

A COMPARISON OF PALEO-ESKIMO AND MEDIEVAL NORSE BONE FAT EXPLOITATION IN WESTERN GREENLAND

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Abstract. The importance of fat in the diet is outlined. The practice of rendering animal bones for their grease content is discussed. A methodology for identifying levels of bone fat exploitation, based upon the analysis of bone fragmentation and bone fracture type, is described. Four Greenlandic sites are analyzed using these methods. Two of these, Sandnes (V51) and Niaquus-sat (V48), are Medieval Norse sites. The others, Qeqertasussuk and Itivnera, are Paleo-Eskimo sites of the Saqqaq culture. In both cultures, land mammal bone was heavily processed for bone fat while seal bones were not. Reasons for this are discussed. The relative levels of bone fat exploitation within these two cultures are contrasted. This study of bone fat exploitation is compared to one based upon the study of fat-loving diptera. The effect that differential levels of bone rendering could have upon bone assemblage quantification is outlined.

Introduction

Animal fat is an essential dietary resource to any society which relies almost exclusively upon animal products for nutrition. Where sources of carbohydrates are absent, lipids become the principle source of energy-giving sustenance. Fats have a much higher calorific value than both carbohydrates and protein (by a ratio of 9:4) (Erasmus 1986:185; Mead et al. 1986:459), and the conversion of proteins to energy is metabolically costly. The exclusive consumption of lean meat can, in fact, lead to severe dietary problems (Speth 1987).

Fat resources would, therefore, have been of great importance to Greenlandic hunter-gatherers and pastoralists alike, neither having had access to good supplies of carbohydrates. Within-bone fat resources are clearly not the only fat resources available for exploitation. Bones are, however, a very

reliable source of good quality fat; the medullary cavities of bones are the last to be plundered in the fat mobilization sequence of a dietarily stressed animal (Peterson et al. 1982; Brookes et al. 1977; Davis et al. 1987). More importantly from an archaeological point of view, the exploitation of, say, subcutaneous fat leaves no detectable trace, but the extraction of within-bone nutrients does leave durable evidence in the form of particular bone fracture and fragmentation patterns.

The extraction of bone marrow requires little effort, but the rendering of cancellous bone, such as articular ends of limb bones and much of the axial skeleton, is an effortful and time-consuming occupation. Rendering involves the comminution of cancellous bone, which must be boiled in water until the fat rises to the top. Once on the surface, the fat can be solidified by the addition of cold water or snow and skimmed off (Binford 1978:158;

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Leechman 1951, 1954; Davis and Fisher 1990:263). This method, as encountered by Binford (1978) in his study of Nunamiut subsistence methods, requires a great deal of effort for the extraction of a very limited amount of bone grease. The effort would have been all the greater before the introduction of metal cauldrons, when many fire-heated stones were required to heat water in wooden buckets (Binford 1978). It is clear from Binford's study that the extent to which bones are exploited for their fat depends upon the level of dietary stress the community is under. Studying patterns of within-bone nutrient use can, therefore, provide information not only about differing subsistence strategies of past peoples, but also about degrees of dietary stress.

Greenland provides an excellent opportunity for such a study. Inhabited in the past by both Paleo-Eskimo hunters and Medieval Norse pastoralists, Greenland sites contain very well preserved and undisturbed archaeological bone assemblages. Buckland et al. (1996) recently postulated a theory regarding bone rendering and relative levels of resource stress among Norse and Paleo-Eskimo populations. They conducted detailed environmental investigations of the deserted Medieval Norse farmsteads of the Western Settlement (located near the modern town of Nuuk) that cluster around the church farm of Sandnes (V51). The Norse Western settlement, which commenced around AD 985, relied principally upon milk and meat from its domestic livestock—cattle, sheep and goats—for its subsistence. This diet was subsidized by land-based hunting of seal, birds, and caribou (McGovern 1985; Buckland et al. 1996). Despite their proximity to and known contact with Thule Inuit, the Norse seem to have learned nothing from them about fishing or ice-hunting. There is a virtual absence of fish bones on Norse sites; nor is equipment for fishing or the exploitation of ringed seals and whales on the sea ice to be found (McGovern 1985; Buckland et al. 1996). Life was clearly very hard and Buckland et al. argue that worsening climate made the maintenance of domestic animals more and more difficult. The lack of will amongst the Norse to adapt to more suitable subsistence methods led to their final downfall by the end of the fifteenth century.

Entomological examination of the Sandnes waste middens (Buckland et al. 1996) showed a distinct lack of diptera (true flies) which feed on fat. This, along with the fragmented nature of the bone assemblages, led Buckland and colleagues to the conclusion that the nutritionally stressed Norse had rendered the vast majority of their bone waste to extract much needed fat. They support their theory by drawing attention to the entomological work carried out at the Paleo-Eskimo site of Qeqertasussuk, where the midden produced many fat-loving diptera (Böcher and Fredskild 1993:20). This led

Buckland and colleagues to conclude that the Paleo-Eskimo population, being more suitably adapted to their environment, were under less subsistence stress than the Norse farmers and did not need to process their bone waste as extensively for fat resources.

Buckland et al. did not examine patterns of bone fracture and fragmentation at these sites in detail. In the present study, I carry out such an examination to ascertain whether these patterns are in agreement with other environmental and paleo-economic indicators, with regard to the importance of bone marrow and grease exploitation. Four sites are studied: Sandnes and Qeqertasussuk; another Norse farmstead, Niaquussat; and another Paleo-Eskimo site, Itivnera. Descriptions of these sites are given in the relevant passages below.

Methods

The degree to which bone fat was exploited in a given archaeological bone assemblage can be assessed by comparison with theoretical models of expected fracture types and bone fragmentation levels. In the case of an assemblage affected by marrow extraction only, one would expect to find fractured long bone shafts, while axial elements and articular ends of long bones should remain relatively unfragmented. To extract fresh marrow, the bones would have to have been fractured while relatively fresh, and therefore would exhibit "green bone" or helical shaft breaks.

If *all* fat resources were exploited within an assemblage, one would expect to find extreme comminution of articular and axial cancellous bone (perhaps to the extent that almost none of these parts remain identifiable). The only fragments surviving to any size would be shaft fragments, and these would bear fresh fracture types. (In rare circumstances shaft fragments can also be rendered [see Binford 1978: Chapter 4], but they have a very low fat yield.) Clearly, there will be stages of processing in-between, where some types of elements are processed less frequently or not at all. Also axial and articular bone grease are different and are perceived as such in more than one ethnographic context (Binford 1978; Wilson 1924), which might contribute to preferential use. The situation is further complicated by the existence of other taphonomic causes of fragmentation and attrition. Trampling, animal gnawing, burning, excavation damage, and recovery bias, for example, will all alter the fragmentation pattern.

Thus, in order sensibly to investigate patterns of bone fat utilization, many variables must be considered. A single statistic for degree of bone fragmentation is not enough; it is essential to quantify how much bone was reduced to given fragment sizes. It is also essential to know what sorts of bone

suffered particular levels of fragmentation. The nature of fracture types must be assessed (i.e., how fresh were the bones when they were fractured?). Burning, dog gnawing, and obvious recent damage must be ascertained and quantified. Finally, in considering all these taphonomic factors together, it may be necessary to allow that the sensible interpretation is that bone fat exploitation patterns are obscured by other postdepositional damage!

Degree of Fragmentation

The analysis of degree of fragmentation principally involved separating the bone assemblage according to size class. Ten size classes were used: <20 mm, 20–30 mm, 30–40 mm, 40–50 mm, 50–60 mm, 60–80 mm, 80–100 mm, >100 mm, bone part, and whole bone. The last two classes are not strictly size classes, but were necessary to distinguish large fragments from unbroken whole or part bones of similar size. A bone was classified as being a “part” if it was an unbroken articular or axial portion. Such parts clearly had not been processed and so were not lumped into a “fragment” size class. A “whole bone” is an entirely undamaged element. These distinctions were considered important only in the larger size classes; very small “whole” bones, such as carpals, were simply assigned to their corresponding size classes.

