Title

Interpreting High Arctic Subsistence: A Zooarchaeological Investigation of Late Dorset and Inuit Fauna and Osseous Technology at Iita, NW Greenland

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Interpreting High Arctic Subsistence: A Zooarchaeological Investigation of Late Dorset and Inuit Faunal Remains and Osseous Technology at Iita, NW Greenland

By

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DISSERTATION

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Abstract

Interpreting High Arctic Subsistence: A Zooarchaeological Investigation of Late Dorset and Inuit Faunal Remains and Osseous Technology at Iita, NW Greenland

The archaeological site of Iita in Inglefield Land, northwestern Greenland is situated within a coastal environment that has relatively high biological productivity for the High Arctic and therefore supports a diverse array of Arctic fauna which, consequently, has attracted Indigenous peoples for millennia. Iita (Etah) is also well known in Arctic exploration literature, as it was home to an Inughuit community employed by several Arctic expeditions in the 19th and early 20th centuries. Located near a large colony of seabirds known to have been exploited by the Inughuit community, it has been suggested that the presence of this large dovekie colony may have influenced the history of human settlement in the region (Darwent and Johansen 2010; Davidson et al. 2018).

The rare formation of several unmixed stratigraphic layers corresponding to consecutive occupations by two distinct foraging groups at Iita presents a novel opportunity to observe changes in the use of animal resources through time. The first recorded inhabitants of this site were the Late Dorset whose material culture is the terminal manifestation of the Arctic Small Tool tradition (ASTt). The Late Dorset have no known cultural or genetic descendants (Raghavan et al. 2014) and it has been suggested that the arrival of a new foraging people may be related to the demise of the Late Dorset, although the nature of contact is still debated (Friesen 2000; Park 2016). Inuit, who are the pre-contact ancestors of the local Inughuit who live in the region today, were the second group to occupy Iita. Previous research has shown that these two cultures employed widely differing technologies, which should be reflected in their subsistence (Maxwell 1985).

Because non-animal sources of food and raw material are nearly absent in High Arctic Greenland, precolonial Indigenous peoples primarily relied on animal resources for their complete subsistence economy. One way to infer subsistence strategies of past cultures is by identifying and quantifying archaeological faunal remains. Examining faunal remains deposited by these two culturally distinct groups at Iita presents an opportunity to assess how various animal sources contributed to the subsistence lifeways of populations at this site.

This dissertation investigates resource use by examining two complimentary aspects of animal remains from archaeological midden deposits, including an assemblage processed for consumption and another assemblage of osseous debris produced from making tools out of various animal skeletal materials. The faunal remains recovered from excavations at Iita in 2012 and 2016 are associated with temporal/cultural contexts spanning nearly 1,000 years from the Late Dorset (1050–1250 CE) through to the Inughuit and Euroamerican periods (1850–1950 CE). This analysis provides the first, detailed investigation of Late Dorset subsistence practices and expands our current knowledge of precolonial Inuit subsistence practices at Iita.

This research suggests that despite both foraging groups having access to the same suite of animal resources, the two foraging groups living at Iita practiced distinct subsistence strategies. The broad differences between Late Dorset and Inuit societies stem from deviations in subsistence strategies and curated technologies such as the bow-and-arrow, dog sledges, and watercraft, which also influence subsistence choices. This research examines variation between the two groups while minimizing variability due to local environmental factors, an advantage associated with analyzing materials from a single archaeological site. This research contributes to our understanding of the persistence of Inuit and disappearance the Late Dorset and variation in human behavior more broadly.

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1. Introduction and Dissertation Overview

This dissertation investigates the similarities and differences in subsistence strategies practiced by two distinct Arctic foraging groups who consecutively occupied the archaeological site of Iita in northwestern Greenland. To accomplish this, I examined faunal remains discarded by Late Dorset and Inuit who occupied Iita at different times over the last 1,000 years. The overarching goal of this zooarchaeological analysis is to explain human behaviors which produced the faunal assemblage. To do this, I ask questions regarding subsistence practices, or how people acquired food and other resources needed to live. Zooarchaeological analysis provides insight on past human-animal interactions, especially as it concerns how people make decisions about which resources to use, such as which animals to use for food or for raw materials. Because animals provide benefits beyond nutrition and calories, modified non-edible portions are also indictors of resource use. I examine debris produced during various stages of bone technology production to assess differences in how these two groups used non-edible, skeletal portions.

Background

The Arctic is geographically and environmentally marginal. Among the various terrestrial environments on Earth, none support fewer types of plants than the biomes found within the Arctic (Billings and Mooney 1968). Greenland has two biomes, a) an icecap or polar desert which covers over 80% of Greenland’s surface and characterizes the interior portion of the island, and b) tundra which is found along the coastlines and characterizes the fjords (Raikar 2023). The tundra has relatively low biodiversity due to consistent average annual temperatures below 0°C, minimal precipitation, and the presence of permafrost and only a minimal number of low and slow growing plant species have adapted to these conditions such as shrubs, heathers, lichens, and moss (Wielgolaski 1972). A further reduction in terrestrial biodiversity occurs at approximately 75° north latitude—an area colloquially referred to as the High Arctic. As vegetation is limited in the High Arctic, the human-animal relationship is pronounced (Howse 2019). Here, animals provide nearly all resources for humans, including the primary food source and various raw materials for everyday items like tools and clothing.

Due in part to the geographical and environmental marginality of this region, the North American Arctic was one of the last global regions to be inhabited, with people migrating from Siberia into Alaska, across the Canadian Arctic and finally reaching Greenland about 4,500 years ago. The first peoples to do so are broadly referred to as Paleo-Inuit with a technological system known as the Arctic Small Tool tradition. Over time, the Paleo-Inuit occupied various regions of the Arctic, expanding, and contracting and adapting to local ecosystems. The last phase of the Arctic Small Tool tradition is known as the Late Dorset, an archaeological culture which occupied a wide range in the North American Arctic from 500–1300 CE. Then, around 1250 CE, ancestors of contemporary Inuit rapidly moved across the Arctic from the Bering Strait region and into Greenland. Archaeological and genetic evidence suggests the newly arrived Inuit population replaced the Late Dorset with little to no genetic exchange, indicating that these two populations were culturally, technologically, and genetically distinct (Raghavan et al. 2014).

Previous research comparing Late Dorset and Inuit resource use suggests that even though these two foraging societies lived in similar Arctic environments and had access to the same limited set of animals, they practiced different subsistence strategies. Howse (2019) suggests that many of the differences in subsistence patterns stem from distinct technological toolkits and hunting gear, rather than from changes in the availability or distribution of animals. For example, the successful hunting of large cetaceans requires large watercraft. There is currently no evidence for Late Dorset watercraft. Conversely, large whale-hunting boats, harpoons, and floats—technologies associated with successful active hunting of whales—are characteristic of classic Inuit material culture. Therefore, the technology curated by each foraging group will also influence subsistence choices. For instance, without watercraft, Late Dorset would be limited in the number and type of cetaceans they could actively pursue and successfully capture. In other words, without the proper set of tools, some animals may require too much time or energy to capture and would therefore only be taken on occasion.

Technological differences manifest in material culture beyond subsistence choices. For instance, the lack of bow-and-arrow technology in the Late Dorset period precludes the use of a bow drill for perforating everyday items. Instead, Late Dorset perforated their objects by repeatedly incising an area, resulting in unique manufacturing traces characteristic of the Late Dorset (see Chapter 4). A sample of technological differences between Late Dorset and Inuit culture is outlined in **Table 1.1**.

Table 1.1. Distinctions in Late Dorset and Inuit technology are outlined below by the presence (✓) or absence (—) of evidence for a sample of technologies. Adapted from Howse (2019) and references therein.

Technology	**Late Dorset**	**Inuit**
Sleds	✓	✓
Dogs	—	✓
Harpoons, spears, lances	✓	✓
Bow & arrow	—	✓
Marine hunting floats	—	✓
Nets	?	✓
Boats	?	✓
Drills	—	✓

Previous studies have compared Late Dorset and Inuit materials to better understand why these two foraging groups practiced such different resource use strategies. For the most part, these have been multi-site analyses, sampling from various sites and features across the Arctic. Additionally, many of these assemblages are from winter occupations and the analyses tend to focus on mammalian remains.

Inglefield Land, the unglaciated portion of northwestern Greenland, has been described as the “Gateway to Greenland” as it was one of the first areas in Greenland occupied by people who crossed the Arctic from Alaska (**Figure 1.1**). In 1996, the Gateway to Greenland Project set out to investigate human habitation and resource use in the Hatherton Bay region of the Thule District of Greenland as part of a large, multidisciplinary research program, “Man, Culture, and Environment in Ancient Greenland” (Arneborg and Guløv 1998).

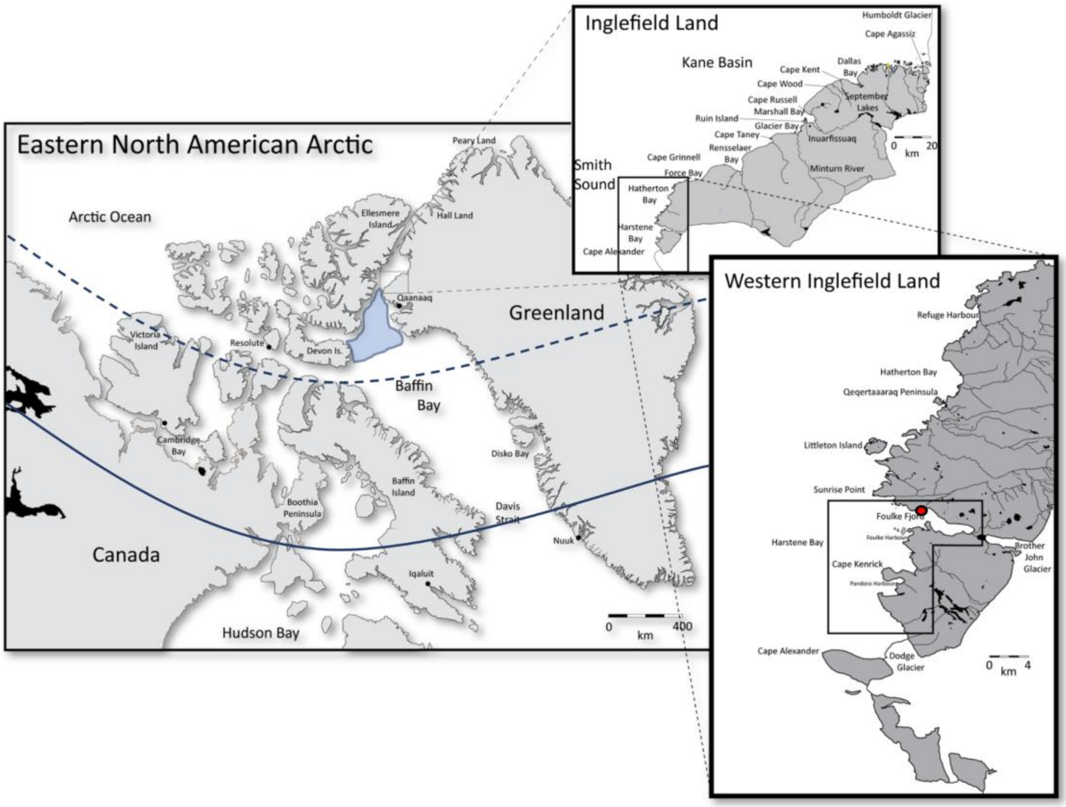

Figure 1.1. Map of the Eastern North American Arctic with the study area detailed in the two regional maps. Iita is located within Foulke Fjord and is represented by the red dot in the bottom right map. The solid blue line indicates the Arctic Circle at 66° North latitude while the dashed blue line represents the High Arctic at approximately 75° North latitude. The North Water polynya is illustrated as the light blue triangular area in norther Baffin Bay. Original map by John Darwent.

The University of California, Davis, Bowdoin College, and the Greenland National Museum formed a joint research project called the Inglefield Land Archaeology project (ILAP) in 2004. The archaeological site of Iita was one of several identified locations of interest during ILAP's continued investigation of human history in this northwestern region of Greenland. The general location of Iita was well known as it had been frequented by Arctic explorers since the mid-1800's. One of the longest, continuous Euroamerican occupations was Donald MacMillan's Crocker Land Expedition from 1913-1917. This expedition employed various scientists who recorded data on the ecology, zoology, and ethnography of the Foulke Fjord region. These archives are kept by the American Museum of Natural History and Bowdoin College at the Peary-MacMillan Arctic Museum and provide indispensable historic information regarding Inughuit lifeways after contact by British and American explorers.

Iita is situated in an area of Greenland that is unique for several reasons. First, it is located at the northern limits of *Pikialasorsuaq*, the North Water polynya, which has been described as an “Arctic oasis” (Darwent et al. 2019; Jeppesen et al. 2018). The polynya, located within Baffin Bay, is continually ice free, providing important feeding grounds for various marine species. For thousands of years, the abundance of zooplankton and small fish in the polynya has attracted migratory birds that nest along the coastline including the rocky cliffs of Foulke Fjord. The most numerous of these migratory birds are dovekies (*Alle alle*), which return to this area every summer in the millions (Jeppesen et al. 2018; Mosbech et al. 2018).

The seasonal aggregation of these small seabirds has significant environmental impacts. Dovekies are considered ecosystem engineers due to their transportation of nutrients from the polynya into the surrounding terrestrial habitat in the form of guano (Davidson et al. 2018; Mosbech et al. 2018). This fertilization stimulates growth of the local vegetation which in turn attracts land mammals like caribou, muskox, hare, and fox. Overall, this is an area that supports an array of Arctic fauna which has consequently attracted and supported human populations for millennia (LeMoine and Darwent 2010, 2016; Schledermann 1990).

The sedimentary structure and site formation of Iita is also unique in that it sits on a sloping kame deposit, or glacial mound, approximately seven kilometers into Foulke Fjord (Darwent et al. 2019). Over time, the downhill movement of soils resulted in the development of stratigraphic layers, which is uncommon for the High Arctic. In the Arctic, soil development is slow and artifacts from the last 4,000 years are typically found intermixed on the surface. However, this unique formation at Iita resulted in a series of unmixed, stratigraphic layers and provides a rare opportunity to examine changes in resource use over time in Northern Greenland **Figure 1.2**.

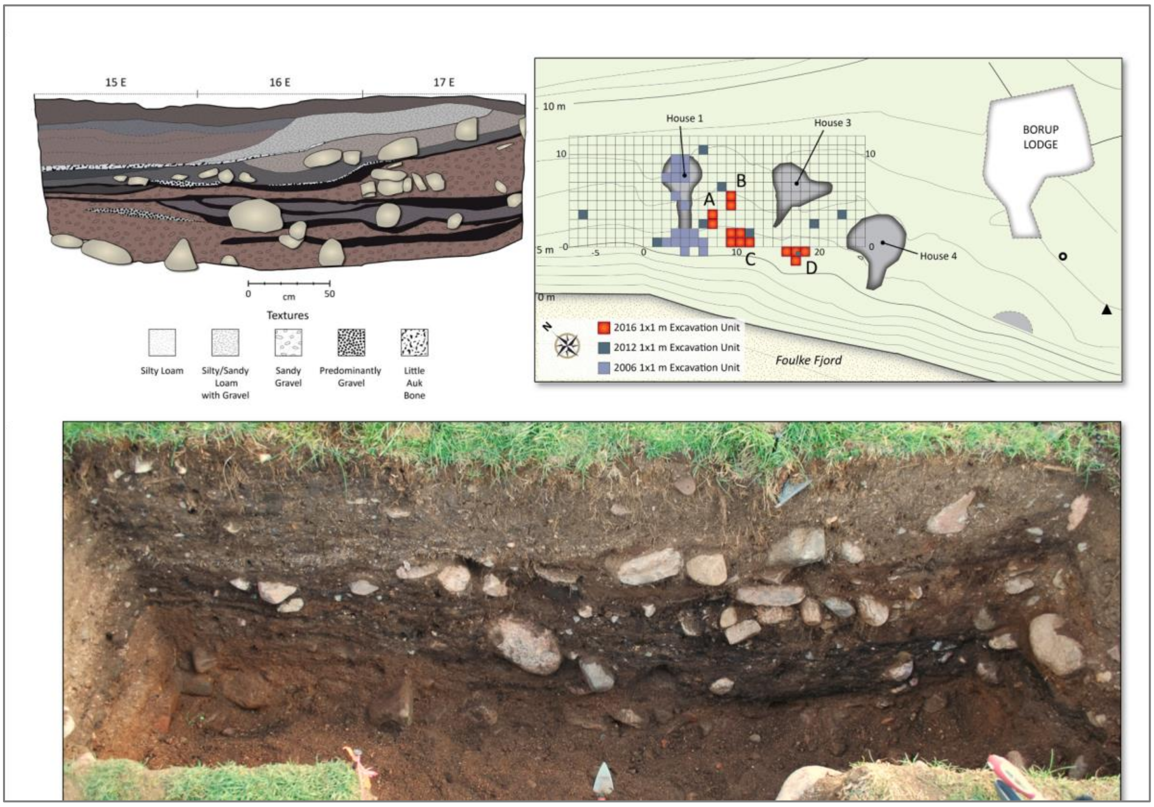

Figure 1.2. The bottom photo and top left illustration demonstrate the stratigraphy of the north wall of excavation Block D. The top right panel shows a plan map of the excavation area. Photo and illustrations by John Darwent.

Excavations in 2006 revealed multiple Historic Inughuit and precolonial Inuit winter houses and associated middens. Faunal remains from the house deposits were identified and the resulting analysis formed the bulk of Johansen’s (2012) dissertation. The 2006 excavations also revealed chronologically older stratigraphic layers beneath these house deposits with chert flakes characteristic of Late Dorset, indicating a Pre-Inuit occupation of Iita. Excavations resumed in 2012 and again in 2016 with a focus on locating deposits with a

Late Dorset association. These deposits were vulnerable to loss via coastal erosion, a complex process resulting from decreasing protection from permafrost and ice, and increased wave action which removes large portions of the coastline (Darwent et al. 2019). Changes in the Iita coastline are illustrated in **Figure 1.3**.

Figure 1.3. Coastal erosion of Iita has rapidly increased over the past decade. Historic images compared to contemporary photos demonstrate site loss. Seen in the left image, Borup Lodge served as the headquarters of the 1913–1917 Crocker Land expedition led by Donald B. MacMillan. The yellow tent in the right photo is in approximately the same location as the Borup Lodge. The historic glass lantern image is courtesy of the Peary-MacMillan Arctic Museum, Bowdoin College (https://www.bowdoin.edu/arctic-museum/). Contemporary photo by John Darwent.

The current research differs from previous research by Johansen (2012) in three main ways. First, I analyzed materials from adjacent middens rather than house contexts. Second, I identified faunal remains from both Late Dorset and Inuit contexts to understand resource use over a 1000-year period. Third, I analyzed a portion of the osseous technology assemblage to better understand skeletal resource use and tool production at Iita. Additional differences in methodological approaches are discussed in the following chapters.

This dissertation is also distinct from previous studies comparing Late Dorset and Inuit resource use. Specifically, I examine faunal remains from Iita, a single site with multiple archaeological deposits spanning from the Late Dorset to Historic Inughuit occupations, allowing me to compare the subsistence strategies of the two groups while keeping the environmental context consistent. Iita also has evidence of winter and summer occupations while many of the previous multi-site analyses examine assemblages exclusively from winter occupations (Darwent 2001; Darwent and Foin 2010; Howse 2019).

Zooarchaeological Materials

Given the overwhelming quantity of faunal remains, and because analysis of Inuit-Inughuit fauna from houses at Iita had been undertaken previously (Johansen 2012, 2013), we selected a representative subsample of three midden units that spanned the entire Inuit-Inughuit occupation at Iita for analysis (refer to **Appendix A** for an inventory of the faunal materials analyzed from each context). The primary faunal data analyzed within includes osseous tools and manufacturing debris, which were recovered from midden deposits at Iita excavated in natural stratigraphic layers and screened using $\frac{1}{4}$ -inch mesh in 2012 and $\frac{1}{8}$-inch mesh in 2016 (Darwent et al. 2019). A total of 15, 1x1 meter units were excavated, and 100% of the faunal remains across all cultural layers were carefully hand sorted for debris from osseous tool production.

The cultural affiliation for each of the stratigraphic layers was determined using the presence of materials indicative of Late Dorset or Inuit. For example, the recovery of stylistically distinct lithic artifacts characteristic of Late Dorset was the initial indicator that a Pre-Inuit group had occupied Iita prior to the Inuit (see Darwent et al. 2019). Strata bearing

Inuit material culture was further broken down into specific periods following previously established research (Holtved 1944; McCullough 1989; Whitridge 2016). Additionally, certain modifications were used to indicate temporal and cultural association. For instance, faunal remains with clear modification using a toothed metal saw were attributed to the Historic period, after Inughuit had access to such implements through trade with European and American explorers. Further descriptions of the cultural periods are in **Table 1.2**.

Table 1.2. Cultural chronology of the Iita archaeological deposits. In addition to artifact typology and modifications, radiocarbon dating of materials from the midden deposits were used to establish the date-ranges for each occupation (**Figure 1.4**).

Period	**Approximate Age Range**	**Description**
Euroamerican period	1910–1950 CE	This period is used for the osseous technology component only. Although the materials in this group were more than likely manufactured by Inughuit, this period is separated due to the contexts' association with British and American occupants of the site. For example, Euroamerican artifacts (e.g., metal buttons) are intermixed with the osseous tools.
Inughuit Period	1850–1950 CE	Osseous artifacts and faunal remains classified as the Inughuit period were recovered predominantly in the first two levels of the site and represent osseous tools that were manufactured by the Inughuit after Euroamerican contact.
Late Inuit/Inughuit Period	1700–1850 CE	This period represents found near the top of the strata levels (usually Level 3 and below) with few to no Euroamerican artifacts present. All Euroamerican artifacts present are small, likely intrusive objects.
Middle Inuit Period	1500–1700 CE	During this period, it is likely that most hunting of bowhead whales had ceased.
Early Inuit Period	1300–1500 CE	Earliest dates correspond with the Ruin Island phase material defined elsewhere in Inglefield Land (Hotved 1944; McCullough 1989) and other initial Inuit migrants to the area; also called Classic Thule.
Mixed Late Dorset-Early Inuit Period	1250–1350/1500 CE	In the case of the Early Inuit Period, the closing date would be 1350. However, as it appears there might be a gap in the midden areas, the closing date may be as late as 1500 AD (essentially 250 years).
Late Dorset Period	800–900 CE, 1050–1300 CE	For the region, the earliest evidence for Late Dorset is ~ 800 CE and the latest is 1350; however, at Iita, most evidence indicates an occupation between 1050–1300 CE. Only one date (KNK3930x244) suggests an earlier presence.

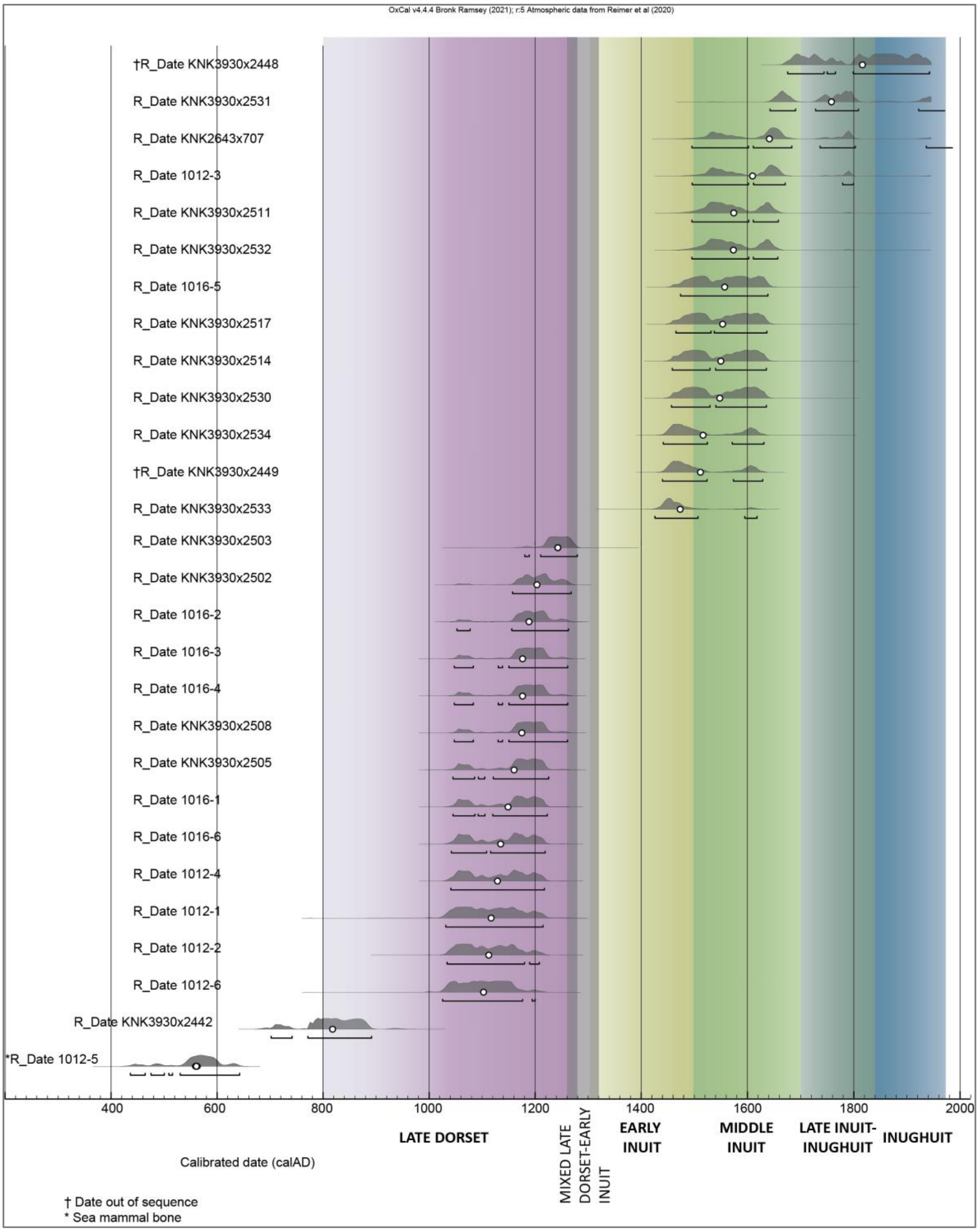

Figure 1.4. Archaeological contexts and associated radiocarbon dates for specimens from midden deposits at Iita. Figure by John Darwent.

Research Objectives

This dissertation aims to describe and characterize foraging strategies of the Late Dorset and Inuit through the analysis of faunal remains. Additionally, we clarify species representation and improve previous understandings of Late Dorset and Inuit skeletal reduction techniques and material preferences through the analysis of debris associated with bone-tool production. The study region of Inglefield Land in northwest Greenland is biogeographically marginal—located at the edge of human geographic habitation. Studying material culture left behind by people who lived in this extreme environment provides us with information on human adaptability, resilience, and can help us understand choices made under certain ecological constraints. Zooarchaeological analysis can provide insight into resource use in these domains. This research addresses the following research questions:

1. How do the two culturally and chronologically distinct groups use the same set of animal resources at Iita?
2. Can the analysis of debris from osseous tool production provide additional insight into the taxa and material type used for osseous technology at Iita?
3. How are patterns of Late Dorset and Inuit resource use at Iita similar to and different from other sites across the Arctic?

Theoretical Framework

To understand the history of human occupation at Iita, I approach the archaeological record from a behavioral ecological perspective. Optimal foraging theory (OFT) predicts dietary choices on the premise that economically rational, self-interested individuals tend to optimize caloric return rates, whether by maximizing returns, minimizing effort, or some combination thereof during resource procurement (MacArthur and Pianka 1966). Although hunters rarely behave optimally, OFT offers well-defined, explicit models for identifying when individuals or societies stray from optimality and allows us to examine why that may be so.

Food items vary in qualities such as caloric value and the average time needed to locate and process them. The Diet Breadth Model, also known as the Prey Choice Model, predicts that individuals will select prey items that offer higher caloric gains to balance the trade-off between time and energy allocation. The diet breadth model can be used to predict whether a single active forager will capture a resource upon encounter (Bettinger 2009). This model assumes a forager will decide which resources to exploit based on previous knowledge of resource quality and density, thus using information about search and handling costs related to energetic return rates. The model also assumes that all prey types in the optimal diet are searched for simultaneously but pursued independently.

The diet breadth model is essentially a contingency scheme to help predict when, and if, a new prey item will be incorporated into a diet (Bettinger 2009; Winterhalder and Smith 1981). A forager decides among prey items that vary in abundance (temporal and spatial), amount of energy produced per item, and costs associated with handling/processing that item. The forager must select a combination of prey items that will maximize energy intake per unit of time spent foraging, producing an optimal diet (Winterhalder and Smith 1981).

The diet breadth model predicts that a new resource will only be added to the diet if its return rate is equal to or less than the previous highest-ranked item. In other words, prey types are incorporated into the diet until the additional pursuit time necessary for including the next prey type is greater than the savings in search time and are ranked by the ratio of energy (kcal) intake to handling time (Bettinger 2009; Winterhalder and Smith 1981). The diet breadth model may therefore be used in conjunction with faunal analysis to predict human-prey interactions over time and across space to inform expected optimal behavior given certain changes in human-prey dynamics (Bettinger 2009).

The low biodiversity of the Arctic presents a simplified case study to evaluate these models, especially when a large resource patch, such as nesting birds, is available. This research will use the diet breadth model from OFT to examine how human foraging decisions are affected when A) there is low biodiversity and B) there are constraints based on hunting technology, such as the lack of watercraft.

Dissertation Overview

This dissertation is organized into three main chapters, each focusing on a different aspect of the faunal remains in my reconstruction of pre-contact subsistence patterns at Iita. Chapters 2, 3, and 4 are intended to be independent manuscripts that address different aspects of the faunal remains and their use in reconstructing subsistence practices at Iita.

Chapter 2 provides a detailed report of the faunal remains from a more traditional zooarchaeological analysis. Here, I present and discuss the bulk of my primary data focusing on the results of a multi-component faunal analysis. This chapter provides the first, detailed investigation of Late Dorset subsistence practices at Iita and expands our current knowledge of precolonial Inuit subsistence. This chapter explores differences in taxonomic composition across the five cultural components in the faunal assemblage, including Late Dorset, Mixed Late Dorset-Inuit, Middle Inuit, Late Inuit-Inughuit, and Inughuit. The faunal assemblage at Iita is unique given that 65% (8,386) of the identified remains are birds. One taxon, dovekies, dominates the faunal assemblage. Although dovekies are well represented across all five archaeological contexts, there is variation in how other animal resources are being used at

Iita. For example, the Late Dorset appear to have taken a wider variety of resources in relatively equal proportions compared to the Inuit. Our findings indicate that, despite both foraging groups having access to the same set of animal resources near Iita, the Late Dorset and Inuit had distinct subsistence practices.

Chapter 3 presents a discussion of the implication of including osseous technology in zooarchaeological reports. In this chapter, I demonstrate how the application of digital microscopy and Zooarchaeology by Mass Spectrometry (ZooMS) or peptide Mass Fingerprinting has allowed for the identification of previously unknown osseous fragments. This technique has shown that marine mammals, particularly small cetaceans such as narwhal, were used much more frequently by the Inuit at Iita than previously reported. For people living in the Arctic, skeletal materials like antler, bone, and ivory were essential to making everyday objects due to the lack of vegetation such as wood. Because certain taxa are only represented in the osseous tool assemblage, I find that our understanding of foraging practices using more traditional zooarchaeological analysis (Chapter 2) does not provide a complete picture of resource use at Iita. These results suggest that the prey choice of Inuit is more diverse than indicated in Chapter 2. This increase in diversity (the number of distinct taxa) is driven by the identification of three whales—bowhead, beluga, and narwhal—which were accessed much more frequently by Inuit than Late Dorset. Despite an increase in taxonomic diversity, the proportion that each taxon contributes to the total assemblage is relatively unequal, indicating a preference for certain taxa. In contrast, our understanding of Late Dorset animal resource use does not change dramatically. In general, resources used by the Late Dorset is reflected in their osseous tools as well as in the faunal remains discarded post-consumption. I argue that attention to modified osseous materials is important for drawing a fuller picture not only of raw material selection for tools but also of subsistence strategies and resource use more generally.

Chapter 4 addresses questions beyond species representation within the osseous technology component, with a focus on the frequency of various raw material types and how they are processed or reduced for toolmaking. Because the two archaeological forging groups, Late Dorset and Inuit, are defined by their use of different material culture, such as the presence/absence of certain technologies, this chapter explores the implications these technologies may have had on the choice of raw materials, and the reduction and processing of those materials.

First, I review a sample of previous literature on Late Dorset and Inuit bone technology. Then, I provide a detailed methodology for two identification criteria: 1) manufacturing actions, which describes how materials were modified, and 2) reduction types, which describes the stage of production. Identification criteria used for distinguishing material types is in **Appendix B**.

In total, I identified 868 pieces of osseous debris attributed to tool manufacture from midden deposits. Most Late Dorset osseous tools are composed of antler and ivory, while Inuit have a more varied tool kit, including some materials which may have been harder to obtain through active hunting for the Late Dorset, such as baleen and narwhal ivory. The chronologically later Inuit components have a higher frequency of waste and discarded portions compared to the earlier components including the Late Dorset. The high frequency of chopping as a manufacturing action used to reduce materials is one commonality shared between the two groups. Iita is one of the few sites in the High Arctic with intact stratified deposits spanning multiple cultural occupations, providing us an opportunity to explore changes in resource use and tool manufacture over its 1000 years of human occupation. Studying osseous technology provides information on resource procurement strategies and other economic decisions such as the curation or reuse of materials of different foraging groups, which complements data reported in Chapter 2.

Chapter 5 includes a synthesis of the data generated from this dissertation. I then present my interpretations of the data using human behavioral ecology and foraging theory. This chapter also compares my findings to conclusions reached by previous research at Iita and the Eastern High Arctic more broadly. Finally, I provide concluding remarks and suggestions for future research.

2. Interpreting High Arctic Subsistence Practices: Analysis of a Multi-Component Faunal Assemblage from Iita, NW Greenland

Introduction

The archaeological site of Iita is situated near the northern limits of the North Water polynya (**Figure 2.1**). The polynya, an area of continually ice-free water surrounded by sea ice, is considered the most biologically productive ecosystem north of the Arctic Circle (Ingram et al. 2002; Stirling 1980). This nutrient rich, ice-free water hosts large plankton blooms, which then attract a series of marine mammals such as walrus, seals, polar bears, bowhead whales, beluga, and narwhal. However, migratory seabirds such as dovekies are one of the most numerous inhabitants of this area, at least for the short summer season (Davidson et al. 2018; Mosbech et al. 2018). Millions of seabirds nest in large rookeries on the cliffs of talus scree which line the coast and fjords. This large aggregation of birds begets the fertilization of the surrounding terrestrial areas with guano. This cycling of nutrients increases the local vegetation which then attracts land mammals like caribou, muskox, hare, and fox. Overall, this is an area that supports a diverse array of Arctic fauna which has consequently attracted and supported human populations for millennia (LeMoine and Darwent 2010; Schledermann 1990).

This chapter presents the results of faunal analysis from a multi-component assemblage from Iita. The faunal remains are associated with five temporal/cultural contexts spanning nearly 1,000 years from the Late Dorset (1050–1250 CE), Mixed Late Dorset-Inuit, Middle Inuit (1500–1700 CE) through to the Late Inuit (1700–1850 CE) and Inughuit periods (1850–1950 CE). This analysis provides the first, detailed investigation of Late Dorset subsistence practices at Iita and expands our current knowledge of precolonial Inuit subsistence practices at Iita. The identification and interpretation of faunal remains provides insight into the choices Arctic foragers were making regarding resource use. Iita presents a unique opportunity to examine how this varies over time and between culturally distinct populations which consecutively occupied Iita.

Despite a limited diversity of animals compared to subarctic zones, precolonial Indigenous peoples of the High Arctic primarily relied on animal resources for their complete subsistence including nutrition and raw materials for many components of their material culture. Because non-animal sources of food are nearly absent in the High Arctic of Greenland, we can assess how different animal sources contributed to the diets of precolonial Indigenous populations at the site level.

It has been established that the broad differences between Late Dorset and Inuit societies stem from deviations in subsistence strategies and curated technologies which also influence subsistence choices (Howse 2019; Howse and Friesen 2016). Our research provides additional evidence for this by examining variation between the two groups while minimizing variability due to environmental factors, an advantage afforded to us by analyzing materials from a single archaeological site. This research contributes to our understanding of the persistence and disappearance of two precolonial arctic cultures, and variation in human behavior more broadly.

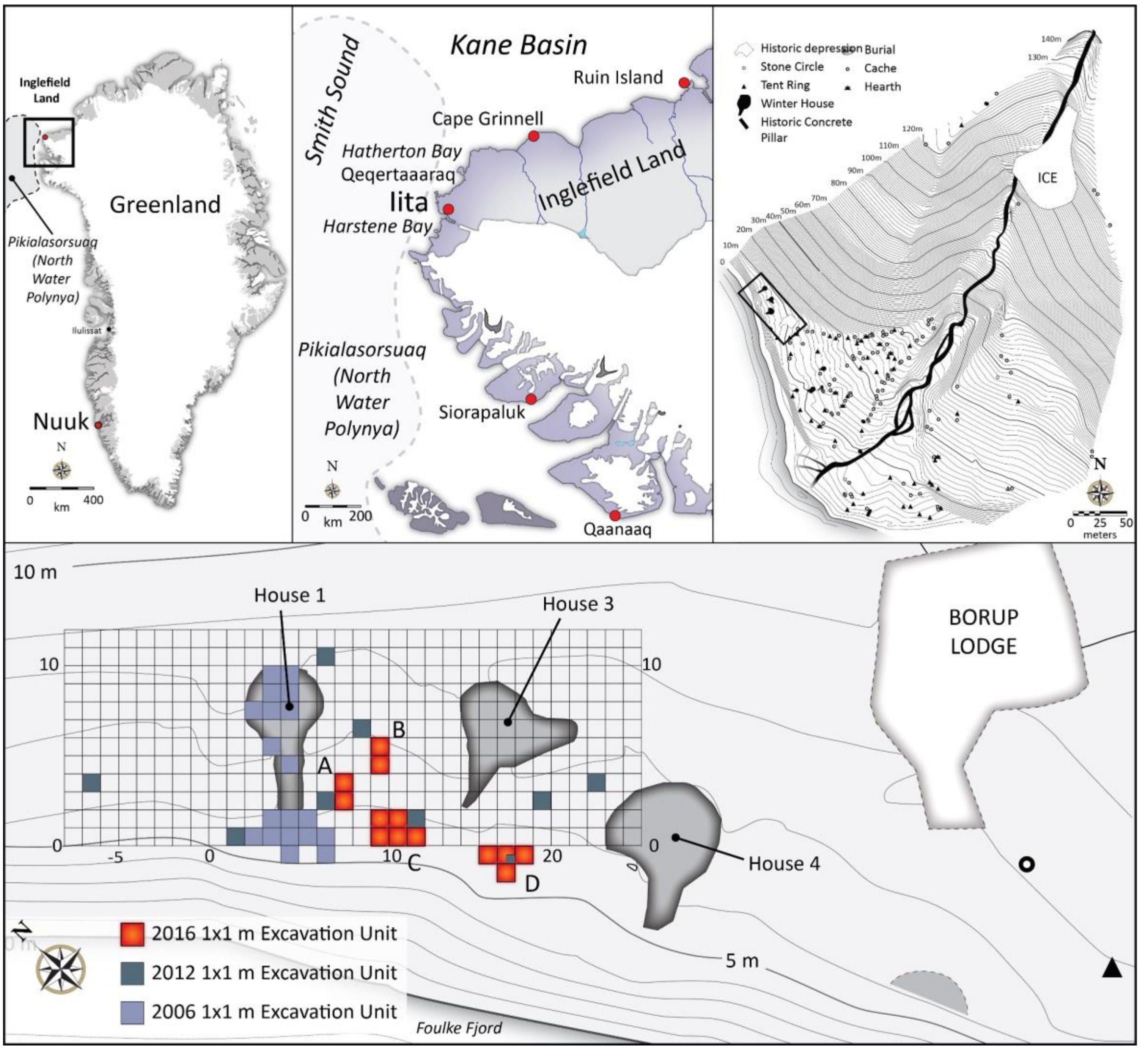

Figure 2.1. Top left and top center panels are maps of the study area with Iita indicated by the red dot in Inglefield Land, North-western Greenland. Iita is located within Foulke Fjord at the northern extremity of the North Water polynya. Top right map illustrates the elevation and location of the site features. The area within the black rectangle is enlarged in the bottom illustration, highlighting the excavation grid at Iita. Map by J. Darwent.

Background

Culture Chronology of the Eastern Arctic

The Pre-Inuit and Inuit are two distantly related but culturally distinct groups that originated in the Bering Strait region and underwent large-scale, pan-Arctic migrations across the eastern Arctic of North America (Maxwell 1985; Raghavan et al. 2014). The Pre-Inuit, descendants of the Bel'kachi archaeological tradition, crossed the Bering Strait from Siberia to northwestern Alaska before 3200 BCE. They expanded across the Canadian Arctic to Greenland and were associated with the Arctic Small Tool (ASTt) technological tradition (Friesen 2016). Archaeologists recognize several ASTt complexes over more than 3,000 years of eastern arctic occupation (Madsen, Grønnow, and Harmsen 2020). However, the Late Dorset phase, which represents the terminal phase of the Pre-Inuit cultures, is the focus of this research. Although the exact timing for the emergence is challenging to determine, this cultural period roughly spans from 500 to 1250 CE (Appelt, Damkjar, and Friesen 2016; Madsen, Grønnow, and Harmsen 2020).

The archaeological record associated with the Late Dorset is distinct from both the earlier Pre-Inuit ASTt and the subsequent Thule-Inuit cultures. For example, many seemingly important technologies including bow-and-arrow, bow drills, dogs, marine mammal hunting floats, and perhaps watercraft were lost during this period (Maxwell 1985; Morey and Aaris-Sørensen 2002). Despite the lack of some technologies, the Late Dorset period is associated with the emergence of large, communal structures known as longhouses, which reached between 14–45m in length and are often associated with numerous external hearth rows, suggesting that the Late Dorset participated in occasional social gatherings of many small family groups, perhaps for cooperative activities such as walrus hunting (Darwent et al. 2008; Friesen 2007).

As defining as the presence of longhouses, Late Dorset material culture is also characterized by finely made objects of bone, antler, and ivory (LeMoine and Darwent 1998). Many of these objects, including harpoon heads and carved animal figurines, are strikingly similar in appearance despite being found hundreds of kilometers apart and likely manufactured by different individuals (LeMoine et al. 1995; Siebrecht et al. 2021). The high degree of uniformity in these objects suggests that strong social connections and trade networks were maintained among groups over long distances and that these figurines were symbolic or spiritual devices (Betts, Hardenberg, and Stirling 2015).

Inuit brought a new way of living to the Arctic, which included bow-and-arrow technology, bow drills, dogsleds, and large boats, enabling the transport of numerous people and communal hunting of large marine mammals, including bowhead whales. Initially defined as “Thule” by archaeologist Therkel Matthiasen (1927), precolonial Inuit cultures of the North American Arctic are the direct ancestors of Canadian and Greenlandic Inuit and Alaskan Iñupiat. Current interpretations suggest Inuit culture developed in the Bering Strait region and spread into the eastern Arctic by 1200 CE (Friesen 2016; Maxwell 1985; Whitridge 2016). Although genetically and culturally distinct from earlier Pre-Inuit groups, scholars do not agree on whether these two cultures interacted or whether such interaction had a causal relationship to the eventual disappearance of Late Dorset (Friesen 2022; Park 2016; Raghavan et al. 2014).

Large, semi-subterranean dwellings of sod, stone, and whale bone typify the *iglu,* the classic Inuit winter dwelling (Whitridge 2016). Inuit occupations are often situated near or on top of earlier Pre-Inuit dwellings, as is the case at Iita (Darwent et al. 2019; LeMoine and Darwent 2010). Radiocarbon dating of sequential cultural layers indicates that the timing of the Late Dorset people’s disappearance and the arrival of Inuit in the eastern Arctic are synchronous, but the extent to which their occupations overlapped remains unclear, and no direct evidence has yet been found for cultural transmission between the two groups (e.g., Darwent et al. 2019; Park 2016).

Inuit communities became regionally specialized and developed geographically unique subsistence and settlement strategies sometime prior to 1700 CE (Mason and Friesen

2017; Whitridge 2016). Inughuit of northwestern Greenland are the most northerly Indigenous peoples in the world and speak Inuktun, a distinct dialect of Inuktitut. The precolonial population size is estimated to have been 100–200 people (Holtved 1944; LeMoine and Darwent 2016). At the time of historic contact, Inughuit did not fish or capture marine mammals in open water; instead, they hunted from the ice edge. Interestingly, like the earlier Late Dorset, knowledge of certain technologies was also lost during this period. Specifically, Inughuit had lost the bow and arrow, fishing leisters, and kayaks sometime in the century prior to contact with British whaler John Ross in 1818 but these technologies were later re-introduced in the 1860's by Inuit from Baffin Island (LeMoine and Darwent 2016).

Shifts in Climate and Culture

Both paleoclimatic and cultural factors must be considered when investigating diachronic changes in resource use. Understanding the role of climate and its effects on the local ecology is essential for interpreting the archaeological record and parsing out changes in resource use which could be due to changes in bioavailability or the distribution of resources. Fluctuations in climate may have potentially large effects on Arctic ecosystems and the organisms, including humans, that inhabit it. Hence, examining the archaeological record for any correlation between climatic shifts and cultural shifts has been an interest to many Arctic archaeologists (e.g., Barry et al. 1977; Bhiry, Marguerie, and Lofthouse 2016; Darwent 2001; Maxwell 1985; Mudie, Rochon, and Levac 2005; Savelle and Dyke 2002).

The Holocene Thermal Maximum began approximately 10,000 years ago but warming did not occur in the eastern Canadian Arctic and Greenland until around 4,800 BP, which corresponds with the earliest arrival of people within the ASTt archaeological complex. Pollen and ice core records indicate neoglacial cooling at around 3,500 BP, which is associated with a decrease in temperature, decreased glacial melt, and an increase in ice cover (Finkelstein 2016).

The current study focuses on the occupation of Iita spanning approximately from 800 to 1950 CE and is associated with two well-known climatic fluctuations: the Medieval Warm Period (MWP), or the Medieval Climatic Anomaly, from 950–1100 CE, and the Little Ice Age (LIA) from 1450–1850 CE. Currently, paleoclimatic data from ice cores and lake sediments in Greenland and Baffin Island indicate a relatively small increase of ~1◦ C in mean temperature in the Eastern Arctic during the MWP. The extent of ecological change associated with this shift is uncertain at this time, with some scholars suggesting that subtle changes associated with the MWP were not significant enough to affect resource availability and therefore not likely to drive cultural change in choices of resource use (Finkelstein 2016; Friesen, Finkelstein, and Medeiros 2020).

Conversely, the Little Ice Age is characterized as one of the coldest periods of the Holocene (Finkelstein 2016). Significant decreases in mean temperature (min of 2◦ C decrease) are thought to have resulted in the advancement of glaciers and brought about maximum sea-ice coverage. The landscape and seascape changes associated with the LIA are thought to have been significant enough to possibly affect resource availability and therefore may have been a causal source of cultural changes (Finkelstein 2016; Friesen, Finkelstein, and Medeiros 2020).

Table 2.1. Climatic variation in NW Greenland with associated time periods and cultural affiliations at Iita. Climate data from Friesen, Finkelstein, and Medeiros (2020)**.**

Climate events	Climate effects	Cultural Traditions at Iita	Notes
Little Ice Age (1450-1850 CE)	Prominent cooling	Inughuit (1850–1950 CE)	Changes in culture associated with prominent cooling post-1400 CE
		Middle, Late Inuit (1500–1700 CE)	
—	Slight cooling	Early Inuit (1300–1500 CE)	Initial Thule/Inuit migration (~1250 CE) into Greenland/Eastern Arctic may be associated with slightly cooler temperatures
Medieval Warm Period (950 – 1100 CE)	Mild warming	Late Dorset (800–1250 CE)	Early Late Dorset occupations of NW Greenland (800–1000 CE) may be associated with warmer climate

Optimal Foraging Theory

Human Behavioral Ecology assumes that foraging behavior directly impacts an individual's survival and therefore is a proxy for fitness (Smith and Winterhalder 1992). Optimal Foraging Theory (OFT) proposes that the goal of an individual forager, and therefore a group of foragers, is to forage optimally. An optimal forager is someone who maximizes their intake (e.g., calories, nutrients, raw materials) while minimizing costs associated with foraging (e.g., searching or processing) (MacArthur and Pianka 1966).

In Optimal Foraging Theory, specialists maximize their foraging efficiency by focusing on only the most high-quality prey. Since specialists are more restrictive about the prey they pursue, they accrue a high cost associated with search time (Bettinger 2009). In contrast, generalists are less restrictive, taking most prey that they encounter. Because lower ranking prey types tend to be encountered more often, this results in a lower cost associated with search time. However, generalists usually have lower total foraging efficiency as they take both cost-effective prey (those requiring little to no search time) and less substantive prey (provides less nutritional value or raw materials).

Many researchers studying one of the questions central to Arctic archaeology have turned to OFT to investigate what factors may have contributed to the extinction of the Late Dorset. Typically, the Late Dorset are described as generalized foragers while the Inuit are almost always described as having a more focused diet. Howse (2019) suggests that Inuit had several advantages over the Late Dorset. Specifically, Inuit had specialized hunting technologies which allowed them to pursue more of the highest-ranked prey (e.g., nets, bow and arrows, watercraft). Additionally, Friesen (2000) and Howse and Friesen (2016) suggest that Inuit likely brought with them a sense of territoriality from comparatively population-dense Alaska and were therefore better prepared for violent conflict over the most productive resource patches, perhaps pushing Late Dorset out of prime hunting locations. The Late Dorset, consisting of smaller and more egalitarian family groups, likely could not compete for the most productive spaces.

Previous Studies on Late Dorset and Inuit Subsistence

In 1996, the Gateway to Greenland Project set out to investigate human habitation and resource use in the Hatherton Bay region of the Thule District of Greenland as part of the large, multidisciplinary research program "Man, Culture, and Environment in Ancient Greenland" (Arneborg and Gulløv 1998). As part of this project, Bo Bendix (1998, 2000) identified faunal remains excavated from Late Dorset structures and associated middens from three sites in the Hatherton Bay region. Bendix (1999; 2000) reported a relatively high percentage of avian remains (18%), mainly migratory birds, which contributed to the total identified faunal remains. Despite this, the focus of the report is the mammalian remains. Bendix found that these assemblages were dominated by Arctic fox and walrus. Furthermore, seals were rare, contrasting with conclusions later drawn by Darwent (2001, 2004). Although there is some variation in the faunal remains between three sites, in general, the faunal data indicate a primary reliance on fox and walrus. Additionally, terrestrial mammals play a larger role (fox and muskox) than reported by others (Darwent 2004; Murray 1996; Schledermann 1990). Interestingly, fish remains were nearly absent from the assemblage, but this may be due to the lack of systematic screening, as only a small portion of excavated material was sieved or bulk sampled (Appelt, Gulløv, and Kapel 1998: 141).

Darwent (2001, 2004) conducted a large-scale analysis of Pre-Inuit faunal assemblages from 68 sites across the High Arctic. Darwent assesses variation in Pre-Inuit resource use through time and space through the lens of optimal foraging theory and offers an interpretation of subsistence strategies based on the creation of various prey indices and measures derived to indicate economic importance of select taxa. Although her analysis reports NISP for all identified taxa, the bulk of this analysis, and therefore interpretations on resource use, centers on mammalian resources. Darwent (2001, 2004) found that assemblages from coastal High Arctic sites tend to have a broader range of prey types represented, where each species is represented more evenly, in comparison to assemblages from inland sites.

In addition, Darwent (2001) found that Late Dorset used more small terrestrial mammals compared to earlier Pre-Inuit groups, resulting in higher evenness values. Arctic fox and hare became a frequently represented resource in the Late Dorset period. This increase is contrasted with a low relative frequency of artiodactyls (caribou/muskox). Walrus became more frequent in early Dorset periods, a pattern correlated with the appearance of new harpoon-head technologies which could more efficiently capture walrus (Darwent 2004; Murray 1996). However, the relative frequency of walrus declines in the Late Dorset period which is likely a result of a increased diet breadth (more resource types being taken) with a focus on locally available prey like fox, hare, and ringed seals. Ultimately, Darwent (2001,

2004) concludes that, unlike earlier Pre-Inuit groups, Late Dorset are processors, spending more time taking a diversity of resources more intensively within a general foraging radius of their settlement—diverging from earlier Pre-Inuit groups who seem to have been travelers, moving from resource patch to resource patch (Bettinger 2009). Darwent (2004) also suggests that the shift from higher ranked artiodactyls to lower ranked fox/hare is due to local resource depression, a hypothesis supported by other archaeological evidence of a slightly higher population density and decreased mobility (e.g., communal structures, longhouses).

Comparative studies of Late Dorset and Inuit subsistence strategies have been carried out at the site-level (Darwent and Foin 2010; Howse and Friesen 2016) and on a regional-level by pooling data from multiple sites (Howse 2019). Compiling faunal data from five eastern Arctic sites, Howse (2019) found that the Late Dorset assemblages generally exhibit a wider variety of species, with each occurring in relatively similar frequencies. In contrast, Inuit assemblages reflect a more focused diet, reflective of Inuit groups specializing in the capture of a few species. These results suggest that although these two cultures accessed a nearly identical range of prey, they maintained different subsistence strategies. This difference is likely due to more specialized Inuit tool kits which allowed them to successfully acquire large amounts of highly ranked resources (Howse 2019).

Although zooarchaeologists recognize that the inclusion of birds affects the outcome of derived measures such as taxonomic richness, evenness, and heterogeneity, many have chosen to exclude avian remains in order to avoid introducing additional variation whether because of seasonality differences in the sites examined (Howse 2019) or the fact that bird bones tend to be more fragile, presenting issues of preservation and its subsequent effect on identification bias (Darwent 2004).

Birds have the potential to play a significant role in subsistence strategies, particularly in northern latitudes where particular species of birds migrate to breeding grounds in the millions. Although documentation and reporting of avian remains is more commonplace than in the past, birds are still often ignored when making interpretations of high latitude subsistence strategies. An exception is the work of Gotfredsen (2004) who provides a detailed report of avian remains from central West Greenland. In addition, Monchot et al. (2016) focus on faunal data from two archaeological sites in subarctic Nunavik, Quebec, illustrating the importance of birds as sources of food and raw materials for Pre-Inuit (Middle and Late Dorset) foragers, thereby emphasizing the importance of birds to subsistence choices.

Recognizing the long-held mammalian-bias of zooarchaeology in general and building on work by Johansen (2012; 2013), my research demonstrates that including birds in future analyses is essential to a more complete understanding of foraging strategies. We can assume that these populations were aware of the limited availability of large, seasonal aggregations of birds and actively chose when and where to access them as with other animal resources. Therefore, avian resources should be considered along with the mammals when describing foraging strategies.

Previous Research at Iita

Inglefield Land has been a destination for American and British Polar explorers since the early 1800s. However, it was not until 1915 that the archaeological features of Iita received attention when George Comer became stranded for two years due to impenetrable sea ice. Although Comer conducted some excavations at Iita during his stay, they were minor compared to his later project at North Star Bay or Ummanak, now known as Comer's

Midden. Unfortunately, Comer did not record the exact locations of the artifacts he collected at Iita during the Crocker Land Expedition and his rescue mission between 1913 and 1917, which means that these artifacts lack specific intra-site archaeological context (LeMoine and Darwent 2010).

The Inglefield Land Archaeology Project (ILAP), launched in 2004, focused partly on investigating the historical occupation of Iita (Darwent et al. 2007; LeMoine and Darwent 2010). In 2006, the excavation of two semi-subterranean Inuit/Inughuit houses was undertaken **(Figure 2.1**). During the excavation of House 1, chert flakes dating back to the Pre-Inuit period were discovered beneath the layers associated with the Late Inuit/Inughuit occupation. This finding prompted further exploration, leading to excavations in nearby midden areas adjacent to House 1 in 2012. These excavations confirmed a Late Dorset occupation predating the Inuit/Inughuit period, but no evidence of earlier, Pre-Dorset occupations were unearthed. Due to coastal erosion impacting the Late Dorset deposits, investigations resumed in 2016 with the goal of mitigating site loss (Darwent et al. 2019).

