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Dampier Cargo Wharf Extension and Landside Redevelopment Project

Underwater Cultural Heritage Investigation

Version 3

Dampier
Western Australia

June 2023

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Underwater Cultural Heritage Investigation

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Prepared for:

Pilbara Ports Authority

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Cover Image: Excavation underway at ST01 (white buoy closest to bow of Mary V). DPLH 10303 located at top right corner surrounded by greenery. (DJI_0679)

Revision	Description	Date	Originator	Reviewer	Approver
V1	First draft	3/3/23	CC, CB, MoL, CM, PK	CC	CC
V1a	Addition of images	5/3/23	CC, PK, MoL	CC	CC
V2	Respond to comments on V1a by PPA.	18/4/23	CC, MoL	CC	CC
V3	Minor corrections regarding formatting, typo corrections and correct naming of project area versus dredge footprint	12/6/23	CC, JM	CC	CC

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Abbreviations

AA	Archae-aus, heritage consultancy
BH19	Borehole 19
CA	Cosmos Archaeology Pty Ltd
CD	Chart Datum
CMOS	Complementary metal-oxide semiconductor
DCW	Dampier Cargo Wharf
DCWELR	Dampier Cargo Wharf Extension and Landside Redevelopment
DEM	Digital elevation model
DTM	Digital terrain model
FOV	Field of view
GNSS	Global navigation satellite system
GSD	Ground sampling distance
HAT	Highest Astronomical Tide
ISO	International Organisation for Standardisation
LAT	Lowest Astronomical Tide (equivalent to CD)
MAC	Murujuga Aboriginal Council
MLWN	Mean Low Water Neaps
MHWN	Mean High Water Neaps
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
OO	Oceanic Offshore, commercial diving contractor
PPA	Pilbara Ports Authority
RPAS	Remote Piloted Aerial System
SCUBA	Self Contained Underwater Breathing Apparatus
SFM	Source Filmmaker
SSBA	Surface Supplied Breathing Apparatus
UCHA	Underwater Cultural Heritage Assessment

1 INTRODUCTION

1.1 Rationale for Investigation

Pilbara Ports Authority (PPA), which operates as a Western Australian Government Trading Enterprise, is the proponent for the Dampier Cargo Wharf Extension and Landside Redevelopment (DCWELR) Project (the Project). PPA is proposing to construct and operate a land backed wharf extension to the Dampier Cargo Wharf (DCW) at the Port of Dampier (the Port). The ultimate scope of the Project incorporates the development of a new (adjoining) southern section of wharf and associated mooring dolphin, wharf connecting structure, dredged berth pocket and vessel manoeuvring area (Figure 1). Of relevance to this investigation are proposed capital dredging works to establish a new berth pocket and manoeuvring area for vessels to access the DCW.

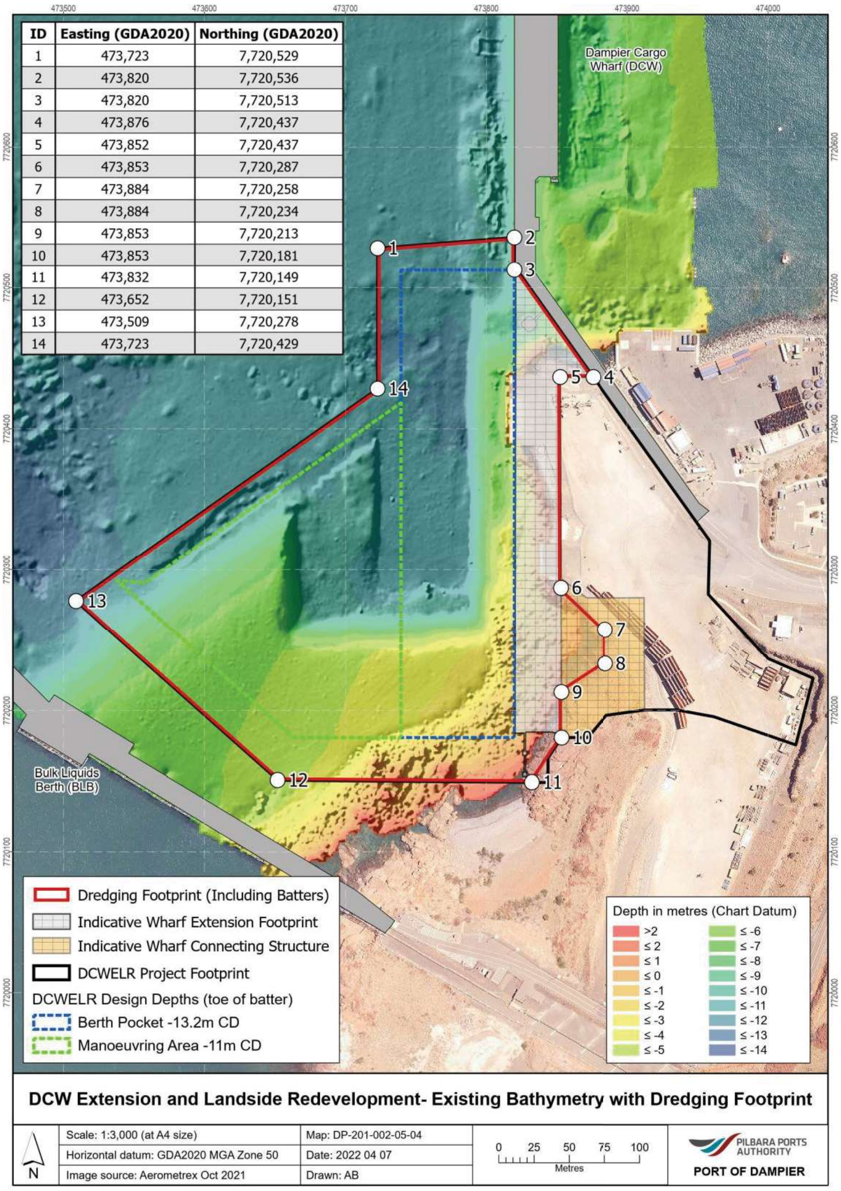

Figure 1: DCWELR Dredging Footprint showing existing bathymetry.

The dredging will remove up to 380,000 m^3 of sediment and substrate from within the Dredging Footprint. Approximately 100,000 m^3 of the dredged material will be granophyre rock in the southeast portion of the Dredging Footprint.

In 2022, PPA commissioned Cosmos Archaeology (CA) to undertake an underwater cultural heritage desktop assessment (Cosmos Archaeology, 2022). The desktop assessment (summarised below in Section 1.2) identified a medium level of confidence that cultural material, likely in the form of lithic artefacts, may be present within the cobble stone formation present within the Dredging Footprint.

PPA shared the desktop assessment with Murujuga Aboriginal Corporation (MAC), and as a result, MAC requested further investigations be conducted. In consultation with MAC, PPA contracted CA to undertake a detailed archaeological investigation to identify if underwater cultural heritage values exist within the Dredging Footprint and the investigation would assess the presence, nature, and significance of any underwater cultural heritage values. CA developed a methodology, endorsed by MAC, to investigate the potential for underwater cultural heritage values within the Dredging Footprint through test excavations and visual surveys.

PPA has referred the DCWELR Project to the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) for assessment under the Environmental Protection and Biodiversity Conservation Act 1999 as well as the West Australian Environmental Protection Authority (EPA) for assessment under the *Environmental Protection Act 1986.* This report, which details the outcomes of the UCH investigation, will be provided by PPA to MAC, and used to support the Project's referrals packages.

1.2 Findings of the Underwater Cultural Heritage Desktop Assessment

The methodology for the desktop assessment utilised a predictive model created by CA and Dr Mick O'Leary (University of Western Australia) to determine the likelihood of survival of aboriginal cultural material within the Dredging Footprint. This model consists of eight steps to determine the likelihood of presence and survivability of cultural material within the Dredging Footprint:

A. Nearshore (intertidal and subtidal) geophysical data analysis and interpretation;
B. Previous landscape disturbance;
C. Submerged landscape reconstruction;
D. Terrestrial site types and landscape/environmental associations;
E. Frequency of terrestrial cultural site type occurrences;
F. Submerged landscape site type association;
G. Site integrity assessment matrix;
H. Likelihood of site presence and condition.

This predictive modelling identified the likely remains of a submerged stone cobble beach existing from 0 m to -6.5 m LAT at the southern portion of the Project Area (Figure 2). The desktop assessment found that there is a medium level of confidence for the presence of cultural material, most likely lithic artefacts including cores, tools, debitage and grinding stones, within the submerged cobble stone beach. Furthermore, the model predicted a possibility that lithic artefacts within the submerged cobble formation could be in a better state of preservation than artefacts observed in the intertidal zone. Other artefacts and features such as rock engravings, standing stones, artefact scatters, and grinding stones associated with other identified submerged landforms (block fields, igneous outcrops, and limestone plain) were predicted with less confidence to be present.

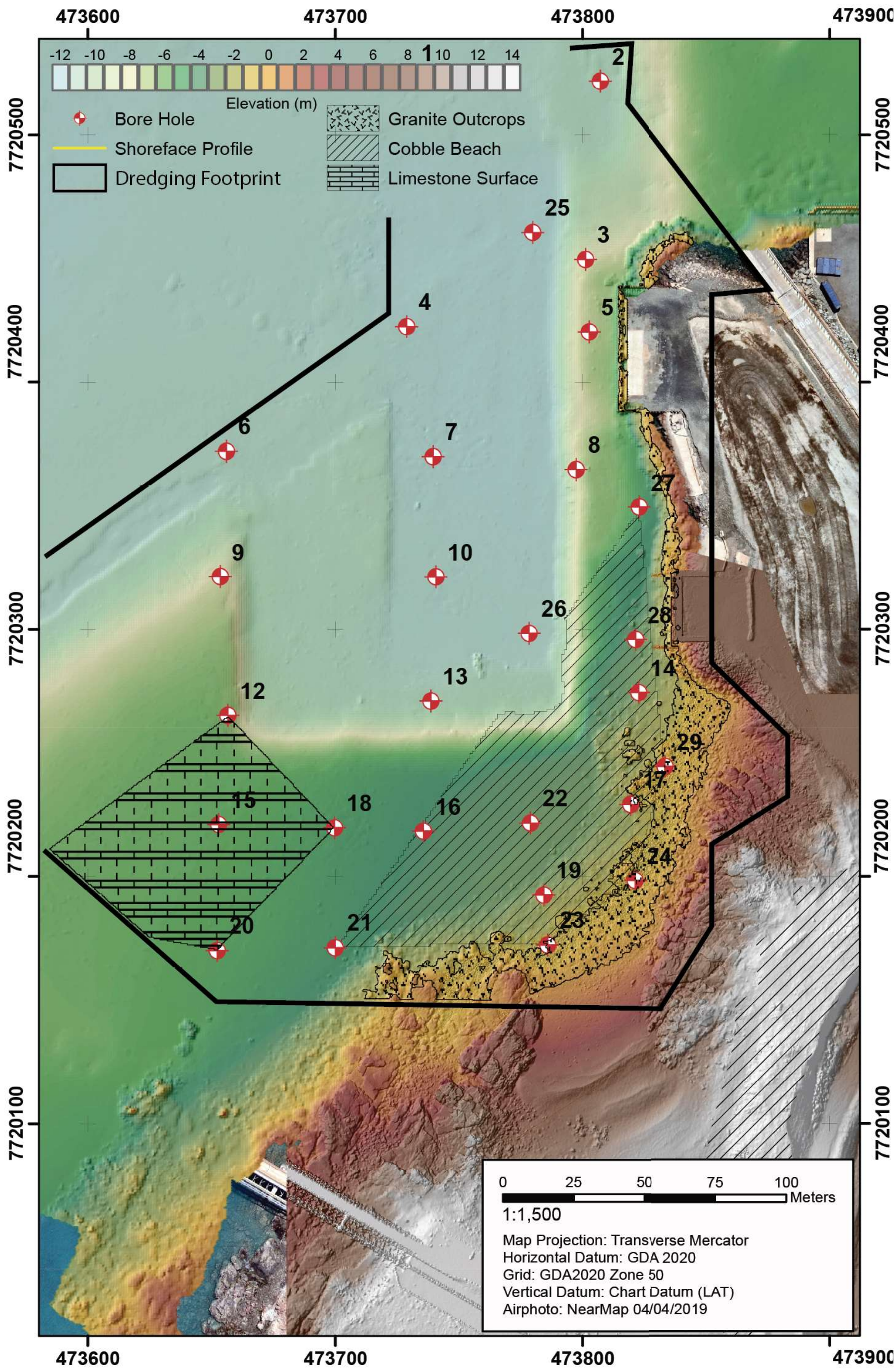

Figure 2: Subtidal extent of cobble formation (Figure 26 from UCHA). Note the solid black line is the Dredging Footprint.

The desktop assessment also investigated previous research conducted on registered site ID 10303, located on the upper terraces of the stone cobble beach, adjacent to the Dredging Footprint (Figure 3). This site has been described as a rare site type for Australian archaeology, with the potential to inform research questions about pebble tool types in Australia. Additionally, it was determined that if DPLH 10303 continued into the Dredging Footprint, the site would provide a clear means of identifying changes in cultural practices within Murujuga between deep time and the current Holocene.

Figure 3: Boundary of DPLH 10303 and other registered DPLH sites in the vicinity of the proposed works.

A cultural heritage significance assessment of the underwater cultural heritage values could not be completed as part of the desktop report, as it is understood that the consultation PPA undertook with MAC and Circle of Elders (a cultural advisory group within MAC) did not discuss these values. As such, only the scientific/archaeological significance of the identified potential archaeological resources was assessed in the desktop report.

The desktop study determined that archaeological sites associated with the cobblestone beaches, block field, igneous outcrops, and karst waterholes have previously been assessed to be of high scientific/archaeological significance. The presence of these site types and features submerged within the Dredging Footprint, depending on their condition, could be expected to have an equitable scientific/archaeological significance to their terrestrial analogues. This significance could be further enhanced due to the current rarity of documented submerged terrestrial sites in Australia.

1.3 Objective of Investigation

The objective of this Underwater Cultural Heritage Investigation is to;

- *identify the presence, nature and significance of any underwater cultural heritage values that may exist within the Dredging Footprint* (PPA September 2022).

By **presence** we have taken it to mean the identification of **artefacts**, with varying degrees of certainty.

By **nature** we have taken it to mean the archaeological integrity of the context(s) in which the potential artefacts were found.

To accomplish this objective, three key indicators need to be met and understood:

1. Spatial extent of cultural landform.
2. The archaeological integrity of the context in which the artefacts are found.
3. The presence of artefacts.

In this case, archaeological integrity is defined as the degree to which artefacts have travelled from where they were initially deposited, both laterally and vertically. Integrity will be assessed by analysing the submerged cobble formation and identifying the site formation processes that may have disturbed this context.

1.4 Scope of Investigation

The scope of this investigation incorporates an assessment of the underwater Aboriginal cultural resource potential and an analysis of site integrity through the excavation and examination of the seabed substrate. The scientific significance of any finds is also assessed. Additionally, organic samples from the subtidal test trenches have been carbon dated to determine the relative age of any potential artefacts found.

The scope of this investigation does not cover:

- Assessment of European/historical maritime infrastructure;
- Cultural heritage potential of sites and artefacts (other than DPLH 10303) above the Highest Astronomical Tide, in so far that this can inform the subtidal heritage values;
- Assessment of cultural significance for potential archaeological remains.

1.5 The Study Area

The primary study area for this archaeological investigation is the portion of the proposed DCWELR Dredging Footprint seaward of the LAT where the cobble formation was identified through geotechnical and geophysical assessment (Figure 4). It also includes the granite outcropping that bisects the subtidal and intertidal/terrestrial formation.

The secondary study area incorporated the cobble formation above LAT including the boundaries of DPLH 10303. Investigations also took place in this area so that the nature and archaeological potential of the subtidal portion of the cobble formation can be better understood.

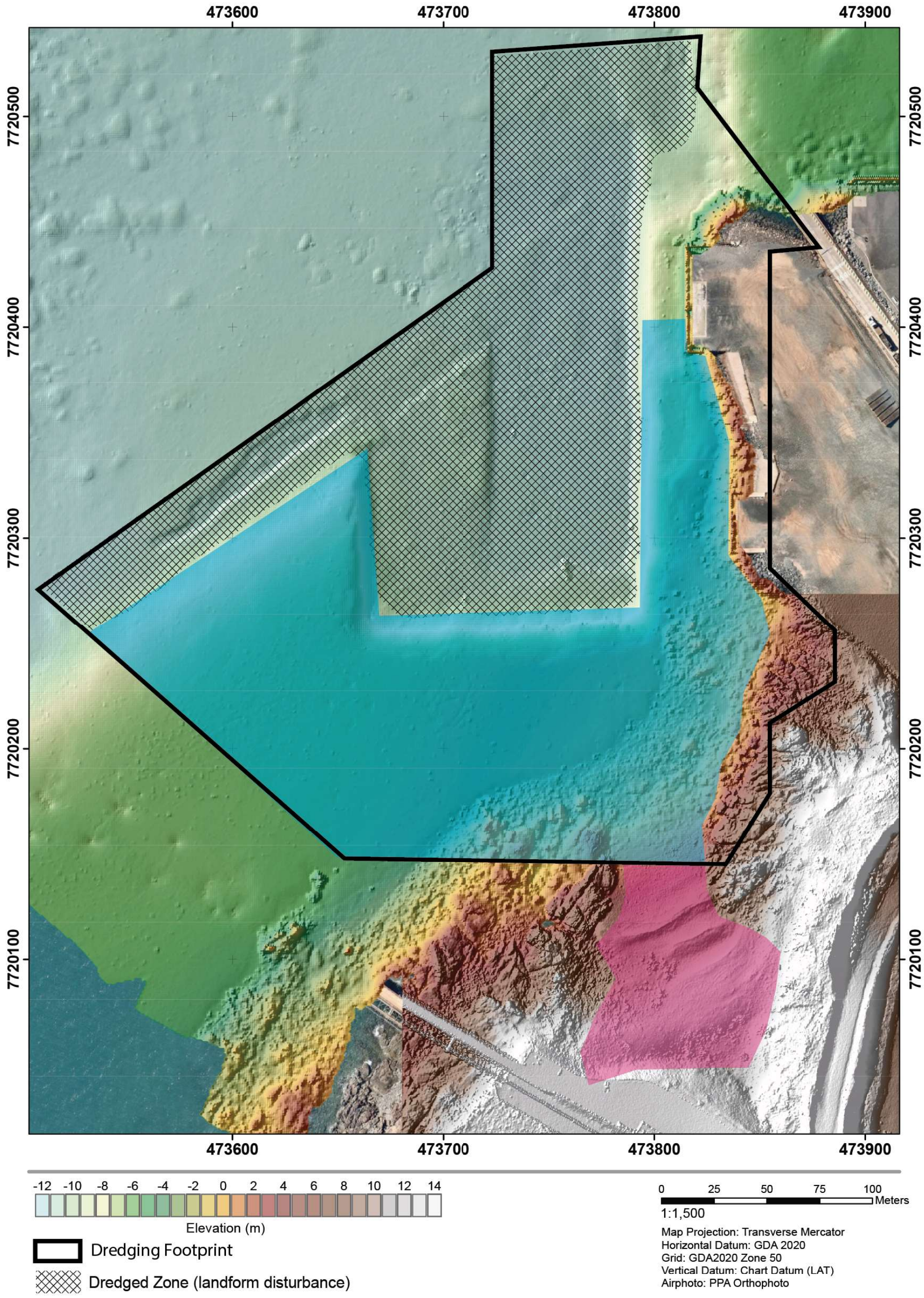

Figure 4: Primary study area (in blue), Dredging Footprint (in solid black outline) and secondary study area (in purple) incorporating DPLH 10303.

1.6 Investigation Approach

The investigation approach revolved around the requirement to understand the potential contextual integrity of any archaeological remains within the subtidal area. This required an understanding of the physical and cultural characteristics of DPLH 10303, which is located on the uppermost 'terrace' at the southern end of the cobble formation and that of the intertidal zone. As DPLH 10303 has not been inundated since human occupation and the intertidal zone has been subjected to constant wave derived kinetic energy for around 8,000 years, they represent both ends of the spectrum with respect to contextual integrity. DPLH 10303, prior to the investigation, was assumed to have the highest level of contextual/archaeological integrity and the intertidal zone was assumed to have the lowest or most disturbed. Therefore, with respect to contextual integrity, the investigation of DPLH 10303 and the intertidal zone would allow the subtidal area to be placed somewhere on a spectrum between DPLH 10303 and the intertidal zone.

The planned approach for this investigation was divided into four phases.

1.6.1 *Phase one – Pedestrian baseline survey*

A visual pedestrian survey transect was to be conducted within the upper terrace of the cobble beach adjacent to, and within, the boundaries of DPLH 10303, as well as a pedestrian survey of the intertidal zone at low tide (see Figure 3). The purpose of these pedestrian surveys were to:

- *Establish an artefact typology for the cobble beach which would be further refined through association with intra-site contexts such as differentiating observations made for the higher terraces, storm lines and current intertidal zone.*
- *Examine weathering on artefacts in relation to distance to and within intertidal zone.*
- *Establish typology of a natural fracturing of clasts to assist in differentiating geofact from artefacts.*
- *Better understand site formation processes, which could be replicated below intertidal. This was to include a collection of coral samples for radiocarbon dating.*
- *Induct the underwater archaeologists to recognise the variety of artefacts that may be encountered.*

During the investigation it was decided that it would be a better use of available resources to commit to improving our understanding of the variety of artefact types in DPLH 10303 and the intertidal zone (for conduct of Phase 1 see Section 3.4). It was also decided, once in the field, that priority for radiocarbon dating was to be given to samples from the intertidal trenches (see Section 3.8.4).

1.6.2 *Phase two – Intertidal trench excavation*

Following the pedestrian surveys, a test trench was to be established within the intertidal zone at the spring low tide, within the boundary of the dredging footprint. A 2 m grid square was to be placed at a suitable location at low tide and the archaeologists were to manually remove the largest clasts and place them on a tarp next to the trench. Once submerged by the rising tide, the intertidal trench (IT01) would be excavated by divers using a water induction dredge and manual handling. The purpose of this intertidal excavation was:

- *For both terrestrial and underwater archaeologists to obtain a shared understanding of the nature of the cobble deposits such as whether the deposit* *becomes more compacted with depth requiring a change of excavation technique. This would allow a shared vocabulary when it comes to describing what is observed on the seabed.*

- *To determine whether excavation based on spits or context was most appropriate.*
- *To develop a better estimate of artefact density.*
- *To establish a baseline for what might be the maximum impact of rolling and wear on artefacts.*
- *To understand site formation processes – rock and sediment composition, weathering, impact scarring, sorting and stratigraphy - in an intertidal zone for comparison with findings of test trenches in deeper water.*
- *To obtain coral samples for C14 dating.*
- *For continued induction for the underwater archaeologists to recognise the variety of artefacts that may be encountered.*

As was decided for Phase 1 when implemented, priority for radiocarbon dating was to be given to samples from the intertidal trenches (see Section 3.8.4).

1.6.3 *Phase three – Dive transects*

To be undertaken by the maritime archaeologists, the purpose of these dive transects were to:

- *Scout for suitable locations for underwater test trenches*.
- *Understand site formation processes. There appears to be bedrock outcropping in places. How would this affect the movement of clasts across the area?*

1.6.4 *Phase four – Excavation of subtidal trenches*

The purpose of the subtidal excavation was to:

- *Recover artefacts below the intertidal zone.*
- *Gather data associated with any artefacts that could provide insights into the degree of archaeological integrity of the artefacts.*
- *Recover samples of coral adhered to recovered clasts for C14 dating.*

The decision of where to site the subtidal excavations in the planning phase was guided by the desire to excavate into the cobble beach formation in deeper water (below LAT) as feasible. This was based on the reasoning that with depth, the effects of wave action from storms since sea level stabilised would be less. Hence the expectation that the clasts that make up the cobble formation would be less weathered than those closer to the current intertidal zone. This would provide a greater opportunity to identify lithic artefacts as predicted in the desktop UCHA (Cosmos Archaeology, 2022:67).

The siting of the trenches was dictated by the amount of perceived silt cover over the cobble formation. Geotechnical evidence showed that silt cover increased northwards (Cosmos Archaeology, 2022:42). To excavate by water dredge into silt sediments deeper than 500mm would take a considerable amount of time moving ‘dead ground’ and a larger area of seabed would need to be excavated to clear enough of an area to excavate into the cobbles. To excavate the cobble formation with more than 500 mm of sediment would require the implementation of a caisson diving method or the use of a bucket dredge / mechanical excavator, both of which were not feasible for this investigation given the budget and time frames for delivery of the findings of the investigation.

Two broad zones were chosen for excavation. The first zone was in the vicinity of where Borehole 19 (BH19) was located at around -2 m LAT (Figure 5). The evidence from this borehole suggested that silt cover was negligible (Cosmos Archaeology, 2022: Figure 20). The second zone chosen for excavation was in the area where the cobbles were covered with around 500 mm of silt (ca – 4 m LAT).

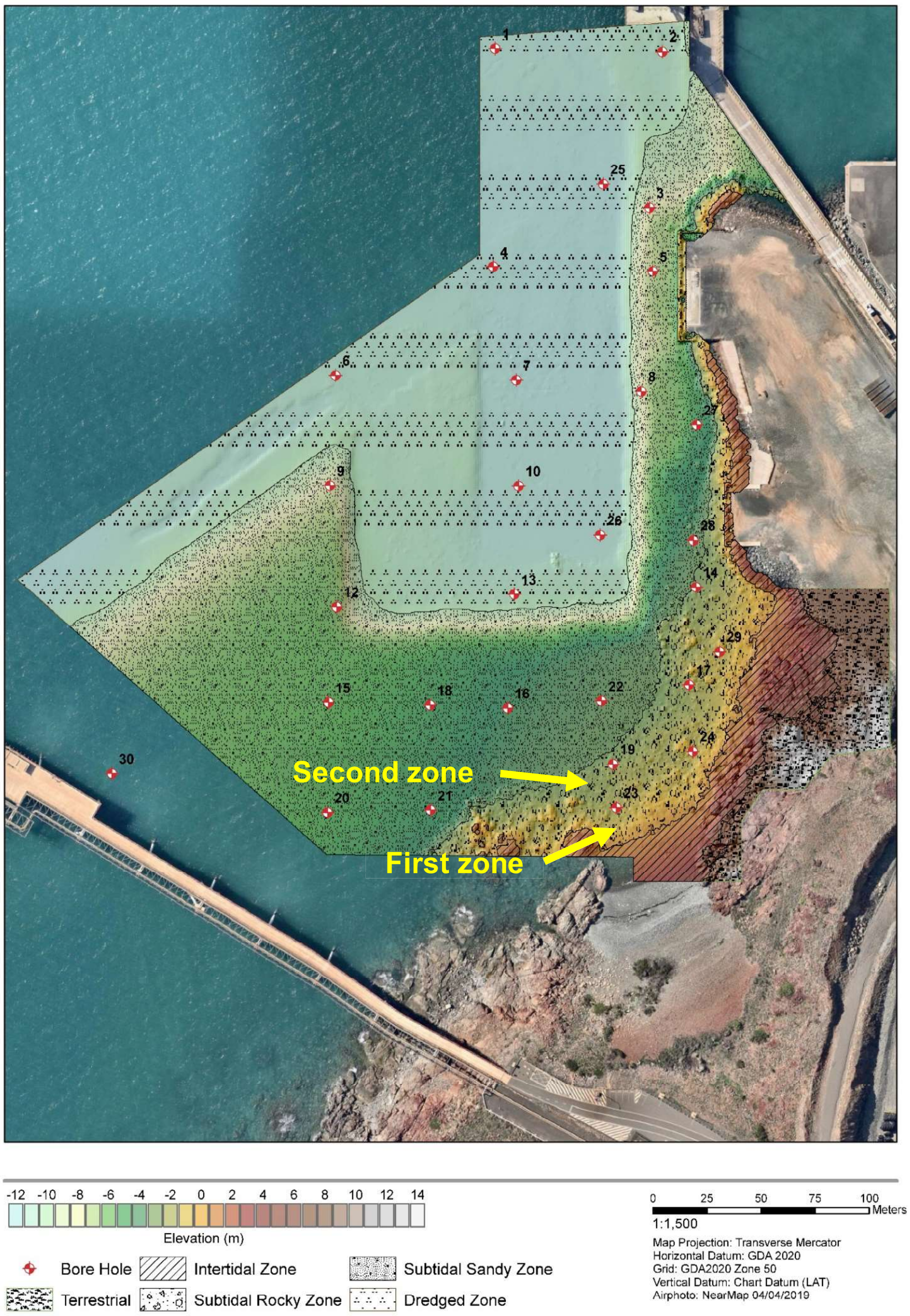

Figure 5: Map showing location of boreholes (Cosmos Archaeology, 2022: Figure 16).

During the field investigation only one of the two zones was excavated (see Section 3.8.2). This is because in the first zone the character of the clasts – a mix of rounded cobbles and angular rock - that made up the cobble formation was what was anticipated to be found in deeper water. It was decided to investigate this area further rather than moving into an area where time would be spent removing around 500 mm of overburden.

The trenches were to be excavated in the same manner described for Phase Two, except that the excavation was to be done solely by diving. The Archae-aus team and the project geomorphologist were to be working on the dive vessel. Sieving was to be done aboard the dive vessel whilst excavation was underway.

The excavation required 100% recovery of all lithic material within the trench. This was to be accomplished by using a water induction dredge and manual handling. The planned depth of excavation for these trenches was down to 500 mm below the surface of the cobble formation.

1.7 Report Authorship

This report was prepared by Cosmos Coroneos (CA), Dr Caroline Bird (AA) and Dr Michael O'Leary (UWA), with contributions by Connor McBrian (CA) and Philippe Kermeen (CA). Annex A has been prepared by Archae-aus with Dr Caroline Bird as the lead author.

2 SETTING

2.1 Overview

The Dampier Archipelago (also known by its Aboriginal name, Murujuga) consists of 42 islands on the northwest coast of Western Australia. The archipelago covers an area of approximately 400 km^2 and the islands range in size from very small (<0.02 km^2) to the largest - Dampier Island (at c.11 km^2). Dampier Island is now known as the Burrup Peninsula as it is connected to the mainland via a causeway. Murujuga is the Ngarluma word for 'hip bone sticking out' and is now commonly used to refer to the whole Archipelago (Figure 6) (MAC 2016; Paterson et al. 2019:218).

Figure 6: Sentinel satellite image of Dampier Archipelago (Murujuga). Red square Dampier Cargo Wharf, yellow marks indigenous underwater cultural heritage sites.

Murujuga is a significant rock art province with an estimated one million engravings, numerous stone structures, middens, quarries and other occupational remains across the Archipelago (McDonald and Veth 2009; Veth et al. 2019). Large areas of Murujuga were listed on Australia's National Heritage List (NHL) in 2007, and in January 2020 was added to the UNESCO World Heritage Tentative List. This place has demonstrated cultural and scientific significance to the nation, through the NHL listing. The State and MAC submitted an application for Murujuga for World Heritage Nomination in February 2023.

2.2 Geological/geomorphological setting

Murujuga represents the westernmost extension of the Archean-age Hamersley Basin and is characterised by a complex geomorphic terrain. The NW–SE trending Eastern Archipelago, including the Burrup Peninsula, is comprised of 2.7-billion-year-old medium-to-fine grained Gidley Granophyre (recently re-identified as Rhyodacite: Fairweather 2019) and a medium-to-coarse grained Gabbro. Islands of the western archipelago including Rosemary Island are comprised primarily of Gabbro and Volcaniclastic sedimentary rocks while Enderby and the Lewis Islands mostly formed of the Andesitic basalt and minor outcrops of the Rhyodacite. Long term weathering of these igneous rocks has resulted in a highly distinctive boulder terrain. These strike-controlled hills and ridges with deeply incised V-shaped gullies and/or broader valleys, form dendritic patterned drainages and are generally free of vegetation (Veth et al. 2019: 5-6). Aeolian calcarenites outcrop along the more protected island shorelines, and their red and weathered nature suggest they formed during or preceding the last interglacial sea level highstand (circa 125,000 years BP). More recent mid to late Holocene coastal beach ridge plains occur in many of the islands' embayed coasts and comprise of carbonate skeletal grains (Figure 7).

The elevated hills and ridges of Murujuga protrude from a low-lying limestone plain and represent the most western extent of this geology in the Pilbara. The Dampier Ranges (prior to sea-level rise) would have been amongst the first ranges encountered by people moving inland from low stand coastal environments, up the paleo drainages of the Maitland, Nickol and Nullagine Rivers, in deep time (Late Pleistocene).

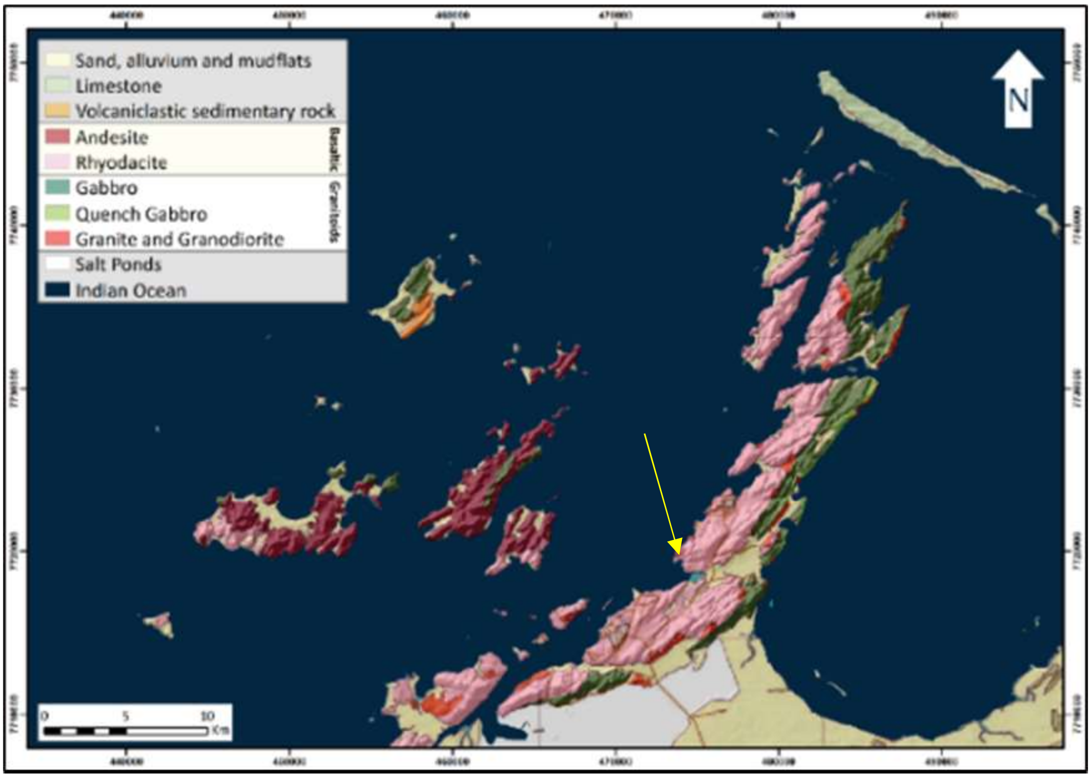

Figure 7: Geological map of the Dampier Archipelago (Murujuga). Study Area shown by yellow arrow.

2.3 Deep time regional context of Murujuga

Around 65,000 to 50,000 years ago is the currently accepted earliest date-range for human entry into Australia and New Guinea (Clarkson et al. 2017; David et al. 2011; McDonald et al. 2018a; Veth 2017). Since that time, approximately 2 million km^2 of the continental land mass has been further exposed and subsequently drowned by postglacial sea-level rise (Figure 8). The 42 islands of the Dampier Archipelago have only existed in their current form since the mid-Holocene when the sea level rose again to its current height. The sea level was last at this approximate height during the last interglacial (130,000 to 115,000 years BP), and many of the coastal limestone formations recognisable around the archipelago were formed at this time.

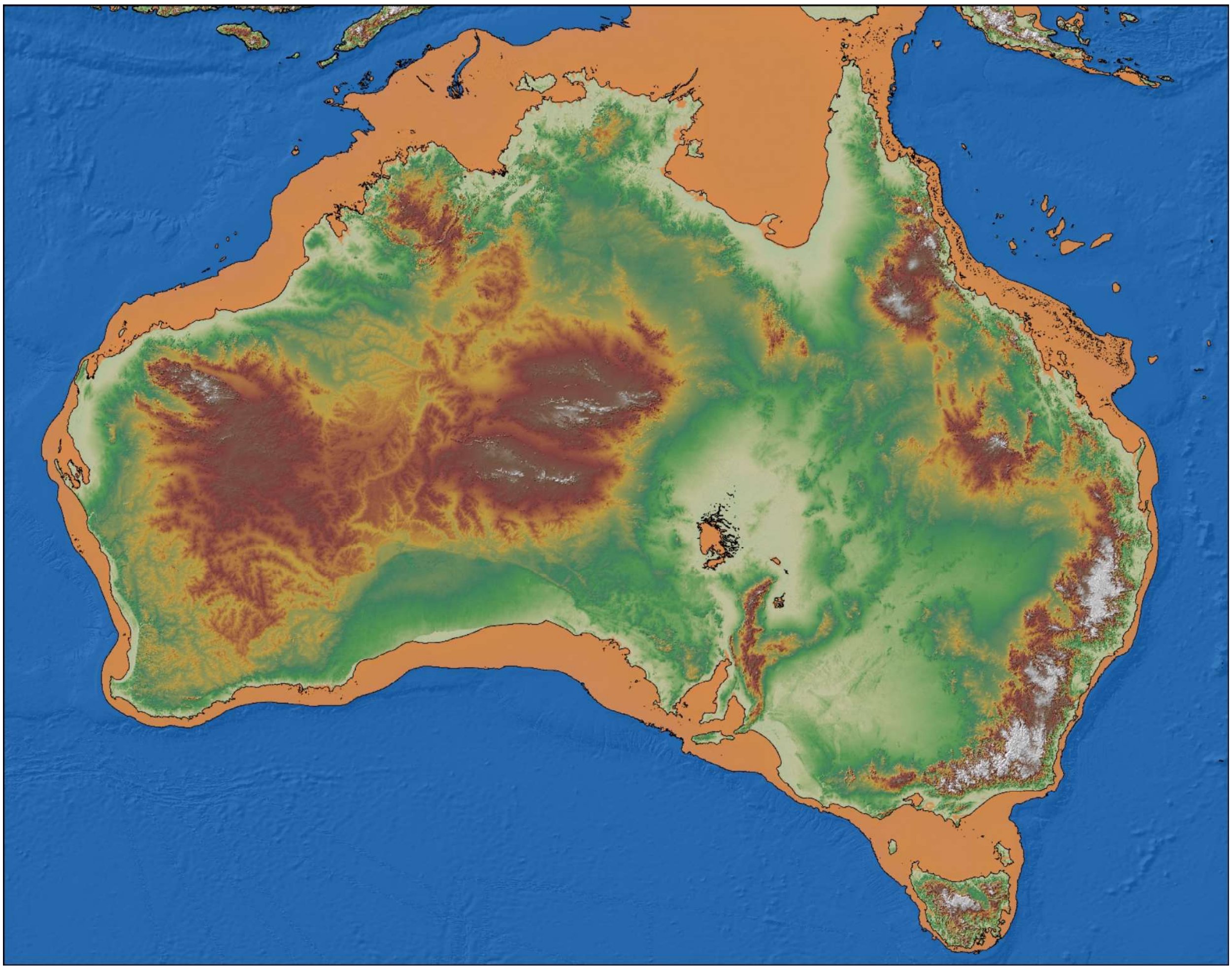

Figure 8: Map of Australia, orange area shows maximum landmass exposed during the peak of the last glacial maximum and subsequently inundated (approximately 2 million square kilometres).

The archaeology and rock art of this region reveal how Aboriginal people adapted their Pleistocene procurement strategies in response to significant environmental and landscape changes in Murujuga. Several recent research projects (see summary in Ditchfield, et al 2022) have illustrated how Aboriginal people have adapted to dynamic environments on the WA coastline from 50,000 years ago and through the Last Glacial Maximum ('LGM' between 30-18,000 years ago) until the recent past. On Barrow Island – near the outer edge of the continental shelf – the deep limestone Boodie Cave has a complete record of this earliest coastal use (Veth et al. 2007, 2014, 2017). The Barrow Island and Montebello Island middens and macrofaunal remains demonstrate increasing reliance on marine resources from 42,000 years ago, but these sequences end at 8,000 years ago when this landmass was isolated by rising sea level.

Several excavations, at Murujuga Rockshelter (McDonald et al. 2018) and Skew Valley (in the 1970s, republished recently: Lorblanchet 2019), have indicated that there was occupation at Murujuga during the LGM. At Murujuga Rockshelter, the focus of occupation shifts away from this shelter towards the encroaching shoreline in the mid-Holocene (McDonald et al. 2018a), whereas at Skew and Gum Tree Valley, Lorblanchet has demonstrated a shift to intensive Anadara collection in West Intercourse Island mound middens through the last 4,000 years.

Recent research suggests several of Murujuga's outer islands have their first occupation in open sites from at least c.15,000 years ago, and there is good evidence for an early peak in occupation here between 10-8,000 year ago (McDonald and Berry 2016; McDonald et al. 2021, in press). There appears to be a short break after islandisation but Aboriginal occupation continued and was seen to be thriving when early explorers first encountered this place (i.e., Dampier in 1699 and King in 1818: see Paterson et al. 2019). The Flying Foam massacre in 1868, resulted in many deaths and massive dislocation for the Yaburara and Marthudhunera people, who were the language groups recorded as belonging to this place (Tindale 1974).

While the islands of the archipelago retain evidence for this long-term use, the submerged and intertidal finds at Cape Bruguieres and Flying Foam Passage (Benjamin et al. 2020; Dortch et al. 2019) are the first evidence that this heritage can also remain on the seabed. Both these sites are located within narrow tidal passes and passages within the Dampier Archipelago and therefore have had the advantage of being protected from high energy oceanic swells and cyclonic events that might have otherwise disturbed these sites. Importantly, these sites represent the first documented evidence for the first 40,000 years (80%) of human use on the coastal plain which has now been submerged by sea level rise.

2.4 Geomorphology of the study area

2.4.1 *Cobble Beach Geomorphology*

The cobble beach where DPLH 10303 is located borders the southern end of the Dredging Footprint. The active beach face is 50 m long, has a northerly aspect, and is formed almost exclusively of well-rounded cobble (64 to 256 mm) and pebble size (4 to 32 mm) clasts, with larger boulders (>256 mm) also present (see Figure 11). The cobble deposit extends 100 m landward of the active beach face.

The active beach exhibits a linear seaward sloping profile between Mean Low Water Spring (MLWS) and Mean High Water Spring (MHWS) then steepens towards the berm/ridge situated at the top of the beach profile (Figure 9). The cobble berm/ridge has an elevation of approximately 6.3 m above CD and 1.2 m above the Highest Astronomical Tide (HAT) datum and therefore represents a feature that formed under storm rather than a fair-weather conditions. The ridge is orientated along a NE-SW axis but curves to towards the west along the western end of the beach where the berm/ridge loses definition and becomes wider with a lower relief.

Landward of the active shoreface are two relict beach/berms, the relic nature of these features is inferred based on the distinct patina which has formed on the cobbles and the fact that they are situated leeward and at higher elevations compared to the active beach/berm.

The lower relict beach/berm has a crest with a height of 8.1 m and situated ~15 m behind the active berm. Similar to the active beach berm, this lower relic berm ridge becomes ill defined along the western half of the feature.

The upper relic beach is represented by a seaward dipping slope however the berm is less well defined, rather the cobble deposit extends landward of the upper relic beach forming a broad (30 m wide) low relief cobble deposit with a maximum height of 11 m above Chart Datum (CD). It is across this upper surface that DPLH 10303 it situated. The cobbles forming the upper relic berm have a much richer patina suggesting they have not experienced any recent inundation or reworking. Further supporting this observation are a scatter of coral clasts across the upper relic cobble deposit which appear heavily iron stained and weathered suggesting this deposit is a more ancient land surface has not been modified by storm events during the late Holocene. Radiocarbon dating of the coral clasts could establish the inundation age of the upper cobble deposit.

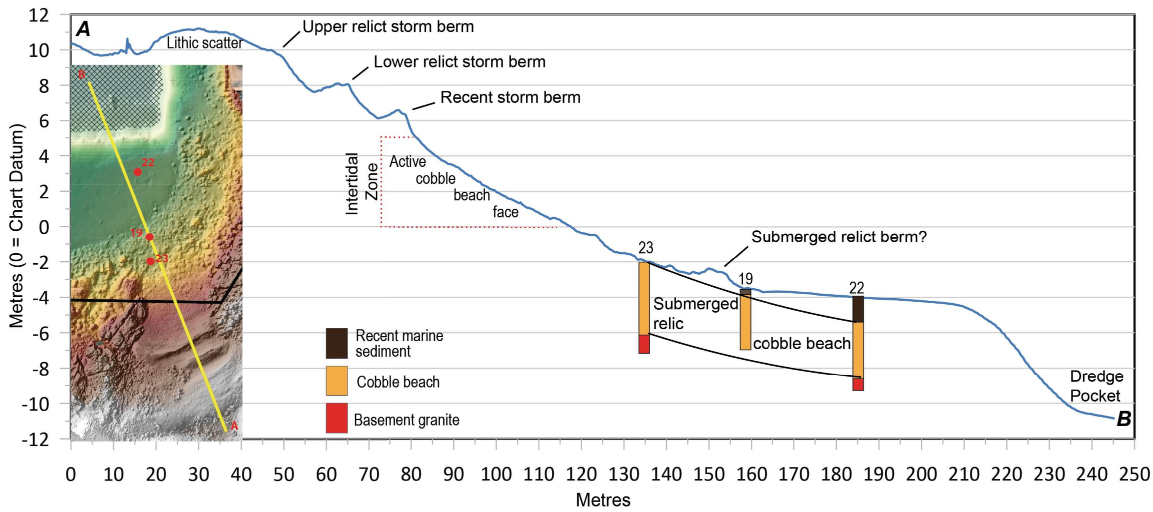

Figure 9: Shoreface profile from terrestrial to subtidal showing occurrence of subtidal cobble deposit. Nineteen, 22, and 23 are boreholes and their locations can be seen in Figure 2. (see Cosmos Archaeology 2022: Section 4.1.1.2). Black line in inset indicates the dredging footprint.

Aerial photography taken during clear water/spring low tide conditions reveals a shallow subtidal seabed characterised by a mosaic of exposed rocky outcrops and cobble/boulder patches which may represent the extension of the cobble beach below the low water line (Figure 10). There are also more recent coral reef build-ups, and sand patches which are likely more recent mid to late Holocene deposits, which cover the pre-inundation land surface. This area extends to a depth of -3.5 to -4.5 m below CD.

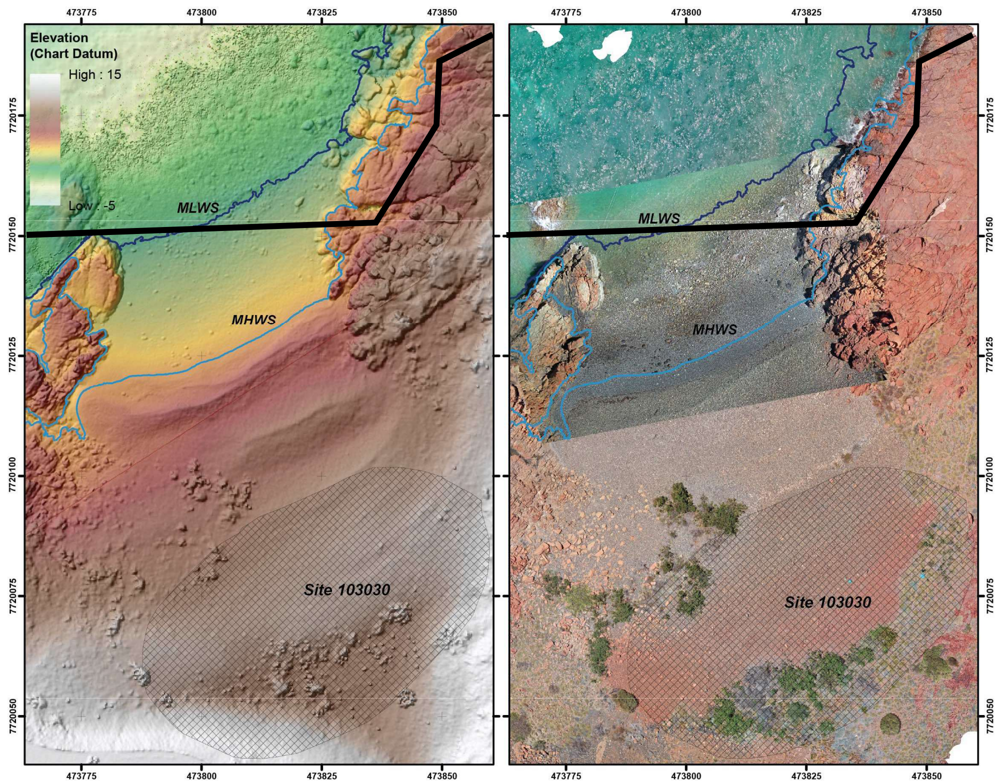

Figure 10: Left Panel shows digital elevation model of the active beach face and berm-ridge as the relic berm ridges. Panel on the right is a high resolution orthomosaic of the cobble beach. Mean low water spring and mean high water spring shown in the blue lines. DPLH 10303 area shown as hatched. Black line indicates Dredging Footprint.

