Spatial Patterns and Behaviour at Dunefield Midden

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"To understand the past we must understand places":

L. Binford (1982:6)

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Abstract

An analysis of the spatial patterning present in the arrangement of material and features at the site of Dunefield Midden, is presented in this thesis. All items from the site are analysed, except the remains of large fauna. The site of Dunefield Midden is situated about two kilometres north of Eland's Bay on the Cape West coast, South Africa. Radiocarbon dates indicate that the site was occupied about 670 years B.P. The nature of the food remains and artefacts from this site suggests a single occupation, for a limited period, by a group of hunter - gatherers. Features from the site examined in detail include ash features (such as hearths, roasting pits and ash dumps) and dumps (in particular, a feature called the 'main dump'). Comparisons with ethnographic and ethnoarchaeological material are made to aid the process of interpretation. Other features common to ethnographic hunter - gatherer campsites, but for which there is no evidence at Dunefield Midden (such as structures), are discussed. The type of site, possible length of occupation and number of people are discussed from the analysis of features and other material. Suggestions are made that the site was a base camp occupied by between ten and twenty - five people for a month to a month and a half.

Finally, conclusions are made about the nature of the behaviours which caused the spatial patterning evident on the site. The level of detail reached in the interpretations of patterning and behaviour is far greater than that possible from more complex, deeply stratified sites. Thus, the value of researching different kinds of sites is shown. The use of a Geographic Information System to analyse information and create distribution maps is unique in spatial archaeological studies. The use of this system shows its value as a new technology of great potential use to all archaeologists. The spatial autocorrelation test of randomness of distributions is also introduced and is compared to other statistical tests used by archaeologists previously. This test is applied to distributions of items from the site, produced with the aid of the Geographic Information System. The use of site indices describes a method of normalising distributions, with the possibility of using satellite technology to analyse these distributions.

This thesis, therefore, reaches a deeper level of interpretation of human behaviour at one particular site, than generally has been achieved previously. It also introduces new techniques and technologies particularly suited to this analysis and potentially of use to other archaeologists, even in different fields of study.

Introduction

The aim of this project is to develop an understanding of a 'place' and thereby to understand the people who used it. Parkington and Mills (1991:355) define a 'place' as: " 'space given meaning' by people". This 'meaning' is given primarily by the behaviours that occurred there. In order to understand the 'place' and the people, the behaviours that transformed the place into a cultural entity need to be understood. The behaviours of individual people are the basis of all behaviours performed at a site; whether the people are acting independently or together, their individuality is important. Whilst it may be argued that the modern concept of individuality is a result of the capitalist society in which we live, it is nevertheless true that even in more 'group-orientated' societies individuals have a significant influence. At the most simplistic level an individual's kin ties will have an influence on group behaviours performed.

Therefore 'place' and 'person' are intricately linked. Furthermore, the identification of 'place' and 'person' allows 'social archaeology'. The aim of social archaeology is to 'put the people back into the past'. It makes the transition from a description of archaeological sequence to a true history, relating the actions, behaviours and lives of people in the past. As such, sites with fine resolution where the people are 'visible' have a significant contribution to make. An understanding of the past may be achieved because human behaviour leaves patterned traces (Kent 1987). These patterned traces are all that remain in the archaeological record of people and places. Therefore the behaviour must be inferred from a study of these traces.

Spatial archaeology uses a variety of different methods to study these traces. Some of these methods are statistical, others are visual and comparative, using ethnoarchaeological models. As will be shown below these two approaches have different contributions to make. This project will concentrate on interpretation and as such will use ethnoarchaeological examples as guidelines in an examination of the material from a particular site. The patterning of this material will form the basis for an attempt to understand the behaviours that caused it. The project will also utilise the labour-saving capabilities of a spatially orientated computer system called a geographical information system or GIS. As such it will introduce this system to southern African archaeology. Statistical methods will play a relatively minor role in this analysis.

The 'place' in this study is a campsite on the Cape West coast which is argued to represent a single episode in the history of the people who inhabited this region. The fine resolution of this site (Dunefield Midden) means that the behaviours of the people during the short space of time represented by the site should be fairly clearly reflected. In other words resolution to the level of 'person' is possible. As shown above, this is vitally important in achieving an understanding of human history. The examination of this site should therefore lead to a greater understanding of the way of life of people inhabiting this region at the time of the site's occupation, as well as adding to the understanding of the way that this section of coastline has been utilised in the past. The site has a very important contribution to make as a place in which it is possible to identify **people** in the past, making the step from South African sequence to South African history.

There are several features that this site possesses which make it a valuable addition to the record of human history in this region, and several of these raise interesting issues which may be pursued at other sites. The investigations of human behaviour made in spatial archaeology centre around discard behaviour, both in the primary and secondary context. In the primary context discard behaviour relates to material created during the process of an activity, for example small bones which fall to the ground during food consumption or the smaller waste from stone tool manufacture. In the secondary context discard behaviour relates to the clearing of the activity areas and the creation of refuse dumps, usually on the fringes of or at a distance from these areas.

Discard behaviour can in turn indicate other behaviours and social factors. The determination of areas where activities were performed allows one to judge whether this activity was the only one performed in that area, or whether several activities took place and the evidence of these activities overlaps spatially. The relationship between different areas where activities took place may also be examined. Thus, a study of the stone artefacts from the site of Dunefield Midden (Vermeulen 1990), allowed the following conclusions to be made. Quartz chips, being waste pieces smaller than 1 cm, were taken as a reliable indicator of the areas of stone tool manufacture; the extremely discrete clustering supported this assumption. Four primary areas of stone tool manufacture were demonstrated, thus allowing the suggestion that between one and four toolmakers were active at the site. It was also found that stone tool manufacture was not spatially segregated from food consumption, although it did tend to occur in different areas from those in which potsherds were utilized (Vermeulen 1990). Questions about the number of toolmakers at a site or the siting of tool manufacture within the context of the site have not been previously addressed in southern African archaeology; thus it can be shown that this kind of analysis adds much to the understanding of the social aspects of human history in the area.

Henshilwood (1990) did a preliminary study of the focal nature of hearths with respect to other activities, examining what occurred within certain areas of hearths. This examination is expanded upon in the section of this project concerning ash features. This project will also address the question of site layout, including the positioning of refuse dumps. It will then be possible to determine the type of site, whether residential or otherwise and suggest the duration of the occupation. Site layout can also allow suggestions to be made concerning social relations within the group. The main basis for these suggestions will be ethnoarchaeological analogy. This study however, will not include an analysis of the fauna, other than some microfauna, from the site, since this will be examined by Nilssen (n.d.).

The use of ethnography can be problematic. Critics state problems such as the fact that all societies studied in the present are the result of a trajectory of time that will have carried these people away from situations such as those faced by people in the past (Blankholm 1991). Whilst this is indeed true, it is nevertheless felt by others that certain generalisations about human behaviour in roughly analogous situations can be made (Yellen 1977). Many of these are the result of physiological requirements which govern the ease of communication, as well as placing physical restraints on activities (Whitelaw 1991). These requirements in turn affect other behaviours. Thus, certain types of discard behaviour are necessary when people are living a certain lifestyle, for example. It is therefore felt that a careful application of ethnoarchaeological models to the archaeological record can greatly aid interpretation. The lifestyle of modern people in certain situations can be shown to be similar to that of people in the archaeological record. This similarity can be shown for certain very basic factors such as economy and habitational situation. The behaviour of these modern people produces patterning of items. Once the basic details of lifestyle have been shown to be equivalent between archaeological and modern populations, then the patterning on the archaeological site can be examined for similarities to the patterning on the modern site. If the patterning is found to be similar then it can be inferred that the behaviours in both cases were similar.

Ethnoarchaeological studies from many different types of habitats around the globe have been published in the last decade or so. These range from studies of the Nunamiut in Alaska by Binford (1978b 1983 1991) to studies of people in the Equatorial forests of Africa (Fisher and Strickland 1991) and in the deserts of Australia (Walters 1984 Binford 1986 O'Connell 1987 Gargett and Hayden 1991 Nicholson and Cane 1991). Perhaps of the most relevance to this study is the research done in Botswana (Yellen 1977 Brooks and Yellen 1987 Bartram *et al.* 1991).There have also been several syntheses of studies, such as the important work done by Whitelaw (1989 1991). These studies will form the basis for comparison in this thesis. The site of Dunefield Midden is, however, in an area similar in many ways to the Kalahari (the closest area with ethnoarchaeological parallels). It is also not substantially separated in age being only approximately 650 years old and is therefore more likely to correspond to modern sites than are sites several thousand years old. Although Dunefield Midden is situated on the coast and the site shows that marine resources were an important component of the diet, it is felt that the way of life represented here (in other words a hunting and gathering economy) is sufficiently similar to that present in the Kalahari ethnography. It is therefore expected that there will be the most similarities between Dunefield Midden and the Kalahari sites.

The use of statistics in spatial archaeology has a fairly long history. Statistics was first applied by Whallon in the early 1970s (Whallon 1973a 1973b 1974). These techniques have been greatly refined, especially within the last decade. There are however, problems with the application of these methods for interpretation. The relevance of the results of statistical tests to human behaviour is problematic. As has been argued elsewhere, the material traces of human behaviour may not yield statistically significant results but are still important. On the other hand, statistically significant results need not be important in terms of the human behaviour they reveal. Several of the statistical tests applied to an archaeological site may not be the most useful in revealing spatial patterning (Blankholm 1991). Nevertheless, some statistical tests may reveal patterning which was not obvious to a visual inspection and this may be useful. It is therefore felt that statistical techniques have their greatest applicability at the level of identification of patterning, but many do not add much clarity to interpretation. It is felt that ethnoarchaeological comparisons can provide potentially more information about the behaviour of people at the site in this study than can statistical analyses. The ethnoarchaeology therefore provides the basis for interpretation, just as statistics can provide the basis for identification of patterning. The emphasis of this project will lie with the former rather than the latter, since it is felt that there is sufficient patterning which can be distinguished visually to allow basic interpretation. It is felt that the application of statistical techniques to reveal further patterning is beyond the scope of this project.

The site of Dunefield Midden is being studied as part of an ongoing project within the Spatial Archaeology Research Unit at the Department of Archaeology, University of Cape Town. The project is headed by Professor John Parkington. A group of students, including myself, has studied different aspects of the site. As mentioned above, there have been several Honours projects - those by Nilssen (1989) and Henshilwood (1990), as well as my own (Vermeulen 1990), have had the most direct influence on this thesis. This part of the analysis is therefore presented within the framework of the other areas of analysis being carried out. As such, and also because excavation of the site is not concluded, it can not be complete and suggestions for further work occur frequently throughout this thesis. Much of the work has been accompanied by discussions with other members of the project team, as is necessary when working on a whole topic. Within this framework, however, the work presented here is my own.

The Area and Sites surrounding Dunefield Midden

The site of Dunefield Midden is situated on the West coast of the Cape Province in South Africa, about 180 km north of Cape Town (see Figures 1a and b). The site itself is at the base of a dune cordon (probably a mid Holocene feature, Miller *et al.* in prep) in a dunefield approximately 600 m from the sea and about two kilometres north of the mouth of the Verlorenvlei and the village of Eland's Bay. The Verlorenvlei is a large body of open water stretching 13,5 km inland with reedbeds and marshland stretching a further 11,5 km inland (Grindley *et al.* 1980 Robertson 1980). The water is brackish with a relatively high salt content, especially in summer when the water level is low and salinity is high due to evaporation. The salinity level of the water has been found to be above the maximum allowable limit for domestic use in South Africa for most of the year, at times reaching a level not recommended for any use by people or livestock (Robertson 1980). The area is a winter rainfall area and generally very arid, especially in summer. Mean annual rainfall measured at the nearest station is 275,7 mm (Lane 1980:57).

The dunefield in which the site is situated is characterised by white dunes of aeolian sand covering a yellow/brown sand base with a high pebble content. This latter is water lain. The site itself is situated on this surface and has been covered by the aeolian sand. The yellow/brown sand therefore formed the lower limit of the excavation, although some areas were excavated deeper in order to check that no deposit had moved down to a lower level. In all areas of the site there appears to be only one stratigraphic level represented, interpreted as the level of the occupation.

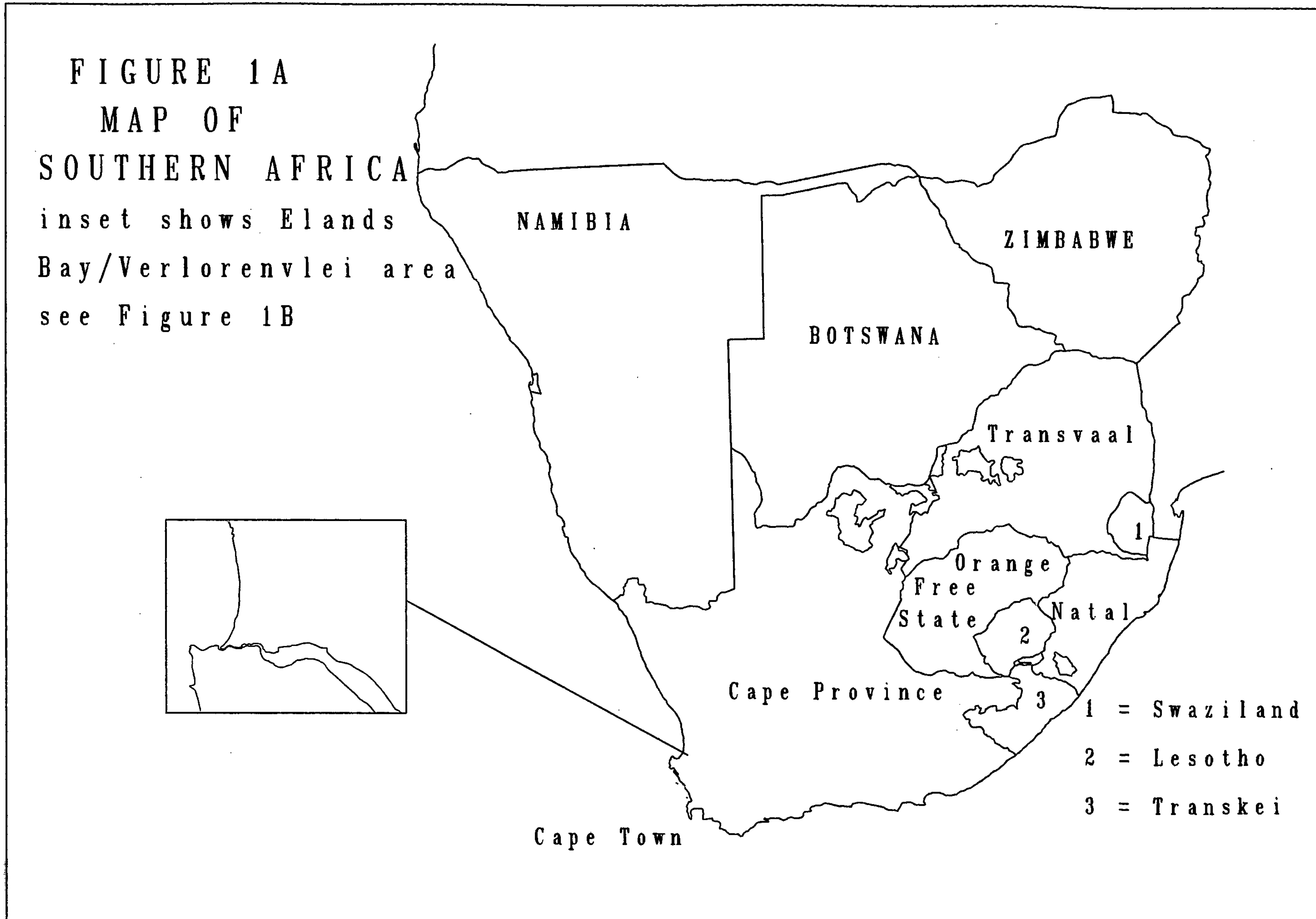


FIGURE 1A
MAP OF
SOUTHERN AFRICA
inset shows Elands
Bay/Verlorenvlei area
see Figure 1B
NAMIBIA
ZIMBABWE
BOTSWANA
Transvaal
Orange
Free
State
Natal
Cape Province
Cape Town
1
2
3
1 = Swaziland
2 = Lesotho
3 = Transkei

6 X 9

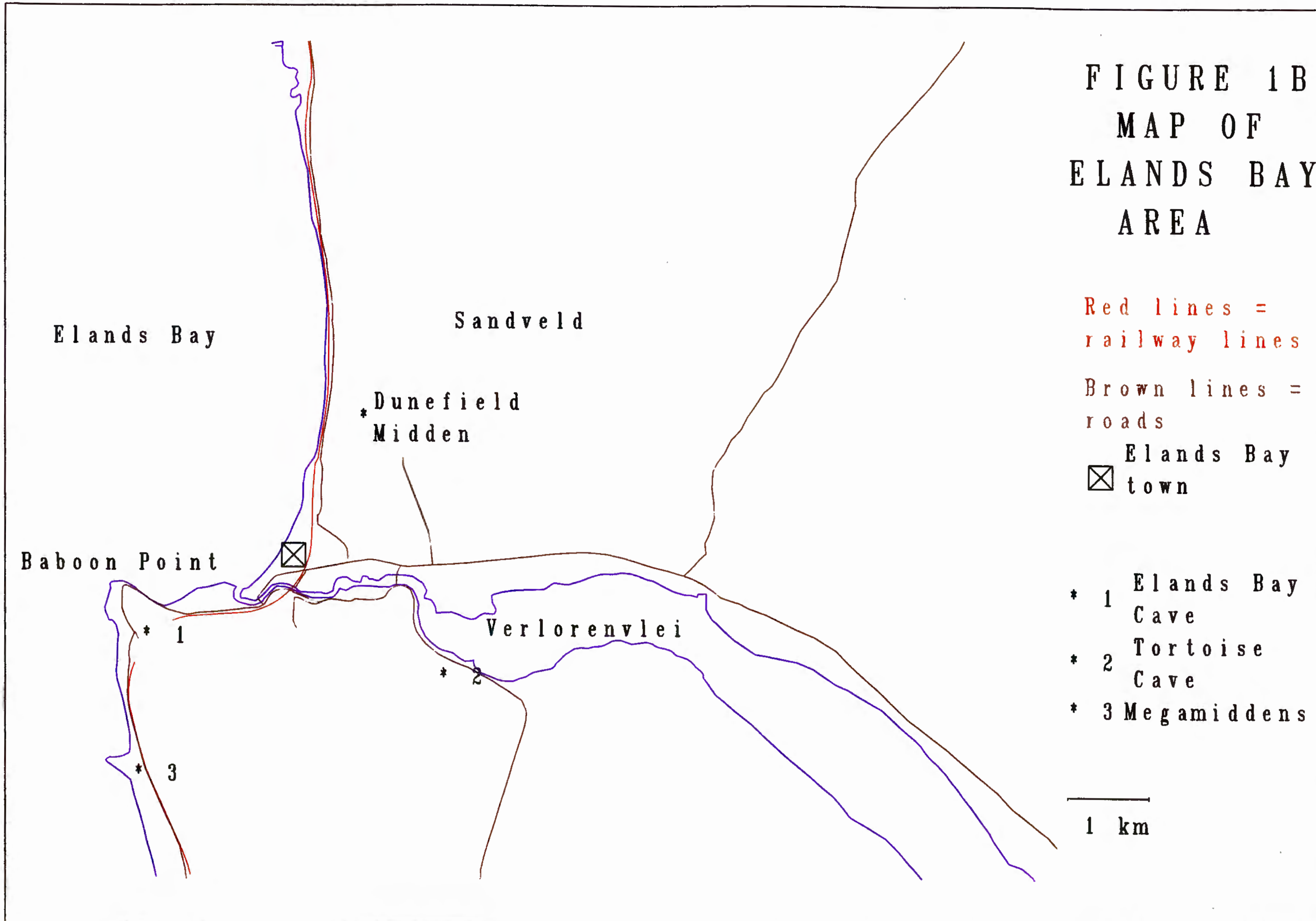


FIGURE 1B
MAP OF
ELANDS BAY
AREA
Red lines = railway lines
Brown lines = roads
Elands Bay town
* 1 Elands Bay Cave
* 2 Tortoise Cave
* 3 Megamiddens
1 km
Elands Bay
Sandveld
Dunefield Midden
Baboon Point
Verlorenvlei
1
2
3

The dunes are presently covered by an exotic Australian wattle species (*Acacia longifolia*), although aerial photographs taken about 20 years ago indicate that at that time the area was free of any vegetation. The vegetation of the general area is known as Strandveld (Grindley *et al.* 1980). It is debated by botanists whether this vegetation can be classed as Fynbos or not (Moll and Jarman 1984a 1984b). The Strandveld vegetation comprises "chiefly broadleaved sclerophyllous woody shrubs" (Lane 1980:60). This vegetation is able to withstand the arid conditions of the area. The region is known as Sandveld, which is generally used as a topographical term, although sometimes applied to the vegetation as well. 'Sandveld' refers to the dunes of soft sand, the general lack of fresh water and presence of vegetation adapted to these conditions, as such it is also applied to other areas, especially to the north and evokes a similar setting to that described here (Bartram *et al.* 1991). There is a general lack of fresh water in the Eland's Bay area, although there is fresh water fairly close to the surface in the dunefield and this is felt to be the reason for the amount of occupation hinted at by the number of sites in the immediate area of Dunefield Midden (Parkington *et al.* 1992). Fresh water from three boreholes in the dunefield area supports the approximately 1000 inhabitants of Eland's Bay village (Robertson 1980).

