

Zooarchaeology in British Columbia*

JONATHAN C. DRIVER

INTRODUCTION

The concept that the interaction between human society and the environment played a significant role in structuring non-economic aspects of culture (especially social organization) became prominent in the processual archaeology of the 1960s and 1970s (Trigger 1989) and continues to be a significant theoretical concept in North American archaeology. Grounded in cultural ecology (Steward 1955) and cultural materialism (Harris 1979), archaeological theory which links resource structure, subsistence methods, paleoeconomies, settlement patterns, and social organization has had an important role in discussions of the development of prehistoric societies in British Columbia. Most archaeologists who have attempted to explain the development of culturally complex hunter-gatherer societies on the British Columbia coast have commented on the significance of the maritime resource base. The best known of these discussions is Fladmark's (1975) proposal that stabilization of sea levels at about 5,000 years ago resulted in increased productivity of salmon and other resources, thus allowing sedentary settlements and denser populations to develop along the coast. This theme of resource stability and abundance has been echoed by other writers such as Matson (1976; 1981; 1983; 1992), Burley (1980), and Ames (1985), all of whom see the foundation of cultural complexity in the nature of the coastal resource base. In the southern Interior Plateau the transition from mobile camps to semi-permanent pit-house villages has also been linked to the development of salmon fisheries along interior rivers (Hayden 1992; Hayden and Ryder 1991; Richards and Rousseau 1987). Given this emphasis on the resource base, it is clearly important to obtain archaeological data which reflect

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human use of the environment, and the most direct evidence for this will be the preserved remains of plants and animals recovered from archaeological sites. The lack of abundant wild plants with significant protein and carbohydrates in most of B.C. means that animals were the main source of food in prehistoric times.

Animal bones and shells are recovered commonly from archaeological sites in B.C., and since the 1960s the term "zooarchaeology" has been used to describe a set of methods to identify and analyze such remains. However, the study of animal remains from archaeological sites has little to do with zoology, and zooarchaeology shares the goals of other subfields of archaeology — to increase our understanding of what happened in the past. On most archaeological sites in B.C. where faunal remains are found, people were responsible for bringing bones and shells to the site, usually because the animals were used as food. Most zooarchaeological studies have therefore dealt with prehistoric subsistence practices, and this will be the main focus of this paper. However, zooarchaeological analyses can contribute to other archaeological problems, and the potential of these studies in B.C. will also be mentioned.

The goals of this paper are: (a) to provide a brief overview of the current state of zooarchaeology; (b) to evaluate the methodological basis of zooarchaeology in B.C.; (c) to review some of the achievements of B.C. zooarchaeology in the last fifteen years; and (d) to suggest future directions for zooarchaeological analysis. In developing this paper I have not reviewed all of the faunal studies in B.C., mainly because so many are presented in unpublished site reports written to fulfil archaeological permit requirements. I have sampled these reports, but I have not read all of them. The same applies to the numerous (and weighty) theses produced by graduate students in B.C. over the last fifteen years. Thus, this paper relies mainly on published books, chapters, and articles. As will become apparent, most attention is given to the southern B.C. coast, because it is here that the greatest numbers of faunal assemblages have been reported. Less attention is given to sites in the southern interior, and virtually no mention is made of sites in northern B.C., because very few faunal assemblages have been recovered from that area. Most examples will be drawn from prehistoric sites occupied by First Nations people.

ZOOARCHAEOLOGY

Zooarchaeology has developed rapidly over the last fifteen years, reflecting the renewed importance given to animal bone studies in archaeology in general. The archaeological community has become increasingly aware of

the value of zooarchaeology in tackling more general questions. For example, Binford has had a considerable effect on the increased visibility of zooarchaeology through his controversial analyses of Palaeolithic faunas (e.g., Binford 1981, Binford and Ho 1985; Potts 1988). Zooarchaeology has contributed to studies of early food-producing societies (e.g., Greenfield 1991), to a better understanding of hunter-gatherer subsistence (e.g., Davis and Reeves 1990), and to analysis of the development of urban society (e.g., Zeder 1992). To some extent this is a legacy of the cultural ecological theory which dominated archaeology in the 1970s, and which continues to exert a powerful influence on archaeological interpretation in spite of newer developments, such as the revived interest in Marxism (McGuire 1992) and historicism (Hodder 1986). In addition, publication of a number of highly readable zooarchaeology textbooks (e.g., Davis 1987, Hesse and Wapnish 1985, Klein and Cruz-Urbe 1984) has made zooarchaeological methods more widely known to archaeologists who are themselves not zooarchaeological "specialists."

If this paper had been written a decade ago, zooarchaeologists working in B.C. would probably have been criticized for inadequate data reporting and lack of attention to the problems of sampling. However, current practice in B.C. zooarchaeology is methodologically quite sound. Casteel (1976) demonstrated the value of column sampling on B.C. sites, and excavators now regularly take column samples of sediments in order to extract small (but often very numerous) bones (e.g., Coupland 1991, Eldridge 1987, Hanson 1991, Kusmer 1988). This attention to small species has resulted in a better appreciation of the diversity of resources exploited, even in regions where salmon were abundant. Zooarchaeologists tend to be fairly explicit in describing their methods (e.g., Calvert and Crockford 1982; Langemann 1987; Kusmer 1990), and data tabulation is often extensive. This attention to high-quality data reporting is important for a number of reasons. First, as will be argued below, we are only going to make sense of zooarchaeological data if we can compare fairly large numbers of different sites. This comparison can only be done if data reporting is standardized. Zooarchaeologists trying to synthesize data from previous analyses frequently find that a lack of standardized information can seriously affect their ability to make sense of previously published material. For example, Hobson and Driver (1989) summarized published data on prehistoric waterbirds from the Strait of Georgia area, and found that the data were not presented in ways which allowed comparisons between sites. A recent study of Gulf of Georgia subsistence patterns encountered similar problems (Hanson 1991), as did a study of different coastal regions in B.C.

