Shell-beading traditions at Asitau Kuru (Timor-Leste)

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Abstract

Asitau Kuru provides a unique record of human behaviour from the first arrival of *Homo sapiens* onto Timor Island around 44,000 years ago through to the near present. In particular, this site has produced a large number of marine shell artefacts which have been central to rewriting our understanding of the sophistication of cultural behaviours enacted by the~~se~~ first populations to move into and through Island Southeast Asia. The 2017 excavations at Asitau Kuru recovered yet more significant numbers of shell artefacts. Here we present the analysis of these finds, bringing the different ornament forms — made on various but carefully selected marine species — together for the first time in a detailed examination of shell-beading traditions at this key site. We also describe a possible shell tool used in the creation of these shell adornments and a fragment of a large horned helmet shell (*Cassis cornuta*) which is suggested to have originated from a shell trumpet, container, adze, or other culturally significant item of material culture.

Keywords: personal ornamentation; adornment; marine shell; inter-island contact.

Introduction

Investigations of archaeological sites located throughout Island Southeast Asia (ISEA) over the past 15 years have produced an enormous quantity of data regarding the initial dispersal of *Homo sapiens* from mainland Sunda through to Sahul and the development of the earliest cultures of this expansive region (e.g., Aubert et al. 2018; Brumm et al. 2017; Kealy et al. 2020; O'Connor 2007; O'Connor et al. 2011, 2023). Asitau Kuru (formerly Jerimalai) has long been prominent in discussions stemming from this ever-increasing Wallacean dataset, providing among other types of evidence, a large number of marine shell artefacts which have been central to rewriting our understanding of cultural behaviours enacted by these first peoples (Figure 1; Langley and O'Connor 2016; Langley et al. 2016; O'Connor 2010; O'Connor et al. 2011).

Here we describe a new assemblage of shell ornamentation recovered from Square C of Asitau Kuru, excavated in 201~~7~~9. While shell adornment recovered from the ~~Pleistocene and Holocene~~ deposits of Asitau Kuru ~~have~~ has been previously reported (Langley and O'Connor 2015, 2016; Langley et al. 2016), these studies have each focused on a single form of bead (*Oliva* beads, *Nassarius* beads, large *Nautilus* pendants) and were restricted in their ability to connect to wider regional and temporal patterns ~~of adornment~~. For the first time, all of these bead types~~,~~ along with~~and~~ additional forms, are compared and contrasted in order to gain a fuller understanding of the marine shell ornamentation technology created and utilised at Asitau Kuru. Additionally, we highlight island-based group identities emerging from the bead assemblages and their implications for regional interaction spheres. Finally, we ~~we~~ describe a possible threading tool (also made on shell), as well as a fragment of a large *Cassis cornuta* shell recovered from the mid-Holocene levels of Asitau Kuru. These symbolic artefacts, considered in total, allow insights into the social milieux of the local population and support the notion of increasing complexity of social networks in the area during the mid-Holocene.

Figure 1: Location of Asitau Kuru and surrounding sites mentioned in text.

Methods and Materials

Three 1 x 1 m^2 excavations (Squares A, B, and C) at Asitau Kuru have revealed a ~1.8 m deep sequence of human occupation reaching back to about 44,000 cal. BP. A total of 74 absolute age estimates have been obtained from these excavations; eight optically stimulated luminescence (OSL) dates, 12 radiocarbon dates on charcoal, and 54 radiocarbon dates on marine shell. There are a number of date inversions between spits, which we partly attribute to the large shells on which many dates were obtained both working their way into the softer, older sediment as well as protruding upwards and being buried by younger sediment.

The deposits of this Square can be divided into three broad occupation phases: Neolithic, mid-Holocene, and Pleistocene (see Table 1; Figure 2). Despite the intrusive shell dates, the integrity of the sequence within these broad phases is attested by the absence of pottery below layer 2; the absence of exotic lithics and *Nassarius* beads in the Pleistocene levels; as well as distinct and consistent patterns between the phases in the proportions of natural versus knapped stone clasts, and the frequency of bones (Shipton et al. 2020).

Figure 2: Stratigraphic profile of Asitau Kuru Square C.

Shipton et al. (2020) found that the frequency distribution of bone, shell, lithics, and ochre indicates a low intensity occupation in the Pleistocene and a possible hiatus in the buildup to the Last Glacial Maximum (LGM) in Square C. Low intensity occupation then resumes after the LGM in Square C, ~~leading to~~before a hiatus around the Pleistocene-Holocene transition, then a high-intensity occupation in the middle Holocene. ~~This pattern of low intensity occupation before 28,000 years ago, sporadic occupation around the LGM, and buildup to a high-intensity occupation in the middle Holocene applies not just to Asitau Kuru but across Timor-Leste sites generally (O'Connor and Aplin 2007; Shipton et al. in press).~~ A greater diversity of lithic materials including obsidian from an off-island source also suggests greater connectivity between populations in the terminal Pleistocene and ~~earlier~~ Holocene phases (Shipton et al. 2020). The introduction of pottery in the Neolithic, together with the increased density of shell and decreased density of bone (most of which is fish at Asitau Kuru), suggest lifeway changes relative to the mid-Holocene, despite overall continuity in lithic technology between these phases (Shipton et al. 2019).

More than 80% of the bone assemblage from Asitau Kuru are marine animals. O'Connor et al. (2011) argued for a taxonomic shift from a dominance of *Scombridae* and *Carangidae* in the Pleistocene and early Holocene to more *Scaridae*, *Ballistidae*, *Serranidae*, and *Acanthuridae* in the middle and late Holocene (O'Connor et al. 2011). However, a recent analysis of the Square C fish bone has suggested that this change may be the result of taphonomic effects, with small fish bone less readily identified in the Pleistocene levels (Boulanger et al. 2023). Further, there is a marked increase in the frequency of bone in the early to mid-Holocene phase, indicating increased fish consumption in general at this time (Shipton et al. 2020).

The Square C material described below includes 323 shell beads and two additional worked-shell artefacts. Each of these items was examined with a Zeiss Stemi 508 stereomicroscope fitted with a Axiocam 105 camera as well as an Olympus DSX1000 digital microscope. Features of interest were photographed using the Zeiss or Olympus software for the microscopy, along with a Canon EOS 400D digital camera for macrophotography. Mitutoyo (CD-6”CX) digital calipers with the jaws covered in a layer of plastic coating to prevent damage to the artefacts were used to gather metric data for intra-site comparison, as well as ~~that~~ to published artefacts of similar context and construction found elsewhere. Other variables recorded include~~d~~ overall bead shape, presence of residues, post-depositional damage, traces of manufacture, perforation construction (uni- or bifacially drilled), and percentage of bead present (100% being intact, 50% being a bead with about half of its circumference missing, etc.).

Identification of the raw material species was based on comparison to reference collection examples held at The Australian National University and the Queensland Museum, as well as comparison to previously examined marine shell artefacts from regional sites of similar antiquity (i.e., Matja Kuru 1 and 2, Lene Hara, Makpan, and previously examined beads from Asitau Kuru itself). Distinction between natural and anthropogenic traces — specifically grinding, cutting, drilling, and pressure flaking — is based on criteria outlined in published examples of worked marine and freshwater shell (e.g., d’Errico et al. 1993, 2005; Guzzo Falci et al. 2019; Szabó 2010; Velazquez-Castro 2012). Terminology for description of these features follows standards set out in the archaeological shell ornament literature.

