WHERE ARE THE MIDDENS ? - AN OVERVIEW OF THE ARCHAEOLOGICAL EVIDENCE FOR SHELLFISH EXPLOITATION ALONG THE NORTHWESTERN AUSTRALIAN COASTLINE

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ABSTRACT

Over the last decade field-based research in the northwest of Western Australia has expanded our knowledge of prehistoric coastal landuse in the region. Although large stratified and mounded shell middens do occur in areas of the northwest there appear to be major differences in the form and distribution of middens on the eastern and western seaboards of Australia. The paper describes new evidence from northwestern Australia and examines patterns of coastal exploitation and the landscapes in which shell middens are found.

A little over a decade ago, in a paper dealing predominantly with the methodology of shell midden analysis, Bowdler (1983) briefly discussed the distribution of shell middens around Australia. At the time, little systematic survey work had been undertaken in coastal Western Australia and she was able to state only that shell "middens as such are apparently absent from the southwestern Western Australian coastline, where most archaeological work has so far been carried out" (Bowdler 1983). She further observed that Western Australia generally appeared to have far fewer middens than might be expected on the basis of the eastern Australian evidence, and that stratified middens were even rarer. The following year Dortch *et al.* (1984) produced a major synthesis of the evidence of mollusc exploitation in the southwest of Western Australia which, while identifying a number of small localised shell scatters, largely corroborated Bowdler's statement.

The results of their survey confirmed that, while not entirely absent as had been previously supposed, evidence for mollusc exploitation is marginal. They located only one unequivocal humanly-derived shell scatter for every 180 km of coastline, and without exception none of these would compare in size or density with their eastern states counterparts. In volume nearly all of the known southwestern shell middens comprise less, and usually much less, than one cubic metre of shells and other accumulated archaeological material (Dortch *et al.* 1984:83).

In the 1983 paper Bowdler also pondered the extent to which the absence of middens resulted from sampling bias, reflecting "the distribution of archaeologists", but her speculation was limited by the lack of archaeological work in large areas of the state, particularly in the north (Bowdler 1983:135-6). In the past ten years a great deal more survey and excavation has been undertaken. In the southwest of the state (from east of Esperance in the south to Geraldton in the north), most sections of the coast have been at least partially surveyed during research projects or surveys preceding development. However, evidence for the exploitation of coastal resources, including shellfish, fish and marine mammals, is still sparse (Dortch *et al.* 1984; Hallam 1987; Lilley 1993; Smith 1993).

While the southwest coast has been fairly intensively investigated, the north of the state has had comparatively little attention. When I began my Ph.D. fieldwork in the Kimberley in 1985 no very significant advances had been made in addressing this issue. The location of middens in the north of the state was one of the primary aims of the field survey, and the elucidation of the patterning of middens in Western Australia generally, was one of the broader aims of my research. Specifically, I wanted to know why no midden sites had been reported from an

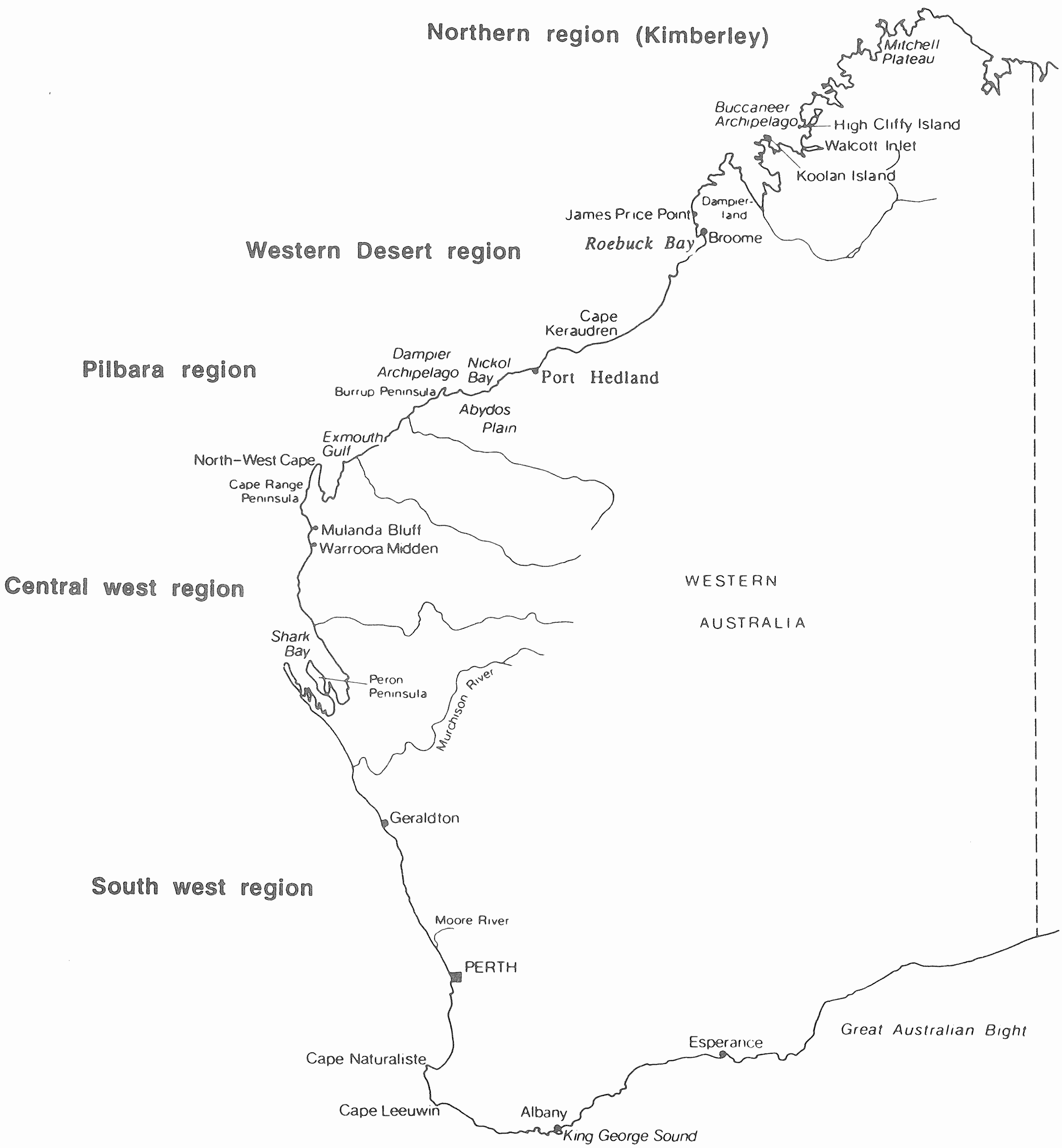

Figure 1: Western Australia, showing regional divisions and places mentioned in the text

area with such a productive marine environment? Was this absence real or did it merely reflect the small amount of systematic survey done in this area? If real, was there some pattern to the distribution of the state's middens? Was the general paucity of middens in the north of Western Australia connected in any way with their absence in the south? Was this apparently widespread phenomenon due to rapid site destruction, or was it rooted in behavioural differences between people living on the eastern and western seaboards? Recent field results from the north of the state indicate that large stratified linear and mounded shell middens typical of those found in eastern Australia do occur in restricted areas. However, it is still true to say that the distribution of middens is patchy and that there appear to be major differences between their form and distribution on the eastern and western seaboards. This paper concentrates on the new evidence from northern Western Australia.

