An investigation of the taphonomic process affecting vertebrate fauna preservation in shell matrix sites at Albatross Bay, Cape York Peninsula, Queensland.

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Australia

Declaration of Candidate

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signature: Emily Evans
Date: 23 April 2020

Abstract

This thesis comprises a taphonomic study of vertebrate faunal remains from three shell mound sites at Prunung (Red Beach), on the shores of Albatross Bay, in Cape York Peninsula, Queensland. Vertebrate fauna are generally agreed to play a major role in food production strategies for Aboriginal groups, yet evidence for this at shell matrix sites across northern Australia is relatively limited. This has led to the argument that vertebrate faunal processing and consumption did not play a major role at shell matrix sites in the region, where shellfish predation and utilisation was a primary focus (Beaton 1985; Bailey 1975a; Faulkner 2013; Harrison 2009; Morrison 2003, 2013a, 2013b, 2015).

For this study, vertebrate faunal specimens recovered from the three shell mounds were placed within their local environmental context and analysed microscopically for physical taphonomic characteristics. A taphonomic framework was developed to document the characteristics present on the specimens, including weight and dimensions for each specimen and undertaking a microscopic analysis of the various taphonomic process visible. This was followed by an inter-site comparison of the resulting dataset to determine if any patterns could be discernable.

The results of this analysis indicate that the specimens from SM:88, SM:91 and SM:93 show evidence of exposure to a variety of taphonomic processes that are likely to be indicative of processes affecting preservation rates of vertebrate fauna. These stem from the shell mound itself and the climactic impacts of the localised environment. The identification of many large mammals at the sites suggests bigger game may have been consumed. Based on this information, it is possible that vertebrate fauna played a greater role in food production strategies around shell matrix sites than has previously been suggested. While further research is required, this study shows that understanding these taphonomic processes can positively supplement current interpretations of shell mound phenomena and add to narratives about the lifeways of coastal Aboriginal peoples being revealed through archaeological research.

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Chapter 1: Introduction

The size and composition of shell mounds across northern Australia has inspired an extensive range of research investigating their chronology, composition, form and function. This research has involved the analysis of shell midden and mound composition, spatial and temporal relationships between sites, and most significantly, what these site types reveal about food production strategies of Aboriginal peoples utilising coastal and riverine landscapes. The main source of data for this research has been the remains of shellfish that constitute the shell midden or mound. Little focus has been afforded to the role of other food resources, such as vertebrate fauna, whose remains can still be found within shell middens and mounds. This, in part, reflects the fact that vertebrate faunal remains constitute only a small component of shell matrix sites, often amounting to less than 1% of the total weight of the shell mound being investigated (Bourke 2012; Faulkner 2013; Morrison 2013a; 2013b; 2015). They are often fragmented, poorly preserved, and as such are difficult to identify to lower taxonomic categories. To date, these materials have not been subjected to detailed analysis to clarify the role of vertebrate fauna at shell matrix sites, and exactly why they are so minimally represented. The purpose of this thesis is to conduct a focused analysis of vertebrate faunal preservation from shell matrix sites to contribute to wider debates about the role and use of vertebrate fauna at shell midden and mound sites in northern Australia.

1.1: What is a shell matrix site?

"Shell matrix site" is a broad term used to refer to all anthropogenic shell scatters, middens or mounds, regardless of their stratigraphy, composition or size (Claassen 1998). This term is particularly useful as it allows for the discussion of sites without reference to any specific attributes. Within this category, further distinctions between site types are made based on the density of the site over the most concentrated 1m² portion (after Morrison 2010:3). A shell scatter indicates a distribution of shells where ground surface is still visible; where 100% of the ground surface is covered the site is termed a midden; and where the shell is significant enough in quantity to form a layer approximately 5cm thick, the site is termed a mound. This terminology is used throughout the thesis.

Determining whether shell matrix sites are anthropogenic or natural is dependent on several characteristics. The presence of charcoal, artefacts, edible species of mollusc and vertebrate faunal material, crushed and whole shells, minimal shell breakage caused by wave action, and the stratification of shells with older material at the bottom and younger at the top are broadly indicative of shell matrix sites (Attenbrow 1992; Bailey et al. 1994:71; Bowdler 2013:364; Coutts 1966). Whilst not all culturally created shell deposits will fit these categories, an analysis of other features such as stratigraphy and site location can assist in identification (Bailey et al. 1994:71,79).

1.2: Shell matrix sites in Northern Australia:

Previous coastal archaeological research in northern Australia has tended to focus on shell matrix sites for several reasons. One concerns the widespread occurrence of *Tegillarca granosa* (formerly *Anadara granosa*)(WoRMS 2019) dominated shell mounds across much of the northern Australian coastline, from tropical north Queensland (Bailey 1975a; Beaton 1985; 1995; Cribb 1986; Morrison 2003, 2010, 2013a, 2013b 2014, 2015), the Northern Territory (Bourke 2004, 2012; Faulkner 2009, 2010, 2013) through to northern West Australia (Harrison 2009). Whilst there is a degree of variability in site composition and form, a notable increase in this site type occurs during the late Holocene, which has sparked interest amongst researchers as to the cause.

Analysis of shell matrix sites has resulted in different interpretations of their function within the landscape. Differentiation between natural and anthropogenic shell mounds has been a key issue

(Bailey 1993:8-9; Bailey et al. 1994:79; McNiven and Hall 1999:87; Morrison 2010:14; 2013b:182; Stone 1992, 1995). Investigating the importance of shellfish to the diet of Aboriginal groups exploiting aquatic resources has formed a key component in reconstructing food production strategies in the region. Some have argued shellfish was almost insignificant as a source of protein overall (Bailey 1975b:52,58, 1977, 1993, 1999:108;), while others conversely suggest that shellfish was an important component of complex food production systems that targeted specific ecosystems for resources (Morrison 2013b:88) and possibly during times of social gatherings (Clune and Harrison 2009:78, Meehan 1982:66; Morrison 2003). The hunting, cooking and consumption of vertebrate fauna is well attested in ethnographic literature throughout northern Australia. These studies have shed light on the methods and strategies used in the capture and processing of vertebrates such as kangaroo, wallaby, fish and a variety of bird species (McConnel 1939; 1953; Meehan 1982; Sutton 1994; Thompson 1939). Whilst it will be discussed during the thesis, a detailed review of this literature is beyond the scope of this investigation, which focuses on the technical aspects of bone taphonomy at shell matrix sites.

Analysis of vertebrate faunal remains by weight has generally revealed that they comprise a very small percentage of the overall weight of the shell midden or mound being studied (Beaton 1985; Bailey 1975a; Faulkner 2013:106; Harrison 2009:88 Morrison 2003, 2013a, 2013b, 2015). The highly fragmented nature of the bones has left little physical evidence demonstrating butchery or large scale consumption of both vertebrate fauna and molluscan fauna simultaneously at these sites. Shell matrix sites often exhibit neutral or alkaline pH levels and are generally agreed to be good preservers of bone. These combined factors have led researchers to conclude that vertebrate fauna represented either a small or non-existent part of the food production systems in place at these sites (Faulkner 2013:106; McNiven 1989:46; Morrison 2015:24). Whilst this may be the case, a detailed investigation into the possible taphonomic causes for this underrepresentation of vertebrate fauna is missing – and has important implications for understanding and interpreting shell matrix sites in the region. This thesis explores this problem through a detailed examination of vertebrate fauna from mounds at Prunung.

1.3: Taphonomy, vertebrate fauna, and shell matrix sites

Taphonomy was first defined by Efremov (1940) as the science of the laws of embedding, or the laws of burial. As a palaeontologist he argued that analysing fossils through the lens of the geological and biological processes that acted on them was essential. Since this time, taphonomy has come to encompass the variety of post depositional processes, both biotic and abiotic, which impact on an organism from the moment it is no longer living (Reitz and Wing 2008).

The poor preservation rates of vertebrate fauna in shell matrix sites across much of northern Australia has been widely reported and so far limited analyses have been undertaken to date, thereby constraining attempts to reconstruct food production strategies associated with shell mound formation (Bourke 2012; Faulkner 2013:80,121; Morrison 2003; 2015:25; Ulm 2002). Taphonomic factors that impact bone preservation at these sites have received limited attention from researchers, and in many cases, the form of the site is accepted at its current appearance (Shiner et al. 2013:70). Whilst heavily degraded and fragmented bones present problems for archaeological analysis, documenting what they do reveal can be significant for site interpretation (Uerpmann 1973:309).

1.4: Research design

This thesis aims to answer one central question: what was the role of vertebrate fauna in shell mound formation and use, and what taphonomic processes are influencing their preservation (or otherwise)? Five key aims have been created to address this question:

- Develop a taphonomic framework suitable for the analysis of vertebrate fauna recovered from shell mound sites;
- Document the physical characteristics and condition of vertebrate fauna recovered from a shell mound site;
- Analyse taphonomic characteristics to identify patterns that exist in relation to mound stratigraphy and composition;
- Contextualise these characteristics and patterns in terms of both past and present environmental changes; and
- Examine the implications of the results for key food production models in northern Australia.

The vertebrate fauna recovered from three shell matrix sites located at Prunung, north of the Mission River at Albatross Bay, are used to test the methodology and answer the research question. The current body of research into shell matrix sites is lacking in a detailed understanding of vertebrate fauna. Undertaking this research is an essential first step into clarifying how taphonomy may be affecting bone preservation at shell matrix sites. Understanding why bone is so poorly represented at these sites will allow for more accurate interpretations of the role of vertebrate fauna to communities living in northern Australia in the past.

1.6: Thesis structure

The thesis is structured as follows: Chapter 2 reviews regional research and theories surrounding shell matrix sites in northern Australia. Chapter 3 examines the study area in greater detail, examining the environmental and taphonomic processes likely to be impacting shell matrix sites in the region. These two chapters present a foundation for developing a methodology that will answer the research question. Chapter 4 outlines this methodology, which documents various bone modifications caused through taphonomic processes. Chapter 5 presents the data gathered during the research phase. Chapter 6 involves a detailed examination of this data, and extrapolates on trends that emerged during analysis. Chapter 7 will revisit the research question, the findings of all the previous chapters, and highlight areas for further research.

Chapter 2: Literature Review

This chapter considers past research and interpretations of shell matrix sites and what they reveal about Aboriginal lifeways and cultural and economic practices from the mid-Holocene in northern Australia. Vertebrate faunal remains are shown to have low recovery rates relative to the overall weight of each shell matrix site under investigation, which has led to the interpretation that vertebrate animals in general were minimally exploited. Research into the taphonomic processes that impact on bone within shell scatters, middens and mounds suggests a variety of processes can affect their overall preservation. To add to the current literature, a deeper understanding of how these processes impact vertebrate faunal recovery rates is necessary.

2.1: Coastal Archaeology in Northern Australia

Numerous archaeological investigations of shell matrix sites have been undertaken in northern Australia to date. These sites are distributed across the northern Australian coastline from Karratha in western Australia to Princess Charlotte Bay on the east coast of the Cape York Peninsula (Figure 1). The following discussion reviews previous work from a regional perspective, including what work has been undertaken, the key results, and to what extent any vertebrate fauna was analysed. This will lay the foundation for reviewing the interpretations of shell matrix site form and function later in the chapter.

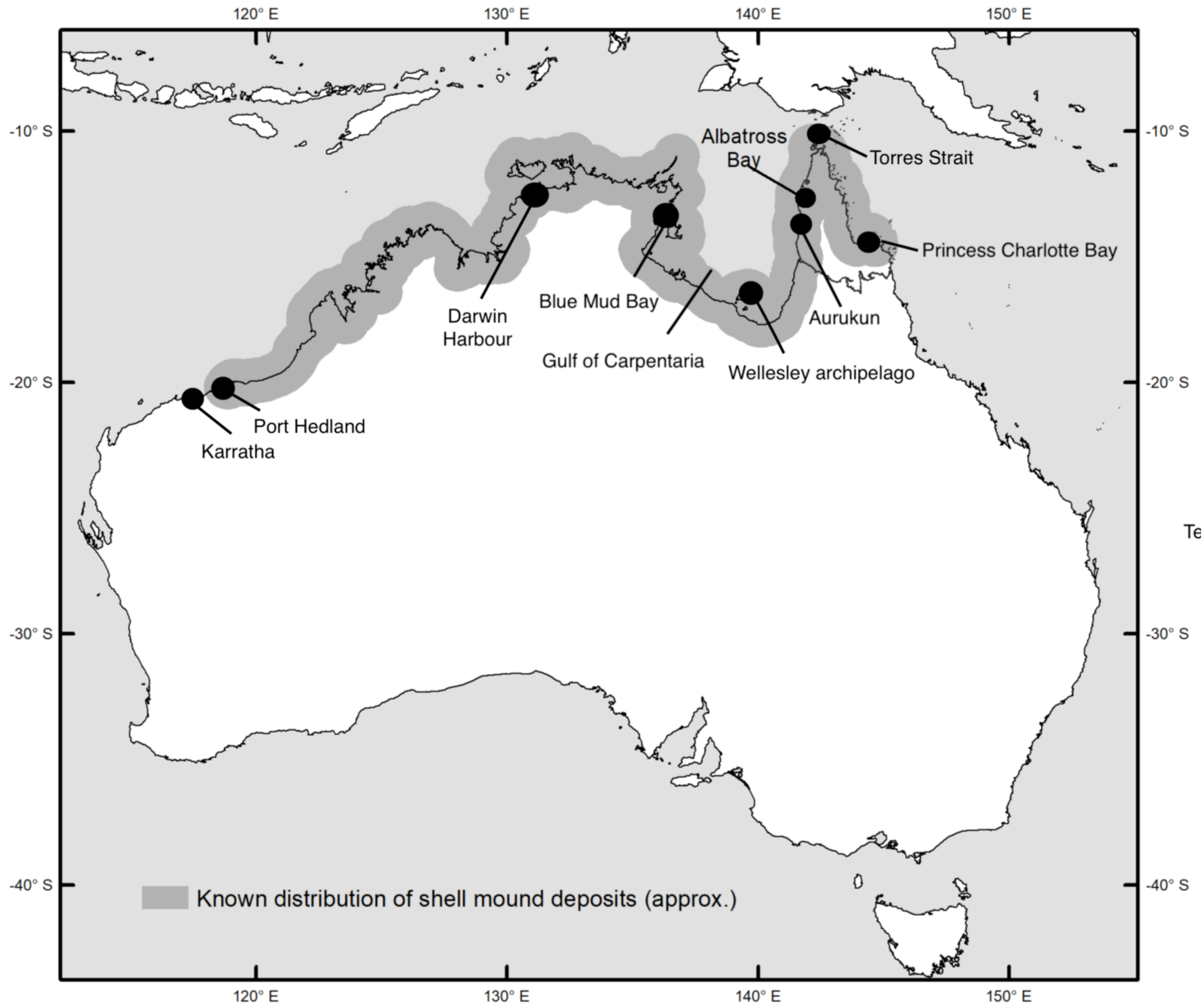

Figure 1 Northern Australia with key shell matrix locations mentioned in text. After Morrison (2013b:79).

2.1.1: Weipa and Albatross Bay

Albatross Bay (Figure 1) is located on western Cape York Peninsula at the confluence of four large rivers: the Pine, Mission, Embley and Hey Rivers, which flow into the Gulf of Carpentaria. The region’s primary vegetation is *Eucalyptus tetradonta* woodlands, with small herbs and shrubs forming the understory and mangrove lined forests close to the water’s edge (Shiner and Morrison 2009:52). At present, approximately 523 shell matrix sites have been documented here (Morrison 2013b:82) located across a range of differing environmental contexts including mangrove swamps, tidal mudflats, exposed dunes, and most often, within the *Eucalyptus tetradonta* woodlands (Bailey

1999:105; Morrison 2003:1; 2013a:165; Stone 1995:82; Wright 1971:135).

Characterised by early visitors such as Roth (1901:7) as examples of food refuse, or by Stanner (1961) as the result of natural phenomena, the middens were not excavated until 1962 when Wright (1964, 1971) excavated sections of two of the largest shell mounds at Weipa, one being the Kwamter mound, a large mound surrounded by smaller middens located on a low ridge of sandy soils at the junction between the Embley and Hey Rivers. Through his excavation he found animal bone, charcoal and artefacts.

After Wright, Bailey (1975a; 1977:132) undertook aerial surveys of Albatross Bay, determining that at least 500 shell mounds were visible. Later he also excavated the Kwamter mound, excavating a 1m² column in 21 units, 3m deep. He was able to show that the mound was composed primarily of *Tegillarca granosa* with little other soil component, with shells becoming more brittle and highly fragmented with depth and with radiocarbon dating indicating irregular rates of accumulation (Bailey 1975a:XVII24-30; 1977:134). A range of stone artefacts and bone specimens were located within the deposit, including 264 mammal bone fragments, 125 fish bones including vertebra jaw and spines, fragments of crab, at least eight polished bone tools, and several wallaby incisors filed to form tools known as “kangaroo-teeth scrapers” (Bailey 1977:136). He continued his analysis of the many shell matrix sites, observing differences in height, rates of accumulation, composition and location, and recorded over 300 mounds across the catchment (Bailey 1977; 1983; 1993; 1999).

Morrison (2003; 2010; 2013a; 2013b; 2015) conducted a series of excavations and surveys aiming to clarify aspects of midden formation and use. At Bweening on the north side of the Mission River, Morrison excavated 50cm² and 1m² column samples over nine shell matrix sites of diverse size. He determined that shell discard events likely occurred episodically, with a large shell mound often acting as a focal point with smaller middens forming around it (Morrison 2013a:179). At Prunung, on the southern banks of the Mission River just north of Weipa, Morrison (2015) excavated six shell middens using similar methodologies employed at Bweening. Here it was observed that discard events could occur simultaneously with the construction of new mounds, and that radiocarbon determinations demonstrate continued use of these sites until the recent past (Morrison 2015:19-20). At both locations, 2mm sieve residues that yielded the highest proportion of non-molluscan fauna were analysed. It was found that the quantities of vertebrate fauna did not increase when compared with the 6mm residues (Morrison 2015:24).

According to recent syntheses of existing and new radiocarbon data the oldest shell matrix sites at Albatross Bay date between 3,500-4,000 BP, with the majority of surveyed mounds falling between 2,000-2,500 cal. BP (Holdaway et al. 2017:11; Morrison 2014:7-9,10). Periods of mound disuse and reuse appear characteristic of the Bay (Bailey et al. 1994; Morrison 2014:9; Shiner et al. 2013). Radiocarbon dating and analysis of organic material at Waandriipayn (Big Willum) Swamp shows that shell matrix and earth mound construction in the area increased between 200-800 cal. BP (Brockwell et al. 2017; Morrison 2014:9; Stevenson et al. 2015). While bone is agreed to be consistently present within shell matrix sites at Weipa, poor rates of preservation are common (Bailey 1999:105; Morrison 2015:25).

2.1.2: Princess Charlotte Bay

Located on the east coast of the Cape York Peninsula, Princess Charlotte Bay (Figure 1) is a relatively shallow, calm and muddy bay with occasional reef outcrops, with three major rivers flowing into it bounded by mangrove forests; the Normanby, Kennedy and Stewart Rivers (Beaton 1985:3). An examination of the coastal geomorphological features here was undertaken by Chappell and Grindod (1984). Beaton’s (1985) survey and subsequent excavations of three rock shelters and thirteen shell midden and mound sites from 1979 to 1980 remain the most detailed archaeological investigations in the area to date. Beaton (1985:5) determined that occupation began approximately 4,700 BP at Walaemini rock shelter, with the mound building phase beginning between 2,000-2,500 BP, with sites often created on top of the most seaward chenier ridges. Radiocarbon dating determined that the mound building phase at the other sites began about 2,000 years ago and ceased around 400 BP (Bailey 1999:107; Beaton 1985:5). He further argued that there was no linear progression for site occupation, meaning that “old” mounds could be reused even if newer mounds were being constructed (Beaton 1985:5-6). The largest mounds located here are ‘Mother Mound’ (850m³) and ‘South Mound’ (535m³), which show similarities in composition to those at Weipa (Bailey 1999:107; Beaton 1985:4,7).

More recent work undertaken by Wright (2018) explores evidence for economic intensification and population expansion through an examination of non-vertebrate faunal material at Yindayin Cave, Stanley Island, off the coast of the eastern most edge of Princess Charlotte Bay, and one of the sites investigated by Beaton (1985). The analysis of shell material found in the cave when compared to environmental data for the region demonstrated that the site went through periods of use, reuse and disuse, rather than long periods of uninterrupted site use and consistent accumulation.

Vertebrate fauna was little discussed in Beaton’s analysis with no data reported. In summarising the data for Alkaline Hill, a site along the Bathurst range close to the Marrett River, he determines that the focus for this site is clearly marine, with “few” terrestrial faunal remains (Beaton 1985:7).

2.1.3: Aurukun

Aurukun is a coastal Aboriginal community located south of Weipa (Figure 1). Local landscapes are diverse, with mobile beach ridges topped with salt resistant vegetation at the coast, a series of parallel Holocene dune ridges running north to south further east, mangrove forests lining the various streams flowing into the region, and an open sclerophyll woodland reaching the Great Dividing Range in the east, with swamps interspersed throughout (Cribb 1986:134). Cribb (1986) conducted an archaeological survey as part of a larger ethnographic project undertaken by the South Australian Museum and the Aurukun Shire Council. Seventy-two shell middens and mounds were documented across the region (Cribb 1986:140). He divided the shell matrix sites into four distinct categories: thin surface middens located on sand dunes, surface middens on a silt substrate, shell mounds composed of small amounts of shell, and high/steep shell mounds (Cribb 1986:141,150). Mounds were found to occur either surrounded by extensive trees and shrubs or located on dune systems. Cribb (1986:146) highlights that many of the mounds were built on clay or silt substrates, with outcrops of trees growing from the top of the mounds (likely having grown after the accumulation of shell). While no excavations were undertaken, surface observations suggest that *T. granosa* was the dominant shell species, with others including *Telescopium telescopium* also occurring in small numbers (Cribb 1986:145). Cribb (1986:148) was uncertain as to whether these sites indicated continued or temporary settlement.

Investigations conducted at nearby Norman Creek, indicate that other shellfish species could be similarly targeted as was *T. granosa*. Cochrane (2014:48) recorded 58 shell matrix sites and indicated their surface composition was mostly comprised of *Marcia hiantina.* This study revealed the potential for regional variations in shell matrix composition in Cape York Peninsula, which suggested that Aboriginal communities occupying intertidal areas likely sought a range of shellfish species, not only one specific type (Cochrane 2014:51).

The studies above were field surveys and therefore faunal analysis was limited to visual surface inspections only. Cochrane's (2014:48) study found no evidence of mammal or fish bone, with a solitary stone core being the only surface artefact.

2.1.4: Gulf of Carpentaria

The entire west coastline of Cape York opens to the Gulf of Carpentaria, an epicontinental sea bounded by Arnhem land to the west and characterised by a series of archipelagos and islands that often preserve shell matrix sites. Rosendahl et al. (2014) undertook a study of the Wellesley Islands;

a group of 23 islands in the southern Gulf of Carpentaria (Figure 1). Shell matrix sites dominate elevated coastlines and beach ridges with human occupation spanning the last 3,300 years (Rosendahl et al. 2014:258). Reviewing the radiocarbon determinations across the islands, Rosendahl et al. (2014:258-259) found that *Anadara antiquata* mounds were consistently constructed during occupation of the area in low quantities until a sudden increase after 1,200 BP. This does not correspond with a decrease in the consumption of marine gastropods, which suggests a diversification of resources rather than an over exploitation of one species (Rosendahl et al. 2014:259,264).

On the Arnhem land coast, Faulkner (2009; 2010; 2011; 2013) excavated shell middens and mounds across the Point Blaine Peninsula, particularly at Blue Mud Bay (Figure 1), to understand how shellfish predation forms part of a larger subsistence strategy in the region. Faulkner (2009:822) examined the rate at which *T. granosa* was being exploited and the nature of the surrounding environment, determining that this mollusc was highly adaptable and able to grow in variable environments that frequently changed in rates of salinity, temperature and coverage by water. Excavating 13 sites from Myaoola Bay and Grindall Bay using 1m² or 0.5m by 1m test pits, an occupation phase spanning the last 3,000 years was observed. By examining the size, age, distribution and potential taphonomic effects on *T. granosa* shell midden sites across the Blane Peninsula, Faulkner (2009:831; 2010:1944; 2011:126) argued that the intensified exploitation of a particular resource should result in smaller individuals dominating the sample, and that it is most likely that the long-term reproductive trends of *T. granosa* were impacted by human predation. On this basis, he proposed that mounds reflect targeted use of marine resources within the region.

Faulkner's (2013:71-72) analysis of six of the shell matrix sites involved sieving all excavated material through 6mm and 3mm nested sieves. The recovered vertebrate faunal material was weighed and subjected to identification where possible, however was not further analysed due to the small quantities recovered (Faulkner 2013:73). The 3mm residues were visually inspected and did not provide and further insight with regards to vertebrate fauna, which led to the argument that the under representation of vertebrate fauna cannot be due to taphonomic factors alone. More likely it reflects the limited role vertebrates played within what he considered to primarily be shellfish processing sites (Faulkner 2013:106). Importantly, he does acknowledge that the tropical climate may be playing a significant role in the overall preservation and representation of bone and otolith material, and further concedes the use of 6mm sieve sizes may affect bone density within the sample (Faulkner 2013:105), though when compared with comparative 3mm residues this does not appear to be the case (Faulkner 2013:105-107).

2.1.5: Darwin Harbour

The Darwin region contains numerous shell matrix deposits that have in the last twenty years become more intensively researched. Bourke (2004, 2012) undertook a detailed excavation of five shell mounds at Hope Inlet, Shoal bay and three shell mounds close by at Darwin Harbour on the Northern Territory coast (Figure 1). Both locations are estuaries lined with mangrove forests and comprise multiple shell matrix sites. Hope Inlet contains almost 200 Aboriginal shell matrix sites and artefact scatters (Bourke 2004). Bourke excavated 1m^2 test pits in each shell matrix site, with both halves of the test pit excavated in 3cm spits to be analysed separately (Bourke 2004:11; 2012:30-31). The shell matrix sites were broadly consistent in composition, with *T. granosa* the most dominant species and fine silty sediments the prevailing soil component. The site returned age determinations of between 500-2,000 BP, with high degrees of fragmentation observed at the surface (Bourke 2004:12,15).

The stratigraphy of the shell matrix sites were observed to be porous. Non molluscan material was observed to fall between loosely packed shell in the upper layers and land at points where the matrix was more tightly packed together. This problem was exemplified by small charcoal fragments falling between stratigraphic units of H181. Bourke notes that observations like these cast doubts on the stratigraphic integrity of tropical shell middens as opposed to south eastern sites (Bourke 2004:12).

Vertebrate fauna fragments were mostly recovered from the 3.2mm sieve, were quantified by weight and were mostly found to be burnt (Bourke 2012:31). As a result identification to specific taxa was difficult (Bourke 2012:31). Across all sites vertebrate fauna represented on average 0.1% by weight of the whole midden. Fish were commonly represented, with macropods and possum species present including two incisors of medium to large mammals with broken points evidence of possible engraving tools (Bourke 2004:16). Shell midden H180 comprised vertebrate fauna concentrated at the bottom of the mound, while the other two middens showed a more even dispersal.

2.1.6: North Western Australia

Shell matrix sites across northern western Australia continue to cause debate centring around human and environmental dynamics. Harrison (2009) undertook a series of excavations which incorporated radiocarbon dating for an archaeological salvage project of seven midden sites south of Port Hedland, Western Australia (Figure 1). A sequence of mound building, with *T. granosa* as the dominant species, was found to span from 50 to 5,250 Cal BP, with evidence of size and composition variation between the seven sites (Harrison 2009:81,84-86,91). This variation, it was argued, is most likely due to formation processes rather than any one particularly foraging strategy by Aboriginal peoples in the area (Harrison 2009:81).

Mean weights for bones were taken with no further analysis attempted due to the highly fragmentary nature of the material (Harrison 2009:88). A total of 23 otoliths were recovered from the study area and analysed to ascertain species, average ages, and sizes for the fish. Three species were identified including snapper and whiting, with a wide variety of ages and sizes evident, suggestive of an indiscriminate fishing method consistent with netting or trapping (Harrison

2009:89). The locations where these otoliths were found, in shell matrix sites with a wider variety of shellfish species, suggested to Harrison that these were likely home or base camps as opposed to processing sites described by Meehan (1982).

2.2: Regional trends and debates

Work across the northern Australian coastline has examined spatial and temporal relationships between shell matrix sites and the local environment, as well as their individual composition. Through this research, several key debates have arisen. Two that are relevant to this thesis are the origins of shell mounds as being either a natural or cultural phenomenon, and the use of shell mounds to develop models of diet and economies. This section will present key findings and examine these issues.

2.2.1: Origins of shell mounds

A continuing issue for shell matrix studies is determining whether mounds are formed by people or through natural processes such as wave action, storms and animals. Some key identifiers for a culturally created shell matrix site include the presence of charcoal or artefacts, a predominance of edible species of mollusc and vertebrate faunal material, crushed and whole shells, minimal shell breakage caused by wave action, and mound stratigraphy indicating older material at the bottom and younger at the top (Attenbrow 1992; Bailey et al. 1994:71; Bowdler 2013:364; Coutts 1966). The issue remains, however, that not all culturally developed middens will contain all these elements, nor will naturally accumulated shell beds be without them, therefore further classificatory systems need to be developed (Bailey et al. 1994:72; Bowdler 2013:364-365; Claassen 1998:97). Examining the stratigraphy and overall composition of shell mounds relative to closely-related natural deposits and mound substrates, together with an understanding of the local environment, may also inform our understanding of mound origin (Bailey et al. 1994:71,79).

The complexities associated with identifying natural and anthropogenic shell matrix construction has been a key focus in previous work at Weipa. Much of Bailey's early work was concerned with differentiating natural from anthropogenic mounds (Bailey 1977; 1999; Bailey et al. 1994). The morphological and spatial characteristics of the mounds were not consistent with naturally accumulated shell beds. He found that low lying smaller middens were often found immediately adjacent to larger mounds, exemplified by the Kwamter mound (Bailey 1977:139). Bailey argued that such a formation allowed larger mounds to be accented, making them appealing campsite locations as they were dry, removed from any seasonal floodwaters and good insulators of heat (Bailey 1975a; 1977:139).

Another important consideration within this debate is the relationships between shell matrix sites and chenier ridges, which are common through the region. Chenier plains are coastal landforms where chenier ridges are separated by broad, hypersaline mudflats (Chappell and Grindrod 1984:197). The ridges are predominantly comprised of shell debris from intertidal molluscs and can be mixed with sands and gravels (Chappell and Grindrod 1984:197). Chenier plains occur throughout the Gulf of Carpentaria, often along low energy coastlines, which are subjected to frequent flooding (Chappell and Grindrod 1984:199). The fact that many anthropogenic shell mounds are sometimes constructed atop these ridges has caused confusion between natural and cultural shell structures (O'Connor and Sullivan 1994:17). The accumulation of shell to form cheniers is also heavily impacted by mud accumulation within the low lying banks of estuaries, which will affect the predominance of shellfish in an area (Chappell and Grindrod 1984:222). These characteristics need to be considered when analysing shell mound or midden stratigraphy and composition (Bailey et al. 1994; O'Connor and Sullivan 1994:25).

A contentious argument concerning a non-human origin for the shell matrix sites Weipa was put forward by Stone (1992; 1995), who suggested that these mounds are incubation mounds for the eggs of the *Megapodius reinwardt* (yellow-footed scrub hen). He argued that the mounds were constructed from natural neighbouring shell deposits, a hypothesis based largely on the size of the mounds and the limited artefacts or cultural materials found within them (Stone 1992; 1995). Challenging these arguments, Bailey et al. (1994) undertook an examination and comparison of the stratigraphy of shell mounds, beach ridges, and scrub fowl nests at Prunung, north of Weipa, with consideration of the environmental and geomorphological characteristics of the region. They found that scrub fowl mound accumulations often reflect the substrate on which they are constructed, as the bird will scrape natural sediments to form the nest (Bailey et al. 1994:73,77). Examining in detail a shell mound that Stone (1992) argued to be a distinctive scrub fowl mound, they found several inconsistences. While the beach ridge plain was composed of a number of different shell species, horizontally stratified with shelly/sandy sediments in the upper layers, the shell mound was composed of broken, clean *T. granosa* shell resting on clean sandy sediments, and with the presence of fishbones (Bailey et al. 1994:75,76). Further to this, many of the shell matrix sites at Bweening, Albatross Bay, are located on bauxite plateau substrates and are positioned away from coastal deposition. These are therefore free from natural occurring shell, and are 3-5m above modern sea levels, meaning the sites must have a cultural origin (Morrison 2013b:182).

An anthropogenic origin for the mounds and Weipa and neighbouring sites is now generally agreed upon by archaeologists (Bailey 1993:8-9; Bailey et al. 1994:70,79; McNiven and Hall 1999:87; Morrison 2010:14; 2013a:182). This debate demonstrates the continuing issue with interpreting archaeological material within shell matrix sites. Importantly, the presence of bone is considered an important component for interpreting anthropogenic mounds and middens.

2.2.2: Models for coastal food production strategies

One central question being asked by researchers is, what do the shell matrix sites tell us about past food production strategies? From his early observations, Wright (1971:135) was convinced that the large shell mounds appeared deliberate and purposeful, as opposed to rubbish or refuse sites. This was largely due to their size and impact on the landscape. He remained wary, however, of assigning any specific functional purpose for their construction (Wright 1971:135). Looking closely at the geomorphological characteristics of the region, Bailey (1977:139-140) argued that shell matrix sites were representative of seasonal hunting practices by small groups, whereby available marine resources were specifically utilised when environmental conditions were favourable. He suggested that annual monsoons in the region inundated floodplains and preferred camping areas near estuaries, encouraging people to move closer towards the river's low marshy banks or small ridges close to mangrove forests, where available resources were exploited (Bailey 1977:140). The location of larger shell matrix sites in these swampy areas, when compared with the smaller scatters documented in the adjacent woodlands, arguably favours this hypothesis (Bailey 1977:134, 139-141). He observed that small 0-1m thick middens were far more common than the more recognisable large shell mounds (Bailey 1977:139).

Morrison (2003, 2010, 2013a, 2013b, 2015) conversely argued that shell matrix sites represent intensive and targeted exploitation of *T. granosa.* This was based on the significantly high representation of *T. granosa* across a range of sites within the Weipa area. Expanding this theory, Morrison (2010; 2013b:89; 2015) later argued that the middens represented specialised production activities that involved targeted exploitation of a variety of intertidal mudflat shellfish species factoring in local and seasonal variations. Estuarine and mudflat ecosystems, though supporting a relatively large biomass, are not static and shift and change through time. This approach allowed for flexibility during seasonal changes, and likely resulted in complex social interactions between local groups during times of intensive harvesting (Morrison 2013b 89; 2010). The niche production model developed by Morrison (2013b) argues that estuarine ecosystems through Albatross Bay were targeted by both large and small groups of coastal communities. It was this environment, rather than any one specific resource in it, that drove shell matrix formation (Morrison 2013a:87-89). *T. granosa* in this way was heavily utilised, but only as part of a dynamic approach to resource use and food production (Morrison 2013b). This suggests coastal groups operated within a complex landscape utilising specific resource types in strategic ways, rather than simply responding to environmental stressors.

Bourke (2004:10,18) argues that a flexible and generalised coastal economy that focused on inland resources is evident at Hope Inlet. Bourke (2012:133-134) observed that examining the distribution of vertebrate fauna across sites of varying locations showed that terrestrial mammals were transported from the hinterland to the coast and fish bone was similarly transported, found at hinterland sites. This led Bourke (2004:19) to argue that the shell matrix sites were not only used for the sole purpose of exploiting *T. granosa*, given their composition and geographical placement near other key resources areas.

Faulkner (2009; 2010; 2011; 2013:1) proposes a similar model where specific intertidal shellfish species such as *T. granosa* are episodically targeted. He argued that most shell matrix deposits are reflective of shellfish species with a long-term presence in the area, and that environmental factors over time can impact availability and physical characteristics (Faulkner 2013:137). He does however explain that behavioural and cultural decisions remain a key component of mound formation.

Other models focus more acutely on the importance of constructing the mounds themselves. Utilising data obtained from excavations at the Abydos plain by Clune (2002) at Karratha and Harrison (2009) at Port Hedland, and other excavations and studies in the region, Clune and Harrison (2009) argue that *T. granosa* shell matrix sites are indicative of regular occupations by large groups of people as part of ceremonial activities carried out after the wet season ends. This is a time of abundant resources, which encouraged greater social and cultural interactions between coastal communities. Groups in the study area should be seen as highly mobile peoples able to exploit specific resource types such as *T. granosa*, when conditions most favour its abundance (Clune and Harrison 2009:77).

