The integrated cultural landscape of North Gidley Island: Coastal, intertidal and nearshore archaeology in Murujuga (Dampier Archipelago), Western Australia

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Abstract

Recent studies conducted in Murujuga Sea Country have confirmed that Indigenous Australian archaeology does not end at the modern shore. Since the earliest peopling of the Australian continent, sea levels have fluctuated significantly, dropping as much as 130 m below modern mean sea level during the Last Glacial Maximum (LGM). During this period, the continent (including Australia and New Guinea) represented a landmass one-third larger than present day Australia. As sea levels rose following the LGM, this extensive cultural landscape was inundated. The recent reporting of archaeological remains in a submerged context at Murujuga has enabled an integrated analysis of the archaeological landscape, based on direct evidence from archaeological sites that were originally formed on dry land, but are now located in intertidal and submerged environments. This study applies a landscape analysis centred on the submerged Cape Bruguieres channel site, and the Gidley Islands, where submerged, intertidal and coastal archaeology has been recorded. Aerial, pedestrian, and intertidal archaeological surveys were conducted to investigate the onshore and offshore landscape, providing new evidence with which to place the stone artefacts in the Cape Bruguieres channel into a wider context. Rock art engravings, grinding patches, quarries and upstanding stones – some of which are in the intertidal zone – point to the use of a landscape that is now submerged and to the possibility of discovering new underwater sites. By integrating evidence from subtidal and

intertidal contexts with the onshore record, we explore the cultural landscape above and below the 'waterline' as a continuum.

Introduction

The recent discovery of direct physical evidence of underwater archaeological material at Murujuga represents Australia's first published sub-tidal ancient Aboriginal archaeological site on the continental shelf (Benjamin et al. 2020; Wiseman et al. 2021). There is now an imperative in Australian archaeological practice to consider onshore terrestrial and offshore submerged landscapes as an integrated cultural whole. This is especially relevant as the current sea-level high-stand is higher than found throughout most of the earlier human occupation of Australia, and projected future sea level rise in the coming century is likely to further submerge at least some archaeological sites and cultural features that are at present on dry land. Here, we report on original fieldwork undertaken to provide an integrated study of a cultural landscape in Murujuga through a case study centred on North Gidley Island, a small but archaeologically rich island where the Cape Bruguieres channel site is situated.

The wider region is of relevance both nationally and internationally to the theme of submerged landscapes and Indigenous underwater archaeology. It has a rich onshore record including millions of rock art engravings, open-air sites with abundant stone artefacts, rockshelter deposits, stone structures, shell middens, and an archaeological sequence that extends back into the low sea-level periods of the last glacial. It has also yielded archaeological materials in the intertidal zone and offshore at greater depth.

The intertidal zone is of particular importance because it often exposes archaeological materials that can provide important clues to patterns of land use when sea levels were lower than present and to the presence of archaeological sites at greater depth and further offshore. Off-shore studies of submerged terrestrial landscapes have often been neglected as they fall midway between the interests of terrestrial archaeologists and underwater archaeologists (Bailey and Hardy 2021). This poses challenges to interpretation because the archaeology present in underwater landscapes may represent materials deposited on a terrestrial land surface when sea levels were lower than present, or artefacts displaced from more recent onshore deposits by erosion, or coastal maritime activities that took place during the most recent mid-to-late Holocene sea-level highstand, for example construction of fish traps (Bailey et al. 2020a:15–16). The modern intertidal zone should be a central feature in a study that seeks to integrate the

archaeological record above and below the present waterline (see also Dortch et al. in press; Morrison 2019).

In this paper we provide a case study of an integrated onshore-offshore landscape investigation focused on the Cape Bruguieres channel and the adjacent islands of North Gidley and Middle Gidley[1]. We summarise the archaeological results obtained from the Cape Bruguieres channel by Benjamin et al. (2020), and present new discoveries resulting from surveys of the adjacent islands in order to place the original discoveries in their wider cultural and landscape settings. We present the methods we have used in the new investigations and discuss the results and their wider significance.

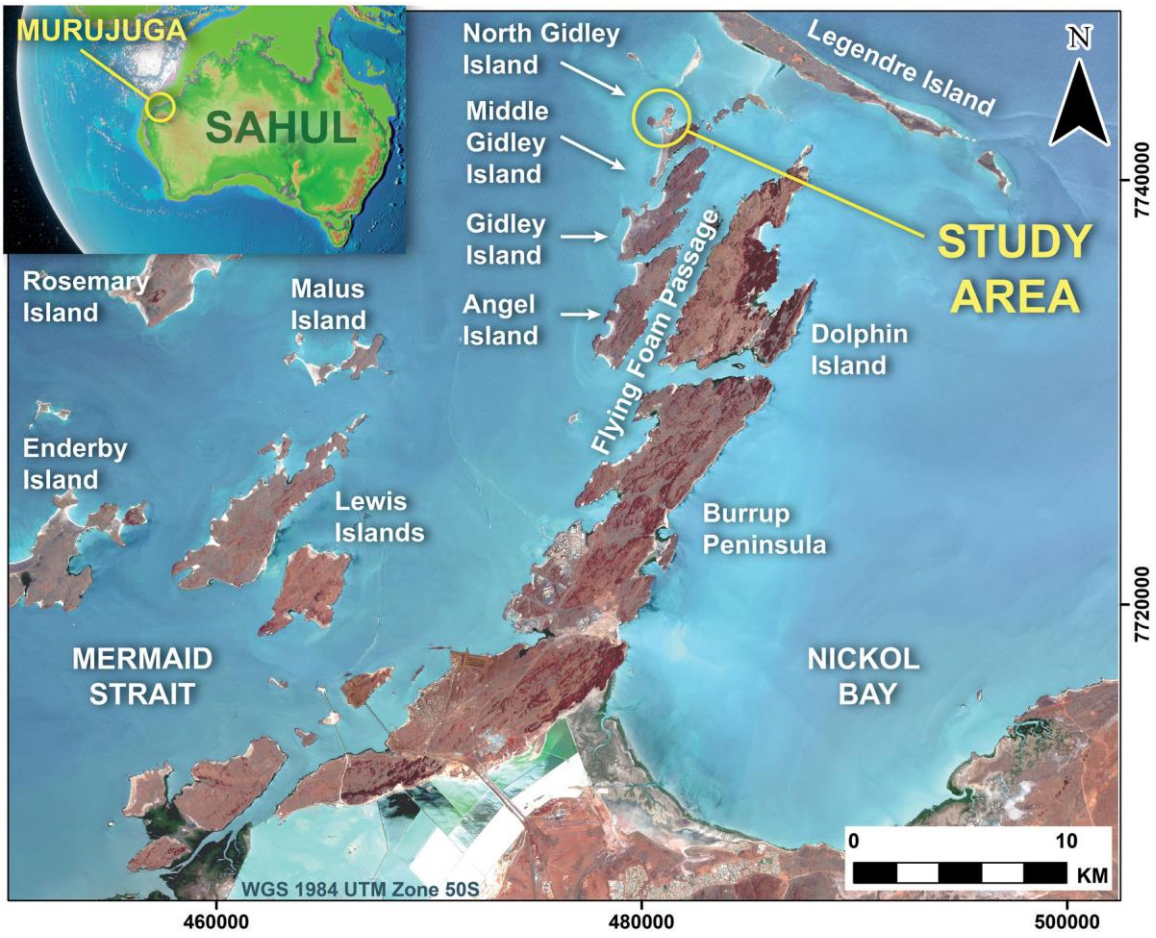

Figure 1 The islands of Murujuga, showing the location of the Study Area. Inset: the extent of sub-aerially exposed land circa 25ka. Copernicus Sentinel data 2016 for Sentinel data.

[1] The two islands directly north of Gidley Island are the focus of this study. These are not currently listed in the Gazetteer of Australia (2012), and as a result, a number of different naming conventions have been used for these places (most recently in Benjamin et al. 2020 and Wiseman et al. 2021). An internal Western Australian Government database for the Pilbara Coast has unofficially named the two islands north of Gidley as Middle Gidley Island and North Gidley Island. For this paper we have assumed that these islands will be gazetted in the near future and hence we adopt this naming convention (i.e. Gidley, Middle Gidley and North Gidley Islands) in this paper.