(Mitchell 1988). Arguments in favour of standardized reporting are given by Driver (1983, 1992) and Grigson (1978). Second, even though bone and shell are relatively stable after excavation, assemblages will not last forever. Langemann (1987) studied fauna excavated in the early 1970s from the Lillooet region and found that some bones had broken or disintegrated since their excavation less than fifteen years before her analysis. This problem will only increase, and reinforces the need for high-quality data reporting. One might also mention that many faunal assemblages are poorly stored and that most fauna is not catalogued. For most collections any separation of bone and shell from the paper bags in which they are usually stored means a complete loss of provenience information.

If current methods of data reporting are adequate, what contribution to B.C. prehistory is made by zooarchaeological studies? There are a number of analytical areas where zooarchaeology is generally considered to make an important contribution to archaeology. Among these are: reconstruction of past environments; the study of subsistence; and analysis of human social organization. For each of these topics a general discussion of the potential of zooarchaeology will be followed by a brief analysis of the situation in B.C. However, we must first consider the problem of what is preserved on archaeological sites.

PRESERVATION

A problem common to the study of all organic remains from archaeological sites is the role of preservation conditions in shaping the assemblage ultimately available for archaeological recovery. Taphonomy (the study of the "laws of burial") was initially developed in palaeontology to study the range of processes which resulted in the formation of fossil assemblages of plants and animals (Allison and Briggs 1991). Taphonomic studies have demonstrated that bone assemblages recovered from palaeontological sites are unlikely to provide a simple reflection of the animal communities which lived around the sites. There are numerous reasons for this, but one can state briefly that the processes which move bones to a site, bury bones, and preserve bones do not result in the ultimate recovery of a representative collection of the local animal population. Thus, palaeontologists study taphonomy to understand how assemblages are formed. Some people see this as correcting a "bias" caused by natural processes; others see taphonomic factors as part of the entire natural process of death and burial which they are studying.

For archaeologists, taphonomy has often been used to refer to the study of the non-cultural processes which affect assemblages of animal remains recovered from archaeological sites (Gifford 1981). Zooarchaeologists want to know what animals (or parts of animals) were brought to a site by people. If all the bones and shells which were brought to a site in pre-historic times were preserved for archaeologists to excavate and study, we would be able to study the way in which humans selected animals from their environment. Unfortunately, various natural processes affect assemblages of bone and shell on archaeological sites. These processes will differentially destroy bone and can have a significant effect on resulting interpretations. For example, bones which are discarded by humans may be used later as food by scavengers, such as dogs or raccoons, or acidic soils may destroy bone or shell. It is therefore important to distinguish between patterns in the assemblage created by deliberate human activity and patterns created by subsequent non-cultural forces.

Taphonomic models derived from modern studies provide hypotheses to account for patterns seen in archaeological assemblages. Because animal anatomies are similar in different parts of the world, the results of modern studies undertaken in other locations may be quite relevant to the understanding of archaeological assemblages from B.C. For example, there have been numerous studies of the effects of scavengers on skeletons of ungulates in regions such as Africa, Europe, or the Arctic. These studies have consistently shown that certain areas of the skeleton are very susceptible to scavenger destruction, while others are quite resistant. Provided that the anatomy of B.C. ungulates is similar to that in other areas, and provided that the scavenging animals are similar, we can use those studies to examine how prehistoric scavenging might have affected bones of ungulate species such as deer or elk in B.C. sites (e.g., Cannon 1991 for Namu, and Hanson 1991 for Pender Canal).

On the other hand, there may be taphonomic problems unique to British Columbia which require local baseline studies. For example, Muckle (1985) experimentally examined the effects of various processes on the preservation of shell, and applied these results to the analysis of shell from a B.C. shell midden. In neighbouring areas of the Northwest, Butler (1993) has examined salmon taphonomy in an attempt to distinguish naturally deposited salmon bones from culturally deposited remains. Other studies are still waiting to be done. Wigen and Stucki (1988) note that we do not yet have a good understanding of the resistance of the bones of different fish species to weathering, and that this is important if we are to quantify the relative frequency of fish species in archaeological sites.

PALAEOENVIRONMENTS

Most knowledge of environmental development in B.C. since the end of the last ice age derives from palynology and geomorphology. Palynological analysis has documented the evolution of the coastal rain forest community (Hebda and Mathewes 1984), and has identified the early post-glacial vegetation communities in the Peace River region (White 1983). Geomorphological analysis has been at the forefront of debates about the "ice free corridor" as a route for the peopling of the Americas (e.g., Bobrowsky and Rutter 1992), has been used to reconstruct coastal environments and resources (Fladmark 1975, 1983), and is important in understanding the evolution of such features as the Fraser Delta (Williams and Roberts 1989).

As fossil remnants of past ecosystems, animal remains have potential for understanding the environments in which humans lived (e.g., Lundelius et al. 1983; Graham, Semken and Graham 1987), although some caution is required in their interpretation (e.g., Grayson 1981). However, relatively little use has been made of this potential in B.C. archaeology. To some extent this is because the majority of sites excavated in B.C. date to within the last few thousand years, and there appears to have been little change in animal populations over that period (with the exception of the last two hundred years of Euro-Canadian impact). This is not to say that no environmental change occurred, or that environmental change would be undetected. For example, Cannon (1991) has proposed that the salmon resources available at Namu on the central coast increased after 6000 BP, tending to confirm Fladmark's (1975) hypothesis concerning the effects of stabilization of the B.C. coastline. Cannon has also proposed that estuary development on the Namu River reduced salmon productivity in later prehistory. The availability of salmon in interior rivers has long been proposed as a contributing factor in the development of semi-sedentary pit-house villages (Fladmark 1986; Kuijt 1989; Richards and Rousseau 1987), and a catastrophic reduction in the resource caused by a major slide on the Fraser River has been blamed for an episode of prehistoric "cultural collapse" near Lillooet (Hayden and Ryder 1991).