Environmental and social factors have also been argued to drive mound formation. Increasing population and social interaction during the late Holocene would necessitate the need for a reliable and plentiful food source, and some have suggested the targeting of the fast reproducing *T. granosa* mollusc is one example of broad foraging adaptations in Australia at this time (Beaton 1985; Lourandos 1997; Veitch 1999). Some have argued more specifically that localised ecological conditions favouring shellfish growth coupled with these social and cultural changes were the primary motivator for exploitation of this resource type (Clune and Harrison 2009:77-78; Faulkner 2009:822; 2013:1-2; O'Connor 1999).

In his evaluation of his and others archaeological investigations of Dugong bone mounds located in the Torres Strait, McNiven (2013:552-553,573-574) argues for a symbolic interpretation for mounding activities. Bone mounds at Mabuyag Island, Torres Strait, were often positioned with a line of site to known Dugong hunting areas, carefully arranged rather than carelessly dumped (McNiven 2013:568). Shell middens and mounds at Goemu village, Mabuyag Island, vary in size and composition and were largely clustered around towns and villages (McNiven 2013:570). Shell mounds are interpreted as deliberate and purposeful structures within the landscape, and should be seen as being in a continuous state of construction. The presence of mounded shell and bone structures would act as a reminder of past social gatherings (McNiven 2013:576). These mounds differ from the shell middens and mounds of Albatross Bay, however this interpretation has important implications for understanding mound building more broadly in the region.

2.3: Taphonomy and vertebrate fauna

It is generally agreed by most researchers working on the northern coastlines of Australia that shellfish consumption was one component of a wider food production strategy targeting available terrestrial and marine resources. The analysis of vertebrate fauna is significant in relation to understanding site use and function, human predation strategies, and the impact of localised environmental changes over time (Lyman 1994:2,161; Yesner 1988:53,56).

Currently, no in-depth study of vertebrate faunal preservation within shell matrix sites has been undertaken for northern Australian sites. This is partly to do with the fact that generally, shell matrix sites are thought to be an excellent preserver of artefacts and organic materials due to their alkaline characteristics (Alvarez et al. 2011:1; Claassen 1998:13; Erlandson 1994:5). Therefore, if vertebrate fauna were butchered and consumed at these locations, a significant body of evidence should remain. Yet there are several other factors, both passive and active, that influence preservation of vertebrate fauna at any site (Lyman 1994:162). For bone to survive within a deposit a stable environment is most suitable, which a shell midden or mound may not be able to provide despite its alkalinity (Claassen 1998:53,54; Fanning et al. 2016:11; Waselkov 1982:73). Moisture content, fluctuating water levels and the surrounding temperature are equally as important as pH for bone to preserve *in situ* (Claassen 1998:53; Linse 1992:329)

Understanding these processes is essential if a deeper appreciation of the site composition is to be reached (Claassen 1998:53). Such factors were explored in an experimental study by Linse (1992), who argued that the inorganic components of bone, such as hydroxyapatite, are susceptible to diagenesis in alkaline environments (Linse 1992:327). Though her results for the archaeological bone were ultimately inconclusive, Linse (1992:338) observed an interesting qualitative aspect about the bones exposed to a more alkaline environment; they were chalky in texture and more susceptible to fragmentation. Shell matrix sites have a complex soil chemistry and this should be considered when evaluating vertebrate faunal preservation (Claassen 1998:85).

Importantly, differential preservation of bone is common between different taxonomic groups, and this can present a problem in reconstructing the role of vertebrate fauna at coastal sites. Fish bones, smaller and more delicate than terrestrial animals, are highly susceptible to breakage and exhibit lower recovery rates (Lyman 1994). This can be due to a variety of factors including climate, sedimentary processes, and sampling biases. It is well established that weathering processes have an impact on preservation of bone in an assemblage (Behrensmeyer 1978). Trampling and scavenging at shell matrix sites are also important considerations (Faulkner 2013:79; Ulm 2002:91).

An example of this problem can be seen in the preservation of fish bones from eight coastal sites located along the southeast Queensland coast. Walters (1985, 1989) argued that intensive discard of fishbones at these sites signals intensification of regional networks and population growth. He maintains that archaeological evidence from a range of sites in south east Queensland indicates an increase in the amount of fish bone discard. He argues that this indicates a semi sedentary marine economy and the development of social exchange in the region (Walters 1986, 1992). After synthesising data from these sites and others within the region, Ulm (2002:80-89,91-92) argues that evidence for fishing intensification through the late Holocene is problematic given the limited consideration for the taphonomic affects acting upon fish bones, issues with comparing different sites, and sampling concerns. Interpreting coastal resource use requires an understanding of all the components of the site under examination, and a firmer grasp of the taphonomy at coastal sites more broadly can assist in this.

Another reason vertebrate fauna have not received focused research in the past is due primarily to the small quantities and rates of preservation (Beaton 1985:4; Harrison 2009:88). While excavating several shell middens and mounds near Richmond River, NSW, Bailey (1975:46) simply states that both fish and mammal bone are “sparsely represented throughout the deposit”. During his excavations at Weipa, he indicates that based on the highly fragmented data only two conclusions can be drawn, that either large quantities of non-molluscan food sources were consumed leaving no evidence in the archaeological record, or that shell matrix sites only represent targeted predation of shellfish (Bailey 1975:XVII31).Beaton (1985:4-6) characterises the mammal and fish bones found at Princess Charlotte Bay as contributing little to the overall weight of the midden, and goes so far as to say they are preserved in “insignificant quantities”, offering that this indicates minimal consumption of these food types. Faulkner (2013:106) offers a similar conclusion to Beaton, suggesting that the low representation of vertebrate fauna within assemblages on the Point Blane Peninsula likely reflect the preference for molluscs as a food staple in these areas. The faunal remains were analysed to confirm species type where possible, with the results suggesting the majority were local taxa to the area (Faulkner 2013:105). Vertebrate faunal material is thus acknowledged as present within excavated shell matrix deposits, but are considered unlikely to assist in interpreting site use.

Whilst vertebrate fauna have not been researched in detail at shell matrix sites, the need for further insight into post depositional processes affecting preservation has been noted. Shiner et al. (2013:70) identified taphonomy as a key area for research to better understand the internal stratigraphy of shell mounds and middens. Bourke (2012:134) notes that within a shell matrix context the variety of taphonomic process that impact bone preservation are not yet fully understood. Morrison (2015:25) and Morrison et al. (2018:24) also observe this problem, and further argue that whilst shellfish consumption is the focus at shell matrix sites, the role of vertebrate fauna needs to be clarified.

2.4: Summary

A review of the past research of shell matrix sites in northern Australia has identified a number of key areas of interest and debate. It is now generally agreed that the shell matrix sites at Albatross Bay are anthropogenic in origin. The importance of shellfish predation and consumption to Aboriginal groups occupying the region continues to be the focus of most research in the region. Vertebrate fauna are seen to play a minimal role in and around shell matrix sites, but there is as yet no direct synthesis of the data. Understanding any potential preservation issues could help clarify the actual role vertebrate fauna played at these sites, which is the primary focus of this investigation.

Chapter 3: The Study Area

This chapter presents a detailed synthesis of environmental and archaeological data for Albatross Bay. This involves an examination of past and current ecology and environmental change, as well as investigations of shell matrix sites undertaken at Prunung. A comprehensive review of work undertaken by Morrison (2010; 2015) on three shell matrix sites, SM:88, SM:91 and SM:93, will be summarised in relation to this thesis. This will bring greater clarity to understanding the taphonomic factors affecting shell matrix sites within the study area, thus providing important context for an investigation of preservation of vertebrate faunal material.

3.1: Physical environment

Four major rivers flow into Albatross Bay: the Pine River, Mission River, Embley River and Hey River (Figure 2). The Bay is characterised by relatively calm waters contrasted with the rougher seas of the adjacent Gulf of Carpentaria. Situated in the North Queensland tropics, the Albatross Bay region is exposed to a variety of climactic processes, from heavy rainfall to periods of relative aridity – with a strong seasonal dimension. The months preceding the monsoon season are characterised by increasing humidity, temperature and thunderstorms, including cyclones (Specht et al. 1977:19). These weather patterns culminate in the full monsoon, typically arriving in January to February. It has been observed that the tides appear higher during these wetter months as opposed to the dry season (Morrison 2010:27). Grass fires are common during the dry season and fires along Cape York have been observed, from the start of the dry season intensifying towards the end of the dry season (Crowley and Garnett 2000:15-17; Eggleton and Taylor 2008:83).

Average temperatures based on monthly averages since 1959 range from a minimum of 18.8°C in August to 24.0°C in January and February, while reaching maximums of 30.4°C in July to 34.8°C in

October (BOM 2018). Average annual rainfall since 1914 sees 1,784mm fall across the region, which occurs predominantly from December to April (approximately 1625.9mm) also known as the wet season (BOM 2018).

The region's underlying geology is sedimentary with gently undulating erosional plains. It is predominately comprised of Cainozoic ferruginous duricrust plateaus, comprising the Weipa bauxite plateau (Taylor and Eggleton 2004). This land system comprises dense units of bauxite 3-12m thick, varying in depth with increasing topography (Taylor and Eggleton 2004:350-351). Overlying this is a series of locally sourced sediments known as "red soil", and in topographically low areas the whole is overlain by a series of mottled clays, either a white/pale grey colour or a reddish brown (Taylor and Eggleton 2004:351).

The geomorphology of Albatross Bay is defined by the four rivers that flow into it. Mangrove forests line the estuaries, with low lying chenier ridges located within and behind the more exposed estuarine shell matrix sites (Bailey et al. 1994:74). These mangrove forests are concentrated around narrow, swampy plains formed by the progradation of intertidal mud flats. Preliminary dates indicate that this process that has been occurring in the Bay since at least 3,000 BP (Bailey et al. 1994:74-75), though there has been limited investigation of this to date. This is comparatively recent when compared with other parts of north Queensland such as at Princess Charlotte Bay, where progradation is evidenced from 6,000 BP (Chappell and Grindod 1984:208-212; Bailey et al. 1994:74). The vegetation of the low lying land beyond the mangrove forests typically comprises tall, open sclerophyll (*Eucalyptus*) woodland, with patches of vine forests punctured by networks of streams (Bailey et al. 1994:74; Thomas 2004:27). The vine forests are thicker along low lying landforms such as the valley floor and Holocene coastal plains (Bailey et al. 1994:74; Thomas 2004:27). *Melaleuca* trees grow in swampy land between the coast and the Holocene tidal flats, with Holocene beach ridges characterising the open coastline and exposed coastal land within the bay.

Moving inland, the higher Holocene tidal flats are generally sparsely vegetated with edible succulents (Bailey et al. 1994:74).

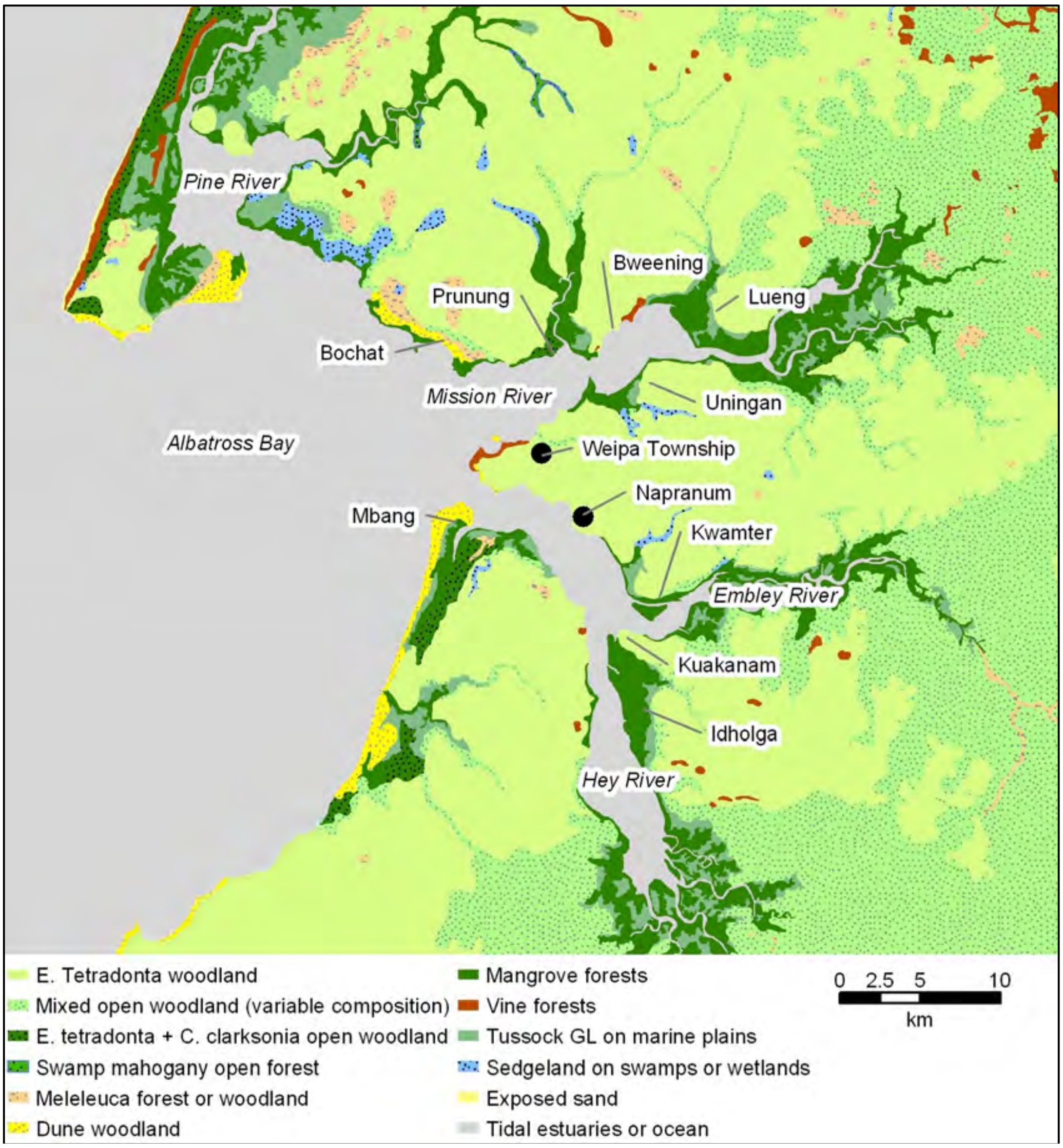

Figure 2 Albatross Bay with key sites, river systems and ecosystems (from Morrison 2010:30).

A diverse range of fauna are found within Albatross Bay. Different habitats play home to different faunal species, with overlap between habitats not uncommon. Thomas (2004) undertook an extensive study of the habitats and terrestrial vertebrate fauna present around Weipa, just south of Prunung. Similar species are likely to have been present around Mission River. Commonly observed native terrestrial fauna in woodland habitats include mammals such as *Canis familiaris* (dingo) *Isoodon macrourus* (northern brown nosed bandicoot), *Pteropus complex* (flying fox complex), and *Macropus agilis* (agile wallaby). Aves are among the most common terrestrial group, with species such as *Tadorna radjah* (radjah shelduck), *Fregata* sp. (frigatebird sp.) and *Threskiornis molucca* (Australian White (Sacred) Ibis).

Feral animals have a significant impact on the landscape as well as native fauna. Common feral species in the region include *Felis catus* (feral cat) and *Sus scrofa* (feral pig). By far the most common feral animal within the Albatross Bay region, particularly in riparian habitats, is the *Bufo marinus* (cane toad). It is poisonous to feral and native animals alike when mouthed or consumed, evidenced by the declining numbers of *Dasyurus hallucatus* (northern quoll).

3.2: Palaeoenvironments of the Holocene

The Last Glacial Maximum (LGM) ending at approximately 17,000 BP, and the beginning of the early Holocene at approximately 11,650 BP, was a period of significant change and one that ultimately shaped the local environments of the Holocene.

The LGM was characterised by drier conditions, decreasing rainfall and lower sea levels. This transitional period is arguably the driest period in north eastern Australia in at least the last 40,000 years (Johnson et al. 1999; Kershaw 1994; Kershaw and Nanson 1993). Studies investigating sedimentary changes in the Gulf of Carpentaria have indicated that from approximately 12,000-40,000 years ago, the Gulf was a large lake bounded by the Northern Territory eastern coast and the western coastline of the Cape York Peninsula. The lake was at its height at 18,000 BP coinciding with the height of the LGM, eventually becoming fully marine by 10,500 cal. BP (Reeves et al. 2008; Torgerson et al. 1983, 1988). The period of time just prior to the early Holocene is characterised by a drier climate and reduced monsoon system (Hope et al. 2004; Johnson et al. 1999; Reeves et al.

2008), evident from the expansive sclerophyll woodlands, a species resistant to a drier climate (Haberle and David 2004; Hope et al. 2004; Johnson et al. 1999; Reeves et al. 2008; Kershaw 1994).

The early to mid-Holocene by contrast is generally viewed as a warmer and wetter climactic period than present (Reeves et al. 2013) The Holocene Climactic Optimum's (HCO) affects were most likely felt in northern Australia between approximately 3,700-6,000 BP, with evidence of a gradual increase in effective precipitation contrasted by the aridity of the preceding period (Kershaw 1995; Lees and Clements 1987; Luly et al. 2006; Prebble et al. 2005; Schulmeister 1992; 1999; Shulmeister and Lees 1995). For the Australasian region this was evident from approximately 4,000 BP with pollen records suggesting the height of these changes was reached at 3,000 BP (Shulmeister and Lees 1995). The mid-Holocene is characterised by the increase of mangrove forests in some areas of northern Australia (Woodroffe et al. 1985; Hope et al. 2004). Radiocarbon dating from the south portion of the Alligator River, Northern Territory, indicates that these extensive Mangrove forests developed approximately 6,000-7,000 BP and flourished for approximately 1,000 years, when they subsequently began to recede (Woodroffe et al. 1985). Mangrove forests were approximately 2.5 kilometres from the banks of Three Quarter Mile lake approximately 3 kilometres closer than present (Luly et al. 2006:1091). To date, no detailed study of mangrove forests of the mid-Holocene at Albatross Bay has been undertaken.

For the Queensland region, arguments have been made for smoothly falling sea levels in line with climactic changes based on analysis of groups of fossil microatolls from coral reefs (Chappell 1983; Chappell et al. 1983). Some have suggested oscillating sea level change is more likely. Lewis et al. (2008) examined fixed biological indicators along the eastern Australian seaboard and up to Torres Strait, which suggested sea levels underwent oscitations at 4,500-4,800 BP and at 2,700-3,000 BP. Perry and Smithers (2011) conversely suggest that the fluctuations identified by Lewis et al. (2008) were the result of data interpolation, and that the data gathered by Chappell et al. (1983) remains the best evidence for sea level change. The rate of sea level fall is likely to have varied regionally, extending up to 3m and 1.5m at Cape York Peninsula (Rhodes 1980; Chappell 1982), and 0.8m to 1m during the mid-Holocene at Torres Strait (Woodroffe et al. 2000). Geophysical modelling suggests variable hydro-isostatic responses in the region may be the reason for these differing results (Lewis et al. 2013:30)

The mid- to late Holocene is generally characterised by drier and more variable conditions (Hope et al. 2004:118; Reeves et al. 2013). This is evident from 4,000 BP with more frequent and severe ENSO events in northern Australia. This means that climate in the Holocene was lower in precipitation and increasing aridity in some areas, while other regions saw greater amounts of rainfall. Different types of vegetation flourished in some areas depending on these climactic oscillations (Hope et al. 2004:119). This is evidenced by studies undertaken at Three Quarter Mile Lake, where Luly and colleagues (2006) noted a trend towards open *E. tetradonta* woodlands, evident in the pollen record for the site, although swamp habitats were observed to have occurred close to the waters' edge.

There is some relative stability in some areas. Pollen and charcoal gathered from Big Willum Swamp at Weipa indicate an extensive swamp phase from 2,200-8,000 BP when it became a permanent body of water (Stevenson et al. 2017). This relatively stable inland wetland habitat is rare for the monsoonal tropical region of Australia because it spans almost the entire Holocene (Stevenson et al. 2017:26). Whilst few comparable studies have been undertaken in the local region, the differences in vegetation and habitat observed during this study highlights the degree of localised climactic variation.

The climate oscillations from the mid-to late Holocene impacted coastal dynamics in the region. Studies completed by Hayne (1992) at Bochat (Figure 2), and Bailey et al. (1994) at Prunung (Figure 2) indicate that the beach ridge plains at Albatross bay were formed by 2,500 BP, while Stone (1992:148-153) argued that they date to 2,700-4,500 BP at Prunung and 1400 BP at Uningan (Figure 2). He further showed that two landward ridges returned an older date of 2,790±80 BP to 4,530±80

BP, with little to no shell in the upper layers, while those closer to the sea dated to 790±220 BP to 1490±80 BP, with a mudflat punctuating the two ridges and a high presence of *T. granosa* shell (Stone 1995:92). The beach ridge plains at Albatross Bay are therefore most likely a late Holocene development, however the limited localised studied undertaken remains problematic (Morrison 2010:43).

3.3: Regional archaeological record

Numerous archaeological surveys and excavations have been completed in the Albatross Bay region, revealing a rich and diverse number of shell matrix sites. These sites are largely concentrated around waterways and estuaries stemming from Albatross Bay (Bailey 1993:3) (Figure 3).

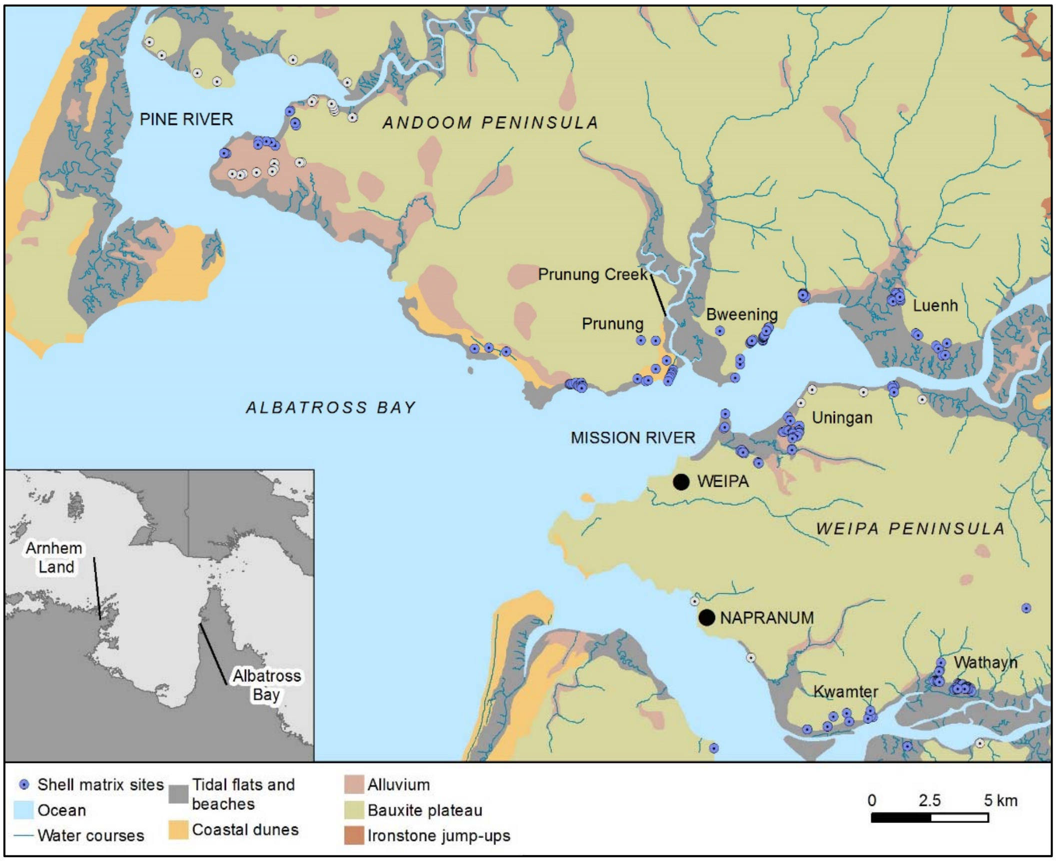

Figure 3 Mission River showing location of places mentioned in text along with known shell matrix sites (from Morrison 2015:2).

Of the 259 sites with recorded spatial information for the Albatross Bay region, 50% are located within 250m of estuaries, while 5% of sites are documented more that 750m from the shoreline (Morrison 2013b:83), and almost 60% of shell matrix sites occur on bauxite substrates (Morrison 2013b:84-85). Site morphology generally comprises shell mounds or elongated middens less than 2m tall with diameters less than 30m (Morrison 2013b:84), and in 97% of cases have a surface composition of *T. granosa* (Bailey 1994; Morrison 2013b:84). The region north of Mission River contains 115 documented shell matrix deposits across Prunung, Bweening, and Luenh, while south of Mission River close to Weipa are 124 documented shell matrix sites (Morrison 2013b:82).

Occupation of the Albatross Bay region extends from at least 3,500-4,000 BP based on radiocarbon determinations from shell mounds at Wathayn (Figure 3) (Holdaway et al. 2017:11-12). The majority of sites date between from 500-2,500 BP (Holdaway et al. 2017:11-13; Shiner et al. 2013). There appears to be a hiatus in mound construction and occupation between 1,500-1,800 BP, however it is unclear as to whether these periods are reflective of a lack of data or a cessation of shell mound construction (Morrison 2014). Between 1,001-1,500 cal. BP, an increase in mound building is observed, with the majority occurring between 501-1,500 cal. BP (Morrison 2014). Several shell mounds along Mission River were constructed after 501 cal. BP, with the youngest site, SM:186, being effectively modern (ca. 1850-1900 CE) (Morrison 2014:6).

Of particular relevance to this current research project are the results of studies undertaken at Weipa, south of Prunung at the junction the Embley and Hey Rivers (Bailey 1975a) and Bweening, an exposed rocky headland on the northern side of the Mission river, east of Prunung Creek (Morrison 2010:184) (Figure 2 and 3). Bailey's (1975a; 1977:136) excavations at Kwamter, Weipa (Figure 2) revealed significant proportions of vertebrate fauna. A total of 264 bone fragments weighing 140g were identified, with a combined mean meat weight of 3.8 kg/m^3 compared with 125 kg/m^3 of shellfish (Bailey 1975a: VII29). The lowest three excavated layers exhibited the lowest proportions of vertebrate fauna (Table 1). Morrison excavated 14 shell matrix sites at Rhum Point, Bweening, with the largest (SM:147) measuring 75m long, 15m wide and almost 1.5m high. A smaller band of shell matrix sites are located at Rhum point west within dry notophyll vine forests, and two isolated shell matrix sites are located further south (Morrison 2013a:167). These sites occur in open woodlands with mangrove forest and vine forest located close by (Morrison 2010:182). The largest site at Bweeining is SM:147, returning an age range of between 818-1,067 cal BP (Morrison 2010:219). No vertebrate fauna has been located at Bweening thus far, with SM:115 and SM:136 yielding small amounts of crab fragments (Morrison 2010:218,231).

Layer	Total Weight (g)	Density (g/m^3)
1	-	-
2	11	110
3	4	40
4	3	27
5	7	70
6	12	104
7	10	95
8	8	84
9	6	75
10	10	125
11	13	108
12	9	72
13	2	22
14	9	64
15	8	47
16	12	120
17	13	92
18	-	-
19	3	30
20	-	-

Table 1 Weights of bone found during excavations at Kwamter, Weipa, per excavated unit (after Bailey 1975:XII30).

3.4: Prunung study area

Prunung is located within the Thaynakwith language area (Thancoupie 2007). It comprises a wide beach ridge plain which has formed adjacent to a bauxite plateau at the mouth of Mission

River as it widens to form an estuary flowing into Albatross Bay, extending from Prunung Creek in the west and mangrove forest in the east (Figure 3) (Bailey 1993; Morrison 2010:238; 2015:3).

Vegetation primarily consists of an open dune woodland increasing in density in a westerly direction, with a seasonal swamp lying on the beach ridge plain (Morrison 2010:238). Vegetation close to the swamp includes *Melaleuca* spp. forests, while dry notophyll rainforests are found in the elevated areas surrounding the swamp (Morrison 2015:3). Erosion has occurred to the southwest of the area exposing mixed shell and sand deposits interpreted by some as natural (Bailey 1993:4).

Important to note is the range of mining and recreational activities that occur within the Weipa and Andoom regions. These processes involve total stripping of natural vegetation, development of tracks for mine vehicles and the clearing of some tree coverage for firewood and recreational activities that have been common since the 1970's (Morrison 2010:240). At Prunung, mining activities and recreational fishing to the southwest of the beach have left distinctive marks in the landscape, including the construction of a gravel track into the area (Morrison 2015:3-4). SM:95 and SM:96 have been significantly damaged due to shell mining and repeated heavy vehicle traffic (Morrison 2010:240-241). SM:88, SM:91 and SM:93 remain relatively undisturbed.

Prunung was first researched by Beaton who collected a range of radiocarbon determinations for shell matrix sites here. His work was never formerly published, and has been later summarised and interpreted by others (Bailey et al. 1994; Stone 1995). Bailey et al. (1994) completed a series of archaeological surveys and excavations at Prunung, designed to differentiate between anthropogenic, natural and scrub fowl shell accumulations. Stone (1992, 1995) undertook an analysis of the parallel beach ridge plains at Prunung, determining that all the shell accumulations were not anthropogenic.

Morrison (2010) excavated a series of shell matrix sites on the beach ridge plain at Prunung (Figure 4). The results of the excavations related to SM:88, SM:91 and SM:93 are summarised below.

The following section describes each site, its stratigraphy and composition, and information relevant to the vertebrate faunal recovery and analysis specifically focused upon here (Table 2).

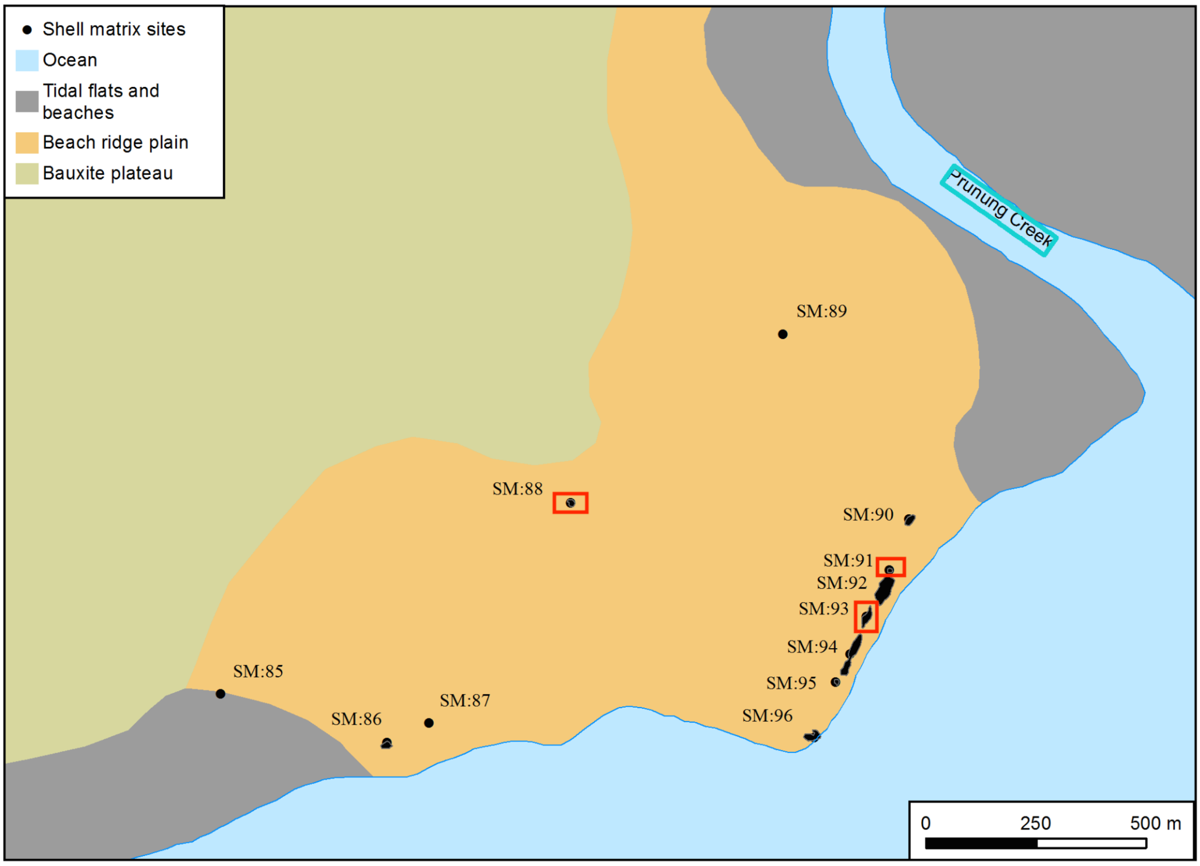

Figure 4 Location of shell mounds mentioned in text. Shell matrix sites under investigation for this thesis highlighted in red (after Morrison 2015:2).

	SM:88	SM:91	SM93
Shell matrix shape	Circular mound	Circular mound	Elongated mound
Maximum Height (m)	0.75	0.3	1.8
Diameter (m)	18	5	18
Length (m)	-	-	50
Deposit volume (g)			
Age estimate	Basal determination WK-14508: 289-463 cal BP; upper determination WK-14509: 431-560 cal BP.	Upper determination Wk-13788: 1-4 cal BP	Basal determination: Wk-11861: 658-859 cal BP; upper determination Wk-11862: 487-636 cal BP.
Recorded stratigraphic layers	3	3	15
Vertebrate fauna (g)	15	3	34.1
Excavated section size	50cm² test pit excavated in the least disturbed portion to a maximum depth of approximately 70cm	50² test pit excavated at highest point of the mound to a maximum depth of approximately 35cm	100cm² test pit excavated at level area due to stabilisation issues with the highest point. Excavated to a maximum depth of approximately 120cm
Distance from the shoreline (m)	450	30	30 (approx)

Table 2 Summary of comparable data for SM:88, SM:91, SM:93. Age determinations are taken from *T. granosa* shell samples (after Morrison 2015:7).

3.4.1: SM:88

SM:88 is a dome-shaped mound located 800 meters northwest of the main group of shell mounds at Prunung Point, placing it considerably further inland that the other shell mounds being examined here (Figure 4). It is located along a narrow sand ridge between the seasonal swamp and the edge of the bauxite plateau. This means that the low-lying areas surrounding the site are inundated during the wet season. An approximate 3m by 4m section of the shell mound has been removed due to quarrying, with the remainder of the site intact (Morrison 2010:272-273).

The stratigraphy of the site comprised three layers. The first (Layer A) was 15cm deep and consisted of whole and fragmented *T. granosa* shell, with humic soils and rootlets throughout. This was followed by a 45-50cm deep layer (Layer B) dominated by *M. hiantina* and *T.granosa* with a high proportion of whole shell, interspersed with high quantities of darker soil than the first layer. The base layer (Layer C) comprised a 15cm fine grained sandy layer with frequent bauxite pisoliths and decreasing fragments of shell with depth (Morrison 2010:273) (Table 3). Radiocarbon determinations from between Layers B and C returned a basal determination of 431-560 cal. BP (Morrison 2015:17).

Vertebrate fauna was found throughout SM:88 with concentrations between excavated units (XU's) 2-5, with a total weight of 14g for the whole site. None of these bones were identified to any taxonomic category (Table 3).

XU	Mean depth (cm)	Gross weight (g)	6mm residue (g)	2mm residue (g)	Soil (g)	Stone (g)	Otoliths (No.)	Crab Fragments (g)	Unidentified Bone (g)
1	7.27	21700	9455	3000	9245	495	-	-	-
2	11.78	24400	8601	3700	12099	205	-	5	5
3	11.95	24500	8168	3500	12832	130	-	5	2
4	10.22	24900	8555	3500	12845	130	1	5	3
5	9.23	26000	9727	3400	12873	400	-	5	4
6	9.52	27500	7012	2500	17988	6048	-	1	-
7	7.28	16000	3452	6500	6048	655	-	-	-

Table 3 Summary of bulk data for SM:88 including number of non molluscan faunal remains per XU (after Morrison 2010:274).

3.4.2: SM:91

SM:91 is a low shell mound site on a sandy substrate with high proportions of naturally occurring shell as well as *T. granosa* shell in a variety of sizes, likely due to its exposed location on the active beach (Table 4). Limited vegetation surrounds or protects the mound, leaving it exposed to abiotic taphonomic factors such as storm surges and the natural deposition of sand, shell and debris (Morrison 2010:261; 2015:12).

The stratigraphy of the mound consisted of three distinctive layers. The upper 3-5 centimetres (Layer A) contained whole and fragmented shell surrounded by humic soils, including bauxite pisoliths and sand in moderate quantities. Layer B comprised densely packed *T. granosa* shell with small quantities of other species, approximately 18cm deep (Figure 5). The bottom layer (Layer C) was culturally sterile and comprised a yellowish orange sand with frequent bauxite inclusions, and only a few shell fragments. Radiocarbon determinations from between layers B and C returned a conventional radiocarbon age of 469 BP, however when calibrated the dates became effectively modern (Morrison 2015:12).