A REGIONAL APPROACH TO THE DISTRIBUTION OF SHELL MIDDENS IN WESTERN AUSTRALIA

To facilitate discussion, the state has been divided into five regions: southwest (discussed above), central, Pilbara, Western Desert and northern (these correspond approximately with the culture areas based on drainage divisions defined by Peterson 1976) (Figure 1).

Where applicable, I have attempted to discuss the physical environmental variables that might influence or limit the exploitation of coastal resources. Additionally, coastal landform and other features of the physical environment, while not necessarily important in terms of marine exploitation, will be influential in terms of site survival (Sullivan 1982:13). Although landscape archaeology should ideally distinguish the physiographic and lithological provinces within each region, such a fine-grained approach is not possible at this time.

Radiocarbon dates presented in the text are uncorrected for marine reservoir effect as there is some uncertainty about the application of the correction factor in northern Australia (see Bowman 1985 and Woodroffe *et al.* 1988; Woodroffe and Mulrennan 1993 for a different view).

The Central-West Region

The central-west region includes the coastline from Geraldton to Exmouth Gulf. Survey has been concentrated most intensively in two areas. They are the Shark Bay region where Bowdler (University of Western Australia) has an on-going archaeological research project, and the Exmouth/Northwest Cape region, currently the focus of research by Kate Morse of the Western Australian Museum. There has been little systematic survey between Geraldton and Shark Bay, and few shell scatters have been reported in the area.

South of Shark Bay near the Zuytdorp Cliffs, Morse (1989) has recorded a series of shell scatters of Aboriginal origin. The majority of shell is either exposed on the surface or appears as a thin subsurface lens containing the marine rock platform limpet species (*Patella laticostata),* chiton (*Acanthopleura hirtosa*), oyster (*Saccostrea* sp.), whelk (*Thais orbita*) and abalone (*Haliotis roei).* Samples of marine shells from two of these sites were dated between 5080±80 BP (Beta 22534) and 4450±70 BP (Beta 22535) (Table 1).

The Shark Bay project began in 1985 and to date has recorded approximately 100 open sites containing marine gastropods on the Peron Peninsula and 18 in other parts of Shark Bay (Bowdler 1990a:50, 1990b). Middens in the region appear generally to consist of surface scatters of marine shell, stone artefacts and occasionally other marine or terrestrial fauna. In only a few cases, are they likely to represent the remains of eroded stratified sites (Bowdler 1990a:51). Although only a handful of middens has so far been dated, Bowdler believes that some idea of the chronology of undated sites can be gained from the shellfish types present. While most of the shell scatters comprise marine species such as baler (*Melo* sp.), turban (*Turbo* sp.), trochus (*Monodonta labio*) and chiton (*Acanthopleura* sp.), a number of middens contain the species *Terebralia sulcata,* which is found only in mangrove stands. These *Terebralia* scatters are confined to the west side of Peron Peninsula and on the open west coast, including Dirk Hartog Island. Samples of shell from three open midden sites on the west of the Peninsula have been dated. These date between approximately 3500 and 7000 BP (Table 1). The earliest Holocene evidence for mangrove exploitation can be found at the Silver Dollar site dated between 7360±190 BP and 6640±260 BP (Bowdler 1990a).

Today, the Peron Peninsula has very restricted areas of mangrove, and these do not support *Terebralia* communities (Bowdler 1987:6, 990a:50). All the *Terebralia* middens date to the time when mangrove communities were more extensive in northern Australia and Southeast Asia following the post-glacial transgression. They appear to achieve their maximum extent at or shortly before the climax of sea level rise and begin to decline within a few thousand years of this (Allen 1987; Chappell 1993:46; Woodroffe *et al.* 1985). The sparsity of shell on most of the open sites does not appear to be due to poor preservation as two rockshelters excavated in coastal locations, where organic material was well preserved, contained only small quantities of shellfish. These sites were both occupied more recently than 1000 BP and include only rocky platform species and some non-edible sand flat species such as *Dentalium novaehollandiae* and *Callista impar* (Bowdler 1990b).

In general, it appears that the oldest Holocene sites such as Silver Dollar indicate the heaviest exploitation of the mangrove environment. The later mid-Holocene sites contain mixed mangrove and rocky reef species and the late Holocene sites indicate only very occasional use of exclusively rocky reef species, probably partly for the acquisition of shell for non-dietary purposes.

Northwest Cape

Kendrick and Morse (1982, 1990) have reported two shell scatters containing mangrove associated shellfish at Warroora and Mulanda Bluff 125 km and 80 km south of Northwest Cape respectively (Figures 1 and 2). These sites are dated to between 7000 BP and 8000 BP (Table 1) and, like the Shark Bay scatters discussed above, document the existence of extensive mangrove communities which disappeared in the mid-Holocene.

Archaeological reconnaissance to the north of these sites, at Northwest Cape and on the western shoreline of the Cape Range Peninsula, has been even more intensive. Morse has identified large numbers of shell scatters in open contexts along the western coast of the Cape Range Peninsula. These sites range from large and diversified scatters of marine shell, bone and stone artefacts to discrete species-specific scatters, with few or no artefacts or other associated cultural material (Morse 1993). The most frequently occurring sites contain a moderate density of shellfish and a low density of generally unspecialised stone artefactual material. These sites are interpreted by Morse as "dinner-time camps" (cf. Meehan 1988). The larger, more complex sites are situated to take advantage of specific environments. They include a diverse range of artefacts, as well as crustacea and the bones of marine mammals, demonstrating that exploitation of the coastal environment was not confined to the intertidal zone (Figure 3). The most commonly occurring shellfish are intertidal marine species such as chiton (*Acanthopleura gemmata*), clam (*Tridacna* sp.), whelk (*Thais* sp.), pyramid shell (*Tectus* sp.) and limpet (*Patelloida* sp.).

Most sites occur in blowouts but the presence of discrete intact surface features, such as hearths and clusters of burnt shell, on several of the sites, indicate that although deflation has occurred the material was never deeply stratified. Of the three middens dated, two, Tulki Well (Figure 3) and Turquoise Bay, date to approximately 5500 BP, and the third, Mangrove Bay, was assayed as modern (Table 1). Morse (in press) notes that the

> presence of only a single layer of midden material at these sites and the lack of any other stratified sites, together with the more recent date from Mangrove Bay, suggests that occupation of the coastal margin was episodic until modern times.

