3D Scanning and Geometric Morphometrics: An Investigation of Dorset Harpoon Head Variability

By

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A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Arts

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St. John's, Newfoundland

July 5th, 2022

Abstract

This thesis aims to improve understandings of harpoon head variability among the Dorset by leveraging novel 3D scanning and geometric morphometric techniques. To achieve this aim, this study first orients the reader by providing a deeper understanding of variability as a research framework and provides more context on how variability frameworks have enabled Arctic archaeologists to understand the relational positioning of harpoon heads within Dorset realities. With the theoretical framework established, this study details emerging techniques used to measure and compare harpoon head morphology using 3D scanning and 3D landmark placement. These are then applied in a study employing geometric morphometrics to harpoon heads from the three near-contemporaneous sites of Saatut (Peha-1), Tayara (KbFk-7), and Philip's Garden (EeBi-1) for the analysis of shape variance with the aim of deriving patterns of variability. The analysis reveals that the shapes of harpoon heads from different sites are statistically distinguishable and that certain aspects of traditional knowledge are observable at different spatial scales. Furthermore, the study will provide some preliminary reflections on the reliability and analytical usefulness of the technique in comparison to previous analytical methods employed in the Eastern Arctic and recommend next steps for future applications of the techniques, their advantages, and their limitations.

Acknowledgements

This project was accomplished with the generous help and support of many individuals and organizations. Thanks is given to the following organizations for providing invaluable financial support: Institute of Social and Economic Research, the Smallwood Foundation, Memorial University of Newfoundland, and Memorial University's Department of Archaeology. Special thanks are given to the Newfoundland and Labrador Provincial Archaeology Office for funding the technology required to accomplish this project.

This project would not have been possible without the access, help, and support received by the museums and repositories which housed the collections studied for this project. Stacey Girling-Christie, Patti Davis-Perkins, Dr. Karen Ryan, Dr. Gabe Yanicki, and Dr. Matt Betts were indispensable during my time at the Canadian Museum of History. A special thanks to Executive Director William Beveridge of Nunavut's Inuit Heritage Trust for permitting me to study Nunavut's amazing archaeological collections. Susan Lofthouse, Elsa Cencig, Candide Harvey, and Directeur Générale Robert Fréchette made my experience studying collections from the Avataq Cultural Institute immensely fun and fruitful. Finally, a big thanks to Dr. Patty Wells and Dominique Lavers for their help with accessing Newfoundland collections.

Dr. Pete Whitridge, my supervisor, thank you for letting me follow my interests and undertake this amazing but complicated project, for supporting and supervising my work, and for all the feedback that brought me back to reality when I wrote too much. Thank you for the opportunity to be part of this department, for letting me grow in experience by taking me to northern Labrador, and for expanding my mind through the theories you taught me in class. Also from the department, I'd like to thank the Department of Archaeology graduate coordinator Dr. Meghan Burchell, and professors Dr. Oscar Moro Abadía, Dr. Michael Deal, Dr. Lisa Rankin, Dr. Veronique Forbes, and Dr. Barry Gaulton for their help and support over the years, in addition to Donna Teasdale for help concerning artifact conservation. I would like to also thank Fran Banfield and Glenda Hiscock for the amazing work they do to help all of the department's students.

Dr. Jim Savelle, thank you for introducing me to arctic archaeology, for letting me participate in four field seasons in the Foxe Basin region, and for showing me the value of quantitative analyses in archaeology.

More thanks are given to James Williamson, for having my back, being a great friend and colleague, for teaching me and pushing me to learn, and for offering interesting opportunities. Greater discussions and disagreements were never had, it has been a pleasure.

A big thank you to the Mikki family in Igloolik, Nunavut for showing me the land and arctic life, for your warmth and friendship, for your patience and understanding, for your willingness to teach and for making me feel part of the family. I love you all and hope to see you all soon.

To my friends who supported me in some way or another throughout this project. Thank you, Johanna Cole for letting me throw ideas at you and always being excited for me and my work. Mads Kildegaard Nielsen, for sharing in both my love for the Arctic and in my woes for academic life. Joe O'Connor and Marion Boulard for being the best roommates and for providing enough laughs to make the stress from a hard day's work just melt away. Sam Walker and Kyle Forsyth, thank you for being the best friends and colleagues over the years. I thank you two for supporting me, with Xenia Kepler, during one of the most emotionally taxing experiences of my life, and for your overall support and help over the years. LA Benoit, thank you for keeping me on task and helping me organize my time when I needed it. Yifeng Wang, thank you for helping me muddle through any methodological, quantitative, and statistical ideas I had or was trying to work out; many parts of this thesis wouldn't have been possible without you.

To my family: mom, thank you for the unending everything you did and do for me. John, thanks for kicking me when I needed it, for all the edits you provided, and for fighting my stubbornness. Victoria, thanks for believing in me even when I didn't. Dad, thanks for reading my stuff and helping me figure out structure. Thank you all for the support you gave me throughout this adventure.

Judah Palluq, you left us too soon and I miss you terribly. My fondest and most vivid memories of my time in the Arctic were when we worked together on your home island of Kapuivik. You showed me the tallest peak, where you had watched the fireworks coming from Igloolik every New Year as a kid. You taught me to hunt with a .303, which was all we had and hilariously overkill for small game. You taught me to butcher and cook meat in the Inuit fashion. My favorite memory is of a particularly warm summer night, we took our camping chairs outside the food tent and sat watching the never-setting arctic sun skim across the horizon as you shared hunting stories. You taught me genuine kindness and selflessness through your every action. Qujannamiik, old friend.

Finally, I would like to thank Dr. Pierre Desrosiers and Dr. Vaughn Grimes for reviewing my thesis with such speed and for providing valuable feedback.

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CHAPTER 1: INTRODUCTION

The main objective of this project was to investigate the nature of shape variability in Dorset Pre-Inuit harpoon heads. This was accomplished through (i) a theoretical review of the processes which create variability in hunter-gatherer material culture; (ii) an assessment of how Dorset harpoon head variability was evaluated and communicated in past scholarly efforts; and (iii) the development, application, and analysis of novel data acquisition techniques using 3D scanning and analytic techniques using R and geometric morphometrics to a large sample of harpoon heads spanning three Middle Dorset sites.

The organic preservation of material culture in the Canadian Arctic offers a unique opportunity to study hunter-gatherer identities, activities, and lifestyles from millennia past. Twentieth century arctic archaeologists (Maxwell 1985; Meldgaard n.d.; Stordeur-Yedid 1980; Taylor 1968) have leveraged variability in organic technologies to create classification schemes and chronologies to inform local and culture-wide Dorset Pre-Inuit culture histories. Together their approaches to typological classifications demonstrate the usefulness of qualitative techniques in identifying large-scale spatiotemporal variability, but each lack precise methods of explaining shape variability in specimens identified as the same type. Despite these shortcomings, their foundational work on Dorset Pre-Inuit harpoon heads in the Eastern Arctic remains at the heart of current scholarly understandings while the overhauling of their technical approaches has not generally been viewed as an urgent priority.

Recognizing the rapid evolution in analytical technologies and techniques related to the analysis of archaeological objects, this project undertakes quantitative analysis, leveraging emerging 3D scanning and 3D geometric morphometrics to investigate shape variability amongst Dorset harpoon head assemblages at different spatial scales. This study applies these new methods to three Middle Dorset assemblages from Nunavut (PeHa-1), the Nunavik marine region (KbFk-7), and Newfoundland (EeBi-1) to reinspect the reliability of the prevalent typological frameworks and evaluate how the combination of qualitative and quantitative techniques can inform methodologies to study variability going forward.

Naturally, there are challenges with the implementation of new technologies. While discussing initial findings, this study will also provide some general commentary on the benefits, drawbacks, limitations, and opportunities for improvements when using 3D methodologies and the statistical analysis of shape variance in other contexts. Nevertheless, this project aspires to shed light on how Dorset traditional knowledge manifests across near-contemporaneous space, how using geometric morphometrics is the natural continuation of previous classification methods, and how the methods employed can inform variability formation processes.

1.1 Research Questions

1. What is variability?

The concepts of variability and variation are central to material culture studies. The nature of pre-industrial manufacturing, as in the case of hunter-gatherer material productions, inherently leads to variability as the means and modes of production may be as fluid as the individual differences between the participants in production and their circumstances throughout time and space. While the question of 'how' material culture varies is the object of many archaeological investigations, understanding 'why' it may vary is a necessary first step. Cultural transmission theory (CT) offers a theoretical framework which evaluates how transmission affects variability at larger evolutionary scales through the variables of context, content, mode, and individual filters (Eerkens and Lipo 2007). Other sources of variability evaluated include the specific circumstances of manufacture, as the individual producing material culture is faced with a variety of situations ranging for resource availability to changing ecological circumstances which may require adaptations. Furthermore, the individuals involved in manufacture have the agency to make choices, such that the processes involved in self-determination and innovation may result in any amount of variability during manufacture. This research question will be addressed in Chapter 2.

2. How has variability previously been studied?

The study of Dorset harpoon heads has a rich history starting in 1925 with the first published recognition of the Dorset as being a separate entity from the Inuit by archaeologist Diamond Jenness. As more material associated with Dorset groups was uncovered and recognized in the first half of the 20th century, scholars continued to propose artifact classification schemes (Collins, 1950; de Laguna, 1946; Holtved, 1944; Mathiassen, 1927) but were severely limited by small and widely spaced samples, collections without secure contexts, and the lack of absolute dating methods. Studies of Dorset harpoon heads from the latter half of the 20th century, however, had access to much larger collections with secure contexts and could benefit from early 14C dating techniques. Taylor's (1968) work defined and named numerous harpoon head types and provides a convincing comparative study, while Maxwell (1985) codified and expanded on Taylor's work to create the most widely accepted typology still in use today. Neither, however, is as compelling as Meldgaard's (n.d.) unpublished typology, which includes a very large and temporally diverse collection from a single defined region. Even without the use of 14C dating, Melgaard was able to successfully employ the effect of isostatic rebound to create a relatively dated chronology using assemblages from successive beach ridges.

Assessing the literature on Dorset harpoon heads revealed that variability was consistently assessed through means of typologies and other classification schemes. It also revealed that the diverse application of these tools, the differing spatial and temporal depth of the material used, and the differential use of lists, descriptions, and visual aids to present each typology lacked standardization between scholars, which in turn affected the accessibility and reusability of each work to differing extents. The present assessment was necessary to ground this project within the history of Dorset harpoon head studies, to contextualize the three collections under study, and to inform the selection of specimen-types for successful intra-type shape comparison. Additionally, this assessment revealed the need for new large scale material culture studies using updated methods and theory as previous works have stood mostly unchallenged since the 1980s. The question of how variability has been previously studied will be addressed in Chapter 3.

3. Is geometric morphometrics capable of distinguishing variability?

The use of geometric morphometrics has found success in the field of archaeology since the early 1990s as scholars continue to try to understand how shape varies in both material culture and in biological specimens (eg. Ameen et al. 2019; Bretzke and Conard 2012; Herzlinger and Goren-Inbar 2019; O'Higgins 2000; Rohlf and Slice 1990). This method makes use of General Procrustes Analysis, which utilizes rotated, scaled, and centered user specified landmarks to create a shape dataset independent of object size. Lithic implements are the most common tool type to undergo geometric morphometric analysis. Such studies, however, are often limited to top-view contour shape based on simple two-dimensional data easily obtained through photographs. Analyses of organic objects rarely make use of such methods, which is likely a result of the usual taphonomic bias which limits the recovery of organic materials in most archaeological settings. Archaeology in arctic environments often presents exceptional preservation, and the recovery of organic material culture and faunal remains is quite common. As a result, the geometric morphometric analysis of three-dimensional organic technology is feasible, but has never been undertaken before this study, and this study aims to determine whether shape variation between specimens and assemblages can be resolved using Dorset harpoon heads. This central question will be featured in the discussions throughout chapters 4, 5, and 6.

4. What patterns of variability are revealed using geometric morphometrics?

In the case that geometric morphometrics is successful using 3D landmark data collected from Dorset harpoon heads, what sort of patterns could the resulting shape relationships produce? The resulting analysis may reveal aspects of traditional knowledge at multiple scales, whether relationships are consistent for different parts of the harpoon heads, and whether the geographical relationship between the three sites effects morphological variability. The patterns which are revealed using geometric morphometrics will be discussed in chapters 5 and 6.

5. What is the relationship between geometric morphometrics and previous analytical methods?

Using the analysis of past efforts to study harpoon head variability in combination with the results and observations obtained from this study, the relationship between geometric morphometrics and traditional approaches to classification will be evaluated in the context of Dorset harpoon heads. What is this relationship? Does each method complement one another, or do they exist on separate planes of analysis? What does the future hold for studies of variability? Addressed throughout this thesis are both the theoretical and methodological ramifications of each distinct method, with more substantial discussions in chapters 5 and 6.

While the goals of this project remain focused on the utility of methods employed and the specific collections used for quantitative comparison, the larger aim of this study is to move arctic archaeology into more quantitative and statistically grounded studies of material culture. Subjectivity, bias, and unclear workflows plague material culture studies, especially when it comes to old classification schemes that have not benefited from thorough revamping. Furthermore, the lack of analytical standardization prevents cross-study comparisons and forces the constant reanalysis of site assemblages which puts undue weight and importance on those recovered earlier. This project seeks to promote easily understood and reproducible methods to understand objects and their shapes in a quantitative fashion. Additionally, this project promotes collection-based work. Hundreds of thousands of artifacts are available for study in museum repositories, many of which have never benefitted from complete analysis. The methods proposed in this project can be used to revisit previously studied or forgotten collections of artifacts, as their statistical and digital nature can potentially squeeze out more data than any of the analyses to which they were subjected. The clear potential deriving from a combination of upgraded theory and method will hopefully serve to reinvigorate material culture studies in eastern arctic and Dorset archaeologies.

CHAPTER 2: VARIABILITY THEORY

Cultural transmission (CT) theory offers an existing and operational foundation by which to study variability. CT is the idea that similarity in behavior and material culture may be caused by a nongenetic mechanism of information exchange; it provides a quantitative framework to model evolutionary processes to understand artifact variation in space and time through the generation of testable hypotheses (Eerkens and Lipo 2007:240).

While CT is implicit in many analytical models developed in the 19th and 20th centuries, as seen in the works of culture historians, it lacked a clear theoretical basis and instead relied on empirical generalizations and diffusion as sufficient explanations for similarities between groups when the movement of populations and goods could not (Eerkens and Lipo 2007:241). Culture historians were interested in the concepts and manifestations of change, similarities, and variability in material culture, but less so in explaining "rates of change, rates of error during transmission, what conditions might foster greater or slower rates of error, different transmission mechanisms, and how diffusion could inform more generally on prehistoric cultures" (Eerkens and Lipo 2007:241). As diffusionists relied on 'culture' as the unit of study, modern CT focuses on the individual, their actions, and decisions, as it recognizes their ability to obtain information, modify it, and transmit modified information. Indeed, it is the recognition that individuals follow rules by which they transmit and accept information, that these rules influence the patterning and distributions of traits in populations, and that there is variation in people, the rules, and their applications which led to the development of CT in anthropology (Eerkens and Lipo 2007:242).

As a non-genetic system of inheritance, it is faster than its genetic counterpart but has less fidelity than biological transmission (O'Brien and Shennan 2010:8). In its greater speed, it allows humans to respond to environmental, social, and economic changes within lifetimes as opposed to between generations (Eerkens and Lipo 2007:243). These differences, however, do not mean that genetic inheritance is an unsuitable analogy for cultural transmission. Much like genetic transmission, material culture is modeled on pre-existing knowledge and forms (O'Brien and Shennan 2010:7). In fact, "CT provides the means by which humans have accumulated a large and complex suite of culture traits" (Eerkens and Lipo 2007:243).

The processes informing cultural transmission as well as the processes undertaken by participating members of cultural transmission are central to the modern study of CT. Eerkens and Lipo (2007:252) divide the processes of CT into context, content, mode, and filters. Context covers the environment within which transmission takes place, content involves the nature of the information being exchanged, mode contains the numerous methods and situations by which information is transmitted, and filters deal with the individual themselves. Exploring these processes and how they are manifested leads to a better understanding of why variability is generated in material culture. The following section will provide an overview of these concepts.

Content refers to the cultural information being transmitted and received. Eerkens and Lipo (2007:247) argue that the "content of what is transmitted has direct implications for the resulting variation and diversity in the material culture." Content, they further explain, is composed of, but not limited to, the complexity of the information, its form, its repetitiveness, and its structure. The complexity of the information impacts its ability to be stored and recalled, and itself impacts error rates when realized in a material medium. This ties into the form which the information takes, whether visual, verbal, written, or tactile. These sensory inputs, combined with information complexity, impact the fidelity of transmission and the strength of information retention. Eerkens and Lipo (2007:247) explain that the "various human sensory systems are different in their accuracy, hence the propensity to produce error during replication of cultural information." Additionally, the repetitiveness of information transfers will impact the fidelity of the information being gained and recalled. The repetition of information reinforces its retention, which leads to reduced rates of variability. Finally, the structure of the information transmitted will affect the information received as it may have great detail or lack it; may be summarized; and may be omitted if deemed unnecessary or 'common knowledge' by the transmitter. For example, Mesoudi and Whiten (2004) determined that social information loses detail in transmission but gains high-level structure as it is summarized and further transmitted verbally. Additionally, Mesoudi et al. (2006) determined that social information, such as gossip, is more accurately transmitted than non-social information of a similar structure.

The context involves the social and physical situation and environment within which the transmission of information takes place. For instance, verbal transmission may be affected if taking place in a crowded and noisy area in comparison to a quiet area (Eerkens and Lipo 2007:249). Transmission in environments with limited light, such as dark arctic winters, limits visual transmission and increases reliance on haptic sensory information (Dawson et al. 2007). The sensory ecology thus likely has an impact on information being transmitted and how it is received.

The mode of transmission, or variability in how people accomplish transmission, has long been recognized in anthropology and led to the development of CT (Eerkens and Lipo 2007:250). Unfortunately, CT is often equated with studying the mode while the other processes affecting transmission get little to no attention. Eerkens and Lipo (2007:250) divide mode into four categories: the number of people involved in transmission, the direction of transmission, biases related to how information is obtained, and finally how the information is packaged. The first one considers how many people interact in events of CT, i.e., whether one-to-one, one-to-many, or many-to-one. For example, research shows that many-to-one transmission results in slower rates of cultural evolution than one-to-many transmission (MacDonald 1998:230; Shennan 2002).

What receives the most attention in studies of CT is the direction of transmission. Summarily, the directions include vertical transmission from parent to child, oblique transmissions involves transmission from adults from the same generation as the parents to the child or when an older child teaches a younger one, and finally horizontal transmission occurs between members of the same generation such as children to children (Lew-Levy et al. 2017:370). Eerken and Lip (2007:251) explain that "vertical transmission results in low variation within household lineages but high interhousehold variation and relatively slow rates of change" while "[h]orizontal transmission tends to minimize interhousehold but increase intrahousehold variation and can result in much more rapid rates of change over time within households."

Another aspect affecting the mode of transmission are the biases in how information is acquired. Two examples of this are 'conformist transmission' and 'prestige-based transmission". The former involves all information being gathered by a group to make well-informed decisions or simply copying the most frequent behavior in the populations (Bentley and Shennan 2003:461). On the other hand, a prestige-bias in transmission comes from the belief (real or not) that certain prestigious individuals have access to superior information (Eerkens and Lipo 2007:251).

The packaging of information is the last mode affecting CT described by Eerkens and Lipo (2007:251). Information is known to 'hitchhike' with other information (O'Brien and Lyman 2003), and involves the student copying not only the item being manufactured but also the methods and designs, perhaps because they are not sure which attributes makes for a superior product. While such aspects as shape, construction, and meaning may be separate, there are unknowable possible combinations of packaging for culturally transmitted information.

It is only possible to divide content, context, and mode on a theoretical and experimental basis, as in reality they are so intricately interconnected that when you address one you inevitably address the others. Their separation, while effectively used by Eerkens and Lipo (2007) to explain the concepts, serves as another reminder that countless conceptual categorizations made by archaeologist only exist in the mind of archaeologists. Additionally, while some of the concepts above may seem mutually exclusive, they were likely all applied in various combinations and to various extents.

Individual filters are also an important part of CT, as humans show variation in their ability to process information and in the fashion they process information. The first filter simply involves variability in sensory perception. The ability to receive and perceive sensory information may differ between individuals, as people's senses may differ in sensitivity. In a more extreme case, a person that is hard of hearing or has a visual impairment does not benefit from oral or visual cultural transmission in the same way others might.

The second filter has been described as a 'worldview' (Eerkens and Lipo 2007:244; Gabora 2004) or 'ontologies' and 'realities' (Alberti 2016). Gabora (2004:6) describes this concept as "the network of understandings that constitute one's internal model of reality." It is through the ontology of individuals that information received through CT is evaluated, interpreted, accommodated, rejected, or ignored. This phenomenon is not limited to cultural information or events of CT; information, experience, sensory input, and stimulus, however they may be manifested or defined, are all subject to these internal processes as people live their lives. Through this internal filter, the modification of information is inevitable, as understandings and meanings vary from individual to individual, and as individuals negotiate the position of new information within their reality. As a result, ontologies are dynamic, ever changing, and adaptive in response to these new experiences, however treated internally. Ontologies also vary according to scale, as interactions between individuals inform and perpetuate shared conceptual meanings which in turn inform shared realities at different scales.

CT provides a framework from which to better understand variability, including how it is created and why it exists. Its promotion of individual agency is one of its great strengths, however, its focus on the contribution of external variables to differential transmission of cultural information overwhelms considerations of the internal processes at the individual level. Judging by the nature of existing CT studies, delving deeply into internal processes, ontologies, and individual agencies does not necessarily mesh well with the quantitatively experimental nature of CT inquiry. While this project may not redress this, these theoretical considerations are central to a better understanding of how and why variability is manifested between the three geographically distinct collections of Dorset harpoon heads used in this project.

Variability, however, cannot simply be understood as the result of cultural transfers of knowledge, nor is it completely explained by the individuals internal processing of cultural information. While these may be sufficient in explaining variability over time from an evolutionary perspective, it is important to acknowledge that an individual’s manufactured tools differ from one another within assemblages, and the reason and extent to which they differ is not necessarily consistent across different groups.

Looking past CT, the whole nature of the resultant tool is determined by the individual’s ability to mentally conceptualize and plan, by the technical abilities required to engineer a functional object, and by the dexterity and physical skills of the manufacturer. This range of abilities thus remains a continuous contributor of variability in both an individual's productions over time as experience is gained, and between individuals with differing aptitudes. Continued refinement, experimentation, and innovation, whether done by all individuals or by a select few and transmitted to others, are also expected contributors to variability.

Additionally, any changes in the processes, tools, and materials involved also introduce more variability (Schiffer and Skibo 1997:2). The methods can be experimented with, materials may differ according to availability and access, and the tools may vary by situation. There may be a vast difference between what an individual may perceive as the ideal situation for manufacture versus one less so, such as manufacture in a setting of security and comfort versus scarcity and survival.

Intricate knowledge of ecology and the adaptation of material culture to different ecological settings is another source of variability. Chukchi hunters and Barrow inhabitants explain how changes in the axis/orientation of the harpoon head endblade/endblade slot can benefit hunting success in different environmental settings, e.g., how a endblade parallel to the orientation of the line hole is better suited for ice-covered seas and one perpendicular to the line hole for open water (Arutiunov and Sergeev 1972:308; Mason 2009:89; Murdoch 1893:221). While the orientation of the blade slot is quite apparent even when the cause is not known, it seems possible that much of the more discrete variability may be informed by similar ecological knowledge. The knowledge transmitted from a teacher to pupil exceeds that of how to make a harpoon head, as the tool cannot be isolated from its relationships to the environment within which is it was created to function. Its intrinsic relationship with the air, the ice, the land, the water, the fauna, and the flora necessitate an intimate knowledge of their various states and beings to better adapt to shifting realities at different scales.

Between the processes involved in the transmission of cultural knowledge and manufacturing, the potential sources which create variability in material culture are numerous. However, the overview presented here is far from being exhaustive. Thus, it remains impossible to create an overarching definition to answer 'what is variability' with regards to hunter-gatherer material culture. Nonetheless, what stands out as the most important aspect of variability remains the individual itself. Without needing to look at the material culture itself, it is evident that human individuals themselves are an expression of immense variability. Ranging from individual ontologies to individual abilities to individual personalities to the agency by which individuals make choices in the processes of transmission and manufacturing, individuals are the focal point in any discussion of variability. Intersecting it all, is the power of self-determination; the capacity to infuse material creations with conscious or unconscious self-expression and identity through anything from intimate shape variation to aesthetic or symbolic styling is inalienable. Furthermore, innovation, experimentation, and hybridization in addition to the adoption of group traditions, or their rejection, at different scales is already noticeable in Dorset harpoon head evolution over time. The influence of surrounding cultures should equally be considered. The following quantitative study of Dorset harpoon heads has the potential to shed light on many such aspects which create variability, laying the groundwork for investigations at different spatial and temporal scales to reveal facets of Dorset traditional knowledge previously inaccessible.

CHAPTER 3: BACKGROUND

3.1 Dorset Culture Background

The Laurentide Ice Sheet, covering the whole of the Eastern Arctic, began its retreat at the beginning of the Holocene, with an end to significant melting by 6800 BP (Carlson et al. 2008:105). Arctic paleoclimates remained unstable following the ice sheet retreat, resulting in highly variable local climates sensitive to the persistence of glacial ice and multi-year ice (Finkelstein 2016:661). 6500 BP marks the earliest signs of Neoglacial cooling, as evidenced by algae and floral pollen samples from Greenland. This was followed by a decline in temperature by 4500 BP with important changes in ice-mass balance and ecosystem dynamics by 4000 to 3000 BP (Finkelstein 2016:662-663).

Evidence of Pre-Inuit (aka Arctic Small Tool Tradition, ASTt, Palaeoeskimo, Palaeo-Inuit) expansions into the Eastern Arctic appears around 4500 BP. They were likely descendant from the Siberian Neolithic Bel'kachi tradition (Finkelstein 2016:674) which migrated from the Bering Strait all the way into Greenland and likely represented one of humanity's last major hunter-gatherer migration events into unoccupied territory (Savelle and Dyke 2009:267). For the next two thousand years, the North American Arctic saw a diversity of ASTt descendant groups whose relationships have been studied with differing degrees of success. The most contentious of these relationships exists between the archaeological complexes of the Pre-Dorset and Dorset, which, despite the names, has proved difficult to properly establish. Ryan (2016:746) explains that "while archaeologists generally concur that Dorset emerged in some manner from the preceding Pre-Dorset during a 'transitional' period typically dated between 2900 and 2500 BP, there is little agreement regarding the details of how, where, or why it occurred" (see Ryan

(2016) for an assessment of competing theories and Houmard (2018) for a review of generally accepted changes from Late Pre-Dorset to Dorset).

Nonetheless, while there is no debate regarding the status of the Dorset as the emergent and dominant cultural entity in the Eastern Arctic following 2500 BP, the division of the Dorset cultural unit into temporal units remains a point of contention. The Early Dorset period is generally assigned from 2600-2500 BP to 2300-2000 BP (Ryan 2016:770), the Middle Dorset from 2300-2000 BP to 1500 BP (Ryan 2016:772), and the Late Dorset from 1500 BP until their demise around 700BP. The Early and Middle Dorset were arbitrarily divided based on the disappearance of the slice on harpoon heads, and their replacement with equivalent non-sliced harpoon heads in the latter period (Maxwell 1985:196). In reality, the sequence of Dorset harpoon heads does not reflect any abrupt changes which would justify the typological weight attributed to the disappearance of the slice, which is evident in high resolution studies of evolutionary harpoon head change such as Meldgaard's (n.d) typology for Foxe Basin. Additionally, Odess (1998:429) demonstrates that the slice's demise did not occur simultaneously across the Dorset range, and that "people continued to make and use the "sliced" harpoon forms that had been out of fashion for at least 200 years in other parts of the Eastern Arctic."

What does distinguish the Early and Middle Dorset is a massive demographic shift which saw the near or complete abandonment of the High Arctic and Greenland, and a southward expansion along the Labrador coast into Newfoundland following significant cooling after 2000 BP (Ryan 2016:772). Furthermore, beyond a gradual evolution in harpoon head styles, other suggested trends include burin-like tools becoming increasingly tabular, some endblades gaining serrated edges and increasingly concave bases, the decline of ground slate and microblade industries, change in needle morphology, and art becoming increasingly widespread (Ryan 2016:773).

The collections studied for this project represent Middle Dorset occupations across the eastern arctic and subarctic regions of Canada. This period was chosen due to the nature and availability of collections; Saatut (PeHa-1) has a large unstudied harpoon head collection, Tayara (KbFk-7) has a well studied collection, and Philip's Garden (EeBi-1) has a large collection which was readily available for study at Memorial University. Together, the three collections represent Middle Dorset occupations and offer material from three spatial extremes. Thus, the focus will be on Middle Dorset cultural manifestations as the following sections briefly explore site distribution, material culture, economy, and ideology. However, it is important to note that the Middle Dorset period is often solely discussed and referenced throughout the literature in comparison to the Early Dorset period, and in turn the Early Dorset is discussed in comparison with the Pre-Dorset.

3.1.1 Dorset Site Distribution

Early Dorset site distribution is characterized as being virtually identical to that of the preceding Pre-Dorset (Maxwell 1985:167). Widespread Early Dorset occupation has been reported for the High Arctic, as far west as Victoria Island, covering the regions of Baffin Island, Igloolik, Hudson Bay and Hudson Strait, Ungava, Labrador, and the west coast of Greenland (Figure 3.1) (Ryan 2009:105). Early Dorset sites are described as being larger and more intensively used than during the Pre-Dorset period (Savelle et al. 2012), and combined with an increased use of food caches suggests lower residential mobility in favor of increased sedentarism (Erwin 2001; Le Blanc 2009; Nagy 2000; Renouf 1993). During this period, communities were likely composed of small extended families, or otherwise small groups, but saw an increase in size throughout the Early and Middle Dorset periods in addition to evidence for an increase in annual aggregation group size to 100 people or more (Dyke and Savelle 2009; Savelle and Dyke 2009; Savelle et al. 2012).

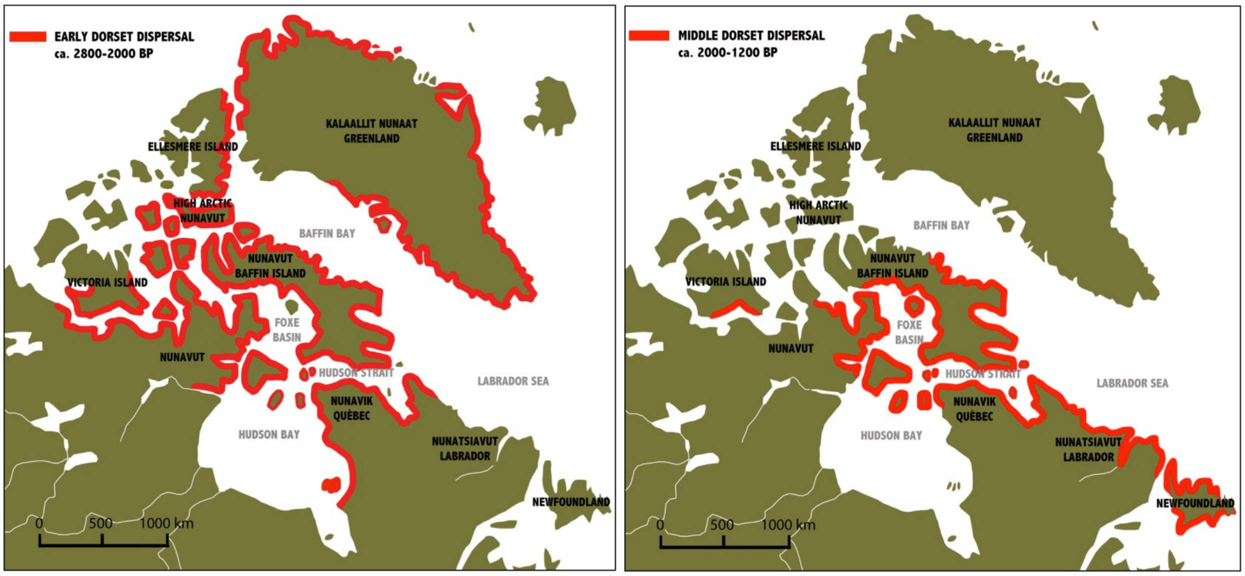


Figure 3.1 Early and Middle Dorset distribution (Hardenberg 2013:111-112)

The Middle Dorset period saw the abandonment of the High Arctic (Fitzhugh 1976:198; Maxwell 1985:198; McGhee 1976; Schledermann 1990) and Greenland (Appelt 2003; Jensen 2005, 2006; Maxwell 1985:210; Schledermann 1990). The prevailing explanation cites a major cooling event that began in the centuries prior to 2000 BP (Ryan 2009:105) and eventually saw the coldest peak of the Neoglacial period, which began some 5000 years prior, by 1800 BP. These climatic changes likely led to high arctic polynyas freezing over, limiting the range of marine mammals and their availability to Dorset high arctic dwellers, and eventually detrimentally impacting Dorset settlement (Schledermann 1980). The size and longevity of arctic sites are also reported as being reduced during the Middle Dorset stage, and possibly more prone to isolation and regionalization than at any other points throughout Pre-Inuit history (Maxwell 1985:198).

The Middle Dorset (Figure 3.1) period also saw a southward movement from Northern Labrador into Newfoundland, Saint-Pierre et Miquelon, and Quebec's Lower North Shore (Ryan 2009:105). Comparatively to northern Middle Dorset sites, Newfoundland Middle Dorset sites prospered; Philip's Garden in Newfoundland saw heavy occupation with over 68 dwelling features (Renouf 2011:32).

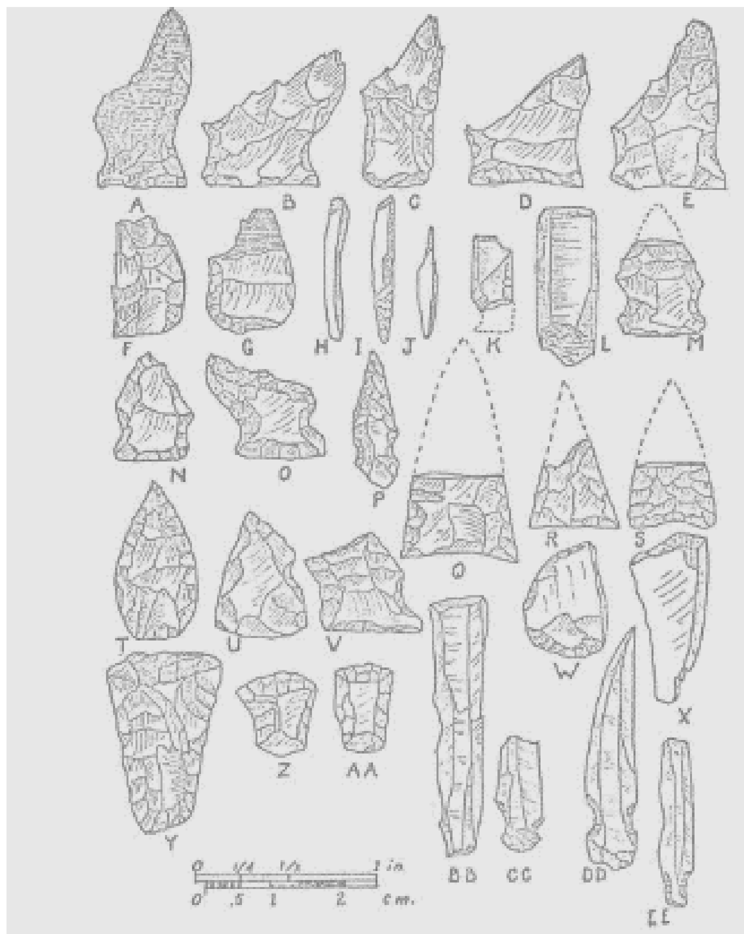


Figure 3.2 Bone Needles (left), Lithic Assemblage (right) (Wells 2012:119; Maxwell 1973: 47A)

3.1.2 Dorset Material Culture

The Dorset are part of the Late Arctic Small Tool Tradition (ASTt), whose members share strong similarities in lithic technologies and types from Siberia all the way into Greenland and Atlantic Canada (Odess 2005; Powers and Jordan 1990:268). The term was coined in the early 60s and is used to describe cultures whose toolkits contain "finely flaked and often minute end and side blades, projectile points, end and side scrapers, microblades, hafted burins, and polished adzes" (Prentiss et al. 2015) (Figure 3.2). While the definition was initially limited to the early complexes of Denbigh, Pre-Dorset, Independence I, and Saqqaq, "it is now common among those working the Eastern Arctic to refer to […] the derivative Dorset culture as "late Palaeoeskimo" or "late ASTt" (Odess 2005:6).

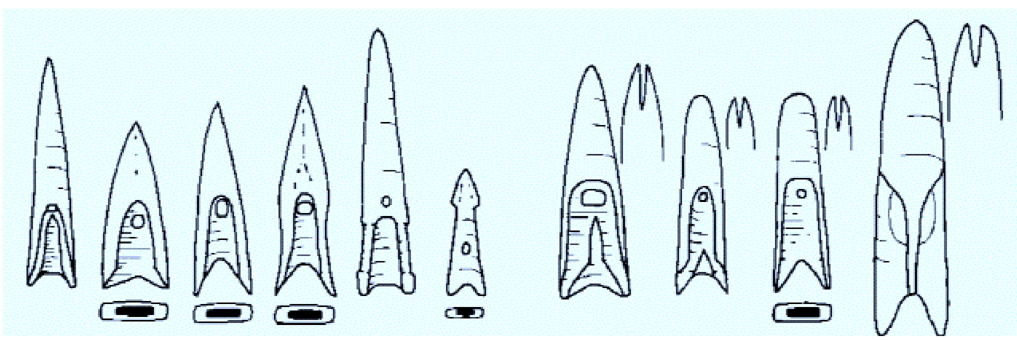


Figure 3.3 Sample of Dorset Harpoon Head Types (Desrosiers et al.

The Dorset are often described in terms of what technologies they lacked when compared to other arctic groups; these include bow drills, atlatls, bows and arrows, dog-drawn sleds, and cold trap architecture (Maxwell 1985:128). Conversely, new ice-related technologies were developed in the Early Dorset, likely in response to changing conditions during the Holocene Neoglacial cooling and an increased focus on maritime subsistence as also evidenced by shifting settlement patterns near areas of extensive fast ice and polynyas; these include snow knives, ice creepers for boots, sled shoes, ice chisels, and ice scoops. Dorset harpoon heads are also described as being adapted to ice hunting rather than open water (Maxwell 1985:135). Also characteristic is the development of the Dorset Parallel, type-line E, harpoon heads for walrus hunting alongside the sudden and substantial appearance of walrus in middens (Figure 3.3). Additionally, the beginning of the Dorset is marked by the appearance of substantial architecture, such as semi-subterranean dwellings, accompanied by deep midden deposits which suggests reduced mobility and larger populations, and the increased occurrence of storage pits implying reliable surplus (Ryan 2016:770).

3.1.3 Dorset Ideology

Dorset ideology has a long history of being assessed through the lens of their art (Figure 3.4). A magico-religious shamanic and shamanistic stance has dominated all interpretation of Dorset art in the 20th century (Blodgett 1974; Harp 1969-1970; Jordan 1979; LeMoine et al. 1995; Mary-Rousselière 1979; Maxwell 1985; McGhee 1974-1975, 1980a; Meldgaard 1960a; Taçon 1983; Taylor and Swinton 1967; Windmiller 1974). While shamanic pertains to the practices of the shaman, shamanistic pertains to the general thoughts and beliefs, or the world view of shamanism in general (Hardenberg 2013; Taçon 1983).

Figure 3.4 Dorset Art (Hardenberg 2013)

Since the initial identification of the Cape Dorset culture in 1925 (Jenness) over 1,500 objects that have been deemed art have been uncovered in and out of their archaeological contexts (Hardenberg 2013). Meldgaard was the first to note that Dorset animal objects have a "definite function in which magic is involved" (1960a: 26). This view was picked up with vigor by Swinton in a paper co-published with Taylor (1967), who laid the groundwork for the magico-religious interpretations of the next 30 years. Relying heavily on Inuit ethnographic material, Swinton attempts to make a distinction between ritual/ceremonial objects and objects purely of magic, such as amulets. These amulets were personal and private objects of magic meant to protect and imbue the wearer with qualities of the represented animal to ensure success in life and the hunt. Ritual/ceremonial objects, Swinton (1967:39) states, are part of the professional equipment of the shaman, individuals "who engage in the social activity of 'taking charge of the relations to the supernatural power that are supposed to interfere with human' on behalf of social groups". His beachhead argument is that art was not the work of occasional carvers, but was mostly, if not uniquely, the work of specialist shaman-artists (and their helpers). He suggests that this tradition was carefully handed down orally and that this accounts for the consistency and recurrence of symbols over a 2000-year tradition. Importantly, his arguments are based on a collection of mixed proveniences, many without context, of only 125 pieces.

The early 2000s offers the last scholarly interpretations of shamanism for Dorset art with Sutherland (2001) acknowledging the misuse of 19th and 20th century Inuit ethnographic material to interpret Dorset material. This was followed by MacRae (2013), who argues that the problem lies in interpretations of the past, that the relationship between art, religion, history, and cultural formation processes is too deeply rooted in an archaeological discourse shaped by Western ontologies. The ideas of shamanism, and even "primitive art," are described as archaic, reductive, simplifying, mythic, and are drained of all significance (MacRae 2013). The shamanistic principle is a generalization, a single explanatory model, that has been "discovered" and is in reality not something natural, nor has it undoubtedly occurred uniformly in the past, but is a specific historical product deeply rooted in Western assumptions (Clifford 2006 [1988]; MacRae 2013). Past scholars have used it with "significant authority, elegance, interpretive purchase, and persuasive power," though it is naught but a "a good story, which conceals the fact that it is only one of many possible stories" (MacRae 2013:191). He further postulates that "such streamlined, reductive, encompassing narratives may make for effective rhetorical persuasion, but not necessarily good science" (MacRae 2013:191).

MacRae argues that Dorset art, specifically what he calls the zoomorphic series (animal carvings) "do[es] not necessarily conjure the occult, mystic world of vast, unfathomable powers, or the restricted, hierarchical, elite and highly codified comings and goings of the shamans" (MacRae 2013:185) but are much more likely to be "vernacular objects, common and part of everyday life, which give expression to the more mundane experiences of peoples in the past […] [and] makes them no less emblematic of Dorset social mores, habits, customs and relations" (MacRae 2013:191). The zoomorphic series is a testament to the detailed knowledge of non-humans brought about by long and careful observation of these animals (MacRae 2013). Indeed, it takes an intimate knowledge and acute spatial awareness (MacRae 2013), born of an intimate relationship with the animal, to capture the realistic detail and proportion, and represent it three dimensionally in another medium. However, this knowledge is not surprising as most of the animals represented are part of their subsistence base and are important for their survival (Harp 1969-1970; Sutherland 1997; Taçon 1983).

Betts et al. (2015) approach the study of bear effigies from a new standpoint, adding to wealth of possible interpretations and addressing old ones. They propose that to gain an understanding of the relationship of Dorset and animals, a detailed reconstruction of the natural ecology for both is necessary and that it should be considered alongside the ideological, social and environmental contexts of the interactions (Betts et al. 2015). Informed by the concept of cosmological deixis, the idea that hunter-gather societies endowed animals with personhood, they attempt to capture the spiritual, cosmological and material relationships of the Dorset and polar bears using data from bear effigies. Their analysis shows that polar bears and the Dorset frequented the same environments for hunting, employed the same techniques and hunted the same prey. This suggests that polar bears and the Dorset had similar or overlapping ontologies, and the authors conclude that the bear "was integral to Dorset self-conceptualization and identity" (Betts et al. 2015:106)

On one hand, while MacRae (2013) does not believe we need to assign these carvings any particular spiritual agency, as has been previously done within the shamanic, shamanistic and hunting magic, it does not mean that the animal representations are without a spirit of their own. MacRae (2013:185) argues that they are "copies of the visible world," but this assertion only attributes the creator a limited sense of perception. On the other hand, using perspectivism, Betts et al. (2015:101) believe that the animal effigies "signify the physicality, perceptions, and capabilities of the animal as well as its relationships with the world and other beings."

3.1.4 Dorset Subsistence and Material Economy

Dorset had a mixed marine-terrestrial subsistence economy which was dominated by walrus and ringed seal (Murray 1996). While Pre-Dorset assemblages show a focus on ringed seal (Murray 1996:83), walrus was the primary subsistence species in the Foxe Basin region of Nunavut due to its abundance and year-round availability during the Early and Middle Dorset periods (Murray 1999:476), though its availability is not uniform throughout the Arctic. As a result, groups from walrus-rich areas may have been regarded as more prestigious and took advantage of the situation to trade walrus products with surrounding regions (Murray 1999). Elsewhere in the arctic, ringed seal usually represents the most abundant species hunted while harp seal dominates Newfoundland Dorset assemblages (Murray 1992:128). Dorset are also known to hunt other species of seal, such as harbour, grey, bearded, and hooded seal in Newfoundland (Murray 1992:37) and bearded in the Arctic (Murray 1996:87). Caribou, waterfowl, bird, and fish also figure in Early and Middle Dorset subsistence.

In terms of Binford's (1980) collector and forager model, Nagy (2000) argues that Pre-Dorset migrants into the Eastern Arctic, or more generally groups new to an area, initially utilized a forager model as knowledge of the land and its resources were gathered before adopting a logistically-oriented collector-based economy. This was shown to have occurred during the Middle Dorset period as migrants moved into Newfoundland (Harp 1976; Ryan 2009:109).

The Dorset raw material economy is in part directly related to the fauna being exploited. Ivory, bone, and antler are the most common organic materials used in Dorset material productions. Ivory was sourced from walrus tusks, narwhal tusks, and from polar bear teeth. Bone materials used are known to come from walrus, cetaceans, and seal, as well as caribou long bones and bird bones. Finally, antler was sourced from caribou (Houmard 2011:50-59). Non-organic materials include a large variety of cherts, quartzites, and crystal quartz, in addition to slate, nephrite, and soapstone. These were either locally found, traded, or transported. For instance, Ramah chert from Ramah Bay in Nunatsiavut is found 450 km north-westward in the Frobisher Bay region of Baffin Island (Odess 1998:423) and all the way south into Newfoundland (Howse 2016:82)

3.2 Harpoons

The harpoon (Figure 3.5) is the technological adaptation most vital for survival in the north (Park and Stenton 1998:141). In an environment with few plant food resources, but with a mostly reliable marine mammal resource base, the harpoon has helped arctic dwellers secure food, fuel, and the raw materials needed in every facet of their livelihood.

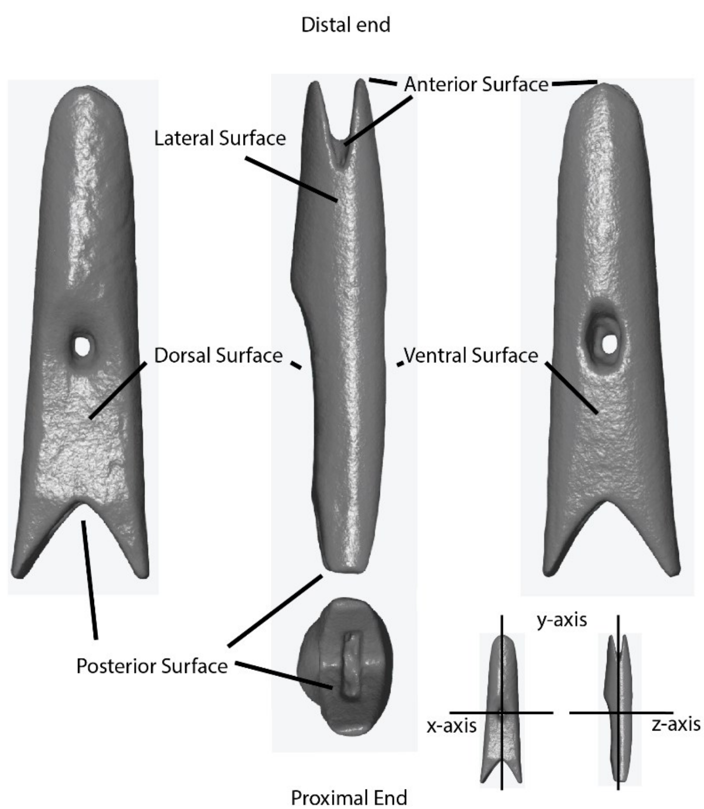


Figure 3.5 Harpoon Head Surfaces and Orientations

The Dorset are thought to have hunted for marine mammals in a variety of marine settings, including ice floes, ice edges, breathing holes, and polynyas (Maxwell 1985; Ryan

2016). No cohesive body of evidence exists to support the idea that Early and Middle Dorset used watercraft for open-water hunting or travel, however, some sparse finds have been interpreted as possible kayak components (Maxwell 1985:136). Miniature representations of boats have also been found (Hardenberg 2013:187-188), though they may actually have functioned as spoons (Mary-Rousselière 2002:156). Finally, a Dorset-associated piece of wood bent at a 136 degree angle from Nunguvik was interpested as a kayak frame rib (Mary-Rousselière 1979:25). Alternatively, some evidence exists for ealier Pre-Inuit boat use; a u-shaped rib in association with the Pre-Dorset Saqqaq culture, dating to about 4200 BP, was uncovered in Southeast Disko Bay, Greenland, and identified as a kayak frame rib (Anichtchenko 2016:46; Grønnow 1994).

While the technology predates the Dorset archaeological complex, harpoons have served as the primary technological adaption for hunting mammals in marine environments throughout the Holocene. The harpoon is a composite tool which includes a shaft, a foreshaft, and a harpoon head to which a line is attached. Figure 3.6 gives an analogous Inuit example of what a complete harpoon may look like; however due to a lack of all complete Dorset harpoon elements found in a related context, what the whole harpoon may look like is still under discussion (Maxwell 1974-75, Houmard 2011). In differentiating the lance, a device meant for stabbing, from the harpoon, Mason (1902:197) defines the latter as a “piercing and retrieving device with a moveable head.” This moveable head, the harpoon head, is found at the distal end of the harpoon and is responsible for the successful functioning of the tool. Many years later, Stordeur-Yedid (1980) expanded on Mason’s definition by identifying three primary functions: the harpoon head must penetrate the prey, it must stay connected to the hunter, and it must stay inside the prey. No analogs for skin floats or plugs found in Inuit assemblages have been identified in Dorset assemblages, thus it is assumed the line was connected to a stationary point or the hunter themselves.

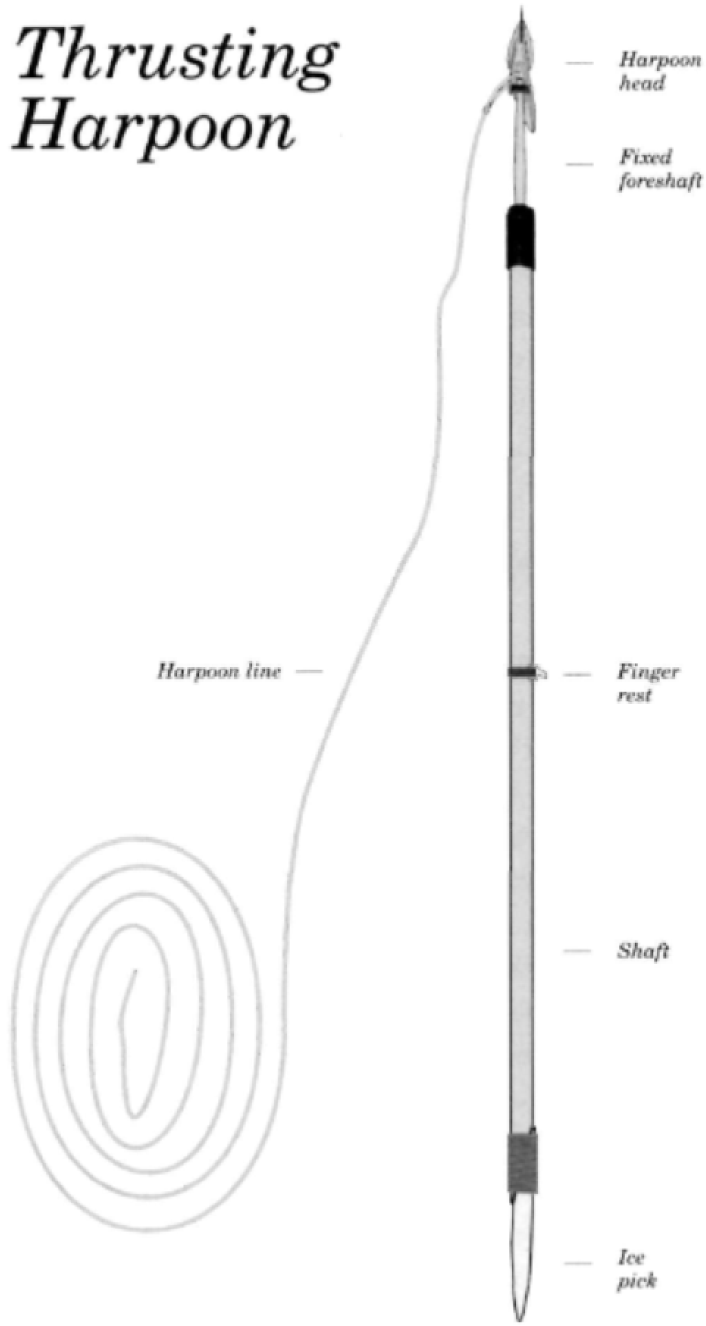


Figure 3.6 Analogous Inuit Harpoon (Park and Stenton 1998: 2)

Though a functional definition is what sets the harpoon head apart as a tool type from others in the Dorset toolkit, the presence and absence of attributes have traditionally been used to differentiate harpoon heads from one another and to map spatiotemporal variability. Typologies have served as the primary tool to organize all attributes and perceived variability into types. In order to understand these harpoon heads and the efforts past archaeologists have put into creating typologies, it is important to identify some of the most recognizable attributes present on these implements.

3.2.1 Parts of the Harpoon Head

The functional definition provided by Stordeur-Yedid (1980) provides a good starting point for understanding the various harpoon head attributes. While the implements which are considered harpoon heads encompass a single tool type with the generally understood purpose of hunting marine resources, there is great variability in attribute combination, attribute morphology, and overall morphology throughout the vast territory and timespan assigned to the Dorset culture. As such, it is important to note that the following attributes were not all contemporaneous, nor is every possible combination reflected in the archaeological record. Additionally, the list is not exhaustive.