The area to the south of the Verlorenvlei contains many outcrops of shale and quartzite of Table Mountain Sandstone or conglomerates of the Klipheuwel series (Lane 1980:55). Several sites are situated in these outcrops, such as Eland's Bay Cave, Tortoise Cave and Diepkloof. The Verlorenvlei flows into the southern part of the Eland's Bay. The bay is bounded on the east by a long sandy beach, extending about 12 kilometres north. South and west of the vlei mouth there is a rocky shore leading up to a high point, known as Baboon Point, in which the site of Eland's Bay Cave is situated. South of this point there is approximately 2 kilometres of beach before another, smaller rocky stretch of shore known as Mussel Point. This area is characterised by large shell middens known as the Megamiddens. These middens are one to two metres in depth and cover areas of several thousand square metres and are almost exclusively formed of the shells of the mussel *Choromytilus meridionalis* and charcoal with very few stone tools or bones. South of Mussel Point the next protrusion of rock into the sea is 50 km away (Parkington *et al.* 1988).

It is therefore most likely that the shellfish found at Dunefield Midden were collected on the rocks between Baboon Point and the mouth of the Verlorenvlei. Limpet species of the genus *Patella* are recorded as being very common here, as are black mussel (*Choromytilus meridionalis*) (Branch 1974b Parkington 1976 Parkington *et al.* 1988). These shellfish are also the dominant species at the site. Other marine resources such as seals and lobsters could have been obtained either at the rocks or along the beach. The Strandveld vegetation is home to small bovids, tortoises and, historically, eland (Skead 1980), which are other important species represented in the faunal assemblage from the site.

There have been excavations in this area for about twenty years. Eland's Bay Cave, situated at Baboon Point facing north west towards the sea, was excavated in the 1970s. There was one season of excavation in 1970, another in 1972, two in 1976 and one in 1978 (Parkington 1976 1980). It contains stratified deposit intermittently covering a period from the late Pleistocene (over 40 000 B.P.) to the last two thousand years (Klein and Cruz-Uribe 1987 Poggenpoel 1987). The upper levels of the site are shell midden. Only the topmost level can provide any comparison with Dunefield Midden in terms of date. However, the use of a 3 mm sieve at this site limits these comparisons. Furthermore, this is a cave site containing stratified deposit and therefore does not possess fine spatial resolution within specific levels. Spatial patterning is indicated on a larger scale by the positioning of bedding towards the back of the cave and hearths towards the front. However, smaller scale patterning is not so readily apparent (Parkington pers. comm.)

The site of Eland's Bay Open is situated immediately below Eland's Bay Cave, at the base of the cliff face. It is a small midden (covering approximately 20 m^2) lying against a boulder formation. It contains four levels, one of which is similar in age to Dunefield Midden (Horwitz 1979). However, the deposit is also stratified and a large sieve size (3 mm) was used. These factors are compounded by the problem of the extremely small size of the site with no apparent spatial patterning, making comparison with Dunefield Midden very difficult (Vermeulen 1990).

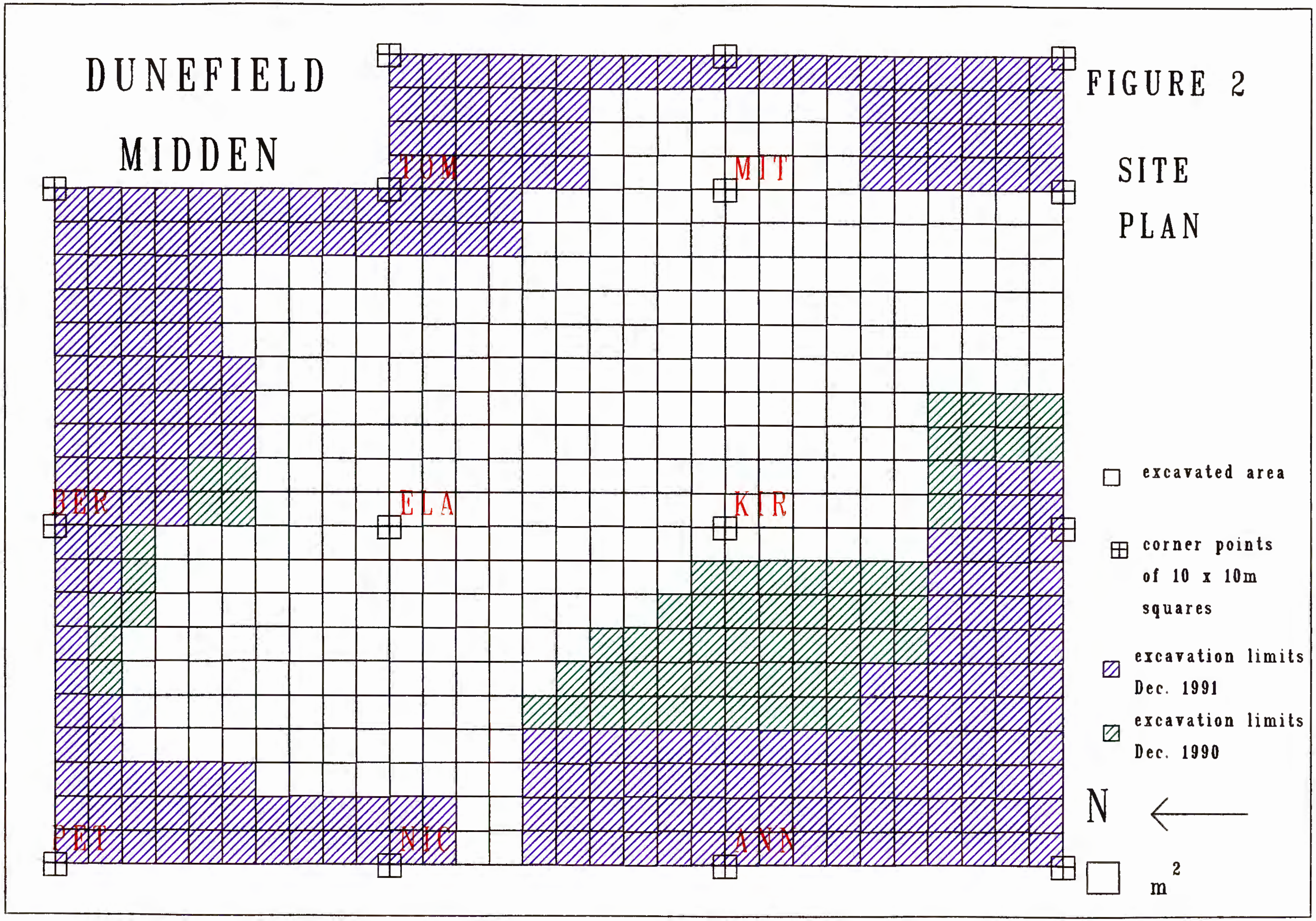
Tortoise Cave lies approximately four kilometres inland on the southern side of the Verlorenvlei. It was excavated between 1978 and 1983 (Robey 1984). There is a shell midden on the talus slope in front of the cave as well as some deposit within the cave itself (Poggenpoel 1987). Deposit from the site is divided into fourteen stratigraphic levels, some of which are subdivided (Klein and Cruz-Uribe 1987). The site dates from about 7700 B.P. to about 760 B.P. The latter is comparable in age to Dunefield Midden, although once again comparison is made difficult because of the stratified nature of the site and the sieve size used in excavation.

These three sites are the closest excavated sites to Dunefield Midden. They would probably have utilised the same resources and show some similarities in age for some occupations. Comparisons are, however, constrained by the factors mentioned above. There have also been analyses of several surface sites, including deflation hollows, in the Sandveld area around Dunefield Midden. Most of the occupation in these sites seems to date to before 1700 B.P. (Manhire 1984) and is represented mainly by stone tool assemblages with a lack of any other kind of deposit evident on the surface. Spatial analysis is not applicable to most of the deflation hollow sites which are very eroded and represent artefacts deflated together from the immediate area. These sites, therefore, are also limited in their comparisons to Dunefield Midden.

Dunefield Midden

The site of Dunefield Midden is currently under excavation. A total of 506 m^2 has been excavated. 63 m^2 of this total are excluded from this analysis, lying to the south of the area studied here. Radiocarbon dates suggest that they form part of other occupations, possibly partly overlapping. As the boundary between the sites is still unclear a cutoff point was taken where the material seemed to exhibit changes. A total of 335 m^2 is included in this project, as covering the greatest area where most of the material has been analysed. Total weight of shellfish and numbers of stone artefacts and potsherds are available for the full 335 m^2. Weight and sizes of specific shellfish species, weights and numbers of bones of fish, snake, tortoise and lobster are available for 263 m^2. The distribution of ashy features as discussed for most of the project is accurate for 335 m^2, although additional information is provided for the processing fires, mentioned briefly.

The site has been excavated over nine seasons: February, April and June/July 1988, February, April and July 1989, February and December 1990 and December 1991 (see Figure 2). The area of the site is divided into 10 x 10 m squares each given a name comprising three letters. Working from east to west and north to south these are: BER, PET; TOM, ELA, NIC; MIT, KIR, ANN; FRA and SHA. FRA and SHA are excluded from this analysis giving dates of 510 ± 40 B.P. (Pta-4807), 580 B.P. ± 50


DUNEFIELD
MIDDEN
FIGURE 2
SITE
PLAN
TOM
MIT
BER
ELA
KIR
PET
NIC
ANN
excavated area
corner points of 10 x 10m squares
excavation limits Dec. 1991
excavation limits Dec. 1990
N
m 2

(Pta-5061), 790 B.P. ± 40 (Pta-5031) and 900 B.P. (Pta-4801). The rest of the site gives dates of 680 ± 40 B.P. (Pta-5070), 690 ± 40 B.P. (Pta-5011), 680 ± 50 B.P. (Pta-4802), 710 ± 45 B.P. (Pta-4799), 640 ± 40 B.P (Pta-5062), 600 ± 40 B.P. (Pta-5277), 620 ± 50 B.P. (Pta-5276), 650 ± 50 (Pta-5280). When calibrated the first five dates from the site give most likely dates of 672 B.P., 673 B.P., 668 B.P., 670 B.P. and 655 B.P. respectively. These dates are regarded as close enough to support the proposition that they represent a single occupation (Parkington *et al.* 1992). Dates Pta-4801, Pta-5031, Pta-5070 and Pta-5011 were calculated from shell samples, which give consistently older dates. Therefore the dates given here are the shell date minus 450 years, currently regarded as the corrective amount. The original dates are: Pta-4801 - 1350 ± 50 B.P.; Pta-5031 - 1240 ± 40 B.P.; Pta-5070 - 1130 ± 40 B.P. and Pta-5011 - 1140 ± 40 B.P.

The site of Dunefield Midden as discussed in this thesis, refers to the area of the site containing 600 - 700 B.P. dates. The southern areas, containing older and younger dates, and areas of possible overlap between the different sites are excluded from this analysis. Therefore 'the site' or 'Dunefield Midden' as referred to here, excludes the southernmost areas and sites of different dates.

Dunefield Midden is a shell midden representing the campsite of a group of people who inhabited it for a few weeks, perhaps a month, utilizing the resources of the coast and Sandveld (Parkington *et al.* 1992). They left behind them various materials in certain places at the site when they finally abandoned it. This material was the concrete result of a series of behaviours, including the processing and disposal of food and other refuse and the manufacture, use and discard of certain cultural items. Both the nature and the patterning of this material gives clues as to these behaviours, an understanding of which is the purpose of this project. It is possible that some of the items left at the site may have been stored with the intention of being recovered when or if the group returned to that area. If this was the case then these items were never reclaimed.

A 1.5 mm sieve was used during excavation in order to retain as much of the very small material as possible. Some of the quartz chips and ostrich eggshell beads from the site are extremely tiny and as wide a range of material as possible needed to be retained for analysis.

Food Remains

Plant Remains

Plant remains, if any were utilized, have not been preserved apart from charcoal and a very few burnt seeds. Nor is there any evidence for other organic items such as wood or leather. As a consequence of this, perhaps, there is no evidence of structures. Any structures would presumably have been shelters such as windbreaks (cf Yellen 1977 O'Connell 1987 Bartram *et al.* 1991) or mat houses (matjeshuise) (Parkington and Mills 1991). There is no source of large stones in the immediate area of the site with which stone dwellings could have been built.

Fauna

The bones of several animals are found at the site. The bones have been analysed by Parkington and Nilssen. Richard Klein has independently analysed the fauna as well. The most significant of the larger animals are eland (*Taurotragus oryx*), seal (*Arctocephalus pusillus*) and steenbok (*Raphicerus campestris*) (see Table 1). As mentioned above these are being studied by Nilssen and will therefore not fall within the scope of this project. Seal bones are the most abundant faunal material. Measurements of the mandibles show that all the animals were first or second year individuals, and this measurement of size suggests that occupation at Dunefield Midden was in winter. The season is confirmed from the evidence of dassie mandibles (Woodborne *et al.* in prep.). Much of the seal bone shows evidence of having been chewed and the actions of jackals, domestic dogs and brown hyena are suspected. Bovid bones, both of large and small animals seem to have been processed for marrow (Parkington *et al.* 1992).

Smaller faunal remains are also found at the site. These include the bones of birds, fish, snake and tortoise, as well as the mandibles of rock lobsters (*Jasus lalandii*). It is not entirely certain whether all of these items have a human origin on the site, but they are found in association with other material. Shellfish form a major component of the faunal remains and will be discussed below.

Table 1

List of Fauna
NISP (Number of Individual Specimens) for Dunefield Midden site (excluding areas with older and younger dates)
(table based on information from R. Klein)

Animal	NISP
Hare (Lepus sp.)	16
Molerat (Bathyergus suillus)	44
Jackal or Dog (Canis sp.)	15
Honey Badger (Mellivora capensis)	1
Genet (Genetta sp.)	1
Egyptian mongoose (Herpestes ichneumon)	0
Grey mongoose (Galerella pulverulenta)	5
Wildcat (Felis libyca)	16
Caracal (Felis caracal)	1
Fur Seal (Arctocephalus pusillus)	1444
Rock Hyrax (Procavia capensis)	26
Eland (Taurotragus oryx)	13
Steenbok (Raphicerus campestris)	6
Grysbok (Raphicerus melanotis)	0
Steenbok & Grysbok (Raphicerus spp.)	190
Sheep (Ovis aries)	4
Small-medium bovid (sheep &/or grey duiker)	8
Large-medium bovid (hartebeest)	11
Large bovid (eland and possibly cattle)	34

Shellfish

The main species represented from the site are four species of limpet (*Patella granatina*, *Patella granularis*, *Patella argenvillei* and *Patella barbara*), and one species of mussel (*Choromytilus meridionalis*). There are also whelks (*Burnapena* spp.) and barnacles (*Balanus* spp. and *Austromegabalanus maxillaris*). Other species, such as *Patella miniata*, *Patella compressa*, *Oxystele* and *Crepidula*, make up a tiny proportion of the whole.

Table 2 illustrates the weights and numbers of the main species occurring at Dunefield Midden. Not all shellfish recovered from the site have been analysed, nor is the excavation of the site complete. This discussion therefore refers to a sample of over 200 m^2. The shellfish indices given elsewhere, calculated on total weight, include approximate values of total weight for squares not included here. The shell weights are given in grams. It can be seen from the table that there is a total of 450,6 kg of analysed shell from this site.

The second column of Table 2 indicates percentage of total weight for each species. It can clearly be seen that there are three species that together account for about 81% of the total weight of shell. These are *Patella granatina*, *Patella granularis* and *Choromytilus meridionalis*. The two limpet species also account for almost 95% of the total number of limpets from the site. It can therefore be argued that these three species constituted the most important part of the shellfish contribution to the diet of the occupants of this site. These species will therefore be a point of focus during the course of this analysis. In contrast, species other than the main species of limpets, mussels, whelk and barnacle illustrated in Table 2 account for less than 2% of the total sample. Their relative unimportance in the make-up of the site therefore leads them to constitute a minor part of this study.

Table 2

Dunefield Midden Shellfish

DUNEFIELD MIDDEN SHELLFISH					
SPECIES	SHELL WT (g)	% TOTAL	% OF CATEGORY	NO.	% OF NO.
LIMPETS	**276024**	**61.3**	**100**	**49076**	**100**
Patella granatina	211835	47	76.7	34242	69.8
Patella granularis	47147.5	10.5	17.1	14005	28.5
Patella argenvillei	6247	1.4	2.3	297	0.6
Patella barbara	9202	2	3.3	488	1.0
Other species	1592.5	0.4	0.6	44	0.1
MUSSELS	**107361**	**23.8**	**100**		
Choromytilus meridionalis	107361	23.8	100		
WHELK	**25332**	**5.62**	**100.0**		
BARNACLE	**33556**	**7.45**	**100.0**		
OTHERS	**8332**	**1.85**	**100.0**		
TOTALS:	**450605**	**100**			

It is possible to compare the shellfish sample from Dunefield Midden with the modern population in the area. The species of shellfish represented at the site conform well with those present in the South-western Cape today (Branch 1971 1974a 1974b), suggesting that conditions at the time of occupation of the site were not very dissimilar to those prevailing at the current time. It is however possible that the mussel species found at greater depths today is not *Choromytilus meridionalis* but an exotic species, *Mytilus galloprovincialis*, favouring similar conditions which has replaced the *Choromytilus* in the lower part of the intertidal zone (Grant *et al.* 1984 Grant and Cherry 1985 Hockey and van Erkom Schurink 1992). *Mytilus* seems to have made its appearance very quickly along the West Coast and is currently spreading to the east along the southern African coast. Its arrival seems to have been on tankers entering Saldanha Harbour from 1976 onwards and it seems to have become established there by 1979, as well as spreading along the coast. *Mytilus* favours wave-exposed rocky shores, but does not extend down into the subtidal benthic substrata, where *Choromytilus* still predominates (Grant and Cherry 1985 Hockey and van Erkom Schurink 1992). However, *Choromytilus* is also more silt-tolerant than *Mytilus* and therefore it is possible that along the rocky shores near the vlei entrance (a source of silt deposit) at Eland's Bay, *Choromytilus* may still predominate. Unfortunately no positive identification of the mussel species present there has been made.

The presence of *Mytilus* would have a further bearing on the information presented below, because it has been determined that *Mytilus* impacts on *Patella granularis* populations as well. Not only does it compete with the limpet, but it provides a surface for the limpets' reproduction and especially an attachment for younger limpets, known as recruits. Therefore, although it does not change the abundance of this species, the presence of *Mytilus* does change the distribution and size of the limpet population. Where *Mytilus* is present very few limpets larger than 25 mm are found and those that are found are older and are considerably larger than 25 mm in length (Hockey and van Erkom Schurink 1992). Since the mean size of *Patella granularis* at Eland's Bay in 1989 and 1990 was above 25 mm, it may be concluded that *Mytilus* had not dominated the intertidal zone at the time the samples were measured.

Shellfish samples were collected in 1989 and 1990 from the rocky shore between the mouth of the Verlorenvlei and Baboon Point. Transects were made from the beach into deep water at different places along the rocky shore. The transects were one metre wide and varied in length from 40 to 59 m. The numbers of limpets of the two main species found at Dunefield Midden, *Patella granatina* and *Patella granularis*, were counted for each square metre within the transect. The limpets were also measured for length. Mussel coverage was estimated for each square metre and the numbers of specimens of other shellfish species, such as *Oxystele*, *Helcion* and *Burnapena* were recorded. Other information such as amount of exposed rock and presence of algae was also noted.

