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Coastal shell middens of the Abydos Coastal Plain, north Western Australia

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Abstract

Anadara granosa dominated middens and mounds began to form on the Abydos Plain sometime between 4400 and 5300 calibrated years before present, and while mounds appear to have ceased forming some 1800-1600 years ago, middens continued to form until the early twentieth century or later. In some cases, the earliest of these middens and shell mounds formed on top of older middens from which *Anadara granosa* is totally absent, in which *Terebralia palustris* (while occurring in relatively low concentrations) is the dominant shell species. *Anadara granosa* dominated middens (*sensu lato*) occur in a variety of forms across the landscape, including large shell mounds, earth mounds (or mounded shell middens), lenses of shell eroding out of well-developed dunes, and undifferentiated surface shell scatters. The large number of middens which occur throughout the region from the mid Holocene, and the volume of shell represented by these sites, points to the occurrence of significant economic and social changes from the mid to late Holocene. The Abydos Coastal Plain experienced increasing aridity, and, as a result, increased resource-stress during the mid Holocene. We suggest that the large, single species *Anadara granosa* middens were occupied during regular periods when large groups of Aboriginal people undertook ceremonial activities after the wet season, when resources were abundant. Changes apparent in the archaeological record, including the occurrence of large numbers of *Anadara granosa* dominated middens and shell mounds, increased establishment of archaeological sites and increased complexity and distance of exchange systems, came about as a result of social, economic and logistical restructuring. This in turn was the result of the effects of resource stress on local Aboriginal people over the course of the mid to late Holocene.

Keywords

Archaeology • shell middens • Abydos Plain • Pilbara • *Anadara granosa*

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Introduction

The mid-Holocene appearance of large, single species *Anadara granosa* shell middens and the shift from mudwhelk to bivalve-dominated assemblages in rockshelter and open site deposits in north Western Australia has been well documented, although details of the timing and meaning of such shifts have not yet been clarified. This paper draws on the results of excavations undertaken by the authors on the Abydos Plain in the northern Pilbara coast to clarify the timing of such shifts, and proposes that the appearance of such sites in the archaeological record results from a series of changes in economic scheduling, resource availability, social organisation and mobility. Our interpretation of this data suggests that the large, single species *Anadara granosa* middens were occupied during regular, annual periods when large groups of Aboriginal people lived in a semi-sedentary fashion immediately after the wet season, when resources were abundant and ceremonial activities were undertaken. This explanation has implications for the interpretation of single species bivalve dominated shell middens throughout north Western Australia.

Previous archaeological research in the coastal Pilbara

Pleistocene occupation of the north Western Australian coast was established by Morse (1993, 1999), whose excavations at Mandu Mandu Creek rockshelter in Cape Range National Park revealed an occupation sequence dating back some 30,000 years. The oldest dated archaeological sites on the western Australian coast are presently Jansz and C99 rockshelters, located approximately 50km north of Mandu Mandu Creek, with occupational sequences dating to 35,000BP and 34,000BP respectively (Przywolnik 2005). The oldest shell midden on the north West Australian coast is presently Wooroora midden, which has been assigned a radiocarbon date of 7810 ± 110 BP (Kendrick and Morse 1982).

Pat Vinnicombe obtained radiocarbon ages from a series of fifteen test pits and three auger sampled sites from a range of different geomorphic zones across the Burrup Peninsula for Woodside Petroleum in 1980-81 (1987). Material from seven of the test pits and one of the augered samples have been dated, provided radiocarbon ages of between 6740 ± 130 BP and 260 ± 10 BP. These ages are associated with a number of different site types including shell middens, open campsites, a stone arrangement site and a rockshelter. Harris (1988) analysed the material from the Georges Valley site, which has three radiocarbon ages ranging between 4190 ± 100 BP and 1360 ± 130 BP. She noted significant differences between the sequences at Skew Valley and Georges Valley, where rocky platform mollusc species dominate the sequence, with the increase of mangrove mollusc species such as *Terebralia* sp. combined with the mid-littoral sand and mudflat species *Anadara granosa* after c.2500BP. Unlike Skew Valley, no microliths were excavated from Georges Valley. These differences in sequences at the two sites is noteworthy, given they are only approximately 10 km apart.

Veth and O'Brien (1986: 57) commented on the apparent lack of stratified archaeological midden sites on the Abydos Plain, with the exception of the Burrup Peninsula. They suggested that this absence was due to erosional processes rather than cultural ones, pointing to the erosion and periodic flooding which occurs in the region. Since this article was published, a number of stratified midden sites have been located on the Abydos Plain, although as Clune notes (2002: 65), in relatively low densities. Bradshaw undertook a series of excavations in the period 1992-1994 to attempt to establish a regional sequence for a section of the coastal Pilbara from the Maitland River to Balla Balla. Radiocarbon ages obtained for these excavations range from 8520 ± 80 BP to 1470 ± 50 BP (Bradshaw 1995). These sites were predominately composed of *Anadara granosa*, and appear to replicate the Skew Valley type sequence of a change from *Terebralia* sp. to *Anadara granosa* after approximately 4000 years BP.

The *Terebralia*-*Anadara* type sequence in north Western Australia

Excavations by Lorblanchet at Skew Valley and Gum Tree Valley on the Burrup Peninsula in 1975-6 and 1984 established the Holocene type sequence for the region. Lorblanchet found that the basal layer of the midden at Skew Valley was composed primarily of the gastropod *Terebralia* spp, while the upper layers were composed predominately of the bivalve *Anadara granosa* (1992: 40). The change in shell species dated to approximately 4000 years BP and was associated with the appearance of microliths in the deposit. Lorblanchet, who noted an association between engraving sites and shell middens, and whose work was primarily concerned with establishing a typological sequence for the rock art, also obtained a date of 18510 ± 260 BP from a large *Syrinx aruanus* shell found in association with rock engravings. However, the association between the shell and stone artefacts found at the site is tenuous (Clune 2002: 64).