The distal end of the harpoon head must penetrate the skin of the prey-animal and thus constitutes a point (Figure 3.7). This takes three forms on Dorset harpoon heads. The harpoon head can incorporate a blade-like structure in its morphology, carved as part of the body. This is termed ‘self-bladed’. Another distal attribute is the ‘endblade slot’, which is carved into the anterior surface to accommodate an end-blade: a triangular blade fashioned from materials like chert or quartzite. These lithic implements have the benefit of being even sharper than their self-

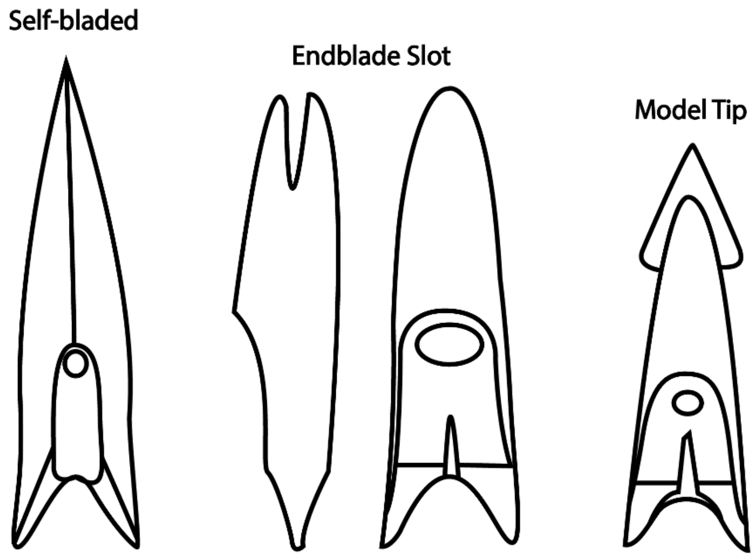


Figure 3.7 Harpoon Head Distal Ends (after Meldgaard n.d.)

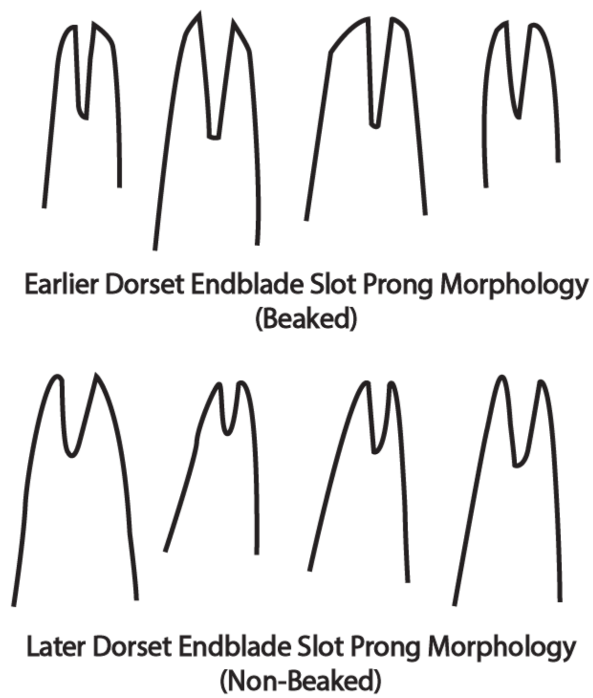


Figure 3.8 Endblade Slot Prong Morphology (after Meldgaard n.d.)

bladed counterparts, and can be easily replaced (Park and Stenton 1998). The third, albeit less common, distal attribute resembles a blade slot with an endblade but carved from the same piece of material as the body of the harpoon head. This attribute will be termed 'model-tipped' after

Stordeur-Yedid's (1980:20) note describing it is as a demonstration model. The model tip can be considered an alternative to the modular blade slot and endblade as it only appears on the distinctive morphology of otherwise endblade-slotted harpoon heads.

The endblade slot fits within two ranges of morphology (Figure 3.8); the first, beaked, appears in the earliest of Early Dorset and progressively changes into a non-beaked form by the end of the Early Dorset. The beaked endblade slot prongs are defined by a distal angular break on either the dorsal or ventral prong which is reminiscent of the bills of birds like the arctic jaeger. While the two morphological extremes are noticeable, the two categories of beaked and non-beaked are presented here for the sake of convenience and not as definitive water-tight categories. Progressive changes in morphology over time blur the line between any possible definitive category.

In addition to the pointed distal end, the harpoon head is morphologically required to accommodate a foreshaft socket thereby connecting it to the rest of the harpoon, as the act of

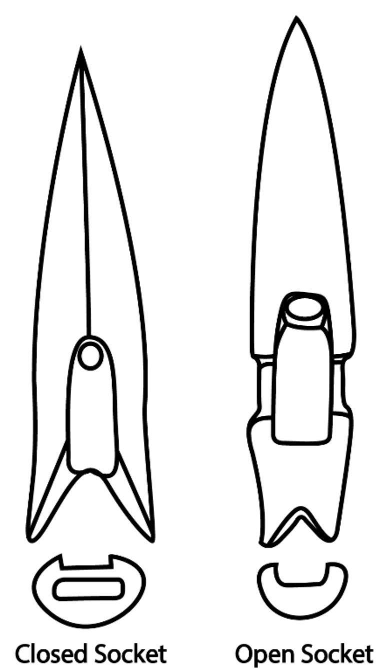


Figure 3.9 Harpoon Head Foreshaft Sockets (after Meldgaard n.d.)

stabbing or thrusting is equally important in penetrating the skin of the prey. Two possible socket types exist; the first is the open socket (Figure 3.9). This attribute is an open concave or flat cavity in which the foreshaft is placed and secured by lashing. Dorset harpoon heads can also feature closed foreshaft sockets. These slots, which begin oval and become increasingly rectangular over time, are cut centrally along the x-axis on the posterior face of the harpoon head. Foreshafts were likely secured in the socket using pressure and a near-perfect fit. Much like endblade-slot morphology, foreshaft sockets also display progressive morphological change over time from an open to completely closed socket. However, unlike the endblade-slot, the different morphologies of open and closed functionally affect the harpoon head and conceptually allow the separation into two different attributes based on the presence of lashing grooves. Nonetheless, there may exist harpoon heads whose socket is sufficiently closed to hold the foreshaft but still features lashing grooves.

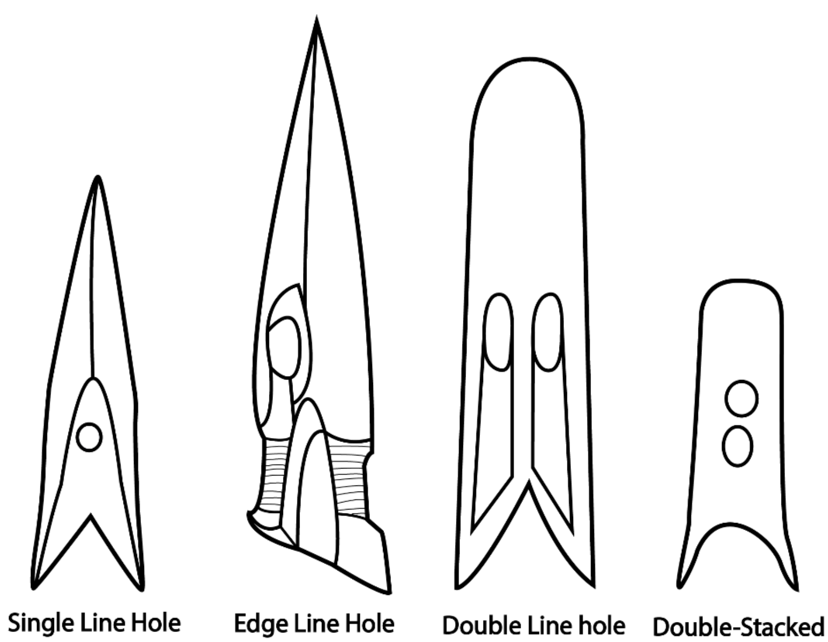


Figure 3.10 Harpoon Head Z-Axis Line Holes (after Holtved 1944 and Wintemberg

The mesial area of Dorset harpoon heads contains a line hole (Figure 3.10). To this, a line is attached which allows the hunter to stay connected to the prey and eventually retrieve it. The most common type is the single line hole. It is usually centrally placed on the x and y axes, while some later Dorset harpoon heads have laterally placed single line holes. Two orientations exist for double line holes; the most common configuration is side by side along the x-axis. The other possible double line hole configuration, albeit less common, has double-stacked line holes: two holes placed atop one another along the y-axis.

Another type is the transverse line hole which goes from one lateral edge to the other along the x-axis (Figure 3.11). Harpoon heads with a transverse line hole may feature a centrally placed hole on the ventral side of the harpoon head. This additional hole internally connects to the transverse one creating what Stordeur-Yedid (1980) called a 'trefoil' transverse line hole, as the cross-section is reminiscent of a three-leaf clover. The first evolutionary iteration of these resembled two x axis-oriented line holes but given its relationship with the trefoil and transverse

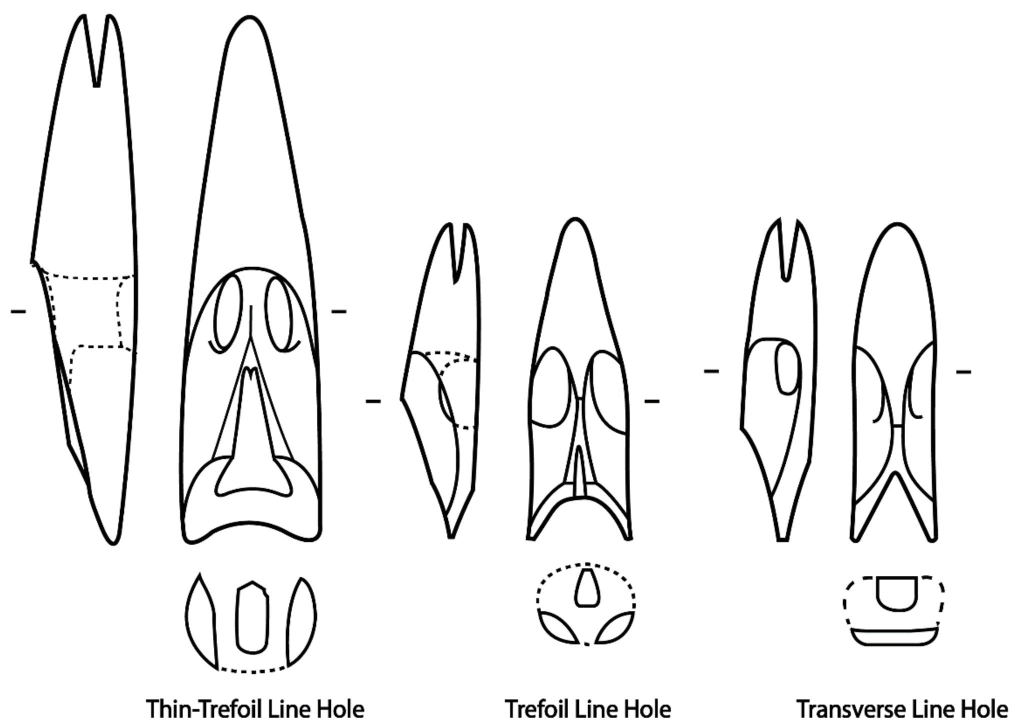


Figure 3.11 Transverse Line Hole Evolution (after Meldgaard n.d.)

line holes, thin-trefoil is a more useful identifier. Attribute distinction for this evolutionary line is not always simple. While the closing of the ventral hole can be used to distinguish trefoil from transverse, the transition from thin-trefoil to trefoil does not have any visible arbitrary distinctions that can be made beyond qualitative observations. Interestingly, the earlier morphologies of this evolutionary line have not made it into mainstream typologies such as Maxwell's (1985).

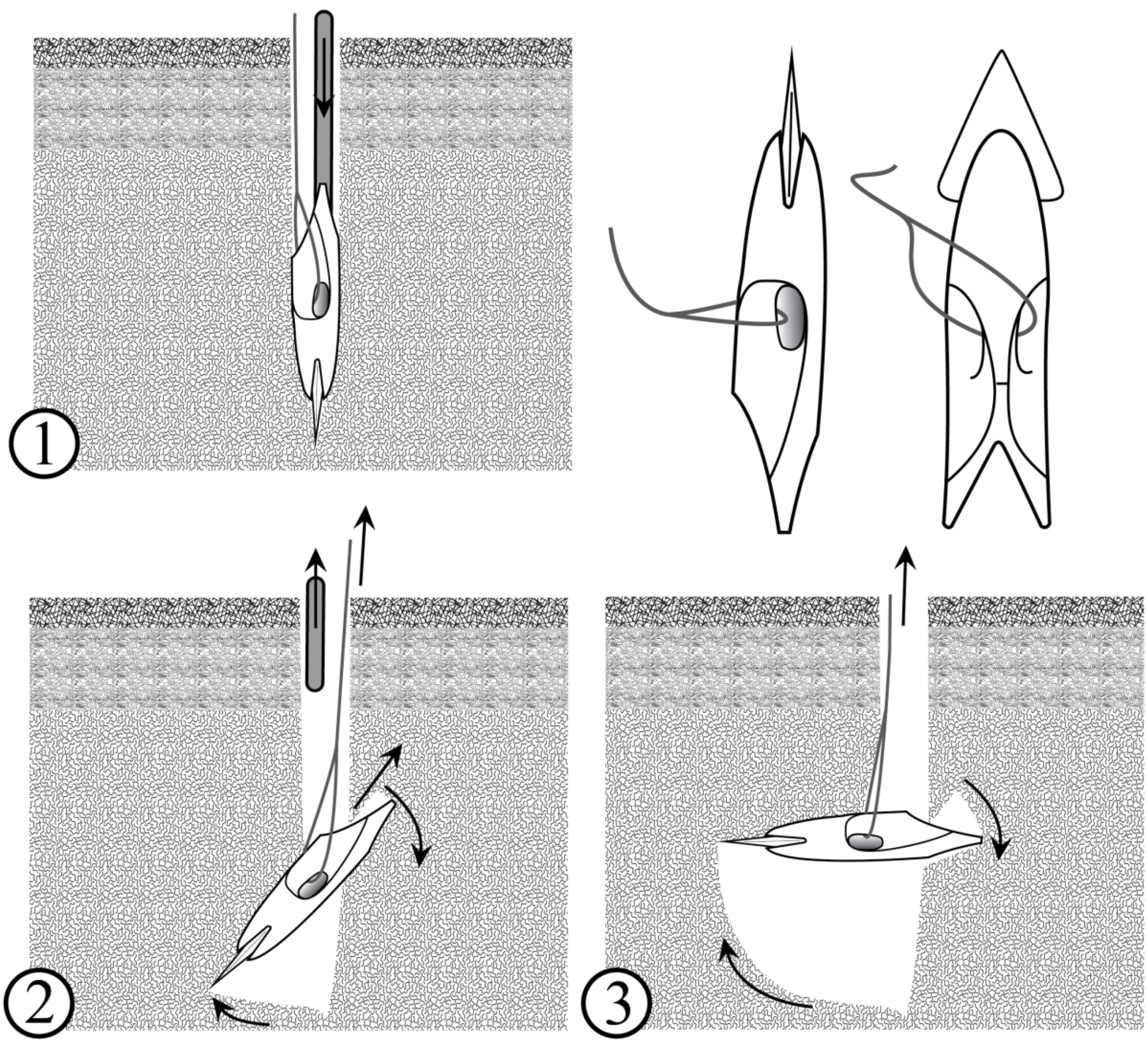


Figure 3.12 Harpoon Head Toggling (after Park and Stenton 1998 and Meldgaard n.d.)

1. The harpoon head is pushed into the prey while still connected to the foreshaft and shaft,
2. The foreshaft either falls out or is pulled out and the line is also pulled,
3. As the lined is pulled, the harpoon head performs a 90 degree turn.

While distal attributes allow the harpoon head to penetrate the prey-animal, and the combination of the line hole and line allow the hunter to stay connected to the animal, the functional attributes which contribute to its ability to remain in the animal remain highly debated. Of the two possible mechanisms, barbs are the most straightforward. Barbs are backwards-pointing protrusions which catch in the flesh to ensure that the object stays lodged and does not exit the entry wound (Park and Stenton 1998:17-18). Though not commonly found on harpoon heads in the Dorset archaeological complex, their Pre-Dorset precursors made occasional use of them. Where the ambiguity lies is in a mechanism called toggling. Harpoon heads which toggle perform a 90 degree turn inside the animal, ending up perpendicular to the entry wound (Figure 3.12). Thus, while the sleek elongated profile of the harpoon head aids in entry, it helps prevent the exit once turned sideways.

Surprisingly, the Dorset literature rarely questions Dorset harpoon heads' ability to toggle, likely relying on the functioning of Inuit harpoon heads as ethnographic analogs or more simply by classifying all harpoon heads that lack barbs as toggling. As such, the parts of the harpoon head responsible for successful toggling have yet to be fully investigated. However, the subject has been commented upon by Park and Stenton (1998) who argue that the spurs are essential and cause toggling, and that without them the harpoon would slip right out. Spurs make up the proximal morphology of the harpoon head, the most common configuration of which is twin, bifurcated spurs. These are symmetrical when viewed from the dorsal or ventral side. The lateral sides of the spurs most often align themselves with the overall morphology of the harpoon head but may also flare outwards. The fork itself, and the posterior morphology, can vary from a 'U' shape to a 'V' shape in a temporally sensitive way (Figure 3.13) and is progressive enough to blur any possible categorical separation.

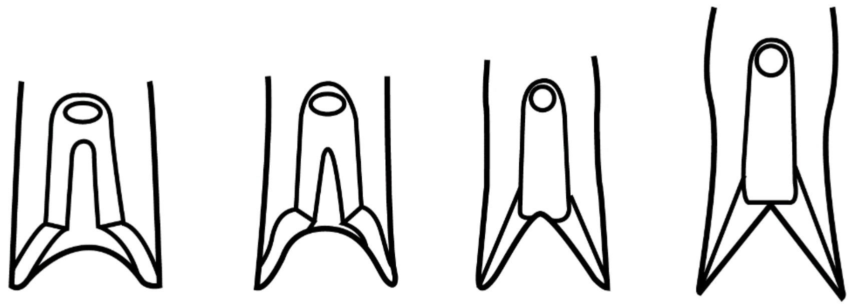


Figure 3.13 Bifurcated Spur Morphology (after Meldgaard n.d.)

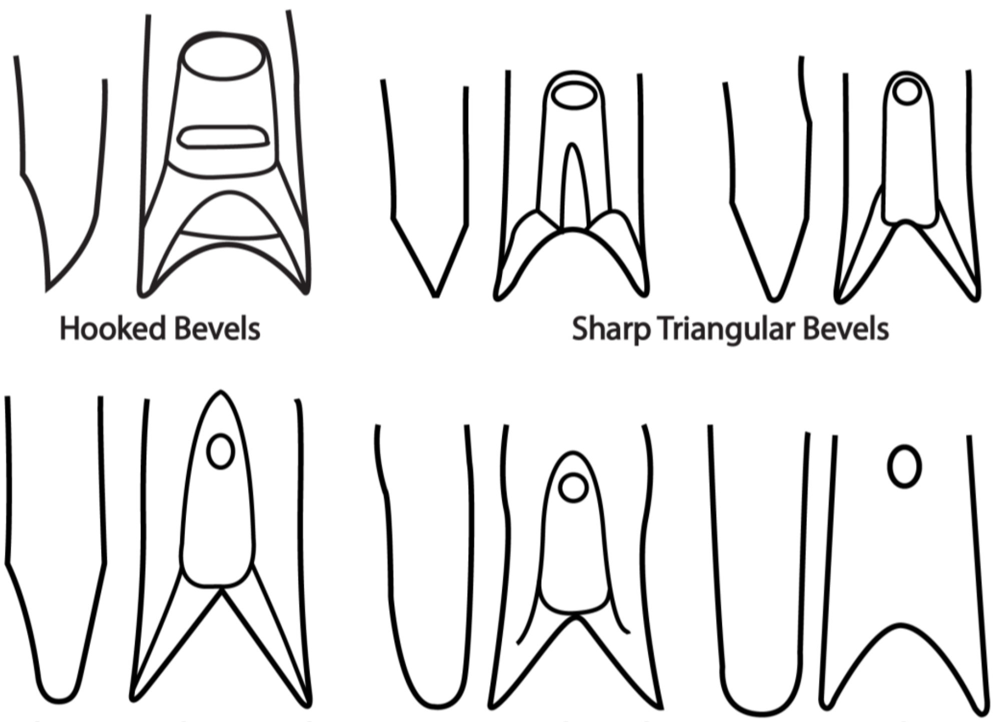


Figure 3.14 Bifurcated Spur Lateral Morphologies (after Meldgaard n.d.)

There are also noticeable geographic and temporally sensitive degrees of spur beveling in bifurcated specimens when observed from the lateral side (Figure 3.14). Meldgaard's (n.d) Foxe Basin schematic shows a progressive change from hooked to triangle to forms with much less pronounced beveling. Newfoundland's Middle Dorset did away completely with beveling, showing little to no difference in profile thickness from distal to proximal ends other than tapering in the endblade slot prongs. While these morphologies are observable, the progressive nature of change does not reflect such easy to separate categories. The morphologies presented in figure 3.13 should not be considered attributes with a range and definitive boundaries, but rather noticeable morphological snapshots in time.

Later Dorset harpoon heads have more varied spur configurations (Figure 3.15). While the bifurcated spurs are still prominent, some harpoon heads feature a single lateral spur with a concave posterior surface. Others have a flat angled bottom spur which results in one side appearing longer than the other. Another spur configuration which was uniquely found in the Late Dorset assemblages of the Thule district uncovered by Holtved (1944:193) simply features no spur, but rather a flat bottom perpendicular to the length of the harpoon head.

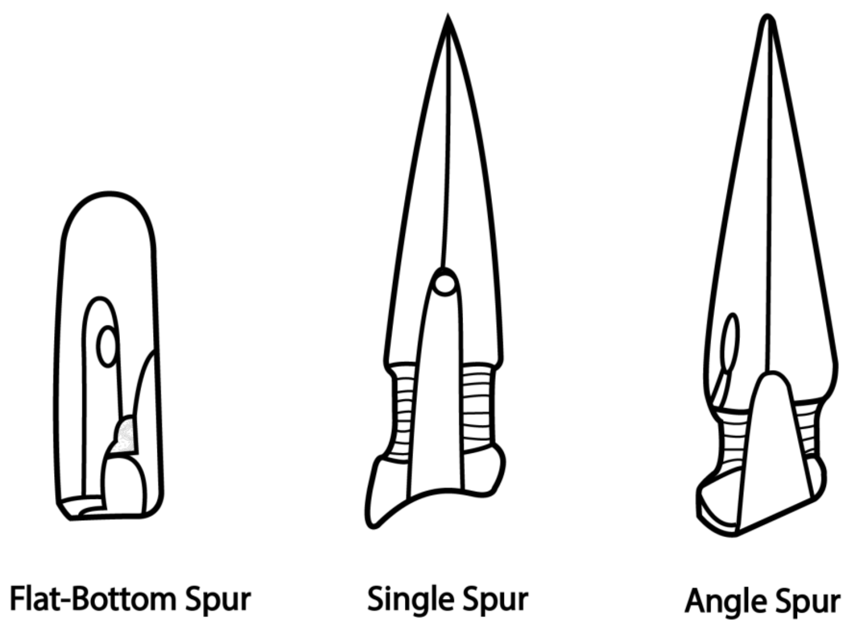


Figure 3.15 Spurless and Single Spur Morphologies (after Holtved 1944 and Meldgaard n.d.)

It must be assumed that Park and Stenton (1998) believe the spurs functioned similarly to barbs, catching in the flesh. However, how the spurs contributed to the 90-degree rotation is not made explicit. With regard to the toggling mechanism, Stordeur-Yedid (1980) asserts that the positioning and orientation of the line hole are the greatest contributors to the harpoon head's ability to pivot 90 degrees inside the animal's flesh. Thus, when tension is put on the line, the mesial placement of the line hole would be responsible for the rotation of the harpoon head. Interestingly, in a separate article, the author lists these same attribute conditions, but expresses doubt that Dorset harpoon heads consistently succeed in toggling (Stordeur 1980:241).

The literature reveals but two instances where toggling was tested using reproductions of Dorset harpoon heads. In the 1970s, Père Guy Mary-Rousselière and his associate Cornelius Nutarak reproduced in antler one of the self-bladed closed socket harpoon heads recovered in their excavations at Saatut (Mary-Rousselière 2002:121-122). Nutarak successfully harpooned a seal with the reproduction and noted upon retrieval that the harpoon head had turned sideways inside the prey. While only one harpoon head design was tested in this manner, it provided the first evidence of functionality beyond reliance on ethnographic analogs. Another experiment was conducted by Tim Rast (2009) using a reproduction endblade-slotted closed socket harpoon head from Newfoundland. Using ballistic gel, into which the harpoon head was stabbed, he was able to demonstrate its ability to toggle. Rast also comments that the mesial placement of the line hole is responsible for toggling.

While very few address the attributes which contribute to the function of toggling in Dorset harpoon heads, and even then little is actually said, it is doubtless that successful toggling relies on more than a single attribute. Nonetheless, it is likely that the placement of the line hole is the only independent attribute which allows potential toggling, while all others are dependent attributes which contribute to successful toggling. However, there remains a single aspect that is often overlooked in the discussion both of toggling and the process of typing: overall morphology.

The overall morphology of Dorset harpoon heads has never been consistently used to classify harpoon head types; the presence and absence of attributes has always taken the forefront in this matter. Where it has been used as a marker for classification is when the overall shape of the object differs so much from its counterparts that no matter what the attribute situation, it must intuitively be separated. Alas, overall morphology cannot be ignored in the study of variability as it cannot be separated from the attributes that make up the harpoon head. Nor can it be confidently said that overall morphology is subject to a different treatment than the one which resulted in the variability of attribute morphology.

Stordeur-Yedid (1980:17) argues that the definition of a harpoon head is functional and not morphological, that to identify one is not to know its form but to recognize the attributes that contribute to its function. Unfortunately, her adherence to functionality limited her ability to assess chronological developments in morphology and forced her to define types which include harpoon heads that share the same functional attributes but would have intuitively been separated based on overall morphology. Some years prior, Maxwell's (1976:69-70) analysis of Pre-Inuit harpoon heads led him to conclude that all harpoon heads were sufficiently adapted and that all variability was simply stylistic as there appeared to be no motivation towards innovation. This would suggest that no change within the span of several thousand year had any effect on the functionality of the implement, thus equating any changes in morphology to shifting pottery styles. However, even if all harpoon heads are functional and have achieved that function prior to the development of Pre-Inuit arctic archaeological complexes, the resolution of his study could not permit such a conclusion.

The argument that shape, or overall morphology, does not affect functionality lacks evidence in both cases. Morphology and function have an intimate relationship as morphology is forced to adhere to a functional design, such as the self-bladed attribute defining the distal morphology, and all attributes must be placed on an object that is shaped to ensure successful functioning. Furthermore, shape must affect function, and such is revealed through a cursory knowledge of ballistics, aerodynamics, hydrodynamics, and in this case fluid dynamics that include ice, water, and flesh. However, no research which investigates the relationship between shape and functionality exists beyond the general assumption that barbed and non-barbed harpoon heads function differently to the same end, and thus the matter cannot be resolved conclusively. What is conclusive is that overall morphology cannot be ignored in the discussion of functionality, such as toggling, nor can it be ignored in the process of evaluating variability through the creation of typologies.

Considering the current lack of knowledge regarding the relationship between functionality and morphology, it is easy to assume that the larger trends of morphological change in Dorset harpoon heads are the result of stylistic choices. Those attributes most often considered stylistic constitute an array of possible dorsal proximal arrangements (Figure 3.16) linked to the foreshaft sockets. The temporal depth and spatial concentration of Meldgaard's (n.d.) typology and the large spatial range used in Maxwell's (1985:110) typology display "a sequence of stylistic variants, from an open socket, to a partially closed, flanged, T-shaped socket, to a closed socket with one or two holes on the dorsal surface, to a closed socket with a narrow triangular slice on the dorsal surface."

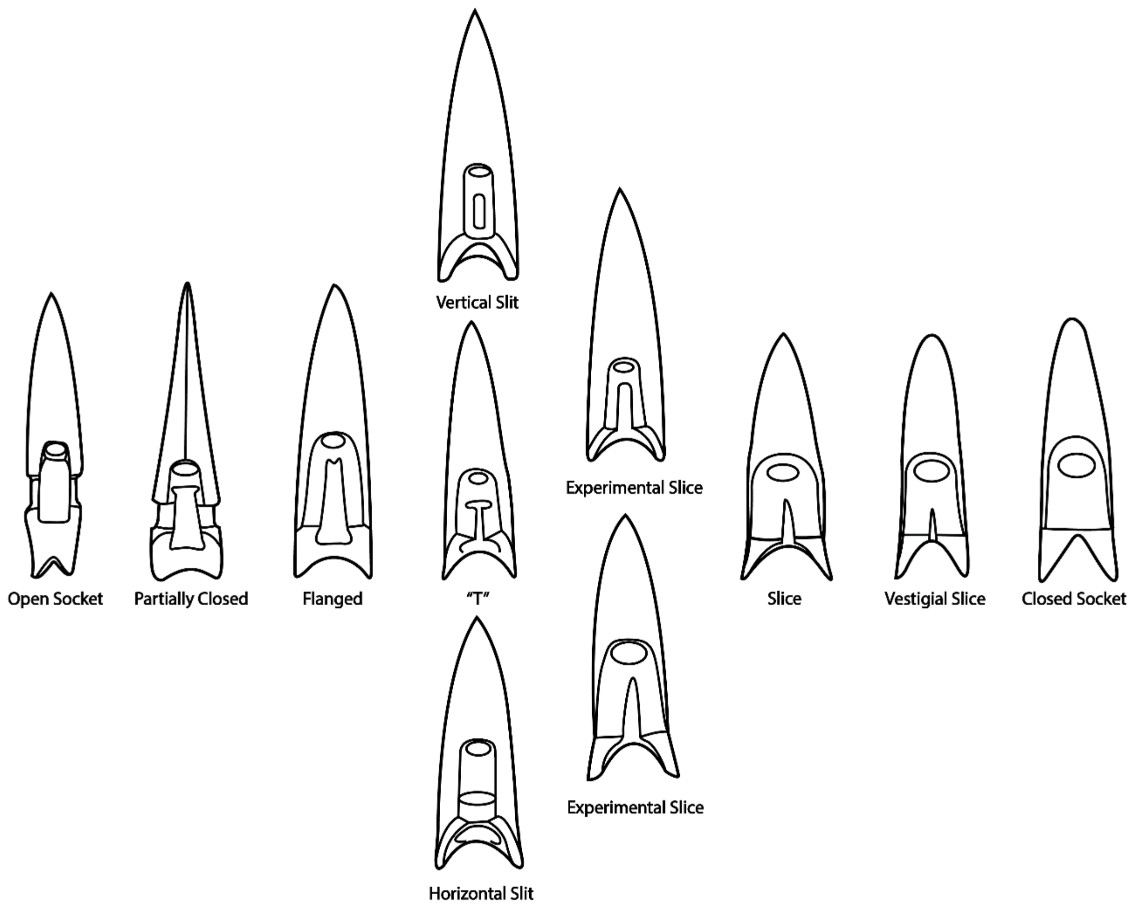


Figure 3.16 Dorsal Proximal Arrangements (after Meldgaard n.d.)

The slice is the only such arrangement that receives attention in the literature, probably due to its commonality. Maxwell (1985:135) states that the slice has no function, but rather makes the foreshaft socket vulnerable to increased breakage in comparison to fully open sockets. He also suggests it may have held the line to provide further streamlining (Maxwell 1974-1975:127). The discussion in Tim Rast's (2010) blog proposes that it may have allowed the closed socket to 'flex' and permit the foreshaft to be held tightly in the socket without risk of breakage under tension. Rast suggests this may be a possibility, but only for harpoon heads in antler since the nature of antler would permit a small degree of flexing, but ivory would not. This would be one of the few examples explored where materials would affect the functionality of morphological attributes. Finally, McGee (Stordeur-Yedid 1980:23) suggests that the slice and similar attributes were used to remove ice which can form inside a closed foreshaft socket.

These dorsal proximal arrangements and their eventual abandonment for a fully closed socket have long been used to demarcate the Early to Middle Dorset transition (Maxwell 1974-1975, 1985; Taylor 1968). However, Odess (1998), and later Desrosiers (2006), argue against the use of a slice (and its variants) as a chronological marker due to its continued use in certain regions after contemporaneous abandonment in others. Odess (1998:428) asks: “Does the retention of such ‘archaic’ forms constitute evidence of isolation, or is it the result of a conscious decision to reject the ‘newer’ forms?” Thus, calling the slice a stylistic attribute may be correct during a certain time and a certain place, just as it was functional or symbolic at another time and place. This serves as a reminder that while functionality is of the utmost importance for a utilitarian tool, it is hard to conclusively allocate attributes or choices in morphology to style, functionality, symbolism, or any other dimension of meaning, but a combination of such dimensions is likely. Considering that such categories are the constructs of archaeologists attempting to organize aspects of material culture, they may not hold up to further investigation.

Unfortunately, positioning morphology in the study of Dorset harpoon head variability is not the only area which proves difficult, but also the simple depiction of shape. Traditionally, at least a single face is depicted as a two-dimensional shape, whether through photography or drawing (Figure 3.17). Harpoon head shapes have also been described using simple geometric shapes as analogs. Measurements representing the height, width, and thickness relay some dimensional information, but completely obscure shape. As a result, the assessment of shape is often qualitative, but it is neither done systematically nor comprehensively. This extends beyond the overall shape, to the shape of individual attributes. While at one scale typologies mostly rely on presence or absence, providing a binary ‘yes’ or ‘no’, the ability to describe and compare shape difference within defined attributes suffers from the same problems. This was even demonstrated in the above attempt to give an overview of Dorset harpoon head attributes and morphologies, even though care was taken to avoid creating certain watertight categories when none exist. The quantification of complex three-dimensional shapes has not truly been possible before the development of 3D digital technologies and geometric morphometrics, and even then, it is hard to describe the resulting quantifications. However, these methods, in addition to a wealth of theoretical advancements, may make it possible to advance studies of artifact variability in directions which were impossible to the typologists of the past century.

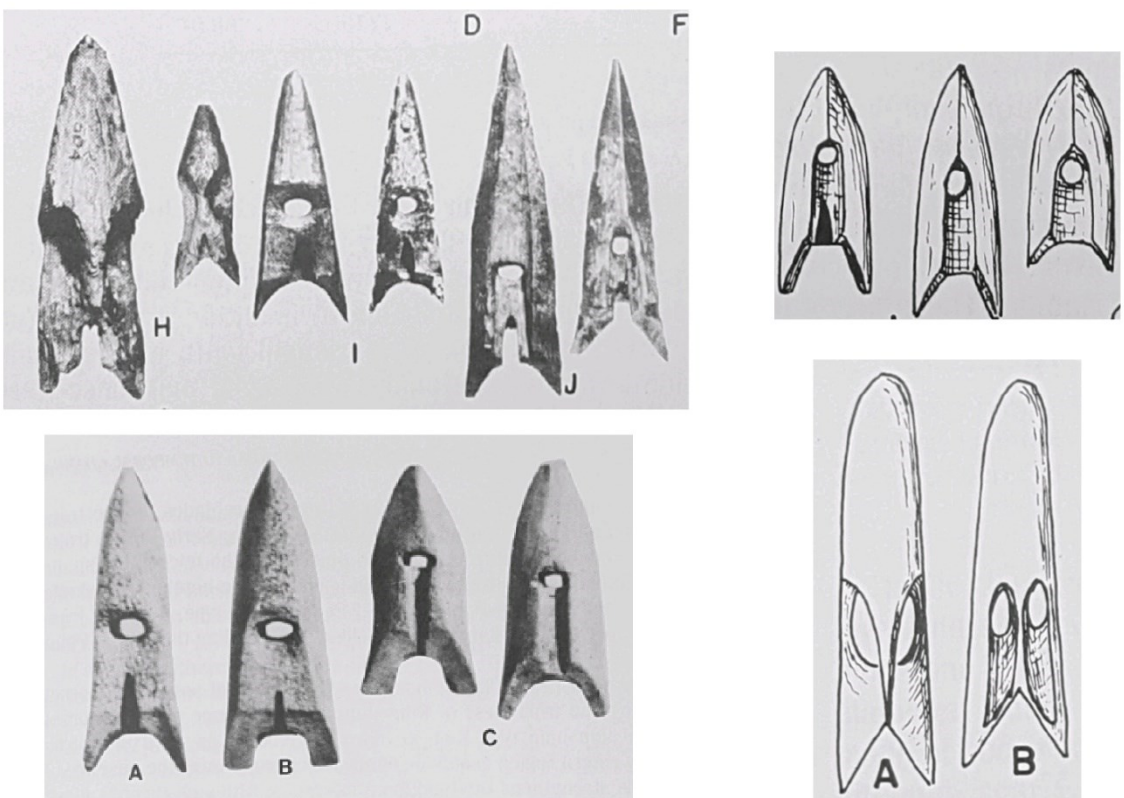


Figure 3.17 Drawings and Photographs of Harpoon Heads (Maxwell 1985)

It is important to note again that the attributes described above cover those most easily observable and do not constitute an exhaustive list, nor should each attribute's equal representation in the figures and descriptions above be considered indicative of their conceptual positioning in Dorset realities or even their simple relative abundance. Most importantly, the attempts to categorize shape beyond attribute presence or absence should always be treated with the most caution as separations of continuously changing shapes may not hold up. Furthermore, the nature of time, space, people, and the complex relationship amongst the three contribute to such variability that it may not be possible to capture it all without simplification, if at all. Frederica de Laguna (1946:111) comments on the subject at a time when culture-historical approaches to artifact classifications were the meat-and-bones of archaeology:

> "Trait lists, because they embody perceptions about what is relevant, may be exceedingly dangerous, and a simple comparison of traits, without an evaluation of finer likenesses and differences, may obscure the most significant point. Our conceptions about types must remain fluid, because types cannot be put into water-tight compartments. Furthermore, the variants of any type cannot be ranged upon a family tree, expressing one-way relationships, as we can classify the related animal orders and species. Types are hybrids; they are focal points for multi-dimensional relationships. The harpoon head may take over barbs from the arrow or leister; it may give decorations to the bodkin; two distinct types of harpoon head may produce a curious litter of mongrels."

The designation of a homogenous 'Dorset' cultural unit does not preclude the people it seeks to study from having formed, maintained, and continuously renegotiated individual, group, and regional identities through what we see as artifact variability. Studying the Dorset archaeological complex, and the use of existing typologies to understand what that complex is, can thus fall short of understanding the people under study.

3.2.2 Typologies

As mentioned before, typologies have been the main tool used to understand Dorset harpoon head variability for the past century. However, each typology is unique; the differences are evident in the purpose of their creation, the material and contextual depth used, the approaches to functionality and style, the importance ascribed to attributes, the overall method of subdivision, and finally in the methods of representing the typology. Indeed, while overlap does exist in each aspect, the influence previous typologies have on subsequent ones being sometimes apparent, the denial or rejection of past work is not uncommon nor is the value attributed to each typology by contemporaries and subsequent scholars by any means equal. That being said, no typology is in itself invalid, regardless of errors now rectified, and the knowledge, interpretations, and opinions now changed. Each is the product of the historical circumstances surrounding its creation.

The harpoon heads in the collections under study encompass many morphologies and attribute combinations, and thus a justification was required in choosing the best specimens for comparison using geometric morphometrics. This technique requires the highest amount of homology, meaning that the harpoon heads must have parts which are identifable at the same location across all specimens. This is easily translateable to specimens with the same attributes, and consequently of the same type. For example, using geometric morphometrics, a single line hole cannot be compared to a double line hole, nor can an open socket be compared with a closed socket specimen. In contrast, a circular single line hole can be compared to an ovoid one with great success, and holds the potential of providing meaningful results. As such, the purpose of this study is to evaluate variability at a resolution previously unaccessible, the resolution being variability between specimens which are considered the same type.

For this reason, past typologies had to be considered not only to situate this study of variability but also to assess the material under study through the lens of past typologists in order to select a meaningful sample. Thus, the purpose, type, materials used, representation of types, and the relationship between types for each Dorset harpoon head typology uncovered were reviewed (Table 3.1).

What immediately stood out was the variability in the nature of each of these assessments and the fact that none could truly represent the complete Dorset archaeological complex without heavy sacrifice to local morphological developments. Even when the practice of typing resembled another, the dimensions of what material was used and relationships between types diverged. The idea of intra-type tolerance to morphological variability instantly presented itself as the dimension of most interest. Type tolerance is the extent to which a type, both in its initial definition and its openeness to new material, is accepting of morphological variation beyond the simple selection of defining attribute combinations. The way in which a typology is represented in its respective publication is the aspect which contributes the most to differing levels of type tolerance. These are typologies characterized using attribute combination lists, written descriptions, and visual examples. While each rarely figures on its own, it is in these ways that typologists communicate what a type is and how how much material it regroups, and that

Typology	Year	Purpose	Type	Materials Used	Representation (by emphasis)	Relationship Between Types
Jenness	1925	Descriptive	Morhpological	Mixed/Lack Context	Visual/ Some Description	Describes distal attribute variation as "minor detail"
Mathiassen	1927	Descriptive	Morphological	Mixed/Inuit Context	Attribute List/ Description/ Some Visual	All small and thin. Some types derive from others.
Holtved	1944	Descriptive	Morphological	Intrasite	Description/ Visual	Describes interchangeable nature of distal attribute
Laguna	1946	Comparative	Morphological	Mixed Collections	Visual	None
Collins	1950	Descriptive/Incidental	Morphological	Intrasite	Attribute List/ Description/ Some Visual	Provides some chronological interpretation.
Taylor	1968	Descriptive/Comparative	Morphological	Intrasite/ Mixed Intersite	Description/ Visual	Comments on temporal and evolutionary relationships.
Meldgaard	1968	Historical	Chronological and Spatial	Intersite/Regional	Visual	Provides visual evolutionary relationship within type-lines, and temporal relationship between type-lines using a relative chronology.
Maxwell	1973	Descriptive/Comparative	Morphological	Intersite/Regional	Description/ Visual	Addresses some larger temporal trends.
Stordeur-Yedid	1980	Intrinsic/Historical	Functional/Chronological	Intersite/Regional	Attribute List/ Description/ Visual	Family and group divisions provide comment on conceptual relationship between types, relative chronology used.
Maxwell	1985	Ancillary/Descriptive/ Comparative/Historical	Morphological/Chronological	Mixed Collections/Intersite	Visual/ Some Description	Provides schematic development of sealing harpoons (relative chronology), standadized type chronology by period without addressing evolutionary states, variants, or relationships.
Park & Stenton	1998	Descriptive/Historical	Morphological	Mixed/ Generalized Material	Visual/ Description	Describes relationship between two types based on distal attributes.
Desrosiers	2006	Descriptive	Morphological	Mixed/Intersite	Visual	Presents some evolutionary comments.
Houmard	2011	Descriptive/Intrinsic/ Historical	Morphological/Chronological	Intersite/ Inter-regional	Visual/ Description	Provides chronological assessment without addressing evolutionary relationships. Some types are noted as "resembling" others.

communication must remain consistent for the typology to find use beyond its originator. Ultimately, it was determined that the larger the spatial and temporal context of the specimens used to define a type, the more tolerant that type is to the inclusion of variability.

3.2.2.1 Attribute Lists

Lists of attribute combinations can be perhaps considered the purest representation of the typing process as it embodies the presence, and reveals the absence, of attributes identified on specimens. Two early typologies use this format, where attribute lists are featured prominently as the primary conveyor of variability.

The first was created by Therkel Mathiassen (1927:28), the archaeologist of the Danish-led Fifth Thule Expedition. His typology used material found in his excavations of precontact Inuit features from Baffin Island, Southampton Island and King William Island, material supplied to him by local Inuit from Southampton Island, a sample of the collection used by Jenness for his typology from the Hudson Bay region, and a review of the contemporaneous literature. Considering that Mathiassen's focus was reserved for the precontact Inuit, little attention is given to the Dorset other than through a simple need to sort and report the material quite randomly recovered.

1. Thin, single line hole, open shaft socket, no separate blade.
2. „ , „ „ „ , closed „ , „ „ „
3. „ , „ „ „ , „ „ , separate, inserted blade.
4. „ , double „ „ , „ „ , no inserted blade.
5. „ , „ „ „ , „ „ , separate, inserted blade.
6. Flat, single „ „ , „ „ , „ „ „

Figure 3.18 Mathiassen' Attribute List Typology (Mathiassen 1927:28)

Mathiassen uses 4 attributes from a pool of 7 to identify 6 types of harpoon heads which he presents in a list (Figure 3.18). From this list alone, an enormous amount of morphological variation may be included, thus making for very tolerant types. The author supports his attribute list with short descriptions, observations, theories, and references to where these types have been found (Mathiassen 1927:28-30). Additionally, of his 6 types, 4 were identified in his excavated material which he visually represents in plates throughout the text, and a fifth he refers to in another text. While his descriptions, observations, and theories add very little to the definitions, his visual referencing of specimens has a contrary effect to that of his list. For example, Mathiassen references Jenness' non-sliced specimens and adds them to his sliced type 3 examples. While his attribute list definitions do not include the slice as an attribute, referencing visuals for the specific morphologies of both sliced and non-sliced specimens reinforces the inclusiveness and high tolerance of the list-defined type. Nevertheless, it also reduces the level of tolerance initially defined by his attribute list by associating his types with specific morphologies. This, however, is only the case for types 2, 3, 5, and 6, as types 1 and 4 are not referenced visually within Mathiassen's text. Considering that those specimens represented visually are not consolidated, but are rather scattered throughout Mathiassen's text and others, the clear, explicit, and consolidated attribute list takes primacy in defining his types and thus type tolerance remains extremely high.

The context of Collins' (1950:20) typology differs drastically from that of Mathiassen's; he was working with the established recognition of Dorset as a culture separate from and antecedent to the Inuit, 25 years' worth of published research, and four previous typologies. For the convenience of referring to specimens excavated in Frobisher Bay, Collins sought to create a classification of known types. In so doing, he made use of his Frobisher collection, the collections from the National Museum of Man (Canadian Museum of History), and published descriptions.

OPEN SOCKET

A. Line hole at edge
- *(a)* Single spur (Plate V, figures 1-3)
- *(b)* Bifurcated spur

B–1. Line hole at centre, above the socket
- *(a)* Single spur
- *(b)* Bifurcated spur (Plate V, figure 4)

B–2. Line hole at centre, inside the socket
- *(a)* Single spur
- *(b)* Bifurcated spur (Plate V, figure 5)

CLOSED RECTANGULAR SOCKET

A. Single line hole
- *(a)* With blade
- *(b)* No blade (Plate V, figures 7, 8)

B–1. Double line holes, at right angle to socket
- *(a)* With blade
- *(b)* No blade (Plate V, figure 6)

B–2. Single line hole, parallel to socket
- *(a)* With blade

Figure 3.19 Collins' Attribute List Typology (Collins 1950:20)

Collins' attribute combination list looks at much more than the presence and absence of attributes, but also includes their position on the harpoon head, for a total of 12 attributes identifying 11 unique types (Figure 3.19). His types are also organized in a manner that addresses relationships, making spur configurations variants for his open socket types, and the distal morphologies variants in his closed socket types. No further descriptions are included with his types, but he provides a visual sample of each type found in his Frobisher sample (Figure 3.20), of which there are only 5. As a result, 6 types solely defined by the attribute list have a higher degree of tolerance to morphological variation. However, his visually represented types have low type tolerances as the bounds of variation are defined by a sample of 1 to 3 visually represented specimens.

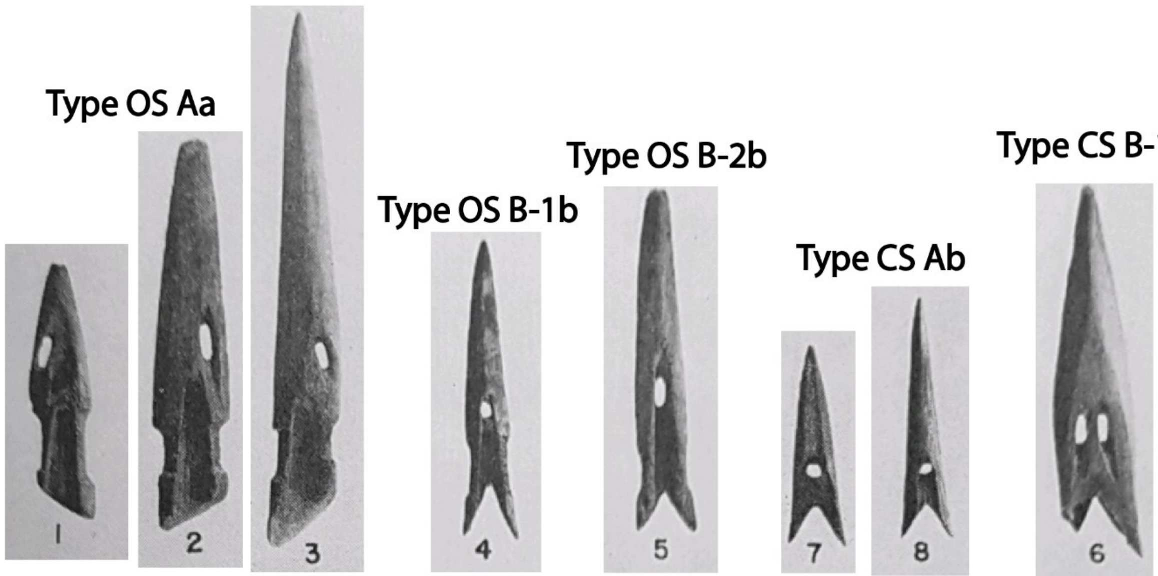


Figure 3.20 Collins' Visually Represented Types (Collins 1950)

In comparing the two approaches to using attribute combination lists, it is clear from the start that Mathiassen's list allows for a much higher type tolerance than Collins', even when considering their respective historical contexts. On one hand, Collins was working with more material and foreknowledge which allowed him recognize more variation. With such knowledge and recognition, he simply uses more attributes as markers for separation. On the other hand, Mathiassen's use of only 4 attributes opens up each type to extremely high internal variability. Mathiassen and Collins' use of visuals both differ in realization and in effect. The use of mixed spatiotemporal visual material by Mathiassen sets high bounds of tolerance in comparison to the use of intrasite visuals in Collins' typology, which has the effect of confining the level of tolerance to morphologies explicit to his Frobisher Bay site.

3.2.2.2 Written Type Defintions

The definition of types using written description allows for a more detailed account of each type without heavy reliance on attributes as presented in lists. It also has the capacity to comment on overall morphology in a way a list cannot. However, with every additional detail, type tolerance is lowered to include only those specimens explicitly encompassed by the description.

B. I) *Closed socket, no blade.* Pl. 1.3 shows this characteristic type, which is very flat and anteriorly pointed, whereas the posterior end is deeply cleft, thus making two symmetrical lateral spurs. On the dorsal side the two transversally placed line-holes open out in a circular pit (as on Pl. 1.5), and on the ventral side deep-cut channels lead posteriorly. A total of six of these was found, four of them of antler and two of walrus ivory, lengths from 8.7 to 5.2 cm.

Figure 3.21 Sample Description by Holtved (Holtved 1944)

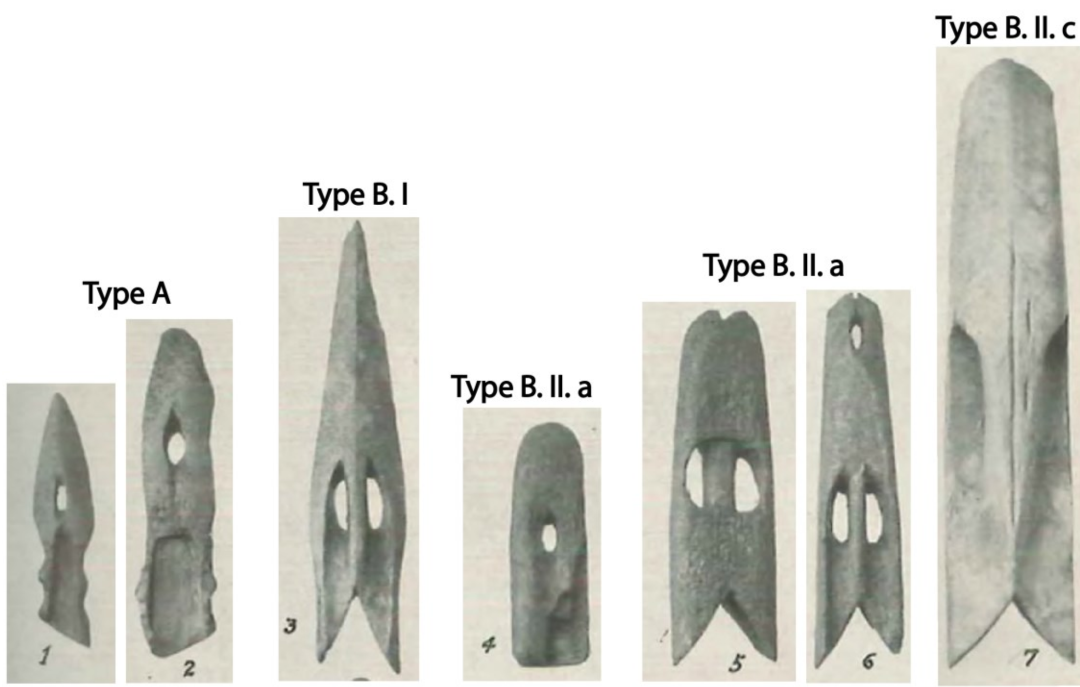


Figure 3.22 Holtved's Visually Represented Types (Holtved 1944)

Holtved's (1944:192-195) excavations in the Thule District, Greenland uncovered Dorset material stratigraphically beneath Inuit material, making it some of the first confirmed evidence of the Dorset being an antecedent culture. Using neither reference to the literature nor other collections, Holtved created a typology to describe (Figure 3.21) and sort his newly excavated Dorset material.

As a purely intrasite typology, it is expected that type tolerance remains very low however the typologists wish to describe the material. In this case, Holtved uses a mix of detailed descriptions paired with some listed attributes, all of which is supported by a plate showing 1-2 specimens for each defined type (Figure 3.22). Each type description is headered by a few attributes meant to define the type. He defines larger type families with two attributes and adds a third or fourth attribute to further differentiate. This is followed by written descriptions of the specimens used to define each type; these provide further details on overall appearance, size, attribute or morphological particularities, and decorations. Additionally, some specimens are described, but not shown. The use of written descriptions to classify intrasite material has the effect of drastically decreasing type tolerance; the visuals work to the same end by further restricting each type to the accepted morphologies shown.