Fragments were assigned to size class by their maximum dimension. This was achieved by quickly running each fragment over a series of drawn rings of graduated diameters. Once assigned to size classes, the fragments were quantified by number and mass. Mass was measured with electronic scales and was recorded to the nearest 0.1 g. Counting was carried out with the aid of a mechanical clocking device.

The quantification of fragments by both mass and number is important since both methods are biased. When quantified by number, small size classes invariably dominate for the obvious reason that one large piece can be broken into many small pieces. Important fluctuations in the numbers of large or unbroken bones may appear insignificant against the vast number of tiny fragments! Quantification by mass gives a more realistic picture of the quantity of bone present, but large fluctuations in levels of small fragments tend not to show up well when quantified by mass. The best course of action is to scrutinize both measures.

Within the size classes, the proportions of different types of bone were recorded by number. An attempt was made to discern between diaphysis, cancellous epiphysis, and axial fragments. In some of the studies below, more details are recorded. Clearly, different degrees of bone type separation are possible in the different size classes. No attempt to identify type was made in the smallest class. A

basic separation between cancellous and dense diaphysis bone was made in the 30–60 mm range. Full details were recorded in the >60 mm range.

Indexing Fracture Type

Dense diaphysis bone has a very distinctive fracture pattern when broken fresh. Fresh fractures are characterized by helical fracture lines radiating from the point of impact. The fracture surface is smooth and forms a sharp (acute or obtuse) angle to the cortical surface of the bone. As bones start to dry out, these fracture properties are lost. Fracture lines become straight (diagonal, transverse, or longitudinal), and the fracture surface becomes more jagged and tends to be more at right angles to the cortical surface (Johnson 1985; Morlan 1984).

Villa and Mahieu (1991), in a study on archaeological assemblages of human bone, used the above criteria, along with some others, to assess levels of fresh fracture. I use the same three criteria of fracture outline, fracture surface texture, and fracture angle to create an index of fracture freshness. All shaft fragments falling in the 40–50 mm size class or above were studied for their freshness criteria. (Where preservation allowed, those in the 30–40 mm range were also studied.) For each criterion a score of 0, 1, or 2 was given: 0 denotes that the fracture is wholly consistent with a fresh break according to that criterion; 1 denotes a mixture of fresh and unfresh features but with fresh features still in the majority (for example, the fracture angle could be acute for 70% of the fracture line but at right angles for 30%); 2 denotes that unfresh features are in the majority. When the scores for all three criteria are added together, there is an index of fracture freshness that ranges from 0 to 6.

It is next essential to establish what score one would expect from a bone assemblage in which bones were broken to extract fat. In many cases the fracturing of bones for their fat content takes place when the bone is entirely fresh, but this is not always so. To complicate matters, in many ethnographic examples, bones are treated in some way prior to fat extraction. Bones were left frozen, were warmed near a fire, or heated in water by Nunamiut Eskimo, to take just one example (Binford 1978: Chapter 4). How such treatments affect bone fracture can be ascertained experimentally.

Experimental studies that replicate different ethnographically encountered bone treatments show that those associated with bone fat exploitation should not generate a freshness index score greater than 3 (Outram n.d. a, 1998). An assemblage, therefore, which averages 3 or below on the freshness index is consistent with an interpretation that the bones were fractured for their fat content.

Evidence that bones were deliberately broken while relatively fresh also can be found in the

presence of dynamic impact scars. Below the point of impact of a hammerstone on a bone shaft, a shallow, conical flake is usually detached, leaving a scar (Fig. 1). Occurrences of such scars were recorded and enumerated.

Levels of Post-Depositional Damage

Damage occurring after human processing is finished and the bones discarded will clearly affect the assessment of fragmentation patterns and must be recorded. A fracture freshness index score of 6 indicates that fresh fracture features have largely been lost, but it does not reflect changes in fracture type as bones age. When a bone has lost its organic content, it tends to break transversely across the shaft and at right angles to the cortical surface (Johnson 1985; Morlan 1984). The fracture surface is reminiscent of the texture of broken biscuit. Mineralized fractures were quantified as an indication of damage the assemblage suffered well after its original deposition.

Similarly, modern breaks were recorded to provide an indication of damage during excavation, processing, and storage of archaeological material. Modern breaks look like mineralized ones but the break surface tends to be unsoiled and of lighter color. Finally, instances of animal gnawing marks, and the number of burned fragments were also recorded.

Seal Bones

Seal bones are very different from land mammal bones, and must be considered separately. They contain no medullary cavity; the epiphyses and diaphysis are both constructed of cancellous bone. Seal bones were separated from the land mammal assemblage during size classification. They were placed into size classes and quantified in the same way as land mammal bones. But, since no distinction between epiphysis and diaphysis bone can be made, they were sorted into appendicular and axial element categories only.

Site Descriptions and Results

Sandnes

The farmstead of Sandnes (V51) is the largest in the Norse Western Settlement and, having a church, was almost certainly at the center of the community (McGovern 1985). Excavations at the site date back to the 1930s (Degerbøl 1936), but more recent excavations have been undertaken in the 1970s and 1980s (McGovern 1985). The mammal bone assemblage from the most recent excavations at the site consists of 7.56% NISP (Number of Identifiable Specimens) cattle, 11.12% sheep or

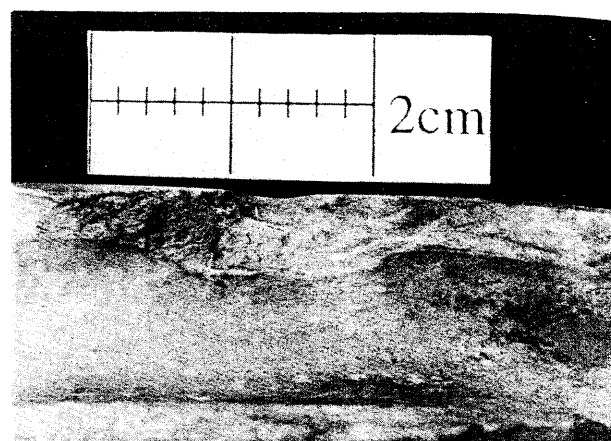


Figure 1. An example of a dynamic impact scar from Sandnes (V51).

goat, 14.72% caribou, and 31.23% seal (McGovern et al. 1996: Table 3). The Sandnes site, possibly because it was of higher social status, has a higher proportion of cattle in relation to sheep and goat, a lower proportion of seal, and a higher proportion of hunted caribou than do the other farmsteads of the Western Settlement (McGovern 1985).

The bone sample used for fracture and fragmentation analysis came from the 1980s excavation assemblage (McGovern et al. 1996), in the expectation that it would represent the best level of archaeological recovery. A large single context from near the midden surface was used as the sample. The choice of this context was somewhat dictated by the way the assemblage had been separated and stored, rather than any particular archaeological reason. It should, however, be as good a bulk sample as any. The separation of seal bone from land mammal bone had already been carried out. It should be noted, however, that some unidentifiable seal elements may yet be present within the indeterminate small size classes of the land mammal assemblage. Also, due to the appearance of a clear pattern, "ribs" were treated as another class of bone type.

Figure 2 shows the Sandnes sample separated by size class and quantified by number (land mammal and seal are differentiated). Among the land mammals, most fragments fall into the smaller size classes and very few bones survived "whole" or "part" whole. The small size classes do not, however, dominate if one quantifies by mass (Fig. 3), though there is still a dearth of "whole" or "part" bones. Apart from the lack of undamaged elements, quantification by mass does not appear to indicate a particularly fragmented assemblage. Examination of fragment type survival somewhat alters this interpretation, though.