2.4.2 *Cobble Beach Sedimentology*

The active beach slope between MLWS and Mean Low Water Neaps (MLWN) is characterised by a very poorly sorted, coarse pebble to medium boulder deposit. The active beach slope between MLWN and Mean High Water Neaps (MHWN) is characterised by a poorly sorted, medium pebble to fine boulder deposit. The active beach slope between MWHN and MHWS is characterised by a moderately sorted fine pebble to coarse cobble deposit with occasional larger medium to coarse boulders clasts also present (see Figure 9). The active beach slope between the MHWS and HAT is characterised by a moderately swell sorted pebble deposit with occasional larger coarse cobble fine boulder size clasts. The active beach slope between HAT and the berm ridge is characterised by a poorly sorted pebble through to fine boulder deposit. Clast size across DPLH 10303 is characterised by a moderately well sorted coarse pebble through to fine boulder deposit. There is a general gradation in clast size across the beach face (Figure 11) with an overall decrease in clast size moving from the lower intertidal zone though the upper intertidal zone, this grainsize distribution can be explained through a decrease in wave energy across the active beach face. The clast size increases across the berm/beach ridge, which is situated above the HAT level and therefore likely formed under elevated storm wave conditions and can explain the coarsening of clast size above the upper intertidal zone. The measured clast size distribution across DPLH 10303 is similar to what is observed along the active beach face and along with the presence of coral clasts and deeper red patina suggests this this leeward most and highest section of the formation was similarly exposed to and modified by wave and tidal current processes, likely during the last interglacial sea level highstand, although there was no particular clast size distribution across the deposit.

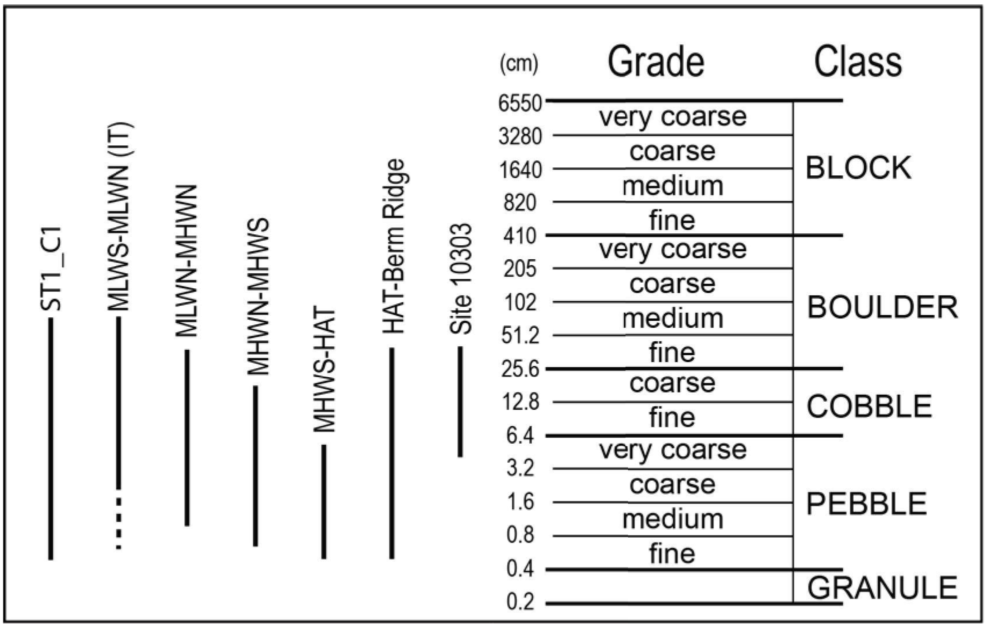

Figure 11: Shows the range of cobble clast size within each tidal zone across the active beach. Cobble clast size on DPLH 10303 is also shown for comparison. Clast size was measured using georeferenced high resolution orthophoto imagery while for IT01 and ST01 trenches the clast size was measured based on the photographs of the contents of the rock cages.

2.4.3 *Nearshore Hydrodynamics*

Wave energy at the cobble beach across a typical year is low. Wave data from the nearest PPA AWAC (BN09) recorded a modal swell height of 0.06 m and peak swell height of 0.59 during 2021 and a modal swell height of 0.05 m and peak swell height of 0.35 m in 2022 (Figure 12). Wind waves had a modal wave height of 0.13 m and peak wave height of 1.55 m during 2021 and a modal wave height of 0.15 m and peak wave height of 1.24 m during 2022. The largest waves to impact the cobble beach during 2021/22 were locally generated wind waves that approach the beach from a northerly direction. While there have been two cyclones that have impacted the archipelago in recent years, Cyclone Veronica passed across the northern archipelago in an east-west direction as a Category 2 system in Feb 2019, and Cyclone Damien passing down the length of Mermaid Sound as a Category 3 system in Feb 2020, both these events were unable to be captured due to recording failures in PPA hydrographic instruments. The maximum spring tidal range calculated from the King Bay Tide gauge across 2021 and 2022 ranged between 0.35 and 5.1 m above CD.

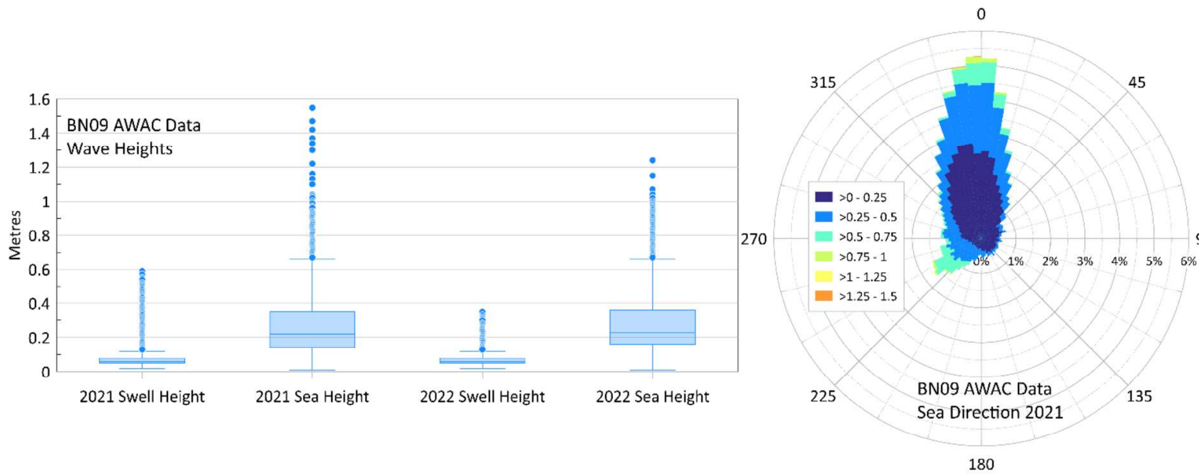

Figure 12: Left panel shows average wave height (blue horizontal line in box), lower 25 and upper 75 percentiles (upper and lower box edges), interquartile range (whiskers), outliers (blue dots). Right panel rose diagram of wave height and direction.

2.4.4 *Cobble Beach Morphodynamics*

An annual timeseries of lower resolution aerial imagery covering the years 2014 to 2022 provide evidence for morphodynamic step change in beach ridge position likely driven by high energy cyclonic events (Figure 13).

July 2014 > Cobble berm/ridge forms a simple, continuous, arcuate feature.

May 2015 > An erosional cusp has formed along the western half of the beach ridge, cobbles appear to have overwashed the berm forming a splay of cobble material behind the western end of the ridge. It is noted that between the July 2014 and May 2015 imagery Cyclone Olwyn (March 11) passed 300 km to the north of the archipelago as a Category 1 system. Given the northernly passage of the cyclone it had the potential to generate a large northerly ground swell that may have been responsible for the erosion and overwash along the western end of the cobble beach.

April 2016 > The cobble beach appears to have remained geomorphically stable with little change in beach morphology from the May 2015 image.

October 2017 > Appears to be little change in beach morphology from the May 2015 image.

April 2018 > There has been infilling of the erosional cusp and the ridge axis appears to be returning to something similar to the July 2014 image.

***April 2019* >** The berm ridge along the western half of the beach has been destroyed and cobble material appears to have overwashed the berm forming a large cobble splay. Cobble material can be seen now covering exposed bedrock or large boulders that were situated behind the beach ridge in the earlier airphotos. The period between the April 2018 and April 2019 imagery saw Cyclone Veronica (March 25) pass across the northern part of the archipelago as a Category 2 system and had the potential to generate a large northerly ground swell that may have been responsible for the erosion and overwash along the western end of the beach, similar to Cyclone Olwyn.

***April 2020* >** The berm ridge appears to have reformed along the length of the beach, while there does not appear to be any change to the footprint/extent of the splay at the western end of the beach, the ridge along the western side of the beach has shifted by up to 5 metres landward. The reforming of a defined cobble berm/ridge likely resulted from Cyclone Damien which tracked down the length of Mermaid Sound with the eye crossing the coast over the town of Dampier (8th Feb 2020).

October 2021 > The berm ridge does not appear to have shifted position, however it does appear less well defined compared to April 2020 and it is possible that beach clasts have been transported into the upper intertidal zone.

November 2022 > There appears to be little change in beach morphology from the October 2021 imagery.

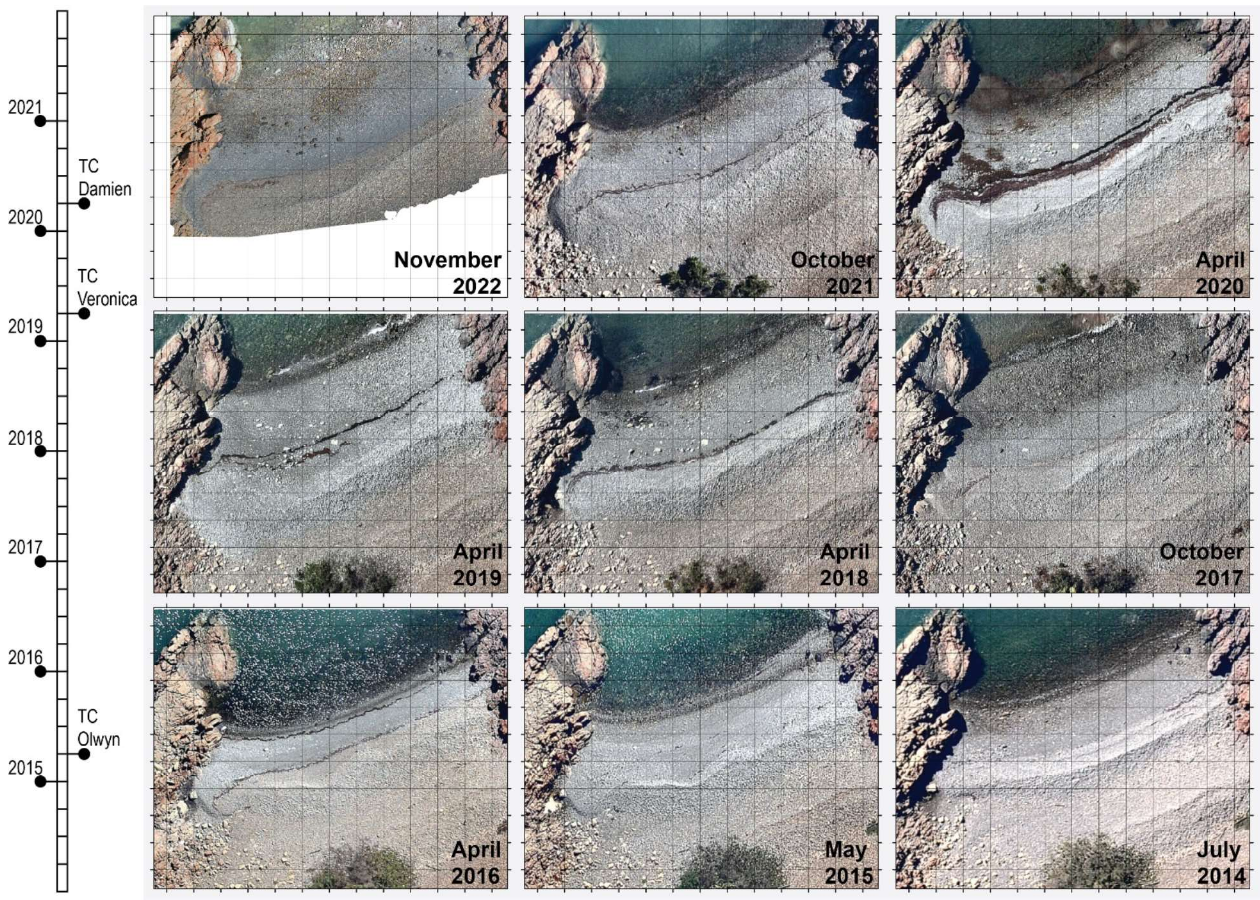

Figure 13: Annual time series of low resolution aerial imagery covering the years 2014 to 2022.

2.4.5 *Cobble movement*

Two very high-resolution drone orthomosaics were collected by PPA on the 21st of September 2020 and Cosmos Archaeology on the 30th of November 2022. The Cosmos orthomosaic was manually re-rectified using the older PPA orthomosaic as the reference frame (Figure 14). It was evident when comparing the two images that there had been significant movement of clasts across the active beach face, but with no obvious change in berm/ridge position. A total of 13 boulders were able to be identified and positions tracked across both images. Boulders located within upper intertidal zone exhibited a net movement of up to 1.5 m down the beach profile. Boulders located within the lower intertidal zone appeared to move up the beach profile by as much as 1 m. It was difficult to identify the same cobble clast across both images and some larger boulders had completely disappeared, likely the result of burial by smaller cobbles.

When overlaying the two images there is also evidence of cobble clasts being transported and deposited further down the beach profile particularly along the eastern and western ends of the active beach face and less so in the middle section of the active beach face. As these are the only two images with a high enough resolution to track individual clasts it is not clear whether the transport of clasts across the active beach occurred gradually over a period of fair-weather conditions or during a single high energy event.

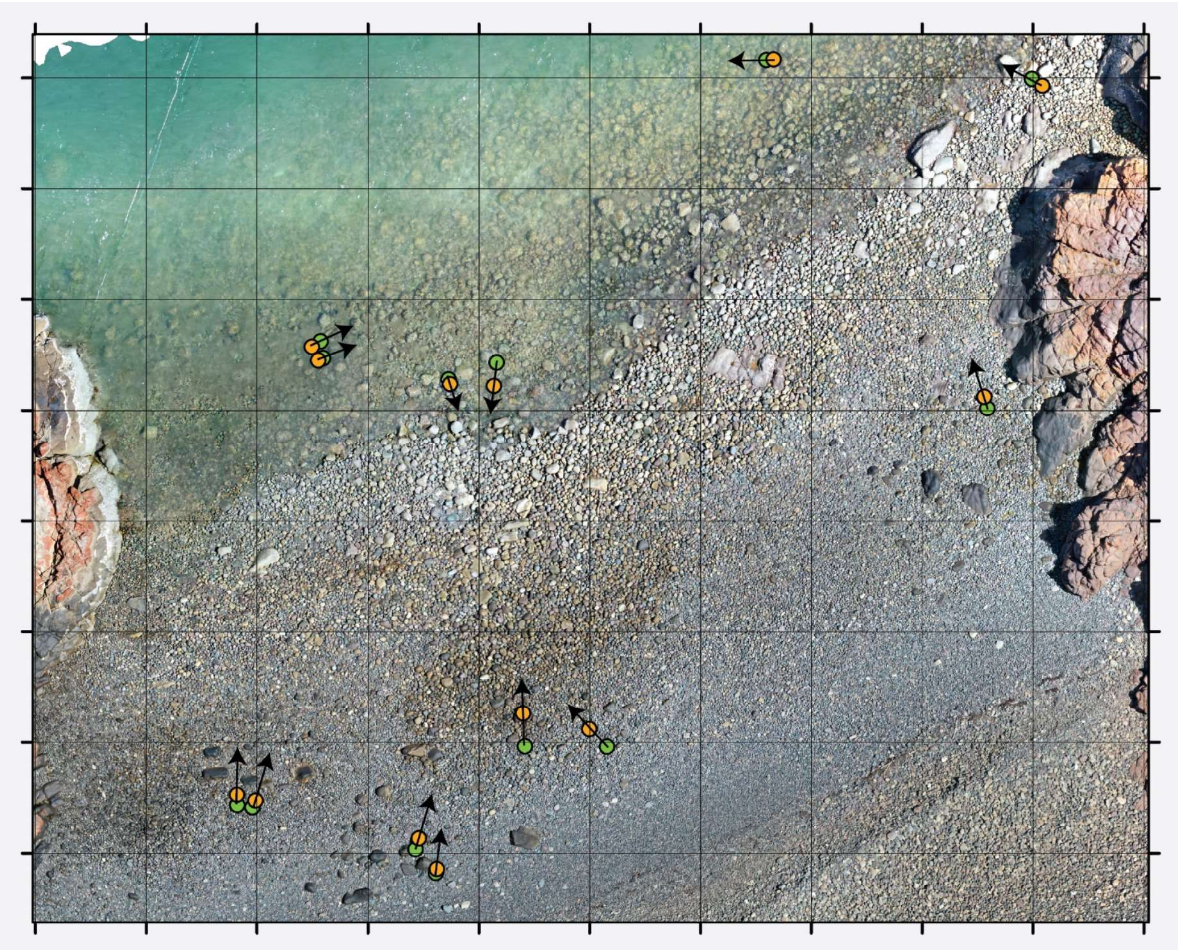

Figure 14: High resolution orthophoto from November 2022. Green dots represent position of cobble/boulder in the Sept 2020 orthophoto and the orange dot showing the location of the same cobble/boulder, arrows give the indicative direction of movement.

The last major cyclonic event to impact the cobble beach was Cyclone Damien which crossed the Dampier coastline on February 8th 2020, prior to the PPA orthophoto imagery being collected and there has been no major cyclone event to impact the archipelago since.

Wave data from the BN09 AWAC recorded two significant swell events of 0.6 m with a 12 second period during the 3rd March and 4th August 2021 and a significant wind wave event of 1.6 m with a 4 second period on the 3rd February 2021. Wave conditions during 2022 were generally more benign than these peak 2021 events.

The observed movement of cobble and boulder clasts across the active beach face over the period between the orthomosaic images suggests that these size clasts are still capable of being transported across the active beach zone during non-cyclonic conditions. It was clear that material above the modern beach ridge have been stable despite across the period of airphoto imagery and two major cyclonic events, though it was unable to be determined if cobble/boulder clasts within the subtidal zone have been actively transported, though it should be noted that the energy experience in the subtidal zone will be significantly less than that experienced on the active beach face.

3 CONDUCT AND METHODS

3.1 Personnel

Cosmos Coroneos (CA) was the Excavation Director (ED) and was responsible for the organisation of the maritime and terrestrial archaeology teams, as well as liaising with Oceanic Offshore, the commercial diving contractor, PPA and MAC. The ED was responsible for ensuring the excavation methodology was maintained and all data was collected to the highest possible standard. Connor McBrian (CA) was a diving maritime archaeologist, in charge of archaeological excavations of the subtidal trenches. Philippe Kermeen (CA) conducted video recording of terrestrial and underwater transects via drone survey and handheld video survey.

Pedestrian surveys of known sites on the Cobble Beach were coordinated by a team of archaeologists from Archae-aus (AA), headed by Dr Caroline Bird (AA) along with Jim Stedman (AA) and Rebecca Ryan (AA). The Archae-aus archaeologists also operated the sieve table during underwater excavations and identified potential artefacts collected.

Dr Mick O'Leary (UWA) provided expert advice on geomorphology and underwater site formation processes. Dr O'Leary was not able to attend the field investigation due to illness at the time.

Robert Brock (PPA) operated as the client representative and escort for all terrestrial operations.

Dive support was provided by Oceanic Offshore (OO), who supplied the research vessels, underwater excavation equipment, SSBA and SCUBA equipment, and provided transportation to and from site.

Table 1: Personnel involved in DCW Underwater Archaeological Investigation.

Name	Title	Company
Cosmos Coroneos	Excavation Director	Cosmos Archaeology (CA)
Connor McBrian	Maritime Archaeologist / Diver	Cosmos Archaeology
Philippe Kermeen	Maritime Archaeologist / Drone Pilot / Diver	Cosmos Archaeology
Dr Caroline Bird	Lead Aboriginal Archaeologist	Archae-aus (AA)
Jim Stedman	Aboriginal Archaeologist	Archae-aus
Rebecca Ryan	Aboriginal Archaeologist	Archae-aus
Dr Mick O'Leary	Geomorphologist	University of Western Australia (UWA)
Robert Brock	Heritage Specialist	Pilbara Ports Authority (PPA)
Benjamin Simpson	Skipper / Dive Supervisor	Oceanic Offshore
Brett Devlin	Vessel Master / Crane Operator	Oceanic Offshore
Andrew Dunn	Commercial Diver	Oceanic Offshore
Glen Nuttall	Commercial Diver	Oceanic Offshore
Ray Scepanovich	Commercial Diver	Oceanic Offshore

3.2 Timings

Fieldwork was conducted between 22 November and 1 December 2022. Archaeological surveys and excavations were conducted over six days between 24 November and 29 November.

Table 2: Project timings, relevant operations and personnel involved.

Date	Operations	Personnel involved
22/11/2022 – Tuesday	CA team arrives in Dampier.	CA
23/11/2022 – Wednesday	AA team arrives in Dampier, equipment for excavation gathered by CA.	CA, AA
24/11/2022 – Thursday	Terrestrial visual survey of Transect T10 within the boundary of DPLH 10303.	CA, AA, PPA
25/11/2022 – Friday	Excavation of intertidal trench and continuing visual survey of T10 and intertidal survey.	CA, AA, PPA, OO
26/11/2022 – Saturday	Underwater video transect survey, location of ST01 determined, seabed probing, finish excavation of IT01.	CA, AA, OO, PPA
27/11/2022 – Sunday	Excavation of ST01, video record IT01 at low tide.	CA, AA, OO, PPA
28/11/2022 – Monday	Finish excavation of ST01, detailed recording of knapping floor on cobble beach (S1) within the boundary of DPLH 10303, locate and begin clearing ST02.	CA, AA, OO, PPA (Ray replaced by Glen for remainder of diving)
29/11/2022 – Tuesday	Finish excavation of ST02, collect C14 samples from subtidal trenches, continued excavation on ST01.	CA, AA, OO
30/11/2022 – Wednesday	Demob, AA team members leave Karratha, artefacts and samples from excavations deposited at MAC offices.	CA
1/12/2022 – Thursday	CA team members leave Karratha.	CA

3.3 Tides and Weather

The information presented in Table 3 was obtained from the Bureau of Meteorology weather observations for Karratha Aerodrome.[1] Tide information in Table 4 was also obtained from the Bureau of Meteorology for Dampier (King Bay).[2]

Table 3: Daily weather conditions.

Date	Temperature (°C)	Wind 09:00 (km/h)	Wind 15:00 (km/h)	Precipitation
22 November 2022	24.0 – 34.1	35 E	35 NNE	0 mm
23 November 2022	23.9 – 33.0	20 NE	22 NNW	0 mm

[1] http://www.bom.gov.au/climate/dwo/202211/html/IDCJDW6064.202211.shtml
[2] http://www.bom.gov.au/ntc/IDO59001/IDO59001_2022_WA_TP011.pdf

Date	Temperature (°C)	Wind 09:00 (km/h)	Wind 15:00 (km/h)	Precipitation
24 November 2022	23.6 – 33.8	9 N	20 NNW	0 mm
25 November 2022	24.1 – 33.7	11 NNW	22 NNW	0 mm
26 November 2022	24.8 – 34.4	11 SSW	24 WNW	0 mm
27 November 2022	23.3 – 35.3	19 ENE	20 NW	0 mm
28 November 2022	25.0 – 36.1	7 NW	24 WNW	0 mm
29 November 2022	26.2 – 35.7	13 SSW	13 NW	0 mm
30 November 2022	25.6 – 34.3	19 W	28 WNW	0 mm
1 December 2022	26.1 – 36.0	19 W	31 WNW	0 mm

Table 4: Tides during vessel operations.

25 November 2022	Time	0524	1130	1724	2324
	Height (m Lat)	0.3	4.0	1.1	4.6
26 November 2022	Time	0600	1206	1759	-
	Height (m Lat)	0.2	4.0	1.1	-
27 November 2022	Time	0000	0638	1243	1837
	Height (m Lat)	4.6	0.3	3.9	1.1
28 November 2022	Time	0037	0716	1323	1918
	Height (m Lat)	4.5	0.4	3.8	1.3
29 November 2022	Time	0117	0758	1407	2004
	Height (m Lat)	4.2	0.7	3.6	1.5

3.4 Terrestrial Surveys

3.4.1 *Location of Surveys*

The terrestrial survey commenced on the 24th November and included the maritime archaeology team. Surveying continued on the 25th and 28th November.

Two transects were located within the recorded boundary of DPLH 10303 (Figure 15). The first (T10) was a two-metre wide transect laid out roughly parallel to the shoreline. It was initially 30 m and the survey commenced at the eastern end. It was quickly realised that the attribution of the flaked stone at this end of the transect as being cultural or natural was problematic. It was observed that beyond the western end of T10, high concentrations of more definite artefacts were present. The transect was extended by 14 m to capture these artefacts as well in the survey. A second 5 x 1 m transect (S1) sampled the densest portion of the artefact scatter in the southwest part of the site.

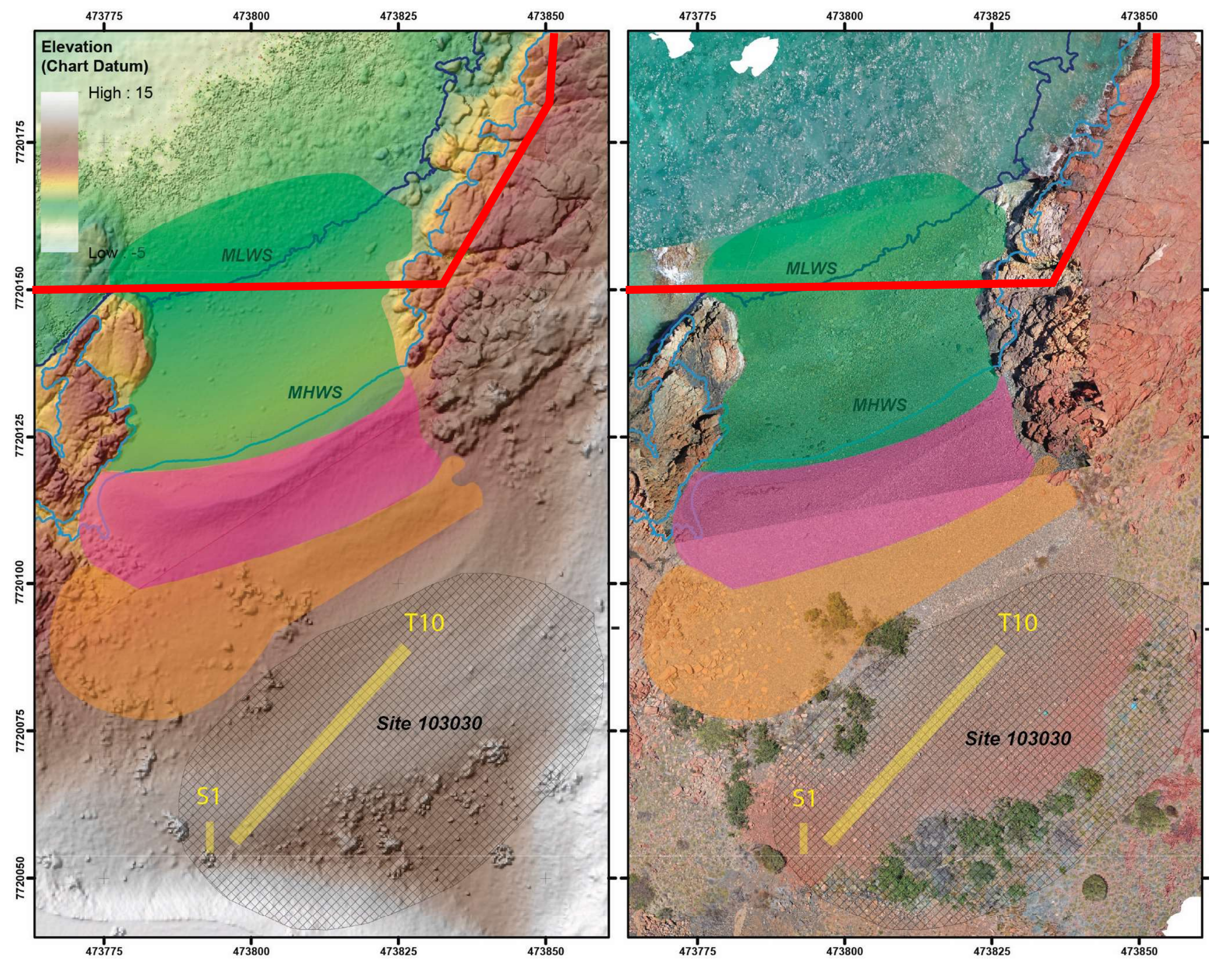

Figure 15: Location of T10, S1 and range of intertidal (green) and beach (pink = berm/terrace 1 and orange = berm/terrace 2) survey. Red line depicts Dredging Footprint.

It was originally planned that similar transects would be recorded in detail in the intertidal zone. However, the small tidal window at the time of the survey – 0555 to 0700 25th November – did not allow for the laying out of a survey line. Instead, the survey team systematically walked across the intertidal zone recording as they went. The extent of the intertidal survey can be ascertained from where the recordings were made (see Figure 15).

All spatial information obtained by the Archae-aus team was collected using a handheld Garmin GPS with a purported accuracy of +/- 3 m. For the reporting however a slightly wider degree of accuracy of +/- 5 m has been adopted. The end points of T10 and S1 were recorded during the drone survey and their coordinates have been corrected to GDA2020 with sub-metre accuracy (see Section 3.6). The adjusted locations of the terrestrial transects are presented in Table 5.

Table 5: Locations of terrestrial transects.

Transect	Start (GDA2020)	End (GDA2020)	Length	Width
T10	473828 mE	473795 mE	44	2
	7720092 mS	7720056 mS		
S1	472793 mE	473793 mE	5	1
	7720059 mS	7720063 mS		

3.4.2 *Recording methods*

Within the sampled area for T10 and S1 all stone artefacts were recorded in detail on proformas and included photography. The same process was intended for the intertidal and beach survey however it was observed that these areas were dominated by rounded pebbles/cobbles and the quantity of fractured material was very sparse and any flaked specimens were recorded as isolated or potential 'artefacts'. The term 'flake' used in this report refers to a fragment detached from a nucleus and a nucleus is any object from which a flake is detached. It is important to note for this study that the term flake (or blade) and nucleus does not imply that they are lithics that have been culturally modified. For more detail on the methods used in the categorising of the finds see Annex A and Cotterell, B. and J. Kamminga 1987.

3.5 Underwater Survey and Excavation Methods

3.5.1 *Work vessel*

The *Mary V* is a 19 m open-decked vessel purpose built for diving, owned by Oceanic Offshore (Figure 16). All dive and excavation operations took place on the vessel as did the examination of the recovered material. The 72 m^2 deck area allowed for a sieve table to be set up and an area at the bow for the larger clasts to be laid out and examined. The deck crane is rated to lift to 5,300 kgs and was used to lift silt boxes and rock cages from the seabed onto the deck.

Aboard the vessel were four crew who were also commercial divers, three maritime archaeologists and three terrestrial archaeologists. PPA representative Robert Brock was also aboard for most of the time.

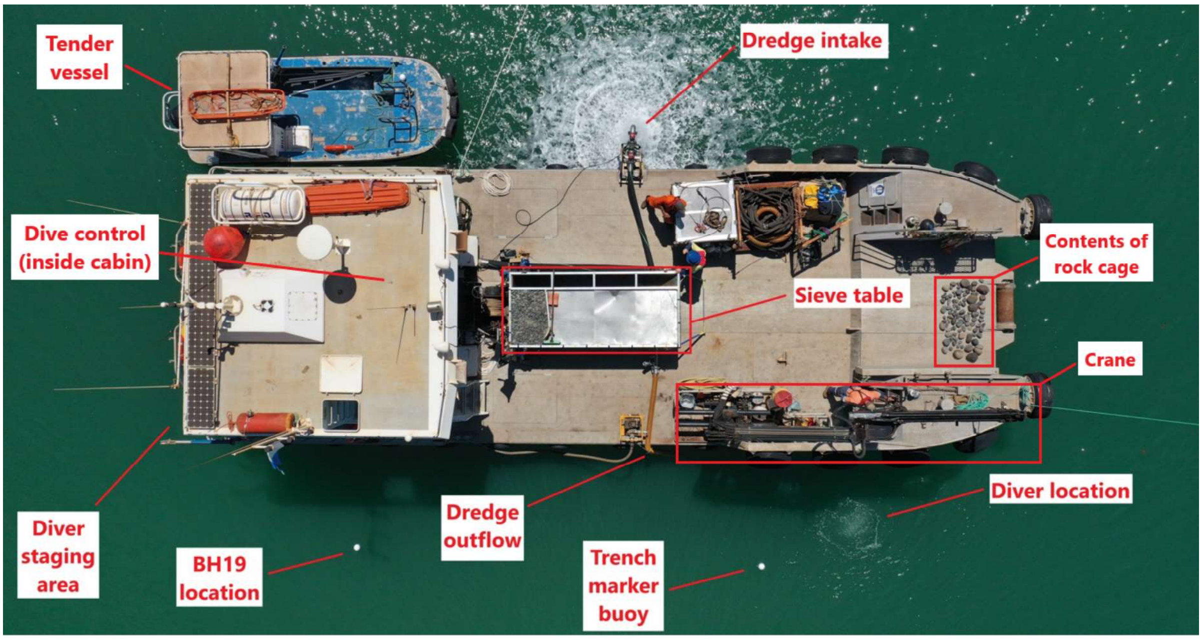

Figure 16: Drone photo of Mary V, with relevant underwater excavation equipment labelled.

3.5.2 *Conduct of Diving*

The underwater archaeological excavation was carried out between 25th November and 29th November 2022. The excavation process was undertaken by five divers, including three commercial divers and two diving maritime archaeologists. Due to the shallow nature of the trench locations (between 2 – 6 m water depth), dive times were limited only to diver fatigue and typically lasted up to 4 hours. Conditions on site were generally conducive to excavation, with no rain, moderate winds, warm water temperature, and favourable tides.

Water visibility over the five days varied from <0.5 m to 2 m. The variation in visibility was due to the silty sediment covering the work site being stirred by wind chop as well as mats or blooms of tan coloured algae (*Trichodesmium sp.*), a common phenomenon at this time of year, floating into the area (Figure 17).

Figure 17: Tan coloured algae moving towards the work site.

In general, diving was carried out using SSBA due to the use of surface powered excavation equipment. Divers on SSBA were connected to the *Mary V* support vessel by an umbilical with hard wired communications, as well as a helmet mounted video camera (Figure 18 and Figure 19). Video recording of underwater transects and trench recording was conducted on SCUBA, as the diver needed to maintain neutral buoyancy above the seabed and avoid entanglements with coral heads and excavation equipment.

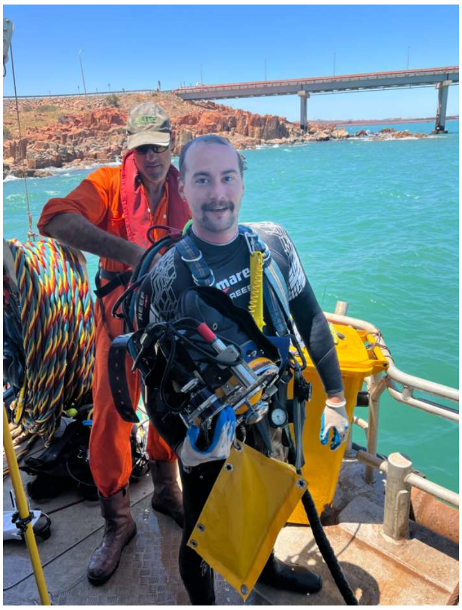

Figure 18: Connor McBrian (CA) and Ray Scepanovich (OO) prepping for dive on SSBA at the diver staging area, rear of vessel.

Figure 19: Dive operations were run from within the cabin of the* Mary V *with comms and video links to the divers. The ED, Cosmos Coroneos, stood by the dive panel and conversed with the divers and recorded observations, times and other details.

3.5.3 *Excavation approach*

The underwater excavation was carried out within fixed 2 x 2 m frames. When a location was chosen, a 2 m x 2 m frame was laid down to provide the boundary of the trench. The frame was made of PVC pipe and marked at 200 mm intervals. Frames were anchored to the seabed by zip-tying the four corners to heavy steel D-shackles which rested on the surface of the seabed and were marked with a small fishing buoy (Figure 20).

The excavation was carried out with a mixture of manual handling and use of a surface operated induction dredge. Clasts larger than fist size were placed by hand in an open top steel cage, the ‘rock cage’ which measured 1 m x 1 m x 1 m in height (Figure 21).

Figure 20: 2 x 2 m square for ITO1. Note the use of shackles in the corner to weigh down the square as driving in pegs was not possible. Also, the clasts from Context 1 are piled onto a blue tarpaulin for raising at high tide

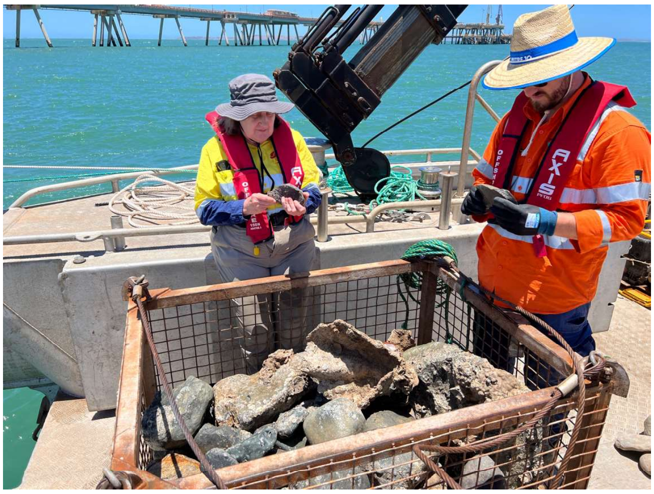

Figure 21: Examining contents of the rock cage.

For the finer sediments within the trench the water induction dredge was used. The principle of the venturi effect whereby high-pressure water is forced through a constricted area, is used to create a vacuum within the pipe system. This enables the diver to excavate at one end and have the spoil transferred to the opposite end using the suction forces created by the venturi effect.

Several components were used for the setup of the water dredge for this project (Figure 22). A metal fabricated dredge head with a rubber cowling was used at the excavation end. Here the dredge head provided three connection points and facilitated the water flow creating the venturi effect. A layflat hose, extending from the water pump on the surface, was connected to the dredge head. This hose delivered high-pressure water into the dredge head and forced it into a constricted space with smaller metal nozzles. The smaller nozzles created an even higher-pressure flow and the water directed 180 degrees creating a vacuum at the dredge head. The spoil end of the dredge head was connected to another 6” flexible hose to transport spoil and artefacts to the silt box. The opposite end of the spoil hose was connected into a cam lock on the purpose-built silt boxes. The silt boxes were prefabricated by OO and were 1 x 1 x 1 m in size with 2 mm stainless steel mesh plates installed (Figure 23). The mesh was used to capture the smallest artefacts while also allowing for water and fine sediment to escape. Subsequently, the combination of the mesh and water escaping the silt boxes acted as a type of mechanical sieve underwater. In addition to the dredge, a small water jet, attached to the pump by a narrow hose, was lowered to the diver to aid in breaking up sediment between the clasts. A valve on the head of the jet allowed the diver to turn the water pressure on and off as needed.

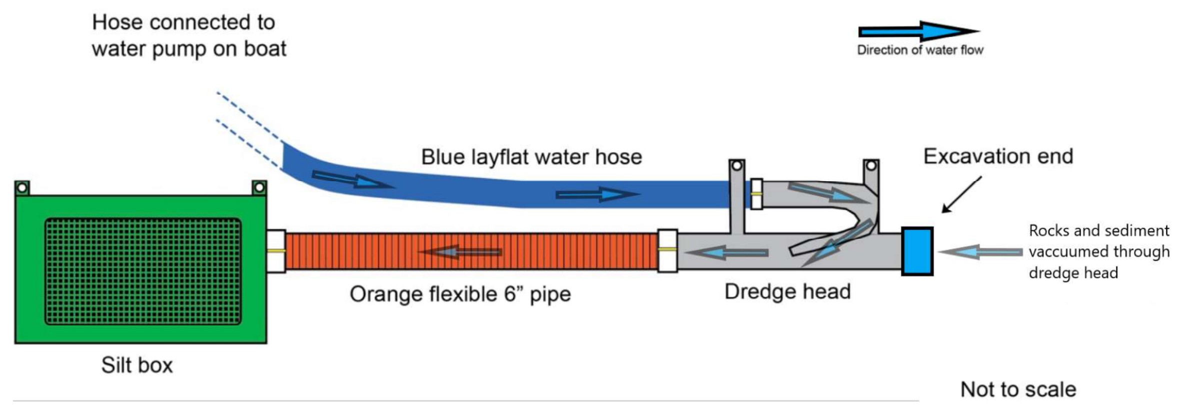

Figure 22: Example of a similar set up for the diver operated water dredge.

Figure 23: Silt box and contents.

3.5.4 *Contexts and spits*

Excavation was carried out in a manner similar to a terrestrial excavation – by contexts and spits. A context (also referred to as a ‘unit’) is defined by the composition/texture of the sediment, shell, coral and rock encountered. Where there was an observable change in the matrix, a new context number was assigned. The context numbering was sequential and unique to each trench, for example Subtidal Trench 01 - Context 1, Subtidal Trench 01 - Context 2, etc.

A spit for the purposes of this excavation is an arbitrary horizontal division within a context. The spit was used when there was no observable difference in the unit but it was suspected there may be subtle changes with depth. As the unit which was excavated was composed of clasts up to boulder in size, it was not feasible for the spit thicknesses to be less than 250 mm.

Contexts and spits were only assigned to material collected for examination and analysis. The silt and coral layers encountered over the cobble formation was not collected and therefore were not assigned contexts.

3.5.5 *Sieving and recording on deck*

The sieve boxes and rock cages were fitted with lifting lugs and when ready were raised onto the deck of *Mary V* by a crane (Figure 24). Once on deck, sieve boxes were shovelled out by hand into buckets, which were then emptied onto a large sieve table on the middle of the deck. The sieve table was a modified skip bin with a 2 mm mesh screen laid on top.

***Figure 24: Sieve box (red circle) being raised onto the deck of* Mary V.**

Once silt box material was placed on the table, a team of archaeologists, led by lithics experts from Archae-aus, examined the material (Figure 25). Any potential artefacts, or geofacts showing specific types of natural fractures, were placed aside, and photographed separately.

Larger clasts and boulders placed in the rock cage were placed directly on the foredeck of the vessel. They were photographed as a group (Figure 26).

Upon completion of the day's excavation, material no longer required for study was returned to the seabed within the Dredging Footprint away from the worksite and the existing dredged footprint to the north.

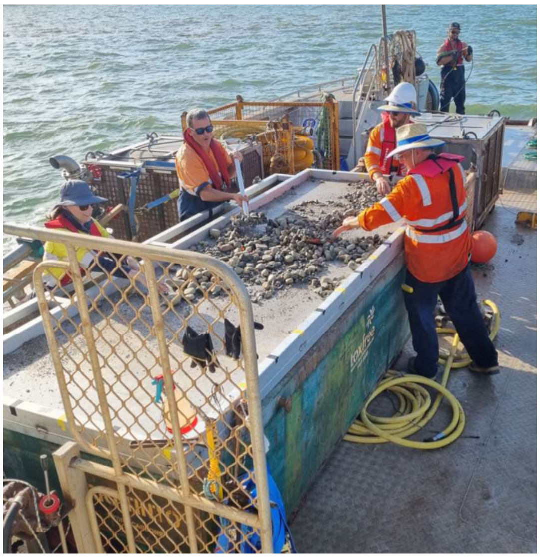

Figure 25: Archaeologists examining contents of sieve box on sieve table.

Figure 26: Photographing material brought up in the rock cage.

3.6 Drone Surveys

Remote Piloted Aerial System (RPAS, a.k.a. aerial drone) surveys were undertaken to record the entirety of the terrestrial, intertidal and subtidal sites. Surveys included the terraces that were evidently used within a cultural material context, the investigative area of the intertidal cobble beach, and the subtidal area around BH19 (473782 mE and 7720190 mS). All pre-flight setup and checklists adhered to the PPA's remotely piloted aircraft systems coordination policies, and the '*Civil Aviation Safety Regulations Part 101*'.

DPLH 10303 has previously been aerial surveyed by PPA's Remote Sensing department on 20th September 2020, however the quality of survey data for archaeological purposes were undefined at the time. The site area is encompassed by a steep incline attached to Rob Vitenbergs Drive to the south and the Heavy Load Out (HLO) Quarry to the east, the northern section of the site is obscured by elevated outcrops of granophyre and small bushland (Figure 27). The landscape elevation from the proposed flight stations exceeded 12 m from 'Terrace 3' (the highest plain on site), thus the first proposed flight for maximum information was surveyed from an altitude of 30 m from Terrace 3 (12.56 m above sea level) (Figure 28).

RPAS surveys were limited by numerous factors:

- PPA aerial vehicle movement (quadcopter and helicopter) between 50–150 m altitude,
- PPA RPAS units operating in <30 m of the area for provisional monitoring and mapping,
- Light post positioning on Rob Vitenbergs Drive (standing height of 8 m from surface),
- Personnel working on site underneath drone mapping routes.

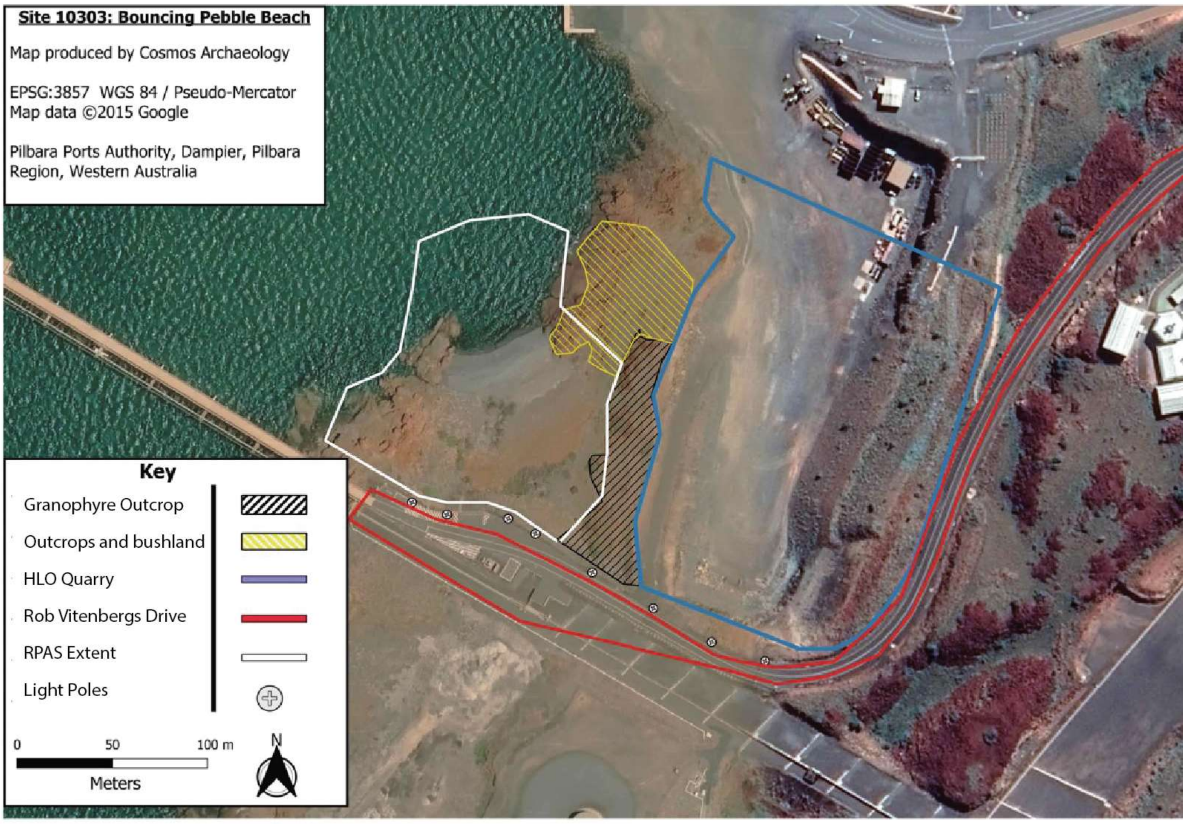

Figure 27: Drone survey general layout

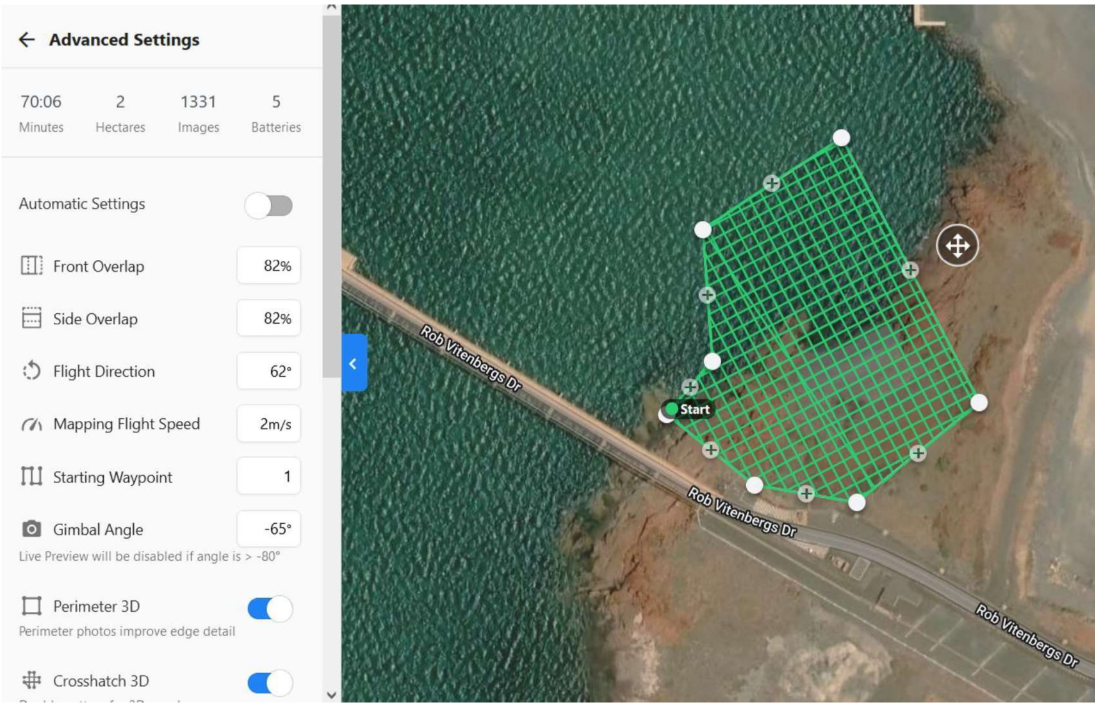

Figure 28: Extent of first drone flight.

