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Derivation and Application of a Meat Utility Index for Phocid Seals

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Due to anatomical differences, economic utility indices for terrestrial mammals are not useful for study of frequencies of skeletal parts of seals and sea lions. A utility index based on the average weight of meat per skeletal portion from four phocid seals we butchered indicates the rib cage is of greatest food utility, the pelvis is second in value, vertebrae rank third, proximal limb elements rank fourth, and distal limb elements (flippers) rank lowest in food value. When applied to archaeological assemblages of seal bones from the Oregon Pacific coast and the eastern Canadian Arctic, the meat utility index serves as an economic frame of reference granting insights to the significance of varied frequencies of skeletal parts.

Keywords: BONE TRANSPORT, MEAT UTILITY INDICES, PINNIPEDS, SEALS AND SEA LIONS, ZOOARCHAEOLOGY.

Introduction

With the publication in 1978 of Binford's *Nunamiut Ethnoarchaeology*, an explicit measure of the food utility of two mammalian taxa became available for use by zooarchaeologists interested in economic behaviours of human foragers. Binford (1978) butchered one adult male caribou (*Rangifer tarandus*) and two domestic sheep (*Ovis aries*), an old female and a 6-month-old lamb, weighing various anatomical portions of all three animals to derive an index of the food value or utility of parts of both species. The manner in which Binford (1978) derived what is now well known as the modified general utility index, or MGUI, has been subjected to some critical evaluation (e.g. Chase, 1985; Lyman, 1985, 1991*b*; Metcalfe & Jones, 1988), but the value of such indices seems clear based on their use by numerous analysts as devices for interpreting the frequencies of skeletal parts (e.g. Speth, 1983; Thomas & Mayer, 1983; Landals, 1990). Perhaps a more striking indication of the perceived interpretive value of such indices is found in the growing number of such indices derived for various animal taxa. There are now available food utility indices for North American bison (*Bison bison*; Emerson, 1990), guanaco (*Lama guanicoe*; Borrero, 1990), musk ox (*Ovibos moschatus*; Will, 1985). Thomson's

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gazelle (*Gazella thomsoni*), Grant's gazelle (*G. granti*), wildebeest (*Connochaetes taurinus*), impala (*Aepyceros melampus*; Blumenschine & Caro, 1986), red kangaroo (*Macropus rufus*; O'Connell & Marshall, 1989) and at least one kind of bird (Kooyman, 1984, 1990). Similar indices based on the probability that skeletal parts of various taxa of African mammals (O'Connell *et al.*, 1988, 1990) will be transported from the kill site to a consumption site by humans have also been developed.

The construction and use of food utility indices for various taxa are presently important aspects of zooarchaeological research. To date, however, virtually all such studies have been concerned with terrestrial mammals, particularly ungulates. In this paper we focus specifically on pinnipeds (seals and sea lions), marine mammals which are anatomically distinct from terrestrial mammals, especially ungulates. Pinnipeds characteristically have streamlined bodies that are more or less spindle-shaped with short limbs that protrude in such a manner as to reduce drag while swimming. Even the ears are much reduced in size, and phocid (family Phocidae) seals are often referred to as earless seals. Further, pinnipeds have a layer of subcutaneous fat or blubber between the skin and the muscle tissues. Dissectible inter- and intra-muscular fat and gut fat are relatively non-existent in pinnipeds; "all dissectible fat in the body occurs in the blubber" (Bryden, 1972: 48). Finally, the appendicular bones of pinnipeds differ from those of ungulates in three ways that are important for our consideration. First, the proximal long bone of both the forelimb (humerus) and the hindlimb (femur) is short and the distal long bone of each (radius/ulna and tibia/fibula, respectively) is long when compared to the relative sizes of these bones in ungulates. Second, in pinnipeds the bones distal to the carpals and tarsals tend to be elongated to enhance their propulsion function when used as flippers; and third, the medulary cavity of pinniped bones is filled with trabecular bone, perhaps making the contained marrow undesirable to a human. These few simple considerations of anatomical differences between ungulates and pinnipeds underscore the inapplicability of food utility indices derived for ungulates when pinniped remains are recovered and the resultant need for such indices for pinnipeds when the analyst desires to perform a "behavioural faunal analysis" (Thomas & Mayer, 1983).

Because much of our research involves marine mammals, we perceive a major gap in the list of utility indices available to zooarchaeologists. In this paper we begin to address this problem by describing the weights of soft tissues associated with different anatomical regions of four seals, representing two taxa, that we processed specifically for this purpose. From those weights we derive a meat utility index that we believe should be applicable to most pinnipeds of the Phocidae family. We conclude with several examples of how these data might be used to help interpret the frequencies of skeletal parts of pinnipeds recovered from archaeological sites.

Methods and Materials

We obtained three harp seals (*Phoca groenlandica*) and one hooded seal (*Cystophora cristata*) from the Arctic Biological Station, Department of Fisheries and Oceans, St Anne-de-Bellevue, Canada, that had been shot near Les Escoumins in the Gulf of St Lawrence (for a general account of the biology of harp seals, see Ronald & Dougan, 1982). The seals were harvested in January 1991 and frozen until we butchered them in February 1991. The viscera of the two adult harp seals (one male, one female) were still partly frozen when we began our work whereas those of the immature harp seal and hooded seal (both males) were completely thawed. This influenced some of our weight measurements; for example, we weighed the adult male harp seal's heart after flushing as much blood as we could from it, but the adult female harp seal's heart was partly filled with frozen blood when we weighed it. This does not significantly compromise the applicability of our data

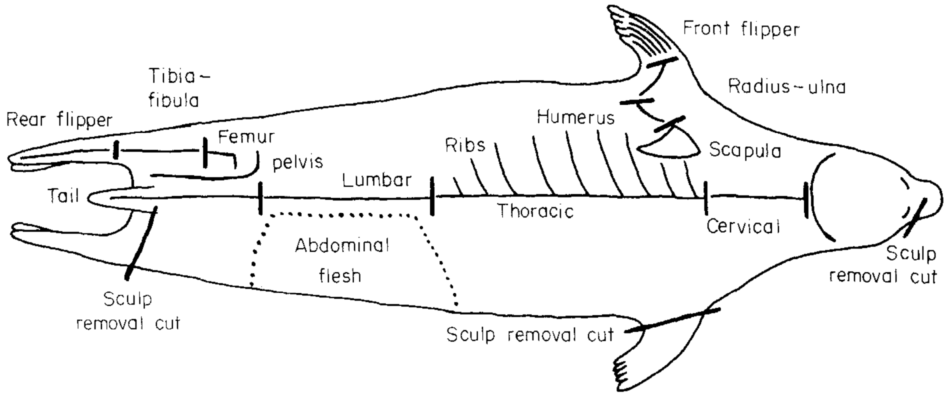

Figure 1. Schematic view of dorsal surface of a phocid seal showing distribution of major skeletal parts (left side) and location of skinning ("sculp removal") cuts.

for utility index derivation, however, as the viscera have no associated bones and thus would not leave archaeologically visible traces. Below, we treat all viscera as a single category when discussing the weight of various parts of the animals. It is thus important to note that the brain was weighed with the skull, and is included as part of the meat weight for that skeletal part.

The adult male harp seal was 24+ years of age (based on dental annuli) and weighed 150 kg. The adult female harp seal was 13 years old (based on dental annuli) and weighed 132 kg, including a foetus that weighed 9·09 kg. Both the juvenile male harp seal and the juvenile male hooded seal were approximately 10 months old, and each weighed 52 kg. All four seals were butchered in similar manners by the authors, with the exceptions that Lyman did not assist with the hooded seal, and two biologists assisted us during the initial stages of butchering the first (adult male harp) seal. Generally, we used steel knives and scalpels to skin, eviserate, dismember and deflesh bones (exceptions noted below). The butchery procedure we followed was directed explicitly towards deriving the weight of meat associated with individual skeletal parts. For example, we made no explicit attempt to produce or avoid producing cut-mark damage on the bones; all soft tissues were discarded after weighing.

We followed standard biological procedures for measurement and dissection of pinnipeds during the early stages of butchering each carcass (Committee on Marine Mammals, 1967). Thus, the total weight of each seal was determined first. Then, ventral blubber thickness near the posterior end of the sternum and dorsal blubber thickness near the posterior half of the thoracic vertebrae were measured. The sculp (hide and attached layer of blubber) was removed from the entire carcass, except for the flippers and tail, and then weighed. The hide was left attached to the flippers by cutting through the hide around the front limbs where they emerged from the body (at about the proximo-distal mid-point of the radius-ulna) and around the tail and rear flippers as a unit (at about the ankle joint of the rear limb, and just proximal to where the tail emerges from the body) (Figure 1). We did not weigh the hide separately from the blubber. In at least one phocid seal, the harbour seal (*Phoca vitulina*), the hide alone makes up 6% of the total body weight whereas the blubber makes up 28–37% of the total body weight (Pitcher, 1986), indicating that sculps make up 34–43% of the total body weight. Accordingly, weights of sculps recorded in this study (46·8 ± 4·9% of total body weight for our four seals) were probably about 14–18% hide and 82–86% blubber.