Figure 4 shows the proportions of different fragment types in the size classes for the land mam-

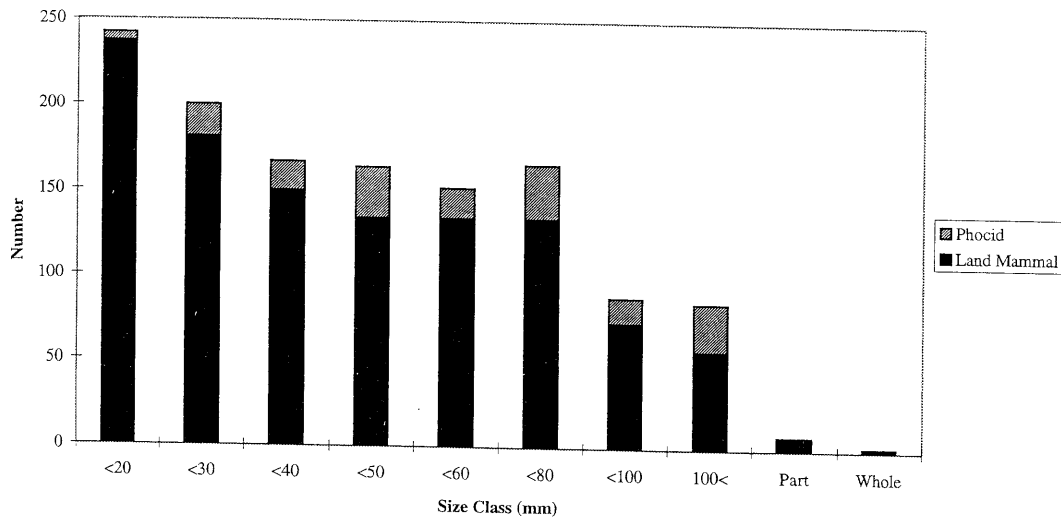


Figure 2. Sandnes (V51): Numbers of bone fragments by size class, with distinction between land mammal and phocid remains.

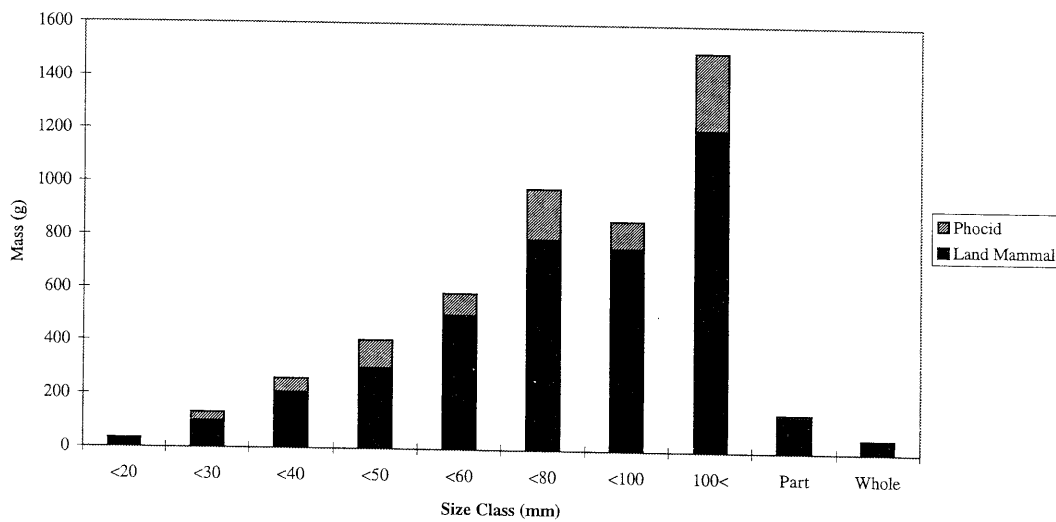


Figure 3. Sandnes (V51): Masses of bone fragments by size class, with distinction between land mammal and phocid remains.

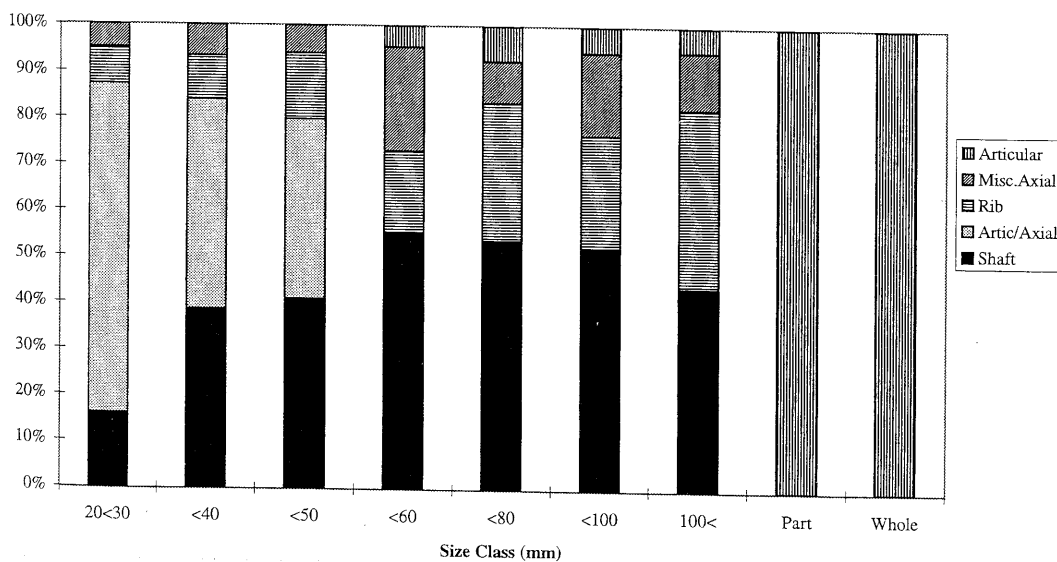


Figure 4. Sandnes (V51): Proportions of bone fragment types by size class.

mal assemblage. It can be seen that the smaller size classes are largely composed of epiphysis and axial cancellous bone. The large size classes are largely made up of a combination of shaft fragments and rib fragments, while cancellous bone from the articulations is very poorly represented. The part and whole classes contain only articular material, but bear in mind that there are hardly any of them!

This is the pattern one would expect if grease rendering had been carried out: cancellous bone has been largely comminuted, and what remains are mostly shaft fragments. If this interpretation is correct, ribs must not have been considered worth processing. Their survival augments the larger size categories and makes the assemblage look less fragmented.

Analysis of fracture type on shaft fragments (good preservation allows including those in the 30–40 mm class) showed that the vast majority of fractures occurred while the bones were fresh. Figure 5 shows some examples of fresh fracture type on shafts from Sandnes. Specimens scoring 0 on the fracture freshness index dominate by far, with hardly any fragments scoring over 3 (Fig. 6). The average score was 0.83 (Table 1), a very low figure, indicating that the assemblage suffered very little damage other than when it was fresh. Furthermore, there is much direct evidence of deliberate fragmentation of fresh bones by humans. The incidence of dynamic impact scars (Fig. 1) is 8.95%, which is very high considering that only fragments from the point of impact will carry such scars.

As a corollary of the above, there is little evidence of postdepositional attrition. Only 3.41% of specimens studied had any traces of possible animal gnawing. As few as 3.38% of specimens showed any indication of breakage after mineralization, and only 1.28% were broken during or

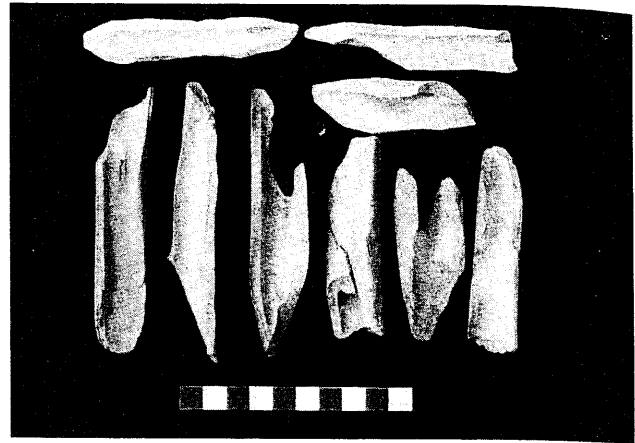


Figure 5. Examples of shaft fragments from Sandnes (V51) displaying helical fractures.

since excavation. Figure 7 shows the proportions of specimens which carry 0, 1, 2, or 3 of these indicators of postdepositional damage for all the sites. At Sandnes all but a few showed none of the indicators. It seems indisputable that almost all the fragmentation in the assemblage occurred while the material was fresh and almost certainly was by human hands. Levels of burning were low in the assemblage at under 1% in all size classes.