The transect survey was completed by a Mavic 2 Pro; the 1" CMOS supports a 20 mega pixle (MP) still image with the resolution of 5472 x 3648. The GNSS inside the unit can link-in to GPS, Baidu, and Galileo in the Pilbara region. The average satellite link ranged from 19 – 23 throughout the day, adjusting coordinate position accuracy accordingly (outliers would be averaged and discarded in post-processing). The barometer within all DJI RPAS units have a 0.3 % inaccuracy rating for altitude measuring, thus, allowing for consistently accurate transect surveys of any given site. Perimeter and crosshatch flight patterns were added in pre-flight directives to gain further information for the digital elevation model (DEM) and higher accuracy and resolution for the 3D landscape render. The crosshatch pattern is important in building a high accuracy orthomosaic, DEM, and Digital terrain model (DTM) as the gimbal on the drone is positioned at a 65° angle to capture the varying elevation across the entire site. Four extra flight surveys managed to capture high resolution images of the 'intertidal excavation', Terrace 1, Terrace 2, and Transect 10 on Terrace 3 (DPLH 10303) which included a tape baseline and offset transect including the area where the highest concentrations of artefacts were observed (Figure 29). Due to intense light from the sun rebounding off the clasts and water's surface, the application of a circular polarizing lens has been added to counteract the distortion and glare effects throughout the flight missions.

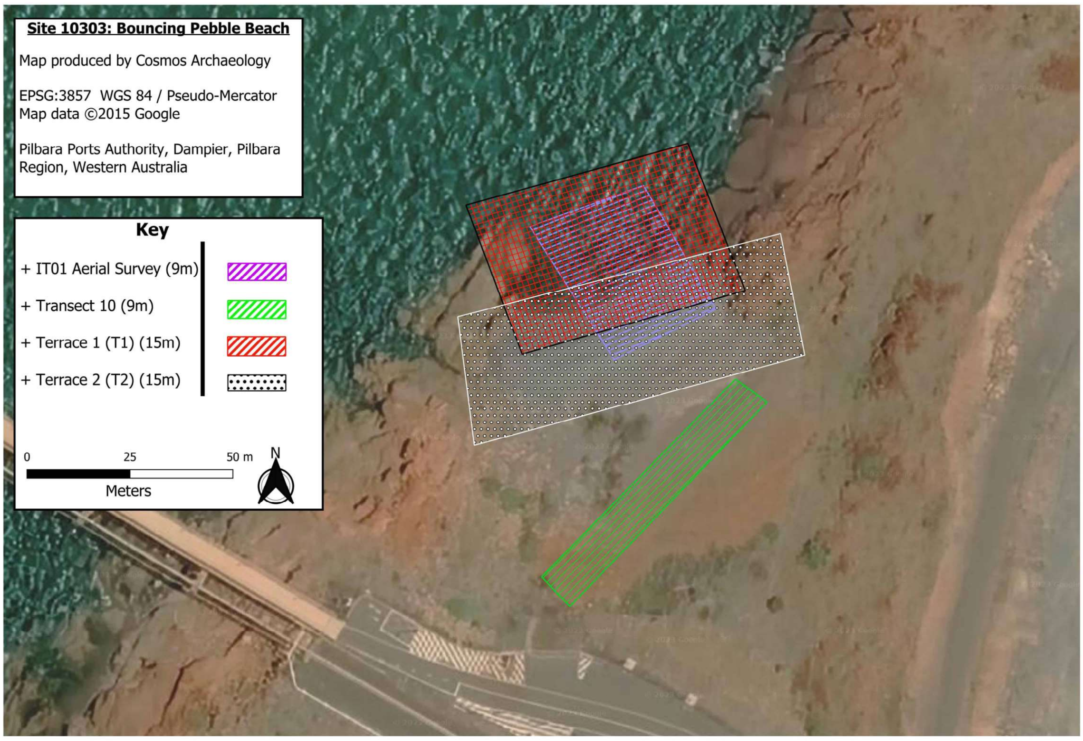

Figure 29: Extent of four drone surveys ranging in height from 9 to 15 m.

The RPAS data from the flight missions successfully recorded the entirety of the study area. The CPL filter was advantageous throughout the flight missions, cancelling out most of the glare and producing high resolution images of the cobbles and material found below the water's surface. The original '30 m flight plan' of DPLH 10303 successfully rendered with a ground sampling distance (GSD) of 0.89 cm/px, recorded within the high confidence of accuracy category applied by DroneDeploy Cloud Mapping Systems (Figure 30). The orthomosaic covers an estimated 42,828 m^2 area, rendering 73% of the model with photogrammetry and 27% being aligned together by the recorded coordinate and matching imaging system. The first 10303 orthomosaic and DEM were able to be compared to the 2020 models produced by PPA, this benefitted from analysing the movement of cobble stones over the two-year range. The accuracy of the two models was able to be investigated and concluded that between the two separate renders from 2020 and 2022, the accuracy had not displayed any large outliers or elevation distortion, giving confidence in the next five drone survey missions.

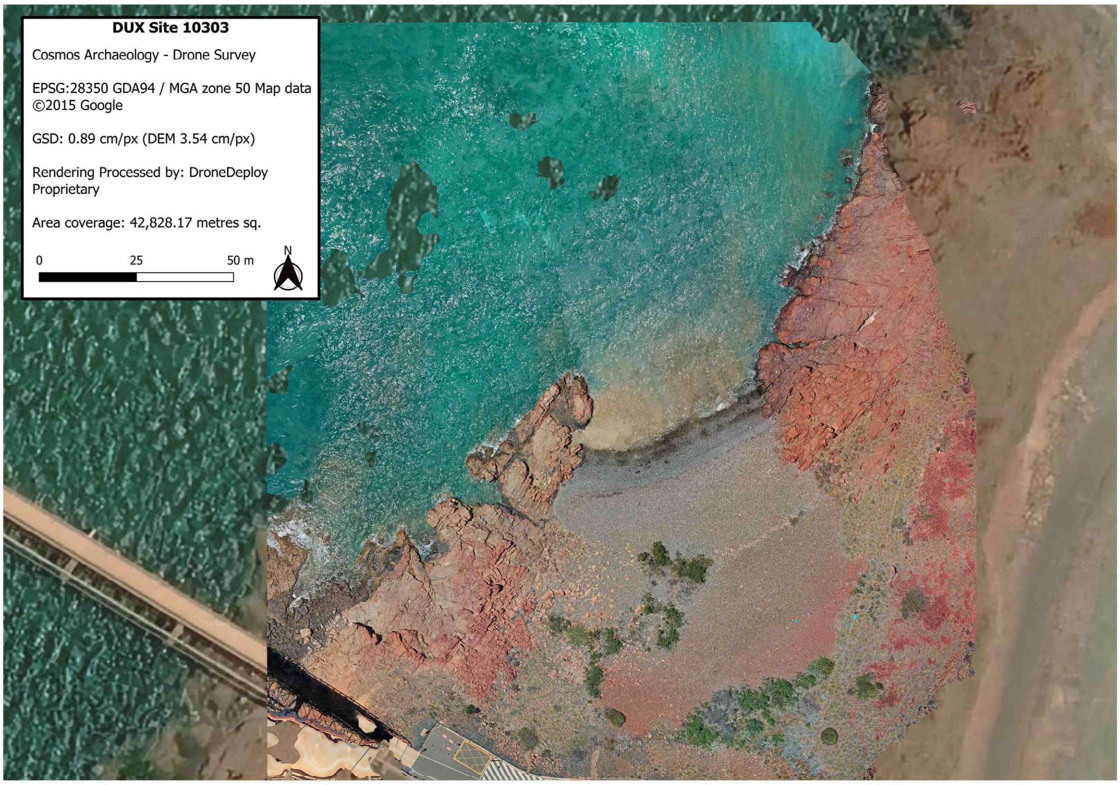

Figure 30: Orthomosaic created by drone survey

Intertidal trench survey

Intertidal trench 01 (IT01), was completed using two flight paths over the site (Figure 31). IT01 was repeated with a crosshatch pattern due to intertidal water movement, blurring edges of the orthomosaic, and the recording of personnel walking within the trench; therefore the focus will be on 'Flight 2' (Figure 32). The area was covered with a crosshatch and perimeter autonomous flight sequence to maximise the accuracy of depth that IT01 had been excavated to. The importance of recording this trench using an aerial survey instead of ground-based photographs was due to the context reach of site area. The clasts removed from the initial context layer were needed to depict the base and side walls of the trench in comparison to the outer cobble beach area The orthomosaics GSD recorded 0.87 cm/px, and 0.82 cm/px for the digital elevation model. With the manual deletion of personnel, the orthomosaic represents the intertidal trench's first context removed before high tide shift took effect over the site. Non-autonomous aerial imagery was taken again with the M2P to observe the continued work post-diving operations. The average GPS coordinate range was auto-tested and recorded at +/- 0.98 m accuracy, facilitating the need to fly the drone close to the target site for greater accuracy.

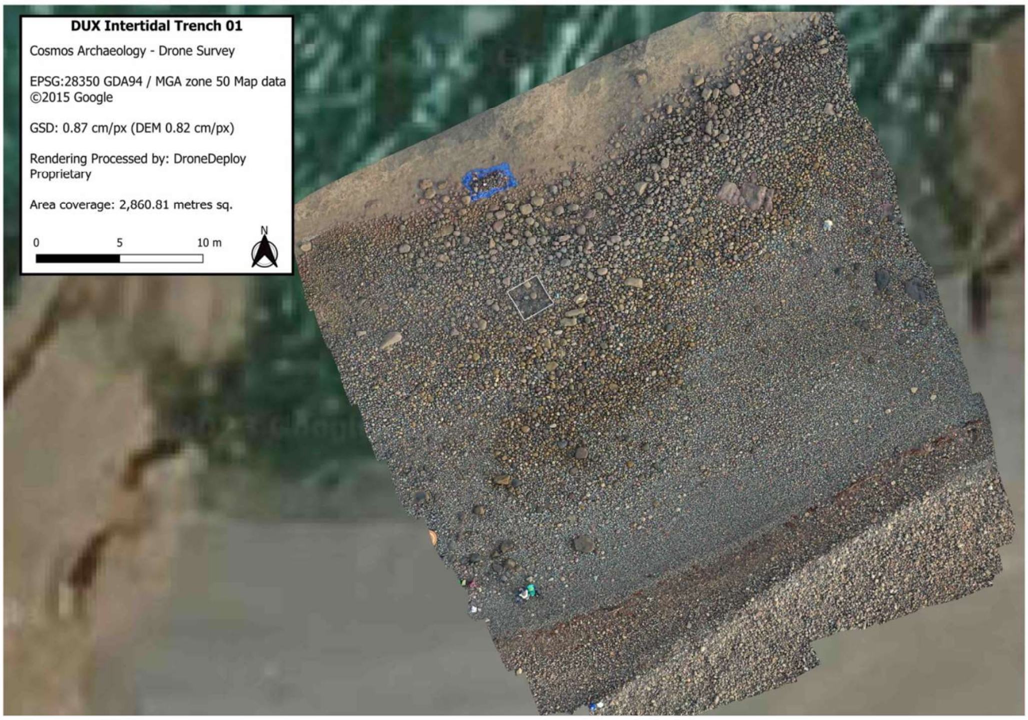

Figure 31: Intertidal area including IT01. Note clasts from Context 1 placed on blue tarpaulin.

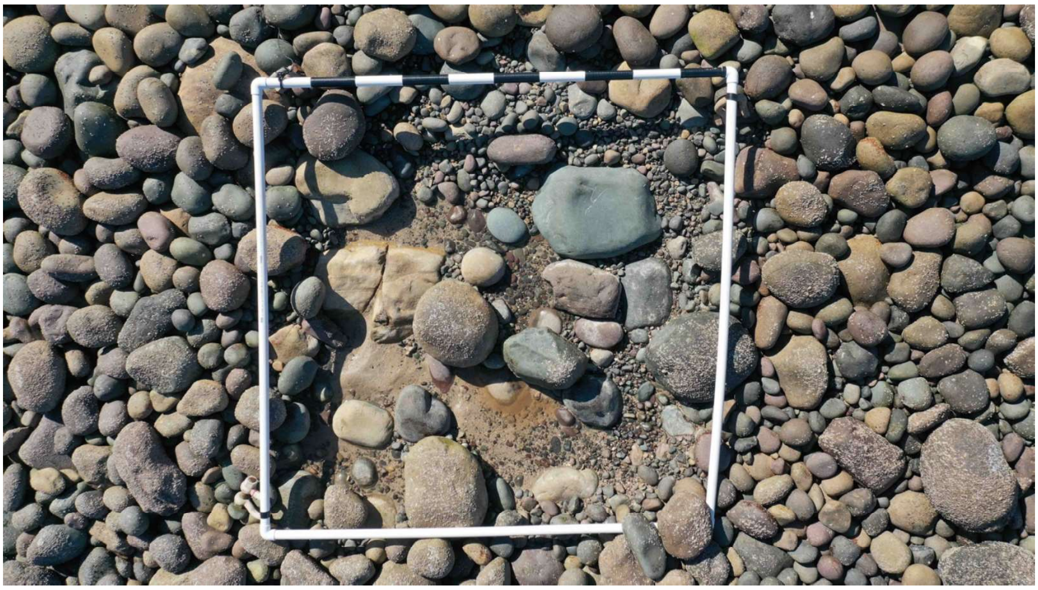

Figure 32: IT01 at completion of Context 2 (when exposed again at low tide).

T10 drone survey

T10 flight survey was undertaken with the objective of recording the baseline start and end point, pink tagged lithics, knapping floor, rock art, and the context of cobble and granophyre material. Due to limited time, the survey was completed by a simple U-transect survey method, edge detailing as expected is blurry but does not affect the main area of study and therefore is successful in the outcome needed. The area bounds covered 6,682 m^2 and GSD recorded 0.87 cm/px. The image alignment registered at 100% of the 326 photos rendered, but the low light and slower shutter speed of 1/50 has evidently caused motion blur on the edges of the orthomosaic (Figure 33).

Terrace 1 and 2 drone survey

Terrace 1 (T1) and 2 (T2) flight surveys were to record the intertidal zone to terrace 1, and then to terrace 2 with the objective of producing two high resolution models at a lower altitude (15 m) from sea level; flight missions were executed from the Oceanic vessel, thus, all heights were +/- 1.5 m from sea level (Figure 34). T1's GSD of 0.87 cm/px covering 7,535.67 m^2 has recorded the context of the site at -2 m below sea level to 5.4 m above sea level. T2's GSD matches T1 and covered 14,728 m^2, with overlapping margins of 35% added to produce a smooth comparison between the two models' DEM GSD results of 1.28 cm/px. Contouring can be applied to visualise all datasets.

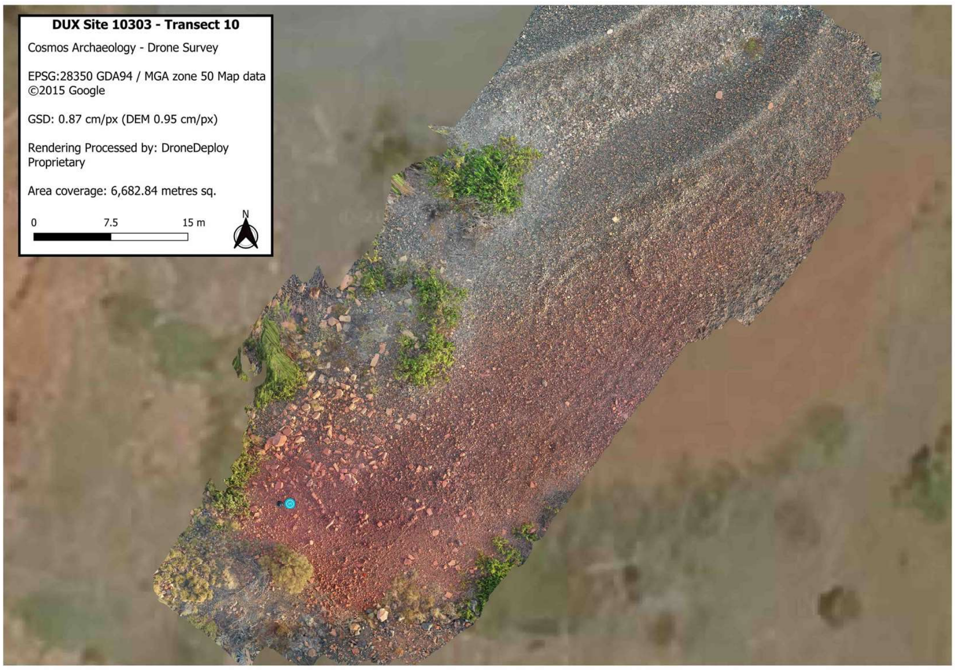

Figure 33: Drone derived imagery of Transect 10.

The use of the RPAS and DroneDeploy can be used to contrast dataset confidence and accuracy as well as monitor the site changes from 2020 and 2022, giving elevation data and material spread for the entire site. The high-resolution datasets can view the entire site and context, to interpret the landscape morphology to the intertidal zone, cobble sizes, differentiating colour of cobble stones and analysing DPLH 10303 to that of IT01.

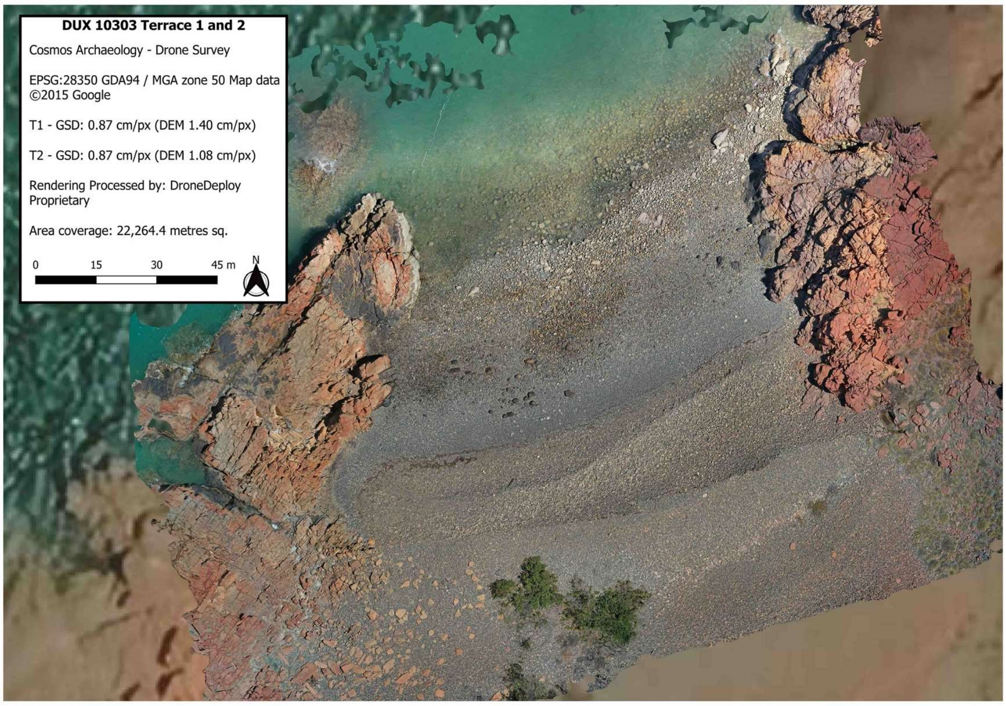

Figure 34: Aerial drone imagery of Terrace 1 and 2.

3.7 Subtidal Video Transects

Transect surveys have the benefit of providing essential information of the surrounding submerged environment, understanding the hydrodynamic affect and tidal change, and building the essential context for the site.

BH19 coordinates (473782 mE and 7720190 mS) were provided by PPA and were used to create the centre point for the subtidal survey. The string-baseline method was implemented with 20 m sections laid out in accordance with the four cardinal directions. The importance of the 20 m sections (40 m x 40 m) was to ensure that the excavation was selected within the vicinity of BH19 (Figure 35). The seafloor surface was a combination of loose sediment, coral debris, shell, and other calcified material from organic marine life. The hydrodynamic flow at the site is consistent with bays that are restricted from continuous water movement in the submerged environment, unless disturbed by larger storm events and cyclonic activity. The restriction of current within the site creates the problem of static sediment dispersal within the water column when disturbed by mechanical movement (i.e., anchors, propellor fanning, divers, umbilicals, and other equipment).

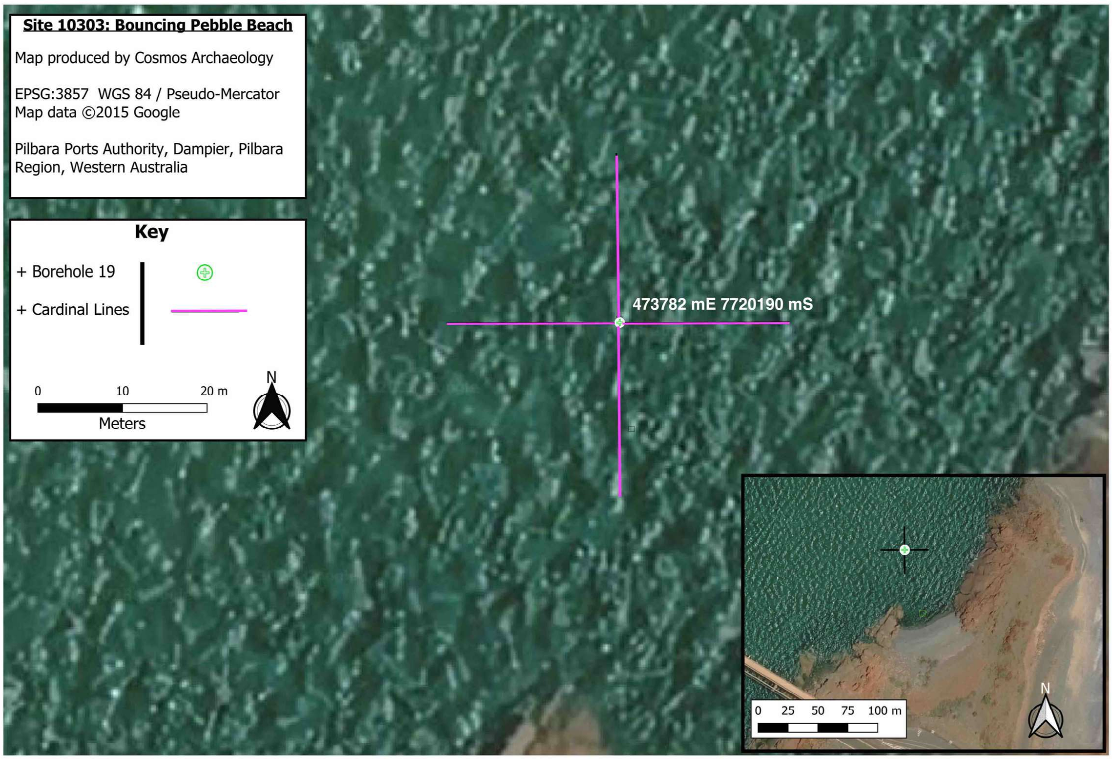

Figure 35: Location of diver transects.

As stated, the need for the transect survey was to facilitate an understanding as to whether the cobble beach continued into the subtidal environment and if it would be feasible for cultural material to be present within that environment, the transect survey would accomplish a rudimentary inspection of the submerged landscape to assess the overall landform. There are two objectives to be accomplished in relation to the submerged landscape:

- Video transects covering the length of the two 40 m string-baselines, accomplishing the task of visualising the submerged landscape and the material exposed on the site as well as recording it for 3D photogrammetry rendering in post-processing.
- Probing the seafloor within borehole footprint to assess the depth from seafloor to potential cobble or bedrock, followed by site perimeter setup and excavation.

3.7.1 *Video*

The recording of the seafloor in the pre-excavation phase used cameras on a 1.8 m pole, separated at measured intervals to include overlapping fields of view which were white balanced in the post-processing phase. The inclusion of the video survey would aid in building a virtual landscape from visually recorded data that was extrapolated and interpreted.

The process of capturing data by video survey was achieved through the use of four GoPro Heros (x2 H10, x1 H9, x1 H8) mounted on a 1.8 m pole, separated at a minimum of 500 mm. To identify the spatial overlap of the camera's field of view (FOV), the average FOV was calculated (Figure 36). The diver would judge the visibility of the water and elevation from the seafloor to correctly adjust the camera positions to achieve continuous overlap for recording (Figure 37). The position of the cameras was held at approx. 90° angle throughout the survey to record the entirety of the corridor, recording maximum detail.

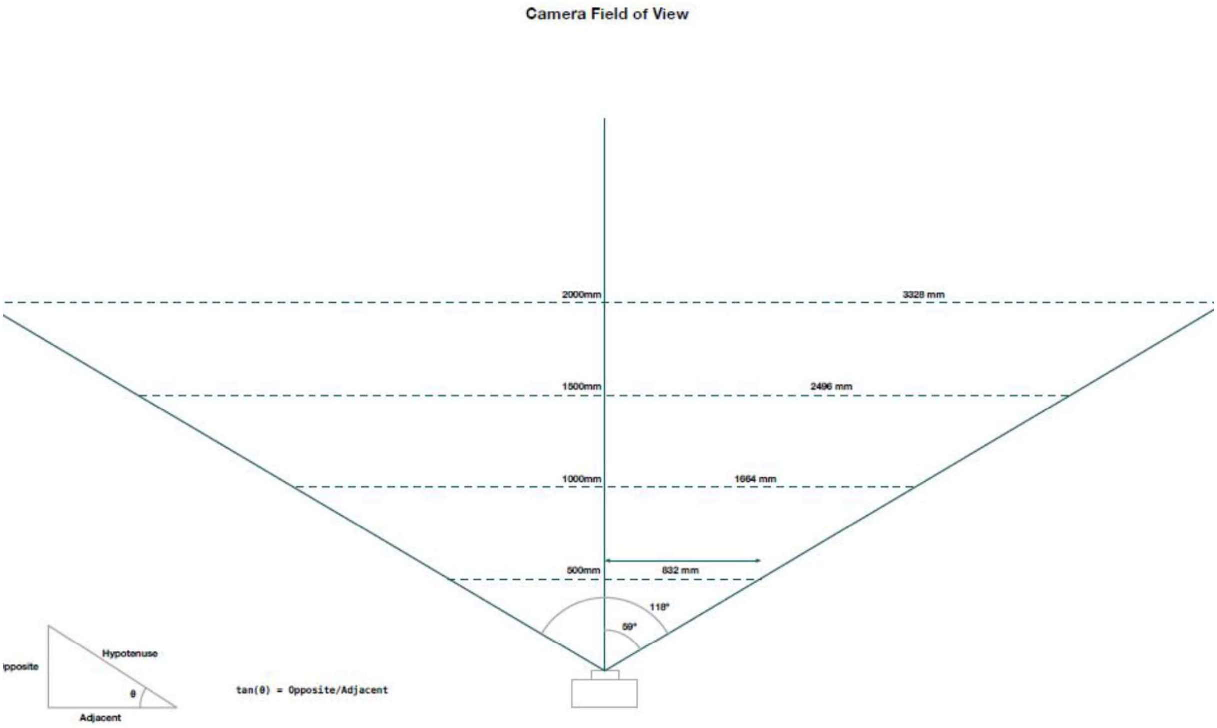

Figure 36: Camera's field of view

Figure 37: Arrangement of cameras to ensure overlap.

The video transects following the cardinal directions over forty metres were achieved by linear survey, with the orange-stringline in visual range of the diver surveying at all times, an essential process in recording and blending the videos in post-processing. Due to the decreasing visibility, the survey's lane width was only 3.6 m. West-East and North-South transects were accomplished over two different days with a U-shaped transect survey pattern (Figure 38).

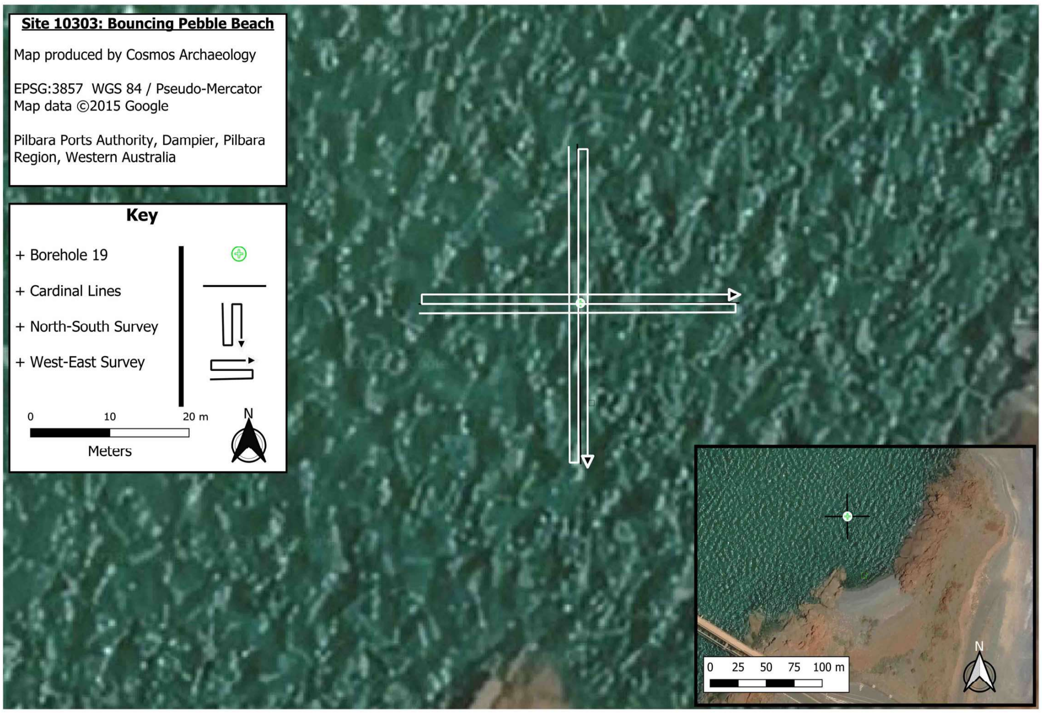

Figure 38: Track of diver video survey.

The video survey of Subtidal Trench 01 (ST01) was accomplished using the same method as the transect surveys. With the 2 m x 2 m pit, the video transects needed to record the trench walls, inclination, visible geomorphology, sediment ingress in the trench, and the overall visible stratigraphy. The 'crosshatch' survey method was used for the recording of the trench to facilitate the recording of important information for interpretation in post-processing, achieving far more coverage over the intended site and greater accuracy and resolution of material observed (Figure 39). The cameras in the first survey were held again at a 90° angle, survey heading north-east/ south-west, then changing to north-west/south-east transect with the cameras adjusted to an approx. 65° angle to capture depth of field of the excavated trench. The recording of ST01 over the course of the excavation included recording the initial top layer, the corresponding layers leading to the final depth, and ST02.

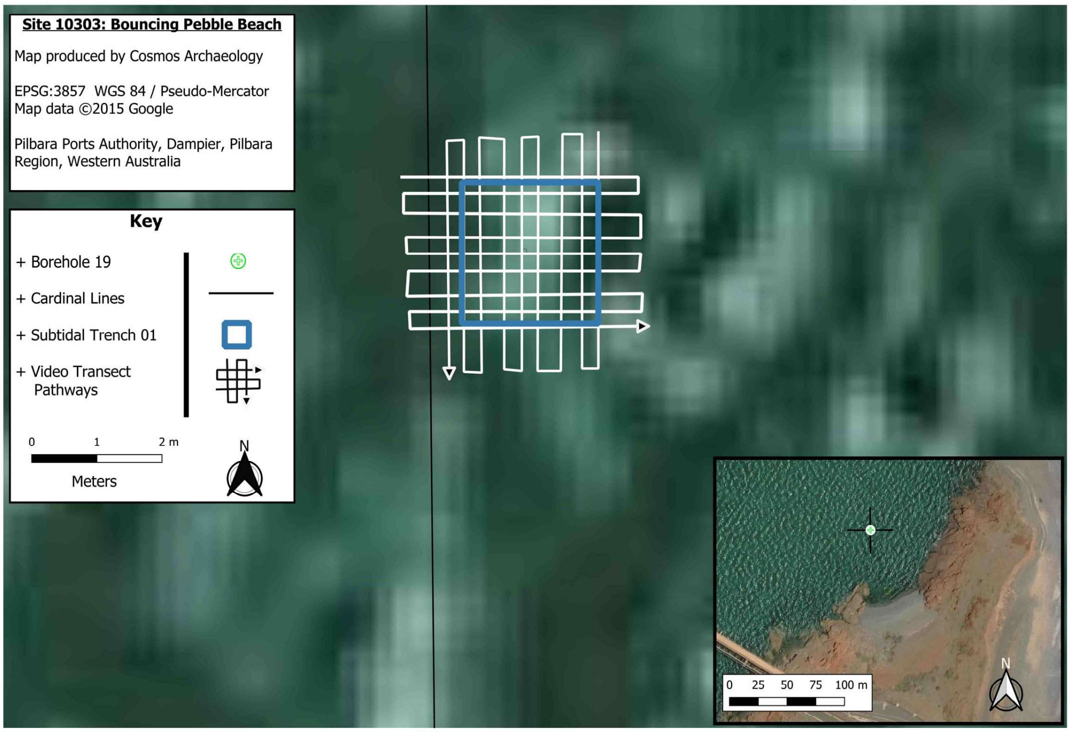

Figure 39: Video track of subtidal trench survey.

Sediment disturbance led to visibility loss in the water column and was the main limitation for video recording; the linear survey method used for the north-south and east-west transects was particularly affected during recording. The crosshatch pattern would aid in subverting this limitation but can only be performed over a small area with maximum efficiency and time spent on the bottom.

3.7.2 *Photogrammetry*

The video transects of subtidal trench 01 (ST01) were able to recreate the seafloor for visual interpretation with scaled measurements applied to further the investigative processes. As previously stated the video transects at minimum needed to stay off the floor by 500 mm, and that was achieved by SCUBA for the free movement and buoyancy control. The scaled measurements have been adjusted according to the 2 m tape section of poly-pipe making up part of the trench frame. The crosshatch transect pattern was the best applied method for a 2 x 2 m trench with low visibility and loose sediment. The trench wall stratigraphy was difficult to render due to ingress of debris from top layer, causing the loose sediment to distort lens and SFM rendering processes.

Seven video transect surveys were applied over the course of the project, including the East-West, North-South, ST01-1 (surface layer), ST01-2 (down to cobble rock material), ST01-3 (down to 500 mm), and ST02 (second trench extension). East-West transect was not able to render for multiple reasons;

- Sediment static in water column from various mechanical tools being placed on the site prior to survey, causing visibility drop from 1 m to <0.5 m,
- Bow and stern anchors and,
- Position of vessel over the eastern portion, causing low light ISO spike which could not outline features of the seafloor for the rendering process.

North-South transect suffered similar limitations at the centre point of Borehole 19 and in the northern section due to bow anchors causing quick decline in visibility. ST01-1 was done by surface air supply diver, highlighting the need for SCUBA method as SSBA diver stirred silt and waved pole too fast for low light and low visibility situation. Furthermore, SSBA diver commented about umbilical becoming stuck on coral outcrops, confirmed by the video footage through blurry movement and shaking effect.

ST01-2 is the first 3D render that has been able to produce usable data within the confines of the limitation, even with backscatter sediment particles observed in footage. The slow, steady and neutral pace of the survey allowed for the camera ISO to adjust to changing depths during recording processes (ascending and descending over coral and rock outcrops), white balancing the videos had a tremendous effect of bring forward colour ratios that could be used by Agisoft Metashape to produce high resolution 3D renders. However, sediment caught in the water column is evident over rock or sediment that changes to a 'lighter' foggy colour (Figure 40). However, the render is able to provide information about the sediment layer surrounding the site (even with the loss of the top layer video transect ST01-1), where the trench sits in context to the south running baseline (orange), and the exposed cobble formation – Context 1 (Figure 41). Again, sediment ingress does not support the objective of visualising the stratigraphy in this 3D rendered trench.

Figure 40: Example of suspended sediment clouding the water.

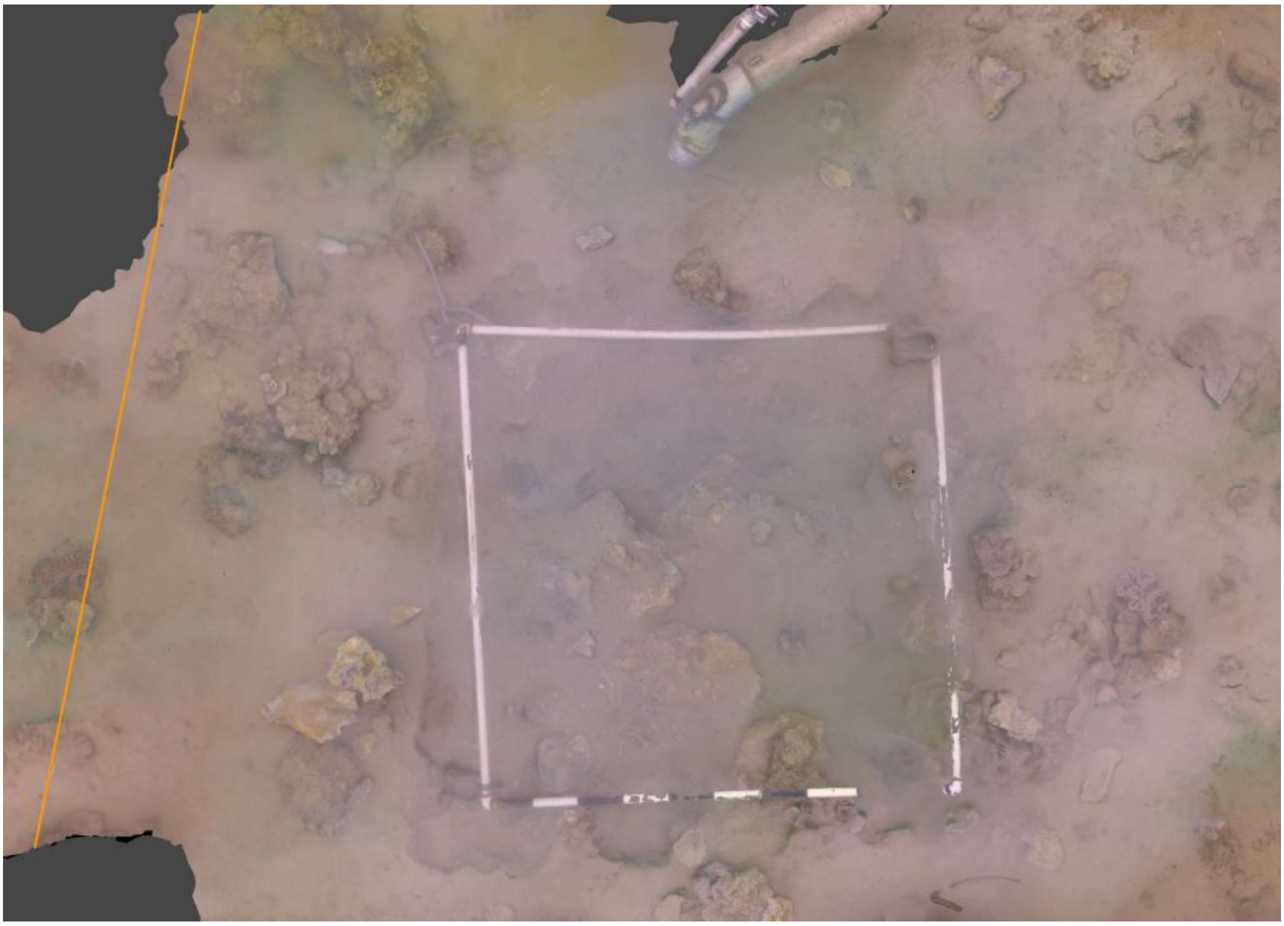

Figure 41: Render of top of cobble formation (Context 1) ST01 after removal of silt and coral rubble. Scale in 200 mm increments and water visibility was 400 mm. Orange line to left is the south transect line while the diver can be seen holding the water dredge at the top of the image.

ST01-3 video transect was applied when the trench had reached the 500 mm depth limit for the site. The video transect had been run in the afternoon after the dredging had been completed. The result of no current and large movement of sediment from an enclosed area provided little visibility for the transect, even with the incorporated crosshatch and perimeter search patterns used, the limitations of the viewable range of the lens through the low visibility area caused a large constraint on processing nodes during rendering. The green colouration observed from the render is confirmation that the sediment movement within the water column reduced the visual range that the cameras could record at, and ISO maximisation has pixelated the seafloor to cause large distortions inside the investigative area. In contrast to ST01-2, ST01-3's northern portion can be used to visualise the stratigraphic layer within the trench, and the context surrounding, but is not in a completed format for accurate measuring and could only be used to observe the type of cobble and stone material present on the seabed.

The northern extension of ST01, labelled ST02, was placed adjacent to northern frame, the rotation of the poly-pipe now featured the scale bared section at the northern end. The video transects for ST02 duplicated the previous survey patterns and included ST01's original for contextual information on the uniformity and trench extension (Figure 42). The visibility during the transect was >1 m with low levels of sediment backscatter recorded in the videos. ST01 had been included due to the speculation by the diver that ST01-3 was going to be unusable during post-process rendering. Moreover, the advantage of visualising both trenches in the same 3D render allows for greater accuracy to be exported from DEM's which can be produced to visualise the depth and incline of the trench walls. The inaccuracy can be observed in the darker coloured sections of the 3D render, the dark shadows appearing on the video was masked during rendering, creating a 'floor' in the model, thus, filtering out any useful information that was observed (Figure 43).

Figure 42: Render of completed ST01 (red square) and ST02 (white grid).

Figure 43: Dark shadow at the base of ST01. This is where Context 2 was excavated.

3.7.3 *Probing*

Probing was conducted along the north-south transect to determine the sediment depth of the seabed (Figure 44). A 1 m metal probe, marked with tape every 100 mm, was inserted by a diver into the seabed every 2 m along the transect. The probe was inserted until the diver determined that it had hit coral rubble and/or rock, with the depth to refusal dictated to the surface vessel.

The probing also provided the opportunity to assess where best to place the sub tidal trenches with respect to the amount of overburden as well as open flat seabed that would accommodate a 2 x 2 m grid. The results of the probe survey are presented in Table 6.

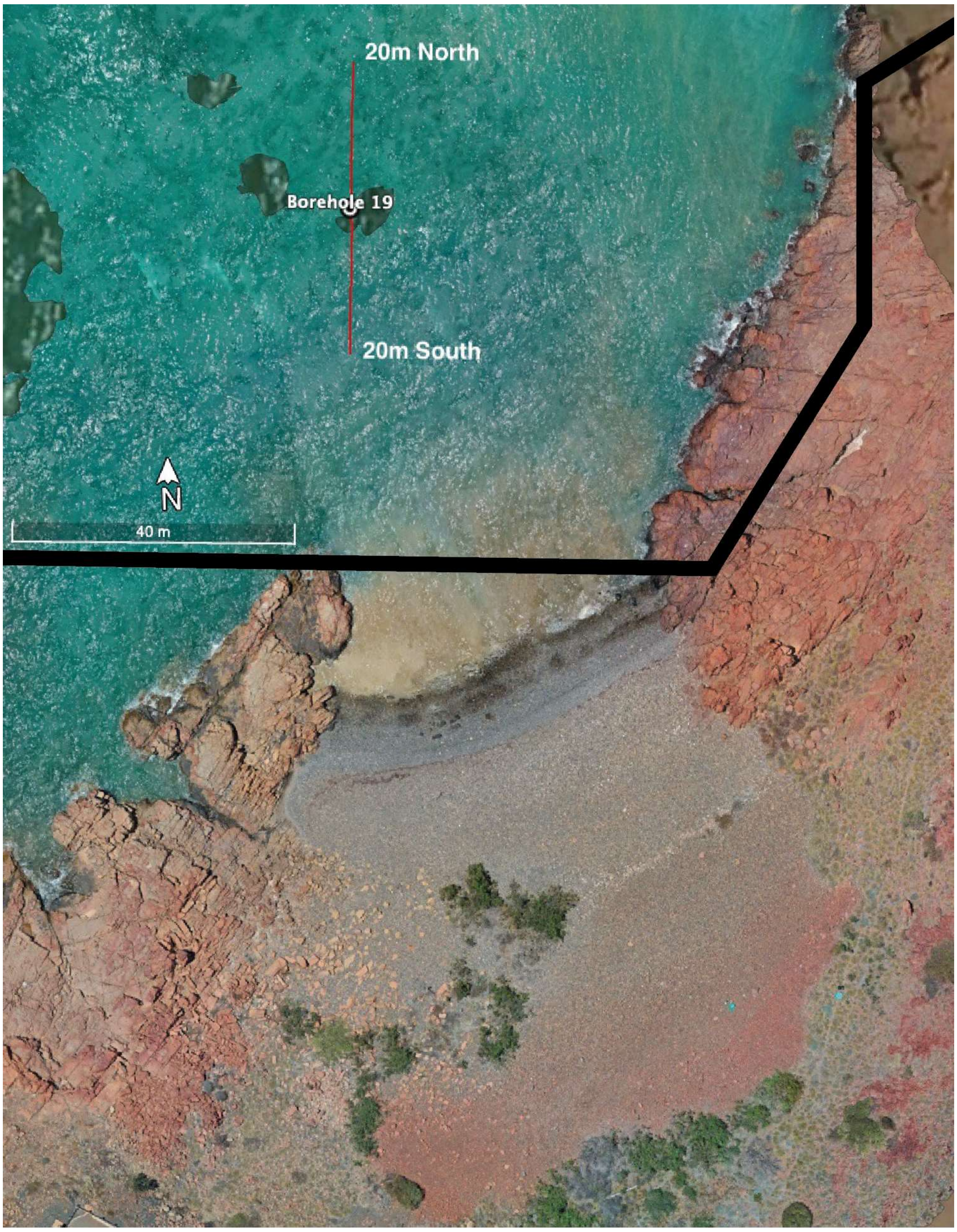

Figure 44: Location and direction of probing. Black line is dredging footprint. (Base image, Google Earth)

Table 6: Probe depths and findings.

Distance	Description	Depth
20 m N	Very flat silt seabed. No big coral growths observed.	900 mm to rock
18 m N	Very flat silt seabed. No big coral growths observed.	700 mm to rock
16 m N	Very flat silt seabed. No big coral growths observed.	700 mm to rock
14 m N	Very flat silt seabed. No big coral growths observed.	700 mm to rock
12 m N	Very flat silt seabed. No big coral growths observed.	300 mm to rock
10 m N	Very flat silt seabed. No big coral growths observed.	100 mm to coral rubble 350 mm to rock
8 m N	Coral rubble strewn across silty seabed.	50 mm to coral rubble 120 mm to rock?
6 m N	Coral rubble and growth, silty seabed.	50 mm to coral rubble 130 mm to rock
4 m N	Large coral growths on silty seabed	100 mm to coral rubble Could not penetrate.
2 m N	Coral growths on silty seabed	50 mm to coral rubble Could not penetrate.
0 m	Borehole 19 (473782 mE and 7720190 mS) Coral growths and rubble on silty seabed.	50 mm to coral rubble 200 mm to rock
2 m S	Coral growths on silty seabed	200 mm to coral rubble and rock.
4 m S	Patches of coral growth on silty seabed	100 mm to coral rubble Could not penetrate.
6 m S	Flat open silty seabed.	50- 100 mm to compacted coral rubble Could not penetrate.
8 m S	Large coral growths on silty seabed	50 to 129 mm to either compact coral rubble or rock.
10 m S	Silty seabed with sparse coral.	100 to 140 mm refusal, probably rock.
12 m S	Coral rubble on silty seabed.	80 mm to rock
14 m S	Coral growth and rubble on silty sediment.	100 mm to rock
16 m S	Seabed covered in coral growth.	30 to 300 mm to coral rubble and rock.
18 m S	Four large coral growths.	100 mm to coral or rock
20 m S	Coral growth across seabed	200 mm to coral or rock

3.8 Conduct of excavation

Three trenches were excavated during this investigation. IT01 was located in the intertidal zone while ST01 and ST02 were in the subtidal zone adjacent to each other (Table 7, Figure 45 and Figure 46).

Table 7: Coordinates of intertidal and subtidal trenches.

