THE TIME OF THE MANGROVES: CHANGES IN MID-HOLOCENE ESTUARINE ENVIRONMENTS AND SUBSISTENCE IN AUSTRALIA AND SOUTHEAST ASIA.

Harry Allen

Department of Anthropology, University of Auckland, Private Bag, Auckland, New Zealand

ABSTRACT

Between 8000 and 6000 years ago sea levels rose to their present height flooding the coastal river valleys of Northern Australia and initiating a 'big swamp' phase. Since then sediments from rivers swollen by monsoon rains have infilled many of these valleys to the extent that today they show freshwater environments with only a narrow band of mangroves on the downstream tidal sections of the rivers which flow through them. The effects of these environmental changes on Aboriginal settlement and subsistence patterns is shown in the archaeological record of the South and East Alligator River valleys and the Magela Plains. There is a recent (2000-200 BP) increase in the number of settlement sites located on the plains near freshwater swamps, rich sources of plant and animal food. The association of settlement sites, artifacts and environmental changes allows the testing of a number of propositions regarding Aboriginal population growth and/or intensification of economic or social organisation in western Arnhem Land. The paper concludes with a discussion of areas elsewhere in Southeast Asia with evidence for a similar sequence of environmental changes and how these might affect their prehistoric record.

INTRODUCTION

The general circumstances surrounding the post-Pleistocene rise in sea levels in Southeast Asia have been recognised for many years. Environmental and ecological changes include the extension of the South China Sea across the Sunda shelf, the creation of the large islands of Sumatra, Java, Bali and Borneo and many small islands, the extension of tropical rainforests and the resumption of the northwest and southeast monsoon systems. Occurring late in the prehistoric record, these environmental changes form the background to the inception of horticulture and the arrival of Austronesian-speaking peoples with superior sea-going abilities.

In this paper, I look at the evidence for the post-Pleistocene infilling of coastal river valleys in northern Australia by the sea, of the regional development of large expanses of mangrove forests and their subsequent replacement by fresh water wetlands (Figure 1). These changes had a marked impact on the diet and settlement locations of the Aboriginal hunter gatherers who lived in these valleys. They are relevant for Southeast Asia where similar environmental circumstances occurred, and they are also important for an understanding of the adaptations evident in some coastal Hoabinhian sites. Like the east coast of Sumatra, many areas of northern Australia, which previously supported widespread mangrove forests, are today covered with river floodplains and freshwater wetlands associated with a monsoon climate dominated by alternating wet and dry seasons. During the wet season, low lying areas are often covered with flood waters for many months providing both opportunities and obstacles for any resident population.

THE LOCAL EFFECTS OF THE SEA LEVEL RISE IN NORTHERN AUSTRALIA

Although the dates and the exact sequence of changes vary from area to area, a general pattern occurs at a number of locations in northern Australia[1]. Between 19,000 and 8000 BP, sea levels rose from -130 to -12 metres below present levels and covered the previously exposed Sahul shelf (Chappell and Shackleton 1986: 137; Woodroffe *et al.* 1987: 199). Between 8000-6000 BP, as

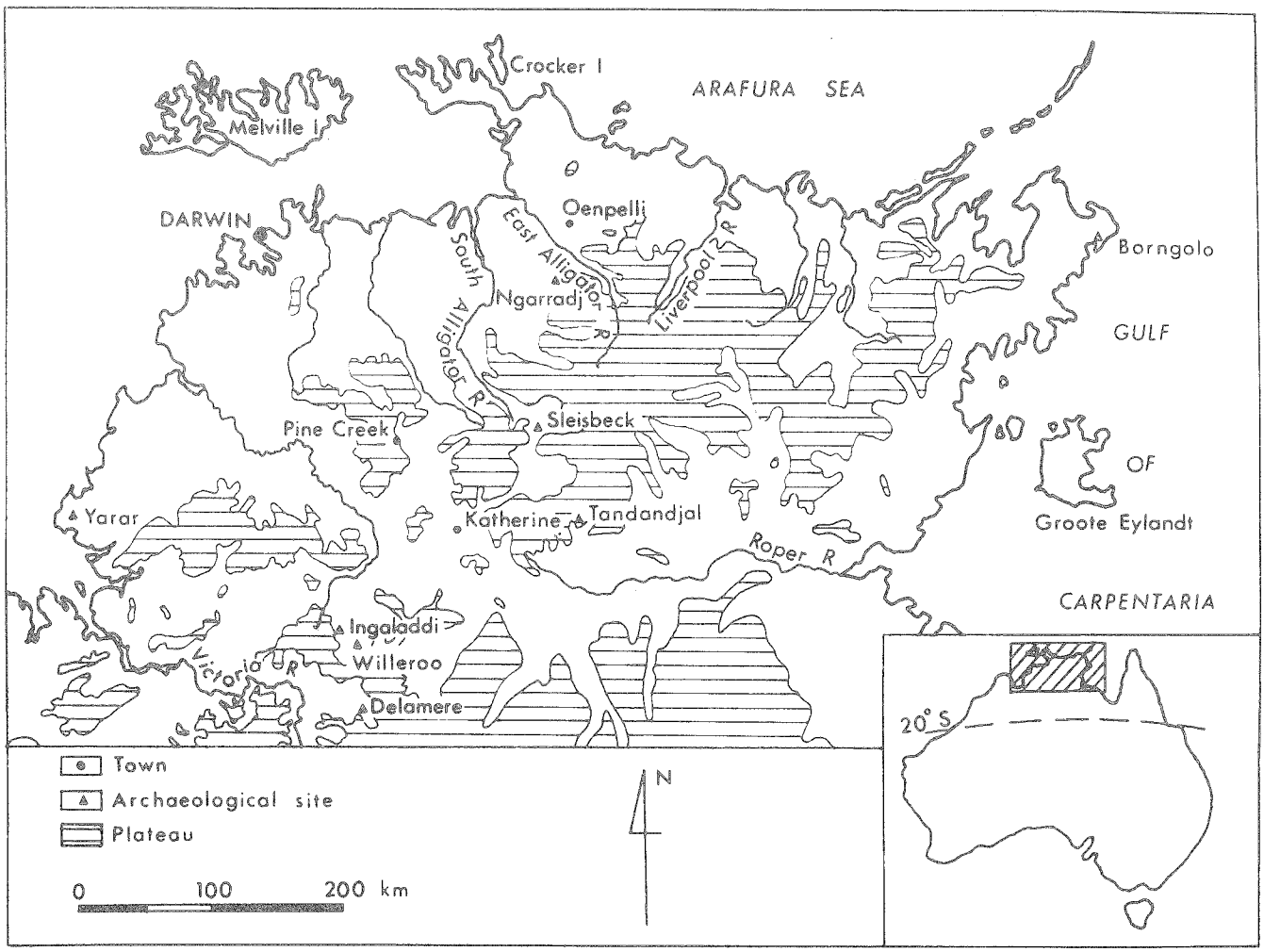

Figure 1: Location of the South and East Alligator Rivers in Northern Australia.