The mussel coverage was estimated in most cases to be several hundred individuals per square metre. As a result of the lack of positive identification of the mussel species, this information will not be used as a comparison with the Dunefield Midden shellfish. A comparison of the limpets and other shellfish species is, however, possible. The total numbers and percentages of each species is presented in Table 3. The percentages are rounded off and thus do not add up to a full 100%. As can be seen from the table the two limpet species, *Patella granatina* and *Patella granularis* account for 94% of the sample, with *Patella granularis* contributing 67% and *Patella granatina* 27%. These percentages are the inverse of the ones from the Dunefield Midden example (see Table 2). The relatively large sizes of the shellfish, compared to modern

Table 3

Shellfish Transect of Modern Shore

Shellfish species	Number of Indiv.	Percentage of Total
P. granatina	1146	27
P. granularis	2870	67
Burnapena	98	2
Helcion	71	1,6
Oxystele	67	1,5
Barnacle	19	0,4
P.argenvillei	1	0,02
P.barbara	1	0,02
Total	4273	99,54

preferentially choosing larger shellfish, and thus collected more of the larger species, *Patella granatina*.

These percentages may also be compared to those given by Buchanan (1988) for the middens in the Eland's Bay area. The values given for the middens parallel the percentages in the Dunefield Midden sample. Numerically, *Patella granatina* outnumbers *Patella granularis* (64% of the total as against 30% of the total), and a similar situation occurs by weight (*Patella granatina* - 67%; *Patella granularis* - 17%).

The modern distribution of shellfish in terms of species seems very similar to the species represented from archaeological sites. The dominant species are *Patella granatina*, *Patella granularis*, *Patella argenvillei*, *Patella barbara*, *Choromytilus meridionalis*, *Aulacomya ater* and all species of whelk (Branch 1971 1974a 1974b Buchanan 1986 1988). However, the respective numbers of each species as represented in the archaeological sites reveal some differences with the numbers found on the shore. The different quantities of each species may be taken as evidence of collecting strategies used by the occupants of archaeological sites. Most of the species listed above may be collected in the Balanoid zone of the intertidal, that is, between the high and low neap tide marks (Buchanan 1986). It would have been relatively easy for people to have collected these shellfish off the rocks at low tide, when they would have been uncovered due to lower water level.

Some species extend into the subtidal zone, leading to suggestions that people may have been utilising the resources of shellfish washed up onto the beach after stormy weather. This behaviour has been observed in Australia in modern times (Meehan

1982). It is possible that size differences within a species such as *Choromytilus meridionalis*, which occurs in both the intertidal and subtidal zones, may help to reveal whether or not this occurred. In addition, the presence of the large barnacle species (*Austromegabalanus maxillaris*) found attached to the backs of mussels from the site, or showing evidence of such attachments, suggests that these mussels may have been washed up onto the beach after storms. This issue will be examined further in other sections below.

Cultural Items

There are both stone tools and non-lithic artefacts found at this site. The non-lithic artefacts include ostrich eggshell beads and water bottles, tortoise carapace bowls and potsherds.

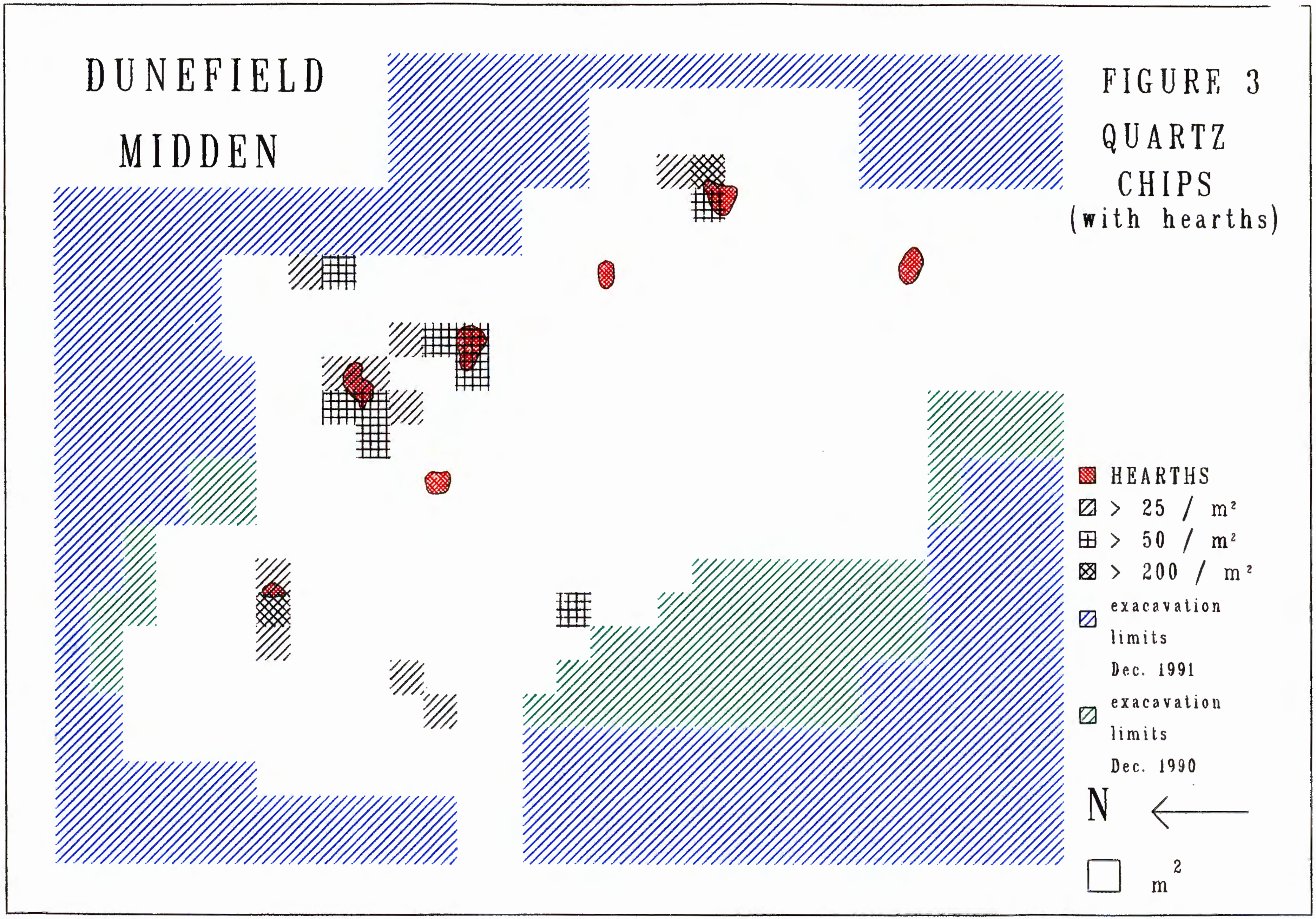
Stone artefacts

The stone artefacts have been analysed as the basis of an Honours project (Vermeulen 1990). In summary, the Dunefield Midden assemblage is a quartz-dominated assemblage with very few formal tools. The formal tools are dominated by backed flakes and bladelets with very few scrapers and no adzes. Comparisons with other sites seem to show many differences between this assemblage and others of similar age and/or geographical location. However, new information about stone tool manufacture has been revealed from the spatial analysis of these artefacts. Four main stone tool manufacturing areas were determined on the site, whilst other areas suggested that some stone artefacts were made for specific tasks and then discarded. These four areas measure about 8 m^2, with a core area of 1 - 3 m^2 (Vermeulen 1990) (see Figure 3).

The bipolar technique (Dickson 1977 Vanderwal 1977) seems to have been used in order to work most of the stone. Bipolar cores, hammerstones and anvils are all found at the site. The tiny slivers of quartz produced as a by-product of this method formed the basis for the designation of stone tool manufacturing areas, since they seem to have remained in the area within which they were produced due to their small size. Stone tool manufacturing areas seem spatially segregated from areas containing other items, although there is some evidence of food remains in the same areas. There is a strong association between hearths and stone artefacts (Vermeulen 1990).

Potsherds

Potsherds are fairly common in some parts of the site. The potsherds were analysed by Nilssen (1989). No complete pots were produced by refitting, so it seems possible that the pottery was not used in a complete form by the inhabitants of the site. There is definite évidence that it was used, because of charred material and staining found on some sherds. The state of preservation of the potsherds is very good, in keeping with most of the material from the rest of the site. Therefore it does not seem that the missing sherds which would go to make whole pots disintegrated through weathering or other forces. It seems likely that broken but usable pieces of pottery made by other people were picked up and used by the inhabitants of the site. The lack of complete pots is regarded as support for the idea that the inhabitants of the site were


DUNEFIELD
MIDDEN
FIGURE 3
QUARTZ
CHIPS
(with hearths)
HEARTHS
> 25 / m²
> 50 / m²
> 200 / m²
exacavation
limits
Dec. 1991
exacavation
limits
Dec. 1990
N
m²

hunter-gatherers and not the pastoralists also present in the region at the time that the site was occupied (Nilssen 1989).

The pottery consists of remnants of pots with necks and shoulders but no spouts and conoid bases. This description is characteristic of much of the pottery found along the West coast, labelled 'Strandloper' pottery (Rudner 1968). It ranges in colour from creamy to salmon and light grey, as well as black, red or brown and grey. Temper ranges from no or slight temper, through medium temper to very coarse temper. Some of the sherds are decorated with grooved lines, circular impressions or impressions made by the rocker stamp method (Nilssen 1989). The large range of variation found at the site seems to support the argument that people were opportunistically using pieces of pot, rather than making their own.

A further piece of evidence for this argument is the presence of marks on two of the refitted sherds, which indicated that pot fragments were being used as scrapers (Parkington *et al.* 1992). The use of the fragments as tools strongly supports the suggestion that complete pots were not being used as storage containers. There is historical evidence from Cape Town that ceramic sherds have been used as scrapers (Hart pers. comm.) and this evidence pushes the behaviour even further back in time.

Ostrich eggshell

Ostrich eggshell is present at the site, both in the form of beads and fragments of eggs which probably were used as water bottles. Some of the fragments reveal that holes were cut into one end of the egg, which is a characteristic of the water bottles used even today in the Kalahari. Ostrich eggshell fragments have been refitted. The refitting of these items shows links between hearths and within the dump, as well as between the hearths and the dump. There are no refits between the northern site and the two southern sites, which gave different dates. The fact that no pieces refit between the sites provides further evidence for the assumption that all the material in the northern site with similar dates relates to a single occupation. The tangle of refitting pieces from the northern site provides an edge to the spread of material. The relative coherency of these refits may be regarded as good evidence for the site representing a single occupation.

Tortoise carapace bowls

Tortoise carapaces seem to have been used as bowls as the edges have been ground to form a rim around the bowl-shaped cavity.

Features

Features on the site include hearths and other concentrations of ash, as well as concentrations of food remains and other items, interpreted as refuse dumps. The features will be discussed in separate sections below.

Taphonomy

Any analysis of an archaeological site must take taphonomic factors into account. The determination of both the type of site represented here and the number of people that may have occupied it are necessarily influenced by the taphonomy of the site. The post - depositional disturbance at Dunefield Midden seems to have been minimal. It seems likely from the position of the site within the sand horizons that the site began to be covered over by aeolian sands fairly soon after it had been abandoned. The relatively rapid covering of the site with sand was probably influenced by its situation at the base of the dune cordon, from which sand would have blown and drifted down to cover the site. The depth of the occupation horizon within the fringes of the dune cordon lends support to this explanation.

As a result of this fairly rapid covering over of the archaeological horizon, very little of the material seems to have been moved due to weathering, deflation or being washed together. The relatively well - defined boundaries of the features, such as the main dump and subsidiaries, suggests that very little dispersal of material occurred. Some items have probably moved in the vertical dimension, although since there is no further archaeological horizon below the level of the site, this is not regarded as a problem and is easily solved by excavation to an adequate depth.

There seems to have been some burrowing by animals, probably mainly the dune mole rat (*Bathyergus suillus*). Once again, this does not seem to have had a dramatic effect upon the position of items on the site. The cohesiveness of areas containing, for example, concentrations of quartz chips, shows that most of the patterning has not been obscured. The patterning of plotted bones is similarly good (Nilssen pers. comm.).

Some bones show evidence of having been gnawed. It is possible that carnivores have disturbed the arrangements of bones on the site, although the plotted bone suggests otherwise. It may be possible to see where on the site gnawed bones occur. If they are relatively confined to the fringes of the site, it is possible that carnivores such as dogs or jackals may have scavenged bones on the edges of the site, even whilst it was occupied. If this activity was later restricted by the covering of the site with sand, then the patterning of the bones, except perhaps on the very edges may not be substantially disturbed. These issues will be dealt with in more detail by Nilssen.

Preservation of bone, shell, ostrich eggshell, potsherds and of course, stone, is generally very good. There is no evidence, however, of vegetable matter, such as plants, fibres or wood (apart from charcoal and a few burnt seeds), or other organic substances such as leather. There is therefore no direct evidence of structures (such as pieces of windbreak framework) or of a possible vegetable content to the diet (such as burnt corm casings), and the latter is not thought to have been very important. There are also no adzes to suggest that wood working took place. Apart from these exceptions, however, the patterning at Dunefield Midden is very clear. The site appears to have remained a very good representation of how it must have looked when abandoned by its inhabitants. It is therefore possible to interpret this patterning in order to reach an understanding of the behaviours that caused it.

Structure of the Project

Having introduced the site and placed it in its context within the area in which it is situated, the rest of the project will deal with interpretation and analysis. Previous spatial studies will be discussed briefly and the role of statistics and ethnography in these studies, as well as their relevance to this project, will be examined. The distinction between ethnography and ethnoarchaeology will also be made. New methods of analysis will be introduced, most notably Site Indices and the use of a Geographic Information System. The analysis of the site itself will be divided into two main areas. These will be: Features and Behaviour. The analysis is progressive, using the site features and their interpretations made in the first section, as a basis for a discussion of factors such as length of occupation; relevant to a discussion of the site. Some of these factors will be length of occupation and number of inhabitants. Taken together these two sections will form the basis for an interpretation of the behaviour of people at the site, the aim of the analysis. The first area of discussion is an introduction to previous spatial studies.

Approaches to Space

Spatial Theory into the 1980s

The study of space with respect to the way in which it is utilised by people is present in many different disciplines. Many of the techniques employed by these disciplines may be used in archaeology. Some of the techniques, such as those which may be used in geography, for example, rely heavily on statistics, others incorporate social theory. Both kinds of technique have been applied to archaeological studies. As will be seen below, many of the statistical techniques are able to define 'work areas' on a site, whilst techniques relying on interpretation of social behaviour, such as by ethnoarchaeological example, analyse these 'work areas' in order to understand the behaviours that produced them. This latter approach is closer to the idea expressed by researchers in many social disciplines that: "in everyday life and language .... the experience of spatial formations is an intrinsic, if unconscious dimension of the way in which we experience society itself. We read space and anticipate a lifestyle" (Hillier and Hansen 1984). The socially-orientated methods of analysis seek to reach this "unconscious dimension" through the analysis of the patterning on sites.

Spatial archaeological studies have undergone changes. Clarke (1977) made several important definitions of spatial archaeology. He also identified three main foci within spatial archaeology, these were the macro, semi-micro and micro levels of analysis. The micro level was the level of "personal and social space", dominated by "individual and cultural factors" (Clarke 1977:11). The semi-micro level was the level within sites of "communal space", dominated by "social and cultural factors" (Clarke 1977:11). The macro level of analysis was that between sites, dominated by geographic and economic issues (Clarke 1977:11). The emphasis of spatial studies in archaeology through time seems to have descended through these levels defined by Clarke (1977), from the macro through to the micro levels.

Into the 1970s spatial archaeology was mainly concerned with settlement studies, or studies on the macro scale (see for example Hodder and Orton 1976 Foley 1977 Hodder 1977). These studies examined the spatial relationships between settlements and their environments and between settlements in space. They included the use of statistical methods such as regression analysis, in some cases (Hodder and Orton 1976). There were some studies that addressed the micro and semi-micro level of analysis. These early studies were anticipating later developments within the discipline. Amongst these were the studies of occupation floors by Whallon (1973a 1973b 1974), who introduced several important statistical techniques. These techniques included nearest neighbour analysis, which has been widely used.

In the 1980s, with the growth of social archaeology, studies in spatial archaeology became more focussed onto the intrasite or micro and semi-micro levels of analysis (see for example Fletcher 1984 Hivernel and Hodder 1984 Johnson 1984 Kroll and Isaac 1984 Munday 1984 Reid Ferring 1984). This study may be categorised as belonging to the micro and semi-micro levels of analysis. New applications of statistical methods were developed in the 1980s, such as k-means testing (Kintigh and Ammerman 1982) and Unconstrained Clustering (Whallon 1984). In addition, ethnoarchaeological studies were done in order to provide a frame of reference for the detailed level of analysis now performed (for example Binford 1983). The next few sections of this thesis will address the use of both statistical methods and ethnoarchaeological parallels in spatial archaeology, as well as introducing new methods. They will assess the main techniques and will rate their appropriateness to this study. Statistical methods will be discussed first.

Statistical Methods in Spatial Archaeology

A few of the most important statistical tests used in spatial archaeology have been selected for discussion here. These are the k-means test, Unconstrained Clustering, Correspondence Analysis and Presab. In addition the Spatial Autocorrelation test will be introduced. It would be impossible to critically evaluate all of the statistical methods that have been used in spatial archaeology. Blankholm (1991) provides an excellent critique of most of the more widely used techniques. This study will therefore examine the techniques deemed most useful by Blankholm (1991). Methods thought by him to be problematic, such as nearest neighbour analysis, although important historically, will not be addressed here. The k-means test is perhaps the most important test used in spatial archaeology. It has been used widely and also forms the basis of other methods used.

The k-means test and Cluster analysis

The k-means statistical test has been used in conjunction with cluster analysis to examine archaeological sites. Kintigh and Ammerman (1982) produced the first synthesis of this method and applied it to the site of Pincevent. Gregg *et al.* (1991) applied the method to Yellen's Kalahari sites and confirmed his interpretation of the sites. Blankholm (1991) tested it using Binford's Mask site and the Scandinavian site of Barmose I. However, this method seems rather limited in its applicability to some questions in spatial archaeology.

Kintigh and Ammerman (1982) argued that spatial analysis is concerned with searching for patterns in the information available and determining the characteristics of these patterns. Their method comprises plotting objects onto a Cartesian plane representing their positioning in space. In other words objects are given x and y coordinates relating to the way they are distributed on the ground. Clusters are then determined after a calculation of Sum Squared Error (SSE or the sum of the squared distances between each point and the others), by attempting to minimise this number in each case. This procedure is repeated for a number of different clusterings.

First all objects are treated as belonging to one cluster. The SSE is measured. The objects are then divided into two clusters. SSE is again calculated. If the distance between objects in the clusters defined is small (in other words the clustering is good), the SSE will be small. Thus successful clustering attempts are indicated by a small SSE. The process is repeated, analysing each newly defined number of clusters to a maximum number of clusters defined by the researcher or until SSE can no longer be decreased by further clustering. In practice, the number defined by the researcher seems to be the most important limit (cf Blankholm 1991). These calculations are performed by a computer program since they would be tedious to do by hand. The results are then compared to randomly generated results in order to characterise the form of clustering present (i.e. whether or not the results may be described as similar to those generated randomly). Gregg *et al.* (1991) used this program in order to analyse Yellen's sites.

The most significant problem seems to be that the number of clusters to be tested for by the program is determined by the user. This means that a great deal of control is exerted on the final result by the user. Unless the user systematically gives an option of an impossibly large number of clusters (which would tend to obscure finer levels of clustering) the number of final clusters will necessarily very closely approximate the number of clusters the researcher expects to find, since the researcher will have instructed the program to search for the expected result. Thus it is not surprising that Gregg *et al.*'s (1991) results so closely match the visual identification of Yellen, since it is unlikely Yellen would have identified clusters which did not exist. Whilst there may be other uses for it, this method can not be regarded as a way of independently verifying a visual spatial analysis and hence does not adequately test for randomness of results. It becomes rather a parallel method of examining the patterning observed visually. The only possible exception to this is sites where material is so densely distributed that a visual identification of clusters is extremely difficult. Even in this case, the reason for testing for any specific number of clusters should be clearly expressed.

A further problem is that it tends to give clusters an artificially circular nature (Blankholm 1991). If taken to be a real analysis of the spatial distribution of activities this may be very problematic. If based on a grid to begin with this problem may be compounded and the final clusters identified by this method may bear very little resemblance to the actual material on the ground.

Although Blankholm (1991) judged this method extremely favourably, it may be argued that it suited only the kinds of questions that he was asking of it. The nature of the questions asked by Blankholm (1991) was mainly that given items distributed across space, what areas contained concentrations of these items and in what proportions? Whilst this is a perfectly valid form of questioning, it does tend to remain on a fairly simplistic level, merely identifying the different areas where items were present. It therefore, as suggested before, has most use on the level of identification. It may be argued that on sites such as Dunefield Midden such an analysis of all material would produce a very unclear result, the most likely conclusion being that most of the site consists of "activity areas". Such a result would ignore the processes of discard behaviour as reported in the ethnoarchaeological record. Although k-means is indeed a method that can be applied to single-class distributions (unlike all other methods preferred by Blankholm (1991)), it is felt that it does not possess the fine resolution of events in cognisance of behavioural factors that a more ethnoarchaeologically informed approach would achieve.