Taylor's (1968) typology (Figure 3.23, 3.24), study of Tayara, and foundational intersite comparison is still held in high regard today. At first glance, the typology appears to be intrasite much like Holtved's, however, his type definitions and their respective type tolerances are inconsistent to that effect. Taylor (1968:51-53) identifies seven types of Dorset harpoon heads recovered from his Tayara excavations. For these, no attribute list is offered but the details written for each type definition surpasses that of Holtved. The morphology of each attribute is described in addition to the overall morphology, specific specimens are also described when they differ from others of the same type. Overall, the type descriptions promote relatively low type tolerances. Only one of the seven types, the Dorset Parallel, is described and defined not in relation to the Tayara specimens, but to specimens from varied spatiotemporal contexts. He appears to have done this having noticed chronologically sensitive changes in morphology from the study of other collections and literature. As such, the Dorset parallel has a much higher tolerance to variation than his other defined types which are based solely on the Tayara specimen descriptions. Each of these types is represented visually with specimens from Tayara at the end of the text (Figure 3.24). Most types have 2-3 example specimens, but two only have one. Since these specimens are closely described in the type definitions, the visuals do little to increase type tolerance.

g. *Dorset Plain type* — total 1 (Fig. 22, m).
This ivory specimen measures 3.5 by 1 by .5 cm. Although complete, the specimen seems too small to have served for hunting; the socket, only 2 mm. deep, could hardly have held a foreshaft securely; probably it was a toy. The specimen is subrectangular in cross section with straight edges and nearly flat surfaces. The base forms a deeply concave parabola in which is cut the completely closed socket with a narrow, rectangular cross section. The forward tip has been carved to form a triangular end blade. The single gouged line hole is set near the center of the piece at right angles to the end blade and socket. There is no scarfing at the base; the only suggestion of scarfing occurs in a slight flattening of one surface from the forward margin of the line hole to the base. This seems to be a rare type in Dorset samples. (KkFb-7-236, Level I).

Figure 3.23 Sample Description by Taylor (Taylor 1968)

Following the type definitions is a comparison section used to evaluate the position of Tayara amongst other known sites. In this section Taylor identifies his types within other collections which ultimately affects the tolerance of each defined type. Admittedly, most identified material fits his definitions well and proportionally increases type tolerance with each comparison. Others, however, do not fit each detail of his descriptions.

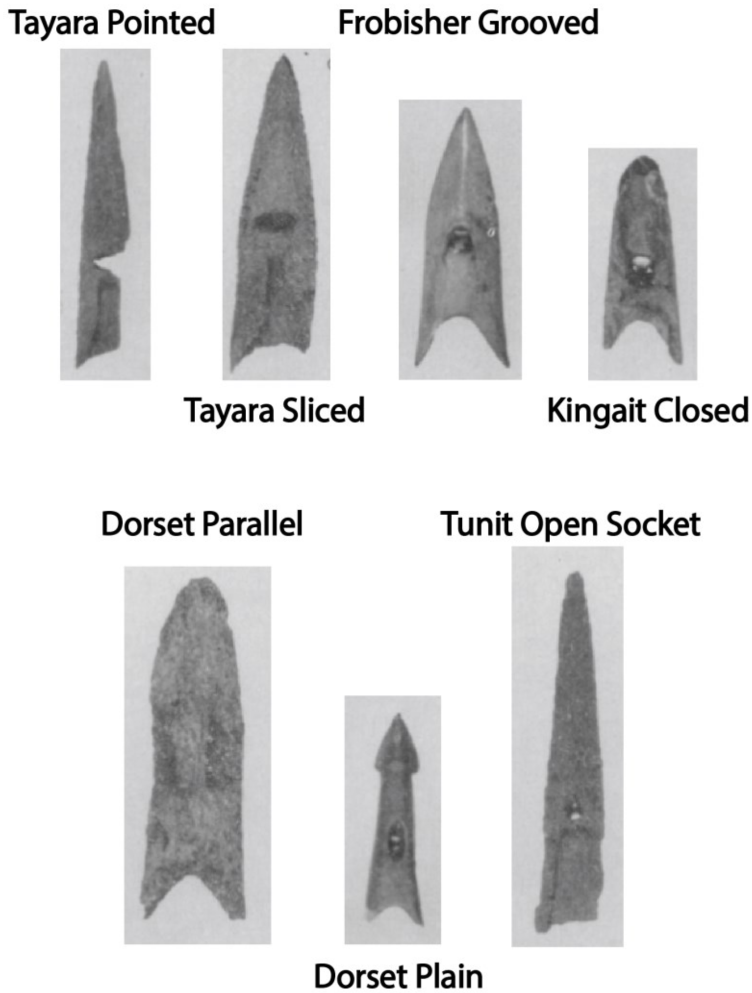


Figure 3.24 Taylor's Visually Represented Types (Taylor 1968)

The biggest point of contention lies in the definition provided for the Dorset Plain (Taylor 1968:53), defined from a single Tayara specimen which features a model-tip. Taylor equates it (Figure 3.25) to a similarly sized and shaped harpoon head from Collin's (1957:49) T3 collection which completely lacks the model tip, and is endblade slotted instead (Taylor 1968:74). The comparison reveals that the model tip was not the defining factor of the type, but likely relied on overall morphology. Nonetheless, the result is a type consisting of two alternate proximal attributes which increases the bounds of type tolerance beyond that of his other types. Taylor's confusing account has failed to be noticed by subsequent researchers, who to this day continue to define Dorset Plain based on the model tip (Desrosiers et al. 2006; Houmard 2011; Jordan 1979; Jordan 1980). Thus, caution is necessary if his descriptions are to be used as type definitions because it is not always clear whether he is describing the Tayara material, defining culture-wide types, or both, resulting in hard to define bounds of type tolerance without close inspection. Furthermore, it reveals that defined types do not necessarily communicate the hierarchy of importance ascribed to each attribute by each author or the author's willingness to bend their definitions, or the degree, to fit more material.

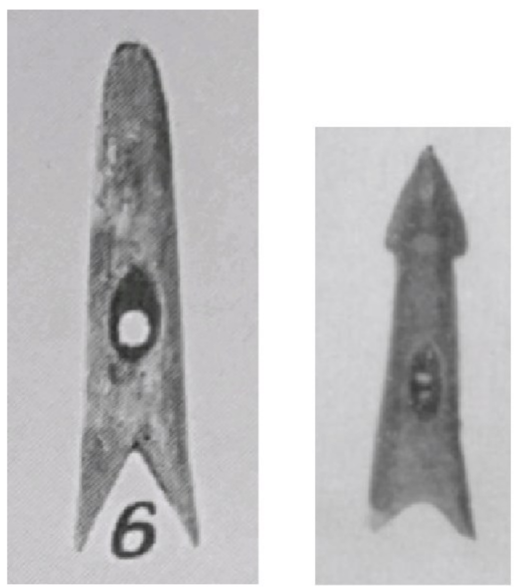


Figure 3.25 T3 and Tayara Dorset Plain (Scaled) (Collins 1957:49. Taylor 1968:74)

The use of type descriptions in both typologies differ significantly. While Holtved uses a balanced mix of description, attribute lists, and visuals, which has the desired effect of limiting type tolerance to intrasite morphologies, Taylor describes materials both from his site and others, expands the written definitions to include more material through comparison, and his visuals effectively end up only showcasing part of the already expanded morphological ranges for each type. What we do see from both is the ability a description has in creating types with low tolerance from the start, the detail of description being correlated with the level of tolerance.

3.2.2.3 Visual Typologies

Typologies that primarily rely on visuals are usually the most accessible. Anyone can pick them up and look at the images to immediately understand how a specimen relates to a defined type. Two of the most famous works on Dorset harpoon heads happen to be nearly completely visual. Furthermore, both are chronological and spatial typologies. Regardless of their similarities on those points, both typologies could not be more different.

Maxwell's (1985) is one such visual typology. His monograph collects material from all over the Eastern Arctic in an effort to study the most explicit morphological forms and changes common throughout the Dorset spatiotemporal continuum. As a result, each of his types are identified at as many sites as he could bring together in his study. From the beginning, that has the effect of increasing type tolerance beyond all other typologies presented here thus far, regardless of representation.

Maxwell (1985:136) provides a visual "schematic development of seal hunting harpoons" from the Pre-Dorset through Terminal Dorset. Being solely for seal hunting it excludes the Dorset Parallel sequence (Figure 3.26). This temporal array is meant to show that "for typological dating, they differ stylistically through time, with similar stylistic treatment appearing simultaneously in widely dispersed sites" (Maxwell 1985:135). Unfortunately, no spatiotemporal relationship is shown beyond their being part of a linear sequence divided into three phases representing Pre-Dorset, a transitional phase, and Terminal Dorset. The relationship between each specimen is also lacking, and thus the possible evolutionary connection between some specimens is nonexistent. Its purpose appears to be to give a ‘sense’ of stylistic evolution throughout the Pre-Inuit phase of the Eastern Arctic, not from the standpoint of individual types or specimens, but rather from what may be found in the hunter’s toolkit during a given period. As a result, its usefulness for subsequent analytics is close to nil. However, if one were to regroup each specimen displayed with those featuring the same attributes, it may show the bounds of type tolerance for that given type. Unfortunately, not all attributes are easily discernable from the schematic.

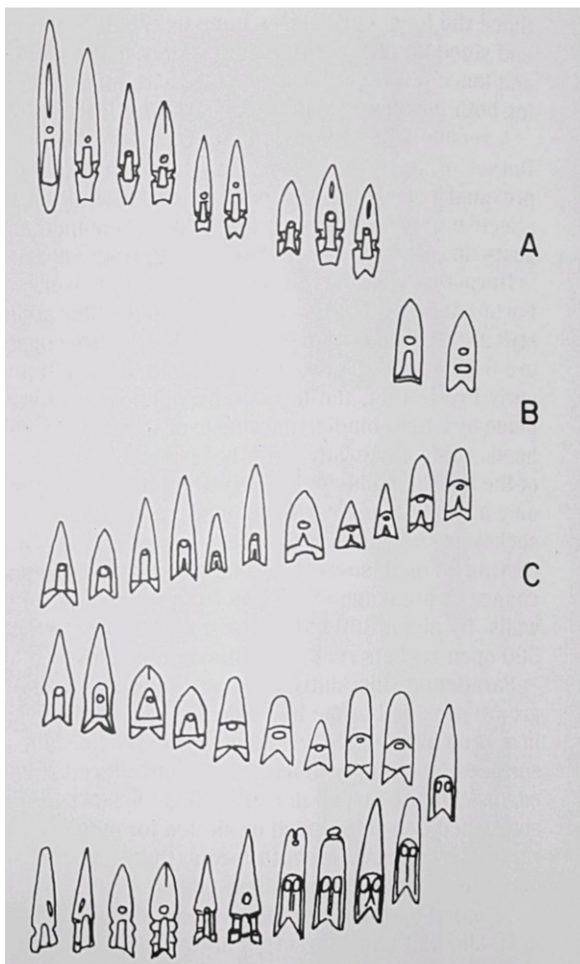


Figure 3.26 Maxwell’s Visual Chronological Schematic (Maxwell 1985:136)

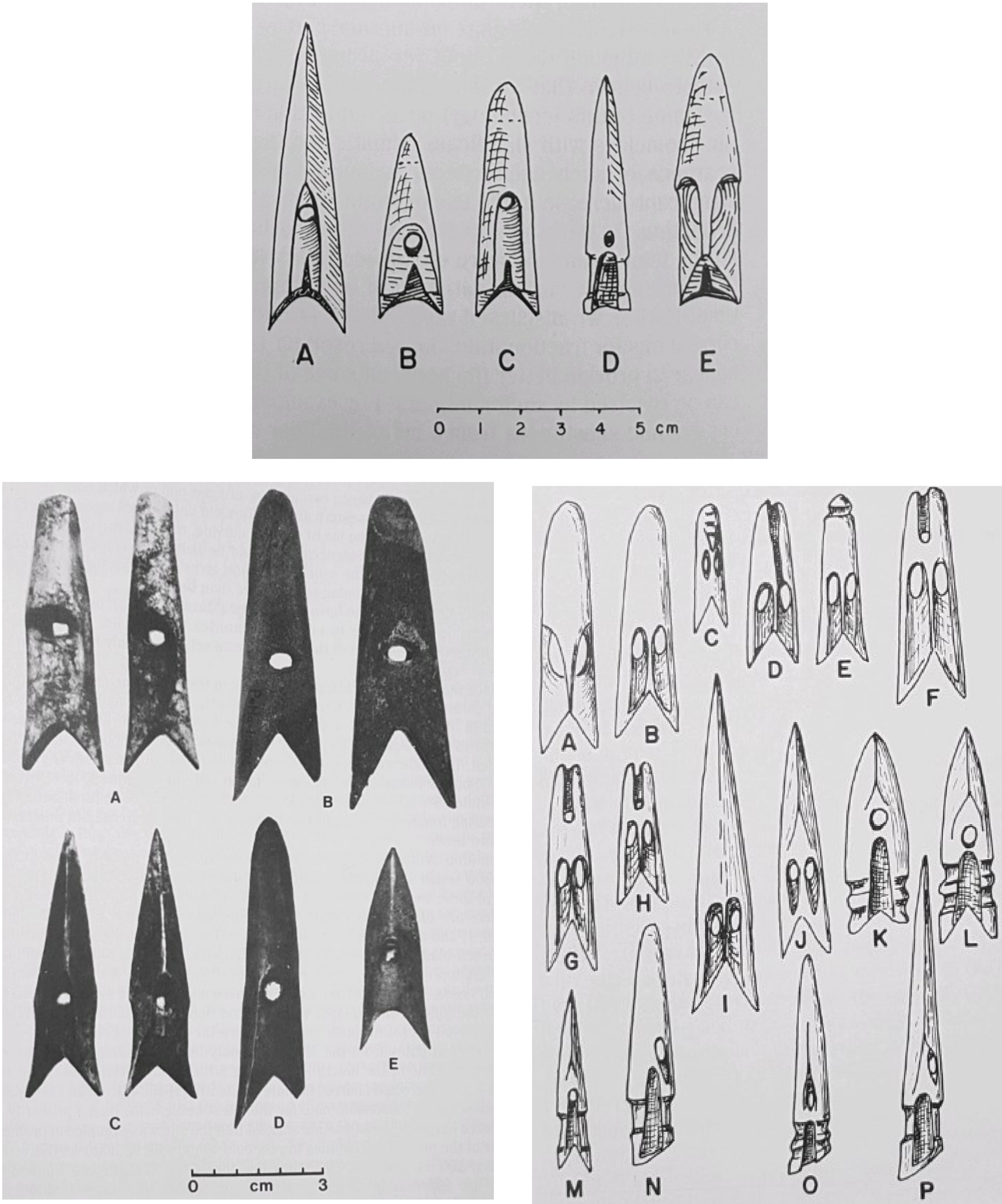


Figure 3.27 Maxwell's Visually Represented Types (Maxwell 1985), Early Dorset (Top), Middle Dorset (Left), Late Dorset (Right)

Nonetheless, with the recognition that harpoon head styles change over time in a spatially consistent manner, he formally divides the Dorset into very broad mutually exclusive categories favoring the most ideal forms with no regard for their evolutionary states, variants, or relationships based on now defunct radiocarbon dates (though likely still accurate on a relative basis). His efforts, however, resulted in these divisions still being widely used today in at least the preliminary identification of material in the field. These Dorset phases are presented in a formal morphological harpoon head typology throughout the monograph. Each type can be found represented visually, either identified in figures specific to site collections or regrouped to display the types for a temporal era (Figure 3.27). Short definitions, comments, and observations are found throughout the text, but do not consistently address each type. As such, the visual representation is the primary mode of communication and in considering the wide spatiotemporal contexts it regroups, each type has a very high tolerance for morphological variability.

The other primarily visual harpoon head typology was produced by Meldgaard (n.d), which remains the most comprehensive analysis of harpoon head temporal variability yet. First, it constitutes a regional typology; Meldgaard's work spanned 11 sites in the northeastern portion of Foxe Basin, Nunavut. The most important of these sites is Alarniq, where Meldgaard (1960b) identified 208 house features spanning thousands of years of near-continuous cultural development, supported by a linear sequence of beach ridges stratified in elevation by the effects of isostatic rebound. As a result of these effects, older shorelines are found at progressively higher elevations throughout this area of the Eastern Arctic thus permitting relative dating at a time when carbon dating was in its infancy. Meldgaard's relative chronology was later supported by C-14 dating (Savelle et al. 2009), making his work at Alarniq and the surrounding region as accurate as it was foundational for an early, and continued, understanding of the Pre-Dorset and Dorset in the Eastern Arctic.

Second, as a typology encompassing a relatively small region, the geographically close-knit nature of each site offers material throughout time that is not subject to too much geographically based variability. Compared to the earlier (and even later) typologies, which have an overall smaller sample from collections near and far, Meldgaard was in the most favorable position to conduct typological work.

Third, the hundreds of harpoon heads spanning the complete Pre-Dorset and Dorset cultural sequences recovered, in combination with the ability to relatively date them, allowed Meldgaard to create a chronological and spatial typology. Such a typology uses attributional and distributional features to discover chronological patterning, and focuses on changes in stylistic attributes rather than functional attributes, as they are likelier to change over time and space (Adams and Adams 1991:220-221). In short, Meldgaard was able to map the evolution of harpoon heads in the region.

Meldgaard uses 9 harpoon head families, type-lines A-H and J, to evaluate their chrono-morphological evolution and to demonstrate a nearly gapless history for harpoon heads. Throughout and between each family, or type-line, there is evidence of innovation; potential loss or abandonment of technical knowledge in favor of style; parallel, converging, and bifurcating evolutions; and discrete and explicit trends over time. The appearance and disappearance of type-lines over time demonstrate the abandonment and development of new styles in the fluid and hybridized manner described by de Laguna a couple of decades earlier.

While it was possible to study Meldgaard's (n.d) original typology for this project, most of it is not published. Type-line A is the most well-known, 20 of the 24 type-states having been published by Maxwell (1976:61; 1985:87) (Figure 3.28). Type-Line A features the evolution of self-bladed, single-line hole harpoon heads from the Pre-Dorset to what could be considered the end of the Middle Dorset, before the Dorset harpoon head toolkit underwent quick and drastic changes which resulted in the Late Dorset phase. Throughout this type-line, the attributes which undergo the most perceivable change begin at the distal tip, then happen more extensively at the proximal end.

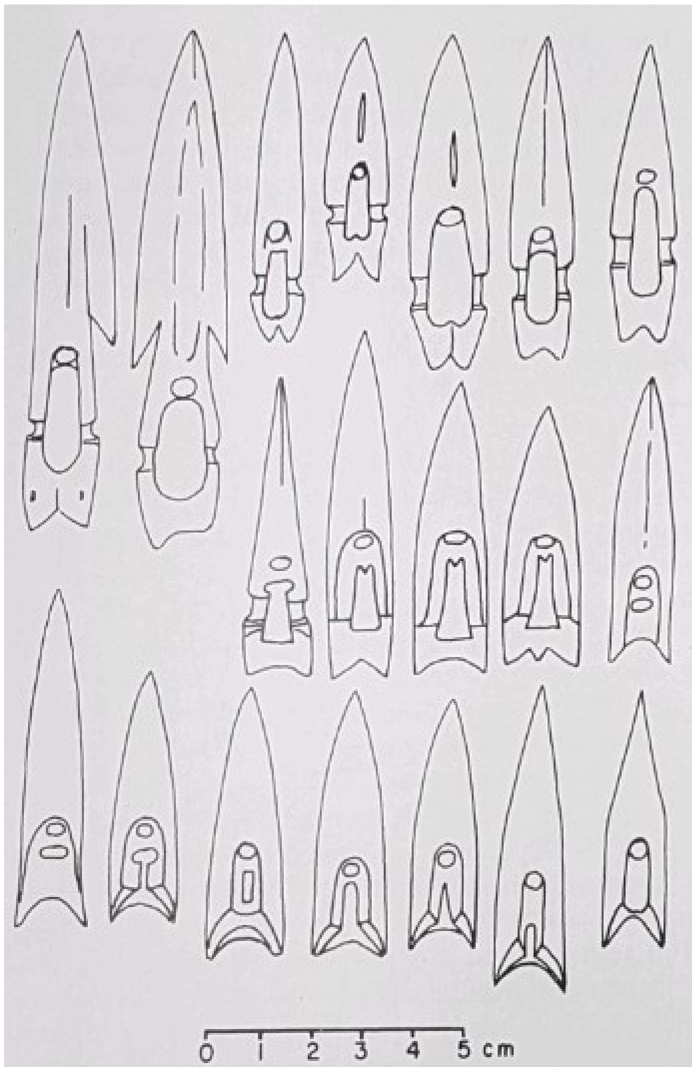


Figure 3.28 Meldgaard's Type-line A (Maxwell 1985:87)

Each of Meldgaard's original type-lines are represented visually in a detailed series of drawings which provide site location and beach ridge elevation, the number of specimens attributed to each type-state, and additional notes on variants, particularities, and general observations. While no systematic identification of each attribute is presented, they are implicit by their repetition in the chronological sequence. Focus, after all, is on the morphological changes in each attribute and overall shape. What is also implicit is the relationship between each type-line and type-state. Type-states are ordered to represent a continuous evolution, though many are contemporaneous judging from the relative dating offered by site elevation. The relative chronology also shows when each type-line appears and demonstrates how some may have started as variants of others which have found success in either function or style. Barring the possibility of varying success in function (i.e., accepting their undoubted overall functionality), Meldgaard's typology demonstrates how flexible the functional design is through the accommodation of such varied morphologies over time.

As a visual typology, the morphological bounds of each type are determined by the specimens displayed. It is evident in Meldgaard's work that he was very sensitive to morphological changes, which allowed him to order what he thought was continuous development for different type-lines, albeit with few specimens to fit within each type-state, and even fewer represented visually. Additionally, the geographic proximity of each site not only contributes to lower the tolerance of each type-state, but in combination with the abundance of material has the effect of creating the most high-resolution picture of variability in any Dorset harpoon head study. Thus, all type-states have very low tolerances, and many more types are created to represent great morphological variation which was otherwise lumped together by Maxwell to create more encompassing and tolerant types.

The chronological assessment of harpoon head evolution sets Meldgaard's typology apart from all others. By creating type-lines composed of morphologically related type-states, Meldgaard endows them with relationships overlooked by most. While Maxwell (1985) recognizes a temporal relationship between a few of his types, such as the Tayara Sliced and

Kingait closed, they are all given equal standing as separate and unique entities. Each of his types should be considered as very inclusive low-resolution snapshots averaging out larger temporal periods of morphological distinctiveness from within a continuous sequence. Conversly, Meldgaard includes the Tayara Sliced and Kingait Closed in type-line D but represents them using over 20 type-states and each with one or two visual specimens plus variants, the effect of which is to give each type-state equal standing at the conceptual level, or even at the potential emic level. To continue the snapshot analogy, Meldgaard presents the whole movie (or most of it), while Maxwell represents the movie using a trailer which reveals too much of the plot leaving those who have seen it thinking they have seen the whole movie. Problems then arise when the movie is studied using only the trailer, or harpoon heads interpreted solely from Maxwell's typology.

The Meldgaard typology thus embodies the best work on Dorset harpoon head variability, is the best positioned in terms of material abundance and spatial context, and is the closest arctic archaeologists have to come to identifying the emic: how Dorset individuals may have conceptually perceived their own harpoon heads through time. Unfortunately, it is impossible to truly attain the emic, and meaning may have changed significantly alongside changes in morphology, even if one type-state appears to lead to the next. It is also quite possible that an older specimen may not be recognized or acknowledged as the same by a later individual making harpoon heads of a later design, even if the linear evolution can trace the old to the new, as morphological changes can be great and the emic itself has a life-history. However, again considering how Meldgaard's work is the closest of all to the emic, it should not be ignored for what it cannot explain but rather accepted for what it can reveal.

Though the different problems and benefits of visualizing and describing variability have been assessed through an overview of past typologies, their value in informing what material to use in this project remains substantial. While Maxwell's low resolution temporal typology covers the largest spatial range, Meldgaard's covers the temporal range of variability at the highest resolution while only concerning itself with a limited spatial range. Together, they are extremely informative about what material has the highest amount of homology and how morphology has changed over time, and allow for the critical assessment of typologies as a concept. Meldgaard's type-line D, which covers the life-history of endblade slotted and single line-holed harpoon heads, is that best represented in the three collections used for this study. Using Maxwell's broader types, these collections have a large abundance of Kingait Closed specimens with a few Tayara Sliced. Both typologies accept that the former precedes the latter, Meldgaard's being the best equipped to explain the temporal relationship. In terms of homology, the Tayara Sliced and the Kingait Closed only differ in proximal dorsal arrangement; the former has a sliced closed socket while the latter lacks the slice and features a fully enclosed socket. In terms of morphology, a qualitative assessment such as Melgaard's reveals that older Tayara Sliced specimens differ from the youngest Kingait Closed specimens, but where the two supposedly transition, they are equivalent in overall shape (Figure 3.29).

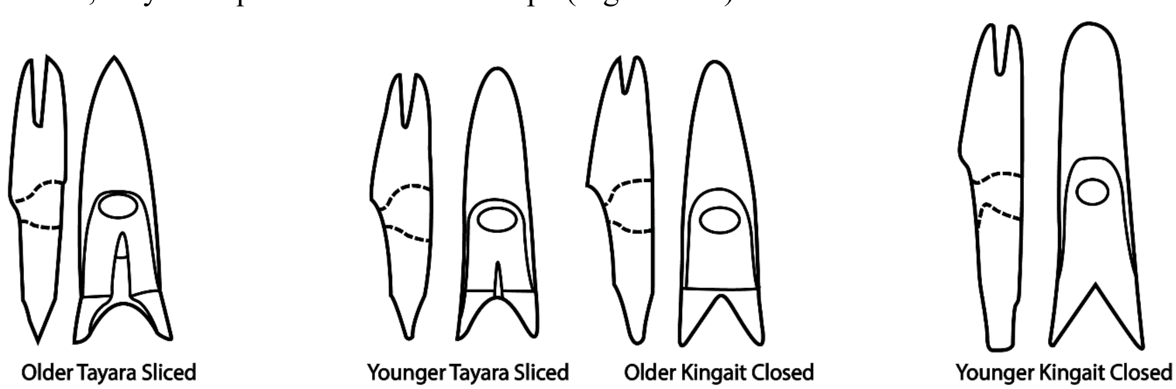


Figure 3.29 Tayara Sliced and Kingait Closed Temporal Variability (after Meldgaard n.d.)

In considering homology, morphology, and temporal characteristics it was decided to focus on those Kingait Closed specimens. Even though the Tayara Sliced would easily be comparable to the Kingait Closed using morphometrics, absolute homology was given precedent. Furthermore, restricting the temporal range to those specimens most contemporaneous is likelier to reveal patterns of local knowledge which may otherwise be obscured by temporal changes. Additionally, the large difference in sample size between the Kingait Closed and the Tayara Sliced simply does not make their morphometric comparison worthwhile. The assessment of local knowledge within a larger scale of temporality would nonetheless be a fruitful future venture but is currently beyond the scope of this project. Thus, the Kingait Closed, a temporal segment in Type-D morphological life-history remains the best possible choice for geometric morphometric analysis. The sites from which the assemblages considered in this analysis derive are described in turn below.

3.3 Site Background and Collections Review

Three distinct site assemblages were investigated for this project. This number was chosen due to the relational nature of the statistical analysis, considering that analyzing two collections would only reveal a single bilateral relationship and three collections would reveal three unique bilateral relationships. As for criteria in choosing the collection, a widely spaced sample was opted for under the hypothesis that they would show the most distinctiveness (Figure 3.30). Furthermore, a comparable sample was needed. While not specifically aiming for the Middle Dorset (Figure 3.31), a collection from northern Baffin Island was identified which contained an abundant sample of harpoon heads and was unstudied since having been typed in the field. The large size of the Saatut's (PeHa-1) harpoon head collection was ideal for the nature of this study, and it was identified as being typologically Middle Dorset. The Philip's Garden Site (EeBi-1) also dated to the Middle Dorset and was easily accessible being on the Memorial University of Newfoundland campus. Tayara (KbFk-7) also has a component dated to the Middle Dorset, and smaller sample of harpoon heads. Tayara and Philip's Garden both have a rich history of archaeological investigations, and as a result are useful to ground Saatut in well-established scholarly foundations.

Figure 3.30 Location of Sites in Eastern Canada Discussed in the Text (Map Produced by James S. Williamson)

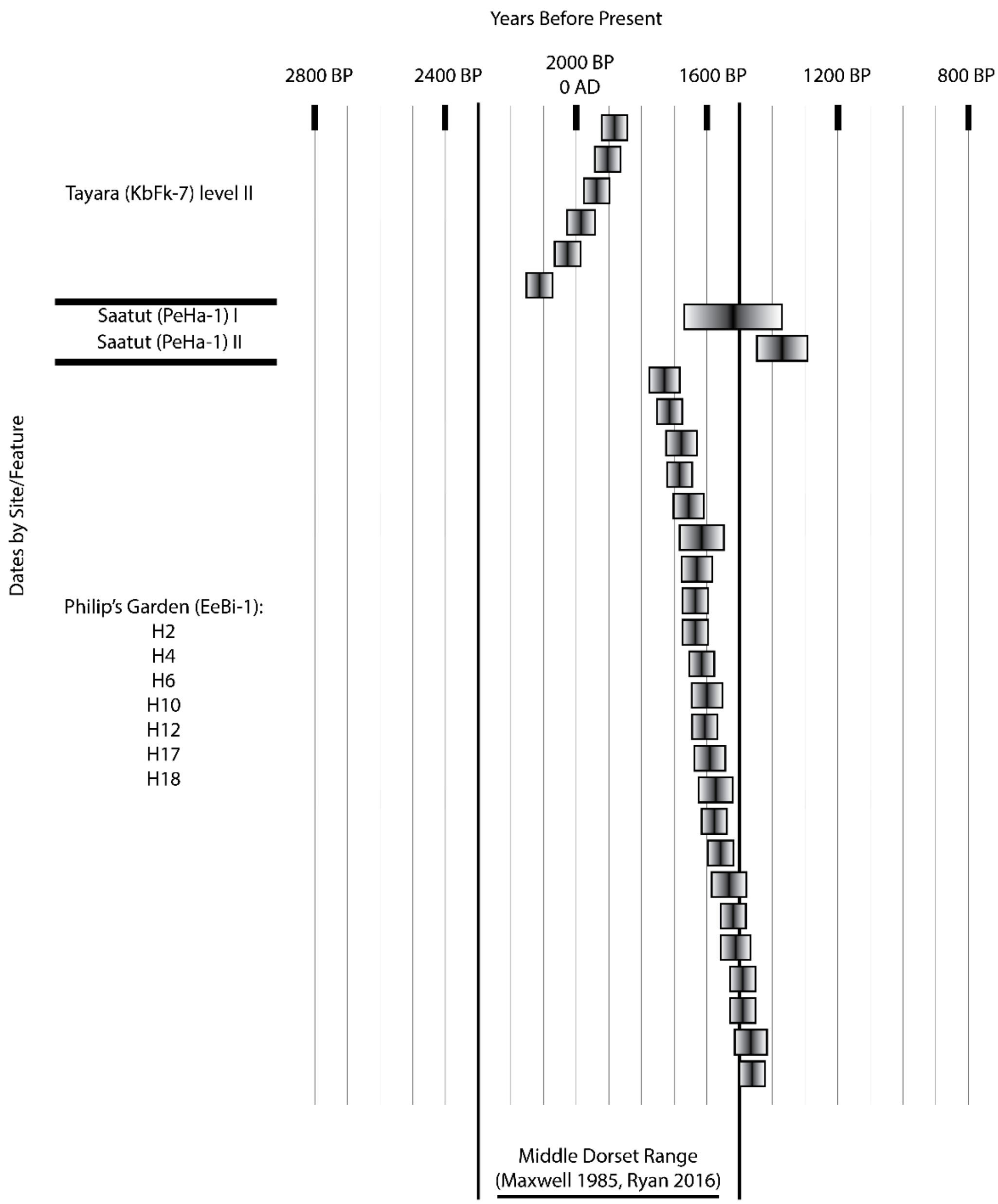


Figure 3.31 Consolidated Dates from Saatut (PeHa-1), Tayara (KbFk-7), and Philip's Garden (EeBi-1) (Mary-Rousselière 2002, Desrosiers 2009, Wells 2012)

3.3.1 Saatut (PeHa-1)

Saatut is located on northern Baffin Island (Figure 2.30, 2.32) on the western shore of Eclipse Sound, just south of the point which marks the beginning of Navy Board Inlet (Mary-

Rousselière 1970; 1976:48; 2002:48). It was first brought to the attention of Father Guy Mary-Rousselière, of the nearby Pond Inlet Catholic Mission, in 1966 by Asarmin Kipumi who discovered artifacts of bone and chert as he cut blocks of sod to build a dog shelter (Mary-Rousselière 2002:79). First explored in 1967 (Mary-Rousselière 1989b:3), it was excavated over 10 seasons between 1969 and 1987 for a total of 71 days (Mary-Rousselière 1989a, 1991).

The site itself faces a now dried-up river bed and is perpendicular to the sea shore (Figure 3.33). Throughout the decade and a half of investigations, erosion at an average rate of 65cm per year was recorded. It is estimated by Mary-Rousseliere that during its occupation the site was up to 800m meters away from the sea shore, leading him to believe it was a river camp rather than a beach camp (Mary-Rousselière 1977, 1983, 1989a).

Figure 3.32 Saatut (PeHa-1) within Navy Board Inlet of Baffin Island (Map Produced by James S. Williamson)

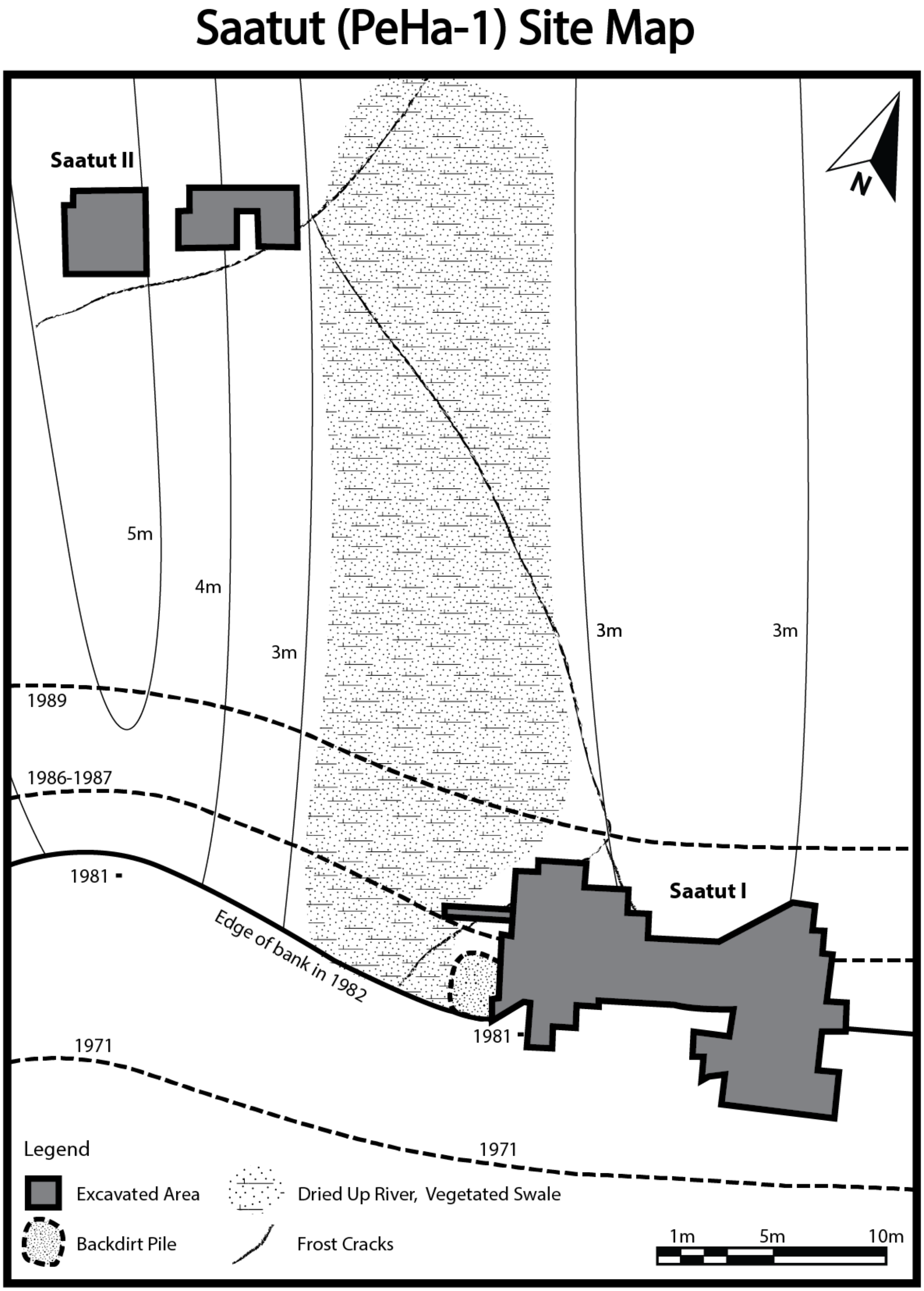


Figure 3.33 Saatut (PeHa-1) Site Map (after Mary-Rousselière 1989)

Cultural deposits were first identified on two successive terraces, at 2.7m asl and 5m asl (Mary-Rousselière 1976:48). While the terraces appear to have been formed by isostatic rebound, the higher elevation being further inland in relation to the sea, the river channel appears to have created ridges perpendicular to the seashore. Saatut I, the lower of the two deposits, covers a low river ridge which peaks at 3.4m asl and slopes to 2.7m asl on either side. Work was mostly concentrated on this feature and constituted salvage work in advance of the eroding shoreline. While rich and well preserved, some 1 m^2 units containing up to 2,200 faunal bones, Saatut I showed no sign of architectural remains or earthworks (Mary-Rousselière 1972, 1976, 2002) . Overall, about 83m^2 were uncovered in this area (Mary-Rousselière 1987:2). The cultural layer was generally 20cm in depth and no more than 35cm (Mary-Rousselière 1970:3).

Saatut II is located further inland and did not appear threatened by erosion when last visited in the late 1990s. Excavation at Saatut II began on a river beach ridge west of the first, at its highest point around 5m asl. Over time, the excavations extended eastward downslope to 3m asl (Mary-Rousselière 1989b). In this area, very faint rectangular depressions were identified (Mary-Rousselière 1972:6); one measuring 4m by 3.5m was fully excavated in addition to part of a midden. Nearby to the north-east, a slightly depressed feature measuring 1m by 0.5m was excavated which produced flagstones, wood, two caribou scapulae, a large piece of antler, and a fragment of flat whale bone. It is described as reminiscent of a similar feature identified as a child's grave at Alarniq by Meldgaard, but contained no human remains (Mary-Rousselière 2002:79). A total of 23m^2 were excavated in this area.

In 1994, Father Guy Mary-Rousselière sadly passed away in a house fire in Pond Inlet. Furthermore, a large part of the archaeological notes and photographs of his work in the region were destroyed. What remains is a plethora of excavation reports which include summaries of the work accomplished and preliminary interpretations, as well as an unfinished manuscript which was eventually published (Mary-Rousselière 2002) thanks to the combined diligent work of some of his contemporaries. While the catalogue entries provide feature and unit context for each artifact, specific measurements including depth no longer exist, nor do excavation maps containing the relational context of each unit. Thus, any analysis of artifact distribution remains impossible. While the situation may lead many to ignore such a collection, as with other museum collections with insecure contexts and collections that have previously been studied, the artifacts themselves still contain a vast amount of information easily freed by geometric morphometrics.

The harpoon head collection from Saatut remains unstudied beyond primary identification, and the impressive abundance of specimens make it an ideal candidate for geometric morphometrics. The reevaluation of the collection counted 182 harpoon heads from the combined Saatut I and II. Mary-Rousselière (2002:83) interprets the majority of the harpoon heads as sealing harpoon heads, with only a small number viable for walrus hunting. Of Meldgaard's Type-line A, he identifies 45 harpoon heads which he roughly assigns to A22, 23, and 24. The independent assessment of the collection yielded 44 closed socket, self-bladed harpoon heads. Though they may be the stylistic equivalents to Meldgaard's A22-24, they cannot be easily assigned to those specific type-states. The self-bladed harpoon heads from Saatut mostly feature a terrace (Figure 3.34), whereas the Igloolik specimens are all grooved. There are 33 such specimens which Mary-Rousselière (1975:5) names type 'Saatut'. All feature a terrace and are describe as distinguished from the Kingait Closed only by the distal attribute. Maxwell identified such a type from his Kemp site, which he first named Type V and interpreted as coeval to his Type III, the Kingait Closed, but later renamed Kemp Pointed (Maxwell 1973:140-141; 1985:200). Maxwell (1985:209) makes reference to a 'Saatut Pointed' when exhibiting material from Saatut, but then wrongly interprets all the Type As as his Native Pointed Grooved, the grooved self-pointed type. Indeed, the Saatut Pointed and the Kemp Pointed have the same attributional definitions and are morphologically indistinguishable. An additional Kemp Pointed specimen features a distal dorsal groove, while another features the proximal dorsal terrace, a distal dorsal groove, and a ventral groove that extends the whole length.

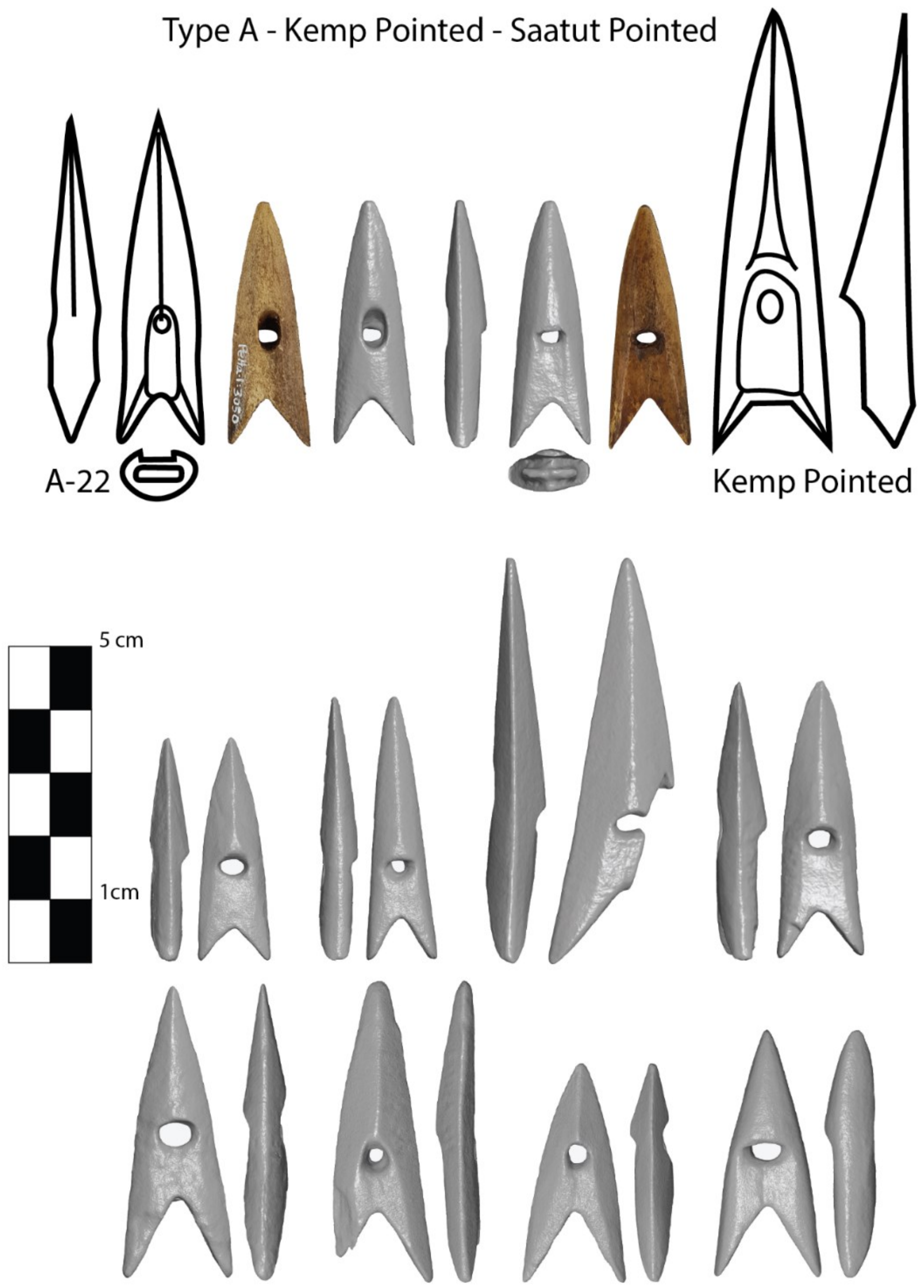


Figure 3.34 Saatut Type A – Kemp Pointed – Saatut Pointed
(Drawings after Meldgaard n.d. and Maxwell 1985:141)

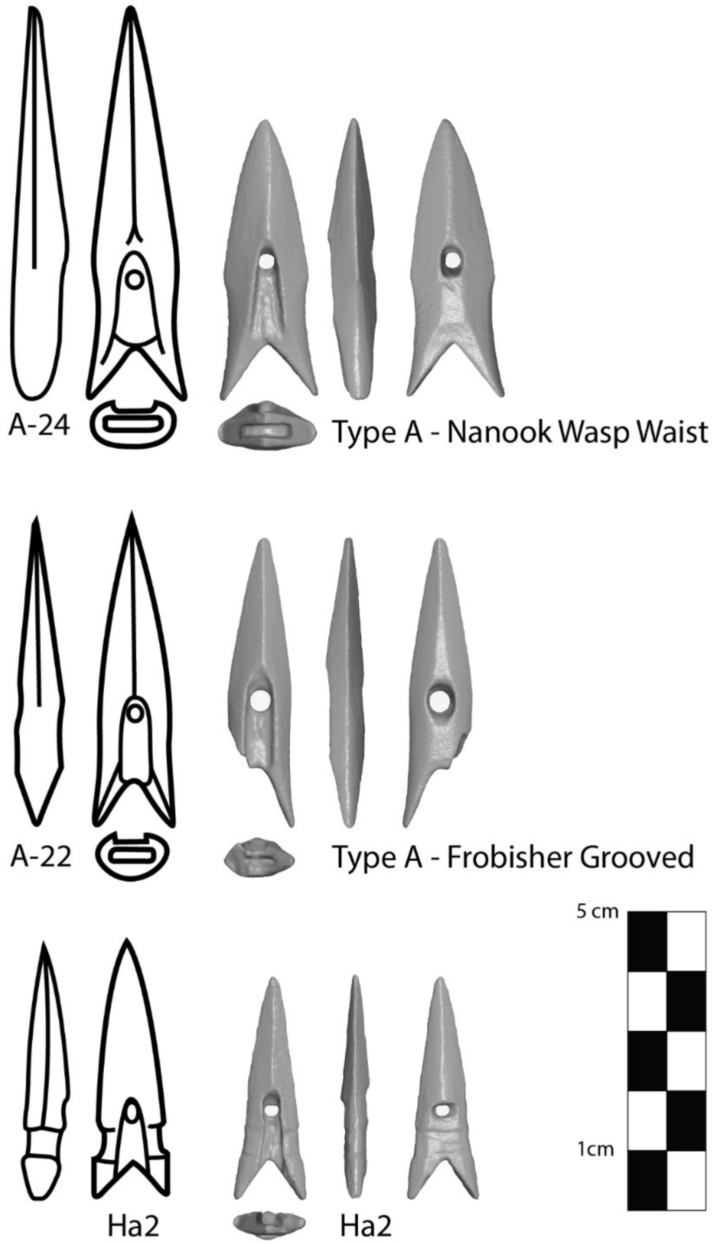


Figure 3.35 Saatut Type A's and Ha2 (Drawings after Meldgaard n.d.)

Of the remaining type As, 5 Frobisher Grooved specimens were identified (Figure 3.35), each defined as having a proximal dorsal groove. Of these, one specimen has an additional distal dorsal groove. There is noticeable variability between these specimens, notably in the depth of the groove and the lateral morphology. One has straight sides, while the three remaining ones which are sufficiently complete have varying degrees of lateral concavity with flared spurs. One specimen is nearly identical morphologically to a single specimen confidently typed as a Nanook Wasp Waisted (Figure 3.35), but with the degree of lateral concavity being the only real difference. While the Frobisher Grooved and the Nanook Wasp Waisted are most certainly related, perhaps evolutionarily, they are likeliest of all the same emic type. An additional 3 specimens could not be identified any further than their inclusion in the type A family from lack of a complete distal dorsal portion.

Three specimens easily attributable to Meldgaard's type Ha2 (Figure 3.35) were recovered at the Saatut site. These are self-bladed and open socketed. The inclusion of these specimens is of great evolutionary interest as they are uncannily morphologically related to the Frobisher Grooved and Nanook Wasp Waisted specimens from the same site. The morphology of the open socket reflects that of the groove, only deepened to replace the space used by the closed socket. The lashing grooves or trenches would thus take advantage of the morphology of the proximal lateral concavities.

Another 3 specimens are identified as Dorset Parallels (Figure 3.36). All three specimens lack a ventral hole, making them properly transversal. They appear to be equivalent to Meldgaard's Types E-17 to 19, with the latter being most similar in spur lateral morphology. These three specimens, however, are considerably smaller than their counterparts from elsewhere in the Arctic, and have even been interpreted as toys (Mary-Rousselière 2002:84).

This interpretation may indeed apply to the smallest of the three specimens which completely lacks a foreshaft socket. The two remaining specimens are slightly larger and are equipped with foreshaft sockets, and one has damage related to use. The near-complete lack of walrus faunal remains, which the Dorset Parallel has been interpreted as being used to hunt, would mean that walrus was indeed not normally hunted at Saatut. The small stature of the

Dorset Parallels may thus indicate their adaptation and use on smaller prey, such as seal, as the breakage pattern on one would indeed indicate use. One specimen, which seems to be completely out of place in the assemblage, is a Type-E specimen with a thin-trefoil line hole that would fit within the range of Meldgaard's Type-E 7 or 9 based on spur morphology and ventral hole visibility from the dorsal face. In Foxe basin, these types appear in a period of the Early Dorset which experimented with various dorsal proximal arrangements.

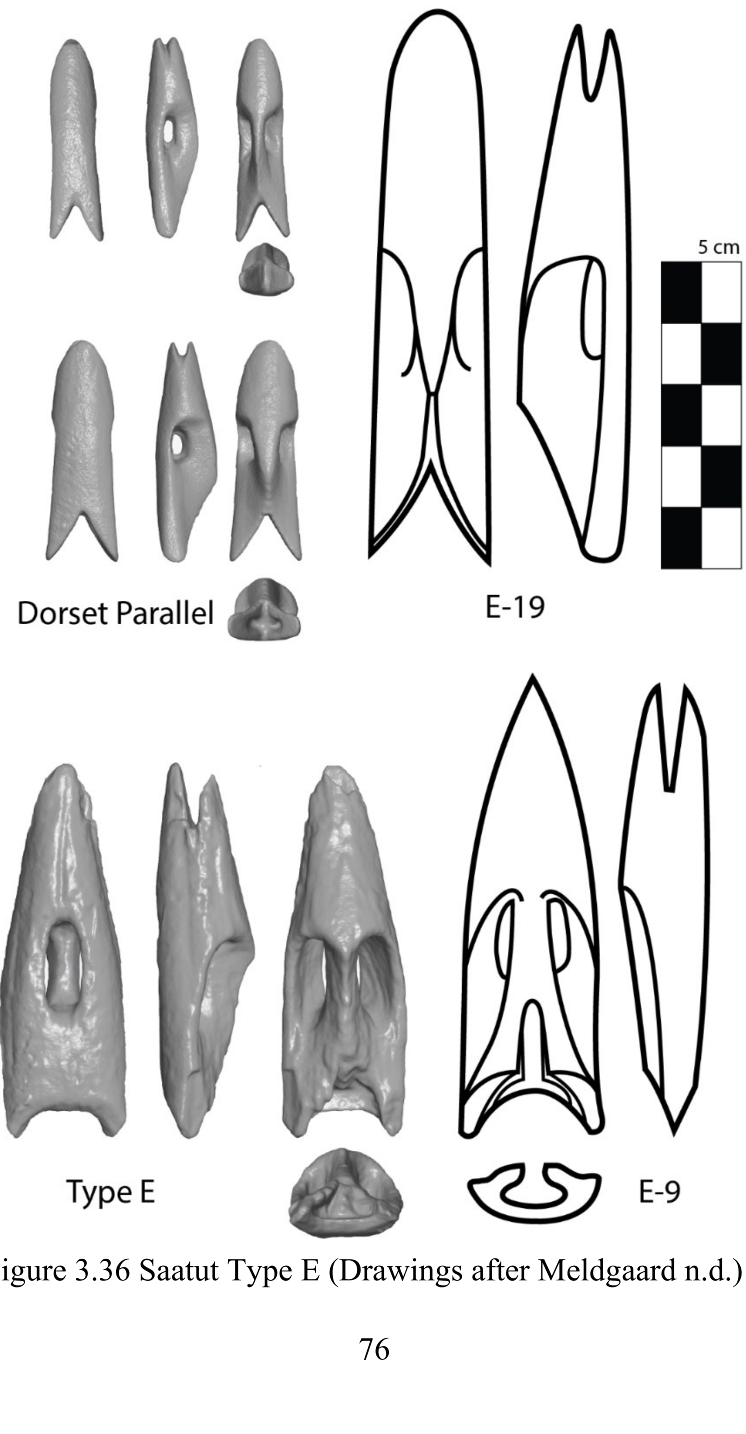


Figure 3.36 Saatut Type E (Drawings after Meldgaard n.d.)

Finally, there are 100 specimens identified as Kingait Closed harpoon heads (Figure 3.37). In no case is there any ambiguity as to their type, as there occasionally was for the Type A's. Each harpoon head is blade-slotted, closed socketed, and has an easily identifiable terrace. Most specimens are unremarkably identical and have very low perceivable variability. As such, their candidature for geometric morphometrics has great potential in revealing objective and quantifiable variability to counter their lack of easily perceived variability. Mary-Rousselière (2002) interpreted these as equivalents to Meldgaard's type states Da7, Da9-10, though Db8 appears a better choice for comparison. They may indeed be the stylistic equivalents albeit having specific morphological variations proper to each region. Twenty-nine specimens remain unidentifiable due to their incomplete or degraded nature. Additionally, there are 2 harpoon head preforms in the collection. One appears to have broken during manufacture, while the other is simply incomplete.

Other notable artifact types from Saatut include a very high number of needles and caribou metatarsal bone debitage and rejects related to the manufacture of harpoon foreshafts and seal fat scrapers (Mary-Rousselière 1976). The faunal remains indicate that seal was predominantly hunted at Saatut I and II, with caribou as a distant second. Walrus appears quite rare, while small terrestrial mammals like the arctic hare appear to have supplemented the diet. Fish is also present, which is not surprising considering the site's proximity to a river, and constitutes the fifth highest NISP (Mary-Rousselière 2002:91). Finally, the presence of fox is indicative of fur harvesting.