Faunal remains recovered from Inuit and historic Inughuit winter house deposits at Iita in 2004 and 2006 were analyzed by Trine Johansen (2012, 2013) and formed the bulk of her dissertation. Zooarchaeological analysis by Johansen (2012) indicated hunting patterns like those of other High Arctic sites apart from copious dovekie (*Alle alle*) remains, a small seabird that migrates to the area annually to nest in rookeries around Foulke Fjord. Dovekies and other birds accounted for 74% of the faunal assemblage as compared to only 1–3% at other eastern Arctic sites, confirming the unique setting of the study site (Darwent and Johansen 2010; LeMoine and Darwent 2010; LeMoine and Darwent 2016; Mosbech et al. 2018).

Comprising 12% of the identified fauna at Iita, marine mammals, namely small seals, were the most abundant mammalian taxa. Interestingly, large terrestrial mammals such as caribou and muskox are rare, representing less than 2% of all identified fauna combined. In contrast, small terrestrial resources of Arctic hare and Arctic fox were consistently abundant, 7% and 3% respectively (Johansen 2012).

The current research differs from that of Johansen (2012) in that we a) undertook excavation and analysis of materials from adjacent middens rather than house contexts; b) recovered and identified faunal remains from both Late Dorset and Inuit contexts to understand resource use over a nearly 1000-year period; and c) analyzed the osseous technology (see Chapter 4). Additional differences in methodological approaches are discussed in the following section. In brief, these differences allow for general comparison of results from Johansen (2012) to that of the current study.

Faunal Materials

Excavated and screened faunal remains collected in 2012 and 2016 comprise the primary data (Darwent et al. 2019). Given the overwhelming quantity of faunal remains, and because analysis of Inuit-Inughuit fauna from houses at Iita had been undertaken previously (Johansen 2012, 2013), we selected a representative subsample of midden units that spanned the entire Inuit-Inughuit occupation at Iita for analysis (refer to Appendix A for a catalogue of the faunal materials analyzed from each context). The primary faunal sample derives from five, 1x1-meter units excavated by discrete, natural layers, and all have occupations that span the entire sequence from Late Dorset through Thule-Inuit and historical Inughuit periods, as detailed in **Appendix A**. Faunal remains from nine additional 1x1 meter test units with discrete Late Dorset components were also analyzed (**Figure 2.1**).

Results of previous zooarchaeological analysis by Trine Johansen (2012) on materials excavated from Iita focused on chronologically younger occupations associated with the Thule-Inuit and Historic Inughuit (1400 –1917 CE). Unlike the 2006 excavations, faunal remains for this study were collected using 1/8-inch mesh and in 2016 by bulk-soil sample and excavated from midden deposits rather than winter house contexts.

Faunal Analysis Methods

Each specimen (bone or fragment thereof) was identified to element, portion, and lowest taxonomic category when possible, using the UC Davis Zooarchaeology Lab's comparative skeletal collection and supplemented with online resources, primarily the Idaho Virtual Museum's osteology collection (https://virtual.imnh.iri.isu.edu/Osteo) and other comparative manuals including resources for mammals (Gilbert 1990; Hodgetts 1999) and birds (Cohen and Serjeantson 1996; Gilbert et al. 1996). Several specimens that could not be identified to genus or lower were assigned to a descriptive taxonomic category based on characteristics such as size, shape, and texture (Driver 2011).

Protocols and methods outlined by Lyman (2008) were used to generate quantitative data and derive zooarchaeological indices. These include methods to estimate taxonomic abundance such as Number of Identified Specimens (NISP) and Minimum Number of Individuals (MNI) from the faunal assemblage. NISP is calculated by summing the number of identified specimens per taxon defined. In this case, taxon can be at any taxonomic level such as species, family, genus, or a broader category as discussed above. MNI is a derived measure calculated by using the most abundant skeletal element of each taxon. MNI calculations for mammals considered factors of age (i.e., epiphyseal fusion, ossification, tooth eruption) and overall size of the specimens in question. These methods used to refine

MNI estimates for mammals are usually impractical for avian remains. For example, birds do not have dentition, and they typically reach adult body size within weeks of hatching, which make age determination difficult (Kaiser 2007). Many species of birds are sexually monomorphic, meaning that there are little to no discernable differences in the skeletons of males and females of the same species, and it is only in life where plumage may differ based on sex (Serjeantson 2009). The presence of medullary bone, an ephemeral bone tissue deposited within various skeletal elements including long bones, can indicate an adult, breeding female (Canoville et al. 2019). However, this tissue is only present during egg laying and therefore the absence of medullary bone does not indicate male (Serjeantson 2009). Medullary bone was not identified in these materials[1].

Minimum Number of Elements (MNE) measures fragmentation and frequency of skeletal parts within taxon. MNE is calculated by assessing the total number of a particular element represented by taking into consideration factors such as epiphyseal fusion/age, portion, side, and sex when possible. The element in question is first separated into lefts and rights. Next, the left and rights are separated into proximal and distal portions. Complete elements of each side will be added to the sided distal and proximal portions to prevent overlap. As per Lyman (2008) portions that cannot be sided are not included. Minimal Animal Units (MAU) are MNE counts divided by the number of times that particular element occurs in the body of a given taxon. MAU is useful for interpreting butchery patterns and transport of animal carcasses (i.e., the schlepp effect).

Taxonomic identification is used to evaluate the faunal assemblage composition and diversity. By comparing the results of each of these quantitative methods, we assess animal

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[1] Increased cortical wall thickness, which could be associated with medullary bone deposition, was noted for one Anatidae long bone specimen in the Mixed Late Dorset – Inuit faunal materials.

exploitation by the two cultural groups through time as well as taphonomic factors generated by non-human agencies (Lyman 1994).

The taphonomic characteristic of each specimen is assessed to understand the human and non-human agents that have shaped the assemblage, such as weathering, carnivore gnawing, burning, and human butchering practices. Skeletal completeness (fragmentation) and skeletal part frequencies assess the dietary contribution of each taxon. Together these form the primary data from which we derive indices used to test hypotheses based on foraging theory. Namely in understanding foraging and processing strategies such as butchery and transport decisions, discard and disposal, site function, taphonomy, and possible cultural differences.

Surface modifications were recorded for each specimen, such as degree of weathering, presence of carnivore gnawing, and type of butchery marks. Additionally, each specimen was assigned to one of five size classes within a standardized coding system based on the maximum size of the specimen.

Carnivore damage

Carnivore damage on bones reflects contact with a carnivore's teeth, tongue and stomach acid (Gifford-Gonzalez 2018); at Iita, these traces may have been made by foxes, dogs, or wolves[2]. Carnivore damage was identified following descriptions by Gifford-Gonzalez (2018) and Lyman (1994). Carnivore scalloping is characterized by the unique "scalloped" or crenulated edges typically present on one or both ends of a bone. Repeated contact of a carnivore's tongue can also produce polish near the scalloped margins. Digested bones are

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[2] Similar to other hypercarnivores, polar bears typically consume only the soft tissues such as blubber and flesh, leaving bones and hard skeletal tissues behind (Sacco and Van Valkenburgh 2004).

identified by the loss of cortical bone resulting in the thinning of bone walls and increased porosity. Digested bones may also have traces of tooth pits and can appear polished from the animal’s stomach acids.

Carnivore pitting is identified by the presence of triangular to round pits on the cortical surface of bones. Although carnivore pitting cannot reliably be distinguished between dogs and wolves (Noe-Nygaard 1989; Pokines 2021), marks left by Arctic fox are typically much smaller and can be suppositionally distinguished from dog/wolf (Gotfredsen and Moberg 2004; Meldgaard 2004).

Butchery and spiral fractures

The systematic skinning, disarticulation, and filleting (i.e., processing) of a skeleton for consumption may result in fragmentation and/or various butchery marks. When present, butchery marks were recorded using descriptive labels such as chop marks, impact scars, light cut marks, heavy cut marks, and saw marks. Anatomical location and orientation were recorded when possible. Additionally, spirally fractured long bones were recorded following Lyman (1994). Spiral fractures were coded based on direction of the fracture in relation to the long bone diaphysis; each observation was recorded as one of the following: longitudinal to shaft, perpendicular to shaft, longitudinal and perpendicular to shaft, or indeterminate.

Age estimation

Skeletal development was used to broadly estimate the age-at-death of mammals and birds. As we were mainly interested in classifying individuals as either adults (skeletally mature) or juvenile/subadults (non-skeletally mature), skeletally immature specimens were classified as one of two age classes, 1) fetal, and 2) juvenile/subadult. Fetal mammalian bones are characterized by the incomplete formation of the element, small size, and often the texture of the cortical bone will be rough and unorganized. Juvenile/subadult mammal remains are characterized by the incomplete fusion of the element's diaphysis or by incomplete/open apical foramen on tooth roots. Epiphyseal fusion was used for age estimation following Takken Beijersbergen et al. (2012) for caribou, Geiger et al (2016) for dogs/wolves, Harris (1978) for foxes, and Storå (2002) for seals. Unfortunately, there are currently no published epiphyseal fusion data available for more precise walrus and bearded seal age estimation. Assuming that pinnipeds reach skeletal maturity at about the same life stages, we follow previous studies (Gotfredsen, Appelt, and Hastrup 2018; Monchot et al. 2013) in applying these data to estimate the life stage for walrus and bearded seal.

For birds, incomplete skeletal element ossification indicates a juvenile/subadult following Searjanston (2009). Because birds reach skeletal maturity within days or weeks after hatching, immature bird remains are more rare (Kaiser 2007; Serjeantson 2009). Only a small quantity of avian bones were incompletely formed and categorized as juvenile/subadult.

Taxonomic composition and diversity

Taxonomic richness (N-taxa) is the number of non-overlapping taxa (species or genera) represented in the assemblage. Taxonomic abundance is the number of individuals per taxon. Both taxonomic richness and abundance are used to calculate indices of taxonomic diversity and evenness (Gifford-Gonzalez 2018; Lyman 2008). Taxonomic evenness is a measure of how equitable the taxonomic abundances are in relation to each other; essentially measuring the distribution of specimens across all taxa. For example, taxonomic evenness will be low if one taxon dominates the assemblage while taxonomic evenness will be high if each taxon contributes equally to the total specimen count (NISP). Diversity measures account for both taxonomic richness and taxonomic evenness. The Shannon-Weiner heterogeneity index is used to compare and interpret the degree of diversity in Late Dorset and Inuit faunal assemblages following methods outlined by Lyman (2008). The Shannon-Weiner index is calculated using the following equation and where p_i = proportion of taxon i in the assemblage:

$$H = -\sum P_i(lnP_i)$$

After heterogeneity (H) has been calculated for each species in question, it is used to calculate the taxonomic evenness statistic (e) (Lyman 2008; Pielou 1966):

$$e = \frac{H}{\ln{(S)}}$$

H= Shannon-Weiner heterogeneity index

Ln= natural log

S= total number of species in sample

The Shannon-Weiner heterogeneity index (H) results in a number between 1.5 (less diverse) and 3 (more diverse). Taxonomic evenness (e) is a measure of how equitable the taxonomic abundances are in relation to each other; essentially this measures the distribution of specimens across all taxa. For example, taxonomic evenness will be 0 (low) if one taxon dominates the assemblage while taxonomic evenness will be 1 (high) if each taxon contributes equally to the total specimen count (NISP). These indices are used to compare and interpret the degree of diversity in Late Dorset and Inuit faunal assemblages. Low species diversity and/or uneven taxonomic abundance within an assemblage is characteristic of a narrow foraging strategy or prey specialization. Conversely, an assemblage with high taxonomic richness is reflective of a more generalized strategy, or wide diet breadth, although the assemblage may be even or uneven (Gifford-Gonzalez 2018; Lyman 2008).

Prey indices

Archaeologists use models within optimal foraging theory as a framework to predict prey choices and to interpret variation in archaeological evidence (e.g., animal skeletal remains within middens). For example, changes in dietary choices are expected to be reflected in changes in the relative abundance of prey species represented at the site. Changes in dietary choice are seen as fluctuations in the number of taxa present (N-taxa, richness), or in the relative contribution of each taxon (evenness) to the total assemblage.

The Prey Choice Model often predicts that large bodied species such as caribou or muskox will be highly ranked and therefore always taken when encountered (Bettinger 2009). A swath of previous studies have outlined hypotheses to explain why archaeological evidence may indicate diachronic variations in the relative abundance of large- to small-bodied prey considering that larger-bodied prey should always be preferred. Three broad hypotheses include: 1) the prolonged acquisition of large prey may lead to changes in resource abundance or availability (e.g., resource depression), 2) the abundance of large-bodied prey may co-vary with the population of social groups (more large-bodied prey may be required to meet the food, raw materials, and social needs of an increased human population), and 3) stochastic variability in climate which may affect large-bodied prey more so than small bodied prey.

Prey indices have been used to calculate the relative abundance of one prey type to another (Darwent 2001; Nagaoka 2001; Betts and Friesen 2004; Codding, Porcasi, and Jones 2010; Codding, Bird, and Bliege Bird 2010). These indices reveal the relative contributions of a specified taxon within the assemblage relative to other taxa. This assessment of faunal composition allows us to test assumptions based on optimal foraging theory by analyzing the proportions that each taxon contribute to the faunal assemblage. Here, greater index values

(1) indicate a greater contribution of birds to the faunal assemblage while lower values (0) indicate their near absence. Diachronic changes in these indices may indicate a shift in prey abundance and/or hunting strategies. Calculated prey indices are summarized in **Table 2.2**.

Table 2.2. Faunal indices, such as these, may indicate the ratio of prey types used among different resource patches.

Prey Index	Index Expression	Purpose and Assessment
Bird/Pinniped	$\sum \text{Birds}_i / \sum (\text{Birds}_i + \text{Pinnipeds}_i)$	Compares birds to medium-large-bodied marine mammal prey
Birds/Fox+Hare	$\sum \text{Birds}_i / \sum (\text{Birds}_i + \text{Fox}_i + \text{Hare}_i)$	Compares birds to other small-bodied terrestrial prey
Birds/Artiodactyl	$\sum \text{Birds}_i / \sum (\text{Birds}_i + \text{Artiodacyls}_i)$	Compares birds to large-bodied terrestrial prey

Faunal Analysis Results

A total of 13,043 faunal specimens were recovered and identified from the sampled midden test units at Iita (**Table 2.3**). Of these, 9,312 (71%) were identified to the level of family or lower. Overall, 14 distinct taxonomic groups (N-taxa) were identified across the assemblage.

Avifauna

Birds represent 65% (n=8,386) of the total identified fauna. Dovekies are the most frequently recovered species overall, representing 58% (n=7,396) of the total faunal assemblage, and the most common species of bird, representing 88% of all the recovered avian remains. The small bird category, which is 7% of the total faunal assemblage (n=918) is most likely dovekie but is composed of non-diagnostic small bird remains that could possibly derive from other small bird species (e.g., snow buntings, northern wheatears). The following taxonomic groups each comprise less than 1% of the total faunal assemblage: murres (n=14), geese (n=31), ducks (n=12), and medium size birds (n=15).

Marine Mammals

Marine mammals comprise nearly 11% (n=1,348) of the identified fauna. Seals were the most frequent (n=1,013, 8%), followed by walrus (n=130, 1%) and pinnipeds (large seals and/or walrus) (n=117, <1%). Only six specimens were identified as polar bear, which contribute to less than 1% of the total identified fauna.

Terrestrial Mammals

Terrestrial mammals comprise less than 9% of all identified fauna (n=1,121). Arctic fox is the most common (n=293), followed by Arctic hare (n=155). Some fragmented elements could not be distinguished between arctic hare and fox; therefore, a category of fox/hare was used (n=288). Specimens of large-bodied terrestrial mammals are relatively less common, with caribou (n=184), muskox (n=17), and dog/wolf (n=61), also contributing to the overall identified fauna.

Mollusks

Mollusks contribute to less than 1% of the faunal assemblage. Seven complete gastropod opercula were recovered. Because of the lack of other gastropod and mollusk remains, the most parsimonious explanation for the presence of these opercula is that they were transported as stomach contents within walrus or bearded seals (Kastelein 2008; Kovacs 2008) that were processed at Iita, rather than as a product of gastropod gathering by Late Dorset or Inuit inhabitants. Because the frequency of mollusks is so low and their presence is only known from the corneous operculum, they are not discussed further.

Taxonomic Composition: Indices of Diversity and Heterogeneity

The taxonomic composition of the faunal assemblage does fluctuate through time and differs throughout the cultural occupations at Iita (**Figure 2.2**). To explore the relationship between species richness and NISP, a bivariate plot and a linear regression analysis using log-log scale was produced with the overall sample size (logNISP) plotted against species richness (logN-taxa). Regression analysis such as this attempts to explain any differences in richness between the contexts by first considering whether sample size (NISP) plays a significant role (Gifford-Gonzalez 2018; Grayson 1984; Lyman 2008). As illustrated in **Figure 2.3**, these results indicate that the variation in data is *not* best explained by the N-taxa–NISP relationship (r^2=0.27, p=0.37). The correlation coefficient of logNISP is 0.09 (SE = 0.09), and has a 95% confidence interval of (-0.18, 0.36) which contains zero. Although we cannot completely rule out the null hypothesis of no relationship between logN-taxa and logNISp, these results indicate that sample size (logNISP) accounts for less than 3% of the variation in species richness (N-taxa), therefore, other variables, such as foraging behavior, are likely driving variation in species richness for each faunal component.

Next, we explore the relationship between heterogeneity and NISP, as the measure of heterogeneity is influenced by taxonomic richness and evenness. A bivariate plot and linear regression analysis was completed where logNISP was plotted against measures of heterogeneity (**Figure 2.4**). This analysis suggests that the variation in heterogeneity between our archaeological contexts is not statistically significant (r^2=0.1, p=0.54) indicating that this variation is unlikely to be due to sample size differences. Additionally, a bivariate plot and linear regression analysis was completed where logNISP was plotted against measures of evenness (**Figure 2.5**). Our analysis suggests that sample size (NISP) and evenness are also not strongly correlated (r^2=0.19, p=0.47).

Late Dorset

The Late Dorset component is relatively diverse (H=2.2) and even (e=0.8). This calculation is not surprising given that many of the 14 taxa contribute somewhat equally except for a single taxon, dovekie, which contributes to 24% of the total Late Dorset faunal remains.

Middle Inuit

The heterogeneity index for the Middle Inuit component is lower (H=1.5) than Late Dorset reflecting that this assemblage is less taxonomically rich (N-taxa of 11). An evenness index of 0.6 also reflects a slightly less even distribution of taxa than Late Dorset, with dovekies (50%) and small seals (12%) dominating the assemblage.

Late Inuit-Inughuit

Despite an N-taxa of 13, the Late Inuit-Inughuit component received a low score on the heterogeneity index, suggesting that this assemblage is not diverse (H=1.0). These taxa were unevenly distributed, with a single taxon, dovekies, contributing to 70% of the total identified specimens (e=0.4).

Inughuit

The Inughuit assemblage is also not diverse (H=1.5) yet scored slightly higher on the evenness index (e=0.6) than the Late Inuit-Inughuit but still lower than Late Dorset. This component has a N-taxa of 11, with most taxa contributing between 1–3% but dovekies and walrus dominate (58% and 6% respectively). Overall, this most closely resembles the Middle Inuit component.

Mixed Late Dorset-Inuit

The Mixed Context component is not diverse (H=1.1) and is moderately even (e=0.5). Here, 66% of the identified fauna is attributed to dovekies, while most other taxa contribute more minimally (N-taxa of 11). When considering taxonomic composition, this component is most like the Late Inuit-Inughuit component, and most likely the fauna derives from discard by Inuit rather than Dorset inhabitants.

Table 2.3. Number of identified specimens (NISP) and their relative frequency (%NISP) of the major faunal groups across archaeological midden contexts at Iita.

	Late Dorset		**Mixed Late Dorset–Inuit**		**Middle Inuit**		**Late Inuit–Inughuit**		**Inughuit**		**Total**	
TAXA	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%
MOLLUSK												
Unidentified Gastropod	3	0.1	2	0.1	1	0.1	1	0.0	-	-	7	0.1
Total mollusk	**3**	0.1	**2**	0.1	**1**	0.1	**1**	0.0	-	-	**7**	0.1
N-taxa	**1**		**1**		**1**		**1**		0		**1**	
BIRD												
Dovekie/little auk (*Alle alle*)	606	24.3	2296	65.9	467	50.1	3262	70.4	765	57.7	7396	57.5
Small size bird (cf. *Alle alle*)	120	4.8	186	5.3	66	7.1	492	10.6	54	4.1	918	7.1
Murre/guillemot (*Uria* sp.)	5	0.2	-	-	-	-	9	0.2	-	-	14	0.1
Eider (*Somateria* sp.)	3	0.1	0	0.0	0	0.0	0	0.0	0	0.0	3	0.0
Long-tailed duck (cf. *Clangula hyemalis*)	0	0.0	0	0.0	2	0.2	1	0.0	1	0.1	4	0.0
Duck (Anatinae)	1	0.0	2	0.1	2	0.2	0	0.0	0	0.0	5	0.0
Goose (Anserinae)	10	0.4	4	0.1	-	-	7	0.2	10	0.8	31	0.2
Medium size bird	5	0.2	4	0.1	-	-	5	0.1	1	0.1	15	0.1
Total bird	**750**	30.0	**2492**	71.5	**537**	57.6	**3776**	81.5	**831**	62.7	**8386**	65.1
N-taxa	**4**		**3**		**2**		**4**		**3**		**4**	
MAMMAL												
Arctic hare (*Lepus arcticus*)	54	2.2	30	0.9	3	0.3	31	0.7	37	2.8	155	1.2
Arctic fox (*Vulpes lagopus*)	147	5.9	47	1.3	22	2.4	57	1.2	20	1.5	293	2.3
Small terrestrial mammal (fox/hare)	101	4.0	77	2.2	19	2.0	58	1.3	33	2.5	288	2.2
Dog/wolf (*Canis lupus* sp.)	9	0.4	23	0.7	5	0.5	13	0.3	11	0.8	61	0.5
Polar bear (*Ursus maritimus*)	6	0.2	-	-	-	-	-	-	-	-	6	0.0
Walrus (*Odobenus rosmarus*)	13	0.5	4	0.1	9	1.0	27	0.6	77	5.8	130	1.0
Pinniped (large seal/walrus)	33	1.3	30	0.9	11	1.2	20	0.4	23	1.7	117	0.9
Bearded seal (*Erignathus barbatus*)	11	0.4	4	0.1	2	0.2	8	0.2	4	0.3	29	0.2

Ringed seal (*Pusa hispida*)	7	0.3	-	-	7	0.8	13	0.3	1	0.1	28	0.2
Small seal (*Phoca*/*Pusa*)	251	10.0	223	6.4	112	12.0	186	4.0	68	5.1	840	6.5
Seal (Phocidae)	27	1.1	52	1.5	6	0.6	12	0.3	19	1.4	116	0.9
Caribou (*Rangifer tarandus*)	128	5.1	10	0.3	8	0.9	14	0.3	24	1.8	184	1.4
Muskox (*Ovibos moschatus*)	10	0.4	-	-	2	0.2	4	0.1	1	0.1	17	0.1
Caribou/muskox (Artiodactyla)	24	1.0	8	0.2	2	0.2	6	0.1	2	0.2	42	0.3
Large terrestrial mammal	51	2.0	11	0.3	7	0.8	8	0.2	4	0.3	81	0.6
Marine mammal	10	0.4	24	0.7	28	3.0	8	0.2	12	0.9	82	0.6
Total identified mammal	**882**	35.3	**543**	15.6	**243**	26.0	**465**	10.0	**336**	25.4	**2469**	19.2
Unidentified mammal	863	34.5	448	12.9	152	16.3	389	8.4	158	11.9	2010	15.6
Total mammal	**1745**	69.9	**991**	28.4	**395**	42.3	**854**	18.4	**494**	37.3	**4479**	34.8
N-taxa	**9**		**7**		**8**		**8**		**8**		**9**	
Unidentified vertebrate	138		14	0	0		0		19		171	
Total identified	2498	100.0	3485	100.0	933	100.0	4631	100.0	1325	100.0	12,872	100.0
Grand total	**2636**		**3499**		**933**		**4631**		**1344**		**13,043**	
N-taxa (richness)	14		11		11		13		11		**14**	
Heterogeneity	**2.2**		**1.1**		**1.5**		**1**		**1.5**			
Evenness	**0.8**		**0.5**		**0.6**		**0.4**		**0.6**			

Table 2.4. Minimum Number of Individuals (MNI) across the five archaeological contexts at Iita.

	Late Dorset	**Mixed Late Dorset-Inuit**	**Middle Inuit**	**Late Inuit-Inughuit**	**Inughuit**	**Total**
TAXA	MNI	MNI	MNI	MNI	MNI	MNI
MOLLUSK						
Unidentified Gastropod	3	2	1	1	0	7
Total mollusk	**3**	**2**	**1**	**1**	0	**7**
N-taxa	**1**	**1**	**1**	**1**	**0**	**1**
BIRD						
Dovekie/little auk (*Alle alle*)	48	96	26	152	40	363
Murre (*Uria* sp.)	1	0	0	2	0	3
Eider (*Somateria* sp.)	1	0	0	0	0	1
Long-tailed duck (cf. *Clangula hyemalis*)	0	0	1	1	1	3
Duck (Anatinae)	0	1	1	0	0	2
Goose (Anserinae)	1	1	0	2	2	6
Total bird	**51**	**99**	**27**	**157**	**43**	**377**
N-taxa	**4**	**3**	**2**	**4**	**3**	**4**
MAMMAL						
Arctic hare (*Lepus arcticus*)	3	2	1	2	2	10
Arctic fox (*Vulpes lagopus*)	5	3	2	3	2	15
Dog/wolf (*Canis lupus* sp.)	1	1	1	2	1	6
Polar bear (*Ursus maritimus*)	1	0	0	0	0	1
Walrus (*Odobenus rosmarus*)	1	1	1	1	2	6
Bearded seal (*Erignathus barbatus*)	1	1	1	1	1	5
Small seals (cf. *Pusa hispida*)	5	4	4	3	2	18
Caribou (*Rangifer tarandus*)	2	1	1	1	2	7
Muskox (*Ovibos moschatus*)	1	0	1	1	1	4
Total mammal	**20**	**13**	**12**	**13**	**13**	**71**
N-taxa	**9**	**7**	**8**	**8**	**8**	**9**

Grand total	**74**	**114**	**40**	**172**	**56**	**456**
N-taxa (richness)	**14**	**11**	**11**	**13**	**11**	**14**

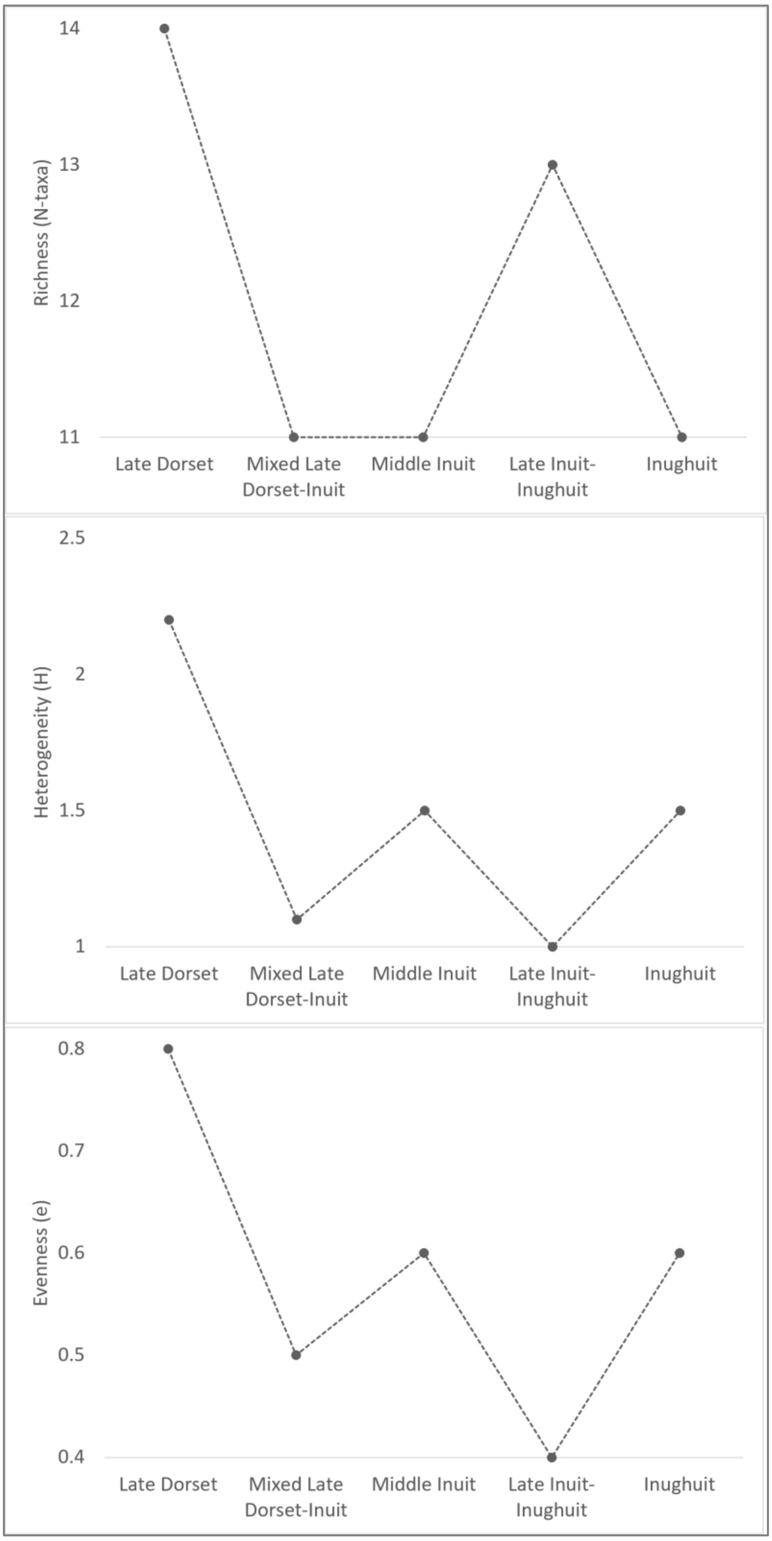

Figure 2.2. Species richness, heterogeneity, and evenness values plotted by context, illustrating the diachronic changes in faunal composition at Iita.

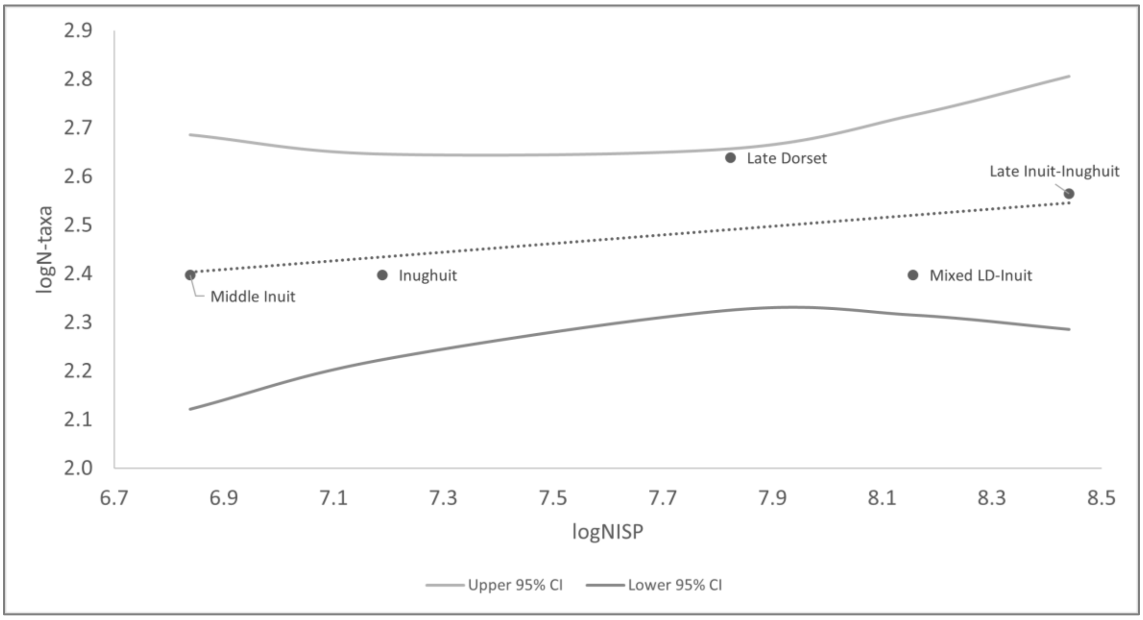

Figure 2.3. The log of NISP and the log of richness (N-taxa) are plotted for each cultural context (r^2=0.27, p=0.37). These results indicate that sample size (logNISP) accounts for less than 3% of the variation in species richness (N-taxa), therefore other variables are likely responsible for the differences in N-taxa between the faunal components.

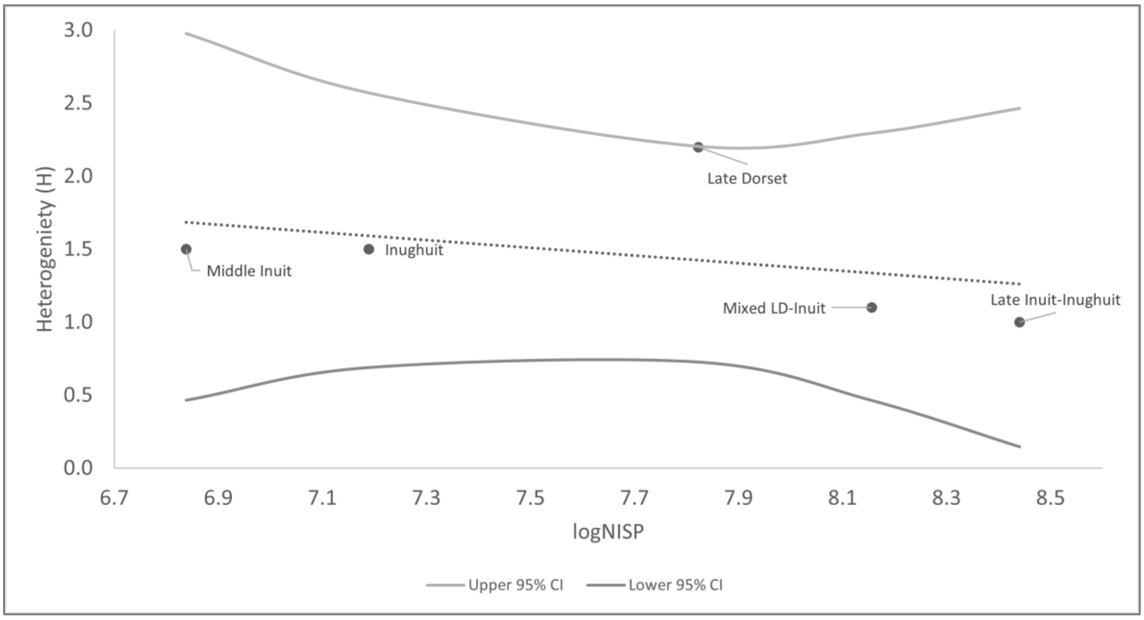

Figure 2.4. The log of NISP and heterogeneity (H) are plotted for each cultural context, suggesting that sample size (NISP) has an insignificant influence on the diversity measure of heterogeneity for this assemblage (r^2=0.14, p=0.54).

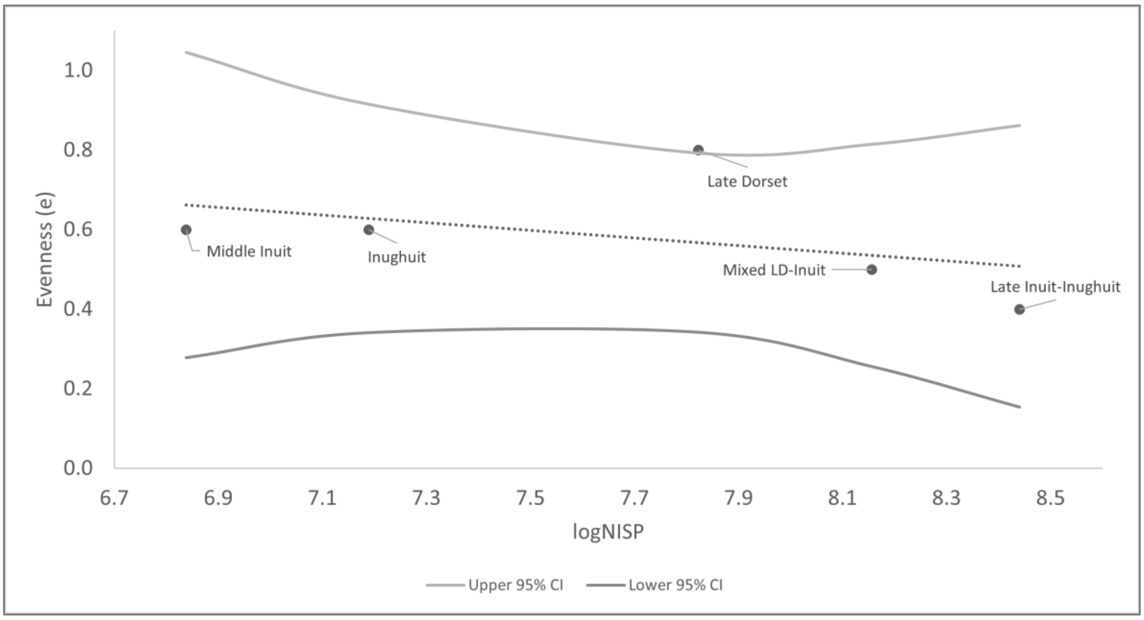

Figure 2.5. The log of NISP and evenness (*e*) are plotted for each cultural context suggesting that sample size (NISP) also has an insignificant influence on the diversity measure of evenness for this assemblage (r^2=0.19, p=0.47).

Biomass and Species Contributions

Another way to assess the contribution of species to the diets of people living at Iita is to estimate biomass. Biomass estimations report the mean total amount of biological tissues represented by each taxon within the various assemblages. Biomass was estimated following Lyman (2008). Live weights and estimated biomass for the major taxa at Iita can be found in **Table 2.5**. Biomass estimates indicate a subsistence economy focused on walrus and seals for all archaeological contexts. These data illustrate how taxonomic abundances can vary dramatically depending on the method of analysis. Here, the relative contribution (%NISP) of the major taxa are compared with the %Biomass estimates. Although dovekies clearly comprise many of the specimens within the faunal assemblage, large-bodied species such as walrus contribute much more biomass overall. Biomass estimates are an imperfect measure of species abundance for two major reasons. First, biomass is calculated from MNI (**Table**

2.4), a derived measure. As a result, MNI tends to overrepresent rare species and underrepresent more abundant species. Second, biomass estimates are based on the total mass of all biological tissues, including edible and non-edible portions. Additionally, biomass estimates assume that complete carcasses are transported. Walrus, for example, are large and heavy, and thus are likely to have been field-processed before transporting the choice portions back to Iita (i.e., the schlepp effect). Therefore, it is important to consider methods of processing and transportation and their associated costs (e.g., time, energy) when interpreting the importance of any taxon.

Prey Indices

Abundance indices are tools to track changes in the abundance of different prey types over time. We compare all birds (dovekie, ducks, and geese) as one prey type to three other prey types: 1) pinnipeds (walrus and seals), 2) fox and hare, and 3) artiodactyls (caribou and muskox) (**Table 2.2**). Three different prey indices were calculated to compare the abundance of birds (dovekies, ducks, and geese) relative to other prey types over time (**Figure 2.6**). Results of all three prey indices suggest that birds are always abundant relative to other prey types. However, the values for all three indices are consistently lower in the Late Dorset period, substantiating the interpretation of a wide diet breadth associated with Late Dorset subsistence practices. Interestingly, the index values are quite high for all Inuit components, ranging from 0.8 to 1.0, again suggesting that birds are a top-ranked prey at Iita. The bird/pinniped index resulted in a comparatively low index value associated with the Middle Inuit, indicating that the relative abundance of birds to pinnipeds decreased during this period.

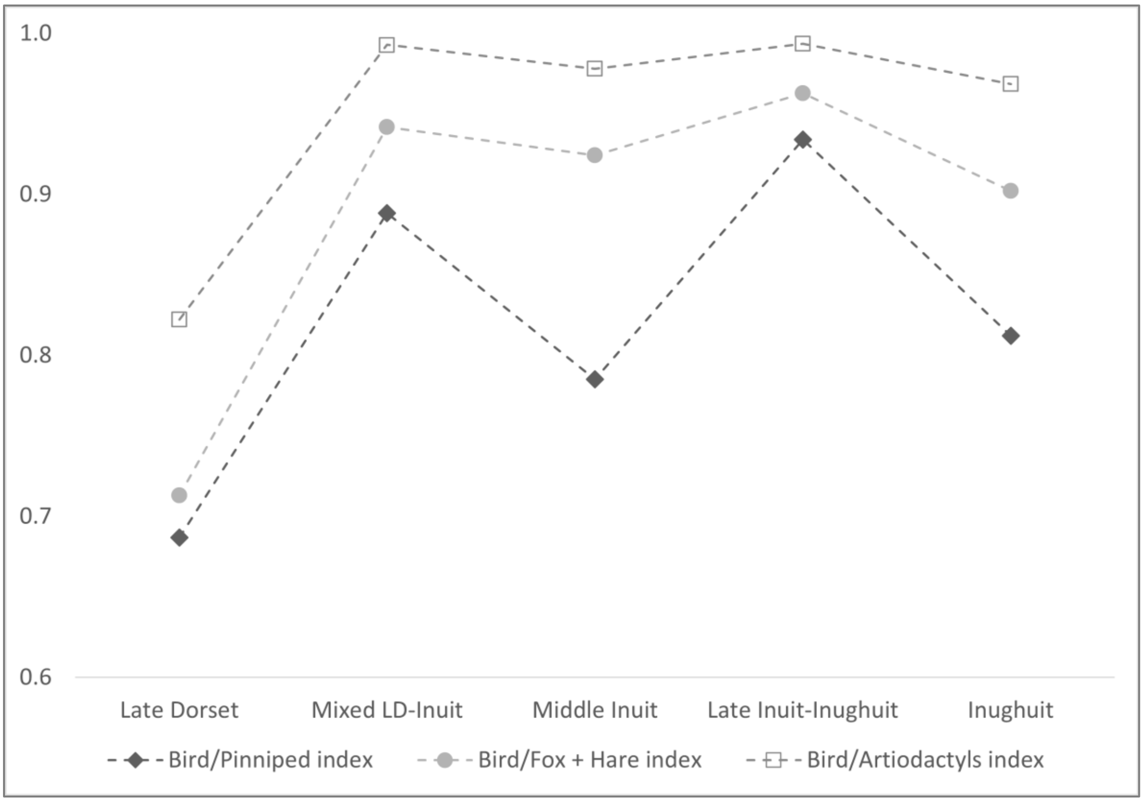

Figure 2.6. Three different prey indices were calculated to compare the abundance of birds to other prey types over time. Index values closer to 1 indicate a greater contribution of birds to the faunal assemblage. Results of all three prey indices suggest that birds are always abundant relative to other prey types.

Table 2.5. Minimum estimates of biomass for the major taxa identified at Iita. All reported estimates of live weight/mass are adult averages from the following sources: dovekies (Warner 2007), arctic hare (Betzler 2015), arctic fox (Prestrud 1991), dog/wolf (Dawes et al. 1986; Johansen 2012), polar bear (Stirling 2008), walrus (Kastelein 2008), bearded seal (Kovacs 2008), caribou (Shefferly 2000; Meldgaard 1986), muskox (Elder 2005).

		Late Dorset			**Mixed Late Dorset-Inuit**			**Middle Inuit**			**Late Inuit-Inughuit**			**Inughuit**		
Taxa	Live Weight (kg)	MNI	Bio	%	MNI	Bio	%	MNI	Bio	%	MNI	Bio	%	MNI	Bio	%
Dovekie/little auk	0.15	48	7.2	0.0	97	14.55	0.7	26	3.9	0.2	152	22.8	1.0	40	6	0.2
Arctic hare	4.5	3	13.5	0.0	2	9	0.4	1	4.5	0.2	2	9	0.4	2	9	0.3
Arctic fox	3.5	5	17.5	0.0	3	10.5	0.5	2	7	0.3	3	10.5	0.5	1	3.5	0.1
Dog/wolf	38	1	38.0	0.0	1	38	1.9	1	38	1.7	2	76	3.4	1	38	1.1
Polar bear	500	1	500.0	0.2	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
Walrus	1200	1	1200.0	0.4	1	1200	59.3	1	1200	53.0	1	1200	53.1	2	2400	68.6
Bearded seal	300	1	300.0	0.1	1	300	14.8	1	300	13.3	1	300	13.3	1	300	8.6
Small seal (cf. ringed seal)	70	5	350.0	0.1	4	280	13.8	4	280	12.4	3	210	9.3	2	140	4.0
Caribou	170	2	340.0	0.1	1	170	8.4	1	170	7.5	1	170	7.5	2	340	9.7
Muskox	260	1	260.0	0.1	0	0	0.0	1	260	11.5	1	260	11.5	1	260	7.4
Total		**68**	**3026.2**		**110**	**2022.05**		**38**	**2263.4**		**166**	**2258.3**		**52**	**3496.5**	

Skeletal Part Representation

Skeletal portions and their relative frequencies for the six most frequently occurring taxa are presented in **Table 2.6** to **Table 2.23**: dovekies, arctic hare, arctic fox, walrus, small seals, and caribou. Note that the NISP values for each may differ from those in **Table 2.3**, as not all elements are appropriate for calculations of MNE and other derived measures of skeletal completeness (e.g., indeterminate long bone fragments).

Taphonomy

Burning, weathering, and fragmentation

Burning is infrequent across all materials in this study (**Table 2.24**). Although, the Late Dorset materials have the highest occurrence, less than 2% of all specimens are burned. Most of these burned materials are between 50–100% calcined, indicating the application of high temperatures or long durations of heat (Ellingham et al. 2015; Gallo et al. 2021; Lyman 1994). Interestingly, no avian remains within this assemblage were burned, as all burning is found on mammalian remains. This finding aligns with previous research by Johansen (2012) who suggests that this lack of burning may be evidence of minimal processing associated with avian remains, particularly for the small-bodied dovekies. It may be that the higher degree of burning also contributed to the higher amount of unidentified remains in the Late Dorset contexts (**Table 2.25**). However, Late Dorset contexts were also more heavily weathered compared to Inuit contexts (**Table 2.26**).

Differential fragmentation was assessed by comparing the natural log of NISP and MNI for all major taxa. Differential fragmentation of one taxon could indicate taphonomic effects such as intensive processing or the weathering of that one taxon. **Figure 2.7** is a bivariate scatterplot illustrating the strong linear relationship of NISP to MNI (r=0.84) for the total assemblage. A linear relationship is expected because as the sample size (NISP) increases, so too should the number of individual animals which comprise the assemblage (MNI) (Gifford-Gonzalez 2018; Lyman 2008). Dovekies are outliers because they have high NISP and MNI values compared to all other taxa. This is likely due to the small birds being transported from nearby rookeries to Iita whole. Additionally, minimal processing of the carcasses prior to consumption likely contributed to the relatively low fragmentation rate for dovekie elements.

While the ratio of NISP:MNI describes fragmentation intensity by reflecting the size of fragments, the ratio of NISP:MNE describes the extent of fragmentation in terms of proportion of complete skeletal elements (Lyman 1994, 2008). The extent of fragmentation was calculated for each cultural context (**Table 2.27)**. The increased extent of fragmentation of the Late Dorset materials is likely due to the longer amount of time these materials were exposed after deposition. In other words, the Late Dorset materials were deposited earlier than the materials from all Inuit contexts; therefore, they have been subjected to weathering and other taphonomic events for a longer period which may have increased their fragmentation. These results are consistent with previous studies (Darwent and Foin 2010; Howse 2008).

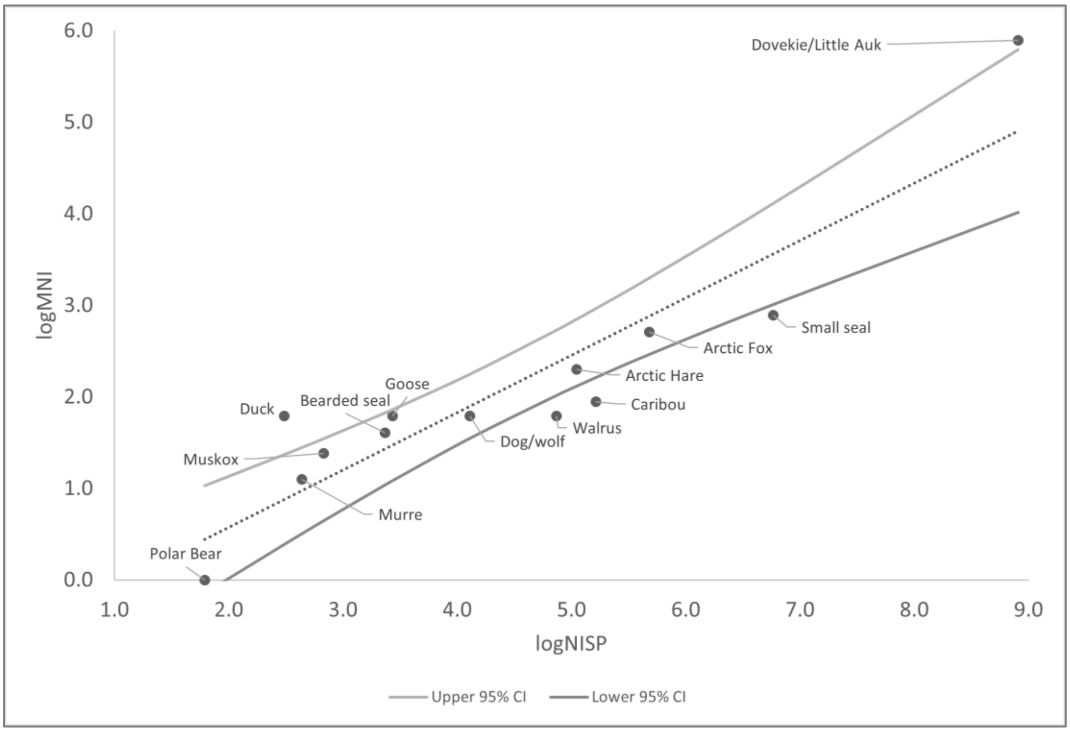

Figure 2.7. Scatterplot showing the relationship between logNISP and logMNI for the total faunal assemblage from the midden deposits at Iita. As expected, there is a strong linear relationship between NISP and MNI because as the sample size (NISP) increases, the more individuals are likely to be identified (MNI). Interestingly, dovekies have the highest NISP and MNI values for the assemblage, likely due to the ease of transportation of whole bird carcasses and minimal processing prior to consumption.

Carnivore damage

Nearly all carnivore pitting on the Late Dorset faunal materials is small, indicating these were likely scavenged by Arctic foxes. This aligns with the current understanding that Late Dorset had little to no access to domesticated dogs (Ameen et al. 2019; Morey and Aaris-Sørensen 2002) and suggests that Arctic wolves were rarely scavenging from the middens at Iita. The Inuit assemblages have a combination of both large and small carnivore pitting present, suggesting that fox and dog/wolf were occasionally accessing the materials.

Carnivore damage was observed on less than 2% of the overall faunal assemblage, suggesting that carnivores had a minimal effect on the materials recovered from middens at

Iita (**Table 2.28**). The contexts with the highest relative frequency of carnivore damage are the Inughuit (2.5%, n=33) and Middle Inuit (2.3%, n=21), respectively. Previous analysis by Johansen (2012) on Inuit and Inughuit faunal remains from house contexts at Iita are consistent with these results. Overall, Johansen (2012) found that 5% of all faunal remains had evidence of carnivore activity, which correlated with periods of increased sled dog presence.

Butchery and spiral fractures

Cut marks and spiral fractures are somewhat rare in the total assemblage; those identified on mammalian remains are summarized in **Table 2.29**. Most spiral fractures occur on terrestrial mammal (i.e., caribou) long bones, suggestive of marrow extraction. Heavy cut marks and chop marks, traces consistent with processing carcasses into smaller units, are the most identified modifications in this assemblage. There is a noticeably higher frequency of cut marks on the walrus specimens within the Late Dorset component (62% of all walrus specimens have been cut) while cut marks are rarer on walrus remains from across all the Inuit components (11–25%).

Age Estimation

Skeletally immature specimens were grouped into one of two broad age categories, fetal or juvenile/subadult. A total of 29 skeletally immature animals were observed within the assemblage. Taxa that are represented by at least one skeletally immature specimen include dovekie, ringed seal, bearded seal, walrus, arctic fox, arctic hare, dog/wolf, and caribou.

Table 2.30 presents the estimated minimum number of skeletally immature individuals (MNI) for the most common taxa identified at Iita. Skeletal portions used in age estimation are listed in **Table 2.31**. The number of skeletally immature individuals identified in this study is too small to draw conclusions regarding differences in seasonal harvest patterns between the two foraging groups and is not discussed further.