It is likely that the environments of the early post-glacial period were the least similar to modern environments, but there has been relatively little analysis of prehistoric faunas in the 11000 to 5000 BP range. There is virtually no evidence for the co-existence of humans with extinct fauna in B.C. Most of the mammoth skeletons which have been found date prior to the last glacial maximum, and there is no evidence for a human presence

in B.C. until after the last glaciation. Currently the only evidence for early post-glacial faunas from an archaeological context is from Charlie Lake Cave, near Fort St. John. This site is unique in B.C. because it consists of a deep, stratified sequence of deposits spanning the post-glacial period. The site contains naturally deposited terrestrial fauna (mice, voles, birds, etc.), the remains of animals hunted by humans, and stone and bone artifacts. Of special importance is the Paleoindian component, radiocarbon dated to about 10500 BP, which contains a basally thinned projectile point and other artifacts (Fladmark, Driver and Alexander 1988). Associated with this component are bones of an extinct bison species which was hunted nearby, while naturally deposited bones include ground squirrel, jackrabbit, and cliff swallow. This early post-glacial fauna probably inhabited a grassland environment very different from the modern vegetation of the Peace River area. The grassland environment and its fauna survived until about 10000 BP, when boreal forest and associated animals replaced the grassland rather quickly (Driver 1988; Driver and Hobson 1992).

It is likely that in most of British Columbia the "typical" faunas were established fairly quickly after deglaciation, although, as noted above, the first important salmon runs into southern interior rivers may have developed within the last five thousand years. However, the situation on the coast was probably more complex, mainly because relative sea levels were generally unstable until about five thousand years ago. There was clearly a human population living on the coast from early in the post-glacial period (Carlson 1990; Fladmark 1986; Fladmark, Ames and Sutherland 1990), but virtually nothing is known about either the coastal resources available to them or the manner in which these resources were exploited. This seems to be because preservation conditions for bone were poor until significant quantities of shellfish were deposited routinely on sites, reducing the acidic soil conditions which tend to destroy bones. By the time shellfish collection was a significant part of prehistoric subsistence, the resource base was fairly similar to today's, and we still lack knowledge about pre-5000 BP maritime adaptations in most places. In a recent summary, Matson (1992: 375-380) describes only four Northwest Coast sites which contain faunal remains and date before 4500 BP — The Dalles in Oregon, Glenrose Cannery and Bear Cove in B.C., and Chuck Lake Cave in Alaska. Namu, on the central coast of B.C., should also be added to this list (Cannon 1991). These sites demonstrate that a wide variety of maritime species was being exploited prior to 5000 BP, although salmon was much less important than in later sites, and land mammals may have been more important. Until more sites with early faunas are excavated we will not see a significant change to our

understanding of early animal resources in B.C. Although one can search systematically for early sites with good faunal preservation, it is probable that such sites will emerge through chance finds rather than systematic fieldwork. However, it is possible to broaden knowledge about the later environments of B.C. through more detailed studies of the later faunas. There are a number of ways in which this could be approached. Ethnographic and historic records of faunal distribution could be viewed more critically when reconstructing the resource base of prehistoric B.C. For example, in the Peace River region moose is regarded as the prime big-game animal in virtually all ethnographies. However, records from the fur trade and from excavations of fur-trade sites demonstrate that bison and elk were important resources in the region (Williams 1978). Faunal data from historic and prehistoric sites in the same area demonstrate that passenger pigeon was common, although it was rarely recorded in historic times (Williams 1978; Driver and Hobson 1992). Similarly, analysis of ethnographic data on whale hunting on the west coast suggests that humpbacks were the main prey species until they were almost exterminated by nineteenth and twentieth century whalers (Kool 1982); modern data concerning whale abundance would no doubt suggest the grey whale as the primary west coast species.

Secondly, evidence for smaller-scale environmental change could be sought in more detailed studies of species which are sensitive indicators of past conditions. For example, shellfish on coastal sites were probably harvested from local beds, and might provide evidence for changing beach environments. Some fish species have fairly specific habitat requirements, and these could also be used to assess changing local environments around coastal sites.

DIET AND SUBSISTENCE

Diet

Undoubtedly the main *raison d'être* for zooarchaeology has been to reconstruct diet (what people ate) and subsistence (how people obtained food). However, the most important development in this field in the past decade has not been in zooarchaeology, but in the chemical analysis of human skeletons, specifically the ratios of two stable isotopes of carbon in preserved bone collagen, as noted in the introduction to this volume. The ratio of ^{13}C to ^{12}C is slightly higher in marine animals than in land animals. If people (or other carnivores) consume a diet which is exclusively marine, their bone collagen will contain relatively more ^{13}C than people who only

eat land animals. Thus the relative amount of ^{13}C in human bone can be used to show what proportion of the diet consisted of marine foods and what proportion consisted of terrestrial foods (Chisholm 1986; Chisholm, Nelson and Schwarcz 1983). While this method of analysis is certainly open to refinement, it has provided extremely useful data for archaeologists, and the supposed "problems" with the method mentioned by Isaac (1988) seem to stem from misunderstanding of the status of salmon as an anadromous species. Analysis of prehistoric skeletons from the B.C. coast confirms what one would suspect from the ethnographies — that virtually all of the protein consumed by coastal people was obtained from the ocean. Analysis of human skeletons from the interior has demonstrated a reliance on marine resources ranging from about 40% to to 60% along the major salmon rivers. As salmon were presumably the only significant marine species being consumed, this provides us with an estimate of the importance of prehistoric salmon consumption in the interior. Interestingly, the earliest southern interior skeleton, the Gore Creek specimen dated at about 8000 BP, had a ^{13}C value which suggests a diet with a minimal marine content and hence little reliance on salmon (Chisholm and Nelson 1983).

