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# A MULTIVARIATE TAPHONOMIC APPROACH TO UNDERSTANDING MIDDEN FORMATION IN THULE INUIT CONTEXTS: A CASE STUDY FROM ARCTIC CANADA

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A MULTIVARIATE TAPHONOMIC APPROACH TO UNDERSTANDING  
MIDDEN FORMATION IN THULE INUIT CONTEXTS:  
A CASE STUDY FROM ARCTIC CANADA

(Spine title: Understanding Midden Formation in Thule Inuit Contexts)

(Thesis format: Monograph)

by

Tom Porawski

Graduate Program in Anthropology

A thesis submitted in partial fulfillment  
of the requirements for the degree of  
Master of Arts

School of Graduate and Postdoctoral Studies  
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London, Ontario, Canada

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## **Abstract**

Archaeologists attempting to reconstruct local and regional Thule subsistence behaviour place great emphasis on faunal assemblages recovered from Thule semi-subterranean house structures and their associated middens (refuse dumps). Despite the importance of this dataset, limited attention has been given to understanding the taphonomic processes that created these assemblages. The faunal material observed in middens can be highly variable due to the impact of natural and cultural formation processes. This thesis uses faunal data collected from a Thule site (NeHd-1, ca. AD 1400-1600) located near Hall Beach, Nunavut to examine the formation and preservation of three different middens. Application of a multivariate taphonomic approach indicates that formation processes played an important role in determining the nature of these samples, affecting each deposit differently. A better understanding of this variability provides the basis for more informed inferences regarding human behaviour at both the intra- and inter-site level.

**Keywords:** Arctic, formation processes, middens, multivariate, taphonomy, Thule Inuit, walrus, zooarchaeology

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Thank you!

## **Dedication**

This is for my family and friends

Thank you for the constant encouragement and support

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## **Chapter 1**

### **INTRODUCTION**

#### **1.1 Defining the Problem**

Semi-subterranean house structures are one of the best-known representations of Thule Inuit culture, and the majority of Thule faunal assemblages that have been studied to date have been recovered from these dwellings and their associated middens (i.e., refuse heaps) (McCartney 1979; Stenton & Park 1994). Given that middens serve as the final repository for most food waste in prehistoric and historic cultures, these assemblages have been especially important in reconstructing local and regional Thule Inuit settlement and subsistence behaviour. Considering the importance of this data set, one might assume that the formation processes that generate and modify midden assemblages have been thoroughly investigated. Surprisingly, limited attention has been given to this area of research (Stenton & Park 1994; Savelle & Habu 2004). Because of the protective properties of permafrost, there seems to be an assumption that all Thule faunal assemblages are well preserved and can be compared between archaeological sites without taking into consideration the processes that created them. Archaeologists cannot assume that all midden assemblages are directly comparable because of the potential complexity involved in their formation. Interpretations must consider not only human activities, but also a wide range of natural taphonomic factors. A better understanding of assemblage formation will provide a firmer footing for comparisons both within and between sites.

This thesis examines the way natural agents, such as the environment, and human behaviour can affect the composition of different Thule midden contexts at the individual

site level. A multivariate taphonomic approach, which applies a sequence of zooarchaeological analyses to bone assemblages, will be used to gain a high-resolution insight into each midden's taphonomic history (*cf.* Bar-Oz & Munro 2004).

Understanding the variability in formation and preservation between these assemblages will help us to make more informed inferences regarding human behaviour. This study will be a useful point of departure for intra-site comparisons and will provide important baseline data for comparisons with other sites.

## 1.2 Defining Taphonomy

Taphonomy is the area of study concerned with the “laws of burial” (Efremov 1940). In archaeology, the primary motivation behind the study of taphonomy is to identify the processes that are responsible for creating a particular pattern observed in the archaeological record. Here, a *taphonomic process* refers to the dynamic force or activity by which the pattern is produced (Lyman 1994:3; Marshall 1989:8). The goal of the investigator is to establish a process-pattern relationship or determine what processes create what patterns (Marshall 1989:7). The subfield of vertebrate taphonomy is particularly relevant to zooarchaeologists, since this considers the processes acting upon animal remains through their transition from living individuals to the archaeological record (Lyman 1994).

Two basic kinds of formation processes create the archaeological record: (1) cultural, where the process of transformation involves human behaviour (e.g., butchering, food sharing, storage, cooking, food consumption, and discard) and (2) natural, in which changes result from processes of the natural environment (e.g., weathering, chemical change, decomposition, pressure from overlying sediment, and carnivore scavenging)

(Schiffer 1987:7). In principle, these formation processes are identifiable because they themselves produce patterns that are regular and predictable (Schiffer 1987:21, 265). As such, processes can sometimes be identified with the *taphonomic agent* or source that created the observed pattern (e.g., gravity, a hyena, or a hominid) (Binford 1981; Lyman 1994:3). Because the archaeological record is cumulative and often represents multiple events, it can be difficult to reconstruct past human behavioural patterns (Gifford-Gonzalez 1991:226; Lyman 1994:452).

The study of taphonomy provides archaeologists with a valuable set of analytical and inferential tools to: (1) identify the taphonomic agents and formation processes responsible for the patterning observed in the archaeological record (Binford 1981; Bonnicksen 1989a:1); (2) strip away the post-depositional taphonomic overprint that alters the archaeological record in ways unrelated to past human behaviours (Lyman 1994:5; Ringrose 1993:123; Schiffer 1987:10-11); and (3) establish how accurately the analyzed assemblage reflects human activities in the past.

### **1.3 Characteristics of Thule Inuit Culture**

The Thule Inuit culture likely developed in the region around Bering Strait and northern Alaska around 900 AD (Morrison 1983a:10; Park 1993:203). Research by McGhee (2000:190) suggests that at least one large-scale population movement took place from North Alaska into the central and eastern Arctic by the thirteenth century AD. This was possibly preceded by a number of small-scale exploratory movements beginning during the eleventh century AD (Friesen 2004:668). The Thule Inuit represent the direct ancestors of the Inuit populations living in the Canadian Arctic and Greenland.

There were important cultural and subsistence changes over time during the Thule period. McCartney (1977) initially divided the eastern branch of Thule culture into two chronological phases. The earlier he referred to as “Classic Thule” while the later he termed “Modified Thule”. The Classic Thule (ca. AD 1200 – 1500) have been characterized as an active whaling culture, based on the use of whale bone and baleen as house construction material (Mathiassen 1927:85; Savelle & McCartney 1999:437). During this time, whaling was an important economic activity that likely involved the cooperative effort of an entire whaling crew (McCartney 1980; Savelle 2002). Savelle and McCartney (1991, 1994) have shown that the Thule selectively hunted these large sea mammals, focusing primarily upon yearlings, and secondarily upon slightly older juveniles. Despite the strong emphasis on whaling, it is also clear that Thule relied on a number of other species (e.g., seal and caribou), especially in areas where bowheads were not accessible or only partially available (Mathiassen 1927:321; McCartney & Savelle 1985:40-41; Savelle & McCartney 1988:26-31).

Modified Thule culture arose during the onset of colder temperatures during the Little Ice Age (ca. AD 1400/1500 – 1850), which halted the migration of bowhead whales into previously occupied areas (Barry et al. 1977:200; Maxwell 1985:304). With the near or complete cessation of whaling, there was a greater emphasis placed on regional resources. During this period the Thule utilized a broad spectrum of terrestrial, avian, and fish species, with a focus on ringed seal (Maxwell 1985:304; McCartney & Savelle 1985:39; Savelle & McCartney 1988:27-31). Although the Thule continued to live in similar house structures, scavenging whale bones for construction material, archaeological evidence suggests that they became more mobile and population levels

were greatly reduced (Savelle 2002:84; Savelle & McCartney 1988:67). The transition from Modified Thule to Historic Inuit occurred after the movement of Europeans into the area. The occasional early contacts had little effect on Inuit culture, other than the introduction of a few European items. However, from the middle of the nineteenth century on, European commercial activities played an increasing role in altering Inuit culture (Maxwell 1985:310).

Archaeologists studying the prehistoric Thule Inuit are in some cases able to apply recent Inuit historic and oral records directly to archaeological contexts. This may be justified because of the unbroken historical sequence that exists between earlier prehistoric Thule societies and recent Inuit peoples of the eastern Arctic (this is known as the direct historical approach). Unfortunately, the ability to use the ethnographic record does not mean that every aspect of modern Inuit lifeways can be directly applied to the Thule archaeological record (Friesen 2002:332). For example, Freeman (1979) and Yorga (1979) question the Classic Thule people's ability to hunt bowhead whale despite ample archaeological evidence to the contrary (e.g., McCartney 1980; Savelle & McCartney 1991, 1994). Both anthropologists base their assessment on ethnographic records of the 18<sup>th</sup> century Labrador Inuit. Furthermore, Friesen (2002) has demonstrated that the settlement patterns and seasonal movements of the Classic Thule on Victoria Island contrast with those of the Caribou Inuit that reside in the same area. In consequence, archaeologists often draw on the entire body of Inuit ethnography from across the Arctic including the Northern Alaskan Inupiat, which may potentially exhibit a stronger degree of stability and continuity from the Thule period (Friesen 2002:332). While debate is likely to continue as to which recent Inuit societies are the best models



for Thule, considering the similarities and differences that may exist between the ethnographic record and the archaeological record can strengthen interpretations (Wylie 1985, 1988, 2002).

#### **1.4 Research Questions**

This study will examine the way human behaviour and natural factors can affect the composition of different Thule midden assemblages in and around a Thule semi-subterranean house structure (Feature 15) at NeHd-1, located on the north-eastern tip of the Melville Peninsula, Nunavut. On the basis of typological comparison, it is suggested that the site was occupied during the Modified Thule phase, when whaling was beginning to lose importance. It is therefore expected that the occupants placed a greater emphasis on regional food resources, instead of whales.

This analysis will examine three midden assemblages from Feature 15, including an external midden (located outside the entrance tunnel), refuse from outside the dwelling wall, and a deposit of debris on top of the dwelling that is interpreted as trash associated with a later occupation. To attain a better understanding of the formation processes active on these refuse deposits, I will address the following key questions: (1) What non-human agents and processes have influenced the midden assemblages? (2) What evidence is there for human impact on the midden assemblages and what does this reflect about human disposal practices? (3) Are there significant differences in the (human and non-human) formation processes creating each of these assemblages?

This site specific study will help to deepen our understanding of the cultural and natural factors involved in the deposition of animal remains on Thule sites throughout the Canadian Arctic. By understanding the variability in formation and preservation between

different midden deposits on a single site, archaeologists will become more aware of the similarities or differences between the mix of factors that fit together and make up the archaeological record. This information can be used to reassess existing interpretations of broader cultural trends and provide a strong foundation for further inter- and intra-site comparisons to be made.

## Chapter 2

### OVERVIEW OF TAPHONOMY: HISTORY, THEORY & ASSUMPTIONS

*“The student of a discipline frequently reads and uses the products of his predecessors as discrete contributions from which he picks and chooses ideas and observations to serve his ends. This activity should be carried out with an appreciation of the intellectual history of the field so the writings of earlier workers may be viewed against generalizations about the thought of their time” (Binford 1981:4).*

#### 2.1 Introduction

This chapter will trace the history of taphonomy from its origins through to recent applications in zooarchaeology and Arctic archaeology. Taphonomy had its origins in paleontology to understand the formation of the fossil record and was later applied in archaeology to study the formation of faunal assemblages. Archaeologists also study formation of archaeological sites typically called the study of site formation processes, but it is effectively a form of taphonomy. Although taphonomy, as applied in archaeology, had precursors in the decades before (e.g., Clark 1939; Dart 1957; White 1952, 1953a, 1953b), it was not until the late 1960s that the importance of both natural and cultural forms of archaeological site formation were considered. This concern with formation processes continued to develop in the 1970s and early 1980s into a multifaceted research effort. This work highlighted the weaknesses of many early analyses, which had been based on an uncritical acceptance of the patterns seen in the archaeological record as products of human behaviour (Binford 1981:4-8; Lyman 1987:254, 257; Schiffer 1972:156, 1976:11). In subsequent decades, analysts adopted a multivariate taphonomic approach as they attempted to move beyond agent identification

studies to gain a better understanding of the role of faunal remains in human subsistence systems and in ecosystems (Bar-Oz & Dayan 2003; Bar-Oz & Munro 2004; Behrensmeyer 1991; Gifford-Gonzalez 1991). The multivariate approach applies a sequence of zooarchaeological analyses, in a roughly hierarchical fashion, to systematically reconstruct the taphonomic history of a faunal assemblage (Bar-Oz & Munro 2004:204-205). Despite increasing emphasis on study of site formation processes in archaeology and taphonomy in zooarchaeology, these issues still receive relatively limited attention in Arctic archaeology.

## 2.2 Origins of Taphonomy

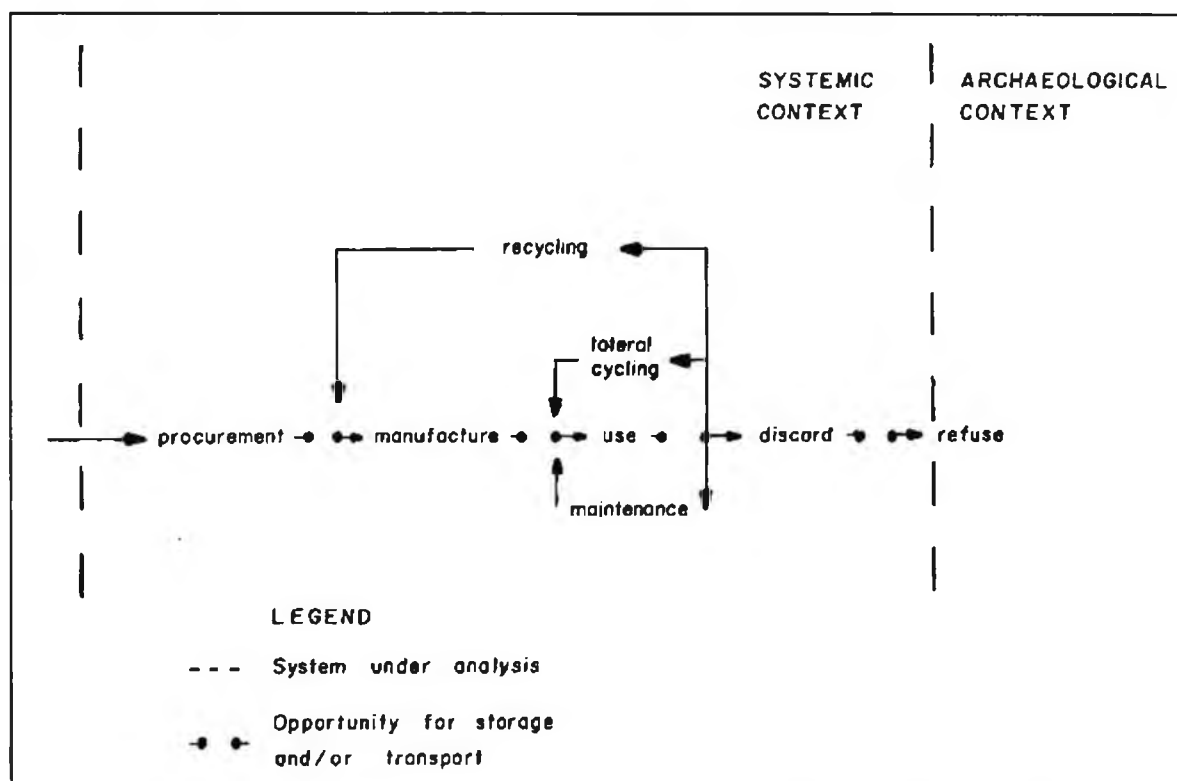
Taphonomy was first established as a branch of paleontology, but over the years it has evolved into a much broader study of the ways in which preservation conditions affect the fossil record (Behrensmeyer 1984; Behrensmeyer & Kidwell 1985:105; Gifford 1981; Hill 1978). Efremov originally coined the term taphonomy in 1940, but German palaeontologists had already laid the foundations in the first three decades of the twentieth century (e.g., Abel 1912, 1914; Wasmund 1926; Weigelt 1927; Richter 1928; Hecht 1933; cf. Behrensmeyer & Kidwell 1985:105-107; Cadee 1991; Gifford 1981:369 for summary). Within the German tradition, viewpoints differed regarding the definition and scope of taphonomy, however, the term *biostratinomy* – “the study of the environmental factors that affect organic remains between an organism’s death and the final burial of the remains” (Lawrence 1979a:99) – was coined by Weigelt (1927; English translation 1989) to describe much of this realm of study (Cadee 1991:10-11; Gifford 1981:369; Lyman 1994:16). Muller (1963) later developed on this work and used the term *diagenesis* to describe processes that took place after final burial of organic remains

(Lawrence 1979b:245; Lyman 1994:16). Unfortunately, many of these studies were largely ignored in other countries because of language barriers and anti-German sentiment during the mid-20<sup>th</sup> century (Cadee 1991:13).

Efremov (1940) played an important role in introducing the concepts being addressed by German palaeontologists to the English-speaking world (Gifford 1981:370). His own research emphasized the incompleteness (information loss and bias) of the fossil record and finding ways to better study the processes and principles governing the transition of organic remains from the living community to the fossil record (Cadee 1991:13; Efremov 1940:85). Ultimately, Efremov was interested in identifying regularities governing the preservation of sediments and their embedded organic remains, making his work directly relevant to both paleontologists and archaeologists (Efremov 1953:150; Gifford 1981:370). However, because of the language barrier, the term taphonomy and the implications of Efremov's research did not become well known in North America until the 1960s; through the work of Everett Olson, who was his friend and translator (Gifford 1981:370).

### **2.3 Behavioural Archaeology**

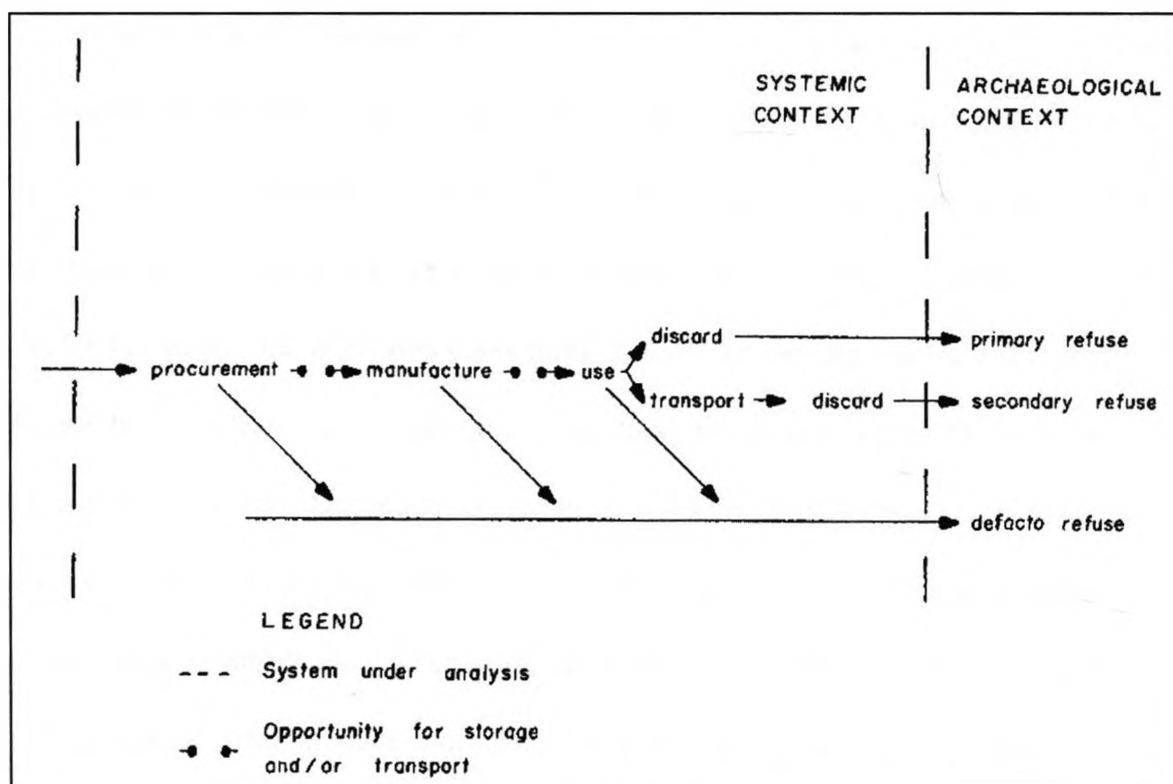
Schiffer (1972, 1983) applied many of these ideas to the study of the formation of archaeological sites. In *Behavioural archaeology*, Schiffer (1976:4; 1987:4) stated that “the subject matter of archaeology is the relationships between human behaviour and material culture in all times and places”. He believed that archaeologists should try to extract from the material record as much social and behavioural information as possible (Schiffer 1983:675). Schiffer (1972:115; 1976:11) accused previous generations of archaeologists of misinterpreting patterns observed in the



**Figure 2.1:** Flow model demonstrating the life history of durable elements (Schiffer 1972:159).

archaeological record directly in terms of past human behaviour, with particular criticism of Lewis Binford's reference to the "'fossil' record of the actual operation of extinct society" (Binford 1964:425). He cautioned that before inferences can be made from archaeological data, the effects of natural and cultural agents must first be identified and differentiated (Schiffer 1976:11-12, 1987:xvii).

To avoid treating the material record as isolated and static, Schiffer (1972) developed a flow model (FIG. 2.1) with which to view the life history of any *element* (anything that is part of a cultural system), and account for its transition from the *systemic* to the *archaeological* context. *Systemic context* refers to elements or artifacts when they are participating in a behavioural system (Schiffer 1972:157; 1987:3). This can include such activities as procurement, manufacture or preparation



**Figure 2.2:** Flow model demonstrating the differences between primary, secondary, and de facto refuse (Schiffer 1972:162).

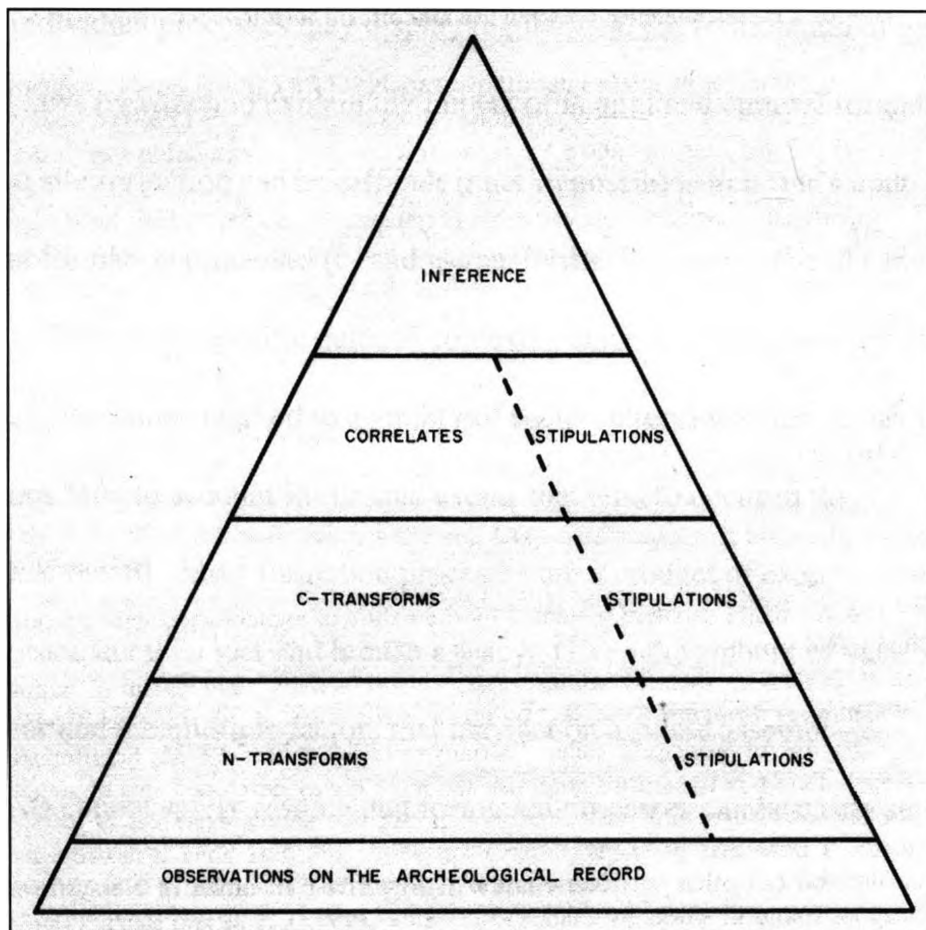
(if the item is consumable), use or consumption, and discard. However not all elements have to follow a unilinear path through the behavioural system. Schiffer (1972:158) states that storage and transport (including trade) are activities that may spatially displace an element. Other elements may also be reused through recycling (which may or may not involve a change in form and function) and lateral cycling (often involving a change in function but not form).

*Archaeological context* describes materials that have passed through a behavioural system and been deposited in the archaeological record (Schiffer 1972:157). Schiffer (1972:160-161) introduces several categories of refuse disposal including (FIG. 2.2): (1) *primary* refuse, which is discarded at its location of use (i.e., through loss); (2) *secondary* refuse, which is discarded away from its location of use

(i.e., in a midden or refuse dump); and (3) *de facto* refuse, which is deposited without deliberate discard behaviour (i.e. upon abandonment of a site). Unless an element is lost, discarded or abandoned and finally buried, all activities in a behavioural system will prevent an element from entering the archaeological context. Schiffer (1976:28-29) further stated that other processes might remove or modify materials once they have entered archaeological contexts. Activities such as scavenging by carnivores, looting, or excavation can transform materials back from archaeological to systemic contexts. Other processes including land-modification activities (i.e., ploughing, mining, dam-building, etc...) can also transform materials from state to state within archaeological contexts. These processes all represent significant sources of variability in the archaeological record and suggest that material remains cannot be interpreted as a direct reflection of past human activities.

In *Behavioural Archaeology*, Schiffer (1976:14-15) also introduced the terms *c-transforms* and *n-transforms* to explain cultural and natural formation processes respectively. He further went on to state that although archaeological remains are a distorted reflection of a past behavioural system, n- and c-transforms themselves exhibit patterns that have regular and predictable physical effects (Schiffer 1976:12, 1987:21, 265). Consequently, there exist systemic (but rarely direct) relationships between archaeological remains and past cultural systems (Schiffer 1976:12). With this principle in mind, Schiffer (1976:12-17) proposed the *synthetic model* (FIG. 2.3) that built upon three basic properties of archaeological data (Schiffer 1976:12): (1) data consist of materials in static spatial relationships; (2) data has been output from a cultural system (*c-transforms*); and (3) data has been subjected to non-cultural





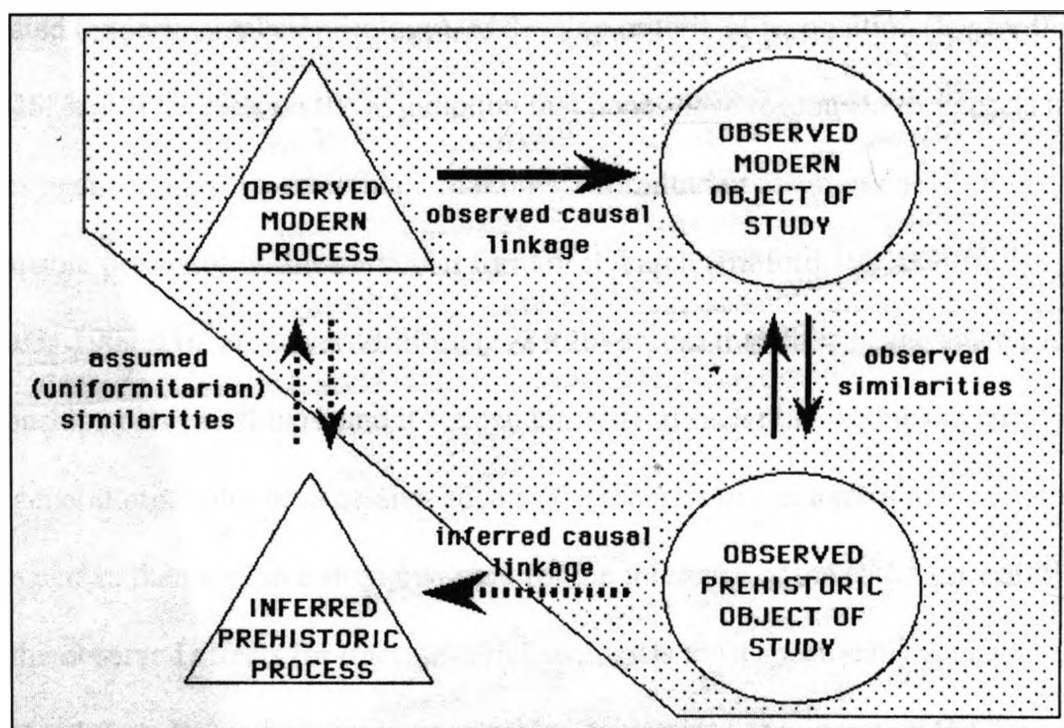
**Figure 2.3:** The Systemic Model (Schiffer 1976:16).

processes (*n-transforms*). In applying the synthetic model, *correlates* are used to connect behavioural (*c-transforms*) and environmental (*n-transforms*) variables to the material record to infer the operations that produced an artifact. *Stipulations* or assumptions made by the researcher must also be stated and tested when considering the above three properties. Schiffer (1976:12, 16) concludes that by continuously stating and testing assumptions (a process referred to as “inference justification”), considering the effects of *c-* and *n-transforms* on the material record, and establishing archaeological correlates, archaeologists can potentially discover regularities that can be expressed as laws.

While individual processes may display regularities, the formulation of general models and laws by which to explain the impact of natural and cultural formation processes on site formation can be difficult if not impossible. Schiffer's approach assumes that formation processes (c- and n-transforms) are universal and can be studied in isolation from specific cultural contexts. Once law-like generalizations are established, these can be applied to a variety of socio-cultural settings. Such an approach does little to account for unique events that tend to occur in the archaeological record. Most formation processes are a product of external events, such as environmental factors and human agency. Given the amount of variability that can occur and the multiple factors that may act on a single assemblage, archaeologists cannot safely assume that formation processes can be easily separated from one another and studied in a straightforward way.

