SHELL MOUNDS AND STONE AXES: PREHISTORIC RESOURCE PROCUREMENT STRATEGIES AT HOPE INLET, NORTHERN AUSTRALIA

Trish Bourke

Department of Anthropology, Northern Territory University, Darwin NT 0909, Australia

ABSTRACT

Recent investigations at Hope Inlet, near Darwin, have revealed this small section of the coast to be rich in large mounded middens, comparable in both type and distribution within the landscape to the Anadara *mound sites described elsewhere in northern Australia and other parts of the Indo-Pacific region. The evidence for concentrated exploitation of the mollusc* Anadara granosa *during the late Holocene indicates significant differences in the past local environment with that of the present. Also found in association with these shell mounds, are earth mounds and stone artefact scatters containing large stone artefacts such as edge-ground axes, pestles and portable mortars. The archaeological and ethnographic evidence suggests that the mound sites are the remains of semi-sedentary seasonal settlements, perhaps involving large ceremonial gatherings. Variability in site type at Hope Inlet may be a reflection of the diverse range of strategies employed in the procurement of prehistoric resources within a changing late Holocene landscape.*

Anadara granosa is a marine bivalve mollusc with an ecological range from northern Australia to Japan. Today this mollusc is commercially cultivated in the Indo-Pacific region, particularly in Thailand and Malaysia (Broom 1985; Mason 1991:271). The presence of numerous shell mounds composed predominantly of *Anadara granosa* on the coasts of northern Australia, Malaysia, Sumatra, northern Vietnam (Bellwood 1985:171), Thailand (Mason 1991) and Japan (Suzuki 1986) attests to the economic importance of this roughbacked cockle in Indo-Pacific prehistory. Most of the shell mounds in Southeast Asia have been destroyed through utilisation as a source of lime (Bellwood 1985:162, 171). However, large numbers of *Anadara* shell mounds have been recorded along the north Australian coast, at Princess Charlotte Bay (Beaton 1985), Weipa (Bailey 1977, 1994), Aurukun (Cribb 1986), around Milingimbi in Arnhem Land (McCarthy and Setzler 1960; Peterson 1973; Roberts 1994), in the Pilbara and Kimberley regions (O'Connor and Sullivan 1994; Veitch 1996), and recently at Hope Inlet near Darwin (Figure 1). The mounds of northern Australia are the most abundant surviving remains of this type of prehistoric site in the Indo-Pacific region. They represent an important cultural resource from which a great deal can be learnt about prehistoric human interaction with a dynamic late Holocene landscape. This paper looks at distribution patterns of the Hope Inlet sites, and inter- and intra-site variability. The archaeological evidence, along with ethnographic and ecological data, is used to explore questions on the extent of sedentism, seasonality and human resource procurement strategies within a changing local environment.

CLIMATE, ENVIRONMENT AND GEOMORPHOLOGY

The Darwin coastal region has a monsoonal tropical climate with a dry season extending between April and November, and a wet season between December and March, during which most of the average annual rainfall of 1624 mm falls. The area is subjected to periodic cyclones during the wet season, which may cause considerable coastal landform changes and destruction of vegetation. Tides along the coastline are macrotidal, with a range up to 7.8 m.

Studies in north Australia have demonstrated that sea levels stabilised following a rise to their present levels at around 6000 years BP (Chappell and Grindrod 1984; Woodroffe *et al.* 1988). The model of estuarine evolution and Holocene deposition demonstrated for the Alligator Rivers is said to apply broadly, with local variations, to other systems in the Top End, including the relatively minor river systems of the Darwin coastal region (Michie 1988; Woodroffe 1995:80). Since the Holocene transgression, vast tidal sandy mudflats have built up in the almost completely