Table 2.6. Dovekie skeletal part frequency for Late Dorset and Mixed Late-Dorset-Inuit contexts, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Dovekie	**Late Dorset**					**Mixed Late Dorset-Inuit**				
	NISP	MNE	MNI	MAU	%MAU	NISP	MNE	MNI	MAU	%MAU
Cranium (1)	6	2	2	2.0	4%	33	18	18	18.0	19%
Mandible (2)	10	8	4	4.0	8%	130	99	49	49.5	51%
Vertebrae (24)	2	2	1	0.1	0%	1	1	1	0.0	0%
Ribs (28)	18	6	1	0.2	0%	64	8	1	0.3	0%
Furculum (1)	23	8	7	8.0	17%	129	27	27	27.0	28%
Coracoid (2)	52	41	20	20.5	43%	233	180	90	90.0	93%
Scapula (2)	27	23	11	11.5	24%	142	99	49	49.5	51%
Sternum (1)	33	6	6	6.0	13%	114	43	43	43.0	44%
Humerus (2)	98	53	26	26.5	55%	326	185	92	92.5	95%
Radius (2)	35	20	10	10.0	21%	152	107	53	53.5	55%
Ulna (2)	78	48	24	24.0	50%	287	194	97	97.0	100%
Carpometacarpus (2)	23	17	8	8.5	18%	125	102	51	51.0	53%
Phalanges (16)	9	6	3	0.4	1%	17	17	5	1.1	1%
Synsacrum + Pelvis (1)	6	2	2	2.0	4%	19	8	8	8.0	8%
Femur (2)	12	8	4	4.0	8%	24	17	8	8.5	9%
Tibiotarsus (2)	142	96	48	48.0	100%	358	155	77	77.5	80%
Tarsometatarsus (2)	12	9	4	4.5	9%	140	103	51	51.5	53%
Total	**586**					**2294**				

Table 2.7. Dovekie skeletal part frequency for Middle Inuit and Late Inuit-Inughuit contexts, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Dovekie	**Middle Inuit**					**Late Inuit-Inughuit**				
	NISP	MNE	MNI	MAU	%MAU	NISP	MNE	MNI	MAU	%MAU
Cranium (1)	11	7	7	7.0	30%	35	23	23	23.0	15%
Mandible (2)	20	18	9	9.0	38%	157	126	63	63.0	41%
Vertebrae (24)	2	2	1	0.1	0%	1	1	1	0.0	0%
Ribs (28)	1	1	1	0.0	0%	5	3	1	0.1	0%
Furculum (1)	22	7	7	7.0	30%	211	47	47	47.0	31%
Coracoid (2)	45	36	18	18.0	77%	364	283	141	141.5	93%
Scapula (2)	29	13	6	6.5	28%	260	205	102	102.5	67%
Sternum (1)	49	15	15	15.0	64%	124	38	38	38.0	25%
Humerus (2)	85	47	26	23.5	100%	499	305	152	152.5	100%
Radius (2)	30	21	10	10.5	45%	248	155	77	77.5	51%
Ulna (2)	63	41	20	20.5	87%	500	290	145	145.0	95%
Carpometacarpus (2)	31	19	9	9.5	40%	223	137	68	68.5	45%
Phalanges (16)	1	1	1	0.1	0%	20	20	9	1.3	1%
Synsacrum + Pelvis (1)	5	1	1	1.0	4%	26	8	8	8.0	5%
Femur (2)	3	2	1	1.0	4%	43	30	15	15.0	10%
Tibiotarsus (2)	48	20	10	10.0	43%	392	218	109	109.0	71%
Tarsometatarsus (2)	19	18	9	9.0	38%	154	106	53	53.0	35%
Total	**464**					**3262**				

Table 2.8. Dovekie skeletal part frequency for the Inughuit context, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Dovekie	**Inughuit**				
	NISP	MNE	MNI	MAU	%MAU
Cranium (1)	12	7	7	7.0	18%
Mandible (2)	31	26	13	13.0	33%
Vertebrae (24)	-	-	-	-	-
Ribs (28)	-	-	-	-	-
Furculum (1)	34	18	18	18.0	45%
Coracoid (2)	70	59	29	29.5	74%
Scapula (2)	54	33	16	16.5	41%
Sternum (1)	45	12	12	12.0	30%
Humerus (2)	138	80	40	40.0	100%
Radius (2)	59	45	22	22.5	56%
Ulna (2)	99	63	31	31.5	79%
Carpometacarpus (2)	32	30	15	15.0	38%
Phalanges (16)	1	1	1	0.1	0%
Synsacrum + Pelvis (1)	7	3	3	3.0	8%
Femur (2)	14	11	5	5.5	14%
Tibiotarsus (2)	137	65	32	32.5	81%
Tarsometatarsus (2)	32	24	12	12.0	30%
Total	**765**				

Table 2.9. Arctic hare skeletal part frequency for Late Dorset and Mixed Late-Dorset-Inuit contexts, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Arctic hare	**Late Dorset**								**Mixed Late Dorset-Inuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	8	2	1	5	1	1	1.0	50%	1	-	-	1	1	1	1.0	100%
Mandible (2)	9	3	2	4	2	1	1.0	50%	1	1	-	-	1	1	0.5	50%
Atlas (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Axis (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cervical (5)	-	-	-	-	-	-	-	-	1	-	-	1	1	1	0.2	20%
Thoracic (12)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lumbar (7)	-	-	-	-	-	-	-	-	2	-	-	2	1	1	0.1	14%
Caudal (16)	-	-	-	-	-	-	-	-	2	-	-	2	2	1	0.1	13%
Sternum (3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ribs (24)	2	-	-	2	1	1	0.0	2%	2	-	-	2	2	1	0.1	8%
Humerus (2)	1	-	-	1	1	1	0.5	25%	1	-	1	-	1	1	0.5	50%
Radius (2)	6	2	4	-	4	3	2.0	100%	4	-	1	3	2	1	1.0	100%
Ulna (2)	3	1	-	2	1	1	0.5	25%	-	-	-	-	-	-	-	-
Metacarpal (10)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sacrum (1)	-	-	-	-	-	-	-	-	4	-	-	4	1	1	1.0	100%
Scapula (2)	5	1	3	1	2	2	1.0	50%	-	-	-	-	-	-	-	-
Pelvis (2)	-	-	-	-	-	-	-	-	1	1	-	-	1	1	0.5	50%
Patella (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Femur (2)	1	-	1	-	1	1	1.0	50%	2	2	-	-	1	1	0.5	50%
Tibia (2)	1	1	-	-	1	1	0.5	25%	1	-	-	1	1	1	0.5	50%
Fibula (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metatarsal (10)	2	-	1	1	1	1	0.1	5%	-	-	-	-	-	-	-	-
Calcaneus (2)	-	-	-	-	-	-	-	-	2	2	-	-	2	2	1.0	100%
Astragalus (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Tarsals (10)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalanges (56)	-	-	-	-	-	-	-	-	3	-	-	3	3	1	0.1	5%
Total	**38**	**10**	**12**	**16**					**27**	**6**	**2**	**19**				

Table 2.10. Arctic hare skeletal part frequency for Middle Inuit and Late Inuit-Inughuit contexts, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Arctic hare	**Middle Inuit**								**Late Inuit-Inughuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1.0	100%
Mandible (2)	-	-	-	-	-	-	-	-	5	1	1	4	1	1	0.5	50%
Atlas (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Axis (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cervical (5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thoracic (12)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lumbar (7)	-	-	-	-	-	-	-	-	1	1	1	1	1	1	0.1	14%
Caudal (16)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sternum (3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ribs (24)	-	-	-	-	-	-	-	-	5	1	1	5	2	1	0.1	8%
Humerus (2)	1	1	1	1	1	1	0.5	100%	3	2	1	1	2	1	1.0	100%
Radius (2)	-	-	-	-	-	-	-	-	4	1	2	2	2	1	1.0	100%
Ulna (2)	-	-	-	-	-	-	-	-	2	1	2	1	2	2	1.0	100%
Metacarpal (10)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sacrum (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scapula (2)	-	-	-	-	-	-	-	-	1	1	1	1	1	1	0.5	50%
Pelvis (2)	-	-	-	-	-	-	-	-	3	1	1	1	2	1	1.0	100%
Patella (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Femur (2)	-	-	-	-	-	-	-	-	3	1	2	-	2	1	1.0	100%

Tibia (2)	1	-	-	1	1	1	0.5	100%	-	-	-	-	-	-	-	-
Fibula (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metatarsal (10)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcaneus (2)	1	1	-	-	1	1	0.5	100%	-	-	-	-	-	-	-	-
Astragalus (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tarsals (10)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalanges (56)	-	-	-	-	-	-	-	-	2	1	1	2	2	1	0.0	
Total	**3**	**1**	**1**	**1**					**30**	**5**	**8**	**17**				

Table 2.11. Arctic hare skeletal part frequency for the Inughuit context, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Arctic hare	**Inughuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	2	1	-	2	1	1	1.0	67%
Mandible (2)	-	-	-	-	-	-	-	-
Atlas (1)	-	-	-	-	-	-	-	-
Axis (1)	-	-	-	-	-	-	-	-
Cervical (5)	-	-	-	-	-	-	-	-
Thoracic (12)	2	-	-	2	1	1	0.1	6%
Lumbar (7)	3	-	-	3	1	1	0.1	10%
Caudal (16)	-	-	-	-	-	-	-	-
Sternum (3)	-	-	-	-	-	-	-	-
Ribs (24)	4	-	-	4	2	1	0.1	6%
Humerus (2)	1	-	1	-	1	1	0.5	33%
Radius (2)	5	2	1	2	3	2	1.5	100%
Ulna (2)	2	2	-	-	2	2	1.0	67%
Metacarpal (10)	-	-	-	-	-	-	-	-

Sacrum (1)	-	-	-	-	-	-	-	-
Scapula (2)	1	1	-	-	1	1	0.5	33%
Pelvis (2)	1	1	-	-	1	1	0.5	33%
Patella (2)	-	-	-	-	-	-	-	-
Femur (2)	4	2	2	-	2	1	1.0	67%
Tibia (2)	3	1	1	1	2	1	1.0	67%
Fibula (2)	-	-	-	-	-	-	-	-
Metatarsal (10)	1	-	1	-	1	1	0.1	7%
Calcaneus (2)	1	1	-	-	1	1	0.5	33%
Astragalus (2)	-	-	-	-	-	-	-	-
Tarsals (10)	-	-	-	-	-	-	-	-
Phalanges (56)	-	-	-	-	-	-	-	-
Total	**30**	**10**	**6**	**14**				

Table 2.12. Arctic fox skeletal part frequency for Late Dorset and Mixed Late-Dorset-Inuit contexts, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Arctic fox	**Late Dorset**								**Mixed Late Dorset-Inuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	33	6	11	16	1	1	1.0	25%	4	2	1	1	1	1	1.0	50%
Mandible (2)	21	8	8	5	8	5	4.0	100%	8	2	4	2	3	3	1.5	75%
Atlas (1)	-	-	-	-	-	-	-	-	1	-	-	1	1	1	1.0	50%
Axis (1)	1	-	-	1	1	1	1.0	25%	2	-	-	2	2	2	2.0	100%
Cervical (5)	1	-	-	1	1	1	0.2	5%	-	-	-	-	-	-	-	-
Thoracic (13)	2	-	-	2	2	1	0.2	4%	2	-	-	2	1	1	0.1	4%
Lumbar (7)	4	-	-	4	2	1	0.3	7%	7	-	-	7	2	1	0.3	14%
Caudal (28)	6	-	-	6	4	1	0.1	4%	1	-	-	1	1	1	0.0	2%
Sternum (3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Ribs (26)	4	-	2	2	3	1	0.1	3%	-	-	-	-	-	-	-	-
Humerus (2)	4	3	1	-	3	3	1.5	38%	-	-	-	-	-	-	-	-
Radius (2)	7	3	2	2	7	2	3.5	88%	2	-	1	1	1	1	0.5	25%
Ulna (2)	3	1	1	1	3	1	1.5	38%	1	-	1	-	1	1	0.5	25%
Carpals (14)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metacarpal (8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sacrum (1)	-	-	-	-	-	-	-	-	2	-	-	2	2	2	2.0	100%
Scapula (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pelvis (2)	5	3	2	-	4	2	2.0	50%	1	1	-	-	1	1	0.5	25%
Baculum (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Patella (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Femur (2)	7	2	2	3	3	2	1.5	38%	2	1	1	-	2	1	1.0	50%
Tibia (2)	8	2	4	2	3	3	1.5	38%	2	-	-	2	1	1	0.5	25%
Fibula (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metatarsal (8)	1	-	-	1	1	1	0.1	3%	1	1	-	-	1	1	0.1	6%
Calcaneus (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Astragalus (2)	-	-	-	-	-	-	-	-	1	-	1	-	1	1	0.5	25%
Tarsals (8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalanges (48)	1	-	-	1	1	1	0.0	1%	1	-	-	1	1	1	0.0	1%
Total	**108**	**28**	**33**	**47**	**47**				**38**	**7**	**9**	**22**	**22**			

Table 2.13. Arctic fox skeletal part frequency for Middle Inuit and Late Inuit-Inughuit contexts, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Arctic fox	**Middle Inuit**								**Late Inuit-Inughuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	6	5	1	-	1	1	1.0	100%	3	1	1	1	1	1	1.0	50%
Mandible (2)	3	2	-	1	1	1	0.5	50%	14	6	4	4	3	2	1.5	75%

Atlas (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Axis (1)	1	-	-	1	1	1	1.0	100%	-	-	-	-	-	-	-	-
Cervical (5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thoracic (13)	1	-	-	1	1	1	0.1	8%	-	-	-	-	-	-	-	-
Lumbar (7)	-	-	-	-	-	-	-	-	1	-	-	1	1	1	0.1	7%
Caudal (28)	-	-	-	-	-	-	-	-	4	-	-	4	4	1	0.1	7%
Sternum (3)	-	-	-	-	-	-	-	-	2	-	-	2	2	2	0.7	33%
Ribs (26)	1	1	-	-	1	1	0.0	4%	3	-	2	1	1	1	0.0	2%
Humerus (2)	1	-	1	-	1	1	0.5	50%	1	-	-	1	1	1	0.5	25%
Radius (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ulna (2)	-	-	-	-	-	-	-	-	1	-	1	-	1	1	0.5	25%
Carpals (14)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metacarpal (8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sacrum (1)	-	-	-	-	-	-	-	-	1	-	-	1	1	1	1.0	50%
Scapula (2)	1	-	-	-	1	1	0.5	50%	1	-	1	-	1	1	0.5	25%
Pelvis (2)	-	-	-	-	-	-	-	-	2	1	1	-	2	1	1.0	50%
Baculum (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Patella (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Femur (2)	-	-	-	-	-	-	-	-	1	1	-	-	1	1	0.5	25%
Tibia (2)	-	-	-	-	-	-	-	-	4	3	1	-	4	3	2.0	100%
Fibula (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metatarsal (8)	4	4	-	-	4	2	0.5	50%	5	4	1	-	4	2	0.5	25%
Calcaneus (2)	-	-	-	-	-	-	-	-	1	1	-	-	1	1	0.5	25%
Astragalus (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tarsals (8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalanges (48)	1	-	-	1	1	1	0.0	2%	2	-	-	2	2	1	0.0	2%
Total	**19**	**13**	**2**	**4**	**12**				**46**	**17**	**12**	**17**	**30**			

Table 2.14. Arctic fox skeletal part frequency for the Inughuit context, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Arctic fox	**Inughuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	1	-	1	-	1	1	1.0	67%
Mandible (2)	1	1	-	-	1	1	0.5	33%
Atlas (1)	-	-	-	-	-	-	-	-
Axis (1)	-	-	-	-	-	-	-	-
Cervical (5)	-	-	-	-	-	-	-	-
Thoracic (13)	-	-	-	-	-	-	-	-
Lumbar (7)	-	-	-	-	-	-	-	-
Caudal (28)	1	-	-	1	1	1	0.0	2%
Sternum (3)	-	-	-	-	-	-	-	-
Ribs (26)	-	-	-	-	-	-	-	-
Humerus (2)	-	-	-	-	-	-	-	-
Radius (2)	2	1	-	1	1	1	0.5	33%
Ulna (2)	-	-	-	-	-	-	-	-
Carpals (14)	-	-	-	-	-	-	-	-
Metacarpal (8)	3	1	1	1	2	1	0.3	17%
Sacrum (1)	-	-	-	-	-	-	-	-
Scapula (2)	-	-	-	-	-	-	-	-
Pelvis (2)	3	2	1	0	3	2	1.5	100%
Baculum (1)	1	-	-	1	1	1	1.0	67%
Patella (2)	-	-	-	-	-	-	-	-
Femur (2)	-	-	-	-	-	-	-	-
Tibia (2)	1	-	1	-	1	1	0.5	33%
Fibula (2)	-	-	-	-	-	-	-	-
Metatarsal (8)	-	-	-	-	-	-	-	-

Calcaneus (2)	-	-	-	-	-	-	-	-
Astragalus (2)	-	-	-	-	-	-	-	-
Tarsals (8)	-	-	-	-	-	-	-	-
Phalanges (48)	1	-	-	1	1	1	0.0	1%
Total	**14**	**5**	**4**	**5**	**12**			

Table 2.15. Walrus skeletal part frequency for Late Dorset and Mixed Late-Dorset-Inuit contexts, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Walrus	**Late Dorset**								**Mixed Late Dorset-Inuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	5	-	-	5	1	1	1	100%	-	-	-	-	-	-	-	-
Mandible (2)	1	-	1	-	1	1	0.5	50%	-	-	-	-	-	-	-	-
Atlas (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Axis (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cervical (5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thoracic (15)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lumbar (6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caudal (8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sternum (8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ribs (30)	3	1	2	-	3	1	0.1	10%	3	0	0	3	1	1	0.03	100%
Humerus (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Radius (2)	1	1	0	0	1	1	0.5	50%	-	-	-	-	-	-	-	-
Ulna (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carpals (14)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metacarpal (10)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sacrum (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scapula (2)	1	0	1	0	1	1	0.5	50%	-	-	-	-	-	-	-	-

Pelvis (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Patella (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Femur (2)	1	0	1	0	1	1	0.5	50%	-	-	-	-	-	-	-	-
Tibia (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fibula (2)	1	0	1	0	1	1	0.5	50%	-	-	-	-	-	-	-	-
Metatarsal (10)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcaneus (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Astragalus (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tarsals (10)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalanges (56)	-	-	-	-	-	-	-	-	1	-	-	1	1	1	0.02	54%
Total	**13**	**2**	**6**	**5**	**9**				**4**	**0**	**0**	**4**	**2**			

Table 2.16. Walrus skeletal part frequency for Middle Inuit and Late Inuit-Inughuit contexts, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Walrus	**Middle Inuit**								**Late Inuit-Inughuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	2	-	-	2	1	1	1	100%	5	-	3	2	1	1	1	100%
Mandible (2)	2	1	1	-	2	1	1	100%	-	-	-	-	-	-	-	-
Atlas (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Axis (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cervical (5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thoracic (15)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lumbar (6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caudal (8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sternum (8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ribs (30)	2	-	2	-	1	1	0.03	3%	7	1	1	5	2	1	0.07	7%
Humerus (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Radius (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ulna (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carpals (14)	1	-	-	-	1	1	0.07	7%	-	-	-	-	-	-	-	-
Metacarpal (10)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sacrum (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scapula (2)	-	-	-	-	-	-	-	-	1	1	-	-	1	1	0.5	50%
Pelvis (2)	1	-	1	-	1	1	0.5	50%	-	-	-	-	-	-	-	-
Patella (2)	-	-	-	-	-	-	-	-	1	1	-	-	1	1	0.5	50%
Femur (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tibia (2)	1	1	-	-	1	1	0.5	50%	-	-	-	-	-	-	-	-
Fibula (2)	-	-	-	-	-	-	-	-	1	-	1	-	1	1	0.5	50%
Metatarsal (10)	-	-	-	-	-	-	-	-	1	-	1	-	1	1	0.1	10%
Calcaneus (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Astragalus (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tarsals (10)	-	-	-	-	-	-	-	-	1	-	-	1	1	1	0.1	5%
Phalanges (56)	-	-	-	-	-	-	-	-	7	-	-	7	4	1	0.1	7%
Total	**9**	**2**	**4**	**2**	**7**				**24**	**3**	**6**	**15**	**12**			

Table 2.17. Walrus skeletal part frequency for the Inughuit context, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Walrus	**Inughuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	19	4	1	14	1	1	1	67%
Mandible (2)	1	-	1	-	1	1	0.5	33%

Atlas (1)	-	-	-	-	-	-	-	-
Axis (1)	-	-	-	-	-	-	-	-
Cervical (5)	1	-	-	1	1	1	0.2	13%
Thoracic (15)	2	-	-	2	2	1	0.1	9%
Lumbar (6)	6	-	-	6	4	1	0.7	44%
Caudal (8)	-	-	-	-	-	-	-	-
Sternum (8)	-	-	-	-	-	-	-	-
Ribs (30)	11	6	4	1	9	1	0.3	20%
Humerus (2)	1	1	-	-	1	1	0.5	33%
Radius (2)	-	-	-	-	-	-	-	-
Ulna (2)	2	-	2	-	2	2	1	67%
Carpals (14)	2	-	1	1	2	1	0.1	10%
Metacarpal (10)	1	-	1	-	1	1	0.1	7%
Sacrum (1)	4	-	-	4	1	1	1	67%
Scapula (2)	1	-	1	-	1	1	0.5	33%
Pelvis (2)	1	-	-	1	1	1	0.5	33%
Patella (2)	1	-	1	-	1	1	0.5	33%
Femur (2)	-	-	-	-	-	-	-	-
Tibia (2)	3	1	1	1	2	1	1	67%
Fibula (2)	-	-	-	-	-	-	-	-
Metatarsal (10)	3	2	1	3	3	2	0.3	20%
Calcaneus (2)	3	2	-	1	3	2	1.5	100%
Astragalus (2)	-	-	-	-	-	-	-	-
Tarsals (10)	1	-	1	-	1	1	0.1	7%
Phalanges (56)	7	-	-	7	3	2	0.3	20%
Total	**70**	**16**	**15**	**42**	**40**			

Table 2.18. Small seal (cf. ringed seal) skeletal part frequency for Late Dorset and Mixed Late-Dorset-Inuit contexts, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Small seal	**Late Dorset**								**Mixed Late Dorset-Inuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	10	-	-	10	1	1	1	40%	13	-	-	13	2	2	2.0	100%
Mandible (2)	7	2	4	1	3	2	1.5	60%	3	2	1	-	2	1	1.0	50%
Atlas (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Axis (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cervical (5)	2	-	-	2	2	2	0.4	16%	1	-	-	1	1	1	0.2	10%
Thoracic (15)	4	-	-	4	1	1	0.1	3%	16	-	-	16	2	2	0.1	7%
Lumbar (5)	8	-	-	8	5	2	1	40%	2	-	-	2	1	1	0.2	10%
Caudal (11)	6	-	-	6	4	2	0.4	15%	4	-	-	4	4	2	0.4	18%
Sternum (8)	2	-	-	2	1	1	0.1	5%	1	-	-	-	1	1	0.1	6%
Ribs (30)	48	5	6	37	11	2	0.4	15%	33	3	3	27	4	2	0.1	7%
Humerus (2)	8	3	2	3	3	2	1.5	60%	6	4	1	1	3	2	1.5	75%
Radius (2)	4	2	2	-	2	2	1	40%	6	3	2	1	2	1	1.0	50%
Ulna (2)	7	6	1	-	3	2	1.5	60%	2	-	2	-	1	1	0.5	25%
Carpals (14)	-	-	-	-	-	-	-	-	1	1	-	-	1	1	0.1	4%
Metacarpal (10)	5	2	-	3	4	1	0.4	16%	4	-	1	3	3	1	0.3	15%
Sacrum (1)	1	-	-	1	1	1	1	40%	-	-	-	-	-	-	-	-
Scapula (2)	10	5	1	3	5	3	2.5	100%	3	-	2	1	1	1	0.5	25%
Pelvis (2)	6	2	2	2	2	1	1	40%	2	1	1	-	2	1	1.0	50%
Patella (2)	2	1	-	1	2	1	1	40%	2	1	-	1	2	1	1.0	50%
Femur (2)	11	6	3	3	4	2	2	80%	7	4	2	1	3	2	1.5	75%
Tibia (2)	5	2	1	2	2	1	1	40%	10	6	2	2	3	2	1.5	75%
Fibula (2)	2	1	1	-	2	1	1	40%	6	2	2	2	3	2	1.5	75%
Metatarsal (10)	4	-	3	1	3	2	0.3	12%	11	4	3	4	7	2	0.7	35%
Calcaneus (2)	1	-	1	-	1	1	0.5	20%	1	-	1	-	1	1	0.5	25%

Astragalus (2)	2	-	2	-	2	2	1	40%	-	-	-	-	-	-	-	-
Tarsals (10)	7	4	2	1	7	2	0.7	28%	5	3	2	-	5	2	0.5	25%
Phalanges (56)	48	5	5	38	22	5	0.4	16%	49	2	-	47	25	4	0.4	22%
Total	**200**	**46**	**36**	**128**	**93**				**188**	**36**	**25**	**126**	**79**			

Table 2.19. Small seal (cf. ringed seal) skeletal part frequency for Middle Inuit and Late Inuit-Inughuit contexts, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Small seal	**Middle Inuit**								**Late Inuit-Inughuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	8	-	-	8	1	1	1.0	50%	-	-	-	-	-	-	-	-
Mandible (2)	1	-	1	-	1	1	0.5	25%	1	-	1	-	1	1	0.5	25%
Atlas (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Axis (1)	2	-	-	2	2	2	2.0	100%	1	-	-	1	1	1	1	50%
Cervical (5)	2	-	-	2	1	1	0.2	10%	-	-	-	-	-	-	-	-
Thoracic (15)	4	-	-	44	2	2	0.1	7%	1	-	-	1	1	1	0.1	3%
Lumbar (5)	3	-	-	3	1	1	0.2	10%	-	-	-	-	-	-	-	-
Caudal (11)	1	-	-	1	1	1	0.1	5%	2	-	-	2	1	1	0.1	5%
Sternum (8)	1	-	-	1	1	1	0.1	6%	1	-	-	1	1	1	0.1	6%
Ribs (30)	26	9	4	13	7	1	0.2	12%	46	13	10	23	22	2	0.7	37%
Humerus (2)	5	2	-	3	1	1	0.5	25%	7	2	4	1	2	2	1	50%
Radius (2)	1	1	-	-	1	1	0.5	25%	7	1	4	2	4	2	2	100%
Ulna (2)	4	3	1	-	4	3	2.0	100%	6	3	1	2	4	2	2	100%
Carpals (14)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metacarpal (10)	1	-	-	1	1	1	0.1	5%	8	2	4	2	7	1	0.7	35%

Sacrum (1)	2	-	-	2	2	2	2.0	100%	-	-	-	-	-	-	-	-
Scapula (2)	2	1	1	-	2	2	1.0	50%	6	3	3	-	3	2	1.5	75%
Pelvis (2)	4	2	2	-	2	1	1.0	50%	3	2	1	-	3	2	1.5	75%
Patella (2)	1	-	-	1	1	1	0.5	25%	2	0	2	-	2	2	1	50%
Femur (2)	1	-	-	1	1	1	0.5	25%	2	2	-	-	2	2	1	50%
Tibia (2)	6	6	-	-	2	2	1	50%	7	2	4	1	4	2	2	100%
Fibula (2)	5	4	1	-	4	4	2.0	100%	2	-	-	2	2	1	1	50%
Metatarsal (10)	2	1	1	-	2	1	0.2	10%	7	3	2	2	5	3	0.5	25%
Calcaneus (2)	1	-	1	-	1	1	0.5	25%	2	1	1	-	2	1	1	50%
Astragalus (2)	1	-	1	-	1	1	0.5	25%	-	-	-	-	-	-	-	-
Tarsals (10)	1	-	-	1	1	1	0.1	5%	1	-	-	1	1	1	0.1	5%
Phalanges (56)	17	-	-	17	8	2	0.1	7%	21	1	1	19	15	3	0.3	13%
Total	**102**	**29**	**13**	**100**	**51**				**133**	**35**	**38**	**60**	**83**			

Table 2.20. Small seal (cf. ringed seal) skeletal part frequency for the Inughuit context, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Small seal	**Inughuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	-	-	-	-	-	-	-	-
Mandible (2)	2	-	-	2	2	2	1	50%
Atlas (1)	-	-	-	-	-	-	-	-
Axis (1)	2	-	-	2	1	1	1	50%
Cervical (5)	1	-	-	1	1	1	0.2	10%
Thoracic (15)	4	-	-	4	2	2	0.1	7%

Lumbar (5)	1	-	-	1	1	1	0.2	10%
Caudal (11)	2	-	-	2	2	1	0.2	9%
Sternum (8)	-	-	-	-	-	-	-	-
Ribs (30)	17	4	5	8	5	2	0.2	8%
Humerus (2)	1	-	-	1	1	1	0.5	25%
Radius (2)	3	1	1	1	2	2	1	50%
Ulna (2)	4	3	1	-	3	2	1.5	75%
Carpals (14)	1	-	-	1	1	1	0.1	4%
Metacarpal (10)	1	1	-	-	1	1	0.1	5%
Sacrum (1)	5	-	-	5	2	2	2	100%
Scapula (2)	2	-	2	1	2	2	1	50%
Pelvis (2)	1	1	-	-	1	1	0.5	25%
Patella (2)	1	-	-	1	1	1	0.5	25%
Femur (2)	-	-	-	-	-	-	-	-
Tibia (2)	3	2	1	-	1	1	0.5	25%
Fibula (2)	2	-	1	1	1	1	0.5	25%
Metatarsal (10)	4	1	3	-	4	1	0.4	20%
Calcaneus (2)	-	-	-	-	-	-	-	-
Astragalus (2)	-	-	-	-	-	-	-	-
Tarsals (10)	2	1	1	-	2	1	0.2	10%
Phalanges (56)	5	2	-	3	3	2	0.1	3%
Total	**64**	**16**	**15**	**34**	39			

Table 2.21. Caribou skeletal part frequency for Late Dorset and Mixed Late-Dorset-Inuit contexts, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Caribou	**Late Dorset**								**Mixed Late Dorset-Inuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	2	-	-	2	1	1	1.0	67%	-	-	-	-	-	-	-	-
Mandible (2)	15	1	1	13	2	1	1.0	67%	-	-	-	-	-	-	-	-
Atlas (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Axis (1)	2	-	-	2	1	1	1.0	67%	-	-	-	-	-	-	-	-
Cervical (5)	2	-	-	2	1	1	0.2	13%	-	-	-	-	-	-	-	-
Thoracic (13)	12	-	-	12	3	2	0.2	15%	-	-	-	-	-	-	-	-
Lumbar (6)	1	-	-	1	1	1	0.2	11%	-	-	-	-	-	-	-	-
Sternum (7)	2	-	-	2	1	1	0.1	10%	-	-	-	-	-	-	-	-
Ribs (26)	8	2	3	3	4	1	0.2	10%	7	-	-	7	2	1	0.1	15%
Humerus (2)	3	0	3	-	1	1	0.5	33%	-	-	-	-	-	-	-	-
Radius (2)	7	4	1	2	3	2	1.5	100%	-	-	-	-	-	-	-	-
Ulna (2)	1	1	-	-	1	1	0.5	33%	-	-	-	-	-	-	-	-
Carpals (12)	2	2	-	-	2	1	0.2	11%	-	-	-	-	-	-	-	-
Metacarpal (2)	6	1	-	5	1	1	0.5	33%	-	-	-	-	-	-	-	-
Sacrum (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scapula (2)	4	1	2	-	2	1	1.0	67%	2	-	-	2	1	1	0.5	100%
Pelvis (2)	4	1	1	2	1	1	0.5	33%	-	-	-	-	-	-	-	-
Patella (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Femur (2)	2	1	-	1	1	1	0.5	33%	-	-	-	-	-	-	-	-
Tibia (2)	4	3	1	-	2	1	1.0	67%	-	-	-	-	-	-	-	-
Fibula (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metatarsal (2)	6	-	-	6	1	1	0.5	33%	-	-	-	-	-	-	-	-
Calcaneus (2)	1	1	-	-	1	1	0.5	33%	-	-	-	-	-	-	-	-
Astragalus (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Tarsals (4)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalanges (24)	1	-	-	1	1	1	0.0	3%	-	-	-	-	-	-	-	-
Total	**85**	**18**	**12**	**54**	**31**				**9**	**0**	**0**	**9**	**3**			

Table 2.22. Caribou skeletal part frequency for Middle Inuit and Late Inuit-Inughuit contexts, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Caribou	**Middle Inuit**								**Late Inuit-Inughuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	1	1	0	0	1	1	1	100%	-	-	-	-	-	-	-	-
Mandible (2)	-	-	-	-	-	-	-	-	1	0	1	0	1	1	0.5	100%
Atlas (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Axis (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cervical (5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thoracic (13)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lumbar (6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sternum (7)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ribs (26)	1	-	1	-	1	1	0.0	4%	9	-	-	9	4	1	0.2	31%
Humerus (2)	1	-	1	-	1	1	0.5	50%	-	-	-	-	-	-	-	-
Radius (2)	1	-	1	-	1	1	0.5	50%	-	-	-	-	-	-	-	-
Ulna (2)	1	1	-	-	1	1	0.5	50%	-	-	-	-	-	-	-	-
Carpals (12)	1	-	1	-	1	1	0.1	8%	-	-	-	-	-	-	-	-
Metacarpal (2)	-	-	-	-	-	-	-	-	1	-	-	1	1	1	0.5	100%
Sacrum (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scapula (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Pelvis (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Patella (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Femur (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tibia (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fibula (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metatarsal (2)	1	-	-	1	1	1	0.5	50%	-	-	-	-	-	-	-	-
Calcaneus (2)	-	-	-	-	-	-	-	-	1	-	-	1	1	1	0.5	100%
Astragalus (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tarsals (4)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalanges (24)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**7**	**2**	**4**	**1**	**7**				**12**	**0**	**1**	**11**	**7**			

Table 2.23. Caribou skeletal part frequency for the Inughuit context, including minimum number of elements (MNE), minimum number of individuals (MNI), and minimum animal units (MAU).

Caribou	**Inughuit**							
	NISP	L	R	n	MNE	MNI	MAU	%MAU
Cranium (1)	-	-	-	-	-	-	-	-
Mandible (2)	2	-	-	2	1	1	0.5	50%
Atlas (1)	-	-	-	-	-	-	-	-
Axis (1)	-	-	-	-	-	-	-	-
Cervical (5)	3	-	-	3	2	1	0.4	40%
Thoracic (13)	1	-	-	1	1	1	0.1	8%
Lumbar (6)	-	-	-	-	-	-	-	-
Sternum (7)	-	-	-	-	-	-	-	-

Ribs (26)	6	-	2	4	4	1	0.2	15%
Humerus (2)	-	-	-	-	-	-	-	-
Radius (2)	2	2	-	-	2	2	1.0	100%
Ulna (2)	1	-	1	-	1	1	0.5	50%
Carpals (12)	-	-	-	-	-	-	-	-
Metacarpal (2)	1	-	-	-	1	1	0.5	50%
Sacrum (1)	-	-	-	-	-	-	-	-
Scapula (2)	-	-	-	-	-	-	-	-
Pelvis (2)	1	-	-	1	1	1	0.5	50%
Patella (2)	-	-	-	-	-	-	-	-
Femur (2)	1	1	-	-	1	1	0.5	50%
Tibia (2)	1	-	1	-	1	1	0.5	50%
Fibula (2)	-	-	-	-	-	-	-	-
Metatarsal (2)	1	-	-	1	1	1	0.5	50%
Calcaneus (2)	-	-	-	-	-	-	-	-
Astragalus (2)	-	-	-	-	-	-	-	-
Tarsals (4)	-	-	-	-	-	-	-	-
Phalanges (24)	2	-	-	2	2	1	0.1	8%
Total	**22**	**3**	**4**	**14**	**18**			

Table 2.24. NISP and %NISP of burning across various archaeological contexts. Burning stages follow Stiner et al. (1995). Late Dorset materials are burned at a higher relative frequency than any other context.

	Late Dorset		Mixed LD-Inuit		Middle Inuit		Late Inuit-Inughuit		Inughuit	
Burning Stage	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%
0 (no evidence of burning)	2588	98.2	3492	99.8	930	99.7	4629	100.0	1333	99.2
1 (localized, <50% carbonized)	2	0.1	1	-	-	-	1	0.0	9	0.7
2 (>50% carbonized)	1	0.0	2	0.1	-	-	-	-	2	0.1
3 (fully carbonized)	9	0.3	3	0.1	-	-	-	-	-	-
4 (localized <50% calcined)	17	0.6	1	0.0	3	0.3	-	-	-	-
5 (>50% calcined)	2	0.1	-	-	-	-	1	0.0	-	-
6 (fully calcined)	17	0.6	-	-	-	-	-	-	-	-
Total burned specimens	**48**	**1.8%**	**7**	**0.2%**	**3**	**0.3%**	**2**	**0.0%**	**11**	**0.8%**
Total specimens	2636		3499		933		4631		1344	

Table 2.25. The size of fragmented mammalian remains were recorded using a standardized coding system.

	Late Dorset		Mixed LD-Inuit		Middle Inuit		Late Inuit-Inughuit		Inughuit	
Fragment Size Code	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%
1 (< 1 cm)	127	8.6	69	8.6	13	6.2	63	9.8	41	10.8
2 (1-2 cm)	675	45.6	451	56.5	96	45.5	316	49.0	162	42.5
3 (2-5 cm)	532	35.9	232	29.1	85	40.3	202	31.3	139	36.5
4 (6-10 cm)	124	8.	38	4.8	17	8.1	57	8.8	32	8.4
5 (>10 cm)	22	1.5	8	1.0	0	0.0	7	1.1	7	1.8
Total	**1480**	100.0	**798**	100.0	**211**	100.0	**645**	100.0	**381**	100.0

Table 2.26. Number of specimens per weathering stage and their relative frequency. Weathering stages adapted from Behrensmeyer (1978) and applied to mammal bone specimens only.

	Late Dorset		**Mixed LD-Inuit**		**Middle Inuit**		**Late Inuit-Inughuit**		**Inughuit**	
Weathering Stage	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%
0 (no cracking or flaking)	1	0.1	1	0.1	2	0.5	7	0.9	14	2.9
1 (some mosaic-like cracking)	33	2.0	116	12.5	40	10.1	27	3.3	51	10.5
2 (some deeper cracks, light surface flaking)	336	20.2	294	31.6	119	29.7	186	22.9	124	25.5
3 (articular surfaces >50% intact, patches of fibrous bone)	698	42.0	413	44.5	143	35.7	357	43.9	202	41.5
4 (splinters loose enough to fall when specimen moved)	476	28.6	105	11.3	95	23.7	225	27.6	95	19.5
5 (severely deteriorated, spongy bone exposed)	118	7.1	0	0.0	2	0.5	12	1.5	1	0.2
Total	**1662**	100.0	**929**	100.0	**401**	100.0	**814**	100.0	**487**	100.0

Table 2.27. The degree of fragmentation calculated for each context by as NISP:MNE following Lyman (1994, 2008). The faunal materials within the Late Dorset and Mixed Late Dorset–Inuit contexts have the highest extent of fragmentation.

Cultural Period	**NISP**	**MNE**	**Fragmentation (NISP:MNE)**
Inughuit	320	164	2.0
Late Inuit-Inughuit	449	184	2.4
Middle Inuit	208	98	2.1
Mixed LD-Inuit	508	94	5.4
Late Dorset	821	254	3.2

Table 2.28. Number of specimens with carnivore damage and their relative frequency. Overall, evidence of carnivore damage is minimal, with less than 2.5% of all specimens having evidence of carnivore activity.

	Late Dorset		**Mixed LD-Inuit**		**Middle Inuit**		**Late Inuit-Inughuit**		**Inughuit**		**Grand Total**	
Carnivore Damage	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%NISP
Carnivore puncture	23	0.9	11	0.3	2	0.2	3	0.1	3	0.2	42	0.3
Carnivore puncture and scalloping	3	0.1	4	0.1	15	1.6	12	0.3	13	1.0	47	0.4
Carnivore scalloping	0	0.0	3	0.1	3	0.3	16	0.3	17	1.3	39	0.3
Digested	8	0.3	16	0.5	1	0.1	2	0.0	0	0.0	27	0.2
Total damaged specimens	**34**	**1.3**	**34**	**1.0**	**21**	**2.3**	**33**	**0.7**	**33**	**2.5**	**155**	**1.2**
Total specimens	2636		3499		933		4631		1344		13043	

Table 2.29. Summary of butchery marks and spiral fractures on mammal remains for each cultural context.

TAXA	**Late Dorset**				
	NISP	cut	%cut	spiral	%spiral
Fox	147	2	1.4	1	<0.01
Polar Bear	6	1	16.7	-	-
Small seal	285	20	7.0	2	<0.01
Bearded seal	11	1	9.1	-	-
Walrus	13	8	61.5	1	7.7
Muskox	10	1	10.0	-	-
Caribou	128	5	3.9	13	10.2
Total	**600**	**38**	**6.3%**	**17**	**2.8%**
	Mixed Late Dorset - Inuit				
	NISP	cut	%cut	spiral	%spiral
Fox	47	0	0.0	2	4.4
Dog/wolf	23	0	0.0	1	4.3
Small seal	275	0	0.0	1	<0.01
Walrus	4	1	25.0	-	-
Caribou/muskox	8	0	0.0	2	25.0
Total	**357**	**1**	**<0.01%**	**6**	**1.7%**
	Middle Inuit				
	NISP	cut	%cut	spiral	%spiral
Walrus	9	1	11.1	-	-
Caribou	8	-	-	2	25.0
Total	**17**	**1**	**5.9%**	**2**	**11.8%**
	Late Inuit-Inughuit				
	NISP	cut	%cut	spiral	%spiral
Small seal	211	4	1.9	-	-
Walrus	27	3	11.1	-	-
Caribou	14	-	-	1	7.1
Muskox	4	1	25.0	-	-
Total	**256**	**8**	**3.1%**	**1**	**<0.01%**
	Inughuit				
	NISP	cut	%cut	spiral	%spiral
Arctic hare	37	1	2.7	-	-
Small seal	88	1	1.1	-	-
Walrus	77	19	24.7	-	-
Caribou	24	7	29.2	3	12.5
Muskox	1	1	100.0	-	-
Total	**227**	**29**	**12.8%**	**3**	**1.3%**

Table 2.30. Minimum number of individuals of immature animals for select taxa. MNI estimates presented here are included in the total MNI count (**Table 2.4**) but are presented separately here for discussion.

TAXA	**Late Dorset**	
	Fetal	Juvenile/subadult
Dog/wolf	-	1
Small seal (cf. ringed seal)	-	3
Caribou	-	1
	Mixed Late Dorset–Inuit	
	Fetal	Juvenile/subadult
Dovekie	-	1
Arctic hare	-	1
Dog/wolf	-	1
Small seal (cf. ringed seal)	1	2
	Middle Inuit	
	Fetal	Juvenile/subadult
Dovekie	-	1
Small seal (cf. ringed seal)	1	1
Walrus	-	1
	Late Inuit–Inughuit	
	Fetal	Juvenile/subadult
Dovekie	-	1
Arctic hare	-	1
Arctic fox	-	1
Dog/wolf	-	1
Small seal (cf. ringed seal)	1	1
Bearded seal	-	1
Walrus	-	1
Caribou	-	1
	Inughuit	
	Fetal	Juvenile/subadult
Arctic hare	-	1
Small seal (cf. ringed seal)	1	1
Walrus	1	-
Caribou	-	1

Table 2.31. Skeletally immature elements or portions used for age estimation.

Arctic hare	**Age Group**	**Element/Epiphysis**	**Description**
Inughuit	Juvenile/subadult	Radius, proximal and distal	Unfused
Inughuit	Juvenile/subadult	Lumbar vertebra, centrum	Unfused
Late Inuit-Inughuit	Juvenile/subadult	Lumbar vertebra, body	Unfused
Mixed LD-Inuit	Juvenile/subadult	Cervical vertebra	Unfused
Mixed LD-Inuit	Juvenile/subadult	Sacrum	Unfused
Arctic fox	**Age Group**	**Element/Epiphysis**	**Description**
Late Inuit-Inughuit	Juvenile/subadult	Tibia, distal	Unfused
Caribou	**Age Group**	**Element/Epiphysis**	**Description**
Inughuit	Juvenile/subadult	Cervical vertebra, cranial	Unfused
Late Inuit-Inughuit	Juvenile/subadult	Metacarpal, distal	Unfused
Late Inuit-Inughuit	Juvenile/subadult	Tibia, distal	Unfused
Late Dorset	Juvenile/subadult	Humerus, proximal	Unfused
Late Dorset	Juvenile/subadult	Thoracic vertebra, body	Unfused
Late Dorset	Juvenile/subadult	Rib, head	Unfused
Dovekie	**Age Group**	**Element/Portion**	**Description**
Late Inuit-Inughuit	Juvenile/subadult	Femur, complete	Unossified
Late Inuit-Inughuit	Juvenile/subadult	Femur, complete	Unossified
Late Inuit-Inughuit	Juvenile/subadult	Tibiotarsus, distal	Unossified
Middle Inuit	Juvenile/subadult	Humerus, proximal	Unossified
Middle Inuit	Juvenile/subadult	Humerus, proximal	Unossified
Mixed LD-Inuit	Juvenile/subadult	Radius, distal	Unossified
Mixed LD-Inuit	Juvenile/subadult	Radius, distal	Unossified
Mixed LD-Inuit	Juvenile/subadult	Tibiotarsus, distal	Unossified
Dog/wolf	**Age Group**	**Element/Epiphysis**	**Description**
Late Inuit-Inughuit	Juvenile/subadult	Canine	Unerupted, in crypt
Late Inuit-Inughuit	Juvenile/subadult	Mandibular molar	Open root
Late Inuit-Inughuit	Juvenile/subadult	Tibia, distal	Unfused
Late Inuit-Inughuit	Juvenile/subadult	Rib, head and neck	Unfused
Late Inuit-Inughuit	Juvenile/subadult	Sacrum, body	Fusion line
Mixed LD-Inuit	Juvenile/subadult	Metacarpals (Right: 1,3,4; Left: 2,3)	Unfused
Mixed LD-Inuit	Juvenile/subadult	Rib, head and neck	Unfused
Late Dorset	Juvenile/subadult	Ulna, distal	Unfused
Ringed seal	**Age Group**	**Element/Epiphysis**	**Description**
Inughuit	Juvenile	Ulna, proximal	Unfused
Inughuit	Juvenile	Ulna, proximal	Unfused
Inughuit	Juvenile	Tibia, proximal	Unfused
Inughuit	Fetal	Fibula	
Inughuit	Fetal	Humerus	
Inughuit	Fetal	Mandible	
Inughuit	Fetal	Radius	
Inughuit	Fetal	Scapula	
Late Inuit-Inughuit	Juvenile	Radius, distal	Unfused

Late Inuit-Inughuit	Juvenile	Radius, proximal	Unfused
Late Inuit-Inughuit	Juvenile	Radius, proximal	Proximal fused, distal unfused
Late Inuit-Inughuit	Fetal	Fibula	
Late Inuit-Inughuit	Fetal	Humerus	
Late Inuit-Inughuit	Fetal	Rib	
Late Inuit-Inughuit	Fetal	Tibia	
Late Inuit-Inughuit	Fetal	Ulna	
Middle Inuit	Juvenile	Canine	Open root
Middle Inuit	Juvenile	Humerus, proximal	Unfused
Middle Inuit	Juvenile	Humerus, proximal	Unfused
Middle Inuit	Fetal	Rib	
Middle Inuit	Fetal	Scapula	
Middle Inuit	Fetal	Vertebra	
Mixed LD-Inuit	Juvenile	Humerus, proximal	Unfused
Mixed LD-Inuit	Juvenile	Humerus, distal	Unfused
Mixed LD-Inuit	Fetal	Phalanx	
Mixed LD-Inuit	Fetal	Rib	
Mixed LD-Inuit	Fetal	Tibia	
Late Dorset	Juvenile	Canine	Open root
Late Dorset	Juvenile	Femur, distal	Unfused
Late Dorset	Juvenile	Femur, distal	Unfused
Late Dorset	Young Adult	Tibia, proximal	Proximal fused distal unfused
Bearded seal	**Age Group**	**Element/Epiphysis**	**Description**
Late Inuit-Inughuit	Juvenile	Radius, proximal	Proximal fused, distal unfused
Walrus	**Age Group**	**Element/Epiphysis**	**Description**
Inughuit	Juvenile	Ulna, proximal	Unfused
Inughuit	Fetal	Calcaneus	
Late Inuit-Inughuit	Juvenile/subadult	Phalanx, proximal	Unfused
Middle Inuit	Young Adult	Mandibular symphysis	Unfused

Discussion

Small, migratory dovekies are the most frequent taxon in the faunal assemblage at Iita. Although the relative abundance of dovekie fluctuates over time and between the pre-Inuit and Inuit groups at Iita, they were clearly an important part of the subsistence round (**Figure 2.8**). Other small resources such as arctic fox and hare are also well represented throughout the assemblage but seem to play a larger role during the Late Dorset occupation. Despite the lack of bow-and-arrow technology, caribou and muskox are much more frequent in the Late

Dorset period than in all later Inuit periods. Seals are ubiquitous throughout our study periods. Lastly, walrus is only well represented in the chronologically later Inughuit period (see chapter 3 and 4 for a discussion on walrus ivory use). In summary, the current analysis suggests that the Late Dorset practiced a subsistence strategy that took a variety of taxa in relatively equal proportions, yet a single species, dovekie, is dominating the assemblage. Conversely, our results suggest that the Inuit practiced a more focal subsistence strategy, with slightly fewer taxa being accessed on average, and with one species, dovekie, dominating the assemblages.

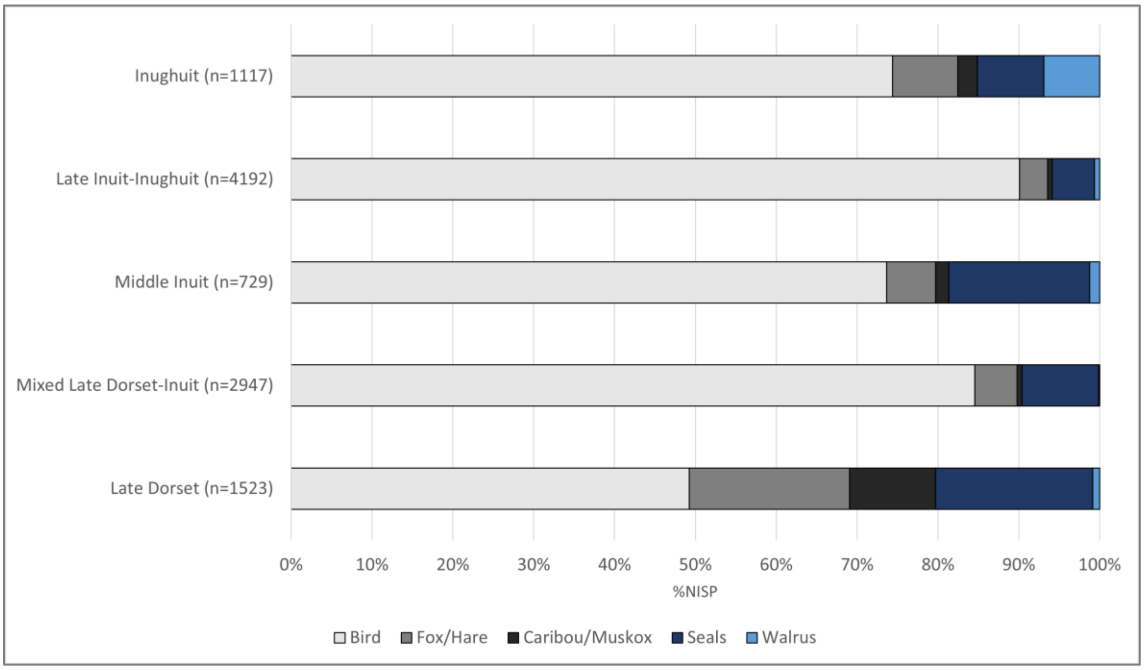

Figure 2.8. Relative frequency of identified specimens (%NISP) for major taxonomic groups across the five archaeological contexts. Birds clearly dominate; however, there is some variation in the frequency of the other taxa groups over time.

Birds as Focal Prey

These results suggest that birds, namely dovekies, are the focal prey for both Pre-Inuit and Inuit foragers at Iita. In optimal foraging theory, tools for predicting foraging behavior, such as the diet breadth model, commonly use body size as a proxy for ranking a resource in terms of dietary importance. This ranking is based on the idea that a forager will aim to maximize net gains (calories, nutrition, raw materials) while minimizing the time and energy spent during pursuit and processing. Because an average individual dovekie is a mere 150g when unprocessed, it alone will not supply many calories. If dovekies are an inefficient resource, then why are they a focal resource for nearly 1000 years of occupation of Iita? Based on a zooarchaeological analysis from chronologically later Inuit periods at Iita, Johansen (2013) suggests that dovekies should not be considered low-ranking prey, particularly if they are captured *en masse*, which reduces overall pursuit costs. When mass captured, dovekies and other birds can provide not only a sufficient number of calories but also raw materials such as skins and feathers for clothing (Ekblaw 1921, 1928).

One of the most effective ways to capture many dovekies at once is through net technology. There is evidence for net use by Inuit across the Arctic and rich ethnographic accounts from Iita recount the use of large nets on long poles of drift wood and narwhal tusks to capture dovekies (Ekblaw 1928) (**Figure 2.9**). Using ethnographic analogy, we assume that similar net technology was used by the precolonial Inuit at Iita to capture birds as well. Although certainly plausible, there is little archaeological evidence from anywhere in the Arctic indicating that the Late Dorset had net technology (Maxwell 1985; Monchot et al. 2016). At any rate, dovekies were captured in relatively large numbers by the Late Dorset residing at Iita, just not as intensively as in later Inuit periods. Whether their lower relative frequency speaks to generally wider diet breadth for Late Dorset occupants, as demonstrated at other Arctic sites (Darwent and Foin 2010; Howse 2018; Howse and Friesen 2016), or to the lack of net technology cannot be disentangled. When our results are considered alongside those of Johansen (2012), clearly dovekies have been an important part of the subsistence economy at Iita for the last 1,000 years.

Small-bodied animals, such as dovekies, tend to be lower ranked as they are assumed to incur higher processing costs (more time and energy) associated with preparing the meat for consumption (Bettinger 2009). Various historic accounts depict the relatively simple dovekie processing techniques practiced by Inughuit after Euro-american contact (Ekblaw 1919; Freuchen 1961). Dovekies could be eaten soon after capture or stored for later use. If eaten fresh after capture, the wings and legs could be removed easily by twisting, then the breast meat and fat from the skin eaten as is, requiring minimal processing (Johansen 2012). One storage technique produced *kiviaq*, a dish prepared by stuffing a blubber-coated sealskin with hundreds of unprocessed dovekies and storing it under a cache of rocks for several months, again requiring minimal processing of the birds (Ebel 2019).

Figure 2.9. Historic glass lantern slide, hand-tinted, depicting an Inughuit woman hoisting a net attached to a long pole into the air to catch dovekies. It is possible that similar nets were used to capture dovekies at Iita prior to Euroamerican contact. Photograph by Donald Baxter MacMillan circa 1913-1917 (Accession #000.32.2038); image provided by the Peary-MacMillan Arctic Museum, Bowdoin College.

Mammalian Resources

Mammals were also important resources for the Late Dorset and Inuit at Iita. **Table 2.32** demonstrates seasonal availability and hunting techniques for some of the most common mammal species.

Arctic hare

Providing a source of lean meat and secondary products such as white fur and bones, the Arctic hare were important raw materials for clothing and needles in ethnographic times (Ekblaw 1921, 1928) and likely for those living at Iita precontact as well. Arctic hare is represented by various axial and appendicular skeletal portions in all five archaeological contexts, although hare is less frequent in the Middle Inuit materials. Vertebrae are not well represented, which may be a preservation issue, but it appears that hares were likely transported and processed at Iita whole. The relative abundance of hare is consistent with other sites in the Eastern High Arctic. Light cut marks (slices) were observed on a single lumbar vertebra in the Inughuit context.

Arctic fox

With white and blue coat varieties available in Northwestern Greenland, Arctic fox were an important source of skins and furs (Ekblaw 1928; Prestrud 1991). According to ethnographic accounts, foxes were only eaten as needed or when body fat was highest in winter, and foxes seem to be most prized for their skins and fur coats for clothing (Ekblaw 1928). At Iita, Arctic fox is represented by various axial and appendicular skeletal elements indicating that foxes were also transported whole and processed on site. Fox is most frequent in the Late Dorset period. However, foxes are much less frequent in the entire Iita assemblage compared to other High Arctic sites. A few spiral fractures were observed, and only in the Late Dorset and Mixed Dorset contexts. Light cut marks (slices) were also observed on several long bones (tibiae and radii) of the Late Dorset assemblage, which indicate removal of skins.

Walrus

Walrus were likely available to hunters in Smith Sound near Iita year-round. A single individual of these large and dangerous sea mammals provided hundreds of kilograms of meat and blubber, along with ivory, a raw material used for many everyday objects including needles and harpoon heads. Skeletal portions of the walrus associated with the most meat are represented in the Late Dorset context, indicating the Late Dorset were more selective about which portions were transported back to camp for further processing. Conversely, the Inuit contexts tend to have more appendicular skeletal portions, such as carpals or tarsals, represented which suggests that walrus in these periods were transported to Iita whole or that these portions with less meat were left attached and brought back to camp for processing (e.g., schlepp effect). This is likely a result of dog sleds, which would have allowed for the transport of more body portions to be hauled over longer distances than by human-pulled sledges presumed to have been used by the Late Dorset. It is also possible that these low-utility limb portions were used as a supply of food for sled dogs, as was observed ethnographically (Ekblaw 1921).Walruses are not as well represented as in other coastal Arctic sites with either Late Dorset or Inuit components, but this may be due to heavy processing of carcasses as these are large animals. For example, 62% of walrus specimens from the Late Dorset period bear cut marks. The frequency of cut marks decreases in the Middle Inuit and Late Inuit-Inughuit period but chopping appears to increase in the Inughuit period. Twenty-five percent of walrus bone is chopped in this period, with most observed on cranial elements which could be associated with ivory extraction.

Small seals

Ringed seals are the smallest yet most abundant seal species with a circumpolar distribution (Hammill 2008). Ringed seals were an important source of food but also for raw materials such as skins for clothing, tents, watercraft, and cordage and blubber for oil lamps (Ekblaw 1921, 1928). The many uses of the ringed seal and its ubiquitous distribution contributes to its high frequencies in faunal assemblages across the Arctic for both the Late Dorset and Inuit contexts. At Iita, these small seals are abundant in all occupations and appear to have been transported as whole carcasses, which is not surprising given their compact bodies which were easy to transport as whole packages. However, there is a decrease in relative abundance of small seals over time. Johansen (2012) also reported a general decrease in seal over time in her analysis of chronologically later occupations at Iita and offered two hypotheses to explain this phenomenon: a) cooling temperatures and increased ice cover led to a decrease in the availability of ringed seal near Iita, and b) a shift to incorporating other resources over time.

It is possible that changes in climate could have affected ringed seal availability. Small seal is most abundant in the Late Dorset period, which is associated with a warm climate while the lowest abundance is in the Inughuit assemblage which is associated with prominent cooling (Friesen, Finkelstein, and Medeiros 2020). Although ringed seals can maintain breathing holes by scratching with their fore-flippers, periods of heavy ice and snow cover could potentially drive these seals out of fjords and into open waters (Ekblaw 1921; Hammill 2008; Johansen 2012).

Caribou

Caribou offered many resources beyond meat and marrow, including skins for clothing, bedding, sinew for thread and cordage, and antler for everyday objects such as knife handles (Ekblaw 1921, 1928; Wissler 1918). Overall, caribou is represented in relatively low numbers at Iita, which is similar to faunal assemblages from other Eastern High Arctic sites (Darwent 2001). Caribou is most abundant in the Late Dorset component despite their lack of bow and arrow technology. This suggests that the caribou population near Iita was substantial during this occupation and/or that the Late Dorset hunters utilized techniques to capture many caribou at once including rock features or bodies of water to funnel their prey into a suitable area for dispatch with spears (Friesen 2013).