Other Clustering Methods

There are several other statistical methods used in spatial archaeology. Blankholm (1991) provides a fairly good critique of many of these methods. However, as stated above it is felt that even those methods judged to be very helpful by him do not have much to add in a study such as this one. The other methods stated by Blankholm (1991) to be the most useful all analyse multiclass distributions. As stated above, it is felt that the application of such methods to Dunefield Midden would obscure more than they would reveal.

This is particularly true of the 'Presab' method outlined by Blankholm (1991). This method can be used on either coordinate or grid-based information. At the site of Dunefield Midden most of the information would have to be analysed according to the grid-based system as coordinates are not available for most of the material, excluding bones. Using the grid-based system, the number of items of each category within each square or 'grid-cell' containing material is counted. Within each category the presence or absence of material is marked by giving a zero for no occurrence and a one for a positive result (Blankholm 1991). Since Dunefield Midden covers such a large area with such a large amount of recovered material, this site would produce a result of presence of material in most categories in most areas of the site and patterning would tend to be obscured. Even with low counts excluded the site would tend to produce a result which would not be as meaningful as one taking density of material into account. It would therefore seem that this method is more suited to sites with a paucity of material, such as Barmose I. Nevertheless, a method similar to this is used in this study for specific questions, such as in order to attempt to identify relatively empty areas on the site, or areas with very low numbers of items within them. In such a case it is only necessary to note the presence or absence of material and the absences become the foci of analysis.

Methods such as Unconstrained Clustering or Correspondence Analysis would give a slightly more meaningful result than Presab since these methods do include density in the analysis (Blankholm 1991). The Unconstrained Clustering method involves the calculation of smoothed density contours as well as local and relative densities over the area (Whallon 1984 Blankholm 1991). These densities are submitted to cluster analysis by any of several methods, including k-means (Blankholm 1991), although Whallon (1984) preferred Ward's method. The clusters produced are analysed visually for their potential for interpretation and clusters may be grouped according to criteria (Blankholm 1991). Correspondence Analysis, also known as Reciprocal Averaging (Gauch 1982), Reciprocal Ordering (Orlóci 1975) or Dual Scaling (Nishisato 1980), is a method of cluster analysis which may be applied in Unconstrained Clustering, for example. Variables are arranged in a matrix to which is applied an appropriate algorithm. There may, however, be mathematical effects which distort the results and the presence of very large or very small values can skew the results (Blankholm 1991). Therefore, it would seem that this method must be used with care.

These methods suffer from the problem mentioned above in that they only go as far as identifying areas where activities took place and do not include an in depth analysis of these areas. Blankholm (1991) does not address the level of interpretation of the patterning. Since this project is concerned with the latter level of analysis, it seems more useful to start from a behaviourally informed identification of potentially interesting areas. Furthermore, it has been argued that "spatial patterns must be described and analysed in their own terms prior to any assumption of a determinative subservience to other variables" (Hillier and Hansen 1984:5). It would therefore seem necessary not to allow the statistics to become deterministic, but rather to limit their influence on the patterning if this seems to be the case. It would seem preferable to apply statistics in a more secondary role, where they merely add to a behaviourally informed analysis, or to use them as suggested above in order to reveal patterning, which can then be interpreted using other methods.

Spatial Autocorrelation

Spatial Autocorrelation seems a far better method by which to analyse the randomness of spatial patterns from archaeological sites since it compares these patterns to an independent determinant of randomness. Autocorrelation refers to the relationship between successive values along a regression line. Strong autocorrelation means that the values are strongly related, that is "they vary in a systematic way" (Ebdon 1977:128). Therefore spatial autocorrelation extends autocorrelation into two dimensions (Ebdon 1977). The technique was developed in geography for examining patterns on maps. It involves relatively simple calculations. However, it also requires a very tedious counting in order to obtain the numbers required for the calculations.

The value of a test for randomness itself must be assessed, since statistical significance need not be a measure of human behaviour. Nevertheless such a test can be useful as a determinant of which patterning to investigate for behavioural aspects in a site such as Dunefield Midden where many different combinations of information are possible. It is also useful to determine whether patterning that can be identified visually has any statistical significance, although the "significance" of statistical significance must also be ascertained.

Statistical significance is defined by Ebdon (1977:2) as "the probability that, again under specified conditions, inferences made on the basis of samples are valid". Used in this way the term has more value. It implies that the experimental method used is valid with respect to the samples chosen. It does not therefore claim importance for conclusions reached from analysis of the samples, merely that the method of analysis was experimentally correct with respect to statistical procedures. Therefore getting a statistically significant result implies that the result is legitimate with respect to the sample, but does not rate the value of the result within the context of the research. The result must be valued according to its contribution to the research. In the context of this study the evaluation could be made with respect to what it reveals about human behaviour.

Spatial Autocorrelation provides an independent measure of statistical significance. As such it need not affect the interpretation as directly as some of the methods discussed above. This is an example of statistics used in a more secondary role. There are several methods of spatial autocorrelation which are discussed in Appendix A. Briefly the technique involves the examination of joins between areas in order to determine whether areas with characteristics defined by the researcher are randomly distributed or not. The simplest method involves a correlation between areas with the characteristics and areas without. More complex methods are available which take density of material into account.

The technique of spatial autocorrelation is applied to distributions whose characteristics are defined within the context of the particular research question. The distributions are therefore based on ethnographically informed or other experimental questions. In most cases these distributions are visually distinguishable and the statistical method is provided as a further dimension. This method is felt to be very useful within the context of this study and is used to evaluate distributions in many sections below.

Geographical Information Systems

GIS or Geographical Information Systems are introduced in this section. They are offered as a new method for assisting spatial analysis. They reflect an addition to spatial studies which is not as strictly methodological as the use of various statistical methods or ethnoarchaeological parallels. Any method may be used in conjunction with a GIS, which is more a tool to aid research. The GIS effectively plays the role of pen and paper in most cases, although its influence is more subtle, and it is not such a neutral tool, as will be discussed below. Nevertheless, it is felt that these systems can be very helpful in spatial archaeology.

GIS are relatively recent tools in archaeological research. The first symposium addressing the topic of their application in archaeology seems to have been the 1989 Archaeological Congress GIS symposium (Allen, Green and Zubrow 1990), although papers and posters addressing GIS-related issues have been presented since the mid-1980s in the United States (Harris and Lock 1990). GIS packages are sets of computer programs specifically designed for analysing spatial information. Their applications to archaeology should therefore be readily apparent, but as an illustration they have been used for extrapolating Cultural Resources Management archaeological surveys in Midwest America (Warren 1990), Montana, USA (Carmichael 1990) and Fort Drum, NY, USA (Hasenstab and Resnick 1990); modelling prehistoric demography (Zubrow 1990), early historic trade (Allen 1990) and social groupings (Savage 1990); and settlement archaeological studies in Ireland (Green 1990) and France (Madry and Crumley 1990).

These systems were first utilised in the 1960s, the first operational one being the Canada Geographic Information System (CGIS), followed by others in the United States. The first commercial system was ARC/INFO, marketed throughout the eighties and into the nineties in several versions. However, these systems still have several limitations (for example in the amounts of information they can process) and continue to be updated (Marble 1990). Archaeology has therefore become involved early enough to dictate some of the directions future systems might follow. Computer systems designed specifically for archaeologists which include GIS functions are making their appearance in the United States (Zubrow 1987). GIS are used extensively in the United States, especially in the fields of urban planning and natural resources management (Ripple 1987) and hence their introduction into cultural resources management. Some work has also been done on the global scale by the Jet Propulsion Laboratory in California for NASA and by the United Nations (Ripple 1987).

The definition of a GIS is given in terms of its functions. There are four main functions recognised, namely input, storage/retrieval, manipulation and output (Zubrow 1987 Kvamme 1989). These functions are explained by Marble (1987:3-4) as follows:

"1. A data input subsystem which collects and/or processes spatial data derived from existing maps, remote sensors etc.

2. A data storage and retrieval subsystem which organises the spatial data in a form which permits it to be quickly retrieved by the user for subsequent analysis, as well as permitting rapid and accurate updates and corrections to be made to the spatial database.

3. A data manipulation and analysis subsystem which performs a variety of tasks such as changing the form of the data through user-defined aggregation rules or producing

estimates of parameters and constraints for various space-time optimization or simulation models.

4. A data reporting subsystem which is capable of displaying all or part of the original database as well as manipulated data and the output from spatial models in tabular or map form. The creation of these map displays involves what is called digital or computer cartography."

The system used in this project is the 1990 version of ARC/INFO for P.C.s developed by ESRI. This system contains all the components mentioned above. The input subsystem is a program called ARCEDIT where spatial information can be added or modified. The most common method of adding the information in map form is by using a digitizer. This is an electronic device which converts "data from graphic to machine readable form" (Tomlinson and Boyle 1987). The map is mounted on a digitizing table and is then traced using a mouse-like instrument whose movements are converted into digital measurements of x and y Cartesian coordinates (Dangermond *et al.* 1987). The minimum spacing between digitised points (resolution) is one one-thousandth of an inch, but the ARCEDIT program treats this spacing as unitless thus allowing the users to work in units of their choice.

The program orientates itself relative to the map through the use of tic points. These are added by the user and allow for consistent orientation of all other features. Tic points and all other features can also be added by giving only the x and y coordinates, which leads to greater precision. In this study the tics and basic grid were added in this way, with other features digitized in, in relation to these coordinates. Whilst digitizing, a minimum distance between points (called snap distance) is set in order to improve accuracy and lines that follow curves are smoothed in order to give a consistent result. Map features can be added in the form of points, lines and areas and can then be manipulated and analysed in various ways. Once the maps are entered into the system they are referred to as "coverages". Coverages are the format in which manipulations take place, whilst "map" refers either to the item before it is entered onto the system or to the final product which is plotted.

Data storage and retrieval is the province of the database. In ARC/INFO either INFO or TABLES may be used as databases. TABLES was used in this project. As a database it is similar to, although more limited than, DBASE. Files can be used interchangeably between the two programs. TABLES is a fairly flexible database with column widths of up to sixteen and relatively large numbers of columns possible. Elementary statistics such as mean, can be easily calculated. Files can be read from or written into ASCII, thus allowing transfer between different programs and databases.

Composite maps of various features can be created, as well as restrictive maps illustrating relationships between certain features and/or certain areas, by using the OVERLAY and ARCPLOT programs. OVERLAY creates permanently joined coverages whilst ARCPLOT allows coverages to be viewed in temporary association with each other. Information can also be analysed within the database of the system (TABLES in ARC/INFO) or within the allied DBASE program. NETWORK is another analysis subsystem and is useful for predictive modelling. The output program is ARCPLOT which allows the user to create and print maps in any format either on a plotter or a laser printer. Both 'raster' and 'vector' GIS systems are available. 'Raster' systems produce patterns of horizontal scanning lines analogous to a T.V. picture. They are used especially in three dimensional representations. ARC/INFO on the P.C. deals only in two dimensions and only vector representations are used.

Working with these systems has many advantages, however there are also disadvantages, especially with respect to theory, that must be taken into account. Advantages include ease of working with the information once entered into the database, as well as ease of displaying results obtained. Analysis is in a spatial form and any postulated combination of maps or subset of a map can be created in a visual format very easily. The systems are structured according to the conventions of computer science and can thus be advantageous in forcing the researcher to develop specific questions and to work through the information in a structured manner. A thorough understanding of both the information put into the database and the method used by the computer to analyse this information is essential in obtaining meaningful results. GIS can therefore be said to be a great aid to process-driven analysis where specific hypotheses are developed and tested in a rigorous way. However, it can also take the further step into the post-processual realm by allowing the researcher to 'play' with the information available, viewing it in literally hundreds of different ways and, if structured correctly, allowing patterns inherent within the information to reveal themselves. Harris and Lock (1990:47-48) reflect this in a quote from D.L.Clarke: "the spatial relationship between the artifacts, other artifacts, site features, other sites, landscape elements and environmental aspects present a formidable matrix of alternative individual categorisations and cross-combinations to be searched for information". This kind of searching is what GIS are designed to do.

On the cautionary side there are disadvantages. Zubrow (1990) warns of the problems of using tools developed in another discipline for archaeological analysis. These can be problems of semantics, as well as conceptual ones. Significant within those that he isolates is the problem of the nature of time as viewed by the different disciplines. He states that geographical studies and GIS in particular tend to be synchronically orientated, thus providing possible problems when applied to information which may not be so orientated (however, certain of the subprograms within some GIS, such as

NETWORK in ARC/INFO can allow steps of time to be built into the analysis). There is also the problem of what he terms "fuzzy concepts" (Zubrow 1990:71). This idea is also discussed by Savage (1990), with regard to the reification of boundaries whose definition may not be as clear as demanded by the system. These boundaries then become fixed entities, when in reality they are not as distinct on the landscape (for example, the exact boundaries of a site) (Kvamme 1989).

Zubrow (1990) also warns that an almost atheoretical tool (i.e. designed without specific reference to a theoretical base) may encourage some researchers to ignore theory within their own work. Furthermore, using the constraints around which the system is based will necessarily influence the questions asked by the researcher who should be as aware of this as of any other influence on the research design. The importance of GIS as a tool for research, one of many that can be used and one that should be used with specific problems in mind, must be stressed (cf Zwart 1992).

The analysis of Dunefield Midden fortunately avoids many of the larger pitfalls presented above. The site, by its nature, largely avoids the problem of time for the immediate phase of the analysis, since it reflects a single slice of time with no stratigraphy. The 'site' itself is also not a bounded definition, limited only by 'unexcavated' versus 'excavated' areas. Research design is motivated mainly towards allowing patterns inherent within the spatial information to become apparent, with consequent interpretation of behaviour. A GIS therefore forms a very useful tool for this analysis.

GIS and Cultural Resources Management

GIS are very useful tools in the field of cultural resources management (CRM). Besides allowing an easily accessible library of comprehensive maps indicating known sites and their attributes, they can enable contract workers to extrapolate information to other areas. This can be very useful when planning archaeological surveys.

Maps of the survey area can be prepared in advance, combining maps of such features as soil type, vegetation, hydrology and known sites in the area. If such maps are available in a fairly complete form then this process would only take minutes to do. The survey can then be planned according to the features on the combined map. Furthermore areas can be highlighted on the map according to criteria such as "within 1 km of water", "at an altitude of less than 500 m" and "not lying within a built-up area", for example. The highlighted areas can be used to indicate areas where an intensive survey is felt to be necessary or unnecessary. After (or during) the survey the map can be updated very easily and thus can suggest ways in which survey strategy may be improved, as well as providing a comparison for further surveys, for example in similar areas. These methods are used to great effect in the United States of America where archaeological survey is a viable commercial field (Altschul 1990 Hasenstab and Resnick 1990).

An example in the local context is archaeological survey within the Cape Town metropolitan area. There are many maps available of Cape Town at different periods as well as information pertinent to those periods. There are also records available of which buildings depicted on these maps are still in existence. The Cape Town City Council is amenable to allowing archaeological work to precede construction and/or renovation work within the Cape Town area, on the condition that they are informed of sites of potential interest to archaeologists. A project is therefore planned whereby a database will be created of maps of old Cape Town and information pertaining to both the maps and existing buildings. Once this is complete, maps for the City Council may be prepared which will enable them to call in the archaeologists as soon as a site of potential interest is threatened. This will enable a survey and/or excavation to be planned timeously so that valuable information is not lost through unrealistic time limits on archaeological work. Furthermore, this database can be used to plan surveys, allowing an expectation of what to find on that site, as well as aiding the writing up of survey reports. Information from surveys and excavations conducted will add to the database and create an interactive source of knowledge about the Cape Town metropolitan area of value to both contract workers and researchers.

The use of a GIS in such a way, although requiring a significant amount of input, especially of time, initially, will prove a time and labour-saving exercise. Initial input will require the digitizing of maps and the entry of information into the database (although information already contained on any database system can be imported into GIS by the use of ASCII files). However, once this is done updating or adding to the system is very easy and not significantly time-consuming; this applies to both maps and information. Since updating or changing maps by hand is very slow, this should balance out the time invested in creating the database. Furthermore, any number of copies of maps contained in the GIS can be produced very easily. Thus ultimately time will be saved in many ways and in this way the use of a GIS is very cost-effective.

GIS and Spatial Archaeology

GIS can be used very effectively in all kinds of spatial archaeology from analysis of settlements on a large scale to small scale analysis of site plans. Predictive modelling also plays an important role in allowing dynamic analysis. In this context the researcher is limited purely by the amount of time involved in entering the maps in a form usable to the system and the information relevant to each map into the database. The amount of time required for this is dependent on the nature of the map itself, but is usually fairly significant. However, once the map is entered it can be used indefinitely and combined with other maps in an infinite number of ways. One could combine coverages of vegetation, hydrology and geology with a coverage of the distribution of sites in order to determine which sites are located in Sandveld, within 100 m of fresh water and within 500 m of a rock outcrop, for example. The database program would then be able to tell one all the characteristics of the selected sites. The site characteristics from the database can also be included in the selection criteria.

Predictive modelling can be done by using a program such as ARC/INFO's NETWORK. This program can be used either to determine shortest possible routes between different elements in a map or to determine the flow of resources between various centres. The latter has been used for building models of demography and trade in early New York State (Zubrow 1990 Allen 1990). The use of the NETWORK program is a very exciting aspect of GIS, since it allows the aspect of the passage of time to be built into the analysis. The model literally grows across the screen. An example of the use of this program would be in modelling the spread of an item such as pottery across southern Africa. Sites could be entered into the model according to the date at which pottery appears. The program would then illustrate the spread of this item across a map of southern Africa on the screen. The growth of the

NETWORK model can be watched as the paths are traced across the screen; thus giving a very dynamic view of the process. Different models of spread could be tested for their likelihood in producing the distribution illustrated. This method of analysis could be used with respect to many other aspects of archaeological research as well.

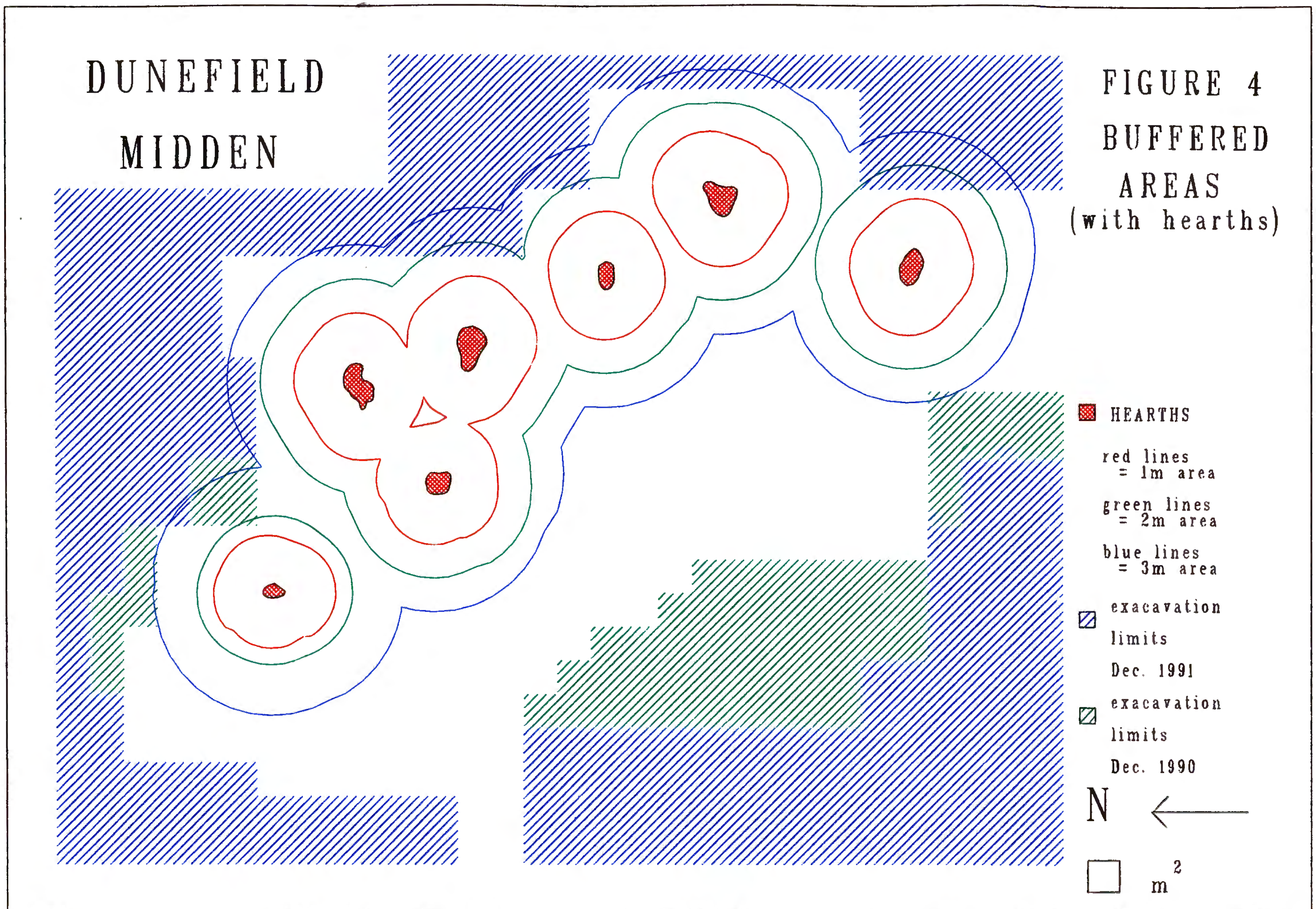
ARC/INFO's program BUFFER is also very useful in spatial analysis. It is used fairly extensively in this project. The BUFFER program calculates the areas within a given distance of specified features. The distance to be buffered from the features is chosen by the user, as are the features to be buffered. Features which may be buffered are any found on a coverage, that is points, lines or polygons. The BUFFER program creates a new coverage containing the polygons formed by the given area around a feature. All results of buffering are polygons, since the area within for example, one metre of a point is a circle of radius one metre, similarly the area within one metre of a line is a polygon and the area within one metre of a polygon is a polygon. The new coverage created by buffering is, of necessity, linked to information in the databases as well as having its own database. As a separate coverage it may be combined with other maps in any form. The BUFFER program is the basic method for determining "areas within 500 m of a river" for example. Other coverages are overlaid with the coverage showing buffered areas in order to determine whether features such as sites, for example, fall within the buffered area or not. A map may be produced of this distribution. The specific application of the BUFFER program to this study is discussed in the next section.

