# New insights into Holocene economies and environments of Central East Timor: Analysis of the molluscan assemblage at the rockshelter site of Hatu Sour

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## Abstract

In the central region of East Timor (the proper name for this nation being Timor-Leste) little is known of prehistoric economies beyond 2000 years ago, most previous archaeological studies having been concentrated around the Baucau plateau and eastern end of the island. The village of Laleia on the Laleia River is located 20 km east of the main district town of Manatuto on the central northern coast. Recent excavations at the nearby rockshelter site of Hatu Sour have revealed a deep archaeological sequence that dates from approx. 11,000 years ago until the recent past. This paper examines the shellfish (i.e., molluscan) assemblage from the excavation at Hatu Sour for what it can reveal about prehistoric economies and the environment of this strategic region throughout the Holocene.

## Introduction

This study was undertaken as part of an Australian Research Council Discovery Project investigating cultural and environmental shifts in Holocene East Timor. This investigation involved a programme of excavation at various archaeological sites to document cultural and environmental histories. One of the key cultural remains in these sites is shellfish (Mollusca), which provide evidence not only of what dietary preferences existed but also what shellfish were locally available and therefore what niches were being exploited. This is also an excellent indicator of past environments, as shellfish are extremely sensitive to changes in their environment. Up until 2010 most of our research had been undertaken at the far eastern end of the island of Timor in the Lautem District. One of our collaborators, the Secretariat of Culture, East Timor Government, was keen for us to investigate other areas of East Timor. In 2010, we located several prospective sites in the Manatuto District on the central northern coast. Here we discuss the results, focusing on shellfish remains, of the excavation at Hatu Sour rockshelter and how they help us to interpret regional prehistoric economies and palaeo-environments.

In the central region of East Timor little is known of prehistoric economies beyond the last 2000 years, most previous archaeological studies being concentrated around the Baucau plateau and the eastern end of the island (Almeida & Zbyszewski 1967; Glover 1986; O'Connor, Spriggs & Veth 2002; O'Connor 2003; O'Connor & Veth 2005; Selimiotis 2006; O'Connor 2007; Oliveira 2008, 2010; O'Connor 2010; O'Connor *et al.* 2010, Oliveira 2010; O'Connor *et al.* 2011, Reepmeyer *et al.* 2011; O'Connor *et al.* 2012). Recent excavations at the rockshelter site of Hatu Sour on the central northern coast have revealed a deep archaeological sequence that dates from approx. 11,000 years until the recent past. The site contains a large shellfish assemblage, vertebrate faunal remains and stone artefacts, and was occupied during a period of dramatic climatic and environmental change that profoundly affected the subsistence and settlement patterns of coastal dwellers. It encompasses the Neolithic transition dating from some 3500 years ago in Timor, which originally brought pottery and possibly the domestic dog, and later subsistence agriculture and other domestic animals (O'Connor 2006). It also covers the contact period from about 1000 years ago when outside influences from Chinese and later Makassar traders to Dutch and Portuguese colonisation deeply affected the indigenous culture and economy (O'Connor *et al.* 2012).


**Fig 1.** Map of study area. (CartoGIS).

**Above left – Fig. 2.** Approaching Hatu Sour rockshelter. (Sue O'Connor)
**Above right – Fig. 3.** Hatu Sour rockshelter and excavation. (Sally Brockwell)

## Study Area

East Timor (the proper name for this nation being Timor-Leste) is located 400 km north-west of Australia in the Timor Sea, and 8 degrees south of the Equator. It shares a land border with West Timor (the proper name for this part of the nation of Indonesia being Timor Barat). Geologically, Timor is an aggressively uplifted coral limestone island. The northern and southern coasts are divided by a steep mountain range rising to 3000 m. The climate is dry tropical with a long dry season from May to November and a shorter wet season from December to April.