There are eight dates available for Saatut, 4 for each feature. Two marine mammal dates can be immediately rejected. Four more dates must unfortunately also be rejected for the use of a method of insoluble collagen extraction which is subject to contamination (Hedges and Law

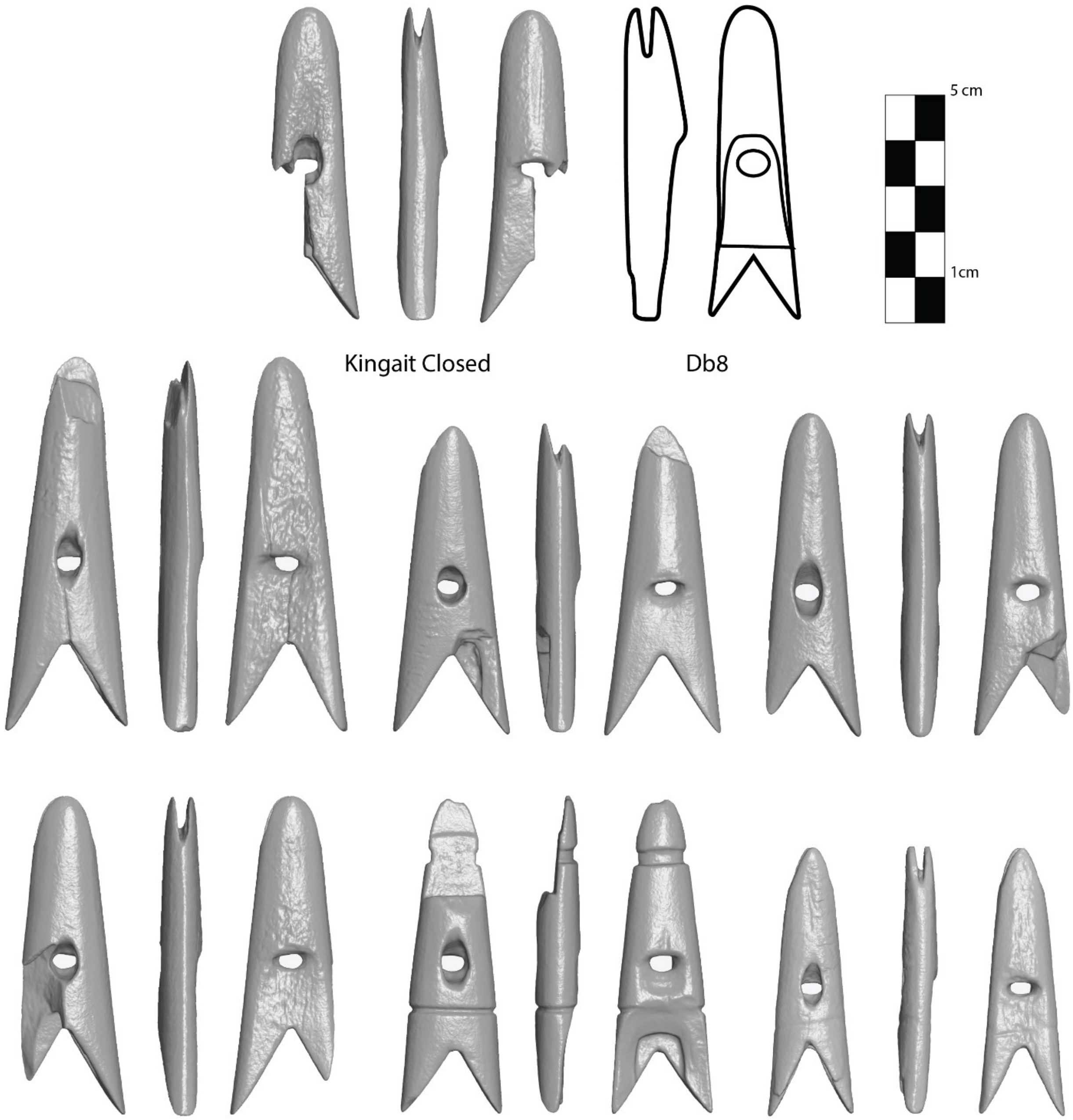


Figure 3.37 Saatut Type D (Drawings after Meldgaard n.d.)

1989). The two remaining dates, prepared with the more reliable soluble collagen form, place the two features within each other's temporal range (Figure 3.30). If Maxwell's temporal ranges are accurate, the Saatut site would fall right at the end and slightly past the Middle Dorset period, which overall lasts from 2300 to 1500 BP Maxwell (1985:198).

Mary-Rousselière (1972:10) interprets the site as late Middle Dorset. The lack of sliced harpoon heads types, the presence of specimens with proximal lateral concavities, and a predominant inclusion of Kingait Closed and Kemp Pointed specimens all point towards the Middle Dorset stylistic period. The near-straight lateral edges of the Kingait Closed and the Dorset Parallel, as well as the latter's overall morphology, indicate the latter part of Middle Dorset. The presence of Ha2 harpoon heads, a type usually attributed to the Late Dorset period, indicates just how late this site was inhabited into the Middle Dorset period and marks the beginning of a possible transition towards the Late Dorset period.

Mary-Rousselière (1970:3) concludes that Saatut was inhabited from late summer to early winter, and was both a fishing and a sealing camp as indicated by location, faunal remains, and the amount of sealing harpoon gear. Furthermore, he interprets the caribou and goose remains as indicative of summer habitation, while the needles are indicative of autumnal clothing manufacture (Mary-Rousselière 2002:92). Inuit were known to inhabit this area around February due to the abundance of seal, which is likely when the Saatut Dorset also engaged in seal hunting (Mary-Rousselière 2002:80). The site may also have been inhabited at all seasons (Mary-Rousselière 1976:80).

Mary-Rousselière believes the absence of architecture and the presence of 22 snow knives at Saatut I suggest that some form of snow house was used. The swampy nature of the terrain and the abundance of *Cassiope tetragona* twigs, which can be used to cover snow platforms, also point towards a winter occupation using snow houses (Mary-Rousselière 1970:3). Mary-Rousselière (2002:80) believed Saatut I and II contemporaneous considering the near-identical composition of artifacts and the morphology of harpoon heads. For the same reasons, and the homogeneity of the sites' stratigraphy, he believed Saatut was inhabited for many years by the same people but during a single period without interruption or subsequent reoccupation (Mary-Rousselière 1972:6). While this is likely the case for the large majority of the material, it is possible that the more substantive Middle Dorset occupation at Saatut I was located atop a much older single occupation Early Dorset snow house from which the very early Type E appeared. That specimen may have also been a treasured heirloom or simply been scavenged; the lack of contextual data may never reveal the true answer. Unfortunately, little more can be said considering the combined lack of architectural remains and the lack of precise material culture contexts and other notes.

3.3.2 Philip's Garden (EeBi-1)

Philip's Garden can be found on the northwest coast of Newfoundland (Figure 3.38), on the north shore of Pointe Riche peninsula, halfway between Calvary Point and Blanche Point (Harp 1964:20). Though human remains with associated artifacts were known from Philip's Garden as early as 1904 (Howley 1915:328), the site was only formally recognized for its archaeological potential by Wintemberg (1939) in 1929 during several reconnaissance missions of Newfoundland's east and west coasts. Erwin (1995:9) describes the climate in the area as highly variable; it receives both heavy winter snowfall and moderately warm and sunny summers, while being prone to intense storms in either season. Wind and ice conditions are considered unpredictable, being influenced by the cold Labrador Current, which brings arctic ice and icebergs throughout the spring season.

Prior to intensive investigations, the site was described as an open (Figure 3.38), oval-shaped grassed over area measuring some 200m by 130m and delimited by a near-unbroken ring of scrub (Harp 1964:20). Luckily, the area had escaped agriculture (Erwin 1995:9) and was instead used for cattle grazing. Three raised terraces subdivide the site and the two uppermost show signs of shallow depressions demarcated by rich vegetal growth. To date, 68 features have been mapped with more slightly visible features that have yet to be investigated (Renouf 2011:32).

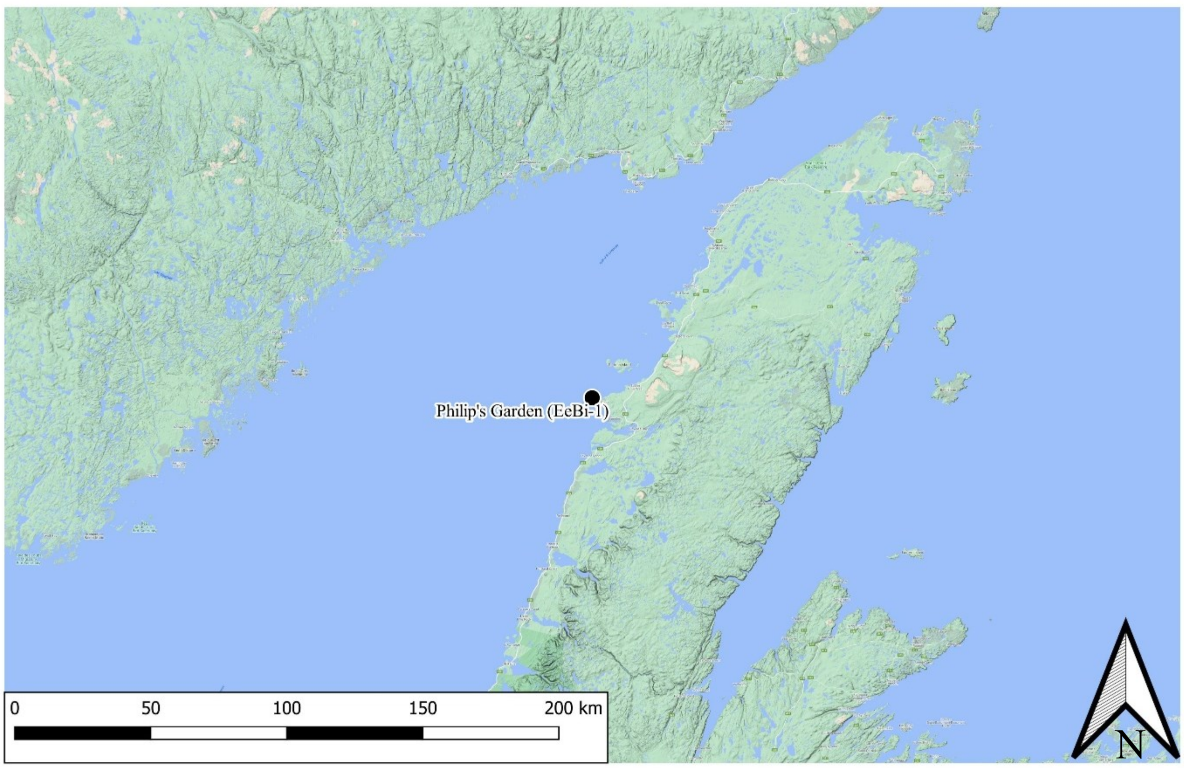


Figure 3.38 Philip’s Garden (Map Produced by James S. Williamson)

Harp (1969-1970:109) was the first to rigorously study Philips Garden starting with tests in the summers of 1949-50 followed by large scale excavations from 1961 to 1963 (Figure 3.39). In this time he fully or partially excavated 20 features (Renouf 1993:198). Work at Philip’s Garden was restarted by Renouf, on behalf of Parks Canada, in 1984 (Erwin 1995:18), and over the next two and half decades she excavated 3 new features, completely re-excavated 2 of Harp's features, and ran trenches through 2 more (Wells 2012).

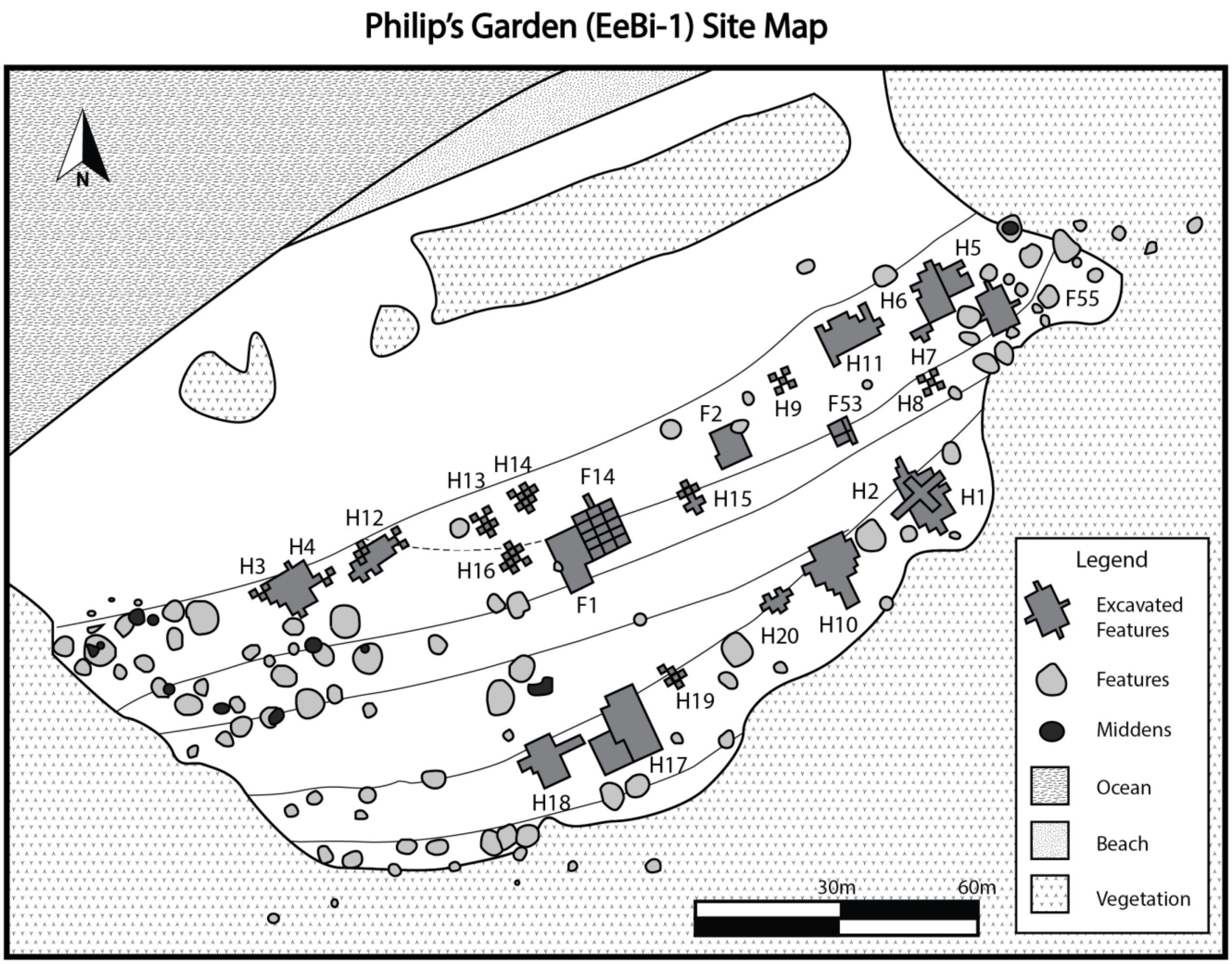


Figure 3.39 Philip's Garden Features and Excavations (after Robinson 2014)

Migratory harp seals constituted the economic basis of Philip's Garden, where they are predictably available twice a year (Renouf 2011:133). In December, seals migrate to the area and the Gulf of St. Lawrence beyond to whelp. From February to March, herds frequent the retreating pack ice and the open water near the ice edge on their way to back to Greenlandic waters (Renouf and Murray 1999). It is in this small area that seals are closer to the shore than anywhere on the western coast of Newfoundland (Hodgetts et al. 2003:107)

Based on the number of dwellings per decade with overlapping C14 dates, the site's 800-year occupation is divided into three phases (Renouf and Bell 2009). The first phase reflects an irregular occupation throughout varied seasons by single families or hunting groups, initially attracted by the presence of seal as part of their seasonal rounds (Erwin 1995:129; Renouf and Murray 1999:130) The faunal assemblages indicate lower selectivity for seal age than in the following period (Hodgetts 2005:74). The middle phase represents a period when the greatest number of houses were occupied concurrently (Erwin 1995:129), probably due to the now apparent predictability of seal herds (Renouf and Murray 1999:130). During this period, the social meaning of the site likely increased in importance, making it economically feasible to host a larger population, thus becoming a site of population agglomeration. Additionally, the geographic location marks it as crossroads, and potential outpost, between the island of Newfoundland and the Canadian mainland, further increasing its social and symbolic relevance as a gathering site (Renouf and Bell 2009:266). The last phase saw a shift from near complete reliance on harp seal to an increasing reliance on fish and bird (Hodgetts et al. 2003:110). Climate data indicates a warming which may have lightened ice packs and shortened their duration, therefore reducing seal availability and predictability to the point where the population density of previous years was no longer sustainable (Renouf and Bell 2009:268). This is further evidenced by changes in seal procurement patterns which again reflected that of the site's early occupation (Hodgetts 2005:74). As a result, the site saw a rapid decline in use and eventual abandonment.

For the purpose of the project, only complete harpoon heads were considered, and then only type-D harpoon heads were analyzed (Figure 3.40). Of the 120 total harpoon heads reported by Wells (2012:63-87), 92 were identified as Kingait Closed. Of these, only 34 were sufficiently complete for the purpose of this project. The specimens have a high perceivable variability, but nonetheless display enough consistency in morphology to be immediately recognized as part of the same local traditions.

It is very fortunate and rare to have any organics for such a southerly site, especially when taking into account the acidic nature of Newfoundland soils. Wells (2012:24) notes that the

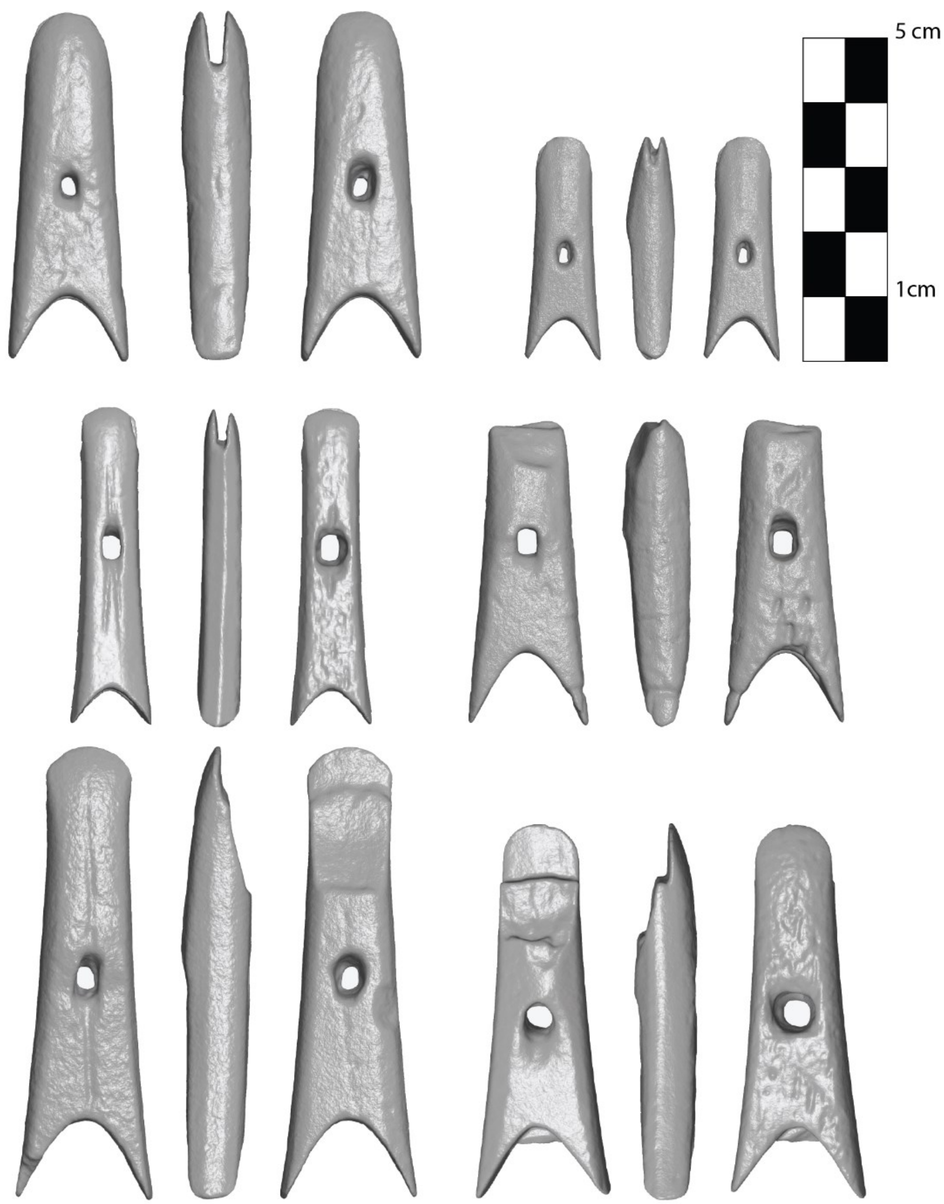


Figure 3.40 Philip's Garden Type D – Kingait Closed

broad limestone outcrop upon which the site is situated helps neutralize such soils. Additionally, she suggests, the large organic deposits would have produced localized anaerobic conditions.

3.3.3 Tayara (KbFk-7)

Overview of Tayara Region

Figure 3.41 Tayara (Map Produced by James S. Williamson)

The site of Tayara (Figure 3.41, 3.42) is located on the western shore of Qikirtaq Island (previously Sugluk Island) which sits at the mouth of Salluit Fjord near mainland Nunavik (Desrosiers 2009; Desrosiers et al. 2006:134; Taylor 1968:46-47). It is part of Nunavut, but also considered part of the Nunavik marine region. The Laurentide ice sheet retreated from this region around 8000-7500 BP, leaving the island submerged during the early Holocene until 7000 BP, with the site area only fully emerging by 4500 BP (Desrosiers et al. 2008:762; Todisco and

Bhiry 2008a:3). Today the site area sits 175m from the current shoreline at an elevation of 18m above sea level (Todisco and Bhiry 2008a), within a valley measuring 200m by 50m (Desrosiers 2009:247). Two streams currently split the area into northern, central, and southern sections.

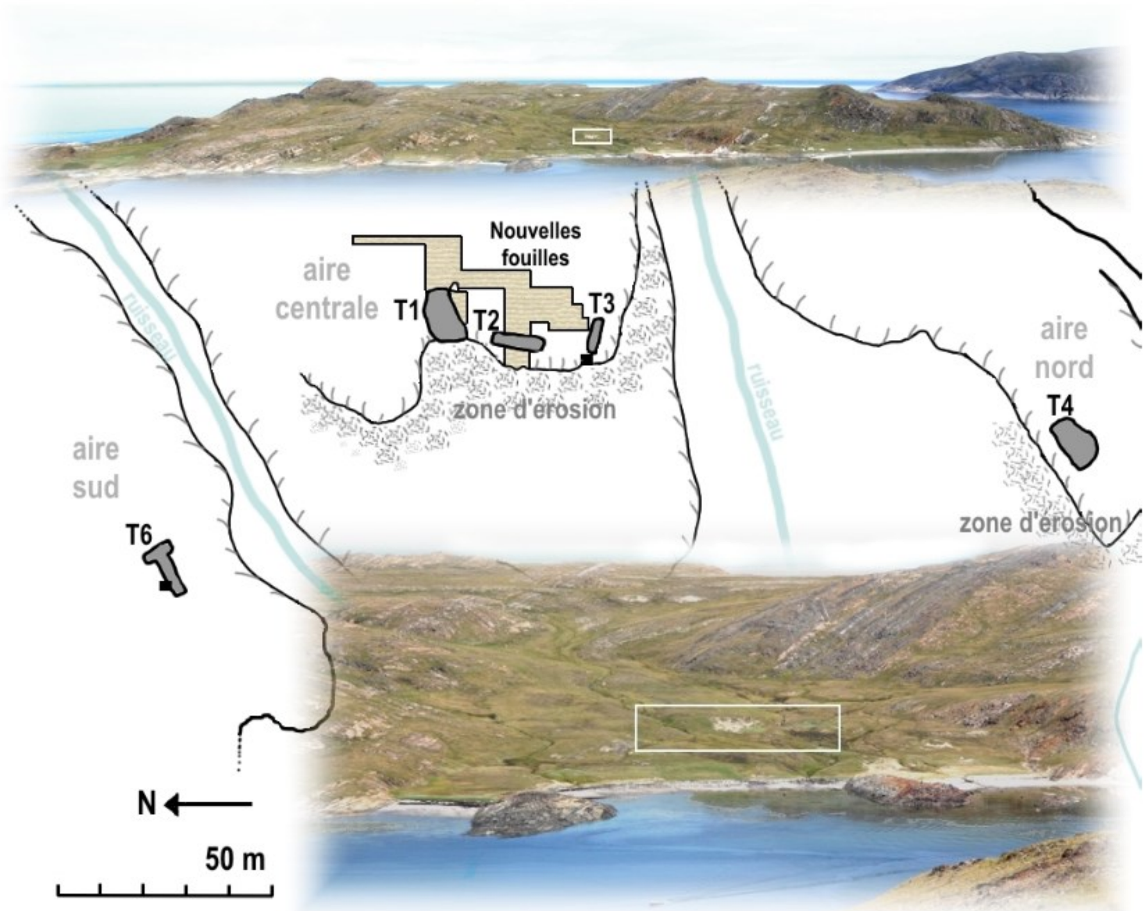


Figure 3.42 Tayara Site Map (Desrosiers et al. 2008)

Tayara was first identified in 1957 by Taylor; it was located besides his camp as he worked on a nearby site. He initially ignored it, explaining that the small scatter of sun-bleached faunal remains was not worth the time. It was only the next year in 1958 that Taylor conducted a more rigorous survey which yielded a variety of organic and lithic materials. This led to excavation which revealed a site "rich, deep, extensive, stratified and clearly early in the Dorset culture sequence" (Taylor 1968:44). Over the next ten days, 6 trenches were dug atop the hillocks separated by the streams of which 5 returned cultural material.

At Tayara, Taylor identified 3 stages of occupation in a similar sequence found in at least 4 of his trenches. This led him to assume that the top layer in each of his trenches was the same layer and treated layers 2 and 3 in the same way. He argued that the site samples represent a single body of data and that artifacts are consistent for their assigned strata (Taylor 1968:46-47). He concluded that the site belongs to the 'hazy' period called the Early Dorset (Taylor 1968:71), prior to the subsequent definition of the Early Dorset by Maxwell (1985) who elevated Tayara to the type site. It also important to mention that Taylor himself believed that Tayara was deserving of a more thorough investigation than he managed in 10 days, that his collection was limited in both size and its ability to address Dorset-wide change, and also openly admitted that trench walls often collapsed leading to the mixing of levels and materials (1968:47).

Work at the site resumed with a 2001 survey by Avataq Cultural Institute meant to establish the potential for further excavations. Excavations were then undertaken in 2002-3 to extend the area around Taylors trenches 1, 2, and 3 in the central area, and in 2005-6 to complete level II and start level III. These levels were interpreted independently from Taylor's previous levels 1, 2, and 3. Efforts were undertaken to reinterpret Taylor's levels in accordance with the new stratigraphic scheme, but this proved to be quite the challenge. Interestingly, the three levels found in Taylor's trenches and interpreted as being the same sequence throughout the site did not hold up to new investigations (Desrosiers 2009:405). Additionally, the unreliability of Taylor's contextual data is further amplified by the presence of cryoturbation and frost cracks in certain areas (Desrosiers 2009:253; Todisco and Bhiry 2008b:190), making it impossible to associate some of the levels in some of Taylor's trenches with the newly interpreted layers. Conversely, intense solifluction contributed to great overall site preservation (Todisco and Bhiry 2008b), and contributed to a low degree of post-depositional spatial disturbance in level II (Todisco et al. 2009). Level II and III are interpreted as being the two main stages of occupation at Tayara (Figure 3.43). The oldest, III, was attributed to the Groswater Pre-Dorset phase and level II to the Classic Dorset after a rigorous analysis of lithic tools by Desrosiers (2009) recovered from the secure chronological contexts of the new excavations (Desrosiers 2009:259). Furthermore, at least 2 distinct occupations are present within the level II (Desrosiers 2009:255).

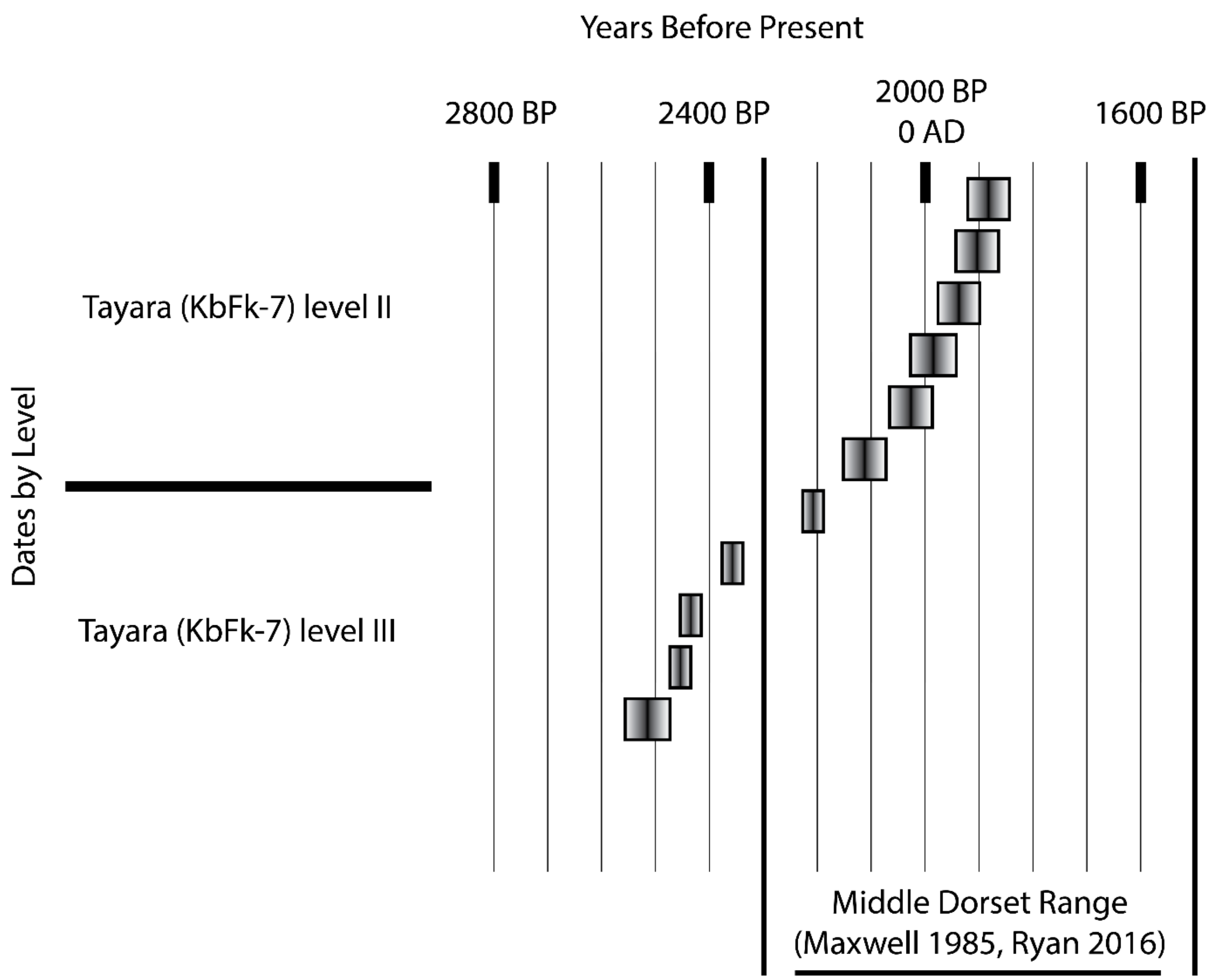


Figure 3.43 Tayara (KbFk-7) Level II and III Dates (Desrosiers 2009)

The typological nature of the Tayara harpoon head collection has for a long time been of such importance and interest that it would be inappropriate not to contribute to the conversation here. Taylor (1968:51-54) identifies, classifies, and names 7 types from his Tayara collection; these are Tunit Open Socket, Tayara Pointed, Tayara Sliced, Kingait Closed, Dorset Parallel, Frobisher Grooved, and Dorset Plain. In addition, he recognized the Dorset Parallel Sliced and Frobisher Sliced from other collections (Taylor 1968:73, 75). These type names have gained popular usage, and today still serve in the identification of material, new and old.

Taylor's types were also adopted by Maxwell (1985:168), who then defined the Early Dorset on the basis of the Tayara Sliced, Tayara Pointed, Tanfield Sliced, Tunit Open Socket, and the Dorset Parallel Sliced. Maxwell (1985:196) used the slice to arbitrarily separate the Early and Middle Dorset periods, having noticed a trend which led to its disappearance mostly consistently throughout the Dorset range (Maxwell 1973:139). For the Middle Dorset, Maxwell established the Kingait Closed, Nanook Wasp Waisted, Nanook Grooved, and the Native Point Grooved (he renamed the Frobisher Grooved) as the types characteristic of the Middle Dorset (Maxwell 1985:199). The arbitrary nature of this separation must be emphasized, as there is very little material culture or socioeconomic patterning to distinguish the Early from the Middle Dorset, though it can be distinguished by a massive demographic shift (Ryan 2016:772).

Separating the Early and Middle Dorset with the slice can be of use: it separates an otherwise long period in a definitive way, and it helps distinguish relative age and organize material accordingly. However, it can also cause problems: it puts undue weight on the slice and its disappearance. The disappearance of the slice was not an abrupt change, but rather the culmination of an evolutionary process which began with the open sockets found in Pre-Dorset harpoon heads followed by a progressive partial closing until its complete closure. Furthermore, the current nomenclature only uses ‘slice’ although the other proximal dorsal arrangements are described by Maxwell (1985:110), and defined by Houmard (2011) and Stordeur-Yedid (1980). As such, all morphologies that resemble a slice always get called thus without further temporal distinctions in morphology as is observed from fully open sockets to fully closed sockets. As a result, this highly inclusive attribute may lead to low resolution temporal interpretations.

With new investigations at Tayara in the 2000s, new harpoon heads were uncovered which led to new interpretations. The recovery of harpoon head specimens which fit Maxwell’s scheme of Early and Middle Dorset were found together within a deposit dated to the Middle Dorset, which led Desrosiers (2009; 2006) to conclude that the harpoon scheme needed to be reevaluated. Additionally, it was proposed that the Early and Middle Dorset be renamed to the Classic Dorset for the Nunavik region, as no ‘Early Dorset’ proper could be identified in this same region.

Regarding the collection itself, level II yielded harpoon heads which can be found in both of Maxwell’s Early and Middle Dorset lists of characteristic types. Level III, however, only had harpoon heads associated with an experimental phase of Early Dorset which are consistent with the Early Dorset harpoon heads interpreted from level II. The following typological and morphological analysis will show that all harpoon heads from Tayara associated with the Early Dorset are temporally too far removed from those associated with the Middle Dorset, rather than reflecting a close temporal relationship, thus suggesting the Early Dorset harpoon heads are intrusive within level II. This analysis was undertaken to be better understand the Tayara collection and to aid in choosing a meaningful sample for this project.

Starting with Type A (Figure 3.44), 16 Frobisher Grooved specimens were identified from level II. Overall, these specimens appear homogenous, but spur morphology may help separate a slightly younger occupation from a slightly older one. Meldgaard's (n.d.) typology from Foxe Basin indicates that Type A specimens during the late Early Dorset to the early Middle Dorset go from U-shaped to rounded V-shaped, which eventually becomes a fully angular V shape beyond that time. Additionally, proximal beveling morphology goes from bifacial and triangular in profile to less pronounced morphologies, such as unifacial beveling, light beveling or indistinct tapering as part of the overall morphology, or no beveling at all within the same timeframe. While it is impossible to absolutely date them considering they were found within the same cultural level, it may be possible to say some specimens are older than others and indicate that the site was occupied early in the Middle Dorset and then again/or continuously until well within the Middle Dorset, but without evidence into late-Middle Dorset harpoon head morphologies. Level II dates support this as they indicate occupation over about 300 years near the beginning of the Middle Dorset period, without reaching its end.

Five Tayara Pointed specimens (Figure 3.43) were recovered: 2 from level II, 1 from a mixed level II/III layer, and 2 from level III. Spur morphology indicates no difference between any of these specimens: all have bowl shaped U spurs and hooked bevels. These two attribute morphologies appear exclusively during the early-Early Dorset; bowl spurs gave way to U spurs later in the Early Dorset, while hooked bevels lose the hook and gave way to triangular bevels. The slice, with the weight it is given, is likewise important in placing these specimens into a relative chronology. The slices, which are visible to differing degrees on the 5 specimens, are wide and relatively flat distally, remaining straight or flaring out slightly as it moves proximally, only for the proximal-most area to flare out more drastically. In them, much of the interior of the socket is visible. While current terminology would well consider it a slice, within the morphological spectrum of Dorset slices it belongs to an early-Early Dorset phase where much experimentation with different proximal dorsal arrangements took place; the term ‘experimental slice’ was used to describe this temporal morphology. Following this phase, the slice becomes the dominant arrangement, where they became much slimmer and pointier with very little of the inner socket exposed. The latter morphology is that which would be expected from a sliced harpoon head at the end of the Early Dorset period before its loss and arbitrary transition into the Middle Dorset forms, and that is not what the Tayara Pointed specimens from Tayara indicate.

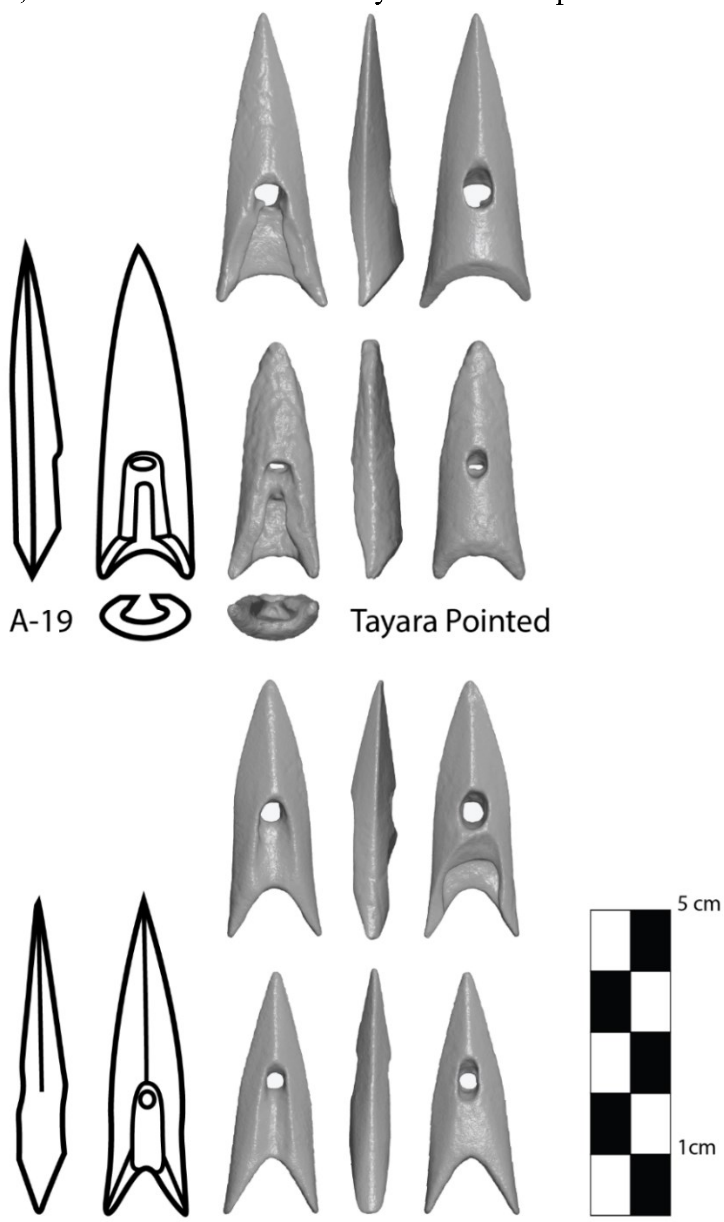


Figure 3.44 Tayara Type A – Tayara Pointed – Frobisher Grooved (Drawings after Meldgaard n.d.)

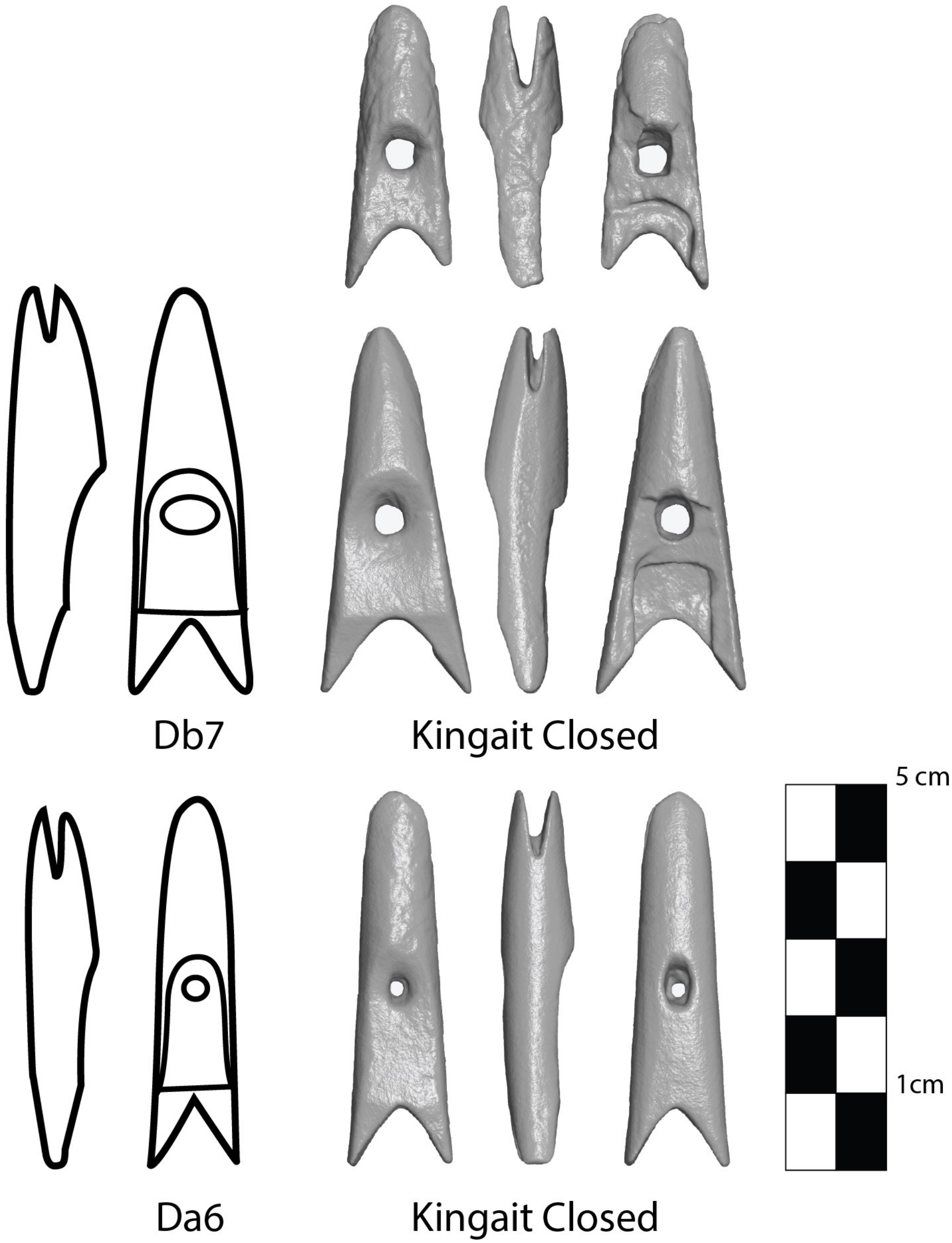


Figure 3.45 Tayara Type D – Kingait Closed (Drawings after Meldgaard n.d.)

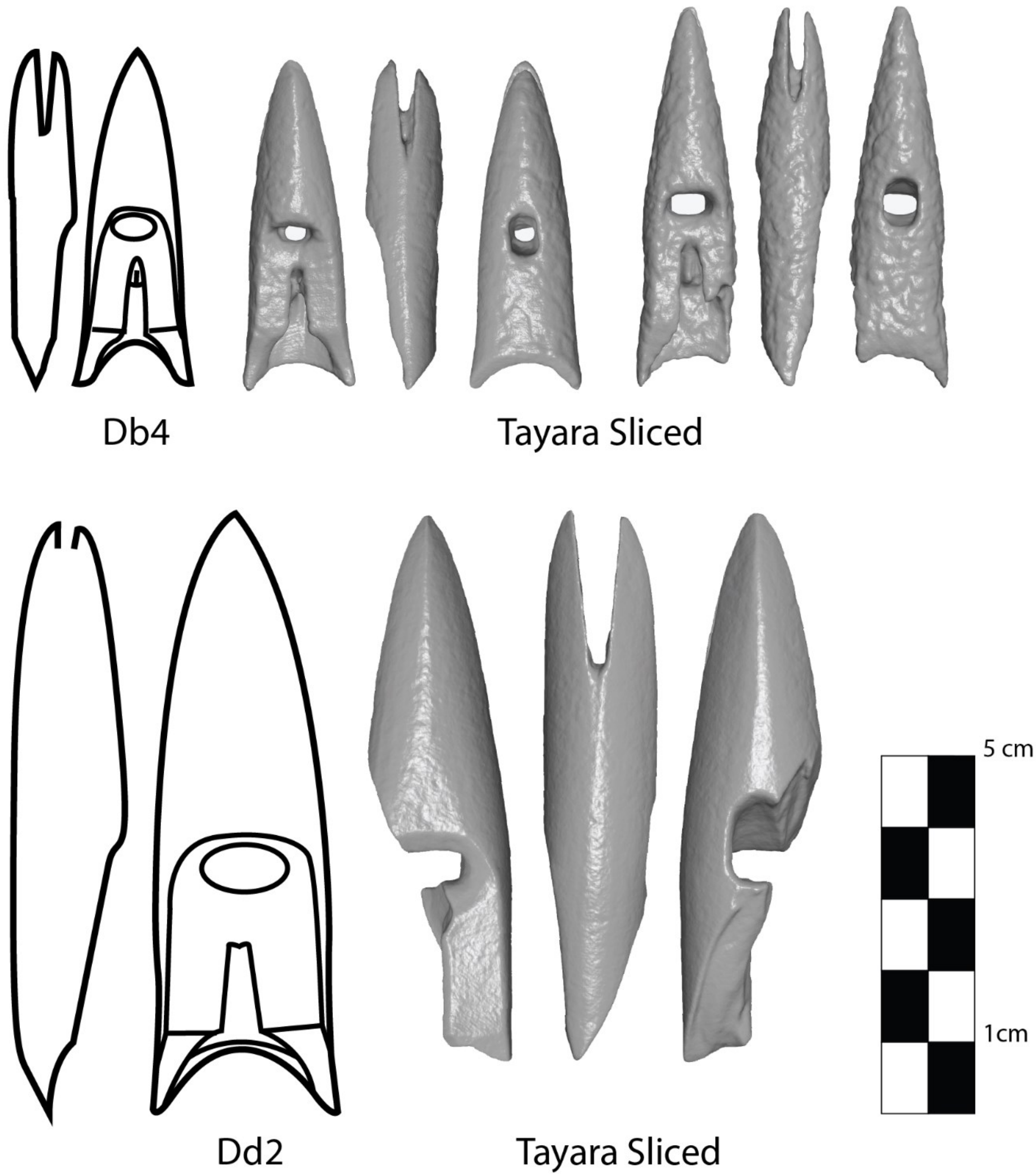


Figure 3.46 Tayara Type D – Tayara Sliced (Drawings after Meldgaard n.d.)

Turning to type D specimens, 9 Kingait Closed specimens were identified (Figure 3.45). seven belong to level II while two are out of context. The morphological development of beveling in type D harpoon heads follows a similar scheme as type A, but bifacial triangular bevels appear to have lost appeal sooner in favor of unifacial beveling and light beveling. Most of the Tayara Kingait Closed specimens have U spurs in combination with triangular and unifacial spur beveling. Meldgaard's (n.d.) typology indicates that for the Foxe Basin region, rounded-V and V spurs had already found popular usage as soon as the slice disappeared, indicating some regional differences with Tayara. Nonethless, the overall morphology of these 8 specimens matches that of late Early Dorset Tayara Sliced specimens and early Middle Dorset Kingait Closed following the disappearance of the slice. As such, the specimens fit within the early Middle Dorset scheme.

One remaining Kingait Closed specimen is unlike the others; it has nearly parallel sides, V spurs, and unifacial beveling, and is smaller than the others. Meldgaard identifies it as being for smaller seal, and evolutionarily mostly follows the same morphologies as the rest of type-line D. What his typology does reveal is an earlier parallelization of lateral sides in these smaller type D's than in the larger Tayara Sliced and Kingait Closed specimens; suggesting that this specimen is not out of place with the other more arrow-shaped early-Middle Dorset type D specimens.

Eight Tayara Sliced (Figure 3.46) specimens were identified; 2 are from level II, 2 from a mixed II/III deposit, 3 from level III, and one lacks a secure context. The situation with the Tayara Sliced reflects that of the Tayara Pointed. All specimens whose spurs and bevels are intact are bowl U shaped and hooked. The slices all appear to be of the early experimental form and reflect the morphology of their Tayara Pointed counterparts. Moreover, the morphology of the distal endblade slot prongs reflects that same period; they are deeper and beaked compared to the shallower and less pronounced morphology of later endblade slots. One specimen from the mixed II/III level, KbFk-7:264, stands out as it is much larger than the others with a somewhat unique but similar overall morphology. While it would fit within the Tayara Sliced spectrum, having the right attributes, such a designation would erase its difference. Meldgaard (n.d.) identified similar specimens as Dd1/2, which he interpretated as being for much larger game, such as whale or walrus, compared to the smaller type D specimens which are interpreted as being for sealing. This form does not remain long and is quite indicative of the experimental phase to which it belongs. The Tayara Sliced specimens all point towards a very Early Dorset. And much like the Tayara Pointed, they do not reflect the forms one would expect to morphologically precede the Kingait Closed. Additionally, the lack of any stark difference in morphology does not support their separation into the two temporally distinct levels II and III.

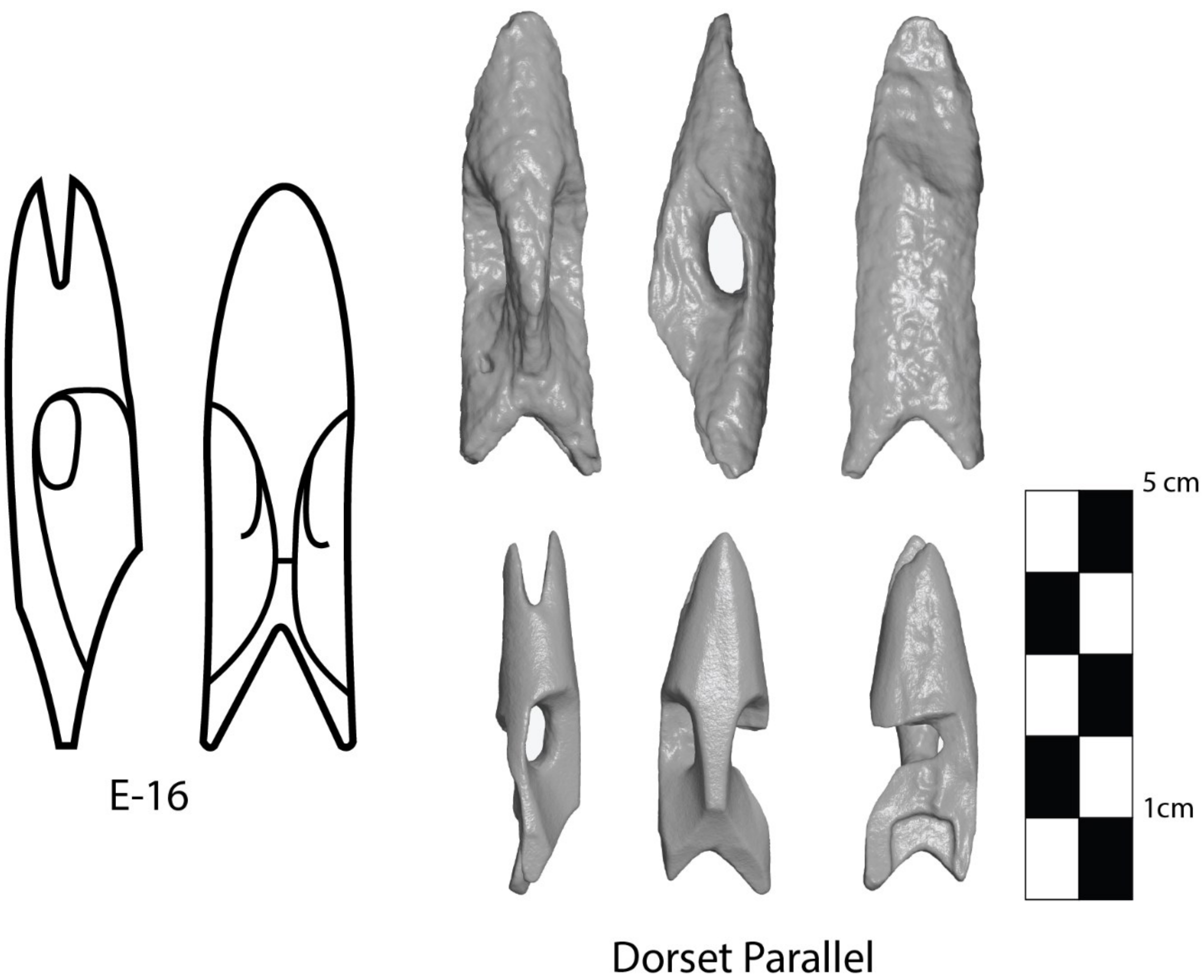


Figure 3.47 Tayara Type E – Dorset Parallel (Drawings after Meldgaard n.d.)