XU	Mean depth (cm)	Gross weight (g)	6mm residue (g)	2mm residue (g)	Soil (g)	Charcoal (g)	Stones/rocks (g)	Crab Fragments (g)	Unidentified Bone (g)
1	4.2	11500	4811	3000	3689	1	260	-	-
2	3.35	13000	4932	2500	5568	1	365	-	0.5
3	3.6	13000	4637	2500	5863	3	230	1	1.5
4	4.25	15000	4673	2500	7827	5	205	1	1
5	2.8	12500	3001	3000	6499	2	295	-	-
6	4.5	14250	3384	2500	8366	2	395	-	-
7	3.4	13000	3062	2000	7938	1	370	-	-
8	4.75	16500	4026	4000	8474	0	475	-	-

Table 4 Summary of bulk data, SM91 (after Morrison 2010:263).

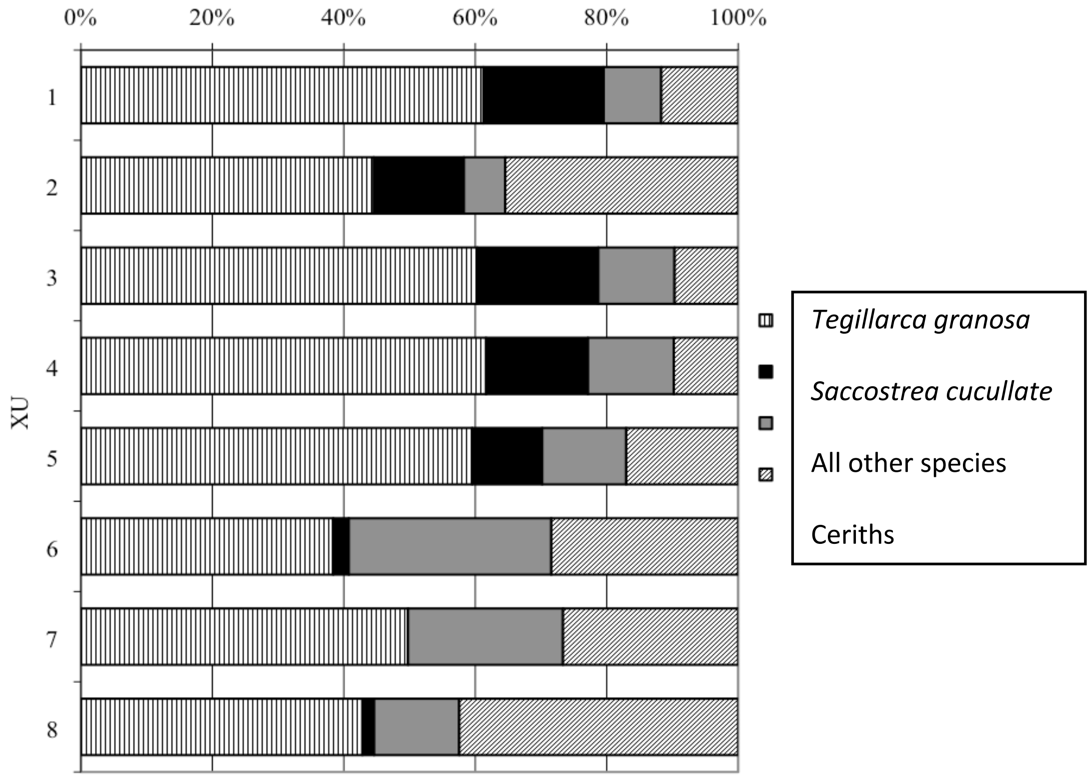

Figure 5 MNI per XU, SM:91 (after Morrison 2015:13).

The vertebrate fauna in SM:91 was found in reasonable numbers but these amounted to a very low weight of 3 grams (Table 4). These were concentrated at XU's 2-4. No specimens were able to be identified.

3.4.3: SM:93

SM:93 is a low and elongated shell mound, adjacent to the shoreline. It rests on the most seaward gently sloping beach ridge, with its 1.8m peak near the centre. The mound appears to have suffered some small surface damage due to shallow animal burrowing and fallen trees. Much of the mound surface is also covered with thick notophyll vine forest with humic material and small grasses and shrubs protruding at some points (Morrison 2010:250).

The stratigraphy of the site primarily consists of densely packed shell, with varying degrees of shell fragmentation and presence of soils and ash defining the individual stratigraphic units (Layers A-O) (Figure 6; Table 5). The upper layers contained loosely packed shell dominated by *T. granosa* with *M. hiantia* also represented. The middle layers were distinguished by the presence of soils and greater quantities of broken shell, while the lower levels were dominated by higher proportions of fine sediments, ash, and charcoal (Morrison 2010:250; 2015) (Figure 6).Radiocarbon determinations from the lower stratigraphic layers indicate the first accumulations occurred between 658-859 cal. BP (Morrison 2015:8).

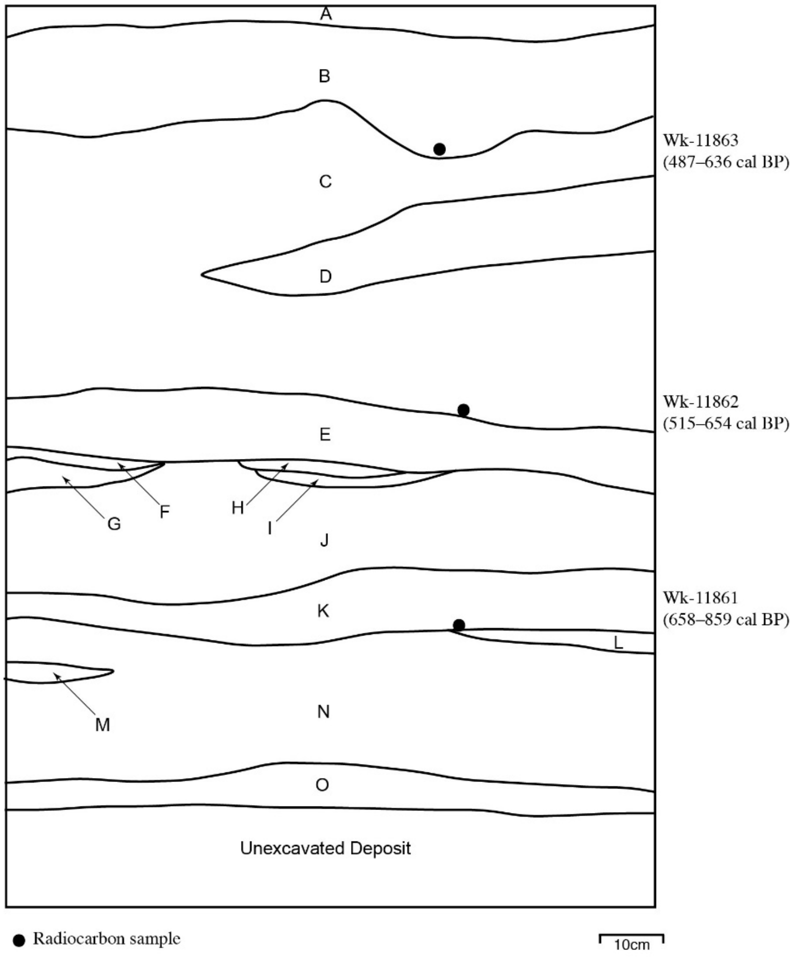

Figure 6 East facing section with stratigraphic layers (A-O) and radiocarbon determinations, SM:93 (from Morrison: 2015:8).

XU	Mean depth (cm)	Gross weight (g)	6mm residue (g)	Non-diagnostic shell (g)	Diagnostic shell (g)	Charcoal (g)	Stones/rocks (g)	XU weight (kg)	Bone (No.)	Bone weight (g)
1	2.86	41900	26337.30	18009.50	8327.80	-	59	41.9	-	-
2	8.07	48200	42111.10	25562	16549.10	0.60	56	48.2	4	3.4
3	12.86	50700	48712.10	21042.50	27669.60	3	31	50.7	4	1.5
4	18.15	35200	27510.60	2794.50	24716.10	2	5	35.2	2	10
5	23.05	39700	34010.21	3529.50	30480.71	3	3	39.7	3	1.5
6	27.73	42700	32893.01	5727.51	27165.50	14.70	9	42.7	5	6.0
7	33.00	36400	29954.01	3796.90	26157.11	5.50	122	36.4	3	1.0
8	36.25	12400	11732.71	1995.90	9736.81	3	13	12.4	-	-
9	39.45	36000	31504.70	4673.00	26831.70	6	7	36.0	-	-
10	44.86	37000	34880.00	6597.00	28283.00	2.50	22	37.0	-	-
11	50.81	43000	41188.80	5245.00	35943.80	7	20	43.0	4	5.0
12	56.40	46900	39258.50	5632.00	33626.50	12.50	18	46.9	1	0.1
13	60.64	35700	21575.80	4940.00	16635.80	24	419	35.7	17	6.0
14	65.55	50700	28283.40	9974.00	18309.40	28	40	50.7	12	2.0
15	70.56	37200	16559.30	7260.00	9299.30	20	61	37.2	2	1.5
16	75.31	46400	23858.00	8157.50	15700.60	32	12	46.4	2	0.1
17	79.48	33000	18708.22	4255.02	14453.20	49	86	33.0	-	-
18	84.54	46000	25489.50	8106.00	17383.50	37	13	46.0	1	0.5
19	89.61	43600	17376.00	7462.00	9914	12	17	43.6	6	3.0
20	93.80	50400	17544.60	6238.00	11306.60	35	117	50.4	-	-
21	99.38	49200	4657.50	1193.00	3464.50	5	415	49.2	4	1.5
22	104.61	41000	2199.00	1282.00	917.00	2	631	41.0	-	-
23	109.09	41900	702.50	443.00	259.50	1	407	41.9	-	-
24	116.06	87900	-	-	-	-	-	87.9	-	-

Table 5 Summary of bulk data, SM93 (after Morrison 2015:9).

The vertebrate fauna within SM:93 was recovered from 6mm residues, with mammal bone fragments, some crab claw fragments and one fish otolith recovered. A possible *Isodoon* sp. (bandicoot) mandible was recovered as well as a tooth, with no other formal identification undertaken due to the fragmentary nature of the dataset. The highest proportions of vertebrate fauna occurred in XU's 2-7, 11-16, 18-21 (Table 5). Crab fragments were also found in small quantities within SM:93, which were thought to be *Scylla serrata* (Giant Mud Crab).

3.5 Analysis of 2mm Residues

Of particular interest to this investigation is the analysis of samples from 2mm residues for SM:88, SM:91 and SM:93 (Table 6). The 2mm residues were retained and underwent preliminary lab analysis to determine if sampling bias was the cause of minimal recovery of vertebrate fauna (Morrison 2010:150:294). This closer investigation did not produce higher quantities of bone compared with the 6mm residues. This would suggest that a sampling bias is not the cause for such low quantities of bone occurring within shell mounds at Prunung (Morrison 2010:293-295).

Site/XU	2mm residue (g)	Charcoal / vegetation (g)	Bone (No.)	Bone (g)	Stone artefacts (No.)	Stone artefacts (g)	Crab (No.)	Crab (g)
SM:88 XU2	2547	4	12	0.45	2	0.02	9	0.03
SM:91 XU2	2662	18	82	3.2	4	0.7	-	-
SM:93 XU6	3752 (50% sorted)	94	10	0.7	-	-	1	<0.5

Table 6 Charcoal, vegetation, bone, stone artefacts, and crab recovered from 2mm residues at Prunung (after Morrison 2015:19).

3.6: Summary

The Albatross Bay region has undergone significant climactic change over time. Today, the region is typified by seasonal monsoonal conditions followed by periods of relative aridity. These fluctuating weather conditions are not conducive to bone preservation, particularly fish bone. A variety of vertebrate faunal species are present in the region, which were likely accessible to Aboriginal groups in the mid to late Holocene. SM:88, SM:91 and SM:93 have been the subject of previous investigations (Morrison 2010; 2013a; 2013b; 2015), giving insight into their stratigraphy and composition. They contain higher proportions of vertebrate fauna than other shell matrix sites at Prunung, and have been exposed to a variety of process that impact their preservation. Determining to what extent this has impacted on the preservation of vertebrate fauna remains an important question.

Chapter 4: Methods

4.1: Sampling

Three shell matrix sites were selected as part of this study; SM88, SM91 and SM93. These deposits were analysed as part of Morrison's doctoral thesis (Morrison 2010; see also 2015), and access to the source materials was provided by Flinders University. Aside from the easy access to the data, these shell matrix sites were chosen because;

- They contained high proportions of non-molluscan fauna from 6mm residues when compared to other sites in the study area, and 2mm residues had been subjected to preliminary analysis (Morrison 2010:278);
- These sites are located in different landscapes within the Prunung study area (see Figure 4). Differential preservation may occur depending on the location of the site, therefore analysing vertebrate fauna from these places would allow for a comparison; and
- The morphology and physical characteristics differ, allowing for an analysis of the relationship between bone recovery and shell matrix site morphology.

Whilst every specimen from all shell matrix sites were weighed and measured, a sampling strategy using the top 50% by weight of specimens per stratigraphic unit, per shell matrix site, was used here for further analysis of taphonomic processes. This was done because;

- The dataset was highly fragmentary, meaning frequent handling of the smallest specimens could cause damage during analysis. Preserving the integrity of the dataset was a top priority;
- The study conducted here uses microscopic technology. The smallest specimens were often so minute that only limited analysis could be carried out; and

- Using the top 50% by weight per shell mound per stratigraphic unit ensured a consistent sample size.

Crab and other non molluscan faunal remains cannot be analysed for taphonomic modifications in the same way that bone fragments can, due to their composition. In the event that any specimens were later identified as non molluscan fauna, the next specimen by weight replaced the mis-identified fragment for modification analysis.

4.2: Specimen weight and dimensions

Each specimen was weighed and its dimensions calculated. This was completed for a variety of reasons. Low weight and small dimensions are generally indicative of an assemblage exposed to a variety of taphonomic processes. Further, a measurement of the total weight of all vertebrate fauna as compared with molluscan fauna has been the most common means of representing vertebrate remains derived from shell matrix sites (Faulkner 2013:79; Harrison 2009:88; Morrison 2010:259). Collecting this data allows for comparison with other datasets across north Australia.

It is important to note that weight as a means of understanding the significance of vertebrate faunal representation is problematic. There are a variety of factors that influence bone weight such as burning, weathering, and through the process of deposition and burial (Chaplin 1971:67; Reitz and Wing 2008; Uerpmann 1973:310-312). Using weight in conjunction with other physical parameters should give better clarity to the data. Each specimen was weighed using a Ohaus Pioneer Precision Balance with an accuracy of 410g at 0.001g, set on a precision balance table with wind guard to ensure greatest accuracy. Dimensions were taken using Mitutoyo Absolute digital callipers.

4.3: Specimen identification

Identifying the species of vertebrate fauna within the data set was attempted to establish;

- Types of vertebrates present at the site;
- Whether these species suggest a contribution to the diet of people using the shell matrix sites; and
- Whether taxonomic groups were differentially preserved

MNI (Minimum Number of Individuals) and NISP (Number of Individual Specimens) are the most common means of quantifying relative abundancies of fauna in zooarchaeological analyses, and have been extensively reviewed and debated from a zooarchaeological perspective (Brain 1969; Chaplin 1971; Daly 1969; Grayson 1984; Lyman 1984; 1994; Payne 1972; Reitz and Wing 2008; Uerpmann 1973). MNI means minimum number of individual animals present within a site, and may need to consider species variation, sex, or age (Lyman 1994:100; Reitz and Wing 2008:206). By contrast NISP Measures the number of identified specimens to a taxonomic group, which can be categorised as species, genus, or family (Lyman 1994:100). MNI is generally considered a more accurate quantification method, as it provides the lowest possible number of individual animals that had to be present to comprise the bone assemblage left behind today. By contrast a NISP count can be biased by high degrees of fragmentation in a dataset (Beisaw 2013:130).

Both these approaches require that a specimen, a part of a recognised skeletal element, can be attributed to a taxonomic group (Lyman 1994:100). The use of MNI and NISP for non-molluscan fauna have not often been carried out in northern Australian shell midden contexts due to the limited quantity and poor preservation; instead where possible bones were identified to a taxonomic group (Bailey 1977:136; Faulkner 2013:73; Harrison 2009; Morrison 2010; Morrison 2015). Even if a faunal assemblage has been significantly damaged over time, higher orders of taxonomic identification can be useful in clarifying aspects of site formation processes and cultural activities occurring in and around a site (O'Connor 2000; Uerpmann 1973).

Where possible, specimens were identified to genus or species (teeth for example could be identified to this level in most cases). Resource collections made available by the Palaeontology Department at Flinders University were used to identify as many specimens as possible to ascertain the common types of vertebrate fauna found in and around the excavated shell matrix sites. A system of classification was developed to identify the specimens as accurately as possible (Table 10). A size classification was not possible for fish, as fish can differ widely in size between species (Beisaw 2013:120). Each specimen was identified as precisely as possible.

Mammal size	Weight(g)	Class	Ave size	Weight(g)	Class
Small	<500	Mouse, rat	Very small	<0.05	Sparrow
Small-medium	500-900	Quoll	Small	50-100	Thrush
Medium	900-1300	Wallaby	Medium	100-400	Pigeon
Large	1300-40000	Kangaroo	Large	400-3000	Chicken
			Very large	>3000	Goose

Table 7 Body size classes.

4.4: Modifications analysis

The previous chapter indicates that bone preservation at shell matrix sites could be affected by a variety of taphonomic processes, brought about by biotic or abiotic agents. By identifying the physical characteristics these processes leave behind, a better understanding of the poor preservation of vertebrate fauna at these sites could be achieved. The following discusses each physical characteristic in turn.

4.4.1: Burning

Bone can become burnt from exposure to flame during roasting or through exposure to natural fire events. Experimental archaeological investigations have assisted in the interpretation of burnt bone. Heat is often found to alter colour, weight, rate of calcification, and susceptibility to fragmentation (Asmussen 2009;

Bennet 1999; Nicholson 1993; Stiner et al. 1995). The ways in which these changes are observed can be problematic. Heat alters bone as evidenced by colour changes, however these will differ depending on duration of heat exposure, and whether the bone was exposed to a direct or indirect flame (Bennett 1999:5-7). These colour changes will also be highly dependent on the taxonomic group, bone size and preservation prior to and during burning (Nicholson 1993:415). Bones exposed to direct heat become calcified, while those buried beneath the heat source show evidence of carbonization only (Bennet 1999; Stiner et al. 1995). Burnt bone can also show surface similarities to weathered or fossilised bones (Lyman 1994; Stiner et al. 1995). These concerns will be further considered during analysis of the results.

Fragmentation provides further evidence for exposure of bone to burning. The greater the exposure to heat, the greater the degree of fragmentation (Stiner et al. 1995:229). Cracks on the bone surface can be indicative of exposure to heat, and can indicate the nature of the bone being burned. Generally fresh bones (fleshed or de-fleshed) will exhibit evidence of both longitudinal splits and transverse cracks, polygonal cracking and evidence of warping, while dry and older bone will show shallower fractures and bending or warping (Whyte 2001:441-444; Asmussen 2009:529).

Measuring the rate of burnt bone involved documenting the colour of each specimen using the Munsell TM colour system. Specimens were then further categorised based on the temperature the bone was possibly exposed to. Unburnt bone will vary from pale browns, white or creamy colours to darker browns. Low heat will produce blackened bone as the bone becomes carbonized. White through to lighter blue tones is indicative of oxidization of the carbonized bone through increasing heat (Asmussen 2009:529) (Table 11). Complete calcification of bone exposed to high temperatures will leave only the mineral component after the flexible organic elements are lost (Reitz and Wing 2008:132).

Heat intensity	Colour of bone
No heat	Pale brown/mid brown
Low	Black
Medium	Grey/white/blue
High	Blue

Table 8 Heat intensity and corresponding surface colour change.

4.4.2: Exposure to weathering

Weathering drives the process of decomposition and its impact is dependent upon the severity of the weathering process, the length of exposure, and the size and state of preservation of the element in question prior to deposition (Reitz and Wing 2008:142). For the purposes of this analysis, weathering is defined as the physical and chemical effects of climactic events. To document the weathering processes that the dataset was exposed to, the six weathering stages as defined by Behrensmeyer (1978) (Table 12) were used as a general guide to defining the characteristics of the bone. This approach has some limitations. Behrensmeyer's weathering stages were developed from samples from sub Saharan Africa, a far drier climate than the tropics of north Queensland. Flesh and bone for example decompose faster in warm damp climates than in any other (Lyman 1994:141). Further, these stages were developed for bones in a greater state of completeness than are available in the current dataset. Despite these limitations, this system is still useful and allows for a broad understanding of the types of climactic conditions the specimens were exposed to over time.

Weathering stages	Definitions
Stage 0	No cracking or flaking visible on bone surface, bone cortex is greasy, tissue and marrow may still be present
Stage 1	Bone shows some cracking, often parallel to the bone fibres (longitudinal for long bones). Articular surfaces may show some cracking. Tissue or marrow may or may not be present
Stage 2	Deeper and more extensive flaking and cracking is visible with these characteristics increasing, long and thinning longitudinal flakes are common, ligaments and cartilage may still be present
Stage 3	Bone surface is likely comprised of rough, homogenously weathered bone that has a fibrous appearance, first starting in patches then spreading to cover the whole bone surface. Fibres are still firmly attached to one another. Weathering does not penetrate more than 1.0-1.5mm of the bone cortex, with cracks often rounded in at the cross section. Tissue rarely attached at this stage
Stage 4	The bone surface is coarse and fibrous, and flake may splinter from the bone, with weathering penetrating into the inner cavities. Cracks may have rounded or splintered edges
Stage 5	Bone is falling apart in situ, with large splinters spread around the bone. Cancellous bone is usually exposed and may represent the entire bone surface. Compact outer surface of the bone often missing

Table 9 Weathering stages (after Behrensmeyer 1978).

Documenting the presence of splitting and cracking was also undertaken to clarify the data provided by the weathering stages. These characteristics are suggested by Behrensmyer (1978:157) to indicate specimens exposed to longer or more severe periods of environmental pressures. Observing their specific rates of occurrence was done to illuminate the role of the tropical climate on vertebrate faunal preservation. Cracking and splitting were documented for each specimen with a simple ‘yes’, ‘no’ or ‘indeterminate’, while observations for the presence of cracking were noted as either shallow or deep.

4.4.3: Fragmentation and break type analysis

Fragmentation of a bone is defined as the number and types of fragments into which a bone has been broken (Villa and Mahieu 1991). Determining exactly how a bone has fragmented is often problematic, as trampling, burning and sedimentary process can show similar characteristics (Lyman 1994:380-381). Analysing the rate of fragmentation is important because it clarifies aspects of site formation process, and creates a fuller picture of how a bone assemblage was affected by post depositional processes.

A break-type analysis was carried out on the data set following Grunwald (2016) (Figure 7). Grunwald's method was selected over others for its simplicity and relatively few break type categories. As the dataset was highly fragmentary, the purpose of this was to establish whether bones specimens from each midden site were fresh or dry prior to entering the shell matrix site. Bones that are broken while fresh often exhibit obtuse or acute angled smooth breaks with fewer jagged edges, while dry bones a far more likely to break unevenly or at a right angle, producing stepped of jagged breaks (Fernández-Jalvo and Andrews 2016:286; Lyman 1994; Villa and Mahieu 1991:34).

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Figure 7 Break types used in analysis (from Grunwald 2016:357).

4.4.4: Abrasions analysis

Abrasion to a bone surface is a fairly general term to describe the rounding and/or polishing of a bone surface, either a small section of the bone or the entire bone (Fernández-Jalvo and Andrews

2016:169). Abrasions to bone surfaces can be caused by a variety of different mechanisms, from alluvial transport of a bone to exposure to abrasive sediments and weathering processes (Behrensmeyer 1991; Fernández-Jalvo and Andrews 2016:169; Lyman 1994). Given that shell middens are composed almost entirely of shell, an abrasive sediment, recording any instances of a polished or abraded surface texture was of interest to understand whether bone movement down the deposit of a shell matrix site could be documented.

Abrasions and surface polish were documented by recording the percentage of the bone surface with this characteristic, from 0%, 1-24%, 25-49%, 50-74%, 75-99% and 100%. The location was also documented, either occurring on the shaft, break points, over the whole bone surface or a combination of these. Recording these attributes allowed for distinctions to be made between specimens that may have been exposed to a significant amount of polish or abrasion, and those that showed small to minimal signs.

4.4.5: Linear marks and pitting analysis

Linear marks are defined as marks with lengths four times their width and longer, with the mark penetrating the bone surface by a cut, incision or by chemical action (Fernández-Jalvo and Andrews 2016:24). Linear marks can be caused by several agents including bioturbation, scavenging by animals or butchery by humans. Animal scavenging of bone can leave behind teeth marks or gauges, with reciprocal marks on the reverse side, consistent with an animal biting down on the bone and removing the flesh. Trampling can also leave linear marks, which are more likely to be multidirectional and located along the shafts of bones rather than at the ends, as would be the case with butchery (Lyman 1994:381).

Linear abrasions caused by stone implements or other tool types such as shell or bone are often V shaped in their cross section due to the sharpness of the implement acting on the surface

(Fernández-Jalvo and Andrews 2016:26-28). Animal gauges caused by gnawing exhibit multiple marks U-shaped marks in the cross section, and comparatively deep when compared with trampling or other forms of bioturbation, which are often shallower although this is not always the case (Fernández-Jalvo 2016:30-33, Lyman 2004). Termites can in some instances affect bone preservation and exhibit irregular linear patterning within bone cracks or starshaped perforations (Fejfar and Kaiser 2005; Pomi and Tonni 2011:169). Marks left behind by plant or root activity are in some cases difficult to identify, as this type of taphonomic process can result in the total destruction of bone.

Pitting by contrast is generally defined as a mark or perforation with a length less than four times its width, and can vary in depth (Fernández-Jalvo and Andrews 2016:101). The most common form of pitting is produced by carnivores gnawing on the bone. The presence and nature of such marks is dependent on a variety of factors including the size of the prey and the carnivore consuming it, as well as what type of bone it is. Perforations can also be indicative of trampling or impacts caused by sedimentary movement or pressure (Fernández-Jalvo and Andrews 2016:109).

The most accurate means to document linear marks and pitting on a bone surface is by using a Scanning Electron Microscope (SEM). This type of microscope has become used with greater frequency on archaeological bone because it allows for higher magnifications, greater depth of field, no destruction to the specimen being analysed, and it can work well other technologies including X-ray (Fernandez-Jalvo and Monfort 2008:158).

This project uses microscopic analysis only and does not utilise this technology, therefore some of the specifics described above could not be as precisely documented. Linear marks were documented as either present or not, whether there were multiple scrapes or singular marks, and whether these more visibly represented V shaped or U shaped linear marks. V shaped marks were determined to be narrower, while U shaped marked were characterised as flatter. Due to the complexities of depth, pitting was simply noted as present or not present.

4.5: Sedimentary processes

Shell matrix sites have a unique sedimentary profile, one that is highly porous and susceptible to a number of taphonomic processes affecting the sediments within (Claassen 1998 53-83; Linse 1992). The interaction between the soils and sediments in which bones are found can assist in understanding what type of processes could be affecting the deterioration (Child 1995:171). The modifications analysis undertaken here aims to document specific characteristics that are active within a shell matrix site. To understand the complexities of these processes, a contextual analysis of the data was undertaken. This involves treating each context as a site within itself. Traditionally this involves the need for MNI and NISP counts (Beisaw 2013:136), however a slightly different approach was undertaken for the purposes of this research.

A series of bar graphs comparing the statistics gathered above for each stratigraphic unit (Layer) for SM:88, SM:91 and SM:93 was developed representing the taphonomic process at work for each layer. By doing this, a deeper appreciation for exactly what modifications are more prevalent at different sites and within the shell mounds themselves could be reached. This also allows for patterns in the data (if any) to become easily recognisable.

Importantly, each excavated unit (XU) was excavated in controlled spits varying in depth between 5-10cm (Morrison 2010). Across all three sites the XUs did not align perfectly with the layers in most cases, and the stratigraphic layers were not uniform across the excavated 50cm^2 or 100cm^2 pit. This meant that each XU from each site had to be assigned to a layer with some minor discrepancies. For SM:88 and SM:91, the mean depth (cm) of each XU was taken and measured against the depth (cm) of each layer. XUs were assigned to the layers where the majority of it was located by depth (cm) (Table 13).

SM:93 had a more complex stratigraphy than SM:88 and SM:91, with a total of 15 distinct layers, therefore a slightly different approach was taken. Each XU was approximately 5cm deep. Each XU was placed with corresponding stratigraphic units. Some of these stratigraphic units showed similarities in type, texture and moisture levels to others and could be grouped together for the purposes of analysis. These will be referred to as stratigraphic unit groups. This is detailed in Figure 8 below.

Site	Excavated Unit containing vertebrate fauna	Mean depth below surface (cm)	Corresponding stratigraphic unit
SM:88	XU1	7.27	Layer A
	XU2	11.78	Layer A
	XU3	11.95	Layer B
	XU4	10.22	Layer B
	XU5	9.23	Layer B
	XU6	9.52	Layer B
SM:91	XU2	4.20	Layer B
	XU3	3.35	Layer B
	XU4	3.6	Layer B

Table 10 SM:88 and SM:91 excavated units and associated stratigraphic units

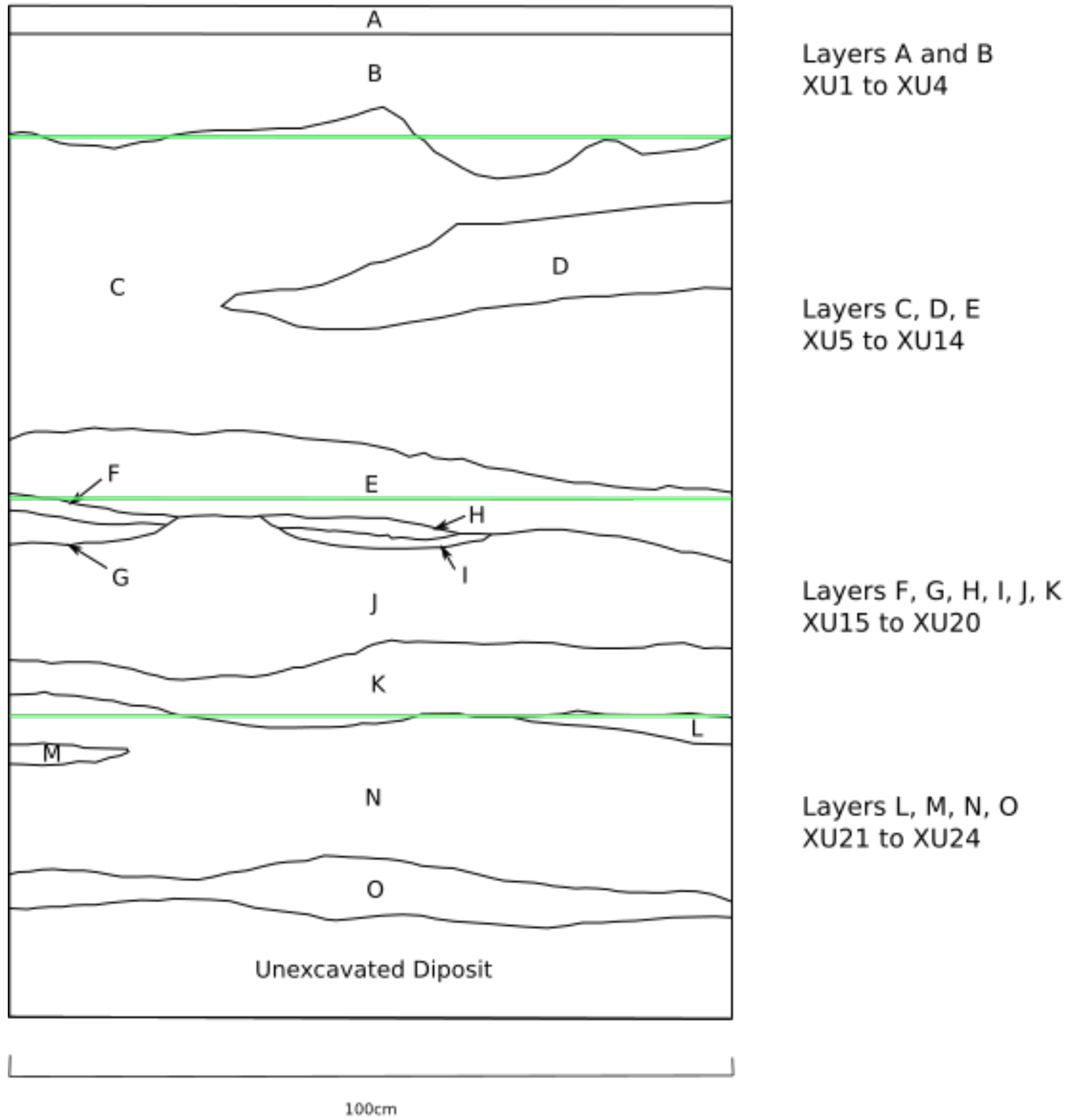

Figure 8 SM:93 Stratigraphic profile with stratigraphic unit group divisions marked in green (after Morrison: 2015:8).

4.6: Summary

The above methodology seeks to extrapolate what taphonomic processes are evident on the vertebrate faunal specimens from SM:88, SM:91 and SM:93. Determining whether certain classes of vertebrate fauna are more likely to survive within each site is also important. By measuring, weighing and examining the specimens for taphonomic signatures, the relationship between vertebrate faunal recovery and shell matrix sedimentary processes may be better understood. This subsequently allows for a richer interpretation of vertebrates at shell matrix sites.

Chapter 5: Results

The following chapter presents the results of the analysis undertaken on the vertebrate faunal remains of SM:88, SM:91 and SM:93. The weight and dimensions will be shown for all three sites, followed by the results of the identification of the specimens. The taphonomic processes evident within the stratigraphic units at each site are then presented.

5.1 Weight and dimensions across SM:88, SM:91, and SM: 93

In total, 295 specimens and associated bone fragments across SM:88, SM:91 and SM:93 were measured by weight, length, width and thickness and the results of the median value per XU per shell mound are presented (Table 11). Of these, 158 specimens were analysed for identification to a taxonomic category and underwent analysis to document physical taphonomic characteristics (Table 11). It should be noted that some XUs appear to have had less than 50% of specimens per XU by weight analysed, while others have had more. This is because some specimens contained multiple fragments that were individually weighed and measured, however multiple bone fragments belonging to the same specimen were not treated as individual specimens for the purposes of taphonomic analysis.

The weight for each specimen from SM:88 and SM:91 shows higher weights at the lowest XU's when compared to the higher stratigraphic units. SM:93 is an exception to this, where the highest weight occurs at the middle XU, 50-55cm below the surface (Table 11; Figure 9). The median length for SM:88 was generally less than 10mm, with the peak at XU5 at 7.70mm, while SM:91 and SM:93 generally exhibited greater specimen lengths. SM:91 showed a trend towards greater specimen length with depth while SM:93 showed lengths varied with depth (Table 11). Peaks are discernible within SM:93 within the first 20cm, and again at 50cm below the midden surface. No width or thickness from any shell mound was greater than 1cm, the highest occurring at 50-55cm depth at SM:93 with 9.77mm (Table 11; Figure 9).