While such isotope studies provide very important information on human diet, they do not provide complete information. The measurements of bone collagen record the average diet, and diet probably varied seasonally. For coastal populations, carbon isotope studies tell us that marine foods were overwhelmingly important, but we do not know the relative importance of different marine species in the diet. In the interior, isotope studies do provide information about one genus (salmon), but the remaining 40% of the diet must be assessed from other sources. It therefore remains the role of zooarchaeology to provide some idea of the relative importance of species, even if the isotope studies tell us the relative importance of marine and terrestrial ecosystems in contributing protein to the human diet. One should also note that human bone collagen only records the relative proportions of different foods consumed at a time when collagen was being formed. It does not record the total intake of foods. If seafood was eaten daily, while land animals such as deer were consumed irregularly, the consumption of large amounts of deer meat on an occasional basis would be masked by the consumption of regular smaller meals of seafood. This might explain why deer and other land mammals seem quite abundant at some coastal sites where analysis of human collagen suggests almost complete reliance on marine species.

Even though isotope studies measure the ratio of marine to terrestrial protein in prehistoric human diets, analysis of the relative abundance of

different species must still be based on the numbers of animal bones and shells excavated from archaeological sites. Quantification of zooarchaeological data has been the subject of numerous debates, reviewed critically by Grayson (1984) and Ringrose (1993), while zooarchaeologists in B.C. have also tackled problems of quantification (e.g., Cannon 1991; Mitchell 1988, 1990). I will not reiterate all of Grayson's and Ringrose's arguments here. Instead, the two basic zooarchaeological quantification methods will be reviewed briefly, and associated problems discussed. A third quantification method will be discussed, mainly to show that it is especially inappropriate for the coastal regions of B.C.

Most methods of quantification either calculate the quantity of bone per species at a site or make an estimate of the minimum number of animals required to produce the bones that were found by archaeologists. Quantity of bone is usually expressed either as a count of identified bones, often abbreviated as NISP (number of identified specimens), or as a weight of bone. NISP is commonly used to deal with vertebrates, which have many bones within each animal. Bone weight is sometimes calculated for vertebrates, and shell weight is a common way of expressing the amount of shell. Once all bones or shells have been identified, quantification is expressed as a per cent frequency of the site total for each species. For example, if an assemblage contains 73 salmon bones, 142 herring bones and 33 rockfish bones, the percentages would be 29%, 57%, and 13%.

Clearly, there are problems with such a method. Different species of animals have different numbers of bones in their body, so some are going to be better represented than others. The bones of some species are more likely to be preserved than others, so they will be better represented. Humans tend to transport small animals to sites as complete individuals with all the bones, whereas large animals may be butchered and some bones may be discarded before the meat is brought to a habitation site. For these and other reasons (see Grayson 1984 for a comprehensive list), many zooarchaeologists have instead used an index which attempts to calculate the smallest number of individuals required to produce the assemblage of bones recovered from a layer within a site.

Calculation of the minimum number of individuals (MNI) per species is achieved relatively easily by working out the smallest number of individual animals required to produce all the bones of that species recovered. To return to the example above, we might find that the seventy-three salmon bones consisted of sixty vertebrae, three left side dentaries, two right side dentaries, and one each of a left quadrate, a right quadrate, a vomer, a left and a right premaxilla, one left and two right maxillae. As any one

salmon contains one left dentary, the three left dentaries must have been produced by three individual salmon. Those three hypothetical salmon could easily produce sixty vertebrae and all of the other bones listed, so the MNI value for salmon is therefore 3. Similar calculations for the other species might lead to values of 4 MNI for herring and 2 MNI for rockfish, with the percentages of species then being presented as 33%, 44%, and 22%.

It has been argued that there are two reasons for calculating MNI instead of NISP or bone weight. First, MNI deals with the problems of "missing" bones lost by poor preservation, inadequate recovery methods, etc. However, as Grayson (1984) has demonstrated, this is a fallacy. MNI and NISP are not independent measures of quantification, and it can be demonstrated that the two values are mathematically linked, such that one can predict MNI from NISP. There appears to be no justification for using MNI as a way of dealing with problems caused by NISP or bone-weight calculations.

Second, it has been argued that if we know the minimum number of individuals in an assemblage we can multiply the MNI value by an average meat-weight value for the species, and thus obtain a better estimate of the relative importance of the species to the human diet. Again, using the hypothetical data given above, the three salmon weigh about 15 kg, the four herring weigh .75 kg, and the two rockfish weigh 2.5 kg (figures from Mitchell 1988). These figures can now be used to look at the percentage importance of the three species — 82%, 4%, and 14%. Unfortunately, this method also has problems. Meat-weight calculations assume that we know what proportion of potentially edible meat was actually consumed and use of average meat weights masks variation in the size of individual animals. One problem is particularly important: the method does not calculate the actual number of individuals represented by the bones, but only the minimum number of individuals. Of course, there is no reason to believe that the minimum number of individuals bears any resemblance to the actual number of individuals. This problem can be illustrated by another example. Suppose that in the hypothetical assemblage described above rockfish was represented by one bone instead of thirty-three bones. If we used bone counts or bone weights, rockfish would be an insignificant part of the assemblage. However, when MNI is calculated, salmon would still be 3, herring would still be 4, and rockfish would be 1 (because even finding one bone requires one individual to produce it). Why should we be willing to allow the single bone of a rockfish to represent one fish, if 142 herring bones only represent 4 fish? Rockfish bones are thought to preserve

very well (e.g., Wigen and Stucki 1988: 108), yet all the other bones of this particular individual are missing from the assemblage. We are apparently willing to believe that many more bones of each individual salmon survived than each individual rockfish, even though salmon bones preserve poorly and rockfish bones preserve well. If one rockfish bone equals one individual, why doesn't one salmon bone equal one individual? There is no answer to this question, and for this reason the MNI index is inherently unsuitable as a method for calculating relative frequencies of either individuals or meat weights. In fact, if we want to "weight" our results to produce figures which reflect the size of the animals, we might consider multiplying the NISP value for each species by the average meat-weight for that species, because the data yielded would be just as valuable as the calculation based on MNI.

