–9) it is suggested here that the paucity of vertebrate remains in the shell deposits from the Point Blane Peninsula cannot be explained by taphonomic factors or recovery processes alone (see Chapters 3 and 4), but is more likely to be a reflection of a limited range of subsistence activities. This interpretation, principally regarding the *A. granosa* shell mounds and as discussed in Chapter 4, is also supported by similar observations from mounds noted in other regions, particularly with the work of Morrison (2010) and Veitch (1996). While differential preservation is undoubtedly a contributing factor in combination with the analysis of only the 6mm residue in this study, the comparative lack of hard skeletal elements, such as teeth or otoliths, suggests that vertebrate fauna may not have been as



an important part of coastal economies compared with the more recent past. This is particularly relevant for the period of mound formation in northern Australia, and has implications for the use of ethnographic data to infer dietary contributions. One of the main discrepancies between the ethnographic and archaeological records is the change in shell discard patterns over time. The ethnographies suggest a change in practices of shell discard from mollusc consumption, resulting in low, horizontally spread out middens rather than the large shell mounds that accumulated before living memory (Bourke 2000:280, 2005:40). Similar differences between the ethnographic and archaeological records have been reported from the Pacific Coast of North America. Based on these data, it has been suggested that it is not appropriate to use ethnographic models to uncritically interpret data from prehistoric sites, and that the differences observed between the ethnographic and archaeological datasets have implications for models of subsistence practice, settlement patterns and seasonal rounds (Moss and Erlandson 1995:29).

Based on this and previous discussions relating to environmental change and variability in the use of resources and habitats, it is highly likely that the contribution of molluscs to the economy follows no single pattern. In fact, the emphasis on molluscan resources probably varied considerably through time and space, and at inter- and intra-regional levels (see for example Erlandson 1988:107; Jones 1991:429, 436; Yesner *et al.* 2003:289; Jerardino 2010). In general terms, the archaeological data from the Point Blane Peninsula suggest that there were quite dramatic differences in the use of resources through time. The period between 2287 and 526 cal BP appears to have been one of quite intensive molluscan exploitation, as evidenced by the spatial and chronological density of shell mounds in the area. After 526 cal BP, with the disappearance of suitable habitats for *A. granosa* in the area, the structure of the economy appears to more closely approximate that of the pre-contact period directly preceding the period during which the historic evidence and ethnographic records were derived, with a decreased use of molluscs evidenced by changes in shell discard practices and habitat use. As observed by Bailey (1975b:45), it is quite clear that the occurrence of large shell mounds alone cannot be taken as sufficient evidence either of prolonged occupation, or an annual economy primarily dependent on molluscs. On the other hand, ecological data suggest that molluscs, and particularly bivalves, are capable of yielding very high output under specific conditions. The possibility that molluscan resources were a dominant component of the diet during the mound period cannot be excluded, as there were some environments dominated by molluscs and largely devoid of other resources, such as islands or peninsulas (Bailey 1975b:58). While this statement correlates well with the data from the study area, it may be possible to extend the premise to other areas containing mounded shell deposits, as these sites are often located in areas that would also have been characterised by high resource biomass (Perlman 1980:272; Rowland 1994b:155; Mannino and Thomas 2002:465). More importantly, molluscan resources may have become more significant where larger-bodied faunal resources were not in abundant enough supply, a situation not uncommon to coastal regions (Glassow and Wilcoxon 1988:47; Erlandson 2001:294; Mannino and Thomas 2002). Provided that adequate water and plant resources were available in the area to offset the effects of protein poisoning (see discussions by Speth and Spielmann 1983; Speth 1987; Noli and Avery 1988), the proliferation of *A. granosa* in the late Holocene may well have enabled hunter-gatherers in coastal areas to refocus their subsistence activities to take advantage of an abundant and seemingly reliable resource.

