BONES AT A CROSSROADS

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BONES AT A CROSSROADS

INTEGRATING WORKED BONE RESEARCH WITH ARCHAEOMETRY AND SOCIAL ZOOARCHAEOLOGY

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Sarah M. Hazell, Susan Lofthouse, Elsa Cencig,
Kathryn Kotar, Peter D. Jordan, and Annelou van Gijn

Abstract

Arctic archaeologists generally accept that Dorset Paleo-Inuit (Tuniit) (*c.* 800 BC-1300 AD) toolkits exhibit high levels of typological uniformity across Arctic Canada and Greenland. This understanding implies that the artifacts were likely produced according to a standardized set of practices that were somehow reinforced over time and shared across the isolated sites and communities inhabiting this vast region. In contrast, recent theoretical developments in the study of technology highlight that material culture traditions are reproduced through localized social practices, and involve both individual and community-based decision-making processes, which would predict a higher level of variability in local manufacture and design features. Our aim in this pilot-study is to test whether Dorset artifacts are, in fact, produced and used in highly standardized ways. We focus on two important tool types crucial to survival in the North: needles and harpoon heads. We sampled assemblages from three Dorset sites located up to 800 km from one other and dating to different Dorset cultural periods. Our results indicate that the sets of tools were made and used in very different ways despite their outward typological similarity. This may reflect the fact that local technological traditions were being learned and practiced differently at each site, though much more work is needed to fully understand the implications of these results in terms of social learning, cultural inheritance, and inter-regional interaction patterns.

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ᐅᑭᐅᖅᑕᖅᑐᒥ ᐃᑦᑕᕐᓂᑕᓕᕆᔨᑦᑐᖅ ᐊᖏᖅᓯᒪᔪᑦ ᑐᐊᓯᑦ ᐃᓅᖅᑳᖅᑐᒥᓃᑦ-ᐃᓄᐃᑦ (ᑐᓃᑦ) (c. 800 BC-1300 AD) ᓴᓇᕐᕈᑏᑦ ᑕᑯᑎᑦᑎᔪᑦ ᖃᓄᐃᑦᑑᓂᖏᑦ ᐊᔾᔨᒌᙱᓐᓂᖏᑦ ᐅᑭᐅᖅᑕᖅᑐᓕᒫᒥ ᑲᓇᑕᒥ ᐊᒻᒪᓗ ᑲᓛᕐᓖᑦ ᓄᓇᖕᒐᓂ. ᑕᒪᓐᓇ ᑐᑭᓯᐊᓇᖅᑐᑦ ᐱᓪᓚᕆᐅᓂᖏᑎᒍᑦ ᐃᑦᑕᕐᓂᑕᐃᑦ ᓱᓇᐃᑦ ᐱᔾᔪᑎᒋᔭᖏᑦ ᒪᓕᒡᓗᒍ ᐋᖅᑭᒃᑕᐅᓯᒪᓂᖏᑦ ᑐᙵᕕᒋᔭᐅᔪᒃᑯᑦ ᐊᑐᖅᑕᐅᔪᑦ ᖃᓄᑭᐊᖅ ᐊᑐᖅᑕᐅᓕᒃᑲᓐᓂᓚᐅᖅᑐᑦ ᑲᔪᓯᓂᑎᒍᑦ

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ᐊᒻᒪᓗ ᓂᕐᒋᖅᑕᐅᓪᓗᑎᒃ ᐅᖓᓯᑦᑐᒥ ᓄᓇᓕᓐᓄᑦ ᓇᔪᕐᕕᒋᔭᐅᔪᓄᑦ ᐊᒻᒪᓗ ᓄᓇᓕᓐᓂ ᓄᓇᖃᖅᑐᑦ ᑕᒫᓂ ᐊᕐᒋᔪᒻᒪᕆᐊᓗᒻᒥ ᓄᓇᒋᔭᒥ. ᖃᐅᔨᒪᓇᖅᑐᖅ ᐊᔾᔨᒌᙱᓐᓂᖓ, ᒫᓐᓇᒃᓴᖅ ᐃᓱᒪᒋᔭᐅᓚᐅᖅᑐᑦ ᓴᖅᑭᑕᐅᔪᑦ ᖃᐅᔨᓴᖅᑎᓪᓗᒋᑦ ᓱᓇᒃᑯᑖᓂᒃ ᖃᐅᔨᓴᕐᓂᒃᑯᑦ ᓴᓇᕿᑎᕐᒋᓐᓂᑦ ᓱᓇᐃᑦ ᐃᓕᖅᑯᓯᒋᔭᐅᔪᒥ ᐊᔾᔨᒋᔭᖓᓂᒃ ᐊᑐᖅᑕᐅᓯᒪᔪᑦ ᐃᓅᖃᑎᒌᓐᓂᒃᑯᑦ, ᐊᒻᒪᓗ ᐃᓚᒋᓪᓗᒋᑦ ᑕᒪᒃᑭᒃ ᐃᒻᒥᒃᑰᖓᔪᒃᑯᑦ- ᐊᒻᒪᓗ ᓄᓇᓕᒥ-ᑐᙵᕝᕕᒃ ᐃᓱᒪᒃᓴᖅᓯᐅᕐᓂᒃᑯᑦ ᐊᑐᖅᑕᐅᔪᒃᑯᑦ, ᑕᒪᓐᓇ ᓂᑎᐅᖕᓇᖅᑐᖅ ᐃᓱᒪᓇᖅᑐᒃᑯᑦ ᐊᔾᔨᒌᙱᓐᓂᕐᒋᑦ ᓄᓇᓕᒥ ᓴᓇᔭᐅᓯᒪᔪᑦ ᐊᒻᒪᓗ ᖃᓄᐃᑦᑑᓂᕐᒋᓐᓄᑦ ᑕᑯᒃᓴᐅᔪᒃᑯᑦ. ᑐᕋᒋᔭᕗᑦ ᑕᒪᓐᓇ ᓯᕗᓪᓕᖅᐹᕆᔭᒃᑯᑦ-ᖃᐅᔨᓴᕐᓂᖅ ᖃᐅᔨᓴᕐᓂᐊᕐᓗᒋᑦ ᑐᓃᑦ ᐃᑦᑕᕐᓂᑕᕐᒋᑦ, ᑕᐃᒪᐅᓪᓚᖑᐅᒻᒪᖕᒫᑦ ᓴᖅᑭᑕᐅᓂᕐᒋᑦ ᐊᒻᒪᓗ ᐋᖅᑭᒃᓯᒪᔭᐅᔪᒃᑯᑦ ᑐᙵᕝᕕᒃᑯᑦ ᐊᑐᖅᑕᐅᓯᒪᒻᒪᖕᒫᑦ ᐊᔾᔨᒌᙱᓐᓂᒃᑯᑦ. ᑐᓖᖅᓯᒪᔪᒍᑦ ᒪᕿᕐᓂᒃ ᐱᒻᒪᕆᐅᔪᓂᒃ ᓴᓇᕿᑎᓂᒃ ᐊᔾᔨᒌᙱᑦᑐᓂᒃ ᐊᒃᓯᕿᓇᖅᑐᒥ ᐊᓐᓇᐅᒪᒐᓯᐊᕐᓂᕐᒧᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ: ᒥᖅᑯᑎᑦ ᐊᒻᒪᓗ ᓴᒃᑯᐃᑦ. ᖃᐅᔨᓴᖅᓯᒪᔪᒍᑦ ᐊᔾᔨᒌᙱᑦᑐᓂᒃ ᐊᔾᔨᒌᕐᓚᒃᑐᓂᒃ ᐱᖓᓱᓂᑦ ᑐᓃᑦ ᓇᔪᕐᕕᒋᔭᕐᒋᑦ 800 ᑭᓚᒦᑕᓂᒃ ᐅᖓᓯᓐᓂᖅᑐᓂᒃ ᓄᓇᒌᑦ ᐊᒻᒪᓗ ᐅᓪᓗᕐᒋᑦ ᐊᔾᔨᒌᙱᑦᑐᑦ ᑐᓃᑦ ᐃᓕᖅᑯᓯᕐᒋᓐᓂᑦ. ᖃᐅᔨᓯᒪᔭᕗᑦ ᐃᓱᒪᓇᖅᑐᑦ ᓴᓇᕿᑏᑦ ᓴᓇᔭᐅᓯᒪᔪᑦ ᐊᒻᒪᓗ ᐊᑐᖅᑕᐅᓯᒪᔪᑦ ᐊᔾᔨᒌᙱᑦᑐᒻᒪᕆᐊᓗᒃᑯᑦ ᖃᓄᐃᒃᑲᓗᐊᖅᑎᓪᓗᒋᑦ ᐊᔾᔨᒌᙱᓐᓂᕐᒋᑦ ᐊᔾᔨᒌᕐᓚᒃᑐᓂᑦ. ᑕᒪᓐᓇ ᐃᓱᒪᓇᖅᑐᖅ ᑕᐃᒪᐅᓪᓚᖑᓐᓂᕐᒋᑦ ᓴᓇᕿᑎᕐᒋᑦ ᐃᓕᖅᑯᓯᒃᑯᑦ ᐃᓕᓐᓂᐊᖅᑕᐅᓚᐅᖅᑐᑦ ᐊᒻᒪᓗ ᐊᑐᖅᑕᐅᓪᓗᑎᒃ ᐊᔾᔨᒌᙱᑦᑐᒃᑯᑦ ᑕᒪᕐᒥᑦ ᐃᒥᒃᑯᑦ ᓇᔪᕐᕕᒋᔭᐅᔪᒥ, ᑭᓯᐊᓂ ᐃᖅᑲᓇᐃᔭᒃᑲᓐᓂᓚᐅᖅᑐᒍᑦ ᑐᑭᓯᐊᔾᔪᑎᒋᓗᒃᑖᕐᓂᐊᕐᓗᒋᑦ ᐃᓱᒪᒋᔭᐅᔪᑦ ᖃᐅᔨᔭᐅᓯᒪᔪᓂᑦ ᐊᑐᕐᓗᒋᑦ ᐃᓅᖃᑎᒌᓐᓂᕐᒋᑦ,ᐃᓕᖅᑯᓯᓇᔭᐅᔪᒃᑯᑦ ᑐᓂᔭᐅᓯᒪᔪᒃᑯᑦ, ᐊᒻᒪᓗ ᐊᑯᓐᓂᕐᒋᑕ-ᓄᓇᖃᖅᑐᑦ ᑕᑯᑦᑕᐅᑎᖅᑲᑎᒌᓐᓂᒃᑯᑦ ᐊᔾᔨᒌᙱᓐᓂᕐᒋᑎᒍᑦ.