Some zooarchaeologists have proposed a third method of quantification, the Lincoln or Peterson index (Fieller and Turner 1982). This method borrows a technique used by biologists to estimate animal populations. Biologists estimate small mammal populations by trapping, marking, and then releasing a group of animals. They then trap the area a second time, and note what percentage of animals trapped the second time had been previously trapped. The small-mammal population of the area in which traps were set is then estimated by multiplying the number of animals trapped the first time by the number of animals trapped the second time, and then dividing by the number of animals trapped on both occasions. Fieller and Turner have argued that one could treat left-right pairs of bones in an analogous fashion to estimate the total population of animals which contributed to a faunal assemblage. Thus, a sample which contained deer mandibles might have fifteen left mandibles and twelve right mandibles, of which two sets of lefts and rights were clearly pairs derived from the same individuals. The total population (the death assemblage) would be calculated by multiplying 15 by 12 and then dividing by 2 (the number of pairs), resulting in an estimate of 90 deer originally hunted. Numerous criticisms have been levelled against this method. It is very difficult to determine positively that a left and a right bone were originally from the same animal. The method assumes the random distribution of bones and a random sampling of bones. However, what makes it inappropriate for coastal studies is the fact that most paired fish bones occur in the head, and fish were often beheaded at catch locations, resulting in assemblages at habitation sites dominated by backbones in which paired bones do not occur (Butler 1993: Figure 4). The Lincoln Index can therefore be dismissed as inappropriate for coastal assemblages on practical as well as theoretical grounds.

TABLE 1

Faunal data from two sites in the Lillooet region (after Langemann 1987)

<i>Species</i>	<i>NISP</i>	<i>MNI</i>	<i>Maximum Meat (kg)</i>	<i>Minimum Meat (kg)</i>
<i>Bridge River Site (EeRl 4)</i>				
Beaver	3	2	60	40
Deer	17	5	1190	350
Salmon	934	11	3736	44
Percentage of Salmon	98	65	75	10
<i>Bell Site (EeRk 4:6)</i>				
Snowshoe Hare	3	1	4.5	1.5
Beaver	50	3	1000	60
Deer	78	4	5560	280
Sheep	12	2	840	140
Salmon	1566	14	6264	56
Percentage of Salmon	92	58	46	10

NOTE: Assumed average weights are 1.5kg (hare), 20kg (beaver), 70kg (deer and sheep), and 4kg (salmon).

The examination of human diet through stable isotope analysis should allow us to test some quantification methods in zooarchaeology. For interior sites, Chisholm (1986) and Lovell et al. (1986) report that late prehistoric human skeletons from the Lillooet area yield results which suggest that about 60% of protein was supplied by salmon. Langemann (1987) has analyzed the fauna from housepit sites in the same area. The two largest samples she discussed are from the Bridge River site (EeRl 4) and from housepit 6 in the Bell Site (EeRk 4). Data on number of bones (NISP) and minimum number of individuals (MNI) are presented in table 1. Two meat weights are then calculated for each species. The maximum meat weight assumes that each bone is all that remains of a single individual, and is calculated by multiplying NISP by a typical live weight for a modern animal. The minimum meat weight is calculated by multiplying the minimum number of individuals by the same live weight value. (Live weights do not, of course, represent the amount of usable meat, but they provide a rough estimate of relative importance based on the size of the animal.) Having calculated meat weights, one can then calculate the percentage represented by salmon. It can be seen that minimum meat weights

suggest about 10% salmon consumption for both sites, while maximum meat-weight values vary between 46% and 75% consumption of salmon. While it would be premature to conclude that NISP multiplied by meat weight is a useful measure of the dietary importance of a species, it is clearly the case that MNI multiplied by meat weight does not provide a means of estimating the relative importance of salmon in the diet.

A similar exercise could be performed on coastal sites, although very few sites in fact have MNI and NISP calculations reported for all classes of data. Based on Chisholm's work, we would expect coastal sites to demonstrate at least 85% reliance on marine resources. I have chosen a site just south of B.C. as a test of this proposition. Wigen and Stucki (1988) have reported in some detail on the Hoko River rockshelter. The largest faunal assemblage is from depositional period 5, within the Gulf of Georgia Phase. Calculating minimum and maximum meat-weight figures in the same way as described above, the figures would suggest an 85% reliance of marine foods if the calculation is based on NISP multiplied by meat weight, and about 75% reliance on marine foods based on MNI multiplied by meat weight. Even with this very large sample (and a very rapid and probably crude calculation) it appears that MNI values are further from the expected results than values calculated from NISP. This might be exacerbated on small assemblages, where MNI tends to overemphasize the importance of rarer species (Grayson 1984).

There appears to be general agreement that whatever method we use for quantification, we are unlikely to be able to calculate for a particular site either the actual or the relative importance to the diet of the various species present. The various factors which result in the formation of an assemblage of shells and bone are simply too diverse to allow us to translate bone assemblages into diet. However, we may be able to gain a broad understanding of diet (and some aspects of subsistence) through a less narrowly focused study which incorporates many assemblages from a larger region.

Regional studies in zooarchaeology are still much less common than site-based studies, but they are becoming increasingly prevalent as more individual site reports are accumulated (e.g., Driver 1985; Leonard 1989; Styles 1981). The main advantage of such studies is that they emphasize large-scale trends in faunal data. Provided that methods of quantification are consistent between sites, one can detect both temporal and spatial variation in assemblages which allow one to suggest the direction of change, if not its magnitude. In B.C. there have been relatively few regional studies, for two reasons. First, considering the size of the province, there are still

relatively few sites excavated, although a few regions have a long history of excavation. Second, the methods of data presentation have been quite varied over the years, making it difficult to integrate data from different excavation projects. Hanson (1991) described twenty-one Strait of Georgia sites from which faunal data were reported. Of these, only thirteen had data on fish bone, and only eight had frequency data, not always quantified in the same fashion. Mitchell (1988) has produced one of the most comprehensive regional faunal studies, for the Queen Charlotte Strait area, mainly because the analyses were undertaken using similar methods. Mitchell reported on two early faunal assemblages, dating 3000 to 500 BC (Obsidian Culture), and a larger sample of later assemblages, dating about AD 300 to the contact period (Queen Charlotte Strait Culture). Quantification was based on meat weights derived from MNI estimates, and demonstrated significant shifts in species use. For mammals, there was a change from deer to sea mammals, and for fish there was an increased use of salmon in the later period sites. The assemblages from Queen Charlotte Strait were then compared with assemblages from other areas. Problems were encountered when doing this, because methods of data reporting varied. However, Mitchell concluded that the Queen Charlotte Strait region demonstrated a shift in faunal utilization which was not documented elsewhere, and ascribed the shift to a change in the ethnic groups who occupied the region.