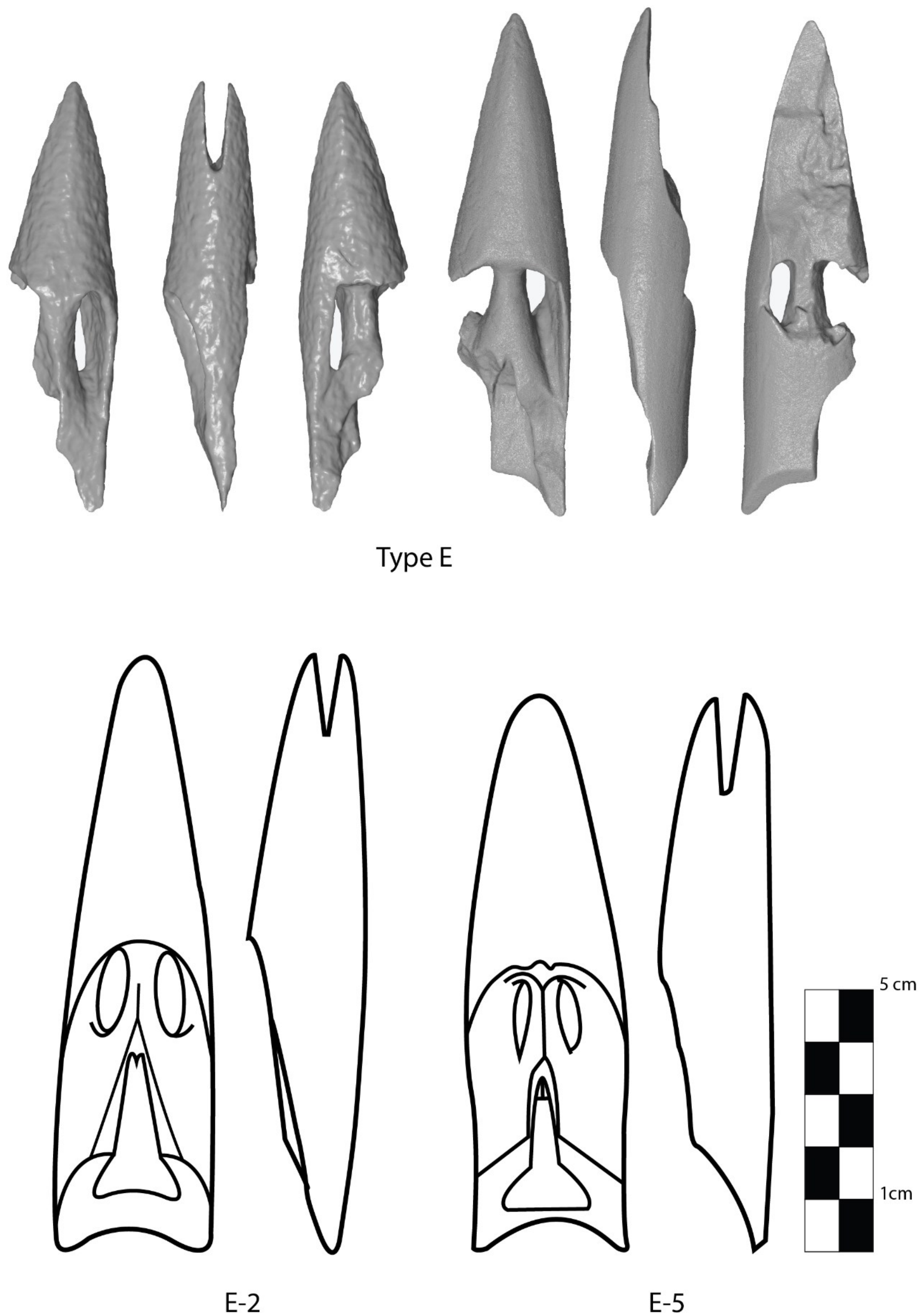


Figure 3.48 Tayara Type E (Drawings after Meldgaard n.d.)

Of the type E harpoon heads (Figure 3.47), 7 Dorset Parallel were identified. Since they all hail from level II and are all morphologically consistent with one another, there is no ambiguity as to their association with the Middle Dorset level. Their overall morphology, such as the conically shaped mesial to distal area, is indicative of early Middle Dorset, as they still share forms with their previously sliced counterparts, and do not reflect the soon-to-begin parallelization of the sides which is also seen in the Kingait Closed temporal evolution.

Two early type E (Figure 3.48) specimens were found in level III. These are undeniably early as Type E undergoes the most drastic of evolutions amongst its peer type-lines, making each 'step' quite distinguishable. These specimens are similar in both morphology and size to the type Dd1/2 specimen earlier described. This is not surprising, considering that type-line D and E both appear simultaneously as offshoots of type-line A before following their distinct evolutions; and it appears both forms were experimentally used to hunt larger mammals with the type E eventually becoming the prevailing form. Only one of the two specimens has a partially intact proximal end, and the size and morphology of the proximal dorsal arrangement may indicate that it is flanged rather than having an experimental slice, or it may be intermediate between the two. These two specimens correspond to Meldgaard's type-states E 2-5, but their damaged state make it hard to pinpoint the closest equivalent. Nonetheless, these specimens reflect the same early-Early Dorset experimental phase as the Tayara Pointed and Sliced.

A single specimen defined as Dorset Plain (Taylor 1968:53) was recovered from level II (Figure 3.49). Its most distinctive feature is the model-tip. However, Taylor equates it to a similarly sized and shaped harpoon head from Collin's (1957:74) T3 collection which completely lacks the model tip, and is blade slotted instead (Taylor 1968:74). The comparison

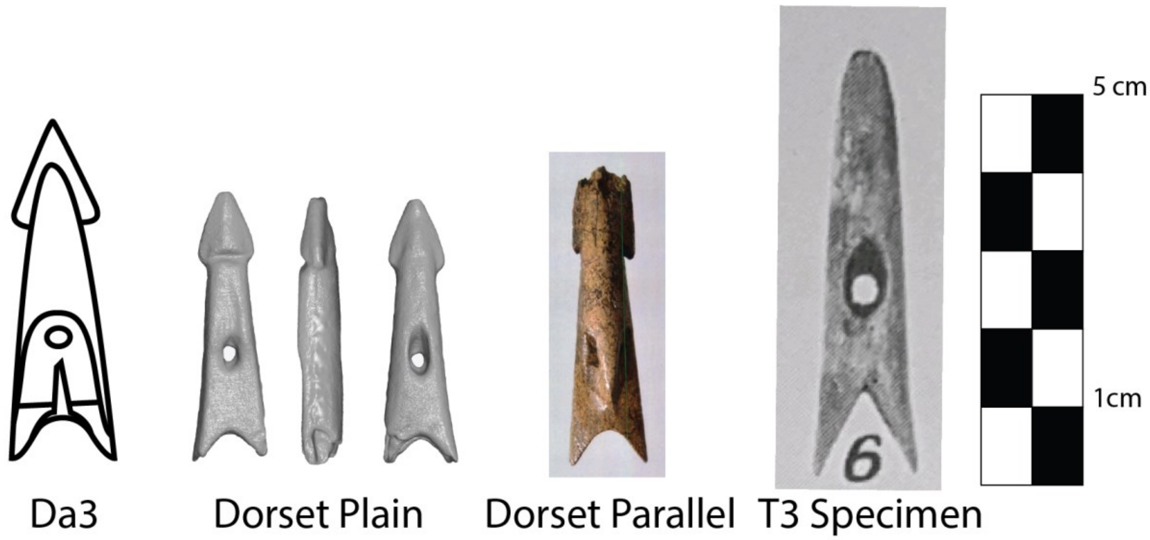


Figure 3.49 Tayara Type D – Dorset Plain (Meldgaard n.d., Wells 2012, Collins 1957)

reveals that the Dorset Plain was not defined based on the model tip, but rather the overall morphology. His definition has been overlooked as the Dorset Plain continues to be defined by the model tip to this day, rather than the overall morphology (Desrosiers et al. 2006; Houmard 2011; Jordan 1979; Jordan 1980). Morphologically, barring the model tip, its attribute combination is homologous to the Kingait Closed. Meldgaard (n.d.) also identified such specimens and included them within their proper type-lines, thus not giving them undue weight as singular and different types. Model-tipped distal ends aren't restricted to this morphology, but have been found on Dorset Parallels (Wells 2012:74), though this variant was never afforded its own type name. Model tips appear exclusively on 'base models' which would normally feature an endblade slot, and never appear in great numbers. It should thus be considered a variant attribute that was part of a carver's toolbox, one which could have been applied for reasons such as style preference, lack of raw chert, or insufficient skill to manufacture an end blade proportional to a small harpoon head. As such, it is only appropriate to follow the tradition of ignoring Taylor's definitions and to establish nomenclature to deal with model-tipped variants: Model-tipped Kingait Closed is not too unwieldy and gets the point across. As for its temporal positioning, the parallel sides and the unadorned spur tips may indicate that it is related to the similarly shaped smaller Kingait closed remarked on above and is inevitably part of the Middle Dorset occupation at Tayara.

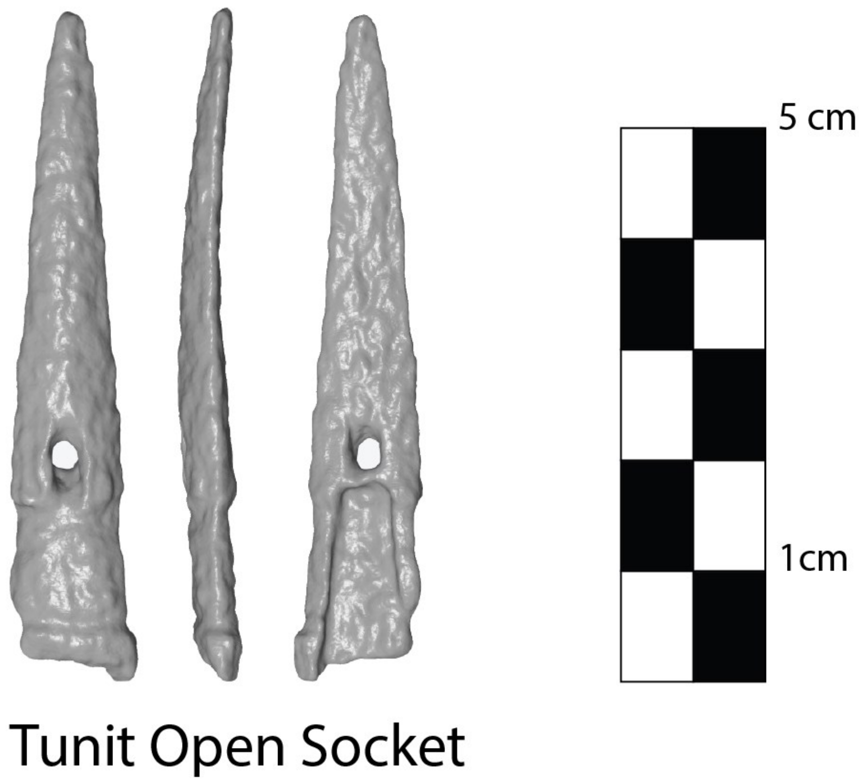


Figure 3.50 Tayara – Tunit Open Socket

The Tunit Open Socket specimen (Figure 3.50) from level III presents an interesting problem. For one, a single specimen was used to define the type; secondly, this type is unique and has not been found elsewhere; three, Maxwell includes it in his list of types characteristic of Early Dorset even though he admits it is either a broken or reworked piece (1985:179). This single specimen has been given too much weight; no type should be defined from a single specimen and the fact that it is not found elsewhere should hint at its abnormality. It has previously been interpreted as a possible Pre-Dorset piece, considering its open socket

(Desrosiers et al. 2006:136). Comparing this specimen's morphology to Pre-Dorset open socket harpoon heads, Dorset lances and fishing spears, and Late Dorset open socket harpoon heads – all of which share some semblance in attribute combination and morphology – has led to no conclusive equivalent from the Foxe Basin region (Meldgaard n.d.). It is likely something reworked or broken, perhaps even a reworked Tayara Pointed, such as the one Taylor (1968) had originally shown in his monograph (Figure 3.11). However, as it is unique, it should not be given undue weight, such as when Maxwell (1985) used it to define a whole temporal era of the Dorset.

After a qualitative, typological, and morphological assessment, it becomes clear that the Tayara Sliced and Tayara Pointed, as well as other elements attributed to the Early Dorset, hail from the same level III occupation and are intrusive within the level II strata. The morphology of the spurs, bevels, and experimental slices can attest to that, as they not only differ from the Middle Dorset harpoon head component, but also do not reflect morphologies expected from harpoon heads prior to the abandonment of the slice. There is no abrupt change in Dorset harpoon head morphologies which would justify these early specimens directly preceding the Middle Dorset specimens, as the necessary evolutionary changes in morphology which would bridge the two phases are not present at Tayara. The presence of two well dated levels, II and III, provides the proper context for these two sets of harpoon heads to exist at the site.

It is not surprising, but rather exciting, that these very Early Dorset harpoon heads are associated with what has been interpreted as a Groswater Pre-Dorset lithic assemblage in level III. These interpretations lend to the obviously very complex nature of culture evolution in this region, especially in terms of reconciling the two archaeological complexes of Pre-Dorset and Dorset, and their transition or continuous evolution, and most importantly highlights the problems with using water-tight classification. It shows that the different material dimensions of groups during this period did not change at a 1:1 rate from Pre-Dorset to Dorset, and that certain traditions may change faster than others while some more resistant to change. It shows that our idea of homogenized archaeological complexes fails to capture the nature of variability at different scales, from the individual to the group, and from region to the overall range.

Variability, as mentioned before, is extremely hard to quantify and communicate, and as a result many of the classifications and typologies in use actually impede its study. This author is in complete agreement with the assessment made by Desrosiers (2009; 2006), that the Dorset harpoon head seriation requires massive reassessment. Maxwell's (1985) typology, which finds the most usage in our field, has completely failed Desrosiers and his team in helping to establish chronology at Tayara for multiple reasons. An arbitrary separation of Early and Middle Dorset based on a single discrete attribute combined with a temporal range for the two completely blurs regional distinctiveness and stylistic timing in favor of overall homogenization. While this may not be as relevant to the Tayara site as previously thought, it is nonetheless an important conclusion to arrive at. However, where the Maxwell typology fails the most is in the extremely high tolerance for variability in defined types. While the inclusion of such wide spatial variability is problematic, it is the inclusion of temporal variability in types such as the Tayara Sliced which hinders the ability to make high resolution chronological assessments. By creating a monolithic chronological marker to demarcate the Early Dorset, it fully ignores that these implements continually change and can provide much more precise chronological markers when taken at smaller temporal scales. This then leads to the interpretation of much older material as younger, and vice versa, as was the case for the Tayara collection. Beyond the classification of harpoon heads, large scale classifications of culture or archaeological complexes seem to have a hard time holding up at supposed ‘transition’ points. While such classification will likely always be part of scholarly work in archaeology, and there are many valid markers or events which may be used to create separations and subdivisions, it is important to acknowledge that these are structures of our own creation imposed on the past.

CHAPTER 4: METHODS

4.1 Analytical Technology

The scanner used for this project is the EinScan-SP (Figure 4.1); it is a structured-light 3D scanner produced by Chinese manufacturer Shining 3D. Structured-light scanning is a method of 3D scanning which uses dual cameras and a projector. A series of patterns is projected onto the object and the cameras capture the way the object deforms the pattern. Triangulation is then carried out to encode the spatial coordinates as identified by where and how the patterns appear on the object (Jecić and Drvar 2003:1-2). These coordinates constitute the sparse cloud: points taken from a pair of images with the purpose of identifying discrete features for valid alignment. The dense cloud is the result of an alignment and comprises all points captured from the object in 3D space. Through the process of surface reconstruction, the dense cloud is converted into a polygon mesh: the 3D model that is the object of study. These operations were accomplished from start to finish using Shining 3D's proprietary EinScan software (v.2.6.0.8)

Figure 4.1 Einscan-SP

The EinScan-SP has a scan resolution ≤0.05mm, which means it can distinguish between two points on the object at the sub-millimetric level. While better and more expensive scanners exist, it is more than sufficient to accurately capture the morphology of harpoon heads in this study. What makes the EinScan-SP the ideal candidate is the resolution to price ratio. At CAD $ 3,200 (purchased April 2018), it is half the price of the next scanner with a comparable resolution.

The scanner is composed of three elements out-of-the-box: the scanner head (Figure 4.1a), the automated turntable (Figure 4.1b), and a fixed stand (Figure 4.1c). The scanner head houses the two cameras, placed at both ends of the long side, and a centrally placed projector. The automated turntable connects directly to the scanner head. Its purpose is to allow an even 360-degree rotation of the object being scanned. It is covered in coded targets which allows each individual scan to be properly calibrated and aligned when using the free-scan mode. The stand bridges the scanner head and the turntable; it places the scanner head at an elevation and angle which permits full coverage of the turntable.

4.2 Primary Data Acquisition: 3D Data

The Einscan-SP offers two scanning modes: fixed-scan and free-scan. The former uses the fixed stand, and the latter allows the scanner to be placed dynamically. Free-scan mode was intended to scan objects too large for the turntable. Coded target stickers are provided to compensate for the lack of standardized positioning provided by the turntable. It became clear early in testing that the fixed stand was inadequate for achieving time-efficient and quality results. The static angle forces the user to constantly move and find ways to prop the objects at different angles to allow their capture. One of the benefits of 3D scanning methodologies, as opposed to traditional methods of artifact studies, is the much-reduced handling of the objects and length of exposure to light. The more an object is handled, the more it is at risk of being damaged. For this, and for practical reasons, the fixed stand was abandoned in favor of an articulated arm mount (Figure 4.2). With its ability to be clamped onto a table, to swivel, to articulate to any position, and to mount any form of camera under 2 lbs using a standardized camera mounting screw, the free scan mode was opted for. Considering that the largest harpoon head is no bigger than 15cm long, the turntable and the inset coded targets provide the points of reference necessary for alignment in free-scan mode.

Figure 4.2 Einscan-SP with Camera Arm Mount

Other options include the choice to scan with or without texture. When texture is captured, a 2D image is wrapped around the 3D model to provide color. A non-texture scan was chosen for this project because color is not required in the study of geometric morphometrics. Another deciding factor was that a textured scan took twice as a long as a non-textured scan, and time was a concern when visiting collections at museum repositories. There is a high dynamic range (HDR) option, as well, which takes each pair of images twice per scan to increase the dynamic range of luminosity. HDR truly helps when scanning darker harpoon heads. The harpoon heads themselves range from a light beige to a dark chocolate hue. Structured light

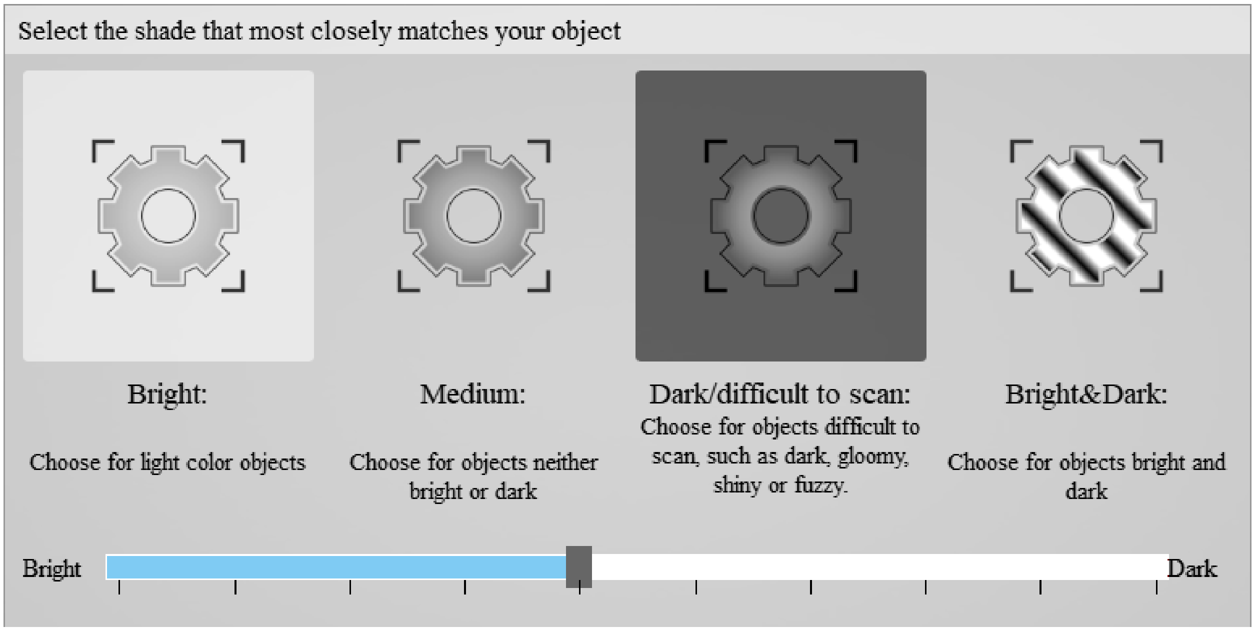


Figure 4.3 Einscan Lighting Options

scanning produces the best results for light-colored, matte objects. Shiny objects are a problem as the light of the projector is reflected off the surface which interferes with the software's ability to calculate the deformities in the projection. Some harpoon heads from EeBi-1 suffered from this problem as a result of shellac resin being used in 20th century conservation efforts. With the permission of MUN's archaeology conservator, chalk, a chemically inert mineral powder, was used to reduce shine following the example of Porter et al. (2016:77). Black or dark objects also pose a problem for structured-light scanning, as the projected light is absorbed. The EinScan software offers the ability to choose the shade of the object being scanned (Figure 4.3). What this does is increase the amount of light projected onto the object the darker it is. Were the object naturally bright or reflective of ambient light, an increase in projected light is required to compensate.

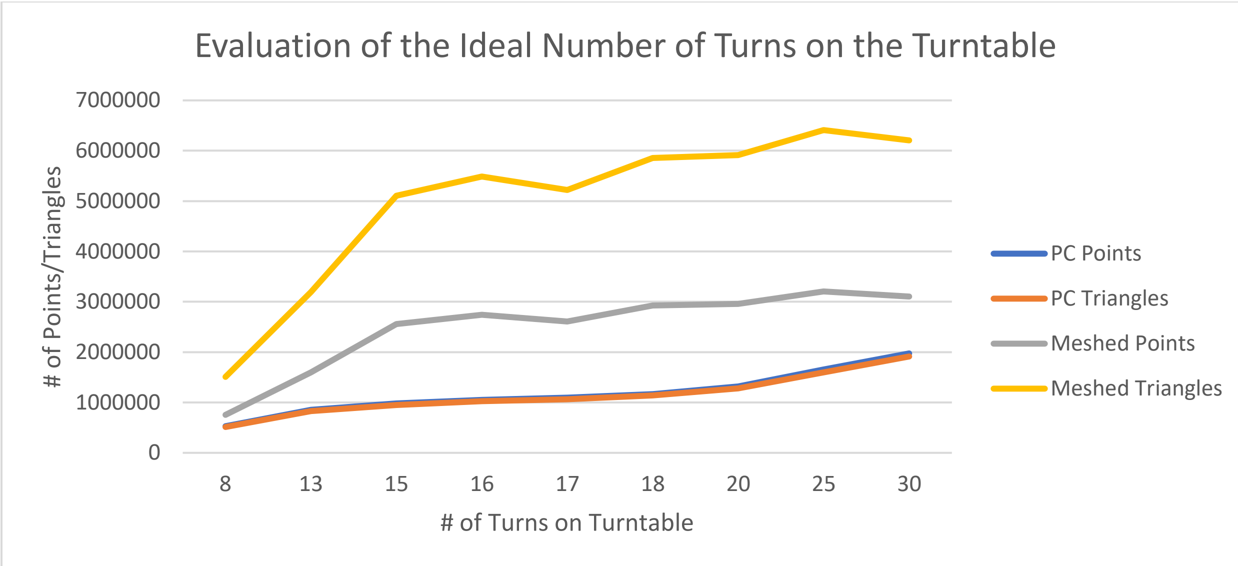


Figure 4.4 Turntable Data Test

The automated turn table is the most essential element in the successful scanning of the object. The user can direct the number of turns it takes, which is equal to the number of individual scans taken. It is possible to choose between 8 and 180 turns on the turntable, by which 360 degrees is divided to complete a full rotation. A test evaluating the amount of data recorded per turn of the turntable was undertaken by looking at the number of points and triangles (combination of three nearby points) for both the point cloud and the resulting mesh. The results show diminishing returns after 15 turns (Figure 4.4). Thus 15 individual scans per side of the harpoon head became the basis for best-case scenarios.

Using mouldable putty covered in plastic wrap to avoid the transfer of unwanted greasy chemicals, the harpoon heads were placed on their side. With the scanner head placed between 35 and 50 degrees, and with the turntable completely filling the view of the dual cameras, it is possible to capture the totality of one lateral edge, and about 75% of the dorsal and ventral sides of the harpoon heads in a set of 15 scans. Each of the 15 scans are automatically aligned and stitched iteratively. Once complete, elements such as the putty can be cropped out. The harpoon is then flipped so that the second lateral edge is upwards, and another 15 scans are produced. The overlap in the central portions of the dorsal and ventral faces are enough for the two sets of scans to be properly stitched together. Were the harpoons lying flat on the ventral or dorsal side, the size of the lateral sides would not produce sufficient points for proper stitching. If there are areas of the harpoon head where data is missing, the turntable can be disabled, and a single scan can be taken by placing the scanner head at the proper angle. Ideally, no further scanning would be required, and the mesh can be produced, taking a total of approximately 15 to 20 minutes total. However, this was only the case for light-colored harpoons heads with damaged distal blade slots and the proximal foreshaft sockets.

Dark colored harpoon heads benefited from 20-30 scans per set, and up to 4 sets, because the number of points captured per scan is significantly reduced compared to the light-colored ones. Additionally, harpoon heads with intact blade slots and foreshaft sockets were much more difficult to scan due to the internal nature of these attributes; the projection of the scanner can only reach the interior at very few angles. Thus, a lot of trial and error is required to properly place the scanner head and multiple single scans are necessary to fill in the gaps. Thankfully, the nature of the data needed for this project does not demand the full internal extent of these attributes, but rather the data pertaining to where they start and end on the exterior surface. Scanning such harpoon heads could take from 30 minutes to upwards of an hour.

Once satisfactorily scanned, the meshes were created using the watertight option in the Einscan software, which makes sure the resulting model has no holes, and the low detail option. Medium and high detail artificially added more points in between each point captured on the harpoon heads which resulted in a dimpled surface. The meshes were then exported as .stl files.

Each 3D model retains the scale of the object, as was confirmed using calipers. Thus, thousand-year-old harpoon heads were immortalized in immensely flexible, yet ephemeral, digital format.

4.3 Secondary Data Acquisition: Landmark Data

The principal raw data in the study of morphometrics consists of landmarks. Bookstein (1991:2) describes landmarks, using biological specimens, as loci with names, such as a “bridge of the nose” or “tip of the chin”, which have the same identifiable location across specimens of interest. Functionally, the landmarks quantify loci as coordinates mapped in 2D or 3D Cartesian space. These maps, which encompass all chosen loci on a specimen, represent the morphological relationships between the different points on the object (Figure 4.5). It is the relationship between all points from one specimens which are used to study the relationship between different specimens within a group and between groups of specimens.

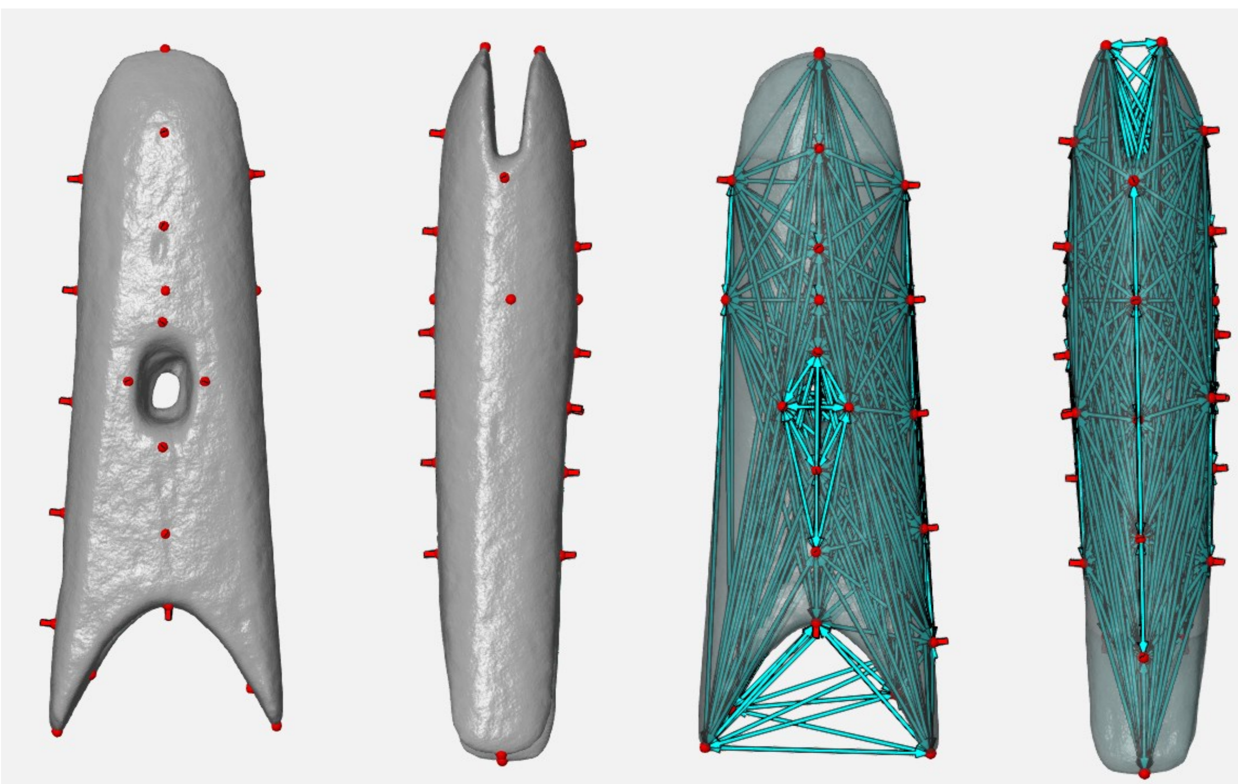


Figure 4.5 Landmarks

4.3.1 Preparation of Primary Data for Secondary Data Acquisition

Before point placement can occur, Meshlab (v. 2016.12) (Cignoni et al. 2008) was used to clean and align the 3D models with the axes. The point of origin/z-axis is manually set at the center of the line hole when looking at the dorsal side, the y-axis runs from proximal to distal end, and the x-axis from lateral edge to lateral edge (Figure 4.6). Proper alignment allows for easier manipulation in GOM Inspect, the software used for landmark placement and data collection.

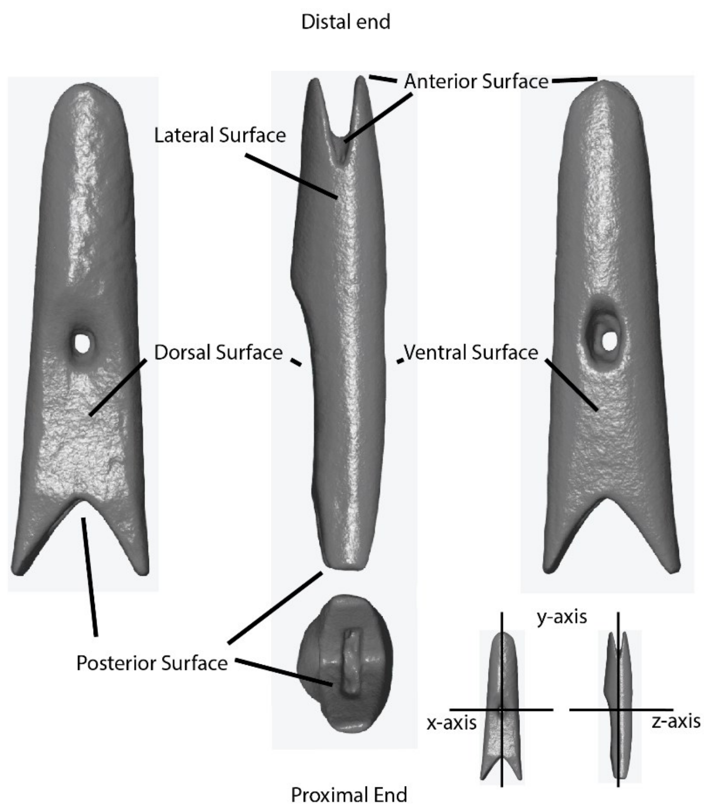


Figure 4.6 Harpoon Head Surfaces and Orientations

GOM is a company that specializes in measuring technologies, or metrology, usually for the purposes of product development and quality control in manufacturing. GOM Inspect is a software package freely available for these purposes, and many others. GOM Inspect (v. 2017.5, v. 2019.2) was chosen for this project over other methods in R for its friendly graphical user interface (GUI), its ability to easily manipulate 3D objects, and the ability to place landmarks with incredible precision using visual aids.

4.3.2 Limitations Informing Secondary Data Acquisition

Thirty-one landmarks were selected on Kingait Closed harpoon head specimens. These encompass the morphology of every distinct attribute on the harpoon heads (where they begin, meet, and end) as well as the overall morphology of the harpoon heads. There are, however, a few caveats that affect the ability to place all 31 landmarks on each harpoon head. The first is differential damage, the second is differential preservation, and the third involves post-creation modifications.

Out of the sample of 119 harpoon heads, only 2 were sufficiently preserved to place all 31 landmarks. Almost every harpoon head in the sample shows damage associated with use. Two major weak points in their design were identified: the blade slot and foreshaft socket. Non-coincidentally, these two attributes are the intersection points with other parts of the harpoon, the endblade and the foreshaft, respectively. When used during the hunt, once the harpoon head connects with the prey-animal, the thrashing of the animal and the flexing of its muscles likely puts great stress on these points of intersection. If the foreshaft fails to disconnect from the harpoon head upon impact and is held onto by the hunter, the animal's thrashing can cause the foreshaft socket to snap in the direction of most stress. This loss of integrity effectively renders the foreshaft socket, and possibly the line hole, useless in the future. Hitting bone, getting stuck between two bones, and the action of toggling, can create stress between the blade slot and the endblade, and can potentially cause one of the two prongs holding the endblade to snap.

The second caveat involves the differential preservation of each harpoon head. Though it is fortunate that such organic objects are recoverable millennia after their deposition, not all survive the test of time unscathed. By taking into consideration the depth of the archaeological features, the potential presence of permafrost mitigates the effects of time. Directly above the permafrost is the active layer, a layer which is subject to seasonal freezing and thawing. In arctic regions, artifacts found in the active layer tend to be surrounded by frozen material during most of the year due to the low mean annual air and ground temperature and are only subject to thawing for a short period. While subjected to many variables, archaeological material may spend many centuries exposed before sufficient vegetal growth and/or decomposition leads to their incorporation in the active layer or the permafrost. The contrasting geological and climactic conditions of each sample site have resulted in varying degrees of decomposition, thus compromising the surficial integrity of artifacts in some cases.

Such cases prevent the utilization of certain landmarks, as the original carved surface, and with it the intent of design and fabrication, no longer exists. All antler and bone harpoon heads in the sample had spongiform cancellous bone exposed on at least one surface. Harpoon heads made from walrus ivory show less advanced decomposition. Ivory, however, is sometimes penetrated by rootlets; this was the case with all KbFk-7 ivory harpoon heads. Those from PeHa-1 and EeBi-1 show varying degrees of degradation, such as sun-bleached surface cracks.

Naturally, once unearthed, organic materials re-enter the influence of elements and time, and until they are stabilized through conservation they may warp, degrade, or lose structural integrity. Even then, the life-history of artifacts has not ended. Methods of conservation from the 20th century do not always hold up and the chemicals used may damage the organic material in the long run. The continued study and storage of collections may still subject the material to all sorts of damage.

The final caveat involves secondary modifications on many harpoon heads from PeHa-1. An industry was identified which sought to repair harpoon heads damaged in the ways described earlier, or harpoon heads with cracks which threatened snapping. Lashing trenches would be carved around the spurs, below and above the line hole, and nearer the distal end, depending on the nature of the damage. In some specimens, a snapped blade slot prong would be modified to hold a replacement piece held on with more lashing. This piece was either manufactured from a scrap of antler or ivory, or was removed from another harpoon head with similar damage. The Dorset at Saatut truly sought to extend the life of their harpoon heads as is attested by the number recovered and their likely use as spare parts.

4.3.3 Landmark Selection and Placement

Of all the type D harpoon heads scanned, 119 had at least four usable landmarks. Each landmark is assigned a numerical variable name, from 1 to 31. As is expected, the presence of loci and the ability to place a landmark at loci is not uniform between harpoon heads. This posed a problem early on by creating an unwieldy data set where many landmarks had low sample sizes. Using symmetry was one feasible option. While the harpoon heads, being manufactured by hand, do not enjoy the same level of symmetry as biological specimens or contemporary industrial goods, the carvers appear to have sought to create symmetry for the dorsal and ventral faces. A simple test (n=75) was conducted by measuring two pairs of symmetrically placed landmarks from landmarks placed on the central Y-axis. The percentage of symmetric difference revealed a minimum of 0.27%, a maximum of 6.8%, and an average of 2.23%. Considering the elatively high level of symmetry, the side of the harpoon head which exhibits the least amount of damage and/or degradation was favored for the placement of landmarks.

The first two landmarks were centrally placed at the distal extremities of the blade slot prongs (Figure 4.7). Landmarks 3 and 4 were placed on the lateral edges where the blade slot begins. Using the reflection of light on the model, when magnified, it is possible to see where the dip which delimits the carved blade slot and the body of the harpoon head begins. The ‘surface curve’ tool in GOM Inspect can be used to place a line which hugs the surface revealing the details of surficial changes (Figure 4.8). Together, the light and a centrally placed surface curve can help identify the exact location down to the sub-millimetric level.

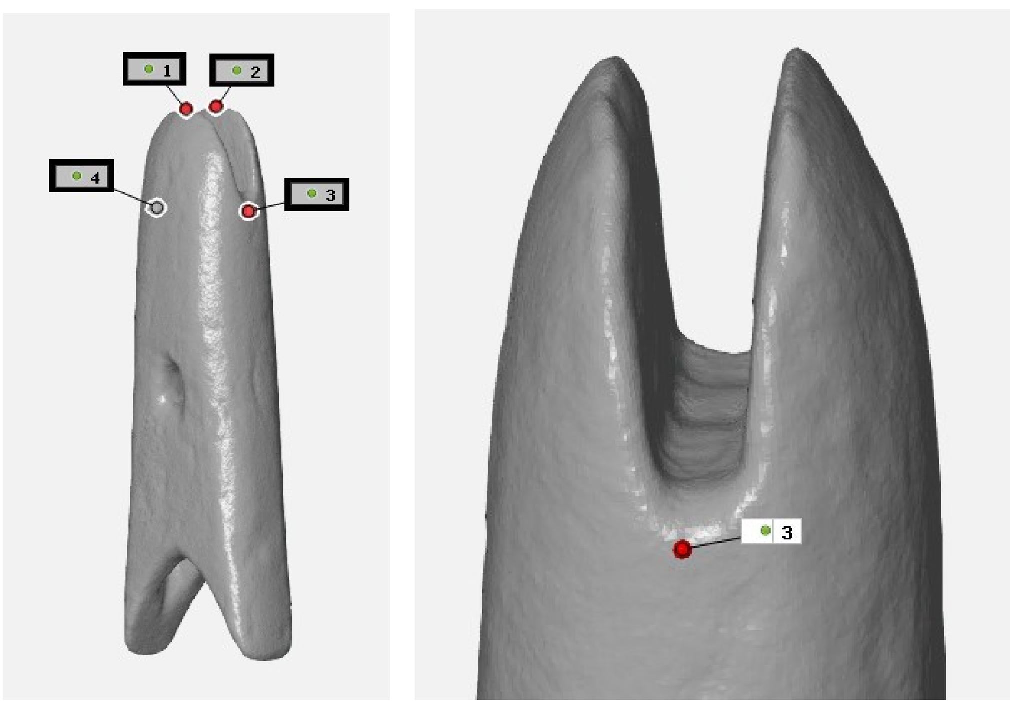


Figure 4.7 Landmarks 1 and 2, 3 and 4

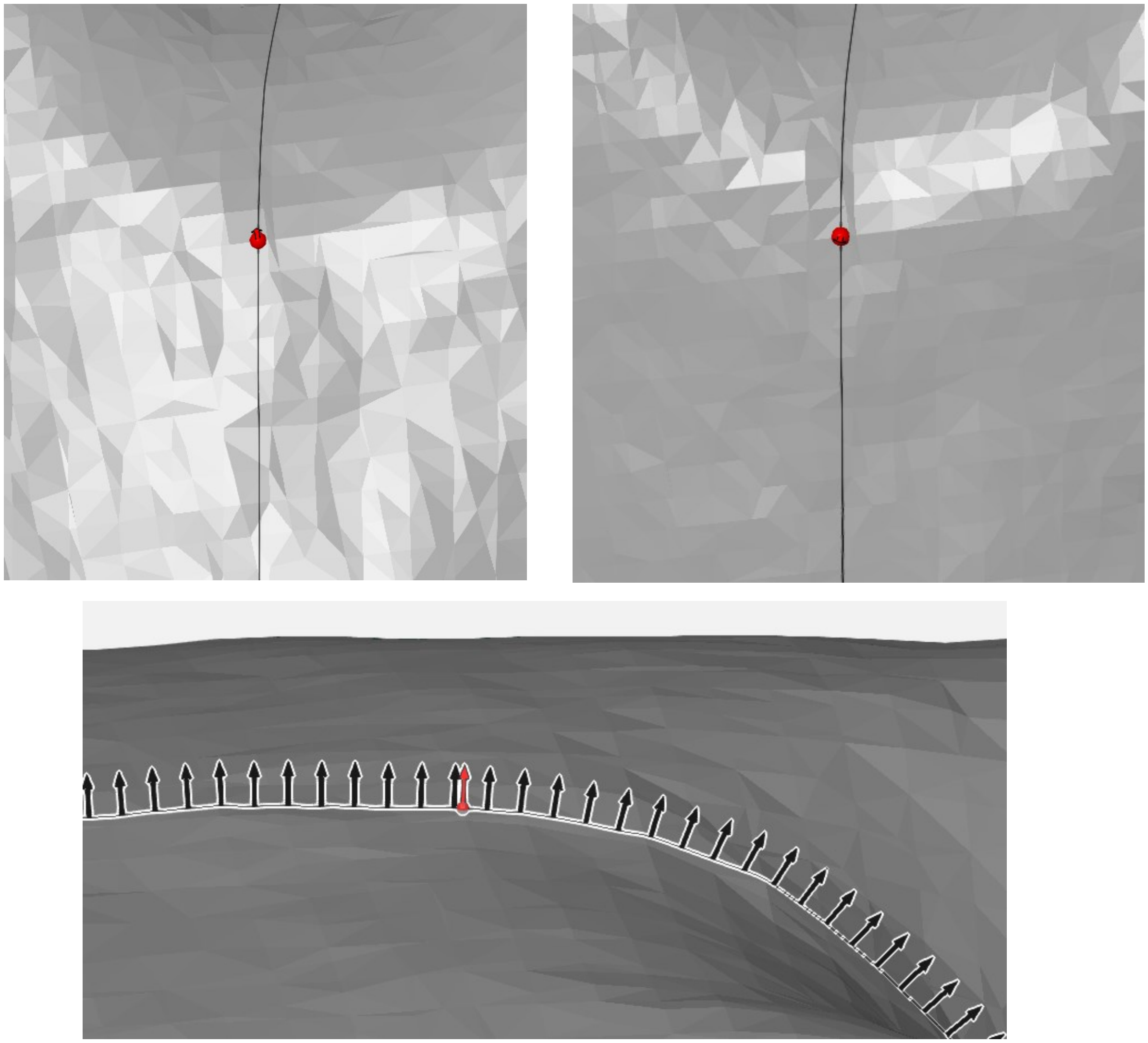


Figure 4.8 Landmarks 3 and 4

Landmarks 5 and 6 are placed centrally at the tip of the proximal spurs. 3 and 5 are always placed on the most complete side, or the dorsal left side by default when both sides are complete. A surface curve was placed between the two points, running centrally along the lateral edge. Division points at 20% intervals were placed along this line (Figure 4.9). From distal to proximal, they are landmarks 7, 8, 9, and 10. Together, landmarks 3, 5, 7, 8, 9, 10 provide the necessary shape information for the lateral edges.

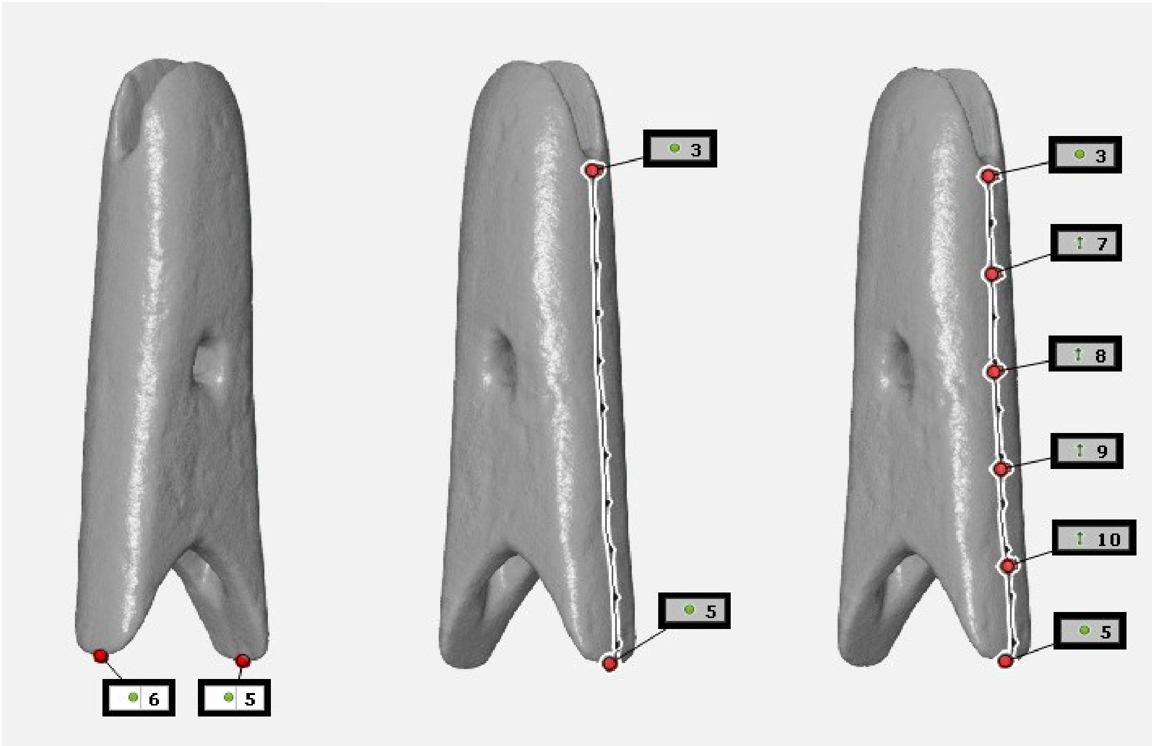


Figure 4.9 Landmarks 5 and 6, and 7, 8, 9, and 10

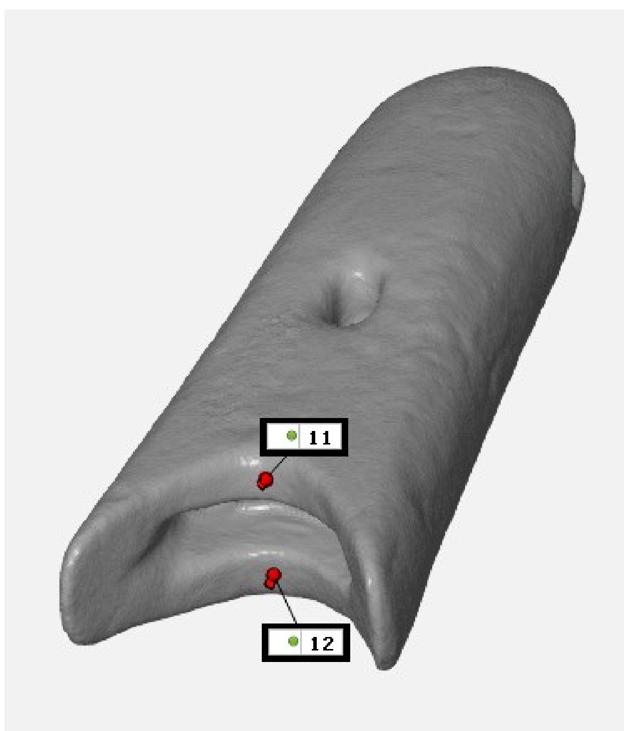


Figure 4.10 Landmarks 11 and 12

Two more, 11 and 12, are placed at the fork of the spurs on the posterior surface. They are positioned centrally between the edge of the body's surface and the edge of the foreshaft socket. 11 is placed on the dorsal side and 12 on the ventral side (Figure 4.10). These two do not require any adjustments dependent on which side is most complete, as they are placed centrally along the y axis.

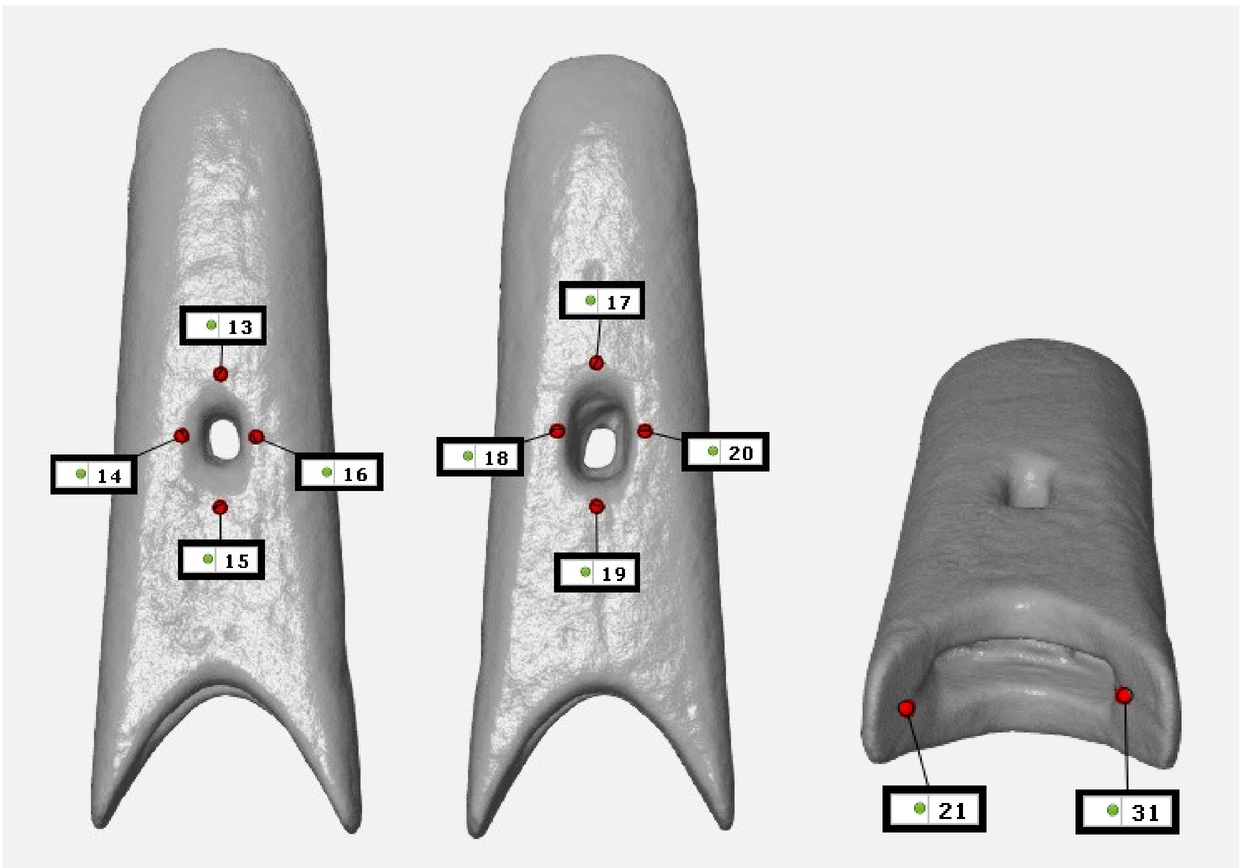


Figure 4.11 Landmarks 13, 14, 15, 16, and 17, 18, 19, 20, and 21 and 31.

The next four points – 13, 14, 15, 16 – cover the four cardinal extremities of the dorsal line hole. Using a grid underlaying the 3D model, it is simple to identify the two tallest points and the two widest points of the mostly ovoid shape. With the aid of more surface curves, the four landmarks can be placed at the dips denoting the beginning of carving. The same procedure is used to place 17, 18, 19, and 20 on the ventral side (Figure 4.11). 16 and 18 are inverted with respect to 14 and 20, respectively, depending on which side is determined to be the most complete.

The following two points, 21 and 31, can be found on the posterior surface delimiting the right and left edges of the foreshaft socket and the body which forms the spurs. A combination of light and surface curves aided landmark placement. These are interchanged so that 31 is always on the most complete side.

Next, surface curves are laid down between landmarks 1 and 13 on the dorsal side, and 2 and 17 on the ventral. Landmarks 22 and 23 are placed at 33% and 66% on the dorsal surface curve, and landmarks 25 and 26 on the ventral side (Figure 4.12). Two more surface curves are used between landmarks 15 and 11, and 19 and 12. Landmarks 24 and 27 are placed between these at the 50% mark, on the dorsal and ventral sides respectively. The placement of these points collect data on the morphology of each face.

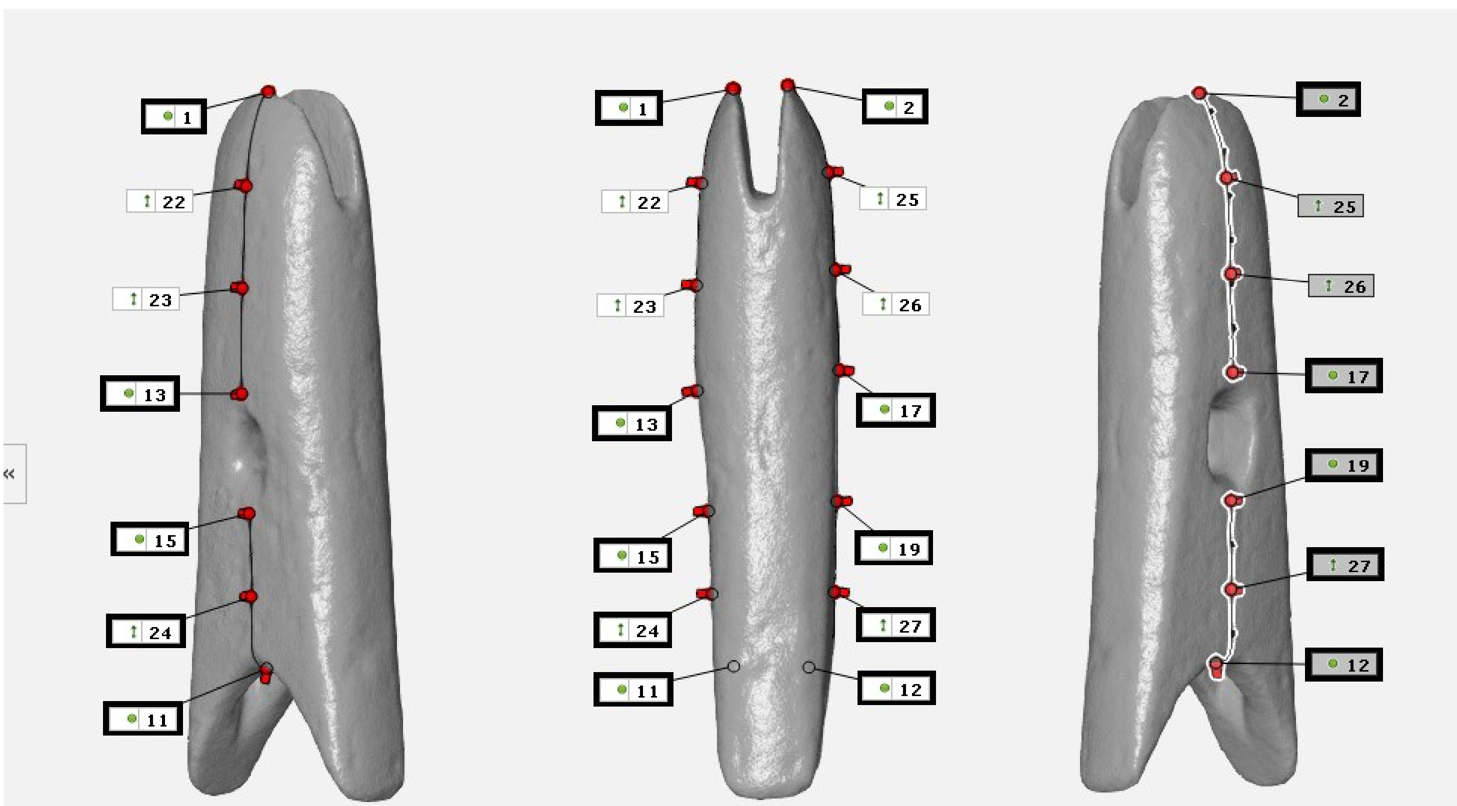


Figure 4.12 Landmarks 13, 14, 15, 16, and 17, 18, 19, 20, and 21 and 31.