## **2.4 Middle-Range Theory**

Binford developed a competing method for the study of formation processes in archaeology. As a zooarchaeologist, he also made a significant contribution to understanding how these processes affect faunal material. Many early studies of bone modification (i.e., Dart 1957, 1960; Hughes 1954; Washburn 1957; White 1952, 1953a, 1953b) involved post hoc interpretations of the patterns found on bones and of the processes responsible for the observed patterns (Binford 1981:181; Lyman 1987:254-257; Marshall 1989:7). This stemmed from the fact that most faunal analysts spent little time establishing the identity of the responsible taphonomic agents, assuming that the observed patterns resulted from human behaviours (Lyman 1987:257). Although human behaviour may be the agent responsible, this is



**Figure 2.4:** A model of inference using relational analogies. The shaded area represents observations made in the present (Gifford-Gonzalez 1999:222).

something that must be demonstrated (Binford 1981:18, 85). Binford (1977a, 1981:23-25, 1987) stressed that the discipline of archaeology needs to adopt a scientific approach to this problem and develop criteria for empirically identifying the taphonomic agents responsible and linking them to processes.

Binford (1977a, 1981) developed *middle-range theory*, defined as “research that emphasizes the study of extant systems in which both processes and the results of processes can be observed” (Nash & Petraglia 1987:194), as a means to identify the dynamics responsible for the static patterns observed in the archaeological record (FIG. 2.4). The procedure involves: (1) isolating the different agents that are expected to produce a given pattern; and (2) conducting studies of these agents in the contemporary world, where the dynamics can be observed (ethnoarchaeology) or

replicated (experimental archaeology), to develop criteria of recognition (Binford 1981:26, 32). This rests on the assumption that bones have responded to impacts of various agents uniformly over time. Making uniformitarian assumptions is an inescapable precursor of this particular form of research (Binford 1981; Gifford-Gonzalez 1989:43). However, Binford (1981:26) argues that “if we can isolate causal relationships between things, and if we can understand such relationships in terms of more general principles of necessity, such as the theories of mechanics or some other basic science, then we have strong warrant for the inference of the cause [or agent] from the observed effects [or traces].” Archaeologists must specifically seek to understand the relationships between variables, taking into consideration the similarities and differences, of the ethnographic record and the material record to limit the interpretive assumptions about uniformity (Wylie 1985, 1988, 2002). For Binford (1981:26-29), a causal relation needs to be “constant and unique” so that analysts may discriminate between “signature patterns” caused by one agent from all others (Lyman 1994:55).

With the aid of middle-range theory, Binford (1983:24) successfully conducted ethnoarchaeological research among the Nunamiut (Binford 1977b, 1978a, 1978b, 1979, 1980), a group of Eskimo caribou hunters in Alaska, and with the Navajo (Binford & Bertram 1977), who are sheepherders in the American Southwest, with the focus of distinguishing the range of cultural and natural formation processes affecting the material record. He also published *Bones: Ancient Men and Modern Myths* (Binford 1981), which supplied a detailed analysis of how bones are modified by different agents. Signature markers for such processes as butchering, carnivore

gnawing, and plant root activity, among others, were clearly described and illustrated. Binford's work, and similar studies conducted by others, has better equipped investigators for recognizing taphonomic agents active on the material record. His ethnoarchaeological research among the Nunamiut and study of bone modification is of particular relevance to this thesis. However, the archaeological record is made up of a very complex and intertwined matrix of processes. Multiple variables need to be considered in order to interpret an event or patterns of behaviour targeted for study (Bar-Oz & Munro 2004; Bonnicksen 1989a; Gifford-Gonzalez 1991). Given this complexity, archaeologists need to take a multivariate approach to make more substantive inferences about human behaviour and ecology.

## **2.5 A Multivariate Taphonomic Approach**

Since the emergence of middle-range theory, zooarchaeologists have successfully used contemporary observations to distinguish the "signatures" produced by various taphonomic agents. However, as zooarchaeologists we generally wish to study "the life relationships – ecological, social, and cultural – of prehistoric hominid species" (Gifford-Gonzalez 1991:226). The new generation of zooarchaeological research attempts to move beyond agent identification studies to reconstructing patterns of human behaviour from multiple archaeological assemblages. This phase of research will be more difficult, Gifford-Gonzalez (1991:217) contends, because "the relationship of patterning in archaeological assemblages to its causal agencies is more ambiguous." Whereas the action of an agent can often be inferred from its trace with confidence, it is more difficult to assign an unambiguous meaning to aggregate patterns of traces and remains in an assemblage (Gifford-Gonzalez 1991:217, 226).

Given that taphonomic histories are cumulative, some processes can obscure the effects of earlier processes, analogous to a palimpsest (Lyman 1994:452, 455-456). Many natural and cultural formation processes can also create similar patterns, a problem many zooarchaeologists refer to as *equifinality* (Lyman 1985, 1994, 2004; Munro & Bar-Oz 2004; Rogers 2004). Consequently, linkages between cause and assemblage pattern effects are less definite (Gifford-Gonzalez 1991:217, 226).

Gifford-Gonzalez (1991:244-245) proposed that a multivariate taphonomic approach, which applies a sequence of complex analyses, might provide more inferences regarding the life ways of prehistoric human groups (*cf.* Bar-Oz & Dayan 2003:885; Bonnicksen 1989b:517). Following Lyman (1994:456), multivariate taphonomic research examines *dimensions*, which are sets of mutually exclusive variables (e.g., burning), and the several *attribute states* that each dimension may display (e.g., unburned, charred, calcined are attributes of the dimension burning) (*cf.* Bar-Oz & Dayan 2003:885; Bar-Oz & Munro 2004:202). The objective here is to “monitor co-variation of the different taphonomic attributes [variables]” to gain a high-resolution insight into an assemblage’s taphonomic history (Lyman 1994:456). A major step in the development of such an approach was first made by Behrensmeyer (1991:315), who proposed a graphic technique for visually summarizing and comparing taphonomic information from multiple assemblages. Since then, other researchers (e.g., Bar-Oz et al. 1999; Bar-Oz & Dayan 2003; Bar-Oz & Munro 2004; Bernabeu et al. 2001; Friesen & Betts 2002; Klein 1989; Munro & Bar-Oz 2005; Stiner 1992, 1994) have used some version of this approach, however, the one proposed by Bar-Oz & Munro (2004) can be most universally applied.

Bar-Oz & Munro (2004) suggest applying a multivariate taphonomic approach that applies a sequence of zooarchaeological analyses to bone assemblages in three analytical stages to determine the most significant agents of assemblage formation (TABLE 2.1). The first stage involves summarizing all taphonomic variables observed in a given assemblage using a table or graph (see Bar-Oz & Dayan 2003; Behrensmeyer 1991; Lyman 1994; Stiner 1992, 1994 for examples). The next stage employs a series of problem-oriented analyses that assess an assemblage's preservation, which includes identifying patterns of decay and fragmentation (see chapter 3 for examples). The final stage refines the conclusions drawn thus far by comparing taphonomic variables and reassessing patterns of preservation amongst subgroups of a bone assemblage that may be differently impacted. This can include comparing different prey types (e.g., walrus and caribou), prey age groups (juvenile and adult), bone tissue type (compact and cortical bone), as well as assemblages from different contexts (midden and living floor). It is this final stage that allows us to bypass problems regarding equifinality and palimpsests to gain a high-resolution insight into the taphonomic history of an assemblage (Bar-Oz & Munro 2004:206).

A variant of this method will be applied in this thesis to determine the most significant agents of midden formation in the three assemblages from NeHd-1. If the natural and cultural agents can be determined, inferences can be made about the decision making process involved during discard of food waste and other debris. Examining each midden sample individually will also help determine whether people employed the same discard strategies in all middens, or if structured differences were present.

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## STAGES OF MULTIVARIATE APPROACH

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### I. SUMMARY OF TAPHONOMIC VARIABLES

1. Primary quantitative data (e.g., NISP, MNI, diversity indices)
2. Spatial distribution of bones (e.g., orientation, context)
3. Bone surface damage from natural agents (e.g., weathering, root etching, carnivore gnawing, abrasion)
4. Bone surface damage by human subsistence behaviours (e.g., cutmarks, hammerstone impact notches, percussion marks, burning)

### II. INVESTIGATION OF ASSEMBLAGE COMPLETENESS AND FRAGMENTATION

1. Analyses of *in situ* attrition
  - i. Ratio of cranial bones to teeth
  - ii. Analyses of element completeness (e.g., carpal and tarsal bones)
2. Analyses of density-mediated attrition
  - i. Relationship between bone survivorship (%MNI) and bone mineral density
  - ii. Relative representation of bone of different densities (e.g., proximal to distal humerus and tibia)
3. Analyses of fragmentation
  - i. Analyses of body-part completeness (e.g., bone portions, bone elements, anatomical units)
  - ii. Mode of bone fragmentation (e.g., fracture angle, fracture outline, shaft circumference)
  - iii. Fragmentation index (NISP/MNI)
  - iv. Relationship between bone survivorship (%MNI) and fragmentation index (NISP/MNI)
4. Analyses for relationship with utility indices
  - i. Relationship between bone survivorship (%MNI) and food utility index
  - ii. Relationship between rate of bone shaft fragmentation (NISP/MNI) and marrow index

### III. ASSEMBLAGE SUBGROUP COMPARISONS

1. Comparison of bone survivorship (%MNI) and bone mineral diversity of different prey types (i.e., different taxa; large vs. small; domestic vs. wild)
  2. Comparisons of body part representation of taxa of different ages (e.g., completeness of long bone shafts and toes)
  3. Comparisons of different bone tissue types (e.g., cortical versus cancellous bone)
- 

**Table 2.1:** Outline of stages of the multivariate approach to taphonomic analysis (Bar-Oz & Munro 2004:203).



## 2.6 Formation Processes in Thule Inuit Contexts

Over the past half-century, semi-subterranean house structures have become one of the most studied archaeological remnants of Thule culture (*cf.* Mathiassen 1927; Maxwell 1981, 1985; McCartney 1977; McCullough 1989; McGhee 1984; Mary-Rousseliere 1979; Morrison 1988; Park 1997, 1998, 2001; Sabo & Jacobs 1980; Taylor & McGhee 1981), however few studies have focused on the formation processes affecting their structure and its associated faunal assemblages. Applying Schiffer's flow models discussed earlier (1972, 1976), McCartney (1979) has shown that each dwelling represents several major stages of human and natural modification including material procurement, construction, use, possible reuse, abandonment, and post-occupation erosion (*cf.* Dawson 2001; Park 1997; Savelle & Habu 2004; Stenton & Park 1994). Hall (1990:407) further outlined the range of post-abandonment processes (e.g. erosion, freeze-thaw cycles, human and animal scavenging among others) believed to have affected the Utqiagvik site in Northern Alaska, demonstrating the potential for substantial modification/alteration of prehistoric Arctic dwellings. Taking all this into consideration, Allen McCartney (1979:303, 309) argued that our understanding of Thule Inuit behaviour "depend[s] on our ability to interpret the sequential stages [or life history] of Thule house existence...." Yet twenty-five years later, Savelle and Habu (2004) lamented the lack of published detailed stratigraphic information to permit the study of cultural and natural formation processes relating to Thule dwellings.

With a few notable exceptions (Friesen & Betts 2002; Lofthouse 2003; Stenton 2001; Stenton & Park 1994; Whitridge 2001), there has also been limited attention

given to the formation processes affecting Thule faunal assemblages. Many early studies have been restricted to an examination of the use and re-use of whale bone for house construction material and its potential effects on understanding the importance of Thule bowhead whale hunting (Freeman 1979; McCartney & Savelle 1985, 1993; Savelle 1997; Stenton & Park 1994:411; Whitridge 2002). Stenton and Park (1994) were the first to provide a theoretical framework that explicitly views faunal data as part of the evolving stages of house use originally discussed by McCartney (1979). Because animal bones are moved around a site through a complex combination of activities that may include discard, house cleaning, and maintenance, faunal data from within a dwelling may not reflect its primary use (Stenton & Park 1994:412-415, *cf.* Friesen & Betts 2002; McGhee 1982:74). In light of this, Stenton and Park (1994:417) argue that Thule faunal assemblages consist largely of mixed, secondary deposits, and advise that formation processes need to be thoroughly investigated before any conclusions can be made regarding Thule subsistence behaviour. Using a multivariate approach, Friesen and Betts (2002) have shown how natural and cultural formation processes have obscured the original (primary) activities within a pre-contact Inuit semi-subterranean house and found that many taphonomic agents do not act equally on all house contexts. An important feature of their analysis was the comparison of faunal material from the midden with that obtained from the house. The results from their study have shown that the midden was more affected by natural formation processes and showed signs of density-mediated attrition. The current thesis looks to build on these findings and determine whether any variability exists in the formation and preservation of different Thule middens.

While little attention has been given to their formation processes, Thule faunal assemblages have nonetheless been used to address a range of research problems. To date, most Thule zooarchaeology has focused on reconstructing diet (e.g., Mathiassen 1927; Rick 1980; Schledermann 1975; Staab 1979), season and intensity of occupation (e.g., Morrison 1983a; Sabo 1991; Sabo & Jacobs 1980; Staab 1979), and animal procurement strategies (e.g., Morrison 1983a; Schledermann 1976; Stanford 1976). It has also tended to focus on broad temporal trends and comparisons between archaeological sites (e.g., Sabo 1991; Savelle 1987; Savelle & McCartney 1988; Stenton 1983, 1991). Because of the protective actions of permafrost, there seems to be an assumption that all Thule assemblages are well preserved and can be compared without worrying about taphonomic histories. House interior refuse is generally assumed to be in primary context and yet is often compared directly to refuse from secondary deposits at the same site (midden refuse) (e.g., Staab 1979) or to assemblages from other archaeological sites (e.g., Sabo 1991; Savelle & McCartney 1988) (*cf.* Stenton & Park 1994:417). Clearly, this does not take into consideration the different taphonomic histories of these assemblages. Because Thule dwellings and associated midden deposits were used in different ways and may have been unequally affected by natural formation processes, archaeologists need to gain an in-depth understanding of their history in order to build a stronger basis for intra- and inter-site comparison.

Although the contributions to Thule archaeology outlined above have provided a detailed summary of the potential impact taphonomic processes may have on different faunal contexts, they fail to take into consideration the amount of variability that may

also exist in the formation of similar deposits. For example, the faunal material observed in middens can be highly variable due to the impact of natural and cultural formation processes, leading to differential preservation and quantity of materials. This thesis attempts to build on earlier studies by examining the formation and preservation of three different Thule middens excavated from a site located near Hall Beach, Nunavut. A multivariate taphonomic approach is used to identify if any variability exists in the formation of these deposits. The degree of variability will allow us to draw more informed conclusions about human behaviour. If little variability is shown to exist, it will suggest that any observed differences are a product of human behaviour facilitating intra-site comparisons. If differences in formation processes are observed, such comparisons can still proceed, but any conclusions must also take into account the impact of different formation histories. This study will also provide important baseline data for a single site in order to facilitate future inter-site comparisons between faunal remains from Thule middens across the Canadian Arctic.

## **Chapter 3**

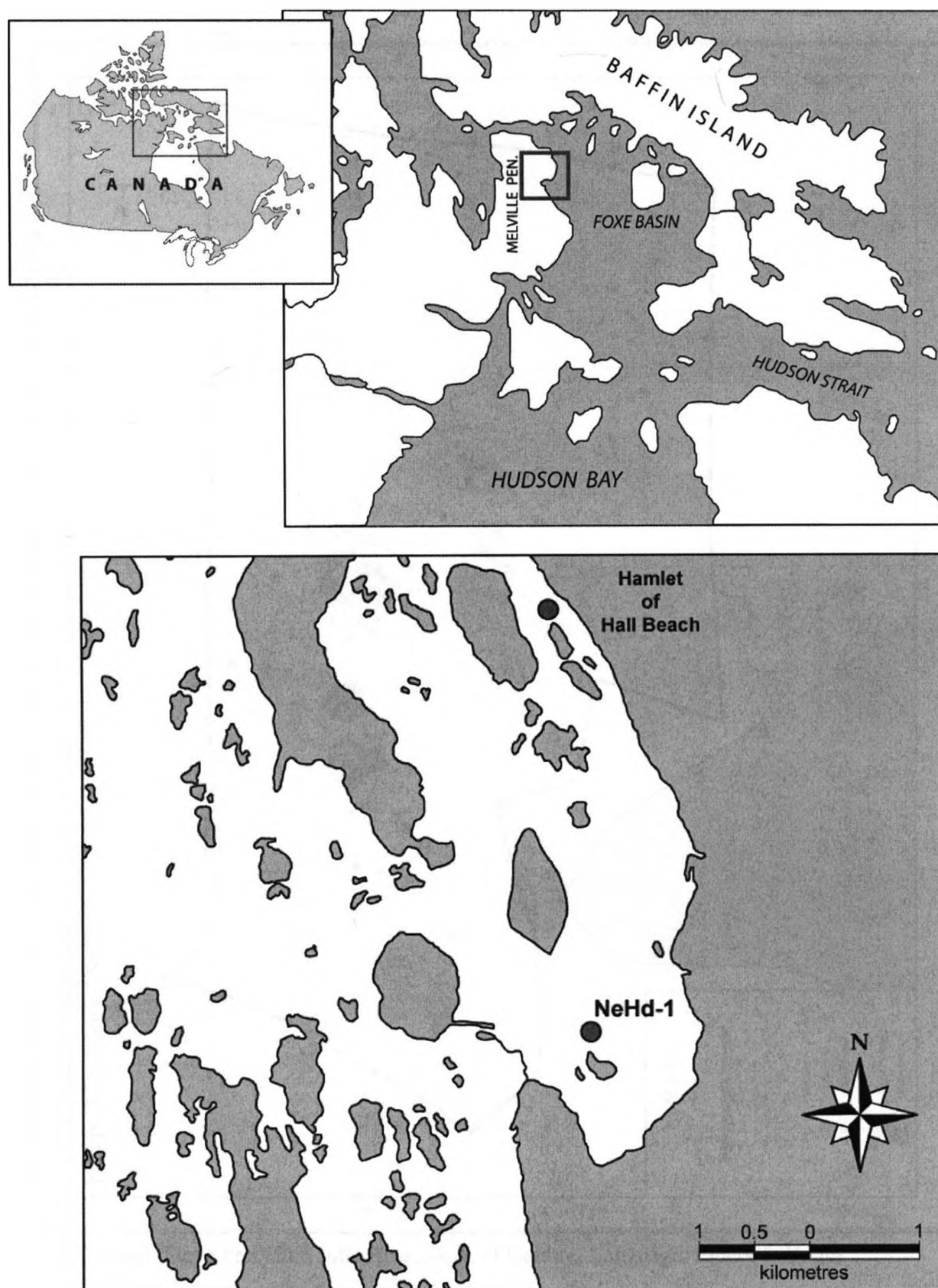
### **METHODOLOGY**

#### **3.1 Site Introduction**

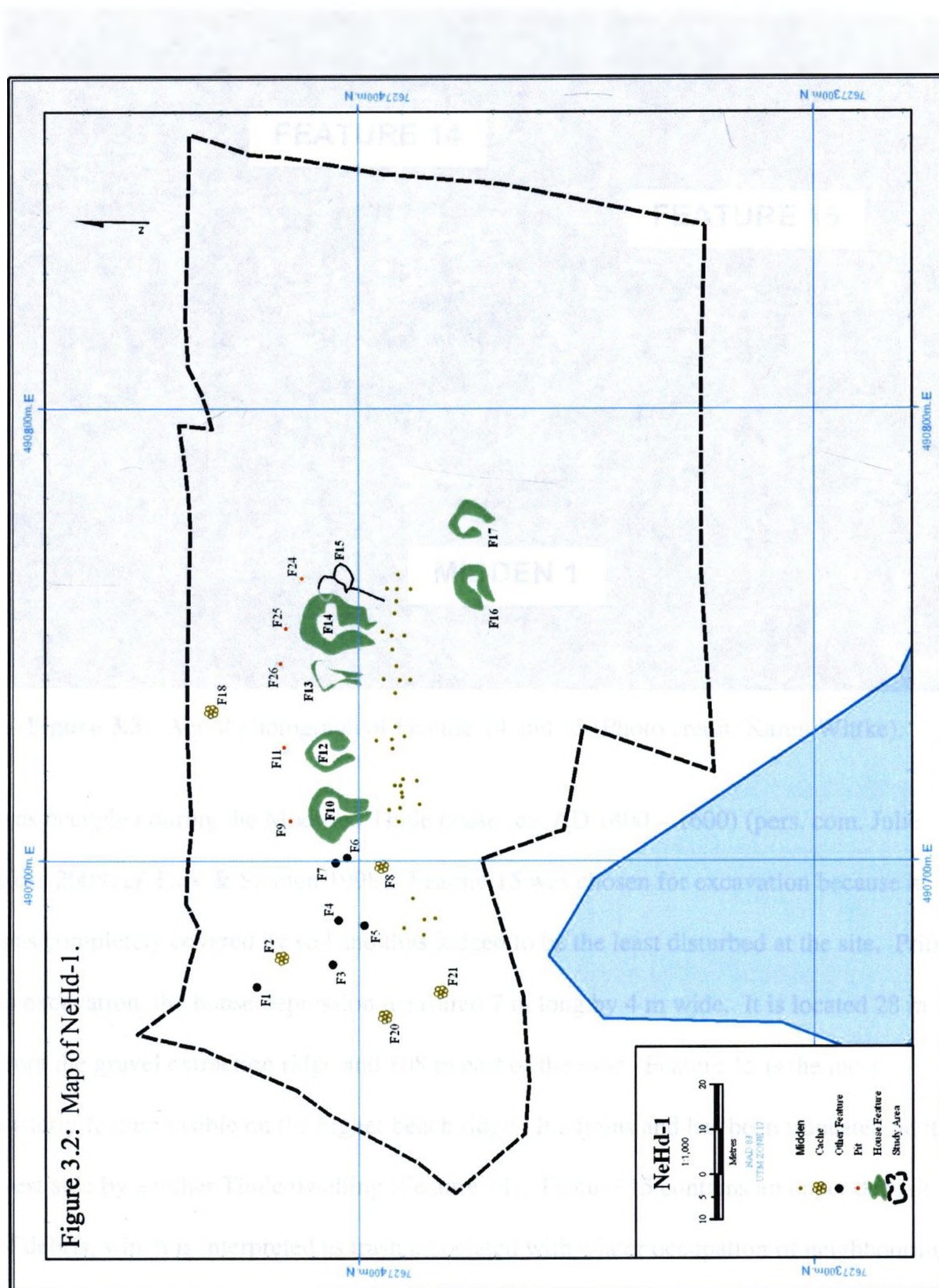
NeHd-1 is a Thule site located at the northeastern tip of Melville Peninsula, near the modern village of Hall Beach, Nunavut. It is situated near the southern edge of the present Fox Main Radar Station on the edge of a south-facing terrace about 700 m west of the shore of Foxe Basin (FIG. 3.1). An archaeological survey conducted by Thompson (1990) located the remains of seven Thule houses at the site, ranging from small single-family dwellings to large multi-family structures (FIG. 3.2). The majority of these dwellings are strung linearly along the seaward edge of a sloping gravel beach ridge, which would have been considerably closer to the shore at the time the site was occupied. The site has also been truncated on the west side by construction of a road and on the north by former gravel extraction operations. Most of the dwelling features retain some partial internal elements, such as sleeping platforms or alcoves, but most have been disturbed by natural slumping. The site is well known to village residents and base personnel suggesting that some vandalism, and looting, has also impacted the integrity of the site.

#### **3.2 Feature 15**

The faunal remains analysed for this thesis were recovered from a Thule semi-subterranean house structure (Feature 15) that was partially excavated during the summer of 2006 (FIG. 3.3). Feature 15 is a small, oval, single-family dwelling with an entrance tunnel. The presence of both Thule Type 3 and Type 5 harpoon heads suggests that it

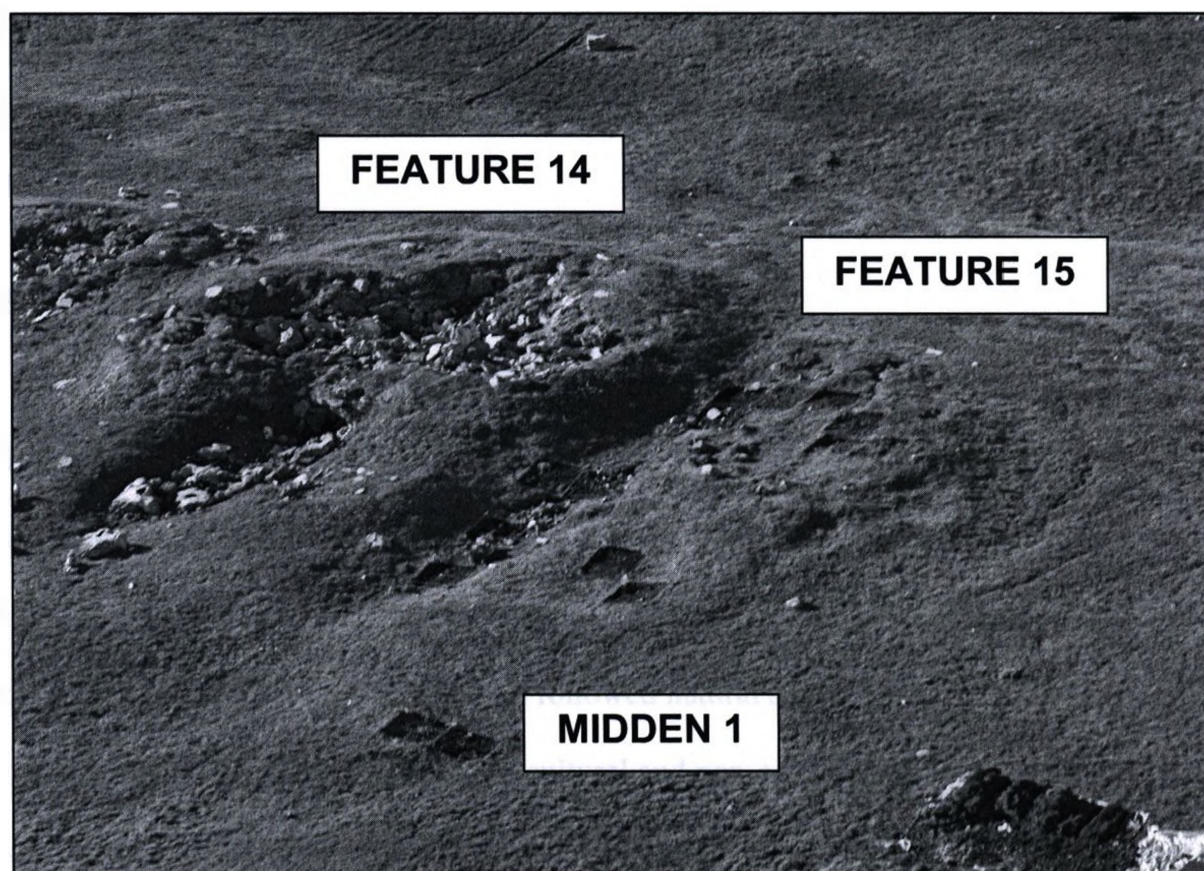


**Figure 3.1:** Location of NeHd-1.



Map credit: Steve Perry and Julie Ross, Dept. of Culture, Language, Elders & Youth





**Figure 3.3:** Aerial photograph of Feature 14 and 15 (Photo credit: Karen Wittke).

was occupied during the Modified Thule phase (ca. AD 1400 – 1600) (pers. com. Julie Ross 2008; *cf.* Park & Stenton 1998). Feature 15 was chosen for excavation because it was completely covered by sod and thus judged to be the least disturbed at the site. Prior to excavation, the house depression measured 7 m long by 4 m wide. It is located 28 m from the gravel extraction ridge and 108 m east of the road. Feature 15 is the most easterly feature visible on the higher beach ridge. It adjoins and has been truncated on its west side by another Thule dwelling (Feature 14). Feature 15 contains an upper deposit of debris, which is interpreted as trash associated with a later occupation of neighbouring Feature 14 (pers. com. Wittke 2008). Additional excavations carried out during the summer of 2007 confirm this interpretation. There is also a clear midden mound

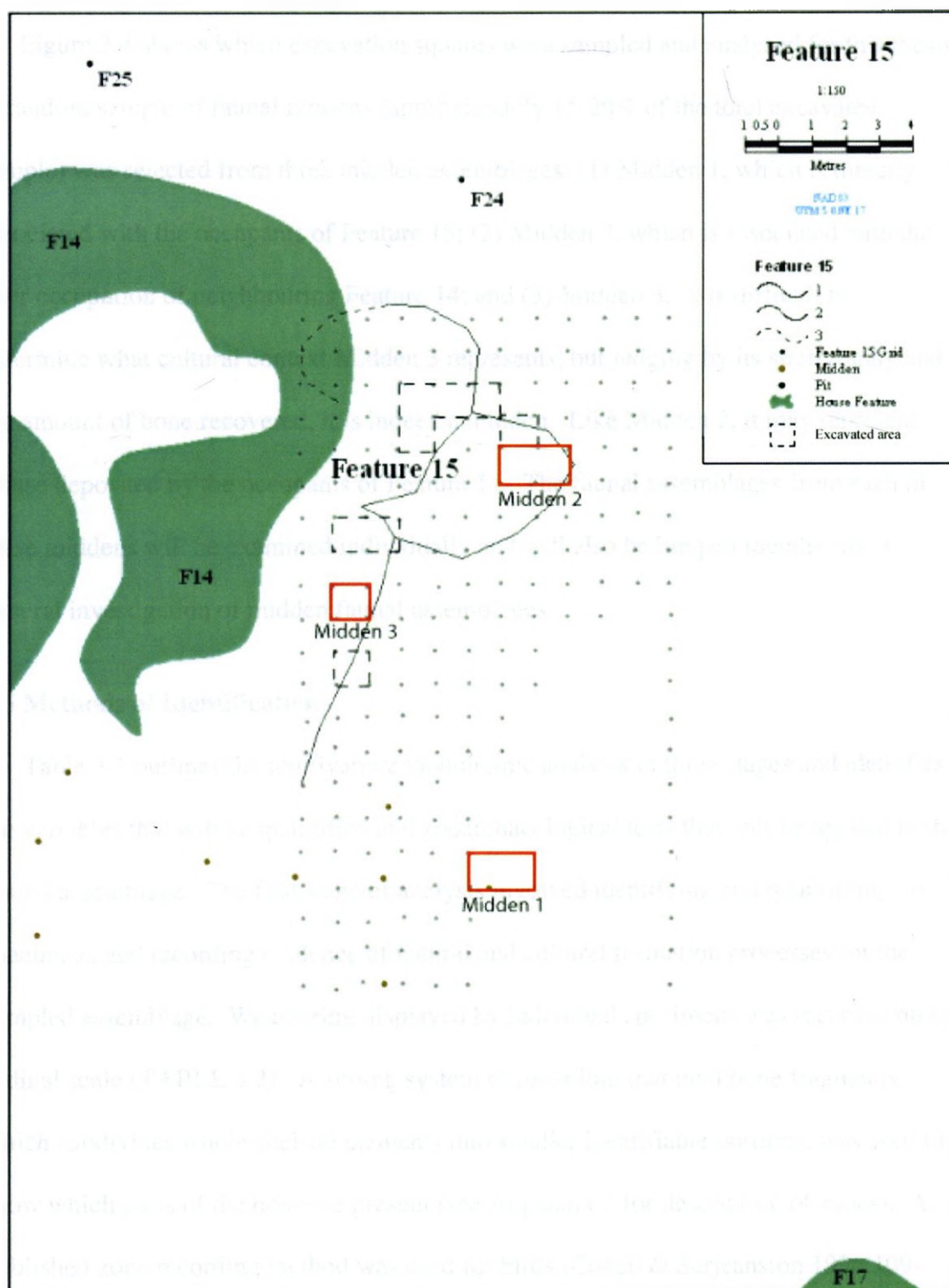


(Midden 1), measuring approximately 4 x 4 m, located in front of Feature 15. Because of this close proximity, it is assumed to be directly associated with the occupation of Feature 15.