From the Interior, Kuijt (1989) summarized data for Middle and Late Prehistoric assemblages, and demonstrated that the shift to salmon seen in isotopic analyses of human skeletons was visible in the faunal assemblages. However Langemann's (1987) study of inter-site variability for the Late Prehistoric period did not detect patterned differences between pit-house sites, probably because most of the sites were from a fairly small area, where environmental and cultural differences would be minimal.

There remains a good potential for more detailed regional studies in British Columbia. Unfortunately, a lot of the earlier reported faunal data may be of limited value, because of the way in which data were reported or quantified, and also because certain classes of animals (notably fish and shellfish in coastal sites) were often not reported in detail. However, much of the data reported in the 1980s and 1990s will serve as a base on which regional studies can be built.

A final problem concerning quantification is the question of sample size. It is a general expectation of ecology that as one identifies more animals in an ecosystem one will find more species. The same is true for archaeological assemblages of artifacts or animal bones — the larger the sample the

greater the diversity. This means that comparison of samples of widely different sizes can result in erroneous assessments of species diversity. For example, Matson (1992: 405) has suggested that there is evidence at the Crescent Beach site for a decrease in species diversity from St. Mungo phase to Locarno Beach and Marpole phases. This is based on analysis of fish remains from the South Trench excavation area. However, sample size also decreases through time in this particular excavation unit, and all the assemblages with more than five hundred identified fish bones occur in St. Mungo and early Locarno Beach phase layers. If one considers the data from the North Trench excavation area (Matson 1992: Table 2) an opposite trend is seen: species diversity increases through time from the St. Mungo phase to the Locarno Beach phase. In this excavation area the largest assemblages are from the later layers, and this results in apparently greater diversity in Locarno Beach than in St. Mungo. Plotting assemblage size against number of taxa for all assemblages at the Crescent Beach site (figure 1) demonstrates the typical curvilinear relationship between taxonomic diversity and sample size (Fisher, Corbet and Williams 1943; Leonard 1989; Bobrowsky 1982). Thus, to investigate regional variation in faunal assemblages, diet, and subsistence it will be necessary to utilize assemblages which are large enough to include most of the exploited species.

Subsistence strategies

Subsistence encompasses the various behaviours whereby food is obtained. Zooarchaeologists employ a variety of techniques to analyze the bone or shells of commonly occurring species to determine what strategies were used by people to obtain the animals.

Season of death can be ascertained using a wide variety of methods (Monks 1981). These methods include analysis of incremental growth in certain areas of skeleton or shell. For example, shells grow throughout the life of a shellfish, and one can distinguish winter and summer growth, with the edge of the shell being the area of most recent growth. If this area is in summer growth, then the shellfish was collected at some time during the year when rapid growth was possible. It may also be possible to estimate what proportion of summer growth has occurred, and thus place the season of collection more accurately (Ham 1982). Similar methods can be applied to incremental growth in fish ear bones (otoliths), fish vertebrae, and mammal teeth. There are also some animals which experience temporary seasonal changes in other parts of their skeletons. For example, cervids grow and shed antler annually. Many female birds develop deposits of

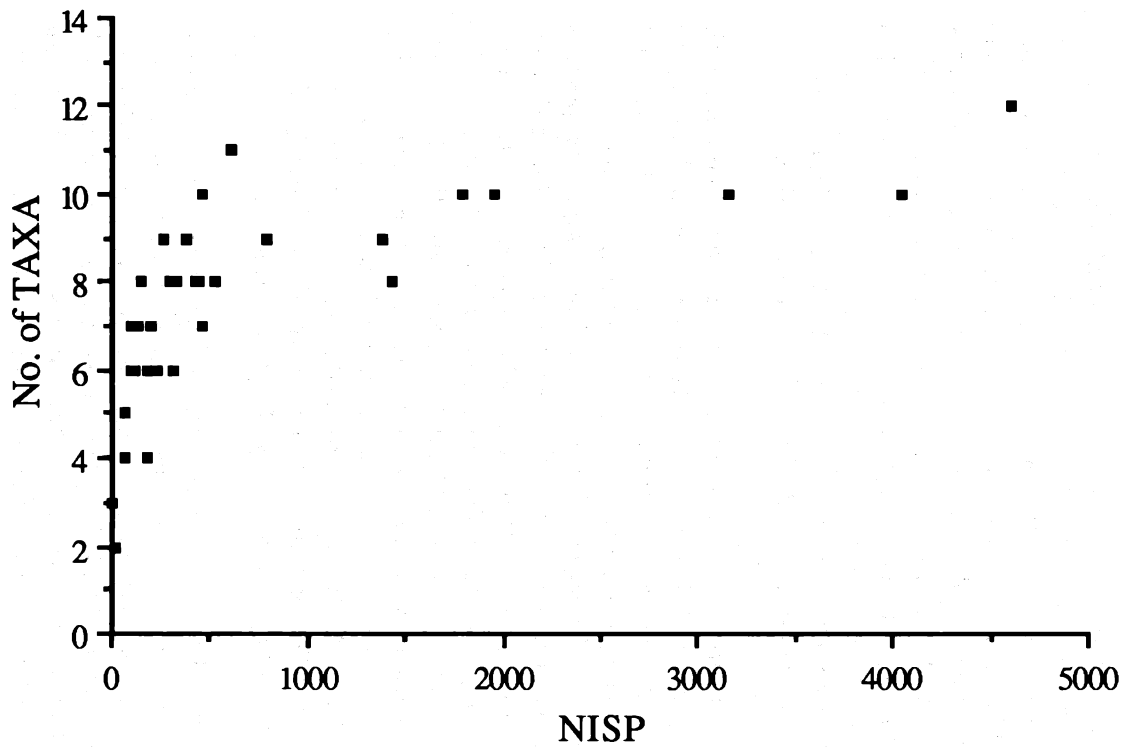


FIGURE 1

Relationship between assemblage size (NISP) and number of taxa for assemblages at Crescent Beach. (Data from Matson 1992: Tables 1 and 2)