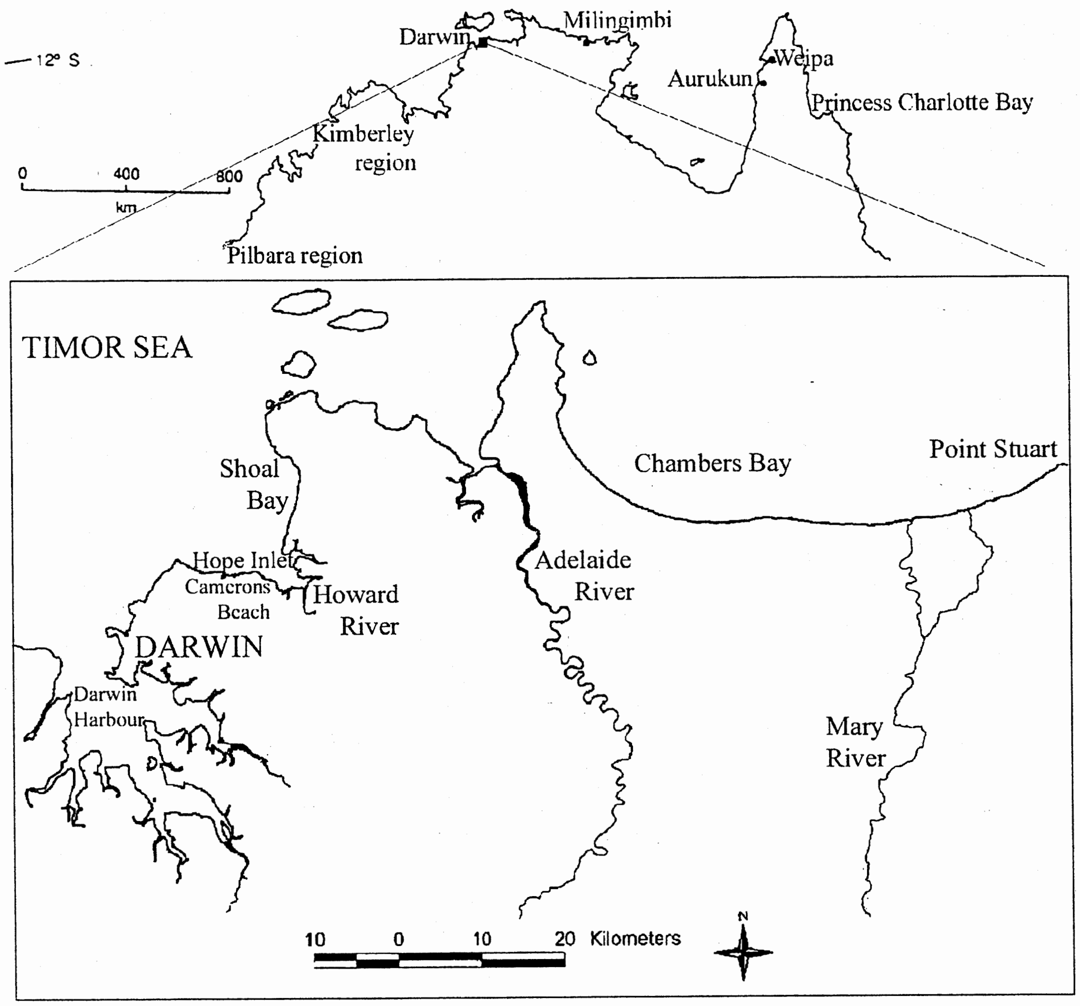

Figure 1: Above: Location of shell mounds along the coast of northern Australia; Below: The study area and places mentioned in the text.

infilled small coastal plains of Hope Inlet (Michie 1988:38). Woodroffe *et al.* (1993:272) note increased coastal sedimentation and later progradation continuing in a westerly direction from the Alligator Rivers system. Episodic chenier ridge formation has occurred as the coastal plains prograded (Woodroffe 1995:80). Chenier ridges, elongated deposits of sand and shell developed on mudflats or saline tidal flats, known as chenier plains, occur commonly in tropical coastal locations (O'Connor and Sullivan 1994:16). The lower parts of chenier ridges may be buried by subsequent muddy sedimentation on wetlands (Sullivan and O'Connor 1993) and this appears to be the case at the Hope Inlet. Radiocarbon dates on shell from chenier ridges at nearby Camerons Beach (Hickey 1981), the Mary River floodplains (Woodroffe and Mulrennan 1993) and at Point Stuart (Lees 1987) provide evidence for recent periods of rapid growth of chenier ridges in the region, at around 2300 years BP and 1000 years BP (Figure 1).

Today, Hope Inlet is a short prograding coastal inlet at the southern extremity of the sandy open shoreline of Shoal Bay. The small mangrove-lined Howard River and Kings Creek flow northwards into the shallow seas of the inlet on either side of Howards Peninsula (Figure 2). Dense mangroves hundreds of metres wide fringe the seaward edge of the coastal plains, which consist of seasonally inundated low level saltflats with saline sandy muds and cracking clays. Tidal channels and mangrove-lined creeks dissect these supratidal saltflats. On the landward edge of the saltflats are samphire sedgelands, perennial freshwater swamps and paperbark and pandanus forests. The adjoining hinterland, a laterized plateau of Cretaceous sediments, slopes down gently toward the coast and juts out as a succession of

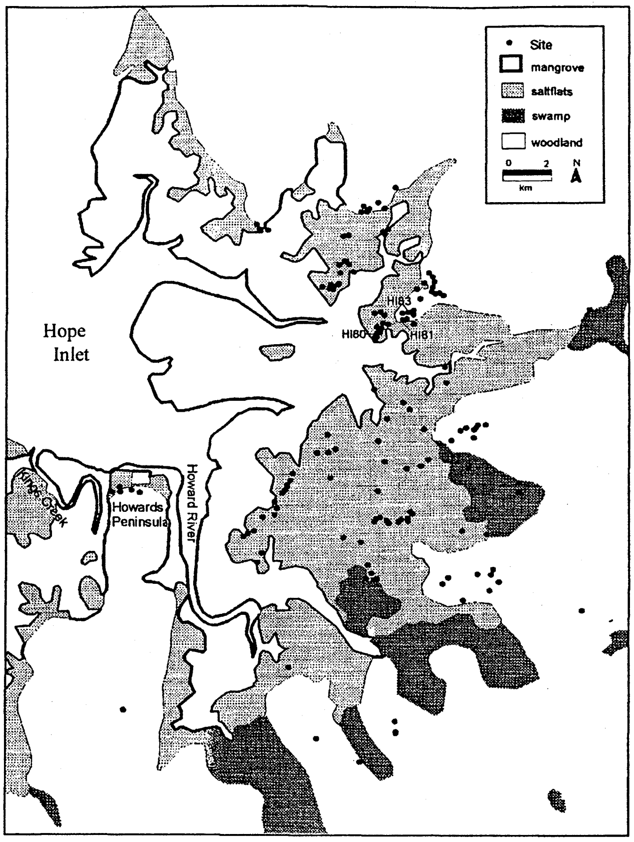

Figure 2: Location of sites at Hope Inlet.

small promontories onto the saltflats. Vegetation on the hinterland boundary includes large areas of cycad palms, patches of monsoon vine forest, mixed closed forest, open forest and open eucalypt woodland. Further inland are numerous freshwater lagoons, seasonal creeks and shallow drainage lines that dissect the hinterland (Wood *et al.* 1985; Wilson and Bowman 1987).

TYPES AND LOCATION OF SITES AT HOPE INLET

Archaeological surveys have located over 150 prehistoric sites in the Hope Inlet area (Figure 2). Site types include small scatters of shell, shell and stone artefact scatters, earth mounds and circular, elongated, and doughnut-shaped stratified shell deposits. The shell deposits are found in a continuum of sizes, from low shell middens one metre in diameter and less than 30 cm in depth, to composite mounds of shell and earth extending for up to 300 m, the largest mound rising seven metres above the surrounding landscape. Other researchers (Beaton 1985:4; Bailey 1994:114) have noted a similar continuum in the size distribution of *Anadara* shell mounds on Cape York Peninsula. These deposits also exhibit a continuum with regard to the composition of relative proportions of shell and earth, from mounds of shell with very little earth matrix, to earth mounds with a few weathered shell fragments evident on the surface.