Site	XU	Median Weight (g)	Median Length (mm)	Median Width (mm)	Median Thickness (mm)	Specimen (and fragment) No.	Specimens analysed for identification and Taphonomic processes	Specimens able to be identified to any taxonomic category no. and %		Specimens unable to be identified to any taxonomic category no. and %	
SM:88	XU1	0.019	6.12	2.73	1.79	27	14	6	43%	8	57%
	XU2	0.026	4.76	3.43	1.82	38	20	5	25%	15	75%
	XU3	0.010	4.77	3.01	1.65	13	8	2	25%	6	75%
	XU4	0.038	6.43	2.46	1.18	19	7	1	14%	6	86%
	XU5	0.040	7.70	3.46	1.94	12	6	3	50%	3	50%
	XU6	0.063	6.24	2.49	1.93	6	3	1	33%	2	67%
		Median across site: 0.026	**Median across site: 5.64**	**Median across site: 3.17**	**Median across site: 1.75**	**Total: 115**	**Total: 58**	**Total: 19**	**Total across site: 33%**	**Total: 39**	**Total across site: 67%**
SM:91	XU2	0.024	8.37	2.88	1.62	73	39	9	23%	30	77%
	XU3	0.066	12.49	5.33	3.25	10	8	5	63%	3	38%
	XU4	0.473	23.18	7.95	3.48	1	1	1	100%	0	0%
		Median across site: 0.030	**Median across site: 8.57**	**Median across site: 3.10**	**Median across site: 1.88**	**Total: 84**	**Total: 48**	**Total: 15**	**Total across site: 31%**	**Total: 33**	**Total across site: 69%**
SM:93	XU2	0.363	19.17	5.24	3.15	9	7	2	28%	5	72%
	XU3	0.424	25.86	7.19	2.96	4	4	2	50%	2	50%
	XU4	0.308	30.86	5.48	2.17	3	3	3	100%	0	0%
	XU5	0.445	19.08	8.76	6.36	3	2	1	50%	1	50%
	XU6	0.102	13.15	5.97	3.47	7	4	4	100%	0	0%
	XU7	0.252	19.70	8.42	4.06	3	2	1	50%	1	50%
	XU11	0.792	31.63	9.77	4.33	4	2	2	100%	0	0%
	XU13	0.242	15.46	6.63	3.19	17	9	9	100%	0	100%
	XU14	0.177	13.31	8.12	3.33	12	8	1	13%	7	88%
	XU15	0.034	9.50	1.57	1.36	15	4	1	25%	3	75%
	XU19	0.18	8.16	4.14	1.31	14	4	2	50%	2	50%
	XU21	0.100	13.75	6.32	1.77	5	3	0	0%	3	100%
		Median across site: 0.225	**Median across site: 13.44**	**Median across site: 5.86**	**Median across site: 2.70**	**Total: 96**	**Total: 52**	**Total: 28**	**Total across site: 54%**	**Total: 24**	**Total across site: 46%**

Table 11 Results for weight and dimensions of excavated units (XU) across SM:88, SM:91 and SM:93. Count of Specimens and specimen fragments per XU is also included, as well as specimens that were analysed for the purposes of identification and taphonomic process

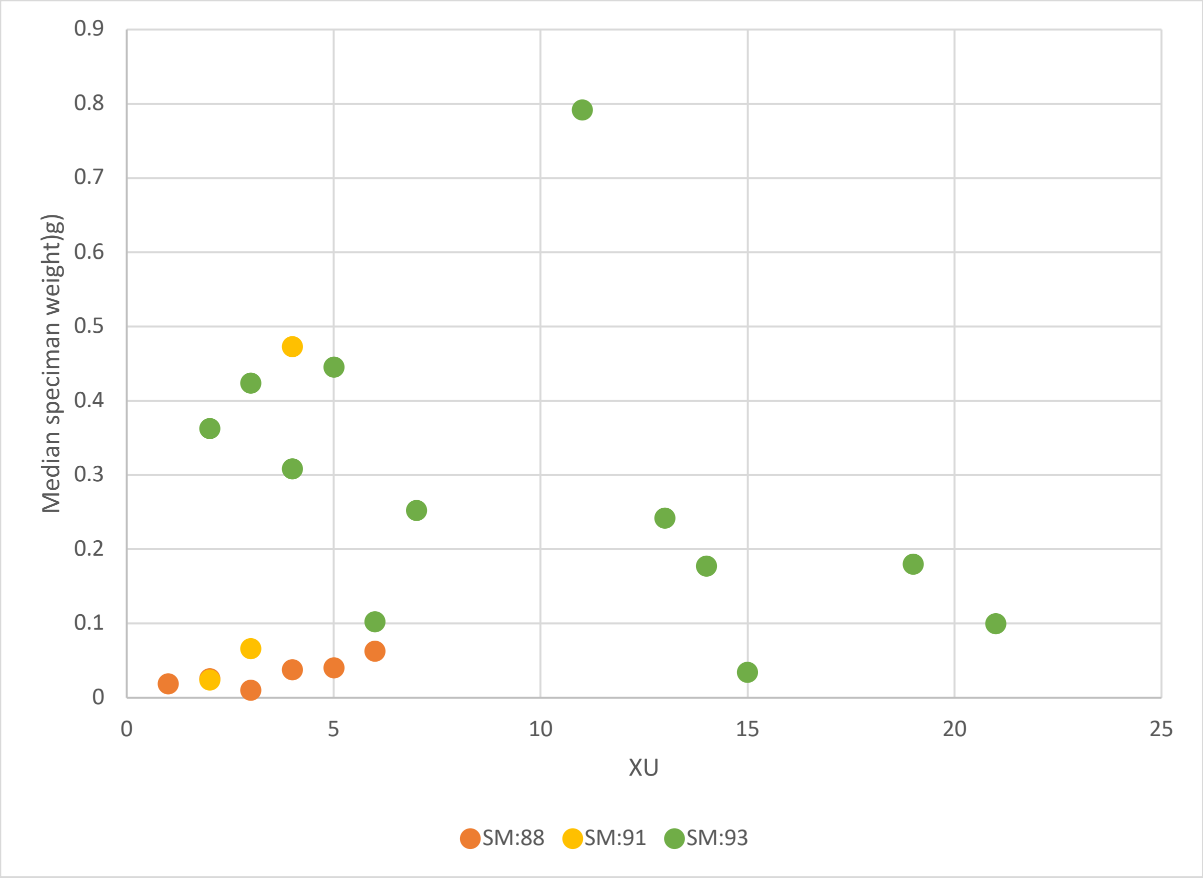

Figure 9 Median weight of specimens per XU, SM:88, SM:91 and SM:93.

5.2: Identification of vertebrate fauna

Identification of the vertebrate fauna was constrained by the fragmented nature of most specimens, which generally had few diagnostic features. A total of 62% of the specimens analysed for taphonomic processes were unable to be identified to any taxonomic category, with 38% of specimens able to be identified to at least one taxonomic category (Table 12). Of these, 34 individual specimens were able to be broadly identified to all four taxonomic categories, and these are presented in Table 13. Mammals were located across all three sites, with SM:93 exhibiting the widest variability in the size of mammals. SM:88 predominantly comprised small to medium sized mammals such as *Isoodon* (Bandicoot) sp., *Phalangeridae* (Possum) sp., or medium to large mammals such as *Macropus* sp. (Table 12; Figure 10). Fish bone fragments were only identified in

SM:91 (Table 12; Figure 11), while several *Macropus antilopinus* or similar Macropus tibia and rib bone fragments were identified in SM:93 towards the centre of the site (Table 13). No birds were identified during the analysis. Long bone and rib bone fragments were the most commonly identifiable skeletal element, with three teeth (whole and fragmented) also identified (Table 13).

Teeth provided the most secure identification and were sparsely represented through the three sites. One partial tooth fragmented belonging to a *Phalangeridae* sp. was found in SM:88, while the two teeth from SM:91 likely belong to *Macropus agilis* (Table 13; Figure 12). The left maxilla of an *Macropus agilis* found in SM:93 was a particularly unique element in the assemblage (Figure 13).

Importantly, some specimens previously weighed and measured were later identified as crab fragments. Crab remains cannot be analysed for taphonomic modifications in the same way that bone fragments can, due to their composition. Following the methodology, the next specimen by weight replaced the identified crab fragment for modification analysis.

Figure 10 Specimens identified as possums from SM:88 (from left to right). Top: SM88-XU1-001, SM88-XU1-005, SM88-XU2-010, SM88-XU2-024. Bottom: SM88-XU3-011, SM88-XU4-008, SM88-XU5-001.

Figure 11 Specimens identified as *Osteichthyes* (fish) (from left to right). Top: SM:93-XU2-12, SM:93-XU2-013, SM:93-XU2-027, Bottom: SM:93-XU3-008, SM:93-XU3-012.

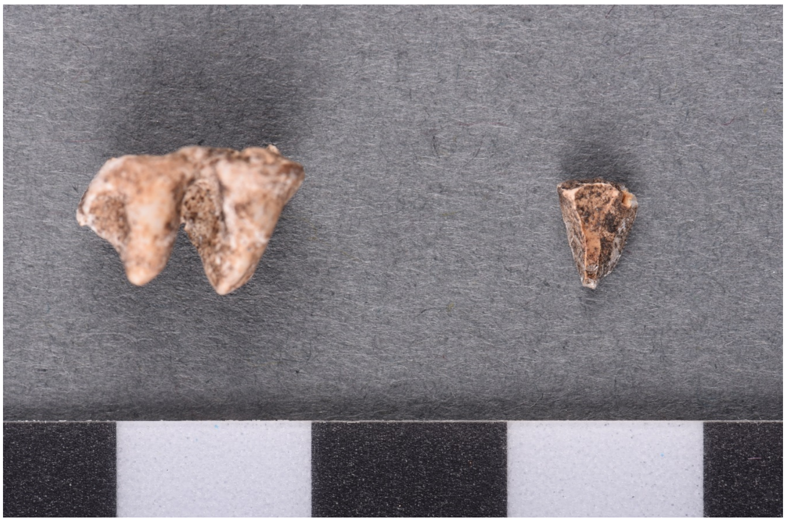

Figure 12 Specimens identified as a Macropus agilis RM4, SM:91-XU2-011 and a wallaby incisor, SM:91-XU2-065.

Figure 13 Specimen SM:93-XU6-007, *Macropus agilis*, sub adult.

Site	SM:88		SM:91		SM:93		Totals	
Taxonomic category	Specimen count	Percent	Specimen count	Percent	Specimen count	Percent	Specimen count	All sites
Unidentified	41	71%	33	69%	24	46%	98	62%
Mammalia small	3	5%	2	4%	0	0%	5	3%
Mammalia small/medium	11	19%	2	4%	3	6%	16	10%
Mammalia medium	0	0%	2	4%	8	15%	10	6%
Mammalia medium/large	0	0%	0	0%	13	25%	13	8%
Mammalia large	0	0%	0	0%	2	4%	2	1%
Mammalia any size	3	5%	4	8%	2	4%	9	6%
Osteichthyes	0	0%	5	11%	0	0%	5	3%
Ave	0	0%	0	0.00%	0	0%	0	0%
Total	58		48		52		158	

Table 12 Specimens identified to a class and size category, SM:88, SM:91 and SM:93.

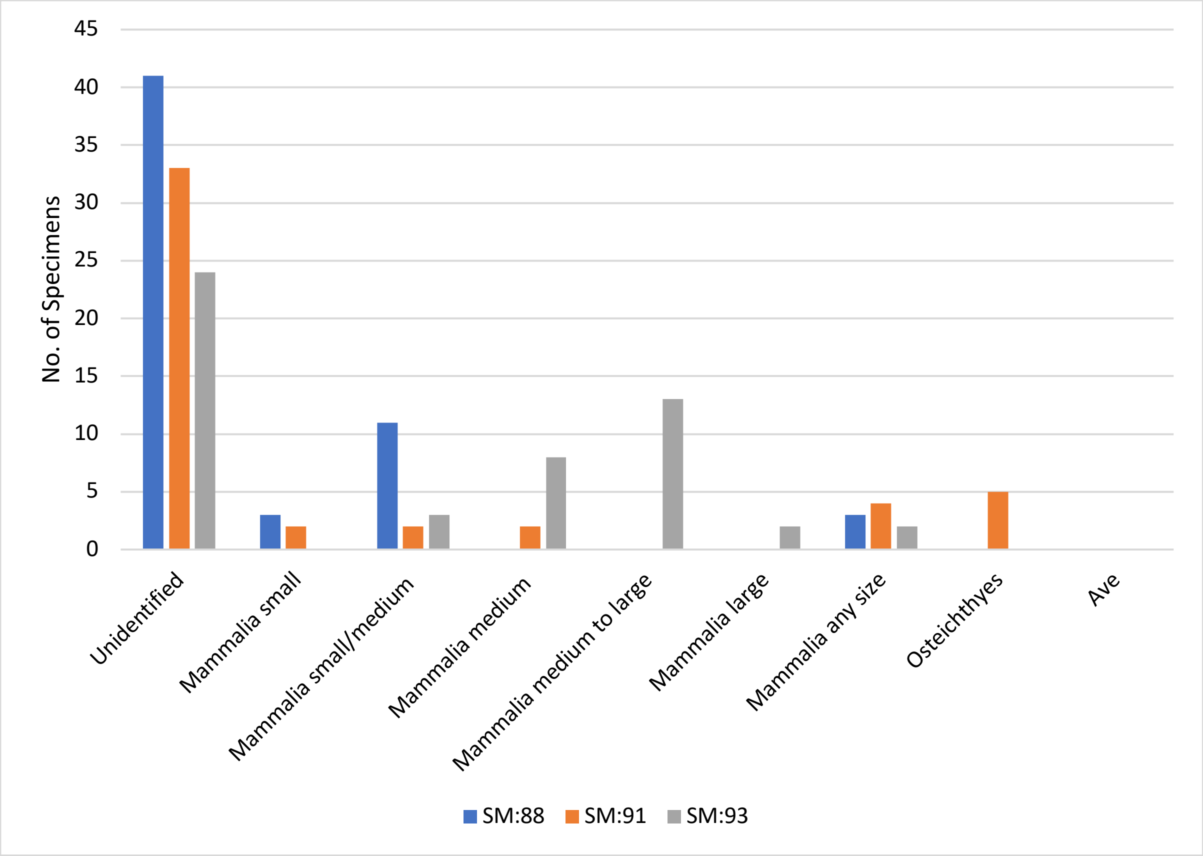

Figure 14 Number of specimens identified to a class and size category, SM:88, SM:91 and SM:93

Site Name	Context	Specimen ID	Class	Size	Species	Skeletal element
SM:88	XU1	1	*Mammalia*	Small/medium	*Phalangeridae* sp. or *Isoodon* sp.	Long bone fragment
SM:88	XU1	5	*Mammalia*	Small/medium	*Phalangeridae* sp.	Rib fragment
SM:88	XU2	10	*Mammalia*	Small/medium	*Phalangeridae* sp.	Root of a tooth
SM:88	XU2	24	*Mammalia*	Small	*Phalangeridae* sp. or similar	Vertebrate
SM:88	XU3	11	*Mammalia*	Small	rat sp. or similar	Centrum (vertebrate) fragment
SM:88	XU4	8	*Mammalia*	Small/medium	*Phalangeridae* sp. or similar	Long bone fragment
SM:88	XU5	1	*Mammalia*	Small/medium	*Phalangeridae* sp.	Right lower P3 molar
SM:91	XU2	11	*Mammalia*	Medium	*Macropus agilis*	RM4
SM:91	XU2	65	*Mammalia*	Medium	*Macropus* sp. (*Macropus agilis*)	Tooth frag
SM:93	XU2	2	*Mammalia*	Large	*Macropus* sp. *(Macropus antilopinus* or similar)	Rib fragment
SM:93	XU2	6	*Mammalia*	Medium/large	*Macropus* sp. *(Macropus antilopinus* or similar)	Rib fragment
SM:93	XU3	3	*Mammalia*	Medium/large	*Macropus* sp. *(Macropus antilopinus* or similar)	Tibia fragment
SM:93	XU3	4	*Mammalia*	Medium/large	*Macropus* sp. *(Macropus antilopinus* or similar)	Tibia fragment
SM:93	XU4	1	*Mammalia*	Medium/large	*Macropus* sp. *(Macropus antilopinus* or similar)	Rib fragment
SM:93	XU4	3	*Mammalia*	Medium/large	*Macropus sp.*	Rib fragment
SM:93	XU5	3	*Mammalia*	Medium/large	*Macropus* sp. *(Macropus antilopinus* or similar)	Tibia fragment
SM:93	XU6	1	*Mammalia*	Medium/large	*Macropus* sp. *(Macropus antilopinus* or similar)	Tibia fragment
SM:93	XU6	3	*Mammalia*	Medium/large	*Macropus* sp. *(Macropus antilopinus* or similar)	Rib fragment
SM:93	XU6	5	*Mammalia*	Medium/large	*Macropus* sp. *(Macropus antilopinus* or similar)	Rib fragment
SM:93	XU6	7	*Mammalia*	Medium	*Macrpus agilis* , sub adult	Left Maxilla, teeth attached
SM:93	XU7	2	*Mammalia*	Medium	Macropod	Tibia fragment
SM:93	XU11	1	*Mammalia*	Large	*Macropus* sp. *(Macropus antilopinus* or similar)	Tibia fragment
SM:93	XU11	4	*Mammalia*	Medium/large	*Macropus* sp. *(Macropus antilopinus* or similar)	Tibia fragment
SM:93	XU13	1	*Mammalia*	Medium	Macropod	Tibia fragment
SM:93	XU13	4	*Mammalia*	Medium	*Macropus* sp. (*Macropus agilis*)	Proximal end of a tibia
SM:93	XU13	5	*Mammalia*	Medium	Macropod	Tibia fragment
SM:93	XU13	11	*Mammalia*	Medium/large	*Macropus* sp. *(Macropus antilopinus* or similar)	Rib fragment
SM:93	XU13	12	*Mammalia*	Medium/large	*Macropus* sp. *(Macropus antilopinus* or similar)	Rib fragment
SM:93	XU13	13	*Mammalia*	Medium/large	*Macropus* sp. *(Macropus antilopinus* or similar)	Tibia fragment
SM:93	XU_19	002	*Mammalia*	Small/medium	*Phalangeridae* sp.	Ischium fragment
SM:93	XU_19	007	*Mammalia*	Small/medium	*Phalangeridae* sp.	Humours fragment

Table 13 Specimens identified to all taxonomic categories. Species name in brackets refers to most likely identification based on species in the local region identified by Thomas (2004).

5.3: Contextual analysis of taphonomic indicators

5.3.1: SM:88

SM:88 comprised three stratigraphic layers, two of which contained vertebrate faunal remains. The most commonly observed taphonomic characteristics across both Layers A and B were deep cracking on the bone surface, two clear breaks across the shaft, and signs of polish or abrasion (Figure 15). Weathering stages 3 and 4 were most common (Figure 16). There was some evidence of burning, with 10% of bone being blackened, and blackened or stained bone occurring in around 30% of cases (Figure 17). White bones were observed however it is difficult to determine whether this was the result of burning or the result of bone splitting or cracking from larger bones.

Bones with only one break were identified exclusively in Layer A. Transverse (irregular) breaks were the most commonly observed break type across both layers, with oblique (irregular) and transverse (regular) breaks occurring in Layer A more frequently than in Layer B (Figure 18). SM:88 had greater evidence of polished bone rather than abraded bone across both layers (Table 14). Layer A contained multiple specimens with polish at 1-24% of the bone surface, while only half this quantity was visible for Layer B. The location of polish varied between Layers A and B. While polish across the shaft or break points were most common, specimens in Layer A also exhibited some abrasion across the whole specimen, while this was not observed in Layer B (Table 15). Linear marks were sparsely observed across the site, however the occurrence of this taphonomic process was relatively low (Table 16).

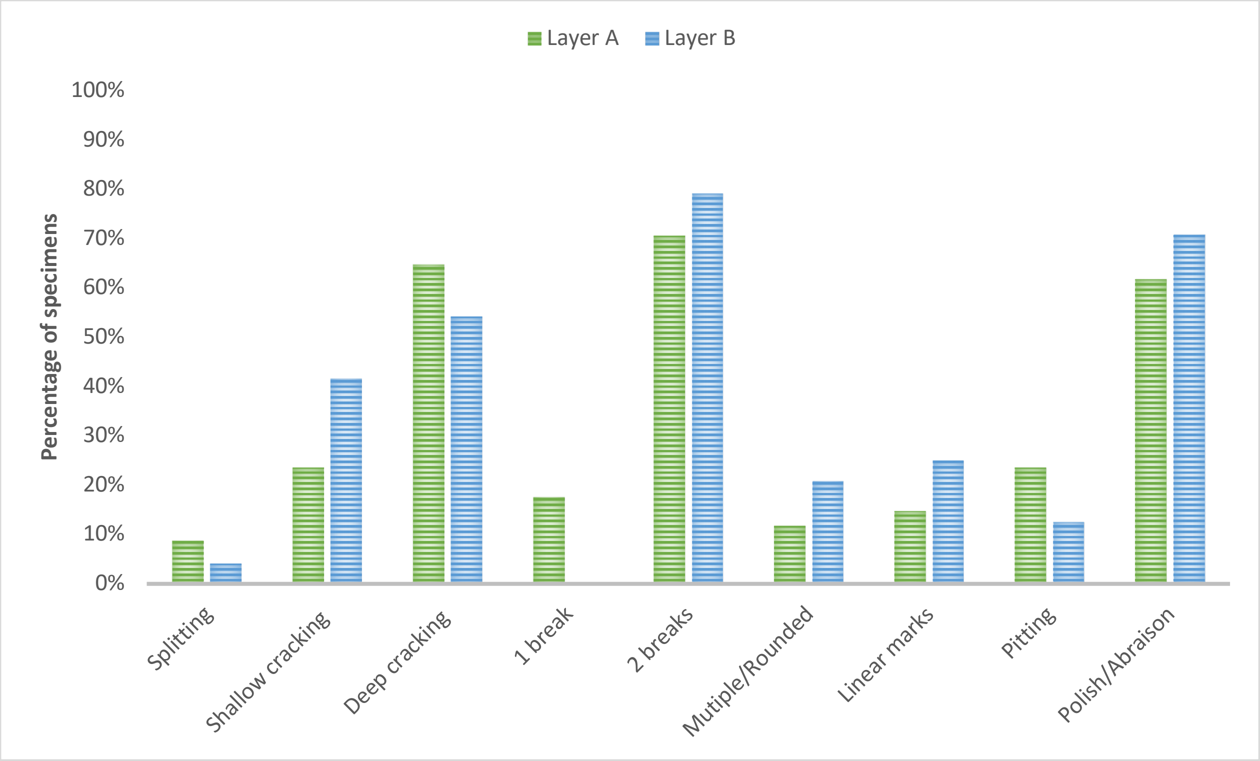

Figure 15 Percentage of taphonomic characteristics represented in each stratigraphic unit, SM:88.

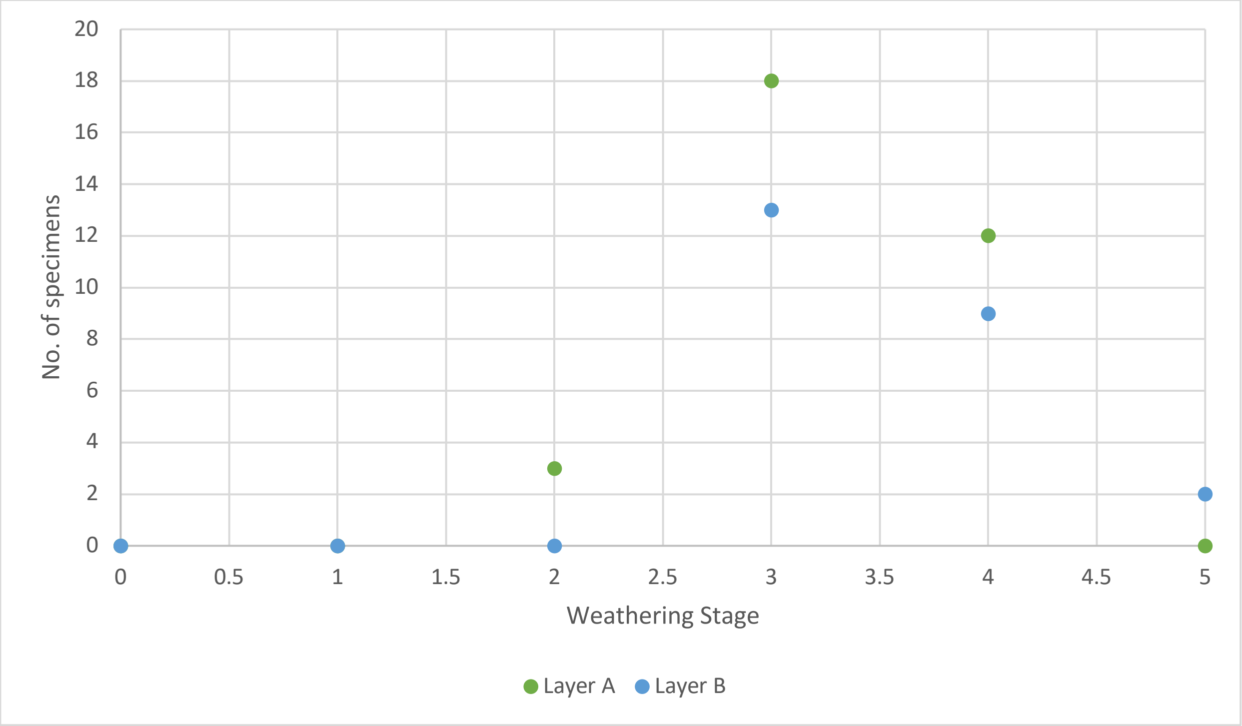

Figure 16 Weathering stages per stratigraphic unit, SM:88.

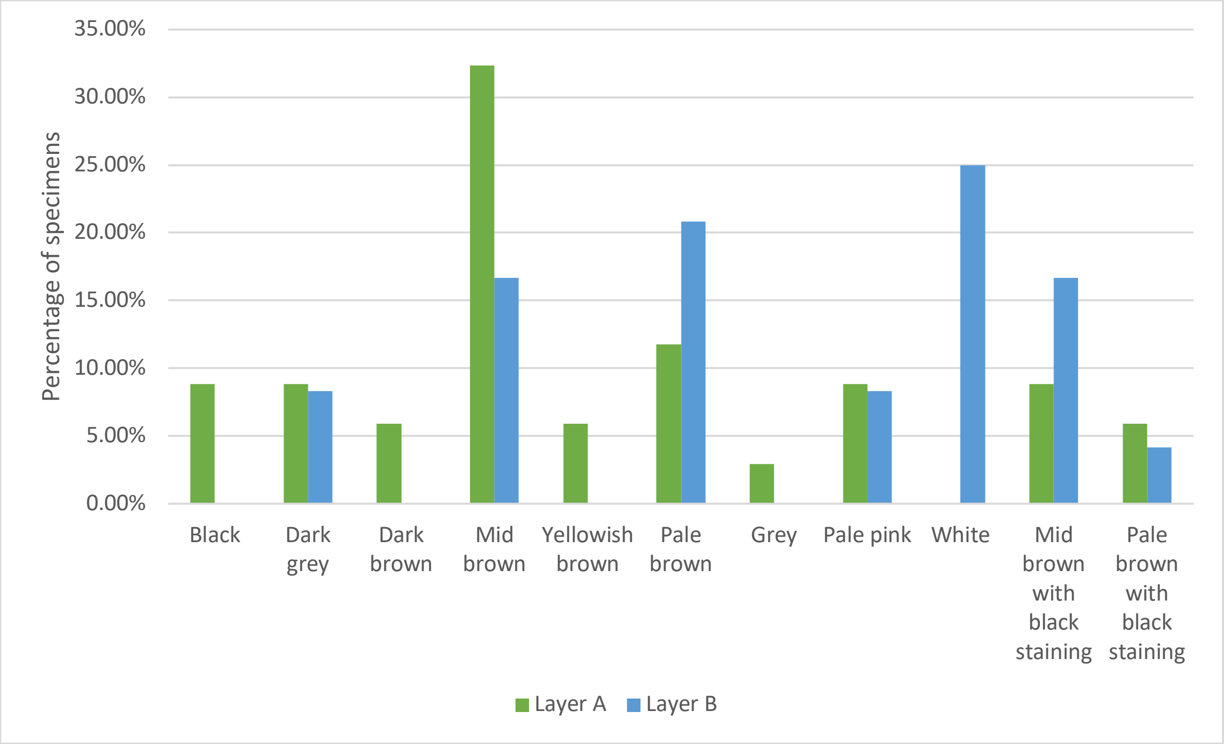

Figure 17 Colour of specimens by stratigraphic unit, SM:88.

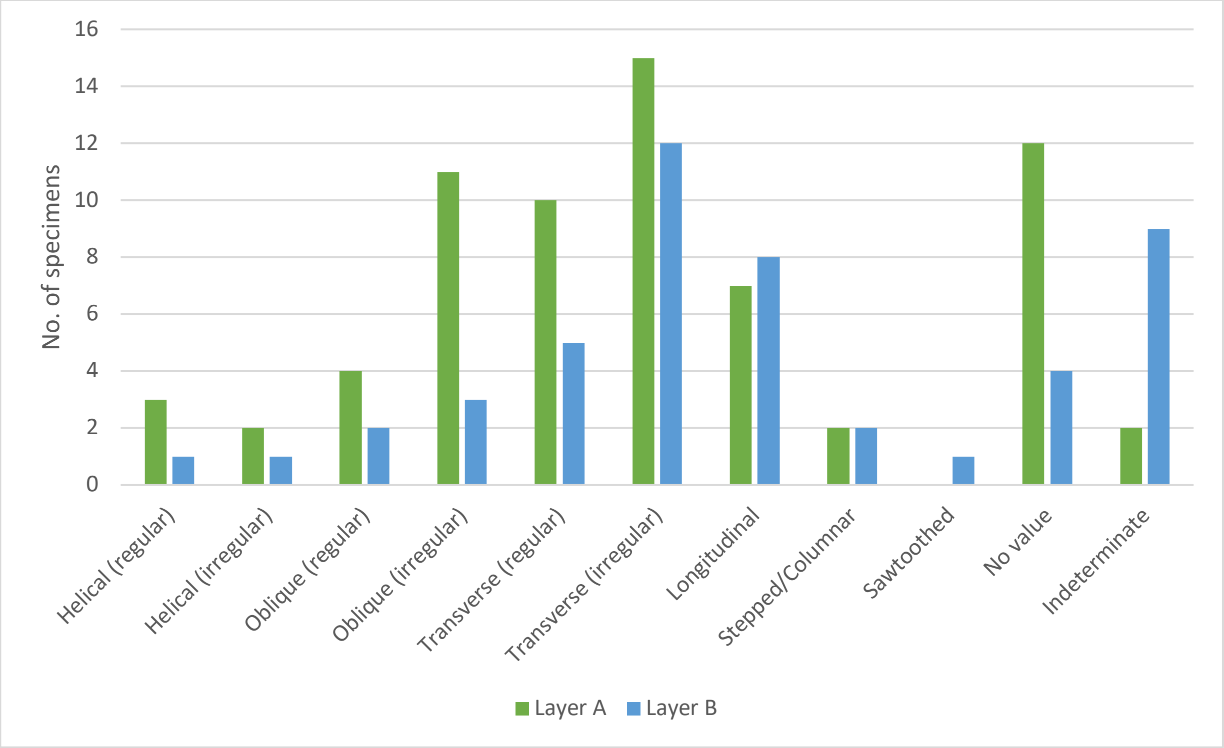

Figure 18 Break types per stratigraphic unit, SM:88.

Percentage of bone cortex with polish/abrasion	Polish present Layer A	Polish present Layer B	Abrasion present Layer A	Abrasion present Layer B
1–24 %	15	8	1	4
25–49 %	1	2	0	1
50–74 %	1	1	0	0
75–99 %	0	0	0	2
100%	0	0	0	0

Table 14 Number of specimens with bone cortex showing signs of polish or abrasion per stratigraphic unit, SM:88.

Location of polish/abrasion	Layer A No.	Layer B No.
Shaft	8	8
Single break points	4	2
Both break points	0	4
One break point and shaft	2	0
Across whole surface	4	3

Table 15 Location of polish and abrasion per specimen per stratigraphic unit, SM:88.

Type of mark(s)	Layer A No.	Layer B No.
Singular V shaped mark	0	1
Multiple V shaped mark	3	0
Singular U shaped mark	0	1
Multiple U shaped marks	1	0
Multiple fine scrapes	1	3

Table 16 Types of linear marks per specimen per stratigraphic unit, SM:88.

5.3.2: SM:91

SM:91 comprised a total of three stratigraphic units, one which contained vertebrate faunal remains. This was Layer B, located in the centre of the pit. The results are shown per excavated unit as well as per stratigraphic unit in some cases, to show changes through Layer B. Similarly to SM:88, the three most commonly observed taphonomic characteristics were deep cracking on the bone surface, two clear breaks across the shaft, and signs of polish or abrasion of the bone surface (Figure 19). Shallow cracking was observed on 30% of the analysed bones, higher than the results for SM:88.

Weathering stage 3 was the most commonly observed weathering stage (Figure 20). Some evidence of burning was present, with 8% of the bones being blackened in colour, and 10% showing evidence of black staining (Figure 21).

Break types were varied, with transverse (irregular), stepped or columnar, and longitudinal breaks the three most commonly occurring across Layer B (Figure 22). Abraded surfaces were more frequently observed than polished ones, with between 1-24% of the surface showing signs of this modification (Table 17). The majority of the polish and abrasion was located along the shaft, seen on 15 specimens. Some polish and abrasion was located on single and both break points, occurring on three specimens each (Table 18). As with SM:88, linear marks were rarely observed on specimens from SM:91 with only 6 specimens showing this characteristic (Table 19).

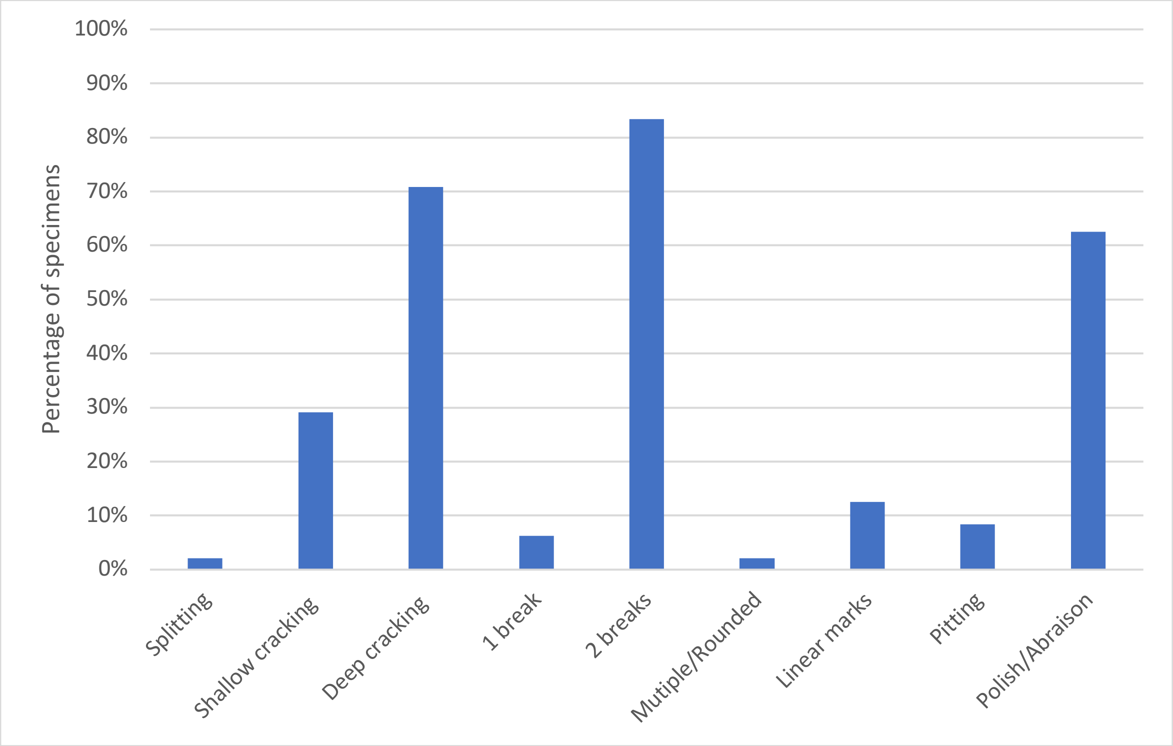

Figure 19 Percentage of taphonomic characteristics represented in each stratigraphic unit, Layer B, SM:91

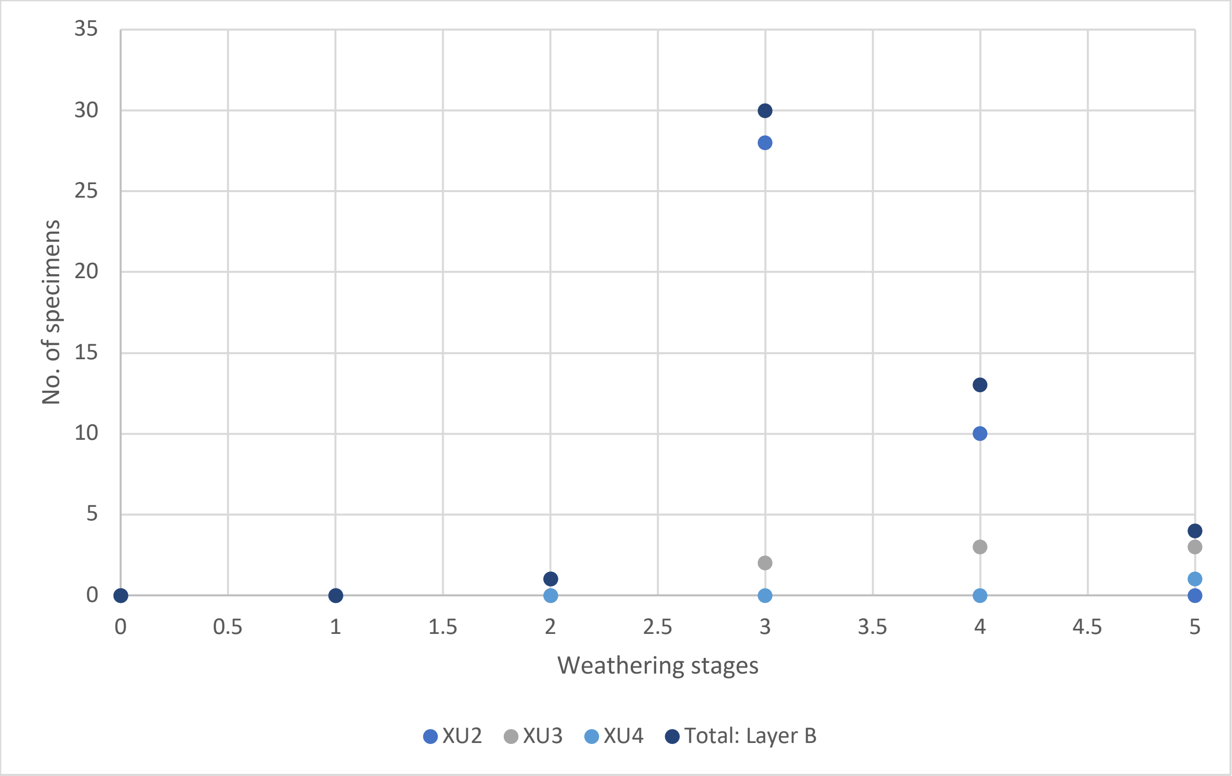

Figure 20 Weathering stages per XU, with total per stratigraphic unit also represented, SM:91.

