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# Changing Perspectives in Australian Archaeology

*edited by*

Jim Specht and Robin Torrence



*Papers in Honour of Val Attenbrow*

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## Changing Perspectives in Australian Archaeology, Part II

### Abydos Plain—Equivocal Archaeology

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**ABSTRACT.** The difficulty of distinguishing between Aboriginal shell middens and natural shell deposits has been addressed in various settings. On the Abydos Plain near Port Hedland in northern Western Australia, archaeologists have generally not acknowledged this issue and have ascribed a cultural origin to most shell deposits. Recent investigations have demonstrated that episodic cyclones or storm waves on the coastal marshes have deposited or re-deposited shells that are similar in appearance to midden deposits, and that previous interpretations of the archaeology of the Plain are not justified. A geo-archaeological approach is essential to reveal the stratigraphic sequences and palaeo-processes which have controlled the formation of shell features on the Plain.

SULLIVAN, MARJORIE, PHILIP HUGHES, AND ANTHONY BARHAM, 2011. Changing perspectives in Australian archaeology, part II. Abydos Plain—equivocal archaeology. *Technical Reports of the Australian Museum, Online* 23(2): 7–29.

The work reported here commenced as an activity to undertake salvage excavations in two areas, Harriet Point and Wedgefield North, near Port Hedland in northern Western Australia, as part of the consent approval to destroy several shell middens (Figs 1–4). As is the case for most contract archaeological work, there was time pressure. In trying to assemble an appropriately qualified team, the authors invited Val Attenbrow to participate. She considered it, saying she would “love to dig a good midden”, but declined because of her workload (or perhaps because she looked at the late November average temperatures for Port Hedland). In retrospect Val was right again. That “good midden” remained elusive, but undoubtedly these deposits would have re-kindled her interest in shell bed reworking.

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The shell deposits listed for salvage were registered archaeological sites<sup>1</sup> that were to be buried by spoil dredged from the nearby harbour, as a key component of a port infrastructure upgrading project.

The authors looked at the survey reports (Gavin Jackson P/L, 2007, 2008) and photographs of the sites in each area, and were concerned that the shell deposits might not be middens. They made short preliminary visits to the areas, and those concerns remained, although it was clear that the deposits were equivocal, and questions about their nature and origin could be resolved only by extensive excavations. As a result of those brief site visits, it was recommended that the salvage excavations should take a geoarchaeological approach, to investigate the shell deposits within their



Figure 1. Location of the study area. Map prepared by BHP Billiton Iron Ore P/L.

landscape settings, and the excavation methods were focused on recovering information on both the shell accumulations and the sedimentary deposits within which they occurred.

### Previous work on shell middens in the Port Hedland area

The origins of the shell deposits on the Abydos Plain as middens have not been questioned previously, although some archaeologists involved in site surveys had commented in conversations that they did not consider all of the deposits to be cultural.<sup>2</sup> Most archaeologists have undertaken surveys or more detailed investigations predicated on the simple assumption that the extensive shell deposits were middens, i.e. that they had a cultural origin as the remains of food gathering, and they were located where the shellfish had been consumed.

In nearby areas geomorphologists pursuing evidence for tsunamis had recorded accumulations of shells as natural deposits created by tsunami events (Nott & Bryant, 2003). Some archaeologists have challenged their interpretations of tsunami events on the grounds that many such deposits are undisturbed shell middens (e.g., Hutchinson & Attenbrow, 2009; Barham & O'Connor, 2007). The shell deposits at Harriet Point and Wedgefield North can contribute information to that debate.

The Abydos Plain shell middens recorded by themselves and others were described by Veth & O'Brien (1986) as comprising predominantly *Anadara granosa* shells, occurring near the mouths of watercourses and extending inland along the watercourses. They did not question the origin of the shell deposits, but described them as middens,

noting that many were extensive, in some instances covering areas of 50,000 m<sup>2</sup>. They excavated two stratified deposits and obtained dates on shells ranging from about 1,000 to 2,500 years BP in one deposit and from about 2,200 to 2,500 in the other.

Recently Clune and Harrison (2009) and Harrison (2009) described shell deposits on the Abydos Plain, similarly without questioning their origin. The area of the investigation described by Harrison (2009), which was also part of a salvage program, was between the two areas to be salvaged for this study (compare Figs 2–4 with Harrison, 2009: fig. 1).

Clune and Harrison (2009: 70) accepted the shell deposits they investigated as cultural features and described them as “large shell mounds, earth mounds (or mounded shell middens), lenses of shell eroding out of well-developed dunes, and undifferentiated surface shell scatters.” They interpreted the archaeological record as resulting from “a series of changes in economic scheduling, resource availability, social organization and mobility”, and suggested that “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.”

In undertaking surveys to identify the impacts of the proposed spoil dumping, the Gavin Jackson P/L 2007 and 2008 teams identified 25 shell middens at Wedgefield North and 52 middens at Harriet Point, which were subsequently included in the DIA sites register. The permits to disturb the areas required the salvage of ten sites at Wedgefield North and 13 sites at Harriet Point, and these are the subject of the present study.