Trench	Coordinates (centre point)	Height
IT01	473797.61 m E	1.1 m CD
	7720137.36 m S	
ST01	473784.23 m E	-2.7 m CD
	7720177.30 m S	
ST02	473784.30 m E	-2 .7 m CD
	7720179.40 m S	

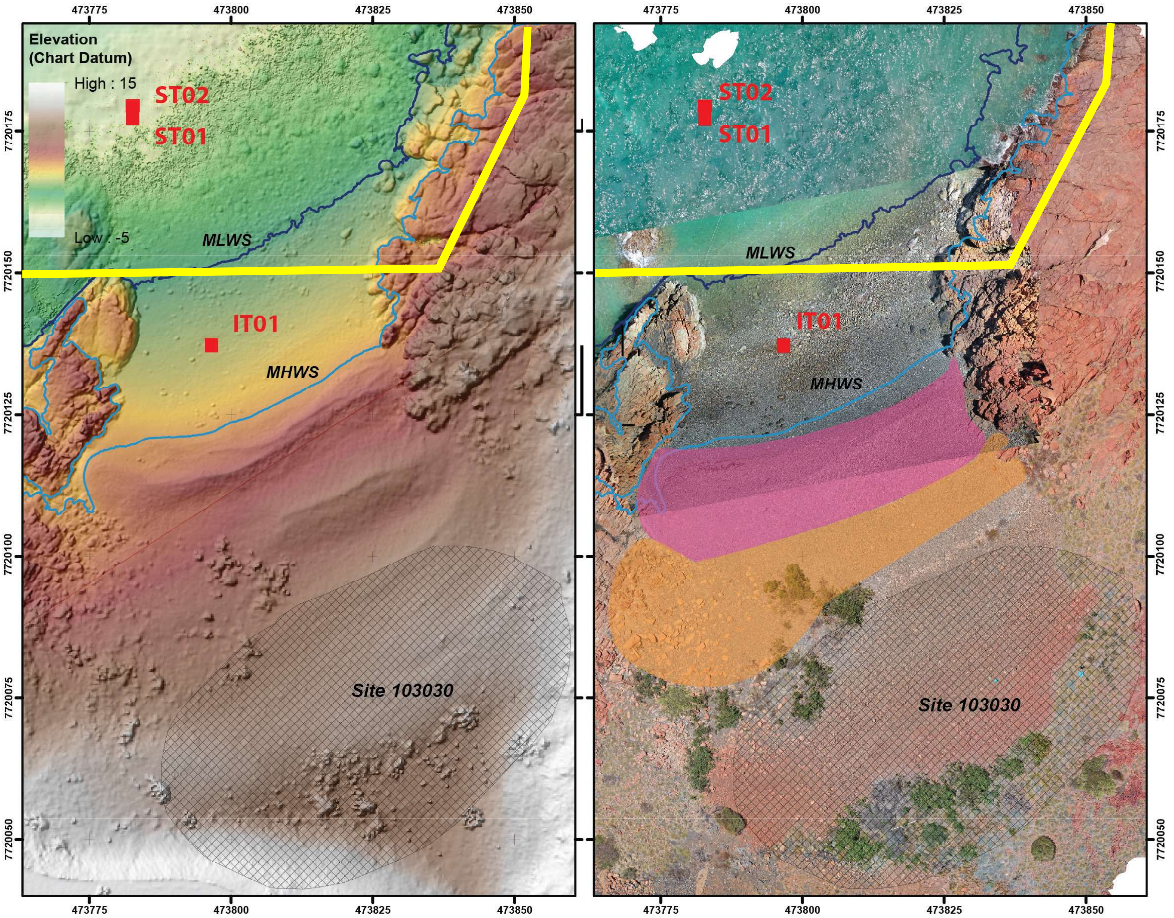

Figure 45: Locations of IT01, ST01 and ST02. Beach (pink = berm/terrace 1 and orange = berm/terrace 2) survey. Yellow line depicts Dredging Footprint.

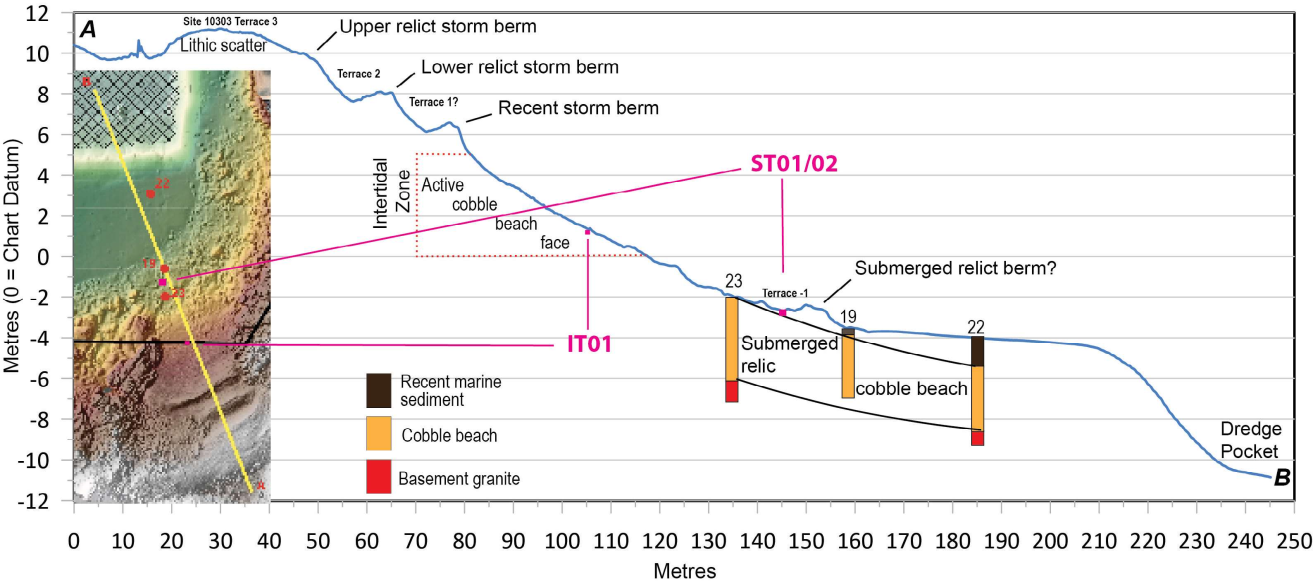

Figure 46: Locations of IT01, ST01 and ST02 in profile.

3.8.1 *Intertidal Trench (IT 01)*

Excavation commenced in this trench on the 25th November at around 0600. Located in the intertidal zone the excavation was divided into two parts – dry and wet excavation. The trench was sited at low tide on that day where there were no clasts too large to be manually lifted. The surface layer of rock (Context 1) was manually removed and placed on a blue tarpaulin at the water's edge (see Figure 20). Excavation continued down to a point where pebbles and small cobbles predominated across the trench. This layer was named Context 2 and it was deemed best that it be excavated with the water induction dredge at high tide which was to be around 4 m on that day (see Table 4).

Excavation switched to underwater mode on the rising tide later that morning. The clasts from Context 1 were loaded onto the rock cage and lifted. The excavation re-commenced with the removal of Context 2 however the water dredge was not operating optimally and so the context could not be completed on the day.

Excavation of Context 2 resumed on the 26th November however the dredge was still inefficient and so excavation was undertaken manually with clasts/sediment being scooped up and transferred to a rock cage lined with a blue tarpaulin. This was a suitable work around as there was no silt or fine sands in the formation of Context 2. Context 2 was completed on 26th November.

3.8.2 *Subtidal Trenches (ST01 and ST02)*

The location for the subtidal trenches was determined by visual survey of the seabed near the location of BH19, as this location was determined to be in the proposed dredging area of the berth pocket and has not been previously dredged. The coring sample taken at BH19 was shown to have both a minimal sediment coverage (less than 20 mm) and contain cobbles, indicating a likely continuation of the cobble beach formation.

ST01 was sited in a flat expanse of silt seabed, 10 m south of BH 19, where it was possible to lay a 2 x 2 m grid without any surface obstructions and that the depth of sediment to the surface of the cobble formation was expected to be less the 150 mm below the seabed. Excavation of ST01 commenced on 27th November.

Commercial divers were then placed in the water to excavate the top layer of sediment and coral rubble above the cobble surfaces. Excavation was carried out by means of a vessel-based water dredge, with the diver controlling the dredge head. The silt at the seabed was relatively easy to remove however as the excavation continued into coral rubble it was observed that the rubble became interlocked and the silt stickier forming a cohesive unit. This was excavated in relatively slower time requiring the use of a trowel.

Once the sediment was cleared across the entire trench, the cobble surface was video recorded and photographed by a diving archaeologist. The northern third of the trench was excavated down to around 500 mm below the cobble surface without any observable change in the composition of the . The following day the remainder of the trench was excavated with Context 1 being removed in two spits, each spit being around 250 mm thick.

On the last day of the investigation, 29th November, a sondage (narrow investigative trench) was undertaken in the northern portion of ST01. This sondage was labelled Context 2 as the composition of the appeared slightly different to that of Context 1.

ST02 was a northern extension of ST01. The same process as described for ST01 was followed with this time a low pressure water hose used to great effect to remove the coral rubble and sticky silt even though this reduced visibility to zero. Only the first one metre of the trench was excavated.

3.8.3 *Lithic Selection*

All the material recovered from the intertidal excavation and the two subtidal trenches was inspected and a sample of fractured cobbles and pebbles was recorded in more detail. This included larger cobbles placed by the divers in the rock cage or the material retained in the sieve. The material recovered included unbroken rounded pebbles and cobbles, rounded pebbles and cobbles with one heavily weathered flake scar, split pebbles and cobbles, some of which had weathered edge-battering, pebbles and cobbles with more than one negative flake scar, angular fragments, thermal blocks with facets clearly resulting from thermal fracture, thermal fragments probably exfoliated from a thermal block, and some ambiguous pieces with flake-like characteristics. These categories were not clearly discrete; there was considerable overlap, largely as a result of differential weathering. The overwhelming majority of material recovered, particularly from the inter-tidal trench, comprised unbroken rounded pebbles and cobbles or rounded pebbles and cobbles with one or two very heavily weathered old negative flake scars.

As far as practical, fractured cobbles, pebbles and angular pieces were recovered for more detailed recording from IT01 and ST01. The sample has limitations because of the very weathered nature of much of the material. Generally, selection focused on angular pieces, some of which had facets that were consistent with exfoliation due to thermal fracture, and mechanically fractured cobbles and pebbles that were less weathered and had at least one discrete fracture surface or flake scar. Every effort was made not to select specimens that 'looked like' possible artefacts, but to collect the full range of fracture types evident in the sample.

Grab samples were taken of cobbles and pebbles from the sieve. These were retained for reference and have not been recorded in detail.

Further detail on the analysis of the collected material can be found in Annex A.

3.8.4 *Sampling*

Sampling was undertaken from the subtidal trenches primarily for the purposes of radiocarbon dating. Shell samples adhering to larger clasts were targeted as these were seen as being mobilised less frequently than smaller clasts. As such, these clasts would give the best indication of the level of disturbance within the vicinity of the trenches. Conversely it was considered that loose shell and coral samples from the grab samples would reflect on going relatively low levels of disturbance and would return more recent dates.

With depth there were fewer large clasts (boulders) with shell on them and so they were being sourced from smaller cobbles and pebbles. There were clasts with white staining indicating that shells once grew on them, but samples could not be collected. The lowest context of the excavation, ST01/Context 2 – which reached 1.3 m below the seabed, recovered no clasts with adhered shell that could be collected.

Table 8 lists the samples collected primarily for radiocarbon dating. All of these were tested and the results are presented in Section 4.3.

Table 8: Samples collected primarily for radiocarbon dating.

Sample	Type	Trench	Context	Notes
13	shell	ST01	C01/S02	ca 300 mm below cobble surface. Shell sample 1.
20	shell	ST01	C01/S02	Rock cage 3. Taken off rock.
22	shell	ST01	C01/S02	Shell on rock.
24	shell	ST02	C01/S01	Rock cage 1. Taken off rock exposed on surface of cobble. Shell sample 2.
25	bulk sample	ST01	C01/S02	Bag 4. Small rock, shell and sediment shovelled into bag.
26	coral	ST02	C01/S01	On top and wedged into surface of C01.
28	shell	ST02	C01/S02	Rock cage 1. Shell sample 3.
29	shell	ST02	C01/S03	Shell sample 4, Rock cage 3. Taken off small rock as no shell on larger rock.
30	bulk sample	ST02	C01/S03	Bulk sample 3. Silt Box 2.
31	bulk sample	ST01	C02	Silt box 1.
32	shell	ST02	C01/S03	Shell sample still on rock. Silt box 2.
33	coral	ST02	Overburden	Collected these from the trench section above the cobble layer.

4 FINDINGS

4.1 DPLH 10303

The two transects within the boundaries of DPLH 10303 recorded 90 stone artefacts in detail. Most of the artefacts were granophyre, the local variety of which is a tough/hard volcanic rock which can be found to be very fine to coarse grained with porphyritic (crystal) inclusions. The assemblage was mostly porphyritic granophyre (60%) with 26% being coarse grained, 12% fine grained and 2 granite artefacts.

Of the 90 artefacts recorded, the majority, 40%, were flakes and flake fragments with unifacially and bifacially flaked cobbles comprising 37% of the assemblage (Figure 48). There were 17 (19%) single and multiplatform cores with one retouched/utilised flake recorded (Figure 48).

Figure 47: Bifacially flaked cobble
(DUX/Site10303/T10/F24_2004)

Figure 48: Multiplatform core
(DUX/Site10303/T10/F38_2105)

Artefact density averaged 0.98 / m^2 however the higher densities (4.2 / m^2) were recorded at the southwestern portion of the site. Towards the northeast, densities dropped away markedly, dropping to 0.25 / m^2 with some places along T10 not recording an artefact within an area of 6 m^2 (Figure 49). For more detail on the finds in DPLH 10303 see Annex A.

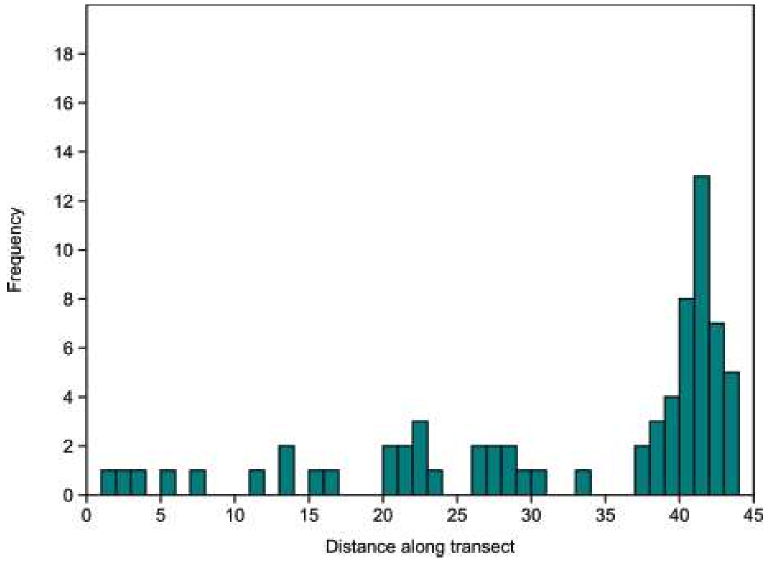

Figure 49: Artefact density along transect T10 (NE-SW).

4.1.1 *Intertidal survey*

Eleven pieces of fractured cobbles were individually recorded during the intertidal survey. None of these were considered likely to be cultural. Several large flakes with classic features of percussion fracture were noted in various states of wear and abrasion with one large fresh flake noted – most probably the result of a recent cyclone. At least one cobble with a single large flake removed was observed (Figure 50 and Figure 51). For more detail on the finds in the intertidal survey see Annex A.

Figure 50: Flaked cobble. (DUX/ITS/ITS06_546).

Figure 51: Flaked cobble. (DUX/ITS/ITS0?_2050).

4.2 Intertidal Trench (IT01)

Intertidal Trench One was located on the lower part of the cobble beach which is only exposed at spring low tides. The trench measured 2 m x 2 m and was orientated north/south.

Figure 52: Start of Context 01, looking southeast. DPLH 10303 at top right where greenery visible. Scale in 100 mm increments. (DUX/IT01_221125_4)

Context 1

This context comprises rounded cobbles which formed the ground surface. They ranged in size from 100 mm to 350 mm across. The exposed surfaces of the clasts were covered with a medium density of small, 1 to 2 mm across, living barnacle-like molluscs.

Figure 53: Rock cage 1 from Context 1. Scale in 100 mm increments. (DUX/IT01/C01/RC01)

Figure 54: Rock cage 2 from Context 1. Scale in 100 mm increments. (DUX/IT01/C01/RC02)

Figure 55: Silt box for C01. (DUX/IT01/C02/SB01_221125_83)

The clasts recovered from this context were counted and graded. Out of 214 clasts, 91.5% were within the cobble range, with 8% being boulder size and one very coarse pebble recorded.

The excavation of Context 1 reached depths of between 120 mm below the grid frame in the NE corner and 240 mm along the southern portion. Excavation of this context ceased upon exposure of a compact layer comprised of clasts less than 100 mm across. This exposed layer was named Context 2 (see below).

No samples were recovered from this context for the purpose of radiocarbon dating.

Figure 56: Limit of excavation of Context 01 - looking NW (left) and looking SE (right).
(DUX/IT01/C02_221125_62 and DUX/IT01/C02_221125_63)

Context 2

This unit was comprised mostly of smaller rounded rock than that recovered from Context 1. There was also observed angular rock and what appears to have been bedrock fragments similar to the exposed bedrock in the SW end of the cobble beach. With depth it was observed that larger clasts were appearing which suggested the emergence of bedrock while in one localised area there was a patch of anerobic gravel with sharp edges.

The excavation of Context 2 ceased at between 200 mm below the grid in the NW corner and 500 mm along the southern edge. The base of the trench was punctuated by large clasts which formed five pockets of varying sizes which were filled with increasing concentrations of angular clasts and pebbles. There was also a concentration of coarse sand developing but this was a function of the manner of excavation where the water induction dredge was not available, and all recovery was done by hand. A boulder, 750 mm across where exposed, was present in the middle of the trench which rested on what appeared to be another larger rock which also started to appear on the north and south portions of the trench.

The clasts recovered was in majority rounded with comparatively fewer angular stones (Figure 57 to Figure 62). Samples of fractured clasts were selected for further examination as part of the ongoing analysis to differentiate natural from cultural features on the clasts within the intertidal zone. A small clear fragment of plastic was also recovered.

Figure 57: Contents of RC03, IT01, Context 2. Scale in 100 mm increments. (DUX/IT01/C02/RC03 or DUX_IT01_C2_RC03)

Figure 58: Selected 'fractured' clasts. (DUX/IT01/C02/RC03/frctrd rck_0466)

Figure 59: Close up of clasts from RC04. (DUX/IT01/C02/RC04_0520)

Figure 60: Clasts from RC04. (DUX/IT01/C02/RC04_0490)

Figure 61: Larger clasts from RC05.
(DUX/IT01/C02/RC05_cobbles only_676)

Figure 62: Clasts from RC05.
Taped edges at 250 mm increment.
(DUX/IT01/C02/RC05_663)

A number of lithics (52) were recovered either because they warranted further examination to determine if they have been culturally modified or for the collection of a type set of rock which displayed a variety of fractures and other surface deformities which could be the result of natural forces. Most flaked material from the intertidal trench was very weathered and rounded compared to flaked artefacts from DPLH 10303 and specimens from the subtidal trenches (Figure 63 and Figure 64). No definite artefacts were identified though ID 111, a fine grained cobble with two flake scars displays promising characteristics of an artefact. For more detail on the lithics collected in IT01 see Annex A.

No samples were recovered from this context for the purpose of radiocarbon dating.

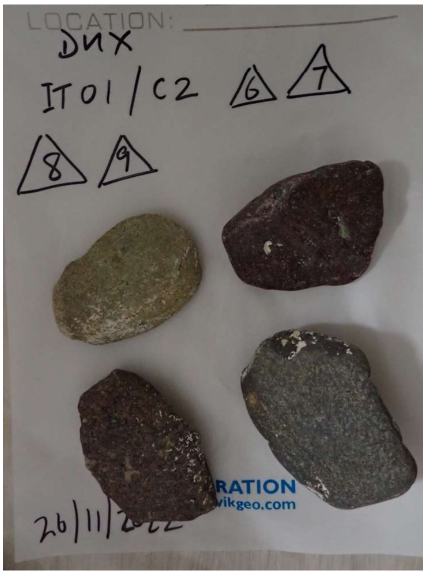

Figure 63: Four lithic samples from Context 2.
(DUX/IT01/C02/A06_07_08_09_0498)

Figure 64: Split pebble, which resembles bi-polar. (DUX/IT01/C02/A23/cbl smpl 98_1063)

Figure 65: Fine grained cobble with two flake scars. (DUX/IT01_221125_65 and DUX/IT01/C02/A01/cbl smpl 111_1127)

4.3 Subtidal Trenches (ST01 and ST02)

4.3.1 *Seabed in vicinity of Borehole 19 and subtidal trenches.*

The following description of the seabed is based on the video recordings of the east/west and north south transects centred on the location of BH19 (see Figure 38).

West to East (from deep to shallow):

The coral presence in the 20 m due west of BH19 is sporadic. Moving towards BH19 from western end point, the coral presence is at its minimum and seabed is mostly sediment (80 %). From 10 m to BH19 (20 m), the coral has begun to group together in small clusters and rock outcrops are observed protruding from beneath the seabed, creating a foundation of marine growth to spooling into a multitude of directions, covering the majority of the seafloor at this point, apart from where there are depressions in the rock. A veneer of sediment covers the marine growth. The height above seabed of the rock outcrops is between 200 mm to 250 mm. BH19 is 60% covered by coral and rock outcropping, furthermore, the entire landscape is covered by a fine layer of silt/ sand sediment, with the few pockets where there is no growth being filled by sediment. East of BH 19 is mostly filled by large coral/ marine-growth that are elevated to 250 mm from seafloor. At around 17 m east of BH 19, large clasts (0.2 m to 1 m) are observed wedged in coral spacing and rock outcrop depressions, these clasts are loose but mostly sit in place undisturbed, with all rock and coral covered in silty sediment. The coral height average diminishes by 40 % as the water depth becomes shallow.

South to North: (little significant depth change)

Clusters of coral growth can be observed on the seabed with an approximate spacing of 10 to 20 cm. The infill is silt/ fine sand sediment and covers 60% of the seafloor. Moving closer to BH19 (around 10 m south) the coral clusters are observed to be nestled between rock structures and other dead coral. ST01 and ST02 are situated in this area. The coral clusters close to BH19 are large in appearance and are elevated 250 - 350 mm from the seafloor, with large depressions creating a natural repository for the fine sand sediment to fill. Five metres north of BH19, coral elevation drops back to < 250 mm and continues to have budding clusters nearer to the 15 m mark. From 15–16 m north of BH19, coral outcrops cease giving over to flat seafloor composed of silty sediment with scattering (< 5%) of dead coral debris. Overall, the transect from south to north is predominantly observed to have coral outcrops and shell/ coral debris littering the seafloor with the fine sand sediment, until

15 m north of BH19, where all coral spawning and marine growth disappear and continue to plain sand seafloor composition with small amounts of dead coral being observed.

4.3.2 *Subtidal Trench 1*

The surface of this trench was that of fine silt. This layer of silt, approximately 100 mm thick overlay a compact matrix of dead loose coral bound together with dense sticky silt with small fragments of shell and coral inclusions. Some coral lumps up to 300 mm across. The coral stratum was around 200 mm thick.

As this was assumed to be a mobile and relatively ephemeral stratum no attempt was made to collect sediments and lithics. They were not given context numbers.

Context 1 – northern portion

The dead coral layer rested on an uneven cobble surface which the divers described as ‘bumpy’ and ‘jumbled’. This cobble surface was assigned Context 1 (Figure 66).

Excavation commenced at the northern edge/sector of the trench, the width of the excavation being around 600 mm. The upper portion of this sector context contained a noticeable proportion of sand with shell grit and small coral fragments as well as larger fragments of dead coral found amongst the cobbles. Larger rock was observed in the NE corner which gave the initial impression that bedrock was becoming exposed.

This portion of the trench, approximately the northern one-third was excavated down to around 600 mm below the cobble surface.

At NE corner at around 500 mm below the cobble surface the composition of the unit was around 50% cobbles and 50% shell/sand/coral with the clasts becoming more angular with depth. In the NW corner it was clayey with very fine sediment amongst the cobbles.

Observations of the recovered clasts were that the majority were rounded (Figure 67 and Figure 68). Some of the rounded clasts had remains of barnacle-like and other forms of dead encrusted marine growth, such as oyster shell, on them (Figure 69). There was also a relatively high proportion of rock which had little or no evidence of water abrasion (Figure 70). There were clearly angular clasts which had facets attributed to heat fracture. Some of the slightly more weathered angular rock- that is had the edges slightly smoothed - had dead barnacle-like shells encrusting their surfaces (Figure 71). Some dead coral fragments were also present within the unit (Figure 72).

Figure 66: Cobble surface of Context 1 exposed after removal of silt and coral rubble.

Figure 67: Clasts recovered from Rock Cage 1, Context 01. (DUX/ST01/C01/RC01).

Figure 68: Contents of Silt Box 1. Taped edges at 250 mm increments. (DUX/ST01/C01/SB01_696)

Figure 69: Example of rounded clast with shell. (DUX/ST01/C01/RC01 221128_30)

Figure 70: Example of angular clast. (DUX/ST01/C01/RC01 221128_32)

Figure 71: Example of angular clast with marine worm casing. (DUX/ST01/C01/RC01 221128_34)

Figure 72: Example of dead coral. (DUX/ST01/C01/RC01 221128_27)

A number of lithics [45] were recovered either because they warranted further examination to determine if they have been culturally modified or for the collection of a type set of rock which displayed a variety of fractures and other surface deformities which could be the result of natural forces. The samples collected were mostly that of a coarse-grained granophyre with a number of examples of thermal flaking.

Figure 73: Split cobble with thermal fractures. (DUX/ST01/C01/cbl smpl 63_0822)

Figure 74: Thermal flake. (DUX/ST01/C01/cbl smpl 71_0847

The remaining two thirds of the trench was excavated in two spits, Spit 1 and Spit 2, whilst maintaining the Context 1 assignation. No samples were collected for radiocarbon dating.

Context 1 – Spit 1

The cobble unit was observed to be tightly packed and interlocking with silt/clay binding them. They were relatively more compacted than in the northern portion of the trench. Some of the larger clasts had oyster shell on them. There were also angular clasts present, with an approximately 200 mm long flake observed at around 250 mm below the cobble surface in the SW quadrant, which was not water worn, with the more angular clasts possibly forming through heat fracture prior to inundation. In this area the diver estimated that around 90% of the rock was angular, up to 200 mm across, and the remaining 10% cobbles.

As the excavation proceeded into the SE quadrant the composition of the unit changed to around 20% angular rock, 50% cobbles and the remainder being coral/shell fragments, sand and silt. There were also larger fragments of dead coral present.

Excavation ceased at around 250 mm below the surface of the cobble formation. The subsequent 250 mm was excavated as Spit 2.

Observations of the recovered smaller grade of clasts noted more angular rock was present than rounded as well as a relatively high proportion of dead coral (Figure 75 and Figure 76). There were the remains of shell growth mostly on the rounded clasts, less on the angular clasts. The larger rock recovered – cobbles and boulders – had a higher proportion that was rounded. Some of the larger examples had shell growth on one side.

Figure 75: Clasts recovered from Rock Cage 2. (DUX/ST01/C01/S01/RC02)

Figure 76: Contents of Silt Box 2. Taped edges at 250 mm increments. (DUX/ST01/C01/S01/SB02_713)

Thirteen lithic samples were recovered from this spit. They were mostly angular fragments with some of these being obvious thermal flakes (Figure 77 and Figure 78).

Figure 77: Large thermal flake with edge damage. (DUX/ST01/C01/cbl smpl 86_1029)

Figure 78: Angular fragment resembling split flake. (DUX/ST01/C01/cbl smpl 87_1031)

Context 1 – Spit 2

The composition of this spit had a higher proportion of rounded rock, around 60-70% with the remainder being angular rock from cobble to boulder size, than the one above. It was also noticed that there were less coral fragments although there was the occasional patch of shell.

The excavation ceased at around 500 mm below the cobble surface (around 800 mm below the seabed surface). The base of the trench was composed of compacted rounder rock with less shell and coral observed. Observed also in the floor of the trench in the NE corner flat rock, 600 mm long and 400 mm across (Figure 79). In approximately the centre of the rock there was a near hemispherical depression 230 mm x 200 mm across and 40 mm deep.

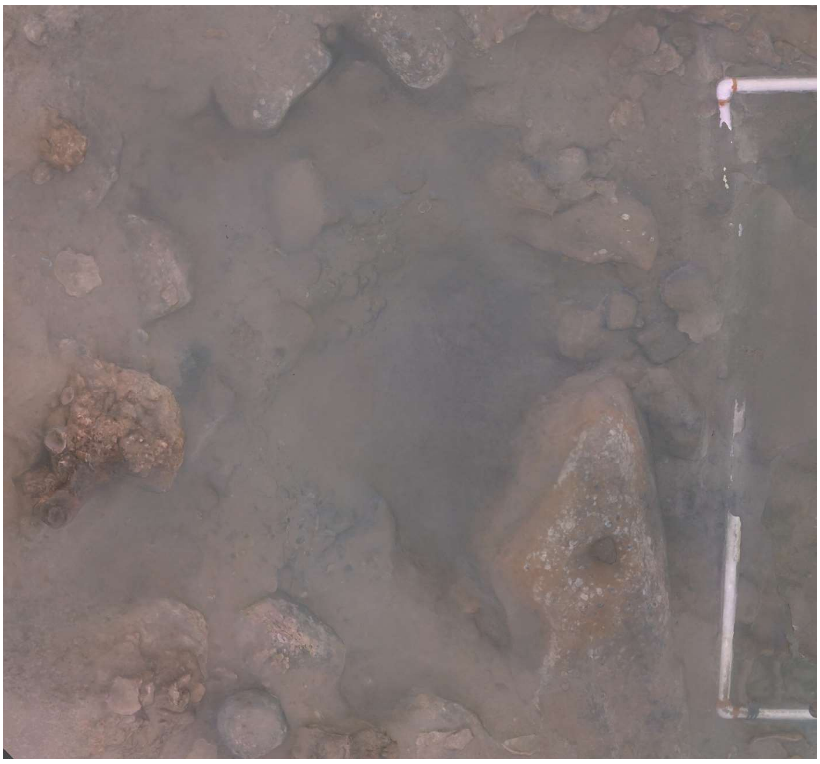

Figure 79: Rendered video image of the completion of ST01 (grid to right is bounding ST02). Bottom right of image is a rock with a near hemispherical depression. Top of image is west.

The rock recovered from this spit were relatively smaller and rounder that those recovered in Spit 1 (Figure 80 and Figure 81). Only one lithic sample was retained from this spit, ID 90, which was a large thermal flake of porphyritic granophyre with edge damage (Figure 82).

Figure 80: Clasts recovered from Rock Cage 3.
(DUX/ST01/C01/S02/RC03)

Figure 81: Clasts and sediment recovered from Silt Box 3. Taped edges at 250 mm increments. (DUX/ST01/C01/S02/SB03_723)

Figure 82: Large thermal flake of porphyritic granophyre with edge damage. (DUX/ST01/C01/cbl smpl 90_1037)

A number of samples [4] were recovered from this context for the purpose of radiocarbon dating. One shell sample, #13, composed of three shells was recovered 300 mm below the cobble surface (Figure 83). Two other shell samples, #20 and #22 (from which a number of shells were obtained), were recovered from large rock (Figure 84). Sample 25 was a bulk sample of shell grit/coral/sediment obtained from Silt Box 3. These samples were dated, and returned the following results (Chronos, February 2023) [Table 9]:

Table 9: Sample Results.

Sample	Dating results
13	988 – 1133 BP
20	Modern
22a	2,434 – 2,621 BP
22b	773 – 916 BP
25a	Modern
25b	Modern

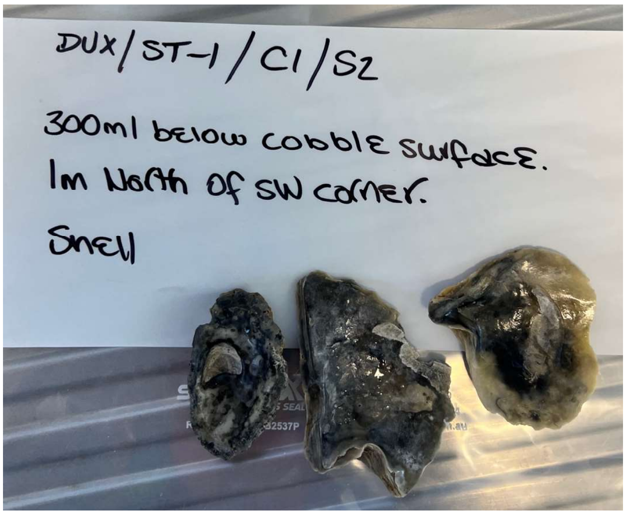

Figure 83: Shell sample # 13 collected 300 mm below cobble surface.
(DUX/ST01/C01/S02/smpl13/shell)

Figure 84: Cobble/boulder from which shell sample 22a and 22b obtained.
(DUX/ST01/C01/S02/RC03/shell sample 22_735)

Context 2

Excavation for this context was localised in the northern portion of the trench, between two boulders, one of which may have been bedrock, while the other was the aforementioned flat rock with the near circular depression. The area excavated was approximately 1 m x 500 mm and 500 mm below the finish level for Context 1.

The unit was silty sand with shell grit dispersed with pebbles and cobbles. There was a mix of round and angular rock (Figure 85). The recovered clasts were relatively smaller and rounder than what had been recorded for Context 1. No clasts were recovered with shell on them. There was a very noticeable number of cowrie shell. They had been observed in the context above but they appeared to increase in frequency with depth.

Figure 85: Contents of Silt Box 1, Context 2.
Taped edges at 250 mm increments.
(DUX/ST01/C02/SB01)

A bulk sample of shell grit/coral fragments/sediment, #31, was collected from this context for the purpose of radiocarbon dating. This sample was tested and returned a date range of 416-599 BP (Chronos, February 2023).

4.3.3 *Subtidal Trench 2*

As with ST01 the overlaying layer of silt and dead coral was removed down to the cobble surface with the coral hard to remove in places as it was stuck to the cobbles. One sample [sample 33] of dead coral collected from the dead coral stratum was radiocarbon dated and returned a modern date (< 70 years old) (Chronos, February 2023).

Context 1 – Spit 1

This spit was composed of the upper most layer of larger rock that was exposed. The clasts recovered from Spit 1 were mostly large cobbles to boulder in size (Figure 86). They were predominantly rounded and most had shell on them.

Figure 86: Clasts and coral recovered from Rock Cage 1, Context 1, Spit 1. (DUX/ST02/C01/Sp1/RC01 or DUX_ST02_C1_S1_RC1

Two samples were recovered from this context for the purpose of radiocarbon dating. The samples were shell, #24, from a large rock (Figure 87) and a large chunk of dead coral, #26 (see bottom right in Figure 86). These samples were dated and both were modern, that is < 70 years old.

Figure 87: Shell sample #24 taken from large rock. (DUX/ST02/C01/Sp1/RC01/shell sample 24_747)

Context 1 – Spit 2

The spit was excavated down to around 250 mm below the cobble surface. The unit was very compacted with silt forming a sticky bond. The composition varied throughout the trench with larger clasts in the NE and smaller cobble-sized clasts in the NW corner.

The clasts recovered from this spit were mostly rounded with the occasional large angular piece (Figure 88 and Figure 89). Shell was found in fewer numbers on fewer clasts, mostly smaller ones. There was also the occasional piece of dead coral.

Figure 88: Clasts recovered from Rock Cage 2. (DUX/ST02/C01/Sp2/RC02)

Figure 89: Contents of Silt Box 1, Context 1, Spit 2. (DUX/ST02/C01/Sp2/SB01_751)

Four lithics were recovered either because they warranted further examination to determine if they had been culturally modified or for the collection of a type set of rock which displayed a variety of fractures and other surface deformities which could be the result of natural forces. A mixture of fine and coarse-grained granophyre, they were either thermal flakes or had blade-like features (Figure 90).

Figure 90: Four lithics recovered from ST02, Context 1, Spit 2.

(in descending order)

ID 116 – Blade with possible platform.

ID 115 - Weathered thermal flake with edge damage

ID 114 – Thermal cortical flake with thermal scar on dorsal surface.

ID 113 - Blade-like flake with one end resembling PFA the other a step termination or transverse break. Edge damage.

A shell sample, #28, was recovered from a large rock for the purpose of radiocarbon dating returned a modern date.

Figure 91: Shell sample #28 taken from this recovered rock.
(DUX/ST02/C01/Sp2/RC02/shell sample 28 _762)

Context 1 – Spit 3

This context was similar in the unit described above. It was excavated down to around 500 mm below the cobble surface to where boulders started appearing (Figure 92). The clasts recovered from this spit were mostly rounded with less observable shell. Clasts had almost no observable shell on them though some displayed evidence of shell having grown on them but having been ground away.

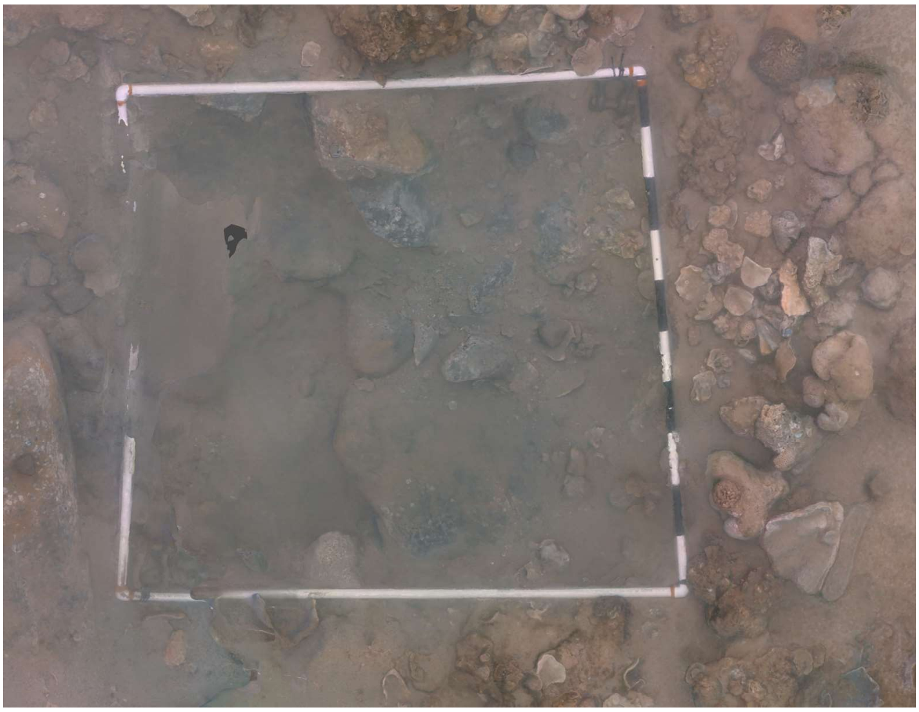

Figure 92: Completion of excavation of Context 3, ST02. Note the excavation took place in the southern half/third of the trench (east side of image). Remainder of the trench was excavated down to cobble surface. Note the coral rubble which overlayed the cobble piled along the edges of the trench.

Figure 93: Clasts from Rock Cage 3, Spit 3, Context 1. (DUX/ST02/C01/Sp3/RC03)

Figure 94: Contents from Silt box 2, Context 1, Spit 3. (DUX/ST02/C01/Sp3/SB02)

Three samples [3] were recovered from this context for the purpose of radiocarbon dating. Two of the samples, #29 and #32, were shell found on clasts, which were relatively small (Figure 95). A bulk sample, #30, of shell grit/coral fragments/sediment was obtained also. They were dated and the results are outlined in Table 10:

Table 10: Sample results.

Sample	Dating results
29	224BP - Modern
30	Modern
32a	211 – 367 BP
32b	120 – 286 BP

Figure 95: Shell sample 29. (DUX/ST02/C01/Sp3/RC03/ shell sample 29_772)

4.3.4 *Interpretation of the sub tidal trenches*

ST01 and ST02 were excavated to a depth of 1.3 m and 0.8 m respectively (Figure 96). Each trench was overlain by a 0.3 m thick layer of soft to firm shelly silt with coral clasts (rubble/fragment) up to 300 mm in diameter overlaying the cobble surface. The coral rubble sitting on the cobbles had become interlocked with the silt forming a cohesive bond.

A single dated coral fragment from this layer returned a modern age (i.e., younger than 1950) suggesting, that this upper sedimentary layer is somewhat mobile and has experienced redeposition of turnover in the last several decades despite the sedimentary layer being relatively cohesive.

A sharp contact separates the overlying silty layer with an extensive cobble unit which likely represents an extension of the cobble beach landform into the subtidal zone. The relatively open matrix between the cobble clasts has been filled with a coarse shell grit and gravelly coral clasts.

There appeared to be larger clasts at the surface (Spit 1) of the cobble layer and a relatively higher proportion of angular or brecciated clasts that exhibited a weathered, pitted surface. Cobbles from higher up in the stratum appeared more rounded and polished while both angular and rounded cobbles/boulders were observed to have a range of invertebrates encrusting the surfaces, including barnacles, serpulids and oysters.

The frequency of angular clasts diminished with depth, with rounded cobbles becoming more dominant. The size of the clasts also diminished with depth as did the frequency of encrusters.

While the presence of rounded/polished looking clasts within a marine environment suggest physical weathering of the cobble surface though wave or current action, the presence of calcareous encrusters and more angular clasts suggest they are from higher up in the profile (Spit 1), and the fact that the cobble deposit is covered in a fine shelly silt would suggest the depositional environment at the excavation has been exposed to generally lower energies compared to the modern intertidal zone were encrusters are entirely absent from the beach cobbles.

The presence of intact and well preserved encrusters on the more rounded clasts higher up in the unit suggests any higher energy events with the potential to transport clasts are relatively infrequent, otherwise the encrusters would appear damaged or removed completely. This observation is supported by radiocarbon dating of encrusters on a number of cobble clasts collected from ST01. The oldest measured age of a cobble encruster was between 2334-2631 years BP indicating that clast has not been actively mobilised since at least this date, a second cobble encruster was dated to 773-916 years BP. Intact shells material collected from the matrix between the cobbles returned a cluster of similar ages between 998-1113, 399-533, 414-549 years BP.

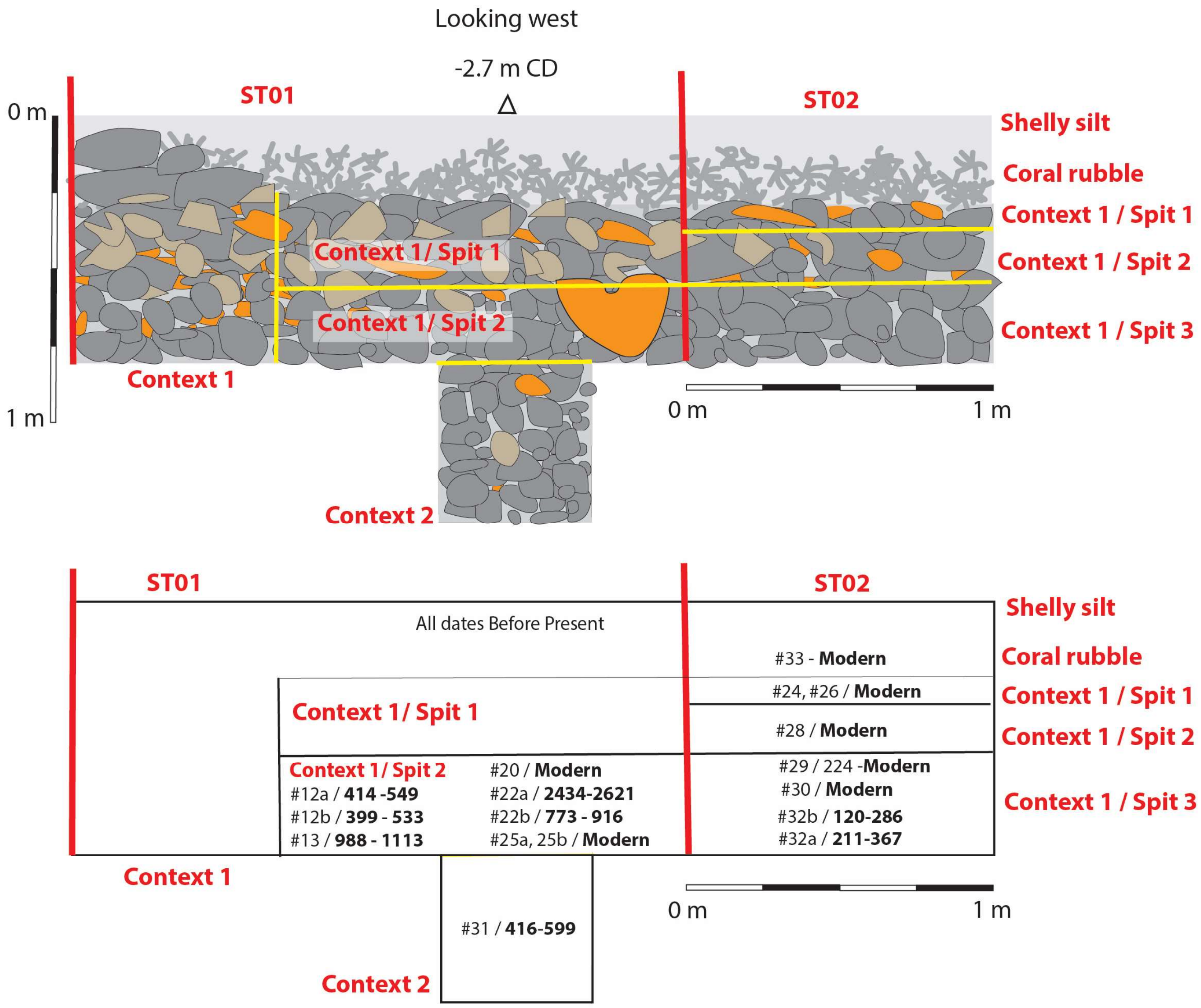

Figure 96: Schematic figure of ST01/02 in profile with results of radiocarbon dating below. Note the excavated cobble layer (Context 1) for ST02 measured 1 x 2 m.

For encrusters to grow on a rock surface it had to be exposed at the seawater interface. The absence of encrusters older than 2,500 years BP might suggest the original cobble beach inundation surface was rapidly buried by sediment, limiting encruster growth during this early-mid Holocene interval and subsequently re-exposed at around 2,500 years BP. An alternative explanation is that the cobbles that formed this original antecedent surface have been mobilised during high energy events resulting in their migration down into and/or across the cobble layer profile. It should be noted that there were clasts which had the remnants of encrusters which could not be sampled which could suggest they may have formed in earlier times but have been worn away. Also, the variety of dates obtained within the contexts could indicate that more dating of samples could have yielded a greater range of dates. The fact however that flakes and nuclei that likely formed through heat fracturing are found within the profile might support the idea of some transport or burial of clasts that were originally situated on the surface of the deposit.

5 SITE FORMATION PROCESSES

The DPLH 10303 quarry site (+11 m CD), the modern active cobble beach (0 to 5.1 m CD), and the subtidal excavation (-3 m CD) are all situated on a single continuous landform consisting of medium pebble to fine boulder size clasts.

There is evidence through relic storm berms and coral rubble, sediment sorting and waterworn clasts that the full extent of the deposit has been inundated and therefore reworked by marine processes over geological timescales with the most recent event occurring during the last interglacial period (130,000 to 115,000 years BP). Following human arrival into the region some 50,000 years BP, the cobble deposit would have consisted of a single continuous northward sloping landform extending from DPLH 10303 through the present intertidal zone and into the now subtidal portion of the feature. This landform would have remained in this configuration for at least 40,000 years post arrival until the lower portion of the feature was inundated following post glacial sea level rise. Evidence of heat fracturing from flake and nuclei samples collected from the subtidal excavation suggests that the cobble deposit was not covered by any significant soil or vegetation cover, with the raw material for lithic manufacture potentially available across the entire formation.

Rising sea levels would have begun inundating seaward most portions of the cobble deposit during the early Holocene, with the surface of the subtidal excavation at -3 m CD entering the intertidal zone, i.e., becoming inundated during the high tide around 8,500 years BP (assuming a 4 m tidal range) and fully subtidal by 7,500 years BP. The modern beach face would have been an active intertidal feature from around 6,500 years BP to present. It should also be noted that during the early phase of inundation, the lower sea levels (up to 4 m lower than present) would have resulted in a shallow nearshore zone and possibly a smaller fetch, potentially limiting the amount of wave energy that could have propagated across this now subtidal portion of the cobble deposit. The presence of angular flakes, likely formed though heat fracturing, rounded cobbles with relatively old and intact encrusters on their surfaces and the overlying deposit of a relatively cohesive shelly silt layer all point to the relatively stable nature of the cobble deposit within the subtidal zone. The fact that some of the encrusted cobble clasts have been buried by other cobbles would suggest that there has been some active transport, but it could be argued that these kinds of events are rare - possibly every few thousand years - and may be the exception rather than a more common occurrence, with transport for smaller clasts and sediments occurring in response to every cyclonic event.

The current active beach face is highly dynamic with pebble right through to small boulder size clasts being transported up and down the beach face, high resolution timeseries of drone orthomosaic imagery shows that clast transport can occur during modal wave conditions (i.e., outside high energy cyclonic events), which may explain the lack of marine encrusters, particularly barnacles, growing in the cobbles where they are highly abundant on the bedrock headlands immediately adjacent to the beach. Barnacles are observed growing on cobbles but only on those located at the lowest part of the intertidal zone suggesting lower energies available here to mobilise or roll clasts.