Background

Over the past 40 years a range of research projects have sought to identify submerged archaeological landscapes in Australia, but the identification of archaeological features has proved elusive. In 1982, Flemming (1983:150–153) conducted systematic diver surveys on the Cootamundra Shoals, a karstic valley system located on the continental shelf between Northern Australia and the island of Timor that is a potential route for the first peopling of Australia (Bird et al. 2018, 2019). No potential archaeological material was identified during these surveys. In 1990, Dortch and Godfrey (1990:3–8) recovered stone artefacts from the bed of Lake Jasper, located in southwestern Western Australia. These were recovered both from the shoreline during low lake levels and from a later diver survey when the lake had returned to normal levels. Although this project confirmed that artefactual material could be identified and retrieved from an underwater context, the lake is located several kilometres inland and could not be considered an analogue for marine contexts. Dortch (1991:1; Dortch and Dortch 2019:15) also attempted to identify submerged sites on Rottnest Island. In the early 2000s, Dortch (2002:38) led diver surveys at Murujuga to identify submerged petroglyphs and other archaeological features. Seven sites at a depth range of 10–20 m were targeted during these surveys, yet archaeological material was not encountered. Coroneos et al. (2007 in Nutley 2014:266) investigated submerged rock shelters at South West Arm at Port Hacking in New South Wales and concluded that it was 'highly probable' that they were utilised by past Aboriginal communities, however they did not identify supporting archaeological evidence.

Scientific recognition of the existence of drowned landscapes and sea-level rise dates back over a century (e.g. Reid 1913). Research in this area initially progressed slowly, but recent advances in underwater archaeology, sea-level analysis, and remote sensing have lent substantial momentum to the subject globally, together with a growing accumulation of underwater archaeological sites amounting to many thousands of find spots, mostly in Europe and North America (Bailey et al. 2017; Bailey et al. 2020b; Benjamin et al. 2011; Evans et al. 2014; Harff et al. 2016). The recovery of Aboriginal artefacts from a submerged context confirms what has been communicated through Indigenous oral histories in many parts of coastal Australia: that Aboriginal people once extensively occupied the now-drowned continental shelf (Bradley and Kearney 2018:292; Nutley 2014:260). Current research has demonstrated the potential for archaeological landscapes to be preserved in a variety of submerged contexts (Veth et al. 2020) and points to the likelihood that thousands of Indigenous archaeological sites are preserved on the continental shelf of the Australian continent.

Deep History of Sea Country (DHSC) and *Murujuga: Dynamics of the Dreaming* (MDD)

The recent *Deep History of Sea Country* project developed a regionally specific survey strategy to identify archeologically prospective submerged features in Murujuga Sea Country (referring to the traditional area of water to the Indigenous people of this region, **Error! Reference source not found.**). The development of a predictive model (McDonald 2015; Veth et al. 2020:16–21) was facilitated by extensive onshore surveys and excavations during the *Murujuga: Dynamics of the Dreaming* project which characterised and dated archaeological sites, and systematically recorded rock art and stone features on the islands of the archipelago (McDonald et al. in press, 2021). The DHSC project mobilised the onshore record to identify similar site types and their landscape contexts on the seabed. Using a multi-scalar and iterative marine survey approach (Wiseman et al. 2021) resulted in the identification of many prospective landforms and geomorphic features (Benjamin et al. 2018, 2020). In this article, we consider the stone artefact concentrations recorded in the Cape Bruguieres channel through the continuous archaeological landscape of the surrounding islands and nearshore environments, extending the scope of the study from site scale to landscape scale.

Environmental Background

Prior to the Last Glacial Maximum (LGM), Murujuga would have been an upland range situated approximately 160 km southeast of the nearest coastline. For coastal communities during this period, this range would have also been the nearest source of rhyodacite outcrops for lithic manufacture. The hinterland separating the Dampier Range from the LGM coastline comprised a broad gently seaward-sloping, alluvial plain interspersed with ephemeral waterways, rivers, estuaries, hillocks, knolls, lithified dunes, stranded calcarenite beach ridges and fossil coral reefs (Benjamin et al. 2020:4; O'Leary et al. 2020; Semeniuk 1993:237; Ward et al. 2013:218). The northward-flowing waters of the Nickol and Maitland Rivers, located to the east and west of the archipelago, would have flowed intermittently following heavy rains (Ward et al. 2013:222). These rivers and ephemeral drainage systems formed a series of overlapping deltas that acted as accretionary systems. This landscape was slowly drowned during the subsequent marine transgression following the LGM.

Marine transgression profoundly transformed the landscape of the western Pilbara ranges. By 18 ka, the sea level had begun to rise and by 12 ka the coastline had encroached to within 30 km of the Dampier Ranges. During this period, coastal communities retreating with the landward transgression of the shoreline would have begun to converge with the upland communities of the Dampier Ranges, allowing more proximal access to marine resources. Terminal-Pleistocene transgression rates were rapid, and the coastline encroached on the outer reaches of the Dampier Ranges by about 10 ka (Ward et al. 2013:220). The valleys became inundated, separating the high points of the Dampier range. By 8 ka, Mermaid Strait had formed; however, Angel Island and the Gidley Islands remained a single landform. By 7 ka, Enderby and Rosemary Islands had separated from the mainland and tidal actions began to infiltrate ephemeral waterways, such as the Cape Bruguieres channel separating Middle and North Gidley Islands. The sea level continued to rise, reaching a high stand approximately 2 m above current levels around 6.5 ka, then regressing to current levels by 2 ka (Lewis et al. 2013:130).

Cultural and Archaeological Background

Murujuga has one of the highest concentrations of Indigenous sites recorded in Australia (McDonald and Veth 2009; Vinnicombe 2002). High site densities have been attributed to a combination of the slowly eroding nature of the fine-grained crystalline rocks (rhyodacite) which dominate the geological terrain (Pillans and Fifield 2013) and the resultant preservation of a proliferation of symbolic and economic archaeological evidence (Lorblanchet 1992; McDonald 2015; McDonald and Veth 2005, 2006; Mulvaney 2015). When people first entered this part of the Pilbara bioregion, they would have encountered a highly dissected hilly (upland) terrain comprising semi-permanent water holes and springs. Once the sea reached its current stand, around 2 ka, the seasonal abundance of coastal marine resources continued to make this landscape attractive to past Aboriginal communities.

The earliest archaeological work in Murujuga was prompted by the development of a port to facilitate iron ore exports from the Burrup Peninsula in the 1960s. As industrial development pressures increased in the region, the Western Australian Museum documented the cultural and archaeological significance of Murujuga (Wright 1972; Palmer 1975). The first large-scale archaeological survey was conducted by Pat Vinnicombe and Jim Rhoads (1987a:8–9) in 1980, prior to the construction of the North West Shelf Karratha Gas Plant. Covering an area of 12 km^2, this was primarily a record-and-salvage project (Vinnicombe 1987b, 2002). A wide range

of site types were recorded including engravings, stone structures, middens and stone tool manufacture sites. By 2006, over 2,500 sites had been registered for Murujuga with the Department of Indigenous Affairs, information which was mobilised during the scientific values assessment for the National Heritage Listing (McDonald and Veth 2006, 2009). While many of these sites were recorded during development clearance surveys (Bird and Hallam 2006:5) information was gleaned from other less extensively surveyed areas, which demonstrated the widespread distribution of sites with high cultural and scientific significance (McDonald and Veth 2009; Veth 1995; Ward and Mulvaney 2018:18). Vinnicombe (2002) determined that the density and continuity of cultural material at Murujuga was sufficient to describe the region as a continuous archaeological and cultural landscape. This has been substantiated by more recent assessments (Lawrence 2012; McDonald and Veth 2011).

Over 60% of the 2,534 sites analysed for National Heritage Listing are engraving sites associated with other site features; 14% also have artefact scatters and modified stone structures (e.g. pits, standing stones, lines, circles and terraces); 2.5% are quarry and reduction areas; and 2.1% are shell middens and grinding patches. Very high site densities have been recorded from a range of research, mitigation and heritage management surveys (see McDonald 2015). Approximately 50 km^2 of the Burrup Peninsula and inner islands have now received some level of recording with an average density of 45.6 sites per km^2 (with a range of 17–254 sites/ km^2) and average petroglyph densities of sites 26.0 per km^2 (with a range of 1.2–218 sites/ km^2, see McDonald 2015: Table 2).

The *Murujuga: Dynamics of the Dreaming* project (McDonald 2015; McDonald and Berry 2017) undertook significant systematic recording of archaeological evidence from across the outer islands, identifying 12,259 rock art motifs, 761 grinding patches and 295 stone features and conducting excavations across 14 landscapes (Dortch et al. in press; McDonald et al. 2018, in press 2021; Paterson et al. 2019).