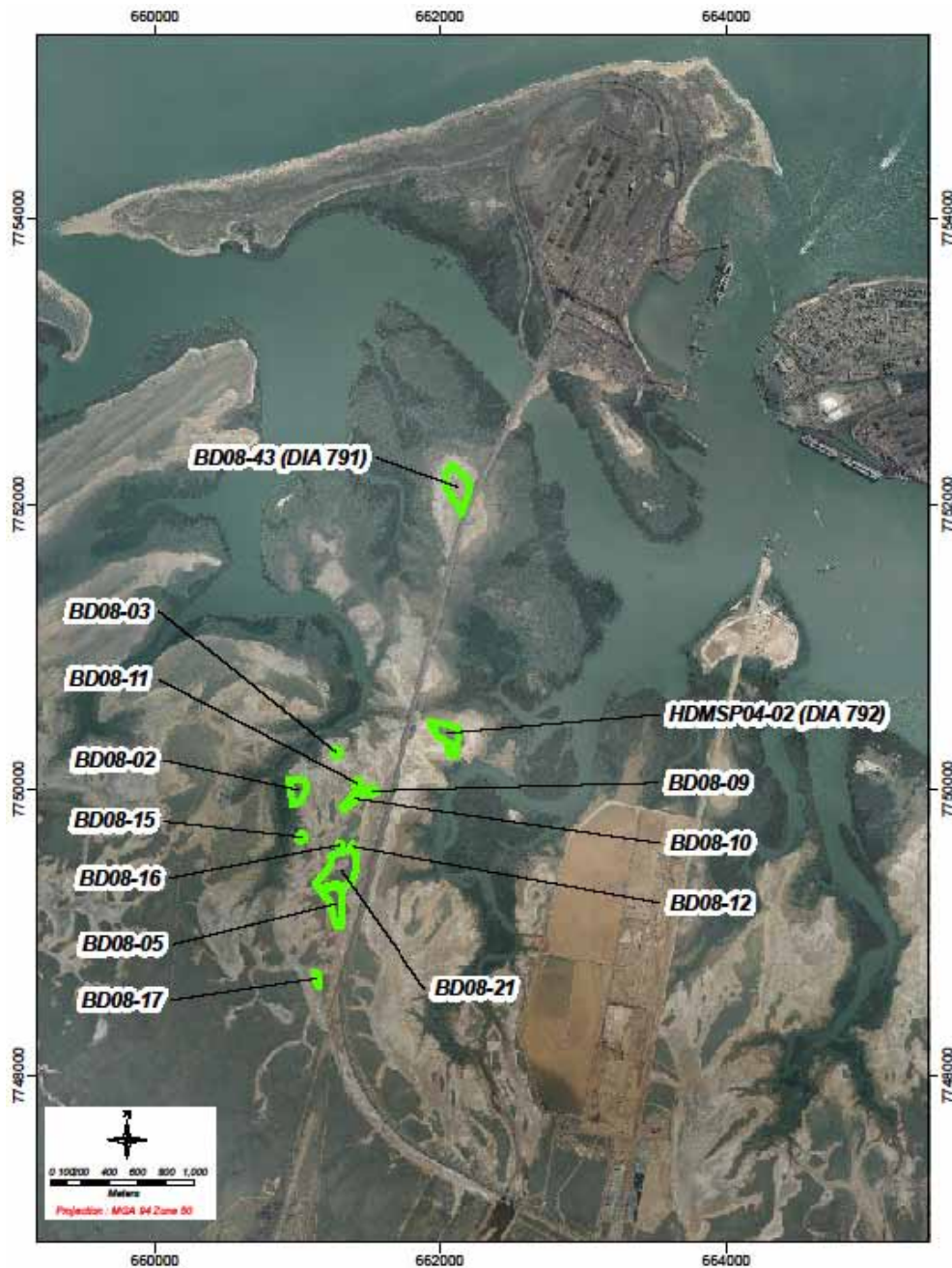


Figure 2. The Harriet Point study area showing the excavated sites. The Harrison (2009) study area is right (east) of the major mangrove-lined tidal creek in the centre of the photo. The Wedgefield North study area is right (east) of the tidal creek on the right side of this image.

### Distinguishing between cultural and other shell deposits

Over many years numerous midden researchers (e.g., Gill, 1954; Coutts, 1966; Hughes & Sullivan, 1974) have noted that shell deposits have been reworked/redeposited through flow or wave action, or that natural shell beds may be difficult to distinguish from shell middens. These researchers have developed criteria for distinguishing between natural shell beds and shell middens, or between re-worked and intact midden deposits.

In 1992 Val Attenbrow applied these criteria to shell deposits near Sydney, and found (1992: 20) that for middens away from the immediate coastline, the presence of juvenile and small (<15 mm) shellfish species in the deposits was the best indicator of disturbance or re-deposition of the shell middens, coupled with location within the landscape and informed by the local soil stratigraphy. Those criteria,

along with the size distribution of the shells, and the degree of weathering of the shells, appear to be important in this Pilbara context.

### Landscape of the Port Hedland intertidal plains

Both the Harriet and Wedgefield North areas comprise predominantly intertidal flats or marshland. At Harriet Point most of the shell deposits interpreted by Gavin Jackson P/L (2008) as middens occur on a dissected calcareous sand sheet mapped on the 1:250,000 Port Hedland geological sheet as Qcs (Table 1, Fig. 5). This sand is largely aeolian and supports a dense cover of spinifex grass (*Triodia pungens*). It is hard-setting when dry, but softens when wet and is referred to as Pindan (brick-making) Sand (Figs 6, 7). The surface of the sand sheet is on average about 0.5 m above mean high tide level, and during high spring tides and tidal surges associated with tropical rain depressions and cyclones,



Figure 3. Oblique airphoto looking north across the Harriet Point study area at low tide showing the sites on the remnants of the sand sheet in the middle, the bare tidal flats and channels surrounding them and the mangrove lined creeks and shoreline in the distance. The Harrison (2009) study area is just beyond the right side of the image (photo by BHPBIO).

it is inundated with saltwater. This sand sheet is dissected by a network of shallow (up to 1.5 m), wide (10–200 m) tidal channels (Qci on the geological sheet—see Table 1), and its margins, especially those facing north and west, are eroding due to wave and tidal action (Fig. 5).

The sand in the sand sheet at Harriet Point is reddish in colour, but at the northern end the sand underlying some of the shell deposits is pale in colour. These sand features were a metre or two lower than most of the sand sheet and would be inundated regularly by waves at high tide. Some of these features appeared to have been formed by wave action rather than wind action (Figs 8–12). One in particular was elongated and shelly, and looked like a chenier (Figs 8, 9).

In contrast, there is no extensive sand sheet at Wedgefield North, because this landform type ends to the south at about the boundary of the Wedgefield industrial area, shown on Figure 3. Instead, on the tidal flats at Wedgefield North there are isolated rises of loose to soft pale reddish brown, brown, yellow and grey coloured sands (Fig. 13). The surfaces of these sand rises are no higher than 1 m above the adjacent tidal flats and 0.5 m above mean high tide level, and they form islands during normal tidal cycles. These rises have a dense cover of spinifex. During high spring tides and tidal surges associated with tropical low pressure rain depressions and cyclones all the sand rises are inundated with saltwater, and regular overwash has resulted in any sandy deposits being

**Table 1.** Landforms in the study areas.

unit	description	field profile
Qcs	Calcareous sand, silt and clay: chiefly of supratidal flats (i.e. the shore area immediately marginal to and above high tide level) Commonly referred to as Pindan Sand.	Pale red loose sand 500–800 mm thick and becoming firmer with depth, abruptly overlying whitish calcrete hardpan about 200 mm thick overlying. Reddish weathered clayey sand of unknown thickness.
Qci	Calcareous clay, silt and sand of intertidal flats. Includes mangrove swamp.	Higher sediments adjacent to the sand sheet are sandy; increasingly muddy towards the centrelines of the tidal channels, especially northwards towards the mangrove swamp. Includes small, pale sand features and sand rises.
Qpb	Bossut Formation. Sandy calcarenite, oolite and calcilutite.	Small, low outcrops at the northern end of each study area. Some outcrops capped with shell.





Figure 4. The Wedgefield North study area showing the excavated sites in green and other recorded sites in red. The Harrison (2009) study area is left (west) of the major mangrove-lined tidal creek on the left side of the image.

truncated, and a “planated” or uniform surface with similar elevations occurs across the whole of Wedgefield North.

Large cyclones, such as that which occurred in Port Hedland in January 1939, have the potential to overtop the sand rises even on neap tides (Bureau of Meteorology, 2010). During high spring tides coinciding with cyclone storm surges, water can be driven to over 10 m above mean sea level at Port Hedland. Such conditions would submerge the spinifex-covered sand rises to water depths of >2–5 m on a regular frequency over 100 year timescales.