Mid-Holocene sea levels may have peaked about 1.5 m above present around 6,500 years ago before slowly falling to present elevations. This period of higher sea levels may be responsible for the formation of the relic storm ridge immediately landward of the active storm ridge. Interestingly, the elevation of this inner berm ridge is 8.1 m which is 1.8 m higher than the modern berm ridge, so likely was formed or was modified during the mid-Holocene highstand. There is no evidence to support Holocene sea levels or storm inundation events reaching or overtopping the inner-most cobble berm on which DPLH 10303 is located and suggests that this feature likely represents as close to its original depositional context as is possible. This observation is also supported by the rich patina which characterises the cobbles forming this innermost cobble deposit. Interestingly, there are cobbles located on DPLH 10303 which have a more polished veneer similar to cobbles currently found in the intertidal zone. Given that it is highly unlikely that waves could have transported and randomly distributed these clasts across the innermost portion of the cobble deposit, it is likely these were carried up the beach by human agency.

6 ASSESSMENT OF PRESENCE AND NATURE OF UCH

The assessment of the presence and nature of underwater cultural heritage requires the consideration of the following:

- *The likelihood of cultural activity having taken place and having left physical evidence.*
- *The presence of material cultural behaviour (expected to be only lithic material) that can be confidently identified as such.*
- *The degree to which past and on-going processes have affected archaeological integrity (or the nature) of underwater cultural heritage that may exist within the Dredging Footprint.*

This assessment has been tempered by an acknowledged constraint of the investigation where it was not feasible for the underwater archaeological excavation to examine areas where there was over 500 mm of silt overburden (see Section 1.6.4). This confined the investigation to what has been interpreted as a relic berm and terrace towards the southern end of the Dredging Footprint. This turns out, in light of observations made on the intertidal and terrestrial zones, to have been the optimal place for this investigation to focus.

The likelihood of cultural activity having taken place leaving physical evidence

The western portion of DPLH 10303 displays a discrete area past activity where stone tools were manufactured out of the granophyre cobbles upon which the site is located. The presence of rock art panels in this work area speaks to some degree of regular activity while the presence of nearby vegetation (*Acacia sp*. and *Ipomoea sp*.) may – but not reliably so - indicate a fresh water source and hence a possible reason for the attractiveness of this particular location within this cobble beach landform. Artefact density markedly decreases towards the east of the registered site. Though the lower terraces or relic berms between DPLH 10303 and the intertidal zone have not been systematically surveyed artefact densities appear to be relatively sparse.

The artefacts recorded within the boundaries of DPLH 10303 display a range of weathering and patination which suggest that the use of the terrace as a quarry for cobbles has continued for many generations and may even precede sea level rise. The presence on this upper or third terrace of cobbles which has a more polished veneer similar to cobbles currently found in the subtidal zone indicates that human agency was the likely means of transport from the current beach.

The terrace on which DPLH 10303 is located, Terrace 3, is part of a sequence of cobble terraces some of which were submerged by rising sea levels at the end of the last ice age. It is likely that most of the artefacts seen today at DPLH 10303 represent the most recent phase of use of the whole landform, which forms part of a continuous cultural landscape, extending offshore.

The relatively level subtidal terrace (Terrace -1) where ST01/02 are located was last above water around 8,500 years ago. Based on available information the cobble formation gradually dips away from the edge of this berm/terrace northwards, albeit a shallower gradient of the current beach profile. Site conditions 8,500 years ago are likely to have been different than today. For instance, if there is a fresh water source close to the knapping floor of DPLH 1303 it is most likely perched atop of a saline layer which may or may not be affected by tide. It is likely that over 8,500 years ago the fresh water table would have been lower, possibly pooling behind the exposed bedrock that runs along the southern edge of Terrace -1 (Figure 97). If proximity to fresh water was a determining factor for siting a work area for stone tool making, then Terrace -1 could have been suitable site. Not only would the terrace have supplied a similar if not greater selection of cobbles it would have been well sited to access resources to the north as well as to the south.

The presence of material cultural behaviour (expected to be only lithic material) that can be confidently identified as such.

The detailed, comprehensive and thoughtful analysis by Dr. Caroline Bird of the lithics recovered from the intertidal and subtidal excavation concluded that as an assemblage (it is rarely possible to be definitive with individual specimens) the samples comprise fractured cobbles that are the result of natural flaking processes operating in the storm beach environment as well as weathering processes operating before sea level rise, rather than cultural flaking (see Annex A).

However, there were specimens in both the intertidal and subtidal samples that would likely have been recorded as artefacts had they been found in an undoubted cultural context, such as DPLH 10303. Similarly, there were artefacts recorded within the registered site that were very similar to specimens from ST01 and IT01 and so might not have been considered culturally modified had they not been found in close association with more definite artefacts in DPLH 10303.

It therefore remains possible that some of the specimens recorded in the subtidal and intertidal samples are artefacts. The best example is a fine-grained flaked cobble recovered from IT01 Context 2, found in environment subjected to relatively high wave energy for the last 7,500 years.

The samples from the ST01 showed much less evidence of rolling and abrasion from wave action than IT01. This presumably reflects the relatively short period of about a thousand years when this part of the seabed passed through the intertidal phase and the relatively stability of the submerged portion of the cobble formation as indicated by the radiocarbon dating. This implies that cultural material, in this case lithics, would be preserved and identifiable within the cobble formation if these older terraces were used in the same way as DPLH 10303. Even in the intertidal trench, some relatively fresh and unweathered specimens were preserved beneath the top layer of cobbles.

These are not surprising observations in underwater archaeological excavation. Objects in marine environments will be mobilised when influenced by wave action. In a sedimentary context this could result in the creation of layers where objects are sorted within the profile according to surface area and relative density. Such deposits in exposed high energy zones are relatively ephemeral as the profile is regularly remobilised and reformed each time with variable depth (below seabed) according to the size of waves.

For this study area the forementioned process is affected by the nature of the material and that the size of the clasts that form the cobble formation. The overwhelming majority of the artefacts associated with the cobble beach formation (functioning as a quarry) would be of similar material with respect to relative densities and as such sorting/pooling/concentrations of artefacts would not be applicable. The size of the clasts – mostly cobbles and boulders – creates numerous cavities between them. This allows smaller objects such as flakes (more so blade like flakes) to fall into these cavities. This process is already occurring before inundation. As the area where ST01/02 were located was becoming submerged wave energy was influencing the formation – how often will be discussed below – with smaller objects within the cavities of the cobbles and boulders remaining protected from water borne sand abrasion and other 'weathering' effects. On occasion when the larger clasts moved due to higher than normal wave energy the smaller objects within the cavities could migrate further down the profile as cavities widen or new ones open up. This would protect them further, though of course edge damage could arise. It is entirely feasible and demonstratable that potential lithic artefacts in this context can be buried relatively quickly and be relatively unaffected by 'weathering' underwater. By extension there is some possibility for the survival of rock engravings if they were overturned and buried at the commencement of inundation. Such an event would have been a very rare occurrence.

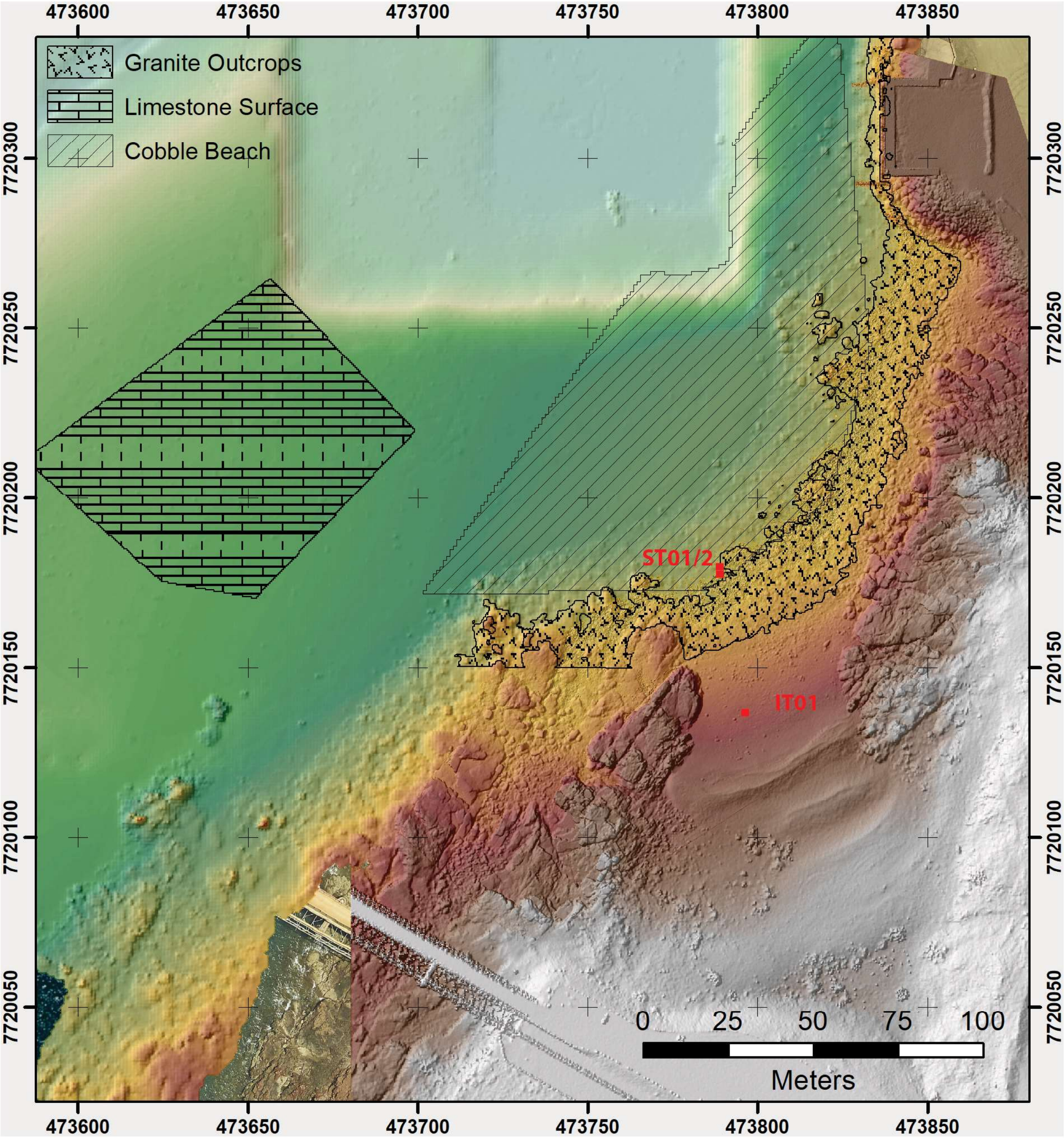

Figure 97: Location of trenches in relation to inferred extent of submerged granite outcrops.

In summary presence of flakes and nuclei with well-preserved flake margins and flake scars in both the intertidal and especially the subtidal samples indicates that any definite artefacts present within the intertidal and subtidal zones would also be protected from abrasion and rolling in some circumstances in the intertidal and subtidal zones. Therefore, it is possible that evidence of past use of older, now submerged, cobble beaches as a source of raw material could survive as could the use of subtidal terraces as nodes for tool making.

The degree to which past and on-going processes have affected archaeological integrity

The previous section described the processes supported by observation that allow for the preservation of potential artefacts within the subtidal area (Dredging Footprint). Archaeological integrity refers to how far artefacts have moved from where they were initially deposited. The more the distance (vertically as well as horizontally) they have moved the less likely that their trajectory from where deposited can be traced. This reduces the ability to interpret the site through the understanding the relationship between artefacts and natural features that make up a site. At its extreme an artefact totally severed from its connection to other artefacts from the same site can almost be considered to have passed from an archaeological context and returned to a geomorphological context. This change in status however does not render the artefact devoid of any cultural heritage values; it just limits its archaeological value.

Archaeological sites passing through the intertidal zone as sea level rises will undergo some form of disruption to their archaeological integrity. Engravings will be erased while loose rock, whether arranged, discarded tools or debitage will move. The greater the movement the lessening of the archaeological integrity of the site.

Observations made in ST01/02 supported by radiocarbon dating point to disturbance, at least in the subtidal period, as being regular though disturbances that mobilise larger cobbles and boulders are relatively in-frequent. For example ST01 Context 2, a cobble was recovered which was encrusted with shells dated to around 2,500 BP. If this clast, and those around it, was mobilised on a more regular basis the fragile encrustations would have been ground off.

Based on the preceding discussions any artefacts (lithics that could be confidently identified as such) present within the cobble formation that forms Terrace -1 would have been substantially disturbed since they were deposited. Smaller artefacts – relative to the average sized clast in the formation – with narrower shapes more likely than not have migrated downward into the profile. Other artefacts with a broader surface area may have propelled horizontally and even upwards for short distances at a time thereby exposing them to sand abrasion for longer periods of time. Larger artefacts such as cobble cores may have taken longer to work their way down the profile (and could also migrate up to and along the seabed surface depending on the jostling between other large clasts in high energy events). Artefacts on the relatively steeper former beach profile could also work their way down the slope.

The composition of the cobble formation in ST01/2 has greater similarities with the upper terrace where DPLH 10303 is located than the current intertidal zone with the presence of such clasts as angular rock and thermal flakes. With that said the archaeological integrity of artefacts, or deposits of artefacts within the subtidal area is likely to be low. If a concentration of artefacts such as those observed in the western portion of DPLH 10303 was present on Terrace -1 it would be expected they would have become diffused/diluted over time resulting in lower densities, much like a midden within a sand dune can become deflated. It should also be considered that a portion of such an assemblage could have been worn to a state where they are not recognisable as being culturally modified. Should Terrace -1 have been utilised such as those (Terrace 1 and 2) below DPLH 10303 then any artefacts densities should be extremely low.

There is reasonable confidence based on observations made on the movement of clasts in recent events in the Dredging Footprint, the differing nature of the clasts (more worn) in the current intertidal zone and the granite outcropping that appears to bisect Terrace -1 from the above water terraces that the movement of clasts between the intertidal zone/upper terraces and the subtidal area is not occurring and has most likely has not occurred. Any artefacts found therefore within the subtidal zone even if their archaeological integrity is low can provide a *terminus ante quem* (i.e. were discarded no later than 8,500 B.P.) thereby contributing to the understanding of the cobble beach landform as a quarry and of cobble tool technology in Murujuga.

Based on the above discussion it is assessed that the archaeological potential – referring to the presence of identifiable evidence of material culture – is high on Terrace -1 with lesser potential on the sloping former beach profile northwards of Terrace -1. The archaeological integrity of artefacts within the subtidal area maybe low, however their very context can provide substantial contributions towards understanding the past cultural practices in Murujuga.

It is considered that should a site similar to DPLH 10303 have existed on Terrace -1 it can be identified with sufficient sampling. It should be noted for the terrestrial survey there were places along T10 where no artefacts were observed for up to 3 x 2 m (see Figure 49). This is the area covered by ST01/02. This said the excavation recovered sufficient material have covered an estimated 12 x 2 m area. Even so a 12 x 2 m transect placed randomly within the current boundaries of DPLH 10303 could conceivably come up with similar results as the underwater excavation if it is kept in mind that some of the lithics recovered in ST01/02 could very likely have been recorded as artefacts because of their context, that is, due to their close proximity to lithics that could be more confidently attributed to have been culturally modified.

7 REVISED SCIENTIFIC SIGNIFICANCE ASSESSMENT

The re-assessment of cultural heritage significance for this report assesses the potential scientific/archaeological values of the predicted archaeological sites/features that are found in association with the submerged landforms identified in this report. Social, Historical, Spiritual and Aesthetic values cannot be assessed without consultation with the Circle of Elders and MAC.

The significance assessment of the scientific/archaeological values of the predicted archaeological sites/features follows that which was presented in Section 5 of the desktop assessment (Cosmos Archaeology, 2022). The discussion below has not been altered significantly from that of the 2022 desktop report, other than more confident statements can be made about the archaeological potential of the cobble beach formation.

Archaeological sites found in granite outcrops and block fields

The NHL listing of the Dampier Archipelago, including the Burrup Peninsula, emphasises the density and diversity of the rock engravings as key elements that warrant the region to be recognised as being of National significance (DAWE NHL). With regards to rock engravings, the listing in part states that:

> *The range of human images found in the Dampier Archipelago include forms characteristic of all the major style provinces in the Pilbara, an area that has been described as the richest and most exciting region of rock engravings in Australia. …. The combination of archaeological sites and high densities of engraved images provides an outstanding opportunity to develop a scientific understanding of the social functions of motifs.*

With regards to standing stones, *there is a high density of stone arrangements within part of the nominated area, the Burrup Peninsula.* And that the … *overall density of stone arrangements on the Burrup Peninsula, the wide range of types of stone features found in the Dampier Archipelago, are exceptional by Australian standards*.

Rock engravings, standing stones and associated artefact scatters, if present within the Study Area, could possibly be accorded a similar level of significance.

Archaeological sites found within the cobble formation

DPLH 10303, which covers the southern and more elevated portion of the cobble stone deposit, has been described as a rare site for Australian archaeology with the potential to inform research questions about pebble tool types in Australia (Green and Marwick 2002:113). While there is evidence of the use of water-worn cobbles and pebbles for stone artefacts elsewhere in Australia, this is a rare occurrence or potentially under reported for the archaeology of Western Australia. These tools may be created from water-worn cobbles sourced from beaches or from freshwater sources including rivers (Williams et al. 2012). One other example of a cobble beach site (a coastal site with worked pebbles) has been published for Western Australia, which is the site complex at Malimup on the state's south coast (Bowdler 2014; Dortch and Gardner 1976). Pebble tools have previously been documented mainly across the southeast of Australia, including Kangaroo Island and Tasmania (Bowdler 2014; McBryde 1976; Walshe 2005).

The cobble formation located adjacent to and within the Dredging Footprint is not geomorphically unique to Murujuga, with an analysis of aerial imagery identifying at least 25 other cobble beaches within the western island group (n=19), along the western Burrup Peninsula (n=4), and on the eastern side of Dolphine Island (n=1). All have distinctive grey coloured active cobble beach rising to a linear berm storm ridge. Additionally, 18 of the 25 cobble beaches also had an older or relic inner storm berm ridge that transitioned from a deep sandy-brown to orange-red patina. Unlike the cobble beach adjacent to the Dredging Footprint, the locations of these cobble beaches tended to be situated on headlands, straight sections of coast or the arms of deep embayments where there is more potential for exposure to higher energy waves generated by cyclones. The active storm berm elevation varied between beaches and is likely to be a function of water levels and storm wave energy experienced at each of these beach locations.

Six DPLH sites contain cobble beach deposits within their registered site boundaries however, however it is not clear whether the reported cultural site is directly related to the relic cobble beach deposit or a proximal landform or feature (Table 11 and Figure 98). Of these six only the Enderby 03 and 04, and West Lewis 03 locations have reported site types that could be associated with a cobble beach deposit. We cannot say conclusively whether any of these other cobble beach locations have archaeological material associated with the deposit.

It is also unknown whether any of these cobble beaches, like the DCW Cobble Beach, extend below the low water line and may have an associated submerged component.

Less than a kilometre away to the south, cobbles were brought up to the now-destroyed Phillip Point Stone Arrangement (DPLH 9878) for flaking (J.W. Rhoads and C. Bird, pers. Comm.). Core tools also occur in the lower levels of the Skew Valley Midden which has been dated to 7,000 BP; these resemble some of the flaked cobbles at DPLH 10303 and the drawings suggest they retain cortex, but it is not clear if these are made on water-worn cobbles (Lorblanchet and Jones 2018).

Table 11 : Relic cobble beaches in Murujuga

Name	Easting	Northing	Relic Cobble Beach	DPLH Site Number	DPLH Site Type
Conzinc 01	479787	7729205	Yes		
Conzinc 02	479911	7729422	Yes		
Conzinc 03	480003	7729733	Yes		
Conzinc 04	480018	7729806	Yes		
DCW Cobble Beach	473811	7720101	Yes	10303	
Dolphine 01	487652	7734100	No		
East Lewis 01	462789	7720084	Yes	11750	Engraving
East Lewis 02	465879	7721411	Yes		
East Lewis 04	463109	7719711	Yes	11749	
Enderby 01	444782	7720355	Yes		
Enderby 02	449667	7720026	Yes	932	Artifacts/Scatter, Quarry
Enderby 03	449849	7720053	Yes	932	Artifacts/Scatter, Quarry
Enderby 04	451964	7719861	Yes		
Enderby 05	452039	7719925	Yes		
Enderby 06	453924	7720853	Yes		
Enderby 07	456642	7724700	No		

Name	Easting	Northing	Relic Cobble Beach	DPLH Site Number	DPLH Site Type
Enderby 08	455308	7724356	No	6080, 6081, 11771	Engraving
LPG Wharf	476896	7723886	No		
Rosemary 01	457129	7733187	No		
Rosemary 02	457287	7733272	No		
Rosemary 03	457629	7733536	No		
West Lewis 01	459542	7720918	Yes		
West Lewis 02	461023	7720793	No		
West Lewis 03	465835	7727111	Yes	6231	Engraving, Fish Trap, Grinding Patches/Grooves
West Lewis 04	463423	7727459	Yes	6230	Artefacts/Scatter, Ceremonial, Engraving, Grinding
Whittaker 01	466332	7728149	Yes		
Whittaker 02	466400	7728238	Yes		

The boundaries of DPLH 10303 do not extend northwards into the intertidal or subtidal zones. The November 2022 investigation did not identify any definite artefacts. It did however demonstrate that within the subtidal zone, where there is a relic berm and terrace, conditions are favourable for the survival of lithic artefacts, although with relatively low archaeological integrity. Further investigation along the relic berm and terrace (Terrace -1) would therefore be required to determine whether a site similar to DPLH 10303 is present. Should this be the case, any archaeological remains associated with the submerged northern portion of the cobble beach would be able to differentiate between deep time and comparatively recent cultural practices associated with this rarely recorded site type in Murujuga.

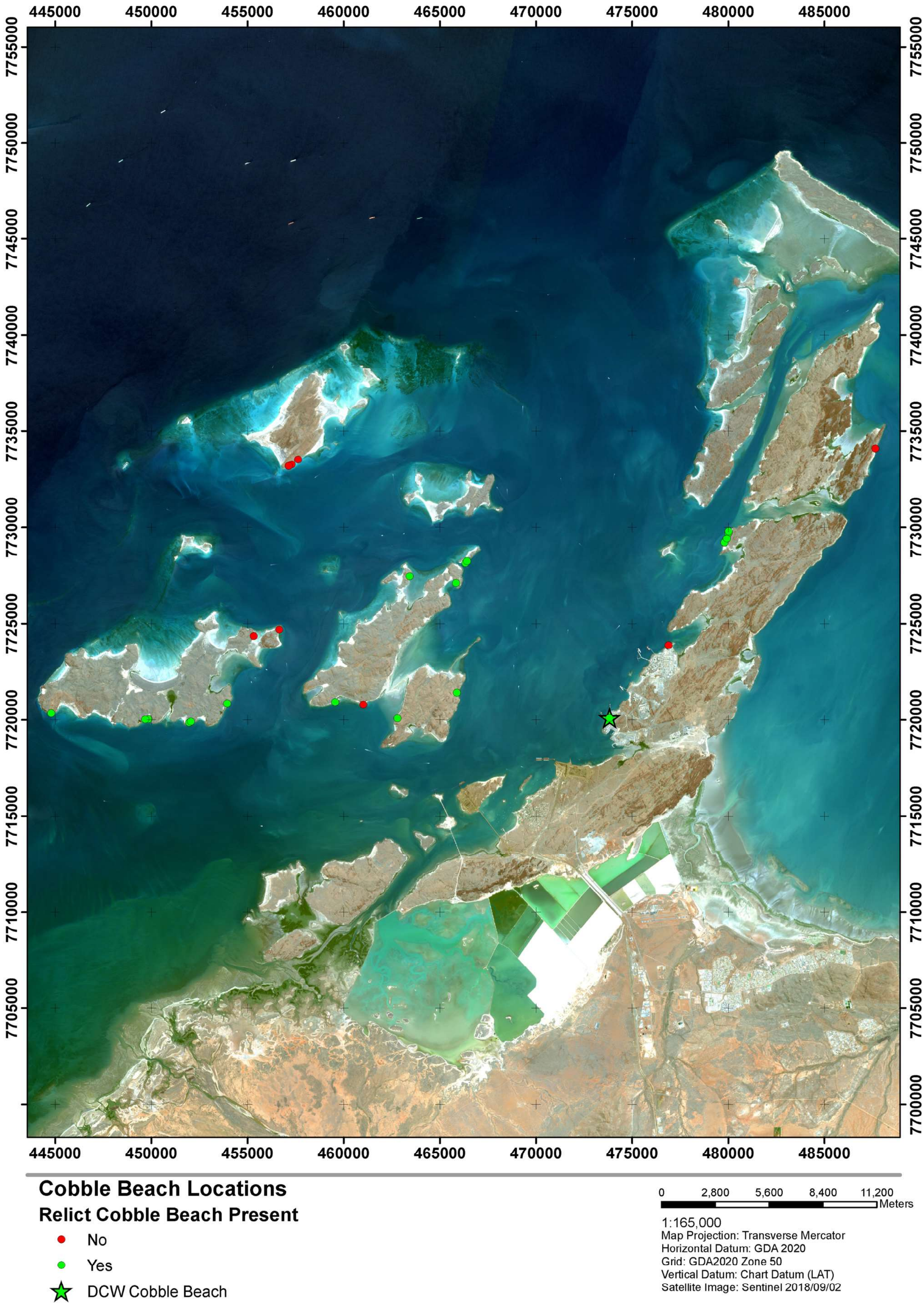

Figure 98: Relic cobble beach locations within Murujuga.

Archaeological sites found within the limestone plain

Underwater archaeological surveys recently conducted at Murujuga have recorded artefact scatters in similar geologies to the predicted limestone plain within the Study Area (Cosmos Archaeology, 2022), however the environmental contexts are different. These recent archaeological finds have been significant not only because of the rarity of recording submerged terrestrial sites within Australia but also because they can contribute to the developing understanding of cultural practices within deep time.

Table 12: Assessed scientific/archaeological significance of predicted site types within Study Area.

<table>
<tr><th>Submerged landforms</th><th>Site Type Association</th><th>Scientific</th><th>Grading</th></tr>
<tr><td rowspan="2">Igneous outcrop and block fields</td><td>Rock Engravings</td><td rowspan="6">The significance of these site types are equivalent to those on land, with enhanced values on the basis that they can be dated (time when inundated). Though these site types are well represented in the Murujuga, they would be considered extremely rare sites if found within the Study Area as few submerged sites in Australia have been documented and none associated with this submerged landform.</td><td rowspan="2">High</td></tr>
<tr><td>Standing Stone</td></tr>
<tr><td rowspan="2">Cobble stone beach</td><td>Artefact Scatter</td><td rowspan="2">High</td></tr>
<tr><td>Grinding Stones</td></tr>
<tr><td rowspan="2">Limestone plain</td><td>Artefact Scatter</td><td>Medium</td></tr>
<tr><td>Karst Waterholes</td><td>High</td></tr>
</table>

8 CONCLUSION

The November 2022 underwater archaeological investigation was composed of a multidisciplinary team comprising underwater and terrestrial archaeologists, a geomorphologist as well as a commercial dive team. It is understood to be the first investigation of its kind in Australia where an underwater archaeological excavation was undertaken for the sole purpose of identifying and recovering Aboriginal artefacts.

The report on the investigation provides a detailed description of the conduct and findings of the survey and excavation undertaken in November. It also contains discussions around site formation processes that includes the results of the radiocarbon dating of shell and coral samples. The report also includes a revised assessment of the scientific significance of the archaeological resource within the Dredging Footprint, with an assessment of the remaining criteria to be completed with input from MAC. Annex A contains a specialist lithics report prepared by Dr Caroline Bird of Archae-aus and includes a multivariate analysis and high-level lithic catalogue. Annex D contains data files associated with drone and underwater video as well as 3D modelling.

Regarding the objective of this archaeological investigation, namely to ….*identify the presence, nature and significance of any underwater cultural heritage values that may exist within the Dredging Footprint,* the following can be said:

Presence

The lithic assemblages recovered from the intertidal and subtidal excavation, when compared to the artefact assemblage of the registered site DPLH 10303, did not produce any definite artefacts. This is not to say that one or more of the lithics recovered from the sub- and intertidal trenches were not artefacts, rather that no recovered lithics could be confidently described as such when compared against the DPLH 10303 assemblage. It was observed however that some of the lithics recovered from the subtidal trenches would likely have been recorded as artefacts if found on DPLH 10303 while some lithics recorded as artefacts within DPLH 10303 may not have been recorded as such if found outside the site boundaries.

This situation is related to context; in this case the relationship (proximity) to lithics which are considered to be definite artefacts. Context also relates to the environment where the lithics were recovered. The mechanical forces acting on lithics as they pass through the intertidal zone can closely replicate clasts fractured through cultural processes. This requires a greater awareness of site formation processes in a marine environment for a lithic to be confidently assessed as having been culturally modified.

Nature

It is notable that during the examination of the silt boxes and rock cages from the subtidal trenches, there was frequent discussion about whether a lithic was a product of cultural behaviour or heat fracture. This is a discussion that could also have taken place on DPLH 10303. Unlike the material recovered within the intertidal trench IT01, which was very water worn, the lithics recovered from ST01/2 had a significant proportion of fresh, sharp edges. This indicates that the underwater terrace, Terrace -1, upon which these trenches were sited spent less time passing through the intertidal zone, perhaps only around 1,000 years, as opposed to the current intertidal zone which has been in this state for around 6,000 to 7,000 years. Furthermore, though the trenches were around 2.7 m below chart datum, wave generated disturbance that would mobilise larger cobbles and boulders appear infrequent. This circumstance is very conducive to the preservation of lithic artefacts.

It also indicates, along with other observations on cobble beach morphodynamics, that there is little likelihood of material from the intertidal zone and above mixing with the deposits in the subtidal zone. Having said this, there is evidence of regular disturbance, at lower energy levels, which would indicate that should a site similar to DPLH 10303 be present on this underwater former beach terrace, then it would be diffused through the cobble formation, much like a deflated shell midden associated with an eroding dune. Artefact densities would be low but such a site could be identifiable through rigorous sampling.

Significance

The assessed significance of the scientific values of the archaeological evidence associated with the cobble beach formation has not significantly changed since the 2022 desktop assessment. Although a definite artefact was not identified, the nature of the subtidal portion of the cobble formation, in particular what is considered to be a former beach terrace, provides greater confidence than before for the preservation of cultural material, in the form of stone artefacts, even though with low archaeological integrity. Nevertheless, any artefacts present within the cobble formation within the subtidal zone could be assigned a *terminus ante quem* of around 8,500 years, which would make this a significant landform for the understanding of cultural activities in Murujuga prior to the cessation of sea level rise and for the study of what appears to be a rare archaeological site type within a National context.

The outcomes of the UCH investigation carried out over five days in November 2022 can be summed up as follows:

- The pedestrian survey conducted within the registered boundary of DPLH 10303 provided a better understanding of the uneven distribution of artefacts across the site and an artefact typology so that finds from the inter and sub tidal trenches could be compared to.
- Lithics with little or no patina were observed within the boundaries of DPLH 10303 indicating the whole of the currently exposed cobble formation has been utilised as a quarry. It would be reasonable to assume that this activity had also taken place across the now submerged portion of the cobble formation.
- The intertidal pedestrian survey and excavation characterised the fractured and worn lithics that have been situated in a relatively high energy environment for around 8,000 years.
- The 6 m^2 subtidal excavation within the dredging footprint of approximately 84,000 m^2, reached depths of between 800 mm (-3.5 CD) and 1,300 mm (-4 m CD) below the seabed.
- The subtidal excavation was undertaken on what appears to be a relic terrace/berm feature similar to those present on the modern cobble beach, the highest terrace being where DPLH 10303 is situated.
- What was significant about the finds from the subtidal trench was the presence of angular clasts which showed little evidence of abrasion arising from wave activity. Lithics recovered were easily recognisable as thermal flakes which may only have been created prior to inundation. Radiocarbon dating indicated that though the area where the subtidal trenches were located is subject to regular disturbance which mobilises sediment and smaller clasts, higher energy events which mobilise boulders and larger cobbles appear infrequent. This indicates that lithic artefacts would not have been abraded to the point where they would be unrecognisable.
- Some of the lithics recovered from the intertidal and subtidal excavation would likely have been recorded as artefacts if located within the boundaries of DPLH 10303, however no definitive artefacts were identified. Furthermore, when viewing the lithics recovered from the excavation as an assemblage compared to the recorded artefacts

from DPLH 10303, they display characteristics resulting from natural processes, whether due to high wave energy or thermal fracturing.

- The UCH investigation has shown that the nature of the submerged cobble formation within the dredging footprint is favourable for the survival of lithic artefacts in a recognisable form. It is reasonable to assume that the whole cobble formation was exploited as a quarry prior to inundation therefore if a site with similar characteristics to DPLH 10303 were present on the submerged berm/terrace along the southern portion of the dredging footprint, it would be identifiable, albeit in a dispersed/dissipated form.

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ANNEX A – LITHICS REPORT (ARCHAE-AUS)

DAMPIER CARGO WHARF EXTENSION PROJECT - SPECIALIST LITHICS REPORT

February 2023

For Cosmos Archaeology

archae-aus

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Warning

Please be aware that this report may contain images of deceased persons and the use of their names, which in some Aboriginal communities may cause sadness, distress or offence.

Disclaimer

The authors are not accountable for omissions and inconsistencies that may result from information which may come to light in the future but was not forthcoming at the time of this research.

Report Format

Section One outlines the scope of the project and describes the Project Area. Section Two discusses the background to the project and includes a theoretical discussion and literature review of the issues involved in distinguishing between cultural and natural stone flaking. Section Three outlines the methods used for data collection and analysis. Section Four describes the results. Section Five summarises the conclusions. Appendix One is a catalogue of the recorded samples of cultural material from the site (DPLH 10303) and fractured cobbles from the excavation.

Spatial Information

All spatial information contained in this report uses the Geocentric Datum of Australia (GDA2020), Zone 50, unless otherwise specified. All information obtained from Cosmos Archaeology is assumed to be accurate to two decimal places. All spatial information obtained during fieldwork was taken using a handheld Garmin GPS with a purported accuracy of ±3 m. Where we report spatial information collected in the field, we have opted for a slightly wider degree of accuracy of ±5 m.

Authorship

This report was written by Dr Caroline Bird, MA *Cantab*, MA (Sc&TechSt) *Deakin*, PhD *W.Aust.,* FAHA and reviewed by Fiona Hook, BA (Hons) Prehistoric Historical Archaeology Sydney.

The GIS data and maps were drafted by Dr Caroline Bird, with assistance from Jim Stedman, BA (Joint Hons Geography and Archaeology) *UOM UK*, MMarArch *W.Aust*., and Rebecca Ryan BA (Hons) Archaeology W.Aust, Master of Museum and Heritage Studies *Sydney*.

The Archae-aus field team comprised Dr Caroline Bird, Jim Stedman and Rebecca Ryan.

EXECUTIVE SUMMARY

Pilbara Ports Authority (PPA) proposes to develop and operate a land-backed wharf extension to the Dampier Cargo Wharf (DCW) at the Port of Dampier. The Project Area is adjacent to Registered Site DPLH 10303, an artefact scatter on a relict cobble terrace. PPA engaged Cosmos Archaeology to undertake an investigation to identify the presence, nature and significance of any underwater cultural heritage values that may exist within the Project Footprint. Key issues are:

- Can artefacts be identified in association with now-submerged cobble deposits and in the current intertidal zone?
- Is there sufficient archaeological integrity of older cobble beaches and terraces that cultural material could be preserved?

Archae-aus was engaged by Cosmos Archaeology to:

- record the assemblage from the Registered Site DPLH 10303, associated with the cobble beach adjacent to the Project Area;
- conduct a pedestrian survey of the beach and intertidal zone;
- record fractured cobbles from excavation trenches in the intertidal and subtidal zones; and
- prepare a specialist lithics report on the stone samples recorded.

The Archae-aus team recorded a sample of artefacts from DPLH 10303 over 1.5 days. They then assisted with sorting and photographing material recovered from the excavation of the intertidal and subtidal trenches and selected samples of fractured cobbles from IT01 and ST01 for more detailed recording.

Analysis involved characterisation of the cultural sample from DPLH 10303 to provide a basis for comparison with fractured cobbles from the intertidal and subtidal zone.

The analysis showed that the samples of fractured cobbles from the intertidal (IT01) and subtidal (ST01) excavations differ significantly from the cultural assemblage recorded from DPLH 10303. These differences are broadly consistent with the effects of natural flaking associated with high energy coastal processes. Therefore, it is concluded that only the sample from DPLH 10303 is fully cultural in origin. Nevertheless, there is some overlap between the samples, and it is not possible to completely rule out the presence of artefacts in the subtidal and intertidal samples.

The conclusions are:

- Heavily patinated and worn artefacts as well as relatively fresh and unpatinated artefacts at DPLH 10303 suggest that the use of the upper terrace as a quarry for cobbles has continued for many generations and probably precedes sea-level rise.
- The presence of flaked unpatinated cobbles within the registered site boundary of DPLH 10303 suggests that the whole beach was a source of raw material, with fresh cobbles from the beach taken to the highest terrace for flaking.
- The terrace on which DPLH 10303 is located is part of a sequence of cobble terraces some of which were submerged by rising sea levels at the end of the last ice age. It is likely that most of the artefacts seen today at DPLH 10303 represent the most recent phase of use of the whole landform, which forms part of a continuous cultural landscape, extending offshore.

- The presence of flakes and nuclei with well-preserved flake margins and flake scars in both the intertidal and especially the subtidal samples suggests that artefacts could be protected from abrasion and rolling in some circumstances in the intertidal and subtidal zones. Therefore, it is possible that evidence of past use of older cobble beaches as a source of raw material could survive. Such evidence might include a range of flaked artefacts associated with cobble testing, decortication, and production of flakes and tools for use elsewhere.
- The low average density of cultural material on the surface of DPLH 10303 means that there is a low probability of finding one or more definite artefacts within the limited sampling window afforded by the intertidal and subtidal excavations.

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SECTION ONE – INTRODUCTION

Scope of Works

Pilbara Ports Authority (PPA) proposes to develop and operate a land-backed wharf extension to the Dampier Cargo Wharf (DCW) at the Port of Dampier. The proposed works relevant to this investigation involve the capital dredging of a new berth pocket and manoeuvring area. The dredging will remove up to 380,000 m^3 to a maximum design depth in places of up to -13.2 m CD.

The Project Area is adjacent to Registered Site DPLH 10303, an artefact scatter on a relict cobble terrace with a distinctive assemblage indicating the use of the cobble terrace as a quarry.

PPA commissioned a desktop study by Cosmos Archaeology, which showed that there was potential for underwater cultural heritage within the development envelope, in the form of possible stone artefacts in the cobble layer identified within the project footprint (Coroneos et al. 2022a, 2022b). Therefore, older cobble beaches could have been used in the same way as DPLH 10303 before being submerged by rising sea levels. PPA has engaged Cosmos Archaeology to undertake an investigation to identify the presence, nature and significance of any underwater cultural heritage values that may exist within the Project Footprint. Key questions are:

- Can artefacts be identified in association with now-submerged cobble deposits and in the current intertidal zone?
- Is there sufficient archaeological integrity of older cobble beaches and terraces that cultural material could be preserved?

Archae-aus has been engaged by Cosmos Archaeology to:

- record the assemblage from the Registered Site DPLH 10303, associated with the cobble beach adjacent to the Project Area;
- conduct a pedestrian survey of the beach and intertidal zone;
- record fractured cobbles from excavation trenches in the intertidal and subtidal zones
- prepare a specialist lithics report on the stone samples recorded.

The aims of the analysis are to:

- Characterise the cultural material from DPLH 10303 to provide a baseline for comparison with fractured cobbles
- Develop an understanding of fracturing and weathering processes acting on cobbles on the beach, intertidal and subtidal zones.
- Identify any artefacts recovered from the intertidal and subtidal excavations.
- Assess the potential for preservation of cultural material in the intertidal and subtidal zones.

Project Area

Figure 1 shows the location of the Project Area within Murujuga, with the location of places mentioned in the text. shows DPLH 10303 and other nearby registered sites adjacent to the Project Area. Table 3 lists the Registered Sites and Other Heritage Places adjacent to the Project Area. AHIS lists other sites in the vicinity all of which have restricted boundaries; however, none seem to be close to the Project Area.

Table 3. Registered Sites and Other Heritage Places in the vicinity of the Project Area

ID	Name	Status	Type	Legacy ID
9061	COBBLE BEACH 1	Registered Site	Artefacts / Scatter, Engraving	P03350
9062	COBBLE BEACH 2	Registered Site	Artefacts / Scatter, Engraving	P03351
9063	COBBLE BEACH 3	Registered Site	Artefacts / Scatter, Engraving, Quarry	P03352
9815	DRD AREA A-09	Registered Site	Engraving	P02359
10303	KING BAY NORTH	Registered Site	Artefacts / Scatter, Quarry	P01889
18706	Phillip Point engraving 2	Registered Site	Engraving	
19793	DNP-01 ENGRAVING	Registered Site	Engraving	
19794	DNP-04 GRINDING PATCHES	Registered Site	Grinding Patches / Grooves	
19833	OMP-03 Engravings	Registered Site	Engraving	
19834	BSC-14 Engraving	Registered Site	Engraving	
18683	Phillip Point Midden	Stored Data / Not a Site	Midden / Scatter	
20190	Ngarluma Thalu Site	Lodged	Ceremonial, Other: Thalu Site	
20191	Western Stevedores Grindstone	Lodged	Artefacts / Scatter	

Figure 1. Murujuga, showing Project Area and places mentioned in the text

Drafted by Caroline Bird, 17 February 2023. GDA2020, Zone 50. Satellite imagery courtesy of Google and Wiki Maps.

Legend

DPLH 10303

Registered sites

archae-aus

Figure 2. Project area, showing DPLH 10303 and other registered sites

Drafted by Caroline Bird, 13/02/2023. GDA2020, Zone 50. Satellite imagery: Google.

ABORIGINAL HERITAGE LEGISLATION

The Aboriginal Cultural Heritage Bill 2021 passed Western Australia's State Parliament and received Royal Assent on 22nd December 2021, effectively giving Western Australia new Aboriginal heritage legislation, the *Aboriginal Cultural Heritage Act 2021* (ACH Act). The ACH Act will replace the *Aboriginal Heritage Act 1972* (the AHA), but before the ACH Act comes into operation there will be a transitional period of at least 12 months during which the regulations, statutory guidelines and operational policies will be developed to ensure the ACH Act will have its intended effects. The transitional period will allow for the new Aboriginal cultural heritage management system to be fully established and to enable parties to prepare for the new system.

During the transitional period the AHA will remain in force to allow proponents to continue to seek section 18 consent for any activity that will impact Aboriginal sites. Any section 18 consents applied for and granted during this period will be limited to 5 years and will be subject to additional protection mechanisms, including the requirement to report new information about the existence or the characteristics of Aboriginal cultural heritage.

While the full interpretation of the new ACH Act will be subject to the development of further guidelines from the Department of Planning, Lands and Heritage, the Act itself provides guidance on some of the changes that proponents will need to consider in relation to Aboriginal Heritage moving forward.

Notably, the definition of 'Aboriginal Cultural Heritage' is broader than the definition contained in the AHA, and includes social, spiritual, historical, scientific and aesthetic values:

> *"Aboriginal cultural heritage —*
>
> *(a) means the* ***tangible and intangible*** *elements that are important to the Aboriginal people of the State, and are recognised through* ***social, spiritual, historical, scientific or aesthetic values****, as part of Aboriginal tradition; and*
>
> *(b) includes the following —*
>
> > *(i) an area (an Aboriginal place) in which tangible elements of Aboriginal cultural heritage are present;*
> >
> > *(ii) an object (an Aboriginal object) that is a tangible element of Aboriginal cultural heritage;*
> >
> > *(iii) a group of areas (a cultural landscape) interconnected through tangible or intangible elements of Aboriginal cultural heritage;" (Section 12, Aboriginal Cultural Heritage Act 2021)*

It is important to note that this description of Aboriginal Cultural Heritage embeds the idea of "Aboriginal Tradition", which is defined in the Act as:

> *Aboriginal tradition —*
>
> *(a) means the* ***living, historical and traditional*** *observances, practices, customs, beliefs, values, knowledge and skills of the Aboriginal people of the State generally, or of a particular group or community of Aboriginal people of the State; and*

*(b) includes any such **observances, practices, customs, beliefs, values, knowledge and skills** relating to particular persons, areas, objects or relationships; (Section 11, ACH Act).*

Further, the Act clearly specifies "*Principles relating to management of activities that may harm Aboriginal cultural heritage*", which will underpin the development of guidelines related to Development Activities that would impact on Aboriginal Cultural Heritage:

"The principles relating to the management of activities that may harm Aboriginal cultural heritage are as follows —

(a) it should be recognised that —

(i) places, objects and landscapes have a range of different values for different individuals, groups or communities, and those values may change for an individual, group or community over time; and

(ii) those values include social, spiritual, historical, scientific, economic and aesthetic values;

(b) the range of different values for places, objects and landscapes held by different individuals, groups or communities, at particular times and over time, should be recognised and respected;

(c) places and objects exist within landscapes and should be considered in that context;

(d) as far as practicable, in order to utilise land for the optimum benefit of the people of Western Australia, the values held by Aboriginal people in relation to Aboriginal cultural heritage should be prioritised when managing activities that may harm Aboriginal cultural heritage." (Section 10, Aboriginal Cultural Heritage Act 2021)

Nevertheless, at the time of writing, the AHA is still the main legislative framework for Aboriginal heritage in the State. Important and significant Aboriginal sites and objects are protected under it. The AHA protects sites and objects that are significant to living Aboriginal people as well as Aboriginal sites of historical, anthropological, archaeological and ethnographic significance. The AHA is currently administered by the Department of Planning, Lands and Heritage (DPLH).

The primary sections of the AHA that need to be considered are section 5 which defines the term 'Aboriginal Site' [1] and section 39 (2) which details what the Aboriginal Cultural Materials Committee (ACMC) should have in regard to considering the importance of objects and places. Section 17 of the AHA states that it is an offence to: alter an Aboriginal site in any way, including collecting artefacts; conceal a site or artefact; or excavate, destroy or damage in any way an Aboriginal site or artefact; without the authorisation of the Registrar of Aboriginal Sites under section 16 or the Minister of Aboriginal Affairs under section 18 of the AHA.

Aboriginal heritage sites are also protected under the *Commonwealth Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (the HPA). The HPA complements state / territory legislation and is intended to be used only as a 'last resort' where state / territory laws and processes prove ineffective. Under the HPA the responsible Minister can make temporary or long-term declarations to protect areas and objects of significance under threat of injury or desecration. The HPA also

[1] http://www.daa.wa.gov.au/en/Heritage-and-Culture/Aboriginal-heritage/Aboriginal-Site-and-other-Heritage-Places/

encourages heritage protection through mediated negotiation and agreement between land users, developers and Aboriginal people.

Aboriginal human remains are protected under the AHA and the HPA. In addition, the discovery of human remains requires that the following people are informed: the State Coroner or local Police under section 17 of the *Coroners Act 1996*; the State Registrar of Aboriginal Sites under section 15 of the AHA and the Federal Minister for Aboriginal Affairs under Section 20 of the HPA.

In terms of broader recognition of Aboriginal rights, the Commonwealth *Native Title Act 1993* (the NTA) recognises the traditional rights and interests to land and waters of Aboriginal and Torres Strait Islander people. Under the NTA, native title claimants can make an application to the Federal Court to have their native title recognised by Australian law. The NTA was extensively amended in 1998, with further amendments occurring in 2007, and again in 2009. Under the future act provisions of the *Native Title Act 1993*, native title holders and registered native title claimants are entitled to certain procedural rights, including a right to be notified of the proposed future act, or a right to object to the act, the opportunity to comment, the right to be consulted, the right to negotiate or the same rights as an ordinary title holder (freeholder).

DPLH Register Status

The Aboriginal Heritage Inquiry System (AHIS), managed by the DPLH, is the tool through which the public can access information about Aboriginal heritage places and their legal status. There are two broad categories in which the AHIS categorises heritage places:

Aboriginal Sites (Registered Sites); and

Other Heritage Places.

A registered Aboriginal Site is a place that fulfils the following definitions for protection under section 5 of the AHA:

a) *any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present.*
b) *Any sacred, ritual or ceremonial site which is of importance and special significance to persons of Aboriginal descent.*
c) *Any place which, in the opinion of the Committee (i.e. the ACMC), is or was associated with Aboriginal people and which is of historical, anthropological, archaeological or ethnographic interest and should be preserved because of its importance and significance to the cultural heritage of the State.*
d) *Any place where objects to which the AHA applies are traditionally stored, or to which, under the provisions of the AHA, such objects have been taken or removed.*

The category ‘Other Heritage Place’ is complex and is not a reliable indicator for the legal status of a heritage place under the AHA. The Other Heritage Place category has two status sub-categories:

Lodged - indicates a potential Aboriginal Site that has been reported but not yet assessed by the ACMC. These places are therefore immediately protected under the AHA; and

Stored Data / Not a Site - a place that has been assessed by the ACMC who have decided that the place does not fulfil the above definitions for an Aboriginal Site, protected under the AHA.

A small number of ‘Other Heritage Places’ have ‘Contact DAA/DPLH’ as their status, indicating that contact needs to be made with the Department of Planning, Lands and Heritage regarding these places, to access further information / advice.

Thus some ‘Other Heritage Places’ are protected under the AHA, while others are not. Consequently, Archae-aus recommends full and transparent consultation with Traditional Owners about all of their heritage places.