Cape Bruguieres channel (North Gidley Island)

The first confirmed sub-tidal Aboriginal archaeological site in Australia was recorded in the Cape Bruguieres channel in the outer islands of Murujuga Sea Country in the Pilbara, North Western Australia (Benjamin et al. 2020). The study area covers the islands bordering the Cape Bruguieres channel: North Gidley Island, Middle Gidley Island and Collier Rocks (Figure 1). The Cape Bruguieres channel is a 2.5 km-long tidal channel separating North Gidley Island

and Middle Gidley Island. It has a central U-shaped curve dividing the Pleistocene aeolianite of North Gidley Island and a cemented calcarenite terrace on Middle Gidley Island. The terrace is flanked by a modern dune system to the south and west and by ephemeral waterways, rocky slopes and mangroves to the east. North Gidley Island comprises Pleistocene aeolianite along the channel fringes, with outcrops of microcrystalline rhyodacite to the west and north separated by a sandy beach alcove. The channel is comprised of relict Pleistocene aeolianite and mobile sands (Benjamin et al. 2020:9).

Diver investigation and pedestrian surveys in the Cape Bruguieres channel revealed the presence of 269 submerged lithics. The stone artefacts were recorded on a relict Pleistocene aeolianite (Benjamin et al. 2020:11) and post-field analysis confirmed that 190 of the artefacts were in a permanently submerged context, while 79 artefacts were recorded in the intertidal zone along the mid-channel sill or outer edges of the channel. A second artefact concentration comprising 455 stone artefacts was recorded on the calcarenite terrace, contiguous with the southern boundary of the channel (Benjamin et al. 2020:11). A single radiocarbon date from a bivalve shell cemented into the top surface of the calcarenite terrace returned an age of 2446±65 BP (1791–2141 cal BP; Wk–49709) (Benjamin et al. 2020:10). A sample of each artefact concentration underwent portable X-Ray fluorescence (pXRF) analysis revealing that they were sourced from locally available materials consistent with the geology of both Middle Gidley Island and North Gidley Island (Benjamin et al. 2020). Although both the Cape Bruguieres channel and terrace artefact concentrations are similar in material composition, they differ statistically in size ranges (based on maximum dimension). The submerged artefacts are primarily in the 6–12 cm range while artefacts in the 2–8 cm range are more prevalent along the onshore terrace (Benjamin et al. 2020).

Artefact types identified in the Cape Bruguieres channel include mullers, core tools, cores, retouched flakes and two potential grindstones. These stone artefacts were interpreted by Benjamin et al. (2020:11) as an in situ concentration which was subsequently submerged approximately 7,000 years BP following marine transgression. Alternative hypotheses for the deposition of the artefacts were examined, including the possibility of secondary displacement by erosion from younger onshore deposits. These were ruled out by geomorphological and taphonomic observations and analyses in favour of in situ deposition on a former land surface.

The stone artefact concentration from the terrace bordering the channel comprises flakes, retouched flakes and cores as well as 57 cairns and curvilinear stone structures, constructed

from fractured plates of calcarenite beach rock. Analysis determined that this archaeological material post-dates formation of the terrace, establishing activity to within the last 2,000 years (Benjamin et al. 2020:14). There is also extensive evidence of associated archaeological shell eroding from deflated midden deposits in the bordering Holocene dune system (Benjamin et al. 2020:14).

No typologies have been developed for the stone artefacts identified within Murujuga. Further to this, no peer reviewed studies have been conducted in the broader Gidley Islands landscape. As such, our study builds on previous research to undertake landscape surveys in the area encompassing the Cape Bruguieres channel to gather data on the integrated onshore and offshore archaeological record of North and Middle Gidley Islands.

Methods

Aerial imagery

Extensive aerial surveys were conducted over Murujuga Sea Country in 2017 and 2018 to acquire high-resolution data to identify terrestrial and submerged landscape features (Wiseman et al. 2021). An HK36TTC-ECO Dimona motorglider with wing-mounted bathymetric and topographic LiDAR sensors and a Canon 5D Mk4 was deployed to collect these data. We utilised the RGB imagery collected with a Canon 5D Mk4 fitted with an EF 24 mm lens synchronised with a Q680i-S (Benjamin et al. 2020:6). Orthomosaics were created with DxO Optics Professional with a pixel size of 15 cm. The orthomosaic covering the Cape Bruguieres channel was assessed to identify landforms and archaeological features consistent with the DHSCs landscape modelling to target field surveys (Veth et al. 2020:11).

Onshore / Intertidal Pedestrian survey

A series of pedestrian surveys were conducted in the landscape surrounding Cape Bruguieres channel to acquire data to contextualise how the landscape was utilised by past Aboriginal communities. Landscape features correlating with the DHSC's landscape modelling (including coastal and interior valleys, outcrops flanking mangroves and sandy bays, dunes and sandy bodies flanking embayments and rhyodacite outcrops) were identified in the aerial imagery and flagged for inspection. The purpose of these surveys was to identify archaeological features including quarry sites, artefact scatters, middens, standing stones, grinding patches, engravings and ephemeral water sources that could inform on the Cape Bruguieres channel stone artefacts (Veth et al. 2020:11).

Drone survey

Two drones were used for the collection of aerial imagery in the field: the DJI Mavic 2 Pro (M2P) and the DJI Phantom 4 Pro (P4P). The M2P was carried on all pedestrian surveys to obtain aerial imagery of archaeological and landscape features identified in the field. This M2P was selected for its compact size, high quality one-inch 20Mp Hasselblad sensor and 32 minute flight time. The larger, Phantom 4 Pro (P4P) was deployed for all pre-programmed missions. The P4P's mechanical shutter is more suitable for mapping but its size makes it impractical to carry during pedestrian surveys.

Drone Deploy 2.83.0 was used to program all drone missions for data capture. Orthomosaics were created with Agisoft Metashape 1.6.2. All orthomosaics were completed with the highest possible settings. Workflows followed standard procedure: align photos, build dense cloud, build mesh, decimate mesh, build texture, build DEM and build orthomosaic. Orthomosaics and DEMs were exported to ArcMap 10.8 for analysis and map generation. The orthomosaics were cross-referenced with photos of archaeological features in the field. The locations of archaeological features were plotted in ArcMap using the location data from photos.

Results

North Gidley - Northwest

An exposed rhyodacite boulder field within a protected sandy embayment northwest of North Gidley Island conformed to predictive landscape modelling and was targeted for inspection. Pedestrian survey identified a quarry and large artefact scatter along 200 m of the shoreline and extending into the intertidal zone. The pedestrian survey, conducted on a spring low but rising tide, initially identified 32 artefacts in the intertidal zone (Figure 2)**.**

Figure 2 (Top Left) Northwest North Gidley Island quarry and artefact scatter; (Top Right) Flake from North Gidley Island quarry and artefact scatter; (Bottom Left) Northwest North Gidley Island mobile sands aerial imagery from 2018; (Bottom Right) Northwest North Gidley Island mobile sands drone imagery from 2019 (Photos: S. Wright and J. Benjamin).

Detailed recording was not completed, however artefacts were photographed and their locations recorded with a Garmin eTrex GPS unit (accuracy of three metres). A mixed assemblage of small flakes, cores and quarried bedrock were identified within the intertidal zone. Large multiplatform cores with dimensions exceeding 400 mm were recorded (**Error! Reference source not found.**). Examples of platform preparation and cortex removal were also identified. Identified flakes ranged in size from 60 – 200 mm. No formal tools were recorded however use wear, edge damage and retouch were identified on the majority of flakes. Several flakes also exhibited dentate retouch. Flaked stone artefacts and worked bedrock were observed along the onshore and intertidal zones although visibility was limited by mobile sands.

Figure 3 Archaeological features recorded in the intertidal zone of Northwest North Gidley. Insets – (Top left) Quarried boulder; (Top right) Large multi-platform core; (Bottom left) Quarried bedrock; (Bottom right) aerial image of Northwest North Gidley intertidal zone (Photos M. O'Leary and J. Benjamin).

The dynamic nature of the site became apparent during the survey. A sand spit had formed off the northern tip of North Gidley Island that was not present in the reviewed aerial imagery from 2018. Comparative analysis of the drone imagery acquired in the field (2019), satellite imagery and RGB imagery from the motorglider survey (2018) revealed high variability between the data sets.

Two highly eroded engraving panels were identified 10 m (horizontal) away from the visible high-water mark on the southern periphery of the intertidal quarry site (see example in **Error! Reference source not found.**). These panels are located approximately 200 m south of the intertidal artefact scatter but on the same rhyodacite bedrock. High concentrations of worked rhyodacite are present along the contiguous rock slopes. Flakes, single-platform cores and multi-platform cores were identified in this area. Sporadic engraved panels are present

throughout this area. There is extensive archaeological material on the high ground of the rock slopes. Engraving galleries, quarry sites, artefact scatters and grinding patches are also present in this area.