The last four remaining landmarks require that it be possible to place landmark 7. Landmark 28 is positioned on the opposite lateral edge to 7. A line which goes through the model is placed in between 7 and 28, and a landmark is placed at the intersection of the new line and the central y axis on both faces; 29 on the dorsal and 30 on the ventral side (Figure 4.13).

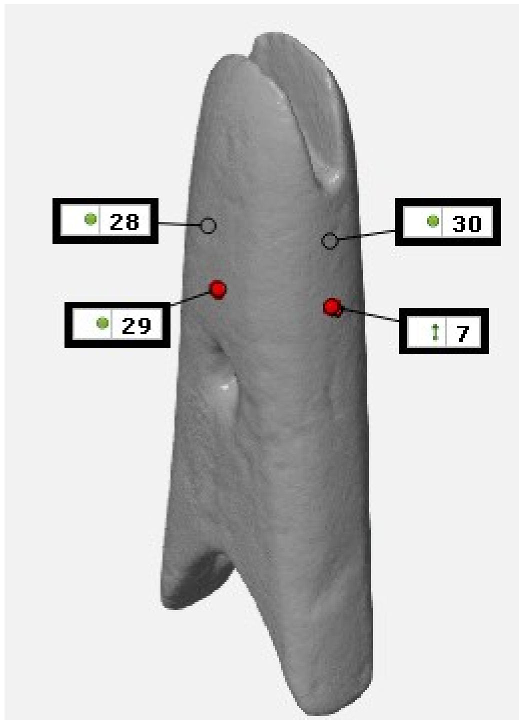


Figure 4.13 Landmarks 7, 28, 29, 30.

4.4 Statistical Evaluation of Landmark Data

Once all the possible landmarks were positioned on the harpoon heads, the data was exported in x, y, z coordinates and then compiled into one .csv file for the succeeding analysis in R. When viewing this data, it becomes clear just how inconsistent the nature and number of landmarks is between each harpoon head in the sample. The use of symmetry and the most complete side of the harpoon head helped alleviate some of the inconsistency; however, in the face of a statistical evaluation of the data, the amount of missing data is not ideal.

4.4.1 Exploration of Missing Data Estimation

The estimation of missing data was one possible remedy to this problem. Three methods were tested. The first two are included in the R package Geomorph (v. 3.1.3) (Adams et al. 2019). The function "estimate.missing" (Adams et al. 2019:35) offers two methods for estimating missing landmark data: thin-plate spline (TPS) and multivariate regression, both of which are defined in Gunz et al. (2009). TPS uses the reflection of present landmarks on either side and warps them to estimate the missing landmarks on the other side simultaneously. Multivariate regression uses complete samples upon which missing landmarks from incomplete specimens are regressed; the resulting linear regression model is used to predict the missing landmarks (Gunz et al. 2009:50). A third method was found in the LOST package (Arbour and Brown 2017). Bayesian Principal Components Analysis (BPCA) uses principal component regression, Bayesian estimation, and an expectation-maximization algorithm to approximate missing landmark values (Arbour and Brown 2014:17; Oba et al. 2003:2089-2091).

A direct observation of the resulting estimated landmarks and their positioning in relation to existing landmarks was undertaken. While these methods have found success in the domains of biology and bioanthropology, they were unsuccessful to varying degrees with the harpoon head sample. One reason it tends to work best for biological samples is the higher degree and consistency of bilateral symmetry in comparison to hand manufactured objects. While the symmetric difference is relatively low in the type D harpoon heads, it is comparatively high and inconsistent in comparison to faunal elements. Another reason is the lack of complete harpoon heads within the sample. With only two complete specimens, algorithms which depend on them cannot operate with great success. The most important reason for the lack of success in estimating missing landmarks is the sample of present landmarks itself. Some harpoon heads only feature four landmarks, making it highly inappropriate to estimate the remaining 27 landmarks, regardless of the methods used.

The direct evaluation showed that BPCA achieved the best results of all the methods. While the nature of the missing loci was not systematically evaluated, different numbers of present loci were used to determine success. It was found that while a higher number of existing landmarks helped in the estimation of missing ones, the nature of the missing loci still determined how well it was estimated. For example, for every test, up to a total of 27 existing landmarks, landmark 11 failed to be estimated to a realistic position repeatedly. As a result, estimating missing landmarks was forgone in this study.

4.4.2 Subdivision of Landmark Data into Variable Sets

There remains the problem of an incomplete dataset, and with the estimation of landmarks problematic, there was only one solution: use an array of landmark combinations. Instead of assessing the whole harpoon head, complete landmarks can be chosen and evaluated amongst the harpoon heads that have them. This solution, however, is not without its own problems. Subdividing the data into sets of complete variables means that not every harpoon will appear in the sample. It also means that each sample will differ in size. Additionally, harpoon heads that have more landmarks are likelier to appear in the sample than those that are less complete. The selection of landmarks to include in the statistical testing can also be cause for sampling bias. However, it does provide some opportunities. While a complete data set may only be evaluated once as a whole, the study of an incomplete data set using different combinations of landmarks forces one to look at the different parts of the object individually. With it comes the reasoning that overall similar objects may have dissimilar parts which have closer semblance with other objects initially deemed dissimilar in overall morphology.

The landmark combinations to be evaluated were based on traditional typological attributes in addition to a new set of attributes meant to assess overall morphology, or rather the space between attributes. Using attributes new and old, the totality of the harpoon head can be evaluated in pieces. Furthermore, all possible combinations of 3, 4, 5, 6, 7, and 8 landmarks were evaluated in order to generate summary statistics and to assess how the inclusions of different landmarks affects readings of variability. Furthermore, no variable set with a sample lower than 20 was evaluated.

4.4.3 Computing and Statistical Environments

Each set of combinations was processed individually using the R statistical environment (v. 3.6.1). Unfortunately, many of the operations and functions used in R do not make use of parallel computing and are limited to single core usage, regardless of the multi-core nature of today's central processing units (CPU). Generating the results for the specific attributes being assessed was not a time intensive process. In assessing all possible combinations, a 'for loop' was used to generate combinations. The overall processing of these combinations, however, is somewhat time-intensive but requires no additional attention once begun.

4.5 Tertiary Data Acquisition: General Procrustes Analysis

Geometric morphometrics relies on Generalized Procrustes Analysis (GPA) to make each specimen within the sample comparable. Considering that shape is the variable of interest, all other variables must be removed. When assessing a single combination of landmarks, which includes no missing data, the centroids of each harpoon head are standardized by being centered at the same point of origin (Adams et al. 2004:6; Rohlf and Slice 1990:41). The centroids are defined as the mean of all landmarks for a specific specimen (Martinón-Torres et al. 2006:2) Next, each specimen is scaled to a common unit size by calculating the square root of the summed squared Euclidean distances of each landmark and the centroid (Martinón-Torres et al. 2006:2; O'Higgins 2000:108; Rohlf and Slice 1990:41). This operation also returns the scaling factor called centroid-size (Martinón-Torres et al. 2006:3). The final step is the rotation of each specimen to achieve the best alignment by minimizing the squared difference between the matching landmarks of each specimen (Adams et al. 2004:7; Rohlf and Slice 1990:41). Thus, the process of Procrustes superimposition results in Procrustes shape coordinates representative of each harpoon head, having eliminated all variables but shape. Generalized Procrustes Analysis was performed using the "gpagen" function in the R package Geomorph (Adams et al. 2019:42).

4.6 Geometric Morphometric Analysis

The analysis of the Procrustes shape data was conducted in three different ways. First morphological disparity was used to assess intrasite variability, then pairwise Procrustes analysis of variance to assess shape differences between groups, and finally PCA biplots were created to visually assess relationships.

4.6.1 Morphological Disparity

Variability within groups is evaluated using morphological disparity. The function "morpho.disparity", from the R package Geomorph (Adams et al. 2019:56), estimates the Procrustes variance using residuals from a linear model fit (Figure 4.13). It is a useful way to evaluate the amount of difference within groups for comparison between groups. Spatial contextual metadata was used to define each group of specimens.

4.6.2 Pairwise Procrustes ANOVA

Pairwise Procrustes ANOVA, ANOVA being short for 'analysis of variance', quantifies relative shape variation using Procrustes distance to estimate probability of variation against the null hypothesis (see below). The function "procd.lm" was used with the pairwise function from the R package Geomorph (Adams et al. 2019:98). This was used to test whether different groups showed any statistical similarities or difference when defined by site.

The results of this test take the form of p-values. The null hypothesis tested by ANOVA states that no significant shape difference exists between the groups being evaluated. P-values below 0.05 (<0.05) are evidence against the null hypothesis and signal that there are significant shape differences. P-values above 0.05 (>0.05) are evidence supporting the null hypothesis and signal that there are no significant shape differences between the groups.

4.6.3 Principal Components Analysis (PCA)

Finally, PCA was performed on the Procrustes shape data. PCA biplots are standard for geometric morphometric data visualization as they easily show the distances and relatedness, or variability, between specimens and populations in the sample (Carayon et al. 2019; Cucchi et al. 2019; Mounier and Lahr 2019; Suárez and Cardillo 2019, etc). The shape data resulting from GPA takes the form of multi-dimensional matrices which PCA can reduce and project onto the first few principal components, which can then easily be visualized in the form of biplots in addition to preserving most of the data's variation. In this study, the first two principal components (PC1 and PC2) were assessed as they were found to represent over 80% of variation in every case.

CHAPTER 5: RESULTS

5.1 Intersite Analysis

This section will look at the global relationship between the three sites under study, how differing parameters affect the results, and the nature of variability at the intersite scale. To reiterate, the sample consists of 119 harpoon heads: 81 from Saatut (PeHa-1), 34 from Philip's Garden (EeBi-1), and 4 from Tayara (KbFk-7). Global results were produced by obtaining the morphological disparity for intrasite variability and p-values from intersite ANOVA pairwise analysis for all possible landmark combinations in sets of 3, 4, 5, 6, 7, and 8 landmark combinations (denoted in the following by Cbn and the # of combinations) with a minimum sample size of 20 specimens. To reiterate, these combinations are composed of landmarks, thus Cbn 3 deals with combinations of 3 landmarks of the 31 possible landmarks.

Table 5.1 Intrasite Pairwise Procrustes Variance/ Morphological Disparity (Low values = more internal consistency/less internal variability, high values= less internal consistency/more internal variability)

Combinations of	**PG (EeBi-1)**	**Tayara (KbFk-7)**	**Saatut (PeHa-1)**	**Mean Sample Size**	**Median Sample Size**
Cbn 3	0.0092	0.0129	0.0036	29.17	27
Cbn 4	0.0111	0.0152	0.0042	25.98	24
Cbn 5	0.0110	0.0147	0.0041	24.34	23
Cbn 6	0.0106	0.0137	0.0039	23.31	22
Cbn 7	0.0103	0.0125	0.0037	22.55	22
Cbn 8	0.0101	0.0115	0.0035	21.96	21

Internal variability, or Procrustes variance, is lowest for Cbn 3 (Table 5.1). This is undoubtedly because combinations of 3 landmarks constitute a simpler geometric shape; a 3-point shape can only be a two-dimensional plane. This would explain the 17-20% difference between Cbn 3 and 4, as the jump from a 2D shape to a 3D one increases the complexity of the shape and the number of landmarks that are compared. While the difference between each set of combinations is not large, each consecutive set of combinations shows a decrease in internal variability. By Cbn 7 and 8, internal variability is near or below that of Cbn3. This may be explained by proportional changes in sample size. As more landmarks are included for each test, the number of possible harpoon heads with the right number of landmarks decreases due to use-breakage and taphonomy. As the sample size decreases, the realm of possible variability also decreases, resulting in slightly more consistent and homogenous datasets at the intrasite level.

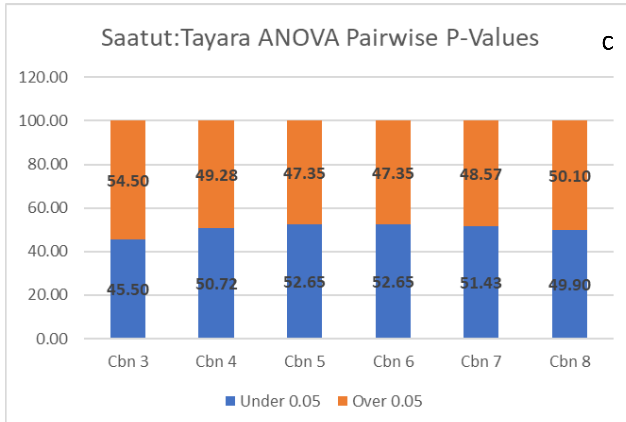
Table 5.2 Mean ANOVA Pairwise P-Values for PG (EeBi-1), Tayara (KbFk-7), and Saatut (PeHa-1).

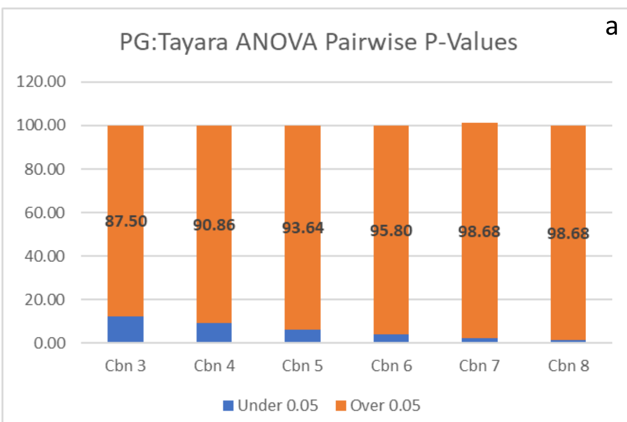
Combinations of	PG:Tayara (p-value)	PG:Saatut (p-value)	Saatut:Tayara (p-value)	n Combinations Evaluated
Cbn 3	0.3950	0.0530	0.1809	2576
Cbn 4	0.3876	0.0147	0.1192	9138
Cbn 5	0.3870	0.0073	0.0964	21207
Cbn 6	0.3867	0.0051	0.0877	35516
Cbn 7	0.3852	0.0041	0.0838	44859
Cbn 8	0.3808	0.0035	0.0818	43509

Mean p-values for ANOVA pairwise analysis also shows a slight decrease with each successive number of combinations (Table 5.2). While both the PG:Tayara and Saatut:Tayara interactions remain above the 0.05 mark indicating no significance difference for each set of combinations, the PG:Saatut interaction reveals that most similarities are found in Cbn 3 with a drastic decrease in similarity starting at Cbn4. These results may suggest that overall similarity decreases the more complex the shape being analyzed but may also be indicative of the same statistical artifact relating to the decrease in sample size observed in Table 5.1.

The proportion of p-values which show differences, or no differences, is affected by the nature of the material and their geometric morphometric relationship in addition to an increase in landmarks used per combinations. While mean p-values show a small decrease in overall similarity for PG:Tayara (Table 5.2), there is an increase in the number of p-values strictly above

0.05 (Figure 5.1a). The same effect is present for PG:Saatut as the percentage of p-values below 0.05 increases with each succeeding number of landmarks being evaluated (Figure 5.1b). Lastly, the Saatut:Tayara interaction remains stable near the 50% mark with half of the p-values suggesting difference and the other half suggesting similarity (Figure 5.1c).





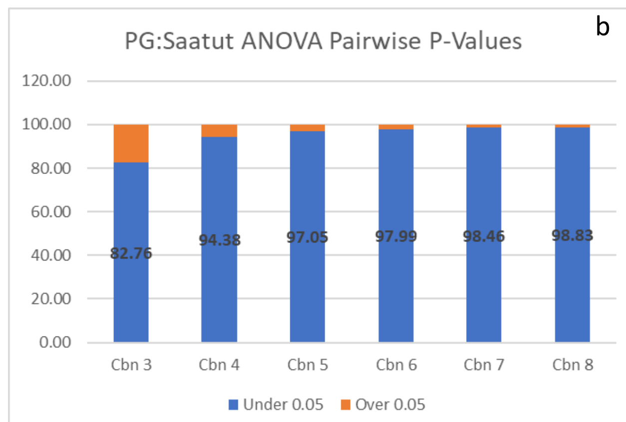


Figure 5.1 a, b, c Total Pairwise P-Value Percentages by Cbn for sites PG (EeBi-1), Tayara (KbFk-7), and Saatut (PeHa-1).

5.1.1 Intersite Discussion

Considering the incomplete nature of the dataset, agglomerated values were obtained to inform global intersite relationships and the state of variability. Combinations of 3 to 8 landmarks, representing a total of 156,805 unique landmark combinations, were used to represent the whole. While combinations of up to 12 landmarks still produced results when the sample size minimum of 20 specimens was met, processing time made their evaluation unwieldy. In contrast, Cbn 13 did not produce any results which met the minimum sample size criteria. Additionally, Cbn 7, which produced 44,859 landmark combinations, represents the peak number of combinations evaluated, while Cbn 8 shows diminished returns (Table 5.2).

Table 5.2 reveals that Tayara has a strong relationship, on average showing no difference, with both PG and Saatut. In relative terms, it appears that the strongest of the two relationships is between PG and Tayara. This is consistent with the results in Figure 5.1a which demonstrates that the relationship between PG and Tayara shows no difference between 87.50 and 98.68 percent of the time. Conversely, Figure 5.1c shows that Saatut and Tayara show no difference only half of the time. Furthermore, while the mean p-value for PG and Tayara remains consistent at around 0.38, that of Tayara and Saatut shows a noticeable decrease with each succeeding Cbn. It is thus fair to conclude that PG and Tayara show more similarities than Tayara does with Saatut, while both pairs reveal a strong overall relationship.

The PG and Saatut relationship, as seen in both Table 5.2 and Figure 5.1b, is not very strong. The former reveals that the differences are statistically significant beyond Cbn 3, and the latter shows difference between 82.76 and 98.83 percent of the time. It can be thus concluded that PG and Saatut are not morphometrically similar.

The relative consistency between the results of different Cbns reveals that adding more landmarks does not change the nature of relationships between the three sites. With as few as 3 landmarks, the various combinations reveal the same overall site relationships as Cbn 8. The relationship between Cbn 3 and Cbn 4, and that of Cbn4 with the rest, indicates that a 3D shape using 4 landmarks may be the most ideal and properly represents the whole dataset should only one Cbn be processed. While complete artifacts were lacking and could therefore not be used, the lack of a significant difference between the results of Cbn 4 and Cbn 8 suggests that whole harpoon heads are not necessary at all, and that meaningful information can be obtained from the damaged and degraded harpoon heads if they have some useable surfaces for landmark placement. In the case of this study, a minimum of 4 placeable landmarks was needed for the specimen to be considered. While which particular 4 landmarks can be placed will be different for each specimen, there exists enough overlap between specimens for the method evaluating all possible combinations to be successful.

Combining cursory spatial data with the relationships previously identified provides new insight on the relationship between traditional knowledge and spatial context. Tayara is located between the two other sites on a near-north-south axis and shows similarities, to differing extents, to the northernmost site and the southernmost site. Conversely, the northern-most site and the southern-most site are significantly different. This may indicate that site-scale ontologies, traditional knowledge, or at the very least the processes which create variability and inform site-scale identities are clinal. As interesting as such an interpretation may be, the scale of this project and the small sample size from Tayara prevent it from being conclusive as it raises more questions than it provides answers.

5.2 Evaluating the Usefulness of Typologies

The following section will evaluate those attributes traditionally used to define the Kingait closed; these are the endblade slot, the single line hole, the closed socket, and the bifurcated spurs. Additionally, a comparison between traditional attributes and attributes concerning overall morphology will be undertaken.

5.2.1 The Endblade Slot

The endblade slot is the characteristic distal attribute of the Kingait closed, and it roughly corresponds to landmarks 1, 2, 3, and 4 (Figure 5.2). The shape of the endblade slot was highly simplified by only using these four points and thus does not touch upon the contour shape of each prong. These landmarks assess the general endblade slot proportions from the proximal carving limit of the slot to the distal-most tip of each prong. This does not stray far from original interpretations as none exist to systematically describe or explain exterior endblade slot shape beyond their attribute presence.

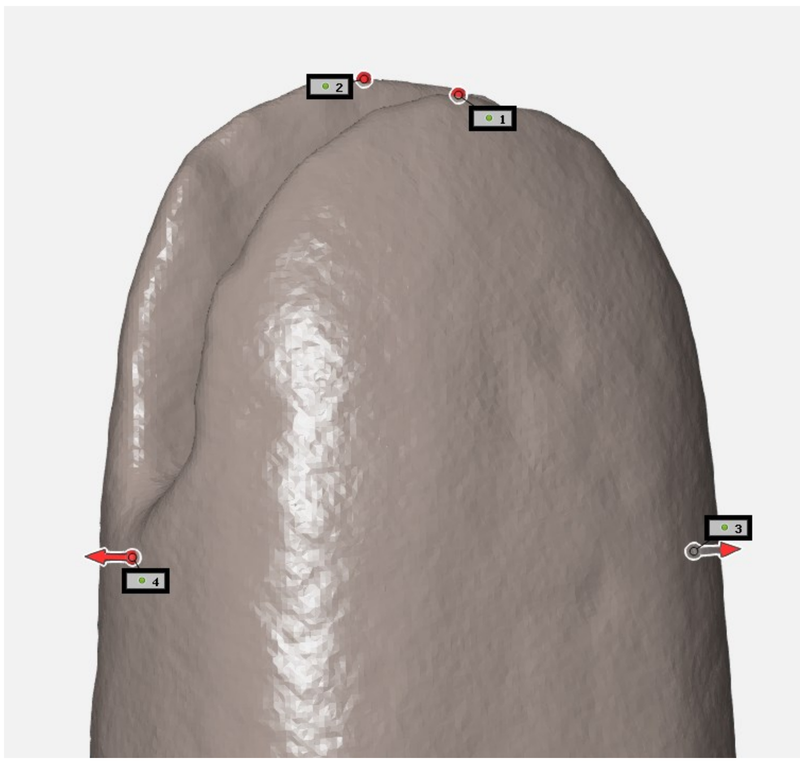


Figure 5.2 Landmarks 1, 2, 3, 4 (Endblade Slot)

Site pairwise analysis (Table 5.3) for overall endblade slot shape and single face prong shape reveals major differences between Philip's Garden and Tayara; this is at odds with the Cbn 4 mean p-value (Table 5.4b) which indicates a close relationship in morphology between the two sites. The data also indicates no similarity in shape between PG and Saatut. Tayara and Saatut here are revealed as having no significant difference in shape, however this is based on the single Kingait Closed at Tayara which was interpreted as being the smaller and morphologically different compared to the other 3 specimens. The visual assessment provided by PCA biplots distinguishes each site (Figure 5.3) and shows no intermingling between Saatut and PG. Tayara's single specimen is seen near Saatut and appears opposite to PG. The internal variability for PG is higher than the mean for Cbn 4, while those from Tayara and Saatut are lower than the mean for their respective sites; each is nonetheless quite close to the mean (Table 5.3a).

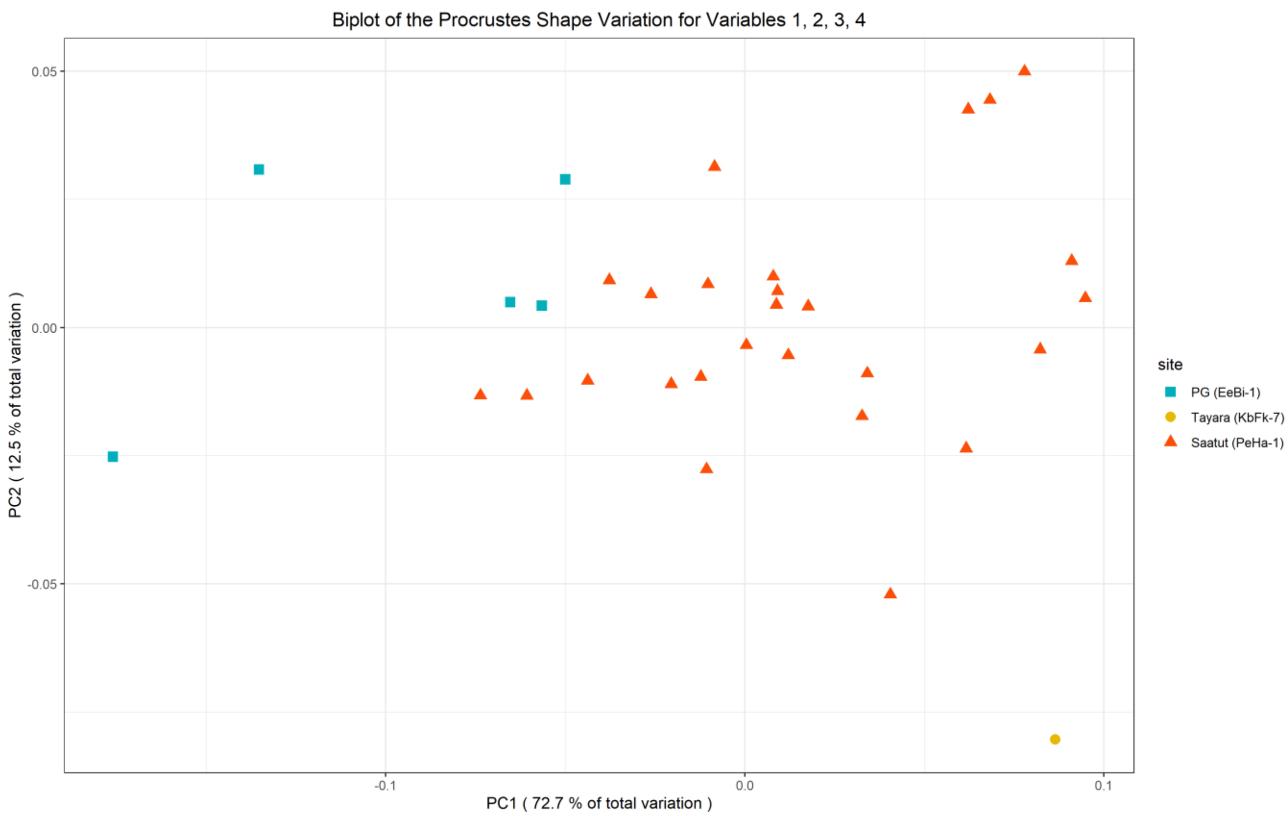


Figure 5.3 PCA Biplot for 1, 2, 3, 4

Table 5.3a Intrasite Pairwise Procrustes Variance by Site (Internal Variability)

Table 5.3b ANOVA Site Pairwise P-Values for PG (EeBi-1), Tayara (KbFk-7), and Saatut (PeHa-1).

	a **PG (EeBi-1)**	**Tayara (KbFk-7)**	**Saatut (PeHa-1)**	b **PG:Tayara (p-values)**	**PG:Saatut (p-values)**	**Saatut:Tayara (p-values)**
Cbn 4 Mean	0.0111	0.0152	0.0042	0.3876	0.0147	0.1192
1, 2, 3, 4	0.0131	0.0142	0.0037	0.0067	0.0002	0.0968

5.2.2 The Dorsal Line Hole

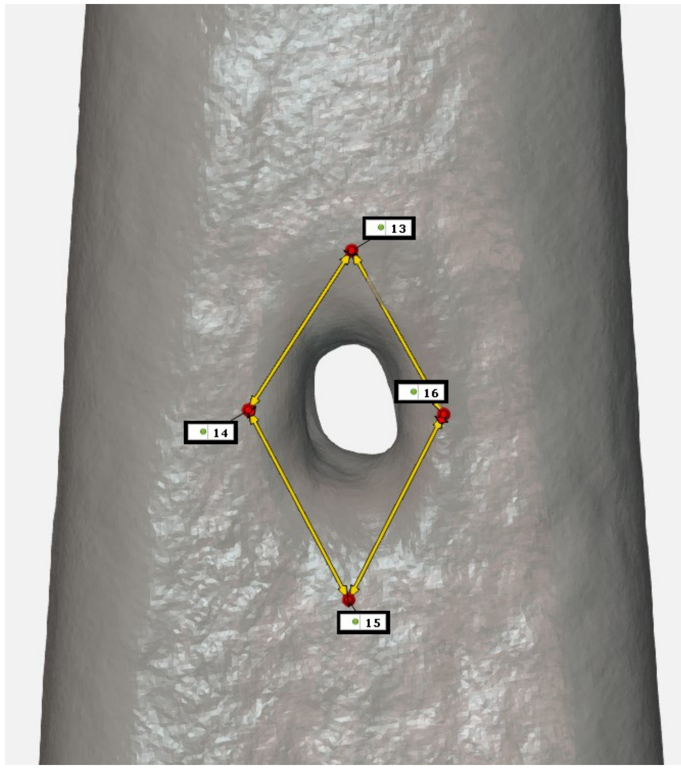


Figure 5.4 Landmarks 13, 14, 15, 16 (Dorsal Line Hole)

Dorsal line hole morphology has a more interesting tale to tell. The landmarks 13, 14, 15, and 16 (Figure 5.4), as well as their various combinations were assessed. Overall morphology using all four points suggests that Saatut and PG are significantly different, while PG and Tayara display no significant difference (Table 5.4b). Tayara and Saatut show only minor differences. The internal variability for dorsal line hole morphology is amongst the highest in the Cbn 4 results (Table 5.4a).

Of most interest are the two clusters formed by PG specimens (Figure 5.5, shaded areas). The biplots produced by the other combinations show that these clusters only appear when landmarks 13 and 15 are both present and are otherwise clustered together when not. Upon inspecting the specimens, the upper group features mostly ovoid line holes with a longer proximal carving limit. Similarly, the outlying PeHa-1 found in the middle of the plot also has a longer proximal carving limit. In contrast, the lower PG group has mostly squared line holes with short proximal carving limits. The presence and degree of terracing does not appear to have played a major part in these group distinctions, as a visual inspection shows them to be quite uniform.

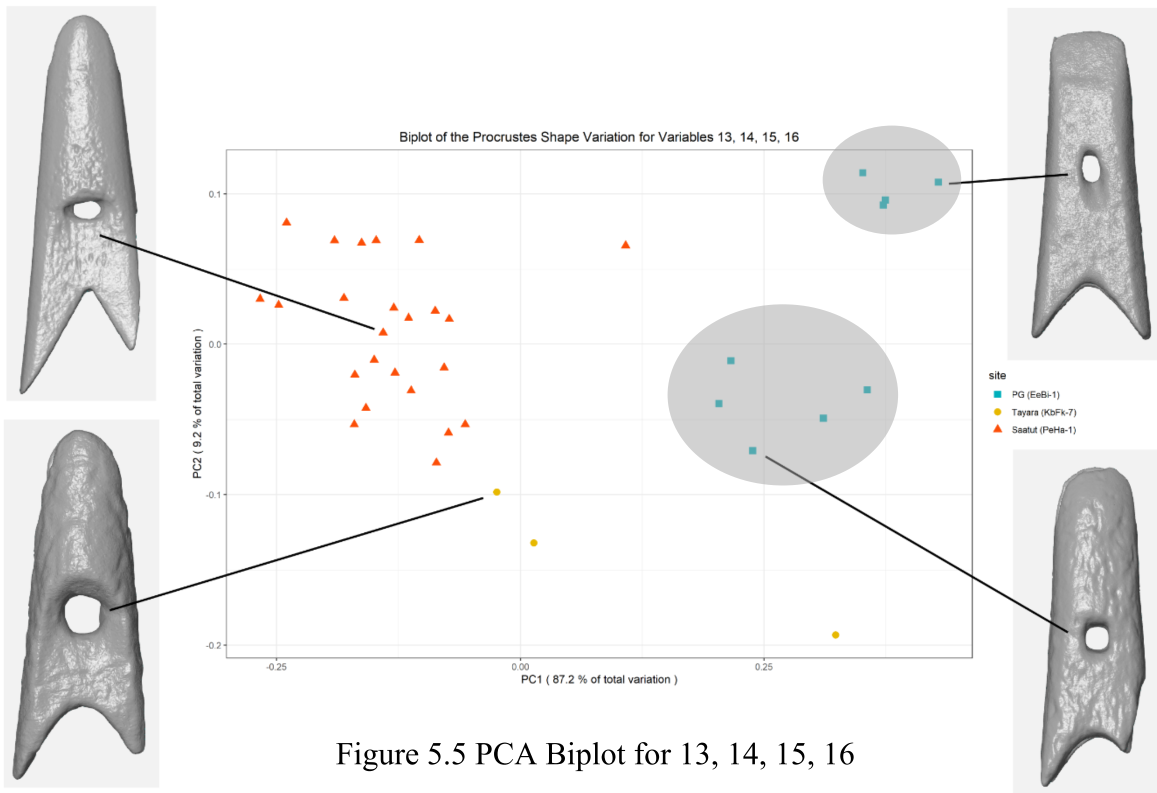


Figure 5.5 PCA Biplot for 13, 14, 15, 16

Table 5.4a Intrasite Pairwise Procrustes Variance by Site (Internal Variability)

Table 5.4b ANOVA Site Pairwise P-Values for PG (EeBi-1), Tayara (KbFk-7), and Saatut (PeHa-1).

	a **PG (EeBi-1)**	**Tayara (KbFk-7)**	**Saatut (PeHa-1)**	b **PG:Tayara (p-values)**	**PG:Saatut (p-values)**	**Saatut:Tayara (p-values)**
Cbn 4 Mean	0.0111	0.0152	0.0042	0.3876	0.0147	0.1192
13,14,15,16	0.1134	0.0581	0.0271	0.0572	0.0001	0.0234
Cbn 3 Mean	0.0092	0.0129	0.0036	0.3950	0.0530	0.1809
13, 14, 15	0.0822	0.0429	0.0201	0.0577	0.0001	0.0221
13, 14, 16	0.0491	0.0635	0.0182	0.9394	0.0001	0.0042
13, 15, 16	0.0847	0.0404	0.0193	0.0717	0.0001	0.0158
14, 15, 16	0.1386	0.0299	0.0293	0.0242	0.0001	0.3203

In assessing the proximal half of the line hole (14,15,16) site pairwise analysis shows that Tayara exhibits no significant difference with Saatut (Table 5.4b). The biplot (Figure 5.7) clearly shows the arrow-shaped Tayara specimens (KbFk-7:1, 4) at the heart of the Saatut cluster, while the parallelized smaller specimen (KbFk-7:3) shows a greater semblance to PG. Otherwise, when the distal end is isolated (13,14,16), the same three Tayara specimens show up amongst the PG cluster (Figure 5.6). This is supported by the pairwise p-values which indicate that the distal dorsal line hole for Tayara and PG show no significant difference while Saatut and Tayara show no similarity (Table 5.4b).

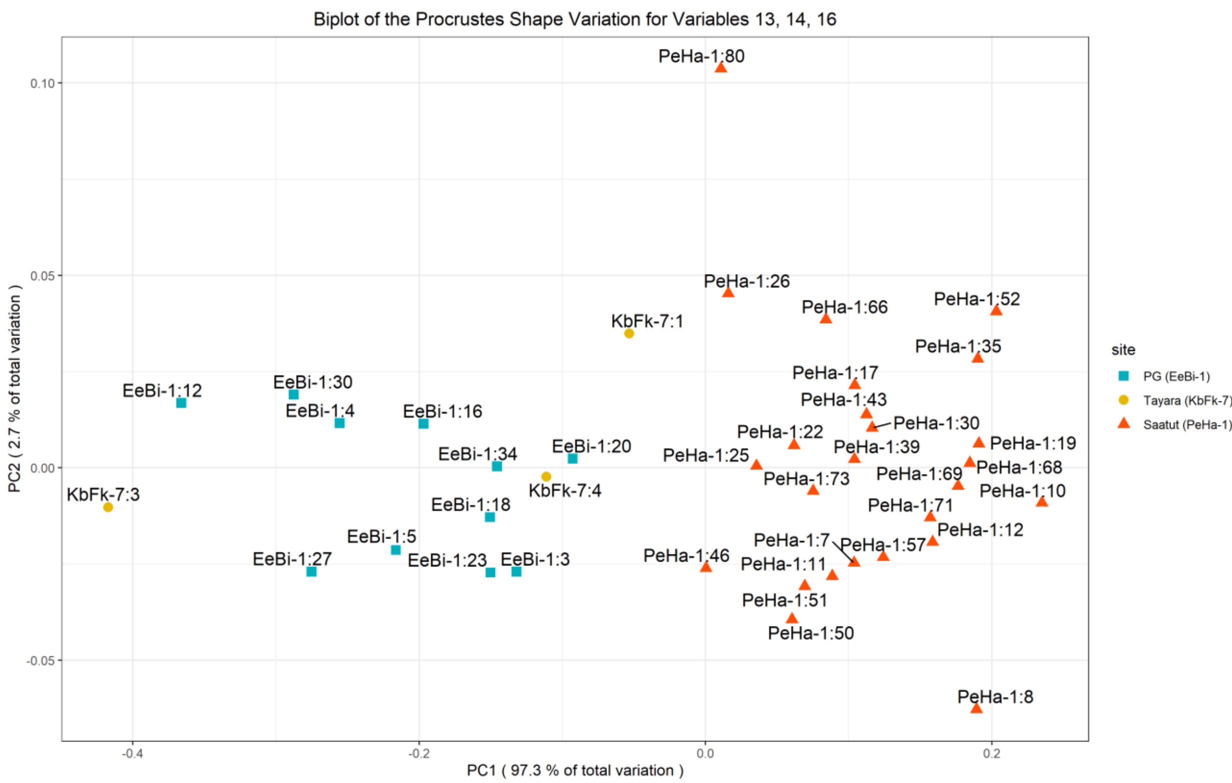


Figure 5.6 PCA Biplot for 13, 14, 16

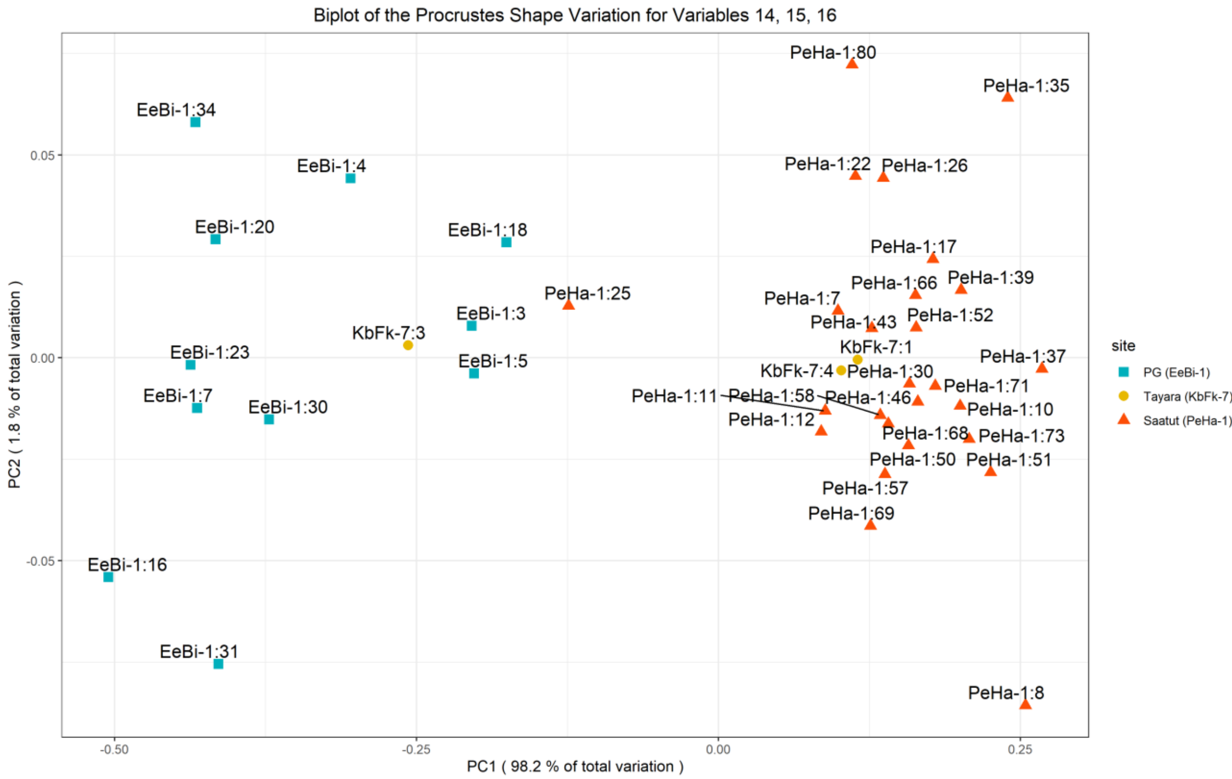


Figure 5.7 PCA Biplot for 14, 15, 16

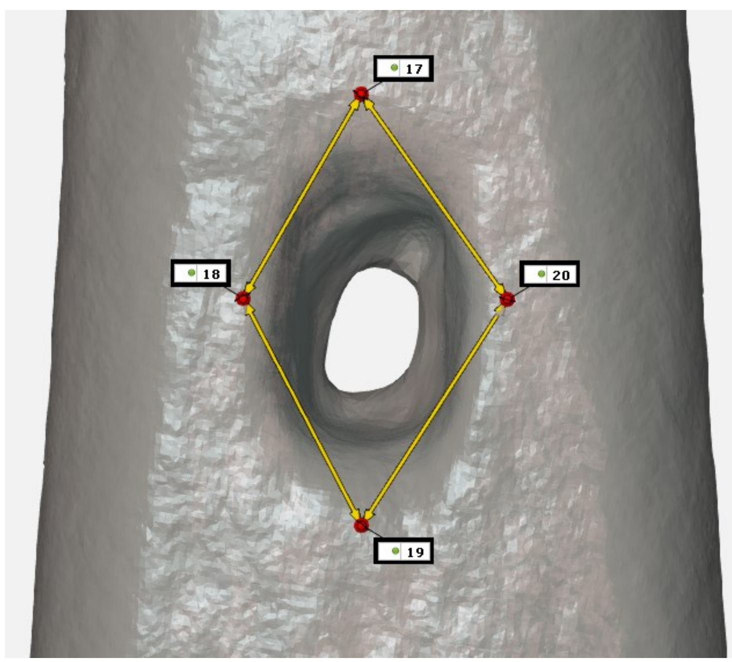


Figure 5.8 Landmarks 17, 18, 19, 20 (Ventral Line Hole)

5.2.3 The Ventral Line Hole

The ventral line hole (Figure 5.8), encompassed by landmarks 17, 18, 19, and 20 only shows significant differences between Saatut and PG. The site pairwise assessment also shows Saatut being closer in relationship with Tayara than Tayara is with PG (Table 5.5b). Overall the biplot illustrates overlap for a good portion of specimens, with Saatut and PG diverging into distinct morphologies (Figure 5.9). Furthermore, there is a surprisingly low amount of internal variability at each site with PG and Tayara lower than their Cbn 4 mean and Saatut slightly higher (Table 5.5a).

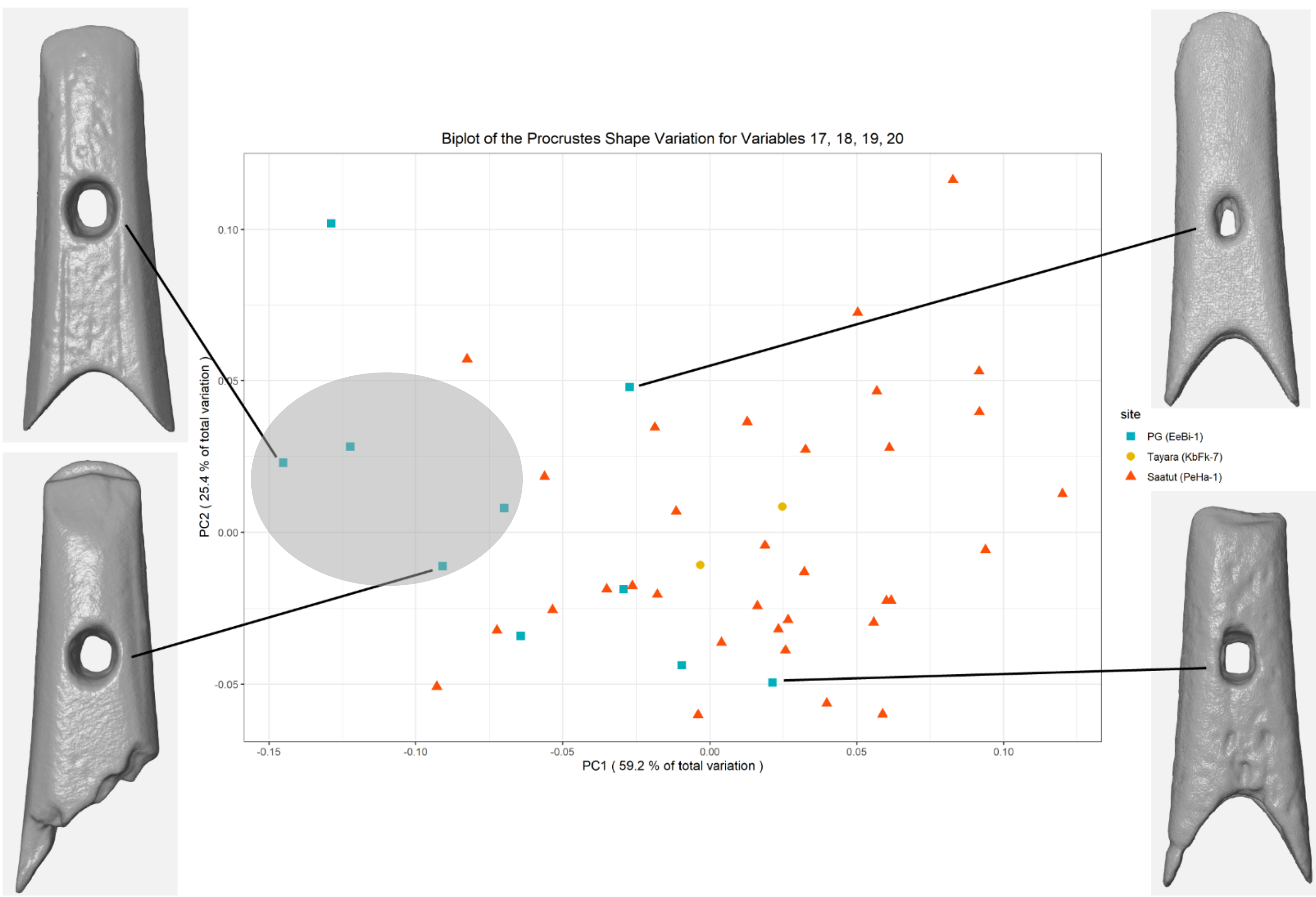


Figure 5.9 PCA Biplot for 17, 18, 19, 20

Four specimens from PG, which make up the bulk of those representing H12 and H18, are nearly perfect circles (Figure 5.9, shaded area). Upon first glance it looks like distinct evidence for drilling, however, Wells (2012:85) interprets it as chiseling rather than drilling or even the gouging that is expected of Dorset harpoon head line holes.

Table 5.5a Intrasite Pairwise Procrustes Variance by Site (Internal Variability)

Table 5.5b ANOVA Site Pairwise P-Values for PG (EeBi-1), Tayara (KbFk-7), and Saatut (PeHa-1).

	a PG (EeBi-1)	Tayara (KbFk-7)	Saatut (PeHa-1)	b PG:Tayara (p-values)	PG:Saatut (p-values)	Saatut:Tayara (p-values)
Cbn 4 Mean	0.0111	0.0152	0.0042	0.3876	0.0147	0.1192
17, 18, 19, 20	0.0099	0.0007	0.0060	0.1782	1.00E-04	0.9939

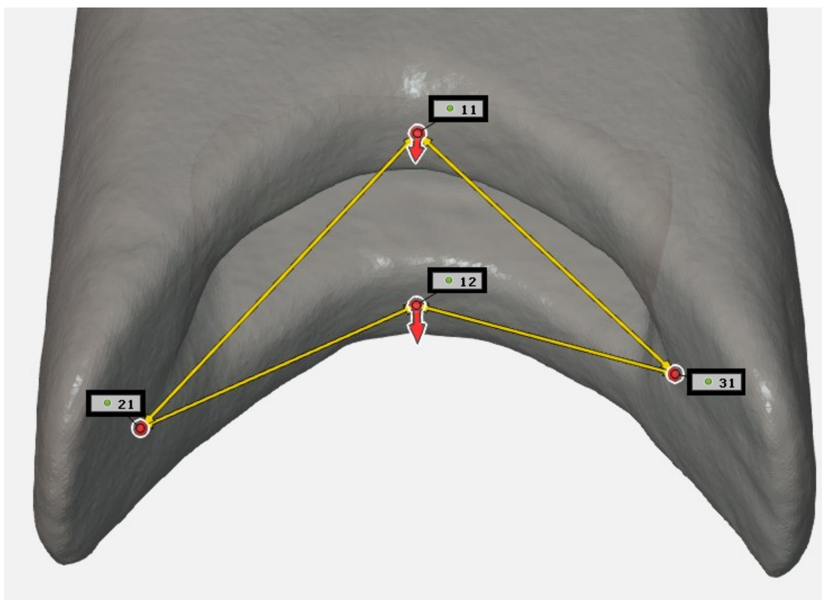


Figure 5.10 Landmarks 11, 12, 21, 31 (Foreshaft Socket)

5.2.4 Closed Foreshaft Socket

The results for closed socket morphology, represented by landmarks 11, 12, 21, and 31 (Figure 5.10), and their various combinations, indicate a clear distinction between Saatut and PG in both the biplot (Figure 5.11) and ANOVA pairwise results (Table 5.6b). These results also indicate that PG and Tayara have the closest relationship, while that between Tayara and Saatut teeters between being similar in shape to not, depending on the landmark combinations. Internal variability is lower than the mean for Tayara, nearly equivalent for PG, and distinctively higher for Saatut (Table 5.6a).

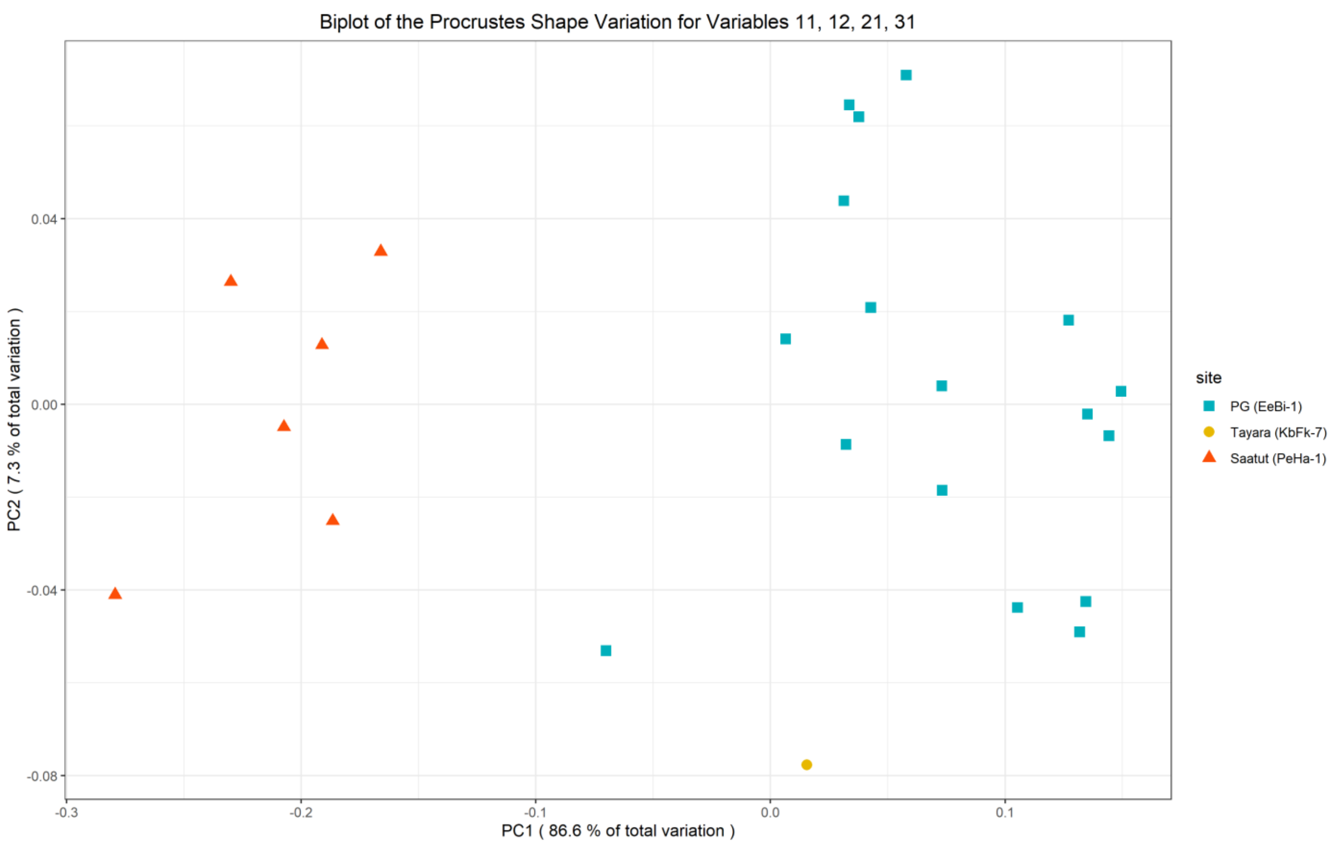


Figure 5.11 PCA Biplot for 11, 12, 21, and 31

Table 5.6a Intrasite Pairwise Procrustes Variance by Site (Internal Variability)

Table 5.6b ANOVA Site Pairwise P-Values for PG (EeBi-1), Tayara (KbFk-7), and Saatut (PeHa-1).

	a PG (EeBi-1)	Tayara (KbFk-7)	Saatut (PeHa-1)	b PG:Tayara (p-values)	PG:Saatut (p-values)	Saatut:Tayara (p-values)
Cbn 4 Mean	0.0111	0.0152	0.0042	0.3876	0.0147	0.1192
11, 12, 21, 31	0.0115	0.0094	0.0473	0.5296	0.0001	0.0976
Cbn 3 Mean	0.0092	0.0129	0.0036	0.3950	0.0530	0.1809
11, 12, 21	0.0067	0.0167	0.0227	0.5077	0.0002	0.0008
11, 12, 31	0.0073	0.0088	0.0173	0.9022	0.0001	0.0084
11, 21, 31	0.0106	0.0036	0.0151	0.4247	0.0001	0.0662
12, 21, 31	0.0099	0.0021	0.0238	0.6510	0.0001	0.1853

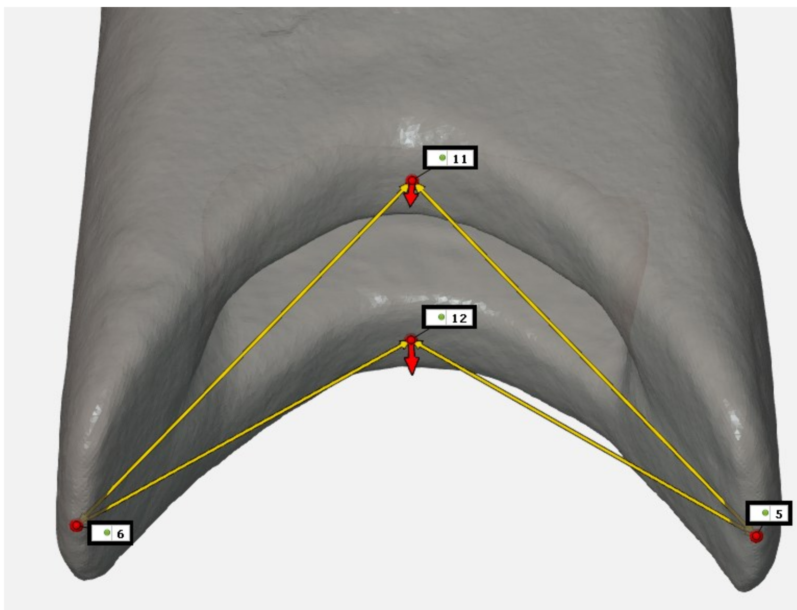


Figure 5.12 Landmarks 5, 6, 11, 12 (Spurs)

5.2.5 Spurs

Spurs shows similar results as the socket. Using Landmarks 5, 6, 11, and 12 (Figure 5.12) as well as different combinations reveals no significant differences between Saatut and Tayara, and PG and Tayara, the latter pair having the closest relationship (Table 5.7b). PG and Saatut register as significantly different. The biplot (Figure 5.13) shows a close but distinguishable cluster for each site, with Tayara in between the two other sites. Internal variability for PG and Saatut is above the mean, while Tayara is below the mean (Table 5.7a).