the sea approached its present height, it entered the coastal valleys formed by the South and East Alligator Rivers. These valleys were quickly filled with marine mud and sands and colonised by *Rhizophora* mangroves (Woodroffe *et al.* 1989: 749-53). These forests created a 'big mangrove swamp' phase which lasted from 7000-5300 BP. After this time, sedimentary infilling and raising of the level of the plains caused the mangroves to be restricted to the margins of the tidal river channels and eventually to migrate towards their seaward entrances. This 'transitional phase' (5000-2500 BP) saw the creation of a mosaic of sedimentary environments ranging from tidal channels with *Avicennia* mangroves to hypersaline flats, though seasonally filled freshwater swamps and streams also existed (Clark *et al.* 1992: 89; Woodroffe *et al.* 1989: 753). After 2500 BP and up to the present day, mangroves are located only in the downstream sections of these rivers while further upstream freshwater swamps and seasonally covered grassy wetlands predominate.

The post-Pleistocene rise in sea levels initiated the big mangrove swamp phase. There is, however, no conclusive evidence that a fall in relative sea level was responsible for the onset of the transition from mangroves to a freshwater environment. In this region indications for any drop in sea level after 5000 BP are limited to ±1 metre (Woodroffe *et al* 1992: 113). Claims for apparent lower or higher sea levels can be explained in terms of the present tidal range of ±1-3 metres, which can go up

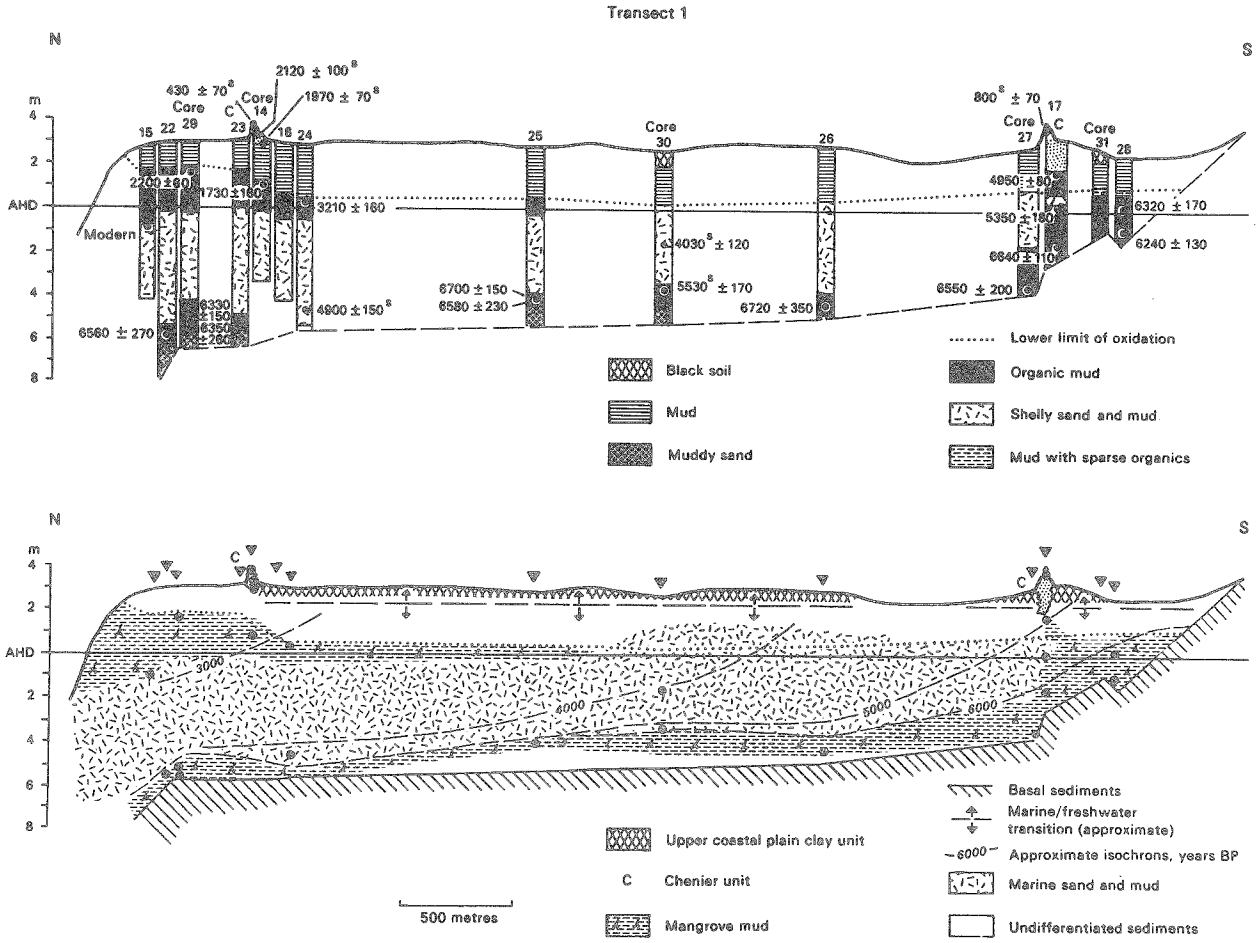

Figure 2: Schematic transects along the coastal plain of the South Alligator River showing the location of cores and radiocarbon dates (above) and stratigraphy (below). From Woodroffe et al. *1986, Fig. 41. Copyright Northern Australia Research Unit, ANU, reproduced by permission.*

to ±6 metres during spring tides, or else through hydro-isostatic processes (Woodroffe *et al.* 1989: 752; Clark *et al.* 1992: 90). The radiocarbon dates which document the build up of sediments in the valleys of the South Alligator River and Magela Creeks and the later migration of mangroves downstream suggest a continuous and gradual regression of the sea (Clark and Guppy 1988: 681, Fig 2). There are, however, indications of minor pulses in the availability of sediments. Lees (1992: 8), using data from coastal dunefields argues that the past 3500 years have been climatically variable showing an overall drying trend interspersed with periods of increased seasonal rainfall and mudflat progradation.