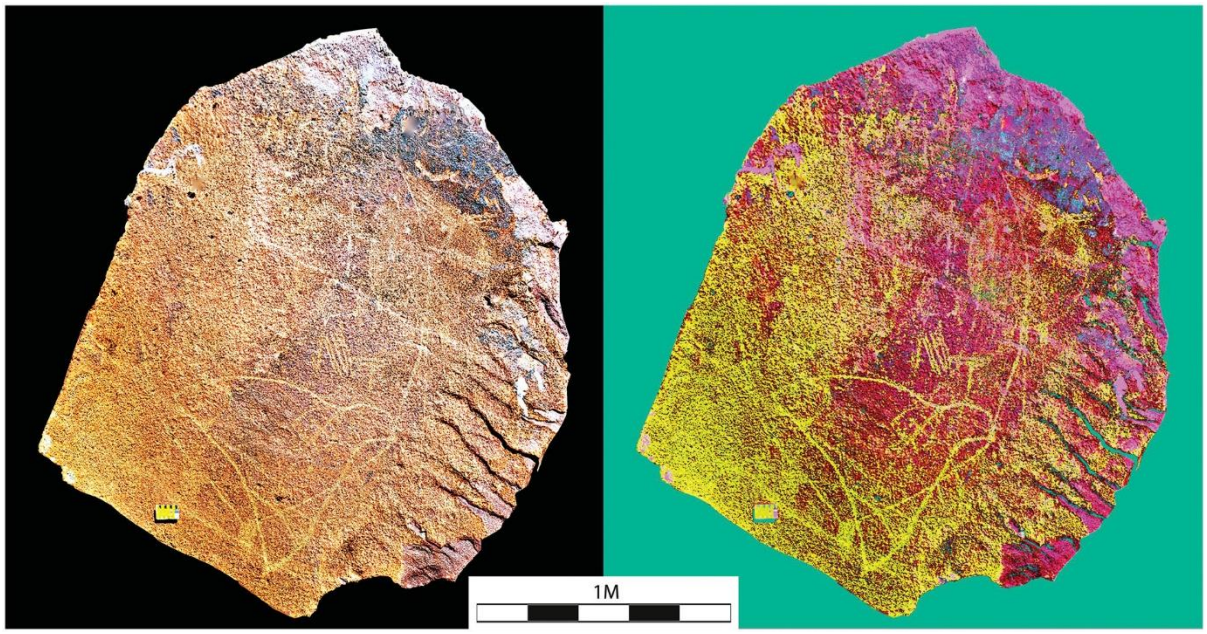

Figure 4 Orthomosaic of the degraded engraving panel, Northwest North Gidley Island (R) with the clearest engravings highlighted (L) (Photos J. Leach).

North Gidley - Northeast

An extensive beach rock exposure, extending approximately 200 m along the shoreline, was identified on northeast North Gidley Island (Figure *5*). Flaked stone tools produced from locally available rhyodacite were observed along the full extent of the exposure, embedded in the beach rock. Rhyodacite outcrops are present on the southern and northern extremities of this exposure. The beach rock is situated slightly above the mean tidal datum indicating that it was probably formed as a result of retreating sea levels following the mid-Holocene highstand 7 to 5 ka. This beach rock should provide a robust dating chronology for the cementation of the artefactual material. A large rhyodacite outcrop continues 50 m further onshore from the beachrock, separated only by mobile sands. Evidence of quarrying continued in multiple locations along the southern rhyodacite outcrop in the intertidal zone. A broad range of detached rhyodacite artefacts are also present in this rock outcrop.

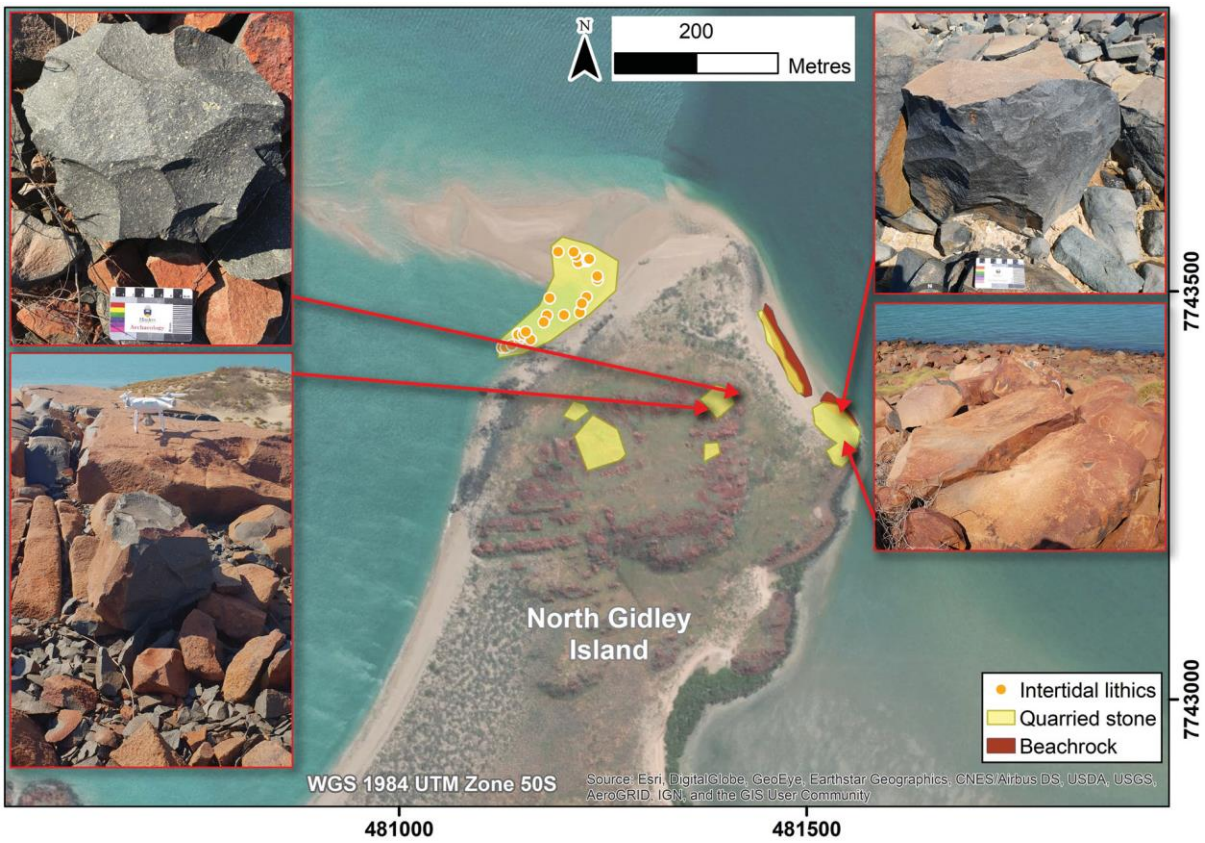

Figure 5 North Gidley Island. Insets – (Top left) Large multiplatform core; (Top right) Quarried boulder in the intertidal zone; (Bottom left) Quarried boulder and artefact scatter; (Bottom right) Grinding patches and associated engravings within quarry site (Photos J. Leach).

Evidence of quarrying continues along the rock outcrop, above the intertidal zone. Further engravings are present upslope, these depicting a range of anthropomorphic, zoomorphic, and geometric figures. Grinding patches are also present at several locations on this outcrop. Concentrations of stone flakes are present in the interstices of angular boulders and open exposures. Degraded shell and artefactual material are present in the sand upslope of the rock outcrop. Restricted ground visibility due to thick spinifex hummocks impeded surface visibility. A large rhyodacite outcrop is located to the west of the beach rock, separated by low sand dunes. Extensive archaeological material was present on the high ground of the rock slopes. High density engraving galleries, quarry sites, artefact scatters and grinding patches were all identified in this area.

North Gidley - Southwest

A large rhyodacite outcrop extends below the waterline on the southwest of North Gidley Island. Isolated engravings were identified proximal to the intertidal zone. These engravings are not located within the current intertidal zone however their surface patina appears to have been impacted by exposure to salt water. A cluster of grinding patches was identified in close

proximity to three lenticular engravings. The density of engraving galleries increases further upslope, away from the intertidal area.

Burrup patches were identified along the summit of the rhyodacite rock outcrop. Burrup patches are defined as 'flat clear areas, like platforms, among the boulder slopes where floors of small compacted angular stones standout as significantly different from the tumbled array of boulders around them' (Vinnicombe 1987b:23). Large areas infilled with small, angular stones were observed here. Some of this material exhibited evidence of flaking, however it is unclear if the concentrations of small stones resulted from natural or cultural processes. High densities of engravings were identified along the summit wherever outcropping rhyodacite was encountered.