### **3.3 Methods of Collection**

Excavations at NeHd-1 took place within a grid established on Feature 15 (FIG. 3.4). The sampling units were 1 x 1 metre squares subdivided into quadrants. Several units were placed on top of the dwelling. Two adjacent units were placed in the exterior midden associated with the house (Midden 1). In total 15 units were excavated over the course of the field season. Excavation followed natural stratigraphic layers with the intention of revealing the sequence of cultural and non-cultural processes active on the structure (*cf.* Schiffer 1987). Recovery techniques involved the use of trowels, and sediments were screened using 3 mm (1/8") mesh. Faunal materials were bagged by level and quadrant for each unit. Excavation was not completed on the main dwelling area due to time constraints, but the exterior midden (Midden 1) was excavated to a sterile sandy beach layer.

This archaeological investigation was undertaken as part of the Sanirajaq Archaeological Field School, organized jointly by the Government of Nunavut (GN) and Inuit Heritage Trust (IHT). Excavation of Feature 15 was carried out by the current author, Karen Wittke (University of Toronto), Ericka Chemko and Krista Zawadski of IHT, several Inuit high school and university students involved with the Sanirajaq Archaeological Field School, and directed by Julie Ross (GN, Department of Language, Culture, Elders, & Youth).



**Figure 3.4:** Map showing excavation grid of Feature 15. (Map credit: Steve Perry and Julie Ross, Dept. of Cultural, Language, Elders & Youth)

### 3.4 Study Sample

Figure 3.4 shows which excavation squares were sampled and analysed for this thesis. A random sample of faunal remains (approximately 15-20% of the total excavated sample) was selected from three midden assemblages: (1) Midden 1, which is directly associated with the occupants of Feature 15; (2) Midden 2, which is associated with the later occupation of neighbouring Feature 14; and (3) Midden 3. It is difficult to determine what cultural context Midden 3 represents, but judging by its stratigraphy and the amount of bone recovered, it is indeed a midden. Like Midden 2, it may represent refuse deposited by the occupants of Feature 14. The faunal assemblages from each of these middens will be examined individually and will also be lumped together for a general investigation of midden faunal assemblages.

### 3.5 Methods of Identification

Table 3.1 outlines the multivariate taphonomic analysis in three stages and identifies the variables that will be quantified and zooarchaeological tests that will be applied to the faunal assemblage. The first stage of analysis involved identifying and quantifying all specimens and recording evidence of natural and cultural formation processes for the sampled assemblage. Weathering displayed by individual specimens was recorded on an ordinal scale (TABLE 3.2). A zoning system of recording mammal bone fragments, which subdivides whole skeletal elements into smaller identifiable portions, was used to show which parts of the bone are present (see Appendix 2 for description of zones). A published zone recording method was used for birds (Cohen & Serjeanston 1996:109-112; see Appendix 3).

Identifications to the most precise taxon possible were made by the current author

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**Table 3.1: Stages of analysis.**


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**I. IDENTIFICATION & QUANTIFICATION OF VARIABLES**

1. Class; quantified using NISP  
Mammal, bird, fish, shell, indeterminate.
2. Taxon; quantified using NISP & MNI  
Family, genus, species.
3. Skeletal Element; quantified using NISP & MNE  
Cranium, femur, humerus, tibia, etc...
4. Side  
Left, right, central, indeterminate.
5. Part of element or zone  
See Appendix B
6. Fusion  
Unfused shaft & epiphysis (U), unfused shaft (S), unfused epiphysis (E), unfused centrum (C), bone fusing with the fusion line still visible (G), completely fused (F), unknown (N).
7. Fracture Type (FT)  
Helical (H), transverse (T), longitudinal & transverse (LT), diagonal (D), columnar (C), irregular (I).
8. Fresh Fracture Index (FFI)  
Based on three criteria: fracture outline, fracture angle, edge texture  
On ordinal scale: 0-6
9. Natural Modification  
Presence/absence: root etching (RE), abrasion (A), rodent gnawing (RG), carnivore damage (CD), corrosion (C).  
On an ordinal scale (1-5): weathering stage (W), see Table 3.2
10. Cultural Modification  
Presence/absence: cut marks (CM), impact scars (IS), burnt (B), flaking (F), polishing (P).

**II. INVESTIGATION OF TAPHONOMIC HISTORY**

1. Analyses of density-mediated attrition
  - a. bone survivorship (%MAU) and bone mineral density.
2. Analyses of fragmentation
  - a. histogram of bone fragments in different size classes (% frequency).
3. Analyses of natural and cultural formation processes
  - a. distribution of identified bone modifications (% frequency)

**III. ASSEMBLAGE SUBGROUP COMPARISONS**

1. Comparison of above attributes between midden deposits/contexts, including:
    - a. Midden 1, associated with occupants of Feature 15.
    - b. Midden 2, associated with the later occupation of neighbouring Feature 14.
    - c. Midden 3, potentially associated with Feature 14.
-

Weathering Stage	Description
0	Greasy, no cracking or flaking
1	Longitudinal and mosaic cracking
2	Exfoliation, flaking of outer surface
3	Homogeneously rough, crack edges are round, penetrates 1-1.5 mm
4	Coarsely fibrous and rough, loose splinters, open cracks, weathering penetrating inner cavities – extensive exfoliation
5	Bone falling apart <i>in situ</i> , large splinters present, bone material very fragile

**Table 3.2:** Weathering stages recorded on specimens (after Behrensmeyer 1978; Lyman 1994).

using the comparative faunal collection at the Zooarchaeology Laboratory, Department of Anthropology, University of Western Ontario. This was further augmented by material at the Howard Savage Faunal Archaeo-Osteology Laboratory at the University of Toronto, with the kind permission of Dr. Max Friesen, and the ornithology collection at the Royal Ontario Museum, with the assistance of Mark Peck. Each identified specimen was assigned a catalogue number and recorded directly into Filemaker Pro 8.5 (for Mac OSX) database.

### 3.6 Methods of Quantification

The quantitative methods employed in the first stage of analysis include: (1) the number of identified specimens (NISP); (2) the minimum number of individuals (MNI); and (3) the minimum number of elements (MNE). NISP and MNI were used to estimate the relative frequencies of taxa in the faunal assemblage. NISP is a simple tally of all specimens, individual bones or teeth, or fragments thereof, assigned to a particular taxonomic category (Grayson 1984:17; Lyman 2005:846). MNI is defined as the smallest number of complete individual animals necessary to account for the specimens



in the faunal assemblage (Grayson 1979:203). There are multiple ways of deriving MNI values, with varying degrees of accuracy and preciseness (*cf.* Reitz & Wing 1999:194-199). Here, MNI is only calculated for specimens identified to the species level by taking the skeletal element, part of the element (*i.e.* zone), and its side (where applicable) into account. Finally, MNE was employed to estimate the relative frequency of specimens from different parts of the walrus skeleton in order to address questions regarding butchery, transport, and disposal habits. Like MNI, it is a derived measure, an estimate of the smallest number of some specific element that could be represented by the faunal assemblage (Lyman 1994:102). MNE estimates are based on a consideration of element portion (*i.e.* zone). To allow for comparisons between elements found in different frequencies in a single skeleton, MNE values are converted into the minimum number of animal units (MAU) by dividing each value by the number of times the element is present in a complete skeleton. NISP, MNE and MAU are used in each individual midden and recalculated when middens are lumped together as one aggregate. MNI is calculated exclusively for middens treated individually.

The quantification and assessment of the relative importance of different species in a faunal sample has always been a major issue in zooarchaeology. Grayson (1979; 1984) provides an overview of these concerns focusing on the quantification of taxonomic abundances using NISP and MNI. Here, he stresses that NISPs cannot be shown to be independent of one another. In other words, there is no way of knowing whether each specimen came from a different individual. MNI avoids these interdependence difficulties because of the way it is calculated, always counting bones that could potentially be from the same skeleton as a single individual, however they tend to

underestimate the number of individuals present in an assemblage. They also encounter problems when different aggregation units are used (Grayson 1979:203-204). Increasing the number of aggregation units (for example, dividing a house assemblage by strata or into single excavation units) will usually increase the MNIs per taxon. Consequently, when studying MNI values, an analyst not only studies taxonomic abundances, but also the decisions made concerning aggregation (Grayson 1984:49). Because MNE is based on similar principles, it is plagued by the same problems as MNI (Lyman 1994:102). Due to these concerns and the nature of archaeological faunal data, Grayson (1979:223) concludes that the taxonomic and skeletal abundances derived from archaeological faunal samples can only provide nominal or ordinal level information.

Many faunal collections have been analyzed using the above counting approaches, however, how well these methods actually quantify the living community of animals or deposited assemblage is difficult to determine. The path of bone from the kill site, through processing, storage, consumption and disposal is so complex that it is impossible to move directly from bone counts to paleoeconomy. Furthermore, the deposited assemblage continues to be affected by other mechanical agents like trampling or the pressure of overlying sediments, or chemical change and decomposition (Hall 1990; Ringrose 1993:124). The operations of all these various processes mean that almost all information relating to absolute abundances is lost, and even relative abundances can be severely distorted. Detailed studies of the taphonomy of archaeological faunal assemblages can help us to interpret these values more effectively.

### 3.7 Methods of Taphonomic Analysis

Many of the analytic methods described above do not take into consideration the formation processes that created the faunal assemblage. Given that middens traditionally serve as the final repository for most food waste in prehistoric and historic cultures, it becomes especially important to understand how these assemblages were formed. Interpretations must consider not only human activities, but also a wide range of natural taphonomic factors.

The second stage of analysis will lump all samples together for a general investigation of the formation processes acting upon Thule midden assemblages. Many kinds of bone destruction, including organic decomposition, are density-mediated. In other words, the denser the element the less destruction it suffers (Lyman 1984a, 1994). Consequently, density-mediated attrition produces faunal assemblages in which dense bone portions are over-represented. However, many natural and cultural processes, including human transport behaviours, can create similar patterns (*cf.* Bar-Oz & Munro 2004; Lyman 1985, 1994, 2004; Munro & Bar-Oz 2004; Rogers 2000). A good starting point in identifying attritional agents is to compare bone survivorship against structural density (Bar-Oz & Munro 2004:206; Lyman 1994). This should reveal a positive correlation, suggesting that destruction has occurred, or no correlation at all. This technique will be applied to the most abundant species in the faunal assemblage. Skeletal part representation will also be compared against the ethnographic record to determine what impact prey transport, butchery, and disposal habits may have had on the assemblage.



Other analyses at this second stage will consider the impact bone fragmentation may have had on the formational history of the faunal assemblage. An effective way to describe levels of fragmentation is to measure fragments and create a histogram of the frequency of fragments in different size classes (Outram 2001:404). If most bone fragments fall into the smaller size classes and few survive whole or in larger size classes, this would suggest that the assemblage was heavily fragmented. Following Outram (1999, 2001, 2002), the freshness fracture index (FFI) will also be calculated when possible to determine if marrow extraction contributed to the fragmentation of land mammal specimens.

For the most part, the zooarchaeological analyses outlined above only identify and measure taphonomic patterns or traces -- the result of a taphonomic process acting on faunal material and the physical modification of a bone (Marshall 1989:8; Lyman 1994:3-4). Which taphonomic agents created these traces thus becomes the focus of further analysis. This second stage of the taphonomic analysis will also inspect the proportion of specimens that display carnivore damage, cut marks, flake and impact scars, the weathering stages displayed by individual specimens (see Table 3.2), and other variables known to be taphonomically interrelated with fragmentation processes and density-mediated attrition. Taphonomic variables were selected based on their relevance to Thule site formation, and include the products of both natural factors and human behaviour. Based on the prevalence of different taphonomic indicators, it may be possible to identify the primary agents of assemblage attrition.

Since only an “average” signal is obtained if formation processes are examined at the site level, the third stage of analysis will divide the complete faunal assemblage into

subgroups. Here, the faunal assemblage is divided into the three different midden assemblages described earlier. Many taphonomic agents (human and non-human) often do not act equally on all deposits (Bar-Oz & Munro 2004:202). The point of isolating each deposit or context is to make us more aware of similarities or differences between the mix of factors that fit together and make up the archaeological record. In other words, subgroup comparisons will allow us to examine the degree of variability in the formation and preservation of different Thule midden contexts at a single site.

Archaeologists cannot assume that all midden assemblages are directly comparable because of the potential complexity involved in their formation. The archaeologist is forced to investigate formation processes, assessing what impact they may have had on each faunal assemblage. Failure to acknowledge and identify these processes can severely bias inferences. Through the application of the multivariate taphonomic approach, we can account for variability in formation and preservation between individual faunal assemblages and draw more informed inferences regarding human behaviour. Such analyses will provide a strong foundation for further inter- and intra-site comparisons to be made.

## **Chapter 4**

### **RESULTS**

#### **4.1 Introduction**

The goal of this chapter is to present a taphonomic analysis of the vertebrate faunal remains recovered from NeHd-1 during the summer of 2006. It will focus on the ways in which human behaviour and natural factors shaped the formation of three Thule middens at the site. A multivariate taphonomic approach will be used to determine the most significant agents of assemblage formation. An important feature of this approach is the comparison between the three middens, which provides a higher degree of resolution with respect to an assemblage's taphonomic history (Bar-Oz & Munro 2004).

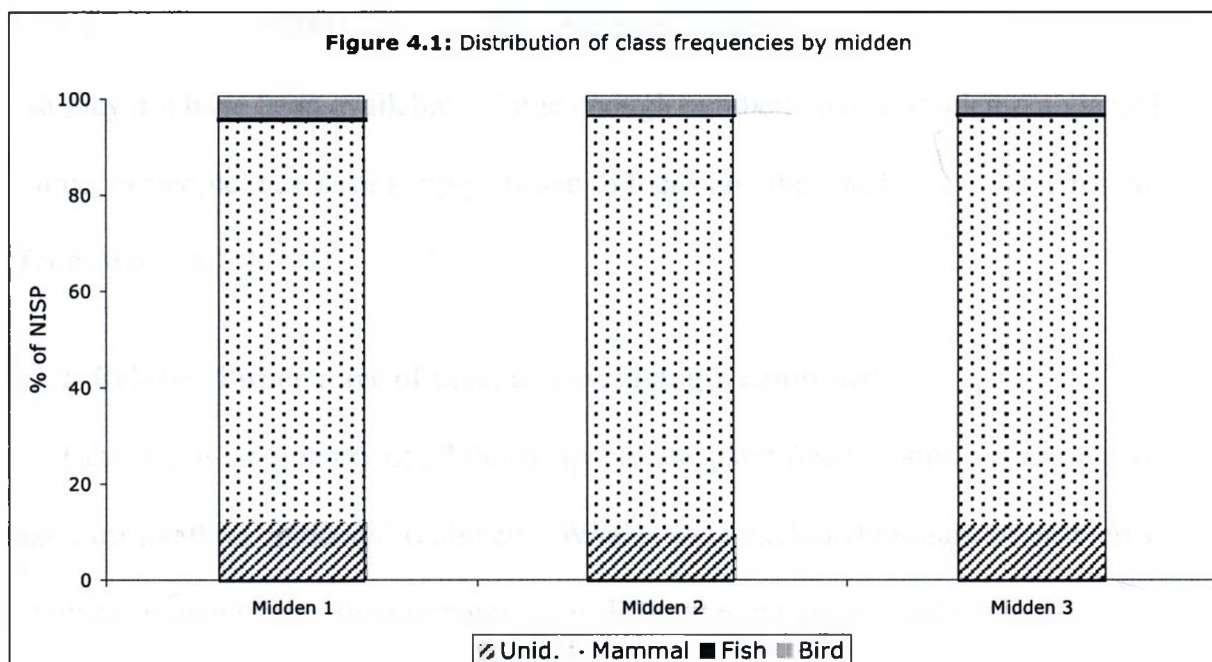
Taphonomic agents often do not act equally on all subgroups of the whole faunal collection (Bar-Oz & Munro 2004:202; Bonnicksen 1989a:2), so the comparative approach taken here will allow us to gain a better understanding of the variability in formation and preservation of the different refuse deposits, allowing us to make more informed interpretations of Thule subsistence behaviour.

#### **4.2 Taxonomic Frequencies**

A total of 6,974 faunal specimens were analyzed from the sampled units. Table 4.1 lists the NISP for each taxon identified, by midden assemblage and for all assemblages combined. MNI was also calculated for specimens identified to species (refer to chapter 3 for methods used to calculate MNI). Appendix 1 contains other tables of raw data used to create the figures in this chapter.

**Table 4.1:** Taxonomic frequencies by midden

TAXON	MIDDEN 1		MIDDEN 2		MIDDEN 3		TOTAL
	NISP	MNI	NISP	MNI	NISP	MNI	NISP
Seal	7		4		6		17
Phocid Seal	64		51		81		196
Ringed Seal	50	2	13	1	37	3	100
Harp Seal	3	1	4	1	1	1	8
Bearded Seal	51	4	43	2	57	1	151
Lg. seal	17		15		5		37
Lg. seal/Walrus	38		24		17		79
Walrus	193	5	97	3	98	3	388
Walrus/Whale	0		0		1		1
Whale	29		31		15		75
Bear	1	1	0	0	0	0	1
Caribou	49	3	21	2	6	1	76
Canis sp.	2		2		1		5
Dog/Wolf	26	2	30	2	11	2	67
Arctic Fox	142	4	107	2	80	3	329
Arctic Hare	1	1	0	0	0	0	1
Rodent sp.	0		3		0		3
Lemming	8		9		10		27
Unid. Sea Mammal	402		217		95		714
Unid. Land Mammal	96		33		14		143
Unid. Mammal	1943		1136		388		3467
<b>TOTAL MAMMAL</b>	<b>3122</b>		<b>1840</b>		<b>923</b>		<b>5885</b>
Loon sp.	0		2		1		3
Red-Throated Loon	0	0	3	1	0	0	3
Anatid	0		1		0		1
Goose sp.	2		0		1		3
Duck sp.	3		6		7		16
Eider sp.	7		9		4		20
Common Eider	1	1	0	0	0	0	1
Long-Tailed Duck	1	1	1	1	0	0	2
Gull Sp.	9		1		0		10
Arctic Tern	1	1	1	1	0	0	2
Unid. Bird	116		40		17		173
<b>TOTAL BIRD</b>	<b>140</b>		<b>64</b>		<b>30</b>		<b>234</b>
Salmonid sp.	12		2		3		17
Lake Trout	2	1	0	0	0	0	2
Arctic Char	10	3	2	1	5	1	17
Unid. Fish	5		8		1		14
<b>TOTAL FISH</b>	<b>29</b>		<b>12</b>		<b>9</b>		<b>50</b>
<b>MOLLUSCA</b>	<b>3</b>		<b>1</b>		<b>3</b>		<b>7</b>
<b>CLASS UNID.</b>	<b>456</b>		<b>210</b>		<b>132</b>		<b>798</b>
<b>TOTAL</b>	<b>3750</b>		<b>2127</b>		<b>1097</b>		<b>6974</b>



#### 4.2.1 Class frequencies

As an initial attempt to determine the impact of taphonomic factors on the animal assemblage, faunal classes from the three midden assemblages are now compared (FIG. 4.1). Class frequencies are similar across the midden contexts, with mammals being the most common. Few birds and fish were recovered. This observation may potentially reflect a general pattern of loss and discard. During periodic cleaning of Thule dwellings, larger mammal bones were probably removed most frequently, while smaller bones, especially birds and fish, would be more likely to be overlooked (Binford 1978a:356; Friesen & Betts 2002:69; Schiffer 1983:679). There is also a greater chance that fish and bird bones could be lost between the bench and floor (Friesen & Betts 2002:69). Another factor, which may contribute to these class frequencies, is carnivore damage. The Thule kept domestic dogs to help expand hunting ranges and to haul sleds of food and equipment to new settlements (Maxwell 1985:248). Dogs would have had ready access to the midden, and can easily consume small fish and bird bones (Friesen & Betts



2002:69; Whitridge 2001:37). Finally, depending on the season of occupation, birds and fish may not have been available in large enough numbers to be considered a viable food source, or people may have simply chosen to focus on other, widely available resources (Whitridge 2001:42-43).

#### **4.2.2 Relative importance of taxa, all assemblages combined**

Table 4.2 is a summary of all faunal specimens identified to Family or more precise taxon for the three middens combined . Whales were excluded because of problems involved in quantifying their remains. It is difficult to compare whale bone counts because these large bones are rarely collected during excavation. Furthermore, the use and re-use of whale bone for house construction by Thule people means that they cannot be considered reliable indicators of whale consumption at a particular site (Kankaanpää 1996:152; Morrison 1983; *cf.* Freeman 1979). Whale bone fragments that were part of the collected faunal assemblage have been quantified and included in Table 4.1. Since they cannot be directly compared with other species, they will be excluded from the remainder of the analysis. Determining the relative abundances of ringed and harp seal was complicated by strong morphological similarities and a degree of overlap in size between the two species, which makes positive identification of several skeletal elements difficult (Hodgetts 2005:63; *cf.* Hodgetts 1999: Appendix B). In summarizing the data, they were grouped together in a phocid seal category. A similar problem was encountered with some fragmented bearded seal and walrus bones. These were identified as large seal/walrus and were combined with large seal remains in a large pinniped category. Finally, because of the difficulties in distinguishing between wolves and domestic dogs, they were combined in a dog/wolf category.

**Table 4.2:** Summary of identified faunal remains, all assemblages combined

<b>TAXON</b>	<b>NISP</b>	<b>% of NISP</b>
<b><i>Sea Mammal</i></b>		
Phocid Seal	304	19.8
Bearded Seal	151	9.8
Walrus	388	25.3
LG Pinniped	116	7.6
<b>Subtotal</b>	<b>959</b>	<b>62.5</b>
<b><i>Land Mammal</i></b>		
Bear	1	0.1
Caribou	76	5.0
Canis Sp.	5	0.3
Dog/Wolf	67	4.4
Arctic Fox	329	21.4
Arctic Hare	1	0.1
<b>Subtotal</b>	<b>479</b>	<b>31.2</b>
<b><i>Bird</i></b>		
Loon sp.	3	0.2
Red-Throated Loon	3	0.2
Anatid	1	0.1
Goose sp.	3	0.2
Duck sp.	16	1.0
Eider sp.	20	1.3
Common Eider	1	0.1
Long-tailed Duck	2	0.1
Gull sp.	9	0.7
Arctic Tern	2	0.1
<b>Subtotal</b>	<b>61</b>	<b>4.0</b>
<b><i>Fish</i></b>		
Salmonid Sp.	17	1.1
Lake Trout	2	0.1
Arctic Char	17	1.1
<b>Subtotal</b>	<b>36</b>	<b>2.3</b>
<b>TOTAL</b>	<b>1535</b>	<b>100.0</b>

**Table 4.3:** Meat weights for most significant species identified

<b>Taxon</b>	<b>WGT per individual (kg)</b>	<b>Edible tissue by % of WGT</b>	<b>Available meat per individual (kg)</b>
Dog/Wolf	20	50	10
Arctic Fox	3.2	50	1.6
Ringed Seal	91	70	67.9
Bearded Seal	280	70	196
Walrus	665	70	465.5
Caribou	95.4	50	47.7

All meat values, with the exception of walrus, taken from Friesen & Arnold (1995:26).

Walrus meat weight value is the average derived from average weights for male and female adult Atlantic walrus, provided in Banfield (1974:393).

Sea mammals dominate the assemblage, comprising 62.5% of the identified specimens (NISP), followed by land mammals at 31.2%. Of the identified mammals, walrus are the most frequently occurring species. Among Inuit groups, walrus have traditionally served as a very important resource providing hunters with valuable ivory and large quantities of meat and fat (Boas 1964; Crowe 1969; Kemp 1976; Nelson 1969; *cf.* Dyke et al. 1992:172). Arctic fox ranks second in terms of NISP, however if meat weights are taken into account, it becomes clear that phocid and bearded seals ranked second after walrus in terms of dietary importance (TABLE 4.3). Other mammalian taxa are present in relatively low frequencies. Although few in number, the fish remains are dominated by a single species, with Arctic char comprising 89.5% of fish identified to the species level. Among the birds, eider ducks dominate the assemblage.

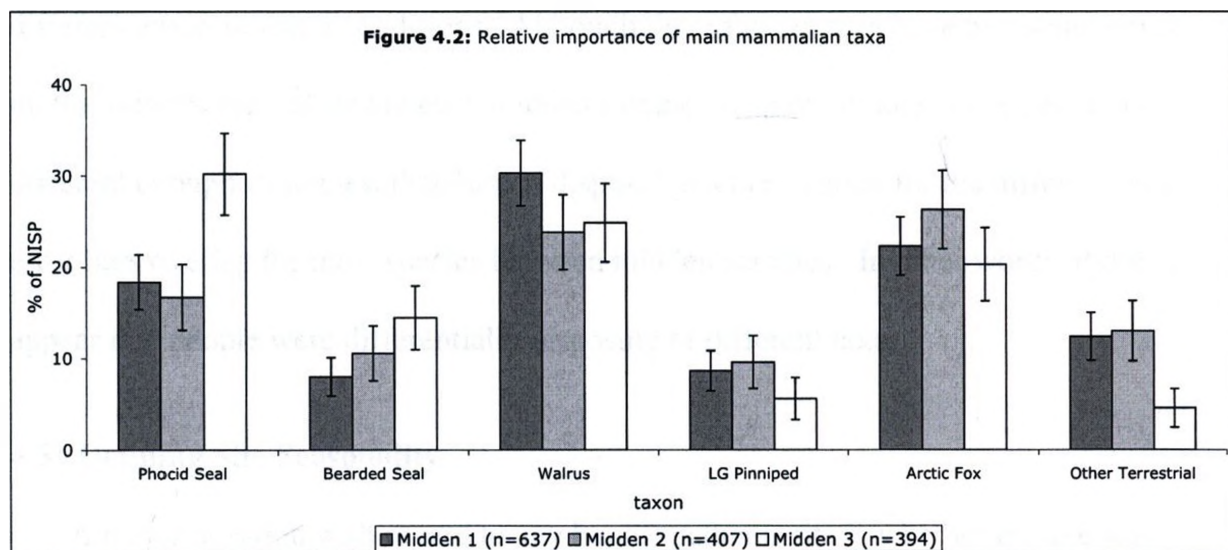
The frequency of walrus at the site is somewhat unusual among Thule assemblages and may relate to the availability of the species in the region (see Dyke et al. 1992; Lofthouse 2003; Porawski 2007). The Foxe Basin, where NeHd-1 is located, has a high level of marine productivity that allowed prehistoric hunter gatherer groups to live in the area successfully (Crowe 1969:5; Sabo 1991:26; Murray 1996:13). Walrus are generally present year-round and in large herds, and conditions for ringed and bearded seal are also



favourable (Crowe 1969:5; Murray 1999:476). These species are all ice-dependent, moving in and offshore depending upon sea ice conditions and time of year (Murray 1996:19). Consequently, the distribution of winter land-fast ice and pack ice, along with formation and break-up processes, can have an important impact on their availability. In most areas in the Arctic, winter sea ice generally lasts for eight to ten months of the year (Sabo 1991:26). The generally continuous availability of walrus is due to the presence of shallow open waters (less than 80 m), which provide access to extensive mollusc feeding areas (Murray 1996:20, 1999:476). Complicated patterns of near shore sea currents and tides also delay autumn sea ice formation and contribute to ice movement during winter months (Crowe 1969:2; Fitzhugh 1976:145; Sabo 1991:26). This provides access to walrus and other seal species for floe edge hunting during the winter, and open water hunting during the summer.

#### **4.2.3 Comparison of major taxa between midden assemblages**

It is difficult to discern whether taxonomic frequencies within the fish and bird categories differ markedly between the different midden contexts. Any variability that does exist probably reflects random variation due to the small sample sizes. However, for the mammalian species there are noteworthy differences between the midden samples. Figure 4.2 presents the NISPs grouped into six general taxonomic categories: phocid seal (ringed and harp seal), bearded seal, walrus, large pinniped (large seal and large seal/walrus), arctic fox, and other land mammals (primarily caribou and dog/wolf). The vertical line in the centre of each bar indicates the 95% confidence limits based on the standard error for the proportions of each species. Again, sea mammals dominate each midden assemblage, however Midden



3 has higher numbers of phocid seal remains. It also has the lowest frequency of 'other terrestrial' mammals (caribou and dog/wolf). Because the error bars do not overlap, these observed differences are significant at the 0.05 level, and may have resulted from differences in availability due to different seasons of occupation or changing environmental conditions.

Hunter-gatherer sites are often occupied seasonally, in order to allow their occupants to exploit seasonally available resources. Midden 3 may represent a slightly different season of use than the others. Shifts in climate can also have an unpredictable influence on caribou availability by placing them under physiological stress and/or altering their migratory patterns (Gunn et al. 2006; Maxwell 1985:33). Distributions of seals, whose way of life is closely tied to sea ice conditions, can also be altered by climate change. During warm periods, the extent of winter and spring fast-ice may disappear too early, drastically reducing seal populations, the size of each individual, and shortening their breeding season (Maxwell 1985:33; Murray 2005:20; Smith et al. 1991). Midden 3 may have been formed a number of years after the other two middens, under

different environmental conditions. Although these factors may have had some impact on the animals represented in each midden sample, the pattern does not appear to be different enough to suggest that human disposal practices varied for the different taxa; error bars overlap for most species between midden samples. In other words, it does not appear that people were differentially disposing of different taxa.

### **4.3. Defining Site Seasonality**

A major question with regard to any hunter-gatherer site is whether the site was seasonally occupied, and if so in which season (Hodgetts 2005; Murray 1996; Rowley-Conwy 1995; Spiess 1976; Woodborne et. al. 1995). Seasonality may be an important taphonomic variable in explaining why certain animals become part of the faunal assemblage. The availability and abundance of certain animals may vary during parts of the year, and subsistence strategies must include responses to such seasonal changes (Reitz & Wing 1999:255). People adjust by storing food, moving to more favourable locations, and choosing different sets of resources. It is therefore necessary to consider whether seasonal differences account for the patterns observed in the faunal record.