The sequence of change from a dominance of the mangrove gastropod *Terebralia* sp. in archaeological sites dating to the early Holocene to a dominance of the sand and mudflat adapted bivalve *Anadara granosa* in the mid Holocene documented at Skew Valley has subsequently been found to occur in a range of north Western Australian coastal sites, including Noala 1 and Haynes Cave on the Monte Bello Islands (Veth 1994, 1995), Clarke's Cave, Anadara Mound and Not-so-Secret Shelter on the Burrup Peninsula (Bradshaw 1995: 37), near Port Hedland at FMGP04-014 (Harrison, this volume), in archaeological sites at Shark Bay (Bowdler 1990a, 1990b) and Cape Range (Morse 1993, 1999, Przywolnik 2005), south of Shark Bay at the Zuytdorp site (cited in Przywolnik 2005: 187), at Tubridgi Well near Onslow (Veitch and Warren 1992), and in the southwest Kimberley at the rockshelter sites of Koolan Shelter 2 and Widgengarri Shelter 1 (O'Connor 1999a).

The earliest *Terebralia* sp. dates on the north Western Australian coast currently come from Cape Range at Jansz rockshelter on the southern Pilbara coast of 10,730BP (Przywolnik 2005) suggesting that the mangrove environments conducive to the growth of the gastropod developed during the terminal Pleistocene. It is useful at this point to draw a distinction between the regional divisions of the Carnarvon Coast, running north from the Murchison River to the Ashburton River, the Pilbara coast, from the Ashburton to the De Grey River, the Canning Coast, from the De Grey to Roebuck Bay, and the Kimberley coast, extending from Roebuck Bay to the Ord River (see Figure 1 after O'Connor 1999b). While *Terebralia* occurs in sites dated to c.10,000BP on the Carnarvon Coast, it first occurs in archaeological sites in the rest of the region during the period 8000-6000BP. It has been argued that widespread mangrove communities flourished in north Western Australia during the early to mid Holocene due to the more humid conditions at this time (Jennings 1975; Semeniuk 1982). The Cape Range sites and other sites on the Carnarvon Coast are noteworthy, as, unlike other archaeological sites in the region, they do not demonstrate the shift to *Anadara granosa* in the mid Holocene, instead showing a change to a range of rocky platform species after c.4500BP. O'Connor (1999b) has noted that (what were at that time) the earliest dates for the shift to *Anadara granosa* occurred on the Pilbara Coast at around 4200BP were associated with the appearance of mounded shell middens, and that a gradation occurs for the earliest dates moving north along the coast. In the southwest Kimberley, *Anadara granosa* dominated shell mounds first appear at around 3500BP, while on the Mitchell Plateau in the northern Kimberley, shell mounds dominated by *Anadara granosa* and *Tapes hiantina* first appear at approximately 3000BP. It was previously thought that shell mounds throughout the north Western Australian coast ceased forming at around 1000BP (O'Connor 1999b), and on the Pilbara Coast by 1600-1800BP (Clune 2002) (but see Harrison, this volume).

Figure 1: Map of north Western Australia showing location of Port Hedland and the Abydos Plain along with other places mentioned in the text. Figure adapted from O'Connor (1999b).

This widespread sequence has been argued to indicate a decline in mangrove forests caused by the stabilisation of sea levels and increased aridity (Bowdler 1990a, Kendrick and Morse 1990, Przywolnik 2005). It has been suggested on this basis that the appearance of monospecific *Anadara granosa* mounds in the middle to late Holocene may be a reflection of ecological change that resulted in species replacement in the diet of Aboriginal people (O'Connor 1999b).

Veitch (1999), however, has argued that the shift from *Terebralia* sp. to *Anadara granosa* may reflect a behavioural change in shellfish gathering strategies rather than an environmentally determined response to mangrove decline. He argues that *Anadara granosa* is an *r*-selected species, which reproduces faster and in greater numbers than *k*-selected species such as *Terebralia* sp. and *Telescopium* sp., and is hence less prone to depletion through gathering or as a result of environmental change. Drawing on Smith's (1986) argument that dune field deserts were not properly occupied until *r*-selected seed grinding technology was introduced 3500 years ago, Veitch suggests that coastal desert groups would have needed a reliable staple like *Anadara granosa* to successfully cope with increased aridity during the late Holocene. He suggests, following the ethnographic observations of Betty Meehan (1982) that this focus on *Anadara granosa* may represent a growing reliance on a staple food that was a reliable and regular contribution to the diet which could be emphasised at times of low calorific intake (Veitch 1999: 57).

O'Connor (1999b) prefers an environmental argument, pointing to the gradation in the dates for *Anadara* mound formation northwards and citing Steven's (1994) and Seminuik's (1995) arguments

climatic zones have been migrating northwards along the coast during the Holocene. She also notes that Lorblanchet's (1992) and Veitch's (1999) contention that the shift to the exploitation of *Anadara* is associated with the appearance of microliths does not stand up to the available dates for the introduction of points and other microliths in the region, which appears to predate the *Anadara* mounds by up to 1500 years. It is worth noting that mound formation seems to be a phenomenon associated almost exclusively with the bivalve *Anadara granosa*, and that where shell mounds show a transition in their basal layers from *Terebralia* to *Anadara*, the deposition rate of *Terebralia* is invariably very low by comparison, suggesting that these layers conserve only low density surface scatters of *Terebralia* underneath the *Anadara* mounds.

