CNOC COIG: THE SPATIAL ANALYSIS OF A LATE MESOLITHIC SHELL MIDDEN IN WESTERN SCOTLAND

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SUMMARY

This thesis concerns the spatial analysis of Cnoc Coig, a late Mesolithic shell midden located on the small island of Oronsay in the Inner Hebrides. Chapter 1 is a brief introduction outlining the general aims and expectations of the study. Chapter 2 is a review of the method and theory of spatial archaeology at the intra-site level, which places the present study in its broad theoretical and methodological context. Chapter 3 is a short introduction to Cnoc Coig and to the recent excavations at the site, while Chapter 4 describes in detail the data categories which form the basic units of analysis. Together, these two chapters provide the specific background information on the site and its contents. Chapter 5 outlines the procedures used to establish the data base and describes the methods of analysis employed in this study.

Chapters 6 to 10 contain the results of the spatial analyses for various categories of material: mammal and bird bones (Chapters 6 and 7); limpet scoops and related beach pebble artifacts (Chapter 8); pitted pebbles and shells (Chapter 9); and unworked antler, antler and bone tools, and items of decoration (Chapter 10). Therefore, these chapters form the substantive core of the study. Chapter 11 is a summary of the results presented in the preceding five chapters, with some additional concluding comments relating the observed site structure to the dynamics of prehistoric behaviour and to the nature of the settlements which are represented at Cnoc Coig.

Finally, two appendices are also included. The first of these is a detailed historical review of the many arguments put forward regarding the function of limpet scoops. The second appendix presents the results of some experimental work regarding various problems relating to beach pebble artifacts. The two appendices constitute an elaboration of points raised within the main body of the thesis, and cross-references are made at several junctures to the discussions in these appendices.

LIST OF ABBREVIATIONS

A.L.S.	antler limpet scoop
A./B.L.S.	indeterminate antler/bone limpet scoop
B.L.S.	bone limpet scoop
C.N.G. I	Caisteal nan Gillean, site I
C.N.G. II	Caisteal nan Gillean, site II
M.N.I.	minimum number of individuals
M.N.D.E.	minimum number of depositional episodes
P.S.L.S.	potential stone limpet scoop
P.S.L.S./H.	potential stone limpet scoop/hammer
S.L.H.	stone limpet hammer
S.L.S.	stone limpet scoop
U.S.L.S.	unused stone limpet scoop

CHAPTER 1

INTRODUCTION

With attempts to develop more rigorous theory and to apply more sophisticated (especially quantitative) techniques, spatial analysis has become an important area of research in archaeology during the past two decades. Within this broad area of inquiry, a major focus of concern has been the study of site structure (i.e. the distribution of artifacts, fauna and features within particular sites) with a concomitant effort to interpret in behavioural terms observed patterns in site structure. The present study falls within this general area of concern within spatial archaeology. Specifically, it involves the spatial analysis of Cnoc Coig, a late Mesolithic ("Obanian") shell midden located on the small island of Oronsay in the Inner Hebrides of western Scotland.

Why Cnoc Coig?

The island of Oronsay contains five such Obanian shell middens, all of which were investigated as part of a long-term research project which was initiated and directed by Dr. Paul Mellars (see Mellars 1978; 1985; Mellars & Payne 1971; Peacock 1978). While all of the sites were excavated in order to record details of stratigraphy and to collect a wide range of sample for various analyses, a second major research objective was the excavation of large areas of one of the shell middens in order to examine the overall stratigraphy and the extent of lateral variability in the contents of the midden and to search for traces of structural features (Mellars 1978: 373; Mellars & Payne 1971: 398). Two of the sites -- Caisteal nan Gillean I and Cnoc Sligeach -- had been extensively excavated during the late 19th and early 20th centuries (see Chapter 3, pp. 62-64), so that work on these sites was necessarily limited to the small-scale excavation of test trenches. The site of Caisteal nan Gillean II is overlain in many places by thick deposits of wind-blown sand which would have made excavation difficult and costly in terms of time and manpower resources (Peacock 1978: 180). In contrast, the low dome-shaped mound of Cnoc Coig presented fewer practical problems for excavation and, at least at the commencement of the recent research project on Oronsay, it appeared as though Cnoc Coig had escaped the attention of previous archaeologists who had carried out field work on the island so that its deposits had remained largely undisturbed (but cf. Mellars 1981; also pp. 62-64 below). The existence of the fifth site, the Priory Midden, was not known until the 1975 field season, midway through the course of field work on the island.

Therefore, during the 1973 field season when a site was chosen for large-scale areal excavation, Cnoc Coig seemed to be the best candidate for pursuing this second major research objective. Four seasons of excavation, beginning in 1973 and ending in 1979, resulted in a large body of data which were suitable for a detailed spatial analysis of the distribution of materials within the Cnoc Coig shell midden. The present study, therefore, was undertaken to fulfil one of the long-term objectives of the recent research project on Oronsay.

Aims and Expectations

What then might be expected to come from the spatial analysis of a shell midden? The first and most basic aim of this research was essentially empirical. That is, this basic aim was simply to determine how much patterning could be observed in the distributions of various materials within the site. Unlike many shell middens found elsewhere in the world, due to the relatively small size of Obanian middens, it was feasible at Cnoc Coig to conduct large-scale areal excavations and to record the precise three-dimensional locations for a wide variety of objects. While presumably few (if any) archaeologists today would argue that shell middens are merely random accumulations of discarded refuse in which there are little or no structured sets of spatial interrelationships, Cnoc Coig presents us with a rare opportunity actually to demonstrate the nature and extent of patterning exhibited by the distributions of various categories of materials within a shell midden. At the very minimum then, it is certainly reasonable to expect that objects will generally not be distributed throughout the midden in an apparently random fashion, but rather that much patterning will be evident in the data.

Of course, intra-site spatial analysis would normally entail a rather more ambitious aim than this. In the study of Palaeolithic and Mesolithic "occupation surfaces" or "living floors", previous spatial analyses have dealt either with single component sites or with particular layers in multi-component sites where the materials within the site or layer are demonstrated, or at least are assumed (see Villa 1982; Villa & Courtin 1983), to be contemporaneous. In other words, the perception has been that these are archaeological entities which have high degrees of what Binford (1981a: 19) has called "resolution" and "integrity", although there are reasons for thinking that in some cases at least this perception is erroneous (e.g. see Binford 1977a; 1981a; 1983: 60-75). In any event, following from this perception, some very elaborate behavioural interpretations have been proposed and some very imaginative reconstructions of living structures have even been presented (e.g. Klein 1973; 1974; Leroi-Gourhan & Brézillon 1966; Lumley 1969a; 1969b; 1969c), although some of them may indeed be considered suspect in light of the results of some recent ethnoarchaeological research (e.g. see Binford 1983: 128-129, 147, 158-159).

However, shell middens are different from other kinds of ancient hunter-gatherer sites in that they are multi-component sites in which discrete occupational layers can not be defined. There can be little doubt, therefore, that an Obanian shell midden such as Cnoc Coig is a stratigraphically complex palimpsest of deposits which represents an unknown number of occupational episodes, each of which will have resulted in numerous depositional events in various areas of the midden. In short, the degree of resolution of such sites intrinsically is low. Thus, in contrast to what is assumed with most single site spatial analyses, one clearly can not assume the contemporaneity of materials even within relatively small areas of the site, let alone across larger portions of the midden. Hence, the kinds of spatial relationships which are the basis of the more spectacular reconstructions referred to above cannot be established at a site such as Cnoc Coig.

Mellars (1978: 389) has noted that the midden is generally composed of two kinds of deposits: namely, "shell heap" areas which would appear to have been mainly used for dumping shells and other refuse, and "occupation surfaces" where less shell was discarded and where presumably a greater range of activities was conducted. Thus, it would be expected that the areas which seem to have been used repeatedly as occupation surfaces would not have sufficient deposits of shells or soil to separate stratigraphically the different occupational events and hence, that they are palimpsests of materials from several overlapping occupations. However, since Mellars also notes that the relative positions of these two types of deposit would seem to have fluctuated to some extent during the occupation of the site, could we reasonably expect that discrete occupational surfaces are preserved within the midden in at least a few instances where these occurred in areas that were normally used as shell dumping localities? Of course, this would not involve following the entire utilized space of one occupation across the midden but rather, it would involve delimiting the central (hearth-centred?) high-use area of the occupation.

However, even this less ambitious reconstructionist goal is likely to prove elusive. It is indeed possible in two or three instances to locate a hearth (or hearths) which occurs in an area that otherwise appears to have been used as a dumping locality, and we could plot the locations of all items which occur around the hearth at the appropriate depths such that they might be stratigraphically contemporaneous with it. Such a procedure would thereby yield a "spatial unit of analysis", and the patterns of distribution of the items in this unit could be examined with a view to isolating meaningful groupings and associations which might indicate something about the nature and structure of activities which were carried out around the hearth.

Such a procedure might sound appealing but it is in fact fraught with difficulties. The biggest problem concerns delimiting the arbitrary (vertical and horizontal) boundaries around the hearth in order to define the spatial unit of analysis in terms of which items are to be included and which are to be excluded. Regarding the vertical boundary, it is indeed possible to determine if objects and features are stratigraphically related such that they might be depositionally contemporaneous. This is not always easy however, and of course, just because items might be depositionally contemporaneous on stratigraphical grounds, it does not follow that they must have been used and deposited during the same occupational episode. Indeed, the assemblage of items comprising such a spatial unit of analysis would almost certainly not be referrable to a single occupation, and it is likely that some spurious patterns and associations would result from this procedure. This problem is compounded greatly when the horizontal limits are defined. Where does one draw such a boundary -- at 1 m, 2 m, 3 m or 4 m? In fact, there are no firm criteria which one can employ in order to determine what is an appropriate radius around the hearth in such a circumstance. Moreover, as the defined area increases, the depositional contemporaneity amongst all the items becomes increasingly less likely and any possible associations become increasingly more tenuous. Such a procedure, therefore, would be so subjective and involve so many arbitrary decisions that the results obtained would be at best highly suspect and at worst totally misleading and unreliable.

But even if all these objections were ignored, such an exercise could only be conducted in two or three cases at most, and the number of finds which would be included in the analysis would represent only a small proportion of the total site inventory. Given this, could the results obtained from such an analysis be taken as being representative of the site as a whole? Would the inferred nature and structure of activities relating to these hearths be characteristic of the pattern of space utilization for all of the midden? At the very least, the answer would have to be: not necessarily. In summary therefore, the expectation that one could isolate depositionally discrete (i.e. with a high degree of resolution) and behaviourally meaningful spatial units of analysis within the midden must be rejected as being hopelessly optimistic, given the palimpsest nature of the midden deposit.

What then is left if some form of a reconstructionist goal is not a realistic expectation? As stated above, it is reasonable to expect that some patterning will be evident in the distribution of materials within the midden. More specifically, we can anticipate that certain object categories will reveal clustered distributions, while others will be more dispersed. In the case of clustered distributions, it should be possible to identify discrete discard episodes in many instances, because the depositing of large quantities of shells should have helped to separate stratigraphically different discard events in highly localized areas. It is also possible to relate distributions to the locations of hearths in the site. By using these two main attributes of the distributions -- namely, the relative tendencies towards clustering or dispersion and the relative degrees to which materials are spatially associated with hearths -- the major aim of this study will be to refer the different categories of objects to different "modes of disposal" (Binford 1978a: 344-348). For example, items (especially small ones) found in clusters around hearths may be seen to indicate dropped refuse, whereas clusters found away from hearths may be seen to represent dumped items. In the case of artifacts, given our understanding of Obanian technology and the likely functions of many types of objects, many of the observed patterns may well make perfect sense in terms of what we would expect regarding the use and discard of the artifacts concerned. Indeed, this understanding will be used as a basis for predicting certain aspects of the nature of the distributions of most artifact categories within the midden, which will then be compared to the observed patterns of distribution. In the case of faunal assemblages, aside from identifying disposal modes, another major aim will be to define for each species or major taxon groupings of spatially associated bones which would appear to be depositionally meaningful subunits of the total assemblages; and these subassemblages might then be useful feedback to the faunal analysts for the analysis of butchery patterns at a subsequent stage of the Oronsay research project.

Thus, even though these aims and objectives are less spectacular than the reconstructionist aim which is usually associated with single site spatial analysis, it should be possible to gain some understanding of the cultural formation processes operative at the site and, to some extent at least, of the manner in which space was utilized, even if only in rather broad and very basic terms. In other words, the study of distribution patterns within the midden should enable us to acquire some understanding of the prehistoric behaviour which produced the patterns observed in the archaeological record. Hence, some behavioural information should be forthcoming from a spatial analysis of the Cnoc Coig shell midden, and we need not lament the fact that sites with a low degree of resolution, such as Cnoc Coig, are likely to frustrate the attainment of a reconstructionist goal.

The Importance of the Obanian

Given that five of the eight known Obanian sites in southwestern Scotland had been extensively excavated previously, two of which had even been entirely destroyed, Cnoc Coig was one of the few such sites left relatively intact at the commencement of the recent research project on Oronsay. In light of the general uniformity of Obanian sites in terms of their artifactual and faunal assemblage composition, the detailed investigation of one site could well be vital for obtaining a more complete understanding of the Obanian as a whole, particularly an understanding of what the Obanian middens on Oronsay represent in terms of a functioning subsistence-settlement system and concomitantly how these middens might relate to other (non-Obanian) sites in adjacent areas of southwestern Scotland. Hopefully, the detailed spatial analysis of Cnoc Coig might eventually contribute to this understanding, even though this is not a specific aim of the present study. Thus, for the Obanian as a whole, the potential importance of studying in detail a single site such as Cnoc Coig is obvious enough.

But what might be the wider relevance of studying a single site and a particular archaeological "culture" such as Cnoc Coig and the Obanian? In fact, the detailed investigation of these shell middens is potentially relevant from a number of perspectives. First, the Obanian is relevant to the British Mesolithic as a whole from a comparative point of view. For example, from a biological perspective, the assemblages of red deer and human bones recovered from the recent excavations at Cnoc Coig and the other Oronsay middens have provided invaluable comparative data for the analysis of red deer and human populations during the Mesolithic period in Britain and Europe as a whole (see Grigson 1985; Meiklejohn & Denston 1985); and the spatial analysis of these bone assemblages in Cnoc Coig as described in the present study contributes further information that is pertinent to some of these comparative questions. Archaeologically, as Mellars and Payne (1971: 397) have pointed out, these Obanian shell middens are of general importance if only because they contain an impressive abundance of evidence (particularly faunal remains) relating directly to the economic activities of Mesolithic human groups; and this evidence is all the more impressive and important given that very few Mesolithic sites in Britain contain any direct evidence relating to subsistence and economy.

Likewise but more specifically, our knowledge of the exploitation of coastal resources during the British Mesolithic is sketchy at best, and Obanian shell middens provide us with the most detailed information on this aspect of the Mesolithic economy in Britain. Of course, it could be argued that the Obanian is an aberrant adaptation by human groups on the geographical periphery and at the temporal end of the British Mesolithic and that, therefore, it is not representative of, nor particularly relevant to, mainland Britain where a terrestrial economy prevailed and where the Mesolithic is documented by more numerous and more typical sites containing microlithic assemblages. This view of the Mesolithic economy as being typically terrestrial and only atypically coastal may in part be biased by the fact that the Mesolithic coastlines of Britain (particularly on the eastern and southern coasts) are now submerged as a result of the eustatic rise in sea level during the postglacial period, so that evidence for a coastal component to the economy is not preserved. However, as Mellars (1978: 393-394) has noted, this same argument cannot be applied to the western and northern coasts of Britain where the Mesolithic coastlines have been preserved due to the delayed effects of isostatic rebound and yet where shell middens or other evidence for coastal exploitation are sparse. While the absence of such evidence from the western and northern coasts of Britain may in part be due to destruction by post-Mesolithic human activity, it remains difficult to argue that coastal resources played a significant role in Mesolithic economies in general. Nevertheless, regardless of how specialized and atypical an adaptation the Obanian may be, and regardless of the role played by coastal resources in Mesolithic economies overall, it is scarcely tenable to argue that a complete understanding of subsistence-settlement systems in Mesolithic Britain can be obtained by simply concentrating on the typical sites and ignoring the atypical ones. Indeed, as Mellars (1978: 393-395) has briefly discussed, these Obanian shell middens raise some intriguing questions regarding the relationships between the people who occupied them and those who generated the more typical microlithic assemblages found at other sites in western Scotland. Moreover, the importance of Obanian shell middens and other "atypical" sites for the British Mesolithic specifically or the European Mesolithic in general is that they raise questions and present problems which not only complicate the overall picture of hunter-gatherer adaptations during the Mesolithic, but also they provide a challenge to our understanding of the organization and long-term development of the subsistence-settlement systems of prehistoric hunter-gatherers in general.

This latter comment leads to the wider issue of how research into a particular archaeological "culture" like the Obanian might potentially contribute to the study of hunter-gatherer subsistence and economy. As is widely appreciated, the ethnographic and ethnoarchaeological record of hunter-gatherers is often sketchy and dominated by particularistic researches; and, as Yesner (1980: 727) for example has pointed out, it largely derives from extant hunter-gatherers living in "marginal" environments, such as the Desert Aborigines of Australia or the San of southern Africa. Moreover, despite some detailed studies (e.g. Meehan 1982), the ethnographic and ethnoarchaeological record of coastal hunter-gatherers is particularly rather poor. Thus, regardless of its limitations, archaeological research offers the only chance for acquiring further knowledge of the adaptations of coastal hunter-gatherers in most areas of the world; and furthermore, as Yesner (1980: 728) has emphasized, archaeological data are mandatory for addressing certain questions which demand a time depth greater than that which is available from ethnographic data. Of course, the importance of studying particular kinds of human societies such as coastal hunter-gatherers relates to anthropological understanding at the broadest level. As Yesner has stated, "...the study of prehistoric maritime adaptations has a great potential for contributing to our understanding of the general process of cultural evolution" (Yesner 1982: 228). From this broad comparative perspective, the study of the Mesolithic Obanian from western Scotland is potentially of considerable anthropological relevance.

Obviously, the present study in itself can make no pretension to contributing directly to our understanding of such broad anthropological issues as the nature of hunter-gatherer adaptations or the long-term processes of cultural evolution. Even in the much more limited field of research into the internal organization of activity space in hunter-gatherer camp sites, the spatial analysis of one archaeological site can scarcely be expected to yield results which are of broad anthropological significance, since the analysis of a single archaeological site is by definition largely particularistic. Nevertheless, researches like the present study can be of more general relevance by providing a testing ground for new analytical concepts to determine their efficacy and utility. In the present case, recent middle-range research has begun to provide a theoretical basis for the study of the site structure of hunter-gatherer settlements; and in this context, as will be discussed more thoroughly in Chapter 2, Binford's work (especially 1978a; 1983: 144-192) is particularly noteworthy. Central to much of Binford's discussions on this topic is the concept of "modes of disposal" (1978a: 344-348, Table 5). As was mentioned above (p. 6), an attempt will be made in the present study to refer the various categories of material to different disposal modes -- and as a result of this exercise, some general comments on the archaeological utility of this concept will be made in Chapter 11.

As with any specific archaeological study, another point of potential relevance of research into the Obanian in general and the spatial analysis of Cnoc Coig in particular concerns the development or testing of techniques. The intensive investigation of the Obanian sites on Oronsay has involved a wide array of specialist studies; and from the point of view of techniques, whether these are new methods of analysis or applications of existing ones, all of these specialized studies could potentially be of wide relevance to the study of shell middens and other kinds of archaeological sites elsewhere in the world. For example, reference could be made to the varied palaeoenvironmental analyses (the results of which are mainly presented in Mellars 1985), or to Peacock's (1978) probabilistic sampling strategy employed at Cnoc Coig, or to the use of fish otoliths as indicators of seasonality (Mellars & Wilkinson 1980; Wilkinson 1981).

Similarly, methods of analysis employed in the present study could be widely applicable in archaeology. For example, even though they have not been widely used in archaeology, sectional or "lane" plots (which are described in Chapter 5, pp. 196 ff.) were found to be of great utility in the present study; and indeed, they are often the clearest way to examine and display spatial relationships within the midden. Of course, their usefulness is primarily for examining distributions in terms of the depth dimension, but shell middens like Cnoc Coig are not the only archaeological sites for which examining spatial distributions in terms of depth is of interest. A second example is Pielou's (1961: 258-259; 1969: 182-183) coefficient of segregation which was employed in the present study and found to be very useful for answering a specific question regarding the spatial interrelationships of some artifact types. This statistical technique has been used previously in archaeological spatial analysis, though not always properly (see Chapter 2, pp. 55-58). However, for its use in this study, Dr. N. R. J. Fieller has extended this statistical measure to deal with three-dimensional distributions, which of course increases its general archaeological utility, and he has developed a statistically more sound method of assessing the significance of the statistical results of this test (see Chapter 5, pp. 205-210; also Fieller et al. 1983). These new developments on an old technique are relevant to all archaeologists who may wish to employ this method in the spatial analyses of their sites, whether they are shell middens or any other kind of archaeological site.

Finally, there is another point of interest which the intensive investigation of Cnoc Coig offers to shell midden analysis in general. Due to the large size of many shell middens around the world and/or to limitations of time and manpower resources, most shell middens are investigated by relatively small-scale sampling rather than by extensive excavation. A point of obvious concern is just how representative of the total midden contents such sampling really is. It is this very concern which underlies Peacock's (1978) research at Cnoc Coig. As Peacock (1978: 180) has pointed out, some researchers in the past have assumed that shell middens are relatively homogeneous at least with respect to the more common elements. However, the spatial analysis of Cnoc Coig presented here and the large-scale areal excavations of the midden upon which they are based amply testify to the fact that this assumption may often be false. As will be seen in Chapters 6 and 7, the distributions of some of the mammal and bird bones in Cnoc Coig are so highly localized that small-scale sampling of the midden could seriously under-represent (or perhaps miss entirely) even the most abundant species such as seal or great auk. By comparing the estimates of the midden contents based on Peacock's (1978) probabilistic sampling strategy with estimates based on the areal excavation of most of the midden, it will be possible to assess just how successful Peacock's sampling strategy was in terms of obtaining truly representative samples. Such a comparison is well beyond the scope of the present study and will be presented at a later stage of the Oronsay project, but some of the results presented herein should contribute to this comparison which is of obvious general interest for shell midden analysis.

The preceding comments should be sufficient to indicate that the study of a single site like Cnoc Coig and a particular archaeological "culture" such as the Obanian are of potential wider relevance from a number of perspectives -- for the British Mesolithic as a whole, for the study of both hunter-gatherer (especially coastal) adaptations and the site structure of hunter-gatherer settlements, and for the development of analytical concepts and techniques. As one part of the recent research project on the Obanian shell middens of Oronsay, the present study will hopefully yield results which, along with other facets of the project, will not simply be an exercise in archaeological particularism and parochialism but will be of some relevance to the wider archaeological community.

CHAPTER 2

A REVIEW OF THE METHOD AND THEORY OF SPATIAL ANALYSIS IN ARCHAEOLOGY

Introduction

Over the past few years, spatial analysis has increasingly occupied the attention of archaeologists, and the development of quantitative techniques in particular has been a major concern in the archaeological literature. Such quantitative approaches to spatial analysis in archaeology are however a comparatively recent development, having not emerged until the early 1970s (e.g. Dacey 1973a; Hodder 1971; 1972: 891-892; Hodder & Hassall 1971: 393-396; Newcomb 1970; 1971; Peebles 1971: 75-78; Whallon 1973a; 1973b; 1974a). *Of course, spatial analysis in archaeology,* or spatial archaeology (Clarke 1977), has a much longer history than this. As has often been observed, prior to the introduction of quantitative techniques, archaeologists studied spatial distributions by the intuitive approach of the visual inspection and interpretation of plots or maps which show the distribution of points in two-dimensional space, whether these were plots of intra-site distributions or, more commonly, areal distribution maps.

Spatial analysis in archaeology is of course a broad term covering a wide area of inquiry. Clarke (1977: 11-15) has defined three "levels of resolution of spatial archaeology" -- namely, the micro level (within-structure systems), the semi-micro level (within-site systems), and the macro level (between-site systems). Not surprisingly, each of these levels of resolution has had a somewhat distinct trajectory in the historical development of archaeology. Largely as a result of connections with geography and anthropology, it is at the macro level where spatial archaeology has its greatest time depth -- for example, the study of archaeological distribution maps in Europe, and settlement pattern studies in the Americas (Clarke 1977: 2-3). At the semi-micro and micro levels, spatial analysis in archaeology is a more recent development on the whole but nevertheless, spatial archaeology at these levels preceded the introduction of quantitative techniques in the early 1970s by a considerable number of years. As Clarke (1977: 11) has observed, it must be appreciated that these three levels of resolution are arbitrary distinctions defined along a continuum of spatial relationships. Nonetheless, with this borne in mind, and also bearing in mind the fact that many quantitative techniques of spatial analysis can be applied to any of these levels of resolution, the main interest here lies at the semi-micro and micro levels. Hence, the discussion which follows will focus attention mainly on the spatial analysis of intra-site distributions; for reviews of spatial analysis at the macro level, see Hodder and Orton (1976) and Hodder (1977).

Palaeolithic Research:
The Study of Occupation Floors

It has already been stated that before the introduction of quantitative techniques archaeologists dealt with spatial distributions by the intuitive approach of visually inspecting plots of point patterns. At the semi-micro level, there are several, now "classic", such studies of Palaeolithic occupation floors -- perhaps the most notable examples are the French sites of Pincevent (Leroi-Gourhan & Brézillon 1966; 1972) and Lazaret (Lumley 1969a; 1969b). Indeed, the increased interest during recent years in the spatial analysis of occupation surfaces has been stimulated to a large extent by research at Palaeolithic sites such as these. Yet, in the case of intra-site distributions, even this traditional "eyeballing" approach is comparatively new, dating to the period following the Second World War. During this time, Palaeolithic archaeologists in particular were becoming increasingly interested in the concept of "living floors".

After World War II, particularly archaeologists who were working in East Africa were increasingly referring to apparently undisturbed open-air sites as "living- or camping-floors" (e.g. Clark 1954a; 1954b; 1958; et seqq.; Leakey 1946; 1952; 1957; et seqq.; Posnansky 1959). This search for living floors was apparently stimulated by Mary Leakey whose background lead her to be interested in investigating sites as loci of settlement rather than merely as collections of artifacts (Binford 1981a: 13-14). Other archaeologists were slow in grasping the important behavioural implications of this concept, with the consequence that such living floors were viewed as being primarily useful as analytic units for assemblage definition (e.g. Clark 1959: 208; 1964: 95-96; Leakey 1957: 217-218; 1960: 1051; Posnansky 1959: 83). Nevertheless, while it is undoubtedly true that much of the research in the African Lower Palaeolithic at this time was still typologically oriented, it is clear that as time progressed it was increasingly recognized that these occurrences represented, in some behavioural sense, former living places of early hominids; and consequently, it was increasingly appreciated that the contextual-spatial information contained in these sites was as valuable a data set as were the assemblages of stone tools and faunal remains.

Concomitant with the development of this concept of living floors was the establishment of new excavation techniques, pioneered particularly by J. Desmond Clark at Kalambo Falls (Clark 1954a; 1954b; 1962; 1964; 1969; 1974; Clark & Bakker 1964). It soon became common practice to adopt areal excavation, to record meticulously the locations of various classes of material, and to plot the distributions of these materials on the occupation surfaces. Aside from Kalambo Falls itself, well-known examples include sites such as Olorgesailie (Leakey 1946; 1952; Posnansky 1959; Isaac 1966; 1977), Olduvai Gorge (Leakey 1954; 1957; 1958; 1959; 1960; M. Leakey 1967; 1971; 1975; Clark 1961), and Isimila (Howell 1961; Howell et al. 1962).

After about a decade of research at such sites, in their review of the African Acheulian, Howell and Clark stated that:

> In order to learn about the livelihood patterns of early hunter-gatherers, like the peoples of the Acheulian, it is essential to locate and investigate their occupation sites. The occurrence of stone artifacts in stratified geological contexts communicates essentially *nothing about the behavior* of extinct human populations. In Africa, and especially eastern Africa, occupation places have been preserved, and their careful excavation has provided some interesting information on life in the time range of the Acheulian industry (Howell & Clark 1963: 512; emphasis added).

Following on from this, Howell and Clark (1963: 522) then proceeded to pose a whole series of specific questions regarding the behaviour of early human populations. Thus, by the early 1960s, the behavioural implications of living floors were well recognized and Palaeolithic archaeologists were asking a much broader range of questions than ever before. And it was not very long before these new developments had been carried over into the Palaeolithic archaeology of the Middle East and Europe, often directly by the same researchers who had pioneered such developments in Africa. Examples include sites such as Latamne in Syria (Clark 1966a; 1966b; 1966c), Torralba in Spain (Howell 1966: 111-140; Freeman & Butzer 1966), and Pincevent (Leroi-Gourhan & Brézillon 1966; 1972), Lazaret (Lumley 1969a; 1969b) and Terra Amata (Lumley 1966; 1969c) in France. Parenthetically, it is worth pointing out that, also during this post-World War II period, similar developments were taking place in the Palaeolithic archaeology of the Soviet Union, particularly in the Ukraine and adjacent areas of Russia where open-air sites are abundant. This work by Soviet archaeologists was, however, not generally well known in the English-speaking archaeological community until brought to their attention through the writings of Richard Klein (1965; 1967; 1969a; 1969b; 1973; 1974), and it represents an essentially independent, though parallel, line of development within Palaeolithic archaeology.

These new directions in Palaeolithic research, in combination with a growing interest in human-environmental relationships, were little short of a contextual and spatial "revolution". This was perhaps a natural development within Palaeolithic archaeology as researchers turned their attention to Pleistocene sites, particularly in East Africa, where seemingly undisturbed occupation floors were abundant and provocative. This statement, and indeed the whole of the preceding discussion, is not negated by Binford's (1977a; 1981a: 6-20, 249-287; 1983: 60-76) recent criticisms that not only have some of these early hominid sites undergone disturbance by natural agencies but also, and even more importantly, that many of them are <u>not</u> living floors in the full behavioural sense of being former home bases which archaeologically have a high degree of both integrity and resolution. The preceding discussion remains valid despite these criticisms because what is important here is that these sites were <u>perceived</u> by Palaeolithic archaeologists as being living floors and that this perception affected their excavation techniques and lead to the adoption of the traditional "eyeballing" method of spatial analysis.

Theoretical Developments

Binford and The New Archaeology

These developments in Palaeolithic archaeology were essentially empirical and methodological contributions to the spatial analysis of occupation floors, but theoretical developments were also necessary. The theoretical foundations for spatial archaeology at the intra-site level lie with the rise of the "New Archaeology" during the 1960s, spearheaded by the writings of Lewis Binford.

As Binford (1968a: 12-14) observed, it was not sufficient in itself, important though this was, merely to increase the range and reliability of archaeological data:

> Facts do not speak for themselves, and even if we had complete living floors from the beginning of the Pleistocene through the rise of urban centers, such

> data would tell us nothing about cultural process or past lifeways unless we asked the appropriate questions (Binford 1968a: 13).

To ask the appropriate questions, Binford and others argued that it was necessary to develop a new theoretical perspective. The role of ethnographic analogy was crucial to the development of this new perspective (see Binford 1967a; 1967b; 1968a: 12-14; 1968b; S. Binford 1968; Freeman 1968). New archaeologists severely criticized the traditional role of ethnographic analogy in archaeological reasoning and the accompanying attitude that our potential understanding of the past is limited by our knowledge of the ethnographic present. Rather, it was claimed that "...the limits on our generalizations are set only by the analytical techniques available, not by our substantive knowledge of the present" (Binford 1967b: 235).

In conjunction with this view, there was a new optimism about the potentialities of the archaeological record: "There has been as yet no attempt to assess the limitations of the archeological record for yielding different kinds of information" (Binford 1968a: 22). Indeed, the claim was made that "The formal structure of artifact assemblages together with the between element contextual relationships should and do present a systematic and understandable picture of <u>the total extinct</u> cultural system" (Binford 1962: 218; emphasis in original), an assertion which Binford repeatedly made (see also 1964: 425; 1968a: 22) and which was echoed by others (e.g. Hill 1966: 9; 1970: 15; Longacre 1968: 91; 1970: 2; Struever 1968a: 286-287; 1968b: 134-135). While such optimistic statements may in retrospect seem rather naive and simplistic, it is important to appreciate the intellectual context within which they occurred -- given the then prevailing pessimistic view of the archaeological record, it was necessary to counter this established attitude with one which would encourage archaeologists to explore the potentialities of the archaeological record and thereby assess more fully its limitations.

The adoption of this more optimistic view and new perspective led new archaeologists to ask a wider range of questions from their data and concomitantly to collect and analyse a broader range of data. This broadening of the horizons of the discipline included spatial archaeology at the intra-site level. In order to deal with this comparatively new area of interest, a number of terms and concepts were defined: locus, activity, activity set, activity area and toolkit (see Binford 1964: 432; 1983: 147-148; Struever 1968a: 285-287; 1968b: 135). By definition, loci and activity areas have "...a spatial dimension, since activities tend to be localized and to a degree spatially segregated within the area of a community" (Struever 1968b: 135). This recognition that activities within settlements involve a spatial component, and thus that archaeological sites may be expected to contain structured sets of spatial interrelationships, contrasted with the traditional view that sites are undifferentiated collections of artifacts, features and other material, a view which led archaeologists to assume that the excavation of one area of a site, or a few small holes indiscriminately scattered around it, would yield a representative sample sufficient to characterize the site as a whole. This traditional view was justifiably attacked, and the use of more rigorous sampling strategies was advised (Binford 1964; 1968c; Rootenberg 1964; Struever 1968b: 141-145; 1971) and was put into practice in a number of cases where complete excavation of the site was not possible, as for example at Broken K Pueblo (Hill 1966: 9; 1968: 104; 1970: 16-17).

However, whereas archaeologists traditionally too often assumed that sites were unstructured loci of activities, the realization that there is structure to human activities within settlements, and hence that there is a spatial dimension to intra-site archaeological distributions, was not a matter of simply adopting the extreme and opposite position to the traditional view. In other words, realizing that the traditional view is erroneous did not involve adopting the following equally naive assumptions:

(1) that every activity must invariably have a discrete and and mutually exclusive locus within a settlement; (2) that tools are always found in their loci of use; and (3) therefore, that tools found in association must refer to a single activity and thereby constitute a toolkit. Yet curiously, criticisms (Larson 1979; Schiffer 1974a; Yellen 1976: 71-72; 1977: 96-97, 134) have been levelled at the new archaeology for making these very assumptions! As Binford (1983: 238; see also 1978a: 353-354; 1979a: 592) points out, Whallon (1973a: 116-119) clearly states that the concepts of activity areas and toolkits do not involve these assumptions.

Thus, regarding the spatial localization of activities within settlements, what was realized by the new archaeology at the time was that "...activities tend to be localized and to a degree spatially segregated..." (Struever 1968b: 135; emphasis added). It remained for archaeologists to demonstrate to what extent and under what conditions different kinds of activities tend to be spatially localized and how such tendencies may be recognized in the archaeological record.

Schiffer and Behavioural Archaeology

Following on from the new archaeology of the 1960s, the contributions of Michael Schiffer and his colleagues, which they refer to as "Behavioural Archaeology", are particularly relevant to spatial archaeology at the intrasite level (Schiffer 1972a; 1972b; 1974b; 1975a; 1975b; 1975c; 1976; Reid et al. 1974; 1975; Schiffer & Rathje 1973). Fundamental to Schiffer's position is the recognition that archaeologists cannot assume that artifacts are always discarded at their locations of use within a site. As a result, a basic problem for archaeologists is to determine to what extent and in what behavioural contexts artifacts and other materials get discarded at their locations of use. To examine this problem, Schiffer has delineated a tripartite division for different types of refuse: primary, secondary and de facto refuse (Schiffer

1972a: 160, 161; 1975a: 64; 1975b: 104; 1976: 30-33). In effect, this division embodies the realization that not all archaeological remains are the same in terms of discard behaviour. In rejecting any simplistic idea that there is a direct relationship between the location of past activities and the locations of material remains in the archaeological record, Schiffer (1972a: 156) asks some very fundamental questions regarding the formation of the archaeological record; and in doing so, he (1972a: 157; 1976: 27-28) draws a basic distinction between "systemic context" and "archaeological context". With this dichotomy in mind, the archaeologist's task thus becomes one of modelling and understanding the processes which link materials in the archaeological record with the participation of those materials in an ongoing behavioural system. This then becomes the central problem of archaeological inference.

These linking processes, which are the formation processes responsible for the archaeological record, involve both a cultural and a non-cultural component (Schiffer 1972a: 156; 1975c: 838-841; 1976: 11-18; Schiffer & Rathje 1973). These cultural and non-cultural formation processes are taken into account by being formulated, either explicitly or more common implicitly, into relational statements (i.e. "laws" or "law-like propositions"), which Schiffer and Rathje (1973) have called "c-transforms" and "n-transforms" respectively. Regarding the former, Schiffer (1976: 28-41) has defined four major categories of cultural formation processes: S-A, A-S, A-A and S-S processes. In addition, Schiffer (1974b: 46; 1975c: 841-842; 1976: 12-14, 16-17) has further elaborated upon his model of archaeological inference by introducing two additional concepts, namely, "correlates"[1] and "stipulations".

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[1] Schiffer adopted the term "correlates" from Hill (1966: Table 6; 1970: Table 12). However, Schiffer has defined the term more precisely for his own purposes, since "...it is not entirely clear in his [Hill's] writings that correlates must pertain only to systemic context phenomena" (Schiffer 1975c: 845).

Thus, the archaeological record is seen to be "...a complexly formed phenomenon in which the constituent materials have been transformed in many ways since their participation in a past behavioral system" (Schiffer 1976: 41). To begin tackling the task of modelling these transformations, Schiffer has advocated the use of specific terms which apply unambiguously to either archaeological context or systemic context -- see Schiffer (1972a: 157; 1976: 45) for definitions of such basic terms as "elements", "durables", "consumables" and so forth. Moreover, Schiffer has presented some general transformation models to address this overall problem (see 1972a; 1975b; 1976: 46-57). In short, Schiffer has not only proposed a general conceptual framework for dealing with archaeological formation processes, but he has also presented some methodological tools which may be used to deal with the problem of formation processes -- indeed, much of his so-called behavioural archaeology is concerned with methodology, as Schiffer (1976: ix) himself points out (see also Goodyear 1977).

Binford, Schiffer and The Pompeii Premise

Binford has also recently drawn attention to the fundamental need to tackle the problem of formation processes (Binford 1977a; 1977b; 1977c; 1978a; 1978b; _et seqq._; Binford & Bertram 1977: 77-78) -- he has called this area of research "middle-range theory"[1]. Binford (e.g. 1977c: 6-7; 1978b: 3, 12; Binford & Bertram 1977: 77) has succinctly stated that the problem of archaeological formation processes is one of making meaningful statements about past, cultural dynamics from contemporary, static facts observable in the archaeological record. In Schiffer's

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[1] Schiffer (1980: 377) reports that the concept of middle-range theory was borrowed from sociology and introduced into archaeology by L. Mark Raab and Albert C. Goodyear in 1973 in a widely circulated paper. Much more recently, Raab and Goodyear (1984) have argued that Binford's conception of middle-range theory is much more narrowly concerned with methodology (specifically with principles of site formation processes) than was its original conception in sociology.

terms, "statics" refer to archaeological context and "dynamics" to systemic context.

Well before these recent discussions of formation processes and middle-range theory, Binford had argued that it was fundamental to link observations made on the archaeological record with the causally relevant variables of the past cultural system which produced that record, and he referred to such linking propositions as "arguments of relevance" (Binford 1968a; 1968d; Binford & Binford 1968: 2-3). Hence, since these arguments of relevance are concerned with bridging the inferential gap between archaeological data and past cultural systems (in effect between statics and dynamics), they are essentially equivalent to what Schiffer later called n-transforms, c-transforms and correlates, as Schiffer himself has observed (1976: 13; cf. 1972a: 163; 1972b: 149). In short, Binford's writings of the 1960s had laid the theoretical foundations on which rest Schiffer's extensive discussions on the importance of formation processes in archaeological inference. In light of this rather conspicuous connection between the new archaeology and behavioural archaeology, Binford and Schiffer would seem to have much in common given their mutual concern with, and interest in, archaeological formation processes.

Yet, this important common ground has become somewhat overshadowed by debate between the two men. The origin of this would seem to lie with Schiffer's (1972a: 156; 1976: 11) point of departure for his discussion on formation processes. It was pointed out above (p. 13) that new archaeologists adopted the optimistic assertion that archaeological remains are "...a 'fossil' record of the actual operation of an extinct society" (Binford 1964: 425). Schiffer claims that this is a fundamental assumption or principle of the new archaeology, and he interprets Binford's (1962: 218; 1964: 425; 1968a: 22) now famous "fossil record" statements as meaning "...that the spatial patterning of archaeological remains reflects the spatial patterning of past activities..." (Schiffer 1972a: 156).

As so stated, this is essentially what Binford (1981b), following Ascher (1961a: 324), refers to as the "Pompeii premise". Of course, Schiffer argues that this so-called fundamental assumption of the new archaeology is false.

Binford (1981b: 199) records that his initial response was simply to ignore Schiffer's misunderstanding. However, perhaps as a result of Schiffer's (1980) critical and even provocative book review, Binford was finally goaded into responding with characteristic vigour by launching an all-out attack on Schiffer (Binford 1981b). As Goodyear has prudently observed, Schiffer's claim that Binford's "fossil record" statements represent a fundamental assumption of the new archaeology is:

> ...an unnecessary overstatement. Binford used the term "fossil" in a metaphorical sense set off originally in quotation marks to convey the notion that the record represents a patterned and systematic byproduct of human behavior. To deny the general truth of this statement is to deny any basis for knowing the past. Admittedly, archaeologists have maintained overly simplified (if not naive) notions about the relationships between activity performance and the ultimate formation of archaeological records. But to hang new archaeology out to dry on the fallaciousness of this assumption seems unnecessary and perhaps a misrepresentation of what Binford originally intended (Goodyear 1977: 669).

Perhaps Schiffer misrepresented Binford's position because he was actually directing his comments more at other new archaeologists than at Binford or, more likely, perhaps he was simply setting up the proverbial "straw man" to knock down in his discussion on archaeological formation processes. One might go even further and argue that he actually misunderstood Binford's arguments -- this is certainly the line of defence that Binford himself takes (1981a: 284; 1981b). But in any case, Binford's position is well documented. If one examines the overall arguments in the context of which his "fossil record" statements were made, it is abundantly clear that he was not arguing for an adoption of the Pompeii premise. Furthermore, Binford himself (1981b: 195-199) has examined the development of this notion and has clarified how his arguments never supported it. However, beyond mere defence, Binford (1981b:

199-206) has taken the opportunity to attack Schiffer for being a reconstructionist who subscribes to a mentalist concept of culture. Schiffer (1983) limited his response to a rebuttal of Binford's (1981b: 203-204) reinterpretation of the Abandonment period at the Joint Site.

At this juncture, it is worth briefly outlining the main points of agreement between the two men. Firstly, Binford (1978a: 344, 348; 1981b: 199) accepts that the basic distinction between systemic context and archaeological context is a useful and relevant one. And accepting this distinction, Binford (1981a: 27-28; 1981b: 199) concurs with Schiffer that the archaeologist's inferential task is to understand the transformation of elements from systemic context into archaeological context or, in other words, to understand archaeological formation processes. And a further point of agreement between the two men is that, in the domain of spatial archaeology at the intra-site level as well as in many other areas of interest, ethnoarchaeological research is fundamentally important for understanding the formation processes which are responsible for the archaeological record.

Middle-Range Theory and Ethnoarchaeology

Thus, the new archaeology of the 1960s and subsequent developments in the 1970s have laid the theoretical foundations for the development of a spatial archaeology at the intra-site level. These foundations are based upon: (1) the recognition that there is structure to human activity within settlements and hence that there is a spatial dimension to intra-site archaeological distributions; (2) the recognition that the fundamental problem of archaeological inference involves understanding the varied and complex processes which are responsible for the formation of the archaeological record. It remained, however, for archaeologists to determine to what extent and under what conditions activities tend to be spatially localized, how such tendencies are reflected by the patterning of material remains, and how such patterning may be identified in the archaeological record. As Binford has repeatedly stressed (e.g. 1977c: 6-7; 1981a: 27; 1983: 19-23), such knowledge can only be acquired through contemporary experience with "living" systems because knowledge of how the static properties of the archaeological record relate to, and are derived from, the dynamics of the past can only be acquired by contemporary observations of the linkages between statics and dynamics. Such "actualistic" research, which is essentially concerned with understanding formation processes, is referred to as "middle-range research or theory building" by Binford (cf. Raab & Goodyear 1984), while Schiffer includes it within his behavioural archaeology.

The Nature and Role of Ethnoarchaeology

Given the close association between archaeology and anthropology (especially in the Americas), it should not be surprising that archaeologists turned to ethnography for relevant actualistic research. However, the inadequacy of the existing ethnographic record in this regard acutely demonstrated that the need for archaeologically relevant ethnographic data was only going to be met if archaeologists conducted their own ethnographic research. As has often been observed (e.g. Gould 1971: 144-145; 1978a: 3-4; 1980: 3-4; Rathje 1978: 50; Schiffer 1978: 229), it was this very apparent need which is largely responsible for the rise of ethnoarchaeological research during the late 1960s and early 1970s.

Of course, ethnoarchaeology is only one variety of middle-range research. As Binford (1981a: 32; 1983: 24-26, 104) has pointed out, actualistic research may be conducted where the relevant dynamics can be directly observed (ethnoarchaeology), have been recorded (historic sites archaeology), or may be replicated or simulated (experimental archaeology). The first two kinds of these actualistic studies are primarily concerned with cultural formation processes, while experimental archaeology also involves non-cultural processes. Yet, Gifford (1978) has argued that ethnoarchaeology also may be concerned with non-cultural as well as cultural formation processes, even if the latter are the more usual interest of ethnoarchaeologists. However, it may be argued that non-cultural formation processes are not strictly speaking in the domain of ethnoarchaeology -- archaeologically relevant they certainly are, but ethnographic data they are not. Thus, it may be suggested that there is a fourth variety of actualistic research in archaeology -- namely, archaeologically relevant taphonomy[1] -- which would include any palaeontological research that is directly relevant to the non-cultural formation processes of the archaeological record, as well as studies by archaeologists into such biological processes as the role of predator-scavengers as bone accumulators (e.g. Binford 1981a: 35-86, 196-242; Brain 1968; 1970: 1116-1119), or such geomorphological processes as the effects of stream action (e.g. Isaac 1967: 32-39; also 1977: 81-83). In any event, as Schiffer (1976: 6; 1978: 230-231) and many others (e.g. Gould 1974: 29; 1977a: 162; 1978a: 8-9; Tringham 1978: 170-171; Yellen 1977: 1) have observed, these various kinds of actualistic researches are closely interrelated and the distinctions between them are by no means absolute[2]. For example, archaeologically relevant experiments may be conducted in an ethnoarchaeological setting, which (Tringham 1978: 171) refers to as "ethnographic experiments".

As the preceding discussion intimates, there is not total agreement as to what actually constitutes "proper"

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[1] Taphonomy, a term coined by the Russian palaeontologist I. A. Efremov in 1950, refers to the "laws of burial" which are concerned with all aspects of the biological and geomorphological-geological processes involved in the transference of organic remains from the biosphere to the lithosphere (Olson 1962: 134). In short, it refers to the formation processes of the palaeontological record.

[2] All of these varieties of actualistic studies fall into Strategy 2 of behavioural archaeology (see Reid _et al._ 1975: 865; Schiffer 1976: 6-7; 1978: 230).

ethnoarchaeological research. Essentially, the main point of divergence concerns the relevance to archaeology required of ethnoarchaeology. Gould (1971: 144-145; 1974: 29-30; 1977a: 162; 1978b: 256-257; 1978c: 816; 1980: 4-5), although he is not entirely consistent in his use of the term, uses ethnoarchaeology in a rather broad and nebulous fashion in which it would seem to include experimental archaeology and even the use of ethnographic analogy[1]. He therefore champions his own phrase "living archaeology" (Gould 1968; 1980) to refer to actualistic studies that most others would call ethnoarchaeology. In any case, Gould emphasizes archaeological relevance in his definition of living archaeology, as does Tringham (1978: 170) in her definition of ethnoarchaeology.

However, some seem to feel that direct relevance to archaeology is not a requisite attribute of ethnoarchaeological research. For example, Rathje states that:

> ...ethnoarchaeologists need not limit themselves to collecting data that are directly relevant _only_ to building reconstructions of the past. They can apply their material-behavior perspective to the study of ongoing processes in modern systems (Rathje 1978: 50; emphasis in original).

Similarly, even though he stresses that the role of ethnoarchaeology is to provide archaeologically relevant "laws", Schiffer says that "The broad subject matter of ethnoarchaeology is the relationships between human behavior and the material-spatial-environmental matrix in which it takes place" (Schiffer 1978: 230). Yet curiously, as a result of the inclusion of Strategies 3 and 4 into their behavioural archaeology, the subject matter of ethnoarchaeology (as expressed in this statement by Schiffer) becomes essentially equivalent to that of archaeology: "...the subject matter of archeology is the relationships between human

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[1] He states that: "Ethnoarcheology, as I see it, refers to a much broader general framework for _comparing ethnographic and archeological patterning_. In this latter case, the archeologist may rely entirely upon published and archival sources or upon experimental results (use and manufacture of pottery, stone tools, etc.) for his comparisons without having to do the actual fieldwork himself" (Gould 1974: 29; emphasis added).

behavior and material culture in all times and places" (Schiffer 1976: 4; see also Reid et al. 1975: 866). And Gould adopts a similar view:

> ...ethnoarchaeology can be viewed as a new kind of anthropology -- the anthropology of human residue (Gould 1978c: 816).
>
> ...archaeology is concerned primarily with the anthropology of human residues in relation to behavior (Gould 1980: 250-251).

Archaeology and ethnoarchaeology, therefore, become inextricably and confusingly intertwined because both are seen as the science of material culture. The natural culmination of this viewpoint is represented by Gould and Schiffer (1981). However, Binford (1981a: 28) takes exception to Schiffer's (1976: 4) characterization of the subject matter of archaeology, and he goes on to argue persuasively in defence of archaeological relevance:

> The point of view adopted here is that actualistic studies or middle-range research is crucial to archaeology and should be conducted *from the perspective of the archaeological record*.... Stated another way, we are not attempting to specify the relationships between "behavior" in any exhaustive sense and material remains. Instead, we are attempting to understand the determinants of patterning and various structural properties of the archaeological record in order to learn about their past (Binford 1981a: 32; emphasis added).