### Implications for population size and mobility

Using archaeological data to assess changes in population size and levels of mobility in hunter-gatherer groups is extremely difficult. Frequently used markers of cultural and demographic change include deviations through time in the rate of site accumulation, both in numbers of

sites and deposition of stone artefacts. Interpretations of regional cultural change in population demography or social organisation have also been derived in similar ways through midden analyses, with emphasis on discard rates of shell and/or the relative frequency of molluscan taxa through time (e.g. Allen and Barton n.d.:88, 104–6; Schrire 1982:233–4). These archaeological indicators are often interpreted at a regional, or local, scale as evidence of changing land- and resource-use patterns, including population increase or redistribution (Kelly 1992:56; Attenbrow 2004:1). As a complicating factor, there are a range of other behaviours that may just as easily account for these kinds of changes in sites and artefacts. For example, they could be the result of the re-organisation of habitation patterns and subsistence strategies, including the adoption of different mobility patterns in the face of environmental change (Attenbrow 2004:1–2), as well as simply reflecting changes in the frequency of re-occupation in a specific locality (Davidson 1990:44; Kelly 1992:56).

The use of accumulation rates to infer changes in population size and mobility is problematic for a number of reasons (as also discussed in Chapter 6). Using only two or three radiocarbon estimates to calculate the rate of site accumulation, as is often the case for shell deposits in northern Australia, is not an accurate measure as it does not take into account variations in the history of site formation (Stein *et al.* 2003:310). In addition, the established convention of small area excavation in Australia for these sites, generally between 1m<sup>2</sup> and 0.5m<sup>2</sup>, while providing a decent sample to evaluate the relative densities of material from the sites, does not enable interpretation of overall site formation. In effect, this method may only represent the rate of accumulation for the excavated area, due to both horizontal and vertical variations in deposition within the site (see for example Mitchell 1993; Hiscock 1997, 2005). Further problems can occur where accumulation rates are used in conjunction with the ethnographic data to model changes in population size. Importantly, different combinations of behavioural elements can be consistent with statistically indistinguishable radiocarbon estimates and rapid accumulation of these deposits, particularly when extrapolating population size and levels of mobility (largely seasonal) from a combination of archaeological and ethnographic data (Bailey 1975b:57; Meehan 1982a:166; Bourke 2000:346). Following this point, it is becoming more widely accepted that ethnographic observations of population density and mobility are poor indicators of pre-contact patterns. As noted by both Beaton (1990:28, 33) and Peterson (1971:241), population limiting factors may occur at intervals beyond the observational period of the ethnographer, and even where there are detailed ethnographic indications of population size relative to the subsistence base (e.g. Meehan 1982; Bird *et al.* 2004), our perception of population trajectory leading into that ethnographic pattern is often inadequate. Essentially, the scales of observation between archaeological data and ethnographic observation do not correspond, and therefore sample points of short duration cannot be used to make inferences regarding the causes or properties of longer-term processes (Winterhalder *et al.* 1988:320–2; Erlandson 2001:295). One way forward is to contextualise those models of varying population size and patterns of mobility suggested for late Holocene northern Australia within the established interpretations of foraging behaviour and the potential economic productivity within a given area, in addition to observing established environmental and climatic patterns. Changes in climate, resources and habitats are not simply background information of little relevance when examining potential changes in population size and patterns of settlement, but must be considered as a constantly shifting set of problems and opportunities, altering the framework for human behaviour (Koike 1986:27; Haberle and David 2004:177). For example, climatic changes on decadal to century time scales can have devastating consequences on human populations by disrupting both resource exploitation and settlement patterns. In effect, these climatic forces call for an ongoing process that probably involves demographic expansion, or contraction, at various scales (Haberle and David 2004:177).