In both areas the deeper channels forming the edges of the intertidal flats are fringed with mangroves. The intertidal plains are further dissected by networks of shallow, sandy tidal channels. On the beds of the tidal channels exposed at low tide, there are extensive but patchy accumulations of mainly cockle shells with occasional patches of fine gravel. At the southern end of the plain at Wedgefield North the landscape has been heavily modified by mounding sand and flattening surfaces for storage/lay-down areas immediately north of the Wedgefield industrial zone (Fig. 4).

Both of the study areas (and, in fact, an extensive zone around Port Hedland within which they fall) are underlain by Pleistocene reddish weathered fluvial clayey sand referred to as Reworked Red Beds (RRB) and described

by BHP (1996: 5) as

“A variable red brown to yellow brown sand in a silty or clayey matrix and containing minor gravels ... This ... deposit is up to 5 m thick and consists of RRB material derived from the underlying sedimentary unit. The RRB material is very stiff to hard when dry and can cause backhoe refusal ... Because of the local cementing action of crystallised salt (probably potassium chloride), an exposed RRB face in a backhoe pit on drying out will show white efflorescence ... ”

This material is highly variable spatially and with depth in colour, texture and degree of weathering. At Harriet Point the RRB was exposed widely at the surface across the tidal flats but at Wedgefield North it was everywhere mantled with estuarine muddy sand and was encountered in the excavations only where these were dug sufficiently deep. On the southern side of the Wedgefield North study area its surface is about 0.5 m above mean high tide, but at about 0.8 km to the north it slopes to about 1 m below mean high tide level. At Harriet Point fluvial RRB appeared to grade seawards into an estuarine deposit, which had accumulated at a time of high sea level in the Pleistocene (perhaps during the last interglacial about 120,000 years ago).





Figure 5. BD08-05. Shell on eroded western flank of sand sheet adjacent to a tidal channel. Trench dug through Pindan Sand to Pleistocene clayey sand, the Reworked Red Beds (RRB).



Figure 6. BD08-05. The base of the excavation through the Pindan Sand is down to the surface of the RRB. No shell was found below about 100 mm.





Figure 7. BD08-05. The layer of wave-dispersed shell about 300 mm below the surface is just above the surface of the RRB.



Figure 8. BD08-03. View looking east along this shelly chenier ridge. Note the mangrove shrub growing on the crest of the ridge.





Figure 9. BD08-03. Trench through the chenier ridge looking north. Between the red mottled RRB and the paler shell-rich upper sand is a layer of c. 300 mm of Holocene estuarine muddy sand, which appears as a darker, greyish brown colour.



Figure 10. BD08-15. The trench cuts through a sandy chenier ridge with concentrations of shell on its lower flank.





Figure 11. BD08-15. Square on lower flank of chenier ridge before shell collected.



Figure 12. D08-15. Square in Figure 10 after shell collected. Shell occurred only on the surface and to a depth of about 50 mm.





Figure 13. WN07-06. The rise is a sandy chenier ridge resting on RRB exposed in the base of the trench. The shell and white sand in the foreground is inundated during every spring tide cycle.

### Methods used in the salvage investigation

The salvage investigations at Harriet Point were undertaken by the authors in late 2008 and the findings and interpretation of observations at Harriet Point influenced the salvage methodology for the Wedgefield North salvage program in April 2009. The geomorphic history of Wedgefield North proved to be very similar to that of Harriet Point and the same major sedimentary units were present in both.

Several excavation methods were employed in the Harriet Point area.

- 1 Where shell was exposed on the eroded sides of sand features or the floors of the drainage lines in contexts where the loose sand had been stripped away, samples of the shell were collected for later analysis from 1×1 m squares by hand and using shovels, with no or only minimal sieving.
- 2 Where shell was exposed in the eroding faces of loose sand or in the sides of machine excavated trenches (see below), pits up to 1 by 1 m in area were excavated in spits 50–100 mm thick using controlled methods, and the excavated materials were sieved. The sections were described, photographed and drawn and column samples of shell and sediment taken for later analysis, including radiocarbon dating (shells) and optically stimulated luminescence (OSL) dating (sediments).
- 3 Trenches were excavated using earth-moving machinery. These trenches extended from the tidal channels, across the exposed shell deposits (which in most cases occur on the eroded edges of the sand sheet adjacent to the tidal channels) and into the centre of the respective sand sheet. Most trenches

were continuous; some longer excavations were in the form of elongated pits. In selected locations pits were dug as deep as practicable to expose the older sediments underlying both the tidal channels and the sand sheets. The stratigraphy of the sediments exposed in the trenches (including any shell deposits) was recorded and samples taken for analysis. Excavations of selected exposed shell deposits were carried out as described in (2) above. For this project and at Wedgefield North a medium-sized rubber-tracked excavator was used. In softer sediments (e.g., the sand sheets) a flat-edged bucket was used but when very hard basal sediments were encountered at Harriet Point, a toothed bucket had to be used to remove the material.

- 4 This machinery was used to excavate open areas on sand sheets. Stratigraphic features, including concentrations of shell deposits, revealed in plan were recorded and sampled as the excavations proceeded.

At Harriet Point the excavation methods included hand excavations of dense clusters of shell on the margins of the sand sheet units, or of clusters identified during the initial survey (Gavin Jackson P/L, 2008) as likely to be exposed parts of stratified midden deposits within the sand sheet. Almost all of the deposits excavated in this way proved to be thin single shell layers. From these salvage investigations it was concluded that machine-excavated trenches were more valuable than hand excavations in revealing the nature of the shell deposits and the stratigraphic sequences at each location. They provided a lateral perspective to identify shell clusters worth systematic excavation by hand; a face within the respective sand deposit from which to excavate; and,

importantly, they demonstrated the nature of the smaller sand bodies, showing the cheniers had a variety of sedimentary textures ranging from sand to coarse shell.

On the basis of that experience, the salvage program at Wedgefield North comprised:

- 1 The establishment of a machine-excavated trench across each feature.
- 2 Where warranted, an adjacent machine-stripped open area excavation of about 25 m<sup>2</sup>.
- 3 Hand excavation, as warranted, to recover information from each of the trenches. Pits were excavated into the sides of the machine-excavated trenches, in controlled spits using trowels or spades as appropriate, and the excavated materials were sieved.

The trench and hand-excavated sections were described, photographed and drawn. Column or spot samples of shell and sediment were taken for later analysis, including radiocarbon and OSL dating. Laboratory-based washing, sorting and measuring of the shells from all sites was carried out in Port Hedland in temporary facilities supplied by BHP Billiton Iron Ore (BHPBIO). That work commenced during the fieldwork periods and the shell measuring was completed later in 2009 by three of the fieldwork team (archaeologists Barbara Rowland and Sarah Robertson, and Archaeological Science Masters student Jay Chin). An independent statistical analysis of the shell measurement, which will be published in full separately, was then undertaken by Dr Pat Faulkner (University of Queensland) who was able to compare these samples with *Anadara granosa* shells from middens on the northern Australian coast.

### Geoarchaeological findings

This study is based on initial field and laboratory observations, and only preliminary interpretations of the nature and evolution of the sediments and landforms at the study areas are presented here. An extensive radiocarbon and OSL dating program has just begun and it is acknowledged that the conclusions may need to be refined when these have been completed and more data come to hand. The study demonstrates that the meaningful interpretation of the shell deposits can be undertaken only in conjunction with the geomorphological/landscape evolution investigations.