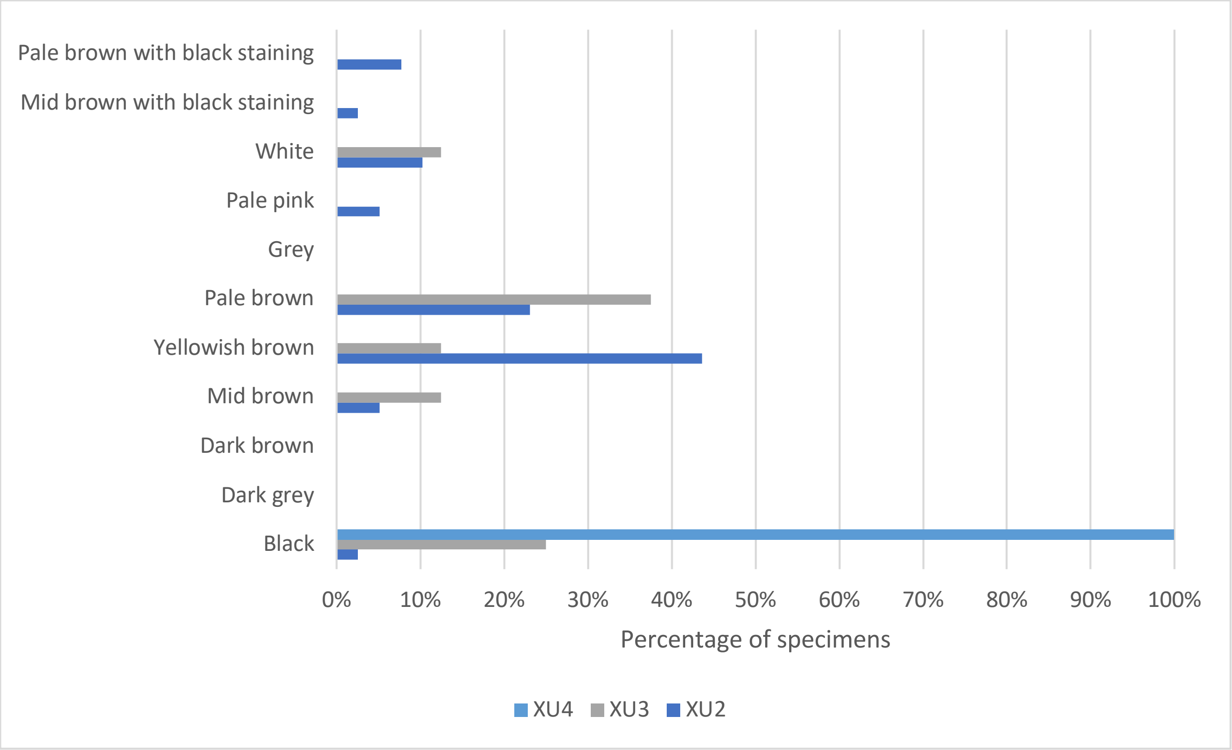

Figure 21 Colour of specimens by stratigraphic unit, SM:91.

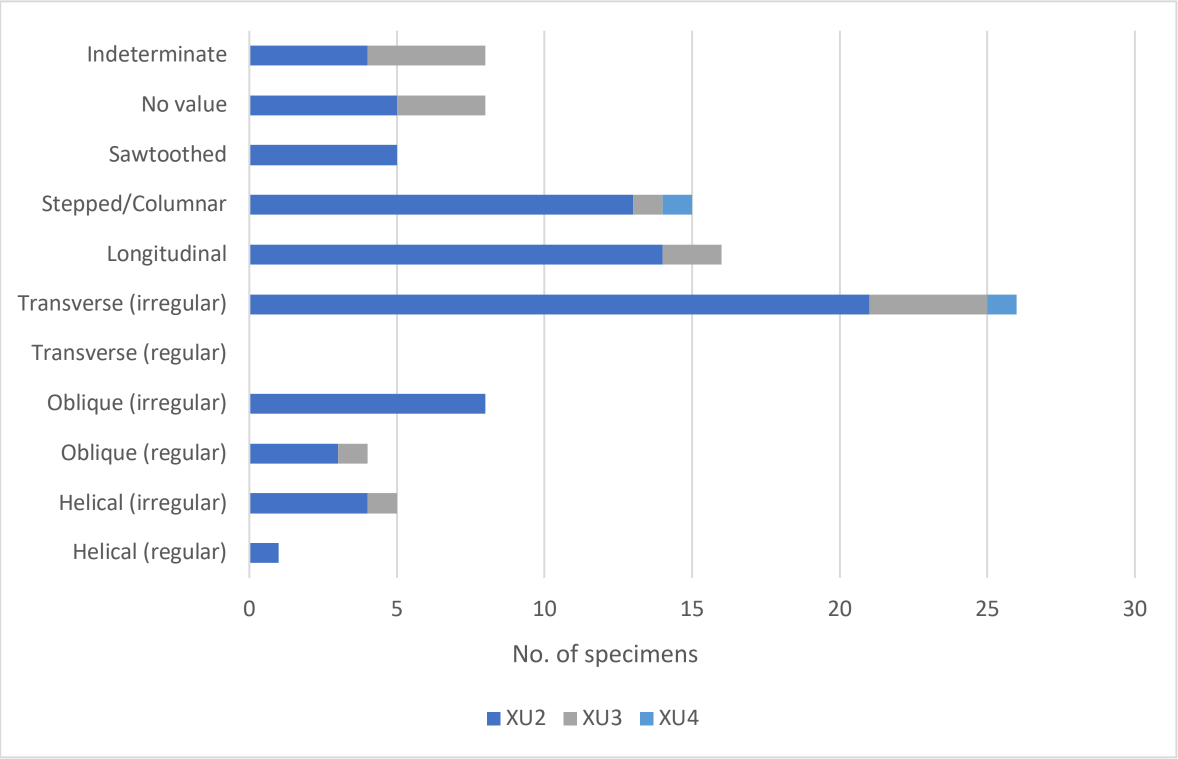

Figure 22 Stacked bar chart showing break types per excavated unit (XU), represented as the total per stratigraphic unit, SM:91.

Percentage of bone cortex with polish/abrasion	Polish present XU2	polish present XU3	polish present XU4	Total polish, Layer B	Abrasion present XU2	Abrasion present XU3	Abrasion present XU4	Total abrasion, Layer B
1–24 %	6	1	0	7	15	3	0	18
25–49 %	1	0	0	1	3	0	0	3
50–74 %	0	0	0	0	1	0	0	1
75–99 %	0	0	0	0	0	0	0	0
100%	0	0	0	0	0	0	0	0

Table 17 Number of specimens with bone cortex showing signs of polish or abrasion per excavated unit (XU), with total per stratigraphic unit also represented, SM:91.

Location of polish/abrasion	XU2 No.	XU3 No.	XU4 No.	Total: Layer B
Shaft	16	3	0	19
Single break points	3	0	0	3
Both break points	3	0	0	3
One break point and shaft	3	1	0	4
Across whole surface	1	0	0	1

Table 18 Location of polish and abrasion per specimen per excavated unit (XU), with total per stratigraphic unit also represented, SM91.

Type of mark(s)	XU2 No.	XU3 No.	XU4 No.	Total number of Specimens Layer B
Singular V shaped mark	2	0	0	2
Multiple V shaped mark	0	0	0	0
Singular U shaped mark	2	1	0	3
Multiple U shaped marks	0	0	0	0
Multiple fine scrapes	0	0	1	1

Table 19 Types of linear marks per specimen, per excavated unit (XU), with total per stratigraphic unit also represented, SM:91.

5.3.3: SM:93

SM:93 comprised a total of 15 stratigraphic units separated into four stratigraphic unit groups for the purpose of analysis (Figure 7). All four of these groups contained vertebrate fauna. Importantly, Layers L, M, N, O only contained three analysed bone fragments and this must be kept in mind when comparing the data. As with SM:88 and SM:91, many of the specimens exhibited multiple breaks across the shaft and showed signs of both shallow and deep cracking (Figure 23). Unlike the preceding sites, splitting occurred to 50% of the analysed specimens in Layers F, G, H, I, J, K while linear marks were documented in over 80% of the analysed specimens from layers A and B, 60% in Layers C, D, E and 37% in Layers F, G, H, I, J, K (Figure 23). Weathering stages 3 and 4 were commonly observed on the specimens (Figure 24). Almost no evidence of burning or exposure to heat was documented in any layer, with the majority of specimens falling into brown colour categories. The exception to this was Layers C, D, E with 4% showing some black staining (Figure 25).

Two break types were found to occur in high numbers, transverse (irregular) and oblique (irregular) (Figure 26). Longitudinal and helical (irregular) break types were documented for 11 specimens each, while all other break types occurred on less than ten specimens each (Figure 26). Polish was noted on six specimens across all stratigraphic unit groups with a concentration at Layers C, D, E (Table 20). Abrasion was observed on six specimens in Layers A and B, and on one specimen in Layers C, D, E (Table 21). In most cases the percentage of the bone surface covered by the polish or abrasion was 1–24%, with one specimen exhibiting 75–99% abraded bone cortex. The polish and abrasion was located on the shaft or isolated to one break point in most cases (Table 21). Linear marks were located in greater numbers in Layers A and B and in Layers C, D, E with a number of types were represented. The most commonly observed type were multiple scrapes, occurring on 14 of the 31 specimens that contain linear marks (Table 22).

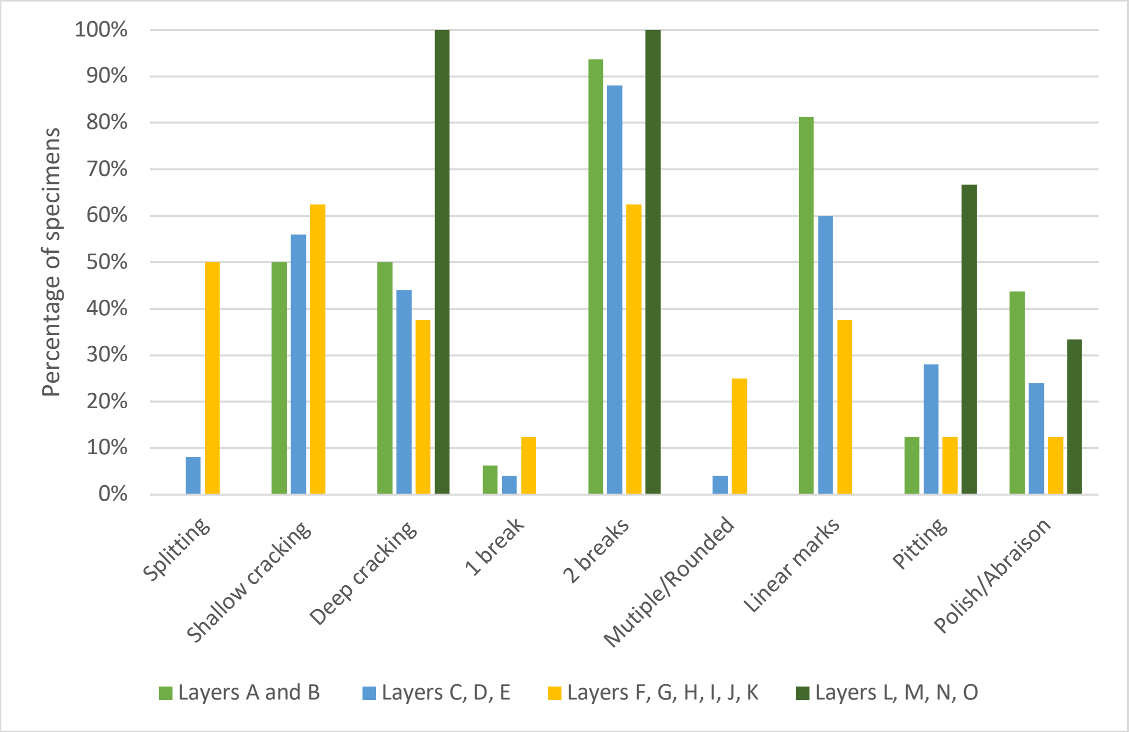

Figure 23 Taphonomic characteristic represented in each stratigraphic unit, SM:93.

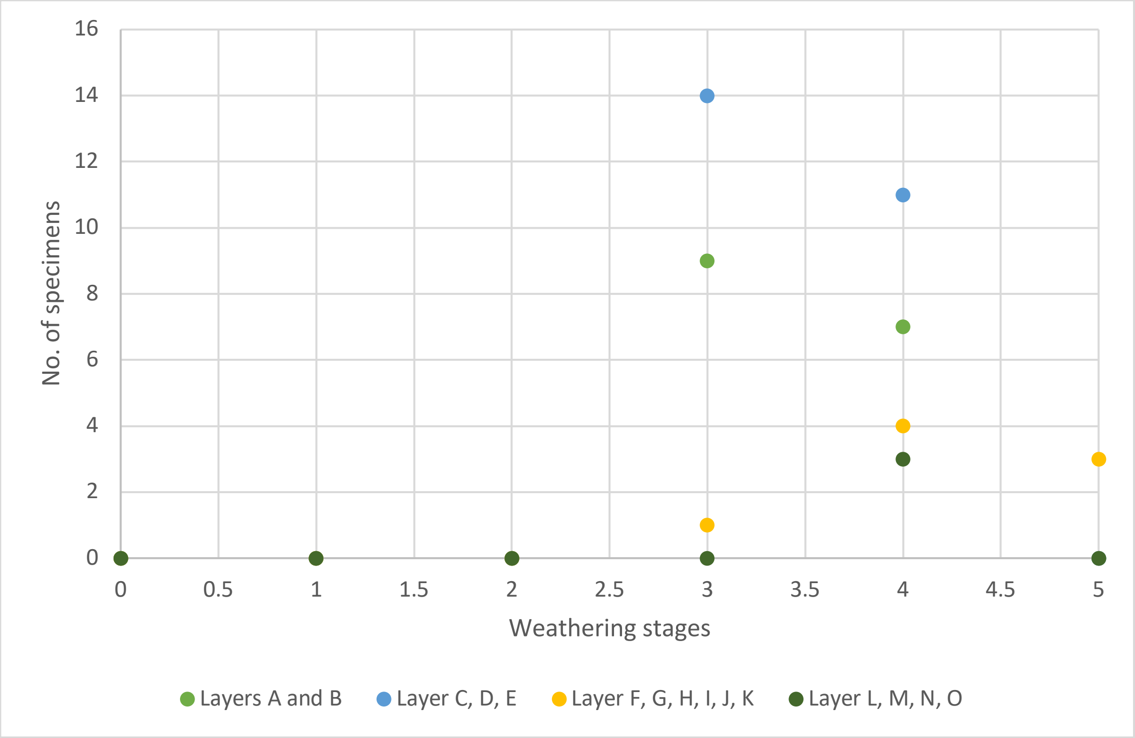

Figure 24 Weathering stages per stratigraphic unit, SM:93.

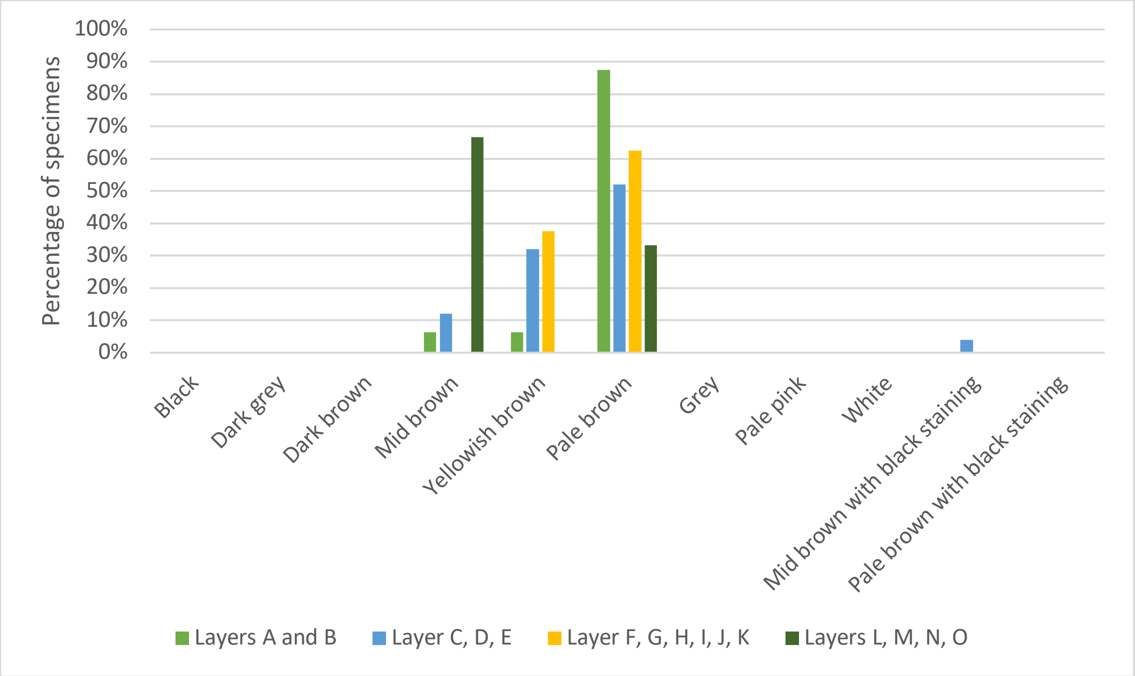

Figure 25 Colour of specimens by stratigraphic unit, SM:93.

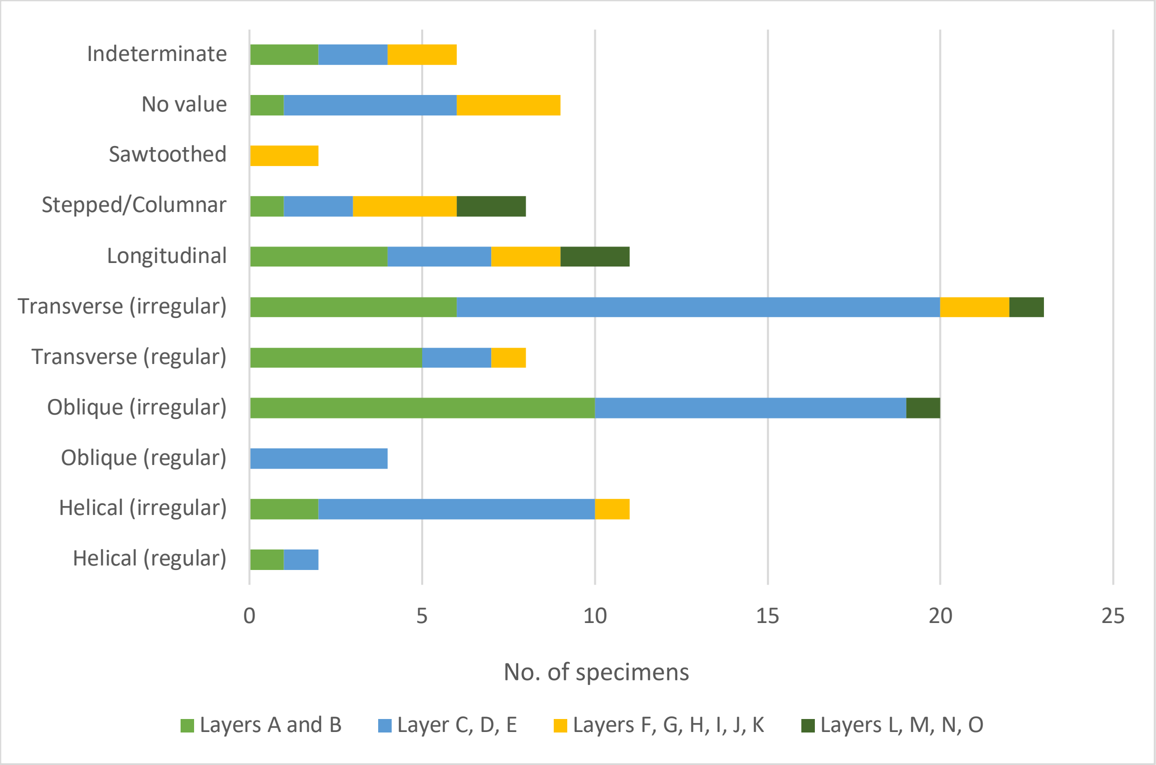

Figure 26 Break types per stratigraphic unit, SM:93.

Percentage of bone cortex with polish/ abrasion	Polish present Layers A and B	Polish present Layers C, D, E	Polish present Layers F, G, H, I, J, K	Polish present Layers L, M, N, O	Abrasion present Layer A and B	Abrasion present Layers C, D, E	Abrasion present Layers F, G, H, I, J, K	Abrasion present Layers L, M, N, O
1–24 %	1	4	1	1	6	1	0	0
25–49 %	0	1	0	0	0	0	0	0
50–74 %	0	0	0	0	0	0	0	0
75–99 %	0	0	0	0	0	1	0	0
100%	0	0	0	0	0	0	0	0

Table 20 Location of polish and abrasion per specimen per stratigraphic unit, SM93.

Location of polish/abrasion	Layers A and B	Layers C, D, E	Layers F, G, H, I, J, K	Layers L, M, N, O
Shaft	1	4	0	1
Single break points	4	1	1	0
Both break points	2	0	0	0
One break point and shaft	0	1	0	0
Across whole surface	0	1	0	0

Table 21 Number of specimens with bone cortex showing signs of polish and abrasion per specimen per stratigraphic unit, SM93.

Type of mark(s)	Layers A and B No.	Layers C, D, E No.	Layers F, G, H, I, J, K No.	layers L, M, N, O No.
Singular V shaped mark	0	2	0	0
Multiple V shaped mark	3	2	0	0
Singular U shaped mark	2	3	0	0
Multiple U shaped marks	1	3	1	0
Multiple fine scrapes	7	5	2	0

Table 22 Types of linear marks per specimen per stratigraphic unit, SM:93.

5.4: Inter-site comparison

The three most common physical taphonomic characteristics documented across all three sites were specimens with two or more breaks along the shaft, polish and abrasion on the bone surface, and signs of both shallow and deep cracking.

The most common break type per specimen across all three sites was a transverse (irregular) break, while oblique (irregular) breaks and longitudinal breaks were also located with some frequency (Figure 27). Transverse (irregular) breaks were observable on specimens at all stratigraphic units at all three sites (Figure 27).

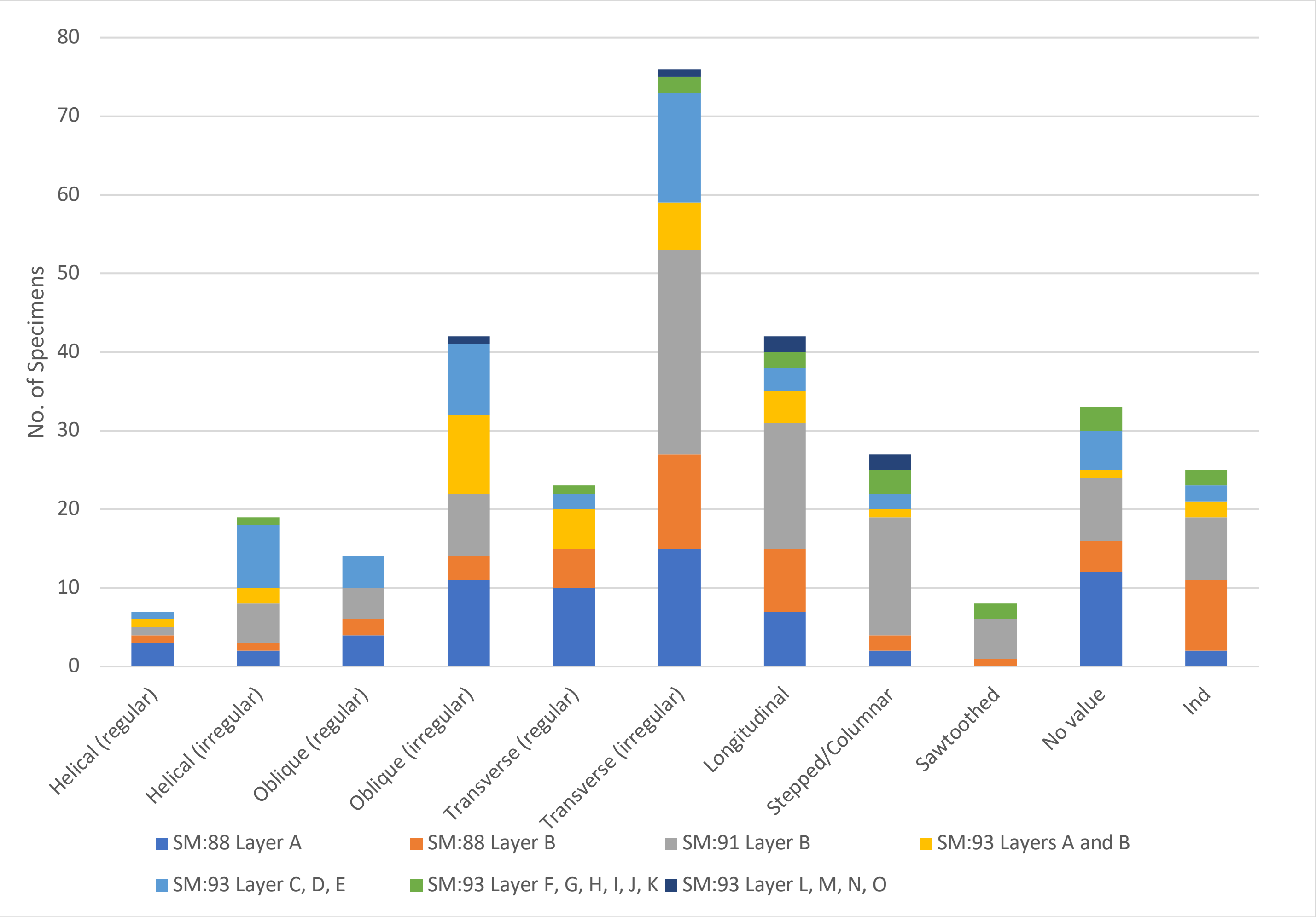

Figure 27 Break type count across SM:88, SM:91 and SM:93 by stratigraphic unit.

Cracking patterns on the bone surface was observed on every specimen in SM:91 and SM:93, while slightly lower rates were documented for SM:88, with 50% for Layer A and 95.83% for layer B (Table 23). For SM:88 and SM:91, rates of deep cracks on the bone surface were higher in each stratigraphic unit than shallow cracking (Figure 28). Both types of surface cracking increased with depth for SM:88. For SM:93,the same rates of shallow and deep bone cracking was observed at the highest stratigraphic unit (Layer A), with steady rates of decreasing deep cracking and increasing shallow cracking with depth until the lowest stratigraphic units, where all specimens showed signs of deep cracking only.

Stratigraphic unit	specimen count	bones showing signs of cracking	Percentage of specimens per stratigraphic unit
SM:88 Layer A	34	17	50
SM:88 Layer B	24	23	95
SM:91 Layer B	48	48	100
SM:93 Layers and B	16	16	100
SM:93 Layers C, D, E	25	25	100
SM:93 Layers F, G, H, I, J, K	8	8	100
SM:93 Layers L, M, N, O	3	3	100

Table 23 specimen count and percentage of specimens with deep or shallow cracking per site per stratigraphic unit.

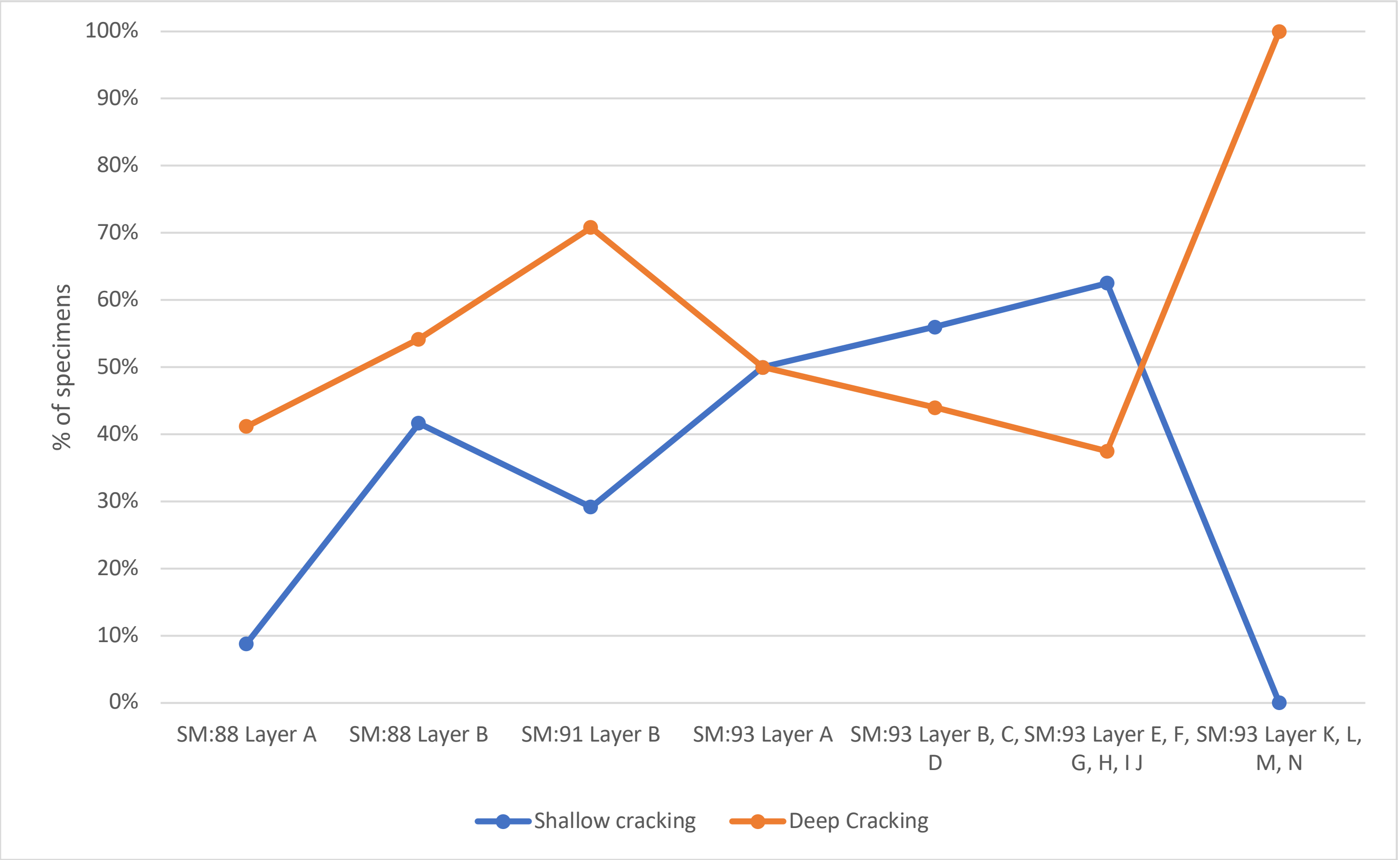

Figure 28 Rate of cracking observed on specimens per site, per stratigraphic unit.

Polish or abrasion was consistently observed, across all three sites. For SM:88 and SM:91, there were higher instances of polish as opposed to abrasion (Figure 29). For SM:93 limited patterns could be observed in the data. Rates of polish were highest at Layers C, D, E and Layers L, M, N, O. Abrasion was observed on 38% of specimens in Layer A, with only 8% of specimens at Layer C, D, E and none at the lower stratigraphic unit groups (Figure 29). Most specimens across all three sites exhibited polish or abrasion to 1–24% of the bone cortex, located on the shaft (Figure 30).

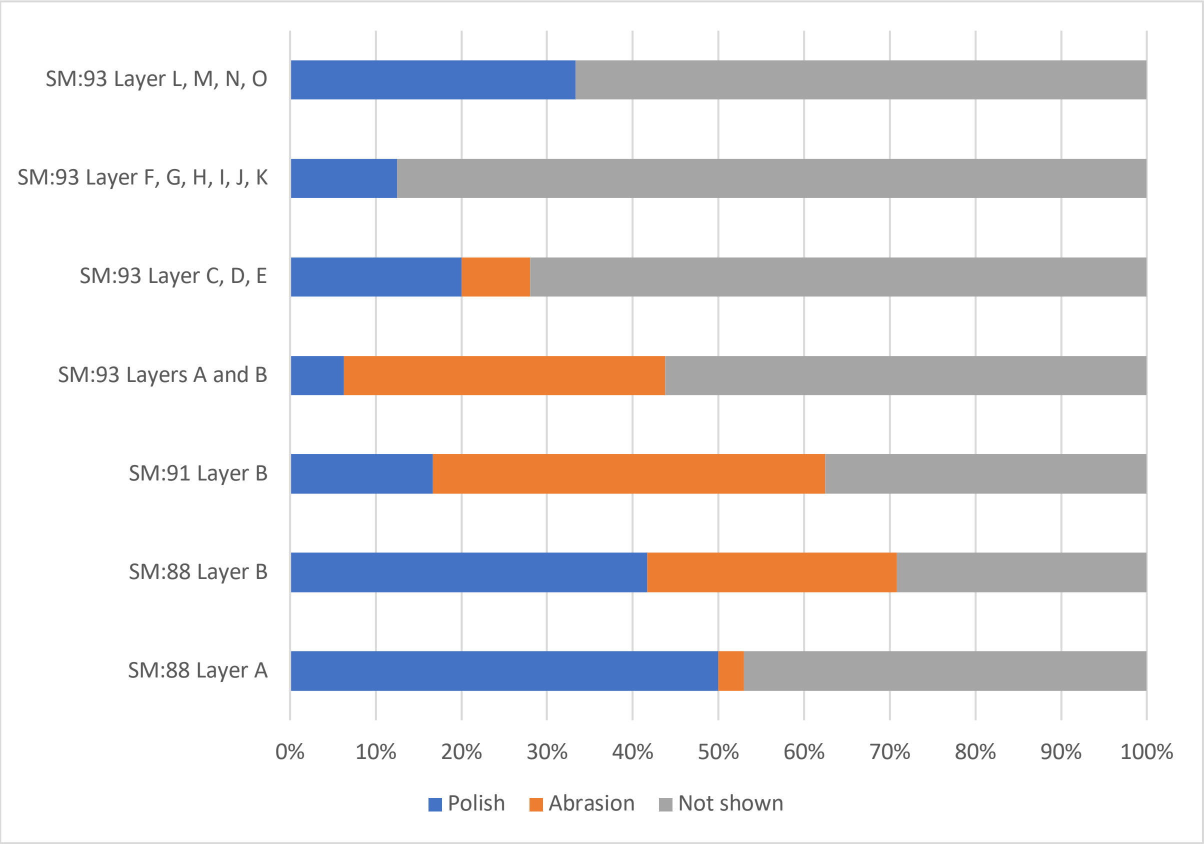

Figure 29 Percentage of polish and abrasion per stratigraphic unit per site.