calcium minerals inside their bones prior to egg laying. Less accurate methods for determining seasonality of death include studies of the developmental stages of tooth formation, eruption, and wear in some mammals. Also prone to inaccuracy are methods which rely on the presence/absence of certain species in archaeological assemblages. It is important to note that all methods of seasonality analysis only describe when the animal was killed. It is tempting to assume that this indicates the season at which a site was occupied. However, there are two problems with this assumption. First, animal foods can be stored and transported, so season of death does not necessarily indicate the full range of seasons at which the site was occupied (Monks 1981: 204). Second, seasonality analysis is often undertaken on a very limited range of species. While this may establish the season at which those species were taken, it does not necessarily indicate the season at which other species were taken. The value of future analyses will be enhanced by trying to study the season at death of as many species as possible.

There has been virtually no study of seasonality on interior sites, although it is commonly assumed that pit-house villages were occupied during the winter. There has been greater attention to this problem on the coast, and seasonality estimates, while not routine, are becoming a more common component of faunal analyses. For example, Ham (1982) proposed a February/March occupation for the Crescent Beach site, based on shellfish seasonality and the presence of herring (which spawn in early spring). Coupland (1991) reached similar conclusions for the Point Grey site. Ham (1984) used the fish assemblages to suggest occupation from May to June and August to September at the St. Mungo site. Eldridge (1987) proposed occupation from late winter to early fall at a site on Denman Island. Bernick and Wigen (1990) proposed a fall to early winter seasonality for a salmon-fishing station at the mouth of the Little Qualicum River. Cannon (1991) used a variety of data to suggest that Namu was a winter village site.

The whole question of prehistoric settlement patterns and the seasonal round on the coast remains a challenge to archaeologists. Ethnographic data suggest a complex settlement pattern, with some variation in different regions (Burley 1980; Mitchell 1983). However, the time-depth of this pattern is unknown (Matson 1992). Analysis of settlement patterns can potentially contribute to better understanding of prehistoric social and political organization. In order to investigate the time-depth of these patterns it is essential to have seasonality data for contemporaneously occupied sites, so as to be able to distinguish functionally and seasonally distinct

locations. Seasonality data are also essential for regional dietary studies of the type described above.

Population structure of exploited species can yield useful information about subsistence strategies (e.g., Klein and Cruz-Urbe 1984: 39-62). A living population can be described by two variables — age and sex distributions. These same variables can also be used to describe the hunted population of animals. Modern biological studies provide a model of the structure of living populations, so the population of dead animals can be used to examine the way in which people selected animals to hunt. For example, a hunter stalking and shooting individual deer can decide before making a kill whether to hunt a particular individual animal, and can therefore select animals for their age and sex. If hunters generally made similar decisions about which animals to hunt, this would be obvious in the archaeological assemblages. Conversely, a group of hunters engaged in a communal surround of deer would tend to trap and kill entire social units, thus resulting in a different population structure in the death assemblage.

Relatively few such population studies have been undertaken on faunal assemblages from sites in British Columbia. Most interior sites produce too small a sample to permit this. On coastal sites the most common bones are from fish, and there has been less attention paid to the implications of fish populations than land animal populations. This is probably because the sea is viewed as an inexhaustible repository of resources, upon which pre-historic people could have little effect. Nevertheless, it would be interesting at least to examine the population structure of some species, such as clams, to ascertain the effect of human exploitation.

Another relatively recent development in subsistence studies has been the concept of utility (Lyman 1992). This has mainly been applied to studies of large animals, where it can be assumed that different parts of the animal have different values for the hunter. The kill of a large animal allows hunters to decide which portions of the animal to transport away from the kill location to another site. Thus, decision-making could be reflected in the portions of a skeleton present at an archaeological site. Virtually no application of this concept has been made on archaeological assemblages from British Columbia, although utility indices have been developed for sea mammals (e.g., Lyman 1991; Lyman, Savelle and Whitridge 1992). Some of the commonly used data presentation methods in utility studies have been criticized recently (Ringrose 1993: 141-151), but the overall concept is likely to advance analysis of animal procurement economies.

Finally, we can consider the potential for zooarchaeological studies to

contribute to ecological modelling. Anthropologists have used various optimal foraging models derived from ecology to investigate human subsistence strategies (Foley 1985; Winterhalder and Smith 1981). Archaeologists have approached this topic in two ways. First, one can use ecological theory to develop models of optimal exploitation patterns, and then test the predictions of the models using archaeological data (e.g., Keene 1981). Alternatively, one can examine the faunal record from a site and use the data to analyze site exploitation territories or catchment areas (e.g., Roper 1979). Neither of these approaches has yet been used extensively in conjunction with faunal remains from sites in British Columbia. However, Croes and Hackenberger (1988) have attempted the first type of modelling for the Hoko River region in Washington, and the potential clearly exists for similar studies in British Columbia. Bernick (1983) has attempted a site catchment study for one site.

Monks (1987) has drawn attention to an interesting ecological phenomenon on the British Columbia coast. He argues that marine-oriented hunter-gatherers exploited food chains rather than single species. As an example, he uses the Deep Bay site where humans exploited the food chain associated with the herring-spawning season. Herring attracted a variety of predators, which in turn attracted other predators. Humans exploited the herring, but also harvested herring predators. This makes sense in terms of patch-use theory, which proposes that foragers will utilize a locale until the energy costs of remaining exceed the energy costs of finding and exploiting a new patch. Monks suggests that we should turn our attention to the use of food chains rather than individual species in order to understand the subsistence decisions made by people living on the British Columbia coast.