**Holocene estuarine sediments.** The lithostratigraphic units had not been recognized in previous geological reports for the Port Hedland area, nor are they mapped. The estuarine silty, muddy sand units occur as discontinuous thin beds and drapes, and are overlain stratigraphically by the sand units in and on which *Anadara* spp. have been located during previous archaeological surveys.

In trenches towards the northern side of the Harriet Point flats, and in almost all of the machine excavated trenches at Wedgefield North, the sand rises (including chenier ridges) were underlain by a layer of muddy sand less than 1 m thick and containing small estuarine shellfish species (but, interestingly, with few exceptions, not the cockle *Anadara*) (Fig. 9). Traces of this muddy sand were found in a trench on one of the higher rises, but none in an adjacent open area excavation on the highest part of the rise.

At both Harriet Point and Wedgefield North this muddy sand is interpreted as Holocene estuarine sediment which once covered the study area and remnants of which survive

buried beneath the cover of younger sands. It is likely that this sediment accumulated at a time when the sea level was higher than at present, and it is likely it pre-dates the environmental conditions under which extensive cockle beds developed. This interpretation is consistent with evidence from intertidal muds forming the surface of Buckley's Plain near Broome (Lessa & Masselink, 2006) that relative sea level was at least 1 m higher than today prior to 2720 radiocarbon years BP.

In the excavation trenches placed across one of the largest sand rises at Wedgefield North, at the northern end of the dissected sand sheet that extends south beneath the Wedgefield industrial area, the brown sand overlying the bleached Holocene beach sand was loose and highly disturbed. The sand contained shell grit, small gastropods and fragmented crab remains throughout as well as variable but generally sparse amounts of poorly preserved cockle shell. This sand has all the characteristics of a beach deposit which, given its looseness and the good state of preservation of much of the small shell fraction and crab material (if not the cockle), must be relatively young (Fig. 14). This young-looking shelly "beach" sand occurs even across the highest part of the rise, some 1.4 m above the adjacent tidal flats.

This layer occurs in a stratigraphic position equivalent to the estuarine muddy sand, wedged between the Pleistocene weathered clayey sand (RRB) and the overlying loose younger sand. The shelly deposit had been bleached by weathering and was capped with a hard layer of calcrite (calcium carbonate) (Fig. 14). As in a southerly site at Harriet Point, this is interpreted as a beach deposit, which formed at a time when the shoreline was further inland than at present, most likely when the estuarine muddy sand described above was accumulating.

The single date so far returned from beach deposits in the Wedgefield North excavations (ANU SSAMS-7712) suggests the estuarine relative higher sea level phase dates to around 3700 cal. BP (3735±40 BP uncalibrated). Most of the concentrates of cockle shell identified both at surface and in eroding sections in previous archaeological surveys at Wedgefield North are likely to post-date this higher estuarine phase on stratigraphic grounds, at least in seaward areas.

**Deposits in the younger sands.** The reddish sands ascribed to Pindan Sand in the southern part of the sand sheet at Harriet Point do not occur prominently in the Wedgefield North study area, although they are widespread immediately to the south beneath the Wedgefield industrial area. Only one site had hard-setting reddish Pindan Sand and this was only at the base of the sand body. Instead most of the sand rises consisted of loose to soft pale reddish brown, brown, yellow and grey coloured sand resting directly on Holocene estuarine muddy sand. These sands contained variable but very small amounts of cockle shells mixed with shell grit, small (<15 mm) molluscs, including gastropods, and crab claws and other fragments of crustacean exoskeleton (including lobster), indicating a strong wave-transported and winnowed element within the sand units.

It is likely that most, if not all, of these sands and their content of whole shells (including the cockle), shell grit and crab remains were deposited by high-energy wave action (storms and cyclones). In some cases windblown sand from the exposed tidal flats may have accumulated on these sand rises. The looseness and lack of weathering of the sand and the good state of preservation of much of the fragmented shell grit and crab remains suggest that these low sand rises formed relatively recently—centuries or even decades rather than millennia ago. In some of the deposits (especially WN07-12, 14 and 17) the original bedding still survives, as evidenced



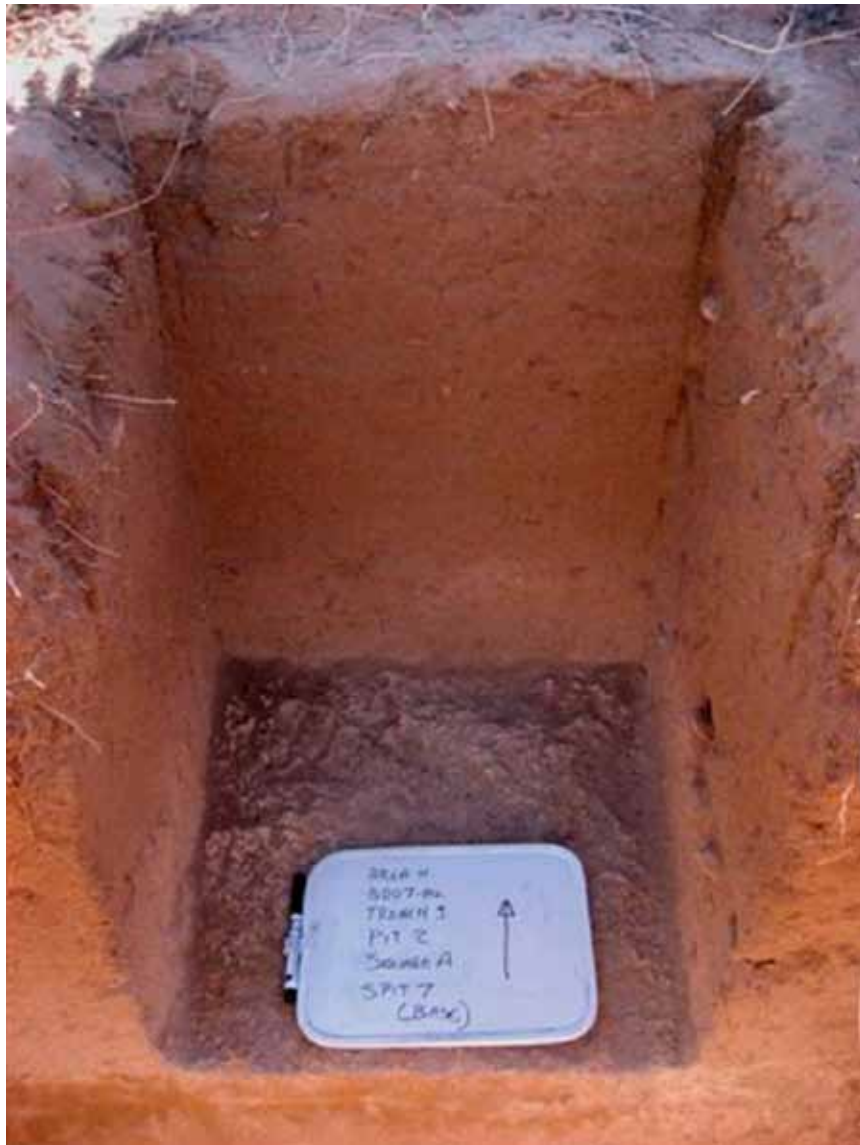


Figure 14. WN07-04. The upper loose brown sand, with disturbed whole shell, shell grit, small gastropods and fragmented crab remains, overlies the bleached calcareated Holocene shelly beach sand at the base of the excavation.

by bands of sand of different texture in the profile. This also suggests a recent origin as bioturbation over time destroys the evidence of sedimentary layering by mixing the sediments.