The study was undertaken on the central northern coast, east of the capital, Dili (Fig. 1 inset). The Hatu Sour rockshelter is located on the Laleia River, 20 km east of the main district town of Manatuto and adjacent to the village of Laleia (Fig. 1). The rockshelter (Figs 2, 3) is about 7 m by 5 m and is located in a limestone outcrop about 1 km west of the village of Laleia. Today Hatu Sour is 4 km south of the northern coastline, which drops steeply away to the continental shelf (O'Connor 2007: 530). There appears to have been Holocene infill within the embayment as indicated in Fig. 1, where the dark green marks represent recent deposition within the Laleia River estuary.

## Previous investigations

Previous investigations immediately to the east, west and south of the current study area (Spriggs, O'Connor & Veth 2003; Chao 2008; Lape & Chao 2008; Forestier & Guillard 2012) have revealed a range of archaeological sites in the region: open sites and rock shelters with cultural assemblages containing stone artefacts, invertebrate remains and, in the upper levels, earthenware and imported tradeware; rockshelters with painted art; shell middens; and fortified hilltop settlements containing ancestral graves and the remains of house sites. All these sites are dated within the last 8000 years, but most within the last 2000 years.

Our surveys in the Laleia region revealed a similar range of sites, including remains of old villages with house stones and concentrations of stone artefacts, marine and estuarine shell remains, pottery and Chinese tradeware. One open site next to the Laleia

River containing a scatter of shell and stone artefacts produced the unexpectedly early date of 9500 cal. BP for the bivalve *Anadara granosa* (Table 1). There are also indigenous sites on hilltops fortified with stone walls. One particular hilltop settlement known as Leki Wakik has been occupied within living memory. These sites contain surface scatters of shell, stone, pottery and Chinese ceramics. One open site dated to 400 cal. BP from a surface shell sample (of the gastropod *Telescopium telescopium*) (Table 1). This is consistent with the ages of other indigenous fortifications, both regionally and elsewhere in Timor, mostly dated to less than 1000 years old (Chao 2008; Lape & Chao 2008; O'Connor *et al*. 2012).

**Table 1**. Radiocarbon dates from Laleia region (Hatu Sour dates after Cooling 2012: 56)

| Site | Spit no. | Lab no. | Sample | C14 (years BP) | Cal. years BP (95.4% probability) |
|---|---|---|---|---|---|
| Kampung Baru 1 | Surface | Wk-28440 | *Anadara granosa* | 9007±31 | 9840–9460 |
| Kampung Baru 2 | Surface | Wk-28441 | *Telescopium telescopium* | 798±32 | 500–250 |
| Hatu Sour | 3 | ANU#26606 | charcoal | 315±25 | 460–305 |
| Hatu Sour | 12 | ANU#27105 | charcoal | 6165±40 | 7168–6849 |
| Hatu Sour | 35 | ANU#26609 | *Anadara granosa* | 9650±45 | 11,198–10,787 |

## Methods

We excavated a 1 m x 1 m square in arbitrary 5 cm spits using standard archaeological techniques. The deposit was sieved though a 1.5 mm wire mesh screen. Finds were initially washed and sorted on site by category (bone, stone, shell, etc). When we returned to our laboratories at the Australian National University (ANU) in Canberra, the finds were further analysed. In this case, molluscan shells were sorted by species, counted and weighed. Results were entered onto a spreadsheet according to MNI (Minimum Number of Individuals), NISP (Number of Individual Specimens) and weight (g). Where the shells were broken, MNIs were based on the part of the shell that was most commonly preserved. The same part of the shell was used consistently for each excavation unit to estimate MNI. While this method potentially underestimates the true number of specimens it ensures that no individuals are counted more than once where pieces of one shell may be distributed over more than one excavation unit. Examples of taxa that could not be identified at ANU were sent to RCW for final determination.

## Results

The excavation reached the limestone bedrock at 2 m, which was unexpectedly deep given the small size of the shelter (Fig. 3). The site contained large quantities of stone, shell, some bone and a few small pottery sherds on the surface. Chinese tradeware made of high-fired porcelain was also restricted to the surface. Three dates were obtained – 400 cal. BP at spit 3, 7000 cal. BP at spit 12, and 11,000 cal. BP at spit 35 (Atkinson

2012: 6; Cooling 2012: 56), as detailed in Table 1.