From a strictly archaeological perspective, it is scarcely possible to disagree with Binford's practical interpretation of the role of ethnoarchaeology and other middle-range research within archaeology.

At any rate, these differences of opinion do not obviate the importance of actualistic research for understanding the linkages between statics and dynamics. In light of the preceding discussion on Palaeolithic archaeology (pp. 9-12), it should not be too surprising to note that a Palaeolithic archaeologist was one of those (Kleindienst & Watson 1956) who first perceived and expressed the need for ethnoarchaeological research in the modern sense. Even more importantly, it was in the context of the African Lower Palaeolithic that actualistic research was largely pioneered, the aim being to aid in interpreting sites in light of such formation processes as the effects of scavenger activity, stream action, exposure, weathering and trampling (e.g. Brain 1967a; 1967b; 1968; 1969; 1970; Isaac 1967; Washburn 1957). In this context, reference should also be made to the seminal work of Robert Ascher (1961a; 1961b; 1962; 1968). Thus, by the late 1960s and early 1970s, ethnoarchaeological and other actualistic researches were being carried out on a number of diverse fronts.

Relevant Hunter-Gatherer Research

In the present context, the relevant ethnoarchaeological studies are ones which deal with how activities are spatially organized in hunter-gatherer settlements and how the patterning of refuse left at such settlements reflects this activity structure. Research among various groups of Australian Aborigines provides some data on this subject. Gould has worked among the Western Desert Aborigines and, even though most of his ethnoarchaeological research has been concerned with lithic technology and the nature of Aboriginal regional subsistence-settlement systems, scattered throughout Gould's extensive writings are some data relating to intra-settlement activity structure (see Gould 1968; 1971: 166-168; 1977a: 166; 1977b: 29-48; 1980). Likewise, Hayden's work with Aborigines in the Western Desert has been mostly concerned with lithic technology, although his plans of some Aboriginal camp sites provide some useful comparative data (Hayden 1979). More relevantly, O'Connell (1977) presents useful data on intra-settlement organization and activity structure at the large, semi-permanent, residential settlements of the Alyawara in north-central Australia. Finally, Meehan's intensive study of the Anbara on the north coast of Arnhem Land includes some information on the activity organization and patterns of disposal at camp sites (Meehan 1982: 112-118). Unfortunately, these researches have been primarily concerned with other matters, so that any data pertaining to intra-settlement activity structure has been somewhat incidental to the studies as a whole -- there has certainly been no attempt to describe in detail a large number of settlements or to analyse thoroughly the factors determining the activity structure and the patterning of refuse disposal. In contrast, Yellen's (1976; 1977) ethnoarchaeological research among the !Kung San of Botswana in south-central Africa is directly concerned with this area of interest and contains much detailed information.

Binford (1980) distinguishes between two organizationally different kinds of hunter-gatherer subsistence-settlement systems, namely, "foragers" and "logistically organized collectors". The studies referred to above deal with forager systems, but Binford has conducted ethnoarchaeological research among a group of collectors, the Nunamiut Eskimo of north-central Alaska. Binford's research interests with the Nunamiut have focused upon problems relating to faunal remains (Binford 1978b; 1981a: esp. Ch. 4; Binford & Bertram 1977) and to the organization of technology (Binford 1977b; 1979b), with particular emphasis on site formation processes and resultant inter-site variability within a settlement system. Furthermore, these researches have prompted Binford to consider in more general terms the nature of hunter-gatherer subsistence-settlement systems and the concomitant archaeological implications for inter-assemblage variability (Binford 1980; 1982). Much of Binford's research is highly relevant to a theory of spatial archaeology of hunter-gatherer settlement systems -- that is, they relate to the spatial archaeology of hunter-gatherers at Clarke's (1977) macro level. Some of his observations on the technological organization of hunter-gatherer settlement systems have relevant implications for the analysis of specific sites -- particular mention should be made of the notion of "curated" as opposed to "expedient" technologies (Binford 1973: 242; 1977b: 34-36; cf. Hayden 1976), and the concept of "embeddedness" in raw material procurement strategies (Binford 1979b: 259-261; cf. Gould & Saggers 1985; also Binford & Stone 1985). However, Binford has also narrowed his focus to the semi-micro and micro levels and looked at the way in which various factors condition the internal activity structure of settlements (Binford 1978a; 1983: 117-192).

Disposal Modes and Site Maintenance. With regards to activity organization and site structure, a basic concept is that of "disposal modes", each of which tends to be associated with particular inventories of items (Binford 1978a: 345-348, Table 5). Following on from this, Binford (1978a: 349, Figs. 4 & 5; 1983: 149-155) has observed that the seating arrangement around hearths conditions the dispersion patterns of items such that discrete "drop zones" and "toss zones" may be identified. Moreover, even though the form and size of objects relate to their mode of disposal, Binford (1978a: 348, 350; 1983: 156-157, 176-177) also points out the importance of situational differences -- that is, in different sites or social contexts, different disposal modes may be associated with the same items. A basic distinction is drawn between dispersal patterns around an outside hearth compared to that found around a hearth within a dwelling structure. Situational differences between inside and outside contexts relate to an additional factor which conditions the structure of the archaeological record, namely, "site maintenance" (Binford 1983: 189-190). Binford has suggested (see also Andresen et al. 1981: 34) that the degree to which an area is maintained is a function of the intensity of its use and the length of time that such intensive use lasts, with the result that highly maintained areas will be associated with specialized disposal areas in the form of dumping zones. A comparison of Gould's (1968: 110, 119; 1977a: 166; 1977b: Figs. 18 & 19; 1980: 197) and O'Connell's (1977: 123, Fig. 2) data on household camps in the residential settlements of Australian Aborigines provides a good example of this.

Facilities and Appliances. An important point embedded in the notions of drop and toss zones and site maintenance is that the locations of hearths tend to be primary conditioners of the spatial structuring of activities on a site and of the consequent pattern of dispersion of refuse (Binford 1978a: 348-349). Similarly, where structures are present, their locations also play a key role in this regard. Hearths and dwelling structures are two major examples of what Binford (1983: 145) refers to as "facilities", the arrangement of which on a site provides the "site framework" around which activities are organized. From an archaeological point of view, hearths may be expected to be the most enduring and conspicuous of these facilities (seen archaeologically as "features"), given the rather ephemeral nature of most dwelling structures, drying and storage racks, and various other facilities in hunter-gatherer settlements. Additionally, certain curated artifacts may also be expected to be particularly conspicuous items of a settlement from an archaeological perspective. Binford (1978a: 339-340; 1979b: 263-264) refers to a class of artifacts which he calls "site furniture" -- these are the site-specific hardware that "goes with the place" and are available for use by any occupant whenever needed. When such artifacts are particularly heavy or bulky, at the end of a particular episode of occupation, they are often left at the site for reuse at a later date, given the not uncommon event of reoccupation of the site. Gould (1980: 71-72) refers to such objects as "appliances". In Schiffer's (1972a: 160; 1975b: 104; 1976: 33) terms, these artifacts would be in the category of "de facto refuse".

Generalized Activity Areas. At residential bases among the !Kung, with the exception of some specialized activity areas on the periphery of settlements, Yellen (1976: 61-69; 1977: 86-96) has observed that most activities performed by members of each basic residential unit (i.e. the household) take place in a generalized activity area within each household camp -- he (1977: 95) refers to such an area as the "nuclear activity area". Essentially the same situation has been documented among the Aborigines of the Australian desert (e.g. O'Connell 1977: 121-123; see also Gould 1968: 119; 1977a: 166; 1977b: 33; 1980: 197, 199).

This recognition of the presence of generalized, activity-mixed, nuclear activity areas leads Yellen (1976: 71-72; 1977: 96-97, 134) to criticize certain new archaeologists for adopting a number of false assumptions -- reference to this has already been made (p. 15), so suffice it here to reiterate Binford's (1979a: 592) comment that Yellen was simply arguing against a "straw man". More importantly however, as a result of his Mask Site study, Binford (1978a: 353-354) disagrees with Yellen's conclusion that nuclear activity areas are so generalized that there is no structured organization of activity space within them -- seemingly unstructured generalized activity areas, like the Mask Site, may indeed involve organized and differential use of space if the question of redundancy in the organization of activity space over time is addressed by the proper analytical frame of reference. Unfortunately, Yellen never narrows his analytical focus to examine how space is utilized over time *within* individual nuclear activity areas.

The Internal Arrangement of Settlements. Reference should also be made to Yellen's (1977) "ring model" since debate over this points out an epistemological difference in current ethnoarchaeological research. A number of studies of hunter-gatherer residential settlements indicate that the spacing and arrangement of household camps is essentially a function of inter-household economic and social relationships (e.g. Gould 1968: 109; O'Connell 1977: 123-124; Silberbauer 1981: 166-167, Fig. 13; Williams 1968: 166, Fig. 1). Indeed, Binford suggests that "The use of physical space to represent social distance...may be a principle common to all hunter-gatherer sites" (1983: 140). A similar situation is found among the !Kung, but Yellen's (1976: 61-64; 1977: 70-71, 86-89) observations concerning the internal arrangement of !Kung residential settlements are particularly important because they enable him to address two of the most fundamental questions that archaeologists would wish to answer from the spatial analysis of particular sites, namely, the number of occupants of a site and the duration of occupation. !Kung residential sites have a circular arrangement in which household camps are located along the circumference of the circle and certain specialized activity areas are located around the periphery of this hut circle. Because of this arrangement, Yellen (1977: 98-131) has developed the "ring model" in which he concludes that the area of the hut circle or inner ring provides a measure of the size of the group at the settlement, while the area of the outer ring primarily reflects the duration of occupation. Yellen (1977: 130-131) is optimistic about the archaeological utility of this model.

However, the settlements of other hunter-gatherer groups have internal arrangements which do not conform to the !Kung pattern and Yellen's ring model. Among the Aborigines of the Australian desert, household camps are not arranged into any particular configuration such as the hut circle (e.g. see Gould 1977b: Fig. 15; O'Connell 1977: Figs. 3-5). Gould sums up the situation among the Western Desert Aborigines thusly:

> There was no consistent pattern of orientation for the entrances of shelters or the sides on which hearths were placed.... At no time was there any attempt to arrange camps in orderly rows or any other pattern aside from the generalized extended family clusters (Gould 1968: 109-110).

Even other San settlements do not conform to the circular pattern found among the !Kung. For example, Silberbauer (1981: 222, Fig. 13) notes that among the G/wi the placement of huts within a settlement is determined by the position of suitable shade trees rather than by some idealized pattern. In short, there is great variability among hunter-gatherers in terms of the internal arrangement and spacing of basic residential units in settlements, variability which exists not only between different groups but also within the seasonal cycle of particular groups (Binford 1983: 139-142). According to what Yellen (1977: 133) calls the "spoiler approach", these data alone are sufficient to refute the ring model as an empirical generalization. More than this however, Binford (1978a: 357-360) has criticized Yellen's interpretations and conclusions on epistemological grounds; specifically, he takes exception to Yellen's position as an empiricist and an inductivist. This same epistemological difference underlies the recent exchange between Binford and Gould with regards to the concept of embeddedness and certain more general issues relating to ethnoarchaeology and archaeological inference (Binford 1985; Binford & Stone 1985; Gould 1985; Gould & Saggers 1985).

Archaeological Implications. In spite of such debates, this body of ethnoarchaeological research has begun to provide archaeologists with the conceptual tools necessary to tackle the problem of interpreting more accurately observed patterns in the archaeological record. If archaeologists can detect and distinguish between toss zones, drop zones and dumping areas in intra-site distributions, and relate these to the locations of hearths and other observable facilities, then we have at least an initial foundation for understanding something about the pattern of refuse disposal and the internal organization of activities, and what these imply about site maintenance and the duration of occupation of the settlements in question. Of course, a major key to this is identifying in intra-site distributions different modes of disposal. In this process, detecting clusters of varying intensities is perhaps easy enough, but being able to attribute reliably observed clusters to different modes of disposal is a less straightforward matter. For example, while tossing would normally result in comparatively loose, low density scatters, both dumping and dropping produce tighter and (perhaps but not necessarily) higher density clusters (e.g. see Binford 1983: Fig. 90); hence, distinguishing between dumping and dropping may prove to be rather difficult, although the relative proximity to hearths may provide a distinguishing criterion in some cases. In any event, despite potential problems of interpretation, the concepts of disposal modes, refuse zones, facilities and so forth provide at least an initial basis for tackling the problem of interpreting archaeological site structure in terms of formation processes and human behaviour.

Of course, it should be obvious that the attainment of such a goal is likely to remain rather elusive unless archaeological sites have a relatively high degree of resolution. Given that much of the debris left at abandoned habitation sites is ephemeral and would not be archaeologically preserved, among both the Western Desert Aborigines and the !Kung (Gould 1980: 26-27; Yellen 1977: 80), individual base-camp occupations would tend to fall below the threshold of archaeological visibility. However, Gould (1968: 107, 112, 119; 1977b: 33; 1980: 26-27, 199) explicitly points out that settlement locations are frequently reused so that over time a considerable amount of durable debris accumulates in these general habitation areas. Although this has the effect of increasing archaeological visibility, it results in an archaeological record which is a massive palimpsest of numerous overlapping occupations and activity areas -- in short, visible sites are likely to have a very low degree of resolution. The same situation essentially would apply to the !Kung and indeed, Binford (1980: 9) has suggested that this situation is characteristic of foragers. Moreover, it would also apply to collectors like the Nunamiut, given the strategic complexity in the spatial organization of activities across the landscape in which site locations are commonly reused, often with situationally different kinds of settlements occurring at the same locations (e.g. see Binford 1982; 1983: 117-138).

Thus, it may be concluded from these observations that the archaeological visibility of many hunter-gatherer sites may be directly related to the amount of redundancy in the use of particular site locations, such that the degree of resolution will be decreased as visibility is increased. As a consequence, many archaeological sites may be massive palimpsests of numerous occupational episodes, even though these separate episodes would appear stratigraphically as a single depositional unit (see Binford 1982: 16-17). This is perhaps not very encouraging for spatial archaeology at the intra-site level, at least not for situations where the site environment is either stable or degradational. On the other hand, in circumstances of an aggradational environment, some stratigraphic separation of different occupations may be expected, depending of course on the frequency of reoccupation and the rate of sediment deposition, in which case we may expect some meaningful spatial information about the activity structure of particular occupations.

Statistical Techniques of Spatial Analysis

Introduction

Embodied in the above discussion on the identification of different disposal modes is the idea that detecting clusters in intra-site archaeological distributions is a necessary prerequisite to any further analysis -- in effect, this is a problem of pattern *detection*. *As noted above* (pp. 14-15), although new archaeologists had recognized that activities within settlements tend to be spatially localized, it remained to be demonstrated how such tendencies could be reliably identified in the archaeological record. In defining activity sets, Struever (1968a: 287; 1968b: 135) referred to the "spatial clustering" of various archaeological remains, while others (e.g. Hill 1966; 1968; 1970; Longacre 1968; 1970) talked about the "non-random" distributions within their sites. Given all this, it is hardly surprising that archaeologists soon turned to statistical techniques of spatial analysis to aid in detecting such spatial clustering and non-random distributions within archaeological sites. Thus, the adoption of quantitative methods of spatial analysis can be directly associated with the new archaeology of the 1960s and, along with the rise of ethnoarchaeology, it represents a major development during the 1970s which is highly relevant to spatial archaeology at the intra-site level.

This interest in quantitative spatial analysis has continued unabated since the early 1970s, and the recent archaeological literature abounds with papers which deal with various quantitative techniques of spatial analysis (e.g. Berry _et al_. 1980; 1983; Donnelly 1978; Graham 1980; Hietala & Stevens 1977; Hodder & Okell 1978; Kintigh & Ammerman 1982; McNutt 1981; Newell & Dekin 1978; Pinder _et al_. 1979; Price 1978; Simek & Larick 1983; Stark & Young 1981; Whallon 1978). It is not necessary here to review, even summarily, all of this material in terms of the statistical technicalities of various methods or their respective strengths and limitations -- indeed, Orton (1982) provides a convenient review of most of the recent archaeological literature from this viewpoint. Rather, our interest here will be twofold: (1) to outline a few of the more general, salient features of the use of statistical methods of spatial analysis in archaeology; and (2) to illustrate some of these features by briefly reviewing those quantitative techniques which are relatively well known and have been more widely used than have other available methods.

Basic Units of Analysis

Before we begin this task, however, we may strike a cautionary note regarding a matter which is strictly archaeological rather than statistical -- this concerns the nature of archaeological data, specifically, the basic analytic units which are employed in archaeological spatial analysis at the intra-site level. Whallon (1974a: 24-34) has examined the distribution of four artifact classes on an "occupation floor" at the Abri Pataud in France, in order to provide an illustrative example of the technique of "nearest-neighbour analysis". Clay (1975) has pointed out that Whallon unfortunately used four gross inventory artifact categories, which were devised as convenient labels for identification purposes during excavation, whereas he should have used formally defined artifact types which would at least have had the advantage of being morphologically homogeneous. While Whallon's retort (cf. 1974b) would no doubt be that the point of the exercise was to demonstrate the potential usefulness of the technique, this nevertheless does point to a general problem which is of fundamental concern.

As Clay (1975: 358) observes, even formally defined lithic tool types from our traditional typologies may well be useless for quantitative techniques of spatial analysis because, in order to yield meaningfully interpretable results, such methods require the use of meaningful basic units of analysis. In the case of spatial archaeology at the intra-site level, these basic units include tool types which may be regarded as having functional and/or behavioural integrity, but it is far from certain as to whether or not our traditional typologies supply us with such meaningful analytic units. If our basic analytical categories are functionally heterogeneous, Clay (1975: 358) quite properly points out that no statistical analysis, no matter how appropriate or sophisticated, will change the fact that the interpretation of the results in terms of human activities and behaviour remains ambiguous, if not totally meaningless.

As a result of their studies of the Mesolithic sites at Havelte in Holland, both Price (1978: 18, 20) and Whallon (1978: 29) are well aware of this serious problem. Price (1978: 20) even suggests that it may be more desirable to use lithic tool types defined on the basis of edge-angles rather than gross morphology, to which we might add that the use of microwear analysis for defining tool types might be an additional productive way to proceed. In any event, Whallon (1978: 29) notes that plant and animal remains, where preserved, may offer more promise for intra-site spatial analysis than do stone tools, since their classificatory units are inherently more functionally meaningful, and they may, therefore, indicate much more directly differential use of space within sites. Regardless of possible solutions to this problem, it should of course be obvious that this problem should in no way discourage archaeologists from exploring the potentialities of various statistical methods of spatial analysis, since it exists whether or not such methods are employed.

General Features of Use in Archaeology

Eclecticism. In light of the eclectic nature of archaeology in general, it should come as no surprise to note that initially archaeologists simply borrowed statistical techniques of spatial analysis from other disciplines, particularly from botanical ecology and human geography. Indeed, as Orton (1982: 1) observes, this is still largely the case a decade later. For example, probably the best known and most widely used technique in archaeology is the Clark and Evans (1954) distance method of point-pattern analysis (or "nearest-neighbour analysis"), which they developed for research in botanical ecology, and which was adopted by human geographers about a decade before it was first applied to archaeological data.

This eclecticism is not in itself lamentable. Indeed, it is arguable that it would have been parochial of archaeologists to ignore potentially useful techniques which had already been developed in other disciplines. What is unfortunate, however, are a number of features which characterize, at least in part, the use of borrowed quantitative techniques of spatial analysis in archaeology. Recalling Thomas' (1978) comments regarding the use of statistics in archaeology in general, these more lamentable features should perhaps come as no surprise.

Ignoring Subsequent Developments. Orton has quite correctly pointed out that "...much of the archaeological work has been based on techniques developed in the 1950s, and subsequent developments in statistical theory have tended to be ignored" (1982: 1). This may involve either ignoring amendments to the initial formulation of a borrowed method, or even ignoring the subsequent development of other statistical tests which overcome some of the problems associated with older tests and which, therefore, may have largely supplanted them. Fortunately, this feature is at least partly redressed by Orton's (1982) recent review, and by some other discussions in the archaeological literature.

Lack of Critical Appraisal. There has often not been sufficient critical appraisal of the underlying assumptions and the inherent problems and limitations of borrowed techniques. As a result of ignoring or misunderstanding or underestimating these problems and limitations, the impression is often conveyed that the techniques employed are more "powerful" than they actually are. And closely related to this, archaeologists also have not sufficiently appraised the degrees to which borrowed techniques, regardless of their inherent merits, are appropriate to archaeological data and problems. Of course, a minor problem of a technique for research in one discipline, such as botanical ecology, can become of much greater consequence when it is applied to the different kinds of data sets found in other disciplines.

Misuses and Abuses. As a result of the preceding feature in particular, there have been both misuses and abuses (see Thomas 1978: 233-240) of statistical techniques of spatial analysis in archaeology. In some cases, the statistical analyses are claimed to be demonstrating something that they do not -- in other words, the statistical results are over interpreted if not misinterpreted. However, even worse than such errors of judgment have been cases of statistical overkill in which quantitative methods are unnecessarily used to demonstrate patterning that is blatantly obvious. Such cases are predicated upon "...the rather dead-end philosophy that complex statistical analysis will somehow make more sense of archaeological data" (Thomas 1978: 238); related to this is the belief that the use of some quantitative technique in itself makes the research more methodologically rigorous which, therefore, makes any observed patterns more objectively "real" than if they had been observed by simpler techniques or even by the more traditional, intuitive approaches. Fortunately, misuses rather than abuses -- which Thomas (1978: 233, 235) refers to as THE BAD as opposed to THE UGLY in quantitative archaeology -- are more characteristic of archaeological applications of statistical methods of spatial analysis.

Obsession with Methodology. A final feature to note is the disproportionate amount of attention which has sometimes been paid to methodology rather than to substantive applications. It is perhaps because of this that the archaeological applicability of some techniques has not been adequately assessed. As a body of literature, there has built up a considerable amount of discussion about the various proposed techniques, sometimes concerning the technical minutiae of these statistics and often being coupled with doctrinaire statements about the need for, and value of, "objective" methodology. Yet as often as not, there are very few or very poor substantive applications which might justify the claims being made. It might be noted that this feature is more characteristic of the more recent literature than it is of the initial uses of statistical methods of spatial analysis in archaeology, which in general were largely concerned with archaeological application. While some of this more recent discussion may well be regarded as necessary debate concerning the problems and archaeological potentiality of a technique, not all of it can be accounted for in these terms. Thus, it is time that archaeologists temper any such obsession with methodology and begin to assess critically the potential value and applicability of various quantitative techniques of spatial analysis -- and if one were to do so on the basis of the published evidence offered to date, many techniques would undoubtedly not withstand the inspection.

With these general comments in mind, we may now examine some quantitative techniques with a view to illustrating some of the points outlined above. Of course, many methods of spatial analysis have been either proposed for, or applied to, archaeological data and problems (see Orton 1982). However, some of these (e.g. Berry et al. 1980; 1983; Graham 1980; Kintigh & Ammerman 1982) have been so recently introduced that it is difficult to determine how archaeologically applicable they will turn out to be and what long-term impact they will have on quantitative spatial analysis in archaeology. The same also applies to other techniques which have been around longer (e.g. Dacey 1973a; Hietala & Stevens 1977; Hodder & Okell 1978; Speth & Johnson 1976) but which have attracted little or no attention in the literature and have been subjected to few (if any) substantive applications.

Quadrat Methods

Still other techniques may already have failed the test of time. A quadrat method -- known as contiguous quadrats or dimensional analysis of variance -- has been suggested by Whallon (1973a: 120-125; 1973b) to be a potentially useful technique for archaeology. As Whallon (1973a: 121; 1973b: 267) and others (e.g. Hodder & Orton 1976: 36) have noted, the great advantage of quadrat methods in general is that they can be applied to sites which were excavated solely by means of grid squares and for which more precise provenance data are not available. However, there are serious problems with quadrat techiques which result from the often small sample sizes of archaeological distributions, the minimum quadrat size used, the necessity of having a square or rectangular grid in which the number of quadrats along each side must be some power of two, and the fact that blocks of intermediate sizes cannot be included (e.g. see Hietala & Stevens 1977: 540; Hodder & Orton 1976: 36-38; Orton 1982: 16; Pielou 1969: 105; Riley 1974; Vincent 1976: 162). While Whallon (1973a: 121-124; 1973b: 267-268; 1974b) is not unaware of these problems, Riley (1974: 489) has suggested that the technique of contiguous quadrats is more limited in its applicability to archaeology than Whallon leads us to believe.

In any case, Newell and Dekin (1978) have critically compared some quadrat methods, and they conclude (1978: 30) that dimensional analysis of variance is not the most sensitive index available (see also Brose & Scarry 1976: 196-197). But even more importantly, their final conclusion (1978: 31-32) is that, given the limitations and problems of quadrat methods in general, distance methods of point-pattern analysis should be adopted instead and hence, that archaeologists should excavate their sites accordingly to provide the necessary provenance data. This conclusion echoes that of Hodder and Orton:

> Because of the very severe problems associated with the use of quadrat methods, the more sensitive tests based on distance measures are more appropriate for most archaeological data (1976: 38).

In short, quadrat methods of spatial analysis have been proposed and scrutinized, and a general concensus would appear to have emerged that such techniques are effectively useless for most archaeological spatial analyses.

Nearest-Neighbour Analysis

Following the development of distance methods of point-pattern analysis in the 1950s, which are generally referred to as "nearest-neighbour analysis", a substantial body of literature in statistical ecology has accumulated (for a partial list, see references cited in Orton 1982: Table 1). Most of these subsequent developments in statistical theory have seldom been cited in archaeological discussions of nearest-neighbour analysis, and the impression could easily be gained that the Clark and Evans (1954) statistic is the only major distance method available, which is of course far from the case. For example, as Graham (1980: 107) points out, the Clark and Evans statistic is the only non-quadrat method discussed by Hodder and Orton (1976: 33-51) in their treatment of point-pattern analysis. To some extent, this choice on their part is understandable because this particular statistical technique of spatial analysis was the first to appear in the archaeological literature, and because it has been the most widely discussed and applied technique in archaeology. For these very reasons, the following discussion on nearest-neighbour analysis will also focus on the Clark and Evans statistic because its use in archaeology best illustrates some of the general features of quantitative spatial archaeology outlined above.

<u>The Borrowing of the Method</u>. In particular, this technique provides a good example of how archaeologists

initially borrow a technique with scant regard for its inherent problems and the degree to which such problems may be exacerbated when applied to archaeological data. Initially, the Clark and Evans nearest-neighbour statistic was used by archaeologists in a number of substantive applications; some of these were concerned with the analysis of intra-site distributions (e.g. Brose & Scarry 1976; Price 1978; Price et al. 1974; Whallon 1974a), but most were concerned with settlement pattern analysis (e.g. Adams & Nissen 1972; Earle 1976; Hammond 1974; Hodder 1972; 1977: 228-230; Hodder & Hassall 1971; Hodder & Orton 1976: 44-46; Newcomb 1970; Plog 1974; Plog 1976; Washburn 1974; Zubrow 1971; 1975). Except for Price and Whallon, virtually none of these studies involved any serious critical assessment of the inherent problems of the technique and of its applicability to archaeological data and problems. Because of this, the impression is usually conveyed that the method is so rigorous that the results obtained are more scientific and more objectively "true" than if the technique had not been used. Unfortunately, this provides an all too good example of some of the comments made above regarding the general features of statistical analysis in spatial archaeology. As will be discussed below, a number of reformulations of the Clark and Evans statistic have been recently proposed as a result of a problem with the initial formulation. Because of this inherent flaw and the lack of critical assessment in the archaeological use of the technique, serious doubt must be cast on all of these early archaeological applications of the Clark and Evans statistic, as Pinder et al. (1979: 430) point out. In short, methodological rigour should not be confused with the employment of quantitative techniques -- the latter is in itself no guarantee of the former.

The borrowing of the Clark and Evans nearest-neighbour statistic by human geographers provides an informative comparison with archaeology. As in archaeology, following the introduction of nearest-neighbour methods into the published literature (Dacey 1960; 1962), the Clark and Evans statistic was enthusiastically employed by human geographers in a number of case studies which involved relatively little critical discussion of the method (e.g. King 1962; Getis 1964; Birch 1967; Kariel 1970; Sherwood 1970; Pinder 1971). Subsequently, the technique was subjected to considerable scrutiny, reappraisal and even damning criticism (see Pinder & Witherick 1972; Dacey 1973b: 132-138; De Vos 1973; Dawson 1975; Charlton 1976; Ebdon 1976; Sibley 1976; Vincent 1976; Pinder 1978). As we shall see, while there has been some critical discussion in archaeology, there has not yet been the same degree of critical reappraisal of the applicability and value of the technique as has occurred in human geography. So far, archaeologists have been more concerned with reformulating the statistic, thus betraying an obsession with methodology, rather than with the practical assessment of whether or not the technique is really worth all the fuss. To redress this imbalance, we may examine nearest-neighbour analysis in archaeology from this perspective.

Sample Size. To begin with, Table 1 summarizes the sample sizes employed in a number of applications of the statistic in human geography and archaeology. Perhaps worst of all, some archaeologists have not even published the sample sizes employed in their analyses, nor even sometimes the precise statistical results! Where sample sizes are indicated, it can be seen that, whereas Clark and Evans (1954: 448-449) used samples ranging from 89 to 197 cases, human geographers and especially archaeologists have tended to apply the statistic to smaller samples and sometimes even to very small samples. In this regard, Earle's (1976) study is particularly noteworthy -- all but four of his nearest-neighbour statistics are based on samples of less than 50 cases, while over half of them are based on samples of less than 10 and even as low as two in one instance! While in one place Earle (1976: Table 7.6) indicates that some samples were insufficient to conduct a nearest-neighbour analysis, we learn elsewhere (1976: Table 7.7) that he absurdly considers insufficient sample sizes to be instances where the number of cases is either zero, one or two! While Charlton (1976: 170) may bemoan the fact

Table 1. Sample Sizes Employed in Some Applications of the Clark and Evans Nearest-Neighbour Statistic in Human Geography and Archaeology.

Author and Source	Sample Sizes
Clark & Evans (1954: Table II)	89, 116, 174, 184, 197
Applications in Human Geography:	
Birch (1967: Table 2)	70, 99, 132, 169
Getis (1964: Table 1)	20, 33, 68, 94, 117, 124, 133
Kariel (1970: Table 1)	79, 80
King (1962: Table 1)	20, 23, 28, 32, 38, 51, 55, 61, 64, 80, 82, 96, 97, 104, 122, 128, 131, 132, 140, 177
Pinder (1971: Table 5)	9, 11, 20, 27, 31, 58
Sherwood (1970: Table 3)	31, 36, 41, 44, 45
Applications in Archaeology:	
Adams & Nissen (1972: 26-28)	??
Brose & Scarry (1976: Tables 4 & 5)	??
Earle (1976: Tables 7.7, 7.11 & 7.13)	2, 3, 3, 3, 4, 4, 4, 4, 4, 4, 4, 5, 6, 6, 6, 6, 6, 7, 7, 8, 8, 8, 9, 9, 9, 9, 10, 11, 13, 13, 13, 15, 17, 18, 19, 21, 21, 22, 25, 26, 31, 31, 34, 37, 43, 45, 59, 62, 69, 104
Hammond (1974: 323-326)	15, 16, 25, 83
Hodder & Hassall (1971: Fig. 4) and Hodder (1972: 892)	25
Hodder & Orton (1976: 46) and Hodder (1977: Table 1)	24, 31, 48, 49, 51, 97, 148
Newcomb (1970: 48)	21
Plog (1974: 84)	??
Plog (1976: Table 5.1)	17, 21, 33
Price (1978: Table 1)	12, 15, 19, 19, 24, 35, 64, 66, 150
Washburn (1974: Table 1)	95, 96, 112, 140, 157, 168, 172
Whallon (1973a: Table 2; 1974a: Figs. 1-4)	15, 18, 20, 20, 32
Zubrow (1971: 137; 1975: 94-96)	??

that the geographical literature gives no guidance about the minimum samples sizes which should be used with the nearest-neighbour analysis, there would appear to be more cause for alarm in archaeology. In any event, Orton (1982: 17) suggests that a sample size of more than 100 is needed (see also McNutt 1981: 573). Thus, solely as a result of considering the question of sample size, most of the archaeological applications of nearest-neighbour analysis shown in Table 1 would have to be called into doubt.

Study Area Size and Shape. This problem of sample sizes is, however, merely a sympton of another, more fundamental problem which relates to the limitations of nearest-neighbour analysis for archaeological data -- this is the problem of area size and shape. In botanical ecology research for which Clark and Evans developed the technique, the size and shape of the study area is defined by the researcher, which thereby ensures that large enough samples can be obtained for analysis. This control is possible because implicit in the technique is that the study area is merely a sample which is well within the total area covered by the entire population (Clark & Evans 1954: 450). In archaeology as in human geography, the size and shape of the study area -- whether it is a settlement, an archaeological site, or a geographical or a political region -- is usually intrinsically defined and is essentially imposed on the researcher at the outset; and to ensure sufficinetly large samples and full investigation of a phenomenon, a researcher may often be in the position of wanting to use the entire area and not just a subarea within it. This can create severe problems because study area size and shape have an effect on the performance of the Clark and Evans nearest-neighbour statistic.

Regarding study area size, as a result of his use of the technique, Getis pointed out the need for "...selecting meaningful study areas where spatial bias is minimized" (1964: 395). Following Hsu and Tiedmann's (1968: Fig. 2 & Table 2B) observations, it has become widely appreciated that the nearest-neighbour value for a given distribution of points, especially for a clustered distribution, will vary with the size of the study area as defined in relation to the total area covered by the entire population (e.g. see Charlton 1976: 170; Hodder & Orton 1976: 41; Pinder & Witherick 1972: 284-285; Pinder et al. 1979: 434-435; Sibley 1976: 164; Whallon 1974a: 22). As Pinder et al. (1979: 435) note, if at all possible, the safest procedure is to follow Clark and Evans' (1954: 450) suggestion that the study area should lie well within the total area covered by the entire population, even though this will undoubtedly mean discarding some information. Getis (1964: 394) used a subjectively determined density limit to define his study area so that peripheral areas with lower densities were excluded from the analysis. Similarly, since excavated areas may be much larger than the main concentrations of material, Price (1978: 9; Price et al. 1974: 50-51) has suggested using artifact density contours in order to delimit occupation floors within archaeological sites to use as the study area for nearest-neighbour analysis.

Boundary Effect. However, if one follows this suggestion and uses a density limit to demarcate the study area, then the shape of the study area is likely to be somewhat (if not highly) irregular, which will only exacerbate another problem, namely, the problem of "boundary effect". The boundary effect is a result of the fact that, by imposing a finite study area on a much larger sampling universe, some nearest-neighbour relationships will be severed because the nearest neighbour for some points inside the area will lie outside it, which tends to raise the average nearest-neighbour distance; and the smaller the sample size and the more irregularly shaped the area (i.e. the more it deviates from a square so that there is relatively more boundary), the greater will be the boundary effect on the results of the analysis (McNutt 1981: 573, 574; Pinder 1978: 379, 384; Pinder et al. 1979: 431).

Although they did not fully explore its ramifications, Clark and Evans (1954: 449-450) touched on this problem of boundary effect. Given their recommendation that the study area should be a centrally located subarea well within the total area covered by the entire population, they have suggested that nearest-neighbour measurements to points outside the main study area should be included where appropriate. This "buffer zone" solution has been followed by a number of researchers (e.g. Earle 1976: 200; Hodder 1977: 228, Figs. 2 & 3; Hodder & Hassall 1971: Fig. 4; Hodder & Orton 1976: Figs. 3.9 & 3.10). However, the use of a buffer zone can seriously decrease sample sizes in cases where the total population is already small, and there is the additional problem of determining if the buffer zone has been made wide enough (Donnelly 1978: 93). Alternatively, adapting Dacey's procedure (1963: 505), another way by which researchers have attempted to deal with edge effects is to eliminate from the analysis any point which is nearer a boundary than its nearest neighbour within the study area (e.g. Price 1978: 9; Whallon 1974a: 22). Once again however, a problem with this solution is that sample sizes are decreased (Hodder & Orton 1976: 43), which could be severe in situations where samples are already small and/or the area is irregularly shaped (i.e. it has relatively more boundary); and there is also the problem that this solution creates a bias in favour of the retention of small nearest-neighbour distances (Diggle 1976: 246).

Reformulations. Therefore, neither of these ways of dealing with edge effects is entirely satisfactory, especially in cases where sizable reductions in sample sizes would occur. So the problem remains: when we define the boundaries of a finite study area, as we must, then the boundary will probably sever some connections between nearest neighbours which will tend to raise the average nearest-neighbour distance for points within the study area. By means of computer simulation, Ebdon (1976) has demonstrated that edge effects build into the formulae used in the Clark and Evans test statistic a significant amount of underestimation, particularly when sample sizes are small. As a result, he concludes that:

> ...it is clear that the accepted significance test for the nearest-neighbour index contains a consistent bias. The test is 'conservative' in relation to a clustered pattern in the sense that it is more difficult than it should be to reject the null hypothesis. In relation to a dispersed pattern, however, the test is 'liberal' to a rather greater extent.... There are obvious dangers in searching for 'regularity', or dispersion, in settlement patterns with a technique which has an inbuilt bias towards finding such patterns (Ebdon 1976: 169)!

By using Ebdon's results, Pinder (1978; Pinder et al. 1979) has presented modified formulae which correct this inherent flaw of the technique, and he optimistically asserts that with this solution to edge effects in hand "...we may return nearest-neighbour analysis to the position it held prior to Ebdon's investigation" (Pinder 1978: 384). Yet, Pinder (1978: 384; Pinder et al. 1979: 434) admits that the boundary effect is variable depending on the shape of the study area and therefore, since his reformulation is based on a square area (following Ebdon), that his "...modified technique must only be applied to square study areas if it is to be truly accurate" (Pinder 1978: 384). Of course, this still imposes severe limitations on the technique since such control over the shape of the study area in archaeology and human geography is often not possible. Moreover, other problems with the technique remain (Orton 1982: 17).

Drawing on Pinder's (1978: 384; Pinder et al. 1979: 434) realization that the problem of boundary effect is specifically related to the length of the perimeter of the study area, McNutt (1981) criticizes Pinder's reformulation for being unnecessarily restricted to square study areas. By using the "old flag trick", McNutt (1981: 574-591) develops formulae for quantifying the boundary effect for square, rectangular, equilateral-triangular and circular study areas. This involves developing a formula for each of these shapes which enables the computation of the number of points within the study area which, under a random distribution, can be expected to have nearest neighbours outside the study area; this is then used to compute another version of the Clark and Evans nearest-neighbour statistic. While McNutt's reformulation allows nearest-neighbour analysis to be applied to a greater range of study area shapes, the problem remains that study areas in archaeology may be irregular in shape and perhaps even highly irregular, especially in the case of excavated areas within sites (such as in the present case of Cnoc Coig).

Realizing that study area shapes may differ considerably, Donnelly (1978) has used computer simulations to provide formulae for the Clark and Evans nearest-neighbour statistic which contain an edge-effect correction which is proportional to the length of the perimeter of the study area but independent of its shape. He concludes that:

> These empirical formulae are sufficiently accurate for more than about 7 points in any region with a reasonably smooth boundary.... However, when the number of points is fairly large the formulae should work even for regions with fairly unsmooth boundaries (Donnelly 1978: 95).

This would thus make Donnelly's reformulation more useful than either Pinder's or McNutt's for many archaeological situations. In any event, we may finally note that Besag and Diggle (1977: 328) have suggested that Monte Carlo simulation tests may be used as a means of determining the significance of observed patterns of distribution with the Clark and Evans test statistic without the need for edge-effect corrections and regardless of the shape of the study area. This suggestion, however, appears to have been ignored by archaeologists and human geographers.

General Applicability and Utility. So far, reference has been made to the interrelated problems of sample size, the size and shape of the study area, and the boundary effect. These are problems with nearest-neighbour analysis which relate to the mechanics of the technique and for which solutions are available so that proper and prudent application of the method in archaeology can be reasonably ensured, although these solutions would preclude its use in many instances (including most of the existing archaeological applications shown in Table 1). In addition to these, we may note a number of more strictly archaeological problems which relate to the nature of archaeological data (see Pinder et al. 1979: 441-443; also Hodder 1977: 230-236; Hodder & Orton 1976: 54). However, except for a few brief and scattered comments, the archaeological literature to date has not addressed the broader problem of the general applicability and utility of the Clark and Evans nearest-neighbour statistic for archaeological data and problems. As a result, the impression could easily be gained from all the discussion in the recent archaeological literature that the Clark and Evans statistic is a quantitative technique which is of major value to archaeological spatial analysis. In actual fact, one could argue that the technique is of minimal importance -- that it is simply not worth all the attention it has been given!

As we have seen, human geographers have used the technique for settlement pattern studies and locational analysis, which involve broadly similar problems and comparable data sets to the study of regional settlement patterns in archaeology. However, human geographers have much more extensively scrutinized and criticized the technique from the perspective of its general applicability and utility than have archaeologists. These comments apply equally well to archaeology and may be summarized briefly as follows:

1. The technique is highly reductionistic in that it gives only a single measure along a clustering-randomness-regularity continuum (Orton 1982: 17; Simek & Larick 1983: 166). Referring to this as the "continuum hypothesis", Dacey notes that "...it is difficult to concur with the hypothesis that positions of spatial distributions on a linear continuum either generates a useful classification scheme or confirms intuitive notions of degree of similarity" (Dacey 1973b: 134).

2. The nearest-neighbour statistic is purely descriptive, but even as a descriptive device, its value is limited because it is well established that very different patterns can yield the same nearest-neighbour values and the resulting values can even contradict what is commonly meant by

clustering and regularity (see Dawson 1975: Figs. 1-3; De Vos 1973: Figs. 2 & 3; Vincent 1976: Fig. 1). Thus, supplementary techniques may well be necessary in order to avoid spurious conclusions about degrees of difference and similarity (Pinder et al. 1979: 441).

3. Such ambiguity occurs because the technique does not in fact measure pattern at all! Rather, because it simply provides information about the distribution of nearest-neighbour distances and does not utilize the internal geometrical properties of a point set, nearest-neighbour analysis provides a measure of "dispersion" as opposed to "pattern"[1] (Sibley 1976: 163-164; Vincent 1976: 161).

4. Even more importantly, the technique does not take into account contextual information which includes both general and specific knowledge of a wide range of potentially relevant variables relating to environment, economy, technology, socio-political organization and so forth (Kintigh & Ammerman 1982: 32).

5. Finally, because it is a simple, reductionistic, descriptive technique which provides only a measure of the dispersion of a spatial distribution and does not utilize contextual information, it provides no insight into the complex formation processes which are responsible for generating a given distribution (Dawson 1975: 43-44; Kintigh & Ammerman 1982: 33). Thus, in some instances (e.g. Hodder 1977: 228-230; Hodder & Orton 1976: 53-54), site distributions have been found to be random and the researcher has been at odds to account for this, even though, as Dawson (1975: 44) emphasizes, the apparently random pattern is clearly not the product of random processes. The value of the technique in such a situation, where confusion rather than clarification is the result of the analysis, must certainly be called into question.

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[1] Pattern or arrangement, dispersion and sometimes also density are considered to be the main components of a spatial distribution according to what Dacey (1973b: 134-137) calls the "independent component hypothesis" of spatial distributions.

Vincent (see also Dacey 1973b: 138) summarizes the overall thrust of these criticisms when he concludes:

> Thus with respect to nearest-neighbour and quadrat methods we have a situation where sophisticated techniques are being used blindly in an attempt to supply information which they simply cannot yield.... When authors of school and undergraduate texts overcome their euphoria in expounding the new-found wonders of the quantitative revolution and provide a more critical evaluation of the methods perhaps the situation will improve (Vincent 1976: 163).

The time has also come for archaeologists to be more critical in their evaluation of borrowed quantitative techniques of spatial analysis such as the Clark and Evans nearest-neighbour test statistic.

The preceding discussion should not be taken to mean that archaeologists should completely abandon nearest-neighbour analysis. Rather, as Pinder (1978: 384; Pinder *et al.* 1979: 443) has pointed out, it should be stressed that the Clark and Evans statistic produces a relatively simple description of a spatial distribution and, as such, that it should form only an initial step in any spatial analysis. To be fair, most archaeologists have used the technique in this way, even if it has too frequently been improperly applied for one reason or another. As has already been noted, most archaeologists have used the method for the study of regional settlement patterns, and it is in this general problem area that nearest-neighbour analysis will probably be found to be most useful in the future.

Utility for Intra-Site Spatial Analysis. In contrast, it would seem that its value is much more limited for the analysis of the distribution of faunal, floral and artifactual remains on occupation surfaces within archaeological sites. This conclusion is certainly borne out by the analysis of the Mesolithic sites near Havelte in Holland (Price *et al.* 1974; Price 1978; Whallon 1978). Overall, the application of quantitative techniques proved to be rather disappointing:

> These analyses have produced few interpretable results and virtually no consistency. The

> results obtained from different kinds of analyses are usually conflicting, and none are more clearly interpretable than others (Whallon 1978: 28).

The one site (H2:1) which was intensively studied by Price "...was selected as an example because, almost uniquely, it exhibits a marked degree of non-random patterning in the distribution of artifacts as well as observable associations" (Price 1978: 28). Not surprisingly therefore, the statistical analyses revealed much patterning in the distributions, but Price readily admits that:

> ...much of this information is actually available from a careful visual inspection of the ground plan. Concentrations of various artifact types can be seen in Figure 1 that closely correspond to the areas defined in the analysis (Price 1978: 20).

While the overall lack of success of the analysis of the Havelte sites is undoubtedly due to a number of problems at all levels of spatial analysis (Whallon 1978: 29ff.), there can be little doubt that the simplicity and inappropriateness of the methods employed contributed greatly to the rather indifferent results.

The usefulness of the Clark and Evans nearest-neighbour statistic for intra-site spatial analysis is reduced even further when we consider the main aim of such analysis. For example, Whallon states that "The aim of such analyses is generally to define 'toolkits', or clusters of artifacts and other items <u>which occur together</u> on occupation floors..." (1973b: 266; emphasis added). Price (1978: 3ff.) and Whallon (1973b: 266-267; 1978: 28) have proposed a three-step approach to intra-site spatial analysis. The first step involves determining whether the individual distributions of particular categories of items are random or non-random. The general expectation is that any non-random patterning will consist of clustered distributions as opposed to regular (uniformly spaced) distributions. The second and third steps involve delimiting spatial clusters on the ground and determining spatial associations among different classes of items; in this way, "activity areas" and "toolkits" are defined. The first step in the procedure is seen as a necessary prerequisite to the second and third steps.

A number of critical comments can be made regarding this approach as it relates to the use of the Clark and Evans nearest-neighbour statistic:

1. The tendency towards clustering for single classes of items, which is all that the Clark and Evans statistic detects, is visually obvious in many instances (e.g. see Price et al. 1974: Figs. 13 & 14; Price 1978: Fig. 1; Whallon 1973a: Fig. 1; 1974a: Figs. 5-8). The use of some statistical technique in such cases is superfluous and can even be a futile waste of time and resources, as Fieller et al. (1983: 161, 162) point out. The use of statistical techniques to detect tendencies towards clustering should thus be aimed at distributions which do not reveal visually obvious patterning (assuming that the detection of such tendencies is deemed to be a desirable objective), a point which Whallon (1978: 27) seems to appreciate.

2. Techniques such as the Clark and Evans nearest-neighbour statistic and dimensional analysis of variance, which Orton (1982) refers to as "univariate" methods, are useful only for the first step in this approach, even though it is abundantly clear that the main interest actually lies with the latter two steps. Although Price and Whallon (Price et al. 1974: 51-52; Price 1978: 6, 14; Whallon 1974a: 23-24) have used nearest-neighbour distances in a rather novel attempt to address the second and third steps of their approach, which is itself not without problems (Hodder & Orton 1976: 207), it should be stressed that nearest-neighbour analysis is not itself required -- that is, the Clark and Evans nearest-neighbour statistic is not actually necessary even in their procedure for tackling the second and third steps. In short, univariate methods of spatial analysis provide no information which would enable us to delimit spatial clusters on the ground and to determine spatial associations between classes of items, which are the main objectives of intra-site spatial archaeology.

3. It is clear, therefore, that Price's and Whallon's use of such methods is predicated on the notion that two distributions must be individually determined to be non-random as a necessary prerequisite to further analysis. However, in terms of spatial associations between two classes of items, Orton (1982: 4, 5) and others (e.g. Pielou 1969: 179; Hietala & Stevens 1977: 539-540) explicitly point out that this notion is fallacious. Likewise, detecting the tendency towards clustering is not a necessary preliminary step to defining specific spatial clusters on the ground, and it may even be misleading. For example, recalling that the Clark and Evans statistic is highly reductionistic, a distribution may still contain some definable clusters, even though nearest-neighbour analysis shows it to be random overall. Therefore, other than for its own intrinsic interest, the first step of this three-step approach -- and consequently the use of techniques like the Clark and Evans statistic -- is not actually a necessary component of intra-site spatial analysis.

In conclusion, univariate methods of spatial analysis, such as the Clark and Evans nearest-neighbour test statistic, are frequently of little or no relevance to the major objectives of intra-site spatial analysis and, therefore, their archaeological utility is not nearly as great as has often been claimed. Moreover, even if the questions addressed by univariate techniques are deemed to be of some interest, we may reiterate that they are often just as readily answered by the simple visual inspection of distribution plots. In this light, it is promising to note that more archaeologically relevant techniques (e.g. Kintigh & Ammerman 1982; Simek & Larick 1983) are being developed for intra-site spatial analysis, techniques which utilize a greater range of information (including contextual elements) and which allow for the detection of multiple levels of patterning.

The Coefficient of Segregation

Given the preceding discussion, methods of spatial analysis which are concerned with two or more classes of items -- which Orton (1982) refers to as "multivariate" techniques -- may often be of more value and interest to the study of intra-site distributions. One potentially useful kind of multivariate techniques are various measures of segregation which are concerned with the interrelationships between the distributions of two types of points. One such segregation measure is Pielou's (1961: 258-259; 1969: 182-183) coefficient of segregation. This technique has been used in some archaeological situations previously (Peebles 1971: 75-78; Price _et_ _al_. 1974: 52-53; Hodder & Orton 1976: 205-207; Hodder & Okell 1978: 105-106; Price 1978: 4, 7, 10-14), and will be employed in the present study. More will be said about this technique in Chapter 5 and so, the present discussion will be confined to a few general comments relating to the applicability and utility of the technique for archaeological intra-site spatial analysis.