As a group the characteristics of these sand rises indicate that they are cheniers: i.e. they are coastal/marshland landforms resulting from episodic high energy wave events and comprising elongated low ridges of shell or shelly/gritty sand with flat bases which rest on estuarine mud (Augustinus, 1989; Neal *et al.*, 2002; Otvos, 2000). These ridges are strongly asymmetric in cross-profile, with a steeper shore-face. The ongoing radiocarbon dating program will have as one of its foci determining the ages of these features.

### Summary overview

Throughout the period people have lived in this region the landscape in and around the study areas has undergone considerable change through time. During the Pleistocene when sea levels were low and the shoreline was tens to hundreds of kilometres north of its present position the study areas were parts of an extensive inland plain (Kendrick *et al.*, 1991). On a low-lying, low-gradient coastline such as the Abydos Plain, relatively minor Holocene oscillations in

mean sea level, now suggested for many parts of the WA coastline (Hearty *et al.*, 2006; Semeniuk, 1982, 1995, 2008), would have significant and complex spatial and sedimentary consequences on intertidal and supra-tidal landforms, and the ecology of such tidal zones.

Some time after the sea reached its present level around 6,000 years ago the estuarine sediments underlying most of the sand features in the study areas accumulated, probably at a time of slightly higher relative sea level. These sediments contained estuarine shells, samples of which will be radiocarbon dated to determine their age. The fact that little or no *Anadara* shell was found in these sediments is intriguing given the dominance of this species in the overlying deposits. It suggests similar environmental changes occurred in this area as in several other parts of the coastal Pilbara, as indicated by the absence of *Anadara* in older shelly deposits and its overwhelming dominance in younger deposits (cf. Clune & Harrison, 2009).

The presence of coarse, cemented shelly beach deposits at the base of one of the larger sand rises at Wedgefield North suggests that at the time this feature accumulated there was a shoreline south of the zone where estuarine muddy sands were accumulating which was subject to at least intermittent

high energy wave events. Subsequently these Holocene estuarine muds and associated beach deposits were eroded by expansion of the network of shallow tidal channels which dominates the area today.

Sand from various sources then accumulated across the study areas, covering both the remnants of the slightly elevated surface of the estuarine muddy sands to the north and the plain and erosion surfaces formed during marine transgression on Pleistocene sediments to the south. At most of the sites the sand and its associated *Anadara* and other smaller shell species, shell grit and fragmented crab remains appears to have been washed up during high energy storm events to form the sand rises (which in most cases are cheniers) on the margins of which the “shell middens” recorded by Gavin Jackson P/L (2007, 2008) occur. Ongoing storm wave action during normal high wet season tides and during cyclone storm surges appears to have planated the land surface across the area.

The field and laboratory observations and geoarchaeological conclusions from the Harriet Point and Wedgefield North salvage programs are summarized in Table 2, with comments by Pat Faulkner on the likely origin of the shell based on sizes and sorting. There are no unequivocal cultural features amongst the sites investigated at either Harriet Point or Wedgefield North, and none of the deposits could be classified with confidence as a shell midden. Apart from four flaked stone artefacts in the strandlines on two sand rises, none of the deposits at Wedgefield North contained unequivocal cultural material. At Harriet Point three stone artefacts occurred on shelly chenier ridges, and some of the associated shell could have been discarded from meals.

At the highest southern part of the Harriet Point flats an extensive zone of sand sheet appeared to contain shell clusters, interpreted in the field, and excavated, as individual shell middens, and considered likely to represent the remains of single meals or occupation events. Initial laboratory analysis of the shells which showed a variable degree of weathering and the presence of shell grit suggested that they were extensively reworked and redeposited, but their sorting characteristics with a modal valve length of 39–41 mm and a normally skewed size distribution, indicate these deposits appear more likely to have originated as shell middens than others on the tidal flats. Subsequent observations of shell clusters in an open excavation in a sand feature at Wedgefield North were that all such clusters there were maintained as termite/ant nests.

All of the shell could have been washed into the area by natural processes from natural shell beds in mud flats beyond the mangrove areas to the north and northwest. This would best explain the preferential concentration of shell (predominantly cockle) along the west, northwest and north-facing strandlines around the sand rises. It is probable that some of the *Anadara granosa* and associated shell in the deposits was brought to the intertidal flats or carried onto the sandy rises by people at some time in the past, but none of the shell is in an undisturbed context, and none is in a deposit that could be classed as a shell midden.

In the Harriet Point area all the shell-rich deposits had at their base a discontinuous but widespread layer of cockle shells that rested on the RRB basement. Field notes made during the excavations described this layer as appearing to be “smeared” across the red-bed surface. This is presumably equivalent to the lowest “midden” layers dated to between 5300 and 4400 cal. BP, identified by Harrison (2009: 96; see also Clune & Harrison, 2009: 78).

In the course of the Harriet Point survey, a search for stone

artefacts was made along the eroded margins of the sand features. The team located and collected 20 stone artefacts, at a density of about 1 artefact/10,000 m<sup>2</sup>, with those of quartz more common to the north of the area, and those of basic volcanic rock more common to the south. There was no noticeable correlation between the frequency of occurrence of stone artefacts and of shell, suggesting the artefacts have mainly been removed from their points of original discard by tidal/wave action.

### Are there shell middens near Port Hedland?

The answer is probably yes, in areas near mangrove-lined channels in the Harriet Point area, and probably in the Anderson Point area investigated by Harrison (2009), but any shell accumulations that have not yet been conclusively demonstrated to be wash or wave deposited are very small, discrete, widely spaced, and constitute a minor element of the landscape. All of the shells are weathered and from disturbed contexts, but shell from some locations appears to have originated potentially from cultural deposits.

The shell features described and illustrated by Harrison (2009) are essentially the same as those at Harriet Point immediately to the west and Wedgefield North immediately to the east in their range of characteristics and their geomorphic settings. The findings of Clune & Harrison (2009) and Harrison (2009) can be restated briefly: not only were all the shell deposits middens, they reflected regular and ceremonial use of the area. If all the *Anadara granosa* shell on the Abydos Plain were of cultural (i.e. shell midden) origin, this would suggest intense occupation in the past, and might necessitate such explanations, invoking as they did ethnographic analogy from areas along the north coast of Australia where fresh water is available and ceremonies are conducted.