ZOARCHAEOLOGY AND SOCIAL ORGANIZATION

British Columbia was home to some of the most famous prehistoric and historic hunter-gatherers in the world. Much of the discussion about the development of social and political organization of coastal societies has revolved around resource use and resource control, yet zooarchaeological research has really not contributed a great deal to this discussion. The most obvious cause of this is the small number of well preserved faunal assemblages from sites older than about five thousand years. The Glenrose Cannery site on the Fraser River has demonstrated some changes in faunal use through time (Matson 1976), but there are no striking changes in the faunal remains. At Namu on the central coast, a maritime adapted economy is evident from as early as 7000 BP (Cannon 1991). If anything,

zooarchaeological studies are pushing the beginnings of the marine-oriented economy further and further back, and it is less easy to see the origins of northwest coast complex hunter-gatherer societies as caused by drastic changes in the marine environment and the associated fauna.

Matson (1992) has argued that the origins of the Northwest Coast "pattern" of ranked societies associated with permanent winter villages does not lie in the development of a maritime economy dependent on salmon, which was the basis of Fladmark's (1975) hypothesis. Instead, he proposes that it was the development of salmon storage which was critical. Stored salmon is indicated by a relatively low amount of cranial bones, because salmon was decapitated before being dried for storage. At the Crescent Beach site the frequency of salmon head bones declines after the St. Mungo phase, suggesting that salmon storage began in Locarno Beach times (c. 3500 BP) (Matson 1992: Figure 14). Clearly zooarchaeological data are critical to this analysis, and further studies along these lines are needed to see if the pattern is found in other sites and other regions.

However, it would be as well to remember Monks' caution against "salmonopia" — focussing archaeological attention on salmon exploitation to the exclusion of other species (Monks 1987: 119). Salmon is certainly common at many coastal sites, but not all faunal assemblages are dominated by salmon. Nor can one suggest that salmon storage alone was responsible for the development of the Northwest Coast ethnographic pattern of social organization. Salmon was caught, processed, and stored in large quantities along the interior rivers of British Columbia, yet population densities do not seem to have been as high as on the coast, nor was social organization as complex. The development of large-scale salmon fisheries and storage capacities per se cannot be linked to the evolution of complex social organization. It is possible that the difference between coastal and interior resource bases is that the former had an abundance of other reliable resources (shellfish, herring, flatfish) which significantly reduced the risk of reliance on a single staple. Conversely, although interior salmon runs were highly productive, there were fewer alternative resources to buffer years of low productivity. Detailed study of the more common species in coastal faunal assemblages might lead to better understanding of risk-reducing strategies.

In spite of claims that resources were controlled by high-status individuals or families in complex hunting and gathering societies (e.g., Hayden 1992), there has been little demonstration of this in British Columbia. This is probably because there has been little systematic effort to investigate intra-site variation in any class of data, let alone faunal remains. For ex-

ample, there has yet to be an excavation of a coastal site in the province which reveals the layout of well-defined prehistoric houses and collects the associated fauna, and it is therefore impossible to relate deposits of animal remains to sub-groups or households within a site. If resources were being controlled through social organization, we can only expect to find evidence for this in the differential distribution of faunal remains. On the coast this should include studies of a range of species, not just salmon. On the Northwest Coast as a whole, house excavations are relatively rare, but two recent excavations in Oregon and Washington show that it is possible to retrieve fauna from relatively complete houses. Chatters et al. (1990) demonstrated that significant spatial variation in faunal remains occur, but Ames et al. (1992) have shown how complex the internal deposits of houses are likely to be, and one must investigate site-formation processes in detail before using intra-site variation as evidence for differential access to resources. From the interior, one might expect different pit-houses to produce evidence of differential resource use, and there is some preliminary data to suggest this may be the case. Berry (1991) reports varying frequencies of different species of salmon in small and large pit-houses. There may also be differences in the relative consumption of deer, in the overall density of bones, and in the degree of storage (K. Kusmer and B. Hayden, personal communication 1993).

Crabtree (1990) has summarized examples of zooarchaeological contributions to social archaeology. Although most of her examples are of zooarchaeological analysis undertaken on state-level societies, there is no reason why the social organization of complex hunter-gatherer cultures could not be examined in the same way. For example, Romanoff (1988) has described in some detail the social importance of deer hunting among the Lillooet. Evidence for deer hunting in archaeological sites could be examined in the light of this study. One might want to know whether there was evidence for division of meat in particular ways, or whether some sites or houses within sites showed evidence for greater consumption of deer. On the coast there is the possibility that evidence for the potlatch might show up in detailed studies of shell middens. Both Ham (1982) and Hanson (1991) have tried to isolate individual depositional episodes in midden sites. One would expect the refuse resulting from potlatches to be quantitatively and qualitatively different from everyday refuse. Without trying these sorts of analyses we cannot explore the full potential of zooarchaeological interpretation. Until they are undertaken we cannot speculate on the possibility of successfully identifying social organization in British Columbia's archaeological sites.

CONCLUSIONS

In reviewing some of the faunal data from B.C., one is struck by the fact that so much of the general archaeological interpretation is based on the concept that access to, and control of, animal resources was a primary factor in shaping prehistoric cultures, yet few faunal analyses have approached the data from this perspective. Most zooarchaeological studies in B.C. have been oriented towards fairly descriptive accounts of species represented at a site. The quality of data reporting is now fairly high, both in published and unpublished analyses, and zooarchaeologists are aware of the need to recover column samples, especially from coastal sites. Data are now routinely collected and described using standards which allow regional syntheses of subsistence and diet. These types of studies are likely to be of far greater use in understanding prehistoric subsistence than individual site reports.

Future trends in British Columbia zooarchaeology are difficult to predict. However, it is to be hoped that zooarchaeologists will try to contribute more to the general theoretical questions raised by complex hunting and gathering societies in many areas of British Columbia. Topics for future research include: seasonality studies of different species on the same site; examination of the importance and reliability of non-salmon species in coastal sites; studies of access to resources; analysis of food storage; human impact on local animal populations.

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