Sites are commonly found in clusters of two or more. Shell mounds are found on each of five hinterland promontories projecting into the saltflats. On two of these promontories, the large "composite mounds", corresponding with those at Aurukun described by Cribb (1996:160), are situated on lateritic ridges which border the seaward edge of the hinterland promontories. Inland of the large mounds, smaller shell mounds and earth mounds are located in mixed forest and eucalypt woodland, approximately 50-100 m apart. On the saltflats, shell mounds are situated close to mangrove lined tidal creeks and channels. Many appear to be partially buried, compacted and salt encrusted through periodic inundation by seawater. Some are situated on partially buried chenier ridges, which, from the geomorphological evidence (see above), are known to have formed in the region within the last 2500 years, indicating a late Holocene age for these mounds. This corresponds with most dates for *Anadara* mounds located in other parts of northern Australia (Mulvaney 1981; Beaton 1985; Bailey *et al.* 1994;). It also coincides with an apparent expansion in the number of open sites in the wetlands of the Adelaide River (Brockwell 1996) and western Arnhem Land (Allen 1989:113) during a period of transition from mangrove forest to freshwater wetlands. Rapid progradation of the coastal plains and increased chenier building have been identified as features of this period (Clark and Guppy 1988).

Composition of Shell Mounds

Excavations of three shell mounds, (HI83) in the woodlands, (HI81) on the hinterland margin and (HI80) on the saltflats (Figure 2), revealed all three deposits are dominated by densely packed Anadara granosa shell. A suite of other molluscs such as the bivalves *Marcia hiantina, Saccostrea echinata* and *Geloina coaxans*, and the gastropods *Cassidula angulata, Chicoreus capucinus, Ellobium aurisjudae, Nerita* sp, *Telescopium telescopium, Terebralia semistriata* and *Volema cochlidium*, occur in small proportions. The deposits contain very little sediment, but large quantities of ash and charcoal throughout. The mollusca in the mounds represent a small selection in relation to over 100 available mollusc taxa in the local environment (Hanley 1988:145; Burns 1994:88), indicating a "degree of selection" which does not occur in natural shell deposits (Attenbrow 1992:9). *Anadara* and *Marcia* inhabit intertidal sandy mudflats, with the highest population densities of *Anadara* found in open areas bordering, but not in, mangrove swamp areas (Broom 1985). *Saccostrea* is an oyster, which lives on rocky platforms or the roots of mangroves, and *Geloina* is found on muddy substrates within the mangroves. The habitat of the gastropods is primarily mangrove forests.

Bone and crab was also recovered, some burnt, much of it fragmented and unidentifiable. Identified thus far are fish bone and otoliths, mammal and snake bone and macropod teeth. It is evident that in addition to a heavy concentration on one mollusc, a variety of marine, estuarine and terrestrial resources were exploited and processed at these sites. The dearth of sediment and presence of abundant charcoal and ash throughout the deposits suggests that large quantities of molluscs were processed over relatively short time periods. Also present are ochre, hearth stones and a low density of stone artefacts (mostly quartz and quartzite flakes 3-6 mm in size). Although low in density, the presence of stone artefacts and ochre also suggests that, as well as food preparation, other manufacturing and possibly ceremonial activities were carried out at the sites. The low density of stone artefacts is a typical feature of tropical shell mounds (see Mitchell 1993; Bailey 1994:114), and reflects the scarcity of stone in this area.

Stone Artefact Scatters

Generally only a few laterite and quartz rocks and stone artefacts (mainly quartz flakes) are found on the surface of the shell mounds, along with an occasional edge ground axe or pestle. Only on one cluster of mounds amongst a network of mangrove-lined creeks and waterholes are stone artefacts found in any quantity. However, located at the edge of one saltflats area on grey cracking clay-pan are a number of higher density surface scatters of stone artefacts and shells, ranging in diameter from 10-100 m. The gastropod *Terebralia*, with a few *Telescopium* and *Anadara*, dominates shell taxa in these scatters. Stone artefacts in these scatters are manufactured from a variety of raw materials. Artefact types include numerous small flakes made from quartz, quartzite, porcellanite, dolerite and volcanic tuff and large pestles made from quartz, sandstone, and a variety of different quartzite types. Mortars made from quartzite, edge-ground axes made from dolerite and hornfels and large blades made from a non-local quartzite are found in lesser numbers.

Other than the locally occurring porcellanite, a fine grained sedimentary rock, and the occasional quartzite and quartz outcrops, these stone raw materials are not found in the Hope Inlet area. Outcrops of the raw materials quartzite and quartz occur commonly in the hinterland around Darwin Harbour, 25 km to the southwest. The nearest sources of the raw materials dolerite, hornfels, volcanic tuff and the exotic quartzite from which the large blades are made are over 60 km inland and must have been carried for long distances to these sites. These relatively rare large blades are similar to those reported as manufactured at quarries in Arnhem Land, associated with ritual and exchange (Allen 1989; Jones 1990).

Chronology of Occupation of Mounds and Surface Scatters

The limited range in type of stone artefacts and raw materials within the *Anadara* shell mounds contrasts with the diversity of artefact types and wide range of exotic raw materials found in the surface scatters of shell and stone, in which the dominant shell component is *Terebralia* rather than *Anadara*. It is conceivable that these two site types, which evidently reflect different activities, may not have been occupied concurrently. Excavation of a shell mound on the saltflats revealed that the deposit extends some 40 cm below the surface. It therefore probably accumulated prior to the sedimentation processes that formed the present day saltflats, on the surface of which the artefact scatters are located. However, probing around a number of shell mounds on the saltflats indicated that not all of them, including the cluster of midden sites with associated stone pestles, extend below the saltflats surface. It is likely that different shell mounds accumulated over time following progradation of the coastal plains, so that the mounds are younger from landward to seaward as Veitch (1996:80) suggests for *Anadara* mounds on the Kimberley coast. Thus occupation of the stone artefact scatter sites appears to be subsequent to accumulation of some of the mounds, but may have been concurrent with occupation of more recent mounds.

SHELL SIZE, HUMAN EXPLOITATION AND ENVIRONMENTAL CHANGE

Studies on prehistoric shell deposits often use shell size as an indicator of extent of human exploitation of the molluscan resources and/or environmental change over time (eg., Swadling 1976; Spenneman 1987). For this analysis, average weight per shell (giving an indication of shell size) was calculated for each spit of the three excavated mounds. This was done by dividing the weight by the minimum number of individuals (Wt/MNI), of unbroken *Anadara* shell (either left or right valves) from each spit. The results show an alternating variation in shell size over time for each of these mounds (Figure 3). Spenneman (1987:86-7) also notes this pattern for Tongan middens, which he suggests may be due to seasonal changes. This interpretation would only apply if the shells were collected at a variety of times during the year (seasons). The mound would have to accumulate sufficiently fast so that shells from one season formed a layer with enough depth to distinguish it from the next layer collected during a different season. It is possible that longer-term cyclic environmental change (climatic) is responsible for the fluctuation in shell size noted in the deposits.