Quarrying was also identified at three locations on southwest North Gidley Island. Two of these quarrying locations comprised single rhyodacite boulders that had been worked on a single edge. Both of these sites were in close proximity to the intertidal zone and may represent the upper periphery of a now submerged quarry site. These are isolated quarrying events rather than evidence of areas of extensive and consistent quarrying to indicate a quarry site, however the summit of this rhyodacite outcrop also exhibits a high density of engravings, grinding patches and flaked stone, correlating with the DHSC landscape model. The aerial imagery reveals that the rocky slope on which these boulders are located extends below the waterline suggesting the potential for evidence of quarrying in a submerged context. Another quarrying site was recorded on the eastern periphery of this outcrop only 500 m from the Cape Bruguieres channel. Sub-tidal quarries are thus a probable site type for future investigation as they should be visible on rocky outcrops on the seabed around the archipelago.

Middle Gidley Island

Two pedestrian surveys were conducted on Middle Gidley Island to investigate an ephemeral waterway and contiguous rhyodacite rock outcrops. The ephemeral waterway is located approximately halfway between a clay pan to the south and the Cape Bruguieres channel to the north. This drainage channel had no water present at the time of survey. A macropod engraving with heavy pecking (potentially a macropod regeneration site, see Daniel 1990) and an engraving of an anthropomorphic figure with a headdress and a boomerang in each hand was identified on a rhyodacite outcrop adjacent to the creekline.

This ephemeral waterway borders mangroves and outcropping rhyodacite at its downstream end. Engravings here are zoomorphic, anthropomorphic, spooromorphic and geometric motifs.

Heavily worn grinding patches were identified on horizontal rhyodacite surfaces, some in association with engravings.

A rhyodacite slope located approximately 100 m east of the mouth of the ephemeral waterway has further engravings, as well as four standing stones. The largest standing stone, approximately 100 cm in height, is located at the top of the slope. Another standing stone, located in a small stone depression is in close proximity to a stone exhibiting a small semi-circular bruised engraving.

Collier Rocks

A brief visit was made to the western side of Collier Rocks, a small rock outcrop 800 m northeast of Cape Bruguieres channel, approximately one hectare in size and surrounded by water. Collier Rocks has a surprisingly high-density of engravings. Anthropomorphic, zoomorphic and geometric figures were all identified however marine species dominated the galleries. A standing stone, approximately 1 m in height, was identified at the summit of the rock outcrop wedged between several large rocks. Engravings are present in the immediate vicinity of this standing stone. A Burrup patch was also identified at this site. Two tidal fish traps were identified in the LiDAR imagery within 1.5 km of Collier Rocks.

Discussion

Pedestrian surveys confirmed remote sensing indicators that there is evidence for a range of subsistence activities across the Gidley Islands group. Grinding patches, quarry sites, semi-permanent water sources and engraved terrestrial and marine species all inform on how past Aboriginal communities interacted with this landscape (

Figure *6*). The archaeological record of the Gidley Islands landscape is an integrated land and sea scape. By understanding this broad range of site types we can enhance our understanding of this cultural landscape, its past inhabitants and their subsistence practices prior to, and during, marine transgression.

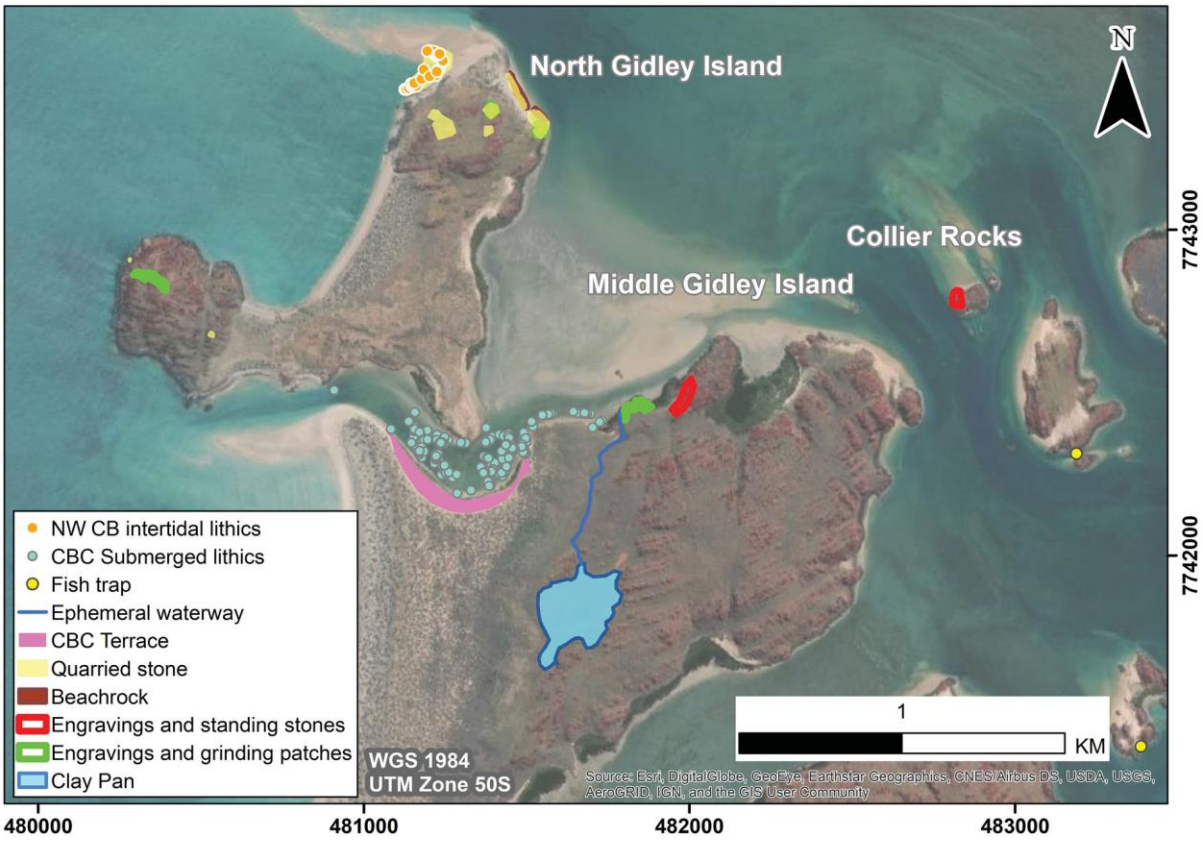

Figure 6 Archaeological features discussed in the northern Gidley Island Group landscape.

A resource-rich landscape

A broad range of archaeological features were identified in the northern Gidley landscape that provide information on subsistence resources utilised by past Aboriginal communities. Grinding patches were identified on Middle and North Gidley Islands at all locations where rhyodacite exposures were investigated (

Figure *7*). Many of the grinding patches exhibit highly polished surfaces and heavy alteration of the stone face. The presence of grinding patches indicates that seed resources, most likely spinifex (Reynan and Morse 2016), were once processed in this landscape. *Triodia epactia* and *Triodia wiseana* are present on the Gidley Islands, spinifex species that were targeted for their seeds by past Aboriginal communities (Murujuga Cultural Management Plan 2016:122–123). Several grinding patches were identified in close proximity to engravings, including at Middle and North Gidley islands, demonstrating this environment was used for a mixture of resource exploitation and other activities. Residue analysis is yet to be carried out on these grinding patches, and is required to confirm their possible uses.

