Landscape Variability in Tool-Use and Edge Damage Formation in South African Middle Stone Age Lithic Assemblages

by

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ABSTRACT

This study explores how early modern humans used stone tool technology to adapt to changing climates and coastlines in the Middle Stone Age of South Africa. The MSA is associated with the earliest fossil evidence for modern humans and complex cultural behaviors during a time period of dramatic climate change. Human culture allows for the creation, use, and transmission of technological knowledge that can evolve with changing environmental conditions. Understanding the interactions between technology and the environment is essential to illuminating the role of culture during the origin of our species. This study is focused on understanding ancient tool use from the study of lithic edge damage patterns at archaeological assemblages in southern Africa by using image-based quantitative methods for analyzing stone tools. An extensive experimental program using replicated stone tools provides the comparative linkages between the archaeological artifacts and the tasks for which they were used. MSA foragers structured their tool use and discard behaviors on the landscape in several ways – by using and discarding hunting tools more frequently in the field rather than in caves/rockshelters, but similarly in coastal and interior contexts. This study provides evidence that during a significant microlithic technological shift seen in southern Africa at ~75,000 years ago, new technologies were developed alongside rather than replacing existing technologies. These results are compared with aspects of the European archaeological record at this time to identify features of early human technological behavior that may be unique to the evolutionary history of our species.

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"Get over your hill and see what you find there,

With grace in your heart and flowers in your hair."

–After the Storm

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CHAPTER 1 – INTRODUCTION

1.0 Introduction to the MSA

This dissertation used experimental and archaeological data to analyze the technological behaviors early modern humans in the Middle Stone Age (MSA) incorporated into their cultural system, used to mitigate challenges imposed by a changing Pleistocene landscape, and discarded based on economic decisions. The MSA is a crucial time period during human evolution because it is associated with the earliest genetic and fossil evidence of modern humans (Tishkoff et al., 2007; Behar et al., 2008; Scheinfeldt et al., 2010). Therefore, the adaptations and environmental context during this time provide clues about how the 'unique' set of biological and cultural traits seen in *Homo sapiens* began (Henshilwood and Marean, 2003; Hill et al., 2009).

Evidence for MSA technologies arguably appear 500 ka at Kathu Pan, South Africa (Porat et al., 2010; Wilkins and Chazan, 2012), and clearly after 300 ka, in the Kapthurin (McBrearty and Tryon, 2005; Tryon et al., 2005) and Gademotta (Sahle et al., 2013; Sahle et al., 2014) formations in Kenya and Ethiopia, respectively. However, these early expressions of MSA technologies tend to lack evidence of complexity and symbolic behaviors found in later MSA sites. In contrast, excavations at MSA sites on the south coast of South Africa in the highly diverse Cape Floral Region (CFR) have demonstrated early evidence for symbolic behavior such as incised ochre (Henshilwood et al., 2009), shell beads (d'Errico et al., 2005), and incised ostrich eggshell (Texier et al., 2010), as well as advanced stone tool technologies such as early microlithic industries (Brown et al., 2012; Porraz et al., 2013) and heat-treatment (Brown et al., 2009). It has been suggested that the unique suite of coastal and terrestrial plant and animal resources found in this area provided the necessary milieu for modern human behaviors to develop, or to become sufficiently prevalent to manifest archaeologically (Marean, 2010b). Recent genetic studies also favor a southern African origin for the modern human lineage (Schuster et al., 2010; Henn et al., 2011), which further highlights the role of this region in particular for the source population of modern humans. Yet, other than the production of certain artifact types, how MSA technology was being used across this diverse landscape is virtually unknown. The research presented here provided insight into how the technology of early modern humans across the Cape Floral landscape in the MSA allowed for population adaptation, survival, and to ultimately spread beyond Africa and across the world.

The MSA was originally defined by the presence of prepared core technology and the production of facetted triangular stone points similar to Levallois points in the Middle Paleolithic of Europe (Goodwin and Van Riet Lowe, 1929). It is also defined by the *absence* of certain types of artifacts: the lack of bifacial Acheulean handaxes separate the earliest MSA from the Earlier Stone Age (ESA), and the lack of small thumbnail scrapers, bipolar technology, grindstone and certain organic tools (e.g., digging sticks, d'Errico et al., 2012) separate the MSA from the Later Stone Age (LSA). Prior to developments of dating methods that extend beyond the radiocarbon ceiling of ~45 ka, the timing and tempo of variability in the MSA was largely unanswerable (Shea, 2011a). Lithic technologies within MSA deposits that once seemed anomalously advanced were viewed as transitional to the LSA (e.g., the Howiesons Poort, Keller, 1973). Recent advances in dating methods and improved excavation techniques are demonstrating dynamic behavioral changes during the African MSA record and blurring the contacts between Stone Age divisions. For instance, bifacial handaxes (ESA) are interstratified between prepared core industries (MSA) in the Kapthurin formation >280 ka (Tryon, 2006). Blades and points (MSA) are present in deposits that have been dated to ~500 ka at Kathu Pan 1 assigned to the Fauresmith Industry, which also contains typical ESA bifacial handaxes (Underhill, 2011; Wilkins, 2013). Bipolar technology at Border Cave suggests the earliest LSA dates to ~44-42 ka (Villa et al., 2012), a time when MSA assemblages still occur in other sites such as the "final MSA" at Sibudu Cave ~37 ka (Jacobs et al., 2007).

Archaeologists have identified more complex and nuanced technological behaviors within the MSA than was previously known. Klasies River main site (KRM) provided the first long MSA archaeological sequence that served as the backbone for understanding MSA technology (Singer and Wymer, 1982; Wurz, 2002). At KRM and subsequent sites, not only does microlithic technology in the form of Howiesons Poort crescents and blades appear earlier than once believed (Jacobs et al., 2008), it is interstratified with more typical MSA points, blades, and prepared cores. To make sense of technological variability in the archaeological record of this time requires linking the temporal record of technological evolution with a spatial context of how tools were being made, used, and discarded across a changing landscape. This study asks the questions of: did human populations in the MSA structure their tool use behavior on the landscape, or were similar tools used for similar activities at both cave and open-air sites? Were tool use behaviors adapted to coastal and interior environments? Were stone tipped spears and projectiles evident throughout the MSA on the south coast? What is the effect of post-depositional processes on tool edge damage formation? This dissertation addressed MSA technological variability by identifying how taphonomic and behavioral damage formed on stone tools in a diverse temporal and spatial sample of MSA assemblages, thus pinpointing the technological adaptations of MSA populations.

1.1 Inferring Technological Adaptations

Until relatively recently all humans lived by foraging for wild plants and animals. Fundamental to the human foraging economy are the technologies and strategies used to acquire resources. Technology is learned from people in a cultural context, is taught within and across generations, and evolves through time via processes both akin to and different from natural selection (Richerson and Boyd, 2005). The predominant archaeological evidence for foraging technology are stone tools. Patterns of stone tool use and discard can reflect technological decisions, provide insight into how foragers prioritized limited currencies (i.e., time and energy, Torrence and Bailey, 1983), and document how technology changed through time. Although stone tools are the most common surviving artifact from most sites, drawing behavioral inferences from them is not straightforward. Lithic classification and description are frequently presented as behavior, and subjective naming conventions seem to imply behavioral justification (e.g., “handaxe”, “scraper”), but much less is known about stone tool function and variability than their nomenclature implies (Shea, 2011b).

Use-wear analysis of stone tools has had some success in inferring lithic function, and therefore, behavior (Shea, 1992). Equifinality of edge damage morphology between behavioral and taphonomic processes create problems determining prehistoric stone tool function (Shea and Klenck, 1993). Use-wear analyses are often subjective, and blind-tests have shown substantial inter-observer variation can exist (Odell and Odell-Vereecken, 1980; Newcomer et al., 1986; Bamforth, 1988; Odell, 2004; Evans, 2014). The method used in this dissertation builds upon a more quantitative approach through analysis of assemblage distributions of edge damage. This approach was initiated by Bird et al. (2007) to look at the patterns of edge damage on a sample of points from Pinnacle Point Cave 13B (PP13B), South Africa, and then refined further by Schoville (2010) using the complete sample of MSA points from PP13B. In these studies, instances of edge damage scars along the edge are mapped onto the artifact images in GIS, and then aggregated by assemblage to create summary distributions. Bird et al. (2007) then analyzed the distribution using circular statistics around the average midline of the artifacts, whereas Schoville (2010) analyzed the distribution relative to the base and tip of each point. In both studies, the archaeological distributions were compared to a random, or uniform distribution of edge damage to argue that the edge damage was unlikely to be of taphonomic origin. Schoville and Brown (2010) advanced this methodology further by demonstrating how experimental populations of edge damage could be compared to archaeological samples in order to make more specific behavioral inferences. This dissertation built upon these studies by creating multiple experimental populations of stone tools that were subjected to controlled taphonomic and behavioral processes. A series of replicated stone tools were used for butchery, as spear-tipped armatures, exposed to water-born tumbling, and trampled by animals. Each tool was recorded before and after use in a GIS framework, and patterns of damage around the perimeter of tool edges summarized by frequency and distribution. These experimental patterns were then quantitatively compared to archaeological stone tool edge damage and macrofractures using novel assemblage-scale statistical analyses that were developed in this dissertation.

Much of our understanding of MSA behavior comes from assemblages excavated in cave or rockshelter environments. These contexts provide long chronological sequences that are more amenable to controlled dating methods, but also have limitations (Barton and Clark, 1993). Caves and rockshelters are discreet locations on the landscape, are generally not in direct association with resources, and are more frequently reoccupied compared to open-air sites (Binford, 1982). By nature of their geography, it is anticipated that caves will tend to reflect strategies where resources have to be brought in from elsewhere. Space within rockshelters is less constrained than in caves, which may allow for a greater diversity of activity areas – but also expose these sites to greater outside disturbance processes. Open-air sites can be extraction sites or camps depending on environment and local setting. Depending on local environmental context (such as sea-caves close to shellfish), caves tend to be located further from resources than open extraction sites, and therefore exhibit a more exaggerated transport bias against low utility materials. In faunal studies, animal skulls are an example of a low utility material that are infrequently transported from kill to camp sites (Daly, 1969; O'Connell et al., 1988; Marean et al., 1992; Schoville and Otárola-Castillo, 2014). In lithic studies, broken points (Holdaway, 1989; Kuhn, 1989; Shea, 1991) and nodule cortex (Brantingham, 2006; Oestmo et al., 2014) are low utility materials less likely to be transported from kill to camp sites. To encapsulate variability in use, transport, and discard, it is necessary to gain an appreciation for the landscape scale spectrum of foraging behavior in the MSA (Kandel and Conard, 2012).

Behavioral ecological observations and models of foraging behavior have provided insight into how prehistoric human foragers may have structured their landscape tool-use behaviors. Ethnographically observed foraging groups base their mobility on the distribution of resources, whose access can be limited by geographic, environmental, social/territorial, and technological restrictions. When resources are distributed patchily, foragers are argued by some to have long-term residential habitation sites and frequent logistical, activity-oriented movements of smaller groups (Binford, 1980; Grove, 2009). Groups that do not move frequently are expected to supply habitation sites, in contrast to frequent movements of people to resources (1980). Whether groups move resources-to-people, people-to-resources, or some combination of both, the spatial distribution of discarded tools will vary because transporting unreliable or exhausted tools after use is more costly (in time, energy, and risk) than discarding broken tools and retooling back at camp when foragers are ‘off the foraging clock’ (Oestmo et al., 2015). As will be discussed in Chapter 4, ethnographically observed foragers near coastal environments tend to (but not always) adapt their technologies and movements to exploit either coastal or interior environments, since each provides a unique suite of ecological resources that often require a toolkit, mobility strategy, and extensive foraging knowledge in order to effectively exploit. Therefore, studying prehistoric foraging technology in a coastal environment requires sampling both within caves and at open-air sites on the landscape, as well as from sites both near and distant from the coast.

To provide insight into the hunting patterns, landscape use characteristics, and technological behaviors in the MSA of southern Africa across this ‘foraging spectrum’ (Kelly, 1995), this research had the following two goals. First was to create experimental collections of stone tools with known behavioral and taphonomic edge damage patterns used to infer the processes behind archaeological lithic edge damage formation. The second goal was to analyze a cross-section of MSA archaeological sites in an area vital to modern human origins – the south coast of South Africa. This was achieved by analyzing points, blades, and flakes from five caves, PP13B, PP5-6, PP9, Nelson Bay (layers 6 and 10), Die Kelders 1 (Layers 6-12), and two open-air sites - Vleesbaai, and Oyster Bay. Within the second goal, the object is to ascertain whether archaeological edge damage patterning is more consistent with experimental taphonomic or behavioral patterning. By accounting for taphonomic effects as best as possible, the purpose of the second goal is to examine behavioral differences in tool-use and discard across the south coast foraging contexts.

The results of this dissertation indicate systematic behavioral patterning in land-use strategies during the MSA. Caves and rockshelters were used in different ways on average than open-air sites. For instance, open-air sites tend to have tools that are more heavily damaged, and with a greater frequency of hunting armatures. Relationship to the coastline also had a strong influence on the observed edge damage patterning. For instance, occupations near the coast tended to be consistent with a greater diversity of processes of edge damage formation.

This dissertation provided evidence for tool function in the MSA. Convergent MSA points are consistent with multi-functional, context contingent tool-use. Points were used as armature tips in some contexts, particularly at open-air sites and interior locations, and as knives in others. Dynamic temporal change in tool-use behaviors are indicated by the use of small, unretouched blades, in armatures during a limited period of time when microlithic industries begin to appear in several South African MSA assemblages.

Other results indicate that taphonomic edge damage in the MSA is quite common, and there appears to be an increasing amount of trampling damage in particular through time. This may be linked to rising population levels or longer occupation of sites on the landscape.

Finally, differences between the South African MSA record studied here and Neandertal assemblages suggest that MSA foragers were using and discarded lithic armatures in very different ways, which has implications for the cultural system of innovating and transmitting technological knowledge in the MSA. The presence of hunting technology even when sites were occupied near the coast in the MSA may also have implications for sexual division of labor at this time.

1.2 Dissertation Outline

The organization of this dissertation is as follows. Chapter 2 provides an overview of the fossil evidence for modern human evolution and places the African Stone Age within this framework. Each archaeological assemblage studied in this dissertation is placed within this context. Chapter 3 provides a background to the environments of the Middle and Late Pleistocene of South Africa. This includes the ecology, geology, and paleoenvironments of the Cape Floral Region and the Agulhas Bank. Chapter 4 provides a theoretical orientation for the dissertation, including the research questions and hypotheses that are being tested. Chapter 5 explains the methodology used in this dissertation, including the design of experiments, edge damage recording procedures, statistical analyses, and various considerations of tool morphology that must be taken into account (i.e., edge angle and tool asymmetry). Chapter 6 provides the results of the experiments and analyses. A discussion of the results with respect to the specific goals and hypotheses is provided in Chapter 7, with the final section summarizing and concluding this dissertation and proposing several hypotheses to be tested in future research.

CHAPTER 2 – BACKGROUND: HUMAN EVOLUTION AND THE AFRICAN STONE AGE

2.0 Introduction

This dissertation is focused on understanding patterns of stone tool edge damage formation relative to site context in the MSA in order to understand prehistoric behaviors and foraging technologies. During this time period, dramatic changes in the archaeological and fossil records suggest significant new adaptations and behaviors developed (Lahr and Foley, 1998; McBrearty and Brooks, 2000). Genetic and fossil evidence points to this time period as crucial for the appearance of the modern human lineage (Ingman et al., 2000; White et al., 2003; McDougall et al., 2005; Garrigan and Hammer, 2006). To place the questions addressed by this dissertation in broader biological evolutionary context, I will present a review of the relevant record for human origins. Additionally in this chapter context is given to the origins and development of modern humans in Africa and the record of technological change. To begin, a brief overview of the fossil evidence for modern human evolution beginning with *Homo erectus*, *H. heidelbergensis*, *H. neanderthalensis*, and finally *H. sapiens* is presented. The various models for modern human origins within Africa will be discussed, including a brief review of the genetic evidence and proposed lineage bottlenecks. The second section will present the evolution of technology in the Stone Age of Africa, including the origins and characteristics of the Earlier, Middle, and Later Stone Age. This section is concluded with a discussion of models for modern human origins in the Middle Stone Age. At the conclusion of this chapter, the foundation of human biological, cultural, and genetic evolution will be established, so that more specific questions about the paleoenvironmental contexts can be explored and linked to the archaeological record with ethnographic and behavioral ecological models in the next chapter.

2.1 Biological Evolution of later *Homo*

By ~1.5 ma *Homo erectus* has many features of the anatomically modern human body plan including increased brain size, retracted facial position, tall stature, and long distal limb proportions (Brown et al., 1985; Antón et al., 2014). These adaptations are often argued to be associated with a 'grassland adaptation' and an efficient gait in order to take advantage of the increasingly open environments of the Early Pleistocene (Cerling et al., 2011). *H. erectus* is the first hominin to migrate out of Africa, suggesting a mobility and capacity for behavioral flexibility in encountering novel environments not yet seen in hominin evolution. In addition to more open environments, *H. erectus* may have also been adapted to increasing climatic variability and aridity (Potts, 1998; Antón et al., 2014). The fossil record of the Middle and Late Pleistocene in Africa is limited, and although it is generally agreed that *H. erectus* evolved in Africa, the earliest fossils attributed to *H. erectus* are ~1.8 million years ago (ma) in Dmanisi, Georgia (Ferring et al., 2011). The five skulls from Dmanisi are highly variable, and some researchers have suggested that some earlier African *Homo*, particularly *Homo rudolfensis* and *Homo habilis*, be subsumed into a more variable *H. erectus* species definition (Lordkipanidze et al., 2013).

The *H. erectus* morphology seems to have arisen as a mosaic over time rather than as a complete package (Antón et al., 2014). Cranially, facial and dental morphological reduction is present in the earlier specimens of *H. erectus*, while the major increases in brain size occur more notably later (<800 ka; Anton 2014). The post-crania are similar to those of modern humans, but with notable differences, particularly in the pelvic girdle. This fact, coupled with a faster life-history compared to later *H. sapiens* as judged by dental development, suggests the modern human pattern of birthing patterns and life-history evolved later (Dean et al., 2001).

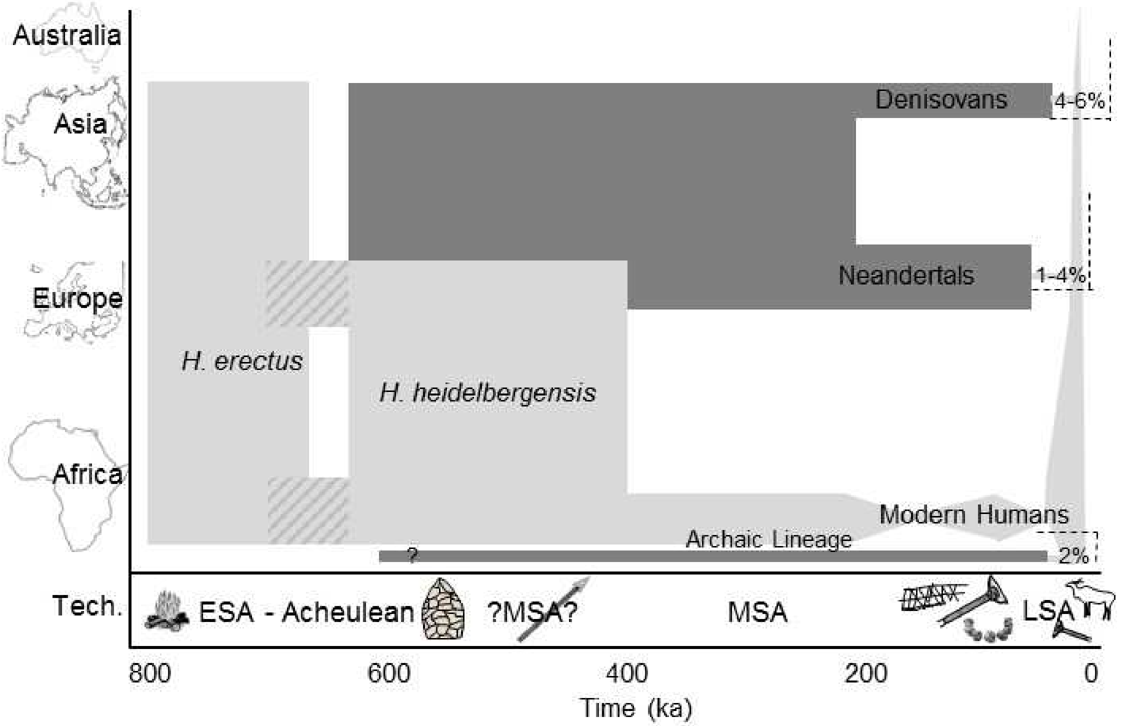

Figure 1. Evolutionary relationships and technological innovations in Middle and Late Pleistocene Homo. Admixture from ancient lineages occurred in Africa (2%), in non-African European and Asian lineages (1-4%), and in Melanesians (4-6%).

By ~600 ka, *H. erectus* disappears from the fossil record (but may have survived genetically in the Denisovan lineage, (Reich et al., 2010)) and a new species, *H. heidelbergensis* appears (Figure 1). While the Middle Pleistocene taxonomy is notoriously “muddled” (Stringer, 2012b), many researchers advocate a single diverse species may have existed across the Old World between ~800-400 ka. This species has a mixture of features too modern to be *H. erectus*, but too archaic to be *H. sapiens*, and some researchers refer to these Middle Pleistocene fossils simply as "archaic *Homo sapiens*" in order to bypass the taxonomic ambiguity at this time (Lieberman et al., 2002), though the phenotypic diversity and vast geographic spread makes this contentious. For instance, *H. heidelbergensis* has larger cranial capacity than *H. erectus* (Stringer, 2012a), but more facial projection and brow ridges than *H. sapiens* (Lieberman et al., 2002). The skull from Bodo in Ethiopia has been dated to ~600 ka (Kalb et al., 1980; Rightmire, 1996:23), and contains many facial features similar to later *H. sapiens* (Rightmire, 1996). European *H. heidelbergensis* are similar to the African samples, but with more post-cranial robusticity, and some features that foreshadow derived morphology of the Neandertal lineage are evident, especially at the site of Atapuerca, Spain, possibly suggesting an early form of Neandertals (Stringer, 2012b).

H. heidelbergensis is likely the last common ancestor of three populations: Neandertals in Western Europe, Denisovans in Eastern Europe, and modern humans in Africa (Stringer, 2012b). The Denisovan population is largely inferred from genetic evidence, as the fossil record of the Denisovans is virtually unknown except for a ~40 ka tooth and finger bone from southern Siberia. The genetic record suggests a divergence of the Denisovan population from *H. heidelbergensis* ~780 ka (Krause et al., 2010; Meyer et al., 2014). However, the genetic record also suggests that this population survived as a breeding population, and much later interbred with modern humans spreading out of Africa much later, ~50 ka (Figure 1), as evidenced by the ~5% contribution of Denisovan genes to the populations east of the Wallace line, including the Philippines, Australia and New Guinea (Reich et al., 2010).

The Neandertal fossil record is much more complete. The Neandertal body form appears to be adapted to cold climates. Their limb proportions – specifically shortened forelimbs and distal legs, overall stout stature, widened nasal structure, and thick musculature point to cold environment adaptations (Schrenk et al., 2009). Overall, bones are thick with evidence for heavy musculature, similar to *H. erectus*. The earliest fossils with traits suggestive of *H. neanderthalensis* apomorphies come from the Spanish site of Atapuerca, however the earliest "fully" Neandertal specimens don't appear until ~200 ka from Biache, France and Ehringsdor-Wimar, Germany (Hublin, 2009). Genetic evidence suggests that the Neandertal and modern human lineages split ~400 ka (Endicott et al., 2010; Krause et al., 2010; Fu et al., 2013) and the Neandertal and Denisovan lineages split ~200 ka (Scally and Durbin, 2012). However, the genetic evidence suggests that individual non-Africans retain 1-4% Neandertal DNA, which indicates some amount of interbreeding (Green et al., 2010) as modern humans left Africa and colonized Eurasia. Using more sophisticated AMS radiocarbon dating techniques and a large sample of Middle Paleolithic sites (including Gibraltar), Higham et al. (2014) suggests a widespread extinction of Neandertal populations throughout Europe by 40 ka.

2.2 Modern Human Biological Origins

The fossil record of early modern humans is sparse, known largely from East Africa. An incomplete near-modern, or 'archaic modern human' skull from Florisbad, South Africa dates to 259 ±35 ka using a combination of ESR/OSL techniques (Grün et al., 1996), but the taxonomic affinity is debated and considered transitional between *H. heidelbergensis* and *H. sapiens*. The earliest fossils considered fully anatomically modern *H. sapiens* are the ~195 ka skull from Omo Kibish 1 (Aubert et al., 2012), Ethiopia and the ~160 ka skull from Herto Bouri, Middle Awash, Ethiopia (White et al., 2003). Fossils from Jebel Irhoud, Morocco have modern human morphology and life-history characteristics from tooth development studies, and are dated by U-Series/ESR to 160 ± 16 ka (Smith et al., 2007:SOM). This suggests that the modern human body plan and developmental life-history characteristics were widespread by ~160 ka, and likely prior to 190 ka. Modern human fossils then occur in the Levant by ~115 ka at Skhul and Qafzeh (Stringer, 2003), suggesting range expansion and contraction events prior to the final push out-of-Africa (~60 ka). In southern Africa, the few human fossil remains from Klasies River have been dated to ~90 ka (Grün and Stringer, 1991), and although have some robust features, are usually assigned to modern *H. sapiens*.

As a result of genetic, archaeological, and paleoanthropological data accumulated over the past 25 years, the debate over modern human origins often characterized as 'multi-regionalism' vs. 'out-of-Africa' is largely settled with most evidence strongly favoring the Out-of-Africa model (Mellars, 2007). This opens a new realm of research questions about the timing, tempo, and location of modern human origins in Africa. Did a single population give rise to all modern humans? Since the modern human genome includes 50% of the Neandertal genome, does a 'mosaic' pattern of modern behaviors and biological features accruing at different places and times better explain the origins of modern humans? Depending on the mutation rate, or 'genetic clock', traditional models situate this origin at ~150-200 ka, but newer mutation rates have suggested an age closer to ~300 ka (Scally and Durbin, 2012). If the traditional rate is accepted (Fu et al., 2013; Green and Shapiro, 2013), then the last common ancestor of all modern humans emerged during the penultimate glaciation (MIS6, 191-123 ka). Some parts of this glacial are similar in severity as the Last Glacial Maxima (LGM, ~21 ka), but lasted much longer. MIS6 is generally considered colder and more arid in Africa (Lahr and Foley, 1998), though the empirical record is sparse. There are only a handful of archaeological sites in Africa that date to this time period, which in itself is considered a sign of the severity of MIS6 for human populations (Barham and Mitchell, 2008; Marean, 2010a).

Many genetic studies have suggested a population bottleneck in the late Middle Pleistocene close to the estimated origin point of the modern human lineage (Marth et al., 2003; Manica et al., 2007). This bottleneck is in addition to a Late Pleistocene bottleneck event considered the final movement of humans out of Africa across Eurasia (Lahr and Foley, 1998). There are two models for human population bottlenecks during the late Middle Pleistocene to explain the reduced genetic variation. The "Founder model" argues for a single progenitor population of modern humans that survived this bottleneck event (Fagundes et al., 2007). This population then subsequently spread across Africa, but there were likely still pockets of archaic populations and through hybridization some introgression of genetic material occurred (~2%, Hammer et al., 2011). The location of this progenitor population has been argued to be North Africa (Smith et al., 2007; Dibble et al., 2013), East Africa (Lahr and Foley, 1998), southern Africa (Marean, 2010b; Henn et al., 2011), or Central/West Africa (Cruciani et al., 2011; Mendez et al., 2013; Rito et al., 2013). Alternatively, the "Fragmentation model" explains the Middle Pleistocene bottleneck as multiple, much smaller populations that became fragmented into isolated refugia with little to no gene flow (Sjödin et al., 2012). Each population would have reduced genetic variability, such that when the populations expanded the total genetic diversity was still reduced compared to the prior population.

2.3 Stone Age Technology and Behavior

Concurrent with biological change during the Middle and Late Pleistocene fossil and genetic record of human evolution, are changes in the technology and behaviors that can be inferred from the archaeological record. There is no simple 1-to-1 relationship between species and technology. There are clear trends in the archaeological record of increasing technological and behavioral complexity through time. However, this is not a linear pattern, and substantial variation occurs. The following section presents an overview of the archaeological record during the Pleistocene, and places technological developments within an evolutionary context.

The tripartite Stone Age nomenclature (Earlier, Middle, Later) for classifying archaeological sites based on lithic typology in Africa was both based on the European Paleolithic system (Lower, Middle, Upper), and used to recognize distinctions in the African record (Goodwin and Van Riet Lowe, 1929). The Stone Age covers at least 2.6 million years, from Oldowan and Acheulean up until the onset of the Iron Age. This system has its limitations, especially with the transitions between industries, but is still in use today because it effectively distinguishes the vast majority of sites into units that share many similarities and are from similar time periods. Clark's (1969) technological "modes" attempt to unify the Paleolithic and Stone Age systems into five stages. Mode 1 is fairly simple pebble cores and flake tools, generally synonymous with the Oldowan. Mode 2 contains large, bifacially worked cores and flakes, typified by the Acheulian Industry. Mode 3 tools are flakes, points, and blades struck from prepared cores. Mode 4 technology is characterized by punch-struck blades, retouched into reoccurring forms. Mode 5 consists of microlithic tools, heavily retouched geometric forms often fitting into composite tools. As originally conceived, the modes were seen as a technological progression through time based on the European record. Subsequent research, largely in Africa but also in Eurasia and Australia, have shown that substantial variation exists, especially in what would generally be thought of as Mode 3 sequences. Shea (2013) attempts to account for this variability by expanding the modes to nine categories, Modes A through I, based on method of production (percussion, fracture, and abrasion) and by organization of production (non-hierarchical cores, retouched flakes, and hierarchical cores). In Shea's scheme, the modes can be combined in order to evaluate behavioral variability across large-scale, evolutionary histories.

For this dissertation, the Stone Age nomenclature will be maintained, largely because the focus is not understanding change in how stone tools were produced, but in how stone tools were used and discarded on the landscape. Although imprecise, the Stone Age system also accounts for time and includes variability in lithic technologies without making assumptions about the nature of the assemblages.

2.3.1 Earlier Stone Age

Until recently, the Earlier Stone Age (ESA) begins with Oldowan technology and the production of flakes generally associated with the first appearance of the genus *Homo*. However, the earliest Oldowan tools were recovered from Gona, Ethiopia, dating to 2.6 ma (Semaw et al., 1997) and associated with *Australopithecus garhi* (Asfaw et al., 1999). Recently discovered stone tools from the 3.3 ma Lomekwi 3 site in West Turkana shows substantial differences with traditional Oldowan tools, including bipolar and 'passive hammer' manufacturing with large anvils (Harmand et al., 2015). The discovery of bones from Dikika, Ethiopia at 3.4 ma with surface modification attributed to stone tools suggests an industry of informal tool-use prior to the Oldowan (McPherron et al., 2010), however these tools have not yet been discovered and may be difficult to differentiate from naturally occurring stone fragments on the landscape (McPherron et al., 2011). Oldowan assemblages tend to be made from sources near to the site (<10 km), but some preference for stone with better fracture properties is evident from conglomerates in the Kanjera Formation located 10-13km away (Braun et al., 2008a). Given the evidence from Dikika, and later Oldowan assemblages containing processing marks such as Bouri (2.5 ma, de Heinzelin et al., 1999) and the 1.85 ma FLK Zinj fauna (Blumenschine, 1995; Dominguez-Rodrigo, 1997; Deino, 2012), Oldowan tools were at least occasionally used for cutting meat and breaking open bones for marrow extraction. The weathered state of the tools generally do not allow for use-wear analyses, but a study by Lemorini et al. (2014) from Kanjera South, Kenya, has suggested processing of plant material such as underground storage organs, grassy stems, and wood occurred on some Oldowan tools. The study by Lemorini et al. (2014) included a blind test of eight used flakes, and five of those were successfully identified to worked material (63%), which indicates room for significant improvement in the use-wear methodology (see section 4.2.2).

Following the Oldowan is the Acheulean Industry that consists of large bifacial tools and cores including handaxes, cleavers, and picks. The earliest Acheulean occurs by 1.75 ma at both Konso, Ethiopia (Beyene et al., 2013) and Kokiselei 4, Kenya (Lepre et al., 2011). It’s not clear how or where Acheulean technology developed. After 1.4 ma, Acheulean technology is associated with *H. erectus*, but both Oldowan and Acheulean artifacts occur together at the earliest Acheulean sites in East Africa. Additionally, the earliest stone tool assemblages outside of Africa considered to be associated with early *Homo erectus*, Dmanisi at 1.85 ma (Ferring et al., 2011) and Java at ~1.49 ma (Morwood et al., 2003), do not have Acheulean technology.

The characteristic tool-type of the Acheulean is the bifacially flaked "hand-axe". Some debate exists over whether the hand-axe itself was the intended product, or if the final shape on some was an unintended consequence of bifacial knapping to produce flakes (McPherron, 2000; Davidson, 2002). Use-wear on handaxes have shown that many were used for wood cutting-scraping purposes or butchery (Keeley, 1980; Dominguez-Rodrigo et al., 2001), but flakes from Acheulean sites were also used for a variety of purposes (Barkai et al., 2010; Agam et al., 2014). It seems likely that handaxes were used as both a tool in itself, and as a core to produce smaller useable flakes in some situations.

Acheulean technology is associated with the earliest evidence for controlled use of fire. The earliest claims for archaeological evidence of fire are from open-air sites in East Africa at ~1.5 ma (Gowlett et al., 1981; Bellomo, 1994) and are not widely accepted (Pickering, 2012). More recently, using sophisticated micromorphology and infrared microspectroscopy techniques, Berna et al. (2012) argue for in situ fire features at 1.0 ma inside Wonderwerk Cave, South Africa. The earliest widely accepted evidence for controlled fire are the clusters of burned artifacts, seeds, and wood along an ancient lake at the site of Gesher Benot Ya'aqov, Israel at ~800 ka suggestive of *in situ* hearth features (Goren-Inbar et al., 2004). After 400 ka, evidence for controlled use of fire appears to be more widespread, and is evident in the Levant (Mercier et al., 1995; Karkanas et al., 2007) and Eurasia (Rolland, 2004; Roebroeks and Villa, 2011). The lack of fire evidence associated with the earliest colonization of high-latitudes by *H. erectus* and *H.*

heidelbergensis is not intuitive (Roebroeks and Villa, 2011), and it has been argued by Sandgathe et al. (2011) that Neandertals did not consistently maintain fire technology. Sandgathe et al. (2011) suggest that, in fact, Neandertals "lost" fire during the coldest periods when fire would be most beneficial, speculating that the cultural information to make fire was lost due to population size decline during harsh climates. The origins and frequency of habitual fire use is critical in our understanding of modern human origins because of fire's link to cooking, protection from climate, disease, and predators, and social organization and extending social interaction time (Wiessner, 2014); which all arguably have implications for brain size, life-history development, and group structure (Wrangham et al., 1999; Carmody and Wrangham, 2009; Wrangham, 2009). Additionally, fire is a pre-requisite for a suite of engineering innovations that occur later, such as mechanical alteration of stone ~70 ka (Brown et al., 2009), clay for ceramics ~20 ka (Wu et al., 2012), and eventually metallurgy ~5 ka (e.g., Greenfield, 2000).

The earliest evidence for the technological transition from Acheulean to prepared-core and point dominated MSA assemblages comes from Fauresmith levels at Kathu Pan 1 (KP1), South Africa (Porat et al., 2010) and in the Kapthurin Formation, Kenya (Tryon, 2006). At both sites, handaxes persist into prepared-core levels, and the nature of the transition is not well understood (Underhill, 2011). In fact, large core-tools similar to the ESA may occur throughout the Stone Age sequence. Unfortunately, no fossil material is present at these sites, but they are often thought to be associated with *H. heidelbergensis* (Porat et al., 2010). At KP1, unifacial and unretouched points are consistent with use as hafted spear-tips (also see Chapter 5 and 6), and the development of hafting at this time presents a major technological advance over prior industries (Wilkins et al., 2012).

The first wide-spread industry following the Acheulean are the heavy duty artifact assemblages associated with the Sangoan. The type site for the Sangoan Industry is at Sango Bay, Uganda (Wayland and Smith, 1923). The Sango Bay site is mainly a surface collection and unlikely to provide dates or clear stratigraphic associations. Artifacts associated with the Sangoan tend to be large core scrapers, core axes, and picks. At other sites such as Kalambo Falls, Zambia the Sangoan clearly falls above Acheulean levels and below light-duty MSA levels suggesting that the Sangoan may be a valid industry and not an artifact of poor excavation or preservation. In East Africa, the Acheulean-Sangoan transition is unclear. Acheulean hand-axes occur in levels above and below Sangoan occupations at Sai Island, Sudan (Van Peer et al., 2003) and in the Kapthurin Formation (Tryon and McBrearty, 2002). The age of the Sangoan is uncertain, but may be ~284 ka as indicated from the Kapthurin Formation (Tryon and McBrearty, 2002) or ~254 ka as indicated from Bete I, Ivory Coast (Liubin and Guede, 2000, as cited in Barham and Mitchell 2008). If the Sai Island material is considered Sangoan as Van Peer, et al. (2003) suggest, then their ages of 220-180 ka may indicate the Sangoan persisted from ~284 – 180 ka, and overlaps with some late occurrences of Acheulean technology.

Stratigraphically above the Sangoan at Kalambo Falls is the Lupemban Industry which has widespread occurrences in central Africa (Clark, 2001b). The *fossiles directeurs* of the Lupemban are well-flaked, bifacial, lanceolate Lupemban points, often occurring alongside heavy-duty tools suggestive of the Sangoan. Well-dated Lupemban sites are rare, and the only absolute date comes from Twin Rivers, Zambia which puts the Lupemban roughly at 265-170 ka based on U-series dating of a flowstone above archaeological strata (Barham, 2002). However, the association of the flowstone with the archaeological material at Twin Rivers has been challenged (Herries, 2011). The only other Lupemban-like assemblage that has been dated is Sai Island, which was OSL dated to 152±10 ka at the base of "Lupemban-related Nubian Complex" (Van Peer et al., 2003; Herries, 2011).

2.3.2 Middle Stone Age

The MSA is defined based on the presence of prepared core technologies, lack of bifacial handaxes, and high frequency of pointed flakes and blades. In the original technological description of the MSA by Goodwin and Van Riet Lowe (1929) emphasized the production of triangular points specifically. Little standardization in core reduction is evident through the MSA, but radial, centripetal, and informal cores are common (McBrearty and Brooks, 2000; Brown, 2011). The earliest widely recognized MSA sites come from deposits in the Kapthurin formation, Kenya, which are >278 ka and consist of prepared cores, blades, and frequent points, but no bifacial handaxes (Tryon et al., 2005). Overall, the MSA is more variable than prior industries, and the meaning of this variability may suggest the beginnings of cultural differentiation. Clark (1988) identified regional expressions of cultural traits that are more homogenous within regions than between regions that may indicate unification of adaptive behavioral systems within the MSA. As Clark (1982) notes, "[MSA] traditions show that there is a greater degree of continuity between stratified assemblages at a single site or within a limited locality through time than can be observed between contemporary assemblages from different geographical regions (p.256)." Without a comparative, quantitative analysis of assemblages analyzed using modern techniques, Clark's assertion is difficult to evaluate. However, if true, it suggests that MSA populations may have been adapting to local conditions – flora, fauna, raw-materials, water availability – for long periods of time in similar ways. McBrearty and Brooks (2000:Figure 5) illustrate the regionally discrete entities in the African MSA based on point typologies that may support the notion of regional identities that persisted through time. Wilkins (2010) argues that such active stylistic expressions as regional point styles may symbolize social relationships within groups, a pattern not seen in prior technological traditions. In contrast, while Neandertals exhibit similar Mode 3 technology (Clark, 1977a; Foley and Lahr, 1997), there is little evidence for regionally discrete behavioral or cultural entities during the Middle Paleolithic.

In southern Africa, the long sequence from Klasies River mouth (KRM) forms the backbone of the Late Pleistocene lithic typology (Singer and Wymer, 1982), and has often been used to link change in MSA cultural sequences to global climates (Volman, 1981). The KRM assemblage was divided into five units, or stages. As described by Singer and Wymer (1982), the MSA stages I-IV are roughly similar – production of flakes, blades, and convergent points are common, retouch is infrequent, and local quartzite is the predominant raw material. MSA I is argued to have characteristic platform trimming (faceting) on elongated blades and thin flakes. MSA II appears to be targeted at point production, with the majority of cores by typologically point-cores, and fewer elongated blades than in MSA I. Points and point cores tend to become smaller through time (Singer and Wymer, 1982:62; Wurz, 2000:64).

Above the MSA II is a major technological shift identified as the Howiesons Poort (HP) Industry. Notable in the HP is an increase in finer-grained silcrete and quartz raw-material relative to coarser grained quartzite (although quartzite is still dominant in the KRM HP). The HP at KRM is characterized by the production of small blades, backed blades and segments, including crescents, trapezes, and triangles (Singer and Wymer, 1982). Wurz (2000) argues that the cores were designed to produce blades and blanks for the backed pieces, and that reduction is not appreciably different from the other MSA stages. At the type-site of the HP, the Howiesons Poort rockshelter in the Eastern Cape, unifacial retouched points are common (Deacon, 1995). A more pronounced raw-material shift is evident from other HP assemblages, including Diepkloof Rockshelter (Porraz et al., 2013), Pinnacle Point Cave 5-6 (Brown, 2011), and Rose Cottage Cave (Soriano et al., 2007).

At KRM, above the HP are the MSA III and IV stages. MSA III is described as similar to MSA I in terms of elongate blade production including long serrated flake-blades, but relatively few pointed flake-blades. However, the cores have more similarity with the HP layers than other MSA stages (Wurz, 2000). There is a small sample of MSA IV material, both from the original Singer and Wymer (1982) excavations in the 1960s and the Deacon (Deacon and Geleijnse, 1988) re-excavation in the 1980s. Fewer elongate flake-blades are present, but there is an increase in the pointed convergent flake-blades (Singer and Wymer, 1982).

Temporal change in blade and flake size in MSA I-IV as noted by Wurz (2000) and Singer and Wymer (1982), may be idiosyncratic to KRM, rather than a regional pattern (Thompson et al., 2010). Differences in edge damage formation between stages are also noted, with the HP sample having the lowest frequency of damage and the MSA III blades having the highest (Wurz, 2000:85). However, this dissertation presents the first large-scale analysis of MSA edge damage formation through the MSA on the south coast in order to address temporal and spatial variability, and also found an increase in edge damage occurrences in the HP at the sites analyzed (Chapter 7).

Volman (1981) adapted and generalized this scheme to fit a larger set of MSA assemblages south of the Limpopo River. Recent excavations have indicated more complexity within the MSA sequence than previously recognized. In South Africa, the MSA stages are interrupted by at least two technological shifts. The HP, as previously mentioned, and the Still Bay (SB) Industry. The SB is known for the production of bifacial foliate points and bone tools (Henshilwood et al., 2009; Villa et al., 2009b). Until relatively recently, it was unclear whether the SB was securely MSA. But now, well-excavated sites with *in situ* SB have shown that the SB is MSA and sits stratigraphically below the HP. Jacobs et al. (2008) provide single-grain OSL ages for both the HP and Still Bay, placing the HP at ~65-60 ka, and the SB from ~72-70 ka. These ages have been contested by an alternative dating program at Diepkloof rockshelter (Tribolo et al., 2009; Porraz et al., 2013) where both are considered to be much older and longer-lasting.

Recent research from MSA sites has provided evidence of technological complexity and symbolic behaviors not present in earlier industries. Abstract engravings on ostrich eggshells from Diepkloof at ~65 ka provide evidence of both symbolic behavior, but also water storage containers that could enable human groups to live in arid areas where there is not daily access to water (Texier et al., 2010). Engraved ochre and a "paint-kit" discovered at Blombos Cave at ~100 ka is argued to be evidence for symbolic behavior such as body painting or cave rock art (Henshilwood et al., 2011). Similarly 'designed' engravings on a shell from Java argued to be associated with Homo erectus, may push the evidence for such behaviors back to 430 ka, however it's difficult to evaluate the cognitive importance of a single engraving pattern. Numerous perforated shell-beads also recovered from Blombos point to clear personal ornamentation for the first time in the archaeological record at ~73 ka (d'Errico et al., 2005; Jacobs et al., 2013).

2.3.3 Later Stone Age

The Later Stone Age (LSA) is characterized as a transition to micro-blades and micro-core technology and occurs roughly synchronously across sub-Saharan Africa – at least in comparison to the ESA/MSA transition (Barham and Mitchell, 2008). In southern Africa, the earliest LSA is identified from Border Cave, South Africa and dates to ~44-42 ka (Villa et al., 2012). The LSA attribution is based on an increase in bipolar technology from post-HP strata, and the presence of organic tools, ostrich eggshell beads, and grindstone tools observed in ethnographically known San groups (d’Errico et al., 2012). The first widespread LSA entity in southern Africa is the Robberg Industry, which dates from 22-11 ka (Kusimba, 2003). The Robberg is best known from Nelson Bay Cave where it is dated between 18-12 ka (Deacon, 1978). This industry is typified by unretouched bladelets and scrapers, often produced on quartz, quartzite, and occasionally silcrete. On the south coast, Robberg fauna suggest open-grassland hunting, including buffalo, hartebeest, and zebra (Klein, 1972), consistent with lowered sea-levels and a nearby grassy plain (as opposed to its current coastal setting). Following the Robberg, Oakhurst industries (Albany on the south coast, Kuruman in the Northern Cape, and Lockshoek in the Karoo) have been dated from 12-8 ka, and are known for being non-microlithic and produced on coarse-grained raw-materials (Mitchell, 1997). Oakhurst industries are typified by large, quartzite, ‘duckbill’ scrapers, and sidestruck flakes. The Wilton Industry (Springbokoog Industry in the Northern Cape) dates from 8-4.5 ka

(Mitchell, 1997). Wilton sites contain a wide range of very small microlithic tools, including distinctive segments, backed pieces, scrapers, bone tools, and numerous ostrich eggshell beads (Deacon, 1972). The Wilton is predominately produced on fine-grained raw-material such as silcrete, chalcedony, and opaline. Sampson (1974) further divides the Wilton into Early, Classic, Post-classic, and Ceramic periods based on the overall structure of material culture present through time in the Wilton.

2.4 Modern Human Behavior and the African Stone Age

There is now a consensus that anatomically modern Homo sapiens evolved in Africa ~200 ka. What is not well understood is whether the apparent disconnect between the less-complex archaeological records of early modern humans (pre-100 ka) and the more complex record of later populations (<100 ka) represent differences in cognitive, social, and technological abilities between the two populations. This disconnect shifts the question of modernity from anatomy to behavior. Definitions of biological modernity are more straightforward than behavioral, but still fraught with issues (Stringer et al., 1997). Various approaches to defining behavioral modernity have been developed and debated using lines of evidence drawn from Paleolithic, MSA, and Australian archaeological assemblages. Prior to developments of dating methods which extend beyond the radio-carbon ceiling at ~45 ka, the timing and tempo of variability in the MSA was largely unanswerable. Features that seemed anomalously advanced (e.g., SB pointed bifaces and HP microliths) were viewed as ‘transitional’ to LSA assemblages (Goodwin and Van Riet Lowe, 1929). Analyses often compared large discreet technologically based units such as the entirety of LSA and MSA sites. This approach masks tremendous variability, and recent dating methods and better excavation techniques are demonstrating dynamic behavioral change during the African MSA record. These debates will be reviewed below, integrating the impact of recent dating chronologies with the developing record of MSA behavior.

Behavioral modernity consists of those behaviors which are unique to *Homo sapiens* (Henshilwood and Marean, 2003; Shea, 2011a). Ancestral ‘non-modern’ behaviors may have originated along the Hominin line from the last common ancestor with chimpanzees to an archaic population of ‘near-modern’ humans. However, there is little consensus about which traits derived uniquely in the lineage ending in *Homo sapiens* (Hill et al., 2009), and how those traits manifest archaeologically (Wadley, 2003). The competence of MSA hunters compared to ethnographically observed foragers was the focus of intense debate historically. Klein (1989, 1999) has argued the division between modern and non-modern populations lay in the division between the MSA and LSA, which occurred towards the limits of radiocarbon dating at ~55-45 ka (Ambrose, 1998; Bird et al., 2003). Archaeologically, later LSA sites are associated with rock-art and artifacts of clear iconic symbolism which do not appear in MSA assemblages (Wilkins, 2010). Extrapolating from these material differences, Klein (1989) approached the faunal records with this dichotomy in mind. The extensive faunal remains from excavations at KRM took on a particularly prominent role throughout these debates. Initial studies of fauna from KRM led to the interpretation that large and small fauna were regularly hunted by MSA foragers (Klein, 1989). However, based on species representation lists, fewer ‘dangerous’ taxa (Cape buffalo and bushpig), and the lack of fish and avian remains compared to LSA sites suggested to Klein MSA hunters were less adept. Binford’s reanalysis of the KRM fauna using skeletal element abundance profiles relative to utility measures generated from his studies of Nunamiut hunting suggested that, not only were MSA foragers less capable hunters than modern foragers, but were only able to scavenge large bovids (Binford, 1984).

Both interpretations have been subsequently critiqued on taphonomic, empirical, and theoretical grounds (Henshilwood and Marean, 2003). First, excavations from KRM were shown to be biased and only complete bones thought to be identifiable were saved (Turner, 1989). Taphonomic experiments by Marean and colleagues show that identification and quantification of shaft fragments represent original abundance of skeletal elements much more closely than epiphyses (Marean and Spencer, 1991; Bartram and Marean, 1999). Therefore, the element profiles used by Binford and Klein are essentially artifacts of excavation. Second, Faith (2008) demonstrated with larger samples of MSA and LSA sites (excluding KRM) indistinguishable frequencies of 'dangerous' prey in faunal assemblages. Third, there is no theoretical justification for arguing buffalo and bushpigs required 'modern' cognition any more than other large bodied prey, or that differences should not be expected to reflect ecological conditions which influence diet breadth rather than aspects of behavioral modernity (Henshilwood and Marean, 2003). Similar debates which played out in the Middle Paleolithic depended largely on the same method of analyzing skeletal element frequencies using epiphyses and complete bones to argue Neandertals scavenged their prey (c.f. Stiner, 2002; with Pickering et al., 2003). More complete analyses indicate that, with shaft fragments included, Neandertals had early access to high utility prey items similar to foragers in the MSA (Marean and Kim, 1998) and modern observed hunters (Marlowe, 2010). If behavioral modernity is restricted to the suite of behaviors unique to *Homo sapiens*, then adeptness in hunting large, dangerous game is an ancestral condition.

Other approaches towards identifying the origins of behavioral modernity proceeded from accumulating lists of material evidence present in assemblages associated with anatomically modern humans and then looking for earlier traces of these traits (Klein, 1995:168). This trait-list approach has the advantage of producing clear archaeological expectations. Historically, behavioral modernity has been argued to be the suite of bone tools, objects of personal adornment, diverse and regionally distinct stone tool forms, and other artifacts which occur in the Upper Paleolithic and not the Middle Paleolithic – often referred to as the "Human Revolution" (Mellars and Stringer, 1989). Radiocarbon dating routinely placed this during OIS3, at the limits of radiocarbon dating. Archaeologists working in Africa and Australia struggled to fit their records of human behavior within this framework (McBrearty and Brooks, 2000; Henshilwood and Marean, 2003; Wadley, 2003). Without reliable radiometric techniques past ~40 ka, it seemed that some MSA assemblages were affiliated with Upper Paleolithic, but produced infinite dates (Sampson, 1974). Australian assemblages were difficult to classify into Paleolithic categories, seemed to lack Upper Paleolithic-like material culture, yet consistently produced dates younger than 40 ka (Habgood and Franklin, 2008). The traditional formulation of the trait-list approach has been recognized to be biased towards technological adaptions in late Pleistocene Europe when anatomically modern humans appear (McBrearty and Brooks, 2000). Technologies outside such conditions would be unlikely to have been adaptive, and therefore there is little reason to anticipate material culture similarities even if they were produced by the same species.

Arguing against a human revolution scenario in Europe, but still relying largely on the trait-list approach, McBrearty and Brooks (2000) argue many of the traits on the traditional list have appearances earlier in the MSA than the ~40 ka ‘revolution’. Gradually accumulating evidence suggesting many traits such as bone tools from central Africa at ~90ka (Brooks et al., 1995), decorated eggshell in southern Africa by ~60 ka, (Texier et al., 2010), >100 km long distance raw material transport in East Africa by 60-77 ka, (Clark et al., 1984), among other innovations had a deeper history and origin within Africa. Additionally, improved dating methods at sites across Africa suggests that modern behavioral innovations appeared in a mosaic fashion and context was critical for their outward expressions. Markers of modernity from trait lists are largely contingent, biased towards European adaptations, and have questionable theoretical underpinnings (Henshilwood and Marean, 2003). Most traits recognized are “neither universal nor eternal” (Nowell, 2010), and researchers need to hone in on what aspects of behavior are essential as well as how to recognize it archaeologically.

The debate about the timing and tempo of behavioral modernity has returned to identifying behavioral and cognitive differences unique to the human lineage. The closest to a consensus of what these traits are, may be in the realm of capacities for symbolic information transmission (but see Hill et al., 2009). Unlike the trait list approach, symbolic behavior is not easily identifiable archaeologically. Henshilwood and Marean (2003) argue that studies of behavioral modernity are better served by shifting focus to evidence for “continuity from presymbolic to symbolic material behavior (p.637)”. Recent discoveries, largely from the southern coast of South Africa, such as worked ochre at PP13B (~162 ka, OSL) have begun to close the gap between the temporal appearance of anatomical and suspected behavioral modernity (Marean et al., 2007). However, evidence for use of ochre, often understood to be associated with symbolic activities, may be pushed back even further. Recent dates of Fauresmith industries at Kathu Pan (~540-470 ka, Porat, et al. 2010) which contain ‘modern’ features such as worked ochre, blades, and unifacial points (Morris and Beaumont, 2004; Herries, 2011) would push behavioral modernity earlier than the earliest anatomical evidence (i.e., the “Earlier Upper Pleistocene model” *sensu* Henshilwood and Marean, 2003) . This would fit well with the evolutionary adage “behavioral change precedes anatomical change” (Washburn and Hamberg, 1965), but it may simply imply that a one-to-one relationship between ochre and symbolic behavior is not warranted (Wadley, 2005) or that infusing behavior with pigment enhanced signals is not reflecting the aspects of behavioral modernity researchers are interested in (Hill et al., 2009).

To side-step such problems of identifying material correlates of symbolism and modernity, Shea (2011a) has attempted to reframe the entire question of modernity towards understanding human capacity for behavioral variability. Recent advances in dating archaeological and fossil material suggest that “capacities for behavioral variability underwriting behavioral modernity… are at least as old as the oldest skeletally modern *H. sapiens* [at 195 ka] (p. 6)”. Shea’s argument has advantages of not being based on any trait-list approach and not tied to arbitrary differences between MSA and LSA records. However, it’s not clear how variable human behavior must be to be considered ‘modern’, and the expression of behavioral variability may be just as contextual dependent as many of the traits in the trait-list approach. Exchanging one poorly defined term (“modernity”) for another (“behavioral variability”) is doubtful to gain many converts (e.g., comments by Conard, Eren, Nowell and others in Shea 2011). As more late Middle Pleistocene assemblages are excavated and better dated, many of the traits thought to represent symbolic capacity and modernity will likely appear even earlier, forcing researchers to better understand paleoenvironmental and demographic contexts of their appearances. Relating derived behavioral traits to these conditions will enable a more complete understanding of uniquely human behavior as well as underlying capacities for behavioral plasticity.

In contrast to the archaeological search for behavioral modernity, researchers approaching human origins from a biological perspective are working to identify aspects of "human uniqueness" that distinguish humans as dramatic outliers compared to all other living biological species (e.g., Bingham, 1999; Hill et al., 2009). Hill et al. (2009) argue that, "the capacity for cumulative culture, creation of social norms, ethnicity, and extensive cooperation between nonkin facilitated by prosocial emotions, along with life-history shifts such as long juvenile period and long life span (p.196)" are fundamental to the human adaptation. Although Hill et al. argue that these behaviors are what "underlies" behavioral modernity, there is a significant difference between the two. Behavioral modernity concepts imply both a temporal component – something can't be modern if there was nothing archaic before it – and a human component in that only modern behaviors are diagnostic of *Homo sapiens* (Chase, 2003). Human uniqueness concepts are more focused on empirical aspects connecting all modern human societies, without necessarily being connected to prehistoric populations or other hominin species. There is no *a priori* reason why Neandertals didn't share many, or all, aspects of human uniqueness; whereas behavioral modernity is predicated on the assumption that there are behaviors only associated with *Homo sapiens* but no other closely related species (Mellars, 2005).

2.5 Conclusion

Modern humans evolved in Africa and the genetic and fossil records point to the time period between 200-150 ka. Archaeologically, this corresponds to the MSA, which begins at least by ~278 ka, and may have its origins much earlier in the Middle Pleistocene. Evidence for modern human behavior, either defined by symbolic material culture, complex technology, or adaptable foraging strategies are present on the south coast of South Africa by ~162 ka. This time period corresponds to a population bottleneck indicated by genetic data, which may suggest a progenitor population that survived on the south coast during this time. Understanding the environments and resources available to early human foragers in this region will enable a more complete picture of the modern human adaption to be developed. In the next chapter, the ecology, geology, and paleoenviornments of the Middle and Late Pleistocene on the south coast of South Africa will be presented. This will provide context for the questions of landscape variation in tool use and discard that this dissertation addresses.

CHAPTER 3 – BACKGROUND: MIDDLE AND LATE PLEISTOCENE ENVIORNMENTS IN SOUTH AFRICA

3.0 Introduction

As discussed in chapter 2, both modern human anatomy and behavioral adaptations evolved during the Middle (781-126 ka) and Late (126-12 ka) Pleistocene in Africa. The genetic record suggests a population bottleneck likely occurred during the Middle Pleistocene (Fagundes et al., 2007), and that the Late Pleistocene population in southern Africa was likely on the lineage leading to all modern humans (Henn et al., 2011; Oppenheimer, 2012), either as the main progenitor population (Founder model), or as one of a few reduced populations (Fragmentation model). This chapter provides the environmental context of modern human origins in southern Africa during the Middle and Late Pleistocene.

In this chapter, the geologic, ecological, and paleoenvironmental background of modern human origins in southern Africa will be presented. Specifically, this dissertation is focused on the south coast in part of the Cape Floral Region - an extremely ancient and speciose vegetation community with unique features for the populations of humans and animals that live in it. Emphasis will be placed on the Pinnacle Point isotopic curve developed by Bar-Matthews et al. (2010) that provides a high-resolution record of rainfall and vegetation on the south coast of South Africa from 90-53 ka. This region sits at the edge of a shallow coastal platform that is sensitive to sea-level changes. Fisher et al. (2010) relate this shifting ancient coastline to the ancient landscape, or paleoscape, of resources available to human populations during this time. The shifting coastline and rainfall patterns influenced the structure and movement of animal communities, and a migration ecosystem may have existed on the coastal platform during periods of lowered sea-levels (Marean 2010). The coastline and vegetation also influenced the availability of stone for tool-making during this time - quartzite is locally abundant on cliffs, but also as cobbles when the coastline is in close proximity. Silcrete is also available as a stone tool making raw material, but requires heat-treating in order to improve its flaking qualities, and heat treatment requires an available source of burning fuel. These pieces are then assembled and the possibility that modern humans near the root of our lineage used the south coast's resources as a refugia during periods of cooler and unstable climatic conditions will be discussed. This provides the paleoenvironmental context that MSA populations were living in and using technology to adapt to. At the end of this chapter, the sites and assemblages that were analyzed to answer questions about modern human behavioral and technological adaptions in this dissertation will be described and situated within the paleoenvironmental contexts for modern human origins.

3.1 South Coast

The environments of South Africa are broadly heterogeneous, and form several natural units based on physical separations between regions by mountain ranges, river systems, and coastlines (Figure 2). Marean, et al. (2014) note that the environment of the greater Cape Floral Region is "heterogeneous geologically" but that "its basic physiographic characteristics are uncomplicated." The Cape Fold Mountains separate the arid Great Karoo from the coast by forming an L-shaped buttress parallel to the south and west. At the base of these mountains, a rolling coastal plain leads to the coastline, and continues underwater for up to 270 km south from Cape Agulhas. The focus here will be

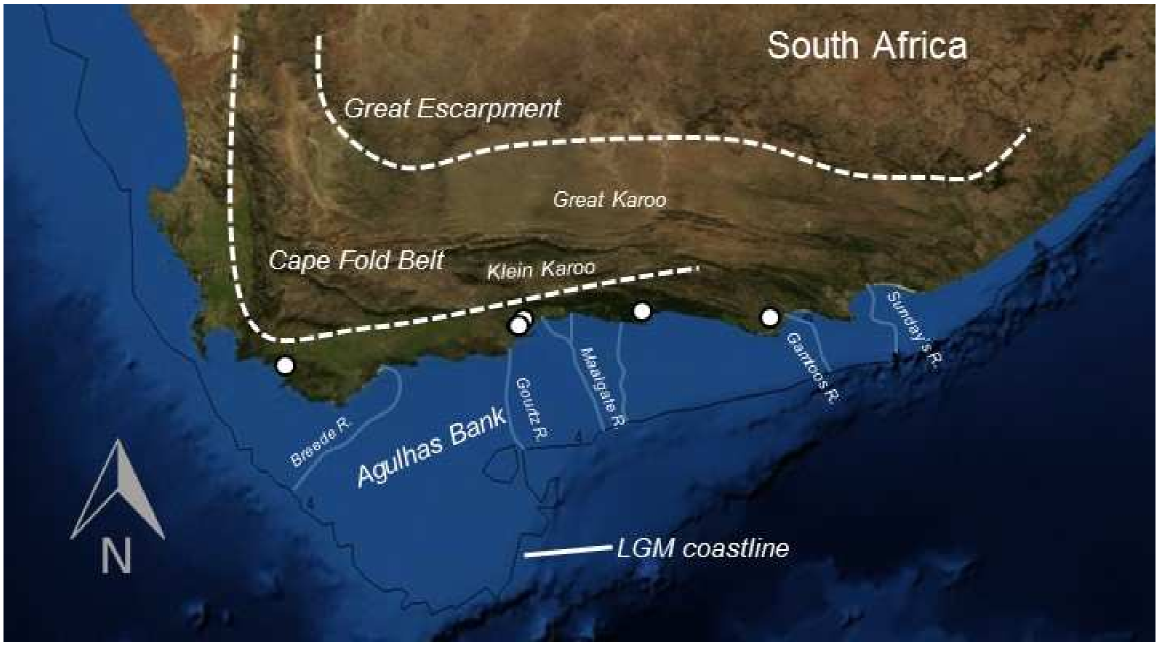

Figure 2. South coast geography. Rivers extrapolated from Compton (2011).

on the south coast, which presents a unique suite of geology, climate, flora, and fauna for understanding MSA behavioral adaptations.

3.1.1 Geology

The south coast geology provides the context for the interface of the human settlement system and their environment. In this section, an overview of the pertinent features of the continental geology formation will be addressed. Rather than a complete overview of the entire CFR geology, this overview will introduce key features unique to the south coast that have immediate bearing on where resources in the MSA were likely located and used. These features are the broad and flat Agulhas Bank that makes the southern coastline sensitive to sea-level fluctuations, the deposition of nutrient poor and rich soils that influence the distribution of plants, and therefore animals, the formation of sea-caves that provide concentrated loci of human behavior, and the availability of raw-materials for stone tool manufacture. This brief overview is intended to provide general

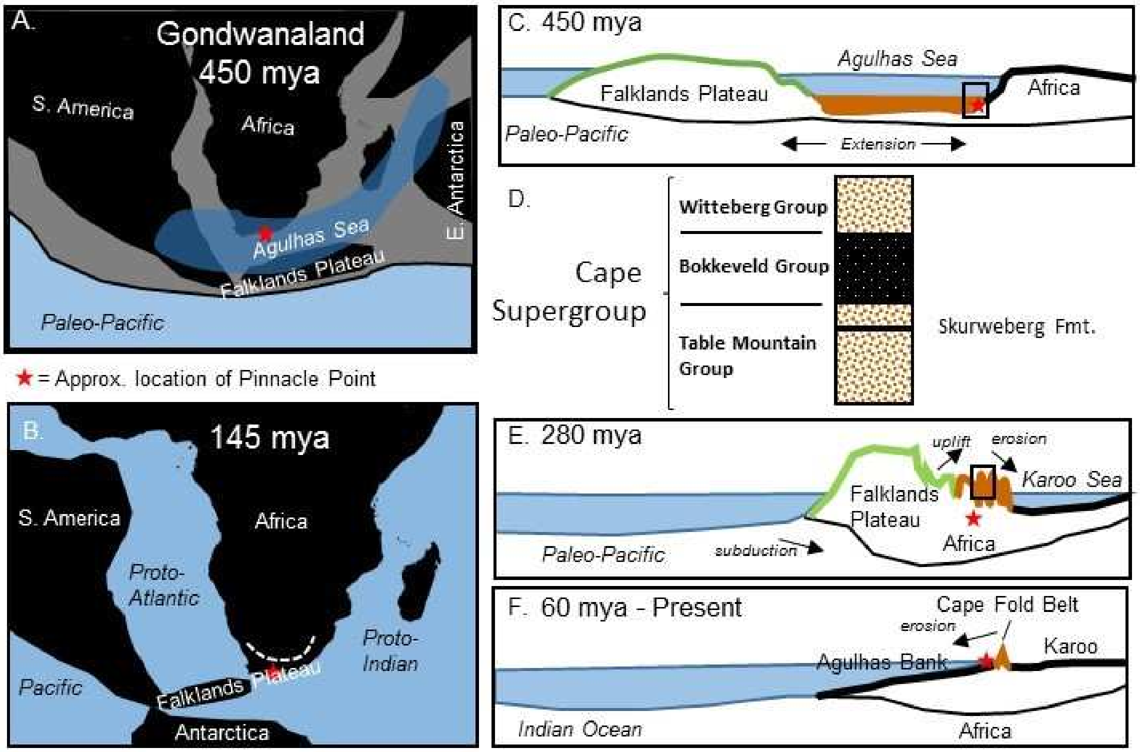

Figure 3. Major geologic events forming modern southern Africa. A) the formation of the Agulhas Sea between the Falklands Plateau, and B) the breakup of Gondwanaland during the Cretaceaous. C) Eroded sediments off the Falklands Plateau accumulated in the Agulhas Sea. D) These consolidated sediments became the Cape Supergroup quartzitic sandstones and shales. E) The Falklands Plateau migrated north and west during the Permian period, and the Cape Supergroup was folded and deformed. F) Erosion sheared several km of sediment from the coastal mountain ranges, and the Falklands Plateau continued migrating west with South America.

to migrate north towards Africa ~280 ma, the Agulhas Sea was closed, and the Cape Supergroup experienced extensive deformation and folding (Newton et al., 2006).

The interior Great Escarpment (Figure 2) formed under southern Gondwana ~180 ma from a mantle plume, which formed an extensive inland swampy sea-floor that accumulated sediment as the Falklands Plateau eroded into the interior Karoo Sea, burying the Cape Supergroup in the process. During the breakup of Gondwana beginning 140 ma, the southern Africa subcontinent was uplifted, and has experienced extensive erosion (>3 km of sheared sediment in areas) ever since (Lindeque et al., 2011). These eroded sediments were drained onto the coastal plane, and the walls of the uplifted Falklands Plateau eroded away from the coastline. In the southern and western Cape, this erosion and uplift uncovered and eroded the Cape Supergroup, leaving only the most resistant quartzitic sandstones as mountain ranges of the Cape Fold Belt, and shales of the Bokkeveld group in valley floors. In contrast to the recent volcanic and rifting activity in East Africa, the basic structure of the South African geography have been in place since the end of the Cretaceous 65 ma.

3.1.1.1 Agulhas Bank

The modern south coast is ~65 km on average from the Cape Fold Mountains (Volman, 1981), but adjacent in some areas (e.g., near Gordon's Bay) and over 80 km elsewhere (e.g., near Cape Agulhas). Between the mountains and the coastline are coastal plains dissected by deep river valleys. This coastal plain extends offshore at a gradual slope, and during periods of lowered sea-levels the coastal plain extends beyond its current location. Even with relatively small sea-level drops, dramatic changes occur, as the currently submerged continental shelf becomes part of the terrestrial coastal plain (Fisher et al., 2010). During maximum glacial periods, some locations that today are on the coastline were more than 200 km from the nearest coast (Fisher et al., 2010). This underwater continental platform forms the Agulhas Bank, which is responsible for many of the unique ocean currents that exist off southern South Africa, including retroflection of warm Indian Ocean water against the cold Antarctic Circumpolar Current, and leakage into the Atlantic. This combination of cold polar water, plus heavy nutrient laden currents makes the south coast one of the most productive marine ecosystems in the world (Parkington, 1977).

3.1.1.2 Soils

The soils which occur in the southern Cape reflect their deep geologic history. Shales laid down in the Bokkeveld Group are present in the valleys where they were protected from erosion and form the most fertile and nutrient rich soils of the region. The surrounding quartzitic sandstones exposed on the hill tops and cliffs form nutrient poor soils. Limestones were deposited on shallow ocean floor adjacent to the Cape Fold Belt and on the Agulhas Plain during periods of high sea-stand, forming the Bredasdorp Formation. Mid and late Pleistocene lithified aeolianites are present as hardened, alkaline calcretes on hill and cliff tops and valley floors. Recent sand dunes cover extensive areas along the current coastline. Large dune structures are also visible in bathymetric data on the Agulhas bank, suggesting dune structures, aeolianites, and vleis (lakes) during glacial phases (Cawthra et al., 2014). The makeup of the soil topography has implications for the distribution of plants in the Cape Region, the animals that consume those plants, and the human populations that exploited these resources that will be discussed below.

3.1.1.3 Sea caves

Caves provide natural catchments for human behavioral traces because they are enclosed spaces that offer environmental protection. In this dissertation, the caves analyzed all formed due to erosion and dissolution by ocean wave action. This includes caves at Die Kelders, Pinnacle Point, and Nelson Bay Cave. Numerous other sea caves are present along the south coast which contain important archaeological sediments from MSA and LSA deposits. Erosion of Table Mountain sandstones (TMS) and Bokkeveld shales by the westerly flowing Agulhas Current produced a series of east-facing half-moon bays between quartzitic and granitic headlands that approximate a log-spiral pattern (Bremner, 1983). Until recently, it was thought that the paucity of ESA artifacts in caves on the south coast was due to the relatively recent age of the caves themselves. Multi-proxy research at Pinnacle Point has demonstrated that sea caves cut into fault breccias of dissected Skurweberg formation quartzites of the Table Mountain Group formed by at least 1.1 mya by a ~20m high-sea stand (Pickering et al., 2013). Similarly, Nelson Bay Cave was formed in breccias that formed between the contact of Table Mountain Group quartzite and younger Early Cretaceous Uitenhage series sandstones that were deposited in the Enon Formation from the erosion of the Karoo supergroup (Butzer, 1973; Lubke and De Moor, 1998). The formation of Die Kelders caves at the contact between the Cape Supergroup and Bredarsdorp group due to dissolution (Tankard and Schweitzer, 1974; Marean et al., 2000b) may suggest an older cave system, however the elevation of DK1 at ~20m is consistent with the 1.1 ma high-sea stand that formed the Pinnacle Point caves and more precise elevation data on the DK1 cave system is needed to be certain (Marean, personal communication).

3.1.1.4 Lithic Raw Materials

Raw materials for stone tool manufacture are an essential component of the foraging economy. As tools wear out, break, and are discarded, tools are repaired or constructed from collected geologic sources. Both primary (*in situ*) and secondary sources are available on the south coast for most raw materials. In the area around Die Kelders, Pinnacle Point, and Nelson Bay Cave, quartzites from the TMS are widely available on coastal cliffs and east-west trending outcrops (Volman, 1981). Quartz veins also occur within seams of TMS. A finer-grained quartzite is also available in the Uitenhage Group of sandstones which occur from the Robberg Peninsula to cliffs near

Pinnacle Point at Cape St. Blaize (Brown, 2011). Quartzite cobbles are available along modern coastal beaches and ancient raised beaches from periods of higher sea-level. Cobbles also occur abundantly in river gravels and conglomerates throughout the southern Cape (Minichillo, 2006). Secondary quartzite is often of higher quality because many of the internal structural flaws are broken by tidal wave action leaving nodules that are relatively homogenous in structure (Thompson and Marean, 2008). With fewer internal flaws, cobbles tend to be more predictable and efficient for knapping, particularly if attention is paid to the internal bedding structure of the cobbles (Brown, 2015).

Silcrete was commonly used by MSA tool makers throughout southern Africa, but is especially common near the south coast. Silcrete is a pedogenic stone formed over a large swath of the Western Cape following the breakup of Gondwana following the Late Cretaceous. Silcrete now occurs in primary context in many regions on the coastal plain (Roberts, 2003), but in larger outcrops ~120-300m asl (Brown, 2011) between Hermanus and Grahamstown (Roberts, 2003). Brown (2011) describes primary sources of silcrete as “globular”, “conglomerate”, or “massive”, with the massive units being the high-quality, finer-grained material. Although originally perceived of as “non-local” and “exotic” raw-material by Singer and Wymer (1982) and Ambrose and Lorenz (1990), Minichillo (2006) showed that silcrete is widely available in secondary sources such as stream and river cobbles, beach cobbles, and alluvial beds associated with the Pleistocene-age Klein Brak Formation conglomerates. Minichillo (2006) suggests silcrete is a local raw-material, but incurred higher search costs rather than transport distance costs to acquire. Adding to the investment required to utilize silcrete is the discovery that most silcrete was heat-treated prior to beginning flaking in the MSA (Brown et al., 2009).

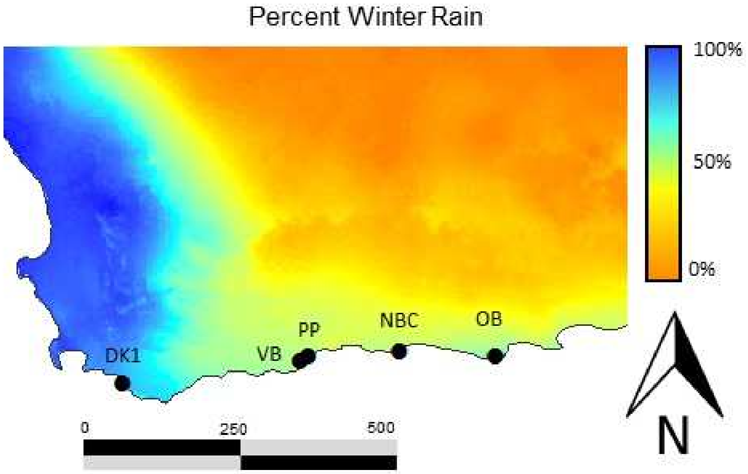

Figure 4. Distribution of Cape Floral Region winter rainfall. Highly seasonal rainfall approaches 100% (blue) winter rain on the west coast, whereas equitable rainfall (yellow) falls on the south, and summer rainfall (orange) towards the east.

3.1.2 Climate

The Cape region of South Africa is generally described as a temperate, dry-summer, or Mediterranean climate (Peel et al., 2007). The south coast currently receives 350-1000 mm of rain annually in a roughly bi-model pattern. Compared to other Mediterranean climate areas and the west coast, the south coast region does not experience regular and severe summer droughts, though summers can be hot and dry and wild fires are common (Cowling and Richardson, 1995). In terms of sites studied in this dissertation, the Pinnacle Point/Vleesbaai region receives the least precipitation (~450 mm) and NBC receives the most (~900 mm) annual rainfall. The average daily temperatures of sites studied here is between 26º C and 7º C (AGIS, 2007), and there is very little variation across sites. Rainfall seasonality is predominantly winter on the west coast, grades into equal contribution on the south coast, and is predominantly summer rainfall in the Eastern Cape (Figure 4). Of the sites included in this dissertation, DK1 has

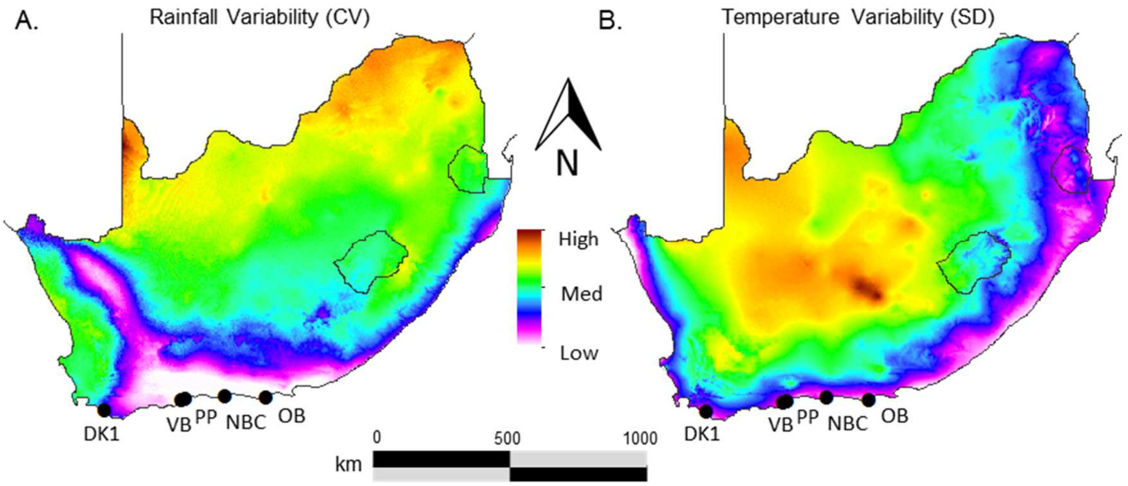

Figure 5. (A) South African rainfall variability as measured by the coefficient of variation for monthly rainfall (B) and temperature variability measured as the monthly standard deviation.

the highest winter rainfall percentage (68%), NBC has the lowest (49%), and Pinnacle Point (50%) and Oyster Bay (65%) fall in between (AGIS, 2007).

In terms of variability, the south coast has the least seasonal rainfall in South Africa (Figure 5A) with a very low coefficient of variation in monthly precipitation and low temperature seasonality (Figure 5B). This stability makes the environment less variable relative to other regions in South Africa, such as in the interior and east coast. Coefficient of variation in rainfall and standard deviation in temperature have been used as proxies for predictability by other researchers as well (Cashdan, 1983; Baker, 2003). The predictable geology, precipitation, and temperature parameters have influenced the origins and evolution of one of the smallest yet most diverse vegetation regimes in the world, the Cape Floristic Region.

3.1.3 Cape Floristic Region

The south coast of South Africa is within the Cape Floristic Region (CFR), a phytogeographic area defined by the spatial extent of significant winter rainfall, strong influence of Cape Fold Mountain geology, and extremely high endemism of plant species and genera (Born et al., 2007). The CFR is sometimes called the South Western Cape, or the Cape Region (Bergh et al., 2014), and is differentiated from the Greater Cape Floristic Region by being more limited in its inclusion of succulents along the west coast and Namaqualand. Within the CFR is the Fynbos Biome, an ecogeographic region that excludes some of the vegetation types commonly found on the south coast such as thicket and renosterveld. In this dissertation, the CFR will be used to denote the similarities in climate, geography, and plant community structures along the southern and western Cape, and the affinities this region would have with the hypothesized environment that would have existed on the exposed Agulhas Bank during periods of lowered sea-level.

There are five main vegetation components of the CFR. The foremost is the *fynbos* vegetation that grows largely on the nutrient-pour quartzite and limestone soils and contributes over 80% of the species to the CFR (Mucina and Rutherford, 2006). Fynbos requires summer drought, recurring fire climax, and low soil-nutrients, and is characterized by the presence of *restioid* plants – a community of shallow-root reeds that quickly absorb water. However, four other types of vegetation communities make up fynbos, including *ericoid* fynbos found in cool, moist environments; tall *proteoid* fynbos (>1.5 m) that prefer low lying areas with deep soils; *dry fynbos* found in low-water retaining soils; and *grassy* fynbos largely in the summer rainfall areas of the Eastern Cape consisting of sub-tropical grasses and shrubs.

The other vegetation types of the CFR include *Renosterveld*, which is typically found on higher nutrient quality shale soils from the Bokkeveld Formation in winter or bimodal rainfall zones. Renosterveld likely supported a range of gregarious ungulate taxa (possibly including Rhinoceros, Cowling and Richardson, 1995), but much of this vegetation was quickly supplanted by agriculture historically due to the higher nutrient quality of the soil it lived on. Renosterveld tends to occur in regions that receive 300-600 mm of annual rainfall (Cowling and Richardson, 1995). *Albany thicket* (or subtropical thicket, *thicket*), is frequently found in fire protected areas with bimodal rainfall, which supports large browsing fauna (e.g., elephant, Potts et al., 2013). Thicket consists of dense, interlocking shrubs, typically in nutrient-rich soils, and between 300-800 mm of precipitation (Cowling and Richardson, 1995). Below 300 mm of rainfall, thicket transitions into *succulent karoo*. These thick, water-retaining plants with tough skins are sparse, and although found in winter-rainfall regions with low precipitation, are not prone to fire due to their sparse ground cover (Cowling and Richardson, 1995). Above 800 mm of precipitation, thicket transitions into *afromontane forests*. These forested plant communities require protection from fires, deep soils, and typically occur at elevations below 1000 m (Cowling and Richardson, 1995). Along the coast, thicket transitions into *strandveld*, generally located on alkaline sandy stabilized dune soils and limestones. The definition of strandveld is somewhat ambiguous (Bergh et al., 2014), as it has affinities with the succulent karoo in the north and thicket to the east. Bergh et al. (2014) suggest that strandveld may best be thought of as a coastal link between the succulent karoo and thicket in the CFR.

The south coast also sees a transition in the carbon-pathways found in the grasses that form the CFR. Specifically, fynbos grasses in the west are C_3 pathway, while the grassy fynbos of the Eastern Cape are tropical C_4 (Bar-Matthews et al., 2010). The summer-winter rainfall gradient shown in Figure 4 also corresponds to the overall distribution of carbon-pathways found in the grass communities – with C_3 vegetation more common in the winter rainfall zones and tropical C_4 grasses in the summer rainfall zones (Vogel et al., 1978). Currently near Pinnacle Point, C_3 limestone fynbos occurs, but further inland C_4 grasses occur in succulent karoo (although grasses are rare), and a mix of C_3 and C_4 can be found in thicket vegetation (Huntley et al., 2014) along the south coast.

Historically, large herbivores avoided the nutrient poor sandstones, limestone, and sand fynbos regions. Mostly small bodied browsers and mixed-feeders (e.g., bushbuck, grysbok, duiker) would be able to take advantage of the low-nutrient plants in fynbos (Skead, 2011). In contrast, the extensive shrublands with grasses dominated by low asteraceous shrubs that form renosterveld and dry fynbos vegetation supported a higher biomass, and accordingly, a greater number of large grazing herbivores (Skead, 2011). Thicket provides high-quality habitats for many large bodied browsing animals, including elephants. The largest aggregations of migratory mammals historically occurred in the succulent karoo, where there are accounts of ‘trekbok’ migrations of springbok in search of water and forage over long distances (Skead, 2011). Using data from Marean et al. (2014) and Bar-Matthews et al. (2010), a summary table is provided in Table 1 indicating the general characteristics of each vegetation community.

Table 1. Vegetation characteristics in the CFR, from Marean et al. (2014) and Bar-Matthews et al. (2010).

Vegetation	Community	Soil	Precip.	Altitude	Rainfall season	Large animals (70 kg+)	Small animals (0-70 kg)
Fynbos	Restioid	Varied, shallow	100-350 or 1400-1600	Variable	Winter/Bimodal	Low diversity and low density, non-migratory, mostly browsing	High diversity, low density, mostly browsing
Fynbos	Ericoid	Quartzitic, acidic humic	1500-2000	1500-2000	Winter		
Fynbos	Proteoid	Quartzitic, deep	600-1000	0-1000	Winter/Bimodal		
Fynbos	Dry/Asteraceous	Calcareous, shallow	100-800	Variable	Winter/Bimodal		
Fynbos	Grassy	Quartzites and Shale	600-800	0-200	Summer		
Strandveld	South Coast	Aeolian Dune, varied	200-500	0-200	Winter/Bimodal	Low density, low diversity, mostly browsers	high diversity, low density
Renosterveld		Shale	250-600	0-200	Winter/Bimodal	Moderate density and diversity, some grazing	high diversity and moderate density
Thicket	Dune	Calcretes and Aeolianites	900-1500	0-200	Bimodal	High density of browsers, diversity of very large taxa	Moderate diversity, high density

Thicket	Valley	Fine-grained soil	300-650	0-200	Bimodal		
Thicket	Arid	Fine-grained soil	200-300	0-400	Bimodal		
Thicket	Thicket	Fine-grained soil	500-800	400-1000	Bimodal		
Succulent Karoo		Varied, shallow	20-300	0-1500	Winter	Low density and low diversity, migratory	High diversity and high density

3.1.4 Agulhas Plain

During phases of lowered sea-levels, the south coast expanded as the currently-submerged continental platform, the Agulhas Bank, became a large terrestrial plain colonized by plants, animals, and human populations (Van Andel, 1989). South of Agulhas, this Plain would extend 270 km across, narrowing to <10 km near Cape Point and < 5km east of the Sunday's River mouth. The geology of the Agulhas Bank largely reflects the inland-geology. Compton (2011) describes a series of barriers across the exposed Agulhas Plain that are extensions of the inland geology. Rocky cliffs and hilltops extend from the west near Cape Town, and this area would consist of a quartzitic sandstone coastal plain and ancient Cape Granites. Marean et al. (2014) argue the plain would be largely featureless due to coastal transgression plaining off the tops of topographic features. The bedrock geology consists of granites to the west, and sandstone, limestone, and shales moving east. During sea-level transgression and regression, erosion and drainage cutting would remove the softer material, leaving large rivers meandering through shallow valleys with alluvium cliffs and large dune cordons. Closer to the coastline, aeolianite barriers and cordon dunes visible in offshore seismic profiling indicate extensive dune fields that may have contained shallow lakes and river drainages (Cawthra et al., 2014).

3.1.5 Paleoclimate and Paleoecology

The earth's climate has oscillated between cold glacial and warm interglacial periods since the end of the Miocene (5 mya). The off-center tilt of the earth's axis (obliquity), the elliptical shape of its orbit (eccentricity), and shifting orbital axis (precession) produce a combined effect at regular time intervals, known as Milankovic

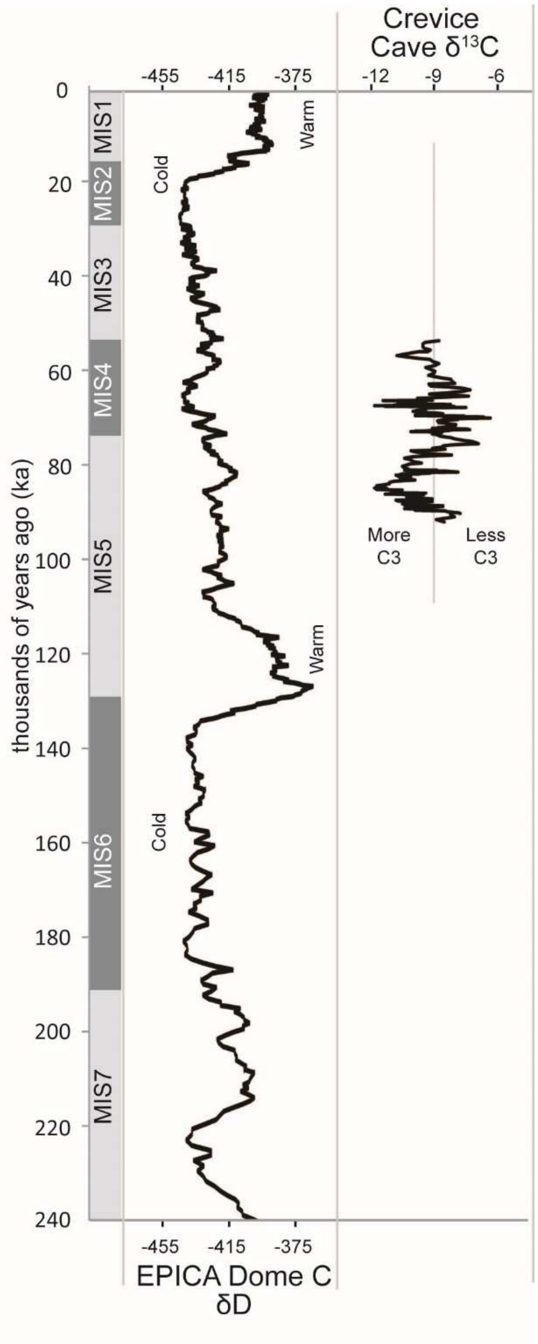

Figure 6. Antarctic ice-core and Pinnacle Point speleothem curves.

Cycles, which forces climatic changes (House et al., 1995). Figure 6 shows the Antarctic (EPICA) ice-core record of climate change for the last 240 ka (Augustin et al., 2004). This period spans seven stages of glacial-interglacial fluctuations, but even within "glacial phases" (even numbered Marine Isotope Stages, or MIS) there is substantial variation and abrupt warming trends occur. MIS1 is the current warm, Holocene interglacial environment that the world has been in for the past 14 ka and is associated with the origins of domestication and agriculture. MIS2 includes the last glacial maximum (22.5 ka), but the cooling period began earlier, around 29 ka. MIS3 is a cool but stable period that began ~57 ka, and is the period when the earliest LSA sites occur, when modern humans spread across the globe to Australia, and when the extinction of Neandertals and possibly the Denisovans occurred (as discussed in Chapter 2). MIS4 begins 71 ka and spans the duration of the Still Bay and HP industries. Global climate records indicate cool and highly variable temperature fluctuations during this time (Jouzel et al., 2007), and the onset may have been amplified by the eruption of the Toba super volcano in Indonesia (Zielinski et al., 1996). Reconstructions for southern Africa during MIS4 are frequently described as cooler and either drier (Klein, 1983) or wetter than today (Chase, 2010); however, few terrestrial paleoenvironmental proxy data exist from this time period (Marean et al., 2014). The warm and wet global conditions in the MIS5 interglacial began ~123 ka, when sea-levels were ~5m higher than today. A dramatic increase in the number of MSA archaeological sites occurs in MIS5, but it is not yet known if this is due to populations being forced to stay along the modern coastline (as opposed to out on the Agulhas Plain and now under water), prior occupations in low-lying sea-caves being scoured out from the high-sea stand, or a true population increase. MIS6 began 195 ka and corresponds with the earliest fossil skeletons of modern humans in East Africa. MIS6 was particularly cold and long-lasting (Petit et al., 1999), which may explain the dearth of MSA sites prior to MIS5 (Lahr and Foley, 1998; Marean, 2010b; c.f. Wurz, 2013), however many of these sites could now be submerged under the ocean. There is very little dated evidence of human occupation in the CFR between MIS6 and the latest occupation by Acheulean-technology using hominins >500 ka.