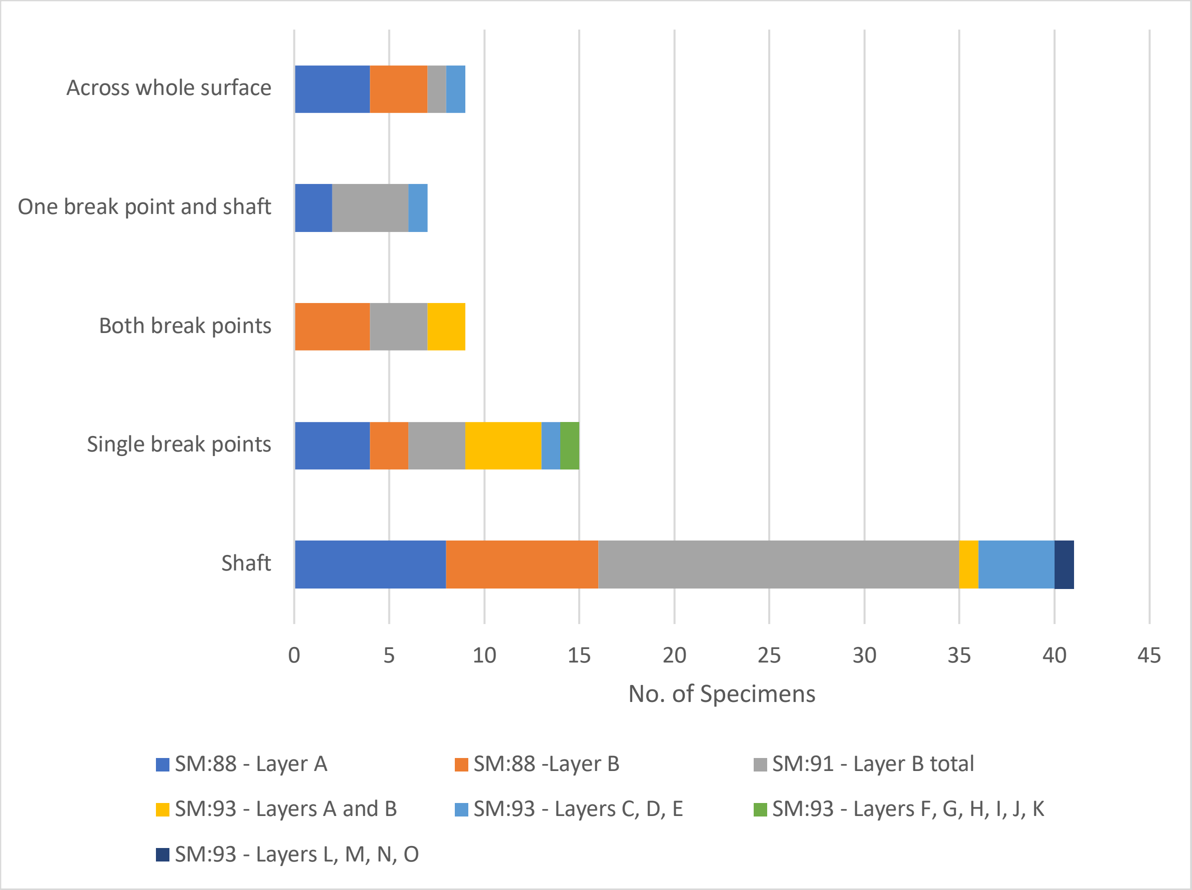

Figure 30 Count of location of polish or abrasion across SM:88, SM:91 and SM:93.

5.5: Summary

The data gathered during the analysis suggests several microscopically visible physical alterations are present on the specimens analysed from SM:88, SM:91 and SM:93. The weight and dimensions of the specimens reflect an assemblage exposed to taphonomic processes. Three taphonomic characteristics occur with greater frequency than the others. Multiple break types across the shaft with transverse (irregular) breaks being the most common at all three sites. Deep and shallow cracking were documented across the majority of specimens, and polish or abrasion to 1-24% of the bone cortex most often on the bone shaft. SM:93 appears to differ from SM:88 and SM:91 in the frequency of these characteristics, with linear marks documented in higher numbers than the other sites. Determining how these characteristics relate to shell matrix morphology and environmental impacts is necessary to contextualise the results.

Chapter 6: Discussion

This thesis set out to investigate the preservation of vertebrate fauna in mound sites through a detailed taphonomic analysis of the physical condition of analysed specimens, and to consider the implications of these data for existing models of mound formation and use. Here, the aims and the central question of the thesis are revisited in relation to the results of the analyses conducted. Firstly, a review of the taphonomic framework and its effectiveness will be considered and areas for improvement will be highlighted. Following this, the most frequently occurring taphonomic processes will be examined. This allows for a subsequent analysis of the patterns in the data and how these patterns relate to site stratigraphy. Examining the evidence for climactic and environmental pressures affecting vertebrate faunal preservation are then considered. After examining these aspects of the results, a re-evaluation of the role of vertebrate fauna in the food production strategies at these sites are assessed. Overall, vertebrate fauna is considered an underutilised resource in understanding shell mound form, function and morphology.

6.1 Assessing the taphonomic framework

Developing a taphonomic framework in which to better view and appreciate vertebrate fauna within shell matrix sites was a central focus of this investigation. It was important to develop a system that could be used to document physical taphonomic signatures on vertebrate fauna specifically so that future investigations may be able to pay greater attention to this underused data-source. The results from the analysis indicate that post depositional taphonomic process are visible on vertebrate fauna microscopically. This is important as this technology is relatively easy to access and has minimal cost. Greater understanding of the post depositional processes affecting vertebrate fauna can be achieved by using the parameters tested here.

There were some flaws with the method that became apparent as the results were being developed. The decision to analyse 50% by weight per stratigraphic unit per shell matrix site was necessary due in part to the fragility of many of the specimens; however, undertaking the identification analysis of all specimens regardless of dimensions should have been attempted. This would have created a more robust understanding of the types of vertebrate fauna present within the mounds. A further problem is that taphonomic processes can differ depending on the class of animal being investigated (Lyman 1984; Reitz and Wing 2008), therefore taphonomic processes affecting fishbones were under analysed and likely minimally understood here. Future use of this method should involve an attempt to identify all of the specimens to give greater clarity to the data.

Certain modifications proved not to be as useful or easy to identify. Weathering as a category was difficult to accurately determine and did not provide any meaningful data, as it is highly likely that the specimens under examination were the themselves the result of weathering processes. The other categories were able to better reveal the nature and mechanisms of the taphonomic process, such as documenting bone cracks on the surface. Pitting marks present on the specimens were difficult to document, as this category requires the ability to determine the depth of the mark as well as the shape of the impression. Despite these problems, recording the presence or absence of these taphonomic processes would earmark particular specimens that may benefit from more detailed analysis.

Mistakenly, several extra specimens were analysed than was intended, which is why 158 specimens were analysed out of 259, instead of 130 as seen in Table 11. While this may have affected some site interpretations, this is unlikely to have been detrimental to the broader results because a larger dataset was produced.

Several physical characteristics investigated during the modification analysis proved to be useful for this particular collection of specimens. The weight and dimensions of the specimens when analysed comparatively per XU per site illuminated several trends. Taking these measurements was very simple and several conclusions could be drawn from their results. Documenting specific break-types allowed for a clarification of the way specimens were moving through the shell mound, as well as with what frequency specimens were broken when dry or when fresh. Surface cracking was likewise easily visible and allowed for some preliminary conclusions about environmental impacts to be reached.

6.2 Taphonomic characteristics

The results obtained during the analysis indicate that there are three taphonomic characteristics that occurred with the greatest frequency across all three sites. These were high levels of fracturing resulting in multiple breaks across the shaft, cracking across the bone surface, and higher rates of polish or abrasion, often covering 1–24% of the bone surface. Looking at the detail of each taphonomic characteristic in turn will enable a more detailed discussion of how they relate to site formation processes. This positions the data in a clearer light before it is placed in the context of shell matrix taphonomy and environmental impacts on vertebrate faunal preservation.

The break-type analysis undertaken was designed to document breaks occurring across long bone fragments. Each fragment suitable for analysis could have a maximum of two break types, one at each end of the bone. Certain skeletal elements, elements with articulated ends, or heavily rounded bone, will not have breaks suitable for analysis and these were given “no value”, while bones too heavily damaged were seen to have an “indeterminate” break-type. The main purpose of this analysis was to determine if any physical characteristics could be documented that trace the movement of bones through the shell mound, specifically whether the bones were broken while fresh, or broken once deposited in the mound. Regular breaks are characterised by smooth fracture patterns and occur on bones broken shortly after the animal’s death, while irregular breaks follow multiple fracture fronts changing direction several times, found on bones broken while dry (Grunwald 2016:357). Observing the rates of fresh or dry breaks would assist in understanding whether bone fragments fall through the porous mound structure of the site therefore becoming more fragmented with depth.

A total of 81% of specimens exhibited multiple breaks across the shaft (Figure 31; Appendix 2). The most commonly observed break type across all sites was a transverse (irregular) break, followed by oblique (irregular) and longitudinal breaks seen in at least 13% of break types each (Figure 27 and 32). This indicates that most of the specimens analysed were broken while dry, possibly within the midden itself. Regular breaks were infrequently observed with transverse (regular) breaks the exception, occurring in 15% of cases (Figure 31).

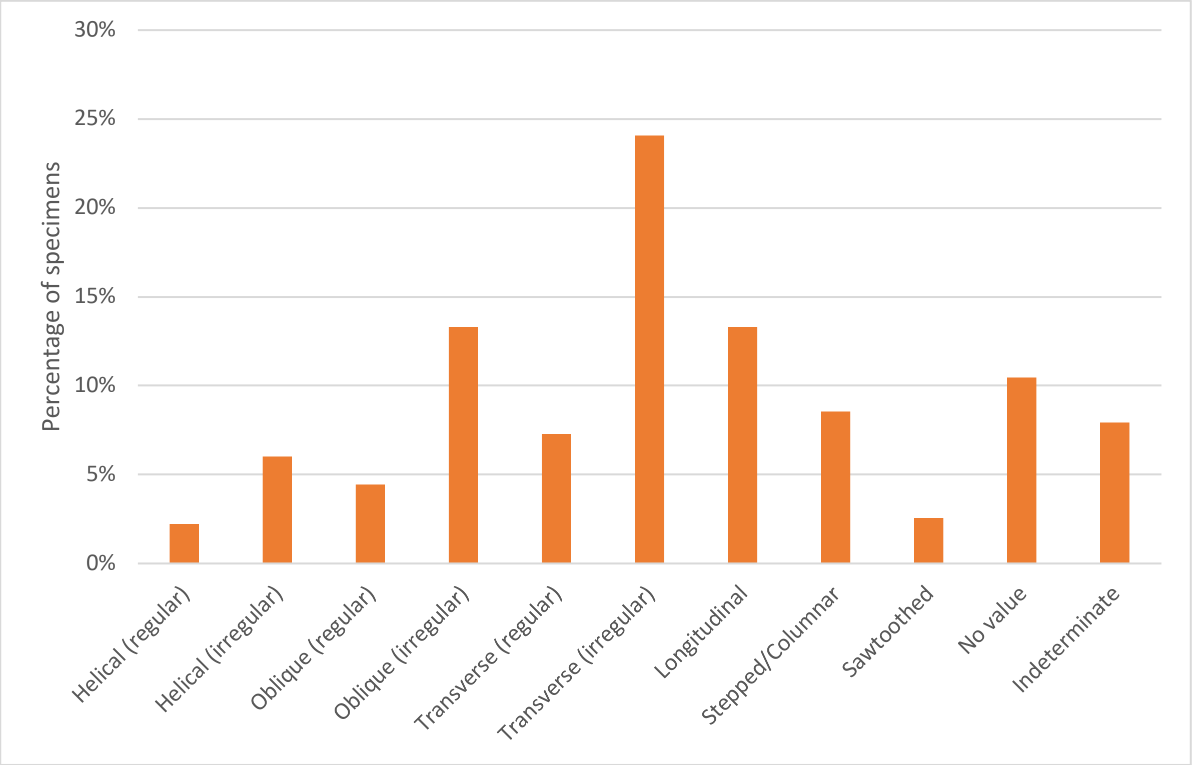

Figure 31 Percentage of break-types across SM:88, SM:91 and SM:93.

The abrasions analysis was undertaken to determine signs of alteration to the bone surface that produced a smoothed surface. These modifications were documented as either present for polish, present for abrasion, or not present. The distinction between polish and abrasion was subtle, with polish having a slight sheen as opposed to the dull and more textured quality of abrasion. Documenting polish or abrasion on the surface of specimens was important to ascertain whether sediments, water, or other abiotic processes were coming into contact with vertebrate fauna within the shell mound with enough force or repetition as to alter the bone cortex.

Abrasion and polish to the bone's surface occurred on 51% of the specimens analysed for taphonomic characteristics collectively. Polish was observed with slightly greater frequency than abrasion, with the first two stratigraphic unit groups of SM:93 the exception (Table 24; Figure 29).

Stratigraphic unit	Polish	Percentage	Abrasion	Percentage	Not shown	Percentage
SM:88 Layer A	17	50.00%	1	2.94%	16	47.06%
SM:88 Layer B	10	41.67%	7	29.17%	7	29.17%
SM:91 Layer B	8	16.67%	22	45.83%	18	37.50%
SM:93 Layers A and B	1	6.25%	6	37.50%	9	56.25%
SM:93 Layer C, D, E	5	20.00%	2	8.00%	18	72.00%
SM:93 Layer F, G, H, I, J, K	1	12.50%	0	0.00%	7	87.50%
SM:93 Layer L, M, N, O	1	33.33%	0	0.00%	2	66.67%

Table 24 Rates of polish and abrasions analysis per stratigraphic unit

Deep and shallow cracks over the bone surface were documented to understand the possible impacts of thermal alteration that the specimens may have been exposed to within the shell matrix site. Bone can be become cracked via multiple mechanisms, from burning to exposure to weathering processes including heat, wind and sunlight (Lyman 1994; Reitz and Wing 2008). The purpose of recording the presence of bone surface cracks was to ascertain if the seasonally shifting climate was causing the specimens to become damaged.

Importantly, the two most-seaward shell matrix sites, SM:91 and SM:93, had 100% of analysed specimens with either shallow or deep cracking on the bone surface (Table 23; Figure 28). In contrast, SM:88 – the more inland of the three sites investigated as part of this study (Figure 3) – had only 50% of specimens with this characteristic observable in Layer A and 94% for Layer B.

6.3 Shell matrix taphonomy and patterns of preservation

This study highlights an interesting relationship between some of the physical taphonomic characteristics noted for site SM:88 and SM:91 when compared to SM:93. Both SM:88 and SM:91 show increasing weight in specimens with depth, increasing rates of polish or abrasion with depth and infrequent evidence of linear marks, while SM:93 shows a peak in specimen weight near the middle XUs (Table 11; Figure 33), decreasing signs of polish and abrasion with depth and a greater frequency of linear marks on specimens throughout the site. A plausible explanation for this is that bone fragments suffer numerous taphonomic processes, eventually degrading significantly as to avoid detection during archaeological excavation, with only the largest bones surviving and smaller fragments ultimately disintegrating. The differences between sites could be caused by differences in site morphology.

Understanding the internal taphonomy of a shell matrix site involves viewing shells as sedimentary particles, with cultural material suspended within them (Claassen 1998:53). Understanding shells in this way better positions a discussion of the possible taphonomic impact shell mound structures have on vertebrate faunal preservation. These sites are porous structures with sediment accumulation occurring over time, and artefacts and bones may be affected by downward movement through the site. This phenomena was observed by Bourke (2012) at Hope Inlet (Figure 1). She noted that many bone fragments were seen to fall a few centimetres through the gaps between the shells during excavations.

This highlights a critical question: to what extent does this porous structure and downward movement contribute to bone taphonomy? To answer the question, it is valuable to explore break-type analysis results for the upper, middle and lower stratigraphic units from each shell matrix site. In most cases, breaks associated with dry bone were more frequent in the middle layers than in the upper stratigraphic units (Figure 32). Oblique (irregular) breaks were observed with the greatest frequency in upper layers, while transverse (irregular) breaks were observed with the greatest frequency in contexts near the middle of the excavation. The lower contexts, with only three specimens analysed in this category, showed both longitudinal and stepped or columnar breaks with greatest frequency. Regular breaks were generally confined to the upper layers of the three sites (Figure 32). Stepped or columnar breaks increased in frequency with depth, while saw-toothed breaks only occurred in the middle stratigraphic layers (Figure 32). Bone fracture mechanics are complicated and can be caused by multiple process, and this must be remembered when interpreting the results (Fernández-Jalvo and Andrews 2016; Grunwald 2016; Karr and Outram 2011). In most cases, breaks associated with dry bone were observed in the middle layers with greater regularity than in the upper stratigraphic units (Figure 32). The evidence gathered as part of the break type analysis suggests that vertebrate faunal remains are at increased risk of becoming fractured the further down the site they are located.

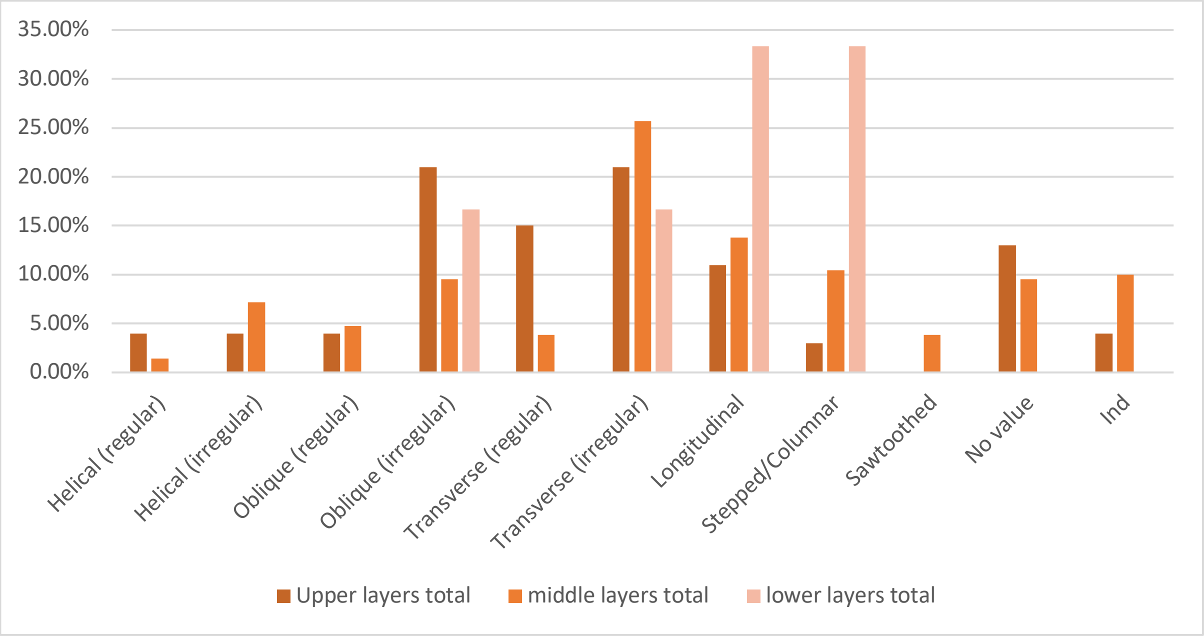

Figure 32 percentage of break-types occurring across the upper, middle and lower layers of SM:88, SM:91 and SM:93. The upper layers are SM:88 Layer A and SM:93 Layer A and B. Middle layers are SM:88 Layer B, SM:91: Layer B, SM:93 Layers C, D, E, SM:93 Layers F, J, H, I, J, K. Lower layers are SM:93 L, M, N, O.

An examination of the median weight per XU and the rate of polish and abrasion adds further support to the possibility that specimens show greater signs of damage with depth. Generally, the mean weight of each specimen per XU increased with depth for SM:88 and SM:91, while the specimen count was lowest at the deepest XU with vertebrate fauna present (Table 13; Figure 33). This downward trajectory could conceivably corrode or smooth the bone surface. This is supported by the abrasion analysis, which generally shows higher instances of polished and abraded surfaces within the middle contexts of SM:88 and SM:91 (Figure 29).

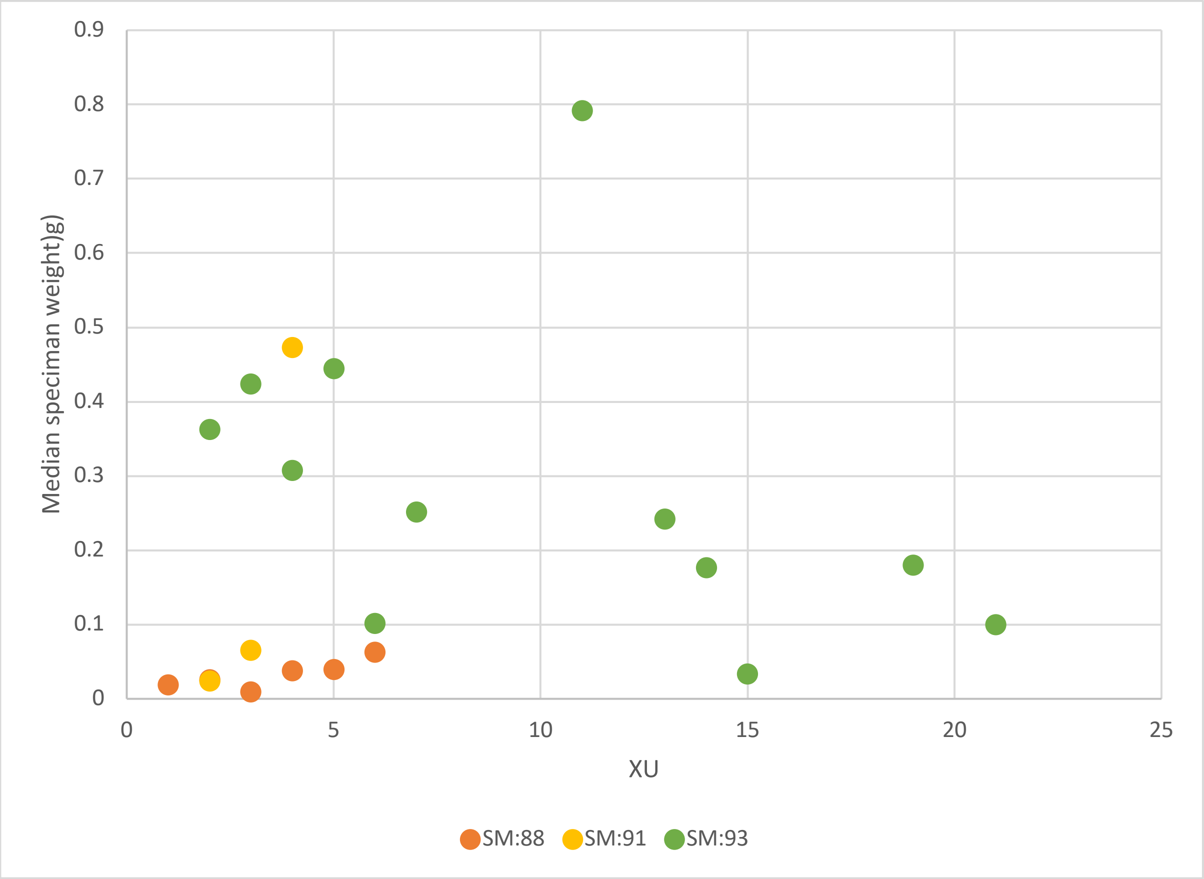

Figure 33 Median weight per XU, SM:88, SM:91 and SM:93.

Given that SM:88 is located further inland that either SM:91 or SM:93, geographic location alone does not explain these results, however comparing site morphology may better contextualise the data. SM:88 and SM:91 are circular middens with three general stratigraphic units indicating a similar composition. By contrast SM:93 is a larger elongated midden with several stratigraphic units (Table 1). These sites were the few at Prunung and Bweening (Figure 2) that contained enough vertebrate fauna for analysis, so comparing these results to nearby sites is problematic. An examination of data obtained by Bailey (1975a) during his excavations at the Kwamter mound at Weipa is more insightful.

The Kwamter mound is the largest in a cluster of nine smaller shell middens, located on the edge of an open forest (Bailey 1975a:XVII:15-16). It is described by Bailey (1975a:XVII:16) as having two construction phases; an earlier more generalised scattering of shell followed by a more localised clustering where the greatest height of the mound occurs. Bailey (1975a:XVII:16-17) observes that the earlier stage is characterised by brittle and broken shell and is clearly visible at the base of the excavated unit. This fits well with the descriptions for SM:88, SM:91 and SM:93, where fragmented shells were characteristic of the lower stratigraphic units (Morrison 2015). Looking specifically at specimen recovery rates, the Kwamter mound also contained fewer specimens at the lowest three excavated units, in keeping with the data gathered for all three sites investigated here (Table 1; Table 14). SM:93 and the Kwamter mound were excavated with a $1m^2$ pit unlike SM:88 and SM:91 that were excavated by $50cm^2$ pits (Table 1; Table 2). This means that two of the mounds compared here have a larger sample size and this is important to keep in mind during the discussion.

Taking the above analysis into account, it is possible that when specimens are deposited into a shell matrix site, they move through the stratigraphic layers, suffering damage that eventually impacts the likelihood of recovering them during archaeological investigation, particularly at the base of the site. There appears to be a relationship between stratigraphy and the rate of some physical taphonomic processes. With more measurement and break type analysis for other sites per stratigraphic unit, this phenomena may be better understood. Viewing the data in this way allows a clearer picture of shell matrix taphonomy to emerge.

6.4 Environmental impacts

An important focus for this investigation was to see if any of the taphonomic characteristics documented on the specimens could be linked to past and present environmental changes. The poor preservation rates of vertebrate fauna from shell matrix sites in northern Australia are rarely considered against the backdrop of the tropical climate and the landscape in which they are situated. If some indications could be discerned that suggest the local environment hinders vertebrate faunal preservation at shell matrix sites, a deeper appreciation for these low recovery rates could be achieved.

Stable temperatures with few water fluctuations are required for optimum bone preservation in the archaeological record (Lyman 1984, Reitz and Wing 2008). There is some evidence to suggest that moisture levels, when stable, can assist in protecting bones from decay (Ross and Cunningham 2011). Water moves through bone much the same way as it moves through soil (Hedges and Millard 1995:156), and fluctuating weather conditions, such as seasonal changes, where bone is potentially exposed to heavy rainfall followed by drier periods can cause the bone surface to become cracked or warped (Fernández-Jalvo and Andrews 2016). Experimental studies have indicated that bones exposed to dry and hot climates exhibited features consistent with rapid degradation, and likely made these specimens more prone to fracturing and splitting soon after deposition (Karr and Outram 2011:558).

Weathering processes affecting faunal preservation vary significantly depending on the localised climactic conditions (Behrensmeyer 1978; Ross and Cunningham 2011:127). Shallow and deep cracking on the bone surface was observed consistently across all three shell mounds under investigation. There are some indications that more inland site SM:88 was better protected evidenced by slightly less rates of surface bone cracking, and higher rates of vertebrate fauna preservation when compared to the overall weight of the shell matrix site. To examine these geographical connections between vertebrate faunal preservation in greater detail, a worthwhile comparison can be made between the Kwamter mound and SM:88. Both these sites are located inland, partially sheltered by forest and separated from the beach by seasonal swampy lands (Bailey 1975a:XVII16; Morrison 2015). It is interesting that like SM:88, the Kwamter Mound exhibited higher rates of vertebrate faunal preservation when compared to other sites within Albatross Bay. The more exposed beach location and minimal coverage by vegetation might be exposing more seaward middens to greater degrees of environmentally driven damage (Morrison 2010:289).

6.5 Re-evaluating models for mound formation at Albatross Bay

Understanding how and why shell matrix sites were constructed has so far been a major focus of past research, specifically how shellfish fit into the diets of Aboriginal peoples of the past (Bailey 1975a; 1975b; Bourke 2012; Faulkner 2013; Morrison 2013a, 2013b, 2015; Veitch 1999; O'Connor 1999). Analysing the vertebrate fauna from SM:88, SM:91 and SM:93 has given insight into the types of animals that maybe have been consumed here. By looking at the results of this study, it is plausible to suggest that vertebrate fauna was consumed with some regularity at these sites. This new information can help supplement current interpretations of shell matrix site use, and therefore add to food production models.

The consumption of a diverse range of vegetables, plant foods, vertebrate fauna and molluscs across the north Australian coast is well attested to in ethnographic literature (e.g. McConnel 1953; Meehan 1982; Thomson 1939). An examination of the physical environment of Albatross Bay indicates that the region supported a variety of vertebrate fauna. Estuaries would be rich with fish, swamp habitats supported a wide variety of birdlife, and savannah woodlands provided a year round supply of large game, fish and plant foods (Bailey 1975a:XVII9,16; McConnel 1953:5-7; Morrison 2015:3). These habitats were and are dynamic landscapes rich in resources (McConnel 1953:6).

Kangaroos and wallabies were and continue to be plentiful and were hunted year round, though more commonly during the drier months, hunted by men with spears alongside shellfish when other vegetable resources were more limited (Bailey 1975a:XVII9-9; Meehan 1982:147,153; Reitz and Wing 2008; Sutton 1978; 1994; Thompson 1939:213,217). Bigger game were often cooked in large earth ovens or on open coal fires in coastal regions (Sutton 1994:34), and in Arnhem land, Meehan (1982:147) indicates that the whole animal was consumed aside from furs and some bones. Meehan (1982:89) also describes a method of cooking using a Manirra oven, which involved steaming fresh shellfish using the older shells as heat retainers. The bones of larger game were in some cases manufactured into barbs for spears, while wallaby incisors were filed down to a fine point for use as an engraving tool (McConnel 1953:8-9; Sutton 1994:48). Though ethnographic data has its limitations (Hiscock and Faulkner 2006), these sources indicate the frequent consumption of vertebrate fauna and utilisation of the bones occurs across northern Australia, as well as specifically in the region surrounding Prunung.

Archaeological evidence in Albatross Bay indicates a continued presence of vertebrate fauna at shell matrix sites (Bailey 1975; Morrison 2015). At the Kwamter mound, Bailey (1975a:VII30) identifies *Macropus agili*s, *Isoodon macrourus*, *Isoodon* sp., and *Mylio* sp. as the most frequently identified vertebrates. The majority of the specimens from SM:88, SM:91 and SM:93 were identified as mammals, with *Macropus* sp. the most frequently observed taxa (Table 15). As the sampling strategy employed for this thesis involved the analysis of 50% of the total specimens (see Chapter 4), it is possible that this impacted the rate of identified mammal specimens. For example, only small amounts of fishbone were observed at SM:93 exclusively, and generally speaking fishbones are smaller than mammal or bird bone (Table 15). Despite this obvious problem, it is interesting to observe that across all three sites, *Macropus* sp. tibia and rib fragments, associated with larger cuts of meat, were the most commonly identified skeletal element (Figures 35 and 36; Table 16). The higher frequency of these skeletal elements at SM:93 is also of interest, as this shell mound is reasonably close to the coast, suggesting that these animals may have been brought to that site.

The difficulty is in determining to what extent vertebrate fauna were incorporated into coastal food production systems (Bailey 1975a:VII5). Many of the models for shell matrix site formation suggested that social gatherings and seasonal factors may have been a driving factor for increased shellfish consumption, resulting in rapid accumulation of shellfish (Clune and Harrison 2009; Bourke 2012). Factoring in the known abundance and use of *Macropus* sp. in and around Albatross Bay, one possible explanation is that large game such as kangaroo or wallaby were consumed as part of these bigger social gatherings alongside shellfish. Determining whether any processing or cooking was being undertaken at these sites may assist in further evaluating this theory.

An important component of the taphonomic framework involved documenting evidence of thermal alteration by examining colour changes to the bone surface. This was designed to highlight any concentrations of specimens that may have been exposed to cooking techniques. Bone can become burnt by human agency or natural occurrence, and documenting colour changes does not give a precise indication as the heat the specimen was exposed to (Asmussen 2009). During this study some signs of burnt bone were documented across all three sites, though patterns were difficult to establish. Most of the specimens fell into brown colour categories, showing limited signs of thermal alteration (Figure 34). Specimens from SM:88 and SM:91 exhibited some signs of burning showing black staining, although these occurred in less than 20% of cases (Figure 34). Though there is imperfect evidence to suggest this occurred at Prunung in the same way as Meehan (1982:89) observed, it poses an interesting question around cooking methods and the use of shell matrix sites in the preparation of food.

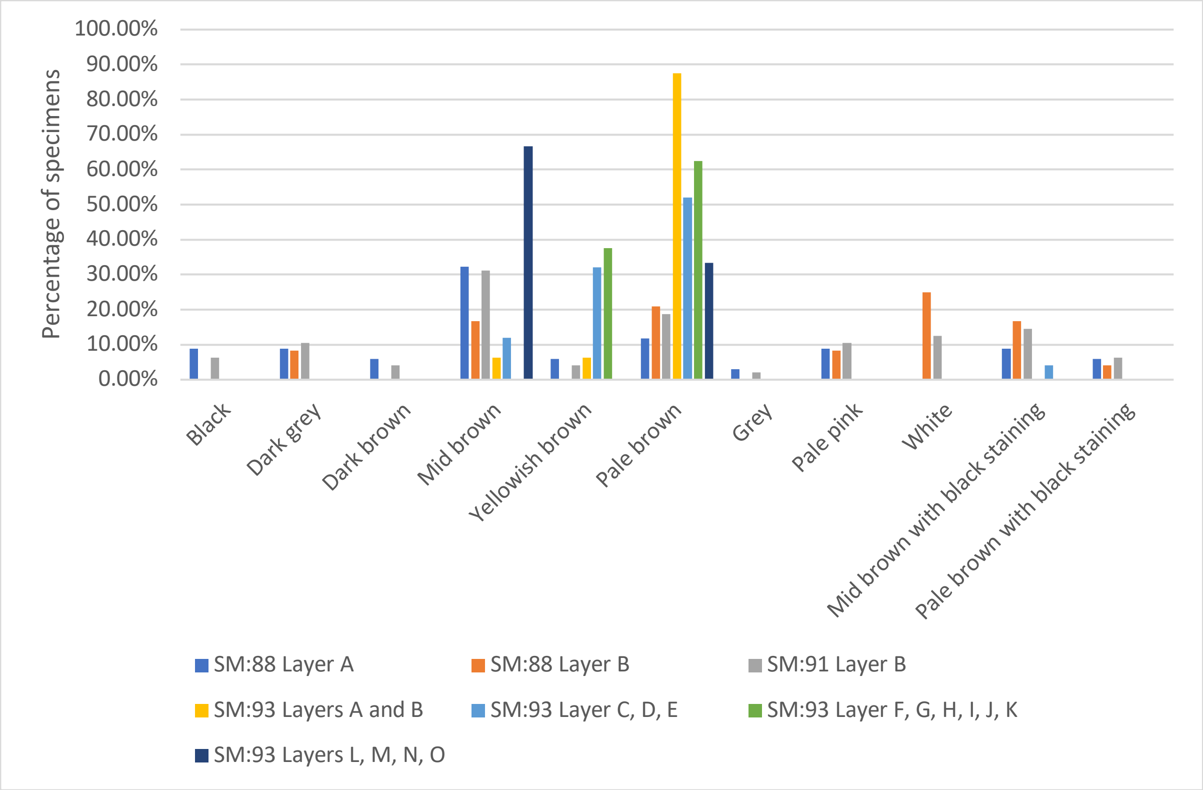

Figure 34 Comparison of specimen colour across SM:88, SM:91 and SM:93 per stratigraphic layer.

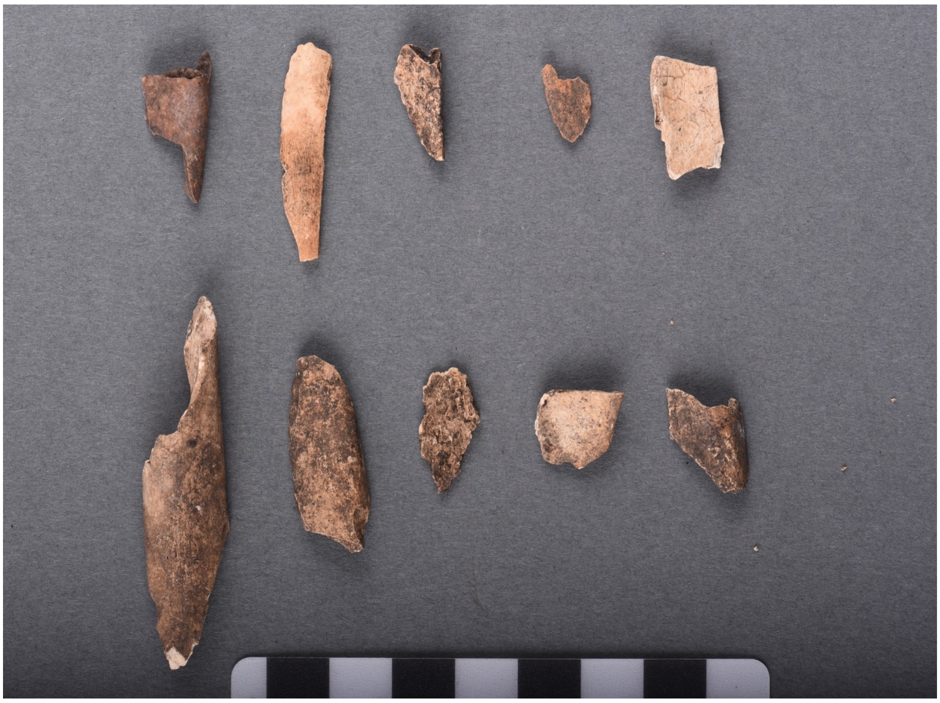

Figure 35 Specimens identified at *Macropus* sp. tibia fragments. Top: SM:93-XU3-003, SM:93-XU3-004, SM:93-XU5-003, SM:93-XU6-001. Bottom: SM:93-XU7-002, SM:93-XU11-001, SM:93-XU11-004, SM:93-XU13-005, SM:93-XU13-013.