The application of GIS to the study of the Dunefield Midden site is discussed below. The specific method is given to aid an understanding of the use of GIS in a study of this sort.

GIS and Dunefield Midden

A template of the site of Dunefield Midden was digitized using ARC/INFO's ARCEDIT program. Tics were positioned at each corner of the 10 x 10 m squares. The program was allowed to create its own labels for the squares in the grid, the original names of which were entered separately for reference. Further coverages were digitized for tortoise carapace bowl fragments, ostrich eggshell fragments and potsherds. These coverages were then overlaid with the template coverage in order to make them directly comparable. The template coverage was copied and then modified for all additional information such as artefacts and faunal remains. This information was imported into the system from LOTUS 1-2-3 files.

Three separate coverages were created for the ashy features from the site. The coverages contained the same tics as the template coverage but no lines marking the squares. The ashy features were digitized off a map composed from a combination of the plots made of the features during excavation, orientated within their square metres, but were added as distinct polygons. The BUFFER program was run on the coverages containing ashy features in order to produce new coverages showing areas within 1 m, 2 m and 3 m of the features. Those chosen to be buffered were the hearths and roasting pits and certain large ash patches lying within the area of the site containing hearths and roasting pits. The BUFFER program computes the required area from the perimeter of each polygon. It collapses areas that overlap. The buffered area exists as a separate coverage that can be called up independently to those containing ash features, or superimposed upon that coverage (see Figure 4).


DUNEFIELD
MIDDEN
FIGURE 4
BUFFERED
AREAS
(with hearths)
HEARTHS
red lines
= 1m area
green lines
= 2m area
blue lines
= 3m area
exacavation
limits
Dec. 1991
exacavation
limits
Dec. 1990
N
m 2

Maps were produced with ARCPLOT illustrating different combinations of the various coverages which would be useful for analysis. The coverages were also combined with selected ranges of information from the database files to create maps of densities or mark features in the coverages. This ability to combine any information from database files with the map features from the different coverages allows for very powerful analysis potential. Maps can be composed on the screen very quickly using ARCPLOT and any selection of information and/or map features, once called onto the screen, can be deleted and any other set called up almost instantaneously. Once a potentially useful map is obtained it can be printed on the laser printer on A4 paper or plotted on a plotter on almost any size paper. GIS are therefore potentially very powerful and efficient research tools.

Site Indices

The use of site indices represents another method for aiding spatial analysis. It is also a fairly neutral method allowing a relatively simple manipulation of categories of information in order to make them comparable to each other. The aim of creating indices is to provide directly comparable sets of values amongst categories of information which may otherwise prove difficult to compare. For example, the total weight of shellfish per excavated square at the site exceeds 20 kilograms in some cases, whilst the number of snake bones per square in most cases is less than 10. A method is needed, therefore, to make such disparate amounts comparable. It is accepted that the varying quantities of each item is important as an indicator of importance in the diet, for example. Nevertheless, valuable information about which items occur in what densities in what areas of the site may be gained from making them directly comparable. The use of a similar method is reported by Boismier (1991).

The use of the site indices is basically a method of normalisation between different distributions. This method was used in conjunction with the use of a GIS. Distribution maps presented in this thesis, as well as distributions discussed in the text, were created using either the original weights of items, or the site index numbers, as appropriate. The details of this method, as well as an example of how it may be used are presented in Appendix C.

Ethnography and Ethnoarchaeology

The use of ethnographic analogy in archaeology has long been a topic of discussion within the discipline. Orme (1973) traced its use to nineteenth century notions that contemporary "primitive" societies lived a "stone age" existence. This notion is the source of the most common criticism of the use of ethnography in archaeology, namely that it ignores the fact that present small-scale societies are just as removed from archaeological societies in time as industrial ones (Yellen 1977). Another common criticism is that ethnography cannot be used to interpret societies with behaviours no longer present, for example big-game hunting on foot in North America (Gould 1978). Fortunately the latter does not apply to this study, since the hunting and gathering economy represented at the site of Dunefield Midden seems very similar to that practised by San in the Kalahari in the recent past, with the addition of shellfish as a substantial component in the diet. There are also records in southern Africa of shellfish consumption (Bigalke 1973 Bigalke and Voigt 1973 Branch 1975 Voigt 1975 Hockey *et al.* 1988) and therefore the economy of the people who inhabited Dunefield Midden would seem to have modern analogs.

In the late 1960s a more critical approach to the use of ethnography began to gain support. Arguments ranged from a denial of any usefulness in the use of ethnographic analogs, to statements that archaeology and ethnography were unavoidably linked (Chang 1967). Binford (1967) and Freeman (1968) argued that fitting the archaeological information into ethnographic models had no value for the interpretation of archaeological material, because of factors such as those mentioned above. Nevertheless, Orme (1973) argued that using the ethnography to determine generalizations about human behaviour which could provide hypotheses to be tested through an investigation of the archaeological material, had potential value.

The testing of hypotheses made from 'laws' of human behaviour has been argued to be the aim of archaeological investigations by many people. Perhaps the earliest example of this reasoning lies in a the following passage quoted by Orme (1973:490):

> "To be serious, I am really of the opinion that if the study of antiquities, in these parts respecting the origin and first ages of nations, be pursued in this line of experimental inductive theorems, which do not pretend to have found out truth, but are only searching their way to it; learning would become more productive of real knowledge"

Thomas Pownall, 1795

This is an extremely perceptive comment, given the date it was made. It was largely due to reasoning of this sort that ethnoarchaeology came into being. It was felt that ethnography as presented by anthropologists and ethnographers, did not detail human behaviour and its relationship to material culture to the extent that archaeology needed it, if 'laws' were to be made which could be tested against archaeological material. These "many small things" (Chang 1967:230) would have to be recorded by archaeologists themselves. Thus ethnoarchaeological projects were started, both amongst peoples studied by ethnographers and within industrial society (such as the Tucson Garbage Project, Schiffer 1978).

Schiffer (1978) and Gould (1978) both discuss the application of these 'laws' of human behaviour. Schiffer (1978) advocates this technique, using conclusions reached by Yellen (1977) as an example of the correct way of expressing such laws. Gould (1978) takes a more critical approach from a difference in the definitions of 'law' and 'process'. For him a 'law' is: "a stated relationship between two or more observed or operationally stated variables that is invariable in terms of time and space"; whilst a 'process': "posits a relationship between variables but does not lay claim to invariability in time or space" (Gould 1978:251). He favours the use of the latter, arguing that the less uniformitarianist arguments need to be invoked in a comparison, the better. Process-driven interpretations could be used to test whether or not the ethnographic information is applicable to the site under analysis. This is the approach used in this study. The archaeology is therefore being used to test the validity of ethnographically derived hypotheses, rather than being fitted into an ethnographic model. If the ethnographic information is thought to be applicable it can be used as a basis for interpretation.

Gould (1978) further argues that the use of ethnographic comparisons from living societies historically continuous with the inhabitants of the site in the same region has the most value, although comparisons from areas with similar environments, resources and technology are also valuable. For these reasons, it is felt that the ethnoarchaeological information gathered from hunter-gatherer groups in the Kalahari will be most relevant to this study. Information in studies from the rest of Africa and Australia will also be used comparatively.

Many of the dangers of ethnographic analogy can therefore be avoided by critical use in archaeological interpretations. As argued above, as long as the archaeology is used to test the validity of the ethnographically derived assumptions and not the reverse, interpretation is greatly aided by ethnography. The role of ethnoarchaeology is particularly important since these studies are made with a concentration on issues that concern archaeologists, particularly the relationship between human behaviour and material culture. Many ethnoarchaeological studies are a reversal of archaeological studies in that they work from the behaviour, features and items in the present, through to an extrapolation of what would be most likely to remain in the archaeological record (see for example Bartram *et al.* 1991 Fisher and Strickland 1991 Gregg *et al.* 1991). This is particularly useful because the archaeological information from a site can be compared to these results and possible interpretations can be made on the basis of the degree of similarity. Furthermore generalizations can be made on the basis of items that would occur archaeologically and these may be tested against material from the site. This project applies ethnoarchaeological examples in this way in order to aid interpretation.

In recent years there have been several ethnoarchaeological accounts of campsites from a spatial archaeological point of view. This literature should prove very useful because this project is concerned with the spatial analysis of a campsite. An analysis of the literature concerning the spatial analysis of campsites reveals certain common features that may be investigated in a campsite. The analysis of contemporary campsites can lead to an understanding of which features on a campsite would survive in the archaeological record, as well as which features no longer present may be extrapolated from those remaining. A comparison of the features present in an archaeological campsite with those in the ethnoarchaeological campsites can allow the definition of the type of site, an estimate of the length of occupation and number of people present and ultimately an understanding of the behaviours and social relations of the people. The determination of features not visible at the archaeological site is also important to ensure that the unique nature of the site is understood and the ethnoarchaeological information is not used in a deterministic way.

The ethnoarchaeology therefore provides a basis for forming questions to be applied to the study of a site. As mentioned in preceeding sections, it may thus be used as an aid to interpretation, in contrast to the application of statistical clustering techniques, which may be used to define patterning on a site. Ethnoarchaeological comparison is therefore not used as a template for the study of the site, but rather as the way of formulating hypotheses to be tested in the study of the site. In this context, deviation from the ethnoarchaeological examples becomes just as important for the sake of analysis and understanding as do patterns that conform to the ethnoarchaeological example.

An introduction to the points made in the ethnoarchaeological literature with respect to campsites will be made here. There are many details available in the literature on the specific topics mentioned below but these will be discussed within the relevant sections of the analysis. Thus, the details available on hearth positioning, hearth size and hearth spacing will be discussed within the section on "Dunefield Midden: Ash Features", for example. Similarly the information on dumps or structures will be elaborated within the relevant section. The following paragraphs therefore serve as an introduction to the information available.

Fisher and Strickland (1991:219) identify five principal features of Efe campsites in Zaire. These are: 1) the edge or perimeter of the camp; 2) huts; 3) fireplaces; 4) trash heaps and 5) a central open area enclosed by huts (see Figure 5). These five basic features seem common to most ethnoarchaeological campsites, although the 'huts' may in some cases be other shelters or windbreaks, depending on the season and latitude. One further feature can be added to this list and that is the category 'special activity area' (cf Brooks and Yellen 1987). Some activities seem to be regarded as needing their own specific area away from the general campsite area either because of a need for

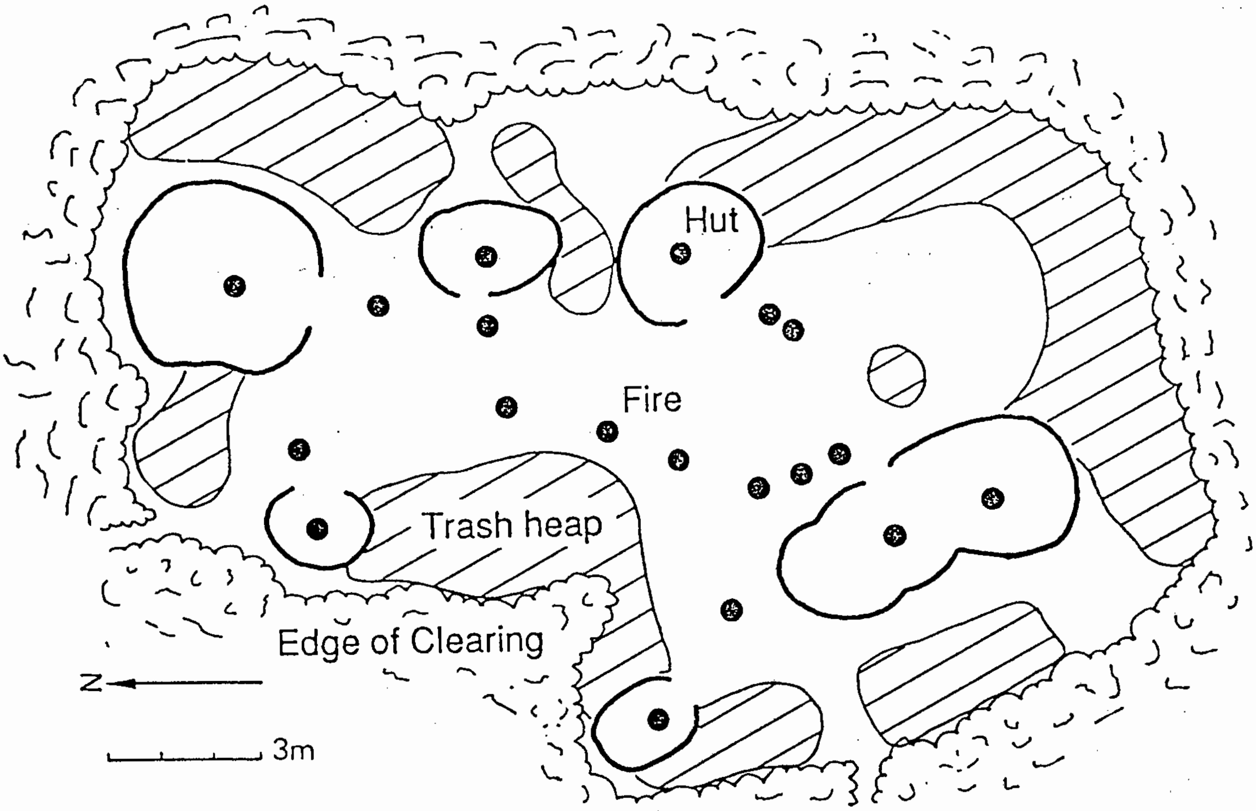


Figure 5 (from Fisher and Strickland 1991) greater space or for hygienic reasons. Examples of this are butchery areas (Binford 1983), bedrock grinding areas or defecation areas (O'Connell *et al.* 1991). However, with this proviso, the general pattern of features mentioned above seems present in campsites ranging from Efe to Hadza in Central Africa (O'Connell *et al.* 1991), !Kung sites in southern Africa (Yellen 1977), Kua (in southern Africa) (Bartram *et al.* 1991) and Australian Aboriginal sites (Gargett and Hayden 1991 Nicholson and Cane 1991). It is also being examined in archaeological campsites such as Peace Point, Canada and Bugas-Holding, USA (Stevenson 1991), and, controversially, Pincevent in France (Binford 1983 Carr 1991 Whitelaw 1991).

All of these features are potentially identifiable in the archaeological record, either by direct evidence or by extrapolation. At Dunefield Midden certain of these features are not evident. Structures, camp perimeter and a possible central open area may be investigated through the presence of 'negative space' (cf Henderson 1990). In other words the lack of items and features can be plotted to give an indication of empty areas either on the edge or in the centre of the site. However, hearths and refuse dumps certainly are present at the site. The latter therefore form the bulk of the following sections. They are presented first, as an interpretation of features which seem similar to those in the ethnoarchaeological record. Those features which do not seem to be present at the site are combined into one section, since there is necessarily less information about them.

The ethnoarchaeological literature also provides a means of determining the possible location of features no longer visible in the archaeological record. Fisher and Strickland (1991:224) give various average distances between hearths in different parts of the campsite and locate features in a very specific way. They illustrate that structures are found near the perimeter of the camp, refuse dumps occur beside and behind structures and within the central open area, the outer edges of these marking the camp perimeter and that almost all structures have interior and exterior hearths and an associated refuse dump. Nicholson and Cane (1991:330 and 340) also give values for distances between hearths and between artefacts and hearths. Hearth spacing is discussed by Gamble (1991) with respect to an overview of the ethnography. Binford (1991) gives various values for household spacing amongst the Nunamiut in Alaska which may be used for comparison. Similarly Gould and Yellen (1987) and O'Connell (1987) give values for household spacing illustrating the differences between !Kung and Western Desert Aborigines.

An examination of all of these features, bearing in mind the issues of settlement size discussed by Fisher and Strickland (1991) and Kent (1991) and layout discussed by Whitelaw (1991), can allow a description of the type of site, and the duration of stay. In other words we may investigate whether it was a residential site or a special purpose site and whether occupation was overnight or continued for days, weeks, months or years. Similarly, an estimation of the average number of people present can be made. Finally the behaviour reflected in the patterning of remains and structures, as well as the influence of social relations on this patterning can be examined. The following sections will examine each of these features at the site Dunefield Midden with reference to the detail contained in the ethnoarchaeological descriptions.