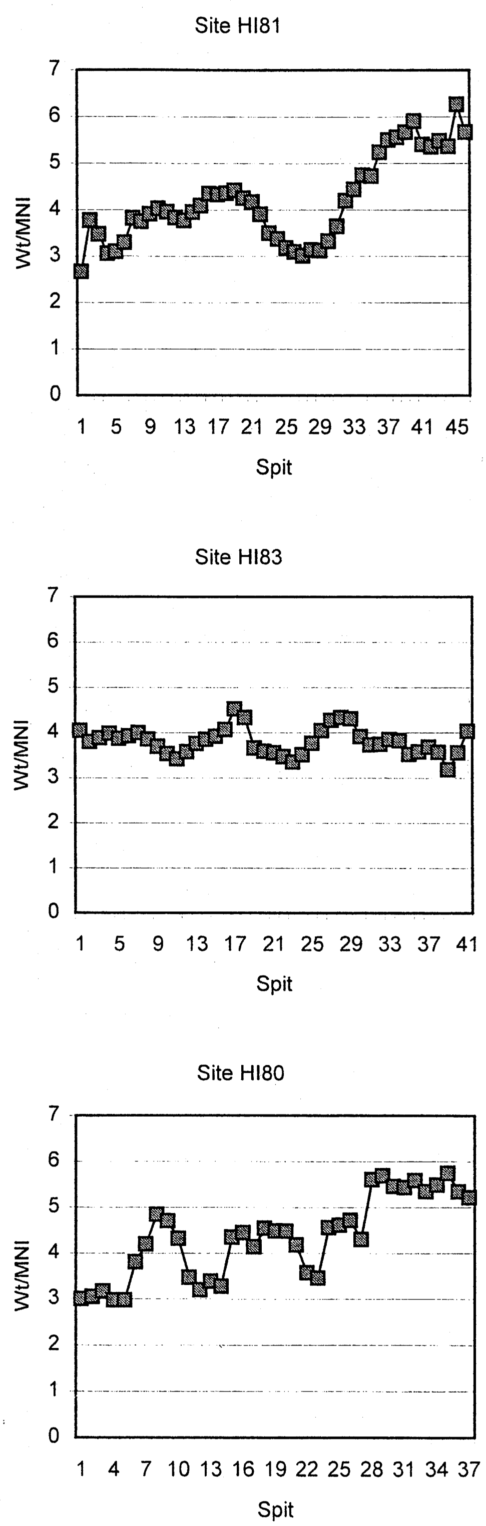

Figure 3: Wt/MNI of Anadara granosa *for Sites HI81, HI83 and HI80.*

More significantly, the results clearly show overall trends in *Anadara* shell size during the accumulation of these mounds. In the sample from HI83 in the woodlands, shell size remains more or less constant over time, while in both HI81 on the hinterland margin and HI80 on the saltflats there is a definite trend of decreasing shell size over time (Figure 3). At first glance this would appear to suggest over-exploitation in the latter mounds. However, further analysis suggests that this is not necessarily the case. Data from Pathansali (1966), on modern *A. granosa* populations in Malaysia, subjected to continuous harvesting which removes larger individuals, has been used by Broom (1985:15) to derive average asyptotic shell lengths of between 30-36 mm. Measurement of maximum *Anadara* shell length (see Spenneman 1987:85) from spits at the base, middle and top for each of these mounds confirms the trends on shell size obtained through the Wt/MNI estimates, but also demonstrates that average shell length remains between 27-36 mm throughout in each of the mounds (Figure 4). Whilst Broom's (1985) paper deals with growth models and not mean shell length as in this paper, the closeness of average shell length in the mounds to the asymptotic shell length (maximum possible > length of shell) of *Anadara* populations, indicates that selective harvesting has been practiced. In *A. granosa* molluscs, gonads mature at 18-20 mm length (Broom 1985:23). Harvesting of shells close to maximum possible size ensures maturity and breeding success.

Measurements indicate an average shell length (mean) of 30 mm throughout the accumulation of HI83. For mounds HI81 and HI80, the average shell length measures 35 mm and 34 mm respectively at the start of accumulation, larger than for HI83, and decreases over time to an average shell length of 29 and 28 mm respectively, slightly less than the average length throughout HI83 (Table 1). In addition, calculations show that in HI83 in the woodlands the proportion of large individual *Anadara* shells >36 mm is small at the start of accumulation and remains relatively constant over time. For both HI81 on the hinterland margin and HI80 on the saltflats, the proportion of large shells is relatively high at the start, and drops sharply during mound accumulation (Table 2).

The data for HI83 is consistent with a population subjected to continuous harvesting, which has removed the larger individuals, prior to and during the formation of the mound. For mounds HI81 and HI80, the data is consistent with a hiatus in harvesting, which allowed the growth of larger shells prior to commencement of these mounds. This may indicate reoccupation of the area after an absence of more than 15 months, given a growth rate of around 15 months for *Anadara* in natural beds to reach a size of 18-32 mm (Broom 1985:14). Following the commencement of accumulation of mounds HI81 and HI80, the evidence suggests