Results

With the additions from the new Square C assemblage, 637 shell beads have thus far been recovered, examined, and reported from Asitau Kuru (Table 1). These beads fall into three main types — ~~disc~~circular or ovoid beads, whole-shell beads, and basket-shaped beads — made on three main genera of marine shell (*Nautilus pompilius*, *Oliva* spp., *Nassarius* spp.) but with a few examples on *Conus timorensis* and other conical form species (Figure 3). The majority of these beads were recovered from the early to mid-Holocene levels (~~,~~Phase 2), though for some of the bead types, earlier indications of their manufacture and use are found in the Pleistocene levels (Phase 1). Furthermore, shell beads continued to be made into very recent times (Table 1).

Table 1: Summary of beads recovered from the Asitau Kuru deposit. Data from this study, Shipton et al. (2019), and Langley and O’Connor (2015, 2016).

Phase		Square	*Nautilus*		*Oliva*	*Nassarius*	*Other conical shell*
			Circular or disc; single perforation	Ovoid; double perforation			
Neolithic	Near Present (Phase 4) (Modern to c. 200 cal. BP)	A None					
		B None					
		C Spits 3-5	20		8	2	2
	Later Holocene (Phase 3) (c. 200 to c. 3,800 cal. BP)	A Spits 1-5			15	2	
		B None					
		C Spits 6-13	71		11	5	4
Middle Holocene	Mid-Holocene (Phase 2) (c. 5,500 to c. 6,700 cal. BP)	A Spits 6-23			87	2	
		B Spits 2- 42			184	20	
		C Spits 14-42	95	1	92	1	
Pleistocene	Terminal Pleistocene (11,700 - 16,000 cal. BP)	A Spit 26					
		B Spits 43-46			2		1
		C None					
	Earlier Pleistocene (Phase 1) (16,000 to 43,000 cal. BP)	A Spit 46					
		B Spit 56			1		
		C Spits 43-54			1		9

Figure 3: The range of shell beads recovered from Square C of Asitau Kuru.

The surfaces of the Asitau Kuru beads (and other shell artefacts) are generally in good condition, with manufacture and use related damage clearly identifiable under low magnification. As such the manufacturing sequence and possible mode of use for each bead form can be reconstructed. Each bead type is considered in detail and their mode of use compared below.

Nautilus **beads**

~~Disc~~Circular or disc-shaped beads made on *Nautilus pompilius* shell dominate the Square C assemblage with 158 intact beads and an additional 28 fragments identified. In addition, one fragment from a ~~two-holed~~doubly-perforated ovoid bead also made on *Nautilus* was distinguished (no. 200 in Figure 3). These beads are restricted to the mid-Holocene phase (Phase 2) and later in the Asitau Kuru deposit (Table 1), though worked and coloured fragments of *Nautilus* shell have been previously found in the Pleistocene layers, including those dating to the earliest occupation levels (Langley et al. 2016).

While root etching, incidental burning, and manganese staining were all observed on these beads, the impact of these taphonomic processes is minimal. Surfaces remain generally clear with anthropogenic traces unaltered. Only in cases where the shell structure has begun to disintegrate and the shell layers are delaminating, is it harder to assess anthropogenic traces.

The assemblage from Square C provides direct evidence that *Nautilus* circular or disc beads were made on site at Asitau Kuru. Several flaked fragments of *Nautilus* shell of a size which would be suitable to be reduced into the discovered beads (c. 2 cm x 1.5 cm) were found along with a 'preform'. This preform has been ground into a disc but the central perforation is yet to be begun (artefact no. 227 in Figure 3). This single artefact suggests that the overall shape of the bead was formed before the perforation was created, rather than the perforation being created on a roughly or carefully trimmed fragment as has been recorded for other organic disc beads (e.g., Burley and Freeland 2019; Miller et al. 2021; Orton 2008). As such, it appears that at Asitau Kuru *Nautilus* shell was first fractured into appropriate-sized fragments, then ground into their final shape before being perforated using either uni-or bifacial hand-drilling (both ~~methods~~approaches are found in the assemblage). This approach, which leaves perforation to the last step is highly unusual for disc bead manufacture and suggests that the bead-makers at the site were very confident in their ability to successfully perforate a near-finished bead without breaking the piece~~it~~. At nearby Matja Kuru 2 some irregularly shaped fragments of *Nautilus* exhibit drilled perforations (O'Connor 2010: 222-3, Figure 3 c and h), so it would appear that both methods were used in the area and there was no single standardised sequence for the production of disc beads ~~in~~ on Timor~~-Leste~~.

To return to the beginning of the *chaîne opértoire* for these beads, breaking a whole *Nautilus* shell (which comes in packages of around 25 cm in diameter) could be as simple as smashing it against a hard surface before further breaking apart larger fragments with a hammerstone or between the hands. Trimming of smaller flakes can be achieved via pressure flaking, and then once it is near to the desired size, grinding using fine-to-medium grain grindstones (or similar abrasive surface). Differences in the degree of symmetry are evident in the assemblage, with some beads being carefully ground into a full circle (Figure 4a, e, f) and others far less so (Figure 4 c and d). While it could be suggested that these less symmetrical beads — which display one or more facets from trimming — are unfinished beads with more grinding to be completed, numerous such examples display traces of use in the form of polish, rounding, and red colourant traces to their perforation edges (Figure 4c and d). The spatial patterning of this use wear ~~and what it suggests for the mode of use for this bead form~~ is considered ~~more~~ below in relation to the mode of use for this bead form.

Figure 4: Disc beads made on *N. pompilius* (a, c-f) and *Conus* spp. (b). The *Nautilus* examples were first trimmed and ground to the desired shape before being perforated using a micro-drill. Grinding striations remain visible on a number of artefacts (red arrows in d) while a red colourant is also frequently present (c and e). *Conus* spp. beads are easily distinguished from the *Nautilus* variety by their bright white colour and dense spiral shell structure (compare a and b). Scale bars = 1 mm.

In terms of creating the single, central perforation, semi-concentric striations are visible running around the interior wall of the perforation, and, on several of the beads,~~beads shoulder~~ striations were also observed running around the rim (shoulder) of the perforation, all suggesting that a handheld lithic micro-drill was used in this operation (see Langley et al. 2016 for results of experimental working of *Nautilus*). Some six lithic artefacts with a suitable projection for drilling these perforations which average between 1 - 2 mm in diameter (see Table 2) have been found in Square C, including examples from Spits 40, 36, and 14, all early to mid-Holocene in age (see example in Figure ~~9~~10). Similar lithic artefacts with drill-like retouch were also found in the Square B excavation from Spits 12 and 7 dating to the early to mid-Holocene (Marwick et al. 2016). As such, appropriate lithic drill forms~~s~~ appear in the Asitau Kuru deposit from the start of Phase 2 at the same time the *Nautilus* disc beads appear in the sequence. A mix of executing the perforation from the dorsal, ventral, or both surfaces was observed and no chronological pattern in which approach was selected was detected.

Table 2: Overview of metrics for the Square C *Nautilus* disc beads.