SECTION TWO – BACKGROUND

DPLH 10303 - PREVIOUS RECORDING

King Bay North, DPLH 10303 (also known as Bouncing Pebble Beach and P1889) is located on a relict cobble beach which served as a quarry. It was originally recorded by John Clarke in 1979. It is not known to what extent the site was systematically recorded by the Dampier Archaeological Project teams in the late 1970s/ early 1980s. The site is briefly described in those reports (Department of Aboriginal Sites 1984, Vinnicombe 1987), but there are no detailed records in the current site file and none have been located at the WA Museum Boola Bardip. The site is described as follows:

> *At the southern end of the Boongaree coastal strip there is an embayment known as Bouncing Pebble Beach which is composed of three distinct pebble terraces, each differentially weathered. The lighter-coloured terrace is nearer to the sea whilst the darkest is furthest from the sea. The height of the darker-coloured terrace is 15 m above sea level, and some of the boulders incorporated in this terrace show signs of desert varnish. Although there was some speculation that these terraces might reflect fluctuations in sea level, they are now considered to be the results of storm action. The pebbles which form these terraces have a peculiar bouncing quality and have been used by the Aborigines as a source material for stone artefacts. Cores, hammerstones and unifacially or bifacially flaked pebble tools lie scattered on Bouncing Pebble Beach (P1889), as well as in isolated positions throughout the adjacent plains, scree slopes and further inland (P3352, P3057*). (Department of Aboriginal Sites 1984, p. 22)

The original DAS team did not record any petroglyphs, but there are several petroglyph sites nearby and an artefact scatter which is apparently a flaking floor. The site was in an area that was 'cleared' for development.

Further investigations took place as part of the East-West infrastructure corridor development in 2002 (ACHM 2002a, 2002b, Green and Marwick 2002). DPLH 10303 was re-recorded at this time and additional sites were also recorded in the vicinity. Green and Marwick (2002, pp. 111–112) described DPLH 10303 as a low-density stone artefact scatter 94 m by 64 m located above the high tide mark on a pebble beach between two rocky headlands. The site covered an area of approximately 5000 m2. A sample of 250 artefacts from a series of 32 5x5 m sample squares and one 10x10 m sample square was recorded, as well as 24 basal grinding stones. The detailed records were included on a CD which is missing from the report. Photographs and statements in the report (pp. 109 ff.) suggest that the assemblage is dominated by cores and core tools made on granophyre cobbles. The summary of the assemblage within the text contains errors and is not consistent with the stone artefact classification described elsewhere in the report (p.19 ff). Table 4 provides a summary (corrected as best as possible). The criteria for identifying the residual categories of debris and flake fragments (more than a third of the assemblage) as artefactual are not clear. Note that the term 'pebble chopper' implies that a chopping tool is the desired end-product. However, the flaked cobble is also a source of flakes (and thus a core). The assemblage is thus unusual in the high proportion of cores and core tools. It is likely that large flakes were removed for use elsewhere. Tested cobbles may also have been removed for further reduction at nearby sites.

Most of the 293 artefacts recorded were fine-grained black granophyre (97%). The beach cobbles are mainly granophyre although it is not clear whether they too are mainly fine-grained black granophyre or whether there has been selection.

The site was described in broadly similar terms by Draper (ACHM 2002a, 2002b). No detailed recording was undertaken but the report mentions a range of cobble choppers (unifacial and bifacial) horsehoof cores, picks, flakes and blades, and retouched tools. The report also highlights smooth cobble-shaped pieces of white coral and indicates that these are culturally significant (ACHM 2002a, p. 25).

An unusual feature of the site is the large number of grindstones recorded by Green and Marwick 2002). They suggest this concentration of grindstones at a quarry reflects the availability of suitable large boulders. Traditional Owner Kenny Jerrold said that they were for processing the seeds of the kurrajong trees growing nearby and dried yam tubers, which provided important food resources. Green and Marwick (2002, pp.114) suggest that stratified deposits may exist at the south-east edge of the site.

Density of artefacts varied considerably over the site. Green and Marwick estimated artefact density, based on systematic recording over 18% sample of the site area, as 0.28/m2 (range 1.88-0.04/m2). This is somewhat lower than Draper's estimate (ACHM 2002b, p. 2), which ranged from 1-10/m2.

Table 4. Recorded sample of artefacts (Green and Marwick 2002)

Type	N	%
Debris	43	17.2
Pebble Chopper – Unifacial	56	22.4
Pebble Chopper – Bifacial	42	16.8
Core – Single Platform	3	1.2
Core – Multi-platform	1	0.4
Complete flake	54	21.6
Longitudinally split flake	9	3.6
Transversely broken flake	1	0.4
Flake fragment	41	16.4

All reports (ACHM 2002b, 2002a, Green and Marwick 2002) highlight the significance of the site at a local and national level in terms of the distinctive and unusual concentration of worked cobbles and pebbles. They draw comparisons with so-called 'Kartan' assemblages from Kangaroo Island and mainland South Australia, Malimup in the south-west of WA and the Hoabinhian technocomplex of SE Asia. It should be noted that there is no cultural connection between these technocomplexes. Rather, the technological similarities between them can be directly attributed to the common use of pebbles and cobbles as a source of raw material.

The original recording team did not record any petroglyphs at the site (Department of Aboriginal Sites 1984). Two petroglyphs were recorded in 2002 (Green and Marwick 2002); these may have been introduced by relocation from nearby sites disturbed by construction activity.

NATURAL FLAKING PROCESSES AND THE PROBLEM OF DISTINGUISHING ARTEFACTS FROM GEOFACTS

Distinguishing the products of human flaking (artefacts) from natural objects (geofacts) is a long-standing problem in archaeology, which goes back to the first debates about the evidence for ancient human artefacts in the 19th century, particularly so-called eoliths from Tertiary age deposits (Johnson 1978). The resulting research, involving both experimentation and observation, laid the foundations of understanding the manufacture of stone artefacts (Cotterell and Kamminga 1987). Much of the initial Eolith debate related to the recognition of humanly flaked flints in river gravels, glacial or beach deposits in northern Europe (Boule, 1905; Warren, 1914; Johnson, 1978; Peacock, 1991). The eolith problem was further compounded by observer bias in the selection of naturally fractured stones towards those that most resembled artefacts (Ellen and Muthana 2013). Improving knowledge about fracture processes was important to the resolution of the debate, although understanding of the natural and cultural context was crucial. In essence, the issue turned on the fact that the key features of conchoidal fracture that are characteristic of isotropic stone are the same whether produced by human flaking or natural processes. In essence, human flaking of stone to produce tools harnesses knowledge of the same mechanical processes and properties of lithic materials that also give rise to natural flaking. This means that there is an overlap between the products of natural and human flaking the parameters of which are still not well understood (Eren et al. 2023).

The debate continues to surface regularly, particularly in relation to demonstrating the presence of humans in certain controversial contexts. For example, the contested presence of pre-Clovis occupation in the Americas continues to give rise to disputes about the status of particular sites based on whether the claimed artefacts are the result of human flaking or natural processes (e.g. Patterson, 1983; Patterson et al., 1987; Chlachula and le Blanc, 1996; Gillespie, Tupakka and Cluney, 2004). Claims for pre-Pleistocene human presence in Asia have also been controversial (Dennell et al. 1988, Hemingway et al. 1989).

A range of natural processes can give rise to mechanical flaking of stone by percussion or pressure that can be comparable to human flaking, including movements of soil and water, rock falls. In addition, thermal fracture can be mistaken for the effects of human flaking (Warren 1914, Pei 1936). Fractures can also be created by recent human activity, such as ploughing or other mechanical earth moving equipment (Barnes 1939). Trampling by humans or animals can also create fractures (Boot 1987, Theunissen et al. 1998).

Various studies have identified a range of diagnostic features as likely to indicate cultural flaking. However, none are definitive or diagnostic in isolation. Some of these features relate to regularity and patterning of flake removal. Others relate to supposed differences in key diagnostic features of percussion fracture relating to human and natural flaking. It is commonly stated, for example, that bulbs of percussion are consistently better developed and more prominent in human flaking. Most of these criteria are difficult to define objectively. None are definitive or diagnostic by themselves and ‘there is no purely technical criterion for distinguishing human work from natural chance’ (Watson 1968 p. 30). The more successful attempts at distinguishing between natural and cultural flaking consider a population of material, consider multiple attributes and compare with a known natural or cultural control sample (Peacock 1991, Gillespie et al. 2004). It is rarely (if ever) possible to be definitive about individual artefacts.

Most studies relate to problems of identifying flint or chert artefacts in the northern hemisphere, particularly in glacial deposits[2]. The question here is the identification of possible artefacts in the inter-tidal and sub-tidal zones adjacent to King Bay North (DPLH 10303). This site comprises an unusual artefact scatter with large numbers of flaked cobbles and pebbles on the highest of three terraces. Past cobble deposits identified in offshore cores (Coroneos et al. 2022a, 2022b) are postulated to represent cobble beaches relating to episodes of lower sea level. If artefacts occur in association with the current beach and intertidal zone and with cobble deposits relating to older now-submerged shorelines, then the manifestation of the site as currently recorded could be interpreted as the most recent episode of exploitation of the cobble beach, with use of earlier beaches extending back before sea-level rise.

The investigation of areas with potential for survival and discovery of submerged archaeological sites has been highlighted in recent years (Dortch 2002, Ward et al. 2013, Veth et al. 2020). Several sites have now been recognised at Murujuga with artefacts in the inter-tidal zone (Dortch et al. 2021, Leach et al. 2021) and other areas are under investigation. These, however, are all low-energy environments and, while there has been debate about the provenance of the artefacts and whether they are in situ, the artefacts themselves have not been seriously questioned. By contrast, the beach at DPLH 10303 is a high-energy environment with the possibility that cobbles and pebbles could be naturally fractured by wave action, particularly during cyclonic storms. It is therefore important to be able to determine with reasonable confidence whether flakes and flaked cobbles found within the intertidal and sub-tidal zones adjacent to DPLH 10303 are the products of human activity or wave action and storm surges on older cobble beaches.

There is little detailed information about the specific effects of wave action on cobble beaches, in terms of creating flaked material resembling artefacts by percussion. The production of flakes and secondary flaking of flake margins by wave action on beaches or in fast-flowing water, imitating the products of human flaking, was described more than a century ago (Boule, 1905; Warren, 1905; Pei, 1936). Flakes could be produced by a large cobble striking against a cobble wedged in place and secondary flaking could be produced by abrasion of the resulting edges through the action of cobbles and pebbles striking against one another in fast-moving water. It should be noted that cobbles and pebbles are quite resistant to mechanical fracture, even in more brittle materials such as obsidian and chert. However, once a fresh scar has been created, it can serve as a platform for further flake removals (Luedtke 1986). Similarly, natural weathering processes and previous percussion points may weaken the integrity of rocks and make them more susceptible to percussion fracture within the intertidal zone.

The mechanical production of large flakes by water action does require quite specific conditions for percussion to occur. Considerable force is required to remove flakes from rounded cobbles, and this is particularly true for granophyre. This force is dissipated under water (Clark 1958) and thus a cobble beach submerged by rising sea level will not be subject to the force required to remove large flakes. Damage to angular edges by tumbling and abrasion by finer particles is more likely; these processes produce flaked edges that could resemble retouch.

A range of attributes have been suggested for distinguishing natural from cultural flaking (Patterson 1983, Luedtke 1986, Peacock 1991, Gillespie et al. 2004, Lubinski et al. 2014). These include:

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[2] Eoliths - Museum of Stone Tools (stonetoolsmuseum.com)

- Flake and core attributes, such as the presence of characteristic features associated with conchoidal fracture (e.g. bulb, éraillure scar, defined platform, and dorsal and ventral surfaces), dorsal scar count, orientation of scars, presence or absence of cortex.
- Post-flaking alteration (e.g. differential weathering or patination, striations)

As noted above, none of the criteria suggested by various studies are definitive by themselves and are applicable to populations rather than individual artefacts. Moreover, the geological and cultural context must be considered carefully – and indeed it is arguable that context is the key to assessment.

Much of the focus of previous studies has been on flakes and fine-grained silicious materials. Studies which focus on volcanic materials and on flaked cobbles are relatively rare (Gillespie et al. 2004, Manninen 2007, Garvey and Mena 2016). This is relevant here as the preponderance of flaked cobbles makes DPLH 10303 a distinctive site, while tough volcanic rocks are characteristic of Murujuga assemblages.

Gillespie et al (2004), in an assessment of claims for culturally flaked cobbles in Late Pleistocene glacial till deposits at two sites in Alberta, Canada, provide a useful methodology for distinguishing between naturally and culturally flaked cobbles. They used samples of culturally flaked cobbles and geofacts derived from glacial till deposits to assess a range of attributes suggested to distinguish humanly flaked cobbles and other artefacts from naturally flaked cobbles. Of the 18 attributes selected, 16 successfully distinguished between the artefact and geofact samples based on a chi-square analysis (Table 5). A scoring system was then devised and applied to the natural, cultural and test samples. Although there was some overlap between the natural and cultural samples, the aggregate scores clearly distinguished between them. The test sample showed more affinity to geofacts than to the known artefacts. Gillespie et al (2004) stress that the method compares an entire assemblage and “cannot be used to test individual cobbles”.

Most of the attributes focus on features commonly thought to be characteristic of human flaking, i.e. focusing on regularity and patterning in technological features. Five attributes relate to post-depositional alteration and are indicative of context and particularly of impact force resulting from high-energy fluvial and colluvial environments. Differential weathering, where scars have very different patination, indicates a substantial time gap between flake removals and thus non-cultural flaking. Two attributes (unidirectional flaking and overlapping retouch forming a patterned edge) did not successfully distinguish between the artefact and geofact samples and were not used in the final analysis.

Although the study did succeed in distinguishing between the geofact and artefact samples, it should be noted that some of the attributes are closely related and thus weight the scoring system. For example, the presence of a marked inverse bulb is likely to be associated with well-defined flake scar borders (arises) as both are indicative of deep scars postulated to be more likely to be the result of human flaking. Number of flake removals is also likely to be related to whether reduction is unifacial or bifacial, as well as the presence of low angle, alternate bifacial flaking.

The investigators acknowledge that some of the attributes involve subjective judgement – ‘logical flaking is an obvious example. However, some of the other attributes are also quite difficult to define in an objective way. For example, the definition of a ‘marked inverse bulb’ and ‘well-defined borders of flake scars’ are open to considerable interpretation and may be susceptible to variation with raw material. Features considered characteristic of conchoidal fracture are well-studied and defined on fine-grained materials such as chert, flint or obsidian, but are commonly much less developed on coarse-grained materials such as quartzite or dolerite.

Some studies appeal to authority by invoking the expertise of the lithic specialist, but there can be considerable disagreement between observers. Garvey and Mena (2016) investigated a disputed assemblage of coarse volcanic rock (CVR) from a rockshelter in Patagonia (Prentiss et al. 2016). They considered several attributes, but also included a blind poll of lithic specialists in their study. They concluded that the overall results showed little support for a cultural origin for the CVR specimens. However, the results also show substantial disagreement among the experts consulted in the number and characteristics of the various attributes observed on individual items.

Table 5. Attributes used in distinguishing natural and cultural flaking on cobbles (Gillespie et al 2004)

Technological attributes	
Platform preparation	Presence of a remnant platform lacking cortex and showing micro-flaking
Uniface/biface	Bifacial reduction considered more characteristic of human manufacture
Inverse bulb	A marked inverse bulb on the core considered more likely in cultural flaking because of the amount of force required to produce a flake
Percentage of cortex	Absence of cortex characteristic of cultural flaking
Scar alignment	Parallel flake scars indicative of cultural flaking – only primary flake scars considered
Secondary retouch	Defined as "presence of additional flake removals from a previously flaked edge of a cobble, usually to create a better working edge or for platform preparation". Crushed or ground edges were not considered secondary retouch
Uniform size of edge flake scars	
Arrises	Well-defined borders of flake scars characteristic of human flaking. This assumes that natural flake removals result in shallow scars, as compared to the deep scars of human flaking.
Low angle, alternate biface flaking	
Logical flaking	A subjective assessment incorporating other attributes
Number of flake removals	Greater in human flaking. This was borne out in the chi-square analysis (mean number of flake removals for natural cobbles 2.7 and for cultural cobbles 12.5)
Post-depositional alteration	
Striations on tools	This postulates that geofacts will be subject to more post-depositional alteration
Striations on flake scars	This must be post-reduction.
Pecking on tools	Small impact scars on cobble surface, which must be post-reduction.
Pecking on flake scars	Small impact scars on flake scars, which must be post-reduction.
Differential weathering	Significant period between flake removals is considered characteristic of natural flaking

Recent studies of submerged artefacts at Cape Bruguieres and Gidley Island, in the north of Murujuga, have demonstrated that artefacts do occur in the intertidal zone. In these cases, the artefacts relate to previous land surfaces inundated by sea-level rise. However, they also occur in low-energy contexts where the artefacts have not been subjected to natural flaking processes characteristic of high energy coastal features (Veth et al. 2020, Dortch et al. 2021, Leach et al. 2021, Ward et al. 2022, Benjamin et al. 2022).

At King Bay North (DPLH 10303) the question is whether any fractured cobbles and pebbles in the intertidal and subtidal zone adjacent to the site are the results of natural or cultural flaking. Geotechnical coring has shown that cobble deposits do occur in the bay and indicate older cobble beach formations submerged by rising sea levels at the end of the last ice age (Coroneos et al. 2022a, 2022b). If there are artefacts in the inter-tidal zone or associated with offshore cobble deposits, then the current manifestation of the site can be regarded as simply the most recent configuration of episodes of exploitation of the broader landform.

The key issues for distinguishing stone artefacts from naturally flaked stone in this study can be summarised as follows:

- Cobble beaches are high energy environments and cyclonic storms could contribute to flaking of artefacts.
- There are numerous natural processes that can produce products that strongly resemble human flaking. In this case, the relevant processes are removal of flakes by percussion as a result of rocks striking against one another, particularly during storm events, and the removal of flakes by pressure due to rocks moving against one another.
- Stone artefacts may also be subject to these processes. This causes wear and abrasion and can obscure key features for identification.
- The raw material is granophyre – a tough relatively coarse-grained volcanic rock. This means that it is relatively difficult to flake compared to fine-grained isotropic materials such as chert. The characteristic features of percussion flaking can also be less developed. However, this also means that it should be relatively resistant to natural flaking.
- At DPLH 10303 there is an undoubted cultural assemblage situated on the top terrace. This terrace is a remnant beach but is not thought to have been subject to wave action since initial human settlement of Australia. By contrast, identifying artefacts on the beach and in the inter-tidal and sub-tidal excavation trenches is problematic because of the possibility that natural processes could cause fractures and that these could be confused with cultural stone-working.
- The cultural assemblage from DPLH 10303 provides a baseline against which samples of fractured cobbles and pebbles from the inter-tidal and sub-tidal excavations can be compared.

The analysis therefore involved two stages:

1. Description of DPLH 10303 and characterisation of the cultural assemblage
2. Comparative attribute analysis of samples from DPLH 10303 (Site) and samples of fractured lithic material from the intertidal trench (IT01) and the subtidal trench (ST01)

The primary objectives were to determine how the material from the IT01 and ST01 compared with the known cultural assemblage and assess the probability that the samples from IT01 and ST01 included cultural material.

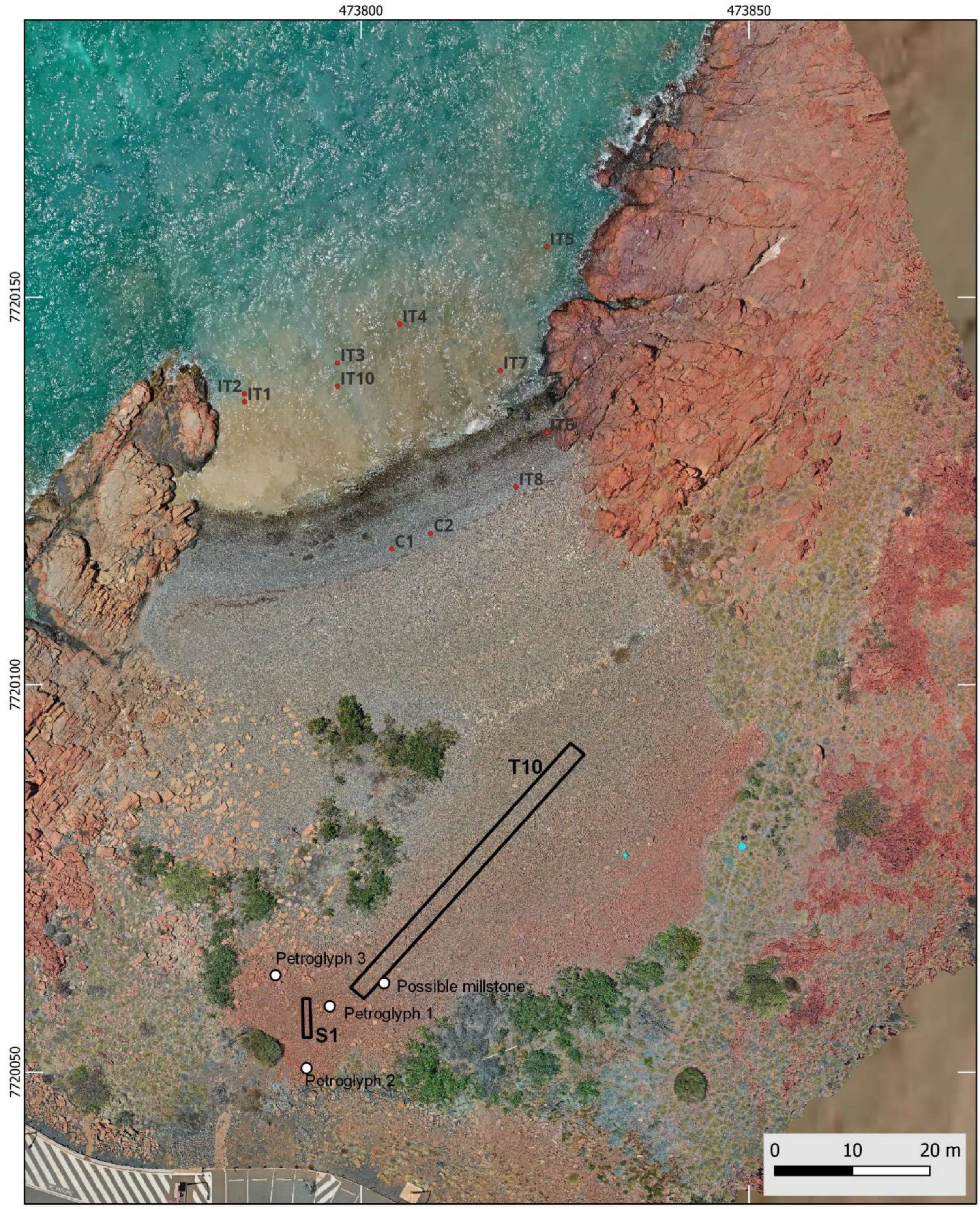

Figure 3. DPLH 10303 site plan, showing registered boundary, transects, recorded features and isolated fractured cobbles.

SECTION THREE – METHODS

Cultural material was recorded within two transects within the recorded boundary of DPLH 10303 (Figure 3). The first (T10) was a two-metre wide transect laid out roughly parallel to the shoreline and extending for 44 m. This transect included the full range of artefact density on the upper terrace. A second 5 x 1 m transect (S1) sampled the densest portion of the artefact scatter in the south-west part of the site. All flaked stone artefacts within the sampled areas were recorded in detail.

It was originally planned that similar transects would be recorded in detail on the beach and in the inter-tidal zone. However, field inspection showed that the intertidal zone and the beach terraces were dominated by rounded pebbles and cobbles and the quantity of fractured material was very sparse. As time was limited, transects in the intertidal zone were systematically walked and any flaked specimens were recorded as isolated 'artefacts'.

All the material recovered from the intertidal excavation and the two subtidal trenches was inspected and a sample of fractured cobbles and pebbles was recorded in more detail. This included larger cobbles placed by the divers in the rock cage or the material retained in the sieve. The material recovered included unbroken rounded pebbles and cobbles, rounded pebbles and cobbles with one heavily weathered flake scar, split pebbles and cobbles some of which had weathered edge-battering, pebbles and cobbles with more than one negative flake scar, angular fragments, thermal blocks with facets clearly resulting from thermal fracture, thermal fragments probably exfoliated from a thermal block, and some ambiguous pieces with flake-like characteristics. These categories were not clearly discrete; there was considerable overlap, largely as a result of differential weathering. The overwhelmingly majority of material recovered, particularly from the inter-tidal trench, comprised unbroken rounded pebbles and cobbles or rounded pebbles and cobbles with one or two very heavily weathered old negative flake scars.

As far as practical, fractured cobbles, pebbles and angular pieces were recovered for more detailed recording from IT01 and ST01. Although some specimens were collected for reference purposes, ST02 was not systematically sampled. The more comprehensive sample from ST01 was considered to represent adequately the range of variation from the subtidal excavation. The reference sample from ST02 was not included in the analysis. The analysed samples IT01 and ST01 have limitations because of the very weathered nature of much of the material. Generally, selection focused on angular pieces, some of which had facets that were consistent with exfoliation due to thermal fracture, and mechanically fractured cobbles and pebbles that were less weathered and had at least one discrete fracture surface or flake scar. Every effort was made not to select specimens that 'looked like' possible artefacts, but to collect the full range of fracture types evident in the sample.

Grab samples were taken of cobbles and pebbles from the sieve. These were retained for reference and have not been recorded in detail.

All material recorded from the site assemblage and the inter-tidal and sub-tidal samples was divided into the categories nuclei and flakes, following Cotterell and Kamminga (1987, p. 676). A nucleus is 'any object from which a flake is detached', while a flake is 'any fragment detached from a nucleus'. Nuclei from the cultural assemblage were further categorised as follows:

- Unifacial cobble – cobble with unifacially flaked edge
- Bifacial cobble – cobble with bifacially flaked edge
- Single platform core – core with flaking from one platform

- Multiplatform core – core with flaking from two or more platforms

Nuclei from the inter-tidal and sub-tidal samples were classified as follows, with the corresponding cultural categories indicated:

- Flaked nucleus – pebble or cobble with at least one negative flake scar that is relatively unweathered – includes unifacial and bifacial cobbles and single platform cores.
- Edge-battered nucleus – pebble or cobble with battering around the edge in the form of a series of small negative flake scars.
- Split nucleus – pebble or cobble which has been split; it may show additional battering or flaking but is primarily characterised by an impact point which has split the nucleus roughly at right angles.
- Angular nucleus – block with angular edges and flat facets that show no clear impact points – most resembles multiplatform cores.
- Thermal nucleus – block with facets resulting from thermal fracture.

The flakes from the site were classified as complete flakes or flake fragments. These all showed characteristic features of conchoidal fracture. Flake fragments were recorded if they showed evidence of an impact point, platform, termination, or any feature indicating an interior flake surface.

Flakes from the inter-tidal and sub-tidal excavations were classified using the following categories:

- Angular fragment – broken piece with angular edges which resembles a flake – equivalent to flakes
- Thermal fragment – flake-like fragment which resembles an exfoliated piece from a thermal block
- Other – ambiguous flake-like pieces – equivalent to flake fragments.

Two additional categories of artefact were recorded at DPLH 10303 – large, retouched flake and retouched/utilised. There was only one retouched/ utilised piece recorded – a worked notch. The large, retouched flakes were large cortical flakes with secondary flaking around part of the margin. These were all weathered and patinated and it is possible these are large natural thermal flakes with edge damage produced by trampling. These were not included in the comparative analysis because of their ambiguous status.

Thermal flakes and nuclei were not recorded on the site as in that context they were generally non-cultural, although the uncertain status of some of the large secondarily flaked pieces should be noted. This indicates some of the practical difficulties of deciding whether particular specimens of flaked stone are considered cultural.

The following attributes were recorded:

- Material: fine-grained granophyre, coarse-grained granophyre, porphyritic granophyre, other.
- Dimensions (mm): Length, width, thickness
- Percentage of cortex (on core surface or dorsal surface of flake): 0, <50%, >50%, 100%
- Platform type (flakes only): cortical, plain, facetted, focal, crushed, missing, other
- Platform width, thickness (mm) (flakes only)

- Termination (flakes only): feather, hinge, step, axial, overshot, missing, other
- Length of longest flake scar (nuclei only)
- Number of flake scars >10mm (nuclei only)
- Length of worked edge (nuclei only)
- Weathering: none, low, moderate, high
- Differential patination: present, absent.

These attributes were chosen because it was considered they could be recorded in the field with acceptable consistency. Several of them are comparable to attributes applied to the cobbles investigated by Gillespie et al (2004) and which successfully distinguished between artefacts and geofacts. Flaked cobbles are also a primary focus of this project as these are a key element of the sample from DPLH 10303.

The attributes that specifically relate to criteria that have been commonly suggested as important in distinguishing between natural and cultural flaking are:

- Percentage of cortex – geofacts are likely to retain more cortex.
- Length of longest flake scar – artefacts are likely to have larger flake scars.
- Number of flake scars >10mm – artefacts are likely to have more large flake scars.
- Length of worked edge – artefacts are likely to have longer continuously worked edges.
- Differential patination – this is a commonly cited criterion as it indicates removal of flakes at very different times; it is considered that multiple flake removals are more likely to occur on artefacts at the same time (Oakley 1975).

No attempt was made to directly follow Gillespie et al (2004) in attempting to judge attributes like flaking regularity, scar alignment or 'logical flaking'. These are somewhat subjective and difficult to apply consistently in the field; the number and size of flake scars, and length of worked edge provide similar information about what is essentially extent and degree of flaking. The attributes in the Alberta study that related to post-depositional alteration were also omitted as they are specific to the local geological context. Instead, amount of weathering was recorded.

It should be noted that flake attributes (platform type, platform size, termination) often could not be recorded with confidence on flakes from the inter-tidal and sub-tidal sample. Some flakes were too weathered. In other cases, the coarse-grained raw material meant that flake attributes were poorly developed.

All specimens were photographed for record purposes.

SECTION FOUR – RESULTS

DPLH 10303

The primary aim of the current survey was to record a sample of artefacts from within the registered site boundary to characterise the cultural assemblage associated with the upper terrace. This sample would then serve as a baseline for comparison with fractured stone collected from excavations within the intertidal zone and from offshore cobble deposits.

This survey should not be regarded as a comprehensive review or re-recording of DPLH 10303.

ASSEMBLAGE DESCRIPTION

Ninety artefacts were recorded in detail at 10303. Most of the artefacts are granophyre (Table 6). The local granophyre is a tough volcanic rock which ranges from very fine to coarse-grained and can also have porphyritic inclusions. The recorded assemblage is mostly porphyritic granophyre (60%) with 26% coarse-grained and 12% fine-grained. Two artefacts are granite. This differs from the assemblage as recorded by Green and Marwick, who state that 97% of the artefacts were fine-grained black granophyre (Green and Marwick 2002, p. 112). This discrepancy may be partly explained by the fact that much of the porphyritic granophyre is relatively fine-grained apart from the porphyritic inclusions.

Flakes and flake fragments comprise 40% of the assemblage, while single and multiplatform cores comprise 19%. Unifacially and bifacially flaked cobbles are a prominent feature of the assemblage (37%) (Figure 4 to Figure 7). One retouched/utilised flake was recorded; this was a large cortical flake with a worked notch (Figure 8).

Table 6. DPLH 10303 - assemblage composition

Type	Fine-grained granophyre	Porphyritic granophyre	Coarse-grained granophyre	Granite	Total
Flake	2	18	9	0	29
Flake fragment	0	5	2	0	7
Single platform core	0	6	3	1	10
Multiplatform core	1	6	0	0	7
Unifacial cobble	3	15	34	0	22
Bifacial cobble	4	3	4	0	11
Large, retouched flake	1	1	0	1	3
Retouched/utilised	0	0	1	0	1
Total	11	54	23	2	90

Figure 4. Unifacially flaked cobble (T10/18)

Figure 5. Bifacially flaked cobble (T10/24)

Figure 6. Single platform core (S1/78)

Figure 7. Multiplatform core (T10/38)

Figure 8. Large cortical flake with worked notch (T10/05)

Artefact density averaged 0.98/m^2 across the site, ranging from 0.25 to 4.2/m^2 (Figure 9). This is slightly higher than Marwick and Green's estimate. The densest area was in the south-west portion of the site.

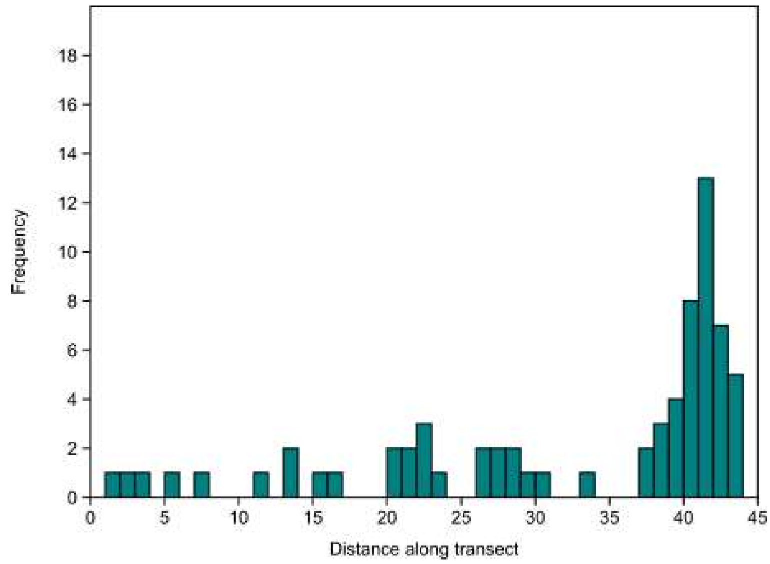

Figure 9. Artefact density along transect T10 (NE-SW)

WEATHERING AND PATINATION

Much of the cultural material (92%) appears relatively fresh and unweathered. However, there are some quite heavily weathered artefacts, and several weathered and flaked cobbles were noted, where it was unclear whether these were naturally flaked cobbles or the flaking was the result of past human activity. Since the primary aim of recording the assemblage at DPLH 10303 was to characterise a known cultural assemblage for comparison with material recovered from the intertidal and subtidal excavations, these were not recorded in detail due to time constraints. However, there is evidence of differential patination and weathering on individual artefacts, indicating that flaking occurred at different times with a considerable interval between flaking events (Figure 10).

Figure 10. Bifacially flaked cobble with differentially patinated flake scars (S1/82)

Also recorded on the site were three large cortical flakes with unifacial flaking around part of the margin (Figure 11). These do not fall clearly into any documented tool category and there was uncertainty as to whether these were the product of deliberate human flaking or edge-damage from trampling by people or animals. Some of the large flakes have evidence of a PFA (point of force application) indicating they were struck from a large cobble or boulder, but others may be thermal flakes as the PFA is either absent or has been removed by edge flaking. All these artefacts are very weathered. It is likely that these differences in weathering indicate that DPLH 10303 has been used over a long period of time.

Most of the cultural material is derived from the upper terrace and the flaked cobbles show the same reddish colouration on their cortical surfaces. However, there are also a few flaked cobbles which are lighter in colour. These must have been brought up from the terraces or beach below (Figure 12).

Figure 11. Large weathered flake with flaking around margins. Top: T10/02. Bottom: T10/07, dorsal (left) and ventral (right) surfaces

Figure 12. Unpatinated flaked cobble, probably brought up from the beach and flaked on site

OTHER CULTURAL FEATURES

Green and Marwick (2002) recorded 34 grindstones. No evidence of these was found in this survey and only one possible millstone was recorded (Figure 13). It seems likely that the 'grindstones' were in fact water-worn boulders, which are found across the terraces and the beach. They also recorded two petroglyphs. These were re-identified and a third petroglyph was also noted (Figure 14 to Figure 16).

Figure 13. Possible millstone

Figure 14. Petroglyph panel 1

Figure 15. Petroglyph panel 2

Figure 16. Petroglyph panel 3

DISCUSSION

There have been very few systematic studies of stone artefact scatters on Murujuga, where the rich rock art has attracted most research interest. As noted by previous surveys, the DPLH 10303 artefact scatter is unusual in the proportion of unifacially and bifacially flaked cobbles and the relative scarcity of flakes. This reflects the fact that the cobble terrace at DPLH 10303 has been used as a quarry. Cobbles have been tested here; they may have been further flaked and the most usable flakes removed for use elsewhere or suitable cobbles themselves may have been taken away as cores.

Less than a kilometre away to the south, cobbles were brought up to the now-destroyed Phillip Point Stone Arrangement (DPLH 9878) for flaking (JW Rhoads and C Bird, pers comm). Core tools also occur in the lower levels of the Skew Valley Midden; these resemble some of the flaked cobbles at DPLH 10303 and the drawings suggest they retain cortex, but it is not clear if these are made on waterworn cobbles (Lorblanchet and Jones 2018).

BEACH AND INTERTIDAL ZONE PEDESTRIAN SURVEY – ISOLATED SURFACE FLAKED STONE

Fractured cobbles and pebbles were rare on the lower terraces and intertidal zone (Figure 17, Figure 18). Those that were present were in varying stages of abrasion. Most were heavily worn and had only one or two flake scars. A few showed edge damage (Figure 21, IT1, IT7), probably from rolling in the surf.

A commonly used criterion for distinguishing geofacts from artefacts is differential patination or weathering. Figure 19 shows a very weathered cobble with three very weathered remnant flake scars and a fourth very fresh and obviously recent flake scar.

Figure 17. General view of the intertidal zone, showing well-rounded cobbles and the location of the intertidal trench

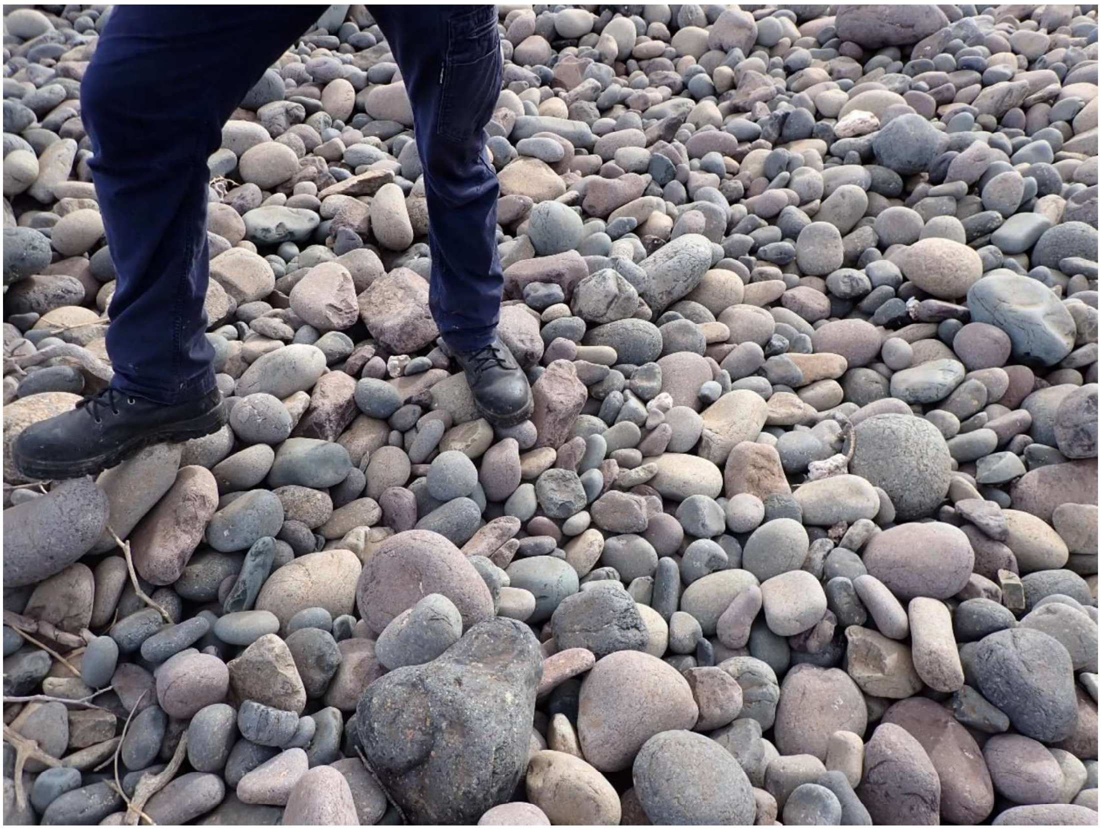

Figure 18. Overview of rounded cobbles on the second beach terrace

Figure 19. Flaked cobble from beach (B/119), showing (left) recent flake scar super-imposed on old flake scar and (right) older flake scars at right angles to the more recent flake scar.

Eleven pieces of fractured stone were individually recorded during the pedestrian survey (Figure 21). None of these were considered likely to be cultural as they were all within the influence of wave action. Several large flakes with classic features of percussion fracture were noted in various states of wear and abrasion (e.g. IT1, IT2). One large fresh flake was noted – most probably the result of a recent cyclone (C2) (Figure 20). At least one cobble with a single large flake removed was observed (IT6).

Table 7. Flaked stone recorded on beach and in intertidal zone.

#	mE	mN	Notes
IT1	473786	7720138	Flat angular granophyre pebble. Looks flake-like with worn edge wear. Likely not artefactual.
IT2	473786	7720139	Large course granophyre, flake-like. Biota present. Likely not artefactual.
IT3	473798	7720143	Flat granophyre pebble, possible point of percussion at one end, close to low tide mark in intertidal zone, not likely artefactual.
IT4	473806	7720148	Angular piece of granophyre, 2 possible flake scars, close to low tide mark in intertidal zone, not likely artefactual.
IT5	473825	7720158	Split granophyre cobble with angular edges, not likely artefactual.
IT6	473825	7720134	Large round granophyre cobble with a flake scar, 100mm x 140mm (flake scar)
IT7	473819	7720142	Large split granophyre cobble with 'worked' edge, not likely artefactual.
IT8	473821	7720127	Small flake-like granophyre pebble. Likely not artefactual.
IT9	473821	7720127	Small flake-like granophyre pebble. Likely not artefactual.
IT10	473798	7720140	Large, elongate fine-grained granophyre pebble, 2 flake scars (superimposed), possibly artefactual, found buried inside the excavation square and replaced (later recovered during underwater excavation and salvaged).
C1	473805	7720119	Broken granophyre cobble
C2	473810	7720121	Small granophyre split cobble

Figure 20. Large flake with fresh unweathered margins, probably produced in a recent cyclone

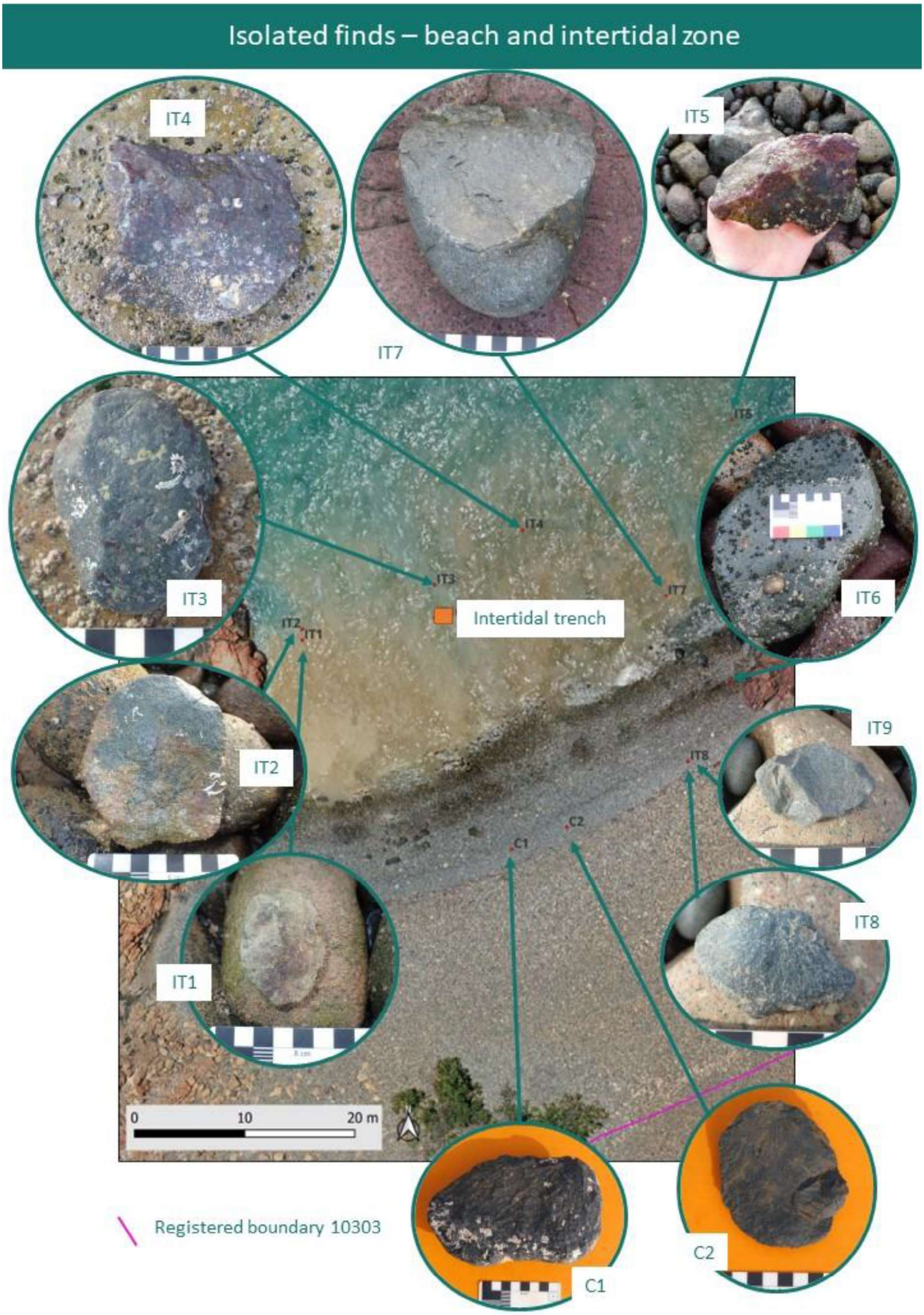

Figure 21. Beach and intertidal zone - individually recorded flaked stone specimens.

COMPARATIVE ANALYSIS

The cultural sample from the site, DPLH 10303, provides a baseline comparison with the excavated samples from the intertidal (IT01) and subtidal (ST01) excavation trenches. This analysis first compares individual attributes recorded for both IT01 and ST01 samples with the known cultural sample from the site. A multivariate analysis for the nuclei summarises the individual results.

The discussion of each attribute focuses mainly on the nuclei. These are the most directly comparable elements of each assemblage and there are more individual attributes for comparison.

RAW MATERIAL

Most (98%) specimens in all three samples were local granophyre and included coarse-grained (CG), fine-grained (FG) and porphyritic (PG) types. Four granite specimens were recorded and one fragment of unknown very decayed material from ST01.

ST01 is mainly coarse-grained granophyre, while porphyritic granophyre is dominant in the cultural assemblage from 10303 (Table 8, Figure 22). There is no significant difference between site 10303 and IT01 samples (chi-square 3.361, df 3, p=0.3391), but ST01 does differ significantly from IT01 (chi-square=17.596, df=3, p<0.01) and 10303 (chi-square= 34.84, df=3, p<0.01).

Table 8. Raw material distribution by sample. (Chi-square 38.49, df=6, p <0.001)

		Site	IT01	ST01	Total
Coarse-grained granophyre	N	23	18	43	84
	%	26	35	73	
Fine-grained granophyre	N	11	9	6	26
	%	12	17	10	
Porphyritic granophyre	N	54	23	10	87
	%	60	44	17	
Granite	N	2	2	0	4
	%	2	4	0	
Total		90	52	59	201

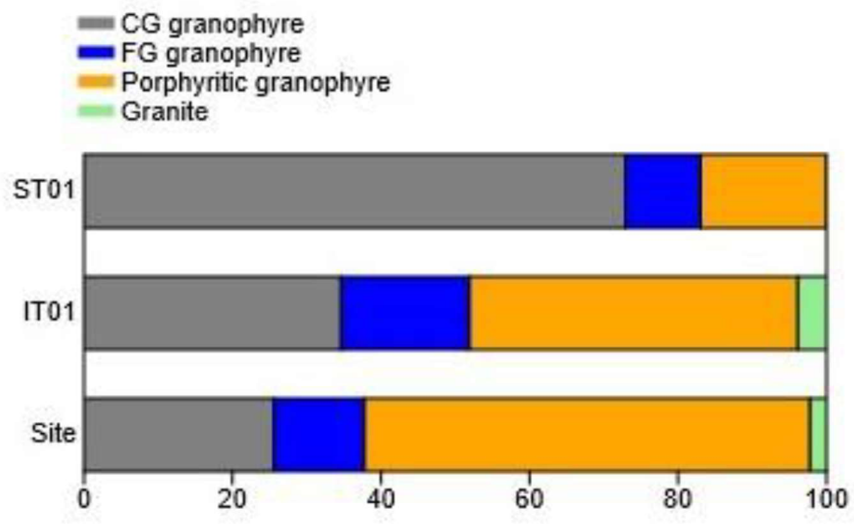

Figure 22. Raw materials by sample

ASSEMBLAGE COMPOSITION

Table 9 summarises the different categories of flaked stone for all three samples. These are not directly comparable between the site and IT01 and ST01 samples because the cultural assemblage has been described above using conventional archaeological classifications. In the methods section, neutral categories were proposed to characterise the intertidal and subtidal samples. In Table 9, the sample from the site has been recoded into neutral categories. Unifacial and bifacial cobbles and single platform cores are recoded as flaked nuclei, while multiplatform cores most resemble the category angular nucleus. Flakes and flake fragments have been similarly recoded as angular fragments and other.