To begin, it should be noted that many of the preceding comments regarding the Clark and Evans nearest-neighbour statistic would also apply to the coefficient of segregation. This statistic is a highly reductionistic technique which provides a simple descriptive measure along a linear segregation-association continuum. As such, it must be kept in mind that it provides information on only one aspect of a given distribution -- nothing is learnt about other important characteristics such as the relative dispersions of the two distributions, as Price _et_ _al_. (1974: 52) and Hodder and Okell (1978: 97) have noted. And of course, the technique provides no direct insight into the potentially complex formation processes which are responsible for generating an observed pattern of segregation-association. Thus, even if Pielou's coefficient detects significant segregation between two types of points, other characteristics of the distributions may still have to be examined in order to distinguish between possible alternative explanations for the observed pattern of segregation. As will be seen in Chapter 8, the limpet scoops in Cnoc Coig are a case in point.

Aside from these general comments, a number of more specific points should be made regarding the coefficient of segregation. Firstly, the technique is sensitive to small-scale patterning when only first nearest neighbours are used (Hodder & Orton 1976: 204-205; Hodder & Okell 1978: 97), so that extending to second or third nearest neighbours may be required. Therefore, depending on the scale at which one expects significant segregation or association to occur, it behooves the researcher to use the technique appropriately in terms of extending it to second, third, etc. nearest neighbours. Secondly, as Price (1978: 7; Price *et al*. 1974: 52) observes, the technique can only be applied to two types of points at a time. If one is interested in the interrelationships among several classes of items, as may well be the case in many or even most intra-site spatial analyses in archaeology, then a whole series of segregation statistics (S values) must be generated, which can become rather cumbersome and make the interpretation of the results rather difficult (e.g. see Price *et al*. 1974: Table 14; Price 1978: Table 3). In an attempt to deal with this, Price (1978: 7, 14, Table 4) has arrayed into a matrix the S values he obtained (transformed into what he calls A values) and used a clustering procedure in an effort to isolate artifact groups or "toolkits".

Unfortunately, Price's use of the coefficient of segregation to define spatial association represents a misuse of the technique in that the statistical results are misinterpreted in order to extract information which the technique does not provide. Price states: "The Index of Segregation provides a measure of association between two different artifact types. Artifact groups (or tool kits) can be defined using this index" (1978: 28). However, this statement is misleading because the statistic does *not* actually measure association in the sense that is involved in the archaeological definition of toolkits; rather, it is primarily concerned with detecting segregation. The statistic produces values between -1.0 and +1.0 -- significant positive values indicate segregation and significant negative values indicate association, while low positive and low negative values indicate random mixing. Pielou (1961: 268; 1969: 183) refers to significant negative values as "negative segregation". In the extreme, when S equals -1.0, negative segregation represents a pattern of association between the two types of points in which the points occur as isolated mixed pairs. Price recognizes that negative segregation is unlikely to occur in intrasite spatial analysis, so he uses the coefficient of segregation to define spatial association thusly:

> For this reason, relationships that are indicated as aggregated [i.e. negatively segregated] <u>or</u> mixed (i.e. not significantly segregated) <u>are</u> assumed to represent spatial association between types. Thus, values of $\underline{S}_p$ that are low negative or even low positive may contain information on association between artifact types (Price 1978: 14; emphasis in original).

However, this assumption by Price is false. While it is true that significant negative values do indicate spatial association, it is important to realize that this negative segregation (especially mixed pairing) is a particular kind of association but not the one, however, which is <u>necessarily</u> implied when archaeologists discuss spatial association in terms of toolkit definition. Moreover and even more importantly, it is simply wrong to assume that low negative and low positive values indicate significant spatial association; in other words, random mixing can <u>not</u> be equated with spatial association for toolkit definition purposes.

If one applied Price's (1978: 14) interpretation of S values to the six Havelte sites (Price <u>et al</u>. 1974: Table 14), the only non-associated pairing of tool types would be between points and backed blades at site HI:II (which produced the only high positive S values). Yet at the other five sites, this pair of artifact types would be declared to be spatially associated, as would the other five pairings of tool types. In effect, with one exception at one site, each of the four artifact types would be interpreted as being spatially associated with each of the other types, and all four types would therefore constitute a toolkit. This is hardly illuminating intra-site spatial analysis, since one could have much more easily said that the four types constitute a toolkit simply because they were all found together in the same sites! In short, recalling our previous comments (pp. 37-38) about the misuse and abuse of quantitative techniques in archaeology, Price's use of Pielou's coefficient of segregation provides a salutary reminder that it behooves archaeologists to assess critically and to apply prudently borrowed statistical methods of spatial analysis.

CHAPTER 3

AN INTRODUCTION TO THE SITE OF CNOC COIG

Location and Dating

The present study deals with the site of Cnoc Coig, which is a late Mesolithic shell midden located on the small island of Oronsay in the Inner Hebrides of western Scotland. At 56° North and 6° 15' West, Oronsay lies immediately south of the larger island of Colonsay, to which it is joined at low tide, and approximately 13 km west and 9 km north-west of the still larger Hebridean islands of Jura and Islay respectively (Fig. 1).

Although the island has an area of approximately 5.8 km^2 today, due to the delayed effects of isostatic rebound following the last glaciation, Oronsay would have had a total land area of less than ca. 4 km^2 and it may even have been divided into two smaller islands during the late Mesolithic period (Jardine 1977: 139; Mellars 1978: 371). At the time of occupation, Cnoc Coig would have been directly on the shoreline on the south-eastern side of the larger northern portion (Fig. 2). In fact, because of Cnoc Coig's position relative to the coastline at the maximum of the Holocene marine transgression, Jardine (1977: 140) argues that the occupation of the site was not until after the sea had begun to recede from its maximal position. Four radiocarbon dates have been obtained from charcoal samples from within the midden, two from the upper part of the deposits (3,545 ± 75 bc and 3,480 ± 130 bc) and two from the lower part of the midden (3,695 ± 80 bc and 3,585 ± 140 bc) (Mellars 1978: Table 1). Two additional radiocarbon dates -- 3,725 ± 60 bc and 3,700 ± 60 bc -- have been obtained from the small "pre-midden" occupation which lies below the main midden in the north-central area of the site (see Mellars 1985).

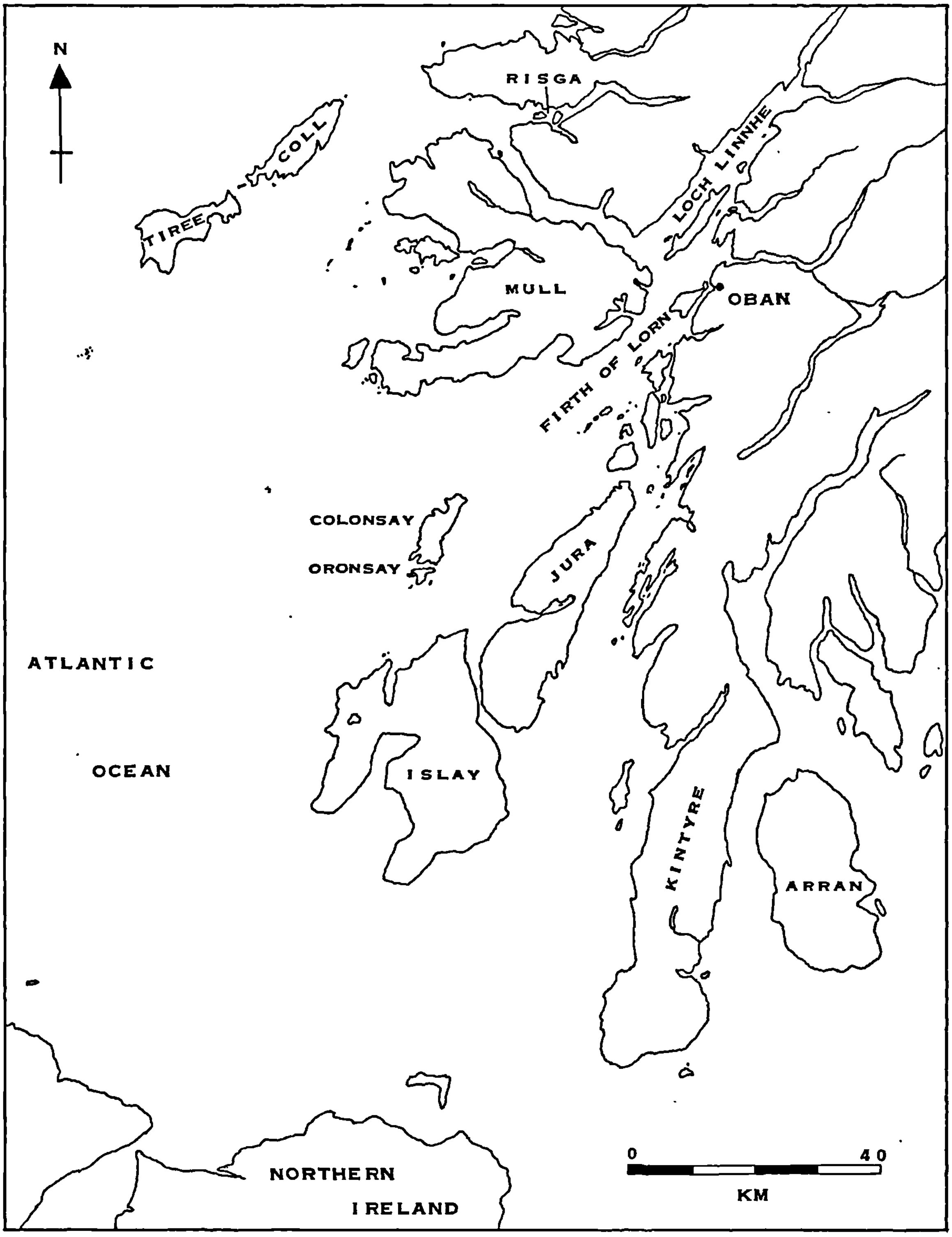

Figure 1. Map of Southwest Scotland Showing the Location of the Island of Oronsay.

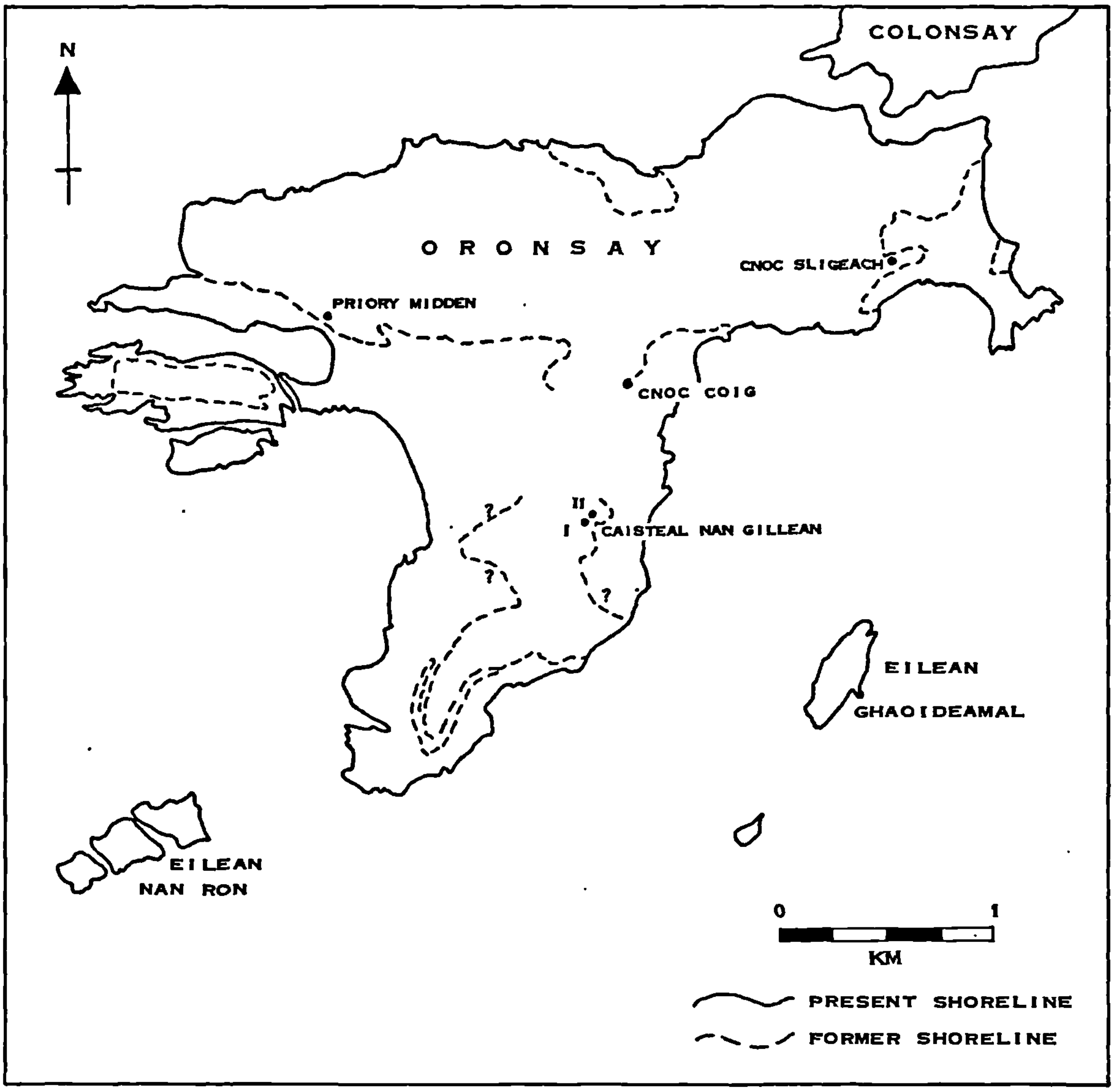

Figure 2. Map of the Island of Oronsay Showing the Locations of the Five Known Mesolithic Shell Middens and the Position of Raised Shoreline Features Associated with the Maximum Post-glacial Marine Transgression. Redrawn after Jardine (1978: Fig. 1) and Mellars (1978: Fig. 2).

Cnoc Coig and Research on the Obanian

The excavations at Cnoc Coig which provide the data for the present study were undertaken as part of a research project which was initiated and directed by Dr. Paul Mellars. A number of preliminary reports and theses dealing with various aspects of this project have already appeared (Grigson 1981; Jardine 1977; 1978; Jardine & Jardine 1978; 1983; Jones 1984; Mellars 1978; 1981; Mellars & Payne 1971; Mellars & Wilkinson 1980; Peacock 1978; Wilkinson 1981), while the final reports on the project are in the process of being prepared and published (see Mellars 1985).

As Figure 2 illustrates, Cnoc Coig is only one of five late Mesolithic shell middens on Oronsay, and these other sites have also been investigated as part of the objectives of the recent research programme (see Mellars 1978: 373-375; Mellars & Payne 1971; Peacock 1978: 179-180). Two of these five sites -- Caisteal nan Gillean II (C.N.G. II) and the Priory Midden -- were discovered as a result of the recent investigations on Oronsay. The other three sites have all been subjected to at least some excavation during the late 19th and early 20th centuries -- the history of these investigations is summarized in Table 2 and is discussed in detail by Mellars (1985).

In the present context, our main concern is with work which was previously carried out at Cnoc Coig. As Table 2 illustrates, it initially seemed (see Mellars 1978: 371; 1981: 516) as though Cnoc Coig had not undergone any excavation prior to the initiation of the recent research project in 1970. However, further work has revealed that this was not entirely the case. One problem centres around the identification of the elusive Cnoc Riach. Anderson's (1898: 312-313) brief report provides no indication as to the mound's precise location and, according to Anderson, Galloway's notes on the excavation of the site were apparently not preserved. However, Grieve (1923: Fig. 23) provides a photograph of the mound and maps its location

Table 2. Summary of Excavations during the Late 19th and Early 20th Centuries at the Mesolithic Shell Middens on Oronsay.

Site	Investigated by	Date	Publications
Caisteal nan Gillean I	William Galloway & *Symington Grieve*	1881-1882	Grieve (1882; 1885: 47-58; 1923: 14-16, 40-66)
Croch Sligach	William Galloway	1884	none, but see Anderson (1898: 311-312)
Croch Riach	William Galloway	1880s	none, but see Anderson (1898: 312-313)
Druim Harstell	Mungo Buchanan	1911	none, but see Wickham-Jones <u>et al</u>. (1982)
Cnoc Sligeach	Henderson Bishop	1913	Bishop (1914)

on his "Archaeological Map of Colonsay and Oronsay". Apparently, Grieve presumed to know its location because he claims (1923: 16) that it was he who drew the attention of Galloway to the existence of both the Cnoc Sligeach and the Cnoc Riach mounds. The location of Cnoc Riach supplied by Grieve was accepted (e.g. see Mellars 1978: Fig. 2; Mellars & Payne 1971: Fig. 1; Peacock 1978: Fig. 12.1) until further research by Mellars (1981: 517-518) demonstrated that the highly conspicuous mound pointed out by Grieve is unlikely to be Cnoc Riach. Mellars (1981: 518) suggests that a disturbed area on the north-western margin of Cnoc Coig could well be the site of Galloway's Cnoc Riach excavations, although admittedly this identification is far from certain. Less problematical is the location of Druim Harstell, even though there was no knowledge of Buchanan's work at this site until only very recently when a manuscript in the Hunterian Museum, University of Glasgow was located, which was well after the current excavations at Cnoc Coig had begun. On the basis of this manuscript record, it is clear that Buchanan's excavations at Druim Harstell included some portions of the mound now known as Cnoc Coig which Buchanan referred to as the "Viking Mound". Mellars (1981: 516-517) records that Buchanan's excavations at Cnoc Coig comprised a comparatively small trench extending from around the highest point of the midden towards the south-eastern edge of the site (see also Wickham-Jones et al. 1982: 18-19).

Aside from these five Mesolithic shell mounds on Oronsay, there are three other related sites in western Scotland (see Fig. 1). Two cave sites at Oban, MacArthur Cave and Druimvargie, were discovered and excavated in the late 19th century by Anderson (1895; 1898), while a site on the small island of Risga in Loch Sunart was dug in 1920; the only published account of this latter site is provided by Lacaille (1951: 115-126; 1954: 229-239). The obvious similarity and uniformity of the assemblages from these eight sites was recognized early on, although, following Anderson (1898: 313), they were originally ascribed to a

Scottish variant or extension of the Azilian "culture" (e.g. see Bishop 1914: 53-55; Breuil 1922: 265ff.; Clark 1932: 14-16; Grieve 1923: 14ff.; Movius 1940: 70-71, 76; 1942: 185). Eventually, adopting Movius' suggestion (1940: 76), these assemblages came to be known as the "Obanian culture", although it was still held that Azilian, as well as Maglemosian, influences could be detected in the Obanian. However, Clark's (1956: 99-102) defence of the Azilian connection notwithstanding, there eventually developed considerable doubt about this supposed Azilian affinity (e.g. see Lacaille 1954: 240-241; Movius 1953: 98-99). Aside from the Azilian, and closer to home, connections were also seen between the Obanian and the so-called (cf. Woodman 1978: 347, 355-356) "Larnian culture" of the Irish Mesolithic (e.g. see Clark 1956: 101-103; Mitchell 1949: 174-177; Movius 1940: 70-76; 1953: 94-95, 108-111).

Regardless of the value and validity of such traditionalist arguments concerning the culture-historical origins and connections of the Obanian, there are certainly strong reasons for regarding these eight sites as constituting a distinct assemblage. However, it is far from clear at the present time as to what this distinct assemblage actually represents, not in terms of traditional diffusionist models of culture history, but rather in terms of late Mesolithic hunter-gatherer subsistence-settlement systems in western Scotland. Mellars has succinctly summed up the matter thus:

> Clearly, the whole of the Obanian artefact assemblage represents a highly specialised tool-kit adapted to the intensive exploitation of coastal economic resources. But the relationships between the human groups who occupied the shell middens and those who manufactured the typical microlithic industries represented abundantly at other sites in western Scotland are extremely difficult to assess (Mellars 1974: 92).

This is certainly one of the major problems concerning the Obanian, but it is not within the scope of the present study. Whether or not an intensive investigation of the intra-site structure of one Obanian shell midden will yield any results which shed light on this general problem will have to await the final stage of the research when all the diverse analyses are brought together to bear on the question of the nature of these sites in terms of prehistoric hunter-gatherer settlement systems.

The 1973-79 Excavations

During the course of the recent research project, all five Obanian sites on Oronsay have been sampled to obtain palaeoenvironmental data, material for radiocarbon dating, evidence on economy and seasonality, and so forth. However, Cnoc Coig is the only site to have involved any extensive areal excavation. The site was excavated during four field seasons -- 1973, 1975, 1977 and 1979. After the 1977 season, Mellars (1978: 375) reported that 156 m^2 of the midden deposit had been totally dug, representing about 60% of the area of the site. After the 1979 field season, the areas on the site which had been completely excavated, as shown in Figure 3, totalled 186.7 m^2, which represents approximately 70% of the area of the site.

In 1973 and 1975, a series of 23 trenches was excavated on or just outside the midden; these trenches were given letter designations, as shown in Figure 3. In addition, in 1975, 23 1 x 1 m squares scattered over the entire midden were dug as part of a programme of probabilistic sampling on the site (see Mellars 1978: 375; Peacock 1978); these numbered sampling squares are also shown in Figure 3. As can be seen, two of these squares (numbers 17 and 20) were dug as integral parts of two trenches (Trenches R and O respectively). During the 1977 and 1979 field seasons, a grid system graded in 1 m intervals was imposed on the site for further excavation, with letter designations running east-west and numbers running north-south (see Fig. 3). As can be seen in Figure 3 from the delineation of the midden boundary, the western two-thirds of the site has been excavated almost in its entirety and thus, most of the 30% unexcavated area of the site lies in

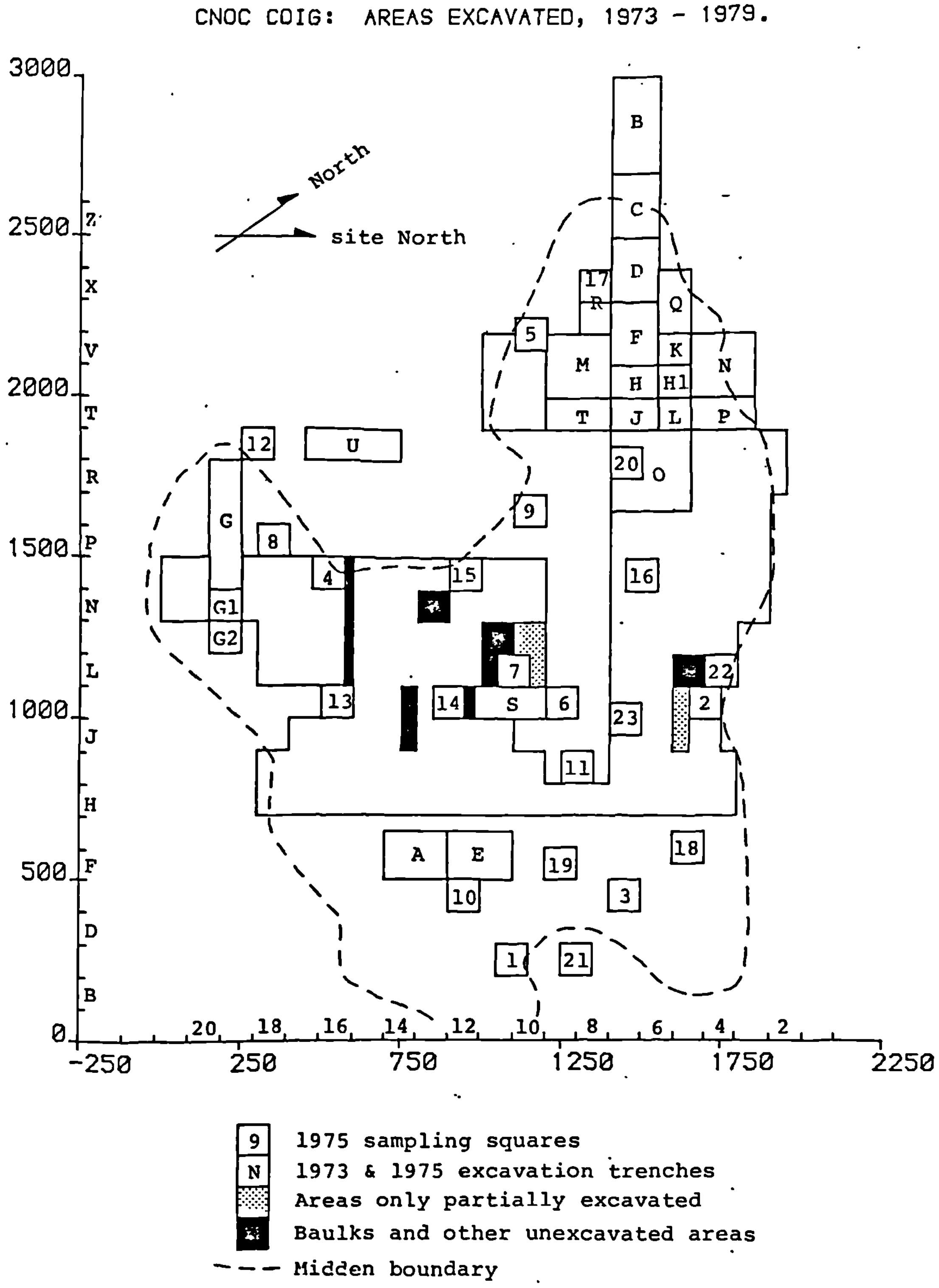

Figure 3. Plan of Cnoc Coig Showing the Midden Boundary, the 23 Trenches Excavated in 1973 and 1975, the 23 Probabilistic Sampling Squares, and the North-South and East-West Grid Square Designations Used during the 1977 and 1979 Field Seasons.

the eastern (seaward) one-third. As was mentioned above, Mellars (1981: 516) notes that Buchanan's 1911 dig at Cnoc Coig lies in this seaward portion of the site, so that it does not overlap any of the recent areal excavations.

Figure 3 delimits the entire area of Cnoc Coig which has been dug as part of the recent work on the site. Involved in these recent excavations was the recording of the precise three-dimensional locations of all artifacts, mammal bones and bird bones which were recovered by trowelling. This extensive body of information from the site thus provides the data base for the spatial analyses put forth in the present study. However, it should be pointed out that not all of the data from the recent excavations are included in the following spatial analyses; several categories of data have been excluded for the reasons outlined below (see Fig. 4).

Firstly, the data from Peacock's (1978) sampling squares were not collected such that the precise three-dimensional locations of finds were recorded and hence, because these data are not amenable to the methods used in the present study, they are not included herein. In effect, for our purposes here, these sampling squares are equivalent to unexcavated areas of the site. However, there are two exceptions to this: because squares 17 and 20 were dug as parts of Trenches R and O respectively, the exact three-dimensional locations of finds from these two squares were recorded and consequently, their data are included herein, in effect as though these squares were solely parts of excavated trenches and had nothing to do with Peacock's sampling programme. However, the data from the 21 other sampling squares are totally excluded from the present study.

Secondly, several other excavated areas of the site are excluded for a number of reasons -- these areas make up the miscellaneous excluded areas shown in Figure 4. Two trenches (Trenches B and U) lie fully outside the shell midden proper (see Fig. 3) and thus are not included here

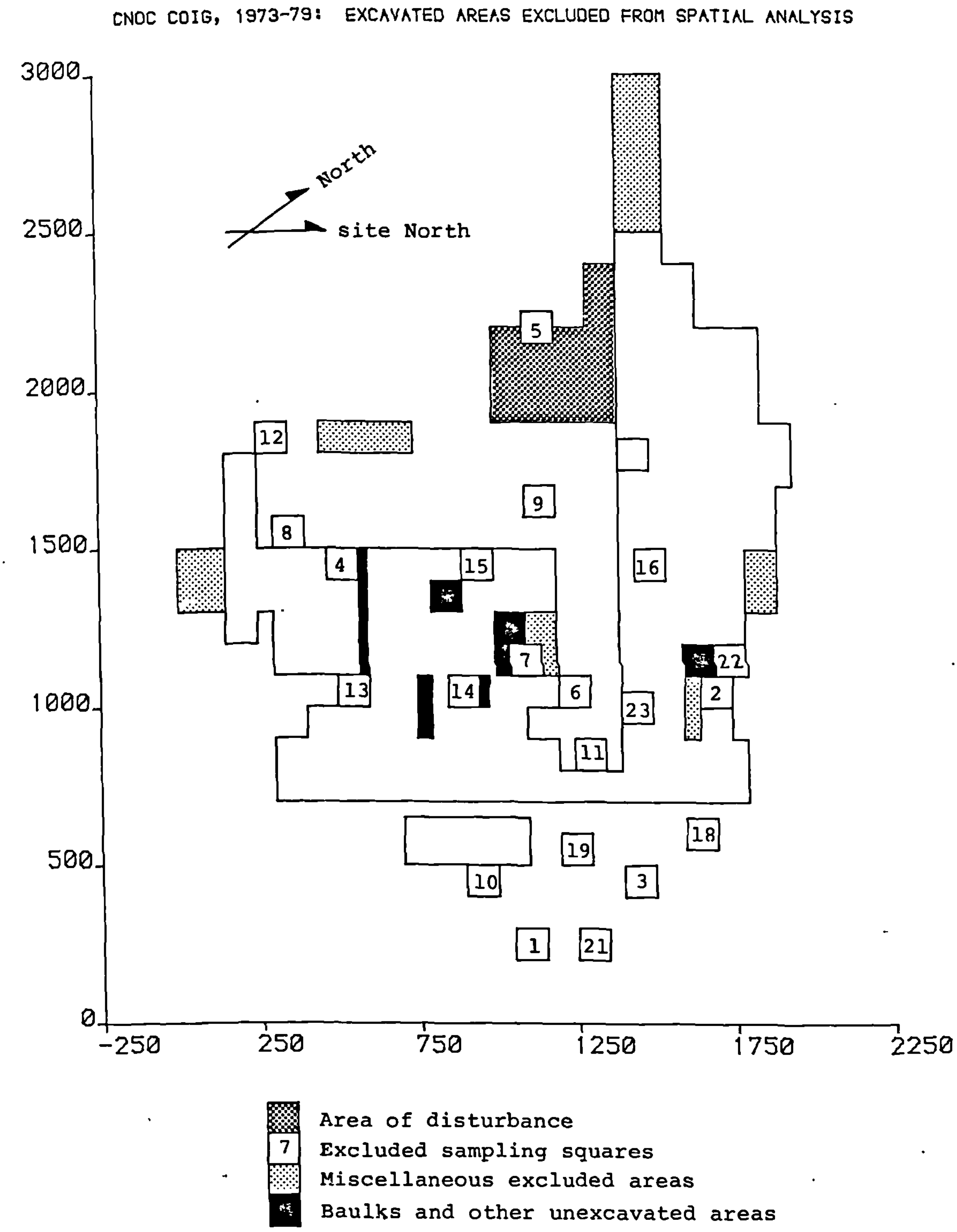

Figure 4. Plan of Cnoc Coig Showing the Excavated Areas Which Are Excluded for the Purposes of Spatial Analysis.

because their data, which are fairly sparse in any case, are a mixture of materials, most of which cannot be definitely ascribed to the late Mesolithic and much of which is clearly post-Mesolithic. Additionally, two squares (N & O / 3) on the northern edge of the midden were dug rapidly without having recorded the precise three-dimensional locations of the few finds within them; as a result, these squares must also be excluded. Two other shallow areas on the periphery of the site (Trench C and the area south of Trenches G and G1) are not included in the present study because they yielded a total of only three *in situ* and two sieved finds and none of the former are data which are of relevance here. Finally, in one square (M / 10) and three half squares (J & K / 5 and L / 10), excavation was begun but was then abandoned and never resumed; because these squares were only partially dug, they are not comparable with the fully excavated squares and hence, the few finds found in their uppermost levels cannot be included herein for spatial analysis.

Furthermore, Figure 4 also shows a comparatively large area on the western side of the site which is also excluded -- this includes Trenches M, R and T and squares T - V / 10 & 11 (see Fig. 3). This area revealed evidence of massively disturbed deposits and for this obvious reason, the data from within these squares cannot be regarded as reliable. It is this disturbed area which Mellars (1981: 518) suggests might be the location of Galloway's dig at Cnoc Riach during the 1880s.

In Chapter 4, where the counts for the various types of finds from within the midden are given, the finds from all these excluded areas (*except* the 21 sampling squares) are grouped within the "other" category as opposed to the "*in situ*" category, regardless of whether or not they were recorded *in situ* when excavated. Also included in this "other" category is the final group of finds which are not included in the spatial analyses which follow. These are finds which do come from areas of the site included herein but which are excluded because they were not recorded *in situ* -- that is, these are the finds, most of which obviously are fairly small fragments, which were not located by trowelling but rather when the trowelled deposits were sieved. Overall, these sieved finds constitute most of those included within the "other" cateogory. As will be seen in Chapter 4, for most types of finds, the "other" category represents a fairly small proportion of the total number of finds. In other words, for most items, the majority of finds were located by trowelling and so are included as *in situ* data.

In summary, the finds from Cnoc Coig fall into four groups: (1) *in situ* finds in areas included in the present study; (2) sieved finds from included areas; (3) *in situ* and sieved finds in areas excluded herein from further analysis; and (4) finds from the 21 sampling squares. No data from group (4) are used in the present work. Groups (2) and (3) form the "other" category used in the tables of Chapter 4 but, aside from being used to show the total numbers of finds from the midden, they play no part in the spatial analyses. Group (1) constitutes the bulk of the finds data from the site and comprises the data base for the present study.

It was stated above that the excavated portions of Cnoc Coig after the four field seasons totalled 186.7 m^2, representing about 70% of the area of the site. However, after eliminating the excluded areas which have just been defined, the total area of the midden that is used in the present study is 136.7 m^2 which, in terms of volume, represents about 42 m^3 of deposit. As can be seen in Figure 5 below, the excavated area used in this study is highly irregular in shape, is composed of three discontinuous areas, and contains four blank areas or "holes" within its boundaries. As will be discussed in more detail in Chapter 5, this imposes severe restrictions on the use of "normal" statistical techniques of spatial analysis employed in archaeology (such as nearest-neighbour analysis), but this does not mean that such an irregular area is completely unamenable to spatial analysis, nor even that it prevents the utilization of some statistical techniques (see Fieller *et al.* 1983).

The Nature of the Cnoc Coig Shell Midden

General Characteristics

By their very nature, shell middens are deposits whose volume accumulates comparatively quickly because the bulk of the deposit is a result of human rather than natural agents. Because of this, there can be little doubt that most of the material found in the deposits is present as a result of human activity. In short, the integrity of shell midden deposits is by definition high, whereas, as was discussed above in Chapter 1, the degree of resolution of such deposits characteristically is low.

In contrast to the much more conspicuous mounds of Caisteal nan Gillean I (C.N.G. I) and Cnoc Sligeach, the Cnoc Coig shell midden is a low dome-shaped accumulation, with the highest point being on the east-north-eastern side of the site from which the midden surface slopes gently away to the west and south. Of course, the depth of the deposit varies considerably, as shown in Figure 5. As can be readily seen, the deepest part of the site is on the eastern (seaward) side where it attains a depth of some 65 cm, while the shallowest areas on the western and south-western margins of the site have less than 10 cm of midden deposit.

Aside from depth, the midden also varies in terms of the nature of the deposit. Generally, it consists of discarded shells intermixed with soil. As with the other Obanian sites on Oronsay, the molluscan shell remains are dominated by limpets (*Patella vulgata* and *P. aspera*), with smaller quantities of the common periwinkle (*Littorina littorea*), the dog whelk (*Nucella lapillus*), the common mussel (*Mytilus edulis*) and several other minor species (see Mellars 1978: 388; Mellars & Payne 1971: 398). However, the deposit is not uniform throughout, neither in

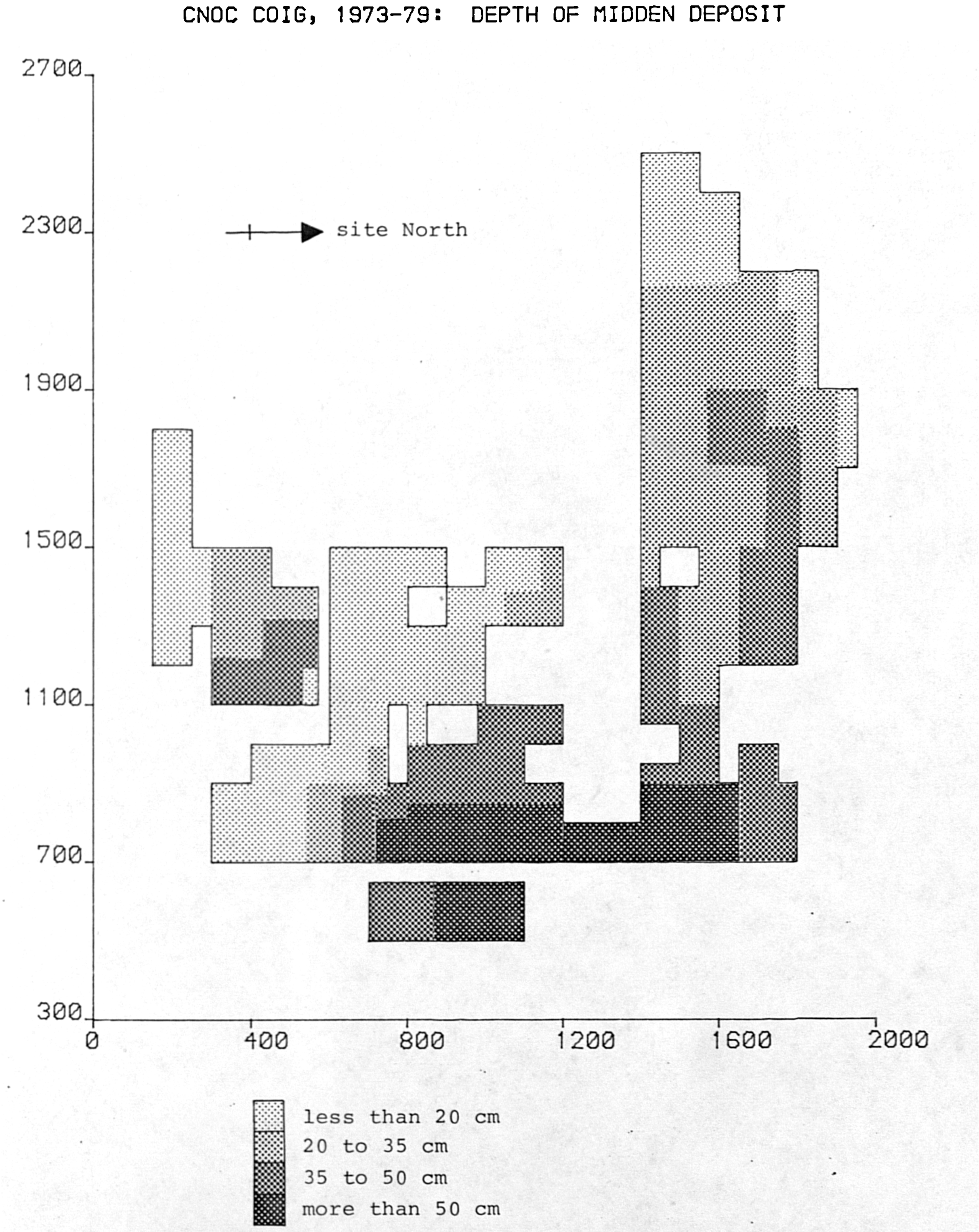

Figure 5. Plan of Cnoc Coig Showing the Depth of the Midden Deposits.

terms of the ratio of shell to soil matrix, nor in terms of the degree of comminution of the shells. Mellars (1978: 389) has noted that the midden essentially comprises two kinds of deposits, which he provisionally refers to as "shell heaps" and "occupation surfaces" -- the former consist of accumulations of very loose and largely unbroken limpet shells with very little intervening matrix, while the latter comprise more highly comminuted shell intermixed with a much higher proportion of soil matrix. In terms of location, it may be generalized that the loose shell heaps tend to occur more commonly on the eastern (seaward) side of the site, whereas the occupation surfaces tend to occur predominantly on the western (landward) side of the midden (Mellars 1978: 389).

The Effects of Occupational Disturbance

This distinction between shell heaps and occupation surfaces leads to another important consideration. The variability of the Cnoc Coig deposits in terms of the degree of comminution of the shells is presumably a function of the amount of trampling during occupation. With regards to spatial analysis and the locations of finds within the site, it is important to consider the possible effects of trampling as a formation process.

As has been realized for some time, and as was explicitly discussed by Matthews (1965), the ongoing activities of people on living sites can involve the stratigraphic disturbance of materials already laid down, particularly in the upper layers of a deposit. As Matthews (1965: 295-296) observed, such human activities as hollowing out hearths and digging post holes or pits or graves result in the upward movement of earlier elements into the later layers and, as this process continues, the major zone of disturbance moves upward as the deposit accumulates; for the sake of discussion, Matthews assumes a zone of disturbance of about 30 cm. Of course, as Villa (1982: 278) has pointed out, gross processes of occupational disturbance such as those referred to by Matthews are comparatively easy to identify stratigraphically.

However, Stockton (1973: 115-117) has recognized a more subtle form of occupational disturbance, namely, trampling. Studying a multi-level inland rock shelter in Australia, which had a loose and fairly dry sandy matrix, Stockton (1973: 115) observed the mixing of apparently undisturbed levels such that it seemed that some objects (especially smaller ones) had been pressed downwards and others (especially larger ones) had been moved upwards. Stockton attributed this vertical mixing and resultant size sorting to trampling and, by means of an experiment, he (1973: 116) showed that trampling can in fact create such an effect (see also Villa & Courtin 1983).

In an ethnoarchaeological context, Gifford (1978: 81-82; Gifford & Behrensmeyer 1977: 257-258) has inferred that trampling of only four days duration on the loose, sandy surface of a Dassanetch occupation site was responsible for the observed size-dependent sorting of animal bones on the site -- larger bones remained on the surface, while smaller bones, representing about 90% of the total site assemblage, were found displaced downwards into the subsurface layer. Yellen (1977: 103) observes that essentially the same situation occurs in !Kung habitation sites. It is not recorded in either case how far below the surface these trampled objects were found. In any case, this size sorting of objects in a deposit may also result from differential scavenging and reuse of artifacts within a site (Baker 1978), while mixing, and perhaps also size sorting, may result from natural processes of pedoturbation, not all of which will necessarily leave clearly visible, macroscopic traces of vertical displacement.

The implications of these researches are far-reaching: individual occupational episodes may in fact be represented by a considerable depth of deposit due to the vertical displacement of objects and, concomitantly, in multi-occupation sites, discrete levels within a seemingly undisturbed deposit may in fact have undergone some mixing as a result of occupational disturbance and other processes. Regardless of the specific processes invoked, a number of recent studies have shown through refitting of conjoinable stone and bone fragments that materials from a single occupational episode can span a considerable depth range, for example, up to 40 cm (Van Noten et al. 1980: 47-48) or even 50 cm (Bunn et al. 1980: 116-118) -- for a recent review and discussion, see Villa (1982).

Since these researches mostly involve sites with fairly soft and loose sandy occupational surfaces, it is questionable just how relevant their results are to shell midden deposits. Because of this, and given that the occupational surface areas on the landward side of Cnoc Coig presumably underwent considerable amounts of trampling, the work of Hughes and Lampert (1977) assumes particular importance since they have pursued this matter of occupational disturbance in relation to shell midden deposits. In general, they note that:

> Shell midden cappings, consisting largely of whole shells and fragments greater than 5 mm, are difficult to disturb, especially by treadage and scuffage, the major processes invoked by Matthews and Stockton. This is especially so on open sites where the deposits are bonded by grasses.... As well as giving physical resistance to displacement, discarded shell has a high bulk for the quantity of food actually consumed, resulting in deposits that are deep for their age, with cultural units well separated vertically, and less likely, therefore, to have suffered mixing of materials significantly disparate in time (Hughes & Lampert 1977: 136).

Their comparison of a coastal shell midden (Currarong I) with an inland rock shelter (Sassafras I) in Australia confirms other investigations which have shown that sites with a loose sandy matrix, like Sassafras I, are highly susceptible to occupational disturbance such that there are only vague relationships between the depth of items and their age, particularly in the case of shallow and slowly accumulating deposits; Currarong I, on the other hand, revealed far more resistance to occupational disturbance and the consequent mixing of separate occupational events and blurring of depth-age relationships. Thus, this study suggests that shell midden sites, like Cnoc Coig, are likely to be deposits with a relatively high degree of stratigraphic integrity, even in areas of a site which have undergone considerable amounts of trampling. And of course, the relatively untrampled shell heap areas at Cnoc Coig may be expected to have suffered virtually no effects from occupational disturbance.

Faunalturbation

Finally, mention should be made of faunalturbation as a potential formation process operative at Cnoc Coig. During the 18th century, rabbits were introduced to Oronsay and Colonsay as a cheap source of food for crofters on the islands. The rabbits have flourished and, not surprisingly, the area around Cnoc Coig has not escaped their incessant burrowing. However, virtually all rabbit burrows encountered during the excavation of the site were located in sterile sand either above or below the midden (P. Mellars, personal communication), the shell deposits themselves presumably offering an unsuitable medium for burrowing which is avoided by the rabbits. Therefore, rabbit burrowing may be presumed to have caused only minimal disturbance of the midden deposits, the only possible significant effect being the occasional collapse of burrows immediately below the midden which might have caused some local subsidence of the deposits. It is not possible to identify specific items which might have been disturbed by such occurrences, but suffice it to say that any vertical displacement of objects caused by the subsidence of rabbit burrows will have tended more to blur patterning in the distribution of items (by obscuring vertical relationships) than to create spurious patterning. Regardless of such possible effects, it would seem fair to say that faunalturbation from rabbits is of minimal importance and should not offer a serious obstacle to a spatial analysis of the Cnoc Coig shell midden.

CHAPTER 4

DESCRIPTION AND ENUMERATION OF THE SMALL FINDS DATA FROM CNOC COIG

In this chapter, details will be given concerning the classification, description and enumeration of the small finds from Cnoc Coig which were recorded *in situ* during the excavations. However, it should be noted that the classified data presented below include not only the *in situ* small finds from the areas of the site used in the present study, but also, as was explained above (pp. 68-71), small finds which either are sieved from areas included in the present study or are from excluded areas. In the counts of the various classes of data given below, these finds are designated as belonging to the category of "other" finds, as opposed to the *in situ* finds which are actually used in the spatial analysis. It should be reiterated that no small finds from the 21 sampling squares are included in this category of "other" finds.

Bone Remains

Introduction

In this section, details will be provided on the vertebrate faunal remains from Cnoc Coig, but this does not include finds of red deer antler or worked bone -- these data will be treated separately in later sections. During the excavations at Cnoc Coig, bones were recorded *in situ* and given a separate finds number if either the fragment was greater than 5 cm in any dimension or the fragment was an articular end or otherwise had diagnostic processes which might enable it to be identified. Similarly, sieved bones were given a small finds number if they met either of these criteria. The remaining small, unidentifiable bone fragments from each "unit" (i.e. each arbitrary 10 cm level) of each square were bagged together as general bone finds from each square/unit.

These vertebrate faunal remains from Cnoc Coig may be coarsely divided into four broad categories: mammal bones, bird bones, fish bones, and unidentifiable bones. The collecting and recording procedure employed during the excavations was such that the use of the two criteria mentioned above for defining which bones were to be treated as small finds was intended to apply to all fragments which might possibly be identified as either bird or mammal. Inevitably, this procedure was overly inclusive in that some bones so collected do not belong to these two classes. In other words, some small-finded bones turned out to be fish bones, while others were not even identifiable to the class level. Because the vast majority of fish bone was collected by a different strategy, these few fish bones which were small-finded, and even recorded _in situ_ in some cases, represent a very small and biased sample, biased towards the larger bones which were mistaken during excavation to be mammal or bird. Because of this, any analysis of the distribution of these few fish bones would give a very misleading picture of the overall distribution of fish remains in the site; hence, these data are not used in the present study. Full details concerning the fish remains from Cnoc Coig and other sites on Oronsay are available elsewhere (Mellars 1978: 380-385; Mellars & Wilkinson 1980; Wilkinson 1981). Thus, the bone data which are relevant to the present study are all identified mammal and bird bones and, to a much lesser extent, the _in situ_ unidentifiable bones.

Before outlining the specific details of the bone identifications from Cnoc Coig, mention should be made of two matters relating to the codification of the bone data in the computer data file; further details of the data base used for computer analysis will be given in Chapter 5. Firstly, there is the matter of what constitutes a single find of bone as codified as one record in the data file and as given in the counts presented in the following tables. In the simplest case, a single bone fragment which was recorded as a separate small find during the excavations is counted as one find. If several fragments were found together and so bagged as one small find, these were also considered to be one find, provided that the two or more fragments were identified as being the same bone element of the same species (i.e. provided that it is reasonable to assume them to be fragments of the same bone). However, if different elements, or of course different species, were included in the fragments of one small find, then each distinct fragment is considered to be a separate find. Thus, because some small finds included fragments of several different bones, the numbers of finds recorded in the following tables are greater than the actual number of small finds collected and recorded during the excavations. On the other hand, because many finds which are treated here as single entities include several fragments (of one bone), the counts of finds in the tables below are less than the actual number of small-finded fragments recovered from the Cnoc Coig excavations.

Secondly, there is the matter of the bone element groupings which were used to codify the bone data onto the data file for computer analysis. Twenty-nine categories have been used, and these are defined in Table 3. As can be seen, some categories are for specific bone elements, particularly in the case of long bones, while others represent groupings of related bones. These multiple bone categories were used for two reasons: firstly, because even if specific categories were used for each bone element, many would have had few (if any) finds within them; and secondly, because many identifications could not be made to specific bones anyway. For example, if a separate category were used for every type of phalange, the largest number of finds would fall into the general category of undifferentiated phalanges anyway, while most of the specific phalange types would have only very small sample sizes. The same situation also applies in particular to skull bones, teeth, ribs, and the specific vertebrae of the different types of vertebra. It should be emphasized that the use of these groupings does not mean that the more specific identifications are unavailable if these are deemed relevant to the

Table 3. Description of the 29 Bone Element Categories.