Pilbara Region - Exmouth Gulf to Cape Keraudren

Again, systematic site survey in this region has been confined to small areas of the coast and has resulted predominantly from site clearance projects preceding development and land management studies. The Pilbara coastline contains definite evidence for stratified middens reminiscent of those found in northeastern Australia. The best known example of such a site is Skew Valley, excavated by Lorblanchet (1977). This is a densely packed shell midden with a basal date of 7070±100 BP (ANU 1503). The lower unit of the site is composed predominantly of the mangrove species *Terebralia* spp. which is replaced by *Anadara granosa* between 4000 and 3000 BP.

Just south of Onslow at Tubridgi, Veitch (Veitch and Warren 1992) undertook a mitigation survey which located nine shell scatters in a transect one kilometre long and 100 m wide. The results of this survey give an indication of the density of shell middens along this coastline and reinforced the idea that mangrove communities were more extensive in the early to mid Holocene. Test excavations of five sites were carried out and revealed coastal exploitation ranging from c. 4500 to 1000 BP and a sequence indicating a change from mangrove to mudflat species. The exploitation of mangrove shellfish species (*Terebralia* spp.) occurred between 4640±200 and 3950±70 BP. These were replaced by *Anadara granosa* and oyster at about 4000 BP. The period of *Anadara* exploitation is bracketed by dates of 4090±70 to 1040±70 (see Table 1). Coral dwelling oysters *Hyotissa* spp. are present in the assemblages from 3830±70 to 1300±80 BP. In addition to shell, these sites contain stone artefacts and turtle bone.

Veitch argues cogently that the lack of dates before 4500 BP results simply from the fact that the dunes investigated began forming after the last marine transgression (Veitch and Warren 1992). He reports scatters of shell on Pleistocene dunes landward of the Holocene dunes and believes these would produce earlier dates. The fact that the shell scatters on the landward dunes comprise predominantly *Terebralia* spp. and stone artefacts lends support to Veitch's contention.

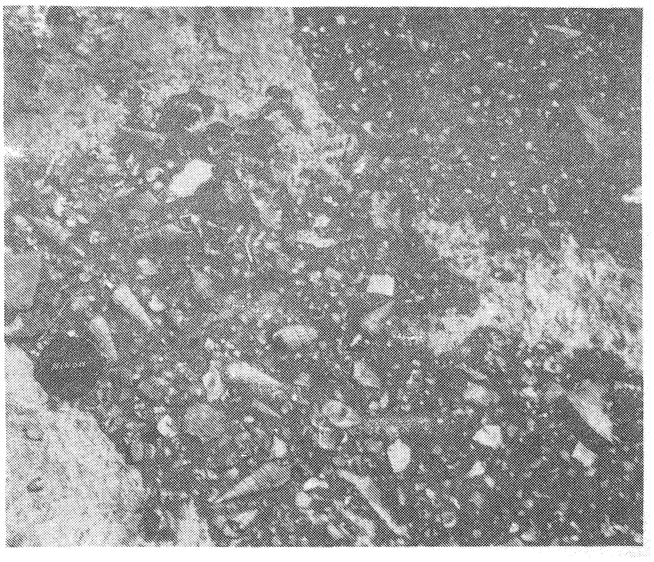

Figure 2: Mulanda Bluff, a 7000 year old midden on the central coast, south of Northwest Cape. The predominant shellfish at this site is the mangrove species Terebralia palustris. *Today the nearest mangrove formations occur 135 km south near the Gascoyne River or 80 km to the north at Exmouth Gulf (photo courtesy of Kate Morse).*

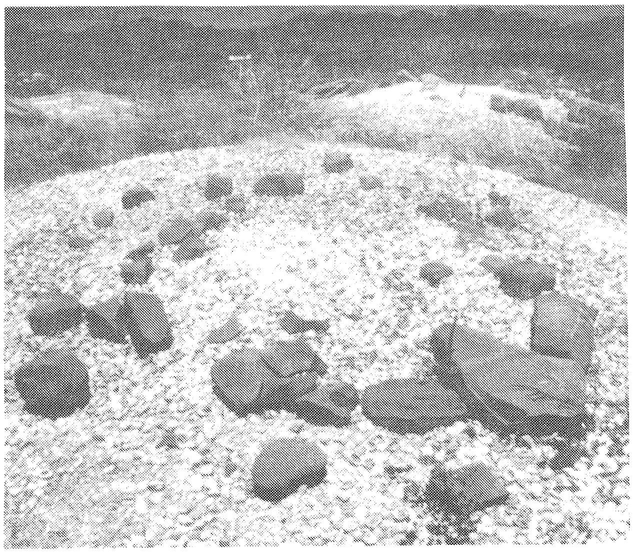

Figure 4: One of a number of shell mounds on West Intercourse Island, one of the closer off shore islands of the Dampier Archipelago. This mound is 2-3 m high and has a stone arrangement on its surface (photo courtesy of Elizabeth Bradshaw).

Figure 3: Tulki Well at Northwest Cape, dated to c. 5500 BP (photo courtesy of Kate Morse)

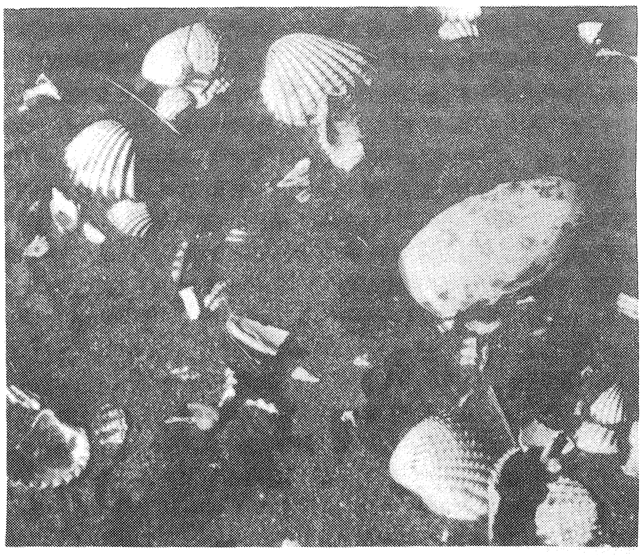

Figure 5: A typical open midden showing shell artefact (baler shell adze, centre), shell and ground ochre fragments at Roebuck Bay, south of Broome.

Elizabeth Bradshaw, a PhD student at the University of Western Australia, is currently undertaking a research project on the Pilbara coast near Nickol Bay (Figure 1). Her results, albeit for only two sites so far, also support the pattern described for Skew Valley. At the Anadara Shelter she has a basal date on *Terebralia* of 6300 BP. The change to *Anadara* is dated at 4200 BP. The Anadara Mound site duplicates this changeover but no dates are yet available. Similar large *Anadara* mounds have recently been located on West Intercourse Island, one of the closer offshore islands of the Dampier Archipelago on the west side of the Burrup Peninsula (Figure 1), and at intervals along the coast as far as Port Hedland. West Intercourse contains at least 14 mounds which are between two and three metres high (Figure 4). These possibly reflect only the upper part of the Skew Valley sequence. One mound excavated by Bradshaw on the Nickol River contains only *Anadara*, but no date for this site is yet available (E. Bradshaw pers. comm.).