In all three samples more than half are nuclei. For the site this is an atypical sample. In most cultural assemblages, flakes are very common, and nuclei (cores) and tools are rare. The unusual characteristics of the cultural sample in this case can be explained by the fact that the cobble terrace has been used as a quarry and that the raw material is in the form of cobbles rather than bedrock outcrops. Flakes could have been removed for use elsewhere. It is also possible that flakes could slip between the gaps in the cobbles and are thus less visible on the surface.

The ratio of flakes to nuclei is similar for all three assemblages, with more nuclei than flakes in all three samples. The intertidal sample has fewer flakes than the other two (Table 9).

All three samples differ in the types of nuclei present. Split nuclei, edge-battered nuclei and thermal nuclei are absent from the site. The site sample consists of flaked cobbles in varies stages of reduction with some angular nuclei (multiplatform cores). Thermal nuclei were clearly recognisable on the site as non-cultural and were thus not recorded. They were however, recorded in the underwater samples as part of the sample of fractured rocks. Thermal and angular nuclei are completely absent from IT01. This suggests that the sample from ST01 has been subject to less rolling and abrasion than IT01.

IT01 also has a higher proportion of split nuclei. These are pebbles or cobbles that have been split by wedging in a natural bipolar fracture rather than a conventional percussion or bending fracture (Cotterell and Kamminga 1987). This technique is used by humans, and involves applying force from immediately above the nucleus, which is held on an anvil. It is particularly used for working small pebbles or pieces of raw material, or for splitting larger cobbles or blocks to create a suitable striking platform. It is uncommon in areas like Murujuga where suitable stone for flaking is abundant and widely available. It does not occur in the cultural assemblage from the site. Many of the split cobbles from IT01 and ST01 have not been flaked further, except sometimes for some edge battering, and the flaked surface is characteristically at right angles to the rest of the cobble. Such fractures could occur naturally if a suitably wedged cobble is struck a perpendicular blow by a sufficiently heavy cobble.

The presence of clearly thermal flakes in ST01 is consistent with the thermal nuclei in that sample. There are no thermal flakes in IT01. Again, thermal flakes were not recorded on the site, as in that context they were clearly not cultural (see discussion in section on methods). Flakes from the site were only recorded if they had clearly developed features of percussion fractures. Weathering and abrasion, particularly in coarse-grained materials, made recognition of these features much more difficult in the underwater samples.

Table 9. Assemblage composition

	Site		IT01		ST01		Total
	N	%	N	%	N	%	
Nuclei							
Flaked nucleus	43	86	9	28	8	24	60
Split nucleus	0	0	21	66	9	27	30
Edge-battered nucleus	0	0	2	6	1	3	3
Angular nucleus	7	14	0	0	8	24	15
Thermal nucleus	0	0	0	0	7	21	7
Nuclei total	**50**		**32**		**33**		**115**
Flakes							
Uncertain	3	8	0	0	0	0	3
Retouched/utilised	1	3	0	0	0	0	1
Angular fragment	29	73	20	100	13	48	62
Thermal fragment	0	0	0	0	10	37	10
Other	7	18	0	0	4	15	11
Flakes total	**40**		**20**		**27**		**87**
Total	**90**		**52**		**60**		**202**
Ratio - Flake:nuclei	**0.8**		**0.6**		**0.8**		

SIZE

There are some size differences between the samples for both flakes and nuclei (**Error! Reference source not found.**). Generally, the intertidal fractured material was smaller than both that from the Site and ST01. This may reflect greater weathering on the intertidal sample. The nuclei from the site had a narrower size range than the other two samples. The nuclei from the intertidal and subtidal samples both included fractured coarse pebbles (size range 32-64 mm), while the cores from the site were almost exclusively cobbles (size range 64-256 mm) (Table 10). These differences are statistically significant and suggest that the cultural sample involves selection for suitably sized cobbles.

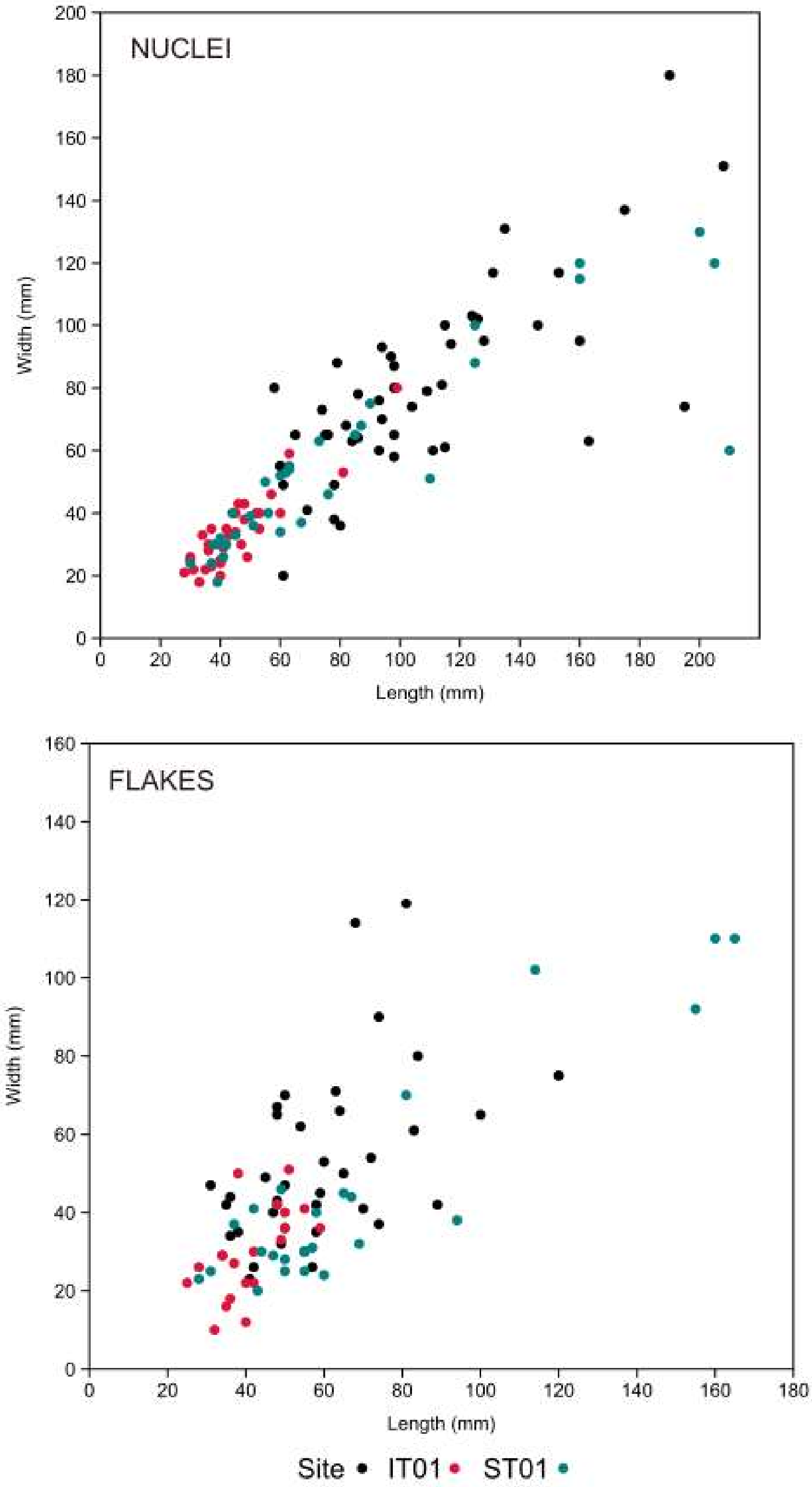

Figure 23. Length and width for nuclei and flakes for all samples.

Table 10. Size classes for nuclei

Sample	Mean length (mm)	SD	Range
Site	107	37	58-208
IT01	46	15	28-99
ST01	81	52	30-210

WEATHERING

Weathering was recorded on a scale of 0 to 3, with 3 the most heavily weathered category. This was difficult to apply consistently. However, Table 11 and Figure 24 show that the cultural material from the site is mostly relatively fresh and unweathered, while the intertidal and subtidal material is mostly heavily rolled and abraded, particularly IT01 (chi-square=201.34, df=6, p<0.001). ST01 has some relatively unweathered angular blocks, and thermally fractured blocks and some thermal flakes so is a bit more diverse. The nuclei and flakes alone each show a similar pattern.

Table 11. Weathering state - all flaked material.

	0	1	2	3	Total
			All		
Site	83	3	3	1	90
IT01	0	4	24	24	52
ST01	8	30	15	7	60
Total	91	37	42	32	202
			NUCLEI only		
Site	47	1	1	1	50
IT01	0	3	14	15	32
ST01	7	12	7	7	33
Total	54	16	22	23	115
			FLAKES only		
Site	35	1	0	0	36
IT01	0	1	10	9	20
ST01	1	18	8	0	27
Total	36	20	18	9	83

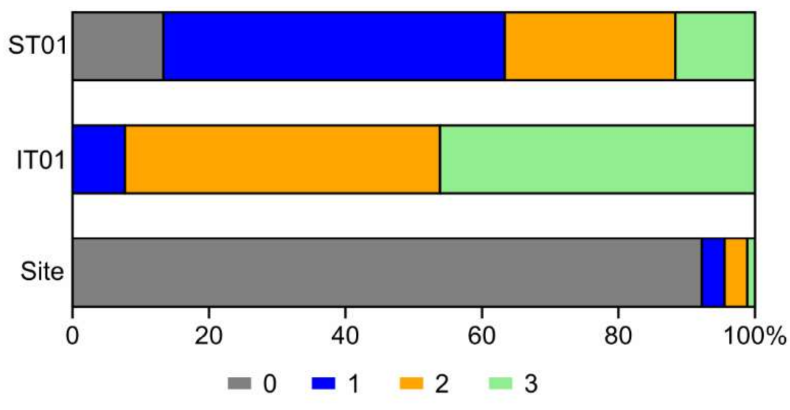

Figure 24. Weathering state – all flaked material

Although most of the cultural assemblage recorded from 10303 was relatively fresh and unweathered in appearance, as noted above (p. 30), there were also some ambiguous pieces, which were relatively heavily weathered (Figure 11).

DIFFERENTIAL PATINATION

The presence of scars removed at different times as evidenced by differential patination is a feature commonly considered to indicate non-cultural flaking (Barnes 1939b, Oakley 1975, Gillespie et al. 2004). These were quite rare in all three samples, but most occurred in the cultural sample from the site, where 8% of artefacts showed evidence of differential patination (Figure 10). This can be accounted for using 10303 as a quarry, where suitable cobbles might be flaked on different occasions. There are other sites on Murujuga where discarded cores or flakes evidently formed a convenient resource and two or more episodes of flaking separated by some considerable time can be seen on the same artefact (CB, personal observation). Some of the minimally flaked cobbles at 10303 can be interpreted as testing to determine the quality of the material. It is conceivable that using a cobble that has already been tested might be more attractive to a later visitor than testing new cobbles. Therefore, it seems that this attribute is not useful for distinguishing cultural from natural flaking in this context.

PERCENTAGE OF CORTEX

Gillespie et al (2004) identify percentage of cortex as a possible distinguishing feature between geofacts and artefacts. Their approach was conservative, only assigning a positive score if no cortex was present. In this case cortex was common and its use as a distinguishing feature for distinguishing between natural and cultural flaking was limited.

10303 is a quarry and the percentage of cortex on all artefacts is relatively high. Usable flakes and suitable cores could have been taken elsewhere. Flakes are commonly cortical and result from the early stages of reduction. Testing of cobbles was probably important at the site and this means that rejected cobbles retaining a substantial amount of cortex and cortical test flakes are common. There is a substantial component of the sample from ST01 that is non-cortical as there are thermal and angular blocks, particularly from the deeper levels, that are presumably derived from weathered bedrock rather than subtidal ancient cobble beach deposits.

Table 12. Percentage of cortex

	No cortex	<50%	>50%	100%	Total
Site	6	31	52	1	90
IT01	6	2	36	8	52
ST01	29	4	25	2	60
Total	41	37	113	11	202
			NUCLEI only		
Site	0	14	34	0	48
IT01	0	0	26	6	32
ST01	17	2	12	2	33
Total	17	16	72	8	113
			FLAKES only		
Site	6	17	18	1	42
IT01	6	2	10	2	20
ST01	12	2	13	0	27
Total	24	21	41	3	89

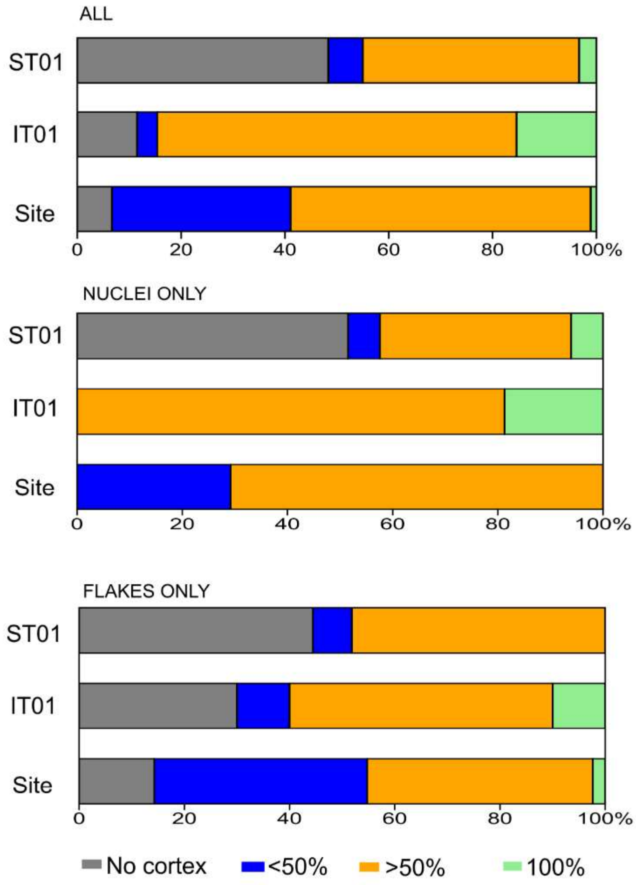

Figure 25. Percentage of cortex

NUMBER OF FLAKE SCARS >10MM

Gillespie et al (2004) hypothesised that more flake removals would characterise human flaking and suggested five flake removals as the cut-off for differentiation. They found that 2.7 was the mean number of flake removals on natural cobbles as compared to 12.7 on artefactual cobbles. The size limit was chosen here because the aim of human flaking is usually to produce large flakes for use or retouch. Even a discarded or exhausted core is likely to have evidence of one or more larger flakes. By contrast many non-cultural fractured nuclei have only numerous small flakes resulting from random impacts or edge-battering. Considerable force is required to remove sizable flakes from granophyre cobbles in a systematic fashion. This also means that incidental edge damage on artefacts in the cultural sample from trampling by people or animals or possibly from use can be excluded.

Relatively few nuclei from IT01 and ST01 have flake scars more than 10 mm long; a high proportion have no large scars. By contrast the cores from 10303 all have at least one scar >10 mm long and up to four is common (Table 13, Figure 26). The relatively low means compared to the Alberta study reflects the conservative size limit chosen here (Gillespie et al. 2004).

Table 13. Number of flake scars >10 mm

	0	1	2	3	4	5	6	7	8	Total	Mean
Site	0	6	16	12	10	1	0	2	1	48	2.9
IT01	13	9	7	3	0	0	0	0	0	32	1.0
ST01	27	4	2	0	0	0	0	0	0	33	0.2
Total	40	19	25	15	10	1	0	2	1	113	

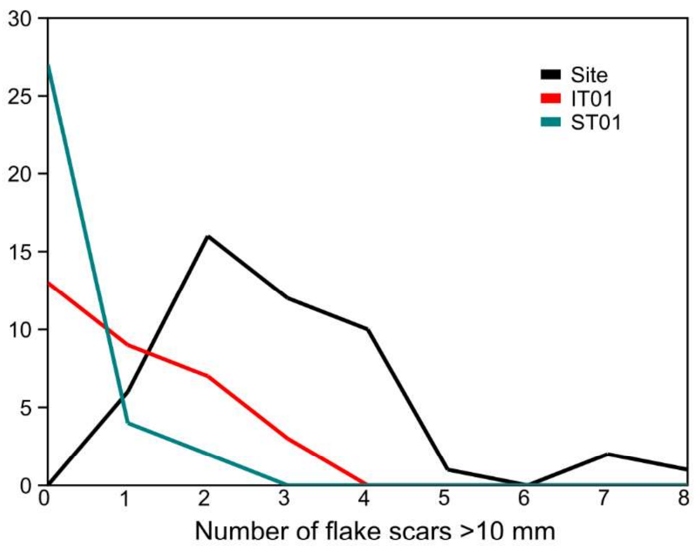

Figure 26. Nuclei only - number of flake scars >10 mm

LENGTH OF FLAKED EDGE

The length of the flaked edge was recorded on the assumption that longer continuous edges would be expected to occur because of human flaking than from natural processes. There was some difficulty in recording this as it was difficult to define what constituted a 'flaked edge' particularly for the samples from IT01 and ST01, or where a single relatively large flake scar intersected the margin of a cobble. Measurements were thus cautious, with generous margins. The results showed that nuclei from the cultural sample from 10303 had significantly longer continuous flaked edges than those from the marine samples.

Table 14. Length of flaked edge (mm)

Sample	N	Mean (mm)	SD	Range
Site	42	65.7	27.9	11-130
IT01	19	30.0	10.1	15-50
ST01	5	39.0	25.9	15-80

LENGTH OF LONGEST FLAKE SCAR

Like the count of flake scars >10 mm, this was recorded on the assumption that the aim of cultural flaking on cores is normally to produce usable large flakes, while natural flaking can be expected to be unsystematic. One unifacially flaked cobble was omitted from the sample from 10303 as the measurement was clearly incorrectly recorded. A flaked nucleus from ST01 was also omitted as it was a single anomalously large flake scar.

Table 15. Length of longest flake scar (mm)

Sample	N	Mean (mm)	SD	Range
Site	47	34.1	15.4	10-65
IT01	19	22.3	8.0	12-43
ST01	5	28.6	27.6	12-77

DISCUSSION

The cultural assemblage from DPLH 10303 can be distinguished from both ST01 and IT01 based on the following attributes:

- Number of flake scars>10 mm
- Length of flaked edge
- Length of longest flake scar.

This is consistent with the Alberta study, which found degree and regularity of flaking was important in distinguishing geofacts from artefacts (Gillespie et al. 2004).

The cultural sample is also distinguished by its relative freshness and lack of weathering, although there are some older more weathered and patinated artefacts. It shows some evidence of size selection in the choice of cobbles to flake and selection by raw material in a preference for fine-grained or porphyritic granophyre.

A multivariate analysis on the nuclei was carried out using discriminant analysis (Hammer et al. 2001, Hammer 2021, pp. 113–114). This distinguished the three samples, albeit with some overlap. IT01 can be interpreted as a subset of ST01; this largely reflects the differences in weathering between the two samples. Both are distinct from the sample from the site.

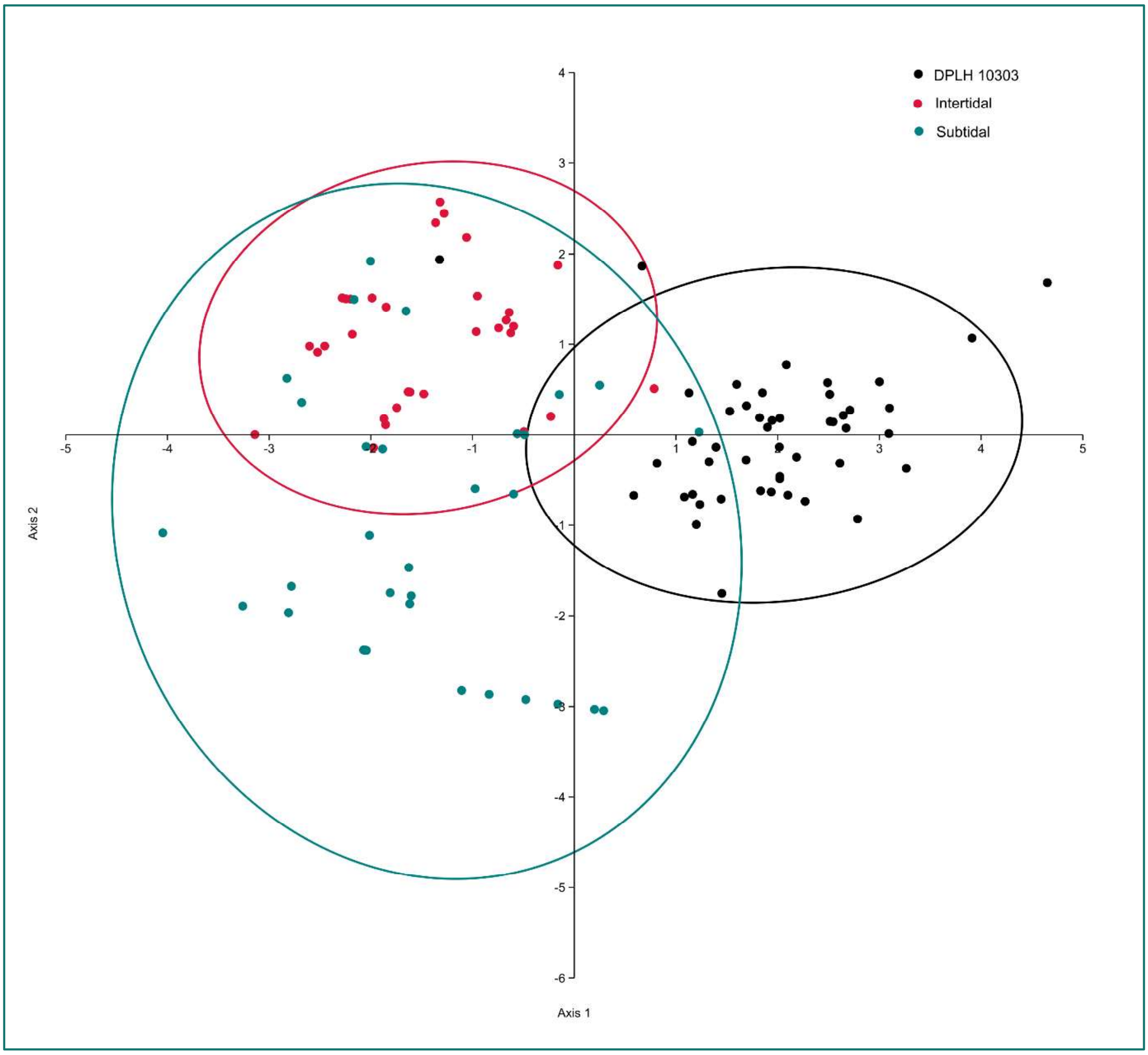

Figure 27. Discriminant analysis of nuclei

As discussed above (Section Two), the problem is best considered at the assemblage level, and it is rarely possible to be definitive about individual artefacts. As an assemblage, then, it can be concluded that the subtidal and intertidal samples comprise fractured cobbles that are the result of natural flaking processes operating in the storm beach environment, rather than cultural flaking. Any natural flaking within the subtidal sample must have occurred during the period when the cobble matrix formed part of a beach. Once completely submerged, further flaking by percussion is no longer possible as the necessary force is dissipated by the water. However, rolling and abrasion by finer particles can still occur.

There is, however, an overlap between the samples. Certainly, there were specimens in both the intertidal and subtidal samples that would probably have been recorded as artefacts had they been found in an undoubted cultural context. Similarly, there were artefacts recorded on the site that were very similar to specimens from ST01 and IT01 and might not have been considered artefacts had they been found on the present beach. This particularly applied to cobbles that, while clearly flaked, had relatively few flake scars and probably resulted from cobble testing. As previously discussed (p. 30ff), there were some ambiguous abraded and patinated artefacts on the site. There are also patinated cobbles on the third terrace, with remnants of old flake scars interpreted as natural flaking from when that terrace was last an active storm beach, prior to human occupation. Unfortunately, the short field time available for recording on the site meant there was limited opportunity to address the full range of flaking processes likely to have affected all three assemblages.

It remains possible that some of the specimens recorded in the subtidal and intertidal samples are artefacts. The best example is a fine-grained flaked cobble recovered from the intertidal excavation below the surface layer of cobbles (Figure 28). This object has two relatively unweathered and superimposed flake scars. The platform from which they were struck has been formed by two older, weathered flake scars, which have created a suitable angle for further flaking. In the discriminant analysis, this nucleus falls comfortably within the overlap between the samples and within the cultural sample. Flaked cobbles similar in appearance can be identified on the site, where they are considered artefacts; however, a very weathered cobble with a similar sequence of flaking events was found on the beach, where it was considered most probably natural.

Figure 28. Fine-grained flaked cobble (IT01/111) from the intertidal trench, showing two successive flake scars

It is of course possible that a complex mix of natural and cultural flaking has operated on the beach terraces over many thousands of years. Such a mix is difficult to tease apart with complete confidence. So, artefacts on the beach and in the intertidal zone could have been initially flaked by people – perhaps cobble testing – and then subject to further flaking by natural processes. Alternatively, cobbles from the beach with one or two flakes removed by storm action could have been collected and further flaked by people. Similarly, large flakes can be produced by storm action, as shown by the recent fresh flake collected from the beach discussed above (Figure 20). These large flakes could then be collected and further modified by people. This perhaps accounts for some of the large, modified flakes in varying states of weathering and patination. Distinguishing with confidence between natural and cultural flaking under these circumstances is extremely difficult. Figure 29 shows a range of examples of large flakes recorded from the beach terraces and intertidal zone to illustrate the difficulty.

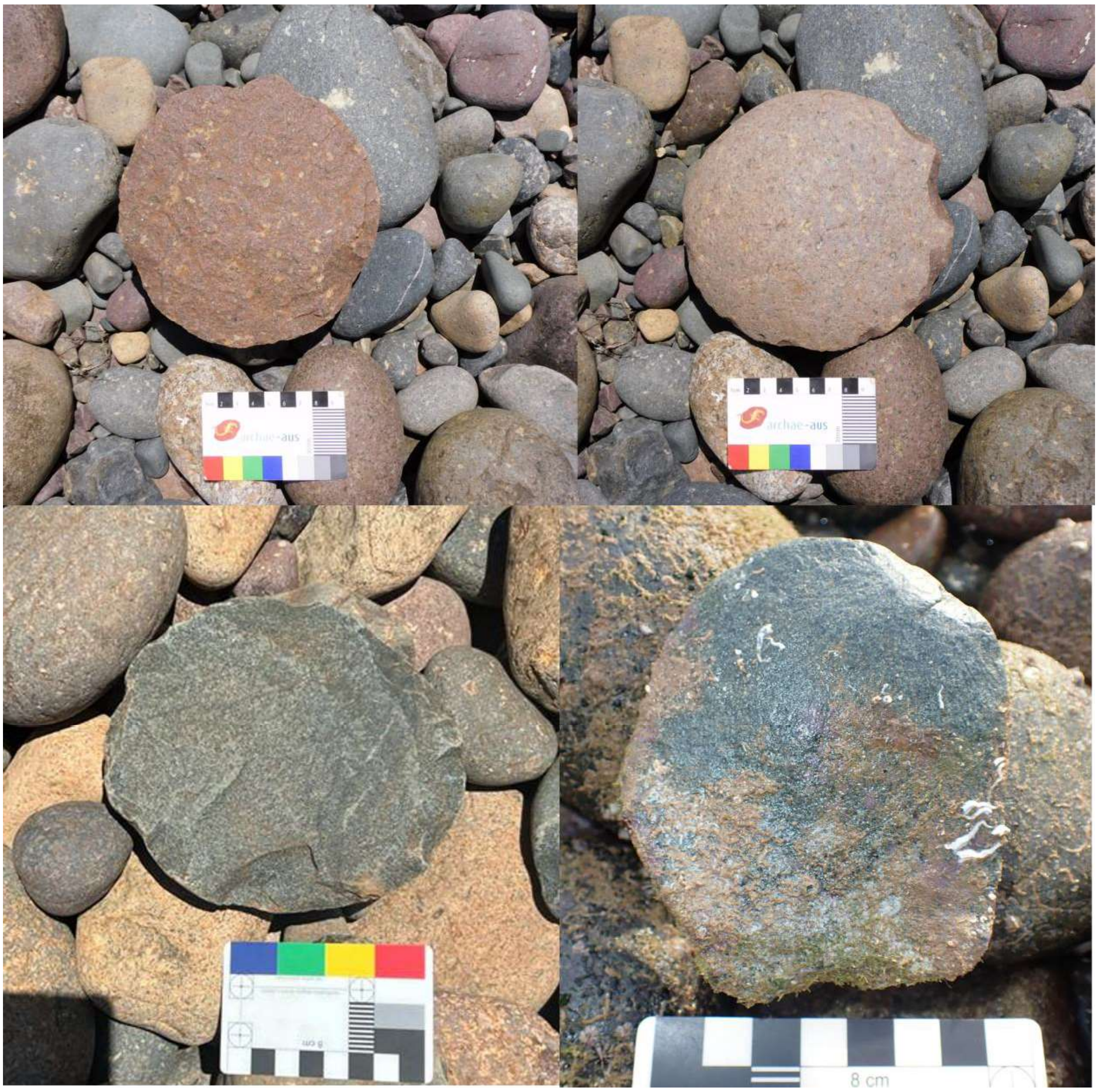

Figure 29. Large flakes from beach terraces and intertidal zone. Top: ventral (left) and dorsal (right) views of cortical flake with edge damage. Bottom left: large cortical flake with extensive edge damage and weathering. Bottom right: large flake from intertidal zone with weathered margins.

In conclusion, the samples of fractured stone from the subtidal and intertidal trenches are best interpreted as the products of natural flaking processes, including percussion fracture through wave action. The subtidal sample also has evidence of natural fracture through thermal processes and natural exfoliation; this presumably relates to weathering processes operating before sea level rise. No definite examples of artefacts were observed.

The samples from the ST01 showed much less evidence of rolling and abrasion from wave action. This presumably reflects the relatively short period of about a thousand years when this part of the seabed was subject to wave action. This implies that cultural material could be preserved and identifiable within the cobble matrix if these older terraces were used in the same way as 10303. Even in the intertidal trench, some relatively fresh and unweathered specimens were preserved beneath the top layer of cobbles. The relatively low artefact density on much of the third terrace means that finding artefacts within the small sampling window of the trenches is low probability.

SECTION FIVE – CONCLUSIONS

- The analysis shows that the samples of fractured cobbles from the intertidal (IT01) and subtidal (ST01) excavations differ significantly from the cultural assemblage recorded from DPLH 10303. These differences are broadly consistent with the effects of natural flaking associated with high energy coastal processes. Therefore, it is concluded that only the sample from DPLH 10303 is fully cultural in origin.
- Nevertheless, there is some overlap between the samples, and it is not possible to completely rule out the presence of artefacts in the subtidal and intertidal samples.
- Heavily patinated and worn artefacts as well as relatively fresh and unpatinated artefacts at DPLH 10303 suggest that the use of the terrace as a quarry for cobbles has continued for many generations and probably precedes sea-level rise.
- The presence of flaked unpatinated cobbles within the registered site boundary of DPLH 10303 suggests that the whole beach was a source of raw material, with fresh cobbles from the beach taken to the highest terrace for flaking.
- The terrace on which DPLH 10303 is located is part of a sequence of cobble terraces some of which were submerged by rising sea levels at the end of the last ice age. It is likely that most of the artefacts seen today at DPLH 10303 represent the most recent phase of use of the whole landform, which forms part of a continuous cultural landscape, extending offshore.
- The presence of flakes and nuclei with well-preserved flake margins and flake scars in both the intertidal and especially the subtidal samples suggests that artefacts could be protected from abrasion and rolling in some circumstances in the intertidal and subtidal zones. Therefore, it is possible that evidence of past use of older cobble beaches as a source of raw material could survive. Such evidence might include a range of flaked artefacts associated with cobble testing, decortication, and production of flakes and tools for use elsewhere.
- The low average density of cultural material on the surface of DPLH 10303 means that there is a low probability of finding one or more definite artefacts within the limited sampling window afforded by the intertidal and subtidal excavations.

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APPENDIX ONE – CATALOGUE

Abbreviations

Context

C Context

SB Silt box

RC Rock cage

Raw material

CG Coarse-grained granophyre

FG Fine-grained granophyre

PG Porphyritic granophyre

GR Granite

O Other

Percentage of cortex

0 0%

1 <50%

2 >50%

3 100%

Table 16. Catalogue of flaked stone artefacts

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>1OMM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
Site	T10	1	Uncertain	GR	320	310	80	2					5	10	210	2	0	Two flaked edges
Site	T10	2	Uncertain	FG	140	130	50	2					1	40	40	2	0	
Site	T10	3	Flake	CG	68	114	43	2	Plain	91	30	Feather				1	0	Red granophyre
Site	T10	4	Single platform core	CG	190	180	70	1					2	30	85	0	0	On large flake?
Site	T10	5	Retouched/utilised	CG	105	94	39	0					1	22	38	0	0	Notch
Site	T10	6	Uncertain	CG	146	57	50	2					1	36	32	0	0	
Site	T10	7	Uncertain	PG	160	140	50	2					4	32	115	1	0	Thermal flake
Site	T10	8	Uncertain	PG	80	71	41	2					1	26	43	0	0	
Site	T10	9	Single platform core	GR	126	102	49	2					1	42	11	0	0	
Site	T10	10	Unifacial cobble	PG	153	117	43	1					3	30	78	0	0	
Site	T10	11	Unifacial cobble	CG	117	94	47	2					3	25	48	1	0	
Site	T10	12	Flake	CG	65	50	17	1	Cortical	44	30	Axial				0	0	
Site	T10	13	Unifacial cobble	PG	98	80	42	1					2	40	78	0	0	
Site	T10	14	Unifacial cobble	PG	128	95	49	1					3	32	61	0	0	
Site	T10	15	Single platform core	CG	163	63	50	1					7	25	130	0	0	Core rejuvenation/core fragment??
Site	T10	16	Flake	PG	84	80	19	1	Cortical	54	18	Overshot				0	0	
Site	T10	17	Unifacial cobble	PG	58	80	81	2					2	27	54	0	0	
Site	T10	18	Unifacial cobble	PG	195	74	122	2					2	37	85	0	0	
Site	T10	19	Unifacial cobble	PG	146	100	39	2					3	30	79	0	0	
Site	T10	20	Flake	PG	72	54	25	2	Cortical	50	21	Axial				0	0	

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>1OMM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
Site	T10	21	Flake	PG	100	65	33	2	Cortical	29	21	Axial				0	0	
Site	T10	22	Unifacial cobble	PG	125	102	27	2					4	24	125	0	0	
Site	T10	23	Bifacial cobble	CG	79	88	64	2					4	62	58	0	0	
Site	T10	24	Bifacial cobble	CG	115	100	44	2					7	35	80	0	0	
Site	T10	25	Flake	PG	81	119	32	1	Cortical	18	28	Feather				0	0	
Site	T10	26	Multiplatform core	PG	98	87	65	2					3	36	49	0	0	
Site	T10	27	Flake	PG	58	42	17	1	Cortical	48	21	Feather				0	0	
Site	T10	28	Flake	CG	63	71	21	1	Cortical	47	17	Overshot				0	0	
Site	T10	29	Flake fragment	PG	48	65	20	1				Axial				0	0	Distal
Site	T10	30	Bifacial cobble	CG	93	76	33	1					4	37	56	0	0	
Site	T10	31	Flake	PG	83	61	15	1	Crushed	14	44	Feather				0	0	
Site	T10	32	Unifacial cobble	PG	94	93	54	2					2	62	71	0	0	
Site	T10	33	Single platform core	PG	135	131	55	2					2	48	82	0	0	
Site	T10	34	Flake	CG	74	90	31	2	Plain	31	14	Axial				0	0	
Site	T10	35	Flake	CG	50	70	18	2	Cortical	11	8	Hinge				0	0	
Site	T10	36	Flake fragment	PG	49	32	8	1	Cortical	14	10	Feather				0	0	
Site	T10	37	Flake	PG	41	23	7	1	Plain	30	9	Axial				0	0	
Site	T10	38	Multiplatform core	PG	131	117	81	1					5	53	75	0	0	
Site	T10	39	Unifacial cobble	FG	115	61	53	2					1	45	27	0	0	
Site	T10	40	Flake	CG	89	42	15	2	Plain	27	13	Axial				0	0	Blade-like, overshot, edge damage
Site	T10	41	Flake	PG	120	75	18	0	Plain	38	11	Feather				0	0	#41 and 42 conjoin - record combined as one - length

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>1OMM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
																		estimated from photograph
Site	T10	43	Bifacial cobble	FG	66	70	30	2					5	40	65	0	1	
Site	T10	44	Bifacial cobble	FG	97	90	65	2					4	55	75	0	0	Photoboard says #45
Site	T10	45	Bifacial cobble	PG	74	73	42	2					4	30		2	0	Primary and secondary cortex, FS cut into both
Site	T10	46	Flake	FG	57	26	14	2	Cortical	116	13	Feather				0	0	
Site	T10	47	Bifacial cobble	PG	61	20	14	1					2	43		0	0	Flake core
Site	T10	48	Flake fragment	PG	74	37	10	2								0	0	
Site	T10	49	Bifacial cobble	FG	98	65	34	2					4	63	90	0	0	
Site	T10	50	Unifacial cobble	FG	93	60	37	2					2	14	79	0	0	Flake core
Site	T10	51	Single platform core	PG	69	41	30	2					2	13	29	3	0	On large pebble
Site	T10	52	Flake	PG	55	30	11	0	Plain	24	6	Feather				0	0	Coarse granophyre - same as conjoin
Site	T10	53	Multiplatform core	PG	86	78	30	2					3	56	54	0	0	some secondary cortex
Site	T10	54	Single platform core	PG	75	65	32	2					2	42	52	0	0	
Site	T10	55	Flake	PG	36	34	9	2	Cortical	13	7	Feather				0	0	
Site	T10	56	Flake	CG	47	40	12	3	Plain	31	14	Feather				0	0	
Site	T10	57	Flake	PG	31	47	17	0	Plain	50	27	Axial				0	0	
Site	T10	58	Flake	CG	42	26	6	1	Cortical	20	6	Hinge				0	0	
Site	T10	59	Flake	PG	48	67	16	1	Cortical	55	20	Axial				0	0	very coarse grained
Site	T10	60	Flake fragment	CG	38	35	12	2	Facetted	28	10					0	0	

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>1OMM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
Site	T10	61	Flake fragment	CG	35	42	15	1	Cortical	45	18					0	0	
Site	T10	62	Flake fragment	PG	58	35	17	0								0	0	
Site	T10	63	Bifacial cobble	FG	111	60	69	2					8	44	81	0	0	
Site	T10	64	Flake	FG	54	62	10	1	Cortical	52	22	Axial				0	0	
Site	T10	65	Flake	PG	70	41	16	1	Cortical	24	14	Overshot				0	0	Retroflex hinge
Site	T10	66	Flake	PG	45	49	9	1	Cortical	20	7	Axial				0	0	
Site	T10	67	Unifacial cobble	PG	124	103	47	2					4	37	78	0	0	
Site	T10	68	Flake	PG	64	66	29	1	Cortical	19	8	Overshot				0	0	
Site	T10	69	Flake	PG	59	45	13	2	Plain	24	13	Feather				0	0	
Site	T10	70	Flake fragment	PG	48	43	10	2	Plain	21	10	Feather				0	0	
Site	S1	71	Unifacial cobble	CG	80	36	35	2					3	32	43	0	0	
Site	S1	72	Flake	PG	60	53	23	2	Plain	30	11	Axial				0	0	
Site	S1	73	Flake	CG	36	44	19	1	Cortical	40	15	Axial				0	0	
Site	S1	74	Single platform core	CG	60	55	33	2					1	22		0	0	
Site	S1	75	Multiplatform core	PG	208	151	65	1					4	38	126	0	1	Flaked on large heat-fractured boulder. Patination present - 2 phases
Site	S1	76	Multiplatform core	FG	114	81	27	1					2	16	37	0	0	
Site	S1	77	Unifacial cobble	PG	61	49	32	2					3	21	42	0	0	
Site	S1	78	Single platform core	PG	104	74	48	1					3	56	70	0	0	Black
Site	S1	79	Bifacial cobble	PG	86	64	46	2					2	18	35	0	1	2 old patinated flake scars ?cultural

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>1OMM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
Site	S1	80	Multiplatform core	PG	78	38	24	1					4	11		0	1	1 patinated flake scar ?cultural
Site	S1	81	Unifacial cobble	PG	175	137	44	1					4	10	124	0	0	Evenly patination. Large cobble flake with worked
Site	S1	82	Bifacial cobble	FG	65	65	25	2					1	15	50	0	1	possible 1x patinated flake scar
Site	S1	83	Flake	PG	50	47	13	0	Plain	48	13	Feather				0	0	
Site	S1	84	Unifacial cobble	PG	60	55	24	2					2	13	32	0	1	1xflake scar patination on another edge
Site	S1	85	Multiplatform core	PG	82	68	98	1					2	30		0	0	
Site	S1	86	Bifacial cobble	CG	94	70	36	2					3	65	80	0	0	
Site	S1	87	Unifacial cobble	FG	78	49	32	2					1	19	24	0	0	
Site	S1	88	Unifacial cobble	PG	109	79	38	2					2	30	53	0	1	Some patination 1 x cultural scar?
Site	S1	89	Single platform core	PG	84	63	22	2					2	15	50	0	1	Possibly two phases of reduction
Site	S1	90	Unifacial cobble	CG	76	65	34	2					3	8	63	0	0	
Site	S1	91	Unifacial cobble	PG	160	95	62	2					3	52	60	0	0	
Site	S1	92	Single platform core	PG	98	58	30	2					1	25		0	0	Hammer?

Table 17. Catalogue of fractured cobble samples from intertidal and subtidal trenches, and the beach

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>10MM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
IT01	2	1	Flaked nucleus	PG	53	35	22	2					1	12	30	2	0	
IT01	2	2	Split nucleus	CG	46	43	43	2					0			2	0	Split pebble
IT01	2	3	Flaked nucleus	FG	42	35	19	2					2	17	15	2	0	Split pebble with larger removals and battering round split edge
IT01	2	4	Edge-battered nucleus	CG	99	80	37	2					3	25	35	3	0	Cobble with battering on one edge
IT01	2	5	Flaked nucleus	PG	60	40	30	2					1	36	20	2	0	Angular pebble with single flake scar
IT01	2	6	Flaked nucleus	PG	57	46	35	2					1	25	20	2	0	Single flake removal - step out
IT01	2	7	Split nucleus	PG	47	30	20	2					0		50	1	0	Split flat pebble with two small flake removals on one edge
IT01	2	8	Split nucleus	PG	48	43	28	2					3	19	40	3	1	Split pebble with battered edges, two flake removals with different weathering, split point of impact is quite obtuse angle

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>10MM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
IT01	2	9	Flaked nucleus	PG	45	34	28	3					1	16	20	3	0	Totally worn pebble with two very worn past flake removals
IT01	2	10	Split nucleus	FG	31	22	22	3					0			3	0	Split pebble with battered edges and bipolar type flake removals
IT01	2	11	Split nucleus	CG	40	24	20	2					2	16		3	0	Bipolar split pebble
IT01	2	12	Flaked nucleus	CG	34	33	23	3					2	17	20	3	0	Two removals completely weathered
IT01	2	13	Edge-battered nucleus	CG	36	30	16	3					0		25	3	0	Numerous small removals
IT01	2	14	Split nucleus	PG	49	26	21	2					1	19	35	3	0	Split pebble numreous small removals
IT01	2	15	Split nucleus	PG	37	35	18	3					1	34	25	3	0	Very weathered with two large flake removals and battering - resembles bipolar core
IT01	2	16	Split nucleus	CG	40	25	17	2					0		30	2	0	Split with battering on edges
IT01	2	17	Split nucleus	CG	28	21	28	2					1	19		2	0	Split pebble - resembles bipolar
IT01	2	18	Split nucleus	FG	33	18	15	2					0			2	0	
IT01	2	19	Flaked nucleus	FG	40	20	15	3					0			3	0	Angular pebble with battering on edges. Very weathered

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>10MM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
IT01	2	20	Split nucleus	PG	35	22	14	2					0			2	0	Split pebble - resembles bipolar
IT01	2	21	Split nucleus	PG	30	26	14	2					3	16	30	2	0	Split pebble - resembles bipolar
IT01	2	22	Angular fragment	CG	25	22	10	1								2	0	Resembles split bipolar cortical flake
IT01	2	23	Split nucleus	CG	30	25	14	2					2	19		1	0	Split pebble - resembles bipolar
IT01	2	24	Angular fragment	FG	40	22	11	1								3	0	Very weathered angular fragment - resembles longitudinal split flake
IT01	2	25	Angular fragment	CG	34	29	9	3								2	0	Distal flake - some battering
IT01	2	26	Angular fragment	CG	28	26	8	3								2	0	Flake-like with some battering along margin - no clear flake ID features
IT01	2	27	Angular fragment	CG	42	22	16	2								3	0	Fragment from pebble no features visible
IT01	2	28	Angular fragment	CG	37	27	11	0								2	0	Battered margin. Large flake scar on "dorsal" surface
IT01	2	29	Angular fragment	PG	51	51	17	2								3	0	Battered margins.
IT01	2	30	Angular fragment	CG	34	29	9	2								3	0	Battered margins.
IT01	2	31	Split nucleus	CG	43	33	18	2					1	18	30	3	0	

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>10MM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
IT01	2	32	Angular fragment	PG	42	30	11	2								3	0	
IT01	2	33	Angular fragment	CG	40	12	8	0								3	0	Triangular 'orange segment' flake -battered margins
ST01	1	34	Thermal nucleus	CG	200	130	120	0								0	0	Large thermal fragment
IT01	2	35	Flaked nucleus	PG	63	59	34	2					1	25	40	3	0	One flake off end of cobble
IT01	2	36	Split nucleus	FG	36	28	27	2					0		20	3	0	Split pebble with flake removed
IT01	2	37	Split nucleus	PG	41	29	24	2					2	20	50	2	0	Split pebble with flake removed
IT01	2	38	Angular fragment	CG	50	40	25	0					0			2	0	AF block with edge damage
ST01	1	39	Angular nucleus	CG	90	75	55	0								2	0	
ST01	1	40	Angular nucleus	CG	85	65	40	0								0	0	
ST01	1	41	Angular nucleus	CG	210	60	12	0								0	0	
ST01	1	42	Flaked nucleus	CG	160	120	65	0					1	85	80	2	0	Recorded as #41 in photo log
ST01	1	43	Angular nucleus	CG	125	100	75	0								0	0	
ST01	1	44	Angular nucleus	CG	160	115	40	0								0	0	One obviously recent flake removed - at least one older

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>10MM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
ST01	1	45	Angular nucleus	CG	55	50	35	0								0	0	
ST01	1	46	Edge-battered nucleus	CG	205	120	50	0								3	0	
ST01	1	47	Angular nucleus	CG	125	88	86	0					1	77		2	0	Bipolar flake removal' - incipient thermal fracture visible
ST01	1	48	Thermal nucleus	CG	62	53	47	0								1	0	
ST01	1	49	Thermal nucleus	CG	63	54	36	0								1	0	
ST01	1	50	Angular fragment	CG	69	32	35	2								1	0	
ST01	1	51	Angular fragment	CG	65	45	42	0								1	0	Edge damage on angular fragment
ST01	1	52	Split nucleus	CG	56	40	22	2								2	0	Possible bipolar
ST01	1	53	Angular fragment	CG	81	70	18	0							110	2	0	Tabular flake? With edge damage
ST01	1	54	Split nucleus	CG	87	68	44	2								1	0	
ST01	1	55	Split nucleus	PG	42	30	29	2								1	0	Split pebble
ST01	1	56	Split nucleus	PG	50	39	30	2								1	0	
ST01	1	57	Split nucleus	FG	76	46	44	2					2	14		3	0	Very weathered split pebble

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>10MM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
ST01	1	58	Flaked nucleus	FG	44	40	21	3								3	0	
ST01	1	59	Flaked nucleus	FG	30	24	22	3							15	3	0	
ST01	1	60	Split nucleus	CG	73	63	22	2							45	3	0	Flat flake from cobble with battered edge - possible bipolar flake
ST01	1	61	Angular nucleus	CG	60	34	28	0								1	0	
ST01	1	62	Angular fragment	CG	50	36	22	0								1	0	Resembles proximal flake
ST01	1	63	Split nucleus	CG	110	51	42	1								2	0	Split cobble with thermal fractures
ST01	1	64	Flaked nucleus	PG	51	36	28	2					1	12		1	0	Thermal flake with short row of edge fractures
ST01	1	65	Angular fragment	CG	58	40	34	1								1	0	Edge damages
ST01	1	66	Split nucleus	CG	38	30	22	2								2	0	
ST01	1	67	Angular fragment	CG	55	30	18	2								0	0	
ST01	1	68	Thermal nucleus	CG	40	30	27	0								2	0	
ST01	1	69	Flaked nucleus	CG	37	24	22	0							20	3	0	
ST01	1	70	Thermal fragment	CG	57	31	11	2								2	0	Thermal flake

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>10MM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
ST01	1	71	Thermal fragment	CG	43	20	9	2								1	0	Thermal flake
ST01	1	72	Thermal fragment	CG	42	41	15	2								1	0	Thermal flake
ST01	1	73	Thermal fragment	CG	48	42	11	2								1	0	Thermal flake
ST01	1	74	Thermal fragment	CG	67	44	6	2								1	0	Thermal flake
ST01	1	75	Thermal nucleus	CG	45	33	16	2								1	0	
ST01	1	76	Other	CG	44	30	10	2								2	0	
ST01	1	77	Split nucleus	CG	41	26	23	1								1	0	
ST01	1	78	Other	CG	47	29	11	0								2	0	
ST01	1	79	Angular fragment	FG	31	25	20	0								2	0	
ST01	1	80	Other	CG	49	46	11	2								2	0	
ST01	1	81	Flaked nucleus	FG	39	18	14	2								3	0	
ST01	1	82	Angular fragment	CG	55	25	12	0								1	0	
ST01	C1RC 2	83	Thermal fragment	CG	165	110	50	0								1	0	Large thermal flake
ST01	C1RC 2	84	Angular fragment	CG	160	110	80	0					5	24		1	0	Large angular fragment with possible flaked edge
ST01	C1RC 2	85	Thermal fragment	CG	155	92	40	2								1	0	Large thermal flake

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>10MM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
ST01	C1SB 2	86	Thermal fragment	PG	94	38	30	2								1	0	Large thermal flake edge damage
ST01	C1SB 2	87	Angular fragment	CG	50	28	9	0								1	0	Resembles split flake
ST01	C1SB 2	88	Other	PG	55	30	10	1	Plain	10	6	Feather				1	0	Resembles flake Acc. 11
ST01		89	Thermal nucleus	PG	63	55	37	0								1	0	Thermal block - fragment has eroded off with new exposure to air
ST01	C1RC 3	90	Thermal fragment	PG	114	102	34	2								1	0	Large thermal flake with edge damage
ST01	C1SB 2	91	Angular fragment	PG	60	24	9	0	Plain	14	9	Axial				2	0	
ST01	C1SB 2	92	Angular fragment	CG	37	37	29	0					2	25		1	0	cf Core fragment - corner of larger flaked core
ST01	C1SB 2	93	Flaked nucleus	PG	67	37	35	2					1	26	35	1	0	Flaked cobble with one removal along face which has stepped out
ST01	C1SB 2	94	Flaked nucleus	FG	60	52	19	2					2	14		0	0	Freshly flaked pebble - probably in dredge or sieve
ST01	C1SB 2	95	Thermal fragment	CG	50	25	7	2	Plain	15	5	Step				1	0	Possible flake with doubtful platform - thermal
ST01	C1SB 2	96	Thermal nucleus	PG	40	32	24	0								1	1	Block with one fairly fresh face cf #92
IT01	2	97	Split nucleus	PG	52	40	17	2								2	0	Split flat pebble

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>10MM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
IT01	2	98	Split nucleus	GR	53	40	22	2								3	0	Split flat pebble
IT01	2	99	Split nucleus	PG	45	40	23	2					2	27		2	0	Flaked pebble - two clear scars, one steppd out, edge battering
IT01	2	100	Angular fragment	PG	59	36	18	2	Cortical	11	4	Other				3	0	Very weathered flake with edge battering distal end
IT01	2	101	Angular fragment	CG	35	16	12	2								2	0	freshest edge of triangular fragment flaked - bipolar?
IT01	2	102	Angular fragment	PG	32	10	7	0								2	0	Resembles split flake
IT01	2	103	Angular fragment	PG	38	50	16	2	Cortical	25	12	Other				3	0	Very weathered red PG flake with battered distal end. Acc.no 6
IT01	2	104	Angular fragment	FG	49	33	12	2	Plain	13	9	Other				1	0	Cortical flake with little weathering and crushing at distal end
IT01	2	105	Angular fragment	PG	50	36	13	0	Plain	14	9	Feather				2	0	Weathered red PG flake Acc. No.8
IT01	2	106	Angular fragment	FG	55	41	18	2								3	0	Very weathered flake-like fragment Acc. 9
IT01	2	107	Split nucleus	PG	37	23	13	2								2	0	Split pebble -ACC.4
IT01	2	108	Angular fragment	GR	36	18	9	0								2	0	Resembles bipolar split flake ACC. 2
IT01	2	109	Split nucleus	PG	48	38	14	2								3	0	ACC. 5. Very weathered split pebble with extensive battering on margin

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>1OMM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
IT01	2	110	Angular fragment	PG	48	42	11	2								2	0	ACC 3. Battered edges - possible split
IT01	2	111	Flaked nucleus	FG	81	53	48	2					2	43	35	1	0	ACC 1. Cobble with end removed forming an acute angle platform. Two flakes removed
ST01	C1S2 B2	112	Angular fragment	O	28	23	11	0								2	0	Weathered fragment unknown material - probably decomposed granite
ST02	C1S2 SB1	113	Angular fragment	CG	62	25	9	0								1	0	Blade-like flake with one end resembling PFA the other a step termination or transverse break. Edge damage
ST02	C1S2 SB1	114	Thermal fragment	FG	75	33	14	2								2	0	Thermal cortical flake with thermal scar on dorsal surface
ST02	C1S2 SB1	115	Thermal fragment	FG	50	19	8	0								2	0	Weathered thermal flake with edge damage
ST02	C1S2 SB1	116	Other	CG	45	25	8	0	Plain	8	5	Step				1	0	Blade with possible platform. This and 113,114,115 are ACC 27
Beach		117	Thermal fragment	CG	96	80	18	2	Crushed			Feather				0	0	Large thermal? Flake from cobble. Crushed ridge cf bipolar. ACC 34

SAMPLE	CONTEXT	ID	TYPE	MATERIAL	LENGTH (mm)	WIDTH (mm)	THICKNESS (mm)	%CORTEX	PLATFORM TYPE	PLATFORM WIDTH (mm)	PLATFORM THICKNESS (mm)	TERMINATION	N FLAKE SCARS>1OMM	LENGTH LONGEST FLAKE SCAR (mm)	LENGTH FLAKED EDGE (mm)	WEATHERING	DIFFERENTIAL PATINATION	COMMENTS
Beach		118	Flaked nucleus	CG	170	108	49	2					3	32		0	0	Large flat cobble, possibly a very weathered large flake with two fresh adjacent flakes removed and two or three older more weathered flakes along same margin. ACC 34
Beach		119	Flaked nucleus	PG	95	66	41	2					4	28		1	0	Large bifacially flaked cobble. At least 4 scars of different ages, the final one very fresh. ACC 34.