	Height (mm)	Width (mm)	Thickness (mm)	Perforation Diameter (mm)
Near Present (Phase 4) (Modern to c. 200 cal. BP)	Range 3.30-11.18 / Average 6.92	Range 2.31-11.24 / Average 6.45	Range 0.01-1.80 / Average 0.76	Range 0.62-3.63 / Average 1.95
Later Holocene (Phase 3) (c. 200 to c. 3,800 cal. BP)	Range 3.94-13.21 / Average 7.83	Range 3.90-13.06 / Average 8.46	Range 0.05-1.74 / Average 0.77	Range 0.58-3.36 / Average 2.14
Mid Holocene (Phase 2) (c. 5,500 to c. 6,700 cal. BP)	Range 2.41-11.25 / Average 5.13	Range 2.30-11.20 / Average 5.22	Range 0.01-1.41 / Average 0.65	Range 0.51-3.63 / Average 1.39

There is significant range in the overall size of the disc beads (Table 2). The smallest example is only 2.3 mm in diameter, while the largest reaches over 13 mm. Overall, 58% of the beads range between 3 and 5 mm in diameter, suggesting that this size bracket was that most sought after. Only 15% (n = 23) of the recovered beads have a diameter greater than 10 mm and the perforations on these larger beads are also larger, averaging 2.5 mm in diameter. No temporal aspect to bead size was found. Both smaller and larger beads are found in the same phases and even the same spit. What this diversity in bead size does indicate is that each *Nautilus* disc bead was ground and finished individually, and not *en masse*, as in the manner observed for ostrich eggshell and marine shell disc beads from the African and American continents respectively (Francis 1989; Goodwin and Van Riet Lowe 1929; Wilmsen 1997).

The *Nautilus* disc beads typically don't display significant key-holing in their perforation wall from stringing, though one example does ~~has~~show extensive wear in its ~~wall~~rim (Figure 4f) and a number of the beads have a pair of shallow notches on either their dorsal or ventral surface leading from the perforation to the outer edge of the bead (Figure 7, considered further below). Additionally, traces of a bright red colourant is present on the perforation walls and/or the flat faces of 53% of the beads. The scattered distribution of this colourant across the surface of the beads and the assemblage of *Nautilus* disc beads as a whole, suggests that the beads were not deliberately painted or otherwise stained, but came into contact with coloured material culture or human bodies where they incidentally gathered these traces of colour.

Oliva beads

The next most common form of bead are whole *Oliva* shells. In total, 107 intact and another five fragments of *Oliva* shell beads were recovered from Square C. Two unworked *Oliva* shells of the same size as the finished beads were also recovered (one in Spit 38 and the other in Spit 22, dating to the earlier to mid-Holocene). Previously, we directly dated the then lowest *Oliva* shell bead recovered from this site to ca. 37,000 cal. BP (Langley and O'Connor 2016). The excavation of Square C recovered an additional example in these lowest occupation levels, the new artefact coming from Spit 44 which is bracketed by dates c.40,000 and 44,000 cal. BP.

As with the previously published *Oliva* spp. shell assemblage recovered from Squares A and B (Langley and O'Connor 2016), those from the 2019 excavation of Square C are predominately *Oliva brettinghami*, which is a common species of small olive shell in the Indo-Pacific region. It is also possible that very similar olive shells — *Oliva sericea* (previously *Oliva textilina*) are also present, but it is impossible to differentiate them from *O. brettinghami* on worked and worn examples as it is the adapical spire which differentiates the species and this is the section that is either largely or entirely removed to create a passage through the shell body, allowing it to be strung.

The Square C assemblage of *Oliva* beads displays the same mix of minor taphonomic damage found on the *Nautilus* artefacts, including incidental burning (resulting in the shell turning grey, gold, brown, or black), root etching, and manganese staining~~ as the *Nautilus* beads~~. Despite these alterations, traces from manufacture and wear remain clear. As with the artefacts reported in 2016, the only alteration undertaken to transfer the whole *Oliva* shell into a string-able bead was to remove the adapical spire. Experiments previously undertaken by us found that this section was quickly and easily removed by repeatedly tapping the apex of the shell against a hard surface with some force (Langley and O'Connor 2016). Examination of this part of the beads found the same pattern of chipping around the perforation which results from this process of transformation.

Examination of the size of shells selected for transformation into beads reveals that while the single example from the Pleistocene occupation levels of Asitau Kuru Square C is quite large (just over 17 mm in ~~height~~length), only 6% (n = 6) of the assemblage measures above 12 mm in ~~height~~length. The assemblage centres around shells about 9.5 mm in ~~height~~length (57.2% measuring between 8.5 and 10.5 mm; Table 3). The size of the perforation is initially constrained by the width of the spire, only becoming significantly larger as wear to the perforation rim progresses (see below).

Table 3: Overview of metrics for *Oliva* beads recovered from Square C.

	Length (mm)	Width (mm)	Thickness (mm)	Perforation Diameter (mm)
Near Present (Phase 4) (Modern to c. 200 cal. BP)	Range 7.09-14.54 / Average 9.72	Range 3.10-7.31 / Average 4.56	Range 2.42-4.79 / Average 3.57	Range 0.73-2.51 / Average 1.28
Late Holocene (Phase 3) (c. 200 to c. 3,800 cal. BP)	Range 6.38-11.71 / Average 9.71	Range 2.73-5.14 / Average 4.15	Range 2.13-4.31 / Average 3.56	Range 0.51-7.96 / Average 1.67
Mid-Holocene (Phase 2) (c. 5,500 to c. 6,700 cal. BP)	Range 6.42-15.57 / Average 9.51	Range 2.14-7.35 / Average 4.29	Range 1.89-6.46 / Average 3.74	Range 0.38-25.36 / Average 1.57
Earlier Pleistocene (Phase 1) (16,000 to 43,000 cal. BP)	Single specimen - 17.16	Single specimen - 6.97	Single specimen - 5.68	Single specimen - 1.56

Wear from use consists of rounding and polish of the adapical perforation edge, with extended use resulting in a notch developing (Figure 5 b-c). On well-worn examples, this notch can extend into the body of the shell (Figure 5d), which in extreme cases extends halfway down the entire length of the whole shell. At the other extremity of the shell, the anterior canal can display faceting, chipping, rounding, and in some cases, also develop a notch. Wear is more rapidly accrued on the outer lip, however, where repeated agitation ~~of this section~~ initially ~~appears~~results in ~~as~~ smoothing to this~~e lip~~ surface (Figure 5 d, f) before developing into a more and more intrusive notch which can develop well into the body of the shell (Figure 5 a, b, e, g). This pattern of wear is consistent with the shell beads having been strung in a consecutive fashion, where the apical perforation rests against or within the anterior canal of the one before it. Those shells which fall at the bottom of the string spray out and away from the string, resulting in the notches seen on the outer lip. The appearance of wear to the upper body whorl on a number of the beads — ranging between a small section where a layer of shell has been rubbed away (Figure 5 d, f) to examples where a large hole has been worn entirely through the shell body — indicates that these strings of beads were worn against another surface, which could be human skin, clothing, or other items of material culture. Analysis of the distribution of wear severity across the spits finds that most beads with the severest wear are located between Spits 16 and 26. While this trend could represent the more intensive use of the shell beads during ~~their~~ this period, it may also simply reflect sample size ~~effect~~ as this section of the deposit has the largest ~~sample~~ number of beads recovered (Table 1).