Forelimbs were removed by cutting between the rib cage and the humerus-scapula. Hindlimbs were removed by cutting between the rear limbs and the pelvis in an anterior direction from the posterior end of the limb to the hip joint. Individual limbs were weighed as complete units, and were dismembered by cutting perpendicularly through the muscle tissues in the vicinity of the major joints (shoulder, elbow and wrist for the forelimb; knee and ankle for the hindlimb). Each individual limb portion was then weighed, defleshed with knives and the flesh weighed separately. While front and rear flippers were weighed separately, we did not deflesh them as they contained very little muscle tissue. They do, however, contain some ligaments that might be considered edible, and we deal with this possibility below.

Abdominal flesh was removed from both sides of each carcass and weighed separately. This tissue makes up a significant portion of the consumable flesh but has no associated bones. Then, the viscera were removed and individual organs were weighed separately insofar as we could identify them. In the cases of the harp seals, muscle tissue lying along the dorso-lateral portion of the thoracic vertebrae and ribs was removed from both sides and weighed separately; this is referred to as "meat easily removed with knives" in the Appendix. The sternum was then removed and weighed, and subsequently each side of the rib cage was removed by pulling the ribs anteriorly and cutting through the articulations of the ribs and thoracic vertebrae, and each side of the rib cage was weighed separately. The head (with mandibles and hyoids), cervical vertebrae, thoracic vertebrae, lumbar vertebrae and pelvis with sacrum and caudal vertebrae were separated into individual units and each was weighed (Figure 1). The sternum was defleshed with knives and the flesh was weighed. The remaining portions of the axial skeleton (head, vertebral sections, and ribs) were boiled until the flesh fell away from the bones. The bones for each of these portions were collected and weighed, and that weight was subtracted from the total weight of each portion to derive a flesh weight.

Because the three of us were essentially equally inexperienced with seal anatomy, we found it took much longer to butcher the first seal (adult male harp seal) than the second (adult female harp seal), third (juvenile male harp), or fourth (juvenile hooded) seal. Further, the precise anatomical locations where dismemberment cuts were made varied from seal to seal, and from one side to the other on each particular seal. However, because at least two of us performed each dismemberment and defleshing task at least once on each seal, and because each of us performed different dismemberment and defleshing tasks on different seals, we believe the intra- and inter-carcass variation in the flesh weights we derived is randomly distributed across the anatomical portions (data presented below substantiate this belief). We present all data here in g, and note that occasionally the total tissue weights for skeletal portions do not equal (but seldom exceed) the original gross weights for skeletal portions (e.g. sum of femur, tibia, rear flipper is less than total hindlimb). At least some of this variation is due to loss of blood, and perhaps also to minor errors in weighing.

Do the above sources of variation in our weight data compromise their value or accuracy? Because it is typical to interpret skeletal part frequencies plotted against utility indices in ordinal scale terms (e.g. Speth, 1983; Thomas & Mayer, 1983; Borrero, 1990), we are confident that our data can be used in similar fashion. Thus, while we present our data in interval scale terms, we emphasize that those data are best viewed as providing only ordinal scale resolution when used to interpret frequencies of skeletal parts of seals recovered from archaeological contexts. Accordingly, we use Spearman's rho (r_s) to assess similarities between various sets of weight data. *Gross weight* is the total weight of a carcass portion including bone (if any) and muscle; weights of viscera and the sculp, neither of which contain bones, are also listed as gross weights. *Flesh weight* is the weight of muscle tissue (excluding bone) associated with a particular anatomical portion.

Table 1. Gross (total of soft tissue and bone) weights of major anatomical portions of three harp seals and one hooded seal (g)

Anatomical portion	Harp seal Adult male	 Adult female	 Juvenile male	Hooded seal Immature male
Sculp	74,780	61,760	26,310	20,680
Viscera	12,152	10,003*	3996	6181
Axial skeleton				
Head (with mandibles and hyoid)	2001	1899	1193	2583
Cervical	3697	2479	1221	1536
Thoracic	2826	2390	758	1774
Lumbar	3324	1627	1673	1955
Pelvis, sacrum, caudal	4281	3778	1178	1919
Rib cage (with sternum)	21,922	14,943	5443	6952
Abdominal meat and diaphragm	5228	3697	1511	1678
Appendicular skeleton (average of left and right)				
Scapula	2069	1728	527	573
Humerus	1100	1020	392	405
Radius/ulna	555	469	233	286
Front flipper	285	378	202	177
Femur	547	411	333	140
Tibia/fibula	1905	1393	623	505
Rear flipper	1255	1171	536	471

*Does not include foetus and placenta, weighing 9090 g.

Results and Derivation of a Meat Utility Index

Gross weights of various major carcass portions are given in Table 1 for each individual seal (detailed data for each carcass are given in the Appendix). Rank orders of these weights are similar between all possible pairs of individual seals (in all cases, $r_s \geq 0{\cdot}90$, $P < 0{\cdot}001$) and thus indicate that even though we did not place dismemberment cuts in precisely the same anatomical location on each carcass, those locations were very similar from carcass to carcass. Further, the similarities in relative gross weights of carcass portions among all three harp seals indicate that any allometric relationship between age and weight of a carcass portion, or any relationship between sex and weight of a carcass portion, is not creating significant ordinal scale variation in the relative gross weights of carcass parts. Further, the similarity of relative gross weights recorded for the hooded seal with each of the three sets of weights for the harp seals indicates it is appropriate to create an average utility index for phocid seals based on these two taxa.

Gross weights of complete left and right limbs, left and right limb parts, left and right halves of the rib cage (without sternum) and left and right abdominal flesh are correlated for each of the four individual seals. For the adult male harp seal, $r_s = 0{\cdot}95$, $P = 0{\cdot}003$; for the adult female harp seal, $r_s = 0{\cdot}96$, $P = 0{\cdot}003$; for the juvenile male harp seal, $r_s = 0{\cdot}99$, $P = 0{\cdot}002$; and for the immature male hooded seal, $r_s = 0{\cdot}99$, $P = 0{\cdot}002$. These coefficients suggest that our dismemberment of these parts of the carcasses did not result in significant alterations of the rank orders of gross weights of left and right carcass portions, even though the coefficients increase in the precise order in which we butchered the carcasses. Averaging of left and right sides within a carcass is thus not precluded.

Following the lead of others who have derived utility indices, we do not include the weight of viscera in the following discussion and analyses. If one wishes to include the kidneys as edible flesh, for example, weights of kidneys for each carcass are given in the Appendix and can be added to the flesh weight associated with the lumbar vertebrae. Other internal organs might be included with a general thoracic-rib cage skeletal portion.

Table 2. Flesh weights per skeletal part. All weights rounded to nearest g from Appendix

	Harp seal			Hooded seal
Anatomical portion	Adult male	Adult female	Juvenile male	Immature male
Head	1536	1479	958	2105
Cervical	3402	2132	1081	1342
Thoracic	2022	1694	450	1354
Lumbar	2825	1231	1517	1733
Pelvis (with sacrum and caudals)	3730	3430	1010	1721
R rib	11,006	7074	2436	2651
L rib	8874	6615	2351	3421
Sternum	238	154	114	97
R scapula	1871	1978	469	488
L scapula	1879	1123	452	525
R humerus	600	707	280	329
L humerus	1256	956	338	292
R radius/ulna	377	307	167	217
L radius/ulna	373	329	152	195
R femur	464	363	201	85
L femur	289	225	314	53
R tibia/fibula	1893	1143	492	363
L tibia/fibula	1285	1074	483	400

We have avoided including visceral organ and sculp weights here, and thus the utility index we derive is most accurately termed a *meat utility index* (MUI, hereafter) for carcass portions with associated bones.

The weights of meat associated with particular skeletal parts of each seal carcass are given in Table 2. Those values are consistently correlated for all possible carcass pairs (in all cases, $r_s \geq 0{\cdot}88$, $P \leqslant 0{\cdot}001$). We thus calculated the average amount of meat associated with each skeletal part for the three harp seals, and for the three harp seals plus the hooded seal. Both sets of average weights of meat associated with particular skeletal parts are given in Table 3. Because we average the meat weights for all four individuals (two species) to derive the MUI, it is important to note that the average flesh weights for the three harp seals correlate with the flesh weights for the single hooded seal ($r_s = 0{\cdot}92$, $P = 0{\cdot}0004$).