01 - skull

02 - maxilla and upper teeth

03 - mandible and lower teeth

04 - undifferentiated teeth

05 - quadrate (for birds only)

06 - atlas, axis and cervical vertebrae

07 - clavicle (for mammals) and furcula (for birds)

08 - coracoid (for birds only)

09 - scapula

10 - sternebrae and ribs

11 - thoracic and lumbar (= dorsal) vertebrae

12 - sacral vertebrae (for mammals) and synsacrum (for birds)

13 - pelvic bones

14 - caudal vertebrae

15 - undifferentiated vertebrae

16 - humerus

17 - radius

18 - ulna

19 - femur

20 - patella

21 - fibula

22 - tibia (for mammals) and tibiotarsus (for birds)

23 - undifferentiated long bones

24 - carpal bones (for mammals) and radiale and ulnare (for birds), and metacarpals (for mammals) and carpometacarpus (for birds)

25 - tarsal bones (for mammals only), and metatarsals (for mammals) and tarsometatarsus (for birds)

26 - undifferentiated metapodials (for mammals only)

27 - phalanges (all for mammals and undifferentiated only for birds), and sesamoids (for mammals only)

28 - wing phalanges (for birds only)

29 - foot phalanges (for birds only)

analysis -- such specific information can always be obtained from the lists of faunal identifications, even if they are not embodied in the computer data file.

Mammal Bones

The mammal bones from the recent excavations on Oronsay have been identified and analysed by Dr. Caroline Grigson, and details about the mammal bone assemblages from Cnoc Coig and the other Oronsay sites are available elsewhere (Grigson 1981; 1985). Our concern here is solely with the Cnoc Coig data, particularly with the mammal bones recorded _in situ_. Table 4 lists the numbers of _in situ_ and "other" bones which have been identified as belonging to various age categories of the different mammal taxa recognized in the assemblage. As can be readily seen, aside from the general category of mammal spp., only seven taxa are represented in the Cnoc Coig assemblage, one of which (ungulate spp.) is a composite category made up of bones which probably belong to two of the identified species.

It can be seen from Table 4 that the seal remains from Cnoc Coig are grouped together as one taxonomic entity, even though two species are present in the assemblage -- the reason for this should be explained. In spite of being aware that both grey seal (_Halichoerus grypus_) and common seal (_Phoca vitulina_) were recognized in the faunal assemblages recovered from earlier excavations at C.N.G. I (Grieve 1885: 54-55) and Cnoc Sligeach (Bishop 1914: 105), Grigson (1981: 174) initially only recognized the presence of grey seal in the material recovered from the recent excavations on Oronsay. Of course, in analysing this material, not all seal remains could be specifically attributed to grey seal -- approximately 52% of the finds of adult seal bone from Cnoc Coig were identified as definite or probable grey seal, while the remainder were identified as being either "definitely seal, species indeterminate" or "probably seal" (ca. 36% and 12% respectively). Since only one species of seal was specifically

Table 4. Summary of Mammal Bone Identifications from Cnoc Coig, 1973-79, Showing the Number of In Situ and "Other" Bones Assigned to Each Age Category of Each Taxon. Counts are based on identifications by C. Grigson (personal communication), except for human bones which are by Meiklejohn and Denston (1985).

Taxon	Age Category	In Situ	"Other"	Total
Seal spp. (*Halichoerus grypus* & *Phoca vitulina*)	foetal	38	11	49
	young	23	9	32
	adult	211	54	265
	all ages	272	74	346
Otter (*Lutra lutra*)	young	3	5	8
	adult	51	45	96
	all ages	54	50	104
Red Deer (*Cervus elaphus*)	young	5	1	6
	adult	48	15	63
	all ages	53	16	69
Pig (Wild Boar) (*Sus scrofa*)	young	4	1	5
	adult	26	21	47
	all ages	30	22	52
Ungulate spp. (red deer? pig?)	young	1	0	1
	adult	3	5	8
	all ages	4	5	9
Human (*Homo sapiens*)	young	1	0	1
	adult	44	2	46
	all ages	45	2	47
Cetacean	young	1	0	1
	adult	8	0	8
	all ages	9	0	9
Mammal spp.	unknown	120	75	195
Totals:		587	244	831

identified, these latter two categories were attributed to grey seal according to standard palaeontological practice (C. Grigson, personal communication). On this basis, the seal remains from Cnoc Coig were treated as a single taxonomic unit for the purpose of spatial analysis. Subsequent to the completion of the spatial analysis contained in the present study, Grigson (1985) has amended her identifications in that two of the adult seal bones are now attributed to common seal. The effect of this amendment is that the less specifically identified seal bones can no longer be assumed to represent only grey seal, although Grigson (1985) points out that most of these bones are still probably referrable to grey seal given the predominance of grey over common seal among the specifically identified bones in the assemblage.

It should also be mentioned that the counts for red deer include about ten bones which are actually identified as being "large ungulate". According to standard practice, these are included with red deer because no other sufficiently large ungulate is recognized in the site's assemblage (C. Grigson, personal communication). In contrast, the bones assigned to the category of ungulate spp. are not of sufficient size to be referrable to red deer on this same basis; rather, on the basis of size and in the absence of any diagnostic features, they could derive either from small red deer or from pigs. The general category of mammal spp. is one of little consequence since it represents unidentifiable fragments which were recorded _in situ_ only because they were judged during excavation to be potentially identifiable, even though they turned out not to be so; they thus represent only a small proportion of the unidentifiable mammal bone from the site, the vast bulk of which was recorded only in terms of square/unit provenance.

Given these comments on the nature of the taxonomic groupings employed, a number of general observations may be made on the data shown in Table 4. Firstly, in terms of numbers of bones, seal is by far the most abundant mammal represented in the Cnoc Coig assemblage, followed distantly by otter and then red deer, pig, human, and cetacean and ungulate spp. Secondly, the age distribution within each taxon shows considerable variation. Considering the subadult bones as a percentage of the total, seal again heads the list, with nearly a quarter (23.4%) of the bones being identified as subadult; on the other hand, the proportion is only 2.1% for human bones, while the other taxa fall between these two extremes (7.7% for otter, 8.7% for red deer, 9.6% for pig, and 11.1% each for cetacean and ungulate spp.).

Another point of interest for our purposes here concerns the relative proportions of the _in situ_ and "other" bones as shown in Table 4. Considering the _in situ_ bones as a percentage of the total, the relative proportions vary considerably, from 100% for cetaceans down to 44.4% for ungulate spp., with the remainder lying somewhere between these two extremes (95.7% for human, 78.6% for seal, 76.8% for red deer, 57.7% for pig, and 51.9% for otter). This variation is of interest because it reflects *differing* degrees of possible bias in the _in situ_ data which might effect the study of spatial distributions. In other words, since these data are a sample of the total assemblage, the _in situ_ counts are presumably a more representative sample for some taxa than for others. In this regard, aside from the general categories of ungulate spp. and mammal spp., otter and pig may be particularly singled out for having relatively small proportions of their bones recorded as _in situ_ data. Nevertheless, even in these two cases, the _in situ_ bones constitute more than 50% of their assemblages, and this is hopefully a sufficiently large sample to allow meaningful statements to be made regarding their spatial distributions.

With this possible sample bias in mind, Table 5 presents, for the _in situ_ bones only, the numbers of bones assigned to the bone element categories for each age category of each taxon. This table is included here in order to outline in general terms the body part

Table 5. Summary of Mammal Bone Identifications from Cnoc Coig, 1973-79, Showing the Number of _In Situ_ Bones Assigned to Each Bone Element Category for Each Age Category of Each Taxon. Counts are based on identifications by C. Grigson (personal communication), except for human bones which are by Meiklejohn and Denston (1985).

	Otter:			Cetacean:		
Bone Element Category	yg.	ad.	all	yg.	ad.	all
skull	0	3	3	0	0	0
maxilla & upper teeth	0	3	3	0	0	0
mandible & lower teeth	1	8	9	0	0	0
undifferentiated teeth	0	1	1	0	0	0
cervical vertebrae	0	0	0	0	0	0
clavicle	0	0	0	0	0	0
scapula	0	0	0	0	0	0
sternebrae & ribs	0	2	2	1	5	6
dorsal vertebrae	0	0	0	0	0	0
sacral vertebrae	0	0	0	0	0	0
pelvic bones	0	0	0	0	0	0
caudal vertebrae	0	0	0	0	0	0
undiffer. vertebrae	0	3	3	0	3	3
humerus	0	3	3	0	0	0
radius	1	5	6	0	0	0
ulna	0	5	5	0	0	0
femur	1	3	4	0	0	0
patella	0	0	0	0	0	0
fibula	0	1	1	0	0	0
tibia	0	1	1	0	0	0
undiffer. long bones	0	0	0	0	0	0
carpals/metacarpals	0	0	0	0	0	0
tarsals/metatarsals	0	3	3	0	0	0
undiffer. metapodials	0	5	5	0	0	0
phalanges	0	4	4	0	0	0
unidentifiable	0	1	1	0	0	0
totals:	3	51	54	1	8	9

Table 5. Continued.

Bone Element Category	Red Deer: yg.	ad.	all	Pig: yg.	ad.	all
skull	4	0	4	0	0	0
maxilla & upper teeth	0	0	0	1	0	1
mandible & lower teeth	0	2	2	0	1	1
undifferentiated teeth	0	0	0	0	2	2
cervical vertebrae	0	0	0	0	0	0
clavicle	0	0	0	0	0	0
scapula	0	1	1	0	0	0
sternebrae & ribs	0	1	1	0	0	0
dorsal vertebrae	0	2	2	0	0	0
sacral vertebrae	0	0	0	0	0	0
pelvic bones	0	1	1	0	1	1
caudal vertebrae	0	0	0	0	0	0
undiffer. vertebrae	0	1	1	0	0	0
humerus	0	0	0	0	0	0
radius	0	2	2	0	1	1
ulna	0	0	0	1	2	3
femur	1	1	2	0	1	1
patella	0	1	1	0	0	0
fibula	0	1	1	0	1	1
tibia	0	2	2	0	5	5
undiffer. long bones	0	4	4	0	0	0
carpals/metacarpals	0	10	10	0	1	1
tarsals/metatarsals	0	10	10	0	4	4
undiffer. metapodials	0	5	5	0	0	0
phalanges	0	4	4	2	7	9
unidentifiable	0	0	0	0	0	0
totals:	5	48	53	4	26	30

Table 5. Continued.

Bone Element Category	Ungulate spp.: yg.	ad.	all	Human: yg.	ad.	all
skull	0	0	0	0	3	3
maxilla & upper teeth	0	0	0	0	2	2
mandible & lower teeth	0	0	0	0	0	0
undifferentiated teeth	0	0	0	0	0	0
cervical vertebrae	0	0	0	1	2	3
clavicle	0	0	0	0	4	4
scapula	0	0	0	0	0	0
sternebrae & ribs	0	0	0	0	1	1
dorsal vertebrae	0	0	0	0	0	0
sacral vertebrae	0	0	0	0	0	0
pelvic bones	0	0	0	0	1	1
caudal vertebrae	0	0	0	0	0	0
undiffer. vertebrae	0	0	0	0	1	1
humerus	0	1	1	0	0	0
radius	0	0	0	0	0	0
ulna	0	0	0	0	0	0
femur	0	1	1	0	0	0
patella	0	0	0	0	1	1
fibula	0	0	0	0	1	1
tibia	0	1	1	0	1	1
undiffer. long bones	0	0	0	0	0	0
carpals/metacarpals	0	0	0	0	5	5
tarsals/metatarsals	0	0	0	0	5	5
undiffer. metapodials	0	0	0	0	0	0
phalanges	1	0	1	0	17	17
unidentifiable	0	0	0	0	0	0
totals:	1	3	4	1	44	45

Table 5. Continued.

Bone Element Category	Seal spp.: ft.	yg.	ad.	all	Mammal spp.
skull	4	2	13	19	0
maxilla & upper teeth	0	0	5	5	0
mandible & lower teeth	1	4	7	12	0
undifferentiated teeth	0	0	1	1	1
cervicle vertebrae	0	0	6	6	1
clavicle	0	0	0	0	0
scapula	1	1	1	3	0
sternebrae & ribs	3	2	45	50	3
dorsal vertebrae	1	1	17	19	0
sacral vertebrae	0	0	1	1	0
pelvic bones	2	0	3	5	0
caudal vertebrae	0	1	4	5	0
undiffer. vertebrae	6	0	12	18	1
humerus	1	1	3	5	0
radius	0	0	2	2	0
ulna	0	0	2	2	0
femur	1	1	3	5	0
patella	0	0	0	0	0
fibula	1	0	4	5	0
tibia	1	1	3	5	0
undiffer. long bones	0	0	0	0	1
carpals/metacarpals	2	2	12	16	1
tarsals/metatarsals	4	1	19	24	0
undiffer. metapodials	0	0	0	0	0
phalanges	10	6	48	64	0
unidentifiable	0	0	0	0	112
totals:	38	23	211	272	120

representation by age and taxon for the mammal bone data used in the spatial analysis in this study -- for the whole of the Cnoc Coig mammal bone assemblage, see Grigson (1985) for further details regarding bone element representation by age and by species.

Bird Bones

The bird bones from the recent excavations on Oronsay have been identified by Dr. Don Bramwell, and full details about the avian remains recovered from Cnoc Coig and the other Oronsay sites will be published in due course. Our concern here lies primarily with the bird bones from Cnoc Coig which were recorded in situ. Table 6 shows the numbers of in situ and "other" bones which have been identified as belonging to the 57 different taxa recognized in the avian assemblage from the site.

Aside from the general category of bird spp., these taxa include 42 species, nine genera or other groupings of closely related species, three families and two orders. Of course, the bones which could only be assigned to the five higher taxonomic units (families and orders) might well belong to the species or genera within them which have been recognized in the site's avian assemblage. Similarly, for four of the nine groups of related species (i.e. goose spp., duck spp., rail/wader spp. and gull spp.), the bones so classified might be attributable to certain species which have been positively identified in the bird bone assemblage; and in two other cases (razorbill/black guillemot and razorbill/guillemot), the bones definitely belong to one of two recognized species. Concerning all of the 14 taxonomic units above the species level, in only one case might the bones assigned to one of these taxa be grouped together with a particular species, on the same basis as with large ungulate/red deer in the mammal bone assemblage. This one case is goose spp. which might be lumped together with greylag goose since no other goose species has been positively identified. However, this has not been done here because the bones assigned to the

Table 6. Summary of Bird Bone Identifications from Cnoc Coig, 1973-79, Showing the Number of In Situ and "Other" Bones Assigned to Each Taxon. Counts are based on identifications by D. Bramwell (personal communication).

Taxon	In Situ	"Other"	Total
Great Northern Diver (*Gavia immer*)	0	1	1
Fulmar (*Fulmarus glacialis*)	5	3	8
Manx Shearwater (*Puffinus puffinus*)	3	0	3
Order Pelicaniformes	1	2	3
Gannet (*Sula bassana*)	10	6	16
Cormorant (*Phalacrocorax carbo*)	14	6	20
Shag (*Phalacrocorax aristotelis*)	4	4	8
Family Anatidae	0	1	1
Bewick's Swan (*Cygnus columbianus*)	29	0	29
Whooper Swan (*Cygnus cygnus*)	5	1	6
Goose spp.	7	5	12
Greylag Goose (*Anser anser*)	4	5	9
Duck spp.	4	5	9
Teal Duck (*Anas crecca*)	12	2	14
Mallard (*Anas platyrhynchos*)	0	2	2
Long-tailed Duck (*Clangula hyemalis*)	2	0	2
Velvet Scoter (*Melanitta fusca*)	1	0	1
Common Scoter (*Melanitta nigra*)	1	2	3
Eider Duck (*Somateria mollissima*)	9	7	16
Shelduck (*Tadorna tadorna*)	0	2	2
Sparrowhawk (*Accipiter nisus*)	1	1	2
Buzzard (*Buteo buteo*)	1	8	9
Quail (*Coturnix coturnix*)	3	8	11
Crane (*Grus grus*)	1	0	1
Corncrake (*Crex crex*)	0	2	2
Spotted Crake (*Porzana porzana*)	0	3	3
Water Rail (*Rallus aquaticus*)	0	1	1
Rail/Wader spp.	0	3	3
Curlew (*Numenius arquata*)	5	3	8
Black-tailed Godwit (*Limosa limosa*)	1	0	1
Greenshank (*Tringa nebularia*)	1	0	1

Table 6. Continued.

Taxon	In Situ	"Other"	Total
Sandpiper sp. (*Tringa* sp.)	1	0	1
Snipe (*Gallinago gallinago*)	0	3	3
Woodcock (*Scolopax rusticola*)	3	1	4
Knot (*Calidris canutus*) (or *Sandwich Tern?*)	0	1	1
Gull (*Larus* spp.)	0	2	2
Herring/Lesser Black-backed Gull (*Larus argentatus*/*L. fuscus*)	2	2	4
Common Gull (*Larus canus*)	0	1	1
Great Black-backed Gull (*Larus marinus*)	0	3	3
Black-headed Gull (*Larus ridibundus*)	0	1	1
Sandwich Tern (*Sterna sandvicensis*)	0	1	1
Family Alcidae	3	1	4
Great Auk (*Alca impennis*)	46	12	58
Little Auk (*Alle alle*)	0	1	1
Razorbill (*Alca torda*)	12	24	36
Black Guillemot (*Cepphus grylle*)	4	1	5
Guillemot (*Uria aalge*)	14	25	39
Razorbill/Black Guillemot	0	9	9
Razorbill/Guillemot	1	1	2
Puffin (*Fratercula arctica*)	2	9	11
Order Passeriformes	0	1	1
Family Turdidae	0	1	1
Blackbird/Ring-ouzel (*Turdus merula*/*T. torquatus*)	0	3	3
Redwing (*Turdus iliacus*)	0	1	1
Redstart (*Phoenicurus phoenicurus*)	1	0	1
Raven (*Corvus corax*)	3	0	3
Bird spp.	28	34	62
Totals:	244	221	465

category of goose spp. include some which may represent a smaller species of goose. At any rate, for the remaining 13 higher taxonomic units, the bones assigned to these taxa could be referrable to at least two species which have been positively identified.

One feature of the bird bone assemblage from Cnoc Coig which is immediately obvious from Table 6 is the large number of bird taxa which have been identified, which is in striking contrast to the mammal bones from the site. Related to this, another conspicuous feature of the avian assemblage which is readily apparent from Table 6 is that most taxa are represented by a small number of bones and indeed, many by only one bone. Based on the total numbers of bones, 17 taxa or 30.4% (excluding the general category of bird spp.) are represented by only one bone, while 37 taxa (66.1%) are represented by a mere five bones or less and 45 taxa (80.4%) by less than ten bones. Thus, only 11 taxa or 19.6% have ten or more bones assigned to them, and only five (8.9%) have 20 or more identified bones. With regard to these 11 most abundant taxa, except for the quail, all are either auks (Alcidae), pelicaniforms or anatids. Of these three groups, auks are by far the most abundant, with four species (great auk, razorbill, black guillemot and guillemot) accounting for 32.0% of the total number of bird bones; the three pelicaniform species (gannet, cormorant and shag) account for 10.1% of this total, while the four most abundant anatids (Bewick's swan, goose spp., teal duck and eider duck) account for 15.3%.

For the purposes of spatial analysis, the _in situ_ bone counts are of greater interest than the total numbers of bones. Of the 56 taxa (i.e. excluding bird spp.), Table 6 shows that 21 taxa (37.5%) are represented by no _in situ_ bones, while 11 other taxa (19.6%) are represented by only one _in situ_ bone and 15 others (26.8%) by between two and five bones. Thus, overall, 47 bird taxa or 83.9% are represented by five or less _in situ_ bones -- obviously, given these small sample sizes, very little can be said about the spatial distribution of these taxa. Of the nine birds which have more than five in situ bones, three species are auks, two are pelicaniforms and four are anatids. As is the case when the total bone counts are considered, the auks account for the largest percentage of the total number of in situ bones (29.9%), while the pelicaniforms account for 9.8% and the anatids for 23.4%. Thus, the general pattern as observed from the total bone counts -- with the auks, pelicaniforms and anatids being the most abundantly represented birds in the assemblage -- is repeated when only the in situ bones are considered. Consequently, despite the fact that 21 bird taxa from the Cnoc Coig assemblage have no in situ bones assigned to them, the in situ bird bone data provide a reasonably sound base for examining the spatial distribution of bird remains within the midden because these 21 taxa represent birds which have so few identified bones in total (less than five in all but one case) that, even if these bones were all in situ, very little could be said regarding their spatial distributions anyway. And on the other hand, the most abundant birds as indicated by the total bone counts are those which also have the highest numbers of in situ bones. However, it should be noted that the relative proportions of in situ to "other" bones varies considerably; for the most abundant taxa, the in situ bones expressed as a percentage of the total numbers of bones varies from 100% for Bewick's swan down to 33.3% for the razorbill.

Regarding the aging of the bird bones from Cnoc Coig, Table 7 provides a breakdown into age categories of the bone counts for each taxon. This table clearly shows that adult bones far outnumber those for subadults. In total, only 1.5% of the bird bones have been identified as being juvenile, while 83.7% are adult bones with the remaining 14.8% being classed as indeterminate -- these relative proportions are almost exactly the same when the in situ or the "other" bone counts are considered separately. Of the seven juvenile bones in the assemblage, only three have been identified to taxa below the class level; and in two of these cases, the juvenile bone is the only one assigned to that taxon.

Table 7. Summary of Bird Bone Identifications from Cnoc Coig, 1973-79, Showing the Number of In Situ and "Other" Bones Assigned to Each Age Category of Each Taxon. Counts are based on identifications by D. Bramwell (personal communication).

Taxon	Juvenile	Adult	Indeterminate	Total
Great Northern Diver	0	1	0	1
Fulmar	0	5	3	8
Manx Shearwater	1	2	0	3
Order Pelicaniformes	0	2	1	3
Gannet	0	16	0	16
Cormorant	0	19	1	20
Shag	0	8	0	8
Family Anatidae	0	1	0	1
Bewick's Swan	0	14	15	29
Whooper Swan	0	5	1	6
Goose spp.	0	11	1	12
Greylag Goose	0	8	1	9
Duck spp.	0	7	2	9
Teal Duck	0	14	0	14
Mallard	0	2	0	2
Long-tailed Duck	0	2	0	2
Velvet Scoter	0	1	0	1
Common Scoter	0	3	0	3
Eider Duck	0	15	1	16
Shelduck	0	2	0	2
Sparrowhawk	0	2	0	2
Buzzard	0	9	0	9
Quail	0	10	1	11
Crane	1	0	0	1
Corncrake	0	2	0	2
Spotted Crake	0	2	1	3
Water Rail	0	1	0	1
Rail/Wader spp.	0	3	0	3
Curlew	0	6	2	8
Black-tailed Godwit	0	1	0	1

Table 7. Continued.

Taxon	Juvenile	Adult	Indeterminate	Total
Greenshank	0	1	0	1
Sandpiper sp.	0	1	0	1
Snipe	0	3	0	3
Woodcock	0	4	0	4
Knot (or Sandwich Tern?)	0	0	1	1
Gull spp.	0	1	1	2
Herring Gull/ Lesser Black-backed Gull	0	4	0	4
Common Gull	0	1	0	1
Great Black-backed Gull	0	3	0	3
Black-headed Gull	0	1	0	1
Sandwich Tern	0	1	0	1
Family Alcidae	0	3	1	4
Great Auk	0	57	1	58
Little Auk	0	1	0	1
Razorbill	0	33	3	36
Black Guillemot	0	5	0	5
Guillemot	0	37	2	39
Razorbill/Black Guillemot	0	9	0	9
Razorbill/Guillemot	0	1	1	2
Puffin	0	10	1	11
Order Passeriformes	1	0	0	1
Family Turdidae	0	0	1	1
Blackbird/Ring-ouzel	0	2	1	3
Redwing	0	1	0	1
Redstart	0	1	0	1
Raven	0	3	0	3
Bird spp.	4	32	26	62
Totals:	7	389	69	465

The only remaining observations which need to be made at this juncture regarding the bird bone data from Cnoc Coig concern the bone elements which are represented by the in situ bone counts for each taxon. These data are presented in Table 8 -- note that the four in situ juvenile bones are indicated in this table, although the adult and indeterminate bones are not distinguished. As can be seen, the body parts which are most highly represented among the in situ bones are wings, the adjoining portions of the shoulder girdle (i.e. furcula, coracoid and scapula), and legs and feet. The most common element by far is the humerus which accounts for 20.5% of all in situ bones, followed by the ulna (9.0%), tibiotarsus (7.4%), coracoid (6.6%), tarsometatarsus (6.1%), and scapula (5.3%). Lumping related bones together, the six bone element categories for wing bones contain a total of 96 which accounts for 39.3% of all in situ bones, while the three categories for the adjoining bones of the shoulder girdle have 36 bones which is 14.8% of the total, and the five categories of leg and foot bones contain 43 bones representing 17.6% of the total. This general pattern for the in situ assemblage as a whole is mirrored by many of the individual taxa, particularly those which are most abundantly represented. For example, the relative proportions of wing, shoulder, and leg and foot bones for the razorbill are 50.0%, 16.7% and 25.0% respectively, while for the great auk these are 23.9%, 19.6% and 19.6%. Of course, as these two examples illustrate, these relative proportions of different body parts vary considerably from species to species.

Unidentifiable Bone

In addition to the small-finded mammal and bird bones, the excavations at Cnoc Coig yielded a substantial number of bones which were recorded in situ and given small finds numbers, but which turned out to be unidentifiable even to the class level. As was explained above (p. 79), like some fish bones, these bones were collected according to the procedure which was aimed at recovering identifiable

Table 8. Summary of Bird Bone Identifications from Cnoc Coig, 1973-79, Showing the Number of In Situ Bones Assigned to Each Bone Element Category for Each Taxon. Counts are based on identifications by D. Bramwell (personal communication). * indicates one juvenile bone.

Bone Element Category	Fulmar	Manx Shear-water	Pelican-iformes	Gannet
skull	0	0	0	0
maxilla	0	0	0	0
mandible	0	0	0	0
quadrate	0	0	0	1
cervical vertebrae	0	0	0	0
furcula	0	0	0	0
coracoid	2	0	0	3
scapula	0	0	0	0
sternebrae & ribs	0	0	0	1
dorsal vertebrae	0	0	0	0
synsacrum	0	0	0	0
pelvic bones	0	0	0	0
caudal vertebrae	0	0	0	0
undiffer. vertebrae	0	0	0	0
humerus	2	1	0	1
radius	0	0	0	0
ulna	1	1	1	2
femur	0	0	0	0
fibula	0	0	0	0
tibiotarsus	0	1*	0	1
undiffer. long bones	0	0	0	0
radiale & ulnare	0	0	0	1
carpometacarpus	0	0	0	0
tarsometatarsus	0	0	0	0
undiffer. phalanges	0	0	0	0
wing phalanges	0	0	0	0
foot phalanges	0	0	0	0
unidentifiable	0	0	0	0
totals:	5	3	1	10

Table 8. Continued.

Bone Element Category	Cormorant	Shag	Bewick's Swan	Whooper Swan
skull	0	0	0	0
maxilla	0	0	0	0
mandible	0	0	0	0
quadrate	0	0	0	0
cervical vertebrae	0	0	0	0
furcula	0	0	1	0
coracoid	0	0	1	0
scapula	0	0	1	1
sternebrae & ribs	1	0	0	0
dorsal vertebrae	1	0	0	0
synsacrum	0	0	0	0
pelvic bones	0	0	0	0
caudal vertebrae	0	0	0	0
undiffer. vertebrae	0	0	0	0
humerus	2	0	2	2
radius	2	1	2	1
ulna	0	1	3	0
femur	1	0	0	0
fibula	0	0	0	0
tibiotarsus	2	0	0	1
undiffer. long bones	0	0	0	0
radiale & ulnare	0	0	2	0
carpometacarpus	0	0	1	0
tarsometatarsus	2	2	0	0
undiffer. phalanges	0	0	0	0
wing phalanges	3	0	2	0
foot phalanges	0	0	0	0
unidentifiable	0	0	14	0
totals:	14	4	29	5

Table 8. Continued.

Bone Element Category	Goose spp.	Greylag Goose	Duck spp.	Teal Duck	Long-tailed Duck
skull	0	0	0	0	0
maxilla	0	0	0	0	0
mandible	0	1	0	0	0
quadrate	0	0	0	0	0
cervical vertebrae	0	0	1	1	0
furcula	0	0	0	1	0
coracoid	0	0	0	2	0
scapula	0	0	0	1	0
sternebrae & ribs	0	1	0	1	0
dorsal vertebrae	0	0	0	0	0
synsacrum	0	0	0	0	0
pelvic bones	0	0	0	1	0
caudal vertebrae	0	0	0	0	0
undiffer. vertebrae	0	0	0	0	0
humerus	1	0	0	2	1
radius	0	0	0	0	0
ulna	1	0	1	0	0
femur	0	0	1	1	0
fibula	0	0	0	0	0
tibiotarsus	1	1	0	0	0
undiffer. long bones	0	0	0	0	0
radiale & ulnare	0	0	0	0	0
carpometacarpus	0	0	1	0	0
tarsometatarsus	1	0	0	1	0
undiffer. phalanges	1	0	0	1	0
wing phalanges	0	0	0	0	1
foot phalanges	1	1	0	0	0
unidentifiable	1	0	0	0	0
totals:	7	4	4	12	2

Table 8. Continued.

Bone Element Category	Velvet Scoter	Common Scoter	Eider Duck	Sparrow-hawk
skull	0	0	0	0
maxilla	0	0	0	0
mandible	0	0	0	0
quadrate	0	0	0	0
cervical vertebrae	0	0	0	0
furcula	0	0	0	0
coracoid	0	0	2	0
scapula	0	0	2	0
sternebrae & ribs	0	0	0	0
dorsal vertebrae	0	0	0	0
synsacrum	0	0	0	0
pelvic bones	0	0	0	0
caudal vertebrae	0	0	0	0
undiffer. vertebrae	0	0	0	0
humerus	1	1	3	1
radius	0	0	0	0
ulna	0	0	1	0
femur	0	0	0	0
fibula	0	0	0	0
tibiotarsus	0	0	1	0
undiffer. long bones	0	0	0	0
radiale & ulnare	0	0	0	0
carpometacarpus	0	0	0	0
tarsometatarsus	0	0	0	0
undiffer. phalanges	0	0	0	0
wing phalanges	0	0	0	0
foot phalanges	0	0	0	0
unidentifiable	0	0	0	0
totals:	1	1	9	1

Table 8. Continued.

Bone Element Category	Buzzard	Quail	Crane	Curlew
skull	0	0	0	0
maxilla	0	0	0	0
mandible	0	0	0	0
quadrate	0	0	0	0
cervical vertebrae	0	0	0	0
furcula	0	0	0	0
coracoid	0	1	0	0
scapula	0	1	0	0
sternebrae & ribs	0	0	0	0
dorsal vertebrae	0	0	0	0
synsacrum	0	0	0	1
pelvic bones	0	0	0	0
caudal vertebrae	0	0	0	0
undiffer. vertebrae	0	0	0	1
humerus	0	1	0	0
radius	0	0	0	0
ulna	0	0	0	0
femur	0	0	0	1
fibula	0	0	0	0
tibiotarsus	1	0	0	1
undiffer. long bones	0	0	0	0
radiale & ulnare	0	0	0	0
carpometacarpus	0	0	0	0
tarsometatarsus	0	0	1*	1
undiffer. phalanges	0	0	0	0
wing phalanges	0	0	0	0
foot phalanges	0	0	0	0
unidentifiable	0	0	0	0
totals:	1	3	1	5

Table 8. Continued.

Bone Element Category	Black-tailed Godwit	Green-shank	Sand-piper sp.	Woodcock
skull	0	0	0	0
maxilla	0	0	0	0
mandible	0	0	0	0
quadrate	0	0	0	0
cervical vertebrae	0	0	0	0
furcula	0	0	0	0
coracoid	0	0	0	0
scapula	0	0	0	0
sternebrae & ribs	0	0	0	0
dorsal vertebrae	0	0	0	0
synsacrum	0	0	0	0
pelvic bones	0	0	0	0
caudal vertebrae	0	0	0	0
undiffer. vertebrae	0	0	0	0
humerus	0	0	0	2
radius	1	0	0	0
ulna	0	0	0	0
femur	0	0	0	0
fibula	0	0	0	0
tibiotarsus	0	1	0	1
undiffer. long bones	0	0	0	0
radiale & ulnare	0	0	0	0
carpometacarpus	0	0	0	0
tarsometatarsus	0	0	1	0
undiffer. phalanges	0	0	0	0
wing phalanges	0	0	0	0
foot phalanges	0	0	0	0
unidentifiable	0	0	0	0
totals:	1	1	1	3

Table 8.

Bone Element Category	Herring/ Lesser Black-backed Gull	Alcidae	Great Auk	Razor-bill
skull	0	0	0	0
maxilla	0	0	0	0
mandible	0	0	2	0
quadrate	0	0	3	0
cervical vertebrae	0	0	3	0
furcula	0	0	2	2
coracoid	0	0	3	0
scapula	0	0	4	0
sternebrae & ribs	0	0	3	1
dorsal vertebrae	0	0	3	0
synsacrum	0	0	1	0
pelvic bones	0	0	1	0
caudal vertebrae	0	0	1	0
undiffer. vertebrae	0	1	0	0
humerus	1	2	5	5
radius	1	0	2	0
ulna	0	0	3	1
femur	0	0	2	2
fibula	0	0	0	0
tibiotarsus	0	0	3	0
undiffer. long bones	0	0	0	0
radiale & ulnare	0	0	0	0
carpometacarpus	0	0	1	0
tarsometatarsus	0	0	4	1
undiffer. phalanges	0	0	0	0
wing phalanges	0	0	0	0
foot phalanges	0	0	0	0
unidentifiable	0	0	0	0
totals:	2	3	46	12

Table 8. Continued.

Bone Element Category	Black Guillemot	Guillemot	Razorbill/ Guillemot	Puffin
skull	0	0	0	0
maxilla	0	1	0	0
mandible	0	0	0	0
quadrate	0	0	0	0
cervical vertebrae	0	1	0	0
furcula	0	1	0	0
coracoid	1	1	0	0
scapula	0	3	0	0
sternebrae & ribs	0	1	0	0
dorsal vertebrae	0	0	0	0
synsacrum	0	0	0	0
pelvic bones	0	0	0	0
caudal vertebrae	0	0	0	0
undiffer. vertebrae	0	0	0	0
humerus	1	5	1	2
radius	0	1	0	0
ulna	2	0	0	0
femur	0	0	0	0
fibula	0	0	0	0
tibiotarsus	0	0	0	0
undiffer. long bones	0	0	0	0
radiale & ulnare	0	0	0	0
carpometacarpus	0	0	0	0
tarsometatarsus	0	0	0	0
undiffer. phalanges	0	0	0	0
wing phalanges	0	0	0	0
foot phalanges	0	0	0	0
unidentifiable	0	0	0	0
totals:	4	14	1	2

Table 8. Continued.

Bone Element Category	Redstart	Raven	Bird spp.	Total
skull	0	0	0	0
maxilla	0	0	0	1
mandible	0	0	1	4
quadrate	0	0	0	4
cervical vertebrae	0	0	4	10
furcula	0	0	0	7
coracoid	0	0	0	16
scapula	0	0	0	13
sternebrae & ribs	0	0	1	10
dorsal vertebrae	0	0	0	4
synsacrum	0	0	2	4
pelvic bones	0	0	0	2
caudal vertebrae	0	0	0	1
undiffer. vertebrae	0	0	5	7
humerus	1	3	1*	50
radius	0	0	0	11
ulna	0	0	4	22
femur	0	0	0	8
fibula	0	0	0	0
tibiotarsus	0	0	3*	18
undiffer. long bones	0	0	2	2
radiale & ulnare	0	0	0	3
carpometacarpus	0	0	0	3
tarsometatarsus	0	0	1	15
undiffer. phalanges	0	0	1	3
wing phalanges	0	0	1	7
foot phalanges	0	0	0	2
unidentifiable	0	0	2	17
totals:	1	3	28	244

mammal and bird bones. There are 177 such unidentifiable fragments which were recorded in situ and were included in the data file on the computer. Additionally, there are numerous other unidentifiable bone fragments which were also small-finded but belong to the category of "other" finds (i.e. they were either sieved finds or came from areas of the site excluded in this study).

It should be pointed out that these small-finded bones represent only a small proportion of all the unidentifiable fragments found in Cnoc Coig, because the majority of unidentifiable bone fragments were not recorded in situ and treated as small finds; rather, they were collected as general finds from each square/unit. Of course, the in situ and "other" small-finded unidentifiable fragments were not included with the general finds because they were incidentally collected with the identifiable mammal and bird bones, presumably in most cases because the fragments met the criterion of being at least 5 cm in the greatest dimension. Thus, the 177 in situ fragments are not a representative sample of the unidentifiable bones, but rather, they are a sample which is biased towards the larger fragment sizes. Because of this, their distribution may not be a very accurate reflection of the distribution of unidentifiable bones as a whole, since there is no reason to assume that the proportion of larger fragments (most of which would have been treated as small finds) to smaller fragments (which would have been treated as general finds) is constant across the site. Therefore, it is doubtful that an analysis of the distribution of these in situ unidentifiable fragments would necessarily provide an accurate understanding of any patterning of unidentifiable bones as a whole -- if such data were deemed to be of interest, a better procedure would be the use of quadrat counts based on the total assemblage of unidentifiable bone fragments.

Moreover, these 177 unidentifiable fragments are a mixture of bones which would include all classes of vertebrates present in the midden (i.e. mammals, birds and at least larger fish). As a result, from the perspective of spatial analysis, their distribution would be a palimpsest of the distribution of many different species, which means that it is difficult to assess what any observed patterning might actually represent. Even if we assumed that most of these bones are from mammals, which would not be entirely unreasonable since mammal bones outnumber those of birds by nearly two to one and since <u>in situ</u> fish bones are relatively rare, then presumably their distribution would primarily reflect that of mammal bone. However, this would hardly be very informative since it would still be a palimpsest of the distribution of several species. For these reasons, the 177 <u>in situ</u> unidentifiable bones may be expected to contribute little, if any, meaningful information about the distribution of bone remains within the midden, and consequently, little attention will be paid to these data in the analysis.

Limpet Scoops and Limpet Hammers

Aside from faunal remains, the Cnoc Coig midden also yielded large quantities of artifactual remains, the most abundant class of which is small flint flakes. These flakes would appear to be expedient tools resulting from the use of the bipolar technique of manufacture on small flint cobbles which are found as glacial erratics in storm beaches on the island. Because of the total absence of any retouch on the flakes so produced, it is not possible to recognize within the assemblage any formal types, except of course for the reduced bipolar or scalar cores (the so-called "outils écaillés" or "lames écaillés" -- see White 1968). The flint assemblage is not included in the present study because the vast majority of flint flakes was not recorded <u>in situ</u> but rather only in terms of square/unit provenance. The second most common class of artifacts, which was recorded as <u>in situ</u> data and so is included in this study, is a group of artifacts most commonly referred to as "limpet scoops".

Description and Enumeration

Limpet scoops found in Obanian sites are made from three types of material: from small, elongated pebbles, primarily of mudstone, which are available locally in storm beaches on Oronsay; from red deer antler which had been transversely broken into chunks and then split longitudinally into suitably sized fragments; and from red deer metapodials or "cannon bones". These various limpet scoops occur abundantly on all Obanian sites and indeed, they are one of the major diagnostic items of the Obanian artifact assemblage. Limpet scoops are characterized by having one end, or more rarely both ends, rounded and bifacially bevelled and typically, but by no means always, one face is bevelled more extensively than the other. On some stone limpet scoops (S.L.S.), but more frequently with bone limpet scoops (B.L.S.), the bevelled end appears to have been flaked prior to acquiring its bevel -- as is explained in more detail in Appendices A and B, this preliminary flaking appears to be a result of the way in which <u>all</u> limpet scoops were manufactured, regardless of whether or not they still reveal evidence of such flaking. In terms of length, the vast majority of limpet scoops of all three material types range between 30 and 80 mm, although a number of S.L.S. exceed this size by a considerable amount; the possible significance of this will be discussed below.

Despite the use of three materials for these objects, a recent metrical study (Reynolds 1983) has demonstrated that all limpet scoops can be regarded as a single type. Although measurement of the maximum length of a large sample of antler limpet scoops (A.L.S.) reveals that they tend to be shorter than either stone or bone specimens, this difference is due to the more fragmentary status of many A.L.S. However, length is one of the least important attributes of limpet scoops anyway. When the more significant variables are considered -- namely, attributes which describe the bevelled end -- all limpet scoops regardless of material type have been shown to constitute a homogeneous group, within which it is not possible to define any

Table 9. Number of *In Situ* and "Other" Small Finds for All Types of Antler and Bone Limpet Scoops from Cnoc Coig, 1973-79.

Type of Limpet Scoop	In Situ	"Other"	Total
A.L.S., single-ended	275	94	369
A.L.S., double-ended	18	3	21
A./B.L.S., single-ended	9	2	11
B.L.S., single-ended	25	8	33
B.L.S., double-ended	2	0	2
Totals:	329	107	436

meaningful subtypes. Consequently, for each material type, only two subtypes have been recognized: single-ended and double-ended limpet scoops. Of course, in terms of function, this distinction cannot be regarded as being of much significance.

Antler and Bone Limpet Scoops (Figure 6). Table 9 shows the number of *in situ* and "other" finds which have been assigned to the various categories of antler and bone limpet scoops. Note that several specimens could not be classified with certainty as to type of material and are therefore grouped into a separate category of indeterminate antler/bone single-ended limpet scoops.

An interesting feature of the limpet scoop assemblage from Cnoc Coig concerns the relative proportions of double-ended to single-ended scoops, particularly the consistency of this ratio regardless of material type. From Table 9, it is possible to calculate the relative frequency of double-ended limpet scoops as a percentage of the total number of scoops for the various materials: for antler, double-ended scoops are 5.4% of all A.L.S. (21 of 390); for bone, they are 5.7% (2 of 35); and for all antler and bone, including indeterminate antler/bone, they are 5.3% (23 of 436). And it may also be noted that for stone,

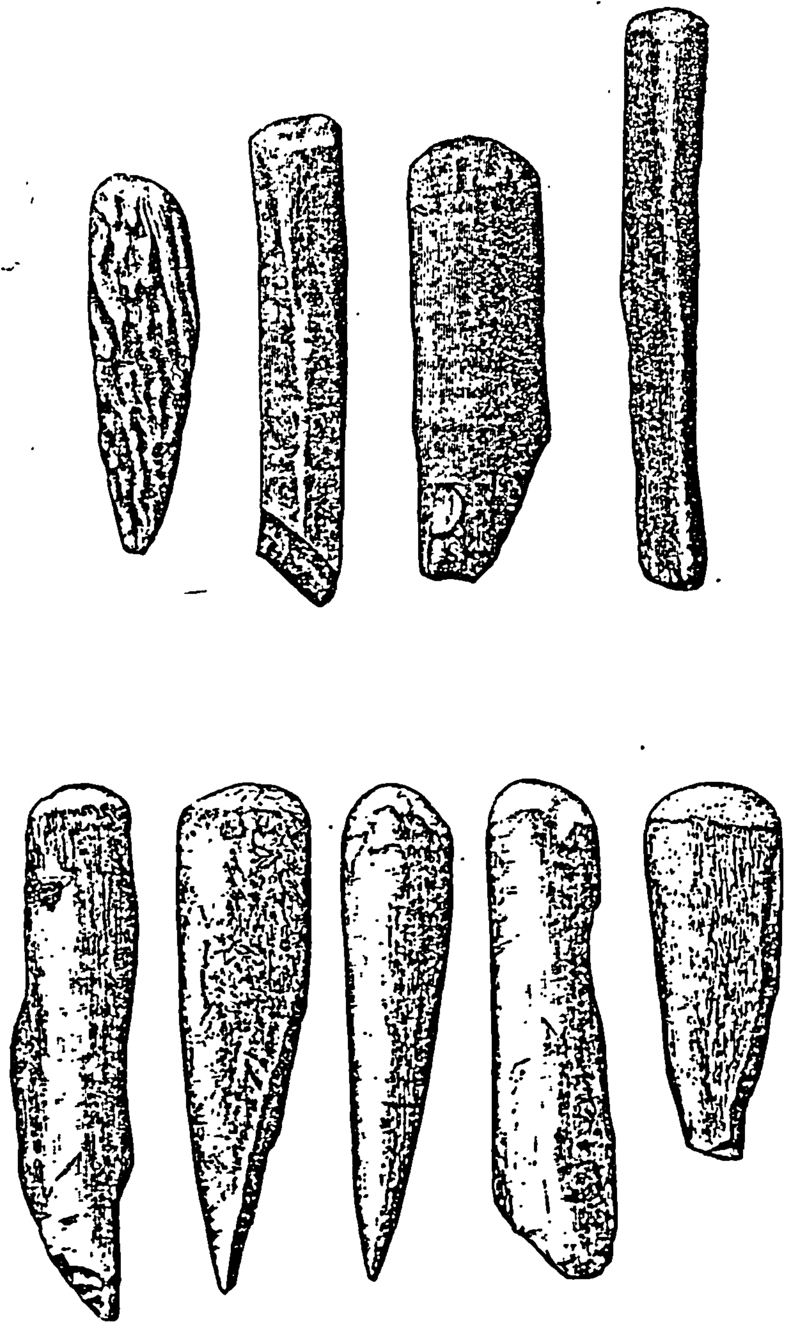

Figure 6. Obanian Antler and Bone Limpet Scoops from MacArthur Cave (top) and Caisteal nan Gillean I (bottom). Scale: 1/1. From Anderson (1895: Figs. 5-8; 1898: Figs. 19-23).

the counts for which are given below in Table 10, double-ended scoops account for 5.6% of all S.L.S. (20 of 359).

This rather remarkable consistency in the frequency occurrence of double-ended limpet scoops in the Cnoc Coig assemblage would not, however, seem to apply to other excavated Obanian sites, at least not as far as can be determined from the few published accounts. These data are summarized below in Table 11 but, for our purposes here, it is sufficient to note that most published reports do not include any quantified data on the finds which were recovered from the various excavations, nor are double-ended forms often mentioned, which cannot necessarily be taken to mean that none are present in the assemblages. The only published accounts which do give quantified data and definitely do mention the presence of double-ended scoops are those of Anderson (1895; 1898). He reports (1895: 219) that, from MacArthur Cave at Oban, two of 140 (1.4%) antler and bone limpet scoops are double-ended. He also notes (Anderson 1898: 308, 311) that Galloway's excavations at Cnoc Sligeach produced 36 antler and bone limpet scoops of which one (2.8%) was double-ended, while Galloway and Grieve's dig at C.N.G. I yielded two or three double-ended forms from a total of 150 antler and bone limpet scoops (1.3-2.0%). Although these data suggest a lower frequency occurrence of double-ended limpet scoops at other Obanian sites than has been found at Cnoc Coig, it would be preferable if the collections from these sites were re-examined and reclassified before any final conclusions were drawn from the data. However, even if Anderson's counts were confirmed, these observed differences amongst Obanian sites are not very great, and it is not entirely clear what, if any, would be the significance of this variability.

Stone Limpet Scoops (Figure 7). Another variable can be introduced to provide another distinction for S.L.S. The waterworn, elongated beach pebbles from which S.L.S. are manufactured are naturally rounded and smoothed at both ends. Yet, in some cases, the pebble is clearly not complete in that the non-bevelled end is not smooth and

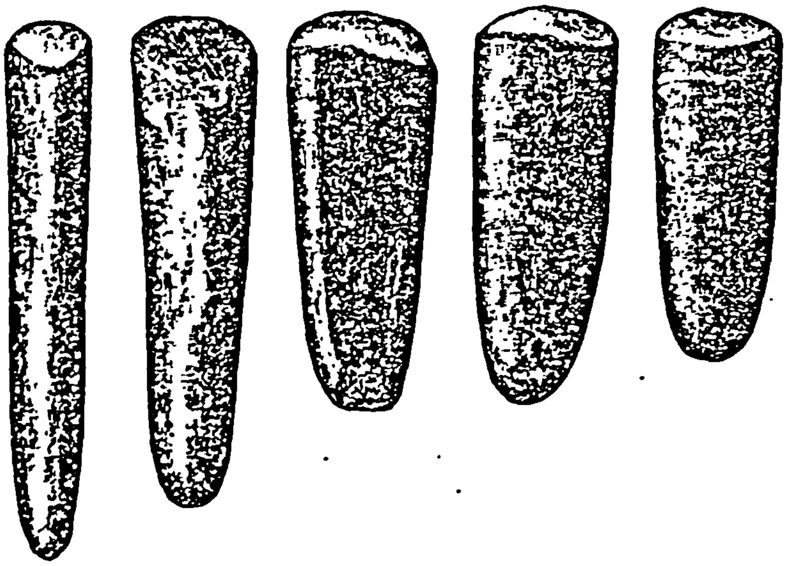

Figure 7. Obanian Stone Limpet Scoops from Caisteal nan Gillean I. Scale: 1/1. From Anderson (1898: Figs. 24-28).

Table 10. Number of *In Situ* and "Other" Small Finds for All Types of Stone Limpet Scoops from Cnoc Coig, 1973-79.

Type of Limpet Scoop	In Situ	"Other"	Total
S.L.S., single-ended, whole pebble	234	34	268
S.L.S., single-ended, truncated pebble	63	8	71
S.L.S., double-ended	19	1	20
Totals:	316	43	359

rounded, but rather, the pebble has been broken or snapped off. Of course, this distinction between S.L.S. made on whole pebbles and those made on truncated pebbles only applies to single-ended limpet scoops, since double-ended ones are bevelled at both ends. Thus, for descriptive purposes, it is possible to recognize three subtypes of S.L.S. Table 10 shows the number of *in situ* and "other" finds which have been assigned to these three groups.

If the distinction between single-endedness and double-endedness is not of any significance in functional terms, the next obvious question to consider concerns the possible significance of the distinction between truncated pebble and whole pebble single-ended S.L.S. This distinction might be seen to be significant if the truncated pebble specimens are regarded as having been snapped off *after* they were made into limpet scoops. If so, then the fact that a substantial number of S.L.S. are "broken" might suggest something about their function -- namely, that they were used in a vigorous and robust activity such that many snapped as a result of use, for example, if they were used as levers. On the other hand, it is possible that the truncated nature of some pebbles has nothing to do with use but simply, that some pebbles which were collected off storm beaches were already broken prior to becoming limpet scoops.