## Shellfish Analysis

As can be seen from Fig. 4, there was a peak in shellfish remains at spit 35 (approx. 11,000 years BP), which subsequently declined, then increased again around spits 15–12 (approx. 7000 years BP), peaked at spit 8, and declined up until the recent past.

The site contained a mixture of marine, mangrove and freshwater associated molluscan species (Table 2, Fig. 5). The major marine species were *Chiton* sp., rock dwellers mainly found in shallow water, and *Anadara granosa*, *Nerita* spp. and *Turbo* spp., all found in the intertidal zone in shallow water. There was a large number of *Turbo* opercula, as opposed to *Turbo* shells themselves. The dominant mangrove species were *Telescopium telescopium*, *Terebralia palustris* and *Geloina erosa*. *Telescopium telescopium* is typically found in intertidal mudflats and mangrove forests (Willan 2013). There was only one species of freshwater or brackish taxon, *Stenomelania* sp.

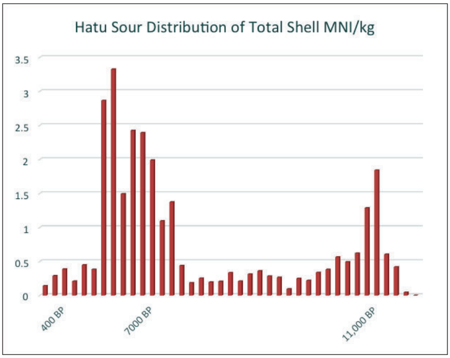


**Fig. 4.** Distribution of total shellfish remains.

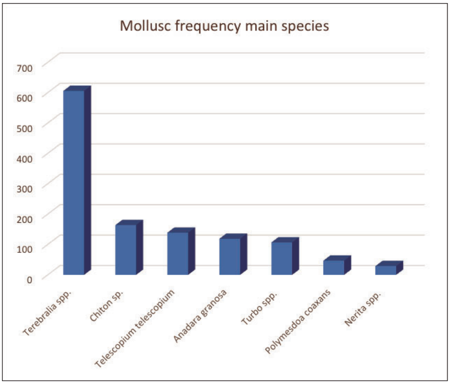


**Fig. 5.** Major molluscan species (MNI).

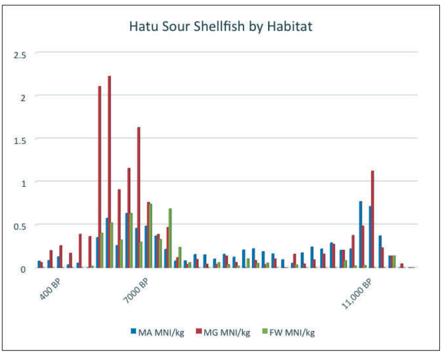


**Fig 6.** Distribution of marine (blue), mangrove (red) and freshwater (green) molluscan species (MNI/kg).

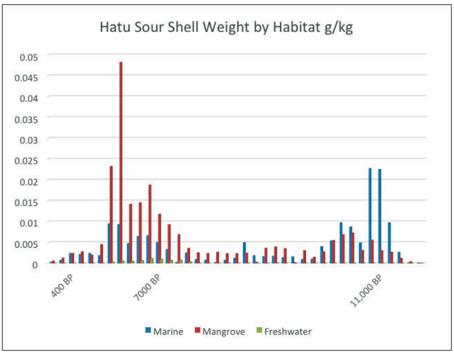


**Fig. 7.** Distribution of molluscan species by habitat and weight.

**Table 2.** Distribution of major molluscan species at Hatu Sour (MNI).

| | | | | | | | | | | | | | Mangrove | | | | Freshwater |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ostreidae sp. | *Saccostrea* sp. | *Dendostrea folium* | *Vasticardium* sp. | *Austriella* cf. *corrugata* | *Anadara granosa* | Cardiidae sp. | *Periglypta puerpera* | *Nautilus* sp. | *Brachidontes* sp. | *Placuna placenta* | *Tridacna maxima* | *Tridacna* sp. | *Terebralia palustris* | *Terebralia sulcata* | *Telescopium telescopium* | *Geloina erosa* | *Stenomelania* sp. |
| | | | | | <1 | 1 | | | | | | | 3 | | <1 | 1 | |
| | 1 | | | | <1 | | <1 | | | | | | 13 | | 1 | <1 | |
| | | | 2 | | 2 | | | | | | | | 14 | | 6 | <1 | |
| | | | | <1 | <1 | | | | | | | | 11 | | 3 | <1 | |
| | | | | | 1 | | | | | | | | 20 | | 1 | <1 | |
| | | | | <1 | <1 | | | | | | | | 17 | | 4 | <1 | 1 |
| <1 | | 1 | | | 6 | <1 | | <1 | | | | | 146 | | 14 | 2 | 31 |