Following the tradition of norming meat weights on a scale of 1–100, we also give the normed or %MUI for each set of average weights in Table 3. The %MUI values are of particular interest because they underscore the fact that the rib cage far surpasses any other skeletal portion in terms of associated meat with the %MUI for ribs being more than twice as large as the next highest %MUI value (Figure 2). The rib cage value would be even greater were the weights of abdominal meat included, which has no associated bone.

Discussion

General issues

Elsewhere, various of the economic utility indices constructed for ungulates have been shown to be potentially ambiguous indicators of differential transport of skeletal parts due to the correlation of those indices with the potential that ungulate bones will survive density-mediated destruction (Lyman, 1985, 1991*b*, 1992*a*). While we do not yet have similar density data for pinnipeds, it seems to us that the potential for such equifinality when attempting to explain skeletal part frequencies is much lower for pinnipeds than for ungulates. That is so for two reasons. First, few of the pinniped remains recovered from some archaeological sites that we have examined display evidence of carnivore gnawing

Table 3. Average flesh weights (rounded to nearest g from Appendix) and %MUI per skeletal part for three harp seals, and one hooded and three harp seals

Skeletal part	Three harp seals Average flesh weight	%MUI	One hooded and three harp seals Average flesh weight	%MUI
Head (HEAD)	1324	20·7	1520	27·4
Cervical (CERV)	2205	34·5	1989	35·8
Thoracic (THOR)	1389	21·7	1380	24·9
Lumbar (LUM)	1858	29·1	1827	32·9
Pelvis (PELV)*	2723	42·6	2473	44·5
Rib (RIB)†	6393	100·0	5553	100·0
Sternum (STER)	169	2·6	151	2·7
Scapula (SCAP)†	1295	20·3	1098	19·8
Humerus (HUM)†	690	10·8	595	10·7
Radius/ulna (RAD)†	284	4·4	265	4·8
Femur (FEM)†	309	4·8	249	4·5
Tibia/fibula (TIB)†	1062	16·6	918	16·5

*Includes sacrum, caudal vertebrae, and both sides of pelvis.
†One (left, right) side only.

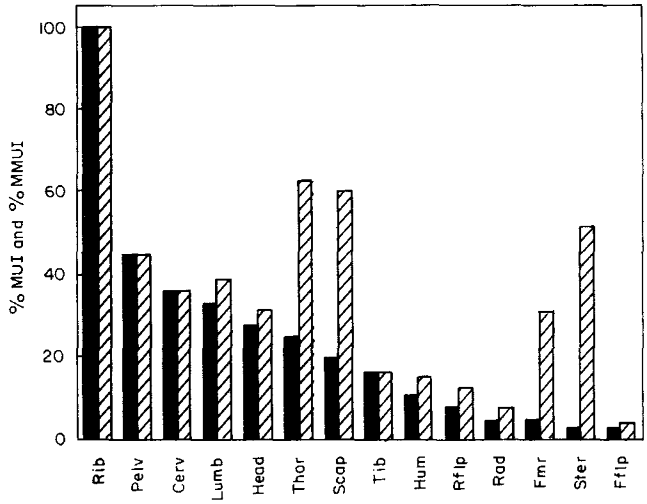

Figure 2. Comparison of the %MUI to the %MMUI. Values are arranged in descending order for the %MUI values. Note the differences in values for lumbar, head, thoracic, scapula, humerus, rear flipper, radius, femur, sternum and front flipper, but note also that $r_s = 0{\cdot}61$ ($P = 0{\cdot}03$). Abbreviations as in Tables 3 and 5. ■ = %MUI, ▨ = %MMUI.

and few of the limb bones have been broken, especially relative to the number of gnawed and broken ungulate bones associated with the pinniped remains (e.g. Lyman, 1991*a*). We suspect that is so because pinniped bones contain little or at least less desirable marrow relative to homologous bones in ungulates. The medulary cavities of long bones of pinnipeds are filled with trabeculated bone and this may have discouraged the extraction of pinniped marrow. Furthermore, the fact that the vast majority of grease is contained in the readily accessible blubber layer may have made unnecessary the extraction of marrow and grease from fractured pinniped bones. The second, and perhaps more

Table 4. Flesh weights and bone weights (in parentheses) of four species of phocid seal as described by Bryden & Felts (1974). All weights in g

Anatomical portion	Ross seal	Leopard seal	Crabeater seal	Elephant seal
Head	4792 (1784)	6650 (3822)	994 (1812)	3472 (2679)
Neck	4628	7722	3564	5148
Spine*	25,850 (6116)	39,736 (8579)	23,728 (4346)	28,298 (8739)
Thorax/ribs†	13,976 (3687)	26,916 (4558)	15,980 (2731)	25,082 (10,228)
Abdominal	10,144	12,556	10,132	16,578
Scapula	4756 (566)	11,006 (1104)	4988 (352)	5720 (806)
Humerus/radius-ulna	724 (958)	1810 (2322)	788 (1000)	1190 (2124)
Front flipper	874 (578)	1838 (1840)	838 (592)	1662 (824)
Pelvis/sacrum‡	3972 (1887)	5608 (2465)	4716 (1237)	3100 (2232)
Femur/tibia-fibula	2702 (1218)	4122 (1960)	2394 (1280)	2614 (1556)
Rear flipper	2786 (1896)	4400 (4020)	2884 (1896)	2042 (2392)

*Bone weight includes all vertebrae except caudals.
†Bone weight includes costal cartilage and sternum.
‡Bone weight includes caudal vertebrae.

important reason we believe density-mediated destruction of pinniped bones may not obscure the utility strategy indicated by frequencies of pinniped bones involves the fact that the density of pinniped bones is much higher than homologous elements in ungulates and other terrestrial mammals. Density is higher in pinniped bones due to greater amounts of trabecular bone and thicker cortical bone in the shafts of limb elements, apparently to enhance diving capabilities (Wall, 1983; see also Stein, 1989). There is evidence suggesting density-mediated destruction of pinniped bones might well occur because in some cases pinniped bones display much evidence of having been gnawed by carnivores and/or the bones are extensively fragmented (K.Cruz-Uribe, pers. comm.; R. G. Klein, pers. comm.). In some assemblages of pinniped bones, gnawing occurs on less than 10% of the pinniped bones, in others it is differentially distributed across skeletal elements such that vertebrae appear to have been more heavily gnawed than other skeletal elements (Whitridge, 1990, unpubl. data). Thus, as with other faunal resources, each assemblage of pinniped remains should be evaluated for evidence of density-mediated destruction, such as the gnawing marks of carnivores.

Our sample of carcasses is limited, but exceeds (e.g. Binford, 1978; Borrero, 1990) or matches (e.g. Emerson, 1990) the number of carcasses others have used to derive utility indices. As well, flesh-weight data for four Antarctic phocid taxa published by Bryden & Felts (1974) supplement our data. One adult male Ross seal (*Ommatophoca rossi*), one adult male leopard seal (*Hydrurga leptonyx*), one "almost mature" male crabeater seal (*Lobodon carcinophagus*), and an "almost mature" female southern elephant seal (*Mirounga leonina*) were collected and dissected by Bryden & Felts (1974). Bryden & Felts removed and weighed individual muscles and individual bones (summarized in Table 4). Since we summed the weights of muscle masses according to their anatomical location relative to major skeletal areas and irrespective of the completeness of the individual muscles included, Bryden & Felts' flesh weight data may vary slightly from ours due to differences in how flesh masses were assigned to skeletal parts.

All pairs of Antarctic flesh weights are correlated (in all cases, $r_s \geq 0{\cdot}85$, $P \leq 0{\cdot}007$). Our flesh weights for the adult male harp seal and hooded seal do not, however, consistently correlate with the Antartic seal flesh weights; of the eight possible pairs, only four are significantly correlated ($P \leq 0{\cdot}05$). This is probably because we measured muscle tissue

Table 5. Soft tissue weights (g) and %MUI for front and rear flippers. See text for discussion of derivation procedure

Skeletal part	Three harp seals Average flesh weight	%FUI	One hooded and three harp seals Average flesh weight	%MUI
Front flipper (with carpals) (FFLP)	144	2·3	130	2·3
Rear flipper (with tarsals) (RFLP)	493	7·7	429	7·7

directly associated with particular bones regardless of the particular muscles involved and regardless of how complete the muscles were after dismemberment. Nevertheless, Bryden & Felts' (1974) data on flesh weights for front and rear flippers can be used to supplement our phocid seal meat utility index. The average proportion of the total weight of front flippers made up of soft tissues is 58·9% and of rear flippers 54·6% (Table 4). Since our gross weights for flippers included the hide whereas Bryden & Felts' (1974) weights apparently did not, we used exactly half the gross weight of the flippers from our harp and hooded seals, in order to omit at least some of the hide's weight, and calculated the MUI and %MUI accordingly (Table 5). Given the nature of the derivation of these values, we do not include them in Table 3, which includes only those MUI and %MUI values we derived directly. However, we believe the utility index values for flippers are reasonable, and can be used at a researcher's discretion.