The obvious test of these alternative hypotheses involves the maximum length of the two kinds of single-ended S.L.S. Since we may reasonably assume that only pebbles within a specified range of lengths were selected for use as limpet scoops, then if the truncated pebbles were broken _before_ becoming limpet scoops, there should be _no_ statistically significant difference in terms of length between the two types, because the only factor governing length would be the process of selection of the suitable raw material and this factor should apply constantly to both groups. Conversely, if the truncated pebbles were indeed broken due to use, then these truncated ones should be statistically significantly _shorter_ than their whole pebble counterparts, because there would be the additional factor of use-breakage involved in determining their maximum lengths.

Since the codified data on the computer data file included the maximum length of all S.L.S. (as variable 13 -- see Chapter 5), and since the _in situ_ truncated and whole pebble single-ended S.L.S. are a large and representative sample of the total number recovered from the site, these data can be used to test these two alternative hypotheses. Using the S.P.S.S. package of statistical programs (Nie _et al_. 1975) on the computer, it was a straigthforward task to obtain basic descriptive statistics and histograms to show the length distributions of each group of S.L.S. These two histograms are shown in Figure 8, with the mean length and standard deviation recorded on each histogram. In addition, a Student's t-test was run to compare these two distributions. As would seem to be intuitively obvious from the histograms, this test showed that the difference between these two distributions is not statistically significant (t value of 0.92 which, with 295 degrees of freedom, is not significant at the 5% level, nor indeed not even at the 10% level). This clearly indicates that truncated pebbles were _not_ broken as a result of use but rather, that they were broken before becoming limpet scoops (presumably by natural agents prior to their having been collected from storm beaches). Thus, all single-ended

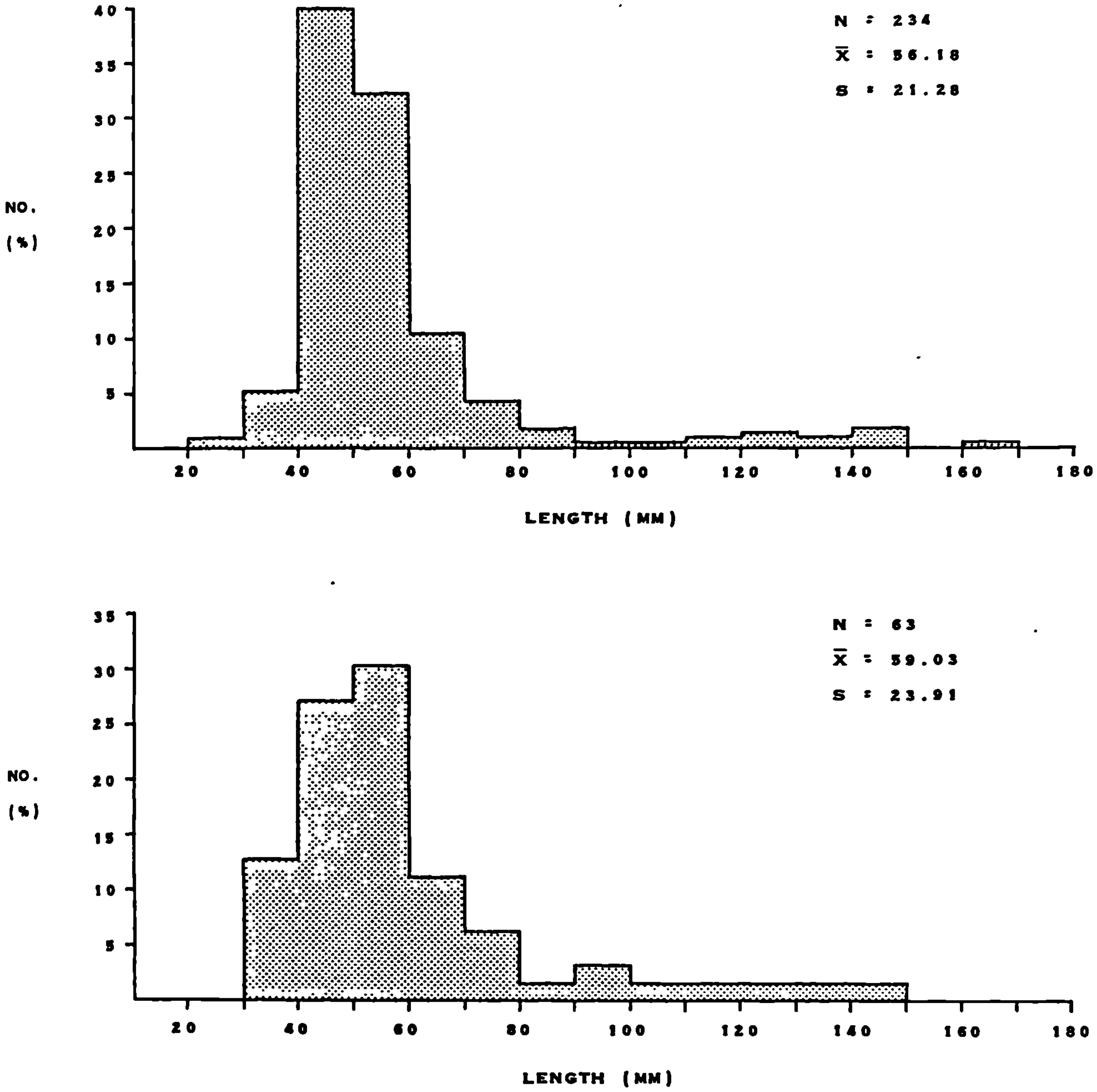

Figure 8. Frequency Distribution of the Maximum Lengths of Stone Limpet Scoops Comparing Whole Pebbles (top) and Broken Pebbles (bottom), Based on the In Situ Small Finds from Cnoc Coig, 1973-79.

S.L.S. may be regarded as being a single, homogeneous population. Overall therefore, although three subtypes of S.L.S. have been recognized for descriptive purposes as shown in Table 10, there is no reason to regard these three subtypes as being significant in terms of function. Hence, for the purposes of examining their spatial distributions, all S.L.S. will be treated as a single class of objects.

However, before leaving this matter of subtypes of S.L.S., mention should be made of one other point. As was referred to above, there are some S.L.S. which are considerably larger (in terms of maximum length) than the norm. Figure 9 shows the frequency distribution of the maximum lengths for all _in situ_ S.L.S. As this histogram illustrates, the population is not totally homogeneous -- the vast majority of S.L.S. have lengths between 30 and 80 mm, but there is a slight indication of a second group of much larger S.L.S. beyond 100 mm and especially between 120 and 150 mm. There are 20 of these S.L.S. which are greater than 100 mm in length, which is 6.3% of all the _in situ_ S.L.S. These data might be seen to suggest that a separate category of large S.L.S. should be defined. However, it should be reiterated that length is not the most critical attribute of limpet scoops, and when the more important variables pertaining to the bevelled end are considered, it has been shown (Reynolds 1983) that these large S.L.S. cannot be readily differentiated from the rest of the population of S.L.S. Therefore once again, on formal grounds, there is no reason to suspect that S.L.S. do not constitute a single category in functional terms.

Comparisons with Other Obanian Sites

As has already been mentioned, previous excavations at all Obanian sites have yielded large quantities of limpet scoops and indeed, these items are one of the most characteristic types of artifacts found in Obanian assemblages. The available published information on the numbers of limpet scoops recovered from the earlier excavations at Obanian sites is summarized in Table 11.

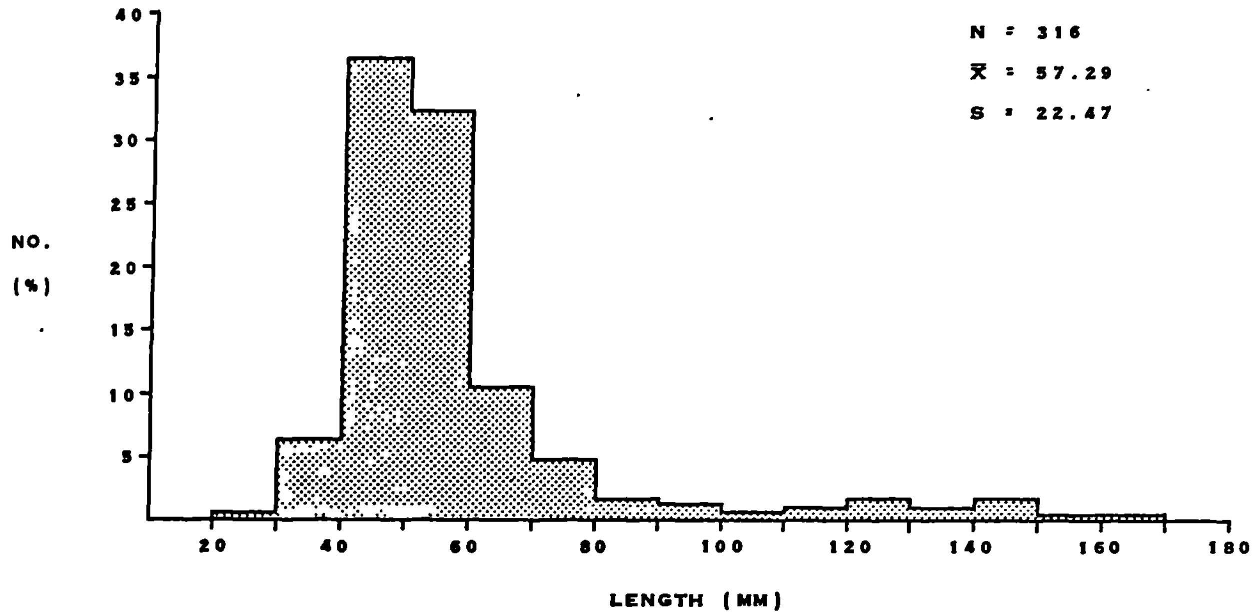

Figure 9. Frequency Distribution of the Maximum Lengths of All In Situ Stone Limpet Scoops from Cnoc Coig, 1973-79.

Table 11. Summary of Published Information on the Numbers of Limpet Scoops and Limpet Hammers Which Have Been Recovered from Earlier Excavations at Obanian Sites.

Site	A.L.S. & B.L.S.	S.L.S.	Any Double-Ended?		S.L.H.	Size (mm):		Published Source
			A.&B.L.S.	S.L.S.		20-100	100+	
MacArthur Cave	140	nil?	2	--	?	138	2	Anderson (1895)
	140	nil	some	--	few			Lacaille (1954)
Druimvargie	18	4	nil?	nil?	?	13 &	5	Anderson (1898)
	18	3	nil?	nil?	1	0	4	Lacaille (1954)
Risga	many	few	some	some?	some	?	?	Lacaille (1951; 1954)
C.N.G. I	some	some	some	some	few	all but	2	Grieve (1882; 1885; 1923)
	150	210	2 or 3	?	?	150 &	0	Anderson (1898)
						c.105	c.105	
Cnoc Sligeach	36	c.150	1	?	some?	36 &	0	Anderson (1898)
						most	c.13	
	many	many	?	?	?	?	?	Bishop (1914)
Cnoc Riach (= Cnoc Coig?)	20	50	?	?	?	most	few	Anderson (1898)
	20	50	?	?	some of largest S.L.S.	?	?	Lacaille (1954)

The most striking feature of these tabulated data is the impoverished and sketchy nature of the published accounts. In most cases, exact counts of limpet scoops are not provided and the presence of double-ended forms in the assemblage is usually far from unequivocal. Antler and bone limpet scoops are generally not distinguished, and even when this data is provided in quantified form (only by Anderson 1898), there must be some doubt about the reliability of the distinction between antler and bone, as will be discussed in more detail below. Overall, the published accounts must be viewed as a very unreliable source of information on the details of the limpet scoop assemblages from these sites. Of course, this is mainly due to the facts that these sites were investigated early on in the development of archaeology and that these early published accounts are very brief, not all of which are even primarily concerned with the archaeological aspects of these sites (especially Grieve 1882; 1885; 1923).

In any case, using these published reports, some comparisons can be made between the material recovered recently from Cnoc Coig and that obtained from previous excavations at Obanian sites. The frequency occurrence of double-ended limpet scoops has already been discussed and all that could be reliably concluded was that double-ended forms certainly have been found at some other Obanian sites, although the available quantified data indicate slightly lower proportions than found in Cnoc Coig. Mention has also already been made of the fact that the Cnoc Coig S.L.S. assemblage included some large S.L.S. (100 mm or greater in length). However, it should also be noted that the Cnoc Coig assemblage included no comparably large antler or bone limpet scoops, nor indeed have any been found in any of the Obanian sites on Oronsay. Yet, as Table 11 shows, two such finds were recovered from MacArthur Cave (see Anderson 1895: 221-222; Lacaille 1954: 204-205), while Druimvargie yielded five (see Anderson 1898: 303-304; Lacaille 1954: 206-207). One from Druimvargie is made of red deer antler but all the others are made from split "leg-bones" (i.e. metapodials?)

of red deer, and they range in length from 4" to 7¼" (ca. 100-180 mm). Despite their length and the fact that a couple are rather broad at the bevelled end, the published descriptions and illustrations certainly suggest that, in terms of the more important attributes describing the bevelled end, these large antler and bone limpet scoops may be regarded as being identical to their shorter counterparts, which Anderson (1895: 222) explicitly pointed out. Although it would be more desirable if observations were based on a thorough metrical analysis of these assemblages, it would seem that, as with S.L.S., the larger antler and bone specimens cannot be regarded as belonging to a separate type.

Concerning the large S.L.S. found in other Obanian sites, Anderson (1898: 311-312) reports that Galloway's excavation of Cnoc Sligeach produced about 150 S.L.S. of which about 13 are longer than 4" (ca. 100 mm) -- thus, these large S.L.S. comprise approximately 8.7% of the whole assemblage, which is in fact very similar to the figure (6.3%) obtained from the recent excavations at Cnoc Coig. However, the other two sites with quantified data on this matter show a much different pattern. Anderson (1898: 306) reports that only four S.L.S. were found in Druimvargie and all of these were large (100 mm or more), although Lacaille (1954: 208) suggests that one of these may be a limpet hammer -- from Anderson's description, it would seem that this interpretation might well be valid. In any case, the fact that all the S.L.S. from Druimvargie are large contrasts with Cnoc Coig and Cnoc Sligeach. However, since S.L.S. are so rare in both sites at Oban, a point which will be discussed in more detail later, this difference with the Oronsay sites is not so striking.

More curious are the published accounts of C.N.G. I. Grieve (1882: 486; 1885: 57) reports that all S.L.S. are small, between 2" and 3" (ca. 50-75 mm), except for two larger specimens. However, pertaining to this same body of data, Anderson (1898: 309-310) states that about half of the 210 S.L.S. are between 1½" and 3" (ca. 40-75 mm), while the remainder range from 4" up to 9" (ca. 100-230 mm)! This sizable discrepancy between the two reports cannot be resolved from the published accounts but, given that a relative frequency for large S.L.S. of about 50% seems inordinately high, Anderson's statement must be regarded as suspect.

Another of Anderson's observations which may be questioned concerns the relative proportions of antler and bone limpet scoops, and this brings up the whole matter of the relative proportions of the three material types of limpet scoops in the various Obanian sites. From the published accounts, it is quite clear that, at both MacArthur Cave and Druimvargie, S.L.S. are uncommon and vastly outnumbered by antler and bone limpet scoops; this also applies to the site of Risga. Anderson does not supply any information about the relative proportions of antler and bone limpet scoops at MacArthur Cave and Druimvargie but, on the basis of the photographs and the specified relative proportions for the larger limpet scoops, it would seem that B.L.S. are somewhat more numerous than A.L.S. In any case, at Risga, B.L.S. definitely outnumber those of antler (P. Mellars, personal communication).

In the Oronsay sites, however, the situation is almost the exact opposite. As can be seen from Tables 9 and 10, at Cnoc Coig, B.L.S. are by far the least common type, comprising only 4.4% of the total limpet scoop assemblage (and even if the indeterminate antler/bone scoops are included with the B.L.S., they still would comprise only 5.8% of the assemblage). On the other hand, A.L.S. are the most frequent type (49.1%), while S.L.S. are nearly as common (45.2%). Overall, antler and bone limpet scoops account for 54.8% of the total limpet scoop assemblage from Cnoc Coig. A slightly different pattern is observed at C.N.G. I where Anderson (1898: 308-309) reports that S.L.S. account for 58.3% of the limpet scoop assemblage, while antler and bone represent the remaining 41.7%. Similarly, at Cnoc Sligeach, S.L.S. outnumber those of antler and bone, though their relative frequency here is greater (80.6%

compared to 19.4% for antler and bone). Despite these differences, the general pattern of the Oronsay sites is that S.L.S. form a substantial proportion of the total limpet scoop assemblages.

Regarding antler and bone limpet scoops only, Anderson (1898: 308) reports that B.L.S. represent 62.0% of the assemblage from C.N.G. I compared to 38.0% for A.L.S. And from the Cnoc Riach excavations, the relative proportions of B.L.S. and A.L.S. are 80.0% and 20.0% respectively (Anderson 1898: 313). These relative frequencies are in marked contrast to Cnoc Coig where B.L.S. constitute only 8.0% of all antler and bone limpet scoops. While the Cnoc Coig data do not necessarily imply that Anderson's distinction between antler and bone is faulty, they do nonetheless suggest that his classification may be suspect. Clearly, before any final conclusions are drawn concerning the relative proportions of antler and bone limpet scoops in Obanian sites, it would be desirable if the early collections were thoroughly re-examined and reclassified.

Explaining the Variability

Despite the inadequacies and sketchiness of the published reports, it is nevertheless clear that there is considerable variability amongst Obanian sites in the relative proportions of different material types of limpet scoops, and this variability is in need of explanation. Grieve proffered the tentative explanation that this variability may be due to differences in the availability of the various raw materials:

> Until we can compare the results of the excavations of more of these shell mounds upon both the mainland and islands, it will be better to leave the question open. It may turn out that the primitive people used whatever materials were most easily obtained to make their implements [i.e. limpet scoops]. On the mainland and inner islands deer bones would be more plentiful, while on the outer islands deer would be less abundant. In the shortage of deer bones the use of stone may have more largely prevailed (Grieve 1923: 48).

Of course, this does not account for all of the observed variability -- in particular, it does not address the differences in the relative proportions of antler and bone in the sites at Oban and on Risga where both would have presumably been in plentiful supply.

However, this simple model may be elaborated to provide a more thorough explanation. Firstly, in addition to the availability of different raw materials, we may also consider the fact that there is some preferential ranking of the three materials for whatever reasons[1]. In the above quotation, Grieve implies that stone was the least preferred material because it was only used when red deer bones and antler were unavailable. The absence of S.L.S. at the Oban sites and at Risga would thus be due to there having been a plentiful supply of raw materials from red deer with the consequent lack of need to use stone, whereas on Oronsay the sporadic supplies of red deer remains would have required a much greater reliance on the abundant supplies of elongated pebbles from storm beaches.

On the other hand, it should be pointed out that pebble storm beaches are not common around Oban. McCann (1966) has surveyed and mapped the postglacial raised shoreline features in the Firth *of Lorn/Loch Linnhe area* (see Fig. 1), and he (1966: Fig. 1) records the presence of only two raised pebble storm beaches near Oban, about 7 and 10 km to the north (just north of Connel Ferry and on the north shore of Ardmucknish Bay). Of course, given an embedded procurement strategy (Binford 1979b: 259-261) and highly mobile hunter-gatherers with an efficient means of water transportation, these distances would not necessarily mean a lack of access to suitable pebbles for S.L.S.;

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[1] Unfortunately, it is difficult to imagine what these reasons specifically might be. Presumably, they pertain to either ease of manufacture or efficiency in use. Since it would seem that a limpet scoop can be made from an elongated pebble in one or two minutes (see Appendix B), it is difficult to see how antler or bone could be significantly more efficacious mediums for making limpet scoops. As for use-efficiency, the experiments described in Appendix B were limited to stone, so it is not possible to assess any potential significant differences here, although it is difficult to imagine why antler or bone should be particularly better than stone in this regard.

moreover, other storm beaches around Oban may not have been detected. Nevertheless, McCann's survey data do not suggest a highly abundant supply of elongated beach pebbles in the vicinity of Oban. Furthermore, a modern storm beach, located about 1.5 km north-west of Oban just below Dunollie Castle, was examined by the author in March 1982 for the presence of potential S.L.S. pebbles -- only one pebble of suitable size and shape was found, and this was a stone which is much harder than the usual mudstone pebbles used for S.L.S. on Oronsay. The storm beach was small in comparison with those on Oronsay and Colonsay where similar collecting times (of about five minutes) would yield dozens of suitable pebbles (see Appendix B). Of course, this modern storm beach may not necessarily be characteristic of postglacial beaches near Oban. Nonetheless, these data do suggest that the Oban area would have had in late Mesolithic times a dearth of elongated beach pebbles to be used as raw material for S.L.S.

Thus, can we turn Grieve's implied ranking on its head and suggest instead that stone was the preferred material and hence, that antler and bone were used at Oban and Risga because stone was not readily available locally? The answer to this question would have to be "no". This is because on Oronsay and Colonsay, both today and at the time of the maximum postglacial marine transgression, storm beach deposits are not rare -- indeed, particularly on the western coasts of the islands, such deposits are quite extensive and dozens of potential S.L.S. pebbles can be acquired from them in a short collecting time. As a result, if stone were the preferred material, one would expect few, if any, bone or antler limpet scoops in the Oronsay shell middens -- and yet, as we have seen, antler and bone limpet scoops are well represented in the Oronsay sites and, at Cnoc Coig, they even outnumber those of stone. It would seem difficult, therefore, to avoid the conclusion that, for whatever reasons, antler and bone were preferred as raw materials over stone for the manufacture of limpet scoops.

But what of the relative ranking of antler and bone? This is a more difficult problem to address but, if we accept that B.L.S. are more frequent than A.L.S. in the assemblages from Risga and the two sites at Oban, we might suggest that the preference was for bone over antler. This is because, if we assume a relatively plentiful supply of red deer, the amount of antler as a potential raw material would considerably exceed that which would be available from the metapodials, especially since shed antler could also be collected. Thus, if antler were preferred over bone, one would expect comparatively little use of metapodials for limpet scoops. Since the opposite would seem to be the case at Risga and at Oban, this suggests that bone was the preferred medium for limpet scoops and that antler was used only when the supply of suitable red deer bones was not adequate.

In summary, we may derive an assumed ranking of bone over antler over stone. The relative proportions of the three material types of limpet scoops in any Obanian site would be a function of how adequately material preferences could be met by the differential availability of the three raw materials. This process would not only involve limpet scoops, since the preferred materials (antler and bone) were also used in the manufacture of other types of artifacts, which will be described below. Thus, the amount of antler and bone available for use as limpet scoops would not only be due to the availability of supplies of these materials, but also to other manufacturing needs which would contribute to the temporary depletion of a preferred type of material and require the use of a less preferred type. This model to explain the variability of different material types of limpet scoops among Obanian sites has implications for the spatial distributions of types of limpet scoops within one site and, in Chapter 8, these implications will be tested using the distribution of antler and stone limpet scoops within Cnoc Coig.

Stone Limpet Hammers (Plate 1)

In the preceding discussion, reference has been made at several points to stone limpet hammers (S.L.H.) as opposed to limpet scoops. The use of these two terms obviously implies a difference in function between the two groups. Mention has also been made of the existence of exceptionally long, but otherwise typical, limpet scoops in Obanian assemblages. S.L.H. are a separate artifact type but, because they are also large elongated pebble tools, there has developed some confusion over the use of the two terms and the distinction between them.

The concept of limpet hammer was introduced very early on in the history of research into the Obanian by Grieve (1882: 486-487; 1885: 57; 1923: 59-61). During their excavation of C.N.G. I, Galloway and Grieve found several large elongated pebbles which Grieve explicitly distinguished from the S.L.S. including the two large ones. He notes that "...many of the stones we call limpet-hammers are quite a foot [ca. 300 mm] in length, and, with the exception of being sometimes fractured at the ends, bear no evidence of having been used" (Grieve 1882: 486). In other words, Grieve claims that these S.L.H. have no bevelling akin to that found on S.L.S., but instead, they exhibit either no evidence of use or some fracturing on the end (see 1923: Fig. 19, Nos. 1 & 2). As will be discussed in more detail below, this definition is somewhat inaccurate since S.L.H. may exhibit <u>some</u> bevelling. Moreover, the specimens lacking any signs of use are certainly not utilized limpet hammers, though they may have been collected with the intention of being used as such -- similar potential S.L.H. have also been found in Cnoc Coig. In any case, Grieve came to the interpretation that these objects were used to detach limpets from rocks by historical analogy -- their native workman identified these stones as being very similar to elongated beach pebbles which were used on occasion as expedient tools by fishermen to collect limpets for use as ground bait. Grieve observes that "hammering" limpets off rocks with such stones causes "...many a fracture upon the end of the implement that was the point of contact" (1923: 60). As can be seen from Table 11, Grieve does not quantify how many of these S.L.H. were found in C.N.G. I, but he implies that there were several[1]. Regardless of the quantities involved, Grieve can be credited with having recognized S.L.H. as a type of elongated pebble tool which is justifiably distinguished from S.L.S. (including the larger ones), even though his definition of S.L.H. has been shown by subsequent research to be somewhat inaccurate and overly inclusive.

Regarding limpet hammers from other Obanian sites, Anderson (1895) makes no reference to similar objects from MacArthur Cave, but Lacaille (1954: 206) reports that a "few" pebbles from the site can be regarded as limpet hammers -- none are illustrated. From Druimvargie, Anderson (1898: 306) notes that one of the four S.L.S. found has "...its pointed end flaked away backwards as if by forcible use like a punch". Lacaille (1954: 208) suggests quite reasonably that this is a limpet hammer but again, no illustration is provided. Anderson (1898: 312) accepts the possibility that some of the larger S.L.S. from Cnoc Sligeach may be considered to be limpet hammers (see also Lacaille 1954: 220). Yet, from his later work at this same site, Bishop (1914) makes no mention of limpet hammers, nor even of large S.L.S., but it is doubtful if this means that none were found -- for example, Jardine recently found two probable S.L.H. in one of his minor excavation pits in the vicinity of Cnoc Sligeach (Jardine & Jardine 1983: 24, Fig. 2, Nos. 1a & 1b). Finally, Lacaille (1951: 125-126; 1954: 229, 234) reports that limpet hammers are included in the assemblages from Cnoc Riach and Risga, but quantities are not given.

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[1] Two specimens are illustrated by Grieve (1923: Fig. 19), although we have already mentioned that one of these should not be regarded as a limpet hammer. Another specimen from C.N.G. I which would belong to this type is illustrated by Breuil (1922: Fig. 4, No. 9; see also Lacaille 1954: Fig. 88, No. 9). And during the course of his recent investigations, Jardine has recovered another S.L.H. from one of his pits in the vicinity of C.N.G. I (Jardine & Jardine 1983: 32, Fig. 2, No. 5).

Therefore, because of the sketchy nature of the published information, little can be said except that S.L.H. seem to occur consistently in Obanian assemblages, albeit in comparatively small numbers. Perhaps not surprisingly therefore, from the recent excavations at Cnoc Coig, only six elongated pebbles have been identified as being limpet hammers[1] (see Plate 1). These range in length from 89 to 172 mm, with a mean length of 140.5 mm, and two specimens have evidence of being used on both ends. Given the vast numbers of limpets contained in Obanian shell middens and this supposed limpet collecting function of S.L.H., the infrequent occurrence of these objects in these sites may be seen to be somewhat anomalous. However, this fact is readily understandable when one considers the likely locations of discard for these items. Clearly, most S.L.H. would have been discarded away from the middens at limpet collecting localities where the tools would break or wear out beyond further use. Assuming that they would be curated until this happened -- that is, that they were not such expedient tools that they were always used only during one collecting episode -- then the few S.L.H. found in the middens simply represent ones which had been brought back to camp with the intention of being used again but were either lost or left as "de facto refuse" when the site was abandoned.

It should be noted that distinguishing S.L.H. from large S.L.S. is not always easy because there is an intergradation of the two forms in terms of the nature of the utilized end. Specimens with well bevelled ends and no flaking may unambiguously be interpreted as limpet scoops but, as was mentioned above (p. 109), some S.L.S. (including small ones) have a combination of flaking and bevelling. If any pebble with any amount of bevelling, regardless of the presence or absence of flaking, is defined as being a limpet scoop, then specimens which only have flaking would

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[1] A seventh S.L.H. from Cnoc Coig was recently found by Jardine in one of his minor excavation pits on the eastern (seaward) side of the site (Jardine & Jardine 1983: 29, Fig. 2, No. 2).

be classed as S.L.H. Certainly, Grieve (1882: 486; 1885: 57; 1923: 59-60) recognized limpet hammers by fracturing and battering on the end of the pebble, and not by bevelling. In the Cnoc Coig assemblage, only a couple of large pebbles have only flaking and no bevelling; the remainder have some bevelling but such bevelling tends to be minimal and not suggestive of a "classic" limpet scoop form and, moreover, there is a considerable amount of flaking. Is it really better to regard these latter examples as large S.L.S. and not S.L.H.? Stated differently, the essential question is: can detaching limpets off rocks produce bevelling on the S.L.H., or only flaking, or some combination of the two?

In order to answer this question, we need to obtain some "actualistic" understanding of what diagnostic characteristics, if any, result from using a stone pebble as a limpet hammer. The earliest experiments aimed at addressing this problem provide some suggestive lines of evidence, though they were certainly far from exhaustive or conclusive. Lacaille (1951: 125-126) reports that he experimented collecting limpets using schistose pebbles and found that this resulted in typically "abraded" ends. His illustration (1951: Fig. 10, No. 3 = 1954: Fig. 105, No. 3) of one of his experimental limpet hammers seems to indicate that by abrasions he means bevelling and not flaking; and yet, he illustrates (1951: Fig. 10, No. 1 = 1954: Fig. 105, No. 1) one S.L.H. from Risga which he describes as abraded and which is characterized by both flaking and bevelling! At any rate, Lacaille (1954: 216-218) identifies limpet hammers by the presence of bevelling and, not surprisingly therefore, he includes in the category of limpet hammers bevelled specimens which are clearly S.L.S., including small ones (e.g. 1954: Fig. 88, Nos. 5 & 7). In short, this experimental evidence unfortunately created more confusion rather than less regarding the distinction between S.L.S. and S.L.H. Nevertheless, on the basis of Lacaille's experimental data, particularly the one illustrated specimen, it would seem that collecting limpets causes bevelling on the utilized end rather than flaking or even a combination of flaking and bevelling. However, because of the limited quantity of his experimental data and the brevity of his report, we cannot regard this conclusion as definitive.

In order to acquire a better understanding, the author conducted some simple collecting experiments during two visits to Oronsay, the details of which are given in Appendix B. Suffice it to note here that, even after comparatively short collection times, all pebbles showed very visible signs of use. This clearly suggests that it is completely inappropriate to include as S.L.H. specimens showing no signs of use, as does Grieve (1882: 486; 1885: 57; 1923: Fig. 19, No. 1) for example. Furthermore, these experiments demonstrated that using elongated beach pebbles to collect limpets produces either flaking (in the case of relatively soft stones) or a combination of flaking and rough bevelling (in the case of harder and less flaky pebbles). However, *not* even with the hardest stones does this bevelling suggest the "classic" limpet scoop form -- it is altogether rougher and less even than that which is found on limpet scoops. In light of these experimental data, Lacaille's (1951: 125-126) experimental evidence must be regarded as curious -- even though he used flaky schistose pebbles, it seems that his specimens acquired bevelling and little or no flaking! Although he does not quantify the amount of use of his S.L.H., either in terms of collecting time or the number of limpets collected, the experimental results reported in Appendix B clearly indicate that, regardless of the amount of use, flaking and at best only minimal bevelling should be produced on such soft and flaky pebbles. These conflicting experimental data cannot be resolved and must remain contradictory.

Interestingly, after conducting the experiments described in Appendix B, I came upon an article by Liversage (1968) in which similar limpet collecting experiments using limpet hammers are described. Liversage's observations are illuminating in that they independently confirm my own and for this reason, they are quoted here at length:

> An examination of the Dalkey Island specimens shows that the bevels are always rougher than the rolled exterior of the pebble, and range from a smooth pocked surface to an irregular and striated one, the striations being in the same direction as the long axis of the implement. This bevelling was sometimes succeeded or preceded by chipping of the end of the stone. The chipping is natural enough if the pebbles were used as hammer stones of any kind, but the bevelling is more of a problem. The only way I have been able to reproduce it is by holding a pebble obliquely and sliding its end along a rock face at an angle of about 45°. A number of short sliding blows made with the stone held like this will produce much the same mixture of pocking and striation that can be seen on the 'limpet scoops'. If such stones had been used for detaching limpets, it would seem that an effective method would have been to direct a sharp sliding blow along the rock at the limpet, taking it by surprise (Liversage 1968: 147).

Since Liversage's observations provide corroborative experimental evidence to my own, Lacaille's observations seem all the more incongruous and must be regarded with a certain amount of scepticism.

In any case, the experiments reported in Appendix B and those of Liversage clearly indicate that S.L.H. can be distinguished from S.L.S. by having a variable combination of flaking <u>and</u> rough and uneven bevelling. In view of this information, it was possible to recognize six large elongated pebbles in the Cnoc Coig assemblage which could be classified as S.L.H. Applying these experimental results to other Obanian assemblages, unfortunately, little can be said with certainty regarding the presence of S.L.H. due to the sketchy nature of verbal descriptions and the dearth of illustrated specimens in the published reports. In spite of this uncertainty, it is clear that some S.L.H. from other Obanian sites are illustrated in the published literature: one from Risga (Lacaille 1951: Fig. 10, No. 1 = 1954: Fig. 105, No. 1) and two from C.N.G. I (Breuil 1922: Fig. 4, No. 9 = Lacaille 1954: Fig. 88, No. 9; Grieve 1923: Fig. 19, No. 2).

The Function of Limpet Scoops

If S.L.H. can be reliably distinguished from S.L.S. on the basis of the nature of the utilized end, and if these objects can be interpreted as tools which were used to detach limpets off rocks, then the next obvious question is: what was the function of limpet scoops? It is at this point where opinions have varied considerably, even remarkably, and where there has developed confusion over the distinction between limpet scoops and limpet hammers. Appendix A provides a detailed review of the functional interpretations which have been applied to both Obanian and non-Obanian limpet scoops. Suffice to note here that most of the proposed ideas can be readily dismissed as being highly unlikely, which leaves us with only two interpretations that demand serious consideration. These are Anderson's (1895: 222-223) idea that they are tools used for dressing animal skins, and Bishop's (1914: 95) suggestion that these implements were used to extract limpets from their shells. As is detailed in Appendix A, after considering the arguments for and against these two interpretations, the use of Bishop's term "limpet scoop" is maintained in the present study because, aside from being a convenient label, the functional connotations of this term are accepted here as being the most plausible interpretation for the function of this class of bevel-ended tools found in Obanian assemblages.

If we accept the limpet scooping function of these objects, we must address the question as to why these tools were used for this purpose. The easiest method of separating limpets from their shells is by boiling, and only a few minutes boiling is quite sufficient to achieve this. Grieve (1923: 54-55) was reluctant to accept the limpet scooping interpretation partly because these artifacts are not found in other (i.e. post-Mesolithic) limpet middens on Colonsay and Oronsay. Presumably, the absence of limpet scoops in these later shell middens is due to the fact that limpets were removed from their shells by boiling using metal and ceramic pots. However, for the Mesolithic occupants of Obanian sites, we may presume that boiling would have involved the use of skin containers and boiling stones. In this situation, the boiling method of extracting limpet meat would be comparatively difficult because the shells comprise the vast weight and bulk of limpets, and so, when boiling, the shells would be the major component cooling the water. Thus, the processing of large quantities of limpets by this method would be difficult and very time-consuming. In such a situation, removing limpet meat from the shell by the use of a special tool would certainly be more efficient and makes perfect sense. However, with the advent of ceramic and metal containers, this functional necessity for limpet scoops would no longer exist and thus, the lack of analogous tools in later prehistoric and historic times where limpets were still used as food is not surprising. In short, we may view the use of limpet scoops in the Mesolithic as an effective adaptation for processing large quantities of limpets in a situation where a particular kind of boiling technology prevailed.

Other Antler and Worked Bone

Aside from an abundance of antler and bone limpet scoops, the Cnoc Coig assemblage includes a variety of other antler and bone artifacts. These have been classified into 12 artifact types, and the numbers of *in situ* and "other" finds assigned to each category are listed in Table 12. The first six of the types listed in this table refer to various classes of tools, that is, objects which have been worked into standardized forms. The last four categories refer to different kinds of unworked fragments of antler, while the remaining two are miscellaneous categories for worked antler and bone artifacts which cannot be classified into any standardized formal tool types.

The numbers of *in situ* finds assigned to the six categories of tools shown in Table 12 are quite low. As a

Table 12. Number of <u>In Situ</u> and "Other" Small Finds for All Types of Antler and Worked Bone Artifacts (except Limpet Scoops) from Cnoc Coig, 1973-79.

Artifact Type	In Situ	"Other"	Total
Delicate Awls of Bird Bone (Pins)	2	5	7
Robust Antler and Bone Awls (Borers)	17	9	26
Bevelled Tine Tips	5	1	6
Antler Harpoon Fragments	2	0	2
Antler Mattock Fragments	11	0	11
Grooved Bones with Bevelled End	2	2	4
Miscellaneous Fragments of Worked Bone	11	2	13
Miscellaneous Fragments of Worked Antler	18	10	28
Antler Bases	10	0	10
Antler Forks and Beams	7	0	7
Unworked Fragments of Antler Tine	31	16	47
Miscellaneous Fragments of Unworked Antler	197	181	378
Totals:	313	226	539

consequence of these small sample sizes, it will not be possible to say a great deal about their spatial distributions, nor will it be possible to perform any statistical manipulations on the individual tool types. Indeed, this observation applies to all of the artifact types in Table 12 except for the category of miscellaneous fragments of unworked antler. At any rate, the low frequency occurrence of these six tool types does not, however, mean that these artifacts necessarily represent only a minor component of Obanian technology or, concomitantly, that the activities in which these tools were used were comparatively unimportant and engaged in only infrequently (in direct proportion to their low frequency occurrence in the assemblage) (see Binford 1973: 242; 1977b: 33-35). This is because it is likely that these tools are items which were highly curated and which, therefore, only entered the archaeological record when they had become broken beyond repair or worn out beyond any further possible use -- and indeed, in most cases, these tool types are represented by small, broken fragments.

Awls (Figure 10)

Table 12 shows that two types of awls have been recognized in the Cnoc Coig assemblage. Following Anderson (1895; 1898) and Bishop (1914), a basic typological distinction is made between "pins" and "borers", on the basis of the relative robustness of the awls. The seven items which have been designated as bone pins are relatively delicate awls made of bird bone which have been ground to a fine, sharp tip. Similar objects have also been found at MacArthur Cave (Anderson 1895: 219, Fig. 3) and at Cnoc Sligeach (Bishop 1914: Fig. 40).

The borers are more robust awls than the pins and are made from both bone and antler. Of the 26 objects so classified, seven are made of bone and ten of antler, while six others consist of only the finely-ground tips of awls so that it is not possible to determine whether they are made from bone or antler. The remaining three borers are

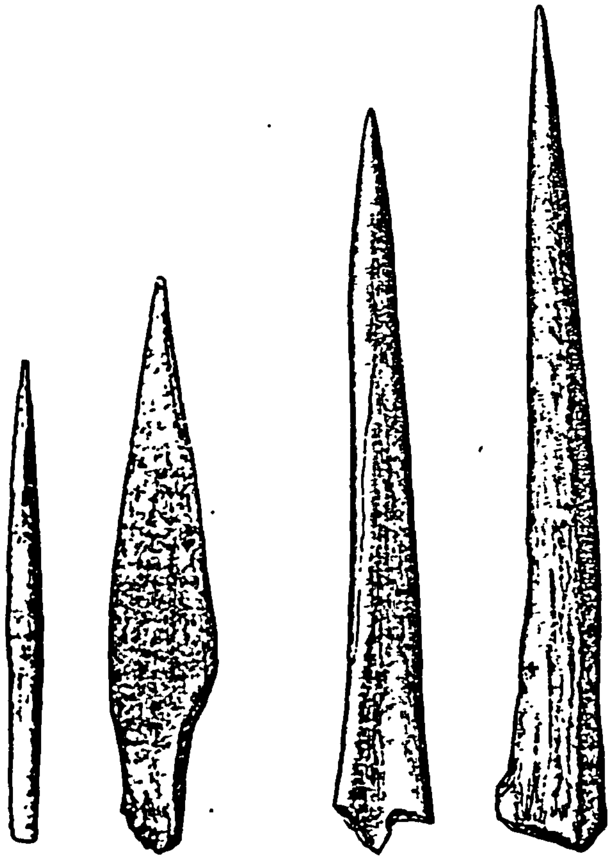

Figure 10. Obanian Antler and Bone Awls from MacArthur Cave (left two) and Druimvargie (right two). Scale: 1/1. From Anderson (1895: Figs. 3 & 4; 1898: Figs. 2 & 3).

made of antler, and although they lack their tips, which is the diagnostic feature of an awl, they are sufficiently intact to be confidently assigned to this type. Some of these borers are quite large, one of the bone specimens from Cnoc Coig being about 120 mm long which is very similar to one from Druimvargie that is 4¼" (ca. 110 mm) in length (see Fig. 10). Indeed, more or less identical awls have been recovered from all other Obanian sites: three from MacArthur Cave (Anderson 1895: 219, Fig. 4), two from Druimvargie (Anderson 1898: 301, Figs. 2 & 3), three from C.N.G. I (Anderson 1898: 307-308; cf. Grieve 1882: 483; 1885: 52), and two or perhaps three from Cnoc Sligeach (Bishop 1914: Fig. 40). In addition, awls were also found at Risga (Lacaille 1951: 124), although it is not possible to determine if these are pins, borers or both.

An interesting feature of the robust awls made of bone is that, of the seven bone borers from Cnoc Coig, three have B.L.S. on their other ends[1]. Likewise, one of the three borers from C.N.G. I has a B.L.S. on its opposite end (Anderson 1898: 307-308, Fig. 21). None of the antler specimens have this feature. This leads to a consideration of the function of these antler and bone awls. The use of the words "awl" and "borer" implicitly suggests that these objects were used to pierce small holes in skins. Indeed, the attribution of such a skin working function seems intuitively reasonable, and certainly no one has suggested any other function for this class of artifacts.

If this function is accepted, then does the presence of B.L.S. on the opposite ends of some bone borers suggest a functional connection between the two tools? In other words, might this not suggest that limpet scoops were indeed used in skin working? It is maintained here that this line of reasoning adds no significant weight to the skin working interpretation of limpet scoops, in light of the strong arguments against this idea and in favour of the limpet scooping interpretation (see Appendix A). The

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[1] Moreover, two other bone borers were found in Peacock's (1978) sampling squares and both of these have B.L.S. on the opposite end.

presence of several "dual-function" bone limpet scoops/borers in Obanian assemblages can be explained in other terms. There is no reason to assume that the two different worked ends on these items were necessarily used in the same activity and at the same time. Instead, it is held here that their use was successive and that these objects are evidence of recycling of a desirable and valuable, but relatively scarce, raw material. In the preceding discussion on limpet scoops, it was suggested that red deer bones were the most preferred raw material for making limpet scoops but that, on Oronsay at least, supplies of this material were only obtained sporadically. Given this situation and the possibility that bone was also preferred for making borers[1], then this suggested recycling of worn-out B.L.S. is perfectly understandable. Suggestively, the only "dual-function" bone limpet scoops/borers come from Oronsay -- the one reported from C.N.G. I and the several found recently at Cnoc Coig.

In any case, the function of bone pins may be thought to be different from borers because their relative fragility would certainly preclude their being used to pierce holes in hides. It has been suggested that they were used as winkle-pickers, that is, for extracting winkle meat from the shell (P. Mellars, personal communication). Such a task does not require robustness as much as it does a relatively fine, long point which can reach far enough into the shell to get sufficient purchase on the meat to pluck it out. While most of the borers are clearly too stout for this purpose, the pins do seem ideally suited for this winkle-picking function.

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[1] If this were so, one might expect that at Oban and on Risga borers would be made of bone and not antler since supplies of the former were presumably plentiful at these locations, and similarly that on Oronsay borers would be made of both antler and bone. Unfortunately, the published reports are not sufficiently informative on this matter to enable us to test thoroughly and reliably this argument.

Bevelled Tine Tips

Although many tips of antler tines have been found at Cnoc Coig, only six tine tip fragments show definite signs of having been worked. The best examples are two large tines, about 90 and 110 mm long, which have been conspicuously worked so that one side of the tip has been flattened. Three smaller tine fragments, between 20 and 30 mm in length, display the same sort of bevelling, and these would appear to represent the snapped-off tips from larger tines. A sixth tine tip, about 60 mm long, has clearly been scraped on one side, and even though it has not been flattened to the same degree as the other specimens, the amount of working is sufficient to place this item in the category of bevelled tine tips.

It should be noted that the bevelling on these tine tips clearly results from the working of the tips by humans and is not the result of natural rubbing by red deer observed on some antler tines. As for other Obanian sites, Bishop (1914: 99, Fig. 35) records finding at Cnoc Sligeach two tines which are worn at the tips, and these might be analogous to the examples from Cnoc Coig, although from Bishop's description and illustrations alone it is not possible to be certain about this identification. It is difficult to ascribe a precise function to these bevelled tine tips, although the fact that three specimens appear to have been snapped off might suggest that they were used in a relatively vigorous activity, for example, as levers to prise open certain objects.

Harpoons (Figures 11 and 12)

More than any other type of artifact recovered from Obanian sites, harpoons attracted the most attention in the early literature. Of course, this is because they were seen to be the most useful objects for engaging in traditional culture-historical systematics, and so, based on similarities between harpoons, much was written about the "cultural" affinities between the Obanian on the one hand and the Azilian and the Maglemosian on the other. In any

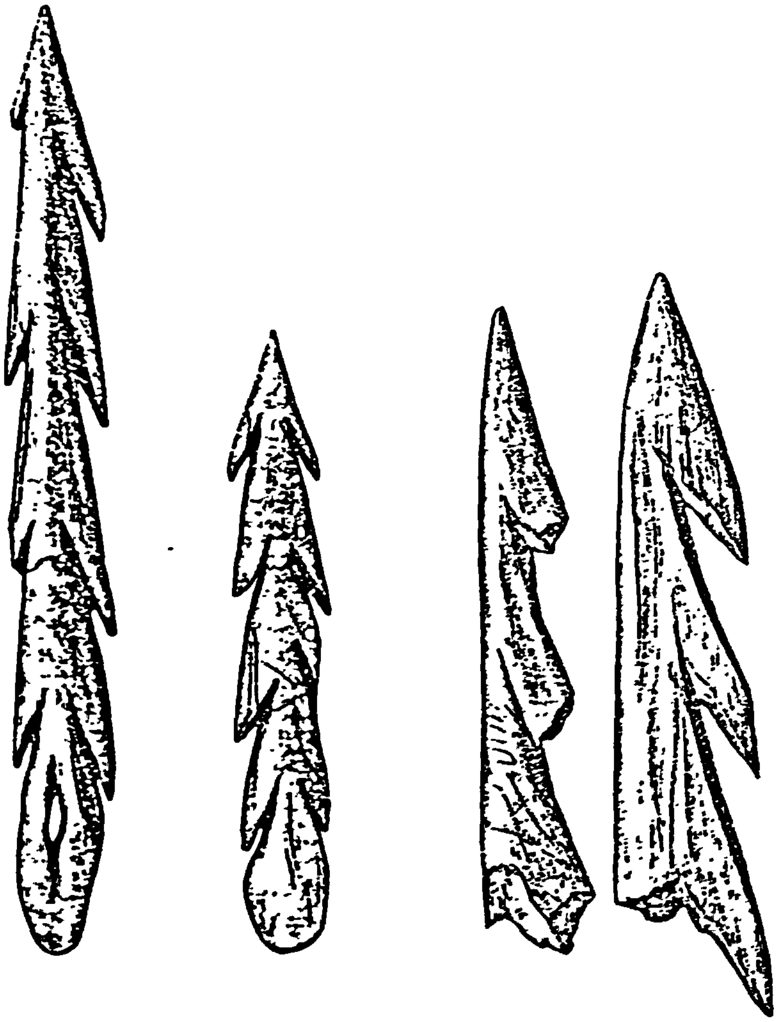

Figure 11. Obanian Antler and Bone Harpoons from MacArthur Cave (left two) and Druimvargie (right two). Scale: 3/4 (left two) and 1/1 (right two). From Anderson (1895: Figs. 11 & 12; 1898: Figs. 1 & 2).