Ash Features

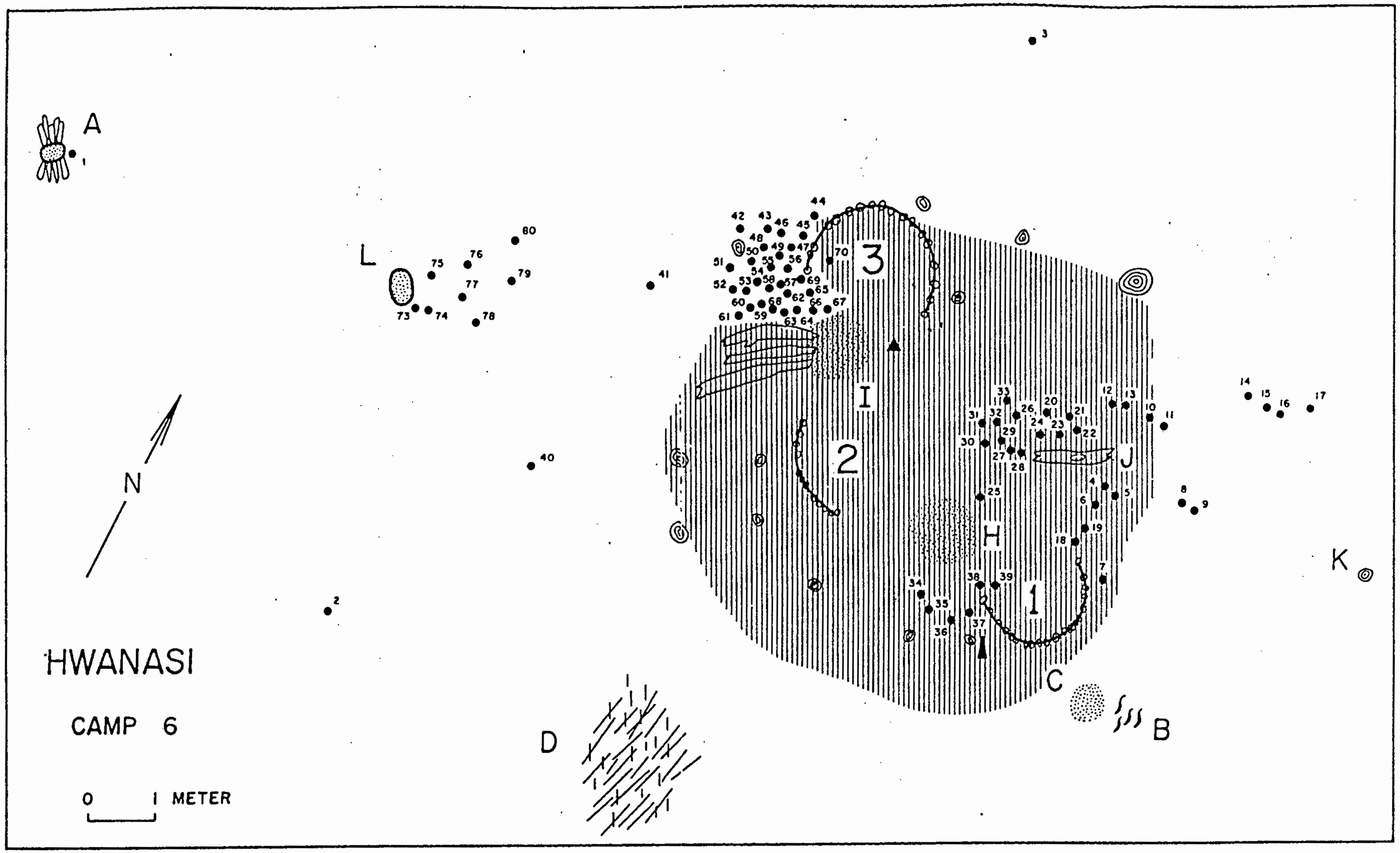
There are several types of ash features present at Dunefield Midden. Differences between these features were noted during excavation and an examination of the field notes allows a division of the features into distinct types. The types of ash features found were assumed to be those described ethnographically from a variety of sources, although peculiarities particular to the specific site were noted and described. This analysis of the field notes is taken to be the most important indicator of the possible function and social meaning of the features described. Nevertheless, other analyses of these features are possible. The areas of the features generated by the GIS software were analysed in order to investigate possible trends in sizes. Spacing of hearths has attracted a fair amount of debate in the ethnographic literature and thus deserves a mention in this analysis. As a further component of the definition of the various types of ash features, the items in direct association with each feature have a direct bearing on the possible function and meaning of the feature. Analysis of this sort begun by Henshilwood (1990), is made easier by the use of GIS and is continued here.

Ethnographic Ash Features

Several ash features may be recognised in the ethnographic literature. Perhaps the most common focal point is the 'domestic hearth'. This feature is described by all researchers looking at campsite layout. These are the hearths around which 'domestic' activities are performed. These activities include food processing and consumption. Tool maintenance and manufacture may be included in these activities, although sometimes these activities are located at a spatially separate location. In general, however, domestic hearths are the focal points for more than one activity and are often reused over relatively long periods of time, perhaps even the entire duration of the occupation. Domestic hearths are most often located at the entrances to shelters or in front of windbreaks (Yellen 1977, Fisher and Strickland 1991, O'Connell *et al.* 1991). They often have associated refuse dumps within a certain distance (Fisher and Strickland 1991). These dumps will contain items associated with the activities performed around the hearth.

Another type of ash feature closely linked to the domestic hearth in terms of the frequency with which it occurs, is the roasting pit. Roasting pits are exclusively associated with food processing and occasionally consumption and are therefore associated primarily with faunal remains, especially of large animals (see Figure 6, from Yellen 1977 Camp Plan 6). Food prepared at the roasting pit may be consumed at the domestic hearth. Roasting pits are often situated towards the fringes of campsites and coals may be specially produced at hearths for these roasting pits (Bartram *et al.* 1991). O'Connell (1987:83) describes roasting pits as oval, basin shaped and 80 - 120 cm long, 30 - 50 cm wide and 20 - 30 cm deep.

Domestic hearths and roasting pits are both in situ features, however some ash features are secondary features. These are described as ash dumps and occur when ash from a hearth is discarded in another location, usually behind the structure (Yellen 1977). The hearth may either just be 'neatened up' in which case relatively small amounts of ash may be gathered up and dumped, or the almost the entire hearth may be dumped (Fisher and Strickland 1991 O'Connell *et al.* 1991).



SITE PLAN: CAMP 6 HWANASI

Figure 6 (from Yellen 1977)

Dunefield Midden Ash Features

Using the ethnographic descriptions as a basis, an examination of the field notes divides the ash features into the following types : domestic hearths, roasting pits, ash dumps and a large in situ ash feature. The last may relate to shellfish processing activities (Parkington and Nilssen pers. comm.). The ash dumps are subdivided into large scatters of ash associated with the main refuse dump in the western part of the site and smaller ash concentrations found in between and behind the hearths, which are predominantly situated in the eastern part of the site.

Domestic hearths were taken to be those ash features containing a concentration of ash and charcoal, surrounded by a spread of this material. The features formed basins in the original surface on which the campsite was situated. Plans and section drawings were made of these features during excavation. All were sampled for charcoal analysis.

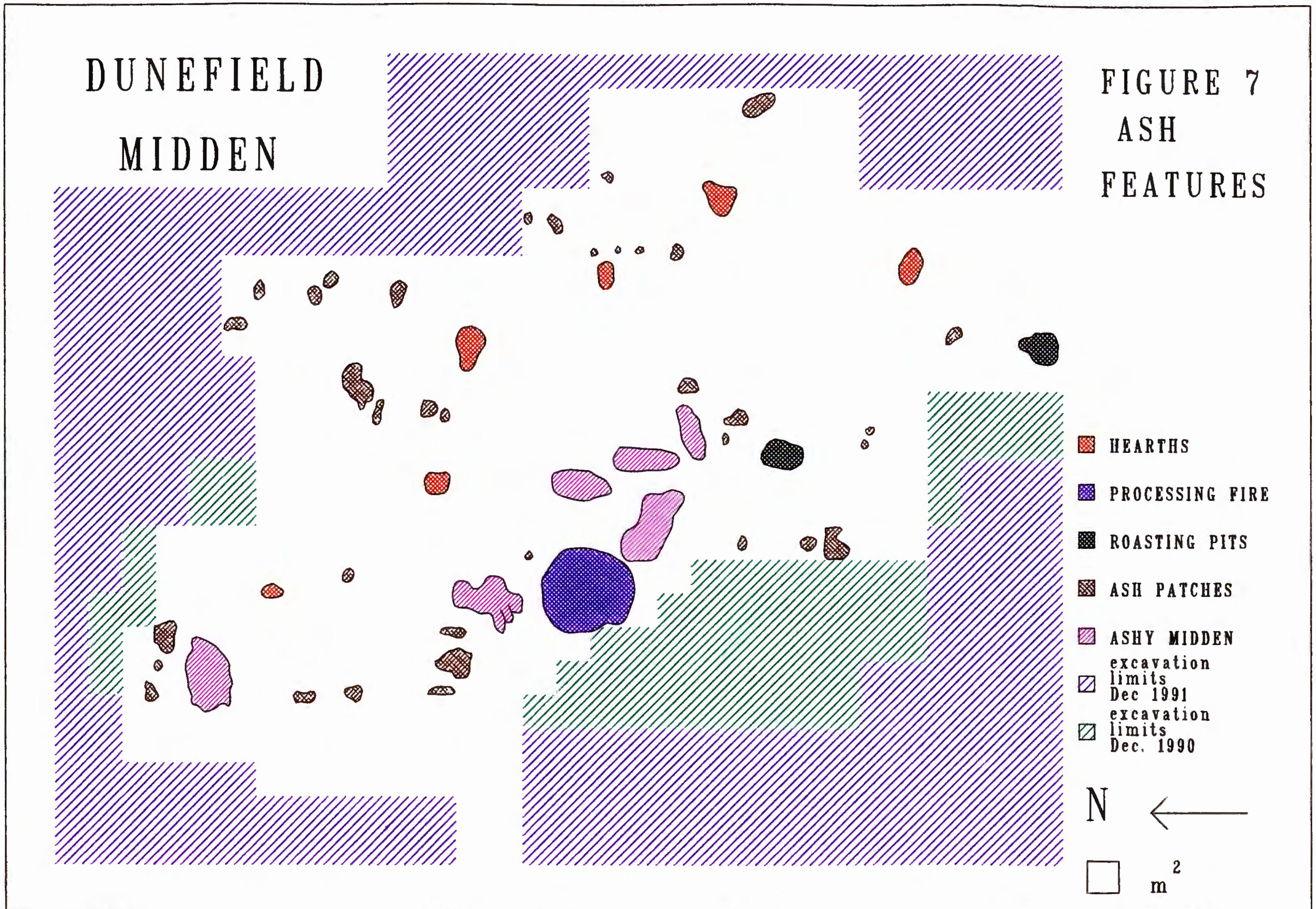
Roasting pits were defined as relatively deep features containing a large concentration of charcoal. They were treated very similarly to hearths during excavation. Very large charcoal samples were taken from these features.

Ash dumps were those scatters of ash and/or charcoal not included in the above two definitions. These tended to be fairly small or diffuse and not set in basins. Section drawings were not made of these features. They included squares within the main dump which contained a large quantity of ash and/or charcoal along with other concentrations of remains.

Large in situ ash features occur on the western end of the site, on the edge of the main dump, one of which is shown in Figure 7. Although similar in size to the larger ash dumps around them, they were clearly in situ and displayed differences to other ash features, having a central core of hardened white ash, surrounded by a large area of ash, charcoal and burnt shell. They are thought to have been used in the processing of shellfish in large numbers.

Areas of Ash Features

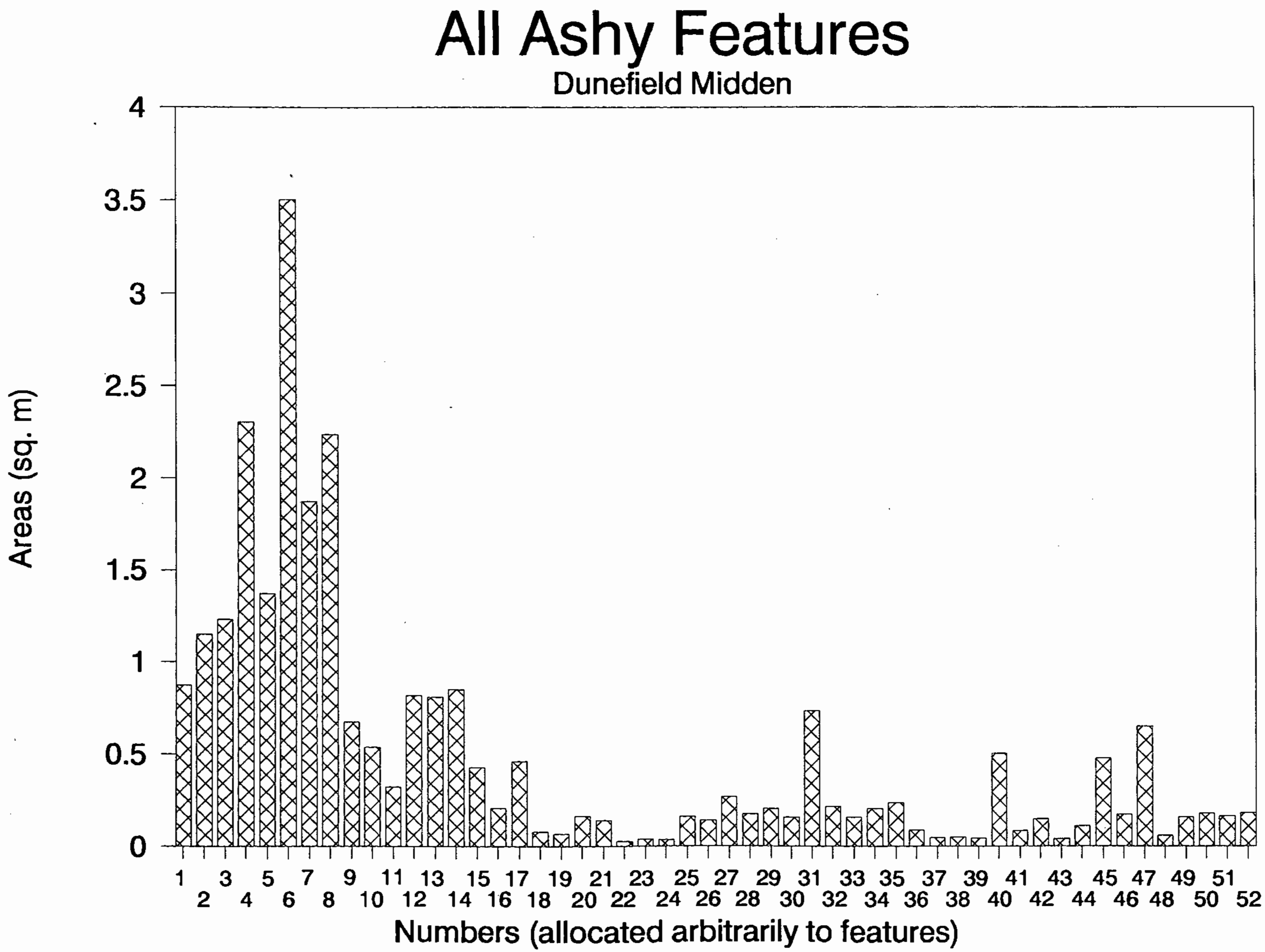
The ash features described above were entered into ARC/INFO as three distinct coverages - one containing hearths and roasting pits; one containing ash dumps associated with the hearths and roasting pits and one containing the ash dumps associated with the main dump, including the large in situ feature. Once coverages have been entered, programs such as CLEAN or BUILD are run to check for errors in digitization and to create database files for the coverages. Part of the creation of these files includes a calculation of the total area and the total perimeter of the polygons entered into the coverages. Due to errors inherent in the plotting of these feature on site and the transference of these plots onto maps prior to their being entered onto the GIS, the diameters of the areas of these features may be regarded as accurate to within 10 cm. In cases where a GIS is used at all stages of the analysis of a site, the transference of maps from one format to another would not be necessary and greater accuracy would be achieved.


DUNEFIELD
MIDDEN
FIGURE 7
ASH
FEATURES
HEARTHS
PROCESSING FIRE
ROASTING PITS
ASH PATCHES
ASHY MIDDEN
excavation limits Dec 1991
excavation limits Dec. 1990
N
m2

The size distribution of ash feature areas is indicated in Figure 8. Areas range from 0,03 m^2 to 3,5 m^2 across the site. General trends within the sizes can be clearly seen. Ash dumps within the main dump range from 0,87 m^2 to 3,5 m^2 (See Figure 9). All except one of these features have an area of greater than 1 m^2. Since the closest geometrical approximation to these features is assumed to be a circle, the approximate diameter of these features can be calculated from the formulae: $r = \sqrt{[A/\pi]}$; $d = 2r$. Therefore all of these features have a diameter of greater than 1m. This can be tested by calculating the perimeter of the assumed circle and comparing it to the actual perimeter. In each case for the ash dumps within the main dump the assumed perimeter was found to be too short by between 0,5 m and 1 m, over 4 to 7 m. This indicates that the circle is a very rough approximation for the actual shape of these features. Nevertheless, it is felt to be adequate for this part of the analysis because, since the assumed circle is calculated on the actual area, the assumed diameter will lie between the minimum and maximum diameters for the feature.

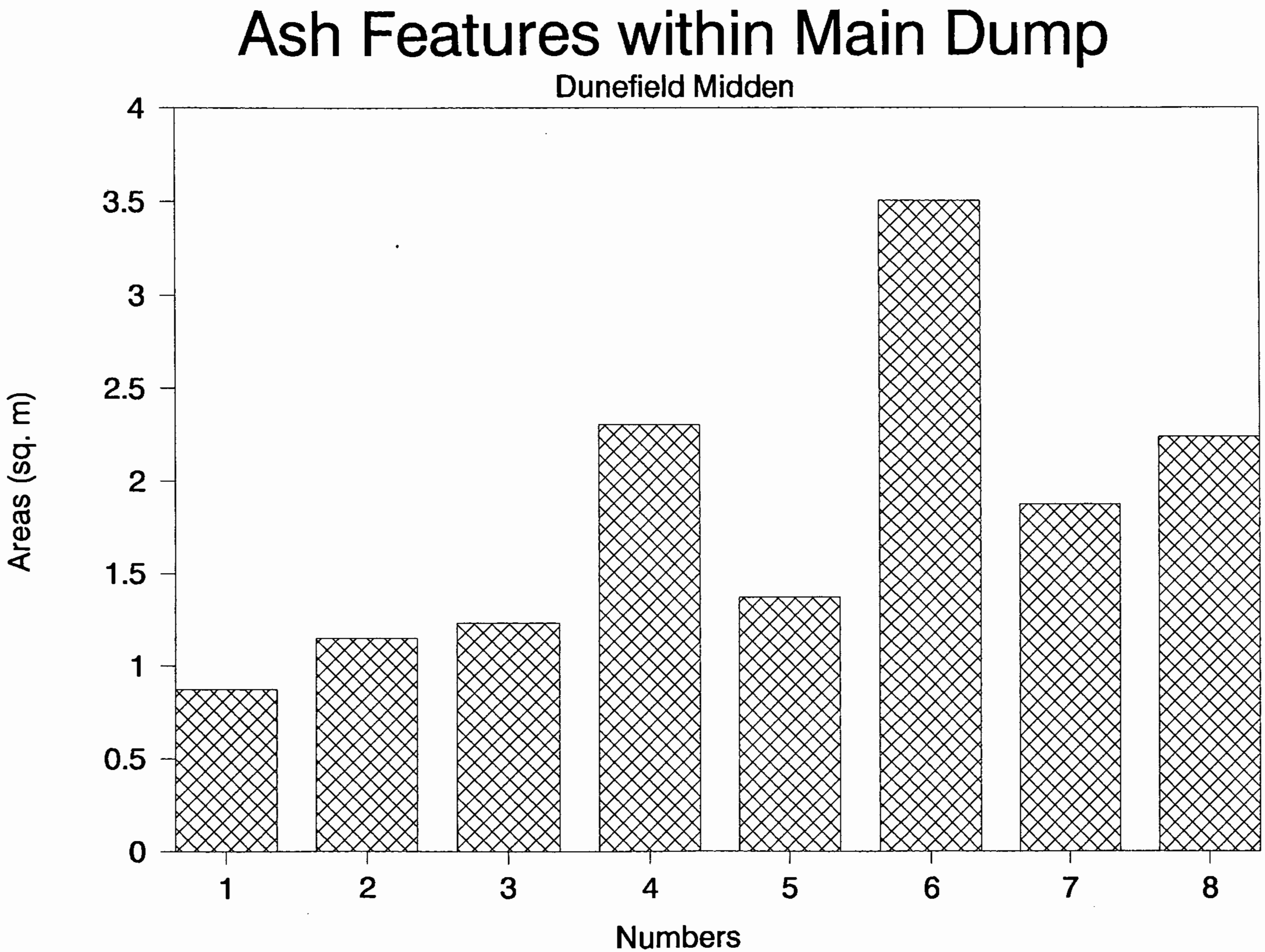
All of the hearths and roasting pits have an area of less than 1 m^2 (See Figure 10). They range in area from 0,21 m^2 to 0,85 m^2, with a mean area of 0,58 m^2. The roasting pits differ in area by only 0,04 m^2. One other hearth falls between the values for the two roasting pits and then these three features taken together differ by 0,13 m^2 from the rest. Once the roasting pits and the other hearth similar in area are excluded the mean area drops to 0,44 m^2. The roasting pits have assumed diameters of almost exactly 1m, whilst the hearths range in assumed diameter from about 0,52 m to 0,93 m.