Assuming that the capping shells on some cheniers, a few clusters in the higher parts of the Harriet Point estuary, and some of the deposits excavated by Harrison (2009) and Clune & Harrison (2009) are in fact middens, their nature and contents suggest the occasional collection and consumption of cockles and a few other shellfish from the mangrove zones, and the discard of what is in effect a background scatter of stone artefacts on parts of the inter-tidal flats. If shell middens exist in the area they are not widespread or extensive, they do not represent repeated occupation, nor do they represent consumption by large numbers of people gathering for ceremonial purposes.

Cockle shell is distributed widely over the surface of the tidal marshlands at Harriet Point and Wedgefield North, especially on the margins of sand sheets or sand rises. Geoarchaeological analyses of the surface shell deposits and of the sedimentary structures and shell contents in the sand features have demonstrated that both the surface shell and shell within the sand rises has been reworked and redeposited by wave action. While some intact shell middens may occur on the Abydos Plain this has yet to be established. Even if some or all of the shell had a cultural origin, none could now be described as midden, but rather as wave deposited or strandline shell.

Most of the rises on the Harriet and Wedgefield North tidal flats are cheniers (variably shelly, sandy or gritty flat-based asymmetric ridges), and as noted in other situations in northern Australia (e.g., Sullivan & O'Connor, 1993; O'Connor & Sullivan, 1994) it is important to distinguish between such naturally accumulated deposits and cultural deposits that may occur on or within those ridges.

## Lessons and methods for future investigations

Surface surveys alone will not identify cultural features buried within the sand rises. If it is assumed that surface shell has been eroded from an adjacent rise or stratigraphic unit, this can be tested only by sub-surface excavation, and such investigations should be completed before shell features are recorded as archaeological sites.

Machine-excavated trenches provide an invaluable window into the structure and contents of low rises. The nature and initiation of shell deposits identified in section in such trenches is not revealed fully in such sections, so open-area excavations that can uncover the tops and structures of shell deposits within the sand features, or can confirm that clusters have depth or integrity, are essential to identify and characterize cultural deposits.

Val Attenbrow's (1992) guide for distinguishing between middens, reworked middens and natural shell deposits should be applied rigorously to shell deposits in these landscapes, along with comparative statistical analyses of shell sizes and sorting.

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### Endnotes

- <sup>1</sup> Included in the Department of Indigenous Affairs (DIA) archaeological sites register, following the provisions of s.5 of the Western Australia *Aboriginal Heritage Act* 1972.
- <sup>2</sup> Lad Nejman August 2008, Ken Mulvaney April 2009.

**Table 2.** Field observations and conclusions from the Wedgefield North and Harriet Point salvage excavations.

DIA/ Field #	field description	description of shell from laboratory analysis	size-frequency interpretation (Faulkner, 2010)	conclusions
<b>Wedgefield North</b>				
24996 WN07-04	Western side of a wide sand rise. Shell dispersed but more concentrated near the surface and base of loose upper sand layer. The sand contained appreciable quantities of highly fragmented shell, small gastropods, crab fragments and calcrete gravel.	Mainly <i>Anadara granosa</i> (cockle) with high variety of sizes. Although some shells are fresh, most are very weathered, with a chalky consistency and very thin. Small mixed gastropods and bivalves, and numerous reasonably to well preserved crustacean (mainly crab) fragments throughout. Small numbers of various species, including <i>A. antiquata</i> , <i>Nerita lineata</i> , <i>Melo amphora</i> (baler) and other unidentified gastropods and bivalves.	Equivocal—natural and/or heavily disturbed cultural deposit.	The stratigraphy of the cockle-bearing upper sand, and the characteristics of its contained shell and crustacea indicate that the sand rise is a former beach, that the deposit is severely reworked or bioturbated throughout, and that it may be recent in age (Fig. 14).
24997 WN07-05	Western end of a relatively high and wide sand rise. Shell clustered in loose sand over estuarine mud. When shell clusters were exposed in open area excavations, all clusters were associated with ant/termite nests. Erosional features in lower (estuarine mud) layers.	The cockle shell throughout the deposit and on the surface was highly fragmented and generally showed a high degree of weathering. Fragments of other larger shells occurred, with crustacean fragments and small gastropods present throughout.	Equivocal—natural and/or heavily disturbed cultural deposit.	The stratigraphy of the cockle-bearing upper sand and the characteristics of its contained shell and crustacea indicate that the sand rise was washed there by wave action and is capped with admixed windblown sand. The deposit appears to be disturbed throughout.
24998 WN07-06	The small, low rise has accumulated on estuarine mud. Cockle shell is dispersed through the upper poorly sorted loose sand, which is completely bioturbated.	Excavated cockle displayed medium degree of weathering, some chalkiness, bleaching and edge wear. Other shell and crustacean fragments recovered.	Equivocal—natural and/or heavily disturbed cultural deposit.	The heavily disturbed stratigraphy of the upper sand and the characteristics of its contained cockle shell and crustacea indicate that the sand rise is a chenier, i.e. the deposit was washed there by wave action (Fig. 13).

<b>DIA/ Field #</b>	<b>field description</b>	<b>description of shell from laboratory analysis</b>	<b>size-frequency interpretation (Faulkner, 2010)</b>	<b>conclusions</b>
25000 WN07-08	Small low rise. Shell was dispersed through the loose upper sand and appeared to be clustered in a few locations. The upper layer is heavily bioturbated. When excavated, all clusters were associated with ant/termite nests.	Cockle shell throughout deposit and on surface was highly fragmented and showed a high degree of weathering, with no complete shells. Cockle shells range from small to medium. Excavated assemblage contained one otolith, some crab and lobster fragments, some of which retained grey colouring. Fragments of <i>Nerita</i> , <i>Melo</i> , <i>Terebralia</i> , <i>Murex</i> and barnacle present as well as small gastropods.	Potentially cultural (ambiguous given depositional context).	This is a chenier deposit with some windblown sand mixed into the bioturbated upper layer. The deposit appears disturbed throughout.
25001 WN07-09	The southernmost of a sequence of extremely low mounds that appears to be the remnant of a formerly more extensive chenier ridge (Fig. 15).	Shell mainly cockle with small quantities of other large species, numerous crustacean fragments, and variety of small gastropods. Cockle shells were mostly weathered, and many were broken or worn.	Potentially cultural (ambiguous given depositional context).	This heavily disturbed shelly chenier is the erosional remnant of a longer chenier ridge now reduced to a series of barely perceptible mounds which become more shelly southwards as shell has accumulated adjacent to deeper water when the tide is high. It is inundated at mean high tide.
25002 WN07-10	Small low rise. Shell appeared clustered in loose sand over estuarine mud, with shell clusters associated with ant/termite nests.	Cockle shell in the deposit and on the surface was fragmented and generally showed a high degree of weathering. Fragments of other large shells occurred, with crustacean fragments and small gastropods throughout.	Equivocal—natural and/or heavily disturbed cultural deposit.	This is a chenier deposit with some windblown sand mixed into the bioturbated upper layer.
15884 WN07-11 Boodarie 03	Small low rise made up of gritty, slightly shelly angular (probably marine) sand, with some windblown sand on the rise.	Surface collection contained cockle, none complete. Most shells chalky with highly eroded and weathered margins and prevalent stress ridges on the valve. Other shells included <i>Melo</i> , <i>Nerita</i> and an <i>Ostereidae</i> sp. and crustacean fragments and a variety of small gastropods.  Excavated cockle displayed medium degree of weathering, some chalkiness, bleaching and edge wear. A significant number of small gastropods of various species, an otolith,	Potentially cultural (ambiguous given depositional context).	This is a chenier deposit which has been highly disturbed.