Figure 5: Beads made on whole *Oliva* shells. The adapical perforation becomes rounded and polished as it wears (a-g), with extensive use resulting in the outer layer of the shell being rubbed away ~~from~~through contact a~~way from~~gainst the body (d, f) and a large notch developing on the outer lip (a, b, e, g). A red residue is found to accumulate in the crevices of the beads (c, f). Scale bars = 1 mm.

Finally, 56% of the *Oliva* shell beads display traces of a red colourant, some more extensive than others; with these traces concentrating along the inside of the lip, within the natural rim running round the neck of the apex, and in the anterior canal. This distribution of colour is consistent with incidental transfer from a red-coloured string and/or a fabric or body which was coloured.

Nassarius beads

Five intact and three fragments of *Nassarius* spp. shell beads join the 24 examples previously recovered from Squares A and B (Langley and O'Connor 2015). The species represented include *Nassarius pullus* and *Nassarius globosus*, species that are similar in appearance and size. The size of the finished beads are more standardised than their *Nautilus* and *Oliva* counterparts (Table 4). Two additional beads of an unidentified *Nassarius* spp. (but of the variety which does not display the smooth white ventral surface) were also found. These two items were treated differently, likely owing to their differing morphology, and only had a small perforation chipped away at the apex (similar to the treatment of the *Oliva* shell beads described above).

The Timor *Nassarius* shell beads have not only been perforated, like those recovered from Middle Stone Age African contexts (e.g., Vanhaeren et al. 2013), but had their whole dorsum systematically chipped away to create a flat bead featuring the shiny white ventral surface (Figure 3 and 6). Raised surfaces on the dorsal surface are rounded and polished (Figure 6a), while the ventral surfaces can display a worn area from repeated rubbing (Figure 6b). Also observed are shallow notches running from the natural aperture running across the ventral surface towards the outer edge of the shell (Figure 6d), as well as polish, rounding, and sometimes restricted faceting around the natural aperture. Traces of the red colourant observed widely on the *Nautilus* and *Oliva* shell beads is rarer on the *Nassarius* items; only one example displaying this residue on its dorsal surface and around the sides of the aperture on the ventral side.

Figure 6: *Nassarius* shell beads from Square C were created by chipping (a-d) and grinding away their dorsum (e-f).~~-~~ Polish and rounding is visible on raised surfaces of the dorsal surface (red arrow in (a) and areas can be worn down on the ventral surface (red arrow in b and f) or

anterior canal (red arrows in c). Thin shallow notches and residues can stem from the natural aperture of the shell (d). Bead 42 is of particular interest owing to its dorsum (e) being ground down and partially also its ventral surface (f). A possible fibre remaining from stringing was identified on ~~artefact 42~~the ventral surface of this artefact (f-g). Scale bars = 1 mm.

Of particular interest is bead 42 from Spit 7 which has been created using a method different to all other *Nassarius* beads thus far recovered from Asitau Kuru~~ (Figure 6e-f)~~. Rather than the dorsum being chipped away, on this specimen the dorsum has been ground away (Figure 6e). Further, the ventral surface has also been ground to create a flatter surface than that naturally provided (Figure 6f). This artefact also preserves a short length of fibre of unknown origin (plant- or animal-based) found inside the aperture (Figure 6f-g). The presence of this alternative mode of bead creation may suggest that this particular artefact was transported to Asitau Kuru from elsewhere.

Table 4: Overview of *Nassarius* bead metrics recovered from Squares A, B, and C.

	Height (mm)	Width (mm)	Thickness (mm)
Near Present (Phase 4) (Modern to c. 200 cal. BP)	Range 8.59-11.78 / Average 10.18	Range 6.39-9.08 / Average 7.73	Range 2.86-3.64 / Average 3.25
Late Holocene (Phase 3) (c. 200 to c. 3,800 cal. BP)	Range 5.96-9.78 / Average 8.21	Range 4.34-7.51 / Average 6.32	Range 1.56-4.29 / Average 3.19
Mid-Holocene (Phase 2) (c. 5,500 to c. 6,700 cal. BP)	Range 6.31-12.62 / Average 9.01	Range 4.76-10.72 / Average 6.98	NA

Beads made on other species

Anthropogenically perforated beads made on other species of shell at Asitau Kuru are very few. There are four disc beads made on *Conus* sp. from Spits 5 and 8 (all shown in Figure 3). These beads are as small as the tiniest *Nautilus* disc beads, averaging only 3.3 mm in diameter (range: 2.58-5.15 mm) and between 0.01-0.47 mm thick. That these artefacts are not *Nautilus* is not clearly evident until viewed under low microscopy when the shell structure of the *Conus* (spiral growth structure, dense white material) — rather than the *Nautilus* (two broad layers, one cream and dense, the other nacreous)— becomes evident (compare a and b in Figure 4). The dorsal and ventral surfaces of these *Conus* beads are ground smooth and flat, and traces of red colourant are located on the perforation walls on one example.

There are two fragmented examples made on a small *Mitridae or Costelloridae* shell (spit 54 of Square C) and another on an *Nassaridae* shell (spit 25 of Square C) of a different species to those described above, which feature a single perforation through the apex (similar to the *Oliva* shells)~~,~~. ~~though a~~All are heavily beach worn and may have been perforated naturally and then opportunistically collected for use.

Lastly, ~~we report~~ 17 apexes of *Strombus* or *Conus* shells were found in the lowest levels of the site, specifically, from spit 31 down to spit 65 (Figure 7 and Table 5). These shell parts display characteristics of being heavily beach worn and we consider it likely that the perforations were produced naturally. No clear traces for the perforations being human-made were detected, nor clear wear related to use, however, each of these specimens must have been collected and brought into the shelter by people in the past as they do not occur in the site naturally.

These manuports are generally much larger that the shell beads described above, averaging 12.8 mm in diameter, but all feature the light cream to white colouration and circular shape that have long drawn the attention of humans in multiple regions of the globe. Considering these qualities, their status as manuports, and the recovery of very similar items previously suggested to have been used as personal ornaments from deep time contexts elsewhere (e.g., d'Errico et al. 2020; Langley et al. 2020), we suggest that these artefacts may represent the earliest exploration of local marine shells for what was~~ to~~ soon to develop into a rich repertoire of shell-based personal adornment in this region.

Figure 7: Examples of the 17 *Strombus* or *Conus* shell tops — probably naturally perforated — brought to Asitau Kuru by its earliest inhabitants and which may have been used as beads.

Table 5: Overview of *Strombus* or *Conus* shell apex manuports, and possibly beads, recovered from Squares A, B, and C.

Square	Spit	Artefact	State	Height (mm)	Width (mm)	Perforation diameter (mm)
A	31	353	Intact	16.2	17.5	4.6 x 5.7
B	53	357	Intact	13.6	16.1	5.4 x 5.2
B	60	359	Intact	14.0	14.1	4.8 x 3.1
B	64	354	Intact	9.6	10.5	1.5 x 1.2
B	64	355	Intact	6.7	7.4	1.5 x 1.7

Square	Spit	Artefact	State	Height (mm)	Width (mm)	Perforation diameter (mm)
	64	356	Intact	8.5	10.6	2.4 x 1.9
	65	358	Intact	21.4	22.9	2.2 x 2.3
C	42	360	Intact	15.8	19.9	6.5 x 6.3
	50	363	Intact	9.8	10.4	2.9 x 3.1
	52	364	Intact	16.7	18.7	7.9 x 7.7
	52	365	Intact	9.1	9.5	3.4 x 3.1
	52	366	Intact	9.2	10.3	1.3 x 1.4
	53	361	Intact	12.6	13.6	2.4 x 4.0
	53	362	Fragment /45% present	11.3	15.6	4.2 x 5.3
	54	367	Intact	14.0	15.0	1.9 x 1.7
	54	368	Intact	10.9	12.2	2.3 x 2.2
	54	369	Intact	7.1	8.3	2.1 x 2.1

Bead use and arrangements

The mode of use of the various types of beads recovered from Asitau Kuru is difficult to determine with certainty without finding them in a contextual arrangement, such as a burial. However, the morphology, and particularly the use wear, does allow some insights.