Although there is a decrease in caribou bones represented in the later Inuit components from the current faunal analysis, the analysis of antler tool debitage indicates that certain portions of caribou were still being used at Iita in these chronologically later occupations (refer to Chapter 4 for a discussion of antler use). It is also possible that shed antler was collected requiring no direct caribou hunting. It has been suggested that caribou populations in northern Greenland are subject to periods of extirpation, either from shifts in climate which limit access to forage (Meldgaard 1986; Roby et al. 1984) or from over exploitation, leading to resource depression (Darwent 2001).

Whole carcasses, except for the most distal portions of the lower limbs which are portions with less meat, appear to have been transported back to Iita by the Late Dorset. In contrast, elements of the upper limb appear to be best represented in the Middle Inuit occupation, suggesting selective transport of particular portions. Whole carcasses with the less desirable bony portions such as the tarsal seem to only have been transported in the Inughuit period.

Taphonomy

Overall, the taphonomic factors affecting the Late Dorset and Inuit deposits at Iita are like those reported by Darwent and Foin (2010), Howse (2008), and Johansen (2012). However, the Late Dorset faunal materials are more heavily weathered compared to the faunal materials from all Inuit contexts. The Late Dorset materials are chronologically older and therefore have been subjected to various taphonomic processes for a longer period. Additionally, there is a difference in preservation of certain soft tissues between materials studied by Johansen (2012) and the current study. For example, Johansen (2012) noted the excellent preservation with the recovery of bird feathers and the presence of dried connective tissues. This decrease in material preservation affects both Late Dorset and Inuit materials and is probably due to the nature of their exposure to the environmental effects of climate change. The loss of vegetation cover and permafrost which once protected the materials at Iita have contributed to the acceleration of soil erosion at the site (Darwent et al. 2019). Despite this, we believe that general comparisons of the faunal data derived from this assemblage can be made with some degree of confidence.

Although modifications such as cut marks and burning are relatively rare in this faunal assemblage overall, there is a clear distinction with the bird remains. The dovekie bones specifically lack evidence of burning and cut marks suggesting that they were minimally processed. Ethnographic accounts suggest many ways to process dovekies for consumption such as removing the wings and then eating the breast meat (Ebel 2019; Freuchen 1961). Some accounts suggest that removal of the bones prior to consumption was unnecessary, as the small bones could easily be chewed and swallowed or spat out (Ekblaw 1919; Freuchen 1961). In ethnographic times, Inughuit would stuff hundreds of whole dovekies into sealskins, tightly sew the skins shut, and cache the packages to ferment over several months, eventually forming a delicacy called *kiviaq*, as previously mentioned (Ekblaw 1919, 1921, 1927, 1928). Although the exact methods of dovekie preparation practiced by Late Dorset and precolonial Inuit are unknown, minimal processing is reflected in their high MNI to NISP values (**Figure 2.7**). Throughout all contexts, elements of the wing and leg are the most frequent. Considering this together with the lack of cut marks and burning on all dovekie elements may suggest that these bones were removed and discarded prior to consumption and that the dovekies were minimally processed.

Seasonality

Iita's proximity to the North Water polynya provided people with the opportunity and access to many year-round resident species including Arctic fox and hare, ringed seal, bearded seal, walrus, caribou, and muskox (**Table 2.32**). The presence of buried semi-subterranean house features associated with Late Dorset occupants, as well as the superimposed ruins of Inuit sod houses support a winter occupation at Iita (Darwent et al. 2019; LeMoine and Darwent 2010). However, the recovery of tens of thousands of dovekie bones from across house and midden deposits are a clear indication that humans resided at Iita during the summer and likely stored them for winter consumption (Johansen 2012, 2013). Dovekies are known to have had seasonal colonies in Greenland for at least 4,000 years based on the presence of bird guano in peat and lake cores (Davidson et al. 2018; Mosbech et al. 2018). They were available during the brief summer (May–August) and were likely netted *en masse* for centuries (Ebel 2019; Johansen 2013).

Contextualizing the Results

Comparing to previous research at Iita

Overall, our results are generally consistent with those of Johansen (2012). The two major distinctions being that a) birds contribute to 8% less of the identified fauna in the current study, and b) dogs/wolves contribute to 75% less of the identified fauna. This is unsurprising given that the current analysis includes fauna from the Late Dorset, a society that is not known to have kept domesticated dogs.

A pattern of interest appears when comparing the current results with those of Johansen (2012). The current study suggests that foxes are almost always more abundant than hare, except for the Inughuit period which is nearly the opposite of what is reported by Johansen (2012). Johansen found that hare was always more abundant than fox throughout all Inuit occupations (Early Thule to Late Historic Inughuit). As we consider this, it is important to remember that Johansen's analysis involved faunal remains from house contexts while the current study is based entirely on remains from midden contexts. While fox was apparently more abundant than hare in the Late Dorset contexts, it is possible that hare and fox were used more equitably throughout the Inuit periods than previously understood. Based on these results, it is possible that fox and hare were differentially discarded by Inuit at Iita over time, with hare being discarded more often within the house and fox outside of the house. This pattern of discard may reflect how these two taxa were prepared and used for consumption and clothing production. As mentioned previously, ethnographic descriptions of the Historic Inughuit describe some differences in the use of arctic hares and foxes. Hare was consumed and its fur and bones were used for clothing production. In contrast, fox was an excellent source of fur but was consumed much less frequently (Ekblaw 1921, 1927, 1928). It may be that hare was processed and consumed inside the house, while fox was processed and discarded outside.

Previous research on faunal remains from Late Dorset middens and house deposits indicate that Late Dorset discarded faunal remains differently than Inuit (Darwent and Foin 2010), and that samples from either house or midden contexts should tell us about use of animal resources at the site (Howse 2008). However, this is likely not the case for Inuit who have more divisions of spatial use (Darwent and Foin 2010; Friesen and Betts 2006). For example, animal processing appears to have occurred in different parts of the household, depending on the animal being prepared. Therefore, the composition of discarded faunal remains from house floors is expected to differ from associated middens (Friesen and Betts 2006). This interesting phenomenon should be explored in future research.

Comparing to other regional studies

At Iita, the Late Dorset appear to be taking a wide variety of taxa, and each type of taxa contributes relatively evenly to the faunal assemblage, and by extension to the diet. There is some variation across the Inuit contexts, but in general, it appears that Inuit are taking a smaller variety of taxa, with certain taxa contributing to most of the faunal assemblage. This is generally consistent with previous studies comparing subsistence strategies of the two Arctic foraging societies. However, our resulting counts of N-taxa are not quite as distinct between Late Dorset and Inuit components at Iita as has been documented at other localities. This is partially driven by the lower number of distinct species available to those living at sites in the High Arctic compared to other lower arctic sites with slightly higher biodiversity.

Our findings based on the faunal analysis of Late Dorset deposits compare favorably with those at other High Arctic localities within NW Greenland such as those reported by Bendix (1999; 2000) in that 1) there is a relatively high percentage of avian remains, particularly of migratory birds, which contributed to the total identified faunal remains, and 2) fish remains were notably absent from the assemblage. In addition, our results are generally consistent with the zooarchaeological analysis by Darwent and Foin (2010) who report on Late Dorset and Inuit house contexts from Cape Grinnell, Northwest Greenland, with the main distinction being that seals play a much smaller role in the current faunal assemblage for both the Late Dorset and Inuit contexts. Iita appears to be unique in the High Arctic with human occupants drawn to the dovekie rookeries for over a millennium. Our results provide supporting evidence for the long-held importance of birds and their products to the Inuit at Iita as discussed by Johansen (2012; 2013).

Table 2.32. Seasonal availability and hunting strategies for the most common taxa recovered from Iita.

		Hunting Methods		
Taxa	**Time of year available**	**Late Dorset**	**Inuit-Inughuit**	**Sources**
Dovekies and other migratory waterfowl	Late spring – summer	Net? Capture when flightless (late summer, August) Eggs in nests Snare traps	Net Capture when flightless (late summer, August) Eggs in nests Snare traps	Ekblaw (1919), Kroeber (1899)
Fox	Year round (fur is in best condition from November to February)	Traps	Traps	Ekblaw (1921), Vibe (1950)
Hare	Year round (fur is best quality if caught in winter)	Snare traps	Snares traps	Ekblaw (1921), Steensby (1910)
Caribou	Possibly available near Iita year-round but better in the fall, likely taken whenever encountered	Spear/lance, communal drives	Spear/lance, drives, bow and arrow[3]	Appelt et al. (2016), Friesen (2013), Mary-Rousselière (1984), Steensby (1916)
Muskox	Possibly available near Iita year-round but better in the fall, likely taken whenever encountered	Spear/lance	Spear/lance, bow and arrow[4]	Appelt et al. (2016), Steensby (1916)
Walrus	Year round	(assumed) Harpooned at ice holes in winter/spring; harpooned at ice edge in summer/fall	Harpooned at ice holes in winter/spring; harpooned at ice edge or from kayak in summer/fall;	Kroeber (1899), Steensby (1910, 1916), Vibe (1950)
Bearded seals	Year round	Harpooned within cracks in ice or breathing holes	Harpooned within cracks in ice, harpoon in open water from kayaks or at breathing holes possible but less common	Kroeber (1899), Steensby (1916), Vibe (1950)
Ringed seals	Year round	Harpooned at breathing holes in ice in late fall and winter, harpooned from ice edge in summer	Harpooned at breathing holes in ice in late fall and winter, harpooned from kayaks or from ice edge in summer	Kroeber (1899), Steensby (1916), Vibe (1950)

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[3] Inughuit did not have bow-and-arrow technology for a period spanning at minimum from 1818–1860. Details of this technological loss are unclear, see LeMoine and Darwent (2016) for discussion. This period of technological loss is likely not captured in the current sample.

[4] Steensby (1910:300) surmises that bow-and-arrow technology used by the Inughuit in historic times may not have been strong enough to take muskox.

Conclusions

The archaeological site of Iita is located near one of the most biologically productive ecosystems north of the Arctic Circle which has supported a diverse array of Arctic fauna and has consequently attracted and supported communities of two distinct Indigenous groups over the last millennium. We presented the results of a multi-component faunal analysis, providing the first, detailed investigation of Late Dorset subsistence practices at Iita and expanded our current knowledge of precolonial Inuit subsistence practices at Iita.

Previous research on the identification and interpretation of faunal remains has provided insight into the choices Arctic foragers were making regarding resource use across the Arctic. However, Iita presents a unique opportunity to examine this variation over time and between culturally distinct populations which consecutively occupied a single site. It has been established that the broad differences between Late Dorset and Inuit societies stem from deviations in subsistence strategies and curated technologies, such as bow and arrows and watercraft, which also influence subsistence choices (Howse 2019; Howse and Friesen 2016). Our research provided additional evidence for this by examining variation between the two groups while minimizing variability due to environmental factors, an advantage afforded to us by analyzing materials from a single archaeological site. Additionally, this research contributes to our understanding of the predicted foraging efficiency of two precolonial Arctic societies and the ultimate persistence of the Inuit and the cultural and genetic extinction of the Late Dorset.

3. Using Bone Technology and ZooMS to Understand Indigenous Use of Marine Mammals at Iita, Northwest Greenland

This chapter is derived, in part, from an article published in the *Journal of Island and Coastal Archaeology* by Erika J. Ebel, Genevieve M. LeMoine, Christyann M. Darwent, John Darwent, and Daniel P. Kirby (Ebel et al. 2023): http://www.tandfonline.com/10.1080/15564894.2023.2213662

Introduction

One way to infer subsistence strategies of past cultures is by identifying and quantifying archaeological faunal remains. Even in exceptionally well-preserved sites, such as permafrost and polar desert conditions of the High Arctic, not all faunal remains will be identifiable based on visual inspection alone. Specifically, debris produced during osseous-tool manufacture can be difficult to identify due to the removal of characteristics typically used to assign a specimen to a meaningful taxonomic category. In addition, osseous tool-making debris has been analyzed separately from that of the non-tool faunal assemblage under the heading of "technology" or bone tools. In other cases, these remains have been overlooked entirely because of the inherent difficulty of identifying them to skeletal part and taxon. The use of Zooarchaeology by Mass Spectrometry (ZooMS) or Peptide Mass Fingerprinting (PMF) has contributed to identifying Type 1 collagen preserved in fragments to the level of family, genus, or species in a number of studies of osseous technology (Brandt, Haase, and Collins 2018; Brown et al. 2021; Desmond et al. 2018; Martisius et al. 2020). Although ZooMS cannot determine a particular skeletal part, this method provides complementary taxonomic information to traditional, visual or morphological faunal analyses. Several studies on highly modified osseous artifacts have demonstrated the significant insight provided by taxonomic identifications using ZooMS. For example, ZooMS has provided insight into human behaviour and the selection of species used for certain bone tools (Bradfield et al. 2021; Brandt et al. 2018; Brown et al. 2021; Desmond et al. 2018; Martisius et al. 2020). Additionally, studies on the identification of cetacean remains have shown that ZooMS can significantly expand the diversity of cetacean species represented at a site compared to traditional morphological approaches (Evans et al. 2016) and to ground-truth ethnographic or historic texts regarding whale use (Charpentier et al. 2022; van den Hurk et al. 2021). These new taxonomic insights highlight how cetacean raw materials can provide information on prehistoric biogeography of various whale species and how these materials may be curated and transported significant distances from where they were originally recovered (Pétillon et al. 2019).

We describe the application of ZooMS to classify previously unidentified specimens resulting from osseous tool production at the archaeological site of Iita in northwestern Greenland (**Figure 3.1**). This site was occupied regularly from 1000 CE to the mid-20th century (Darwent et al. 2019) and provides a unique opportunity to examine diachronic changes in the use of marine mammals for food and raw material resources by two culturally distinct Indigenous groups, 1) Pre-Inuit, or Late Dorset, and 2) Inuit-Inughuit cultures. Because the High Arctic has a dearth of trees, and driftwood is limited, we may infer from this lack of wood resources that raw materials, such as bone and ivory, were crucial for toolmaking. Continuity of past Arctic cultures depended on successfully adapting to variable conditions and, consequently, on adjusting subsistence and tool-making strategies accordingly.

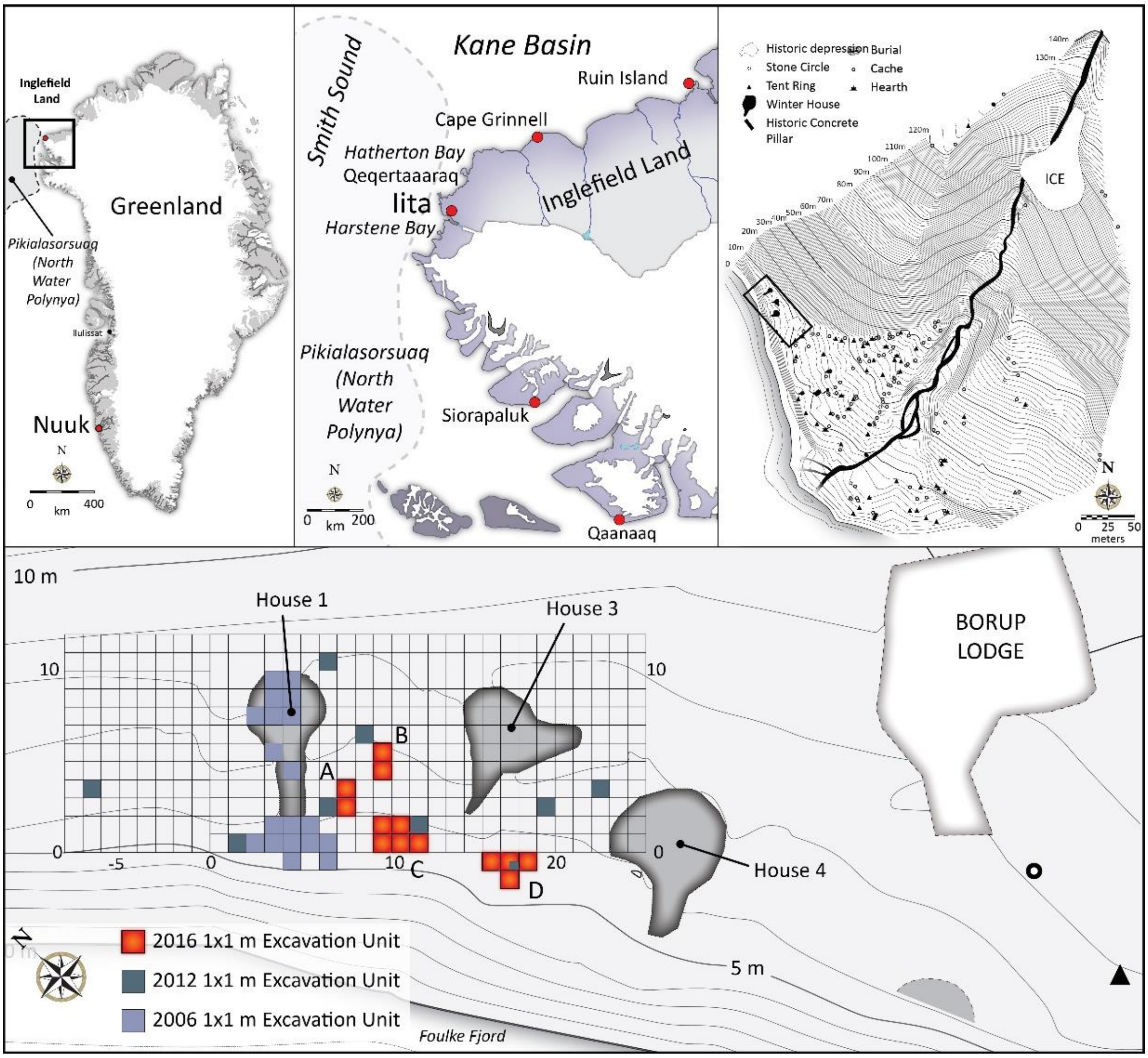

Figure 3.1 The top three panels illustrate a regional map of the study area with Iita indicated by the red dot in Northwestern Greenland. Note the proximity of Iita to the northern limits of the North Water Polynya which provides year-round habitat for various marine mammals. The bottom panel is the excavation grid layout at Iita. Excavations in 2006 were focused on the interior of House 1, while excavations in 2012 and 2016 were primarily focused on external midden deposits. Built in September of 1913, Borup Lodge served as the headquarters of the 1913–1917 Crocker Land expedition led by Donald B. MacMillan. Figure by J. Darwent.

Iita is located adjacent to the North Water polynya in Smith Sound, which is home to several species of marine mammal, including large and small varieties of whale and seal (Vibe 1950). When highly fragmented, these osseous marine-mammal remains often are unidentifiable beyond a broad taxonomic or general body-size category (e.g., whale, pinniped, small seal). Whole carcasses of whales or walrus may be field processed and only meat, skin, blubber, and bone or ivory for tool production selected for transport. Large bones were chopped into smaller, transportable pieces, and further processing produced ubiquitous fragments—less taxonomically and anatomically identifiable—leading to routine underrepresentation of certain marine mammals in the zooarchaeological record. As Richter et al. (2022) observe, ZooMS is a particularly powerful tool when applied to aquatic ecosystems, which tend to yield a larger number of possible identifiable taxa in a faunal assemblage than terrestrial species by increasing the ability to differentiate between species that are morphologically similar; a complication when analyzing faunal assemblages with fragmented marine mammal remains.

The assortment of osseous raw materials should reflect cultural and behavioural differences by the groups who inhabited Iita. More importantly, it provides additional insight on raw-material procurement and the taxa represented at the site. We demonstrate with the use of ZooMS, that marine mammals, particularly narwhals, are generously represented in the Inuit osseous technology component of the Iita assemblage, but they are absent from the rest of the faunal assemblage. With data from both technological and dietary sources, we can better understand observed differences in animal resource use between two culturally distinct groups who lived at the same Arctic locality.

Cultural Chronology and Background

Two distantly related but culturally distinct groups originated in the Bering Strait region and undertook major pan-Arctic migrations across the eastern Arctic of North America (Maxwell 1985; Raghavan et al. 2014): 1) Pre-Inuit, and 2) Inuit. Prior to 3200 BCE, Pre-Inuit descendants of the archaeological tradition known as Bel’kachi crossed the Bering Strait from Siberia to northwestern Alaska and expanded across the Canadian Arctic to Greenland. Archaeologically they are associated with a technological tradition known as the Arctic Small Tool tradition (ASTt) (Friesen 2016). Archaeologists recognize several ASTt complexes over more than 3000 years of eastern Arctic occupation, but here we focus on the Late Dorset, the terminal phase of these Pre-Inuit cultures.

Late Dorset material culture is characterized by elaborate carvings of bone, antler, and ivory (LeMoine and Darwent 1998), increased use of local copper and meteoritic iron sources (Jolicoeur 2020), and large, communal structures known as longhouses (~14–45m in length), which are often associated with numerous hearth rows (Darwent et al. 2008; Friesen 2007). Interestingly, bow-and-arrow technology, dogs, and small boats seem to have been lost by this last manifestation of ASTt Pre-Inuit peoples (Maxwell 1985; Morey and Aaris-Sørensen 2002).

Initially defined as “Thule” by archaeologist Therkel Matthiasen (1927), precolonial Inuit cultures of the North American Arctic are the direct ancestors of Canadian and Greenlandic Inuit and Alaskan Iñupiat. Current interpretations suggest Inuit culture developed in the Bering Strait region and spread into the eastern Arctic by 1200 CE (Friesen 2016; Maxwell 1985; Whitridge 2016). Although genetically and culturally distinct from earlier Pre-Inuit groups, scholars do not agree on whether these two cultures interacted or whether such interaction had a causal relationship to the eventual disappearance of Late Dorset (Raghavan et al. 2014). Inuit brought a new way of living to the Arctic, which included bow-and-arrow technology, dog-sled transport, and large boats (*umiak*) enabling transport of numerous people and communal hunting of large marine mammals, including bowhead whales. Large, semi-subterranean dwellings of sod, stone, and whale bone typify the *iglu,* the classic Inuit winter dwelling (Whitridge 2016). Inuit occupations are often situated near or on top of earlier Pre-Inuit dwellings, as is the case at Iita (Darwent et al. 2019; LeMoine and Darwent 2010). Radiocarbon dating of sequential cultural layers indicates that the timing of the Late Dorset people's disappearance and the arrival of Inuit in the eastern Arctic are synchronous, but the extent to which their occupations overlapped remains unclear, and no clear evidence has yet been found for cultural transmission between the two groups (Darwent et al. 2019).

Prior to 1700 CE, Inuit communities became regionally specialized and developed geographically unique subsistence and settlement strategies (Mason and Friesen 2017; Whitridge 2016). Inughuit of northwestern Greenland are the most northerly Indigenous peoples in the world and speak Inuktun, a distinct dialect of Inuktitut. Precolonial population size is estimated to be 100–200 people (Holtved 1944; LeMoine and Darwent 2016). At the time of historic contact, Inughuit did not fish or capture marine mammals in open water; instead, they hunted from the ice edge. Inughuit had lost the bow and arrow, fishing leisters, and kayaks sometime in the century prior to contact with British whaler John Ross in 1818 (LeMoine and Darwent 2016).

The Archaeological Site of Iita

Iita is located on Smith Sound at the southern end of Inglefield Land in northwestern Greenland. This location was attractive to Arctic peoples because of its proximity to the North Water polynya (**Figure 3.1**), which is an area of permanently open water surrounded by sea ice and often characterized as an "arctic oasis" due to the large aggregation and concentration of marine life (Born 2001; Mosbech et al. 2018; Vibe 1950). Marine mammals such as polar bear, bowhead whale, beluga, narwhal, walrus, and ringed and bearded seals are found nearby and were harvested by the various occupants of Iita (Johansen 2012).

Iita sits on an alluvial fan and stratigraphic layers have accumulated over time because of continual downhill movement of sediment. This is different than what is typically seen across the High Arctic where abandoned archaeological ruins dot the surface of the landscape and remain visible for thousands of years due to slow soil development in the polar desert environment. This phenomenon often results in artifacts from multiple time periods exposed and intermingled on the surface. Thus, the distinct stratigraphic occupation layers at Iita present a novel opportunity to observe changes in the use of marine mammal resources through time.

Previous Research at Iita

Inglefield Land has attracted American and British Polar explorers since the early 1800s, but Iita's archaeological features were not investigated until 1915, when George Comer was landlocked for two years by impenetrable sea ice. Comer's excavations here were minor, however, compared to his later undertakings at North Star Bay or Ummanak, now known as Comer's Midden. During his stay at Iita, Comer partially excavated several archaeological features he described as old house sites, but he did not record their locations; thus artifacts collected during the Crocker Land Expedition and Comer's rescue mission between 1913–1917 lack intra-site archaeological context (LeMoine and Darwent 2010; Wissler 1918). Comer recovered artifacts from several of these house features in the vicinity of Iita including ivory sled shoes and carvings, bone and antler hafts for knives, antler hammers, baleen (referred to as whalebone), barbed wooden objects, variously shaped chipped flint, and "a large series of whale bone slabs used in making sleds" (Wissler 1918:119).

The Inglefield Land Archaeology Project, which focused partly on the historical period occupation at Iita, initiated its investigations of the region in 2004 (Darwent et al.

2007; LeMoine and Darwent 2010). Two semi-subterranean Inuit/Inughuit houses were excavated in 2006 (**Figure 3.1**). During the excavation of House 1, Pre-Inuit-period chert flakes were discovered under the feature's Late Inuit/Inughuit period occupations. To explore these findings further, excavations resumed in 2012 in midden areas adjacent to House 1, confirming a Pre-Inuit, Late Dorset occupation, but with no evidence of earlier occupations. The site's Late Dorset deposits were being impacted by coastal erosion so investigations resumed in 2016 to mitigate site loss (Darwent et al. 2019).

Johansen's (2012, 2013) analysis of zooarchaeological remains from Inuit and historic Inughuit winter house deposits at Iita indicated hunting patterns similar to those of other high Arctic sites with the exception of copious dovekie (*Alle alle*) remains, a small seabird that migrates to the area annually to nest in rookeries around Foulke Fjord. These dovekies and other birds accounted for 74% of the faunal assemblage as compared to only 1%–3% at other eastern Arctic sites, confirming the unique setting of the study site (Darwent and Johansen 2010; LeMoine and Darwent 2010; LeMoine and Darwent 2016; Mosbech et al. 2018).

The small proportion of marine mammal remains (~12%) Johansen (2012) identified at Iita is interesting given its prime location for accessing the ubiquitous large sea mammals in Foulke Fjord. In addition to walrus, ethnographic and historic accounts describe the importance of beluga and narwhal to the Inughuit (MacMillan 1918; Savelle 1994; Vibe 1950), yet whale of any species was scarce, constituting less than 1% of all identified specimens. This may indicate that whales were processed at the kill site before select parts, namely the muscle and blubber, were brought back to camp (Johansen 2012).

Current zooarchaeological research on the chronologically older Late Dorset faunal materials recovered from midden deposits reveals a similar pattern (Chapter 2, this volume). However, by incorporating materials from the osseous technology component, we now recognize that marine mammal resources, particularly cetaceans, were underrepresented, and were therefore accessed by the inhabitants of Iita more often than previously concluded.

Zooarchaeological Materials and Methods

The primary faunal data analyzed here, including osseous tools and manufacturing debris, were recovered from midden deposits at Iita excavated in natural stratigraphic layers and screened using $\frac{1}{4}$ -inch mesh in 2012 and $\frac{1}{8}$ -inch mesh in 2016 (Darwent et al. 2019). A total of 15, 1x1 meter units were excavated, and 100% of the faunal remains across all cultural layers were carefully hand sorted for debris from osseous tool production. Faunal remains recovered from discrete Late Dorset deposits in nine units were subjected to traditional faunal analysis. Given the overwhelming quantity of faunal remains, and because analysis of Inuit-Inughuit fauna from houses at Iita had been undertaken previously (Johansen 2012, 2013), we selected a representative subsample of three midden units that spanned the entire Inuit-Inughuit occupation at Iita for analysis (refer to **Appendix A** for an inventory of the faunal materials analyzed from each context).

Each specimen (bone or fragment thereof, see Lyman 1994, 2008) was identified to skeletal element, portion, side, and lowest taxonomic level possible using the UC Davis zooarchaeology laboratory's comparative skeletal collection supplemented by other comparative resources (e.g., Idaho Virtual Museum's osteology collection: https://virtual.imnh.iri.isu.edu/Osteo). Following Driver (2011) specimens that could not be identified to genus or lower were assigned to a descriptive taxonomic category based on characteristics such as size, shape, and internal osteological structure (e.g., cetacean, large pinniped, small seal).

Protocols and methods outlined by Lyman (2008) were adopted to generate quantitative data and derive zooarchaeological indices. These include methods to estimate taxonomic abundance such as the Number of Identified Specimens (NISP), the relative frequency of each taxon (%NISP), and indices of taxonomic diversity. Taxonomic richness (N-taxa) is the number of non-overlapping taxa (species or genera) represented in the assemblage, whereas taxonomic abundance is the number of specimens per taxon. Both taxonomic richness and abundance are used to calculate indices of taxonomic diversity and evenness. The Shannon-Weiner Heterogeneity index results in a number between 1 (less diverse) and 3 (more diverse). Taxonomic evenness is a measure of how equitable the taxonomic abundances are in relation to each other; essentially measuring the distribution of specimens across all taxa. For example, taxonomic evenness will be 0 (low) if one taxon dominates the assemblage while taxonomic evenness will be 1 (high) if each taxon contributes equally to the total specimen count (NISP). These indices are used to compare and interpret the degree of diversity in Late Dorset and Inuit faunal assemblages. For example, low species diversity and/or uneven taxonomic abundance within an assemblage is characteristic of a narrow foraging strategy or prey specialization. Conversely, an assemblage with high taxonomic richness is reflective of a more generalized strategy, although the assemblage may be even or uneven (Lyman 2008).

Osseous Technology Analysis

To create a tool, raw osseous material must be reduced and shaped from its original form. This study focuses not on finished objects but rather on the debris portions of osseous technology—specimens colloquially described as debitage, blanks, and minimally modified materials. We exclude formed or nearly formed objects such as carvings, harpoons, and other items with clear forms and generally accepted functions. This sampling strategy was chosen for two main reasons: 1) many of the formed objects, such as carvings and harpoons, were described in previous publications (see Darwent et al. 2019), and 2) we assert that there is much overlooked potential in manufacturing debris. For example, no completed artifacts of narwhal ivory have been identified at Iita, yet there are hundreds of pieces of waste debris from the working of this osseous material.

Differentiating tool manufacturing debris from highly fragmented faunal remains can be difficult. Therefore, the osseous technology component was approached conservatively. Specimens not bearing clear evidence of working or use wear were excluded to segregate specimens reduced for the purpose of butchery from those reduced for toolmaking. This decision has potentially reduced the total amount of osseous technology debris identified and therefore, our approach means we consider the count a minimum number of modified specimens. For example, bone had to have been modified beyond a simple chop or slice, which may have been associated with the butchery process. Flakes from percussion impacts were excluded as they may have resulted from processes other than tool production unless the flake is otherwise modified, indicating use as a tool. Rather, we focus on reduction sequence by-products, which are morphologically distinct with clues to their formation from intentional shaping following methods outlined by Betts (2007), Bovy et al. (2019), and Nagy (1988).

Examples of these reduction sequence by-products include the following: shavings, curls, drill holes, and variations on cutting and snapping (e.g., grooved and snapped, drilled and snapped, chopped and snapped), and a series of cuts in a pattern and/or accompanied by incisions, drill holes, polish, etc. **Figure 3.2** features debris with modifications consistent with various stages of the reduction sequence. For example, Figure 3.2a features a small ivory shaving and 3.2b features a 3 cm quadrangular bone fragment, in which all sides have been cut, an action that is inconsistent with reduction for consumption. Both specimens in Figure 3.2 are debris consistent with secondary reduction techniques from osseous tool manufacture and are representative of the debris within the osseous tool assemblage herein. All nonedible parts, such as baleen, antler, and ivory, were included in our sample, even if minimally modified. Refer to Chapter 4 for a more detailed analysis of the reduction techniques that produced these debris.

The methods used to record faunal specimens were extended to the osseous tool production debris to maintain consistency but were expanded to allow for the collection of information on modifications. For example, taphonomic effects, such as weathering and burning, were recorded following the same methods used in the faunal analysis, and each specimen was assigned to a size class based on the maximum size of the specimen.

Due to the nature of the small debris, it was inevitable that many pieces were modified to an extent that few diagnostic features remained. In this case, the size, shape, and internal structure were used to best identify each specimen to taxonomic category. When necessary, the osseous tool debris were analyzed with a DinoLite digital microscope (model #AM73915MZTL) to aid in the identification of materials and document modifications (**Figure 3.2**). Microscopy was essential for examining individual structures and composition in order to identify the material type of all 868 osseous specimens. The internal and external anatomical characteristics of each material type (antler, bone, ivory, horn/hoof) were distinguished using various identification guides (e.g., Baker et al. 2020; Locke 2013). **Appendix B** provides distinguishing criteria specific to each material with various examples.

The highly fragmentary nature of the osseous tool assemblage makes it difficult to estimate the minimum number of individuals (MNI) that would have contributed to the total assemblage. Calculations of MNI rely on identifying and counting overlapping anatomical portions, which only occur once per individual. Many of these specimens are small (1–2 cm) and are modified to such an extent that identification to skeletal portion is not feasible. Therefore, they cannot be used reliably for MNI estimation. The number of identified specimens (NISP) is probably a much more accurate measure than MNI in this case. Portions of caribou antler can be used to estimate MNI, but for counting consistency we use NISP (for further discussion see Driver 2011; Lyman 2008). MNI estimates from the osseous technology debris are discussed in **Chapter 4**.

In cases where anatomical portion is unknown, taxonomic identification is limited. Our application of ZooMS to the osseous debris at Iita is the first step to understanding which species are represented within the osseous technology component. Ancient DNA analysis could identify and distinguish between individuals but that is beyond the scope of this project, which seeks information pertaining to taxonomic composition of the assemblage rather than individual animals.

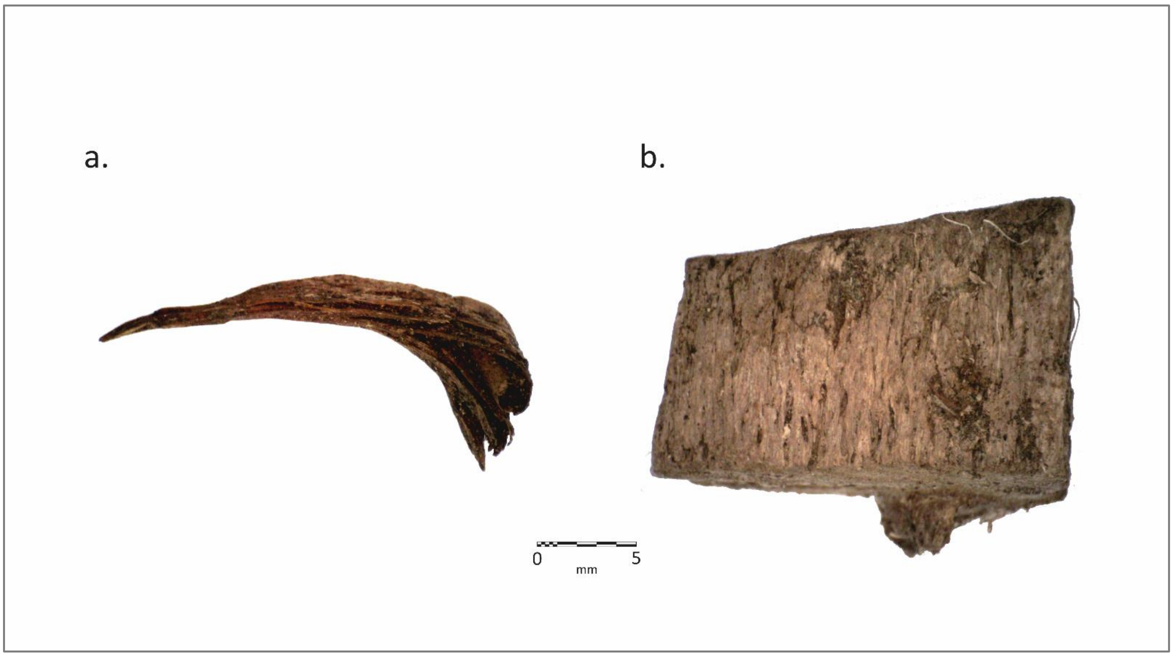

Figure 3.2 Osseous debris as viewed through a Dinolite digital microscope: a) this open curl of narwhal ivory is consistent with debris resulting from carving (KNK3930x2555); b) a fragment of bowhead/right whale bone modified by cutting and snapping (KNK3930x2541). The small size and nature of these specimens made it nearly impossible to identify to species using traditional zooarchaeological methods. ZooMS helped to identify or confirm specimens to meaningful taxonomic categories (species and family respectively).

Zooarchaeology by Mass Spectrometry (ZooMS)

Many of the osseous tool specimens could not be identified using unaided and aided visual analysis due to the nature and extent of the modification. One hundred and thirty specimens were chosen for Peptide Mass Fingerprinting (PMF) to identify previously unknown osseous materials and their taxonomic origin. Identification of these specimens promotes a better understanding of osseous tool production.

PMF involves the enzymatic digestion of proteins followed by Matrix Assisted Laser Desorption-Ionization Time of Flight Mass Spectrometry (MALDI) analysis of the resultant peptide mixture. In the case of bone and ivory, Type 1 collagen is the major constitutive protein, and for each mammalian source, the amino acid sequence of Type 1 collagen, albeit highly conserved, may have one or more amino acid substitutions. These substitutions change the mass of some peptides detected in the MALDI spectrum of the protein digest, which are then used as markers for specific mammalian sources. Marker ions from known reference materials are compared with those from unknown samples for identification. When PMF is employed to identify the taxonomic origin of zooarchaeological materials, such as our unidentified tool and tool-production fragments, it is known as ZooMS.

The ZooMS (PMF) method was a simplified procedure based on that described in Kirby (2019). Since there are no cystines in collagen, the cystine reduction and end capping steps were omitted. In addition, spectral quality was sufficient to provide confident identifications in all cases where collagen was detected, so no purification or fractionation was required. Some spectra (~15%) had weak or absent A and/or G markers, but those markers were not required for accurate identifications for these samples. In all cases only a single sample was digested and analyzed.

The first author sampled the specimens at the UC Davis Zooarchaeology Lab with sample sticks—polystyrene strips with fiber optic polishing film attached on two sides—which are used to abrade and entrap a small amount of material for analysis. A freshly laundered lab coat, KN95 or surgical facemask, and nitrile examination gloves were worn during handling of all osseous materials. To avoid cross-contamination, gloves were changed, and the workstation was thoroughly sterilized with 70% alcohol wipes between each sample. Samples were obtained by rubbing the object lightly in a circular motion for 10 seconds. After sampling, the tip of the sample stick containing the abrasive film and entrapped sample is cut off, placed in an Eppendorf tube, and forwarded for analysis. Polishing films (30um alumina or diamond particles, final size 2.5 x 2.5mm) were from Precision Fiber Products, Inc. and polystyrene strips (1.5 x 2.5 x 400mm) were from Walthers.

Photographs of each specimen were taken with a DinoLite digital microscope to document the area sampled. The sampling site is generally invisible to the naked eye, and the procedure consumes a miniscule amount of each specimen. Thus, it is considered a minimally destructive sampling technique by most museum conservators.

Each specimen and Eppendorf tube was given a unique sample number. Additional samples from the same location were collected on three specimens (KNK912x300; KNK3930x1571, x1822) because they yielded low-quality spectra on the first sample run. These are considered “second passes”, in which collagen was sampled from the same location but from a deeper anatomical component of the specimen, such that a better quality and/or greater quantity of collagen could be obtained.

PMF analysis of the 130 samples collected was then undertaken at the Northeastern University Mass Spectrometry Core Facility following procedures outlined by Kirby et al. (2013, 2019). Digestion: 60µL of 50mM ammonium bicarbonate (AMBI) were added to each sample (on the sample stick tip in a 600µL Eppendorf tube) and heated to 75°C for 60min. After cooling, 8µL Promega Sequence Grade trypsin (0.02µg/µL in 50mM AMBI) was added and digestion proceeded overnight at 37°C.

MALDI analysis: 2µL of the digest were added to 20µL 40% acetonitrile (ACN), 0.1% trifluoroacetic acid (TFA) with saturated α-Cyano-4-hydroxycinnamic acid (CHCA) matrix. 0.65µL of the mixture was spotted onto the MALDI plate. Spectra were obtained with an Applied Biosystems/Sciex 5800 MALDI-TOF-TOF instrument operated in positive reflector mode. Calibration was done with a standard mixture of peptides: 757.3992Da, 1046.5418Da, 1296.6848Da, 1347.7354Da, 1619.8223Da, 2093.0867Da, 2465.1983Da, and 3147.4710Da. Spectra were coadditions of 1200 – 2000 laser shots. Acquired spectra were exported from Applied Biosystems Data Explorer software as text files and imported into mMass (Strohalm et al. 2010) for analysis. Spectra were manually inspected for markers. Markers used to identify mammalian sources are compiled from Buckley et al. (2009, 2014) and Kirby (2013). Raw spectra data are curated by Dryad (https://doi.org/10.25338/B8W644).

Results of Zooarchaeological Analysis

A total of 13,911 faunal specimens from Iita were included in this study. Of them, 11,722 were identified to species, family, or broad taxonomic category (e.g., cetacean). **Table 3.1** shows the quantity and relative contribution of each taxon to the total assemblage. Specimens from the osseous technology component are presented in parentheses.

The Late Dorset material is represented by a total of 2,684 specimens, 48 of which are osseous technology. Early Inuit is represented by 22 specimens from the osseous technology assemblage (refer to Johansen 2012 for Early Inuit faunal remains). The Middle Inuit materials are comprised of 1,189 specimens, 256 of which are osseous technology. The 4,789 specimens of the Late Inuit period include 158 specimens from the osseous technology assemblage. The Inughuit materials are represented by 1,673 specimens, 329 of which are osseous technology. The Euroamerican period is represented by 8 osseous tool specimens (refer to Johansen 2012 for faunal remains from historic periods at Iita). An additional 3,546 specimens are a mixture of Late Dorset and early Inuit material culture, with 55 specimens from osseous technology.

Fewer Late Dorset faunal materials were recovered from Iita for two main reasons: 1) the Late Dorset occupation of Iita spans 300 years (800–1250 CE) compared to the Inuit/Inughuit occupation, which spans 600 years (1250–1850 CE), and 2) the Late Dorset occupation at Iita was actively eroding while salvage archaeological recovery was undertaken. Refer to Darwent et al. (2019) for details on how climate change resulting in loss of permafrost and coastal erosion has led to a decrease in material culture, particularly organic remains, recovered for the Late Dorset period. Some of the Late Dorset deposit was potentially lost to coastal erosion prior to archaeological recovery. Additionally, the materials from the Late Dorset context are chronologically older; thus, time is a likely factor for decreased preservation of these materials.

A total of 868 specimens were identified as discarded debris or waste from osseous technology, such as semi-formed objects or production waste debris. Because of their unique morphology with evidence of intentional modification indicative of reduction during osseous tool production rather than from butchery, these specimens constitute the osseous technology component, and are analyzed separately from the traditional faunal assemblage. Of those specimens, 130 (15%) that could not be identified or only tentatively identified using digital microscopy were sampled for identification using ZooMS.

Taxonomic Composition

Calculations of heterogeneity and evenness presented in **Table 3.1** consider taxa contributing from both the traditional faunal analysis and the osseous technology assemblages–refer to Table 2.3 for indices which consider only the traditional faunal assemblage. When comparing diversity and evenness indices calculated from both the osseous technology and the traditional faunal assemblage (**Table 3.1**) to only traditional faunal data, it is clear that the presence of certain taxa in the osseous technology assemblage, specifically marine mammals, contributes to our understanding of Late Dorset and Inuit-Inughuit subsistence strategies.

Late Dorset

The Late Dorset component is relatively diverse (H= 2.2) and even (e=0.8). This calculation is not surprising given that many of the 15 taxa contribute somewhat equally except for a single taxon, dovekie (*Alle alle*), which contributes to 36% of the total faunal remains. Narwhal was not identified in the traditional faunal assemblage, therefore identifying this species in the osseous technology assemblage (n=2) contributed to an increase in the taxonomic richness. However, as narwhal constitutes less than 1% of all taxa in the Late Dorset component, this increase in richness is not reflected in the diversity indices, which remain unchanged for calculations including and excluding the osseous technology component.

Middle Inuit

The heterogeneity index for the Middle Inuit component is lower (H=1.9) than Late Dorset reflecting that this assemblage is less taxonomically rich (N-taxa of 14) by a single species. An evenness index of 0.7 also reflects a slightly less even distribution of taxa like Late Dorset with certain taxa (dovekies) dominating the assemblage. When considering the traditional faunal material and osseous technology together there is an increase in taxonomic diversity (H increases from 1.5 to 1.9) and in evenness (*e* increases from 0.6 to 0.7). Taxa such as cf. muskox (Bovidae), narwhal, beluga, bowhead, and unknown cetacean are present only in the osseous technology assemblage, driving the increase in diversity for the indices when both assemblages are combined.

Late Inuit-Inughuit

The Late Inuit-Inughuit component received a low score on the heterogeneity index, suggesting that this assemblage is not diverse (H=1.1). These taxa were unevenly distributed, with a single taxon, dovekies, contributing to 74% of the total identified specimens (*e*=0.4).

A combined index provides a negligible increase in diversity (H rises from 1.0 to 1.1), yet evenness remains unchanged (*e*=0.4). This slight increase in diversity is driven by an increase in taxonomic richness, again from the inclusion of cetaceans which are absent from the traditional faunal analysis.

Inughuit

The Inughuit assemblage is not diverse (H=1.8) yet scored relatively high on the evenness index (*e*=0.7). Here most taxa contribute between 1–3% but dovekies and walrus dominate (51% and 19% respectively). Combined calculations reveal that this component becomes more diverse (H rises from 1.5 to 1.8) but only slightly more even (*e* from 0.6 to 0.7). Taxonomic richness is increasing due to the inclusion of murre, cf. muskox, and cetaceans, which are absent in the traditional faunal assemblage.

Mixed Late Dorset-Inuit

Considering both assemblages together results in a more taxonomically rich but slightly less even assemblage. For example, calculations with and without the osseous technology component both result in an H index of 1.1, despite the increase in taxonomic richness from 11 to 14. Here, cf. muskox (Bovidae), narwhal, bowhead, and unknown cetacean are identified in the osseous technology but are absent in the traditional faunal assemblage, which increase richness but lower overall evenness in the combined indices

Table 3.1 Relative frequency (%NISP) of major faunal groups across archaeological midden contexts at Iita. Specimen counts within parentheses [#] represent the number of modified specimens and are part of the osseous tool assemblage. For example, there are 40 total walrus specimens attributed to the Late Dorset, 27 of which are modified osseous tool products.

	Late Dorset		**Mixed Late Dorset-Inuit**		**Early Inuit**		**Middle Inuit**		**Late Inuit-Inughuit**		**Inughuit**		**Euro-american**		**N**	
TAXA	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%
MOLLUSK																
Unidentified Gastropod	3	0.2	2	0.1	-	-	1	0.1	1	0.0	-	-	-	-	7	0.1
Total mollusk	**3**		**2**		**-**	**-**	**1**		**1**		-	-	-	-	**7**	
N-taxa	**1**		**1**		**-**	**-**	**1**		**1**		-	-	-	-	**1**	
BIRD																
Dovekie/little auk (*Alle alle*)	606	36	2296	74.4	-	-	467	45	3262	74.1	765	51.4	-	-	7396	63.1
Small size bird (cf. *Alle alle*)	120	7.1	186	6	-	-	66	6.4	492	11.2	54	3.6	-	-	918	7.8
Murre (*Uria* sp.)	5	0.3	-	-	-	-	-	-	9	0.2	1 [1]	0.1	-	-	15	0.1
Duck (Anatinae)	4	0.2	2	0.1	-	-	4	0.4	1	0.0	1	0.1	-	-	12	0.1
Goose (Anserinae)	10	0.6	4	0.1	-	-	-	-	7	0.2	10	0.7	-	-	31	0.3
Medium sized bird	5	0.3	4	0.1	-	-	-	-	5	0.1	1	0.1	-	-	15	0.1
Total bird	**750**		**2492**		-	-	**537**		**3776**		**832**		-	-	**8387**	
N-taxa	**4**		**3**		-		**2**		**4**		**4**		-		**4**	
MAMMAL																
Arctic hare (*Lepus arcticus*)	54	3.2	30	1.0	-	-	4 [1]	0.4	31	0.7	37	2.5	-	-	156	1.3
Arctic fox (*Vulpes lagopus*)	147	8.7	47	1.5	-	-	22	2.1	57	1.3	20	1.3	-	-	293	2.5
Small terrestrial mammal (fox/hare)	101	6	77	2.5	-	-	19	1.8	58	1.3	33	2.2	-	-	288	2.5

Dog/wolf (*Canis lupus* sp.)	9	0.5	23	0.7	-	-	5	0.5	13	0.3	11	0.7	-	-	61	0.5
Polar Bear (*Ursus maritimus*)	6	0.4	-	-	-	-	-	-	-	-	-	-	-	-	6	0.1
Walrus (*Odobenus rosmarus*)	40 [27]	2.4	16 [12]	0.5	[9]	40.9	26 [17]	2.5	116 [89]	2.6	290 [213]	19.5	[5]	62.5	502	4.3
Pinniped (large seal/walrus)	33	2.0	30	1.0	-	-	11	1.1	20	0.5	25 [2]	1.7	-	-	119	1.0
Bearded seal (*Erignathus barbatus*)	11	0.7	4	0.1	-	-	2	0.2	8	0.2	7 [3]	0.5	-	-	32	0.3
Ringed seal (*Pusa hispida*)	7	0.4	-	0.0	-	-	7	0.7	13	0.3	1	0.1	-	-	28	0.2
Small seal (Phoca/Pusa)	251	14.9	223	7.2	-	-	112	10.8	186	4.2	68	4.6	-	-	840	7.2
Seal (Phocidae)	27	1.6	52	1.7	-	-	6	0.6	12	0.3	19	1.3	-	-	116	1
Caribou (*Rangifer tarandus*)	146 [18]	8.7	23 [13]	0.7	[4]	18.2	26 [18]	2.5	44 [30]	1	75 [51]	5	[2]	25.0	320	2.7
Muskox (*Ovibos moschatus*)	10	0.6	-	-	-	-	2	0.2	4	0.1	3 [2]	0.2	-	-	19	0.2
cf. Muskox (Bovidae)	-	-	[1]	0.0	-	-	[1]	0.1	-	-	[1]	0.1	-	-	3	0.0
Caribou/muskox (Artiodactyla)	24	1.4	8	0.3	-	-	2	0.2	6	0.1	2	0.1	-	-	42	0.4
Large terrestrial mammal	51	3	11	0.4	-	-	7	0.7	8	0.2	5 [1]	0.3	-	-	82	0.7
Beluga (*Delphinapterus leucas*)	-	-	-	-	-	-	[1]	0.1	-	-	-	-	-	-	1	0.0
Narwhal (*Monodon monoceros*)	[2]	0.1	[17]	0.6	[4]	18.2	[182]	17.6	[19]	0.4	[23]	1.5	[1]	12.5	248	2.1
Beluga/narwhal (Monodontidae)	-	-	-	-	-	-	-	-	-	-	[1]	0.1	-	-	1	0.0
cf. Bowhead whale (Balaenidae)	-	-	[2]	0.1	[3]	13.6	[17]	1.6	[10]	0.2	[14]	0.9	-	-	46	0.4
Unidentified Cetacean	-	-	[2]	0.1	[2]	9.1	[18]	1.7	[10]	0.2	[10]	0.7	-	-	42	0.4
Marine mammal	10	0.6	24	0.8	-	-	29 [1]	2.8	8	0.2	12	0.8	-	-	83	0.7
Total identified mammal	**929**		**590**		**22**		**499**		**623**		**657**		**8**		**3328**	
Unidentified mammal	864 [1]		448		0		152		389		165 [7]		0		2018	
Total mammal	**1793**		**1038**		**22**		**651**		**1012**		**818**		**8**		**5346**	
N-taxa	**10**		**10**		**4**		**11**		**10**		**10**		**3**		**12**	

Unidentified vertebrate	138		14		-		-		-		19		-		171	
Total identified	**1682**	100	**3084**	100	**22**	100	**1037**	100	**4400**	100.0	**1489**	100	**8**	100	**11722**	100
Grand total	**2684**		**3546**		**22**		**1189**		**4789**		**1673**		**8**		**139111**	
N-taxa (richness)	**15**		**14**		**4**		**14**		**15**		**14**		**3**		**17**	
Heterogeneity	**2.2**		**1.1**		**-**		**1.9**		**1.1**		**1.8**		**-**			
Evenness	**0.8**		**0.4**		**-**		**0.7**		**0.4**		**0.7**		**-**			

Results of ZooMS

Of the 130 samples, 129 were positively identified (**Table 3.2**). A single specimen (KNK912x300) was carbonized and, therefore, did not yield collagen. The remaining specimens generally displayed high quality spectra and yielded taxonomically identifiable markers, with 91 specimens identified to species (see **Figure 3.3**). Previous studies using similar, minimally destructive sampling techniques have had relatively lower success rates for taxonomic identification compared to this study (Coutu et al. 2021; von Holstein et al. 2014). The high success rate of our identifications is likely due to better collagen preservation in the cold and dry conditions of a polar desert, conditions which persisted until relatively recently.

Greenland has only 26 native mammal species, and even less are found in northwestern Greenland. Limited faunal diversity in the High Arctic assists in reducing the possibilities of identified taxa when peptide markers may not be able to distinguish between specific taxa. For example, the ZooMS spectrum for sample KNK3930x2679 identified collagen consistent with Bovidae but not the exact species. Also, the spectrum for KNK3930x1769 was identified as keratin, using published markers (Solazzo et al. 2013). The keratin markers could preclude baleen as the source but only identify the sample as likely bovine. As muskox (*Ovibos moschatus*) is the only bovid species in Greenland (Lent 1988; Schmidt et al. 2015), these specimens are almost certainly muskox, but we refer to them as Bovidae in the results table.

Likewise, 35 specimens were identified as belonging to the Balaenidae family. Currently, bowhead (*Balaena mysticetus*) and right whales (*Eubalaena glacialis*) cannot be distinguished by PMF (Buckley et al. 2014), but the specimens in our assemblage are presumably bowhead, as right whale populations are not currently or historically known to inhabit waters this far north (Heide-Jørgensen et al. 2021). Further, specimen KNK3930x2671 was identified to the level of genus as *Lepus* sp., but it is most likely Arctic hare, due to the singular distribution of this species in Greenland (Best and Henry 1994).

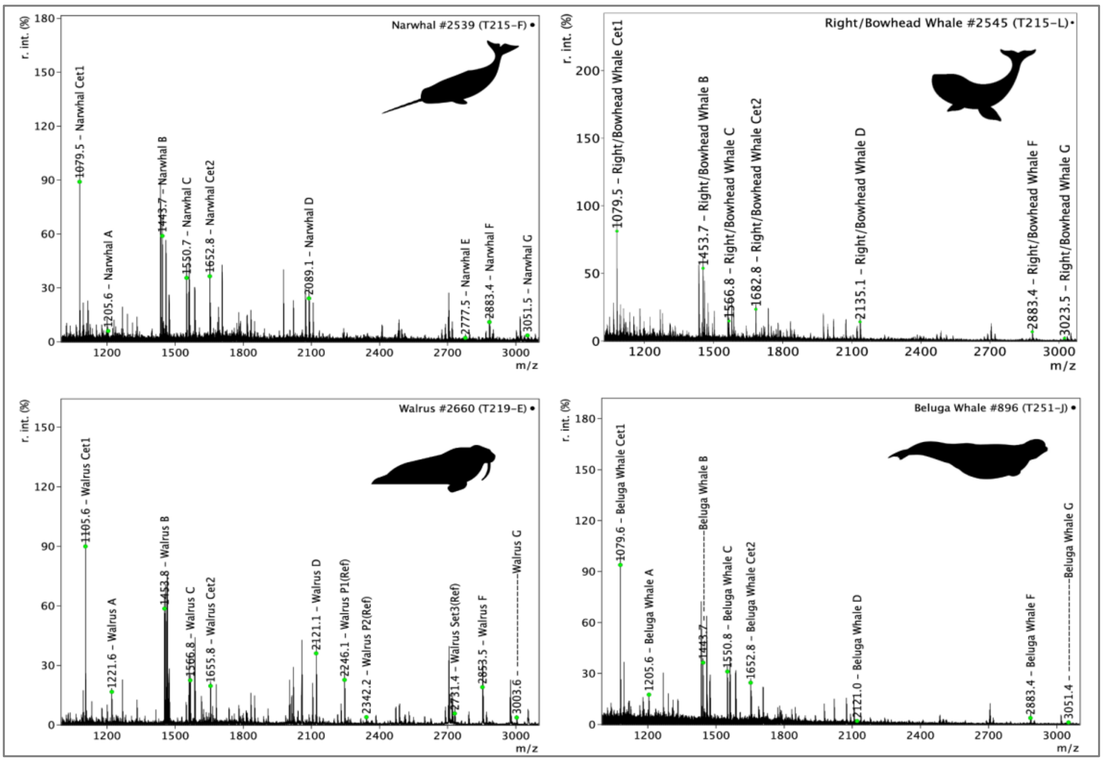

Figure 3.3 Example spectra for osseous tool debris of marine mammal origin identified via ZooMS (Animal icons from various online sources: large whale and beluga from Adobe Stock under Standard License; walrus from "The Noun Project" by Ed Harrison under Creative Commons License; and narwhal from Clipartmax.com under free personal use license).