As has been discussed, the environment of the south coast CFR is highly varied, and includes mountains, valleys, and plains, and coastal and inland environments. The vegetation is intimately tied to the physical environment and the patterns of precipitation that are driven by ocean circulation (Bradshaw and Cowling, 2014). Climatic fluctuations during the Pleistocene magnified already heterogeneous environments by creating geographic barriers, coupled with variable rainfall and temperature changes (Carto et al., 2009). The global climate record indicates that during glacial phases the African continent tended to be cooler and largely drier, though it appears that much of the Western Cape was actually wetter than today (Adams and Faure, 1997; Chase and Meadows, 2007). The speleothem oxygen and carbon isotope curve at Pinnacle Point provides a continuous record of predominant vegetation regime (C_3-C_4) and season of rainfall (O^{18}) from 90 ka – 53 ka (Bar-Matthews et al., 2010; unpublished). This record indicates that summer rain and C_4 plants are positively linked with each other, but negatively correlated with global proxies of temperature. During cooler climates such as MIS4 and early MIS3, an increase in summer rainfall and an increased presence of C_4 grasses (although succulent karoo and thicket plants have C_4 and CAM carbon pathways) occurred on the south coast (Marean et al., 2014). The presence of C_4 vegetation on the south coast suggests an expansion from their current distribution largely in the Eastern Cape out onto the Agulhas Bank.

The inferred C_4 grassland on the exposed Agulhas Bank during glacial phases corresponds with Klein's (1983) observations of numerous grazing taxa present in the fossil assemblages at Klasies River and Nelson Bay Cave during glacial phases, corroborated by the presence of Cape buffalo, wildebeest, and hartebeest at PP13B (Rector and Reed, 2010). Rector and Verrelli (2010) analyze the trophic composition of faunal assemblages on the west and south coasts and argue that there are no significant changes through glacial-interglacial phases in the proportions of grazers vs. browsers in the CFR from MIS6 to present. However, given biases in skeletal part transport, the skulls and mandibles of larger animals are less likely to be transported to the cave sites (Schoville and Otárola-Castillo, 2014) analyzed by Rector and Verrelli (2010). Since the majority of small, completely transported (size 2-3) prey are grazers (13/17, 76%), there may be a methodological bias against detecting compositional change. Using the presence of indicator species such as springbok and wildebeest, Marean (2010b) argues a grassland and shrubland interface at the junction of the current quartzitic cliffs and the Paleo-Agulhas Plain around Pinnacle Point during glacial phases is likely. These taxa in particular are consistent with an extinct grazing ecosystem, possibly moving from the east during the summer to the west during the winter (Figure 9) to capture seasonal precipitation and plant growth (Marean, 2010b).

3.2 South Coast in Context

3.2.1 Cape Refugium

The Cape Floral Kingdom is unique among the six floristic kingdoms in the world for the high abundance of endemic plant species that occur in a very small area (Cowling and Richardson, 1995). High endemism and high diversity are characteristics of a biological *refuge* (Linder, 2001), and identifying Pleistocene refugia and conserving them is a concern of biologists worldwide (Mittermeier et al., 2011; Keppel et al., 2012). While the CFR has long been identified as a biodiversity ‘hotspot’, archaeology is providing evidence of the role the south coast has played for human populations during periods of climatic change (Marean, 2010a). The south coast presents a unique environment for human foraging. The warm, nutrient waters from the Agulhas current meet cold Atlantic upwelling to create the most productive coastline in Africa in terms of species diversity (the west coast has higher biomass). Shellfish, seals, fish, penguins, and whale wash-ups are available on the coastline – given the knowledge of when and how to exploit them (Marean, 2011). The diverse Fynbos Biome has an array of seasonably edible plants, including those with carbohydrate-rich underground storage organs. Marean (2010b) argues this combination of geophytes and regularly accessible protein would provide a stable, reliable, and productive resource base for human populations on the south coast during the Middle Pleistocene. The evidence for the exploitation of shellfish from PP13B at 162 ka, a period of extreme aridity elsewhere in Africa (Lahr and Foley, 1998), suggests that humans had knowledge of how to exploit the intertidal regions. The complex archaeological record on the south coast shortly thereafter suggests that human populations had an expanded behavioral repertoire that included using ochre pigments (Henshilwood et al., 2009; Henshilwood et al., 2011), bone tools (Henshilwood et al., 2001), shell beads (d'Errico et al., 2005), “beauty” shells (Jerardino and Marean, 2010), decorated ostrich eggshell and ostrich eggshell flasks (Texier et al., 2010), and stone heat-treatment technology (Brown et al., 2009). At PP13B, occupation intensity is related to the appearance of coastal use; when the coastline is near Pinnacle Point site intensity was greater than when it was further away (Marean, 2010b). This is supported by the record further inland at Boomplaas Cave (Klein, 1978; Faith, 2011b) where site occupation was sparse until after the LGM, suggesting humans were following the coastline out as sea-levels dropped. However, the lack of volumetric data coupled with radiometric dates from this time period makes this hypothesis difficult to test at present. Given the dynamic relationship between site occupation, sea-level, and the resources available to human foragers, controlling site context during MSA occupation is critical for understanding landscape scale human behavior. Therefore, the environmental and temporal context for each site studied in this dissertation will be presented in the following section.

3.3 Overview of MSA Study Sites

This dissertation is aimed at identifying and explaining patterns of behavioral and taphonomic tool edge damage in the southern African MSA. As has been discussed, this region has evidence for complex behavior, a rich archaeological record, and relative to most other areas in Africa, a well-studied paleoenvironmental context. The MSA assemblages studied for this dissertation (Figure 7) each contribute valuable context to our understanding of how MSA foragers structured their behaviors on the landscape, either through the site context sampled (coastal, interior, cave, open-air) or by the time period sampled (MIS 6 – 3). At sites where luminescence dating has occurred, only the approximate mean-age will be provided (e.g., "~95 ka"), but it should be noted that these are each associated with an error range not always included for brevity and clarity. For each assemblage, a single numerical value for the age is provided, but in many cases this is extremely speculative and is only provided here so that the assemblages can be placed in an approximate temporal order in later chapters. These ages should not be considered

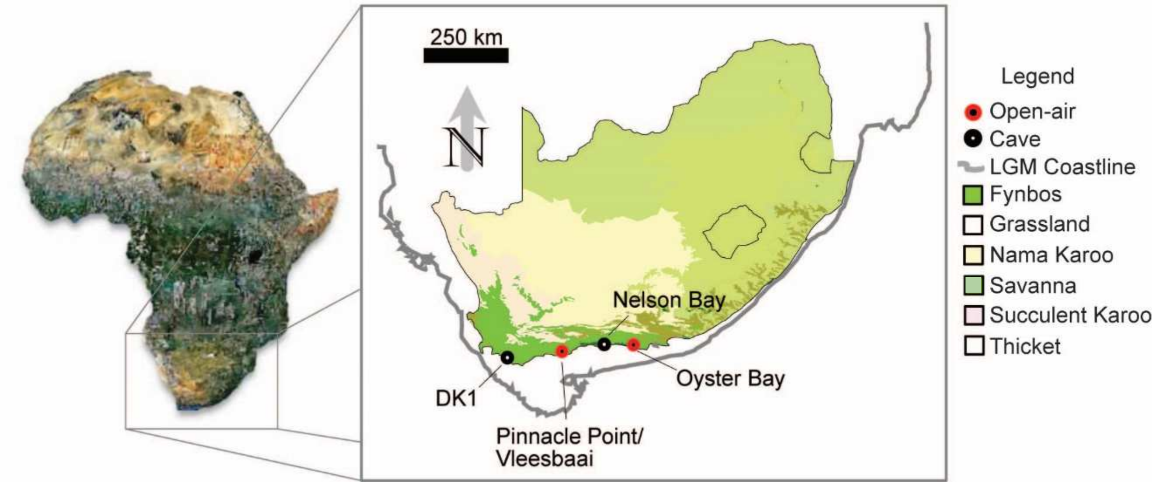

Figure 7. Location of sites analyzed in this dissertation and major vegetation biome relative to current coastline and LGM coastline.

the ‘true-age’, but are simply based on an age-model developed in this dissertation and subject to further refinement with additional dating and field work in the future.

3.3.1 Pinnacle Point

Pinnacle Point is located on the south coast of South Africa near the town of Mossel Bay (Figure 8). Kaplan (1997) surveyed the coastline along Pinnacle Point prior to the development of a golf course and identified 15 coastal caves and rockshelters with archaeological deposits. These caves are eroded into the quartzitic headland of the exposed Skurweberg formation of the Table Mountain Sandstone Group (Marean et al., 2004). Recent multi-proxy dating methods have shown that the caves formed at least 1.1 ma (Pickering et al., 2013). The caves were sequentially numbered from east to west, and excavations at three of these caves have recovered an extremely well-dated sequence of MSA occupation from 164-90 ka at PP13B, 90-50 ka at PP5-6, and two ephemeral occupations between 130 and 120 ka at PP9 (Matthews et al., 2011). Excavation methods are described elsewhere (Marean et al., 2004; Dibble et al., 2007), but the important aspects will be reiterated here. Excavation units are nested such that a “stratigraphic unit” (=StratUnit) composes the most discreet homogenous sedimentary lens, which are aggregated into “sub-aggregates” (=SubAgg) of similar composition, which are then grouped into “stratigraphic aggregates” (=StratAgg) of largely similar depositional geology. All visible artifacts are piece-plotted during excavation using a total station and a barcode scanner to record specimen number and provenience information. All excavated material was wet-screened through a nested 10-3-1.0 mm sieve, and sorted in a nearby laboratory.

Excavations at PP13B occurred in three areas (Marean et al., 2010), towards the front of the cave (Eastern Area), the back of the cave (Western Area), and 'lightly cemented MSA' (LC-MSA) deposits along the cave wall (see Marean et al., 2010:Fig 3 for abbreviations). The Western Area contains deposits that date to three general occupation times based on single-grain OSL techniques (Jacobs, 2010): ~95 ka (LB/DB Sand 1-3), ~123 ka (LBG Sand Middle), and ~160 ka (LBG Sands 2-4). The Eastern area contains two slightly younger occupation deposits, ~95 ka (SB Sand) and ~110 ka (LRSpall). The LC-MSA contains two occupation deposits, the Upper LC-MSA dates to ~120 ka, and the Lower LC-MSA which dates to ~162 ka. The excavations at PP13B were targeted in order to achieve a systematic sample of poorly preserved deposits, therefore overall sample sizes are relatively small. For purposes of this dissertation, these deposits were grouped into those which have been dated to MIS6 (191-130 ka, centered at ~160 ka) and those dated to MIS 5 (129-72, centered at ~95 ka). These same groupings were used by Thompson (2010b, a) for zooarchaeological analysis of the PP13B fauna, allowing for comparisons between edge damage and faunal exploitation to be made (Chapter 7). Very little systematic patterning is evident in the stone tools from PP13B – the production of large points, blades, and flakes on quartzite (79% of all tools), typically cobbles, is predominant (Thompson et al., 2010).

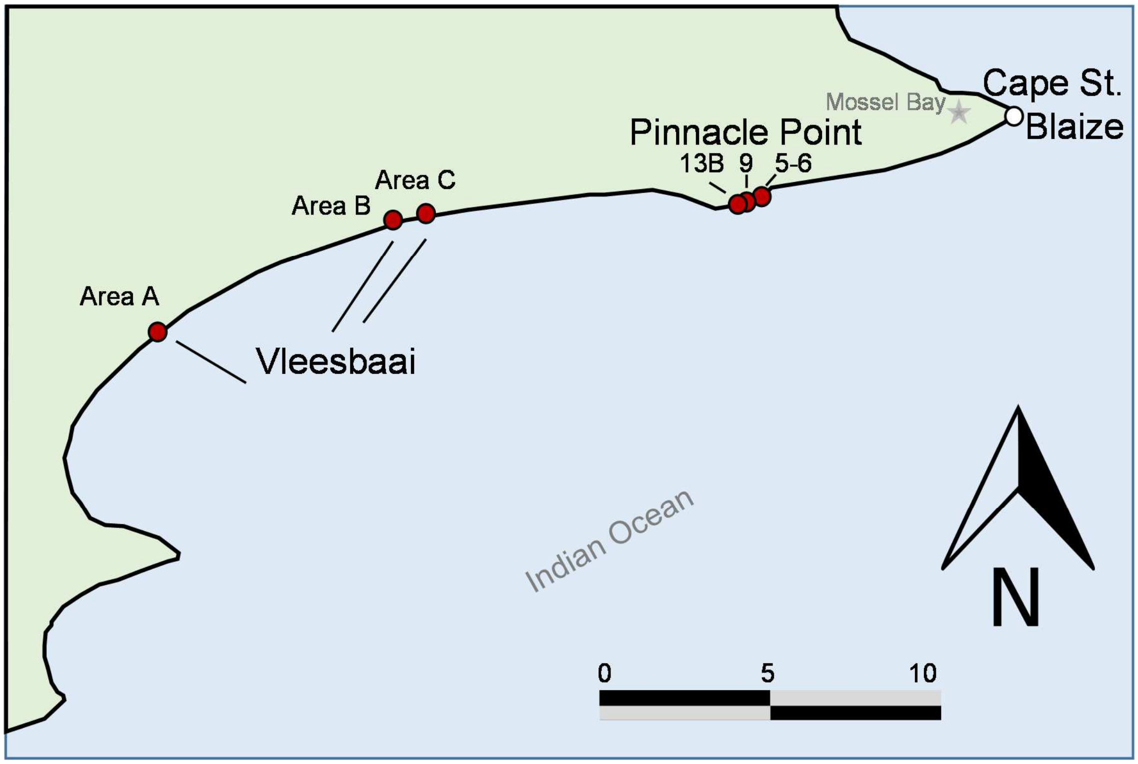

Figure 8. Location of Pinnacle Point Caves PP13B, PP9, and PP5-6 and Vleesbaai localities on the south coast of South Africa.

Excavations at PP5-6 are still ongoing, but have documented a nearly continuous sequence of occupation ~14m in vertical thickness that consists of 11 major StratAggs and over 300,000 individual plotted finds. PP5-6 has also been dated by more than 65 single-grain OSL ages (Karkanas et al., 2015), which provides a detailed chronology of site occupation. As described by Karkanas et al. (2015), at the base of the assemblage is the nearly sterile YBS, which is an Aeolian dune that is likely equivalent to the dune that seals PP13B. This transitions to the YBSR (~89 ka), a unique early silcrete dominant occupation. Above is the LBSR (~81 ka), a predominantly quartzite assemblage with occasional lenses of quartz or silcrete dominant raw materials. Just above the LBSR is the ALBS (~72 ka) and SADBS (~71 ka) where the earliest backed blades in the assemblage have been identified. Above these are the OBS 1 (~69 ka), the SGS (~64 ka), OBS 2 (~63 ka), and DBCS (~61 ka). The DBCS (and probably the OBS2 and SGS) are identified as the formal HP at PP5-6 (Wilkins et al., 2014), and the shape and size of the backed pieces are consistent with HP artifacts at other sites (Brown et al., 2012). Above these layers are the BCSR and RBSR with mean ages of 52 and 51 ka, respectively (Karkanas et al., 2015).

Cave PP9 was excavated in 2006 in two chambers, 9B, and 9C. The MSA occupation in PP9 seems to have been light, and the assemblage is small, possibly reflecting a few brief occupations. However, there are a fairly large number of points and blades compared to cores. Three OSL ages between 130 and 120 ka suggest an ~MIS5 occupation (Matthews et al., 2011), but the ages are largely overlapping and Matthews et al. suspect the micromammal assemblage may straddle the boundary between MIS6 and MIS5. For the purposes of this dissertation, the youngest age will be used (~120 ka) because the overall sandy deposits and mammal remains are more suggestive of coastal occupation, but this should be considered as a minimum age for the occupation of PP9.

3.3.2 Vleesbaai

Vleesbaai (VB) is located west of Pinnacle Point on a half-moon bay between the Mossel Bay and Fransmanhoek headlands. VB contains a widespread series of red paleosols with surface exposures of MSA artifacts that have been researched by the SACP4 project since 2005. The sequence appears to span ~120-50 ka based on the formation of dune field and aeolianites that have been dated elsewhere (Bateman et al., 2004) and thus provides a good sequence overlap to the PP sequence, and together the two provide a sample of cave/rockshelter and open-air locations close enough to be within the same daily foraging radius of a hunter-gatherer band (~7 km apart, Figure 8).

Extensive in-field artifact coding and edge damage analysis have documented three areas, A-C, of which two appear to have HP or earlier microlithic affiliations including four backed blades and a notched blade all on fine grained, heat-treated silcrete (Oestmo et al., 2014). At least one of the paleosols has a *preliminary* OSL age of ~53 ka (Oestmo et al., 2015), but the dating and sequence is still undergoing analysis. This age is consistent with the presence of the HP backed pieces, and will be used as a general estimate for the occupation of Vleesbaai in this dissertation.

3.3.3 Die Kelders Cave 1

Die Kelders Cave 1 (DK1) is located 160km southeast of Cape Town in the coastal town of Die Kelders. Excavations at DK1 were initiated by Schweitzer in the early 1970s targeting the extensive LSA deposits (e.g., Schweitzer, 1970, 1974). In the early 1990s, research resumed at the site under G. Avery, C. Marean, and F. Grine in order to expand the MSA artifact collection, explore the paleoenvironmental context of the cave sequence, and understand the geologic contexts. While the absolute dating of the full DK1 sequence is still not fully known, it is arguably close to 70 ± 10 ka (Feathers and Bush, 2000; Schwarcz and Rink, 2000). Grine et al. (1991) report the MSA lithic assemblage from the Schweitzer excavations and note a dramatic increase in the frequency of fine-grained raw materials (silcrete) in Layer 9-12, while also indicating that the assemblage is not typologically linked to the HP or SB. Subsequent analysis by Thackeray (2000) and Brown (1999) confirmed the raw-material shift from quartzite (layers 6-8) to high frequency silcrete layers (beginning in layers 9-11, but culminating in layer 12), and then back to quartzite predominant raw material in layers 13-15. Retouch at DK1 is low (less than 3.5%) and no backed tools have yet to be identified, even within layer 12 (high silcrete layer). MSA layers 6 - 9 have abundant marine mammals and shell (in micromorphology), whereas Layers 10 - 16 have no evidence for marine shells and very few marine vertebrates, and may have been deposited during a period of lowered sea-level (Goldberg, 2000:Table 3; Klein and Cruz-Uribe, 2000). For the purposes of this dissertation, two occupation aggregates will be used for DK1 – layers 6-9 as a coastal occupation (~68 ka); and layers 10-16 as an interior occupation with a date centered within the ESR date (~75 ka). These age estimates are highly speculative and are subject to change, but serve as a starting point for this analysis.

3.3.4 Nelson Bay Cave

Nelson Bay Cave (NBC) is located on the south side of the Robberg peninsula on the south coast of South Africa near Plettenburg Bay, and contains a well-studied LSA sequence, and an MSA component including HP and pre-HP MSA industries (Volman, 1981). NBC was excavated by Inskeep in 1965 and by Klein between 1970-1971 (Klein, 1972). The stratigraphy at Nelson Bay Cave was excavated in spits of 5-10 cm that followed natural stratigraphic bedding planes. The top of the MSA starts at a "crust", and goes down to Level 10 (or "Spit 10"). The HP is reported by Volman to be in the crust through level 6, then level 7 is a mixture of HP and MSA II, level 8 is MSA II, and levels 9 and 10 are MSA I. Volman (1981) reports a high frequency of quartzite throughout the sequence, with an increased proportion of silcrete, quartz, and chalcedony in the HP layers. The cores at NBC appear to be highly reduced, and there are fewer cortical flakes through the sequence than other MSA localities (Volman, 1981). Two layers were analyzed for edge damage in this dissertation – Layer 6 (HP) and Layer 10 (MSA I). As at DK1, the dating at NBC is approximate. The MSA component has not been dated, but if the HP is analogous to the widespread dating efforts by Jacobs et al. (2008), the crust through Level 6 may date to ~65-60 ka. Although speculative, the high frequency of quartz in the PP5-6 SGS may have similarities with NBC Layer 6, placing the occupation at ~64 ka.

Layer 10 analyzed in this dissertation is more difficult to place in temporal context. There are no faunal remains from the MSA layers to correlate with environmental context (Klein, 1972), and the ~10m height of the cave mouth (Deacon, 1978) would make any deposit older than ~120 ka susceptible to being washed out during the MIS5e high sea-stand. The paucity of silcrete in Layer 10 may also imply that the occupation pre-dates the increase to silcrete noted at other south coast sites (e.g., at PP5-6 and KRM). Therefore, the MSA deposit at NBC in layer 10 is likely constrained between ~120-80 ka (a centered estimate of ~100 ka is used here). But again, these dates are highly speculative and only serve as a starting point in this analysis until additional work refines the ages.

3.3.5 Oyster Bay

Oyster Bay (OB) is located 10 km west of St. Francis Bay on the south coast of South Africa. Artifacts and fossils on the surface of an exposed paleosol were collected by J. Brink and J. Binneman in 1993. The random sample of artifacts has been only briefly described, although the fossil coprolites and pollen have been published (Carrion et al., 2000). The site is suggested to be affiliated with the HP due to the presence of backed, crescent shaped blades (Carrion et al., 2000), but unifacial and bifacial points are also present (personal observation). Based on pollen (*Stoebe*/*Elytropappus* type), similar to grasslands surrounding Boomplaas cave (Cowling et al., 1997:73) and vertebrate mammals (zebra and buffalo) located within the paleosol, the environment is reconstructed as being much more inland grassland than present – consistent with lower sea-levels during the HP. Given these observations, an age towards the beginning of the HP when sea-level was at its lowest (Fisher et al., 2010) is tentatively assigned to Oyster Bay (~65 ka), but again this is highly speculative and subject to future dating results.

3.3.6 Inferring Site Context

In this dissertation, a distinction of environmental context and proximity to available coastal and interior resources during site occupation is made so that variability in technological adaptations on the landscape may be understood (Table 3). As previously discussed, the seven sites studied in this dissertation are currently on the coast, but at various points in the past were located more interior. Therefore, a distinction will be made between archaeological site occupation that was *paleocoastal* and *paleointerior*. The environments around paleocoastal sites will be assumed to be similar, but not identical to the modern *neocoastal* site context. For sites with secure OSL ages, the paleocoastline model developed by Fisher et al. (2010) will be used to classify site

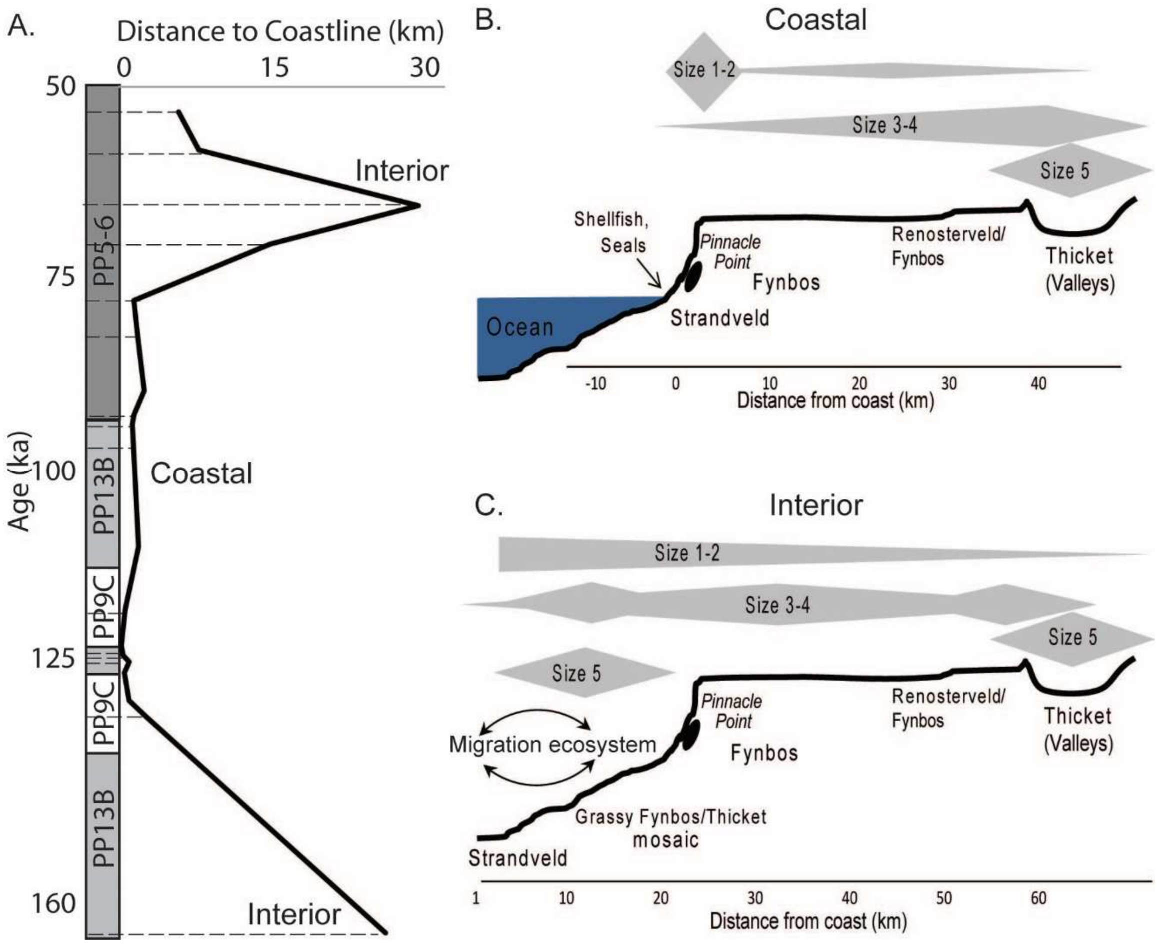

Figure 9. Schematic of the south coast landscape, (A) relating age with coastline, also see Table 3. (B) During interglacial periods, paleocoastal sites are within the foraging range of coastal resources and small terrestrial mammals. (C) During glacial phases, paleointerior caves allow foraging at the intersection of the migration ecosystem on the Agulhas Plain, as well as interior large mammals. Elevation change exaggerated to demonstrate effect of lowered sea-level, actual Agulhas plain would be flat.

context. Paleocoastal sites are those estimated to be located within the average modern hunter-gatherer daily foraging radius (~12 km) of the coastline (Marlowe, 2005). Paleointerior sites are positioned further than 12 km from the paleocoastline. For sites without secure OSL ages linked to a modeled paleocoastline distance, classifications are made based on the presence/absence of marine resources and the presence/absence of terrestrial mammals often found near coastlines or coastal vegetation.

It is anticipated that site context within the paleoscape during occupation will strongly influence the technological needs and therefore how tools were utilized and discarded on the landscape (Figure 9), but it must be stressed that the coastal/interior designation is a heuristic tool in order to evaluate the relationship between changing site context and stone tool use in the MSA. Unfortunately, there is not perfect agreement between the paleoscape coastline distance and the faunal assemblage (particularly shellfish) that would be expected. For instance, the SGS layer at PP5-6 has a mean OSL age of 64 ± 3 ka and a mean paleocoastline distance of 20.7 km, but the layer is named "shelly gray sand" due to the high amount of shell present, which is unexpected for a cave located that far from the coast. Similarly, taphonomic processes are known to have removed shell remains from archaeological deposits, particularly at DK1 (Goldberg, 2000). This could lead to misassigned layers as interior contexts based on the perceived "absence" of shell remains. Despite these caveats, the paleocontext designations made in this dissertations serve as a starting point for the investigation of the influence of environment on MSA technology and landscape use. Future work refining the paleoscape coastline distance model as well as faunal and shellfish analyses of the analyzed assemblages will improve upon the analyses and results presented in this dissertation (Table 3).

Paleocoastal assemblages on the south coast would have access to many of the plants and animals available around the site locations today, plus several additional extinct species. The percentage of main habitat types within 12 km of each site's neocoastal context is shown in Table 2. The predominant vegetation around each site consists of fynbos vegetation, currently. Thicket only occurs around the open-air sites, Vleesbaai (6.4%) and Oyster Bay (6.8%), while strandveld mainly occurs around the caves. Coastal protein resources such as shellfish, washed up seals and whales, would have been available at paleocoastal sites, however terrestrial animals would have been more limited to small bodied prey such as tortoises, dune mole-rats, and smaller ungulates such as grysbok and steenbok.

Table 2. Terrestrial vegetation within 12km radius of sites in this study under modern conditions.

Environment	DK1	VB	PP	NBC	OB
Fynbos	52%	69%	56%	80%	38%
Renosterveld	-	17%	9%	-	35%
Thicket	-	6%	-	-	7%
Strandveld	44%	2%	30%	-	17%
Forest	2%	-	-	15%	1%
Other	2%	6%	5%	4%	3%
Ocean	45%	32%	34%	57%	26%

The paleointerior site context, in contrast, would have a broad array of large bodied terrestrial fauna available nearby, but coastal resources would be less available. Thompson's (2010a) analysis of the PP13B archaeological fauna noted that size 1 (4.5-20 kg) (prey body size groupings from Bunn et al., 1988) ungulates are more common during MIS5 while size 5 (900+ kg) ungulates are more abundant in MIS6, consistent with this expectation. A similar pattern is shown from nearby Blombos Cave (Thompson and Henshilwood, 2011), where larger animals are brought in by humans during cooler climates, and many more size 1-2 ungulates during warmer periods. At DK1, layers 10/11 are inferred to be a paleointerior setting (Table 3), but there are a large number of size 1 bovids. However, these were predominantly brought in by raptors (Marean et al., 2000a), and the human-accumulated component is actually focused on large prey (size 3-4) consistent with expectations. Ethnographic and archaeological studies of shellfish transport show that movement over 10 km is uncommon (Erlandson, 2001). Although size 2-3 taxa are transported nearly completely by modern hunter-gatherers in Tanzania (Monahan, 1998), there are none transported further than 6 km (Bunn et al., 1988; O'Connell et al., 1988, 1990; Bunn, 1993), and there is only a single observation of a few giraffe ribs being transported 14 km (Bunn et al., 1988). The inferred site context for each archaeological assemblage studied is presented in Table 3 at the end of this chapter.

3.4 Conclusion

The south coast of South Africa provides a unique setting in order to investigate changes in how humans used technology on the landscape. The dynamic interplay of climate change, coastline fluctuation, diverse geology, unique vegetation, and changing animal communities in the Middle and Late Pleistocene CFR provide the background to this investigation. In the next chapter, the theoretical underpinnings of archaeological inquiry will be developed in order to link past human behavior with a static archaeological record. How foragers develop and use technology on the landscape has important implications for their ability to meet challenges and structure their economies. Within the paleoenvironmental background of the south coast CFR, the structure of human foraging adaptations can now be addressed.

Table 3. Paleo-context of assemblages used in this study. Approximate mean age estimates and setting inferred from references cited in text (errors not included for simplicity). Assemblages in approximate stratigraphic order, but future work is needed to resolve relative stratigraphic positioning between sites; *denotes assemblage with disagreement between amount of shell and coastal assignment.

Site/ Assemblage	~Age	MIS	Industry	km to Coast	Setting
PP5-6 RBSR	51	3	MSA	11.6	Interior
PP5-6 BCSR	52	3	MSA	10.1	Interior
Vleesbaai	60(?)	3	HP?		Interior
PP5-6 DBCS	62	4	HP	17.2	Interior
PP5-6 OBS2	63	4	HP?	17.3	Interior*
NBC 6	64(?)	4	HP		Interior
PP5-6 SGS	64.5	4	HP?	20.7	Interior*
Oyster Bay	65(?)	4	HP		Interior
DK1 6-9	68(?)	4	MSA		Coastal
PP5-6 OBS1	69	4	Microlithic	20.5	Interior
PP5-6 SADBS	71	4	Microlithic	15.1	Interior*
PP5-6 ALBS	72	5a	MSA	10.7	Interior*
DK1 10-16	75(?)	5a	MSA		Interior
PP5-6 LBSR	81	5a	MSA	1.1	Coastal
PP13B MIS5	95	5c	MSA	1.4	Coastal
PP5-6 YBS	96	5c	MSA	1.4	Coastal
NBC 10	100(?)	5d	MSA		Coastal
PP9	120	5e	MSA	0	Coastal
PP13B MIS6	160	6	MSA	26.1	Interior*

CHAPTER 4 – THEORETICAL ORIENTATION

4.0 Introduction

The previous chapters provided a background into the origin and evolution of the modern human lineage, as well as a context for MSA foragers on the south coast that may provide some of the earliest evidence for modern human population's behavioral complexity. What follows in this chapter is the background that bridges the archaeological record with actualistic studies of how stone tools develop damage due to use, and broader theory about how human foraging populations make technological decisions. This chapter begins with a discussion of how Middle Range theory connects the past and present, and how it is applied through the remaining chapters of this dissertation. There are two levels of inference building being applied in this dissertation – the first are lower level causal chains following uniformitarian assumptions about how artifacts exposed to experimental process today can be used to infer behavior in the past. The second are higher level inferences about human behaviors at the landscape scale. Ethnographic observations and optimal foraging theory provide bridging arguments that connect patterns of tool use and discard on the landscape, with how foraging populations living on a dynamic south coast environment would structure their movements and use technology on the landscape to acquire resources. At the end of this chapter, the goals and hypotheses of this dissertation are presented, which combines the two levels of Middle Range inference to postulate about how modern human groups in the MSA were using technology to adapt to a dynamic environment on the south coast of South Africa.

4.1 Middle Range Theory

Theory is required to bridge the gap between how objects were used and discarded in the past and the observations about artifacts and their contexts archaeologists make in the present. Inferential chains based on uniformitarian assumptions and analogic reasoning are used to link experimental patterns generated from actualistic studies to past processes. Uniformitarianism is the assumption that the same natural laws and processes that operate now, were also operating in the past (Gould, 1965; Lyman, 1994). Uniformitarian assumptions help to limit the range of inference to only those processes that can be observed in the present, removing unlikely processes from the specter of possibility. Without uniformitarian assumptions, there are no constraints on interpretive possibility, and no system for evaluating the strength of bridging arguments.

Actualistic research provides trace-agent linkages by making controlled observations of modern processes to infer how they operated in the past. Gifford-Gonzalez (1991) developed an inferential model for understanding zooarchaeological taphonomic processes that is equally applicable to understanding edge wear formation on stone tools. In both cases (lithic artifacts and faunal assemblages), researchers are attempting to make sense of artifact patterning that could be due to taphonomic (trampling, turbation) or behavioral processes (cutting/cut-marks, spear-tips/human accumulation). According to Gifford-Gonzalez's model, a *trace* is a visible attribute displayed on an artifact or ecofact – the archaeological patterning in need of explanation. The *causal agency* is the physical cause of the trace. The *effector* is the material that contacts and effects artifact modification. The *actor* is the source of external energy on the effector. The strength of this inferential chain is related to the direct observation

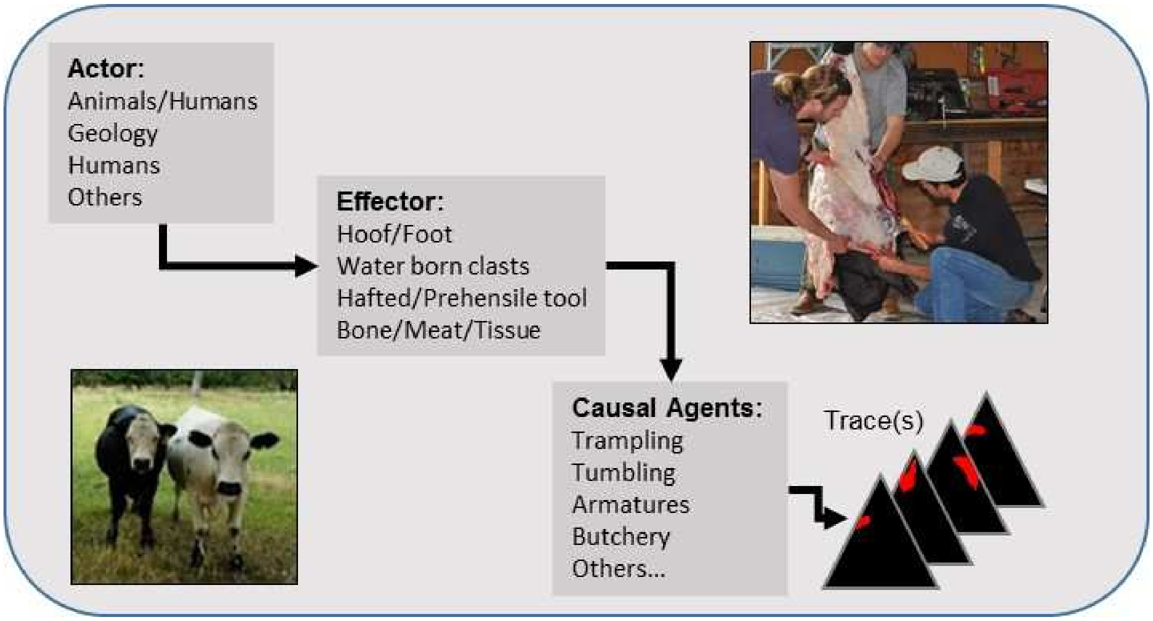

Figure 10. Flowchart of causal experimental chain between observed actors and resulting traces guiding Middle Range research.

between trace and actor (Gifford-Gonzalez, 1991; Marean, 1995). The inferential link between archaeological trace and an actor is strengthened by either the distinctiveness of the linkage - only one actor produces the trace in question (Wylie, 1985); or in the ability to quantify the likelihood of the linkage such as a statistical assessment of likelihood or probability (Burnham and Anderson, 2002). In lithic use-wear research, the focus has been almost exclusively on finding distinctive linkages between trace and actor that can be shown to be diagnostic through blind-testing (Donahue, 1994; Evans, 2014).

In archaeology, the process of constructing bridging arguments between past and present constitutes what Binford (1977, 1981) considered Middle Range Theory (MRT). MRT connects ideas about past processes (General Theory) with empirical observations made in the present. As Binford (1977) asks,

> “What meaning may we justifiably give to contemporary static facts regarding past dynamics? What conditions of dynamics, not available for observation, produce the forms and structures observable as static patterning in the archaeological record? In

> approaching this problem, we must develop ideas and theories (middle-range theory) regarding the formation processes of the archaeological record. Only through an accurate understanding of such processes can we reliably give meaning to the facts that appear, from the past, in the contemporary era. (p.6)"

Despite over 30 years of archaeological research, there is still a need for Middle Range research, ethnoarchaeological field work, and experimentation, and this dissertation bridges the gap between archaeological patterns of edge damage on stone tools, and the behaviors and processes which formed those patterns.

A common issue in archaeology with inferring past processes, is that different actors can result in the same observed archaeological traces. This is known as equifinality. Archaeologists have many tools available for recognizing patterns, but fewer Middle Range tools for ascribing meaning to patterning. As Todd (1983) states, "Our ability to recognize patterning in the archaeological record far outstrips our present competence to give behavioral meaning to our observations – either at the site specific or general theoretical level (p. 9)." While additional actualistic research can provide insight on many lingering questions in archaeological research, they often point towards equifinality issues that had previously been unidentified. Identifying vague similarities between experimental and archaeological traces are insufficient, informed inferences about the archaeological record must take into account plausible explanations based on uniformitarian assumptions, and then make statements about the probability with which each may account for observed phenomenon.

In this dissertation, MRT is operating at two levels of inference in order to understand early modern human behaviors in the MSA. The lower-level inference falls within uniformitarian assumptions linking stone tool edge wear traces to prehistoric effector and actors. To make these inferences, experimental assemblages of edge damaged artifacts exposed to known behavioral and taphonomic processes are compared to archaeological assemblages. It is assumed that stone tools today break in the same ways when stepped on, used as a spear tip, or as a butchery tool, as they always have in the past. Those processes that are statistically dissimilar to archaeological patterning can be removed from consideration, and interpretive focus placed on those patterns that do explain a significant amount of the variation in edge damage patterning. The higher level MRT inference falls within the realm of ethnoarchaeology and behavioral ecology, but also incorporates inferences from the lower level MRT. These higher level causal chains operate at the landscape scale of hunter-gatherers using and discarding stone tool technology, and attempting to understand MSA patterns of technological organization and foraging patterns. Ethnographic and ethnoarchaeological research are used in order to generalize about human behavior, and develop hypotheses about prehistoric behaviors that are tested.

4.2 Middle Range Theory: Artifact Inference

Experimental archaeology seeks to provide the Middle Range research that connects physical artifacts with past processes, using modern observable processes as analogs (Gifford-Gonzalez, 1991).Using experimental archaeology methods designed to develop and test hypotheses about artifact patterning have a long history in archaeology (Ascher, 1961; Semenov, 1964), and researchers of Pleistocene archaeological sites have often been at the forefront (Isaac, 1971; Toth and Schick, 1983; Frison, 1989). Since nearly every archaeological context is a palimpsest of site use to some degree (Foley, 1981), Schiffer (1987) argues that inference must begin by identifying both cultural and natural processes that formed the archaeological record. Experimental archaeology includes a wide array of approaches, including highly controlled laboratory and field experiments (Shea et al., 2001; Sisk and Shea, 2009; Iovita et al., 2014), and observations of actualistic and naturalistic studies (e.g. Blumenschine, 1988; Marean et al., 1992; Atici, 2006). The challenge for understanding prehistoric behavior using experimental archaeology is identifying which analogous processes are relevant to the past behavioral and taphonomic contexts, and what assumptions are being made about those processes (Domínguez-Rodrigo, 2008).

4.2.1 Experimental Archaeology

As previously mentioned, Gifford-Gonzalez (1991) articulates the role of analogy in experimental archaeology as a series of nested inferences from the trace (such as an edge-wear scar), its immediate causal agent (butchery activity), the effector of the trace (hitting bone while cutting), the actor (stone-tool wielding hominin), and the behavioral and ecological context. Reid (1982) notes that there are an infinite number of combinations of such a hierarchy that could, in theory, contribute to an archaeological deposit (Schiffer, 1983). Experimental archaeology focuses the range of possibilities both by excluding processes that are unlikely, providing support for those that are more plausible, and by building the inferential chain between trace and actor.

That some (or many) processes or combinations of processes do not necessarily produce patterns diagnostic of that combination is a problem of equifinality (Lyman, 1987). Lyman (1987) proposes a more probabilistic method, based on which processes have the highest likelihood based on context, suggesting that “the development of criteria allowing an identification that is to some specifiable degree *probable* is difficult but is nonetheless often how we operate (p.278, emphasis in original).” Developing inferential chains based on probabilistic determinations of likelihood provides linkages between trace and actor behavior that are grounded in a positivist scientific method. Observations in the archaeological record are difficult to explain using the scientific method, in part, because the tenant of ‘reproducibility’ requires repeated outcomes from the same process. Individuals acting in single moments in the past produced the material record and were subject to post-depositional histories unique to its own context. Due to lack of reproducibility, Aristotle suggests in *Prior Analytics* that there can be no “science of the individual”. Because science is in search of “universals”, it struggles to explain unique events (Larkin, 1971); therefore, since every archaeological observation is, in a sense, unique and non-replicable, universal patterns that are statistically discernable in aggregate have more inferential power than one-to-one comparison, and fall more securely within the scientific method. Generating assemblage-scale expectations for behavioral and taphonomic processes helps to identify the formational history acting on an assemblage by ascribing statistical confidence in the comparisons.

Experimental archaeology provides a method towards creating the MRT that “gives meaning to the facts that appear, from the past, in the contemporary era (Binford, 1977).” Lithic analysts are particularly dependent on using experimental methods to create the causal chains that join wear trace observations with human behavior due to the lack of contemporary ethnography on human foragers using stone tools, but also because stone-tools break in reliable, law-like ways amenable to producing reliable predictions. However, inferring tool function involves a series of assumptions about past modes of hafting, use, and taphonomy that makes it more controversial and difficult to generate confident inferences.

4.2.2 Inferring Tool Function

Historically, making statements about prehistoric stone-tool function was subjective and speculative, based on artifact form and ethnographic analogy (e.g., Bordes, 1961). Terms such as "scraper" and "hand-axe" suggest their potential uses, but much less is known about these artifacts actual functional histories than their nomenclature would imply (Shea, 2011b). To inform interpretations of artifact tool function, experimental studies of tool use and discard have developed along three main lines: use-wear, indirect measures, and diagnostic impact fractures.

Use-wear analysis identifies traces of microfractures, polishes, and residues that are argued to have been generated by use-action of certain configurations of tools (i.e., hafting presence, cutting action) being applied to different materials. Use-wear is commonly divided into "high power" approaches that use magnifications >100x, and "low power" techniques that rely on macroscopic traces and features visible at <25x. Lithic use-wear analysts create experimental collections of tools that consist of raw-materials, hafting/prehension arrangements, and use-intensity that are deemed analogous to the time period and archaeological culture under investigation (Rots et al., 2011). Use-wear analysts then use a combination of microscopic polishes, striations, "bright spots", and edge scarring/dulling to infer the life history of a tool by comparison with observations from the experimental collection. Blind-tests are used to assess the accuracy of analyst functional history interpretations. This analogical approach emphasizes the size of the experimental assemblage, the experience and training of the analyst to generate archaeological data of tool function (Rots and Plisson, 2014). Although the results of blind-tests have cast some doubt on aspects of functional interpretations (Newcomer et al., 1986; Wadley et al., 2004), some analysts have achieved high scores on blind-tests (Odell and Odell-Vereecken, 1980; Rots et al., 2006). The impact of post-depositional processes is not often explicitly addressed – flakes that appear weathered or rolled are excluded from analysis, as are flakes from "disturbed" contexts, but the assemblage patterning is rarely described and the criteria for establishing contextual integrity are rarely made explicit (Shea, 2011b). Taphonomic damage is often claimed to be 'random' (Tringham et al., 1974; Pryor, 1988), but statistical methods for differentiating patterned distributions are lacking. A critique of use-wear is provided in the next chapter, and an alternative methodology that accounts for the assemblage distribution of damage distribution is presented.

Indirect measures are variables that suggest the feasibility of certain tools to have functioned for specific tasks. For instance, Shea (1998) uses differences in frequency of pointed lithic tools to infer hunting strategies (intercept and encounter hunting in steppe and woodland environments, respectively) at Levantine Mousterian sites. Other indirect measures such as tip-cross section area (TCSA) measure the size of the hole a ballistic armature would create on impact (Hughes, 1998). TCSA has been used to classify stone points as arrows, darts, or spears (Hughes, 1998), and have been used to look for the origins of projectile technology in Europe and Africa (Shea, 2006). The problem with an indirect measure of tool function is that it is only a statement of feasibility without demonstrating actual use (Sisk and Shea, 2011:2).

To demonstrate associations between tools and hunting, Lombard suggests the frequency of *diagnostic impact fractures* (DIFs; Figure 11) on pointed tools is positively correlated with the intensity and importance of prehistoric hunting (Lombard, 2005b). DIFs are macroscopic breaks that are argued to only form when tools are exposed to high longitudinal force at their tip (Fischer et al., 1984). DIFs are defined based on their initiation and termination characteristics as defined by the Ho committee (1979). Fischer et al. (1984) argue that step-terminating bending-initiating fractures, unifacial spin-offs >6mm, bifacial spin-offs, and impact burinations are "diagnostic" of impact. Villa et al. (2009b) argue that the frequency of impact fractures likely have more to do with site

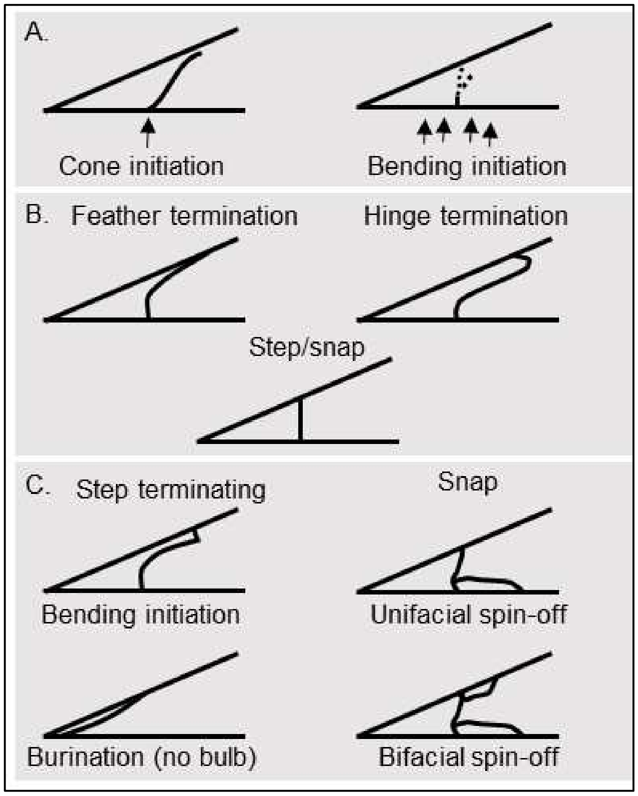

Figure 11. Fracture characteristics. A) Fractures initiate either with a cone, leaving a negative bulb of percussion where narrow force was applied, or in a bending initiation where broad force was applied. B) Fractures terminate differently given the amount of and direction of force. C) Fractures considered "diagnostic" of impact.

function rather than the importance of hunting. DIFs will be used in this dissertation since their frequency from behavioral and taphonomic processes may be useful indicators of hunting technology.

Behavioral interpretations of how stone tools were used are complicated by the effects of post-depositional processes on the surface and edges of artifacts. Historically, taphonomy is concerned with the study of how an organism transitions from the "biosphere to the lithosphere" (Lyman, 1994), but has taken on a more general definition of how natural processes influence the burial of artifacts at multiple scales of observation (Barton et al., 2002). Stone tools are the most common surviving artifact from most Pleistocene archaeological contexts, and are subject to the same processes of burial as faunal remains. Trampling, turbation, and transport are common post-depositional processes influencing the preservation of stone tools and their edge modification (Dibble et al., 2006). Frequency of post-depositional tool damage formation is directly related to the degree of artifact disturbance. Shea and Klenck (1993:187) found increasing amounts of edge damage occurring on stone tools that were un-trampled, moderately trampled (15-30 minutes), and heavily trampled (45 minutes) . Pargeter (2011a) demonstrates increasing trampling intensity with cattle compared to human tramplers corresponds to an increase in the formation of lithic breaks that mimic DIFs.

Since the extent of damage due to both behavioral and taphonomic processes is dependent on the duration of exposure to disturbance forces, patterning on less intensively trampled stone may be more ambiguous than heavily trampled tools (Bamforth, 1988: table 5). Trampling edge damage can produce small regions of randomly placed edge wear, or substantially alter edges depending on exposure to disturbance processes. Morphologically, taphonomic edge damage is often described as elongated scars (Tringham et al., 1974) that are dispersed along flake edges (Gifford-Gonzalez et al., 1985; Nielsen, 1991), but occasionally cluster similar to retouched tools (Flenniken and Haggarty, 1979; McBrearty et al., 1998) or hafted tools (Marreiros et al., 2015). Shea and Klenck (1993) and Pryor (1988) found that trampling scars could be broad and clustered depending on the intensity of trampling and frequency of scars. Pryor (1988) shows that lithic artifacts trampled on sandy surfaces can produce short, broad, randomly placed scarring, whereas loamy surfaces can produce more elongated and clustered edge damage scars. Bird et al. (2007) argue that the collective result of taphonomic studies of edge damage is that right now it is "virtually impossible to determine whether sparse damage is due to trampling or use of individual artifacts." Similarly, Akoshima (1987) concludes that with current methodologies, "a certain scar cannot be a definitive clue to functional determination and the features of flaking scars on the edge as a whole should be the unit of analysis and interpretation".

Given that patterns of edge modification that relate to the behavioral component of an assemblage's formational history are of interest for addressing questions about human evolution, it is necessary to evaluate, account for, and 'peel back' (Marean and Bertino, 1994) the post-depositional component of lithic edge-damage formation. Post-depositional processes are not uniform across time or space, and a methodology that can identify taphonomic patterning and temper behavioral inferences accordingly are needed. For instance, Pargeter (2011a) and Sano (2009) both have demonstrated independently that DIFs can occur on stone flakes exposed to trampling. Thus, even features termed "diagnostic", are not fully indicative of a behavioral signature. However, the frequency with which they occur can be consistent with certain assemblage-scale behavioral patterns (Figure 12). Less than 2% of tools exposed to trampling incurred a DIF, whereas >40% of experimental tools that are used as projectiles develop a DIF, and sites where hunting technology and site function are well known have shown systematic differences in the frequency of DIFs (Wilkins et al., 2012). For instance, points recovered from Holocene kill sites have nearly 43% DIFs, whereas residential sites only have ~15% DIFs on points that are known to have been used as arrows (Fischer et al., 1984; Villa et al., 2009b; Sano, 2012). Accounting for taphonomic and behavioral wear patterning allows statements about prehistoric behaviors to be teased from site formation processes.

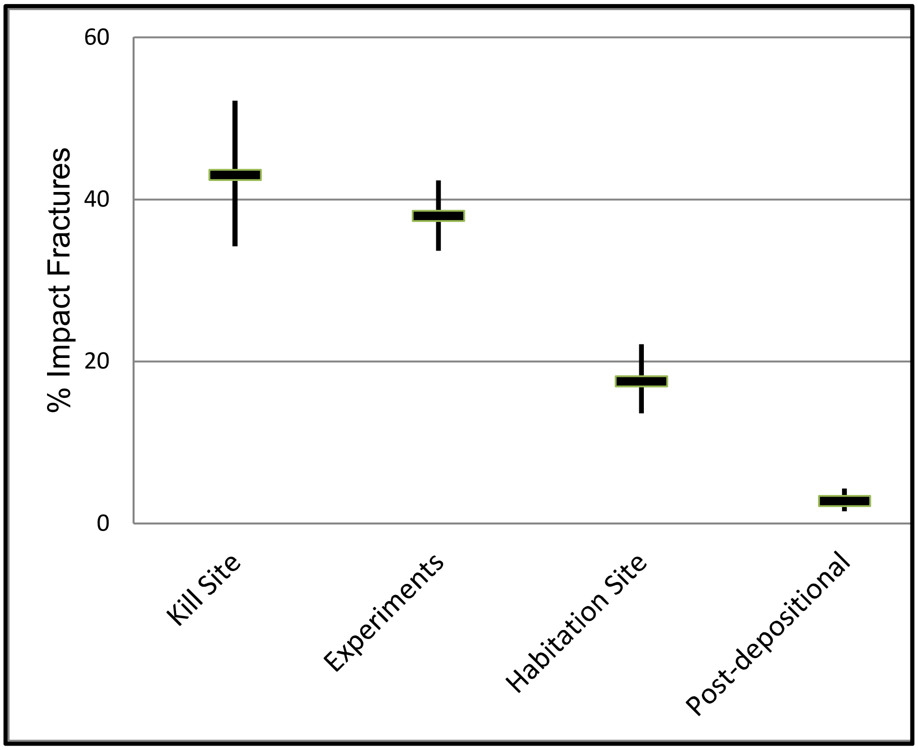

Figure 12. Frequency of DIFs from four different processes and site contexts (using data from Wilkins, et al. 2012).

4.2.3 Lithic Variability

Stone is a reductive commodity - cores are reduced to flakes, flakes reduced during use, and retouch reduces worn edges. The traditional archaeological approach to making sense of stone tool variability tends to be focused on the end of this reduction sequence by grouping the retouched portion of the tool assemblages into form-based categories. The assumption is that tool makers had a preconceived ‘mental template’ of the final artifact that archaeologists can detect and utilize to understand prehistoric behavior. This is exemplified by the myriad of scraper categories developed by Bordes for the French Paleolithic (Bordes, 1961). In his effort to make sense of Paleolithic variability, Bordes separated sites into culture-groups based on the relative frequencies of different types of scrapers. Sites with similar frequencies were argued to be from the same culture-groups. Binford and Binford (1969) challenged this approach by arguing that these differences in material culture were more likely tied to differences in ecological adaptations rather than cultural traditions. Even in the critique of Bordes approach, the underlying assumption that tool forms represent ‘real’ categories of deliberate and intentional shaping was never in question (e.g., Binford and Binford, 1969).

Interpretations such as these stem from the ‘final artifact fallacy’ (Davidson, 2002). Assuming that the stone tools found archaeologically were the *initially* intended size and shape of the manufacturer is almost certainly wrong because tools change throughout their life cycle (Barton, 1990). The life-history of a stone tool can see a number of transformations based on the needs of the user and the durability of the tool (Dibble, 1995; Barton et al., 1996). Ethnographic observations of intentionally reworking an edge to produce a predetermined form occurs largely in the context of hafting, and more often edge retouch can be attributed to resharpening (McCall, 2012). Decisions to either resharpen tools or produce flakes with fresh edges involve calculated tradeoffs in time investment, transport costs, and tool efficiency (Kuhn, 1995; Brantingham and Kuhn, 2001). When raw-material is abundant and transport costs are low, it may be more adaptive to have low curation and high frequencies of unretouched flakes and tools. Barton (1990), Holdaway and Douglass (2011) and others have shown that the reductive nature of tool resharpening means that highly retouched tools are more likely the unintended result of tool “life history” extension (Dibble, 1995; Riel-Salvatore and Barton, 2004). In other words, many retouched tool categories are more parsimoniously linked to flakes that have undergone varying numbers of sharpening events. From this perspective the relatively low frequency of retouch in many MSA assemblages represent a “fast” life-history with very few tools remaining in the toolkit to an “old-age” (i.e., to a stage where retouch frequency is high).

4.2.4 Causal Chain of Inference Summary

Following Gifford-Gonzalez (1991), the chain of inference adopted in this dissertation follows the nested structure of trace, causal agent, effector, actor, and behavioral context (Figure 10). In the experimental studies, everything but the resulting trace is tightly controlled so that causal relationships between processes and patterns can be established. Rather than being directed at generating a wide diversity of tools being used for a wide variety of tasks, the emphasis is on understanding the probability of edge wear, and edge damage distributions. This results in generalizations about the relationship between process and pattern, rather than assertions about the generalizability of individual features on unique processes.

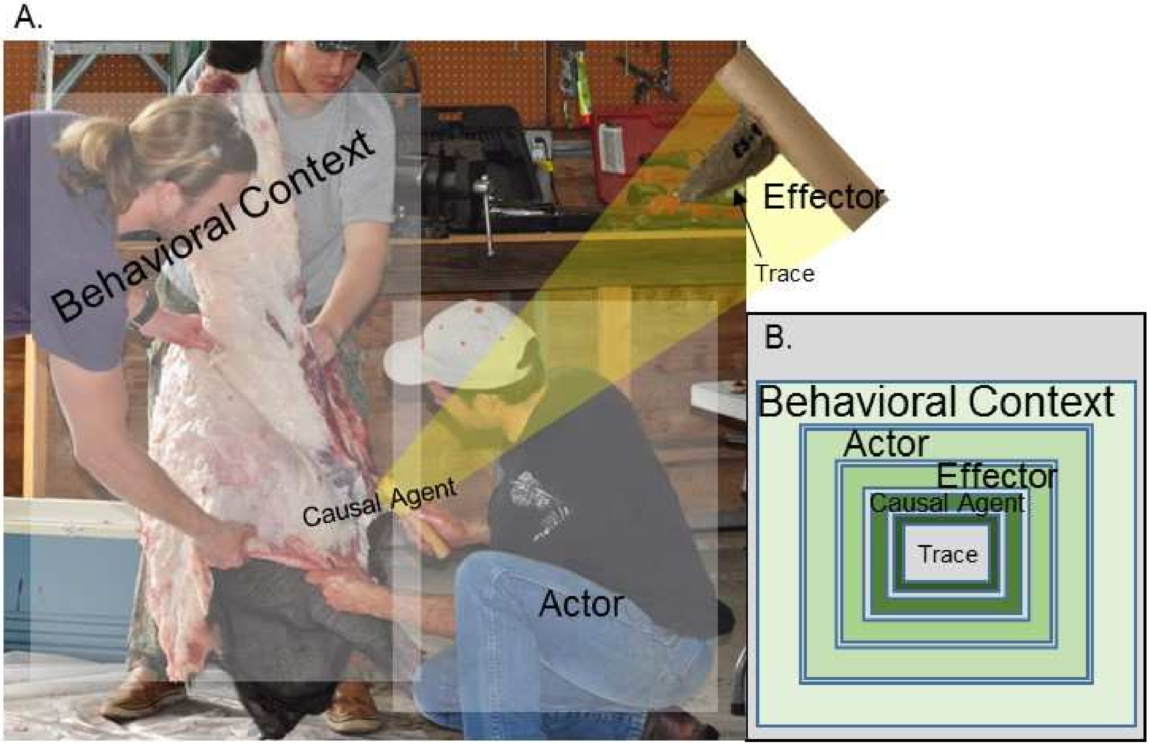

Figure 13. Nested causal linkage in edge damage experiments. A) Applied to a butchery experiment. B) Nested structure of inference, from Gifford-Gonzalez (1991).

This causal chain is illustrated in Figure 10 and Figure 13 for the behavioral context of field-dressing an animal with a quartzite butchery tool. In this example, the actual observations are made on the *traces* of edge damage on the tool edges. As will be explained in the next chapter, these observations are then aggregated, so that assemblage scale patterns of edge damage frequency and distribution across tool edges can be analyzed. These traces are due to the causal agent of the butchery action cutting meat, tendon, bone, and cartilage. The effector is the hafted stone tool used for the butchery tasks, and the butcher (Jeremiah Harris) was the actor. As in all the experiments performed in this dissertation, every step in the causal chain is fully documented with video, photos, or motion capture cameras (for the long-term trampling experiments) so that there can be no question whether the trace is causally linked to the other parameters in the causal chain in each actualistic experiment.

4.3 Middle Range Theory: Landscape Behavioral Inference

Understanding how humans use technology on the landscape requires higher level inference that do not necessarily fall under the umbrella of uniformitarian principles as previously outlined for the causal chain of artifact wear trace inference (c.f. Gould and Watson, 1982; Cameron, 1993). Archaeologists tend to rely on ethnographic analogy over explicit modeling in order to create inferences of prehistoric behavior (but see below). Establishing a causal chain for inferring *prehistoric* human foraging and social behavior is difficult to operationalize because cultural practices are unlikely to be uniformitarian in nature, and therefore referential reasoning is used to create a causal chain of inference (McCall, 2012). Referential reasoning identifies linkages between human behavioral variability within cultural systems and resulting patterns of material remains. These analogies tend to be broad generalizations about how human behavior produces material culture (Gould and Watson, 1982). Wylie (1980) suggests that the strength of such analogical argumentation is increased the more frequently it occurs, in the specificity of its occurrence, and the range of occurrences across time and space. In other words, ethnographic analogies are most useful when taken from situations as similar as possible to the archaeological question. However, the ethnographic present contains a small subset of the diversity of behaviors and activities present in the archaeological record. For example, Marean (1997) argues the dearth of ethnographic observations from tropical grasslands (where foragers were displaced by pastoralists by ~4000 BP) has limited our ability to make statements about significant events in human biological and behavioral evolution. Instead, Marean (1997) creates a comparative framework where the relevant ecological parameters driving human behavioral variability are identified, then finding ‘structural correlates’ between ecological variation and human behavior using macro-ecological methods (Hill, 2002), and constructing a conceptual model that is then tested with archaeological data.

One avenue for making predictions about human behavioral variation and environmental context is human behavioral ecology, or HBE. HBE brings evolutionary mechanisms (natural selection) together with human behavior to create explicit models that can be tested with empirical datasets (Borgerhoff Mulder and Schacht, 2012). The underlying assumption in behavioral ecology, and evolutionary biology in general, is that natural selection has promoted cognitive decisions to be made in an optimizing way in a given environment (Smith and Winterhalder, 2006). The hypotheses generated from human behavioral ecology (HBE) modeling, including game-theory, optimization, and marginal value models, can be tested with empirical data obtained from ethnographic research.

Modern hunter-gatherers are intimately tied to their environment and make decisions about how to spend their time based on perceived costs and benefits (O'Connell, 1995). In an evolutionary perspective, foraging seeks to optimize the amount of resources that may be acquired at the lowest cost possible (Stephens and Krebs, 1986). To maximize their return rate human foragers can also use and adjust their technology accordingly (Surovell, 2009). Constructing models of costs and benefits that relate to goals and behaviors of interest in prehistory produces predictions that can be compared to empirical datasets. Models that fit archaeological datasets are supported, and those that do not fit suggests one or more of the model parameters (or assumptions) are falsified.

In this dissertation, the broad patterns that relate how human populations move across the landscape while using, repairing, and discarding technology for acquiring resources are operationalized as a series of models, distilled from explicit HBE studies. Archaeological inferences are then made as a series of inferential steps starting with models of the ecological and environmental context prehistoric humans operated within and creating expectations for human behavior. These expectations can then be tested with the archaeological inferences from the artifact wear trace analysis. The result is a more holistic analysis of MSA behaviors across the landscape, rather than a laundry list of which tools were used for what task at each individual site. However, future modeling work can improve the specificity and accuracy of the parameters and hypotheses to be tested.

4.3.1 Land-use Patterns

Technological organization is constrained by human land-use patterns in as much as there is a finite amount of material that can be carried by a forager, and decisions must be made about what is transported and what is discarded. Binford (1980) described land-use systems along a continuum of mobility depending on how frequently co-residential groups change central-places (residential mobility) versus sending small task-specific groups out and returning (logistical mobility). Mobility patterns are related to the abundance and distribution of resources through time and across space (Kelly, 2013:79). When resources are clustered across space (patchy), hunter-gatherer groups tend to have long-term residential habitation sites and frequent logistical movements (Binford, 1980;

Grove, 2009). Schott (1986) argues that groups with fewer residential moves are able to have a larger, more diverse toolkit because ‘carrying costs’ constrain the number of tools that can be regularly moved. Binford (1980) called these groups “collectors”. In contrast, groups that frequently make residential moves by group members moving residential camps regularly to resources are called, “foragers”.

Because the forager and collector models reflect the structure of activities on the landscape, they also provide insight into where tools are manufactured, used, and discarded. Following Kuhn’s (1989) formal mathematical model of tool provisioning, collectors tend to replace tools periodically based on loss of tool reliability during use (also see Bleed, 1986). Foragers tend to have continuous manufacture and replacement of tools, discarded when they are exhausted and no longer maintainable (Bleed, 1986). Under both systems, the spatial distribution of discarded tools will vary because transporting unreliable or exhausted tools after use is more costly (in time and energy) than discarding broken tools and retooling back at camp when groups are ‘off the foraging clock’ (Figure 14).

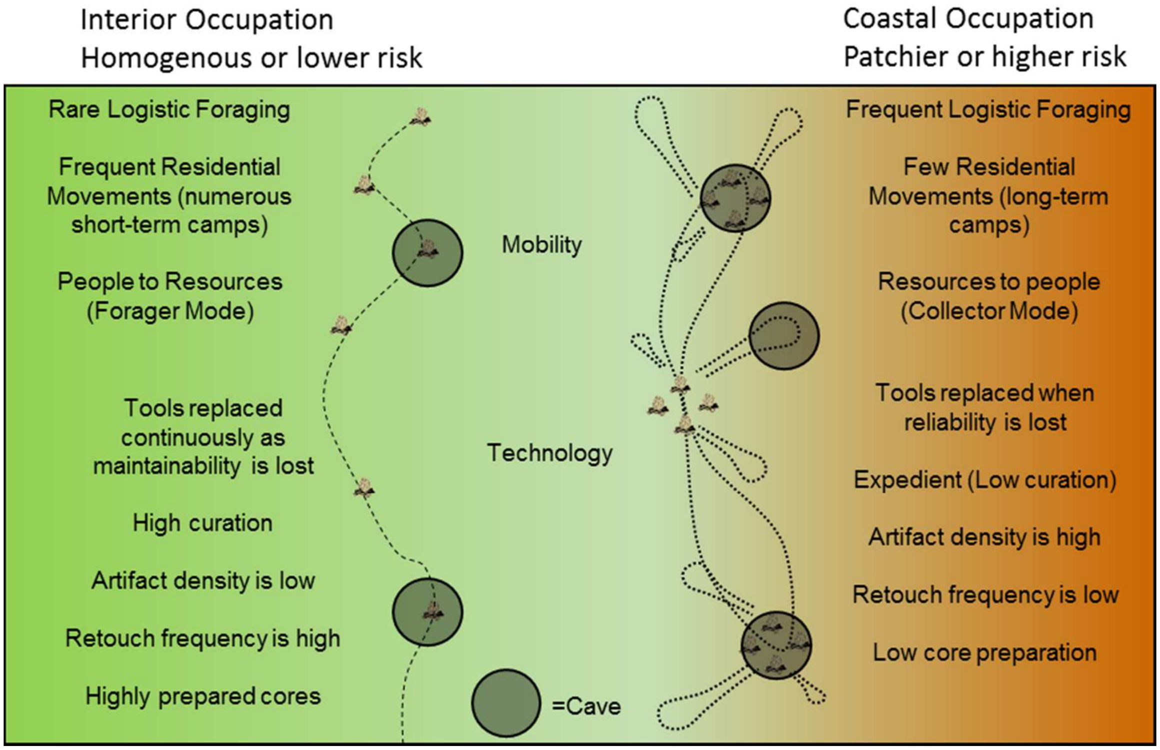

Figure 14. Characteristics of forager mobility and technological organization model based off Binford (1980) and others cited in text. Logistic node may appear more similar to forager mode. "Risk" refers to the probability of resource shortfall during foraging rounds, which may be higher when resource density is low and spaced far apart.

Riel-Salvatore and Barton (2004; Barton and Riel-Salvatore, 2014) have argued that mobility strategies may be inferred archaeologically from assemblage analysis of stone tool retouch frequency and volumetric density. When sites are short-term occupations (forager mode), they tend to leave light densities of artifacts, whereas long term occupations (collector mode) leave more dense accumulations. An agent-based model illustrated that mobility and place provisioning have strong effects on the composition of the archaeological record (Barton and Riel-Salvatore, 2014). Although lacking in empirical ethnoarchaeological evidence due to the few modern hunter-gatherers still using stone, this model is consistent with empirical archaeological evidence from numerous sites in Europe (Riel-Salvatore et al., 2008), Australia (Holdaway et al., 2010), Africa (McCall, 2007), and North America (Surovell, 2009). Forager occupations with low artifact densities will also tend to be focused on conserving, or curating (Bamforth, 1986), stone rather than creating new flakes since raw materials are not being replenished during site occupation. As sites are occupied for longer periods, more effort may be expended in acquisition of raw material during foraging, and therefore stone is more disposable and used more expediently prior to discard.

Odell (1996) presents a model of tool-use mobility whereby degree of sedentism/mobility is related to the diversity of tasks per tool, and the duration of use for each tool. As foraging groups become more sedentary, according to Odell's model, their risk of resource shortfall increases, and groups will develop more highly specialized and curated tools – especially hafted tools – in order to increase returns. More mobile groups will encounter a greater diversity of activities, however, and therefore each tool will need to be used for a wider array of tasks. According to this model, each tool type will tend to serve more functions with increased mobility. Additionally, increased mobility should result in tools that have been utilized more intensively. When risk is high in sedentary camps, tools will be discarded well before they are exhausted in order to reduce risk of breakage at crucial times of need.

Land use strategies also influence when and where the repair and discard of worn tools on the landscape. Andrefsky (2008) demonstrated how bifacial points with impact fractures were discarded depending on the distance to obsidian source in pre-house pit occupations in southeastern Oregon. Obsidian bifaces from sources greater than ~40 km had fewer impact fractures from projectile use than sources less than ~40 km. At quarry sources, both local and non-local bifaces had the same frequency of impact fractures. Andrefsky argues this pattern reflects the land-use strategy of tool use, maintenance, and discard of foragers at this time.

4.3.2 Toolkit Organization

The technological organization of human foraging is defined by Nelson (1991) as, "the selection and integration of strategies for making, using, transporting, and discarding tools and the materials needed for their manufacture and maintenance. (p. 57)." These strategies directly influence when and where tools are manufactured, used, and discarded on the landscape. There are many facets to analyzing how foragers make technological organization decisions. One facet explores the complexity, or diversity of the toolkit. In Oswalt's worldwide analysis of food getting technologies (1976), he demonstrates a strong pattern with foragers in colder climates having many more tool parts (techno-units) than temperate and tropical foragers, but the influence of having pack animals (sled-dogs) may also contribute to this pattern. Oswalt shows that hunting more 'mobile' prey is also associated with higher degrees of technological complexity, and groups hunting aquatic animals require more complex toolkits than those hunting terrestrial animals. The worldwide patterns in technology Oswalt identified may be a result of multiple conflated factors that can be difficult to tease apart (Torrence, 1989; Bamforth and Bleed, 1997; Marlowe, 2005). Latitude correlates with many variables such as length of growing season, above ground biomass, and temperature, and researchers have tried to focus on those that may be most relevant (e.g., Binford, 2001).

"Risk" of resource failure, has been suggested to play a role in increasing toolkit complexity (Torrence, 1989; Bousman, 2005). Extrinsic environmental variability (i.e., rainfall and temperature variance) are often used as proxy measures for the probability of resource failure (Asseng et al., 2011; Buchanan et al., 2015). Increased risk of resource failure tends to result in a more complex toolkit that can increase the probability of successful foraging. Although some studies have found positive correlations between technological organization and resource failure (Collard et al., 2005; Read, 2008), the patterns seem to be most robust at macro-scales such as between tropical and temperate foragers. Collard et al. (2011) analyzed a single region of hunter-gatherers, the Pacific Northwest, between two habitats that may have had different degrees of resource failure risk (in terms of the variance of primary resource availability), the interior plateau and the coast, and found no evidence for significant differences in tool complexity or diversity. However, the nature of the resources being exploited may outweighed any difference in environmental risk that could be detected in this study because foragers that exploit marine animals tend to have more complex toolkits in general (Oswalt, 1976:101). A more recent analysis by Collard et al. (2013a) found that one proxy of resource failure risk (mean rainfall of the driest month) could explain technological complexity among hunter-gatherers in western North America better than population size, but most researchers seem to agree that there is a dynamic interplay between environmental and demographic factors influencing technological complexity (Collard et al., 2013b). It should also be noted that between-family food-sharing and storage are primary means of daily risk management among most foragers, but within family food-sharing is more common among farming economies (Winterhalder, 1990). Any impact of technological organization is most likely at larger scales of resource failure risk (annual, decadal, etc.), but this is also an area for further study.

Henrich's (2004) model for explaining the loss of technological complexity in Tazmanian islanders beginning 8 ka addresses the issue of material culture complexity through a formal cultural evolution model. According to Henrich's model, a sudden reduction in population size reduces the cultural knowledge in a population, much like genetic founders effect (such as the previously discussed argument for Neandertal loss of fire making ability). Without the surviving knowledge, some technological abilities are lost. At the other end of the spectrum, larger group-sizes allow for more innovators and increased cultural complexity (Derex et al., 2013). Shennan (2001) demonstrated the role large populations play in allowing innovative and adaptive technologies to reach fixation. Applying this model to the spread of modern humans into Europe, Powell et al. (2009) argue that the archaeological appearance of complex cultural traits associated with 'behavioral modernity' is a function of population size. According to Powell et al., the appearance of complex material cultural with the arrival of modern humans in Europe can be explained better by demographic factors rather than evolved cognitive traits. More recently, Derex and Boyd (2015) show that the structure of populations strongly influence how likely they are to generate complex culture. Large, partially connected populations can generate more complex artifacts than individuals or small groups can.

4.3.3 Foraging on the South Coast and Agulhas Plain

As discussed in Chapter 3, resources are distributed on the south coast in a heterogeneous pattern of resource habitats. In this section, the land-use Middle Range theory that has been developed by researchers is combined with the specifics of the Middle and Late Pleistocene south coast environment to develop a model of MSA forager mobility patterns.

During warmer interglacial phases, the south coast was a rich but spatially restricted habitat containing rocky-intertidal shellfish, sandy beach shellfish, fynbos, renosterveld, strandveld, and thicket. All these habitats occur within 12 km of the coastline around the sites studied here, and have very different expectations for return rates of plants and animals (Marean et al., 2014). Hunter-gatherers living in less-patchy (more homogeneous) environments are often associated with 'forager-mode' foraging. Binford (1980) argues that "in relatively large or "homogenous" resource patches…the number of residential moves may be increased but the distances between them reduced (p. 5)". In contrast, foraging in heterogeneous environments with clustered habitats distributed in space (as the south coast region likely was) may lead to more collector-mode foraging, which tends to be associated with long-term camps, logistic foraging, and low curation toolkits which manifest archaeologically through low retouch, high density assemblages. During periods of lowered sea-level, the south coast geology doesn't change but the addition of an Agulhas Plain intersecting the foraging range would have a dramatic influence on how hunter-gatherers would be expected to structure their mobility. Although some resource patchiness between geological boundaries would still be expected (i.e., shale would still be associated with renosterveld and limestone associated with fynbos assuming significant amounts of winter rainfall), the new featureless plain consisting of C4 grasslands would be much more homogenous, supporting large grazing ungulates. Tree species that are not regular components of fynbos vegetation but are common in thicket would also be more common and available. Importantly, there would be no highly reliable patches of shellfish or stranded marine mammals within the daily foraging radius of the paleointerior sites. Although it seems unlikely that the changes in climatic “risks” of resource shortfalls would cause a switch to favor a complete forager-mode strategy, the timing and spatial distribution of resources within a substantial portion of the foraging range would be expected to have a cascading effect on hunter-gatherer land-use strategies, such as increased residential movements, increased territory size, and increased occupation duration (Grove, 2009:Figure 3).

It is expected that simply due to the difference in geographic proximity to coastal resources, prehistoric contexts will reflect different aspects of the MSA foraging system. Near coastal environments, modern foragers sometimes adapt either to coastal or terrestrial resources. This is observed in the greater Andaman Islands with the cultural separation of forest/coastal groups identified by Radcliffe-Brown (1948:30), as well as with Inuit groups that developed coastal⁄interior adaptations such as the Taremiut and Nunamiut, respectively (Murdock, 1969). LSA populations on the south coast of South Africa also appear to have followed a similar pattern – interior populations were adapted to acquiring interior resources year-round, while coastal populations adapted to acquiring coastal resources (Sealy and Van der Merwe, 1992; but see ; Sealy, 2006). Although some groups do trek between coastal and interior locations seasonally such as the Wik Monkan in Northern Australia, the activities they engage in are very different such that, “seeing these people at different seasons of the year would find them….with weapons and utensils differing so much in character, that if he were unaware of the seasonal influence on food supply…he would conclude that they were different groups (Thomson, 1939).” It is expected that coastal and interior tool use and discard patterns reflect these different adaptations regardless of group or seasonality because of the vast difference in exploitable resources, which provide insight into the landscape tool-use strategies of MSA populations on the south coast.

Similarly, caves and open-air contexts are anticipated to reflect different aspects of the MSA foraging system due to differences in proximity to resources and associated costs in transport. Binford (1980:9) suggested that there are two basic types of spatial context for the discard of artifacts – one is the residential base, or the hub of subsistence activities; and the other are *locations* - a place where extractive tasks are carried out. Caves are discreet locations on the landscape, are generally not in direct association with resources, and are more frequently reoccupied compared to open-air sites (Binford, 1982). It is anticipated that caves will tend to reflect strategies where resources have to be brought in from elsewhere. This is well known with respect to faunal studies, often referred to as the 'schlepp effect' (Perkins and Daly, 1968). Figure 15 shows the distribution of species by body size between open-air and cave sites combined from 82 European Middle Paleolithic faunal assemblages. Open-air assemblages have high relative frequencies of large prey taxa such as mammoth and whooly rhino, whereas caves have higher relative frequencies of size 2 fauna. To understand foraging strategies requires sampling both ends of this site occupation and land-use continuum.

Locations are deposited across the landscape. Binford (1980) argued that due to their ephemeral nature, *locations* tend to be less archaeologically visible, therefore what is considered an open-air "site" here may suggest redundant extraction sites or camps depending on environment and local setting. Although contextual, caves will tend to be

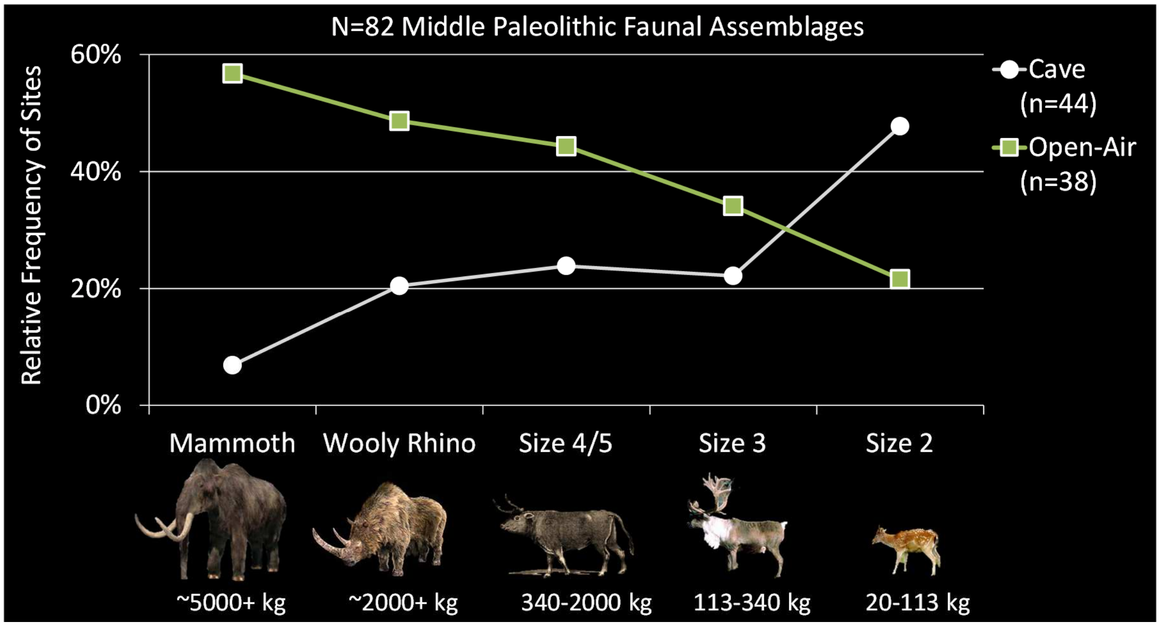

Figure 15. Relative frequency of prey by body size at caves and open-air sites from European Middle Paleolithic assemblages.

located further from resources. In the case of sea-caves, the productive inter-tidal resource zones may be located very nearby, however when sea-level goes down these resources will be located further away. As distance from resources increase a more exaggerated transport bias against low utility raw material (e.g., broken points) may be seen (Kuhn, 1994). Tools discarded in cave contexts will tend to either be towards the end of their use-life, or used very opportunistically if the cave is being regularly supplied with raw material (e.g., Will et al., 2013). Caves will have lower frequency of impact fractures because broken hunting tools are often discarded at locations such as kill-sites (e.g., Holdaway, 1989; Villa et al., 2009a; Wilkins et al., 2012:Fig. 2) and because a greater variety of activities take place at residential sites, of which hunting tools will be a smaller proportion. This context-dependent artifact discard was shown in Figure 12 where projectile points from kill sites have a significantly higher frequency of impact fractures compared to residential sites. It should be noted from Figure 12 that not every broken projectile is discarded on landscape. This may be due to retooling tasks such as melting resin or untying broken spears/arrows occurring mainly at residential sites, as well as carcass transport that may unintentionally bring broken and dislodged points back to residential sites within carcass parts.

Other foraging related tasks such as field dressing, especially of larger game, occurs in the field where viscera and internal organs are removed and disarticulation occurs. Field dressing is important in order to avoid meat spoilage, and to make carcasses more transportable. Tools used for these differing tasks are often expediently produced, and deposited after dulling or becoming clogged with fat and fur (Nilssen, 2000), and disarticulation activities results in more tool damage than defleshing (Braun et al., 2008b).

4.4 Technology and Modern Human Origins

Human foragers have occupied nearly every environment within a time frame of ~50 ky after leaving Africa. The human niche is broad and includes an array of plants and animals captured using an array of extra-somatic adaptations. The ecological expectations of a human sized carnivore do not accurately predict the position human foragers fill at the top of the carnivore guild (Thompson, 2008). Hunting is vital to nearly all hunter-gatherers for meat, but also for use as a commodity for prestige (Hawkes and Bliege Bird, 2002; Speth, 2010), gift giving (Gurven et al., 2000; Patton, 2005), and other social activities rarely performed with items acquired from gathering (Hill and Hurtado, 1996; Bliege Bird, 1999). Technology used by modern humans for reliable hunting developed through cultural accumulation and transmission as part of the larger suite of stone tool manufacturing behaviors. The predominant archaeological evidence for technology at

MSA sites are lithic tools. Patterns of stone tool discard reflect technological decision making, and provide insight into how prehistoric foragers structured activities on the landscape. Technology is used to acquire resources; however these activities are rarely performed in a cave where much of the archaeological information for the MSA comes from. Therefore, understanding prehistoric activities requires linking stone tool patterning with predictions based on how more recent foragers use resources across the landscape.

Kaplan et al. (2000) have argued that once hominins have regular access to large resource packages such as big game, a suite of life-history changes may be triggered such as increased juvenile dependency period, post-reproductive lifespan, and short inter-birth intervals. Some of the earliest evidence for technologically assisted hunting of large game may be from Boxgrove, England where a horse scapula with a large circular perforation indicates a sharpened wooden spear was used to dispatch game (Roberts and Parfitt, 1999). The 2m long wooden artifacts recovered from Schöningen, Germany may have been spears used for hunting large game (Thieme, 1997). Hafted points in the MSA and Middle Paleolithic after around 300 kya were likely sometimes used as spear tips. In Africa, the earliest evidence for hafted hunting technology at 500,000 years ago was reported from Kathu Pan 1 in South Africa (Wilkins et al., 2012), suggesting a deeper antiquity to stone-tipped hunting equipment than what was previously thought.

MSA points are often thought of as spear tips for hunting (Milo, 1998; McBrearty and Brooks, 2000). Analysis of the points from Sibudu Cave (Lombard, 2005a; Villa et al., 2009b), Blombos Cave (Lombard, 2007a), Rose Cottage Cave (Villa and Lenoir, 2006), and Kathu Pan 1 (Wilkins et al., 2012) have emphasized the use of points as hunting implements. A piece of stone embedded in a cervical *Pelorovis* vertebra at KRM from Cave 1 MSA levels would seem to support such an interpretation (Milo, 1998), although Marean and Assefa (1999) have noted the unlikely position of the embedded stone as a hunting lesion, and suggest the stone was broken during butchery. O'Driscoll and Thompson (2014) have shown that embedded stone during butchery is unlikely, and suggest projectile impact damage is a more parsimonious explanation despite its unusual position, although Milo (1998) presents 17 other instances of embedded stone in KRM fauna where butchery was the inferred cause due to similarities with his own butchery experiments where stone became lodged in bone (1998:122). Others have noted pointed lithic forms likely served many functions in the MSA, as projectiles do ethnographically (Greaves, 1997), and analyses by Kuman at ≠Gi and Florisbad (1989), and Schoville at PP13B (2010) indicate points were often used and deposited from use as cutting tools. A technological shift is evident in HP assemblages, where the frequent production of microlithic blades, crescents, and notched blades imply composite tools and possibly some of the earliest evidence for bow and arrow technology (Clark, 1977b; Lombard and Phillipson, 2010; Brown et al., 2012). Abundant, large-bodied fauna from MSA archaeological sites implicate humans as the primary accumulator (Marean et al., 2000a; Thompson and Henshilwood, 2011), including many so-called 'dangerous' animals (Faith, 2008). Sites such as PP13B, and Florisbad where points have been analyzed and are argued to have not been used as armature tips still have large game (Brink, 1988; Thompson et al., 2010), presumably from active hunting (but see Wadley, 2010b). Given the antiquity of hafted hunting technology and the zooarchaeological evidence, the question is not whether MSA hominins had hunting tools, but what those tools were, how they were used across the landscape, and how the technologies for acquiring resources were invented, maintained as cultural knowledge, and either evolved or lost through time.

Modern humans on the south coast inherited the cognitive capabilities to create hafted hunting technology and rapid cultural ‘ratcheting’ and structuring of the landscape into residential, and logistical foraging groups based on the availability of resources implies a sophisticated system of foraging strategies. Since evidence for hafting and hunting technology has implications for how the cognitive behaviors attributed to MSA foragers, then factors that may influence the discard and archaeological visibility of hunting technology on the landscape needs to be understood. Strategies of technological organization that emphasize serial replacement of broken and worn tools leads to variable discard locations across the landscape rather than focused retooling events at residential camps. Basing our understanding of the evolution of technology solely from assemblages in caves or other highly visible archaeological deposits that tend to be from residential occupations may make certain innovations invisible by restricting the amount of behavioral variability being sampled. By incorporating a more complete sample of landscape-scale technological wear traces, hypotheses about the diversity of hunting technology, toolkit organization, and landscape use strategies can be tested.

4.5 Goals and Hypotheses

In the following chapters, the methodology and results for creating Middle Range linkages integrating behavioral ecology models and experimental archaeology to achieve two research goals relevant to modern human origins are presented.

4.5.1 Goal 1 – Experimental Work

The first goal is to establish linkages between traces of assemblage lithic edge damage distributions and causal agents of *known* taphonomic and behavioral processes. Post-depositional damage is reported to be undirected and random along tool edges (McBrearty et al., 1998), but rarely quantified (c.f., McPherron et al., 2014). In contrast, behavioral wear is often concentrated at frequent areas of use (Tringham et al., 1974). The goal of most use-wear analyses is to identify individual tool function using a reference collection composed of many different tool types, arrangements, and use-actions. However, the multitude of prehistoric and taphonomic wear combinations (and resulting wear-trace equifinality) is rarely addressed because sample variation is emphasized over sample size. As a result, traditional use-wear analysis suffers from a lack of robust statistical testing by which other researchers can assess their results. The work presented in the following chapters provides more general patterns identifiable from archaeological assemblages compared to experimental distributions, with the behavioral/taphonomic processes with the highest likelihood being quantitatively arbitrated. Creating experimental assemblage distributions of edge damage allows behavioral inferences to be made by quantitatively linking to archaeological patterns of edge damage through the nested actualistic chain of inference.