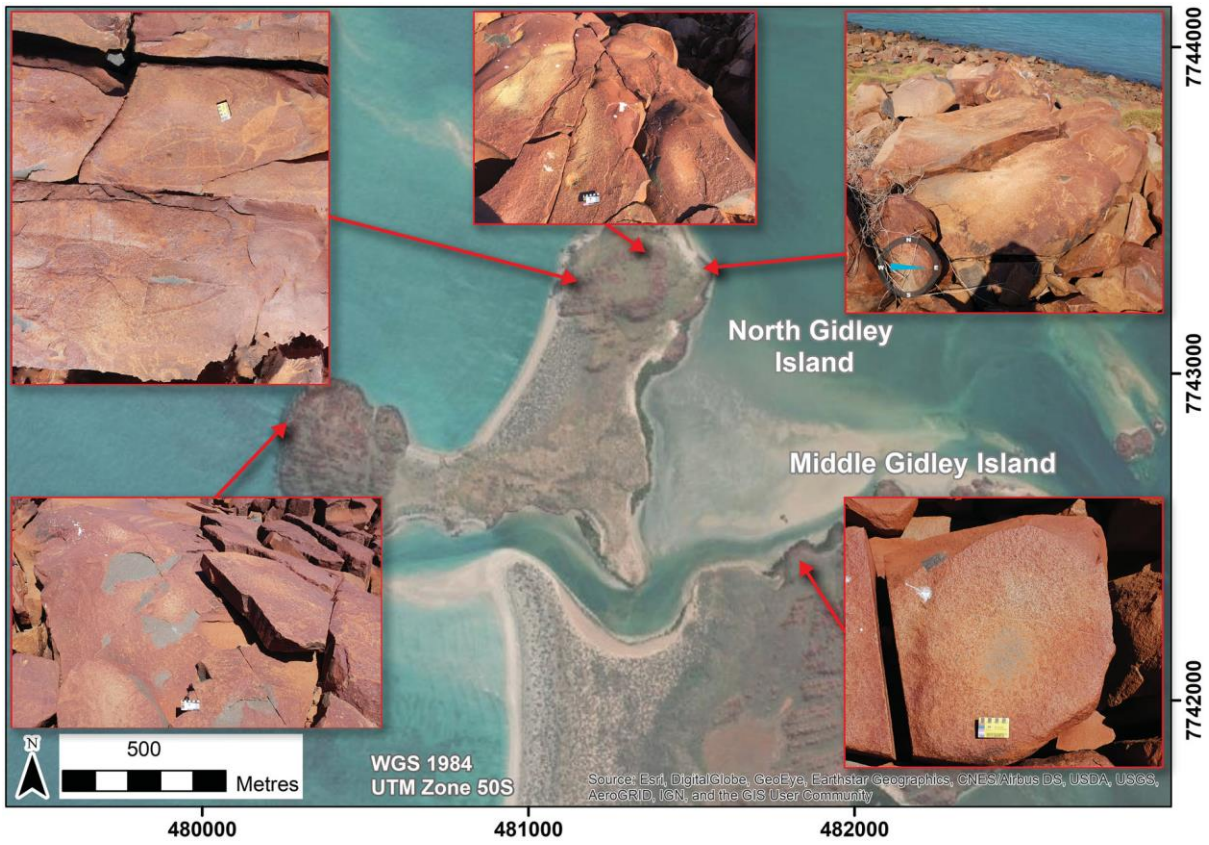

Figure 7 Grinding patches identified in the North Gidley Island landscape (Photos J. Leach).

Two large stone slabs identified in Cape Bruguieres channel during diver surveys are interpreted as portable grindstones (Benjamin et al. 2020;

Figure *8*). Despite heavy concretion, almost all granophyre objects found in the channel bore distinctive marks of cultural use, mostly as stone tools or flakes, while those not identifiable as modified were generally very small and/or concreted. This suggests that almost all granophyre material in the channel was brought there by humans. These two large granophyre objects found in the channel bed represent by far the largest objects found in the channel and were interpreted as possible grindstones. Archaeological evidence of grinding is ubiquitous in this environment in the form of grinding patches. These two stones are at the upper limit of portability with respect to weight, and, given their weight, are especially unlikely to have been introduced by any natural process. In both cases the stones appear to have flat surfaces with possible traces of grinding, although the presence of concretions and the very hard nature of the rock make it impossible to determine this definitively.

Figure 8 Two potential portable grind stones identified in a submerged context in the Cape Bruguieres channel (Photos H. Yoshida and J. Benjamin).

There is evidence that marine resources were exploited by Aboriginal communities in this landscape. Deflated middens were identified on the surface and eroding out of dunes adjacent to the calcarenite terrace next to the Cape Bruguieres channel. These contain a range of species including *Melo* sp. (Baler) and *Tegillarca granosa* (syn. *Anadara granosa*, blood cockle) (Benjamin et al. 2020). Two intertidal fish traps were identified in the aerial imagery on the eastern periphery of the study area. These sites have not been confirmed by pedestrian survey as yet. The engraving galleries depict a wide range of marine species, including dugong, turtle and a range of fish, that were utilised by past Aboriginal communities.

A recurring observation throughout archaeological studies conducted in Murujuga is that archaeological features, particularly high-density engraving sites, are concentrated around water sources (Bednarik 2007:236; McDonald 2015:132; McDonald and Veth 2009:56; Mulvaney 2011:22; Veth et al. 2020:2; Vinnicombe 1987a:2). Murujuga is arid with no permanently flowing waterways: rock holes and other ephemeral water sources were integral for the survival of past Aboriginal communities (Bindon 1997:174). The ephemeral waterway identified on Middle Gidley Island drains a large clay pan, which fills following heavy rain. The proximity of engravings and grinding patches on rhyodacite outcrops contiguous with this waterway may indicate that past Aboriginal communities targeted this as a seasonal water source (Bednarik 2007:236; McDonald 2015:132; Vinnicombe 1987a:32, 1987b:32). Changing climates in Murujuga during human occupation are summarised by Ward et al. (2013:217) and show a pattern of general aridity giving way to increasing humidity after 11.7

ka. This may have improved access to food sources and facilitated reduced population mobility, although aridity increased again from 6.5 ka after the stabilisation of sea level.

The scale of quarrying on North Gidley Island suggests that the lithic material found here was highly valued. Pedestrian survey recorded 32 examples of worked stone in the intertidal zone on Northwest North Gidley Island. Extensive quarrying and high-density artefact scatters were also documented along the adjacent rhyodacite slope and summit. The northeast of North Gidley Island exhibits further quarrying and lithic materials extending into the intertidal zone. Single platform cores, multi-platform cores, flakes and debitage are present throughout the intertidal zone in the northwest, across the summit of the large rhyodacite outcrop in the north of the island, and into the intertidal zone in the island's northeast. Tens of thousands of flakes appear to be present in some deposits. Some of these lithic deposits are so large that they are visible in the orthomosaics created from the drone data. The sheer scale of this site suggests that quarrying was intensive in this area. As noted by Vinnicombe (1987a, 1987b), Murujuga is a palimpsest (see Bailey 2007), and it is difficult to clearly define boundaries between sites.

A review of archaeological sites in Murujuga identified quarry sites and reduction areas as accounting for just 2.5 percent of sites in the archipelago (Veth et al. 2020:10). The presence of these quarrying and reduction sites in association with engravings and grinding patches, extending into the intertidal zones suggests that the archaeological record of the Gidley Island group is of high significance (Vinnicombe 1987a:62). It is not possible to determine if the onshore and intertidal lithic materials are contemporaneous, and it unknown whether these stone resources were targeted by past Aboriginal communities prior to the relative stabilisation of modern sea levels during the mid to late Holocene. Diver surveys will be required to determine how long this quarry site was utilised and how important it was regionally as a source for stone artefacts.

A symbolic landscape

North Gidley Island is a highly modified landscape. Engraved galleries and standing stones which are found across the entire archipelago (McDonald & Veth 2011:51; Vinnicombe 1987b:32) were all identified during this study. Standing stones are found in many parts of Australia where they have been interpreted as landscape markers (Elkin 1933:283) or physical manifestations of ancestral spirits (Gould 1968:101). In Murujuga, standing stones take the form of naturally formed columnar stones found wedged between rocks in a vertical position (Vinnicombe 1987b:32). They are generally found on prominent ridges or other conspicuous

locations and they are sourced from naturally occurring, local stone. They have been recorded as individual stones, in pairs, and in large groupings (Vinnicombe 1987a:69). McDonald and Veth (2013:75) state that stone features generally may have become more prevalent in the last millennium, with a decrease in petroglyph production, and that they may contribute a ritual component that was previously fulfilled by engraving production. Five standing stones were identified in the Gidley group landscape; four on Middle Gidley Island (

Figure *9*) and one on Collier Rocks. Fifty-seven stone features were also recorded on the calcarenite terrace platform of Middle Gidley Island by Benjamin et al. (2020).

Figure 9 Standing stone on Middle Gidley Island overlooking the Cape Bruguieres channel (Photo J. Leach).

Regeneration sites are ceremonial areas of rock art where flora and fauna were depicted with the aim of encouraging their presence or increase. This type of site is known in the Western Pilbara as 'thalu' (plural thalus) (Daniel 1990). Many of these depict an indeterminate species of kangaroo or wallaby and are referred to with the generic term 'macropod regeneration site'. Thalus can are generally represented by a standing stone, a pile of stones, a boulder arrangement (McDonald and Veth 2011:45) or a stone pit (Piddington 1932:395). Rituals performed at these sites often involve hammering the ceremonial object with round stones or clubs (McCarthy 1961:146) or impersonating the actions of the subject being willed (Clement 1903:6). The extensive geographic network of thalu sites present on Murujuga demonstrates a spatially co-ordinated pattern of landscape modification and attests to the cultural significance of this landscape (McDonald and Veth 2011:46). A macropod engraving with heavy pecking

was recorded on Middle Gidley Island near the clay plan (Figure 10). This engraving site is consistent with a thalu, and is interpreted as a possible regeneration site. Prior to marine transgression, this area was composed of open plains and rocky slopes, corresponding with the environmental range of large macropods. If this engraving represents the presence of a macropod regeneration site, this could indicate increased pressure on traditional food resources that were more widely present in the landscape before the onset of marine transgression, however this suggestion requires further investigation of the archaeological record of the Gidley Islands.