As stated above, the distribution of use wear observed on the *Oliva* shells indicates that these beads were strung sequentially on a string. Whether these strings were worn as necklaces or on long strands attached to clothing (etc.) ~~is not able to~~cannot be ascertained at this time. Interestingly, we have some small indications that some of the *Nautilus* beads may have been included on strings with other bead types.

As shown in Figure 8, unique circular stigmata which appear to have been partially cut/ground into the ventral surface of a large (c. 11.8 mm diameter) *Nautilus* bead from Spit 8 was discovered. These marks are located on opposing sides of the central perforation (~~three~~four on one side and ~~two~~five on the other) and are not consistent with any of the taphonomic processes (such as root etching, trampling) observed across the entire site assemblage. The diameter of these five partial circles range between 0.9 and 1.5 mm which sits perfectly in the range of the perforation diameter of the

Oliva shell beads (see Table 3 above). As such, we suggest that these marks may have resulted from the *Nautilus* disc bead being strung above an *Oliva* shell bead, with the distal edge of that *Oliva* shell bead (the circular perforation edge) resting directly against the *Nautilus* shell surface. The weight of the beads above the *Nautilus* disc would result in it rubbing on the top edge of the *Oliva* shell bead, resulting in the latter beginning to 'drill' into the *Nautilus* surface (Figure 8).

Figure 8: *Nautilus* disc bead (no. 27) with distinctive circular marks on its ventral surface.

No other *Nautilus* beads recovered from Square C display these same marks. Instead they feature a high polish on the edges of the creamy dorsal surface suggesting that this part of the bead was in repeated and/or prolonged contact with another surface. A number of the beads also display linear striations or notches leading from the central perforation towards the outer edge of the bead (Figure 9a-d). Several others display similar striations and notches running along their top (Figure 9e), and in a few cases, across much of their surface (Figure 9f). Red colourant is often associated with these striations and notches.

Figure 9: The *Nautilus* disc beads display a set of reoccurring use-related features which suggest their mode of use. Striations (a-b) and notches (c-d) running from the central perforation to the bead edge; Striations (e) and notches (f) on the faces and faceting and chipping (c, d, g) on the bead edges appear to have accrued in use. An unusual circular stigmata may indicate that this bead was closely associated with a smaller disc bead (h). Scale Bar = 1 mm.

The placement of these marks suggests that the beads were strung in a fashion where the string passed through the perforation and held tight against each side of the bead. Such an arrangement suggests they were either then attached dorsal face down to a surface (as in an appliqué) or strung consecutively where each bead lays partially over the next and is held tight to create a band of tightly packed disc beads (as seen on ethnographic examples; Guzzo Falci et al. 2019). This latter option, where the disc beads are in contact with one another and stress is created on the bead edges may account for a breakage pattern observed where disc beads often display one to four flat facets or small fractures on their edge (Figure 9c, d, and g). In either case, the attachment of the *Nautilus* disc beads to a backing fabric or in this overlapping consecutive fashion makes sense for effectively utilising the shiny nacreous surface that the ventral face presents. Certainly, we have previously argued that the use wear on the *Nassarius* shells can only be fully explained by their use as shell appliqués (Langley and O'Connor 2015).

Threading tool?

Another shell artefact, a unipoint made on a slither of what appears to be a larger *Conus* or *Strombus* shell, may ~~also~~ have been used as a needle or awl to help thread the beads described above. This artefact, shown in Figure 10c, is 20.09 mm long with a tip measuring only c.0.1 mm in width and height. Unfortunately, the very tip of the point has been damaged in more recent times, evident from the bright white and clean~~er~~ surface, and as such we cannot assess use wear that might have been originally present on that section. The surfaces along the length of the shell, however, present a high polish that would be produced from extended handling or repeated passing through a soft material. This artefact was recovered from the Phase 2 mid-Holocene deposit of the site, and as such, appears in the same period that the disc beads and *Nassarius* shells first appear.

Figure 10: Beading tools. (a) Stone micro-drill recovered from Asitau Kuru; (b) Bone unipoint recovered from Here Sorot Entapa on Kisar (previously reported in O'Connor et al. 2019); and (c) shell unipoint recovered from Spit 16, Square C of Asitau Kuru.

Interestingly, Glover (1986) found what appears to be a very a similar tool at Uai Bobo 2, Timor, which he interpreted as "a bird bone needle or awl" (Glover 1986:190). That artefact is made on a shaft of bird bone, one end has been flaked to create a point and "in its present state is 37 mm long by about 2 mm in diameter, taper~~p~~ing to 1 mm at one end where a bevelled surface has been ground" (Glover 1986:190). This tool was recovered from Horizon VIII ~~which was~~ dated to about 5,000 years BP and is thus contemporary with the Asitau Kuru shell artefact. Additionally, a small bone point was recovered from Here Sorot Entapa on Kisar. This artefact, shown in Figure 10b, measures only 20 mm long and 2.1 mm in diameter and displays light traces of red ochre on its surface. This artefact was recovered from Spit 17 in Square B which has a date of 13,750-13,484 cal. BP (O'Connor et al. 2019). While different raw materials were used here — bone and shell — the overall morphology and size of these three artefacts suggests that they may have all functioned similarly and threading the hundreds of shell beads created on Timor and surrounding islands is our favoured hypothesis on current evidence.

Helmet shell artefact: Trumpet, adze, or container?

The last shell artefact to be described here is a fragment from a very large marine shell, a *Cassis cornuta* (horned helmet shell) (Figure 11). Recovered from Square B spit 9, this artefact dates to 4900-4640 cal BP and has fractured in antiquity. While the fragment measures only 3.5 (maximum height) by 3.6 mm (maximum width), comparison with the Queensland Museum reference collection found that the piece originated from an adult shell some 20-25 cm long. The fragment was able to be matched to a section of the body whorl based on surface contour and texture (Figure 11). The surface of this species features a creamy colour with linear arrangements of small lines which appear stronger closer to the parietal wall.

C. cornuta are ~~a~~ large sea snails which inhabit~~s~~ sandy floors of lagoons or around reefs and ~~are~~is known to grow to 41 cm in length. For this fragment to be recovered from Asitau Kuru, it must have been brought into the site by its human inhabitants. At this time no other fragments of this same species has been identified in the recovered shell material.