Arguments about season of site occupation are based on the presence or absence and seasonal availability of animal species identified in the faunal assemblage. Table 4.2 presents a list of the taxa identified in the faunal sample at NeHd-1. The seal species, walrus, arctic fox, and caribou represent the bulk of the archaeological material. It is difficult to assess seasonality using these species because they are locally available throughout the year (Brody 1976:160, 166; Crowe 1969:2, 9; Murray 1996:51). Ethnographic accounts may provide suggestions regarding any potential season specific procurement of these species.

In historic times, the area offshore from Hall Beach had the best year-round walrus hunting conditions in the region and provided an excellent spring outpost for ringed seal and bearded seal (Crowe 1969:51). Ringed seals pup in large numbers about the beginning of April and bearded seals in late April and early May (Banfield 1974:336, 374; Murray 1996:53). The presence of 20 foetal/neonate seal specimens in the faunal assemblage suggests some procurement of these species during late winter and very early spring. However, seals could have been hunted on open water into the fall and on the sea ice during winter. Although waterfowl did not contribute significantly to the Thule diet, the presence of eider ducks and gulls implies that the site was also occupied in late spring and summer, when these species migrate to the area (Brody 1976:170; Montgomerie 1983:70). Caribou in this region show marked shifts in range and population, but historically were successfully hunted north and west of Hall Lake toward the end of summer and early fall, when skin for garments were at their best (Brody 1976:159-160; Crowe 1969:51). In the early 1900s, the Iglulingmiut residing in the Foxe Basin region typically divided into groups of older and younger hunters, the older ones staying on the coast to hunt walrus and the younger moved inland for caribou hunting (Damas 1969; Whitridge 2001:18). The small number of caribou identified in the sample suggests that the Thule may have acted in a similar manner, moving inland into temporary camps in late summer/early fall to take advantage of this resource, and bringing back stores of dried meat and skins for garments. While inland, the Thule could have also fished for arctic char and lake trout, which spawn at about the same time in the fall. Fishing from Hall Beach was historically concentrated on Hall Lake, and the Ikarktoriak and Shagvak rivers that flow into Foster Bay (Brody 1976:168-169; Crowe 1969:51). However, fish

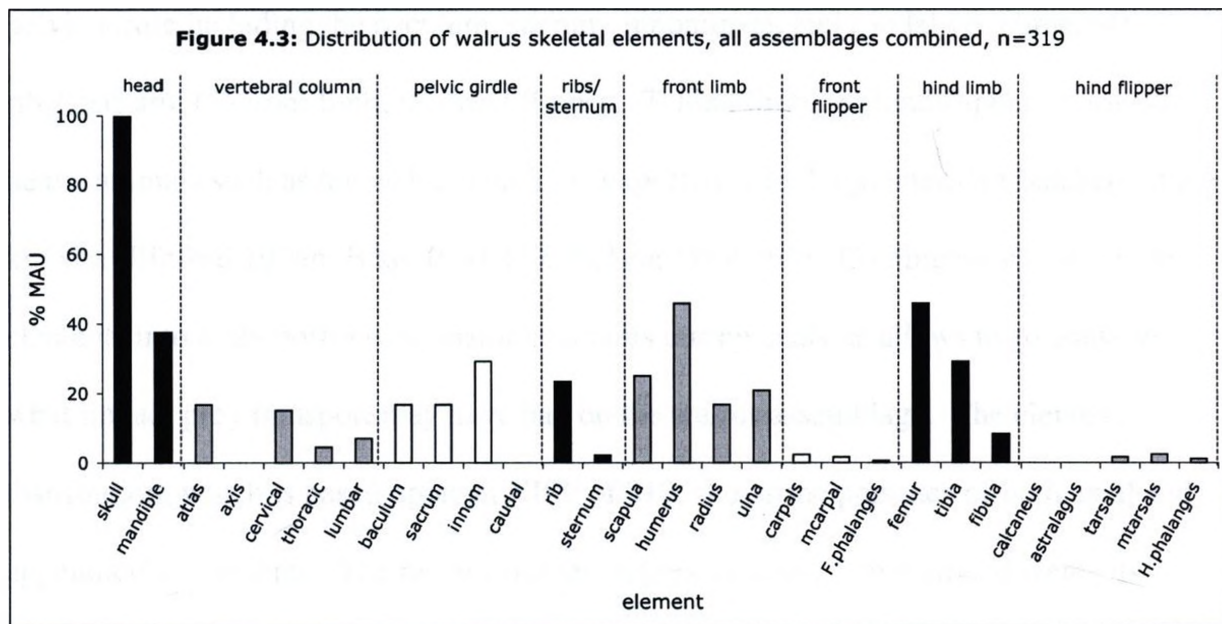


probably served a minor dietary role for the Thule because of the scheduling conflict with walrus and caribou hunting (Whitridge 2001).

The species composition of NeHd-1's faunal assemblage does not provide any strong seasonal indicators; however, the presence of some foetal/neonate seal specimens and migratory waterfowl suggests at least a spring occupation. Considering that seal and walrus are present in the area year-round and dominate the assemblage (particularly walrus), it is likely that the site was also occupied in the winter. This interpretation is supported by the site architecture, which is composed of the Thule semi-subterranean houses traditionally associated with a cold season occupation (Maxwell 1985:283-285; McCartney 1979:302; Park 1988:168-170). Low frequencies of caribou and fish bones identified in the sample may represent stored foods acquired at temporary inland camps, possibly toward the end of the summer or early fall.

#### **4.4 Walrus Skeletal Part Frequency**

One of the most readily observed properties of a faunal assemblage is the frequency of different skeletal elements present in the collection (Lyman 1994:223; Marshall 1989:9). Following the death of an animal, the original skeleton becomes increasingly fragmented and depleted (Munro & Bar-Oz 2004:2). Element frequencies of a bone assemblage usually differ from of a complete skeleton because of the action of: (1) differential destruction, or attrition, by natural factors; and/or (2) selective transport by humans from kill site to base camp (Gifford 1981:400). The comparison of the relative frequencies of skeletal elements observed in the faunal record with a complete skeletal model identifies what parts of the skeleton are under or over-represented (Munro & Bar-



Oz 2004:2). This provides a good starting point in identifying why and how specific parts were removed from the assemblage.

Walrus bones make up the great majority of the mammalian remains at NeHd-1, providing an opportunity to examine element representation and density-mediated destruction in detail. Unfortunately, sample sizes for other species are too small to usefully compare element distributions and determine patterns of density-mediated attrition.

#### 4.4.1 Distribution of walrus skeletal elements, all assemblages combined

Initial exploration of bone representation was undertaken through a detailed inspection of walrus skeletal part profiles. Figure 4.3 presents the distribution of walrus element frequencies expressed as % MAU for all assemblages combined (refer to chapter 3 for methods used to derive MAU). The data in Figure 4.3 are partitioned according to ethnographically described butchering packages (Nelson 1969:366-369). These are: (1) head; (2) vertebral column including the cervical, thoracic, and lumbar vertebrae; (3)

pelvic girdle including the baculum, sacrum, innominate, and caudal vertebrae; (4) ribs/sternum; (5) front limb; (6) front flipper; (7) hind limb; (8) hind flipper. Large and heavy animals such as the walrus would be expected to undergo intensive butchery at the kill site (Binford 1978b; Boas 1964:114; Nelson 1969:368). Compression of individual elements into body portions or anatomical units during analysis allows us to consider what impact prey transport may have had on the walrus assemblage. The element distribution, which is based upon an NISP of 319, shows the presence of both axial and appendicular elements. The fairly complete representation of post-cranial elements suggests that walrus hunting occurred locally and most if not all body parts were transported back to the home base (*cf.* Lofthouse 2003:82). However, some notable patterns are present.

Walrus crania were the most abundant element in the combined assemblage. This suggests that ivory was a valued material used for tool manufacture. Direct evidence of ivory extraction was found on several walrus skull specimens, including impact scars on the anterior alveolus of four specimens. Skulls were also typically broken sagittally into left and right maxillae and right and left calva. This pattern was also observed at several Late Dorset walrus hunting sites on Little Cornwallis Island and was interpreted as the first step taken before extracting the ivory tusk from its alveolus (Lemoine & Darwent 1998:76-77). Ivory debitage was also very common at NeHd-1.

Vertebrae are relatively rare, and the axis and caudal vertebrae are completely absent. Sternums are also very rare. It is not clear why these differences occur, but it is possible they were abandoned during butchery or that they have not survived because they are relatively low in density and easily destroyed. Of particular note is the fact that

front and rear flipper bones are found in the lowest numbers. Among ethnographically known Arctic hunter-gatherer groups, flippers of many pinniped species were considered favoured delicacies and were usually the last portions left behind at the kill site (Diab 1998:11; Friesen & Betts 2002:71; Murray 2000:62; Nelson 1969:368, 372).

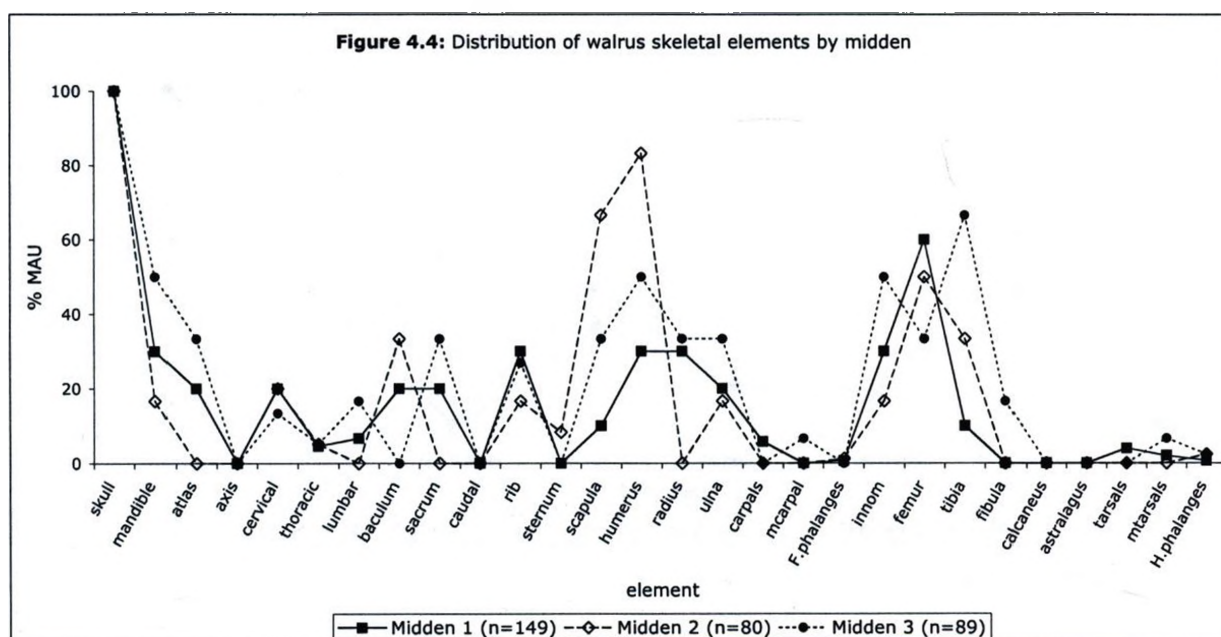
Furthermore, flipper bones represent some of the densest elements making up the walrus skeleton. It is unlikely these were destroyed by attritional agents, considering that elements of lesser density are present in the assemblage (Marean 1991). It is tempting to interpret this pattern as evidence of selective transport and/or discard of prized body portions treated differently from the rest of the skeleton. However, it is just as likely that this pattern is a result of simple loss and discard. Considering that walrus carpals, tarsals, and phalanges are all small bones, it is more likely that they were overlooked during cleaning episodes and lost on the living floor or bench of the dwelling instead of being discarded in the midden (Friesen & Betts 2002:71).

#### **4.4.2 Distribution of walrus skeletal elements in each midden assemblage**

Figure 4.4 presents the walrus element frequencies expressed as % MAU for each of the midden assemblages. The general pattern appears to be very similar in all three middens. All skeletal part profiles include few flipper bones, sternum, and vertebrae excluding the cervical, but are rich in cranial, rib, and limb bones. However, some differences in element frequencies are evident between the samples.

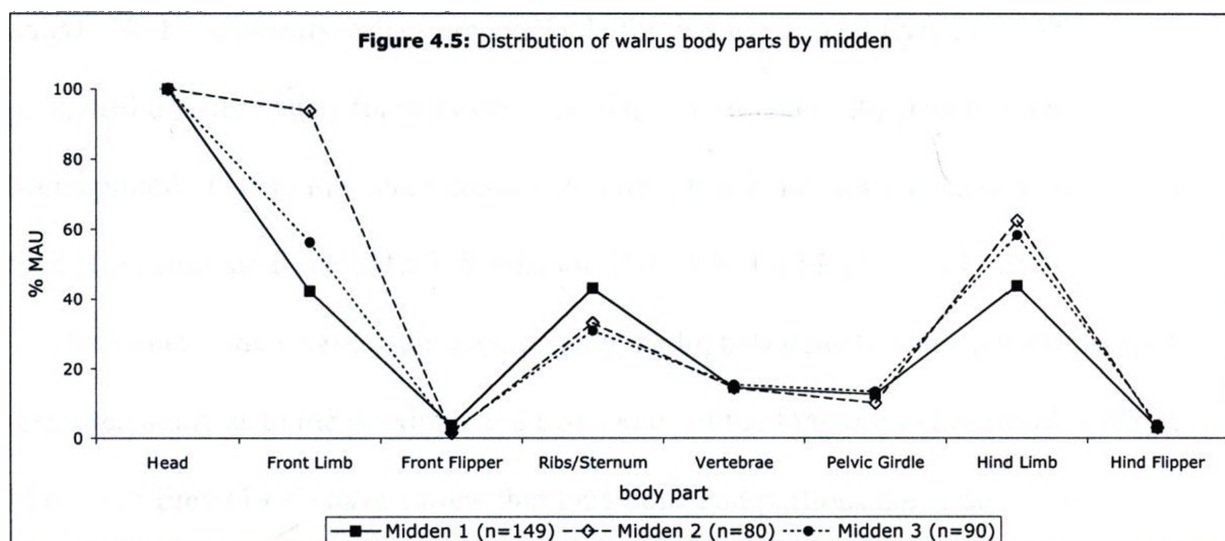
The scapula and humerus occur in proportionally higher frequencies in Midden 2 than the other midden assemblages. It is not clear what agent created this pattern, but it appears that these elements may have been treated as a butchery unit. This type of patterning could be explained by differential element transport or sharing of meat





packages (*cf.* Murray 2005). There is also an inverse relationship for lumbar, baculum, and sacrum bones between Midden 2 and Midden 3. This fluctuation in element frequencies suggests that walrus were further dismembered, possibly after transport from the kill site, and deposited as separate elements. However, this pattern could also result from an inadequate sample size. For Midden 3, the same elements are almost equally represented, suggesting they were deposited as a unit.

To permit a more robust explanation of walrus element frequencies, individual elements were compressed into anatomical units. Individual elements were aggregated into the eight major butchery units outlined previously. Figure 4.5 presents the distribution of walrus body portions expressed as % MAU for each of the midden assemblages. Again, the patterns in each sample are very similar. Flipper bones are under-represented for each of the three samples, which is probably the result of loss and discard, and front limbs again occur in proportionally higher frequencies in Midden 2. It is not clear what agent created this observed difference. It may be attributable to a



number of factors including: (1) differential element transport; (2) sharing of meat packages leading to differential disposal; (3) selective carnivore damage; and (4) an inadequate sample size ( $NISP < 100$  for Middens 2 and 3). However, the overall pattern does not appear to be different enough to suggest that human disposal practices varied for each walrus body part. In other words, there appears to be little deliberate differential disposal of walrus body parts in the three midden assemblages.

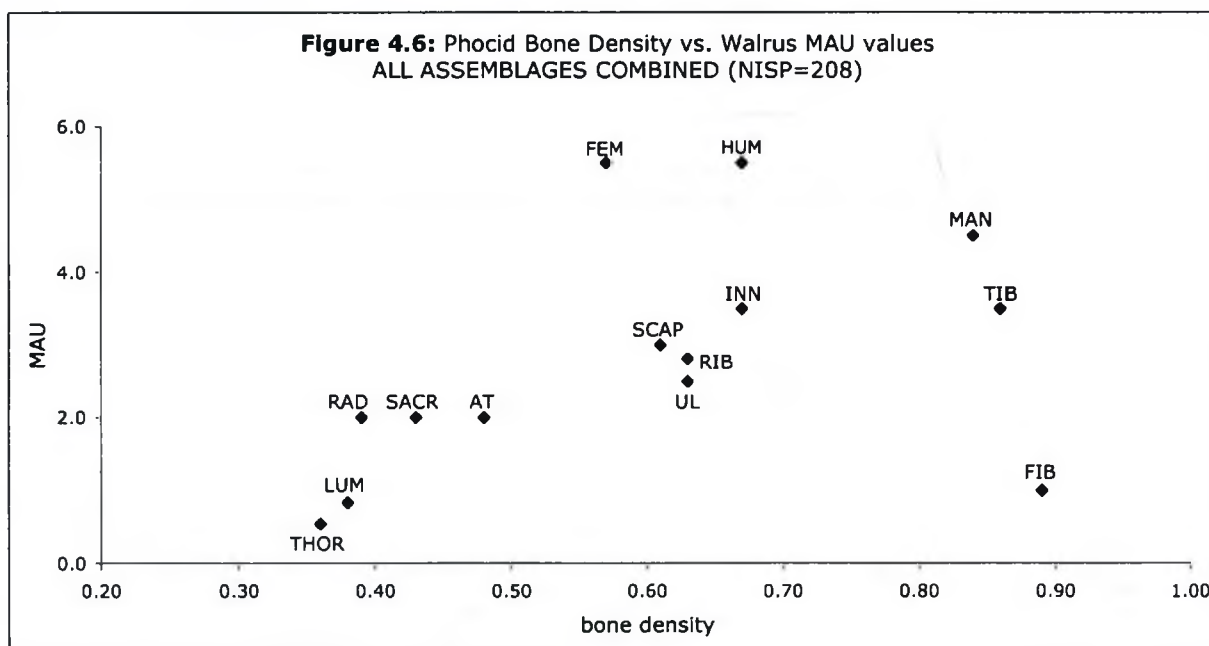
#### 4.4.3 Application of phocid seal bone density indices to the walrus assemblage

Skeletal part representation has also been employed to evaluate the effects of natural factors upon the walrus assemblage. Many kinds of bone destruction, including organic decomposition, are density-mediated. In other words, the denser the element the less destruction it suffers (Lyman 1984a, 1993, 1994). Consequently, density-mediated attrition produces faunal assemblages in which dense bone portions are over-represented. Plotting bone survivorship against structural density should reveal a positive correlation, suggesting that destruction has occurred, or no correlation at all (Lam et al. 2003:1701). Here, bone survivorship is calculated in terms of MAU (the minimum number of animal

units). No bone density values are available for walrus; instead Lyman's (1994) published density values for scan sites distributed throughout the phocid skeleton has been applied. Due to the inter-taxonomic variation in bone density, these values will be treated on an ordinal scale (Lam & Pearson 2004:109-110; Lyman 1994:252).

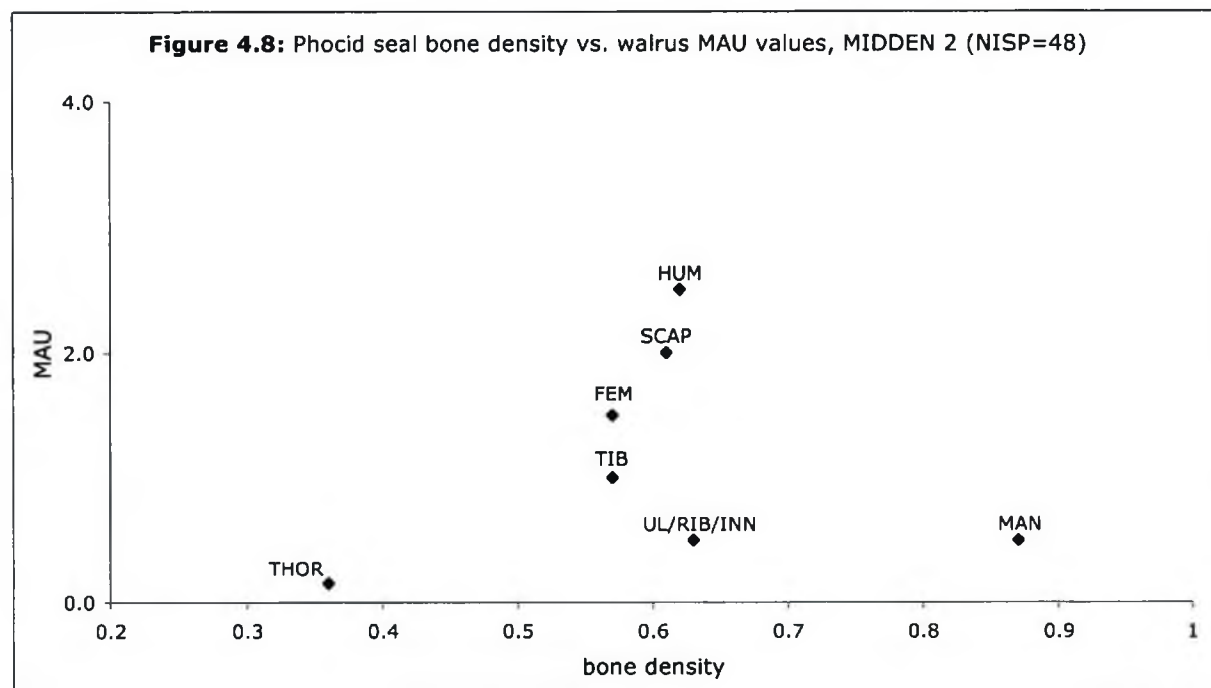
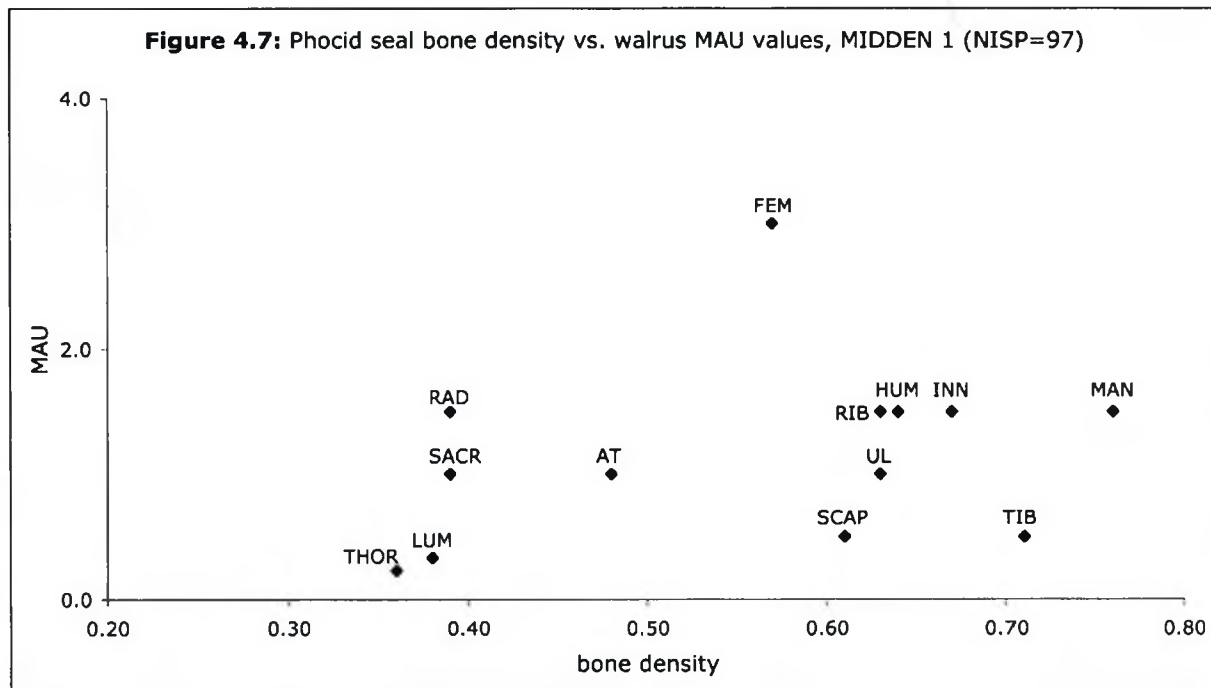
Previous studies have often applied only the highest density value per element, or restricted analysis to the proximal and distal ends of the long bone (Lam et al. 1998:561). Marean & Frey (1997) have shown that long bone end portions are sensitive to taphonomic processes and thus will produce inaccurate assessments of density-mediated attrition. They suggest other parts of the bone, such as middle shaft portions, be included in such analyses. The present study uses the density scan site associated with the most frequently occurring part or zone for each element, be it the middle shaft portion or long bone ends. If more than one zone dominates, the average density between scan sites is used. Using a bone density value from the part of each element used to derive MAU provides a more accurate assessment of density-mediated attrition at the site.

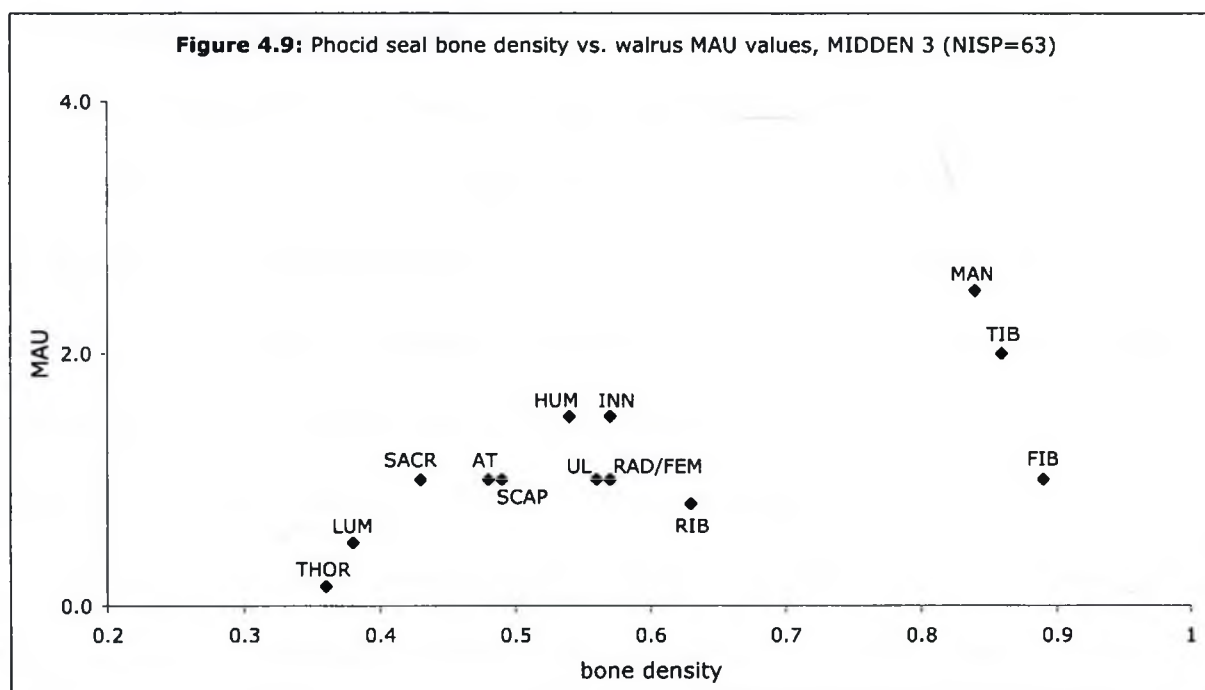
Figure 4.6 illustrates the relationship between phocid seal bone density and the frequency of walrus anatomical parts (as MAU) for all assemblages combined. Spearman's Rank Correlation test revealed a moderate positive correlation between these variables ( $r_s = .543$ ,  $p < .001$ ;  $r_s$  value of 0 = no correlation,  $r_s$  value of 1 or -1 = a perfect correlation). This suggests that some density-mediated attrition has occurred. Bones with low structural densities, such as the vertebrae, are not represented as well as bones with high structural densities, such as the mandible and tibia. However, the fibula, although dense, appears in low numbers. This could be attributable in part to problems regarding identifiability, since a walrus fibula has very few diagnostic markers.



Figures 4.7-4.9 illustrate the relationship between phocid seal bone density and the frequency of walrus anatomical parts (as MAU) for each midden sample. In no case is there a strong correlation between bone density and MAU. Spearman's Rank correlation test reveals a weak positive correlation between these variables for Midden 1 ( $r_s=.345$ ,  $.2>p<.5$ ) and Midden 3 ( $r_s=.374$ ,  $.1>p<.2$ ). Midden 2 reveals a negative correlation ( $r_s=-.418$ ,  $p<.01$ ), suggesting that density-mediated attrition was not responsible for the varying frequencies of skeletal elements. However, these patterns could also be influenced by small sample size (NISP<100 in all cases).

Skeletal part studies have been used to address diverse zooarchaeological questions involving resource availability, human subsistence strategies, processing and carcass transport, and other cultural activities (Marean 1991:678; Munro & Bar-Oz 2004:1). The representation of bone elements may also be due to differential destruction by natural agents, many of which are density-mediated (Lyman 1985, 1994; Munro & Bar-Oz 2004; Rogers 2000). Aside from flipper bones, the representation of all parts of the walrus





skeleton in the NeHd-1 middens suggests that entire skeletons were transported to the site and that differential representation does not result from variation in transport decisions. The lack of flipper bones in the faunal collection is very likely the result of human activity (i.e. loss and discard). Another possibility is that the Thule did not value flippers as much as some Inuit groups, and left them behind at the kill site. The large numbers of walrus cranial elements identified in the assemblage also suggests that ivory was being exploited for tool manufacture. Other than this, human activities at the site probably had a minor impact on walrus element representation. There also appears to be a lack of correlation between bone density and relative abundance for all of the midden assemblages, which is likely a result of small sample size. If all samples are aggregated, it looks as though density-mediated attritional processes did affect bone survivorship to some degree. At this point in the analysis, it is too early to determine what agent(s) are responsible for this observed pattern.