Five of the ash dumps near hearths seem relatively isolated from the rest in terms of area (See Figure 11), they seem closer to the values for hearths (See Figure 10). The mean area of these five (0,57 m^2) is very similar to the mean area of hearths and roasting pits (0,58 m^2). It is possible that these reflect instances where an entire hearth



All Ashy Features
Dunefield Midden
Areas (sq. m)
4
3.5
3
2.5
2
1.5
1
0.5
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52
Numbers (allocated arbitrarily to features)

Figure 8



Ash Features within Main Dump
Dunefield Midden
Areas (sq. m)
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
8
Numbers

Figure 9

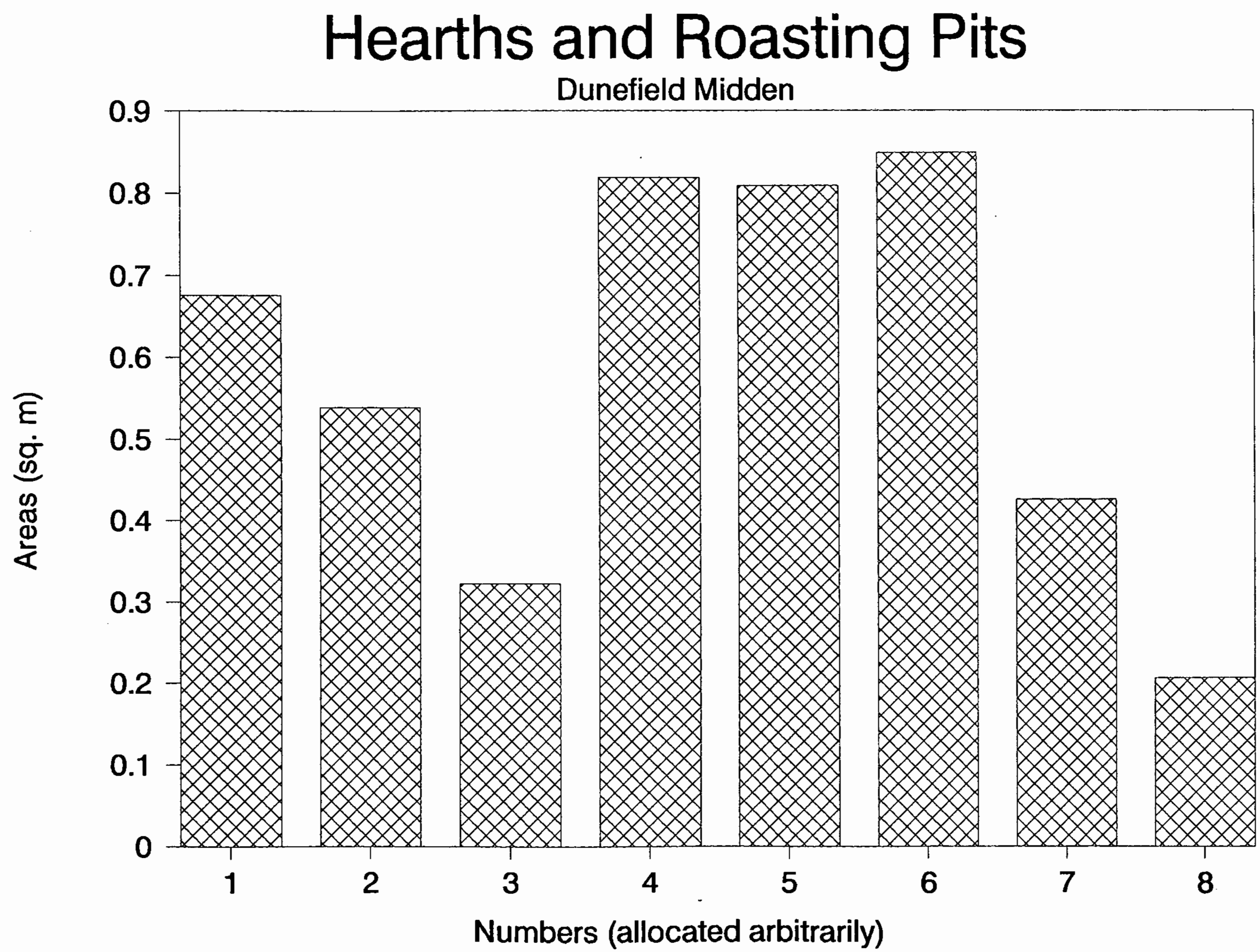
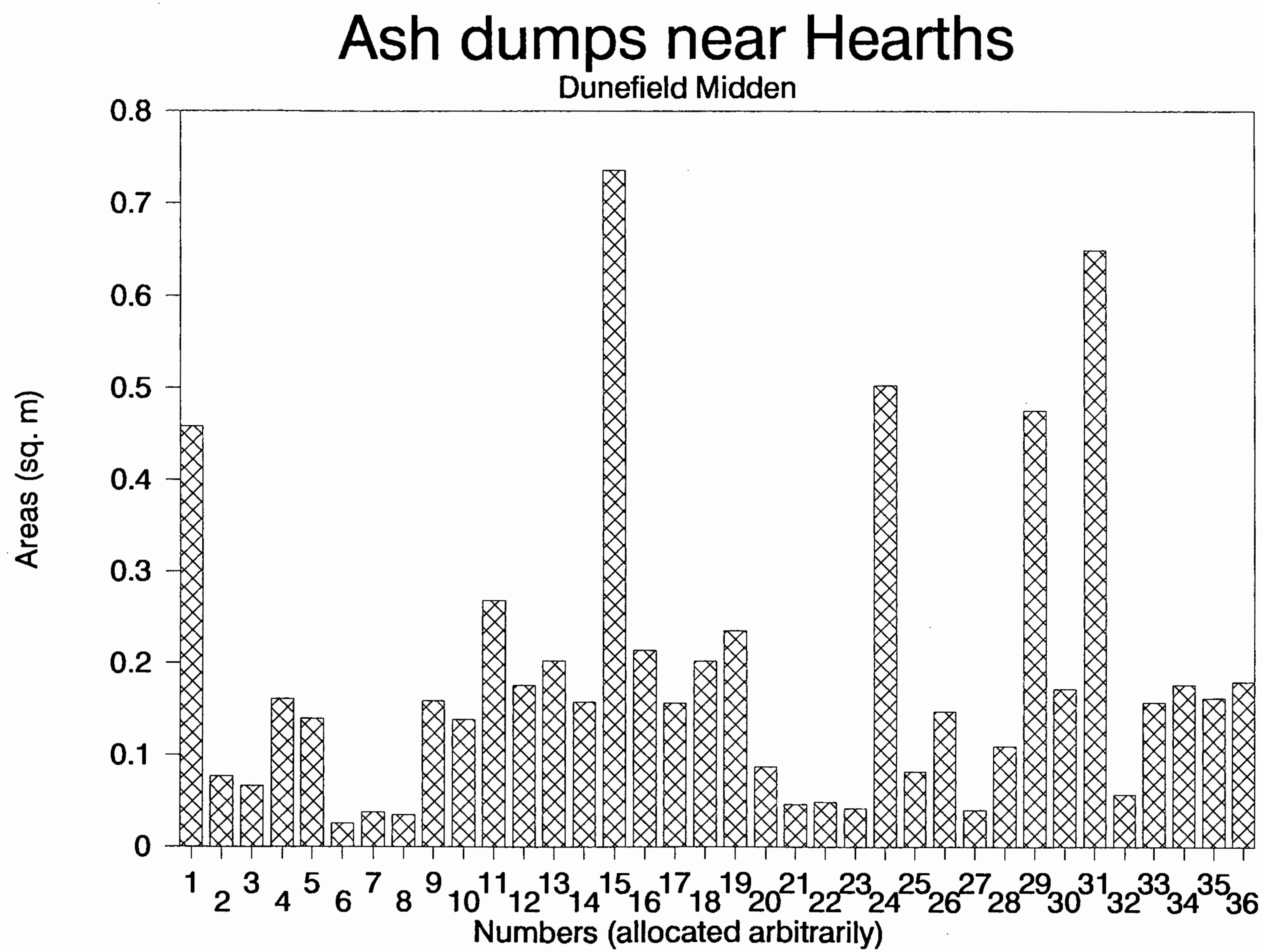

Hearths and Roasting Pits
Dunefield Midden
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Areas (sq. m)
1
2
3
4
5
6
7
8
Numbers (allocated arbitrarily)

Figure 10



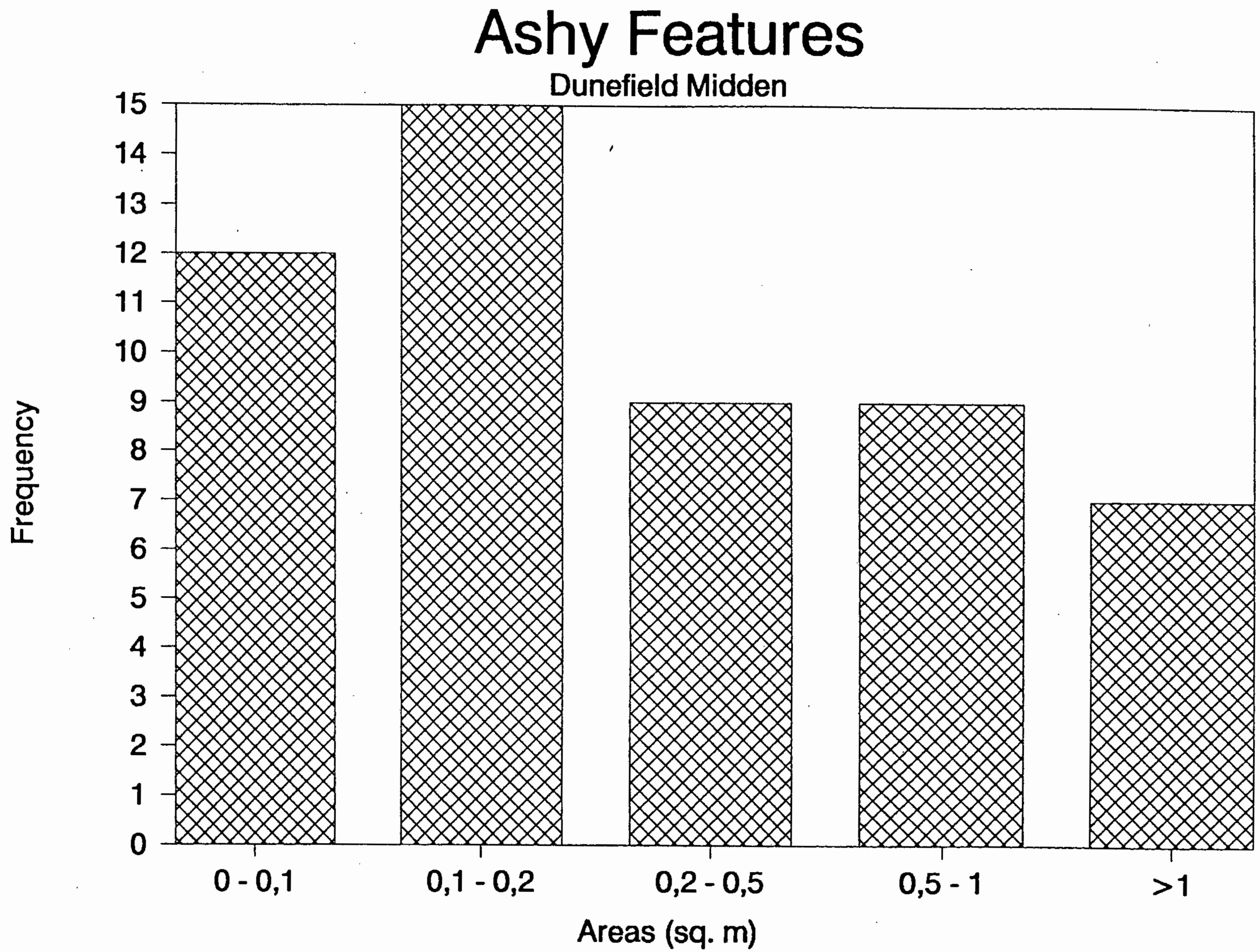
Ash dumps near Hearths
Dunefield Midden
Areas (sq. m)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Numbers (allocated arbitrarily)

Figure 11

was dumped, or they may reflect in situ hearths which were not included with the others as a result of different on-site interpretations. The other 31 dumps fall mostly below an area of 0,25 m^2 and therefore have an assumed diameter of less than 0,56m. These may be described as secondary dumps of ash from hearths.

These hearth areas differ to a fairly large degree from the areas of hearths discussed by Nicholson and Cane (1991) for Australian Aboriginal sites. Hearths from rockshelter sites were found to give areas of between 0,05 m^2 and 0,58 m^2, whilst open sites yielded hearths with areas from 0,05 m^2 to 0,32 m^2 (Nicholson and Cane 1991:314 - 319). These values are all significantly smaller than those for Dunefield Midden, which although an open site, has a mean hearth area equivalent to the largest rockshelter hearth area in this sample. However, hearths within rockshelters are not directly comparable to hearths from open sites since they are created under different spatial constraints. Nevertheless, a graph of the frequency of hearth areas shows some interesting similarities to the same graph of Nicholson and Cane's (1991:327) material (See Figure 12). The numbers of hearths between 0 and 0,2 m^2 are similar in both cases, although in the Dunefield Midden material the graph, after an initial decrease, then flattens out, showing far greater numbers of larger areas than in the Australian sample. The similarities in numbers of features with a smaller area may simply refer to the fact that the Australian sample is generally smaller, however, it may also be evidence of similar ash dumping behaviours, where small amounts of ash and charcoal are occasionally cleared away from the hearths and dumped elsewhere. This is especially likely in the 0 - 0,1 m^2 range, since if these do in fact reflect hearths, the diameter is unrealistically small (less than 0,35 m).

It is not known why there is such a great discrepancy in hearth sizes between these two samples, although further comparative material is lacking and may fill in the gaps



Ashy Features
Dunefield Midden
Frequency
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0 - 0,1
0,1 - 0,2
0,2 - 0,5
0,5 - 1
>1
Areas (sq. m)

Figure 12

perceived here. It is also possible that factors such as length of occupation, number of people present and season of the year may have influenced the types of hearths made at each site. It may also be that the presence of dangerous predators in Southern Africa, but not in Australia, may mean that Southern African fires are made bigger and kept burning longer (cf Gould and Yellen 1987 O'Connell 1987 but see also Gargett and Hayden 1991 Kent 1991). A possible taphonomic reason for the discrepancy is that the Dunefield Midden is situated on a loose, pebbly surface of an old beach and was covered by soft aeolian sands. Therefore the ash and charcoal may have become relatively dispersed, giving slightly larger areas for hearths.

Analysis of the hearth areas has therefore given general support to the identification of ash features made from an analysis of the field notes, and interpretations made during excavation. Furthermore it has indicated that certain ash features, which are relatively larger than the others and which have areas very similar to the areas of hearths and roasting pits, deserve further attention.

Hearth spacing

Mean distance between hearths is a commonly discussed item in the ethnographic literature. Gamble (1991:12) discussed a '3 m rule', stating that most societies in the ethnographic literature, regardless of environment, tended to place their hearths approximately 3 m apart. He noted that this applied to sites in the Arctic, Papua New Guinea, southern Africa, the Australian Western Desert, as well as Paleolithic and Mesolithic Europe. Fisher and Strickland (1991:224) reported similar values only for the mean distances between exterior and interior fires (2,68 m). However, the mean distance between hearths in the outer ring of the settlement was 6,18 m and the distance between fires within huts, only 1,34 m, thus showing a discrepancy with the '3 m rule'. Nicholson and Cane's (1991:330) values for mean distance between hearths is closer to Gamble's '3 m rule', with an overall mean of 2,2 m. Sleeping hearths were an average of 1,99 m apart and cooking hearths were an average of 2,59 m apart. However, Gould and Yellen (1987:77) give values which differ quite markedly from this rule: a mean of 7,77 m for !Kung hearths and one of 36,7 m for those of the Western Desert Aborigines. This difference could be the result of a difference in interpretation, or sample. It is possible that Gamble's (1991) rule refers to all hearths within a site, whilst Gould and Yellen (1987) refer mainly to the 'household hearth' disregarding other types of hearths such as those in the communal area (O'Connell *et al.* 1991), thus giving a distance between households rather than a straight hearth to hearth distance.

Household spacing is often related to inter-hearth spacing. Although there may be more than one hearth to a household, in some instances it appears that the inter-hearth spacing is used to measure distances between households. Gargett and Hayden (1991) state that hearths can be used to measure household spacing. Both Gargett and Hayden (1991:26) and O'Connell (1987:100) give values of 5 - 7 m for !Kung household spacing, which compares well with Gould and Yellen's (1987) values for hearth spacing. Similarly, they give values for household spacing among the Alyawara (25 - 40 or 45 m), which compare well with Gould and Yellen's (1987) value for Western Desert Aborigines. Fisher and Strickland's (1991:221) mean distance between huts of 4,8 m falls nicely between their values for outer ring hearths, and their mean distance between interior and exterior hearths. It also, perhaps, compares better to Gamble's 3 m rule. Binford (1991) gives values for Nunamiut household spacing in Alaska that compare more favourably with the Australian values (about 20 m to nearly 90 m). Even his values of mean distance between all hearths, including intra-household hearths, is fairly large (33,9 m). O'Connell *et al.* (1991) give values of

4 - 7 m for household spacing amongst the Hadza in Africa, and 3 to 3,5 m for the Ache in South America.

The measurement of hearth spacing therefore seems fairly ambiguous. Furthermore, there are several ways in which this distance could be measured, and few of the authors seem to state their method specifically. It is assumed that most of the values are calculated by comparing the distance between each hearth and its nearest neighbour, since this is the method discussed most often. In this analysis of Dunefield Midden the mean distance between hearths (as opposed to all ash features) was calculated in this manner. The distance between each hearth and its nearest neighbour was be measured. This gives five values for hearth spacing for eight hearths (since if two hearths are their own nearest neighbours this gives one value as opposed to two). The distance was taken from the approximate centre of each hearth. The question of whether this value represents hearth spacing or household spacing will be discussed in other parts of the analysis.

Mean hearth spacing for Dunefield Midden was calculated at 5,05 m. This value was calculated for those ash features described as 'hearths'. The inclusion of roasting pits increases this mean slightly, giving a value of 5,12 m. Since the degree of possible error given above is larger than this difference, these two values may be regarded as the same for the purposes of this analysis. The inclusion of the five largeish ash dumps near the hearths decreases this value slightly to a mean of 4,8 m. This difference is larger than the estimated error and therefore reflects a real decrease in mean size, although slight.

The mean hearth spacing, whether excluding or including roasting pits, falls within the range given for !Kung hearth and household spacing in the ethnography. It is also fairly close to the values for outer ring hearth spacing and household spacing reported by Fisher and Strickland (1991) for the Efe of Zaire. It is closer to Gamble's 3 m rule than the Australian and Alaskan values, but can not be said fully to support this rule. Since the site itself lies in a geographical area thought to have been inhabited by a people closely related to the !Kung, the hearth spacing gives support to the contention that !Kung ethnography may report many behaviours in common with those of the site's inhabitants. It is very clear that this site is closest in comparison to other African sites and the Kalahari sites in particular. In terms of size and spacing it has very little in common with the larger sites such as in Australia, although the features discussed are common to all sites, regardless of region. It is therefore justifiable to regard the southern African ethnography as the closest analog to Dunefield Midden.

The question of whether this hearth spacing reflects household spacing or not is probably best addressed from the types of remains that surround each hearth. Some preliminary analysis of this issue was done by Henshilwood (1990), although at that stage the ash features had not been divided into categories such as hearths and ash dumps. He looked at densities of various types of remains occurring in areas 3 x 3 m and 5 x 5 m centred on ash features and found that there was a strong association between some remains, especially stone and some small fauna and hearth squares, whilst ostrich eggshell and potsherds occurred mainly within the 3 x 3 m area. Other remains such as shellfish, lobster and seal, were mostly found in the main dump (Henshilwood 1990).

The distance between households is related to social relations between members of the group, in particular kinship (cf Yellen 1977 Binford 1991). Some hearths at Dunefield Midden are closer together than others, this could be interpreted as illustrating closer kinship ties amongst some members of the group, with respect to the others. The close siting of structures (indicative of households) is often also related to dependence, with dependents living closer to those whom they are dependent upon than to other group members (Yellen 1977 Binford 1991). It is therefore possible to suggest that the four hearths in the eastern part of the site may represent two groupings of close kin; the two hearths in the north-eastern area representing one group and the two hearths in the central eastern area representing another group. These two groups are at a slightly greater distance from the hearth in the southern part of the site and the hearth in the north-western part of the site. However, these interpretations are hypothetical, since the exact positioning of structures is unknown.

Hearth Activity Spacing

There is much in the ethnographic literature referring to the positioning of activities around hearths. Binford (1987:501) noted: "the basic physiological requirements of living, eating, sleeping, child care etc. condition the internal spatial accommodations found in domestic life space". This is the same idea as reflected in a quote in Gamble (1986:252) of Freeman stating: "A stationary individual can conveniently reach an area of two and a half to three square metres and this dimension is related only to stature and reach, which vary within a limited range among European populations of the genus Homo, living or extinct". Gamble (1986:252) adds that a seated individual can reach a smaller area and that these areas form an arc "due to the mechanics of the arm and shoulder". This idea has been discussed by many other authors and it would seem that whilst the specific culture may have a mediating effect, certain actual distances, especially between cultures with similar structure in similar environments, may have meaning as testable generalizations.