Figure 10 Possible macropod regeneration site; note the battering across the panel. (Photo J. Leach).

Engravings were identified throughout the North Gidley Island landscape, wherever rhyodacite outcrops were found. A small sample of engravings were assessed in relation to the recognised Murujuga art phases (McDonald 2015; Mulvaney 2015). Current typological schemes of rock art analysis (McDonald 2015) suggest that the earliest rock art in the landscape may date to 8.5 ka; however the majority of identified engravings are more recent, suggesting intensive occupation of this landscape after the islands were formed. Representations of marine species (especially turtles and dugong, and tails of marine animals such as whales, sharks and dugongs) are ubiquitous in the Gidley Islands engraved galleries supporting this contention (Mulvaney 2015:324), along with documentary evidence that the Yaburara (Traditional Owners of the

study area) hunted dugong with nets and wooden spears (Durlacher 2013:61; McDonald 2015:129; Mulvaney 2011:33).

Future surveys in Murujuga Sea Country should aim to determine if any engraving panels survived marine transgression. Dortch (2002:37–42) reports that there is high potential for the identification of submerged engravings in areas where galleries occur on rocky slopes that continue below the water line. This landscape feature was identified in three locations on North Gidley Island as well as on Collier Rocks. These are highly prospective research locations in which to test this hypothesis. Mulvaney (2015:170–171) contends that sea spray has a detrimental impact on the preservation of the patina in which the engravings are produced. Targeted research in the intertidal zones on rhyodacite outcrops with engravings is needed to determine if these can survive inundation.

Conclusion

A diverse range of cultural activities is present across North Gidley Island, including evidence for seed processing, marine resource use, lithic quarrying/production, rock art production and ceremonial activities. Dating this range of activities remains challenging, but there is some indication from engravings and submerged material that North Gidley Island was inhabited at the terminal Pleistocene and into the Holocene following marine transgression. The integration of subtidal, intertidal, and terrestrial archaeological material provides a comprehensive view of this cultural landscape, and the results reported here identify the Gidley Islands group as a perfect target for such an integrated approach, and should be a priority target for future investigations integrating land-based and diver teams.

The submerged stone artefacts in Cape Bruguieres channel are part of a landscape that is richly covered with stone artefacts. Previous work based on detailed analysis has demonstrated that significant differences in size and morphology can be found between those artefacts in the channel and those found on the immediately adjacent terrestrial land surfaces (Benjamin et al. 2020). Grinding patches found across these islands, and the basal portable grindstones identified in the submerged channel, demonstrate a continuity between the underwater and terrestrial archaeological evidence. Seed processing appears to have been a significant activity across the North Gidley Island landscape.

This island group exhibits a broad range of archaeological features within, or proximal to, the intertidal zone, including quarried stone, artefact scatters, artefacts embedded in aeolianite, engravings, and grinding patches. High density engraving galleries, quarrying sites, artefact

scatters, and grinding patches are a contiguous onshore record, with a potentially rich intertidal and submerged landscape needing exploration. Artefacts embedded in aeolianite in a number of contexts provide an opportunity to understand the age of at least some of these surface stone artefacts, which could be augmented by excavation both on land and in the more sheltered and sediment-rich intertidal zones north of the Cape Bruguieres channel. This would enable comparative analyses of the onshore and offshore artefact concentrations. Several high potential rhyodacite outcrops and aeolianite deposits exist beyond the intertidal zone off the northeast of the island, making these key targets for future exploration (Veth et al. 2020:16–21).

The current sea level represents an arbitrary boundary in the archaeological record, often separating terrestrial and underwater sites which were once a continuum. The modern coastal landscape has served as both a practical and cognitive boundary to knowledge generation in Australian archaeology, which can be bridged with the offshore archaeological record. The Gidley Islands represent a continuous cultural landscape that tell the story of human responses to climate change: a story that incorporates the re-negotiation of landscape use between maritime and arid coastal communities. This integrated landscape-scale analysis, inspired by the discovery of a submerged record in the Cape Bruguieres channel, demonstrates the potential for improved understanding of cultural activity and adaptation strategies employed by Aboriginal people in response to marine transgression. Future more-detailed investigations based on this integrated landscape approach will increase our understanding of Murujuga's Land and Sea Country. A similar approach is needed all around Australia's coastal margins and islands, where the transformative cultural processes associated with sea-level change during the Pleistocene-Holocene transition are sorely underrepresented in the terrestrial record.

Acknowledgements

The authors wish to recognise the Murujuga Aboriginal Corporation Council of Elders and Land and Sea Rangers Unit as core collaborators on this project, and we wish to thank Peter Veth, Ken Mulvaney, Shakti Chakravarty, Victoria Anderson, Hiro Yoshida, Tom Allardyce, Graham and Michelle Evans, and the AustMarine staff for their support.

References

Bailey, G. 2007 Time perspectives, palimpsests and the archaeology of time. *Journal of Anthropological Archaeology.* 26(2): 198-223.

Bailey, G. and K. Hardy 2021 Coastal prehistory and submerged landscapes: Molluscan resources, shell-middens and underwater investigations. *Quaternary International*, 584:1-8.

Bailey, G., J. Harff and D. Sakellariou (eds) 2017 *Under the Sea: Archaeology and Palaeolandscapes of the Continental Shelf*. Cham: Springer.

Bailey, G., **N.** Galanidou, H. Peeters, H. Joens, and M. Mennenga 2020a The Archaeology of Europe's drowned landscapes: Introduction and overview. In G. Bailey, N. Galanidou, H. Peeters, H. Jöns, and M. Mennenga (eds) *The Archaeology of Europe's Drowned Landscapes,* pp.1–23. Cham*:* Springer.

Bailey, G., N. Galanidou, H. Peeters, H. Jöns and M. Mennenga (eds) 2020b *The Archaeology of Europe's Drowned Landscapes*. Cham: Springer.

Bednarik, R. 2007 The science of Dampier rock art – Part 1. *Rock Art Research* 2:209-246.

Benjamin, J., C. Bonsall, C. Pickard and A Fischer (eds) 2011 *Submerged Prehistory*. Oxford: Oxbow Books.

Benjamin, J., M. O'Leary, J. McDonald, C. Wiseman, J. McCarthy, E. Beckett, P. Morrison, F. Stankiewicz, J. Leach, J. Hacker, P. Baggaley, K. Jerbić, M. Fowler. J. Fairweather, P. Jeffries, S. Ulm and G. Bailey 2020 Aboriginal artefacts on the continental shelf reveal ancient drowned cultural landscapes in northwest Australia. *PLoS ONE* 15(7):e0233912.

Benjamin, J., M. O'Leary, I. Ward, J. Hacker, S. Ulm, P. Veth, M. Holst, J. McDonald, P.J. Ross, and G. Bailey 2018 Underwater archaeology and submerged landscapes in Western Australia. *Antiquity* 92(363):e10.

Bindon, P.R. 1997 Aboriginal people and granite domes. *Journal of the Royal Society of Western Australia* 80:173-179.

Bird, C. and S. Hallam 2006 Archaeology and Rock Art in the Dampier Archipelago. Unpublished report prepared for the National Trust of Australia.

Bird, M.I., R.J. Beaman, S.A. Condie, A. Cooper, S. Ulm and P. Veth 2018 Palaeogeography and voyage modeling indicates early human colonization of Australia was likely from Timor-Roti. *Quaternary Science Reviews* 191:431-439.

Bird, M.I., S.A. Condie, S. O'Connor, D. O'Grady, C. Reepmeyer, S. Ulm, M. Zega, F. Saltré and C.J.A. Bradshaw 2019 Early human settlement of Sahul was not an accident. *Scientific Reports* 9:8220.

Bradley, J. and A. Kearney 2018 You whitefellas pull it all apart: Epistemic learnings in exploring landscape. In P. Howard, I. Thompson, E. Waterton, and M. Atha (eds) *The Routledge Companion to Landscape Studies*, pp.288-298. Oxfordshire: Routledge.

Daniel, D. 1990 *Thalu Sites of West Pilbara: A Description of some of the Tribal Increase Sites of the West Pilbara*. Perth: Department of Aboriginal Sites, Western Australian Museum.

Dortch, C.E. 1991 Rottnest and Garden Island prehistory and the archaeological potential of the adjacent continental shelf, Western Australia, *Australian Archaeology* 33:38-43.

Dortch, C.E. 2002 Preliminary underwater survey for rock engravings and other sea floor sites in the Dampier Archipelago. *Australian Archaeology* 54(1):37-42.