The sedimentary reflection of these changes are best seen in longitudinal sections recorded from bore holes in the valley of the South Alligator River. Figure 2 shows a transect up the valley created by the South Alligator coastal plain and shows the location of bores, radiocarbon dates and a schematic sedimentary section. The sequence contains three major components, firstly, basal Pleistocene terrestial sediments older than 7000 BP, secondly, a mangrove component with dates between 7000 BP and 2200 BP, showing both the period when the entire valley was covered in mangroves (7000-3500 BP) and the subsequent migration of mangroves towards the

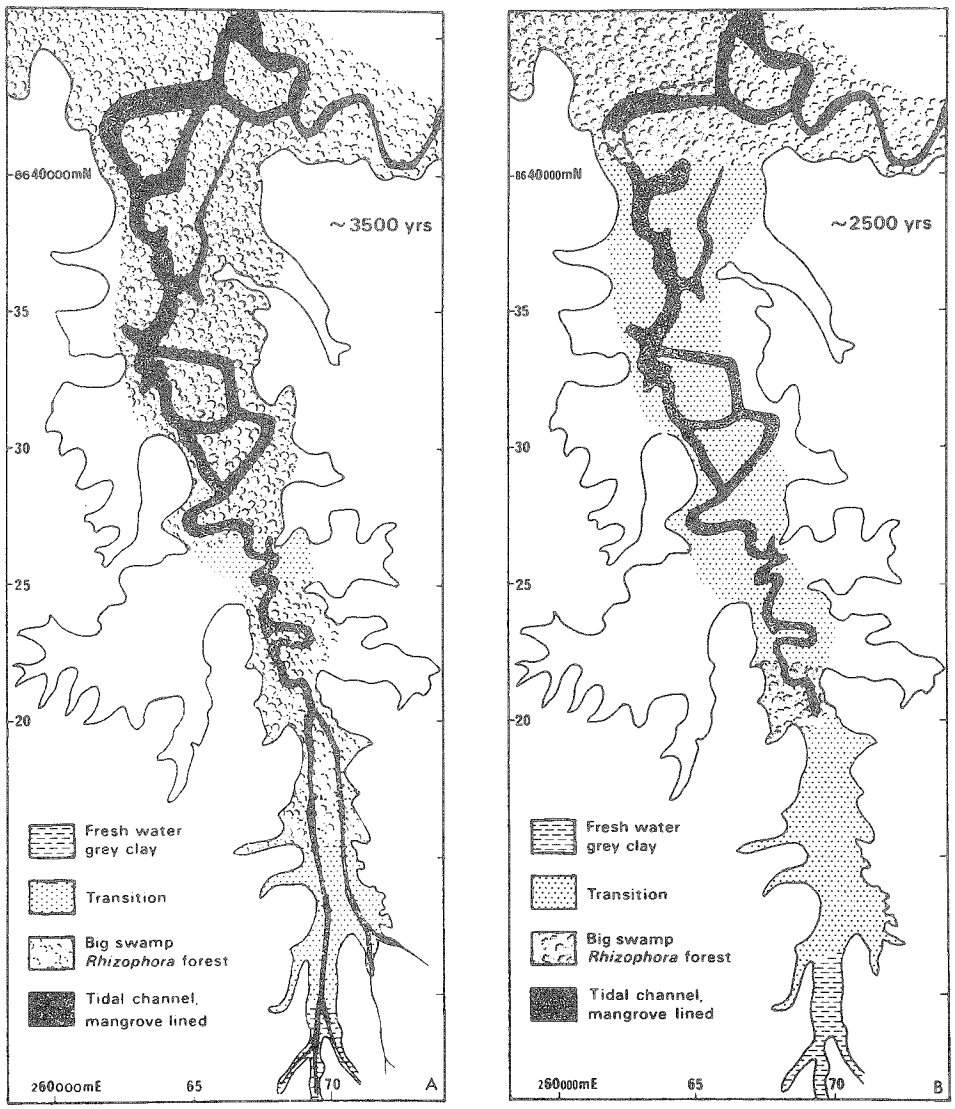

Figure 3: Sedimentary environment of the Magela Creek: A, at 3500 BP and B, at 2500 BP. From Clark et al. *1992, Figs 4.21 and 4.22. Commonwealth of Australia copyright, reproduced by permission.*

river margins and mouth (3500-2000 BP). Finally, there is a recent veneer of freshwater clay deposits associated with the extant swamps and seasonal wetlands which covers the estuarine sediments of the mangrove phase.

Figure 3, from the adjacent Magela Creek system, shows the distribution of vegetation zones at 3500 BP and 2500 BP. At 3500 BP, the valley was choked with mangroves. A thousand years later, at 2500 BP, the transition phase was in full swing and mangroves were restricted to the river margins and the downstream junction with the East Alligator River. The highly productive seasonal wetlands and swamps of the present day date only to the last 1500 years.