While we have some confidence in the analytical value of our phocid seal meat utility index for archaeological applications, we do not yet have, as Binford (1978) did, informants to tell us about the validity of that index within a particular ethnographic context. Ethnographic data on traditional pinniped butchering techniques are limited, with most such descriptions being within the context of seal-sharing partnerships (e.g. Vand de Velde, 1956; Balikci, 1970: 133–135). These data primarily concern dismemberment *after* the seal has been transported to a residential base, and do not include information on differential transport of carcasses or carcass parts under varying conditions. One of us (Whitridge) has recently conducted a study of such initial carcass processing by the Inuit of Clyde River in the eastern Canadian Arctic, during the late winter and early spring. At this time of year hunting is heavily oriented towards procurement of ringed seals (*Phoca hispida*), a phocid seal that is smaller (average live weight of an adult male if 68 kg, with females being slightly smaller) than, but anatomically very similar to, both the harp seal and hooded seal. Data were collected for 20 ringed seals killed at their breathing holes on the sea ice, some 10–20 km from the village. Nine of these 20 carcasses were subjected to primary processing at the kill site, including seven carcasses from which some skeletal parts were culled and discarded at the kill site (detailed results of Whitridge's study will be presented elsewhere). These carcasses were only partially disarticulated at the kill site, resulting in transport of a variable number of vertebral segments, and four large or primary butchery units: 1. one side of the rib cage with attached fore limb, 2. the other side of the rib cage with attached fore limb and sternum, 3. the head and neck, and 4. the pelvic girdle and rear limbs (not separated into left and right halves). These observations indicate that the phenomenon of "riders" (skeletal parts of low food value that remain attached to skeletal parts of high value during transport from the procurement or primary processing site to a consumption site), as described by Binford (1978), is operative at least occasionally during the butchery and transport of pinniped carcasses.

To begin to account for the phenomenon of "riders", we used a procedure similar to that used by Binford (1978; see also Metcalfe & Jones, 1988: 503–504 for a detailed description of that procedure). If a skeletal part or portion with a low associated flesh

Table 6. Derivation of the %MMUI from flesh weights

Anatomical portion	Flesh weight	Parts averaged	Modified flesh weight	%MMUI
Head	1520	Head and cervical	1754·5	31·6
Cervical	1989	None	1989	35·8
Thoracic	1380	Thoracic and rib	3466·5	62·4
Lumbar	1827	Lumbar and pelvis	2150	38·7
Pelvis	2473	None	2473	44·5
Rib	5553	None	5553	100·0
Sternum	151	Rib and sternum	2852	51·4
Scapula	1098	Rib and scapula	3325·5	59·9
Humerus	595	Scapula and humerus	846·5	15·2
Radius/ulna	265	Humerus and radius/ulna	430	7·7
Front flipper	130	Radius/ulna and front flipper	197·5	3·6
Femur	249	Pelvis and tibia	1695·5	30·5
Tibia	918	None	918	16·5
Rear flipper	429	Tibia and rear flipper	673·5	12·1

weight was adjacent to or articulated with another skeletal part or portion with a high associated flesh weight, we averaged the two flesh weights and assigned the average to the skeletal part with the low flesh weight. If a skeletal part or portion with low flesh weight was between (adjacent to or articulated with) two skeletal portions with high flesh weights, we averaged the latter two flesh weights and assigned the average flesh weight value to the skeletal part with low flesh weight. Averaged skeletal parts and results for all skeletal parts are given in Table 6. Following tradition, we label the utility index derived from the modified flesh weights the "modified meat utility index" (MMUI). Also following tradition we normed the MMUI to a scale of 1–100 and label the result the "%MMUI" (Table 6).

We agree with Binford (1987: 453) that "economic anatomy can be considered quite literally as a *frame of reference*, functioning much like a screen upon which slides are projected" (emphasis in original). We see the economic anatomy "frame of reference" as only one, perhaps the initial, screen upon which skeletal part frequencies should be projected. Other reference frames may be conceived, such as structural density of skeletal parts (Lyman, 1985, 1991*b*, 1991*a*) or cost-benefit considerations of butchery activities (e.g. O'Connell *et al.*, 1990), and may also ultimately help explain observed frequencies of skeletal parts. Below, we offer several examples of such initial projections, not so much to test the validity of our utility index as to show how that index might be used to help understand and explain skeletal part frequencies as represented in a variety of archaeological settings. For the archaeological samples we consider here, the %MUI and the %MMUI values serve as frames of references from which to *initiate* an analytical search for explanations of skeletal part frequencies of pinnipeds.

Quantification

Since their introduction, utility curves have been constructed by plotting frequencies of skeletal parts on the y-axis (ordinate) against the utility index on the x-axis (abscissa). Skeletal part frequencies have been measured as minimal animal units (MAUs) after Binford's (1978: 70) sound argument that "our interest is in the actual use made of animals as food." The procedure for calculating MAUs involves dividing the observed minimum number of skeletal parts or elements (usually abbreviated as MNE) for a particular

Table 7. MAU frequencies of pinniped remains of various species from various sites

Skeletal part	Oregon coast* Harbour seal	Steller's sea lion	Eastern Canadian Arctic Igloo†	Thule dwelling‡	*Qarmangs*‡	Tent rings§
Head	9	37·5	1	2	5	10
Cervical	3	29	0·9	1·3	1·6	0·57
Thoracic	No data	No data	0·8	1·3	1·2	0·6
Lumbar	No data	No data	0·8	1·6	3·8	0·4
Pelvis	3·5	28·5	2	2	13	4
Rib	No data	No data	0·8	3·8	0·6	1·07
Scapula	4·5	23·5	2	4	5·5	4
Humerus	4·5	33	1·5	3·5	14	4
Radius/ulna	5	45	2	4·5	4·5	5
Front flipper	1·5	20	No data	No data	No data	1
Femur	5	35·5	1	1·5	9	5
Tibia/fibula	6·5	29	2	9·5	12	3
Rear flipper	3	20·5	No data	No data	No data	1·5
Sternum	No data	No data	0	0	0	0·71

*From Lyman, 1991*a*.
†From Savelle, 1984.
‡From Savelle, 1987.
§From Whitridge, 1990.

element by the frequency of that element in one complete animal. Thus the observed MNE frequency of humeri or proximal femora are divided by two, the MNE of skulls is divided by one, the MNE of first phalanges in an artiodactyl by eight, the MNE of ribs by 26 etc. This procedure is meant to provide "undistorted conversions of the actual count of bones into animal units," to "accurately describe the relative proportions of anatomical parts," and to avoid overestimating the amount of meat present at a site (Binford, 1978: 70, 71).

Analysts have traditionally inferred utility strategies based on visual inspection of the point scatter resulting from plotting MAU frequencies of skeletal parts (y-axis) against their respective utility index values (e.g Speth, 1983; Thomas & Mayer, 1983). Below, we employ Spearman's rho to help assess the meaning of the utility scatterplots.

Applications

Oregon coast pinnipeds

Remains of harbour seals are regularly recovered from late Holocene Pacific coastal archaeological sites located in Oregon (Lyman, 1991*a*). MAU frequencies of this taxon as represented in an assemblage at one of those sites (Lyman, 1991*a*) are given in Table 7. The assemblage dates between 250 and 850 BP, and was recovered from a site representing a village or base camp located within 2 km of a hauling-out area presently used by harbour seals (Lyman, 1988, 1989, 1991*a*; for a detailed analysis of the butchering patterns, see Lyman, 1992*b*). The MAU frequencies, when plotted against the %MUI or the %MMUI, produce a point scatter reminiscent of Binford's (1978) "bulk utility strategy" (Figure 3). However, the MAU values correlate with neither the %MUI ($r_s=0{\cdot}1$, $P=0{\cdot}75$) nor the %MMUI ($r_s=0{\cdot}17$, $P=0{\cdot}61$), although the latter coefficient is stronger than the former, a fact we will return to below. That the coefficients are insignificant may result from the fact that most of the skeletal remains are from newborn seals, and thus individual carcasses would have weighed about 6 kg, a size not expected to demand logistical decisions about which parts to transport and which to leave at the kill site. We do have gross weight, and