The interpretation of the land mammal bone sample at Sandnes must be that marrow was extracted from appendicular elements, and that appendicular epiphyses and most cancellous axial elements (with the exception of ribs) were comminuted in the process of grease rendering. The dearth of whole or part bones suggests that the rendering of those elements was fairly exhaustive. The lack of cancellous bone cannot be due to the differential

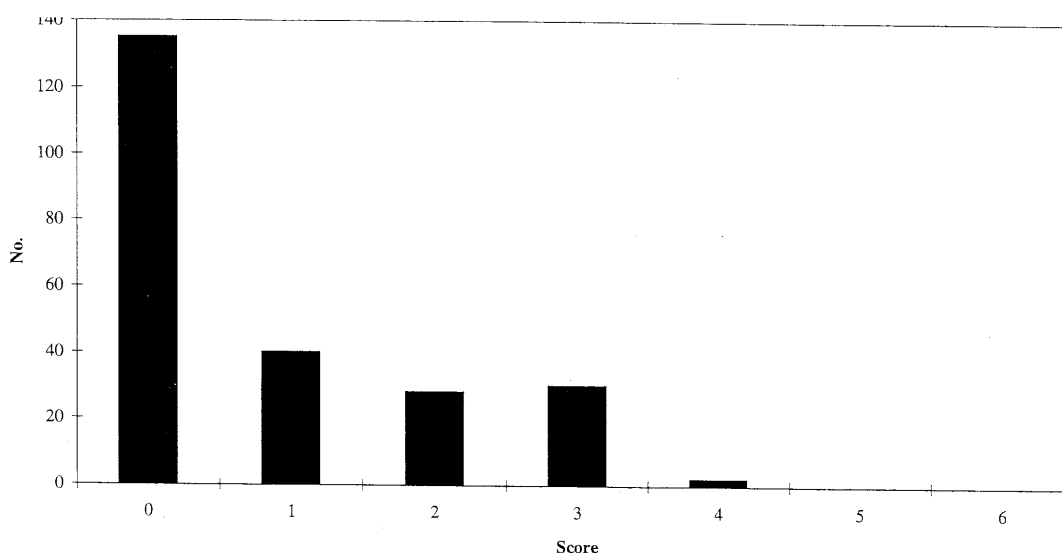


Figure 6. Sandnes (V51): Frequencies of fracture freshness scores.

Table 1. Summary of fracture study statistics for Sandnes (V51), Niaquussat (V48), and Itivnera.

| | Sandnes | Niaquussat | Itivnera |
|-------------------------------------|---------|------------|----------|
| Sample size (N) | 235 | 208 | 544 |
| Mean Fracture Freshness Index Score | 0.83 | 1.11 | 0.36 |
| % Gnawed | 3.41 | 3.84 | 0.0 |
| % Impact Scarred | 8.94 | 8.65 | 15.07 |
| % Mineralized Fractures | 3.83 | 2.40 | 0.18 |
| % Cut-Marked | 0.43 | 0.48 | 0.0 |
| % Modern Fractures | 1.28 | 1.92 | 3.12 |

survival of dense bone over cancellous bone, for a couple of reasons. First, there is little evidence that the well-preserved assemblage suffered substantial postdepositional attrition that could have caused a bias in preservation according to density. Second, if low density had caused the differential loss of articulations and vertebrae, it would have also affected the damage-prone ribs. It did not.

Moving on to the phocid bone assemblage, the size class graphs (Figs. 2 and 3) show that the quantity of seal bone is relatively small. The distribution of seal material across the size classes is generally in proportion with that of the land mammals. The interpretation, however, is different.

Since almost all seal elements are made up of cancellous bone, this admittedly small sample includes much material that, if it were from land mammals, one would expect to have been comminuted for rendering. Little can be said for certain, but

it appears that seal cancellous bone was not being processed to the extent that land mammal bone was.

Taken in all, the evidence from study of fracture and fragmentation agrees with the entomological evidence of Buckland et al. (1996). The lack of fat-eating flies in the middens is probably due to extensive rendering of bones for fat. It seems doubtful, however, that the rendering process extended to ribs or seal bones.

Niaquussat

The farmstead of Niaquussat (V48) is also in the Western Settlement, but has a somewhat different representation of species within its faunal assemblage. It can probably be regarded as a site of lower status than the church farm of Sandnes and thus adds to a fuller picture of Norse subsistence activities.

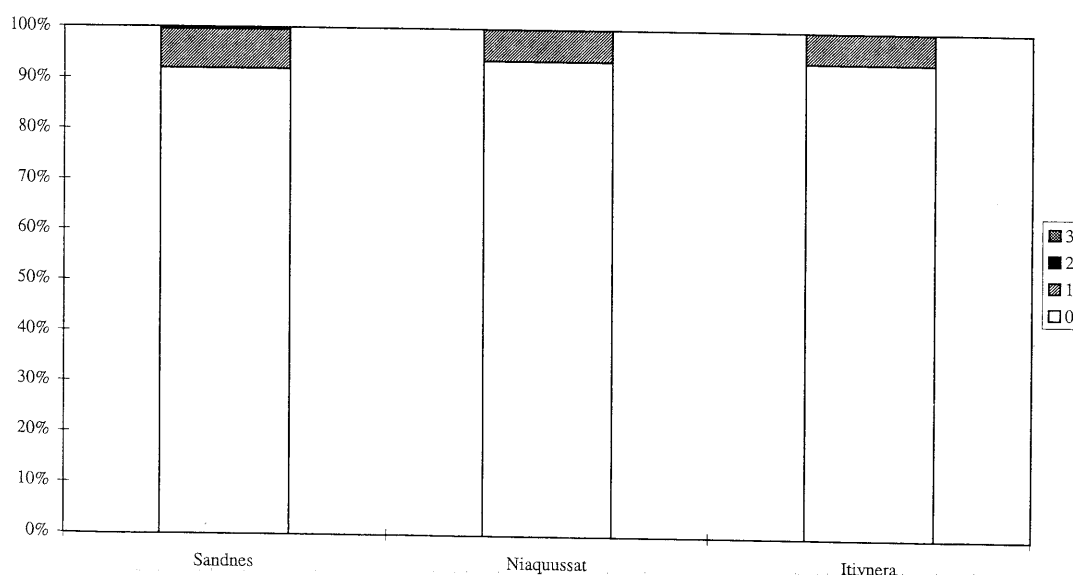


Figure 7. Proportions of fragments in Sandnes (V51) (N=235), Niaquussat (V48) (N=208), and Itivnera (N=544) samples displaying 0, 1, 2, and 3 indicators of postdepositional damage.

The site was excavated in 1976/77 and is very rare amongst the sites in providing a well-stratified midden showing three distinct phases (McGovern 1985). The three phases have very similar statistics regarding species composition. There are far fewer cattle at Niaquussat than at Sandnes (1.15–2.96% TNB, or Total Number of Bones). The proportion of caprine bones is similar at 9.11–11.21%. There are less hunted caribou (4.75–6.56%), the major constituent of the assemblage being seal at 79.27–84.99% (McGovern 1985: Table 6).

The sample taken for fracture and fragmentation analysis came from the area of the midden which stands to the greatest height (approximately 140 cm) (unpublished archive material, Copenhagen Zoological Museum). The bones studied came from a one-meter square column (C9) that was dug through the entire depth of the midden and included material from all three phases. Unfortunately, the sample from the earlier phases was too small to study temporal changes in fracture/fragmentation. Most of the material can be attributed to the latest phase (phase III).