Figure 36 Specimens identified as *Macropus* sp.tibia fragments. Top: SM:93-XU2-001, SM:93-XU2-006, SM:93-XU4-001, SM:93-XU13-011. Bottom SM:93-XU4-003, SM:93-XU6-003, SM:93-XU6-005, SM:93-XU13-012. Note that SM:93-XU13-0111 and SM:93-XU13-012 have been refitted here.

6.5 Summary

This discussion examined the results obtained during the analysis of vertebrate faunal specimens from SM:88, SM:91 and SM:93. Five areas were focused on that directly reference the aims of the thesis, and address the research question. The taphonomic framework provided some useful ways to view highly fragmented vertebrate fauna. While there is scope to improve the methods, the data obtained here provided robust and meaningful insights on the broader research question posed. Three taphonomic characteristics were seen to occur with the greatest frequency; bone fracturing, surface cracks along the bone cortex and polish or abrasion on the surface. These were seen to occur in different rates depending on the stratigraphic units, with notable patterns with depth. Environmental impacts appear to affect sites with closer proximity to the coastline. There is a degree of variability independent of geographical location, and this poses some interesting questions around the role of stratigraphy in vertebrate faunal preservation. The high proportions of large game particularly at SM:93 indicates that vertebrate fauna may have been used with greater frequency at shell matrix sites than previously thought. This highlights the strong need for detailed analysis of vertebrate fauna using a taphonomic framework, and future work at shell matrix sites would benefit from this perspective.

Chapter 7: Conclusion

This thesis has aimed to demonstrate that far from being a problematic data source, the broken and fragmented remains of vertebrate fauna from shell matrix sites can reveal much about the depositional histories of the sites under investigation. The research question and five key aims were designed to determine what role vertebrate fauna played at shell matrix sites, and what taphonomic processes could be affecting their recovery rates. By approaching vertebrate faunal remains from shell matrix sites with more rigorous analysis, a deeper understanding of past food production strategies and site formation processes can be achieved (Madgwick and Mulville 2015:255). Three shell mound sites from Prunung, Albatross Bay, were used to answer the research question, SM:88, SM:91 and SM:93.

The first aim of the thesis was to develop a taphonomic framework that could be used to document physical characteristics on vertebrate fauna from a shell matrix site. This would allow for an understanding of the types of processes affecting vertebrate faunal preservation. Prior to creating this framework, a detailed review of past archaeological investigations in northern Australia was needed. The literature review undertaken in Chapter 2 revealed that the shell matrix sites at Albatross Bay have a human origin (Bailey 1977; Bailey et al. 1994; Morrison 2013a; 2013b; 2015). There are several ways to determine whether shell mounds or middens are likely to be anthropogenic, and a number of key characteristics have been outlined (Attenbrow 1992; Bailey et al. 1994:71; Bowdler 2013:364; Coutts 1966). The presence of animal bone is used as one of many characteristics to differentiate between natural and culturally constructed shell matrix sites (Gill 1954). Despite this, vertebrate fauna remains significantly under investigated at shell matrix sites, with weight being the only data available to compare between sites across northern Australia. Given that vertebrate fauna is continuously documented as present at these sites, and used to affirm sites as human constructions, it remains a problem that this data source has undergone such minimal analysis to date. This study was designed to be a first step in resolving this problem via a detailed analysis of taphonomic processes affecting faunal preservation in shell matrix sites.

To further understand the types of taphonomic processes inhibiting vertebrate faunal recovery, an investigation into the past and present environmental conditions as well as previous archaeological investigations was required. Albatross Bay is situated in the northern Australian tropics, with distinctive wet and dry seasons. A variety of edible vertebrate faunal species were found present in the region, which were likely accessible to Aboriginal groups in the mid- to late Holocene. Mid- to late Holocene climactic changes altered the landscape, with different ecosystems emerging and receding over time. SM:88, SM:91 and SM:93 were previously investigated by Morrison (2013a; 2013b; 2015), and were found to have the highest vertebrate faunal recovery rates at Prunung. An examination of the ecological conditions indicated that heat and shifting moisture levels are not favourable to bone preservation.

After these two important analyses, a taphonomic framework was developed. This method had three distinct elements; documenting the weight and dimension of each specimen, identifying the vertebrate fauna, and then documenting a series of physical taphonomic signatures visible microscopically on the specimens. The goal here was that the relationships between low vertebrate faunal recovery rates, environmental process and shell matrix form and function might be made clearer through such analysis. The taphonomic framework developed to answer the research question was able to shed light on the complexity of shell matrix taphonomy. The framework allowed for the successful documentation of several physical processes impacting vertebrate faunal preservation. The microscopic analysis was designed to be succinct and relatively cost effective, and this was ultimately successful. There were some errors within the framework that should be addressed if these methods are to be replicated. For instance, the decision to identify only 50% of the specimens in keeping with the sampling strategy likely skewed the data set in favour of mammals. To avoid this problem, identification of the specimens should have occurred alongside the weight and dimensions analysis.

The next step in this process was to test this framework and determine its effectiveness by analysing the vertebrate faunal specimens from SM:88, SM:91 and SM:93. The results of the analyses indicates the assemblage has physical alterations that can be documented microscopically. Examining the weight and dimensions of the specimens showed a highly fragmented dataset. Through the analysis of each stratigraphic layer within each site, three taphonomic characteristics were observed with the greatest frequency. These included multiple breaks across the shaft of long-bone fragments, deep and shallow cracking across the bone cortex in 100% of cases for SM:91 and SM:93, and surface abrasions to 1-24% of the bone cortex frequently located along the bones shaft. Some similarities in the rates of these characteristic exist between SM:88 and SM:91.

The data was then discussed in the context of mound stratigraphy, environmental processes and their impacts on vertebrate fauna within a shell mound. The porosity of the shell matrix sites when contextualised alongside the frequent annual climactic oscillations may be impacting on vertebrate faunal preservation. This was seen in the high rates of bone fractures and surface cracking across the bone cortex. The tropical environment may be causing damage to the specimens with the seaward sites most affected by this trend. The final aim of the thesis was to use the data to re-evaluate current food production strategies in the region. The identification analysis in particular allowed for a re-evaluation of the role of vertebrate fauna had in food production models for Albatross Bay. The higher rates of *Macropus* sp. tibia and rib fragments throughout the site when balanced with ethnographic and archaeological data suggests larger game were possibly utilised with greater frequency than previously thought. The results do not indicate a mysterious taphonomic process is at work within these three sites, nor does it suggest that mammals were of equal or greater significance than shellfish at shell matrix sites. What the results of the thesis show is that bones are exposed to a variety of taphonomic impacts that affect their preservation over time, and that to ignore these processes is to minimise their role in understanding both the practices contributing to mound formation, and to subsequent site formation processes.

There are, however, areas for future research that this investigation has highlighted. This study was limited to a microscopic analysis, and future projects may be able to better contextualise the data found here through the use of other technologies such as SEM. This technology may be able to better capture details regarding alterations to bone surfaces. There remains a limited understanding of how shell matrix sites may have been used in food preparation, specifically in terms of cooking techniques. A real gap exists in understanding what types of foods were consumed around these sites, not only in terms of vertebrate fauna, but other resources such as plant foods. This was beyond the scope of the investigation here, but a fuller and more detailed analysis of these issues might allow for a more robust interpretation of the taphonomic characteristics documented.

This investigation has hopefully repositioned vertebrate faunal remains found within shell matrix sites. By viewing these fragmented specimens as part of a larger story of shell matrix site creation across northern Australia, a fuller picture of shell midden and mound form and function within the landscape can be achieved.

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Appendix 1: Photos of specimens SM:88, SM:91 and SM:93


SM88XU1001


SM88XU1001(2)


SM88XU1002


SM88XU1002(2)


SM88XU1003


SM88XU1003(2)


SM88XU1005


SM88XU1005(2)


SM88XU1006


SM88XU1006(2)


SM88XU1007


SM88XU1007(2)


SM88XU1008


SM88XU1008(2)


SM88XU1011


SM88XU1011(2)

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 SM88XU1017	 SM88XU1017(2)


SM88XU1018


SM88XU1018(2)


SM88XU1021


SM88XU1021(2)


SM88XU2001


SM88XU1001(2)


SM88XU2009


SM88XU2009(2)

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 SM88XU2012	 SM88XU2012(2)
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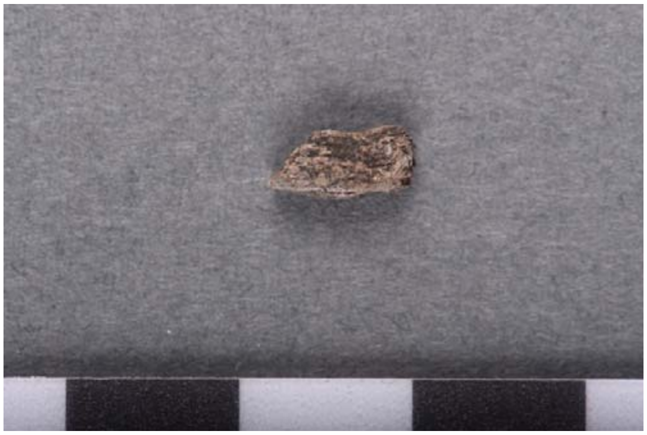
 SM88XU2014	 SM88XU2014(2)

SM88XU2015

SM88XU2015(2)

SM88XU2016



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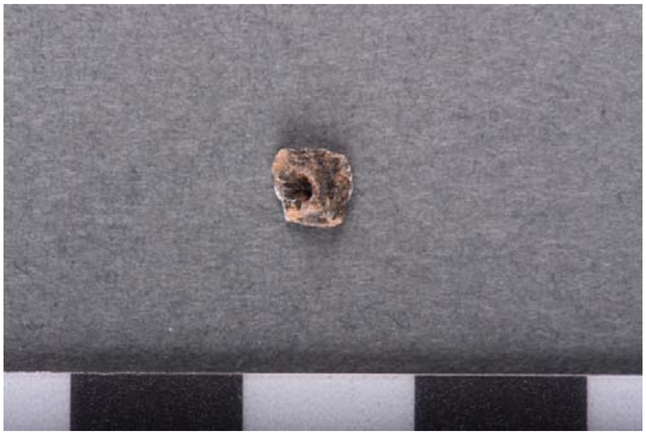

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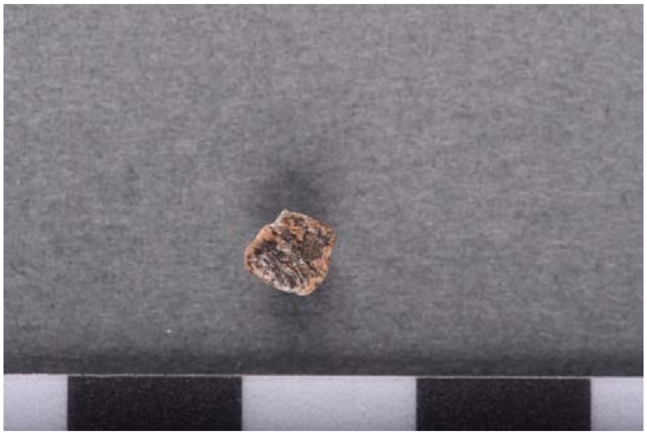

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 SM88XU2024	 SM88XU2024(2)
 SM88XU2025	 SM88XU2025(2)


SM88XU2026


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SM88XU2027(2)


SM88XU2032


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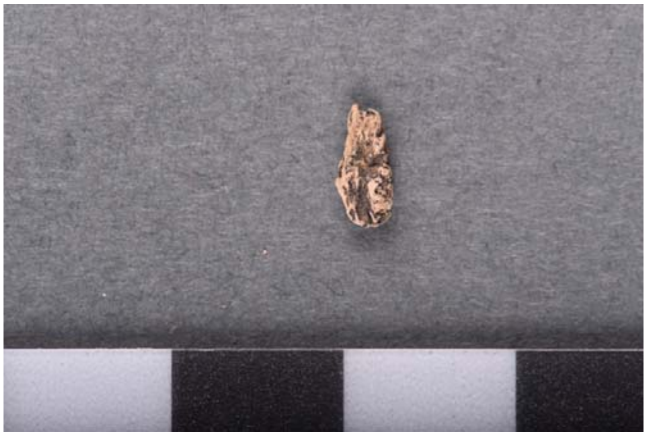
SM88XU2034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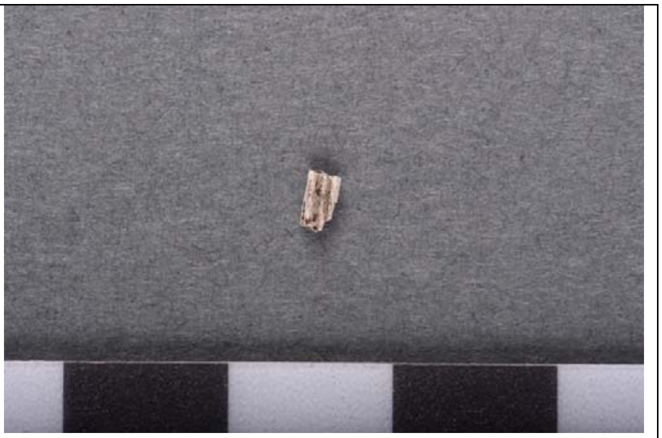
SM88XU3003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SM88XU4007


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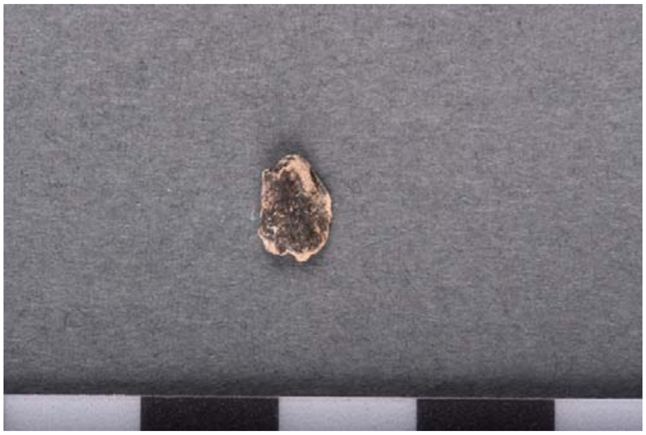 SM88XU5007	 SM88XU5007(2)
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SM88XU6004


SM88XU6004(2)


SM88XU6005


SM88XU6005(2)


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SM91XU2001(2)


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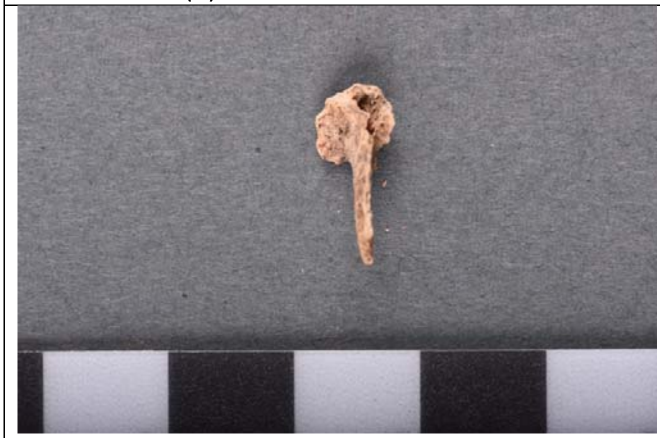
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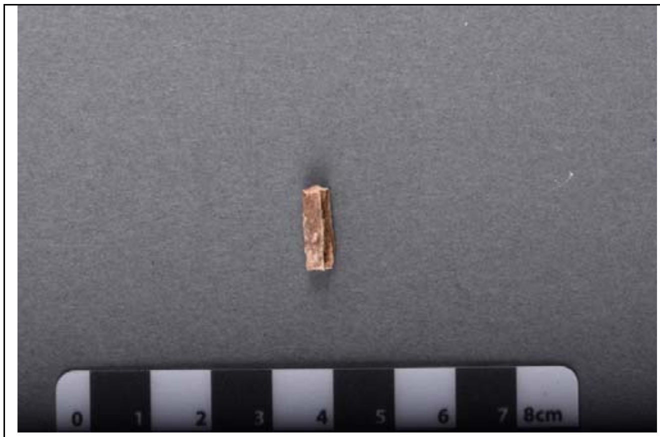

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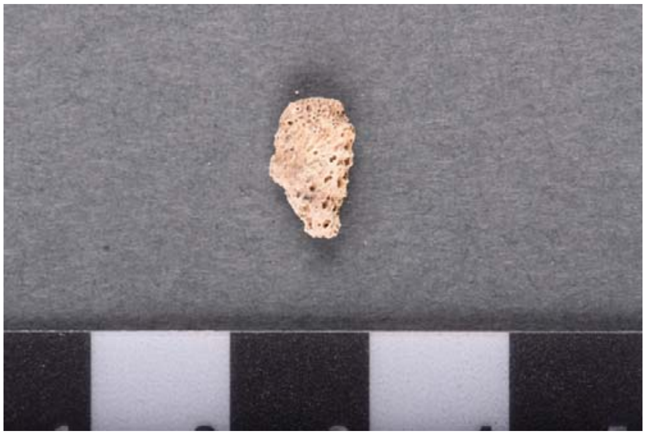
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SM93XU21004(1)

SM93XU21004(2)

Appendix 2: Raw data SM:88, SM:91 and SM:93

SM:88

Stratigraphic layer	Context	Speciman ID	Fragment ID (Where necessary)	Weight_g	Length_mm	Width_mm	Thickness _mm	Class	Size	Species	Skeletal element fragment	Weathering stage	Splitting present	Cracks	Number of breaks	Break type1	Break type 2	Linear marks present	Catagorisation of Linear marks	Pitting present	Polish/abrasion present	% of surface with polish/abrasion	Location of polish/abraison	Colour	Colour catagory
Layer A	XU1	1		0.0750	8.650	5.510	1.910	Mammalia	Sml/med	Phalangeridae or Isoodon sp.	Long bone	3	No	Yes - deep	2	Transverse (regular)	Transverse (irregular)	No	No value	No	Yes - Polish	1-24	Shaft	Brown 7.5 YR 4/3	Mid brown
Layer A	XU1	2		0.0330	7.340	2.500	1.820	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Transverse (irregular)	Transverse (irregular)	No	No value	No	No	0	No value	Dark yellowish brown 10YR 4/4	Yellowish brown
Layer A	XU1	3		0.1420	16.620	3.860	2.610	Mammalia	Sml/med	Unidentified	Limb bone,	3	No	Yes - shallow	2	Oblique (irregular)	Longitudinal	Yes	Multiple scrapes	No	Yes - Polish	50-74	All	Dark brown 7.5YR 3/3	Dark brown
Layer A	XU1	4		0.0100	3.370	2.730	2.250	Mammalia	Unidentified	Unidentified	Unidentified														
Layer A	XU1	5		0.0340	6.120	2.440	2.270	Mammalia	Sml/med	Phalangeridae sp. or similar	rib fragment	4	Yes	Yes - deep	2	Oblique (irregular)	Transverse (irregular)	No	No value	No	No	0	No value	Brown 7.5YR 4/3	Mid brown
Layer A	XU1	6		0.0420	7.020	2.860	1.790	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	1	Transverse (irregular)	No value	No	No value	No	No	0	No value	Pink 7.5YR 8/3	Pale pink
Layer A	XU1	7		0.1020	11.980	4.270	2.870	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Oblique (irregular)	Oblique (irregular)	No	No value	No	Yes - Polish	0	No value	Black 7.5YR 2.5/1	Black
Layer A	XU1	8		0.0800	9.740	4.300	1.790	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (irregular)	Longitudinal	No	No value	No	Yes - Polish	1-24	Break 1 and Shaft	Black 7.5YR 2.5/1	Black
Layer A	XU1	11		0.0420	6.500	4.090	2.110	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Oblique (regular)	Transverse (regular)	No	No value	No	Yes - Polish	0	No value	Brown 7.5YR 4/2	Mid brown
Layer A	XU1	13		0.0690	6.590	4.820	2.140	Mammalia	Unidentified	Unidentified	Limb bone	4	No	Yes - deep	2	Transverse (regular)	Oblique (irregular)	No	No value	No	Yes - Polish	1-24	Shaft	very dark greyish brown 10YR 3/2	Dark brown
Layer A	XU1	14		0.0330	9.330	3.450	1.450	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Helical (regular)	Oblique (regular)	Yes	Linear marks V shape (multiple)	No	Yes - Polish	1-24	Shaft	Pale brown 10YR 6/3	Pale brown
Layer A	XU1	16		0.0300	7.750	4.010	1.930	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Longitudinal	Transverse (irregular)	Yes	Linear marks V shape (multiple)	No	No	0	No value	Greyish brown 10YR 5/2	Mid brown
Layer A	XU1	17		0.0190	6.910	1.950	1.020	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (irregular)	Oblique (irregular)	Yes	Linear marks U shape (multiple)	No	No	0	No value	Dark greyish brown 10YR 4/2	Dark grey
Layer A	XU1	18		0.0200	5.520	3.170	1.690	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (irregular)	Helical (irregular)	Yes	Linear marks V shape (multiple)	Yes	Yes - Polish	1-24	Shaft	Brown 10YR 4/3	Mid brown
Layer A	XU1	19		0.0110	5.170	1.410	1.360																		
Layer A	XU1	20		0.0100	6.640	2.950	1.150																		
Layer A	XU1	21		0.0240	7.480	1.900	1.880	Mammalia	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (irregular)	Stepped/Columnar	No	No value	Yes	Yes - Polish	1-24	Shaft	Very pale brown 10YR 8/2	Pale brown
Layer A	XU1	22		0.0110	5.430	3.820	0.720																		
Layer A	XU1	23		0.0120	4.470	2.690	1.490																		
Layer A	XU1	24		0.0110	3.820	3.310	1.980																		
Layer A	XU1	25		0.0190	4.570	2.680	2.030																		
Layer A	XU1	26		0.0050	4.300	1.650	0.880																		
Layer A	XU1	27		0.0070	3.360	2.060	1.200																		
Layer A	XU1	28		0.0120	5.950	1.920	1.500																		
Layer A	XU1	29		0.0070	3.920	1.530	1.260																		
Layer A	XU1	30		0.0120	5.450	1.740	1.400																		
Layer A	XU1	31		0.0100	3.830	2.590	1.860																		
Layer A	XU2	1		0.0240	6.520	5.010	1.560	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	multiple, too significantly rounded	Ind	Ind	No	No value	No	Yes - Polish	1-24	Shaft	Yellowish brown 10YR 5/4	Yellowish brown
Layer A	XU2	2		0.0180	7.010	2.710	1.210																		
Layer A	XU2	3		0.0150	4.760	3.590	1.040																		
Layer A	XU2	4		0.0120	3.850	3.810	1.440																		
Layer A	XU2	5		0.0210	5.010	3.340	1.760																		
Layer A	XU2	6		0.1040	4.220	2.900	1.990																		
Layer A	XU2	7		0.0160	5.260	2.310	1.850																		
Layer A	XU2	8		0.0100	4.320	2.930	1.420																		
Layer A	XU2	9		0.0270	6.500	2.240	1.660	Unidentified	Unidentified	Ind	Limb bone	3	Yes	Yes - deep	2	Transverse (irregular)	Transverse (regular)	No	No value	Yes	Yes - Polish	1-24	Break 1	Brown 7.5YR 5/3	Mid brown
Layer A	XU2	10		0.0260	5.870	3.200	2.230	Mammalia	Sml/med	Phalangeridae sp.	Root of a tooth	3	No	Yes - shallow	1	Transverse (regular)	No value	No	No value	No	Yes - Polish	1-24	All	Brown 7.5YR 5/3	Mid brown
Layer A	XU2	11		0.0130	3.200	2.800	1.420																		
Layer A	XU2	12		0.0780	10.810	4.160	2.010	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Oblique (regular)	Longitudinal	No	No value	Yes	Yes - Polish	1-24	Break 2	Grey 7.5YR 6/1	Grey
Layer A	XU2	13		0.1000	9.760	5.340	1.910	Unidentified	Unidentified	Unidentified	Unidentified	2	No	No	2	Transverse (irregular)	Oblique (irregular)	No	No value	No	Yes - abraison	1-24	Shaft	Brown 7.5YR 5/4 and black 7.5YR 2.5/1	Mid brown
Layer A	XU2	14		0.0400	5.760	4.750	2.190	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	Multiple, rounded bone fragmented no typical breaks	No value	No value	Ind	No value	Yes	No	0	No value	Black 7.5 YR 2.5/1	Black
Layer A	XU2	15		0.0740	8.580	4.960	1.590	Mammalia	Sml/med	Unidentified	Limbone	2	No	No	2	Transverse (regular)	Transverse (regular)	No	No value	No	No	0	No value	Brown 7.5YR 5/4	Mid brown
Layer A	XU2	16		0.0650	8.610	3.800	1.770	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Oblique (irregular)	Transverse (irregular)	No	No value	No	No	0	No value	Dark gray 7.5YR 4/1	Dark grey
Layer A	XU2	17		0.0340	4.460	4.460	2.980	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	1	Oblique (irregular)	No value	No	No value	No	No	0	No value	Brown 7.5YR 5/4	Mid brown
Layer A	XU2	18		0.0630	8.370	5.360	1.840	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Longitudinal	Oblique (irregular)	No	No value	No	Yes - Polish	1-24	Break 1	Light brown 7.5YR 6/3	Pale brown
Layer A	XU2	20		0.0090	4.450	2.350	0.680																		
Layer A	XU2	21		0.0460	5.400	5.360	1.970					4	No	Yes - shallow	multiple rounded bone fragment	No value	No value	No	No value	Yes	Yes - Polish	0	No value	Very dark gray 7.5YR 3/1	Dark grey
Layer A	XU2	23		0.0360	8.040	3.550	1.980	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Longitudinal	Transverse (irregular)	No	No value	No	Yes - Polish	25-49	Break 1	Light Brown 7.5YR 6/3 and black 7.5YR 2.5/1	Pale brown with black staining
Layer A	XU2	24		0.0350	6.180	3.770	2.360	Mammalia	Sml	Phalangeridae sp. or similar	Likely vertebrate	2	No	No	multimple/unsure	No value	No value	No	No value	No	No	0	No value	Brown 7.5YR 5/3 and black 7.5YR 2.5/1	Mid brown with black staining
Layer A	XU2	25		0.0270	8.270	3.780	1.380	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Transverse (regular)	Helical (regular)	No	No value	No	Yes - Polish	1-24	Break 2 and shaft	Light Brown 7.5YR 6/3 and black 7.5YR 2.5/1	Pale brown with black staining
Layer A	XU2	26		0.0290	4.680	3.640	1.800	Unidentified	Unidentified	Unidentified	Unidentified	4	Yes	No	2	Stepped/Columnar	Transverse (irregular)	No	No value	No	No	0	No value	Light Brown 7.5YR 6/3 and black 7.5YR 2.5/1	Mid brown with black staining
Layer A	XU2	27		0.0250	4.090	3.620	3.020	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	1	Oblique (irregular)	No value	No	No value	No	Yes - Polish	1-24	All	Pink 7.5YR 7/3	Pale pink
Layer A	XU2	28		0.0180	3.500	2.860	3.130																		
Layer A	XU2	29		0.0150	4.590	4.000	0.970																		
Layer A	XU2	30		0.0080	2.350	1.890	1.080																		
Layer A	XU2	31		0.0200	4.750	2.400	1.630																		
Layer A	XU2	32		0.0360	6.160	3.420	1.180	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (regular)	Oblique (regular)	No	No value	Yes	Yes - Polish	1-24	Shaft	Brown 7/5YR 4/2	Mid brown
Layer A	XU2	33		0.0120	3.640	3.410	2.110																		
Layer A	XU2	34		0.0290	6.870	3.250	1.930	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - shallow	2 - rounding at edges	Helical (irregular)	Helical (regular)	No	No value	No	Yes - Polish	1-24	All	Light brown 7.5YR 6/3	Pale brown
Layer A	XU2	35		0.0200	4.060	3.380	1.730																		
Layer A	XU2	36		0.0290	4.460	4.240	4.030	Mammalia	Sml/med	Unidentified	Unidentified	3	No	Yes - shallow	1	Transverse (regular)	No value	No	No value	Yes	No	0	No value	Light brown 7.5 YR 3/5	Pale pink
Layer A	XU2	37		0.0000	2.870	1.470	0.620																		
Layer A	XU2	38		0.0100	3.930	2.150	2.080	(Mammalia)	unidentified																
Layer A	XU2	39		0.0150	3.620	2.360	1.860																		
Layer A	XU2	40		0.0330	4.680	3.430	2.860	Mammalia	Sml/med	Unidentified	Unidentified	3	No	Yes - shallow	1	Longitudinal	No value	No	No value	No	No	0	No value	Brown 7.5YR 5/3 and black 7.5YR 2.5/1	Mid brown with black staining
Layer B	XU3	1		0.0410	8.010	4.830	1.960	Unidentified	Unidentified	Unidentified	Unidentified	3	No	No	2	Transverse (irregular)	Stepped/Columnar	Yes	Multiple scrapes	No	No	1-24	Break 1 and 2	White 7.5YR 8/1 and black 7.5YR	White
Layer B	XU3	2		0.0210	5.230	4.170	1.820	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	ind	No value	No value	No	No value	No	No	0	No value	White 7.5YR 8/1 and black 7.5YR 2.5/1	White
Layer B	XU3	3		0.0110	3.340	3.010	0.950	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Longitudinal	Transverse (regular)	No	No value	No	No	0	No value	White 7.5YR 8/1 and black 7.5YR 2.5/1	White
Layer B	XU3	4		0.0260	6.370	4.090	1.320	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Sawtoothed	Ind	No	No value	No	Yes - abraison	1-24	Break 1 and 2	White 7.5YR 8/1 and black 7.5YR 2.5/1	White
Layer B	XU3	5		0.0360	7.170	4.630	1.100	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2 nodular shape	Transverse (irregular)	ind	Yes	Linear mark U shape (singular)	No	Yes - abraison	25-49	Shaft	White 7.5YR 8/1 and black 7.5YR 2.5/1	
Layer B	XU3	6		0.0090	3.190	3.270	2.140	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	nodular no breaks visable	Ind	Ind	Yes	Linear mark V shape (singular	No	Yes - abraison	75-99	All	White 7.5 YR 8/1 some balck 7.5 YR 2.5/1	Pale brown with black staining
Layer B	XU3	7		0.0070	4.270	3.160	1.860	Mammalia																	
Layer B	XU3	8		0.0000	4.030	1.660	1.170																		
Layer B	XU3	9		0.0240	4.690	1.820	1.650	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	ind	Ind	Ind	No	No value	No	Yes - abraison	75-99	All	White 7.5YR 8/1	White
Layer B	XU3	10		0.0010	4.820	2.250	1.830																		
Layer B	XU3	11		0.0100	4.770	2.250	1.760	Mammalia	Sml	Rat sp. or similar	Centrum (vertebrate)	3	No	Yes - deep	2	Stepped/Columnar	Ind	No	No value	Yes	Yes - Polish	25-49	Shaft	Brown 7.5YR 4/4 and black 7.5YR 2.5/1	Mid brown with black staining
Layer B	XU3	12		0.0000	4.760	1.680	1.050																		
Layer B	XU3	13		0.0080	4.880	2.660	0.500	Mammalia	unidentified																
Layer B	XU4	1		0.0120	7.520	2.290	0.820																		
Layer B	XU4	2		0.0540	6.740	4.400	1.480	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Transverse (regular)	Transverse (irregular)	No	No value	No	Yes - Polish	1-24	Shaft	Brown 7.5YR 5/4	Mid brown
Layer B	XU4	3	003a	0.0330	4.910	2.690	0.820																		
Layer B	XU4		003b		4.890	3.050	0.750																		
Layer B	XU4		003c		4.640	2.360	1.040																		
Layer B	XU4	4	004a	0.0780	10.940	2.460	1.300	Unidentified	Unidentified	Unidentified	Unidentified	3	Yes	Yes - shallow	2	Longitudinal	Transverse (irregular)	No	No value	Yes	Yes - Polish	1-24	Break 1	Strong brown 7.5YR 6/6 and black on outer 7.5YR 2.5/1	Mid brown with black staining
Layer B	XU4		004b		5.370	2.380	0.910																		
Layer B	XU4	5		0.0190	3.800	4.320	0.930																		
Layer B	XU4	7	007a	0.0420	10.840	2.180	1.830	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Transverse (regular)	Transverse (regular)	No	No value	No	No	0	No value	Light brown 7.5YR 6/3	Pale brown
Layer B	XU4		007b		6.050	2.450	1.180																		
Layer B	XU4		007c		5.430	1.590	1.460																		
Layer B	XU4	8	008a	0.0860	10.540	4.700	1.060	Mammalia	Sml/med	Phalangeridae sp. or simlar	Long bone fragment	3	No	Yes - shallow	2	Longitudinal	Transverse (irregular)	No	No value	No	Yes - Polish	1-24	Shaft	Brown 7.5 YR 4/4 and black 7.5 YR 2.5/1	Mid brown with black staining
Layer B	XU4		008b		4.370	4.300	0.850																		
Layer B	XU4	9		0.0320	9.370	3.230	1.670																		
Layer B	XU4	10		0.0660	6.680	3.210	3.020	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	ind	Ind	Ind	No	No value	No	Yes - abraison	1-24	Shaft	Brown 7.5YR 5/4 and Dark brown 7.5 YR 3/1	Mid brown with black staining
Layer B	XU4	11		0.0980	12.450	3.230	2.890	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Oblique (regular)	Longitudinal	No	No value	No	Yes - Polish	25-49	Break 1 and 2	Light brown 7.5YR 6/4	Mid brown
Layer B	XU4	12		0.0050	4.950	2.170	0.750																		
Layer B	XU4	13		0.0380	10.900	2.260	1.640	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Longitudinal	Transverse (irregular)	No	No value	No	Yes - abraison	1-24	Break 2	Brown 10YR 5/3	Mid brown
Layer B	XU4	14		0.0120	6.430	1.700	1.390	(Mammalia)																	
Layer B	XU5	1		0.0340	5.880	4.740	2.530	Mammalia	Sml/med	Phalangeridae sp. or similar	Right lower P3 molar	3	No	Yes - deep	NA	No value	No value	No	No value	No	Yes - abraison	1-24	All	Very pale brown 10YR 7/4	Pale brown
Layer B	XU5	2		0.0110	7.800	1.630	1.110																		
Layer B	XU5	4	004a	0.0210	4.830	2.020	1.140	(Mammalia)																	
Layer B	XU5		004b		4.160	0.900	0.640	(Mammalia)																	
Layer B	XU5	6		0.0390	6.100	3.390	1.980																		
Layer B	XU5	7		0.0410	7.700	5.790	1.940	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (irregular)	Transverse (irregular)	No	No value	No	Yes - Polish	1-24	Break 1 and 2	Pink 7.5YR 7/3	Pale pink
Layer B	XU5	8		0.0400	8.080	3.140	1.970	Mammalia	Sml	Unidentified	Unidentified	5	No	Yes - deep	2	Longitudinal	Transverse (irregular)	No	No value	No	Yes - Polish	1-24	Shaft	Very dark greyish brown 10YR 3/2	Dark grey
Layer B	XU5	9		-	-	-	-																		
Layer B	XU5	10		0.0590	12.820	3.460	0.750	Mammalia	Sml/med	Unidentified	Limb bone	4	No	Yes - deep	2	Helical (regular)	Oblique (regular)	Yes	Multiple scrapes	No	Yes - Polish	1-24	Break 1 and 2	Dark grey 7.5YR 4/1	Dark grey
Layer B	XU5	12		0.1020	13.470	4.210	1.560	Unidentified	Unidentified	Unidentified	Unidentified	5	No	Yes - deep	2	Transverse (irregular)	Transverse (irregular)	Yes	Multiple scrapes	No	Yes - Polish	50-74	Shaft	Light brown 7.5 YR 6/4	Pale brown
Layer B	XU5	13	013a	0.3750	19.100	4.550	4.890	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Helical (irregular)	Transverse (regular)	Yes	No value	No	No	0	no value	Pink 7.5YR 7/3	Pale pink
Layer B	XU5		013b		6.750	4.300	3.110																		
Layer B	XU6	2		0.0210	5.990	1.920	1.850																		
Layer B	XU6	3	003a	0.0460	3.690	2.640	2.000	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (irregular)	Longitudinal	No	No value	Yes	Yes - Polish	1-24	Shaft	Brown 10YR 5/3	Mid brown
Layer B	XU6		003b		6.480	2.330	1.620																		
Layer B	XU6		003c		3.970	1.880	1.850																		
Layer B	XU6	4		0.0790	7.890	5.660	2.870	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Oblique (irregular)	Longitudinal	No	No value	No	No	0	No value	Light brown 7.5 YR 6/3	Pale brown
Layer B	XU6	5		0.1860	15.320	7.020	3.390	Mammalia	Sml/med	Limb bone	Unidentified	4	No	Yes - deep	2	Oblique (irregular)	Oblique (irregular)	No	No value	No	No	0	No value	Light brown 7.5 YR 6/3	Pale brown