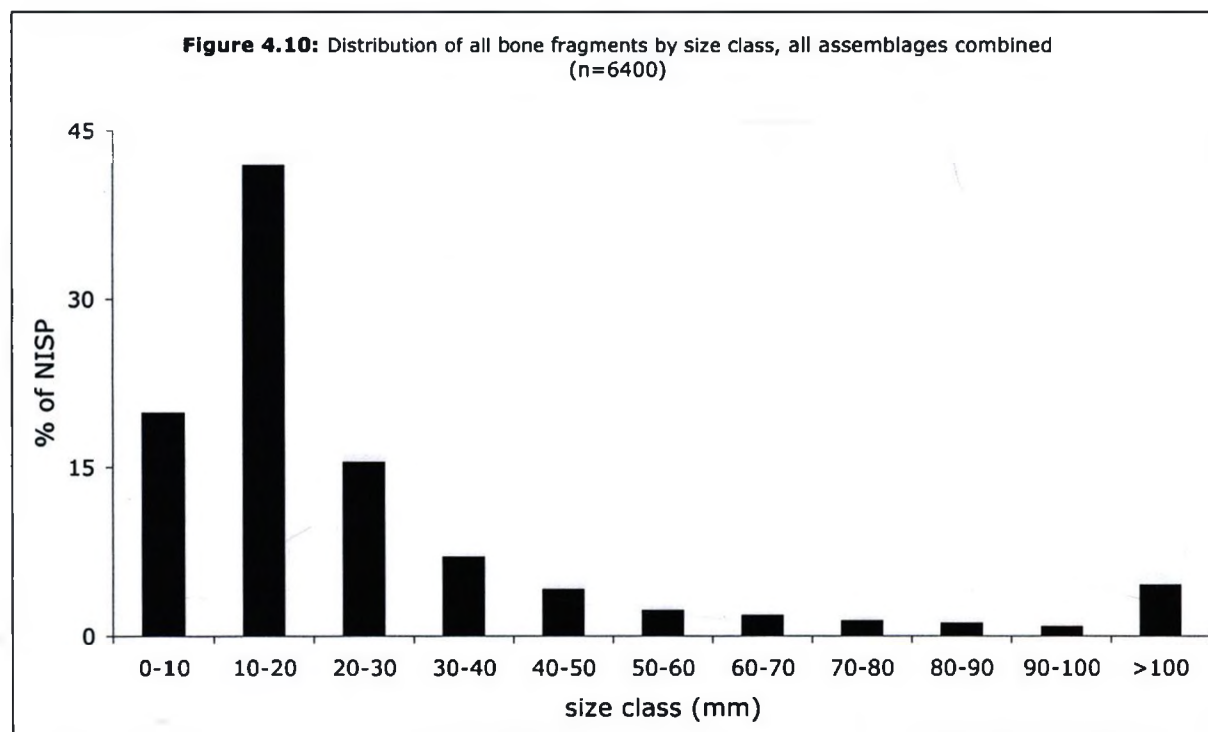


#### 4.5 Intensity of Fragmentation

Many researchers (e.g. Enloe 1993; Marshall & Pilgrim 1991; Outram 1999, 2001) have argued for the integration of fragmentation studies into zooarchaeological analyses to help enable differentiation between taphonomic agents. Identifying the taphonomic agents responsible for fragmentation can be difficult, but it can tell us much about the formation history of a faunal assemblage (Lyman 1994:324). Major causes of bone fracture can include (but are not limited to) bone tool production (Lyman 1984b; Semenov 1964), marrow extraction (Enloe 1993; Outram 1999, 2001, 2002), scavenging by carnivores (Hill 1989; Kent 1981), and factors related to climate such as weathering (Behrensmeyer 1978).

For the purposes of this analysis, estimating the intensity of fragmentation involved assigning individual specimens to size classes (Outram 1999:105). Eleven size classes were used: 0-10 mm, 10-20 mm, 20-30 mm, 30-40 mm, 40-50 mm, 50-60 mm, 60-70 mm, 70-80 mm, 80-90 mm, 90-100 mm, and >100 mm. Bone fragments were assigned to size class by placing each fragment over a series of drawn circles of graduated diameters. Bone fragments that were exactly 10 mm, 20 mm, and so on, were placed in the larger size class. Specimens larger than 100 mm were measured to the nearest millimetre using an osteometric board. Once assigned to size classes, bone fragments were quantified by number.

Whole or entirely undamaged elements, including unbroken articular and axial specimens, have been excluded from the analysis. The majority of whole specimens identified in the assemblage are represented by small dense bones, which are less susceptible to carnivore damage, marrow extraction, and other agents that are interrelated

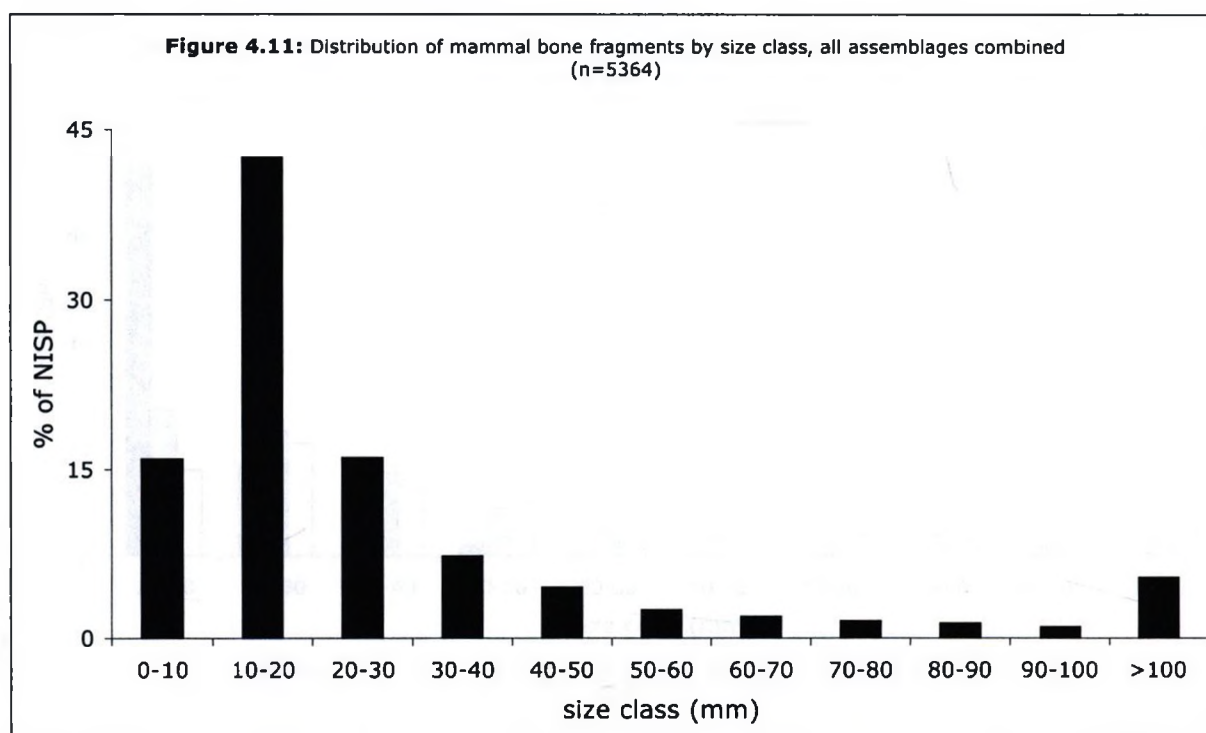


with fragmentation processes. As a result, this category cannot always be taken as a measure of reduced fragmentation.

#### 4.5.1 Intensity of fragmentation, all assemblages combined

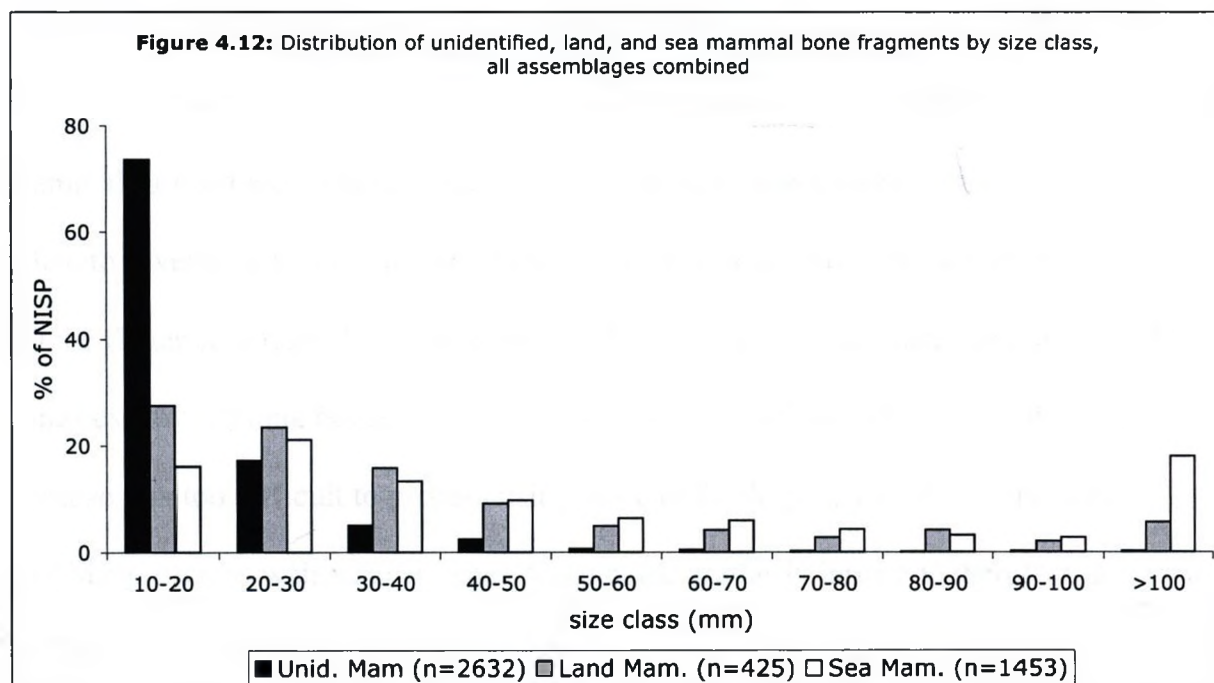
Figure 4.10 shows the distribution of all bone fragments (mammal, fish, bird and unidentified) by size class for all assemblages combined. The sample consists of 6400 specimens. Most fragments fall into the smaller size classes and few bones survived in size classes greater than 30-40 mm. This suggests that the assemblage has been fragmented to some degree. More fragments occur in the 10-20 mm range than the 0-10 mm size class, which is likely attributable to a combination of factors. Many specimens in the 0-10 mm range could have been: (1) more susceptible to density-mediated destruction (e.g., weathering, abrasion, decomposition, and chemical change) and therefore less likely to survive in the archaeological record; (2) overlooked during house





cleaning episodes and not deposited in the midden; and (3) lost or overlooked by the archaeologist while screening sediment. For these reasons, the 0-10 mm size class is thought to be under-represented. Figure 4.11 shows the distribution of mammal bone fragments by size class for all assemblages combined. Again, more fragments occur in the 10-20 mm range than the 0-10 mm size class further supporting the above interpretation. Because of this, the 0-10 mm size class will be excluded from the remaining fragmentation analysis.

Figure 4.12 provides a more detailed view of fragmentation at the site. It shows the distribution of mammal bone fragments by size class, with distinction between indeterminate, land, and sea mammal remains. Among the indeterminate mammals, most fragments fall into the smaller size classes. This distribution differs significantly when compared to the fragmentation rates of land (Kolmogorov-Smirnov two-sample test,



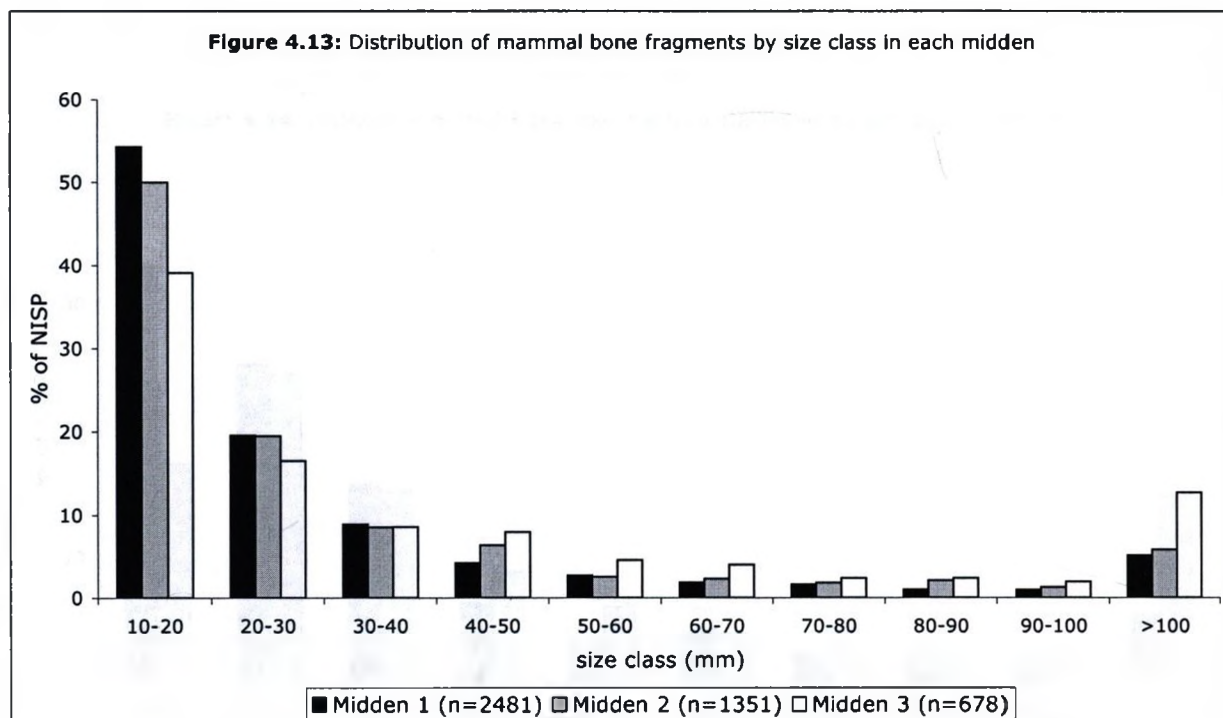
$D=0.460$ ,  $P>0.05$ ) and sea (Kolmogorov-Smirnov two-sample test,  $D=0.575$ ,  $P>0.05$ ) mammal specimens. This result is likely attributable to the fact that identifications are easier to make among the larger size classes. Many specimens in the 10-20 mm range could not be assigned to class. As one moves to larger size classes, fragments become identifiable to either land or sea mammal. The frequency distribution of land and sea mammal specimens across the size classes appears broadly similar. However, the two distributions are significantly different statistically (Kolmogorov-Smirnov two-sample test;  $D=0.164$ ,  $P<0.05$ ). The greatest differences occur in the 10-20 mm and >100 mm size classes. Proportionally more fragments are represented by land mammal specimens in the smaller size class, whereas sea mammal bones dominate the >100 mm size class. This suggests that land mammal bones are being more intensively fragmented than sea mammal specimens.

Taken in all, the evidence from this study suggests that a high degree of fragmentation is present in the assemblage. Most mammal bone fragments fall into

smaller size classes and few bones survived in size classes greater than 30-40 mm. At this point, little can be said about what caused this fragmentation, but it appears that land mammals are subject to higher rates of fragmentation than sea mammals. This could relate to several factors including; (1) the relatively higher bone density of sea mammals; (2) the flatter structure of sea mammal long bones, which makes them less susceptible to compression; (3) long bones of sea mammals are not traditionally processed for marrow because it is too difficult to process using basic technologies; and (4) sea mammal specimen, such as walrus, even when fragmented are fairly large and therefore dominate the larger size classes.

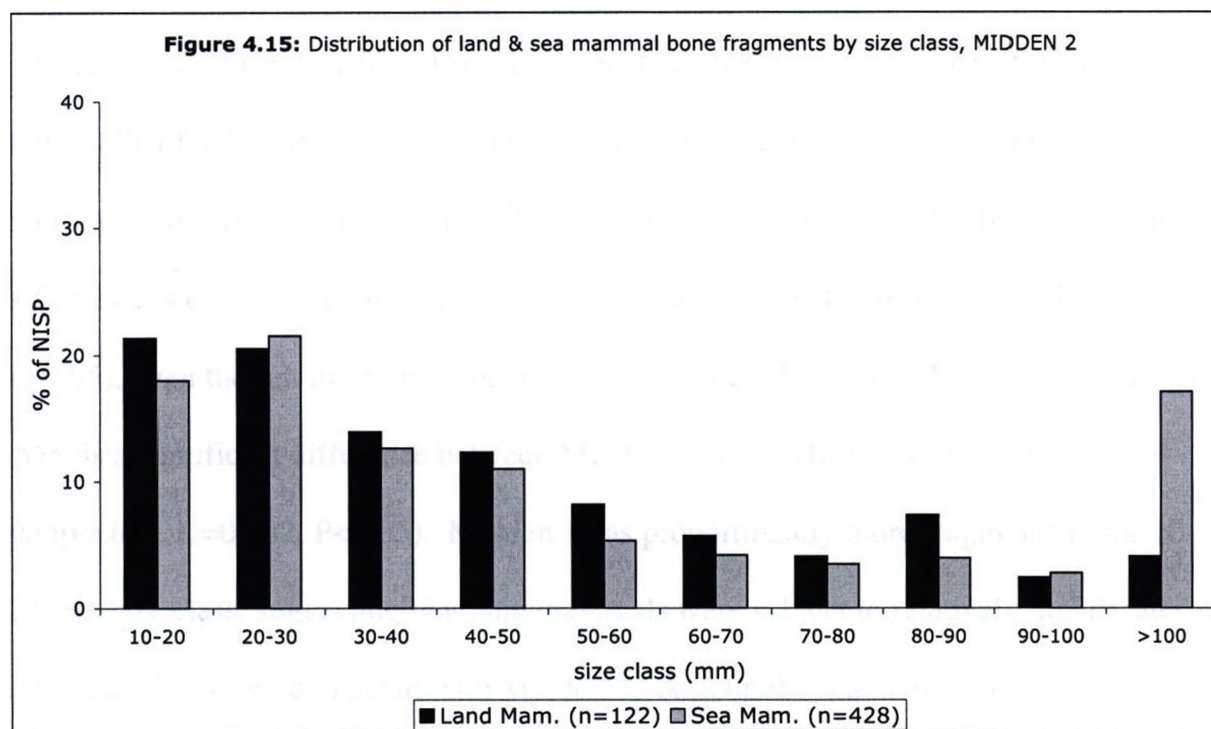
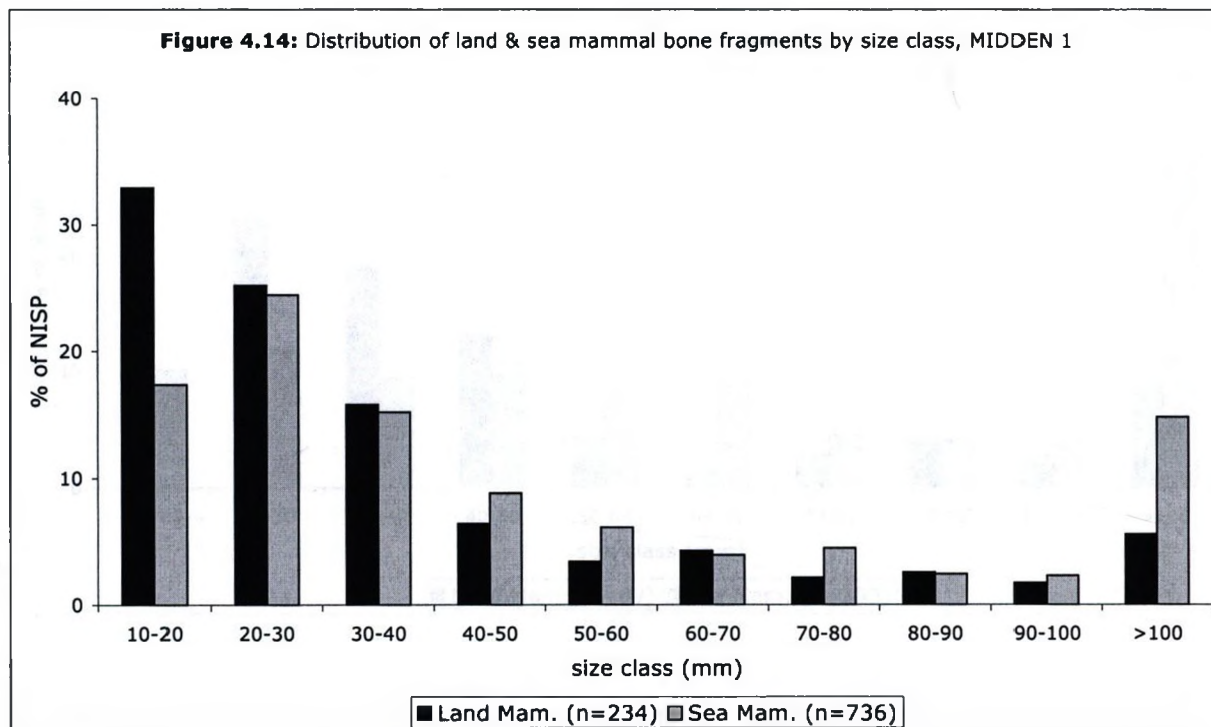
#### **4.5.2 Intensity of fragmentation in each midden assemblage**

Figure 4.13 presents the distribution of mammal bone fragments by size class between midden assemblages. For Middens 1 and 2, the distributions appear to be very similar, suggesting similar rates of fragmentation. However, there is a statistically significant difference between the two distributions (Kolmogorov-Smirnov two sample,  $D=0.47$ ,  $P<0.05$ ). Most fragments fall into smaller size classes and few bones survived in size classes greater than 20-30 mm in both these assemblages, however Midden 1 has more fragments in the 10-20 mm size class signifying it was subject to slightly higher rates of fragmentation. Midden 3 is also significantly different from the other two midden samples (vs. Midden 1 Kolmogorov-Smirnov two sample,  $D=0.185$ ,  $P<0.05$ ; vs. Midden 2 Kolmogorov-Smirnov two-sample,  $D=0.138$ ,  $P<0.05$ ). The distribution of mammal specimens across size classes suggests that Midden 3 is less intensively fragmented than the Midden 1 and 2 samples because the former has fewer fragments in the smallest size category. Also, Midden 3 has proportionally more specimens in the

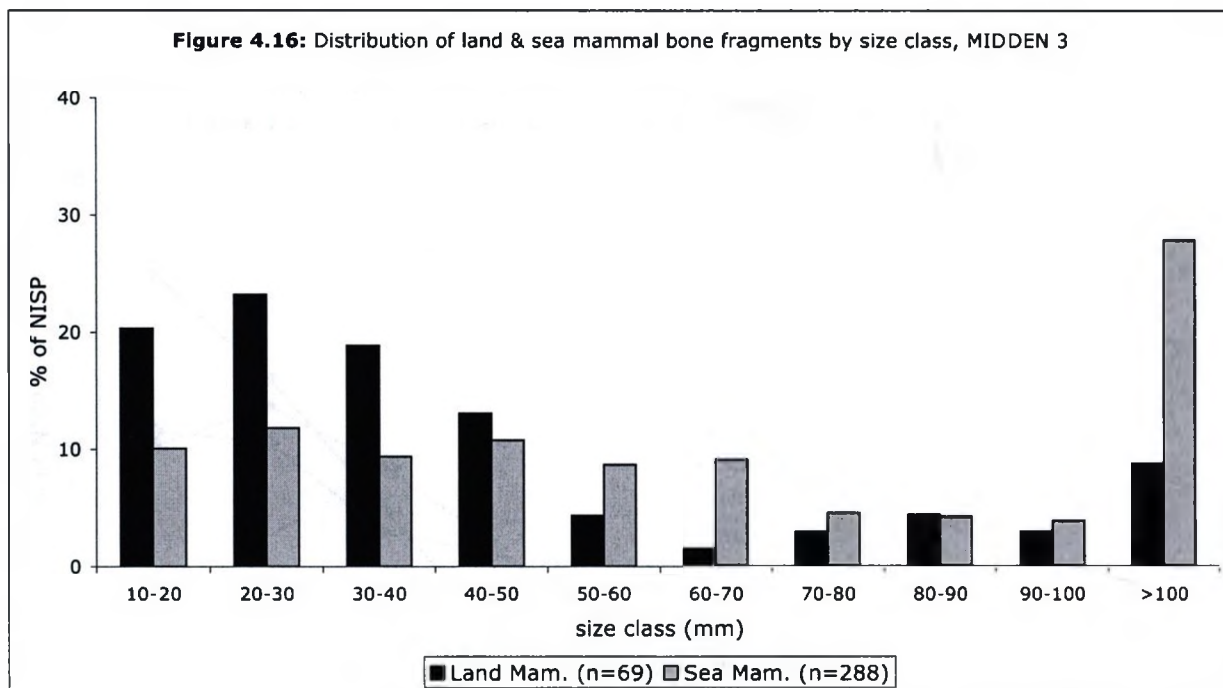


>100 mm size class. This is likely due to the higher numbers of sea mammal bones in the Midden 3 assemblage, which are more dense and therefore not as easily fragmented as land mammal bones (refer to FIG. 4.2).

Figures 4.14-4.16 show the distribution of mammal bone fragments by size class for each midden sample, with distinction between land and sea mammal remains. There are significant differences between the fragmentation of land and sea mammal bones in the Midden 1 (Kolmogorov-Smirnov two-sample test,  $D=0.169$ ,  $P<0.05$ ) and Midden 3 (Kolmogorov-Smirnov two-sample test,  $D=0.333$ ,  $P<0.05$ ) samples. Here, a larger portion of land mammal specimens fall into the smaller size classes and sea mammals dominate the >100 mm size class. This suggests that land mammals were subject to higher rates of fragmentation in both assemblages. For Midden 2, the two distributions are not significantly different (Kolmogorov-Smirnov two-sample test,  $D=0.133$ ,  $P>0.05$ ),

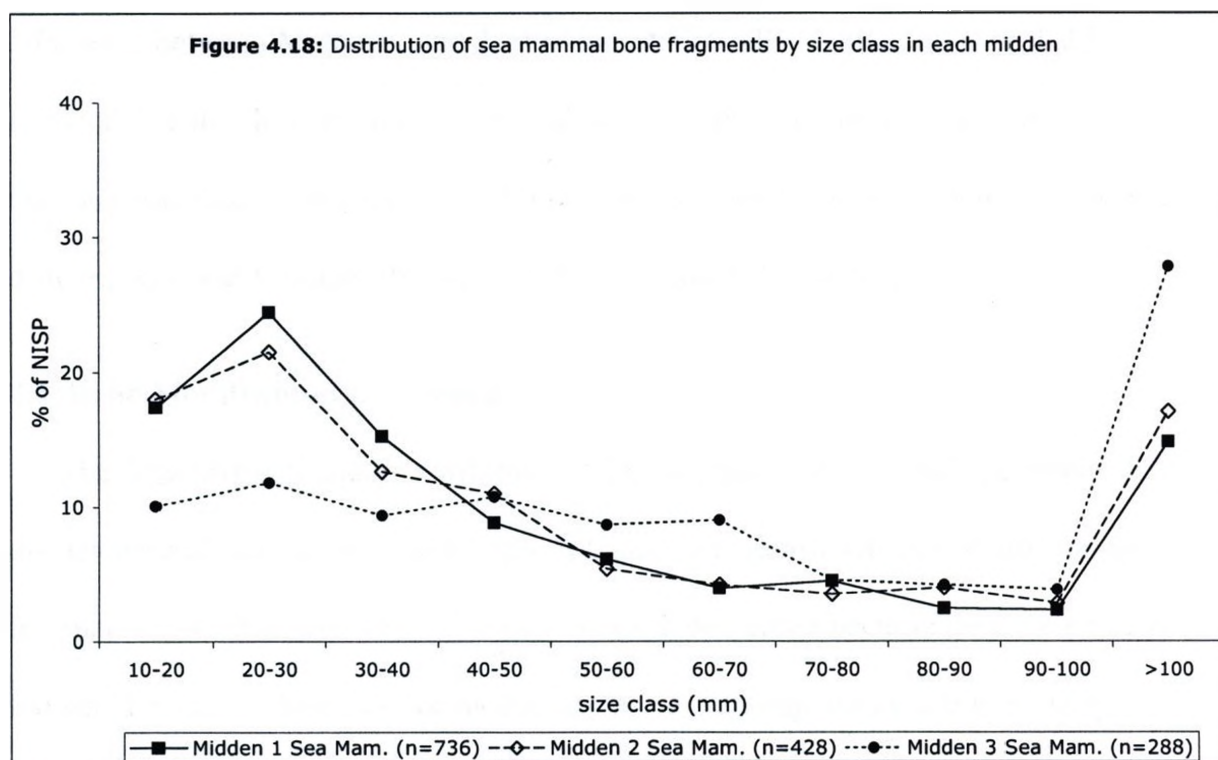
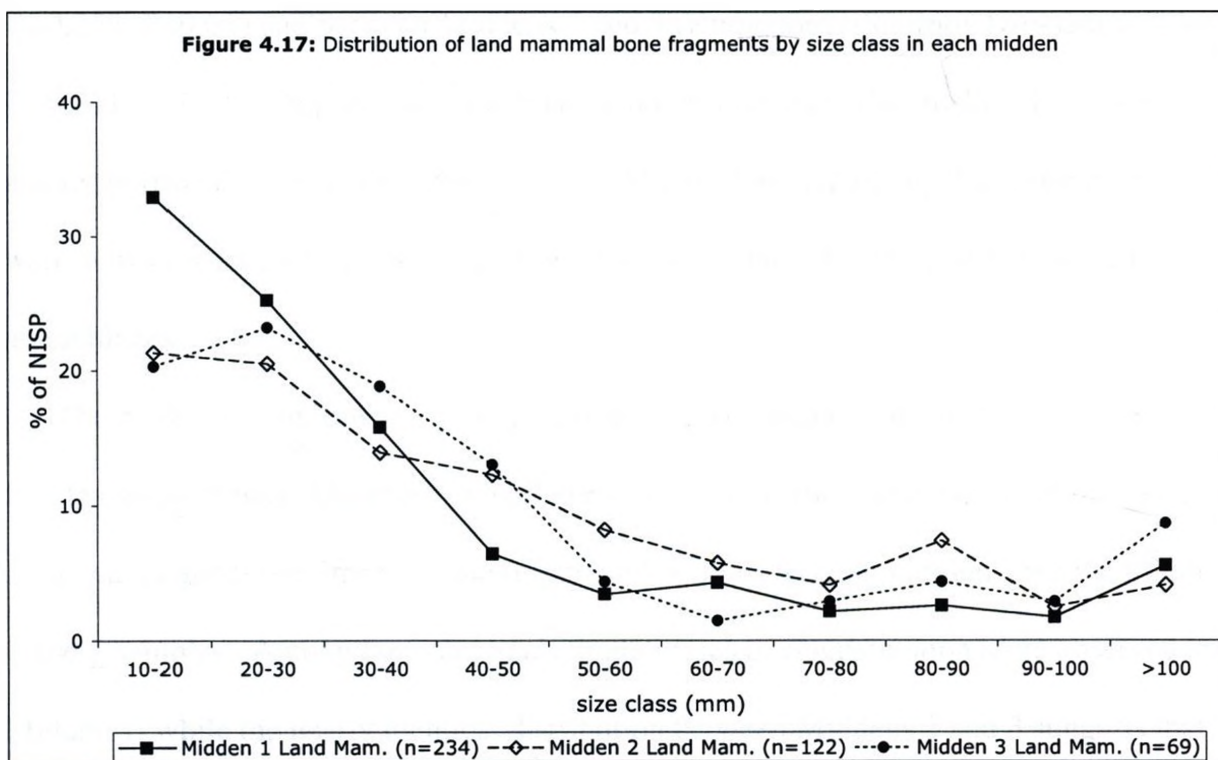






suggesting sea and land mammals were subject to similar rates of fragmentation, even though sea mammals dominate the >100 mm size class.