Discussion

We undertook traditional analysis of faunal remains along with analysis of osseous tool debris by visual and microscopic methods, and we complemented these studies with ZooMS to identify indeterminate pieces of manufacturing debris. Comparing the results of traditional faunal analysis with osseous toolmaking debris, each assemblage on its own yields an incomplete picture of the species accessed by the past occupants of Iita (**Figure 3.4** and **Figure 3.5**).

Previous research indicated cetaceans comprised less than 1% of the identified specimens at Iita (Johansen 2012). As illustrated in **Figure 3.4**, we would have reached a similar conclusion based on traditional faunal analysis of the Pre-Inuit and Inuit periods. By including the osseous technology component, however, we see a higher relative frequency of marine mammals than previously reported. Specifically, we found a greater variety of cetaceans represented in the osseous technology assemblage than understood through traditional faunal analysis alone. For example, narwhal, beluga, and bowhead whale are all represented in the technological assemblage but are absent from the rest of the midden assemblage fauna. The precision of taxonomic identification using ZooMS has expanded the diversity and frequency of marine mammals within the technological assemblage. We could expect a similar increase if ZooMS was also applied to the unidentified fragments within the traditional faunal assemblage. However, the specimens of osseous waste debris tend to be smaller fragments of heavily modified material, which typically do not retain anatomical indictors of taxon.

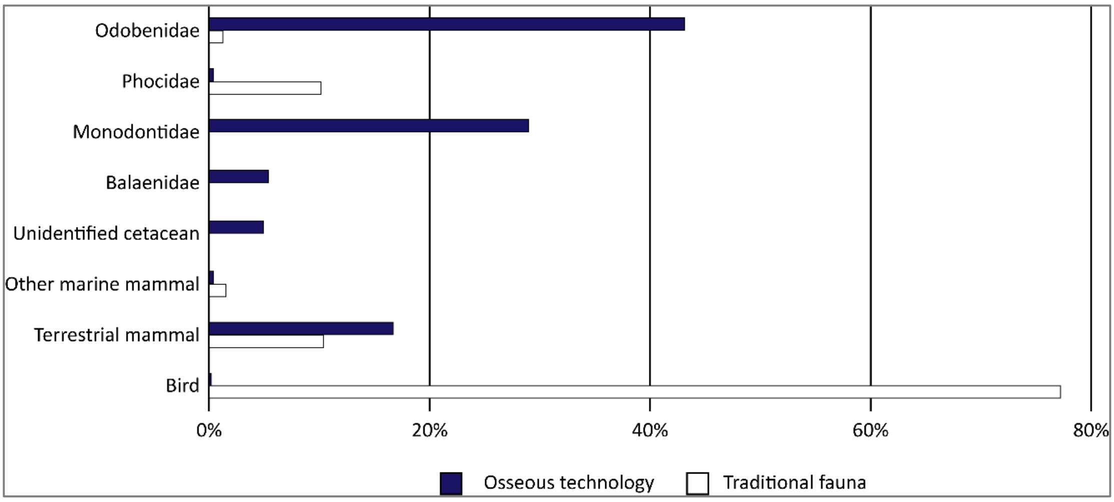

Figure 3.4 Relative frequency (%NISP) of major taxonomic groups (n=11,722). The percentages of identified taxa within the traditional faunal assemblage are compared to the osseous technology assemblage. The differences in taxa identified in each assemblage confirms osseous technology should be examined together with the faunal assemblage. For example, interpretations of resource use based solely on traditional faunal analysis would not include the variety of cetaceans accessed at Iita.

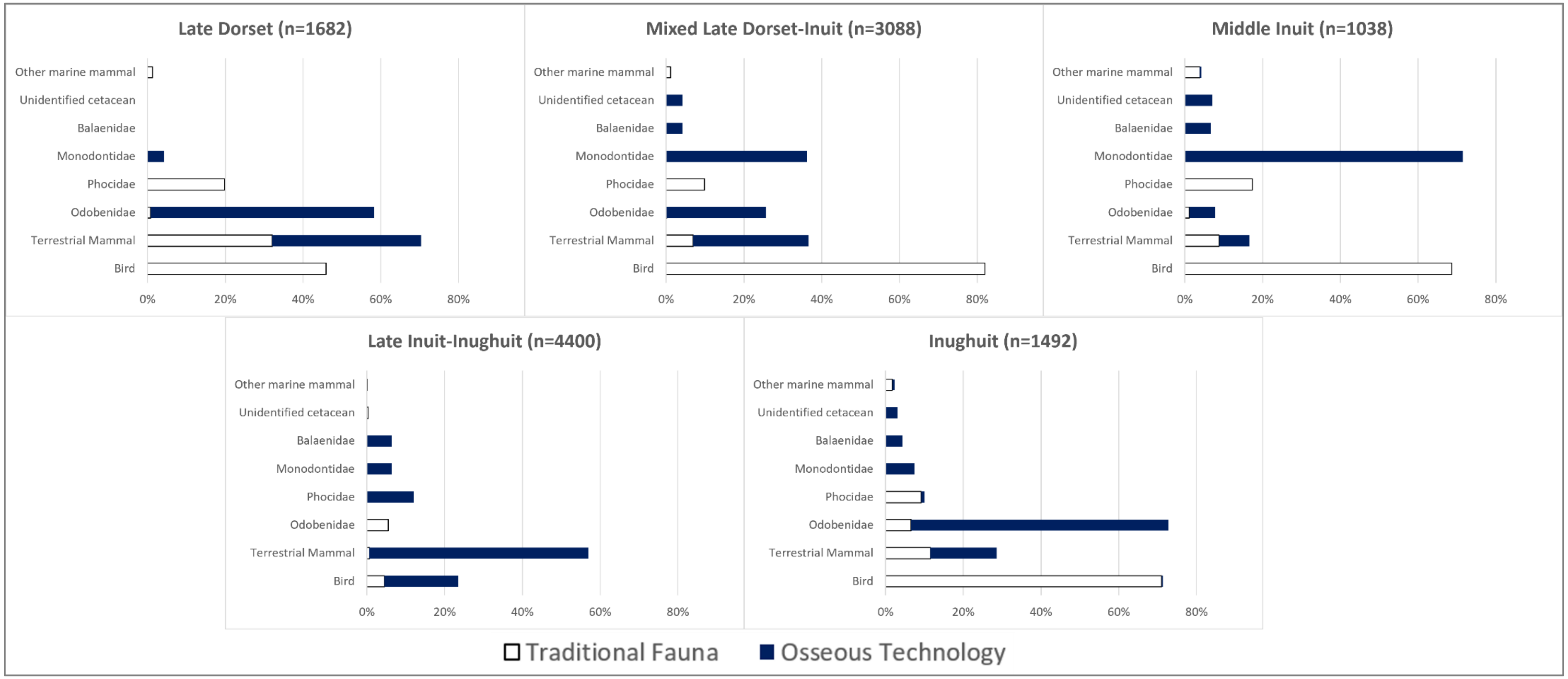

Figure 3.5 Relative frequency (%NISP) of major taxonomic groups by cultural affiliation where the percentages of identified taxa within the traditional faunal assemblage are compared to the osseous technology assemblage. Early Inuit and Euroamerican assemblages are omitted as they are only represented by osseous technology.

Narwhal is represented by modified ivory in the form of waste debris (**Figure 3.2a**) and semi-formed objects (i.e.: blanks). Bowhead whale is represented by modified baleen and bone in various stages of reduction from blanks to waste debris (**Figure 3.2b**). Beluga is represented by a single bone flake, which exhibits intentional shaping and polish. Thus, our findings confirm the assertion by Seersholm et al. (2022) that many of the cetacean remains at archaeological sites are represented by artifacts or osseous materials useful in house construction or toolmaking, including waste debris.

Nearly three decades ago, Savelle (1994) summarized the prehistoric use (or lack thereof) of small cetaceans in the Eastern Canadian Arctic and Greenland. He provided several hypotheses to explain the dearth of cetacean bone, which included taphonomy, processing and transport, and lack of appropriate archaeological data. Ultimately, Savelle (1994) rejected each of these and concluded the most parsimonious explanation for this phenomenon was that small cetaceans did not contribute significantly to the diets of the region's precolonial populations.

Iita presents an opportunity to revisit these hypotheses. Savelle (1994) recognized that this conclusion was based chiefly on data from winter residential sites. The presence of buried semi-subterranean house features associated with Late Dorset occupations, as well as the superimposed ruins of Inuit sod houses support a winter habitation at Iita (Darwent et al. 2019; LeMoine and Darwent 2010). However, recovery of tens of thousands of dovekie bones from across house and midden deposits are a clear indication that humans resided at Iita during the summer and stored them for winter consumption (Johansen 2012, 2013). Dovekies are known to have had seasonal colonies in the cliffs near Iita for more than 6,000 years (Darwent and Johansen 2010; Mosbech et al. 2018). They were available during the brief summer (May–August), and were likely netted *en masse* for centuries (Ebel 2019; Johansen 2013). Our data, derived from winter and summer occupations, provides evidence that precolonial populations at Iita were exploiting small cetaceans, offering further support for the alternative hypotheses by Savelle (1994).

Narwhal and walrus—the two ivory-bearing species in the High Arctic—are both represented at Iita. However, the Pre-Inuit, or Late Dorset, inhabitants hunted walrus and used their ivory much more commonly than narwhal, as 93% of the ivory from Late Dorset cultural levels were identified as walrus (n=29). Although the sample size is considerably greater, Inuit-Inughuit occupants of Iita used both walrus (n=291, 56%) and narwhal (n=226, 44%) ivory relatively equally. The stark contrast in narwhal use by Late Dorset and Inuit groups merits reconsideration of a number of hypotheses put forward by Savelle (1994).

As mentioned previously, Late Dorset, compared to earlier Pre-Inuit groups, did not have dogs, and did not use bows and arrows or boats. However, they retained large walrus-hunting harpoons (Darwent 2004; Murray 19966). Without boats it would have been difficult to hunt small whales in open water. Beluga and narwhal can become trapped within a *savssat*, an Arctic seascape formation that can occur when temperatures drop abruptly, and sea ice quickly forms over large distances (Laidre et al. 2012), entrapping dozens, or sometimes hundreds, of whales which can then be harvested from the ice edge. It is possible small whales could have been taken by Late Dorset hunters on occasion if this phenomenon occurred, but it is more likely that the two fragments of narwhal ivory were obtained by beached-carcass scavenging.

It is well known that early Inuit inhabitants of Iita possessed the specialized technologies required to capture cetaceans. Specifically, both large and small boats, drag-floats, large harpoons, and killing lances (Maxwell 1985; Whitridge 2016). They also had dogs for packing and pulling sleds (Brown et al. 2013; Ameen et al. 2019). Analysis of the osseous debris reveals that narwhal tusks were used extensively by Inuit-Inughuit occupants of Iita—28% of the osseous technology assemblage is narwhal ivory. In contrast, Johansen (2012) found only a single narwhal bone, which dates to the early 20th century. We have photographic and written documentation (Peary-MacMillan Arctic Museum Archives) of the use and capture of narwhal by Inughuit during that period, yet there is scant evidence of this resource in the archaeological record.

Additional factors that intersect with the lack of boating and large harpoon technology that may explain the variable use of ivories include 1) differences in behavior and physiology of narwhal and walrus, and 2) the preference of certain material qualities by the toolmakers. Narwhals are highly elusive, occupying inaccessible areas of deep, open waters and traveling in small pods of 2–10 individuals except for periods of migration when many pods may swim together to seasonal habitats (Heide-Jørgensen 2008). Alternatively, gregarious walrus are more frequently encountered as they often haul out on ice in the hundreds (Kastelein 2008). Further, ivory-bearing narwhal occur less frequently as it is generally only the male narwhal that boasts a long, single tusk while both male and female walrus each have two tusks.

The scarcity of narwhal ivory in the technological assemblage may relate to its complex, spiral morphology which may result in spirally directed cracks (Brear et al. 1993) making it less desirable compared to walrus ivory; however, this hypothesis remains untested[5]. With a hollow pulp cavity, narwhal tusks also provide less mass generally than walrus tusks, limiting their value for making some items. Information regarding the preferability of ivories by precolonial toolmakers is insufficient, yet the high occurrence of narwhal ivory fragments indicates that the material was not disregarded by the Inuit toolmakers at Iita. Ethnographic accounts of Inughuit from the early 20th century briefly mention that both walrus and narwhal ivory was used for a variety of purposes with little distinction between the two types and their specific attributes. Walrus tusks were used for "harpoon heads and points and other essential artifacts" while the "narwhal's tusk of ivory is shaped to many implements of household and hunting use" (Ekblaw 1921:143).

The paucity of corresponding whale skeletal remains is most likely a taphonomic product of body-part selection, transportation decisions, and tool production. Cetaceans are large and require extensive processing at the kill or scavenging site, potentially resulting in an absence of skeletal materials at the home base. In addition, the bone and ivory of cetaceans and other large marine mammals at Iita were heavily processed, and in most cases, this removed many of the morphological traits used for taxonomic identification beyond broad categories.

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[5] Information regarding the properties of narwhal ivory is limited, no doubt due to the strict regulations that control the sale of this product. An anonymous art dealer informed the first author that narwhal ivory is similar in workability to walrus ivory with contemporary tools but noted that walrus ivory is generally preferred because it lacks a hollow pulp cavity and has more workable dentine due to its larger diameter (i.e., bigger blanks to carve or sell).

Conclusions

This study focused on methods of taxonomic identification to evaluate the composition of taxa from the Iita faunal assemblage, and to assess differences between the site's archaeological contexts. Examination of ivory and modified bone reveals that cetaceans provided an array of raw materials and perhaps contributed more to the subsistence practices of Inuit cultures of northern Greenland than previously recognized. We compared the species composition of faunal remains with those of osseous technology in the Late Dorset and Inuit-Inughuit deposits at Iita and found their selection of osseous material to reflect technological or cultural differences in how the two groups accessed marine resources. We argue that attention to modified osseous materials and use of microscopy and ZooMS to identify these small fragments is important for drawing a fuller picture not only of raw material selection for tools but also of subsistence strategies and resource use more broadly.

Climate change is dramatically impacting sites such as Iita, resulting in poorer preservation of organic materials in archaeological sites that were once stabilized in permafrost (Darwent et al. 2019). Decreased permafrost, rising sea levels, and increased coastal erosion brought on by a warming planet is expected to accelerate the loss of arctic archaeological sites (Hollesen et al. 2018). Therefore, archaeologists may expect a decrease in the quality and quantity of the well-preserved animal remains needed for identification by traditional zooarchaeological methods based on morphology.

Several molecular identification methods, such as identifying ancient DNA, may mitigate some of the challenges of morphologically undiagnostic skeletal fragments by providing high-resolution, population-level genomic data. However, ZooMS may be more appropriate for studies which require lower resolution taxonomic identifications to genus or species level. Currently, ZooMS offers taxonomic identification that is more affordable, minimally invasive, and less sensitive to degradation. This study suggests that minimally destructive sampling techniques have the potential to provide successful identification of type-1 collagen in archaeological materials recovered from similar taphonomic contexts such as polar desert environments.

Using ZooMS to complement the traditional analysis methods for faunal remains can greatly increase our understanding of which species were represented and being accessed. This is particularly true for whales and large marine mammal species, which tend to be underrepresented due to a gamut of taphonomic processes that affect their recovery and identification.

Table 3.2. Results of the 130 specimens sampled for identification via ZooMS including material type for each specimen. A single specimen, KNK912x300, was not identifiable via ZooMS, but the internal structure is consistent with marine mammal bone. KNK refers to Nunatta Katersugaasivia (Greenland National Museum); KNK 912 is the museum accession number for materials recovered in 2012, and KNK 3930 is the number for materials recovered in 2016.

Cultural Affiliation	KNK Number	PMF Run	Material Type	ZooMS Identification
Late Dorset	3930x2743	T250-R	Ivory	*Odobenus rosmarus*
Late Dorset	3930x2748	T251-P	Ivory	*Odobenus rosmarus*
Late Dorset	3930x2837	T250-Q	Ivory	*Odobenus rosmarus*
Late Dorset	3930x9	T221-G	Antler	*Rangifer tarandus*
Mixed LD-Inuit	912x110	T251-O	Bone	Bowhead/right whale
Mixed LD-Inuit	3930x52	T250-S	Bone	Bowhead/right whale
Mixed LD-Inuit	3930x576	T251-G	Bone	*Monodon monoceros*
Mixed LD-Inuit	3930x2706	T221-F	Bone	*Monodon monoceros*
Early Inuit	3930x2685	T220-H	Ivory	*Monodon monoceros*
Early Inuit	3930x63	T251-I	Bone	*Odobenus rosmarus*
Early Inuit	3930x2686	T220-I	Ivory	*Odobenus rosmarus*
Middle Inuit	3930x2679	T220-B	Bone	Bovidae
Middle Inuit	3930x160	T250-O	Bone	Bowhead/right whale

Middle Inuit	3930x684	T250-A2	Bone	Bowhead/right whale
Middle Inuit	3930x2540	T215-G	Bone	Bowhead/right whale
Middle Inuit	3930x2661	T219-F	Bone	Bowhead/right whale
Middle Inuit	3930x2666	T219-K	Bone	Bowhead/right whale
Middle Inuit	3930x2702	T221-B	Bone	Bowhead/right whale
Middle Inuit	3930x2703	T221-C	Bone	Bowhead/right whale
Middle Inuit	3930x2704	T221-D	Bone	Bowhead/right whale
Middle Inuit	3930x1304	T220-U	Bone	Bowhead/right whale
Middle Inuit	3930x896	T251-J	Bone	*Delphinapterus leucas*
Middle Inuit	3930x2671	T219-P,	Bone	*Lepus* sp.
Middle Inuit	912x300*	T250-G, T255-E, T255-F	Bone	No ID (marine mammal)
Middle Inuit	3930x2547	T215-N	Ivory	*Monodon monoceros*
Middle Inuit	3930x2548	T215-O	Ivory	*Monodon monoceros*
Middle Inuit	3930x2549	T215-P	Ivory	*Monodon monoceros*
Middle Inuit	3930x2550	T215-Q	Ivory	*Monodon monoceros*
Middle Inuit	3930x2551	T215-R	Ivory	*Monodon monoceros*
Middle Inuit	3930x2552	T215-S	Ivory	*Monodon monoceros*
Middle Inuit	3930x2553	T215-T	Ivory	*Monodon monoceros*
Middle Inuit	3930x2554	T216-A	Ivory	*Monodon monoceros*
Middle Inuit	3930x2555	T216-B	Ivory	*Monodon monoceros*
Middle Inuit	3930x2556	T216-C	Ivory	*Monodon monoceros*
Middle Inuit	3930x2557	T216-D	Ivory	*Monodon monoceros*
Middle Inuit	3930x2558	T216-E	Ivory	*Monodon monoceros*
Middle Inuit	3930x2559	T216-F	Ivory	*Monodon monoceros*
Middle Inuit	3930x2560	T216-G	Ivory	*Monodon monoceros*
Middle Inuit	3930x2561	T216-H	Ivory	*Monodon monoceros*
Middle Inuit	3930x2562	T216-I	Ivory	*Monodon monoceros*
Middle Inuit	3930x2563	T216-J	Ivory	*Monodon monoceros*
Middle Inuit	3930x2564	T216-K	Ivory	*Monodon monoceros*
Middle Inuit	3930x2565	T216-L	Ivory	*Monodon monoceros*
Middle Inuit	3930x2566	T216-M	Ivory	*Monodon monoceros*
Middle Inuit	3930x2567	T216-N	Ivory	*Monodon monoceros*
Middle Inuit	3930x2568	T216-O	Ivory	*Monodon monoceros*
Middle Inuit	3930x2677	T219-V	Ivory	*Monodon monoceros*
Middle Inuit	3930x2569	T216-P	Ivory	*Odobenus rosmarus*
Middle Inuit	3930x2672	T219-Q	Ivory	*Odobenus rosmarus*
Middle Inuit	3930x2678	T220-A	Ivory	*Odobenus rosmarus*
Middle Inuit	3930x2689	T220-L	Antler	*Rangifer tarandus*
Middle Inuit	3930x2705	T221-E	Antler	*Rangifer tarandus*
Middle Inuit	3930x1996	T251-D	Bone	*Rangifer tarandus*
Late Inuit-Inughuit	3930x285	T250-K	Bone	Bowhead/Right whale

Late Inuit-Inughuit	3930x1026	T220-P	Bone	Bowhead/Right whale
Late Inuit-Inughuit	3930x1083	T250-H	Bone	Bowhead/Right whale
Late Inuit-Inughuit	3930x1540	T250-P	Bone	Bowhead/Right whale
Late Inuit-Inughuit	3930x1773	T251-F	Bone	Bowhead/Right whale
Late Inuit-Inughuit	3930x1819	T250-B2	Bone	Bowhead/Right whale
Late Inuit-Inughuit	3930x1987	T220-Q	Bone	Bowhead/Right whale
Late Inuit-Inughuit	3930x2541	T215-H	Bone	Bowhead/Right whale
Late Inuit-Inughuit	3930x2545	T215-L	Bone	Bowhead/Right whale
Late Inuit-Inughuit	3930x2579	T251-C	Bone	Bowhead/Right whale
Late Inuit-Inughuit	3930x2828	T251-M	Bone	*Monodon monoceros*
Late Inuit-Inughuit	3930x2675	T219-T	Ivory	*Monodon monoceros*
Late Inuit-Inughuit	3930x2676	T219-U	Ivory	*Monodon monoceros*
Late Inuit-Inughuit	3930x1812	T251-N	Bone	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x1822*	T250-U, T255-C, T255-D	Bone	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2542	T215-I	Bone	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2586	T250-F	Bone	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2657	T219-B	Bone	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2668	T219-M	Bone	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2795	T251-T	Bone	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2697	T216-T	Bone	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2544	T215-K	Ivory	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2658	T219-C	Ivory	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2659	T219-D	Ivory	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2660	T219-E	Ivory	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2667	T219-L	Ivory	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2687	T220-J	Ivory	*Odobenus rosmarus*
Late Inuit-Inughuit	3930x2656	T219-A	Antler	*Rangifer tarandus*
Late Inuit-Inughuit	3930x2803	T250-I	Bone	*Rangifer tarandus*
Inughuit	3930x1769	T220-S	Keratinous Horn/Hoof	Bovidae
Inughuit	912x302	T250-N	Bone	Bowhead/Right whale
Inughuit	3930x595	T251-L	Bone	Bowhead/Right whale
Inughuit	3930x940	T251-K	Bone	Bowhead/Right whale
Inughuit	3930x1227	T250-T	Bone	Bowhead/Right whale
Inughuit	3930x1641	T250-C2	Bone	Bowhead/Right whale
Inughuit	3930x1955	T220-R	Bone	Bowhead/Right whale
Inughuit	3930x2536	T215-C	Bone	Bowhead/Right whale
Inughuit	3930x2537	T215-D	Bone	Bowhead/Right whale
Inughuit	3930x2543	T215-J	Bone	Bowhead/Right whale
Inughuit	3930x2664	T219-I	Bone	Bowhead/Right whale
Inughuit	3930x2690	T220-M	Bone	Bowhead/Right whale
Inughuit	3930x2691	T220-N	Bone	Bowhead/Right whale

Inughuit	3930x2830	T250-D	Bone	Bowhead/Right whale
Inughuit	3930x2695	T216-R	Bone	Bowhead/Right whale
Inughuit	3930x447	T250-M	Bone	*Erignathus barbatus*
Inughuit	3930x2539	T215-F	Bone	*Monodon monoceros*
Inughuit	912x114	T251-Q	Bone	*Odobenus rosmarus*
Inughuit	3930x594	T251-S	Bone	*Odobenus rosmarus*
Inughuit	3930x1571*	T250-E, T255-G, T255-H	Bone	*Odobenus rosmarus*
Inughuit	3930x1962	T250-J	Bone	*Odobenus rosmarus*
Inughuit	3930x2466	T251-U	Bone	*Odobenus rosmarus*
Inughuit	3930x2538	T215-E	Bone	*Odobenus rosmarus*
Inughuit	3930x2665	T219-J	Bone	*Odobenus rosmarus*
Inughuit	3930x2834	T250-L	Bone	*Odobenus rosmarus*
Inughuit	3930x2698	T215-A	Bone	*Odobenus rosmarus*
Inughuit	3930x1108	T220-V	Ivory	*Odobenus rosmarus*
Inughuit	3930x1569	T220-T	Ivory	*Odobenus rosmarus*
Inughuit	3930x2570	T216-Q	Ivory	*Odobenus rosmarus*
Inughuit	3930x2663	T219-H	Ivory	*Odobenus rosmarus*
Inughuit	3930x2669	T219-N	Ivory	*Odobenus rosmarus*
Inughuit	3930x2673	T219-R	Ivory	*Odobenus rosmarus*
Inughuit	3930x2674	T219-S	Ivory	*Odobenus rosmarus*
Inughuit	3930x2680	T220-C	Ivory	*Odobenus rosmarus*
Inughuit	3930x2681	T220-D	Ivory	*Odobenus rosmarus*
Inughuit	3930x2682	T220-E	Ivory	*Odobenus rosmarus*
Inughuit	3930x2683	T220-F	Ivory	*Odobenus rosmarus*
Inughuit	3930x2684	T220-G	Ivory	*Odobenus rosmarus*
Inughuit	3930x2692	T220-O	Ivory	*Odobenus rosmarus*
Inughuit	3930x2696	T216-S	Ivory	*Odobenus rosmarus*
Inughuit	3930x126	T251-E	Bone	*Ovibos moschatus*
Inughuit	3930x1971	T251-R	Bone	*Ovibos moschatus*
Inughuit	912x288	T251-H	Bone	*Rangifer tarandus*
Inughuit	3930x253	T215-B	Antler	*Rangifer tarandus*
Inughuit	3930x2546	T215-M	Antler	*Rangifer tarandus*
Inughuit	3930x2662	T219-G	Antler	*Rangifer tarandus*
Inughuit	3930x2670	T219-O	Antler	*Rangifer tarandus*
Inughuit	3930x2688	T220-K	Antler	*Rangifer tarandus*

*Second pass samples; specimen resampled from deeper anatomical components to acquire better collagen yield.

4. Assessing Osseous Technology Materials, Manufacturing and Reduction Techniques at Iita, NW Greenland

Introduction

Osseous material, which includes ivory, bone, and antler, was used to create a multitude of objects over the more than 4000-year Indigenous history of the North American Arctic and continues to be used today. However, the types of debris produced during the manufacture of these various artifacts are poorly understood. This paper presents the first detailed bone technological analysis for the archaeological site of Iita, NW Greenland. Initial human habitation of Iita began over 1000 years ago, with near continuous occupation until the early 20th century. It is one of only a handful of Arctic sites with intact stratified deposits. We previously reported on species identification of these debris using ZooMS and discussed the implications of these findings regarding taxonomic composition, focusing on the archaeological invisibility of certain marine mammals (Ebel et al. 2023). Here, we present results of the analysis of reduction by-products, with the goal of examining the similarity in osseous technology between the two contiguous but culturally distinct populations living at Iita.

Archaeologists infer subsistence strategies of past people in several ways, including the examination of recovered faunal remains and analyzing technological tool kits. The composition of osseous technological assemblages is affected by the availability and distribution of raw material sources, foraging strategies, and limitations on resource access in the form of hunting technology (e.g., watercraft to access open water sources, bow and arrow). Therefore, the assortment of osseous raw materials should reflect cultural and behavioural differences between the people who inhabited Iita. Additionally, it provides insight on raw-material procurement and the taxa represented at the site.

In this paper, we identify and describe more than 860 pieces of osseous debitage attributed to tool manufacture from midden deposits excavated in 2012 and 2016. We characterize the biological (raw material, body portion, species) and cultural (manufacturing traces) aspects of the osseous tool assemblage and compare those aspects between the cultural periods of Iita, spanning from the Late Dorset to the Historic Inughuit and Euroamerican occupations. Ultimately this will allow us to draw inferences regarding the decisions made by two distinct foraging populations at Iita including raw material selection and transport, which we contextualize by comparison with a more traditional faunal analysis.

There have been many studies on Arctic bone-tool assemblages. Since the current study approaches bone technology in similar ways and adapts methods from many of these previous studies, we offer a short literature review to provide context within this existing research. Morrison (1986) explored similarities and differences between the reduction strategies for antler and bone tools of Mackenzie Inuit and neighboring Kutchin of the Northern Yukon territory. Nagy (1988) examined reduction techniques of Mackenzie Inuit material culture from the Trail River site, which included antler and bone tools in all stages of reduction from cores to finished objects and their manufacturing debitage. Microscopic examination of use wear on completed Inuit tools of bone and antler from the Mackenzie Delta region was undertaken by LeMoine (1994). LeMoine and Darwent (1998) describe walrus ivory reduction techniques for Late Dorset based on sites on Little Cornwallis Island. LeMoine (2005) was an early proponent of examining the frequency of raw material types in Late Dorset osseous technology. Betts (2007) examines

Mackenzie Inuit whale bone implements and their manufacturing stages and the implications that the reduced archaeological visibility of producing whale bone tools has on our understanding of socio-economics of prehistoric groups. Wells (2012) explores how osseous technology shaped the social life of the Middle Dorset by analyzing the material type, tool form, manufacture, and use at the site of Philips Garden which was occupied for 800 years. Houmard (2015) presents a typological and technological study of Pre-Inuit osseous tools from the Tayara site in the eastern Canadian Arctic, while Houmard and Grønnow (2017) describe the manufacturing process for antler, bone, and ivory artifacts from the eastern Arctic Thule culture type site of Naujan in the eastern Arctic. Despite Naujan being the first Arctic site to be professionally excavated, waste debris from tool manufacture were rarely collected and faunal remains associated with the houses and middens were only collected for a portion of the site. Houmard et al. (2019) describe caribou antler exploitation and reduction techniques at the Pre-contact site of Nunalleq in southwest Alaska by providing a preliminary report on completed artifacts, artifacts in the process of being made, and antler debitage. More recently, Siebrecht et al. (2021) took a microscopic approach to the analysis of needles and harpoon heads from various archaeological sites within the Foxe Basin of the Canadian Arctic, and found considerable variability in Late Dorset manufacturing techniques which produce outwardly similar artifacts.

Many of these previous studies are focused on materials recovered in the western Arctic and a few select Central Arctic sites and report on bone technology of either the Late Dorset or Inuit. The current study presents data from a single Eastern High Arctic site with a stratigraphic sequence which spans two culturally and technologically distinct archaeological cultures. Within this assemblage, we examine reduction sequence by-products (waste debris) and unfinished items rather than completed objects.

Site Description

The site of Iita is located on Smith Sound in northwestern Greenland (**Figure 4.1**). The site itself sits on the northern side of Foulke Fjord and is approximately 8km from the open water of the sound. The narrow and deep fjord is lined with cliffs of talus scree. In the summer, these cliffs are transformed into rookeries for millions of migratory sea birds. Additionally, this location draws large aggregations of marine life because of its location within a protective fjord and its proximity to the North Water polynya (Born 2001; Mosbech et al. 2018; Vibe 1950). These features clearly made the site an attractive location for Arctic peoples over the last 1,000 years.

Iita is on an alluvial fan where stratigraphic layers have accumulated over time because of continual downhill movement of sediment (**Figure 4.2**). This geological phenomenon differs from what is typically seen across the High Arctic where abandoned archaeological ruins dot the surface of the landscape and remain visible for thousands of years due to slow soil development in the polar desert environment. These surface exposed sites can often result in artifacts from multiple time periods becoming intermingled on the surface and the organic remains, including osseous materials, are typically poorly preserved. Recent excavations at Iita have produced relatively well-preserved faunal materials from distinct strata. With data from both technological and dietary sources, we can better understand observed differences in animal resource use between two culturally distinct groups who lived at the same Arctic locality. The history of occupation combined with the abundance of osseous debris at Iita makes an ideal opportunity for comparison.

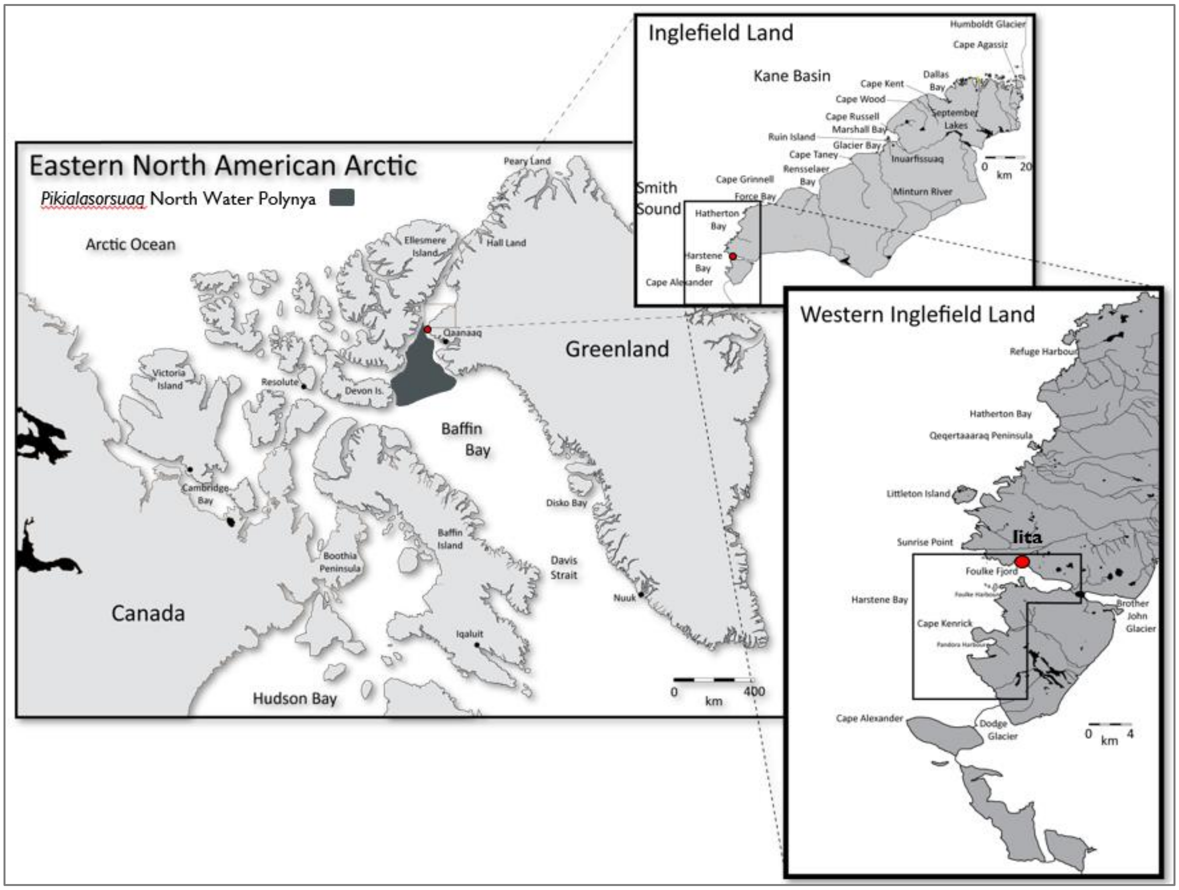

Figure 4.1. Map of study area with Iita indicated by the red dot in North-western Greenland. The site is located within Foulke Fjord at the northern extremity of the North Water polynya. Map by J. Darwent.

Cultural Chronology

Two distantly related but culturally distinct groups originated in the Bering Strait region and undertook major pan-Arctic migrations across the eastern Arctic of North America (Maxwell 1985; Raghavan et al. 2014): 1) Pre-Inuit, and 2) Inuit. Prior to 3200 BCE, Pre-Inuit descendants of the archaeological tradition known as Bel’kachi crossed the Bering Strait from Siberia to northwestern Alaska and expanded across the Canadian Arctic to Greenland. Archaeologically they are associated with a technological tradition known as the Arctic Small Tool tradition (ASTt) (Friesen 2016). Archaeologists recognize several ASTt complexes over more than 3000 years of eastern Arctic occupation, but here we focus on the Late Dorset, the terminal phase of these Pre-Inuit cultures.

The exact timing of the emergence and termination of the Late Dorset period is difficult to pinpoint, but the period spans approximately 500 to 1250 CE (Appelt, Damkjar, and Friesen 2016; Madsen, Grønnow, and Harmsen 2020). The Late Dorset archaeological record is distinct from both the earlier Pre-Dorset ASTt and the subsequent Thule-Inuit cultures. For example, this period is associated with large, communal structures known as longhouses (~14–45m in length), which are often associated with numerous hearth rows suggesting occasional social gatherings of many small family groups, likely for cooperative activities such as walrus hunting (Darwent et al. 2008; Friesen 2007).

Additionally, bow-and-arrow technology, drills, dogs, and small boats seem to have been lost by this last manifestation of ASTt Pre-Inuit peoples (Maxwell 1985; Morey and Aaris-Sørensen 2002). Although their tool kits may seem limited, Late Dorset did have some specialized hunting equipment such as different types of toggling harpoons used for seals and walrus (Maxwell 1985; Park and Stenton 1998). Bone needles recovered in large numbers provide indirect evidence for the production of high quality clothing and other skin gear undoubtedly needed to survive in the Arctic (Appelt et al. 2016; Siebrecht et al. 2021).

Late Dorset material culture is characterized by elaborate carvings of bone, antler, and ivory (LeMoine and Darwent 1998). The various items produced by Late Dorset people are finely made, whether they are realistic or abstract/stylized. Burin-like lithic tools and adzes were used to craft elaborate figurines and other tools. Lithic blades were produced for knives, harpoons, and lances. These blades were likely hafted to osseous materials such as antler or bone and secured with sinew. Late Dorset are also known for their microblade technology. Local copper and meteoritic iron were also materials for knives and endblades (Jolicoeur 2020).

Initially defined as “Thule” by archaeologist Therkel Matthiasen (1927), precolonial Inuit cultures of the North American Arctic are the direct ancestors of Canadian and Greenlandic Inuit and Alaskan Iñupiat. Current interpretations suggest Inuit culture developed in the Bering Strait region and spread into the eastern Arctic by 1200 CE (Friesen 2016; Maxwell 1985; Whitridge 2016). Although genetically and culturally distinct from earlier Pre-Inuit groups, scholars do not agree on whether these two cultures interacted or whether such interaction had a causal relationship to the eventual disappearance of Late Dorset (Park 2016; Raghavan et al. 2014).

Inuit brought a new way of living to the Arctic, which included the bow-and-arrow technology, drills, dogsleds, and large boats (*umiak*) enabling transport of numerous people and communal hunting of large marine mammals, including bowhead whales. Pre-contact Inuit material culture was composed of a diverse set of materials including stone, bone, ivory, sinew, baleen, and metals like meteoric iron and native copper. Drill bits and blades were made from local lithic materials as well as metal. Bone, antler, and ivory were used in composite tools such as arrowheads and harpoon heads, while bone was commonly used for needles and needle cases (Madsen, Grønnow, and Harmsen 2020; Whitridge 2016).

Large, semi-subterranean dwellings of sod, stone, and whale bone typify the *iglu,* the classic Inuit winter dwelling (Whitridge 2016). Inuit occupations are often situated near or on top of earlier Pre-Inuit dwellings, as is the case at Iita (Darwent et al. 2019; LeMoine and Darwent

2010). Radiocarbon dating of sequential cultural layers indicates that the timing of the Late Dorset people's disappearance and the arrival of Inuit in the eastern Arctic are synchronous, but the extent to which their occupations overlapped remains unclear, and no clear evidence has yet been found for cultural transmission between the two groups (e.g., Darwent et al. 2019; Park 2016).

Prior to 1700 CE, Inuit communities became regionally specialized and developed geographically unique subsistence and settlement strategies (Mason and Friesen 2017; Whitridge 2016). Inughuit of northwestern Greenland are the most northerly Indigenous peoples in the world and speak Inuktun, a distinct dialect of Inuktitut. Precolonial population size is estimated to be 100–200 people (Holtved 1944; LeMoine and Darwent 2016). At the time of historic contact, Inughuit did not fish or capture marine mammals in open water; instead, they hunted from the ice edge. Inughuit had lost the bow and arrow, fishing leisters, and kayaks sometime in the century prior to contact with British whaler John Ross in 1818 (LeMoine and Darwent 2016).

Previous Research at Iita

Inglefield Land has attracted American and British Polar explorers since the early 1800s, but Iita's archaeological features were not investigated until 1915, when George Comer was landlocked for two years by impenetrable sea ice. Comer's excavations here were minor, however, compared to his earlier undertakings at North Star Bay or Ummanak, now known as Comer's Midden. During his stay at Iita, Comer partially excavated several archaeological features he described as old house sites, but he did not record their locations; thus artifacts collected during the Crocker Land Expedition and Comer's rescue mission between 1913–1917 lack intra-site archaeological context (LeMoine and Darwent 2010; Wissler 1918). Comer recovered artifacts from several of these house features in the vicinity of Iita including ivory sled shoes and carvings, bone and antler hafts for knives, antler hammers, baleen (referred to as whalebone), barbed wooden objects, variously shaped chipped flint, and “a large series of whale bone slabs used in making sleds” (Wissler 1918:119).

The Inglefield Land Archaeology Project, which focused partly on the historical period occupation at Iita, initiated its investigations of the region in 2004 (Darwent et al. 2007; LeMoine and Darwent 2010). Two semi-subterranean Inuit/Inughuit houses were excavated in 2006. During the excavation of House 1, Pre-Inuit-period chert flakes were discovered under the feature’s Late Inuit/Inughuit period occupations. To explore these findings further, excavations resumed in 2012 in midden areas adjacent to House 1, confirming a Pre-Inuit, Late Dorset occupation, but with no evidence of earlier occupations (**Figure 4.2**). The site’s Late Dorset deposits were being impacted by coastal erosion so investigations resumed in 2016 to mitigate site loss (Darwent et al. 2019).

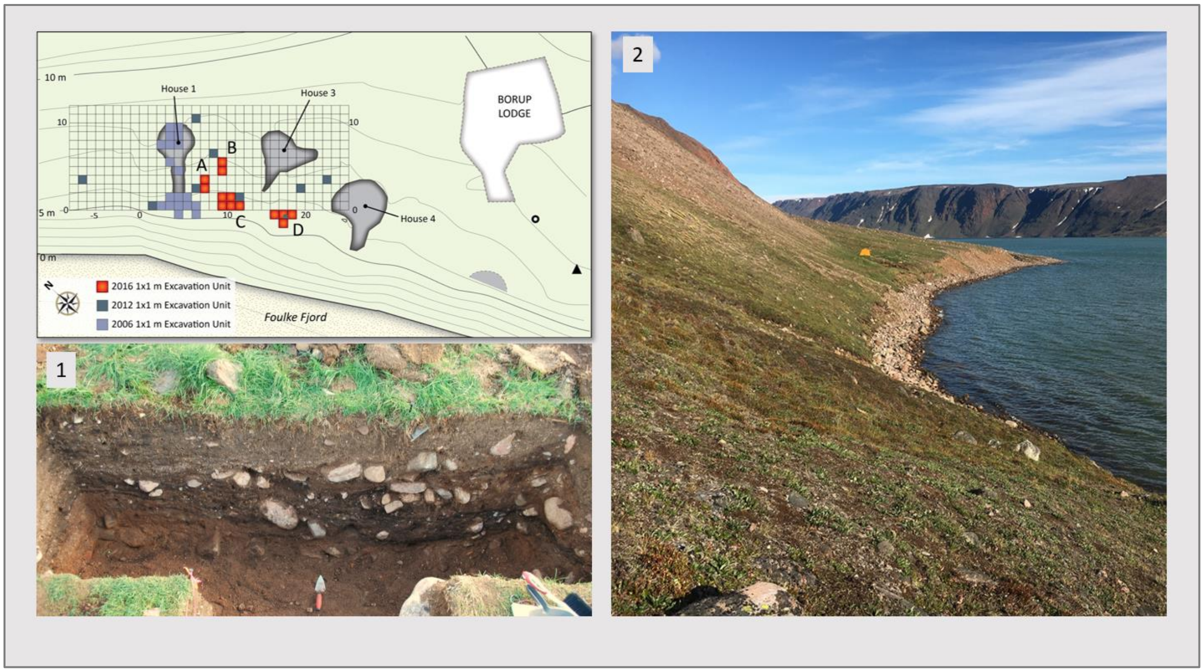

Figure 4.2. Excavation grid and site layout at Iita. Excavations in 2006 were focused on the interior of House 1, while excavations in 2012 and 2016 were primarily focused on external midden deposits. (1) Example of stratigraphy from the north wall of excavation unit D, and (2) photograph of the site in 2016. The yellow tent is where Borup Lodge was once located, which served as the headquarters of the 1913–1917 Crocker Land expedition led by Donald B. MacMillan. Figure by J. Darwent.

Previous research by Johansen (2012, 2013) on zooarchaeological remains from Inuit and historic Inughuit winter house deposits at Iita indicated a heavy reliance on small, seasonally available sea birds (dovekie [*Alle alle]*) supplemented by small seals, Arctic fox and hare. Current zooarchaeological research on the chronologically older Late Dorset and Inuit faunal materials recovered from midden deposits reveals a similar, slightly more generalized pattern of resource use (Chapter 2).

Recent identification of debris from osseous technology has revealed that marine mammal resources, particularly cetaceans, are underrepresented in these traditional faunal analyses using traditional zooarchaeological methods. Cetaceans appear to have been heavily processed by the Inuit for the manufacture of osseous tools (Chapter 3).

A preliminary analysis and identification of a selection of formed artifacts has been published by Darwent et al. (2019) and is summarized in **Table 4.1**. The new analysis presented here expands our current knowledge of resource use at Iita by (a) identifying and describing the various osseous materials used in production of osseous tools and (b) characterizing the manufacturing actions which produced these debris.

Table 4.1. Various osseous artifacts recovered from Iita are provided here to contextualize the osseous debris analyzed in this study (data from Darwent et al. 2019).

	Late Dorset	**Inuit-Inughuit**
Antler blank	X	-
Antler dart head	-	X
Antler harpoon head	-	X
Antler knife handle	X	-
Antler snow-knife handle	X	X
Antler spatula	X	-
Baleen box part	-	X
Ivory adze socket	-	X
Ivory carved animal figurines	X	X
Ivory carved human figurines	-	X
Ivory harpoon head	X	X
Ivory stylized bear harpoon head	X	-
Ivory wound pin	-	X
Ivory pendant	-	X

Overview of Raw Materials

Raw material selection is an essential part of any tool-maker’s decision-making process. The selection of reliable materials for various tools is especially important in high-risk foraging contexts, such as in the High Arctic. Further, resource material types are limited by the bioavailability of materials such as wood and a relatively limited number of animals from which raw materials can be harvested. The range of raw materials available to toolmakers at Iita each have their own set of mechanical and morphological properties which need to be considered when interpreting manufacturing choices.

Each material has structural properties that make them well suited for a variety of uses. Bone, antler, and ivory are each composed of an organic (collagen, lipids) and inorganic (apatite) matrix (Locke 2013). These materials may appear outwardly similar, but they differ significantly in structure and composition. The composition and mechanical structure of bone contributes to its ability to provide a durable raw material. The macroscopic structure of bone can vary by taxon and is associated with anatomical and physiological differences. For example, mammals tend to have more robust skeletal structures than birds. Further, there is variability within these taxonomic classes such that one can distinguish mammals from certain environments, such as marine versus terrestrial mammal bone. These osteological characteristics give various animal bones recognizable traits which may be selected for when choosing raw materials. For example, bowhead whale bone is highly porous, yet hard, which allows it to absorb high energy loads without fracture (Betts 2007).

Antlers possess a unique structure resulting from the outer cortical layer and the inner spongy layer slowly transitioning into one another. This structure enables antler to resist fracture, making for a strong material that is resilient under stress (Krzyszkowska 1990; Morrison 1986). Antler is also flexible because of its high collagen content and therefore more forgiving than bone (Picavet and Balligand 2016).

Ivory is the hard dentine layer of mammal teeth and is characteristically rigid. Tusks are simply enlarged teeth. In the case of walrus, these are enlarged maxillary canines. For narwhals, it is typically their left canine that grows outward directly through the left side of their maxilla, with a distinctive spiral shape (Nweeia et al. 2012). The microstructure of dentine behaves like fine-grained lithic material when struck, sometimes producing flakes that retain bulbs of percussion. Although ivory is rigid, it has superior workability. For example, it may be cut and shaped without splintering, unlike bone (Tiley-Nel and Antonites 2015).

Keratinous materials such as baleen, horn and hooves were also potential raw materials accessed by occupants of Iita, although they are rare in this assemblage. In life, keratinous materials are flexible and provide a strong protective layer. Keratin is one of the toughest biological materials but degrades over time eventually losing its flexibility, and becoming brittle (Locke 2013; Wegst and Ashby 2004).

Zooarcharchaeological Materials

The primary data analyzed here includes incomplete osseous tools and manufacturing debris recovered from midden deposits at Iita excavated in natural stratigraphic layers and screened using $\frac{1}{4}$ -inch mesh in 2012 and $\frac{1}{8}$-inch mesh in 2016 (Darwent et al. 2019). A total of 15, 1x1 meter units were excavated, and debris from osseous tool production were separated by hand sorting 100% of the faunal remains across all cultural layers (refer to **Appendix A** for a catalogue of the faunal materials analyzed from each context). In total 868 examples of debris were analyzed in this current study.

Fewer Late Dorset osseous materials were recovered from Iita for three main reasons: 1) the Late Dorset occupation of Iita spans 300 years (800–1250 CE) compared to the Inuit and Inughuit occupations, which spans 600 years (1250–1850 CE), 2) there is also a considerable difference in area/volume excavated, and 3) the Late Dorset occupation at Iita was actively eroding while salvage archaeological recovery was undertaken. Refer to Darwent et al. (2019) for details on how climate change resulting in loss of permafrost and coastal erosion has led to a decrease in material culture, particularly organic remains, recovered for the Late Dorset period.

This study focuses not on finished objects but rather on the debris portions of osseous technology—specimens colloquially described as debitage, blanks, and minimally modified materials. We exclude formed or nearly formed objects such as carvings, harpoons, and other items with clear forms and generally accepted functions. This sampling strategy was chosen for two main reasons: 1) many of the formed objects, such as carvings and harpoons, were described in previous publications (see Darwent et al. 2019), and 2) we assert that there is much overlooked potential in manufacturing debris. Chapter 3 of this volume discusses the prevalence of waste debris from the working of narwhal ivory despite no completed narwhal ivory artifacts identified at Iita (see also Ebel et al. 2023).

This research aims to identify the raw materials and describe the processing and reduction methods used by the various occupants of Iita for each material type. We approached this by conducting a detailed visual analysis using microscopy and integrating taxonomic identifications via ZooMS (Zooarchaeology by Mass Spectrometry or Peptide Mass Fingerprinting). A morphological analysis using digital microscopy on the various by-products assisted in determining their material type and identifying the marks preserved on the debris. Together, the morphology of these debris and the traces left by processing tools provides information on the methods and tools used to reduce raw materials at Iita.

Identification Methods

Each specimen (osseous element or fragment thereof) was identified to skeletal element, portion, side, and lowest taxonomic level possible using the UC Davis zooarchaeology laboratory's comparative skeletal collection supplemented by other comparative resources (e.g., Idaho Virtual Museum's osteology collection: https://virtual.imnh.iri.isu.edu/Osteo). Following Driver (2011) specimens that could not be identified to genus or lower were assigned to a descriptive taxonomic category based on characteristics such as size, shape, and internal osteological structure (e.g., cetacean). The specimens that constitute the osseous technology component are analyzed separately from the traditional faunal assemblage because of their unique morphology with evidence of intentional modification indicative of reduction during osseous tool production rather than from butchery (refer to Chapter 2 for the zooarchaeological analysis). The methods used to record faunal specimens were extended to the osseous tool-production debris to maintain consistency, but they were expanded to allow for the collection of information on modifications.

For example, taphonomic effects, such as weathering[6] and burning, were recorded following the same methods used in the faunal analysis, and each specimen was assigned to a size class based on the maximum size of the specimen (see **Table 4.8** and **Table 4.9**).

Microscopy

Due to the nature of the small debris, it was inevitable that many pieces were modified to an extent that few diagnostic features remained. In this case, the size, shape, and internal structure were used to best identify each specimen to taxonomic category. Osseous tool debris were analyzed with a DinoLite digital microscope (model #AM73915MZTL) and DinoCapture 2.0 imaging software to aid in the identification of materials and to document modifications. Microscopy was essential for examining individual structures and composition to identify the material type of all 868 osseous specimens. The internal and external anatomical characteristics of each material type (antler, bone, ivory, tooth, baleen, and keratinous horn/hoof) were distinguished using various identification guides (e.g., Baker et al. 2020; Locke 2013). **Appendix B** provides distinguishing criteria specific to each material with various archaeological and museum quality examples.

Zooarchaeology by mass spectrometry

Despite the ability to distinguish between material types using microscopy, many specimens, particularly of bone and ivory, could not be assigned to genus/species. For example, many of the

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[6] Weathering data was recorded only for specimens of bone using codes defined by Behrensmeyer (1978). The degree of weathering has implications for the interpretation of osseous technology. For example, the more extreme the weathering the higher the likelihood that traces of manufacture will be obscured.

bone specimens were identified to only general taxonomic categories such as cetacean or mammal while many of the ivory samples were tentatively identified as narwhal/walrus ivory. One hundred and thirty specimens were chosen for peptide mass fingerprinting (PMF) to identify the taxonomic origin of these osseous specimens. As reported in Chapter 3, PMF analysis of the 130 samples collected was undertaken at the Northeastern University Mass Spectrometry Core Facility following procedures outlined by Kirby et al. (2013, 2019) and the resulting spectra were analyzed using mMass software (Strohalm et al. 2008).

After each specimen was assigned to taxon and skeletal portion or material type, it was inspected for two features: (1) manufacturing traces left by tools during the reduction process, and/or (2) distinct morphologies which could distinguish them as by-products of certain manufacturing actions.

Manufacturing Actions

This analysis is adapted from previous studies on worked bone (Betts 2007; Cunliffe and Brooks 2016), antler (Nagy 1988), and ivory (LeMoine and Darwent 1998). Standard features are used to identify manufacturing actions and the various marks they produce on the processed materials including chopping, cutting, grooving, whittling, and perforating.

Chopping

A manufacturing technique used to reduce and/or shape raw materials using direct percussion. Chopping implements used at Iita include adzes, which are typically composite tools with handles and sockets of dense bone or antler and bits (cutting edge) of ground stone or meteoric iron. Chop marks were identified as either a sheared surface where bone was removed or as V-shaped notches where a tool had impacted the surface of the raw material.

Cutting

Cut marks are produced by sharp-edged tools (e.g., burins, knives), which are applied to the surface of osseous materials in various manners. When possible, I distinguish between two general types of cut marks, (1) slicing and (2) sawing. Slicing is identified as relatively narrow, elongated, linear striations with V-shaped cross sections. Slicing can be heavy cuts or light slices, but always from low-impact pressure and resulting in linearly organized, usually thin V-shaped striations. Slice marks typically result from one sweeping motion of a blade. In contrast, saw marks typically result from a continuous pulling and pushing motion, resulting in multiple stacked slice marks. Sawing was distinguished from slicing by the presence of deep and wide, mostly rectilinear cut marks with sloping walls and linear striations. While there are differences in cut marks produced by metal and lithic blades (Greenfield 2002), I do not distinguish them here unless the marks display characteristics of toothed, metal handsaws introduced by British and American explorers, which produce distinct, overlapping, and consistently spaced striations (Symes et al. 2010).