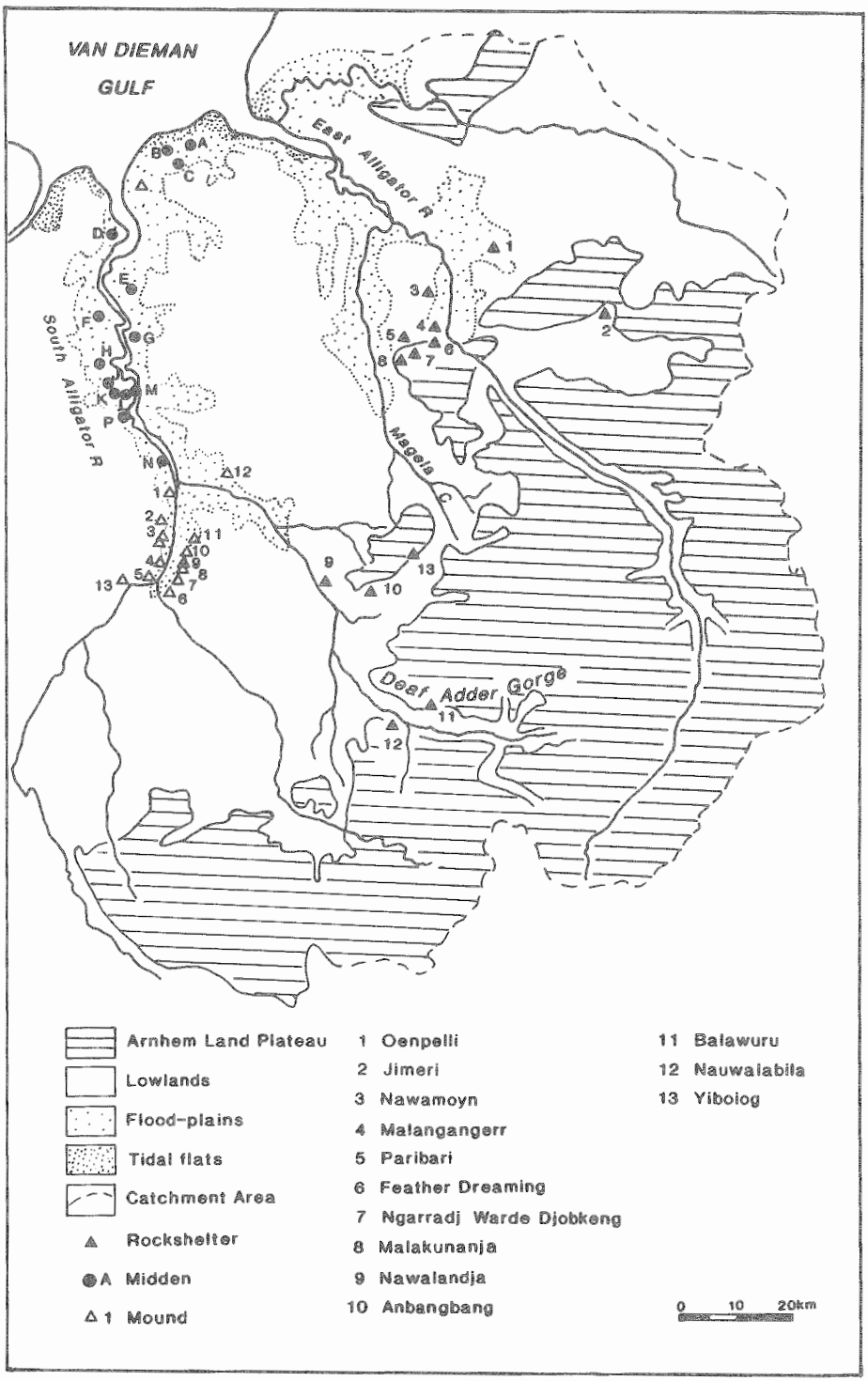

Figure 4: Location of the archaeological sites along the western margin of the Arnhem Land Plateau and on the South Alligator River plains.

ABORIGINAL SETTLEMENT AND SUBSISTENCE ALONG THE SOUTH AND EAST ALLIGATOR RIVER VALLEYS AND MAGELA CREEK

The environmental changes outlined above profoundly influenced Aboriginal subsistence and settlement patterns. Furthermore, they have had an impact on the subject matter of the rock art in the shelters adjacent to these plains (Chaloupka 1985) and on Aboriginal material culture and social life. The distribution of archaeological rockshelters along the western margin of the Arnhem Land Plateau, and of midden and mound sites on the plains of the South Alligator River, are shown in Figure 4[2]. These sites are the composite result of more than 25,000 years of Aboriginal occupation. Changes in site occupation and distribution are discussed below, in turn, for the periods 26,000 to 7000 BP, 7000 to 5000 BP, 5000 to 1500 BP and finally, from 500 BP to the present day .

26,000 to 7000 BP

The plains of the South and East Alligator Rivers have been occupied since 50,000 BP (Roberts *et al.* 1990) or c.30,000 BP depending on whether one accepts the thermoluminescence dates as valid or not. Prior to the post-Pleistocene rise in sea levels, environmental conditions varied between semi-arid woodland and open tropical forest (Allen and Barton 1989: 7-9) and hence would have been suitable for camping and hunting throughout the period in question (Figure 5A). Current archaeological evidence for the early period, however, is limited to rockshelters along the eastern margin of these plains, at sites such as Malakunanja II, Nawamoyn, Malangangerr, Nauwalabila I, Ngarradj Warde Djobkeng, and Nawulandja (Allen 1989: 106-9, Figure 4). Stone artefacts, including edge ground axes, ochre pieces and large numbers of stone flakes, together with sedimentary evidence are the only surviving remains. There are, however, indications of an increase in both the number of rockshelters used and densities of artefacts discarded at them towards the end of this period (18,000-7000 BP), which indirectly suggest an increase in the Aboriginal population of the region or at the least a marked change in stone tool discard patterns. The absence of direct evidence of Aboriginal settlement on the river plains is almost certainly a product of site visibility and survival, although there may also have been seasonal deficits in water availability due to a changed and reduced pattern of rainfall after 18,000 BP which would restrict access to the plains during dry periods.