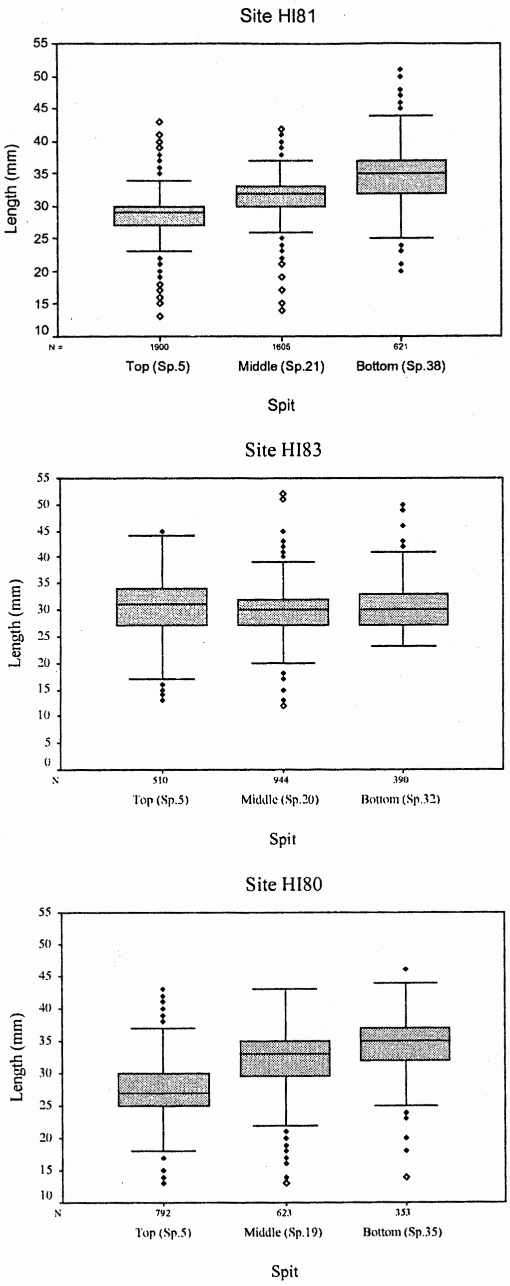

Figure 4: Size distribution of Anadara *shells in Sites HI81, HI83 and HI80, showing the median, interquartile range, outliers and extremes for spits at the top, middle and base of each mound.*

that harvesting of molluscs was continuous until accumulation of these mounds ceased.

Modern populations of *Anadara* beds sufficient for the construction of the Hope Inlet mounds no longer occur in the Darwin region. The predominance of *Anadara* deposited

Table 1. Mean length (mm) and Standard deviation of *Anadara* shell from spits at the top, middle and base of each mound.

Site	Top		Middle		Base	
	Mean	SD	Mean	SD	Mean	SD
HI80	28	4	32	5	34	4
HI81	29	3	32	3	35	5
HI83	30	5	30	4	30	4

Table 2: Proportion of *Anadara shell* >36mm from spits at the top, middle and base of each mound.

Site	Top	Middle	Base
HI80			
no. of shells	792	623	353
no. > 36 mm	20	86	104
% > 36 mm	3%	14%	29%
HI81			
no. of shells	1900	1605	621
no. > 36mm	45	76	197
% > 36mm	2%	5%	32%
HI83			
no. of shells	425	944	390
no. > 36mm	38	52	34
% > 36mm	9%	6%	9%

in large numbers of mounds in this small area suggests that extensive *Anadara* shell beds once existed which could be easily and heavily exploited. Hiscock (1997) has argued that the environment changed from the optimal habitat conditions for *Anadara,* of open sandy mudflats with scattered stands of mangrove, to the extensive mangroves and mudflats which form a barrier hundreds of metres wide along most of the coastline today.

The data from this research suggests sustainable continuous exploitation of this molluscan resource over a long period of time. It is possible that the smaller mean shell size during terminal accumulation of HI80 on the saltflats, which would have accumulated more recently than the landward mounds, indicates more pressure on the *Anadara* resource, but further investigations are required to confirm this. If it is so, this may be due to human predation or environmental change (see Spennemann 1987), or a combination of both.

SITE DISTRIBUTION PATTERNS AND SEDENTISM

Site location, size and structure, and the distribution of cultural remains within a site, have been seen as indicators of the extent of site permanence. Researchers have developed criteria based on ethnographic data, to apply as possible archaeological indicators of increasing sedentism. The Hope Inlet sites meet some of these criteria, such as resource abundance, changing discard patterns, increased site size, increasing midden development, increasing artefact density and diversity, and increasing use of heavy implements (Rowley-Conwy 1983:123; Kelly 1992:55-6; Shoocongdej 1996:210). Rowley-Conwy (1983) suggests that large middens would be expected to accumulate near permanent sites, which would be more likely to be located in sheltered areas such as inlets, rather than on open coasts.

The excavated woodland mound (HI83) is one of a cluster of discrete shell and earth deposits on a narrow promontory jutting into the saltflats. These are located 300 m inland of a large composite mound site on the hinterland margin and form a distribution pattern where all are situated just within view of each other, 50-100 m apart. If the deposits are contemporaneous, this cluster may represent an occupation site for a large gathering of people. An ethnoarchaeological study in the Phuket Islands of Thailand by Engelhardt and Rogers (1997) found that in permanent base settlements shell midden deposits are spatially segregated in a structured way, as they are on the Hope Inlet promontories. If we make the reasonable assumption that the deposits represent household campsites (see Gargett and Hayden 1991:29), such a spatial distribution is also consistent with the idea of "privatization of space", identified by researchers as a strategy used to resolve increased social conflict resulting from increasing sedentism (Kelly 1992:56). Gargett and Hayden (1991) argue that amongst hunter-gatherer groups, relatively high inter-household spacing, as found at Hope Inlet, would occur in richer environments, where subsistence is based on readily and constantly available small-package food items, and the need for sharing is low.

ETHNOGRAPHY AND SEASONAL RESOURCE PROCUREMENT

Ethnographic studies have been used to show a link between the extent of fisher-gatherer-hunter mobility and the seasonal nature of their resource base (Kelly 1983; Rowley-Conway 1983; Pickering 1994:155). Such studies provide information on the parameters of seasonal resource availability within which resource procurement strategies must operate. Research on *Anadara* populations in Malaysia and Thailand found evidence of a two-month seasonal spawning period varying between July and December, depending on location. Prior to and during the spawning period there is an increase in the dry:wet weight ratio of flesh (Broom 1985:24), probably due to a build up of glycogen and carbohydrates, which Bailey (1975:59) noted gave oysters their "quality of 'fatness' and appeal to the palate". "Fatness" is a quality indicating that a food is in prime condition, which is emphasised by contemporary Aboriginal people in their resource procurement strategies (Davis 1985:300; Meehan 1982:142). Meehan's (1982:76) ethnographic observations of the Anbarra of Arnhem Land show that although *Anadara* was eaten year round, much larger quantities were collected during July and August, and contributed to the diet of participants of ceremonial activities. Major ceremonies were held on the Arnhem Land coast in the mid-dry season at a time when there was a surplus of food (Jones 1990). A link between *Anadara* and ceremonies is also noted by Warner (1958:463), who in connection with the *Anadara* shell mounds of Milingimbi, refers to a "shell and ritual season" involving large gatherings of people over two to three months.