In many respects, this kind of approach is entirely dependent on the scale of analysis; decadal scale patterns are almost impossible to discern from the archaeological record given the error margins in dating methods (although see Morrison 2010 for a different perspective). A sample of archaeological sites containing any type of subsistence data, large enough for reliable interpretation, often represents a palimpsest of activities ranging over a substantial period of time, and as such, is representative of average trends in human behaviour (Bailey 1981b:109). The long time scales of archaeological inquiry result in a situation where small-scale fluctuations are smoothed out. For example, aspects such as oscillating patterns of population pressure become a constant. Therefore, issues of scale affect research questions, particularly those directed at linear or uni-directional interpretations of behaviour (Bailey 1981b:108). This issue is particularly relevant for the work of Haberle and David (2004) in correlating the long-term climatic and archaeological data for the Cape York Peninsula. In acknowledging the generally accepted pattern of long-term increase in population size (for example Beaton 1985, 1990; Davidson 1990; White *et al.* 1990), it was suggested that increased social regionalism and socio-structural transformation followed a major and sustained population increase during the early-to-mid Holocene climatic optimum, with increases in human population tied to high biomass productivity in north Queensland by approximately 6000 BP. When natural levels of bio-production decreased and climatic variability increased during the late Holocene, larger regional populations began to fission into new and distinctively smaller land-owning and land-using groups around 3700 BP. Following this there was a broad-spectrum revolution on mainland Australia, with the use of smaller, intensive resources (such as seeds, molluscs and toxic plants). It was argued that this process of socio-structural and dietary innovation enabled an increase in human population to be sustained over the short- and long-term (Haberle and David 2004:172–7). This argument is similar in many respects to the ‘broad-spectrum revolution’ hypothesis proposed for Australia and other areas of the world (Flannery 1969; Cohen 1977; Lourandos 1980, 1983; Hayden 1981; Veitch 1996:85–6 1999b:60). In this case, it is argued that the archaeological record reflects a coherent pattern of more or less continuous population expansion, accommodated by progressive environmental and economic adaptations, such as a broadening diet and intensive exploitation of secondary resources, in conjunction with distinct cultural changes.

The main problem with this argument is that it can be interpreted in a way that glosses over the particular challenges posed to coastal groups during the mid-to-late Holocene resulting from those environmental and climatic changes previously outlined. The effects of changes to the environment following the marine transgression, possibly affecting the type, distribution and density of resources, may well have had dramatic effects on human population structures. As these processes would have continued for some time after sea level stabilisation, it is possible that population sizes may actually have been reduced as a result. The ongoing development of coastal habitats leading into the late Holocene created a situation where the establishment and relatively long-term proliferation of resources, such as *A. granosa*, may have enabled an increase in population size. This was possibly only a moderate increase as the available data are more suggestive of an increase in the intensity of resource exploitation and site deposition. This ties into the notion whereby any factor that reduces the environmental challenges that hunter-gatherers must face may lead to substantial population increases (Stiner and Munro 2002:206). While the intensive use of these resources may well signify a ‘new, specialised and focussed subsistence strategy’ (Haberle and David 2004:172) between approximately 3000 and 500 BP on the north Australian coast, it was not a pattern that continued into the present in most areas, and as such it was not a unidirectional or linear progression in human behaviour. The subsequent restructuring of the economy on the Point Blane Peninsula, and in other areas of coastal northern Australia,

relates to a general decrease in biomass of coastal resources around 500 BP and extending into the more recent past. This pattern may well correspond with a decrease in population size (Hiscock 1986) or patterns of demographic reorganisation (Hiscock 1999:99–100).

Added to this, several researchers (e.g. Winterhalder *et al.* 1988:323; Stiner *et al.* 1999; Stiner *et al.* 2000; Boone 2002:12–5; Stiner and Munro 2002; Lupo and Schmitt 2005:347) have suggested that hunter-gatherer populations are liable to have characteristically fluctuating population sizes through time, largely based on the availability, density and distribution of resources. This argument relies on a strong relationship between overall carrying capacity, prey density and population density. People may well have responded to opportunities afforded by a productive marine coastal environment, rather than being forced to do so as a consequence of population pressure. It has also been argued that, instead of being a mere response to population growth occurring elsewhere, the adoption of coastal subsistence strategies can be a substantial causal factor behind population growth (Yesner 1987; Erlandson 2001:289; Mannino and Thomas 2002). Rather than population pressure, an alternative argument is that the increasing abundance of smaller bodied resources, such as molluscs, may have lead to a restructuring of foraging practices to focus on these resources. Related to the regional population density of the resource, and compared with larger bodied animals, the abundance and relative proximity of these resources would have increased the return rates from mass collecting relative to handling and processing (Madsen and Schmitt 1998:451–2; Lupo and Schmitt 2005:336).