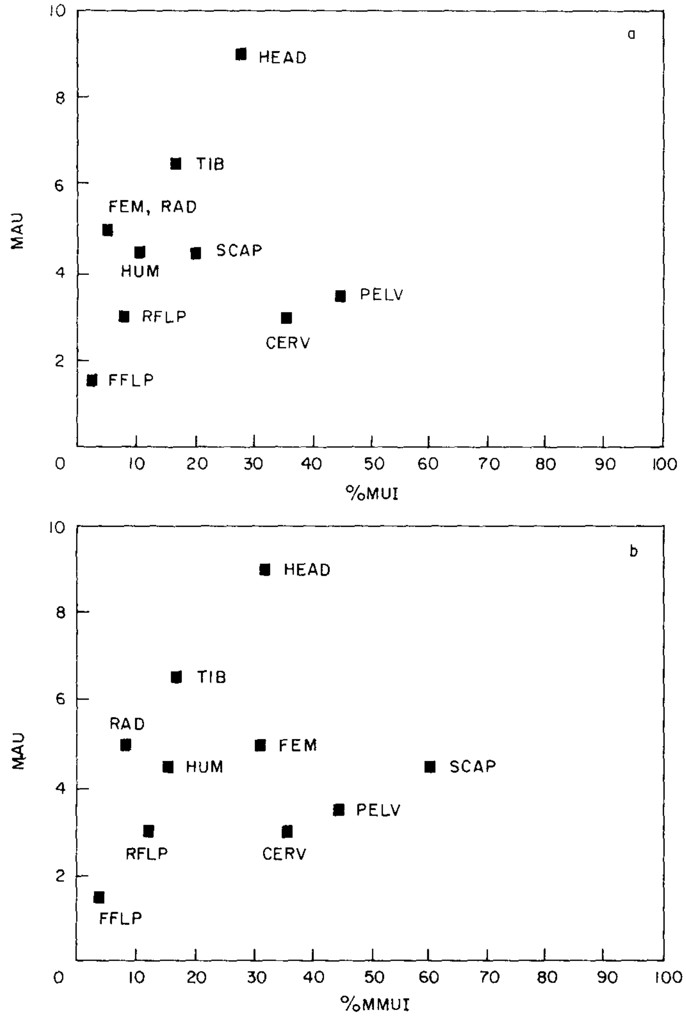

Figure 3. Scatterplots of MAU frequencies of harbour seal bones from Oregon coast against (a) %MUI and (b) %MMUI. Data from Table 7. See Tables 3 and 5 for abbreviations.

total flesh weight data for the foetal harp seal (Appendix), but that does not help explain the variation in skeletal part frequencies of the newborn harbour seals. Here, then, is one area where pinniped utility indices (or, utility indices for any taxon) might be expanded: how does intrataxonomic variation in ontogeny and allometry influence flesh weights and transport logistics?

A large sample of Steller's sea lion (*Eumetopias jubatus*) remains was recovered from another site on the Oregon coast (Lyman, 1991*a*). These remains date between 150 and 400 BP, and were recovered from a village or base camp within 0·5 km of prime Steller's sea lion habitat (Lyman, 1988, 1989, 1991*b*; see Lyman 1992 for a detailed analysis of butchering patterns). When plotted against the %MUI and %MMUI, the MAU values produce a scatterplot similar to a "reverse utility strategy" or L-shaped curve (Figure 4; after Thomas & Mayer, 1983). The MAU values are, however, not correlated with the

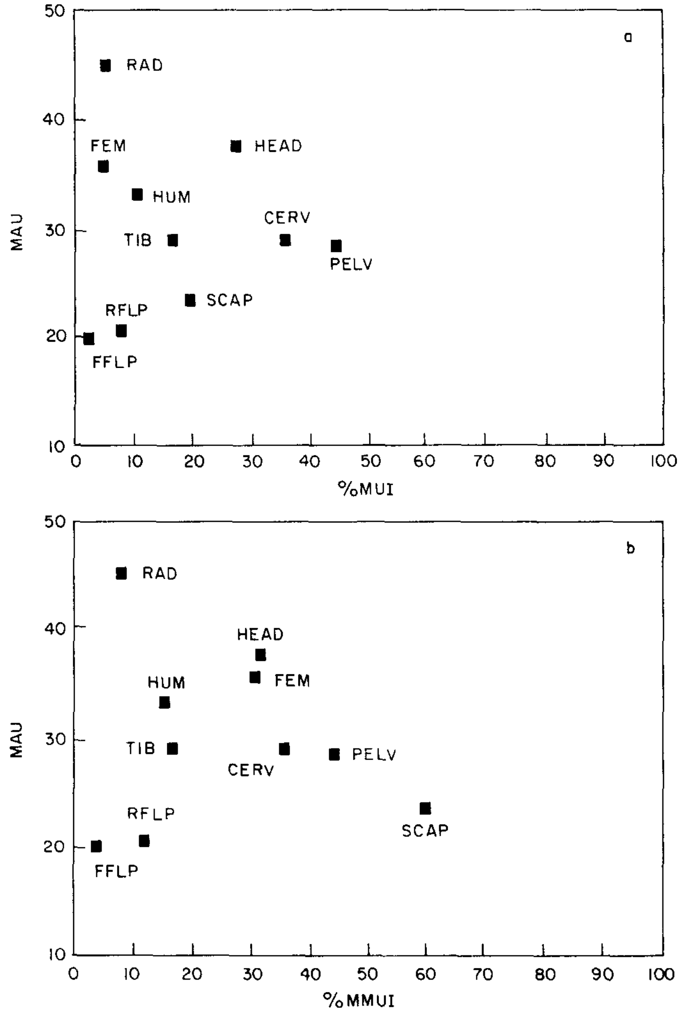

Figure 4. Scatterplots of MAU frequencies of Steller's sea lion bones from Oregon coast against (a) %MUI and (b) %MMUI. Data from Table 7. See Tables 3 and 5 for abbreviations.

%MUI ($r_s = 0{\cdot}04$, $P = 0{\cdot}88$) or with the %MMUI ($r_s = 0{\cdot}001$, $P = 0{\cdot}92$). The insignificant coefficients might be explained as resulting from the fact that Steller's sea lions are not phocid seals but rather are otarids (Otariidae family). Howell (1929), for example, reports that the neck of phocids is "fleshier" than that of otarids, otarids tend to be more slender than phocids and the forelimb tends to be longer in otarids than in phocids. Much as Emerson (1990) has recently shown that North American bison and caribou are sufficiently dissimilar in anatomical details to warrant distinct utility indices for each taxon, we suspect otarids and phocids are sufficiently different to suggest our phocid %MUI and %MMUI measures should not be applied to otarids.

O'Connell *et al.* (1990) hypothesized that the probability that a particular skeletal part will be transported from the site of procurement to a consumption site depends not only on the amount of meat associated with a skeletal part, but also on the cost of defleshing that skeletal part. They suggest that skeletal parts which have relatively high defleshing costs will be transported more often than the relative food utility of the part suggests. Perhaps the fact that our %MUI and %MMUI values do not account for the cost of defleshing pinniped skeletal parts significantly weakens the correlations between that index and the frequencies of pinniped skeletal parts in Oregon archaeological sites. We note that in Figures 3 and 4 the plotted axial elements (head, cervical vertebrae, pelves) are precisely those skeletal elements we did not deflesh with knives but rather boiled. Omitting those axial elements from consideration, the correlation coefficients between MAU values and %MUI, and between MAU values and %MMUI, are all stronger. For the harbour seal remains, $r_s = 0{\cdot}31$ ($P = 0{\cdot}46$) for %MUI, and $r_s = 0{\cdot}45$ ($P = 0{\cdot}26$) for %MMUI. For the Steller's sea lion remains, $r_s = 0{\cdot}00$ for the %MUI, and $r_s = 0{\cdot}21$ ($P = 0{\cdot}61$) for the %MMUI. The low abundances of cervical vertebrae and pelves are weakening the correlations; why those abundances are low is unclear (but see below). The abundant head remains are also contributing to weakening the statistical relationship between skeletal part frequencies and the utility indices. Limited evidence (Lyman, 1991*b*) suggests Steller's sea lion heads were afforded special treatment for as yet unclear reasons, and the same may apply to harbour seal heads. Perhaps as Stiner (1991) has recently suggested, skulls were valued for the fat associated with the brain and were transported in high abundances for that reason.

Eastern Canadian Arctic pinnipeds

Phocids are typically among the most frequently identified species in prehistoric and historic coastal Eskimo sites in the eastern Arctic (e.g. Maxwell, 1985; Savelle & McCartney, 1988). Ethnoarchaeolgocial data recently collected by Whitridge and ethnographic accounts suggest that in the majority of instances complete seal carcasses are transported to residential sites. Therefore, a significant proportion of the variability in frequencies of phocid seal remains from eastern Canadian Arctic contexts may not be reflective of primary processing and transport, but rather of taphonomic processes that affected skeletal parts during and after residential site occupations. Such processes include caching, dog feeding and natural post-depositional processes.