4.5.2 Goal 2 – Archaeological Hypothesis Testing

The second goal of this dissertation is to analyze a cross-section of MSA *cave* and *open-air* archaeological assemblages from across *paleoscape* contexts and will proceed with two objectives. The *first objective* is to identify whether taphonomic processes are entirely influencing archaeological edge damage patterning. The *second objective* focuses on understanding behavioral differences in edge damage formation by testing for differences in how stone tools are used and discarded in coastal/interior and cave/open-air contexts. The following series of hypotheses are made using experimental and behavioral ecology models for how tool use and discard behaviors may differ across the landscape.

4.5.2.1 Hypothesis 1

Stone tools from open-air contexts indicate greater exposure to weathering processes, whereas cave contexts indicate greater exposure to trampling.

Distributions of edge damage from open-air and cave sites will be compared to the fluvial and trampling experiments. Frequency of rolled and water-worn surfaces will be identified and compared between assemblages. Importantly, if archaeological edge damage distributions are not significantly different from the taphonomic damage patterns, then no behavioral interpretations of edge damage can be made from those assemblages. However, if both site contexts are significantly different from the experimental pattern, then fluvial and trampling processes are unlikely to have significantly influenced the formation of edge damage.

4.5.2.2 Hypothesis 2

Sites on the paleocoast will reflect different patterns of hunting and butchery on points, blades, and flakes, compared to sites in the paleointerior.

A vastly different array of plants and animals were available in paleocoastal contexts compared to the paleointerior (chapter 3). Much like today, it is anticipated that during paleocoastal occupation, resources important to human foragers will tend to be distributed patchily (i.e., seal colonies, mollusks, geophyte patches), and the fauna living in coastal Fynbos vegetation tends to be small-bodied (Skead, 1980). For paleointerior occupation (including sites that are today located on the coast, but were located in the interior during periods of lowered sea-levels), it is anticipated that the expansion of a grassland ecosystem south of the modern coastline onto the Agulhas bank would bring with it a more homogenous suite of large-bodied grazing terrestrial fauna such as black wildebeest, giant hartebeest, and long horned buffalo (Marean, 2010b; Compton, 2011; Faith, 2011a). The foraging strategies represented by each analyzed lithic assemblage are likely to vary in response to site context during the time of occupation, and it is anticipated that paleointerior occupation will differ from paleocoastal occupation. Ethnographically, small bodied animals are frequently hunted with snares, traps, and untipped arrows (Churchill, 1993), which would decrease the amount of hunting evidence left on stone tools. If paleocoastal cave sites tended to be residential, long-term occupations, then less intensively used cutting edges will be predicted since long-term residential sites are supplied with fresh stone more regularly (e.g., Binford, 1980; Surovell, 2009; Barton and Riel-Salvatore, 2014). If no significant difference between site proximity to the coastline is observed, then it is possible that MSA foraging patterns were less dichotomous and similar lithic discard behaviors occurred across the landscape. Therefore, by testing for differences in tool use and discard between paleoscape contexts a better understanding of the foraging system on the south coast during the MSA may be gained.

4.5.2.3 Hypothesis 3

Caves will have fewer DIFs and less overall damage; whereas open-air sites will have higher frequency of DIFs and more overall damage.

It is hypothesized that tools discarded in cave contexts will tend to either be towards the end of their use-life, or used very opportunistically depending on whether the cave is being regularly supplied with raw material. Caves will have lower frequency of impact fractures because broken tips are more often discarded on the landscape, frequently at kill sites (Villa et al., 2009a; Wilkins et al., 2012) and because a greater range of activities take place at residential sites, so the relative frequency of hunting tools is lower. It is not clear how retouch, the use of foreshafts, and armature delivery mechanism influence where broken points are repaired or discarded on the landscape. In Holdaway's (1989) model, broken point bases from use as armatures are expected to be more common at residential sites when they are removed from the haft prior to inserting a fresh point, while the broken distal end is 'lost' on the landscape and not returned to camp. Flenniken (1991) has shown that on arrows from North American prehistoric sites, the ratio of base (complete points and proximal bases) to tips (distal tips and midsection) reflect site function - kill sites have a 1:1 ratio of bases:tips, whereas camp sites have a nearly 4:1 ratio of bases to tips. Perhaps counter-intuitively, since broken projectile tips are more likely to contain evidence of impact fractures, and the tip portion is more likely to be deposited in the field, then the expectation may be that the relative frequency of impact fractures will be higher on the landscape than in a residential site, as was shown in Figure 12.

Most archaeological examples of this patterning involve technology that includes a foreshaft where the stone point is physically attached. Fewer studies have addressed how stone points directly attached to a main shaft would be treated after breakage. Foreshafts are advantageous in that they reduce the likelihood of losing the costly main spear shaft, reduce the overall weight that is carried when multiple armatures are carried, and allow for quicker in-field repairs (Churchill, 1993; Ellis, 1997). Their downside is an increased time investment prior to hunting, and higher likelihood of breakage during use (Ellis, 1997). The discard of tips in the field may be related to the discard of broken foreshafts in the field.

Extraction activities such as disarticulation creates more edge damage (Braun et al., 2008b), which will tend to occur outside of cave contexts. Caves tend to be supplied with material; therefore tools are expected to be damaged less intensively. It is anticipated that open-air tools will be damaged more heavily and distributed more similarly to the experimental set of disarticulation tools. If no significant difference between site context is observed, then it is possible that MSA foraging was either highly residential (and thus open-air sites are also residential) or perhaps caves were not as residential as anticipated. Either way, by comparing edge damage patterns across site contexts, insight into the landscape use strategies of MSA populations on the south coast will be gained.

4.5.2.4 Hypothesis 4

Blades from open-air sites will reflect field-butchery patterns of edge damage more closely, and blades from caves will reflect defleshing tasks.

Given that experimental butchery patterns of field-dressing and defleshing tasks can be distinguished (which will be tested in Chapter 6), it is also hypothesized that on average, field-dressing tasks will tend to occur at *localities* on the landscape, and that defleshing tasks will occur more frequently at habitation and residential sites. These tasks will be evident in the patterns of edge damage on the stone tools from these different settings.

4.5.2.5 Hypothesis 5

Temporal change across sites will show shift from spear-technology using points to microlithic and blade-based projectile technology.

Projectile technology arguably appears by 71 ka at Pinnacle Point in the microlithic technology in the SADBS at PP5-6. Many have argued that the backed geometric blades and segments (portions of blades) in the HP is indicative of the first evidence for projectile technologies. However, MSA technologies typical of sequences before and after the HP never totally disappear. If convergent-MSA points were at least sometimes used as spear-points, then the question becomes whether this technology is replaced during the HP, or if the innovations during the HP add technological complexity onto existing technology that is maintained within the cultural system. Given a return to typical prepared core stone tool technologies after the HP, the most parsimonious explanation is that quartzite points were used for the same tasks, or range of tasks, throughout the MSA. The alternative possibility is that tasks completed with quartzite tools become more specialized, while silcrete tools are used for many of the tasks formerly used mainly by quartzite points and blades.

4.6 Conclusion

In order to make statements about MSA technological behaviors on the south coast of South Africa, Middle Range research must be conducted that provides linkages between how humans structured their mobility in the past and present, and between patterns of edge modification recognizable archaeologically and patterns incurred during experimentation today. A model of hunter-gatherer mobility and lithic use was presented, which led to the formulation of a series of hypotheses about MSA technological behaviors on the south coast. Combining experimental archaeology, and archaeological data from coastal and interior caves and open-air sites provides the data with which these hypotheses may be tested. The following chapter provides the methodological procedures that were performed to accomplish these tasks.

CHAPTER 5 – METHODS

5.0 Introduction

In this chapter, the development and history to the methods used in this dissertation are presented. The assemblage edge damage approach arose out of perceived shortcomings with traditional use-wear methods being applied to MSA artifacts on the south coast. Traditional use-wear is performed on fine-grained raw materials, ideally with organic residue preservation. It typically lacks firm statistical footing due to the small sample sizes. The method advocated here documents edge wear instances on fine and coarse grained raw materials using GIS software. These are then used to create an aggregate distribution of damage along tool edges, from proximal to distal, for large samples of different tool types. Generating edge damage distributions for experimental taphonomic and behavioral processes allows post-depositional patterning to be separated from tool use patterns. In the following chapter, these methods are described, and the analytical procedures outlined with which the hypotheses presented in Chapter 4 can be tested.

5.1 Edge Damage Background

The formalization of stone tool use-wear came with the pioneering work of Semenov (1964) published in Russian in 1957, but translated into English in 1964. Others had been interested in the question of how tools were used, but assumptions were made based on morphology, ethnographic similarity, and archaeologist's intuition about how tools "should" be used. Semenov (1964) analyzed tool striations and made comparisons with how metal tools were striated to argue for tool function. In Western countries, use-wear experimentation first became more truly Middle Range with the work of Sonnenfeld (1962) who wanted to know whether stone adzes were used as hoes, and devised a series of experiments to test this hypothesis. Inspired by the English translation of Semenov's book, Tringham and colleagues (1974) developed an extensive experimental collection of stone tools used for a variety of tasks and analyzed them under low-power microscopy to identify patterns of edge damage due to tool use. As discussed in the previous chapter, as archaeological science developed more sophisticated techniques in other fields, analysis of stone tool edge-wear also experienced a fluorescence of methods and techniques for identifying prehistoric function. One branch of use-wear studies sought to identify microfractures on tool edges under low-power microscopes that could be used to determine the orientation of cutting motions and the types of materials being worked (Odell, 1977; Odell and Odell-Vereecken, 1980; Kamminga, 1982). This method has the advantage of being relatively quick, with the ability to analyze large assemblages of tools. The other branch of use-wear studies looks at fine-grained materials under high-magnification for polishes, striations, and abrasion that can be linked to experimental observations of these micro-traces. This method has been argued to be more reliable on some aspects of tool use such as the material being worked, but is very time intensive – both in time spent analyzing per tool, and time required for training. Micro-traces of residues have been explored on tool edges using new instruments capable of detecting blood (Kooyman et al., 1992; Downs and Lowenstein, 1995), plant and animal tissues and polish (Briuer, 1976; Anderson, 1980; Kealhofer et al., 1999; Lombard, 2004), and ochre and mastics from hafting (Lombard, 2007b). More recently, amid calls for standardization of all these methods (Evans and Donahue, 2005; Evans et al., 2014), some researchers are developing machine-learning methods (Stevens et al., 2010) and high-resolution scanning of tool edges and polishes (Evans and Donahue, 2008; Evans and Macdonald, 2011; Macdonald, 2014) to classify worn edges and remove the subjectivity in use-wear that has long been criticized (Newcomer et al., 1986; Unrath et al., 1986; Shea, 1987). While not yet fully realized, such methods hold promise of a completely objective methodology for confidently identifying prehistoric tool use.

The current methodology for inferring tool function in the South African MSA record has several issues that this project seeks to overcome. (1) Identifying residues is dependent on good organic preservation (Crowther and Haslam, 2007), which is uncommon at the timescale of the MSA. (2) Traditional "high-powered" microwear studies (i.e., polishes, striations) are generally only visible on very fine-grained stone tools, and while present, are a minority of raw materials in the MSA (Rots et al., 2006), which has limited the utility of microwear studies during this time period. (3) Due to time constraints, residue and microwear analyses are often on a small portion of an assemblage studied based on *a priori* expectations rather than the complete, unbiased assemblage. These pre-selected pieces are often retouched, and although present in MSA assemblages, are much less common than at contemporary sites in Europe or the Levant. (4) Most use-wear analyses are based on subjective similarities between individual archaeological and experimental tool sets, which although informative, lack quantitative means of testing researcher assertions, and blind-test results have shown a need for significant improvement. (5) In terms of impact fracture frequencies (DIFs, as defined in Chapter 4), only a handful of studies have identified how taphonomic processes may form DIFs, leading some to question how 'diagnostic' of projectile use these fracture types could possibly be (Sano, 2009; Pargeter, 2011b). (6) Morphometric variables indirectly linked to tool use as hunting tips are based on the range of variation in ethnohistoric tool observations, and may not be representative of Pleistocene technologies. With few alternative methods for understanding how stone tools were used in the past, this aspect of human evolution has been largely unknown. Developing methods to not only make inferences about stone tool use, but also how tool use varied across the landscape is critical for understanding technological adaptations during the MSA.

Many current studies still use high-powered and low-powered microscopy to address questions of tool function (Lombard, 2005a; Rots, 2013); however as will be described in this chapter, this dissertation takes a different approach in many respects. The operational sequence of traditional use-wear is generally along the following: 1) create a well-controlled experimental collection with a wide variety of tool types used for a wide variety of function. 2) Study the experimental tools and learn how to identify where use damage occurred, and how to classify it. 3) Study a selected portion of archaeological stone tools. 4) Identify individual tools that have characteristics subjectively similar to pieces in the experimental collection. 5) Disregard taphonomic processes as possible agents of wear formation. Making individual comparisons and classifications makes it difficult for other researchers to evaluate the claims made by use-wear analysts. It could be argued that the blind-test provides the means by which use-wear claims may be judged, however even blind-tests are difficult to evaluate since there is no standardized protocol for how they are administered, how they are scored, or how they are reported (Young and Bamforth, 1990). The diversity of archaeological assemblages far exceeds the diversity of experimental lithic collections, and it could be argued that unless blind-tests are performed on the same raw material as the assemblage being analyzed, then the results have little meaning anyway.

Alternatively, the method advocated here is an assemblage-scale, probabilistic approach, or simply the “assemblage approach” (Wilkins et al., 2015). This method overcomes problems with the traditional use-wear analysis reliance on linking individual features on individual tools, and the subsequent lack of statistical power to make confident inferences about wear formation causes. With the assemblage approach, populations of damage on experimental tools are compared to populations of damage on archaeological tools. It is difficult to assess the individual function of individual tools, but through the analysis of a population of tools, patterning that is consistent with some processes over others can be quantitatively assessed. The operational sequence is as follows: 1) create large samples of well-controlled experimental tools exposed to both taphonomic and behavioral processes so that patterns can be analyzed on distributions. 2) Photograph experimental tools both before and after and map damage to exact location on tool edge for analysis and so the trace-agent causal linkage is documented. 3) Analyze complete archaeological assemblages of tools. 4) Quantitatively compare the frequencies and distributions of archaeological edge damage to the experiments to make confident statements about likely causes of edge damage patterning. 5) Identify taphonomic edge damage patterning, and utilize to understand site formational processes and prehistoric edge damage dynamics.

To understand variability in MSA tool use, there is a need to develop methods that quantitatively examines such assemblage-scale patterns. Bird et al. (2007) use image analysis and GIS to examine the distribution of edge damage from a sample of points from PP13B. In their analysis, Bird et al. mapped edge damage onto shapefile outlines of lithic artifacts. Using the centroid of the artifact, they created polar distributions of edge damage using the degrees around the tool relative to the midline. This approach has the advantage of precisely recording edge damage in a geospatial environment with very large samples, from which statistical tests of whether damage is distributed randomly or non-randomly may be performed and is more objective than traditional use-wear because it is based on aggregated assemblage distributions and no attribution of individual edge damage features is made. With polar statistics, Bird et al. (2007) argue points from PP13B exhibit patterned damage, unlikely to be the result of taphonomic processes. Schoville (2010) continued this line of research by looking at both the frequency and distribution of edge damage on every point from PP13B. Schoville also used GIS to record edge damage by mapping edge scars to an image of the tool, creating a permanent record of damage observations. Schoville then analyzed the perimeter of tool edges using common linear statistical tests by dividing points into edges based on the segment between point proximal platform and distal tip (Schoville, 2010; Schoville and Brown, 2010). The frequency and distribution was then compared to random, or uniform, distributions with the Kolmogorov-Smirnov test (Schoville, 2010) and to an experimental distribution of points used as spear points (Schoville and Brown, 2010). These results demonstrated that the points from PP13B have edge damage that is non-randomly distributed, and significantly different from spear-tipped armatures. Wilkins et al. (2012) used the assemblage approach to analyze the damage patterns on 500,000 year-old banded ironstone points from Kathu Pan 1 (KP1), South Africa. The edge damage at KP1 was distributed significantly different from random, and consistent with experimental spear-points using knapped ironstone points. This result establishes an early time period for hafted hunting technology in the early MSA (Wilkins et al., 2012).

5.1.1 Objections

The assemblage edge damage method has recently been challenged by Rots and Plisson (but see Lazuen, 2014; 2014). In their view, function can only be established by observing wear traces on individual archaeological tools that can be linked to a "large" referential collection. To establish projectile function, Rots and Plisson (2014) argue that multiple "diagnostic" traces must be observed on an individual tool that are suggested to be indicative of projectile function. However, this assertion has not been shown in the literature, neither statistically nor anecdotally. Rots and Plisson (2014) also suggest that post-depositional damage cannot be understood within an assemblage of tools because there is no way to sort the "blur" of taphonomic edge damage from behavioral patterns. Wilkins et al. (2015) argue that at an assemblage scale, post-depositional damage is distributed differently than behavioral damage, which allows it to be statistically differentiated. Assemblage scale analyses allow for quantification and statistical evaluation of archaeological patterning to contextualize behavioral meaning in ways that individual artifact approaches cannot (Riel-Salvatore et al., 2008).

An important point to make here is that the assemblage approach is not argued to replace the existing microscopic use-wear methodology, but to move lithic functional analyses forward by placing lithic modification observations into a universal format (GIS) and provide more objective and quantitative tools for analyzing those observations. The focus of this dissertation is on macroscopic edge damage analysis because large samples of tools can be analyzed on coarse and (relatively) fine-grained raw material types (i.e., quartzite and silcrete, respectively), distributions of damage can be statistically compared to experiments, and distributions of lithic edge damage are detectable even at low exposure durations (Shea and Klenck, 1993). Analyzing assemblage patterns has stronger statistical power compared to interpreting individual wear traces. Here, the existing methodology is improved upon and populations of stone tools from *entire* MSA assemblages at multiple scales are compared to a wider variety of experimental processes.

Evans (2013) argues that the assemblage approach suffers from a lack of blind-testing by which other researchers can judge its efficacy. Blind-tests are important tools to critique the practitioners of microwear and improve the methodology. The assemblage edge damage approach does not lend itself as easily to blind-testing validation for several reasons. First, it is an assemblage approach, therefore individual classifications that are either “true” or “false” are not made. The only observer classification is which areas of an edge are damaged or not, which is akin to identifying flake scars at a small-scale, which is not difficult. Secondly, the edge damage method makes probabilistic statements using statistical methods instead of relying on ‘expert opinion’ after adequate blind-test proficiency. In other words, with the assemblage edge damage approach, statements are made about whether two distributions are from the same populations with 95% confidence; with blind-tests, the probability of wear trace attribution being correct is relative to the analyst’s performance on a limited set of blind-test scores (often less than 20 flakes; Evans, 2014). These test scores are frequently around 50%, although some researchers have achieved 90% accuracy (Rots, 2006). Since the assemblage damage method has an alpha of 0.05, it is a more conservative approach to questions of tool function.

5.1.2 Shape and Edge Angle

Morphological characteristics of analyzed tools can influence edge damage formation and must be accounted for. Protruding edges form damage due to cutting motions more quickly, while scraping damage forms concave notches (Tringham et al., 1974). The frequency with which tool edges will form visible damage is also influenced by lateral edge angle. Thinner edges form damage more readily than steeper angles (Grace, 1989). The complicating aspect of edge angle, is that on some types of detached pieces, edge angle may be non-randomly distributed (McPherron et al., 2014). Since edge angle is correlated with taphonomic edge damage formation, if edge angles are non-randomly distributed then edge damage may be non-randomly distributed as well. McPherron et al. (2014) found that edge angle on flakes was non-randomly distributed, but did not examine points or blades. Schoville (2014) found that trampling edge damage on silcrete blades formed randomly, implying that the edge angle may not be patterned on blades as it is on flakes. Comparing edge damage to a random or uniform distribution as a proxy for taphonomic damage is reasonable when there is no systematic patterning in edge angle, but when there is, or when the distribution of edge angle is unknown, it is necessary to compare with empirical experimental assemblages that include the same variability in edge angle as archaeological assemblages. In other words, finding that an assemblage distribution of damage is significantly non-random (i.e., Bird et al. 2007; Schoville, 2010) does not necessarily imply behavioral edge damage formation. To account for both tool shape and edge angle in this dissertation, damage distributions will be compared to random, but also to empirical taphonomic edge damage distributions from lithic material separated into morphologically similar categories as archaeological tools so that edge angle is accounted for. The three categories that will be analyzed separately are (1) blades, defined as having a maximum length greater than two times the width; (2) points, defined as detached pieces greater than 2 cm in maximum length with converging lateral edges; (3) flakes, complete detached pieces that terminate in a distal feather, hinge, overshoot, or step (when confident not a snap). Since there is no reason to suspect the distribution of edge angle is different between the experimental and archaeological tool shape categories, the edge damage patterns account for variation in edge angle – whether random or non-random. Performing the taphonomic experiments to generate edge damage distributions is a crucial aspect of this research since no methodology yet exists to quickly obtain edge angle data at the same scale as the edge damage data.

5.2 Edge Damage Methods

5.2.1 Edge Damage Populations

Central to this project is the motivation for generating statistically meaningful experimental populations of lithic edge damage that can be used to infer prehistoric behavior from archaeological distributions (Table 4). Since any behavioral input to edge wear occurred in minutes or hours and post-depositional processes have been acting on artifacts for at least 50,000 years, the first step in analysis must be testing whether the patterning, or lack thereof, is consistent with taphonomic processes rather than behavioral tool use. Two of the most common post-depositional processes that influence artifact movement are trampling and fluvial saltation. Therefore, a population exposed to both of these processes were generated. The next step is to generate behavioral processes that can be compared. Two behaviorally meaningful uses of stone tools are as butchery cutting tools and as armature tips. Although stone tools can be, and likely were, used for a wide range of tasks (Shea, 2011a), these two functional categories are frequently juxtaposed in MSA studies. Some studies emphasize tools used for cutting tasks (Kuman, 1989; Iovita, 2011), others emphasize their use as armatures (Lombard, 2005a; Brooks et al., 2006; Sisk and Shea, 2011), and ethnographically points were often used as both (Greaves, 1997). Stone tools have been used for general cutting and butchery purposes since the origin of the archaeological record (Semaw et al., 2003; McPherron et al., 2010). However the landscape variability in this behavior is not well known, especially on the south coast MSA where the availability of terrestrial animals was in flux due to changing coastlines and precipitation (Marean et al., 2014). By limiting the comparisons to ‘butchery’ and spear-tipped armatures, the evidence for landscape behavioral change in the MSA can begin to be evaluated. Additionally, these two tasks reflect differences in where extractive behaviors occur on the landscape because armatures are more frequently discarded on the landscape (such as kill sites, Villa et al., 2009a) whereas generalized cutting tools may be discarded more frequently in residential sites either sequentially or during retooling prior to logistical forays (Kuhn, 1989; Shea, 1991) because tools are discarded when exhausted in a serial fashion (Kuhn, 1989:38). Future work will expand the range of variation in tool distributions, but the scope of this dissertation is tightly focused on the edge damage patterning created by trampling, tumbling, butchery, and spear-tipped armatures.

Table 4. Summary of tool use experiments in this study.

Experimental Processes	**Description**
Spear Armatures	Pointed flakes shot at four culled springboks with a calibrated crossbow
Butchery Tools	Unhafted and hafted knives used for butchering three domestic pigs
Trampling	Grids laid out at small farm with low, medium, and high activity for five months of trampling by cows, unshod horses, and wildlife
Tumbling	Commercial rock tumbler with loose gravels used for 5 minutes per tool

5.2.2 Edge Damage Recording Procedures

With one exception (Vleesbaai), all tools were analyzed and recorded following the same method. The method involves taking photographs of tools being studied, georeferencing those images in GIS, creating shapefiles and mapping the damage locations, and then bringing the shapefiles into a format to analyze relative damage distributions. This procedure creates an archive of digital shapefiles that encode the edge damage spatial information and allows for a variety of analyses, but the focus here will be on the frequency and distribution of edge damage on complete flakes, blades, points, and retouched pieces.

Every tool was first photographed on the dorsal and ventral surface with a DSLR camera with macro lens onto a grid using a portable light tent to ensure uniform clarity and color correction ability. The camera was mounted to a tripod with adjustable horizontal arm to ensure stable imagery, and every photograph is taken from an appropriate height above the artifact to minimize image distortion. Digital images were then georeferenced in ESRI ArcGIS 10.2 using a background grid for landmarks (Figure 16). For every specimen a shapefile was created for both the dorsal and ventral that contains the specimen number, damage classification codes, and damage metrics. A polygon is then traced around each specimen.

Every specimen was then analyzed for macroscopic fractures under a binocular stereomicroscope with strong incident lighting. A maximum of 30x magnification was used to identify the nature of damage. Using the digitized image as a guide, individual edge damage occurrences are traced around individual damage scars by visually identifying on the imagery the outline of edge damage identified under microscopy. Each damage polygon is categorized based on visual morphology (e.g., crushing, snap, rounded - following Tringham et al. (1974)); and retouch is defined as continuous invasive edge modification with negative bulbs of percussion.

5.2.3 Cumulative Distributions

Each shapefile was standardized based on the location of damage from the platform to tip. For non-pointed artifacts, the tip is defined as the most distal point of a flake perpendicular to the platform, roughly synonymous with where "technological length" is taken. An excel template was then used to calculate total edge length and scale to 100. This removes the effect of size differences so that edge damage locations along

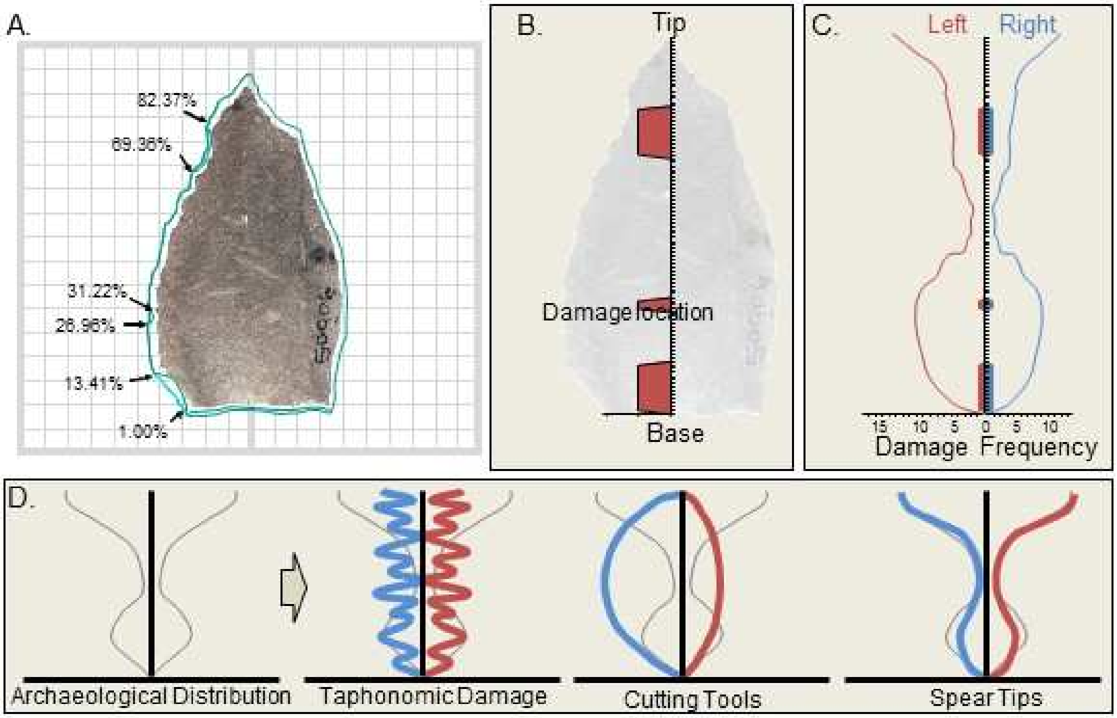

Figure 16. Collection of edge damage data. A) Photographs taken from dorsal and ventral views onto a grid, then georeferenced and the outline digitized. Edge damage occurrences are "cut" out of the tool perimeters. B) The tool is divided into left and right sides for analysis, and the relative location of damage is calculated so that tool size is standardized. C) Archaeological assemblage damage is aggregated by adding damage locations into a frequency distribution. D) Archaeological assemblages (grey) may then be statistically compared to experimental distributions (red/blue).

the tool edge are all relative to the standardized tool edge length between the platform and tip. The resulting data matrix consists of each tool face and edge (i.e., dorsal left edge of specimen 305308) and 100 columns where the presence/absence of edge damage is expressed as either "1" (present) or "0" (absent). For instance, if there was an edge damage scar that was 3% of the total edge length centered halfway up the edge, then columns 49, 50 (the exact midpoint), and 51 would have a value of "1" for that edge, while the remaining 97 locations would have a value of "0". These damage counts can then be totaled for the location (sum of all damage that occurs at a single relative location), for a tool edge, for a complete tool, for a stratigraphic level, and higher scales of analysis. For example, if there were 100 tools, and every edge of every tool was completely damaged, then the total amount of damage possible would be 100 tools * 4 edges * 100 locations each edge could possibly be damaged in = 40,000. However, in reality the amounts of damage are way lower than this, but this illustrates how damage counts may be totaled, and undamaged areas excluded.

Cumulative distributions of edge damage frequency along tool edges are compared with the Kolmogorov-Smirnov (KS) test. The KS statistic is used to compare two cumulative distributions of edge damage in order to test whether both samples are drawn from the same distribution (Shennan, 1997). This statistic has the advantage of not making assumptions of what the underlying distributions are, and in that way is similar to bootstrapping methods. With each distribution represented by the cumulative frequency of edge damage from the platform to the tip (Figure 16), the KS test subtracts distributions and compares the maximum observed difference (in percentage) to a calculated D-statistic set to the desired confidence level ($\alpha = 0.05$). If the maximum difference is greater than the D-statistic, the null hypothesis (equal distribution) is rejected. The locations of edge damage along the edges of lithic points are the distributions being compared (Figure 16). Distributions are also compared to a theoretical, “uniform”, distribution that reflects edge damage that formed with equal probability along the tool edge. Although this is roughly equivalent to a “random” distribution, the term “uniform” is used for these analyses to clarify that the comparison was not randomly sampled or resampled, but simply a uniform distribution of edge damage along the tool edge. Many experimental studies have demonstrated that damage from different activities creates different edge-wear distributions (Tringham et al., 1974;

Keeley, 1980; Rots et al., 2011) and the KS statistic helps tease apart these processes based on the observed damage patterning.

5.2.4 Best-Fit Models

Human behavior is extremely variable, and there are more possible combinations of tool types, hafting arrangements, and tool uses than in any experimental collection. The KS statistic is a hypothesis-testing approach (sensu Hilborn and Mangel, 1997), but given variability in assemblage composition it is expected that many sites may be significantly different from all experimental populations. Therefore, the experimental distributions of lithic edge damage are treated as models and assessed against the archaeological patterning, and the best model can be quantitatively arbitrated using a model selection inference criterion called the Akaike information criterion (AIC), which not only accounts for the increase in fit with added parameters (e.g., multiple edge damage distribution process combinations), but also penalizes a model for having added parameters without sufficient increase in the explained variance, which prevents over-fitting (Burnham and Anderson, 2002). Results of this maximum likelihood approach provide the best possible model given the currently available data, making them comparable among assemblages (Hilborn and Mangel, 1997).

This statistical procedure is an advance over previous work that relied solely on hypothesis testing because it is multivariate, less sensitive to low sample sizes, and less susceptible to Type II errors (Akaike, 1974; Hilborn and Mangel, 1997). The stepwise regression models were analyzed in JMP Pro 11 statistical analysis software using a forward stepping (additive) procedure where the term with the lowest *p*-value is added first, and then subsequent terms are added and removed until the best model is found. The best model is one with the lowest value for AIC, but if the change in AIC (ΔAIC) is <2, then the models are considered equivalent and no "best" is selected. Each term is given equal weight to enter the model, but will explain different amounts of the residual error. In other words, a best model with multiple terms (e.g., spears + trampling) will be selected based on the overall improvement in model fit, but the terms will explain different amounts of the variance in observed archaeological edge damage patterning.

The results are presented for two models. The first is the result from fitting a single parameter to the archaeological data. The resulting best-fit variable AIC and R^2 values can then be compared against a full-set parameter model where the model fitting algorithm sequentially adds and subtracts parameters until a model with the lowest AIC is reached. With n-parameters, the best fit model can contain anywhere from 1 to n variables. When $n>1$ in the full-set model, the R^2 value will always be lower than the single-fit model. On many models, the R2 values are low, even though the likelihood procedure identified it as the best-fitting model. Highly variable data can produce low R2 values, even though a significant trend has been fit. Given the multitude of processes that can influence edge damage formation, it is unlikely to find a perfect fit. However, the model-fitting procedure identifies the most likely process or combination of processes *given the currently available data*. Therefore, the model that is chosen is selected based on quantitative criteria, but is subject to further refinement in the future as additional experimental processes are added as potential terms for the model fitting. The methodology outlined here should serve has a baseline for future likelihood approaches to lithic use-wear and functional analyses.

An example of this procedure is illustrated in Figure 16D. If the first panel is the archaeological distribution being analyzed, the model-fitting procedure will systematically add and subtract parameters for trampling damage, cutting damage, and projectile damage, until a best-fit combination with the lowest AIC is obtained (likely just the “spear tip” model in this example).

5.3 Taphonomic Experiments

Stone tools can be subjected to a variety of processes during the production, use, and discard. Archaeologists are generally interested in the behavioral component of an artifact’s life history. Once artifacts are discarded, trampling and fluvial transport can alter the provenience and cause breakage to lithic material. Some of this post-depositional damage can appear similar to behaviorally caused damage, and accounting for this equifinality is the first priority for a functional analysis of lithic edge damage analysis. In addition to refining behavioral interpretations, post-depositional patterning may provide insight into some other aspects of site formation, such as walking paths and occupation intensity.

All stone tools used in the following experiments were knapped by Kyle Brown using raw-materials obtained from primary sources near Mossel Bay, South Africa. The raw-material was obtained from some locations where no permit was required, although a permit was obtained for collecting geologic samples as part of the NSF funded Paleoscape Modeling Project (NSF #BCS-1138073 to C. Marean). All silcrete was heat-treated prior to knapping following Brown et al. (2009). Silcrete and quartzite were knapped using hard-hammer percussion and punch techniques similar to MSA assemblages (Soriano et al., 2007).

5.3.1 Trampling

After being discarded and prior to burial, stone tools are vulnerable to being stepped on by humans and animals. There have been numerous studies directed at understanding the effects of trampling on stone tools. Several factors have been shown to influence the production of trampling damage to flakes, including raw material, the duration of trampling, the density of artifacts, and how compact the sediment is. These factors also influence the spatial disturbance of artifacts.

Unlike previous studies of trampling that tend to be short, focused, intentional trampling events (Shea and Klenck, 1993; Eren et al., 2010; Pargeter, 2011a; McPherron et al., 2014), for this experiment a long-term study site was used. Artifact burial is likely a process on the order of weeks or months (if not years), therefore a long-term study site is more applicable to the archaeological record than 30 minutes of human trampling. These experiments were performed at the Alpen Cellars property winery in Northern California that also maintains a small herd of cattle, two unshod horses, and is home to a variety of wild animals such as deer, bear, and small mammals passing through (Figure 17). Three different contexts were selected for trampling sites based on the degree of animal activity that was expected. The high-intensity site is a coral used periodically to restrict the movements of the cattle prior to being transported off-site. Horses and cattle are periodically fed in the coral, attracting their presence frequently. The ground surface in the coral is barren, and the sediment is soft clayey-silt, that turns into mud during rainstorms. Although substrate has been shown to influence the amount of damage that occurs due to trampling, prior studies have not found significant differences in the distribution of damage due to substrate (Pryor, 1988). The medium-intensity site is

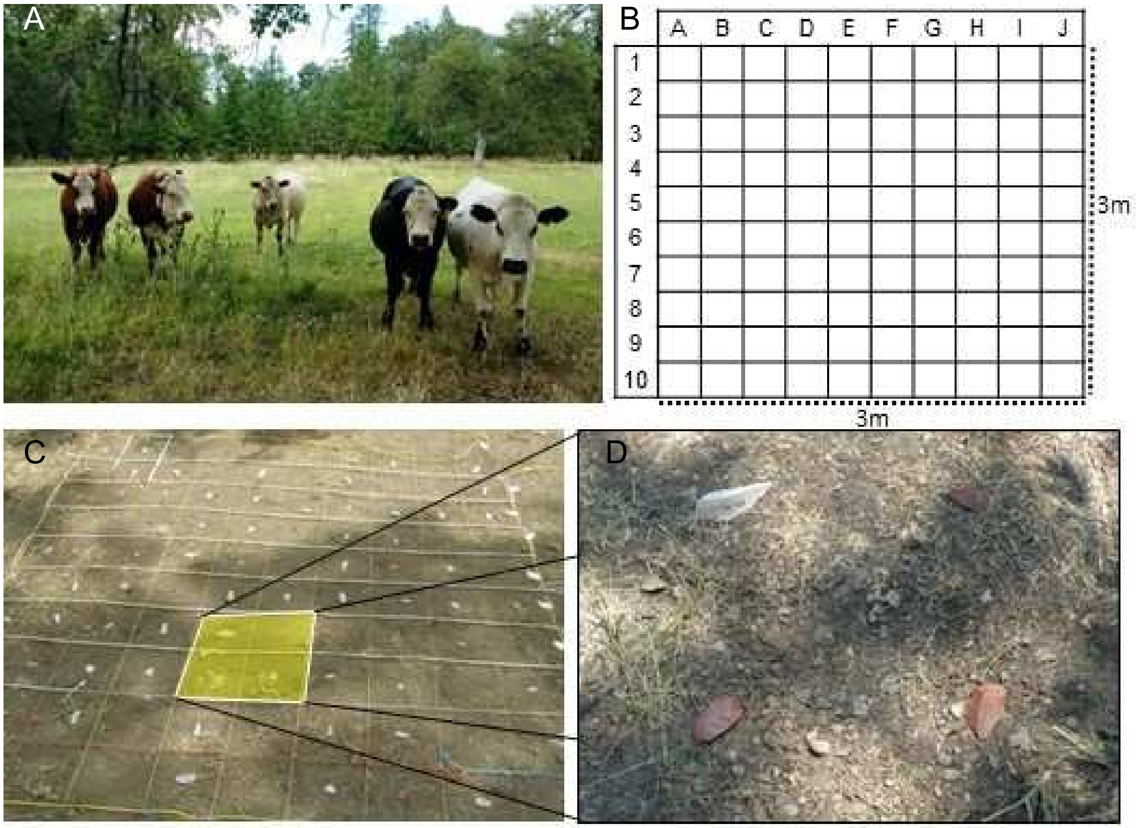

Figure 17. Trampling experiment layout. A) Cattle preparing for trampling. B) Grid used at each site. C) Grid on the ground. D) Tools pre-trample.

adjacent to a cattle trail that leads to the coral, located on a small grassy field between two water culverts. Animals would pass through this area, and occasionally graze on the grasses, but it is not a large area nor a constrained area in which intensive activities would take place. The area is surrounded by deciduous trees, and the leaf-litter was raked clear prior to laying out the flakes. The soil is a silty loam, and highly organic with grasses, roots, and weeds present. The low-intensity site is located on the edge of a large field. While the area is occasionally grazed by cattle and horses, it's a large area and no repeated concentrations of animals was anticipated. This area is a fluvial silty floodplain, mostly covered with perennial rye grasses (non-native). Some small granite and shale cobbles were noted in the area. This area was not raked clear, as the leaf-litter was much lighter than in the medium-intensity area.

Motion-sensitive digital cameras were used to monitor the actual activity of these three areas. Similar “camera-traps” are used to monitor wildlife activity by hunters, biologists, and conservationists all over the world, and are widely available. A camera was placed ~2m high (above cattle height) on nearby trees, with an empty 16 GB SD memory card. These cameras are rated for 6 month-battery life, but the batteries were changed after 3 months (October) to ensure functionality.

At each trampling site, 100 flakes were used consisting of 40 quartzite, 40 silcrete, and 20 quartz and ironstone flakes. A variety of shapes and sizes were used (see Appendix A). Flakes were laid out in a 3 x 3m grid, divided into ten evenly spaced columns (A-J) and rows (1-10) using string, so that 100 cells of equal 30x30cm size were created. This allows each artifact to have a buffer around it that may be less realistic for comparisons with cave and rockshelter settings, but it is important to establish a baseline of damage patterning before incorporating increasingly complex variables. Metal stakes were driven into the corners of each trampling area to ensure recovery after 6 months of trampling. A stratified-random assignment of flakes to trampling area, column, and row was used. Flakes were then laid out by alternating dorsal and ventral side-up in the center of each cell (established by using a straight-edge to connect the corners and placing the flake in the center “X”). In this way, each trampling site was randomized, containing equivalent frequencies of flake raw-material and side-up. The layout of each trampling area is shown in Appendix B.

After 5 months of exposure (August – December, 2012), the tools were collected prior to the onset of winter when snow cover could make recovery difficult. Unfortunately a total station wasn't available when the tools were laid out, but a Topcon Total Station was used during recovery to piece plot the location of each tool. Since the starting position of each tool is known relative to the corners of the 3x3 grid, starting coordinates were able to be retro-calculated by obtaining the coordinates of the grid corners, and then offsetting for each cell. For instance, cell A1 would be in the Northwest corner of each grid, and the center of the cell is 15cm south and 15cm east of the corner coordinates. Each tool that was recovered in-situ was piece-plotted to total station, and the side-up was recorded. This allows for tool recovery rates, disturbance distance, and side-up "flipping" to be calculated for each trampling area.

5.3.2 Rock Tumbler

Chambers (2003) has shown that during flume experiments, lithic damage only formed during artifact saltation. A water-filled rock tumbler is often used by geologists to mimic the effects of long-term fluvial saltation in a short amount of time (e.g., Argast et al., 1987; Smith and Nelson, 2003:8). In this experiment a mixture of coarse gravels (avg. 26mm length), water, a quartz hammerstone, and

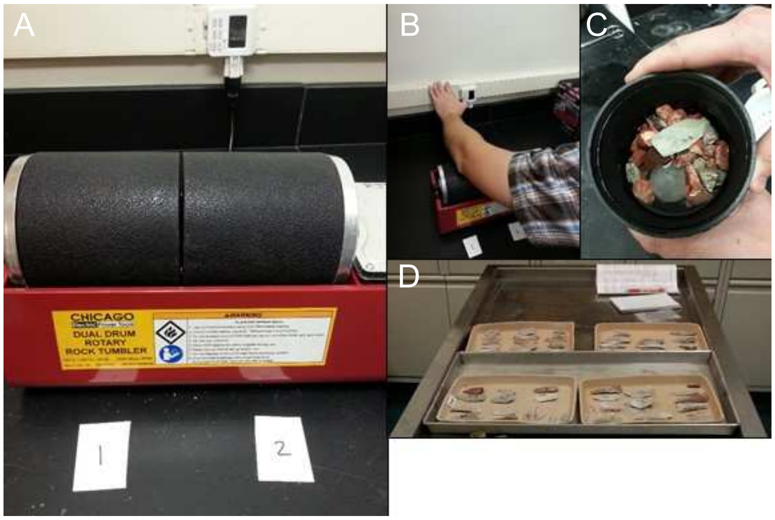

Figure 18. Rock-tumbler setup. A) Two drums. B) Digital timer switch. C) Drum with water and gravel matrix. D.) Tools after tumbling laid out to dry.

individual silcrete and quartzite flakes were placed into a two chamber commercial rock-tumbler to simulate the impact of fluvial activity on stone tool edges (Figure 18). The mass of each barrel including water, gravel, and hammerstone was similar (Barrel 1 = 422g; Barrel 2=434g). Sixty tools evenly split between quartzite and silcrete were prepared for this experiment. Tools were paired so that a silcrete flake and quartzite flake of similar size were run simultaneously in one of the two barrels. The barrels were alternated between raw-materials after each trial run so that neither quartzite nor silcrete were in the same barrel. After trial and error, a duration of 5 minutes was decided on, which created some damage without completely rounding all the edges.

5.4 Behavioral Experiments

Experimental collections of stone tools with both known taphonomic and behavioral wear patterns are needed to understand archaeological patterns of lithic edge damage. At the artifact scale, many types of stone breakage are indistinguishable between behavioral and depositional processes. It is often argued that post-depositional damage tends to be undirected and random along tool edges (McBrearty et al., 1998) and that, in contrast, behavioral wear is concentrated at frequent areas of use (Tringham et al., 1974). The goal of most use-wear analyses is to identify individual tool function using a reference collection composed of many different tool types, arrangements, and use-actions. However, the multitude of prehistoric and taphonomic wear combinations (and resulting wear-trace equifinality) is rarely addressed because sample variation is emphasized over sample size. As a result, traditional use-wear analysis suffers from a lack of robust statistical testing by which other researchers can assess their results. This is exemplified in the recent debate over the function of 500,000 year old points from KP1.

In their critique of Wilkins et al. (2012), Rots and Plisson (2014) suggest that for a tool to be considered to have had functioned as an armature, it has to exhibit, “two wear features”. This assertion is not referenced, and has no statistical reasoning behind it. Assertive statements such as, “…more than 50% of the pieces could hardly have been used in any way other than to tip arrows…” (Lombard, 2011) and “this pattern is interpreted as being caused by a thrusting spear that is turned (twisted) to one side (the right) immediately after insertion…” (Rots et al., 2011) are presented as fact, often with little supporting statistical analyses with which other researchers can evaluate the claims. This project seeks more general patterns identifiable from archaeological assemblages compared to experimental distributions, with the behavioral/taphonomic processes with the highest likelihood being quantitatively arbitrated.

5.4.1 Spear Armature Tips

A calibrated crossbow was constructed following Shea et al. (2001) to create experimental patterns of edge damage from thrusting spear use (Figure 19). Experimental points similar to those recovered from PP13B were replicated by K. Brown using quartzite local to the Pinnacle Point caves (n=62). Each convergent flake was hafted to a wooden dowel using a combination of *Acacia karroo* mastic and cow (*Bos taurus*) tendon (Figure 19). Each experimental point was initially thrust once and then examined for edge wear. Each surviving point (i.e., still forming a point) was thrust until a catastrophic break occurred, up to a maximum of six trials. The crossbow was calibrated to 28 kg of draw force similar to Shea et al. (2001) and was kept constant for each replication. Four

Figure 19. Spear armature setup. A) Quartzite point hafted. B) Points drying in kiln. C) Point lodged in carcass after being fired. D) Calibrated crossbow setup.

springbok carcasses (*Antidorcas marcupialis*) culled from a nearby ranch for the purpose of experimentation and consumption served as the target.

5.4.2 Butchery

Three butchery experiments were completed using domestic pigs obtained from small-scale residential farms located near Arizona State University. These experiments were all performed by an experienced butcher, hunter, and licensed journeyman farrier with extensive knowledge of ungulate anatomy, Jeremiah Harris. A single butcher was used to keep butchery technique constant and remove inter-experimenter variability in stone tool use. A total of 60 tools were prepared for the butcher.

Each pig was dispatched using modern techniques, but all subsequent butchery was performed using a combination of quartzite and silcrete tools. In addition to unhafted

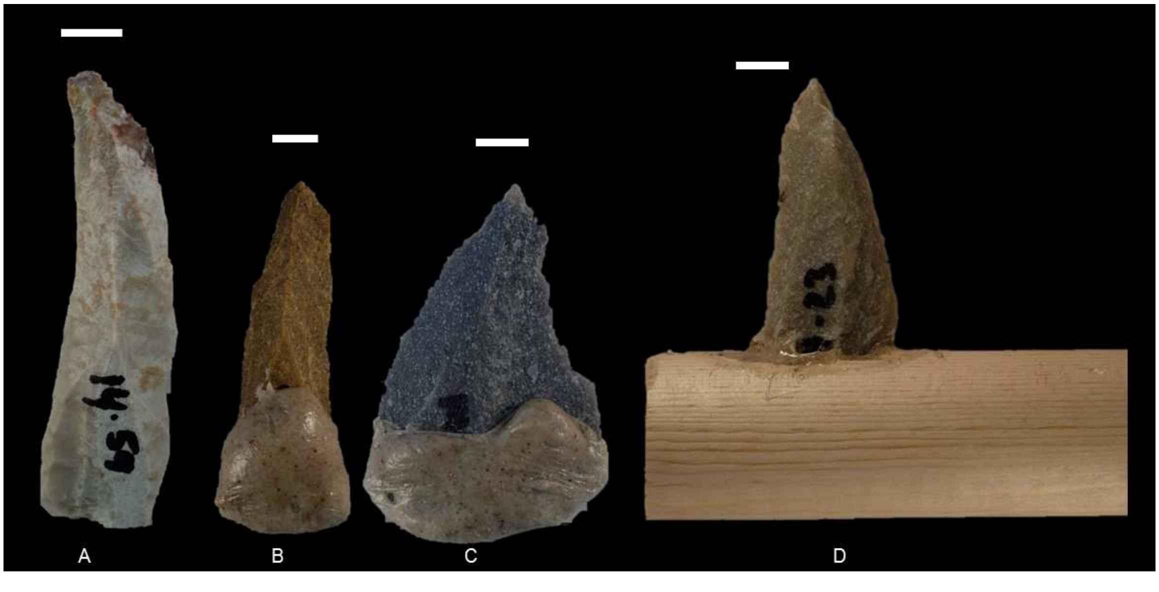

Figure 20. Butchery tools. A) Silcrete, B) silcrete with mastic, C) quartzite with mastic, D) quartzite in slot haft with mastic.

Figure 21. Field dressing during butchery.

tools, two basic hafting styles (Figure 20) were made using mastic obtained from commercial grade acacia gum ("gum Arabic") following designs used by Australian Aborigines and traditional *leillara* blades (Tindale, 1965). While there are numerous possibilities for hafting methods, these two strategies involve the fewest techno-units (Oswalt, 1976), are well known from the ethno-historic record, and serve as a starting point for the assemblage edge damage method. The powdered resin was mixed with water over low heat on a stove using an initial ratio of 2.5g resin, 2.5g water, and 1g sand, following the recipe provided by Zipkin et al. (2014). The mixture was allowed to air dry until tacky, then applied to stone tools. Ten quartzite MSA points were lodged into 20cm long hard-wood handles using a slot-haft, then reinforced with the mastic mixture. Mastic 'globs' were applied to both quartzite points and silcrete blades following Tindale (1965).

Figure 22. Defleshing butchery.

The butchery was divided into two stages that represent different activities in order to test whether there was a difference in behavioral signature between the two. The first stage was the initial "field dressing", where the animals were eviscerated, skinned, and disarticulated into manageable units as shown in Figure 21. The second stage of "defleshing" involved cutting the meat from around the bones and reducing conjoined elements into parts that could be efficiently managed while cooking shown in Figure 22.

5.5 Archaeological Assemblages

The analyzed archaeological assemblages cover a cross-section of MSA *cave* and *open-air* assemblages from across *paleoscape* contexts (see section 6.2 for archaeological results and sample sizes in Table 20). Data have been collected periodically since 2007, and with some adjustment, have remained largely the same throughout the data collection period of this dissertation.

5.5.1 Die Kelders Cave 1 (DK1)

DK1 is a coastal cave located near the town of Gansbaai in the winter rainfall region of the CFR. Edge damage data were collected at the Iziko South African Museum. Only the lithic assemblage from the 1995 excavations, layers 6 through 14, was used for the analysis since the database from A. Thackeray was kindly made available. The 1993 excavations were primarily LSA and were not analyzed here. From the 1995 excavations, the complete assemblage of convergent points (n=85) were located and analyzed for edge damage under 30x power using a binocular stereomicroscope with strong incidence lighting. These points are described as "convergent flakes" by Thackeray. Unfortunately, due to museum upgrades subsequent to my brief 2010 visit, the DK1 collection was in storage and I was unable to sample flakes and blades from DK1.

5.5.2 Vleesbaai

Vleesbaai (VB) is an open-air locality approximately 10 km west of Pinnacle Point. Three areas have been intensively surveyed along the raised dune sands and red paleosols where dense artifact scatters occur (Oestmo et al., 2014). In field data recording began at Vleesbaai in 2010. In field edge damage analysis began in 2012, and the methods differed from the other sites analyzed due to the constraints of field recording. At VB, no artifacts were collected. Instead, every artifact was coded in the field and then returned to its original location. This includes the edge damage analysis which had to be adapted for field recording. For the in-field edge damage analysis, an iPad 2 protected with a Survivor® case was mounted onto a tripod using the iMount® attachment (Figure 23). Artifact images were taken using the onboard camera, and the edge damage outlines were drawn onto the artifact image using the "Notability" application available from the iTunes store. These files were then exported into ArcGIS and the lines transferred to shapefiles, and then treated as the other archaeological and experimental assemblages. All complete flakes, blades, points, and retouched pieces recorded in 2012 and 2013 were analyzed for edge damage in the field using a 30x optical jeweler's loupe.

Figure 23. In-field artifact edge damage data collection at Vleesbaai.

5.5.3 Pinnacle Point

The lithic collections from PP13B, PP9, and PP5-6 are stored at the Munro House on the Diaz Museum grounds, Mossel Bay. Initially, only complete points from PP13B identified by Thompson et al. (2010) were analyzed in 2008 and previously published (Schoville, 2010). Subsequently, all the complete blades and points from PP13B were analyzed (N=509). At PP5-6, all points examined by Brown (2012) were initially analyzed, and the complete points, flakes, blades, and retouched pieces (N=1628) were examined later (Wilkins et al., 2014). The complete assemblage of points, flakes, blades, and retouched pieces from PP9 were analyzed (N=88) using the database compiled by Erin Thompson (unpublished).The methods for recording edge damage were the same for all sites from Pinnacle Point.

5.5.4 Nelson Bay Cave

The NBC lithic collection is curated at the Field Museum, Chicago. Most of the artifacts are grouped into general artifact class by level by Volman (1981). The artifacts are not individually bagged, but usually in a box (often a cigar box) with other similar artifacts, separated by raw material. The typological designations from Volman (1981) were used for this analysis, although some incomplete flakes were excluded. The complete flakes, blades, points, and retouched pieces from Layers 6 and 10 were analyzed for this dissertation. To protect the artifacts and provide a numbering system, artifacts were individually bagged and small tags were created starting in Layer 10 with number 1 through 260 and Layer 6 numbered 261 through 512.

Layer 10 was located in drawers labeled 12 and 13, although no cores were found in these drawers. There were no artifacts other than quartzite. Initially, 139 artifacts were analyzed, with the “irregular end-struck” and “irregular side-struck” flakes only being 20% randomly sampled due to time constraints. Before leaving the collection, the remaining non-sampled portion of those two groups were given numbers and individually bagged for future work. Layer 6 (located in drawers 6 and 7) had much more variable raw materials. Of the 210 artifacts analyzed, 57 were excluded because they were fragmentary. As in Layer 10, some artifact categories were sampled due to time constraints, and a randomized 1-in-5 (20%) sampling strategy was selected. Before leaving the collection, I was able to individually bag and tag the unsampled “pointed flakes”, but not the other sampled categories.

5.5.5 Oyster Bay

The Oyster Bay surface lithic scatter was collected over a two day period by James Brink and Johann Binneman in 1993. Artifacts were bagged based on loose spatial association in “sites” and “zones”. The main HP component is from Zone 3, Site 3, but artifacts from sites 1, 2, and 4 may be from the same occupation component. The artifacts are curated at the Albany Museum, Grahamstown, but have not yet been described and published. For this dissertation, artifacts were coded following the protocols at Pinnacle Point (Wilkins, et al., 2014) with the assistance of Dr. Jayne Wilkins, and then edge damage was analyzed. All artifacts from bags referred to as “HP” were analyzed, and there did not seem to be any selection bias as there were a large number of small, broken flake fragments. Artifacts were assigned unique identification numbers, starting at 1, through 623, and individually bagged. Edge damage analysis was performed on all complete flakes, blades, points, and retouched pieces from the HP bags that were coded (N=157), but none from the “bulk analysis” bags from other areas.

5.6 Conclusion

This chapter presented the methods and samples used to analyze MSA behavioral variability and technological adaptations on the south coast. In total, 482 experimental tools were prepared for this portion of the study (Table 5). These form the linkages between archaeological edge damage patterning and MSA behavioral inferences.

Table 5. Experimental sample size.

Experiment	Total Sample Size
Trampling	300
Rock Tumbler	60
Spear Armature Tips	62
Butchery	60

The combination of experimental and archaeological data generated can now be used to test hypotheses about edge damage formation proposed in chapter 4. In the next chapter, the results of these experiments are presented, and the comparisons with the analyzed archaeological assemblages are made.

CHAPTER 6 – RESULTS

6.0 Introduction

This chapter presents the results of the taphonomic and behavioral experiments, as well as results of the archaeological edge damage analysis. The frequency and distribution of edge damage compared to a random, or "uniform", distribution are analyzed across tool edges. Patterns characteristic of the four experimental processes (trampling, rock-tumbling, butchery, and spear-tip armatures) are summarized, and in the final section the results of a novel "line-fitting" procedure that quantitatively links archaeological edge damage patterning to the best-fitting experimental models are provided. These results provide insight into the agent(s) of edge damage formation in the South African MSA, and highlight behavioral patterns with implications for modern human evolution.

6.1 Experiment Results

6.1.1 Trampling

A series of 300 quartzite, silcrete, quartz, and ironstone points, flakes, and blades were exposed to trampling by unshod horses, cows, and wildlife on a winery in northern California for five months. The results of the long-term trampling experiment are provided below. The number of images taken by the motion cameras positioned at each trampling site (Table 6) indicate that the corral had the greatest animal activity (4 times as much as either the other two locales), but that the field had more animal activity than the trail location. Based on the images, the animals tended to stay and graze in the open field for longer periods, which caused the camera trap to take more photographs. In contrast, the trail had a greater diversity of animals, but images were typically of them walking through and not lingering in that location.

Table 6. Frequency of camera-trap images taken at trampling locations.

Location	Within Field	Trail Adjacent	Within Corral
Anticipated Trampling Intensity	Low	Med	High
Total Images	2734	2147	8231
Average/day	21.7	17.0	65.3

Table 7. Artifact recovery at each trampling location (N_{start}=100 in each locale). All recovered tools from the field and trail were plotted with the total station.

Location	Total Station Plotted (% of total recovered)	Total Recovered (% of start)	Flipped from Start (% of plotted)
Field	95 (100%)	95 (95%)	36 (38%)
Trail	87 (100%)	87 (87%)	38 (44%)
Corral	22 (34%)	65 (65%)	13 (59%)

In terms of recovery rate, the three areas followed a trend consistent with expectations (Table 7). The field had the highest recovery rate, followed by the trail, and the corral. At the corral, only 22 of the recovered 65 tools were able to be piece plotted because of the severity of artifact movement both vertically within the clayey mud, as well as laterally outside of the trampling grid. After trowel excavating the entire 3 x 3m grid 20cm deep, it was determined that due to time constraints a 1m perimeter around the

Figure 24. Motion camera photos from trail ("medium intensity") context. A) endangered Humboldt Marten; B) cattle passing through trampling area during day; C) deer passing through trampling area at night; D) cattle lingering in trampling area; E) donkey passing through trampling area; F) recovering tools and piece plotting in the trampling area at the end of the experiment.

grid would be excavated with shovels and screening through ¼" mesh. This method resulted in the recovery of an additional 43 tools, which have no post-experiment provenience. At the field and trail sites, artifacts were generally still located on the surface and very little excavation was needed. Every artifact recovered was piece plotted at these two trampling areas. Similar to the recovery rate data, the rate of artifact flipping (i.e., from dorsal to ventral side-up or vice-versa) was correlated with the expected trampling intensity. The corral had a high-degree of artifact flipping (59% of piece-plotted tools) while the field had the lowest degree of flipping (38%). Despite the difference in motion-detection photographs between the trail and field locations, it seems that the trail was subjected to more disturbance than the field (Figures 24, 25, and 26).

This may be because animal movement causes more damage than animal loitering, which was generally the case in the field.

Figure 25. Motion camera photographs in field ("low intensity") context. A) Cattle lingering in trampling area; B) Deer lingering in trampling area at night; C) horse passing through tramping area at night; D) deer lingering in trampling area during day; E) Kyle Brown checking battery levels mid-way through experiment; F) Recovery and piece-plotting of artifacts at the end of the experiment.

Figure 26. Motion camera photos in corral ("high intensity") trampling location. A) small mammal disturbance; B) cattle laying down on trampling area during day; C) cattle laying down in trampling area at night; D) cattle in trampling area; E) fox (?) in trampling area; F) excavating the trampling area at the end of the experiment to recover tools.

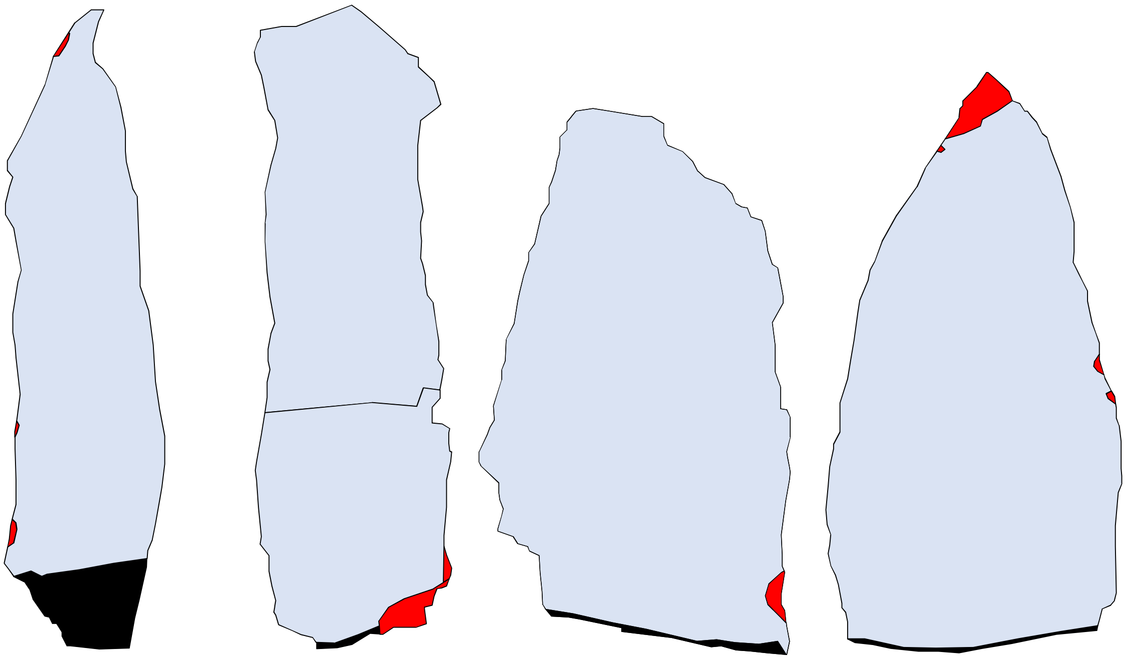

Figure 27. Shapefiles showing trampling edge damage scars on blades, flakes, and points. Red areas are edge damage, platform filled black.

Edge damage scars were variable from trampling. Small, discrete scars, and large, invasive notches (approximating retouch) were observed, as well as lateral and transverse snaps. Examples of edge damage resulting from trampling are shown in Figure 27.

6.1.1.1 Frequency of Edge Damage

Table 8. Trampling location damage total and mean damage per recovered tool.

Location	Edge Damage Total	Total recovered tools	Mean damage per recovered tool
Field	1085	95	11.4
Trail	1954	87	22.5
Corral	1501	65	23.1

Edge damage was frequently noted on the trampled tools from each of the three locations. The mean damage per recovered tool corresponds well with trampling intensity expectations, although the trail and corral have nearly equivalent mean damage frequencies (Table 8).

Unexpectedly, the left and right edges often have significantly different frequencies of damage. Overall, there is more damage on the right edges than the left ($\chi^2 = 17.301$, df = 1, $p = 0.0001$), and more damage on the dorsal face than the ventral ($\chi^2 = 12.032$, df = 1, $p = 0.005$). An equal number of tools were randomly chosen to be placed dorsal and ventral face up. The high dorsal damage is being driven in particular by the much higher dorsal-right edge damage total (n=1321, $\chi^2 = 55.552$, df = 3, $p < 0.0001$). A chi-square test of only the other three edges suggests no significant differences in damage frequency ($\chi^2 = 1.470$, df = 2, $p = 0.4795$). It's not known why the dorsal-right edge in particular would result in an increased amount of damage compared to the rest of the tool edge, but future work will examine the role shape variation is playing in this experimental set. Tables 7-9 show the total amount of edge damage on each edge by flake shape - blades, points, and flakes, respectively.

Table 9. Edge damage on trampled blades with left vs. right comparison using chi-square, p-values <0.05 indicate significant difference.

Location	Face	Side	Edge Damage Total	p-value	chi-square
High Intensity	Dorsal	L	118	0.000	12.529
		R	179		
	Ventral	L	67	0.001	10.876
		R	111		
Med Intensity	Dorsal	L	180	0.000	19.835
		R	275		
	Ventral	L	190	0.181	1.791
		R	217		
Low Intensity	Dorsal	L	128	0.757	0.096
		R	133		
	Ventral	L	78	0.000	12.565
		R	129		
Total		Left	761		
		Right	1044		
		Dorsal	1013		
		Ventral	792		

Table 10. Edge damage on trampled points with left vs. right comparison using chi-square, p-values <0.05 indicate significant difference.

Location	Face	Side	Edge Damage Total	p-value	chi-square
High Intensity	Dorsal	L	70	0.001	19.03
		R	132		
	Ventral	L	98	0.061	3.5
		R	126		
Med Intensity	Dorsal	L	159	0.120	2.424
		R	188		
	Ventral	L	165	0.912	0.012
		R	163		
Low Intensity	Dorsal	L	100	0.666	0.186
		R	94		
	Ventral	L	55	0.241	1.374
		R	68		
Total		Left	703		
		Right	647		
		Dorsal	1344		
		Ventral	743		

Table 11. Edge damage frequency on trampled flakes and left vs. right comparison using chi-square, p-values <0.05 indicate significant difference.

Trampling Location	Face/Side	Edge Damage Total	p-value	chi-square
High Intensity	Dorsal Left	115	0.001	11.681
	Dorsal Right	173		
	Ventral Left	194	0.000	70.693
	Ventral Right	60		
Med Intensity	Dorsal Left	48	0.000	32.895
	Dorsal Right	123		
	Ventral Left	141	0.000	12.789
	Ventral Right	87		
Low Intensity	Dorsal Left	94	0.000	41.525
	Dorsal Right	24		
	Ventral Left	79	0.686	0.163
	Ventral Right	74		

6.1.1.2 Distribution of Edge Damage

The distribution of damage on all trampling tools is shown in Figure 28 as the total amount of edge damage at each location along the tool perimeter (excluding the platform) divided by the total amount of damage for that edge. Combined, the distribution of edge damage on trampled flakes, blades, and points is not significantly different from a uniform distribution (KS-test, *p* = 0.791).

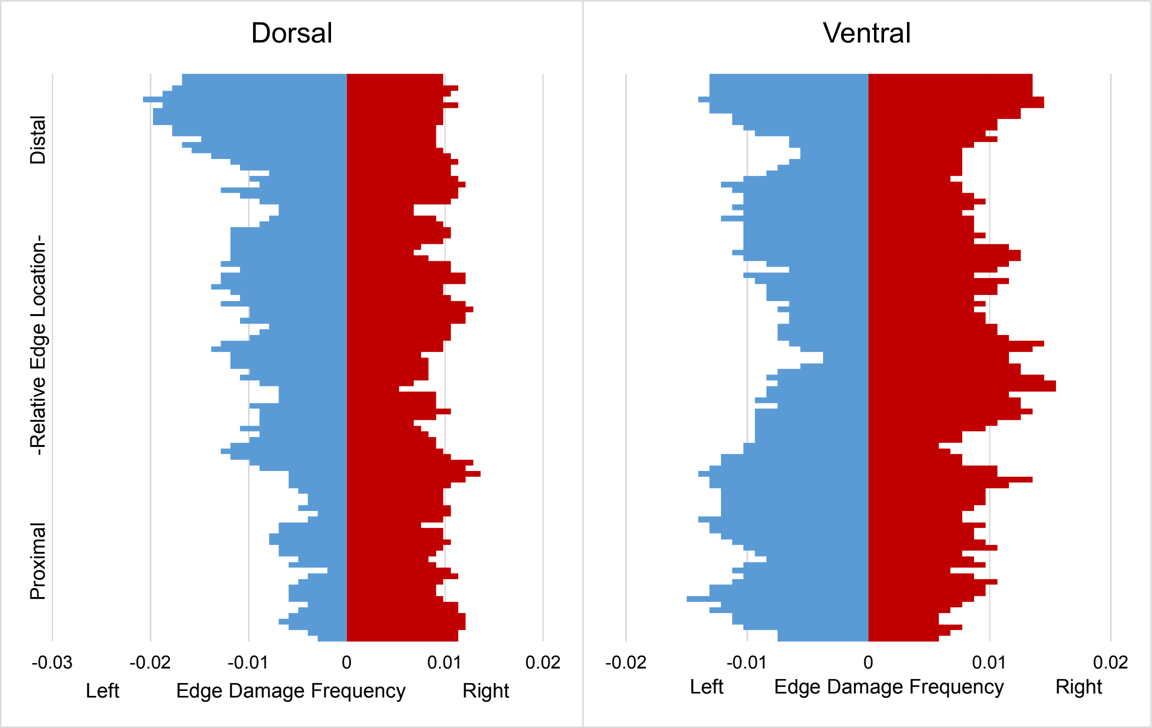

Figure 28. Edge damage distribution on all trampled tools. X-axis is relative edge damage frequency for left (blue) and right (red) edges of the dorsal and ventral surfaces. Y-axis is relative edge location from the proximal platform (bottom) to the distal end (top).

Separately, the distribution of damage on blades is also not significantly different from uniform (KS-test, p=0.497), however flakes and points are significantly non-uniform

(KS-test, p=0.012, and p<0.0001, respectively). This is consistent with recent findings from McPherron, et al. (2014) who found a significantly non-random distribution of edge damage on trampled flakes, which they relate to uneven distribution of "edge angle" on flakes in particular.

Contrary to expectations, the left and right edges for all areas have significantly different distributions of edge damage from each other, except for the high-intensity ventral surface (*p*=0.1395). The left and right distributions of edge damage on points in particular are significantly different (Table 12). The signal is mixed for blades and flakes, the dorsal left and right distributions of blades are not significantly different, and the ventral left and right distributions of flakes are not significantly different.

Table 12. Comparison of left and right trampling edge damage distributions for dorsal and ventral faces. *P*-values <0.05 indicate significantly different distributions (using Kolmogorov-Smirnov test).

Left and Right Distribution Comparison	Dorsal	Ventral
Field (low)	0.0001	0.0001
Trail (med)	0.0235	0.0001
Corral (high)	0.0001	0.1395
Points (all areas)	0.0001	0.0001
Blades (all areas)	0.2137	0.0305
Flakes (all areas)	0.0001	0.2483

6.1.1.3 Side-up

In terms of side-up frequency, there is clearly a pattern (consistent with McPherron et al. 2014; contra Tringham et al. 1974) where damage forms more readily on the upward facing surface. The trampling experiments by Tringham et al. (1974) were done by human tramplers for 30 minutes, on only 10 flakes, which likely influences the discrepancy in results. Table 13 shows this pattern for the three trampling intensity areas. At every location, when dorsal was face up, the dorsal face had the most damage, and when ventral was up, ventral had the most damage (Dorsal up, $\chi^2 = 71.426$, df = 1, $p = 0.0001$; Ventral up, $\chi^2 = 7.392$, df = 1, $p = 0.0066$).

Table 13. Total trampling edge damage by surface facing up.

Trampling Location	Total dorsal up		Total ventral up	
	Dorsal	Ventral	Dorsal	Ventral
High Intensity	436	248	351	408
Low Intensity	321	207	252	276
Med Intensity	375	309	598	654

6.1.1.4 Trampling Summary

The trampling data appear to be more patterned than anticipated, as has been noted by McPherron et al. (2014), and in contrast to studies with more subjective observation of trampling damage distributions described as ‘random’ (e.g., Tringham et al., 1974; McBrearty et al., 1998). Patterned taphonomic edge damage has implications for behavioral inferences based on the statistical difference between archaeological edge damage distributions and random (e.g., Bird et al., 2007)– testing archaeological data against random alone is insufficient to exclude post-depositional damage processes as the causal agent. Therefore, in this dissertation, archaeological damage distributions will be compared to the actual trampling distributions rather than ‘random’ (or uniform) alone to identify post-depositional patterning. The following points summarize the key findings from the trampling experiments:

- Animal movement affects trampling damage intensity more than animal presence.
- Trampling damage tends to form on the side-up surface. In these experiments, the side-up was evenly distributed between dorsal and ventral, but there are reasons to expect that archaeological side-up frequencies can be different (Schoville 2014).

- Trampling damage is randomly distributed on blades, but non-random on points and flakes, likely reflecting more uniform edge angles (e.g., McPherron, et al. 2014).
- The frequency of damage on left and right edges are significantly different, but it is not known why the dorsal-right edge in these experiments were so heavily damaged. The other three edges are not significantly different from each other. Future research will address assemblage patterning in edge shape.

6.1.2 Rock Tumbler

After exposing flakes and blades made from quartzite and heat-treated silcrete to five minutes of tumbling in a rock-tumbler, extensive damage across all tool types was observed. Although some tools had nearly continuous damage around the tools, the damage tended to be very shallow (e.g., Figure 29).

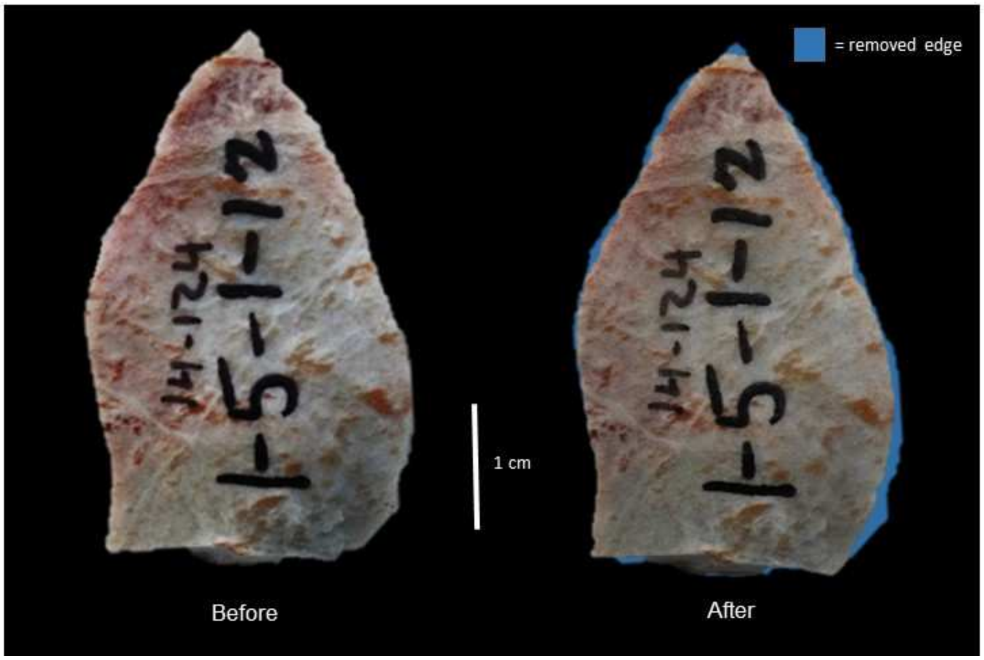

Figure 29. Example of damage formation area on tools tumbled in a rock-tumbler for 5 minutes.

6.1.2.1 Frequency of Edge Damage

There are no significant differences in how damage formed across the flake surface (dorsal/ventral and left/right, χ^2, $p>0.05$), but within flakes (not blades), there is a significant tendency to form damage unequally on the dorsal-right/ventral-left cutting edge (Table 14).

Table 14. Rock tumbler total edge damage by typology, face, and side.

Typology	Face	Side	Total
Blade	Dorsal	L	518
		R	578
	Ventral	L	523
		R	526
Flake	Dorsal	L	207
		R	266
	Ventral	L	278
		R	179

6.1.2.2 Distribution of Edge Damage

Overall, the distribution of damage due to tumbling in a rock-tumbler is not significantly different from random (KS-test, p = 0.3669; Figure 30). This pattern holds when separated into tool shape, the distribution of damage on tumbled blades (KS-test, p = 0.999) and flakes (KS-test, p = 0.456) are not significantly different from random. The distribution of damage is not statistically different between the left and right sides for both flakes and the ventral surface of blades. The dorsal edges of blades have significantly different distributions of damage between the left and right sides (KS-test, p=0.007).

6.1.2.3 Tumbling Summary

Overall, the experimental sample of flakes and blades exposed to five minutes of rock-tumbling exhibit damage that occurs randomly across edges. No large transverse snaps were caused by the tumbling action, although damage could occasionally be extensive along the tool edge. The following points summarize the key findings from the tumbling experiments:

- Edge damage from rock tumbling results in damage equally on each edge.
- Rock tumbling produces damage distributed uniformly across each edge.

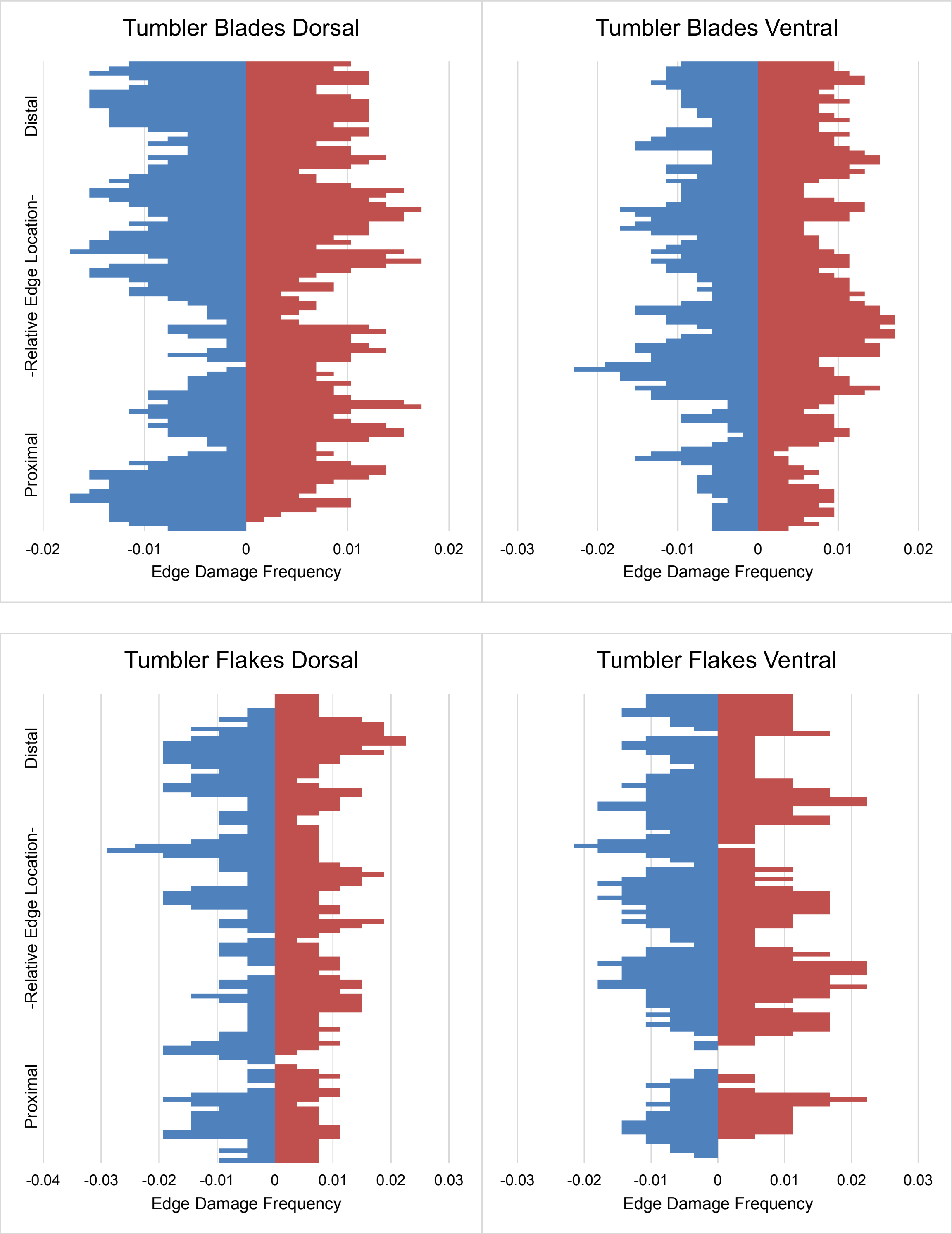

Figure 30. Edge damage distribution on flakes and blades from being tumbled. X-axis is relative edge damage frequency for left (blue) and right (red) edges of the dorsal and ventral surfaces. Y-axis is relative edge location from the proximal platform (bottom) to the distal end (top).

6.1.3 Butchery

Of the 60 tools prepared for the butchery task, the butcher used 29. Of those, 25 exhibited visible edge damage during analysis. Butchery tasks were divided between the initial “field dressing” activities of skinning, eviscerating, and disarticulating, and the subsequent “defleshing” activities of removing meat from the disarticulated bones. Points and blades were used for these activities, and damage was observed on the majority of the used tools, despite few of them being used to exhaustion (*per* comments from the butcher, Jeremiah Harris). Visible damage was highly variable, and included slight edge rounded, some invasive scarring, and distal snaps (Figure 31).

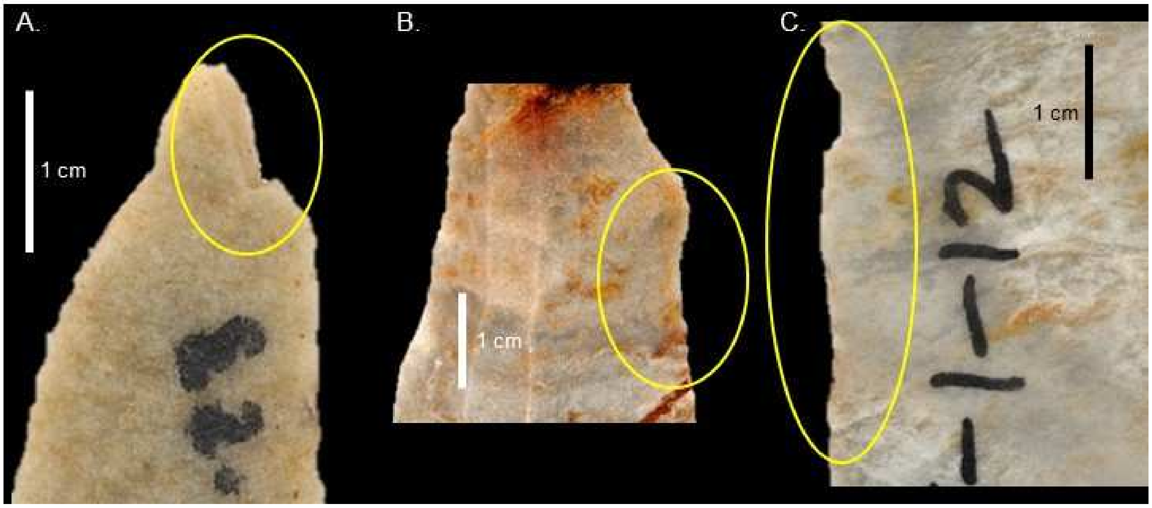

Figure 31. Edge damage on butchery tools. A) DIF, burination, on tool 14-23; B) slight damage on dorsal right, 14-56; C) notch on ventral left edge, 14-50.

6.1.3.1 Frequency of Edge Damage

Overall, there is more damage on the left edge compared to the right (585 and 477, respectively; $\chi^2 = 10.983$, df=1, p=0.0009), but the dorsal and ventral faces do not have significantly different frequencies of damage (549 and 513, respectively; $\chi^2 = 1.220$, df=1, *p*=0.269; Table 15).

Table 15. Total edge damage on butchery tool edges.

Damage Total	Dorsal	Ventral
Left	251	334
Right	298	179

6.1.3.2 Distribution of Edge Damage

As anticipated, damage from butchery is non-randomly distributed. Both on the dorsal and ventral surfaces, damage on the left and right sides are distributed significantly differently (Dorsal: KS-test, *p*=0.0444; Ventral: KS-test, p<0.001; Figure 32).

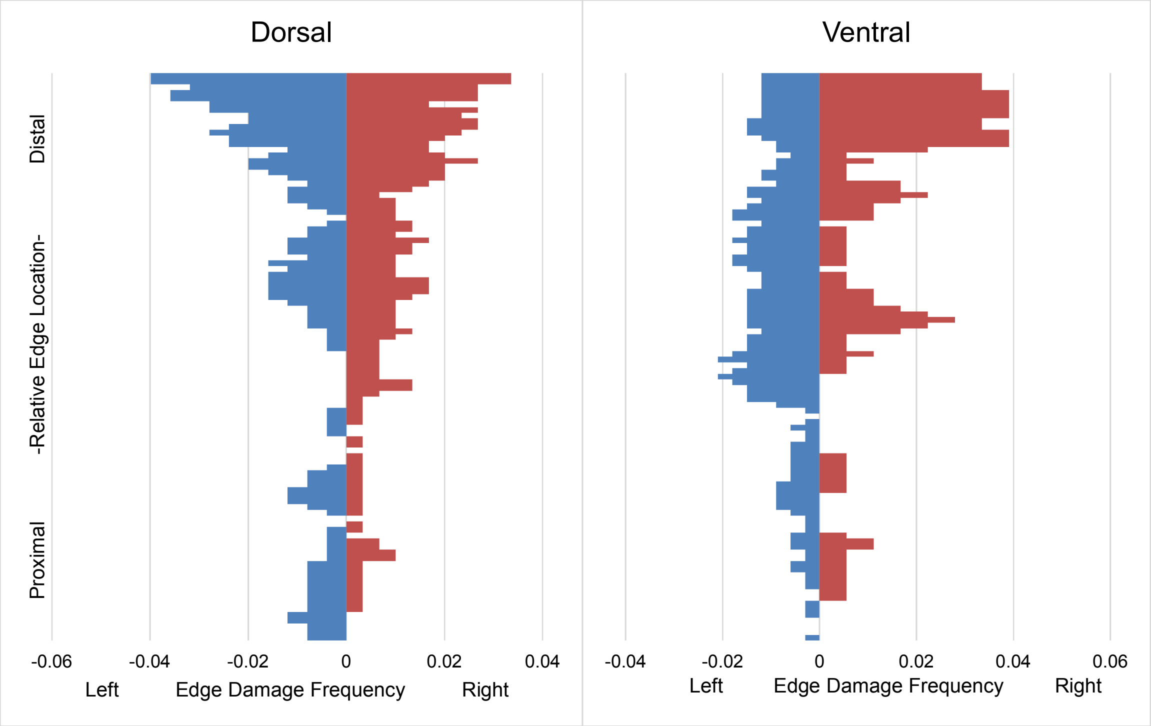

Figure 32. Edge damage distribution on butchery tools. X-axis is relative edge damage frequency for left (blue) and right (red) edges of the dorsal and ventral surfaces. Y-axis is relative edge location from the proximal platform (bottom) to the distal end (top).

6.1.3.3 Field Processing vs. Defleshing Butchery Patterns

The distribution of edge damage created from defleshing and field processing activities are significantly different (D=0.15726, p<0.0001). Within each activity group, the left and right distributions are generally distributed differently, with the exception of the damage located on the dorsal face of the defleshing tools (Table 16). The edge damage distributions for defleshing is shown in Figure 33, and the field dressing pattern is shown in Figure 34.

Table 16. Comparison of left and right butchery tool edge damage distributions using KS-test. P-values <0.05 indicate significantly different distributions of edge damage between left and right edges.

Butchery Type	Dorsal	Ventral
Defleshing	.3178	0.0001
Field Processing	0.0422	0.0001

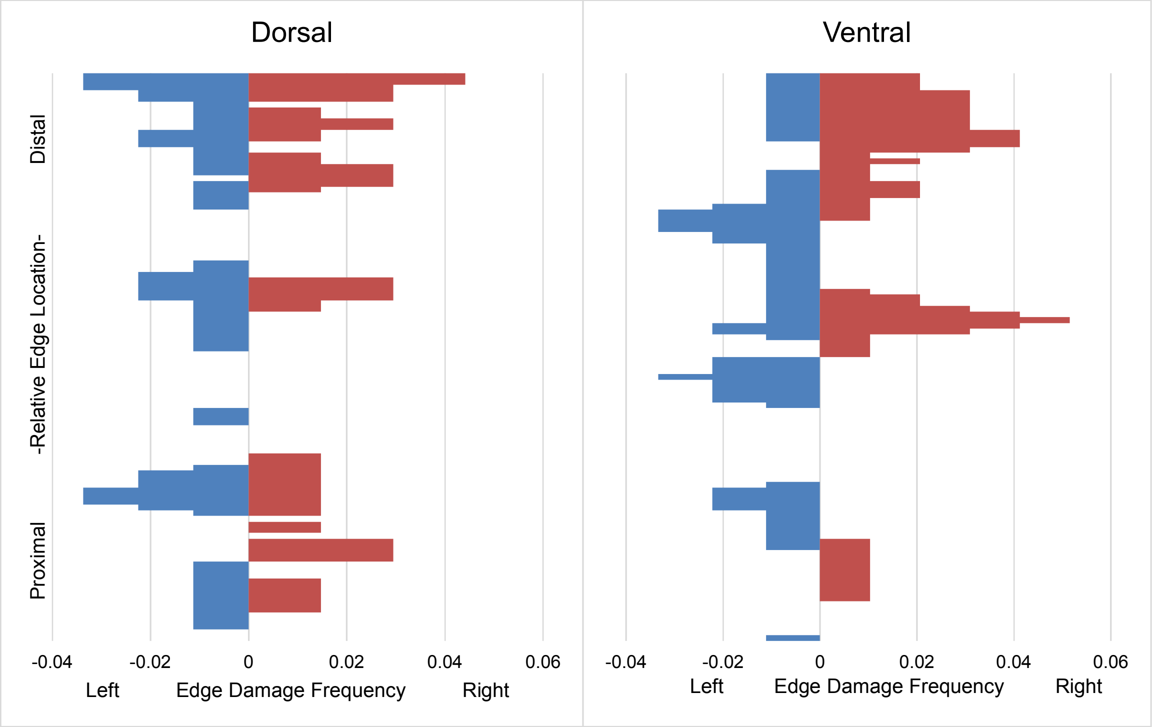

Figure 33. Defleshing edge damage distributions. X-axis is relative edge damage frequency for left (blue) and right (red) edges of the dorsal and ventral surfaces. Y-axis is relative edge location from the proximal platform (bottom) to the distal end (top).