<b>DIA/ Field #</b>	<b>field description</b>	<b>description of shell from laboratory analysis</b>	<b>size-frequency interpretation (Faulkner, 2010)</b>	<b>conclusions</b>
		lobster fragments, <i>Nerita</i> , and <i>Melo</i> fragments and a barnacle recovered.		
25004 WN07-12	Small low rise. Clearly bedded, soft, loose, marine sand with some windblown sand in the upper layers.	Mainly Cockle with small quantities of other large shell species, numerous crustacean fragments, and a variety of small gastropods. Cockle mostly weathered, and many shells were broken or worn.	Equivocal—natural and/or heavily disturbed cultural deposit.	This is a chenier deposit, and is probably of recent origin.
25006 WN07-14	Small low rise. One shell cluster excavated. It contained ant-nest material, mixed shell sizes, fragmented and small shells, fragments of glass, and merged upslope into recent debris. This and the shell was probably material pushed from the roadway by earthmoving machinery. Strongly bedded thinly layered uppermost layers indicate very recent overbank deposition across the levee/rise.	Predominantly cockle. On eastern side shells all highly weathered—chalky, white and cracked both horizontally and vertically. One unidentified gastropod fragment, and one greenish brown glass fragment. On western side a few other species present. Fragments included baler shell and others. Cockle weathered and chalky, but sturdy. Generally medium to large, with a few small shells.	Equivocal—natural and/or heavily disturbed cultural deposit.	This is an active sandy levee. The shell appearance was consistent with the hypothesis that it had been scraped to its present position from the roadway.
25009 WN07-17	The very low rise is gritty shelly sand with red/cream coloured laminations, over estuarine mud.	Cockle. None was complete; all showed a medium degree of weathering with medium to high degree of edge wear, but no chalkiness or bleaching. Most shells were of medium size and had remnants of green algae on them.	Equivocal—natural and/or heavily disturbed cultural deposit.	This is a chenier deposit, and is probably of very recent origin (decades rather than centuries old). It is not clear how the shell clusters along the strandline accumulated on the surface of the deposit, but they were probably washed to a sheltered position at the base of the chenier ridge.
<b>Harriet Point</b>				
25621 BD08-02	Thin surface-eroded sand sheet with scattered <i>Anadara granosa</i> (cockle) shell and occasional partly dispersed clusters of shell in the sand and along the eroded western	Shell recovered mainly from upper part the thin relatively loose sand. Shell originally interpreted as midden was concentrated on the western part of the sand sheet and along its eroded western margin.	Potentially cultural.	The shell clusters may have originated as discrete shell middens, but the shell has been reworked. There has been considerable wave reworking of the whole surface of the sand sheet as well

DIA/ Field #	field description	description of shell from laboratory analysis	size-frequency interpretation (Faulkner, 2010)	conclusions
	margin, close to a mangrove-fringed tidal channel. On the lower eastern side of the sand sheet are extensive concentrations of recent natural shell mixed with reworked shell washed over and off the feature by waves from the tidal creek to the west.			as its eroding western margin.
25622 BD08-03	Small elongated mound rising about 1m above surrounding tidal flat. In the pit dug on the crest of the mound a high concentration of shell throughout the 0.5 m thick capping of sand, with the density decreasing with depth where the sand became increasingly muddy. The shell was predominantly cockle but other species were recovered, including small numbers of edible gastropods.	Entire deposit contained numerous juvenile cockle and numerous non-economic small gastropods as well as sub-angular, small gravels, characteristic of chenier deposits. No cockle found in the underlying Holocene estuarine muddy sand.	Ambiguous— natural recruitment or size biased.	A shelly chenier ridge deposit containing shell grit and mixed species and sizes of shell in a sandy matrix, with some archaeological deposit on and adjacent to it, including four stone artefacts.  The bulk of the deposit is a chenier ridge, not a shell midden (Figs 8, 9).
25624 BD08-05	The most inland large site. A complex site on a low sand sheet in the north of the area. Highly variable amounts of shell exposed. Mainly mature cockle shells, but on the lower eroded flank there is shell grit, small shells and gravel.  A discontinuous subsurface scatter of predominantly cockle shell across the sand sheet at all levels. Occasional clusters of shell (initially exposed as lenses in the sections of the two trenches) were found, with a concentration of shell clusters occurring in the open area	In most clusters shells weathered, bleached, chalky, in some instances soft, and commonly fragmented, with broken hinges, damaged umbos and considerable valve edge damage. Most showed high variation in size from juvenile to mature adult. In one excavated spit a very high proportion of juvenile and very small shells. In one cluster shells were chalky but relatively intact and uniform (medium) size.	Potentially cultural.	The clusters of edible shell in aeolian sand probably originated as shell middens apparently deposited at different times during the Holocene. Many almost certainly represent single meal events. Clusters considered in the field to represent stratified cultural deposits were found to be severely disturbed and water-worn, indicating they were washed across the older land surface.  In one shell layer there was a cluster of stones, possibly a hearth, and in another several fish otoliths. Two flaked stone artefacts were recovered from this excavation. This was almost certainly

DIA/ Field #	field description	description of shell from laboratory analysis	size-frequency interpretation (Faulkner, 2010)	conclusions
	excavation. One cluster dominated by <i>Terebralia palustris</i> was collected from the basal part of the sand in the open area excavation. Other species of edible shell occurred in a few of the clusters, including <i>A. antiquata</i> . Several clusters were resting on the Pleistocene clayey sand but others terminated just above it. Shell was dispersed in a dense scatter at the interface with the Pleistocene sediments.			deposited as shell midden, but the initial shell accumulations have been dispersed through the respective sand layers by wave action.  The archaeologically richest site in the Harriet Point study area, but while field observations suggested the clusters might be intact midden, laboratory analysis demonstrated they were weathered and severely damaged (bioturbated).  The dispersal of shell was almost certainly from wave action, especially that at the base of the Holocene sand, which is the same level at which the beach deposit was recorded in the northern trench less than 30 m away.
25628 BD08-09	Shell cluster with abundant shell grit and small shells facing the direction of wave/tidal action concentrated on gently sloping eroded flank of a sand rise in the north of the plain. Wave ripples visible within shell deposits. Mixed shell and gravel deposit extends across tidal channels to BD08-11.	Concentrations of cockle, mixed with <i>A. antiquata</i> , <i>Melo</i> , <i>Terebralia</i> , <i>Tapes Sirex</i> , <i>Siphonaria</i> , <i>Murex</i> , <i>Velacumantis</i> shells and worm tubules. Many shells small, or of species too small to have been eaten. Many fractured into shell grit and mixed with gravel.	Potentially cultural (ambiguous given depositional context).	This is not a shell midden, and whether any, some or all of the shell is completely reworked and redistributed midden shell, rather than natural shell, is equivocal.
25629 BD08-10	Surface exposure of small clusters of shell of both recent (cream-yellow) and more bleached appearance. Only small amounts of subsurface <i>A granosa</i> shell revealed in the machine-excavated trench, concentrated in small patches. Two surface collections of whole shells made, but shell fragments and small	From northern square most shells unweathered, complete and free of wear. A minority exhibited a medium degree of weathering. These shells had holes in the umbos, were much more worn, with other damage to their edges and umbos.  From southern square assemblage highly weathered, chalky and bleached. No complete shells except for two articulated cockles.	Potentially cultural.	A complex Holocene aeolian sand sheet overlying Holocene estuarine muddy sand.  Shell was concentrated in patches in the sand, suggesting they might be the remnants of midden clusters that had been redistributed by wave washover processes.  No unequivocal or nearly intact cultural