7000 to 5000 BP

The rise in sea levels affected human behaviour in a number of ways. Occupation of rockshelters continued, however, and in addition there is some limited evidence for open camps on the landward margin of the mangrove swamps (Figure 5B). The most obvious change is the presence of shellmiddens comprising mangrove and mudflat crabs and shellfish, fish remains and bone points (probably for fish spears) at Ngarradj, Malakunanja II, Nawamoyn and Malangangerr in layers dating between 7000 and 3000 BP, together with the occupation of new shelters, Paribari and Argaluk. The shellfish genera present include *Nerita, Cerithidea, Terebralia, Telescopium, Cassidula, Ellobium* and *Geloina*. These are all available from the mangrove and salt flats zones. *Cerithidea* in particular can be collected in large numbers from mangrove trunks at low tide. The presence of brackish/freshwater fish, such as barramundi (*Lates calcarifer*), catfish (*Hexanematichthys* and *Neosilurus* sp.) and sleepy cod (*Oxyeleotris lineolatus*), together with long-necked turtle (*Chelodina expansa*), indicates the local availability of both tidal channels and freshwater swamps. However, current markers of large-scale wetlands such as the magpie goose (*Anseranas seimpalmata*) are absent or only present in small numbers from the uppermost midden layers of these rockshelters. Similarly, the vast majority of crab remains at these sites are *Sesarma* sp., which makes its home on the banks of tidal channels, rather than the large mangrove crab *Scylla serrata*. Consequently, most Aboriginal collecting seems to have taken place on the landward margins of the mangrove forest rather than along the tidal channels within it.

Prior to the intensive geomorphological study of the South Alligator River sediments, the presence of the mangrove shellfish species in these rockshelters presented problems of interpretation. Today the nearest mangrove patches are 25-30 km downstream and even these are not substantial (though estuarine mudflats on the East Alligator River are closeby). Aboriginal informants initially suggested 'Noah's Flood' as a possible explanation. The presence of large areas covered by mangrove, while a useful source of food for Aboriginal hunter gatherers, would have presented a barrier to movement and settlement in the area. Nonetheless, White *et al.* (1990: 175) argue that the mangrove swamps improved the natural productivity of the area resulting in an increase in both the population density and the total number of people supported by these plains.

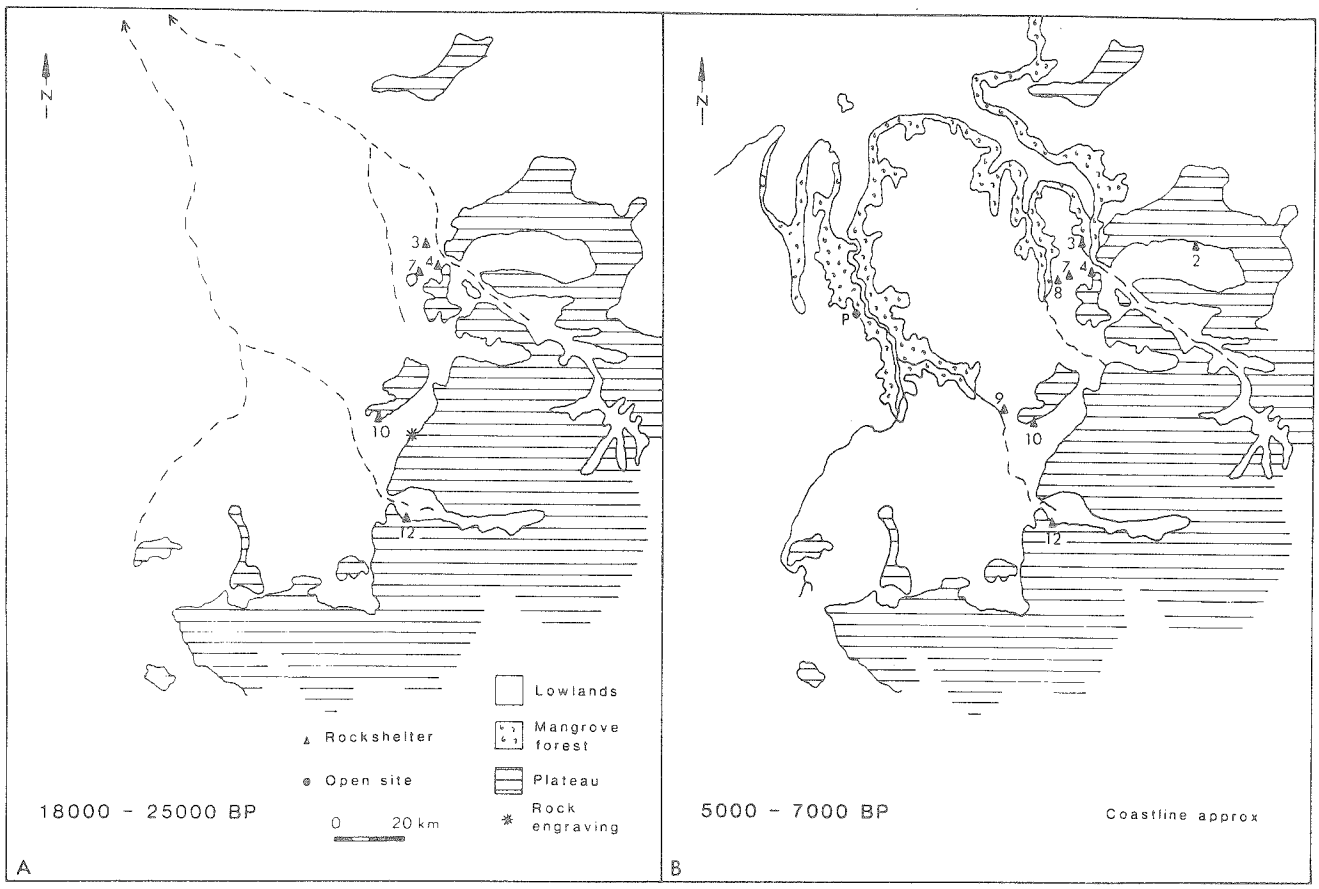

Figure 5: Distribution of archaeological sites along the western margin of the Arnhem Land Plateau and on the South Alligator plains: A, dated between 25,000 - 18,000 BP and 7000 - 5000 BP.

5000 - 1500 BP

The majority of rockshelters already in use continued to be used through the transition period when the area covered by mangrove forests was substantially reduced and saline flats separated the river channels from the woodland margins. However, by about 2500 BP, some rockshelters, such as Nawamoyn, Malakunanja II and Ngarradj Warde Djobkeng ceased to be used in any substantial manner. This suggests that the changes in the local environment, especially the shift in the location of the mangroves, removed their usefulness as base camps. Other rockshelters, particular those near permanent freshwater streams or swamps such as Nauwalabila I, Jimeri I and Nawulandja, or closer to a tidal river such as Malangangerr and Paribari, show continuous occupation despite the changes in the local environment. It is difficult to gauge the extent of settlement on the floodplains at this time as their surface has been covered by more recent mud and clays. Some middens are present and these have been dated to this period of transition (Figure 6A).