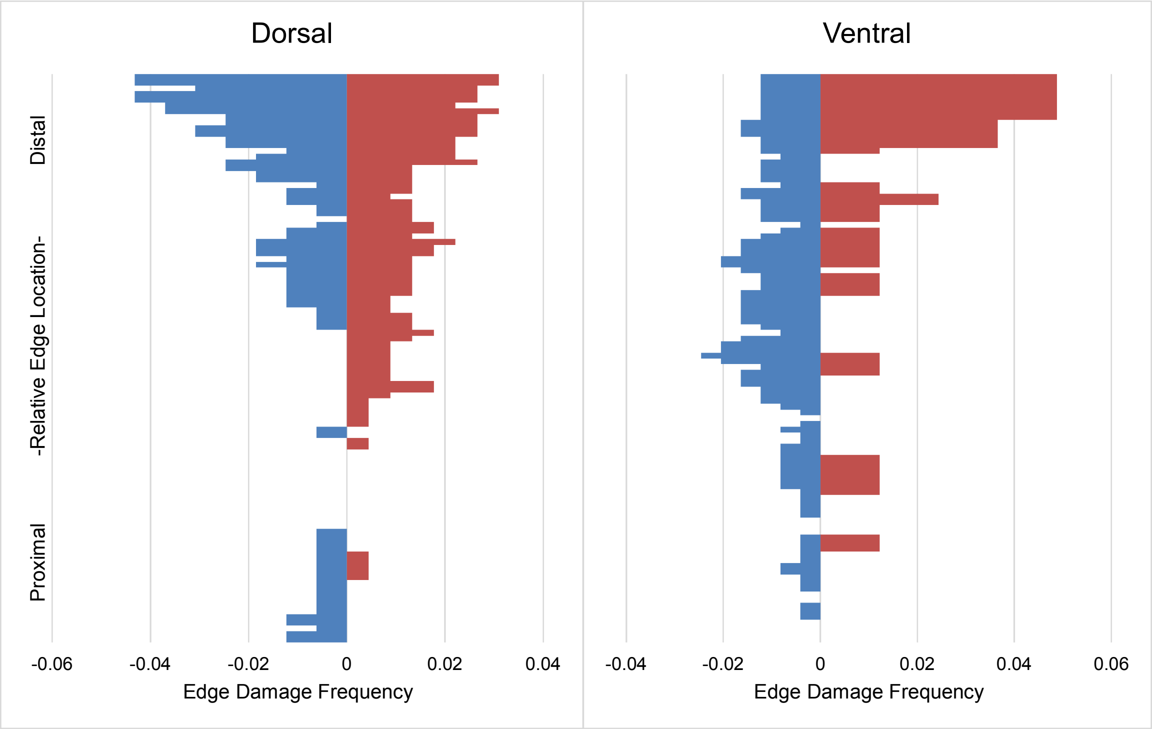

Figure 34. Field dressing butchery edge damage distributions. X-axis is relative edge damage frequency for left (blue) and right (red) edges of the dorsal and ventral surfaces. Y-axis is relative edge location from the proximal platform (bottom) to the distal end (top).

6.1.3.4 Butchery summary

The butchery experiments produced extensive damage that exhibit patterning on both points and blades. It is unknown how the idiosyncrasies of the individual butcher influence the overall frequency and distribution of damage, but with these data as a starting point, the following points can summarize the butchery edge damage results:

- Butchery resulted in more damage on the left edge than the right, but was formed equally between dorsal and ventral faces. It is not known how handedness affects this pattern, but it is anticipated to be the opposite for a left-handed butcher (Schoville, 2010).
- Butchery resulted in damage significantly different from random, and the left and right edges had different distributions.

- Field processing and defleshing activities result in significantly different distributions of edge damage. Particularly near the distal ends of tools, field dressing activities produced more damage.

6.1.4 Spear-tip Armatures – MSA Points

In these experiments, MSA points (detached pieces with converging scars that form a point) made from mostly quartzite (61/64 points, silcrete 3/64) were hafted and thrust into springbok a total of 150 times for all points (mean = 2.34 thrusts per point). These experiments resulted in extensive edge damage to the points, including numerous distal breaks and impact fractures, as well as hafting damage closer to the proximal end of the points. Microscope images of these fractures are shown in Figure 35.

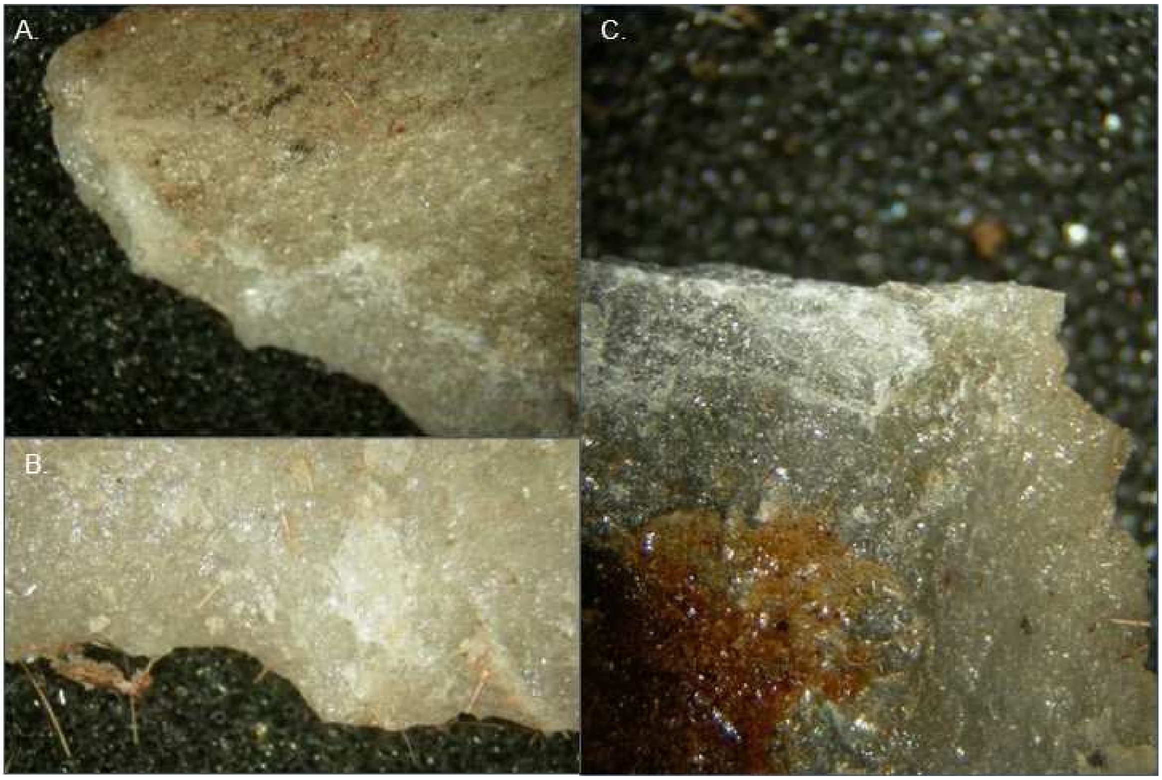

Figure 35. Fractures on quartzite spear armature tips. A) Point H-8, distal tip damage; B) Point H-9, distal termination of lateral burination; C) Point H-5, ventral stepped-crushing on transverse snap.

6.1.4.1 Frequency of Edge Damage

The total amount of damage, regardless of location along the edge, from use as spear-tip armatures formed unequally on the dorsal and ventral faces (D=2200, V=2645; χ^2=40.872, df=1, *p*=0.0001, Table 17). In contrast, the total amount of edge damage, regardless of location along the edge, was not statistically different between the left and right sides (L=2458, R=2387; χ^2=1.040, df=1, *p*=0.3077, Table 17).

Table 17. Edge damage totals from experimental spear-tip armatures.

Edge	Dorsal	Ventral	Total
Left	1239	1219	2458
Right	961	1426	2387
Total	2200	2645	4845

6.1.4.2 Distribution of Edge Damage

As previously reported by Schoville and Brown (2010) but with an additional 29 spears points, the overall distribution of damage on spear points (i.e., where the damage is located on average along the tool edge) is concentrated at the tip. The distribution of spear point damage along the point edge is not significantly different between the left and right sides (KS-test, *p*=0.1613), or between dorsal and ventral faces (KS-test, *p*=0.9963, Figure 36), and a slight increase near the base of points is seen, what Schoville and Brown (2010) referred to as a “hafting bump”.

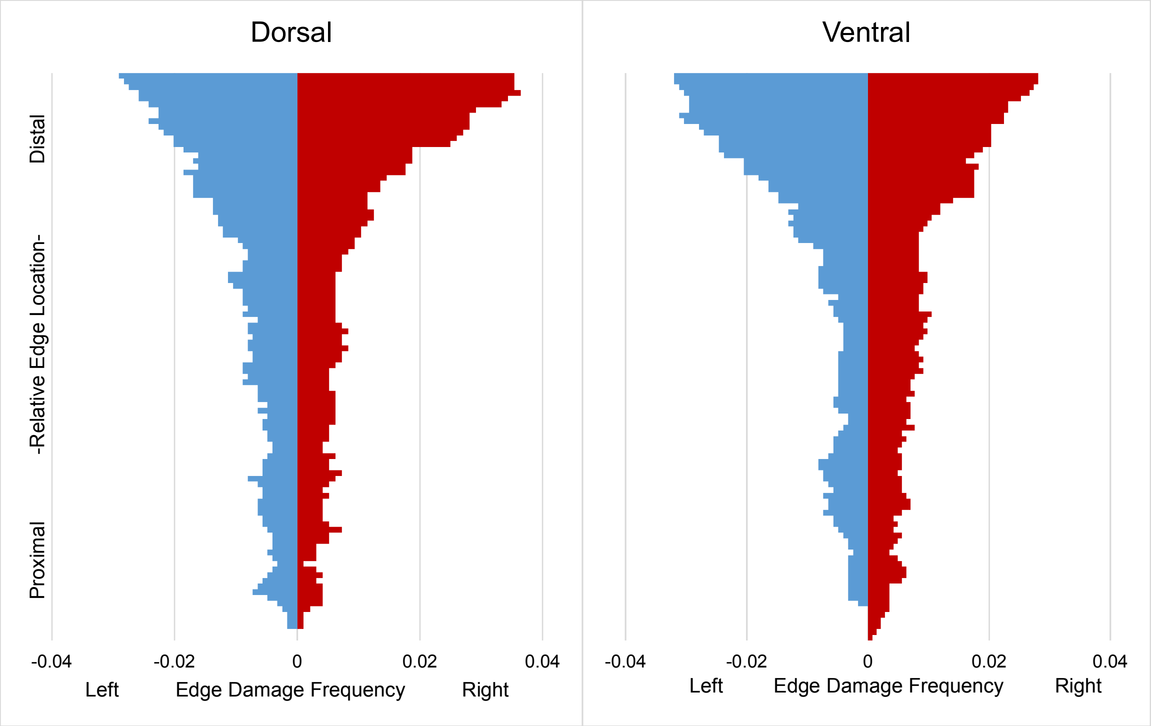

Figure 36. Distribution of experimental spear-tip armature edge damage.

6.1.4.3 Spear-tip armature summary

Using MSA points as spear-tipped armatures is extremely effective at penetrating the target, and produces extensive damage to the point edges. It's unknown how different hafting scenarios would influence the patterning of edge fractures, but all spear tips used in these experiments were constructed in the same fashion, and therefore serves as a baseline for experimental edge damage distributions due to spear-tipped armature function. The following points summarize the results of the spear-tip armature experiments.

- The ventral surface forms edge damage from armature-tips more frequently than the dorsal surface. Schoville and Brown (2010) suggested this is due to the slight curvature of detached pieces from prepared cores common in the MSA.

- The left and right sides form damage equally frequently, with equivalent distributions.

6.1.5 Experimental DIF Frequency

Overall, diagnostic impact fracture formation was relatively rare. No DIFs formed from tumbling points and blades in a geologic rock-tumbler. Trampling resulted in a small number of DIFs (2.6%, Table 18), while butchery had a slightly higher frequency especially on slot hafted points (10%, Table 18). As expected, spear-tip armature tips formed the highest frequency of DIFs (24%, Table 18).

Table 18. Frequency of experimental DIF formation.

Experimental Sample	Points w/ DIF	Total Points	Blades w/ DIF	Total Blades (N)	Flakes w/ DIF	Total Flakes (N)
Tumbler	0	22 (0%)	0	40 (0%)	-	-
Trampling	0	61 (0%)	3	117 (2.6%)	0	59 (0%)
Butchery	2	20 (10%)	0	9 (0%)	-	-
Spear-tips	6	25 (24%)	-	-	-	-

6.1.6 Summary of Experiments

The overall pattern of edge damage formation from the four experimental processes examined here is summarized in Table 19. No two experiments have the same frequency, distribution, and DIF characteristics. Therefore, these criteria provide the linkages between observed patterns of edge damage on archaeological tools (traces) to the causal agents observed in the experiments. The method presented here provides the ability to objectively link traces to causal agents of edge damage accumulation in archaeological assemblages without referring to subjective or unobserved causation.

Incorporating these processes into a model of edge damage formation allows the various parameters of damage formation to be explored in ways that are more difficult when edge wear traces are examined individually or through univariate analyses (Hilborn and Mangel, 1997).

Table 19. Summary table of edge fracture characteristics of experimental processes linking causal agent with observed edge damage (traces).

Experiment	Frequency (Dorsal vs. Ventral)	Frequency (Left vs. Right)	Observed Distribution vs. Random	Distribution (Left vs. Right)	DIFs (95% C.I.)
Trampling	Dorsal >? Side-up dependent	Right>?	Blades = Points/Flakes ≠	≠	0.3-3.8%
Tumbling	Same	Same	Same	Same	0%
Butchery (Rt Handed)	Same	Left	≠	≠	0.8 – 23%
Spear-tip Armatures	Ventral >	Same	≠	Same	11-44%

6.2 Archaeological Results

A summary of the number of tools analyzed, and the number with identified edge damage is provided in Table 20. Summary of archaeological tools analyzed by assemblage of aggregated archaeological levels sorted by temporal approximation.. The most complete samples come from PP5-6, Vleesbaai, Oyster Bay, and Nelson Bay Cave, where points, flakes, and blades were all analyzed. The sample from PP13B includes all recovered points and blades, but the sample from DK1 only includes points due to logistical constraints. Published data from Kathu Pan 1 provided by Wilkins et al. (2012) is also included for comparison in some tests. A variety of edge damage trace morphologies were noted, including notches, rounding, slight edge ‘nibbling’, ‘fresh’ damage (excluded from analysis), retouch (excluded from analysis due to damage associated with retouching), snap/step fractures, and the full suite of fractures considered “diagnostic impact fractures” (DIFs). A sample of these from PP5-6 where the greatest number of tools were analyzed are illustred in Figure 37, in order to provide a sense of the variation in edge damage types across the different raw materials sampled.

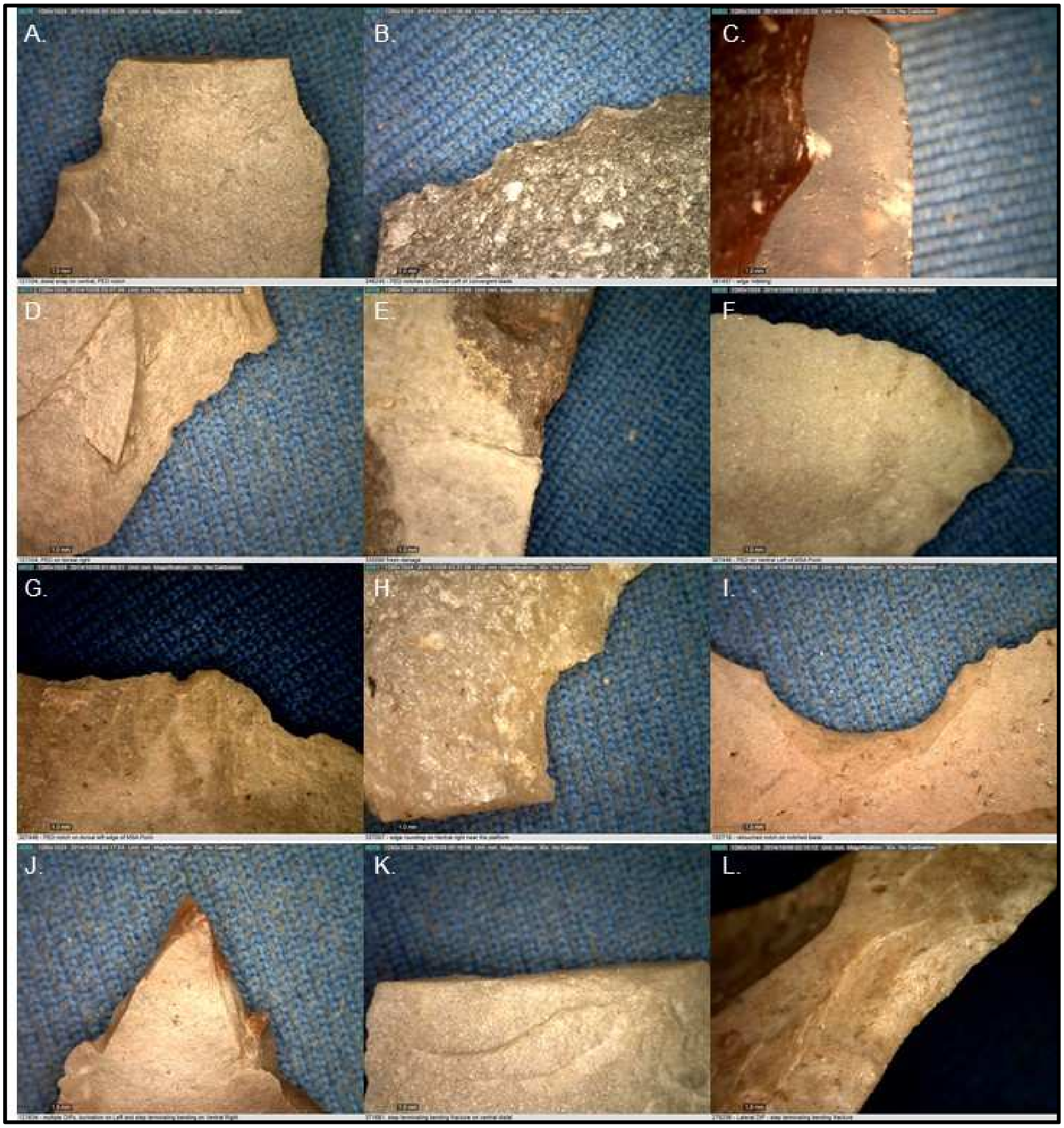

Figure 37. Archaeological edge damage from PP5-6. Spec No., StratAgg, and raw material are, A) distal snap and left lateral notch (121104, DBCS, silcrete); B) damage on dorsal left edge (348245, YBSR, quartzite); C) slight edge 'nibbling' (381457, YBSR, chert); D) edge damage on dorsal right (121104, DBCS, silcrete); E) fresh damage (335090, YBSR, silcrete); F) damage on ventral left edge and G) small notch on dorsal left edge of MSA point (307446, YBSR, silcrete); H) edge rounding on ventral right (337007, OBS1, quartzite); I) invasive retouched notch on blade (122718, DBCS, silcrete); J) two DIFs – burination on left, and step terminating bending fracture on right (121634, DBCS, silcrete); K) DIF, step-terminating bending fracture (371681, YBSR, silcrete); L) DIF, step-terminating bending fracture (279258, YBSR, silcrete).

Table 20. Summary of archaeological tools analyzed by assemblage of aggregated archaeological levels sorted by temporal approximation. In most cases, complete assemblages were analyzed, but see section 5.5 for caveats (i.e., NBC and OB).

	Assemblage	Total Analyzed				Edge Damage Identified			
Assemblage	Total	Point	Blade	Flake	Total	Point	Blade	Flake	Total
PP5-6 RBSR	286	7	30	52	89	3	13	34	50
PP5-6 BCSR	1470	2	48	235	285	0	21	92	113
Vleesbaai	2772	13	27	341	381	3	3	56	62
PP5-6 DBCS	790	7	45	126	178	4	27	61	92
PP5-6 OBS2	1063	2	30	192	224	1	13	62	76
NBC 6	252	28	58	90	176	19	10	49	78
PP5-6 SGS	92	1	4	15	20	0	3	4	7
Oyster Bay	622	51	20	86	157	26	6	26	58
DK1 6-9	37	37	NA	NA	37	12	-	-	12
PP5-6 OBS1	393	0	15	84	99	0	8	28	36
PP5-6 SADBS	202	15	17	34	66	10	10	11	31
PP5-6 ALBS	83	5	3	15	23	3	1	9	13
DK1 10-16	50	50	NA	NA	50	24	-	-	24
PP5-6 LBSR	1638	70	94	477	641	48	43	168	259
PP13B MIS5	3466	203	178	NA	381	71	66	-	137
PP5-6 YBS	6	1	1	1	3	1	1	1	3
NBC 10	260	51	0	70	121	34	0	38	72
PP9	159	23	5	60	88	15	3	21	39
PP13B MIS6	1979	89	39	NA	128	16	12	-	28
Total	15620	655	614	1878	3147	290	240	660	1190

Table 21. Summary of total amount of edge damage on archaeological tools by assemblage of aggregated archaeological levels sorted by temporal approximation.

	Blade				Flake				Point			
	Dorsal		Ventral		Dorsal		Ventral		Dorsal		Ventral	
Assemblage	L	R	L	R	L	R	L	R	L	R	L	R
PP5-6 RBSR	184	159	82	53	442	386	373	337	66	65	18	17
PP5-6 BCSR	238	359	175	240	1457	1443	1106	872	-	-	-	-
Vleesbaai	57	29	8	18	582	481	304	270	32	61	16	37
PP5-6 DBCS	146	315	203	277	791	764	445	707	106	92	20	66
PP5-6 OBS2	91	128	13	54	772	390	329	331	8	39	3	0
NBC 6	27	69	32	22	346	434	372	295	74	147	95	137
PP5-6 SGS	73	45	0	24	63	51	33	27	-	-	-	-
Oyster Bay	86	139	110	94	326	263	160	273	345	229	261	260
DK1 6-9	-	-	-	-	-	-	-	-	95	128	32	52
PP5-6 OBS1	48	41	29	35	157	146	249	207	-	-	-	-
PP5-6 SADBS	73	42	140	47	111	70	22	34	128	46	86	52
PP5-6 ALBS	0	0	7	0	76	107	35	68	56	73	35	18
DK1 10-16	-	-	-	-	-	-	-	-	198	224	142	153
PP5-6 LBSR	478	497	207	405	1448	1568	1444	1048	485	476	329	337
PP13B MIS5	557	503	442	489	-	-	-	-	1153	887	632	576
PP5-6 YBS	9	12	36	14	1	0	0	14	31	11	0	10
NBC 10	-	-	-	-	289	352	190	310	248	276	183	277
PP9	28	0	31	6	77	127	44	146	87	42	94	141
PP13B MIS6	64	145	25	127	-	-	-	-	314	223	144	98

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6.2.1 Archaeological Frequency

The damage for each site and level by three artifact shape groupings (point, blade, and flake) are shown in Table 21. Unfortunately, there is uneven representation by site, shape, and raw-material, but with a total a total amount of edge damage instances of 42,408, there should be adequate coverage to test the hypotheses outlined in Chapter 4. Table 22 provides the results of chi-square test of the edge damage frequency data for each archaeological assemblage by tool shape, face, and side. The significant p-values ($p<0.05$) were then translated to whichever face or side had the predominant frequency of edge damage in Table 23. If there was no statistically different edges, an equal-sign represents equivalent frequencies of damage.

Edge damage intensity was calculated by dividing the percentage of damage per tool by the total number of tools exhibiting any amount of damage. This is an estimate of the intensity of edge damage in each assemblage that is summarized by tool shape and environmental context in Figure 38.

Table 22. Comparison of edge damage frequency by face and edge (χ^2), p<0.05 is significantly different. Assemblages arranged in ~temporal order.

	Blade		Flake		Point	
Assemblage	Dor. vs. Ven.	Left vs. Right	Dor. vs. Ven.	Left vs. Right	Dor. vs. Ven.	Left vs. Right
PP5-6 RBSR	0	0.014	0.003	0.019	0	0.880
PP5-6 BCSR	0	0	0	0.001	-	-
Vleesbaai	0	0.089	0	0.638	0.001	0
PP5-6 DBCS	0.536	0	0	0	0	0.058
PP5-6 OBS2	0	0	0	0	0	0.001
NBC 6	0.001	0.009	0.003	0.772	0.605	0
PP5-6 SGS	0	0.737	0	0.172	-	-
Oyster Bay	0.311	0.074	0	0.118	0.180	0.001
DK1 6-9	-	-	-	-	0	0.003
PP5-6 OBS1	0.043	0.936	0	0.054	-	-
PP5-6 SADBS	0	0	0	0.060	0.042	0
PP5-6 ALBS	0.008	0.008	0	0.001	0	1
DK1 10-16	-	-	-	-	0	0.167
PP5-6 LBSR	0	0	0	0.001	0	0.238
PP13B MIS5	0.004	0.875	-	-	0	0
PP5-6 YBS	0.001	0.024	0.001	0.001	0	0.170
NBC 10	-	-	0	0	0.041	0.001
PP9	0.264	0	0.003	0	0	0.917
PP13B MIS6	0.003	0	-	-	0	0

Table 23. Translation of p-values in Table 17 into assemblage edge damage frequency characteristics, cell is the face/side with greater damage frequency, = represents no significant difference; blanks indicate no data.

	Blade		Flake		Point	
Assemblage	D. vs. V.	L. vs. R.	D. vs. V.	L. vs. R.	D. vs. V.	L. vs. R.
PP5-6 RBSR	Dorsal	Left	Dorsal	Left	Dorsal	=
PP5-6 BCSR	Dorsal	Right	Dorsal	Left		-
Vleesbaai	Dorsal	=	Dorsal	=	Dorsal	Right
PP5-6 DBCS	=	Right	Dorsal	Right	Dorsal	=
PP5-6 OBS2	Dorsal	Right	Dorsal	Left	Dorsal	Right
NBC 6	Dorsal	Right	Dorsal	=	=	Right
PP5-6 SGS	Dorsal	=	Dorsal	=		
Oyster Bay	=	=	Dorsal	=	=	Left
DK1 6-9					Dorsal	Right
PP5-6 OBS1	Dorsal	=	Ventral	=		-
PP5-6 SADBS	Ventral	Left	Dorsal	=	Dorsal	Left
PP5-6 ALBS			Dorsal	Right	Dorsal	=
DK1 10-16					Dorsal	=
PP5-6 LBSR	Dorsal	Right	Dorsal	Left	Dorsal	=
PP13B MIS5	Dorsal	=			Dorsal	Left
PP5-6 YBS	Ventral	Left	Ventral	Right	Dorsal	=
NBC 10			Dorsal	Right	Dorsal	Right
PP9	=	Left	Dorsal	Right	Ventral	=
PP13B MIS6	Dorsal	Right			Dorsal	Left

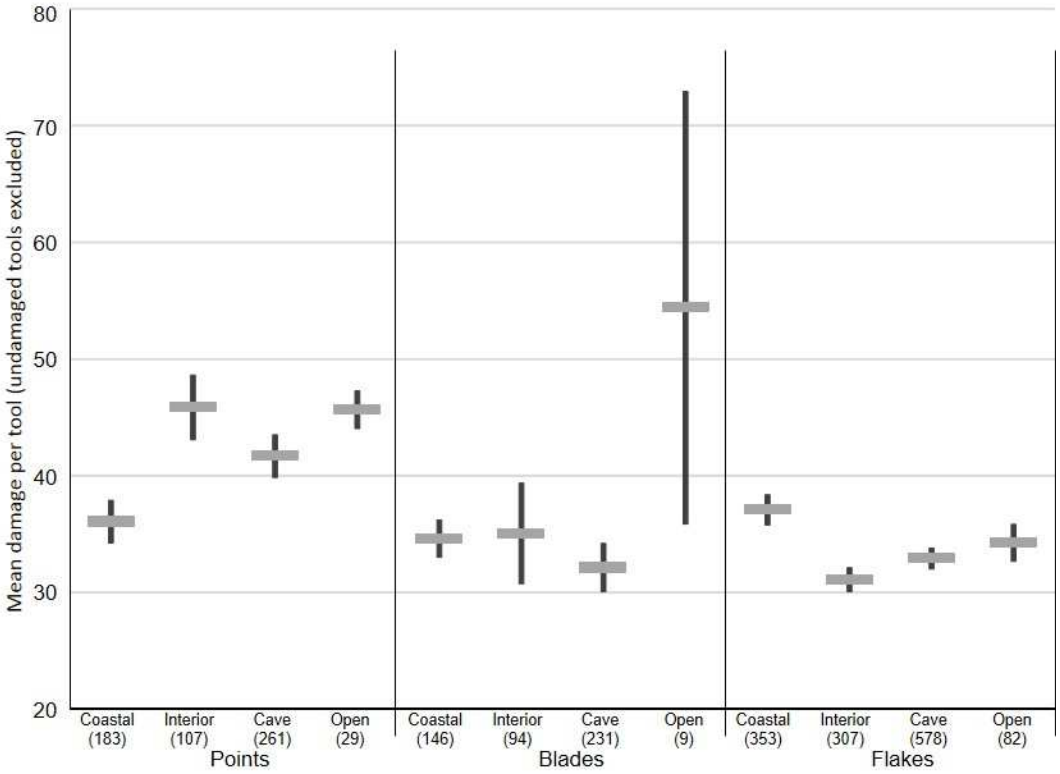

Figure 38. Edge damage intensity as measured by the mean damage per tool by tool shape and environmental context with undamaged edges excluded. The vertical extent are the 95% confidence interval limits on proportion of DIFs, horizontal bar is mean damage intensity.

6.2.2 Archaeological Distribution

A graphical display of edge damage distribution histogram for each archaeological assemblage are provided in Appendix C, and the statistical analyses will just be summarized here by tool shape.

In Table 24, the chi-square *p*-value for assemblage distributions compared to a uniform distribution and a comparison of the left and right edges (KS-test *p*-values) are shown for points.

Table 24. Point *p*-values for Kolmogorov-Smirnov comparisons between edge damage distributions of archaeological assemblages and uniform, and between archaeological left and right distributions. In approximate temporal order.

Assemblage	All edges vs. Uniform	Distribution Left vs. Right
PP5-6 RBSR	0.000	0.081
Vleesbaai	0.995	0.001
PP5-6 DBCS	0.999	0.000
NBC 6	0.000	0.000
PP5-6 OBS2	1.000	0.000
Oyster Bay	0.000	0.001
DK1 6-9	0.973	0.375
PP5-6 SADBS	0.002	0.000
PP5-6 ALBS	0.986	0.000
DK1 10-16	0.000	0.000
PP5-6 LBSR	0.001	0.888
PP13B MIS5	0.000	0.000
PP5-6 YBS	0.065	0.012
NBC 10	0.000	0.053
PP9	0.000	0.070
PP13B MIS6	0.000	0.055

The assemblage distribution of edge damage on points from DK1 layers 6-9, PP5-6 ALBS, PP5-6 DBCS, PP5-6 OBS2, PP5-6 YBS, and Vleesbaai, are not significantly different from a uniform distribution of edge damage. The assemblages from DK1 layers

6-9, NBC layer 10, PP13B MIS6 layers, PP5-6 LBSR, PP5-6 RBSR, and PP9 have distributions of edge damage on the left and right edges that are not significantly different.

The distribution of edge damage on blades for each archaeological assemblage are summarized in Table 25. The majority of damage on blades from the archaeological assemblages are not significantly different from uniform, and only the blades from PP13B MIS5, PP5-6 BCSR, PP5-6 DBCS, PP5-6 LBSR, and PP5-6 SGS are significantly different from a uniform distribution. More assemblages have significantly different distributions of edge damage between left and right edges.

The distribution of edge damage on flakes for each archaeological assemblage are summarized in Table 26.

Table 25. Blade p-values for Kolmogorov-Smirnov comparisons between edge damage distributions of archaeological assemblages and uniform, and between archaeological left and right distributions. Assemblages arranged in approximate temporal order.

Assemblage	All edges vs. Uniform	Distribution Left vs. Right
PP5-6 RBSR	0.936	0.000
PP5-6 BCSR	0.000	0.000
Vleesbaai	0.930	0.058
PP5-6 DBCS	0.000	0.023
PP5-6 OBS2	0.100	0.100
NBC 6	0.999	0.000
PP5-6 SGS	0.000	0.080
Oyster Bay	0.933	0.026
PP5-6 OBS1	0.257	0.005
PP5-6 SADBS	0.166	0.034
PP5-6 ALBS	0.651	NA
PP5-6 LBSR	0.033	0.000
PP13B MIS5	0.000	0.006
PP5-6 YBS	1.000	0.000
PP9	0.966	0.285
PP13B MIS6	0.083	0.000

Table 26. Flake p-values for Kolmogorov-Smirnov comparisons between edge damage distributions of archaeological assemblages and uniform, and between archaeological left and right distributions. Assemblages arranged in approximate temporal order.

Assemblage	All edges vs. Uniform	Distribution Left vs. Right
PP5-6 RBSR	0.093	0.000
PP5-6 BCSR	0.000	0.001
Vleesbaai	0.013	0.119
PP5-6 DBCS	0.000	0.035
PP5-6 OBS2	0.661	0.000
NBC 6	0.113	0.021
PP5-6 SGS	0.749	0.000
Oyster Bay	0.864	0.001
PP5-6 OBS1	0.000	0.003
PP5-6 SADBS	1.000	0.035
PP5-6 ALBS	0.078	0.150
PP5-6 LBSR	0.000	0.014
PP5-6 YBS	0.841	0.413
NBC 10	0.998	0.023
PP9	0.917	0.131

6.2.3 Archaeological DIF Frequency

Impact fractures were relatively rare in the archaeological assemblages analyzed in this dissertation. They were identified on points, blades, and flakes, but predominantly on points. A summary of the DIF frequencies is shown in Table 27.

Table 27. Frequency of 'diagnostic impact fractures' (DIFs) on archaeological points, blades, and flakes. Assemblages arranged in approximate temporal order.

Site	Points w/ DIF	Total Points (N)	Blades w/ DIF	Total Blades (N)	Flakes w/ DIF	Total Flakes (N)
PP5-6 RBSR	1	7 (14%)	2	30 (6.7%)	2	52 (3.8%)
PP5-6 BCSR	0	2 (0%)	3	48 (6.3%)	0	235 (0%)
Vleesbaai	1	13 (7.7%)	0	27 (0%)	0	341 (0%)
PP5-6 DBCS	0	7 (0%)	4	41 (9.8%)	4	126 (3.2%)
PP5-6 OBS2	0	2 (0%)	0	30 (0%)	0	192 (0%)
NBC 6	0	28 (0%)	1	52 (1.9%)	1	120 (0.8%)
PP5-6 SGS	0	1 (0%)	0	4 (0%)	0	15 (0%)
Oyster Bay	4	29 (14%)	1	20 (5%)	1	86 (1.2%)
DK1 6-9	1	37 (2.7%)	-	-	-	-
PP5-6 OBS1	-	-	1	15 (6.7%)	0	84 (0%)
PP5-6 SADBS	1	15 (6.7%)	1	17 (5.9%)	0	35 (0%)
PP5-6 ALBS	0	5 (0%)	0	3 (0%)	0	15 (0%)
DK1 10-16	1	50 (2.0%)	-	-	-	-
PP5-6 LBSR	2	70 (2.9%)	1	94 (1.1%)	1	477 (0.2%)
PP13B MIS5	4	184 (2.2%)	0	178 (0%)	-	-

PP5-6 YBS	0	1 (0%)	0	1 (0%)	0	1 (0%)
NBC 10	3	60 (5%)	-	-	0	61 (0%)
PP9	0	23 (0%)	0	5 (0%)	0	60 (0%)
PP13B MIS6	1	54 (1.9%)	0	39 (0%)	-	-

6.2.4 Best-Fit Models

With the general assessments of the frequency and distribution of edge damage from MSA assemblages completed, they can be used as a reference point for a more thorough analysis of edge damage patterning. In the following section, the process with the most support will be quantitatively arbitrated using a model-fitting procedure. These models take into account both the frequency and distribution of edge damage simultaneously, while also providing an indication of whether the pattern is best fit by a single process (and what that process is) or best fit by a combination of processes (and what those processes are). The logic and details of this methodology were outlined in Chapter 5, and will be tested here using experimental and hypothetical distributions prior to analysis of the MSA archaeological edge damage distribution data.

As discussed previously in Section 5.2.4, stepwise regression models were constructed using JMP Pro 11 statistical analysis software with forward stepping such that the term with the lowest p-value is added first and subsequent terms are added and removed until the best model is found. A best model with multiple terms (e.g., spears + trampling) is selected based on the overall improvement in model fit, but in reality, the terms will explain different amounts of the variance in observed archaeological edge damage patterning. In the following sections, the results are presented for two models. The first is the result from fitting a single term with the lowest *p*-value to the archaeological data. This provides an indication of the primary process (of those being tested here) that accounts for the largest amount of variance in archaeological edge damage. The second is the full model consisting of all possible combination of terms with the lowest AIC, as long as the change in AIC is greater than 2. Otherwise alternative models are considered equivalent, and only the single-best fitting term is reported. Within the full model, each term will explain different amounts of the residual variance in observed archaeological edge damage. However, for the purposes of the landscape scale analyses in section 6.3, these are interpreted as having contributed equally to the formation of the observed edge damage patterning because the goal of this dissertation is to test hypotheses of landscape scale edge damage formation processes. If an experimental process helps to explain any amount of variation in the best-fit model, then it is inferred to have contributed to the observed archaeological patterning and those are the processes on the landscape which are being explained. In the analyses of temporal variability, only the single best-fit variables are used to look for patterning in the main causal agents of edge damage through time.

6.2.3.1 Testing the Procedure

Each of the experimental distributions were included in a stepwise regression model in order to test the ability of the procedure to identify the process(es) that are most consistent with the archaeological edge damage distribution curves. Each experimental distribution consists of the complete distribution of edge damage that includes all four

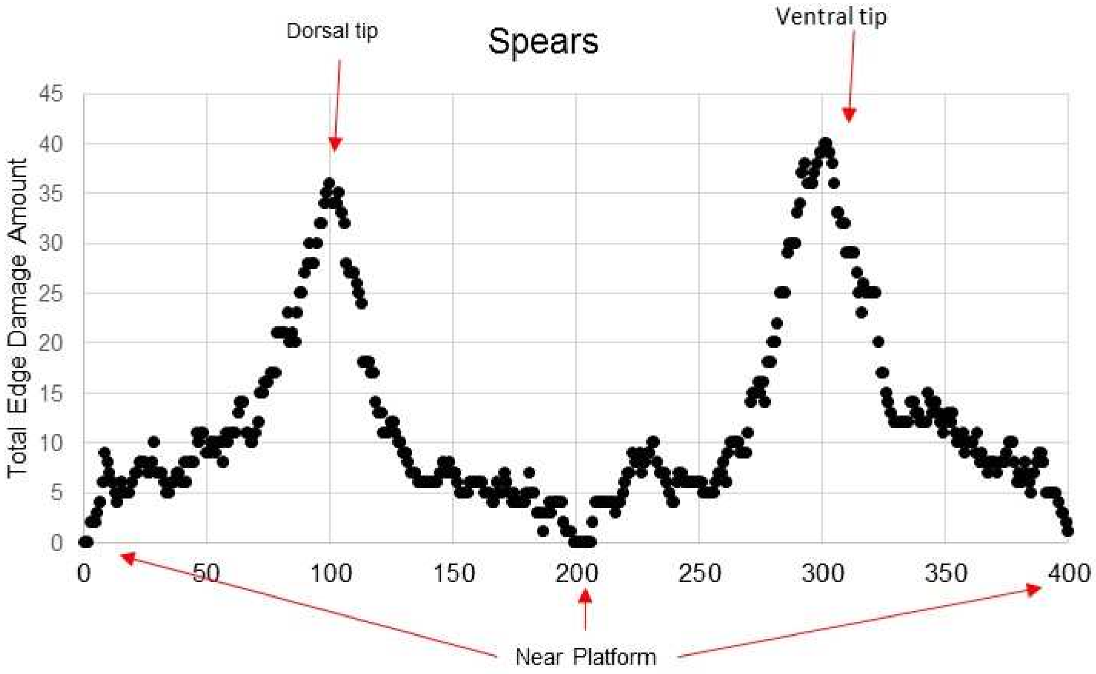

Figure 39. Spear-tipped armature edge damage combined into a single distribution of dorsal and ventral edge damage for the line-fitting stepwise regression modeling.

edges. This is illustrated in Figure 39 for the spear-tipped projectiles edge damage distribution.

In Table 28, the four experimental edge damage distribution models of known causal agency (spear-tip armatures “spears”, combined trampling areas “trampling”, butchery processes combined “butchery”, and rock tumbler “tumbling”) were used as parameters for five modeled distributions consisting of n= 10000, 1000, 500, 100, and 50 random instances of edge damage. The random distributions were created by randomly sampling from a uniform distribution of edge damage (i.e., each location along edge had equal probability of damage) n-times with replacement. Since these are random distributions, we would not anticipate behavioral processes to fit the distribution, nor would the trampling and tumbling distributions necessarily. In fact, we find that for each random model (n=10000, 1000, 500, 100, and 50), post-depositional processes are the single best-fit variables, but generally only account for less than 1% of the variability. This highlights that post-depositional processes are not as undirected as previously thought, but also that this procedure does not fit behavioral causal agents to random trace patterning.

The same four experimental processes were used as parameters for the edge damage distribution from Kathu Pan 1 that have been shown to be best explained by a combination of spear-use and post-depositional processes (Wilkins and Schoville, 2016). Using the line-fitting procedure, a similar result is reached. The single best prediction variable are experimental armatures ("spears"). The best complete model consists of (in decreasing order of importance), spears, trampling, and butchery processes. The distribution of experimental spear tipped armatures alone explain 33.2% of the observed variance in archaeological edge damage on KP1 points, and the addition of trampling and butchery distributions as model parameters only explains an additional 1.6% of the variance.

Table 28. Test of line-fitting procedure using samples outside experimental edge damage distributions generated here. Ironstone spear-tip edge damage reported by Wilkins et al. (2012).

Site	Best Single Variable	AICc	R^2	Best Model Out of All Combinations	AICc	R^2
Experimental Ironstone Spears	Spears	1942.87	0.332	Spears+Trampling +Butchery	1945.36	0.348
Random (n=10,000)	Trampling	2942.17	0.001	None		
Random (n=1000)	Tumbler	2088.91	0.002	None		
Random (n=500)	Tumbler	1782.70	0.002	None		
Random (n=100)	Trampling	1117.79	0.036	Trampling+Spears	1114.13	0.050
Random (n=50)	Trampling	907.00	0.001	None		

The line-fitting procedure is consistent with expectations and results from prior research using edge damage distributions. Therefore, the following section provides the best-fit models using the Akaike Information Criterion (AIC) for the archaeological assemblages studied here. The raw data for each experiment and assemblage used for the line-fitting analyses are provided in Appendix D.

6.2.3.2 Points

The results of the line-fitting procedure for the archaeological points is shown in Table 29. Most assemblages are best explained by a combination of processes, although a few are best explained by a single predictor variable such as "tumbling" in the DBCS layer at PP5-6 (a debris flow layer, Brown et al., 2012) and "butchery" in the PP13B MIS5 layers (consistent with Schoville, 2010). Other assemblages are explained by a combination of two processes, such as "trampling" and "spears" at Oyster Bay and Vleesbaai (both open-air sites) as well as in Nelson Bay Cave layer 10, and "butchery" and "trampling" in the PP5-6 YBS layer. Other assemblages are more ambiguous and are best-fit by three terms (i.e., PP13B MIS6 layers, PP5-6 LBSR, or PP5-6 ALBS), or four terms (Nelson Bay Cave layer 6, PP5-6 SADBS, DK1 layers 10-16).

Table 29. Result of line-fitting procedure for archaeological points. The single best experimental causal agent that explains the most variation and the best model out of all combinations are provided. Assemblages in approximate temporal order.

Assemblage	Best Single Variable	AICc	R^2	Best Model Out of All Combinations	AICc	R^2
PP5-6 RBSR	Spears	331.40	0.180	Spears+Tumbler	328.19	0.190
Vleesbaai	Trampling	686.02	0.019	Trampling+Spears	681.38	0.036
PP5-6 DBCS	Tumbler	767.19	0.033	Tumbler	767.19	0.033
PP5-6 OBS2	Butchery	251.48	0.011	Butchery+Trampling+Spears	249.30	0.027
NBC-6	Spears	1188.69	0.190	Spears+Butchery+Trampling+Tumbler	1159.55	0.258
Oyster Bay	Spears	1546.81	0.391	Spears+Trampling	1536.07	0.410
DK1 6-9	Trampling	986.85	0.060	Trampling+Tumbler+Spears	999.79	0.086
PP5-6 SADBS	Butchery	933.87	0.163	Trampling+Spears+Butchery+Tumbler	852.17	0.328
PP5-6 ALBS	Tumbler	657.10	0.032	Tumbler+Spears+Trampling	650.39	0.058
DK1 10-16	Spears	1487.81	0.101	Spears+Trampling+Butchery+Tumbler	1462.74	0.168
PP5-6 LBSR	Spears	1740.66	0.045	Trampling+Butchery+Spears	1724.48	0.065
PP13B MIS5	Butchery	2258.07	0.027	Butchery	2258.07	0.027
PP5-6 YBS	Butchery	265.15	0.011	Butchery+Trampling	263.82	0.019
NBC-10	Spears	1580.58	0.194	Spears+Butchery	1548.03	0.261
PP9	Spears	1100.48	0.046	Spears+Trampling+Tumbler	1097.96	0.062
PP13B MIS6	Trampling	1577.94	0.012	Spears+Butchery+Trampling	1577.35	0.023

6.2.3.3 Blades

For line-fitting of the blades, the experimental sample included the “spears”, although this experimental sample only consists of points. Additionally, the experimental “butchery” blades were separated into the “defleshing” and “field-dressing” blade distributions. Since the MSA layers that are being sampled include microlithic industries, generally on silcrete, the archaeological blades were also divided into blades <30mm in maximum length (“small”) and blades >30mm (“big”). The arbitrary value of 30mm was chosen as the division point because “microlithic” industries are often those with mean length less than 30mm (Clark, 2001a; Brown et al., 2012). The results are provided in Table 30 for big blades and Table 31 for small blades.

In general, the “big” quartzite blades tend to best be explained by multiple parameters including a butchery process and a post-depositional process. The single best-estimator parameters are “field dressing” followed by “defleshing”, however the experimental spear distribution explains a substantial amount of variation in the PP5-6 LBSR quartzite blades and is the best prediction model of all possible combinations. Similarly, the PP5-6 OBS2 blades are best explained by a single taphonomic variable – rock tumbling. The blades from Nelson Bay Cave where the presence of water in the sediments is well-documented (Butzer, 1973) does not appear to have resulted in edge damage patterning consistent with a rock-tumbler on the blades from layer 6 (no layer 10 blades were examined).

In contrast, the edge damage distribution curves of “big” silcrete blades tend to be best explained by the taphonomic experimental parameters, including both trampling and rock tumbling. However, the best model for all the assemblages (except PP5-6 SADBS)

Table 30. Results of line-fitting procedure for large (>30 mm) archaeological blades. Assemblages in approximate temporal order.

Assemblage	Type	Best Single Variable	AICc	R^2	Best Model Out of All Combinations	AICc	R^2
PP5-6 RBSR	Quartzite >30 mm	Field	241.33	0.050	None		
Vleesbaai		Deflesh	610.79	0.022	Field+Deflesh+Spears	607.52	0.040
PP5-6 DBCS		Field	210.30	0.092	None		
PP5-6 OBS2		Tumbler	-123.39	0.014	Tumbler	-123.39	0.014
Oyster Bay		Field	671.26	0.360	Field+Spears+Deflesh+Tumbler	617.61	0.449
PP5-6 SADBS		Field	384.88	0.023	None		
PP5-6 LBSR		Spears	1134.17	0.038	Spears	1134.17	0.038
PP13B MIS5		Field	1757.34	0.101	Field + Deflesh	1753.92	0.113
PP9		Deflesh	423.48	0.028	Field+Deflesh+Trampling+Spears	413.85	0.066
PP13B MIS6		Deflesh	1138.64	0.056	Deflesh+Trampling+Field	1114.41	0.121
PP5-6 RBSR	Silcrete >30 mm	Field	662.95	0.043	Field+Spears+Trampling	646.40	0.091
PP5-6 BCSR		Spears	940.52	0.118	Spears+Field+Trampling+Tumbler	940.52	0.213
PP5-6 DBCS		Spears	1044.91	0.059	Field+Spears+Trampling+Tumbler	988.80	0.195
PP5-6 OBS2		Trampling	926.05	0.171	Trampling+Spears+Field+Deflesh	910.08	0.215
NBC 6		Spears	420.45	0.054	Spears+Deflesh+Field	416.65	0.072
Oyster Bay		Tumbler	629.50	0.048	Tumbler+Spears+Trampling+Field	613.62	0.099
PP5-6 OBS1		Trampling	-489.15	0.013	Trampling+Spears	-496.98	0.037
PP5-6 SADBS		Tumbler	397.33	0.033	Tumbler	397.33	0.033
PP5-6 ALBS		Trampling	-492.15	0.020	Trampling+Spears	-492.38	0.026
PP5-6 LBSR		Trampling	1514.74	0.115	Trampling+Spears+Deflesh+Tumbler	1509.16	0.141
PP5-6 YBS		Trampling	353.93	0.043	Trampling+Tumbler+Field+Spears	342.16	0.085
PP13B MIS5		Field	49.95	0.038	Field+Spears+Trampling	1.35	0.148

Table 31. Results of line-fitting procedure for small (<30 mm) mostly silcrete (except for the MIS5 quartzite assemblage) archaeological blades. Assemblages in approximate temporal order.

Assemblage	Type	Best Single Variable	AICc	R^2	Best Model Out of All Combinations	AICc	R^2
PP5-6 RBSR	Silcrete <30 mm	Trampling	976.48	0.044	Trampling+Field	988.28	0.059
PP5-6 BCSR		Field	1294.60	0.141	Field+Trampling	1292.48	0.150
PP5-6 DBCS		Field	1050.19	0.291	Field+Spears	1035.87	0.312
PP5-6 OBS2		Tumbler	140.29	0.024	Spears+Deflesh+Tumbler+Field	123.03	0.080
NBC 6		Trampling	395.76	0.090	Trampling+Field+Spears	371.15	0.153
PP5-6 SGS		Spears	662.41	0.068	Spears+Trampling+Field	653.87	0.097
PP5-6 OBS1		Deflesh	659.31	0.023	Deflesh	659.31	0.023
PP5-6 SADBS		Spears	537.95	0.381	Spears+Deflesh+Trampling	554.00	0.393
PP5-6 LBSR		Trampling	12.66	0.115	Trampling+Field+Tumbler	-7.38	0.167
PP13B MIS5qz		Field	205.35	0.035	Field+Tumbler+Spears	197.02	0.064
PP13B MIS5		Field	-296.05	0.055	None		
PP13B MIS6		Field	-77.07	0.044	Field+Tumbler+Spears	-96.49	0.098

consisted of 2+ parameters. Interestingly, the experimental spear edge damage distribution was the single best predictor for Nelson Bay Cave layer 6 and the PP5-6 DBCS, both layers attributed to the Howiesons Poort - although the PP5-6 BCSR is not HP and the large silcrete blades are explained by the distribution of experimental spear edge damage.

The small blades are generally silcrete, except for the small assemblage from PP13B MIS5 made on quartzite. The experimental edge damage distribution from “field dressing” butchery is the single best explanatory parameter for several of the assemblages. The small blades from the PP5-6 SADBS and SGS are best explained by the experimental “spear” distribution, although the full best-fit model also includes trampling and butchery parameters. The best single variable for the HP assemblages in the PP5-6 DBCS and NBC 6 are not best explained by "spears" as the large blades from these assemblages were. This is interesting because the backed pieces from the HP, often argued to be projectile armatures, are larger than 30 mm (~33mm on average), whereas the backed pieces from the SADBS and SGS are significantly smaller (~27 mm, Brown et al., 2012). In other words, backed pieces from the HP are large and often argued to be used as projectiles, and the large blades from the HP assemblages in the DBCS and NBC 6 have edge damage patterning consistent with spear-tip armature experiments, but the small blades don't. Backed pieces from the SADBS and SGS are small, and the small blades from these layers have edge damage patterning consistent with spear-tip armatures, but the large blades don't.

6.2.3.4 Flakes

Flakes are more difficult to classify because they are the gradation between points and blades, are highly variable in size and shape, and therefore were likely used in a variety of ways across this continuum. Additionally, as previously discussed, the time period sampled includes microlithic blade layers that may have a different edge damage formation history than larger blades. No typological "flakes" were used in the butchery experiments (just "points" and blades"), and the spear experiments only included points. Therefore, the flake model selection parameters are divided into small (<30 mm) and large (>30 mm) flakes, which are being compared to flakes (trampling, tumbling), blades (butchery), and points (butchery and armatures). This value is arbitrary and was selected for the same reason as the 30mm cutoff for blades – microlithic industries typically produce flakes and blades with mean length less than 30mm. The model fitting procedure provides an indication of the nature of the distributions for flakes, as well as if they are providing a different signal of edge damage formation history as the archaeological points and blades. The results of the line-fitting procedure for flakes is provided in Table 32 for big flakes and Table 33 for small flakes.

Table 32. Results of line-fitting procedure for big (>30 mm) archaeological flakes.

Assemblage	Best Single Variable	AICc	R^2	Best Model Out of All Combinations	AICc	R2
PP5-6 RBSR	Butchery points	1347.93	0.054	Butchery points	1347.93	0.054
PP5-6 BCSR	Spears	1449.3	0.392	None		
Vleesbaai	Butchery points	1553.51	0.028	Butchery points+Butchery blades	1553.04	0.034
PP5-6 DBCS	Spears	1406.49	0.020	Spears+Trampling+Tumbler	1398.681	0.042
PP5-6 OBS2	Spears	929.383	0.059	Spears+Butchery blades	915.666	0.096
NBC 6	Butchery blades	1758.73	0.099	Butchery blades+Trampling+Spears+Tumbler	1739.41	0.155
Oyster Bay	Butchery blades	1138.32	0.021	Butchery blades	1138.32	0.021
PP5-6 OBS1	Trampling	1196.2	0.062	Butchery blades+Spears+Trampling+Butchery points	1173.154	0.119
PP5-6 SADBS	Butchery blades	369.19	0.027	None		
PP5-6 ALBS	Trampling	582.061	0.035	None		
PP5-6 LBSR	Butchery blades	2195.35	0.175	Butchery blades+Trampling+Butchery points	2161.17	0.250
PP5-6 YBS	Tumbler	-197.82	0.026	None		
NBC 10	Butchery points	1397.38	0.017	Butchery points+Spears	1387.13	0.0467
PP9	Butchery points	1123.16	0.089	Butchery points+Butchery blades	1119.425	0.098

Table 33. Results of line-fitting procedure for small (<30 mm) archaeological flakes.

Assemblage	Best Single Variable	AICc	R^2	Best Model Out of All Combinations	AICc	R2
PP5-6 RBSR	Butchery - blades	1500.48	0.088	None		
PP5-6 BCSR	Spears	2422.05	0.264	Spears+Butchery-blades+Trampling	2394.63	0.320
Vleesbaai	Butchery - blades	976.721	0.064	Butchery blades+Spears+Butchery points	959.67	0.112
PP5-6 DBCS	Spears	2170.03	0.227	Spears+Butchery-blades+Trampling		
PP5-6 OBS2	Spears	1745.47	0.005	Spears	1745.47	0.005
NBC 6	Butchery - points	799.972	0.044	None		
PP5-6 SGS	Butchery - blades	743.198	0.017	Butchery - blades	743.198	0.017
Oyster Bay	Trampling	990.336	0.068	Butchery -blades+Spears+Butchery -points+Trampling	939.805	0.191
PP5-6 OBS1	Butchery - blades	1282.16	0.161	Butchery blades+Spears+Tumbler+Trampling	1284.59	0.217
PP5-6 SADBS	Tumbler	1017.21	0.015	Tumbler	1017.21	0.015
PP5-6 ALBS	Buchery - blades	801.302	0.005	None		
PP5-6 LBSR	Butchery - blades	1837.06	0.071	Butchery blades+Trampling+Spears+Tumbler	1817.12	0.130
NBC 10	Buchery - blades	286.706	0.225	Butchery - blades+Spears+Tumbler+Trampling	1569.86	0.095
PP9	Butchery - blades	681.663	0.292	None		

In general, the "butchery blades" term tends to fit small flakes (<30 mm) as the best single variable, however the best complete model often includes multiple variables. There is no clear pattern with the large blades, with butchery points and blades, post-depositional variables, and even spears occurring in equal frequencies as the single best parameters. Two of the single best-fit parameters explain an extremely low amount of variation in flake edge damage distribution (PP5-6 ALBS and PP5-6 OBS2 flakes <30 mm have $R^2 = 0.005$), which suggests that the experimental distributions are not adequately explaining the variability in edge damage.

6.3 Landscape variability

In the following sections, the edge damage patterning evident at the landscape scale is analyzed in order to examine the hypotheses outlined in Chapter 4. These hypotheses relate tool use and taphonomy to the archaeological context on the landscape in which they were deposited – including open-air, caves, inland, and coastal setting variables. Patterning through time is also examined, in order that these results can be placed within the context of technological variability within the MSA as a whole.

Following the general outline of this chapter, the landscape patterning identifiable from points, blades, and flakes are discussed in order.

6.3.1 Caves vs. Open-Air

6.3.1.1 Points

Table 34 provides the frequency each experimental process occurs in the best-fit model across archaeological contexts for points. Although the sample of open-air sites is low and not statistically significant, they provide an indication that edge damage on points from these contexts is consistent with a combination of armature tips and trampling ($\chi^2 = 4.000$, df = 3, $p = 0.262$). This pattern holds if the published assemblage of points from KP1 is included which is best fit by the 2-parameter equation of spears and trampling. Cave assemblages contain a diverse suite of edge damage formation processes, with no single process being dominant ($\chi^2 = 1.000$, df = 3, $p = 0.801$).

Table 34. Summary of best-fitting model parameters by archaeological assemblage context for points.

Context	Trampling	Tumbling	Butchery	Spears
Cave (n=14)	10	7	9	11
Open-Air (n=2)	2	0	0	2

Although the sample of open-air assemblages is small (as is common for all MSA contexts on the south coast), this pattern is suggestive of point discard from spear-tip use at open-air sites. This is better supported by the frequencies of DIFs between cave and open-air assemblages shown in Figure 40. Open-air assemblages have significantly more impact fractures on points compared to cave assemblages (Fisher's exact test, *p*=0.0137).

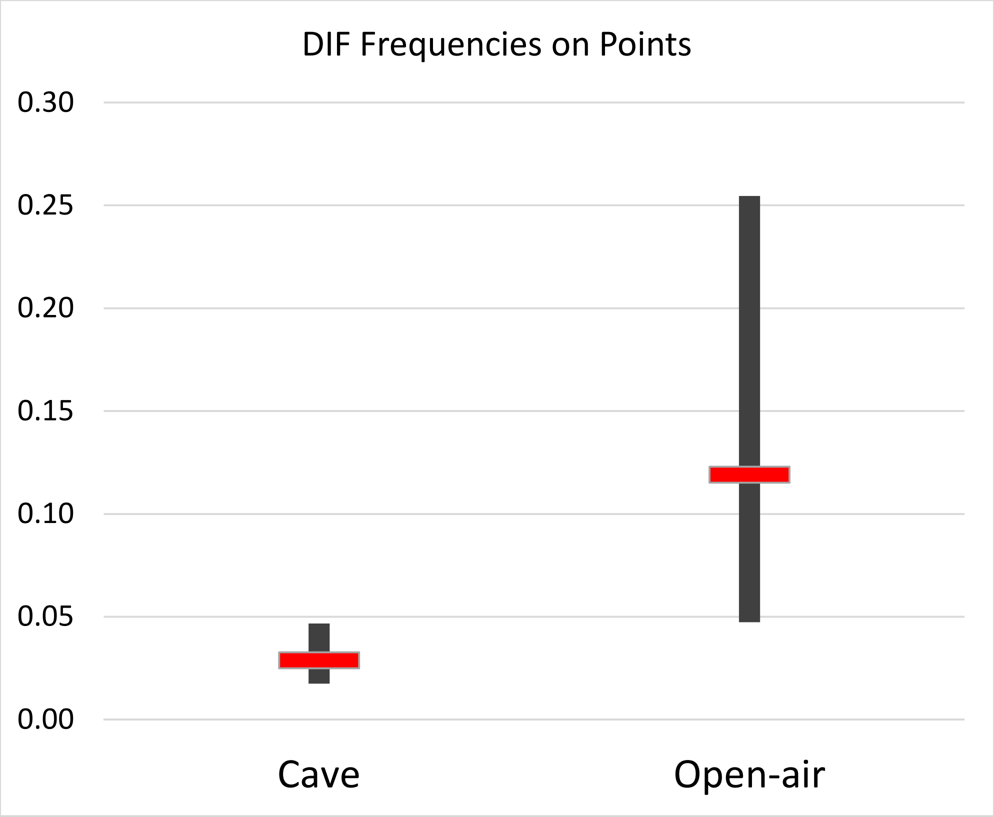

Figure 40. 95% C.I. on proportion of DIFs on points from cave and open-air site contexts. Dark rectangle indicates 95% confidence limits, red bar is mean.

6.3.1.2 Blades

Table 35 provides the frequency each experimental process occurs in the best-fit model across archaeological contexts for blades. A similar diversity of edge damage formation processes are apparent from cave contexts. With butchery split between the "defleshing" and "field dressing" patterns, cave contexts have a higher frequency of "field dressing", and "spears", however a chi-square test indicates the difference is not significant ($\chi^2 = 6.394$, df=4, p=0.1716). Blades from open-air contexts exhibit a diversity of processes as well, and there are no significant differences between their frequencies ($\chi^2 = 1.273$, df=4, p=0.8659).

Table 35. Summary of best-fitting model parameters by archaeological assemblage context for blades.

Context	Trampling	Tumbling	Defleshing	Field Dressing	Spears
Cave (n=14)	17	9	9	18	18
Open-Air (n=2)	1	2	2	3	3

The high frequency of edge damage patterning on blades consistent with damage from experimental spear-tipped armatures may indicate that the range of detached pieces suitable for use as armatures includes unretouched blades. This has been argued for backed blades present in the MSA by at least 71 ka (Brown et al., 2012), and may include unretouched blades as well.

The high frequency of "field dressing" compared to "defleshing" edge damage patterning at caves may be consistent with size-dependent transport patterns common in faunal remains from MSA assemblages (see Chapter 4, figure 2). Since small animals can be completely transported, very little field processing occurs, and this could result in an increased frequency of tools used for both primary and secondary butchery tasks in cave assemblages. Since field processing creates more damage in general, it would tend to be the predominant edge damage signal from mixed butchery tasks. It is difficult to ascertain how representative two open-air assemblages of blades are in terms of edge damage patterning, but it's conceivable that the approximately even frequency of defleshing and field processing parameters indicates both tasks occurred at open-air sites in equal measure. Additional research is needed to more fully examine the distribution of cutting tasks on the landscape during the MSA, but assemblage analysis of edge damage patterning appears to be a promising step forward.

6.3.1.3 Flakes

Table 35 provides the frequency each experimental process occurs in the best-fit model across archaeological contexts for flakes. Again, cave assemblages represent a diversity of edge damage formation processes, especially post-depositional and butchery processes, but also experimental spear distributions. Open-air assemblages have flake edge damage patterning less influenced by post-depositional processes, and largely influenced by butchery patterns – either blades or points, although there is some evidence for small-blades to have edge damage patterning consistent with spear tipped armatures.

Table 36. Summary of best-fitting model parameters by archaeological site context for flakes.

Context	Trampling	Tumbling	Butchery - blades	Butchery - points	Spears
Cave (flakes >30 mm) (n=11)	4	2	5	5	5
Cave (flakes <30 mm) (n=12)	5	5	7	1	6
Open-Air (flakes >30 mm) (n=2)	0	0	2	1	0
Open-Air (flakes <30 mm) (n=2)	1	0	2	2	2

6.3.2 Coastal vs. Interior

6.3.2.1 Points

The frequency each experimental process occurs in the best-fit model between coastal and interior archaeological contexts for points are provided in Table 37. Regardless of inferred coastal or interior context during occupation, sites have a very uniform frequency of processes consistent with edge damage formation (Coastal, χ^2=0.857, df=3, *p*=0.836; Interior, χ^2=1.2, df=3, *p*=0.753). There does not appear to be any support for a difference in coastal and interior site context and best-fitting model parameters.

Table 37. Summary of all best-fitting model parameters by archaeological assemblage setting for points.

Context	Trampling	Tumbling	Butchery	Spears
Coastal (n=6)	4	2	4	4
Interior (n=10)	8	8	5	9

6.3.2.2 Blades

Table 38 provides the frequency each experimental process occurs in the best-fit model between coastal and interior archaeological contexts for blades. Both coastal and interior occupations have a uniform diversity of processes that are consistent with the formation of edge damage on blades (Coastal, χ^2=4.875, df=4, p=0.300; Interior, χ^2=4.545, df=4, p=0.337).

Table 38. Summary of best-fitting model parameters by archaeological assemblage setting for blades.

Context	Trampling	Tumbling	Defleshing	Field Dressing	Spears
Coastal (n=5)	9	4	3	9	7
Interior (n=11)	11	7	8	14	15

6.3.2.3 Flakes

Table 39 provides the frequency each experimental process occurs in the best-fit model between coastal and interior archaeological settings for flakes. As was the case with points and blades, there is a uniform frequency with which each best-fitting model parameter occurs by context and flake size. No significant differences between best-fitting model parameters was noted for flakes.

Table 19. Summary count of frequency of best-fitting model parameters by archaeological assemblage setting for flakes.

Context	Trampling	Tumbling	Butchery - blades	Butchery - points	Spears
Coastal (flakes >30 mm) (n=5)	1	0	2	3	1
Coastal (flakes <30 mm) (n=5)	3	2	3	0	3
Interior (flakes >30 mm) (n=7)	3	2	5	3	4
Interior (flakes <30 mm) (n=7)	3	3	5	2	4

6.3.3 Temporal variability

6.3.3.1 Points

The single best-fitting experimental distribution parameter for each assemblage is plotted by estimated age in Figure 41 for points. Assemblages with edge damage distributions consistent with the experimental spear-armatures span nearly the entire range of the MSA sampled in this dissertation, other than PP13B layers from MIS6. Assemblages of points with a distribution best-fit by the experimental butchery data are more constrained between 100-60 ka. In terms of damage intensity, there is no clear

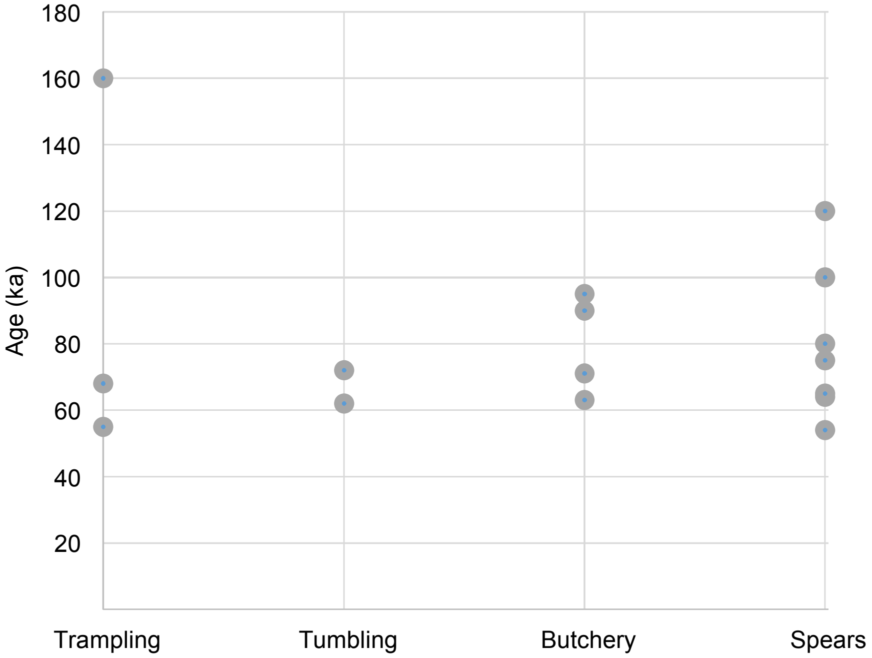

Figure 41. Single best-fit variable by time for points.

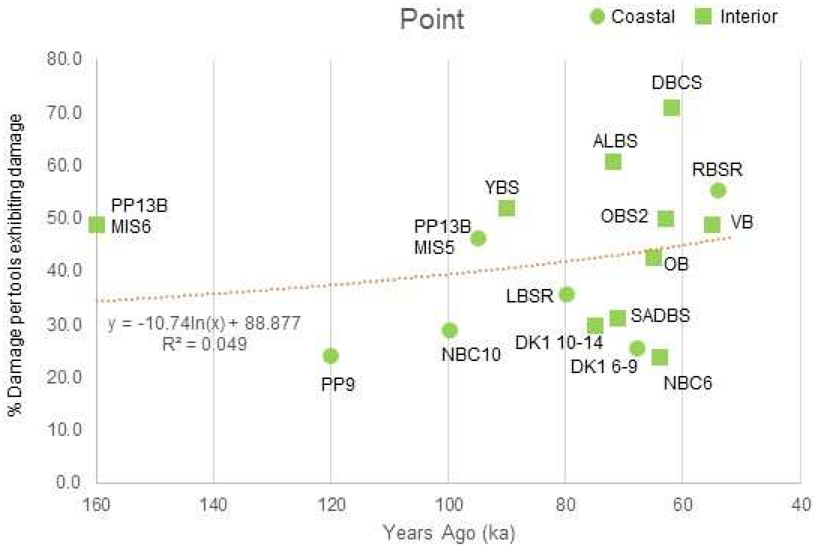

Figure 42. Archaeological edge damage intensity on points through time.

temporally vectored change in edge damage formation on archaeological points (Figure 42).

6.3.3.2 Blades

The single best-fitting experimental distribution parameter for each assemblage is plotted by estimated age in Figure 43 for blades. Assemblage distributions of damage on blades which are consistent with the experimental spear damage are constrained to ~80-60 ka, a time period during which microlithic technology first appears at PP5-6 (Brown et al., 2012), and becomes widespread throughout South Africa in the HP. Blades consistent with cutting tasks such as defleshing and field butchery occur throughout the span of the MSA. Damage attributable to a trampling origin occur after MIS5e, and few assemblages are consistent with the tumbling pattern of damage formation, even at Nelson Bay Cave where water transport is likely.

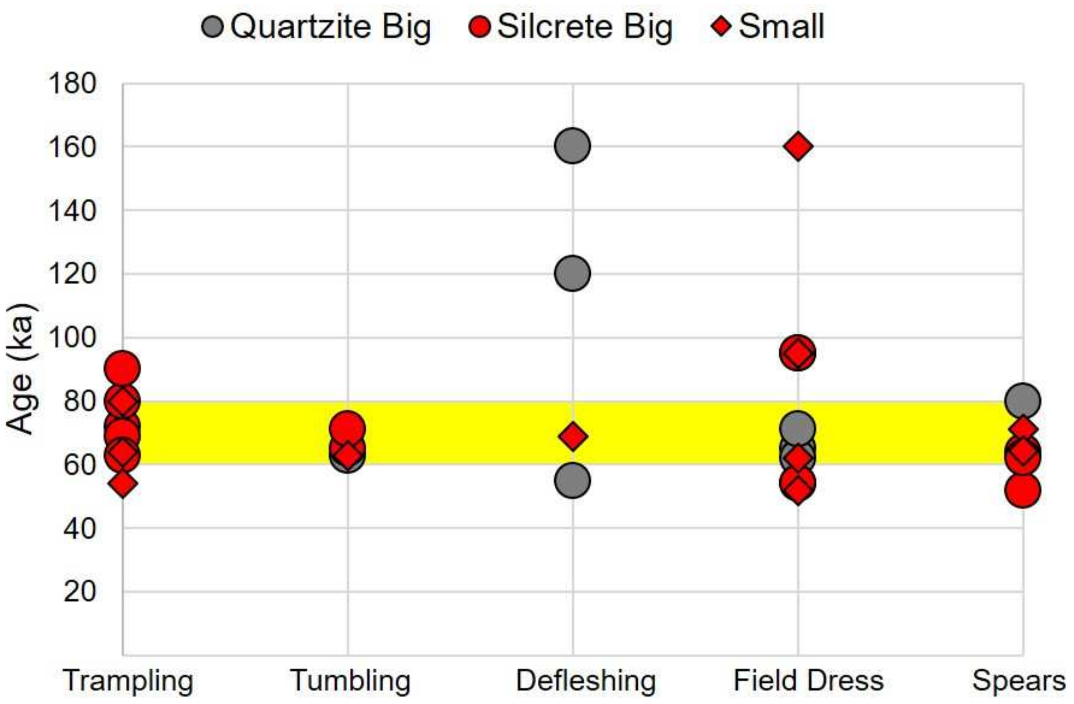

Figure 43. Single best-fit variable by time for blades. Time period of microlithic technologies at other MSA sites highlighted in yellow. Big blades are >30mm and colored grey for quartzite and red for silcrete; small blades are <30mm, all silcrete.

Edge damage intensity on blades through time is shown in Figure 44. There does not seem to be any temporally vectored change in the average amount of edge damage on blades that have at least one instance of edge damage. This is similar to the lack of patterning seen in archaeological point edge damage intensity through time.

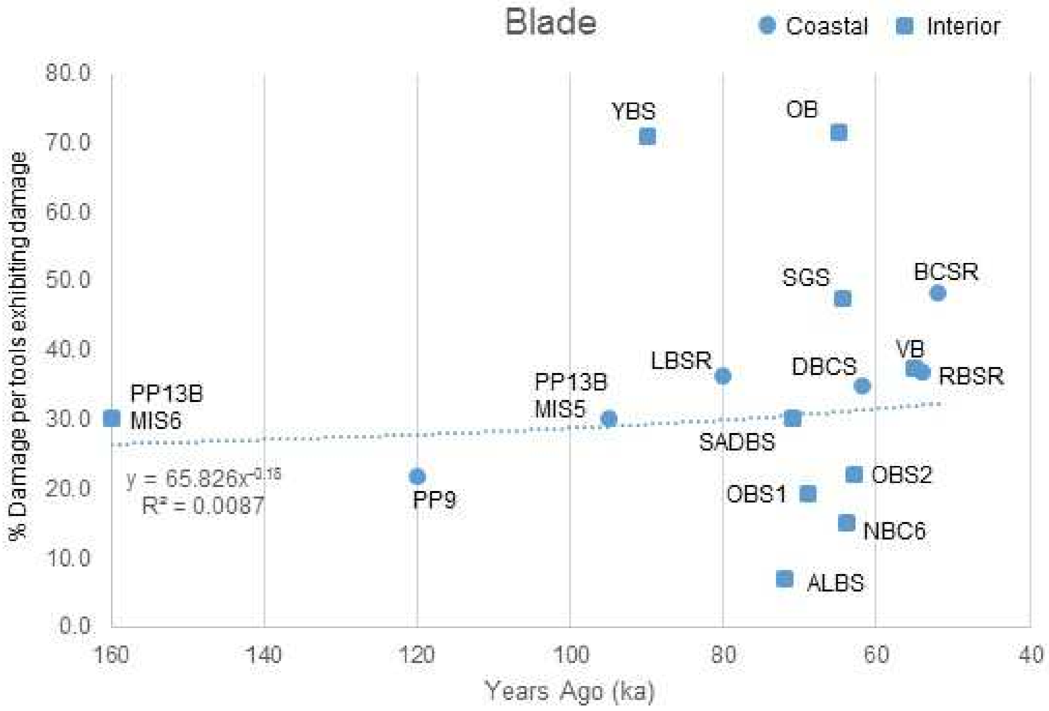

Figure 44. Little patterning is seen in archaeological edge damage intensity on blades through time.

6.3.3.3 Flakes

The single best-fitting experimental distribution parameter for each assemblage is plotted by estimated age in Figure 45 for flakes, split by the arbitrary maximum length of 30mm. Flakes with damage distributions consistent with cutting tasks such as butchery with blades and points are the most common best-fit parameter, and occur throughout the MSA time period sampled here (no PP13B flakes were examined). Several assemblages with flakes consistent with spears do occur after ~65 ka. Flakes with damage patterning consistent with trampling only occur in the time period between ~70-60 ka. This is also true for blades. Since trampling damage is correlated with disturbance activity, there may be a correlation between additional activity in these assemblages during this time period

– possibly due to increased population sizes, reduced mobility, or both (Ambrose and Lorenz, 1990).

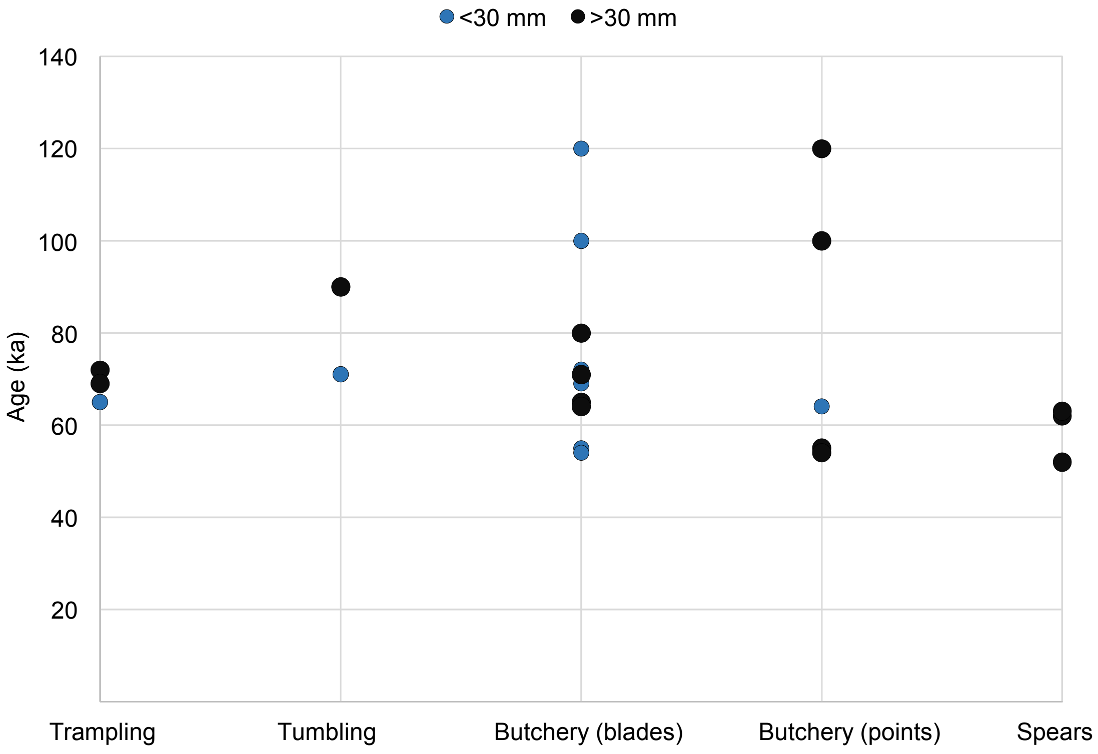

Figure 45. Single best-fit variable by time for flakes.

The intensity of edge damage on flakes through time is shown in Figure 46. Unlike points and blades, there does appear to be a strong temporal pattern in edge damage intensity on flakes – more recent flakes have more edge damage per tool than older flakes. A logistic curve fit to these data has R^2=0.420.

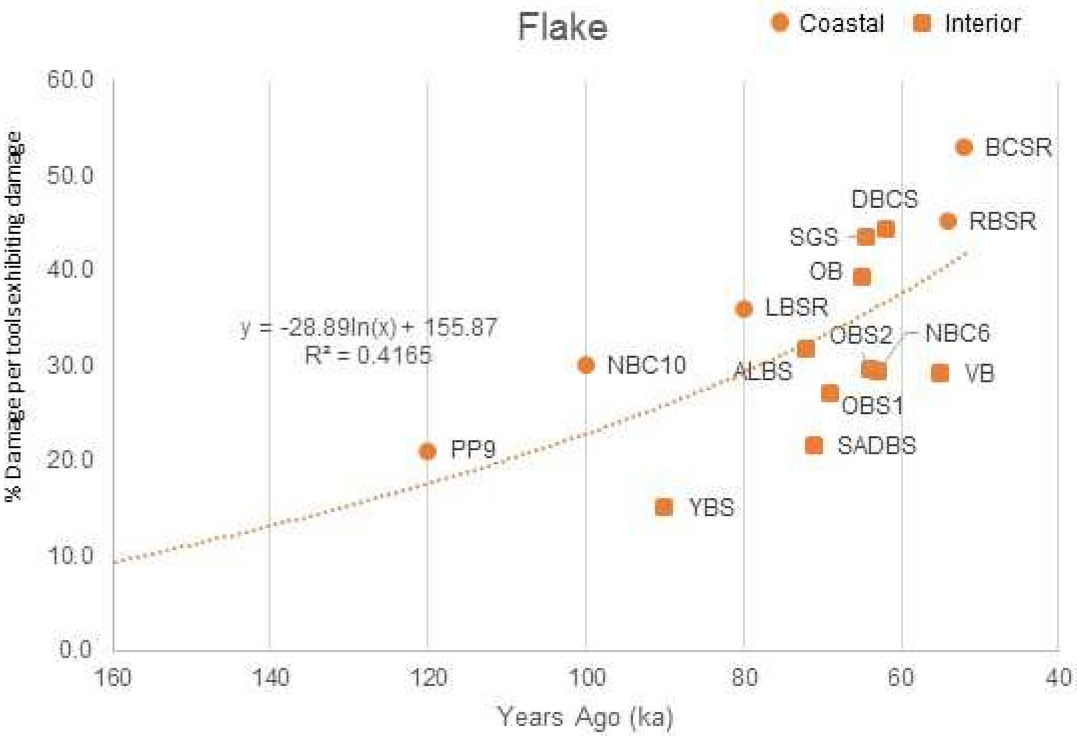

Figure 46. Edge damage intensity is strongly patterned through time on flakes.

6.4 Summary

In this chapter, the results of the experimental and archaeological edge damage analyses were presented that will form the basis of the discussion in the next chapter. The hypotheses put forward in chapter 4 will be examined with these results, and behavioral and technological variability in the MSA will be discussed.

CHAPTER 7 – DISCUSSION AND CONCLUSIONS

7.0 Introduction

In this chapter, the results of the trace-agent edge damage formation experiments and archaeological patterning of edge damage distribution is related back to the goals and hypotheses laid out in Chapter 4. The objective of this dissertation was to understand the behavior of modern humans on the south coast of South Africa during the MSA, but edge damage analysis also allows aspects of site formation to be examined that can inform other facets of archaeological interpretations. To begin, the first two goals of this dissertation will be evaluated in light of the results presented in chapter 6. As part of goal 2, the five hypotheses laid out in chapter 4 that relate landscape archaeological patterns in inferred edge damage processes will be examined, with the evidence providing some support for three (Hypotheses 2, 3, and 5), and not supporting two (Hypotheses 1 and 4). The third section of this chapter will consist of site-specific discussions, as the results from chapter 6 also highlight patterns that are informative to site-specific formation processes and behavioral inferences. In the final section, I will discuss the implications of this project for technological variability in the MSA, it's bearing on modern human behavior, and dispersal out of Africa; and MSA landscape use by using edge damage and macrofracture patterning as lines of evidence. At the end of this chapter, the overall project background, objectives, results, and conclusions will be summarized.

7.1 Goal 1

The first goal of the dissertation was to create an experimental database of taphonomic and behavioral edge damage. These experiments provided the trace-agent linkages through which behavioral interpretations about the past ultimately can be made, but also pave the way for additional work that can strengthen and improve the approach used in this dissertation.

One key limitation of the experimental design is that only a subset of the range of processes that influence edge damage formation were tested. A wide range of other activities are needed to expand the range of behaviorally meaningful activities that can be distinguished using this method. The generally low R^2-values indicate that much of the variation in edge damage patterning still needs to be accounted for, and additional experiments can begin to identify the causal agency behind variability in edge damage formation processes unidentified by the experimental causal agents examined here.

The long-term trampling study provided valuable data on artifact edge damage formation, recovery attrition, movement, and displacement. Doing similar experiments in other settings (e.g., dune sand, caves and rockshelters) with more human trampling, or with less spacing between artifacts can provide insight into trampling damage variability. Artifact compaction is a serious issue at many sites (especially layer 6 at DK1, Marean et al., 2000b) and experiments are needed to evaluate how this process may influence damage formation relative to trampling processes.

Additional behavioral experiments are needed to understand how different cutting, scraping, and drilling tasks form edge damage at an assemblage-scale. The experiments separating field-dressing from defleshing butchery in this dissertation provides an archaeological correlate that is unlikely to be visible at the scale of a single artifact. In other words, traditional edge damage approaches are unlikely to be able to discern the stage in the butchery process beyond “meat-cutting”. In addition to more scar-trait statistical analyses, such as shape, size, orientation along the edge, additional behavioral experiments will improve the accuracy of trace-agent linkages. With more precise linkages, the range of behavioral and taphonomic formational processes stone tools were exposed to on the landscape in the MSA can be further identified.

Although this study identified armatures in some MSA assemblages on the south coast, identifying armature method (spear, atlatl, bow) archaeologically has been an elusive task for researchers (Sisk and Shea, 2011). Some progress has been made using micro-stress features visible as ‘velocity-dependent fracture surface features’ such as Wallner lines or fracture wings (Hutchings, 2011) from high energy impact fractures but these are only visible on very fine-grain, homogenous materials (Hutchings, 1997; Sahle et al., 2013). To see whether this was possible for heat-treated silcrete, backed blades shot as high-velocity projectile armatures (Schoville et al., 2013) were supplied to Karl Hutchings for analysis but no velocity-dependent fracture surface features were visible (Hutchings, personal communication), and even fine-grained quartzites do not show these features. Other methods for identifying armature methods such as tip cross-sectional area and perimeter (Sisk and Shea, 2011) have been critiqued for their reliance on ethnographic data from outside Australia – and when Australian data are added there is very little distinction in armature sizes (Clarkson, 2011; Newman and Moore, 2013). Clarkson (2011) argues that impact fracture size may be able to distinguish thrusting/throwing spears from higher velocity weaponry, but so far these data are limited and additional experimentation is needed. For now, the identification of armature tips on points and blades suggest changes in prehistoric weaponry occurred, but the exact nature of these developments requires further experimental work.

7.2 Goal 2

Utilizing the trace-agent inferential chain to identify behavioral and taphonomic processes in MSA assemblages provided evidence for (1) the multi-functionality of points throughout the MSA; (2) the use of blades, even unretouched ones, as armatures during the HP; and (3) changes in the taphonomic formation of damage on flakes through time may relate to site use intensity, increased population, reduced residential mobility, or some combination of the three. The outcome of the analyses during Goal 2 also identified several limitations in the current study: there was uneven coverage of sites and time periods, and few open-air assemblages; uneven representation of flakes and blades from some sites, especially the lack of blades from DK1 makes understanding the functional and stylistic variability of un-retouched HP blades difficult and the analysis only focused on the unretouched assemblage component. Some of these issues are systematic to Stone Age archaeology – more sites, better dates, and improved environmental data are always needed. Despite these caveats, the methodology and sites surveyed provided a sufficient test of MSA edge damage variability to begin identifying patterns of behavioral and taphonomic processes operating on multiple scales of analysis.

In chapter 4, there were five hypotheses proposed that relate patterning in edge damage on MSA points, flakes, and blades, to how MSA foragers may have been utilizing the landscape. The results of these hypotheses are as follows.

7.2.1 Hypothesis 1

Stone tools from open-air contexts indicate increased exposure to weathering processes, whereas cave contexts indicate increased exposure to trampling.

Post-depositional damage influences archaeological material in every context in some way. It was hypothesized that open-air sites, as unprotected micro-contexts, would be exposed to increased levels of artifact rolling and turbation due to their exposed location on the landscape. This was expected to result in a higher frequency of tools with a distribution of damage consistent with the experimental rock-tumbler damage. In contrast, cave contexts are restricted spaces that concentrate activity within them. This was expected to result a higher frequency of tools with a distribution of damage consistent with trampling damage.

From the analysis presented in the prior chapter, this hypothesis is not supported. Although more assemblages fit trampling distribution in caves than tumbling (36 of 59 trampling, 61% vs. 23 of 59 tumbling, 39%), the difference is not statistically significant (*p*=0.091). A similar pattern is evident at open-air sites, where 4 of 6 tool assemblages fit a trampling (66%) pattern, and only 2 of 6 fit a tumbling (34%) pattern, but again, the difference is not statistically significant (*p*=0.414). Some have argued that trampling is simply a more common post-depositional processes acting on archaeological assemblages, and is more difficult to detect (McPherron et al., 2014), which may make the edge damage distribution signal weaker. Additionally, tumbling may not result in damage at the energy-levels of archaeological site formation because they are lower than what experimentation of fluvial transport and edge damage formation have used (Lenoble and Bertran, 2004; Chu et al., 2015). For example, in a fabric analysis of sediments from

PP13B, Bernatchez (2010) illustrates that most artifacts are subjected to disturbance intensity less than that from ‘shallow run-off’, except for two stratigraphic aggregates in the Western excavation area (LB Sand 1 and LBG Sand 2). In flume experiments, Chu et al. (2015) demonstrate that transport of at least medium-size gravels are required for damage to form on flint artifacts due to fluvial movement, which are generally larger than what is found in the archaeological deposits analyzed here (e.g., Karkanas and Goldberg, 2010; Karkanas et al., 2015), and requiring higher velocity fluvial movement. When fluvial transport occurred archaeologically, it does not appear to have resulted in as much edge alteration as trampling in the contexts analyzed here. In summary, MSA sites are exposed to trampling damage on average in similar frequencies between open-air and cave assemblages, contrary to Hypothesis 1.