Related to these possible variations in population size and foraging reorganisation, there are direct implications for patterns of settlement and levels of mobility, particularly given environmental changes and resource availability during the mid-to-late Holocene. Increasing population sizes may eventually lead to lower levels of mobility, or alternatively, as mobile populations become increasingly sedentary, their populations grow (Kelly 1992:58–9, 1998:19). As with evaluating variation in population size, assessing changes in mobility depends on the scale of analysis in conjunction with the use of ethnographic analogy. Long-term regional views of increasing sedentism throughout the Holocene do not take into account shorter-term fluctuations, and create an averaged, unidirectional pattern (Perlman 1985:48). The use of ethnographic data feeds into this model, particularly for the interpretation of the late Holocene archaeological record, where there has been an assumed, if not explicitly acknowledged, level of cultural continuity in patterns of settlement and seasonal mobility. This situation has arisen largely as a result of many archaeologists' tendency to think of mobility in terms of a continuum of residential mobility, from highly mobile to completely sedentary, but also possibly as a point of no return, a behavioural threshold from which more sedentary populations cannot return to a mobile lifestyle (Kelly 1992:50). In defining differing levels of mobility, Binford (1980) distinguished between residential mobility, the movement of the entire band or local group from one camp to another, and logistical mobility, foraging movements of individuals or small task groups out from, and back to, the residential camp (see also Kelly 1992). Added to this is the concept of territorial or long-term mobility, encompassing cyclical movements of a group of people among a set of territories, largely as a conservation measure, or as a response to subsistence stress. These differences are strongly linked to the subsistence base and related variations in demography, with low growth rates among groups with higher levels of long-term mobility.

The argument proposed here is similar for that previously outlined for possible changes in population size, largely due to the fact that, although many variables affect mobility, subsistence and foraging strategies are likely to be the primary ones (Perlman 1985; Kelly 1992:46). It is not possible to assess changes in population size and levels of mobility prior to 3000 BP on the Point Blane Peninsula due to the lack of archaeological evidence, based on the climatic and environmental data available for the region, however, it is possible that regional populations were



smaller and more mobile, largely as a result of rising sea levels. These patterns may well have been maintained following sea level stabilisation, due to patchily distributed resources along the coastline, relative to ongoing processes of coastal habitat reorganisation. In line with changes to the organisation of the foraging economy and already hypothesised changes to the size of populations in the area following 3000 BP, the establishment of expansive sand and mud flats through progradation and sedimentary infill, and the proliferation of a reasonably stable and dependable resource, could very well have created a situation that enabled people to lower their levels of mobility. The fact that *A. granosa* is not as seasonally constrained as other resources is likely to have been a contributing factor to this pattern. The spatial and chronological density of shell mounds in Grindall Bay, in combination with the contemporary occurrence of lower-lying shell middens in Myaoola Bay, indicates that there were changes to both residential and logistical mobility. The suggestion made here is that these factors provided people with the opportunity to become semi-sedentary, rather than fully sedentary, during this time.