Unlike Sandnes, the material from Niaquussat had not been sorted by species. Phocid fragments had to be separated out during size classification. Since this sorting was done quickly, some phocid fragments may have been missed in the smaller size categories. It was again possible to include fragments in the 30–40 mm size class in the fracture study due to good preservation.

Figure 8 shows the frequency distribution of fragments across the size classes, with phocid fragments indicated by different shading. Once again the small size categories dominate. Furthermore, the vast majority of the larger fragments are from seal. Land mammals are hardly represented in the “whole” or “part” classes. If the same material is quantified by mass (Fig. 9), the small size classes still dominate for the land mammals. The fragmentation in the land mammal assemblage must have been very severe for small fragments to dominate by mass as well as by number. On the other hand, many large or whole seal bones survived.

If one considers the fragment types by size class within the land mammal assemblage (Fig. 10), it is clear that very little cancellous bone from the epiphyses survived uncomminuted. The proportion of shaft fragments generally increases with size class. Surviving cancellous bone in the larger classes is almost all axial and, as at Sandnes, largely rib.

Also as at Sandnes, the shaft fragments from Niaquussat display mostly fresh fracture types (Figs. 11 and 12). Fragments scoring 0 on the fracture freshness index dominate the sample and there are few specimens scoring over 3. The average score is 1.11 (Table 1). Indicators of postdepo-

sitional damage are, once again, scarce. Some 3.84% of specimens showed evidence of animal gnawing, while only 2.4% had been broken after mineralization, and 1.92% appeared to have been broken recently (Table 1). Most fragments (approximately 94% showed none of these indicators of postdepositional damage; the rest showed just one (Fig. 7). Niaquussat showed a high incidence of dynamic impact scars at 8.65% (Table 1), again suggesting that most fracture was deliberately carried out by human hands.

Levels of burning were significantly higher than at Sandnes. Over 30% of fragments in the smallest size class at Niaquussat appeared to be burned. This percentage drops quickly with increase in size, to under 10% in the 40–50 mm size class. This high level of burning is not surprising if bone grease rendering was common, with many small fragments being created in proximity to fire. It is more surprising that the level of burning at Sandnes was so low, (unless hearth and fire pit waste was deposited elsewhere in the midden.)

With regard to land mammals, the pattern at Niaquussat is very much the same as at Sandnes, although the level of fragmentation may be even greater. It seems likely that marrow was being exploited and bone grease extracted through the rendering of limb articulations and axial elements. Once again, ribs seem not to have been exploited in the rendering process.

The larger sample of seal bones at Niaquussat seems to confirm the tentative interpretation of the Sandnes seal material. Seal bones were not being comminuted for the extraction of their fat content by the Norse at these farmsteads.

Qeqertasussuk

The Paleo-Eskimo site of Qeqertasussuk is located in the southern part of Disco Bay and is of the Saqqaq culture (2400–1000 BC) (Grønnow 1988:24; Böcher and Fredskild 1993). The site has C-14 dates of occupation ranging from 3900–3100 BP (Böcher and Fredskild 1993:3). It was excavated between 1984 and 1987 and very well preserved organic remains were recovered from the permafrost peat (Böcher and Fredskild 1993:3). The specialist animal bone report has not yet been published, but the faunal assemblage includes seal, fish, whale, caribou, and many bird species including the great auk (Böcher and Fredskild 1993:3). The vast majority of the assemblage is phocid and the other species occur in very small proportions (J. Møhl, personal communication, 1997). That the site was effectively a specialist seal hunting site is certainly borne out in the discussion below.

The sample studied for fragmentation came from one of the main midden areas (Felt C Vest, 82/250:2) and was a discrete contextual unit that

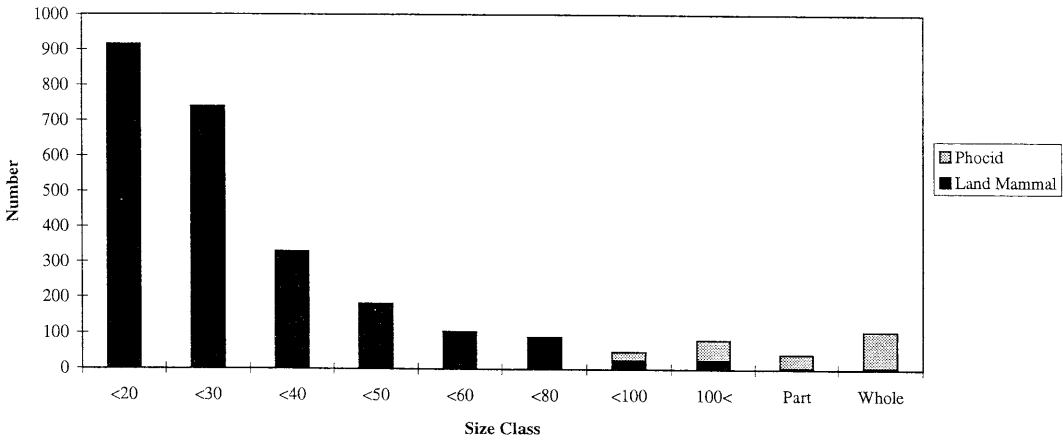


Figure 8. Niaquussat (V48): Numbers of bone fragments by size class, with distinction between land mammal and phocid remains.

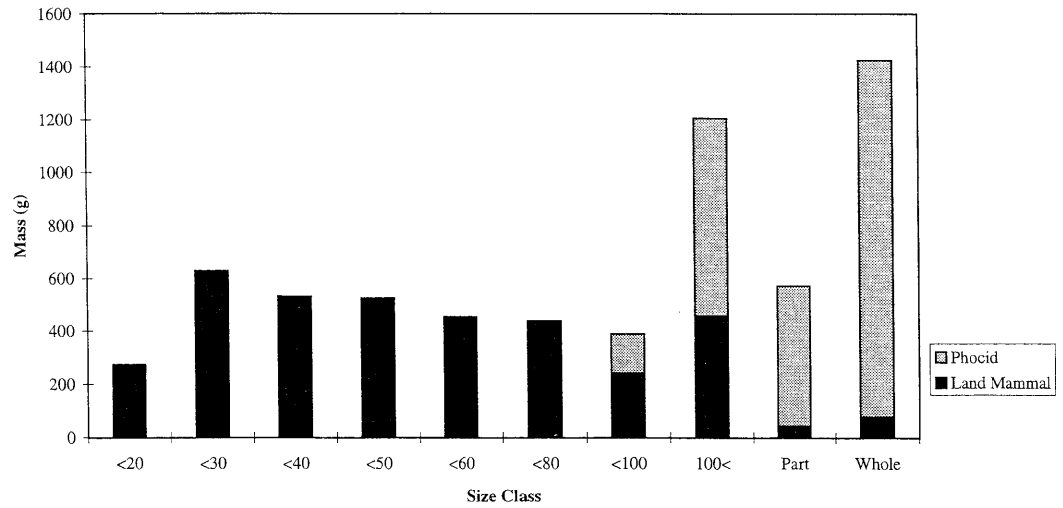


Figure 9. Niaquussat (V48): Masses of bone fragments by size class, with distinction between land mammal and phocid remains.