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Stratigraphic layer	Context	Speciman ID	Fragment ID (Where necessary)	Weight_g	Length_mm	Width_mm	Thickness _mm	Class	Size	Species	Skeletal element fragment	Weathering stage	Splitting present	Cracks	Number of breaks	Break type1	Break type 2	Linear marks present	Catagorisation of Linear marks	Pitting present	Polish/abrasion present	% of surface with polish/abrasion	Location of polish/abraison	Colour	Colour catagory
Layer B	XU_2	001		0.073	14.150	4.040	3.550	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Helical (irregular)	Oblique (irregular)	No	No value	No	No	0	no value	White 7.5 8/1	White
Layer B	XU_2	002		0.011	5.350	1.710	1.470																		
Layer B	XU_2	003		0.174	18.110	3.660	2.400	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Oblique (irregular)	Oblique (irregular)	No	No value	No	Yes - Abrasion	1-24	All	Light brown 7.5YR 6/4	Pale brown
Layer B	XU_2	004		0.101	11.130	4.080	2.650	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Stepped/Columnar	Transverse (irregular)	Yes	Linear mark U shape (singular)	No	Yes - Abrasion	1-24	Break 1	Light brown 7.5YR 6/4	Pale brown
Layer B	XU_2	005		0.049	9.980	4.420	3.430	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	multiple	Ind	Ind	No	No value	No	No	0	No value	Black 7.5 YR 2.5/1	Black
Layer B	XU_2	006		0.152	14.660	3.880	2.460	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Helical (regular)	Helical (irregular)	No	No value	No	No	0	No value	Pink 7.5YR 7/3	Pale pink
Layer B	XU_2	007		0.051	12.980	3.190	1.340	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Helical (irregular)	Transverse (irregular)	No	No value	No	Yes - Polish	1-24	Break 1	Light brown 7.5YR 6/4	Pale brown
Layer B	XU_2	008		0.056	12.790	3.480	2.060	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Longitudinal	Oblique (regular)	No	No value	No	Yes - Abrasion	1-24	Shaft	Light yellowish brown 10YR 6/4	Yellowish brown
Layer B	XU_2	009		0.094	12.560	3.590	2.510	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Oblique (irregular)	Longitudinal	Yes	Linear mark U shape (singular)	No	No	0	No value	Light yellowish brown 10YR 6/4	Yellowish brown
Layer B	XU_2	010		0.132	11.410	6.080	2.160	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Transverse (irregular)	Oblique (irregular)	No	No value	Yes	No	0	No value	Light yellowish brown 10YR 6/4	Yellowish brown
Layer B	XU_2	011		0.448	11.720	7.620	6.370	Mammalia	Med	Macropus sp. (Macropus agilis or similar)	RM4		No	Yes - shallow	no value	No value	No value	No	No value	Ind	Ind	0	No value	Very pale brown 10YR 8/2	Pale brown
Layer B	XU_2	012		0.125	12.350	7.190	1.760	Osteichthyes	Med	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (irregular)	Transverse (irregular)	No	No value	No	No	0	No value	Very pale brown 10YR 7/3 and black 10YR 2/1	Pale brown with black staining
Layer B	XU_2	013		0.079	14.220	6.980	4.790	Osteichthyes	Med	Unidentified	Unidentified	3	No	Yes - shallow	1	Longitudinal	No value	No	No value	No	Yes - Abrasion	1-24	Shaft	Very pale brown 7/3	Pale brown
Layer B	XU_2	014		0.056	7.050	4.440	3.260	Unidentified	Unidentified	Unidentified	Unidentified	2	No	Yes - deep	2	Oblique (regular)	Stepped/Columnar	No	No value	No	No	0	No value	White 10YR 8/1	White
Layer B	XU_2	015		0.017	7.370	2.880	0.930	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Sawtoothed	Ind	No	No value	No	Yes - Abrasion	1-24	Break 2 and shaft	Yellowish brown 10YR 5/4	Yellowish brown
Layer B	XU_2	016		0.057	9.330	4.480	2.510	Unidentified	Unidentified	Unidentified	Unidentified	4	Yes	Yes - deep	2	Sawtoothed	Stepped/Columnar	Ind	No value	No	Yes - Polish	1-24	Shaft	Light yellowish brown 7.5YR 6/4	Yellowish brown
Layer B	XU_2	017		0.031	10.160	1.970	1.910	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (irregular)	Transverse (irregular)	No	No value	No	Yes - Abrasion	1-24	Break 1 and 2	Pale browm 10YR 6/3 and dark gray 10YR 4/1	Pale brown
Layer B	XU_2	018		0.028	7.060	2.950	1.550	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Transverse (irregular)	Stepped/Columnar	No	No value	No	Yes - Abrasion	1-24	Break 1 and 2	Very pale brown 10YR 7/4	Pale brown
Layer B	XU_2	019		0.074	11.300	3.630	1.800	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Longitudinal	Sawtoothed	No	No value	No	No	0	No value	Very pale brown 10YR 7/4 and dark grayish brown 10YR 4/2	Pale brown with black staining
Layer B	XU_2	020		0.067	12.310	2.930	1.900	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Longitudinal	Longitudinal	No	No value	No	Yes - Abrasion	1-24	Shaft	Light Yellowish brown 10YR 6/4 and very dark grey 10YR 3/1	Mid brown with black staining
Layer B	XU_2	021		0.018	7.440	3.790	1.530																		
Layer B	XU_2	022		0.039	7.980	2.760	2.560	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Longitudinal	Longitudinal	No	No value	No	Yes - Abrasion	1-24	Shaft	Very pale brown 10YR 7/4 and dark grey 10YR 4/1	Pale brown with black staining
Layer B	XU_2	023		0.031	7.550	2.570	2.140	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Transverse (irregular)	Longitudinal	No	No value	No	Yes - Abrasion	1-24	Shaft	Light yellowish brown 10YR 6/4	Yellowish brown
Layer B	XU_2	024		0.017	5.490	2.860	2.600	Mammalia	Unidentified	Unidentified	Unidentified														
Layer B	XU_2	025		0.033	6.930	2.920	2.020	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Helical (irregular)	Transverse (irregular)	No	No value	No	Yes - Abrasion	50-74	Shaft	Brown 7.5YR 5/3 and very dark grey 7.5YR 3/1	Mid brown
Layer B	XU_2	026		0.030	10.120	2.000	1.950	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Oblique (irregular)	Longitudinal	No	No value	No	No	0	No value	Pink 7.5YR 6/4 some very dark grey 7.5YR 3/1	Pale pink
Layer B	XU_2	027		0.030	8.880	2.260	2.640	Osteichthyes	Med	Unidentified	Unidentified	3	No	Yes - deep	2	Sawtoothed	Transverse (irregular)	No	No value	Yes	Yes - Polish	1-24	Shaft	Light yellowish brown 10YR 6/4 and very dark gray 10YR 3/1	Yellowish brown
Layer B	XU_2	028		0.048	9.030	2.820	1.620	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Oblique (regular)	Transverse (irregular)	No	No value	No	Yes - Abrasion	1-24	Shaft	Pale brown 10YR 6/3 and some dark gray 10YR 4/1	Pale brown
Layer B	XU_2	029		0.032	7.540	2.990	1.900	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Transverse (irregular)	Transverse (irregular)	No	No value	No	Yes - Abrasion	1-24	Shaft	White 10YR 8/1	White
Layer B	XU_2	031		0.021	9.680	2.400	1.620	Mammalia	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Stepped/Columnar	Transverse (irregular)	No	No value	No	Yes - Polish	25-49	Shaft	Light yellowish brown 10YR 6/4	Yellowish brown
Layer B	XU_2	032		0.030	9.880	2.670	1.560	Mammalia	Sml	Unidentified	Unidentified	3	No	Yes - deep	2	Longitudinal	Longitudinal	No	No value	No	No	0	No value	Dark yellowish brown 10YR 4/4	Yellowish brown
Layer B	XU_2	033		0.035	7.670	4.030	2.220	Mammalia	Sml	Unidentified	Unidentified	3	No	Yes - deep	2	Stepped/Columnar	Transverse (irregular)	No	No value	No	Yes - Polish	1-24	Shaft	Light yellowish brown 10YR 6/4	Yellowish brown
Layer B	XU_2	034		0.025	8.000	2.720	1.360	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Stepped/Columnar	Transverse (irregular)	No	No value	No	No	0	No value	Very pale brown 10YR 7/4	Yellowish brown
Layer B	XU_2	035		0.036	11.650	1.770	1.730	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Stepped/Columnar	Stepped/Columnar	No	No value	no	Yes - Abrasion	25-49	Shaft	Light yellowish brown 10YR 6/4	Yellowish brown
Layer B	XU_2	036		0.036	7.320	3.660	1.320	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Transverse (irregular)	Transverse (irregular)	No	No value	No	Yes - Polish	1-24	Shaft	Very pale brown 10YR 7/4	Pale brown
Layer B	XU_2	037		0.024	8.460	2.560	1.100	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Oblique (irregular)	Transverse (irregular)	No	No value	No	Yes - Abrasion	1-24	Break 1	Light yellowish brown 10YR 6/4	Yellowish brown
Layer B	XU_2	038		0.006	NA	NA	NA																		
Layer B	XU_2	039		0.039	8.400	3.450	1.370	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Stepped/Columnar	Longitudinal	No	No value	No	No	0	No value	Yellowish brown 10YR 5/4	Yellowish brown
Layer B	XU_2	040		0.034	10.070	2.250	1.860	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Stepped/Columnar	Sawtoothed	No	No value	No	Yes - Abrasion	1-24	Break 1 and 2	Light yellowish brown 10YR 6/4	Yellowish brown
Layer B	XU_2	041		0.020	7.580	2.840	1.990																		
Layer B	XU_2	042		0.026	6.500	2.260	1.910	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Oblique (irregular)	Ind	No	No value	No	Yes - Abrasion	25-49	Break 2 and shaft	Not taken	Ind
Layer B	XU_2	043		0.021	6.800	2.540	1.380																		
Layer B	XU_2	044		0.018	10.260	1.700	1.020																		
Layer B	XU_2	045		0.007	6.540	1.750	0.900																		
Layer B	XU_2	046		0.021	3.600	3.000	2.010	(Mammalia)																	
Layer B	XU_2	047		0.011	4.900	3.560	0.810	(Mammalia)																	
Layer B	XU_2	048		0.007	NA	na	na																		
Layer B	XU_2	049		0.014	6.830	2.010	1.260																		
Layer B	XU_2	050		0.023	5.740	4.280	1.310	(Mammalia)																	
Layer B	XU_2	051		0.011	7.220	2.420	1.470																		
Layer B	XU_2	052		0.021	7.020	3.690	1.140	(Mammalia)																	
Layer B	XU_2	053		0.011	5.260	2.130	1.000																		
Layer B	XU_2	054		0.020	8.790	1.820	1.190																		
Layer B	XU_2	055		0.011	6.690	1.610	1.310																		
Layer B	XU_2	056		0.005	NA	NA	NA																		
Layer B	XU_2	057		0.009	NA	NA	NA																		
Layer B	XU_2	058		0.013	3.940	3.350	1.140	(Mammalia)																	
Layer B	XU_2	059		0.022	5.450	3.240	1.020																		
Layer B	XU_2	060		0.006	NA	NA	NA																		
Layer B	XU_2	061		0.014	4.270	2.760	1.220	(Mammalia)																	
Layer B	XU_2	062		0.016	10.160	1.530	0.880																		
Layer B	XU_2	063		0.017	NA	NA	NA																		
Layer B	XU_2	064		0.009	NA	NA	NA																		
Layer B	XU_2	065		0.048	5.360	4.220	2.050	Mammalia	Med	Macropus sp. (Macropus agilis or similar)	Tooth frag	3	No	Yes - shallow	1	Transverse (irregular)	No value	Yes	Linear mark V shape (singular	No	Yes - Polish	1-24	Shaft	White 10YR 8/1	White
Layer B	XU_2	066		0.008	NA	NA	NA																		
Layer B	XU_2	067		0.012	5.680	2.050	1.160																		
Layer B	XU_2	068		0.013	6.830	1.910	0.860																		
Layer B	XU_2	069		0.028	8.680	2.540	1.590	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Stepped/Columnar	Stepped/Columnar	Yes	Linear mark V shape (singular	No	Yes - Abrasion	1-24	Shaft	Light yellowish brown 10YR 6/4	Yellowish brown
Layer B	XU_2	070		0.021	8.370	2.000	1.080																		
Layer B	XU_2	071		0.013	8.840	1.480	1.110																		
Layer B	XU_2	072		0.008	NA	NA	NA																		
Layer B	XU_2	073		0.006	NA	NA	NA																		
Layer B	XU_2	074		0.337	23.590	6.710	3.750	Mammalia	Sml/med	Limb bone	Unidentified	3	No	Yes - shallow	1	Longitudinal	No value	No	No value	No	Yes - Abrasion	25 -49	Break 2 and shaft	Light yellowish brown 10YR 6/4	Yellowish brown
Layer B	XU_3	002		0.240	17.990	4.840	2.860	Mammalia	Sml/med	Limb bone	Unidentified	3	No	Yes - shallow	2	Longitudinal	Stepped/Columnar	No	No value	No	Yes - Abrasion	1-24	Shaft	Yellowish brown 10YR 5/4	Yellowish brown
Layer B	XU_3	003		0.516	18.100	8.760	3.420	Mammalia	Unidentified	Unidentified	Unidentified	5	No	Yes - deep	Ind	Ind	Ind	Yes	Linear mark U shape (singular)	Yes	No	0	No value	White 10YR 8/1	White
Layer B	XU_3	008		0.106	14.380	7.610	1.520	Osteichthyes	Ind	Unidentified	Unidentified	4	No	Yes - shallow	Multiple	Ind	Ind	No	No value	No	Yes - Polish	1-24	Shaft	Very pale brown 10YR 7/4	Pale brown
Layer B	XU_3	009		0.045	11.810	10.530	4.240																		
Layer B	XU_3	010		0.222	13.170	5.500	3.070	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Oblique (regular)	Transverse (irregular)	No	No value	Yes	No	0	No value	Brown 7.5YR 5/2	Mid brown
Layer B	XU_3	011		0.029	5.350	4.840	2.090	Mammalia	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (irregular)	Helical (irregular)	No	No value	No	Yes - Abrasion	1-24	Break 1 and Shaft	Light brown 7.5YR 6/4	Pale brown
Layer B	XU_3	012		0.056	9.780	5.160	1.900	Osteichthyes	Ind	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (irregular)	Transverse (irregular)	No	No value	No	Yes - Abrasion	1-24	Shaft	Very pale brown 10YR 7/4	Pale brown
Layer B	XU_3	013		0.043	13.470	7.190	3.530	Unidentified	Unidentified	Unidentified	Unidentified	5	No	Yes - deep	2	Ind	Longitudinal	No	No value	No	No	0	No value	Black 10YR 2/1	Black
Layer B	XU_3	014		0.076	7.810	4.390	4.310	Unidentified	Unidentified	Unidentified	Unidentified	5	No	Yes - deep	Ind	Ind	Ind	No	No value	No	No	0	No value	Black 10YR 2/1	Black
Layer B	XU_3	015		0.036	5.400	3.940	3.760																		
Layer B	XU_4	001		0.473	23.180	7.950	3.480	Mammalia	Unidentified	Unidentified	Unidentified	5	No	Yes - shallow	2	Stepped/Columnar	Transverse (irregular)	Yes	Multiple scrapes	No	No	0	No value	Black 10YR 2/1	Black

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Stratigraphic layers	Context	Speciman ID	Fragment ID (where necessary)	Weight_g	Length_mm	Width_mm	Thickness _mm	Class	Size	Species	Skeletal element fragment	Weathering stage	Splitting present	Cracks	Number of breaks	Break type1	Break type 2	Linear marks present	Catagorisation of Linear marks	Pitting present	Polish/abrasion present	% of surface with polish/abrasion	Location of polish/abraison	Colour	Colour Catagory
Layers A and B	XU2	001		0.817	28.820	7.250	5.640	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Longitudinal	Oblique (irregular)	Yes	Multiple scrapes	No	No	0	No value	Pale brown 10YR 6/3	Pale brown
Layers A and B	XU2	002		0.725	28.160	5.240	3.450	Mammalia	Lg	Macropus sp. (Macropus antilopinus or similar)	Rib fragment	4	No	Yes - deep	2	Oblique (irregular)	Oblique (irregular)	Yes	Multiple scrapes	No	No	0	No value	Pale brown 10YR 6/3	Pale brown
Layers A and B	XU2	003	003a	0.031	10.050	2.980	1.270	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Oblique (irregular)	ind	No	No value	No	No	0	No value	Very pale brown 10YR 8/2	Pale brown
Layers A and B	XU2		003b		3.390	2.300	0.860																		
Layers A and B	XU2	004		0.235	3.710	4.610	3.000	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Transverse (regular)	Oblique (irregular)	Yes	Linear mark U shape (singular)	No	No	0	No value	Very pale brown 10YR 7/3	Pale brown
Layers A and B	XU2	005		0.422	22.270	9.640	3.580	Unidentified	Unidentified	Unidentified	Long bone fragment	4	No	Yes - deep	1	Transverse (regular)	No value	Yes	Linear marks V shape (multiple)	No	Yes - Abrasion	1-24	Break 1	Very pale brown 10YR 7/3	Pale brown
Layers A and B	XU2	006		0.403	22.340	9.270	1.980	Mammalia	Med/lg	Macropus sp. (Macropus antilopinus or similar)	Rib fragment	3	No	Yes - shallow	2	Transverse (regular)	Oblique (irregular)	Yes	Linear marks V shape (multiple)	No	Yes - Abrasion	1-24	Break 1	Very pale brown 10YR 7/3	Pale brown
Layers A and B	XU2	007		0.323	19.170	4.980	3.150	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (irregular)	Helical (irregular)	No	No value	No	Yes - Abrasion	1-24	Shaft	Very pale brown 10YR 7/3	Pale brown
Layers A and B	XU2	008		0.302	11.360	10.090	5.290																		
Layers A and B	XU3	001		0.217	17.860	7.080	3.510	Unidentified	Unidentified	Unidentified	Long bone fragment	3	No	Yes - deep	2	Helical (regular)	Transverse (regular)	No	No value	No	Yes - Abrasion	1-24	Break 1	Very pale brown 10YR 7/3	Pale brown
Layers A and B	XU3	002		0.329	27.680	5.060	3.530	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Helical (irregular)	Stepped/Columnar	Yes	Multiple scrapes	No	No	0	No value	Light yellowish brown 10YR 7/4	Yellowish brown
Layers A and B	XU3	003		0.586	24.030	10.520	2.410	Mammalia	Med/lg	Macropus sp. (Macropus antilopinus or similar)	Tibia fragment	3	No	Yes - shallow	2	Oblique (irregular)	Longitudinal	Yes	Multiple scrapes	No	Yes - Polish	1-24	Break 1 and 2	Brown 7.5YR 4/2	Mid brown
Layers A and B	XU3	004		0.518	34.580	7.290	2.220	Mammalia	Med/lg	Macropus sp. (Macropus antilopinus or similar)	Tibia fragment	3	No	Yes - shallow	2	Transverse (irregular)	Transverse (irregular)	Yes	Linear marks V shape (multiple)	Yes	No	0	No value	Very pale brown 10YR 7/3	Pale brown
Layers A and B	XU4	001		0.274	28.560	5.300	2.170	Mammalia	Med/lg	Macropus sp. (Macropus antilopinus or similar)	Rib fragment	3	No	Yes - shallow	2	Transverse (regular)	ind	Yes	Multiple scrapes	No	No	0	No value	Very pale brown 10YR 7/3	Pale brown
Layers A and B	XU4	002		0.526	31.420	6.850	2.230	Mammalia	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Oblique (irregular)	Longitudinal	Yes	Multiple scrapes	No	No	0	No value	Very pale brown 10YR 7/3	Pale brown
Layers A and B	XU4	003		0.308	30.860	5.480	2.110	Mammalia	Med/lg	Likely Macropus sp. (Macropus antilopinus or similar)	Rib fragment	3	No	Yes - shallow	2	Longitudinal	Transverse (irregular)	Yes	Multiple scrapes	No	Yes - Abrasion	1-24	Break 2	Very pale brown 10YR 7/3	Pale brown
Layers A and B	XU5	001		0.330	17.280	6.860	4.520																		
Layers A and B	XU5	002		0.613	25.190	8.760	6.360	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Transverse (irregular)	Oblique (irregular)	Yes	Linear marks U shape (multiple)	Yes	Yes - Abrasion	1-24	Break 1 and 2	Very pale brown 10YR 7/3	Pale brown
Layers A and B	XU5	003		0.445	19.080	9.320	7.350	Mammalia	Med/lg	Macropus sp. (Macropus antilopinus or similar)	Tibia fragment	3	No	Yes - shallow	2	Transverse (irregular)	Oblique (irregular)	Yes	Linear mark U shape (singular)	No	No	0	No value	Very pale brown 10YR 7/4	Pale brown
Layers C, D, E	XU6	001		0.103	12.950	6.930	1.810	Mammalia	Med/lg	Macropus sp. (Macropus antilopinus or similar)	Tibia fragment	3	No	Yes - shallow	2	Transverse (irregular)	Oblique (irregular)	Yes	Linear mark U shape (singular)	No	Yes - Polish	1-24	Shaft	Very pale brown 10YR 7/3	Mid brown
Layers C, D, E	XU6	002		0.072	11.260	3.050	2.870																		
Layers C, D, E	XU6	003		0.101	13.350	3.160	2.750	Mammalia	Med/lg	Macropus sp. (Macropus antilopinus or similar)	Rib fragment	3	No	Yes - shallow	2	Longitudinal	Transverse (irregular)	No	No value	No	Yes - Polish	1-24	Shaft	light yellowish brown 10YR 6/4	Yellowish brown
Layers C, D, E	XU6	004		0.036	6.630	5.910	4.060	Mammalia																	
Layers C, D, E	XU6	005		0.226	17.510	6.030	4.330	Mammalia	Med/lg	Macropus sp. (Macropus antilopinus or similar)	Rib fragment	3	No	Yes - deep	2	Transverse (irregular)	Transverse (irregular)	Yes	Linear marks V shape (multiple)	No	No	0	No value	Very pale brown 10YR 7/4 and very dark gray 10YR 3/1	Yellowish brown
Layers C, D, E	XU6	007		4.551	31.410	19.170	17.200	Mammalia	Med	Macropus agilis, sub adult	Left Maxilla, teeth attached	4	Yes	Yes - deep	na	No value	No value	No	No value	Yes	No	0	No value	Pale brown 10YR 6/3, teeth white 10YR 8/1	Pale brown
Layers C, D, E	XU6	008		NA	NA	NA	NA																		
Layers C, D, E	XU7	001		0.113	9.790	4.690	4.060																		
Layers C, D, E	XU7	002		0.578	19.700	10.570	3.450	Mammalia	Med	Macropod	Tibia fragment	3	No	Yes - shallow	2	Oblique (irregular)	Transverse (irregular)	Yes	Linear marks U shape (multiple)	No	Yes - Polish	1-24	Shaft	Very pale brown 10YR 8/3	Pale brown
Layers C, D, E	XU7	003		0.252	24.380	8.420	4.550	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - deep	2	Transverse (irregular)	Transverse (irregular)	No	No value	Yes	No	0	No value	Brown 10YR 5/3	Mid brown
Layers C, D, E	XU11	001		3.271	59.330	13.620	4.970	Mammalia	Lg	Macropus sp. (Macropus antilopinus or similar)	Tibia fragment	3	No	Yes - shallow	2	Helical (irregular)	Oblique (irregular)	Yes	Multiple scrapes	Yes	No	0	No value	Very pale brown 10YR 7/3	Pale brown
Layers C, D, E	XU11	002		0.566	31.310	8.040	4.340		Lg																
Layers C, D, E	XU11	003		0.187	15.100	6.790	2.470																		
Layers C, D, E	XU11	004		1.017	31.950	11.490	4.310	Mammalia	Med/lg	Macropus sp. (Macropus antilopinus or similar)	Tibia fragment	3	Yes	Yes - deep	2	Helical (regular)	Transverse (irregular)	No	No value	No	No	0	No value	Light yellowish brown 10YR 6/4	Yellowish brown
Layers C, D, E	XU13	001		0.223	19.990	9.730	1.820	Mammalia	Med	Unidentified	Tibia fragment	4	No	Yes - deep	2	Stepped/Columnar	Longitudinal	No	No value	No	No	0	No value	Brown 10YR 5/3 and Black 10YR 2.5/1	Mid brown with black staining
Layers C, D, E	XU13	003		0.558	34.460	11.690	1.840	Mammalia	Med	Unidentified	Tibia fragment	3	No	Yes - shallow	2	Longitudinal	Transverse (irregular)	No	No value	No	No	0	No value	Very pale brown 10YR 7/4	Pale brown
Layers C, D, E	XU13	004		0.637	23.870	13.020	3.160	Mammalia	Med	Macropus agilis	Proximal end of a tibia	3	No	Yes - shallow	2	Transverse (irregular)	Oblique (regular)	Yes	Linear mark U shape (singular)	No	No	0	No value	Very pale brown 10YR 7/4	Pale brown
Layers C, D, E	XU13	005		0.344	12.270	12.350	3.270	Mammalia	Med	Unidentified	Tibia fragment	3	No	Yes - shallow	2	Oblique (regular)	Transverse (irregular)	Yes	Linear marks V shape (multiple)	Yes	No	0	No value	Very pale brown 10YR 7/4	Pale brown
Layers C, D, E	XU13	006		0.151	13.460	6.610	2.210	(Mammalia)																	
Layers C, D, E	XU13	007		0.107	13.300	3.740	3.320																		
Layers C, D, E	XU13	008		0.069	7.330	5.490	5.200	(Mammalia)																	
Layers C, D, E	XU13	009		0.574	29.740	6.640	5.060	Mammalia	Sml/med	Unidentified	limb bone missing artictulated ends	4	No	Yes - deep	2	Transverse (irregular)	Oblique (irregular)	Yes	Multiple scrapes	No	No	0	No value	Very pale brown 10YR 7/4	Pale brown
Layers C, D, E	XU13	010		0.046	9.530	3.300	1.630																		
Layers C, D, E	XU13	011		0.482	21.840	4.680	6.110	Mammalia	Med/lg	Macropus sp. (Macropus antilopinus or similar)	Rib fragment	4	No	Yes - deep	2	Helical (irregular)	Helical (irregular)	Yes	Multiple scrapes	Yes	No	0	No value	Very Pale brown 10YR 8/4	Pale brown
Layers C, D, E	XU13	012		0.260	17.460	4.820	4.350	Mammalia	Med/lg	Macropus sp. (Macropus antilopinus or similar)	Rib fragment	4	No	Yes - deep	2	Oblique (regular)	Transverse (regular)	Yes	Linear mark U shape (singular)	No	No	0	No value	Light yellowish brown 10YR 6/4	Yellowish brown
Layers C, D, E	XU13	013		0.394	19.950	11.760	3.210	Mammalia	Med/lg	Macropus sp. (Macropus antilopinus or similar)	Tibia fragment	3	No	Yes - shallow	2	Helical (irregular)	Helical (irregular)	Yes	Linear marks U shape (multiple)	No	Yes - Abrasion	1-24	Shaft	Yellowish brown 10YR 5/4	Yellowish brown
Layers C, D, E	XU13	014		0.090	10.980	8.090	1.450																		
Layers C, D, E	XU13	015		0.097	10.860	4.230	2.900																		
Layers C, D, E	XU13	016		0.048	8.070	5.670	1.270																		
Layers C, D, E	XU13	017		1.022	28.920	12.490	10.570	Mammalia	med	Macropod (likely Juvinelle agile (Macropus agilis)	Proximal end of a right tibia (tip not fused) fragment	3	No	Yes - shallow	1	Transverse (regular)	No value	Yes	Linear marks U shape (multiple)	No	No	0	No value	Very pale brown 10YR 7/4	Pale brown
Layers C, D, E	XU13	018		NA																					
Layers C, D, E	XU14	001		0.366	10.800	8.580	6.480	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - shallow	Rounded	No value	No value	Ind	No value	No	No	0	No value	Very pale brown 10YR 7/4	Pale brown
Layers C, D, E	XU14	002		0.120	9.720	8.120	2.320																		
Layers C, D, E	XU14	003		0.015	5.660	3.500	2.130																		
Layers C, D, E	XU14	004		0.123	13.310	5.370	2.430	Unidentified	Unidentified	Unidentified	Longbone frag	4	No	Yes - shallow	2	Oblique (regular)	Stepped/Columnar	Yes	Multiple scrapes	Yes	No	0	No value	Brown 5/3	Mid brown
Layers C, D, E	XU14	006		0.537	17.300	9.760	8.920	Unidentified	Unidentified	Unidentified	Unidentified	4	Ind	Yes - deep	2	Oblique (irregular)	ind	No	No value	No	Yes - Abrasion	75-99	All	Light yellowish brown 10YR 6/4	Yellowish brown
Layers C, D, E	XU14	007		0.526	20.190	12.020	6.440	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	2	Oblique (irregular)	Oblique (irregular)	Ind	No value	No	No	0	No value	Pale brown 10YR 6/3	Pale brown
Layers C, D, E	XU14	008		0.181	15.130	6.320	3.330	Mammalia	Med	Macropus sp. (Macropus agilis or similar)	Left dentary (bit where muscels attach)	4	No	Yes - deep	2	Helical (irregular)	Transverse (irregular)	Yes	Linear mark V shape (singular	No	No	0	No value	Light yellowish brown 10YR 6/4	Yellowish brown
Layers C, D, E	XU14	009		0.011	NA	NA	NA																		
Layers C, D, E	XU14	010		0.197	20.520	7.070	1.550	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Transverse (irregular)	Oblique (irregular)	Yes	Linear mark V shape (singular	Yes	No	0	No value	Yellow 10YR 7/3	Yellowish brown
Layers C, D, E	XU14	011		0.172	10.270	8.220	4.920	Unidentified	Unidentified	Unidentified	Unidentified	4	No	Yes - shallow	2	Oblique (irregular)	ind	Ind	No value	No	Yes - Polish	1-24	Break 1	Pale brown 10YR 6/3	Pale brown
Layers C, D, E	XU14	012		0.479	24.370	9.570	4.630	Unidentified	Unidentified	Unidentified	Unidentified	3	No	Yes - shallow	2	Helical (irregular)	Helical (irregular)	Yes	Multiple scrapes	No	Yes - Polish	25-49	Break 1 and Shaft	Very Pale Brown 10YR 7/4	Pale brown
Layers C, D, E	XU14	016		0.037	9.650	2.090	1.820																		
Layers F, G, H, I, J, K	XU15	001		0.056	7.710	5.680	3.120	Unidentified	Unidentified	Unidentified	Cellulose bone	5	Ind	Yes - deep	ind	No value	No value	Ind	No value	Ind	No	0	No value	Very Pale Brown 10YR 7/4	Pale brown
Layers F, G, H, I, J, K	XU15	002		0.015	8.360	1.400	0.830																		
Layers F, G, H, I, J, K	XU15	003		0.005	NA	NA	NA																		
Layers F, G, H, I, J, K	XU15	004		0.005	NA	NA	NA																		
Layers F, G, H, I, J, K	XU15	005	005a	0.214	27.890	3.850	1.710	Unidentified	Unidentified	Unidentified	Unidentified	4	yes	Yes - shallow	2	Longitudinal	Stepped/Columnar	Yes	Linear marks U shape (multiple)	No	No	0	No value	Very Pale Brown 10YR 7/4	Pale brown
Layers F, G, H, I, J, K	XU15		005b		11.230	1.610	1.560																		
Layers F, G, H, I, J, K	XU15		005c		5.640	1.850	0.760																		
Layers F, G, H, I, J, K	XU15	006		0.021	6.180	3.670	2.650	Mammalia	Unidentified	Unidentified	Unidentified	4	No	Yes - deep	ind	ind	ind	Ind	No value	no	no	0	no value	Very Pale Brown 10YR 7/4	Pale brown
Layers F, G, H, I, J, K	XU15	007	007a	0.232	23.400	3.280	2.780	Unidentified	Unidentified	Unidentified	Unidentified	4	Yes	Yes - shallow	2	Longitudinal	Stepped/Columnar	Yes	Multiple scrapes	no	no	0	no value	Very Pale Brown 10YR 7/4	Pale brown
Layers F, G, H, I, J, K	XU15		007b		20.890	1.450	0.960																		
Layers F, G, H, I, J, K	XU15		007c		12.500	1.250	0.860																		
Layers F, G, H, I, J, K	XU15		007d		10.630	1.530	1.180																		
Layers F, G, H, I, J, K	XU15		007e		7.150	1.480	1.530																		
Layers F, G, H, I, J, K	XU15		007f		6.280	1.090	0.810																		
Layers F, G, H, I, J, K	XU15	008		0.046																					
Layers F, G, H, I, J, K	XU19	001		NA																					
Layers F, G, H, I, J, K	XU19	002		0.397	25.410	11.330	7.950	Mammalia	Sml/med	Phalangeridae sp.	Ischium	4	yes	Yes - shallow	2	Transverse (irregular)	Sawtoothed	Yes	Multiple scrapes	no	Yes - Polish	Jan-24	Break 1	light yellowish brown 10YR 6/4	Yellowish brown
Layers F, G, H, I, J, K	XU19	003	003a	0.103	8.320	6.140	3.640	Unidentified	Unidentified	Unidentified	Unidentified	5	yes	Yes - deep	1	Sawtoothed	No value	No	No value	no	no	0	no value	light yellowish brown 10YR 6/4	Yellowish brown
Layers F, G, H, I, J, K	XU19		003b		8.160	5.810	4.500																		
Layers F, G, H, I, J, K	XU19		003c		6.090	3.300	2.860																		
Layers F, G, H, I, J, K	XU19	005	005a	0.033	6.520	4.120	1.250	Unidentified	Unidentified	Unidentified	Unidentified	3	no	Yes - shallow	2	Stepped/Columnar	Transverse (regular)	no	No value	no	no	0	no value	light yellowish brown 10YR 6/4	Yellowish brown
Layers F, G, H, I, J, K	XU19		005b		4.490	4.140	0.970																		
Layers F, G, H, I, J, K	XU19		005c		3.500	1.640	0.870																		
Layers F, G, H, I, J, K	XU19	007	007a	0.265	17.530	5.810	1.540	Mammalia	Sml/med	Unidentified	Phalangeridae humerous	5	ind	Yes - shallow	2	Transverse (irregular)	Helical (irregular)	no	No value	yes	no	0	no value	Pale Brown 10YR 6/3	Pale brown
Layers F, G, H, I, J, K	XU19		007b		11.870	5.910	1.370																		
Layers F, G, H, I, J, K	XU19		007c		11.010	5.160	0.970																		
Layers F, G, H, I, J, K	XU19		007d		11.380	3.720	1.310																		
Layers F, G, H, I, J, K	XU19		007e		7.840	3.090	1.190																		
Layers F, G, H, I, J, K	XU19		007f		6.260	2.600	1.210																		
Layers L, M, N, O	XU21	001		0.146	14.070	6.090	2.010	Unidentified	Unidentified	Unidentified	Unidentified	4	no	Yes - deep	2	Stepped/Columnar	Oblique (irregular)	no	No value	no	Yes - Polish	Jan-24	Shaft	Dark greyish brown 10YR 4/2	Pale brown
Layers L, M, N, O	XU21	002		0.171	13.420	6.550	2.560	Unidentified	Unidentified	Unidentified	Unidentified	4	no	Yes - deep	2	Stepped/Columnar	Transverse (irregular)	no	No value	yes	no	0	no value	brown 10YR 5/3	Mid brown
Layers L, M, N, O	XU21	003		0.030	10.700	2.890	1.140																		
Layers L, M, N, O	XU21	004		0.100	14.500	7.670	1.530	Unidentified	Unidentified	Unidentified	Unidentified	4	no	Yes - deep	2	Longitudinal	Longitudinal	no	No value	yes	no	0	no value	brown 10YR 5/3	Mid brown
Layers L, M, N, O	XU21	005		0.000																					