Other middens located during the Dampier salvage project are small scatters of shell, most commonly *Anadara* or *Terebralia*, with no or few associated artefacts or other cultural materials (Vinnicombe 1987:23). They usually occur adjacent to the environment of the shell species represented and have been interpreted as dinner-time camps (*ibid.*). Larger shell scatters also occur on the Burrup Peninsula in association with other materials suggestive of residential camp activities, such as a diverse range of faunal refuse, discrete hearths, stone artefacts, grinding stones and baler shell water containers. Few of these have any evidence of stratification, but a few with potential for stratification were excavated during the Burrup Salvage Project. While these sites were found to have some depth of deposit they comprised scattered shell and other cultural material in a sediment matrix (Vinnicombe 1987:36-42). A good example of such a site is Georges Valley Midden which has a basal date of 5620±110 BP (SUA 1872) (Harris 1988).

Veth and O'Brien (1986) have reviewed the evidence for middens on the Abydos Plain and report that the extensive shell scatters are found up to 10 km inland. Again, these sites are mostly unstratified. They usually comprise scatters of *Anadara granosa* and are located at the mouths of creeks and rivers near seasonal pools. The largest also contain numerous pieces of grinding material and stone artefacts. The sites display little evidence of vertical development and Veth and O'Brien believe that this is probably "a true representation of site formation in an arid environment" (1986:57). They postulate both environmental and cultural reasons for this. Firstly, they believe that as this landscape is characterised by erosion and periodic flooding, material may have had little opportunity to accumulate. Secondly, they think site use in such an arid environment would be characterised by high mobility. One such site at Cape Lambert was dated between 2640±185 BP (WAIT 92) and 2930±265 BP (WAIT 94). Veth and O'Brien conclude that the low density material was deposited in a "rapidly accumulating environment". Erosion is argued to be responsible for removing deposit above the present surface date of 2640 BP (Veth and O'Brien 1986:51). Popes Nose Creek P5431, another typical *Anadara* midden similarly dates between c 1500 and 3000 BP (see Table 1). Veth and O'Brien (1986) note that more than 45 shell scatters have been recorded in the Nickol Bay region of the Pilbara (Figure 1) and state that the number would be substantially increased if systematic survey was carried out.

Western Desert Region

The Western Desert region includes the area north of Cape Keraudren to Lagrange and includes the coastal area known as the Eighty Mile Beach. No archaeological work has been carried out there and no midden sites have been described for this region.

The Northern Region (Kimberley)

The northern region is defined as the area between Lagrange and the Northern Territory border. The southwest, central-west, and northwest Kimberley are discussed separately as they are very distinct environmentally and so have different site distribution patterns (Figure 1). Survey and excavation in the Kimberley region has recovered evidence for the exploitation of marine and estuarine shellfish, although once again their distribution is patchy, and stratified middens are uncommon along much of the Kimberley coast.

The Southwest Kimberley Region

Recent research by the author south of Broome has located large numbers of shell scatters. Most of these take the form of extensive linear scatters, many of which are actively deflating and reworking (O'Connor and Veth 1993). In the vicinity of and immediately south of Lagrange large deflated middens occur on the dunes immediately behind the coast. These sites are dominated by marine rocky platform species and some are spatially associated with large fishtraps. These sites contain few stone artefacts and in areas where they have deflated and dispersed will be almost undetectable in years to come.

Immediately south of Broome on the Roebuck Plain, mound middens of *Anadara* and *Anadara* scatters overlying natural chenier ridge deposits have been reported

(O'Connor and Sullivan 1994). The mounds are composed predominantly of *A. granosa* but contain small amounts of fish bone, charcoal and few stone artefacts. The area has been insufficiently surveyed to give an accurate estimate of site density, however *Anadara* scatters on natural beach ridges close to the present coast appear to be numerous. These contain sparse stone artefacts and grinding material. The sites are confined to the period from c. 3600 BP to the European contact period.

Shell scatters have also been reported near the town of Broome and from Dampierland (Akerman 1975; Bradshaw and Fry 1989; O'Connor and Veth 1993; O'Connor and Sullivan 1994). A recent survey of an 80 km coastal strip south of Broome located 13 sites where shellfish comprised the dominant component of the assemblage. These sites have been reported in detail elsewhere (O'Connor and Veth 1993). They comprise extensive linear scatters of shell on coastal dune systems (Figure 5). In places they appear to have some stratification, but to what extent this results from reworking of the cultural material into the unstable landsurfaces has not yet been established. Dates on shell collected from the surface of the sites indicates that they range in age from modern to about 3000 BP (Table 1) .

Surveys north and west of Broome have similarly located open sites containing shellfish. Most common are extensive surface scatters of shell on the Holocene dunes behind sandy beaches or on the Pleistocene red pindan soils on cliffs overlooking the coast, such as at Cable Beach near Broome. They vary in size and content from small discrete species-specific heaps of shell to extensive dispersed scatters of shells and artefacts over large areas of dune. Most are located adjacent to rocky platforms and comprise marine intertidal species still available on the platforms today, including chiton, turban, nerites and trochus shells (*Acanthopleura spinosa, Turbo cinereus, Nerita polita, N. undata* and *Trochus* sp.). Associated with the shell scatters is a variety of other dietary debris including turtle and dugong bone, as well as stone and shell artefacts and baler shell bowls. The shell scatters do not appear to be dispersed by wind deflation, as discrete intact hearths containing charcoal and antbed are periodically exposed by shifting dune sands.

The Central-west Kimberley

Moving northeast to the Buccaneer Archipelago the broad sandy beaches and deep dunes of Dampierland give way to steep, rugged topography with restricted areas of sandy beach and large mangrove-fringed inlets. As discussed elsewhere, a survey of 13 islands and large sections of the mainland coast failed to reveal any middens or shell scatters in open contexts (O'Connor 1984, 1989). Shellfish scatters in open contexts are as rare in this area of the Kimberley as they are in the southwest. Elsewhere I have reviewed the lack of archaeological evidence for shellfishing in the central-west Kimberley (O'Connor 1989). On the basis of the archaeological survey results and ethnographic accounts of current Aboriginal land users, it was concluded that the absence of shellfish on open sites largely results from extremely dynamic weathering processes, choice of sandy beaches for campsite locations and the largest tidal variation of any area in Australia (O'Connor 1989). Even given these factors, however, it seems unlikely that shellfishing ever assumed the importance in this area that it appears to have had in many parts of eastern Australia. For example, in the Holocene levels of the rock shelters where preservation is good, there is no evidence that shellfish were a resource of great importance. As opposed to many of the south coast New South Wales shelters, these coastal Kimberley shelters comprise a sediment matrix containing shell which, even in the densest upper levels, never makes up more than 5% of the volume of the deposit.