<b>DIA/ Field #</b>	<b>field description</b>	<b>description of shell from laboratory analysis</b>	<b>size-frequency interpretation (Faulkner, 2010)</b>	<b>conclusions</b>
	gastropods were observed.			deposits could be identified.
25630 BD08-11	Extensive thin layer of mainly mature cockle shells on highly eroded remnant of sand inundated in spring high tides.	Shell bleached and weathered.	Equivocal—natural and/or heavily disturbed cultural deposit.	A sandy chenier mound with dense clusters of cockle shells on its flanks. Small quantities of shell within the mound are dispersed through the sandy sediments by wave action. This is not a shell midden.
25631 BD08-12	A single cluster of cockle shell on eroding edge of northwest facing lobe on southern side of a sand sheet and extending onto tidal flats.	Shell from sand sheet bleached and weathered. Some shell from the tidal flat appeared fresh and unweathered.	Equivocal—natural and/or heavily disturbed cultural deposit.	This could have originated as a single-event shell midden. The deposit is extensively disturbed, almost certainly from wave action and has been completely reworked.
25634 BD08-15	Dense concentration of yellow shell mixed with shell grit and small shells on eroded flank of a sand rise, and extending onto tidal flats. Small quantities of shell are dispersed through the sand within the mound.	Highly weathered shells, chalky, friable/ brittle and highly fragmented. Majority felt light and had the outer cortex/layers removed. Few complete shells and many showed umbo holes. High variation in size, from juvenile to large mature shells. Bone, crustacean fragments, very small gastropods and some gravel present.  Two stone artefacts were recorded at the base of the site – a small flake and a multiplatform core with smoothing on its flaked edges, suggesting it had been rolled in waves for some time.	Equivocal—natural and/or heavily disturbed cultural deposit.	A sandy chenier ridge with clusters of cockle shells on its lower flanks. If they were from cultural deposits, the shells have been redistributed by wave action. A single layer of cockle shells extends horizontally over 2 m through the ridge. Although it may have originated as a midden deposit this shell has subsequently been dispersed and displaced, and cannot be classified as a shell midden. The artefacts cannot be associated directly with the shell deposit. The flake was located on a deflated surface in the tidal zone.
25635 BD08-16	A single cluster of mainly bleached cockle shells on the eroding face of a sand sheet.	Shells chalky and weathered.	Equivocal—natural and/or heavily disturbed cultural deposit.	Although this may have originated as a shell midden, the deposit has been reworked and is extensively disturbed by wash and wave action.
25636 BD08-17	A cluster of cockle shells on the eroding flanks of the sand sheet at the inland margin of the tidal flats	Although described as possibly eroding from the sand sheet, the shell was all on the exposed face and was weathered and	Equivocal—natural and/or heavily disturbed cultural	This might have been a single-event shell midden but the shell has been disturbed/redeposited by wash and wave

DIA/ Field #	field description	description of shell from laboratory analysis	size-frequency interpretation (Faulkner, 2010)	conclusions
		fragmented.	deposit.	action.
25640 BD08-21	Irregularly shaped area of sand sheet near the inland margin of the tidal flats, with extensive irregularly shaped scatters of shell interspersed with areas with no shell. A sparse scatter and a few dispersed clusters of predominantly cockle shell in a thin layer of Holocene sand resting on Pleistocene clayey sand. Occasional lenses which may have been shell midden clusters were exposed in the trench sections.	From a surface collection at the north end preservation was excellent. Shells creamy and fresh with minimal breakage and edge damage. In other areas severe edge wear prevented valve measurements and abundant gravel, crab/crustacean fragments and small gastropods present. In patches many shells chalky with a green (algal) tinge with half the assemblage being small to medium in size. Further south on surface patches a diverse range of shell species present including <i>Nerita lineata</i> and fragmented <i>Ostreidae</i> , <i>Terebralia</i> sp., and crab. Very little material recovered from more southerly excavations, but the assemblages extremely weathered and fragmented, with edge wear on the valve margins. An adjacent lens of shell demonstrated minimal fragmentation with the cockle shells almost intact, while from another excavated sample weathering was moderate but shells exhibited edge wear damage, and crustacean fragments and gravel were present throughout.	Equivocal—natural and/or heavily disturbed cultural deposit.	Relatively little shell was exposed in the thin cover of the sand sheet which appears to have undergone subsequent lateral dispersal and erosion by wave action. Shells deposited at the northern margin appear more recent. Those on and in the sand to the south are more mixed and reworked. The deposit is highly disturbed and variable.
<b>Previously excavated sites on calcarenite ridges, Harriet Point</b>				
792 HDM SP04-02	A thin layer of reworked and disturbed shell trapped on surface of a calcarenite outcrop. This Mapayi midden was test-excavated by L. Warren (1995). The mound surface has been disturbed by vehicles, and it appears that shell	Shell predominantly cockle, and all highly weathered and fragmented. A wide variety of shell sizes present.	Not analysed.	The upper part of the very thin layer of shell deposit capping this ridge lies well above the normal tidal range and it is likely that this deposit is a shell midden. The lower parts of the shell deposit are within extreme tidal range and show numerous characteristics of having been

DIA/ Field #	field description	description of shell from laboratory analysis	size-frequency interpretation (Faulkner, 2010)	conclusions
	may have been removed from the site in the recent past.			reworked.
791 BD08-43	Large (several hundred m <sup>2</sup> ) low rise about 2 m above surrounding tidal flat. Two distinct dense shell mounds c. 0.6 m thick on highest point. On calcarenite outcrop. Test-excavated by L. Warren in 1995.	Assemblage contained both cockle and <i>Terebralia</i> shells. All cockle exhibited edge damage and some cortical abrasion. The majority of the assemblage medium but size distributions high, and juvenile to mature shells were present. In the north mound <i>Terebralia</i> highly weathered and both <i>T. palustris</i> and <i>T. sulcata</i> present. One piece of fish bone recovered.	Ambiguous—natural recruitment or size biased.	The deposit is mainly shell midden but the presence of large amounts of shell grit and species too small to have been eaten indicates it has been reworked in its original location by wave activity. The site is very exposed to storm wave activity.