| | | | | | 4 | | | | | | | | 62 | 5 | 12 | 2 | 19 |
| | | | | | 3 | | | | | | | | 27 | 1 | 14 | <1 | 15 |
| | | | | | 7 | | | | | 1 | | | 44 | | 8 | 1 | 29 |
| 1 | 1 | 1 | | | 5 | | | | | | | | 63 | | 8 | <1 | 13 |
| | | | | | 6 | <1 | | | | | | | 28 | | 8 | <1 | 35 |
| | | | | | 3 | | | <1 | | | | | 14 | | 6 | <1 | 17 |
| | | | | | | | | | | | | | 17 | | 5 | 2 | 35 |
| | | | | | 2 | | | <1 | | | | | 2 | | 4 | <1 | 12 |
| | | | | | 1 | | | | | | | | 2 | | <1 | <1 | 3 |
| | | | | | | | | <1 | | | | | 5 | | <1 | <1 | <1 |
| | | | | | <1 | | | | | | | | 1 | | 1 | <1 | |
| | | | | | <1 | | | | | | | <1 | <1 | 1 | <1 | 1 | 3 |
| | | | | | | | | | | | | | 2 | | <1 | 5 | 2 |
| | | | | | <1 | | | | | | <1 | | <1 | | | 3 | 1 |
| | | | | | 1 | | <1 | | | | | | <1 | | | | 7 |
| | | | | <11 | | | | | | | | <1 | 3 | | <1 | 2 | 3 |
| | 1 | | 1 | | <1 | | | | | | | <1 | 2 | | <1 | <1 | 3 |
| | | | | | <1 | | | | | | | | 4 | | | 1 | |
| | | | | | | | | | | | | | | | | <1 | |
| | | | | | <1 | | | | | | | | 1 | | 5 | 3 | 2 |
| | | | | | <1 | | | | | | | | 2 | | 1 | <1 | |
| | | | | 1 | <1 | | | | 1 | | | <1 | 5 | | <1 | <1 | |
| | | | | <1 | <1 | | | | | | | <1 | 5 | | 2 | 1 | |
| <1 | | | | 1 | <1 | <1 | | <1 | | | | | 13 | 1 | <1 | 2 | |
| <1 | | | | <1 | 2 | | | | | | <1 | | 8 | 1 | <1 | 1 | 4 |
| <1 | | | | <1 | 9 | | | | | | | | 8 | | 9 | <1 | 1 |
| | | | | <1 | 18 | <1 | <1 | | | | | | 10 | 1 | 5 | 1 | 1 |
| | | | | <1 | 24 | | | | | | | | 35 | | 6 | | |
| | | | | <1 | 8 | | | | | | | | 3 | | 2 | | |
| | | | | <1 | <1 | 2 | | | | | | | <1 | | 2 | | 2 |
| | | | | | <1 | <1 | | | | | | | 1 | | 2 | | |
| | | | | | <1 | | | | | | | | <1 | | | <1 | |
| 1 | 3 | 2 | 3 | 2 | 102 | 3 | | | 1 | | | | 591 | 10 | 129 | 28 | 239 |

From 11,000 to 7000 years BP the MNI shows that there is steady foraging of both mangrove and marine molluscs with marine species dominating from spit 30 until spit 15, when mangrove species begin to take over. *Stenomelania* sp. was being exploited, but only in low numbers until spit 15, when its presence increased significantly. From this time post-7000 years BP, species from all habitats increased with mangrove species dominating and peaking in spit 8 (Fig. 6). There is a significant decline in all species from spit 6 onwards, although mangrove species continue to dominate. Shellfish weights show this pattern even more clearly than MNI (Fig. 7).