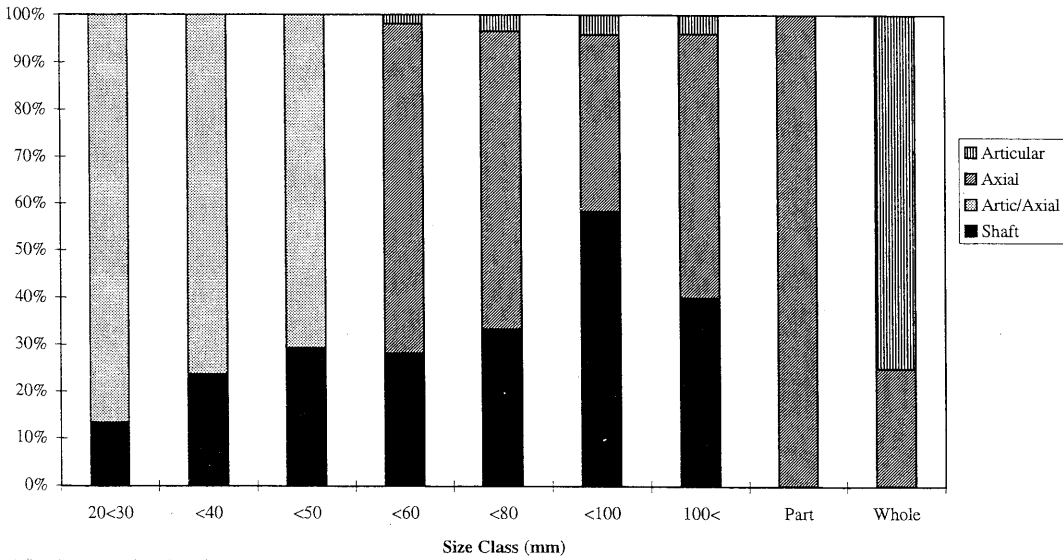


Figure 10. Niaquussat (V48): Proportions of fragment types by size class.

had not been sorted. There are literally only a handful of bones that were not phocid; a few bird bones and only two indeterminate land mammal specimens. This study, therefore, is purely one of seal bone fragmentation. As previously stated, seal bones cannot be studied for fracture type, because they lack dense diaphysis bone.

Figure 13 shows the assemblage split into size classes and quantified by number. This graph also distinguishes between bone types (miscellaneous fragments, appendicular, miscellaneous axial/cranial, and rib). Fragments smaller than 30 mm, for which identification of bone type is difficult, were placed in a single "miscellaneous" category. In numerical terms, the smaller categories dominate, but the "part" and "whole" categories are quite well represented. All parts of the skeleton are represented and many appendicular elements survive whole. In terms of mass (Fig. 14), it is the "part" and "whole" categories which dominate, with both axial and appendicular elements surviving undamaged. The degree of preservation at this site was excellent (it was just about possible to create whole seal reference skeletons from the material!)

The preponderance of undamaged elements leads to the conclusion that seal bones were not comminuted in any quantity for the purposes of bone grease rendering. The bones therefore, entered the midden with their full fat content, which explains the high incidence of fat-loving diptera in the midden deposits (Böcher and Fredskild 1993:20; Buckland et al. 1996).

Itivnera

Itivnera is a Paleo-Eskimo hunting camp of the Saqqaq culture located at the head of a fjord in the Godhåbsfjord complex (Møhl 1972:5). This is within the area of the Norse Western Settlement



Figure 11. Examples of fresh-fractured shaft splinters from Niaquussat (V48).

(T. McGovern, personal communication). The site was excavated in 1960 and has been C-14 dated to 2960 ± 100 BP. Analysis of the faunal assemblage shows that it was a specialist caribou-hunting site, with that species comprising approximately 95% of the bone assemblage. Around 2% of the assemblage is seal and the remaining 3% is comprised of various sea bird species (Møhl 1972:6).

Due to the early date of the excavation it is possible that recovery was not as complete as that attained in the other, more recent, excavations considered above. Since no sieving took place (J. Møhl, personal communication, 1997), values in the smallest size categories may be artificially depressed. The sample taken for fracture and fragmentation analysis was from a previously unstudied midden context of area B (Pose 3, V-1).

When the Itivnera assemblage is divided into size class and quantified by number (Fig. 15), the

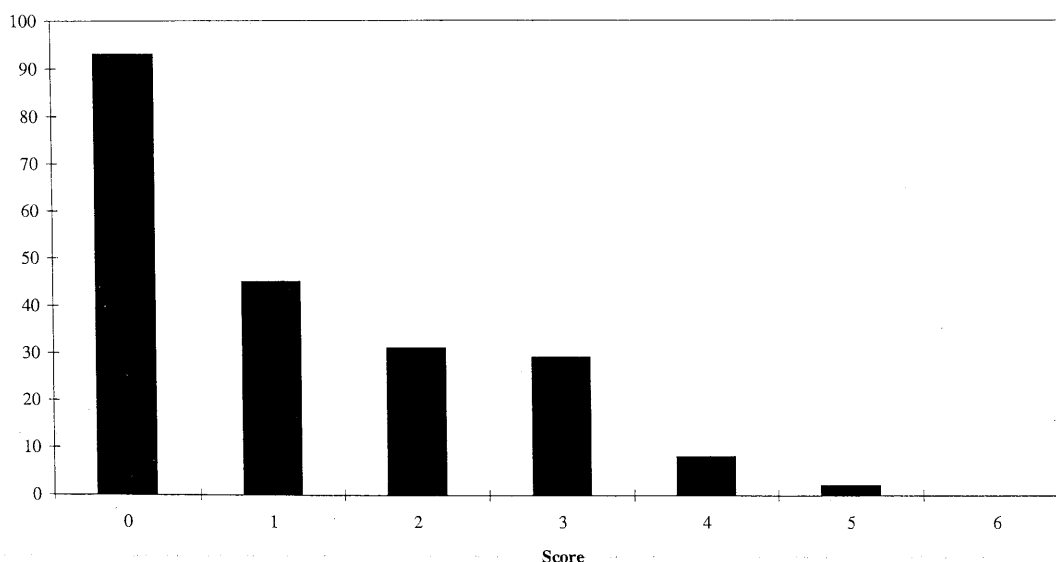


Figure 12. Niaquussat (V48): Frequencies of fracture freshness scores.

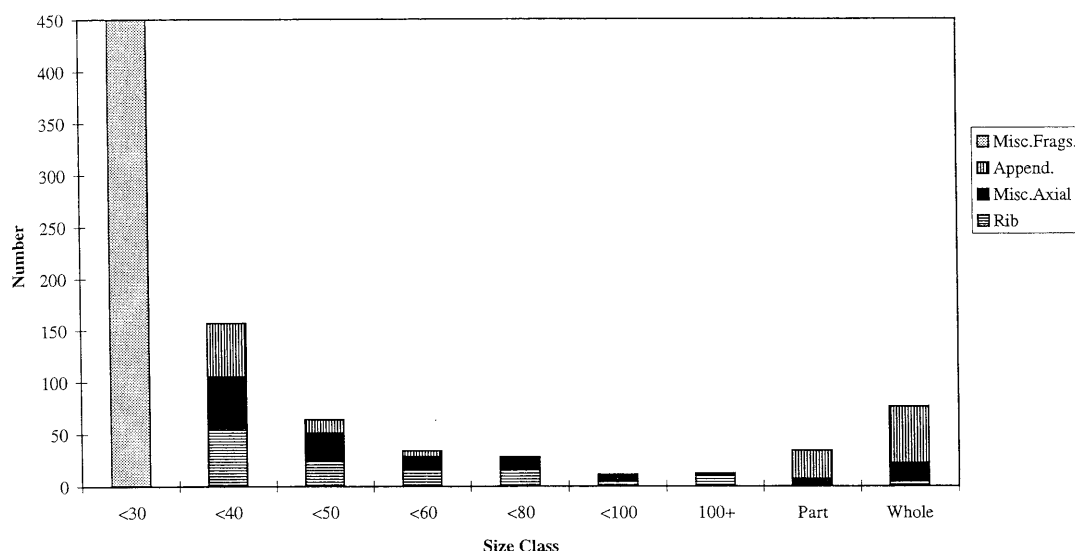


Figure 13. Qeqertarsussuk: Number and types of seal bones by size class.