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ANNEX B –RADIOCARBON DATING REPORT

07 February 2023

Michael O'Leary (on behalf of Cosmos Coroneos)
The University of Western Australia
School of Earth Science
Perth, WA 6009

Dear Michael,

Please find below the results of the samples sent for radiocarbon analysis in Table 1**.** All samples have been assigned a unique UNSW Laboratory Code, which should be referenced for publications.

Table 1 indicates the chemical pre-treatment method used for samples and associated matrix matched backgrounds and standards. Additional details of the chemical pre-treatment and duration can be found in Turney *et al.*, 2021, full reference below. Should you have any queries about the pre-treatment and analysis methods please do not hesitate to get in touch.

Pretreatment Code LC:

> Pretreatment Code LC is used for the preparation of carbonates (including shells), involves the removal of surface contamination by physical abrasion and prolonged sonication in distilled water. The sample surface is then etched with 0.1 M HCl, resulting in the removal of the outer 10% (by weight) of the sample, before being rinsed with ethanol and oven-dried at 70°C. Large samples are pulverized with a vibratory mill in a tungsten carbide grinding bowl with a single disc (typically ground to 95% minus 75-micron material in approximately three minutes depending upon their mass and physical characteristics). Pulverized pretreated samples are further etched with 0.1 M HCl on the automated Carbonate Handling System (CHS2), resulting in the dissolution of 10% (by weight) of the sample before the sealed sample containers are flushed with Helium. The pretreated samples are converted to CO_2 by reaction with 85% H_3PO_4 and flushed through a water trap (phosphorus pentoxide) into the Automated Graphitization Equipment (AGE3) system with helium gas. The CO_2 is concentrated in a zeolite trap, which is heated to 420°C to release pure CO_2 into the graphitization reactor tube. The sample is then reduced to graphite at 580°C with hydrogen on iron powder.

Table 1 documents the certified laboratory measurement with the corresponding UNSW laboratory code and reported as a conventional uncalibrated ^{14}C age in ^{14}C yr BP or a fractionation-corrected fraction modern ($F^{14}C$).

UNSW Laboratory Code	Sample Label	Pre treatment Code	Age* (^{14}C yr BP)	Age Error ± (^{14}C yr BP)	$F^{14}C$	$F^{14}C$ ±
UNSW-1910	DUX_12A	LC	940	31	0.8895	0.0034
UNSW-1911	DUX_12B	LC	921	31	0.8916	0.0034
UNSW-1912	DUX_13	LC	1,575	32	0.8219	0.0033
UNSW-1913	DUX_20	LC			1.0633	0.0039
UNSW-1914	DUX_22A	LC	2,872	36	0.6994	0.0031
UNSW-1915	DUX_22B	LC	1,380	34	0.8422	0.0035
UNSW-1916	DUX_23	LC			1.0119	0.0037
UNSW-1917	DUX_24	LC			1.0435	0.0038
UNSW-1918	DUX_25A	LC			1.0858	0.0039
UNSW-1919	DUX_25B	LC			1.0676	0.0039
UNSW-1920	DUX_26	LC			1.0899	0.0039
UNSW-1921	DUX_28	LC			1.0922	0.0040
UNSW-1922	DUX_29	LC	637	30	0.9238	0.0035
UNSW-1923	DUX_30	LC			0.9376	0.0036
UNSW-1924	DUX_31	LC	995	32	0.8835	0.0035
UNSW-1925	DUX_32A	LC	739	31	0.9121	0.0036
UNSW-1926	DUX_32B	LC	667	31	0.9203	0.0035
UNSW-1927	DUX_33	LC			1.0290	0.0038

Table 1: Radiocarbon Analysis. *Age (^{14}C yr BP) is not reported where $F^{14}C$ is close to or >1.

For publication of these data, the following conventions for the reporting of ^{14}C determinations apply:

- The laboratory measurement should be reported as a conventional ^{14}C age in ^{14}C yr BP or a fractionation-corrected fraction modern ($F^{14}C$), with the corresponding UNSW laboratory code.

- Quoted errors are 1 standard deviation due to counting statistics multiplied by an experimentally determined Laboratory Error Multiplier.

- The sample material dated, and the pretreatment methods applied, should be reported. Please reference our current facility paper (Turney et al., 2021, full reference below) as this describes in detail the analytical methods required for chemical pre-treatment and AMS analysis.

- Where data are calibrated, the calibration curve used should be reported.

Please find further detail and first approximations about the results in the appendix below. Please contact us if you have queries about our interpretation of the calibration in the appendix. Thank you for choosing the Chronos [14]Carbon-Cycle Facility to process your radiocarbon samples.

With best wishes,

Juee Vohra, Technical Officer — j.vohra@unsw.edu.au
Dr William T Hiscock, Technical Officer — w.hiscock@unsw.edu.au
Dr Christopher E Marjo, Director — c.marjo@unsw.edu.au

Reference:

Turney, C., Becerra-Valdivia, L., Sookdeo, A., Thomas, Z.A., Palmer, J., Haines, H.A., Cadd, H., Wacker, L., Baker, A., Andersen, M.S., Jacobsen, G., Meredith, K., Chinu, K., Bollhalder, S., & Marjo, C. (2021). Radiocarbon Protocols and First Intercomparison Results from the Chronos ^{14}Carbon-Cycle Facility, University of New South Wales, Sydney, Australia. *Radiocarbon*, 63, 1003-1023, doi: 10.1017/RDC.2021.23.

Notes:

Please use the latest Southern Hemisphere Calibration Curve (SHCal20; Hogg et al. 2020) for the calibration of 14C age determinations from terrestrial Southern Hemisphere samples, the Southern Hemisphere Bomb (region 1,2) Curve (Bomb21 SH1_2; Hua et al. 2021) for the calibration of $F^{14}C$ measurements for ‘modern’ samples, and the Marine20 calibration curve (Heaton et al. 2020) for marine samples. For marine samples, please note that a local marine reservoir correction (ΔR) should always be applied (see calib.org/marine20 for more details).

Hogg, A. G., Heaton, T. J., Hua, Q., Palmer, J. G., Turney, C. S., Southon, J., Bayliss, A., G, B. P., Boswijk, G., Ramsey, C. B., Pearson, C., Petchey, F., Reimer, P., Reimer, R., & Wacker, L. (2020). SHCal20 SOUTHERN HEMISPHERE CALIBRATION, 0–55,000 YEARS CAL BP. *Radiocarbon*, *62*(4), 759–778. https://doi.org/10.1017/RDC.2020.59

Hua, Q., Turnbull, J.C., Santos, G.M., Rakowski, A.Z., Ancapichún, S., De Pol-Holz, R., Hammer, S., Lehman, S.J., Levin, I., Miller, J.B. and Palmer, J.G., 2021. Atmospheric radiocarbon for the period 1950–2019. *Radiocarbon*, pp.1-23.

Heaton, T.J., Köhler, P., Butzin, M., Bard, E., Reimer, R.W., Austin, W.E., Ramsey, C.B., Grootes, P.M., Hughen, K.A., Kromer, B. and Reimer, P.J., 2020. Marine20—the marine radiocarbon age calibration curve (0–55,000 cal BP). Radiocarbon, 62(4), pp.779-820

Radiocarbon measurements are always reported in terms of years `before present' (BP). This figure is directly based on the proportion of radiocarbon found in the sample. It is calculated on the assumption that the atmospheric radiocarbon concentration has always been the same as it was in 1950 and that the half-life of radiocarbon is 5568 years. For this purpose, `present’ refers to 1950.

Appendix:

UNSW Laboratory Code	Sample Label	Marine20 Calibration Age (^{14}C yr BP)	Marine Reservoir Corrected Age (^{14}C yr BP)
UNSW-1910	DUX_12A	326-461	414-549
UNSW-1911	DUX_12B	311-445	399-533
UNSW-1912	DUX_13	900-1045	988-1133
UNSW-1913	DUX_20		
UNSW-1914	DUX_22A	2346-2533	2434-2621
UNSW-1915	DUX_22B	685-828	773-916
UNSW-1916	DUX_23		
UNSW-1917	DUX_24		
UNSW-1918	DUX_25A		
UNSW-1919	DUX_25B		
UNSW-1920	DUX_26		
UNSW-1921	DUX_28		
UNSW-1922	DUX_29	136-Modern	224-Modern
UNSW-1923	DUX_30		
UNSW-1924	DUX_31	328-511	416-599
UNSW-1925	DUX_32A	123-279	211-367
UNSW-1926	DUX_32B	32-198	120-286
UNSW-1927	DUX_33		

Table 2: Calibrated Radiocarbon Analysis. Marine20 Calibration Age (^{14}C yr BP) is the calibration of $F^{14}C$ measurements and provides a calibrated estimate which utilizes the Marine20 calibration curve (Heaton et al. 2020). Marine Reservoir Corrected Age (^{14}C yr BP) is a correction of the Marine20 Calibration Age and provides a calibrated estimate with a local marine reservoir correction (ΔR) which utilizes a weighted mean from the Marine Reservoir Correction database. Radiocarbon measurements are always reported (^{14}C yr BP) and `before present' (BP) refers to 1950.

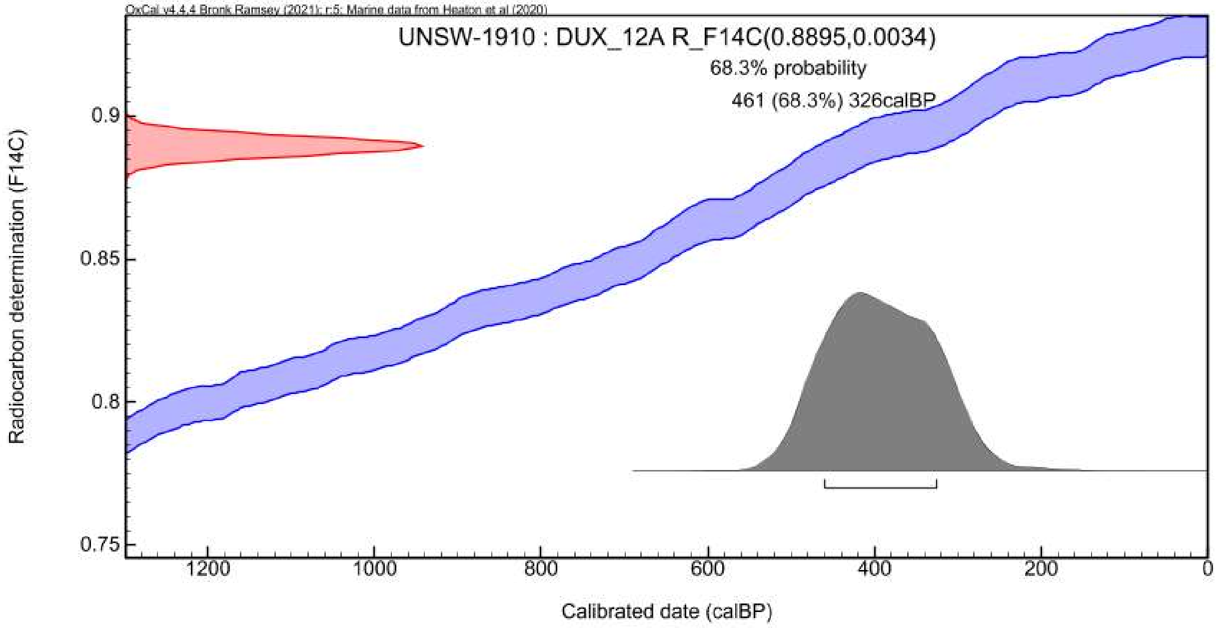
Map No.	Lon.	Lat.	∆R	∆R Err	Reference	Locality
1691	113.8350	-28.6820	-86	30	Peter Squire, 2013	East Indian Ocean
1578	122.1760	-17.9730	-89	30	O'Connor, S; 2010	Gantheaume Point
1576	122.2830	-18.0860	-84	35	O'Connor, S; 2010	Roebuck Bay
392	122.2300	-17.9700	-43	78	Bowman, G M,1985	Broome, WA
393	122.2300	-17.9700	-137	78	Bowman, G M,1985	Broome, WA
394	122.2300	-17.9700	-141	109	Bowman, G M,1985	Broome, WA
396	122.2300	-17.9700	-145	119	Bowman, G M,1985	Broome, WA
397	122.2300	-17.9700	-194	119	Bowman, G M,1985	Broome, WA
398	122.2300	-17.9700	-40	78	Bowman, G M,1985	Broome, WA
1575	122.2360	-17.9620	-84	30	O'Connor, S; 2010	Broome
Weighted Mean ∆R			-88	23		

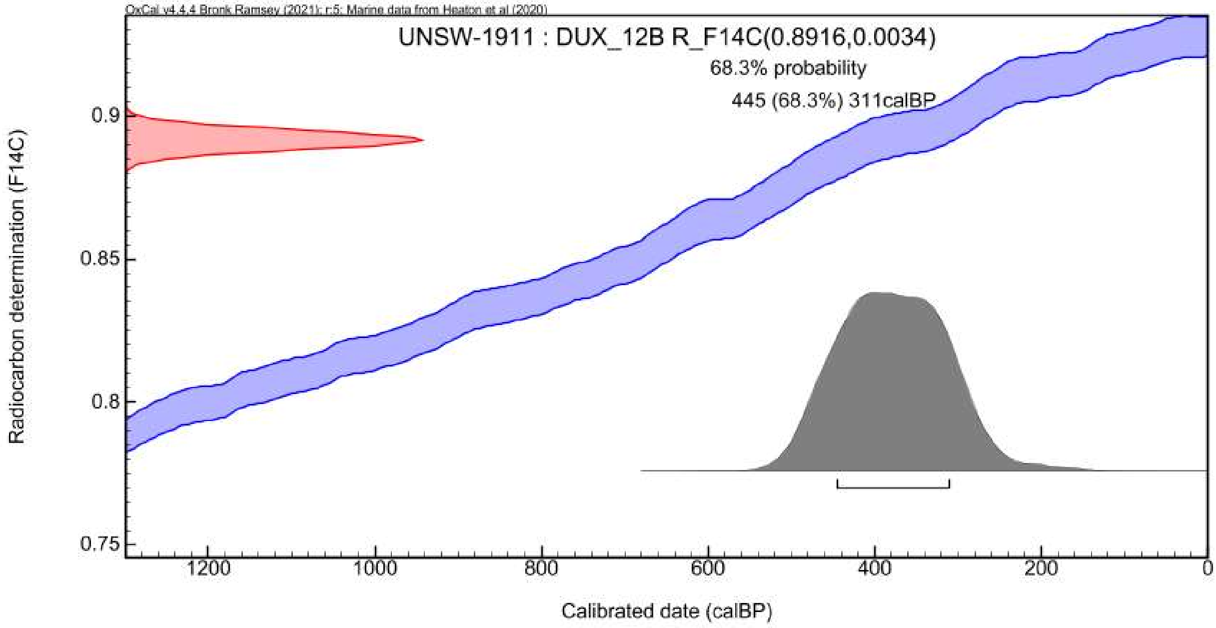
Table 3: A collection of 10 locations from the Marine Reservoir Correction database in proximity of the samples being reported and a weighted mean Marine Reservoir Correction (∆R) intended for use with the radiocarbon calibration program OxCal (Bronk Ramsey, 1995) using the marine calibration dataset. (Reimer PJ, Reimer RW, 2001. A marine reservoir correction database and on-line interface. *Radiocarbon* 43:461-3.)

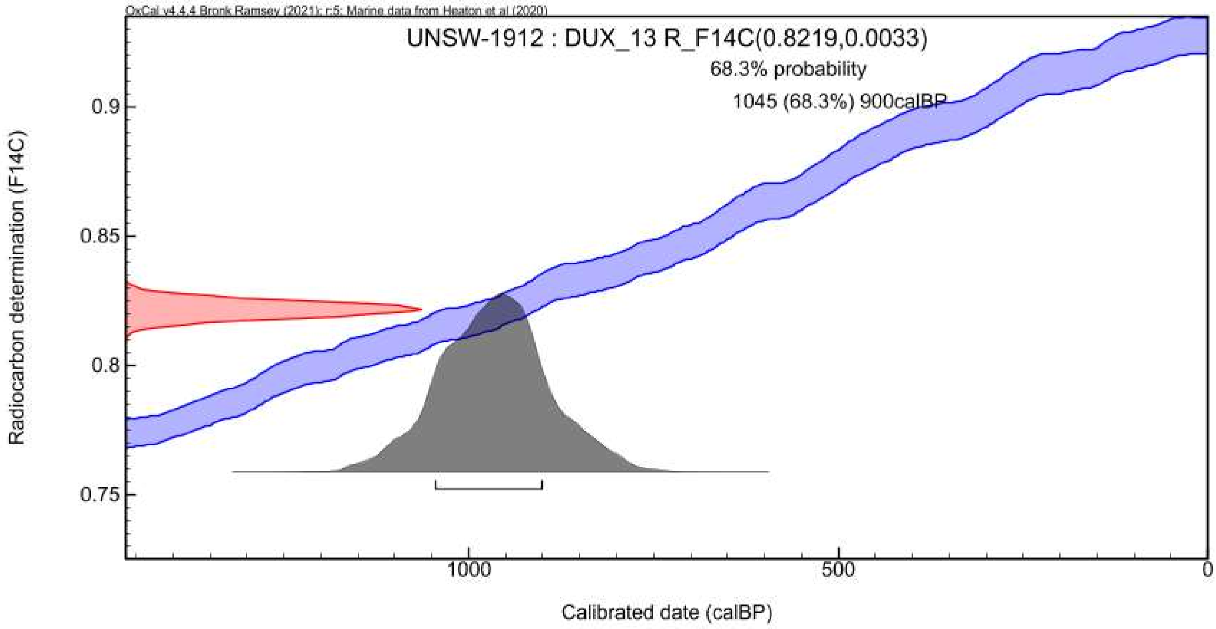
Radiocarbon ages of samples formed in the ocean, such as shells, fish, marine mammals etc., are generally several hundred years older than their terrestrial counterparts. This apparent age difference is due to the large carbon reservoir of the oceans. A correction is necessary to compare marine and terrestrial samples, but because of complexities in ocean circulation the actual correction varies with location. This regional difference from the average global marine reservoir correction is designated ΔR (Stuiver and Braziunas, 1993). As a first approximation, ΔR is assumed to be a constant for a given region and is calculated from the difference in ^{14}C years of known age marine samples and the marine model age for that calendar age.

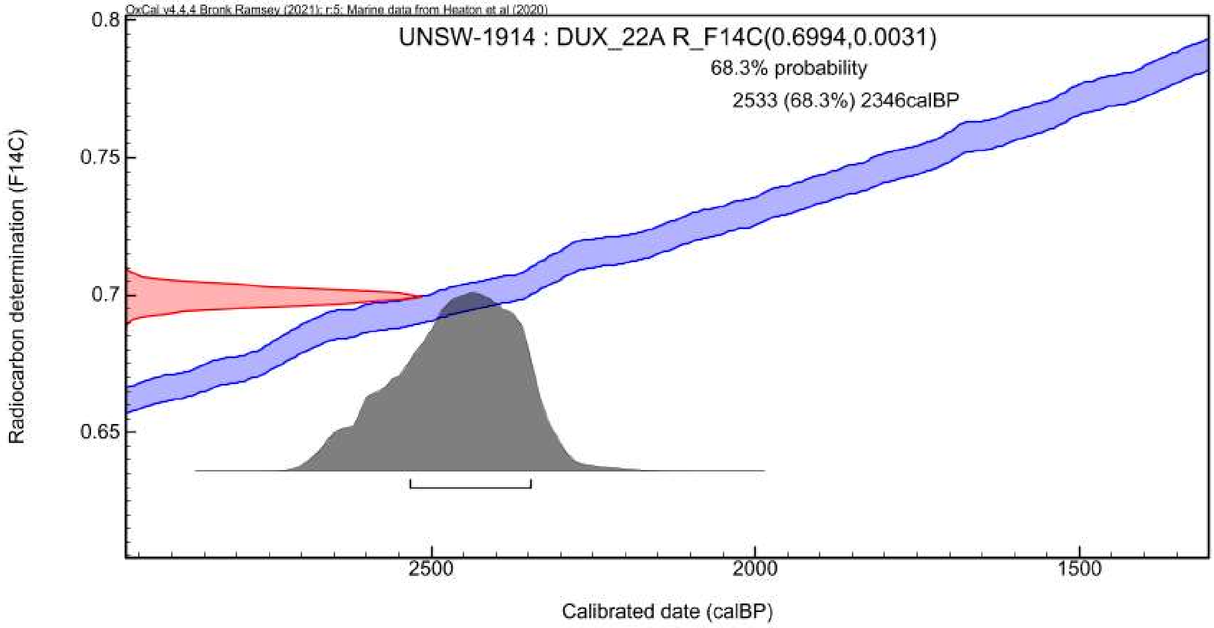
ΔR values were calculated from the difference in the ^{14}C age of known-age, pre-nuclear marine samples and the 2004 marine calibration dataset (Reimer *et al.*, 2004), which is identical to the 2009 marine calibration dataset during the Holocene. Samples from depths greater than 75 m were not included in the database, because the marine model ages in the marine calibration dataset are only valid for the surface mixed layer. In cases where the ^{14}C measurements were originally reported as $\delta^{14}C$, $\Delta^{14}C$, or pMC values, we recalculated the conventional ^{14}C age, correcting for isotopic fractionation if that had not been done previously.

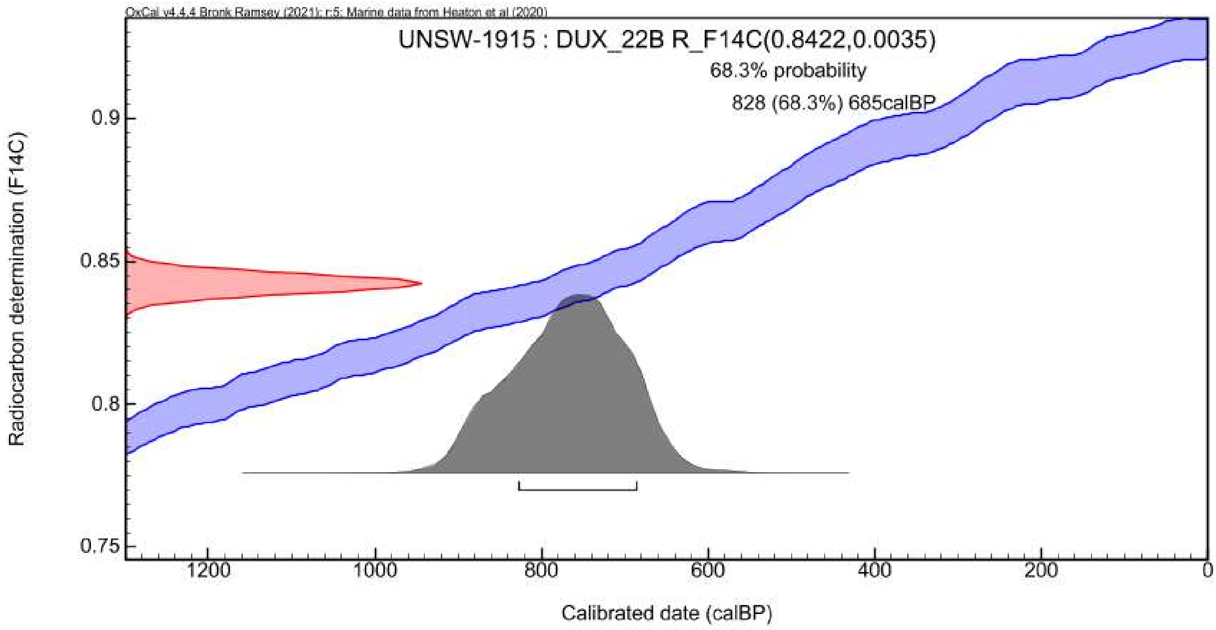
Local Marine Reservoir Correction (∆R): Depending on the age of the marine carbonate, a 200- to 500-year correction (*i.e.* global marine reservoir correction) is applied automatically for all marine carbonates. This automatic correction means the radiocarbon date gets more recent in time because it takes 200-500 years for present-day carbon dioxide in the atmosphere to be incorporated and distributed (equilibrated) through the ocean water column. A ∆R correction is applied to the sample that has already been corrected with the global marine reservoir correction. Note: A negative ∆R will make the date older (typically presuming freshwater dilution from the global marine average).

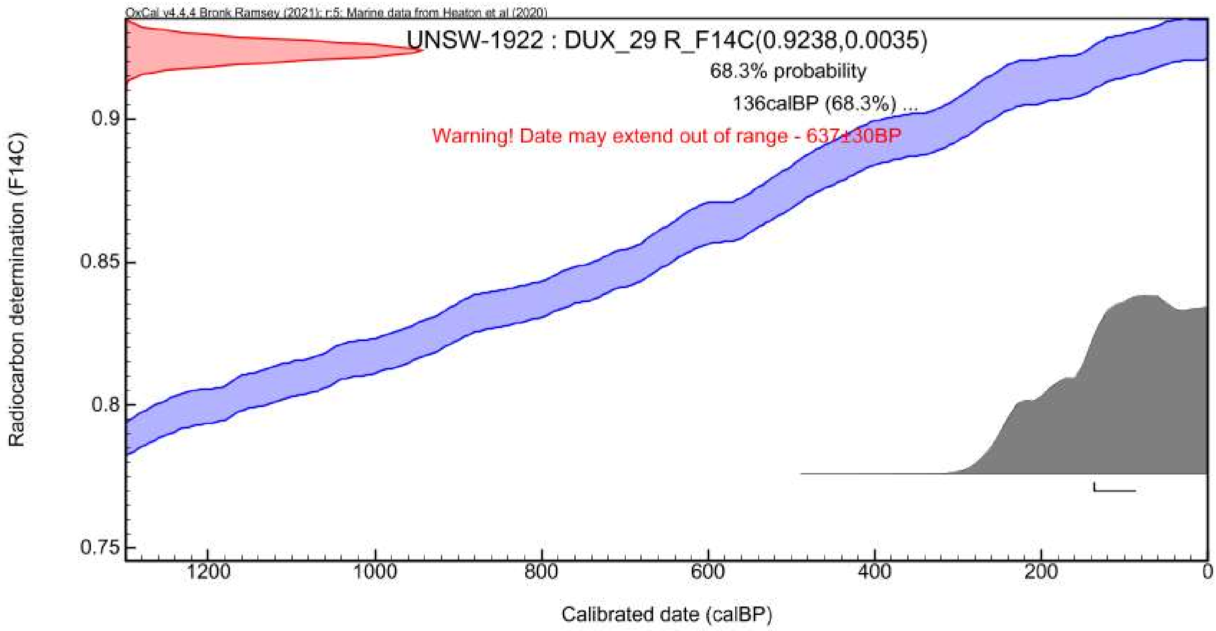

OxCal v4.4.4 Bronk Ramsey (2021); r:5; Marine data from Heaton et al (2020)
UNSW-1910 : DUX_12A R_F14C(0.8895,0.0034)
68.3% probability
461 (68.3%) 326calBP
Radiocarbon determination (F14C)
Calibrated date (calBP)

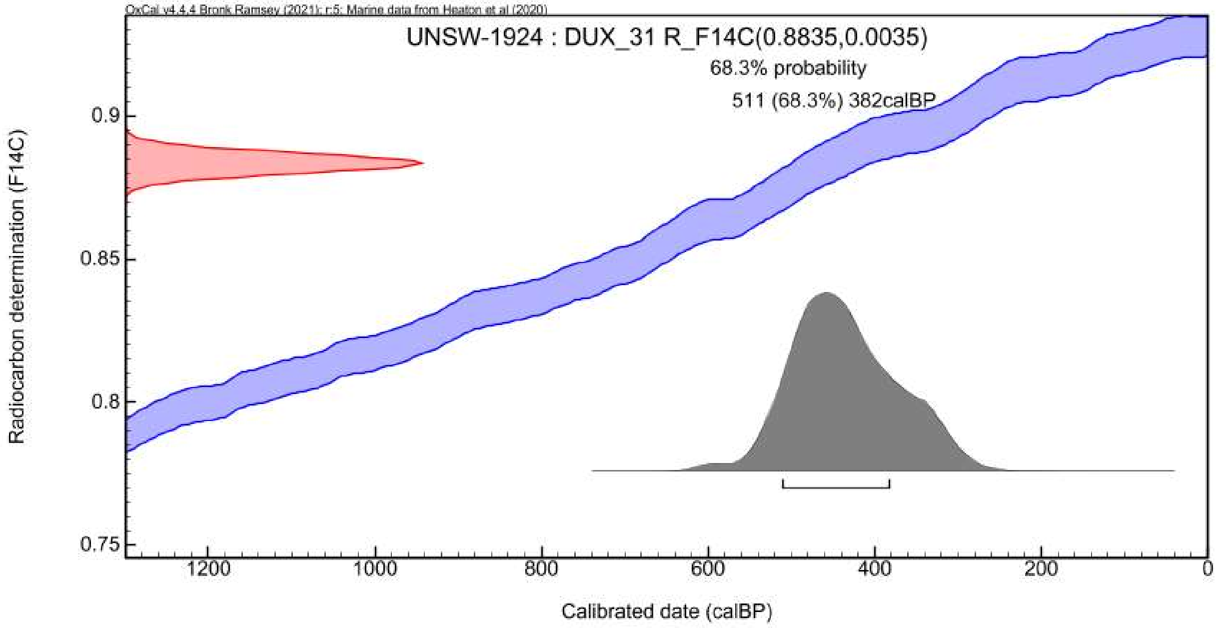

OxCal v4.4.4 Bronk Ramsey (2021); r:5; Marine data from Heaton et al (2020)
UNSW-1911 : DUX_12B R_F14C(0.8916,0.0034)
68.3% probability
445 (68.3%) 311calBP
Radiocarbon determination (F14C)
Calibrated date (calBP)

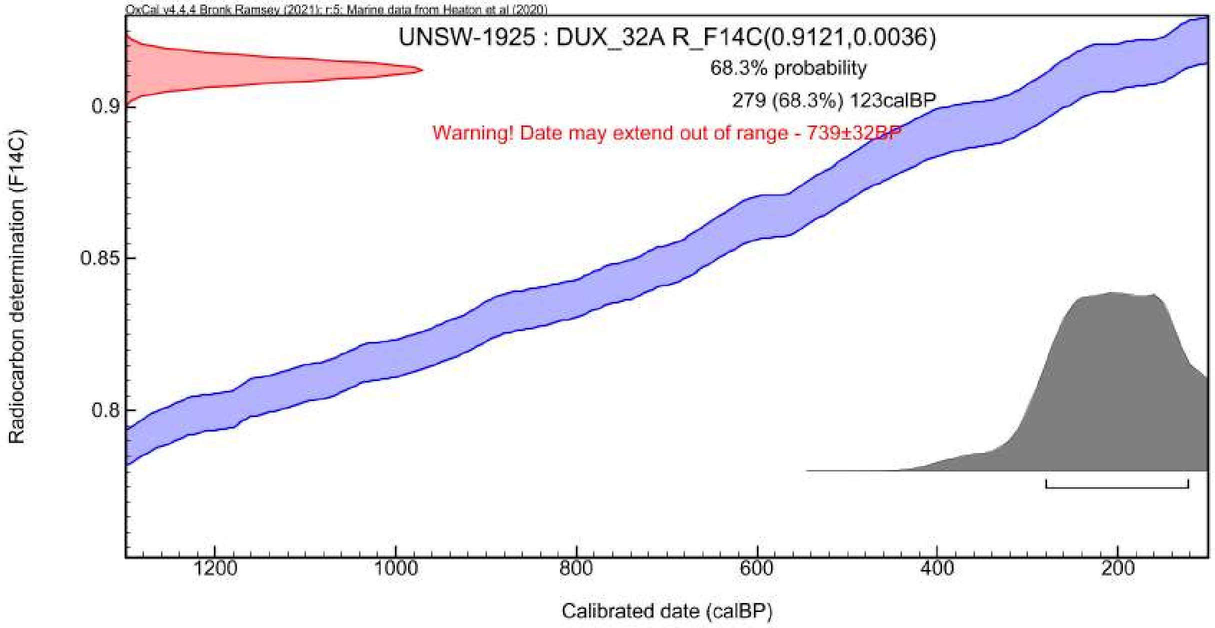

OxCal v4.4.4 Bronk Ramsey (2021); r:5; Marine data from Heaton et al (2020)
UNSW-1912 : DUX_13 R_F14C(0.8219,0.0033)
68.3% probability
1045 (68.3%) 900calBP
Radiocarbon determination (F14C)
Calibrated date (calBP)

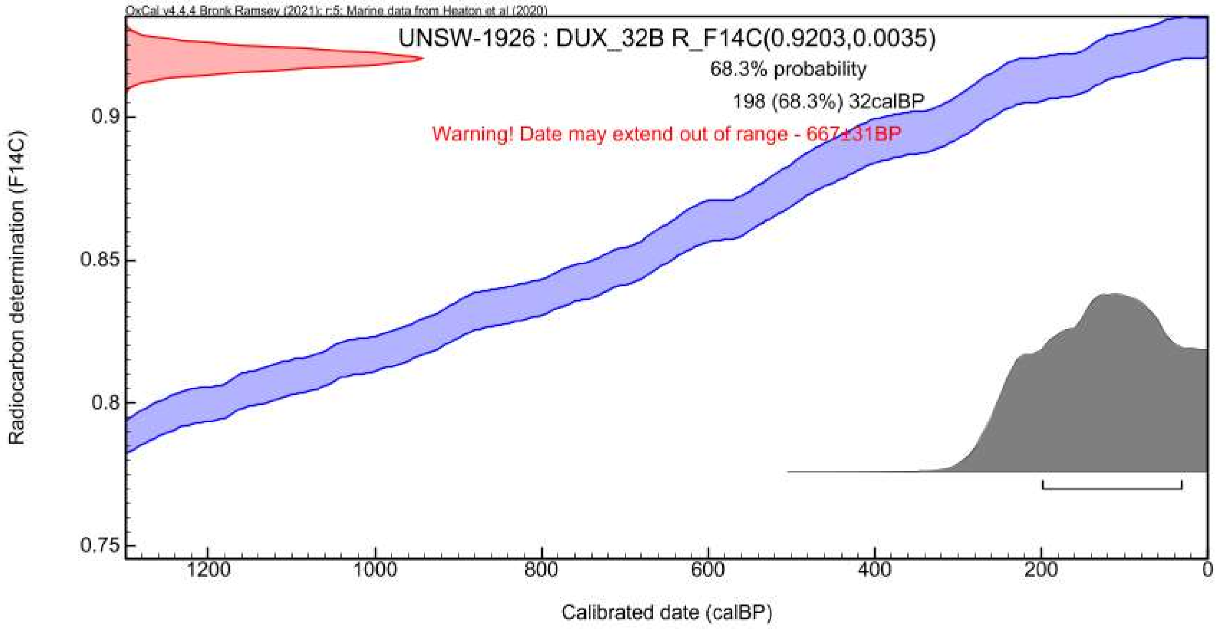

OxCal v4.4.4 Bronk Ramsey (2021); r:5: Marine data from Heaton et al (2020)
UNSW-1914 : DUX_22A R_F14C(0.6994,0.0031)
68.3% probability
2533 (68.3%) 2346calBP
Radiocarbon determination (F14C)
0.8
0.75
0.7
0.65
2500
2000
1500
Calibrated date (calBP)


OxCal v4.4.4 Bronk Ramsey (2021); r:5: Marine data from Heaton et al (2020)
UNSW-1915 : DUX_22B R_F14C(0.8422,0.0035)
68.3% probability
828 (68.3%) 685calBP
Radiocarbon determination (F14C)
0.9
0.85
0.8
0.75
1200
1000
800
600
400
200
0
Calibrated date (calBP)


OxCal v4.4.4 Bronk Ramsey (2021); r:5: Marine data from Heaton et al (2020)
UNSW-1922 : DUX_29 R_F14C(0.9238,0.0035)
68.3% probability
136calBP (68.3%) ...
Warning! Date may extend out of range - 637±30BP
Radiocarbon determination (F14C)
0.9
0.85
0.8
0.75
1200
1000
800
600
400
200
0
Calibrated date (calBP)


OxCal v4.4.4 Bronk Ramsey (2021); r:5; Marine data from Heaton et al (2020)
UNSW-1924 : DUX_31 R_F14C(0.8835,0.0035)
68.3% probability
511 (68.3%) 382calBP
Radiocarbon determination (F14C)
Calibrated date (calBP)


OxCal v4.4.4 Bronk Ramsey (2021); r:5; Marine data from Heaton et al (2020)
UNSW-1925 : DUX_32A R_F14C(0.9121,0.0036)
68.3% probability
279 (68.3%) 123calBP
Warning! Date may extend out of range - 739±32BP
Radiocarbon determination (F14C)
Calibrated date (calBP)


OxCal v4.4.4 Bronk Ramsey (2021); r:5; Marine data from Heaton et al (2020)
UNSW-1926 : DUX_32B R_F14C(0.9203,0.0035)
68.3% probability
198 (68.3%) 32calBP
Warning! Date may extend out of range - 667±31BP
Radiocarbon determination (F14C)
Calibrated date (calBP)

ANNEX C – DIGITAL RECORDS

Files supplied on external hard drive

File/Folder Name	Description	File Type	Size (GB)
DroneDeploy_30m_PK	RAW data from BPB flight survey at 30 m alt. Recorded: 24/11/2022	.jpeg	13.5
DroneDeploy_Intertidal Zone (1)_PK	RAW data from BPB flight survey of Intertidal zone 1. Recorded: 25/11/2022	.jpeg	1.93
DroneDeploy_Intertidal Zone (2)_PK	RAW data from BPB flight survey of Intertidal zone 2. Recorded: 25/11/2022	.jpeg	3.68
DroneDeploy_Transect10_PK	RAW data from BPB flight survey of Transect 10. Recorded: 25/11/2022	.jpeg	2.83
Intertidal_DUX1_PK	RAW data from BPB flight survey of IT01 for 3D rendering potential. Unused. Recorded: 25/11/2022	.jpeg	1.37
DroneDeploy_IT01_Terrace 1_PK	RAW data from BPB flight survey of Terrace 1. Recorded: 28/11/2022	.jpeg	12.0
DroneDeploy_IT01_Terrace 2_PK	RAW data from BPB flight survey of Terrace 2. Recorded: 28/11/2022	.jpeg	11.6
BH19_ST01_CM: CAM01_H10_RR	Video transect of ST01 on 26/11/22	.mp4	0.96
BH19_ST01_CM: CAM01_H8_R	Video transect of ST01 on 26/11/22	.mp4	0.98
BH19_ST01_CM: CAM01_H9_L	Video transect of ST01 on 26/11/22	.mp4	0.99
BH19_ST01_CM: CAM01_H10_LL	Video transect of ST01 on 26/11/22	.mp4	0.75
EAST-WEST_PK:	Video transect of east to west on 26/11/22	.mp4	5.56
SOUTH-NORTH_PK	Video transect of south to north on 26/11/22	.mp4	22.1

BH19_ST01_2nd_PK	Video transect of ST01 at cobble layer (spit 2) on 27/11/22	.mp4	17.1
BH19_ST01_3rd(@Depth)_PK	Video transect of ST01 at depth (spit 3) on 29/11/22	.mp4	13.4
BH19_ST01_CupuleFormation_PK	Video transect of ST01 large bedrock with natural cupule formation on 29/11/22	.mp4	0.87
BH19_ST01_ST02_NorthernExtension_PK	Video transect of ST02 at depth on 29/11/22	.mp4	5.08
BPB Drone Entire Survey Data (30 m)	Orthomosaic recorded on 24/11/22	.TIF	0.75
BPB Drone Entire Survey Data (30 m)	Digital Elevation Model recorded 24/11/22	.TIF	0.026
BPB Drone Entire Survey Data (30 m)	Digital Terrain Model recorded 24/11/22	.TIF	0.015
BPB Drone Entire Survey Data (30 m)	3D Render Model recorded 24/11/22	.obj	1.69
BPB_Intertidal Zone(1)_Drone Survey Data	Orthomosaic recorded on 25/11/22	.TIF	0.027
BPB_Intertidal Zone(1)_Drone Survey Data	Digital Elevation Model recorded 25/11/22	.TIF	0.075
BPB_Intertidal Zone(1)_Drone Survey Data	Digital Terrain Model recorded 25/11/22	.TIF	0.075
BPB_Intertidal Zone(1)_Drone Survey Data	3D Render Model recorded 25/11/22	.obj	0.022
BPB_Intertidal Zone(2)_Drone Survey Data	Orthomosaic recorded on 25/11/22	.TIF	0.038
BPB_Intertidal Zone(2)_Drone Survey Data	Digital Elevation Model recorded 25/11/22	.TIF	0.016
BPB_Intertidal Zone(2)_Drone Survey Data	Digital Terrain Model recorded 25/11/22	.TIF	0.016

BPB_Intertidal Zone(2)_Drone Survey Data	3D Render Model recorded 25/11/22	.obj	0.14
BPB_TRANSECT_10_Drone Survey Data	Orthomosaic recorded on 25/11/22	.TIF	0.079
BPB_TRANSECT_10_Drone Survey Data	Digital Elevation Model recorded 25/11/22	.TIF	326
BPB_TRANSECT_10_Drone Survey Data	Digital Terrain Model recorded 25/11/22	.TIF	326
BPB_TRANSECT_10_Drone Survey Data	3D Render Model recorded 25/11/22	.obj	176
BPB_Terrace1_Drone Survey Data	Orthomosaic recorded on 28/11/22	.TIF	0.038
BPB_Terrace1_Drone Survey Data	Digital Elevation Model recorded 28/11/22	.TIF	0.016
BPB_Terrace1_Drone Survey Data	Digital Terrain Model recorded 28/11/22	.TIF	220
BPB_Terrace1_Drone Survey Data	3D Render Model recorded 28/11/22	.obj	140
BPB_Terrace2_Drone Survey Data	Orthomosaic recorded on 28/11/22	.TIF	176
BPB_Terrace2_Drone Survey Data	Digital Elevation Model recorded 28/11/22	.TIF	0.068
BPB_Terrace2_Drone Survey Data	Digital Terrain Model recorded 28/11/22	.TIF	0.068
BPB_Terrace2_Drone Survey Data	3D Render Model recorded 28/11/22	.obj	537
DUX_POSTPROCESSING_EAST _WEST_TRANSECT	3D Model developed 10/01/23	.obj	5.36
N_S TRANSECT	3D Model developed 10/01/23	.obj	0.75

2ND_AT DEPTH	3D Model developed 12/12/22	.obj	8.87
3rd @ depth	3D Model developed 23/12/22	.obj	7.02
DUX_NORTHERN EXTENSION_AT DEPTH	3D Model developed 15/01/23	.obj	14.4
ST01_Final_withExtension	3D Model developed 05/12/22	.obj	0.34
ST01_Final_WB_withExtension	3D Model developed 08/12/23	.obj	48.6
ST01-2nd	Video run through of ST01 2nd (cobble layer) dated: 07/02/23	.mp4	0.92
ST01_ST02_FinalExcavation	Video run through of ST01_ST02. Dated: 07/02/23	.mp4	1.05
DUX/1st Tce	7 labelled images of fractured lithics	.jpg	
DUX/General	84 labelled images of team members and general shots.	.jpg	
DUX/Intertidal survey	96 labelled images of the intertidal survey including lithic samples	.jpg	
DUX/IT01	447 labelled images of the excavation and findings of IT01 including lithic samples and contents of rock cages and silt boxes.	.jpg	
DUX/Site 10303	576 labelled images of the survey of DPLH 10303 including artefacts	.jpg	
DUX/ST01	Four folders containing 283 labelled images of the excavation and findings of ST01 including lithic samples and contents of rock cages and silt boxes.	.jpg	
DUX/ST02	Three folders containing 68 labelled images of the excavation and findings of ST02 including lithic samples and contents of rock cages and silt boxes.	.jpg	