Keywords: Dorset, Paleo-Inuit, Arctic, microwear analysis, organic material culture

Introduction

The Dorset culture[1] existed in Arctic Canada and Greenland between approximately 800 and 1300 AD (Appelt, Damkjar, and Friesen 2016; Friesen and Mason 2016; Ryan 2016). Ever since it was first described by anthropologist Diamond Jenness (1925), a suite of features considered "typical" of Dorset technology (such as the apparent absence of drilling technology) have come to define the culture in the minds of archaeologists. It has been generally accepted that Dorset material culture exhibits high levels of typological uniformity across much of the culture's known geographic range and that this uniformity persists across the full Dorset chronological sequence. This implies that all or most Dorset artifact types were made in the same ways, despite the culture's longevity and the often-great distances separating occupied areas. By contrast, ongoing theoretical developments in the study of technology highlight that material culture traditions in small-scale communities are reproduced through localized social practices and involve both individual- and community-based decision-making processes (which would predict a higher level of variability in local manufacture and design features) and that traditions would exhibit change over time (Lemonnier 1993; Jordan 2015). Given these contradictions between current understandings and theoretical predictions, our aim in this paper is to test these assumptions about standardized manufacturing practices. We focus on two tool types crucial to survival in northern coastal regions, needles and harpoons, using materials from three Dorset sites in two widely separated parts of Nunavut, from Early to Late Dorset times. We employ microscopic analysis to assess local variability versus uniformity in manufacturing practices and use.

1 Throughout the paper, we employ the term "Dorset" to refer to the later culture phases of the Paleo-Inuit tradition. The term "Paleo-Inuit" is an established academic term (Friesen 2015) also known as "pre-Inuit." Inuit of Nunavut (Nunavummiut) typically employ the Inuktitut term "Tuniit" to refer to the latter Paleo-Inuit peoples who thrived in Arctic Canada and Greenland prior to the arrival of Thule Inuit in the mid-to-late thirteenth century AD. (Raghavan *et al.* (2014) have established a genetic distinction between Dorset and Thule Inuit populations.) Throughout the paper, we employ the term "Dorset" to allow easier comparison with other academic papers investigating this culture group.

Research context: Dorset subsistence, settlement, and technology

The nature of social interaction and the exchange of ideas both within and between different Dorset groups is difficult to reconstruct. Existing knowledge of Dorset culture phases relates predominantly to studies of subsistence and settlement. Though osteoarchaeological remains from Dorset sites are rare (Lynnerup *et al.* 2003) and typically less well-preserved than those from later Thule Inuit sites, zooarchaeological research shows that Dorset hunting patterns focused on marine mammals, such as small phocid seals (*e.g., Pusa hispida*), bearded seals (*Erignathus barbatus*), and Atlantic walrus (*Odobenus rosmarus*), although terrestrial mammals, such as caribou (*Rangifer tarandus*) and musk ox (*Ovibos moschatus*), were also hunted, depending upon location (Murray 1996; Howse 2015; Betts 2016). Excavations and surveys have revealed much about the nature of Dorset settlement patterns, which typically varied according to region, time period, and seasonality. Generally, summer dwellings consisted of skin tents, while in winter, people built more robust structures, including semi-subterranean houses (Maxwell 1985; Ryan 2003; Friesen 2007; Ryan 2016). In terms of social organization, the assumption is that in most regions, Dorset communities would have consisted of a small number of families for most of the year, with the possibility of larger aggregations seasonally in certain areas, depending on the availability of resources (Friesen 2007; Appelt, Damkjar, and Friesen 2016).

Why such high levels of material culture uniformity exist across time and space is an important topic for discussion. Investigations of objects through the *chaîne opératoire* approach highlight the role of skilled practice and focus attention on the multiple steps of artifact manufacture (Martinón-Torres 2002). Most steps involve a degree of technological choice, which highlights the role of human decision-making processes and how particular material traditions are learned and reproduced in small and often isolated communities. Modifications can still be made to an artifact following its “completion,” and the technological choices made during manufacture relate specifically to how the artifact will be used, and are thus integral to the intentionality (both practical and symbolic) of the maker. For example, while a tool may be created with the material restrictions of a particular physical task in mind, other requirements relating to the role the tool plays in the wider symbolic system of the society may also be considered by the maker or makers (Lemonnier 1993). In this way, investigating the *chaîne opératoire* of an object is not only limited to examining the steps of manufacture but also promotes the idea that an artifact is a manifestation of social learning based on the technological choices made during its manufacture and use (Jordan 2015).

In the present study, we investigate the *chaîne opératoire* through the microscopic traces created during the manufacture and use of objects (van Gijn 2010). Investigating artifacts at this higher level of detail has many advantages. First, although the observable morphological characteristics of two objects from different regions or time periods may appear similar when observed with the naked eye, microscopic examination could show differences in how the artifacts were produced and used. This may have significant implications for differences in the creative choices and everyday practices of the two groups. Previous studies have incorporated a similar methodology into their framework when investigating organic material culture from sites in the Canadian Arctic (Houmard 2011; Houmard 2018). However, these studies

Figure 1. Map showing the location of the three focus sites in the Foxe Basin (source: Esri).

have mainly been focused on typological and technological developments over time, whereas we also aim to identify regional variation in technological choices employed by contemporary groups.