While the abundance of *A. granosa* may have permitted semi-sedentary occupation of some coastal areas during a period of relative climatic instability, other resources would also have been necessary to fulfil dietary requirements. Support for this hypothesis, while limited to a certain degree by the very small sample size, comes from the stone artefacts. All of the artefacts in the study area are predominantly of locally available raw materials, indicating a localised use of resources, a pattern that goes some way towards reinforcing the interpretation of semi-sedentary occupation for the area. Bourke (2000:140, 262–3) has noted a similar pattern in Darwin Harbour, where local stone dominates the assemblages during the period of mound formation, with an increase in exotic stone procurement after approximately 500 BP. This pattern suggests lower levels of mobility preceding 500 BP, corresponding with a reduction in trade and exchange of stone raw material. The important archaeological problem of distinguishing more permanently settled from seasonally settled occupations, as well as assessing the pressure, or intensity, of predation, may ultimately only be resolved with quantifiable measures that can determine seasonal and annual periods of occupation (Russo 1998:159). Russo (1998:148–9; see also Koike 1986:28) suggests that the use of modal size classes in archaeological shell analyses, and therefore an investigation of the population age structure, may be a useful measure of seasonal resource exploitation. This does not appear to be the case here, although this may relate to a combination of rapid site formation, chronological resolution, and the particular nature of *A. granosa* itself (e.g. rapid growth). This hypothesis could be resolved by examining incremental growth structures in combination with stable isotopic analyses as measures of seasonality (see for example Luebbers 1978; Lightfoot and Cerrato 1988; Milner 2001; Mannino *et al.* 2003; Jones *et al.* 2005; Stephens *et al.* 2008).

After approximately 526 cal BP, the dramatic change to the structure of the resource base on the Point Blane Peninsula may have been accompanied by a corresponding increase in levels of mobility and a decrease in population size. Evidence for this type of change has been noted in the archaeological records of other areas, particularly through the stone artefact assemblages (e.g. Hiscock 1986, 1999; Bourke 2000). With a reduction in the available resource biomass on the Point Blane Peninsula, the potential for the over-exploitation of intertidal resources may well have necessitated regular mobility for these resources to be sustainable. During this period, foraging behaviour and seasonal mobility began to more closely approximate the ethnographically observed patterns of high seasonal resource availability, which was possibly linked to the continuing development of wetland areas and shifting economic focus by people on the resources in these locations. In this case, the highly seasonal nature of resource availability would have required cyclical or episodic patterns of movement within broad coastal areas, or further afield into non-coastal areas (Yesner 1987:293; Mannino and Thomas 2002:467). While these are the general patterns for the study area, in effect, resource density and availability will



exhibit a logistic population response, with human populations expanding and contracting accordingly. The relationship between forager and prey biomass is time dependent; it is consistent but it is not proportional, linear, or direct. Therefore, it is unlikely that a stable equilibrium and fixed relationship exists between forager and prey biomass (Winterhalder *et al.* 1988:320). For example, variations in the spatial distribution of both midden and mound sites between 2287 and 526 cal BP, in conjunction with the level of chronological variability observed within and between the mound sites, suggest that population size and levels of mobility would not have been stable within this period.

### **Concluding remarks: The ebb and flow of human behaviour**

The issue of how much change and variability in economic and social systems occurred during the late Holocene in Blue Mud Bay is addressed here with a particular focus on the nature and structure of the archaeological record. In combination with data on environmental and climatic processes acting on the northern Australian coastline during the mid-to-late Holocene, these data have enabled a number of phases of economic reorganisation to be identified relative to the abundance and availability of specific resources. These phases also indicate that economic and social change during this period was multi-directional, rather than following a linear or progressive developmental model.

The suggestion here is that the *A. granosa*-dominated shell mounds on the Point Blane Peninsula are not consistent with either continuous low level harvesting or sporadic high intensity harvesting, but are consistent with a more focussed level of activity within the landscape. As such, this interpretation relates to coastal foragers operating within a distinctly different economic pattern during the period of *A. granosa* mound formation to that seen historically, with people regularly and intensively exploiting shell beds. Therefore, the observable differences between shell mounds and ethnographically observed foraging behaviour, patterns of discard and site function, and the resultant patterning of cultural midden material within the landscape relates to variability in settlement strategies and resource exploitation, patterns of mobility and population size between the pre-contact and historic periods. The ongoing development of coastal habitats leading into the late Holocene created a situation where the establishment and relatively long-term proliferation of resources, such as *A. granosa*, may have enabled a lowering of mobility levels and an increase in population size. This was possibly only a moderate increase, as the data are more suggestive of an increase in the intensity of resource exploitation and site deposition. The spatial and chronological density of shell mounds on the Point Blane Peninsula, in combination with the contemporary occurrence of lower lying shell middens on the opposite coastline, suggests that there were changes to both residential and logistical mobility. The suggestion is that these factors provided people with the opportunity to become semi-sedentary, rather than fully sedentary, during this time. The restructuring of the economy on the Point Blane Peninsula after approximately 526 cal BP relates to a general decrease in biomass of coastal resources extending into the more recent past. This pattern is interpreted here as corresponding with an increase in levels of mobility and a decrease in population size. With a reduction in the available resource biomass on the Point Blane Peninsula, the potential for the over-exploitation of intertidal resources may well have necessitated regular mobility for these resources to be sustainable. During this period, particularly following the cessation of mound formation, patterns of foraging and seasonal mobility began to more closely approximate the ethnographically observed type of organisation noted for the pre-Macassan contact period.