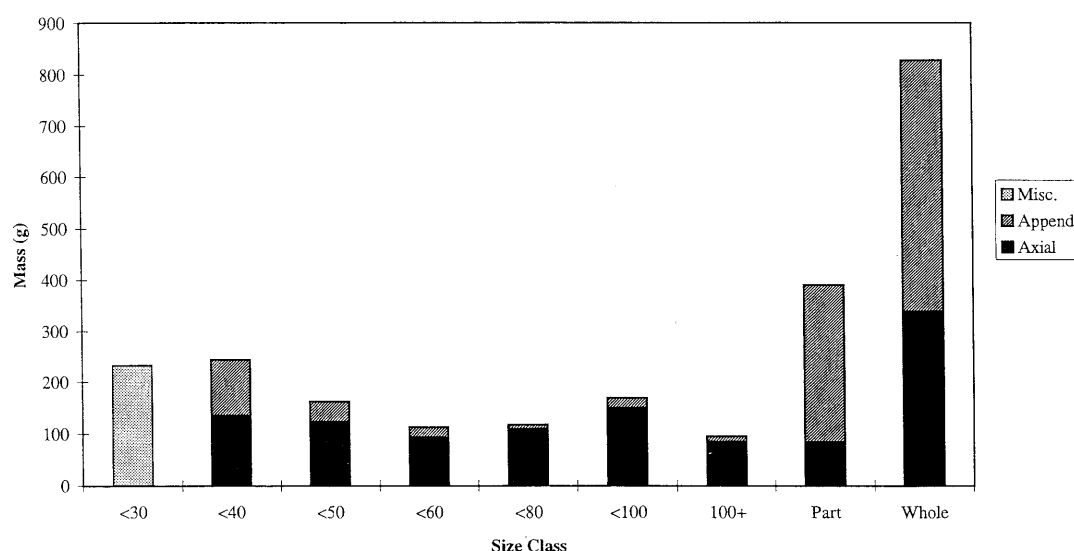


Figure 14. Qeqertarsussuk: Mass and type of seal bones by size class.

smaller size classes dominate (apart from the smallest, which may be depressed by recovery bias). The number of "part" or "whole" elements is not insignificant when compared to Sandnes or Niaquusat. Considered in terms of mass (Fig. 16), the larger size classes dominate. This is a picture not too dissimilar to that at Sandnes, except for the very strong representation of "part" and "whole" bones.

If the separation of bone type by size class (Fig. 17) is examined, shaft fragments dominate, particularly in the larger classes. Many of the large shaft pieces are complete diaphysis cylinders exhibiting fresh spiral fractures at both ends. This is suggestive of a pattern noted by Binford (1978: Chapter 4) among the Nunamiut, where epiphyses were deliberately removed so they could be stored

for later rendering, and the contents of the medullary cavity could be easily poked out. That articulations were rendered at Itivnera seems likely since very few survive in pieces of any size (apart from those which are entirely undamaged).

The assemblage at Itivnera is even more dominated by fresh fractures than the other sites studied (Fig. 18); no fracture freshness index score above 3 was recorded. The average score is an extremely low 0.36 (Table 1). Evidence of postdepositional damage is, again, slight. Only 0.18% of specimens displayed mineralized fractures, no dog gnawing was noted (although bone surface preservation was not as good at this site as at the others), and only 3.12% displayed modern breaks (Table 1). Approximately 94% of specimens displayed no

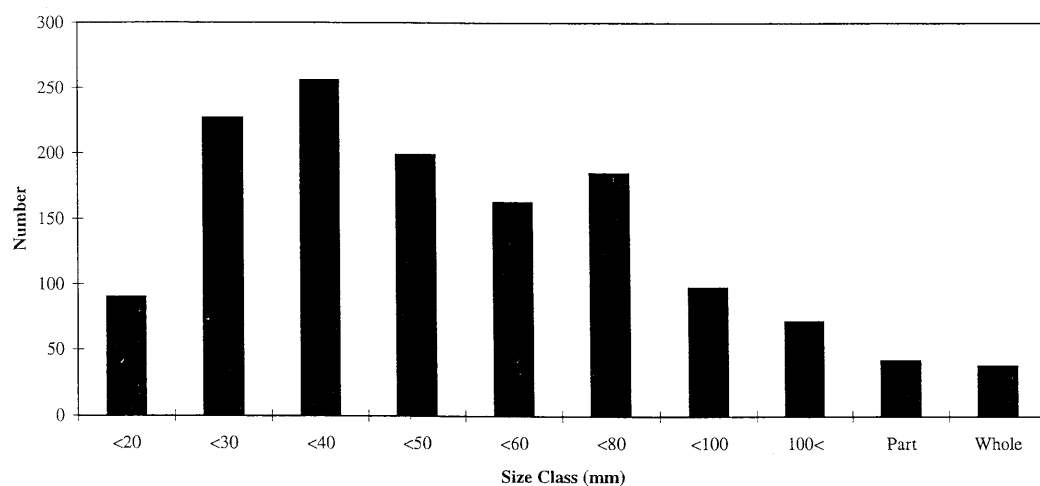


Figure 15. Itivnera: Number of bone fragments by size class.

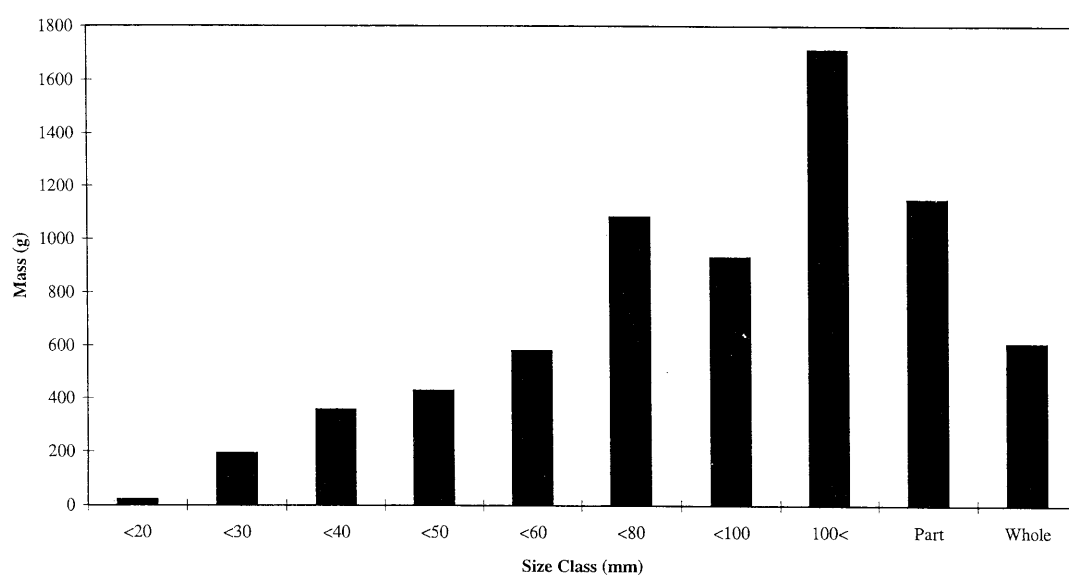


Figure 16. Itivnera: Masses of bone fragments by size class.

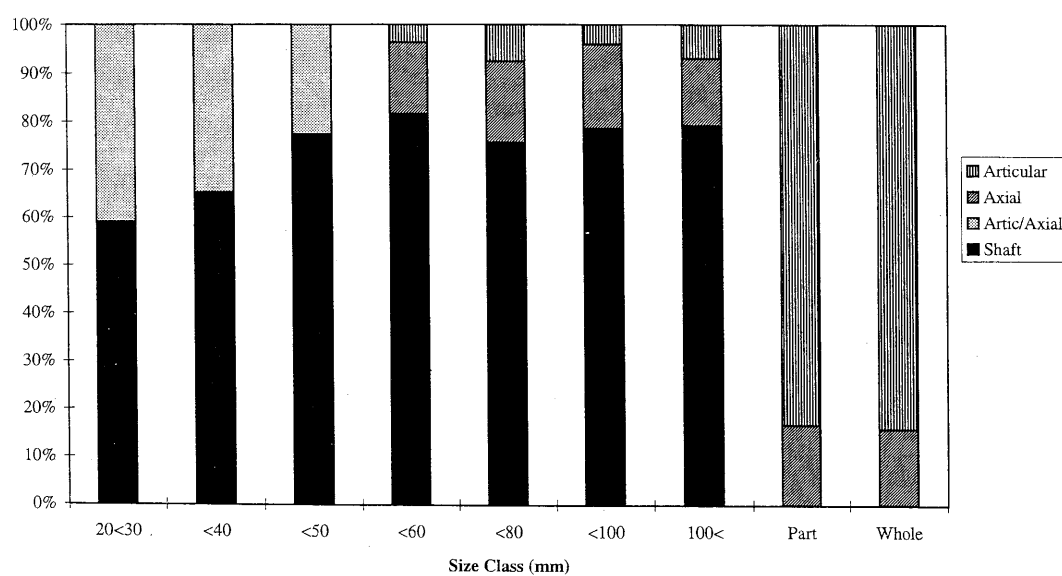


Figure 17. Itivnera: Proportions of fragment types by size class.