Recent archaeological studies of *Anadara* shell mounds in Queensland and the Northern Territory are also relevant in discussing the significance of the appearance of bivalve dominated shell middens and mounds on the northern Australian coast during the mid to late Holocene. Patricia Bourke, who undertook detailed studies of shell mounds near Hope Inlet in the Northern Territory (Bourke 1993, 1994), has argued that even in areas where large shell mounds of several metres height are found, it would be hasty to see this as evidence for a specialised maritime economy. Instead, she argues that the evidence from Hope Inlet suggests that *Anadara* mounds were created and used as part of a generalised and flexible coastal subsistence economy (Bourke 1994: 10). She disagrees with Veitch's social explanation for the appearance of *Anadara* mounds in the Kimberley, arguing instead that the appearance of mounds in the NT is clearly linked to the appearance of optimal environmental conditions for the growth of *Anadara granosa*.

In a reconsideration of the Weipa shell mounds on the west coast of Cape York Peninsula, perhaps the best known of the northern Australian *Anadara granosa* mounds (eg Bailey 1977, 1991, 1993, 1999; Bailey et al 1994; Cribb 1986, 1996), Morrison (2003) reviews in detail the biology of *Anadara granosa*. He points out that *Anadara granosa* are extremely sensitive in terms of the habitat they require. Their optimal habitat is soft mud or silty sediment between 0.5m and 1m in depth. Sediments that are compacted, too sandy or overly turbid are not suitable for the shellfish to grow (Morrison 2003: 2). Tidal patterns, weather conditions, minor drops in the level of salinity and variations in temperature can all effect the growth rates and mortality levels of the shell fish (see also Richardson 1987). He summarises the results of interviews with Aboriginal people who reside in nearby villages who recount that *Anadara* beds often shift from season to season, and that the species is known to disappear from whole estuary systems for several years (Morrison 2003: 2). His Aboriginal informants suggested that at specific times and places, the shellfish could be collected in very large numbers very easily. In these instances, 'floors of boats' or even whole 'stringy bark canoes' could be filled with the shells.

Morrison (2003: 2-4) agrees with Bailey (1999) and Veitch (1999) that *Anadara granosa* is a relatively *r*-selected species which can fill ideal habitats quickly, but points out that populations of the species are also prone to dramatic reduction due to variation in environmental conditions. He suggests that the shellfish is unlikely to have been seasonally available in large quantities at specific locations, disagreeing with Bailey's suggestion that mound clusters were used permanently throughout the wet and early dry seasons, and pointing to the lack of species diversity in the mounds as evidence. Instead, Morrison favours a model in which shell mounds represent the results of successive short term gatherings of large numbers of people for ceremonial or social reasons. These gatherings would be stimulated by the observation of local abundance of the shellfish species at a particular time and place.

Ethnographic models of shell midden site function and formation

Betty Meehan (1982) set out to investigate the role of shellfish in the economy of the Anbarra people whose traditional land encompasses the coastal plains of the Blyth River estuary on the northern Arnhem Land Coast. For a continuous 12 month period she camped with the Anbarra,

recording aspects of the foraging for shellfish by Aboriginal women and girls, monitoring the diet in detail and recording the archaeological correlates of this behaviour. Meehan recorded that shellfish, although creating large, highly visible archaeological traces in the landscape, played a minor role in the diet in terms of calorific intake, but was a consistent and reliable source of protein in the diet. While Anbarra people considered shellfish, particularly the bivalve *Tapes hiantina*, as one of the prime sources in their territory, proximity to the sources of which was a strong determinant of base camps, even during the wet season when shellfish consumption was highest, they never accounted for more than 10% of the energy intake of the group. Meehan (1982: 159) points to the significant social role of shellfish collection in the life of the group as one way of accounting for this discrepancy.

Meehan recorded three main types of sites associated with shellfish collection: dinner time camps, home bases and processing sites.

Dinner time camps are often located adjacent to shell beds under the shade of a tree on high, flat ground with a supply of freshwater. Dinner time camps may be used once or repeatedly, in which case sitting areas are scraped repeatedly to form flat seating platforms. These are usually used by women and girls during the day while men are hunting.

Home bases are more regularly visited sites where men and women come together, but are created in the same way as dinner-time camps. Usually an evening camp, shell may be moved from the source to the Home base site for consumption.

Processing sites are place where the remains of some shellfish are left behind after the meat has been removed from shell for transport back to home bases. These manifest as species specific piles of shell located immediately adjacent to the shell bed.

Meehan (1982: 66) also observed a correlation between particularly heavy periods of shell collection and ceremonial activities, during which time men were involved in ritual preparations and had little time to hunt for food. These observations have recently been cited by Clune (2002), Morrison (2003) and Harrison (this volume) in support of the interpretation of large, single species shell mounds as sites associated with ceremonial gatherings.

The archaeology of the Abydos Coastal Plain

Excavations at Cleaverville and Nickol Bay near Karratha

Clune (2002) excavated and made surface collections from three mounded midden sites in the vicinity of Cleaverville and Nickol Bay near Karratha on the Abydos Plain (see Figure 2). These shell middens, like others in the region, were composed primarily of the bivalve *Anadara granosa*. The excavation at Nickol Mound 2 reached a depth of 1.4m below surface level, and Clune obtained radiocarbon ages which ranged between 4250±60BP at the base of the deposit and 3480±60BP for the surface (2002: 126). Her excavation of the mounded midden site Roebourne Gap returned a series of radiocarbon ages which were statistically indistinguishable at the 95.8% level of confidence, with the upper and lower layers dating to 1020±50BP and 970±55BP respectively (Clune 2002: 188). Clune (2002: 189) notes that this site represents the end period of mound formation in the region (discussed further below). The two shell mounds, although large and dense like other mounds in the region, were found to have accumulated over a relatively short period of time. A date of 1810±50BP was obtained from the surface of the *Anadara granosa* shell scatter Cleaverville South (Clune 2002: 238).