## Other archaeological evidence

Turning to the evidence from the stone artefact assemblages that were analysed by Cooling (2012), there was a large peak in artefact numbers between spits 3 and 9 post 7000 BP. On the basis of dates for peaks in stone artefact deposition from other rockshelter sites in East Timor, Cooling (2012: 57, 70) cautiously assigned the peak at Hatu Sour in spits 6–8 to between 5000–3000 years BP.

Other faunal remains at Hatu Sour are mostly fishes, rodents (murids), crabs and bats (all endemic fauna), most of which appear burnt. There is also a small amount of reptile vertebrae including snake, and a few unidentified bird bones. At least three species of murid exist, one of which is quite small (probably *Rattus exulans*), another larger, and the third a giant rat now extinct in Timor (two bones were found in spits 17 and 18). Most of the fish are parrotfish, a common reef fish. Exotic fauna are only found in upper levels and include remains of pig and dog (Stuart Hawkins, pers. comm.).

The few small sherds of pottery and Chinese tradeware that were found were restricted to the surface of the site (Cooling 2012: 34).

## Discussion

Hatu Sour's current distance from the shoreline is about 4 km. Due to the depth of the Ombai Strait between East Timor and the island of Alor to the north, the northern coast of the island drops away sharply (O'Connor 2007: 230). Consequently, the coastline would have been more or less stable throughout the Holocene period despite sea level rise. The distance of the rockshelter from the Laleia River is currently 1 km. Before sea level stabilisation approx. 6000 years BP, rising seas would have flooded former embayments and river valleys, subsequently infilling them with sediment derived from both the land and the sea (Chappell 1988; Woodroffe 1988; Woodroffe, Thom & Chappell 1993). This scenario is suggested for the Laleia River estuary by the Google Earth image where the green shading indicates recent infill (Fig. 1). Infill would have encouraged the expansion of mangroves on the floodplains of the river (Chappell 1988; Woodroffe 1988; Woodroffe, Thom & Chappell 1993) and potentially rendered mangrove resources closer than previously. Increased sedimentation within river systems in East Timor could also be the result of increased rainfall in the mid-Holocene. A recent review (Reeves *et al.* 2013) from northern Australia suggests that the early to mid-Holocene was warmer and wetter than at present across tropical northern Australia with drier and more variable conditions beginning sometime after the mid-Holocene.

The persistent presence of marine, mangrove and freshwater molluscan species from 11,000 years BP until recently at Hatu Sour implies that the rockshelter was occupied continuously throughout the Holocene and the occupants had access to all these habitats. The large number of *Turbo* spp. opercula (as opposed to actual *Turbo* spp. shell remains) may relate to the foraging strategy. Living *Turbo* spp. could have been processed near to their site of collection to separate the flesh from the heavy shells. However, the opercula would firmly adhere to the foot of the animal and would therefore be returned to the rockshelter, distorting the ratio (Szabó 2009: 197, 201).

The peaks in shellfish distribution at 11,000 and 7000 years BP suggest increased regional occupation at these times with a decline in occupation between these dates. Increases in occupation can be correlated with increased productivity of the environment. The exponential increase in numbers of mangrove shellfish species from 7000 years BP can be associated with an expansion of mangroves in the river estuary as a consequence of Holocene infill, as seen in Fig. 1, and closer proximity of mangrove resources to the rockshelter. The significant increase in the presence of *Stenomelania* sp. at Hatu Sour from spits 15 to 7 could be suggestive of increased rainfall and freshwater in the environment in the mid-Holocene that would also have allowed for an expansion of regional occupation. There is some evidence from northern Australia that this may be the case (see below). The collapse of all shellfish numbers post spit 7 suggests decreased occupation.