While this is perhaps only to be expected at the Widgingarri shelters, given their location two kilometres from the present coastline, the High Cliffy Shelter and Koolan Shelter 2 are both located directly on the coast and might be expected to contain denser shell deposits (O'Connor 1990). A recent detailed survey of Walcott Inlet, a mangrove-fringed tidal inlet adjacent to Koolan Island, conducted by staff of the Western Australian Department of Aboriginal Sites, has similarly failed to locate any shell scatters of definite human origin (C. Stokes pers. comm.).

When contrasted with Dampierland and the Broome region to the south, the open coastal environments of the central Kimberley compare unfavourably as productive habitats for many intertidal marine molluscs. In the Dampierland region, both rock platform and coral reef substrates are present (M. Smith pers. comm.), whereas in the study area flat rock platform is uncommon in the intertidal zone. Furthermore, rock type in the Dampierland region is more variable and extensive areas of limestone rock platform are found off parts of the peninsula. The large, smooth, rounded boulders of quartz sandstone found at the water's edge in the study area do not provide such an ideal environment for marine gastropods. The living coral reef also common in the study area provides a very poor environment for most species of marine gastropod (Wells and Bryce 1985:21). The same cannot, however, be said of the mangroves and mudflats that fringe the inlets and embayments. These are extremely productive environments where species such as *Terebralia* spp., *Telescopium* sp. and *Naquetia* sp. are in large supply and easily accessible. Surprisingly, no middens focused on these resource zones were found. However, 100 km to the north of Koolan Island, below the Mitchell Plateau, such sites are abundant.

The Northern Kimberley

In the northern Kimberley, on the Mitchell Plateau, large mound middens have been reported and several have been excavated (Figure 1). These dense shell packed stratified sites are up to 1.3 m deep and consist almost exclusively of *Marcia hiantina* towards the base and *Anadara granosa* in the upper unit, or are almost solely comprised of *A. granosa.* As in the southern Kimberley mounds, mudwhelks are found throughout but always contribute less than 5% of all shell. *Terebralia* and *Telescopium* are extant in the mangrove forests of this area today.

Content analysis suggests that these sites are similar to the northern and northeastern Australian mounds (Beaton 1985; Bailey 1977, 1993), in that they contain little organic material aside from shellfish and almost no lithics (B. Veitch pers. comm.) (Figure 6). Veitch (pers. comm.) reports that shell mounds of this type are common above intertidal mud flats. Dates recently obtained by Veitch for the basal layers indicate that all middens accumulated over the last 3000 years (Table 1). According to the traditional owners, at least two were used into the European contact period. To the north of the Mitchell Plateau no archaeological reconnaissance has been carried out.

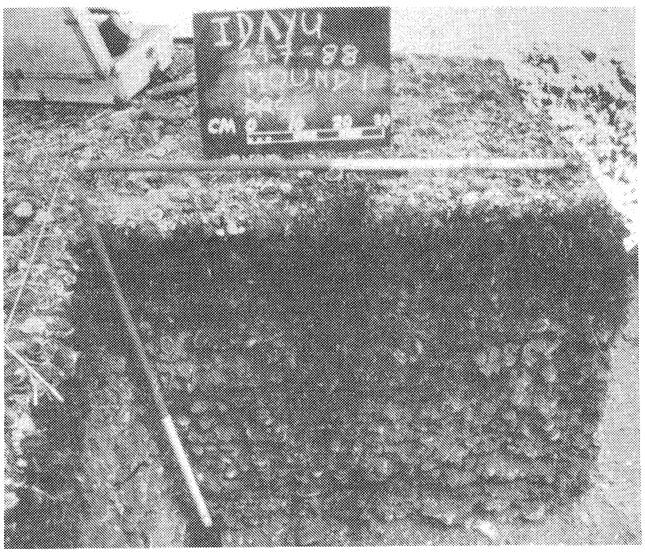

Figure 6 Idayu shell mound on the Mitchell Plateau is composed predominantly of Anadara granosa *to a depth of 70 cm. Below this is predominantly* Tapes hiantina *on which a basal date of 2090±50 BP was obtained (photo courtesy of Bruce Veitch).*

SUMMARY OF WESTERN AUSTRALIAN MIDDEN DISTRIBUTION

In summary, it would appear that the size and frequency of occurrence of middens increases with distance north along the Western Australian coastline and corresponds closely to particular physiographic and landscape features.

1) *Sites containing marine mollusc remains are rare south of the Murchison River*. Comparing site density and structure to the eastern states temperate regions, the contrast is marked. Reasons for this are likely to be both behavioural and environmental. It has been argued elsewhere that a variety of physiographic and landscape features combine to make shellfish a poor choice in terms of human subsistence and scheduling strategies. The combination of small amounts of rock platform, low ocean productivity, few significant estuaries and restricted tidal range would all be contributing factors (Dortch *et al.* 1984; Hallam 1978; White and O'Connell 1982; see O'Connor 1990 for an extensive argument along these lines and Smith 1993 for a counter argument).

2) *From the Murchison as far north as the Burrup Peninsula middens take the form of surface expressions rather than stratified sites*. Where shell is stratified it is as thin lenses. In many cases this does not appear to be due to deflation or erosion but rather to be a reflection of the importance of coastal resources in the diet.

Rocky platforms are few in number and restricted in area along much of the Western Australian coastline. Most areas where rocky substrate does occur have little horizontally-bedded rock platform or are of a smooth weathering type, lacking the depressions that provide a habitat for intertidal shellfish. Furthermore, the southwest and central coast of Western Australia is far less indented than its latitudinal equivalent in eastern Australia.

Ocean productivity is another important factor influencing abundance of marine resources. On a world scale, ocean productivity is generally greatest along the western margins of continents, where upwelling occurs, and lowest in low-latitude areas where little mixing takes place (Davis 1986:124). The Western Australian coast is an exception (Godfrey and Ridgway 1985). There is no evidence of upwelling along the western coast of Australia, and the waters are consequently relatively unproductive (Rochford 1979; Wooster and Reid 1963:272). The main reason for this is the Leeuwin Drift, a warm current flowing seasonally southwards along the Western Australian continental shelf, which brings an influx of low-salinity, nutrient poor warmer waters of tropical origin (Pearce and Cresswell 1985). The Leeuwin Drift affects the area from Northwest Cape to Cape Leeuwin in the southwest and then flows east towards the Great Australian Bight.

3) *There is abundant evidence for coastal exploitation immediately following the marine transgression.* At Shark Bay, Coral Bay, Exmouth Gulf, the Pilbara coast and in the rockshelters of the Kimberley we have evidence for the exploitation of marine/estuarine environments between 8000 BP and 6000 BP. Where this is not the case, it appears to be due to mid-late Holocene landscape changes, both erosional and progradational.