Dortch, J. and C.E. Dortch 2019 Late Quaternary Aboriginal hunter-gatherer occupation of the Greater Swan Region, South-Western Australia. *Australian Archaeology* 85(1):15-29.

Dortch, C.E. and I.M. Godfrey 1990 Aboriginal sites in a submerged landscape at Lake Jasper, South Western Australia. *Australian Archaeology* 31:28-33.

Dortch, J., E. Beckett, A. Paterson and J. McDonald in press (accepted 2019) Stone artifacts in the intertidal zone, Dampier Archipelago: Evidence for a submerged coastal site in Northwest Australia. *The Journal of Island and Coastal Archaeology*.

Durlacher, J. 2013 *Landlords of the Iron Shore*. Carlisle: Hesperian Press.

Elkin, A. 1933 Totemism in North-Western Australia (The Kimberley Division). *Oceania* 3(3):257-296.

Evans, A., N. Flemming, and J. Flatman J. (eds) 2014 *Prehistoric Archaeology of the Continental Shelf: A Global Review*. New York: Springer.

Flemming, N. C. 1983 A survey of the late Quaternary landscape of the Cootamundra Shoals, north Australia: A preliminary report. In *Proceedings of the Seventh International Diving Science Symposium of CMAS*, pp.149-180. Padova: CMAS.

Gould, A. 1968 Living archaeology: The Ngatatjara of Western Australia. *Southwestern Journal of Anthropology* 24(2):101-122.

Harff, J., G.N. Bailey and F. Lüth (eds) 2016 *Geology and Archaeology: Submerged Landscapes of the Continental Shelf: An Introduction*. London: Geological Society.

Lawrence, C. 2012 The Potential Outstanding Universal Value of the Dampier Archipelago site and Threats to that Site. Unpublished report prepared for the Australian Heritage Council.

Lewis, S.E., C.R. Sloss, C.V. Murray-Wallace, C.D. Woodroffe, and S.G. Smithers 2013 Post-glacial sea-level changes around the Australian margin: A review. *Quaternary Science Reviews* 74:115-138.

Lorblanchet, M. 1992 The rock engravings of gum tree valley and skew valley, Dampier, Western Australia: Chronology and functions of sites. In J. McDonald and I. Haskovec (eds) *State of the Art: Regional Rock Art Studies in Australia and Melanesia*, pp.39-59. Melbourne: AURA.

McDonald, J. 2015 I must go down to the seas again: Or, what happens when the sea comes to you? Murujuga rock art as an environmental indicator for Australia's north-west. *Quaternary International* 385:124–135.

McDonald, J. and M. Berry 2017 Murujuga, North Western Australia: When arid hunter gatherers became coastal foragers. *The Journal of Coastal and Island Archaeology* 12(1):24-43.

McDonald, J. and P. Veth 2005 Desktop Assessment of Scientific Values for Indigenous Cultural Heritage on the Dampier Archipelago, Western Australia. Unpublished report prepared for the Heritage Division of the Department of Environment and Heritage, Canberra.

McDonald, J. and P. Veth 2006 A Study on the Distribution of Rock Art and Stone Features across the Dampier Archipelago. Unpublished report prepared for the Heritage Division of the Department of Environment and Heritage, Canberra.

McDonald, J. and P. Veth 2009 Dampier Archipelago petroglyphs: Archaeology, scientific values and National Heritage listing. *Archaeology in Oceania* 44(1):49-69.

McDonald, J. and P. Veth 2011 Study of the Outstanding Universal Values of the Dampier Archipelago Site, Western Australia. Unpublished report prepared for the Australian Heritage Council.

McDonald, J. and P. Veth 2013 Rock art in arid landscapes: Pilbara and Western Desert Petroglyphs. *Australian Archaeology*, 77(1):66-81.

McDonald, J., A. Paterson, K. Mulvaney and P. Veth (eds) 2021 in press. *Murujuga Dynamics of the Dreaming: Rock Art Recording and Excavation Reports.* CRAR+M Monograph #2. Perth CRAR+M, UWA.

McDonald, J., W. Reynen, K. Ditchfield, J. Dortch, M. Leopold, B. Stephenson, T. Whitley, I. Ward and P. Veth 2018 Murujuga Rockshelter: First evidence of Pleistocene occupation on the Burrup Peninsula. *Quaternary Science Reviews* 193:266-287.

Morrison, P. 2019 The Geoarchaeology of a Submerged Aboriginal Site in the Intertidal Zone of Dolphin Island, Murujuga. Unpublished BA(Hons) thesis, University of Western Australia, Perth.

Mulvaney, K. 2011 About time: Toward sequencing of the Dampier Archipelago Petroglyphs of the Pilbara region, Western Australia. *Records of the Western Australian Museum Supplement*, pp. 30-49.

Mulvaney, K. 2015 *Murujuga Marni: Rock Art of the Macropod Hunters and Mollusc Harvesters*. Crawley: University of Western Australia Press.

Murujuga Aboriginal Corporation 2016 Ngaayintharri Gumawarni Ngurrangga: Murujuga Cultural Management Plan, Murujuga Aboriginal Corporation, Karratha: Pindan Printing Pty Ltd.

Nutley, D. 2014 Inundated site studies in Australia. In A.M. Evans, J.C. Flatman and N.C. Flemming (eds), *Prehistoric Archaeology on the Continental Shelf: A Global Review*, pp.255-273. New York: Springer.

O'Leary, M., V. Paumard and I. Ward. 2020 Exploring Sea Country through high-resolution 3D seismic imaging of Australia's NW shelf: Resolving early coastal landscapes and preservation of underwater cultural heritage. *Quaternary Science Reviews* 239:106353.

Palmer, K. 1975 Petroglyphs and associated Aboriginal sites in the north west of Western Australia. *Archaeology and Physical Anthropology in Oceania* 10(2):152-160.

Paterson, I., R. Anderson, K. Mulvaney, S. de Koning, J. Dortch and J. McDonald 2019 So ends this day: American whalers in Yaburara country, Dampier Archipelago. *Antiquity* 93(367):218-235.

Pillans, B. and K. Fifield 2013 Erosion rates and weathering history of rock surfaces associated with Aboriginal rock art engravings (petroglyphs) on Burrup Peninsula, Western Australia, from cosmogenic nuclide measurements: Reply. *Quaternary Science Reviews* 91:98-106.

Reid, C. 1913 *Submerged Forests*. Cambridge: Cambridge University Press.

Reynen, W., and K. Morse. 2016 Don't forget the fish–towards an archaeology of the Abydos Plain, Pilbara, Western Australia. *Australian Archaeology* 82(2):94–105.

Semeniuk, V. 1993 The Pilbara coast: A riverine coastal plain in a tropical arid setting, northwestern Australia. *Sedimentary Geology* 83(3-4):235–256.

Veth, P. 1995 Aridity and settlement in northwest Australia. *Antiquity* 69:733-746.

Veth, P., J. McDonald, I. Ward, M. O'Leary, E. Beckett, J. Benjamin, S. Ulm, J. Hacker, P.J. Ross and G. Bailey 2020 A strategy for assessing continuity in terrestrial and maritime landscapes from Murujuga (Dampier Archipelago), North West Shelf, Australia. *Journal of Island and Coastal Archaeology* 15(4):477-503.

Vinnicombe, P. 1987a Salvage archaeology of the Burrup Peninsula. *Australian Archaeology* 25:53-79.

Vinnicombe, P. 1987b Dampier Archaeological Project: Resource Document, Survey and Salvage of Aboriginal Sites, Burrup Peninsula, Western Australia. Unpublished report prepared for Woodside Offshore Petroleum Pty Ltd.

Vinnicombe, P. 2002 Petroglyphs of the Dampier Archipelago: Background to development and descriptive analysis. *Rock Art Research* 19(1):3-27.

Ward, G. and K. Mulvaney 2018 Archaeology and Petroglyphs of Dampier: Editor's Introduction, Archaeology and Petroglyphs of Dampier (Western Australia): An Archaeological Investigation of Skew Valley and Gum Tree Valley. Unpublished report prepared for The Australian Museum.

Ward, I., P. Larcombe, K. Mulvaney and C. Fandry 2013 The potential for discovery of new submerged archaeological sites near the Dampier Archipelago, Western Australia. *Quaternary International* 308-309:216-229.

Wiseman, C., M. O'Leary, J. Hacker, F. Stankiewicz, J. McCarthy, E. Beckett, J. Leach, P. Baggaley, C. Collins, S. Ulm, J. McDonald and J. Benjamin 2021 A multi-scalar approach to marine survey and underwater archaeological site prospection in Murujuga, Western Australia. *Quaternary International* 258:152-170.

Wright, B. 1972 Rock engravings of striped mammals: The Pilbara region, Western Australia *Archaeology and Physical Anthropology in Oceania* 7(1):15-23.