Materials

We focus our attention in the present study on Foxe Basin and northern Hudson Bay, situated at the centre of the wider Dorset geographic distribution (Figure 1). Although archaeological evidence of the Dorset culture can be found across Arctic Canada and Greenland, our focus area has long been considered the "emergence point" of the culture, particularly in terms of development from the earlier Pre-Dorset culture (Maxwell 1976; McGhee 1976; Nagy 1994; Savelle and Dyke 2014; Ryan 2016).

Our study sites include the Needle Point complex (NgFv-4, -6, -7, -8, -9, -10) on Rowley Island (known in Inuktitut as Salliq) and Kapuivik (NjHa-1) on Jens Munk Island (Kapuiviit)– both in the northern Foxe Basin – and Qulliapik (JlGu-3) on Mansel Island (Pujjunaq) in the northeastern Hudson Bay. There is sufficient geographic and chronological diversity among these locales to examine whether artifacts exhibit any spatiotemporal variability in manufacture and design. The two northern locales (Needle Point and Kapuivik) are approximately 800 km distant from the southern site (Qulliapik). There are also chronological distinctions among the chosen assemblages from each site: The selected Needle Point material dates from the Early to Late Dorset periods, the Kapuivik material from Early to Middle Dorset periods (*c.* 800 BC-500 AD) and the Qulliapik material to the Late Dorset period (*c.* 500-1300 AD) (Table 1).[2] Additionally, the sites are similar in terms of both quaternary geology and ecology.

Since the Needle Point complex of Dorset sites was described by Arthur S. Dyke (Geological Survey of Canada) and James M. Savelle (McGill University) in 2003, several field seasons of survey and excavation have been carried out by McGill researchers Susan Lofthouse in 2004 and 2005 (Lofthouse 2004; Lofthouse 2005) and Sarah M. Hazell in 2005 and 2006 (Hazell 2006; Hazell 2007). The material selected for analysis in the present study comes from the collections held by both researchers: NgFv 6-9 (Lofthouse) and NgFv4 and 10 (Hazell). Together, these contexts span nearly the entire Dorset period, from Early/ Middle to Late Dorset.

The multicomponent site Kapuivik was visited in 1954 and 1957 by Danish archaeologist Jørgen Meldgaard. Since then, the site has been the focus of extensive archaeological investigation. The material for the present study is a selection of the collection excavated in 2016 by a McGill field crew organised by James M. Savelle (Desrosiers 2018). Although Kapuivik has yielded material from a wide range of time periods, the material chosen for this study dates to the Early/Middle Dorset period.

Finally, the Qulliapik site on Mansel Island was investigated by William E. Taylor (National Museum of Canada) and Charles Martijn (Université Laval) in the late 1950s along with Inuit from the community Ivujivik. The Late Dorset material chosen for the present study was recovered in 2017 during the salvage dig of this site by Elsa Cencig and a field crew from the Avataq Cultural Institute (Avataq Cultural Institute 2018).

While there have been many studies concerning the *chaîne opératoire* of Dorset technology, the majority of these have focused on lithic technology (cf. Sørensen 2006; Dionne 2015; Coulson and Andreasen 2020). Similarly, the majority of usewear analysis in the Arctic has also focused mainly on lithic technologies (cf. Monchot *et al.* 2013; Wells, Renouf, and Rast 2014; Paquin 2016; Chabot, Dionne, and Paquin 2017; Park, Milne, and Stenton 2017), and there have been very few focusing on a microscopic analysis of organic materials, not only in the Arctic but also the wider Canadian region (cf. LeMoine 1994; Gates St-Pierre 2007). A analytic comparison with studies focusing on lithic technology has not been included in the present study, as the *chaîne opératoire* of lithic technology is highly distinct from that of organic materials and so is not comparable when conducting

2 Date ranges taken from Appelt, Damkjar, and Friesen (2016), Friesen and Mason (2016), and Ryan (2016). The exact site dates for each feature can be found in the site reports.

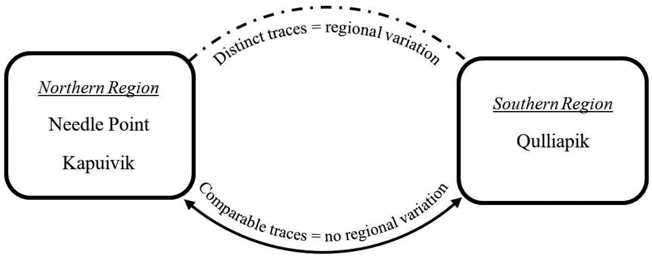
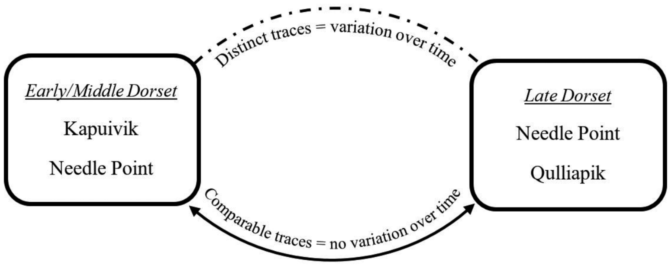
	Qulliapik	Needle Point	Kapuivik
Needles	22	24	27
Harpoon heads	24	18	18
Time period examined	Late Dorset (*c.* 500-1300 AD)	Early/Middle and Late Dorset (800 BC-1300 AD)	Early/Middle Dorset only (800 BC-500 AD)
Regional variation			
Chronological variation			

Table 1. Overview of the chosen material and associated time periods from the three sites and the hypothesized patterns of regional and chronological variability in the *chaîne opératoire*.

an analysis of tools made from bone, antler, and ivory. Similarly, a comparison of usewear analyses between the two technologies (lithics versus organics) is not relevant for the present study because (a) the traces observed on lithics versus organics are very different, and (b) the uses for which stone tools and bone tools would have been implemented cannot easily be compared. While a cross-craft analysis combining a microscopic investigation into the *chaîne opératoire* of both lithic and organic Dorset materials would be highly beneficial to the discipline, such a broad scope was not possible for the present study, and so we focused on the less-studied organic material.

The most frequently occurring artifact categories present across all three sites are needles and harpoon heads (Table 1) (comprising 73 needles and 43 harpoon heads), which were analyzed for macroscopic and microscopic traces related to manufacture and use (LeMoine 1994). The hypothesized patterns of variability that these traces could demonstrate is highlighted in Table 1.

Needles were – and remain – one of the most essential elements of Arctic Indigenous toolkits. Across much of the pre-modern Arctic, wood was scarce, and so Dorset communities relied on stone, sod, bone, and animal skin when constructing their winter and summer structures (Maxwell 1985; Ryan 2003). Skin would have been used to create portable tents in the summer and water- and windproof roofs in the winter. Additionally, all clothing would have been made from skins, and the ability to properly insulate and waterproof clothing would have been essential. All of this would have been impossible to maintain without the use of needles of varying dimensions capable of piercing hides of a range of thicknesses while also allowing for tight stitches of sinew thread, ease of handling, and portability.

Similarly, harpoon heads were an essential tool in the procurement of food. In addition to terrestrial hunting, the Dorset engaged in maritime-focused subsistence activities, hunting walrus and various seal species (Ryan 2016). This increased focus on maritime hunting was facilitated by the use of toggling harpoon heads designed to rotate 90° within the wound (Maxwell 1985).