4) *In the area from Shark Bay to the Pilbara Coast, the early Holocene coastal phase is characterised by the presence of Terebralia and other mangrove gastropods, indicating the rapid establishment of mangrove communities and associated biota.*

5) *In several of the these areas such as Shark Bay, Exmouth Gulf and along the Pilbara Coast, the sites with mangrove gastropods have a restricted time range between 8000 and 4000 BP.* In some cases mangrove communities are not found in these areas at all today, in others they are found but are restricted in size and species represented and do not support *Terebralia* and *Telescopium* communities. It seems likely that there was a more diversified intertidal environment in the middle Holocene than exists today (Kendrick and Morse 1990; Morse 1993).

This possibly indicates that exploitation of marine resources was more viable in the past when mangrove communities were more extensive. Alternatively or additionally, the preservation of these early to mid-Holocene middens may have been facilitated by the prograding shoreline, which promoted sandbars and barrier development thus protecting the early sites from recent coastal influence (Kendrick and Morse 1990). Sites of a comparable age in the South Alligator River area in Kakadu are now buried beneath a black soil plain and have only been detected in cores (Woodroffe *et al.* 1985).

The reasons for the appearance and demise of the mangrove phase are still not entirely understood. Jennings (1975) identified mangroves trees in the Fitzroy estuary, Derby, with trunks which had circumferences far in excess of any of the living trees, which suggested the presence of tall mangrove forest in the past. These were dated to between 7400 and 6000 B.P. He believed this indicated a longer wet season with higher rainfall than is found with the present tropical monsoonal semi-arid climate (Jennings 1975). A recent study, however, by Woodroffe *et al.* (1985) on the South Alligator River links the growth of these forests with the interaction of sea level change and sedimentation. Here the subsequent decline of the 'big swamp' occurred as a result of increased sedimentary infill which eventually led to the establishment of blacksoil plains. These authors stress that a

> similar pattern will have occurred in other tidal rivers of northern Australia, with each river differing according to its own particular sediment output and the dimensions of its lower valley and estuarine systems (Woodroffe *et al.* 1985:713).

They emphasise however that their results neither support nor refute the 'wetter climate' theory proposed by Jennings.

For Mulanda Bluff, Kendrick and Morse (1990) have suggested mangrove decline resulting from a combination of factors specific to the local environment, such as sand barrier formation and decreased interdunal runoff. At Shark Bay the position of the *Terebralia* scatters immediately above the open coastal bays demonstrates that neither the factors invoked for the South Alligator River nor the factors operating at Mulanda Bluff will explain the mangrove decline here. The earliest Holocene sites at Shark Bay show the heaviest exploitation of mangrove species; followed by the exploitation of a roughly equal mix of mangrove and rocky reef environments, and finally the near abandonment of the region in the late Holocene. *Terebralia sulcata* and *Turbo cinereus*, the dominant species on the early-mid Holocene Shark Bay sites, are today only found north of Shark Bay. Stevens (1994) argues that this indicates the southern limit of the tropical climate regime has moved northwards since the mid-Holocene. The resultant increased aridity has had wide reaching impact on all aspects of the biota.

What seems clear from the above discussion is that mangrove communities on the Western Australian coast from Shark Bay in the south to the northern Pilbara coastline were considerably more extensive in the mid-Holocene than they are today. No single factor or combination of factors has yet been advanced which satisfactorily explains all expressions of this phenomena (O'Connor in press).

6) *After the demise of the mangrove phase the middens are dominated by open coastal reef species south of the Pilbara coast. On the Pilbara coast, Anadara replace*

Terebralia at c. 4000 BP. In the northern Kimberley Anadara mounds do not appear until c. 3000 BP. This raises the interesting and perennial question of the reasons for the late exploitation of *Anadara*, pursued below.

7) *No open middens have yet been found in the inlets between Dampierland and the Mitchell Plateau.* Reasons for this have been discussed in detail elsewhere, where it was suggested to be a result of both cultural and physiographic factors similar to those operating in parts of north Queensland (O'Connor 1989; Anderson and Robins 1988).

8) *The only large mounded middens reminiscent of those from north Queensland and the Northern Territory are those containing the mangrove and mudflat species Anadara and Tapes.* Those comprising predominantly *Anadara* occur on the Pilbara coastline, the southern Kimberley coast near Broome and the north Kimberley coast near the Mitchell Plateau. Those comprising *Tapes hiantina* overlayed by *Anadara* are found only in the north Kimberley. These bear comparison with the Weipa and Princess Charlotte Bay mounds (Bailey 1975; Beaton 1985). None of these appear before 4200 BP and most postdate 3000 BP. Bailey (1993: 15) has noted that a striking feature of these sites throughout their distribution is their restriction to the last two or three millennia. The Western Australian mounds indicate that here at least the mounds began to form earlier and to appear earlier in the southern part of their distribution. Whether this is to do with the late establishment of these environments or cultural factors is unknown at present. On the Pilbara coast they seem to cease c. 2000 BP. and extant *Anadara* beds are not known from this area today (S. Slack-Smith pers. comm.). In the northern Kimberley, *Anadara* beds are extant and are still sometimes collected.

9) *No large mounded or deeply stratified linear middens formed from rock platform species are found in Western Australia.* Sandy beach species are also underrepresented. This is as true for the northwest as for the southwest. No dense middens of oyster, mussel, abalone, turban, *Trochus,* limpets or pipi are known. Sites composed of marine rock platform species take a dispersed form and contain a low percentage of shell by volume in the deposit. Although many of the sites are situated on unstable landforms such as Holocene dunes, their dispersed form cannot be put down solely to deflation, as the sites that have been investigated have evidence for intact and discrete features such as hearths and aggregates of burnt shell and flaking areas.

The sandy beaches along the southwest coast of Western Australia are shorter and less commonly fed by freshwater systems than the latitudinal equivalent in eastern Australia. These conditions apparently make them less ideal habitats for large sandy beach bivalves (S. Slack-Smith pers. comm.). The sandy beaches north of Geraldton support a variety of bivalves of the families Arcidae (ark shells), Glycymerididae (dog cockles), Cardiidae (cockles) and Veneridae (Venus shells) (Wells and Bryce 1985). These molluscs, however, are rarely recovered from shell scatters.

This overview gives an idea of the variety of expression of coastal exploitation on the Western Australian coastline and the diversity of physical environments in which shell middens occur. While it might be thought that a review at this stage of our knowledge is premature, patterns do emerge which are worthwhile summarising and which may serve to direct future research.