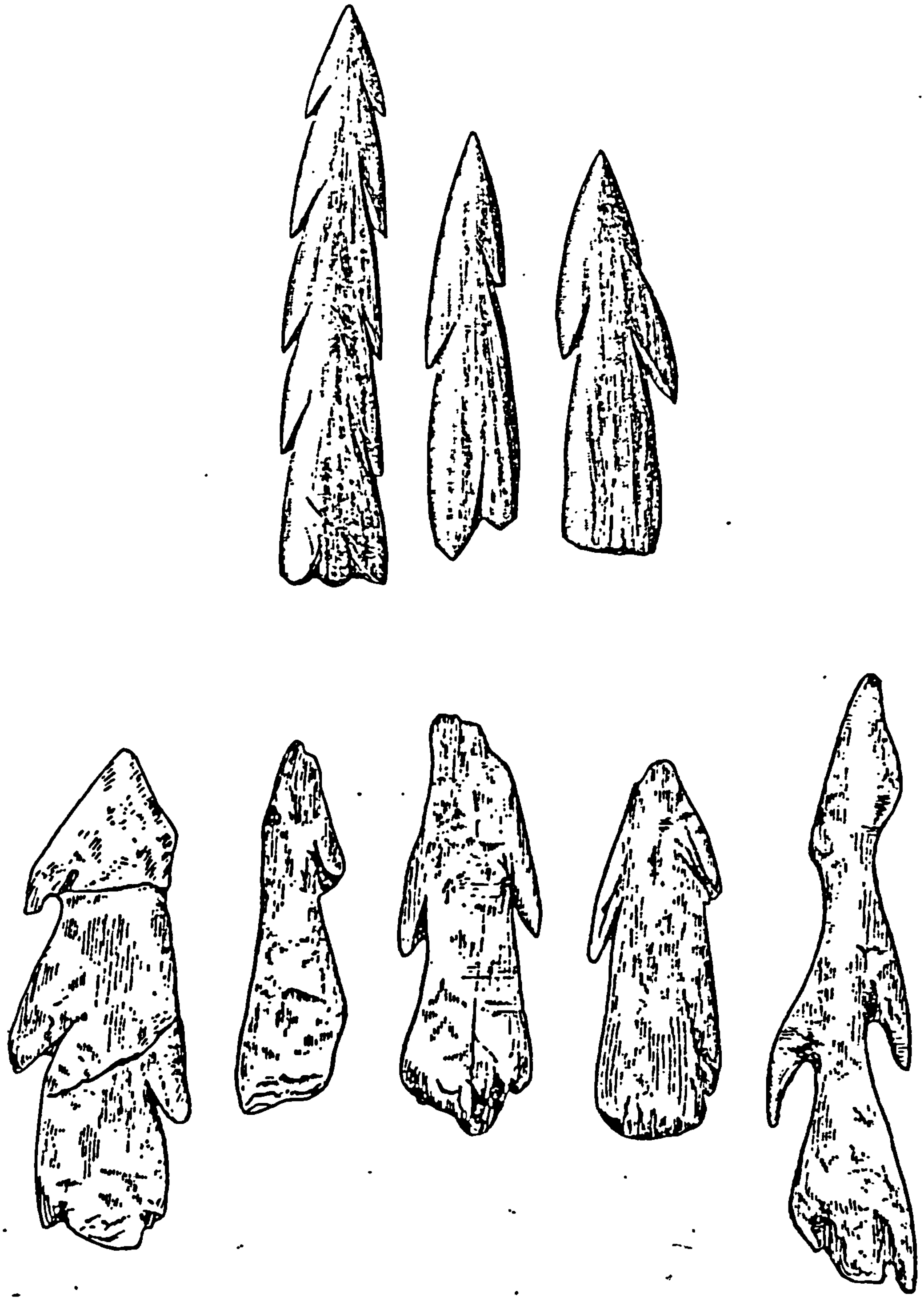

Figure 12. Obanian Antler and Bone Harpoons from Caisteal nan Gillean I (top) and Cnoc Sligeach (bottom). Scale: 1/1. From Anderson (1898: Figs. 16-18) and Lacaille (1954: Fig. 97).

event, harpoons have been recovered from all Obanian sites: seven antler harpoons from MacArthur Cave (Anderson 1895: 223-224, Figs. 11-13), two bone harpoons from Druimvargie (Anderson 1898: 300, Figs. 1 & 2), at least three bone harpoons from Risga (Lacaille 1951: 123, Fig. 9, Nos. 18-20; 1954: 232, Fig. 104, Nos. 18-20; see also Clark 1956: 92), eleven bone harpoons from C.N.G. I (Anderson 1898: 307, Figs. 16-18), and six of bone and one of antler from Cnoc Sligeach (Bishop 1914: 96-97, Fig. 38), as well as an additional bone specimen from near the main midden at Cnoc Sligeach (Jardine & Jardine 1978). The two Druimvargie specimens are barbed on one side only (Fig. 11), while all the others are barbed on both sides.

Undoubtedly, harpoons were tools which were highly curated and two specimens from MacArthur Cave illustrate well the degree of maintenance of them. These two harpoons are only "...2 inches in length [ca. 50 mm], with two barbs each, and have the butt-end rounded off, as if made from a broken portion of a longer implement, the marks of the incisions of another pair of barbs being still visible at the base" (Anderson 1895: 224). Not surprisingly therefore, most of the harpoons found are incomplete and indeed, many are merely small fragments of the tip or base of the implement. Of course, harpoons would certainly have been used and broken at locations other than these sites where they have been found, but their occurrence in these contexts is not so surprising. Binford (1977b: 33-34) has observed that under conditions of curated technologies maintained tools broken "off-site" are frequently returned to camp either for repair or to be recycled into other items. Thus, the harpoons which have been found in Obanian sites represent either items which were broken beyond any further possible maintenance or, in the few cases of complete harpoons, ones which were lost.

In any event, only two fragments of the basal portions of harpoons were recovered from Cnoc Coig despite the fact that this site has been extensively and thoroughly excavated -- this contrasts particularly with the other

Oronsay sites of C.N.G. I and Cnoc Sligeach. Yet, this observation is not as puzzling as it might at first seem. Cnoc Coig has been shown to have been occupied primarily during the autumn (Mellars 1978: 380-384; Mellars & Wilkinson 1980: 34, 36-39; Wilkinson 1981: 113-115, 126). Assuming that harpoons were used mainly for hunting seals, this is the one time of year when they would not have been used (and therefore possibly broken and discarded), since the seals haul out onto land to breed during the autumn where they could be readily exploited without harpoons (P. Mellars, personal communication). Hence, the relative absence of harpoons from Cnoc Coig is understandable in light of this other information.

The function of harpoons is clear enough, but which specific resources were exploited with these implements is less obvious. It was assumed above that harpoons were used primarily to hunt seals. However, earlier workers were of the opinion that these artifacts were fish-spears used to catch the larger species of fish found in the middens (see Anderson 1895: 223, 225, 226-227; Bishop 1914: 102, 104; Grieve 1923: 45-46, 48-51, 57, 61-64; Lacaille 1954: 200, 204, 213, 225, 232), while seals were simply clubbed and stoned while hauled out onto land (see Bishop 1914: 104; Lacaille 1951: 126; 1954: 234). It is true that the bones of a variety of larger fish were found at MacArthur Cave (Anderson 1895: 227-228), C.N.G. I (Grieve 1882: 485; 1885: 54), Cnoc Sligeach (Bishop 1914: 106) and Risga (Lacaille 1951: 116; 1954: Table V). However, the quantities of these fish represented in the middens are not provided. Recent investigations of fish bone samples from four of the five Oronsay middens, which included fine-scale sieving for smaller fish bones, has shown that these larger fish species are comparatively less abundant and that the vast majority of fish remains belong to first- and second-year saithe, Pollachius virens (Mellars 1978: 377-378; Mellars & Wilkinson 1980: 19; Wilkinson 1981: 55, 59). These young saithe are certainly too small to have been speared and the relative paucity of remains of larger fish strongly suggests that Obanian harpoons were probably not used predominantly, and certainly not exclusively, for fishing. It seems more likely that they functioned primarily as seal hunting weapons and only secondarily as fish-spears.

Antler Mattocks (Figure 13)

Antler mattocks are represented in the Cnoc Coig assemblage by 11 relatively small fragments, five of which represent pieces of the bevelled end and six portions of the perforation. Of course, fragments which do not include either of these two parts of these tools would be indistinguishable from ordinary unworked antler. One of the finds of mattock consists of two fragments which were found near each other and join together to form a complete perforation, while a second specimen is of special interest because its perforation was never finished.

Similar fragments of broken mattocks have been recovered from most other Obanian sites. Anderson (1898: 302, 309) clearly describes a fragment of a mattock perforation from Druimvargie and eight from C.N.G. I, while Lacaille (1954: 214) recognizes a ninth specimen from this site. Several fragments apparently from the bevelled ends of mattocks were found at Cnoc Sligeach (Bishop 1914: 98, Fig. 39; see also Clark 1956: Fig. 3), while Anderson (1898: 311) describes a specimen from Galloway's excavations at Cnoc Sligeach which might also be a mattock fragment. Lacaille (1951: 123, Figs. 8 & 9; 1954: 232, Figs. 103 & 104) recognizes three from Risga, although a fourth specimen seems to be included in the site's assemblage (see 1951: Fig. 7, No. 11 = 1954: Fig. 102, No. 11).

Except for one of the Risga examples and another from Cnoc Sligeach (Fig. 13), all of these finds represent quite small fragments, as a result of which they were regarded as enigmas by the earliest workers on the Obanian. Lacaille (1951: 123; 1954: 208, 214, 224-225, 232; cf. Clark 1956: 93) was the first to recognize that these fragments of worked antler belong to a well-known class of

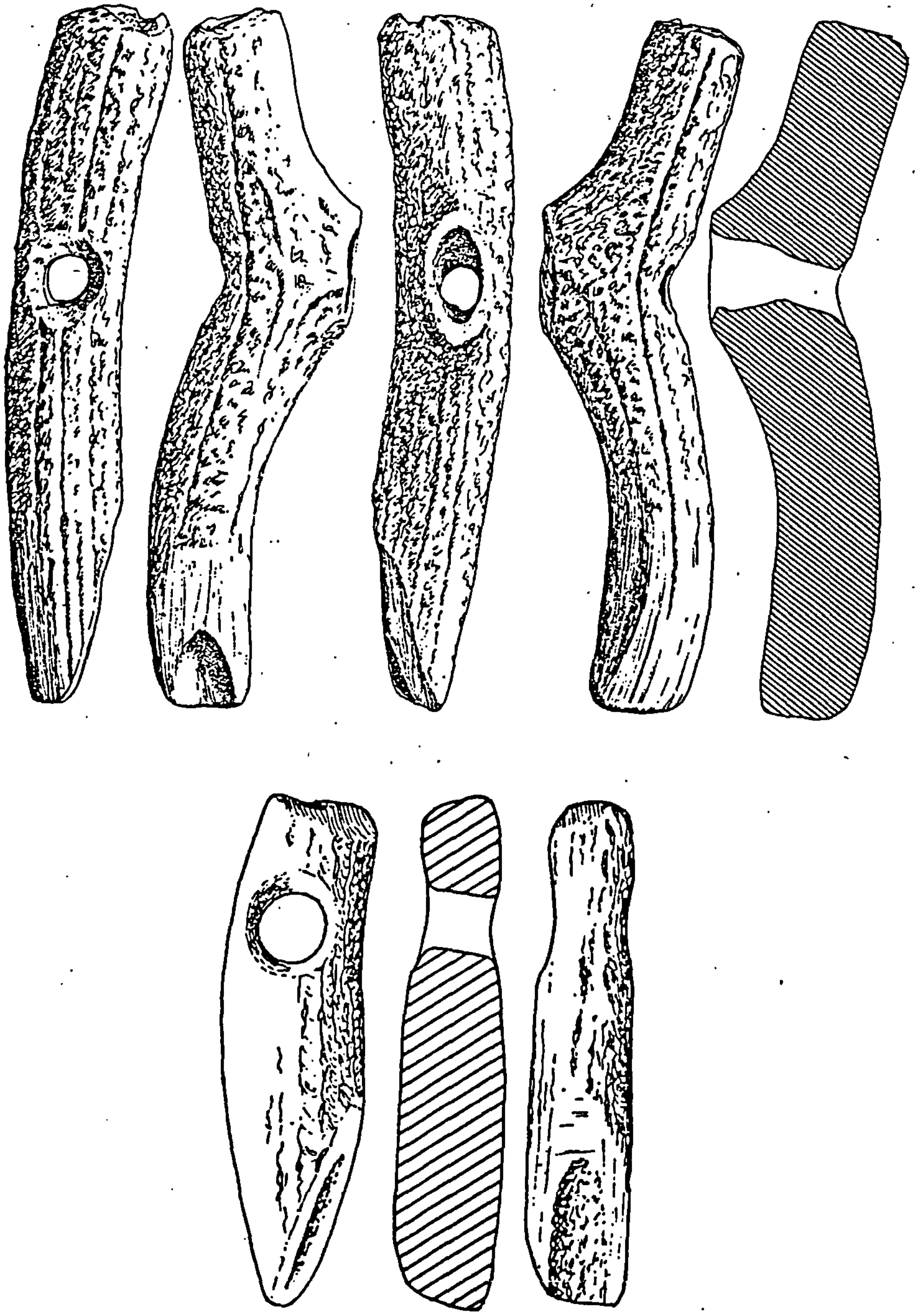

Figure 13. Antler Mattocks from Meiklewood (top, 5 views) and Cnoc Sligeach (bottom, 3 views). Scale: 1/3 (top) and 2/3 (bottom). From Clark (1956: Figs. 2 & 3).

objects found in other Mesolithic contexts and referred to as mattocks or, sometimes, blubber mattocks. From the carse clay deposits of the Firth of Forth around Stirling, a classic specimen of this type was found at Meiklewood (Fig. 13) in direct association with the skeleton of a stranded whale, an association which appears to be repeated in at least three other find spots in this area (Clark 1947: 91, Fig. 3; Lacaille 1954: 169-175; Turner 1890). This particular association between whales and mattocks led very early on (Turner 1890: 791) to the interpretation that these axe-like implements were used as flensing tools for stripping blubber and flesh off whales, to which we might add that presumably mattocks could also be used for flensing seal carcasses. That this was one function of these tools seems scarcely deniable, although their occurrence in inland contexts in other parts of Europe suggests that they may have had numerous potential functions.

Clark (1956: 98, Fig. 4) describes and illustrates how mattocks typically are made from the middle section of an antler beam. Clark also claims that a lighter variety could be made from the upper end of the beam at the base of the crown, although he refers to no known examples of this (except for a possible "blank" mattock from C.N.G. I). Furthermore, he suggests that large tines could also be used, as with the comparatively small but complete specimen from Cnoc Sligeach (Fig. 13). In any case, even the smallest mattocks are rather large chunks of antler and because of this, it is not surprising that they are usually found only as small fragments in Obanian sites. Mattocks were undoubtedly highly curated tools, but once broken, they were presumably not usually discarded immediately as substantially whole though broken tools. Rather, it seems likely that they were regarded as a useful supply of raw material and so were broken up to be used for the manufacture of other, smaller implements such as A.L.S. This recycling of mattocks which were no longer serviceable would presumably have been more characteristic of the occupations on Oronsay where supplies of antler were less abundant and more sporadic than on the mainland. In the

Cnoc Coig assemblage, such recycling of mattocks is indicated by one A.L.S. which is clearly made on a fragment from the bevelled end of a mattock, and by another A.L.S. which is probably made on a reused mattock fragment. Likewise, Anderson describes one limpet scoop from Cnoc Sligeach which has "...one end rounded and the other slanted and finely polished by friction" (1898: 311), which might also be an example of a reworked mattock fragment; and Breuil (1922: Fig. 5, No. 2) illustrates a "bone" limpet scoop from C.N.G. I which might be yet another example. However, these latter two cases might be interpreted differently, as examples of grooved bones.

Grooved Bones with Bevelled Ends

Four artifacts from Cnoc Coig have been classified as "grooved bones with bevelled ends", which represent a hitherto unrecognized tool type in Obanian assemblages[1]. All of these finds consist of elongated fragments approximately the length of antler and bone limpet scoops (ca. 40-80 mm). They are characterized by being highly ground and polished on one end and along one side to form a curving, rather stout, though fairly sharp edge; the opposite (non-edge) side is straight and has a flat platform which is perpendicular to the faces of the tool. Indeed, because of this platform-like side, it would be very easy to interpret these fragments as being backed tools of some sort. However, their true character is revealed by two fragments which were found quite far apart (ca. 14 m) in different areas of the midden. These two fragments actually fit together to form the complete end of one of these tools. The flat, platform-like, apparently "backed" sides are in fact the two edges where the fragments join together -- in other words, these flat sides are where the tool broke longitudinally. Because these two fragments fit together so well, it seems highly unlikely that these tools were

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[1] Additionally, three other specimens were found in Peacock's (1978) sampling squares, making a total of seven from the site. One of these three fragments has a B.L.S. on the non-bevelled end.

purposefully split lengthways to form a "backed" tool, although it is possible that once they were broken beyond further use these grooved bones were so split to facilitate their being recycled into B.L.S. or other small tools. In any event, these few fragments represent tools made from mammal long bones which had been split longitudinally into two semi-circular grooved halves which were then highly ground to form a curved and bevelled end. Since they are represented only by small fragments, it is impossible to say how long a complete tool might have been.

It seems likely that these grooved bones were highly curated tools. However, as with mattocks, it would appear that, once broken, they were treated as a useful supply of raw material to be recycled into other, smaller tools. Such recycling is evidenced by the fact that two of these grooved bone fragments (including one of the three from Peacock's sampling squares) has a B.L.S. on the other (non-bevelled) end. In light of the argument above that mammal bones were a relatively scarce raw material on Oronsay, this recycling is consistent with other observed aspects of Obanian technology, in particular the recycling of broken mattocks and the reworking of B.L.S. into borers. Since these grooved bones with bevelled ends appear to have been broken up and recycled once no longer serviceable, as a result of which they are only represented by small fragments, it is not surprising that this tool type has not been recognized before by earlier researchers. However, this does not mean that such fragments are not present in the assemblages from other Obanian sites. For example, as referred to in the preceding discussion on mattocks, Anderson (1898: 311) describes an artifact from Cnoc Sligeach which might be a grooved bone fragment reworked into a limpet scoop, as well as another artifact which might be a fragment of a grooved bone. One of the B.L.S. from C.N.G. I illustrated by Breuil (1922: Fig. 5, No. 2 = Lacaille 1954: Fig. 87, No. 2) also might be a recycled fragment of the bevelled end of a grooved bone. Moreover, Bishop (1914: Fig. 35) illustrates an object from Cnoc Sligeach which resembles the one from C.N.G. I shown by

Breuil, though it does not have a limpet scoop on its one end. In all these cases, however, in the absence of being able to refer directly to the actual specimens, it is not possible to say if these are grooved bone fragments or if they are mattock fragments, since both of these tool types could yield fragments which are highly polished and bevelled.

Regarding their function, these grooved bones must remain as somewhat of an enigma. Bishop, when musing over the function of mattock fragments which had then not been recognized as such, wryly stated that "...we may not be wrong in seeking their explanation in that last resort of the puzzled archaeologist -- that they were used in some sort of skin-dressing process" (Bishop 1914: 98)! Although it might be tempting to regard grooved bones as the best candidates for such a function, rather than falling back on this "last resort", it is perhaps best simply to leave open the question of the specific function of these grooved bones with bevelled ends.

Miscellaneous Fragments of Worked Antler and Bone

As can be seen from Table 12, 28 and 13 artifacts in total have been classified respectively into the categories of miscellaneous fragments of worked antler and worked bone. Several specimens, eight of antler and four of bone, appear as though they might be objects which had been initially shaped into limpet scoops but were never finished or used. Most of the other objects are idiosyncratic and need not be described or mentioned further.

However, three are sufficiently intriguing to merit some further attention. The first object is a piece of worked bone, or perhaps even tusk, which is quite thin and has a curious mustachioed shape; it might be suggested that this is an unfinished ornament of some kind. Another item is an awl-like fragment of (bird?) bone which is oddly flattened on the end towards the tip, though the tip itself is broken off. Despite being flattened, this is not like the bevelled tine tips, nor is it a bone pin, although it is perhaps best regarded as an unfinished pin which has been initially thinned and shaped but not enough to acquire the characteristic rounded form. In any case, Anderson (1895: 219) describes three bird bones from MacArthur Cave which are simply flattened on one side; these would seem to be akin to this one artifact from Cnoc Coig. Similarly, Bishop (1914: Fig. 40) illustrates one "pin" from Cnoc Sligeach which also seems to be a cognate artifact with these other examples. The third object is a rather straight piece of porous and badly eroded antler (or seal bone?) which is about 150 mm long and was found broken into three fragments. It could be an unbarbed projectile point, although, except for one rather dubious fragment from Risga (Lacaille 1951: Fig. 9, No. 21 = 1954: Fig. 104, No. 21), no unbarbed projectile point has ever been recorded from any Obanian site -- and because of its very eroded nature, it is doubtful that this specimen could be confidently identified as being the first definite example of an unbarbed Obanian projectile point.

In any event, little can be said regarding the spatial distribution of these artifacts because these two general categories are a hotchpotch of peculiar and idiosyncratic objects. Nonetheless, since many of them may be interpreted as unfinished artifacts, their locations within the midden might be of some interest in terms of the definition of loci of manufacturing activities, especially when viewed in light of other lines of evidence.

Fragments of Unworked Antler

The final four categories from Table 12 which have yet to be discussed refer to various pieces of unworked antler. These include fragments of varying sizes from very small bits to comparatively substantial chunks of antler beams and tines, although by far the largest amount of this antler is small, broken fragments. In describing these as unworked, it is meant that these pieces of antler show no traces of shaping or working in any way beyond the initial stage of breaking up the antler into smaller pieces for the manufacture of various implements. Clark (1956: 93-98) has argued that, in the absence of burins in Obanian flint assemblages, the Obanian method of working antler did not involve the groove-and-splinter technique; rather, the antler was divided into sections by "nibbling" through the hard outer wall at an oblique angle, presumably using any suitable flint flake on hand. Traces of this nibbling process can be observed on many of the antler fragments from Cnoc Coig.

Table 12 shows that ten antler bases were found and recorded in situ from the recent excavations at Cnoc Coig. Seven of these bases are from antlers which had been shed, while the other three are unshed which would have been acquired when a deer was killed. Traces of nibbling can be seen on these bases where the bez tine and beam were cut off from the base -- as an example, Clark (1956: Fig. 6, cf. Fig. 4C) illustrates an unshed antler base from Druimvargie. In the process of reducing antler into sections suitable for manufacturing various tools, these bases are pieces of antler which were of no further utility and so were the discarded by-products of antler working.

In addition to these bases, seven relatively large portions of beam were recorded in situ from Cnoc Coig. One of these is a long, straight piece of beam *with no adjoining* tines or basal portions thereof. Two others are three-pronged forks representing the upper end of the beam and the crown, while a fourth is a two-pronged fork from the crown with complete tines. The remaining three specimens are pieces of the upper end of the beam with only the basalmost portion of the crown -- Clark (1956: Fig. 5A, cf. Fig. 4A) illustrates an identical specimen from C.N.G. I. More numerous than bases or beams are fragments of tine. Although a few of these are fairly large pieces, most are only small fragments of tine tips. These 47 finds represent the unworked fragments of antler tine but, as described above (p. 140), there are also six tine tips which have clearly been worked.

By far the most numerous category shown in Table 12 is that of miscellaneous fragments of unworked antler. All of these finds consist of small bits and pieces of antler, some of which are very small and broken up -- hence, many were only picked up by sieving which accounts for the fact that nearly 50% of these are not in situ finds. Of course, none of these fragments show any signs of working, except in some cases for "nibbling" marks where the antler had been broken up into smaller chunks. Most of these finds include between one and five fragments, but in a few cases, there are considerably more, though invariably these are highly comminuted. Many of these fragments of antler are so small that they undoubtedly represent the discarded, useless waste by-products of antler working. Nevertheless, a few pieces are large enough to have been utilizable as blanks for making smaller tools, most particularly A.L.S.

This observation and the fact that a few rather large chunks of antler beam were found at Cnoc Coig leads to a consideration of the question of the availability and abundance of the supply of antler. In the preceding discussion, it was noted that broken mattocks were often recycled for the manufacture of other tools due to the relative difficulty of obtaining antler on Oronsay. Moreover, a model was suggested to explain the presence of different material types of limpet scoops in which it was held that supplies of antler were intermittent on Oronsay so that the Mesolithic inhabitants frequently had to revert to using the less desirable beach pebbles for making limpet scoops. Does not the presence of quantities of unused but utilizable pieces of antler contradict this argument, in particular the notion that supplies of antler were insufficient for manufacturing needs?

This objection can, however, be answered. Firstly, the amount of discarded but useful antler is actually not that great. Most of the tine fragments and the miscellaneous pieces are too small to have been of any use; thus, only the seven beams and forks represent any substantial amount of potentially workable antler. Secondly and more importantly, the abundance of supplies of antler may be presumed to have not been constant -- that is, the supply would have been sporadic because antler had to be obtained on some island other than Oronsay, possibly on Colonsay but more likely on Jura or Islay (cf. Grigson 1981: 170-171). It seems highly unlikely that people would make task-specific trips to one of these other islands solely for the purpose of procuring a supply of antler -- in other words, we may presume that antler would have been acquired by a procurement strategy that was embedded in basic subsistence scheduling (see Binford 1979b: 259-261). Accepting this, then it is not difficult to envisage how supplies of antler would be sporadic, _if_ the subsistence schedule did not involve sufficiently frequent visits to the other islands where antler would be obtained. Therefore, it is suggested here that people on Oronsay were not frequenting other islands where red deer were available often enough to obtain a steady supply of antler to meet all their manufacturing needs at all times. Yet on the other hand, their visitations to these places were not so infrequent that antler was regarded as a critically scarce raw material which was only acquired very infrequently and unpredictably. If this were so, one would expect a more parsimonious and prudent utilization of antler than was actually the case. Specifically, one would not expect antler to be used for such pedestrian items as limpet scoops which were tools with relatively short use-lives and for which another suitable material (stone) was locally abundant. Moreover, one would expect that antler would not be treated with such abandon that large, usable chunks were discarded or left lying around to be abandoned as de facto refuse.

Thus, regarding the supply of antler, we can imagine a variable situation in which antler was acquired fairly frequently, though not always sufficiently to satisfy all manufacturing needs at all times. Sometimes, the amount of antler would be insufficient for all manufacturing requirements throughout a particular occupation or during a particular span of time, and in this situation, people would recycle as much antler as they could (mostly in the form of broken mattocks) and would revert to making limpet scoops out of elongated beach pebbles. At other times, the amount of available antler would be adequate for all manufacturing needs during a particular occupation and even in some instances, more than adequate so that relatively large pieces were discarded or simply left as de facto refuse. And of course, in any situation or at any time, usable fragments of antler might occasionally be lost. It does not seem difficult, therefore, to account for the mere seven or so relatively large pieces of antler found at Cnoc Coig, and it is maintained here that the presence of some unused but utilizable antler does not contradict the arguments put forward earlier regarding the recycling of antler mattocks and the explanation of the existence of different material types of limpet scoops.

Other Stone Artifacts

Potential and Unused Stone Limpet Scoops

In addition to S.L.S., there are a number of other types of stone artifacts found at Cnoc Coig which are included in the present study. The most abundant of these are a group of elongated beach pebbles which are very similar in form and size to S.L.S. but which have no signs of use or modification of any sort. In short, these pebbles presumably represent excess raw material which had been collected from storm beaches with the intention of being used as S.L.S. Within this basic category, a distinction may be made between the smaller and larger specimens -- the former are referred to as "potential stone limpet scoops" (P.S.L.S.), while the latter (100 mm or more in length) are designated as "potential stone limpet scoops/ hammers" (P.S.L.S./H.) since these longer elongated beach pebbles could potentially have been used either as S.L.S. or S.L.H. In addition, a distinction may be made between whole and truncated pebbles on the basis of whether they are rounded and smoothed on both ends or only on one end. Table 13 shows the number of in situ and "other" finds

Table 13. Number of In Situ and "Other" Small Finds of Potential and Unused Stone Limpet Scoops and Hammers from Cnoc Coig, 1973-79.

Type of Elongated Pebble	In Situ	"Other"	Total
P.S.L.S., whole pebble	113	18	131
P.S.L.S., truncated pebble	26	10	36
P.S.L.S./H., whole pebble	14	2	16
P.S.L.S./H., truncated pebble	4	0	4
U.S.L.S.	9	0	9
Totals:	166	30	196

assigned to these various subtypes of potential stone limpet scoops and hammers. Such P.S.L.S. and P.S.L.S./H. are not reported from any of the previously excavated Obanian sites, except for a supposed S.L.H. from C.N.G. I illustrated by Grieve (1923: Fig. 19, No. 1) which would here be classified as a P.S.L.S./H. For the Oronsay middens at least, the lack of reference to such artifacts is almost certainly due to the fact that such unworked, commonplace items as these were simply ignored by the earlier workers, and it is undoubtedly not a reflection of their absence in these sites.

The presence in the midden of both whole and broken pebble P.S.L.S. and P.S.L.S./H. provides further confirmation of the argument presented above (pp. 114-115) that truncated S.L.S. were indeed broken before becoming limpet scoops and not as a result of use. As with S.L.S., despite the fact that some are whole pebbles and others truncated, the length distributions of these two groups are not highly significantly different. Using the in situ specimens as a large and representative sample and the S.P.S.S. package of statistical programs (Nie et al. 1975) on the computer, the following descriptive statistics and results were obtained. The mean maximum length of the 127 whole pebble P.S.L.S. and P.S.L.S./H. is 76.49 mm with a standard deviation of

26.16, while that of the 30 broken specimens is 67.10 mm with a standard deviation of 24.63. A Student's t-test comparing these two distributions yielded a t value of 1.79 which, with 155 degrees of freedom, is significant at the 5% level though not at the 2.5% level, suggesting at most only marginal significance. Thus, with P.S.L.S. and P.S.L.S./H., as with S.L.S., there is no reason to regard the distinction between whole and broken pebbles as being of any particular importance, and it will not be used in any subsequent analysis of these artifacts.

Bishop's (1914: 95) hypothesized life history of a S.L.S. is described and discussed in detail in Appendix A. Confirmation of Bishop's model is provided by the P.S.L.S. and P.S.L.S./H. from Cnoc Coig. Bishop suggested that a S.L.S. was made by flaking away the end of a pebble to produce a sharp cutting edge to use for scooping limpets from the shell. The implication of this is that the removal of several flakes from the end of a pebble should result in S.L.S. being significantly shorter than unmodified elongated beach pebbles. Figure 14 shows two histograms comparing the length distribution of all _in situ_ S.L.S. with that of all _in situ_ P.S.L.S. and P.S.L.S./H. From this, it seems intuitively clear that P.S.L.S. are indeed longer than S.L.S. and, not surprisingly, a t-test run on these data shows that this difference is highly significant. This t-test yielded a t value of 7.51 which, with 471 degrees of freedom, is significant at the 5% level and indeed even at much higher levels of significance. Thus, this simple test provides even further supporting evidence for Bishop's ideas about S.L.S.[1]

In addition, another type of artifact found at Cnoc Coig provides even more support. Table 13 shows that there were nine artifacts recorded _in situ_ which are

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[1] As an interesting aside, Figure 14 reveals that in terms of length the population of P.S.L.S. and P.S.L.S./H. is not homogeneous; in addition to the main group, there is an indication of a second group occurring between 130 and 180 mm with a break around 120 mm. This exactly mirrors the pattern for S.L.S. except that the whole distribution is shifted about 20 mm to the right.

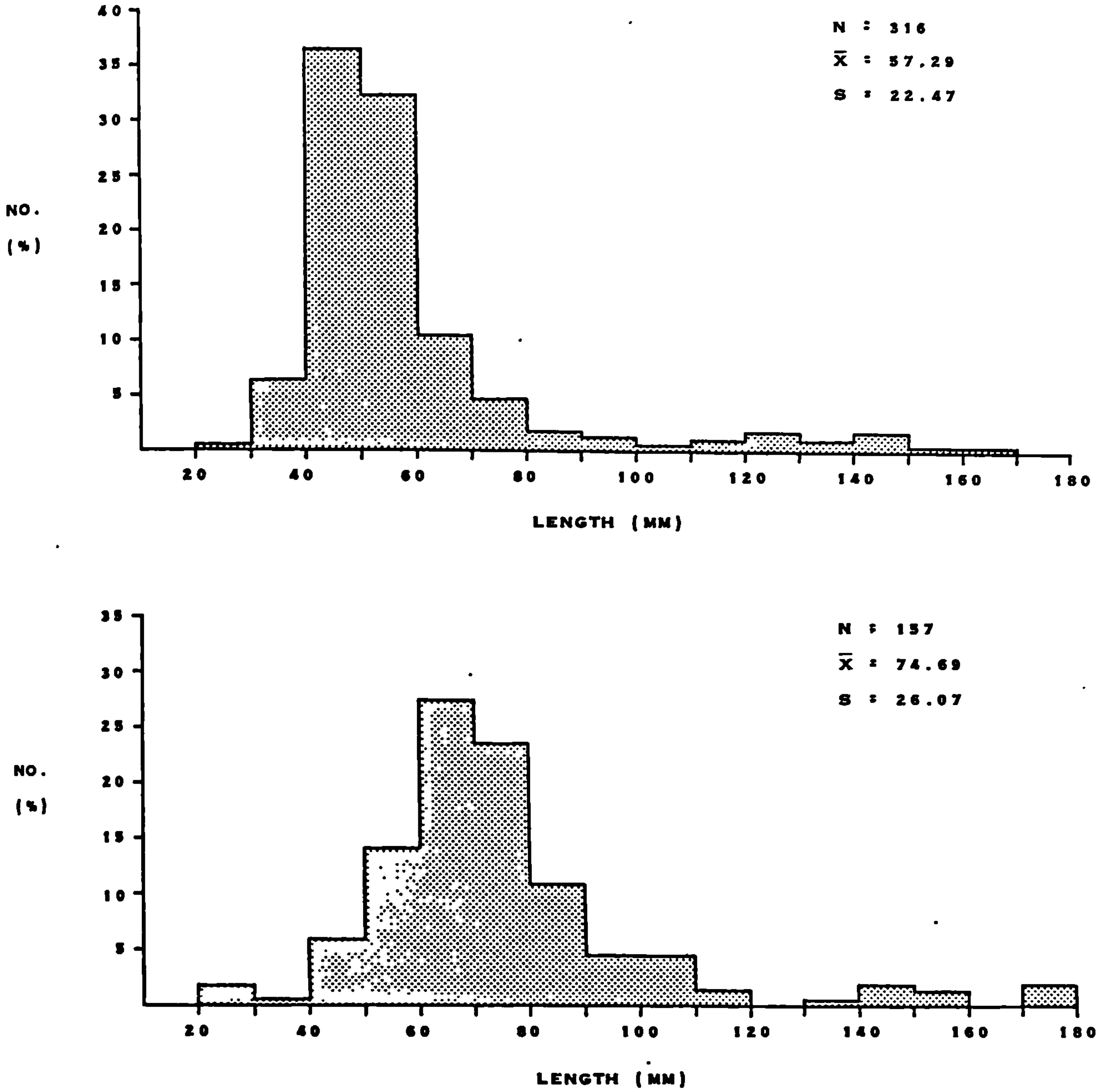

Figure 14. Frequency Distribution of the Maximum Lengths of Stone Limpet Scoops (top) Compared to Potential Stone Limpet Scoops (bottom), Based on the <u>In Situ</u> Small Finds from Cnoc Coig, 1973-79.

designated as "unused stone limpet scoops" (U.S.L.S.). These are elongated beach pebbles which are bifacially flaked so that the end has a sharp, straight, chisel-like edge which is transverse to the long axis of the pebble. While they might be considered a distinct type of tool, these end-flaked pebbles conform exactly to Bishop's suggested initial form for S.L.S. Three of these are made on whole pebbles and three on truncated pebbles, while two others are double-ended (i.e. flaked in the same manner on both ends). But of special interest is the ninth specimen which suggestively is a U.S.L.S. on one end and a S.L.S. on the other. Thus, these few end-flaked pebbles would represent S.L.S. which are in their pristine form (i.e. immediately after manufacture) because they had been discarded, abandoned as de facto refuse or lost before being used, or at least before being used to any observable degree.

Pitted Pebbles (Plate 2)

Another class of Obanian stone artifacts are "pitted pebbles" which are relatively large, flat, round to oblong beach pebbles with marked pitting in one or more places on the pebble. Three types of pitted pebble may be defined on the basis of where the pitting occurs. Hammerstones are pebbles which are pitted along the edge of the stone, while anvilstones have pitting on the face and hammer/anvilstones are pitted both on the edge and on a face. In addition, anvilstones and hammer/anvilstones may be further classified into subtypes on the basis of whether the stone is pitted on one face only or on both faces; in a number of cases of broken or more irregularly shaped pebbles, this distinction cannot be applied and so these objects have been classified as indeterminate. The pitting on anvilstones tends to be localized and confined to fairly small, roughly circular patches on the face, and it occurs either in the centre of the pebble or off-centre towards one of the ends or, in a few instances, in both places.

Table 14. Number of In Situ and "Other" Small Finds for All Types of Pitted Pebbles from Cnoc Coig, 1973-79.

Type of Pitted Pebble	In Situ	"Other"	Total
Hammerstones	2	1	3
Hammer/Anvilstones			
one face only	3	0	3
both faces	16	6	22
indeterminate	1	0	1
total	20	6	26
Anvilstones			
one face only	6	5	11
both faces	17	5	22
indeterminate	4	3	7
total	27	13	40
Totals:	49	20	69

Table 14 shows the numbers of in situ and "other" finds from Cnoc Coig assigned to each of these types and subtypes of pitted pebbles. It can be seen from this table that hammerstones are less common than anvilstones and, in particular, that pebbles which have no pitting whatsoever on a face are very rare indeed (only 3 out of 69, or 4.3%). Regarding anvilstone use, it can be seen that anvils with pitting on both faces are considerably more common than those with only one pitted surface (44 or 63.8% of all pitted pebbles compared to 14 or 20.3%).

Analogous objects from other Obanian sites are described or illustrated in published reports: from MacArthur Cave (Anderson 1895: 218), C.N.G. I (Anderson 1898: 310; Grieve 1882: 482-483; 1885: 51-52; 1923: Fig. 21, No. 1), Cnoc Sligeach (Anderson 1898: 312; Bishop 1914: 91, Fig. 32), and Risga (Lacaille 1951: 126; 1954: 234). Bishop (1914: 91) attributes the pitting on some (most?) of these pebbles to their having been used for breaking open the shells of dog whelks. Certainly, dog whelks were broken in order to extract the meat, and it seems likely that anvilstones would have been used for this purpose. However, experiments conducted by the author (reported in Appendix B) indicate that this activity is by itself not sufficiently robust to account for the marked pitting found on most of these stones. Bishop (1914: 91) also suggests that the pitting on at least one pebble from Cnoc Sligeach was a result of fracturing flint nodules, while Lacaille claims that the hammerstones from Risga "...are bruised mainly from their having been used to flake stone" (1951: 126). That hammerstones and anvilstones were also used for fracturing flint cobbles is indeed likely. Nevertheless, as Lacaille (1954: 214) himself points out, it is reasonable to suggest that these artifacts were multi-purpose tools used in a wide range of domestic and industrial tasks involving the breaking, crushing or cutting of various objects and materials.

Pumice Stones

Also found at Cnoc Coig were 23 finds of pumice stone, of which six and 17 are _in situ_ and "other" finds respectively. Although about half of these are small and even very small fragments of pumice, especially those which were not found _in situ_, a few are moderately large pieces of pumice including the six _in situ_ finds. The only other Obanian site reported to have contained pumice pebbles is Cnoc Sligeach (Bishop 1914: 99, Fig. 40). Bishop suggests that they were used as grinders or hones for manufacturing antler and bone awls, this function being indicated by the presence of channels or grooves worn into the two pumice pebbles from the site. That pumice stones were used in antler and bone working seems plausible enough, and in fact, one of the _in situ_ pumice pebbles from Cnoc Coig does have a groove-like trough across one face of it, although it cannot unambiguously be said to have been the result of antler working.

Shells and Ornaments

By its very nature as a shell midden, the most abundant remains in Cnoc Coig are not surprisingly the whole or broken shells of various species of shellfish. By far the most numerous of these are limpets, with smaller quantities of dog whelks, periwinkles, mussels, pectens, oysters, razor-shells and so forth. These molluscs may be divided into two broad categories: those which were exploited as food resources, and those which were not but whose shells were employed as artifacts of one kind or another.

The Remains of Food Molluscs

The first of these categories comprises the vast bulk of shellfish remains within the midden. It includes the limpet (Patella vulgata and P. aspera), the dog whelk (Nucella lapillus), the common periwinkle (Littorina littorea), the common mussel (Mytilus edulis), the European oyster (Ostrea edulis), razor-shells (Ensis spp.) and a few very minor species of bivalves[1]. The majority of these molluscs inhabit the littoral (intertidal) zone, at least in part, and can be so readily collected with the most rudimentary technology that there can be no doubt that their shells in the midden, regardless of their respective quantities, represent discarded food remains. Because of the vast quantities and/or the highly comminuted nature of these remains, obviously these data were generally not treated as small finds, nor were their exact locations within the site recorded.

There are however a number of exceptions to this. The general procedure employed during the excavation of Cnoc Coig was to treat as small finds the shells of any conspicuously uncommon mollusc found within the midden,

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[1] The taxonomic binomials used in this study for the various species of molluscs follow the nomenclature used by Beedham (1972) and Tebble (1976). Any references to the biology of these shellfish, particularly to habitat distributions, are also from these sources.

regardless of whether or not they are likely to be food remains. This of course rules out the most commonly occurring shellfish, namely, limpets, dog whelks and periwinkles. Remains of the mussel, and to a lesser extent razor-shells, are not uncommon in the midden, but these shells are so brittle and fragile that they are usually represented only by highly comminuted fragments. Hence, in the few rare instances when shells were found more or less complete, in six cases for the mussel and four for razor-shells, they were treated as small finds. However, because these only represent a minute fraction of the total remains of these two species, these few small finds are of no particular value for spatial analysis and so they are not used in this study.

Several other bivalve molluscs are represented in the midden by only a handful of small finds. These species include four small finds of the dog-cockle (*Glycymeris glycymeris*), two of the common cockle (*Cerastoderma edule*), five of the venus clam (*Venus casina*), and nine of the carpet-shell (*Venerupis* spp., probably *V. decussata* and/or *V. rhomboides*). Of course, these small finds do not necessarily constitute all of the remains of these shellfish in the midden, but owing to the relative robustness of these shells, they are not represented by large quantities of highly comminuted fragments, as is the case with mussels and razor-shells. Hence, these molluscs are truly rare species in the midden. At any rate, it is difficult to determine whether these finds represent shells collected when washed up on beaches, as is likely for the relatively deep-water species of the dog-cockle and the venus clam, or whether they are shellfish which were very uncommon around Oronsay owing to a lack of suitable habitats but which were collected as food on rare occasions, as is likely for the cockle and carpet-shells. In either case, it is of little relevance here because there are so few finds of these shellfish that no meaningful statements can be made about their spatial distributions within the midden.

However, the same cannot be said about the European oyster. There are 96 small finds of oyster recorded in situ from Cnoc Coig, of which 92 are from the areas of the site used in the present study. Although these represent only the larger fragments of oyster shell, they form a sufficiently large sample to investigate the distribution of oyster remains within the midden. The oyster is not an intertidal mollusc but, because it is a sessile organism and is non-burrowing, and because it does occur from the low-water mark to further offshore, it would have been possible to locate with ease and collect oysters at extreme low tides whenever encountered in the extreme upper sublittoral zone. It seems reasonable, therefore, to regard oysters as a food resource which was exploited, albeit relatively infrequently, by the Mesolithic inhabitants of Oronsay. This is the only food mollusc from the midden which will be included in the present study because it is the only one for which an appropriate body of data exists.

Utilitarian Shell Artifacts

The second category of shellfish are all sublittoral molluscs which inhabit relatively deep water but which, unlike the oyster, are not sessile non-burrowers. Hence, their exploitation as a food resource by Mesolithic groups can almost certainly be ruled out. Because the shells of these species are today commonly found washed up on beaches on Colonsay and Oronsay, sometimes in considerable numbers, it seems likely that the shells of these molluscs were collected from the beaches by the Mesolithic inhabitants of Oronsay for use as expedient tools. Therefore, since the remains of these shellfish are best viewed as artifacts rather than discarded food refuse, these shells were treated as small finds and were recorded in situ during the excavation of Cnoc Coig. It should be noted, however, that this procedure only applied to either whole shells or substantially intact ones (i.e. when more than half of the shell was present); smaller, more comminuted fragments were treated in the same way as the remains of the other shellfish. Of course, these small-finded shell artifacts constitute only a minute fraction of all the shellfish remains from the site.

By far the most common of these shell artifacts are the shells of the great scallop or pecten, Pecten maximus. Pectens are inequivalve bivalve molluscs, with the left valve being flat and the right valve convex. Both valves are represented in Cnoc Coig, and Table 15 shows the numbers of in situ and "other" small finds of whole and incomplete pecten shells of both valve types. If pectens were actually collected as a food resource, one would expect an approximately equal number of left and right valves (P. Mellars, personal communication). However, as can be seen from Table 15, the left (flat) valves are considerably less common than the right valves (44 compared to 171). This disproportionate representation is exactly what one might expect from a bivalve mollusc whose shells were collected when washed up on the beach. This bias towards right valves in the midden might reflect the fact that the Mesolithic people occupying Oronsay preferred them because their convex shape made them more useful than the flat valves, although this bias might also result from a differential tendency for right valves to be caught in turbulent water and so washed up on beaches.

In any case, pecten shells have been consistently found in all previously excavated Obanian sites, although there has been some confusion over the specific identifications of pectinids in these sites. Anderson (1898: 299) records the presence of pecten shells in Druimvargie and, although he does not generally provide taxonomic binomials, he (1895: 216) specifically mentions that shells of Pecten maximus were found at MacArthur Cave. Moreover, Bishop (1914: 106) records that Pecten maximus is the only positively identified pectinid represented at Cnoc Sligeach -- the few illustrated specimens (1914: Fig. 41) clearly confirm this identification. On the other hand, Grieve (1882: 485; 1885: 55; 1922: 166) only recognizes the queen scallop, Pecten (i.e. Chlamys) opercularis, from C.N.G. I,

Table 15. Number of In Situ and "Other" Small Finds for All Types of Pecten Shells from Cnoc Coig, 1973-79.

Type of Pecten Shell	In Situ	"Other"	Total
Flat Valve, complete	22	2	24
Flat Valve, incomplete	18	2	20
Convex Valve, complete	67	0	67
Convex Valve, incomplete	100	4	104
Totals:	207	8	215

although the one illustrated specimen from this site (Grieve 1923: Fig. 21, No. 3) is clearly a great pecten and not a queen scallop even though it is labelled as the latter -- this suggests that Grieve has erroneously identified the pectinids from this site. Similarly, Lacaille (1951: 116; 1954: Table V) only recognizes the queen scallop from Risga but, due to the lack of any illustrated specimens, it is not possible to say whether this identification is correct or not. At any rate, in the middens on Oronsay at least, the large pectinids almost certainly all belong to Pecten maximus, although the presence of a few specimens of Chlamys opercularis cannot entirely be ruled out. However, no whole or substantially complete shells of the queen scallop were recovered from the recent excavations at Cnoc Coig.

Less common than pecten shells are those of the Iceland cyprina, Arctica (formerly Cyprina) islandica, and the prickly cockle, Acanthocardia echinata. Like the pecten, these bivalve molluscs inhabit the sublittoral zone and their shells may be presumed to have been collected when washed up on beaches. Table 16 shows the numbers of in situ and "other" finds of both whole and incomplete shells of these two species. Because both of these molluscs are equivalve, the distinction between the left and right valves has not been included in the presentation of this

Table 16. Number of In Situ and "Other" Small Finds of Cyprina and Prickly Cockle Shells from Cnoc Coig, 1973-79.

Type of Shell	In Situ	"Other"	Total
Cyprina Shells			
complete	8	3	11
incomplete	13	2	15
total	21	5	26
Prickly Cockle Shells			
complete	11	0	11
incomplete	3	0	3
total	14	0	14

table, since there is no reason to regard that there is any functional relevance in terms of the use of the two types of valves. Moreover, the sample sizes of these two species are too small to consider the matter of the unequal representation of one or the other valves as could be done with pectens, so this distinction is not relevant for this purpose either.

Although cyprina shells appear not to have been found at either of the two sites at Oban or at Risga (see Anderson 1895: 216; 1898: 299; Lacaille 1951: 116; 1954: Table V), they are reported from earlier excavations on Oronsay, at C.N.G. I (Grieve 1882: 485; 1885: 55; 1922: 166) and at Cnoc Sligeach (Bishop 1914: 106). The presence of prickly cockle shells is less certainly indicated. Anderson (1895: 216; 1898: 299) records the presence of "cockles" in both MacArthur Cave and Druimvargie but, due to the absence of taxonomic binomials, it is not clear which species of cockle (Cardiidae) are represented at these sites. From C.N.G. I, Grieve (1882: 485; 1885: 55) notes finding two species of cockle from the site: the common cockle, Cardium (i.e. Cerastoderma) edule, and Laevicardium norvegicum (i.e. L. crassum). Whether any of the shells assigned to these two species are misidentified prickly cockles is not certain, although Lacaille (1954: Table V) seems to feel that the common cockles from this site are in fact prickly cockles, *Cardium echinatum* (i.e. *Acanthocardia echinata*). Similarly, Lacaille (1954: Table V) records the presence of the prickly cockle from Risga even though he had previously (1951: 116) regarded these as belonging to the common cockle. Finally, Bishop (1914: 106) notes that the prickly cockle was found at Cnoc Sligeach, along with the related species *Cardium norvegicum* (i.e. *Laevicardium crassum*) and *Cardium tuberculatum* (i.e. *Acanthocardia tuberculata*). It would seem, therefore, that some shells of the prickly cockle have been found at least in the two previously excavated Oronsay middens, and probably also at Risga.

The early researchers mostly seemed to regard the shells of pecten, cyprina and prickly cockle found in Obanian middens as being discarded food refuse like all the other shellfish remains in these sites. However, Bishop (1914: 99) proposed that pectens were used as scoops or ladles, and in support of this idea, he noted that many specimens are worn from use along the margin of the shell. Following this, Grieve (1922: 166; 1923: Fig. 21) suggested that pecten and cyprina shells served as vessels to hold liquids or, more specifically, as drinking cups, although obviously this interpretation could only be applied to the convex valves. Of course, these two suggestions are not in conflict since there is no reason to think that such shells fulfilled only one specific function. Rather, it seems reasonable to regard pecten, cyprina and prickly cockle shells as multi-purpose containers and scoops. Aside from the fact that there are many ethnographic examples of mollusc shells being used as containers of one sort or another (e.g. Meehan 1982: 69, Plate 4), there is direct evidence from Cnoc Coig which supports the interpretation that these shells were indeed used for this purpose. One prickly cockle shell was found with 16 cowry shells placed inside it, and a cyprina shell was found with 60 perforated cowries within it -- both of these finds undoubtedly represent cowry collections which had been cached with the intention of being used later but which had accidentally been buried.

One peculiar feature of some Obanian assemblages are large perforated shells. Bishop (1914: 100-101, Fig. 44) records finding at Cnoc Sligeach several large shells with large (ca. 20-35 mm across), roughly circular holes which had been purposefully cut out approximately in the centre of the shells -- from his illustration, these appear to be mostly oyster shells, although one convex valve pecten shell is also shown. No such large perforated shells are reported being found at any other Obanian site, but two convex valve pectens were found at Cnoc Coig which are perforated in the same manner as those from Cnoc Sligeach. Moreover, Liversage (1968: 117, Plate XI) reports finding one identically perforated pecten shell from the Southern Basal Midden, Site II at Dalkey Island in Ireland. Bishop was at a loss to account for these items. It is certainly clear that these shells were perforated in this manner intentionally, although the purpose of this remains enigmatic. In any case, cutting such holes in pecten shells would have precluded their use as containers.