Methods

Manufacture

To test for the degree of microscopic similarity of needles and harpoons across the three sites, we first identified a series of morphological traits found on almost every artifact examined. These traits represent manufacturing steps in the *chaîne opératoire*, and each trait reflects a distinct design "decision" on the part of the maker. The identifications were made using the material culture reference collection held at the Leiden University Laboratory for Artifact Analysis. The traits associated with manufacture were identified using an AM7115MZT Dinolite microscope, while an Olympus BX-51 metallographic microscope with an SC50 camera attachment was used to identify the presence of usewear traces.

One of the most fundamental decisions in the manufacturing process of any object is determining its size. We have limited our consideration of size to width and thickness; length is excluded due to the high percentage of broken objects. For harpoon heads, only 19 of the 43 objects are complete, with the remainder broken either at the socket or the blade-slot. Similarly, only 12 of the 73 needles are complete; with the majority including only a shaft and proximal end, suggesting that needles were discarded once the tip – the pointed, distal end – had broken off. Because there are only a limited number of complete needles, the length can therefore not be used as a characteristic to make valid comparisons between site assemblages. However, test measurements of a selection of pieces suggests that the width and thickness of the needles remains consistent across the length of the needle, excluding the very tip of the pointed distal end. Those pieces limited to the distal end (classified as "tip only") are measured at their widest parts; this is considered an approximate representation of the main shaft of the needle and so is comparable to the other needle fragment measurements.

Analyzing the size and shape of the harpoon heads is complicated by the great diversity of harpoon-head types and local variants, some of which are at least partly determined by size (Maxwell 1976a; Houmard 2011). Not accounting for these typologies would arguably invalidate the results of our analysis. Qulliapik includes only two harpoon head types, Dorset Parallel and Dorset Type Ha. Excavations at Needle Point and Kapuivik both produced the Dorset Parallel and Tayara Sliced types. Needle Point also includes an example of Dorset Type J, and Kapuivik includes the Nanook Wasp Waist and Pre-Dorset types. The only harpoon-head type that is present at all sites is the Dorset Parallel;

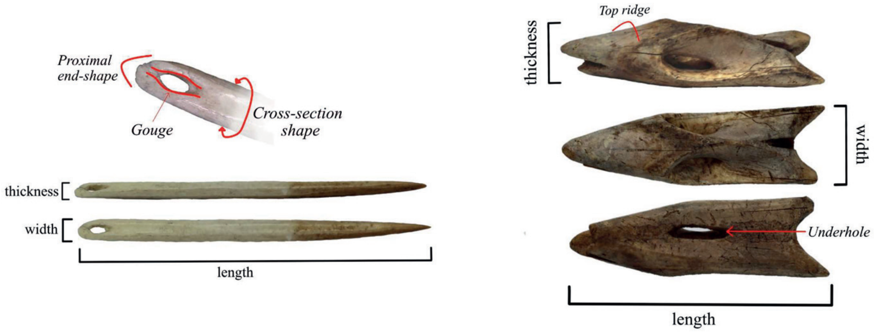


Figure 2. Measurement parameters and morphological traits observed on the needles (left) and harpoon heads (right). The harpoon head pictured here is the Dorset Parallel type.

therefore, the size comparisons have been restricted to this type (see Figure. 2). We also investigated (a) the top-ridge shape (either "curved" or "faceted") and (b) the presence or absence of an underhole (a secondary line-hole on the underside of the object).

For needles, there are three additional morphological traits to consider: (a) cross-section shape, (b) proximal end-shape, and (c) perforation shape (Houmard 2018) (Figure. 2). As previously mentioned, the perforations on all Dorset objects were created using a gouging action, including the eyes of the needles. We have recorded the gouge length (the extent of the gouge marks on the surface around the perforation) and the gouge angle (whether angled or straight, defined by its position when compared against the needle length).

Usewear

While traits such as size and shape can be used to investigate variations in manufacturing choices while creating tools, the interpretation of microscopic usewear traces can provide insights into the way that the tools were used. For the present study we investigate the variations in polish, striations, and handling traces on needles and harpoon heads.

Figure 3 details the different usewear traces observed, which include different polish types, the presence of longitudinal versus circumferential striations, and the presence of handling traces. The polish observed on an artifact is related to the material upon which the artifacts were being used (*e.g.*, types of skin). Polish variability is assessed by examining the brightness (dull, bright, very bright), texture (smooth, rough) and degree of linkage (the extent to which patches of polish visible on an object's surface merge together) (González-Urquijo and Ibáñez-Estévez 2003). Linkage is related to the hardness of the contact material, but also to the degree of wear development. Some of the artifacts examined – especially the needles – have more than one variety of polish along the entire length, which may be evidence of multiple uses (this will be explored in a follow-up study focusing on experimental archaeology). In the present study, we identified only the dominant polish type on each artifact.

Striations are created when contact with an external material creates microscopic scratches on the artifact surface (Gates St-Pierre 2007); such evidence can only be viewed at high magnification. During initial observations of the needles, it was noted that the striations show variability in directionality. No striations were observed on the harpoon heads; this is likely due to the difference in activity associated with the two