Ethnographic data suggests that the edge-ground axes, stone mortars and pestles found on the saltflats could have been used for a variety of activities, including woodworking, processing plant foods, breaking up animal bones, and grinding ochre for pigment to decorate implements or bodies for ceremonies (Hayden 1979:109; Peterson 1968). In Arnhem Land, Jones and Meehan (1989:124-5) observed stone mortars and pestles being used to crush cycad nuts, which are then baked in earth ovens with heated ant-bed lumps. There are extensive stands of cycads at Hope Inlet which would provide here, as in Arnhem Land, enough nuts to feed large gatherings of people during the mid-late dry season. Excavations of earth mounds containing shell in the Hope Inlet woodlands revealed ant nest material as well as charcoal, ochre, and bone. Many other plant foods are available during the mid-late dry season. Traditionally important staples such as spike rush and waterlilies as well as wild rice may have been gathered from the freshwater swamps and processed using mortars and pestles (Peterson 1968; Jones and Meehan 1989; Russel-Smith *et al.* 1997). Ducks, magpie geese and file snakes are abundant in freshwater swamps in the late dry, and are still harvested by Aboriginal people around Darwin today (Povinelli 1992). Barramundi and catfish would have been available in the estuarine rivers and creeks and on the saltflats flooded by the king tides in the late dry/ early wet season, documented as the peak time for fishing (Baker 1981:5).

Availability of fresh water is also an important factor in fisher-gatherer-hunter resource management strategies in coastal wet-dry tropical areas during the long seven-month dry season, when all streams except major rivers and springs dry up for variable periods. For the Weipa area, Bailey (1975:11) proposes an alternating pattern of population dispersal during the early dry when water is freely available, and aggregation as water becomes scarce. In this area water tables remain high, and the lower horizons of soils on the coastal plains are perennially waterlogged (Williams 1969:75). In some coastal areas fresh water can be found in depressions between sand dunes behind the mangroves (Christian and Stewart 1953:117). Peterson (1973:187) described a number of wells dug along a seasonal watercourse close to shell mounds in Castlereagh Bay and early explorers noted wells dug by Aboriginal people as they traversed the coastal plains of Chambers Bay, north of Hope Inlet. This information supports the idea that coastal areas were occupied at times when surface water was scarce, during the mid-late dry season (Baker 1981:55-7).

Peterson (1968) noted in Arnhem Land that large stone artefacts such as mortars and pestles were left behind when people moved, at sites that were semi-permanent pre-wet or wet season camps. In the Hope Inlet case the location of the stone artefact scatters on the saltflats, which are inundated during the wet season and remain wet for some time into the dry, would limit the use of these site types to the mid-late dry. Mounds in northern Australia have previously been interpreted as seasonal wet season camps in locations which provide elevation above the surrounding landscape and optimal access to a variety of seasonal resources (Peterson 1973; Bailey 1975; Meehan 1988, 1991). I would argue, as Baker (1981:75) does for Chambers Bay, that the extent of elevation provided by the mounds on the saltflats is suitable only for occupation during the early and late wet season and may only have been feasible throughout the wet on the relatively higher ground of the hinterland promontories.

CONCLUSION

It is well known that tropical estuarine and coastal zones, including mangroves, swamps and forests, are areas of high resource biomass capable of supporting relatively large populations of fisher-gatherer-hunters. At Hope Inlet the hinterland promontories projecting onto the saltflats provide the ideal central platform for optimal accessibility to all surrounding ecological zones. The spatial distribution pattern of mounds on these promontories, if they are shown to be contemporaneous, suggests that they represent the remains of semi-sedentary seasonal settlements, occupied at least for half the year during the mid-late dry season, the optimal season to procure *Anadara*, and perhaps involving large ceremonial gatherings. This idea is consistent with the patterns exhibited in the excavated mounds, of long-term sustainable, continuous exploitation of an abundant molluscan resource for protein, possibly complemented by large quantities of carbohydrates, in the form of cycad nuts cooked in earth ovens.

We now know from the available evidence that the Holocene was a period of dynamic climatic and subsequent ecological variability, both on a global and local scale (Stahl 1996). Fisher-gatherer-hunters utilise a variety of resource procurement strategies to survive seasonal, annual and longer-term environmental changes and subsequent resource fluctuations (Kelly 1983:301). Variability in site types at Hope Inlet may reflect changing economic strategies over time. Decreasing availability of a large mono-specific resource, whether due to environmental change, human predation, or a combination of both, may have required different resource procurement strategies including the use of large stone implements. It is hoped that continuing analysis of the data will answer some of the questions on the interaction of humans and environment within the late Holocene landscape.

ACKNOWLEDGEMENTS

I would like to thank the Australian Institute of Aboriginal Studies (AIATSIS) for funding the fieldwork for this research, and members of the Larrakia community for permission to undertake research on the Hope Inlet sites, and assistance in the field. Thanks also to Ian Walters, Peter Hiscock and Sally Brockwell for helpful comments, Richard Willan for mollusc identification, and all my volunteer fieldworkers.

REFERENCES

Allen, H. 1989. Late Pleistocene and Holocene settlement patterns and environment, Kakadu, Northern Territory, Australia. *Bulletin of the Indo-Pacific Prehistory Association* 9:92-116.

Attenbrow, V. 1992. Shell bed or shell midden. *Australian Archaeology* 34:3-21.

Baker, R. 1981. The Aboriginal and Environmental History of the Chambers Bay Coastal Plains. BA(Hons) dissertation, Department of Prehistory and Anthropology, Australian National University, Canberra.

Bailey, G.N. 1975. The Role of Shell Middens in Prehistoric Economies. PhD dissertation, University of Cambridge, Cambridge.

Bailey, G.N. 1977. Shell mounds, shell middens, and raised beaches in the Cape York Peninsula. *Mankind* 11:132-43.