Items of Decoration

Whatever the function of perforated pectens and oysters might have been, there are other perforated shells whose purpose is less obscure. Mention was made above of 60 perforated cowry shells (Trivia spp.) found at Cnoc Coig placed inside a cyprina shell. Bishop (1914: 100, Fig. 42) reports finding numerous pierced cowries at Cnoc Sligeach, 42 of which are illustrated. These shells are perforated in two places and the holes always occur in the same place on the shell. These ornaments could have been strung together in the fashion of a necklace, as Bishop's illustration suggests (see also Lacaille 1954: 219), or a bracelet; or alternatively, they could have been items of decoration sewn onto clothing or other objects. In any case, some perforated cowry shells were also found at

Risga (Lacaille 1954: 233), and cowries were recovered from C.N.G. I, although apparently they are not perforated (Grieve 1882: 485; 1885: 55). Mention has also already been made of a cache of 16 unpierced cowries from Cnoc Coig found inside a prickly cockle shell; additionally, two isolated unperforated cowry shells were recovered *in situ* at Cnoc Coig. Bishop (1914: 100) also notes finding at Cnoc Sligeach some "periwinkle" shells which have a single perforation in them. At Cnoc Coig, one isolated flat periwinkle (*Littorina littoralis*) with a single perforation in it was found *in situ*.

Aside from these shell ornaments, another item of decoration has been frequently found in Obanian sites, namely, ochre. From Cnoc Coig, 37 lumps of red ochre were recovered as small finds and 32 of these were recorded *in situ* from the areas of the site used in the present study. Similarly, Bishop (1914: 102) records the presence of "red pigment" in Cnoc Sligeach, and Lacaille (1951: 125; 1954: 233) notes that pieces of red and brown ochre were found at Risga.

CHAPTER 5

PROCEDURES FOR ESTABLISHING THE DATA BASE AND METHODS OF ANALYSIS

The excavated areas of Cnoc Coig which will be used in the present study were defined above in Chapter 3 (pp. 66-71), where it was noted that all finds which were recorded in situ within these areas will comprise the data base used for spatial analysis. In this chapter, the procedures used to establish this data base will be outlined, and this will be followed by a discussion on the methods of analysis which are employed in the following study.

Establishing the Data Base

Extracting Information from the Site Records

During the excavation of Cnoc Coig, it was standard procedure to record the precise three-dimensional locations of all finds which were recovered by trowelling[1]. This procedure, naturally enough, could not be applied to all kinds of data within the site. In particular, certain highly abundant materials were not treated as small finds and so were not recorded in situ for obvious reasons -- these include fish bones, crab remains, and the shells of limpets, dog whelks and periwinkles, as well as the more comminuted fragments of other shellfish species. Of course, all these data were extensively sampled. The main categories of objects which were treated as small finds include: all pieces of antler, both unworked fragments and antler tools or portions thereof; all worked bone; all avian and mammalian bone fragments which have articular ends or are greater than 5 cm in length, though inevitably some larger

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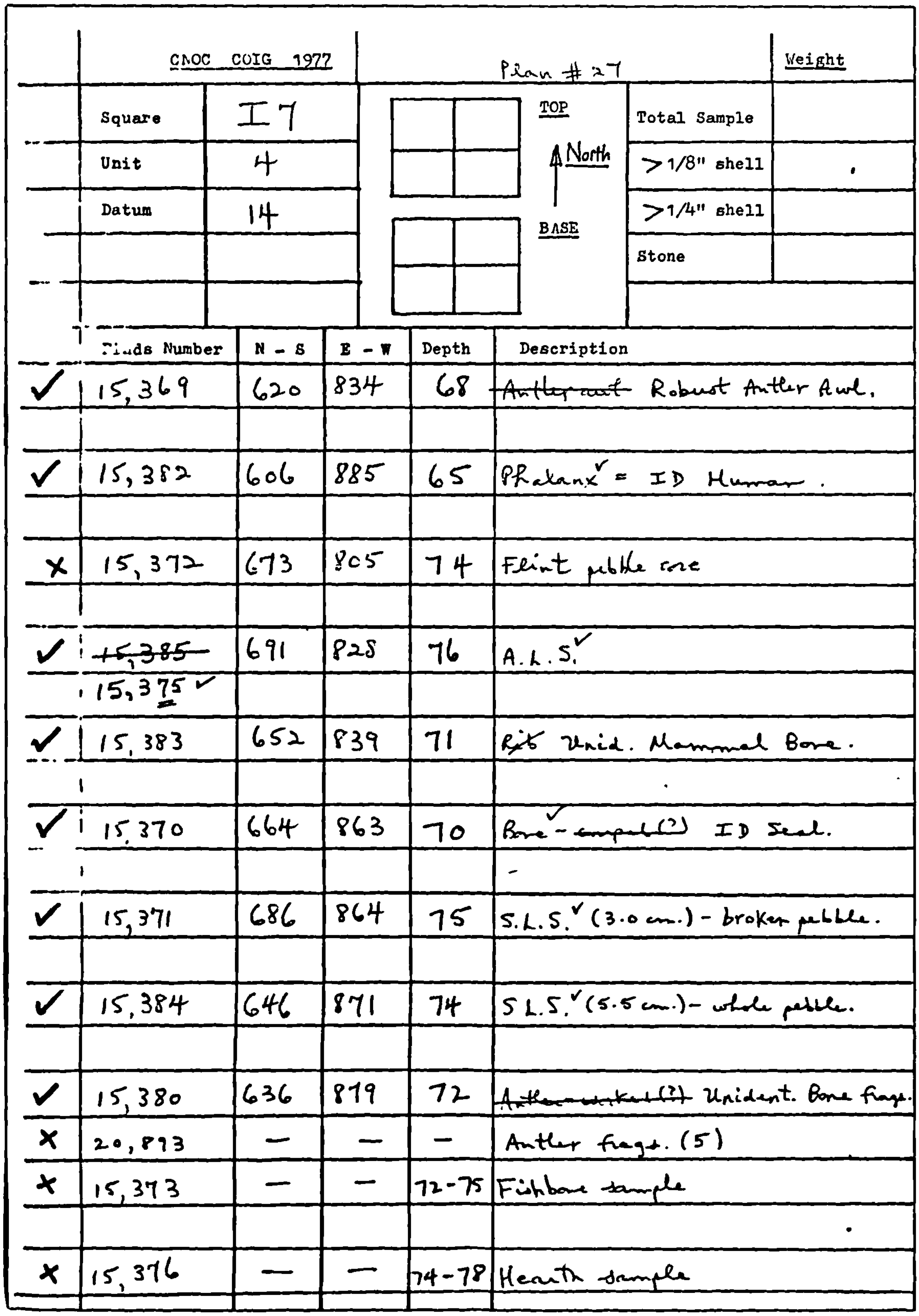
[1] Details on the excavation and sampling procedures employed at Cnoc Coig and other sites on Oronsay can be found in Mellars (1985; see also Mellars 1978: 373-375; Peacock 1978). All data on these matters reported here are from P. Mellars (personal communication).

pieces of fish bone were also included in this category; all elongated beach pebbles, including worked, use-worn and unworked/unworn specimens; all large, flat beach pebbles with pitting on any surface or edge which might indicate use; and the complete or substantially intact shells of the less common species of shellfish. Of course, some small finds of these objects were only recovered by sieving and not by trowelling, so their precise three-dimensional locations were not recorded. Nevertheless, the number of small finds recorded in situ totalled well over 3,000 objects. Full details on the classification and enumeration of the small finds from Cnoc Coig were given above in Chapter 4.

Of course, the information on this extensive body of data was scattered throughout the site records. So the initial task was to extract all pertinent details from the various unit plans, finds lists, excavation notebooks, section drawings and so forth. The main source of information concerning the location of objects are the unit plans and hence, the task of extracting the relevant data began with these. Due to the stratigraphic complexity of the Cnoc Coig shell midden, as is usual with such sites, excavation proceeded by arbitrary levels or "units" (of 10 cm depth in this case), although it should be noted that, whenever discernible natural layer boundaries were encountered, they were used to define unit boundaries. Despite this, the site was dug as a series of descending units, each of which was more or less 10 cm deep. For each trench (in 1973 and 1975) or block of squares (in 1977 and 1979), a two-dimensional plan was drawn for each unit, on which was recorded the locations of all small finds found in situ, fish bone and other kinds of samples, hearths and various other features. In total, there were over 200 such unit plans drawn for the site. Each separate unit plan was given its own plan number, and the relevant information on the small finds from the plans was extracted and recorded onto a series of sheets. A separate sheet was created for each unit of each square (or portion thereof) of the site grid which was established in 1977 (see Fig. 3) -- and onto these was recorded, for each find, the small finds number and the description of the object along with its two-dimensional grid co-ordinates. It should be noted that the 1973 and 1975 trenches were divided into their constituent grid squares and that sheets were created for these grid squares and not for the trench as a whole. The plan number and the local datum peg number used for recording depth measurements for that particular square were also recorded on each sheet. This exhaustive process resulted in several hundred of these square/unit sheets -- Figure 15 is a specimen of one of these sheets for a grid square excavated in 1977.

Having thus extracted all _in situ_ finds recorded on the unit plans, the next step was to obtain the depth co-ordinates of the finds as measured from the various local datum points. During 1977 and 1979, each unit of each square had a finds sheet on which was listed all small finds found in that particular square/unit with the small finds number, description of the object and depth co-ordinate recorded on the sheet; in 1973 and 1975, this same information was listed by trench in the excavators' note-books. From these records, the depth co-ordinates of the finds were extracted and added onto the square/unit sheets, thus completing the data on the three-dimensional locations of the _in situ_ finds. Additionally, listed in the finds lists were all the sieved small finds, which of course had not been included on the unit plans and so had not yet been transcribed onto the square/unit sheets. Thus, at this stage, any non-_in situ_ small finds listed in the finds lists were added to the appropriate square/unit sheets.

This process of consulting the finds lists had yet another function. The system used on the site involved a site supervisor recording the small finds number and the provisional identification of all _in situ_ finds three times: once on the unit plan, once in the finds lists, and once on the labelled bag containing the find (where the square/unit provenance was also recorded). This three-tier level of recording provided a built-in crosscheck on the



CAOC COIG 1977		Plan # 27	Weight
Square	I7	Total Sample	
Unit	4	>1/8" shell	.
Datum	14	>1/4" shell	
		Stone	

	Finds Number	N - S	E - W	Depth	Description
✓	15,369	620	834	68	~~Antler awl~~ Robust Antler Awl.
✓	15,382	606	885	65	Phalanx✓ = ID Human.
✗	15,372	673	805	74	Flint pebble core
✓	~~15,385~~ 15,375 ✓	691	828	76	A.L.S.✓
✓	15,383	652	839	71	~~Rib~~ Unid. Mammal Bone.
✓	15,370	664	863	70	Bone✓ - ~~carpal(?)~~ ID Seal.
✓	15,371	686	864	75	S.L.S.✓ (3.0 cm.) - broken pebble.
✓	15,384	646	871	74	S.L.S.✓ (5.5 cm.) - whole pebble.
✓	15,380	636	879	72	~~Antler worked(?)~~ Unident. Bone frags.
✗	20,893	—	—	—	Antler frags. (5)
✗	15,373	—	—	72-75	Fishbone sample
✗	15,376	—	—	74-78	Hearth sample

Figure 15. Reproduction of a Square/Unit Sheet for One Unit of a Grid Square Excavated in 1977.

list of in situ finds found in each square/unit. Thus, when the list extracted from a unit plan was tallied against the finds list, and later also against the bagged and labelled finds themselves, any transcriptional errors in any of these three records would be immediately revealed by a readily apparent discrepancy, and so, by careful scrutiny of all site records, the error could be located and corrected. Inevitably, such simple transcriptional errors did occur but, by this crosschecking procedure, they were usually sorted out with ease.

One other sort of "error" involves the provisional identifications given to objects by site supervisors. The labels used were fairly gross inventory categories, and the assignment of items into various categories was by no means consistent throughout four field seasons involving many different excavators and supervisors. Therefore inevitably, many misidentifications and assignments to improper categories were made. These are not recording errors as such, because these provisional identifications functioned only as temporary labels of convenience to help keep track of objects during excavation and the processing of small finds. As was discussed above in Chapter 2 (pp. 34-35), it is fundamentally important to realize that such gross inventory categories are not the result of a rigorously and methodically defined formal typology, nor are the assignments of items into the various categories a result of a thoroughly and consistently applied formal typology -- and perhaps more appropriately, it is important to realize that such provisional identifications are not intended to be a final classification to be used for later analyses.

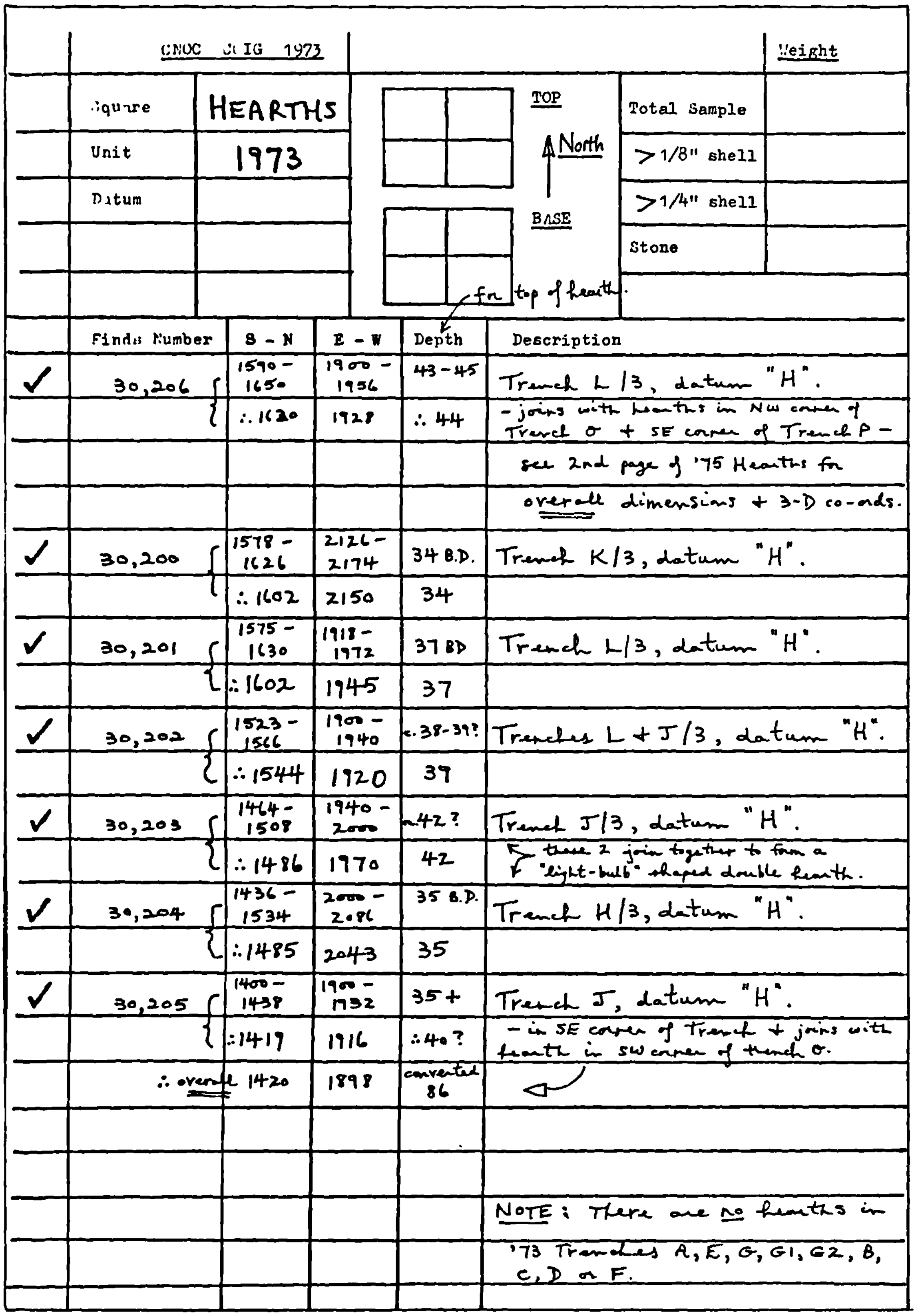
Hence, having extracted from the site records all the information on the three-dimensional locations of all finds recorded in situ, the next major step in establishing the data base was to devise a formal typology for the Cnoc Coig assemblage and to apply this typology thoroughly and consistently. Under the supervision of Dr. Paul Mellars and drawing on the work of earlier researchers (e.g. Anderson 1895; 1898; Bishop 1914), such a typology was established and then applied to all in situ and sieved small finds from all the excavated areas of Cnoc Coig except for the 21 sampling pits. The detailed results of this process of classifying the Cnoc Coig assemblage were given above in Chapter 4. When an object was assigned to a particular category, this identification was noted on the appropriate square/unit sheet. As can be seen in Figure 15, if the provisional identification given on the site by the supervisor was confirmed and if no further information was required, then the procedure was simply to place a tick beside the named category on the square/unit sheet; but if the provisional label was inappropriate to the formal typology or the identification was wrong, then it was stroked out and the proper category label recorded on the sheet instead.

This classificatory process concerned all the artifacts from the site, that is, everything except mammal and bird bones. For these items, the lists of bone identifications produced by the faunal specialists -- Dr. Don Bramwell (birds) and Dr. Caroline Grigson (mammals) -- were used, since these lists were effectively the bone equivalents of the formal typology of artifacts. Not all the information on faunal identifications was transcribed onto the square/unit sheets -- as Figure 15 shows, only a short note concerning the taxonomic identification (and sometimes also the bone element) was recorded onto the sheets.

Two final categories of data should also be mentioned at this juncture, namely, hearths and spot heights for the surface of the midden. Concerning the former, for the sake of consistency of definition, and because of his extensive first-hand knowledge of the excavation of the site, Dr. Paul Mellars scrutinized all the site unit plans in order to confirm the boundaries of all charcoal/ash deposits which are interpreted as hearths (as opposed to the more diffuse scatters of hearth material which also occur on the site). These were then given separate identification numbers, and a three-dimensional location representing the approximate central point at the top of the hearth was recorded; the lateral two-dimensional extent of the hearths was also noted. Because hearths frequently cross grid square boundaries, these data were not recorded on the square/unit sheets used for the small finds but rather on separate sheets -- a specimen is reproduced here as Figure 16.

To obtain the spot heights of the surface of the midden, the unit plans for every trench (in 1973 and 1975) or block of squares (in 1977 and 1979) were examined and, using these and the site supervisors' notebooks, the top-most unit of the midden for a particular trench was identified. All top of the midden heights were then extracted from the appropriate unit plans. This resulted in several hundred measurements which were transferred onto a map showing all of these recorded surface of the midden spot heights. Additionally, Dr. Paul Mellars examined the 126 section drawings from Cnoc Coig (which includes 63 drawings from the walls of the 21 sampling pits from which the data are otherwise not used in the present study) in order to define clearly the surface of the midden. Spot heights were taken from these section drawings at 50 cm intervals which were also transferred onto the map of the midden surface spot heights. Together, these two sources of data provided a large body of measurements for the height of the surface of the midden.

At points of overlap (i.e. at the boundaries between trenches or blocks of squares), there are available two independent measurements for the spot heights of the exact same points -- indeed, in a few instances where the corners of four trenches met, there are available four measurements for one point. This redundancy is further enhanced by the fact that the section drawings provide additional independent measurements for any points along the line of a section which had spot heights recorded on a unit plan. This wealth of redundant measurements made it possible to compare any two or more measurements for the same point and so to note any discrepancies between them. Without going into the detailed results of this exercise,



CNOC SLIG 1973

Weight

Square: HEARTHS

Unit: 1973

Datum

TOP

North

BASE

fr top of hearth.

Total Sample

>1/8" shell

>1/4" shell

Stone

	Finds Number	S - N	E - W	Depth	Description
✓	30,206	1590 - 1650	1900 - 1956	43 - 45	Trench L/3, datum "H".
		∴ 1620	1928	∴ 44	- joins with hearths in NW corner of Trench O + SE corner of Trench P -
					see 2nd page of '75 Hearths for
					overall dimensions + 3-D co-ords.
✓	30,200	1578 - 1626	2126 - 2174	34 B.D.	Trench K/3, datum "H".
		∴ 1602	2150	34	
✓	30,201	1575 - 1630	1918 - 1972	37 BD	Trench L/3, datum "H".
		∴ 1602	1945	37	
✓	30,202	1523 - 1566	1900 - 1940	c. 38-39?	Trenches L + J/3, datum "H".
		∴ 1544	1920	39	
✓	30,203	1464 - 1508	1940 - 2000	~42?	Trench J/3, datum "H".
		∴ 1486	1970	42	these 2 join together to form a "light-bulb" shaped double hearth.
✓	30,204	1436 - 1534	2000 - 2086	35 B.D.	Trench H/3, datum "H".
		∴ 1485	2043	35	
✓	30,205	1400 - 1438	1900 - 1932	35 +	Trench J, datum "H".
		∴ 1419	1916	∴ 40 ?	- in SE corner of Trench + joins with hearth in SW corner of trench O.
	∴ overall	1420	1898	converted 86	
					NOTE: There are no hearths in
					'73 Trenches A, E, G, G1, G2, B, C, D or F.

Figure 16. Reproduction of a Specimen Sheet Used to Record Data on Hearths.

it may simply be noted here that discrepancies in measurements ranged considerably, from zero to about 13 cm, with an overall average discrepancy of about 3 cm. These discrepancies are a result of several possible factors, the most notable of which are measurement error and recording error. Despite a few larger discrepancies (i.e. more than 7 cm), it is worth pointing out that both the average value and the majority of discrepancy values are well within the overall size range of individual limpet shells. Viewed in these terms, these redundant measurements demonstrate that there is considerable consistency overall and only a very minor amount of significant measurement or recording error.

At any rate, given that many points on the midden surface have two or more recorded spot heights, the procedures used to derive a single spot height for such points should be briefly outlined. Generally, all available measurements for a single point were used, and a single height was thus obtained by averaging the available measurements. This simple procedure sufficed for most points which have more than one recorded spot height. However, for any point which had an unusually high discrepancy (i.e. greater than 7 cm) between any two measurements, a different procedure was adopted. If three or more measurements were available and one of them was aberrant from the others, then this seemingly "faulty" measurement was ignored and the spot height was established using the remaining measurements as per normal. If only two measurements were available and these were widely disparate, and if one of these was from a section drawing and the other from a unit plan, the former measurement was used on the assumption that section drawing measurements were the more accurate -- it is worth noting that this assumption is not simply held to be reasonable on intuitive grounds, but that the process of comparing redundant spot height measurements showed a definite tendency for comparisons between unit plan measurements to have higher discrepancy values than comparisons between section drawing measurements. In other cases of two spot heights being highly disparate, where this strategy could not be adopted, the overall range of heights for points around the particular point in question invariably suggested which of the two measurements was more likely to be the more aberrant one; hence, the less "offending" measurement was used as the final spot height.

Thus, this large number of spot heights for the surface of the midden, and the consequent comparing and crosschecking of any redundant measurements, resulted in a large body of reliable and highly scrutinized data on the absolute height of the entire excavated surface of the midden. As will be seen shortly, these data form an important component of the data base to be used in the spatial analyses which follow.

Codification of the Data and File Structure

Having thus extracted from the site records all the data on *in situ* and sieved small finds, hearths and midden surface spot heights from all of the excavated areas of Cnoc Coig (except the 21 sampling squares), and having fully scrutinized these data by crosschecking different site records whenever possible, it remained to extract the relevant pieces of data, to codify these and to put them in a file on the computer. From the stock of several hundred square/unit sheets, the first step was to remove all sheets for those squares which were not to be included in the area used for spatial analysis -- in other words, those sheets for the excluded trenches and squares which were defined above in Chapter 3. This initial step involved removing only a small percentage of the square/unit sheets. For the remainder, all relevant data on *in situ* small finds had to be codified onto data preparation sheets from which the codified data could be transferred into a file on the computer.

To achieve this, the first thing was to decide what variables would be included on the computer file, then to devise a structure for these variables within the file, and finally to create a series of coded values for the different states of each variable. The number of variables that was decided upon was 13. Since the coded values of all the variables for one item could readily fit into the 80 columns of one record in the computer's filestore, each item -- small find, hearth or top of the midden spot height -- was allocated one line or record in the file. A fixed format was used in which each variable had a specific column or columns within each record. Figure 17 is an illustrative specimen of a portion of the file, showing this file structure.

The sequence of variables within the file, and the different states for each variable, are as follows. The first variable is a unique identification number for each separate item: for most finds, the small finds numbers were used; for some small finds however, where two or more finds were bagged together as one, which occurred particularly in the case of bones when it transpired that the bone fragments bagged together were found to be different bones and not fragments of one bone, a new identification number was assigned to each of the second, third and subsequent items of the find; and finally, a series of identification numbers was allocated for the hearths and for the surface of the midden spot heights. The second, third and fourth variables of the file are the X (= south-north, in cm), Y (= east-west, in cm) and Z (= depth, in mm) co-ordinates for each item; the values of these variables are of course continuous data represented by real numbers, rather than integers which represent discrete values of discontinuous data, as is the case with all the remaining variables except one. The fifth variable is material type, of which there are seven states: antler, indeterminate antler/bone, worked bone, unworked bone, shell, stone, and other (into which hearths and midden surface spot heights are included). The sixth variable is the type of find, of which there are 46 categories: 41 for different artifact types and subtypes; one each for mammal, bird and unidentifiable bone; one for hearths; and one for top of the midden spot heights.

The seventh to thirteenth variables pertain mainly to the three general categories of bone in variable six; these seven additional variables provide all the specific

```
07283  1156  1074  -0705  4  19  01 3 03 2 1 1 024
07313  1136  1088  -0785  1  01  00 0 00 0 0 1 000
07269  1127  1070  -0695  1  07  00 0 00 0 0 1 000
07271  1077  1066  -0685  4  19  05 3 19 0 1 1 036
07310  1098  1026  -0835  1  01  00 0 00 0 0 1 000
07312  1040  1070  -0775  6  29  00 0 00 0 0 0 035
07302  1015  1057  -0785  4  21  00 0 00 0 1 0 000
07328  1018  1036  -0875  1  01  00 0 00 0 0 1 000
07323  1024  1033  -0845  1  01  00 0 00 0 0 1 000
07303  1021  1012  -0775  4  21  00 0 00 0 1 0 000
07300  1061  1045  -0785  1  01  00 0 00 0 0 1 000
07325  1056  1018  -0555  5  27  00 0 00 0 0 0 000
07301  1077  1039  -0785  6  29  00 0 00 0 0 0 052
07299  1094  1029  -0765  4  20  37 3 05 0 2 1 000
07298  1094  1038  -0785  4  19  02 3 22 2 1 1 078
07329  1089  1010  -0885  3  14  00 0 00 0 0 1 000
30032  1089  1010  -0885  3  11  00 0 00 0 0 1 000
07318  0997  1069  -0825  4  19  06 2 03 1 1 1 000
07320  0989  1075  -0825  1  06  00 0 00 0 0 1 000
07319  0982  1070  -0815  4  21  00 0 00 0 1 0 000
07321  0988  1052  -0835  1  06  00 0 00 0 0 1 000
07330  0998  1001  -0685  1  01  00 0 00 0 0 1 000
07331  1199  1052  -0715  1  02  00 0 00 0 0 1 000
07336  1168  1058  -0895  5  27  00 0 00 0 0 0 000
07337  1076  1017  -0935  3  18  00 0 00 0 0 1 000
07333  1065  1049  -0915  1  06  00 0 00 0 0 1 000
07343  1037  1025  -0935  4  20  36 0 07 0 1 1 000
07344  1190  1069  -0935  4  20  13 3 28 0 2 1 000
17031  0865  0742  -0456  6  29  00 0 00 0 0 0 051
17048  0867  0746  -0506  4  19  09 0 00 0 1 1 000
17050  0830  0734  -0595  4  21  00 0 00 0 1 0 000
17049  0813  0731  -0556  1  01  00 0 00 0 0 1 000
17061  0807  0745  -0685  4  20  35 3 07 0 1 1 000
30033  0807  0755  -0686  4  20  35 3 10 0 1 1 000
30034  0807  0735  -0686  4  20  39 3 07 0 1 1 000
30035  0817  0745  -0686  4  20  39 3 10 0 1 1 000
30036  0797  0745  -0685  4  20  39 3 02 0 1 1 000
17052  0823  0713  -0566  1  01  00 0 00 0 0 1 000
17093  0842  0744  -0745  1  06  00 0 00 0 0 1 000
17070  0854  0795  -0666  4  19  02 3 03 2 1 1 021
17092  0871  0754  -0726  4  19  01 3 11 0 1 1 054
20973  0886  0744  -0676  1  06  00 0 00 0 0 1 000
17071  0886  0742  -0676  4  19  04 3 18 1 1 1 075
17122  0865  0773  -0766  4  19  01 3 10 0 1 1 134
17057  0889  0776  -0585  4  19  09 0 00 0 1 1 000
17072  0879  0799  -0676  4  21  00 0 00 0 1 0 000
17151  0803  0735  -0826  1  01  00 0 00 0 0 1 000
17134  0823  0784  -0846  6  29  00 0 00 0 0 0 056
17141  0836  0749  -0826  4  21  00 0 00 0 1 0 000
17142  0832  0767  -0816  4  19  08 3 24 0 1 1 000
17143  0840  0768  -0805  4  19  09 0 00 0 1 1 000
17176  0805  0777  -0846  1  01  00 0 00 0 0 1 000
```

Figure 17. Reproduction of a Sample of the Codified Data in the Computer Data File.

information regarding the bone identifications. Variable seven is species or other taxonomic unit, of which there are 49: eight for various taxa of mammals, 39 for various taxa of birds, and one each for unidentifiable mammal bones and unidentifiable bird bones. The eighth variable is age, of which there are four states: foetal, young or juvenile, adult, and not recorded/not relevant. The ninth variable is bone element, of which there are 29 categories for various bones or groupings of related bones; full details concerning the definition of these bone element categories were given in Chapter 4 (see Table 3). The tenth variable concerns the body side of a bone element, of which there are three conditions: left, right, and indeterminate/not recorded/not relevant. The eleventh variable concerns the degree of completeness of a bone, for which there are three conditions: whole bone, bone fragment, and not recorded/ not relevant. The twelfth variable refers to the charred condition of an item, for which there are three states: burnt, unburnt, and not recorded/not relevant. This latter variable was recorded not only for bones but also for antler, antler/bone and worked bone objects. The final variable is the only other real number variable for continuous data -- it is the maximum length (in mm) of an item, which was recorded for most of the identifiable mammal bones and for all of the elongated beach pebble artifacts.

With the file structure thus established, the next step was to codify all the relevant bits of information for all of the items which would be used in the spatial analyses. Using the file structure and codifying system which has just been outlined, all relevant data were codified and recorded onto 109 data preparation sheets. In this codification process, the depth co-ordinates on the square/unit sheets, which are all relative to various local datum pegs, had to be converted to a depth relative to an overall standard reference point, namely, the site's main datum peg; this simply involved adding to an item's depth co-ordinate the depth below site datum of the relevant datum peg. For all small finds and hearths, once the relevant data on the square/unit sheets were codified onto the data preparation sheets, a tick was placed in the left-hand margin of the square/unit sheet beside the finds number to show that the item had been processed (see Figs. 15 & 16); for items which were not transferred onto the data preparation sheets, an X was placed beside the finds number instead. For the midden surface spot heights, this procedure did not apply because the data from the map containing these spot heights was transferred directly onto the data preparation sheets. Additionally, for identified bones, because most of the information to be codified was on the lists of identifications produced by the faunal specialists rather than on the square/unit sheets, the finds number on the lists of identifications was also checked to show in these lists that the bone had been processed onto the data preparation sheets.

After all this codified and transcribed information was double-checked for any possible copying or codification errors, the codified sheets were given to the Data Preparation Service of the Computer Services Department at the University of Sheffield where the data was key-punched onto cards. The cards were then fed into a file on the mainframe I.C.L. 1906S computer and this data file was then transferred to the Sheffield Prime-A computer system, since it was on this latter computer where most of the computer analysis was to be carried out. A copy of the resultant data file was output on the line printer and this was then thoroughly checked for any key-punching or other errors. Such errors were readily corrected using the flexible editing facilities of the Prime. After some additional finds data had been appended onto the file at a later date, the final data file contained all relevant information on 2,564 *in situ* small finds, 64 hearths and 466 spot heights for the surface of the midden, making a total of 3,094 records in the file. Figure 17 is an illustrative specimen of a small portion of the file.

Methods of Analysis

In Chapter 2, methods of spatial analysis used in archaeology were reviewed and it was noted that the most basic method is the traditional approach of the visual inspection of plots of spatial distributions. As Kintigh and Ammerman (1982: 31) have observed, this intuitive approach has been abandoned, and even berated, by those who aspire to greater methodological rigour and who therefore have pioneered the use of more "objective" approaches involving quantitative techniques of spatial analysis. As was discussed in Chapter 2 in some detail, even though there is some justification for this attitude, the statistical techniques which have been championed, such as quadrat methods or nearest-neighbour analysis, are not without their difficulties and limitations when they are applied to archaeological data and problems -- consequently, in terms of archaeological applicability, such methods have often failed to live up to the claims which have been made for them. In short, both the traditional intuitive approach and the more recent quantitative techniques have advantages and disadvantages, as Kintigh and Ammerman (1982: 31-33) point out.

The traditional "eyeballing" approach initially involved the examination of hand-drawn distribution maps. However, while this method is quite adequate for certain situations, it lacks the information processing capacity that is required when large data sets are involved or where there may be multiple levels of patterning. As a result, the computer has become a valuable, and even indispensable, tool to assist in generating and displaying large numbers of distribution plots which show a wide variety of different spatial relationships between various data categories. And of course, for many quantitative techniques of spatial analysis, the computer is virtually requisite for such analyses. The attitude adopted here is similar to that of Kintigh and Ammerman (1982) -- that is, intuitive approaches are not eschewed on principle as being worthless, but instead, using computer-based methods of display, the visual inspection approach will be employed along with some statistical analysis in order to recognize and define spatial patterning within the data. Hopefully, any such observed patterning will be referrable to some of the cultural formation processes which generated the spatial distributions in the first place.

Computer-Based Methods of Display

The most basic level of analysis employed in the present study involves the visual inspection of a wide variety and large number of computer-generated plots of the distribution of items within Cnoc Coig. As will be shown in subsequent analyses, this visual inspection method can indeed yield productive results. Three different kinds of computer-generated plots are used in this study and each of these will be discussed in turn. But first, brief mention should be made of the computing procedure required to generate these various plots.

Extracting Subsets from the Data File. In the preceding section, the procedures used to establish the data file on the computer were outlined, and a brief description of the file structure was given. Obviously, this main data file as it stands cannot be used to produce particular plots showing the distribution of specific categories of material. Before such plots can be generated by the computer, specific subsets of the data must be extracted from the main data file. This is accomplished by an extraction program[1], the running of which involves two steps.

First, for each variable in sequence from variables 2 through 13, the researcher is requested to specify if a variable is to be used for selecting a subset from the main data file. If the answer is "no", the program proceeds to the next variable, but if the answer is "yes", before

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[1] This and the other computing programs used in this study were designed and written by Mr. David J. Robson and Dr. N. R. J. Fieller of the Department of Probability and Statistics, University of Sheffield.

proceeding to the next variable, the researcher is asked to specify how many values of that variable are to be selected and what these values are. This applies to discontinuous data variables represented by integer values (variables 5 to 12), but for continuous data represented by real numbers (variables 2 to 4 and 13), the researcher specifies maximum and minimum values for the variable. After the program has received all this requested information, using the discontinuous data variables, all combinations based on the specified values for all the selected variables are given an indicator number. At this stage, the resulting categories can be left as they are or they can be merged as desired, and any nonsensical ones can be dropped. This selection procedure is sufficiently versatile to allow the researcher to select any category of finds based on any combination of values for any number of variables. Having thus completed this first step of the definition of categories to be selected, the program proceeds to sort through the main data file and to extract all finds which meet the specified selection categories. The resultant extracted subset of finds is then put into a separate data file, and the running of the program is thereby completed.

These selected subsets provide the working data files for all later computer analyses, including the computer-generation of distribution plots. A program using the GINO graphics package was used to produce these plots. Referencing a specific extracted data file, and another file which defines the boundaries of the excavated areas of Cnoc Coig, this program uses a GINO plotting symbol for each category in the file as represented by the indicator numbers, and it then draws a plot of the distribution of all the finds of each category contained in the extracted data file. Although a larger number of categories could have been used, the number of categories, and hence the number of different symbols on the plots, was limited to eight because it was found in practice that too many different symbols on one plot meant that the plot contained too much information to be interpretable by visual inspection, especially if there are large numbers of items in each category. Indeed, even eight or less categories on one plot, when large sample sizes are involved, can be visually confusing (e.g. see Fig. 19 below). At any rate, the restriction of the number of categories to eight is not a limitation to analysis, since the generation and consequent comparison of two or more plots enable the researcher to compare the distributions of a huge number of categories without the visual confusion which results from many categories being plotted on a single distribution plot.

Depth-Compressed Horizontal Plots. In most cases of the spatial analysis of occupation surfaces, distributions are studied only in two dimensions because the sites under study are, or at least are assumed to be, the result of single occupations. In other words, any differences in depth distributions are regarded as being unimportant in terms of occupational episodes. As was discussed in Chapter 1, this is emphatically not the case with Cnoc Coig which is clearly a palimpsest of numerous occupational events. Hence, the dimension of depth must be taken into account and obviously, this considerably complicates the problems of spatial analysis. Of course, the addition of the depth dimension means that any distribution plots based solely on the X and Y co-ordinates of items may well reveal patterning, such as clusters or associations, but such patterning might simply be a spurious result of collapsing three dimensions into two. Consequently, it might be concluded that such plots would be meaningless and can serve no useful purpose in the present study.

However, this is not entirely the case. Given that the Cnoc Coig midden is an accumulation of several occupational episodes, an interesting question is whether or not the organization of activity space remained essentially the same throughout the history of the site. In short, was there redundancy in the use of space from occupation to occupation? If so, then we should expect that at least certain categories of objects would tend to be consistently localized only in certain areas of the site due to the consistent use of different modes of disposal for different kinds of objects -- for example, items which were dropped in high-use activity areas would be localized in such areas, whereas objects which were dumped would occur in dumping zones away from the high-use areas. Any tendencies for various categories of objects to be localized in certain areas of the midden, which might reflect redundancy in the organization of space, would be most clearly shown by depth-compressed horizontal plots. Thus, such plots can play a useful role in analysing spatial distributions in Cnoc Coig -- Figure 18 is an example of one such plot. However, it is important to remember that clusters of particular items, or associations of different items, which are shown on such depth-compressed plots are possibly nothing more than spurious by-products which result from ignoring differences in depth and therefore in the depositional history of the site.

Depth-Selective Horizontal Plots. In order to investigate the depositional integrity of clusters or associations which appear on depth-compressed plots, it is necessary to take into account the depth dimension by the use of the other two kinds of distribution plots. The first of these also involves plotting the X and Y co-ordinates of items but, instead of plotting all objects of a certain type or types regardless of depth, only the items within a particular depth range are plotted. In effect, these are plots of arbitrary levels within the midden. The range of depths selected to define a particular level for such depth-selective plots is determined solely by the researcher's own judgement and discretion as to what might be appropriate.

It is of course possible, and even desirable, to use depth ranges of varying sizes. Obviously, the larger the depth range, the greater is the amount of "distortion" resulting from compressing a wide range of depths onto one surface. Hence, in selecting particular depth ranges, one is attempting to minimize the amount of compression or, in other words, to maximize the depositional integrity of any

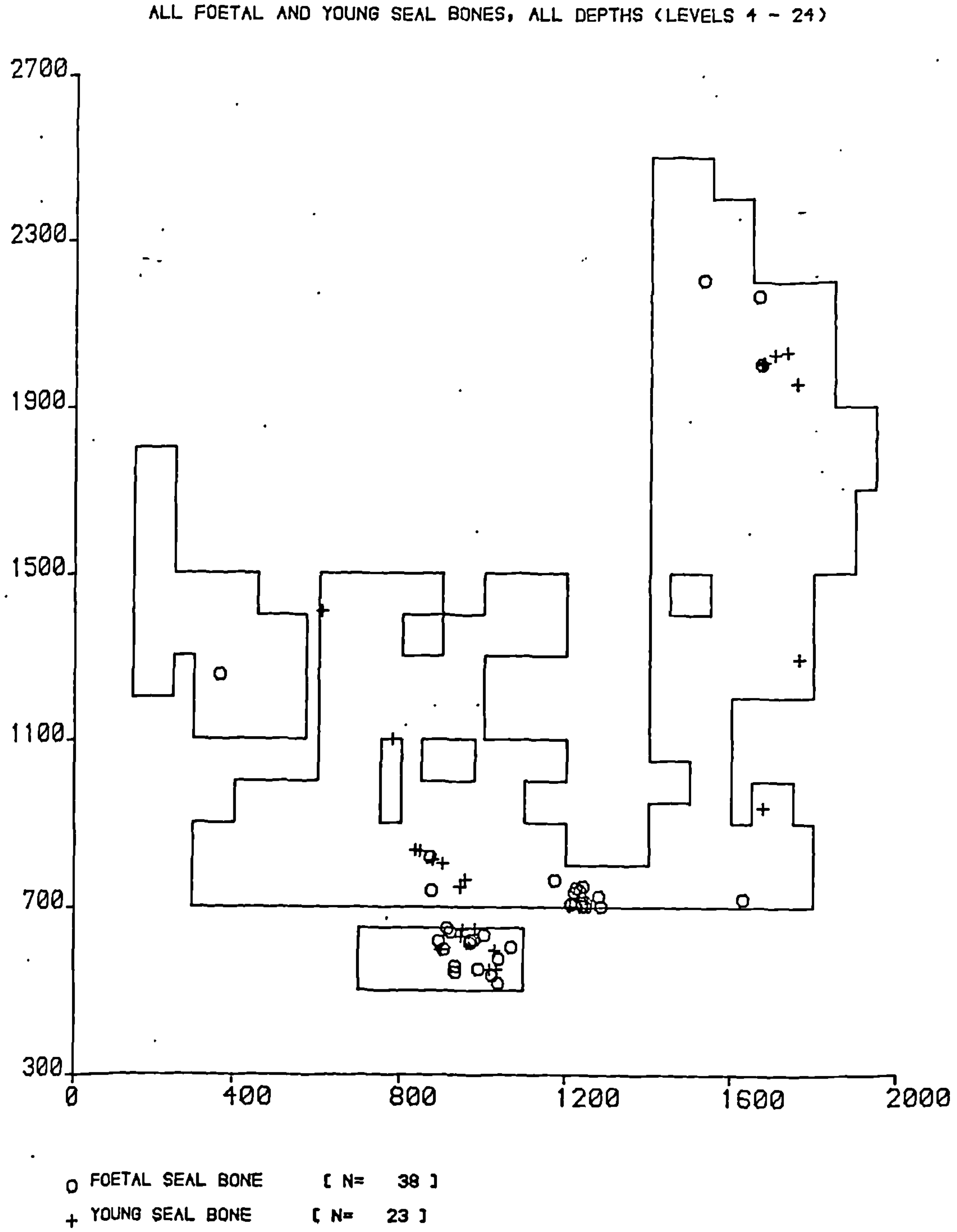

Figure 18. Example of a Depth-Compressed Horizontal Plot, Showing the Distribution of All Foetal and Young Seal Bones in All Levels.

localized groupings which appear on the plots. At the same time, one is trying to maximize the number of points to be plotted. If the depth range is very small, even though this maximizes depositional integrity, it results in a very small sample size so that the resultant plot of the arbitrary level contains only minimal information and is therefore not very useful. In short, in defining arbitrary levels, one is attempting to minimize distortion due to depth compression on the one hand and to maximize sample size on the other.

As a general rule, it was found that 5.0 cm is the minimum useful depth range. Thus, for the Cnoc Coig deposits which range overall from 20.0 to 165.0 cm below site datum, there are 29 of these minimal 5.0 cm arbitrary levels. For convenience of reference, these levels were assigned level numbers -- these are listed in Table 17 which also shows the number of hearths and the total number of in situ small finds within each of these levels. It should be emphasized that the depth ranges selected for particular plots need not necessarily conform to these arbitrary levels; in some cases, 5.0 cm (or larger) levels which crosscut these numbered arbitrary levels may be defined. Nevertheless, although there is no need to be rigidly bound in all instances by the 5.0 cm levels defined in Table 17, generally these arbitrary levels provide useful and sufficiently flexible depth units to employ for depth-selective horizontal plots for the more abundant categories of objects within the midden. For less abundant kinds of materials, a greater depth range is required to increase sample sizes; generally, this could be accomplished simply by combining two or perhaps three of these arbitrary levels and thereby selecting a depth range of 10.0 or 15.0 cm. Overall, it was found that depth ranges exceeding 15.0 cm became too coarse grained to be of much value. Figures 19 and 20 are two examples of these depth-selective horizontal plots.

In interpreting these plots, two important points must be kept in mind. Firstly, because the midden deposit

Table 17. List of Arbitrary 5.0 cm Depth Levels Showing the Number of Hearths and the Number of _In Situ_ Small Finds for Each Level.

Level No.	Range of Absolute Depths (cm) B. D.	No. of Hearths	Number of Small Finds
1	20.0 - 24.9	0	6
2	25.0 - 29.9	0	17
3	30.0 - 34.9	0	27
4	35.0 - 39.9	0	27
5	40.0 - 44.9	0	47
6	45.0 - 49.9	1	55
7	50.0 - 54.9	1	73
8	55.0 - 59.9	2	107
9	60.0 - 64.9	1	145
10	65.0 - 69.9	1	203
11	70.0 - 74.9	4	278
12	75.0 - 79.9	6	364
13	80.0 - 84.9	12	290
14	85.0 - 89.9	11	270
15	90.0 - 94.9	6	173
16	95.0 - 99.9	9	151
17	100.0 - 104.9	3	71
18	105.0 - 109.9	2	31
19	110.0 - 114.9	0	29
20	115.0 - 119.9	0	12
21	120.0 - 124.9	0	16
22	125.0 - 129.9	0	14
23	130.0 - 134.9	0	32
24	135.0 - 139.9	0	33
25	140.0 - 144.9	1	27
26	145.0 - 149.9	3	16
27	150.0 - 154.9	0	16
28	155.0 - 159.9	1	14
29	160.0 - 164.9	0	20
	Totals:	64	2,564

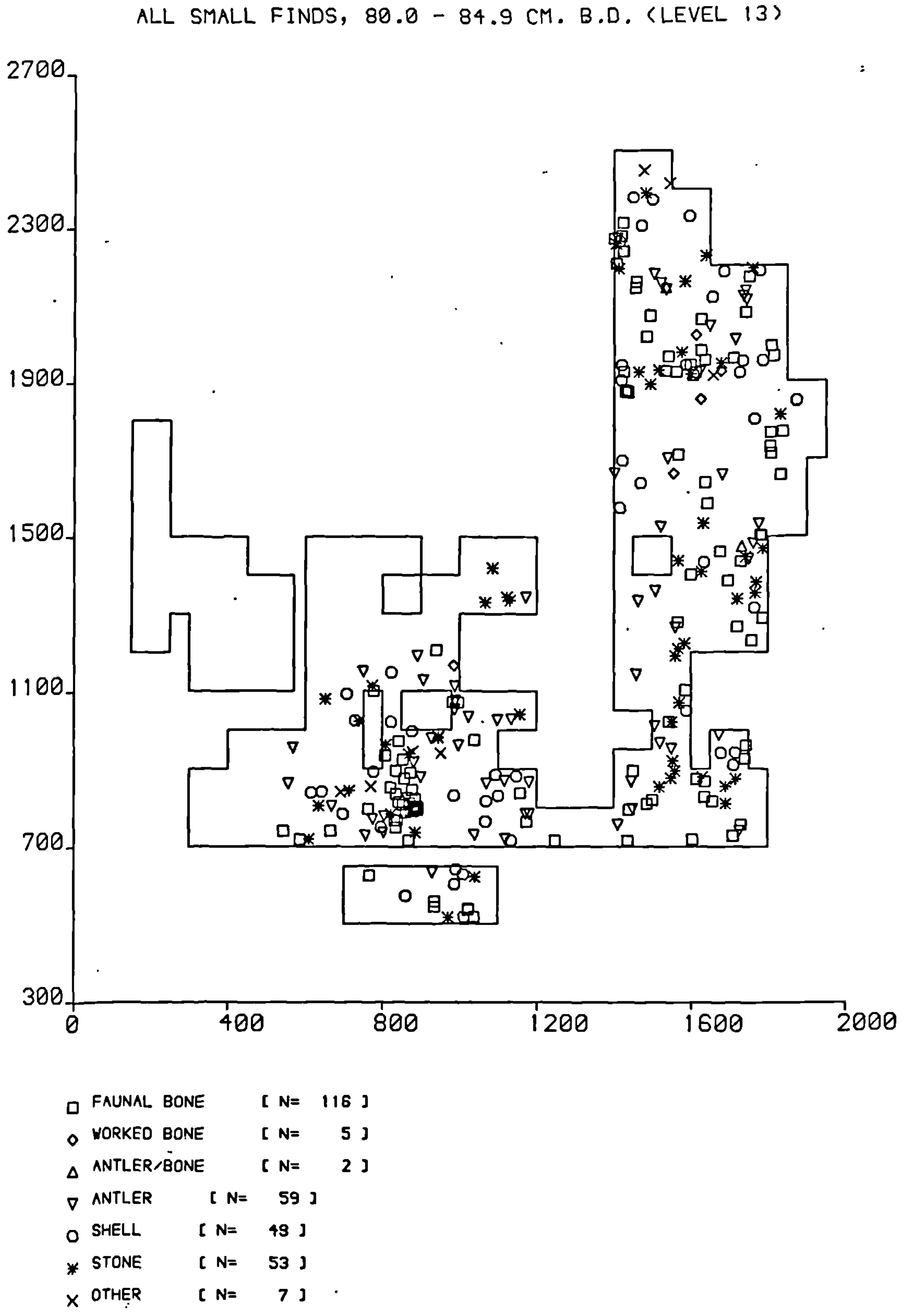

Figure 19. Example of a Depth-Selective Horizontal Plot, Showing the Distribution of All Small Finds in Level 13.