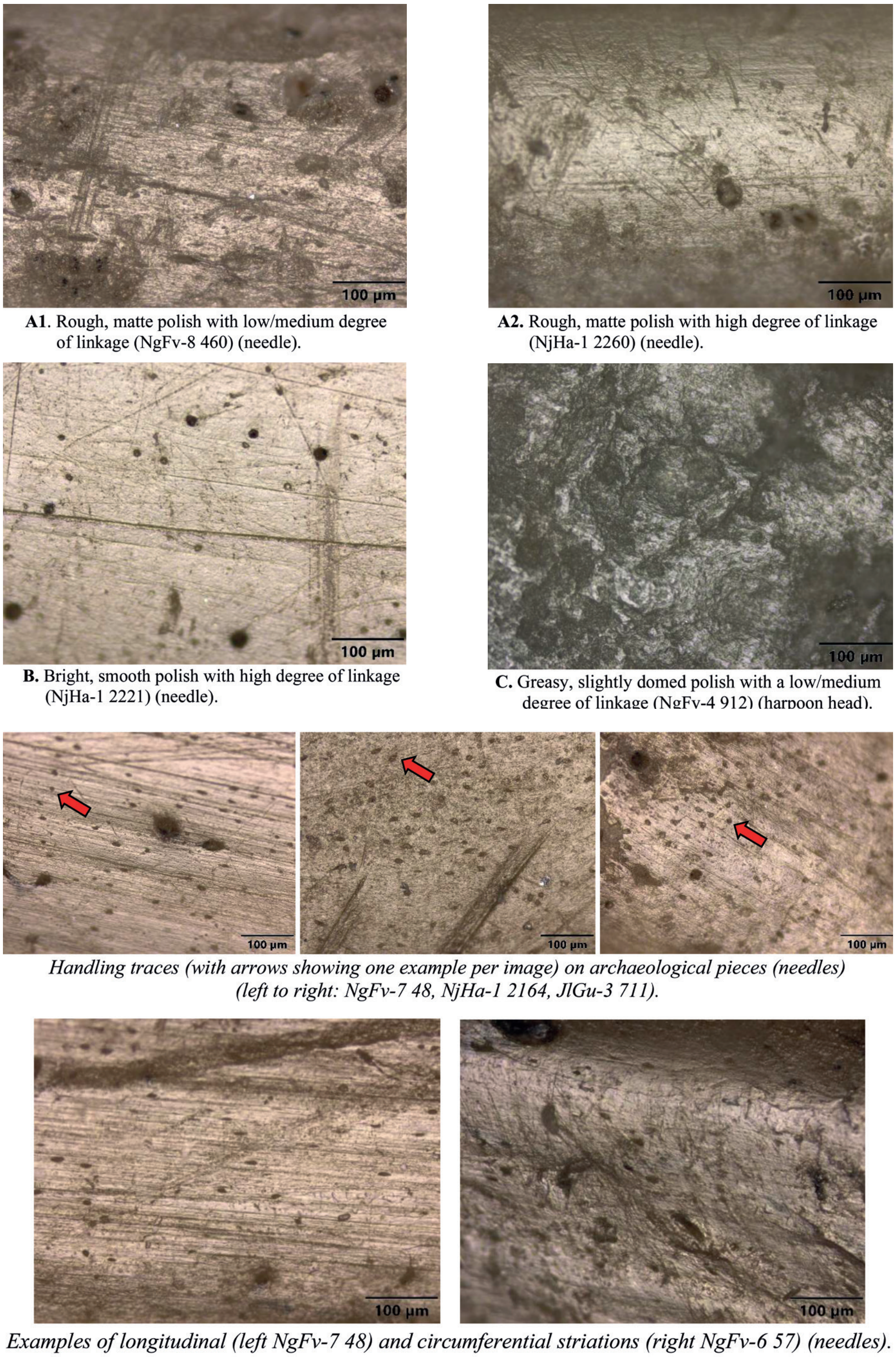


Figure 3. Examples of the different usewear traces considered in the present analysis, including different polish types (upper), the presence of longitudinal versus circumferential striations (middle), and the presence of handling traces (lower).

artifact types. While needles are used more often and in a repetitive motion, harpoon heads are used in short, intense bursts of activity, likely followed by extended periods of non-use in storage. In general, there is very little interpretable usewear present on the harpoon heads, and experiments by the first author have shown that very little usewear is created on a harpoon head used the same number of times as a needle (Siebrecht and Pomstra 2020).

Experimental research has shown that the handling of organic objects – especially bone tools – results in small pinpricks referred to as handling traces (Maigrot 2003; van Gijn 2006). It is still unclear how these traces develop. Previous studies investigating the formation of handling traces have also noted the creation of polish during handling (D'Errico 1993). However, because in the present study we are unable to reliably differentiate between polish associated with human handling and that associated with the various types of skin we intend to experiment with, we believe that the presence of the pinprick-like traces is a more reliable sign of human handling. Examples of these tiny pinpricks are shown in Figure 3; they are not to be confused with the larger pockmarks representing osteons or Volkmann canals.

Results

Manufacturing traces on needles

For all needles, the thickness is generally smaller than the width (Figure 4). This correlates with the assumed manufacturing technique of the groove-and-split method,[3] whereby a thinner preform allows a quicker and easier cut. The needles from the southern site of Qulliapik are generally larger in terms of both width and thickness than needles from the northern locales of Needle Point and Kapuivik. Although there is variation between the two northern locales, there is a higher degree of similarity between them when compared with Qulliapik. Although this may imply that there is indeed a regional distinction between the northern and southern sites, it is also necessary to consider the different chronologies of the assemblages.

As seen in Table 1, all the selected material from Qulliapik dates to the Late Dorset period, while the material from Needle Point includes dates from the Early/Middle Dorset period to the Late Dorset period, and the assemblage from Kapuivik includes only Early/Middle Dorset material. The same characteristics must therefore be examined in consideration of the associated time period. For the Late Dorset artifacts, there is a strong similarity between the needles from Qulliapik and those from Needle Point both in terms of width and thickness, though the median for Qulliapik remains slightly larger in both measurements. The same is true when comparing the two Early/Middle Dorset collections; the needles from Kapuivik are slightly thicker and wider than those from Needle Point. (The data may be biased slightly by two irregularly-shaped outliers.) Therefore, when considering the variation in needle measurements over time period – without considering their geographic location – Late-Dorset needles are generally slightly thicker than Early/Middle-Dorset needles, although the width remains roughly the same.

When comparing the cross-section and (proximal) end-shapes, the needles from Needle Point and Kapuivik have more similarities with one another than either

3 The "groove-and-split" method involves creating a groove in a piece of bone with, for example, a stone tool. Once this groove has reached an appropriate depth, a small stone wedge is used to split the material completely.

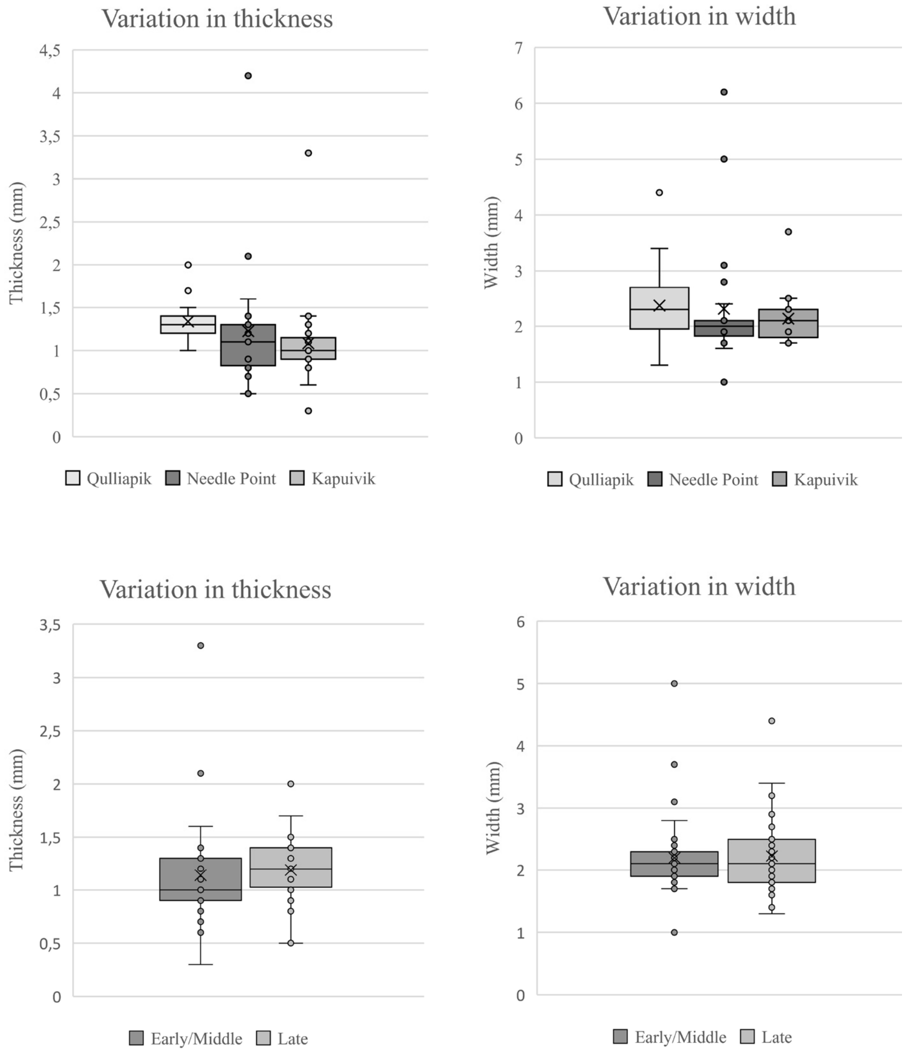


Figure 4. Comparisons of needle thickness (left) and width (right), according to site (upper) and time period (lower).

assemblage has with Qulliapik (Figure 5). The greatest percentage of needles from Qulliapik are quadrangular, whereas at both northern locales, the most common shape is oval. Additionally, both Needle Point and Kapuivik include needles with a diamond-shaped cross-section, which is not present in any of the needles from Qulliapik. The only cross-section shape that remains consistent across all sites is the lens shape.

A large percentage of the end-shapes from all sites are unidentifiable, as many needles include only the shaft or the distal tip. In general, both Needle Point and Kapuivik have a higher percentage of pieces with a pointed end-shape, with some curved ends, while Qulliapik includes a higher percentage of needles with a curved end-shape and some flat ends. Therefore, this manufacturing trait is more similar between the two northern locales than between the northern and southern sites.