Figure 11: This *Cassis cornuta* (horned helmet shell) fragment originated from the body whorl of an adult shell some 20-25 cm long which was brought into the site

This species provide a large quantity of edible meat and their shells — as well as that of other large trumpet shell species (*Syrinx aruana, Charonia tritonis*) — are recorded as having been widely used as musical instruments (shell trumpets) and as containers for holding a range of liquids (water, medicine) and solid goods (Clark 2021; David et al. 2005; Haddon 1935). *C. cornuta* shell is also known to have been used to create shells adzes, these tools previously ~~being~~ found in middle to late Holocene levels at Golo Cave on Gebe Island north of Timor (Szabó et al. 2007), as well as further afield in Oceania (e.g., Mariana Islands, Carson 2016; Marshall Islands, Weisler 2001). As such, the fragment discovered in Asitau Kuru may have originated from a shell used as a container for liquids, as a shell trumpet, or from a shell reduced to make shell adzes. That this fragment is so far unique in the recovered shell assemblage suggests that it originated from~~or~~ a curated item, rather than a shell reduced for tool manufacture.

Discussion

The additional 323 shell beads found in Square C of Asitau Kuru confirms the antiquity of the *Oliva* shell beads beyond 40,000 years BP and consolidates our understanding of how marine shell bead use intensified during the mid-Holocene. It is worth noting that as the island of Timor has a steep bathymetric profile, distance from the site to the coast differed minimally with changing sea levels, and as such, changes in bead production intensity cannot be simply tied to access to marine shells. In fact, the only change which can be tied to sea level change is the the introduction of *Nassarius* shells, these species first appearing with the stabilisation of the near shore coastal environment accompanying the slowing of marine transgression (Chappell and Veth 1978; see Langley and

O'Connor 2015 for discussion). The availability of the other ornamental shell species remained constant over the entire period of human occupation on Timor, and thus, the increased production and use of the shell bead repertoire during the mid-Holocene must reflect other (social) conditions.

This intensification of bead production and use is mirrored in sites surrounding Asitau Kuru (Table 6), revealing that this medium likely played an important role in social interactions of the people who inhabited these islands during this period. Indeed, Shipton et al. (2020) argue that the appearance of shell adzes in the middle and early Holocene in the Nusa Tenggara Archipelago suggests the creation of dugout canoes facilitated regular access to neighbouring islands. This inter-island contact is found in the appearance of exotic obsidian in the Asitau Kuru sequence from the Terminal Pleistocene-Early Holocene ~~boundary~~contexts (Reepmeyer et al. 2011; Shipton et al. 2020). Additionally, obsidian with the same geochemical signature has ~~also~~ been found on Timor at Matja Kuru 1 and 2, Bui Ceri Uato, Bui Ceri Uato Mane, and Laili. The same obsidian was also identified at Tron Bon Lei some 300 km away on neighbouring Alor Island and on Kisar Island to the north-east — all dating to the terminal Pleistocene or early Holocene in first appearance (Maloney et al. 2018; O'Connor et al. 2023; Reepmeyer et al. 2016). Increased numbers of sites in the terminal Pleistocene and earlier Holocene and increased occupation intensity at sites with earlier occupation phases is a broader pattern across Timor (Shipton et al. in press), suggesting increasing population sizes as well as connectivity.

~~This~~ More frequent~~increasing~~ contact with ~~neighbours~~ neighbouring groups would no doubt support the creation of body adornment which was more visually arresting, perhaps allowing visiting individuals to be more easily identified on sight and at a distance. While the published corpus of marine shell beads from Island Southeast Asia shows that four main forms of shell ornaments were produced across the excavated sites: biconical beads (*Oliva*), disc beads (*Nautilus*, *Conus*, *Strombus*, *Rochia*), ~~two-holed~~ovoid doubly-perforated beads (*Nautilus*, *Rochia*), and basket-shaped beads (*Nassarius*, *Cypraea*); the proportions of bead types at each site reveals some early indications of island-based identity creation (Table 6). Said another way, the popularity of specific bead forms on each island — as represented in their archaeological deposits — indicates that cultural choices were at work when selecting which beads to produce. In particular, differences are noticeable in the form that *Nautilus* shell beads take at sites on different islands. At both Makpan ~~on~~ (Alor Island) and Here Sorot Entapa (~~on~~ Kisar Island), *Nautilus* disc beads are heavily outnumbered by the presence of the two-holed variety. At Asitau Kuru and Matja Kuru, both on Timor on the other hand, the opposite is true. Here~~, with~~ *Nautilus* disc beads dominate~~ing~~ the assemblage ~~and~~with only a single two-holed specimen (which was fragmented) ~~was~~ identified. As such, while both the singly-perforated disc and ovoid double-perforation bead forms were known on each of these three islands (Timor, Alor, and Kisar), the decision to make predominantly one form (either disc or ovoid) over the other was adhered too. Furthermore, the rarity of the opposite type in a site suggests that ~~these~~

~~unusual beads~~they were not made on site, but instead introduced to the location ~~by a person wearing this ornament form~~through contact with people from elsewhere.

An~~other~~other interesting observation ~~between~~regarding the *Nautilus* bead assemblages of Asitau Kuru and Makpan is that while most beads at Makpan were fragmentary (only 36 intact of the 577 identified bead artefacts recovered; Langley et al. ~~in press~~2023) those found at Asitau Kuru are mostly complete (161 intact of the 187 disc beads). This difference in bead fragmentation rate ~~of the beads~~ may be owing to the ~~two-holed~~doubly-perforated versions being weaker ~~owing to~~because of the additional perforation, than the single-holed disc beads.

Table 6: Appearance of shell bead types at sites surrounding Asitau Kuru, gathering data from this study; Glover 1986; Langley and O'Connor 2015, 2016; Langley et al. ~~in press~~2023; O'Connor 2010; O'Connor et al. 2019; Shipton et al. 2019.

	Site	*Nautilus Circular or disc; single perforation*	*Nautilus* ovoid; double-perforation	*Oliva*	*Nassarius*	*Conus / Strombus Disc*	*Rochia Disc*	*Other*
Neolithic (Post c. 3,800 cal. BP)	Asitau Kuru, Timor	91		34	9	5		
	Lene Hara, Timor			3				
	Uai Bobo 1, Timor	20		4	1			
	Lie Siri, Timor	1						
	Here Sorot Entapa, Kisar	1						
Mid-Holocene	Bui Ceri Uato, Timor 3500-5500		4	1				
Early to Mid-Holocene (c. 5,500 to c. 11,700 cal. BP)	Asitau Kuru, Timor	95	1	365	23	1		
	Matja Kuru 1, Timor	60		76	17	51	18	1 cypraea
	Matja Kuru 2, Timor	2	2	8	1	1	1	
	Lene Hara, Timor			96	6			
	Uai Bobo 2, Timor	38		8				1 cockle / 1 helmet shell / 1 cypraea
	Makpan, Alor	3	26					

	Site	*Nautilus Circular or disc; single perforation*	*Nautilus* ovoid; double-perforation	*Oliva*	*Nassarius*	*Conus / Strombus Disc*	*Rochia Disc*	*Other*
	Here Sorot Entapa, Kisar	3	18			1		
Pleistocene (11,700 - 43,000 cal. BP)	Asitau Kuru, Timor			5		9		
	Matja Kuru 1, Timor			7				
	Makpan, Alor		5					

In terms of these *Nautilus* beads — whether they are disc-shaped or ~~two-holed~~ovoid with a double perforation ~~in form~~ — creating the numbers that are present in the archaeological record would be a significant investment ~~in~~ of time and effort. From the differences in size of these beads, it appears they were shaped into their final form individually, rather than *en masse*; a method which significant speeds up disc bead production. Indeed, some of the *Nautilus* beads are incredibly tiny (less than 2.5 mm in diameter) and must have required considerable skill to produce~~ in such symmetry~~.