Figure 4.17 compares the distribution of land mammal bone fragments by size class between the midden samples. The nearly identical distribution between Middens 2 and 3 suggest that land mammals were subject to similar rates of fragmentation (Komogorov-Smirnov two-sample test,  $D=0.073$ ,  $P>0.05$ ). There is also no statistically significant difference between Middens 1 and 3 (Komogorov-Smirnov two-sample test,  $D=0.146$ ,  $P>0.05$ ), even though more small bone fragments were observed in Midden 1. However, there is a significant difference between Middens 1 and 2 (Komogorov-Smirnov two-sample test,  $D=0.182$ ,  $P<0.05$ ). Midden 1 has proportionally more fragments in the 10-20 mm size class, suggesting that land mammals were subject to relatively higher rates of fragmentation when compared with Midden 2. Among the sea mammals, the size class graph (FIG. 4.18) indicates very similar rates of fragmentation between Middens 1 and 2 (Komogorov-Smirnov two-sample test,  $D=0.050$ ,  $P>0.05$ ). However, there is a



significant difference between Middens 1 and 3 (Komogorov-Smirnov two-sample test,  $D=0.258$ ,  $P<0.05$ ) and between Middens 2 and 3 (Komogorov-Smirnov two-sample test,  $D=0.211$ ,  $P<0.05$ ) samples. Midden 3 has fewer specimens in the smaller size classes and proportionally more specimens in the  $>100$  size class, indicating that sea mammals were subject to lower rates of fragmentation when compared with the other midden assemblages.

The evidence from this study suggests that fragmentation varies across the different midden assemblages. Generally lower levels of fragmentation were observed in Midden 3 for sea mammal specimens, while fragmentation rates were similar between the Midden 1 and 2 samples. Among land mammals, higher rates of fragmentation were observed in Midden 1, while the nearly identical distribution between Middens 2 and 3 suggests that they were subject to similar rates of fragmentation. However, there is no statistically significant difference between Midden 1 and 3 implying (by association) that the difference between Midden 1 and 2, although statistically significant, is probably minimal. Finally, land mammals were subject to slightly higher rates of fragmentation than sea mammals, although in Midden 2 fragmentation rates were similar. Why all these differences occur becomes the focus of the next stage of analysis.

#### **4.6 Bone Modification Frequencies**

The final phase of analysis will inspect the proportion of mammal specimens that display natural and cultural modifications linked with density-mediated attrition and fragmentation. Bones of other classes were excluded either because they were rare or are too small to easily show surface modifications. No attempt was made to identify modifications made to bone fragments in the smallest size classes. Full details were

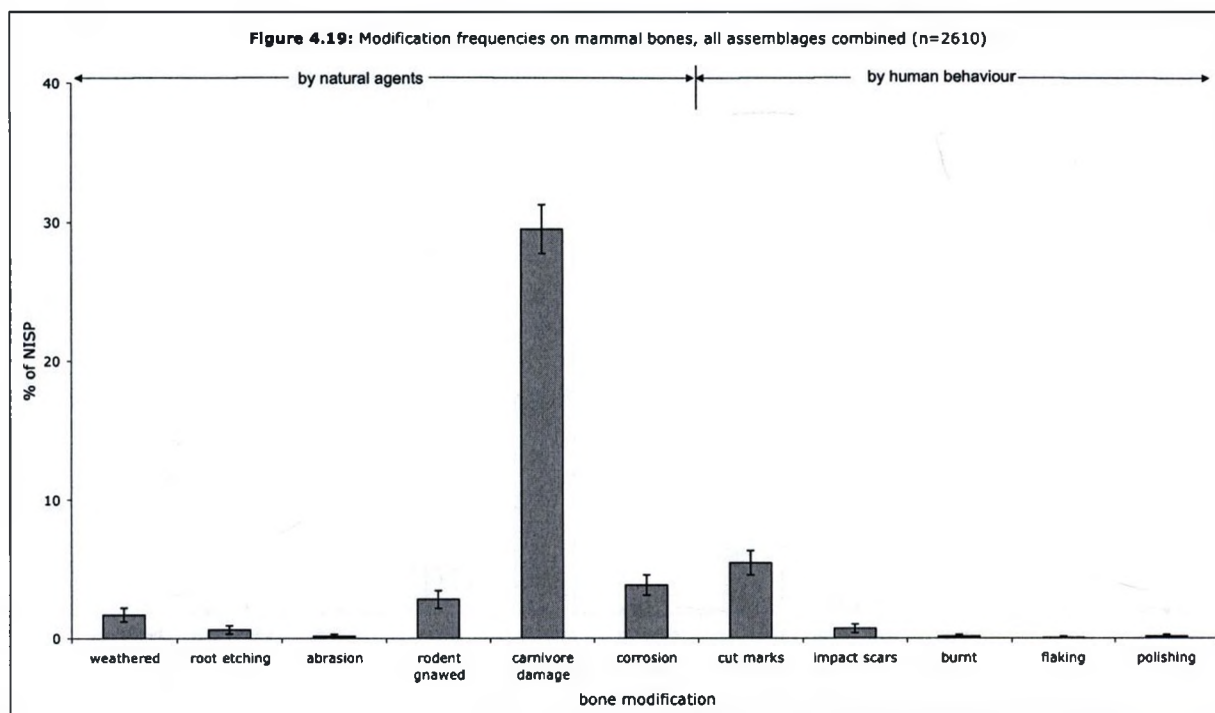


recorded for all mammal specimens in the >20 mm range. Taphonomic variables were selected based on their relevance to Thule site formation and included markers caused by natural factors (e.g., weathering, root etching, soil abrasion, rodent gnawing, carnivore gnawing, digestive corrosion) and human behaviour (e.g., cut marks, impact scars, burning, flaking, and polishing). Based on the prevalence of different indicators, it may be possible to identify the primary agents of assemblage attrition and fragmentation. Identifying the taphonomic agent(s) responsible for the patterns observed in the previous stage of analysis will tell us much about the formation history of each midden assemblage.

#### **4.6.1 Modification frequencies on mammal bones, all assemblages combined**

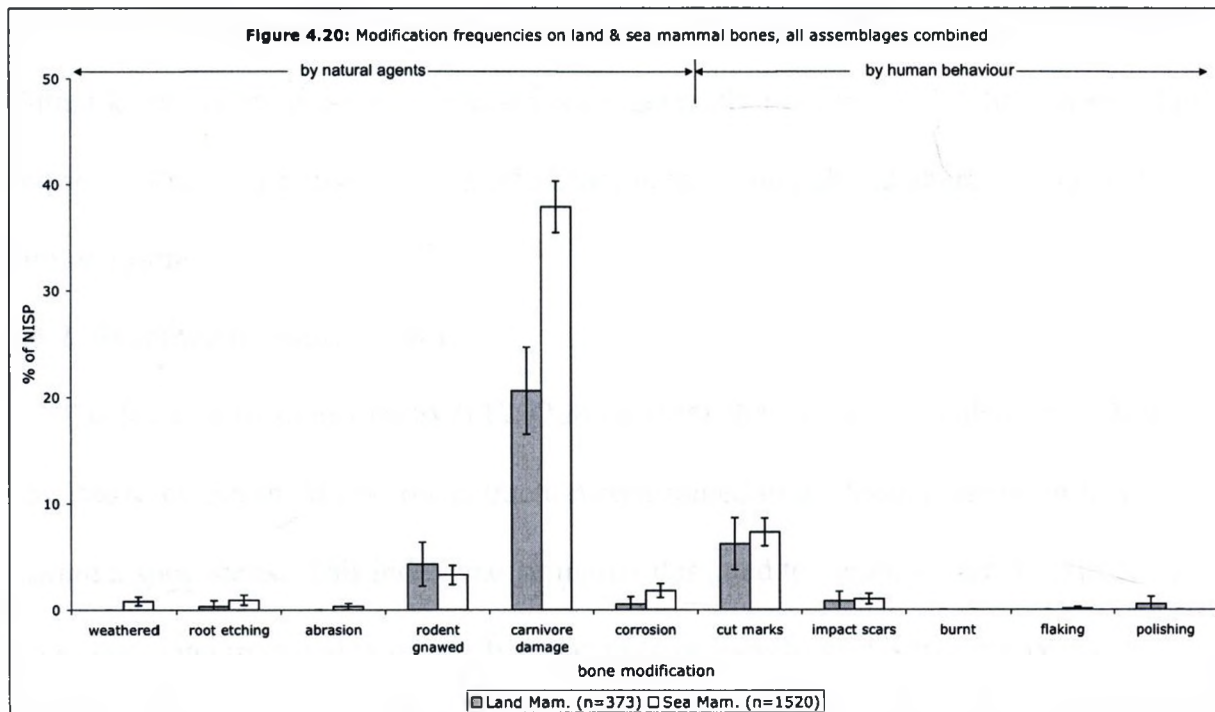
Figure 4.19 presents the distribution of modification frequencies on mammal bones for all assemblages combined. The sample consists of 2610 specimen. Because the error bars do not overlap for every variable, there are some significant differences at the 0.05 level. The most frequent form of modification was evidence of carnivore damage. This evidence was found on a range of taxa and elements in the form of canine punctures, scoring, and dragmarks. Digestive corrosion, another form of carnivore modification, was observed on phalanges, metapodials, and small unidentifiable mammal bone fragments. Rodent gnawing was identified on only a small portion of bones. Rodent gnawing is not always easily recognizable and only the most obvious examples were quantified. Other natural bone alterations did not occur in high frequencies and probably did not significantly alter the faunal assemblage.

Among modification caused by human behaviour, cutmarks were the most dominant, but were identified on only a small portion of bones. They were found primarily on



walrus ribs and long bones. Other modifications caused by human behaviour were either rare or absent. The low frequency of burnt specimens observed in each midden assemblage is not surprising since ethnographic evidence indicates that among the Inuit most meat was boiled or eaten raw (Murdoch 1892:62). Flaking and polishing is thought to be under-represented in the faunal sample because these modifications are generally associated with tool manufacture. The majority of bones that exhibit evidence of tool maintenance and manufacture were catalogued as artifacts and therefore not included in the faunal analysis.

Figure 4.20 presents the distribution of modified specimens for all assemblages combined, with distinction between land and sea mammal remains. The greatest difference occurs in the frequency of carnivore damage observed. Although it dominates in both, modifications associated with carnivore damage were observed in higher frequencies on sea mammal bones. Because the error bars do not overlap, this observed



difference is significant at the 0.05 level and is likely attributable to one or a combination of the following. First, if large land mammals were processed for marrow prior to disposal, their reduced nutritional value likely made them less attractive to carnivores (Bar-Oz & Munro 2004:210). Second, the majority of land mammal specimens in the assemblage are arctic fox, which are generally less susceptible to carnivore damage because of their size and limited marrow and fat content. Third, ethnographic evidence indicates that seal and walrus meat was often fed to dogs (Balikci 1970; Nelson 1969:372). Finally, although there is a lot of food value in sea mammal bones in the form of oil, sea mammal bones were not traditionally processed by people because their lipid content cannot be extracted using basic technologies (Balikci 1970:85; Outram 1999:116).

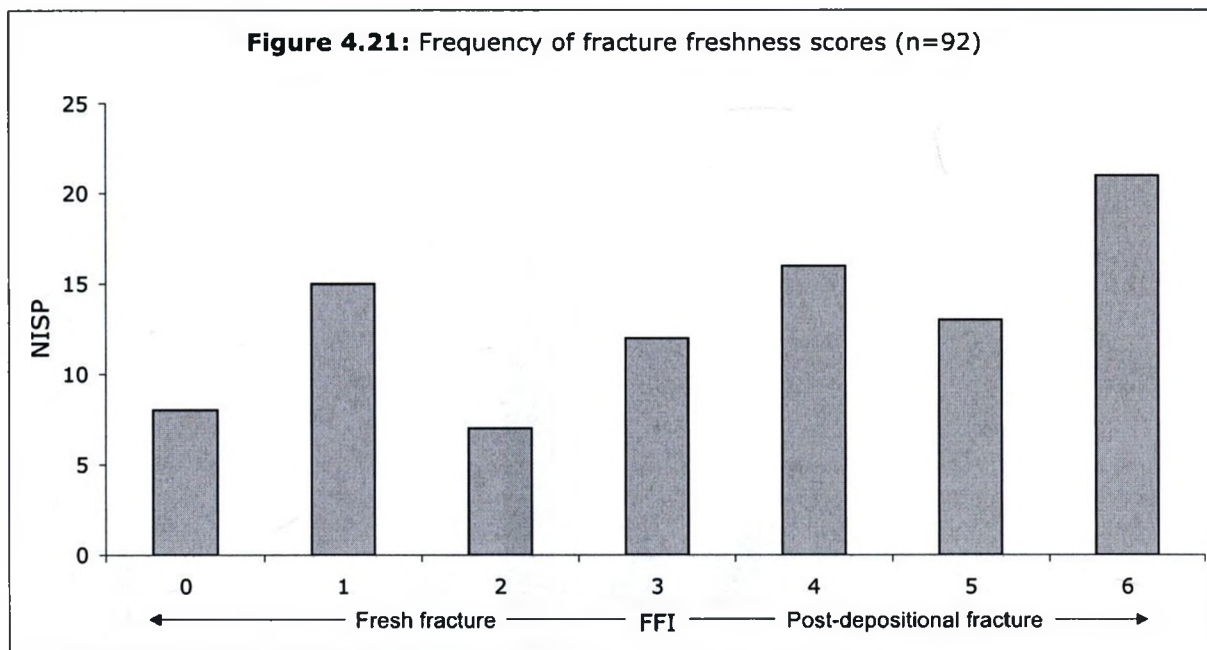
The frequency of other taphonomic damage types is similar between land and sea mammal specimens suggesting that they may have experienced fairly uniform

depositional histories (all error bars overlap; no significant difference at the 0.05 level). Cutmark and rodent gnawing frequencies are generally low, and variability between land and sea mammal specimens is limited. Other natural and cultural alterations are either rare or absent.

#### **4.6.2 Fracture freshness index**

The fracture freshness index (FFI, Outram 1999, 2002) was also calculated when possible to determine if marrow extraction contributed to the fragmentation of land mammal specimens. This index was primarily designed to identify marrow extraction from large land mammal bone shafts and cannot be used to assess fracture types on cancellous bone (Outram 2002:61). The three principal criteria of fracture angle, fracture outline, and edge texture were used in the creation of the FFI. The index ranges from zero to six; zero indicates a specimen entirely consistent with fresh fracture, three indicates a mixture of fresh and post-depositional fracture, and six indicates a specimen that has no observed fresh fracture features (Outram 2002:56). Since sea mammal bones contain no medullary cavity and do not contain marrow in the same way as terrestrial mammal bones (the epiphyses and diaphysis are both constructed of cancellous bone), the FFI was not calculated for these specimens (Outram 1999:106).

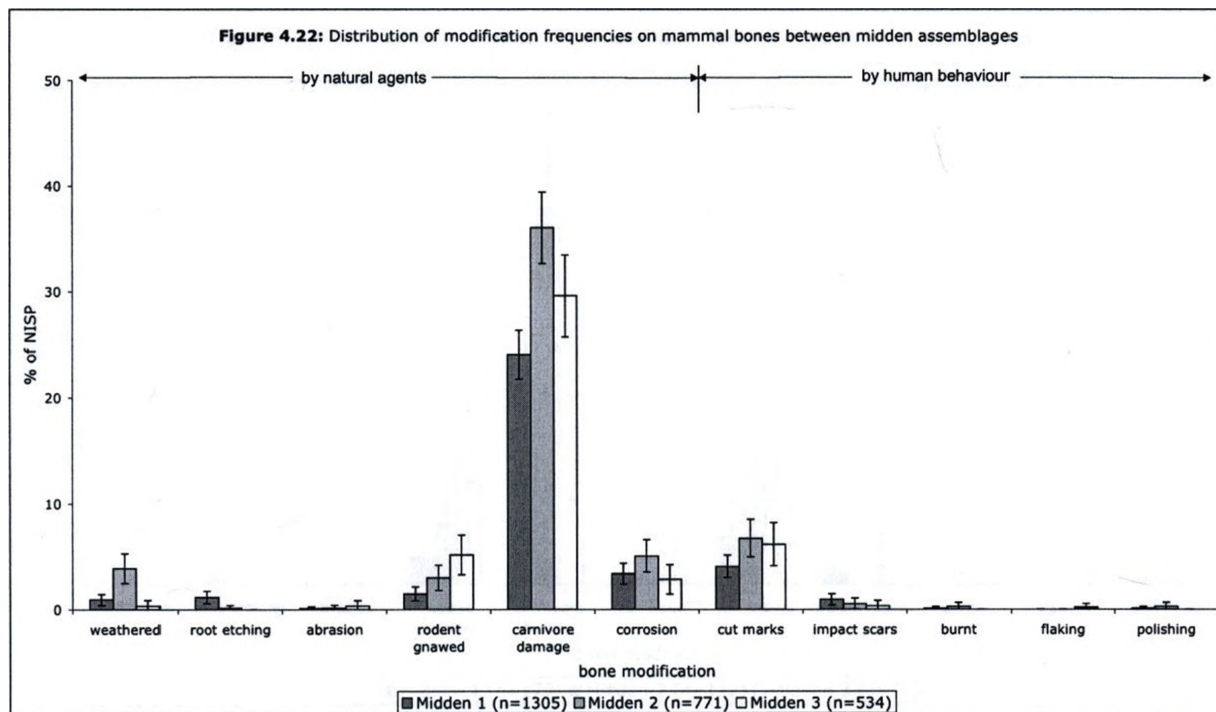
Figure 4.21 presents the frequency distribution of fracture freshness scores recorded on land mammal long bone shafts. Scores of four to six dominate by a small margin, but scores between zero and two are also well represented (particularly one). These were observed mainly on caribou long bones (and shaft fragments attributed to caribou-sized mammals and indeterminate mammals). The mean FFI score for the sample is 3.48 (n=92). Clearly not all specimens were fractured while fresh and there is evidence



suggesting that some damage occurred after the bones had dried. However, the average is close to three, and there is a strong representation of specimens scoring one. This suggests that most of the fragmentation in the combined faunal assemblage was due to near-fresh fracture, much of which was the result of marrow extraction.

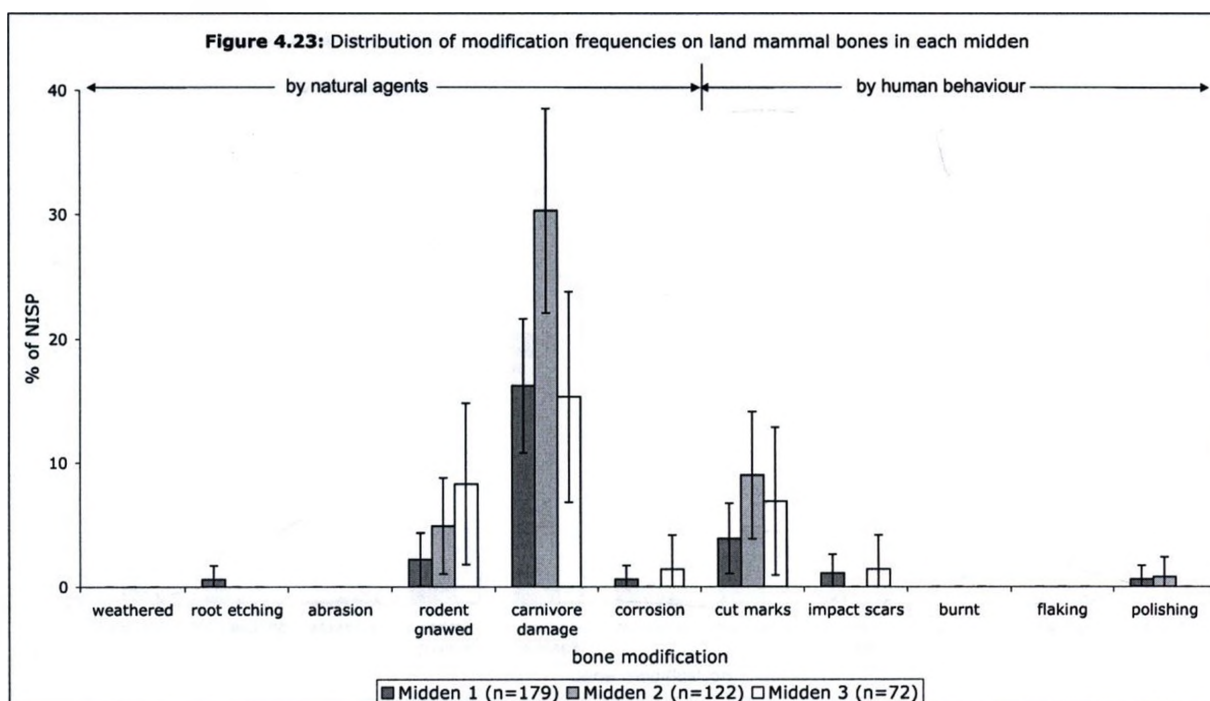
Taken in all, the evidence from this study shows that carnivore damage was the most frequent form of modification present at the site. This was observed in significantly higher frequencies on sea mammal bones. The FFI indicates that fragmentation of land mammal bones, primarily caribou long bones and shaft fragments of indeterminate mammals, was the result of some marrow extraction. These were probably the primary agents responsible for fragmentation and density-mediated attrition observed at the site. Cutmarks were also identified on a small proportion of both land and sea mammal bones. It does not appear that other natural and cultural processes significantly altered the faunal assemblage.





#### 4.6.3 Modification frequencies on mammal bones in each midden assemblage

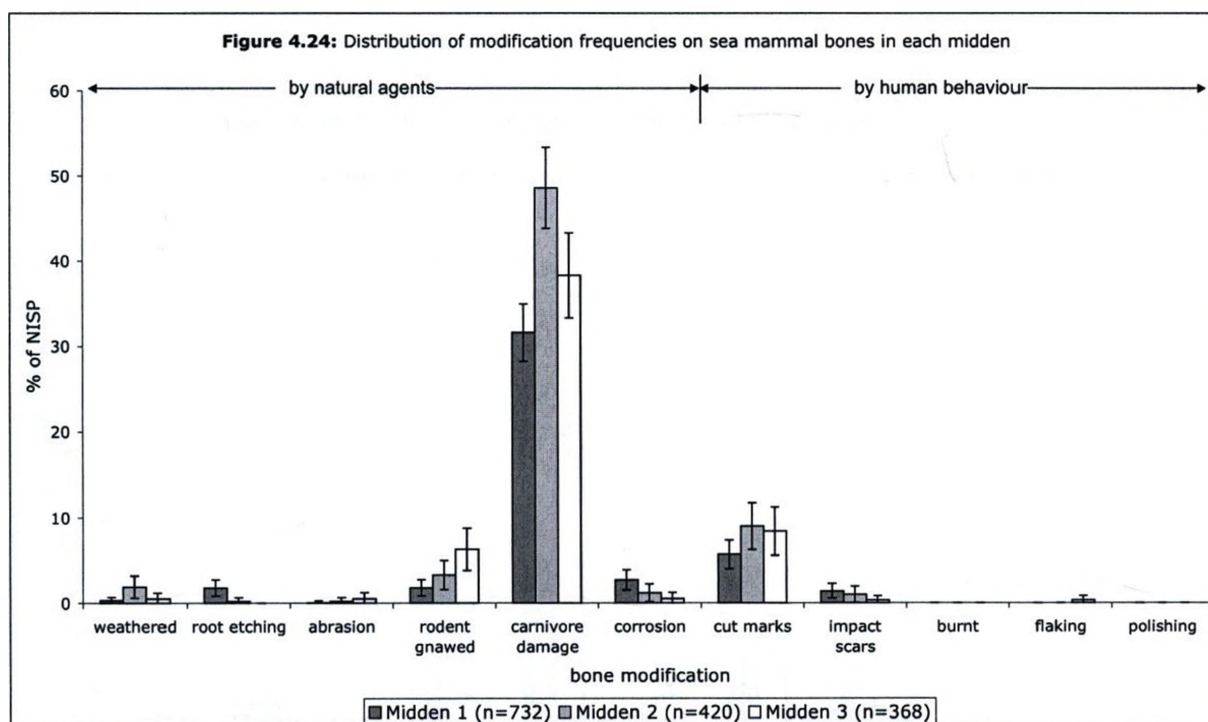
Figure 4.22 compares the distribution of modification frequencies on mammal bones between midden samples. Because the majority of error bars between midden samples overlap for most taphonomic variables, many of the observed differences are not significant at the 0.05 level. However, a few of the differences are statistically significant and the overall pattern merits a brief explanation. Carnivore modification had a significant impact on all three assemblages, however it was observed in higher frequencies in Midden 2. This difference is likely attributable to several potential factors acting alone or in concert: (1) Midden 2 was formed less quickly exposing it to further modification; (2) Midden 2 was used as a dog shelter by the occupants of neighbouring Feature 14; and (3) after abandonment by its human occupants, Midden 2 may have been more intensively scavenged by dogs, wolves, and arctic fox than the other two middens. Weathering was observed in significantly higher frequencies in Midden 2 and both



carnivore damage and corrosion were also observed in slightly higher frequencies than in the other samples. Together, these lines of evidence suggest that the Midden 2 assemblage was not buried as quickly as the other midden samples.

Figure 4.23 compares the distribution of modification frequencies on land mammal bones from each midden assemblage. Once again, carnivore damage is the most common taphonomic variable identified and was observed in higher frequencies in Midden 2. Cutmarks are present in low frequencies and variability between contexts is limited and not significant. Among sea mammals, the modification graph (FIG. 4.24) shows that specimens were exposed to similar taphonomic variables. However, carnivore damage again appears in significantly higher numbers (difference significant at the 0.05 level) in Midden 2, reinforcing the suggestion that this midden experienced slower rates of burial.