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Table 1 Radiocarbon dates from shell middens and other sites where shell is a dominant component
NB: This table continues over the next four pages

Site Name	Site Type	Location	Uncorrected Conv. Age	Lab. no.	Material	Depth below surface
Goala	mound	Mitchell Plateau	2090±50	(Wk 1621)	*T. hiantina*	130 cm (basal)
Idayu	mound	Mitchell Plateau	2010±50	(Wk 1619)	*A. granosa*	70 cm
			2090±50	(Wk 1618)	*T. hiantina*	90 cm (basal)
Wundadjingangnari	mound	Mitchell Plateau	3130±60	(Wk 1620)	*A. granosa*	170 cm (basal)
High Cliffy Shelter	shelter	Central Kimberley/	2620±50	(Wk 1286)	*Turbo cinereus*	1-5 cm
		High Cliffy Island	2740±50	(Wk 1257)	*Turbo cinereus*	5-10 cm
			3210±100	(Wk 1096)	*Turbo cinereus*	15-20 cm
Widgingarri 1	shelter	Central Kimberley	1700±90	(Wk 1490)	*Turbo cinereus* /*Nerita* sp.	32-38 cm
Widgingarri 2	shelter	Central Kimberley	1510±50	(Wk 1397)	*Turbo cinereus*	15-20 cm
			4970±60	(Wk 1398)	*Turbo cinereus*	36-40 cm
			7780±390	(Wk 1101)	*Turbo cinereus*	44-50 cm
Koolan Shelter 2	shelter	Central Kimberley Koolan Island	3710±90	(Wk 1372)	*Turbo cinereus/ Monodonta labio*	2-27 cm
			10550±150	(Wk 1099)	marine shell	48-53 cm
Dampierland	midden	NWDampierland	1170±50	(SUA 2603)	marine shell	
James Price Pt	midden	Sth of Broome	1270±60	(SUA 2826)	marine shell	
Mangalagun	mound	Sth of Broome	1220±60	(SUA 2826)	*A. granosa*	15 cm
			3640±60	(SUA 2827)	*A. granosa*	basal
Roebuck Plains 2	mound	Sth of Broome	3550±70	(Wk 2602)	*A. granosa*	surface
Sheep Camp	midden	Sth of Broome	3110±60	(Wk 2663)	*A. granosa*	upper section
			3070±60	(Wk 2664)	*A. granosa*	middle section
			2960±110	(Wk 2603)	*A. granosa*	base
Thangoo Mound 1	mound	sth of Broome	2300±60	(Wk 2661)	*A. granosa*	surface-10cm
			2380±50	(Wk 2733)	A. granosa	basal
Cockle Well	mound	sth of Broome	1520±80	(Wk 2601)	*A. granosa*	surface
Site 34 Homestead site	midden	sth of Broome	3100±60	(Wk 2110)	*Terebralia*	surface
Site 32 Thangoo	midden	sth of Broome	1390±70	(Wk 2106)	*Barbatia* sp	
Site 4	midden	sth of Broome	1800±70	(Wk 2107)	*Barbatia* sp.	100 cm
Site 20	midden	sth of Broome	1700±60	(Wk 2109)	*Terebralia*	surface
Site 19	midden	sth of Broome	3060±50	(Wk 2108)	*Terebralia*	surface

Anadara Shelter TP 1/7	shelter	Pilbara/Burrup P.	4240±60	(Wk 2647)	*A. granosa*	
TP 1/15			6380±70	(Wk 2648)	*Terebralia*	basal
MV 47/112-CS1-12	midden	Pilbara/Burrup P.	2430±60	(Wk 2649)		basal
Not so Secret TP1	shelter	Pilbara/Burrup P.	6140±130	(Wk 2650)		basal
Pistol Range P2772	midden	Pilbara/Burrup P.	1960±90	(SUA 1862)	*A. granosa*	1-5 cm
			1820±100	(SUA 1863)	*A. granosa*	20 cm
			7190±130	(SUA 1864)	*Terebralia*	25 cm basal
Skew Valley P0406	midden	Pilbara/Burrup P.	2770±80	(ANU 1838)	shell	
			3410±90	(ANU 1839)	shell	
			3540±90	(ANU 1843)	*A. granosa*	
			3770±90	(ANU 1837)	*A. granosa*	
			3910±90	(ANU 1845)	*A. granosa*	
			4150±90	(ANU 1834)	*A. granosa*	
			4150±80	(ANU 1502A)	*A. granosa*	
			4290±70	(ANU 1502B)	*A. granosa*	
			6600±110	(ANU 1835A)	gastropod	
			6280±100	(ANU 1835B)	gastropod	
			6960±110	(ANU 1836)	gastropod	
			6620±100	(ANU 1503)	*T. palustris*	80-90 cm
Georges Valley P1885	midden	Pilbara/Burrup P.	1810±130	(SUA 1869)	*A. granosa*	10-20 cm
			4320±110	(SUA 1870)	*Turbo cinereus*	20-30 cm
			4640±110	(SUA 1871)	*T. cinereus*	50-60 cm
			6070±110	(SUA 1872)	*A. antiquata*	basal
King Bay P1843	midden	Pilbara/Burrup P.	5210±100	(SUA 1868)	*Turbo cinereus*	20-30 cm
King Bay P1846	midden	Pilbara/Burrup P.	2740±80	(SUA 1858)	*A. granosa*	sur-10 cm
King Bay P2299	hunt hide/ midden	Pilbara/Burrup P.	4730±100	(SUA 1861)	*T. cinereus*	10-15 cm
Tartaruga P1562	midden	Pilbara/Burrup. P	1910±90	(SUA 1855)	*A. granosa*	
			2630±90	(SUA 1856)	*Acanthopleura* sp.	
Fish Trap Inlet P2599	midden	Pilbara/Burrup P.	1470±90	(SUA 1859)	*A. granosa*	surface
Fish Trap Inlet P2585	midden	Pilbara/Burrup P.	2590±100	(SUA 1865)	*A. granosa*	surface
			2720±100	(SUA 1866)	*A. granosa*	
			2670±100	(SUA 1867)	*A. granosa*	c. 30 cm
Hearson Cove P1488	AS/shell	Pilbara/Burrup P.	710±80	(SUA 1860)	*A. granosa*	surface
Cape Lambert P4665	midden	coastal Pilbara	2640±185	(WAIT 92)	*A. granosa*	TP 4 surface
			2710±165	(WAIT 93)	*A. granosa*	TP 4 15-18 cm
			2930±265	(WAIT 94)	*A. granosa*	TP 4 28 cm
			2900±135	(WAIT 91)	*A. granosa*	TP 5 15-18 cm
Popes Nose P5431			1530±250	(WAIT 102)	*A. granosa*	TP 1 10-20 cm
			1740±320	(WAIT 104)	*A. granosa*	TP 5 10-20 cm