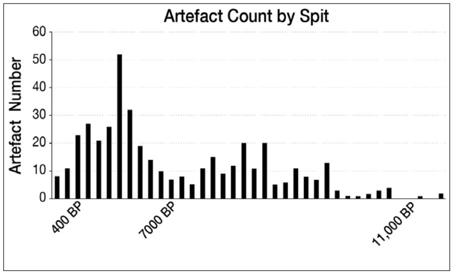


**Fig. 8.** Artefact count by spit (after Cooling 2012: 38).

The argument for increased occupation post 7000 BP is supported by the large peak in stone artefact numbers around spit 7 (Fig. 8). If Cooling (2012) is correct with her extrapolation regarding stone dates based on depth, this peak period is from 5000 to 3000 years BP. Can the decline in occupation at Hatu Sour in the late Holocene, as indicated by the decrease in numbers of shellfish and stone artefacts, be associated with drier conditions? Could it also mark a concurrent increasing reliance on subsistence farming introduced about 3500 years BP? After spit 3 dated to 400 years BP, there is a drop off of overall artefact numbers suggesting a decrease in occupation (Cooling 2012: 38). Is this reorganisation of occupation coincident with European colonisation of the region? (cf O'Connor *et al*. 2012).

Northern Australia has the same climatic regime as Timor, being located in the wet/dry tropics. To some extent, the events recorded at Hatu Sour mirror what was happening at sites in northern Australia during the Holocene. Following the Last Glacial Maximum approx. 20,000 years ago, rising seas flooded down-cut river valleys in the early Holocene. Subsequent sedimentation led to infill and the expansion of highly productive mangroves swamps that dominated the floodplains of northern rivers. This is known as the 'Big Swamp Phase' and is dated from 7000–5000 BP in northern Australia (Woodroffe, Thom & Chappell 1985; Chappell 1988; Woodroffe 1988; Woodroffe, Mulrennan & Chappell 1993). The high productivity of these swamps is reflected archaeologically in the form of extensive estuarine shellfish middens in rockshelters along the floodplains of the East Alligator River indicating widespread exploitation of mangrove environments during this period (Schrire 1982; Allen 1987, 1996; Hiscock 1999). The decline of mangrove species in Hatu Sour from spit 6 could be similar to the period approx. 5000–3000 years BP in northern Australia where further sedimentation choked off the tidal influence and restricted mangroves to the coastal fringe and river margins (Woodroffe, Thom & Chappell 1985; Chappell 1988; Woodroffe 1988; Woodroffe, Mulrennan & Chappell 1993). This was reflected archaeologically by the concurrent decline in mangrove shellfish exploitation in the rockshelters of the East Alligator River (Schrire 1982; Allen 1987, 1996; Hiscock 1999).

At Hatu Sour, relationships between climate change, changing environments and economic strategies can be clarified with further dating and isotope analysis of the archaeological shells (Bourke *et al.* 2007).

## Conclusion

There has been continuous Holocene occupation in the Laleia region of East Timor from approx. 11,000 years BP until the recent past. Early Holocene occupation was associated with exploitation of marine and estuarine resources, with some terrestrial fauna. Increases in artefacts and mangrove shellfish after 7000 BP suggest an increase in regional occupation linked to the spread of highly productive estuarine environments. Hatu Sour shows a subsequent decrease in occupation in the late Holocene. A similar decrease in site use has been noted at other sites in East Timor after 3000 cal BP, and has often been associated with changing settlement patterns as the population is assumed to have predominantly occupied open village sites once subsistence practices changed to a farming economy. Cave sites would have continued to be used, but as hunting bivouacs rather than base camps (Glover 1986: 206–207). Hatu Sour shows further decrease in use post 400 years BP which may be due to changing settlement patterns associated with European occupation (O'Connor *et al.* 2012).