7.2.2 Hypothesis 2

Sites on the paleocoast will reflect different patterns of hunting and butchery on points, blades, and flakes, compared to sites in the paleointerior.

Human behavior is adapted to the availability of needed resources. Since a different array of plants and animals were available in paleocoastal contexts compared to paleointerior contexts – especially with regard to shellfish access, it was anticipated that humans would have used and discarded tools differently in these two contexts. By testing for differences between paleoscape contexts, aspects of the technological behavior within the MSA foraging system can be identified.

The results from analyses presented in Chapter 6 provide some tentative support for Hypothesis 2. Rather than clear cut differences in exactly which processes form edge damage on tools differently between paleocoastal and paleointerior sites, it appears that there may simply be more diversity of processes in paleocoastal contexts. One way to examine this pattern is to look at the equability of experimental processes identified in each context. To do this, the Shannon evenness index was calculated on the frequency of best-fit model parameters (Faith and Gordon, 2007), where evenness is equal to $-\Sigma p_i \ln p_i / \ln S$, where S is the number of types of edge damage processes possible from the line-fitting procedure (e.g., defleshing, tumbling) and p_i is the standardized proportion of processes for the *i*-th context (i.e., coastal or interior). In this analysis, evenness values (E) that are close to 1 represent assemblages where each edge damage formation processes is represented equally, whereas values closer to 0 represent assemblages where the processes of edge damage formation are unevenly represented (Shennan, 1997). For instance, if one context had edge damage on tools attributed to butchery, armatures, tumbling, and trampling one time each, then the evenness would be equal to 1. The more uneven the frequency of edge damage processes, the lower the value of E.

Points have edge damage patterning slightly more equitably distributed on coastal assemblages compared to interior assemblages (interior points E=0.969, coastal points E=0.980). In contrast, both blades and flakes have edge damage patterning more equally represented across interior sites than coastal sites (interior flakes E=0.966, coastal flakes E=0.803; interior blades E=0.980, coastal blades E=0.947), though the difference is not significant. The rationale behind Hypothesis 2 is that the distribution of resources in coastal environments would provide different opportunities for stone tool use than interior locations. The results presented here suggest that, in terms of the somewhat limited number of processes tested here, there are not significant differences between the diversity of processes that tools were exposed to in coastal contexts compared to interior contexts.

As discussed in chapter 4, the intensity of behavioral edge damage formation may be causally linked to degree of curation. Following Odell (1996), as foraging groups become more mobile, tools will tend to serve more functions and be utilized more intensively. Edge damage formed significantly more heavily on points from interior locations compared to coastal sites (coastal=36.0%, interior=45.9%; t-test, $p<0.001$), consistent with more frequent use of points in contexts where larger game are present such as Renosterveld and Thicket vegetation. Blades have ~equal damage formation between coastal (34.6%) and interior (35.0%) assemblages (t-test, $p=0.824$), whereas flakes have higher amount of damage per tool in coastal contexts (38.4%) compared to interior (32.1%) assemblages (t-test, $p<0.0001$). Blades appear to have been exposed to a similar diversity of edge damage processes at both coastal and interior locations, and also exhibit similar intensity of damage. Flakes have significantly higher edge damage intensity in coastal environments but were possibly exposed to less diversity of edge damage formation processes at coastal locations.

7.2.3 Hypothesis 3

Caves will have fewer DIFs and less damage intensity; whereas open-air sites will have higher frequency of DIFs and higher damage intensity.

It was hypothesized that tools discarded in cave contexts will tend to either be towards the end of their use-life, or used very opportunistically depending on whether the cave is being regularly supplied with raw material. Caves will have lower frequency of impact fractures because broken tips are more often discarded on the landscape, frequently at kill sites (Villa et al., 2009a; Wilkins et al., 2012) and because a greater range of activities take place at residential sites, so the relative frequency of hunting tools is lower.

The results of this dissertation are consistent with fewer ‘impact fractures’ in enclosed cave contexts (2.9%) compared to open-air sites (11.9%; Fisher’s exact test, p=0.0137), consistent with the findings of Wilkins, et al. (2012) and Villa, et al. (2009a). This is also consistent with discard of broken points with impact fractures more frequently on the landscape rather than transported back to caves. The ubiquity of this pattern likely represents an optimal solution regarding where to retool, and where to discard broken tools, but then the question becomes, how is this the optimal solution?

As tools become worn and break, it is necessary to replenish the toolkit either by repairing broken tools or replacing those beyond repair. Retooling tasks frequently occur at habitation sites during times when other foraging tasks are not possible (e.g., evening and night), and thus lower the overall cost of tool maintenance tasks (Binford, 1980; Torrence, 1989). It could be expected that broken points (proximal pieces, mostly) would be more common where retooling occurs because resins and bindings would need to be loosened, a process that often involves heat to soften mastic (Hunzicker, 2008). Other researchers have argued that broken point tips are discarded on the landscape (Holdaway, 1989; Flenniken, 1991), repairable points are transported back to residential camps for retouch (Shea, 1991), and broken proximal ends are discarded at camp sites during retooling (Hunzicker, 2008). Andrefsky (2008) argues that raw-material proximity influences where broken points are discarded, and localities located near quarries will tend to have higher frequencies of impact fractures than residential areas located more than a day's walk from raw material sources.

What may be informative in this case is to analyze how more recent hunter-gatherers used and discarded broken stone points on the landscape. Paleo-Indian sites in North America are notable in several respects, including their finely made spear-tips (possibly atlatl), the high visibility of kill-sites on the landscape (Kelly and Todd, 1988), and points hafted to a foreshaft (Stanford, 1996; Pearson, 1999). Paleoindian kill-sites indicate a very high frequency of points with projectile impact fractures are discarded on the landscape as part of the Paleo-Indian hunting and tool use system (Figure 47). This pattern is arguably similar to the patterning seen in MSA point impact fractures. Although comparative data are limited, it is notable that this pattern is the opposite of that seen in Neandertal assemblages in European Middle Paleolithic assemblages (Figure 47) where a low frequency of impact fractures on the landscape at open-air sites, and high frequency of impact fractures in caves is seen (Villa and Lenoir, 2006; Villa et al., 2009a). Holdaway (1989) found the ratio of point tips to bases at two Mousterian rockshelters to be the opposite of what is found at sites with projectile armatures. This may imply that the system of point use and discard used by modern humans is different from what was being employed by Neandertals, either in terms of technology being used, transport decisions made on carcasses with point tips embedded within them, or the structure of toolkit repair timing.

One possibility may be the use of a foreshaft as part of the hafting complex. Foreshafts are a 'breakthrough' technology (e.g., Brown et al., 2009; Wrangham, 2009) in the sense that it makes hunting less dangerous by allowing multiple strikes with a spear

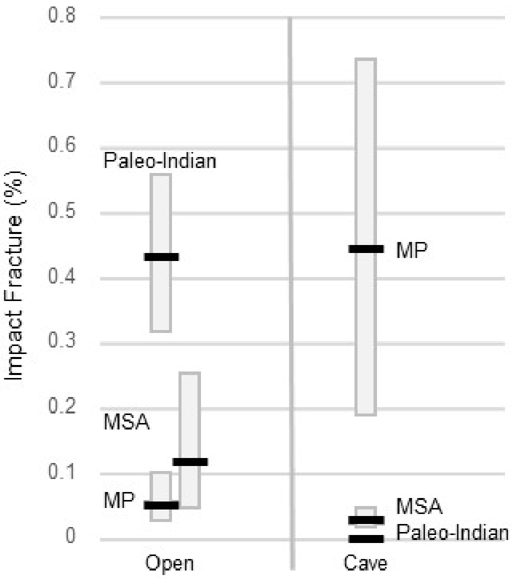

Figure 47. Impact fracture frequency by site context between Middle Paleolithic ("MP") (Callow, 1986; Villa and Lenoir, 2006), Paleo-Indian (Hutchings, 1997; Villa et al., 2009a), and MSA (here) sites. Paleo-Indian data from Sandia Cave and the Casper site.

during hunting, is less cumbersome than carrying around multiple spears, reduces the risk of breaking or losing the wooden spear shaft, and the hafted foreshaft set may also function easily as handled knives (Churchill, 1993). The origin of this technology is not well understood, but are minimally in place in the Magdalenian (~17 ka, Chauvière et al., 2006), at Paleoindian sites (~12 ka, Stanford, 1996)), and within the ethnographic record of Australian aborigines (Allen, 2011). On the south coast of South Africa, foreshafts at the end of wooden spears would be especially economical because few trees suitable for spear shafts exist (Van Wyk and Gericke, 2000; Brown and Marean, 2010), and the use of foreshafts would mitigate the risk of loss or damage to the more valuable end. Foreshafts are multifunctional, and the use of points as knives in some contexts (e.g., PP13B MIS 5, PP5-6 OBS2) is consistent with this interpretation. It's possible that the different broken point discard patterning seen in Mousterian sites is related to the lack of foreshaft technologies, however this proposition requires additional experimentation.

In terms of the edge damage intensity, overall, open-air sites tend to have more edge damage per tool. Blades have significantly greater damage per tool in open-air contexts ($p<0.0001$), and the average for open-air points and flakes is greater than cave contexts, although the differences are not statistically significant (p=0.1603 and p=0.2918, respectively). As described in chapter 4, increased frequencies of behavioral edge damage is suggested to occur on more highly curated toolkits. Tools taken on logistical forays tend to be more heavily curated (i.e., less expedient) than those produced and used at residential sites. This is consistent with a more logistical pattern of tool-use on the landscape, where they become more heavily worn prior to discard. Supplying caves with raw-material during longer occupations may lead to more expedient tool use, and less damage intensity.

7.2.4 Hypothesis 4

Blades from open-air sites will reflect field-butchery patterns of edge damage more closely, and blades from caves will reflect defleshing tasks.

Since the experimental butchery processes of field-dressing and defleshing resulted in significantly different distributions, it was hypothesized that field-butchery would tend to occur on the landscape where animals are initially dispatched and processed for transport. In contrast, caves would tend to be areas where animal parts are transported and with additional processing largely influenced by defleshing tasks for meat distribution.

While intuitive, the results do not provide support for this hypothesis. In fact, field-dressing edge damage patterning was included as a best-fit variable much more frequently at caves than defleshing patterning was. This may be because butchery that occurs at caves is from smaller animals that must be completely butchered, or that this pattern is similar to other processes not currently sampled by an experimental distribution (e.g., hide scraping?).

7.2.5 Hypothesis 5

Temporal change across sites will show a shift from spear-technology using points to microlithic and blade-based projectile technology.

Temporal change was identified, most clearly in how blades were being used. Points were multi-functional throughout the MSA, including use as armature tips and as knives. The temporal pattern for flakes is most clearly associated with increased damage intensity through time, and the possible meaning behind this will be discussed further in section 7.4.

Many have argued that the backed geometric blades and segments (portions of blades) in the HP is indicative of the first evidence for projectile technologies. However, MSA technologies typical of sequences before and after the HP never totally disappear. If convergent-MSA points were occasionally used as spear-points, then the question becomes whether this technology is replaced during the HP, or if the innovations during the HP add technological complexity onto existing technology that is maintained within the cultural system. It was hypothesized that the microlithic industries that appear ~70 ka mark a shift to projectile technology that replaces the existing armature toolkit, and quartzite points would be used mostly as cutting tools during this time period.

The results of this analysis indicate that the use of quartzite points associated with typical Mode 3 technologies are multi-purpose, including use as both spear-tipped armatures and knives. This variability in tool use continues into the time period associated with microlithic industries starting ~71 ka and ending by ~60 ka. During this time period, the typical mode 3 industries that occur throughout the MSA do not disappear, but become less frequent and an increase in finer-grained silcrete blades occurs. Small silcrete blades have edge damage patterning consistent with use as armature tips only during this period of time. Although retouched backed pieces are frequently thought to have been forms of projectile armatures (Lombard and Phillipson, 2010; Brown et al., 2012), it was unexpected that the unretouched blades may have been used in this fashion. This is not without analogy, however. Ethnographic and museum examples of microlithic blades hafted to projectiles are known from numerous locations (Clark, 1977b; Nuzhnyi, 1993; Yaroshevich et al., 2010). Use-wear analyses restricted to retouched tools or small subsamples of unretouched tools may overlook such patterning, highlighting the value of the assemblage edge damage approach to inferring function.

The use of points as spear-tip armatures during this time period suggests that rather than a replacement of technology, these industries operated in parallel. Increased technological complexity is often associated with the creation of task-specific toolkits (Oswalt, 1976; Odell, 1998). Task specific activities may occur embedded within residential movements, but more frequently as part of increased frequency of logistical foraging activities (Binford, 1980). Frequent residential movements would tend to discourage task-specific toolkits that would require frequent transport of a larger number of tools (Kuhn, 1994; Collard et al., 2005). Low residential mobility and long-term occupation may also be suggested in the HP particularly by the dense burning layers that occur at KRM (Singer and Wymer, 1982), PP5-6 (Karkanas et al., 2015), and Sibudu (Wadley, 2010a).

7.3 Site-Specific Implications

Although the overarching theme of this dissertation is to evaluate landscape-scale technological behaviors in the MSA, the results provide several insights into site specific patterning that warrants discussion.

7.3.1 PP13B

The analysis of points from PP13B indicated their use as cutting tools in MIS5 (F-ratio=10.989, p=0.001, R^2=0.027), as has been suggested by separate but similar analyses from Bird et al. (2007) and Schoville (2010). This highlights both the consistency of edge damage analysis at the assemblage scale, but also indicates that points discarded at PP13B at this time were unlikely to have been predominantly used as spear points prior to discard.

This analysis also provides some indication that points in MIS 6 have edge damage more consistent with post-depositional damage, but also as armature tips (F-ratio=4.569, p=0.034, R^2=0.023). This pattern is somewhat inconsistent with Schoville (2010) who did not identify any major differences between MIS 6, late MIS 6, early MIS 5, and late MIS 5 (the MIS 6 points had not been analyzed prior to the Bird et al. study). The different groupings used may influence the ability to tease out edge damage patterning, but the line-fitting statistical procedure used here also has clear advantages in its ability to identify multiple processes that may have influenced damage formation.

The evidence for quartzite points being occasionally used as spear-tips is supported by the faunal evidence from PP13B. O'Driscoll (2012) argues that three bones of size 3 mammals identified by Thompson (2008) from PP13B have stone fragments embedded in them consistent with armature lesions. One of the fragments is from MIS 6, and the other two are from MIS 5 (O'Driscoll, 2012:72). Although there is little evidence for spear-points based on the edge damage and impact fractures from MIS 5, this likely reflects patterns of broken tool discard on the landscape and mobility and foraging strategies. Additionally, the fauna from MIS 6 is notably larger than MIS 5 (Thompson, 2010b), and it isn't clear how faunal transport bias may affect the archaeological frequencies of projectile bone lesions and lithic impact fractures on stone armatures (O'Driscoll and Thompson, 2014).

At PP13B, small and large blades are consistent with the butchery cutting distributions in MIS 5 and 6 on both quartzite and silcrete. In terms of blade use, there does not seem to be any differentiation in use as seen in later assemblages such as the HP levels and SADBS. The bladelets identified at PP13B by Marean, et al. (2007) did not have any observable edge damage - all the blade edge damage observed in this study was on tools greater than 10mm in width. This may indicate that this subset of tools were not necessarily intended products of the knapping process. The lack of bladelet cores at PP13B (Thompson et al., 2010) also suggests that this subset of tools were not necessarily intended knapping products. At PP13B, there is a unimodal blade size continuum that includes bladelets (Thompson et al., 2010). This same unimodal blade size pattern is also observed at Kathu Pan 1 (Wilkins and Chazan, 2012), which has been dated to ~500 ka (Porat et al., 2010), and in pre-HP levels at Sibudu (Villa et al., 2005). In those analyses (KP1 and Sibudu), the presence of bladelets are seen as opportunistic occurrences, rather than a true bladelet technology. It seems more parsimonious to conclude that the bladelets at PP13B fall within this category as well.

An important caveat for the inclusion of PP13B MIS 6 as an interior context is that Marean et al. (Marean et al., 2007) and Fisher (2010) indicate there are periods during MIS6 occupation of PP13B when the coastline was near, therefore making it a coastal assemblage - particularly in the LC-MSA Lower. Other MIS6 StratAggs such as DB Sand 4 and LBG Sand 2-3 are consistent with distant coastlines. Our current resolution linking radiometric ages with the global sea-level curve is not yet precise enough to be certain, but the general trend is for the coastline during MIS 6 to be located greater than 20 km from Pinnacle Point throughout MIS 6 (Fisher et al., 2010), which is why it was analyzed as such here. Relatively brief sea-level progressions during MIS 6 may have an influence on these results that should be taken into consideration. The shell and whale barnacle found in the LC-MSA Lower would suggest that considerable variability in coastline position existed in MIS6.

Table 40. PP13B site formation processes from Karkanas and Goldberg (2010:table 1) and single best-fitting variable from line-fitting procedure.

Assem.	Main Formation Processes	Age (ka)	Points	Blades
MIS 5	Anthropogenic input from superimposed combustion features	130-90	Butchery	Field Butchery
MIS 6	Superimposed combustion features, roof spalling, Aeolian activity, slumping	180-150	Trampling	Field Butchery

7.3.2 PP5-6

There is a diversity of edge damage patterning evident at PP5-6, and the complex post-depositional history identified by Karkanas et al. (2015) is also seen in the edge damage. In Table 41, the main post-depositional formation processes identified through micromorphology analysis at PP5-6 (Karkanas et al., 2015) is presented alongside the inferred main edge damage formation process. Post-depositional processes are the best fitting single variable for 6 of 9 stratigraphic aggregates with large silcrete blades. However, there are behavioral signals within the assemblage that the edge damage analysis identified. Points have edge damage patterning consistent with spear tips in the RBSR and LBSR, including high frequency of DIFs (14% in RBSR, but only 2.9% in LBSR); and cutting tasks in OBS2, SADBS, and YBS. Blades at PP5-6 have edge damage patterning that is size dependent. Large quartzite blades are consistent with "field butchery" tasks in the DBCS, RBSR, and SADBS, as spear tips in the LBSR, and a taphonomic signal from the OBS2. Large silcrete blades are consistent with "field butchery" tasks in the RBSR, a post-depositional pattern in the ALBS, LBSR, OBS1, SADBS, and YBS, and as spear-tips in the BCSR and DBCS. Small silcrete blades are consistent with "field butchery" tasks in the BCSR and DBCS; defleshing tasks in the OBS1, a taphonomic pattern in the LBSR, OBS2, and RBSR; and as spear tips in the SADBS and SGS. Large flakes have more edge damage patterning consistent with behavioral processes while the small flakes have more taphonomic damage patterning.

Table 41. PP5-6 StratAgg formation processes from Karkanas et al. (2015) and single best-fitting variables from line-fitting analysis for quartzite points, silcrete blades, and flakes (big >30 mm, small < 30mm).

StratAgg	Main Formation Processes	Age	±	Points	Big Blades	Sm. Blades	Big Flakes	Sm. Flakes
RBSR	Aeolian, debris flow, pedogenesis	51	2	Spears	Butchery	Trampling	Butchery	Butchery
BCSR	Combustion, Aeolian, debris flow, decalcification	52	3	NA	Spears	Butchery	NA	Spears
DBCS	Debris flow, aeolian, combustion, decalcification	62	3	Tumbler	Spears	Trampling	Spears	Spears
OBS2	Aeolian, decalcification, trampling, combustion, debris flow	63	3	Butchery	Trampling	Tumbler	Spears	Spears
SGS	Combustion, trampling, Aeolian	64	3	NA	NA	Spears	NA	Butchery
OBS1	Aeolian, trampling, combustion, debris flow, sheetwash, partial decalcification	69	3	NA	Trampling	Butchery	Trampling	Butchery
SADBS	Trampling, Aeolian, combustion	71	3	Butchery	Tumbler	Spears	Butchery	Tumbler
ALBS	Aeolian, combustion, trampling	72	3	Tumbler	Trampling	Butchery	Trampling	Butchery
LBSR	Free-fall roofspall, sheetwash, small-scale debris flow, combustion, trampling, cementation	81	4	Spears	Trampling	Trampling	Butchery	Butchery
YBS	Aeolian	96	6	Butchery	Trampling	NA	Tumbler	NA

7.3.3 PP9

At PP9, points have edge damage patterning consistent with spears and taphonomic damage, but there are fewer DIFs than anticipated for armature tips, which may simply be part of the larger pattern for caves to have fewer DIFs in general. All blades at PP9 are larger than 30mm and fit a “defleshing” butchery pattern, but the full model fits ‘field dressing+defleshing+trampling+spears’. Flakes indicate use as cutting tools, both small and large flakes fit “butchery” patterns. The overall damage intensity at PP9 is low compared to the other assemblages (points=24.3%, blades=21.7%, flakes=29.1% for PP9, the overall averages are points=37.6%, blades=33.6%, flakes=36.6%), consistent with the ephemeral use of this site (Matthews et al., 2011).

7.3.4 DK1

The assemblage from DK1 has the ability to highlight interesting aspects of spatial structuring of behavioral adaptations in the MSA because of presence of a similar raw-material shift to increased silcrete seen in HP assemblages, but without the backed pieces diagnostic of the HP. Unfortunately, I was unable to analyze the blades from DK1 for this dissertation, which may have provided additional insight into this question. The published zooarchaeological data from DK1 indicate very small mammals being brought in by humans (Armstrong, 2013) but the primary accumulator of small bovids is argued to be from raptor predation (Marean et al., 2000a). However, even with small bovids removed from their analysis, Clark and Kandel (2013) have suggested that there is a shift to small prey during MIS 4 across the South African MSA record, including at DK1. A reasonable hypothesis, is that a significant portion of the silcrete blades from DK1 functioned as armatures, as is suggested by the edge damage analysis from other MIS 4 sites including PP5-6 and NBC layer 6, but this clearly needs to be tested. The MSA points from DK1 layers 10-16 are consistent with a diversity of edge damage processes (all four), but fit spear points the best (R^2=0.168). Intensive compaction, diagenesis, and roof-fall occurred in layer 6 (Marean et al., 2000b), and the points from DK1 layers 6-9 are consistent with trampling damage. This damage patterning only explains 6% of the variation in edge damage (R^2=0.06), and it is not clear how similar trampling and diagenetic compaction processes influence edge damage formation.

Table 42. DK1 geologic formation processes from Goldberg (2000:table 3) and best-fit single variable for DK1 points edge damage formation.

Assem.	Main Formation Processes	Artifacts	Points
6-9	L6: collapsed roof rock, loam; L8: loam, bioturbation.	Abundant bone, ash, and shell.	Trampling
10-16	Decalcification, loam, '*eboulis secs'*, post-depositional disturbance by animals, humans, or wind.	Charcoal, bone, carnivore coprolite.	Spears

7.3.5 Nelson Bay Cave

At Nelson Bay Cave, edge damage on points appears to be the same between layers 6 and 10 - spear-tip armatures are the best single variable, and the best full model includes spear-tips and butchery. The larger blades in NBC 6 are consistent with use as spear-tip armatures, similar to the HP assemblages at PP5-6 (DBCS), however the small blades have damage more consistent with trampling processes. Small and large flakes in both NBC 6 and 10 show edge damage consistent with cutting tasks. Overall, the taphonomic experimental processes did not explain much variation in the edge damage patterning at NBC, which may be somewhat surprising given the water-logged nature of the sediments – suggesting churning and debris flow were not influential processes in edge damage formation. Overall, NBC fits the general pattern of edge damage formation identified in the PP5-6 sequence.

Table 43. NBC geologic formation processes (Butzer, 1973; Deacon, 1978) and single best-fit edge damage formation variables for points, blades (small <30 mm, big >30 mm), and flakes.

Assem.	Main Formation Processes	Points	Big Blades	Sm. Blades	Flakes
6	Angular roofspall, dark loam, saturated, ferruginized.	Spears	Spears	Trampling	Butchery
10	Lag deposit, loam, saturated.	Spears	N/A	N/A	Butchery

7.3.6 Vleesbaai

At Vleesbaai, points have a high frequency of impact fractures (7.7%) consistent with use as spear-tipped armatures, but the edge damage patterning is more consistent with the combined processes of trampling and use as spear-tipped armatures. Edge damage patterning on the large blades (>30 mm) at Vleesbaai are consistent with butchery patterns, and no small (<30 mm) blades were analyzed. This is consistent with the observation that tools at Vleesbaai are larger, with more cortex than those that were brought into nearby caves PP13B and PP9 (Oestmo et al. 2014). Small and large flakes are consistent with butchery patterns, but these processes explain a low amount of the overall variation in edge damage (R^2=0.064 and 0.028 on large and small flakes, respectively).

7.3.7 Oyster Bay

At Oyster Bay, points are also consistent with use as spear-tipped armatures based on the edge damage patterning (R^2=0.391) and high frequency of impact fractures (14%). Large quartzite blades are consistent with butchery, but a diversity of processes (4) are in the best fit model. Large silcrete blades fit the tumbler distribution. Large flakes are consistent with trampling, small flakes consistent with butchery patterns. Overall, this is similar to the analysis from Vleesbaai.

Fauna from OB has been identified as mostly large open-habitat grazers, consistent with, but not diagnostic of, an occupation of OB during a glacial phase (Carrion et al., 2000). However, so far no taphonomic analyses of these faunal remains have been conducted, and analysis of the complete lithic assemblage is ongoing (Schoville and Wilkins, n.d.), therefore it is difficult to relate the edge damage patterning to a broader archaeological context at OB.

7.4 MSA technological variability

Within the last 20 years, there has been a shift in how MSA behavioral adaptations are perceived (McBrearty and Brooks, 2000; Henshilwood and Marean, 2003). The traditional perspective viewed MSA foragers as less adept hunters, technologically less sophisticated, and culturally less complex than LSA and Upper Paleolithic hominins (e.g., Klein, 1999). Now it is widely recognized that MSA hunters were highly skilled at acquiring diverse and ‘dangerous’ species and scavenging was not their predominant method of acquiring meat (Marean and Assefa, 1999; Marean, 2007; Faith, 2008). Tortoises, shellfish, and mole-rats were frequently obtained in parallel with the acquisition of large (size 3-5) antelope (Marean et al., 2007; Wadley, 2010b; Thompson and Henshilwood, 2014). MSA technology includes many novel techniques for constructing tools, including heat-treatment of silcrete, pressure-flaking, and the use of complicated ochre mastic recipes for hafting (Wadley, 2005; Brown et al., 2009; Mourre et al., 2010; Wadley, 2010a). Culturally, artifacts with symbolic purposes have been found from several sites, including shell beads, cross-hatched ochre incisions, ‘beauty’ shells, and engraved ostrich eggshell (d'Errico et al., 2005; Henshilwood et al., 2009; Jerardino and Marean, 2010; Texier et al., 2010). This study fits within this paradigm shift by exploring the emergent complexity seen in the manufacture, use, and discard of stone tools in the MSA through a landscape-scale perspective. This approach allows variability in technological behaviors on the south coast to be explored at multiple scales that provide insight into early modern human behavior.

7.4.1 Dynamic Settlement System

Most studies of MSA behavioral variability tend to be more site-specific than landscape-broad (Wadley, 2007; Porraz et al., 2013). For instance, Blombos Cave is frequently thought to have been a unique activity place for early humans on the south coast (Thompson, 2010b; Henshilwood and Dubreuil, 2011). This small cave located on the bank of a steep cliff contains symbolic evidence unparalleled in the MSA record including a ‘paint kit’, and has a faunal assemblage distinct from other well analyzed zooarchaeological assemblages at DK1 and PP13B (Thompson, 2010b; Henshilwood et al., 2011). However, identifying site-specific behavior is likely more a function of the small sample of well-excavated sites available for discussion in the MSA and does little to explain landscape scale settlement, foraging strategies, or cultural and stylistic patterning in the MSA (Conard, 2001; Marean et al., 2014). Characterizing site-specific behavior provides some insight into behavior, but is limited in its ability to address how common those behaviors were, how they varied across the landscape, or change through time.

As shown by the results of testing Hypotheses 2 and 3, there are patterns in MSA technological behavior across the landscape that are not site-specific. An increased diversity of processes causing edge damage patterning are implicated in paleocoastal environments compared to paleointerior sites, and paleo-interior tools tend to form damage more intensively. This pattern is consistent with longer or more frequent residential occupation in paleocoastal environments, and more short term activity focused site occupation when in paleointerior contexts. As described in Chapter 3, the environment on the south coast provides an abundance of collectible protein such as shellfish, marine mammal wash-ups, and tortoises that may influence the site occupation strategies reflected in the lithic technology. The division of labor within human foragers is probably affected by the availability of collectible plants and animals (Kuhn and Stiner, 2006). The addition of smaller but collectible resources reduces the daily variance and may allow males in particular more time to pursue higher ranked game and engage in other pursuits (Hawkes, 1996). Since there is no evidence for fewer hunting tools during occupation of the paleocoast, hunting likely maintained an integral role in the foraging strategy across the landscape – possibly implying a division of labor common to modern foraging societies. Gurven and Hill (2009) identify five aspects of hunter-gatherer socioecology which are anticipated to result in a sexual division of labor: (1) prolonged childhood dependence, (2) need for both protein and carbohydrate in diet, (3) skill-dependent foraging efficiency, (4) spatiotemporal segregation of important resources, and (5) sex-specific comparative advantages in certain foraging tasks. Of these, (1), (2), (3), and (5) likely had their root much earlier in human evolution. Occupation of coastal environments while still maintaining a hunting adaptation implies that (4) was also in place at this time because large animals optimally hunted with spear technology are spatio-temporally separated from the collectible resources on the coast.

In addition to the differential transport and discard of tools with impact fractures on points, caves tend to have blades with 'field-dressing' edge damage patterning, whereas more open contexts have an even frequency of 'field-dressing' and 'defleshing' butchery patterns. Although these two processes are not completely representative of the range of cutting behaviors that occurred in the MSA, they do provide an indication of differential processes of edge damage formation across the landscape on blades. The reasons for this patterning require further investigation, but may be due to differential carcass transport patterns and the overall tendency for more damage to form from field dressing (disarticulating) activities than defleshing (Braun et al., 2008b).

7.4.2 Dynamic Temporal Change

The results from this study suggests that quartzite MSA points were used as spear-tips throughout the MSA, but were multi-functional. Blades may also have been used as armature-tips for short periods of time centered on 70 ka, but otherwise used as cutting tools throughout MSA.

I follow Brown et al. (2012) and consider the HP and SADBS assemblages as microlithic in character (*contra* Igreja and Porraz, 2013). The retention of mode 3 technologies being used for the same variety of tasks with the addition of microlithic technology is unique in terms of the global pattern of microlithization outside of South Africa (Kuhn and Elston, 2002; Groucutt et al., 2015). More frequently, microlithization is a process of technological changeover from prior toolkit strategies, such as the case in East Africa at the Naisiusiu Beds and in East Asia by ~40 ka (Groucutt et al., 2015), arguably associated with spread of modern humans out of Africa (Mellars et al., 2013). This may suggest that the microlithization in the HP is a niche broadening strategy – the prior techniques and strategies for MSA foragers were still viable, but additional technology allowed for increased foraging returns (McCall and Thomas, 2012).

Behavioral ecological prey-choice models may provide an illustration of why existing technologies would be maintained alongside new innovations. The prey-choice model explains forager decisions to pursue encountered prey as a response to perceived return rate and encounter rates of different prey (Krebs and Davies, 1981; Stephens and Krebs, 1986). Highly ranked prey will always be pursued upon encounter because they will maximize the return rate. Moving down the list of prey rankings, at some point it is more productive to keep searching than to pursue low-ranked animals that are encountered. However, this equation can change as the population of higher ranked prey becomes reduced (lower encounter rates) or new technologies decrease the pursuit costs of otherwise lowly ranked prey. This has been described for foraging groups in South America where monkeys are only hunted once shotguns are available (Hill and Hawkes, 1983). If decisions to maintain the cultural knowledge to produce different technologies are substituted for prey species, then the decision to broaden the technological repertoire may have maximized return rates for foragers between ~80-60 ka compared to the option of removing the existing technology from the repertoire and focusing solely on the production of microlithic technology.

The use of specific raw-materials for certain functional tasks such as the new technologies seen in the HP also contrasts with the pattern of lithic utilization observed in some Middle Paleolithic assemblages in Portugal where both relatively coarse-grained quartzite and finer grained cherts are available (Pereira, 2013). In those contexts, Neandertal toolmakers made the same tools for the same tasks despite the different functional characteristics of the raw materials, whereas modern humans in the Upper Paleolithic developed parallel technologies to optimize the functional characteristics of flint, quartz, and quartzite (Pereira, 2013). The initial colonization of the central Iberian region that is flint-poor may have been stalled due to time needed for cultural knowledge and foraging networks to develop into a cultural package capable of effectively exploiting this region. The development of parallel technological systems appears to be an adaptation modern humans utilized in multiple contexts in prehistory.

7.4.3 A Time and Place Model

Parkington (1980) interprets lithic variability in south coast LSA archaeological assemblages in terms of patterning identifiable from an analysis of site placement in temporal and spatial context. As Parkington notes, "by 'place' is meant not simply the latitude and longitude of an assemblage location but rather the set of opportunities offered by the location and thus the likelihood of particular activities taking place there (p.73)." To understand the temporal and spatial aspect of technological change in the context of human evolution in the MSA, the functional component of site-occupation needs to be identified, so that the stylistic and cultural elements can be derived through comparison with assemblages in disparate site contexts (Parkington, 1980).

Some researchers have argued that the technological innovation of projectile armatures (in the HP) imply diet breadth broadening (Lombard and Phillipson, 2010; Dusseldorp, 2012). But as Churchill (1993) and others (Ellis, 1997) have shown, projectile armatures such as bow-and-arrow are associated with smaller prey, but not necessarily a wider diet breadth. However, the co-occurrence of MSA points used as armature tips alongside small blades arguably used as projectiles, implies a co-occurrence of technologies that are associated with a broader range of prey taxa, and thus *do* suggest diet breadth expansion. Spear tips are almost exclusively associated with large game hunting, or small-medium animal hunting after they have been disadvantaged in some way (Churchill, 1993). Ethnographic observations of disadvantaging prey include cooperative drives, persistence hunting, pit-falls, or by trapping animals in natural landscape features (Carrier, 1984; Churchill, 1993). The use of parallel technologies provides access to a greater range of prey sizes from a wider spectrum of strategies.

The dramatic technological shift in the HP may be due to demographic changes – either increased population or reduced territory sizes (Ambrose and Lorenz, 1990; Powell et al., 2009). Both would create conditions in which an optimal solution would be to intensify resource acquisition within the foraging area. The possibility of increased demographic pressure between 70-60 ka is also suggested by the frequency of taphonomic edge damage during this time period – particularly due to trampling, which is also seen in micromorphology at PP5-6 (Karkanas et al., 2015). Sites that are re-occupied more frequently or continuously occupied for longer require clearing out debris to maintain the living space (Binford, 1980). When lithic debris is accumulating faster than deposition covers tools or humans clear them out, then they are more frequently exposed to human trampling (Nielsen, 1991). This appears to be the case on the south coast, particularly for flakes. There is a clear pattern for edge damage to become heavier through time on flakes that may have been used very briefly. This increase may reflect trampling intensity, however this is not reflected in the edge damage patterning of flakes. Additional investigation is required to explore the relationship between demography, site occupation, and edge damage formation, but these results provide some hypotheses for testing this relationship.

7.5 Conclusion

In this chapter, the results of this dissertation were discussed across multiple scales – from site specific inference to landscape scale patterning and finally broader issues of modern human behaviors in the MSA. Five hypotheses that relate spatial and temporal behaviors to lithic edge damage processes were tested. There was no support for the hypothesis that weathering and trampling processes are different between open-air and cave contexts (Hypothesis 1). There is some evidence that assemblages occupied in paleocoastal and paleointerior contexts were exposed to differing intensities of edge damage on points and flakes consistent with Hypothesis 2. Open-air assemblages have significantly greater frequencies of DIFs and have more damage per tool than in interior assemblages, consistent with Hypothesis 3. Blades from open-air and caves do not seem to reflect differences in butchery tasks (Hypothesis 4). As would be expected, there is significant temporal change in edge damage processes (Hypothesis 5), particularly in how blades were being used, but also in the increased amount of trampling damage on flakes through time. Points are consistent with multi-functional tools throughout the MSA, including use as armature tips and as knives.

Modern human populations on the south coast were using and discarding tools dynamically depending on the availability of resources and perceived economic decisions relating to site context and overall land-use strategies. Caves were not simply base camps, and open-air sites are not simply extraction localities; both constitute aspects of the landscape foraging continuum with patterned behaviors in how stone tools were made, used, and discarded across space. Rather than a single static techno-foraging strategy, new technologies were developed ~70 ka and used alongside existing mode 3 technology. New technologies being used for parallel tasks (armatures, cutting) may suggest a niche widening strategy, which is concordant with the (somewhat limited) faunal record at this time.

Two features identified in this analysis may help identify aspects of ‘modern human behavior’, in that they appear to contrast with the foraging strategy of Neandertals in Europe at this time and are not seen in earlier archaeological records in Africa (and are thus, derived in an evolutionary sense). First, lithic technology was used in paleocoastal environments for a more diverse range of tasks than in the paleointerior, and spear-tipped armatures were still in use in the paleocoastal contexts, which I’ve argued suggests a sexual-division of labor in place by this time. Kuhn and Stiner (2006) have noted that there is very little evidence for similar labor divisions in Neandertal faunal and lithic records. Secondly, the pattern of broken point discard in the south coast MSA is the opposite of that seen in the Middle Paleolithic, and consistent with that seen in much later

Paleoindian sites. Fractures described as ‘diagnostic’ of armature use are more frequent at open-air sites on the south coast than in caves, whereas in the Middle Paleolithic the reverse is true. This is concordant with the pattern of “tips-to-bases” analyzed by Holdaway (1989) for Mousterian sites if compared to late Archaic sites in North America (Flenniken, 1991). The meaning of this pattern is less clear, and I have proposed that it may relate to a lack of complex foreshaft technology on Mousterian armatures, but other possibilities exist.

A defining trait of the human lineage is the creation, use, and transmission of cultural and technological knowledge. Understanding the interactions between technology and the environment is essential to illuminating the role of culture and its evolution during the origin of our species. This study focused on understanding ancient tool use from the study of lithic edge damage patterns at archaeological assemblages in southern Africa by using novel quantitative methods for analyzing stone edge wear. An extensive experimental program of modern tool use using replicated stone tools provided the inferential linkages between artifact wear trace and causal agent. This analysis provided new insights into how and why stone tools were made, used, and discarded – with important implications for the evolution of hunting, foraging, landscape use, and site formation processes. The south coast of South Africa has a rich and complex MSA archaeological record, and landscape variability in edge damage formation provide an additional source of information about the origins and evolution of early modern human behavior.

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APPENDIX A

EXPERIMENTAL TOOL METRICS

Exp.	Exp. Group	Year	Exp. No.	Other	Raw Mat.	Shape	Len.	Wid.	Thk.	Mass (g)	Comments
Butchery	after spears	2009	09P2		Quartzite	Point	48	38	8	11	
Butchery	after spears	2009	09P4		Quartzite	Point	54	36	10	15	
Butchery	after spears	2009	09Si2		Silcrete	Point	71	29	7	13	
Butchery	after spears	2008	P12		Quartzite	Point	65	49	11	30	used for butchery - not hafted
Butchery	after spears	2008	P13		Quartzite	Point	72	44	14	29	used for butchery
Butchery	after spears	2008	P15		Quartzite	Point	77	38	15	40	used for butchery - not hafted
Butchery	after spears	2008	P9		Quartzite	Point	77	35	12	23	used for butchery
Butchery	Pig 1	2014	14-10	Field Dressing	Quartzite	Point	76	35	12	31	Dowel
Butchery	Pig 1	2014	14-11	Defleshing	Quartzite	Point	64	32	15	27	Dowel
Butchery	Pig 1	2014	14-18	Defleshing	Quartzite	Point	60	34	14	25	Dowel
Butchery	Pig 1	2014	14-19	Defleshing	Quartzite	Point	84	31	15	35	Unhafted
Butchery	Pig 1	2014	14-22	Defleshing	Quartzite	Point	85	31	13	31	Unhafted
Butchery	Pig 1	2014	14-3	Field Dressing	Quartzite	Point	76	38	13	39	Dowel
Butchery	Pig 1	2014	14-36	Field Dressing	Silcrete	Blade	86	19	7	11	Proximal Mastic
Butchery	Pig 1	2014	14-38	Field Dressing	Silcrete	Point	65	21	9	9	Proximal Mastic
Butchery	Pig 1	2014	14-55	Field Dressing	Silcrete	Point	85	31	13	30	Unhafted
Butchery	Pig 1	2014	14-56	Field Dressing	Silcrete	Blade	83	36	14	36	Unhafted
Butchery	Pig 1	2014	14-6	Field Dressing	Quartzite	Point	76	50	11	35	Proximal Mastic
Butchery	Pig 1	2014	14-7	Field Dressing	Quartzite	Point	74	36	18	40	Proximal Mastic
Butchery	Pig 2	2014	14-13	Field Dressing	Quartzite	Point	73	27	11	18	Unhafted

Butchery	Pig 2	2014	14-21	Field Dressing	Quartzite	Point	63	47	16	33	Proximal Mastic
Butchery	Pig 2	2014	14-24	Defleshing	Quartzite	Point	65	29	11	12	Dowel
Butchery	Pig 2	2014	14-29	Field Dressing	Quartzite	Point	52	24	8	7	Dowel
Butchery	Pig 2	2014	14-39	Defleshing	Silcrete	Blade	93	18	12	18	Proximal Mastic
Butchery	Pig 2	2014	14-41	Field Dressing	Silcrete	Blade	82	29	12	29	Lateral Mastic
Butchery	Pig 2	2014	14-47	Field Dressing	Silcrete	Point	70	27	12	21	Lateral Mastic
Butchery	Pig 2	2014	14-52	Field Dressing	Silcrete	Blade	74	17	7	6	Unhafted
Butchery	Pig 3	2014	14-17	Field Dressing	Quartzite	Point	73	45	14	23	Unhafted
Butchery	Pig 3	2014	14-2	Defleshing	Quartzite	Point	68	22	11	12	Dowel
Butchery	Pig 3	2014	14-23	Defleshing	Quartzite	Point	76	30	9	17	Dowel
Butchery	Pig 3	2014	14-27	Field Dressing	Quartzite	Point	64	30	13	15	Dowel
Butchery	Pig 3	2014	14-45	Defleshing	Silcrete	Blade	74	23	8	13	Lateral Mastic
Butchery	Pig 3	2014	14-5	Defleshing	Quartzite	Flake	64	33	11	23	Dowel
Butchery	Pig 3	2014	14-50	Field Dressing	Silcrete	Blade	87	32	16	45	Lateral Mastic
Butchery	Pig 3	2014	14-60	Defleshing	Silcrete	Blade	56	23	6	8	Unhafted
Butchery	Pig 3	2014	14-8	Field Dressing	Quartzite	Point	72	44	11	26	Proximal Mastic
Spear	1 shots	2009	09H11		Quartzite	Point	44	44	11	14	
Spear	1 shots	2009	09H2		Quartzite	Point	62	27	8	14	
Spear	1 shots	2009	09H8		Quartzite	Point	72	44	15	33	7 day resin top coated with fresh resin
Spear	1 shots	2009	09H9		Quartzite	Point	69	59	11	32	
Spear	1 shots	2009	09P1		Quartzite	Point	70	35	10	16	
Spear	1 shots	2009	09P10		Quartzite	Point	88	30	9	20	
Spear	1 shots	2009	09P11		Quartzite	Point	63	36	9	16	

Spear	1 shots	2009	09P13		Quartzite	Point	62	24	7	15	
Spear	1 shots	2009	09P3		Quartzite	Point	86	40	11	44	
Spear	1 shots	2009	09P5		Quartzite	Point	74	34	10	18	
Spear	1 shots	2009	09P6		Quartzite	Point	79	24	9	14	
Spear	1 shots	2009	09P7		Quartzite	Point	72	29	9	14	fresh reheated resin
Spear	1 shots	2009	09P9		Quartzite	Point	61	33	10	14	
Spear	1 shots	2009	09Si3		Silcrete	Point	61	24	5	8	
Spear	1 shots	2009	09Si4	ALB	Silcrete	Point	78	35	13	23	reheated fresh resin
Spear	1 shots	2009	09Si5	ALB	Silcrete	Point	75	42	12	36	
Spear	1 shots	2008	HH5		Quartzite	Point	76	44	15	31	failure after round 1
Spear	1 shots	2008	HH7		Quartzite	Point	59	29	13	17	failure after round 1
Spear	1 shots	2008	P1		Quartzite	Point	83	37	9	23	failure after round 1
Spear	1 shots	2008	P10		Quartzite	Point	83	24	11	20	CF on first shot
Spear	1 shots	2008	P14		Quartzite	Point	69	44	14	32	CF on shot #1
Spear	1 shots	2008	P7		Quartzite	Point	67	44	12	25	failure after round 1
Spear	2 shots	2009	09P12		Quartzite	Point	63	38		28	
Spear	2 shots	2009	09SB1		Silcrete	Point	72	32		20	on 1st shot, haft came loose
Spear	2 shots	2009	09Si1		Silcrete	Point	56	25		8	
Spear	2 shots	2008	HH3		Quartzite	Point	69	39	16	30	damage with hafting failure on first shot of round 2
Spear	2 shots	2008	P4		Quartzite	Point	64	29	8	13	CF on shot into HM
Spear	2+ shots	2008	HH8		Quartzite	Point	62	41	13	19	hafting failure, lateral ED
Spear	3 shots	2009	09H10		Quartzite	Point	60	38		23	
Spear	3 shots	2009	09H4		Quartzite	Point	62	51		20	

Spear	3 shots	2009	09H6		Quartzite	Point	59	37		21	
Spear	3 shots	2009	09P8		Quartzite	Point	64	46		36	
Spear	3 shots	2009	09SB2		Silcrete	Point	62	30		19	
Spear	3 shots	2008	HH9		Quartzite	Point	68	26	10	15	double step fracture on shot #2
Spear	3+ shots	2008	HH11		Quartzite	Point	70	46		42	stopped after interesting tip breakage, found tip
Spear	4 shots	2009	09H3		Quartzite	Point	57	27		14	
Spear	5 shots	2009	09H7		Quartzite	Point	63	33		16	
Spear	5 shots	2008	P11		Quartzite	Point	63	35	11	15	small break on #1, bigger break on #5
Spear	6 shots	2009	09Si6	ALB	Silcrete	Point	57	26	8	8	
Spear	6+ shots	2008	HH1		Quartzite	Point	62	40	11	23	no breakage, no haft slippage (prox break when hafting was removed)
Spear	6+ shots	2008	HH10		Quartzite	Point	41	32	9	12	tip notch on shot #3
Spear	6+ shots	2008	HH2		Quartzite	Point	91	37	13	39	small tip break on #3, large notch on #4, possible burin on #5
Spear	6+ shots	2008	HH4		Quartzite	Point	42	44	10	18	
Spear	6+ shots	2008	HH6		Quartzite	Point	55	34	11	17	tip breakage after #1
Spear	6+ shots	2008	P2		Quartzite	Point	75	44	11	30	
Spear	6+ shots	2008	P3		Quartzite	Point	76	37	14	29	
Spear	6+ shots	2008	P5		Quartzite	Point	74	27	12	18	
Spear	6+ shots	2008	P6		Quartzite	Point	77	50	15	38	
Spear	6+ shots	2008	P8		Quartzite	Point	71	31	11	21	
Spear	7 shots	2009	09H5		Quartzite	Point	52	40	19	29	reheated haft after 2 shots

Spear	7 shots	2009	09SB3	1-ALB-A	Silcrete	Point	72	38	11	28	
Spear	N/A	2009	09H1		Quartzite	Point	73	23	12	13	dropped when hafting
Trampled	Corral	2012	5		Quartzite	flake	71	37	13	36	(started dorsal up)
Trampled	Corral	2012	9	P-3	Quartzite	blade	54	24	7	8	punch or HH? (started dorsal up)
Trampled	Corral	2012	12		Quartzite	Point	76	28	11	22	(started dorsal up)
Trampled	Corral	2012	13		Quartzite	flake	47	31	14	17	(started dorsal up)
Trampled	Corral	2012	21		Quartzite	Point	77	37	11	24	(started dorsal up)
Trampled	Corral	2012	23	10H-2	Quartzite	Point	62	56	12	33	(started dorsal up)
Trampled	Corral	2012	25	10H-1	Quartzite	Point	54	32	13	19	(started dorsal up)
Trampled	Corral	2012	29		Quartzite	flake	85	47	13	55	(started ventral up)
Trampled	Corral	2012	32		Quartzite	blade	71	33	19	40	(started ventral up)
Trampled	Corral	2012	33		Quartzite	flake	67	35	11	24	(started ventral up)
Trampled	Corral	2012	37		Quartzite	blade	84	40	12	52	(started dorsal up)
Trampled	Corral	2012	38		Quartzite	blade	77	18	8	13	(started ventral up)
Trampled	Corral	2012	39		Quartzite	blade	76	23	10	22	(started dorsal up)
Trampled	Corral	2012	42		Quartzite	blade	79	36	12	40	(started ventral up)
Trampled	Corral	2012	45		Quartzite	flake	63	35	8	25	(started ventral up)
Trampled	Corral	2012	48		Quartzite	irregular blade	72	34	11	41	(started ventral up)
Trampled	Corral	2012	49		Quartzite	irregular blade	71	29	8	18	(started dorsal up)
Trampled	Corral	2012	50		Quartzite	blade	82	38	13	40	(started dorsal up)
Trampled	Corral	2012	52		Quartzite	irregular blade	82	22	12	22	(started ventral up)
Trampled	Corral	2012	54		Quartzite	blade	82	35	14	37	(started dorsal up)
Trampled	Corral	2012	59		Quartzite	flake	65	34	12	27	(started ventral up)
Trampled	Corral	2012	63		Quartzite	blade	80	30	10	25	(started ventral up)
Trampled	Corral	2012	67		Quartzite	flake	90	47	12	57	(started ventral up)
Trampled	Corral	2012	69		Quartzite	blade	106	33	12	41	(started dorsal up)

Trampled	Corral	2012	73	Quartzite	blade	74	32	8	18	(started ventral up)
Trampled	Corral	2012	74	Quartzite	flake	59	45	9	31	(started ventral up)
Trampled	Corral	2012	76	Quartzite	blade	79	29	11	25	(started dorsal up)
Trampled	Corral	2012	78	Quartzite	Point	44	24	6	6	(started dorsal up)
Trampled	Corral	2012	82	Quartzite	Point	63	30	11	20	(started ventral up)
Trampled	Corral	2012	86	Quartzite	Point	47	25	9	12	(started ventral up)
Trampled	Corral	2012	88	Quartzite	Point	53	28	9	10	(started dorsal up)
Trampled	Corral	2012	91	Quartzite	Point	73	36	10	23	(started ventral up)
Trampled	Corral	2012	93	Quartzite	Point convergent	64	35	11	27	(started dorsal up)
Trampled	Corral	2012	101	Quartzite	blade	79	31	11	25	(started ventral up)
Trampled	Corral	2012	106	Quartzite	flake	34	19	3	4	(started dorsal up)
Trampled	Corral	2012	108	Quartzite	flake	36	21	7	8	(started ventral up)
Trampled	Corral	2012	111	Quartzite	Point convergent	55	30	10	21	(started dorsal up)
Trampled	Corral	2012	114	Quartzite	blade	88	39	14	47	(started dorsal up)
Trampled	Corral	2012	117	Quartzite	Point	74	45	18	54	(started ventral up)
Trampled	Corral	2012	118	Quartzite	Point	73	35	10	27	(started ventral up)
Trampled	Corral	2012	123	Silcrete	flake	50	30	11	14	(started ventral up)
Trampled	Corral	2012	125	Silcrete	Point	48	31	7	10	(started dorsal up)
Trampled	Corral	2012	128	Silcrete	blade	44	15	4	3	(started dorsal up)
Trampled	Corral	2012	131	Silcrete	Point	61	35	6	15	(started ventral up)
Trampled	Corral	2012	132	Silcrete	Point irregular	53	26	7	8	(started dorsal up)
Trampled	Corral	2012	137	Silcrete	blade	62	25	9	8	(started dorsal up)
Trampled	Corral	2012	140	Silcrete	blade convergent	36	15	3	1	(started dorsal up)
Trampled	Corral	2012	142	Silcrete	blade convergent	42	14	7	3	(started ventral up)
Trampled	Corral	2012	147	Silcrete	blade	70	28	13	25	(started dorsal up)
Trampled	Corral	2012	151	Silcrete	flake	40	24	13	7	(started ventral up)

Trampled	Corral	2012	155	Silcrete	Point	62	28	9	9	(started ventral up)
Trampled	Corral	2012	164	Silcrete	Point	52	33	11	16	(started dorsal up)
Trampled	Corral	2012	173	Silcrete	convergent blade	53	24	6	9	(started dorsal up)
Trampled	Corral	2012	178	Silcrete	blade	54	21	6	6	(started ventral up)
Trampled	Corral	2012	179	Silcrete	Point	47	20	7	5	(started dorsal up)
Trampled	Corral	2012	180	Silcrete	blade	94	25	6	15	(started ventral up)
Trampled	Corral	2012	181	Silcrete	blade	92	37	14	59	"naturally backed" (started dorsal up)
Trampled	Corral	2012	183	Silcrete	blade	77	17	8	9	cortical dorsal (started ventral up)
Trampled	Corral	2012	185	Silcrete	blade	72	18	5	7	(started ventral up)
Trampled	Corral	2012	186	Silcrete	blade	48	23	8	5	(started dorsal up)
Trampled	Corral	2012	188	Silcrete	blade	57	21	7	8	(started dorsal up)
Trampled	Corral	2012	190	Silcrete	blade	93	26	10	19	(started ventral up)
Trampled	Corral	2012	191	Silcrete	convergent blade	52	17	7	5	(started ventral up)
Trampled	Corral	2012	192	Silcrete	blade	63	24	10	12	(started ventral up)
Trampled	Corral	2012	193	Silcrete	blade	44	17	10	5	(started ventral up)
Trampled	Corral	2012	194	Silcrete	blade	56	18	6	6	(started dorsal up)
Trampled	Corral	2012	196	Silcrete	Point	52	25	10	10	(started dorsal up)
Trampled	Corral	2012	202	Silcrete	convergent blade	48	23	6	2	(started ventral up)
Trampled	Corral	2012	205	Silcrete	blade	62	29	8	11	(started ventral up)
Trampled	Corral	2012	206	Silcrete	blade	65	26	6	5	missing platform (started dorsal up)
Trampled	Corral	2012	220	Silcrete	blade	68	26	11	17	(started ventral up)
Trampled	Corral	2012	221	Silcrete	blade	74	18	6	7	(started dorsal up)
Trampled	Corral	2012	222	Silcrete	blade	83	25	9	16	(started ventral up)
Trampled	Corral	2012	227	Silcrete	flake	43	22	6	5	(started dorsal up)
Trampled	Corral	2012	230	Silcrete	flake	33	15	6	2	(started dorsal up)

Trampled	Corral	2012	232		Silcrete	blade	77	37	15	36	(started dorsal up)
Trampled	Corral	2012	233		Silcrete	blade	79	37	14	36	(started ventral up)
Trampled	Corral	2012	235		Silcrete	flake	63	34	12	26	(started dorsal up)
Trampled	Corral	2012	241		Silcrete	Point	58	44	7	13	(started ventral up)
Trampled	Corral	2012	244		Silcrete	flake	41	21	6	3	(started dorsal up)
Trampled	Corral	2012	245		Silcrete	irregular blade	90	47	12	45	(started ventral up)
Trampled	Corral	2012	246	1	BIF	flake	66	63	21	96	(started ventral up)
Trampled	Corral	2012	248	45	BIF	flake	78	53	12	48	(started dorsal up)
Trampled	Corral	2012	252	21	BIF	flake	45	58	10	33	sidestruck (started ventral up)
Trampled	Corral	2012	256	131	BIF	flake	53	31	13	20	crushed platform (started dorsal up)
Trampled	Corral	2012	260	62	BIF	flake	43	29	8	6	(started ventral up)
Trampled	Corral	2012	265		BIF	flake	36	22	6	5	(started dorsal up)
Trampled	Corral	2012	266		BIF	blade	35	12	3	1	(started dorsal up)
Trampled	Corral	2012	269		Quartz	flake	26	19	4	1	(started ventral up)
Trampled	Corral	2012	271		Quartz	Point	45	33	9	11	(started ventral up)
Trampled	Corral	2012	275		Silcrete	notched blade	73	42	12		(started ventral up)
Trampled	Corral	2012	277		Silcrete	notched blade	53	45	11		(started ventral up)
Trampled	Corral	2012	278	12-38	Silcrete	backed blade	32	9	4	1	prepared for rusty trampling (started dorsal up)
Trampled	Corral	2012	285	12-51	Silcrete	backed blade	18	9	2	0	prepared for rusty trampling (started dorsal up)
Trampled	Corral	2012	290	12-58	Silcrete	backed blade	22	9	4	1	prepared for rusty trampling (started ventral up)

Trampled	Corral	2012	294	12-67	Silcrete	backed blade	37	12	4	2	prepared for rusty trampling (started dorsal up)
Trampled	Corral	2012	295	12-68	Silcrete	backed blade	52	16	6	5	prepared for rusty trampling (started ventral up)
Trampled	Corral	2012	297	12-74	Silcrete	backed blade	27	9	2	1	prepared for rusty trampling (started ventral up)
Trampled	Corral	2012	298	12-75	Silcrete	backed blade	38	16	5	3	prepared for rusty trampling (started dorsal up)
Trampled	Corral	2012	299	12-76	Silcrete	backed blade	28	11	5	1	prepared for rusty trampling (started dorsal up)
Trampled	Field	2012	3		Quartzite	flake	55	46	13	27	cobble platform (started dorsal up)
Trampled	Field	2012	4		Quartzite	blade	63	26	10	18	(started dorsal up)
Trampled	Field	2012	7		Quartzite	Point	74	40	15	37	(started ventral up)
Trampled	Field	2012	8		Quartzite	blade	87	37	15	48	cortical lateral, prox, and distal (started dorsal up)
Trampled	Field	2012	11		Quartzite	convergent blade	80	28	13	23	(started dorsal up)
Trampled	Field	2012	14		Quartzite	flake	59	53	11	34	(started dorsal up)
Trampled	Field	2012	19		Quartzite	convergent blade	76	23	10	17	(started dorsal up)
Trampled	Field	2012	20		Quartzite	Point	75	34	17	45	large heavy point. Prior removal scar on dorsal right (started dorsal up)
Trampled	Field	2012	22		Quartzite	flake	62	28	11	16	(started dorsal up)
Trampled	Field	2012	24	10X-1	Quartzite	Point	51	30	10	14	unknown knapping technique (started dorsal up)

Trampled	Field	2012	26	10P-2	Quartzite	Point	89	41	9	39	(started ventral up)
Trampled	Field	2012	28	10H-3	Quartzite	Point	90	31	10	24	(started ventral up)
Trampled	Field	2012	31		Quartzite	blade	65	23	11	16	(started ventral up)
Trampled	Field	2012	34		Quartzite	blade	76	22	9	20	(started dorsal up)
Trampled	Field	2012	40		Quartzite	blade	75	31	14	41	(started ventral up)
Trampled	Field	2012	43		Quartzite	flake	73	45	14	50	(started dorsal up)
Trampled	Field	2012	44		Quartzite	flake	59	33	8	18	(started dorsal up)
Trampled	Field	2012	46		Quartzite	flake	66	41	11	30	(started dorsal up)
Trampled	Field	2012	51		Quartzite	blade	76	27	8	22	not sure what Pm is (started ventral up)
Trampled	Field	2012	55		Quartzite	flake	73	44	11	34	(started dorsal up)
Trampled	Field	2012	58		Quartzite	flake	66	46	13	35	(started ventral up)
Trampled	Field	2012	64		Quartzite	blade	82	35	12	37	(started dorsal up)
Trampled	Field	2012	66		Quartzite	convergent blade	79	42	9	29	(started ventral up)
Trampled	Field	2012	68		Quartzite	irregular blade	81	32	13	37	(started dorsal up)
Trampled	Field	2012	72		Quartzite	blade	70	22	13	20	very small platform (started ventral up)
Trampled	Field	2012	77		Quartzite	flake	56	42	12	28	(started dorsal up)
Trampled	Field	2012	80		Quartzite	Point	50	18	6	7	(started ventral up)
Trampled	Field	2012	85	F3	Quartzite	Point	55	35	10	17	(started ventral up)
Trampled	Field	2012	87		Quartzite	Point	51	23	7	9	(started ventral up)
Trampled	Field	2012	90		Quartzite	convergent blade	46	19	4	5	(started dorsal up)
Trampled	Field	2012	92		Quartzite	convergent blade	59	22	11	17	(started dorsal up)
Trampled	Field	2012	95		Quartzite	Point	79	33	11	25	(started ventral up)
Trampled	Field	2012	96		Quartzite	convergent blade	85	44	14	57	(started ventral up)
Trampled	Field	2012	97		Quartzite	Point	70	47	21	48	(started ventral up)

Trampled	Field	2012	98		Quartzite	Point	71	32	9	29	(started dorsal up)
Trampled	Field	2012	99		Quartzite	Point	69	36	9	22	(started ventral up)
Trampled	Field	2012	104		Quartzite	irregular blade	78	30	23	39	very thick (started ventral up)
Trampled	Field	2012	107		Quartzite	blade	48	16	6	6	(started ventral up)
Trampled	Field	2012	110		Quartzite	convergent blade	72	33	9	25	(started dorsal up)
Trampled	Field	2012	112		Quartzite	flake	51	31	14	28	(started ventral up)
Trampled	Field	2012	113		Quartzite	Point	72	34	10	29	(started ventral up)
Trampled	Field	2012	126		Silcrete	Point	42	39	13	18	(started dorsal up)
Trampled	Field	2012	127		Silcrete	Point	45	24	6	4	(started ventral up)
Trampled	Field	2012	133		Silcrete	flake	64	38	21	38	(started dorsal up)
Trampled	Field	2012	136		Silcrete	Point	72	43	12	26	(started ventral up)
Trampled	Field	2012	138		Silcrete	blade	46	17	5	3	(started dorsal up)
Trampled	Field	2012	139		Silcrete	blade	45	14	7	5	(started ventral up)
Trampled	Field	2012	144		Silcrete	convergent blade	68	24	6	9	(started dorsal up)
Trampled	Field	2012	148		Silcrete	blade	78	30	13	20	(started ventral up)
Trampled	Field	2012	149		Silcrete	blade	63	19	4	3	(started ventral up)
Trampled	Field	2012	154		Silcrete	flake	48	33	13	13	(started dorsal up)
Trampled	Field	2012	156		Silcrete	Point	53	29	14	17	(started dorsal up)
Trampled	Field	2012	158		Silcrete	blade	63	26	7	9	(started dorsal up)
Trampled	Field	2012	161		Silcrete	blade	58	29	12	18	(started ventral up)
Trampled	Field	2012	162		Silcrete	irregular blade	68	33	9	15	(started dorsal up)
Trampled	Field	2012	165		Silcrete	blade	49	17	8	6	(started ventral up)
Trampled	Field	2012	167		Silcrete	blade	120	31	11	45	dorsal right completely retouched? (started ventral up)
Trampled	Field	2012	169		Silcrete	Point	44	20	12	5	from 2010 points (started ventral up)

Trampled	Field	2012	171		Silcrete	Point	46	26	8	8	from 2010 points (started ventral up)
Trampled	Field	2012	172	10P-1	Silcrete	Point	44	31	8	8	from 2010 points (started ventral up)
Trampled	Field	2012	175		Silcrete	convergent blade	69	34	11	25	(started dorsal up)
Trampled	Field	2012	177		Silcrete	flake	45	29	11	12	(started ventral up)
Trampled	Field	2012	182		Silcrete	blade	75	15	6	9	(started dorsal up)
Trampled	Field	2012	184		Silcrete	blade	68	18	9	9	(started dorsal up)
Trampled	Field	2012	189		Silcrete	blade	94	32	16	36	(started dorsal up)
Trampled	Field	2012	195		Silcrete	blade	60	25	12	14	(started dorsal up)
Trampled	Field	2012	200		Silcrete	blade	63	21	9	12	(started ventral up)
Trampled	Field	2012	204		Silcrete	blade	69	28	12	11	changed to Dorsal during setup (started dorsal up)
Trampled	Field	2012	208		Silcrete	blade	87	33	15	40	(started dorsal up)
Trampled	Field	2012	209		Silcrete	blade	84	29	14	29	(started ventral up)
Trampled	Field	2012	210		Silcrete	flake	39	28	8	4	(started dorsal up)
Trampled	Field	2012	212		Silcrete	Point	48	24	6	4	(started ventral up)
Trampled	Field	2012	213		Silcrete	flake	43	27	10	7	(started ventral up)
Trampled	Field	2012	218		Silcrete	blade	80	22	10	20	(started ventral up)
Trampled	Field	2012	219		Silcrete	blade	80	30	9	24	(started ventral up)
Trampled	Field	2012	225		Silcrete	convergent blade	47	18	7	7	(started dorsal up)
Trampled	Field	2012	229		Silcrete	blade	57	25	12	14	(started ventral up)
Trampled	Field	2012	231		Silcrete	blade	40	17	7	3	(started dorsal up)
Trampled	Field	2012	234		Silcrete	blade	61	31	12	22	(started ventral up)
Trampled	Field	2012	236		Silcrete	flake	57	44	12	20	(started dorsal up)
Trampled	Field	2012	238		Silcrete	irregular blade	74	37	9	24	(started dorsal up)
Trampled	Field	2012	239		Silcrete	Point	62	44	12	22	(started dorsal up)

Trampled	Field	2012	240		Silcrete	blade	69	29	13	19	(started dorsal up)
Trampled	Field	2012	247	125	BIF	flake	70	48	9	39	(started ventral up)
Trampled	Field	2012	250	54	BIF	flake	53	52	12	34	no platform (started ventral up)
Trampled	Field	2012	251	50	BIF	flake	28	55	12	20	sidestruck (started dorsal up)
Trampled	Field	2012	253	26	BIF	flake	35	45	13	18	sidestruck (started ventral up)
Trampled	Field	2012	259	30	BIF	flake	47	36	15	16	split flake (started dorsal up)
Trampled	Field	2012	261	139	BIF	flake	32	34	7	8	sidestruck (started dorsal up)
Trampled	Field	2012	262	140	BIF	flake	41	22	4	5	fragment (started dorsal up)
Trampled	Field	2012	263		BIF	flake	82	43	13	50	(started dorsal up)
Trampled	Field	2012	272		Quartz	flake	50	50	10	21	(started ventral up)
Trampled	Field	2012	276		Silcrete	notched blade	54	28	7		(started ventral up)
Trampled	Field	2012	279	12-40	Silcrete	backed blade	22	9	3	1	prepared for rusty trampling (started ventral up)
Trampled	Field	2012	281	12-42	Silcrete	backed blade	16	9	3	0	prepared for rusty trampling (started ventral up)
Trampled	Field	2012	283	12-49	Silcrete	backed blade	27	10	5	1	prepared for rusty trampling (started dorsal up)
Trampled	Field	2012	286	12-52	Silcrete	backed blade	24	9	4	1	prepared for rusty trampling (started dorsal up)
Trampled	Field	2012	287	12-54	Silcrete	backed blade	31	10	3	1	prepared for rusty trampling (started ventral up)
Trampled	Field	2012	289	12-57	Silcrete	backed blade	38	16	4	3	prepared for rusty trampling (started ventral up)

Trampled	Field	2012	292	12-63	Silcrete	backed blade	43	16	6	4	prepared for rusty trampling (started ventral up)
Trampled	Field	2012	301		Silcrete	backed blade	40	16	6		made by Kyle for J-10 square; low density (started dorsal up)
Trampled	Trail	2012	1		Quartzite	blade	106	38	18	76	cortical distal and prox (started ventral up)
Trampled	Trail	2012	2		Quartzite	convergent blade	71	26	12	25	(started dorsal up)
Trampled	Trail	2012	6		Quartzite	convergent blade	75	20	11	13	(started ventral up)
Trampled	Trail	2012	10		Quartzite	Point	73	26	10	23	(started ventral up)
Trampled	Trail	2012	15		Quartzite	convergent blade	74	31	16	30	(started ventral up)
Trampled	Trail	2012	16		Quartzite	convergent blade	71	24	17	19	(started dorsal up)
Trampled	Trail	2012	17	H	Quartzite	Point	48	26	9	9	(started dorsal up)
Trampled	Trail	2012	18		Quartzite	irregular point	50	23	5	6	sort of split (started ventral up)
Trampled	Trail	2012	27	10X-2	Quartzite	convergent flake	71	34	11	24	(started ventral up)
Trampled	Trail	2012	30		Quartzite	flake	71	43	12	35	(started ventral up)
Trampled	Trail	2012	35		Quartzite	flake	83	48	20	96	(started dorsal up)
Trampled	Trail	2012	36		Quartzite	blade	79	35	11	39	(started dorsal up)
Trampled	Trail	2012	41		Quartzite	blade	83	38	16	54	(started dorsal up)
Trampled	Trail	2012	47		Quartzite	flake	61	42	8	27	(started dorsal up)
Trampled	Trail	2012	53		Quartzite	blade	71	36	12	37	(started ventral up)
Trampled	Trail	2012	56		Quartzite	flake	70	40	11	33	(started ventral up)
Trampled	Trail	2012	57		Quartzite	flake	63	49	12	32	(started dorsal up)
Trampled	Trail	2012	60		Quartzite	blade	65	25	8	13	(started ventral up)

Trampled	Trail	2012	61	Quartzite	irregular blade	83	30	12	31	(started dorsal up)
Trampled	Trail	2012	62	Quartzite	flake	78	46	16	58	(started dorsal up)
Trampled	Trail	2012	65	Quartzite	blade	87	27	11	21	(started dorsal up)
Trampled	Trail	2012	70	Quartzite	blade	87	30	8	18	(started dorsal up)
Trampled	Trail	2012	71	Quartzite	flake	64	38	17	42	(started ventral up)
Trampled	Trail	2012	75	Quartzite	irregular blade	82	28	11	16	(started ventral up)
Trampled	Trail	2012	79	Quartzite	Point	45	20	5	6	(started dorsal up)
Trampled	Trail	2012	81	Quartzite	Point	49	22	8	9	(started dorsal up)
Trampled	Trail	2012	83	Quartzite	Point	69	34	13	31	(started ventral up)
Trampled	Trail	2012	84	Quartzite	Point	46	26	10	11	(started dorsal up)
Trampled	Trail	2012	89	Quartzite	Point	63	24	9	13	(started dorsal up)
Trampled	Trail	2012	94	Quartzite	Point	71	34	13	32	(started dorsal up)
Trampled	Trail	2012	100	Quartzite	Point	63	30	10	16	(started dorsal up)
Trampled	Trail	2012	102	Quartzite	flake	44	26	10	8	(started ventral up)
Trampled	Trail	2012	103	Quartzite	blade	57	21	7	11	(started ventral up)
Trampled	Trail	2012	105	Quartzite	Point	61	35	14	22	(started ventral up)
Trampled	Trail	2012	109	Quartzite	blade	64	23	10	17	(started ventral up)
Trampled	Trail	2012	115	Quartzite	convergent blade	85	39	18	60	(started ventral up)
Trampled	Trail	2012	116	Quartzite	irregular blade	87	23	6	18	(started ventral up)
Trampled	Trail	2012	119	Quartzite	convergent blade	70	30	9	19	(started ventral up)
Trampled	Trail	2012	120	Quartzite	Point	98	39	16	49	(started dorsal up)
Trampled	Trail	2012	121	Silcrete	Point	51	26	6	7	(started ventral up)
Trampled	Trail	2012	122	Silcrete	Point	52	27	13	13	(started ventral up)
Trampled	Trail	2012	124	Silcrete	Point	41	32	10	12	(started dorsal up)
Trampled	Trail	2012	129	Silcrete	blade	57	24	11	13	(started ventral up)
Trampled	Trail	2012	130	Silcrete	flake	53	32	10	17	(started dorsal up)

Trampled	Trail	2012	134	Silcrete	blade	55	22	9	10	(started dorsal up)
Trampled	Trail	2012	135	Silcrete	irregular blade	69	25	9	13	(started dorsal up)
Trampled	Trail	2012	141	Silcrete	blade	33	13	4	1	(started dorsal up)
Trampled	Trail	2012	143	Silcrete	blade	51	21	3	5	(started ventral up)
Trampled	Trail	2012	145	Silcrete	flake	41	19	4	2	missing platform (started dorsal up)
Trampled	Trail	2012	146	Silcrete	blade	54	23	7	7	(started ventral up)
Trampled	Trail	2012	150	Silcrete	blade	53	22	8	8	(started ventral up)
Trampled	Trail	2012	152	Silcrete	Point	49	23	8	7	(started ventral up)
Trampled	Trail	2012	153	Silcrete	blade	73	36	11	31	(started ventral up)
Trampled	Trail	2012	157	Silcrete	blade	63	30	14	22	(started dorsal up)
Trampled	Trail	2012	159	Silcrete	Point	77	38	10	28	(started ventral up)
Trampled	Trail	2012	160	Silcrete	convergent blade	48	20	7	4	(started ventral up)
Trampled	Trail	2012	163	Silcrete	Point	69	42	17	40	(started dorsal up)
Trampled	Trail	2012	166	Silcrete	blade	103	30	11	33	(started dorsal up)
Trampled	Trail	2012	168	Silcrete	Point	45	23	7	6	from 2010 points (started ventral up)
Trampled	Trail	2012	170	Silcrete	Point	39	23	8	5	from 2010 points (started ventral up)
Trampled	Trail	2012	174	Silcrete	convergent blade	68	32	12	28	(started dorsal up)
Trampled	Trail	2012	176	Silcrete	flake	71	37	13	42	"naturally backed" (started dorsal up)
Trampled	Trail	2012	187	Silcrete	blade	60	20	4	6	(started dorsal up)
Trampled	Trail	2012	197	Silcrete	Point	51	32	17	24	(started ventral up)
Trampled	Trail	2012	198	Silcrete	flake	72	47	16	42	(started dorsal up)
Trampled	Trail	2012	199	Silcrete	Point	56	30	12	16	(started ventral up)
Trampled	Trail	2012	201	Silcrete	blade	77	19	7	5	(started dorsal up)
Trampled	Trail	2012	203	Silcrete	blade	47	14	6	2	(started dorsal up)

Trampled	Trail	2012	207		Silcrete	convergent blade	80	25	15	22	(started ventral up)
Trampled	Trail	2012	211		Silcrete	Point	63	34	12	21	(started dorsal up)
Trampled	Trail	2012	214		Silcrete	flake	39	22	5	2	(started dorsal up)
Trampled	Trail	2012	215		Silcrete	Point	47	36	12	16	(started dorsal up)
Trampled	Trail	2012	216		Silcrete	blade	103	39	21	73	(started dorsal up)
Trampled	Trail	2012	217		Silcrete	convergent blade	83	26	14	38	(started ventral up)
Trampled	Trail	2012	223		Silcrete	blade	55	24	7	7	(started ventral up)
Trampled	Trail	2012	224		Silcrete	blade	59	28	11	16	(started ventral up)
Trampled	Trail	2012	226		Silcrete	blade	48	14	5	3	(started ventral up)
Trampled	Trail	2012	228		Silcrete	blade	41	15	6	3	(started ventral up)
Trampled	Trail	2012	237		Silcrete	flake	71	39	13	31	(started ventral up)
Trampled	Trail	2012	242		Silcrete	convergent blade	45	19	7	3	(started dorsal up)
Trampled	Trail	2012	243		Silcrete	blade	48	19	5	4	(started dorsal up)
Trampled	Trail	2012	249	5	BIF	flake	68	51	8	26	(started dorsal up)
Trampled	Trail	2012	254	143	BIF	flake	57	32	8	23	(started ventral up)
Trampled	Trail	2012	255	3	BIF	flake	60	55	13	47	(started ventral up)
Trampled	Trail	2012	257	24	BIF	flake	34	33	8	14	(started ventral up)
Trampled	Trail	2012	258	12	BIF	flake	61	37	11	29	(started ventral up)
Trampled	Trail	2012	264		BIF	blade	60	26	8	15	(started dorsal up)
Trampled	Trail	2012	267		Quartz	flake	43	22	8	5	(started dorsal up)
Trampled	Trail	2012	268		Quartz	flake	36	28	9	6	(started ventral up)
Trampled	Trail	2012	270		Quartz	blade	37	14	4	2	(started dorsal up)
Trampled	Trail	2012	273		Silcrete	notched blade	55	31	10		(started dorsal up)
Trampled	Trail	2012	274		Silcrete	notched blade	63	34	12		(started ventral up)
Trampled	Trail	2012	280	12-41	Silcrete	backed blade	18	8	3	0	prepared for rusty trampling (started dorsal up)

Trampled	Trail	2012	282	12-47	Silcrete	backed blade	29	12	4	1	prepared for rusty trampling (started ventral up)
Trampled	Trail	2012	284	12-50	Silcrete	backed blade	33	14	6	2	prepared for rusty trampling (started dorsal up)
Trampled	Trail	2012	288	12-56	Silcrete	backed blade	26	11	4	1	prepared for rusty trampling (started dorsal up)
Trampled	Trail	2012	291	12-60	Silcrete	backed blade	37	18	6	3	prepared for rusty trampling (started dorsal up)
Trampled	Trail	2012	293	12-66	Silcrete	backed blade	30	11	4	1	prepared for rusty trampling (started dorsal up)
Trampled	Trail	2012	296	12-70	Silcrete	backed blade	32	13	5	2	prepared for rusty trampling (started ventral up)
Trampled	Trail	2012	300	12-77	Silcrete	backed blade	25	11	5	1	prepared for rusty trampling (started dorsal up)
Tumbler		2014	14-101		Silcrete	Point	52	20	10	6	Unhafted
Tumbler		2014	14-102		Silcrete	Blade	69	24	6	8	Unhafted
Tumbler		2014	14-103		Silcrete	Blade	55	26	5	6	Unhafted
Tumbler		2014	14-104		Silcrete	Blade	64	31	11	16	Unhafted
Tumbler		2014	14-105		Silcrete	Blade	76	29	12	22	Unhafted
Tumbler		2014	14-106		Silcrete	Flake	70	40	8	19	Unhafted
Tumbler		2014	14-107		Silcrete	Point	64	29	9	17	Unhafted
Tumbler		2014	14-108		Silcrete	Blade	61	24	6	9	Unhafted
Tumbler		2014	14-109		Silcrete	Blade	66	24	16	20	Unhafted
Tumbler		2014	14-110		Silcrete	Point	62	28	9	15	Unhafted
Tumbler		2014	14-114		Silcrete	Blade	57	28	10	14	Unhafted
Tumbler		2014	14-116		Silcrete	Blade	63	21	10	12	Unhafted
Tumbler		2014	14-117		Silcrete	Blade	87	23	8	20	Unhafted

Tumbler	2014	14-118	Silcrete	Point	70	51	17	46	Unhafted
Tumbler	2014	14-119	Silcrete	Blade	31	14	6	2	Unhafted
Tumbler	2014	14-12	Quartzite	Flake	59	36	12	22	Unhafted
Tumbler	2014	14-120	Silcrete	Blade	39	17	4	1	Unhafted
Tumbler	2014	14-121	Silcrete	Point	35	13	7	3	Unhafted
Tumbler	2014	14-122	Silcrete	Blade	44	20	3	1	Unhafted
Tumbler	2014	14-123	Silcrete	Point	68	37	11	20	Unhafted
Tumbler	2014	14-124	Silcrete	Point	42	24	11	10	Unhafted
Tumbler	2014	14-125	Silcrete	Blade	43	17	7	5	Unhafted
Tumbler	2014	14-126	Silcrete	Blade	77	26	9	16	Unhafted
Tumbler	2014	14-128	Silcrete	Blade	76	24	9	17	Unhafted
Tumbler	2014	14-129	Silcrete	Blade	83	28	10	15	Unhafted
Tumbler	2014	14-130	Silcrete	Blade	78	37	17	32	Unhafted
Tumbler	2014	14-14	Quartzite	Point	73	29	8	19	Unhafted
Tumbler	2014	14-15	Quartzite	Point	67	30	13	22	Unhafted
Tumbler	2014	14-16	Quartzite	Flake	73	37	20	35	Unhafted
Tumbler	2014	14-20	Quartzite	Point	68	29	13	18	Unhafted
Tumbler	2014	14-26	Quartzite	Point	59	36	9	17	Unhafted
Tumbler	2014	14-4	Quartzite	Point	66	36	17	34	Proximal Mastic
Tumbler	2014	14-46	Silcrete	Blade	55	13	7	3	Lateral Mastic
Tumbler	2014	14-51	Silcrete	Blade	63	25	10	14	Unhafted
Tumbler	2014	14-53	Silcrete	Point	54	30	10	13	Unhafted
Tumbler	2014	14-54	Silcrete	Blade	51	18	5	3	Unhafted
Tumbler	2014	14-58	Silcrete	Blade	59	20	5	5	Unhafted
Tumbler	2014	14-59	Silcrete	Blade	73	20	9	11	Unhafted
Tumbler	2014	14-61	Quartzite	Flake	52	40	12	20	Unhafted
Tumbler	2014	14-62	Quartzite	Point	54	34	17	27	Unhafted
Tumbler	2014	14-65	Quartzite	Point	85	41	9	24	Unhafted
Tumbler	2014	14-66	Quartzite	Point	44	31	13	12	Unhafted

Tumbler	2014	14-67	Quartzite	Blade	77	37	11	37	Unhafted
Tumbler	2014	14-68	Quartzite	Point	78	33	13	27	Unhafted
Tumbler	2014	14-69	Quartzite	Flake	52	44	13	21	Unhafted
Tumbler	2014	14-70	Quartzite	Blade	75	31	13	26	Unhafted
Tumbler	2014	14-71	Quartzite	Flake	70	46	19	38	Unhafted
Tumbler	2014	14-72	Quartzite	Flake	51	26	10	12	Unhafted
Tumbler	2014	14-73	Quartzite	Blade	52	21	14	12	Unhafted
Tumbler	2014	14-74	Quartzite	Blade	60	20	8	7	Unhafted
Tumbler	2014	14-75	Quartzite	Blade	81	31	13	24	Unhafted
Tumbler	2014	14-76	Quartzite	Blade	78	31	10	31	Unhafted
Tumbler	2014	14-77	Quartzite	Flake	78	31	13	32	Unhafted
Tumbler	2014	14-78	Quartzite	Point	74	49	13	29	Unhafted
Tumbler	2014	14-79	Quartzite	Blade	73	30	8	17	Unhafted
Tumbler	2014	14-80	Quartzite	Blade	90	30	10	31	Unhafted
Tumbler	2014	14-91	Quartzite	Blade	70	35	10	22	Unhafted
Tumbler	2014	14-92	Quartzite	Point	43	31	11	9	Unhafted
Tumbler	2014	14-93	Quartzite	Flake	59	32	8	12	Unhafted
Tumbler	2014	14-94	Quartzite	Point	45	30	7	7	Unhafted
Tumbler	2014	14-95	Quartzite	Blade	52	20	9	7	Unhafted
Tumbler	2014	14-96	Quartzite	Blade	60	28	11	14	Unhafted

APPENDIX B

TRAMPLING GRID LAYOUTS

Each grid consists of tool number (e.g., 12-45 is tool “12-45”, a quartzite flake) in 30 x 30 cm grid squares (e.g., F2 is a 30 x 30 square in the high intensity trampling area). These are provided to illustrate the spacing and relative placement of each trampled flake at the beginning of the experiment.

B.1 Group 1 – High Intensity corral tool layout. Tool in square A1 was placed ventral side up, and then alternated dorsal/ventral across rows.

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
1	12-42	12-69	12-118	12-266	12-269	12-54	12-246	12-78	12-32	12-5
2	11-67	11-74	12-23	11-58	12-232	12-45	12-244	12-260	12-128	12-33
3	12-63	12-179	12-117	12-196	12-277	12-188	12-180	12-106	12-192	12-132
4	12-181	12-48	12-88	12-82	12-12	12-233	12-265	11-68	12-9	12-271
5	12-52	11-38	12-252	12-137	12-123	12-111	12-193	12-235	12-178	12-147
6	12-256	12-67	12-173	12-202	12-230	12-245	12-114	12-38	12-39	12-229
7	12-86	11-76	12-222	12-13	12-291	12-125	12-73	12-93	12-183	12-164
8	11-51	12-275	12-186	12-155	12-248	12-74	12-194	12-241	12-50	12-101
9	12-205	12-76	12-131	12-140	12-151	12-221	12-220	12-25	12-185	12-49
10	12-227	12-191	11-75	12-142	12-37	12-190	12-206	12-108	12-21	12-59

B.2 Group 2 – Medium intensity trail tool layout grid. Tool in square A1 was placed dorsal side up, and then alternated ventral/dorsal across rows.

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
1	12-243	12-146	12-124	12-199	12-99	12-228	12-273	12-129	12-47	12-254
2	12-274	12-211	12-27	12-36	12-116	12-157	11-70	11-77	12-6	12-264
3	12-166	12-60	12-242	12-226	12-203	12-150	12-187	12-103	12-201	12-197
4	12-255	12-141	12-170	12-134	12-53	12-65	12-115	12-84	12-1	12-57
5	12-214	12-160	12-135	12-143	11-50	12-30	12-145	12-217	12-130	12-15
6	12-18	12-2	12-121	12-249	12-258	12-270	12-71	12-89	12-10	12-100
7	11-66	12-56	12-267	12-223	12-174	12-83	12-120	12-122	11-60	12-105
8	12-152	12-62	12-257	12-81	12-75	12-198	12-153	12-163	12-159	12-41
9	12-35	12-109	12-216	11-47	12-61	12-268	11-56	12-207	12-70	12-119
10	12-168	12-79	12-224	12-215	11-41	12-17	12-102	12-176	12-237	12-16

*11-41 is ventral up

B.3 Group 3 – Low intensity field tool layout grid. Tool in square A1 was placed dorsal side up, and then alternated ventral/dorsal across rows.

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
1	12-90	12-7	12-261	12-177	12-11	11-63	12-3	12-87	12-4	12-276
2	12-234	12-154	12-113	12-259	12-167	12-184	12-95	12-175	11-42	12-19
3	12-210	12-250	12-24	12-219	12-239	12-247	12-126	12-161	12-236	12-171
4	12-96	12-55	12-148	12-133	12-213	12-8	12-112	12-144	12-212	12-158
5	12-240	12-58	12-263	12-139	12-68	12-80	12-20	12-85	11-49	12-209
6	12-149	12-251	11-57	12-231	12-72	12-34	12-172	12-156	12-104	12-195
7	12-64	12-218	12-208	12-127	12-262	12-66	12-204	11-40	12-138	12-200
8	12-136	12-92	12-28	12-43	11-54	12-238	12-165	12-162	12-107	12-225
9	12-182	12-40	12-77	12-99	12-46	12-31	12-110	12-51	12-44	12-169
10	12-97	12-189	12-253	12-22	12-26	12-14	12-272	12-98	12-229	12-301

APPENDIX C

EDGE DAMAGE DISTRIBUTIONS

C.1 Edge damage histograms

In this appendix, graphs of the edge damage distribution on each assemblage tool type is shown graphically. Each graph has the same format. Each distribution is relative to the location on the edge on the y-axis. At the bottom of the y-axis (0) is the proximal edge adjacent to the platform. At the top of the y-axis (100) is the distal most extent of the tool, roughly synonymous with where the point of 'technological-length' measurement is taken. The edge damage frequency is on the x-axis, and is divided between the left edge (blue shaded histogram on the 'negative' side) and right edge (red shaded histogram on the 'positive' side). The edge damage frequency is relative to the amount of damage on that edge for the entire assemblage of that tool type. For instance, if there are 3 instances of damage at 15% of the relative location up tool edges and 348 total instances of damage, the value at the location 15% up the tool edge will be 0.0086 (3/348). There are two graphs for each assemblage-tool combination, and Dorsal is always on the left and Ventral is on the right.

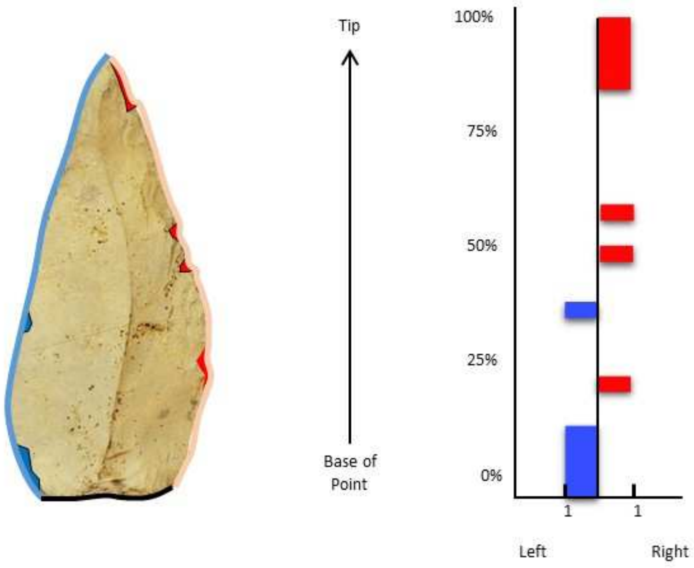


Figure 48. Edge damage histogram, following Wilkins et al. (2012).