Grooving

Grooving is a technique which applies heavy downwards pressure in a linear motion to lacerate raw materials repeatedly. Possible grooving implements at Iita include burin-like tools and knives of meteoritic iron. This technique was applied to (1) create channels or slots in objects where blades, for example, could be inserted, and (2) to methodically reduce materials into smaller working units. Often, larger sections of raw material were partially grooved and subsequently snapped, a reduction technique found throughout the Arctic (Betts 2007; Nagy 1988) and beyond (Clark and Thompson 1954).

Grooving was identified in this assemblage by the presence of multiple, deep linear trenches left on the specimen. The profile of the grooved channel, when viewed in cross section, is generally rectangular but may either be V-shaped or U-shaped, depending on factors such as the sharpness of the tool used to groove and how it was held by the tool maker (**Figure 4.3**). Additionally, debris exhibiting traces of grooving were identified by small ridges of parallel striations on the edges where raw materials were split transversely or longitudinally. These edges were often associated with a burr of material, which was not fully lacerated and remained on the debris after the object was snapped into smaller units.

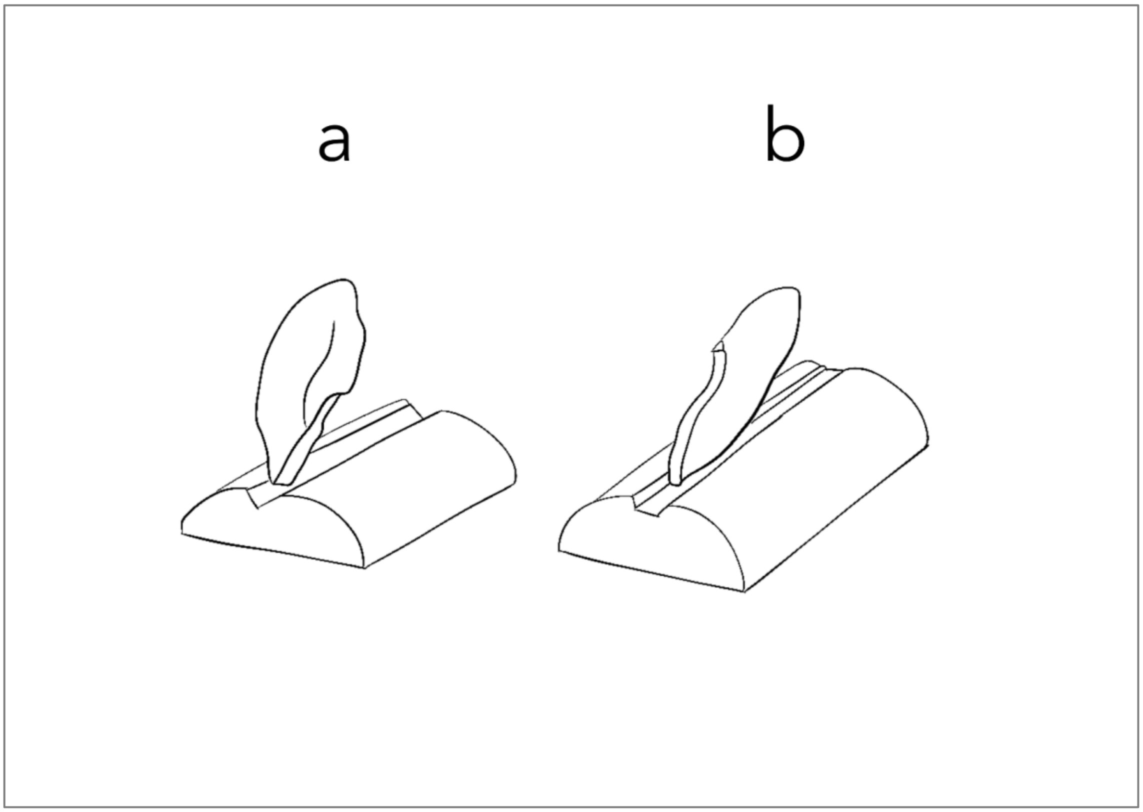


Figure 4.3. Sections of osseous material were often deeply grooved and then snapped to reduce the items size. Grooving, using a burin-like tool, may produce various profiles depending on how the tool is held, including (a) V-shaped profiles and (b) rectangular or U-shaped profiles. Illustration by E. Ebel, modified from Nagy (1988, Fig. 23).

Perforations

There are two distinct methods of creating perforations in osseous materials throughout the Arctic, both of which are represented at Iita: (1) gouging by incising, and (2) drilling. It is generally accepted that Pre-Inuit Dorset cultures did not have drill technology (Appelt et al. 2016; Rowley 1940). Instead, Pre-Inuit Dorset gouged holes into objects by creating small, linear incisions using burin-like tools or other sharp-edged tools. Perforations by gouging were identified by the traces of long, linear incision marks above and below the perforation.

Perforations made by gouging are ovoid and/or form an elongated, V-shaped valley with a long yet thin hole in the material which is made from the repeated incisions (**Figure 4.4**).

Drilling is a technique to cut a hole into material which uses a combination of rotation and pressure. Bow drills with drill bits of stone or meteoric iron were likely used by the Inuit to perform this action (Kroeber 1899; Mathiassen 1927; Nagy 1988; Whitridge 2016). Drilling was used in multiple ways such as drilling holes for various attachments, decoration, and as a method to reduce materials into smaller sections, known as drill-and -snap. This method of reduction was accomplished by drilling multiple holes in a row to create a weakened area that could more easily be snapped (Kroeber 1899; Morrison 1986; Nagy 1988).

Drilling was identified in this assemblage by the presence of rounded, conical holes (**Figure 4.4**). Drilled perforations were sometimes modified further by whittling away material around the circumference, likely as a quick way to increase the size of the perforation. Although this is a variation on drilling, we tabulate these observations separate from unmodified drill holes (**Table 4.12**). In this study, drilled holes were identified as either complete or incomplete to allow for interpretations of the ways in which drilling was being used. For example, we might expect specimens to have complete drilled holes for the purpose of adding attachments (e.g., threading through sinew or cordage) while we might expect multiple, aligned, incomplete holes to be the result of breakage, possibly from the drill-and-snap reduction technique (**Figure 4.5**).

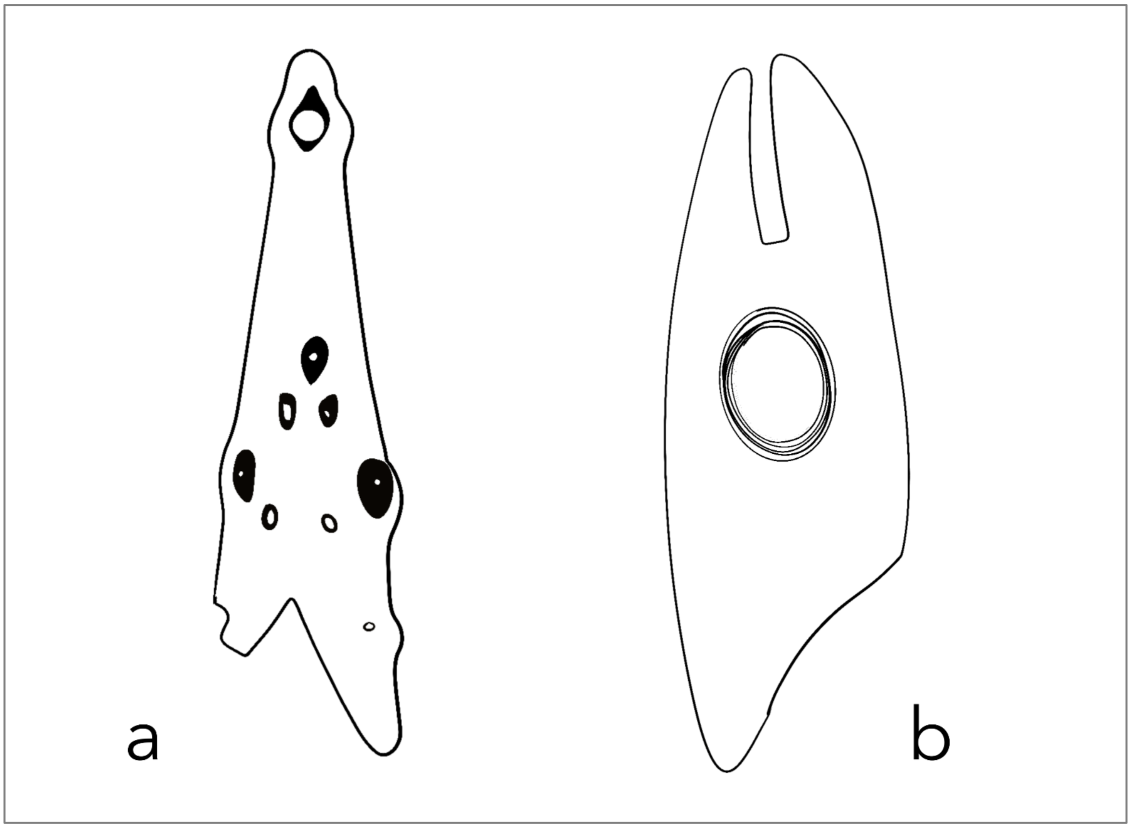


Figure 4.4. The two main methods of perforating. (a) Gouging by incising as evidenced by the elongated relief incised on either side of the gouged perforation, represented in black here. (b) Drilling, which is evidenced by circular to ovoid holes, which often taper and/or have circumferential striations within the walls of the perforation. These mostly complete artifacts were used as comparative materials for identifying perforation types but were not included in the study sample. See Darwent et al. (2019) for artifact photos. Illustration by E. Ebel. Not to scale.

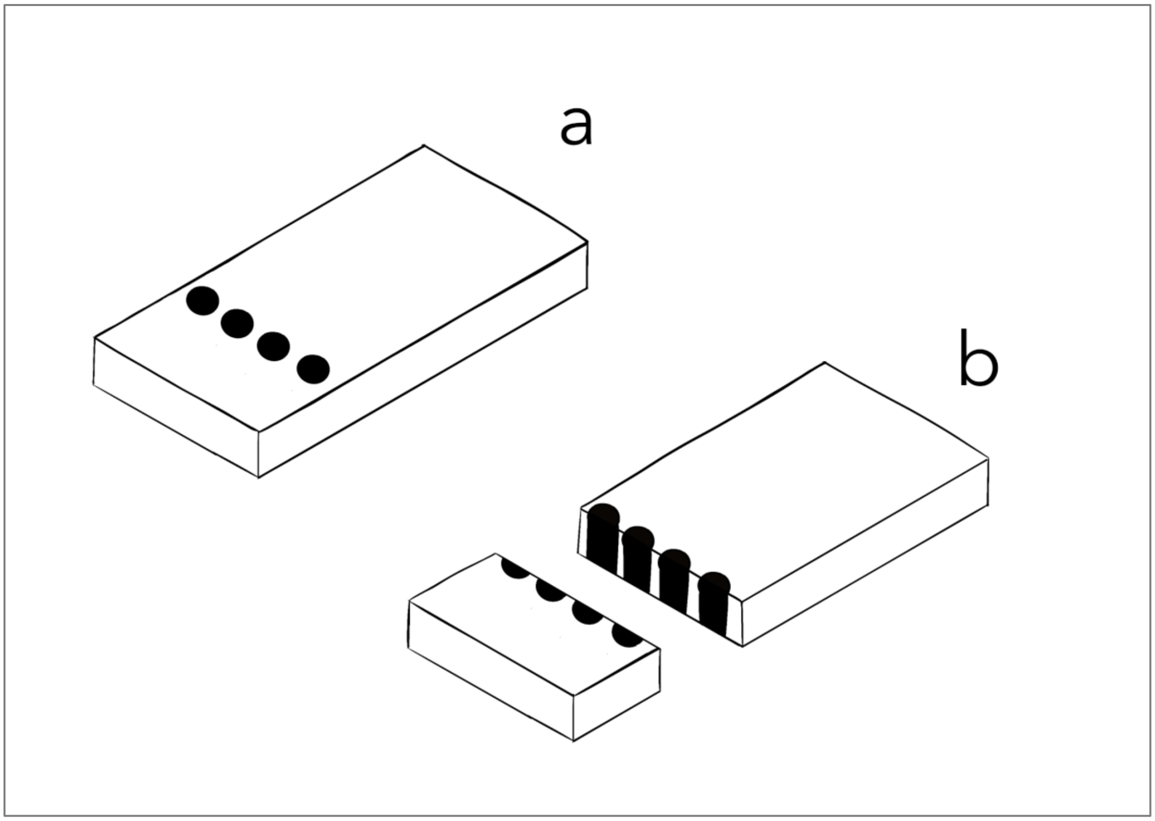


Figure 4.5. Illustration of the drill-and-snap reduction technique. Drilled perforations were recorded as either (a) complete drilled perforations or (b) incomplete drilled perforations. Illustration by E. Ebel.

Whittling

A technique which is used to carve or otherwise finely shape an object. The toolmaker removes one shaving of osseous material at a time by applying pressure directly from the wrist or from indirect percussion if using a chisel. Evidence of whittling can be found directly on worked objects and by the presence of whittling by-products, namely shavings.

Whittling evidence found directly on the objects was identified by the presence of longitudinal striations with flat bottomed channels and/or hinges which create breaks in the working surface where the toolmaker changed the position of their whittling tool (Nagy 1988).

By-products of whittling include shavings of various morphologies, from slightly curved shavings to tight “corkscrew” curls.

Other

Other qualitative variables recorded for specimens, but at low frequency, included presence of an inset object, impact depression, and attachment of an unknown fibrous material, discoloration, and root etching (root etching may sometimes be confused for human- or animal-produced marks). Detailed microscopic use-wear analysis of the osseous debitage was beyond the scope of this study, but limited information on wear and use was collected when visible with the unassisted eye or under low-power magnification, including abrasion, polish, or a combination of both. Abrading is a surface reduction technique that uses a grinding implement to wear away material by the application of friction. Abrasive materials possibly used in tool production include abrasive stone or leather (Betts 2007; LeMoine 1994). Abrasion was identified by the presence of unnaturally smoothed or flattened surfaces with concentrations of shallow, randomly oriented crisscrossed striations. These surfaces may be dull or lustrous. If the area is lustrous, then it is considered polished. Polish can result from the application of a fine-grained abrasive; however, polish can also be a result of use over time.

Reduction Stages and Types

We recognize two reduction stages, primary and secondary, following Betts (2007), LeMoine and Darwent (1998), and Nagy (1988). Additionally, we apply terminology from Nagy (1988) to all osseous materials as summarized here.

The primary reduction stage involves actions intended to initially prepare sections of raw material for further reduction (i.e., chopping an antler beam from the pedicle). The osseous material is then reduced in various stages, which generally follow from sections into smaller cores and blanks. The preliminary reduction stage is generally complete when the raw material has been transformed into a rough outline of the desired object, at the preform stage.

Secondary reduction involves shaping and more detailed techniques to produce the objects' final form. Various manufacturing actions can be applied to the osseous materials to produce a finished product. A few examples are whittling to remove materials in a controlled manner, incising fine lines to provide artistic details, or intentional polishing to give a fine smoothing and sheen.

Debitage is produced in all stages of raw material reduction and tool production. The size and morphology of debris will depend on the manufacturing action. It may be possible to identify if the debris resulted from primary or secondary reduction techniques, but this is not always feasible. Primary debitage was only identified for antler and ivory. Examples of debitage from the primary reduction stage include antler tines or the most proximal and distal portions of walrus tusk which were removed and discarded during initial preparation of the materials, while examples of debitage from the secondary reduction stage include shavings from whittling.

To organize our analysis, we assigned the debris to one of four reduction type categories based on their morphology and/or the presence of tool marks (**Table 4.2**): (1) primary debitage—section preparation and extraction, (2) secondary debitage—shavings/curls, (3) unidentified debitage, and (4) blanks, preforms, and otherwise semi-formed objects. Identifying the debris types and at what stage of the reduction sequence they were created allows us to understand and compare how different material types were being processed at Iita.

Table 4.2. Reduction stages and their by-products with examples of archaeological expectations. Example specimens are illustrated in **Figure 4.6**.

Reduction stage	Example	By-products	Expected archaeological materials
Primary	Raw material is initially sectioned, cores and blanks obtained	Primary debitage	Discarded unwanted portions to create section; larger fragments of raw material with minimal and/or simple modification(s). Examples: KNK 3930x2535 and KNK 3930x 2784 are removed and discarded portions.
Secondary	Preforms transformed with detailed/fine shaping, applying decorations	Secondary debitage	Discarded debris from fine shaping; smaller fragments of raw material with more complex shapes and/or modification(s) Example: KNK 3930x 2562 and various shavings produced from whittling/carving.

Figure 4.6. Examples of primary and secondary osseous debitage from Iita. Primary debitage a) sectioned antler beam KNK 912x1917; b) discarded antler tine KNK 3930x2535 and secondary debitage c) shaving/curl of narwhal ivory KNK 3930x2562.

Results

A total of 868 specimens were identified as waste or discarded debris from osseous technology, such as semi-formed objects or production waste debris, all of which were identified to species, family, or broad taxonomic category (e.g., mammal). Nearly 75% of the osseous technology specimens are small fragments of debitage between 1–5 cm (**Table 4.8**).

Taxonomic Identifications

The degree of modification limited the ability to identify a portion of the specimens to genera and/or species using traditional zooarchaeological or morphological analysis. Of those specimens, 130 (15%) that could not be identified or only tentatively identified using digital microscopy were sampled for identification using ZooMS. Of the 130 samples, 129 were positively identified (see Chapter 3). A single specimen (KNK912x300) was carbonized and, therefore, did not yield collagen. The remaining specimens generally yielded high-quality, well-preserved type-1 collagen with taxonomically identifiable markers, and of these, 91 specimens could be identified to species, a single specimen was identified to genus, and 37 identified to the level of family.

Table 4.3 lists the frequency and relative frequency of specimens associated with each period and/or cultural affiliation, and the relative contribution of each taxon to the total osseous technology assemblage. The osseous technology of the Late Dorset (n=48) predominantly consists of walrus (56%), followed by caribou (38%), narwhal (4%), and unidentified mammal (2%). The Mixed Context assemblage (n=47) is chiefly composed of narwhal (36%), caribou

(28%), walrus (26%), balaenids and unidentified cetaceans (each 4%), and muskox (2%). The Early Inuit component (n=22) is more limited, with 41% of the osseous material attributed to walrus, 18% each to narwhal and caribou, 14% to balaenids, and 9% to unidentified cetaceans. The Middle Inuit assemblage (n=256) is dominated by narwhal (71%), while walrus, caribou, balaenids, and unidentified cetaceans each contribute 7%. Walrus (56%) comprises the bulk of the Late Inuit-Inughuit component (n=158), along with caribou (19%), narwhal (12%), balaenids (6%) and unidentified cetaceans (6%). The Inughuit component has the largest sample size (n=329) and is comprised of walrus (65%), caribou (16%), narwhal (7%), balaenids (4%), unidentified cetacean (3%), unidentified mammal (2%), while bearded seals, unidentified pinnipeds, and muskox each contribute 1% each. In contrast, the smallest sample size belongs to the Euroamerican component (n=8), which is 63% walrus, 25% bearded seal, and 13% narwhal.

Table 4.3. Number of Identified Specimens (N) and percentage of identified specimens (%NISP) by taxa for the osseous technology assemblage.

	Late Dorset		**Mixed LD–Inuit**		**Early Inuit**		**Middle Inuit**		**Late Inuit–Inughuit**		**Inughuit**		**Euroamerican**		**N**	
TAXA	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
BIRD																
Murre/guillemot (*Uria* sp.)	-	-	-	-	-	-	-	-	-	-	1	0.3	-	-	1	0.1
Total bird	-	-	-	-	-	-	-	-	-	-	**1**	0.3	-	-	1	0.1
MAMMAL																
Arctic hare (*Lepus arcticus)*	-	-	-	-	-	-	1	0.4	-	-	-	-	-	-	1	0.1
Walrus (*Odobensus rosmarus*)	27	56.3	12	25.5	9	40.9	17	6.6	89	56.3	213	64.7	5	62.5	372	42.9
Pinniped (large seal/walrus)	-	-	-	-	-	-	-	-	-	-	2	0.6	-	-	2	0.2
Bearded seal (*Erignathus barbatus*)	-	-	-	-	-	-	-	-	-	-	3	0.9	-	-	3	0.3
Caribou (*Rangifer tarandus*)	18	37.5	13	27.7	4	18.2	18	7.0	30	19.0	51	15.5	2	25.0	136	15.7
Muskox (*Ovibos moschatus*)	-	-	-	-	-	-	-	-	-	-	2	0.6	-	-	2	0.2
c.f. muskox (Bovidae)	-	-	1	2.1	-	-	1	0.4	-	-	1	0.3	-	-	3	0.3
Large terrestrial mammal	-	-	-	-	-	-	-	-	-	-	1	0.3	-	-	1	0.1
Beluga (*Delphinapterus leucas*)	-	-	-	-	-	-	1	0.4	-	-	-	-	-	-	1	0.1

Narwhal (*Monodon monoceros*)	2	4.2	17	36.2	4	18.2	182	71.1	19	12.0	23	7.0	1	12.5	248	28.6
Beluga/narwhal (Monodontidae)	-	-	-	-	-	-	-	-	-	-	1	0.3	-	-	1	0.1
c.f. bowhead whale (Balaenidae)	-	-	2	4.3	3	13.6	17	6.6	10	6.3	14	4.3	-	-	46	5.3
Whale (Cetacea)	-	-	2	4.3	2	9.1	18	7.0	10	6.3	10	3.0	-	-	42	4.8
Marine mammal	-	-	-	-	-	-	1	0.4	-	-	-	-	-	-	1	0.1
Total identified mammal	**47**	97.9	**47**	100.0	**22**	100.0	**256**	100.0	**158**	100.0	**321**	97.6	**8**	100.0	859	99.0
Unidentified mammal	1	2.1	-	-	-	-	-	-	-	-	7	2.1	-	-	8	0.9
Total mammal	**48**	100.0	**47**	100.0	**22**	100.0	**256**	100.0	**158**	100.0	**328**	99.7	**8**	100.0	867	99.9
Grand total	**48**	100.0	**47**	100.0	**22**	100.0	**256**	100.0	**158**	100.0	**329**	100.0	**8**	100.0	868	100.0

Material Types

Table 4.4 presents numbers of specimens (NISP) of the various materials identified within the osseous technology assemblage. All 868 specimens were identified to one of six general osseous material types: antler, baleen, bone, keratinous horn or hoof, ivory, or tooth. Relative to the total assemblage, ivory is 67% (n=578), bone is 16% (n=142), and antler is 15% (n=132), while baleen (n=11), tooth (n=3), and keratinous horn/hoof (n=2) each contribute to less than 1% of the total assemblage.

Table 4.4. Frequency of material types affiliated with each cultural group. Ivory is the most frequent material type overall.

	Antler		Baleen		Bone		Horn/ Hoof		Ivory		Tooth		N	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Euroamerican	2	2	-	-	-	-	-	-	6	1	-	-	**8**	1
Inughuit	50	38	-	-	65	46	1	50	210	36	3	100	**329**	38
Late Inuit-Inughuit	29	22	-	-	32	23	-	-	97	17	-	-	**158**	18
Middle Inuit	17	13	8	73	33	23	-	-	198	34	-	-	**256**	29
Early Inuit	4	3	3	27	3	2	-	-	12	2	-	-	**22**	3
Mixed LD-Inuit	12	9	-	-	8	6	1	50	26		-	-	**47**	5
Late Dorset	18	14	-	-	1	1	-	-	29	5	-	-	**48**	6
	132	100	**11**	100	**142**	100	**2**	100	**578**	100	**3**	100	**868**	100

The frequency of each material type within each component of the archaeological assemblage at Iita is summarized in **Figure 4.7**. The Late Dorset osseous technology assemblage is comprised of three material types: antler (38%), bone (2%), and ivory (60%). The Mixed Context Late Dorset-Inuit assemblage is comprised of four osseous material types. The dominant material type is ivory (55%), succeeded by antler (26%), bone (17%), and keratinous horn/hoof (2%). Likewise, the Early Inuit osseous technology consists of four material types including antler (18%), baleen (14%), bone (14%), and ivory tusk (55%). The Middle Inuit component consists of four material types including antler (7%), baleen (3%), bone (13%), and ivory tusk (77%). The Late Inuit-Inughuit is composed of only three material types: antler (18%), bone (20%), and ivory tusk (61%). The assemblage with the most variation is associated with the Inughuit (post-1850). This component consists of five material types: antler (15%), bone (20%), keratinous horn/hoof (<1%), ivory (64%), and tooth (1%). Finally, the Euroamerican component was composed of only two material types, antler (25%), and ivory (75%). However, the lack of variation in material types is not surprising given the small sample size (n=8).

Greenland has only 26 native mammal species, and fewer are found in northwestern Greenland. This limited faunal diversity in the High Arctic assists in reducing the possibilities of species to which certain materials belong. For example, all antler specimens are attributed to caribou (*Rangifer tarandus*) as they are the only cervid species in Greenland (Meldgaard 1986). Similarly, a keratinous horn or hoof specimen was identified to the bovid family using ZooMS (see Chapter 3 for further discussion) and is attributed to musk oxen (*Ovibos moschotus*) as they are the only bovid species in Greenland (Lent 1988; Schmidt et al. 2015). Likewise, all baleen is assumed to derive from bowhead whale (*Balaena mysticetus*) as it is the only baleen whale species to consistently occupy waters this far north (Heide-Jørgensen et al. 2021). All modified teeth at Iita were post-canine peg teeth from walrus (*Odobenus rosmarus*) identified using standard zooarchaeological techniques. In contrast to the other material types, which can be assigned to a single taxon, ivory and modified bone derive from a variety of different taxa and each are discussed below.

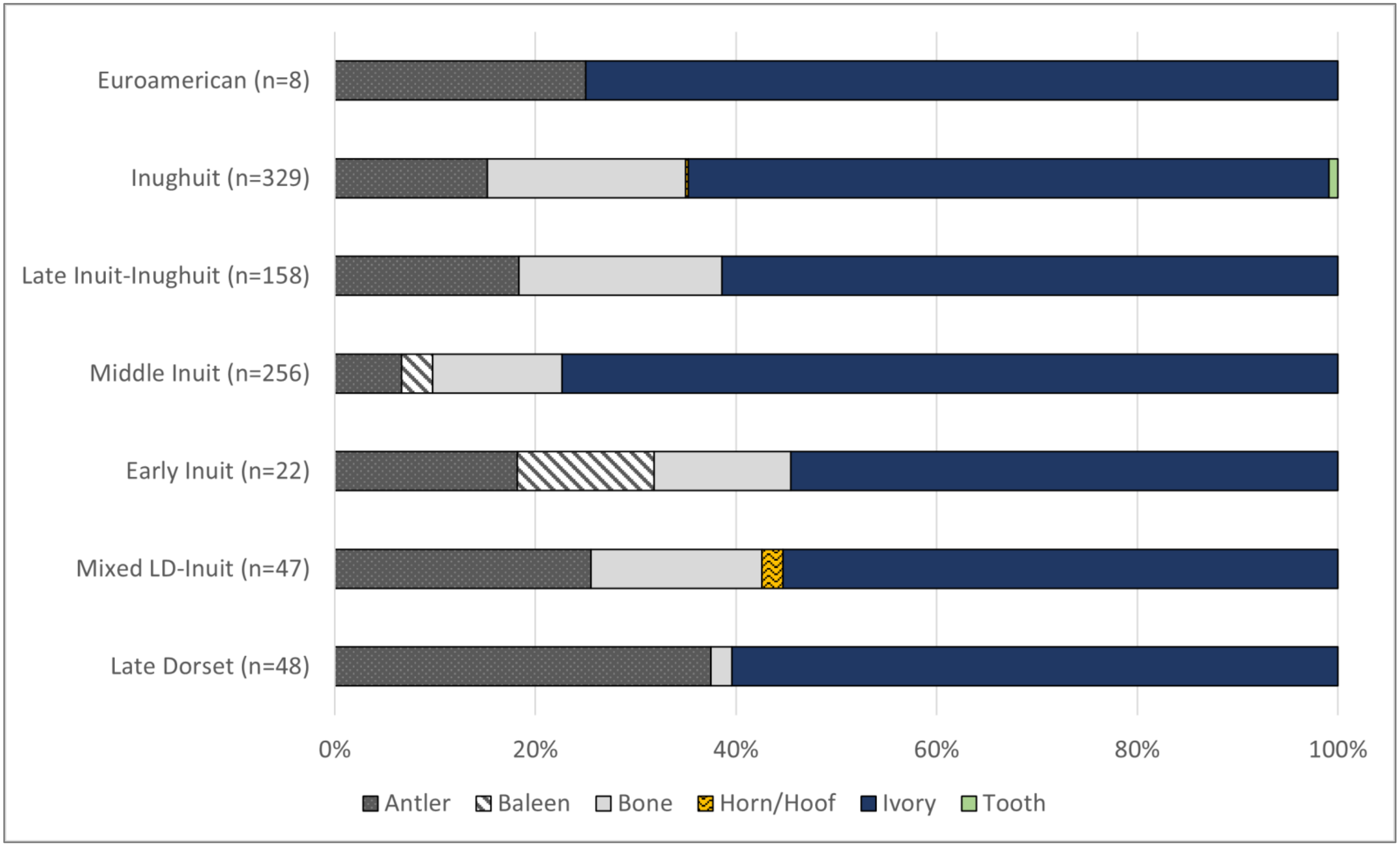


Figure 4.7. The relative frequency (%NISP) of osseous material types among the temporal/cultural affiliations (n=868). Raw count data presented in **Table 4.3.**

Modified ivory

There are two ivory-bearing species available to the inhabitants of Iita, narwhal and walrus. A total of 578 specimens of ivory were identified within the assemblage (67% of the total assemblage). Ivory tusks from walrus and narwhal can typically be distinguished by their unique morphological differences, the main one being the spiral growth pattern in a narwhal tusk (see Appendix B for further discussion). Therefore, most specimens were identified by visual, morphological analysis. However, 53 specimens were identified via ZooMS. Of these 53 specimens, 26 were identified as narwhal and 27 were identified as walrus.

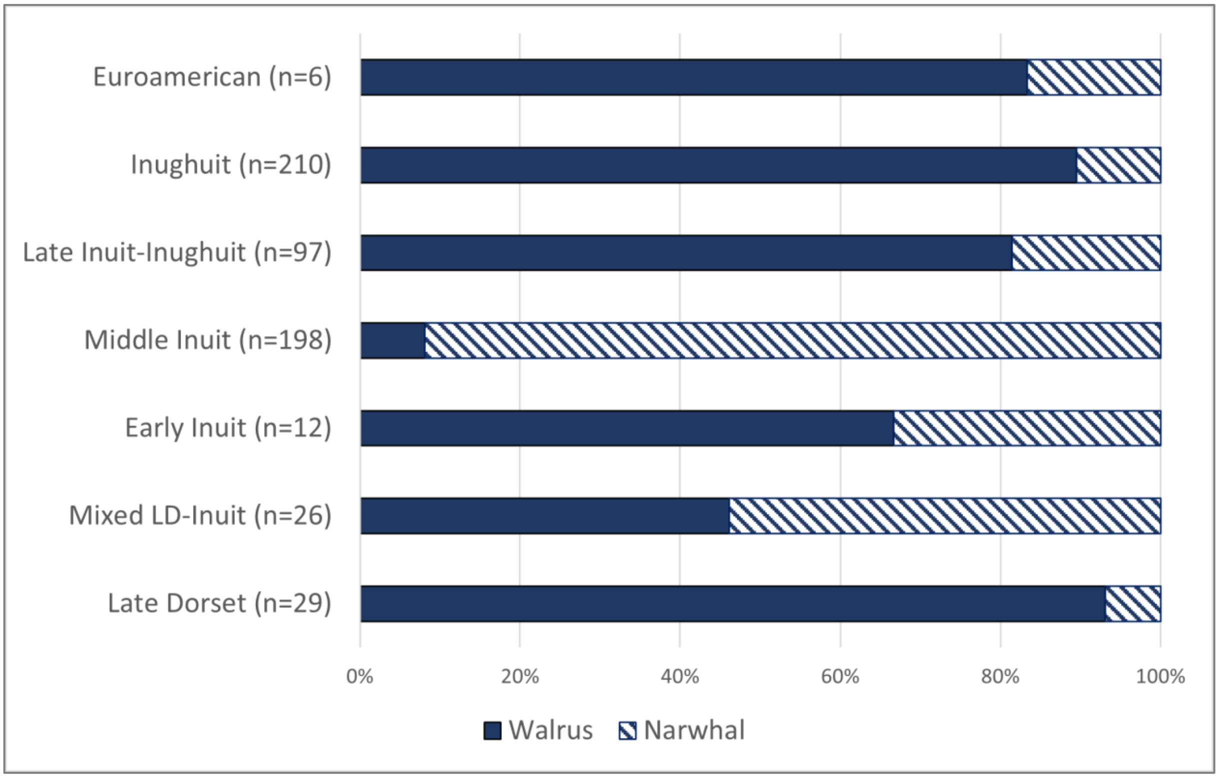


Figure 4.8. Relative frequency (%NISP) and composition of ivory within the osseous technology component (n=578). Both walrus and narwhal were sources of ivory for the inhabitants of Iita. Fragments of walrus ivory are more frequent in most cultural assemblages, except for the Middle Inuit and Mixed Contexts.

Modified bone

Modified bone represents 16% of the osseous technology assemblage. As summarized in **Figure 4.9**, modified bone is represented by various taxa identified to species, family, and the class mammal. Of the 142 bone specimens, 67 were identified by ZooMS. The remaining specimens were identified using standard zooarchaeological methods. **Appendix B** provides details on methods used to distinguish taxon by anatomical differences in bone structure. Nine major taxonomic groups are represented in the bone assemblage including murre, Arctic hare, caribou, muskox, pinnipeds (walrus and large seals), monodontids (beluga and narwhal), balaenids (bowhead whale), unidentified cetaceans, and unidentified mammals.

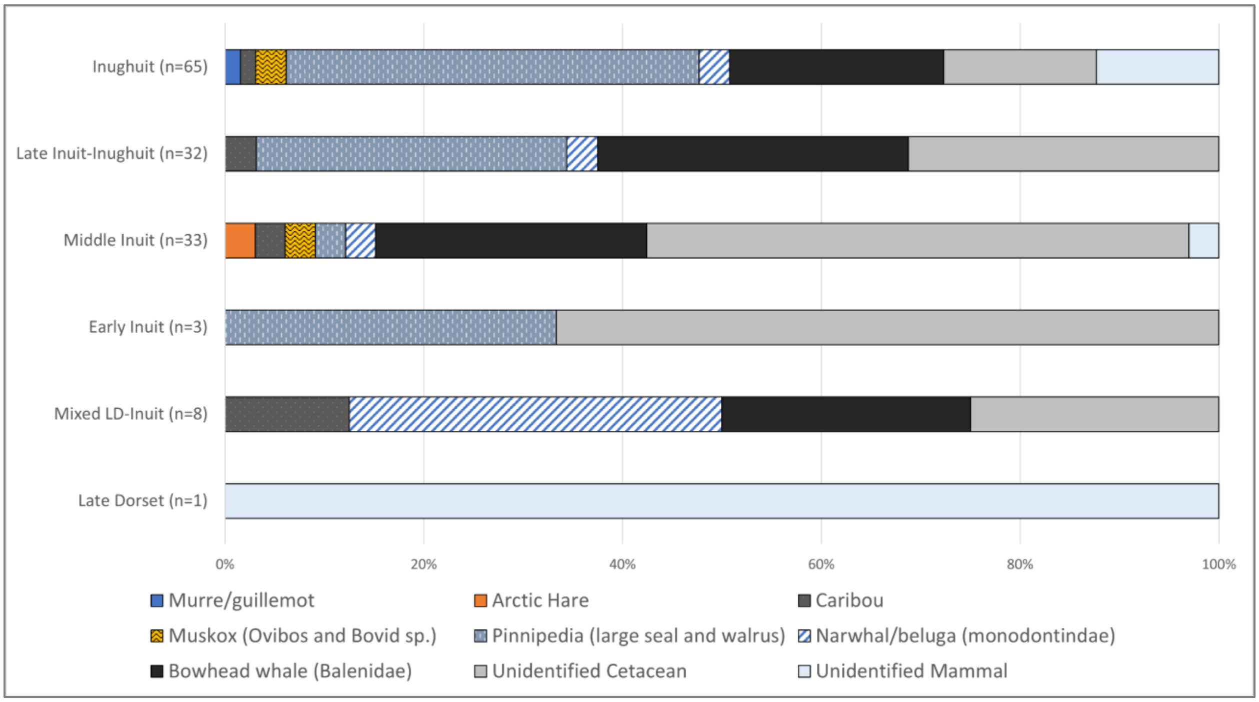


Figure 4.9. Species composition of all modified bone (n=142). Relative frequency (%NISP) of bone fragments for each taxon is plotted by archaeological context to visualize the variation in species contributing to the bone portion of the osseous technology component.

Skeletal Elements, Portions and MNI Calculations

The anatomical segment of each specimen was recorded for antler and bone when possible. Nearly 60% of all antler specimens were assigned to a specific portion (defined in Appendix B, Figure B.16). As described in **Table 4.6**, 42% of all antler specimens derive from the main beam. However, as summarized in **Table 4.7**, only 25% of the modified bone specimens were identified to anatomical portion (n=38). This is unsurprising given the high degree of modification of the bone specimens.

In a multi-site analysis, LeMoine (2005) calls attention to the discrepancy between the large quantities of osseous raw materials (e.g., antler, walrus ivory) within the artifact assemblages and the dearth of related skeletal materials (e.g., butchered caribou and walrus bones) identified within the faunal records. While this issue is most apparent with cetaceans in this assemblage (**Chapter 3**), we find an interesting trend for the non-cetacean raw materials. For example, caribou comprises only 1.4% of the traditional faunal assemblage yet this species contributes to 16% of the osseous tech assemblage. Similarly, walrus accounts for a mere 1% of the traditional fauna and yet 43% of the osseous technology is attributed to walrus. Nevertheless, there is a general correspondence between the MNI estimates calculated for caribou and walrus between the traditional faunal assemblage and the specimens within the osseous technology assemblage. This is likely a result of the inability to accurately calculate MNI from these small, heavily modified debris. MNI calculations rely on counting overlapping anatomical portions, or body parts which only occur once per individual. Due to the nature of the debris, many could not be identified to portion and therefore could not be accounted for in the estimation of MNI.

Table 4.5. The relative abundance (%NISP) reflects the contribution of the species to the total assemblage. The minimum number of individuals (MNI) for caribou and walrus is calculated from specimens within each assemblage and compared.

	Traditional Fauna		**Osseous Technology**	
	%NISP	MNI	%NISP	MNI
Caribou	1%	7	16%	6
Walrus	1%	6	43%	5

Fragment Size Categories

Each specimen was assigned to a size class based on the maximum size of the specimen.

Figure 4.10 illustrates the distribution of size classes of all aggregated materials for each cultural context, while **Figure 4.11** illustrates the distribution of fragment size by both material type and cultural affiliation.

Antler and ivory are represented in nearly all size categories for many of the contexts. Yet, antler and ivory are the only materials represented in size category 1. Perhaps these materials were subjected to very fine, detailed working more frequently than other raw materials at Iita. By comparison, bone specimens are typically in size categories 3 and 4. It is not surprising to have recovered typically larger fragments of bone when you consider that 59% of all modified bone is cetacean in origin (n=83). Although these specimens tend to be larger, they are still highly modified and heavily reduced when you consider that these were much larger fragments of raw material to work with compared to other available species.

Table 4.6. Number of caribou antler specimens identified to portion for each cultural context. The majority (59%) of specimens were identified to a distinct portion of the antler rack.

	Late Dorset	Mixed LD-Inuit	Early Inuit	Middle Inuit	Late Inuit-Inughuit	Inughuit	Euroamerican	N
Beam	9	5	1	9	12	18	1	**55**
Beam + bez	-	-	-	1	-	-	1	**2**
Bez or shovel	-	1	-	-	-	-	-	**1**
Coronet	1	-	-	-	-	1	-	**2**
Coronet + beam	-	-	-	-	-	1	-	**1**
Coronet + main beam + bez	-	-	-	-	1	-	-	**1**
Coronet, brow tine + beam	1	-	-	-	-	1	-	**2**
Tine	-	-	-	-	3	7	-	**10**
Tine + beam	-	-	1	-	1	2	-	**4**
Unidentified	7	6	2	7	12	20	-	**54**
Total	**18**	**12**	**4**	**17**	**29**	**50**	**2**	**132**

Table 4.7. Number of bone specimens identified to a specific portion. No bone specimens were identified in the Euroamerican sample. Specimens marked with (*) are identified to species/taxon without identification of the element or portion as these specimens were identified to taxon via ZooMS.

	Late Dorset	Mixed LD-Inuit	Early Inuit	Middle Inuit	Late Inuit-Inughuit	Inughuit	N
Murre (*Uria* sp.)							
Humerus, dist shaft						1	**1**
Hare (*Lepus* sp.)							
Unidentified*				1			**1**
Walrus							
Cranium, maxilla				1	1	8	**10**
Cranium, unidentified						**2**	**2**
Rib, midshaft			1		2	2	**5**
Fibula, dist + 3/4 shaft						1	**1**
Mandible, body					1		**1**
Baculum midshaft						1	**1**
Rib, head + neck						1	**1**

Unidentified					6	7	**13**
Bearded seal							
Radius, dist epiphysis						1	**1**
Rib, midshaft						1	**1**
Unidentified*						1	**1**
Pinniped (large seal or walrus)							
Rib, midshaft						2	**2**
Caribou							
Metatarsal, midshaft		1					**1**
Unidentified*				1	1	1	**3**
Muskox (Bovidae)							
Unidentified*				1		2	**3**
large terrestrial mammal							
Long bone						1	**1**
Beluga whale							
Unidentified*				1			**1**
Narwhal							
Cranium (maxilla?)		1					**1**
Sternum, body					1		**1**
Unidentified*		2				1	**3**
Narwhal/Beluga (Monodontidae)							
Cranium (maxilla?)						1	**1**
Bowhead whale							
Mandible, horizontal ramus				1			**1**
Rib, midshaft				2		2	**4**
Unidentified*		2		6	10	12	**30**
Cetacean							
Mandible				1			**1**
Unidentified		2	2	17	10	10	**41**
Marine Mammal							
Rib, midshaft				1			**1**
Mammal							
Unidentified	1					7	**8**
Total	**1**	**8**	**3**	**33**	**32**	**65**	**142**

Table 4.8. Number of specimens and relative frequency by size within the osseous technology assemblage.

Size Class/Group	**Fragment Size** (Maximum Dimension)	**N**
1	< 1 cm	25
2	1–2 cm	303
3	2–5 cm	346
4	6–10 cm	138
5	>10 cm	56
Total		**868**

Table 4.9. All 142 bone specimens were assigned to one of six weathering stages following Behrensmeyer (1978). Weathering was not recorded for the other material types.

Weathering Stage	**Late Dorset**	**Mixed LD-Inuit**	**Early Inuit**	**Middle Inuit**	**Late Inuit-Inughuit**	**Inughuit**	**N**
0	-	-	-	-	-	2	2
1	-	2	-	3	7	16	28
2	1	6	3	11	15	22	58
3	-	-	-	19	8	25	52
4	-	-	-	-	2	-	2
Total	**1**	**8**	**3**	**33**	**32**	**65**	**142**

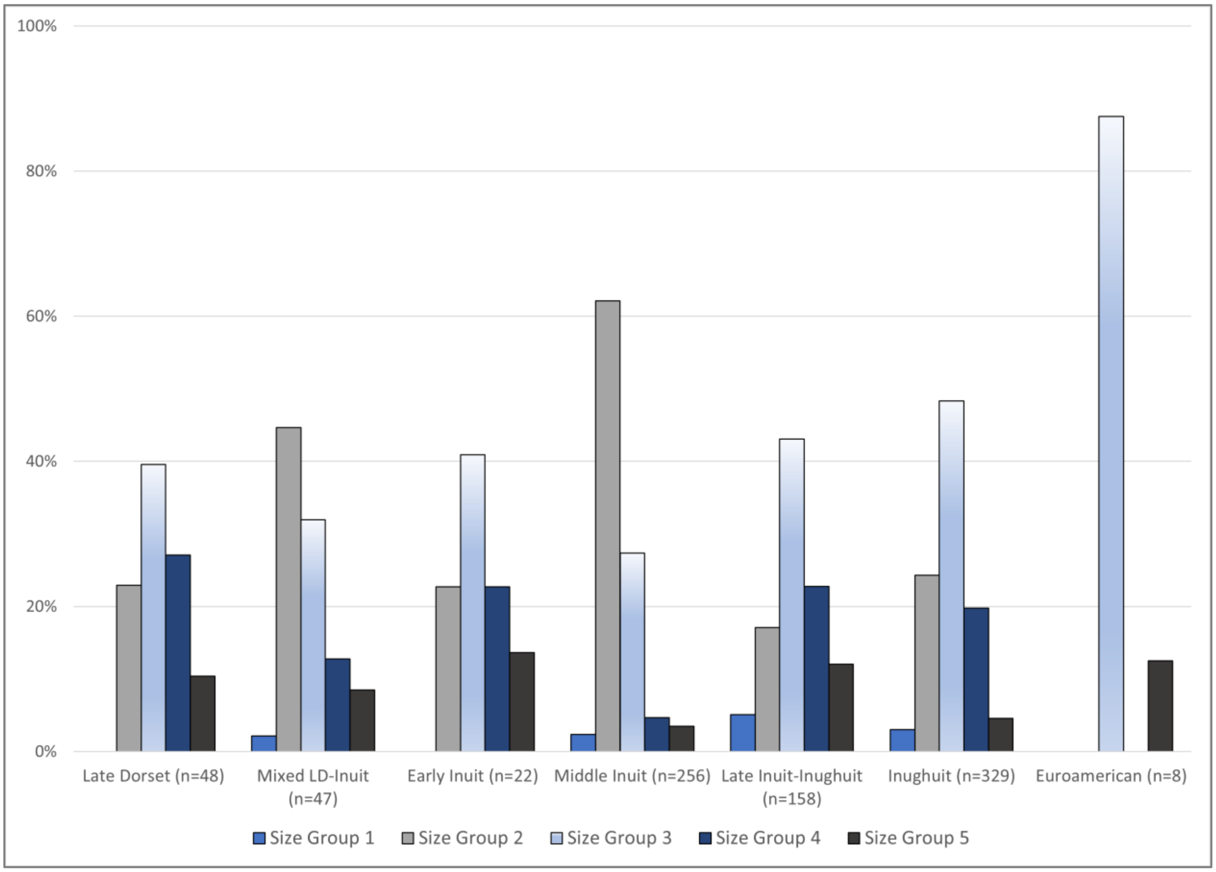
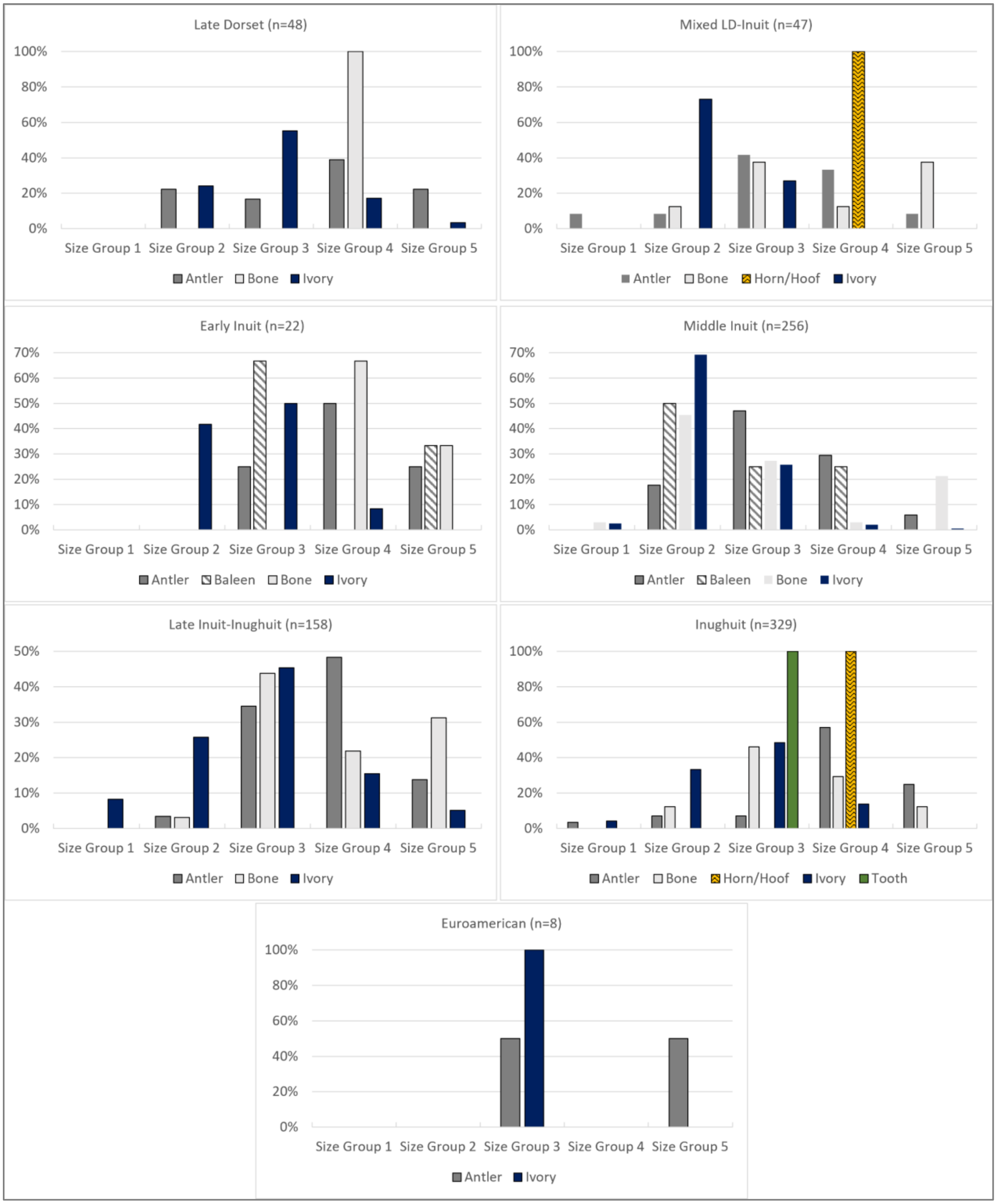


Figure 4.10. Distribution of osseous specimens by size class/group for each cultural affiliation (n=868). Specimens most frequently fall into Size Group 3 (2–5cm max). Note that there are more large-sized specimens (Size Group 4 and 5) within the chronologically later contexts.



Late Dorset (n=48)

Mixed LD-Inuit (n=47)

Early Inuit (n=22)

Middle Inuit (n=256)

Late Inuit-Inughuit (n=158)

Inughuit (n=329)

Euroamerican (n=8)

Figure 4.11. Each chart illustrates the distribution (% frequency) of osseous specimens by size class/group and material type within each archaeological context.

Manufacturing Actions

A total of 764 modification attributes were recorded; 47% (n=359) were observed on ivory, 30% (n=225) on bone, 22% (n=170) on antler, <1% (n=2) on baleen, <1% (n=4) on tooth, and <1% (n=4) on the keratinous horn/hoof specimens. Manufacturing actions on a selection of specimens are illustrated in **Figure 4.12**.

Exactly 50% of the specimens (n=434) had clear evidence of manufacturing actions (i.e., traces of tool marks). The remaining specimens were manufacturing by-products—fragments with morphology consistent with certain manufacturing actions—and therefore did not yield direct tool marks. For example, the action of whittling produces shavings/curls. Therefore, the morphology of these specimens provides insight into what action created the fragment (e.g., whittling).

Chopping

The most frequent processing technique was chopping, representing 40% of all modifications (n=410) and appearing on 19% of the total assemblage (n=868). Chopping was observed on 162 specimens across four material types: antler, bone, ivory, and tooth. Chop marks were observed on specimens in all seven archaeological contexts, yet the materials from the Inughuit (post-1850) context have the highest number of chop marks (50%). The chop-and-snap reduction method was confidently identified on an additional five specimens across three archaeological contexts: one ivory specimen from Late Dorset, one antler from Middle Inuit, and one antler and two bone specimens from Inughuit.

Cutting

A total of 22 slice marks indicating a cutting action were recorded across three material types including antler, bone, and ivory and in four archaeological contexts Mixed, Middle Inuit, Late Inuit-Inughuit, and Inughuit. Saw marks were slightly more abundant (n=28). However, they were only observed in the three chronologically later contexts. For instance, specimens of ivory, antler, and bone were sawn in the Late Inuit-Inughuit context, while saw marks were only observed on ivory specimens within Inughuit and Euroamerican contexts.

Grooving

Grooves were observed on a total of 21 specimens including antler, bone, and ivory. Grooving was observed in all archaeological contexts excluding the Euroamerican sample. Ten specimens were grooved and snapped, again observed across all samples except for Euroamerican. Grooving and grooving and snapping is recognized as one of the main reduction methods observed in many assemblages across the Arctic, including pre-Inuit and Inuit contexts. It is possible that other implements such as metal saws were used in the Euroamerican period, which could reduce the frequency of grooving.

Whittling

A total of 45 specimens bore direct evidence of shaping by whittling. Whittled skeletal materials include antler, bone, ivory, and tooth. The only archaeological context in which direct whittling was not observed was in the Mixed Late Dorset-Inuit sample. In contrast, the context with the most observed whittled specimens was the Inughuit.

Evidence of whittling is more prevalent if you also consider the by-products of whittling such as shavings and curls. These debris do not necessarily bear direct traces of whittling, such as the broad flat channels associated with the removal of material, but instead are the outcome of such action. For example, their curled morphology is easily recognized and often described as curls or shavings. We identified 131 of these products of whittling (**Table 4.11**). Shavings of narwhal ivory are the most frequent, although there are a small number of specimens of antler, bone, and walrus ivory. Seventy-nine percent of all shavings are found in the Middle Inuit context (n=103) while shavings were absent from Early Inuit and Euroamerican contexts.

Perforations

A total of 138 perforations were recorded across five material types including antler, bone, horn/hoof, ivory, and tooth. The material with the most observed perforations is ivory. Most perforated specimens derive from the Inughuit component (57%, n=78). Nearly all perforations were drilled (99%, n=136) except for two antler specimens with gouged holes from the Late Dorset context.

Of the 136 drilled perforations, 50% (n=68) are incomplete, 25% (n=32) are complete and the remaining 25% of specimens have both complete and incomplete drilled perforations present. Incomplete perforations are observed on all material types more commonly than complete perforations, possibly indicating that these specimens are debris from the drill-and-snap method of reduction. The drill-and-snap reduction method was confidently identified on eight specimens from all contexts excluding Late Dorset and only on material types of antler, bone, and ivory. The material must have multiple, aligned incomplete drill holes along the edge to be considered drilled-and-snapped. Single incomplete drill holes may have failed (broken) by other forces including by accident during use or various post-depositional taphonomic factors.

Other

Infrequent but noteworthy attributes were placed in the category “other” and are briefly described here (**Table 4.15**). Unknown organic fibers were present on a single Inughuit antler specimen. Further microscopic or proteomic investigation is needed to confirm the fibrous material. One Inughuit walrus ivory specimen was inset with a 2x3 mm peg of wood. Impact depressions were identified on a total of three specimens: 1) one bone specimen from the Middle Inuit context, and 2) two ivory specimens, one each from Middle Inuit and Inughuit contexts. Root etching was identified on a single Inughuit walrus ivory specimen.

Abrasion, with and without polish, was identified on antler (n=23), bone (n=29), and ivory (n=26) specimens in relatively equal proportions. Interestingly, 53% (n=42) of observations are found on specimens from Inughuit contexts.

Red discoloration was noted on a single specimen of walrus ivory from the Inughuit context. The origin of the red pigmentation is unknown at this time, but we speculate that this could be the result of contact with iron-rich metals in the form of tools or unprocessed fragments of meteoritic iron (Buchwald 1985) or perhaps red ochre (Taçon 1983). Five specimens with black discoloration were noted. Two of these are bone from Middle Inuit contexts, two are bone from the Late Inuit-Inughuit context, and one is an ivory specimen from the Late Dorset context. This discoloration is presumably carbonization from burning. However, it is also possible that this is lamp oil, darkly pigmented with soot, that was applied to the object prior to fragmentation. Sooty lamp oil was applied to the incised reliefs of various archaeological and ethnographic pieces and continues to be used by contemporary Inuit carvers as an artistic way to add contrast and shading (Kaalund 1979).