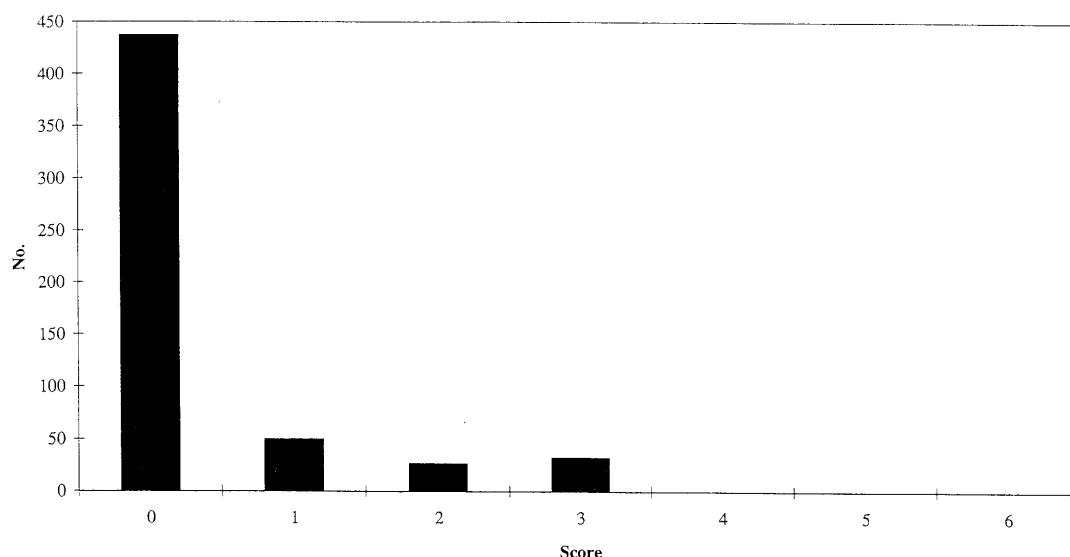


Figure 18. Itivnera: Frequencies of fracture freshness scores.



Figure 19. An example of a dynamic impact scar with opposing rebound scar from Itivnera.

indicators of postdepositional damage at all and the remaining 6% displayed only one (Fig. 7). Burning was noted at low levels (less than 5%) in the smaller size classes.

A very large number of dynamic impact scars was noted at the site, with 15.07% of fragments having such marks. A number of these specimens displayed both impact and opposing rebound scars (Fig. 19). This feature is indicative of the use of a hammer and anvil in fracturing bones. The impact scar is created by the hammerstone, and the equal but opposite force exerted on the other side of the bone by the rebound off the anvil creates a similar scar.

There is very strong evidence at Itivnera for bone grease rendering. Much fracturing of bones occurred by human hands and most cancellous

bone was comminuted. The breaking of epiphyses from bone cylinders is ethnographically associated with grease rendering. Given that a fair proportion of bones and bone parts survived undamaged, it also seems likely that the exploitation of bone grease was not as thorough at Itivnera as at Sandnes or Niaquussat. At the Norse sites very few potential bone grease sources were ignored (perhaps just the ribs). At Itivnera a significant number of appendicular bones and articulations seem to have been unprocessed.

Discussion

Phocid Bone Lipids and Seasonality

In all three sites where seal bones were studied—Sandnes, Niaquussat and Qeqertasussuk—it appears that phocid bones were not utilized for their fat content. There are two possible reasons why seal bone fat was ignored. The first is related to the lipid chemistry of marine mammals.

Seal fats, or more correctly oils (they are liquid at room temperature) contain many highly unsaturated fatty acids which can have up to six double bonds in their carbon chain (Hilditch and Pathak 1947; Shahidi et al. 1994; Erasmus 1986:206). The more unsaturated an oil is, the lower its melting point is likely to be (Erasmus 1986). Some of the constituent fatty acids in seal oil, such as eicosapentaenoic acid (20:5), docosapentaenoic acid (22:5), and docosahexaenoic acid (22:6) (Shahidi et al. 1994:233; Erasmus 1986:206), have melting points as low as -40°C or -50°C (Erasmus 1986:206). Preparation of seal oils for analysis, in fact, requires a low-temperature rendering process (Hilditch and Pathak 1947:421; Shahidi et al. 1994:233).

The ethnographically encountered method of rendering bones for fat relies upon the fact that fat will rise to the surface of hot water, where it can be removed after it has been congealed by the addition of cold water or snow (Binford 1978: Chapter 4). Seal lipids would be very difficult to extract by this method since they would remain liquid. I could find no ethnographic accounts of seal bones being processed for their fat content. Balikci (1970:85) described in great detail the use and processing of seal carcasses by Netsilik Eskimo. He stated that "*with the exception of the bones, the whole seal was utilized*" (Balikci 1970:85, emphasis added) and goes on to describe in detail how the blubber was utilized for oil.

A second reason why seal bones were not exploited for their bone lipids may be related to seasonal levels of fat supply (P. Buckland and T. McGovern, personal communication). Seals provide a very large quantity of fat from their blubber and, as a result, when sealing is taking place, there will be a glut of fat. Exploitation of seal bones for fat may be irrelevant. In the case of the Norse settlers, sealing most likely took place in the spring (McGovern 1985:101), when the fat supply was probably good. Slaughter of domestic mammals would almost certainly have taken place in the fall, in order to reduce the number of animals requiring fodder over the winter. The supply of fat for the winter months would, therefore, probably have come from the bones of those slaughtered animals.

Implications Regarding Species Quantification

The implications of this study extend beyond discussion of bone fat exploitation and dietary stress. The dichotomy between exhaustively processed and highly comminuted land mammal skeletons and virtually unprocessed and unfragmented seal skeletons has distinct implications for quantification. If the vast majority of land mammal bones were rendered (literally) unidentifiable, while most seal elements survive to be counted, then species representation statistics for the Norse farmsteads may seriously overrepresent seal remains.

Conclusion

It seems clear from examination of the Sandnes and Niaquussat assemblages that the Medieval Norse settlers of Western Greenland fairly exhaustively exploited the bones of land mammals for their marrow and grease content. This agrees with the conclusion of Buckland et al. (1996), based on entomological evidence, that the nutritionally stressed Norse settlers needed to exploit all their available resources. Seal bones, however, appear not to have been rendered for the reasons outlined above.

The conclusion that Paleo-Eskimo inhabitants of Qeqertasussuk were less nutritionally stressed, based on the presence of many fat-loving diptera in the middens (Buckland et al. 1996), is now flawed. The presence of much fly-attracting fat in the midden is almost certainly the result of seal bones being unprocessable for their fat content, rather than the Paleo-Eskimos deliberately ignoring the resource. At this specialist seal hunting site, the inhabitants would have had to rely upon blubber for their fat supply.

The basic premise that the well-adapted Paleo-Eskimos were less resource stressed than the Norse settlers may, however, prove correct. At the caribou hunting site of Itivnera there is good evidence for marrow extraction and grease rendering; however, processing does not appear to have been as exhaustive as noted for the Norse sites. The fact that the Paleo-Eskimos could afford to leave some fat resources unutilized suggests that they may well have been less stressed than the Norse.

This study has demonstrated the usefulness of bone fracture and fragmentation analysis as a paleoeconomic tool. It is a tool which can provide information not only related to fat exploitation, but also to degrees of resource stress and important taphonomic biases that affect quantification, and therefore our general understanding of a given economy.

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