Bailey, G.N. 1994. The Weipa shell mounds: natural or cultural? In M Sullivan, S. Brockwell, and A. Webb (eds), *Archaeology In The North,* pp.107-29. Darwin: Australian National University, North Australia Research Unit,

Bailey, G, J. Chappell and R. Cribb. 1994. The origin of *Anadara* shell mounds at Weipa, North Queensland, Australia. *Archaeology in Oceania* 29:69-80.

Beaton, J.M. 1985. Evidence for a coastal occupation time-lag at Princess Charlotte Bay (north Queensland) and implications for coastal colonization and population growth theories for Aboriginal Australia. *Archaeology in Oceania* 20:1-20.

Bellwood, P. 1985. *Prehistory of the Indo-Malaysian Archipelago*. Sydney: Academic Press.

Brockwell S. 1996. Mound sites on the Adelaide River coastal plains. In I.C. Glover and P. Bellwood (eds), *Indo-Pacific Prehistory: The Chiang Mai Papers. Bulletin of the Indo-Pacific Prehistory Association* 15:159-64.

Broom, M.J. 1985. *The Biology and Culture of Marine Bivalve Molluscs of the Genus* Anadara. Manila: International Centre for Living Aquatic Resources Management.

Burns, P. 1994. Mound Over Matter: Origins of Shell and Earth Mounds of Northern Australia. An Evaluation of Mounds on Channel Island and Middle Arm Mainland, Darwin Harbour. BA(Hons) dissertation. Department of Anthropology, Northern Territory University, Darwin.

Chappell, J. and J. Grindrod. 1984. Chenier plain formation in northern Australia. In B.G. Thom (ed.), *Coastal Geomorphology in Australia* pp.197-231. Sydney: Academic Press.

Christian, C.S. and G.A. Stewart. 1953. *General Report on Survey of Katherine-Darwin Region, 1946.* Canberra: Commonwealth Scientific and Industrial Research Organization, *Land Research Series* No.1.

Clark, R.L. and J.C. Guppy. 1988. A transition from mangrove forest to freshwater wetland in the monsoon tropics of Australia. *Journal of Biogeography* 15:665-84.

Cribb, R. 1986. A preliminary report on archaeological findings in Aurukun Shire, western Cape York. *Queensland Archaeological Research* 3:133-58.

Cribb, R. 1996. Shell mounds, domiculture and ecosystem manipulation on western Cape York Peninsula. In P. Veth, and P. Hiscock (eds), *Archaeology of Northern Australia*, pp.150-73. St. Lucia: Anthropology Museum, University of Queensland, *Tempus* Vol. 4.

Davis, S. 1985. Aboriginal Knowledge and use of the coast and sea in northern Arnhem Land. In K.N. Bardsley, J.D.S. Davie and C.D. Woodroffe (eds), *Coasts and Tidal Wetlands of the Australian Monsoon Region*, pp.297-312. Darwin: Australian National University, North Australia Research Unit, *Mangrove Monograph* No.1.

Engelhardt, R.A. and P.R. Rogers. 1997. Maritime adaptive strategies in Post-Pleistocene Southeast Asia: an ethnoarchaeological model for the nature and distribution of archaeological sites. *Bulletin of the Indo-Pacific Prehistory Association* 15:177-92.

Gargett R. and B. Hayden. 1991. Site structure, kinship, and sharing in Aboriginal Australia: implications for archaeology. In E.M. Kroll and T.D. Price (eds), *The Interpretation of Archaeological Spatial Patterning* pp.11-32. New York: Plenum Press.

Hanley, J.R. 1988. Invertebrate fauna of marine habitats in Darwin Harbour. In H.K. Larson, M.G. Michie and J.R. Hanley (eds), *Proceedings of the Workshop on Research and Management held in Darwin 2-3 September, 1987*. pp.135-52. Darwin: Australian National University, North Australian Research Unit, *Mangrove Monograph* No. 4.

Hayden, B. 1979. *Palaeolithic reflections: Lithic technology and ethnographic excavation among Australian Aborigines.* Canberra: Australian Institute of Aboriginal Studies.

Hickey, S.H. 1981. *Preliminary Investigation of Stranded Beach Ridges, Shoal Bay, NT. A Small Chenier Plain?* Darwin: Northern Territory Geological Survey, *Technical Report* GS81/1.

Hiscock, P. 1997. Archaeological evidence for environmental change in Darwin Harbour. In J.R. Hanley, G. Caswell, D. Megirian and H.K. Larson (eds), *The Marine Flora and Fauna of Darwin Harbour, Northern Australia*, pp.445-9. Darwin: Museums and Art Galleries of the Northern Territory.

Jones, R. 1990. Hunters of the dreaming: some ideational, economic and ecological parameters of the Australian Aboriginal productive system. In D.E. Yen and J.M.J. Mummery (eds), *Pacific Production Systems: Approaches to Economic Prehistory,* pp.25-53, Canberra: Australian National University, Department of Prehistory, Research School of Pacific Studies,

Jones, R. and B. Meehan. 1989. Plant foods of the Gidjingali: ethnographic and archaeological perspectives from northern Australia on tuber and seed exploitation. In D.R. Harris and G.C. Hillman (eds), *Foraging And Farming: The Evolution of Plant Exploitation,* pp.120-35. Unwin Hyman: London.

Kelly, R.L. 1983. Hunter-gatherer mobility strategies. *Journal of Anthropological Research* 39:277-306.

Kelly, R.L.1992. Mobility/Sedentism: concepts, archaeological measures, and effects. *Annual Review of Anthropology* 21:43-66.

Lees, B.G. 1987. Age structure of the Point Stuart chenier plain: a reassessment. *Search* 18(5):257-9.

Mason, G.M. 1991. The molluscan remains. In C.F.W. Higham, and R. Bannanurag (eds), *The Excavation of Khok Phanom Di: a Prehistoric Site in Central Thailand, Volume II, The Biological Remains*, pp. 249-319. London: The Society of Antiquaries of London.

McCarthy, F. and F.M. Setzler. 1960. The Archaeology of Arnhem Land. In C.P. Mountford, (ed.), *Records of the American-Australian Expedition to Arnhem Land. Vol. 2, Anthropology and Nutrition*, pp. 215-95. Melbourne: Melbourne University Press.

Meehan, B. 1982. *Shell Bed to Shell Midden*. Canberra: Australian Institute of Aboriginal Studies.