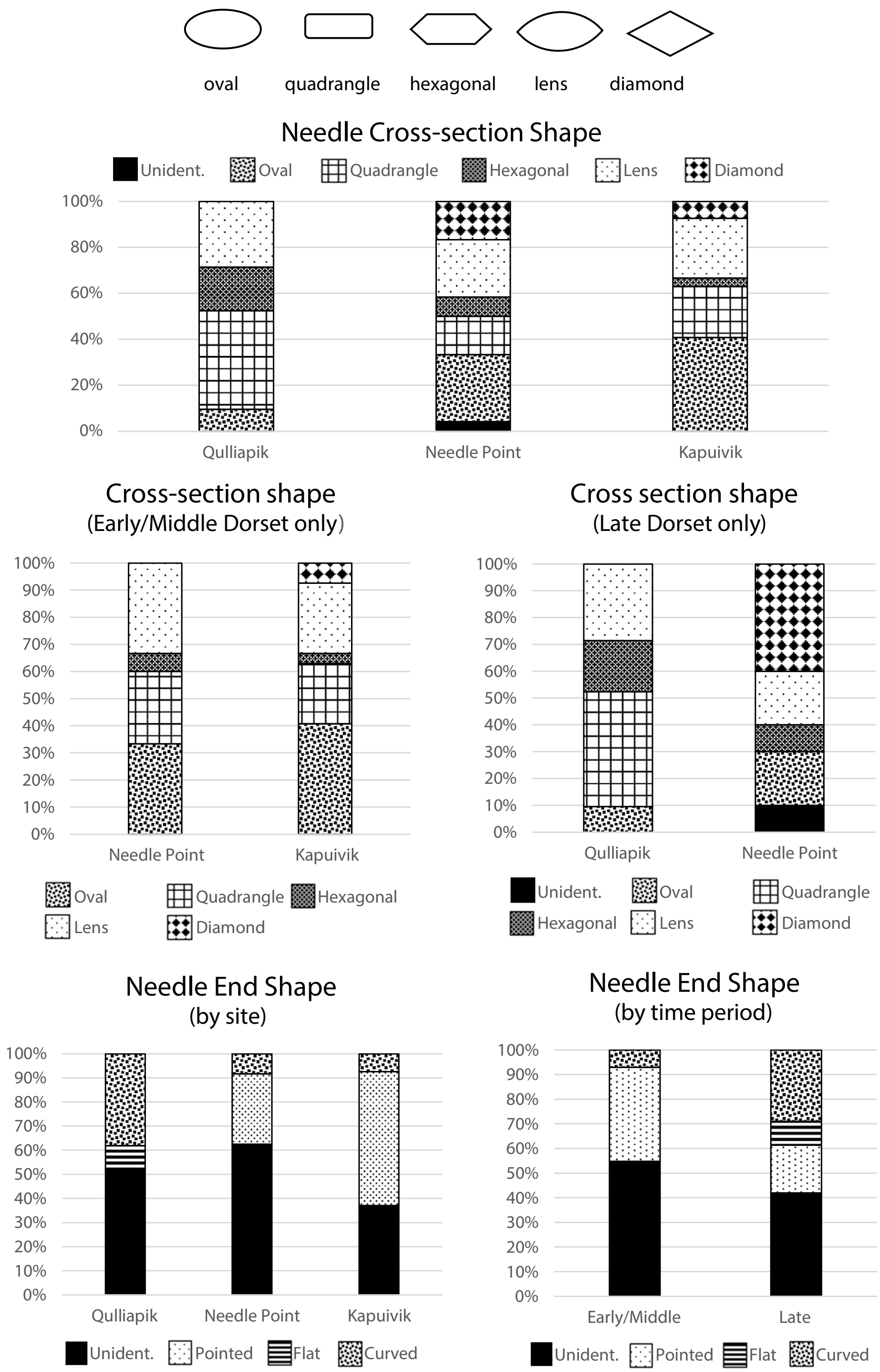


Figure 5. Comparisons of the percentage of needle cross-section shapes across all sites (upper) and time periods (middle) and the percentage of needle (proximal) end-shape (lower) across all sites (left) and time periods (right). ("Unident." = unidentifiable)

Site	Gouge angle (% of site total)			Gouge length (% of site total)		
	Unident.	Straight	Angled	Unident.	Long	Short
Qulliapik	62	29	9	62	19	19
Needle Point	71	29	0	71	21	8
Kapuivik	26	56	18	26	52	22

Table 2. Comparisons of needle gouge angle (left) and length (right) according to site ("Unident." = unidentifiable.)

When considering variations in needle shape between time periods, the two Early/Middle Dorset assemblages from Needle Point and Kapuivik show a high degree of similarity. The main differences are the inclusion of diamond-shaped cross-sections at Kapuivik but not at Needle Point, as well as a higher percentage of pointed end-shapes at Kapuivik. The Late Dorset collections from Qulliapik and Needle Point differ more, especially in the proximal end-shape. The majority of Late-Dorset needles from both sites have a curved end-shape, but Qulliapik also includes objects with flat ends, and Needle Point has some with pointed ends. When considering the percentages of different cross-section shapes and end-shapes at the two sites, this contrast between regions becomes even clearer.

Although there are some variations across time periods – with a more defined relationship between end-shape (compared with cross-section shape) at Early/Middle and Late Dorset sites – the needle shapes appear to be generally comparable within regions. Notably, when considering the cross-section shape, the two northern locales show a much greater similarity in needle shape than does either site with Qulliapik, even when considering the differences in chronology.

Comparing the length of the gouge marks around the perforations suggests a stronger degree of similarity between the two northern locales than between either Kapuivik or Needle Point with Qulliapik (Table 2). Approximately half of the gouge lengths from Qulliapik are long, whereas the two northern locales have a significantly lower percentage of long gouges. However, comparing the gouge angle suggests a different pattern whereby the strongest similarity is between Needle Point and Qulliapik, although there is also some similarity between Kapuivik and Qulliapik, which are the only two sites to have needles with angled gouge marks. However, these relationships do not correlate with either a regional or temporal relationship, and could simply be due to the limited variability that is possible when creating a perforation (there are only so many ways to gouge a hole). With both the gouge length and gouge angle, no variability was observed when comparing between time periods, thus suggesting that local regional factors have greater influence on this trait of manufacture, if at all.

Manufacturing traces on harpoon heads

Comparisons between the width and thickness of the harpoon heads suggests that time had a stronger influence on this particular trait of manufacture (Figure 6). When comparing by site, we see that even without taking chronology into account, Needle Point and Qulliapik have objects with similar dimensions, though there is some variation in that the Needle Point pieces are generally thicker than the two Qulliapik objects. However, when comparing