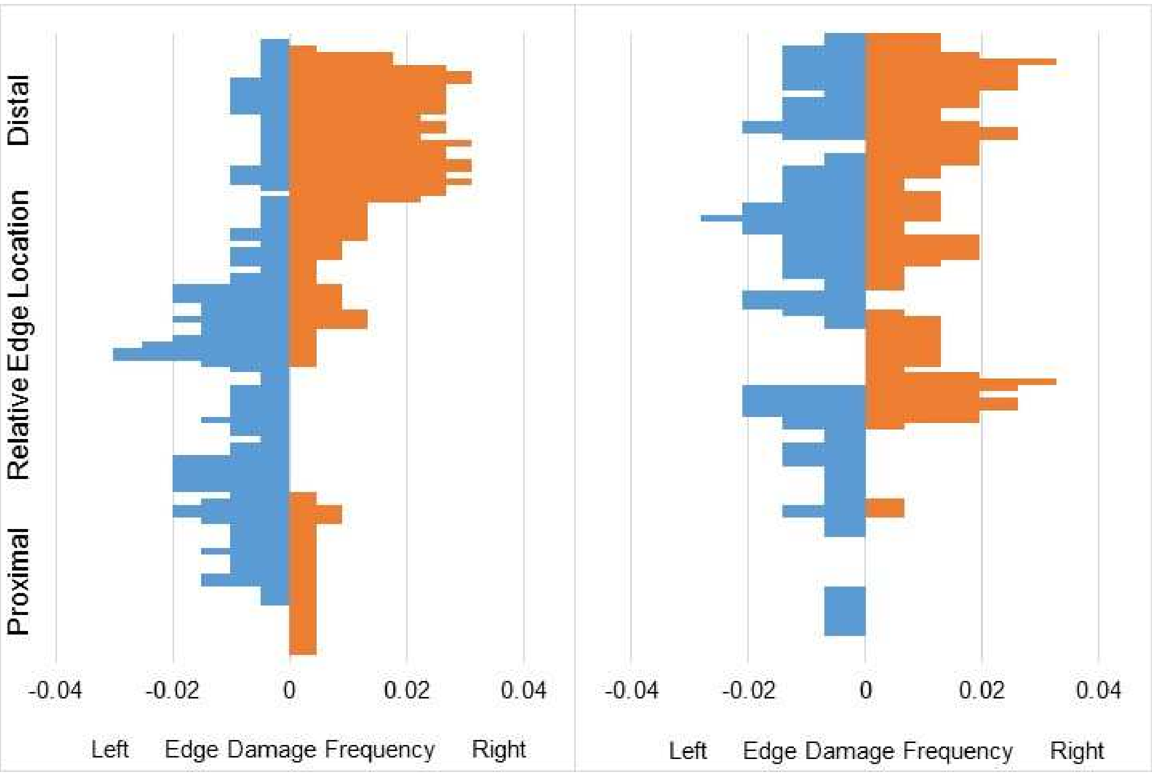


Figure 49. DK1 10-16 points edge damage distribution.

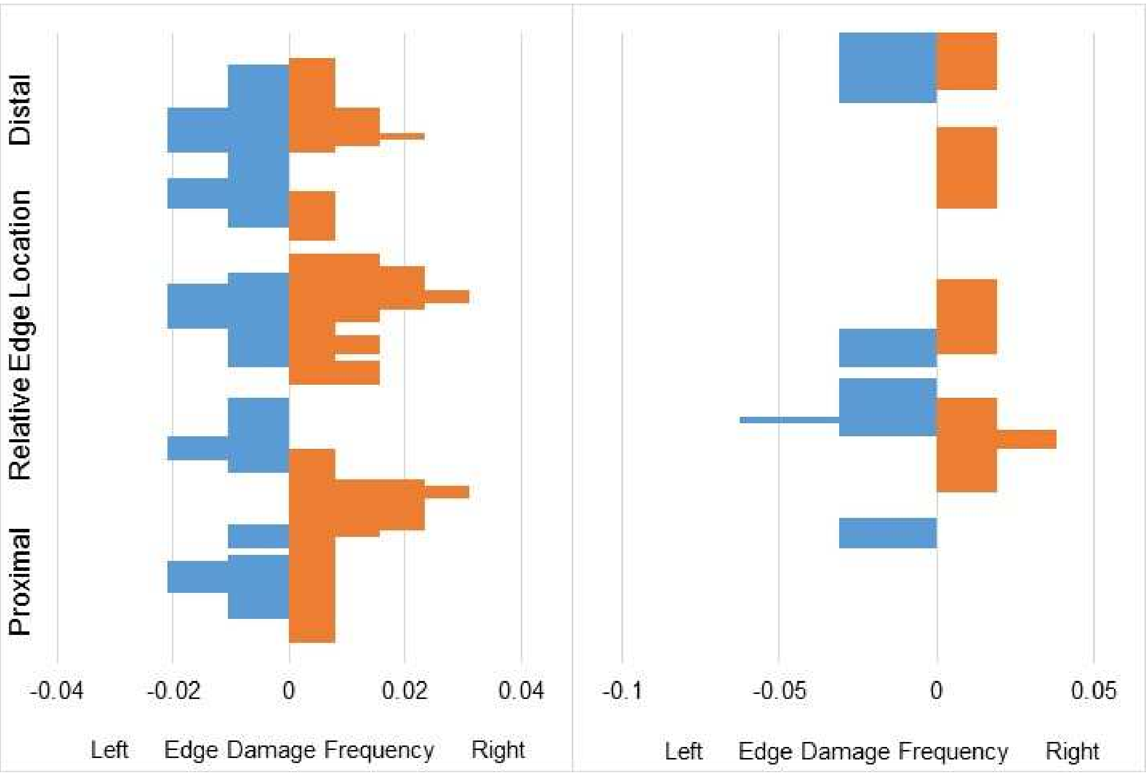


Figure 50. DK1 6-9 points edge damage distribution.

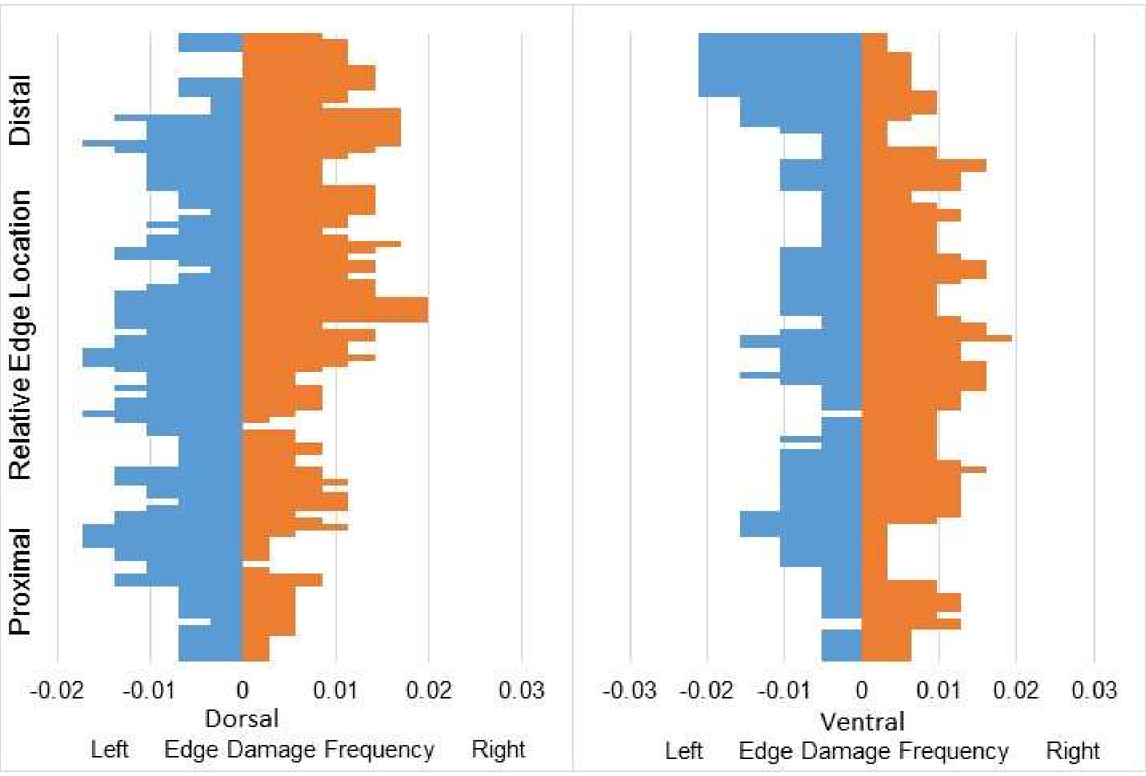


Figure 51. Nelson Bay Cave layer 10 flakes edge damage distribution.

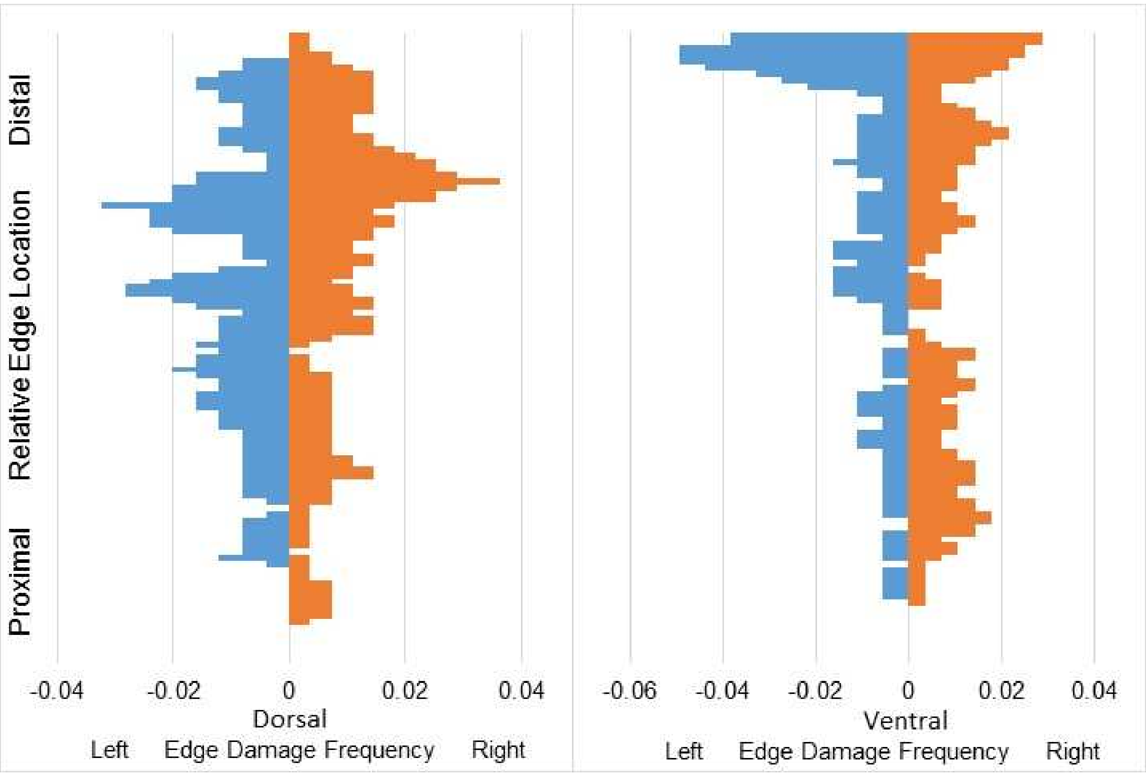


Figure 52. Nelson Bay Cave layer 10 points edge damage distribution.

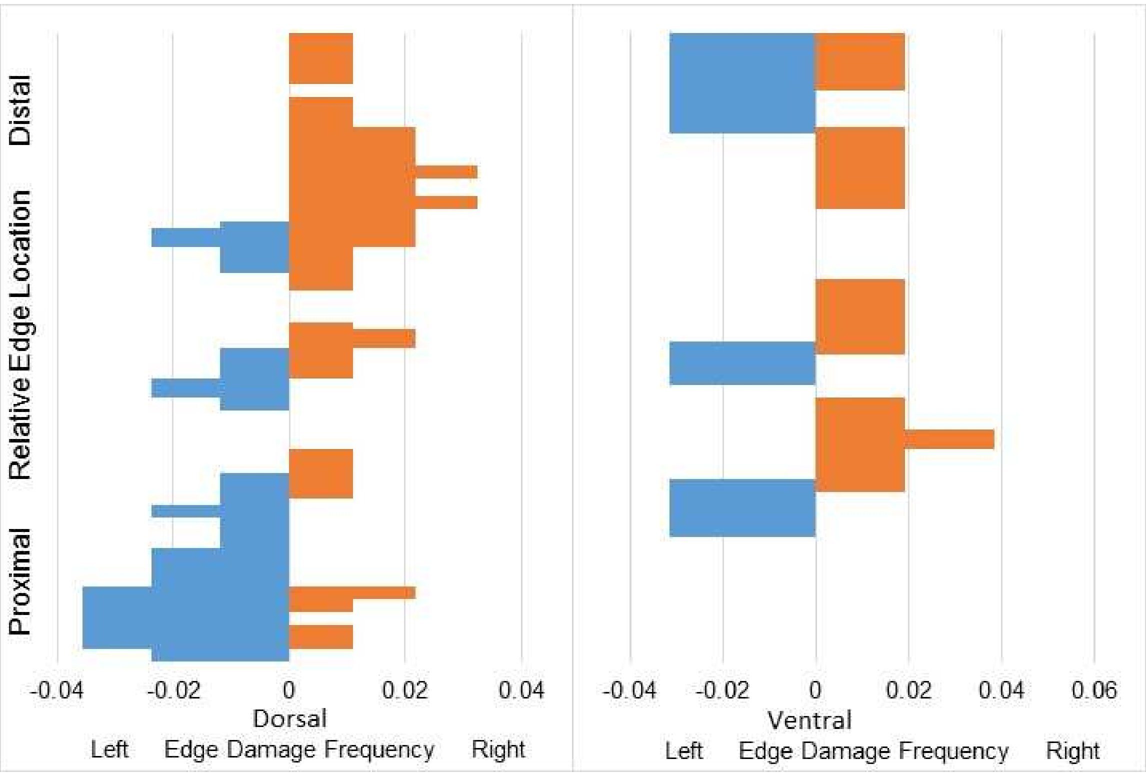


Figure 53. Nelson Bay Cave layer 6 blades edge damage distribution.

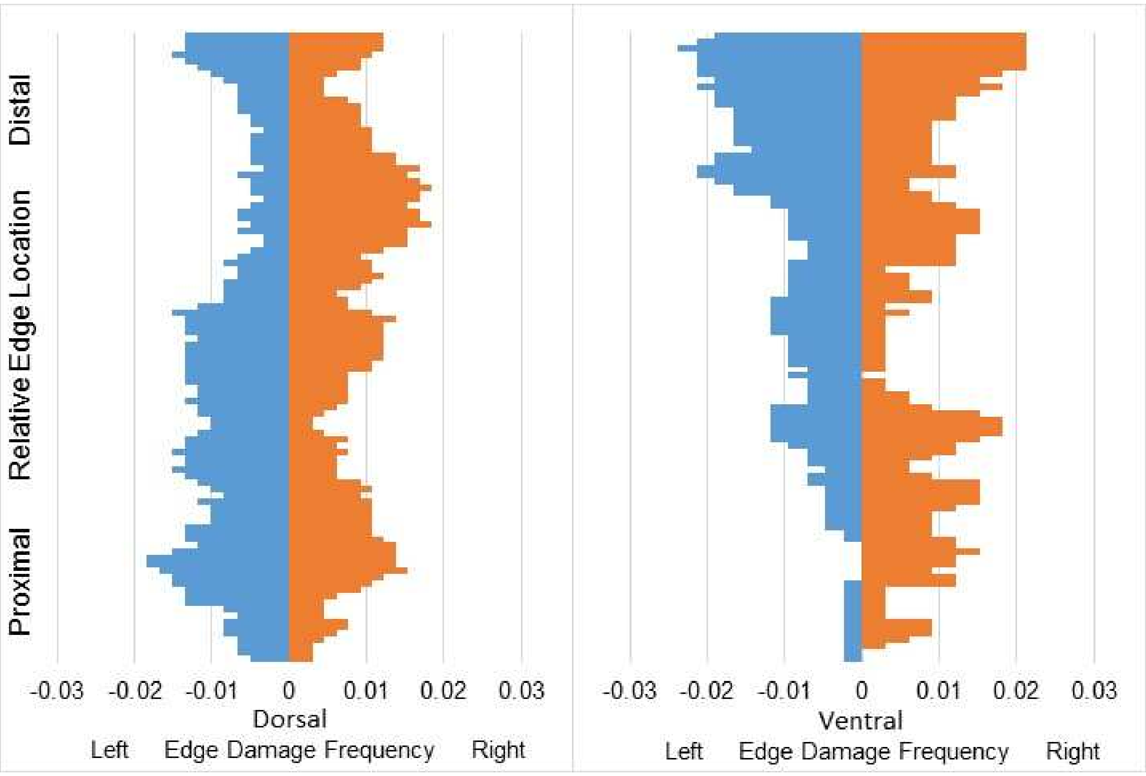


Figure 54. Nelson Bay Cave layer 6 flakes edge damage distribution.

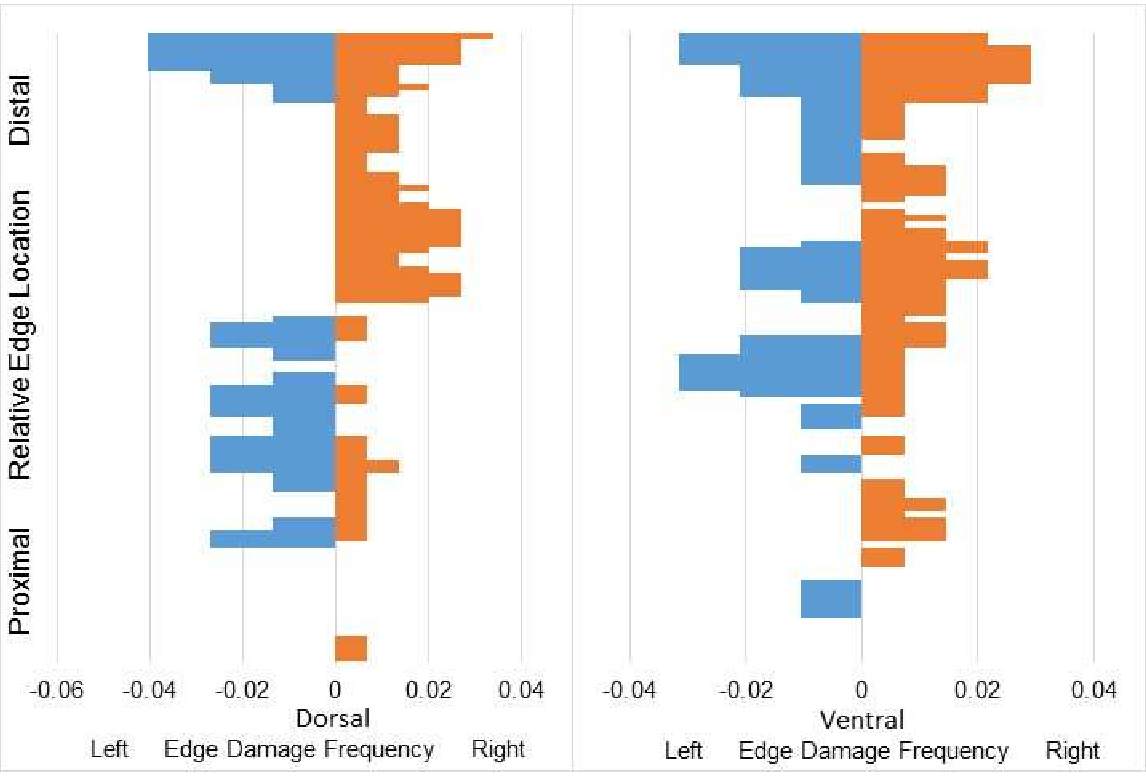


Figure 55. Nelson Bay Cave layer 6 points edge damage distribution.

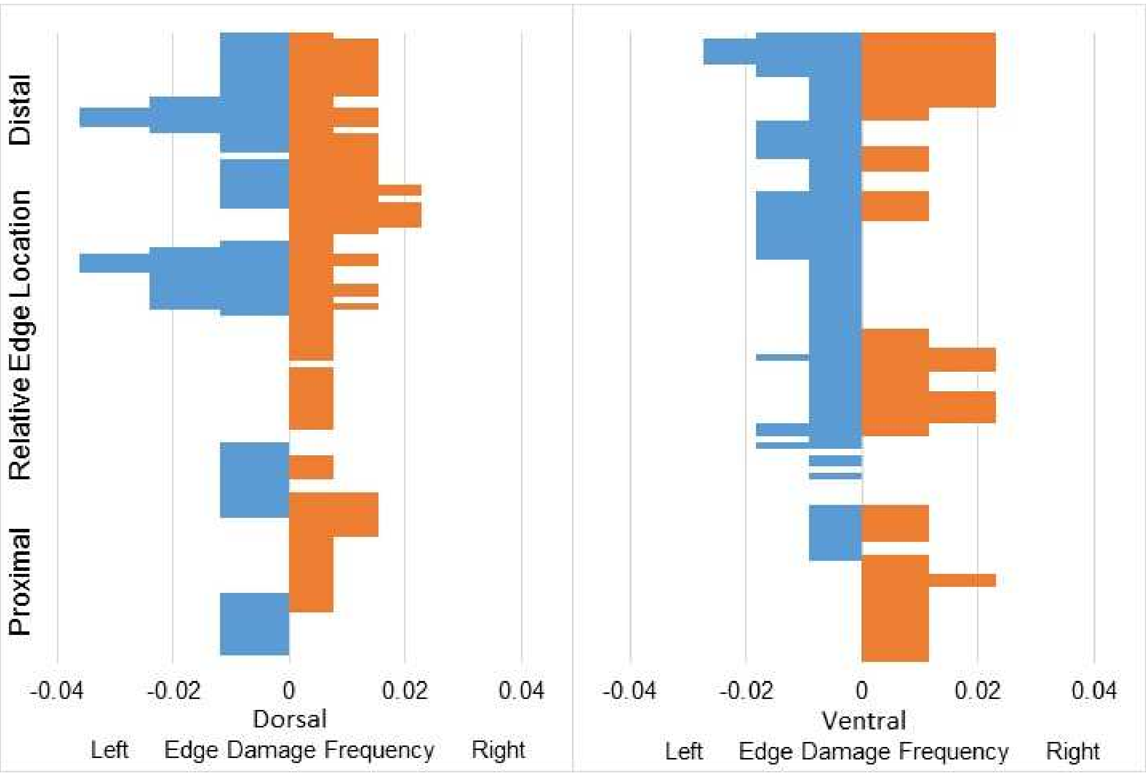


Figure 56. Oyster Bay blades edge damage distribution.

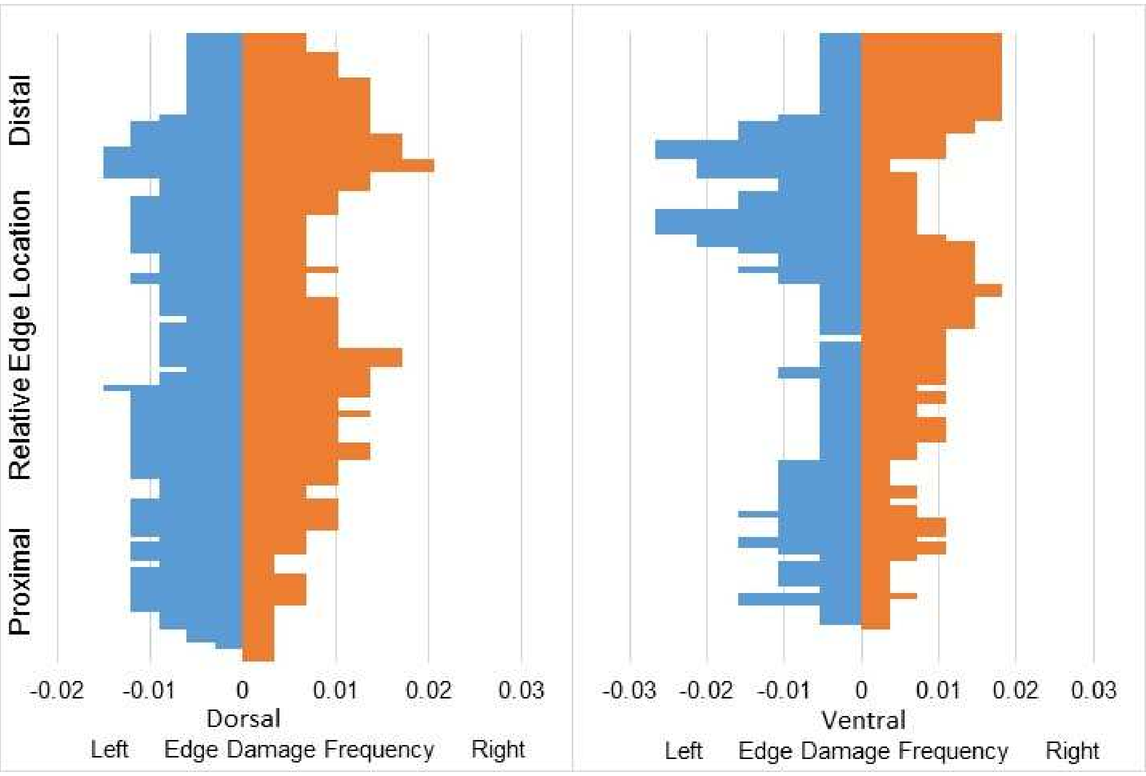


Figure 57. Oyster Bay flakes edge damage distribution.

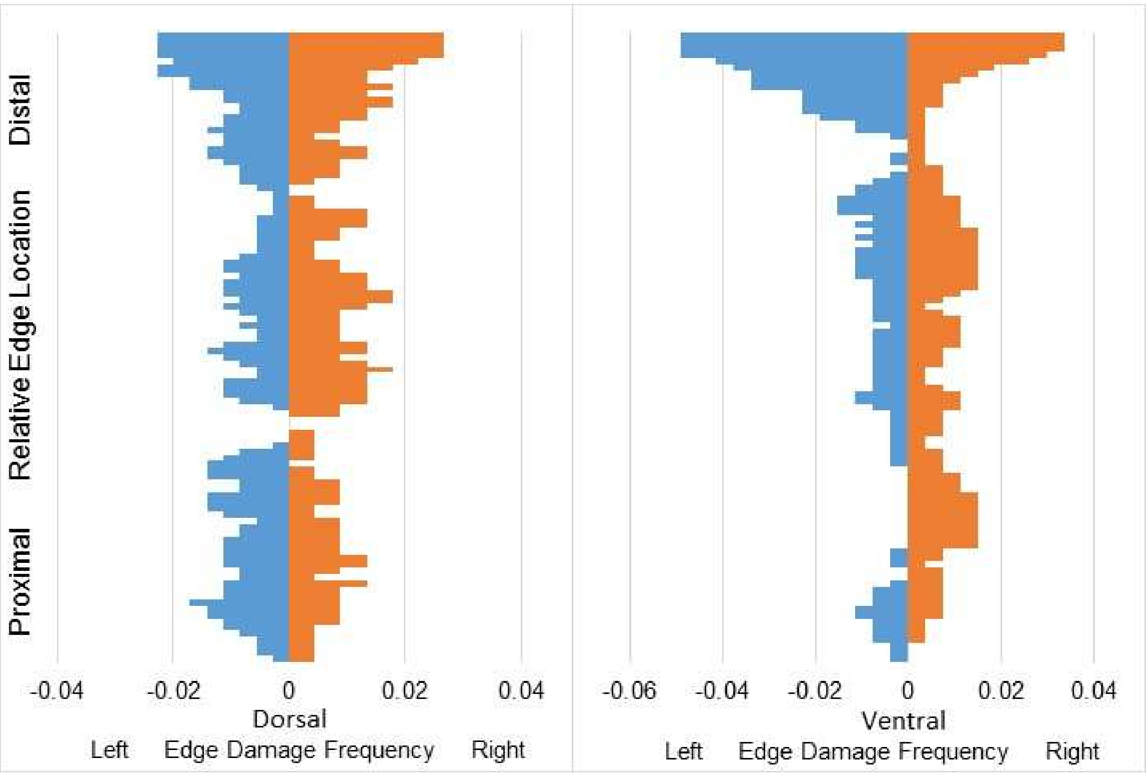


Figure 58. Oyster Bay points edge damage distribution.

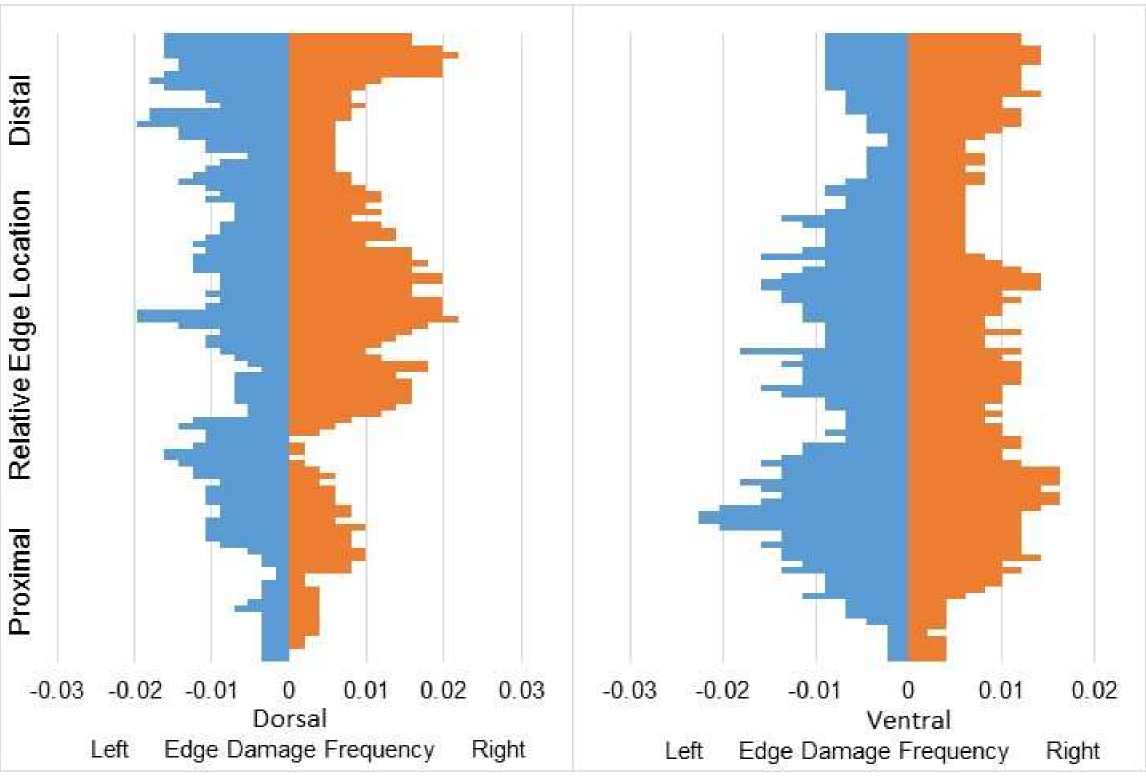


Figure 59. PP13B MIS 5 blades edge damage distribution.

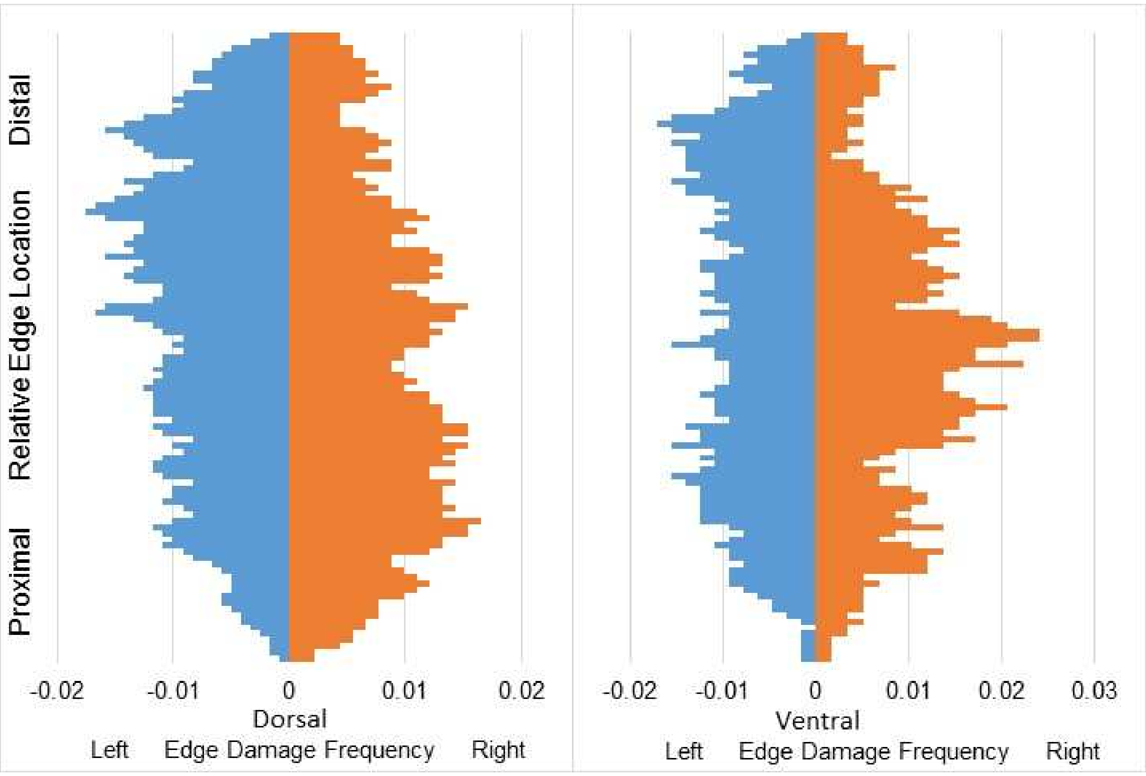


Figure 60. PP13B MIS 5 points edge damage distribution.

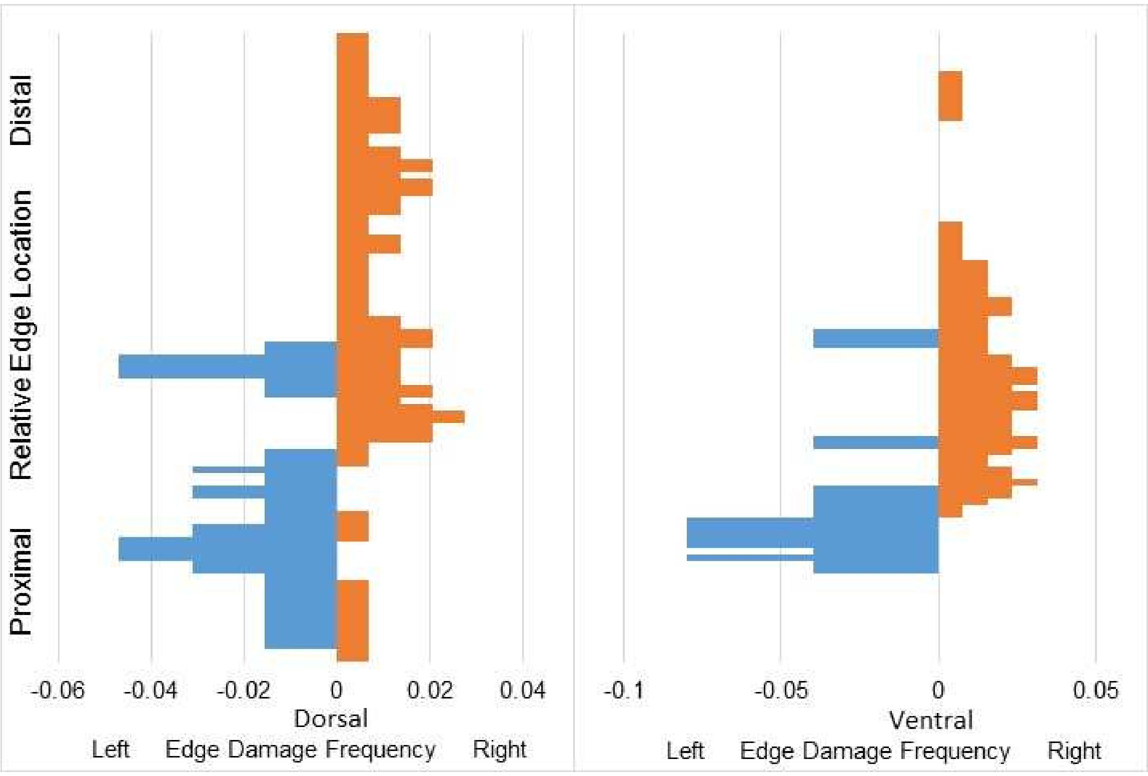


Figure 61. PP13B MIS 6 blades edge damage distribution.

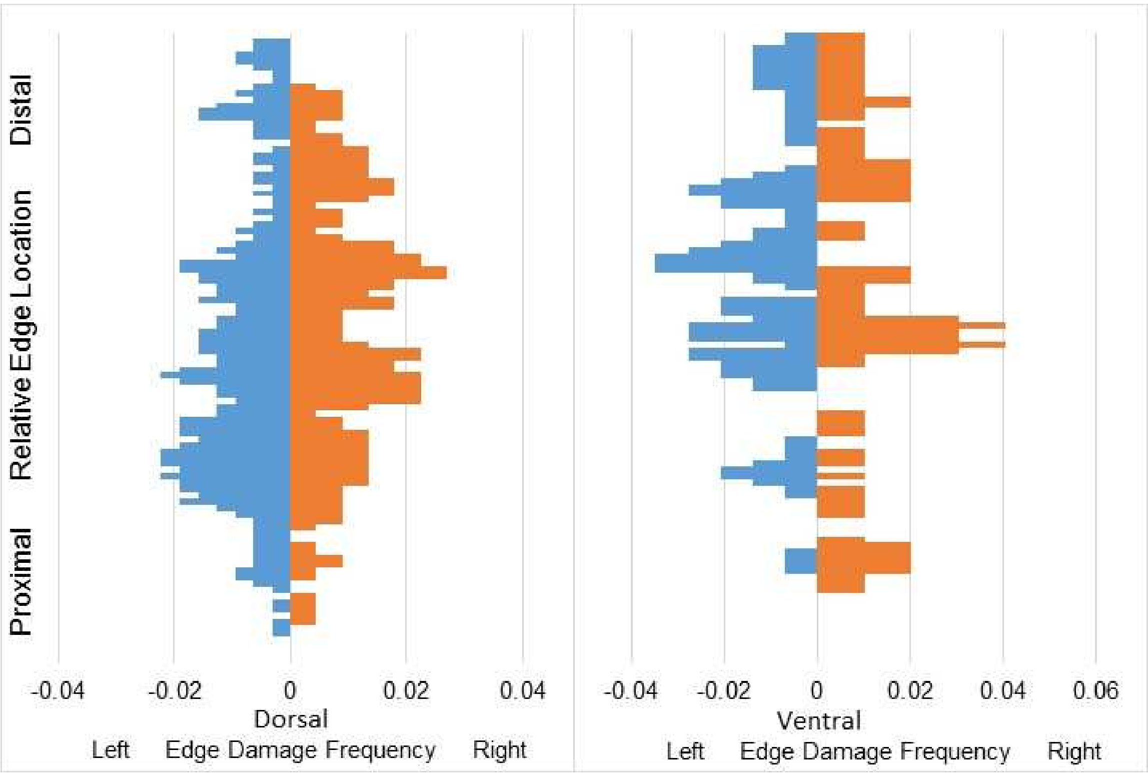


Figure 62. PP13B MIS6 points edge damage distribution.

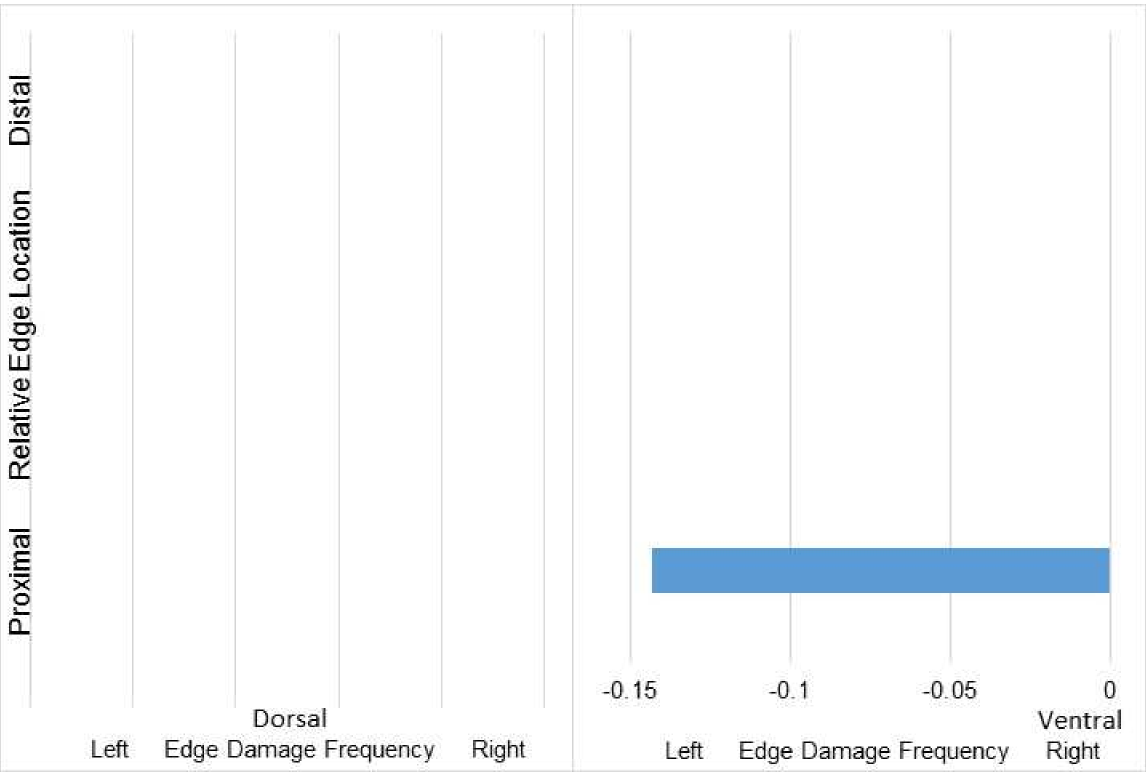


Figure 63. PP5-6 ALBS blades edge damage distribution. No dorsal or ventral right edge damage observed.

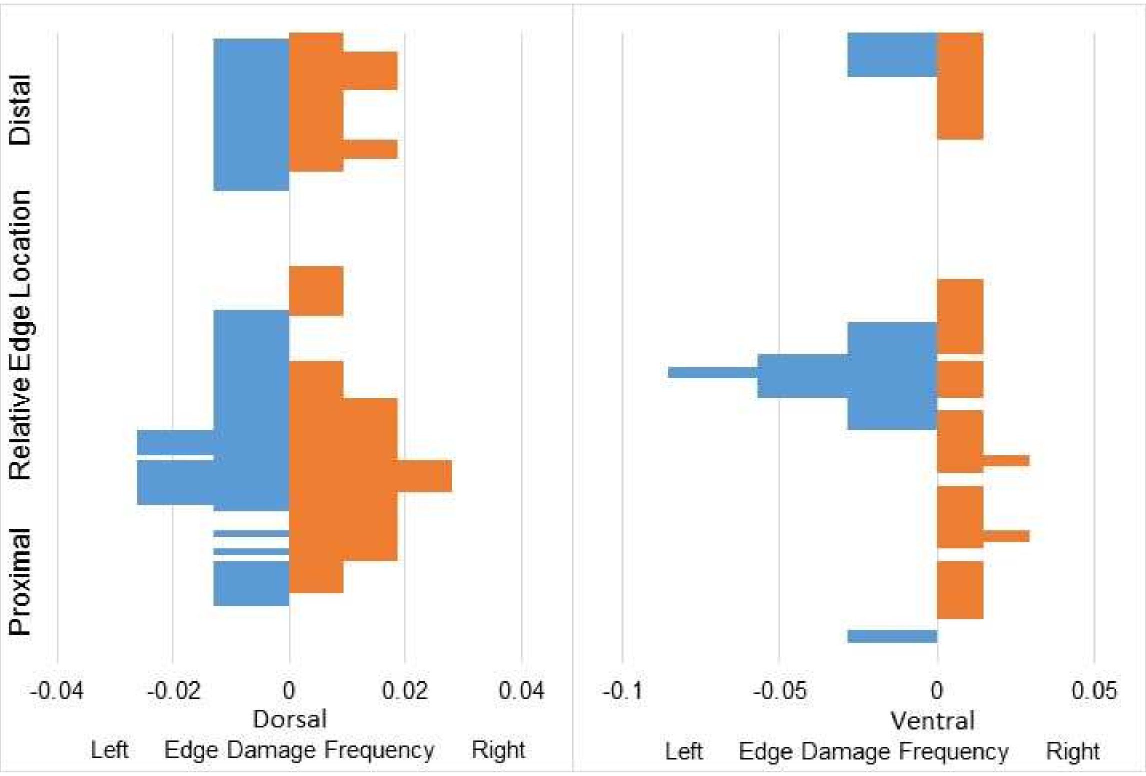


Figure 64. PP5-6 ALBS flakes edge damage distribution.

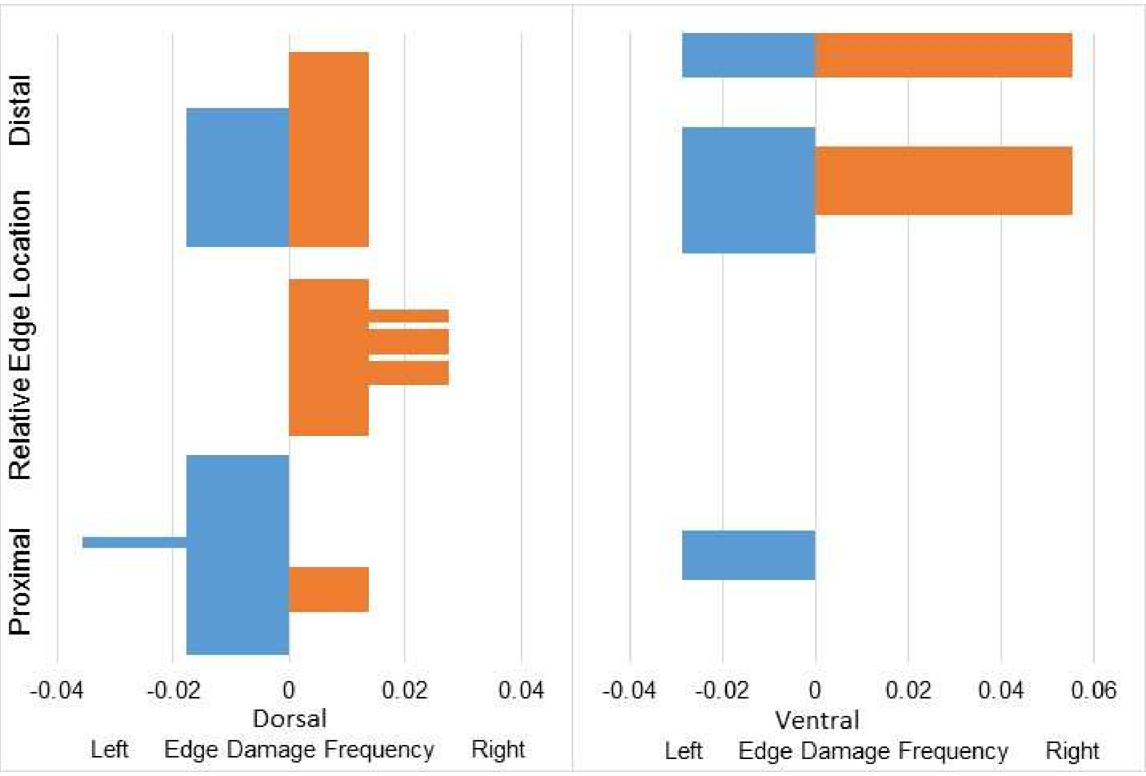


Figure 65. PP5-6 ALBS points edge damage distribution.

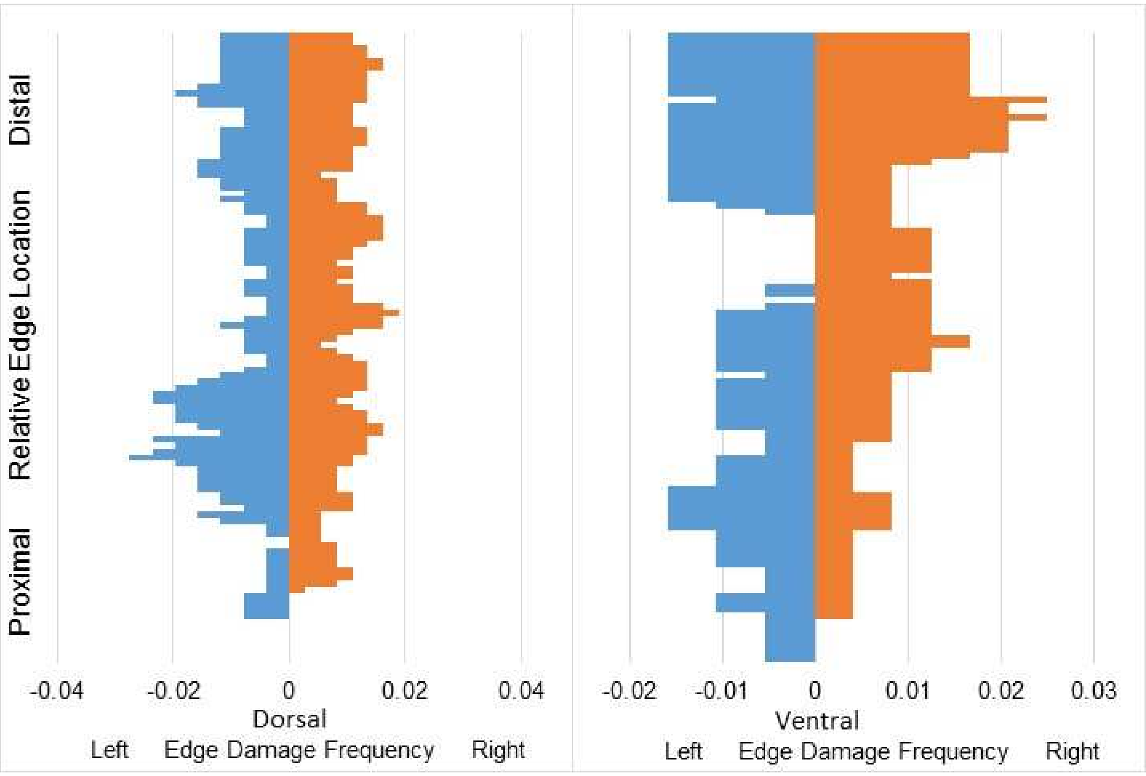


Figure 66. PP5-6 BCSR blades edge damage distribution.

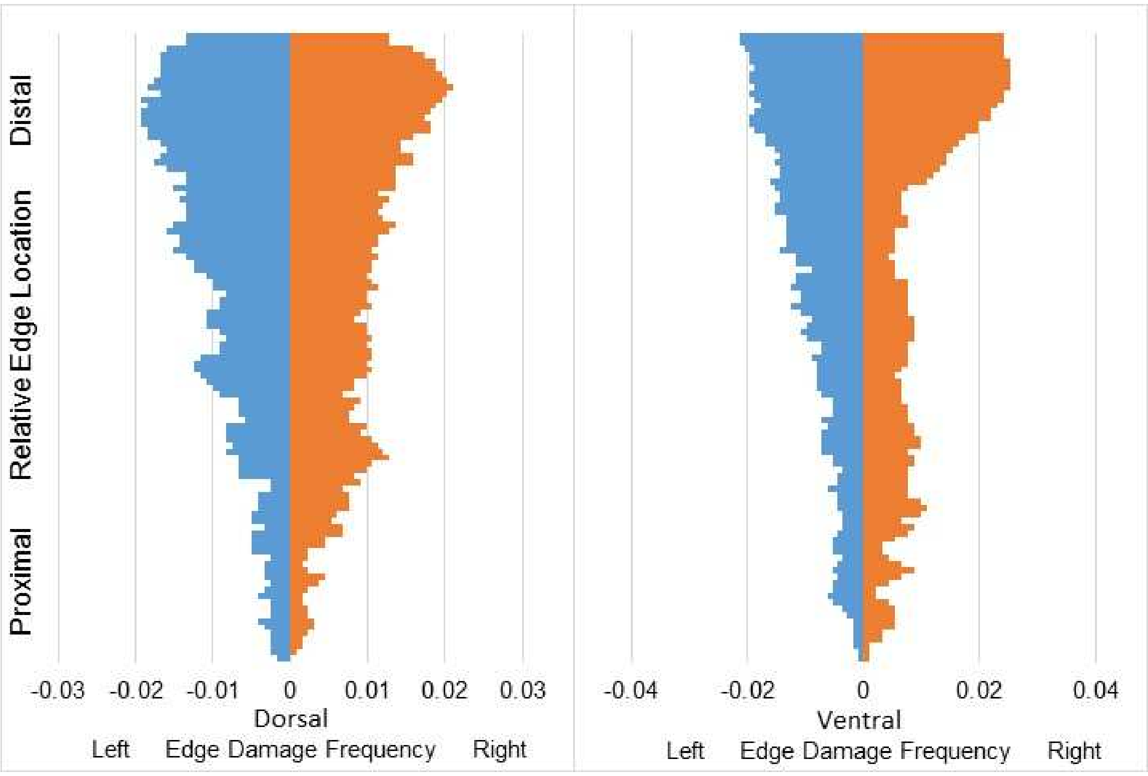


Figure 67. PP5-6 BCSR flakes edge damage distribution.

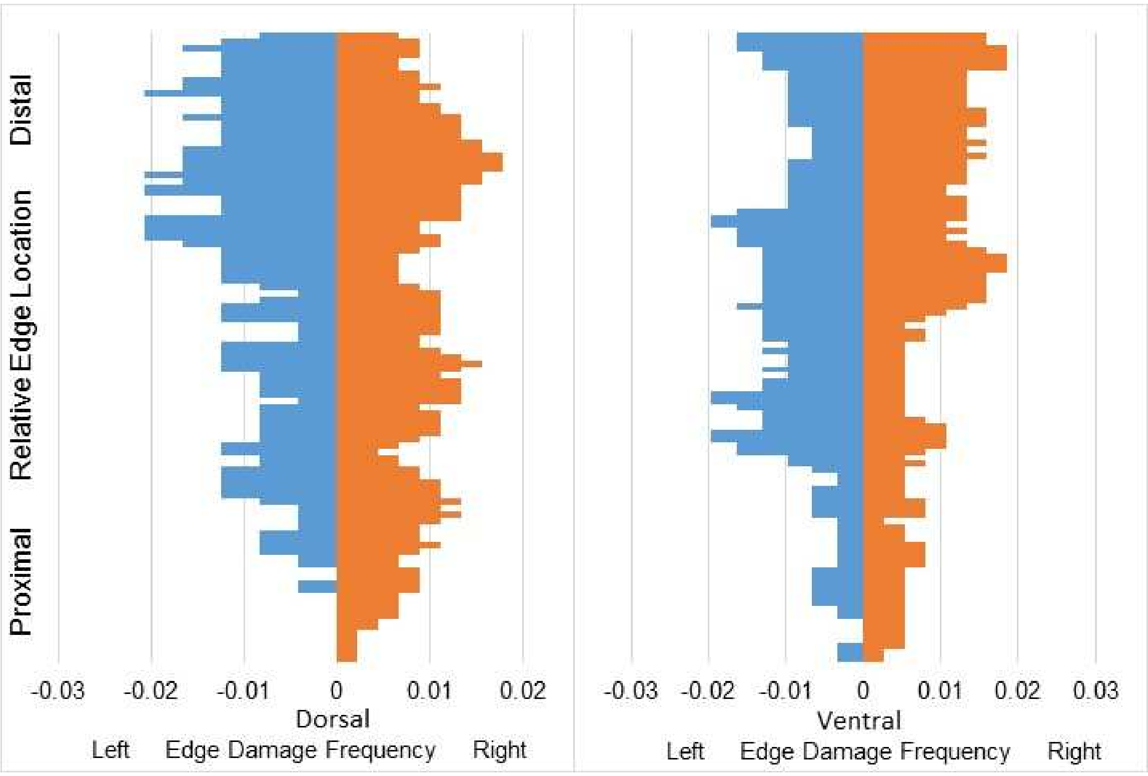


Figure 68. PP5-6 DBCS blades edge damage distribution.

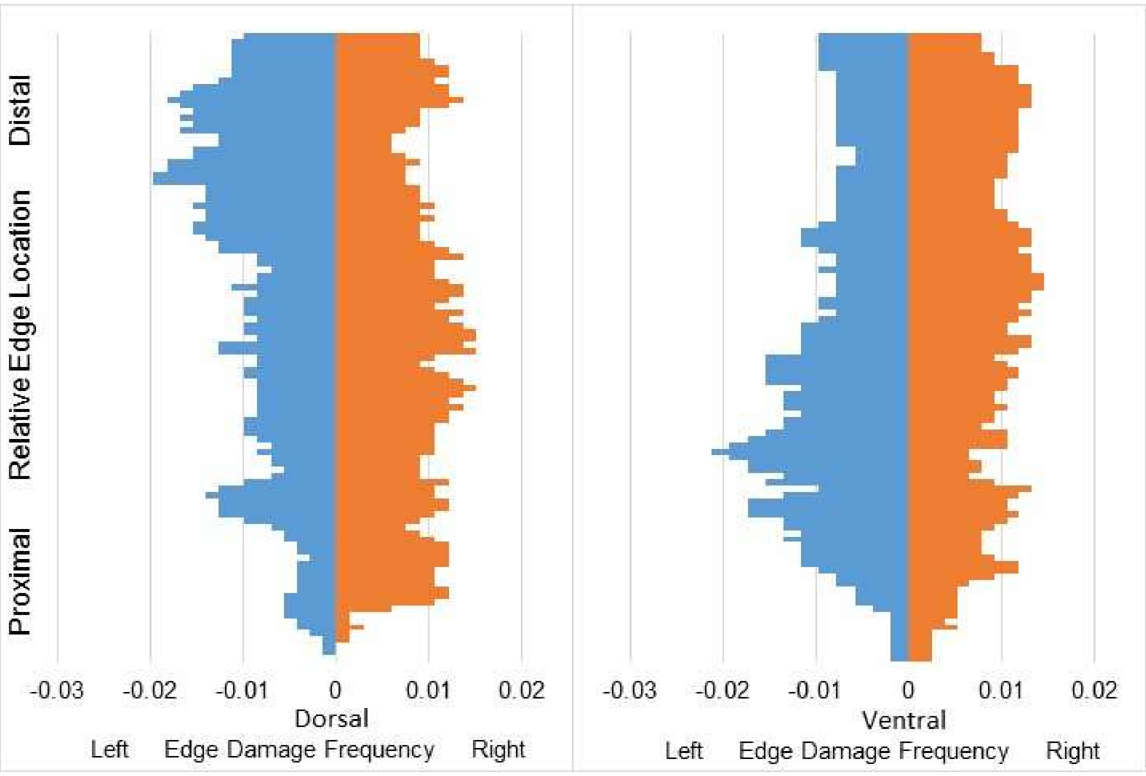


Figure 69. PP5-6 DBCS flakes edge damage distribution.

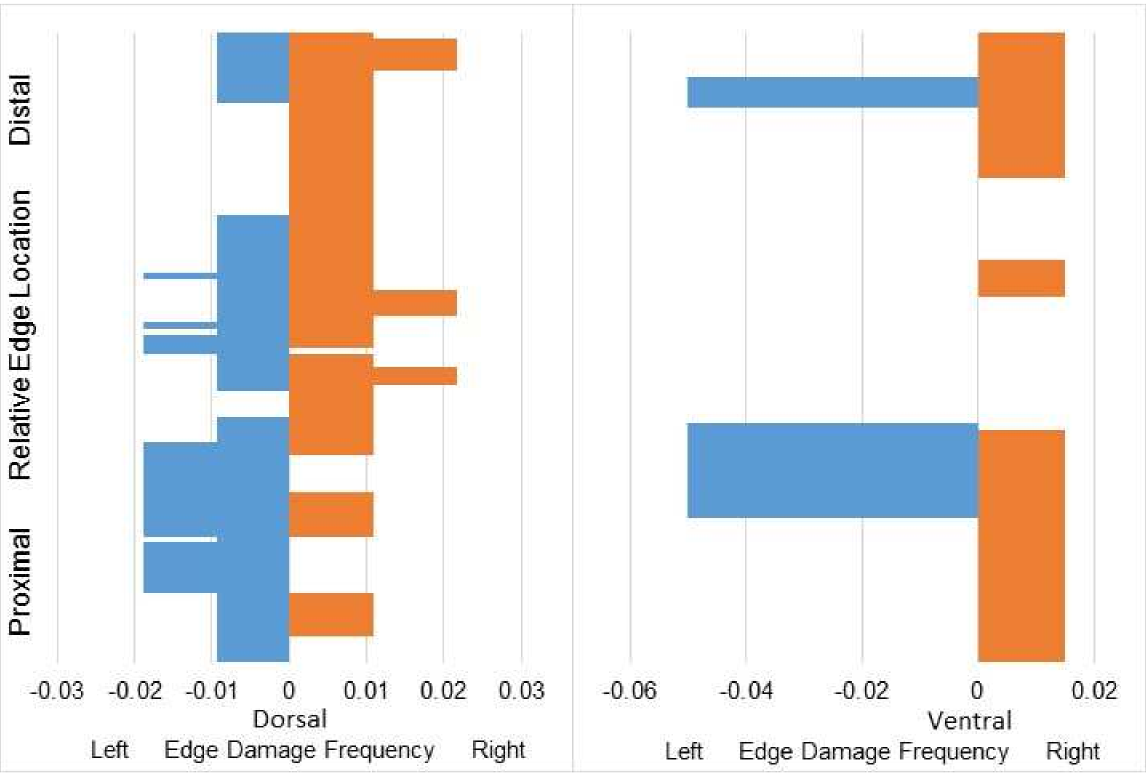


Figure 70. PP5-6 DBCS points edge damage distribution.

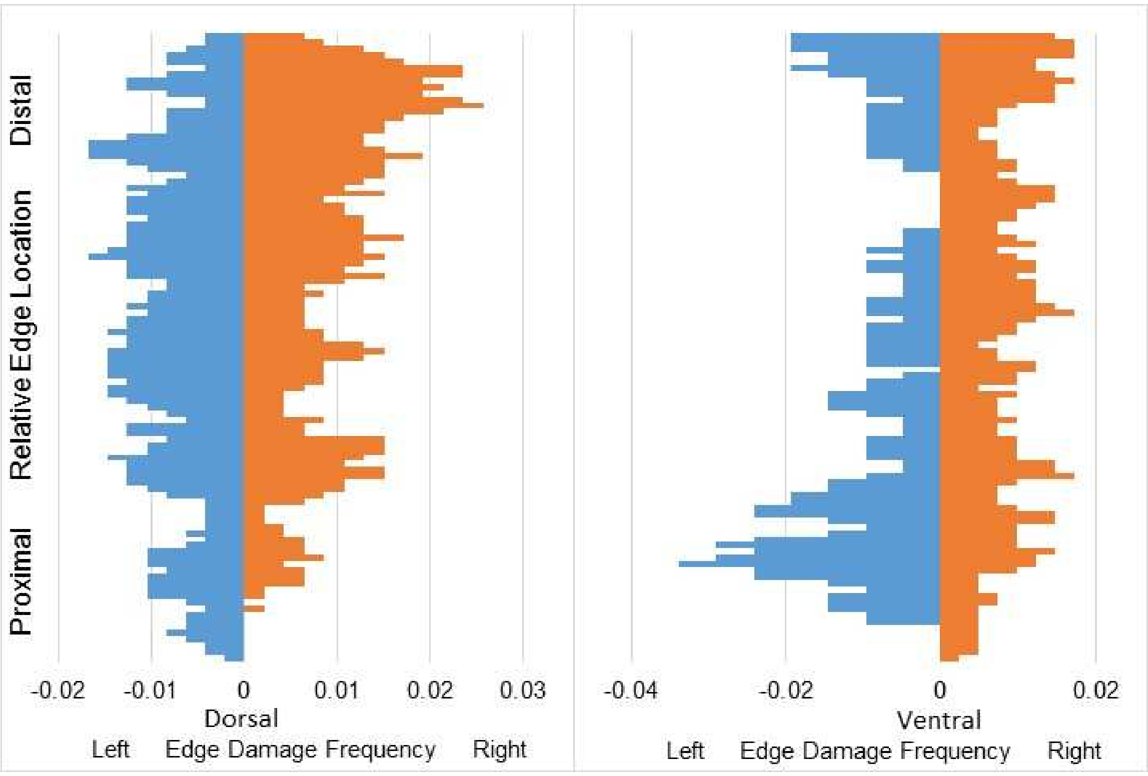


Figure 71. PP5-6 LBSR blades edge damage distribution.

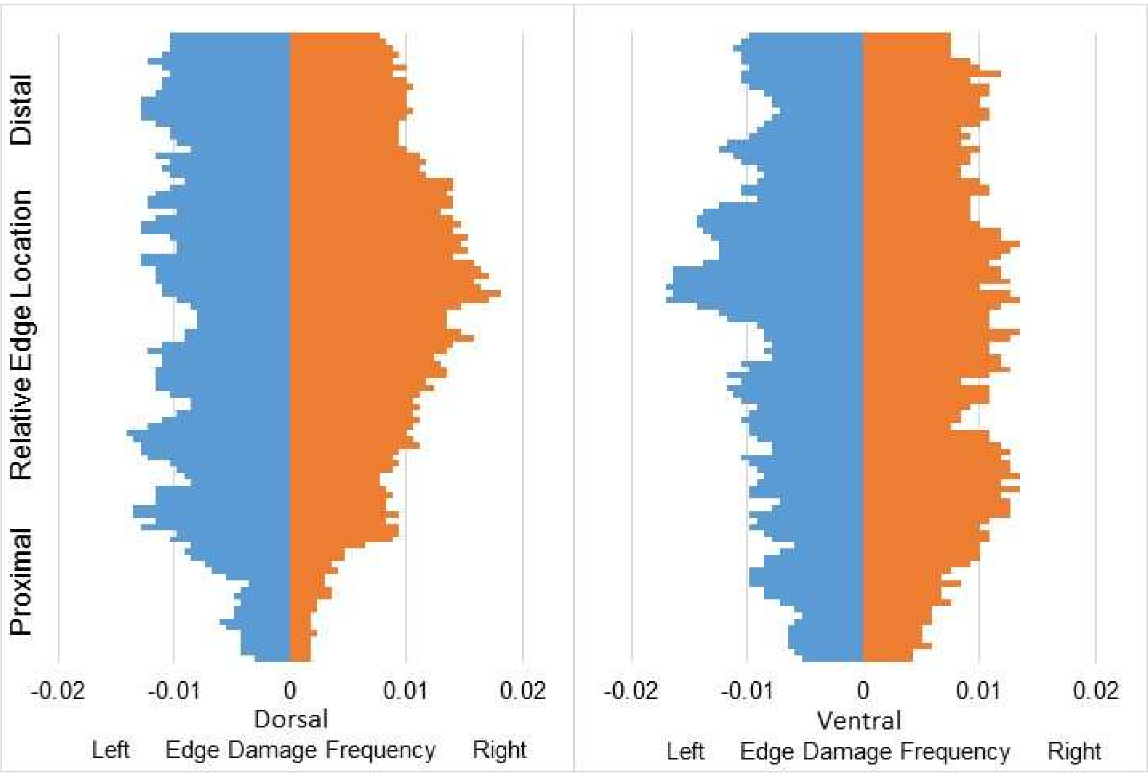


Figure 72. PP5-6 LBSR flakes edge damage distribution.

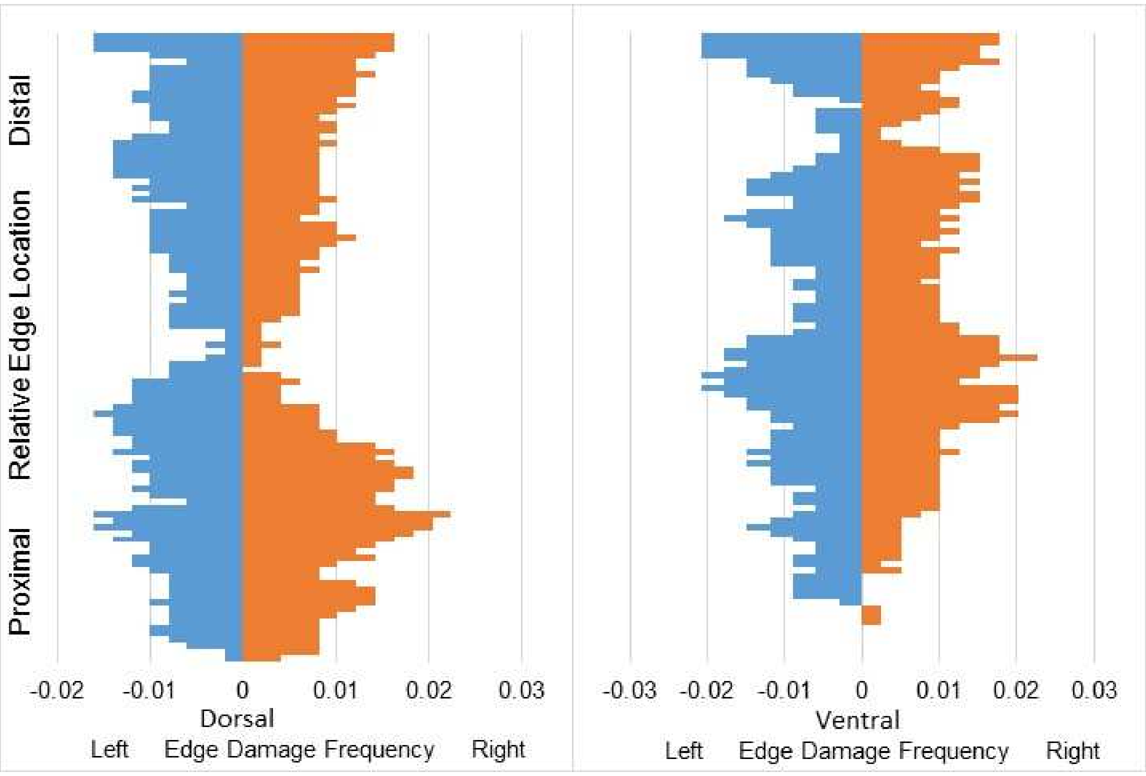


Figure 73. PP5-6 LBSR points edge damage distribution.

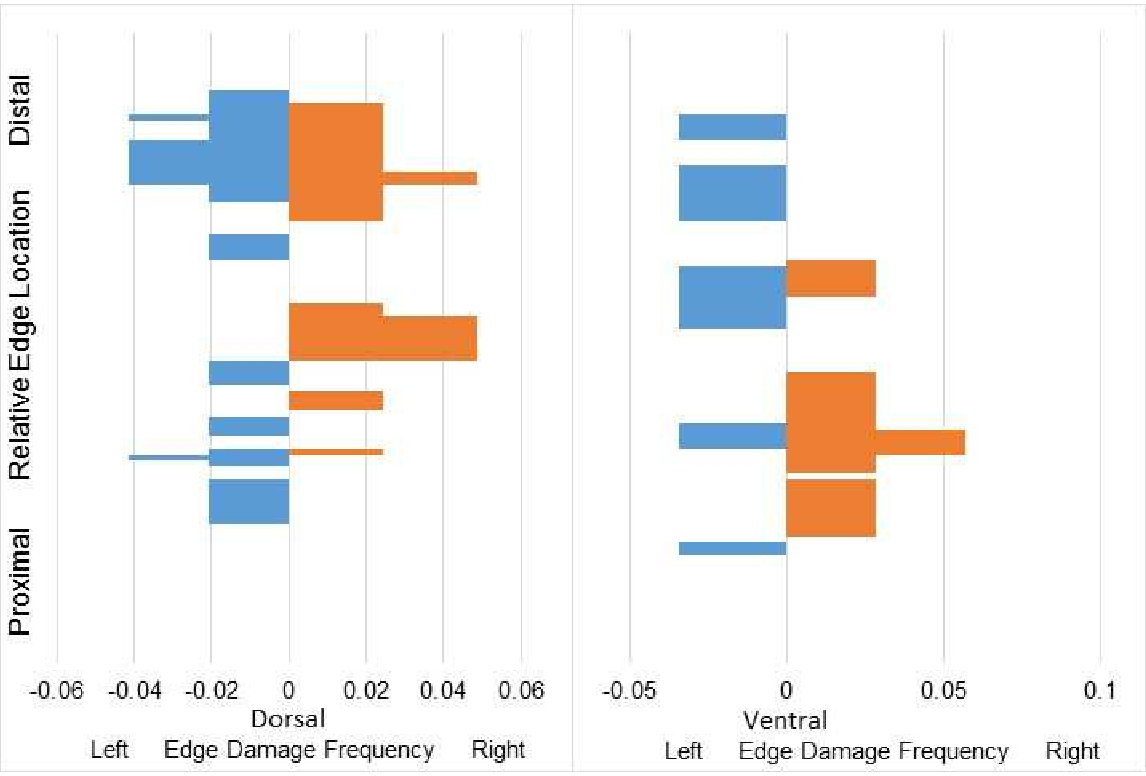


Figure 74. PP5-6 OBS1 blades edge damage distribution.

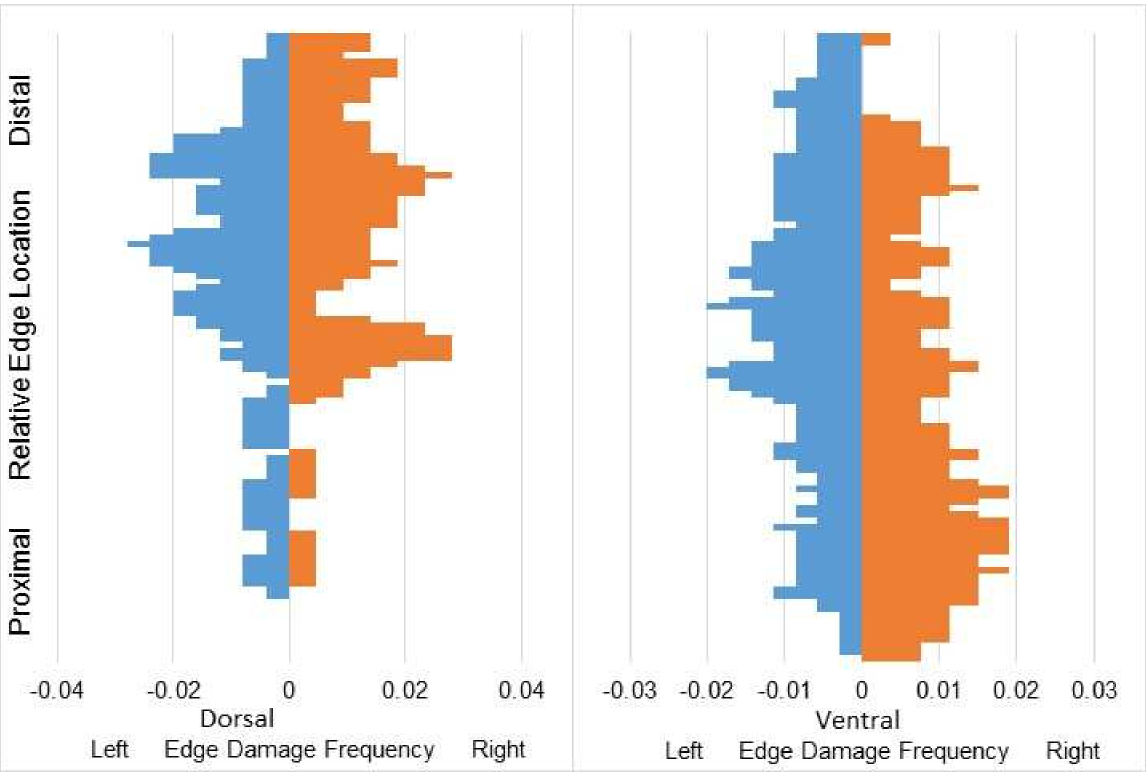


Figure 75. PP5-6 OBS1 flakes edge damage distribution.

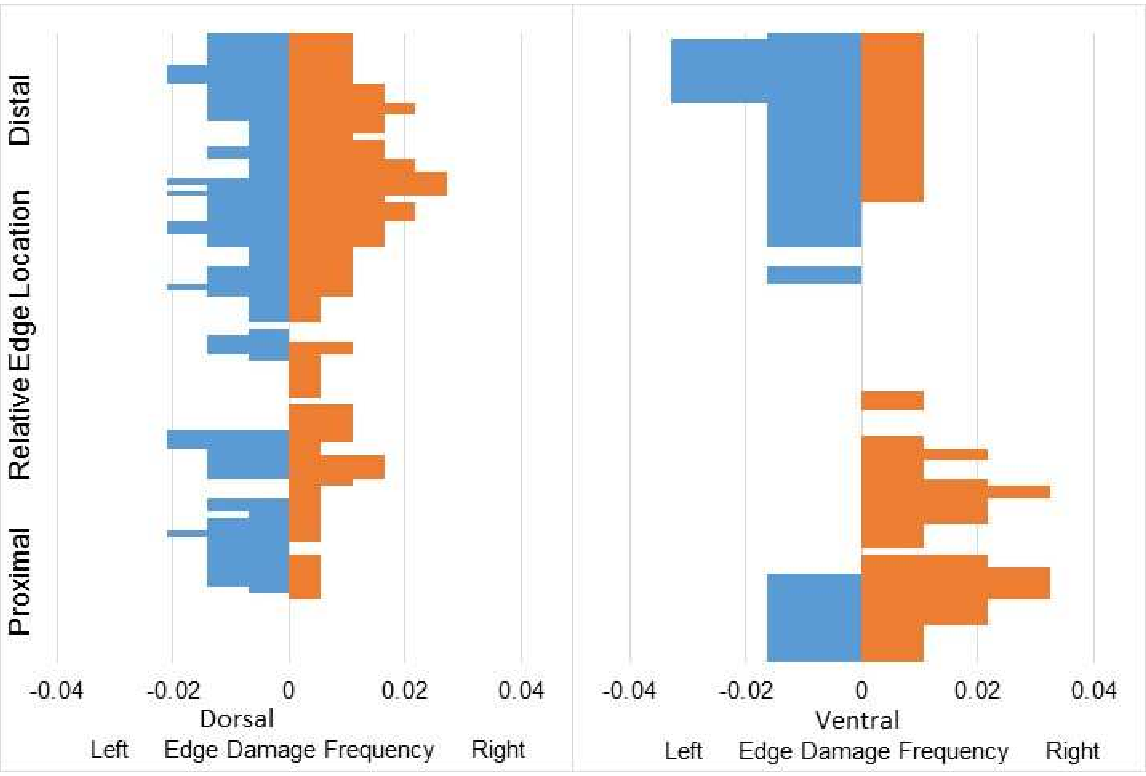


Figure 76. PP5-6 OBS2 blades edge damage distribution.

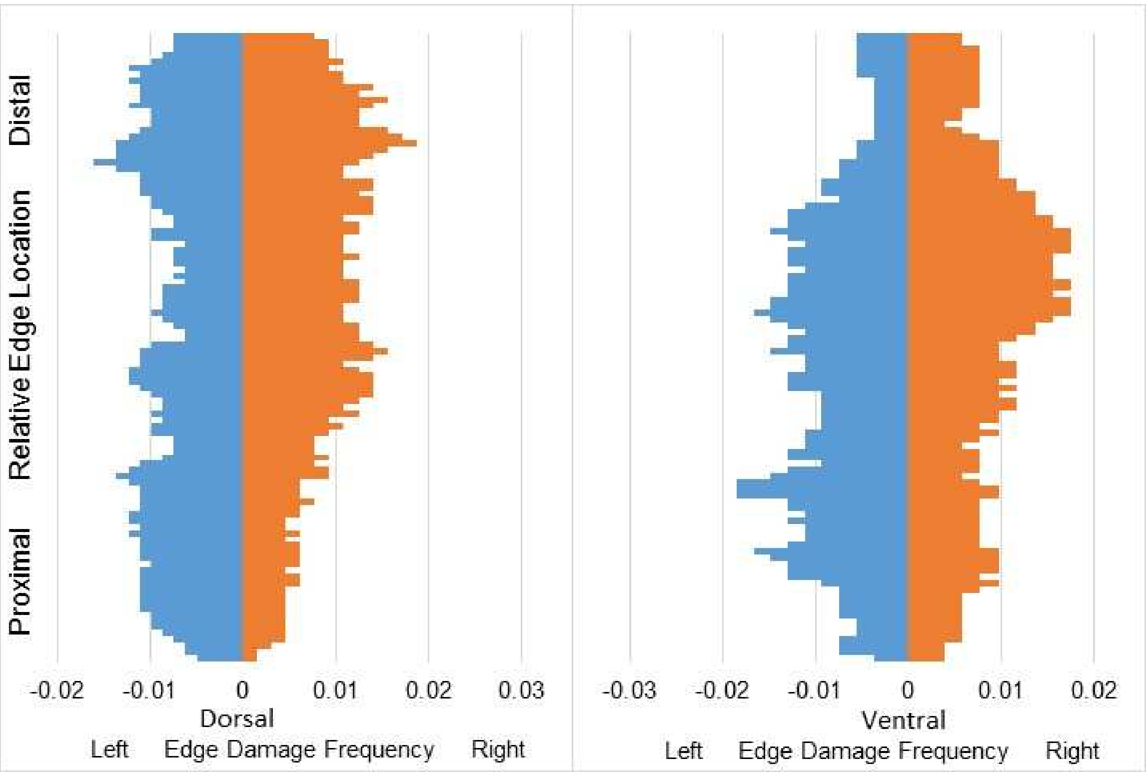


Figure 77. PP5-6 OBS2 flakes edge damage distribution.

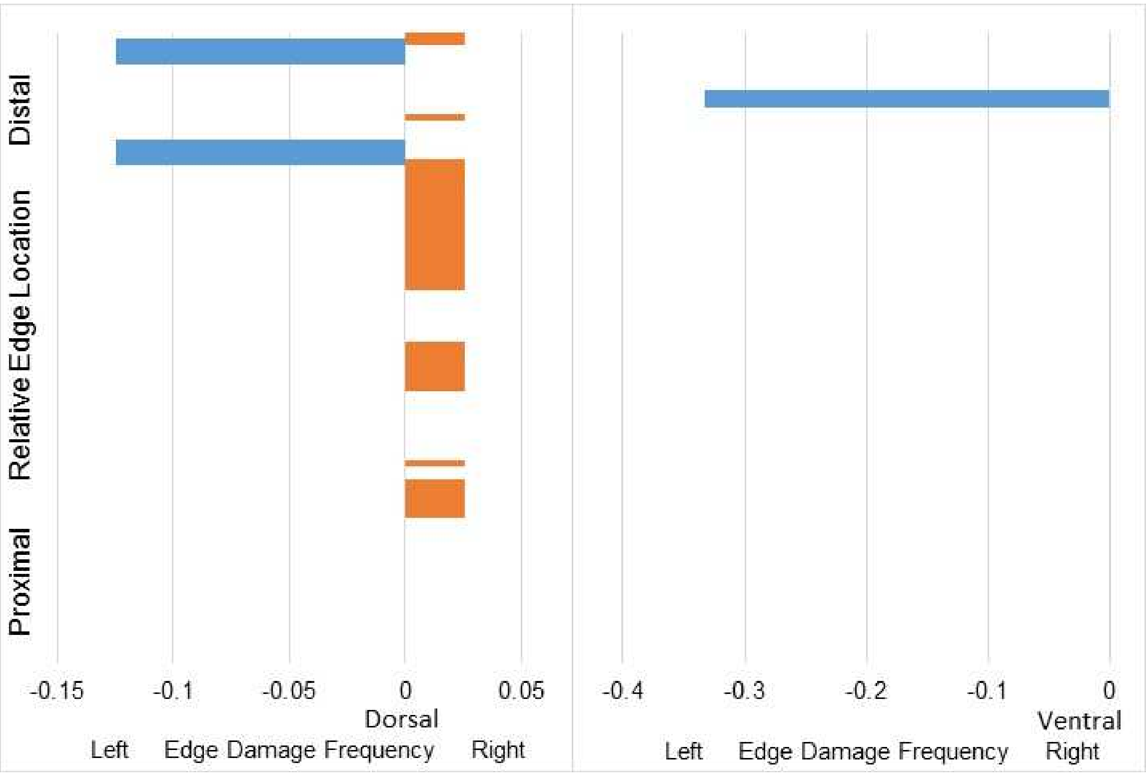


Figure 78. PP5-6 OBS2 points edge damage distribution.

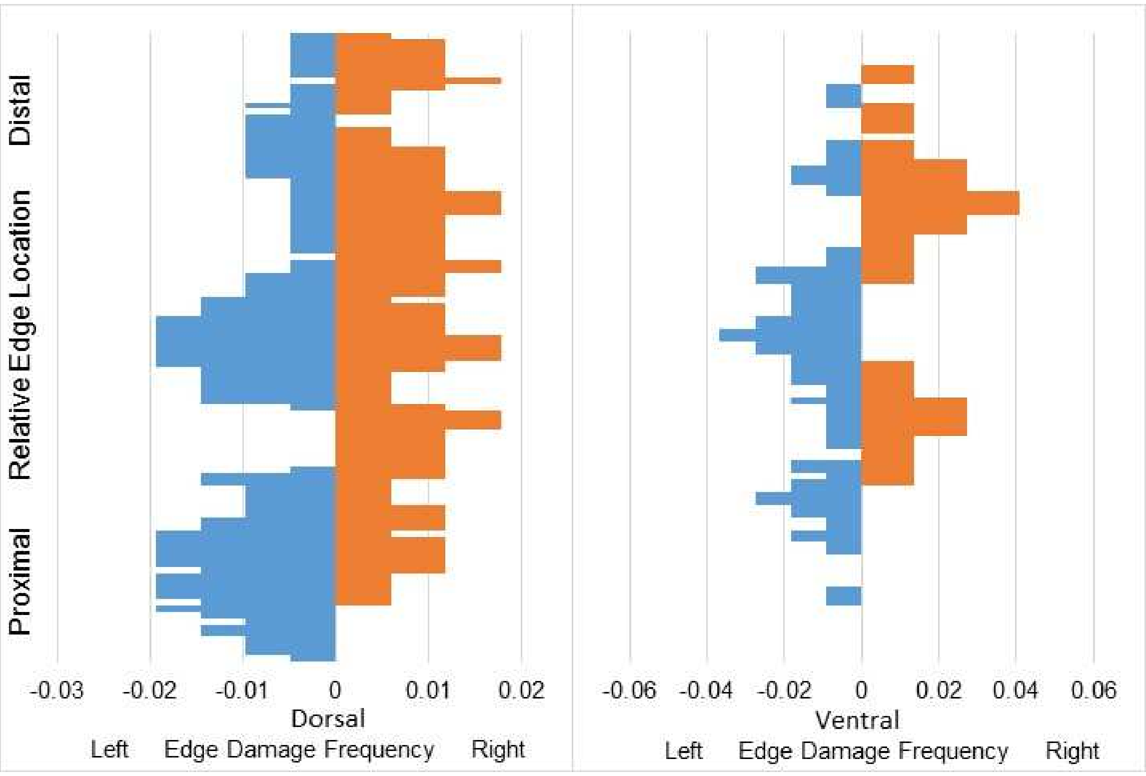


Figure 79. PP5-6 RBSR blades edge damage distribution.

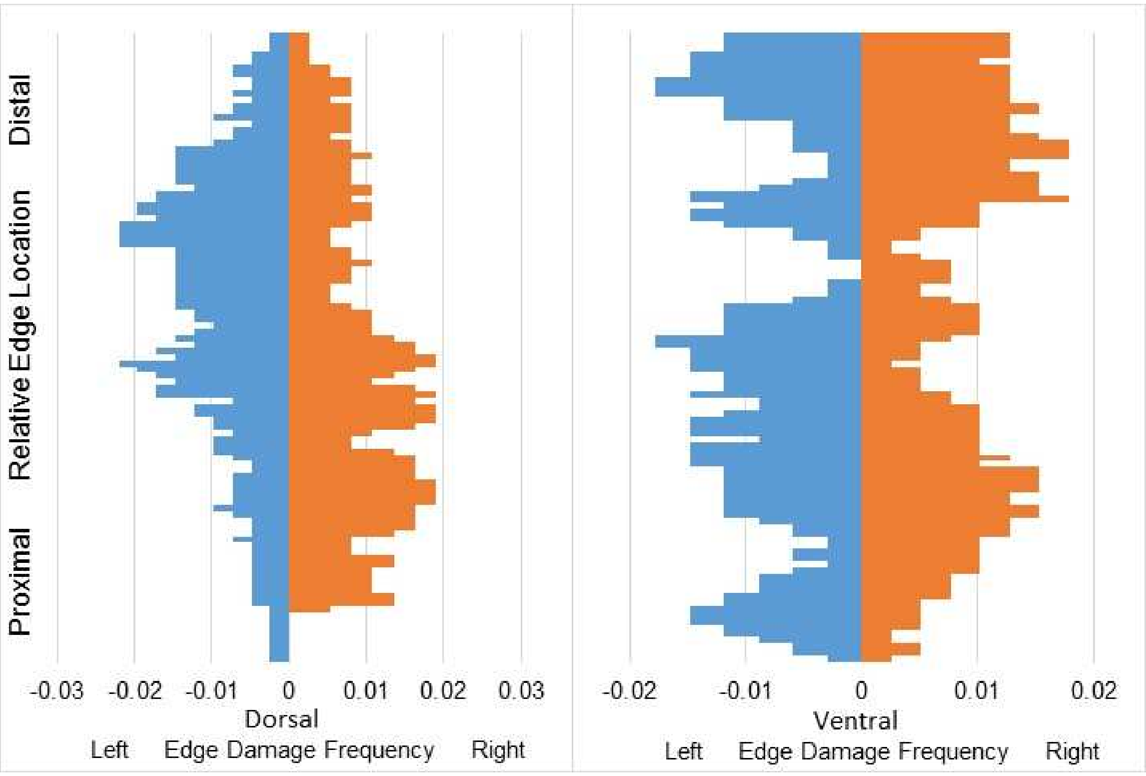


Figure 80. PP5-6 RBSR flakes edge damage distribution.