Site name	Date	Material	Reference	Lab Number	Depth b.s.	Site type
Roebourne Gap	830±50	<i>Anadara granosa</i>	Clune 2002	Wk8834	25	midden
Roebourne Gap	970±55	<i>Anadara granosa</i>	Clune 2002	Wk8835	35	midden
Roebourne Gap	1020±50	<i>Anadara granosa</i>	Clune 2002	Wk8833	surface	midden
Cleaverville south	1810±50	<i>Anadara granosa</i>	Clune 2002	Wk8840	surface	midden
Nickol 2	3480±60	<i>Anadara granosa</i>	Clune 2002	Wk8836	surface	mound
Nickol 2	4160±60	<i>Anadara granosa</i>	Clune 2002	Wk8837	30	mound
Nickol 2	4180±60	<i>Anadara granosa</i>	Clune 2002	Wk8838	70	mound
Nickol 2	4250±60	<i>Anadara granosa</i>	Clune 2002	Wk8839	110	mound

Table 1: Uncalibrated radiocarbon dates obtained by Clune (2002) for *Anadara granosa* dominated middens and shell mounds near Karratha, WA

Figure 2: Map of the Abydos Coastal Plain showing location of archaeological sites discussed in the text

Clune (2002: 339ff) concluded that the large mounds recorded on the mainland and Burrup are located in areas of high resource biomass, and in relatively close proximity to permanent or semi-permanent sources of freshwater. Unstratified accumulations of shell material in varying densities were recorded along the coastline and along the margins of the Nickol River and ephemeral creeks of the mainland, and in the valleys of the Burrup Peninsula, which she interpreted as reflecting the movement of people across the landscape and through adjacent environmental zones. Clune suggested that the form of shell accumulations is both a product of environmental factors, in the sense that large mounds usually form near fresh water sources and extensive mudflats, and cultural factors, in the sense that they reflect varying group aggregation sizes and different modes of land use.

Excavations at Port Hedland

Harrison (this volume) obtained a series of radiocarbon dates from seven *Anadara granosa* dominated shell mounds, middens and shell lenses located immediately south of Port Hedland (see Figure 2). These excavations revealed an almost continuous sequence of archaeological sites dating from between 5350calBP and 50calBP (see Table 2). Site FMGP04-014 was found to replicate the type sequence from Skew Valley of a shift from *Terebralia palustris* to *Anadara granosa*, but this shift was found to be associated with significantly older radiocarbon ages of between 5249calBP and 4399calBP, or an uncalibrated age of 4592±133BP (Wk19853). Each of the seven sites had a reasonably limited period of formation and use, averaging approximately 600-800 years, but they were established and abandoned at different times. The sites were found to form an almost continuous series of occupations over the last 5000 years. Although all sites were dominated by the remains of the shellfish *Anadara granosa*, the sites showed significant variation in form,

manifesting as shell mounds, earth mounds or lenses of shell exposed in dune cuttings. Harrison (this volume) argued that these varied site types derived from different site formation processes, and that the sites should be interpreted as a suite of places associated with similar forms of economic behaviour.

A revised chronology

As noted above, recent archaeological excavations in the Port Hedland region document the appearance of *Anadara granosa* dominated shell middens and mounds on the Abydos Coastal Plain as early as 4592±133 uncalibrated years BP, or some time between 4400 and 5300 calibrated years before present. While it was previously thought that *Anadara granosa* dominated shell midden formation ceased on the Abydos Coastal Plain between 1800 and 1600 years BP (Clune 2002), we accept Harrison's (this volume) argument that mounds should be seen as part of the same suite of behaviours represented by other bivalve dominated middens, mounds and surface scatters in the region, and that environmental or taphonomic explanations for the cessation in mound formation must be sought. When calibrated, radiocarbon determinations obtained on *Anadara granosa* shell from middens at Hearson Cove on the Burrup Peninsula (SUA1860), from Roebourne Gap near Karratha in the south western Abydos Plain (Wk8834) and from FMGP04-002 4/2c (Wk19846) and P703 (Wk4052 and Wk4053) near Port Hedland in the north western Abydos Plain all provide radiocarbon ages which are close to, or overlap with, statistically modern ages (see Harrison, this volume). It is now apparent that large, *Anadara granosa* dominated middens continued to form up until the late nineteenth and early twentieth century on the Abydos Plain.

The continued formation of single species dominated *Anadara granosa* middens into the contact period on the Abydos Plain strengthens the likelihood that their origins can be sought in a consideration of ethnographically observed patterns of Aboriginal social organisation and economy from the area. It is to these patterns that we briefly turn, prior to a discussion of the possible social and economic changes which gave rise to the formation of large, single species *Anadara granosa* mounds and middens in the mid Holocene in north Western Australia.

Aboriginal social organisation on the Abydos Plain

Prior to the arrival of European settlers, there were at least 28 languages spoken in the coastal Pilbara. The Dampier Archipelago (including the Burrup Peninsula), along with a section of the adjacent mainland, is believed to have been occupied during pre-European times and the early post-contact period by the *Yaburara*, who are assumed to have died out due to a combination of introduced European diseases (including the smallpox epidemics of 1865 and 1870), 'blackbirding', and the Flying Foam Massacre of 1868 (Vinnicombe 1987: 5). *Ngaluma* people occupied territory to the east, and the land immediately west of the Archipelago and adjacent mainland was inhabited by the *Mardudunera*. Tribal boundaries are uncertain, but it seems likely that seasonal movement and trade between local occupants would have occurred between these three areas (Green 1982a, 1982b). *Kariyarra* is the language that was (and is still) spoken in the Port Hedland region and the languages *Ngarla* and *Nyamal* are spoken just north and south of the area. Radcliffe-Brown (1913:170), during his 1910-1911 study of Aboriginal social organisation and totemic systems of the *Mardudunera*, *Ngaluma*, and *Kariyarra*, produced a map of West Pilbara tribal boundaries which incorporated the Burrup Peninsula into *Ngaluma* territory, and also included the land between the Maitland and Sherlock Rivers. He placed *Mardudunera* territory to the west of the Maitland River. Radcliffe-Brown reported that he was unable to gather detailed information, as numbers of *Ngaluma* and *Mardudunera* were small. An attempt to demarcate tribal boundaries, based largely on earlier ethnographic accounts was made by Tindale in 1940. Tindale highlighted the significant connection between tribal boundaries and environmental zones in the Pilbara (1940; 1974:58-59).