The effort required to produce the *Nautilus* beads is in sharp contrast to the *Oliva* shell beads. This latter variety w~~ere~~as widely used at the Timor sites, with both shells perforated naturally (beach wear) and ~~those~~ artificially ~~perforatedation by~~ through repeated tapping of the~~is~~ apical section~~,~~ - a process which only takes seconds (see Langley and O'Connor 2016)~~ able to be utilised~~. This ease of *Oliva* bead production may account for their apparent popularity, however, the effort put into making the *Nautilus* beads is made up for in that they are more spectacular to view, being iridescent and able to catch the light. The *Nassarius* shell beads, on the other hand, also appear to have required some effort to manufacture, their dormus being carefully chipped away using a tool edge. These shells only appear in the archaeological sequences when they become present in the surrounding environment (stabilisation of the sea level during the mid-Holocene), however~~,~~; ~~and~~then providing~~e~~ another method of producing a visually arresting display of shiny white appliqués.

~~Finally, the *C. cornuta* shell fragment deserves further consideration. This species provide a large quantity of edible meat and their shells — as well as that of other large trumpet shell species (*Syrinx aruana, Charonia tritonis*) — are recorded as having been widely used as musical instruments (shell trumpets) and as containers for holding a range of liquids (water, medicine) and solid goods (Clark 2021; David et al. 2005; Haddon 1935). *C. cornuta* shell is also known to have been used to create shells adzes, these tools previously being found in middle to late Holocene levels at Golo Cave on~~

Gebe Island north of Timor (Szabó et al. 2007), as well as further afield in Oceania (e.g., Mariana Islands, Carson 2016; Marshall Islands, Weisler 2001). As such, the fragment discovered in Asitau Kuru may have originated from a shell used as a container for liquids, as a shell trumpet, or from a shell reduced to make shell adzes. That this fragment is so far unique in the recovered shell assemblage suggests that it originated for a curated item, rather than a shell reduced for tool manufacture.

Conclusion

The prominence of shell as a raw material for making artefacts and personal decorations on Timor and its neighbouring islands in Wallacea is becoming increasingly apparent. That the sites contain a wealth of shell technology is perhaps not surprising in view of the maritime focus of these island communities and the depauperate land-based fauna available from which to fashion boneosseous tools. Prior to these findings, the focus had been on lithic artefacts which exhibited minimal change over the 44,000 years duration of human occupation compared with *H. sapiens* assemblages elsewhere in the Old World (e.g., Marwick et al. 2016; Shipton et al. 2019). Shell artefacts, including fish hooks, adzes, and beads transformed these island societies. *Oliva* beads — and perhaps the larger naturally perforated cone shaped shells — first appear in Asitau Kuru coincident with *H. sapiens* arrival on the island. In the Terminal Pleistocene, and increasingly through the early to mid-Holocene, new types of beads and appliqués made on flat discs of lustrous *Nautilus* shell appear in Asitau Kuru and other Timor sites as well as in those sites located on neighbouring islands Kisar and Alor islands. Their appearance coincides with the initial appearance of small flakes made on an exotic obsidian, and we suggest that the *Nautilus* beads may have been worn as emblems or tokens denoting the special relationship or bond betweenthat communities had to their particular island, and to the related communities on the surrounding on different islands.

With increased intensity of occupation in the early to mid-Holocene, the people of Asitau Kuru created a more and more complex shell adornment repertoire, reflected in the increased numbers of beads created and the incorporation of new shell species as they become available in the landscape (i.e., *Nassarius*). In the Neolithic, pottery was not the only novel item of material culture, with the *C. cornuta* fragment of a large helmet shell providing the first glimpse into a broader use of marine shell in the symbolic and/or social milieu of these island communities.

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References

Aguirre A, Etxeberria F, Herrasti L (2004) El yunque de hueso para afilar la hoz metalica dentada. Munibe 56:113-121.

Aubert M, Setiawan P, Oktaviana AA, Brumm A, Sulistyarto PH, Saptomo EW, Istiawan B, Ma'rifat TA, Wahyuono VN, Atmoko FT, Zhao J-X, Huntley J, Taçon PSC, Howard DL, Brand HEA (2018) Palaeolithic cave art in Borneo. Nature 564:254-257.

Boulanger, C. Hawkins S, Samper Carro, SC, Ono R, O'Connor S (in press) Continuity and variability in prehistoric fishing practices by *Homo sapiens* in Island Southeast Asia: new ichthyofaunal data from Asitau Kuru, Timor-Leste. World Archaeology

Brumm A, Langley MC, Moore MW, Hakim B, Ramli M, Sumantri I, Burhan B, Saiful AM, Saigain L, Suryatman, Sardi R, Jusdi A, Abdullah, Mubarak AP, Hasliana, Hasrianti, Oktaviana AA, Adhityatama S, van den Bergh GD, Aubert M, Zhao J-X, Huntley J, Li B, Roberts RG, Saptomo EW, Perston Y, Grün R (2017) Early human symbolic behavior in the Late Pleistocene of Wallacea. Proceedings of the National Academy of Sciences 114(16):4105-4110.

Burley DV, Freeland T (2019) A shell disc bead maker's workshop from Kavewa Island, northern Fiji. Archaeology in Oceania 54:120-126.

Carson MT, (2016) Archaeological Landscape Evolution. The Mariana Islands in the Asia Pacific Region. Springer, Cham.

Chappell J, Veeh HH (1978) Late Quaternary tectonic movements and sea-level changes at Timor and Atauro Island. Geological Society of America Bulletin 89:356-368.

Clarke M (2021) Some basics on shell trumpets and some very basics on how to make them. In: Hopkin B, Tewari S (eds) Sound Inventions. Routledge, London, pp 302-309.

David B, Crouch J, Zoppi U (2005) Historicizing the spiritual: *Bu* shell arrangements on the island of Badu, Torres Strait. Cambridge Archaeological Journal 15:71-91.

d'Errico F, Henshilwood C, Vanhaeren M, van Niekerk K (2005) *Nassarius kraussianus* shell beads from Blombos Cave: Evidence for symbolic behaviour in the Middle Stone Age. Journal of Human Evolution 48:3-24.

d'Errico F, Jardon-Giner P, Soler-Mayer B (1993) Critères à base expérimentale pour l'étude des perforations naturelles et intentionnelles sur coquillages. In: Anderson PC, Beyries S, Otte M, Plisson H (eds) Traces et Fonction: Les Gestes Retouves. Editions ERAUL 50, Liège, pp 244-253.

d'Errico F, Pitarch Marti A, Shipton C, Le Vraux E, Ndiema E, Goldstein S, Petraglia MD, Boivin N (2020) Trajectories of cultural innovation from the Middle to Later Stone Age in Eastern Africa: Personal ornaments, bone artifacts, and ocher from Panga ya Saidi, Kenya. Journal of Human Evolution 141:102737.

Francis PJ (1989) The Manufacture of Beads from Shell. In: Hayes C, Ceci L (eds) Proceedings of the 1986 Shell Bead Conference. Rochester Museum and Science Center, Research Records 20, Rochester, pp 25-36.

Glover I (1986) Archaeology in Eastern Timor, 1966-67. Terra Australis 11. ANU Press, Canberra.