MAU values of ringed seal remains from a late historic (1958–59 AD) snow dwelling (igloo) on the Union River, Somerset Island, in the eastern Canadian arctic (Feature I2 in Savelle, 1984) are presented in Table 7. The MAU values are not significantly correlated with the %MUI ($r_s = 0{\cdot}09$, $P = 0{\cdot}76$) but they nearly are with the %MMUI ($r_s = -0{\cdot}52$, $P = 0{\cdot}08$). Scatterplots, especially using the %MMUI (Figure 5*b*), appear to describe a "reverse utility strategy." Axial elements are contributing to this inverse relationship; Spearman's rho between frequencies of appendicular elements only and the %MUI is $0{\cdot}67$ ($P = 0{\cdot}18$) and between appendicular elements only and the %MMUI $r_s = -0{\cdot}11$ ($P = 0{\cdot}81$). That is, omitting the axial elements, as with the Oregon harbour seals, makes the coefficients more strongly positive (or less strongly negative). We return to this issue below.

Ringed seal remains recovered from a prehistoric Thule Eskimo (*c*. 1000–1200 AD) semisubterranean dwelling at Lord Mayor Bay, Boothia Peninsula (Savelle, 1987) are not correlated with the %MUI ($r_s = 0{\cdot}04$, $P = 0{\cdot}86$) or the %MMUI ($r_s = -0{\cdot}34$, $P = 0{\cdot}25$). The point scatters, especially using the %MMUI, appear to depict a "reverse utility strategy" (Figure 6). Yet again the axial skeletal parts seem to be exerting a strong influence on the correlation coefficients and the appearance of the scatterplot. Omitting all but the appendicular elements, the correlation between bone frequencies and the %MUI improves to $0{\cdot}5$ ($P = 0{\cdot}32$), and between bone frequencies and the %MMUI $r_s = -0{\cdot}30$ ($P = 0{\cdot}56$).

An assemblage of ringed seal remains recovered from two late historic *qarmang* (shallow, sod-walled tent features) at Lord Mayor Bay (Savelle, 1987) is not correlated with the

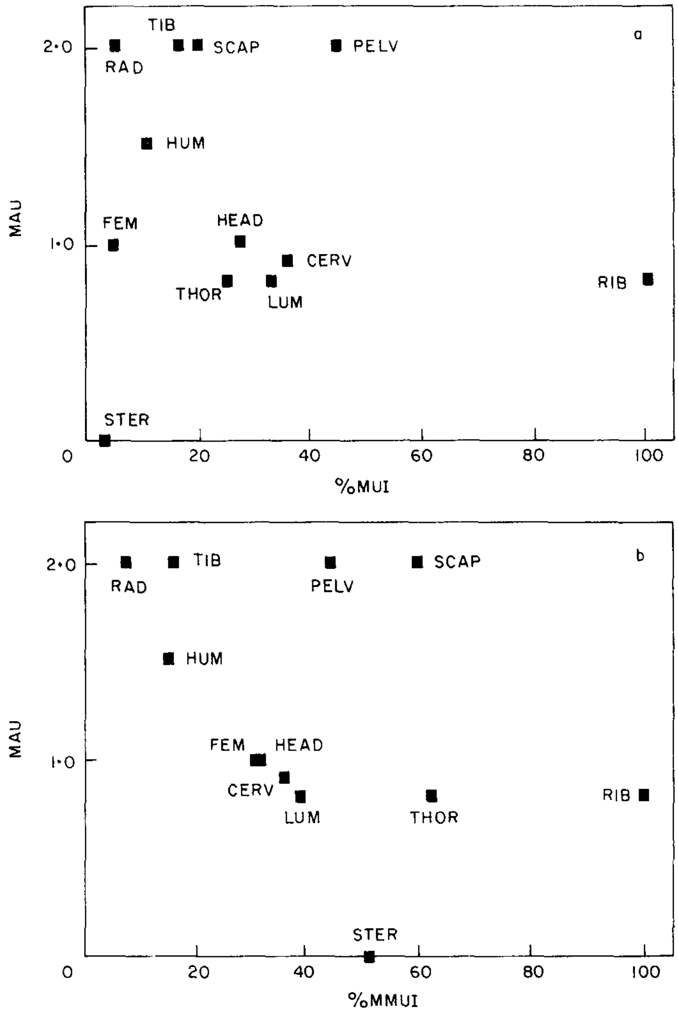

Figure 5. Scatterplots of MAU frequencies of ringed seal bones from eastern Canadian Arctic igloo against (a) %MUI and (b) %MMUI. Data from Table 7. See Tables 3 and 5 for abbreviations.

%MUI ($r_s = -0{\cdot}12$, $P = 0{\cdot}70$) but is significantly correlated with the %MMUI ($r_s = -0{\cdot}58$, $P = 0{\cdot}05$). The scatterplots, especially the one using the %MMUI, again describe a "reverse utility strategy" or L-shaped curve (Figure 7). The correlation between frequencies of appendicular skeletal parts only and the %MUI for the *qarmang* is $r_s = -0{\cdot}12$ ($P = 0{\cdot}82$), and between those frequencies and the %MMUI it is $r_s = 0{\cdot}0$.

Axial elements (head, vertebrae, ribs, sternum, and pelves) are precisely those elements we did not attempt to deflesh with knives but instead boiled because of the difficulty of removing meat from these generally irregularly shaped bones. Since dog teams were in use at the time the igloo, Thule dwelling, and *qarmang* were occupied, the generally low abundances of axial elements may reflect initial transport of these elements and subsequent feeding of them to dogs after stripping of easily-removed meat for human consumption. Dog stake-out areas were identified at the igloo and *qarmang* sites, but bone associated with

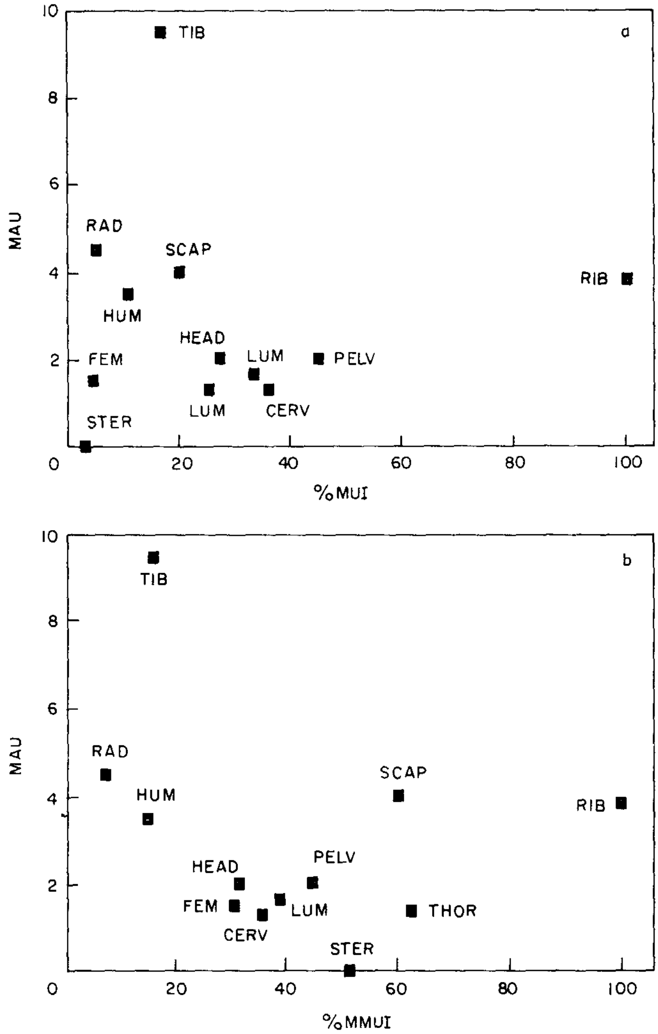

Figure 6. Scatterplots of MAU frequencies of ringed seal bones from eastern Canadian Arctic Thule dwelling against (a) %MUI and (b) %MMUI. Data from Table 7. See Tables 3 and 5 for abbreviations.

those areas was not analysed. Appendicular elements, which we defleshed with some ease, are relatively frequent in the igloo, Thule dwelling, and *qarmang* (along with the pelvis) assemblages.