Figure 4.12. Examples of manufacturing actions on materials from Iita. (a) Drilled whale bone, KNK 3930x45; (b) drilled and grooved antler tine, KNK 3930x2535; (c) drilled whalebone with enlargement/shaping of perforation by whittling, KNK 3930x2690; and (d) whittled and chopped bone, KNK 3930x2820.

Table 4.10. Number of specimens (N) with traces of manufacturing actions tabulated by material type.

		Late Dorset	**Mixed LD-Inuit**	**Early Inuit**	**Middle Inuit**	**Late Inuit-Inughuit**	**Inughuit**	**Euroamerican**	**N**
Antler	Whittled	1	0	1	1	3	6	1	13
	Chopped	2	2	2	4	9	11	1	31
	Grooved	2	0	1	2	1	0	0	6
	Drilled and snapped	0	0	1	0	1	0	0	2
	Grooved and snapped	0	1	1	1	1	1	0	5
	Chopped and snapped	0	0	0	1	0	1	0	2
	Sliced	0	0	0	2	1	4	0	7
	Sawn	0	0	0	0	0	7	0	7
	Unidentified shaping	5	3	0	5	5	9	0	27
	Total	**10**	**6**	**6**	**16**	**21**	**39**	**2**	**100**
Baleen	Shaped	0	0	2	0	0	0	0	2
	Total	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**2**
Bone	Whittled	0	0	0	1	2	5	0	8
	Chopped	0	0	0	8	19	34	0	61
	Grooved	0	1	0	0	0	0	0	1
	Drilled and snapped	0	0	0	1	0	2	0	3
	Chopped and snapped	0	0	0	0	0	2	0	2
	Sliced	0	1	0	3	0	4	0	8
	Sawn	0	0	0	0	0	1	0	1
	Unidentified shaping	0	2	2	4	6	14	0	28
	Total	**0**	**4**	**2**	**17**	**27**	**62**	**0**	**112**
Horn/ hoof	Drilled	0	1	0	0	0	0	0	1
	unidentified shaping	0	1	0	0	0	0	0	1
	Total	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**2**
Ivory	Whittled	1	0	0	1	6	16	0	24
	Chopped	6	2	2	9	13	36	1	69
	Grooved	0	0	0	3	3	7	0	13

	Drilled and snapped	0	0	0	0	2	1	0	3
	Grooved and snapped	1	0	0	0	1	3	0	5
	Chopped and snapped	1	0	0	0	0	0	0	1
	Sliced	0	1	0	1	2	3	0	7
	Sawn	0	0	0	0	5	12	3	20
	Unidentified shaping	3	1	0	11	5	19	1	40
	Total	**12**	**4**	**2**	**25**	**37**	**97**	**5**	**182**
Tooth	Whittled	0	0	0	0	0	1	0	1
	Chopped	0	0	0	0	0	1	0	1
	Total	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**2**

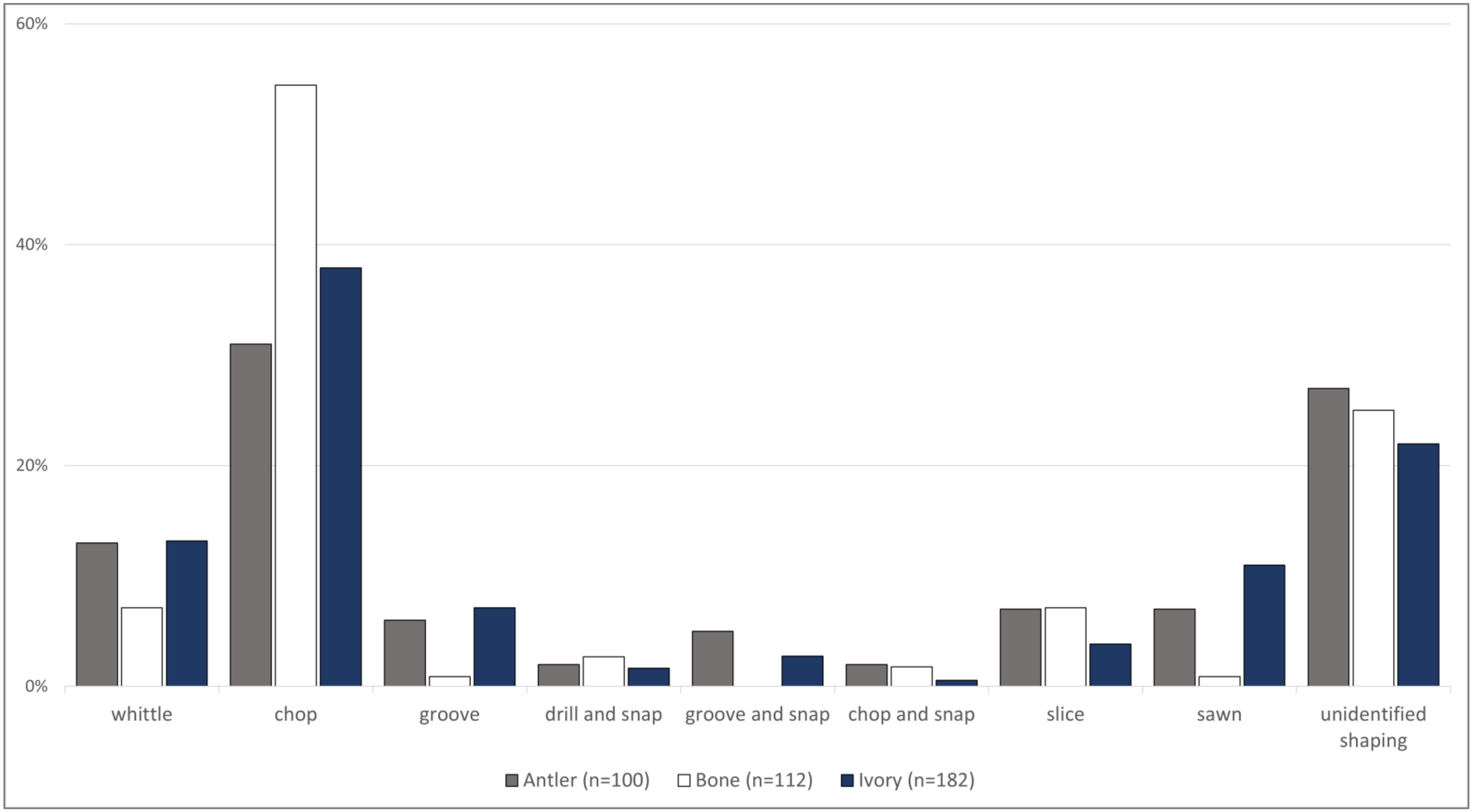


Figure 4.13. Frequency of the most common manufacturing techniques by material type for all contexts (n=400). Baleen, horn/hoof, and tooth not plotted due to small sample size (see **Table 4.10**). Considering the total assemblage, chopping is the most frequently identified manufacturing action.

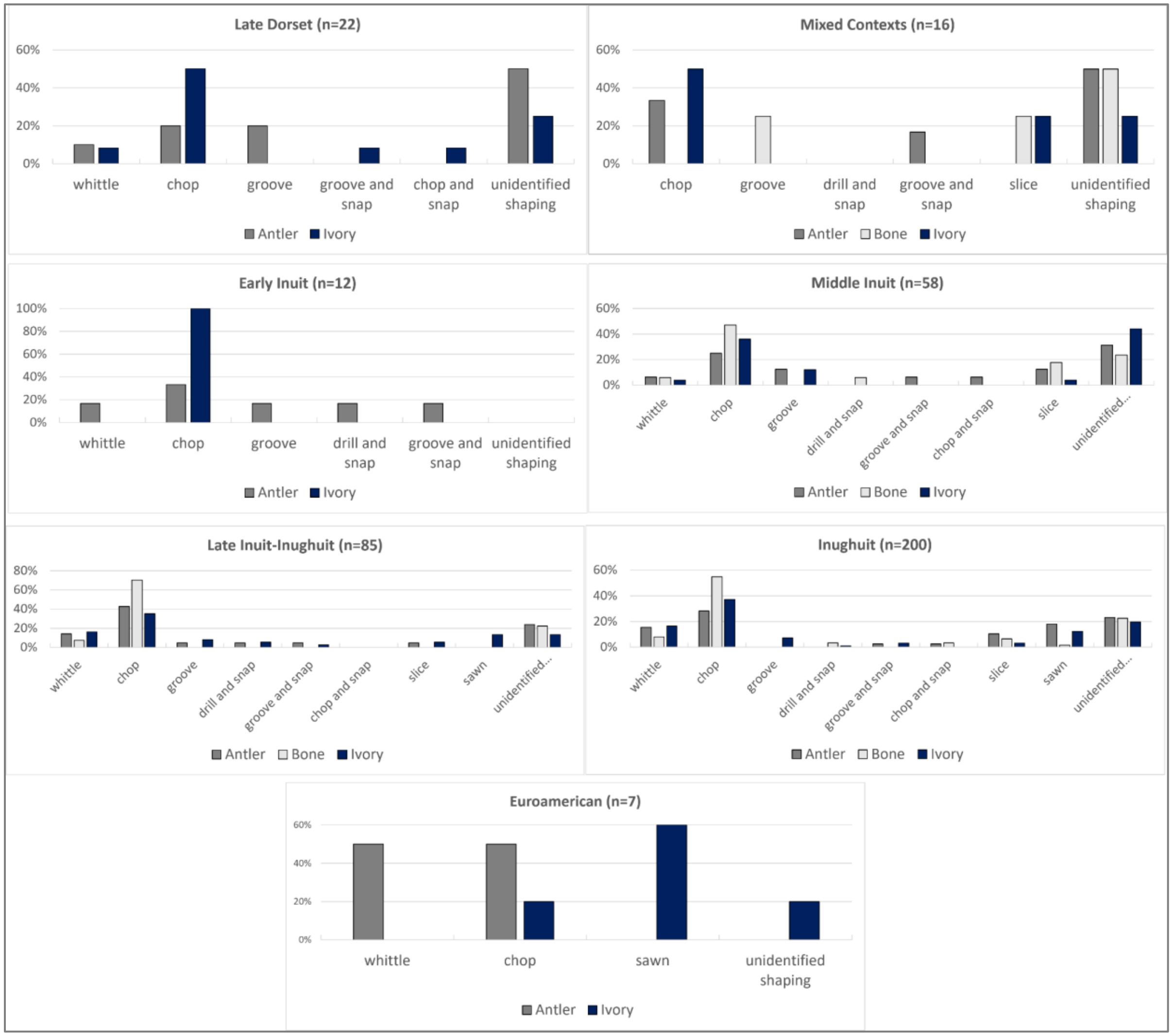


Figure 4.14. Frequency of specimens with manufacturing actions by material type and by temporal period/cultural context. Baleen, horn/hoof, and tooth not included here because of small sample size (see **Table 4.10**).

Table 4.11. Minimum number of whittling by-products such as shavings and curls. These by-products are predominately represented by narwhal ivory. These whittling debris is concentrated in the Middle Inuit contexts and absent in the Early Inuit and Euroamerican contexts.

	Late Dorset	**Mixed LD-Inuit**	**Middle Inuit**	**Late Inuit-Inughuit**	**Inughuit**	**N**
Antler	3	5	2	7	4	21
Bone	0	0	1	0	1	2
Narwhal ivory	1	2	100	2	0	105
Walrus ivory	1	0	0	0	2	3
Total	**5**	**7**	**103**	**9**	**7**	**131**

Table 4.12. Number of specimens (N) with perforations tabulated by the three perforation techniques identified within the osseous technology assemblage.

		Late Dorset	**Mixed LD-Inuit**	**Early Inuit**	**Middle Inuit**	**Late Inuit-Inughuit**	**Inughuit**	**Euroamerican**	**N**
Antler	Drilled	0	1	3	2	2	9	0	17
	Drilled and whittled	0	0	0	1	0	1	1	3
	Gouged	2	0	0	0	0	0	0	2
	Total	**2**	**1**	**3**	**3**	**2**	**10**	**1**	**22**
Bone	Drilled	0	1	2	2	15	19	0	39
	Drilled and whittled	0	0	0	0	0	2	0	2
	Total	**0**	**1**	**2**	**2**	**15**	**21**	**0**	**41**
Horn/hoof	Drilled	0	0	0	0	0	1	0	1
	Total	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
Ivory	Drilled	0	1	0	8	16	45	1	71
	Drilled and whittled	0	1	0	0	0	1	0	2
	Total	**0**	**2**	**0**	**8**	**16**	**46**	**1**	**73**
Tooth	Drilled	0	0	0	0	0	1	0	1
	Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**

Table 4.13. Completeness of drilled holes. Number of specimens (N) with complete, incomplete, or a combination of drilled perforations.

		Late Dorset	**Mixed LD-Inuit**	**Early Inuit**	**Middle Inuit**	**Late Inuit-Inughuit**	**Inughuit**	**Euroamerican**	**N**
Antler	Complete	0	0	1	0	1	3	0	5
	Incomplete	0	0	1	2	3	3	1	10
	Both	0	1	1	1	3	3	0	9
	Total	**0**	**1**	**3**	**3**	**7**	**9**	**1**	**24**
Bone	Complete	0	0	0	1	2	6	0	9
	Incomplete	0	1	1	1	9	10	0	22
	Both	0	1	1	0	2	3	0	7
	Total	**0**	**2**	**2**	**2**	**13**	**19**	**0**	**38**
Horn/hoof	Incomplete	0	0	0	0	0	1	0	1
	Total	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
Ivory	Complete	0	0	0	2	4	11	0	17
	Incomplete	0	1	0	4	8	21	1	35
	Both	0	0	0	2	4	14	0	20
	Total	**0**	**1**	**0**	**8**	**16**	**46**	**1**	**72**
Tooth	Complete	0	0	0	0	0	1	0	1
	Total	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**

Table 4.14. Types of wear present on various osseous materials. Number of specimens (N) with observed wear are tabulated.

		Late Dorset	Mixed LD-Inuit	Early Inuit	Middle Inuit	Late Inuit-Inughuit	Inughuit	Euroamerican	N
Antler	Abrasion	2	0	1	2	2	9	0	16
	Polish	0	0	1	0	1	5	0	7
	Total	**2**	**0**	**2**	**2**	**3**	**14**	**0**	**23**
Bone	Abrasion	0	2	1	2	4	6	0	14
	Abrasion with polish	0	0	0	1	0	0	0	1
	Polish	0	1	0	4	2	6	0	13
	Total	**0**	**3**	**1**	**7**	**6**	**12**	**0**	**29**
Ivory	Abrasion	2	0	0	0	5	9	0	16
	Abrasion with polish	0	0	0	0	1	2	0	3
	Polish	1	0	0	0	1	5	0	7
	Total	**3**	**0**	**0**	**0**	**7**	**16**	**0**	**26**

Table 4.15. Number of specimens (N) with various “other” taphonomic attributes.

		Late Dorset	Mixed LD-Inuit	Early Inuit	Middle Inuit	Late Inuit-Inughuit	Inughuit	Euroamerican	N
Antler	Unknown fibers present	0	0	0	0	0	1	0	1
	Total	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
Bone	Discolored black, burned	0	0	0	2	2	0	0	4
	Impact depression	0	0	0	1	0	0	0	1
	Total	**0**	**0**	**0**	**3**	**2**	**0**	**0**	**5**
Ivory	Discolored black, burned	1	0	0	0	0	0	0	1
	Discolored red	0	0	0	0	0	1	0	1
	Impact depression	0	0	0	1	0	1	0	2
	Inset present	0	0	0	0	0	1	0	1
	Root etching evident	0	0	0	0	0	1	0	1
	Total	**1**	**0**	**0**	**1**	**0**	**4**	**0**	**6**

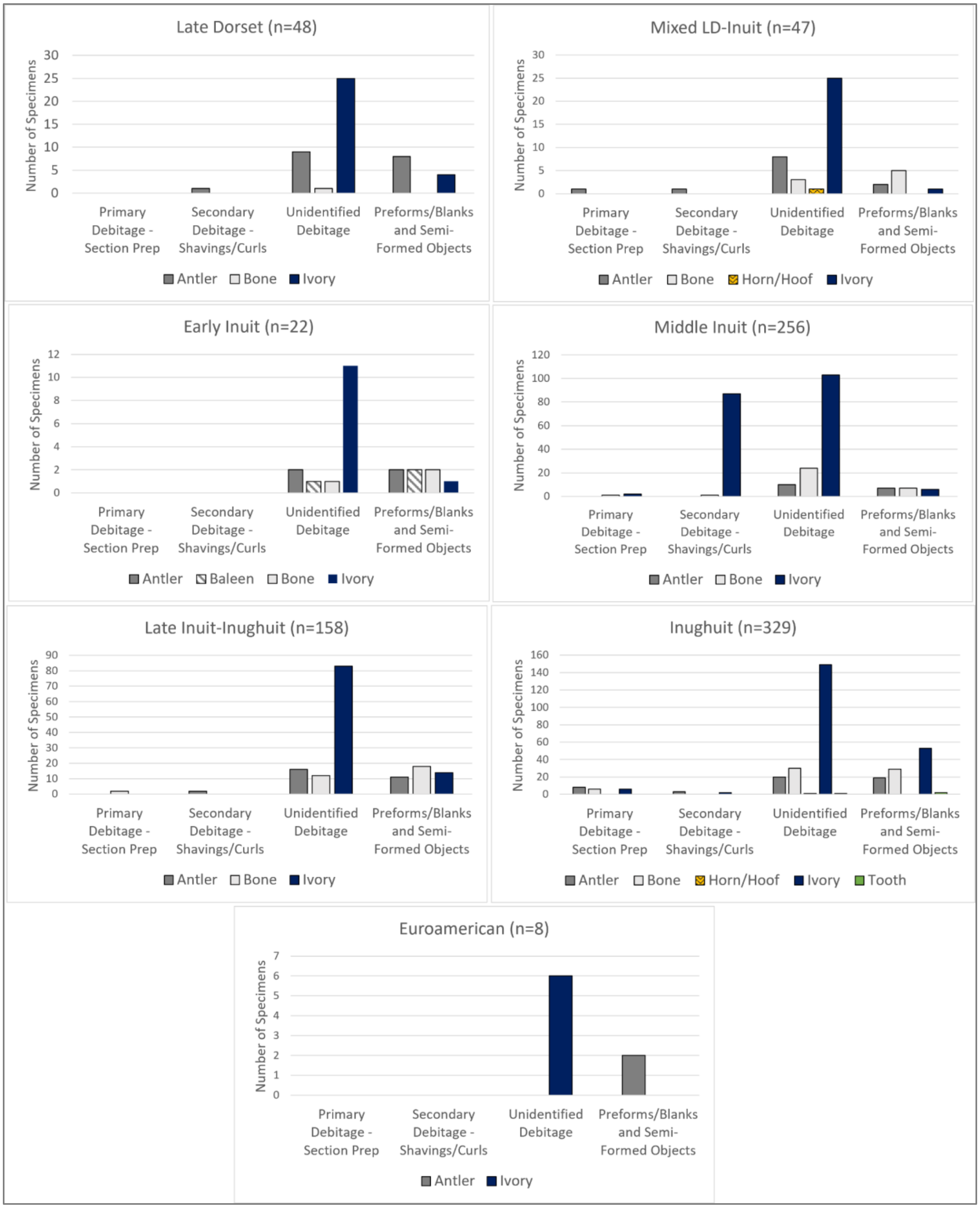


Figure 4.15. Specimens were assigned to one of four possible reduction type categories. Each chart demonstrates the number of osseous specimens within each category as well as the variation in material type.

Discussion

The various species accessed by the occupants of Iita served as both an important source of food and as a source of raw materials for everyday objects and tools, particularly as other resources like wood were limited. Overall, our analysis of the osseous tool debris from Iita reflects differences in the types of raw materials used and the way in which tools were manufactured between the Late Dorset and Inuit assemblages.

Material types

In the Eastern Arctic of North America, LeMoine (2005) was an early proponent of examining differential raw material use across Late Dorset osseous technological assemblages. After analyzing formed osseous artifacts from three Canadian High Arctic sites, LeMoine (2005) concluded that Late Dorset seemed to prefer antler and ivory over other skeletal materials in general, and that specific materials appeared to be selected for certain artifact types. For example, various utilitarian items like handles, sockets, boxes, and Dorset "Type-G" sealing harpoon heads are more frequently made of antler. In contrast, items such as sled shoes, carvings, spatulas, and "Type-E" walrus hunting harpoons are more frequently made of walrus ivory. Lastly, needles seem to be made from bone. Although the species was not confirmed for many of these small bone needles, LeMoine (2005) speculates that they are likely bird bone.

The current analysis of debris from osseous tool manufacture offers an additional way to test the hypothesis of Late Dorset material use and preference. We found that the debris associated with Late Dorset does support this original hypothesis. For preferences related to the raw material's mechanical or aesthetic properties, Late Dorset seem to use caribou antler and walrus ivory for the majority of their toolkit (LeMoine 2005) and this is reflected in the manufacturing waste debris recovered at Iita.

In contrast, the various Inuit contexts are typically more diverse in raw materials. Not only are materials like baleen, tooth, and horn/hoof associated with Inuit contexts, but bone also constitutes a larger proportion of the Inuit osseous assemblages than Late Dorset. This variation could result from a difference in raw material preference between the two cultural groups. However, the composition of osseous technology assemblages is also affected by the availability and distribution of raw material sources, foraging strategies, and limitations on resource access in the form of hunting technology. For example, Inuit groups had increased access to cetaceans through active hunting compared to the Late Dorset who are thought to have only had occasional access to small whales and/or beach-carcass scavenging (Savelle 1994). A wider variation in material types within Inuit contexts is not atypical and appears to be reflected in previous studies on Inuit bone technology. For example, an analysis by Houmard and Grønnow (2017) reports that whale bone, walrus ivory, and caribou antler dominate the assemblage but there are also items of caribou bone, fox tooth, walrus baculum, muskox horn. Of the 142 modified bone specimens in this study, 59% are cetacean and are present across every Inuit context at Iita (**Figure 4.9**). In general, bone from various taxa, both small and large bodied, terrestrial and marine, are found in Inuit contexts much more frequently than in Late Dorset contexts.

Manufacturing actions

For many objects of bone, antler, and ivory made by Pre-Inuit Dorset and Inuit from sites across the Arctic, grooving appears to be the most well documented manufacturing action used to section raw materials into smaller units while whittling characterizes the further shaping of the objects (Houmard et al. 2019; Houmard and Grønnow 2017; LeMoine and Darwent 1998; Nagy 1988; Wells 2012).

In the Iita assemblage, the manufacturing action most frequently identified on nearly all material types and across all archaeological contexts is chopping. Materials from both the Late Dorset and Inuit contexts are chopped in similar frequencies. Chopping represents 40% of all modifications (n=410) and appears on 19% of the total assemblage (n=868). Although the assemblage is dominated by ivory, bone is the material with the most observations of isolated chops (54%), while chopping accompanied by snapping was observed on 2% of both bone and antler specimens. Ultimately this suggests that bone and antler were chopped for initial reduction, producing smaller units of workable material.

The next most frequently observed manufacturing action is whittling. Again, materials from both the Late Dorset and Inuit contexts are whittled in similar frequencies (except for the Euroamerican context, which is likely an effect of small sample size). Ivory and antler are both whittled at the same relative frequency of 13%. Specimens of bone and tooth are also whittled but much less frequently. Ivory and antler tend to be more amenable to whittling due to their high collagen content, which allows toolmakers to remove material without splintering the core of material.

Although grooving and grooving-and-snapping are observed on various materials in nearly all contexts at Iita, it is less frequent than other reduction methods. This may be due to the larger quantity of worked bone within the assemblage compared to previous studies which tend to focus on antler (Houmard et al. 2019; Nagy 1988). For example, bone, particularly whale bone, tends to be large and dense and chopping may be a more efficient method of reduction (Betts 2007).

Reduction types

The use of certain raw materials, such as walrus ivory and caribou antler, by Pre-Inuit Dorset groups has been described as efficient, in that the maximum amount of material will be utilized while producing the least amount of waste or unusable material. For example, with little waste debris recovered from two walrus ivory working sites on Little Cornwallis Island of the Canadian Arctic, LeMoine and Darwent (1998) concluded that walrus ivory was highly prized by the Late Dorset with the material being reused rather than wasted. Likewise, an analysis by Wells (2012) of the Middle Dorset osseous technology assemblage from Philips Garden, Newfoundland, suggested that sections of unmodified caribou antler are rare. With a paucity of waste debris from shaping, Wells (2012) suggests that antler sections were likely prepared elsewhere, and antler was brought to the site as preforms that required little shaping. Additionally, Wells (2012) reported that only small cores of walrus ivory, typically of lower quality ivory, were recovered indicating that ivory was also exhausted or used efficiently with little waste. Overall, it seems that little is wasted or discarded by the Dorset which is consistent with our results at Iita. On the other hand, studies on Inuit osseous tool assemblages have large quantities of discarded raw material (Nagy 1988). This may indicate that Inuit preferred certain portions of raw materials over others, creating more waste portions. Either way, it appears that Inuit may have been able to be “less economical” in their raw material use.

Most specimens recovered from the midden deposits at Iita are discarded manufacturing debris unidentified to a specific action or stage in the reduction sequence. In general, the largest meaningful category is composed of semi-formed objects such as blanks and preforms. This is true for all contexts except for Middle Inuit in which secondary debitage in the form of shavings/curls constitute most identified debris (**Figure 4.15**). Whittling of ivory in the Middle Inuit period was clearly an important activity which took place within the site. Future excavations are needed to confirm if this is representative of the entire Middle Inuit context at Iita or if this sample happened to recover a large debris disposal area.

The spectrum of reduction types along with the observed manufacturing actions suggests that all stages of reduction were occurring at Iita, at least on occasion, from preparing raw materials by removing the unwanted portions through to finishing by whittling. Yet, there is an interesting lack of primary debitage in most contexts. For example, primary debitage is absent in the Late Dorset, Early Inuit, and Euroamerican samples. In total, only 9% of all osseous debris were identified as primary debitage (n=77).

Antler is the material most frequently identified as primary debitage. Forty-two percent of all antler specimens derive from the main beam (n=132). This is unsurprising as the main beam provides the largest amount of workable material. Still, portions such as tines and palms were removed from the main beam and discarded. These discarded portions indicate primary reduction during the phase of reducing antler beams into smaller units. It is interesting that these discarded and un-worked portions are rare in chronologically earlier contexts but are more frequent in Late Inuit and Inughuit contexts. Several related hypotheses may explain this: (a) as suggested by others (LeMoine and Darwent 1998; Wells 2012), the earlier inhabitants are exhausting all available antler, essentially reducing the archaeologist’s ability to recover and identify those antler portions, (b) earlier occupants are removing tines and palms in a way that does not preserve their distinct morphologies, (c) earlier inhabitants are not accessing these portions of antler, instead they are only accessing the main beam, perhaps through the large, established trade networks throughout the High Arctic, (d) the later groups of Inuit-Inughuit may be discarding more unworked antler tines, or (e) the midden samples used in this study are not representative of the full Late Dorset reduction sequence. It is true that the Late Dorset materials were recovered under certain constraints inherent to a salvage archaeological excavation (see Darwent et al. 2019). Equally, perhaps the Late Dorset were discarding debris elsewhere within the vicinity of Iita or at a different location altogether (LeMoine 2001). It is likely that all these suggestions have some merit, but future investigations are needed.

The remaining primary debris pieces are associated with the removal of tusks from the maxillary bone of walrus. These are represented by maxillary bone fragments and walrus ivory fragments from the portion where the tusk exits the alveolar socket (LeMoine and Darwent 1998). Interestingly, this primary debitage is only associated with Middle Inuit, Late Inuit, and Inughuit contexts and only in relatively small quantities. The rare occurrence of the less desirable portions of ivory may indicate that most walrus tusks were being brought to Iita after initial processing, likely near where the animals were dispatched.

Conclusions

Osseous tools were essential to everyday life in the Arctic. Describing the types of raw materials used and how these materials were subsequently reduced or made into tools can provide information on the various decisions people made regarding use of animal resources. This is of particular importance in marginal environments such as the High Arctic where animal skeletal tissues were the primary source of raw material and plant materials (e.g., wood) are scarce.

This study presented a detailed description of osseous debitage from the Late Dorset and Inuit deposits at Iita. This site is one of only a few locations in the High Arctic with intact stratified deposits spanning multiple cultural occupations, providing us an opportunity to explore changes in resource use and tool manufacture over its nearly 1000 years of human occupation. We examined more than 860 pieces of osseous debitage produced during tool manufacture and found distinctions regarding material type and reduction methods between the Late Dorset and Inuit. Most Late Dorset osseous tools are made of antler and ivory, while Inuit are much more varied in their material tool kits, including some types that may have been more difficult to obtain through active hunting for the Late Dorset such as baleen and narwhal ivory. We also found that the chronologically later Inuit components have a higher frequency of waste and discarded portions compared to the earlier components including the Late Dorset. One commonality shared between the two groups was found in the manufacturing actions used to reduce materials. We found that osseous materials from both the late Dorset and Inuit contexts are frequently chopped and whittled and suggest that this may be due to the higher frequency of bone within the Iita assemblage which may require different reduction methods than antler.

Future excavations at Iita may be impractical due to the logistical difficulties stemming from the remoteness of the site and the ever-increasing likelihood of archaeological material loss by coastal erosion. However, additional excavations could increase archaeological sampling of other activity areas which would potentially expand our current understanding of animal resource use at this site. Future investigations of the complete assemblage of osseous technology at Iita will allow for better comparisons to other assemblages from various Arctic localities and could reveal interesting aspects on the composition and function of these Arctic sites.

This research ultimately adds to the current understanding of precolonial lifeways. For example, studying osseous technology provides information on resource procurement strategies and other economic decisions such as the curation or reuse of materials of different foraging societies. Additionally, the study of osseous materials offers a way to understand cultural continuity over time and space and enriches our understanding of how people utilize animals beyond a source of food.

5. Concluding Remarks

Throughout this dissertation, I highlighted the unique setting of Iita, discussed why, and illustrated how faunal remains from this site provide new insight into precolonial subsistence patterns. I approached my study of Arctic subsistence through the analysis of two separate but related faunal components—faunal remains from middens and debris produced during tool manufacture.

Chapter 2 presents an analysis of faunal remains using a traditional zooarchaeological approach. In this section, I focus on primary data obtained from a multi-component faunal assemblage. This chapter represents the first comprehensive investigation into the subsistence practices of Late Dorset at Iita. In addition, this chapter contributes to the understanding of precolonial Inuit subsistence practices in the region. This examination encompasses deposits across the five cultural affiliations including Late Dorset, Mixed Late Dorset-Inuit, Middle Inuit, Late Inuit-Inughuit, and Inughuit. A remarkable feature of the Iita faunal assemblage is its high representation of avian remains, constituting 65% (8,386) of the identified specimens. Among the avian taxa, dovekies emerge as the dominant species in the assemblage. While dovekies are prevalent across all five archaeological contexts, there are noticeable differences in the use of other animal resources at Iita. For instance, the Late Dorset seem to have exploited a more diverse range of resources in relatively equal proportions compared to the Inuit. Our findings demonstrate that despite both foraging groups having access to the same animal resources near Iita, the Late Dorset and Inuit exhibited distinct subsistence practices.

In the Arctic, where vegetation such as wood is scarce, skeletal materials like antler, bone, and ivory played a crucial role in crafting everyday objects. **Chapter 3** delves into the significance of incorporating osseous technology with traditional zooarchaeological analysis when interpreting subsistence practices. Here, I demonstrate the effectiveness of digital microscopy and Zooarchaeology by Mass Spectrometry (ZooMS) in identifying previously unidentified osseous fragments. This research allowed us to test previous hypotheses on the capture of small whales by Inuit (Savelle 1994). Through a combination of ZooMS, faunal analysis and digital microscopy, it became evident that Inuit at Iita relied much more heavily on marine mammals, especially small cetaceans like narwhals, than previously understood.

The analysis of the osseous tool assemblage revealed certain taxa that were not represented in the traditional zooarchaeological analysis from Chapter 2, indicating that previous understandings of foraging practices at Iita were incomplete. I found that the Inuit's prey choice is more diverse than what was initially reported by the analysis presented in Chapter 2. This increase in diversity is primarily due to the identification of three whale species—bowhead, beluga, and narwhal—which were more frequently utilized by Inuit compared to the Late Dorset at Iita. Despite this rise in taxonomic diversity, certain taxa remain preferred over others, suggesting a selective approach to resource use. In contrast, the understanding of Late Dorset animal resource use remains relatively unchanged. Generally, the resources used by the Late Dorset are reflected both in their osseous tools and in the faunal remains left after consumption. Consequently, I argue that consideration of modified osseous materials is crucial for gaining a comprehensive picture, not only of raw material selection for tools, but also of subsistence strategies and overall resource use.

Chapter 4 went beyond examining the species present in the osseous technology assemblage and instead focused on the processing of different raw material types in toolmaking. The chapter delved into the distinct material cultures of the two archaeological foraging groups, the Late Dorset and Inuit, and how their use of specific technologies influenced their selection of raw materials and the way they processed and reduced these materials for tool production. In total, I examined 868 fragments of osseous tool debris and reported patterns in manufacturing techniques and stages of reduction. The majority (75%) of these were small, heavily modified fragments of bone, antler, and ivory between 1–5 cm. Of the bone tool debris, 50% were classified as by-products, such as curls or shavings produced during whittling. Overall, this chapter provided further insight into the selection and reduction of skeletal materials brought to Iita by the two foraging groups.

In summary, this comprehensive analysis of the faunal assemblage has shown that at Iita, Late Dorset seem to be hunting a wide range of animal species, with each type of taxa contributing relatively equally to the overall collection of animal remains and, consequently, their diet. On the other hand, Inuit appear to have relied on a smaller variety of taxa, with specific taxa like dovekies dominating the animal remains recovered from their midden deposits. This pattern is consistent with previous studies comparing the subsistence strategies of these two Arctic foraging cultures (Darwent and Foin 2010; Howse 2019).

However, the distinction between the faunal assemblages of Late Dorset and Inuit components at Iita is not as clear as in other locations. This is partly because settlements in the High Arctic have fewer distinct species available compared to lower latitude sites with slightly higher biodiversity.

In this study of Late Dorset deposits at Iita, I found similarities with other High Arctic locations in Northwest Greenland. Notably, there is a relatively high percentage of avian remains, especially migratory birds, contributing to the identified animal remains, while fish remains are notably absent. These findings align with the zooarchaeological analysis by Darwent and Foin (2010) who studied Late Dorset and Inuit house contexts at Cape Grinnell, Northwest Greenland, although the main difference is that seals play a smaller role in the current faunal assemblage for both Late Dorset and Inuit contexts. Overall, Iita stands out as a unique High Arctic site with a history of human occupation for over a thousand years, driven by the attraction to dovekie rookeries.

Future directions

Unfortunately, future excavations at Iita may be impractical due to the logistical difficulties stemming from the remoteness of the site and the ever-increasing likelihood of archaeological material loss to permafrost degradation and coastal erosion. However, additional excavations have the potential to increase archaeological sampling of other activity areas which would expand our current understanding of animal resource use at this site. Future investigations of the complete assemblage of osseous technology at Iita will allow for better comparisons to other assemblages from various Arctic localities and could reveal interesting aspects on the composition and function of various Arctic sites.

Several bulk soil samples were collected during the 2016 excavations. Preliminary analysis of these bulk samples indicates many small axial elements from dovekies were not recovered in the screened samples. While this is not unexpected, it suggests that the number of dovekies processed and deposited at Iita may be much greater than estimated based on the screened remains. Comparing results of the bulk analyses can potentially improve our understanding of bird abundance but it could also improve our understanding of bird processing. For example, a pattern in the presence (or absence) of axial elements such as vertebrae and phalanges should be explored across samples from various cultural contexts. Differences in skeletal part representation could indicate variations in the techniques of processing of these small but numerous birds. Methods of capture and processing directly determine the efficiency of the animal resource and its rank within the diet breadth. Therefore, any additional insight into the processing and disposal of dovekies could be fruitful.

This study focused on the incomplete or unfinished portions of bone tools including debris produced during their manufacture. Future meta-analysis of the complete bone tool assemblage, including the formed artifacts and carvings can now be undertaken. As with many projects, my research on the osseous technology portion revealed many more interesting questions that were outside the scope of the current project. For example, it is unclear how differences in material properties of narwhal and walrus ivory may have impacted decisions made by toolmakers. This is relevant to other studies of osseous tools since differences in material properties are assumed to influence preferences of the toolmakers.

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Appendix A: Complete Faunal Dataset

Table A1. All faunal materials analyzed in this study arranged by cultural affiliation.

Cultural Affiliation	Unit North	Unit East	Level	Quad	Year Excavated	Faunal Specimen Count	Faunal Weight (grams)	Osseous Technology Specimen Count
Late Dorset	-2	18	5B	NE	2016	72	62.1	-
	-2	18	5C	NE	2016	103	34.7	-
	-2	18	5C	NW	2016	37	31.1	1
	-2	18	5D	NE	2016	6	2.4	-
	-2	18	5D	NW	2016	17	28.0	-
	-2	18	5E	NW	2016	1	40.6	-
	-1	17	4B	NW	2016	13	2.1	-
	-1	17	4B	SW	2016	43	3.8	2
	-1	17	5A	NE	2016	5	1.0	-
	-1	17	5A	NW	2016	16	2.5	-
	-1	17	5A	SE	2016	34	6.8	-
	-1	17	5A	SW	2016	3	0.6	-
	-1	17	5B	NW	2016	2	0.1	-
	-1	17	5B	SE	2016	32	13.3	-
	-1	17	5C	SW	2016	-	-	1
	-1	17	5C-D	SE	2016	4	2.6	-
	-1	17	5D	NE	2016	2	1.0	1
	-1	17	5F	SW	2016	2	0.3	-
	-1	18	4	SE	2012	1	7.3	-
	-1	18	5A	NE	2016	21	45.2	-
	-1	18	5A	NW	2016	9	4.6	-
	-1	18	5A	SW	2016	66	55.2	2
	-1	18	5A	N/A	2016	5	0.6	-
	-1	18	5B	NE	2016	9	17.0	-
	-1	18	5B	NW	2016	8	10.2	-
	-1	18	5B	SW	2016	32	6.7	2
	-1	18	5C	NE	2016	8	4.1	1
	-1	18	5C	SW	2016	6	2.3	3
	-1	18	5D	NE	2016	14	22.1	-
	-1	18	5E	SE	2016	5	10.1	-
	-1	18	5E-F	NE	2016	10	7.1	-
	-1	18	5E-F	SW	2016	7	7.3	-
	-1	18	6	SE	2012	1	13.5	-
	-1	19	5	NW	2016	6	0.2	-
	-1	19	5A	NW	2016	8	2.2	-
	-1	19	5A	SW	2016	23	16.4	-
	-1	19	5D	NE	2016	27	10.7	-
	-1	19	5D	NW	2016	32	22.1	-
	-1	19	5D	SE	2016	16	1.5	-
	-1	19	5D-E	SW	2016	34	24.1	-
	-1	19	5E	NE	2016	5	0.6	-
	-1	19	5E	NW	2016	12	2.7	-
	-1	19	5E	SE	2016	1	0.3	-

	-1	19	5E	SW	2016	48	17.6	-
	-1	19	Colluvium	NE	2016	8	4.3	-
	-1	19	Colluvium	SW	2016	5	0.9	-
	0	11	8-9	NE	2016	-	-	1
	0	12	4	NE	2016	71	63.6	2
	0	12	4	SE	2016	81	206.6	2
	0	12	4	SW	2016	38	42.6	-
	0	12	4	-	2016	-	-	1
	1	10	7	NE	2016	5	181.2	-
	1	10	8	NE	2016	53	30.2	-
	1	10	8	NW	2016	12	30.1	-
	1	11	7	NE	2016	18	11	2
	1	11	7	NW	2016	6	0.1	-
	1	11	7	SE	2016	9	0.8	-
	1	11	7	SW	2016	7	1.2	1
	1	11	7	-	2016	16	2.7	-
	1	11	8	NE	2016	-	-	1
	1	11	8	NW	2016	85	59.1	-
	1	11	8	SE	2016	12	7.2	-
	1	11	8	SW	2016	26	48.1	1
	1	11	8-9	NE	2016	43	63.3	-
	1	11	9	NW	2016	36	7.7	-
	1	11	9	SE	2016	93	70.0	2
	1	11	9	SW	2016	66	93.0	3
	1	11	10	NW	2016	4	5.4	-
	1	11	10	SE	2016	1	0.1	-
	1	11	10	SW	2016	1	0.1	-
	1	12	4	NW	2016	-	-	2
	1	12	4	SW	2016	-	-	2
	2	6	5	NE	2012	29	46.6	-
	2	6	5	NW	2012	174	150.7	3
	2	6	5	SE	2012	7	6.3	1
	2	6	5	SW	2012	3	0.1	-
	2	6	6	NE	2012	17	13.7	1
	2	6	6	NW	2012	4	11.8	-
	2	6	6	SW	2012	8	4.3	-
	2	7	5	NE	2016	221	604.2	-
	2	7	5	NW	2016	17	9.0	-
	2	7	5	SE	2016	149	111.4	1
	2	7	5	SW	2016	92	64.2	-
	2	7	5B	NE	2016	11	2.9	1
	2	7	5B	SE	2016	16	7.6	1
	2	7	5-7	Cleaning	2016	2	10.3	-
	2	7	6	NE	2016	3	2.4	-
	2	7	6	NW	2016	5	4.1	-
	2	7	7	NE	2016	17	3.1	-
	2	7	7	NW	2016	5	1.1	-
	2	7	7	-	2016	3	0.3	-
	2	7	-	SW	2016	2	0.3	-
	3	7	5B	NE	2016	74	11.5	-
	3	7	5B	SE	2016	-	-	1
	3	7	5B	SW	2016	20	5.0	-

	3	7	6	NE	2016	2	0.1	-
	3	7	6	NW	2016	21	6.3	-
	3	7	6	SE	2016	5	26.1	-
	3	7	6	SW	2016	16	4.5	3
	3	7	7	NE	2016	20	5.1	-
	3	7	7	NW	2016	31	4.7	-
	5	8	5	NW	2016	-	-	1
	5	9	5	NE	2016	142	332.6	1
	5	9	5	NW	2016	14	66.1	1
	5	9	5	SE	2016	4	5.9	-
Mixed Late Dorset – Inuit Context	-2	18	5B	NW	2016	-	-	3
	-1	17	4	NE	2016	-	-	1
	-1	17	4B	NE	2016	-	-	2
	-1	17	4B	NW	2016	-	-	2
	-1	18	4B	NE	2016	171	193.6	1
	-1	18	4B	NW	2016	134	162.1	1
	-1	18	4B	SW	2016	170	55.1	-
	1	11	5	NW	2016	-	-	1
	2	6	4	NE	2012	1018	207.2	15
	2	6	4	NW	2012	301	296	3
	2	6	4	SE	2012	122	148.3	3
	2	6	4	SW	2012	779	120.5	4
	2	6	5	NW	2012	-	-	1
	2	6	6	NW	2012	-	-	1
	2	6	6	SE	2012	11	27.1	-
	3	7	5	NE	2016	-	-	6
	3	7	5	NW	2016	1	0.69	1
	3	7	5	SE	2016	792	261.2	1
	3	7	5B	NW	2016	-	-	1
Early Inuit	0	10	7	SE	2016	-	-	5
	0	10	7	SW	2016	-	-	2
	0	10	8	NE	2016	-	-	1
	0	10	8	SE	2016	-	-	2
	0	10	9	NW	2016	-	-	1
	0	10	9	SE	2016	-	-	1
	0	10	9	SW	2016	-	-	2
	0	10	10	NE	2016	-	-	1
	0	10	10	SE	2016	-	-	4
	0	10	10	SW	2016	-	-	3
Middle Inuit	-2	18	4A	NW	2016	-	-	1
	-2	18	4A	SE	2016	-	-	2
	-2	18	4A	SW	2016	-	-	4
	-2	18	5	SW	2016	-	-	15
	-2	18	5B	SW	2016	-	-	1
	-2	18	5C	SE	2016	-	-	2
	-2	18	5C	SW	2016	-	-	188
	-2	18	5D	SW	2016	-	-	1
	-1	18	4A	NE	2016	10	5.2	-
	-1	18	4A	NW	2016	415	143.0	5
	-1	18	4A	SW	2016	64	59.6	1
	0	10	4	SW	2016	-	-	4

	0	10	5	NE	2016	-	-	1
	0	10	5	NW	2016	-	-	1
	0	10	5	SE	2016	-	-	2
	0	10	6	SW	2016	-	-	4
	0	11	1	E	2016	-	-	1
	0	11	1-2	W	2016	-	-	1
	0	11	5	NW	2016	13	7.4	-
	0	11	5	SW	2016	-	-	1
	0	11	5B	NE	2016	3	0.6	-
	0	11	6	N	2016	3	1.8	-
	0	11	6	NE	2016	1	0.1	-
	0	11	6	SE	2016	3	70.1	-
	1	11	4	NE	2016	38	12.4	-
	1	11	4	NW	2016	7	5.9	-
	1	11	4	SE	2016	37	22.1	1
	1	11	4	SW	2016	70	100.2	-
	1	11	5	NE	2016	42	8.5	-
	1	11	5	NW	2016	38	7.7	1
	1	11	5	SE	2016	18	19.0	-
	1	11	5	SW	2016	47	92.5	1
	1	11	6A	NE	2016	38	18.7	-
	1	11	6A	SE	2016	9	2.5	-
	1	11	6A	SW	2016	30	54.9	-
	1	11	6A	NW	2016	42	63.8	2
	2	6	3	NE	2012	-	-	1
	2	7	4	NE	2016	3	1.06	2
	2	7	4	NW	2016	2	0.66	1
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	2	7	4	SW	2016	-	-	1
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	5	8	4	NW	2012	-	-	1
	10	5	6	SE	2012	-	-	1
	10	6	4	NW	2012	-	-	1
	10	6	4	SE	2012	-	-	1
Late Inuit-Inughuit	-2	18	3	NE	2016	-	-	1
	-2	18	3	SE	2016	-	-	1
	-2	18	3	SW	2016	-	-	6
	-1	17	3	NE	2016	-	-	2
	-1	17	3	NW	2016	-	-	3
	-1	17	3	SE	2016	-	-	5
	-1	17	3	SW	2016	682	533.5	2
	-1	18	3	NE	2016	116	13	1
	-1	18	3	NW	2016	1589	537.2	15
	-1	18	3	SW	2016	1206	426.1	3
	-1	18	3B	NE	2016	2	0.2	-
	0	10	2	NE	2016	-	-	1
	0	10	2	SE	2016	-	-	2
	0	10	3	SE	2016	-	-	1

	0	11	4	NE	2016	-	-	1
	0	11	4	NW	2016	-	-	1
	0	11	4	SW	2016	-	-	1
	0	11	3-4	SW	2016	-	-	1
	0	11	3-5	SW	2016	-	-	1
	1	11	3	Cleanup	2016	25	3.1	-
	1	11	3	NE	2016	107	112.9	3
	1	11	3	NW	2016	113	98.3	3
	1	11	3	SE	2016	254	101.3	5
	1	11	3	SW	2016	29	75.2	-
	1	12	2	SE	2012	-	-	1
	1	12	2	SW	2012	-	-	2
	2	6	3	NE	2012	131	68.7	5
	2	6	3	NW	2012	35	47.1	2
	2	6	3	SE	2012	190	144.7	1
	2	6	3	SW	2012	148	115.5	2
	2	7	3	NE	2016	-	-	10
	2	7	3	NW	2016	-	-	8
	2	7	3	SE	2016	-	-	5
	2	7	3	SW	2016	-	-	2
	2	7	4	NW	2016	1	1.43	-
	3	-6	4	SE	2012	-	-	2
	3	7	3	NE	2016	-	-	10
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	3	7	3	SE	2016	-	-	8
	3	7	3	SW	2016	-	-	9
	3	7	4	NW	2016	2	0.73	-
	3	7	4	SE	2016	-	-	1
	3	7	4	SW	2016	1	0.74	1
	4	9	3	NE	2016	-	-	2
	4	9	3	SE	2016	-	-	1
	4	9	4	SE	2016	-	-	3
	4	9	4	SW	2016	-	-	3
	4	9	4-5	NW	2016	-	-	1
	5	9	3	SE	2016	-	-	1
	5	9	3	SW	2016	-	-	1
Inughuit	-2	18	1	NE	2016	-	-	2
	-2	18	1	NW	2016	-	-	1
	-2	18	1	SE	2016	-	-	3
	-2	18	1	SW	2016	-	-	3
	-2	18	2	E ½	2016	-	-	1
	-2	18	2	E ½	2016	-	-	1
	-2	18	2	NE	2016	-	-	2
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	-2	18	2	-	2016	-	-	5
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	-2	18	2B	SE	2016	-	-	3
	-1	17	1	NE	2016	-	-	4
	-1	17	1	NW	2016	-	-	5
	-1	17	1	SE	2016	-	-	12
	-1	17	1 Extension	SW	2016	-	-	1

	-1	17	2	NE	2016	-	-	12
	-1	17	2	NW	2016	-	-	10
	-1	17	2	SE	2016	-	-	10
	-1	17	2	SW	2016	-	-	7
	-1	17	2B	NW	2016	-	-	1
	-1	17	2B	SE	2016	-	-	2
	-1	17	2B	SW	2016	-	-	5
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	-1	18	2B	SW	2016	67	-	4
	-1	18	2-3	NW	2016	-	-	1
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	-1	19	2	SW	2016	-	-	1
	-1	19	SOD	NE	2016	-	-	2
	-1	19	SOD	NW	2016	-	-	1
	-1	19	SOD	SW	2016	-	-	1
	-1	19	SOD	-	2016	-	-	1
	0	10	SOD	NE	2016	-	-	10
	0	10	SOD	NW	2016	-	-	10
	0	10	SOD	SE	2016	-	-	2
	0	10	SOD	SW	2016	-	-	4
	0	11	SOD	E?	2016	-	-	1
	0	11	SOD	N	2016	-	-	3
	0	11	SOD	S	2016	-	-	3
	0	11	SOD	W	2016	-	-	2
	0	11	SOD	-	2016	-	-	1
	0	10	1	SE	2016	-	-	2
	0	11	1	N	2016	-	-	4
	0	11	1	N?	2016	-	-	1
	0	11	1	-	2016	-	-	2
	0	11	1	E 1/2	2016	-	-	1
	0	11	1-2	W	2016	-	-	1
	0	11	-	-	2016	-	-	2
	0	12	SOD	E	2016	-	-	2
	0	12	SOD	N	2016	-	-	3
	0	12	SOD	S	2016	-	-	1
	0	12	SOD	SE	2016	-	-	2
	0	12	SOD	W	2016	-	-	3
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	1	10	1	SE	2016	-	-	6
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	1	10	2	SW	2016	-	-	1
	1	11	SOD	NE	2016	-	-	1
	1	11	SOD	-	2016	24	1525.7	2
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	1	11	2	SE	2016	77	105.3	-

	1	11	2	SW	2016	13	34.7	1
	1	12	1	SW	2012	-	-	1
	1	19	1	NE	2012	-	-	2
	1	19	2	NE	2012	-	-	1
	2	6	1	NE	2012	35	91.2	-
	2	6	1	SE	2012	39	36.3	3
	2	6	1	SW	2012	41	25.5	-
	2	6	2	NE	2012	285	352.2	11
	2	6	2	NW	2012	56	191.5	5
	2	6	2	SE	2012	509	123.5	2
	2	6	2	SW	2012	47	62.8	-
	2	7	2	NE	2016	-	-	3
	2	7	2	NW	2016	-	-	3
	2	7	2	SE	2016	-	-	3
	2	7	2	SW	2016	-	-	3
	3	-6	2	NE	2012	-	-	2
	3	-6	2	SE	2012	-	-	2
	3	-6	3	NE	2012	-	-	1
	3	2	3	NW	2012	-	-	1
	3	2	3	SE	2012	-	-	13
	3	2	4	SW	2012	-	-	2
	3	2	6	SW	2012	-	-	2
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	3	7	2	NE	2016	-	-	11
	3	7	2	NW	2016	-	-	5
	3	7	2	SE	2016	-	-	4
	3	7	2	SW	2016	-	-	5
	4	9	1	NW	2016	-	-	5
	4	9	1	SE	2016	-	-	2
	4	9	1	SW	2016	-	-	2
	4	9	2	NE	2016	-	-	2
	4	9	2	NW	2016	-	-	1
	4	9	2	SW	2016	-	-	1
	4	9	4-5	SE	2016	-	-	1
	5	8	2	NE	2012	-	-	1
	5	8	3	NW	2012	-	-	1
	5	9	SOD	N/A	2016	-	-	2
	5	9	1	NW	2016	-	-	2
	5	9	1	SE	2016	-	-	2
	5	9	1	SW	2016	-	-	1
	5	9	2	SE	2016	-	-	1
	10	6	1	NW	2012	-	-	1
	10	6	2	NW	2012	-	-	4
	10	6	2	SW	2012	-	-	1
	10	6	3	NE	2012	-	-	4
	10	6	3	SW	2012	-	-	1
Euroamerican	-2	18	1	SW	2016	-	-	1
	-1	17	1	SE	2016	-	-	2
	-1	17	1	SW	2016	-	-	1
	-1	17	2B	SE	2016	-	-	1
	-1	17	SOD	SE	2016	-	-	1
	-1	18	2B	SW	2016	-	-	1

	1	10	1	NW	2016	-	-	1
GRAND TOTAL						**13,043**		**868**

Appendix B: Material Identification Criteria for the Osseous Technology Assemblage

This guide provides examples of the various materials identified within the osseous technology assemblage analyzed for this dissertation (see also **Appendix A**). Traditional zooarchaeological methods were used to identify the modified or worked osseous specimens using the UC Davis Zooarchaeology Lab skeletal comparative collections and various key material guides, particularly Locke (2013) and Baker et al. (2020).

Each specimen (complete skeletal element or fragment thereof (Lyman 2008) was identified to element, portion, and lowest taxonomic level following protocols outlined by Driver (2011). Specimens not identified to genus or lower were assigned to a descriptive taxonomic category based on characteristics such as size, shape, and texture of the specimen. Criteria for these identifications are presented here. A conservative approach was taken, which resulted in a few broad categories such as cetacean, pinniped, marine mammal, and large terrestrial mammal.

It can be difficult to identify the taxa or material of specimens if they are incomplete, modified, or otherwise lacking distinct anatomical features. The osseous materials sampled for this research are specifically debris from reducing the materials into various objects. Due to the nature of reducing osseous materials, many are modified to an extent that few diagnostic features remain, making skeletal portion and species difficult or impossible to ascertain.

The focus of this Appendix is to summarize methods for identifying ivory, bone, and antler. Non-ivory teeth and keratinous materials such as baleen and horn are briefly mentioned. This research focuses on the identification of animal remains from a single High Arctic archaeological site, Iita in Northwest Greenland. Therefore, the materials in this guide are focused on a limited set of Arctic species.

Additionally, the materials are archaeological and therefore are not of museum or collectors' quality such as those often featured in other material identification guides. The criteria herein were used to identify the material type in conjunction with traditional zooarchaeological methods of identification. **Figure B.1** features a decision matrix for identification of the four most common material types and guides the analyst through their unique characteristics. This document provides criteria used to identify various materials with an unassisted eye and using a microscope with 10–100-times magnification. A digital microscope (Dino Lite model #AM73915MZTL) and SLR digital camera (Nikon D5200) were used for photographing the following specimens.