Figures 4.25-4.27 compare the distribution of modification on land mammal remains with those on sea mammals for each midden assemblage. In all cases, significantly

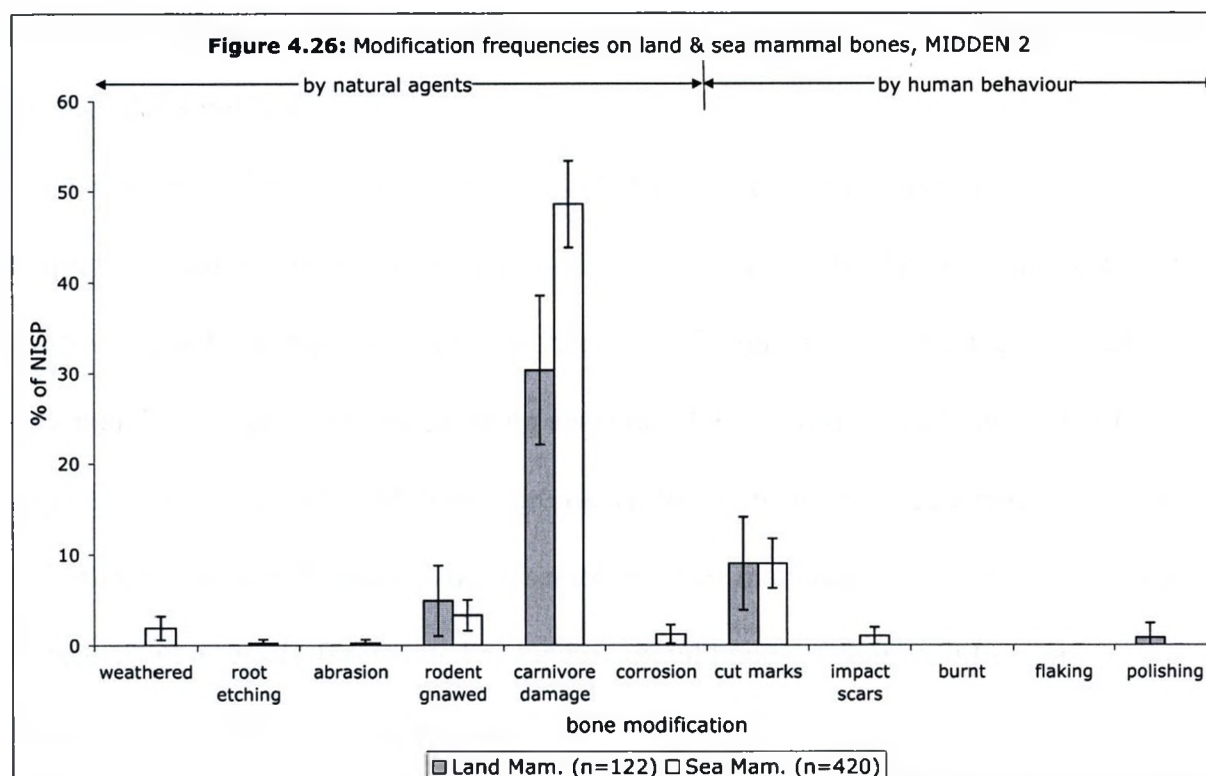
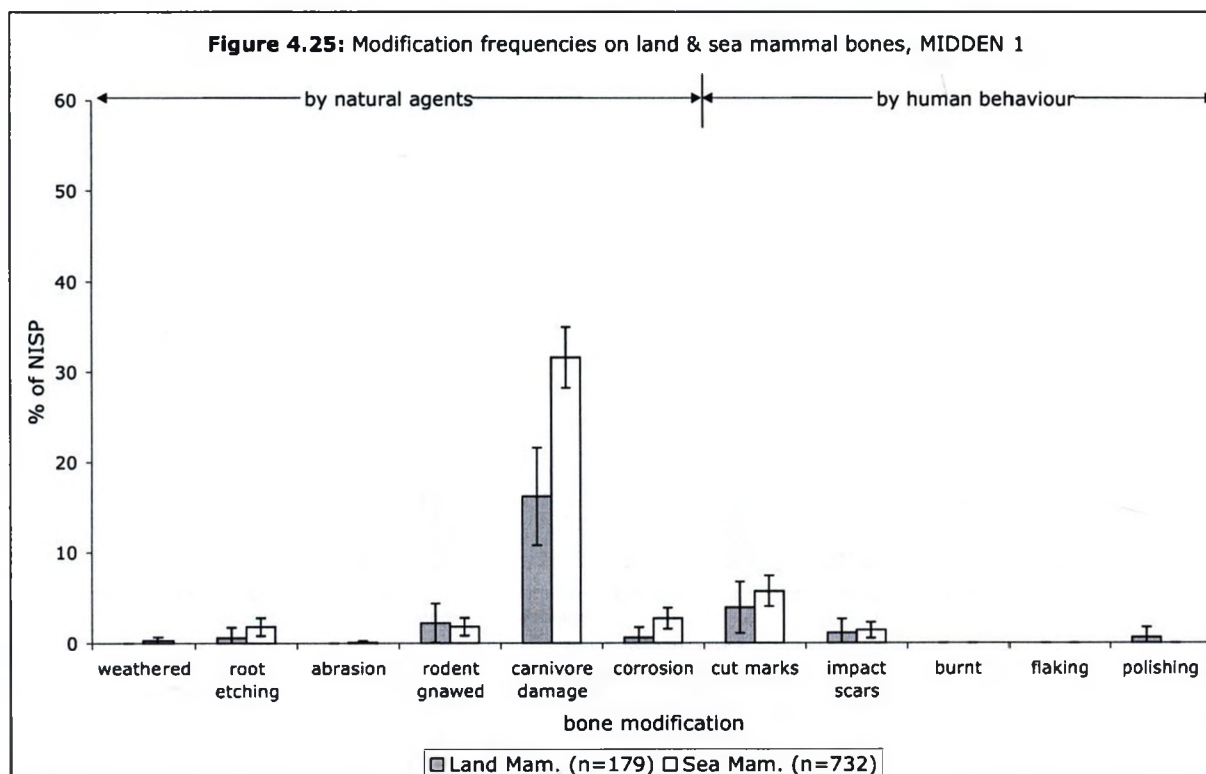


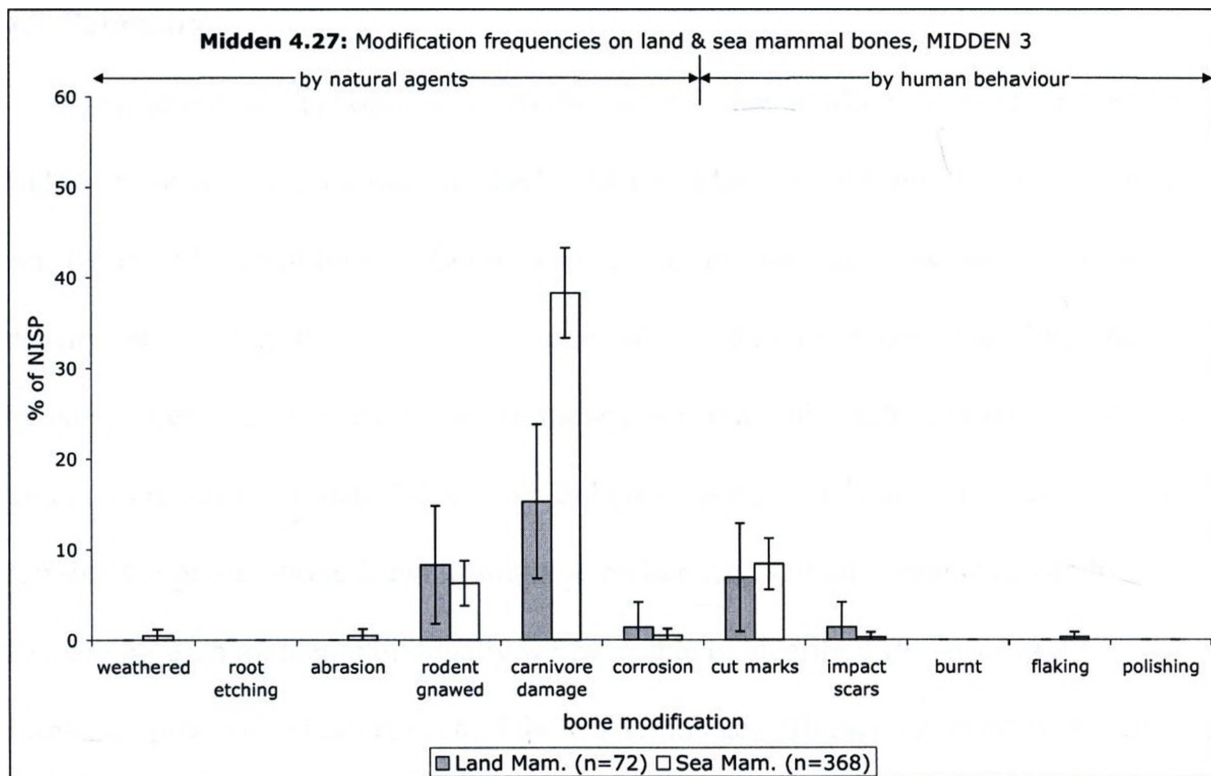
higher carnivore damage frequencies were observed on sea mammal specimens (error bars do not overlap in all cases; observed difference significant at the 0.05 level).

Cutmark and rodent gnawing frequencies are low and their variability is limited and not significantly different (at the 0.05 level) between land and sea mammal bones. Other natural and cultural alterations were either rare or absent.

In summary, the evidence from this study shows that carnivore damage had the most significant impact on all three assemblages, and it was observed in significantly higher frequencies in Midden 2. Digestive corrosion and weathering are also observed in higher frequencies in Midden 2 than in the other midden samples. Together, these results suggest that Midden 2 experienced slower formation and longer periods of exposure on the surface, providing carnivores with greater access. Sea mammal bones consistently displayed significantly higher carnivore damage frequencies in all midden assemblages, perhaps because they were fed to dogs. This is likely the primary agent responsible for







the fragmentation of sea mammal bones and density-mediated attrition observed in the walrus assemblage. Other natural alterations do not appear to have significantly altered the faunal assemblage.

Among modification caused by human behaviour, cutmarks were present in low frequencies and variability between midden samples is limited. Human processing for marrow is partly responsible for the higher rates of fragmentation observed in land mammals, although carnivore gnawing also contributed. The overall lower rates of fragmentation observed in Midden 3 are likely due to the higher frequencies of walrus and other sea mammal bones in the assemblage. Sea mammal bones are also denser and therefore not as easily fragmented as land mammal bones. Other modifications associated with human behaviour were rare or absent.

#### 4.7 Summary

The multivariate taphonomic approach indicates that non-human agents and processes had the most significant impact on the NeHd-1 midden assemblages. Carnivore damage was the most frequent form of modification at the site and was the primary source of density-mediated attrition and fragmentation observed in the assemblage. Other than human processing for marrow, the assemblage was only minimally impacted by cultural processes relating to human behaviour. Subgroup comparisons played a crucial role in refining the observations drawn from these earlier stages of taphonomic research.

Examining each midden individually we were able to identify differences in the formation processes creating each of these assemblages. Higher frequencies of carnivore damage, digestive corrosion, and weathering in Midden 2 indicate that it experienced slower formation and longer periods of exposure on the surface. This accounts for the higher rates of fragmentation observed in Midden 2 when compared to Midden 3.

Midden 3 was shown to have lower rates of fragmentation than the other middens, likely a product of the higher frequency of sea mammal bones in the assemblage. Finally, land mammals are most fragmented in Midden 1, which potentially was the result of marrow extraction.

## Chapter 5

### DISCUSSION & CONCLUSION

#### 5.1 The Problem

The semi-subterranean whale bone house is among the most common contexts excavated by archaeologists studying the Thule Inuit culture. The majority of faunal assemblages that have been studied to date have been recovered from these dwellings and their associated middens. Middens serve as the final repository for most food waste in prehistoric and historic cultures. Because of the large quantity of faunal material often recovered from middens, they have become especially important in reconstructing local and regional Thule Inuit settlement and subsistence behaviour. With a few notable exceptions (e.g., Friesen & Betts 2002; Lofthouse 2003; Stenton 2001; Stenton & Park 1994; Whitridge 2001), limited attention has been given to the study of the natural and cultural formation processes that generate and modify these Thule middens. Researchers often assume that permafrost has reduced the amount of damage natural formation processes can inflict on a bone assemblage to a negligible level. They also assume that variability in the cultural formation processes of middens is limited. There is a widespread, though often unstated assumption that faunal remains in Thule middens are representative of the originally deposited assemblage and can be compared within and between archaeological sites without taking into consideration the processes that created them (e.g., Savelle & McCartney 1988:23; *cf.* Stenton & Park 1994:410-411).

Interpretations based on faunal materials recovered from middens must take several factors into consideration. Midden bones can be differentially exposed to mechanical agents like trampling or pressure from overlying sediments, as well as chemical change

and decomposition (Hall 1990). The contents of midden assemblages are also influenced by resource availability, human subsistence strategies, processing and carcass transport, discard during periods of maintenance and cleaning of Thule dwellings, and other cultural activities (Friesen & Betts 2002; Stenton & Park 1994). Archaeologists therefore cannot assume that all midden assemblages are directly comparable because of the potential complexity in their formation. A better understanding of how bone assemblages have been affected by natural and cultural formation processes will provide a firmer footing for comparisons both within and between sites.

## **5.2 Questions and Answers**

This thesis examined the way human behaviour and natural factors have shaped the formation of different midden assemblages in and around a Thule semi-subterranean house structure at NeHd-1. A random sample of faunal remains was selected from three midden assemblages from Feature 15, including an external midden (Midden 1, which is located outside the entrance tunnel), a deposit of debris on top of the dwelling which is interpreted as trash associated with a later occupation (Midden 2), and refuse from outside the dwelling wall (Midden 3). A variant of the multivariate taphonomic approach, originally proposed by Bar-Oz and Munro (2004), was used to determine the most significant agent(s) of assemblage formation. The first stage of analysis involved identifying and quantifying all specimens and recording evidence of natural and cultural formation processes for the sampled midden assemblages. The second stage employed a series of problem-oriented zooarchaeological analyses to assess the impact that density-mediated attrition and human behaviour (e.g., prey transport, butchery, and disposal habits) may have had on the walrus bone assemblage. Other analyses at this stage also



considered the impact fragmentation may have had on mammal specimens in the faunal collection. The final stage refined the conclusions drawn thus far by comparing taphonomic variables and rates of fragmentation amongst the different middens. It is this final stage of analysis that allowed for a more detailed examination of the similarities and differences between each midden assemblage.

Using the multivariate approach, this study concludes that natural formation processes had the most significant impact on the complete faunal assemblage. Carnivore damage, observed in the form of canine punctures, scoring, and dragmarks, was the most frequent form of modification at the site and was the primary source of density-mediated attrition and fragmentation observed in the collection. In comparison to land mammal bones, sea mammal specimens displayed higher frequencies of carnivore modification, perhaps because they were fed to dogs. Although cultural formation processes were primarily responsible for the formation of these deposits (e.g., animal procurement, transport, consumption, and discard), most bone modification caused by human behaviour was observed in low frequencies. Cutmarks were identified on only a small portion of bone and walrus skeletal part representation was similar in all 3 middens, indicating consistent patterns of transport. However, human processing for marrow was shown to be a factor responsible for the higher rates of fragmentation observed in large land mammal specimens.

Upon individual examination of each midden assemblage, important differences in the natural formation processes creating each of these assemblages was revealed. Most notably, the Midden 2 assemblage saw the highest frequencies of carnivore damage, digestive corrosion, and weathering. This suggests that it experienced slower rates of

formation and longer periods of exposure on the surface, making these bones more prone to environmental processes and carnivore activity. Despite the generally excellent preservation characteristic of Arctic environments, natural taphonomic factors did play an important role in determining the nature of these faunal samples, and affected each assemblage differently. Variability in the modifications caused by human behaviour was limited between the three midden assemblages, however some differences in fragmentation rates were observed. Most notably, land mammal specimens were most fragmented in Midden 1, which is potentially the result of more intensive marrow extraction. Midden 3 was the least fragmented, however this likely because sea mammal bone, which is more dense than land mammal bone and less subject to fragmentation for marrow extraction, dominated this assemblage.

### **5.3 Implications**

Application of a multivariate taphonomic approach to the NeHd-1 middens provided a way to measure and assess the impact of several formation processes on the NeHd-1 middens. Although each midden experienced varying levels of modification, these differences were probably not significant enough to drastically distort settlement and dietary reconstructions. If similar patterns can be documented at other Thule sites, it will provide a stronger foundation for inter-site comparisons of settlement and diet.

The comparative approach taken here allowed us to observe some subtle differences in the human activities that formed each midden and make some basic cultural interpretations about the site. Although sea mammals dominate each midden assemblage, Midden 3 has higher numbers of phocid seal and the lowest frequencies of caribou and dog/wolf than any other midden. This contrast may represent a slightly different season



of occupation than the other middens. Another possibility is that Midden 3 may have been formed either prior or subsequent to the other two middens, under environmental conditions that favoured phocid populations. Since other natural and cultural formation processes have been ruled out as having a significant impact on species composition, this pattern is likely the result of the two factors outlined above acting either alone or in combination.

The rate of deposition/formation of each assemblage can provide information regarding the intensity of site occupancy. As mentioned previously, Midden 2 experienced slower rates of formation than the other middens. This evidence suggests that the contents of Midden 2 were accumulated more gradually and the site was less intensively occupied. This subtle difference would not have been detected if a more traditional zooarchaeological approach were taken. These results show that if a more rigorous approach is taken, one that involves subgroup comparisons, otherwise invisible aspects of human behaviour become apparent.

The results from this study signify that the NeHd-1 midden assemblages largely reflect human behaviours, with a relatively limited non-human taphonomic signature. However, one cannot assume a limited non-human impact on an assemblage; it must be demonstrated before any subsequent interpretations of human behaviour are made. By embracing the ideas and methods of the multivariate taphonomic approach, archaeologists can begin to measure and evaluate the impact of multiple taphonomic agents on a faunal collection. If little variability is shown to exist, it suggests that the observed differences are the product of the patterns of human behaviour targeted for study. If differences in formation processes are observed, archaeologists can only

conduct inter- and intra-site comparisons once the variability in formation processes is accounted for.

#### **5.4 Future Research**

This study provides baseline data from which to begin broader regional scale studies of human settlement and subsistence behaviour. The results from this study need to be compared to faunal data with known taphonomic histories from archaeological sites across the Canadian Arctic, to begin understanding the variability of midden formation between sites. It is not expected that the same patterns and levels of destruction will be found in all middens. However, this information can be used to reassess existing interpretations of broader cultural trends and provide a strong foundation for further inter- and intra-site comparisons to be made.

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## Appendix 1

### FAUNAL DATA

<b>Appendix 1.1: Walrus Element Representation: NISP, MNE</b>								
	<b>Midden 1</b>		<b>Midden 2</b>		<b>Midden 3</b>		<b>Total Site</b>	
<b>Element</b>	<b>NISP</b>	<b>MNE</b>	<b>NISP</b>	<b>MNE</b>	<b>NISP</b>	<b>MNE</b>	<b>NISP</b>	<b>MNE</b>
skull	36	5	21	3	19	3	76	12
mandible	5	3	2	1	4	3	11	9
atlas	1	1	0	0	1	1	2	2
axis	0	0	0	0	0	0	0	0
cervical	5	5	4	3	2	2	11	9
thoracic	5	3	4	2	4	2	13	7
lumbar	4	2	0	0	3	3	7	5
baculum	2	1	1	1	0	0	3	2
sacrum	2	1	0	0	1	1	3	2
caudal	0	0	0	0	0	0	10	7
rib	50	39	19	13	25	21	0	0
sternum	0	0	2	2	0	0	94	73
scapula	1	1	7	4	2	2	2	2
humerus	6	3	6	5	3	3	10	6
radius	3	3	0	0	3	2	15	11
ulna	4	2	1	1	3	2	6	4
carpals	4	4	0	0	0	0	8	5
mcarpal	0	0	0	0	2	2	4	4
F.phalanges	1	1	1	1	0	0	2	2
innom	4	3	2	1	4	3	2	2
femur	10	6	4	3	2	2	16	11
tibia	2	1	3	2	5	4	10	7
fibula	0	0	0	0	2	1	3	2
calcaneus	0	0	0	0	0	0	0	0
astralagus	0	0	0	0	0	0	0	0
tarsals	2	2	0	0	0	0	2	2
mtarsals	1	1	0	0	2	2	3	3
H.phalanges	1	1	3	2	2	2	6	4
<b>TOTAL</b>	<b>149</b>		<b>80</b>		<b>89</b>		<b>319</b>	

**Appendix 1.2: Phocid Bone Density vs. Walrus MAU, TOTAL SITE**

<b>Element</b>	<b>Scan Site</b>	<b>Zone</b>	<b>NISP</b>	<b>MNE</b>	<b>Elements/Skeleton</b>	<b>MAU</b>	<b>Bone Density</b>
	<b>(Lyman 1994)</b>						
MAN	DN2	2	11	9	2	4.5	0.84
AT	AT1/2	2,3	2	2	1	2.0	0.48
THOR	TH1/2	7	13	7	13	0.5	0.36
LUM	LU1	7	7	5	6	0.8	0.38
SACR	SC1	2,3	3	2	1	2.0	0.43
RIB	RI4	4	94	73	26	2.8	0.63
SCAP	SP3	6	10	6	2	3.0	0.61
HUM	HU4	6,7	15	11	2	5.5	0.67
RAD	RA4	5	6	4	2	2.0	0.39
UL	UL1/2/4	2,4,6	8	5	2	2.5	0.63
INN	IS1	8	10	7	2	3.5	0.67
FEM	FE4/5	7	16	11	2	5.5	0.57
TIB	TI3	6	10	7	2	3.5	0.86
FIB	FI3/4	3	3	2	2	1.0	0.89
TOTAL			208				

**Appendix 1.3: Phocid Bone Density vs. Walrus MAU, MIDDEN 1**

<b>Element</b>	<b>Scan Site (Lyman 1994)</b>	<b>Zone</b>	<b>NISP</b>	<b>MNE</b>	<b>Elements/Skeleton</b>	<b>MAU</b>	<b>Bone Density</b>
MAN	DN1/2/3	1 to 3	5	3	2	1.5	0.76
AT	AT1/2	2,3,5	1	1	1	1.0	0.48
AX	AX1/2	-	0	0	1		
THOR	TH1/2	7	5	3	13	0.2	0.36
LUM	LU1	7,9 1 to	4	2	6	0.3	0.38
SACR	SC1/2	4,9,10	2	1	1	1.0	0.39
RIB	RI4	4	50	39	26	1.5	0.63
SCAP	SP3	5,6	1	1	2	0.5	0.61
HUM	HU4/5	4,6,7	6	3	2	1.5	0.64
RAD	RA4	5	3	3	2	1.5	0.39
UL	UL1/2/4	2,4,6	4	2	2	1.0	0.63
INN	IS1	8	4	3	2	1.5	0.67
FEM	FE4/5	7	10	6	2	3.0	0.57
TIB	TI3/4	5,6,7	2	1	2	0.5	0.71
FIB	FI1/2/3/4/5	-	0	0	2		
CALC	CA1/2	-	0	0	2		
ASTR	AS1/2/3	-	0	0	2		
TOTAL			97				

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**Appendix 1.4: Phocid Bone Density vs. Walrus MAU, MIDDEN 2**


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<b>Element</b>	<b>Scan Site (Lyman 1994)</b>	<b>Zone</b>	<b>NISP</b>	<b>MNE</b>	<b>Elements/Skeleton</b>	<b>MAU</b>	<b>Bone Density</b>
MAN	DN2/3/4/5/6/7	2 to 6	2	1	2	0.5	0.87
AT	AT1/2	-	0	0	1		
AX	AX1/2	-	0	0	1		
THOR	TH1/2	2,6,7	4	2	13	0.2	0.36
LUM	LU1	-	0	0	6		
SACR	SC1/2	-	0	0	1		
RIB	RI4	4	19	13	26	0.5	0.63
SCAP	SP3	6	7	4	2	2.0	0.61
HUM	HU3/4	6 to 9	6	5	2	2.5	0.62
RAD	RA1/2/3/4/5	-	0	0	2		
UL	UL1/2/4	1 to 7	1	1	2	0.5	0.63
INN	IL2/AC1/IS1/2	3 to 9	2	1	2	0.5	0.63
FEM	FE4/5	7	4	3	2	1.5	0.57
TIB	TI1/2/3/4	3,4,6,7	3	2	2	1.0	0.57
FIB	FI1/2/3/4/5	-	0	0	2		
CALC	CA1/2	-	0	0	2		
ASTR	AS1/2/3	-	0	0	2		
<b>TOTAL</b>			48				

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**Appendix 1.5: Phocid Bone Density vs. Walrus MAU, MIDDEN 3**

Scan Site		Zone	NISP	MNE	Elements/Skeleton	MAU	Bone Density
Element	(Lyman 1994)						
MAN	DN2	2	4	5	2	2.5	0.84
AT	AT1/2	2 to 4	1	1	1	1.0	0.48
AX	AX1/2	-	0	0	1		
THOR	TH1/2	2,4,6,7	4	2	13	0.2	0.36
LUM	LU1	4 to 7	3	3	6	0.5	0.38
SACR	SC1	2,3	1	1	1	1.0	0.43
RIB	RI4	4	25	21	26	0.8	0.63
SCAP	SP1/2	1,4	2	2	2	1.0	0.49
HUM	HU2/3/4	6 to 10	3	3	2	1.5	0.54
RAD	RA2/5	3,6	3	2	2	1.0	0.57
UL	UL1/2/3/4	2 to 6,8	3	2	2	1.0	0.56
INN	AC1/IS1	6,8	4	3	2	1.5	0.57
FEM	FE4/5	5 to 7	2	2	2	1.0	0.57
TIB	TI3	5,6	5	4	2	2.0	0.86
FIB	FI3/4	3	3	2	2	1.0	0.89
CALC	CA1/2	-	0	0	2		
ASTR	AS1/2/3	-	0	0	2		
TOTAL			63				



**Appendix 1.6:** Frequency of mammal bone fragments by size class (mm), TOTAL SITE

<b>TAXON</b>	<b>0-10</b>	<b>10-20</b>	<b>20-30</b>	<b>30-40</b>	<b>40-50</b>	<b>50-60</b>	<b>60-70</b>	<b>70-80</b>	<b>80-90</b>	<b>90-100</b>	<b>&gt;100</b>	<b>Total</b>
Seal	0	2	3	3	1	0	0	1	0	0	0	10
Phocid Seal	3	33	35	7	4	8	8	1	2	2	13	113
Ringed Seal	0	5	12	7	4	4	1	3	3	2	9	50
Harp Seal	0	1	0	0	0	1	0	1	1	1	0	5
Bearded Seal	1	5	7	4	3	4	7	6	4	3	26	69
LG seal	0	7	9	2	4	5	1	1	1	0	1	31
LG seal/Walrus	0	2	9	13	12	6	4	3	3	4	6	62
Walrus	1	2	9	15	21	23	22	23	17	20	177	329
Walrus/Whale	0	0	0	0	0	0	0	0	0	0	0	0
Whale	0	0	4	5	9	8	4	8	8	5	23	74
Bear	0	0	0	0	0	0	0	1	0	0	0	1
Caribou	0	5	4	7	6	3	6	3	6	6	15	61
Canis sp.	1	0	0	0	0	0	0	0	0	0	0	0
Dog/Wolf	2	10	8	4	9	1	1	1	2	1	4	41
Arctic Fox	12	58	42	35	15	7	8	4	8	2	2	181
Arctic Hare	0	0	0	0	1	0	0	0	0	0	0	1
Unid. Sea Mam.	2	177	218	137	85	34	26	15	8	3	7	710
Unid. Land Mam.	2	44	46	21	8	10	3	3	2	0	3	140
Unid. Mam.	830	1936	454	133	62	18	13	5	3	4	4	2632
Bird	6	63	60	38	16	8	11	3	3	1	1	204
Fish	4	15	11	3	2	0	0	0	0	0	0	31
Unid.	405	316	57	11	1	1	0	0	0	0	0	386
<b>TOTAL</b>	<b>1269</b>	<b>2681</b>	<b>988</b>	<b>445</b>	<b>263</b>	<b>141</b>	<b>115</b>	<b>82</b>	<b>71</b>	<b>54</b>	<b>291</b>	<b>5131</b>

**Appendix 1.7: Frequency of Mammal Bone Fragments by size class (mm), MIDDEN 1**

<b>TAXON</b>	<b>0-10</b>	<b>10-20</b>	<b>20-30</b>	<b>30-40</b>	<b>40-50</b>	<b>50-60</b>	<b>60-70</b>	<b>70-80</b>	<b>80-90</b>	<b>90-100</b>	<b>&gt;100</b>	<b>Total</b>
Seal	0	2	1	1	0	0	0	1	0	0	0	5
Phocid Seal	2	14	18	3	0	0	4	0	0	1	3	45
Ringed Seal	0	4	7	3	2	1	0	2	2	2	5	28
Harp Seal	0	1	0	0	0	0	0	0	0	0	0	1
Bearded Seal	0	2	2	2	1	2	2	1	2	1	12	27
LG seal	0	4	5	0	2	3	0	1	0	0	0	15
LG seal/Walrus	0	2	7	5	3	3	0	2	1	1	2	26
Walrus	1	1	7	11	12	14	7	16	6	9	80	164
Walrus/Whale	0	0	0	0	0	0	0	0	0	0	0	0
Whale	0	0	4	3	6	4	2	1	2	1	6	29
Bear	0	0	0	0	0	0	0	1	0	0	0	1
Caribou	0	4	4	4	4	1	5	2	3	4	10	41
Canis sp.	1	0	0	0	0	0	0	0	0	0	0	1
Dog/Wolf	2	5	6	4	1	1	0	1	0	0	1	21
Arctic Fox	8	33	15	16	6	1	4	0	3	0	0	86
Arctic Hare	0	0	0	0	1	0	0	0	0	0	0	1
Unid. Sea Mam.	0	98	129	84	39	18	14	10	5	2	1	400
Unid. Land Mam.	2	35	34	13	3	5	1	1	0	0	2	96
Unid. Mammal	421	1142	246	71	24	14	7	0	0	2	4	1931
Unid.	223	194	26	7	0	0	0	0	0	0	0	450
<b>TOTAL</b>	<b>660</b>	<b>1541</b>	<b>511</b>	<b>227</b>	<b>104</b>	<b>67</b>	<b>46</b>	<b>39</b>	<b>24</b>	<b>23</b>	<b>126</b>	<b>3368</b>

**Appendix 1.8: Frequency of Mammal Bone Fragments by Size Class (mm), MIDDEN 2**

<b>TAXON</b>	<b>0-10</b>	<b>10-20</b>	<b>20-30</b>	<b>30-40</b>	<b>40-50</b>	<b>50-60</b>	<b>60-70</b>	<b>70-80</b>	<b>80-90</b>	<b>90-100</b>	<b>&gt;100</b>	<b>Total</b>
Seal	0	0	2	1	0	0	0	0	0	0	0	3
Phocid Seal	1	13	11	3	1	2	0	1	1	0	2	35
Ringed Seal	0	1	3	1	1	0	0	1	0	0	1	8
Harp Seal	0	0	0	0	0	0	0	1	1	1	0	3
Bearded Seal	1	1	3	2	2	0	0	1	0	0	7	17
LG seal	0	2	3	2	2	1	0	0	1	0	1	12
LG seal/Walrus	0	0	2	7	7	1	2	1	2	0	1	23
Walrus	0	0	2	3	7	6	7	3	7	6	42	83
Walrus/Whale	0	0	0	0	0	0	0	0	0	0	0	0
Whale	0	0	0	1	1	2	2	4	2	4	15	31
Bear	0	0	0	0	0	0	0	0	0	0	0	0
Caribou	0	0	0	3	2	1	1	0	3	2	3	15
Canis sp.	0	0	0	0	0	0	0	0	0	0	0	0
Dog/Wolf	0	4	2	0	6	0	1	0	2	0	1	16
Arctic Fox	2	16	16	9	4	4	3	3	2	1	1	61
Arctic Hare	0	0	0	0	0	0	0	0	0	0	0	0
Unid. Sea Mam.	2	60	66	34	26	11	7	3	3	1	4	217
Unid. Land Mam.	0	6	7	5	3	5	2	2	2	0	0	32
Unid. Mam	335	572	146	44	24	1	6	4	2	2	0	1136
Unid.	128	59	19	4	1	0	0	0	0	0	0	211
<b>TOTAL</b>	<b>469</b>	<b>734</b>	<b>282</b>	<b>119</b>	<b>87</b>	<b>34</b>	<b>31</b>	<b>24</b>	<b>28</b>	<b>17</b>	<b>78</b>	<b>1903</b>

**Appendix 1.9: Frequency of Mammal Bone Fragments by Size Class (mm), MIDDEN 3**

<b>TAXON</b>	<b>0-10</b>	<b>10-20</b>	<b>20-30</b>	<b>30-40</b>	<b>40-50</b>	<b>50-60</b>	<b>60-70</b>	<b>70-80</b>	<b>80-90</b>	<b>90-100</b>	<b>&gt;100</b>	<b>Total</b>
Seal	0	0	0	1	1	0	0	0	0	0	0	2
Phocid Seal	0	6	6	1	3	6	4	0	1	1	8	36
Ringed Seal	0	0	2	3	1	3	1	0	1	0	3	14
Harp Seal	0	0	0	0	0	1	0	0	0	0	0	1
Bearded Seal	0	2	2	0	0	2	5	4	2	2	7	26
LG seal	0	1	1	0	0	1	1	0	0	0	0	4
LG seal/Walrus	0	0	0	1	2	2	2	0	0	3	3	13
Walrus	0	1	0	1	2	3	8	4	4	5	55	83
Walrus/Whale	0	0	0	0	0	0	0	0	0	0	0	0
Whale	0	0	0	1	2	2	0	3	4	0	2	14
Bear	0	0	0	0	0	0	0	0	0	0	0	0
Caribou	0	1	0	0	0	1	0	1	0	0	2	5
Canis sp.	0	0	0	0	0	0	0	0	0	0	0	0
Dog/Wolf	0	1	0	0	2	0	0	0	0	1	2	6
Arctic Fox	2	9	11	10	5	2	1	1	3	1	1	46
Arctic Hare	0	0	0	0	0	0	0	0	0	0	0	0
Unid. Sea Mam.	0	19	23	19	20	5	5	2	0	0	2	95
Unid. Land Mam.	0	3	5	3	2	0	0	0	0	0	1	14
Unid. Mammal	74	222	62	18	14	3	0	1	1	0	0	395
Unid.	54	63	12	0	0	1	0	0	0	0	0	130
<b>TOTAL</b>	<b>130</b>	<b>328</b>	<b>124</b>	<b>58</b>	<b>54</b>	<b>32</b>	<b>27</b>	<b>16</b>	<b>16</b>	<b>13</b>	<b>86</b>	<b>884</b>