WK number	Site	Square/ Trench	Spit/Section	Depth b.s. (cm)	Material	Weight (g)	Description	Result (BP)	dC13	Calibrated age range at 68.2% confidence level*	Calibrated age range at 95.4% confidence level*
19840	FMGP04-001	TRENCH 1	SECTION 1	7	<i>A. granosa</i>	10.1	Top of midden	1586±64	0.034±0.2	1229.5 - 1069.5 calBP	1279.5 - 989.5 calBP
19841	FMGP04-001	SQ1	SPIT 3	25	<i>A. granosa</i>	7.02		2110±68	-0.488±0.2	1789.5 - 1599.5 calBP	1859.5 - 1519.5 calBP
19842	FMGP04-001	SQ1	SPIT 5	53	<i>A. granosa</i>	10.05		1913±57	0.058±0.2	1529.5 - 1379.5 calBP	1599.5 - 1319.5 calBP
19843	FMGP04-001	SQ1	<i>in situ</i>	71	<i>T. palustris</i>	57.25	Basal	2099±39	-3.567±0.2	1739.5 - 1609.5 calBP	1799.5 - 1559.5 calBP
19844	FMGP04-002	TRENCH 4	SECTION 2	1	<i>A. granosa</i>	12.4	Top of midden	1821±53	-0.66±0.2	1409.5 - 1289.5 calBP	1499.5 - 1269.5 calBP
19845	FMGP04-002	TRENCH 4	SECTION 2	30	<i>A. granosa</i>	9.83		2352±57	-0.511±0.2	2049.5 - 1889.5 calBP	2129.5 - 1829.5 calBP
19846	FMGP04-002	TRENCH 4	SECTION 2	58	<i>T. palustris</i>	28.43	Basal	594±39	-3.477±0.2	289.5 - 139.5 calBP	319.5 - 99.5 calBP
20139	FMGP04-013	SQ1	SPIT1	10	<i>A. granosa</i>	9.81	Top of midden	1004±61	-0.503±0.2	634.5 - 534.5 calBP	679.5 - 489.5 calBP
19847	FMGP04-013	SQ1	SPIT 7	63	<i>A. granosa</i>	9.8	Basal	1453±98	0.09±0.2	1129.5 - 899.5 calBP	1229.5 - 789.5 calBP
19848	FMGP04-014	SQ1	SPIT 1	1	<i>A. granosa</i>	16	Top of upper midden layer Base of upper	578±44	-1.846±0.2	279.5 - 139.5 calBP	309.5 - 59.5 calBP
19849	FMGP04-014	SQ1	SPIT 3	30	<i>A. granosa</i>	12.1	midden layer Top of lower	1604±55	-0.282±0.2	1239.5 - 1099.5 calBP	1279.5 - 1029.5 calBP
19850	FMGP04-014	SQ1	SPIT 6	50	<i>Cerithidea reidi</i>	13.5	midden layer	4592±133	-5.573±0.2	4979.5 - 4589.5 calBP	5249.5 - 4399.5 calBP
20110	FMGP04-014	SQ1	SPIT 7	70-80	<i>T. palustris</i>	26.5	Basal	4865±72	-4.607±0.2	5279.5 - 5059.5 calBP	5359.5 - 4919.5 calBP
19851	FMGP04-023	SQ 1	SPIT 2	7	<i>A. granosa</i>	5.93	Top of midden	3126±96	-1.3±0.2	3029.5 - 2779.5 calBP	3189.5 - 2719.5 calBP
19852	FMGP04-023	SQ 1	SPIT 3	25	<i>A. granosa</i>	6.12	Base of midden	2981±97	-1.045±0.2	2899.5 - 2649.5 calBP	2999.5 - 2449.5 calBP
19853	FMGP04-023	TRENCH 1	<i>in situ</i>	48	<i>A. granosa</i>	10.9	Lowest shell sample	2716±64	-1.239±0.2	2519.5 - 2319.5 calBP	2669.5 - 2289.5 calBP
19854	FMGP04-031	SQ 2	SPIT 1	1	<i>A. granosa</i>	12.41	Top of midden	1161±55	-0.158±0.2	759.5 - 649.5 calBP	849.5 - 619.5 calBP
19855	FMGP04-031	SQ 2	SPIT 2	30	<i>A. granosa</i>	5.3	Base of midden	1137±86	-0.795±0.2	789.5 - 619.5 calBP	879.5 - 539.5 calBP
20138	FMGP04-059	SQ 1	SPIT 2	10-20	<i>A. granosa</i>	29.85	Top of midden	3404±42	-1.804±0.2	3339.5 - 3219.5 calBP	3389.5 - 3149.5 calBP
19856	FMGP04-059	SQ 1	SPIT 3	30	<i>A. granosa</i>	9.92	Base of midden	3900±73	-1.722±0.2	3979.5 - 3759.5 calBP	4089.5 - 3669.5 bp
19857	FMGP04-094	SQ 1	SPIT 2	5	<i>A. granosa</i>	11.13	Top of midden	3163±75	-1.622±0.2	3069.5 - 2849.5 calBP	3169.5 - 2759.5 calBP
19858	FMGP04-094	SQ 1	SPIT 5	50	<i>A. granosa</i>	18		3041±55	-1.659±0.2	2869.5 - 2739.5 calBP	2949.5 - 2709.5 calBP
20140	FMGP04-094	SQ 1	SPIT 6	70	<i>A. granosa</i>	6.01	Base of midden	3329±97	-1.796±0.2	3319.5 - 3059.5 calBP	3409.5 - 2909.5 calBP

Table 2: Radiocarbon ages obtained from shell submitted from each of the seven excavated midden sites. *calculated using the Oxcal version 4.0 radiocarbon calibration program (Bronk Ramsey 1995, 2001) using the Marine 04 Calibration curve (Hughen et al 2004) and a ΔR marine correction of 52+/-69 which is a combination of several historic marine shell values from around the west coast of Australia (Fiona Petchey pers comm., January 2007).