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## References

Allen H. (1987) Holocene mangroves and middens in northern Australia and Southeast Asia. *Bulletin of the Indo Pacific Prehistory Association* 7, 1–16.

Allen H. (1996) The time of the mangroves. *Bulletin of the Indo Pacific Prehistory Association* 15, 193–205.

Almeida A. de and Zbyszewski, G. (1967) A contribution to the study of the prehistory of Portuguese Timor – lithic indiustries. In: *Archaeology at the 11th Pacific Science Congress* (ed. Solheim W.), pp. 55–67. Asian and Pacific Archaeology Series No. 1, Social Sciences Research Institute, University of Hawaii Press, Honolulu.

Atkinson L. (2012) Stratigraphy and geomorphology of the Hatu Sour Rockshelter, Timor Leste. ARCH 8030. Supervised Research Project in Archaeological Science. Unpublished Report, School of Archaeology and Anthropology, Australian National University, Canberra.

Bourke P., Brockwell S., Faulkner P. and Meehan B. (2007) Climate variability in the mid to late Holocene Arnhem Land region, north Australia: Archaeological archives of environmental and cultural change. In: *Climate Change and Archaeology in the Pacific: Archaeology in Oceania* 42 (ed. Lape P.), pp. 91–101.

Chao C-Y. (2008) A microregional approach to the social dynamics in late prehistoric Manatuto, East Timor, eleventh-eighteenth century. Unpublished PhD Thesis, Department of Anthropology, University of Washington, USA.

Chappell J. (1988) Geomorphological dynamics and evolution of tidal river and floodplain systems in northern Australia. In: *Floodplains Research. Northern Australia: Progress and Prospects, vol. 2.* (eds Wade-Marshall D. and Loveday P.), pp. 34–57. North Australian Research Unit, Darwin.

Cooling S. (2012) Investigations of site use through the analysis of the lithic assemblage from the site of Hatu Sour, East Timor. ARCH 8029: Supervised Research Project in Archaeological Science. Unpublished Report, School of Archaeology and Anthropology, Australian National University, Canberra.

Forestier H. and Guillaud D. (2012) A limestone outcrop as a landmark of prehistoric settlement in the Manatuto region (East Timor). In: *Unearthing Southeast Asia's Past: Selected Papers from the 12th International Conference of the European Association of Southeast Asian Archaeologists* vol. 1. (eds Klokke M. and Degroot V.), pp. 13–19. National University of Singapore, Singapore.

Glover I. (1986) *Archaeology in Eastern Timor, 1966–67*. Terra Australis 11. Department of Prehistory, Research School of Pacific Studies, Australian National University, Canberra.

Hiscock P. (1999) Holocene coastal occupation of Western Arnhem Land. In: *Australian Coastal Archaeology. Research Papers in Archaeology and Natural History No. 31.* (eds Hall J. and McNiven I.), pp. 91–103. Archaeology and Natural History Publications, Australian National University, Canberra.

Lape P. and Chao C.-Y. (2008) Fortification as a human response to late Holocene climate change in East Timor. *Archaeology in Oceania* 43, 11–21.

O'Connor S. (2003) Report of nine new painted rock art sites in East Timor in the context of the western Pacific region. *Asian Perspectives* 42(1), 96–128.

O'Connor S. (2006) Unpacking the Island Southeast Asian Neolithic Cultural Package, and Finding Local Complexity. In: *Uncovering Southeast Asia's Past: Selected Papers from the 10th International Conference of the European Association of Southeast Asian Archaeologists* (eds Bacus E. and Glover I.), pp. 74–87. NIAS Press, Singapore.

O'Connor S. (2007) New evidence from East Timor contributes to our understanding of earliest modern colonisation east of the Sunda Shelf. *Antiquity* 81, 523–535.

O'Connor S. (2010) Continuity in shell artefact production in Holocene East Timor. In: *50 Years of Archaeology in Southeast Asia: Essays in Honour of Ian Glover* (eds Bellina B., Bacus E., Pryce T.O. and Wisseman Christie J.), pp. 219–233. River Books, Bangkok.