Meehan, B. 1988. Changes in Aboriginal exploitation of wetlands in northern Australia. In D. Wade-Marshall and P. Loveday (eds), *Floodplains Research. Northern Australia: Progress and Prospects.* Vol. 2, Appendix 2. Darwin: North Australia Research Unit, Australian National University Press.

Meehan, B. 1991. Wetland hunters: some reflections. In C.D. Haynes, M.G. Ridpath and M.A.J. Williams (eds), *Monsoonal Australia: Landscape, Ecology and Man in the Northern Lowlands*, pp.197-206. Rotterdam: Balkema.

Michie, M.G. 1988. Sediments, sedimentary environments and palaeoenvironments in Port Darwin. In H.K. Larson, M.G. Michie and J.R. Hanley (eds), *Proceedings of the Workshop on Research and Management held in Darwin 2-3 September, 1987*, pp. 32-41 Darwin: Australian National University, North Australian Research Unit, *Mangrove Monograph* No. 4.

Mitchell, S. 1993. Shell mound formation in northern Australia: a case study from Croker Island, Northwestern Arnhem Land. *The Beagle: Records of the Northern Territory Museum of Arts and Sciences* 10(1):179-92.

Mulvaney, J. 1981. Salvaging salvage archaeology. *Australian Archaeology* 12:61-2.

O'Connor, S. and M. Sullivan, M. 1994. Distinguishing middens and cheniers: a case study from the southern Kimberley, W.A. *Archaeology in Oceania* 29:16-28.

Pathansali, D. 1966. Notes on the biology of the cockle *Anadara granosa* L. *Proceedings of the Indo-Pacific Fisheries Council* 11:84-98.

Peterson, N. 1968. The pestle and mortar: an ethnographic analogy for archaeology in Arnhem Land. *Mankind* 6(11):567-70.

Peterson, N. 1973. Camp site location amongst Australian hunter-gatherers: archaeological and ethnographic evidence for a key determinate. *Archaeology and Physical Anthropology in Oceania* 8:173-93.

Pickering, M. 1994. The physical landscape as a social landscape: a Garawa example. *Archaeology in Oceania* 29:149-61.

Povinelli, E.A. 1992. "Where we gana go now": foraging practices and their meanings among the Belyuen Australian Aborigines. *Human Ecology* 20(2):169-202.

Roberts, A. 1994. *Cultural landmarks: the Milingimbi mounds.* In M. Sullivan, S. Brockwell and A. Webb (eds), *Archaeology In The North,* pp.176-87. Darwin: Australian National University, North Australia Research Unit.

Rowley-Conwy, P. 1983. Sedentary hunters: the Ertebolle example. In G. Bailey (ed.), *Hunter-Gatherer Economy in Prehistory: A European Perspective,* pp.111-26. Cambridge: Cambridge University Press.

Russel-Smith, J., D. Lucas, M. Gapindi, B. Gunbunuka, N. Kapirigi, G. Namingum, K. Lucas, P. Giuliana and G. Chaloupka. 1997. Aboriginal resource utilization and fire management practice in western Arnhem Land, monsoonal northern Australia: notes for prehistory, lessons for the future. *Human Ecology* 25(2):159-95.

Shoocongdej, R. 1996. Rethinking the development of sedentary villages in western Thailand. *Bulletin of the Indo-Pacific Prehistory Association* 14:203-15.

Spenneman, D.H.R. 1987. Availability of shellfish resources on prehistoric Tongatapu, Tonga: effects of human predation and changing environment *Archaeology in Oceania* 22(3):81-96.

Stahl, P.W. 1996. Holocene biodiversity: an archaeological perspective from the Americas. *Annual Review of Anthropology* 25:105-26.

Sullivan, M. and O'Connor, S. 1993. Middens and cheniers: implications of Australian research. *Antiquity* 67:776-88.

Suzuki, K. 1986. Volumetry and nutritional analysis of a Jomon shell-midden. In T. Akazawa and C.M. Aikens (eds), *Prehistoric Hunter-Gatherers in Japan.* Tokyo: University of Tokyo Press.

Swadling, P. 1976. Changes induced by human exploitation in prehistoric shellfish populations. *Mankind* 10:156-62.

Veitch, B. 1996. Evidence for mid-Holocene change in the Mitchell Plateau, Northwest Kimberley, Western Australia. In P. Veth and P. Hiscock (eds), *Archaeology of Northern Australia,* pp.66-89. St. Lucia: Anthropology Museum, University of Queensland, *Tempus* Vol. 4.

Warner, W.L. 1958. *A Black Civilization: A Social Study of an Australian Tribe.* New York: Harper and Row, Revised Edition.

Williams, M.A.J. 1969. Geomorphology of the Adelaide-Alligator area. In M.A.J. Williams, A.D.L. Hooper, R.E. O'Ferrall and J.R. McAlpine (eds), *Lands of the Adelaide-Alligator Area Northern Territory,* pp.71-94. Melbourne: Commonwealth Scientific and Industrial Research Organization, *Land Research Series* No. 25.

Wilson, B.A. and D. Bowman. 1987. Fire, storm, flood and drought: The vegetation ecology of Howard's Peninsula, Northern Territory, Australia. *Australian Journal of Ecology* 12:165-74.

Wood, B.G., P.J. Fogarty and K.J. Day. 1985. *The Land Systems of the Darwin Region.* Darwin: Conservation Commission of the Northern Territory, *Technical Report* No. 24.

Woodroffe, C.D. 1995. Response of tide-dominated mangrove shorelines in northern Australia to anticipated sea-level rise. *Earth Surface Processes and Landforms* 20:65-85.

Woodroffe, C.D., J. Chappell and B. Thom. 1988. Shell middens in the context of estuarine development, South Alligator River, Northern Territory. *Archaeology in Oceania* 23:95-103.

Woodroffe, C.D. and Mulrennan, M. 1993. *Geomorphology of the Lower Mary River Plains, Northern Territory.* Darwin: Australian National University, North Australia Research Unit.

Woodroffe, C.D., M. Mulrennan and J. Chappell. 1993. Estuarine infill and coastal progradation, southern van Dieman Gulf, northern Australia. *Sedimentary Geology* 83:257-75.