Radcliffe-Brown believed that intermarriage between local descent groups, as well as a woman's retention of rights to access her homeland, and a man's to his mother's country, meant that tribal boundaries were permeable (Radcliffe-Brown 1913:147, 160-161). On the basis of the testimony of the historical and ethnographic sources, it appears that the organisation and movement of Aboriginal groups in this area followed a model similar to a model outlined by Poiner (1976) for coastal NSW, whereby people are not restricted to one geographic zone, but moved between coast and hinterland to exploit seasonally available resources. Veth et al. (1993:36) emphasise the point that the tribal groups occupying the Pilbara coast were "linked by kinship and intermarriage, economic interdependence, trade, and shared ritual obligations". This would have a significant bearing on the nature and distribution of archaeological sites on the Abydos Plain.

Mid-Holocene social and economic changes on the Pilbara coast

In the absence of intensive analyses of archaeological sites on the Abydos Plain containing non-molluscan faunal remains, with the notable exception of the Skew Valley midden (Baynes 1981; Lorblanchet 1978; see also Harris 1988 and Vinnicombe 1987 for brief description of faunal assemblages of other Burrup sites), it is difficult to place shellfish exploitation in the context of the total subsistence regime. Furthermore, it is likely that differential preservation has affected non-molluscan faunal remains and obscured their archaeological visibility. The Holocene sandy substrates upon which many sites which presumably incorporated faunal remains were formed are highly mobile, and the processes of sedimentation and erosion which characterise the geomorphology of the area (Semeniuk 1982) do not favour good faunal preservation. While there is evidently a significant difference in the comparative archaeological visibility of shellfish remains and other types of faunal remains, it is clear that coastal resources played an important role in subsistence in the coastal Pilbara from at least the early Holocene onwards. It is likely that some resources were exploited on a seasonal basis, and the movement between ecological zones that this entailed had implications for settlement, intra- and inter-group dynamics, and ceremonial activity. We offer the following discussion of shell middens on the Abydos plain in the hope that further research might contribute to developing a more detailed understanding of their place within the mid to late Holocene subsistence economy of north Western Australia.

Arid environmental conditions have been interpreted as determining hunter-gather technological, social and economic adaptations in the Pilbara and in other parts of the world (e.g. Gould et al. 1973; Lee and DeVore 1968; Veth 1993; Veth and O'Brien 1986). We argue that these conditions were an integral force in the adaptations and innovations of groups occupying the Abydos coast during the Holocene. While we do not suggest that environmental factors were the sole determinants of change, environmental stress may have been a catalyst for significant behavioural change, resulting in archaeologically visible modifications to group social organisation and economy. Some of the potential consequences of, and adaptations to, survival in the arid environment of the Abydos coast during the mid to late Holocene are outlined below.

Mobility versus sedentism

Binford argued for two distinct modes of mobility in the hunter-gatherer society of the Nunamiut of North America (Binford 1980), and these were subsequently adapted by Lourandos to fit a more generalised Australian hunter-gatherer context (Lourandos 1987, 1997). Lourandos suggests that the two sociocultural strategies may have operated in similar natural environments, but in different ways. These two strategies may be visible archaeologically. He discussed logistical mobility strategies in terms of 'delayed return' strategies, or more sedentary sociocultural adaptations (Lourandos 1987, 1997:20-21). Residential strategies represent the other end of the mobility scale of hunter-gatherer societies. Residential, or mapping on, strategies involve an immediate return accompanied by increased mobility. Lourandos noted that hunter-gatherer sociocultural organisation and economic behaviour may lie somewhere between these two extremes of land use pattern (Lourandos 1988, 1997:20).

Increased sedentism as a direct or indirect cause or result of significant changes in social and economic organisation and in technology has been argued by a number of researchers (eg. Beaton 1985; Hayden 1981; Veitch 1999). These arguments are based on the premise that a sedentary lifestyle allows for the development of the economic and technological aspects of a group which may have been previously curtailed by the constraints imposed by frequent mobility. Conversely, economic and technological innovations may have allowed groups a more sedentary lifestyle by decreasing the necessity for frequent movement.

A non-continuous chain of low-density surface archaeological material (mostly cultural shell and stone) has been documented along the rivers, coastline, and ephemeral watercourses of the coastal zone of the Abydos Plain. The majority of archaeological sites on the Abydos Plain recorded to date take the form of small and unstratified accumulations of shell and stone artefacts, with occasional grinding material incorporated into the assemblage (Veth and O'Brien 1986; Warren 2001; Clune 2002; Harrison this volume). The lithic assemblage of the area is characterised by unspecialised, unmodified flake forms, with little evidence for curation (Clune 2002). All of these factors suggest that groups occupying the coast of the Abydos Plain exercised a relatively high degree of mobility. The ethnohistorical and ethnographic literature further suggest a relatively high level of mobility on the Abydos coast, characterised by inter-group gatherings for the purposes of joint subsistence activities involving the exploitation of seasonally abundant resources, the strengthening of kinship ties, and the performance of ceremonies and maintenance of spiritual obligations towards the land (Radcliffe-Brown 1913: 147; cf. Stafford 1983: 81).