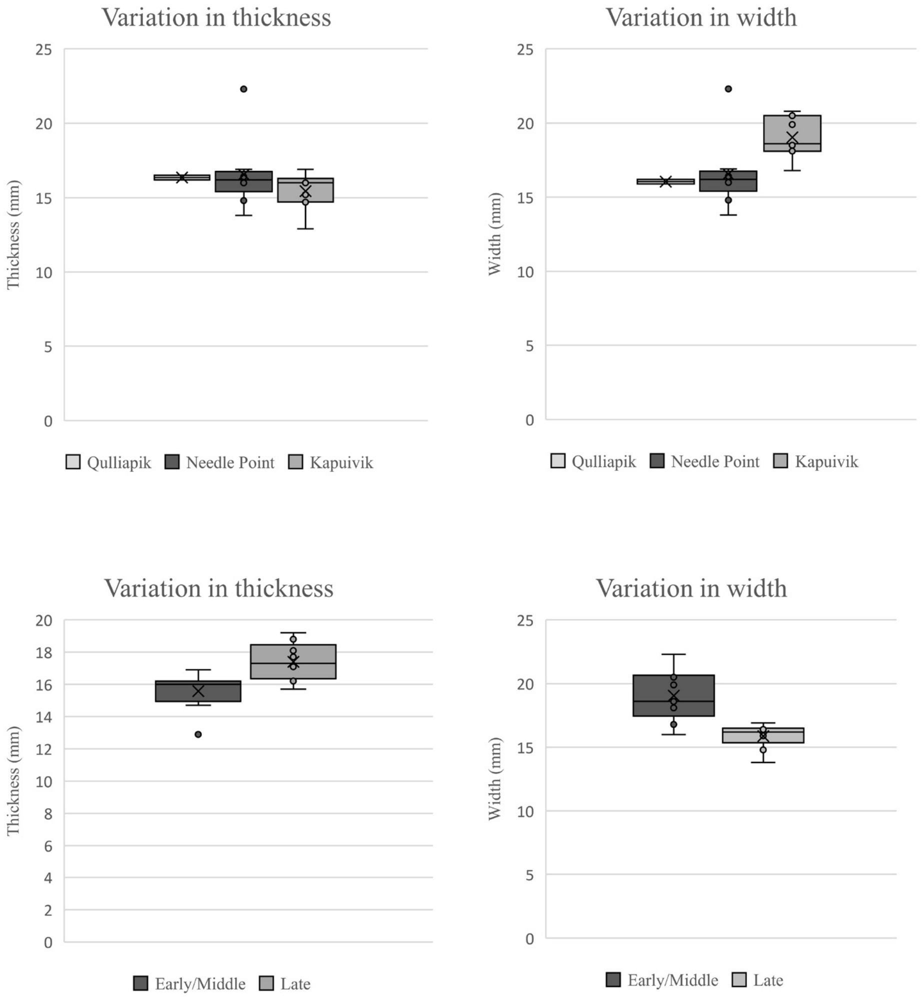


Figure 6. Comparisons of Dorset Parallel harpoon-head thickness (left) and width (right) according to site (upper) and time period (lower).

the two time periods, it becomes clear that Late Dorset pieces are thicker, while Early/Middle Dorset pieces are wider, which suggests a possible change in size over time.

All the harpoon heads from the Qulliapik assemblage have faceted top-ridges. This contrasts with the two northern locales, where the majority of the objects have curved top ridges. Even when considering the influence of time period, the shape of the top ridge appears to be regionally determined.

The presence of an underhole cannot accurately be compared across all three sites because, due to issues of preservation, it was not possible to identify the presence or absence of this trait on the Dorset Parallel harpoon heads from Qulliapik. However, when comparing the Early/Middle and Late Dorset assemblages from Needle Point and Kapuivik, the underhole is absent from all objects from the later period. Although there may be insufficient data in the present study to validate this result, it does support the suggestion by Houmard that the creation of underholes in harpoon heads is a distinctly Early/Middle Dorset manufacturing choice (Houmard *pers. comm.*).

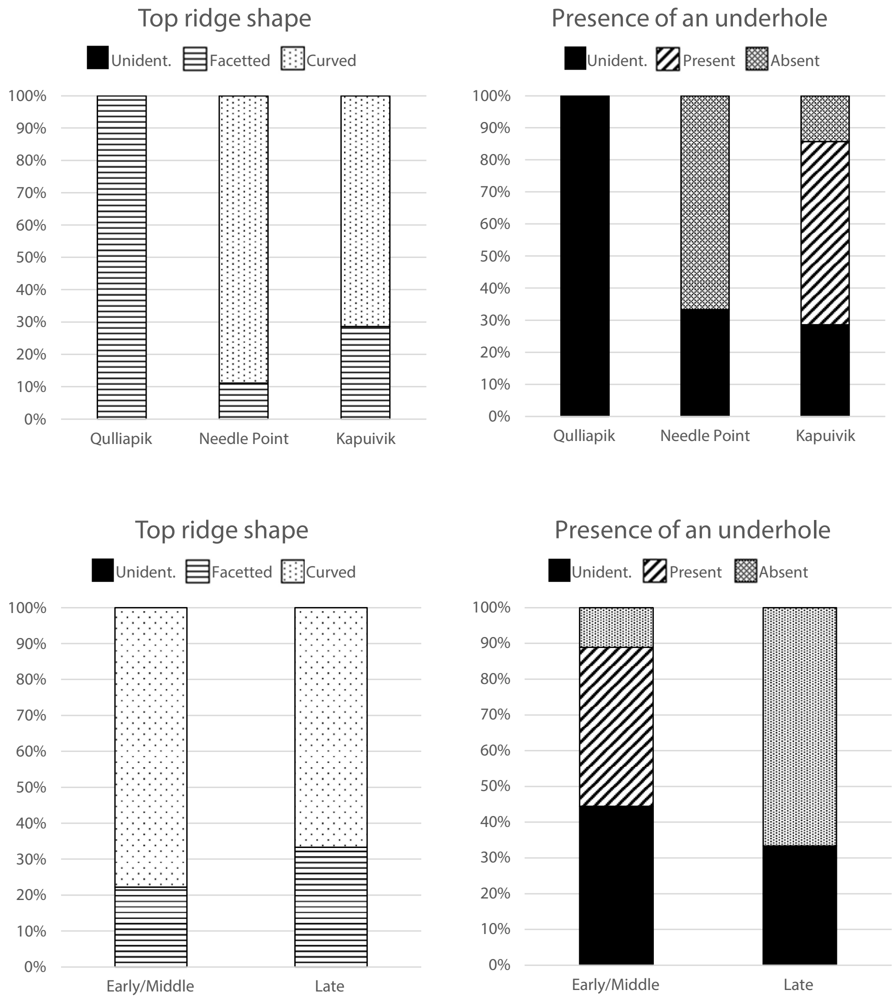


Figure 7. Comparisons of top-ridge shape (left) and the presence of an underhole (right) in Dorset Parallel harpoon heads according to site (upper) and time period (lower). ("Unident." = unidentifiable.)

Usewear traces on needles and harpoon heads

Table 3 presents the results of the usewear analysis, showing the percentages of the different usewear traces observed on the needles and harpoon heads from all three sites. As previously mentioned, the aim of the analysis in the present study is to identify whether there is any variation in the type of usewear present on objects between the different regions and time periods. The reasons behind such variation will be the subject of an upcoming experimental study, which will then provide the necessary data to allow interpretation of the different usewear traces observed (for example, experiments to investigate the possibility of distinguishing between the type of polish and striations created through contact with terrestrial versus maritime mammal skin, the effect of contact with storage vessels on the preservation of needle usewear traces, *etc.*).

The results of the comparative analysis shows that the polish on the needles from Needle Point and Kapuivik is more comparable than that between Qulliapik and either of the two northern assemblages. Qulliapik has a higher percentage of objects with A1 polish and no pieces with the brighter B polish, which is present on a relatively high percentage of the needles from the two northern locales. Polish variation therefore seems to be associated less with change over time than with regional location.

Striations included "longitudinal" (those running lengthwise along the needle body) and "circumferential" (those curving around perpendicular to the length of the needle body) varieties (Figure 3). Compared with the harpoon heads, the needles demonstrate significant variation in the observed striation morphology. However, the reasons for this variation remain unclear. Compared with other usewear traces, the analysis of the striations does not reveal a clear distinction in terms of chronology or region for either the longitudinal or the circumferential striations. There is a slightly greater degree of similarity between Kapuivik and Needle Point compared to Qulliapik, as the ratio of pieces with longitudinal striations is higher at the northern locales than at the southern site. This regional relationship remains strong even when comparing the presence or absence of striations on needles from the different time periods at the northern and southern sites.