			2270±250	(WAIT 103)	*A. granosa*	TP 4 70-80 cm
			2870±250	(WAIT 101)	*A. granosa*	TP 5 80-90 cm
Tubridgi Site 2 E	midden	near Onslow	1040±70	(Wk 2614)	*A. granosa*	Surface
Tubridgi Site 2 TP3			1300±80	(Wk 2610)	*Hyotissa* sp.	0-5 cm
Tubridgi Site 2 C TP2			1420±60	(Wk 2611)	*Hyotissa* sp.	0-9 cm
Tubridgi Site 2 ATP1			2270±70	(Wk 2612)	*Hyotissa* sp.	0-64 cm
Tubridgi Site 4 A	midden	near Onslow	940±60	(Wk 2615)	*A. granosa*	surface
Tubridgi Site 5 TP2	midden	near Onslow	2340±80	(Wk 2616)	*A. granosa*	surface
Tubridgi Site 6	midden	near Onslow	3980±80	(Wk 2613)	*A. granosa*	surface
Tubridgi Site 7 TP1	midden	near Onslow	4020±70	(Wk 2618)	*A. granosa*	25-30 cm
			4200±70	(Wk 2617)	*A. granosa*	surface
Tubridgi Site 8A	midden		3490±70	(Wk 2622)	*Hyotissa* sp.	surface
			3950±70	(Wk 2619)	*Terebralia* sp.	surface
Tubridgi Site 8B	midden	near Onslow	3560±80	(Wk 2627)	*A. granosa*	surface
			4110±80	(Wk 2621)	*Terebralia* sp.	surface
Tubridgi Site 9	midden	near Onslow	3830±70	(Wk 2629)	*Hyotissa* sp.	surface
			4040±70	(Wk 2626)	*A. granosa*	surface
			4350±90	(Wk 2624)	*Terebralia* sp.	surface
Tubridgi Site 9 TP2			4090±70	(Wk 2623)	*A. granosa*	8.5-12.5 cm
			3890±70	(Wk 2620)	*A. granosa*	19.5- 22.5 cm
			4640±220	(Wk 2628)	*Terebralia* sp.	46.5- 54 cm
Tubridgi Site 9 TP4			3450±80	(Wk 2625)	*A. granosa*	40.5-42.5 cm
Tulki Well P5649	midden	Northwest Cape	5660±110	(ARL 245)	*Turbo* sp.	surface
Turqoise Bay Nth	midden	Northwest Cape	5430±200	WAIT 118	*Turbo* sp.	25-35
Low Point	midden	Northwest Cape	4820±60	(Wk 1430)	*T palustris*	surface
Giralia Road site 11	AS/shell	Northwest Cape	1640±90	(Wk 2859)	*Melo amphora*	surface
Giralia Road site 9	AS/shell	Northwest Cape	1528±60	(Wk 2858)	*Melo amphora*	surface
Mangrove Bay	midden	Northwest Cape	109.2±0.8	(Beta 26269)	*Tectus pyramis*	surface
Coral Bay	midden	Sth of NW Cape	6270±120	(Wk 1728)	mang. gastropod	surface
Coral Bay	midden	Sth of NW Cape	5620±60	(Wk 1729)	marine	surface
Warroora	midden	Sth of NW Cape	7810±115	(SUA 1735)	*T. palustris*	surface
Mulanda Bluff	midden	Sth of NW Cape	7210±70	(Wk 1429)	*T. palustris*	surface
Notch Point	midden	Dirk Hartog I	7460±60	(Wk 2997)	*Terebralia*	surface
	midden	Dirk Hartog I	5160±60	(Wk 2996)	*Turbo* sp.	surface
Useless Inlet 3	midden	Shark Bay UL	7020±70	(Wk 2561)	*Terebralia*	surface
Useless Inlet 4	midden	Shark Bay UL	6620±70	(Wk 2562)	*Terebralia*	42-53 cm
Useless HK	midden	Shark Bay UL	7400±70	(Wk 2755)	*Terebralia*	surface
Heirisson Prong 1	midden	Shark Bay	5980±70	(Wk 2754)	*Turbo* sp.	surface
Heirisson Prong 2	midden	Shark Bay	4890±140	(Wk 2439)	turban	surface
Denham Site 9	midden	Shark Bay	3460±70	(Beta 31497)	*Melo* sp.	surface
Whale Well	midden	Shark Bay	1820±130	(WK 2438)	*Melo* sp.	24 cm

			1240±290 (140)	GS/CC 290	*Melo* sp.	surface
			1510±310 (150)	GS/CC 291	*Melo* sp.	surface
Eagle Bluff	midden	Shark Bay PP	4690±110	(ANU 7459)	*Terebralia*	22 cm
			4690±220	(WAIT 141)	*Terebralia*	surface
			4870±90	(Beta 31498)	*Terebralia*	surface
Eagle Bluff Well 2	midden	Shark Bay PP	3970±70	(Beta 31499)	*Terebralia*	surface
Silver Dollar	midden	Shark Bay PP	6640±260	(ANU 7457)	*Terebralia*	57 cm
			6950±70	(ANU 7456)	*Terebralia*	0-1 cm
			7240±130	(Wk 2433)	*Terebralia*	23 cm
			7260±160	(Wk 2434)	*Terebralia*	9 cm
			7290±140	(Wk 2436)	*Terebralia*	24 cm
			7360±190	(Wk 2435)	*Terebralia*	9 cm
Zuytdorp gully site	midden	Sth of Shark Bay	4450±70	(Beta 22535)	*Patella laticostata*	
Zuytdorp clifftop site	midden	Sth of Shark Bay	5080±80	(Beta 22534)	*Patella laticostata*	
Middle Head unit 3		southwest	6290±100	(SUA 1660)	*Nucella orbita*	
Middle Head unit 4		southwest	3450±90	(SUA 1661)	*Turbo intercostalis*	
Calgardup Brook		southwest	4310±110	(ARL 134)	*Nucella orbita*	
Ellen Brook		southwest	550±80	(SUA 1621)	*Patella laticostata*	
			4250±70	(Wk 1881)	marine shell	
Sandy Point North		southwest	4860±90	(SUA 1667)	*Turbo intercostalis*	
Sandland Island		southwest	5330±90	(SUA 1472)	*Turbo intercostalis*	
Green Head		southwest	5260±90	(SUA 1471)	*Turbo intercostalis*	
Moore River		southwest	5220±80	(SUA 1853)	*Turbo intercostalis*	
Sandy Point		southwest	1390±80	(SUA 1629)	*Turbo intercostalis*	
Herald Point		southwest	1010±80	(SUA 1812)	*Nucella orbita*	
Conspicuous Cliff		southwest	580±80	(SUA 1811)	*Turbo intercostalis*	
Cheyne Bay		southwest	500±70	(SUA 1808)	*Nerita atramentosa*	
Lights Beach		southwest	500±80	(SUA 1809)	*Turbo intercostalis*	
Malimup Midden 1		southwest	330±80	(SUA 1622)	*Nerita atramentosa*	
Sandy Bight Creek		southwest	420±80	(SUA 1914)	*Nerita atramentosa*	
Whalebone Point		southwest	390±80	(SUA 1810)	*Nerita atramentosa*	

The table attempts to compile all radiocarbon dates in WA from shell middens, mounds or sites where shell comprises the dominant visual component. Only shell dates have been included. Where the information is not available I have left the entry blank. Obviously there are sites which are currently being investigated and there will be inevitable ommisions. I have not included the Pleistocene shell dates from Silver Dollar, Mandu Mandu Creek Rockshelter, Koolan Shelter 2 or Widgingarri Shelter 1 for, while they obviously suggest contact with the coast, these sites were not directly coastal at this time. All dates presented are the 'conventional age' and have not had the environmental reservoir correction factor applied.