Territorial boundaries and land use patterns on the Abydos Coastal Plain

Elsewhere, Clune has suggested that the land-use patterns of groups occupying the Burrup Peninsula and western Abydos coast during the mid to late Holocene were underpinned by a complex social organisation involving diametrically opposed inclusion and exclusion strategies (Clune 2002: 322-327). Territorial boundaries were strictly observed for parts of the year, but ecological constraints are likely to have made mobility, ephemeral site use and interaction between groups necessary for survival in a resource-stressed environment, as suggested by the ethnographic, ethnohistorical and linguistic sources. Interaction between groups may have been intrinsically complex in this area because of the sheer necessity of enabling access to as wide a resource base as possible, particularly when most of the food and water resources, or at least those resources which traditionally comprised the majority of the groups' energy requirements, were seasonally determined and unpredictable.

This type of social organisation, which has been construed to involve elements of both aggregation and dispersal strategies (Allen 1974; Veth 1993:69), is paralleled by a bipartite mobility system incorporating both highly mobile and semi-sedentary elements. Groups may have exercised semi-sedentary strategies during seasonal periods of relative abundance, such as the wet season on the Burrup Peninsula, and focused on more mobile strategies for the majority of the year when resource stress was more pronounced. This combination of juxtaposed mobility and economic strategies may have ensured the survival of groups living on the arid coast.

In the Great Sandy Desert of Western Australia, the timing of the aggregation of groups was determined largely by seasonal changes in the availability of plant and water resources (Cane 1984, discussed by Veth 1993:71). During the wet season, groups sought protection from the weather in rock shelters. After the wet season, these groups employed a more mobile strategy characterised by use of ephemeral and widely-dispersed temporary water-sources. Groups targeted more permanent water sources when these ephemeral sources dried up, decreasing the length of time between residential moves (Veth 1993:71). Veth describes a broadly similar pattern operating among the Martu of the Western Desert, whereby seasonal influences such as biological, climatic and

astronomical events overlap to dictate periods of aggregation and dispersal (Veth 1993:71; Walsh 1987:41).

The ethnographic, ethnohistorical, linguistic and archaeological evidence from the western Abydos Plain suggests that mobility patterns may share some of the characteristics of these Western Desert behaviours, while retaining a specifically coastal adaptation. Clune (2002) argues that the Burrup Peninsula may have become a focus of intergroup gatherings during the wet season, when freshwater had collected in soaks, ephemeral watercourses, and stone pits. The Burrup is highly elevated and provides protection from cyclone-related flooding. Littoral species, including fish, turtles and turtle eggs and marine mammals in the area are abundant during the summer months, and the highly indented coast and extensive mudflats of the peninsula provided excellent habitats for *Anadara granosa* and other food resources. Much of the coastal zone of the low-lying adjacent mainland may have been inundated during the wet season, and groups occupying the area may have travelled west to the Burrup to share in the exploitation of species which thrive in the wet season. Inland groups may have done likewise (Radcliffe-Brown 1913).

We suggest that, in the light of recent excavations in the Port Hedland region (Harrison this volume), this pattern could be interpreted as having occurred throughout the Abydos plain during the mid to late Holocene. We interpret the spatial distribution of midden sites, i.e. a small number of large mounded middens within a discontinuous distribution of small midden sites, to be an archaeological reflection of these inter-group gatherings. *Anadara granosa* would have provided a stable and reliable resource during the extreme environmental stress experienced on the Burrup during the dry season, when populations of terrestrial vertebrates may have significantly decreased and predictable food species such as *Anadara granosa* and grass seeds may have constituted a significantly greater proportion of the diet than in times of relative abundance. In this way, groups may have employed a dual mobility strategy incorporating elements of relatively high mobility and relative sedentism, and periods of aggregation and dispersal. The wet season and the period immediately following this may have been marked by increased mobility among groups traditionally occupying the mainland. During this period, groups may have gathered to exploit seasonally abundant resources, strengthen kinship ties and conduct ceremonies. The presence of potable water in ephemeral water sources would have allowed a greater degree of residential mobility. During the dry season when these ephemeral water sources were no longer reliable, groups may have been less mobile, remaining in close proximity to permanent water sources.

In summary, we argue that the seasonal availability of resources in different parts of the study area and adjacent zones underpinned Aboriginal people's social organisation, economic rationale, and mobility strategy. While individuals or groups were observed during both the wet and dry seasons on the Burrup and adjacent mainland (Stafford 1983), the archaeological and ethnohistorical evidence (especially Radcliffe Brown 1913) suggests that traditional boundaries were permeated during specific times of the year.

The ecological imperative for group interaction and the development of a relatively complex social organisation may have been significantly less pronounced in the period preceding c.4500 BP, when the climate of the study area was less stressful. It has been argued elsewhere that north Western Australia experienced a higher rate of precipitation and was warmer during the early Holocene before the onset of a 'climatic reversal' (Jennings 1975; Semeniuk 1982; Wyrwoll et al. 1986, 1992). We suggest that less mobile land-use strategies and closed social networks were more likely to have been effective in north Western Australia during this early to mid Holocene period than in the arid mid to late Holocene (see also Przywolnik 2005). This scenario differs markedly from the increased sedentism inferred by some researchers for the mid to late Holocene in other parts of Australia.

Anadara granosa dominated shell middens and social change

While shellfish represented a portion of the diet of coastal groups in the area from Pleistocene times (eg Veth 1994), they had probably only ever been used ephemerally and as a supplement to the diet. It is possible that terrestrial vertebrate species played a more significant role in the Pleistocene than in the subsequent period. We argue that shellfish took on a much more significant role in the subsistence suite of groups occupying the Abydos coast during the mid Holocene than they had played in early Holocene, because survival in a harsh and resource-stressed environment demanded an increased focus on predictable resources. The increased intensity of group interaction in the coastal zone of the western Abydos Plain combined with a revised economic strategy characterised by a focus on predictable shellfish species may have resulted in the appearance of large and single species shell mounds and middens from c.4500 BP onwards. Shellfish may have supported large groups of people gathering for ceremonial and resource-sharing purposes (cf. Bailey 1993). We posit, therefore, that the shell middens and mounds of the Abydos Plain do not necessarily reflect increased sedentism. Rather, these sites are indicative of a perceived need to strengthen a weak link in the subsistence programme through an increased focus on predictable, relatively *r*-selected shellfish resources due to environmental pressure on other resources, in particular, terrestrial resources.