In interpreting the archaeological record from the Point Blane Peninsula in this way, it is also important to recognise the limitations of archaeological data, particularly in relation to economic and social systems. Due to processes of differential preservation of material, such as the breakdown

of organic material or the post-depositional destruction or disturbance of sites, a complete record of past human behaviour is rarely, if ever, presented within the archaeological record. Archaeological data are therefore drawn, not from a complete body of information, but from the evidence that has survived. For example, the shell midden and mound sites recorded in the study area may represent a smaller proportion of the overall possible economy of people inhabiting this area throughout the late Holocene. For these reasons, interpretations of archaeological material are made carefully and objectively, based on the observable evidence. In recognising these restrictions, archaeological material of the kind found on the Point Blane Peninsula can still tell us a great deal about human behaviour. The diversity of the archaeological record indicates the range of activities carried out in the past, the intensity of occupation within an area, and the relative time span for occupation and use of the landscape. Archaeological research on the Point Blane Peninsula has identified significant patterns of economic and social change during the late Holocene, patterns that are often not recognised for other areas of coastal northern Australia. The most likely reason for this is the direct reliance on the ethnographies as an interpretive tool, and the scales of analysis between archaeology and ethnography simply do not match. Using ethnographies to directly interpret the archaeological record can lead to the depiction of prehistory as a generalised representation of the kind of behaviour recorded during the historic period. The process of analogical reasoning in this way leads to an interpretive model that relies more heavily on generalised ethnographic patterns than it does on archaeological evidence (Moss and Erlandson 1995:29). As a result, regional patterns of change and variability through time are often obscured, preventing the development of alternative or multiple versions of the past. By viewing the archaeological record as reflecting human-environmental interactive processes, an opportunity is provided in which change can be recognised in a number of ways. For example, differential focus on resources, variations in group size and levels of mobility can all be identified. It has also been shown that human-environment interactions are non-linear or progressive. The use of ethnographies does not often allow for this, as it assumes a continuum of behaviour from when the ethnographies were recorded into the more distant past. When it is acknowledged that the interaction of people with their environment is not a passive process, because neither human behaviour nor the environments that people inhabit are static, then the potential arises for multi-directional phases of human behaviour and change to be recognised.

Within the Blue Mud Bay region, shell mounds represent a broad phase of economic restructuring, one that was characterised by an intensive focus on specific resources and landscapes. These mounds represent variability in the intensity of molluscan exploitation and discard, rather than reflecting a continuation of the kind of foraging behaviour observed during the historic period. It would appear that it is only when these sites are placed within a strict ethnographic framework, and analysed in isolation from other archaeological evidence, that the interpretation of these sites becomes problematic. Interpretations often conform to the types of economic and social systems recorded during the historic period, regardless of the fact that shell mounds do not conform to any ethnographic pattern. As has been noted by Rowland (1999a:34), complex, non-linear relationships frequently occur between humans and their environments. As such, environmental explanations of cultural change need not be considered more, or less, deterministic than those that consider the role of social factors. In effect, the impacts of environmental variability will depend as much on the previous history, size and density, and adaptive strategies of a population as on the scale and duration of the environmental change itself (Rowland 1999a:34). The archaeological evidence presented here indicates that foraging behaviour on the coastal margins of the Point Blane Peninsula was indeed flexible and dynamic. Through time, people actively changed their foraging strategies to incorporate newly available or increasingly abundant species. Rather than being forced into molluscan exploitation through increasing population pressure (Veitch 1996:85-6, 1999b:60; Haberle and David 2004:177), the abundance of *A. granosa* between approximately