O'Connor S. Aplin K., St Pierre E. and Feng Y.-X. (2010) Faces of the ancestors revealed: discovery and dating of a Pleistocene-age petroglyph in Lene Hara Cave, East Timor *Antiquity* 84, 649–665.

O'Connor S., McWilliam A., Fenner J. and Brockwell S. (2012) Examining the origin of fortifications in East Timor: Social and environmental factors. *Journal of Island and Coastal Archaeology* 7(2), 200–218.

O'Connor S., Ono R. and Clarkson C. (2011) Pelagic fishing at 42,000 years before the present and the maritime skills of modern humans. *Science* 334, 1117–1121.

O'Connor S., Spriggs M. and Veth P. (2002). Excavation at Lene Hara Cave establishes occupation in East Timor at least 30,000–35,000 years ago. *Antiquity* 76, 45–50.

O'Connor S. and Veth P. (2005) Early Holocene shell fish hooks from Lene Hara Cave, East Timor establish complex fishing technology was in use in Island Southeast Asia five thousand years before Austronesian settlement. *Antiquity* 79, 249–256.

Oliveira N. (2008) *Subsistence Archaeobotany: Food Production and the Agricultural Transition in East Timor*. Unpublished PhD Thesis, Department of Archaeology and Natural History, College of Asia and the Pacific, Australian National University, Canberra.

Oliveira N. (2010) From Bui Ceri Uato to Bui Ceri Uato Mane: A new archaeobotanical assemblage from East Timor. In: *50 Years of Archaeology in Southeast Asia: Essays in Honour of Ian Glover* (eds Bellina B., Bacus E., Pryce T.O. and Wisseman Christie J.), pp. 78–91. River Books, Bangkok.

Reepmeyer C., O'Connor S. and Brockwell S. (2011) Long-term obsidian use in East Timor documented at Jeremalai. *Archaeology in Oceania* 46, 85–90.

Reeves J., Bostock H., Ayliffe L., Barrows T. *et al.* (2013) Palaeoenvironmental change in tropical Australasia over the last 30,000 years – a synthesis by the OZ-INTIMATE group. *Quaternary Science Reviews* 74, 97–114.

Schrire C. (1982) *The Alligator Rivers: Prehistory and Ecology in Western Arnhem Land*. Terra Australis 7 Department of Prehistory, Research School of Pacific Studies, Australian National University, Canberra.

Selimiotis H. (2006) *The Core of the Matter: Core Reduction in Prehistoric East Timor*. Unpublished M. Phil Thesis, Australian National University, Canberra.

Spriggs M., O'Connor S. and Veth P. (2003) Vestiges of early pre-agricultural economy in the landscape of East Timor. In: *Fishbones and Glittering Emblems: Southeast Asian Archaeology*. (eds Karlstrom K. and Kallen A.), pp. 49–58. Museum of Far East Antiquities, Stockholm.

Szabo K. (2009) Molluscan remains from Fiji. In: *The Early Prehistory of Fiji. Terra Australis 31*. (eds Clark G. and Anderson A.), pp. 183–211. ANU EPress, Canberra.

Willan R.C. (2013) A key to the potamidid snails (longbums, mudcreepers and treecreepers) of northern Australia. *Northern Territory Naturalist* 24, 68–80.

Woodroffe C.D. (1988) Changing mangrove and wetland habitats over the last 8000 years, northern Australia and Southeast Asia. In: *Floodplains Research. Northern Australia: Progress and Prospects* vol. 2 (eds Wade-Marshall D. and Loveday, P.), pp. 1–23. NARU, Darwin.

Woodroffe C., Thom B. and Chappell, J. (1985) Development of widespread mangrove swamps in mid-Holocene times. *Nature* 317, 711–713.

Woodroffe C., Mulrennan M. and Chappell J. (1993) Estuarine infill and coastal progradation, southern van Diemen Gulf. *Sedimentary Geology* 83, 257–285.