1500 BP- Present Day

The creation of swamps and freshwater wetlands after 1500 BP appears to have stimulated a reorganisation of Aboriginal site location and subsistence strategies (Figure 6B). Numerous small and large mound sites have been reported on the flood plains of the South and East Alligator Rivers and the Magela Creek (Meehan *et al.* 1985). Those shown on Figures 4 and 6B represent only a minority of those currently known to be present

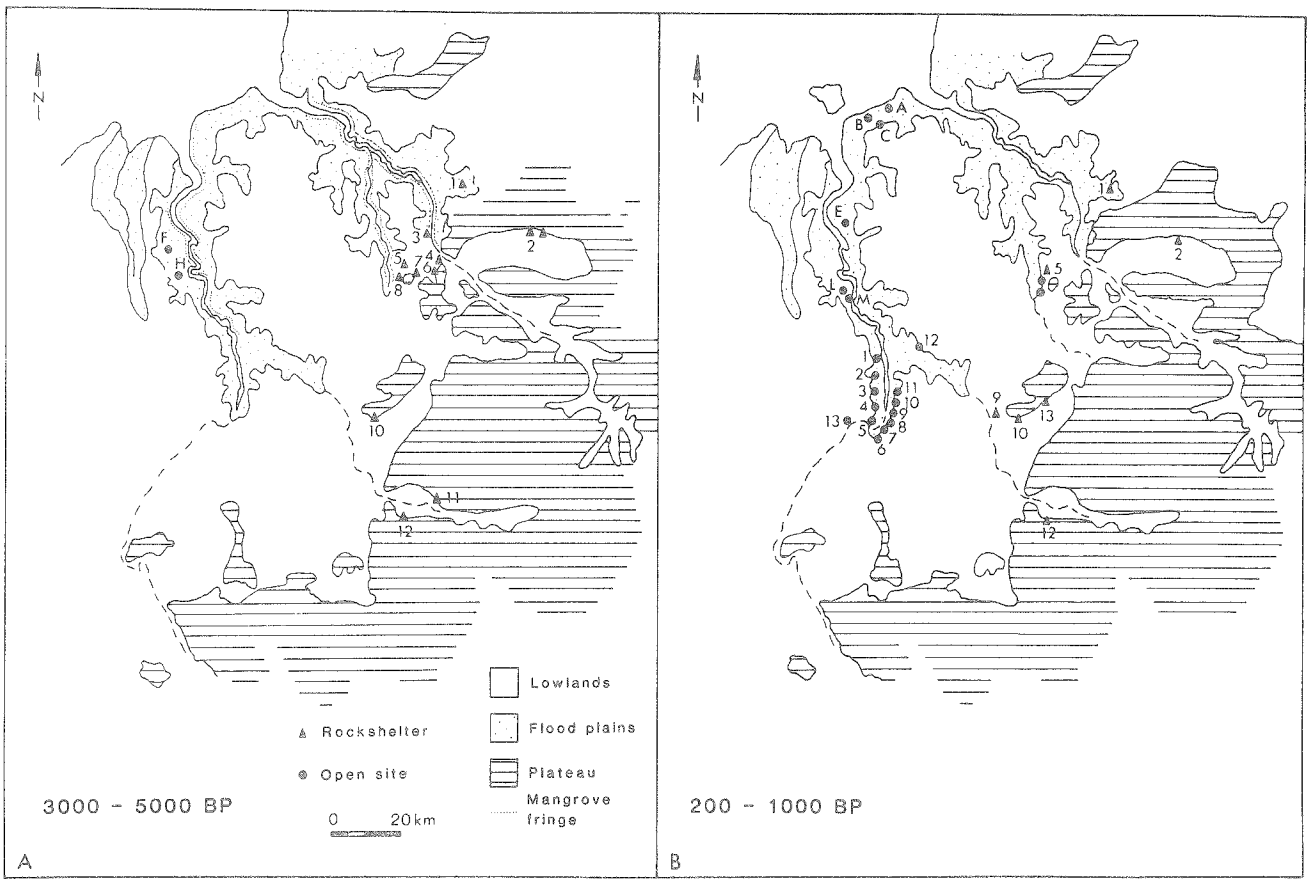

Figure 6: Distribution of archaeological sites along the western margin of the Arnhem Land Plateau and on the South Alligator plains: A, dated between 5000 - 3000 BP, and B, from 1000 - 200 BP.

(Brockwell 1989; Hiscock *et al.* 1992). Rockshelters such as Nauwalabila 1 show a decline in artefact numbers and densities after 1000 BP (White *et al.* 1990: 174) while other shelters close to freshwater, such as Anbangbang 1 and Yiboiog, reverse this trend and show increased usage over the same time period (Brockwell 1989: 226). Jones (1985: 292-4) sees the creation of the freshwater wetlands over the past 1500 years as transforming the area into one of extremely high natural productivity for Aboriginal hunter gatherers. This change is reflected in an increase in the density of archaeological sites, together with an increase in Aboriginal populations and a reorganisation of the Aboriginal economy to take full advantage of the increased food supply.

ABORIGINAL RESPONSES TO ENVIRONMENTAL CHANGE

The complexity of the changes outlined above and the detailed archaeological record now available for western Arnhem Land enables us to examine the response of the Aboriginal population to these environmental shifts.