The relative percentages of needles from Needle Point and Kapuivik with and without handling traces are more similar to one another than to those from Qulliapik (Figure 6).[4] However, a comparison according to chronology suggests that perhaps temporal variation has more of an influence than geography. A reasonable explanation for this relationship requires further investigation.

The same criteria are used to distinguish polish types on harpoon heads as on needles. There is more similarity between the polish types on harpoon heads from the two northern locales than on those from either northern site and the southern site. Qulliapik has only a small percentage of pieces with A1 polish, with the majority demonstrating the C type. By contrast, both Needle Point and Kapuivik have a higher percentage of pieces with A1 polish than with C polish. Notably, the two northern locales also include a small number of pieces with the brighter B-type polish. Regional location, rather than time period, seems to have a stronger influence on the type of polish exhibited on harpoon heads from the analyzed assemblages.

The percentage of harpoon heads with handling traces is higher for the Late Dorset period than for the Early/Middle Dorset period. Further investigation is required to determine how long a piece must be handled before handling traces appear and the resulting relationship between the handling of an object and the concentration of handling traces. Although other studies have investigated the formation of handling traces (D'Errico 1993; Maigrot 2003), further specialized exploration is still necessary. Additionally, considering the extent to which a needle must be handled – even during manufacture – it seems unlikely that an object would have no handling traces at all; despite the generally excellent preservation of northern latitudes, taphonomic factors may be impacting the analysis. It is also important to consider how modern handling and treatment by archaeologists might negatively impact the preservation of traces on organic materials.

The combined results of the complete analysis are presented in Table 4, which provides a general overview of variability in traits pertaining to the manufacture and use of the needles and harpoon heads. Clearly there is a much higher level of variation in these traits

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4 Those pieces classified as unidentifiable were considered too badly preserved to accurately identify whether handling traces were indeed present on the surface. Those pieces that are designated as having no handling traces were sufficiently preserved to enable their identification; however, they did not exhibit any handling traces on their surface.

Usewear traces		Site comparison			Chronological comparison	
		Qulliapik	*Needle Point*	*Kapuivik*	*Early/Middle*	*Late*
Needles (% of pieces)	Polish	Unident.: 14 % A1: 57 % A2: 29 % B: 0 % C: 0 %	Unident.: 12 % A1: 21 % A2: 42 % B: 25 % C: 0 %	Unident.: 11 % A1: 26 % A2: 41 % B: 19 % C: 3 %	Unident.: 7 % A1: 24 % A2: 45 % B: 22% C: 2 %	Unident.: 19 % A1: 45 % A2: 29 % B: 7 % C: 0 %
	Striations present	Unident.: 10 % Longitudinal: 81 % Circumferential: 48 %	Unident.: 13 % Longitudinal: 75 % Circumferential: 29 %	Unident.: 4 % Longitudinal: 93 % Circumferential: 44 %	Unident.: 10 % Longitudinal: 83 % Circumferential: 38 %	Unident.: 6 % Longitudinal: 84 % Circumferential: 42 %
	Handling traces	Unident.: 10 % Present: 52 % Absent: 38 %	Unident.: 8 % Present: 75 % Absent: 17 %	Unident.: 4% Present: 81% Absent: 15%	Unident.: 7 % Present: 74 % Absent: 19 %	Unident.: 6 % Present: 68 % Absent: 26 %
Harpoon Heads (% of pieces)	Polish	Unident.: 29 % A1: 14 % A2: 0 % B: 0 % C: 57 %	Unident.: 17 % A1: 33 % A2: 0 % B: 17 % C: 33 %	Unident.: 0 % A1: 39 % A2: 0 % B: 22 % C: 39 %	Unident.: 4 % A1: 37 % A2: 0 % B: 22 % C: 37 %	Unident.: 25 % A1: 25 % A2: 0 % B: 6 % C: 44 %
	Handling traces	Unident.: 43 % Present: 14 % Absent: 43 %	Unident.: 28 % Present: 22 % Absent: 50 %	Unident.: 0 % Present: 17 % Absent: 83 %	Unident.: 7 % Present: 15 % Absent: 78 %	Unident.: 38 % Present: 24 % Absent: 38 %

Table 3. An overview of the results from the usewear analysis of both the needles and the harpoon heads ("Unident." = unidentifiable), including regional and chronological comparisons.

Artifact category	Manufacture traces	Trend observed	Use traces	Trend observed
Needles	Size	Variations over both region and time	Polish	Regional variation
	Cross-section shape	Regional variation	Striations	Similarities over both region and time period
	Proximal end-shape	Mainly regional variation	Handling traces	Variation over time period, with some regional differences
	Perforation	Possibly random		
Harpoon heads	Size	Mainly variation over time period	Polish	Regional variation
	Top-ridge shape	Regional variation		
	Underhole presence	Possible variation over time period (data limits)	Handling traces	Temporal variation

Table 4. Summary of the main spatiotemporal trends in the dataset.

than would have been predicted by a purely superficial typological approach, and so we can refute the long-held assumption that Dorset tools were made and used in the same way across larger areas. Interpreting and explaining these patterns of variability is more challenging, and we offer some suggestions below.

Discussion and conclusion

In this study, we aimed to develop a new perspective on the nature of technological practice among Dorset groups. The unique Dorset material culture has long been used to define this tradition in relation to earlier Paleo-Inuit and later Thule-Inuit cultures as well as to draw conclusions about the extent of cultural contacts between them, especially the poorly-understood interactions between Late Dorset communities and early Thule Inuit peoples. As a result, Dorset material culture was defined in terms of superficial typological criteria that emphasized similarity and downplayed internal variability. Recent theoretical perspectives on technological practice highlight the fact that material culture traditions are acquired and reproduced via situated social practices and that the production and subsequent use of any artifact is subject to a wide array of copying errors and deliberate cultural choices, which have the capacity to inject high levels of variability and change into technological traditions (Shennan 2008; Hosfield 2009). This may especially be true of small and relatively isolated groups of hunter-gatherer-fishers, such as the Dorset. These theoretical frameworks led us to question the assumptions underlying the general consensus that Dorset material culture was highly standardized over large geographic areas.

Using the *chaîne opératoire* approach to undertake a detailed microscopic analysis of the manufacturing and usewear traits in needles and harpoons recovered from three Dorset locales, we are able to demonstrate higher degrees of variability than could have been predicted by a purely typological approach. This raises a number of important new questions about what generated these patterns, including the manner in which the two technological traditions – needles and harpoon heads – were acquired, practiced, and shared, both regionally and over time. Accounting for these patterns of variability on the basis of the current dataset is challenging. Clearly, the most compelling possible explanations potentially relate to dynamic developments in local learning and social practice, regional interaction patterns (including the trade or exchange of objects, partners, skills, and ideas), and their impacts on long-term cultural inheritance. However, drawing firm conclusions would be speculative at this early stage. Although traces of manufacture and use can be observed and described, they will only lead to interpretations, not identifications (van Gijn 2014; Bradfield 2016). Any interpretations made here, or in any study investigating the *chaîne opératoire*, should always be open for re-interpretation in future studies (Coulson and Andreasen 2020). Further research is needed to test these ideas more explicitly, using more targeted case-studies, as well as larger datasets drawn from more sites, periods, and artifact categories.

Our primary conclusions are that (a) Dorset material culture was produced and used in subtly different ways, even within the same superficial typological categories; (b) a microscopic approach to manufacturing trace and usewear analysis, combined with theoretical concepts from the anthropology of technology, is an effective approach to investigating and documenting this diversity and (c) a much larger project scale and dataset of research is still required to properly document and fully explain these patterns. Clearly, our appreciation of Dorset technology and material culture has reached a new threshold, and much important work remains to be done before we fully understand the deeper social significance of its production and use.

Acknowledgments

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