Meehan (1982: 66) documented the correlation between particularly heavy periods of shell collection and *Anbarra* ceremonial activities, during which men were heavily involved in ritual preparations. The spatial co-occurrence of midden material on the Abydos coastal plain with *thalu*, or ceremonial increase sites (see McCarthy 1962; Warren 2001; Harrison this volume) suggests that middens in this region might best be interpreted in the light of this ethnographic analogue as the result of large gatherings associated with ceremonial activities during periods when local *Anadara* beds were producing numerous shellfish. A spatial and chronological association between rock art sites and shell mounds and middens on the Burrup Peninsula and Abydos Plain has been observed by several researchers (Green 1982a, 1982b; Llorblanchet 1992; Veth et al. 1993; Vinnicombe 1987; Warren 2001; Harrison this volume). We suggest that this archaeological relationship may reflect the activities of groups congregating on the Burrup and other locations where shell middens occur in large concentrations, such as the area around Port Hedland (Harrison this volume), to share in the exploitation of seasonally abundant resources and to conduct ceremonial activities. The subject matter of the rock art, and other seasonal indicators indicates that these gatherings may have taken place during or immediately after the wet season. This association further supports the argument that the archaeologically visible change in economic strategy was accompanied by changing sociocultural dynamics.

Mid Holocene Sexual division of labour

We have argued that the mid Holocene was characterised by significant sociocultural and economic change, evolving as a result of resource stress brought about by increased aridity (Clune 2002). It is possible that these changes may also have encompassed shifts in the sexual division of labour of groups occupying the area. If increasing resource stress during the mid to late Holocene indeed led to a greater focus on predictable shellfish resources (and possibly grass seeds), the economic role of women must have changed to reflect this. While Meehan observed men occasionally gathering shellfish during the course of her year with the *Anbarra* (Meehan 1982:126-127), and men may occasionally have gathered shellfish as a snack while engaged in other pursuits (Bowdler 1976:252), the collection of shellfish throughout Australia during the contact period was always a female prerogative.

Women, who may always have played a significant role in meeting the subsistence needs of the group by providing staple food which was dependable and predictable, may have taken on a greater responsibility for the provision of nutrition approximately 4500 years ago on the Abydos coast (bearing in mind, of course, that gender roles do not necessarily remain an ethnographic constant over time). The shell mounds of the Abydos Plain, Burrup Peninsula, and islands of the Dampier

Archipelago represent the cumulative efforts of women, at least in the collection, if not in the consumption, of shellfish. When shellfish resources became a significant dietary focus, the contribution of women to the fulfilment of the group's nutritional needs must have increased in direct proportion to this.

O'Connor (1999b:48) suggests that the appearance of mounds may reflect the substitution of plant resources by *Anadara granosa* in the diet by women. We see no reason to suggest that plant resources played a less significant role in the mid to late Holocene than they did during the preceding period. The presence of significant amounts of grinding material associated with shell mounds in the area suggests that plant resources formed a significant part of the diet during this period. Plant material, and particularly those species adapted to an arid environment, may have become more important during times of increased resource stress and may have played a similar role to *Anadara granosa* in providing a predictable dietary supplement during these times of low precipitation.

Conclusion

Anadara granosa dominated middens and mounds began to form on the Abydos Plain sometime between 4400 and 5300 calibrated years before present. In some cases, these middens formed on top of older middens from which *Anadara granosa* is totally absent, which are dominated by small quantities of *Terebralia palustris* shell. The *Anadara granosa* dominated middens occur in a variety of forms across the landscape, including large shell mounds, earth mounds (or mounded shell middens), lenses of shell eroding out of well developed dunes, and undifferentiated surface shell scatters. All of these types of middens are characterised by a general scarcity of stone artefacts. They seem to be differentiated only in terms of the small number of other shell fish and faunal remains they contain. Harrison (this volume) has interpreted these differences in the light of Meehan's (1982) observations of *Anbarra* shellfish gathering sites to suggest that middens with shellfish remains representing few resource zones should be interpreted as processing sites or dinner time camps, while middens with more resource zones represented and higher quantities of stone artefacts, might be interpreted as 'home-base' camps. The large number of *Anadara granosa* dominated middens which occur throughout the region from the mid Holocene, and the volume of shell represented by these midden sites, points to the occurrence of significant economic and social changes in the region at this time.

The Abydos Coastal Plain experienced increasing aridity increased resource-stress during the mid to late Holocene. We suggest that changes apparent in the archaeological record, including the establishment of large, *Anadara granosa* dominated middens and shell mounds, increased frequency of occupation and establishment of archaeological sites and increased complexity and distance of exchange systems came about as a result of social, economic and logistical restructuring, which was the result of the effects of resource stress on the population.

People living on the Abydos Coastal Plain followed a relatively mobile strategy during the mid to late Holocene that may have become more seasonally determined due to increased environmental pressure. We propose that regular, annual periods during which large groups of Aboriginal people lived in a semi-sedentary fashion may have occurred immediately after the wet season when resources were abundant, and suggest a link between these sites and large gatherings linked to ceremonial activities. Finally, we suggest that these significant social changes may also have encompassed shifts in the sexual division of labour of groups occupying the area. If increasing resource stress during the mid to late Holocene indeed led to a greater focus on predictable shellfish resources, the economic role of women must have changed to reflect this.

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