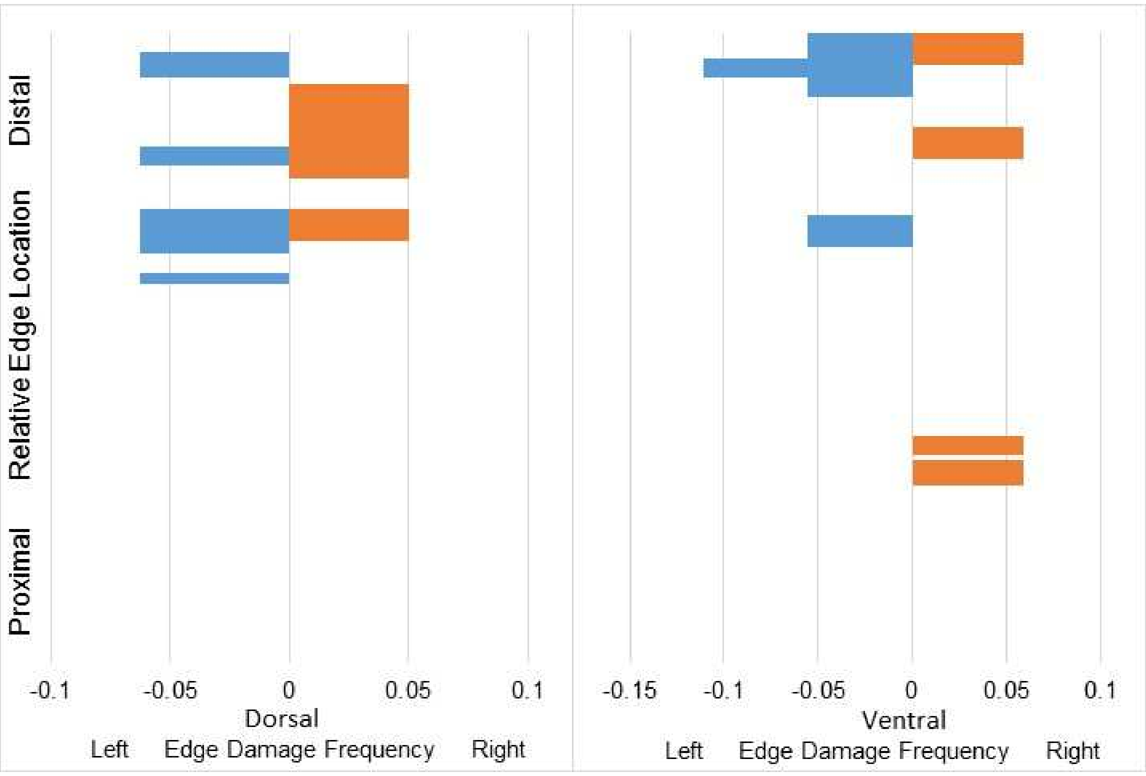


Figure 81. PP5-6 RBSR points edge damage distribution.

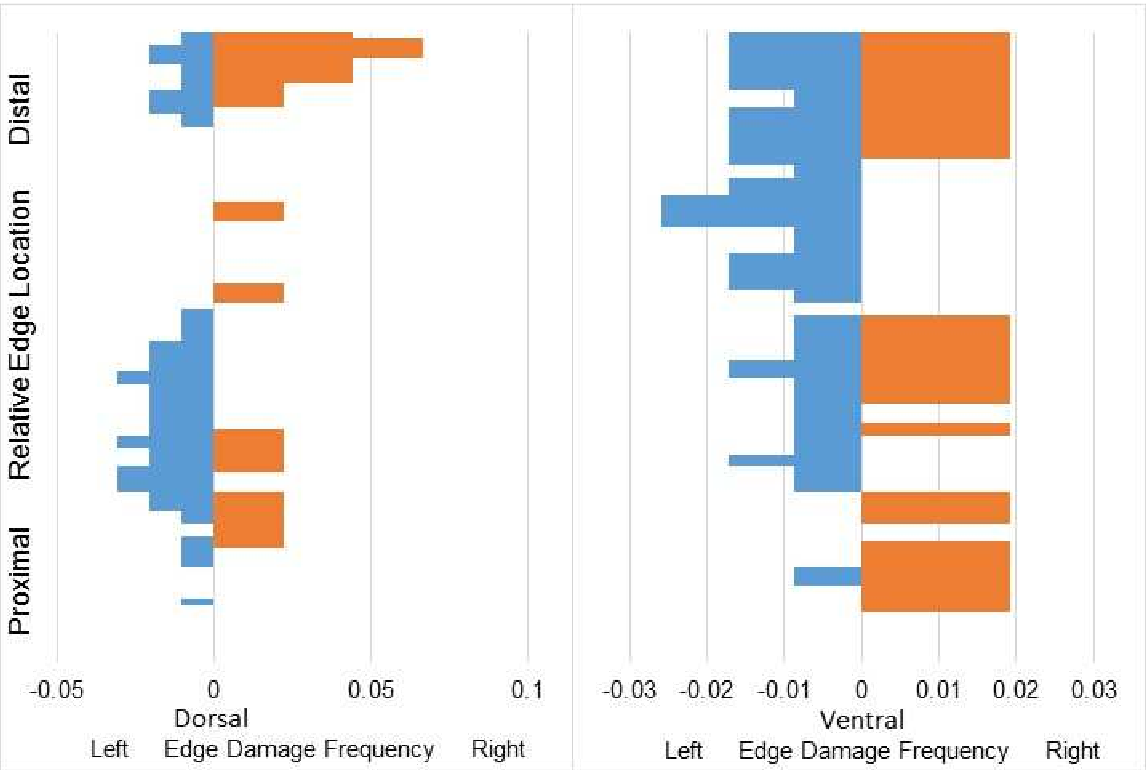


Figure 82. PP5-6 SADBS blades edge damage distribution.

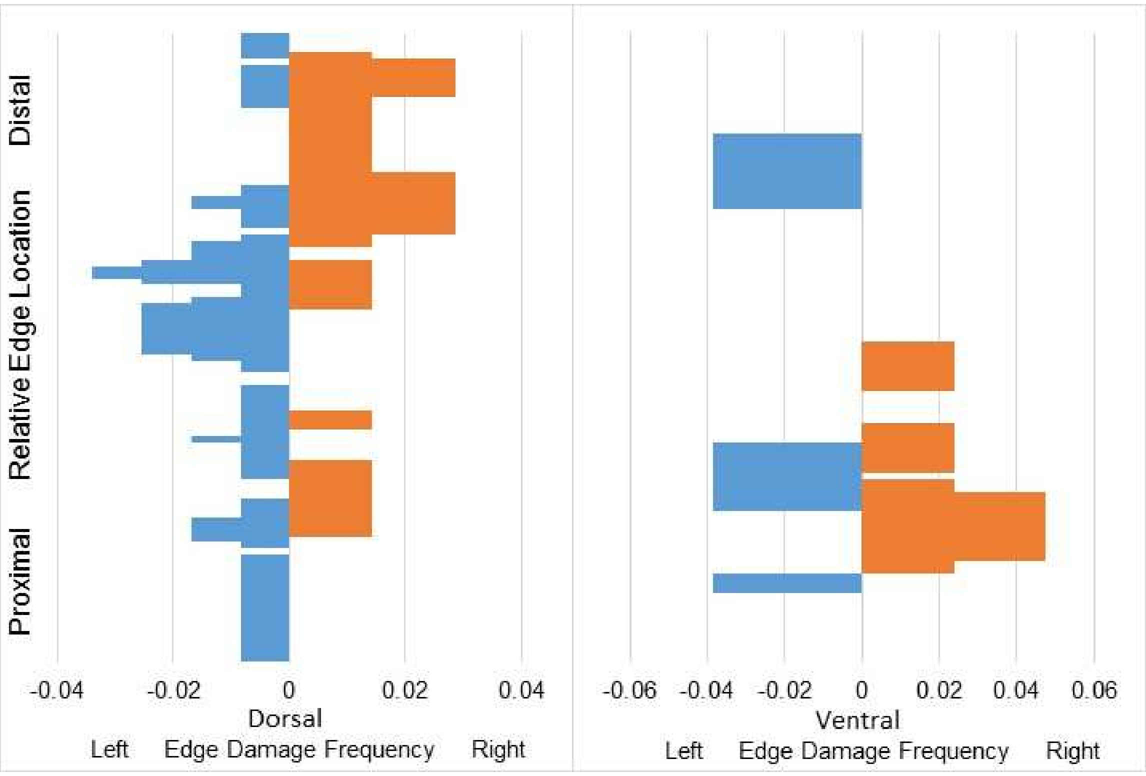


Figure 83. PP5-6 SADBS flakes edge damage distribution.

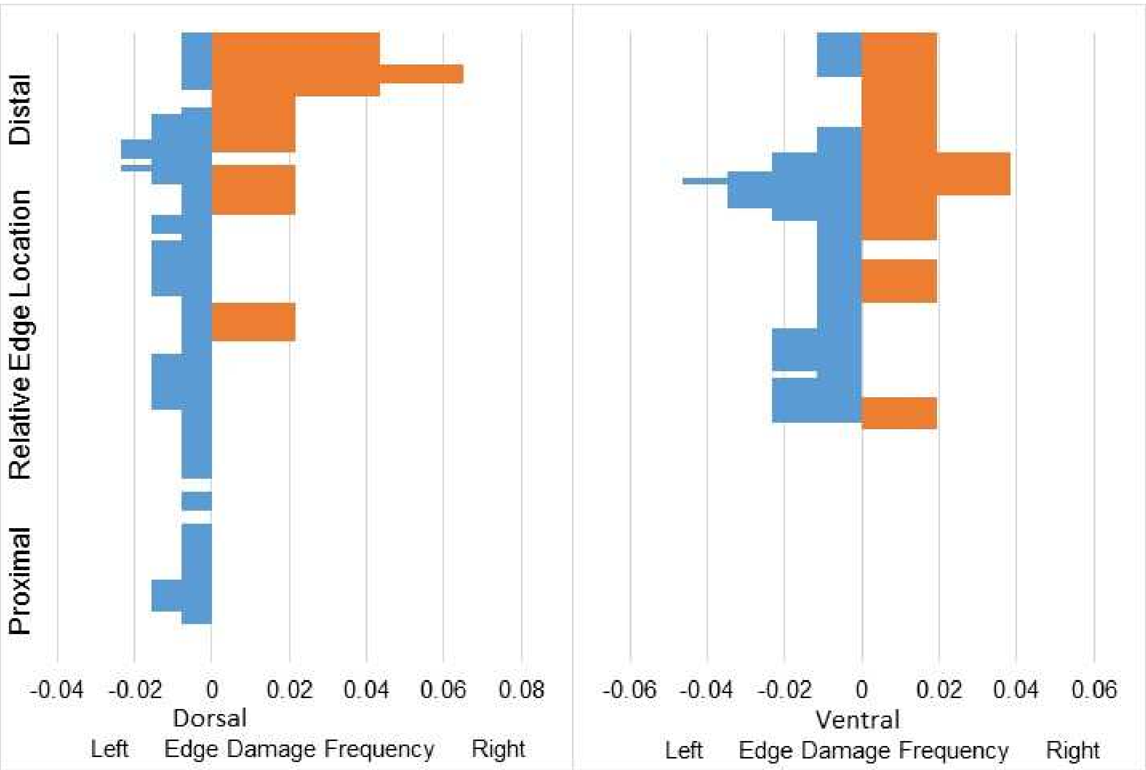


Figure 84. PP5-6 SADBS points edge damage distribution.

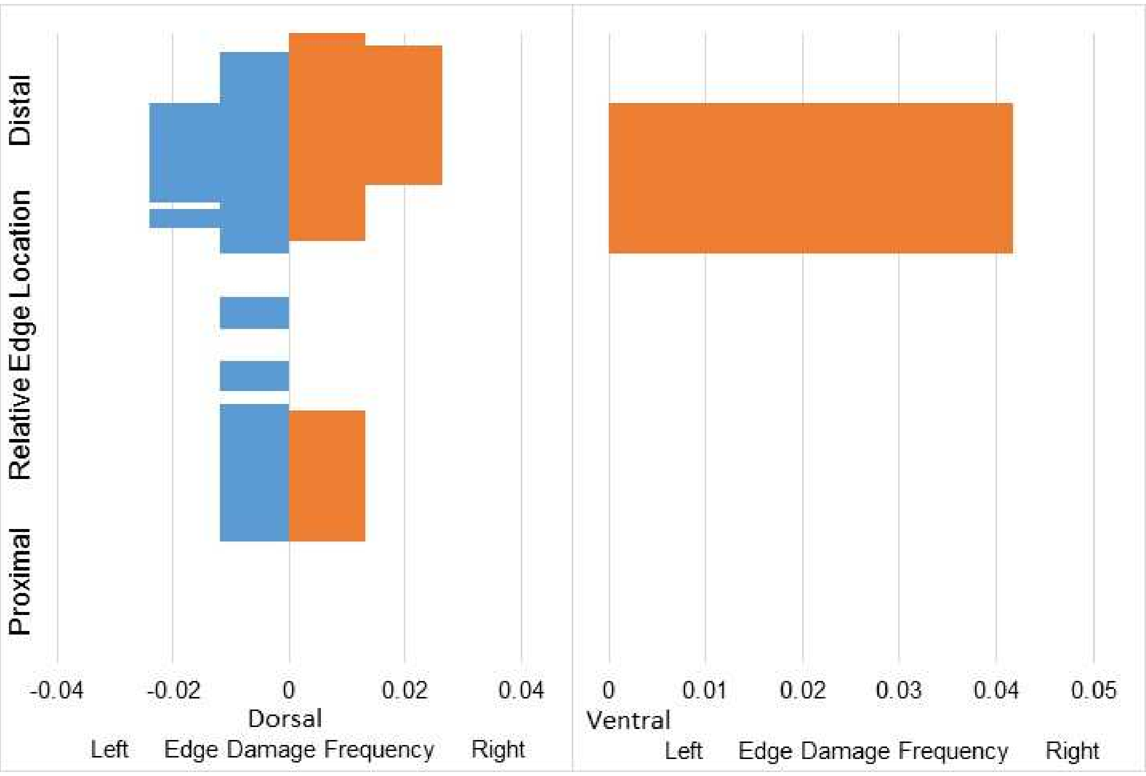


Figure 85. PP5-6 SGS blades edge damage distribution.

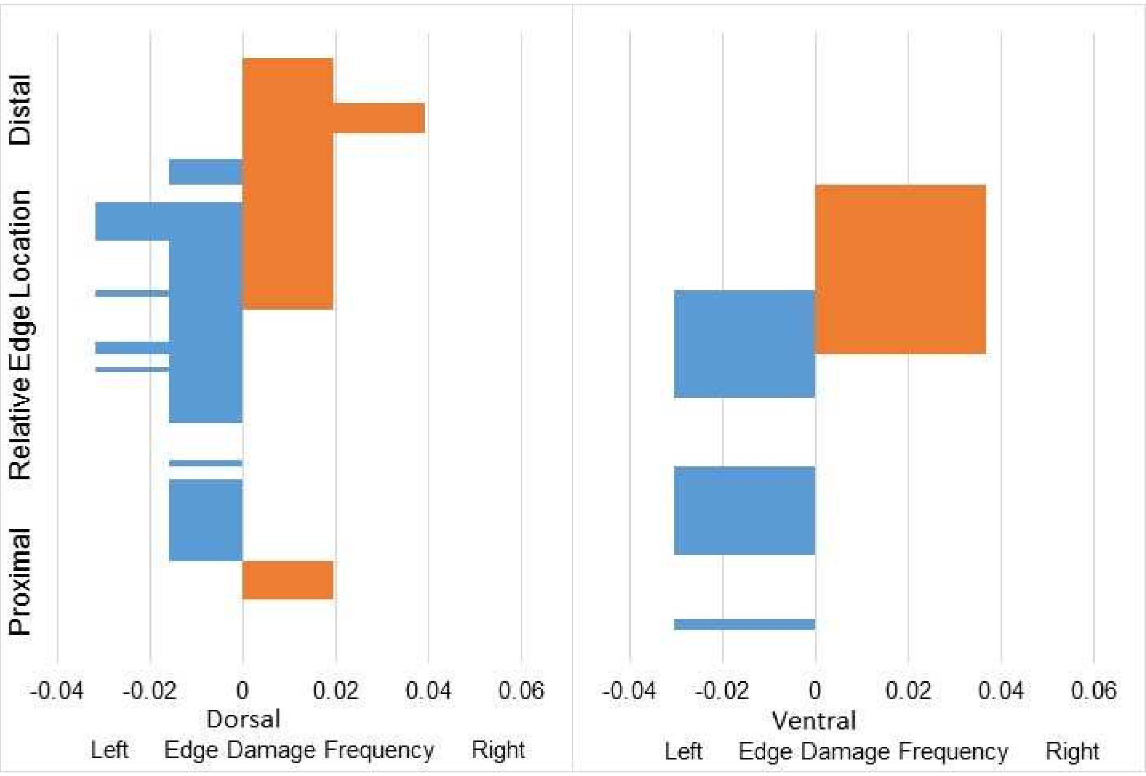


Figure 86. PP5-6 SGS flakes edge damage distribution.

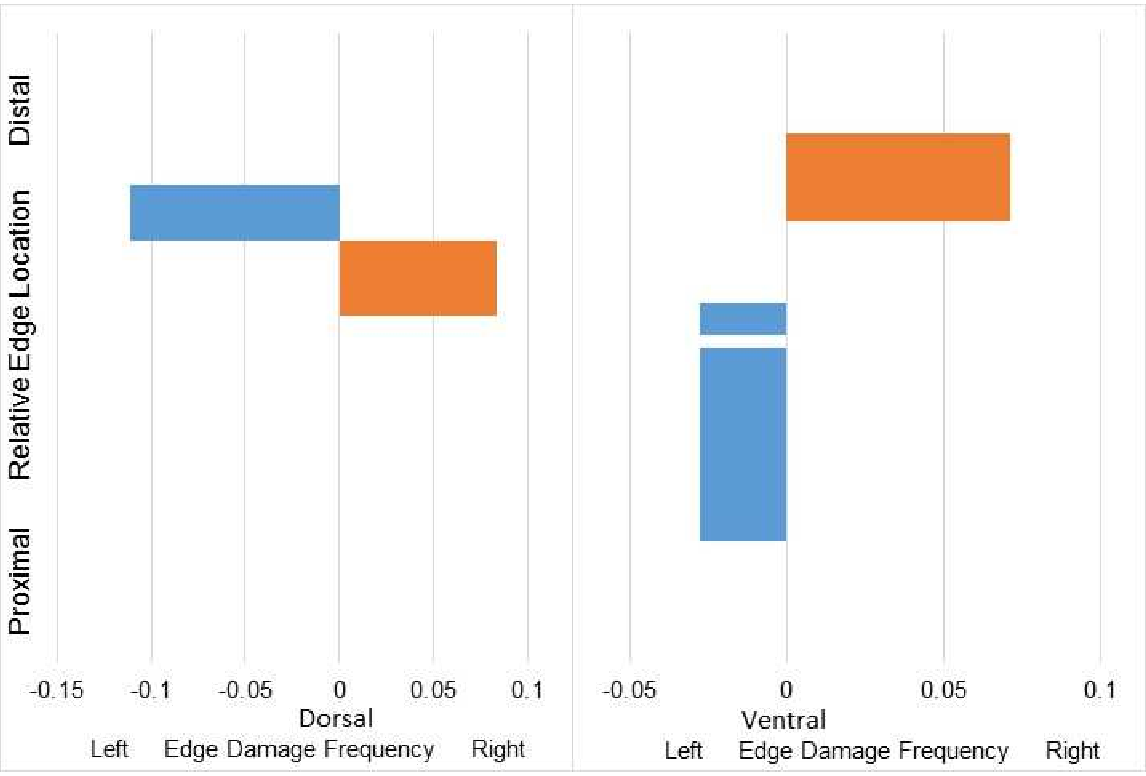


Figure 87. PP5-6 YBS blades edge damage distribution.

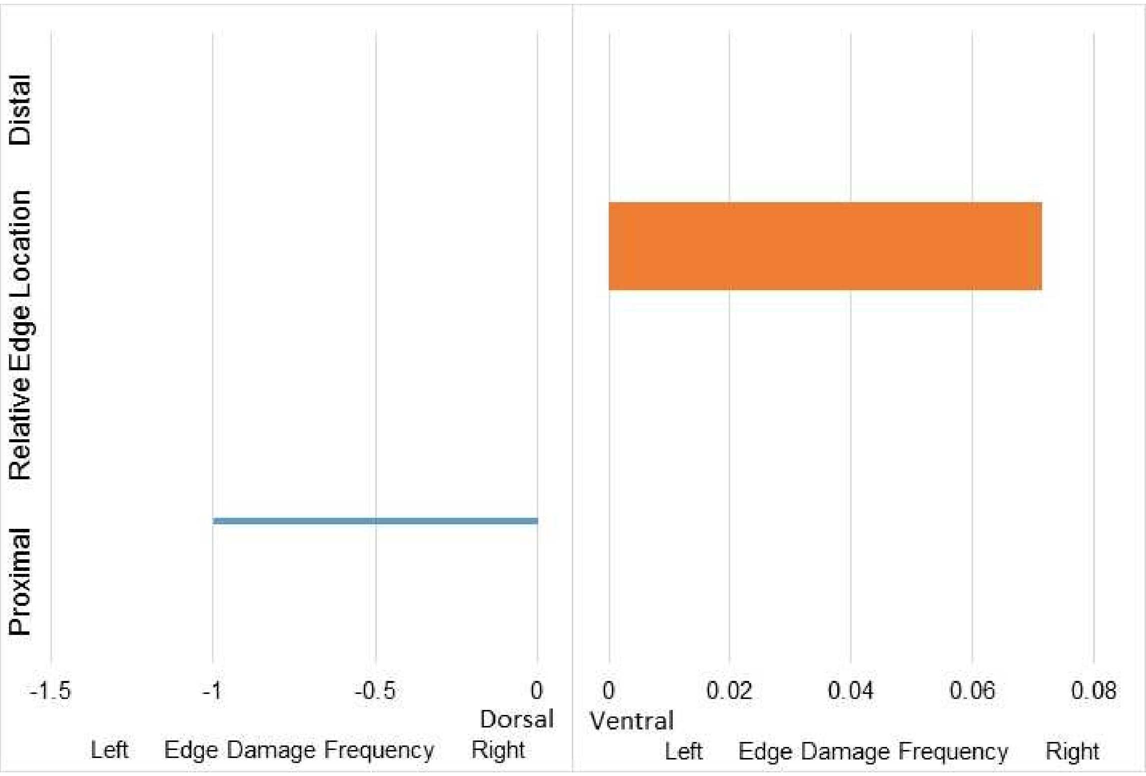


Figure 88. PP5-6 YBS flakes edge damage distribution.

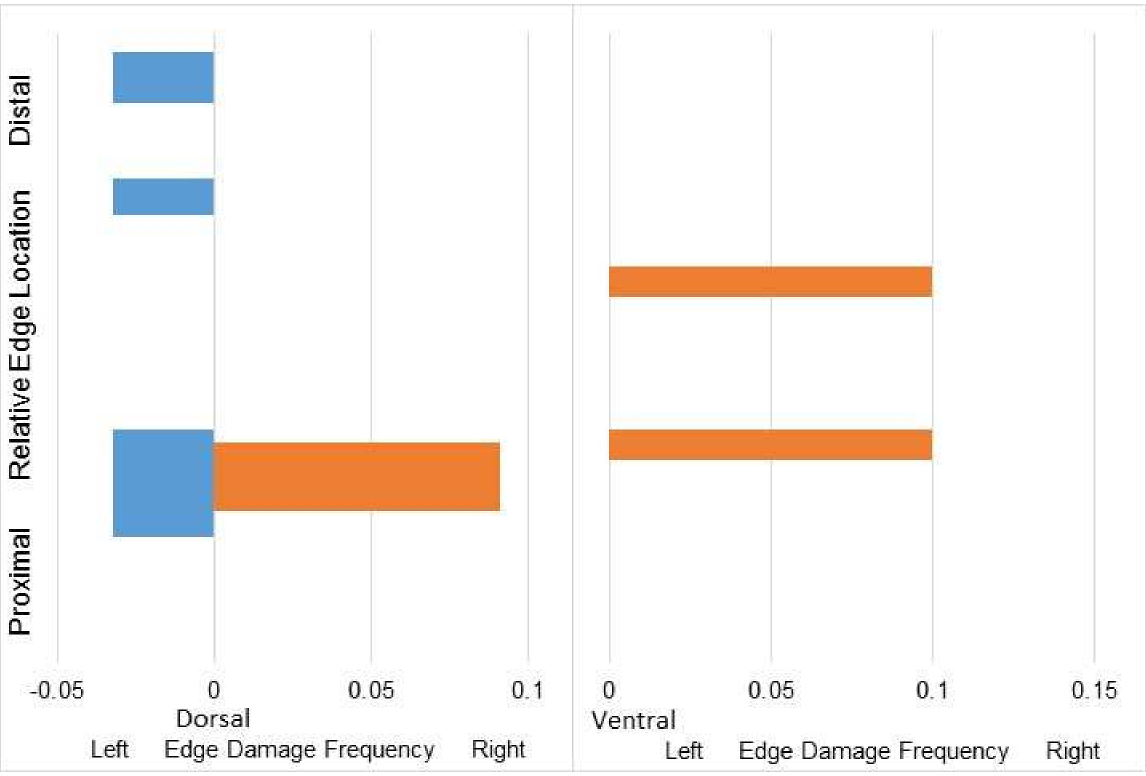


Figure 89. PP5-6 YBS points edge damage distribution.

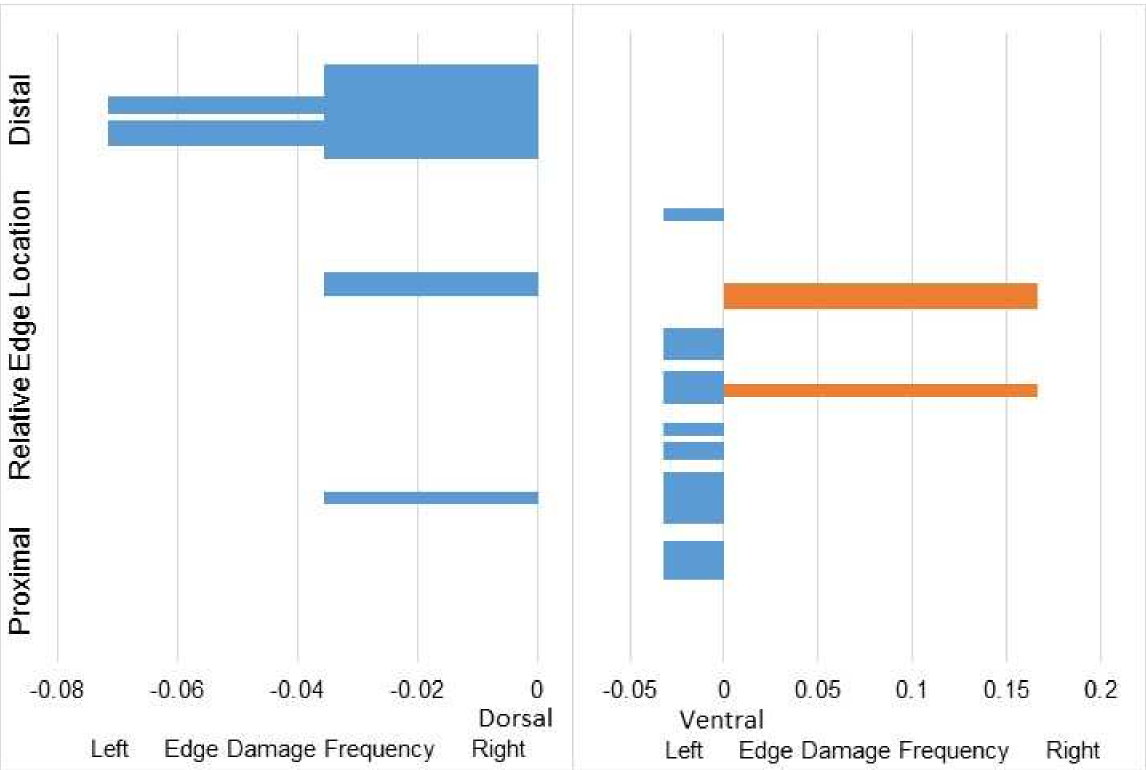


Figure 90. PP9 blades edge damage distribution.

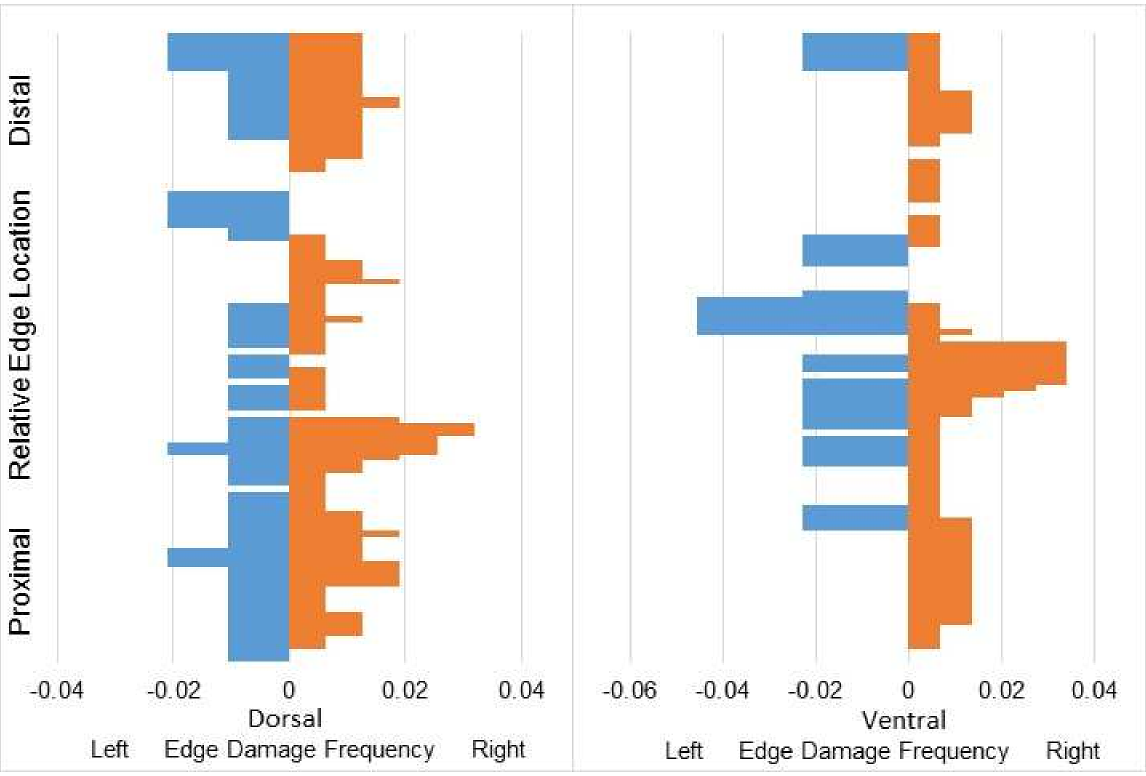


Figure 91. PP9 flakes edge damage distribution.

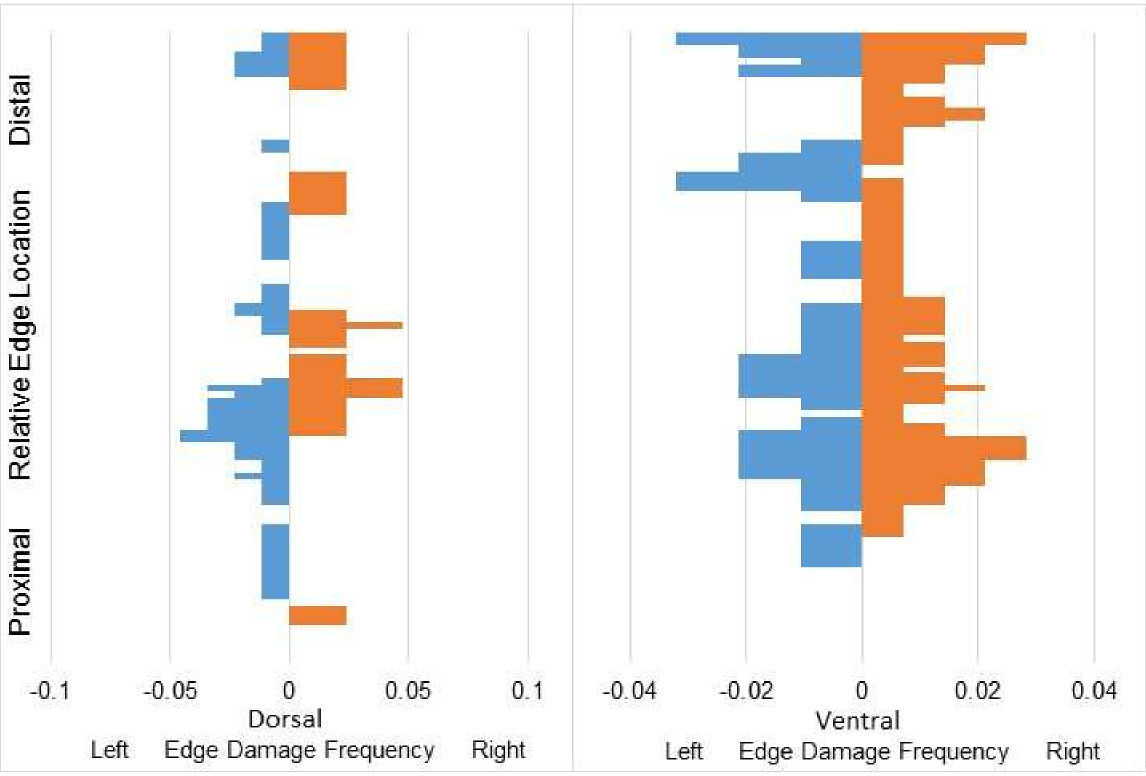


Figure 92. PP9 points edge damage distribution.

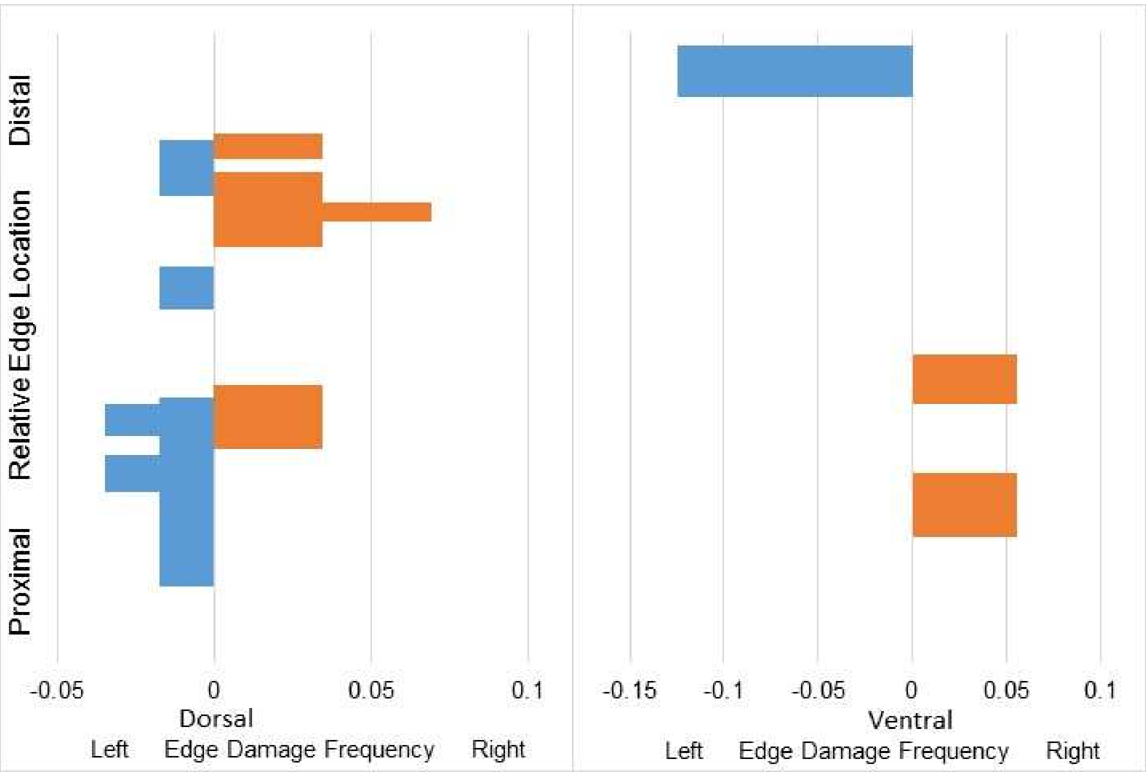


Figure 93. Vleesbaai blades edge damage distribution.

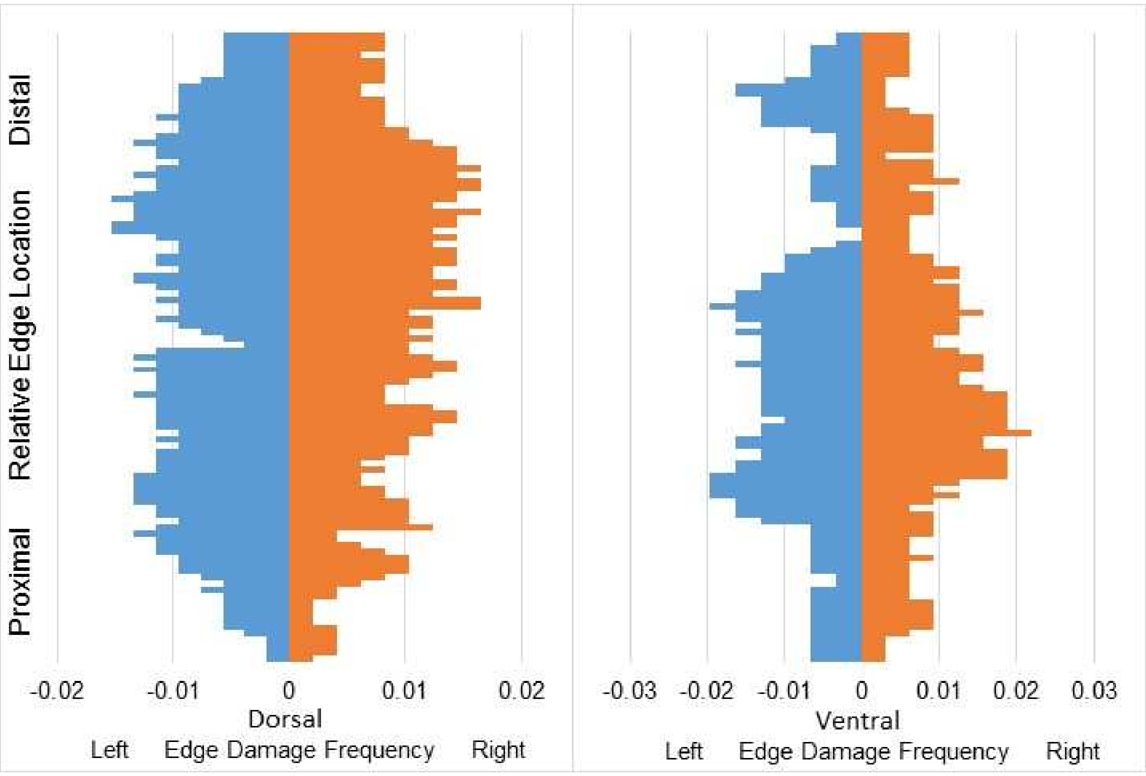


Figure 94. Vleesbaai flakes edge damage distribution.

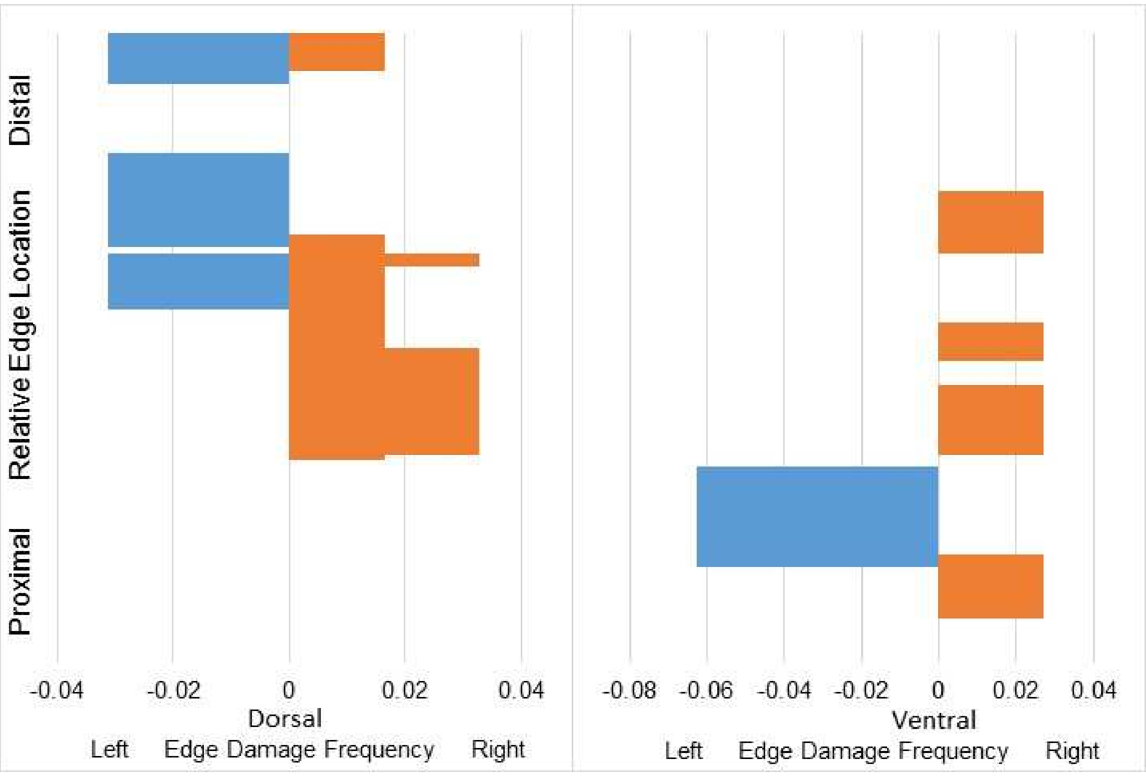
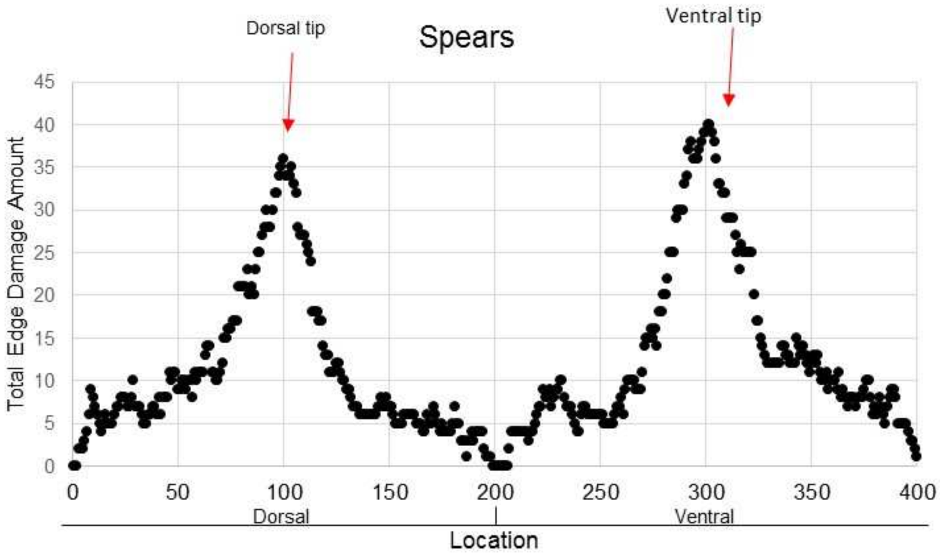


Figure 95. Vleesbaai points edge damage distribution.

APPENDIX D

EDGE DAMAGE DATASETS

In the following appendix, the raw data used in the step-wise regression models is provided. As discussed in Chapters 5 and 6, these data are ordered from 1-400 such that 1-100 is the dorsal left edge damage, 101-200 is the dorsal right edge damage, 201-300 is the ventral left edge damage, and 301-400 is the ventral right edge damage. Each value represents the total number of edge damage scarring at that relative location along tool edges. Both experimental and archaeological data are provided for the points, blades, and flakes studied in this dissertation.



D.1 Points

D.1.1 Experimental Data

Location	Spears	Butchery	Defleshing	Field Dressing	Trampling	Tumbler
1	0	1	0	1	0	2
2	0	1	0	1	0	1
3	2	2	1	1	1	2
4	2	2	1	1	1	1
5	2	2	1	1	1	1
6	3	2	1	1	0	4
7	4	2	1	1	0	4
8	6	2	1	1	1	3
9	9	2	1	1	1	3
10	8	2	1	1	1	3
11	7	2	1	1	1	3
12	6	2	1	1	1	2
13	5	2	1	1	1	3
14	4	2	1	1	2	4
15	5	1	0	1	2	3
16	6	1	0	1	3	1
17	5	1	0	1	3	0
18	5	1	0	1	3	1
19	5	1	0	1	3	1
20	6	1	0	1	3	1
21	7	0	0	0	3	0
22	7	0	0	0	2	1
23	8	1	1	0	1	2

24	8	2	2	0	1	4
25	8	3	3	0	1	4
26	7	3	3	0	1	3
27	7	3	3	0	1	2
28	8	2	2	0	1	2
29	10	2	2	0	1	1
30	7	2	2	0	2	1
31	7	1	1	0	3	1
32	7	0	0	0	3	1
33	6	0	0	0	4	1
34	5	0	0	0	5	1
35	5	0	0	0	6	2
36	6	0	0	0	5	3
37	6	0	0	0	4	1
38	7	0	0	0	4	2
39	7	1	1	0	3	2
40	6	1	1	0	3	1
41	8	1	1	0	3	0
42	6	0	0	0	4	0
43	8	0	0	0	2	1
44	8	0	0	0	2	1
45	8	0	0	0	1	2
46	11	0	0	0	3	2
47	10	0	0	0	5	2
48	11	0	0	0	5	1
49	11	0	0	0	5	0
50	9	0	0	0	5	1
51	9	0	0	0	5	2

52	10	1	1	0	5	2
53	10	1	1	0	5	1
54	9	1	1	0	3	1
55	10	1	1	0	2	3
56	10	1	1	0	1	4
57	8	1	1	0	2	4
58	11	1	1	0	2	4
59	10	2	1	1	2	3
60	11	3	1	2	2	1
61	11	4	2	2	2	1
62	11	4	2	2	2	1
63	13	4	2	2	3	2
64	14	4	2	2	3	2
65	14	4	2	2	2	2
66	11	3	1	2	2	4
67	11	4	1	3	3	6
68	10	2	0	2	3	5
69	10	3	0	3	2	3
70	11	3	0	3	2	2
71	12	3	0	3	2	1
72	15	1	0	1	3	1
73	15	1	0	1	3	2
74	16	1	0	1	3	2
75	16	0	0	0	5	2
76	17	1	0	1	3	1
77	17	2	1	1	3	1
78	17	2	1	1	3	1
79	21	2	1	1	4	3

80	21	2	1	1	6	4
81	21	1	1	0	5	4
82	21	3	0	3	5	3
83	23	4	1	3	3	3
84	20	4	1	3	4	2
85	21	4	1	3	5	3
86	20	3	1	2	5	4
87	23	3	1	2	5	4
88	25	4	2	2	5	4
89	25	3	1	2	4	4
90	27	3	1	2	6	4
91	28	3	1	2	8	3
92	30	3	1	2	9	2
93	28	3	1	2	8	3
94	28	5	1	4	8	1
95	30	5	1	4	8	2
96	32	6	2	4	9	1
97	32	6	2	4	7	1
98	34	6	3	3	6	0
99	35	8	3	5	7	0
100	36	8	3	5	7	0
101	34	8	3	5	6	2
102	34	8	3	5	6	2
103	34	6	2	4	5	2
104	35	6	2	4	4	2
105	33	6	2	4	4	2
106	32	3	0	3	3	4
107	28	4	0	4	3	5

108	27	3	0	3	3	5
109	27	4	1	3	3	5
110	27	4	1	3	3	6
111	26	5	1	4	3	6
112	25	4	1	3	3	4
113	24	3	0	3	3	5
114	18	3	0	3	3	3
115	18	4	1	3	3	3
116	18	5	1	4	3	2
117	17	4	2	2	2	2
118	17	4	2	2	2	2
119	14	4	2	2	4	1
120	13	3	2	1	3	2
121	13	2	1	1	3	4
122	11	0	0	0	2	4
123	11	1	0	1	2	3
124	11	1	0	1	1	3
125	12	1	0	1	1	3
126	12	1	0	1	1	2
127	11	2	0	2	1	1
128	10	2	0	2	2	1
129	10	2	0	2	3	2
130	9	2	0	2	3	2
131	9	1	0	1	3	2
132	8	2	0	2	4	2
133	7	2	0	2	5	2
134	7	2	0	2	5	2
135	7	2	0	2	6	2

136	6	2	0	2	6	2
137	6	3	1	2	5	3
138	6	3	1	2	4	4
139	6	3	1	2	5	5
140	6	2	1	1	5	4
141	6	2	1	1	6	4
142	6	2	1	1	8	3
143	6	1	0	1	7	2
144	6	1	0	1	8	2
145	7	1	0	1	6	2
146	8	1	0	1	5	3
147	7	1	0	1	5	3
148	7	1	0	1	4	2
149	8	1	0	1	4	5
150	7	1	0	1	3	4
151	7	1	0	1	3	3
152	6	1	0	1	3	2
153	5	1	0	1	3	1
154	5	2	0	2	3	2
155	5	2	0	2	2	2
156	5	2	0	2	1	2
157	6	1	0	1	1	3
158	6	1	0	1	3	3
159	6	1	0	1	4	3
160	6	1	0	1	4	2
161	6	1	0	1	3	3
162	6	1	0	1	3	4
163	5	0	0	0	3	4

164	5	0	0	0	3	3
165	5	1	0	1	5	4
166	4	1	0	1	5	4
167	4	0	0	0	4	4
168	6	1	1	0	5	4
169	5	1	1	0	5	2
170	5	1	1	0	5	2
171	7	1	1	0	6	2
172	6	1	1	0	6	3
173	5	1	1	0	6	2
174	4	1	1	0	5	2
175	5	1	1	0	5	3
176	4	1	1	0	5	2
177	4	1	1	0	6	1
178	4	1	1	0	6	0
179	4	0	0	0	6	0
180	5	0	0	0	5	1
181	7	0	0	0	7	2
182	5	0	0	0	5	3
183	5	2	2	0	5	2
184	3	2	2	0	5	2
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187	1	0	0	0	5	2
188	3	0	0	0	5	1
189	4	0	0	0	5	2
190	3	1	1	0	5	2
191	4	1	1	0	4	2

192	4	1	1	0	4	2
193	4	1	1	0	5	3
194	4	1	1	0	6	3
195	2	1	1	0	6	3
196	1	0	0	0	6	2
197	1	0	0	0	5	2
198	1	0	0	0	4	2
199	0	0	0	0	3	2
200	0	0	0	0	3	2
201	0	1	1	0	3	0
202	0	0	0	0	3	1
203	0	0	0	0	3	2
204	0	0	0	0	3	2
205	0	0	0	0	4	3
206	0	0	0	0	5	3
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213	4	2	0	2	7	3
214	4	2	0	2	7	2
215	4	1	0	1	7	2
216	3	1	0	1	6	2
217	4	2	1	1	5	3
218	4	2	1	1	6	2
219	5	2	1	1	6	1

220	6	1	1	0	7	1
221	7	1	1	0	8	0
222	7	1	1	0	7	0
223	9	2	1	1	6	0
224	8	3	2	1	5	0
225	8	3	2	1	4	1
226	9	3	2	1	3	1
227	7	3	2	1	3	0
228	8	3	1	2	3	1
229	9	2	0	2	3	2
230	9	2	0	2	4	3
231	10	2	0	2	3	2
232	10	2	0	2	3	3
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234	7	2	0	2	4	3
235	7	2	0	2	4	3
236	7	1	0	1	2	3
237	6	1	0	1	2	3
238	5	1	0	1	2	5
239	4	1	0	1	2	5
240	4	0	0	0	2	4
241	6	1	0	1	2	4
242	7	2	1	1	1	4
243	7	4	2	2	1	5
244	6	4	2	2	1	4
245	6	4	2	2	2	3
246	6	5	2	3	2	3
247	6	5	3	2	2	1

248	6	4	2	2	2	2
249	6	4	2	2	1	2
250	6	5	2	3	0	2
251	6	4	0	4	0	3
252	5	3	0	3	0	4
253	5	3	0	3	0	3
254	5	3	1	2	0	4
255	5	2	1	1	0	3
256	5	2	1	1	0	4
257	6	2	1	1	0	5
258	7	2	1	1	1	4
259	7	3	1	2	1	4
260	8	3	1	2	1	5
261	6	3	1	2	1	4
262	9	3	1	2	1	3
263	10	2	1	1	1	3
264	10	2	1	1	0	1
265	10	3	1	2	0	2
266	10	3	1	2	0	3
267	9	4	1	3	0	5
268	9	4	1	3	0	6
269	9	4	1	3	0	5
270	11	3	1	2	0	3
271	14	4	2	2	0	2
272	15	4	2	2	0	3
273	15	3	2	1	0	3
274	16	2	2	0	0	3
275	15	3	2	1	1	3

276	16	4	2	2	0	5
277	14	3	1	2	0	5
278	18	3	1	2	0	3
279	18	4	1	3	0	3
280	20	4	1	3	0	3
281	20	3	1	2	1	4
282	22	4	1	3	1	3
283	25	3	1	2	1	3
284	25	2	0	2	2	2
285	25	2	0	2	2	1
286	29	1	0	1	3	2
287	30	2	0	2	3	2
288	30	2	0	2	4	3
289	30	3	1	2	4	4
290	33	4	1	3	4	4
291	34	4	1	3	5	3
292	37	4	1	3	6	0
293	38	3	1	2	6	1
294	36	3	1	2	8	2
295	36	3	1	2	8	2
296	36	3	1	2	9	4
297	37	3	1	2	9	4
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299	39	3	1	2	8	3
300	39	3	1	2	8	3
301	40	5	2	3	6	2
302	40	5	2	3	6	2
303	39	5	2	3	6	2

304	38	6	3	3	6	2
305	36	6	3	3	6	2
306	33	6	3	3	6	2
307	33	6	3	3	6	2
308	32	6	3	3	6	2
309	32	5	3	2	5	3
310	29	5	3	2	5	1
311	29	6	4	2	4	1
312	29	6	4	2	5	1
313	29	6	4	2	4	1
314	27	4	3	1	3	1
315	25	1	1	0	3	1
316	23	2	2	0	3	1
317	26	1	1	0	3	1
318	25	1	1	0	3	1
319	25	1	1	0	3	2
320	25	3	2	1	3	2
321	25	3	2	1	4	3
322	25	4	2	2	5	3
323	20	3	1	2	5	4
324	17	2	1	1	5	4
325	17	2	1	1	4	2
326	15	2	1	1	3	2
327	14	0	0	0	3	3
328	13	1	0	1	2	3
329	12	1	0	1	3	1
330	12	1	0	1	3	1
331	12	1	0	1	4	1

332	12	1	0	1	4	1
333	12	1	0	1	4	0
334	12	1	0	1	4	1
335	12	0	0	0	4	1
336	14	1	0	1	2	1
337	14	1	0	1	3	1
338	13	1	0	1	3	2
339	13	2	1	1	3	1
340	12	2	2	0	2	2
341	12	2	2	0	2	1
342	12	3	3	0	2	2
343	15	4	4	0	1	3
344	14	5	5	0	2	3
345	13	4	4	0	3	3
346	14	3	3	0	5	3
347	13	1	1	0	5	3
348	12	1	1	0	5	2
349	11	1	1	0	5	2
350	12	2	1	1	5	2
351	13	1	0	1	4	1
352	12	1	0	1	5	1
353	13	1	0	1	5	1
354	11	0	0	0	5	1
355	10	0	0	0	4	2
356	10	0	0	0	3	3
357	11	0	0	0	2	2
358	9	0	0	0	2	4
359	10	0	0	0	4	4

360	10	0	0	0	4	4
361	10	0	0	0	4	3
362	9	0	0	0	3	3
363	11	0	0	0	2	4
364	8	0	0	0	2	3
365	9	0	0	0	2	3
366	8	0	0	0	2	2
367	7	0	0	0	3	1
368	8	0	0	0	4	2
369	8	0	0	0	4	3
370	8	0	0	0	5	3
371	7	1	0	1	4	3
372	8	1	0	1	5	3
373	8	1	0	1	4	2
374	8	1	0	1	3	1
375	9	0	0	0	3	1
376	10	0	0	0	3	0
377	10	0	0	0	3	0
378	8	0	0	0	3	0
379	6	0	0	0	4	0
380	7	0	0	0	4	0
381	6	0	0	0	3	0
382	8	1	0	1	3	1
383	7	2	1	1	3	1
384	6	2	1	1	4	0
385	5	1	1	0	4	1
386	7	1	1	0	4	3
387	8	1	1	0	4	4

388	9	1	1	0	3	3
389	9	1	1	0	3	2
390	8	1	1	0	4	2
391	5	1	1	0	3	2
392	5	1	1	0	3	2
393	5	1	1	0	3	2
394	5	0	0	0	2	2
395	5	0	0	0	2	1
396	4	0	0	0	2	0
397	3	0	0	0	1	0
398	3	0	0	0	2	0
399	2	0	0	0	1	0
400	1	0	0	0	1	0

D.1.2 Archaeological Data

Location	**PP9**	**OB**	**NB-6**	**NB-10**	**VB**	**ALBS**	**DBCS**	**LBSR**	**OBS2**	**RBSR**	**SADBS**	**YBS**	**PP13B-MIS6**	**PP13B-MIS5**	**DK1 6-9**	**DK1 10-16**
1	0	1	0	0	0	0	1	1	0	0	0	0	0	1	0	0
2	0	2	0	0	0	1	1	1	0	0	0	0	0	2	0	0
3	0	2	0	0	0	1	1	3	0	0	0	0	0	2	0	0
4	0	2	0	0	0	1	1	4	0	0	0	0	0	2	0	0
5	0	3	0	0	0	1	1	5	0	0	0	0	1	3	0	0
6	0	4	0	0	0	1	1	5	0	0	0	0	1	4	0	0
7	0	4	0	0	0	1	1	4	0	0	1	0	1	5	0	0
8	0	5	0	0	0	1	1	4	0	0	1	0	0	5	1	0
9	0	5	0	0	0	1	1	4	0	0	2	0	1	6	1	0

10	0	6	0	0	0	1	1	5	0	0	2	0	1	7	1	1
11	1	4	0	0	0	1	1	4	0	0	2	0	0	7	1	1
12	1	4	0	0	0	1	2	4	0	0	2	0	1	6	2	1
13	1	4	0	0	0	1	2	4	0	0	2	0	2	6	2	3
14	1	3	0	0	0	1	2	4	0	0	1	0	3	6	2	3
15	1	3	0	0	0	1	2	5	0	0	1	0	3	7	2	2
16	1	4	0	1	0	1	2	6	0	0	1	0	2	8	2	2
17	1	4	0	3	0	1	2	6	0	0	1	0	2	10	1	2
18	1	4	0	2	0	1	2	5	0	0	1	0	2	11	0	3
19	1	4	2	2	0	2	2	5	0	0	1	0	2	13	1	2
20	1	4	2	2	0	2	1	7	0	0	1	0	2	12	1	2
21	1	3	2	2	0	1	2	6	0	0	1	1	2	13	1	2
22	1	3	1	2	0	1	2	8	0	0	1	1	2	14	1	2
23	0	2	1	2	0	1	2	7	0	0	0	1	2	12	0	3
24	0	4	0	1	0	1	2	8	0	0	0	1	3	10	0	4
25	0	5	0	0	0	1	2	6	0	0	1	1	4	11	0	4
26	1	5	0	1	0	1	2	3	0	0	1	1	6	13	0	3
27	1	5	0	2	0	1	2	5	0	0	1	1	5	12	0	2
28	1	3	1	2	0	1	2	6	0	0	0	1	6	12	0	4
29	1	3	1	2	0	1	2	5	0	0	0	1	6	10	0	4
30	2	5	1	2	0	1	2	5	0	0	1	1	7	13	0	4
31	1	5	2	2	0	1	2	6	0	0	1	1	6	14	1	4
32	1	5	2	2	0	1	2	6	0	0	1	1	7	14	1	4
33	2	4	2	2	0	1	2	5	0	0	1	1	7	13	2	4
34	2	3	2	2	0	0	2	7	0	0	1	1	7	11	2	2
35	2	1	2	2	0	0	2	6	0	0	1	1	6	12	2	2
36	4	0	2	2	0	0	1	6	0	0	1	1	5	10	2	1
37	4	0	1	2	0	0	1	7	0	0	1	1	6	13	1	2

38	3	0	1	3	0	0	1	7	0	0	1	0	6	14	1	2
39	3	0	1	3	0	0	1	7	0	0	1	0	6	12	1	3
40	3	0	2	3	0	0	0	8	0	0	1	0	4	14	1	2
41	3	1	2	4	0	0	0	7	0	0	2	0	4	14	1	2
42	3	3	2	4	0	0	0	6	0	0	2	0	3	14	1	2
43	2	4	2	4	0	0	0	6	0	0	2	0	4	14	0	2
44	3	4	2	3	0	0	1	6	0	0	2	0	4	15	0	2
45	1	4	1	3	0	0	1	6	0	0	2	0	6	14	0	1
46	0	2	1	4	0	0	1	4	0	0	2	0	7	13	0	1
47	0	2	0	5	0	0	1	4	0	0	2	0	6	14	0	2
48	0	3	0	4	0	0	1	4	0	0	2	0	4	13	1	3
49	0	4	1	4	0	0	1	2	0	0	2	0	4	13	1	6
50	0	5	1	3	0	0	2	1	0	0	1	0	5	11	1	6
51	0	4	2	4	0	0	2	2	0	0	1	0	5	12	1	5
52	0	2	2	3	0	0	2	1	0	0	1	0	5	11	1	4
53	1	2	2	3	0	0	1	1	0	0	1	0	5	13	1	3
54	1	3	2	3	0	0	2	4	0	0	1	0	4	14	2	3
55	1	2	1	3	0	0	1	4	0	0	1	0	4	16	2	4
56	2	3	0	2	0	0	1	4	0	0	1	0	3	20	2	3
57	2	4	0	4	1	0	1	4	0	0	1	0	3	19	2	3
58	1	3	0	5	1	0	1	3	0	0	1	0	5	14	2	4
59	1	4	0	7	1	0	1	4	0	0	2	0	4	13	2	4
60	1	4	0	7	1	0	1	3	0	0	2	0	4	13	2	4
61	0	4	0	6	1	0	1	3	0	1	2	0	5	16	1	2
62	0	3	0	5	1	0	2	3	0	1	2	0	5	17	1	2
63	0	4	0	3	1	0	1	4	0	0	2	0	6	16	0	1
64	0	4	0	1	1	0	1	4	0	0	2	0	6	15	0	2
65	1	3	0	2	1	0	1	4	0	0	2	0	3	19	0	2

66	1	2	0	2	0	0	1	5	0	1	2	0	4	16	0	2
67	1	2	0	2	1	1	1	5	0	1	2	0	3	17	0	1
68	1	2	0	2	1	1	1	5	0	1	1	0	2	16	0	2
69	1	2	0	5	1	1	1	5	0	1	2	0	3	15	0	2
70	1	2	0	6	1	1	1	5	0	1	2	0	2	15	1	1
71	1	2	0	6	1	1	1	5	0	1	2	0	1	19	1	1
72	1	1	0	6	1	1	0	5	0	1	1	1	2	21	1	1
73	1	1	0	8	1	1	0	3	0	0	1	1	1	20	2	1
74	0	1	0	5	1	1	0	6	0	0	1	1	1	18	2	1
75	0	1	0	5	1	1	0	5	0	0	1	1	2	16	2	0
76	0	2	0	5	1	1	0	6	0	0	1	1	1	15	2	1
77	0	3	0	4	1	1	0	5	0	0	2	1	2	17	2	2
78	0	3	0	4	1	1	0	7	0	0	2	0	2	14	1	2
79	0	3	0	1	1	1	0	7	0	0	3	0	1	11	1	2
80	0	4	0	1	1	1	0	7	1	1	2	0	2	10	1	1
81	0	5	0	1	1	1	0	7	1	1	3	0	2	14	1	1
82	1	5	0	2	0	1	0	7	1	1	3	0	1	15	2	1
83	1	4	0	3	0	1	0	7	1	0	3	0	0	16	2	1
84	0	4	0	3	0	1	0	6	0	0	2	0	2	17	2	1
85	0	5	0	3	0	1	0	4	0	0	2	0	2	19	2	1
86	0	4	0	2	0	1	0	4	0	0	2	0	2	17	2	1
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318	1	1	0	5	0	0	1	2	0	1	1	0	1	3	1	3
319	1	1	0	4	0	1	1	4	0	1	1	0	1	2	1	3
320	1	1	1	4	0	1	1	6	0	1	2	0	1	1	1	3
321	1	1	1	4	0	1	1	6	0	0	2	0	2	3	1	3
322	0	2	2	3	0	1	1	6	0	0	2	0	2	3	1	2
323	0	2	2	3	0	1	1	5	0	0	2	0	2	4	1	2
324	1	2	2	3	0	1	0	6	0	0	2	0	2	4	1	1
325	1	2	2	3	0	1	0	5	0	0	2	0	2	6	1	1
326	1	2	2	2	1	1	0	6	0	0	2	0	2	5	1	2
327	1	3	1	2	1	1	0	6	0	0	1	0	2	7	1	2
328	1	3	0	3	1	1	0	5	0	0	1	0	0	5	1	2
329	1	3	1	3	1	1	0	4	0	0	1	0	0	6	0	2
330	1	3	2	4	1	0	0	5	0	0	1	0	0	7	0	2
331	1	3	1	4	1	0	0	4	0	0	1	0	1	7	0	1
332	1	4	2	3	1	0	0	5	0	0	1	0	1	9	0	1
333	1	4	2	2	1	0	0	4	0	0	1	0	1	8	0	3
334	1	4	3	2	1	0	0	3	0	0	0	0	0	9	0	3
335	1	4	3	2	1	0	0	5	0	0	0	0	0	7	0	3
336	1	4	2	1	0	0	0	4	0	0	0	0	0	6	0	3
337	1	4	3	1	0	0	1	4	0	0	1	0	0	7	0	2
338	1	4	3	0	0	0	1	4	0	0	1	1	2	8	0	1
339	1	4	3	1	0	0	1	4	0	0	1	1	2	9	0	1
340	1	4	2	2	0	0	1	3	0	0	1	1	2	8	1	1
341	1	4	2	2	0	0	1	4	0	0	1	1	1	7	1	1
342	1	3	2	2	0	0	1	4	0	0	1	1	1	8	1	0
343	2	2	2	2	0	0	0	4	0	0	1	0	1	7	1	0
344	2	1	2	2	0	0	0	4	0	0	0	0	1	5	1	0
345	2	2	2	0	0	0	0	4	0	0	0	0	1	9	1	1

346	2	3	1	0	0	0	0	4	0	0	0	0	3	11	1	2
347	2	3	2	0	1	0	0	5	0	0	0	0	4	12	1	2
348	2	3	2	1	1	0	0	5	0	0	0	0	3	14	1	2
349	1	3	2	1	1	0	0	7	0	0	0	0	3	14	1	2
350	2	3	2	2	1	0	0	7	0	0	0	0	4	12	1	2
351	2	2	1	4	1	0	0	7	0	0	0	0	3	10	1	2
352	2	2	1	4	1	0	0	9	0	0	0	0	1	10	0	2
353	2	2	1	3	0	0	0	7	0	0	0	0	1	13	0	2
354	1	1	1	3	0	0	0	6	0	0	0	0	0	9	0	1
355	2	1	1	3	0	0	0	6	0	0	0	0	0	8	0	3
356	2	1	1	4	0	0	0	5	0	0	0	0	0	8	0	5
357	3	2	1	4	1	0	0	8	0	0	0	0	0	8	0	4
358	2	3	1	3	1	0	0	8	0	0	0	0	0	9	0	3
359	2	3	1	2	1	0	0	8	0	0	1	0	0	10	1	4
360	1	3	1	3	1	0	0	7	0	0	1	0	0	12	1	4
361	1	2	1	3	1	0	0	8	0	0	1	0	1	10	1	3
362	1	2	0	3	1	0	0	7	0	0	1	0	1	9	1	3
363	2	2	0	3	1	0	0	5	0	0	1	0	1	9	1	1
364	2	2	0	2	1	0	1	4	0	0	0	1	1	8	2	0
365	4	1	1	2	1	0	1	4	0	1	0	1	0	10	2	0
366	4	1	1	2	1	0	1	4	0	1	0	1	0	8	2	0
367	4	2	1	3	1	0	1	5	0	1	0	1	1	5	1	0
368	4	2	0	3	0	0	1	4	0	0	0	1	1	4	1	0
369	3	2	0	4	0	0	1	4	0	1	0	0	1	3	1	0
370	3	2	0	4	0	0	1	4	0	1	0	0	0	5	1	0
371	3	3	0	4	0	0	1	4	0	1	0	0	1	4	1	0
372	3	3	1	4	0	0	1	4	0	1	0	0	0	4	1	0
373	2	3	1	3	0	0	1	4	0	0	0	0	1	6	1	0

374	2	4	1	3	0	0	1	4	0	0	0	0	1	7	0	0
375	2	4	2	4	0	0	1	4	0	0	0	0	1	7	0	1
376	1	4	2	4	0	0	1	4	0	0	0	0	1	6	0	1
377	1	4	1	5	0	0	1	3	0	0	0	0	1	5	0	1
378	1	4	2	5	0	0	1	2	0	0	0	0	0	6	0	0
379	1	4	2	4	0	0	1	2	0	0	0	0	0	8	0	0
380	1	4	2	4	0	0	1	2	0	0	0	0	0	5	0	0
381	0	4	2	2	0	0	1	2	0	0	0	0	1	4	0	0
382	0	4	0	3	0	0	1	2	0	0	0	0	2	6	0	0
383	0	2	1	3	0	0	1	2	0	0	0	0	2	8	0	0
384	0	2	1	2	1	0	1	2	0	0	0	0	2	7	0	0
385	0	1	1	1	1	0	1	1	0	0	0	0	2	7	0	0
386	0	2	0	1	1	0	1	2	0	0	0	0	2	7	0	0
387	0	2	0	1	1	0	1	0	0	0	0	0	1	3	0	0
388	0	2	0	1	1	0	1	0	0	0	0	0	1	4	0	0
389	0	2	0	1	1	0	1	0	0	0	0	0	1	3	0	0
390	0	2	0	1	1	0	1	0	0	0	0	0	0	3	0	0
391	0	2	0	1	1	0	1	0	0	0	0	0	0	3	0	0
392	0	2	0	0	1	0	1	1	0	0	0	0	0	3	0	0
393	0	2	0	0	1	0	1	1	0	0	0	0	0	2	0	0
394	0	1	0	0	0	0	1	1	0	0	0	0	0	3	0	0
395	0	1	0	0	0	0	1	0	0	0	0	0	0	2	0	0
396	0	1	0	0	0	0	1	0	0	0	0	0	0	2	0	0
397	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0
398	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
399	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
400	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0

D.2 Blades

D.2.1 Experimental Data

Location	**Butchery-Deflesh**	**Butchery-Field**	**Trampling**	**Tumbler**
1	0	2	2	4
2	0	2	2	6
3	1	1	3	7
4	1	2	4	7
5	1	2	3	7
6	1	1	3	7
7	1	1	2	9
8	1	1	3	9
9	1	1	4	8
10	1	1	4	7
11	1	1	3	7
12	1	1	2	8
13	1	1	0	8
14	1	1	2	5
15	0	1	2	6
16	0	1	3	4
17	0	1	3	3
18	0	1	4	1
19	0	1	5	2
20	0	1	4	2

21	0	0	4	4
22	0	0	2	4
23	1	0	2	5
24	2	0	3	4
25	3	0	2	5
26	3	0	2	6
27	3	0	3	5
28	2	0	4	4
29	2	0	4	5
30	2	0	4	5
31	1	0	4	3
32	0	0	4	3
33	0	0	5	3
34	0	0	6	2
35	0	0	4	1
36	0	0	3	0
37	0	1	3	2
38	0	1	4	4
39	1	0	4	2
40	1	0	4	1
41	1	0	4	1
42	0	0	4	3
43	0	0	3	4
44	0	0	3	4
45	0	0	3	1
46	0	0	3	2
47	0	0	3	2
48	0	0	2	2

49	0	0	3	3
50	0	0	3	4
51	0	0	3	6
52	1	0	5	6
53	1	0	5	5
54	1	0	4	6
55	1	0	3	8
56	1	1	4	8
57	1	1	6	7
58	1	1	5	4
59	1	1	5	5
60	1	2	7	9
61	2	2	5	8
62	2	2	6	8
63	2	2	6	7
64	2	2	6	7
65	2	2	6	5
66	1	2	4	6
67	1	3	5	4
68	0	2	4	5
69	0	3	6	5
70	0	3	7	6
71	0	3	8	7
72	0	2	7	8
73	0	2	7	8
74	0	1	5	6
75	0	0	2	7
76	0	1	2	6

77	1	1	2	5
78	1	2	3	5
79	1	2	4	4
80	1	2	4	5
81	1	1	3	3
82	0	3	2	3
83	1	3	2	5
84	1	4	4	4
85	1	4	4	3
86	1	3	5	5
87	1	2	7	7
88	2	4	8	7
89	2	4	6	7
90	2	5	7	7
91	1	5	6	8
92	1	4	7	8
93	1	4	8	8
94	1	6	8	8
95	1	6	7	6
96	2	7	7	5
97	2	7	7	6
98	3	5	8	8
99	3	7	7	7
100	3	7	7	6
101	3	7	7	6
102	3	7	7	5
103	2	6	9	7
104	2	6	9	7

105	2	6	8	7
106	0	5	10	4
107	1	7	8	4
108	1	6	8	6
109	2	6	9	7
110	2	6	8	7
111	1	6	8	7
112	1	5	7	7
113	0	5	7	7
114	0	5	7	5
115	1	5	8	7
116	1	6	8	7
117	2	3	7	6
118	2	3	7	4
119	2	3	7	6
120	2	3	9	6
121	1	3	9	8
122	0	2	12	7
123	0	3	11	6
124	0	3	7	3
125	0	3	7	4
126	0	3	8	4
127	0	4	7	6
128	0	4	7	9
129	0	3	6	8
130	0	5	5	7
131	0	4	2	8
132	0	4	2	10

133	0	3	2	9
134	0	3	4	9
135	0	3	4	7
136	0	3	6	7
137	2	3	6	7
138	2	3	5	5
139	2	3	4	6
140	2	2	5	4
141	1	2	5	9
142	1	2	3	8
143	0	3	3	10
144	0	3	3	8
145	0	3	3	6
146	0	4	4	4
147	0	3	3	3
148	0	2	3	5
149	0	2	3	5
150	0	2	2	2
151	0	2	3	3
152	0	2	2	4
153	0	2	3	4
154	0	2	4	3
155	0	4	3	2
156	0	4	3	3
157	0	2	7	7
158	0	1	5	8
159	0	1	5	6
160	0	1	5	6

161	0	1	4	7
162	0	1	2	8
163	0	0	3	6
164	0	0	4	6
165	0	1	5	4
166	0	1	5	4
167	0	0	8	5
168	1	0	8	4
169	1	0	10	6
170	1	0	8	5
171	1	0	9	5
172	1	0	7	6
173	1	0	5	9
174	1	0	6	10
175	1	0	6	6
176	1	0	5	5
177	1	0	5	6
178	1	0	4	8
179	0	0	4	9
180	1	0	4	9
181	1	0	5	7
182	0	0	6	4
183	2	0	7	4
184	2	0	7	5
185	2	1	6	4
186	2	1	6	6
187	0	1	7	8
188	0	1	8	8

189	0	1	8	7
190	1	0	5	5
191	1	0	5	4
192	1	0	5	4
193	1	0	4	3
194	1	0	5	6
195	1	0	5	6
196	0	0	6	4
197	0	0	7	2
198	0	0	8	1
199	0	0	8	0
200	0	0	8	0
201	1	0	2	3
202	0	0	2	3
203	0	0	3	3
204	0	0	4	3
205	0	1	4	3
206	0	1	4	3
207	0	1	2	2
208	0	0	2	3
209	0	0	2	4
210	0	1	2	4
211	0	1	2	4
212	0	1	3	4
213	0	2	3	3
214	0	2	2	3
215	0	1	1	5
216	0	1	2	8

217	1	1	3	7
218	1	1	3	5
219	1	1	4	3
220	1	0	5	2
221	1	0	4	1
222	1	0	5	2
223	1	1	3	2
224	2	1	3	5
225	2	1	4	5
226	2	1	5	3
227	2	1	5	2
228	1	2	5	2
229	0	2	5	7
230	0	2	5	7
231	0	2	5	8
232	0	2	5	6
233	0	2	3	9
234	0	2	2	9
235	0	2	2	12
236	0	1	2	10
237	0	1	3	7
238	0	2	3	7
239	0	1	3	8
240	0	0	1	8
241	0	1	2	6
242	1	2	2	5
243	2	3	3	3
244	2	3	2	4

245	2	3	2	6
246	2	4	2	6
247	3	4	3	8
248	2	4	2	8
249	2	3	1	5
250	2	5	1	3
251	0	6	1	3
252	0	5	1	4
253	0	5	1	3
254	1	4	2	4
255	2	2	2	4
256	2	3	2	6
257	1	4	3	6
258	1	4	2	7
259	1	4	2	5
260	1	4	2	7
261	1	4	4	6
262	1	4	4	5
263	1	3	4	4
264	1	3	6	7
265	1	3	6	9
266	1	4	3	8
267	1	5	5	7
268	1	5	5	8
269	1	4	5	9
270	1	4	5	6
271	2	4	5	5
272	2	3	4	5

273	3	2	4	5
274	3	1	4	5
275	3	3	4	6
276	3	3	5	4
277	2	3	5	6
278	1	3	4	6
279	1	4	4	3
280	1	4	5	3
281	1	2	5	3
282	1	3	5	8
283	1	3	5	8
284	0	3	5	7
285	0	3	4	6
286	0	2	2	6
287	0	3	2	3
288	0	3	2	3
289	1	3	2	4
290	1	4	4	4
291	1	4	4	5
292	1	4	4	5
293	1	3	4	5
294	1	3	4	5
295	1	3	4	6
296	1	3	4	7
297	1	3	4	6
298	1	3	4	6
299	1	3	5	6
300	1	3	5	5

301	2	4	7	5
302	2	4	7	5
303	2	4	7	6
304	3	4	7	7
305	3	4	8	7
306	3	4	8	5
307	3	4	6	4
308	3	4	6	5
309	3	3	5	6
310	3	3	5	4
311	4	3	5	4
312	4	3	5	5
313	4	3	4	6
314	3	1	3	4
315	1	0	3	4
316	2	0	3	6
317	1	0	4	5
318	1	0	4	5
319	1	0	3	6
320	2	1	4	7
321	2	1	3	8
322	2	2	3	8
323	1	2	4	6
324	1	1	3	7
325	1	1	3	6
326	1	1	4	4
327	0	0	4	3
328	0	1	4	3

329	0	1	4	3
330	0	1	4	5
331	0	1	5	7
332	0	1	6	7
333	0	1	6	6
334	0	1	5	6
335	0	0	4	3
336	0	1	3	3
337	0	1	3	3
338	0	1	3	4
339	1	1	4	4
340	2	0	4	4
341	2	0	5	5
342	3	0	5	6
343	4	0	6	6
344	5	0	5	6
345	4	0	5	4
346	3	0	4	5
347	1	0	4	6
348	1	0	5	6
349	1	0	4	6
350	1	1	3	7
351	0	1	4	6
352	0	1	4	7
353	0	1	3	8
354	0	0	5	8
355	0	0	7	9
356	0	0	9	9

357	0	0	7	8
358	0	0	7	9
359	0	0	5	9
360	0	0	6	7
361	0	0	5	8
362	0	0	5	8
363	0	0	6	8
364	0	0	4	4
365	0	0	4	4
366	0	0	3	5
367	0	0	3	5
368	0	1	3	6
369	0	1	3	6
370	0	1	6	8
371	0	1	7	7
372	0	1	8	5
373	0	1	7	5
374	0	1	6	4
375	0	0	6	3
376	0	0	6	5
377	0	0	5	5
378	0	0	4	5
379	0	0	3	6
380	0	0	4	6
381	0	0	3	5
382	0	1	3	4
383	1	1	5	2
384	1	1	5	1

385	1	0	2	2
386	1	0	3	2
387	1	0	4	3
388	1	0	3	4
389	1	0	4	3
390	1	0	5	2
391	1	0	5	4
392	1	0	5	5
393	1	0	4	5
394	0	0	4	5
395	0	0	4	4
396	0	0	3	5
397	0	0	3	5
398	0	0	3	3
399	0	0	3	4
400	0	0	2	2

D.2.2 Archaeological Data – Blades (Quartzite >30mm)

Loc.	**RBSR**	**VB**	**DBCS**	**OBS2**	**OB**	**SADBS**	**LBSR**	**PP13B-MIS5**	**PP9**	**PP13B-MIS6**
1	0	0	0	0	0	0	1	2	0	0
2	0	0	0	0	0	0	2	2	0	0
3	0	0	0	0	0	0	2	2	0	1
4	0	0	0	0	0	0	2	2	0	1
5	0	0	0	0	0	0	2	2	0	1
6	0	0	0	0	0	0	2	2	0	1

7	0	0	0	0	0	0	2	2	0	1
8	1	0	0	0	0	0	2	2	0	1
9	1	0	0	0	0	0	1	4	0	1
10	0	0	0	0	0	0	2	3	0	1
11	0	0	0	0	0	0	3	2	0	1
12	0	0	0	0	0	0	3	2	0	1
13	0	1	0	0	0	0	3	2	0	1
14	0	1	0	0	0	0	3	1	0	1
15	0	1	0	0	0	0	2	1	0	2
16	0	1	1	0	0	0	3	2	0	2
17	0	1	1	0	0	0	3	2	0	3
18	0	1	1	0	0	0	3	3	0	3
19	0	1	1	0	0	0	2	5	0	3
20	0	1	1	0	0	0	2	6	0	3
21	0	1	1	0	0	0	2	6	0	2
22	0	1	1	0	0	0	1	6	0	2
23	0	1	1	0	0	0	1	6	0	1
24	0	1	1	0	0	0	0	5	0	1
25	0	1	1	0	0	0	0	5	0	1
26	0	1	1	0	0	0	0	6	1	1
27	0	1	1	0	0	0	1	6	1	2
28	0	2	0	0	0	0	1	6	0	2
29	0	2	0	0	0	0	1	5	0	1
30	0	2	0	0	0	0	1	6	0	1
31	0	2	0	0	0	0	1	6	0	2
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226	0	0	0	0	0	0	2	7	1	1
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384	0	0	0	0	0	1	1	7	0	0
385	0	0	0	0	0	1	1	5	0	0
386	0	0	0	0	0	1	1	6	0	0
387	0	0	0	0	0	1	1	5	0	0
388	0	0	0	0	0	1	1	5	0	0
389	0	0	0	0	0	1	1	4	0	0
390	0	0	0	0	0	1	1	3	0	0
391	0	0	0	0	0	1	0	2	0	0
392	0	0	0	0	0	1	0	2	0	0
393	0	0	0	0	0	0	0	2	0	0
394	0	0	0	0	0	0	0	2	0	0
395	0	0	0	0	0	0	0	2	0	0
396	0	0	0	0	0	0	0	1	0	0
397	0	0	0	0	0	0	0	2	0	0
398	0	0	0	0	0	0	0	2	0	0

399	0	0	0	0	0	0	0	2	0	0
400	0	0	0	0	0	0	0	2	0	0

D.2.3 Archaeological Data – Blades (Silcrete >30mm)

Loc.	**RBSR**	**BCSR**	**DBCS**	**OBS2**	**NB6**	**OB**	**OBS1**	**SADBS**	**ALBS**	**LBSR**	**YBS**	**PP13B-MIS5**
1	0	0	0	0	1	0	0	0	0	0	0	0
2	1	0	0	0	1	1	0	0	0	0	0	0
3	1	0	0	0	1	1	0	0	0	0	0	0
4	1	0	0	0	1	1	0	0	0	1	0	0
5	1	0	0	0	1	1	0	0	0	2	0	0
6	1	0	0	0	1	1	0	0	0	1	0	0
7	1	0	0	0	1	1	0	0	0	1	0	0
8	1	1	0	0	1	1	0	0	0	1	0	0
9	1	1	0	0	1	1	0	0	0	1	0	0
10	1	1	0	0	1	1	0	1	0	1	0	0
11	1	1	0	0	1	1	0	0	0	2	0	0
12	1	1	1	0	1	0	0	0	0	2	0	0
13	1	1	1	1	0	0	0	0	0	2	0	0
14	1	1	0	1	0	0	0	0	0	2	0	0
15	1	1	0	1	0	0	0	0	0	2	0	0
16	1	1	0	1	0	0	0	1	0	2	0	0
17	1	1	0	1	0	0	0	1	0	2	0	0
18	1	1	1	1	0	0	0	1	0	2	0	0
19	1	0	1	1	0	0	0	1	0	1	0	0
20	1	0	1	1	0	0	0	1	0	0	0	0

21	1	0	1	2	0	0	0	0	0	1	0	0
22	1	0	0	1	0	0	0	0	0	1	0	0
23	1	0	0	1	0	0	0	0	0	1	0	0
24	1	0	0	1	0	1	0	0	0	2	0	0
25	1	0	0	2	0	1	0	1	0	2	0	0
26	1	1	1	2	0	1	0	1	0	2	0	0
27	1	1	1	0	0	1	0	1	0	3	0	0
28	1	2	1	0	0	1	0	1	0	4	0	0
29	1	2	1	0	0	1	0	1	0	5	0	0
30	1	2	1	2	0	1	0	1	0	5	0	0
31	1	2	1	2	0	1	0	1	0	5	0	0
32	0	1	0	2	0	1	0	1	0	5	0	0
33	0	2	0	2	0	1	0	1	0	5	0	0
34	0	2	1	2	0	1	0	1	0	3	0	0
35	0	1	1	3	0	1	0	2	0	3	0	0
36	0	1	1	3	0	0	0	2	0	2	0	0
37	0	0	0	3	0	0	0	1	0	2	0	0
38	0	1	0	0	0	0	0	1	0	2	0	0
39	0	1	0	0	0	0	0	1	0	1	0	0
40	0	0	0	0	0	0	0	1	0	3	0	0
41	0	0	0	0	0	0	0	1	0	5	0	0
42	0	1	0	0	0	0	0	1	0	6	0	0
43	0	1	0	0	0	0	0	1	0	6	0	0
44	0	1	0	0	0	0	0	1	0	5	0	0
45	0	0	0	0	0	0	0	2	0	4	0	0
46	0	0	0	0	0	0	0	2	0	5	0	0
47	0	0	1	0	0	0	0	1	0	5	0	0
48	1	0	1	0	0	0	0	1	0	5	0	0

49	1	0	1	1	0	0	0	1	0	4	0	0
50	1	0	1	2	0	0	0	1	0	4	0	0
51	1	0	1	2	0	0	0	1	0	3	0	0
52	1	0	0	2	0	0	0	1	0	2	0	0
53	1	0	0	1	0	0	0	1	0	3	0	0
54	1	0	0	0	0	0	0	1	0	3	0	0
55	1	0	0	1	0	0	0	1	0	3	0	0
56	1	0	0	1	0	1	0	1	0	3	0	0
57	1	0	0	1	0	1	0	0	0	4	0	0
58	1	0	0	1	0	1	0	0	0	3	0	0
59	1	0	0	2	0	1	0	0	0	3	0	0
60	1	0	1	2	0	1	0	0	0	2	0	0
61	1	0	1	1	0	1	0	0	0	1	0	0
62	1	0	1	1	0	1	0	0	0	3	0	0
63	0	0	1	1	1	2	0	0	0	3	0	0
64	0	0	0	0	1	2	0	0	0	3	0	0
65	0	0	0	0	1	2	0	0	0	4	0	0
66	0	0	0	0	0	1	0	0	0	3	0	0
67	0	0	1	0	1	0	0	0	0	2	0	0
68	0	0	1	0	1	0	0	0	0	2	1	0
69	0	0	1	1	1	0	0	0	0	2	1	0
70	0	0	1	1	1	0	0	0	0	2	1	0
71	0	0	1	1	0	0	0	0	0	2	1	0
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73	0	0	0	1	0	0	0	0	0	2	1	0
74	0	1	0	1	0	0	0	0	0	2	1	0
75	0	1	1	1	0	0	0	0	0	3	1	0
76	0	1	1	0	0	0	0	0	0	4	1	0

77	0	1	0	1	0	0	1	0	0	2	0	0
78	1	2	1	0	0	0	1	0	0	1	0	0
79	1	2	1	0	0	0	1	0	0	3	0	0
80	1	2	1	0	0	0	1	0	0	4	0	0
81	1	2	1	1	0	0	1	0	0	6	0	0
82	1	2	1	1	0	0	1	0	0	6	0	0
83	1	2	0	0	0	0	1	0	0	6	0	0
84	1	2	0	0	0	0	0	0	0	4	0	0
85	1	2	1	0	0	0	0	0	0	2	0	0
86	1	2	1	0	0	1	0	0	0	2	0	0
87	1	2	2	0	0	1	0	0	0	1	0	0
88	1	2	1	0	0	1	0	0	0	1	0	0
89	1	3	1	0	0	1	0	0	0	0	0	0
90	0	3	1	0	0	1	0	0	0	0	0	0
91	0	3	2	0	0	0	0	0	0	2	0	0
92	0	2	1	0	0	0	0	0	0	4	0	0
93	0	1	1	1	0	0	0	0	0	4	0	0
94	1	1	0	1	0	0	0	0	0	3	0	0
95	1	1	0	1	0	0	0	0	0	2	0	0
96	1	1	0	1	0	0	0	0	0	3	0	0
97	1	1	0	1	0	0	0	0	0	3	0	0
98	1	1	1	1	0	0	0	0	0	2	0	0
99	1	1	1	1	0	0	0	0	0	2	0	0
100	1	1	0	1	0	0	0	0	0	2	0	0
101	0	1	1	2	0	1	0	1	0	3	0	0
102	0	1	1	2	0	1	0	1	0	4	0	0
103	0	2	1	2	0	1	0	1	0	4	0	0
104	0	2	1	2	0	1	0	1	0	4	0	0