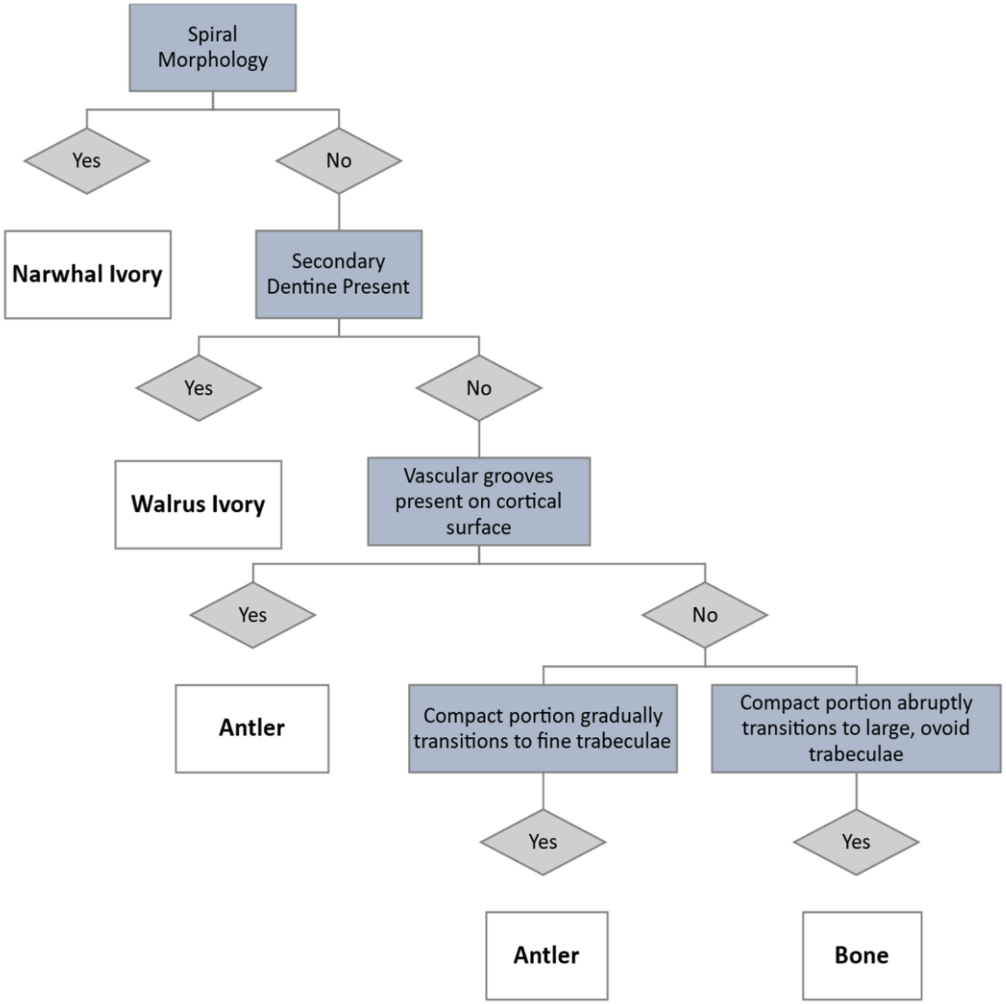

Figure B.1: Decision matrix for identifying the four most frequent osseous tool raw materials recovered from Iita. Modified from the preliminary identification scheme by Baker et al. (2020), CITES *Identification Guide for Ivory and Ivory Substitutes*.

Ivory

Mammal teeth are composed of a crown, the portion extending above the gumline, and the root, the portion within the alveolar bone of the jaws. All have three layers: 1) the outer layer of enamel (covering the crown) or cementum (covering the root), 2) the middle dentine or dentin layer, and 3) the inner pulp cavity with apical foramen, which contains nerves and blood vessels (**Figure B.2**). For many mammals, the apical foramen of the root closes as the animal ages; however, for some the roots do not close and new dental tissues will continue to be added throughout the animal's life. Ivory is used interchangeably with the middle dentin layer. However, the term "ivory" is reserved for enlarged teeth or tusks that typically protrude from the mouth of the animal. Ivory-bearing taxa include elephants, walrus, warthogs, hippopotamus, narwhal, and sperm whale.

These dental tissues are anatomically distinct due to their differing proportions of organic and inorganic components. The following descriptions include approximate proportions of these components following Locke (2013) and Mass (2008). Cementum is a bone-like tissue that helps to anchor the tooth into the alveolar socket and in non-human animals, can extend from the tooth root onto the crown. Cementum is comprised of a mineral component (~65%) of hydroxyapatite and organic component (~20%), which includes cementocytes and collagen fibers. The main component of ivory is dentine, a tissue that is continuously deposited in layers throughout life. The inorganic component consists of hydroxyapatite (~75%) and the organic component of dentine consists mainly of collagen fibrils (~25%). The crown of most mammalian teeth is covered by a cap of enamel. Enamel is the hardest and most mineralized tissue within the body, consisting of 95% hydroxyapatite while the other 5% is water and various proteins. However, enamel is nearly absent in the tusks of narwhal and walrus; it is restricted to the distal tip of their tusks and is often worn away with use during life.

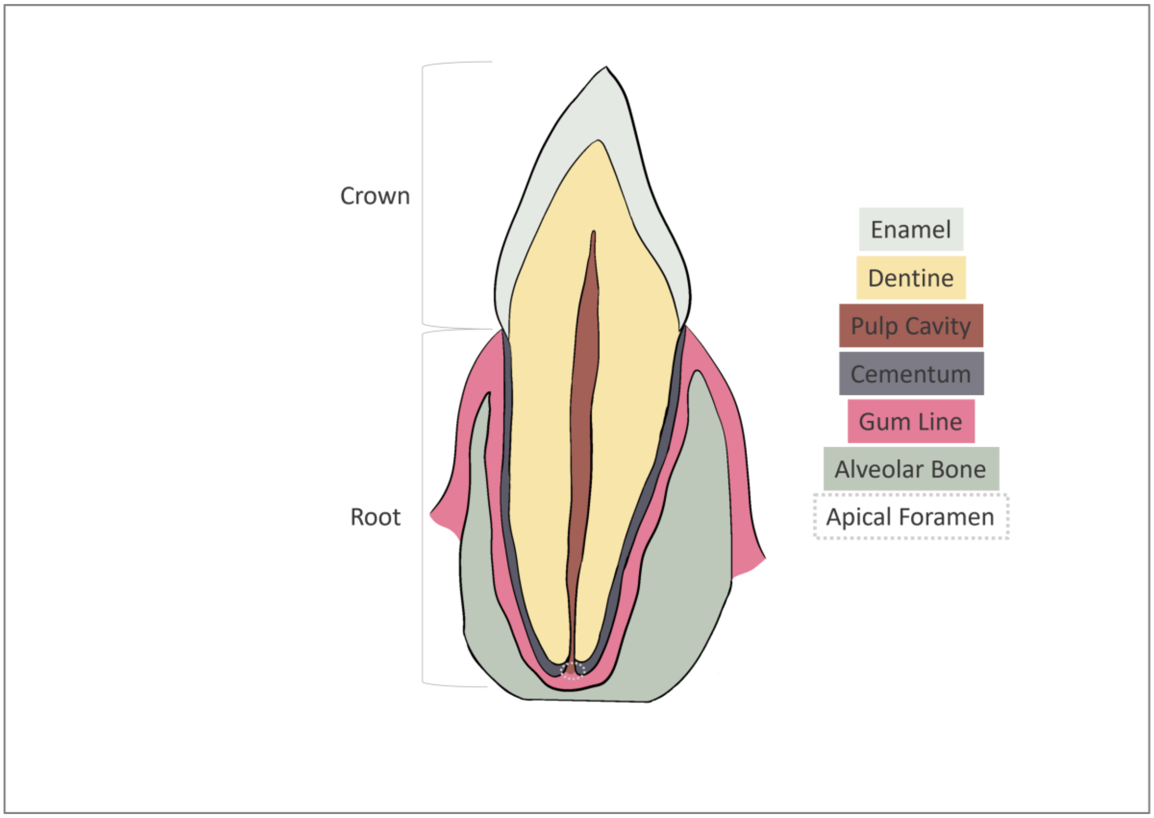

Figure B.2: Simplified cross-section of a typical mammalian canine tooth. The features of the tooth consist of the crown, root, and apical foramen. The various dental tissues that form and anchor the tooth are represented by unique colors. Illustration by

Depending on the size, degree of modification, and overall preservation of the specimen, ivory can be distinguished from bone and antler. Ivory lacks trabeculae as found in spongy portions of bone and antler. However, some fragments of ivory may be too small, degraded, or otherwise undiagnostic. Because the organic component of ivory is mostly proteinaceous collagen, it is an ideal tissue to identify using proteomic analysis such as Peptide Mass Fingerprinting (PMF) when specimens lack identifying features.

Narwhal ivory

Although they are a toothed whale (parvorder Odontoceti), narwhals lack other fully developed teeth, with two vestigial maxillary teeth embedded within the upper jaw. Generally, male narwhals have a single, large upper canine (tusk) which can grow 2–3 meters in length that almost exclusively erupts from the left maxilla (Baker et al. 2020). Interestingly, a narwhal's tusk exits the rostrum, piercing the skin, rather than through their oral cavity or mouth. Females may also develop a tusk, albeit smaller, and males may, on occasion, develop two tusks (Heide-Jørgensen 2008).

The narwhal tusk is distinct from other ivories in that it has a counterclockwise (left) spiral growth pattern. The tusk continues to grow in a relatively straight trajectory, as compared to walrus tusks, which grow with a slight inward or posterior curvature (**Figure B.3**).

Figure B.3: Narwhal and walrus with tusks. Notice the straight trajectory of the narwhal's tusk while the walrus tusks curve slightly inward towards the body. Narwhal image courtesy of Gazprom Neft under the Creative Commons Attribution-Share Alike 4.0 International license. Walrus image is CC0 Public Domain.

The narwhal tusk is essentially a cylindrical tube formed by a relatively thin outer layer of cementum and a thick inner layer of dentine (**Figure B4**). The superficial layer of cementum is characterized by ridges that form the left-handed, counterclockwise spiral morphology. The inner layer of dentin is solid and consistent in appearance.

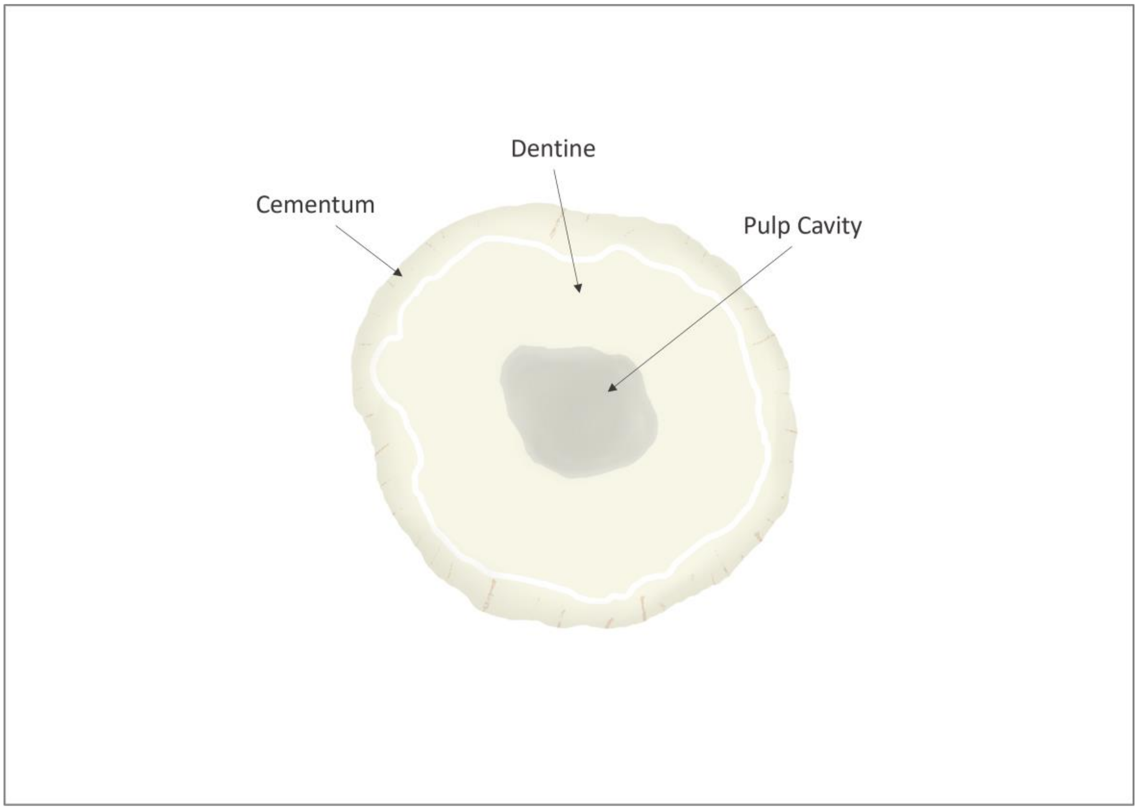

Figure B.4. Transverse cross section of a narwhal tusk. The tusk is composed of two dental tissues, cementum and dentine. The center of a narwhal’s tusk is hollow, containing a pulp tissue throughout life. Illustration by E. Ebel.

Narwhal tusks are hollow except for the solid distal tip (**Figure B.5**). In life, the hollow center is filled with a pulp matrix, a mix of various cells, blood vessels, and nerves (Heide-Jørgensen 2008; Locke 2013). This soft pulp matrix is surrounded by a relatively thin, hardened layer of pulp tissue (Nweeia et al. 2014). Together, the presence of cementum ridges, a left spiral, and pulp cavity are key indicators of narwhal ivory (**Figures 5 and 6**).

Figure B.5. A large, modified fragment of narwhal tusk retaining many of the unique identifying characteristics, specimen KNK 3930x76. (a) **E**xterior surface of tusk—note the spiral morphology of the cementum ridges; b) interior view of sectioned tusk with distinct hollow pulp cavity. Image by E. Ebel.

Figure B.6. Modified narwhal ivory fragment, specimen KNK 3930x69. (a) Exterior surface of the tusk with visible cementum ridges despite modification; (b) interior view of tusk with a small portion of the pulp cavity present. Image by E. Ebel.

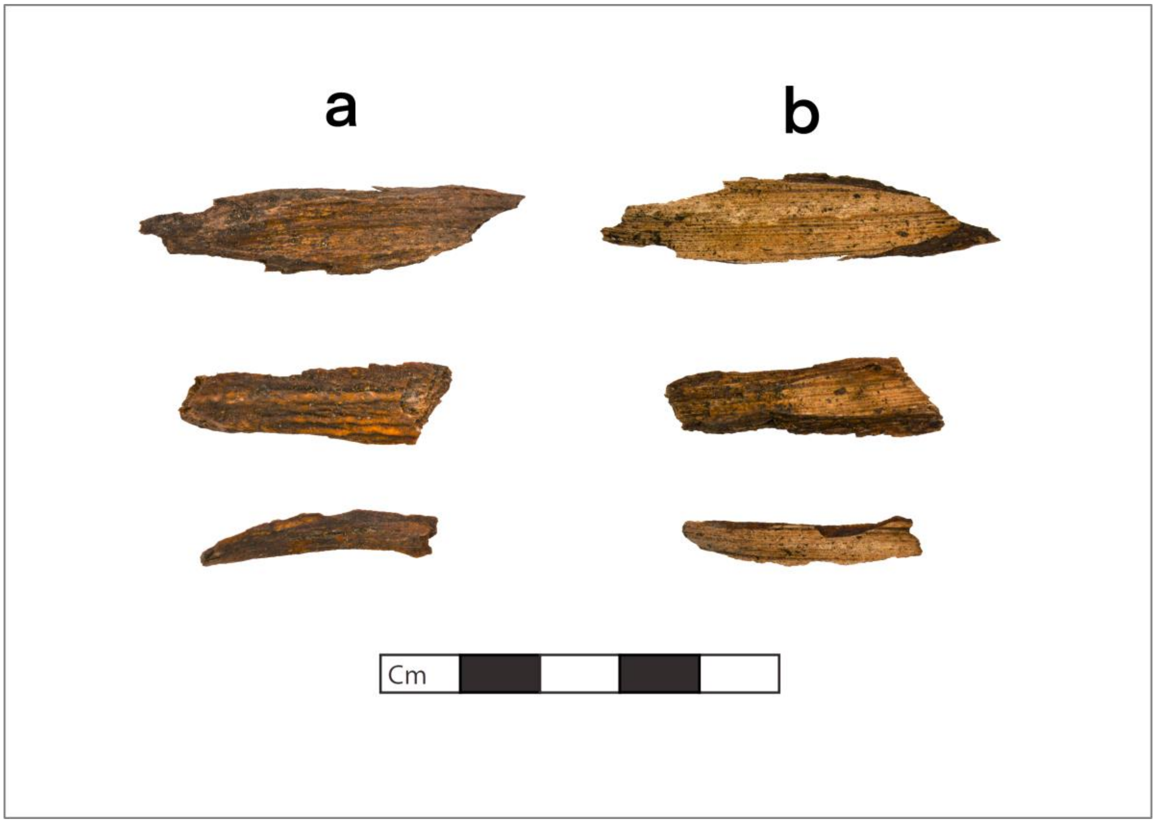

Figure B.7. Small fragments of narwhal ivory retaining only cementum ridges, specimen lot KNK 3930x888. (a) Exterior view of three different fragments, likely removed from the same tusk, with prominent cementum ridges; b) interior view of corresponding fragments with lighter colored dentine present. Most of the narwhal ivory recovered from Iita are of this size and quality. Image by E. Ebel.

Walrus ivory

Walrus tusks are maxillary canines, which exit the maxilla and curve inwards towards the ventral side of the walrus (**Figure B.3**). Both sexes have tusks, but males are generally greater in overall size (length and circumference) with an average length of 50 cm and a maximum length of 1 m (Baker et al. 2020; Berkovitz 2013; Kastelein 2008).

Walrus ivory consists of three dental tissues: 1) a relatively thin band of cementum, 2) primary dentine, and 3) secondary dentine (**Figure B.8**). Most worked walrus ivory will be

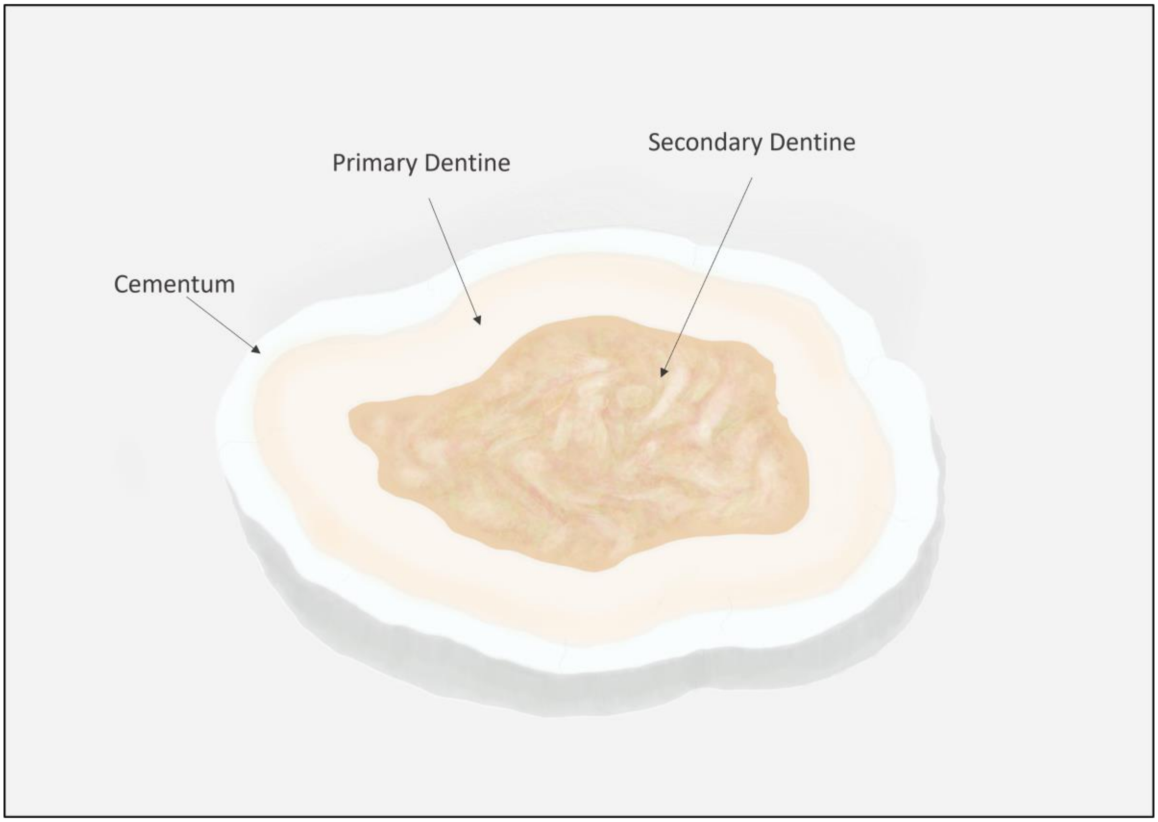

Figure B.8. A transverse cross-section of walrus tusk demonstrating the relative composition and placement of the three dental tissues (oblique view). Illustration by E. Ebel.

primary dentine, which is uniform in appearance. Primary dentine has behavioral properties similar to chipped stone materials in that when it is struck it may exhibit a conchoidal fracture pattern and retain a bulb of percussion (**Figure B.9**), although this will not be present on every fragment depending on method of removal from the tusk (LeMoine and Darwent 1998). Walrus tusks are not hollow, but instead they are filled with secondary dentine which appears as an inner pearly core. Secondary dentine is produced much like primary dentine; however, it deposited by

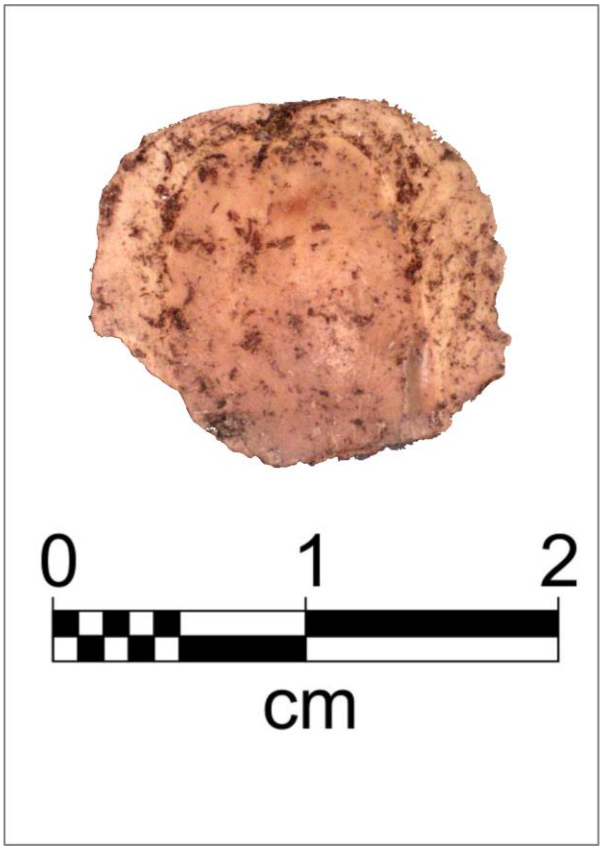

Figure B.9. Ventral surface of walrus ivory flake with visible impact point and bulb of percussion, specimen KNK 912x585. Image by E. Ebel.

cells after the eruption of the tusk and during life. This secondary dentine, which has the appearance of small pearls or accretions, is unique to walrus ivory and distinguishes it from other types of ivory like narwhal (**Figures B.10 and B.11**) or elephant.

Walrus ivory has a smooth, consistent texture and is generally solid as opposed to narwhal ivory. Archaeological walrus ivory is usually ivory white to golden in color; however, there is some variation, and it can appear marbled, mottled, or speckled depending on depositional environment. In addition to the presence of secondary dentine, walrus tusks often

Figure B.10. Cut walrus ivory fragment, specimen KNK 3930x 95. (a) External view with longitudinal fissures in primary dentine layer; (b) internal view with nodules of secondary dentine which form the pearly core; (c) superior view of the cut surface with concentric and radial fissures in primary dentine layer. Image by E. Ebel.

have fissures which run parallel longitudinal to the main axis of the tusk (**Figures B.10a and B.11a**).

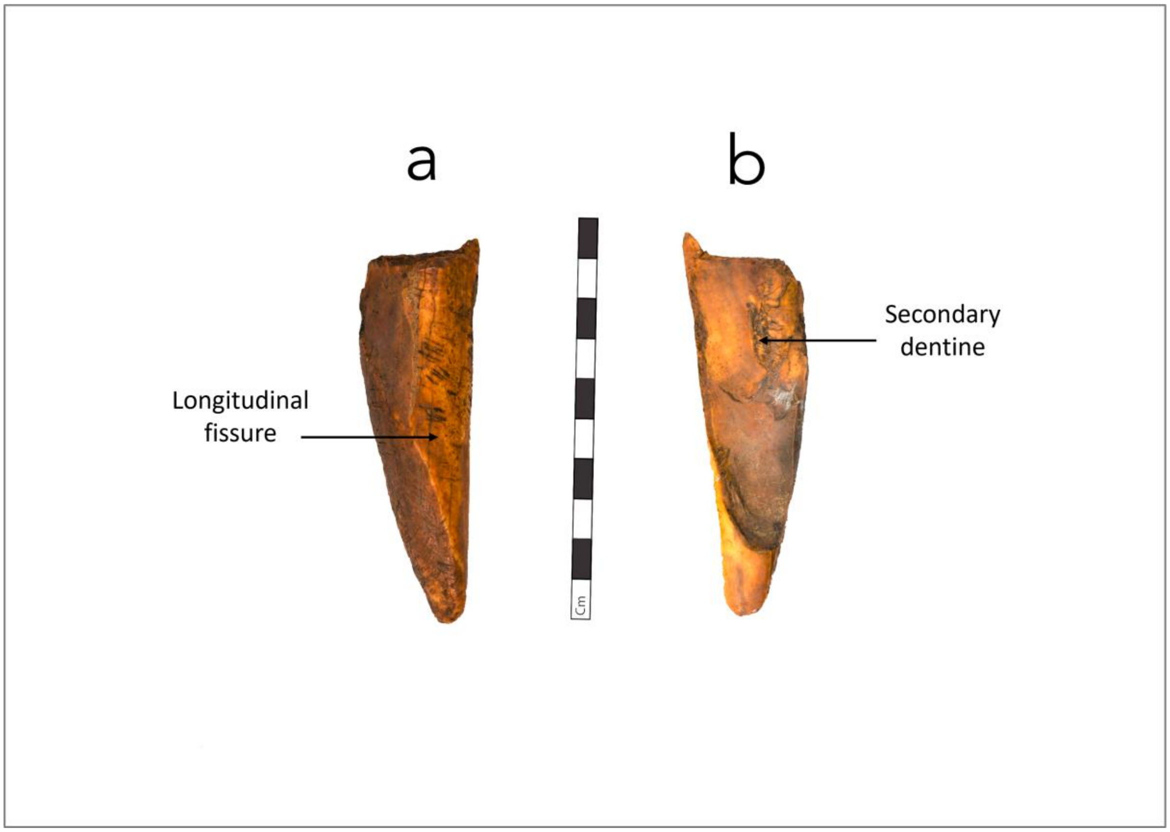

Figure B.11. Distal end of a fragmented walrus tusk, specimen KNK 3930x84. (a) External view, longitudinal fissures are present and distinct from other modifications on surface such as chop marks; (b) internal view indicating the pearly core of secondary dentine. Image by E. Ebel.

A typical adult walrus has a total of 36 teeth, with a dental formula of I(1/0), C(1/1), P(3/3) (Kastelein 2008). Their post-canines are modified and considered “molariform”, meaning that they are broad, flat, peg-shaped teeth and cannot be distinguished from one another. Walrus post-canines are not typically considered “ivory” due to their smaller size (2–5cm in length) and dental tissue composition. These teeth often have hypercementosis, where excess cementum coats the outer layers of the teeth, leading to their irregular appearance. Additionally, adult post-canines are often highly occluded, likely from highly abrasive sand entering the mouth during feeding, resulting in unevenly worn occlusal surfaces (Cobb 1933; Kastelein 2008). Despite these characteristics, there are archaeological and contemporary examples of walrus molariform teeth modified into small items including pendants (Baker et al. 2020). **Figure B.12** features a walrus post-canine tooth modified by chopping on the side of the tooth (intention of the modification unclear). In comparison, the tusks provide superior quality and quantity of materials for reducing into various forms.

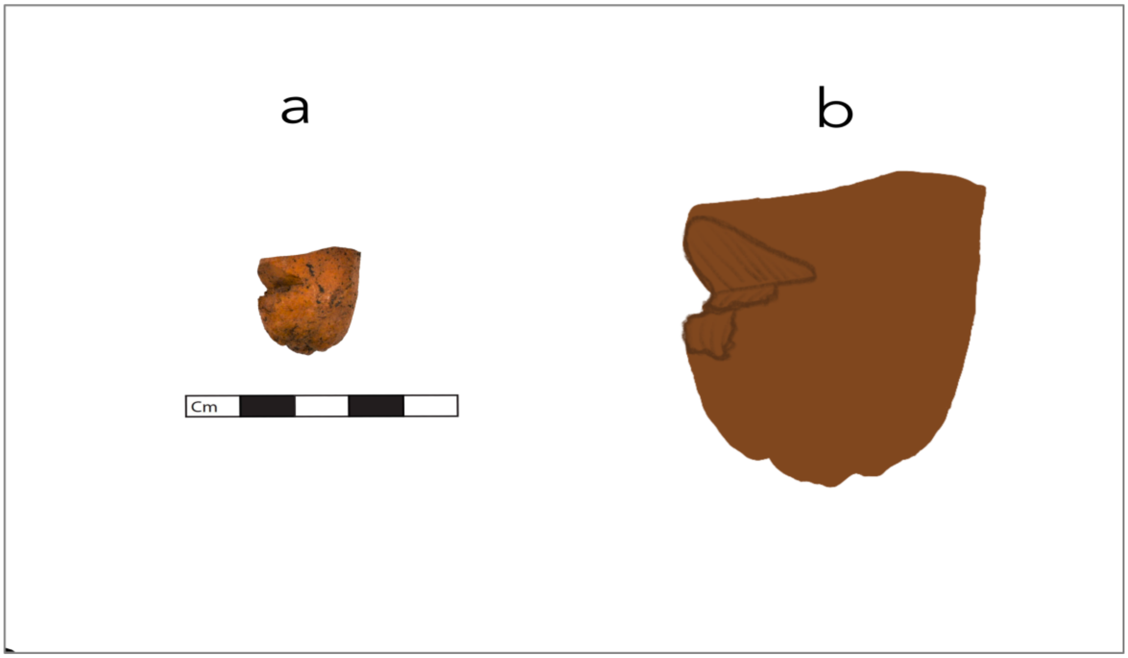

Figure B.12. Modified walrus post-canine or molariform tooth, specimen KNK 912x301. (a) Post-canine with modified edge—tooth root extending toward bottom of page; b) enlarged illustration indicating chop mark. Illustration by E. Ebel.

Bone

Bone is composed of an intercellular matrix and three types of cells. The intercellular bone matrix consists of approximately 33% organic matter (primarily Type 1 collagen) and about 67% inorganic matter (primarily hydroxyapatite crystals). Three bone cells—osteocytes, osteoblasts, and osteoclasts—all perform different duties related to the growth and maintenance of bone tissue.

Bone is composed of calcified collagen fibers aligned according to the skeletal element's structural requirements, resulting in two main types of bone—spongy and compact, which are usually classified based on their gross morphology (Mass 2008). Spongy bone (also referred to as cancellous bone) is characteristic of the internal structure of mammalian bones. Spongy bone has large interconnecting trabeculae, or voids, with spicules of bone, providing a supporting structure (Locke 2013; Mass 2008). Compact bone (also called osteonic or cortical bone) is characterized by cylindrical structures called osteons which house blood vessels, nerves, and connective tissues. Compact bone is a solid, dense bone without trabeculae (Locke 2013; Mass 2008).

The arrangement of these bone types, including the presence of trabeculae, may be used to identify the skeletal portion (appendicular vs. axial element) and to assign bone fragments to taxonomic class such as mammalian or avian. The diaphysis of a typical mammalian long bone is composed of a thick layer of compact bone that surrounds the medullary cavity while the epiphyses are primarily composed of spongy bone enveloped in a relatively thin layer of compact bone. Short and irregular bones are typically composed of a core of spongy bone enveloped by a layer of compact bone.

Bone specimens from Iita were initially identified to element and portion, then to lowest possible taxon using comparative materials. For fragmentary or highly modified specimens without distinguishing characteristics, it was sometimes possible to separate mammalian (terrestrial and marine) and avian bone. Specimens that could not be classified into one of these main categories were candidates for identification using PMF (47% of bone specimens in the osseous technology assemblage were sampled using this technique). In general, bone lacks a gradual transition from the compact to spongy portions.

Marine mammal bone

Marine mammal bones are generally distinct from terrestrial mammal bones due to a long history of evolutionary adaptations to life in water. Adaptations to aquatic life include a change in skeletal architecture to reflect a decrease in gravity/weight bearing form of locomotion and a reduction in limb length which allowed for more efficient swimming (Gray et al. 2007). Together, these have led to the development of shortened appendages which are externally morphologically distinct from terrestrial mammals. Internally, the bony spicules of the spongy portion tend to be thick, creating large and square to ovoid trabeculae (**Figure B.13**). The cortical walls of compact bone are generally thin compared to the spongy yet dense centers and there is an abrupt transition from compact to trabecular bone.

Figure B.13. Cetacean bone fragment, specimen KNK 3930x1955, identified as bowhead/right whale via PMF/ZooMS. (a) and (b) represent opposing views of the same fragment. Note the numerous large, square- to ovoid-shaped trabeculae; this type of spongy bone is characteristic of marine mammals. Image by E. Ebel.

Interestingly, there are two opposing osteological adaptations that evolved independently in marine mammal taxa—an increase in bone density in shallow divers, and, in contrast, a decrease in bone density in deep divers (Gray et al. 2007; Wall 1983). Walrus and some species of seal, including ringed and bearded, have an *increased* bone-mineral density (Mass 2008; Wall 1983).

Compared to homologous skeletal elements in terrestrial mammals, certain cetaceans, including small, toothed whales like beluga and narwhal, have *reduced* bone mineral density and most post-cranial elements have a higher spongy- to cortical- bone ratio (Gray et al. 2007; Mass 2008). One contributing factor for this increased ratio is that spongy bone essentially replaces the medullary cavities in most marine mammals including cetaceans.

Archaeological cetacean bone can be difficult to identify for several reasons. Overall, a decrease in bone density and the processing techniques practiced by Inuit to break down a whale carcass for transport greatly decreases the chance of identifying a specimen to species (see chapter 3 for discussion). Usually, these fragments are identified as “marine mammal” or “cetacean” and proteomic analysis such as PMF or ancient DNA is often needed to identify species (Charpentier et al. 2022; Seersholm et al. 2022).

Avian bone

Skeletal adaptations for flight have made avian bone unique. Particularly, the bones of the wing have developed adaptations for increasing strength against bending and torsion while slightly decreasing overall weight (Kaiser 2007; Sullivan et al. 2017). Bird skeletal adaptations are diverse and vary by species. However, one of the main characteristics of bird bone is pneumatization, which refers to replacement of the marrow within the diaphyseal cavity with air. Pneumatization is hypothesized to serve many functions, perhaps making the bones lighter for flight and as a part of birds complex respiratory system (Kaiser 2007; Sullivan et al. 2017).

Avian bones are typically hollow with relatively dense yet extremely thin cortical walls of compact bone, which are supported by thin and infrequent spicules of bone near the epiphyses often referred to as struts or ridges (**Figure B.14**). Overall, avian bones are distinguished from mammal bones by their thin cortical walls, hollow long-bone diaphysis, and the presence of infrequent trabecular spicules at the epiphyseal ends (**Figure B.15**).

Figure B.14. Oblique view of a split bird long bone; specimen KNK 3930x2731. Note the thin cortical walls of the diaphysis, the smooth hollow interior cavity, and the presence of thin bony struts on the distal end. Image by E. Ebel.

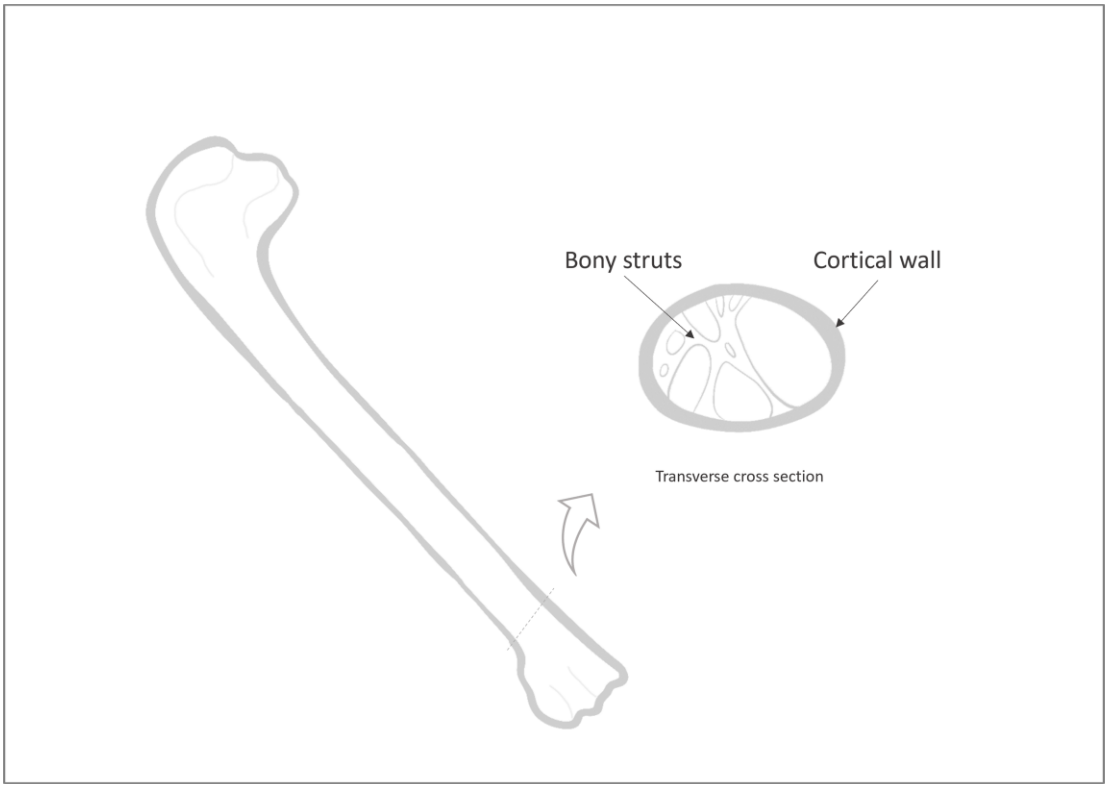

Figure B.15. Diagram of a bird bone. Unlike mammals, the long bones of birds often have thin cortical walls supported by bony struts near the epiphyses. Illustration by E. Ebel.

Antler

Antler is bone that is grown externally in cervids. It is vascularized for a seasonal growth period, is deposited in a manner distinct from internal skeletal elements and discarded rather than resorbed. These unique physiological features make antler the fastest growing organ in the animal kingdom, and also allow antler to be distinguished from bone despite their similar histological compositions. Compared to bone, antler has very low mineral content and a high collagen (Type 1) content (Picavet and Balligand 2016).

Antlers grow from a superiorly projecting portion of the frontal bone known as the pedicle. A knobby joint known as the coronet (or burr) forms a junction with the main beam. Various tines may protrude from the main beam, usually anteriorly. However, antler shape and tine branching are species specific. **Figure B. 16** illustrates the main features of caribou antler identified during analysis of the Iita assemblage. Unlike internal bone, antlers have an additional source of vascularization which aids in their development. Antlers are provided with nutrients via various vessels which lie under the velvet layer during growth. The presence of this external vascularization creates unique rugose patterns on the outer cortex not seen in bone.

Antlers are shed annually and break at the pedicle-coronet junction when bone cells (osteoclasts) weaken this joint. The season of shed depends on the species but generally occurs after rut from late fall into early spring. Antler is bone that has undergone adaption as a trait of secondary sexual selection and to provide defense during the rut (Locke 2013). The necessity of defense and the unique growth pattern makes antler a tough material, stronger (but not harder due to increased collagen content) than internal bone (Currey 1979; Picavet and Balligand 2016). These evolutionary pressures have structured this skeletal element to resist damage when impacted or under torsion rather than to store and transport nutrients as in internal bone (Locke 2013). (**Figures B.17 and B.18**).

As in internal bone, there are two major macroscopic types: spongy and compact. The trabeculae of the spongy portion of antler are much smaller than those in spongy internal bone, particularly compared to marine mammal bone. The main trait distinguishing antler from bone is the transition zone of compact to spongy portions. In antlers, the trabeculae gradually transition in size from small near the compact portion and increase in size towards the center of beam; this characteristic is absent in internal bone (**Figure B.19**).

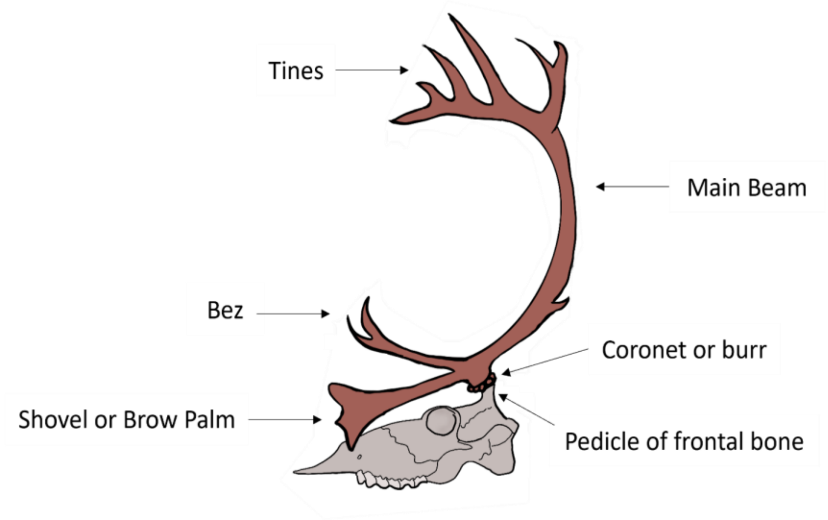

Figure B.16. Diagram indicating the distinct portions of caribou antler identified and referenced herein. Illustration by E. Ebel.

Figure B.17. Antler from recently hunted caribou (non-archaeological). The sub-velvet vascular grooves are clearly visible on portions of the main beam of this fresh specimen. Additionally, the beam and palmating tines are flattened, creating a wider and thinner antler rack compared with other cervids. Image modified from Alaska DIY Caribou with Arctic Air Flying Kotzebue AK. https://arcticairflying.com/photo-galleries#260e6833-f722-401d-b207-ca01851c9146

Figure B.18. Caribou antler beam fragment, specimen KNK 3930x2741. (a) and (b) represent two sides of the same beam, each having a visible vascular groove on the cortical surface. These grooves are retained even the after the cessation of sub-velvet vascularization and shedding of the velvet layer. The vascular grooves are discreet from human modifications such as cut marks, which are visible on the ends of the specimen. Image by E. Ebel.

Although taphonomic variation can greatly alter the sub-velvet shell surface of antler, the texture of antler is typically softer or more felt-like than bone-like. One explanation for this soft texture could be the tightly packed lamellar bone that lines the outer sub-velvet surface (Locke 2013).

Caribou Antler

Caribou are the only cervids in which antlers are grown by both sexes, although female antlers are much smaller. Male caribou begin growing their antlers by March and shed them in October just after the rut, while females begin growing antlers in May and shed their antlers June of the following year (Valkenburg and Arthur 2008).

When considering body size, caribou have the largest and heaviest antler racks of all cervid species (Locke 2013). Caribou have flattened, palmate racks of antler that are different in cross section from other cervids, which have a more cylindrical shaped main beam (e.g., wapiti, deer). Because of this flattened main beam, caribou antler tends to have a higher ratio of spongy inner core relative to the dense outer cortex. Caribou antler derived from portions such as brow palms tend to be flattened (wide and thin) and lanceloid in cross-section (**Figures B.19** and **B.20**).

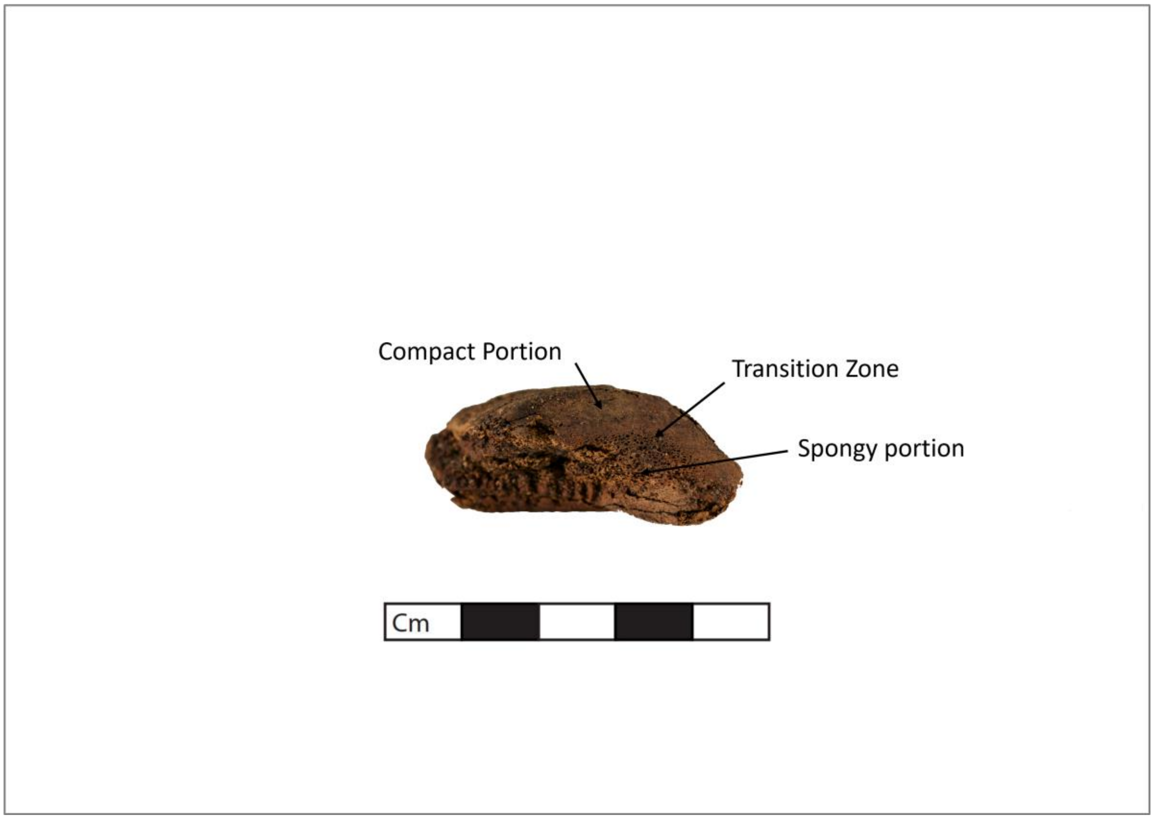

Figure B.19. Transverse cross-section of caribou antler beam, specimen KNK 3930x2741. Note that the compact type gradually transitions into the spongy type—a characteristic unique to antler. Image by E. Ebel.

Figure B.20. Sagittal cross-section of caribou antler beam, specimen KNK 3930x990. Note the small, fine trabeculae, which gradually increase in size from the outer compact portion to the inner spongy portion. Image by E. Ebel.

Keratinous Materials

Keratin is a protective layer that develops on various external structures in mammals from hair, horn, and skin, to nails, claws and hooves. Only two keratinous materials were identified during analysis, baleen and an unknown skeletal portion of bovid origin, most likely a fragment of muskoxen horn or hoof.

Bowhead whale baleen

Baleen only occurs in the suborder Mysticeti. Baleen forms several hundred keratinous plates that extend down from the maxillary palate of the cranium **(Figure B.21**). These keratinous plates are composed of fibrous, hollow, hair-like structures, which are densely packed into large sheets (Bannister 2008). These baleen sheets are “fringed” to assist with the filter feeding process. Baleen grows continuously throughout a whale’s life and wears away on the fringed, lingual edge as the whale feeds (Bannister 2008; Locke 2013).

In life, baleen is durable and flexible, but most archaeological samples are brittle and delicate (Locke 2013). Archaeologically, baleen is often represented by small, shaped or otherwise human-modified plates or loose strands (**Figure B.22**). The dark colored hair-like, appearance of baleen is easily recognizable and therefore distinct from other material types in this study.

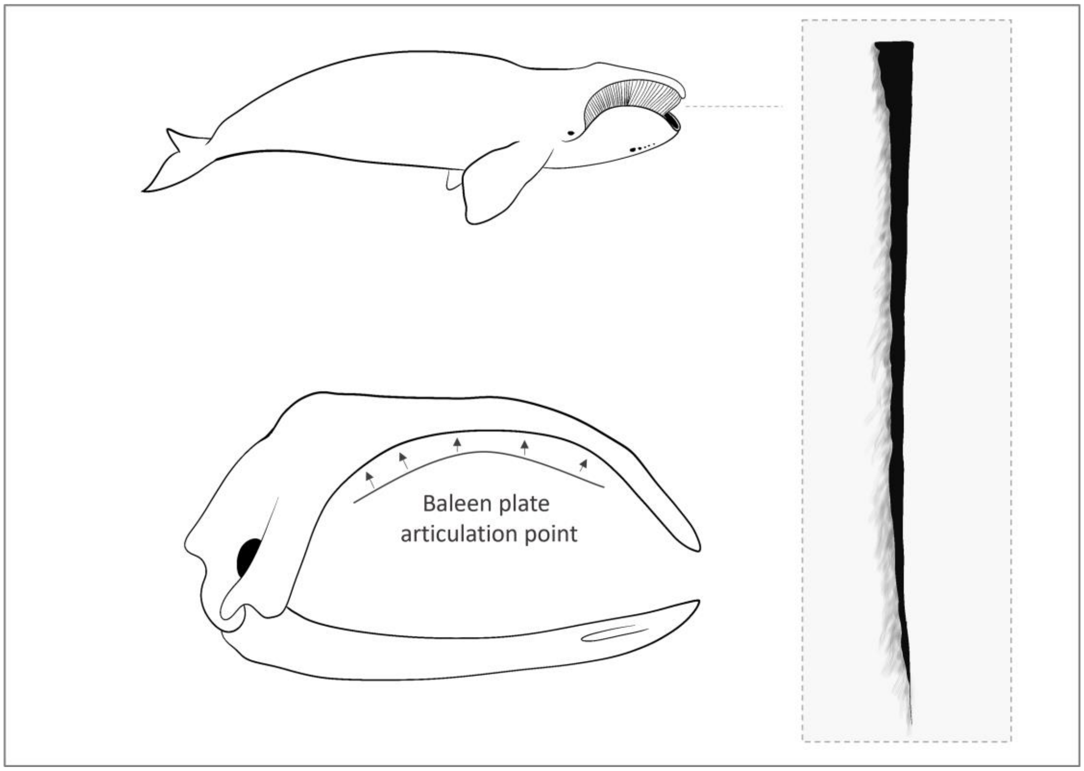

Figure B.21. Baleen attaches to the maxillary bones. Bowhead whales can have 300–400 baleen plates, each of which can reach up to 14 m in length. Illustration by E. Ebel.

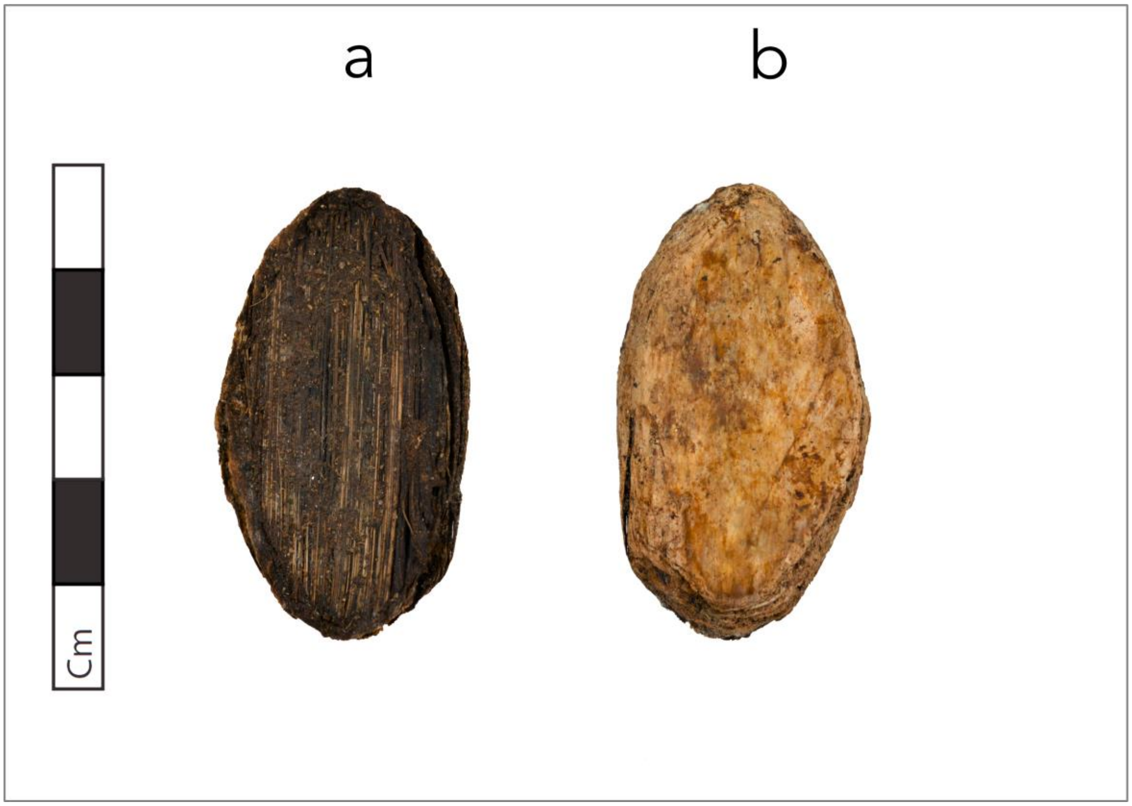

Figure B.22. Modified baleen fragment, possibly a bladder mending disc; specimen KNK 3930x14. (a) Lingual side has keratin tubules, which give the baleen a stringy, hair-like appearance; (b) labial side is a smooth, flat keratin plate. Image by E. Ebel.

Depending on the size and preservation of the baleen specimen, it may be possible to identify the species using attributes such as shape and color. For example, Bowhead whales have black baleen plates that can reach 4 meters in length with fine off-white fringe (Rice 2008). In this study, baleen was attributed to species based on geographic distribution of baleen species. The few specimens of baleen included in this study are attributed to bowhead in consultation with the current and historical distribution of bowhead whales near the study site of Iita in Northwest Greenland (Bannister 2008; Heide-Jørgensen et al. 2021). Other baleen whales such as the right whale do not inhabit arctic waters as far north as the North Water Polynya and Smith Sound.

Muskoxen horn or hoof

A sheath of keratin covers the bony horn core of both sexes of muskoxen. This keratinous sheath can be very thick, particularly in males who have a thick, but flat, horn base, referred to as a *boss*, which covers much of the frontal bone (**Figure B.23**). Externally, muskox horns are brown to cream colored and become dark brown to black at the distal tip. Internally, the horn is golden and white. The internal structure of the *boss* is characterized by “eyes” with white cores which are surrounded by keratinous cylinders. In well preserved horn these structures are easily visible to the unaided eye. However, this feature was not identified in this archaeological assemblage.

Figure B.23. (a) Male muskox with *boss*. Image modified with permission under [CC 3.0 license](); (b) lateral view, and (c) superior view of female muskox skull; specimen WFB 3480 at the UC Davis Museum of Wildlife and Fish Biology, photographed by E. Ebel.

Like horns, hooves are also keratinous sheaths that cover a bony base; however, this structure articulates with a system of connective tissues essential to locomotion. Keratin takes various hard and soft forms within the hoof system including a hard, laminate keratin band, which comprises the bulk of the hoof wall and a softer elastic pad known as the sole (Locke 2013). **Figure B.24** features museum specimens of muskox horn and hoof collected in mainland Alaska.

Two specimens were identified as keratinous materials within the osseous technology assemblage. Specimens KNK 3930x1769 and KNK 3930x1876 are consistent with the structure in macro- and microscopic examination and were therefore identified as the same keratinous material **(Figure B.25**). Specimen KNK 3930x1769 was submitted for PMF and based on the abundance of keratin and collagen identified as Bovidae. Muskoxen are the only bovid species in the Arctic. Due to the extreme modification of the internal and external structure of these specimens they could not be assigned to a specific skeletal portion but are likely from the horn sheath or the hard laminate portion of a muskoxen hoof.

Figure B.24. The keratinous bovid specimens may derive from muskoxen horn or hoof, such as these specimens held at the University of Alaska, Museum of the North, collected by the Bureau of Land Management: a) partial hoof wall, *Ovibos* UAM:ES:32421 https://arctos.database.museum/guid/UAM:ES:32421, and b) left horn sheath, *Ovibos* UAM:ES:11022 https://arctos.database.museum/guid/UAM:ES:11022 (accessed 1/18/2023).

Figure B.25. Keratinous materials from Iita. (a) Specimen KNK 3930x1769 has keratin peptide markers consistent with animals from the family Bovidae and is likely a fragment of muskox horn or hoof; (b) specimen KNK 3930x1876 has a similar appearance both macro- and microscopically and is likely also muskox horn or hoof. Image by E. Ebel.