Table 5.7a Intrasite Pairwise Procrustes Variance by Site (Internal Variability)

Table 5.7b ANOVA Site Pairwise P-Values for PG (EeBi-1), Tayara (KbFk-7), and Saatut (PeHa-1).

	a **PG (EeBi-1)**	**Tayara (EeBi-1)**	**Saatut (EeBi-1)**	b **PG:Tayara (p-values)**	**PG:Saatut (p-values)**	**Saatut:Tayara (p-values)**
Cbn 4 Mean	0.0111	0.0152	0.0042	0.3876	0.0147	0.1192
5,6,11,12	0.0122	0.0014	0.0152	0.6593	0.0001	0.3306
Cbn 3 Mean	0.0092	0.0129	0.0036	0 .3950	0.0530	0.1809
5, 6, 11	0.0100	0.0025	0.0050	0.5776	0.0001	0.0976

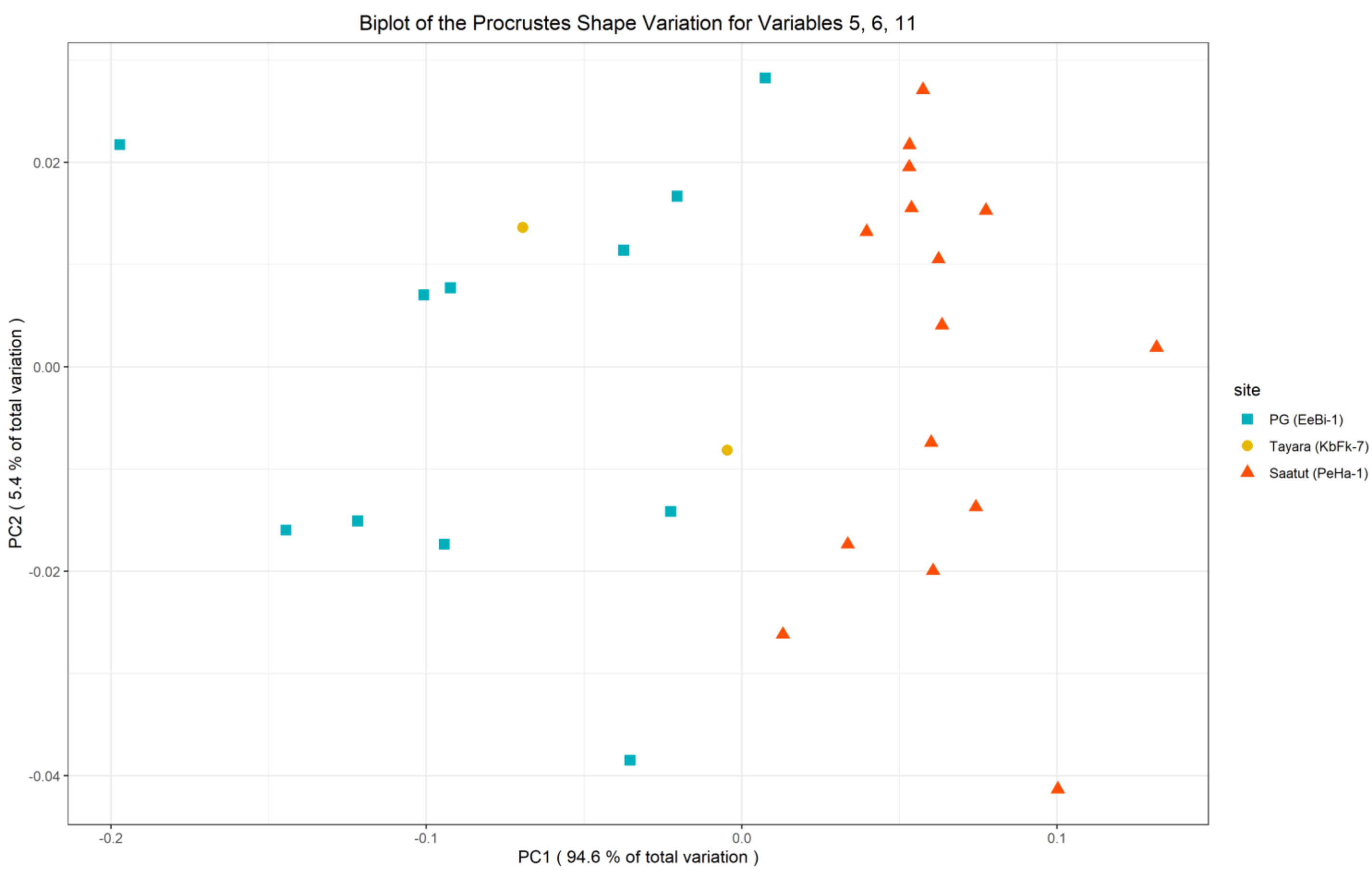


Figure 5.13 PCA Biplot for 5, 6, 11

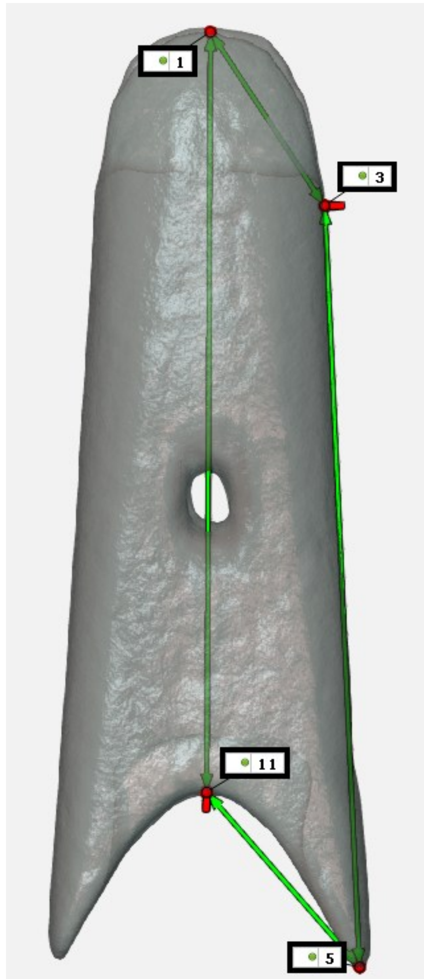


Figure 5.14 Landmarks 1, 3, 5, 11 (Contour)

Table 5.8a Intrasite Pairwise Procrustes Variance by Site (Internal Variability)

Table 5.8b ANOVA Site Pairwise P-Values for PG (EeBi-1), Tayara (KbFk-7), and Saatut (PeHa-1).

	a **PG (EeBi-1)**	**Tayara (EeBi-1)**	**Saatut (EeBi-1)**	b **PG:Tayara (p-values)**	**PG:Saatut (p-values)**	**Saatut:Tayara (p-values)**
Cbn 4 Mean	0.0111	0.0152	0.0042	0.3876	0.0147	0.1192
1, 3, 5, 11	0.0034	0.0030	0.0016	0.4526	0.0001	0.0909
Cbn 3 Mean	0.0092	0.0129	0.0036	0.3950	0.0530	0.1809
3, 5, 11	0.0051	0.0057	0.0021	0.0267	0.0001	0.1178

5.2.6 Contour Shape

Though not a traditional attribute, the contour shape has always been of interest but has been difficult to qualitatively assess. It can be evaluated using both 1, 3, 5, 11 and simply 3, 5, 11 (Figure 5.14), the latter having nearly double the sample size. Both biplots (Figures 5.15, 5.16) display distinguishable clusters for Saatut and PG. Site pairwise indicates that PG and Tayara, and Tayara and Saatut show no significant difference while PG and Saatut continue to differ significantly (Table 5.8b). By removing landmark 1, the site pairwise shows an increase in differences between Tayara and PG. The cause is observable in the biplot as two arrow-shaped specimens (KbFk-7:1, 4) from Tayara are added (Figure 5.14). These distinguish themselves completely from the smaller and parallelized Tayara Kingait closed (KbFk-7:3), which is nestled among PG and Saatut specimens. Internal variability is revealed to be lower than the mean for all sites (Table 5.8a).

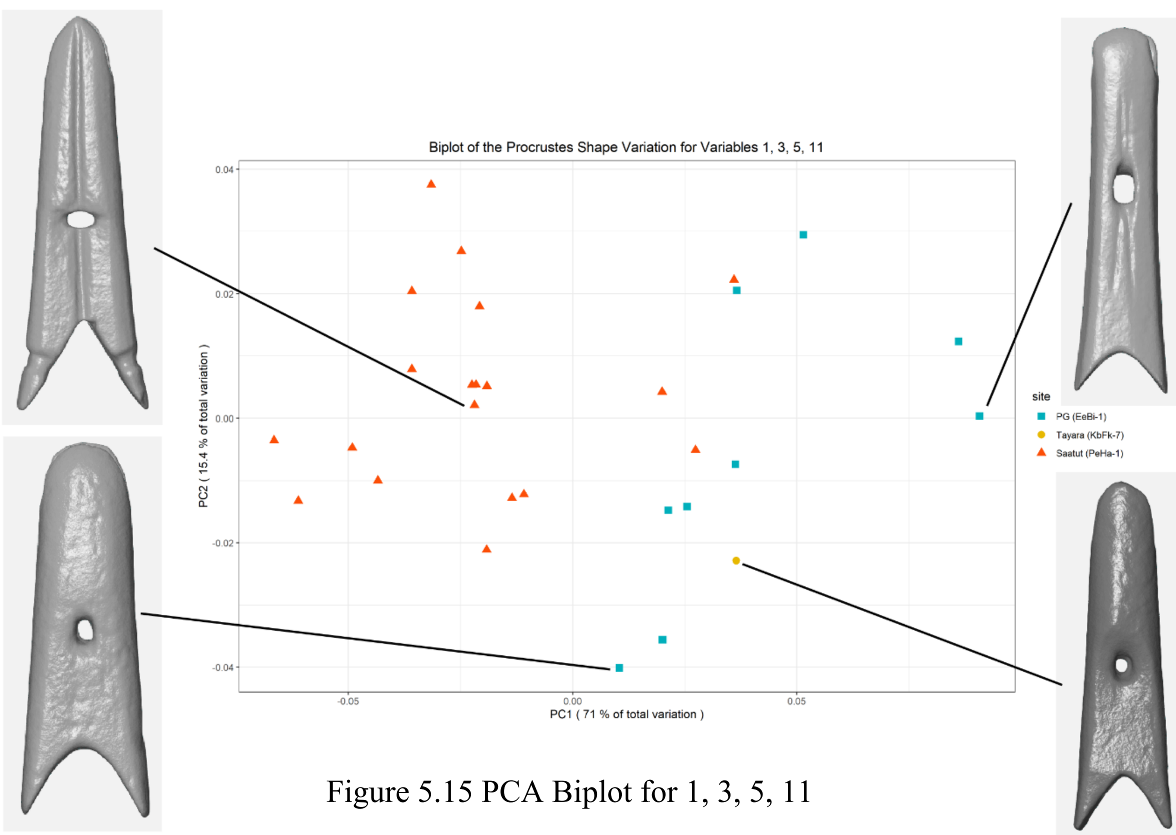


Figure 5.15 PCA Biplot for 1, 3, 5, 11

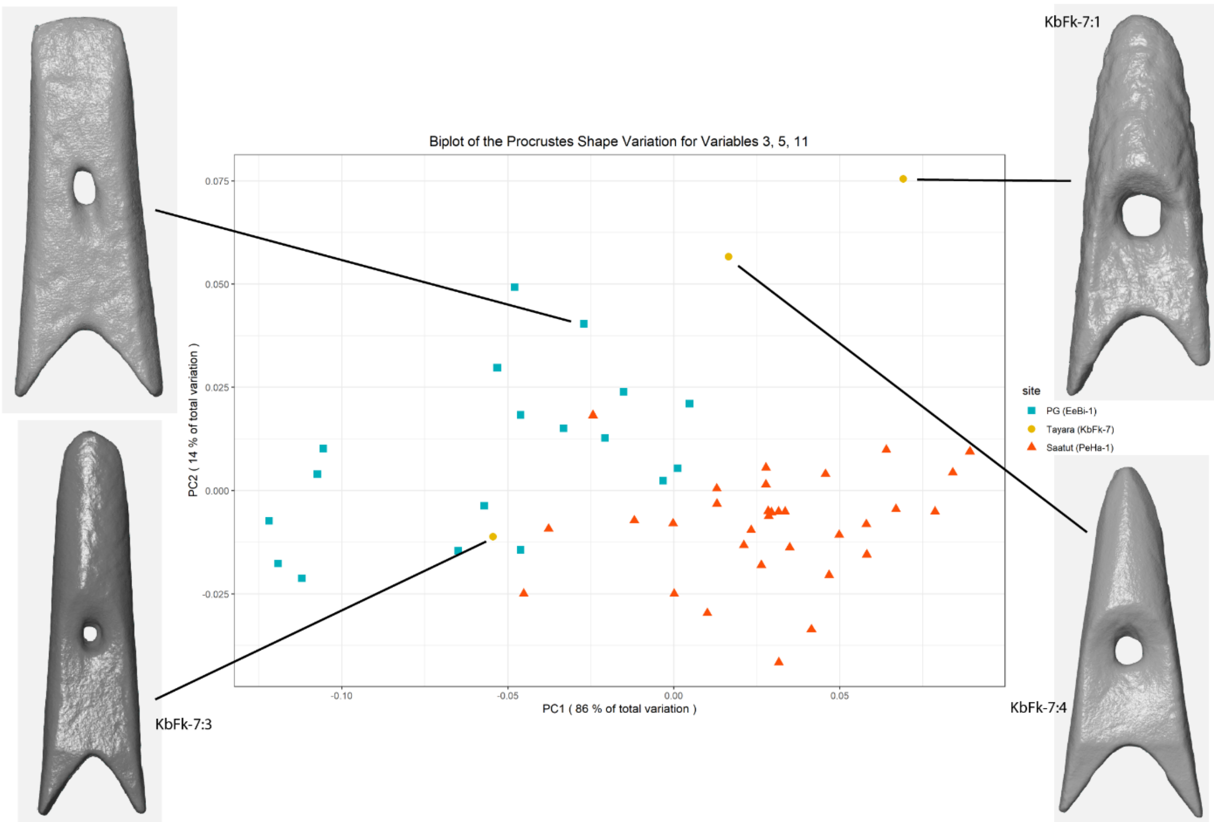


Figure 5.16 PCA Biplot for 3, 5, 11

5.2.7 New Attributes

A new set of landmark combinations were chosen to represent overall shape (Table 5.9, Figures 5.17-20), or more precisely the space between attributes, to capture what typologies have never been able to systematically define or assess. These combinations are not objective but rather subjective, based on my idea of how overall shape can be represented using the network of landmarks initially adapted to take advantage of incomplete specimens. Nonetheless, the combination of both sets of attributes provides a more complete picture than either would independently. It also provides the opportunity to evaluate how traditional attributes fare against attributes representing overall shape.

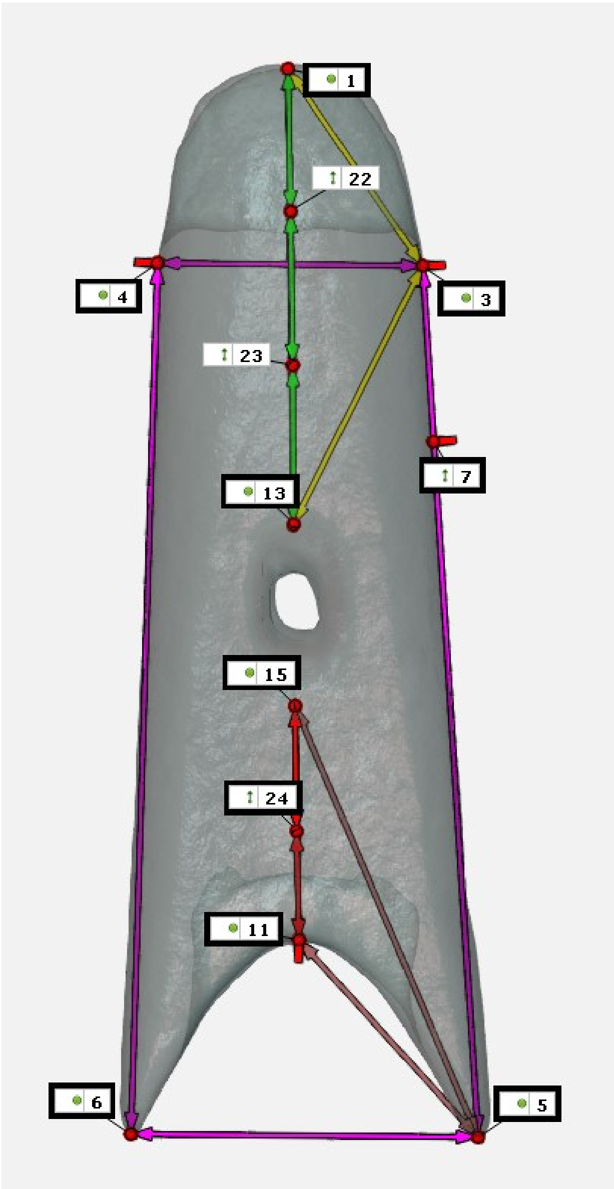


Figure 5.17 Sample of Landmark Combinations Used in New Attributes (Dorsal View)

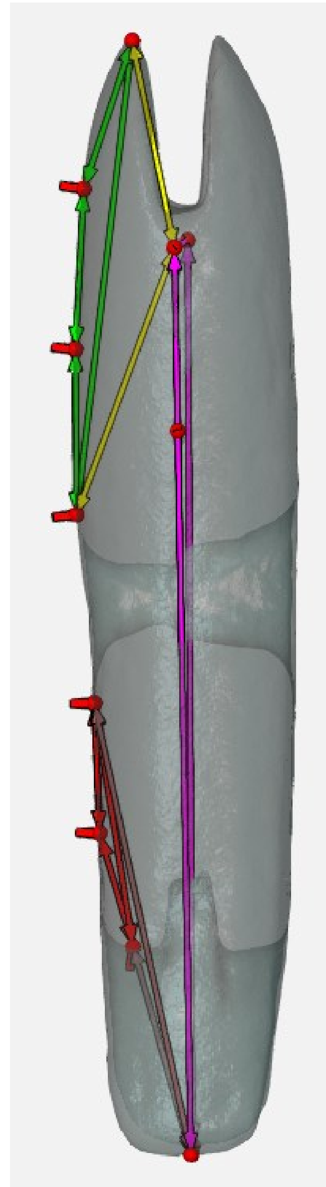
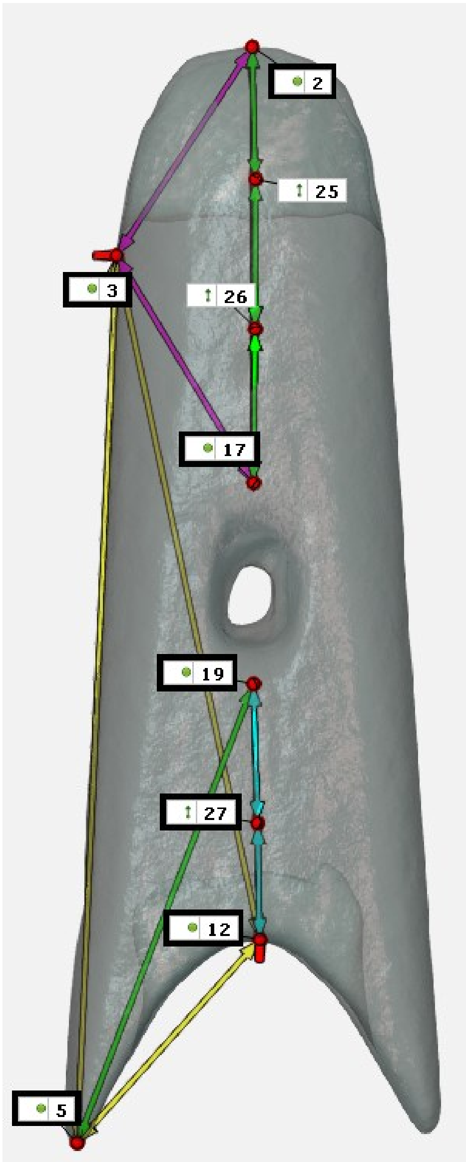


Figure 5.18 Sample of Landmark Combinations Used in New Attributes (Profile)

1, 13, 22, 23	**2, 17, 25, 26**	**3, 5, 12**
1, 3, 13	**2, 3, 17**	**3, 5, 7, 8, 9, 10**
11, 15, 24	**2, 3, 5, 12**	**5, 11, 15**
12, 19, 27	**3, 4, 5, 6**	**5, 12, 19**
7, 28, 29, 30	**1, 3, 5, 11**	**3, 5, 11**

Table 5.9 Landmark Combinations Representing New Attributes



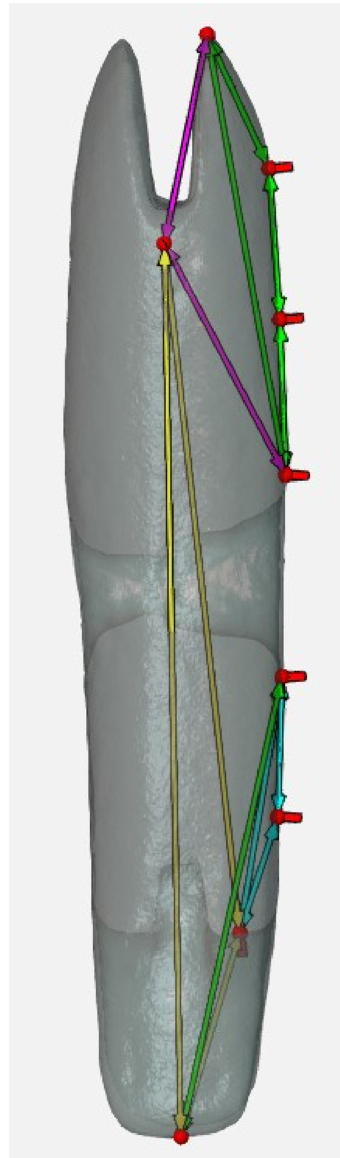


Figure 5.19 Sample of Landmark Combinations Used in New Attributes (Ventral View)

Figure 5.20 Sample of Landmark Combinations Used in New Attributes (Profile)

The Procrustes variance, or internal variability, for each attribute in addition to the means for combinations of 3 and 4 reveal that attributes for overall shape have noticeably higher internal consistency, or less variability (Table 5.10). Additionally, they have lower values of variability than the mean. Conversely, traditional attributes display more variability than the new attributes and their values are also either consistent or higher than the mean values.

Table 5.10 Procrustes Variance of Traditional Attributes (White) vs New Attributes (Green) for PG (EeBi-1), Tayara (KbFk-7), and Saatut (PeHa-1).

Landmarks	Tayara
1, 13, 22, 23	0.00001
3, 5, 7, 8, 9, 10	0.00006
2, 17, 25, 26	0.00014
17, 18, 19, 20	0.00067
11, 15, 24	0.00168
5, 6, 11	0.00255
1, 3, 5, 11	0.00300
3, 4, 5, 6	0.00300
3, 5, 11	0.00568
12, 19, 27	0.00587
5, 11, 15	0.00604
3, 5, 12	0.00793
11, 12, 31	0.00884
2, 3, 5, 12	0.01198
Mean Cbn 3	0.01291
1, 2, 3, 4	0.01421
Mean Cbn 4	0.01516
5, 12, 19	0.01640
1, 3, 13	0.01782
7, 28, 29, 30	0.05053
13, 14, 15, 16	0.05812
2, 3, 17	0.06842

Landmarks	PG
3, 5, 7, 8, 9, 10	0.00010
12, 19, 27	0.00065
1, 13, 22, 23	0.00102
2, 17, 25, 26	0.00157
3, 4, 5, 6	0.00231
11, 15, 24	0.00304
2, 3, 5, 12	0.00305
1, 3, 5, 11	0.00343
3, 5, 12	0.00447
3, 5, 11	0.00509
11, 12, 31	0.00726
Mean Cbn 3	0.00916
17, 18, 19, 20	0.00999
5, 6, 11	0.01001
Mean Cbn 4	0.01106
7, 28, 29, 30	0.01114
2, 3, 17	0.01256
1, 2, 3, 4	0.01311
5, 11, 15	0.01323
5, 12, 19	0.01326
1, 3, 13	0.02084
13, 14, 15, 16	0.11344

Landmarks	Saatut
3, 5, 7, 8, 9, 10	0.00003
2, 17, 25, 26	0.00016
1, 13, 22, 23	0.00019
12, 19, 27	0.00042
11, 15, 24	0.00049
3, 4, 5, 6	0.00083
1, 3, 5, 11	0.00162
2, 3, 5, 12	0.00170
3, 5, 11	0.00210
1, 3, 13	0.00272
3, 5, 12	0.00306
2, 3, 17	0.00358
Mean Cbn 3	0.00359
1, 2, 3, 4	0.00369
Mean Cbn 4	0.00422
5, 11, 15	0.00482
5, 6, 11	0.00496
7, 28, 29, 30	0.00569
17, 18, 19, 20	0.00608
5, 12, 19	0.00826
11, 12, 31	0.01725
13, 14, 15, 16	0.02711

Site pairwise results (Table 5.11) were assessed for the new and old attributes and indicate that neither provides special explanatory power when evaluating the similarities or differences between sites. Furthermore, the proportions of attribute pairwise p-values indicating difference/no difference mostly follow the overall proportions found for all combinations of 3 and 4. The Saatut:Tayara values for each attribute, however, do not reflect the global results.

Landmarks	PG:Tayara	PG:Saatut	Saatut:Tayara
13, 14, 15, 16	0.057194281	1.00E-04	0.02339766
17, 18, 19, 20	0.178282172	1.00E-04	0.99390061
11, 12, 31	0.902209779	1.00E-04	0.00839916
5, 6, 11	0.577642236	1.00E-04	0.097590241
3, 5, 11	0.02669733	1.00E-04	0.117788221
1, 3, 13	0.325367463	0.00049995	0.080191981
1, 13, 22, 23	0.133786621	1.00E-04	0.855014499
2, 3, 17	0.052894711	0.00819918	0.00439956
3, 5, 12	0.228077192	1.00E-04	0.138586141
2, 3, 17	0.052894711	0.00819918	0.00439956
2, 17, 25, 26	0.087391261	1.00E-04	0.208479152
3, 5, 7, 8, 9, 10	0.348665133	0.060893911	0.142185781
5, 12, 19	0.464053595	1.00E-04	0.191080892
7, 28, 29, 30	0.02319768	1.00E-04	1.00E-04
11, 15, 24	0.871912809	0.00719928	0.077192281
12, 19, 27	0.03349665	0.945805419	0.03449655
5, 11, 15	0.438056194	0.01939806	0.457054295
1, 3, 5, 11	0.452554745	1.00E-04	0.090890911
2, 3, 5, 12	0.02969703	1.00E-04	1.00E-04
3, 4, 5, 6	0.435456454	0.00219978	0.736726327

Table 5.11 ANOVA Site Pairwise P-Values for Traditional (Red) and New (Green) Attributes (P-values > 0.05 (Yellow), p-values < 0.05 (Blue), 1.00E -04 = 0.00009999, or significant difference)

5.2.8 Attribute Discussion

Typological work serves a purpose: it helps distinguish material culture based on attribute presence or absence. It also serves a purpose for geometric morphometrics as it helps identify specimens with the highest amount of homology: specimens with the same identifiable and thus comparable parts. In previously comparing the most commonly used typology, created by Maxwell (1985), to the most comprehensive but generally unavailable typology, Meldgaard's (n.d), it was determined that including more material from a wide range of spatiotemporal contexts resulted in a heavy sacrifice to local contemporaneous variability and temporal morphological developments. The more such material is included, the more the typologist finds the need to use broader definitions to include that material. Meldgaard's use of more spatially constrained material allowed him to assess what Maxwell could not: local contemporaneous diversity and temporally sensitive changes in style and morphology within larger type-families. Geometrics morphometrics can bridge the gap between the two by providing useful and meaningful statistical and visual outputs in the assessment of shape relationships for a wide range of material and contexts. As a result, typological work is a means to an end, but it cannot be the end, as it constitutes only a preliminary means of assessing homology.

The internal variability results reveal that typologists, in recognizing the most homologous elements of the harpoon head, also recognized those elements which differ the most in shape. It is hard to determine if it is coincidental or purposeful, but it is more likely a question of what they could conceptually identify and communicate effectively. The attributes used by typologists were the easiest vehicle they could use to explain differences, since complex shapes cannot be qualified or quantified easily. However, variability within specific attributes has only been broadly used, if at all, by typologists. Meldgaard made use of variability within attributes as it effects the variability of the whole harpoon head, however, Maxwell did not. Maxwell's attributes were static, they did not change other than through their various combinations to define very broad harpoon head types. Conversely, the descriptive typologists were able to address differences within attributes, sometimes simply through describing specific specimens, but with a complete lack of standardization for describing specific differences and changes in attribute shape in space and time. Thus, while the old attributes were the inevitable shapes and features captured by typologists, the lack of ability or willingness to differentiate the shapes of these attributes does not properly communicate variability with which they were faced. As such, attributes were likely chosen as focal points because they could easily be communicated and not because these attributes necessarily captured the most variability amongst themselves. In fact, Meldgaard is the only scholar to have worked on Dorset harpoon heads to be exempt, as he was able to perceive, analyze, and visually communicate what others have not.

This forces us to delve further into the actual processes of designing, engineering, and manufacturing that can only be touched upon theoretically here. These traditional attributes, the focal points which led to determining how specimens are homologous, do indeed appear to be the most complex elements of the harpoon head, and perhaps such complexity correlates with increased variability. However, to the Dorset individual, was it easier to carve the space between attributes than the attributes themselves? Do they conceptually understand it as 'putting' the attributes on a properly shaped blank? Are there parts of the harpoon head which individuals used specifically for self-determination? How is functionality balanced with design and manufacturing decisions that do not concern functionality? Can the different parts of the harpoon head be separated from the whole? How were the parts of the harpoon heads emically understood? More questions arise from these results than answers, however, they do indicate that some process in designing, engineering, and manufacturing has led to the overall shape being more consistent within the same space and time than those features traditionally defined as attributes. It is nonetheless fair to conclude that typologists have managed to identify elements of harpoon heads which are simultaneously the most homologous and the most variable, whether they fully grasp it or make use of the observed variability within attributes or not.

In investigating known and recognizable attributes used to define the Kingait Closed using geometric morphometrics, it was possible to evaluate their respective morphology statistically in a way Meldgaard could only do qualitatively and relatively using simple metric measurements and a keen eye for differences. Simple PCA biplots of Procrustes shape variables allows for a new kind of visual representation backed by the mathematical advances of the 20th century using 21st century computing and 3D technologies. It is also capable of representing a greater number of specimens simultaneously, while still visually presenting individual specimens of interest as is typical of typologies. While the reasons for choosing specific specimens for display in the past was never fully explained, it can be assumed that those displayed are either the most complete, best represent the morphological range within a given context, or best represent the attribute states the analyst considered significant. However, in these cases the relative abundance of identified forms, that is within defined types and not between types, is never quantified. Using biplots, it is possible to identify specimens of statistical interest, whether it be outliers or specimens representing clusters, sites, features or any other metadata, while conserving their statistically defined visual relationships which relay their relative abundance.

Pairwise analysis of mean Procrustes distances uses whatever metadata or contextual data are available for absolute relationships to be calculated. At the site level it determines whether each group presents no difference or difference using p-values. While p-values are often considered binary in their interpretation, anything above 0.05 showing no difference while anything below is determined to be different, they can also be ranked. Within the results sometimes PG has a larger p-value in association with Tayara than Saatut does with Tayara while both are above the 0.05 threshold. This allows for interpretation beyond the binary as it indicates the *degree* to which they are similar. Feature/level pairwise analysis could inform on relationships at a smaller scale. In combination with site pairwise, it would show how differences between certain features can influence site-wide pairwise differences.

Using these statistical and visual outputs, it is possible to evaluate each typological attribute beyond their simple presence. This assessment reveals that the parts may divulge just as much as, if not more than, their sum. At one scale, the proximal and distal halves of the dorsal line hole revealed differing relationships. At another scale, an attribute such as the endblade slot shows Tayara to have a closer relationship with Saatut, while Tayara has a closer relationship with PG for the dorsal line hole. Most importantly, while the different parts of the harpoon head may reveal new and different information than the whole, the parts which we are used for assessing attributes are not necessarily the most revealing, the most important, or represent the best emic subdivisions of the object. It shows that traditional knowledge is not a single 'package' of morphological identities transmitted within the same group consistently and continuously as one would assume, based on the distinctiveness discerned from analysis of the whole object. Rather, the distinctiveness of the whole is composed of complex combinations of elements, each with complex spatial and temporal relationships between individuals and groups at different scales. At every scale, variability is created by forming, maintaining, and continuously renegotiating identities, each informed by and further informing dynamic ontologies, while contributing to and perpetuating the ontological entity of the harpoon head which we study in material form. As such, there is not only value in subdividing shape for the analysis of geometric morphometrics, whether it be the attributes we are used to or random combinations of shape variables, but there is also value in broken and deteriorated artifacts from which we can extract information pertaining to the complex ontologies, relationships, and life-histories which led to their being.

5.3 Traditional Design Parameters

In inspecting the various results from both sets of attributes, a few combinations stood out from the rest as having peculiar relationships. These had a mix of low internal variability, visually indistinguishable sites in the biplots, and have very little to no statistical difference. Six such combinations were identified, with more likely to be hidden within the numerous, but finite, possible combinations of landmarks.

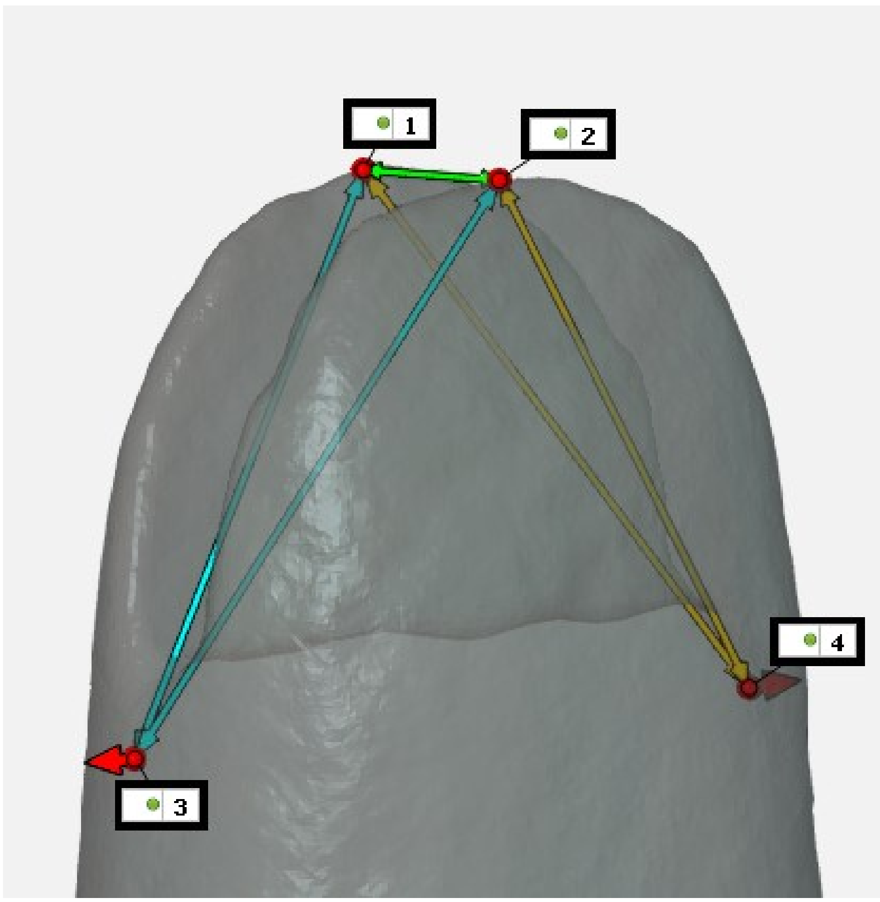


Figure 5.21 Landmarks 1, 2, 3 and 1, 2, 4

5.3.1 Distal Parameter 1, 2, 3 and 1, 2, 4

One such combination was found while inspecting the blade slot and its various combinations (Figure 5.21). The first clue was ANOVA testing which identified no differences between the three sites for landmarks 1, 2, 4, and 1, 2, 3. These points consist of the two distal prong tips and one point indicating the proximal carving limit of the blade slot. Thus, these combinations address the space between the two tips with the third point to turn it from a segment to a two-dimensional shape. Looking deeper with pairwise analyses, Tayara constitutes the only driver towards there being differences between sites (Table 5.12b). This is uncommon, as usually the greater differences were found between PG and Tayara. An inspection of the biplot (Figure 5.22) shows PG and Saatut intermingled within the same cluster with Tayara's small and parallelized Kingait closed specimen appearing as a slight outlier. In this case the sample size of one did not help its case, as we see certain minor outliers for both PG and Saatut, and this one specimen may have constituted an extreme had there been a larger sample to show the nature of variability at Tayara. The close relationship between PG and Saatut was the key point of interest. Finally, the internal variability for each site was inspected and revealed great internal consistency at both PG and Saatut in comparison to the other landmark combinations evaluated for the blade slot (Table 5.12a).

Table 5.12a Intrasite Pairwise Procrustes Variance by Site (Internal Variability)

Table 5.12b ANOVA Site Pairwise P-Values for PG (EeBi-1), Tayara (KbFk-7), and Saatut (PeHa-

	a **PG (EeBi-1)**	**Tayara (EeBi-1)**	**Saatut (EeBi-1)**	b **PG:Tayara (p-values)**	**PG:Saatut (p-values)**	**Saatut:Tayara (p-values)**
Cbn 4 Mean	0.0111	0.0152	0.0042	0.3876	0.0147	0.1192
1, 2, 3, 4	0.0131	0.0142	0.0037	0.0067	0.0002	0.0968
Cbn 3 Mean	0.0092	0.0129	0.0036	0.3950	0.0530	0.1809
1, 2, 3	0.0016	0.0077	0.0012	0.0444	0.4429	0.0053
1, 2, 4	0.0008	0.0054	0.0014	0.0598	0.9982	0.0435

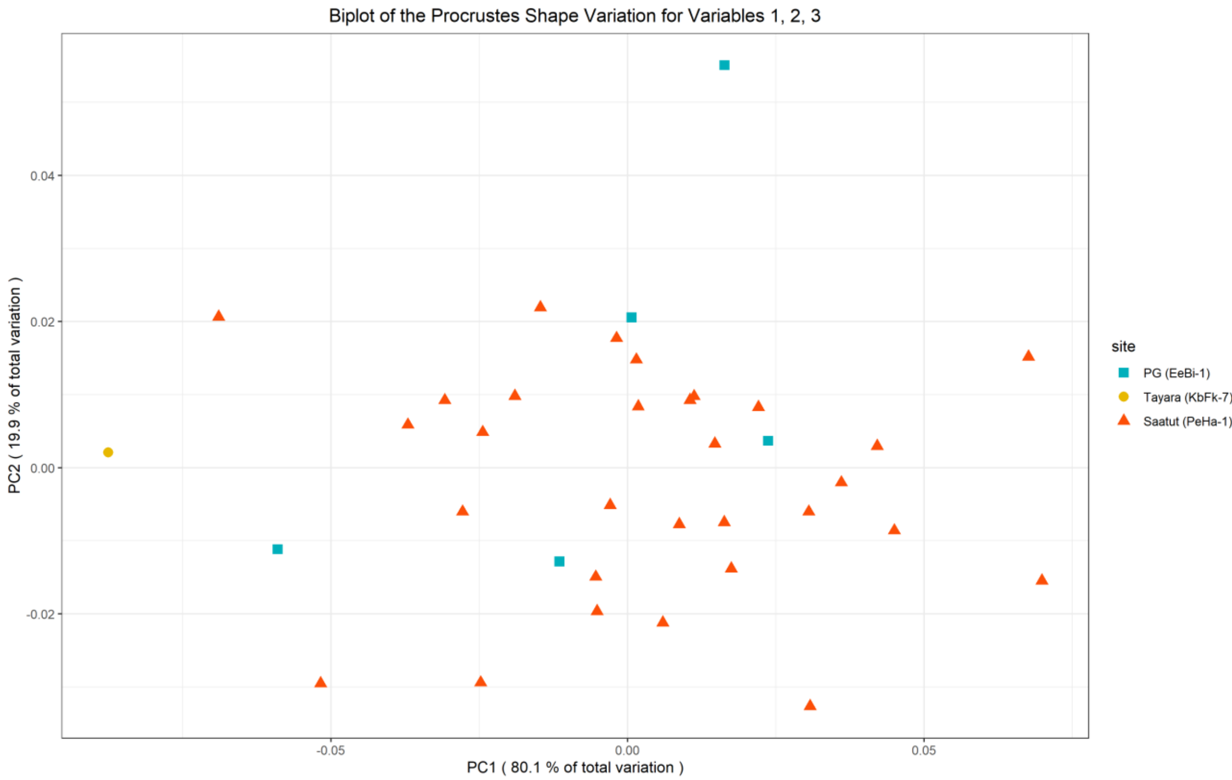


Figure 5.22 PCA Biplot for 1, 2, 3

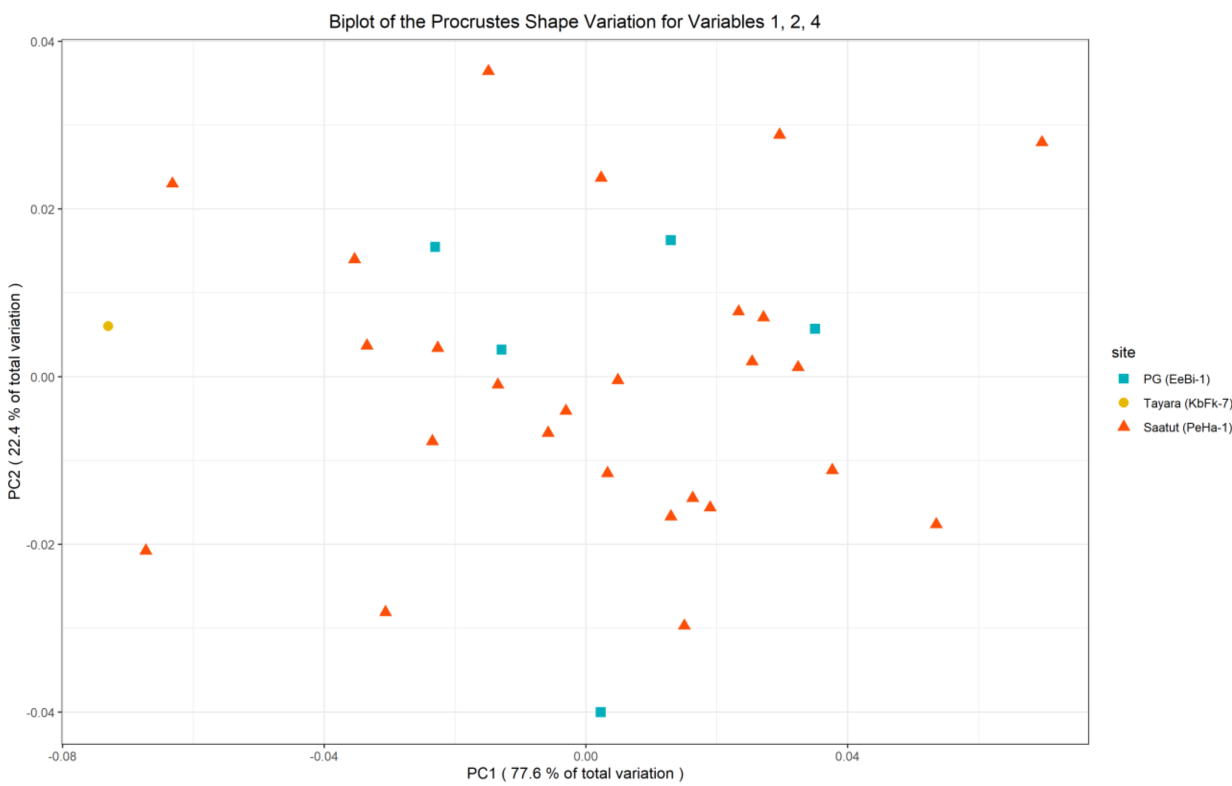


Figure 5.23 PCA Biplot for 1, 2, 4

The consistency in shape and distance involving the two distal prong tips is likely due to its interfacing nature with an external element: the lithic endblade. The need for co-standardization with the endblade is essential for such a modular design to function, and for the two elements to be interchangeable. Indeed, that is one of the most apparent technological advantages of the endblade slotted harpoon heads; endblades can be swapped should they be damaged or break free while their self-bladed counterparts would require reshaping to regain functionality, if even possible. For two sites which normally display differences to have made efforts towards standardization, which is reflected both at the intrasite and intersite scales, supports the idea that the same traditional knowledge was present in both loci of local knowledge, thus potentially constituting a culture-wide parameter for Kingait Closed harpoon head design and manufacture beyond attribute combination. It is also worth keeping in mind that PG and Saatut are both contemporaneous and 2700 km apart, implying either strong information networks or a rapid migration, but more likely the former: cultural transmission systems that maintained similarly important knowledge about harpoon head and endblade modular designs across substantial distances.

5.3.2 Proximal Parameters 12, 19, 27 and 11, 16, 24

Most identified parameters for the Kingait Closed appear at the proximal half of the harpoon head. 12, 19, 27 (Figure 5.25) and 11, 15, 24 (Figure 5.24) are landmark combinations that constitute the shape between the fork, the proximal carving limit for the line hole, and the landmark placed at the 50% mark on a surface line connecting the two, on the ventral and dorsal sides, respectively.

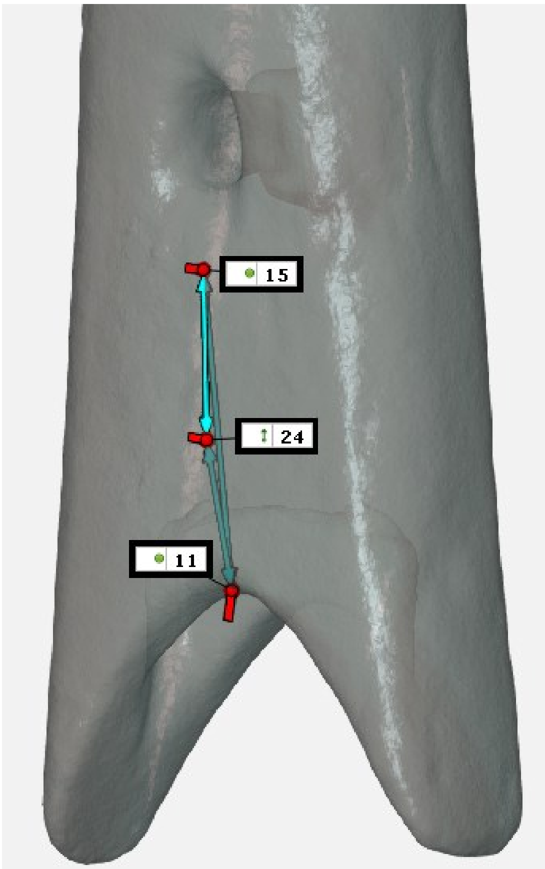


Figure 5.24 Landmarks 11, 15, 24 (Dorsal View)

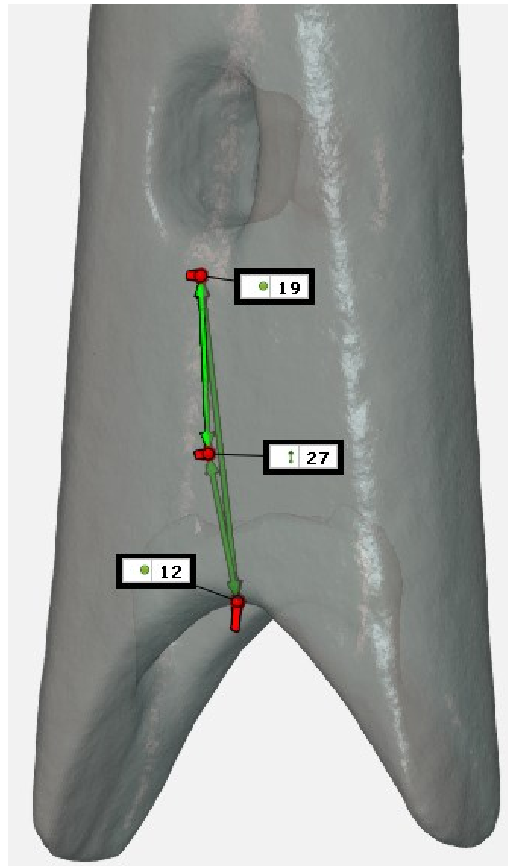


Figure 5.25 Landmarks 12, 19, 27 (Ventral View)

Attribute 12, 19, 27 showed considerably higher internal consistency than most attributes, old and new, for both PG and Saatut (Table 5.10). Additionally, the two sites, which usually differ, show intermixing in the biplot (Figure 5.26) and no difference whatsoever in the pairwise analysis (Table 5.13b). Internal variability reveals this combination to be considerably lower than the mean for combinations of 3 (Table 5.13a). Tayara's single specimen in the sample of this landmark combination is considerably different from the two other sites, as seen from both the biplot and the site pairwise analysis. Tayara's specimen was identified as one of the arrow-shaped Kingait Closed specimens, which, upon close inspection, differs for one obvious reason: it has ventral proximal beveling that extends past the spurs and past the fork (Figure 5.26, top left).