Frequencies of ringed seal skeletal parts recovered from four Thule tent rings at Hazard Inlet, Somerset Island (Whitridge, 1990) are not correlated with the %MUI ($r_s = -0{\cdot}18$, $P = 0{\cdot}53$) or the %MMUI ($r_s = -0{\cdot}32$, $P = 0{\cdot}25$). With the exception of head parts, axial elements (vertebrae, ribs, sternum, and to some extent the pelvis) tend to be low in abundance relative to appendicular elements (Figure 8). These low abundances may be due to various of the taphonomic processes listed above, but it is important to note that frequencies of appendicular elements are not correlated with the %MUI ($r_s = 0{\cdot}05$, $P = 0{\cdot}86$) or the %MMUI ($r_s = 0{\cdot}42$, $P = 0{\cdot}31$). The tent ring assemblage is older than the igloo

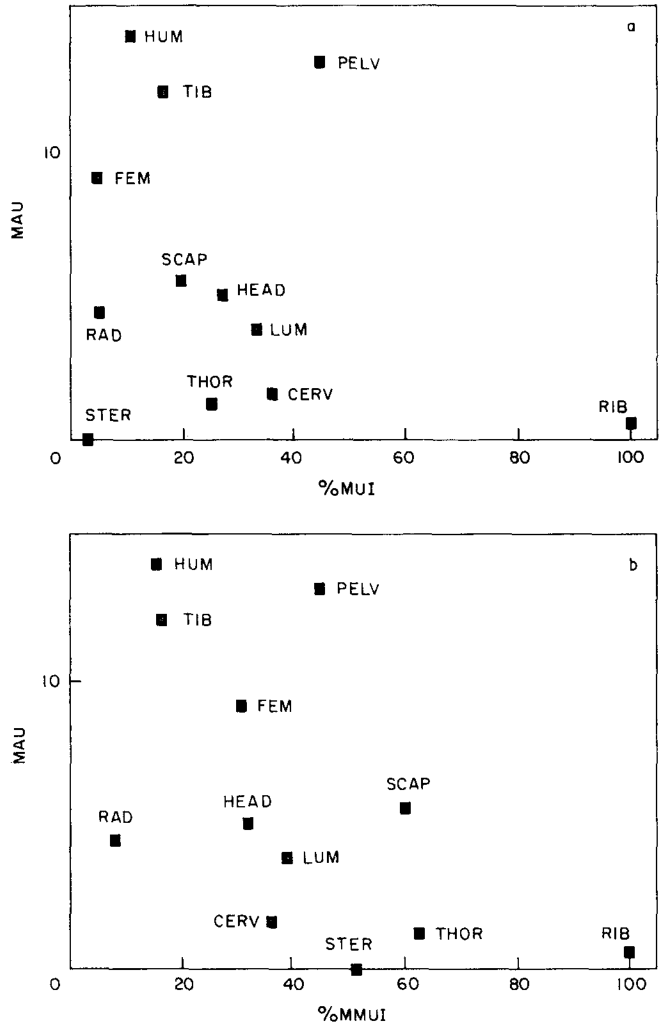

Figure 7. Scatterplots of MAU frequencies of ringed seal bones from eastern Canadian Arctic *qarmanq* against (a) %MUI and (b) %MMUI. Data from Table 7. See Tables 3 and 5 for abbreviations.

and *qarmang* assemblages by 600–800 years, and was well above the permafrost zone unlike the other Thule assemblage (Figure 6). It is therefore possible that differential preservation and other post-occupational taphonomic factors (e.g Schäfer, 1972; Sutcliffe, 1989) have influenced the frequencies of skeletal parts more than differential transport or utilization by humans. We are pursuing this possiblity by measuring the structural density of phocid skeletal parts following procedures outlined by Lyman (1984). Head parts may be frequent due to the ease with which such parts are identified and/or the high fat value associated with the brain (Stiner, 1991).

Conclusions

In our initial applications of the %MUI and %MMUI we have found only one significant ($P<0{\cdot}05$) correlation between those indices and skeletal part frequencies (Canadian

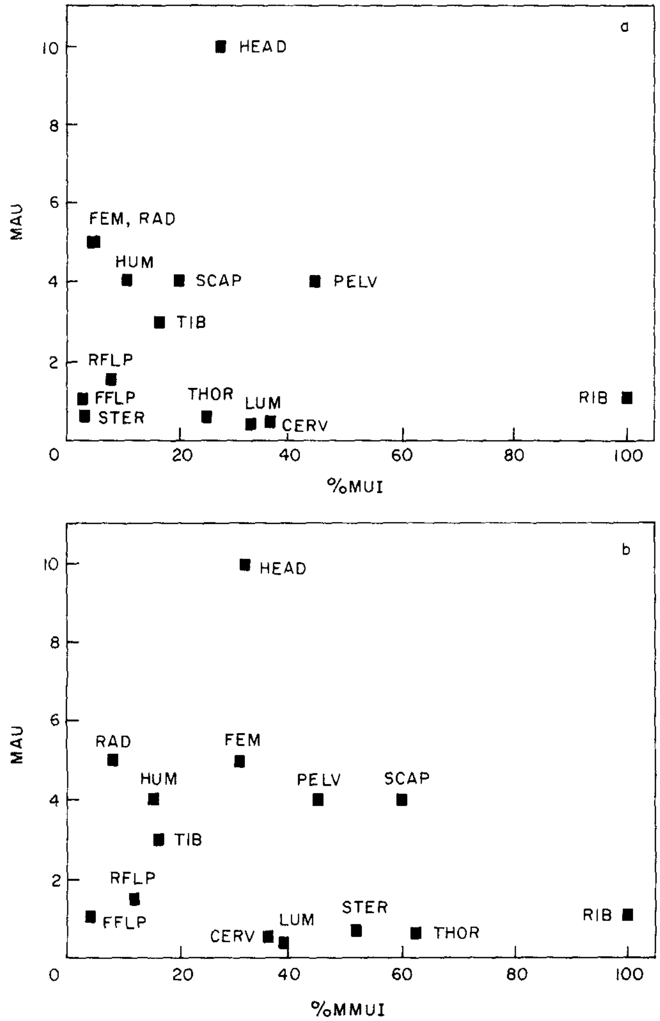

Figure 8. Scatterplots of MAU frequencies of ringed seal bones from eastern Canadian Arctic Thule tent rings against (a) %MUI and (b) %MMUI. Data from Table 7. See Tables 3 and 5 for abbreviations.

Arctic *qarmang* and the %MMUI). That might be because the %MUI does not account for riders, but the %MMUI does account for riders, and with the exception of the Oregon Steller's sea lion remains, the five assemblages of phocid remains are all more strongly correlated with the latter index. This lends some credence to the notions that the meat utility index we have derived might only be applicable to phocid seals and not otarids, and that in the cases examined here seal carcasses may have been transported in butchery units similar to those Whitridge has documented for the modern Inuit. Neither the %MUI nor the %MMUI takes into consideration the cost of manually defleshing skeletal parts. The latter factor, however, is not clearly evident because axial skeletal parts tend to have relatively low frequencies in all of the cases examined here. Stronger positive (or less strongly negative) and more significant correlations between the utility indices and skeletal part frequencies are found when axial skeletal parts are omitted. Low frequencies of axial elements may be the result of feeding these hard-to-manually-deflesh skeletal parts to dogs in the cases of the Canadian Arctic assemblages. While canids are represented in the Oregon assemblages, very few of the marine mammal remains from those contexts display evidence of having been gnawed (Lyman, 1991*a*).

The desire to do "behavioral faunal analysis" (Thomas & Mayer, 1983) has resulted in numerous archaeologists constructing and using indices of the food utility of various vertebrates. Virtually all such indices have, to date, concerned terrestrial mammals, especially ungulates. We perceive a need for additional indices for other kinds of mammals, especially marine mammals. Pinniped remains, for example, are found in many coastal areas other than those mentioned here (e.g. Klein & Cruz-Uribe, 1987; Marean, 1985). This prompted us to acquire and butcher several pinniped carcasses. While receiving some rather incredulous looks from the people at the research stations where we did our work, we believe we have taken a major step towards expanding the realm of anatomical forms for which utility indices are available. We do not presume to have taken the last step in that regard, nor have we completely covered the realm of marine mammals. However, employing the utility index we have derived for phocid seals as a "frame of reference" (Binford, 1987) has provided additional insights into possible processes resulting in the faunal assemblages we consider here. As well, our applications of the index underscore the need for utility indices for closely related (otarids) and distantly related (bison, caribou) species, as well, perhaps, as indices for differently aged individuals of a taxon.