2287 and 526 cal BP may have enabled people to moderately increase population size while decreasing levels of mobility. During this period, the exploitation of molluscan resources was far more focussed and intensive than was observed during the historic period, contrary to the interpretations of a number of other researchers who have relied on the ethnographies to explain the role of molluscs within the diet (e.g. Bailey 1975a; Bourke 2000). Within this general pattern, variability in mound size and patterns of occupation are seen to reflect the differential variability in the availability of other resources in the area through time, inclusive of non-molluscan resources such as water and vegetable foods. Following the cessation of mound formation, there appears to have been a broadening or diversification of the diet. This increase in diet breadth appears to have been related to the disappearance of the reliable, productive molluscan resources, combined with the development of extensive wetland systems. A greater focus on a diversity of seasonally available resources from different terrestrial and aquatic habitats after 526 cal BP, the majority of which were seasonally constrained in their abundance and distribution, indicates that the nature of foraging and land-use were beginning to approximate the seasonal round of more recent observations. Tied to these changing patterns of resource exploitation are increased levels of mobility and a decrease in group size.

The arguments presented above are also relevant for countering the large-scale, continent-wide models of human behaviour, such as the 'Intensification' model. Lourandos and Ross (1994:59) have criticised the use of small-scale regional studies for identifying patterns of human behaviour, stating that challenging small components of the model ignores the general patterns that it explains. It has been shown by a number of other researchers (e.g. Hiscock 1986; Holdaway *et al.* 2002, 2005; Attenbrow 2004; Asmussen 2005; Ulm 2006a), however, that the only way to evaluate a model of this scope is an assessment on a regional basis. Regardless of the region in focus, all of these studies have demonstrated that the archaeological record of the late Holocene was a period of greater variability than had previously been thought. In addition, while there is a high degree of regional variability in the timing and nature of change, these studies have shown that many of these changes are neither linear, nor progressive. There was no clear trajectory in human behaviour from simple to complex, nor was there a unidirectional pattern of decreasing mobility or population growth. This suggests that the uncritical application of broad, low-resolution models to different regional contexts does not take into account the degree of variability in human behaviour that existed, an approach that is simplistic and essentially flawed. Following this point, it is suggested that the variability in resource exploitation, economic reorganisation and changes in population size and levels of mobility through time identified here may broadly apply to other coastal regions of northern Australia as a result of similar environmental and climatic changes. Given that the findings of this research are based on one area of eastern Arnhem Land, the potential for regional variability, and the possibility of comparable archaeological manifestations of different behaviours should not be ignored. This is particularly the case when this research is viewed in combination with the detailed archaeological studies undertaken by both Bourke (2000) and Morrison (2010). By the same token, given similar coastal environments and similar processes of Holocene environmental and climatic change along the north Australian coast, the possibility undoubtedly exists that, at a broad scale, shell mounds reflect similar processes in other areas. This is not to suggest that these patterns and interpretations can be extrapolated and simply applied to other regions across the north, particularly given the evidence for inter- and intra-regional variability in the archaeological record, but undoubtedly, the potential is there for re-evaluation of existing interpretations.

Based on the results presented here, what has been made abundantly clear is that there has been a greater degree of economic and social reorganisation during the late Holocene in coastal northern Australia than may have been previously been accepted. In acknowledging the complexity of

human behaviour apparent within the Holocene archaeological record, as has also been seen in the chronological and spatial diversity from a number of other regional studies scattered across the continent, it is evident that local or regionally focussed studies must be conducted to provide the context for the 'bigger picture', not the other way around. Only in this way can the extent of human behavioural variability through time and space be adequately investigated.