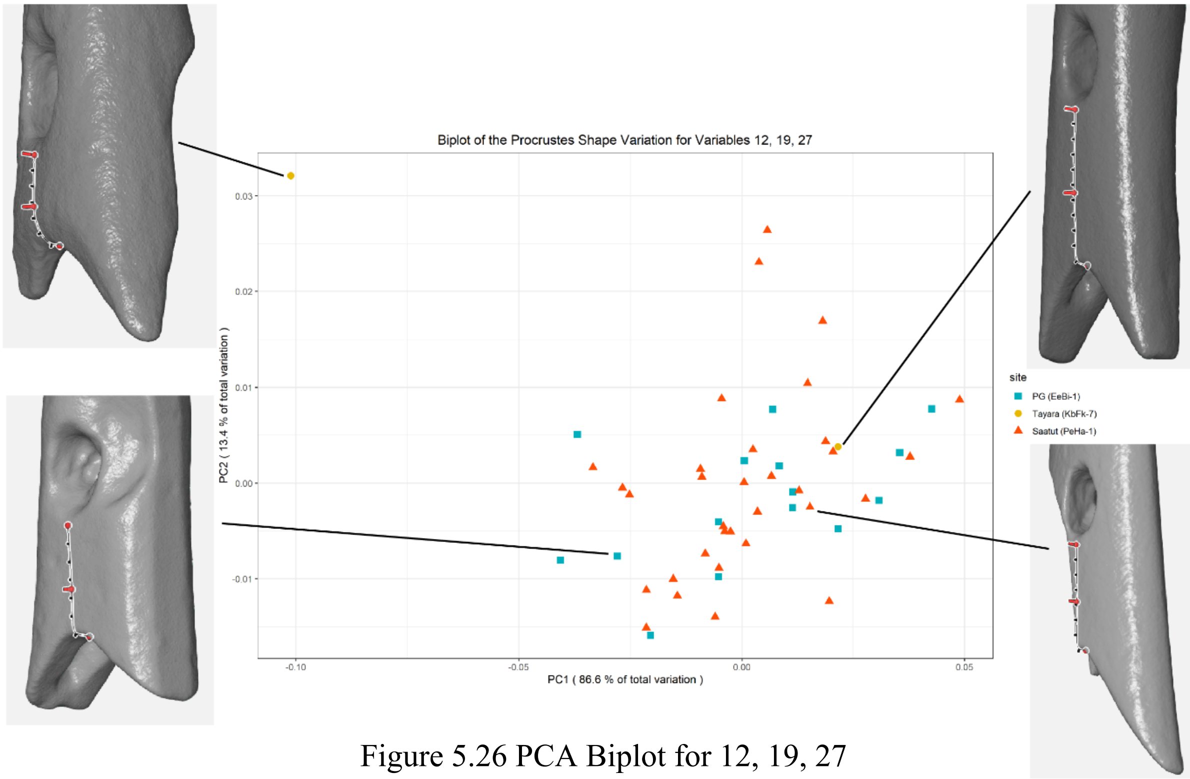


Figure 5.26 PCA Biplot for 12, 19, 27

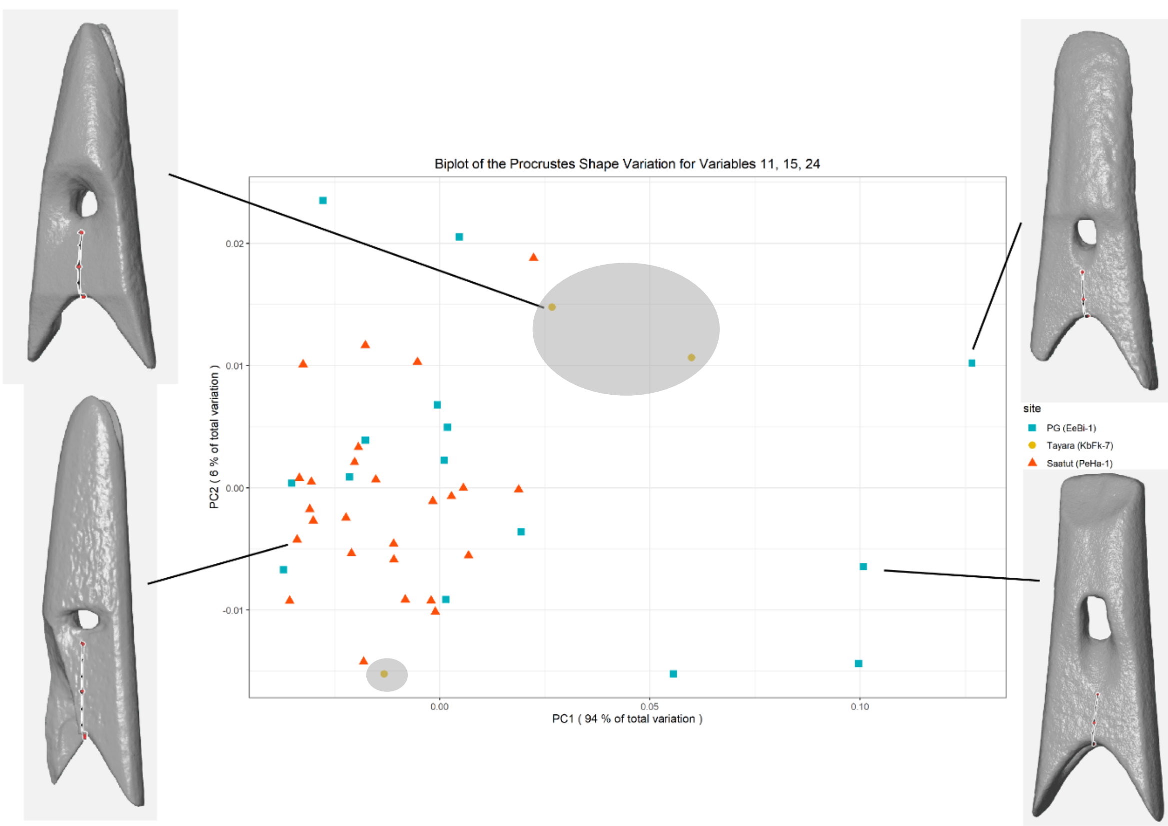


Figure 5.27 PCA Biplot for 11, 15, 24

Table 5.13a Intrasite Pairwise Procrustes Variance by Site (Internal Variability)

Table 5.13b ANOVA Site Pairwise P-Values for PG (EeBi-1), Tayara (KbFk-7), and Saatut (PeHa-1).

	a **PG (EeBi-1)**	**Tayara (KbFk-7)**	**Saatut (PeHa-1)**	b **PG:Tayara (p-values)**	**PG:Saatut (p-values)**	**Saatut:Tayara (p-values)**
Cbn 3 Mean	0.0092	0.0129	0.0036	0.3950	0.0530	0.1809
11, 15, 24	0.0030	0.0017	0.0005	0.8719	0.0072	0.0772
12, 19, 27	0.0007	0.0059	0.0004	0.0335	0.9458	0.0345

Landmarks 11, 15, and 24 tell a similar but more complex story. Here the site pairwise reveals that both PG and Saatut have a close shape relationship with Tayara, but again PG and Saatut show substantial differences (Table 5.13b). The biplot reveals that a good part of PG's specimens cluster indiscriminately with Saatut while several more show up as outliers (Figure 5.27, specimens on right). Overall, internal variability for each site is much lower than their respective means for combinations of 3 (Table 5.13a). An examination of those PG specimens which do not cluster with the rest reveals that each have a proximally lower carving limit, one that also tends to slightly veer sideways instead of staying central. While the proximal carving limit was the identifiable locus used to place landmarks, it does not necessarily mean that the relationship between the fork and the line hole differ from the rest. Rather, it is likely that the same technical traditions are being adhered to, but with a stylistic twist explained by a unique demonstration of self-determination.

The arrow-shaped and parallelized Tayara Kingait Closed specimens yet again reveal a familiar pattern. The parallelized specimen is featured on the edge of the large PG/Saatut cluster and thus has a closer relationship with them (Figure 5.27, highlighted in grey at bottom), while the arrow-like specimens cluster together (highlighted in grey at top); the latter are distinguishable from the parallelized specimen as well as from the larger PG/Saatut cluster.

Inspecting the specimens directly does not yield an obvious explanation the way it did for these same points on the ventral side. However, the biplot for landmarks 11, 15, and 25 reveals a similar relationship between the arrow-shaped specimens and Saatut to the biplot for the dorsal line hole (Figure 5.5, landmarks 13, 14, 15, 16). Thus, it is likely that landmark 15 has a great influence on the outcome of this combination's relationships. Unlike the outlying PG specimens, the reason for their observed relationship with the rest of the sample and the parallelized Kingait Closed reflects technical knowledge that is different than that of other Tayara Kingait closed specimens. Overall, it appears that the relationship between the proximal end of the line holes, both dorsal and ventral, and the fork appears consistent for most Kingait Closed specimens.

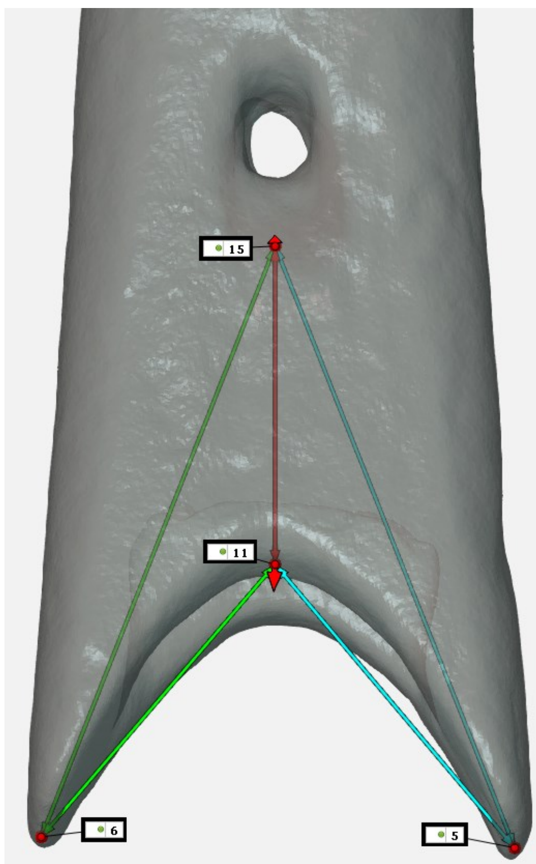


Figure 5.28 Landmarks 5, 11, 15 and 6, 11, 15

5.3.3 Proximal Parameter: 5, 11, 15 and 6, 11, 15

The relationship between the spur, the fork, and the dorsal proximal carving also shows intersite consistency (Figure 5.28). The 5, 11, 15 biplot (Figure 5.29) reveals that a good portion of PG's specimens cluster with Saatut, while all the outlying specimens have line holes with longer proximal carving limits, including centralized and left-hanging carving limits. However, most of the PG specimens which cluster with Saatut have longer non-central proximal carving limits, thus revealing a much more complex shape relationship that cannot be explained by the proximal line hole. The only visual clue is that in general the outlying specimens have much more angular contours with sharper edges between each face than those in the larger cluster. Additionally, those outlying specimens on the left side of the biplot appear to be slimmer and longer than the rest, while the specimen EeBi-1:13 (Figure 5.29, top right) is angular while retaining the overall shape proportions of those in the cluster. Interestingly, feature/level pairwise analysis reveals no significant difference at all for this combination's dataset, regardless of the minor differences indicated between PG and Saatut at the pairwise site level (Table 5.14b). Thus, while there are internal differences as visually revealed by the biplot, especially for PG, these differences are not statistically significant (Table 5.14a).

Table 5.14a Intrasite Pairwise Procrustes Variance by Site (Internal Variability)

Table 5.14b ANOVA Site Pairwise P-Values for PG (EeBi-1), Tayara (KbFk-), and Saatut (PeHa-

	a PG (EeBi-1)	Tayara (KbFk-7)	Saatut (PeHa-1)	b PG:Tayara p-values	PG:S7aatut p-values	Saatut:Tayara p-values
Cbn 3 Mean	0.0092	0.0129	0.0036	0.3950	0.0530	0.1809
5, 11, 15	0.0132	0.0060	0.0048	0.4381	0.0194	0.4571
6, 11, 15	0.0067	0.0090	0.0045	0.4190	0.0165	0.2592

Comparing landmarks 6, 11, 15 indicates that perhaps the sample is too small to corroborate the results from 5, 11, 15. Moreover, the PG specimens with longer line hole limits somewhat cluster but do so distinguishably apart from those which do not share such longer limits. This includes specimens that previously clustered with Saatut for 5, 11, 15. The idea that the sample is too small to inform more complex shape relationships is supported by the measures of internal variability which more than doubles for 5, 11, 15.

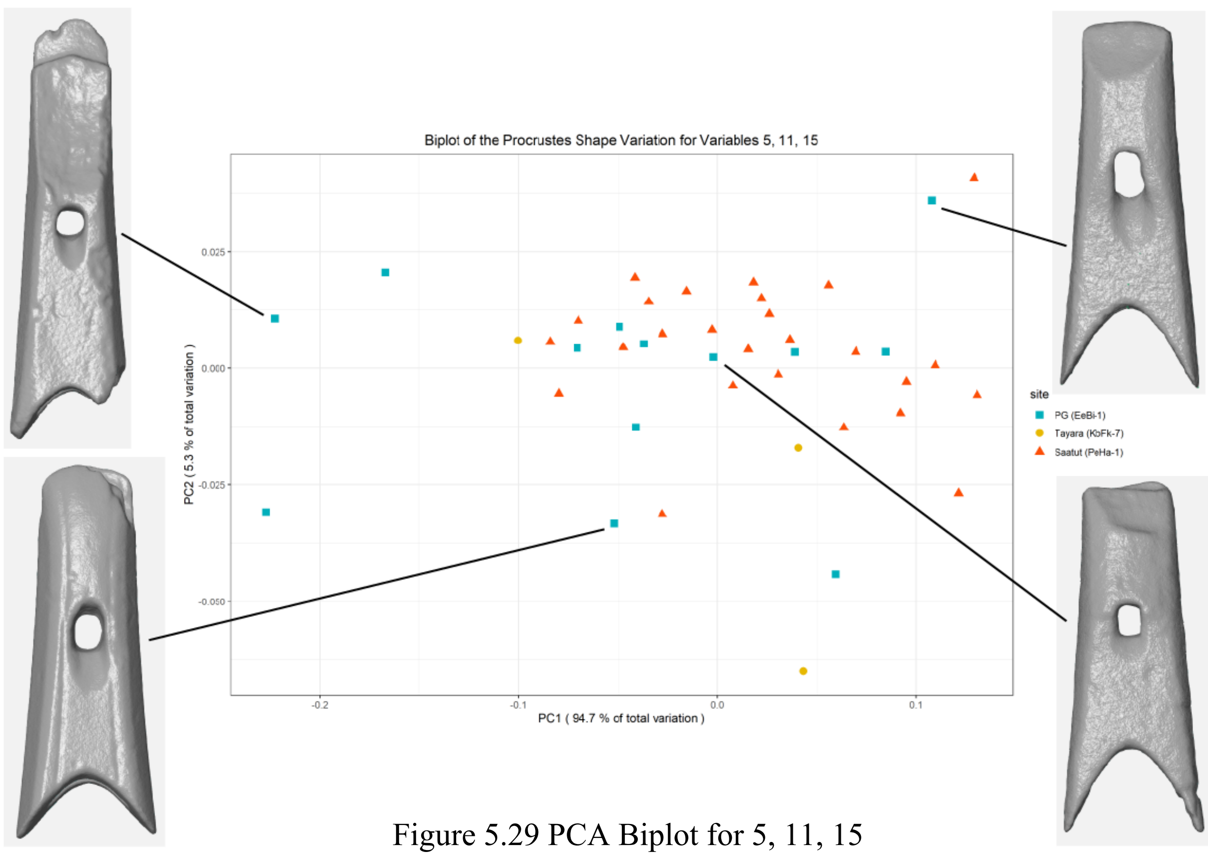


Figure 5.29 PCA Biplot for 5, 11, 15

5.3.4 Posterior Parameters

Finally, there appears to be a close and consistent relationship in the shape encompassing the spur tip, the closed socket carving limit, and the fork (Figure 5.30, 5.31). Thus, this parameter would inform the placement of the socket upon the posterior surface of the harpoon head, how far it extends proximally, and the spatial proportions for all posterior elements. Both 5, 11, 31 and 6, 12, 21 reveal no pairwise difference at the site level (Table 5.15b), only showing differences between Tayara and the two sites while PG and Saatut show no indication of any differences. For all four combinations, internal variability is lower than the mean for PG and slightly above the mean for Saatut (Table 5.15a). All three sites visibly cluster together in the biplots; the 5, 11, 31 biplot is the clearest as it has the largest sample and is thus most representative for all analyses (Figure 5.32).

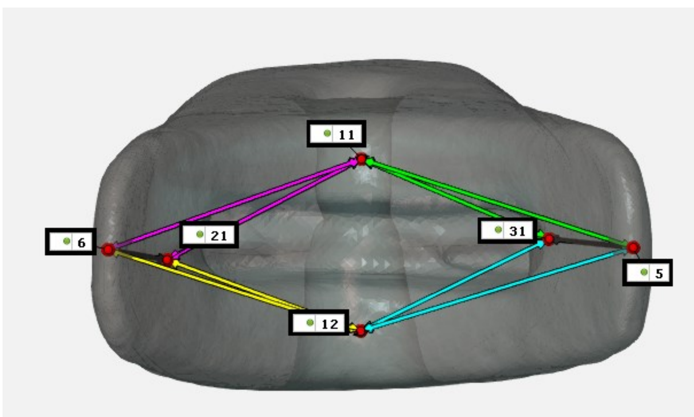


Figure 5.30 Posterior Landmarks

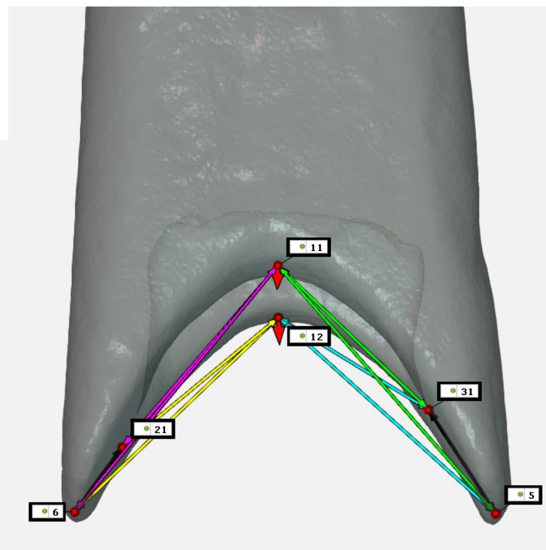


Figure 5.31 Posterior Landmarks (Dorsal View)

Table 5.15a Intrasite Pairwise Procrustes Variance by Site (Internal Variability)

Table 5.15b ANOVA Site Pairwise P-Values for PG (EeBi-1), Tayara (KbFk-7), and Saatut (PeHa-1).

	a PG (EeBi-1)	Tayara (KbFk-7)	Saatut (PeHa-1)	b PG:Tayara p-values	PG:Saatut p-values	Saatut:Tayara p-values
Cbn 3 Mean	0.0092	0.0129	0.0036	0.3950	0.0530	0.1809
5, 11, 31	0.0049	0.0038	0.0042	0.3224	0.0709	0.1126
5, 12, 31	0.0065	0.0158	0.0062	0.0453	0.0361	0.0132
6, 11, 21	0.0072	0.0197	0.0047	0.0270	0.2977	0.0059
6, 12, 21	0.0064	0.0159	0.0036	0.0799	0.3416	0.0610

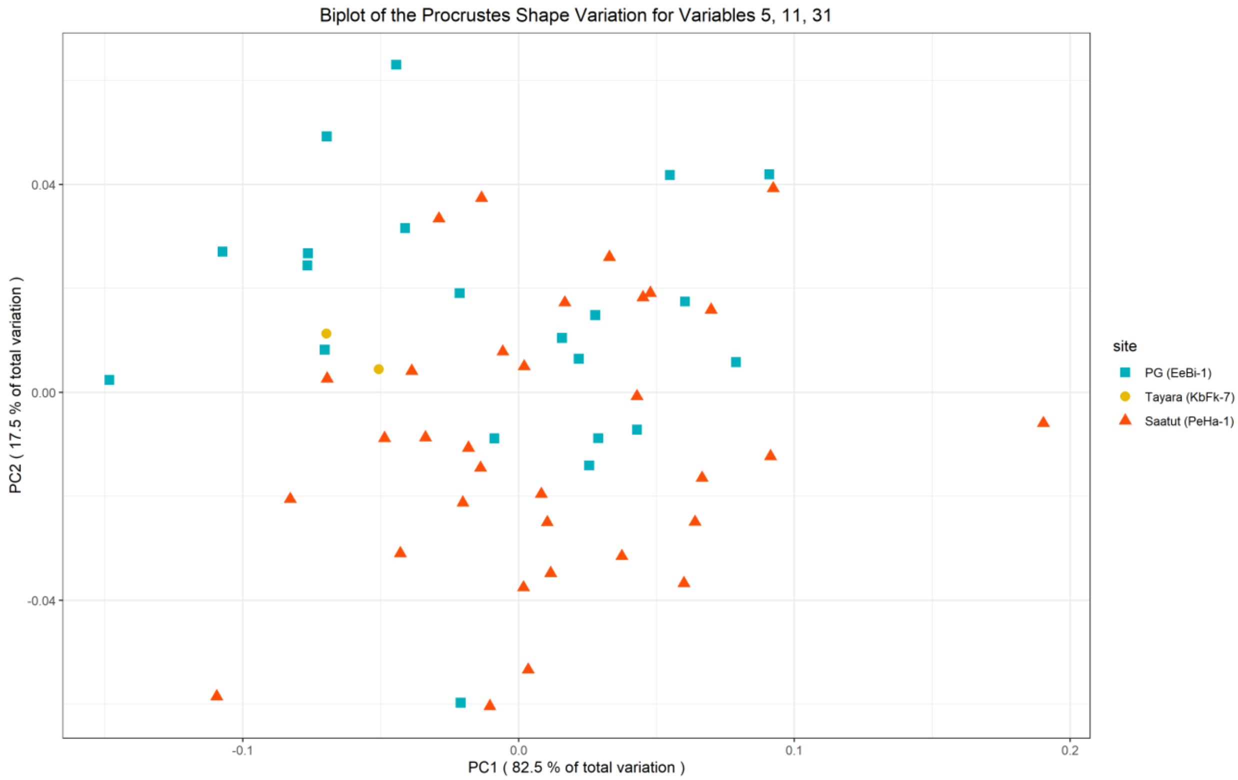


Figure 5.32 PCA Biplot for 5, 11, 31

5.3.5 Traditional Design Parameters Discussion

These landmark combinations, the shapes that together they form, and the parts of the harpoon heads which they represent imply a unique relationship between PG and Saatut when most combinations reveal important and distinguishable differences between the two sites.

Unfortunately, Tayara's ability to inform these special relationships is limited considering the small sample size. However, the inclusion of material from Tayara that was observably distinct at both the qualitative and quantitative level, and was interpreted as resulting from temporal differences, adds a level of insight which PG and Saatut alone could not. With all three sites together, parameters for harpoon head design and manufacture were identified which transcend both space and all possible sources of variability resulting in unique morphological identities. These parameters are present in different loci of local knowledge separated by vast distances and were found to be unaffected by localized variability.

The reason for using this type of harpoon head, the Kingait Closed, was for its narrow range of variability and its close homology (and abundance in our collections). As previously discussed, typological work as we know it is a preliminary step towards finding the greatest homology; it is a simple classification scheme to find specimens which are the most comparable. In so doing, it also identifies spatial and temporal trends which have the possibility of revealing ontological entities, that is living spheres of knowledge, meaning, understandings, or more simply realities, found both within the individuals who perpetuate them but also independently as they transcend their relationships with the humans who created them by accumulating in the archaeological record. The Kingait Closed is one such entity, one whose presence was identified by Maxwell as being universal to Dorset during a certain temporal period. Meldgaard revealed that the Kingait closed entity is but a segment in the extensive life-history of his type-line D, as he found it to also include the Tayara sliced and even older evolutionary forms. Furthermore, he documented this entity's relationships with other type-lines. Thus, it is not only possible to see how certain type-lines appear to have started as experimental types diverging from established ones, as well as using knowledge from other material spheres, but also the continuous relationship between these type-lines throughout their life-histories.

Geometric morphometrics has made it possible to statistically analyze the Kingait Closed period of this entity's life-history, often referred to as the Middle Dorset period (and possibly into the Late Dorset period), to reveal how it is manifested at different spatial scales. What Maxwell started by defining a type both so homologous and so tolerant to variability can be completed for a greater understanding of relationships between people in different places, while

Meldgaard's work provides insight into temporal variability within the period, and insight into relationships prior to this period. While geometric morphometric efforts potentially complete, enhance, and rectify past works, this method's capabilities go far beyond what could have ever been imagined by these pivotal figures in arctic archaeology; geometric morphometrics can access specific knowledge about the design and manufacture of these harpoon heads within the ontological understandings shared by members of the groups who inhabited Saatut, Tayara, and PG.

The consistent nature of the identified landmark combinations suggests that they may be pivotal to the proper functioning of the harpoon head, making it ill advised to deviate from these established technological parameters. Functionality, however, may not be the driving force here as the effects of morphology on functionality remain to be investigated for Dorset harpoon heads. While possible drivers for variability at the individual level have been investigated, it is hard to assess what the drivers for change at larger scales are, and how the larger trends identified by Maxwell are maintained across such a large territory. While calling these combinations 'technical parameters' was my first instinct, considering they are part of design and manufacturing, it is likely a result of my own ontological bias to relegate such things as construction and manufacture to functionality. Perhaps 'traditional design parameters' would serve as a more neutral descriptor for these recognized commonalities, as it could encompass technical and stylistic knowledge, parameters, or trends, but without alienating such aspects as meanings and understandings that belong within Dorset realities.

What is observable from the inclusion of the arrow-shaped Kingait Closed specimens from Tayara is that these parameters are adapted or are created as overall shape changes. The Middle Dorset period may be arbitrarily defined by Maxwell through the loss of proximal dorsal slices, but the earliest such specimens defined as Kingait Closed greatly resemble the latest Tayara Sliced specimens albeit lacking the slice. Meldgaard's work reveals that late Tayara Sliced and early Kingait Closed share an arrow-like contour shape that becomes increasingly straight and parallel and finds stability thenceforth. This sort of observation is not new, as contour shape is qualitatively identifiable, but as previously mentioned it is hard to communicate shape, especially without falling prey to lumping and watertight categories when reality shows much more fluidity. This statistical analysis does indeed show that the arrow-shaped Kingait Closed specimens from Tayara show distinguishable differences which extend to the identified traditional parameters. Whatever the reasons behind the presence of such traditional parameters, their consistency within a sea of noticeable variability highlights their importance. While it is premature to conclude that such parameters appear culture-wide during the Kingait Closed's Middle Dorset phase (and beyond), for which a larger spatial context is warranted, the fact that they were at one of the southern-most and one of the northern-most contemporaneous Dorset sites weighs heavily in favor of this notion.

CHAPTER 6: GENERAL DISCUSSION

6.1 General Discussion

Having applied their works to this project, Meldgaard and Maxwell proved to serve as an effective foundation for future typological work. Together the two provide a unified perspective: Meldgaard explores local variability over time, mapping the evolution of marine mammal hunting technology, and Maxwell shows us that similar implements exist throughout the Dorset range, sharing attributes which constitute types. Maxwell also shows us that there was a consistent change in time throughout this vast space. His approach provides a broad temporal and spatial context, while Meldgaard enables high resolution interpretation in a more restricted context. The two taken together are more useful than each alone, but both have their limitations. As we have observed, the scale of Maxwell's work can only tell broadly if Early, Middle, or Late Dorset inhabited a region according to how the material culture fits within his broad types and temporal categories. It cannot be used for fine-grained temporal analysis, or for comparative work as it does not address – and only fitfully visually communicates – the amount of spatial and temporal variability found within his broad categories. Meldgaard shows us a near-continuous evolution in material culture for a single region from the earliest to the latest Pre-Inuit occupants. His amazing effort showed us the morphological potential and complexities of Pre-Inuit material culture over time, but the typological analysis of the material included in this project shows that while some material fits perfectly in Meldgaard's schemes, some does not. They may be different but still interpretable as equivalent, or they may show different attribute preferences with similar overall morphologies, but indisputable 1:1 comparisons are not always possible. These are the limitations in Meldgaard's typology: while it may be accurate and precise for the Foxe Basin region, it may not be applicable to other regions beyond the broader parameters proposed by Maxwell. The spatial overview provided by Maxwell showed that objects with similar attributes can feature great variability. This project was able to statistically demonstrate the presence of such variability, confirming that different areas occupied by different groups may have followed culture-wide traditional knowledge at one scale but also manifested differences and particularities at another scale.

As this project has sought to show, the morphology of harpoon heads can be captured quantitatively and then be compared statistically to reveal variability both within groups and between groups. While only the latter was addressed in full, variability within groups using smaller scale metadata such as features or excavated units and levels can inform intrasite chronologies and occupation histories. The intersite analysis demonstrated that morphology can be distinct enough to differentiate between sites, that the most complex parts of the harpoon heads are the most variable, and that some traditional knowledge was maintained across these three distant sites while some does not appear to be reinforced in the same way. Because the relationship between the people occupying PG, Saatut, and Tayara remains hidden, the actual relationship between the three sites could only be tentatively addressed. The three sites are comparable on the bases that they hail from the same general archaeological culture, they share comparable material culture, and they belong to the same Middle Dorset period (based on dates and artifact homology). However, comparing these three sites will not truly inform the relationship between them. Geometric morphometrics and principal components analysis work at a relational level; they only compare and display relationships based on the data which is present. As the three sites are several thousand kilometers apart, to truly understand the relationships between them would require data relating to occupations from the vast space between them, especially if a clinal relationship is supported at a wider scale. Much more data is thus required to further evaluate the shape relationships, and in turn the actual relationships, between different groups in different areas throughout time. Only with more data will the full potential of geometric morphometrics be realized.

Geometric morphometrics approach has the ability to offer what Meldgaard achieved at the scale Maxwell addressed; it captures the shape of any implement or tool and then compares it to those most comparable. This method can quantitatively assess shape difference in ways both Meldgaard and Maxwell could only do qualitatively, and in a consistent, standardized, and repeatable manner. The objectivity and scalability unlocked using this methodology has not yet been deployed and analyzed in the arctic literature. Also lacking is comparative work that uses all available culture-wide material, which is understandable considering the size of such a feat. As such, much comparative work is limited to comparing key sites amongst one another or to new material. This results in over-indexing sites which were identified earlier. Using traditional methods for artifact classification, more material often leads to making compromises, which leads the broad approach adopted by Maxwell. Using geometric morphometrics alleviates the weight of having to juggle so much material, of having to identify and classify every difference or similarity, and of having to compromise precision to increase the sample size. Once the landmark placement scheme is developed and the landmarks laboriously placed, all specimens can be analyzed to provide statistically informed relationships, only to be limited the nature of the sample.

Geometric morphometrics, however, is not meant to outright replace typological and classification work. We have already touched upon how previous typological work informs the quantitative method by identifying homologous material, but not how it may inform typological work going forward. Future typological work should partner well with geometric morphometrics;

attributes will still be used to inform homology, but differences within attributes will be assessed using geometric morphometrics. For instance, bifurcated spurs and single spurs will be identified and separated, but the different shapes formed by bifurcated spurs need not be qualitatively assessed and separated into shapes such as ‘U’ or ‘V’. They will simply be ‘bifurcated’, and the geometric morphometric analysis will quantitatively assess differences from ‘U’ to ‘V’. The same could be done for spur beveling. They need not be separated into ‘hooked bevels’ or ‘no bevels,’ but rather the shape of each will be compared quantitatively to inform relationships.

These future efforts will not make use of paper and pen, but rather 3D models, digital databases, and integrated quantitative statistical methodologies. Most important of all, it will be visual. If the assessment of past typological work using harpoon heads in the Eastern Arctic has revealed anything, it is the need for accessible and understandable visual representations of the material and the analyses being performed. This new imagined typology will be mixed, like all typologies analyzed, and should easily accommodate attribute lists and description, but the relationship between the three types of representations will also be different. For instance, an attribute list can still be used to describe a range of morphologies. Selecting a list of attributes within a database would give visual access to all specimens which it describes. The homology defined by the attribute list can then be used for the statistical comparison of the specimens, which in turn provides biplots informing shape relationships in tandem with the ability to inspect the 3D models themselves. While typologies created for specific research purposes have utility (see Houmard 2011), typologies work better when they are useful to a broader audience.

Additionally, if the classification system is flexible enough, it can appeal to and serve anything from broad to specific research purposes; it would also be infinitely reproducible as the processes used in classification are recorded and transparent. Naturally, more work must go into developing a new typological methodology which incorporates geometric morphometrics, but it has the potential of being more useful, flexible, standardized, and inclusive than previous methods of classification, one which lets the harpoon heads speak for themselves.

Assessing shape relationships using culture wide samples would be informative about Dorset identities, such as identifying possible group identities, their geographic distributions, change over time, relationships between distinct and similar groups, the rate of variability and change as they relate to geography (e.g., to evaluate Core Area vs Multiple Core-Area theories), and possible trade or other exchange networks. This method also highlights traditional knowledge, how it is maintained and how it is changed, and the importance attributed to certain elements in comparison to others, and has the potential to reveal much about cultural transmission processes and networks. Other prospects include determining if variability is clinal throughout Dorset space, combining different material dimensions to assess the consistency of identity markers and variability, evaluating possible extra-cultural influences, how climate and climate change may have affected morphology and variability in different areas. Geometric morphometrics can leverage material culture in ways that traditional artifact studies could only achieve in limited capacities, if at all.

While studying all material culture available for the Dorset would presently be virtually impossible, the standardized nature of data collection for this sort of analysis opens the possibility for democratization in a similar fashion already undertaken for Western Alaska (Maschner et al. 2015). This data does not need to be collected by a single individual. Instead, any researcher using these methods can create an online database of gathered data, offer guides for standardization, and then enable any other researchers to contribute their newly excavated material or old collections. As seen in other fields, the democratization and publication of data can broadly resolve problems relating to sample size, and remove the need for any individual to undertake a Herculean effort as Meldgaard did. For geometric morphometric, more specimens for comparison makes for richer comparisons, and some specimens are better than no specimens. Ideally, a handful of specimens is sufficient to represent any subdivision of the metadata (site, feature, level, etc.). However, with only a single specimen representing a site, it's impossible to assess the breadth of variability within that site. That single specimen may represent an extreme outlier in morphology, but without more specimens from the same assemblage, this possibility cannot be evaluated. Nonetheless, having a single specimen represent a site is forgivable when multiple sites are compared, as it is the only information available and that should not exclude this particular site from macroregional analysis. Thus, impoverished or rich, any collection that has usable specimens is a worthwhile addition to the growing corpus of data. If the database is complete enough, there may be more incentive for collaboration, as it is hard to imagine not wanting to compare new material to a rich quantitative database of similar material.

The nature of the data and the samples used for geometric morphometrics remain the biggest weakness of the method. Use-damage, modifications and repair, differential preservation, post-excavation treatment, or any factor contributing to the object's life-history, have the potential to complicate landmark placement for geometric morphometrics. In order to reveal the intent in design, the original manufactured object, geometric morphometrics requires as little post-creation modifications as possible. However, given that these objects have had long life-histories, only two harpoon heads of the 119 assessed in this project were complete enough to place all 31 landmarks. This created a huge problem and immediately eliminated the possibility of performing over-arching analyses in the current attempt. For instance, if two harpoon heads do not share a single landmark, they cannot be compared directly. Instead, design symmetry and sets of landmarks were relied upon to create useful samples for comparison. This, however, was not without its own difficulties. Overarching analyses had to be stitched together from large sets of possible landmark combinations. Wading through the results from each possible landmark combination is impossible, and as such makes it difficult to pinpoint interesting and meaningful results. Using landmarks constituting traditional typological attributes as the starting point proved useful; it led to the discovery of traditional design parameters and a better understanding of how traditional typological attributes compare to overall morphology in terms of variability. However, from a methodological standpoint, the most important result is the fact that broken and degraded objects can absolutely be used for geometric morphometric analysis, albeit with some workarounds. This project has shown that the nature of the sample is the biggest factor contributing to the difficulty of geometric morphometric assessment, but that useful data can be captured and evaluated in any case. Furthermore, evaluating parts of the harpoon head individually and separately has allowed for a more in-depth assessment than if a single overarching analysis was performed. Indeed, it was revealed that parts of the harpoon head had different relationships with different sites, suggesting much more complex relationships than anticipated. Additionally, a geographically clinal relationship was observed between the three sites. This independently led to the hypothesis that contemporaneous groups will display the most distinctiveness at the geographical extremities of their cultural range, while all groups in between will show a completely clinal relationship, broken only by major geomorphological features causing geographic separations or perhaps strong ethnic divides. Only with further research using larger data sets would it be possible to elaborate more on this subject.

The aforementioned prediction is far from being new: it belongs to the early development of cultural transmission theory. Boas wrote in 1896(3) that "the nearer the people, the greater the number of common elements; the farther, the less the number." While today diffusion is no longer considered the driver of similarities, the original premise remains a worthy topic of investigation. The results derived from using geometric morphometrics on harpoon heads, the quantitative nature of the technique, and the highly variable nature of Dorset harpoon heads across space and time all suggest that the study of cultural transmission in this area would be possible with a larger dataset. As mentioned in an earlier chapter, modern cultural transmission focuses on the individual, their actions, and decisions, as it recognizes their ability to obtain information, modify it, and transmit modified information. What this project has uncovered is interesting in itself, but is just the stepping stone towards a better understanding of Dorset individuals. Geometric morphometrics may have the potential to achieve the objectives of cultural transmission theory and the prospect of adding more data to leverage this method is a potential gold mine for such research. Additionally, the potential related to the evolutionary change in Dorset harpoon heads, and changes in the context and modes of transmission, make this quantitative methodology ideal for studying CT.

The geometric morphometric study of artifacts does not have a long history in the Arctic. Helmer and Robertson (1990) appear to be the first to have used the method in the Arctic using a small lithic sample from Devon Island, and were successful in showing the method's potential in studying variability for more statistically founded typological assessments. In 1990, geometric morphometrics was still in its infancy, and its accessibility was not as widespread as today with the internet, easy-to-use programming and statistical languages, and user interfaces. This may account for its lack of adoption and continued use for the study of variability in the Arctic, but another explanation may be the general loss of interest in purely artifact studies. Recent work in the Western Arctic has made use of the method to study fluted point variability, to better understand Paleoindian dispersal from the Old to New World (Smith and DeWitt 2017; Smith and Goebel 2018; Smith et al. 2019; Smith and Tune 2019). The Democratization of Science project (Maschner et al. 2015) has over 4,000 artifacts 3D scanned and 12,000 photographed from Alaska and even features certain measuring tools for analysis, but does not have a fully integrated geometric morphometrics tool. Otherwise the method has found most of its use in the biological sciences, recently spawning an in-depth analysis of arctic dog cranial morphology (Ameen et al. 2019). While the method is not unknown in arctic archaeology, it is far from being common to the archaeologist's toolkit. However, based on the study presented here, the potential benefits of geometric morphometrics are undeniable.

Geometric morphometrics can revitalize artifact and typological studies, and by doing so generate new interest in studying old collections. Visiting the Canadian Museum of History, and studying the PG, Saatut, and Tayara collections, revealed evidence that not all collections are equal. While no collection or material is inherently superior, the nature of the recorded data which includes context, observations, or any data beyond the material culture itself varies to such a degree that it can indeed be discouraging. For instance, the Saatut collection had no real contextual information after most of it was destroyed in a fire. All that was available was feature and unit information, the latter being completely useless as no excavation map indicating unit placement survived. This complicates the intrasite study but ultimately did not greatly impact intersite studies, as the broadest contextual information can still be useful. Related or not, the degree to which different collections have been studied also greatly varies, from not having been looked at since excavation (Saatut) to decades of study by different researchers (the Igloolik region sites initially excavated by Meldgaard). Using geometric morphometrics invites an alternative approach to artifact and collection studies, as it has the ability to leverage more information from the artifact itself and thus rejuvenates collections previously ignored or unstudied due to potentially inferior contextual information. Additionally, the process of 3D scanning material culture ensures the longevity of the collections themselves. While digital formats are by no means infallible, the ability to replicate, transfer, and store files may be the best safeguard any collection could hope for, especially in face of what happened to the National Museum in Rio de Janeiro in 2018, where over 18 million artifacts were lost to a fire. Furthermore, the wealth of available collections currently sitting in repositories could supplement multiple lifetimes of scholarly work without the need to ever step into the field, resulting in more cost-efficient research and an increase in more ethical non-invasive approaches to archaeological studies. Naturally the way research is conducted depends on the research objectives, but the idea should encourage further consideration of current methodologies. However, considering the current climate crisis, there is, or soon will be, an irrefutable need for large scale salvage operations in the Arctic. In 2025 we will be celebrating the 100th anniversary of Dorset archaeological research, but by the 150th anniversary museum collections will likely be valued to a greater degree as more of the Arctic's past is lost to the effects of climate change, as has already been the fate of the Saatut site.

CHAPTER 7: CONCLUSION

This project has been successful in developing data acquisition methodologies for complex three-dimensional shapes, in adapting quantitative methods for the statistical analysis of shape to Dorset harpoon heads, and in revealing patterns of intersite variability. Dorset harpoon heads proved to be an ideal choice for studying variability, as past typologies have shown both great homogeneity in design and heterogeneity in manufacture over time and space. The vast quantity and quality of specimens available for study, beyond those used in this project, can be leveraged in future research to better understand relationships across the Eastern Arctic. Nonetheless, the scale of this project was sufficient to establish the potential of the material and the method, and is an important step towards what might be a very fruitful avenue for future research.

1. What is variability?

This project first explored potential sources of variability through cultural transmission, manufacturing processes and decisions, and through the individual manufacturer's skills and ability to self-express. Cultural transmission theory highlights the mode, context, content, and individual filters involved in the transmission of cultural knowledge as sources of variability. The process of manufacturing itself is an immense source of variability as the tools, processes, methods, materials, and settings can greatly influence the outcome. The ecological knowledge involved in designing and fabricating the appropriate tool for the activity and setting adds another dimension to what may be conceived as variability. The individual remains the focal point in the creation of variability. As both transmitter and receiver of cultural information, and the manufacturer, the individual's choices and abilities are the foremost factors in the creation of variability. Only through individual choices are cultural traditions adopted or abandoned, as are the decisions which lead to innovation, experimentation, hybridization, aesthetic or symbolic styling, and most importantly to self-expression. This project has shown, through variability, elements of traditional knowledge which are reinforced across a great range, while others appear to belong to a more intimate scale of self-expression.

2. How has variability previously been studied?

The project then turned to discussing typologies, the most common vehicle used to classify and study Dorset harpoon heads. Maxwell's typology provides broad types for broad temporospatial contexts and yields a low-resolution temporal assessment of harpoon head change in the Eastern Arctic. Meldgaard's typology provides a high-resolution spatial chronology for the region of Foxe Basin and addresses evolutionary changes and relationships while providing easy to understand visuals. Together, the two provide an overview of what to expect from Dorset harpoon heads, are informative about typologies as a communicative medium, and provide a useful foundation when considering the sample analyzed for this project. However, traditional typologies were found to be limited in their ability to analyze and communicate variability at multiple scales simultaneously. Furthermore, when a large quantity of contextually diverse material was involved in classification, broadness and lumping were noticeable symptoms. The pervasive lack of standardization has led to numerous attempts at classification, all of which struggled in their ability to communicate variability in addition to the processes undertaken to classify variability.

3. Is geometric morphometrics capable of distinguishing variability?

With variability and typology discussed, this project demonstrated that geometric morphometrics was broadly capable of distinguishing different sites based on variability in morphology. Artifact homology, informed by past typologies, provided the basis of comparison for this project and revealed large-scale traditional knowledge. The Kingait Closed type was indeed used by members of the same archaeological culture at three widely separated sites, but at a smaller scale these specimens show discernible and distinguishable applications of the same overall body of traditional knowledge. The method proved valuable for discerning site-based visual clustering while revealing a possible spatially clinal relationship between the sites.

4. What patterns of variability are revealed using geometric morphometrics?

Using geometric morphometrics on this sample revealed that certain parts of the harpoon head, namely the more complex and interfacing parts often described as 'attributes,' display more variability than the parts of the harpoon head which connect the attributes, i.e., the space that makes up overall morphology. In studying the morphology of attributes, it was revealed that certain parts of the harpoon head show great standardization amongst the three sites, even between the sites which show the most statistical difference. These were termed traditional design parameters and are suggestive of differences in the transmission and maintenance of traditional knowledge at different scales. A spatially clinal relationship between the three sites was also observed, suggesting that the closer sites are the stronger the shape relationship of the harpoon heads will be. However, more data would be required to firmly support this observation. Different relationships between the three sites were observed when different parts of the harpoon heads were analyzed, suggesting a more complex relationship than anticipated and opening a possible avenue to study how information is packaged. These last two patterns may reveal a punctuated omni-directional clinal relationship, which should be expected as inter-group and inter-spatial relationships have been shown to change over time (Odess 1998). More data would provide more insight on these patterns, perhaps one day being able to elucidate more profound networks of inter-group relationships through shape relationships.

5. What is the relationship between geometric morphometrics and previous analytical methods?

The present project concludes that the traditional classification methods and geometric morphometrics can work in tandem to achieve more penetrating insights into variability. Existing typologies are longstanding and sturdy tools that have established which harpoon heads display the most homology through the creation of broad types, but other than Meldgaard's work, these typologies have not been able to successfully capture and explain variability at a smaller scale. Pre-existing typologies, and their broad attribute-based types, show us what specimens are comparable for geometric morphometrics, which in turn can inform high-resolution studies of variability at any scale. Arguably, typologists in the past went as far as they could in the study of variability with the methods and theories available to them. 3D scanning and geometric morphometrics now offer the means not to replace traditional classifications, but to extend their utility for studying variability. Geometric morphometrics is a suitable next step in studying variability, but it's true potential will be realized only when larger datasets are accumulated, developed, and shared between researchers.

This project, its results and conclusions, all point towards the benefits of using geometric morphometrics techniques. The success achieved at the scale of three sites and 119 harpoon heads offers but a glimpse into the scope of insights that could be elucidated from using material aggregated at a larger scale. However, the various results and interpretations derived from a culture-wide sample would likely take decades to disseminate in short article format or even larger monographs, as even in this project with only three sites much could not be discussed. Furthermore, current paper formats cannot satisfactorily communicate the variety of three-dimensional data assessed in this thesis. This problem is not new; lack of standardization in how harpoon head typologies from the last century chose to communicate variability underlines this. Investigating how the Dorset communicated and maintained ideas and knowledge at different scales revealed a dire need for those elements of publication in research and academia to be reassessed. In the age of information, data has become central to our society; it is regularly exchanged on social media and message boards, it is constantly gathered or stolen and sold, and it changes hands continuously through ever-changing transmission networks. The patchwork nature of archaeological research and the lack of large-scale material culture studies do not reflect the potential of emerging technologies. This project lays the groundwork for an approach which could address both the need for large scale work and the need for better dissemination solutions; the way forward is collaborative and democratized, standardized but flexible, visual and analytical. Geometric morphometrics will play a key part within larger framework for the study of variability. This new body of work revealed much about Dorset traditional knowledge, Dorset cultural transmission, and Dorset identities, but most importantly revealed how little we know about those aspects of Dorset life-histories.

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Appendix A – Harpoon Heads Examined

Project ID	Specimen ID	Borden	Site	Feature or Level	Material
EeBi-1:1	7A2DB388	EeBi-1	Philip's Garden	H17	Osseous
EeBi-1:2	7A207DC327	EeBi-1	Philip's Garden	H17	Osseous
EeBi-1:3	7A249B1194	EeBi-1	Philip's Garden	H18	Osseous
EeBi-1:4	7A249C803	EeBi-1	Philip's Garden	H18	Osseous
EeBi-1:5	7A259A286	EeBi-1	Philip's Garden	H19	Osseous
EeBi-1:6	7A259A1224	EeBi-1	Philip's Garden	H18	Osseous
EeBi-1:7	7A259P979	EeBi-1	Philip's Garden	H18	Osseous
EeBi-1:8	7A271D230	EeBi-1	Philip's Garden	H17/18	Osseous
EeBi-1:9	7A0281D35	EeBi-1	Philip's Garden	H17	Osseous
EeBi-1:10	7A368D354	EeBi-1	Philip's Garden	F73	Osseous
EeBi-1:11	4439	EeBi-1	Philip's Garden	H17	Osseous
EeBi-1:12	4444	EeBi-1	Philip's Garden	H17	Osseous
EeBi-1:13	4445	EeBi-1	Philip's Garden	H6	Osseous
EeBi-1:14	4446	EeBi-1	Philip's Garden	H18	Osseous
EeBi-1:15	4448	EeBi-1	Philip's Garden	H12	Osseous
EeBi-1:16	4449	EeBi-1	Philip's Garden	H4	Osseous
EeBi-1:17	4453	EeBi-1	Philip's Garden	H5/6	Osseous
EeBi-1:18	4457	EeBi-1	Philip's Garden	H17	Osseous
EeBi-1:19	4458	EeBi-1	Philip's Garden	H12	Osseous
EeBi-1:20	4459	EeBi-1	Philip's Garden	H17	Osseous

EeBi-1:21	4460	EeBi-1	Philip's Garden	H12	Osseous
EeBi-1:22	4461	EeBi-1	Philip's Garden	H12	Osseous
EeBi-1:23	4464	EeBi-1	Philip's Garden	H12	Osseous
EeBi-1:24	4465	EeBi-1	Philip's Garden	H12	Osseous
EeBi-1:25	4470	EeBi-1	Philip's Garden	H6	Osseous
EeBi-1:26	4477	EeBi-1	Philip's Garden	H18	Osseous
EeBi-1:27	4478	EeBi-1	Philip's Garden	H6	Ivory
EeBi-1:28	4482	EeBi-1	Philip's Garden	H10	Osseous
EeBi-1:29	4484	EeBi-1	Philip's Garden	H10	Ivory
EeBi-1:30	4822	EeBi-1	Philip's Garden	H2	Osseous
EeBi-1:31	17866	EeBi-1	Philip's Garden	H17	Osseous
EeBi-1:32	17922	EeBi-1	Philip's Garden	H17	Osseous
EeBi-1:33	19256	EeBi-1	Philip's Garden	H6	Osseous
EeBi-1:34	20338	EeBi-1	Philip's Garden	H18	Osseous
KbFk-7:1	132	KbFk-7	Tayara	T4 L1	Ivory
KbFk-7:2	248	KbFk-7	Tayara	T6 L1	Ivory
KbFk-7:3	2641	KbFk-7	Tayara	II	Ivory
KbFk-7:4	2642	KbFk-7	Tayara	II	Ivory
PeHa-1:1	12	PeHa-1	Saatut	F I	Osseous
PeHa-1:2	64	PeHa-1	Saatut	F I	Ivory
PeHa-1:3	65	PeHa-1	Saatut	F I	Osseous
PeHa-1:4	103;1	PeHa-1	Saatut	F I	Osseous
PeHa-1:5	103;2	PeHa-1	Saatut	F I	Osseous

PeHa-1:6	107	PeHa-1	Saatut	F I	Ivory
PeHa-1:7	124;1	PeHa-1	Saatut	F I	Ivory
PeHa-1:8	124;2	PeHa-1	Saatut	F I	Osseous
PeHa-1:9	421	PeHa-1	Saatut	F I	Osseous
PeHa-1:10	422	PeHa-1	Saatut	F I	Osseous
PeHa-1:11	423	PeHa-1	Saatut	F I	Osseous
PeHa-1:12	565	PeHa-1	Saatut	F I	Osseous
PeHa-1:13	641	PeHa-1	Saatut	F I	Ivory
PeHa-1:14	642	PeHa-1	Saatut	F I	Osseous
PeHa-1:15	705	PeHa-1	Saatut	F I	Osseous
PeHa-1:16	706	PeHa-1	Saatut	F I	Osseous
PeHa-1:17	730	PeHa-1	Saatut	F I	Osseous
PeHa-1:18	851	PeHa-1	Saatut	F I	Osseous
PeHa-1:19	852	PeHa-1	Saatut	F I	Ivory
PeHa-1:20	853	PeHa-1	Saatut	F I	Osseous
PeHa-1:21	935	PeHa-1	Saatut	F I	Osseous
PeHa-1:22	936	PeHa-1	Saatut	F I	Osseous
PeHa-1:23	937	PeHa-1	Saatut	F I	Osseous
PeHa-1:24	1019	PeHa-1	Saatut	F II	Osseous
PeHa-1:25	1060	PeHa-1	Saatut	F I	Ivory
PeHa-1:26	1061	PeHa-1	Saatut	F I	Osseous
PeHa-1:27	1109	PeHa-1	Saatut	F II	Ivory
PeHa-1:28	1110	PeHa-1	Saatut	F II	Osseous

PeHa-1:29	1165	PeHa-1	Saatut	F I	Osseous
PeHa-1:30	1182;2	PeHa-1	Saatut	F I	Osseous
PeHa-1:31	1185	PeHa-1	Saatut	F I	Osseous
PeHa-1:32	1194;1	PeHa-1	Saatut	F I	Osseous
PeHa-1:33	1194;2	PeHa-1	Saatut	F I	Osseous
PeHa-1:34	1314;1	PeHa-1	Saatut	F I	Osseous
PeHa-1:35	1314;2	PeHa-1	Saatut	F I	Osseous
PeHa-1:36	1332;1	PeHa-1	Saatut	F I	Osseous
PeHa-1:37	1332;2	PeHa-1	Saatut	F I	Osseous
PeHa-1:38	1332;3	PeHa-1	Saatut	F I	Ivory
PeHa-1:39	1402	PeHa-1	Saatut	F I	Osseous
PeHa-1:40	1417	PeHa-1	Saatut	F I	Ivory
PeHa-1:41	1441	PeHa-1	Saatut	F I	Osseous
PeHa-1:42	1488	PeHa-1	Saatut	F II	Osseous
PeHa-1:43	1510	PeHa-1	Saatut	F II	Osseous
PeHa-1:44	1631	PeHa-1	Saatut	F I	Osseous
PeHa-1:45	1635	PeHa-1	Saatut	F I	Osseous
PeHa-1:46	1637	PeHa-1	Saatut	F I	Ivory
PeHa-1:47	1683	PeHa-1	Saatut	F I	Osseous
PeHa-1:48	1716	PeHa-1	Saatut	F I	Ivory
PeHa-1:49	1738	PeHa-1	Saatut	F I	Osseous
PeHa-1:50	1806	PeHa-1	Saatut	F I	Osseous
PeHa-1:51	1807	PeHa-1	Saatut	F I	Osseous

PeHa-1:52	1808	PeHa-1	Saatut	F I	Osseous
PeHa-1:53	1809	PeHa-1	Saatut	F I	Osseous
PeHa-1:54	1810	PeHa-1	Saatut	F I	Osseous
PeHa-1:55	1905	PeHa-1	Saatut	F I	Osseous
PeHa-1:56	2143	PeHa-1	Saatut	F II	Ivory
PeHa-1:57	2146	PeHa-1	Saatut	F II	Ivory
PeHa-1:58	2271	PeHa-1	Saatut	F I	Osseous
PeHa-1:59	2272	PeHa-1	Saatut	F I	Osseous
PeHa-1:60	2273;1	PeHa-1	Saatut	F I	Ivory
PeHa-1:61	2273;2	PeHa-1	Saatut	F I	Ivory
PeHa-1:62	2314	PeHa-1	Saatut	F I	Osseous
PeHa-1:63	2455	PeHa-1	Saatut	F I	Osseous
PeHa-1:64	2624	PeHa-1	Saatut	F I	Osseous
PeHa-1:65	2681	PeHa-1	Saatut	F I	Osseous
PeHa-1:66	2683	PeHa-1	Saatut	F I	Osseous
PeHa-1:67	2685	PeHa-1	Saatut	F I	Osseous
PeHa-1:68	2686	PeHa-1	Saatut	F I	Osseous
PeHa-1:69	2687	PeHa-1	Saatut	F I	Osseous
PeHa-1:70	2688	PeHa-1	Saatut	F I	Osseous
PeHa-1:71	2706	PeHa-1	Saatut	F II	Osseous
PeHa-1:72	2744	PeHa-1	Saatut	F I	Osseous
PeHa-1:73	2838	PeHa-1	Saatut	F I	Osseous
PeHa-1:74	2861	PeHa-1	Saatut	F I	Osseous

PeHa-1:75	3004	PeHa-1	Saatut	F I	Osseous
PeHa-1:76	3005	PeHa-1	Saatut	F I	Osseous
PeHa-1:77	3007	PeHa-1	Saatut	F I	Osseous
PeHa-1:78	3196	PeHa-1	Saatut	F II	Osseous
PeHa-1:79	3377	PeHa-1	Saatut	F II	Ivory
PeHa-1:80	3382	PeHa-1	Saatut	F II	Ivory
PeHa-1:81	3387	PeHa-1	Saatut	F II	Osseous

Appendix B – R Code

```
# Pairwise Procrustes ANOVA (Geomorph package v. 3.1.3)
VB.df <- geomorph.data.frame(VB.gpa, site = VB$site)
VB.df$Csize <- VB.gpa$Csize
VB.site.model <- procD.lm(coords ~ site, data=VB.df, iter=10000, print.progress = FALSE)
null.model <- procD.lm(coords ~ 1, data=VB.df, iter=10000, print.progress = FALSE)
VB.site.pw <- pairwise(fit = VB.site.model,  fit.null = null.model, groups = VB.df$site)

#Morphological Disparity using procD.lm for Site (Geomorph package v. 3.1.3)
VB.md <- morphol.disparity(coords ~ 1, groups = ~ site, iter=10000, print.progress = FALSE,
data = VB.df)

#Function plots a set of Procrustes shape variables in tangent space along their principal
component axes (Geomorph package v. 3.1.3)
VB.pca <- plotTangentSpace(VB.gpa$coords, legend = TRUE, warpgrids = FALSE)
```