Woodroffe *et al.* (1988: 96-7) document middens on the South Alligator Plains in four environmental situations: coastal middens on top of chenier ridges (estuarine and marine shellfish); surface mounds on the estuarine plains (mangrove shellfish); middens on the banks of river paleochannels (mangrove shellfish); and finally, surface scatters of a few shells. Radiocarbon dates from 14 middens span three periods. Firstly, c. 6000 BP (midden P), secondly, c. 4600 to 1900 BP (middens D,F,G,H,J,K and N), and finally, 800 to 200 BP (middens

A,B,C,E,L and M) (Allen 1989: 101-2). The coastal middens dated so far belong to the final, most recent period. The periodicity of the dated mangrove middens is a reflection of the environmental changes in combination with sampling error. The 1000 year period between 800 and 1900 BP is as yet unrepresented by any site on the plains. At the same time, Meehan *et al.* (1985: 152) suggest that the sites at the southern end of the South Alligator River floodplain (sites 1-13 on Figure 4), with freshwater shellfish, also date between 1000 to 400 BP. Hiscock and Mowat (1993: 23) use midden shellfish contents to demonstrate that the Aboriginal response to changing environmental circumstances was highly variable. The dates from mangrove shellfish middens on the banks of palaeochannels of the South Alligator River, ranging from 4000 to 500 BP (Woodroffe *et al.* 1988: 97), illustrates the complexity of the changes in question. Mangroves fringing the tidal channels and infilled palaeochannels still formed a utilisable resource zone at the same time as highly productive freshwater swamps were forming on the plains.

Precise parallels between the utilisation of camping places and ethnographic patterns of hunting and gathering in this region can only be valid for the last most recent period of Aboriginal occupation. For earlier periods, the environmental circumstances were quite different. Whatever pattern of seasonal movements the Aboriginal occupants of these rockshelters were making during the 'big mangrove swamp phase' the physical barrier of the swamps would have prevented movement through and across them. The information currently available does not confirm Schrire's (1982: 249-52) proposed seasonal model for the Aboriginal utilisation of these plains which used the archaeological evidence from rockshelter sites to the east. In this model, which is based largely on ethnographic observations from elsewhere in Arnhem Land, Aborigines moved out onto the plains and swamps during the dry season and retreated to the rockshelters on higher ground during the wet. The surveys of large sites on the plains with extensive stone artefact scatters (Meehan *et al.* 1985: 135-40) supplemented by the data on smaller sites (Hiscock *et al.* 1992) suggests that populations were more sedentary and less mobile than Schrire's (1982) model indicated. It is likely that Aborigines used both large camps and smaller sites within the plains for varying periods of time throughout the year.

Changes through time in the composition of stone artefact assemblages at sites and rockshelters in this region only indirectly reflect the changes in the environment. This suggests that the two are not causally related. The major changes are as follows. From an initial archaeological signature of quartzite cores, flakes and ground edge axes there is an increase in the discard of small quartz and chert flakes and cores by c. 18,000 BP. At c. 5000 BP numbers of stone projectile points and flake adzes are deposited in the rockshelters; finally, over the last 2000 years or so, the numbers of small projectile points being manufactured dwindles, and flakes with use-polish, large endstruck blades and numerous small quartz flakes and cores are present (Allen 1989: 93-9). Hiscock (pers. comm. 1994) relates some of the changes in raw materials, especially the presence of many quartz flakes on the wetlands sites, to local availability. The flakes with use polish are closely associated with the freshwater swamps which suggests some specialised functional relationship with them.

The rise in sea level, at 7000 BP, the creation of the coastal environment and the initiation of the big mangrove swamp phase are reflected archaeologically in the rockshelters and middens on the plains by the presence of fish, mangrove shellfish and fishing equipment (bone points). Changes in stone artefacts, the manufacturing of stone projectile points and the use of flake adzes, at c. 5000 BP, do not coincide with this major environmental change though they may partly be a delayed and indirect response to it.

A number of attempts have been made to correlate changes in Aboriginal rock art styles with these environmental changes (Chaloupka 1985), however, only the most recent style, polychrome X-ray art, can definitely be related to any environmental zone, in this case with the presence of tidal river channels and freshwater wetlands.

For prehistoric Australia it has been assumed that intensification of production and an increase in Aboriginal population densities, as measured by the number of residential sites present and the discard rates of stone artefacts at them, has only occurred during the past 5000 years. This is explained as a reaction either to the Holocene amelioration of climate or to socially generated change (Beaton 1983; Hughes and Lampert 1982; Lourandos 1983). More recent evidence suggests thet there were regional responses to environmental and other changes rather than any Australia-wide pattern (O`Connor *et al.* 1993).

In western Arnhem Land, the first indications of intensive site occupation occur at Nauwalabila I, Malakunanja II, Ngarradj Warde Djobkeng, Nawamoyn and Malangangerr at about 18,000 BP, well within the Pleistocene (Allen and Barton 1989: 77-87). The shifts in ecological conditions marked by the onset of the big mangrove swamp phase, and the later transition, first to

saline flats and later to freshwater wetlands, have been interpreted as marking cumulative and increasing peaks in both the natural productivity of the area and in the total population and population density of its Aboriginal inhabitants. Commentators have been less certain as to whether the increased productivity of the region has led to a more complex economic and social organisation over time. Jones (1990: 32-4), in particular, has argued (*contra* Lourandos 1983) that there was no transformation of social structure but rather a tighter packing of small clan territories in the richer coastal area. Problems with both the evidence for increasing populations over the period in question (Hiscock 1981) and with the definition of Aboriginal social and economic organisation makes it difficult to test these propositions. The range of indicators used at present is too narrow. The current evidence is unable to demonstrate continuity of use of the floodplains over the past 7000 years let alone an incremental increase in population. The analysis of middens accumulated during the mangrove swamp phase (eg., Schrire 1982: 80), which shows the gathering of small mangrove shellfish in relatively low numbers, does not suggest a super-productive environment. Similarly, the mangrove shellfish middens on the plains are small and scattered compared to other areas of northern Australia. The information currently available could as easily prove a thesis of resource or population stress between 6000 and 3000 BP. On the other hand, the production of small projectile points in large numbers, together with evidence for trading ceremonies in this region (Berndt 1951), might well reflect the existence of social mechanisms necessary to allow many groups of semi-sedentary hunter gatherers to coexist in a restricted area of land. The evidence for the extensive use of the wetlands after 1500 BP is more secure and probably does represent both an increase in the region's productivity and the number of people supported there.

Beaton (1985) has argued that there was a timelag between the termination of the last marine transgression at the present sea level (by 6000 BP) and Aboriginal use of resources from littoral zones as part of a developed coastal economy (4700 BP). Evidence from Princess Charlotte Bay in north Queensland (Beaton 1985: 5-10) indicated intensive use of the coast and a building up of large shell middens between 2000 and 500 BP, reflecting rather than causing an increasingly dense population. The information from the Alligator Rivers region above and from north Western Australia (O'Connor and Veth 1993: 30) suggests that the Aboriginal response to the rising sea level, and the survival of evidence regarding that response, was highly variable depending on the environmental circumstances.