Acknowledgements

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Appendix

HARP SEAL (*Phoca groenlandica*); PgE-90/91-1; adult male, 150 kg; nose-tail length: 155 cm max. girth: 132 cm; sternal blubber thickness: 5·2 cm; dorsal blubber thickness: 6·5 cm (dorsal skin thickness: 0·5 cm); sculp (skin + blubber) weight: 74·78 kg

Anatomical portion	Gross weight (g)	Meat weight (g)	Bone weight (g)
VISCERA			
Stomach (empty)	949·40		0·0
Liver	2810·61		0·0
Kidneys (two)	441·76		0·0
Pancreas and spleen	564·20		0·0
Intestines (with contents)	3171·19		0·0
Testes (two)	418·28		0·0
Lungs (two)	1760·65		0·0
Heart (frozen)	735·29		0·0
Bacculum	178·68	132·78	45·90
Misc. viscera and oesophagus	1122.32		0·0
Total viscera =	12,152·38		
AXIAL			
Head (with mandibles and hyoid)	2000·64	1535·95	464·69
Cervical	3696·79	3401·59	295·20
Thoracic	2826·29	2021·51	804·78
Lumbar	3324·09	2825·29	498·80
Pelvis and sacrum and caudal	4280·80	3730·30	550·50

Appendix *(Continued)*

Anatomical portion	Gross weight (g)	Meat weight (g)	Bone weight (g)
R rib cage	11,626·39	11,006·11	620·28
(8610 g of meat easily removed with knives)			
L rib cage	9781·99	8874·41	887·58
(6790 g of meat easily removed with knives)			
Sternum	513·83	238·5	275·33
Diaphragm meat	—	518·00	0·0
Abdominal meat	—	2088·71 (left)	0·0
	—	2621·60 (right)	0·0
APPENDICULAR (limbs)			
R forelimb	3681·70		
R scapula	2041·34	1870·87	170·47
R humerus	772·00	599·91	172·09
R radius/ulna	561·41	376·70	184·71
R front flipper (with hide)	302·39	—	—
L forelimb	4338·74		
L scapula	2095·89	1878·65	217·24
L humerus	1427·95	1256·03	171·92
L radius/ulna	549·05	372·82	176·23
L front flipper (with hide)	267·25	—	—
R rear limb	4044·02		
R femur (with prox. tibia)	670·50	463·83	206·67
R tibia/fibula (minus prox. end)	2161·87	1892·63	269·24
R rear flipper (with hide)	1212·34	—	—
L rear limb	3351·37		
L femur	424·06	289·15	134·91
L tibia/fibula	1648·55	1285·49	363·06
L rear flipper (with hide)	1297·93	—	—

HARP SEAL (*Phoca groenlandica*); PgE-90/91-2; adult female, 132 kg (with foetus); nose-tail length: 162 cm; max. girth: 135 cm; sternal blubber thickness: 5·2 cm; dorsal blubber thickness: 6·5 cm; sculp weight: 61·76 kg

Anatomical portion	Gross weight (g)	Meat weight (g)	Bone weight (g)
VISCERA			
Stomach (frozen)	554·18		0·0
Liver	1967·77		0·0
Kidneys (two)	386·06		0·0
Heart (frozen, with blood)	1316·88		0·0
Lungs (two)	2322·40		0·0
Intestines	2781·90		0·0
Misc. viscera and oesophagus	673·32		0·0
Total viscera =	10,002·51		
AXIAL			
Head (with mandibles and hyoid)	1899·39	1479·49	419·90
Cervical	2479·48	2131·98	347·50
Thoracic	2390·00	1694·10	695·90
Lumbar	1627·15	1230·85	396·30
Pelvis and sacrum and caudals	3778·13	3429·73	348·40
R rib cage	7532·30	7074·20	458·10
(5523·75 g of meat easily removed with knives)			

Appendix *(Continued)*

Anatomical portion	Gross weight (g)	Meat weight (g)	Bone weight (g)
L rib cage	7082·01	6614·51	467·50
(4635·29 g of meat easily removed with knives)			
Sternum	328·51	154·35	174·16
Diaphragm meat	—	453·06	0·0
Abdominal meat	-	1424·19 (right)	0·0
	—	1819·34 (left)	0·0
APPENDICULAR			
R forelimb	3944·26		
R scapula	2178·97	1978·24	200·73
R humerus	872·21	707·47	164·74
R radius/ulna	449·36	306·60	142·76
R front flipper (with hide)	403·72		—
L forelimb	3283·45		
L scapula	1276·16	1123·00	153·16
L humerus	1167·92	955·87	212·05
L radius/ulna	488·09	329·34	158·75
L front flipper (with hide)	352·16	—	—
R hindlimb	3032·95		
R femur	469·13	362·62	106·51
R tibia/fibula	1410·86	1142·86	268·00
R rear flipper (with hide)	1151·65	—	—
L hindlimb	2924·24		
L femur	352·75	225·18	127·57
L tibia/fibula	1376·01	1074·39	301·62
L rear flipper (with hide)	1189·48	—	
FOETUS, total weight (with placenta): 9090·00 g			
Length = 91·5 cm			
Placenta	1239·96		
Skin and fat	1540·78		
Viscera	551·96		
Total bone	778·07		
Meat	2955·64		
Total =	7066·41		

HARP SEAL (*Phoca groenlandica*); PgE-90/91-3; immature male, 52 kg; nose-tail length: 123·5 cm; max. girth: 97 cm; sternal blubber thickness: 5·0 cm; dorsal blubber thickness: 5·1 cm; sculp weight: 26·31 kg

Anatomical portion	Gross weight (g)	Meat weight (g)	Bone weight (g)
VISCERA			
Stomach (empty)	506·78		0·0
Liver and pancreas and spleen	883·33		0·0
Kidneys (two)	169·98		0·0
Heart (empty)	326·98		0·0
Lungs (two)	620·03		0·0
Intestines	1360·65		0·0
Misc. viscera	128·49		0·0
Total viscera =	3996·24		
AXIAL			
Head (with mandibles and hyoid)	1192·87	957·73	235·14
Cervical	1221·35	1081·25	140·10

Appendix *(Continued)*

Anatomical portion	Gross weight (g)	Meat weight (g)	Bone weight (g)
Thoracic	757·75	449·93	307·82
Lumbar	1673·34	1516·86	156·48
Pelvis and sacrum and caudal	1177·93	1009·74	168·19
R rib cage (1604·40 g of meat easily removed with knives)	2652·78	2435·81	216·97
L rib cage (1378·88 g of meat easily removed with knives)	2536·42	2351·42	185·00
Sternum	253·44	113·52	139·92
Diaphragm meat	—	141·80	0·0
Abdominal meat	—	702·69 (left)	0·0
	—	666·59 (right)	0·0
APPENDICULAR			
R forelimb	1382·70		
R scapula	543·26	469·25	74·01
R humerus	373·15	279·65	93·50
R radius/ulna	249·68	166·62	83·06
R front flipper (with hide)	218·93	—	—
L forelimb	1326·29		
L scapula	511·70	452·00	59·70
L humerus	411·21	338·48	72·73
L radius/ulna	216·27	152·15	64·12
L front flipper (with hide)	185·10	—	—
R hindlimb	1418·40		
R femur	271·02	201·30	69·72
R tibia/fibula	629·73	492·33	137·40
R rear flipper (with hide)	526·87	—	—
L hindlimb	1556·53		
L femur	394·41	314·37	80·04
L tibia/fibula	616·00	483·34	132·66
L rear flipper (with hide)	544·30	—	—

HOODED SEAL (*Cystophora cristata*); immature male, 52 kg; nose-tail length: 146 cm; nose-anus length: 130 cm; max. girth: 95 cm; sternal blubber thickness: 3·8 cm; dorsal blubber thickness; 3·0 cm; sculp weight: 20·68 kg

Anatomical portion	Gross weight	Meat weight	Bone weight
VISCERA			
Stomach (with contents)	729·90		0·0
Liver	1538·75		0·0
Kidneys (two)	274·35		0·0
Pancreas	332·47		0·0
Intestines (with contents)	1332·10		0·0
Lungs (two)	1305·51		0·0
Heart	403·24		0·0
Oesophagus	264·27		0·0
Total viscera =	6180·59		
AXIAL			
Head (with mandibles and hyoid)	2582·72	2105·45	477·27
Cervical	1536·43	1341·76	194·67
Thoracic	1774·20	1354·25	419·95
Lumbar	1954·95	1733·33	221·63

Appendix *(Continued)*

Anatomical portion	Gross weight	Meat weight	Bone weight
Pelvis and sacrum and caudal (includes bacculum)	1919·22	1721·44	197·78
R rib cage	3027·18	2650·59	376·59
L rib cage	3690·95	3420·69	270·26
Sternum	234·01	97·03	136·98
Abdominal meat	—	839·78 (left)	0·0
	—	838·15 (right)	0·0
APPENDICULAR			
R forelimb	1464·43		
R scapula	559·47	487·59	71·88
R humerus	422·58	329·20	93·38
R radius/ulna	294·30	216·78	77·52
R front flipper (with hide)	178·65	—	—
L forelimb	1428·67		
L scapula	587·41	525·15	62·26
L humerus	386·94	292·00	94·94
L radius/ulna	277·42	195·22	82·20
L front flipper (with hide)	175·56	—	—
R rear limb	1110·82		
R femur	149·45	85·42	64·03
R tibia/fibula	477·63	363·00	114·63
R rear flipper (with hide)	480·61	—	—
L rear limb	1121·82		
L femur	130·84	52·66	78·18
L tibia/fibula	531·87	399·64	132·23
L rear flipper (with hide)	461·21		