**Appendix 1.10: Modification Frequencies On Mammal Bones**

	<b>Midden 1</b>		<b>Midden 2</b>		<b>Midden 3</b>		<b>Total Site</b>	
<b>Quantitative Data</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>
<b>Mammal NISP (size cat. &gt;20)</b>	1305		771		534		2610	
<b>Bone Damage By Natural Agents</b>								
Weathering stage 3 or higher	12	0.9	30	3.9	2	0.3	44	1.7
Root etching	15	1.1	1	0.1	0	0.0	16	0.6
Abrasion	1	0.1	1	0.1	2	0.3	4	0.2
Rodent gnawed	19	1.5	23	3.0	31	5.2	73	2.8
Carnivore damage	314	24.1	278	36.1	178	29.6	770	29.5
Corrosion	44	3.4	39	5.1	17	2.8	100	3.8
<b>Bone Damage By Human Subsistence Behaviour</b>								
Cut marks	53	4.1	52	6.7	37	6.2	142	5.4
Impact scars	12	0.9	4	0.5	2	0.3	18	0.7
FFI (>3)	20		5		4	0.7	29	1.1
Burnt	1	0.1	2	0.3	0	0.0	3	0.1
Flaking	0	0.0	0	0.0	1	0.2	1	0.0
Polishing	1	0.1	2	0.3	0	0.0	3	0.1

**Appendix 1.11: Modification Frequencies On Land Mammal Bone**

	<b>Midden 1</b>		<b>Midden 2</b>		<b>Midden 3</b>		<b>Total Site</b>	
<b>Quantitative Data</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>
<b>Land Mammal NISP (size cat. &gt;20)</b>	179		122		72		373	
<b>Bone Damage By Natural Agents</b>								
Weathering stage 3 or higher	0	0.0	0	0.0	0	0.0	0	0.0
Root etching	1	0.6	0	0.0	0	0.0	1	0.3
Abrasion	0	0.0	0	0.0	0	0.0	0	0.0
Rodent gnawed	4	2.2	6	4.9	6	8.3	16	4.3
Carnivore damage	29	16.2	37	30.3	11	15.3	77	20.6
Corrosion	1	0.6	0	0.0	1	1.4	2	0.5
<b>Bone Damage By Human Subsistence Behaviour</b>								
Cut marks	7	3.9	11	9.0	5	6.9	23	6.2
Impact scars	2	1.1	0	0.0	1	1.4	3	0.8
Burnt	0	0.0	0	0.0	0	0.0	0	0.0
Flaking	0	0.0	0	0.0	0	0.0	0	0.0
Polishing	1	0.6	1	0.8	0	0.0	2	0.5



**Appendix 1.12: Modification Frequencies On Sea Mammal Bones**

	<b>Midden 1</b>		<b>Midden 2</b>		<b>Midden 3</b>		<b>Total Site</b>	
<b>Quantitative Data</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>
<b>Sea Mammal NISP (size cat. &gt;20)</b>	732		420		368		1520	
<b>Bone Damage By Natural Agents</b>								
Weathered stage 3 or higher	2	0.3	8	1.9	2	0.5	12	0.8
Root etching	13	1.8	1	0.2	0	0.0	14	0.9
Abrasion	1	0.1	1	0.2	2	0.5	4	0.3
Rodent gnawed	13	1.8	14	3.3	23	6.3	50	3.3
Carnivore damage	231	31.6	204	48.6	141	38.3	576	37.9
Corrosion	20	2.7	5	1.2	2	0.5	27	1.8
<b>Bone Damage By Human Subsistence Behaviour</b>								
Cut marks	42	5.7	38	9.0	31	8.4	111	7.3
Impact scars	10	1.4	4	1.0	1	0.3	15	1.0
Burnt	0	0.0	0	0.0	0	0.0	0	0.0
Flaking	0	0.0	0	0.0	1	0.3	1	0.1
Polishing	0	0.0	0	0.0	0	0.0	0	0.0

## Appendix 2

### DEFINITION OF MAMMAL BONE ZONES

<b>Appendix 2.1: Definition of sea mammal bone zones</b>		
<b>Element</b>	<b>Zone</b>	<b>Description</b>
Walrus skull	1	Inferior edge of premaxillary
	2	Anterior edge of premaxillary bone
	3	Maxillary bone including tooth row
	4	Most anterior portion of maxillary bone, above nasal canal
	5	Posterior edge of maxillary
	6	Frontal including orbital region
	7	Jugal bone including the zygomatic arch
	8	Parietal
	9	Mandibular fossa including the tympanic bone
	10	Temporal
	11	Mastoid process including the auditory bullae
	12	Nuccal crest
	13	Occipital including the occipital condyle
	14	Basioccipital
	15	Pterygoid region
	16	Palate
	17	Ventral portion of maxillary bone
Seal skull	1	N/A
	2	Anterior portion of the premaxillary
	3	Maxillary
	4	Nasals
	5	Sphenoid
	6	Frontal including orbital region
	7	Jugal
	8	Parietal
	9	Zygomatic arch
	10	Temporal bone
	11	Mastoid process including the auditory bullae
	12	Nuccal crest
	13	Occipital including the occipital condyle
	14	Basioccipital
	15	Pterygoid region
	16	Palate
	17	Inferior portion of maxillary bone
Walrus mandible	1	Anterior portion of mandible including the mandibular symphysis

Element	Zone	Description
Walrus mandible cont'd	2	Tooth row including mental foramen
	3	Posterior portion of ramus
	4	Angular process
	5	Condyle and neck
	6	Coronoid process
Seal mandible	1	Anterior portion of mandible including incisors
	2	Tooth row
	3	Ramus
	4	Condyle including angular process and posterior edge
	5	Coronoid process
Atlas	1	N/A
	2	Anterior articular facets
	3	Posterior articular facets
	4	Right lateral transverse process
	5	Left lateral transverse process
Axis	1	Spinous process
	2	Anterior articular facet
	3	Posterior articular facet
	4	Body of centrum
	5	Left lateral transverse process
	6	Right lateral transverse process
	7	Neural arch
Cervical	1	Spinous process
	2	Anterior articular facet
	3	Posterior articular facet
	4	Body of centrum
	5	Left anterior and posterior zygapophysis
	6	Right anterior and posterior zygapophysis
	7	Rest of neural arch
	8	Left lateral transverse process
	9	Right lateral transverse process
Thoracic	1	Spinous process
	2	Anterior articular facet
	3	Posterior articular facet
	4	Body of centrum
	5	Left lateral transverse process including anterior zygapophysis
	6	Right lateral transverse process including anterior zygapophysis
	7	Neural arch

<b>Element</b>	<b>Zone</b>	<b>Description</b>
Lumbar	1	Spinous process
	2	Anterior articular facet
	3	Posterior articular facet
	4	Body of centrum
	5	Left anterior zygapophysis
	6	Right anterior zygapophysis
	7	Neural arch
	8	Left lateral transverse process
	9	Right lateral transverse process
Caudal	1	Spinous process
	2	Anterior articular facet
	3	Posterior articular facet
	4	Body of centrum
	5	Left lateral transverse process
	6	Right lateral transverse process
	7	Neural arch
Sacrum	1	Spinous process
	2	Cranial articular facet
	3	Left alae including lateral facet
	4	Right alae including lateral facet
	5	Left lateral transverse process
	6	Right lateral transverse process
	7	Anterior portion of neural arch
	8	Mid portion of neural arch
	9	Posterior portion of neural arch
	10	Anterior portion of ventral surface
	11	Mid portion of ventral surface
	12	Posterior portion of ventral surface
Rib	1	Head
	2	Tubercle including the neck
	3	Angle
	4	Shaft including costal groove
	5	Sternal end
Scapula	1	Supraglenoid tubercle
	2	Anterior half of glenoid cavity
	3	Posterior half of glenoid cavity
	4	Neck including the acromion process
	5	Distal portion of blade
	6	Distal portion of blade including the scapular spine and nutrient foramen
	7	Mid portion of blade including supraspinous fossa

<b>Element</b>	<b>Zone</b>	<b>Description</b>
Scapula cont'd	8	Mid portion of blade including spine and supraspinous fossa
	9	Portion of blade including anterior angle
	10	Portion of blade including posterior angle
Humerus	1	Lateral tuberosity
	2	Medial tuberosity including intertuberal groove
	3	Head
	4	Lateral condyle
	5	Medial condyle
	6	Lateral distal half of shaft
	7	Medial distal half of shaft
	8	Lateral mid portion of the shaft including deltoid tuberosity
	9	Medial mid portion of the shaft
	10	Proximal portion of the shaft
Radius	1	Lateral portion of humeral articular surface
	2	Medial portion of humeral articular surface
	3	Proximal portion of shaft
	4	Mid portion of shaft
	5	Distal portion of shaft
	6	Medial portion of distal articulation
	7	Lateral portion of distal articulation
Ulna	1	Olecranon
	2	Portion of ulna between the olecranon and anconeus process
	3	Portion of shaft posterior to articular surfaces
	4	Trochlear notch
	5	Lateral coronoid process
	6	Portion of shaft inferior to articular surfaces
	7	Distal portion of shaft
	8	Styloid process
Innominate	1	Medial portion of tuber coxae
	2	Lateral portion of tuber coxae
	3	Portion of ilium that articulates with the sacral wing
	4	Remaining portion of ilium
	5	Cranial portion of acetabular fossa
	6	Ventral portion of acetabular fossa
	7	Lateral portion of acetabular fossa
	8	Portion of pubis including ilio-pectineal eminence
	9	Remaining portion of pubis including the pubic symphysis
	10	Portion of ischium opposite the obturator foramen
	11	Portion of ischium including the ischiatic tuberosity

<b>Element</b>	<b>Zone</b>	<b>Description</b>
Innominate Cont'd	12	Remaining portion of ischium
Femur	1	Head
	2	Greater trochanter
	3	Trochanteric fossa and neck
	4	Proximal portion including intertrochanteric crest
	5	Mid and medial portion of shaft
	6	Lesser trochanter
	7	Distal portion of shaft
	8	Medial condyles and epicondyles
	9	Lateral condyles and epicondyles
	10	Trochlea
Tibia	1	Lateral condyle
	2	Intercondylar fossa
	3	Lateral condyle
	4	Proximal portion of shaft
	5	Mid portion of shaft, including nutrient foramen
	6	Remaining mid portion of shaft
	7	Distal portion of shaft
	8	Lateral malleolus
	9	Medial malleolus
Fibula	1	Proximal tibial articular surface
	2	Proximal portion of shaft
	3	Distal portion of shaft
	4	Distal tibial articular surface and lateral malleolus
Astragalus	1	Medial half of trochlea
	2	Lateral half of trochlea
	3	Medial half of distal articulation
	4	Lateral half of distal articulation
Calcaneus	1	Calcaneal tuber
	2	Sustentaculum tali, shelf on medial side of the calcaneus including posterior articular surface
	3	Anterior articular surface for the talus
	4	Distal tuberosity and articulation
Metapodials/ Phalanges	1	Proximal articulation
	2	Shaft region (excluding 3 <sup>rd</sup> phalanx)
	3	Distal articulation



**Appendix 2.2: Definition of land mammal bone zones**

<b>Element</b>	<b>Zone</b>	<b>Description</b>
Cervid skull	1	Premaxillary
	2	Turbinate
	3	Anterior portion of maxillary
	4	Mid portion of maxillary including the tooth row
	5	Posterior portion of maxillary
	6	Nasal
	7	Lacrima
	8	Jugal
	9	Zygomatic arch
	10	Frontal including the postorbital bar
	11	Posterior portion of frontal
	12	Parietal
	13	Temporal
	14	Sphenoid region including the alisphenoid and orbitosphenoid
	15	Mandibular fossa including the tympanic
	16	Mastoid process including the auditory bullae
	17	Occipital condyle including the paraoccipital process
	18	Nuccal crest
	19	Basioccipital
	20	Pterygoid region
	21	Palate
Canid skull	22	Inferior portion of maxillary bone
	1	Premaxillary
	2	Maxillary
	3	Nasal
	4	Jugal
	5	Zygomatic arch
	6	Frontal region
	7	Braincase region including the parietal, temporal, and Sphenoid
	8	Sphenoid
	9	Auditory meatus
	10	Occipital including the supraoccipital shield, occipital Condyle, paraoccipital processes
	11	Pterygoid region
	12	Palate
Cervid mandible	1	Symphyseal surface
	2	Diastema including mental foramen
	3	Tooth row
	4	Ascending ramus
	5	Condylar process
	6	Condyle and neck

Element	Zone	Description
Cervid mandible cont'd	7	Coronoid process
Canid mandible	1	Anterior portion including incisors & canine
	2	Tooth row including mental foramina
	3	Ascending ramus
	4	Condyle & angular process
	5	Coronoid process
Atlas	1	Spinous process
	2	Anterior articular facets
	3	Posterior articular facets
	4	Right lateral transverse process
	5	Left lateral transverse process
	6	Neural arch
	7	Ventral surface
Axis	1	Spinous process
	2	Anterior articular facet
	3	Posterior articular facet
	4	Body of centrum
	5	Left lateral transverse process
	6	Right lateral transverse process
	7	Neural arch
Cervical	1	Spinous process
	2	Anterior articular facet
	3	Posterior articular facet
	4	Body of centrum
	5	Left lateral transverse process
	6	Right lateral transverse process
	7	Anterior portion of neural arch including anterior zygapophysis
	8	Posterior portion of neural arch including posterior zygapophysis
	9	Left lateral ventral surface
	10	Right lateral ventral surface
Thoracic & Lumbar	1	Spinous process
	2	Anterior articular facet
	3	Posterior articular facet
	4	Body of centrum
	5	Left lateral transverse process
	6	Right lateral transverse process

<b>Element</b>	<b>Zone</b>	<b>Description</b>
Thoracic & Lumbar vertebra cont'd	7	Anterior portion of neural arch including anterior zygapophysis
	8	Posterior portion of neural arch including anterior zygapophysis
Caudal	1	Spinous process
	2	Anterior articular facet
	3	Posterior articular facet
	4	Body of centrum
	5	Left lateral transverse process
	6	Right lateral transverse process
	7	Neural arch
Canid 10 <sup>th</sup> caudal vertebra	1	Anterior portion
	2	Body of centrum
	3	Posterior portion
Sacrum	1	Spinous process
	2	Cranial articular facet
	3	Left alae including lateral facet
	4	Right alae including lateral facet
	5	Anterior portion of left transverse process
	6	Mid portion of left transverse process
	7	Posterior portion of left transverse process
	8	Anterior portion of right transverse process
	9	Mid portion of right transverse process
	10	Posterior portion of right transverse process
	11	Anterior portion of ventral surface
	12	Mid portion of ventral surface
	13	Posterior portion of ventral surface
Rib	1	Head
	2	Tubercle including the neck
	3	Angle
	4	Shaft including costal groove
	5	Sternal end
Scapula	1	Supraglenoid tubercle
	2	Anterior half of glenoid cavity
	3	Posterior half of glenoid cavity
	4	Distal portion of blade including acromion and tuber of spine
	5	Distal portion of blade including nutrient foramen
	6	Mid portion blade including spine and supraspinous fossa
	7	Mid portion of blade including infraspinous fossa

<b>Element</b>	<b>Zone</b>	<b>Description</b>
Scapula cont'd	8	Proximal portion of blade including spine and anterior angle
	9	Proximal portion of blade including posterior angle
Humerus	1	Lateral tuberosity
	2	Head including medial tuberosity and intertuberal groove
	3	Lateral epicondyle
	4	Medial epicondyle
	5	Lateral condyle
	6	Medial condyle
	7	Lateral distal half of shaft including musculospiral groove, coronoid and olecranon fossa
	8	Medial distal half of shaft including nutrient foramen and coronoid fossa
	9	Deltoid tuberosity
	10	Teres tubercle
	11	Proximal portion of shaft
Radius	1	Lateral portion of humeral articular surface including coronoid process and radial tuberosity
	2	Medial portion of humeral articular surface including glenoid cavity and radial tuberosity
	3	Lateral portion of distal articulation
	4	Medial portion of distal articulation
	5	Proximal portion of shaft incorporating proximal inter-osseous space
	6	Lateral portion of shaft including proximal portion of ulna scar below nutrient forament
	7	Medial portion of shaft
	8	Shaft including remaining ulna scar
	9	Distal shaft incorporating distal inter-osseous space
	10	Medial portion of distal shaft
Ulna	1	Olecranon
	2	Portion of ulna between the olecranon and anconeus process
	3	Anconeus process, semilunar notch and posterior portion
	4	Lateral articular surface
	5	Portion of shaft inferior to articular surfaces including inter-osseous space
	6	Mid portion of shaft
	7	Mid to distal portion of shaft
	8	Distal portion of shaft
	9	Styloid process

Element	Zone	Description
Innominate	1	Tuber coxae
	2	Portion of ilium which articulates with sacral wing
	3	Remaining portion of ilium
	4	Iliopubic eminence
	5	Cranial portion of acetabular fossa
	6	Ventral portion of acetabular fossa
	7	Dorsal portion of acetabular fossa
	8	Portion of pubis including ilio-pectineal eminence and pubic tubercle
	9	Remaining portion of pubis including acetabular and symphyseal branch
	10	Portion of ischium opposite obturator foramen
	11	Remaining portion of ischium excluding the ischiatic tuberosity
	12	Ischiatic tuberosity
Femur	1	Greater trochanter
	2	Lesser trochanter
	3	Third trochanter
	4	Head
	5	Trochanteric fossa and neck
	6	Mid portion of shaft
	7	Lateral portion of shaft including nutrient foramen and vascular groove
	8	Medial portion of shaft including supracondylar crest and supracondylar fossa
	9	Medial condyle and epicondyles
	10	Lateral condyle and epicondyles
	11	Trochlea
Tibia	1	Medial condyle
	2	Intercondylar fossa
	3	Lateral condyle
	4	Proximal tuberosity and area between tubercles of spine
	5	Medial malleolus
	6	Lateral malleolus
	7	Proximal portion of shaft including most of crest and muscle attachment lines
	8	Mid portion of shaft including nutrient foramen and distal end of anterior crest
	9	Remaining mid portion of shaft
	10	Distal portion of shaft
Fibula	1	Proximal tibial articular surface
	2	Proximal portion of shaft

Element	Zone	Description
Fibula cont'd	3	Distal portion of shaft
	4	Distal tibial articular surface and lateral malleolus
Calcaneus	1	Calcaneal tuber
	2	Shaft
	3	Sustentaculum tali, shelf on medial side of the calcaneus including posterior articular surface
	4	Distal tuberosity
	5	Anterior articular surface for the talus
Metacarpal/ Metatarsal	1	Lateral portion of proximal articulation
	2	Medial portion of proximal articulation
	3	Lateral condyle
	4	Medial condyle
	5-6	Proximal half of shaft divided by vascular groove
	7-8	Distal half of shaft divided by vascular groove
Proximal / Intermediate Phalanx	1	Proximal articulation
	2	Shaft region
	3	Distal articulation
Distal Phalanx	1	Proximal articulation
	2	Distal articulation

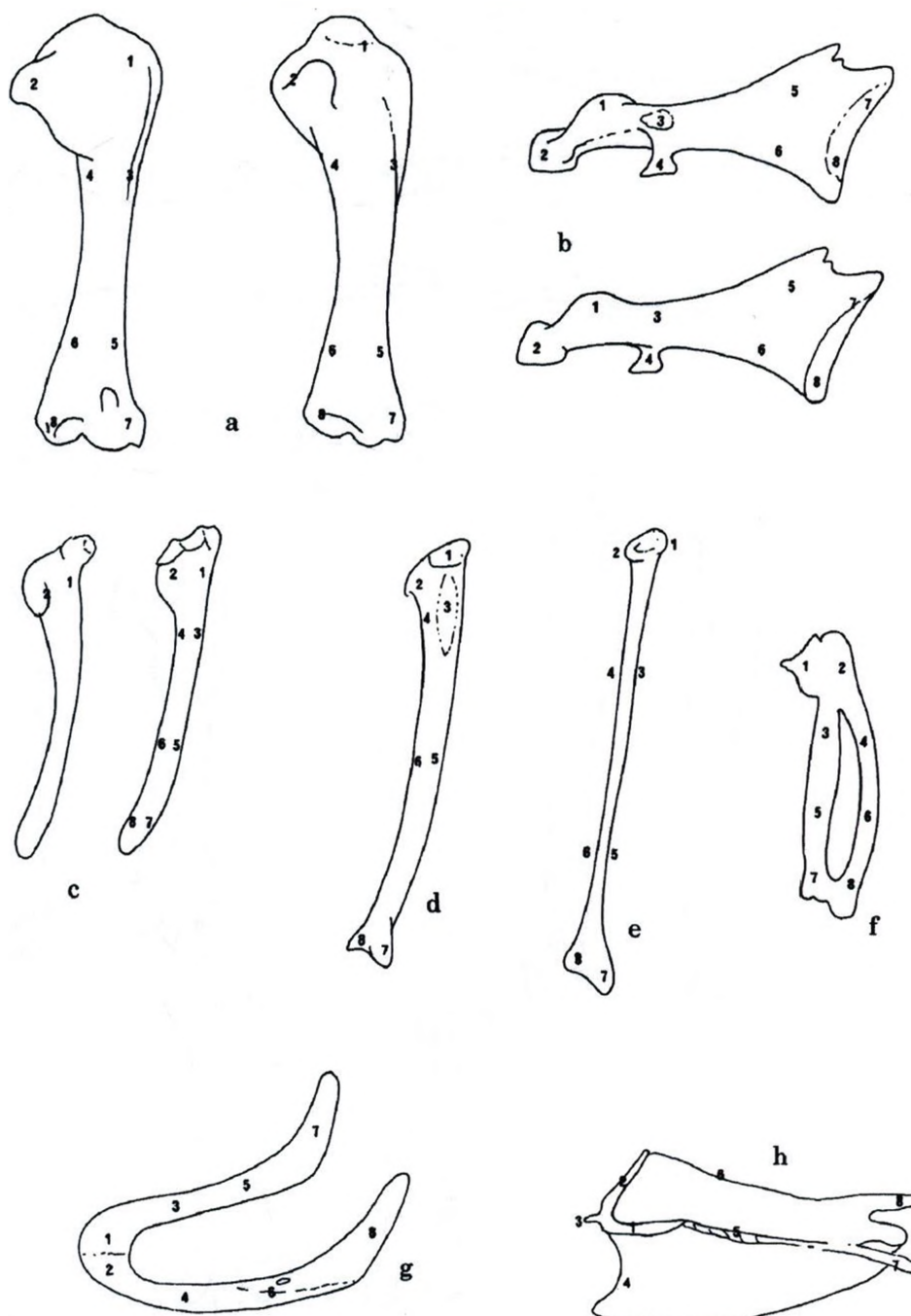


### Appendix 3

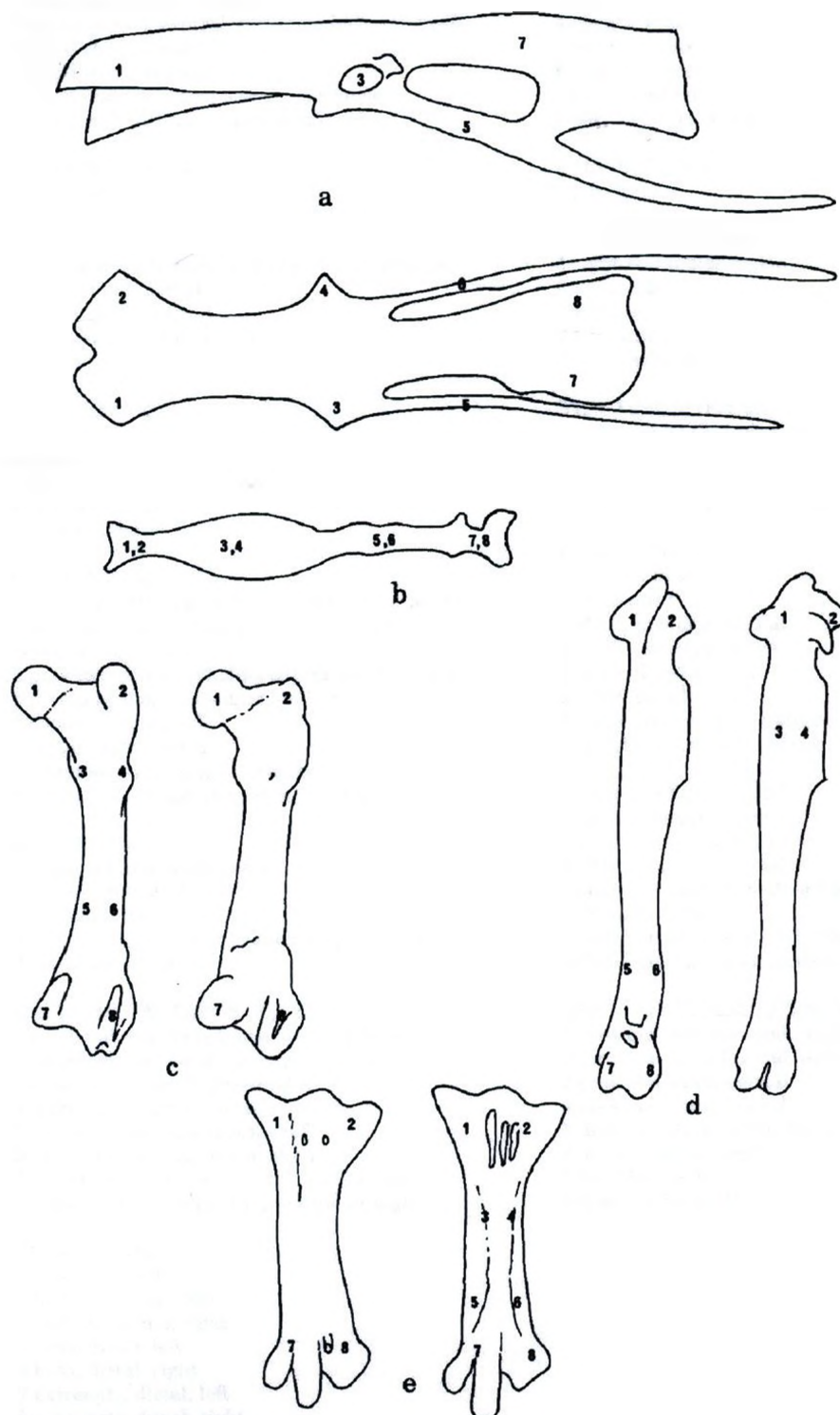
#### DEFINITION OF BIRD BONE ZONES

(Cohen & Serjeanston 1996:110-112)

**Appendix 3.1:** Zone recording method: (a) humerus, (b) coracoid, (c) scapula (d) ulna, (e) radius, (f) carpo-metacarpus, (g) furcula, (h) sternum



**Appendix 3.2: Zone recording method: (a) pelvis, (b) synsacrum, (c) femur, (d) tibio-tarsus, (e) tarso-metatarsus**



### Appendix 3.3: Definition of bird zones on previous 2 pages

#### HUMERUS (Fig. 8a)

- 1 proximal end, including head
- 2 proximal end, including fossa
- 3 proximal shaft, including deltoid crest
- 4 proximal end, ventral, including bicipital crest
- 5 distal shaft, dorsal
- 6 distal shaft, ventral
- 7 distal end, including dorsal epicondyle
- 8 distal end, including ventral epicondyle

#### CORACOID (Fig. 8b)

- 1 articular facet
- 2 acrocoracoid process
- 3 proximal shaft, including scapular facet
- 4 proximal shaft, including procoracoid process
- 5 distal shaft, dorsal
- 6 distal shaft, ventral
- 7 sterno-coracoid process
- 8 sternal facet

#### SCAPULA (Fig. 8c)

- 1 acromion
- 2 glenoid facet
- 3+4 blade, proximal
- 5+6 blade, distal
- 7+8 blade, distal

#### ULNA (Fig. 8d)

- 1 proximal articular end, including dorsal cotyla
- 2 proximal end, including prominence for anterior articular ligament
- 3 proximal shaft, including depression for brachialis
- 4 proximal shaft, including quill knobs
- 5 distal shaft, dorsal
- 6 distal shaft, ventral
- 7 distal end, including dorsal condyle
- 8 distal end, including ventral condyle

#### RADIUS (Fig. 8e)

- 1+2 proximal articular end
- 3+4 proximal shaft
- 5+6 distal shaft
- 7 distal end, including ligamental prominence
- 8 distal end, ventral

#### CARPO-METACARPUS (Fig. 8f)

- 1 proximal end, including extensor process
- 2 proximal end including carpal trochlea
- 3 major metacarpal, proximal shaft
- 4 minor metacarpal, proximal shaft
- 5 major metacarpal, distal shaft
- 6 minor metacarpal, distal shaft
- 7 distal end, including facet for major digit
- 8 distal end, including facet for minor digit

#### FURCULA (8g)

- 1+2 interclavicle
- 3 body, proximal, left
- 4 body, proximal, right
- 5 body, distal, left
- 6 body, distal, right
- 7 extremity, distal, left
- 8 extremity, distal, right

#### STERNUM (Fig. 8h)

- 1 left coracoidal groove
- 2 right coracoidal groove
- 3 rostrum
- 4 apex of keel
- 5 left rib facets
- 6 right rib facets
- 7 pars hepatica, left
- 8 pars hepatica, right

#### PELVIS (Fig. 9a)

- 1 left ilium
- 2 right ilium
- 3 left acetabular region
- 4 right acetabular region
- 5 left pubis
- 6 right pubis
- 7 left ischium
- 8 right ischium

#### SYNSACRUM (Fig. 9b)

- 1+2 synsacral thoracic vertebrae
- 3+4 synsacral lumbar vertebrae
- 5+6 synsacral sacral vertebrae
- 7+8 synsacral caudal vertebrae

#### FEMUR (Fig. 9c)

- 1 femoral head
- 2 trochanter
- 3 shaft, proximal medial
- 4 shaft, proximal lateral
- 5 shaft, distal medial
- 6 shaft, distal lateral
- 7 distal end, medial condyle
- 8 distal end, lateral condyle

#### TIBIO-TARSUS (Fig. 9d)

- 1 cranial cnemial crest
- 2 proximal articular surface
- 3 shaft, proximal medial
- 4 shaft, proximal including fibular crest
- 5+6 shaft, distal
- 7 distal articular end, including internal condyle
- 8 distal articular end, including external condyle

#### TARSO-METATARSUS (Fig. 9e)

- 1 proximal articular end, including medial cotyle
- 2 proximal articular end, including lateral cotyle
- 3 proximal shaft, medial
- 4 proximal shaft, lateral
- 5 distal shaft, including facet for 1st metatarsal
- 6 distal shaft, lateral
- 7 trochlea for MTII
- 8 trochlea for MTIV