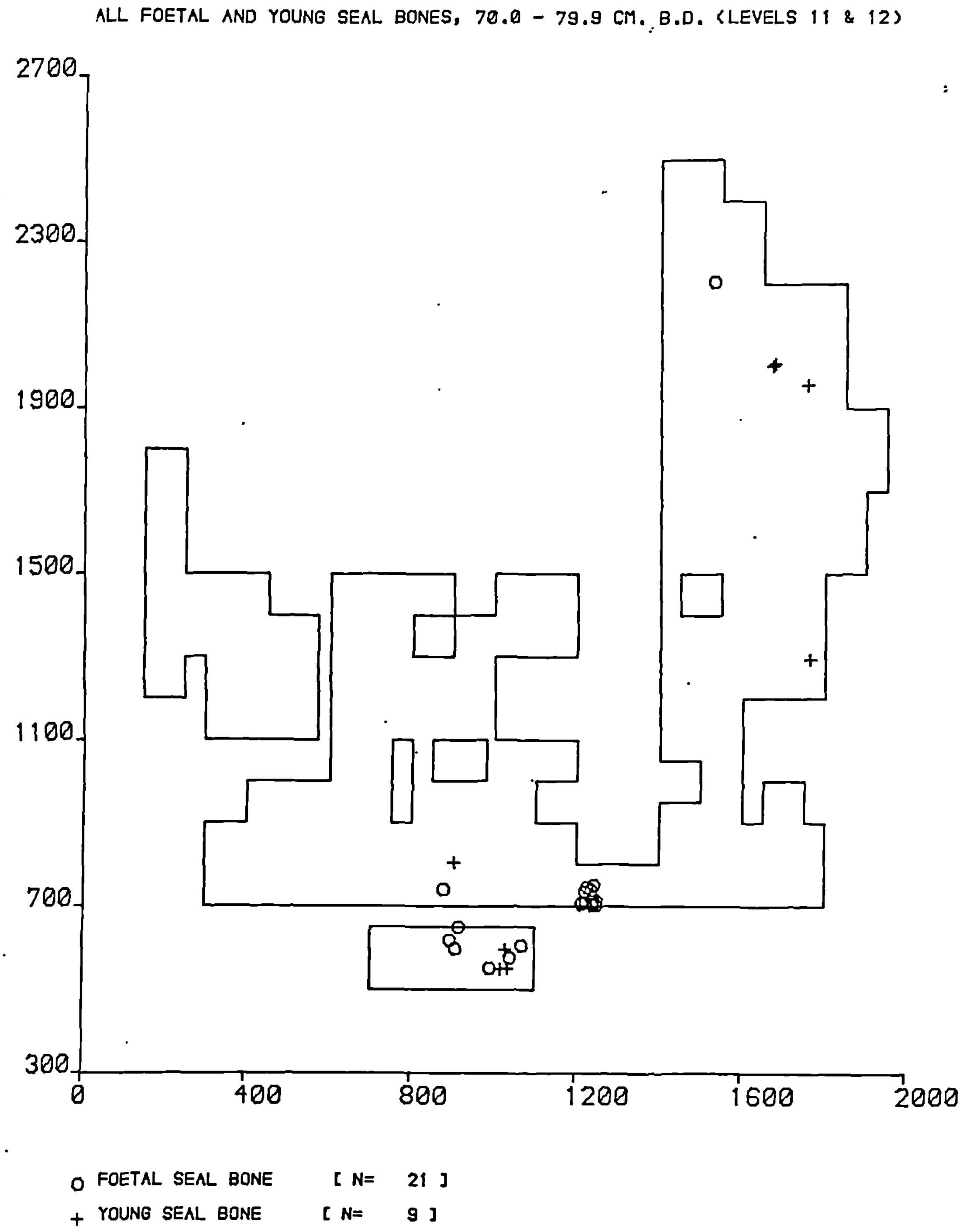

Figure 20. Example of a Depth-Selective Horizontal Plot, Showing the Distribution of Foetal and Young Seal Bones in Levels 11 and 12.

varies considerably across the site both in terms of the absolute depth at which the midden begins and in terms of the overall depth of the deposit, any particular arbitrary level will in fact only contain midden deposit in a portion of the excavated areas of the site as demarcated by the excavation boundaries shown on these plots. As is suggested by the numbers of finds recorded in Table 17, Levels 10 to 15 are those which have the largest portion of the total excavated area of the site with midden deposit present -- for example, see Level 13 in Figure 19. Thus, the absence of plotted points in certain areas of the site which appear on these depth-selective horizontal plots must not be interpreted as being necessarily due to differential distribution within the midden; rather, these blank areas are most likely a result of the fact that no midden deposit exists in those areas at that particular range of depths. In order to take account of this factor when interpreting depth-selective plots during analysis, for each of the 29 arbitrary levels, a distribution plot was generated which shows all the finds at that particular level and thereby delimits areas of the site at that level which lack midden deposit -- Figure 19 is one example of these plots. Thus, by referring to these 29 level plots during the analysis, any possible errors of interpretation due to this factor were readily avoided.

The second important point to bear in mind when interpreting depth-selective plots concerns the depositional contemporaneity of points on one plot. Although a depth-selective plot of particular items shows depositionally meaningful groupings of objects in localized areas of the site (e.g. see Fig. 20), it obviously does not follow that all the objects from all parts of the site shown in such arbitrary levels were necessarily deposited during one occupation; indeed, it is highly likely in the majority of cases that objects in different areas of the site on such plots were not deposited during one occupational episode. This of course points out a major deficiency of these depth-selective plots. Because these levels are arbitrary slices through the midden which crosscut numerous layer boundaries and thereby intermix many depositional events, there is no necessary depositionally meaningful relationship between all the objects shown on one plot (except for items found together in very localized parts of the midden). Moreover, items which are depositionally related but span several centimetres of deposit will be split up and appear in two or more of these levels. Of course, by examining a whole series of these level plots down through the midden, relatively tight groupings of objects in particular localized areas can be followed down through several of these levels. However, for more diffuse scatters, this procedure may not be much help for establishing the depositional contemporaneity of objects, and for dealing with this problem, the third kind of computer-generated plots must be used.

Depth-Projected Sectional Plots. The two kinds of distribution plots discussed above involve the horizontal plotting of the X co-ordinate against the Y co-ordinate, which is the usual way of displaying distributions in spatial archaeology. However, it is also possible to have the computer plot the X or Y co-ordinate against the depth co-ordinate, thereby producing vertical projections of the midden deposit. These sectional plots are potentially very informative about spatial relationships because they enable the researcher to view distributions from a different perspective; in particular, they can be used to take into account differences in depth distribution which cannot be so readily investigated by the standard horizontal plots.

Such vertical plots have not been widely used in the spatial analysis of intra-site distributions in archaeology, primarily because the entities studied by spatial analysis (sites or layers within them) are regarded as single occupations wherein differences in depth are not of any significance. Bunn et al. (1980: Figs. 5, 6 & 8) have used vertical plots to show in profile the distribution of stone artifacts and bone fragments from an early Pleistocene site in Kenya. Their north-south profiles involve compressing a width of 14 metres (in the east-west dimension) onto one surface; obviously, such wide vertical projections are comparatively coarse grained, similar to the depth-compressed horizontal plots discussed above. However, Bunn *et al*. (1980: 127) do state that further analysis will include the lane-by-lane dissection of the site, although they do not say how wide these lanes will be.

Of course, the choice of lane width is an arbitrary decision which the researcher makes on the basis of his judgement and discretion as to what is most appropriate and most informative. In effect, the choice of lane width is governed by similar considerations to the choice of the depth range to use in depth-selective horizontal plots. The wider the lane, the greater is the amount of blurring due to the fact the objects occur on slopes and not on perfectly level planes. Hence, in using these sectional plots, one is attempting to relate objects to depositional episodes -- that is, to reveal depositionally discrete groupings and depositionally separate occurrences. At the same time, one is trying to maximize the number of points on a plot; if the lane is too narrow, even though this minimizes blurring effects, the sample size may be too small for the plot to be very informative.

Generally, it was found in the present study that the optimal lane width was one metre. Except for a few highly abundant classes of data, lanes narrower than this had too few plotted points for the lane to contain much useful information, while lanes over a metre in width suffered too much blurring. For convenience of reference, these one metre lanes were labelled by the grid designations used during the 1977 and 1979 excavations. Thus, lanes running south-north are designated by letters, sequentially proceeding from east to west; and lanes running east-west are designated by numbers, sequentially proceeding from north to south. These lanes are delimited in Figure 21.

There are a number of features shown on these sectional plots which should be described. Firstly, as can be seen from Figure 21, many of these lanes contain lacunae

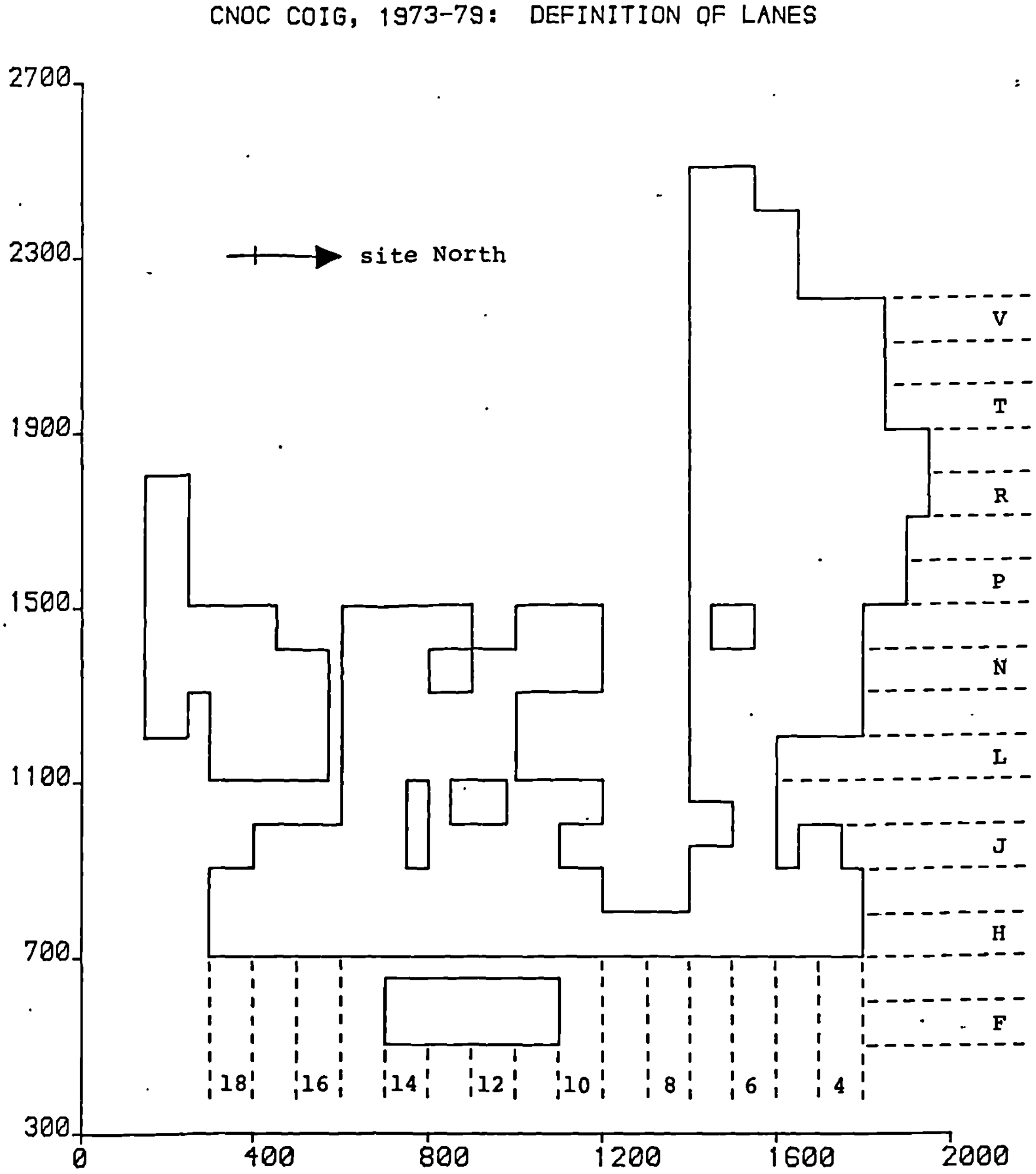

Figure 21. Plan of Cnoc Coig Delimiting the Lanes Used for the Depth-Projected Sectional Plots.

or discontinuities where either the midden was not dug or the data were not recorded _in situ_. In some cases, the discontinuity occurs for the whole width of the lane, while in others it is only partial. As an example of one of these sectional plots, Figure 22 shows the distribution of mammal and bird bones in the east half of Lane 5. This sectional plot for this portion of Lane 5 contains two discontinuities, one partial and one whole, and Figure 22 illustrates the conventions used on these plots to show where these occur -- partial discontinuities are indicated by broken lines and whole ones by diagonal hatching. Of course, in the case of partial lacunae, finds can and do occur within the areas delimited by the broken lines.

In the preceding section, mention was made of the fact that 466 recorded spot heights for the surface of the midden were included in the main data file on the computer. The main purpose of including these data relates to these sectional plots. As Figure 22 illustrates, these spot heights for the top of the midden are used to plot the surface of the midden as it exists in the different lanes, in order to provide a reference line for the plotted points on the various sectional plots. Note that disturbances in the surface of the midden, which were revealed by the many section drawings from the site, are shown on these sectional plots. Where such disturbances occur, two spot heights for one point were recorded, representing the top and bottom of the disturbance. On the sectional plots, a solid line is drawn through the base points of these disturbed pits and a broken line through the top points, since the top of these disturbances is sometimes difficult to define and hence their spot heights are somewhat problematical. Four of these surfaces disturbances are shown in Figure 22 and, as this plot illustrates, most of these disturbances are only shallow and small intrusions into the midden surface.

It should be noted that the top of the midden line shown on a particular sectional plot is in nearly all cases not based on _all_ the available spot heights within the one metre width of the lane. Rather, a single line running the

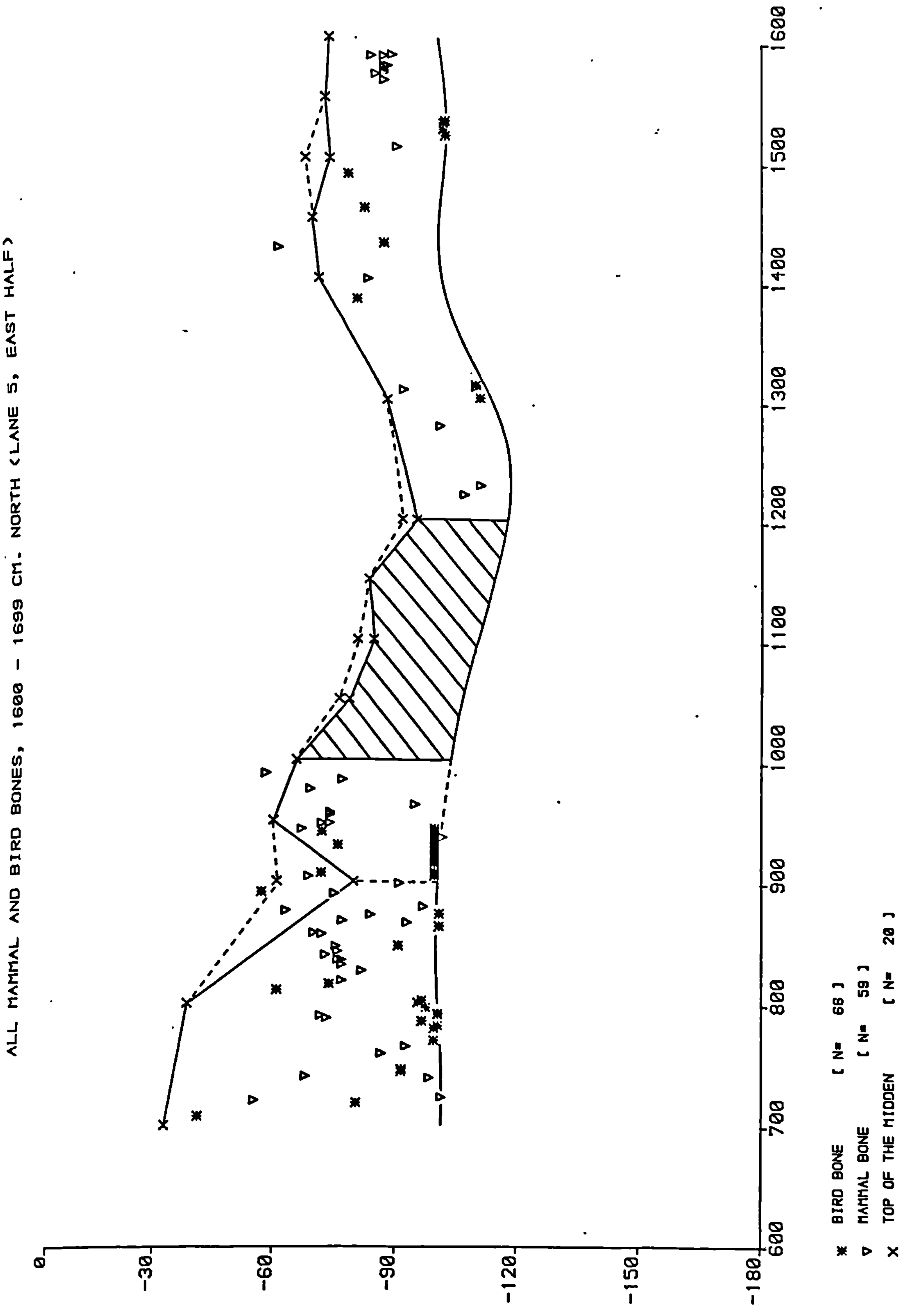

Figure 22. Example of a Depth-Projected Sectional Plot, Showing the Vertical Distribution of Mammal and Bird Bones in the Eastern Half of Lane 5.

full length of the lane was chosen and only the spot heights for points along this line were used. However, in the case of Lanes 5 and 6, since no one line runs the full length of the lanes, it was necessary to join two lines together to create a single, full-length line. Because most spot heights for the midden surface were recorded on the edges and corners of grid squares, and because the lanes are defined in terms of the site grid so that they are made up of a succession of grid squares, these top of the midden lines nearly always represent one of the edges of the lane and not the central line running through the middle of the lane. The latter situation would have been more ideal because, in relation to the top of the midden line, finds would have been projected on the sectional plot from a maximum distance of 50 cm on either side of the line. As it is however, since this ideal situation could not be employed, finds are projected from distances of up to one metre away from the top of the midden line.

Although this does not create serious problems for the use of these sectional plots, it does mean that some finds when plotted in relation to the top of the midden line appear to occur above the midden when in fact they do not -- for example, note the two mammal bones in Figure 22. This situation only occurs where a lane runs perpendicularly through a relatively steeply sloping part of the midden, so that finds which are approaching the maximal distance of one metre away from the top of the midden line are higher than this line in terms of their absolute depths. Such instances are relatively uncommon, but in any case, the relationships of finds to these top of the midden lines are not all that important since the main interest of these sectional plots lies with the spatial interrelationships of the finds themselves -- the top of the midden is included on the sectional plots merely as a reference line. Of course, the same sort of projection problem can arise with regards to the interrelationships of small finds which occur on a steeply sloping surface. In effect, this is a kind of distortion which results from the projection of three-dimensional data onto a two-dimensional surface. However, such distortion can be monitored by viewing distributions from the perspective of two different sectional plots which run perpendicularly to each other (since all finds occur in two lanes, one running south-north and the other east-west). Indeed, the use of sectional plots running in both directions is essential in order to gain the fullest possible understanding of spatial interrelationships so that spurious and misleading interpretations based on sectional plots running in only one direction can be avoided.

As Figure 22 illustrates, the sectional plots also include a reference line for the base of the midden. A sectional plot was generated for each lane showing the occurrence of all small finds within that lane. Using the lowermost finds on these plots (except for those few finds which are known to occur below the midden deposits), a hypothetical line was drawn to represent the approximate base of the midden. This procedure was adopted rather than using surveyed spot height measurements because it was not always clear from the unit plans where the midden deposits precisely ended. Of course, the section drawings would have been suitable for this purpose, but, because they do not extensively cover all of the site, they cannot provide a comprehensive body of base of the midden spot heights which yield a sufficient number of measurements within all lanes. The alternative procedure adopted here produces base of the midden surface representations which, although approximations, are suitable as reference lines.

Some of the sectional plots used in the present study also show the locations of hearths within the various lanes. However, it should be noted that a hearth is only shown in the particular lane in which its centre point is located -- clearly, either the larger hearths or ones whose centre point is near the boundary between two lanes may well extend into an adjacent lane. As well, it should be pointed out that these sectional plots show the maximum horizontal (either south-north or east-west) extent of a hearth through its centre point along the top of the hearth only. Thus, its full depth is not shown and, of course, across the full width of the lane, the hearth is not as wide or long as is indicated. Nonetheless, the conventions used here to represent hearths on these sectional plots are sufficient to illustrate the main features of the spatial relationships of objects to nearby hearths.

One final aspect of these sectional plots which should be mentioned concerns the scale of the X- and Y-axes. For all the sectional plots presented in this study, the Y-axis, which represents the depth co-ordinate, is fixed and constant, ranging from zero down to -180 cm below site datum. In all cases, the depths of individual plots do not span this full depth range. However, this fixed Y-axis is used for all plots in order to show differences in the depth below site datum of the midden deposit in the various lanes and so to facilitate the visual comparison between lanes from different parts of the site. The X-axis on the sectional plots represents either the X or Y co-ordinate, depending if the lane runs south-north or east-west respectively. Of course, since lanes are of various lengths, the X-axis on the sectional plots is not fixed in terms of either length or the absolute range of X (south-north) or Y (east-west) co-ordinate values. What is fixed, however, is the ratio of the X- and Y-axes on the plots. As can be seen from Figure 22, the Y-axis is marked off in six 30 cm intervals, whereas on the X-axis these intervals represent 100 cm. Thus, the sectional plots involve a distortion of the two axes in which the X-axis is compressed three and one-third times relative to the Y-axis -- in other words, the depth co-ordinate as plotted along the Y-axis is stretched out by a factor of 3.33 relative to the X-axis. This distortion was used to reduce somewhat the overall length along the X-axis of the sectional plots. This could also have been accomplished by using a larger (and equal) scale for the X- and Y-axes -- for example, intervals representing 200 cm -- but this would result in such compression of the depth dimension that differences in depth would be totally impossible to detect. Thus, the main purpose of using a distortion ratio of 1 : 3.33 is that it exaggerates differences in the depth dimension to facilitate distinguishing any discrete depositional occurrences. It should be pointed out that a distortion ratio of 1 : 3 is used by Mellars (1985) for the published section drawing diagrams from the site. Of course, it must be remembered when interpreting these sectional plots that this stretching out of the depth dimension not only exaggerates the differences in depth but also, as a result, that it makes slopes appear steeper than they actually are.

Despite the fact that <u>all</u> of the computer-generated distribution plots are schematic representations of the archaeological "reality" of the midden deposits, it is the depth-projected sectional plots which are the best approximations of this reality and which provide the researcher with the clearest means of investigating and interpreting the distribution of materials within the site. As will be seen in Chapters 6 and 7, the analysis of the mammal and bird bone assemblages from Cnoc Coig involves defining for each species or major taxon a number of groupings of bones which are hypothesized to represent depositionally meaningful subunits of the total assemblage of each species. Following the analysis of the seal bone assemblage, a comparison was made between the locations of some of the seal bone groupings as revealed on the sectional plots and some of the drawn stratigraphic sections from the site in order to see if the depositional groups of seal bones made sense in terms of the recorded stratigraphy.

One of the longest stratigraphic section drawings, which runs north-south and corresponds to Lane H, was particularly illustrative since Lane H includes many seal bones contained in several distinct groupings, and since the stratigraphy in this area of the site was particularly well defined. Figure 22A shows this section drawing, and superimposed onto it are the locations of the 72 seal bones in Lane H. In general, the seal bone groupings in Lane H as revealed on the depth-projected sectional plot (Fig. 54)

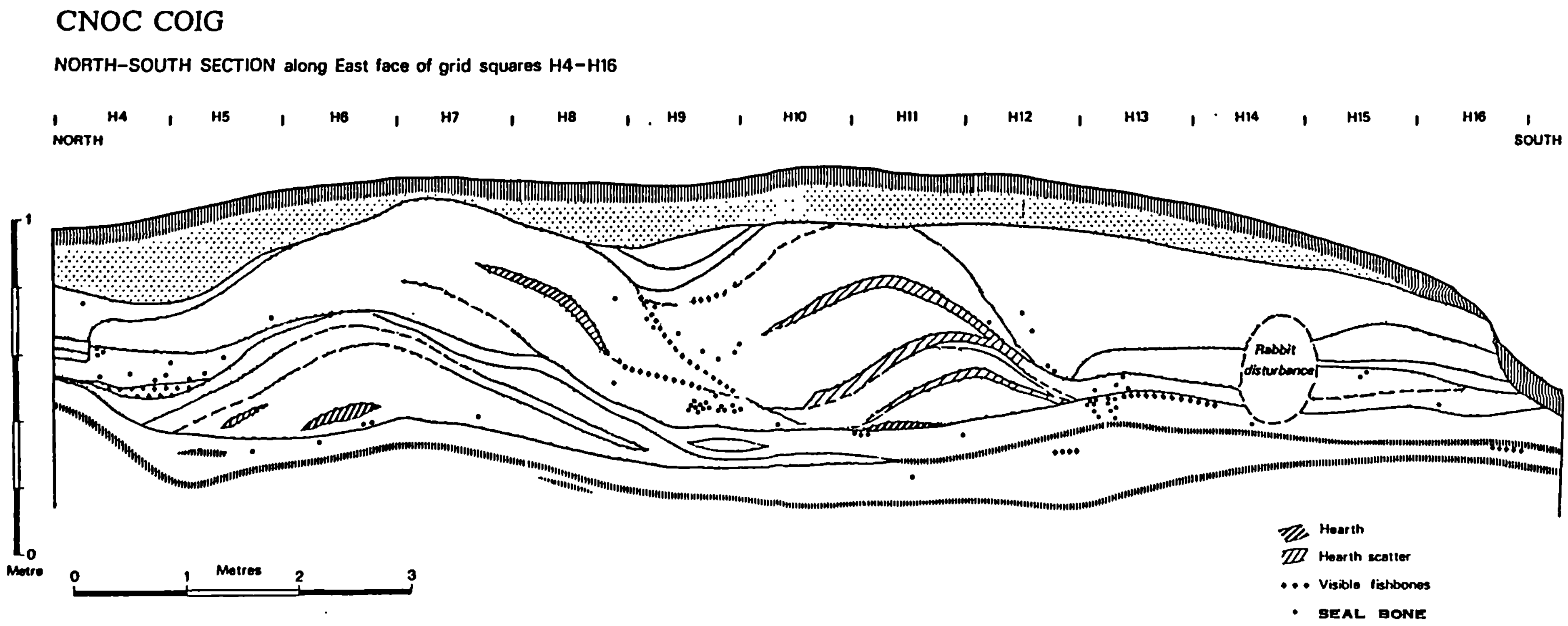

Figure 22A. Section Drawing of the East Face of Grid Squares H4 - H16 Showing the Locations of Seal Bones in Lane H in Relation to the Recorded Stratigraphy. Redrawn from, and for further stratigraphic details see, Mellars (1985: Fig. 15.10).

make quite good sense stratigraphically, since most of these apparent groupings can be seen to occur more or less within discrete strata. Although there is not complete correspondence between apparent groupings and specific strata, it should be remembered that the seal bones are compressed from a one metre wide strip of midden deposit onto this section drawing; and this compression of a three-dimensional distribution onto a two-dimensional surface largely accounts for the fact that a few seal bones seem to occur in separate strata from the other bones of the group nearby. Thus, the overall correspondence is remarkably good. Along with a few smaller comparisons between lanes and section drawings in other areas of the site, this trial study involving Lane H offers much promise for future comparisons to be made between the results obtained in the present study and the detailed stratigraphy of the midden, and it must lend considerable confidence to the fact that the computer-generated distribution plots (especially the sectional plots) used in the present study can be a reliable tool for investigating the spatial and depositional relationships within the Cnoc Coig shell midden.

Spatial Relationships to Hearths

It was noted above that 64 hearths occur within the excavated areas of Cnoc Coig used in the present study. It was also stated that the locations of hearths are shown on some of the depth-projected sectional plots, to which it might be added that they are also shown on some of the depth-selective horizontal plots. One aspect of the present analysis of the distribution of material within Cnoc Coig involves assessing the spatial relationships of various categories of items to the many hearths in the midden.

Basic Procedure. For mammal and bird bones, this simply involves a few qualitative statements about the proximity of bones to nearby hearths which are stratigraphically related such that they might be referrable to the same (or to temporally close) occupational episodes.

However, the spatial relationships of artifacts to hearths are assessed in quantitative terms, so that different artifact categories can be readily compared in terms of their relative proximities to hearths. The spatial proximity to hearths was assessed by determining the distance of an artifact to the centre of the nearest hearth. These distances provided a body of measurements on which basic descriptive statistics could be obtained using S.P.S.S. (Nie *et al*. 1975) to facilitate the comparison of different artifact types.

The centre rather than the edge of a hearth was used because hearth boundaries can be rather diffuse and difficult to define in places, thereby making it difficult sometimes to determine a precise distance, whereas the estimated centre of a hearth provides a fixed point of reference for determining the distances of all objects in all directions around the hearth. The hearth chosen for a particular object was the closest one which *might* on stratigraphical grounds be depositionally related to, and therefore possibly contemporaneous with, the artifact in question. In other words, in some cases, the nearest hearth will be one which lies more or less directly below or above a particular artifact, but, in such instances where hearths are clearly stratigraphically earlier or later than the find in question, such vertical distances were not used; instead, a stratigraphically more appropriate hearth nearby was chosen. Thus, despite the fact that there is obviously *some* vertical separation between some artifacts and their nearest hearths, the distances used are essentially horizontal distances. Nevertheless, it should be noted that the nearest hearth to a particular artifact is not necessarily in the same 5.0 cm level as plotted on the depth-selective horizontal plots. Although many are in the same level, many others occur one or even two levels either above or below, especially with objects which are relatively far away from a hearth. Of course, determining the nearest hearth to particular objects within the midden requires a certain amound of subjective assessment as to what can be considered likely, or at least possible, stratigraphic association. Nevertheless, with prudent discretion, this can be done with reasonable certainty. In fact, for the majority of artifacts, determining which hearth is nearest to them is fairly straightforward since they are not very distantly separated.

As a final remark, it should be emphasized that this procedure does *not* assume that the nearest stratigraphically related hearth to an object was necessarily one which was in active use when the item was discarded; rather, it only assumes that the hearth is stratigraphically situated so that it *could* have been a contemporaneously active hearth. In any case, the point of the exercise is simply to obtain a body of quantitative data which can be used to compare the *relative* spatial proximities to hearths for various categories of objects found within the midden. It is maintained here that the distances to their nearest hearths for objects which were discarded around active hearths should, given a large enough sample, reveal a significant tendency for these objects to be on average in closer proximity to hearths than are those items which were discarded away from active hearths.

Testing for Randomness. In other words, this procedure is simply a comparative device aimed at assessing in relative terms the spatial proximities to hearths for the various types of artifacts found in the site. As will be seen in Chapters 8 to 10, and as is summarized in Chapter 11, an array of values for the mean distance to the nearest hearth was obtained for various artifact types; these values range from just under 1.0 m to just over 2.5 m (see Figs. 23 to 34, and especially Table 43). However, although clearly the broad range of values obtained must mean that at least some of the artifact categories deviate significantly away from the distribution of a pattern of points which are located randomly in relation to hearths, the possibility must be recognized that some of these artifact types may be essentially distributed at random in relation to hearths.

In order to test for this possibility, a pattern of 100 points randomly located within the midden was generated using a random numbers table; the overall distribution of these points is shown in Figure 22B. Using the same procedures outlined above and employed in Chapters 8 to 10 for the various artifact types, the distances to the nearest spatially associated hearths for these 100 points were determined; these data are graphically summarized in Figure 22C. As will be seen, some of the artifact types reveal a pattern of spatial association with hearths that is remarkably similar to this random pattern, whereas other categories are significantly more closely associated with hearths or (more rarely) less well associated. Further comments comparing the distribution of distances shown in Figure 22C with the results obtained in Chapters 8 to 10 (Figs. 23 to 34) will be made in Chapter 11.

Object Category and Object Size. One final matter requires consideration at this juncture since it particularly relates to the spatial association of objects to hearths. The analyses in the present study are based on object category rather than some other classificatory criterion such as object size. As referred to in Chapter 2, in his ethnoarchaeological study of the Mask Site, Binford (1978a: 344-348, Table 5) has recognized several "disposal modes" used in the discard of materials, and these disposal modes provide a conceptual foundation for subsequent analysis (such as identifying "drop zones" and "toss zones" and relating these to the "site framework"). It is clear from Binford's study that both the form and size of objects relate to the particular disposal modes employed in their discard. In the present study, an attempt is made to identify the principal modes of disposal used in the discard of various materials (particularly artifacts), and a major variable which is used in this task involves the relative degrees to which objects are spatially associated with hearths (since research such as Binford's Mask Site study has shown that hearths serve as primary conditioners of the spatial structuring of activities on a site and of the consequent pattern of dispersion of refuse). This

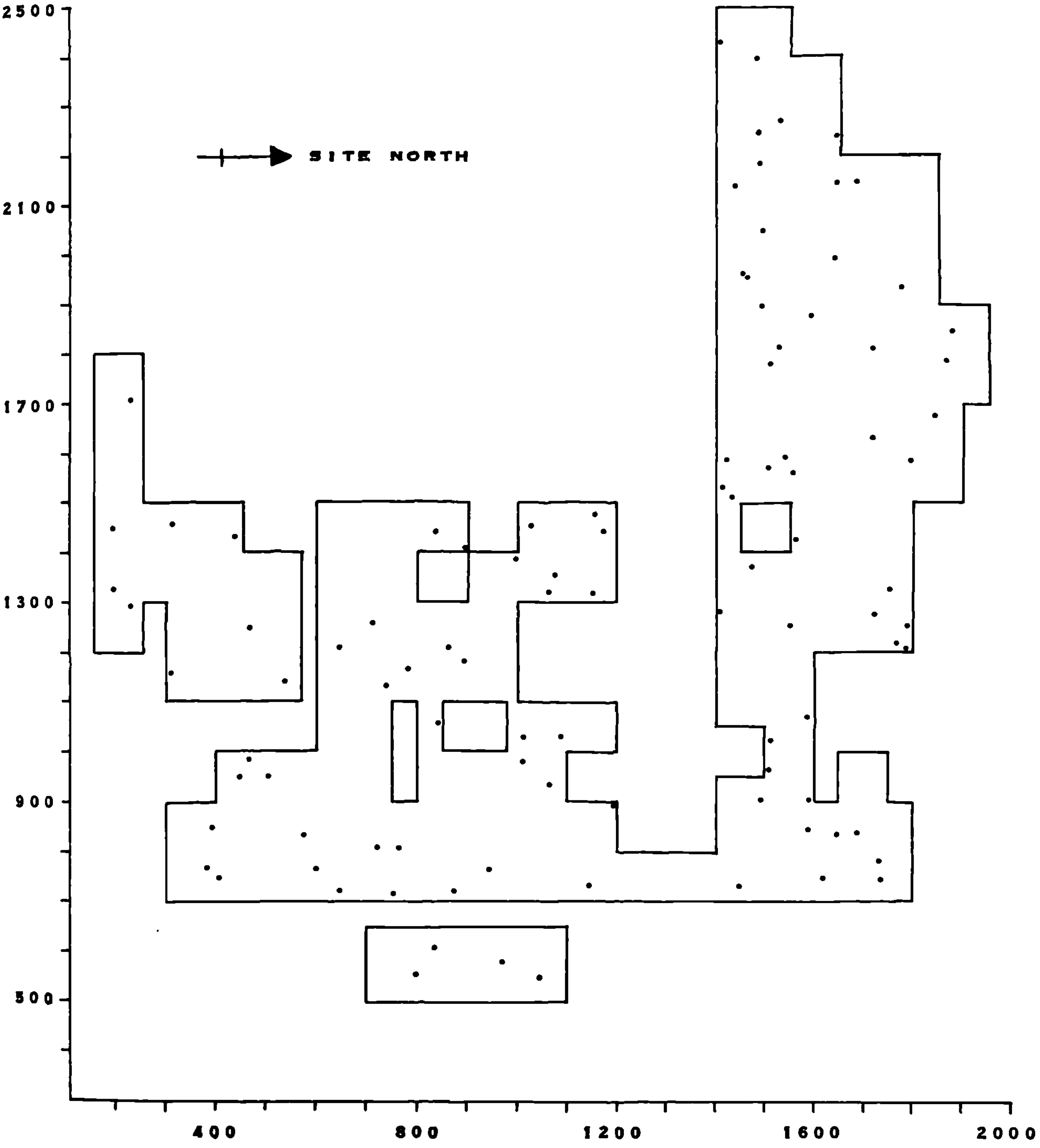

Figure 22B. Horizontal Plot Showing the Distribution of 100 Points Randomly Located within the Cnoc Coig Shell Midden.

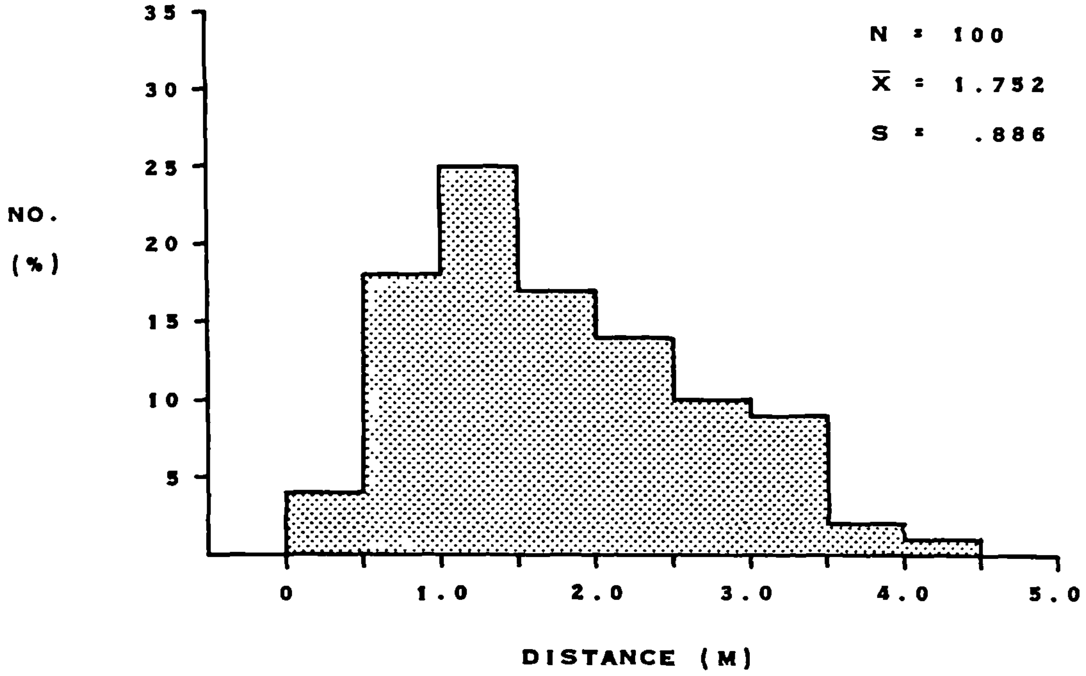

Figure 22C. Frequency Distribution of the Distances to the Centres of the Nearest Stratigraphically Related Hearths for the 100 Randomly Located Points.

analysis is carried out on the basis of object category with, as will be seen, some success. However, the same exercise might be done using a classification based on object size, since the size of an item is clearly a major factor determining the choice of disposal mode used in its discard. Such an analysis might also be expected to reveal some interesting patterning in the data.

Nevertheless, this does not mean that the use of object categories produces meaningless results or, in other words, that object size is the only useful classificatory criterion. For one thing, in the case of artifacts, there is a strong correlation between artifact type and object size, since most of the artifact types recognized in Obanian assemblages are precisely defined such that they have a fairly narrow size range. For example, the vast majority of S.L.S. have a maximum length of between 30 and 80 mm (see Fig. 9), and even the more fragmentary A.L.S. do not deviate much from this size range. Most other artifact types -- such as P.S.L.S., U.S.L.S., pitted pebbles, pecten shells, antler and bone borers, and so forth -- are similarly quite consistent in terms of size. Certainly they are consistent enough that one could use with reasonable reliability the existing typology as a basis for creating a number of size categories for the various artifactual materials found in the site without there being a pressing need to reclassify the objects individually from scratch. Indeed, no doubt because of this, it might be simply noted here that most of the artifact types which are in relatively close proximity to hearths are relatively small objects, whereas most of the types of larger artifacts are more distantly removed from hearths. This correlation is certainly not absolute, but then object size is not the only variable, nor indeed not necessarily even the most important variable, governing the discard processes by which artifacts enter the archaeological record. For one, whether or not an artifact is still potentially usable is a major factor determining the mode of disposal employed.

In any event, these comments regarding artifacts do not pertain to non-artifactual faunal remains. For example, the variable of potential future utility does not apply to most discarded mammal or bird bones since most of these are useless waste once the edible portions have been consumed. In addition, unlike artifacts, the bone fragments resulting from the butchered carcases of any particular species vary greatly in size from highly comminuted fragments to much larger pieces -- or in other words, the bones from any particular animal species (the species being the taxonomic equivalent of artifact types) cannot be said to be within a fairly consistent size range, and the larger the animal, the greater will be the (potential) variability in fragment size. In the case of bone assemblages therefore, object size may be thought to be a more important variable determining the disposal mode employed than is the case with artifacts. And this is certainly demonstrated in Binford's Mask Site study (e.g. compare bone splinters and chips with articular ends -- 1978a: Fig. 13, Table 5). Be this as it may, in the present study, identifying disposal modes for the mammal and bird bone assemblages was not as major an objective of the analysis as it was for the artifactual remains. Nevertheless, it must be conceded that analysing the distribution of mammal and bird bones on the basis of fragment size could well be expected to produce some definite patterning in the data, particularly in terms of how well the definable groupings of bones are spatially associated with hearths.

The Coefficient of Segregation

In Chapter 2, quantitative techniques of spatial analysis in archaeology were reviewed. It was seen that most archaeological applications have involved what Orton (1982) calls "univariate" techniques, that is, methods which are concerned with the distribution of single classes of items. The most widely used of these techniques has been the Clark and Evans (1954) distance method of nearest-neighbour analysis. The many problems associated with this technique were thoroughly examined and, in light of this discussion, it should come as no surprise to learn that the Clark and Evans nearest-neighbour statistic cannot be employed at Cnoc Coig where there are discontinuities in the excavated areas of the site and where there is so much boundary due to its highly irregular shape.

It was also shown that, in the context of studying intra-site spatial distributions, univariate distance or quadrat methods have been employed in some cases (e.g. Dacey 1973a: 321; Whallon 1973b: 266-267; 1978: 28) because it was felt that the detection of non-randomness in the patterning of individual classes of items is a prerequisite to examining spatial associations between several classes of items. Orton (1982: 4, 5) and others (e.g. Pielou 1969: 179; Hietala & Stevens 1977: 539-540) explicitly point out that this view is fallacious. Consequently, the questions addressed by univariate techniques may frequently be of little or no relevance to the main interests of intra-site spatial analysis.

As a result, methods of spatial analysis which are concerned with the distribution of two or more classes of items, which Orton (1982) refers to as "multivariate" techniques, may often be of more value and interest to archaeologists, and this is certainly the case for some of the problems which arise in the analysis of patterns of distribution at Cnoc Coig. One such multivariate technique is Pielou's (1961: 258-259; 1969: 182-183) coefficient of segregation, which was briefly discussed above in Chapter 2 (see pp. 55-58). This segregation statistic was adapted for use in the present study by Dr. Nick Fieller and Mr. David Robson of the Department of Probability and Statistics, University of Sheffield. Aside from some of the general problems with quadrat methods of segregation (see Hodder & Orton 1976: 204; Pielou 1961: 255; 1969: 181), there were particular reasons in the present study for adopting a distance-based method, specifically, "...because they are more easily generalised to three dimensions and because of the difficulty of defining a system of quadrats that were entirely interior to the study area" (Fieller et al. 1983: 165). The basic form of Pielou's coefficient of segregation (S) is as follows:

> Each point of the pattern is examined and the type of its nearest neighbour is determined. The coefficient is based upon the number of "mixed pairs", i.e. where one point has a different type of point as its nearest neighbour. It is defined as
>
> $$S = 1 - \frac{\text{observed number of mixed pairs}}{\text{expected number of mixed pairs}},$$
>
> the expected number being calculated on the assumption of random mixing. If we display the various forms of nearest neighbour pairs in a two-way table:
>
> | | | type of nearest neighbour A | B | total |
> |---|---|---|---|---|
> | Type of | A | a | b | m |
> | base point | B | c | d | n |
> | | total | r | s | N |
>
> then we have that
>
> $$S = 1 - \frac{N(b+c)}{(ms+nr)}$$
>
> It is easy to see that S ranges in value from +1 when every point has the same type as its nearest neighbour (b=c=0), to -1 when the whole population is composed of isolated mixed pairs (Fieller et al. 1983: 165).

This coefficient of segregation can be applied to either two- or three-dimensional data. Although in the case of narrow depth ranges (such as one or two of our 5.0 cm levels) distributions are essentially two-dimensional, so that a program using two-dimensional data could be used, all data in the present study are strictly speaking three-dimensional; hence, a program using three-dimensional data was devised and has been employed in the present study.

Aside from this coefficient of segregation based on first nearest-neighbour distances,

> ...a corresponding coefficient, S_2 say, can be calculated in terms of second nearest neighbours. This measures segregation on a larger scale and is independent of the small scale micro pattern of the distribution.... Our analysis was performed in terms of the two statistics S and S_2 (Fieller et al. 1983: 166).

The use of a second nearest-neighbour measure is advisable for two reasons: first, they are generally regarded to be more robust; and second, because the S_2 statistic measures larger scale patterning, it overcomes the problem that first nearest-neighbour statistics may be detecting "spurious" segregation patterns resulting from peculiar distributions, such as when points occur as isolated pairs of the same type (thereby indicating highly significant segregation) (N. Fieller, personal communication). This latter situation is perhaps more likely to be found with botanical data and overall, one would expect with intra-site archaeological distributions that there would be broad agreement between first and second nearest-neighbour measures.

Of course, it is necessary to assess the significance of a given value of S or S_2 to determine whether it represents evidence for segregation or whether it is no greater than might be expected from chance. For the present study, a Monte Carlo or simulation test by random relabelling was developed, as described by Fieller et al.:

> To assess the significance of the coefficient of segregation S calculated from m points of type A and n points of type B, the Monte Carlo procedure requires an artificial set of points with the same number of each type and placed in the same region subject to the same boundary constraints and weightings as the original. One method would be to place m+n points randomly in the region, the first m being designated type A (1983: 168).
>
> An alternative procedure...is the random relabelling procedure. This takes the given positions of the points, and then each simulation consists of selecting randomly m points from the set of m+n and labelling them as type A, the others being regarded as type B; the coefficient S is calculated from this randomly relabelled set (1983: 169).
>
> [This relabelling procedure]...is repeated a large number of times, in our study 499 times, and the complete set of 500 numerical measures is sorted into rank order. If the value from the actual pattern is larger than say 95% of those obtained from random patterns, then we conclude that the actual pattern exhibits a "significant" degree of segregation, in fact significant at the 5% level (1983: 163).

When using Monte Carlo tests, the level of significance which can be legitimately ascribed to a particular observed value in relation to the simulation values is related to the number of simulations carried out, so that increasingly higher levels of significance require increasingly larger numbers of simulations (Marriott 1979). For example, 99 simulations are sufficient for the 5% level of significance to be used, 249 simulations for the 2% level, and 499 simulations for the 1% level. The program developed for the present study carries out anywhere between 249 and 499 simulations for each observed S or S_2 value, thus allowing a level of significance as high as the 1% level. Finally, it should be noted that, despite suggestions to the contrary (Pielou 1961: 258; 1969: 182; see also Hodder & Orton 1976: 205), a chi-square test of significance is not valid because the two-way table of nearest-neighbour relationships is not a contingency table (Fieller *et al.* 1983: 165-166).

It was noted in Chapter 2 that edge effects can present a major problem in employing the Clark and Evans (1954) nearest-neighbour statistic. Obviously, in the case of highly irregular regions like the excavated areas at Cnoc Coig, edge effects can be a serious problem with any distance-based method of spatial analysis, such as Pielou's coefficient of segregation. To take into account the possible edge effects on S values, a system of weighting nearest-neighbour values was adopted:

> If a base point is closer to a boundary than its distance from its nearest neighbour within the excavated region then it is plausible to permit that particular nearest neighbour distance to contribute less weight to the measure of spatial pattern, than if its nearest neighbour were known with certainty. We suggest that the appropriate weight to use is the proportion of the area of the disc, (or volume of the sphere in three dimensions) which is centred on the base point and has radius equal to the apparent nearest neighbour distance, which is contained as interior to the excavated region. Points which are closer to their neighbour than to a boundary would thus have weight 1, otherwise the weight is less than 1 (Fieller *et al.* 1983: 166).

This system weights the amount that a point contributes for determining the values of a, b, c and d in the two-way table of nearest-neighbour relationships which provides the basis for calculating particular S and S_2 values. To determine the specific weights of particular points, a method based on the calculation of "winding numbers" was developed, the details of which are described elsewhere (Fieller _et al_. 1983: 166-168).

Finally, it may be noted that edge corrections utilizing weighted nearest-neighbour values tended to produce results which surprisingly were virtually unaltered from those derived from unweighted measures (see Fieller _et al_. 1983: 169). Thus, despite the highly irregular nature of the excavated areas of Cnoc Coig, it would seem that edge effects do not pose as much of a problem as had been expected. Nevertheless, it remains inadvisable to use results which are based solely on unweighted values without taking any account of possible edge effects. Thus, in the following analysis where the coefficient of segregation is used, the coefficient based on three-dimensional nearest-neighbour distances and weighted nearest-neighbour values will be employed.