Goodwin AHJ, Van Riet Lowe C (1929) The Stone Age Cultures of South Africa. Annals of the South African Museum 27:1-289.

Guzzo Falci C, Cuisin J, Delpuech A, Van Gijn A, Hofman CL (2019) New insights into use-wear development in bodily ornaments through the study of ethnographic collections. Journal of Archaeological Method and Theory 26:755-805.

Haddon AC (1935) Reports of the Cambridge Archaeological Expedition to Torres Strait, Vol. 1: General Ethnography. Cambridge University Press, Cambridge.

Kealy S, O'Connor S, Mahirta, Sari DM, Shipton C, Langley MC, Boulanger C, Kaharudin HAF, Patridina EPBGG, Algifary MA, Irfan A, Beaumont P, Jankowski N, Hawkins S, Louys J (2020) Forty-thousand years of maritime subsistence near a changing shoreline on Alor Island (Indonesia). Quaternary Science Reviews 249:106599.

Langley MC, O'Connor S (2015) 6,500-year-old Nassarius shell appliqués in Timor-Leste: Technological and use wear analyses. Journal of Archaeological Science 62:175-192.

Langley MC, O'Connor S (2016) An enduring shell artefact tradition from Timor-Leste: Oliva bead production from the Pleistocene to Late Holocene at Jerimalai, Lene Hara, and Matja Kuru 1 and 2. PLoS ONE 11(8):e0161071.

Langley MC, Kealy S, Mahirta, O'Connor S (in press) Sequins from the sea: The Nautilus ornament technology of Makpan, Alor Island, Indonesia. Antiquity

Langley MC, O'Connor S, Piotto E (2016) 42,000-year-old worked and pigment-stained Nautilus shell from Jerimalai (Timor-Leste): Evidence for an early coastal adaptation in ISEA. Journal of Human Evolution 79:1-16.

Langley MC, Amano N, Wedage O, Deraniyagala S, Pathmalal MM, Perera N, Boivin N, Petraglia MD, Roberts P (2020) Bows and arrows and complex symbolic displays 48,000 years ago in the South Asian tropics. Science Advances 6:eaba3831.

Maloney TR, Mahirta, O'Connor S, Reepmeyer C (2018) Specialised lithic technology of terminal Pleistocene maritime peoples of Wallacea. Archaeological Research in Asia 16:78-87.

Marwick B, Clarkson C, O'Connor S, Collins S (2016) Early modern human lithic technology from Jerimalai, East Timor. Journal of Human Evolution 101:45–64.

Miller JM, Keller HM, Heckel C, Kaliba PM, Thompson JC (2021) Approaches to land snail shell bead manufacture in the early Holocene of Malawi. Archaeological and Anthropological Sciences 13:37.

Morwood MJ, Hobbs DR (1997) The Asian connection: preliminary report on Indonesian trepang sites on the Kimberley coast, N.W. Australia. Archaeology in Oceania 32:197-206.

O'Connor S (2007) New evidence from East Timor contributes to our understanding of earliest modern human colonisation east of the Sunda shelf. Antiquity 81:523-535.

O'Connor S (2010) Continuity in shell artefact production in Holocene East Timor. In: Bellina B, Bacus EA, Pryce TO, Wisseman CJ (eds), 50 Years of Archaeology in Southeast Asia: Essays in Honour of Ian Glover. River Books, Bangkok, pp 219-233.

O'Connor S, Aplin K (2007) A matter of balance: An overview of Pleistocene occupation history and the impact of the Last Glacial Phase in East Timor and the Aru Islands, eastern Indonesia. Archaeology in Oceania 42(3):82–90.

O'Connor S, Mahirta, Kealy S, Boulanger C, Maloney T, Hawkins S, Langley MC, Kaharudin HAF, Suniarti Y, Husni M, Ririmasse M, Tanudirjo DA, Wattimena L, Handoko W, Alifah, Louys J (2019) Kisar and the archaeology of small islands in the Wallacean Archipelago. Journal of Island and Coastal Archaeology 14:198-225.

O'Connor S, Ono R, Clarkson C (2011) Pelagic fishing at 42,000 years before the present and the maritime skills of modern humans. Science 334(6059):1117–1121.

O'Connor S, Kealy S, Reepmeyer C, Samper Carro SC, Shipton C (2023) Terminal Pleistocene emergence of maritime interaction networks across Wallacea. World Archaeology DOI: 10.1080/00438243.2023.2172072.

Orton J (2008) Later Stone Age ostrich eggshell bead manufacture in the Northern Cape, South Africa. Journal of Archaeological Science 35:1765-1775.

Paz V (2012) Accessing past cosmologies through material culture and the landscape in the Philippines. In: Rountree K, Morris C, Peatfield AAD (eds), Archaeology of Spiritualities. Springer, New York, pp. 133-161.

Reepmeyer C, O'Connor S, Brockwell S (2011) Long-term obsidian use at the Jerimalai rock shelter in East Timor. Archaeology in Oceania 46(2):85–90.

Reepmeyer C, O'Connor S, Mahirta, Maloney T, Kealy S (2016) Late Pleistocene/early Holocene maritime interaction in Southeastern Indonesia – Timor Leste. Journal of Archaeological Science 76:21–30.

Shipton C, O'Connor S, Jankowski N, O'Connor-Veth J, Maloney T, Kealy S, Boulanger C (2019) A new 44,000-year sequence from Asitau Kuru (Jerimalai), Timor-Leste, indicates long-term continuity in human behaviour. Archaeological and Anthropological Sciences 11:5717-5741.

Shipton C, O'Connor S, Reepmeyer C, Kealy S, Jankowski N (2020) Shell adzes, exotic obsidian, and inter-island voyaging in the Early to Middle Holocene of Wallacea. Journal of Island and Coastal Archaeology 15:525-546.

Shipton, C., Kealy, S., O'Connor, S. in press. Pleistocene and early Holocene occupation on the eastern Wallacean islands. In Fitzpatrick, S. & Erlandson, J. M. (ed.) *Handbook of Island and Coastal Archaeology*. Oxford: Oxford University Press.

Szabó KA, Brumm A, Bellwood P (2007) Shell artefact production at 32,000-28,000 BP in Island Southeast Asia. Thinking across media? Current Anthropology 48:701-723.

Szabó KA (2010) Shell artefacts and shell-working within the Lapita cultural complex. Journal of Pacific Archaeology 1:115-127.

Vanhaeren M, d’Errico F, van Niekerk KL, Henshilwood CS, Erasmus RM (2013) Thinking strings: Additional evidence for personal ornament use in the Middle Stone Age at Blombos Cave, South Africa. Journal of Human Evolution 64:500-517.

Velazquez-Castro A (2012) The study of shell object manufacturing techniques from the perspective of experimental archaeology and work traces. In: Ollich-Castanyer I (ed), Archaeology, New Approaches in Theory and Techniques. InTech, Rijeka, pp 231-250.

Weisler M (2001) Life on the edge: Prehistoric settlement and economy on Utrok Atoll, northern Marshall Islands. Archaeology in Oceania 36:109-133.

Wilmsen E (1997) The Kalahari Ethnographies (1896-1898) of Siegfried Passarge: Nineteenth Centure Khoisan- and Bantu-Speaking Peoples. The Botswana Society, Gaborone.

Wilson B (1994) Australian Marine Shells: Prosobranch Gastropods, Vol. 2. Odyssey Publishing, San Diego.