105	0	2	1	2	0	1	0	1	0	5	0	0
106	0	2	1	2	0	1	0	1	0	8	0	0
107	0	1	1	2	0	1	0	1	0	8	0	0
108	1	1	1	2	0	1	0	1	0	6	0	0
109	1	1	1	3	0	1	0	1	0	8	0	0
110	1	1	1	3	0	1	0	1	0	7	0	0
111	1	1	1	3	0	0	0	1	0	8	0	0
112	1	0	1	4	0	0	0	1	0	8	0	0
113	1	1	1	4	0	0	0	0	0	6	0	0
114	0	1	1	3	0	0	0	0	0	5	0	0
115	0	1	1	3	0	0	0	0	0	4	0	0
116	1	1	1	3	0	0	0	0	0	4	0	0
117	1	1	1	2	0	0	0	0	0	3	0	0
118	1	1	1	3	0	0	0	0	0	3	0	0
119	2	1	1	3	0	0	0	0	0	4	0	0
120	2	1	1	3	0	0	0	0	0	6	0	0
121	2	1	1	3	0	0	0	0	0	5	0	0
122	2	1	2	3	0	0	0	0	0	5	0	0
123	2	0	2	3	0	0	0	0	0	5	0	0
124	2	0	2	3	0	0	0	0	0	4	0	0
125	2	0	2	3	0	1	0	0	0	3	0	0
126	2	0	2	3	0	1	0	0	0	5	0	0
127	2	0	1	1	0	1	0	0	0	2	0	0
128	2	0	1	1	0	1	0	0	0	2	0	0
129	2	0	1	1	0	1	0	0	0	2	0	0
130	2	0	1	1	1	1	0	0	0	3	0	0
131	1	0	0	1	1	1	0	0	0	3	0	0
132	1	0	0	1	1	1	0	0	0	3	0	0

133	1	0	0	1	1	0	0	0	0	5	0	0
134	1	0	0	1	1	0	0	0	0	3	1	0
135	1	0	0	0	1	0	0	0	0	3	1	0
136	1	0	0	0	1	1	0	0	0	4	1	0
137	1	0	0	0	1	1	0	0	0	4	1	0
138	1	0	0	1	1	0	0	0	0	3	1	0
139	1	0	0	1	1	0	0	0	0	5	1	1
140	1	0	0	1	1	0	0	0	0	4	1	1
141	1	0	0	1	1	1	0	1	0	2	1	1
142	1	0	0	1	0	1	0	1	0	3	1	1
143	0	0	0	1	0	0	0	1	0	3	1	1
144	1	1	0	1	0	1	0	0	0	3	1	1
145	1	2	0	1	0	0	0	0	0	2	1	1
146	1	1	0	1	0	0	0	0	0	2	0	1
147	1	1	0	0	0	0	0	0	0	2	0	1
148	1	1	0	0	0	0	0	0	0	3	0	1
149	2	1	0	0	0	0	0	0	0	2	0	0
150	2	0	0	1	0	1	0	0	0	4	0	0
151	2	1	1	1	0	1	0	0	0	5	0	1
152	2	2	2	0	0	1	0	0	0	5	0	1
153	1	3	2	0	0	0	0	0	0	3	0	1
154	1	3	2	0	0	1	0	0	0	3	0	1
155	0	3	2	0	0	1	0	0	0	3	0	1
156	0	2	3	0	0	1	0	0	0	3	0	1
157	0	2	3	0	0	1	0	0	0	2	0	1
158	0	2	3	0	0	1	0	0	0	1	0	1
159	0	1	3	0	0	1	0	0	0	1	0	1
160	1	2	2	1	0	1	0	0	0	1	0	0

161	1	2	2	1	0	1	0	0	0	1	0	0
162	1	2	2	1	0	1	0	0	0	3	0	0
163	1	2	1	1	0	1	0	0	0	2	0	0
164	0	2	1	1	0	0	0	0	0	2	0	0
165	0	2	1	1	0	0	0	0	0	5	0	0
166	0	2	1	1	0	0	0	0	0	5	0	0
167	0	1	1	1	1	0	0	0	0	5	0	0
168	0	1	1	1	1	1	0	0	0	4	0	0
169	0	1	0	1	1	1	0	0	0	5	0	0
170	1	1	0	1	1	1	0	0	0	7	0	0
171	1	1	0	1	1	1	0	0	0	7	0	0
172	0	1	1	1	1	0	0	0	0	4	0	0
173	0	1	1	1	1	0	0	0	0	4	0	0
174	0	1	0	1	1	1	0	0	0	3	0	0
175	0	1	1	1	0	1	0	0	0	2	0	0
176	0	1	1	1	0	1	0	0	0	1	0	0
177	0	0	3	1	0	1	0	0	0	1	0	0
178	0	0	3	1	0	1	0	0	0	0	0	0
179	0	0	3	1	0	1	0	0	0	1	0	0
180	0	1	3	1	0	1	0	0	0	1	0	0
181	1	1	2	1	0	0	0	0	0	2	0	0
182	1	2	2	0	0	0	0	0	0	2	0	0
183	1	2	1	0	0	0	0	0	0	2	0	0
184	1	2	0	1	0	0	0	0	0	3	0	0
185	1	1	0	1	0	0	0	0	0	1	0	0
186	1	1	1	1	0	0	0	0	0	2	0	0
187	0	1	1	1	0	0	0	0	0	2	0	0
188	0	1	1	1	0	0	0	0	0	3	0	0

189	0	1	1	1	1	0	0	0	0	1	0	0
190	0	0	1	1	1	0	0	0	0	1	0	0
191	0	0	1	0	1	0	0	0	0	0	0	0
192	0	0	1	0	1	0	0	0	0	1	0	0
193	0	0	1	0	0	0	0	0	0	0	0	0
194	0	0	1	0	0	0	0	0	0	0	0	0
195	0	0	1	0	1	0	0	0	0	0	0	0
196	0	0	0	0	1	0	0	0	0	0	0	0
197	0	0	0	0	1	0	0	0	0	0	0	0
198	0	0	0	0	1	0	0	0	0	0	0	0
199	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0
201	0	1	0	0	0	0	0	0	0	0	0	0
202	0	1	0	0	0	0	0	0	0	0	0	0
203	0	1	0	0	0	0	0	0	0	0	0	0
204	0	1	0	0	0	0	0	0	0	0	0	0
205	0	1	0	0	0	0	0	0	0	0	0	0
206	0	1	0	0	0	0	0	0	0	0	0	0
207	0	1	0	0	0	0	0	0	0	2	0	0
208	0	1	0	0	0	0	0	0	0	2	0	0
209	0	2	0	0	0	0	0	0	0	2	0	0
210	0	2	0	0	0	0	0	0	0	2	0	0
211	0	2	0	0	0	0	0	0	0	2	0	0
212	0	1	0	0	0	0	0	0	1	2	0	0
213	0	1	0	0	0	0	0	0	1	3	0	0
214	0	0	0	0	0	0	0	0	1	4	0	0
215	0	0	0	0	0	0	0	0	1	4	0	0
216	0	0	0	0	0	0	0	0	1	4	0	0

217	0	0	0	0	0	1	0	0	1	3	0	0
218	1	0	0	0	0	1	0	0	1	3	0	0
219	1	0	0	0	0	1	0	0	0	4	0	0
220	1	0	0	0	0	1	0	0	0	4	1	0
221	1	0	0	0	1	1	0	0	0	3	1	0
222	0	0	0	0	1	1	0	0	0	2	1	0
223	0	0	0	0	1	1	0	0	0	3	1	0
224	0	0	0	0	1	1	0	0	0	3	1	0
225	0	0	0	0	1	1	0	0	0	3	1	0
226	1	0	0	0	1	0	0	0	0	2	1	0
227	1	0	0	0	1	0	0	0	0	2	1	0
228	0	0	0	0	1	0	0	0	0	0	1	0
229	0	0	0	0	1	0	0	0	0	0	1	0
230	0	0	0	0	0	1	0	0	0	0	1	0
231	1	0	1	0	0	0	0	0	0	0	1	0
232	1	0	1	0	0	1	0	0	0	0	1	0
233	0	0	1	0	0	1	0	0	0	1	1	0
234	0	0	1	0	0	0	0	0	0	1	1	0
235	0	0	1	0	0	1	0	0	0	1	1	0
236	0	0	1	0	0	0	0	0	0	1	1	0
237	0	0	1	0	0	1	0	0	0	0	1	0
238	0	0	0	0	0	1	0	0	0	0	1	0
239	0	0	0	0	0	0	0	0	0	0	1	0
240	0	0	0	0	0	0	0	0	0	1	1	0
241	0	0	1	0	0	0	0	0	0	2	1	0
242	0	0	1	0	0	0	0	0	0	2	1	0
243	0	0	1	0	0	0	0	0	0	2	1	0
244	0	0	1	0	0	0	0	0	0	1	1	0

245	0	0	1	0	0	0	0	0	0	1	1	0
246	0	0	0	0	0	0	0	0	0	0	1	0
247	0	0	1	0	0	0	0	0	0	0	1	0
248	0	0	0	0	0	0	0	0	0	0	1	1
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250	1	0	0	0	0	0	0	0	0	0	1	1
251	1	0	0	0	0	0	0	0	0	0	0	0
252	1	0	0	0	0	0	0	0	0	0	0	0
253	1	0	0	0	0	0	0	0	0	0	1	0
254	0	0	0	0	0	0	0	0	0	0	1	0
255	0	0	0	0	0	0	0	0	0	1	1	0
256	0	0	0	0	0	0	0	0	0	1	1	0
257	0	0	0	0	0	0	0	0	0	1	1	0
258	0	0	0	0	0	0	0	0	0	1	0	0
259	0	1	0	0	0	0	0	0	0	0	0	0
260	0	1	0	0	0	0	0	1	0	0	0	0
261	0	0	0	1	0	0	0	1	0	0	0	0
262	0	0	0	1	0	0	0	1	0	0	0	0
263	0	0	0	1	0	0	0	1	0	1	0	0
264	0	0	0	0	0	0	0	1	0	1	0	0
265	0	0	0	0	0	1	0	1	0	1	0	1
266	0	0	0	0	0	1	0	0	0	1	0	1
267	0	0	0	0	0	1	0	0	0	1	0	1
268	0	0	0	0	0	1	0	0	0	1	0	1
269	0	0	0	0	0	1	0	0	0	1	0	1
270	0	0	0	0	0	1	0	1	0	0	0	1
271	0	0	0	0	0	1	0	1	0	0	0	1
272	0	0	0	0	0	1	0	1	0	0	0	0

273	0	0	0	0	0	1	0	1	0	0	0	0
274	0	0	0	0	0	1	0	1	0	0	0	0
275	0	0	0	0	0	1	0	0	0	0	0	0
276	0	0	0	0	0	0	0	0	0	0	0	0
277	0	0	0	0	0	0	0	0	0	0	0	0
278	0	0	0	0	0	0	0	0	0	0	0	0
279	0	0	0	0	0	0	0	0	0	1	0	0
280	0	0	0	0	0	0	0	0	0	1	0	0
281	0	0	0	0	0	1	0	0	0	2	0	0
282	0	0	0	0	0	1	0	0	0	2	0	0
283	0	0	0	0	0	1	0	0	0	2	0	0
284	0	0	0	0	0	1	0	0	0	2	0	0
285	0	0	0	0	1	1	0	0	0	1	0	0
286	0	0	0	0	1	1	0	0	0	1	0	0
287	0	0	0	0	1	0	0	0	0	1	0	0
288	0	0	0	0	1	0	0	0	0	1	0	0
289	1	0	0	0	1	0	0	0	0	1	0	0
290	1	0	0	0	1	0	0	0	0	0	0	0
291	1	1	0	0	1	0	0	0	0	0	0	0
292	1	1	0	0	1	0	0	0	0	0	0	0
293	0	1	0	0	1	0	0	0	0	0	0	0
294	0	1	0	0	1	0	0	0	0	1	0	0
295	0	1	1	0	1	0	0	0	0	2	0	0
296	0	1	1	0	1	0	0	0	0	1	0	0
297	0	1	1	0	1	0	0	0	0	1	0	0
298	0	1	1	0	1	0	0	0	0	2	0	0
299	0	1	1	0	1	0	0	0	0	2	0	0
300	0	1	1	0	1	0	0	0	0	2	0	0

301	0	2	3	0	1	0	0	0	0	5	0	0
302	0	2	3	0	1	0	0	0	0	5	0	0
303	0	2	3	0	1	0	0	0	0	5	0	0
304	0	2	3	0	1	0	0	0	0	5	0	0
305	0	2	3	0	1	0	0	0	0	3	0	0
306	0	2	3	0	1	0	0	0	0	3	0	0
307	0	2	2	0	1	0	0	0	0	4	0	0
308	0	2	2	0	1	0	0	0	0	4	0	0
309	0	2	2	0	1	0	0	0	0	3	0	0
310	0	2	2	0	1	0	0	0	0	3	0	0
311	0	4	2	0	1	0	0	0	0	3	0	0
312	0	3	2	0	1	0	0	0	0	2	0	0
313	0	3	2	0	1	0	0	0	0	1	0	0
314	0	4	2	0	1	0	0	0	0	1	0	0
315	0	3	2	0	1	0	0	0	0	1	0	0
316	0	3	2	0	1	0	0	0	0	0	0	0
317	0	3	2	0	1	0	0	0	0	0	1	0
318	0	3	3	0	1	0	0	0	0	1	1	0
319	0	3	3	0	0	0	0	0	0	1	1	0
320	0	2	3	0	0	0	0	0	0	1	1	0
321	0	1	2	0	0	0	0	0	0	2	1	0
322	0	1	2	0	0	0	0	0	0	2	1	0
323	0	1	2	0	0	0	0	0	0	1	1	0
324	0	1	2	0	0	0	0	0	0	2	1	0
325	0	1	2	0	0	0	0	0	0	3	1	0
326	0	1	2	0	0	0	0	0	0	4	1	0
327	0	1	3	0	0	0	0	0	0	4	1	0
328	0	1	3	0	0	0	0	0	0	3	1	0

329	0	1	3	0	0	0	0	0	0	3	1	0
330	0	1	3	0	0	0	0	0	0	3	1	0
331	0	1	3	0	0	0	0	0	0	1	0	0
332	0	2	3	0	0	0	0	0	0	1	0	0
333	0	2	2	0	0	0	0	0	0	2	0	0
334	0	2	2	0	0	0	0	0	0	3	0	0
335	0	2	2	0	0	0	0	0	0	2	0	0
336	0	2	3	0	0	0	0	0	0	2	0	0
337	0	2	3	0	0	0	0	0	0	2	0	0
338	0	2	3	0	0	0	0	0	0	2	0	0
339	0	2	3	0	0	0	0	0	0	1	0	0
340	0	2	3	0	0	0	0	0	0	2	0	0
341	0	2	3	0	0	0	0	0	0	2	0	0
342	0	2	3	0	0	0	0	0	0	2	0	0
343	0	2	3	0	0	0	0	0	0	2	0	0
344	0	2	3	0	0	0	0	0	0	3	0	0
345	0	2	3	0	0	0	0	0	0	4	0	0
346	0	2	2	0	0	0	0	0	0	3	0	0
347	0	2	2	0	0	0	0	0	0	3	0	0
348	0	2	2	0	0	1	0	0	0	3	0	0
349	0	2	2	0	0	0	0	0	0	2	0	0
350	0	2	1	0	0	0	0	0	0	2	0	0
351	0	1	1	0	0	1	0	0	0	3	0	0
352	0	1	1	0	0	1	0	0	0	3	0	0
353	0	1	1	0	0	1	0	0	0	4	0	0
354	0	1	1	0	0	1	0	0	0	4	0	0
355	0	1	1	0	0	1	0	0	0	3	0	0
356	0	1	1	0	0	1	0	0	0	3	0	0

357	0	1	1	0	0	1	0	0	0	1	0	0
358	0	1	1	1	0	2	0	0	0	3	0	0
359	0	1	1	1	0	2	0	0	0	3	0	0
360	0	1	1	1	0	2	0	0	0	3	0	0
361	0	1	1	0	0	2	0	0	0	3	0	0
362	0	1	1	0	0	2	0	0	0	3	0	0
363	0	1	2	0	0	1	0	0	0	2	0	0
364	0	1	2	0	0	1	0	0	0	2	0	0
365	0	1	2	1	0	0	0	0	0	3	0	0
366	0	1	2	1	0	0	0	0	0	3	0	0
367	0	1	1	2	0	0	0	0	0	3	0	0
368	0	1	1	2	0	0	0	0	0	3	0	0
369	0	1	1	1	0	0	0	0	0	4	0	0
370	0	1	1	1	0	0	0	0	0	4	0	0
371	0	1	1	1	0	0	0	0	0	5	0	0
372	0	1	1	1	0	0	0	0	0	3	0	0
373	0	1	1	2	0	0	0	0	0	2	0	0
374	0	2	1	2	0	0	0	0	0	2	0	0
375	0	2	1	1	0	0	0	0	0	2	0	0
376	0	2	1	1	0	1	0	0	0	3	0	0
377	0	2	1	1	0	1	0	0	0	4	0	0
378	0	2	0	1	0	1	0	0	0	4	0	0
379	0	2	1	0	0	1	0	0	0	3	0	0
380	0	1	1	0	0	1	0	0	0	3	0	0
381	0	1	1	0	0	1	0	0	0	3	0	0
382	0	1	1	0	0	0	0	0	0	3	0	0
383	0	1	1	0	0	0	0	0	0	4	0	0
384	0	1	1	0	0	1	0	0	0	4	0	0

385	0	1	1	0	0	1	0	0	0	4	0	0
386	0	1	1	1	0	1	0	0	0	3	0	0
387	0	1	1	1	0	2	0	0	0	1	0	0
388	0	1	1	1	0	2	0	0	0	1	0	0
389	0	1	1	1	0	1	0	0	0	1	0	0
390	0	1	1	1	0	1	0	0	0	2	0	0
391	0	1	1	1	0	1	0	0	0	3	0	0
392	0	1	1	1	0	1	0	0	0	2	0	0
393	0	1	1	1	0	1	0	0	0	2	0	0
394	0	0	1	1	0	1	0	0	0	2	0	0
395	0	0	1	1	0	1	0	0	0	2	0	0
396	0	0	1	1	0	1	0	0	0	2	0	0
397	0	0	1	1	0	1	0	0	0	2	0	0
398	0	0	1	1	0	1	0	0	0	2	0	0
399	0	0	1	1	0	1	0	0	0	2	0	0
400	0	0	1	1	0	1	0	0	0	1	0	0

D.2.3 Archaeological Data – Blades (Silcrete <30mm)

Loc.	**RBSR**	**BCSR**	**DBCS**	**OBS2**	**NBC6**	**SGS**	**OBS1**	**SADBS**	**LBSR**	**PP13B-MIS5 qz**	**PP13B-MIS5**	**PP13B-MIS6**
1	1	0	0	0	0	0	0	0	0	0	0	0
2	1	0	0	0	0	0	0	0	0	0	0	0
3	1	0	0	0	0	0	0	0	0	0	0	0
4	1	0	0	0	0	0	0	0	0	0	0	0
5	1	0	0	0	0	0	0	0	0	0	0	0

6	1	0	0	0	0	0	0	0	0	0	0	0
7	1	0	0	0	0	0	0	0	0	0	0	0
8	1	0	0	0	0	0	0	0	0	0	0	0
9	1	0	0	0	0	0	0	0	0	0	0	0
10	1	0	0	0	0	0	0	0	0	0	0	0
11	2	0	0	0	0	0	0	0	0	0	0	0
12	2	0	0	0	0	0	0	0	0	0	0	0
13	2	0	0	0	0	0	0	0	0	0	0	0
14	2	0	0	0	0	0	0	0	0	0	0	0
15	2	0	0	0	0	0	0	0	0	0	0	0
16	2	0	0	0	0	0	0	0	0	0	0	0
17	2	0	0	0	0	0	0	0	0	0	0	0
18	2	0	0	0	0	0	0	0	0	0	0	0
19	2	0	0	0	0	0	0	0	0	0	0	0
20	2	0	0	0	0	1	0	0	0	0	0	0
21	2	1	0	0	0	1	0	0	0	0	0	0
22	1	1	0	0	0	1	0	0	0	0	0	0
23	1	3	0	0	0	1	1	1	0	0	0	0
24	1	4	0	0	0	1	1	1	0	0	0	0
25	1	2	0	0	0	1	1	1	0	0	0	0
26	1	2	0	0	0	1	1	1	0	0	0	0
27	1	2	1	0	0	1	1	1	0	0	0	0
28	1	2	1	0	0	1	1	1	0	0	0	0
29	1	2	1	0	0	1	1	1	0	0	0	0
30	1	2	1	0	0	1	0	1	0	1	0	0
31	0	2	1	0	0	1	0	1	0	1	0	0
32	0	3	1	0	0	1	1	0	0	1	0	0
33	0	4	1	0	0	1	2	0	0	1	0	0

34	0	3	1	0	0	1	1	0	0	1	0	0
35	0	3	1	0	0	1	0	0	0	1	0	0
36	0	4	0	0	0	1	0	0	0	1	0	0
37	0	2	0	0	0	1	1	0	0	1	0	0
38	0	2	0	0	0	1	1	0	0	1	0	0
39	0	3	0	0	0	1	1	0	0	1	0	0
40	0	4	0	0	0	1	0	0	0	1	0	0
41	1	4	0	0	0	1	0	0	0	1	0	0
42	3	4	0	0	0	0	0	0	0	1	0	0
43	3	4	1	0	1	0	0	0	0	1	0	0
44	3	3	1	0	1	0	0	0	0	1	0	0
45	3	3	1	0	1	0	1	0	0	1	0	0
46	3	2	1	0	1	0	1	0	0	1	0	0
47	3	1	1	0	1	0	1	0	0	1	0	0
48	3	0	1	0	1	0	1	0	0	1	0	0
49	3	0	1	0	1	0	0	0	0	1	0	0
50	3	1	1	0	1	0	0	0	0	1	0	0
51	3	1	1	0	0	0	0	0	0	1	0	0
52	3	1	0	0	0	0	0	0	0	1	0	0
53	3	1	0	0	0	0	0	0	0	1	0	0
54	3	2	0	0	0	0	0	0	0	1	0	0
55	3	2	1	0	0	0	0	0	0	1	0	0
56	2	1	1	0	0	0	0	0	0	1	0	0
57	2	1	1	0	0	0	0	0	0	0	0	0
58	2	1	0	0	0	0	0	0	0	0	0	0
59	1	2	0	0	0	0	0	0	0	0	0	0
60	1	2	0	0	0	0	0	0	0	0	0	0
61	1	2	1	0	0	0	0	0	1	0	0	0

62	1	1	1	0	0	0	0	0	1	1	0	0
63	1	1	1	0	0	0	0	0	1	1	0	0
64	1	2	1	0	0	0	0	0	1	1	0	0
65	0	2	1	0	0	0	1	0	1	1	0	0
66	1	2	1	0	0	1	1	0	1	1	0	0
67	1	2	1	0	0	1	1	0	1	1	0	0
68	1	2	2	0	0	1	1	0	1	1	0	0
69	1	2	2	0	0	1	0	0	1	1	0	0
70	1	1	2	0	0	2	0	0	1	1	0	0
71	1	1	2	0	0	2	0	0	1	1	0	0
72	1	2	2	0	0	2	0	0	1	1	0	0
73	1	2	2	0	0	1	0	0	1	1	0	0
74	1	2	2	0	0	2	1	0	1	0	0	0
75	1	1	2	0	0	2	1	0	0	0	0	0
76	1	2	2	0	0	2	1	0	0	0	0	0
77	1	2	2	0	0	2	1	0	0	0	0	0
78	1	2	2	0	0	2	1	0	0	0	0	0
79	1	2	1	0	0	2	1	0	0	0	0	0
80	1	2	1	0	0	2	1	0	0	0	0	0
81	1	1	1	0	0	2	1	0	0	0	0	0
82	1	1	1	0	0	2	1	0	0	0	0	0
83	1	1	1	0	0	2	1	0	0	0	0	0
84	1	1	1	0	0	2	1	0	0	0	0	0
85	1	1	1	0	0	2	1	0	0	0	0	0
86	1	0	1	0	0	2	1	1	0	0	0	0
87	1	0	1	0	0	2	2	1	1	0	0	0
88	0	0	1	0	0	2	1	1	1	0	0	0
89	0	1	1	0	0	2	1	1	1	0	0	0

90	0	1	1	0	0	1	1	1	1	0	0	0
91	0	2	2	0	0	1	1	1	1	0	0	0
92	0	2	2	0	0	1	0	1	1	0	0	0
93	0	2	2	0	0	1	0	1	1	0	0	0
94	0	2	2	0	0	1	0	1	1	0	0	0
95	0	2	2	0	0	1	0	1	0	0	0	0
96	0	2	2	0	0	1	0	1	0	0	0	0
97	0	2	2	0	0	1	0	1	0	0	0	0
98	0	2	2	0	0	0	0	1	0	0	0	0
99	0	2	1	0	0	0	0	1	0	0	0	0
100	0	2	1	0	0	0	0	1	0	0	0	0
101	0	3	1	0	1	1	0	1	0	0	0	0
102	1	3	2	0	1	1	0	1	0	0	0	0
103	1	3	2	0	1	1	0	1	1	0	0	0
104	1	3	2	0	1	1	0	1	1	0	0	0
105	1	4	1	0	1	1	0	1	1	0	0	0
106	1	4	1	0	1	1	0	1	1	0	0	0
107	1	4	2	0	1	1	0	0	1	0	0	0
108	1	4	2	0	1	1	0	0	1	0	0	0
109	0	4	2	0	0	1	0	0	1	0	0	0
110	0	4	2	0	0	1	0	0	0	0	0	0
111	0	4	2	0	1	1	0	0	0	0	0	0
112	0	4	2	0	1	1	1	0	0	0	0	0
113	0	3	2	0	1	1	1	0	0	0	0	0
114	0	3	4	0	1	1	1	0	0	0	0	0
115	0	3	4	0	1	1	1	0	0	0	0	0
116	0	4	4	0	2	1	1	0	0	0	0	0
117	0	4	4	0	2	1	1	0	0	0	0	0

118	0	4	4	0	2	1	1	0	0	0	0	0
119	0	3	4	0	2	1	1	0	0	0	0	0
120	0	3	4	0	2	1	1	0	0	0	0	0
121	0	3	4	0	2	1	1	0	0	0	0	0
122	0	3	2	0	2	1	1	0	0	0	0	0
123	0	2	2	0	2	1	2	0	0	0	0	0
124	0	3	2	0	1	1	2	0	0	0	0	0
125	0	3	2	0	1	0	1	0	0	0	0	0
126	0	3	2	0	1	0	1	0	0	0	0	0
127	0	3	4	0	2	0	1	0	0	0	0	0
128	0	5	4	0	2	0	1	0	0	0	0	0
129	0	4	4	0	1	0	1	0	0	0	0	0
130	0	5	4	0	0	0	1	0	0	0	0	0
131	0	5	3	0	0	0	0	0	0	0	0	0
132	0	5	3	0	0	0	0	0	0	0	0	0
133	0	5	4	0	0	0	0	0	0	0	0	0
134	0	4	4	0	0	0	0	0	0	0	0	0
135	0	4	4	0	0	0	0	0	0	0	0	0
136	0	4	3	0	0	0	0	0	0	0	0	0
137	1	3	3	0	0	0	0	0	0	0	0	0
138	1	4	3	0	0	0	0	0	0	0	0	0
139	1	4	3	0	0	0	0	0	0	0	0	0
140	1	3	3	0	0	0	0	0	0	0	0	0
141	1	4	3	0	0	0	0	0	0	0	0	0
142	1	4	3	0	0	0	0	0	0	0	0	0
143	1	4	3	0	0	0	0	0	0	0	0	0
144	1	5	2	0	0	0	1	0	0	0	0	0
145	1	5	2	0	0	0	1	0	0	0	0	0

146	1	5	2	0	0	0	2	0	0	0	0	0
147	1	5	2	0	0	0	2	0	0	0	0	0
148	1	3	2	0	0	0	2	0	0	0	0	0
149	1	2	1	0	0	0	2	0	0	0	0	0
150	1	2	1	1	0	0	2	0	0	0	0	0
151	1	2	2	1	0	0	2	0	0	0	0	0
152	1	2	2	1	0	0	2	0	0	0	0	0
153	1	2	2	1	0	0	0	0	0	0	0	0
154	1	2	1	1	0	0	0	0	0	0	0	0
155	1	2	1	1	0	0	0	0	0	0	0	0
156	1	3	1	1	0	0	0	0	0	0	0	0
157	1	3	1	1	0	0	0	0	0	0	0	0
158	1	2	1	1	0	0	1	0	0	0	0	0
159	1	2	1	0	0	0	1	0	0	0	0	0
160	1	2	1	0	0	0	1	0	0	0	0	0
161	2	3	2	0	0	1	0	0	0	0	0	0
162	2	3	1	0	0	1	0	0	0	0	0	0
163	2	4	2	0	0	1	0	0	0	0	0	0
164	2	4	2	0	0	1	0	1	0	0	0	0
165	2	3	1	0	0	1	0	1	0	0	0	0
166	2	3	1	0	0	1	0	1	0	0	0	0
167	2	4	1	0	0	1	1	1	0	0	0	0
168	2	3	2	0	0	1	0	1	0	0	0	0
169	2	3	2	0	0	1	0	1	0	0	0	0
170	1	2	2	0	0	1	0	1	0	0	0	0
171	1	2	2	0	0	1	0	0	0	0	0	0
172	1	2	1	0	0	1	0	0	0	0	0	0
173	1	2	1	0	0	1	0	0	0	0	0	0

174	1	3	2	0	0	1	0	0	0	0	0	0
175	1	3	2	0	0	1	0	0	0	0	0	0
176	1	3	2	0	0	1	0	0	0	0	0	0
177	1	2	1	0	0	1	0	0	0	0	0	0
178	1	2	0	0	0	1	0	0	0	0	0	0
179	1	2	0	0	0	1	0	0	0	0	0	0
180	1	1	0	0	0	1	0	0	0	0	0	0
181	1	1	0	0	0	1	0	0	0	0	0	0
182	1	1	1	0	0	0	0	0	0	0	0	0
183	1	1	1	0	0	0	0	0	0	0	0	0
184	1	1	1	0	0	0	0	0	0	0	0	0
185	1	1	1	0	0	0	0	0	0	0	0	0
186	1	2	1	0	0	0	0	0	0	0	0	0
187	1	2	1	0	0	0	0	0	0	0	0	0
188	1	1	1	0	0	0	0	0	0	0	0	0
189	1	0	1	0	0	0	0	0	0	0	0	0
190	1	0	1	0	0	0	0	0	0	0	0	0
191	1	0	1	0	0	0	0	0	0	0	0	0
192	0	0	1	0	0	0	0	0	0	0	0	0
193	0	0	1	0	0	0	0	0	0	0	0	0
194	0	0	0	0	0	0	0	0	0	0	0	0
195	0	0	0	0	0	0	0	0	0	0	0	0
196	0	0	0	0	0	0	0	0	0	0	0	0
197	0	0	0	0	0	0	0	0	0	0	0	0
198	0	0	0	0	0	0	0	0	0	0	0	0
199	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0
201	0	0	1	0	0	0	0	0	0	0	0	0

202	0	0	1	0	0	0	0	0	0	0	0	0
203	0	0	1	0	0	0	0	0	0	0	0	0
204	0	0	0	0	0	0	0	0	0	0	0	0
205	0	0	0	0	0	0	0	0	0	0	0	0
206	0	0	0	0	0	0	0	0	0	0	0	0
207	0	0	0	0	0	0	0	0	0	0	0	0
208	0	0	1	0	0	0	0	0	0	0	0	0
209	0	0	1	0	0	0	0	0	0	0	0	0
210	1	0	2	0	0	0	0	0	0	0	0	0
211	1	0	2	0	0	0	0	0	0	0	0	0
212	1	0	2	0	0	0	0	0	0	0	0	0
213	0	0	2	0	0	0	0	0	0	0	0	0
214	0	1	2	0	0	0	0	0	0	0	0	0
215	0	1	2	0	0	0	0	0	0	0	0	0
216	0	1	1	0	0	0	0	0	0	0	0	0
217	0	1	1	0	0	0	0	0	0	0	0	0
218	0	1	1	0	0	0	1	0	0	0	0	0
219	0	1	1	0	0	0	1	0	0	0	0	0
220	0	1	1	0	0	0	0	0	0	0	0	0
221	0	1	1	0	0	0	0	0	0	0	0	0
222	0	2	1	0	0	0	0	0	0	0	0	0
223	0	2	1	0	0	0	0	0	0	0	0	0
224	1	2	1	0	0	0	0	0	0	0	0	0
225	1	2	1	0	0	0	0	0	0	0	0	0
226	1	2	1	0	0	0	0	0	0	0	0	0
227	1	2	1	0	0	0	0	0	0	0	0	0
228	1	2	1	0	0	0	0	0	0	0	0	0
229	1	2	0	0	0	0	0	0	0	0	0	0

230	0	2	0	0	0	0	0	0	0	0	0	0
231	0	2	0	0	0	0	0	0	0	0	0	0
232	0	2	1	0	0	0	0	0	0	0	0	0
233	0	2	1	0	0	0	0	0	0	0	0	0
234	0	1	1	0	0	0	0	0	0	0	0	0
235	0	1	1	0	0	0	1	0	0	0	0	0
236	0	1	1	0	0	0	1	0	0	0	0	0
237	0	1	1	0	0	0	1	0	0	0	0	0
238	0	2	1	0	0	0	1	0	0	0	0	0
239	0	2	1	0	0	0	0	0	0	0	0	0
240	0	2	1	0	0	0	0	0	0	0	0	0
241	0	2	1	0	0	0	0	0	0	0	0	0
242	0	2	2	0	0	0	0	0	0	0	0	0
243	0	2	2	0	0	0	0	0	0	0	0	0
244	0	2	2	0	0	0	0	0	0	0	0	0
245	1	2	2	0	1	0	0	0	0	0	0	0
246	1	1	2	0	1	0	0	0	0	0	0	0
247	1	2	2	0	1	0	0	0	0	0	0	0
248	1	2	2	0	1	0	0	0	0	0	0	0
249	1	2	2	0	1	0	0	0	0	0	0	0
250	1	2	3	0	1	0	0	0	0	0	1	0
251	1	2	2	0	1	0	0	0	0	0	1	0
252	2	2	3	0	0	0	0	0	0	0	1	0
253	2	2	3	0	0	0	0	0	0	0	1	0
254	2	2	3	0	0	0	1	0	0	0	1	0
255	2	2	3	0	0	0	1	0	0	0	1	0
256	2	2	3	0	0	0	1	0	0	0	1	0
257	2	1	4	0	0	0	1	0	0	0	1	0

258	2	0	3	0	0	0	1	1	0	0	1	0
259	2	0	3	0	0	0	1	1	0	0	1	0
260	2	0	3	0	0	0	1	1	0	0	1	0
261	2	0	3	0	0	0	1	1	0	0	1	0
262	2	0	3	0	0	0	1	1	0	0	0	0
263	2	0	3	0	0	0	1	1	0	0	0	0
264	0	0	3	0	0	0	0	1	0	0	0	0
265	0	0	3	0	0	0	0	1	0	0	0	0
266	0	0	3	0	0	0	0	1	0	0	0	0
267	0	0	4	0	0	0	0	1	0	0	0	0
268	0	0	4	0	0	0	0	1	0	0	0	0
269	0	0	4	0	0	0	0	1	0	0	0	0
270	0	0	5	0	0	0	0	2	0	0	0	0
271	0	0	5	0	0	0	1	2	0	0	0	0
272	0	1	4	0	0	0	1	2	0	0	0	0
273	0	2	2	0	0	0	1	2	0	0	0	0
274	0	3	2	0	0	0	1	2	0	0	0	0
275	0	3	2	0	0	0	1	2	0	0	0	0
276	0	3	2	0	0	0	1	2	0	0	0	0
277	0	3	2	0	0	0	1	2	0	0	0	0
278	0	3	2	0	0	0	1	1	0	0	0	0
279	0	3	2	0	0	0	1	1	0	0	0	0
280	0	3	2	0	0	0	0	2	0	0	0	0
281	0	3	1	0	0	0	0	2	0	0	0	0
282	0	3	1	0	0	0	0	2	0	0	0	0
283	0	3	1	0	0	0	0	2	0	0	0	0
284	0	3	1	0	0	0	1	2	0	0	0	0
285	0	3	1	0	0	0	1	2	0	0	0	0

286	0	3	2	0	0	0	1	2	0	0	0	0
287	0	3	2	0	0	0	1	2	0	0	0	0
288	0	3	2	0	0	0	0	2	0	0	0	0
289	0	3	2	0	0	0	0	1	0	0	0	0
290	0	2	2	1	0	0	0	1	0	0	0	0
291	0	2	2	1	0	0	0	1	0	0	0	0
292	0	2	2	1	0	0	0	2	0	0	0	0
293	0	2	2	1	0	0	0	2	0	0	0	0
294	0	2	2	1	0	0	0	2	0	0	0	0
295	0	2	2	1	0	0	0	2	0	0	0	0
296	0	2	2	1	0	0	0	2	0	0	0	0
297	0	2	2	1	0	0	0	2	0	0	0	0
298	0	2	2	1	0	0	0	2	0	0	0	0
299	0	2	2	1	0	0	0	2	0	0	0	0
300	0	2	2	0	0	0	0	2	0	0	0	0
301	0	2	1	0	0	0	0	1	0	0	0	0
302	0	2	1	0	0	0	0	1	0	0	0	0
303	0	2	1	0	0	0	0	1	0	0	0	0
304	0	2	1	0	0	0	0	1	0	0	0	0
305	0	2	1	0	0	0	0	1	0	0	0	0
306	1	2	1	0	0	0	0	1	0	0	0	0
307	1	2	1	0	0	0	0	1	0	0	0	0
308	1	2	1	0	0	0	0	1	0	0	0	0
309	0	2	1	0	0	0	0	1	0	0	0	0
310	0	2	1	0	0	0	0	1	0	0	0	0
311	0	2	1	0	0	0	0	1	0	0	0	0
312	1	2	1	0	0	1	0	1	0	1	0	0
313	1	2	1	0	0	1	0	1	0	1	0	0

314	1	2	1	0	0	1	0	1	0	1	0	0
315	1	2	1	0	0	1	0	1	0	1	0	0
316	1	2	1	0	0	1	0	1	0	1	0	0
317	0	2	1	0	0	1	0	1	0	1	0	0
318	1	2	1	0	0	1	0	1	0	0	0	0
319	1	2	1	0	0	1	0	1	0	0	0	0
320	1	2	2	0	0	1	0	1	0	0	0	0
321	2	2	2	0	0	1	0	0	0	0	0	0
322	2	1	2	0	0	1	0	0	0	0	0	0
323	2	1	2	0	0	1	0	0	0	0	0	0
324	2	1	2	0	0	1	0	0	0	0	0	0
325	2	1	1	0	0	1	0	0	0	0	0	0
326	3	1	1	0	0	1	0	0	0	0	0	0
327	3	1	1	0	0	1	0	0	0	0	0	0
328	3	1	1	0	0	1	0	0	0	0	0	0
329	3	1	1	0	0	1	0	0	0	0	0	0
330	2	1	1	0	0	1	0	0	0	0	0	0
331	2	1	1	0	0	1	0	0	0	0	0	0
332	2	1	2	0	0	1	0	0	0	0	0	0
333	1	1	2	0	0	1	0	0	0	0	0	0
334	1	1	2	0	0	1	0	0	0	0	0	0
335	1	1	2	0	0	1	0	0	0	0	0	0
336	1	1	2	0	0	0	0	0	0	0	0	0
337	1	1	2	0	0	0	1	0	0	0	0	0
338	1	1	2	0	0	0	1	0	0	0	0	0
339	1	0	2	0	0	0	1	0	0	0	0	0
340	1	1	2	0	0	0	1	0	0	0	0	0
341	0	1	2	0	0	0	1	0	0	0	0	0

342	0	1	2	0	0	0	1	0	0	0	0	0
343	0	1	2	0	0	0	0	0	0	0	0	1
344	0	1	1	0	0	0	0	0	0	0	0	1
345	0	1	0	0	0	0	0	0	0	0	0	1
346	0	1	0	0	0	0	0	1	0	0	0	1
347	0	1	0	0	1	0	0	1	0	0	0	1
348	0	1	0	0	1	0	0	1	0	0	0	1
349	0	2	0	0	1	0	0	1	0	0	0	1
350	0	2	0	0	1	0	0	1	0	0	0	1
351	0	2	0	0	0	0	0	1	0	0	0	1
352	0	2	0	0	0	0	0	1	0	0	0	1
353	0	2	0	0	0	0	0	1	0	0	0	1
354	0	2	0	0	0	0	0	1	0	0	0	1
355	0	1	0	0	0	0	1	1	0	0	0	1
356	0	1	0	0	0	0	1	1	0	0	0	1
357	0	1	0	0	0	0	1	1	0	0	0	1
358	0	1	0	0	0	0	1	1	0	0	0	1
359	1	1	0	0	0	0	1	1	0	0	0	1
360	1	1	0	0	0	0	1	0	0	0	0	1
361	1	1	0	0	0	0	1	0	0	0	0	0
362	1	1	1	0	0	0	1	0	0	0	0	0
363	1	1	1	0	0	0	1	0	0	0	0	0
364	1	1	1	0	0	0	2	0	0	0	0	0
365	0	1	1	0	0	0	2	0	0	0	0	1
366	0	0	1	0	0	0	2	0	0	0	0	1
367	0	0	1	0	0	0	2	0	0	0	0	1
368	0	0	0	0	0	0	1	0	0	0	0	0
369	0	0	0	0	0	0	1	0	0	0	0	0

370	0	0	0	0	0	0	1	0	0	0	0	0
371	0	0	0	0	0	0	0	0	0	0	0	0
372	0	0	0	1	0	0	1	0	0	0	0	0
373	0	0	1	1	0	0	1	0	0	0	0	0
374	0	0	1	1	0	0	1	0	0	0	0	0
375	0	0	1	1	0	0	1	0	0	0	0	0
376	0	0	1	1	0	0	1	0	0	0	0	0
377	0	0	1	1	0	0	1	0	0	0	0	0
378	0	0	1	1	0	0	1	0	0	0	0	0
379	0	0	1	1	0	0	1	0	0	0	0	0
380	0	0	1	1	0	0	1	0	0	0	0	0
381	0	0	1	1	0	0	0	0	0	0	0	0
382	0	0	2	1	0	0	0	0	0	0	0	0
383	0	0	2	0	0	0	0	0	0	0	0	0
384	0	0	2	1	0	0	0	0	0	0	0	0
385	0	0	2	1	0	0	0	0	0	0	0	0
386	0	0	1	1	0	0	0	0	0	0	0	0
387	0	0	1	1	0	0	0	0	0	0	0	0
388	0	0	1	1	0	0	0	0	0	0	0	0
389	0	0	1	1	0	0	0	0	0	0	0	0
390	0	0	1	1	0	0	0	0	0	0	0	0
391	0	0	1	0	0	0	0	0	0	0	0	0
392	0	0	1	0	0	0	0	0	0	0	0	0
393	0	0	1	0	0	0	0	0	0	0	0	0
394	0	0	1	0	0	0	0	0	0	0	0	0
395	0	0	1	0	0	0	0	0	0	0	0	0
396	0	0	1	0	0	0	0	0	0	0	0	0
397	0	0	1	0	0	0	0	0	0	0	0	0

398	0	0	1	0	0	0	0	0	0	0	0	0
399	0	0	0	0	0	0	0	0	0	0	0	0
400	0	0	0	0	0	0	0	0	0	0	0	0

D.3 Flakes

D.3.1 Experimental Data

Location	Butchery-Blades	Butchery-Points	Trampling	Tumbler
1	1	1	1	2
2	1	1	2	1
3	0	2	2	2
4	1	2	2	1
5	1	2	2	1
6	0	2	2	4
7	0	2	2	4
8	0	2	2	3
9	0	2	1	3
10	0	2	1	3
11	0	2	1	3
12	0	2	1	2
13	0	2	1	3
14	0	2	2	4
15	0	1	1	3
16	0	1	1	1
17	0	1	1	0

18	0	1	1	1
19	0	1	0	1
20	0	1	0	1
21	0	0	0	0
22	0	0	0	1
23	0	1	0	2
24	0	2	1	4
25	0	3	1	4
26	0	3	1	3
27	0	3	1	2
28	0	2	1	2
29	0	2	1	1
30	0	2	0	1
31	0	1	2	1
32	0	0	3	1
33	0	0	3	1
34	0	0	2	1
35	0	0	2	2
36	0	0	2	3
37	1	0	2	1
38	1	0	3	2
39	0	1	2	2
40	0	1	2	1
41	0	1	2	0
42	0	0	2	0
43	0	0	2	1
44	0	0	2	1
45	0	0	3	2

46	0	0	3	2
47	0	0	3	2
48	0	0	3	1
49	0	0	4	0
50	0	0	4	1
51	0	0	4	2
52	0	1	4	2
53	0	1	3	1
54	0	1	3	1
55	0	1	4	3
56	1	1	3	4
57	1	1	3	4
58	1	1	3	4
59	0	2	3	3
60	0	3	4	1
61	0	4	4	1
62	0	4	4	1
63	0	4	5	2
64	0	4	4	2
65	0	4	5	2
66	0	3	5	4
67	0	4	5	6
68	0	2	5	5
69	0	3	4	3
70	0	3	3	2
71	0	3	2	1
72	1	1	2	1
73	1	1	2	2

74	0	1	1	2
75	0	0	1	2
76	0	1	2	1
77	0	2	2	1
78	1	2	3	1
79	1	2	3	3
80	1	2	3	4
81	1	1	1	4
82	0	3	3	3
83	0	4	3	3
84	1	4	3	2
85	1	4	3	3
86	1	3	4	4
87	0	3	4	4
88	2	4	4	4
89	3	3	5	4
90	4	3	5	4
91	3	3	4	3
92	2	3	4	2
93	2	3	4	3
94	2	5	4	1
95	2	5	4	2
96	3	6	5	1
97	3	6	5	1
98	2	6	4	0
99	2	8	3	0
100	2	8	3	0
101	2	8	0	2

102	2	8	0	2
103	2	6	1	2
104	2	6	1	2
105	2	6	1	2
106	2	3	2	4
107	4	4	2	5
108	4	3	2	5
109	4	4	1	5
110	4	4	1	6
111	2	5	1	6
112	2	4	2	4
113	2	3	2	5
114	2	3	3	3
115	2	4	3	3
116	2	5	4	2
117	1	4	5	2
118	1	4	5	2
119	1	4	4	1
120	2	3	4	2
121	2	2	3	4
122	2	0	1	4
123	2	1	1	3
124	2	1	1	3
125	2	1	1	3
126	2	1	3	2
127	2	2	5	1
128	2	2	5	1
129	1	2	5	2

130	3	2	5	2
131	3	1	5	2
132	2	2	3	2
133	1	2	4	2
134	1	2	5	2
135	1	2	4	2
136	1	2	4	2
137	2	3	5	3
138	2	3	4	4
139	2	3	4	5
140	2	2	4	4
141	1	2	5	4
142	1	2	6	3
143	2	1	6	2
144	2	1	5	2
145	2	1	5	2
146	3	1	5	3
147	2	1	6	3
148	1	1	6	2
149	1	1	6	5
150	1	1	5	4
151	1	1	5	3
152	1	1	6	2
153	1	1	5	1
154	0	2	4	2
155	2	2	4	2
156	2	2	3	2
157	1	1	4	3

158	0	1	4	3
159	0	1	3	3
160	0	1	5	2
161	0	1	5	3
162	0	1	4	4
163	0	0	4	4
164	0	0	4	3
165	0	1	2	4
166	0	1	2	4
167	0	0	1	4
168	0	1	1	4
169	0	1	2	2
170	0	1	3	2
171	0	1	3	2
172	0	1	3	3
173	0	1	3	2
174	0	1	2	2
175	0	1	2	3
176	0	1	3	2
177	0	1	3	1
178	0	1	4	0
179	0	0	3	0
180	1	0	1	1
181	1	0	1	2
182	0	0	2	3
183	0	2	2	2
184	0	2	1	2
185	1	2	1	3

186	1	2	0	3
187	1	0	0	2
188	1	0	1	1
189	1	0	2	2
190	0	1	3	2
191	0	1	3	2
192	0	1	3	2
193	0	1	4	3
194	0	1	4	3
195	0	1	4	3
196	0	0	4	2
197	0	0	4	2
198	0	0	4	2
199	0	0	4	2
200	0	0	4	2
201	0	1	3	0
202	0	0	3	1
203	0	0	5	2
204	0	0	5	2
205	1	0	4	3
206	1	0	5	3
207	1	0	5	4
208	0	0	5	4
209	0	0	3	4
210	0	1	2	3
211	0	1	2	3
212	0	1	1	2
213	0	2	2	3

214	0	2	2	2
215	0	1	1	2
216	0	1	2	2
217	0	2	3	3
218	0	2	3	2
219	0	2	3	1
220	0	1	2	1
221	0	1	2	0
222	0	1	3	0
223	0	2	4	0
224	0	3	5	0
225	0	3	5	1
226	0	3	5	1
227	0	3	5	0
228	0	3	6	1
229	0	2	6	2
230	0	2	6	3
231	0	2	6	2
232	0	2	5	3
233	0	2	5	2
234	0	2	5	3
235	0	2	5	3
236	0	1	6	3
237	0	1	5	3
238	1	1	5	5
239	0	1	5	5
240	0	0	7	4
241	0	1	6	4

242	1	2	5	4
243	1	4	6	5
244	1	4	6	4
245	1	4	5	3
246	1	5	4	3
247	2	5	4	1
248	2	4	4	2
249	1	4	4	2
250	2	5	3	2
251	2	4	3	3
252	2	3	5	4
253	2	3	6	3
254	2	3	6	4
255	2	2	6	3
256	3	2	6	4
257	3	2	4	5
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262	2	3	4	3
263	2	2	4	3
264	2	2	4	1
265	1	3	5	2
266	2	3	4	3
267	2	4	4	5
268	2	4	6	6
269	1	4	7	5

270	2	3	6	3
271	2	4	6	2
272	1	4	7	3
273	2	3	7	3
274	2	2	7	3
275	3	3	8	3
276	2	4	6	5
277	2	3	7	5
278	1	3	7	3
279	1	4	7	3
280	1	4	7	3
281	0	3	7	4
282	0	4	5	3
283	1	3	3	3
284	1	2	1	2
285	1	2	1	1
286	1	1	1	2
287	1	2	1	2
288	1	2	1	3
289	1	3	1	4
290	1	4	2	4
291	1	4	2	3
292	1	4	2	0
293	1	3	2	1
294	1	3	2	2
295	1	3	2	2
296	1	3	2	4
297	1	3	1	4

298	1	3	1	3
299	1	3	1	3
300	1	3	1	3
301	1	5	1	2
302	1	5	1	2
303	1	5	1	2
304	1	6	1	2
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307	1	6	1	2
308	1	6	1	2
309	1	5	1	3
310	1	5	1	1
311	1	6	1	1
312	1	6	1	1
313	1	6	1	1
314	0	4	2	1
315	0	1	2	1
316	0	2	2	1
317	0	1	1	1
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319	0	1	1	2
320	0	3	1	2
321	0	3	1	3
322	0	4	1	3
323	0	3	1	4
324	0	2	1	4
325	0	2	1	2

326	0	2	2	2
327	0	0	2	3
328	0	1	3	3
329	0	1	3	1
330	0	1	2	1
331	0	1	3	1
332	0	1	3	1
333	0	1	3	0
334	0	1	3	1
335	0	0	3	1
336	0	1	4	1
337	0	1	6	1
338	0	1	5	2
339	0	2	4	1
340	0	2	3	2
341	0	2	3	1
342	0	3	2	2
343	0	4	3	3
344	0	5	3	3
345	0	4	3	3
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348	0	1	5	2
349	0	1	5	2
350	0	2	4	2
351	0	1	4	1
352	0	1	4	1
353	0	1	5	1

354	0	0	5	1
355	0	0	5	2
356	0	0	4	3
357	0	0	3	2
358	0	0	4	4
359	0	0	4	4
360	0	0	4	4
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372	0	1	1	3
373	0	1	1	2
374	0	1	1	1
375	0	0	1	1
376	0	0	1	0
377	0	0	1	0
378	0	0	1	0
379	0	0	1	0
380	0	0	2	0
381	0	0	3	0

382	0	1	3	1
383	0	2	2	1
384	0	2	2	0
385	0	1	2	1
386	0	1	2	3
387	0	1	2	4
388	0	1	1	3
389	0	1	2	2
390	0	1	2	2
391	0	1	2	2
392	0	1	2	2
393	0	1	2	2
394	0	0	2	2
395	0	0	1	1
396	0	0	1	0
397	0	0	2	0
398	0	0	3	0
399	0	0	3	0
400	0	0	3	0

D.3.2 Archaeological Data – Large Flakes (>30mm)

Loc.	**RBSR**	**BCSR**	**VB**	**DBCS**	**OBS2**	**NBC6**	**OB**	**OBS1**	**SADBS**	**ALBS**	**LBSR**	**YBS**	**NBC10**	**PP9**
1	1	0	1	0	1	2	0	0	0	0	4	0	2	1
2	1	0	1	0	1	3	0	0	0	0	6	0	2	1
3	1	0	1	0	1	3	1	0	0	0	6	0	2	1
4	1	0	1	0	1	3	2	0	0	0	6	0	2	1

5	1	0	1	0	2	4	2	0	0	0	6	0	2	1
6	1	0	2	1	2	4	3	0	0	0	8	0	2	1
7	1	0	2	1	2	4	3	0	0	0	8	0	1	1
8	1	0	2	1	2	3	2	0	0	0	6	0	2	1
9	1	0	2	1	2	4	3	0	0	0	6	0	2	1
10	2	0	2	1	2	7	3	0	0	1	5	0	2	1
11	2	0	2	1	2	7	3	0	0	1	6	0	2	1
12	2	0	3	0	2	7	3	0	0	1	5	0	2	1
13	2	0	2	0	2	8	3	1	0	1	5	0	4	1
14	2	0	3	0	2	8	3	1	0	1	6	0	4	1
15	2	0	4	0	2	9	3	1	0	1	8	0	3	1
16	2	0	4	0	2	10	2	1	0	1	9	0	3	1
17	1	0	4	0	3	10	3	1	0	0	11	0	4	1
18	1	2	4	1	3	8	3	0	0	1	12	0	4	1
19	1	2	4	1	3	6	3	0	0	0	11	0	5	0
20	2	2	4	2	3	7	2	0	0	0	14	0	5	0
21	2	2	5	2	3	7	2	0	0	1	13	0	5	0
22	2	2	4	3	2	7	2	0	0	0	17	0	5	0
23	2	2	4	4	2	5	2	0	0	0	15	1	4	0
24	3	2	4	4	2	5	2	0	0	0	17	0	4	0
25	3	1	4	4	1	5	2	0	0	1	17	0	3	0
26	2	1	5	5	1	6	3	0	0	1	14	0	2	0
27	2	1	5	6	1	4	2	0	0	1	14	0	3	0
28	2	1	5	5	1	5	2	0	0	1	14	0	3	0
29	2	1	5	3	1	6	2	0	0	1	9	0	4	1
30	2	3	5	3	1	7	2	0	0	1	11	0	4	1
31	1	3	4	2	1	7	2	0	0	1	11	0	4	1
32	1	3	4	3	1	6	2	0	0	1	12	0	2	1

33	2	2	4	3	1	6	2	0	0	0	15	0	2	1
34	3	3	4	3	2	7	2	0	0	1	16	0	2	2
35	3	3	3	2	2	6	2	2	0	1	17	0	2	2
36	3	4	4	3	2	6	2	2	1	1	17	0	2	1
37	3	4	4	3	2	5	2	2	1	1	17	0	3	1
38	3	4	5	2	2	5	2	2	1	0	15	0	3	1
39	3	3	6	3	1	5	2	2	1	0	13	0	4	1
40	3	3	6	1	1	5	2	2	1	0	12	0	5	0
41	3	3	6	1	1	5	2	2	1	0	10	0	4	1
42	2	3	5	1	1	6	2	2	1	0	10	0	4	1
43	6	4	6	1	1	5	2	1	1	0	14	0	3	1
44	6	4	5	1	1	5	3	1	1	0	16	0	4	1
45	5	5	5	1	1	6	3	0	0	0	17	0	3	0
46	4	5	5	1	1	6	3	0	0	0	18	0	3	1
47	4	5	6	1	1	6	2	0	0	0	18	0	4	1
48	5	5	5	1	1	6	3	0	0	0	17	0	5	1
49	2	5	6	1	1	6	3	1	0	0	17	0	5	1
50	3	3	5	2	1	6	3	1	1	0	18	0	5	0
51	2	3	1	2	1	6	3	1	1	0	16	0	4	1
52	3	3	2	1	1	5	3	2	1	0	13	0	4	1
53	2	3	3	1	1	6	3	2	1	0	12	0	3	1
54	1	5	4	1	1	7	3	2	1	0	10	0	4	1
55	1	5	5	1	2	8	2	2	1	0	10	0	4	1
56	1	4	4	2	2	8	3	2	1	0	10	0	4	1
57	1	3	4	2	2	7	3	2	1	0	9	0	4	1
58	1	3	5	2	2	5	3	2	1	0	11	0	4	0
59	1	4	4	2	2	5	3	2	1	0	13	0	4	0
60	1	4	5	3	2	5	3	1	0	0	13	0	3	0

61	1	3	6	2	1	5	3	1	1	0	14	0	2	0
62	1	3	6	2	1	4	3	1	1	0	12	0	2	0
63	1	3	5	2	1	4	2	1	1	0	12	0	1	0
64	1	4	6	1	2	5	2	2	1	0	14	0	2	0
65	1	5	6	1	2	4	2	2	1	0	14	0	4	0
66	1	5	5	3	1	3	3	2	1	0	10	0	4	0
67	4	4	5	3	1	2	3	2	1	0	10	0	3	0
68	4	3	6	3	1	2	3	1	0	0	11	0	3	1
69	4	5	8	3	1	4	3	1	0	0	15	0	2	1
70	3	5	8	3	0	3	3	0	0	0	15	0	3	2
71	2	5	7	3	0	3	3	0	0	0	15	0	2	2
72	2	5	7	2	1	3	3	0	0	0	14	0	1	2
73	2	5	7	3	1	2	3	0	0	0	16	0	2	2
74	1	5	8	3	1	2	3	0	0	0	16	0	2	2
75	1	4	7	3	2	2	3	0	0	0	14	0	2	2
76	1	5	6	3	2	2	3	0	0	0	13	0	3	0
77	2	3	6	4	2	2	3	0	0	0	12	0	3	0
78	2	4	7	4	2	4	4	3	0	0	12	0	3	0
79	2	4	6	2	3	2	3	3	0	0	13	0	3	0
80	2	4	5	3	3	3	3	3	0	0	13	0	3	0
81	2	4	6	2	2	3	3	3	0	0	14	0	3	0
82	2	2	6	2	2	3	3	3	0	0	9	0	4	0
83	2	2	7	2	2	3	2	3	0	0	11	0	5	0
84	1	2	6	2	1	3	2	3	0	0	12	0	3	0
85	1	2	5	4	1	2	2	2	0	0	13	0	3	0
86	1	3	5	3	1	3	2	1	0	0	13	0	3	0
87	3	3	6	4	1	3	1	1	0	0	14	0	4	0
88	2	2	5	4	1	4	1	1	0	0	14	0	1	0

89	2	2	4	4	1	4	1	1	1	0	14	0	1	0
90	1	3	4	4	1	4	1	1	1	0	14	0	1	0
91	2	2	4	3	1	4	1	1	1	0	13	0	2	0
92	1	3	4	3	1	4	1	1	1	0	12	0	2	0
93	1	2	3	1	2	5	1	1	1	0	12	0	2	0
94	2	2	2	1	2	6	1	1	1	0	13	0	0	0
95	2	2	2	1	2	7	1	1	1	0	12	0	0	0
96	1	2	2	1	2	8	1	1	0	0	14	0	0	0
97	1	2	2	1	2	8	1	1	0	0	15	0	0	0
98	0	2	2	1	1	7	1	1	0	0	14	0	2	0
99	0	2	2	1	1	7	1	1	0	0	14	0	2	0
100	0	2	2	1	1	7	1	1	0	0	14	0	2	0
101	0	2	4	2	0	7	1	1	0	1	10	0	2	0
102	0	2	4	2	1	7	1	1	0	1	11	0	3	0
103	0	4	4	2	1	7	1	1	0	1	12	0	3	0
104	0	5	3	2	1	7	2	0	0	2	12	0	3	0
105	0	6	4	2	2	6	2	1	0	2	11	0	3	0
106	0	6	3	2	2	6	2	1	0	2	12	0	4	0
107	0	7	3	2	3	4	2	1	0	2	10	0	4	0
108	1	7	3	2	3	3	3	0	0	2	12	0	4	0
109	1	7	2	2	3	3	3	0	0	2	13	0	4	0
110	1	6	2	2	2	3	3	0	0	1	13	0	3	0
111	0	6	2	2	2	5	3	0	0	1	12	0	3	1
112	1	6	2	2	3	5	3	0	0	1	12	0	2	1
113	1	6	1	1	2	5	3	0	0	1	13	0	5	0
114	1	7	1	1	2	5	2	0	0	1	12	0	5	0
115	1	7	2	1	2	5	2	0	0	1	12	0	5	0
116	1	6	3	1	1	6	2	0	0	1	13	0	5	0

117	0	6	3	1	1	6	3	0	0	1	13	0	5	0
118	1	5	4	1	2	6	3	0	0	2	13	0	5	0
119	1	5	5	1	1	6	3	0	0	2	14	0	4	0
120	2	6	5	2	1	8	3	1	0	2	16	0	3	0
121	2	6	5	3	1	8	4	1	0	1	17	0	2	0
122	2	5	6	3	0	9	4	1	0	1	16	0	3	0
123	2	4	6	3	0	7	3	2	0	0	17	0	3	0
124	2	5	6	3	0	9	3	2	0	0	20	0	3	0
125	3	4	6	3	0	10	3	1	0	0	19	0	5	0
126	3	3	6	3	0	9	3	1	0	0	18	0	5	0
127	3	4	6	3	0	9	3	1	0	0	19	0	5	0
128	4	3	5	3	0	8	3	1	0	0	20	0	5	0
129	4	3	6	3	0	9	3	1	0	0	18	0	5	0
130	4	4	5	3	0	10	2	1	0	0	20	0	4	0
131	3	4	5	3	0	11	2	1	0	0	20	0	4	0
132	2	4	4	3	0	10	2	0	0	0	19	0	3	0
133	2	5	5	2	1	10	2	0	0	0	21	0	4	0
134	2	5	4	2	1	10	2	0	0	0	20	0	6	0
135	3	5	5	2	1	8	2	0	0	0	20	0	5	0
136	3	4	5	2	1	6	2	0	0	0	18	0	4	0
137	3	3	5	2	1	7	2	1	0	0	19	0	5	1
138	2	2	5	2	1	7	3	1	0	0	21	0	5	1
139	2	2	5	1	1	8	2	1	0	0	22	0	4	1
140	2	2	6	1	1	7	2	0	0	0	20	0	5	2
141	1	3	6	1	1	6	2	0	0	0	21	0	5	1
142	1	2	5	1	1	4	2	0	0	0	22	0	5	1
143	2	2	7	1	1	5	3	0	0	0	20	0	7	1
144	3	2	7	0	1	5	3	0	0	0	17	0	7	1

145	4	2	4	2	1	5	3	0	0	0	15	0	7	1
146	4	2	5	2	1	7	3	1	0	0	14	0	7	2
147	4	2	5	3	1	6	3	3	0	0	15	0	3	1
148	4	3	5	3	1	6	3	3	0	0	18	0	5	1
149	5	3	6	3	1	6	3	3	0	0	20	0	5	1
150	6	2	5	3	1	6	3	3	0	0	17	0	4	1
151	6	2	5	4	2	6	4	3	0	0	17	0	4	1
152	6	2	6	3	1	6	4	4	0	0	16	0	5	0
153	6	2	7	3	1	6	4	3	0	0	16	0	4	0
154	4	2	7	4	1	6	3	2	0	0	17	0	3	1
155	3	1	6	5	1	4	3	2	0	0	16	0	2	1
156	2	1	5	5	1	4	3	1	0	0	13	0	2	1
157	3	0	4	5	1	4	3	1	0	0	14	0	3	1
158	4	0	4	4	1	4	3	1	0	0	12	0	3	1
159	4	2	3	4	1	4	2	1	0	0	11	0	3	1
160	5	2	5	4	1	3	2	0	0	0	12	0	3	1
161	5	2	6	4	1	2	3	0	0	0	12	0	2	0
162	5	2	6	4	0	2	2	0	0	0	13	0	1	3
163	4	2	5	4	0	2	2	0	0	0	13	0	0	5
164	2	1	5	4	0	3	2	0	0	0	13	0	2	5
165	1	1	4	5	0	4	2	0	0	0	13	0	2	4
166	1	2	4	5	0	3	3	0	0	0	14	0	3	4
167	3	2	4	5	0	3	3	1	0	0	12	0	3	4
168	3	2	3	3	0	3	3	1	0	0	11	0	2	3
169	3	2	2	3	0	3	2	1	0	0	11	0	2	2
170	4	2	3	3	1	3	2	1	0	0	9	0	3	2
171	3	1	3	3	1	3	2	1	0	0	8	0	3	1
172	4	1	3	5	1	5	2	1	0	0	8	0	4	1

173	4	0	4	4	1	6	1	1	0	0	9	0	3	1
174	4	1	4	4	1	5	1	1	0	0	10	0	4	1
175	4	1	5	5	1	6	2	0	0	0	9	0	4	1
176	3	1	5	5	0	6	2	0	0	0	9	0	4	1
177	3	1	5	4	0	6	2	0	0	0	11	0	2	2
178	3	1	5	3	0	6	2	0	0	0	10	0	3	2
179	3	2	6	3	0	6	2	0	0	0	12	0	4	2
180	3	2	2	4	0	6	1	1	0	0	12	0	2	3
181	1	1	2	5	0	7	1	1	0	0	11	0	1	2
182	1	1	3	5	1	8	1	1	0	0	9	0	1	2
183	1	1	4	6	1	8	1	1	0	0	6	0	1	2
184	3	1	5	6	1	8	0	1	0	0	6	0	1	2
185	3	1	5	6	1	8	0	1	0	0	5	0	0	3
186	2	1	5	5	1	9	0	1	0	0	6	0	1	3
187	2	2	4	5	1	7	1	1	0	0	4	0	3	3
188	2	2	3	5	1	6	1	1	0	0	4	0	3	3
189	2	0	2	5	0	5	1	0	0	0	5	0	2	1
190	3	0	2	5	0	4	1	0	0	0	5	0	2	1
191	3	0	1	5	0	3	1	0	0	0	3	0	2	1
192	2	0	1	3	0	3	1	0	0	0	3	0	2	1
193	0	0	1	1	0	3	1	0	0	0	2	0	2	2
194	0	1	1	1	0	5	1	0	0	0	2	0	2	2
195	0	1	2	2	0	5	1	0	0	0	2	0	2	2
196	0	1	2	1	0	4	1	0	0	0	3	0	2	2
197	0	0	2	1	0	3	1	0	0	0	2	0	1	1
198	0	0	2	0	0	2	1	0	0	0	2	0	1	1
199	0	0	2	0	0	2	1	0	0	0	2	0	1	0
200	0	0	1	0	0	2	1	0	0	0	2	0	1	0

201	1	1	2	1	1	1	0	0	0	0	7	0	1	0
202	2	1	2	1	1	1	0	1	0	0	8	0	1	0
203	2	2	2	1	1	1	0	1	0	0	9	0	1	0
204	2	2	2	1	1	1	0	1	0	1	9	0	1	0
205	3	2	2	1	1	1	0	1	0	1	8	0	1	0
206	3	2	2	1	1	1	0	1	0	0	8	0	0	0
207	4	2	2	1	1	1	1	1	0	0	8	0	0	0
208	4	2	2	1	1	1	1	1	0	0	7	0	1	0
209	4	2	2	2	1	1	1	2	0	0	7	0	1	0
210	3	3	2	2	1	1	2	2	0	0	8	0	1	0
211	3	3	2	2	1	1	2	2	0	0	10	0	1	0
212	2	3	2	2	1	1	0	2	0	0	10	0	1	0
213	2	3	1	2	1	1	1	1	0	0	12	0	1	0
214	2	3	1	2	3	0	1	1	0	0	12	0	1	0
215	2	4	2	2	3	0	1	1	0	0	12	0	1	0
216	1	3	2	2	3	0	1	1	0	0	11	0	2	0
217	2	2	2	2	3	0	0	2	0	0	10	0	2	0
218	2	2	2	2	3	0	1	2	0	0	8	0	2	0
219	1	2	2	2	3	0	2	2	0	0	6	0	2	0
220	1	2	2	2	2	1	2	2	0	0	9	0	2	0
221	2	2	2	2	2	1	1	2	0	0	9	0	3	0
222	2	1	2	2	2	2	1	2	0	0	11	0	3	1
223	3	0	3	2	2	2	1	0	0	0	10	0	3	1
224	3	0	4	4	1	2	2	1	0	0	11	0	3	1
225	3	0	4	5	1	2	1	1	1	0	9	0	2	1
226	3	0	4	5	1	2	1	0	1	0	8	0	2	0
227	3	0	4	4	1	2	1	0	1	0	13	0	2	0
228	3	0	4	2	1	2	1	0	1	0	13	0	2	0

229	3	0	4	3	1	3	1	0	1	0	12	0	2	0
230	3	0	4	3	1	3	1	0	1	0	11	0	2	0
231	3	0	3	4	1	2	1	0	1	0	12	0	2	0
232	3	0	3	4	1	3	1	0	1	0	13	0	2	1
233	2	0	2	4	2	3	0	1	1	0	14	0	2	1
234	2	0	2	4	2	3	0	1	1	0	10	0	2	1
235	2	0	2	3	2	3	0	1	1	0	11	0	1	1
236	1	0	2	2	2	4	0	1	0	0	13	0	2	1
237	3	0	2	2	1	4	0	1	0	0	14	0	1	0
238	3	0	2	2	1	4	0	1	0	1	15	0	1	1
239	3	0	1	2	0	4	0	1	0	1	16	0	1	1
240	2	0	2	2	0	4	0	1	0	1	15	0	0	1
241	1	0	2	2	0	4	0	1	0	1	14	0	1	1
242	1	0	2	1	1	3	0	2	0	1	16	0	1	1
243	3	0	2	1	1	3	0	3	0	1	17	0	1	1
244	2	1	2	1	1	3	0	4	0	1	18	0	1	1
245	2	1	2	2	1	3	0	4	0	1	16	0	2	1
246	2	1	2	2	1	3	1	5	0	2	16	0	3	0
247	3	1	2	2	1	2	1	5	0	2	13	0	2	1
248	4	1	3	2	1	3	1	5	0	1	14	0	2	1
249	4	1	2	2	0	3	1	4	0	1	10	0	2	1
250	4	0	2	2	0	3	1	4	0	1	10	0	2	0
251	4	0	2	2	0	3	1	3	0	1	9	0	3	0
252	4	2	2	2	0	3	0	4	0	1	10	0	3	0
253	2	3	3	2	0	4	1	4	0	1	11	0	2	2
254	2	3	2	2	0	4	1	4	0	1	12	0	1	2
255	2	2	3	1	0	4	1	4	0	0	15	0	1	2
256	2	3	3	1	1	4	1	4	0	0	16	0	2	2

257	2	4	4	2	1	4	1	5	0	0	19	0	2	2
258	1	3	4	2	1	4	1	4	0	0	22	0	2	2
259	0	3	4	1	1	3	1	3	0	0	21	0	2	1
260	0	5	3	1	1	3	1	3	0	0	22	0	2	0
261	0	5	3	1	0	3	2	3	0	0	21	0	2	0
262	0	4	3	1	0	3	2	4	0	0	20	0	2	0
263	0	3	2	1	0	3	3	4	0	0	20	0	2	0
264	0	4	2	0	0	3	2	3	0	0	17	0	2	1
265	0	4	2	0	0	3	2	3	0	0	15	0	2	1
266	0	4	1	0	0	3	2	3	0	0	16	0	2	1
267	0	4	1	0	0	3	3	3	0	0	16	0	1	1
268	1	4	0	0	0	4	3	3	0	0	17	0	1	1
269	1	4	0	0	1	4	4	3	0	0	18	0	1	0
270	3	4	1	0	1	4	4	2	0	0	19	0	1	0
271	3	4	1	0	1	4	4	2	0	0	19	0	1	0
272	3	4	1	0	1	4	4	2	0	0	19	0	1	0
273	2	5	1	0	1	4	2	2	0	0	17	0	1	0
274	3	4	2	0	1	4	2	2	0	0	12	0	1	0
275	3	4	2	0	2	6	2	2	0	0	14	0	1	0
276	2	4	2	0	2	6	1	2	0	0	13	0	2	0
277	1	4	2	0	2	7	1	2	0	0	12	0	2	0
278	0	3	2	0	2	8	3	2	0	0	10	0	2	0
279	0	3	2	0	2	8	3	2	0	0	11	0	2	0
280	0	3	1	0	2	7	3	2	0	0	12	0	2	0
281	0	3	1	0	1	7	4	2	0	0	13	0	1	0
282	1	2	1	0	1	5	4	1	0	0	14	0	1	0
283	1	4	1	1	1	6	4	1	0	0	12	0	1	0
284	1	4	1	1	1	6	2	1	0	0	10	0	1	0

285	1	5	2	1	1	6	2	1	0	0	9	0	2	0
286	1	6	4	1	1	6	2	1	0	0	7	0	3	0
287	2	6	4	1	1	6	1	1	0	0	7	0	3	0
288	2	6	4	1	1	6	1	1	0	0	7	0	3	0
289	2	6	4	1	1	7	1	2	0	0	9	0	3	0
290	2	6	4	1	1	6	1	2	0	0	9	0	3	0
291	4	6	5	1	1	6	1	2	0	0	10	0	4	0
292	4	6	5	1	1	7	1	2	0	0	12	0	4	0
293	4	6	3	1	1	6	1	2	0	0	12	0	4	0
294	4	6	2	1	1	7	1	1	0	0	12	0	4	0
295	4	6	2	2	1	8	1	1	0	0	11	0	4	1
296	4	7	2	2	1	8	1	1	0	0	13	0	4	1
297	4	7	2	2	1	8	1	1	0	0	13	0	4	1
298	2	8	2	2	1	9	1	1	0	0	14	0	4	1
299	2	8	1	2	1	8	1	1	0	0	13	0	4	1
300	2	8	1	2	1	7	1	1	0	0	12	0	4	1
301	3	6	2	2	1	7	2	0	0	0	6	0	1	1
302	3	6	2	2	1	7	2	0	0	0	6	0	1	1
303	3	6	2	2	2	7	2	0	0	0	6	0	1	1
304	3	6	2	2	2	7	2	0	0	0	6	0	2	1
305	2	6	2	2	2	7	2	0	0	0	7	0	2	1
306	2	5	2	2	2	7	2	0	0	0	8	0	2	1
307	2	5	2	2	2	6	2	0	0	0	9	0	2	1
308	2	5	1	2	2	5	2	0	0	0	7	0	2	1
309	2	5	1	2	2	6	2	0	0	0	9	0	2	1
310	2	5	1	2	2	5	2	0	0	0	9	0	3	2
311	2	5	1	2	2	4	2	0	0	0	9	0	3	2
312	3	5	1	2	2	4	2	0	0	0	9	0	3	2

313	3	5	2	1	1	4	2	0	0	0	10	0	3	2
314	2	6	2	1	1	4	2	0	0	0	10	0	2	2
315	2	5	2	1	1	3	2	1	0	0	10	0	1	2
316	2	5	2	1	2	3	2	1	0	0	9	0	1	2
317	3	5	2	1	2	3	1	1	0	0	10	0	1	1
318	4	5	2	1	2	3	1	1	0	0	10	0	1	1
319	4	5	2	1	2	3	1	1	0	0	11	0	3	0
320	4	5	1	1	2	3	1	1	0	0	10	0	3	0
321	4	5	3	1	2	3	1	1	0	0	10	0	5	1
322	3	4	3	1	2	4	1	1	0	0	9	0	5	1
323	3	3	3	1	2	4	2	1	0	0	9	0	4	1
324	3	3	4	0	2	2	2	1	0	0	11	0	4	1
325	3	2	2	0	2	2	1	1	0	0	11	0	4	1
326	3	1	3	0	2	3	1	1	0	0	11	0	2	1
327	4	1	3	0	2	3	1	1	0	0	9	0	2	1
328	2	1	3	0	2	4	1	1	0	0	9	1	3	0
329	2	1	3	1	2	5	1	1	0	0	9	1	4	0
330	2	2	2	1	2	5	1	1	0	0	9	1	4	1
331	2	2	2	1	2	5	1	1	0	0	10	1	3	1
332	1	2	1	1	2	5	1	1	0	0	12	1	3	1
333	1	2	1	0	3	4	1	0	0	0	12	1	3	1
334	0	2	1	0	3	4	2	0	0	0	13	1	3	1
335	0	2	1	1	3	4	2	0	0	0	12	1	3	0
336	1	2	2	1	3	4	2	0	0	0	10	1	4	0
337	1	2	2	1	3	4	2	0	0	0	9	1	5	0
338	1	1	3	1	3	1	2	0	0	0	10	1	5	0
339	1	1	3	1	2	2	2	0	0	0	11	1	5	0
340	1	1	2	0	2	2	2	0	0	0	11	1	4	0

341	1	1	3	0	2	2	2	0	0	0	9	1	3	0
342	1	2	3	0	2	3	2	1	0	0	12	0	3	0
343	1	2	3	0	2	3	1	1	0	0	13	0	3	0
344	2	2	3	0	2	1	1	1	0	0	11	0	3	1
345	2	2	4	0	2	2	1	1	0	0	10	0	3	1
346	2	2	3	0	1	1	1	1	0	0	10	0	4	1
347	2	2	3	0	1	1	1	1	0	0	10	0	5	1
348	2	2	3	0	1	1	1	0	0	0	11	0	5	2
349	1	2	2	1	1	1	1	1	0	0	10	0	6	1
350	0	1	2	1	1	1	1	1	1	0	9	0	4	5
351	0	1	3	1	1	1	1	2	1	0	9	0	4	5
352	0	1	4	1	1	1	1	2	1	0	10	0	4	5
353	0	1	4	1	1	1	1	2	1	0	10	0	5	5
354	1	1	4	2	1	1	1	2	1	0	11	0	5	5
355	1	1	4	2	1	0	1	1	1	0	9	0	5	5
356	1	2	4	2	1	1	1	1	1	0	8	0	5	5
357	1	2	5	3	2	1	1	1	1	0	10	0	5	4
358	2	2	6	3	2	2	1	1	0	0	10	0	4	3
359	2	2	6	3	3	2	1	0	0	0	10	0	4	2
360	2	2	5	3	2	3	0	0	0	0	9	0	4	2
361	2	2	5	3	2	5	0	0	0	1	8	0	3	2
362	2	2	5	3	2	6	1	0	0	1	8	0	3	1
363	2	2	5	3	1	6	1	1	1	1	7	0	3	1
364	2	2	6	3	1	6	1	1	1	1	10	0	3	1
365	2	2	4	3	1	5	1	1	1	1	10	0	3	1
366	2	2	4	3	1	4	1	1	1	1	11	0	3	1
367	2	2	5	2	1	4	1	2	1	1	11	0	3	1
368	3	2	5	2	0	3	1	2	1	2	10	0	3	1

369	3	2	5	2	0	2	0	2	1	2	11	0	4	1
370	4	2	5	1	0	2	0	2	1	1	11	0	5	1
371	4	2	5	1	0	3	0	2	0	0	12	0	4	1
372	4	1	3	1	0	5	0	2	1	0	11	0	4	1
373	4	1	3	3	0	5	1	2	1	1	13	0	4	1
374	3	1	4	2	0	5	1	2	1	1	12	0	4	1
375	3	1	3	2	0	5	1	2	1	1	13	0	4	1
376	4	2	2	3	0	4	1	2	1	1	13	0	4	1
377	4	2	2	3	0	3	1	2	1	1	13	0	4	1
378	4	0	2	3	1	3	2	3	1	1	11	0	3	1
379	4	1	2	3	1	3	2	3	1	1	10	0	1	1
380	4	2	2	2	1	3	2	3	1	1	11	0	1	1
381	4	2	1	2	1	4	1	3	1	1	11	0	1	1
382	4	2	1	1	1	4	2	3	1	0	10	0	1	1
383	4	2	1	2	1	5	2	3	1	0	9	0	1	1
384	4	2	2	2	1	4	2	2	1	0	9	0	1	1
385	4	4	2	4	1	4	1	2	0	1	8	0	1	2
386	4	5	2	3	1	3	1	2	0	1	7	0	1	2
387	3	3	2	2	1	4	1	1	0	1	6	0	1	2
388	3	2	2	1	2	4	1	1	0	1	8	0	3	2
389	3	1	2	0	2	1	1	1	0	1	6	0	3	2
390	3	1	2	0	1	1	2	1	0	1	6	0	4	2
391	2	3	3	0	1	1	1	1	0	1	7	0	4	2
392	2	4	3	0	1	1	1	1	0	1	7	0	4	2
393	2	4	3	0	1	1	1	1	0	1	7	0	3	2
394	2	4	3	0	1	3	1	1	0	0	7	0	4	2
395	2	4	3	1	1	3	1	1	0	0	6	0	4	1
396	1	2	2	0	1	3	0	1	0	0	6	0	2	1

397	1	2	1	0	1	2	0	1	0	0	6	0	2	1
398	2	1	1	0	1	1	0	1	0	0	7	0	2	1
399	2	1	1	0	1	0	0	1	0	0	5	0	2	0
400	1	1	1	0	1	0	0	1	0	0	5	0	2	0

D.3.3 Archaeological Data – Small Flakes (<30mm)

Loc.	**RBSR**	**BCSR**	**VB**	**DBCS**	**OBS2**	**NBC6**	**SGS**	**OB**	**OBS1**	**SADBS**	**ALBS**	**LBSR**	**NBC10**	**PP9**
1	0	2	0	0	3	1	0	0	0	1	0	1	0	0
2	0	3	0	1	4	1	0	0	0	1	0	1	0	0
3	0	3	0	1	4	1	0	0	0	1	0	1	0	0
4	0	3	0	1	5	1	0	0	0	1	0	1	0	0
5	0	3	1	2	5	1	0	0	0	1	0	1	0	0
6	0	4	1	2	6	1	0	0	0	1	0	1	0	0
7	0	5	1	2	6	1	0	0	0	1	0	2	0	0
8	0	3	1	3	6	1	0	1	0	1	0	2	0	0
9	0	3	1	3	7	1	0	1	0	1	0	2	0	0
10	0	3	1	3	7	1	0	1	0	1	0	2	0	0
11	0	5	1	3	7	1	0	1	1	1	0	2	0	0
12	0	4	1	3	7	1	0	1	1	1	0	2	0	0
13	0	3	1	3	7	1	0	1	1	1	0	1	0	0
14	0	4	1	3	7	1	0	1	1	1	0	3	0	0
15	0	4	1	3	7	1	0	1	1	1	0	3	0	0
16	0	4	1	3	6	1	0	1	1	1	0	3	0	1
17	1	3	1	2	6	1	1	1	1	1	0	3	0	1

18	1	4	2	2	6	1	1	1	1	0	0	3	0	1
19	1	4	2	2	6	1	1	1	1	1	0	3	0	1
20	1	4	2	2	6	1	1	1	1	2	0	3	0	1
21	0	4	2	2	7	1	1	2	1	2	0	3	0	1
22	0	2	2	2	7	1	1	2	2	2	0	4	0	1
23	0	4	1	3	8	1	1	2	2	2	0	4	0	1
24	0	4	2	5	8	1	1	2	2	1	0	5	0	1
25	1	4	2	5	8	1	1	2	2	1	0	5	0	1
26	1	4	2	4	8	1	1	1	2	1	1	5	0	1
27	1	4	2	4	8	1	1	1	2	0	1	5	0	1
28	1	2	2	4	8	1	1	1	2	0	1	5	0	0
29	1	2	2	4	9	1	1	1	2	0	1	5	0	0
30	1	5	2	2	10	1	0	2	1	1	1	4	0	0
31	1	5	2	2	9	2	0	2	1	1	1	5	0	0
32	1	5	2	2	8	2	1	2	1	1	1	5	0	0
33	1	6	2	2	6	2	0	2	1	1	1	5	0	0
34	1	7	2	3	4	2	0	2	0	1	1	5	0	0
35	1	6	2	3	4	2	0	2	0	1	1	4	0	0
36	1	6	2	3	4	2	0	2	0	1	1	5	0	0
37	0	6	1	4	6	2	0	2	0	0	1	6	0	0
38	1	6	1	5	6	1	0	2	0	0	1	5	0	0
39	1	4	0	4	6	1	1	2	0	0	1	5	0	0
40	2	5	0	5	7	2	1	2	0	0	1	4	0	0
41	2	5	0	5	6	2	1	2	0	0	1	4	0	0
42	1	5	1	5	6	2	1	2	0	0	1	4	0	0
43	1	7	1	5	7	2	1	2	0	0	1	3	0	0
44	1	8	1	5	8	2	1	2	0	0	1	3	0	0
45	1	8	1	5	9	2	1	0	0	0	1	2	0	0

46	3	9	1	6	9	2	1	0	1	0	1	1	0	0
47	4	10	1	6	9	2	2	0	2	1	1	1	0	0
48	4	10	1	5	8	2	1	0	2	1	1	1	0	0
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311	3	17	0	8	2	0	0	3	0	0	1	3	0	0
312	3	16	0	8	2	0	0	3	0	0	1	3	0	0
313	3	15	0	8	2	0	0	3	0	0	1	3	0	0
314	3	14	1	8	2	0	0	3	1	0	1	3	0	0
315	3	13	1	8	1	0	0	2	1	0	1	2	0	0
316	3	13	1	8	1	0	0	2	1	0	1	1	0	0
317	3	11	1	8	2	0	0	2	1	0	1	1	0	0
318	3	10	1	8	3	0	0	2	1	0	0	0	0	0
319	3	9	1	8	3	0	0	2	2	0	0	1	0	0
320	3	8	0	7	3	0	0	2	2	0	0	1	0	0
321	1	8	0	7	3	0	0	0	2	0	0	1	0	0
322	2	8	0	7	3	0	0	0	2	0	0	1	0	0
323	3	8	0	7	3	0	0	0	2	0	0	1	0	0
324	3	7	0	7	4	0	0	0	2	0	0	1	0	0
325	3	5	0	7	4	0	1	1	3	0	0	2	0	0

326	3	5	0	7	5	0	1	1	2	0	0	2	0	0
327	3	5	0	7	5	0	1	1	1	0	0	2	0	0
328	2	5	0	7	5	0	1	1	1	0	0	2	0	0
329	2	5	0	7	5	0	1	1	1	0	0	2	0	0
330	2	5	0	7	6	0	1	1	1	0	0	2	0	0
331	2	5	0	8	6	0	1	1	1	0	0	2	0	0
332	1	3	1	9	7	0	1	1	1	0	0	2	0	0
333	1	3	1	10	6	0	1	2	1	0	0	2	0	0
334	1	3	1	10	6	0	1	2	2	0	0	3	0	0
335	1	3	1	8	6	0	1	2	3	0	0	3	0	0
336	1	2	1	9	5	0	1	2	3	0	0	4	0	0
337	2	3	1	9	5	0	1	2	3	0	0	4	0	0
338	2	4	1	9	5	0	1	2	2	0	0	4	0	0
339	2	4	1	10	6	0	1	2	2	0	0	3	0	0
340	2	6	1	11	7	0	1	2	1	0	1	4	0	0
341	1	6	1	11	7	0	1	3	1	0	1	3	0	0
342	1	5	1	10	6	0	1	3	1	0	1	3	0	0
343	2	5	1	10	7	0	1	3	2	0	1	3	0	0
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345	2	5	1	10	7	0	1	3	2	0	1	3	0	0
346	2	6	1	9	7	0	1	3	2	0	1	3	0	0
347	2	6	1	8	6	0	1	3	2	0	1	3	0	0
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350	2	6	1	9	4	0	1	2	1	0	1	4	0	0
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352	2	6	1	6	4	0	0	2	1	0	0	4	0	0
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354	1	5	1	7	5	0	0	2	2	0	1	4	0	0
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356	1	4	0	6	4	0	0	2	2	0	1	2	0	0
357	1	4	0	5	4	0	0	1	2	0	1	3	0	0
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361	2	5	1	4	3	0	0	2	2	0	0	2	0	0
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365	2	7	1	5	3	0	0	2	2	0	0	3	0	0
366	2	7	1	5	2	0	0	1	2	0	0	3	0	0
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368	2	6	1	3	4	0	0	1	2	0	0	4	0	0
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371	2	5	1	4	3	0	0	1	1	0	0	4	0	0
372	2	6	1	6	4	0	0	1	2	0	0	3	0	0
373	2	6	0	7	5	0	0	1	3	0	0	3	0	0
374	2	6	0	7	5	0	0	1	3	1	0	2	0	0
375	2	8	0	6	4	0	0	0	2	1	0	2	0	0
376	2	8	0	5	4	0	0	1	1	1	0	2	0	0
377	2	7	1	6	4	0	0	1	2	1	0	2	0	0
378	1	6	1	5	3	0	0	1	2	1	0	2	0	1
379	1	7	1	4	3	0	0	1	2	1	0	2	0	1
380	1	5	1	4	3	0	0	1	2	1	1	2	0	1
381	0	3	1	4	3	0	0	1	2	1	1	2	0	1

382	0	1	1	5	3	0	0	1	2	1	1	2	0	1
383	0	1	1	4	4	0	0	1	2	1	0	3	0	1
384	0	2	1	5	4	0	0	0	2	1	0	3	0	1
385	0	2	0	5	4	0	0	0	2	1	0	3	0	0
386	0	3	0	6	4	0	0	0	3	1	0	2	0	0
387	0	3	0	5	3	0	0	0	3	0	0	2	0	0
388	0	2	0	4	3	0	0	0	3	0	0	2	0	0
389	0	1	0	4	2	0	0	0	3	0	0	2	0	0
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391	0	1	0	4	2	0	0	0	3	0	0	2	0	0
392	0	1	0	4	2	0	0	0	2	0	0	0	0	0
393	0	1	0	4	2	0	0	0	2	0	0	0	0	0
394	0	1	0	3	2	0	0	0	2	0	0	0	0	0
395	0	1	0	3	2	0	0	0	2	0	0	0	0	0
396	0	1	0	2	2	0	0	0	2	0	0	0	0	0
397	0	1	0	2	2	0	0	0	2	0	0	0	0	0
398	0	0	0	2	1	0	0	0	1	0	0	0	0	0
399	0	0	0	2	1	0	0	0	1	0	0	0	0	0
400	0	0	0	2	1	0	0	0	1	0	0	0	0	0