THE POST-PLEISTOCENE SEA RISE AND SOUTHEAST ASIA

Areas where a major mangrove phase may have been present during the mid-late Holocene are briefly reviewed by Allen (1987: 7-8). Those areas likely to show changes parallel to the ones documented for northern Australia above should be similarly subject to tropical monsoon climates, with marked seasonal variations, and located near high sediment-bearing rivers on low-energy coasts. The archaeological marker will be mangrove/mudflat shellfish middens now located in areas of freshwater swamp land well away from contemporary mangrove zones or coastlines.

The combination of factors responsible for the big mangrove swamp phase in northern Australia noted above are repeated in a number of tropical Asian regions. Similar sedimentary sequences are known from the Bengal Basin, the Gulf of Thailand, along the coasts of Vietnam and South China, and in the Straits of Malacca. Areas of Kalimantan and north Java are likely to be similarly affected.

Banerjee and Sen (1988: 703-31) discuss the results from a series of cores taken near Calcutta in the Bengal Basin, between 50 and 100 km from the present sea coast. These cores reveal deep marine deposits and mangroves from 7000 to 5000 BP, underlying terrestrial sediments containing a freshwater bioassemblage dating between 5000 and 2500 BP to the Recent period.

Along the coasts of the South China Sea, during the mid-Holocene transgression, sea water intruded inland along the rivers. Marine layers dating between 8000 and 3000 BP were deposited around the river mouths and on adjacent plains, such as the Longhai, and Puning Plains, the Hanjiang, Pearl River and Moyangjiang Deltas, the Nandujiang estuary in Guangdong, Hong Kong and the Hepu Basin of Guangxi (Huang and Chen 1988: 294). Marine sediments were replaced by terrestial or fluvial deposits after 3000 BP. Huang and Chen (1988: 307-8) note that the apparent regression of the sea can be explained by river deposition and hydro-isostatic changes and that it is unnecessary to infer any higher mid-Holocene sea level.

A higher mid-Holocene sea level of +4 m for coastal Vietnam is invoked by Bui Vinh (1994) to explain the presence of marine shell middens (dating between 6000 and 5000 BP) 10 km inland in the coastal area of Quynh Luu district, and 30 to 40 km inland near the Thanh Hoa mountains. The evidence for the higher sea level is am-

biguous, as by 4000 BP the sea had withdrawn to its present position.

Higham and Bannanurag (1991: 10-2) discuss cores taken from the Bangkok and Chanthaburi areas of Thailand and outline a complex sequence of changes associated with the flooding of the Chao Phraya and Bang Pakong river valleys. They note that the

> main sublittoral-shallow marine phase [for the Bangkok cores] lies between 7500 and 4600 BP...*In situ* mangrove wood was dated at c. 7800 BP.

At Chanthaburi, a poorly sampled and dated core shows a sequence from a transitional swamp, followed by zones of *Rhizophora* and later a change to freshwater lagoon sediments and pollen, though other cores show the mangroves above a zone of freshwater deposits.

Higham and Bannanurag (1991: 18) accept Geyh *et al.*'s (1979) evidence that sea levels in the Straits of Malacca were *circa* five metres above the present mean between 5000 and 4000 BP. However, little is known about post-Pleistocene isostatic movements for this region and this claimed higher sea level may be more apparent than real. Maloney (1991: 92) notes that cores adjacent to the Khok Phanom Di site suggest the area was covered by a shallow sea or in the inter-tidal zone between 8000 and 6300 BP, with a high *Rhizophora* and *Bruguiera* mangrove content. Grass pollen indicative of human interference increases dramatically after this time. The reconstruction of the changes in the environment of Khoh Phanom Di between layer 11 (>4400 BP) and layer 4, except for the claimed higher sea level, parallels the North Australian situation exactly.

Another area that fits the locational and environmental requirements for a mid-Holocene shift from an extensive mangrove zone to freshwater swamps, without the necessity of higher sea levels, is on both sides of the Straits of Malacca. Geyh *et al.*'s (1979) data showing mangrove deposits between 8000 and 6000 BP beneath peats dating 5000 BP to the present suggest similarities. In addition, the location, dating and shellfish content (mangrove/mudflat/ estuary species) of Hoabinhian shellmiddens in Sumatra, now many kilometres inland (McKinnon 1990), suggests that further environmental surveying of the eastern Sumatran floodplain would provide a sequence of changes already documented for North Australia and the coasts of central Thailand and South China.

It would be wrong to try to extrapolate directly from the northern Australian experience to all other tropical regions. Detailed examination of situations and sedimentary sequences is required in each case. It is clear that in some areas quite different patterns of marine transgression and river valley infilling occurred. The lower 80 km of the Sepik-Ramu valley in northern Papua New Guinea, for instance, was invaded by an inland sea at about 6000 BP without any major mangrove phase being present. This valley filled with sediment so that there was a rapid change from saline to freshwater swamps and peat conditions (Swadling *et al.* 1989).

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NOTES

1. Fossil middens with mangrove shellfish species indicative of more widespread mangrove forests during the mid-Holocene to Recent period have been recorded in northern Australia between Exmouth Gulf in the west (Kendrick and Morse 1990; O'Connor and Veth 1993) and Arnhem Land in the east. Mangroves still flourish along the entire coast of northern Australia (Galloway 1982: 37), but with a reduced distribution since 5000 BP in the north.
2. That hydro-isostatic adjustments explain the expansion and subsequent reduction of mangroves in the northern Australian river valleys does not imply that mid-Holocene changes in sea level might not have occurred elsewhere. In particular, Dickinson *et al.* (1994) argue convincingly that there was a mid-Holocene highstand across much of the southwest Pacific. They rightly point out that oceanic areas can be expected to respond quite differently in this regard compared to areas closer to the continental margins.
3. The number of sites shown on the South Alligator plains in Figure 4 reflects data available up to 1989. More recently, Hiscock *et al.* (1992) have conducted more intensive surveys and recorded many more sites which complement the known range, particularly at the smaller end.

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