Binford's (1987) idea of physiological requirements is closely linked to his (1978a 1983) identification of 'drop' and 'toss' zones. A 'drop' zone is the immediate area around a person where smaller items of refuse tend to fall. Since these items are small and unobtrusive, they tend to be left in situ. (This idea of size sorting of remains will be further discussed with reference to dumping behaviour below). The 'toss' zone is the area into which larger items of refuse are thrown. It occurs at a greater distance from the person than the 'drop' zone. Larger items would be obtrusive in the immediate area where people are occupied with whatever tasks, and thus they are discarded at a greater distance. Binford (1978a:349) gives values of an approximate 20 cm radius around the person for a 'drop' zone and one of 1 - 1,5 m for tossed bones and 2,5 m for tossed cans, as measured at an Eskimo hunting stand in Alaska. He also states that people will sit within 1 m of a hearth.

A similar interpretation may be given to the values given by Whitelaw (1989) for personal distance. It is possible to interpret these values in terms of the relationship between people and their objects as well as between people and other people. Since the placing of remains occurs, in the primary context, as a result of the actions of an individual, the effects of personal distance seem most relevant. Whitelaw (1989:32) gives values of 45 - 75 cm for the 'close phase' of personal distance and 75 - 120 cm for the 'far phase' of personal distance. These distances approximate the values for Binford's 'drop' and 'toss' zones.

Nicholson and Cane (1991:340) give a distance of 0,3 to 2,8 m between artefacts and hearths at Western Australian Aboriginal sites. They state that most artefacts occur between 1,5 and 2 m of a hearth. Thus they seem concentrated at a 'toss' zone distance from the hearth, but are also found within 'drop' zone distance.

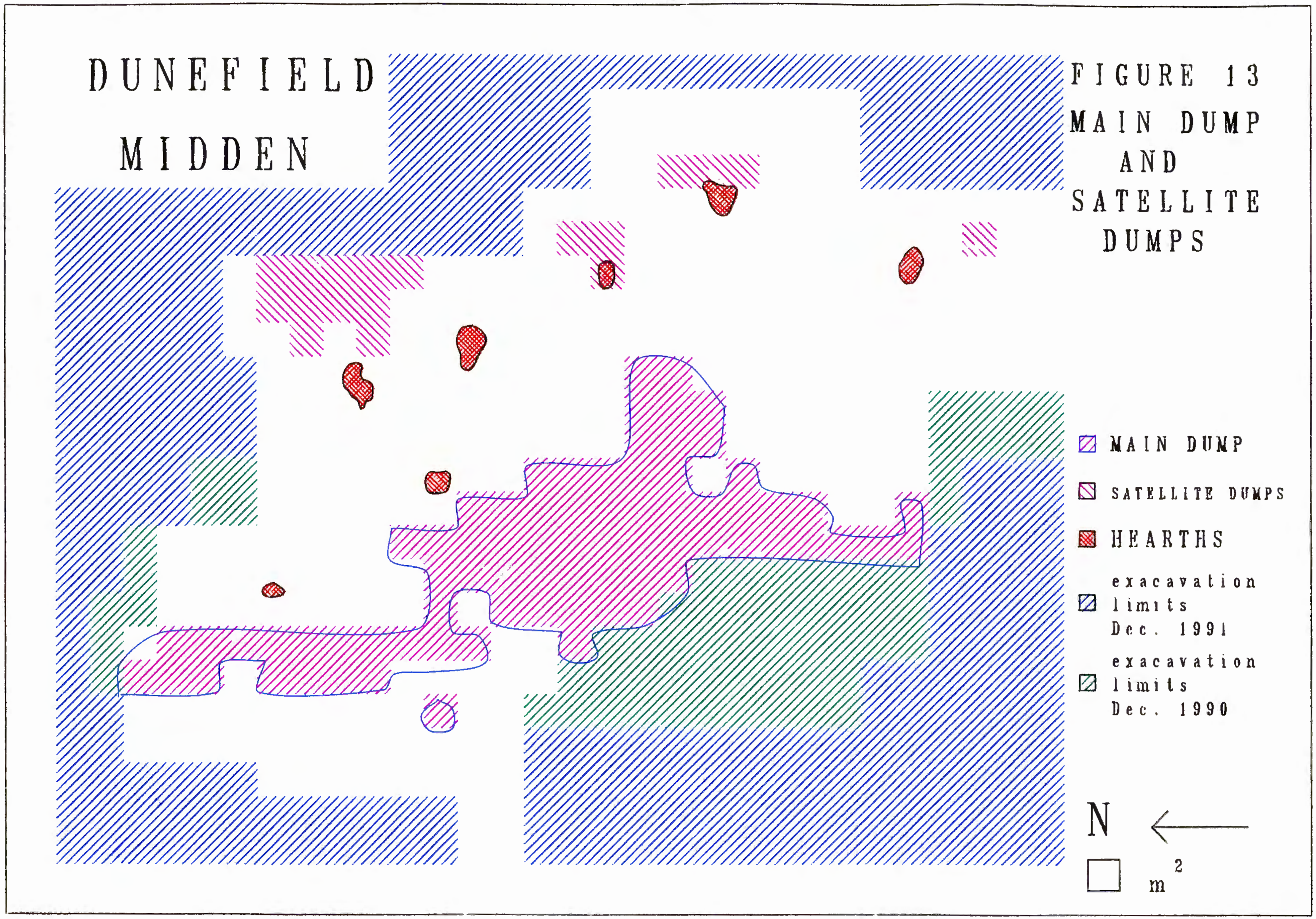
Dunefield Midden: Spacing around Hearths

Bearing all the ethnographic values for spacing of remains around hearths in mind, the Dunefield Midden areas within 1 m, 2 m and 3 m of hearths and roasting pits were established using the BUFFER program of ARC/INFO. The distribution of shellfish, other small fauna and artefacts within these areas was measured. Small items are taken to be most representative of activity areas on the site, in other words places where they were used or consumed. They are also more likely to be the major components of small refuse dumps that may occur within the area of the hearths. The index value of each category (according to the measure of site index discussed in the relevant section above) was used for comparison rather than the actual number or weight of objects in order that they be directly comparable with one another.

Analysis of the small fauna is not complete for relatively small areas in the extreme northern and extreme western part of the site. However, since most of the hearth areas fall outside these areas a general impression may be gathered. The results for small fauna distributions in a 3 m area around hearths and roasting pits indicate that most small fauna fall within this area. Index values above 80 indicate areas with concentrations of these remains. Only four squares or about 15 % of the total number of squares containing values above 80 lie outside the 3 m area. The distribution of small fauna with respect to the area within 2 m of hearths is less clear. Although all hearths and one roasting pit do have associated fauna, these occur in relatively small amounts. Several of the concentrations extend outside the 2 m area. Thus the 3 m area is a better indicator of small faunal remains than the 2 m area. It is possible that the discrepancies shown at the 2 m level indicate that hearths other than those indicated here were linked to small fauna consumption as well. This will be examined below.

When the component categories of the small fauna index are analysed it is clear that these animals are found in adjoining, but seldom overlapping squares. The majority are also found within a 3 m area of hearths. Not only are different species of animals found adjacent to each other, but the animals from a single species tend to be found in clusters covering more than 1 m^2. The distribution of tortoise is unusual in having seven non-conjoining squares containing the highest density range. This indicates that tortoise plastron fragments tend to be found clustered in relatively large numbers within a single square metre. In other words tortoise was consumed in relatively large amounts in relatively coherent areas of approximately 1 m^2 or less in several different parts of the site. In comparison, other species seem to have been consumed mainly in one or two areas on the site and are in clusters covering more than 1 m^2.

Shellfish are found in the greatest densities (up to greater than 20 kg per square metre) within the area of the main dump. In fact, they form an important means of defining this feature. However, smaller concentrations are found in other areas of the site. Figure 13 indicates squares with more than 2000 g of shellfish, which defines the main dump. There are other smaller concentrations containing 750 - 2000 g of shell. It can be concluded that these represent satellite dumps in the area of the site characterised by hearths. Most of these fall within the 3 m area of hearths and roasting pits. One concentration extends out of this 3 m area in the northern area of the site. There are several other squares within containing 750 - 2000 g of shell that are situated on the edges of the main dump and probably reflect the edges of this feature. In other words the distribution of shellfish indicates the presence of smaller dumps within the 'hearth area' of the site. These smaller dumps will be re-examined in a following section on dumping behaviour.

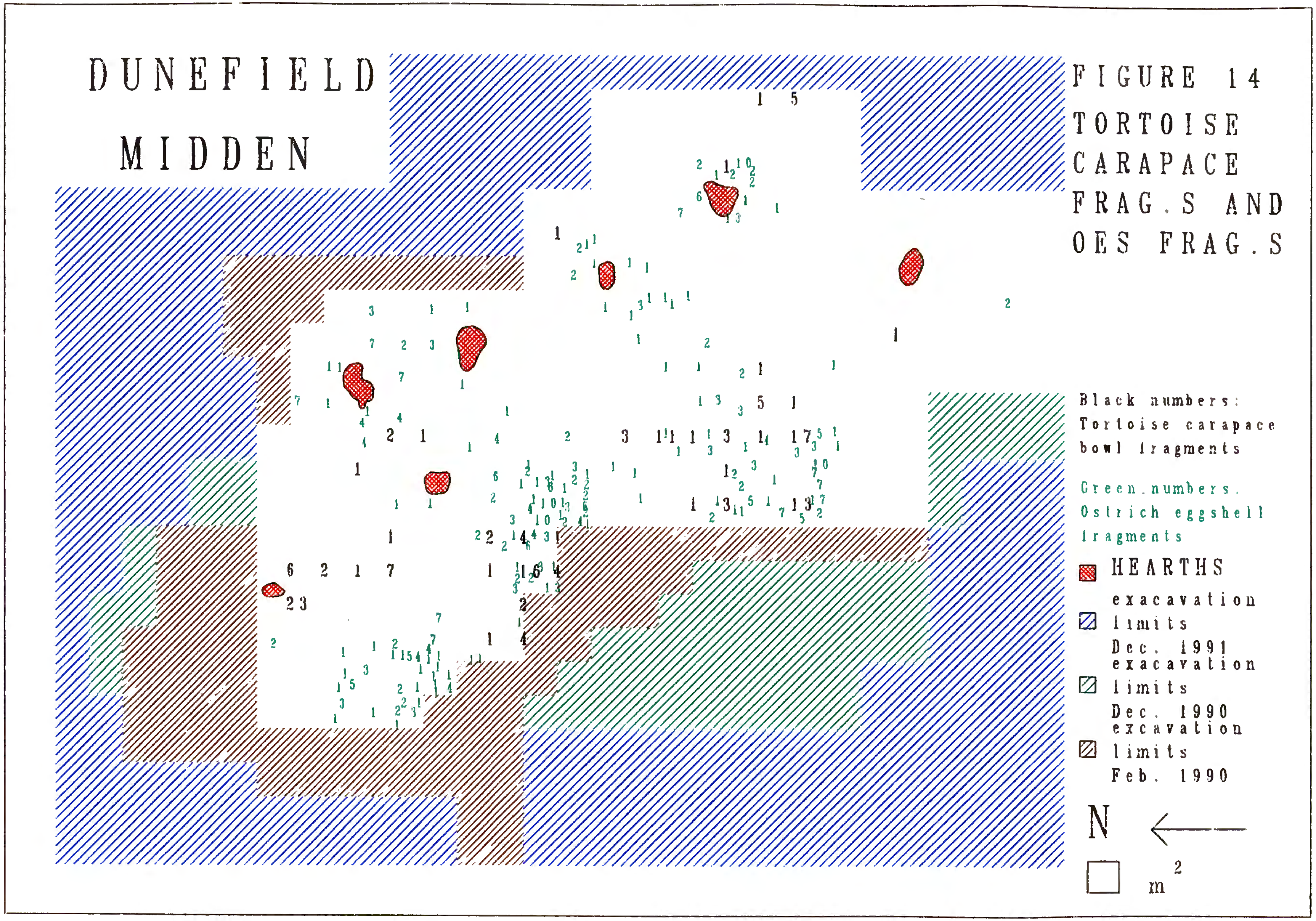

DUNEFIELD
MIDDEN
FIGURE 13
MAIN DUMP
AND
SATELLITE
DUMPS
MAIN DUMP
SATELLITE DUMPS
HEARTHS
exacavation
limits
Dec. 1991
exacavation
limits
Dec. 1990
N
m 2

Although stone artefacts and potsherds are almost completely spatially separated with respect to the square metres in which they were found, they are found predominantly in the same part of the site (with the exception of the large concentration of potsherds found in the main dump). Similarly both are commonly described under the general term 'artefacts' in the ethnography. The combined index of these features was therefore used in this analysis in order to examine the occurrence of 'domestic' activities in association with hearths. It is nevertheless significant that hearths associated with concentrations of stone artefacts usually have low numbers of potsherds and vice versa. Thus it would be fair to conclude that they were used for different activities. In other words, stone artefacts were generally not used for food processing as potsherds probably were, but were used for some other activity that did not include the use of potsherds. This spatial separation of activities suggests a social separation, although whether of gender, time or function it is difficult to say.

Predominantly low numbers of artefacts are found within the main dump, except for two squares with high values. These two squares reflect mainly the presence of large numbers of potsherds, presumably discarded in the main dump. Artefacts are mostly found in close proximity to the hearths, most lying in squares immediately adjacent to the hearths, thus confirming Nicholson and Cane's (1991) observations as to the average distance between artefacts and hearths. They observed a distance of 0,3 to 2,8 m between artefacts and hearths at Western Australian Aboriginal sites. Thus, although the size of the hearths and spaces between them differ between these sites and Dunefield Midden, artefacts were used at a similar distance from the hearth. This distance is presumably linked to the physiological factors mentioned above, as well as the fact that people tend to work with artefacts around hearths, either during manufacture (Bleek LVIII 26 8316-8320 Binford 1986), or during use. The distribution of artefacts with respect to the possible presence of additional hearths is investigated below.

Two other categories of items may be described as artefactual. These are ostrich eggshell fragments (from water-bottles) and tortoise carapace bowl rim fragments. Most of these items occur in the main dump, since they were presumably discarded as broken. However, their distributions with respect to hearths and roasting pits are interesting. Tortoise carapace bowl rim fragments are either absent or occur in very small numbers, except with respect to one hearth and one roasting pit where they occur in large numbers (See Figure 14). However, these features are on the edge of the main dump and it is therefore possible that they are actually associated with this feature, although they may also represent the abandonment of almost complete bowls at these locations. Nevertheless, this distribution does illustrate their different distribution to that of tortoise plastron fragments discussed below. A spatial autocorrelation test performed on the distribution of tortoise carapace bowl rim fragments gave a test statistic (z) of -6.93. This result is significant at $p = 0.001$ (see Appendix A). Ostrich eggshell fragments occur in the greatest numbers in two main concentrations in the dump (see Figure 14). They are also associated with the roasting pit on the edge of this feature, as well as in smaller numbers with some other hearths, where they occur mainly within a 2 m area. This distribution indicates perhaps that these items originated in the hearth areas and were then discarded in the dump. The distribution of ostrich eggshell fragments gave a test statistic (z) of -8.86, when the spatial autocorrelation test was applied to their distribution. This result is significant at $p = 0.001$.

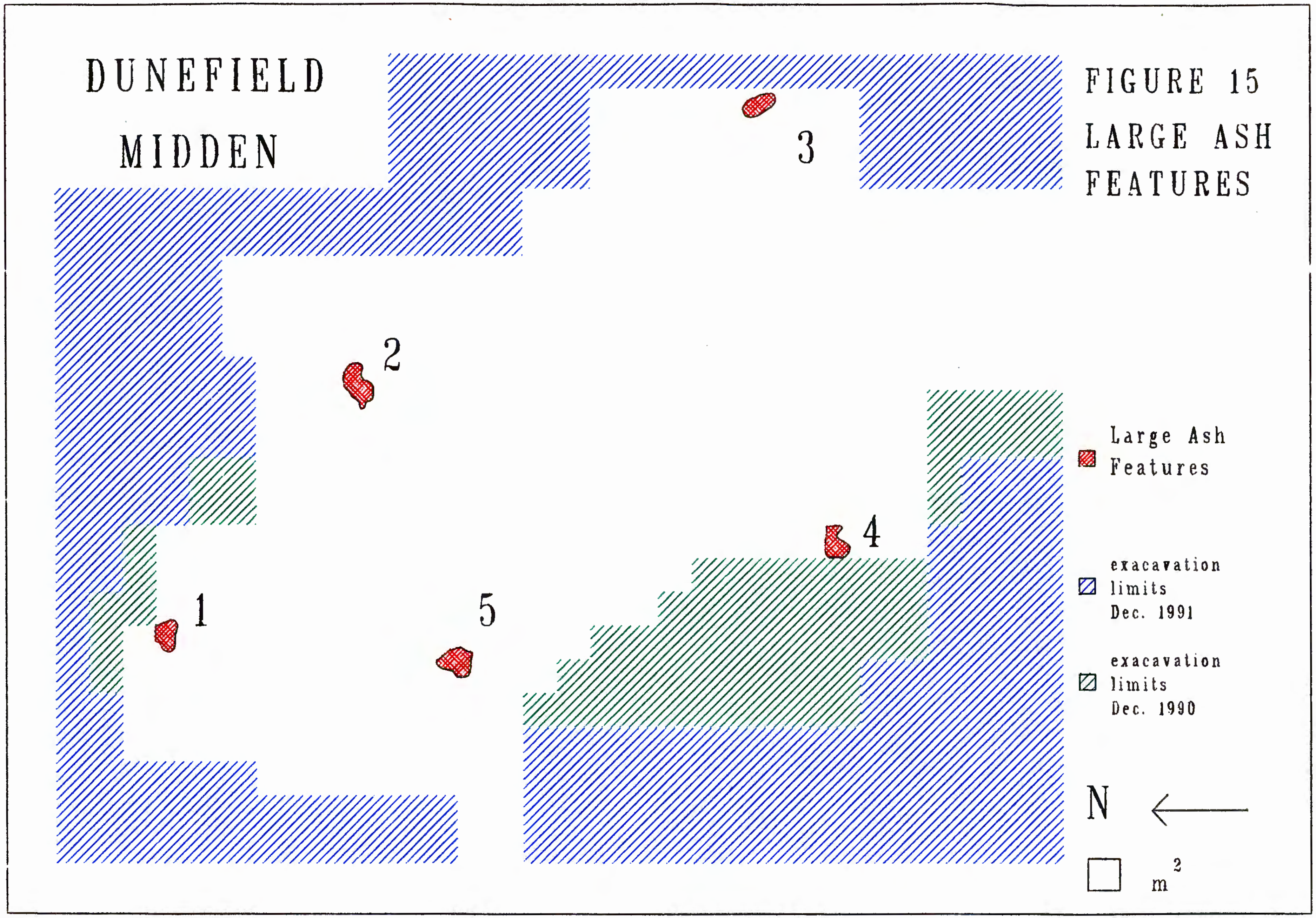
The large ash concentrations mentioned above may now be compared to the pattern found for hearths. These 'ash dumps' were differentiated from other ash concentrations, being relatively larger than other ash dumps not associated with the main dump, although not part of the main dump themselves. It has been suggested above that these features may reflect the dumping of complete hearths, or in situ hearths not recognised during excavation. If very small items such as quartz chips or


DUNEFIELD
MIDDEN
FIGURE 14
TORTOISE
CARAPACE
FRAG.S AND
OES FRAG.S
Black numbers:
Tortoise carapace
bowl fragments
Green numbers:
Ostrich eggshell
fragments
HEARTHS
exacavation
limits
Dec. 1991
exacavation
limits
Dec. 1990
excavation
limits
Feb. 1990
N
m2

small faunal remains are present it is likely that these features represent either in situ or complete dumped hearths.

All of the large ash dumps except one, which lies outside the area of analysed small fauna, are strongly associated with very small items. Quartz chips are even better indicators of in situ activities. These items are very small (less than 1 cm) and would therefore be very likely to fall into the sand in the immediate area where they were produced and not to be discarded on secondary refuse dumps (Fehon and Scholtz 1978 O'Connell 1987 Vermeulen 1990), unless they fall into a hearth which is itself discarded. Index values were used to represent these items so that they would be directly comparable with other artefacts and food remains. One large ash dump is closely associated with one of the concentrations of quartz chips found in the north-eastern part of the site. However, the other features do not seem to be as strongly correlated with quartz chip concentrations.

In conclusion, therefore, Feature 1 (see Figure 15) is associated with large numbers of small faunal remains, but not with quartz chips. It may represent either a hearth or the dumping of a hearth with associated small faunal remains. Feature 2, on the other hand, is associated with concentrations of both small fauna and quartz chips, making a strong case that this may be an in situ hearth, since these concentrations seem to fall immediately around as opposed to within it. It is also associated with small numbers of ostrich eggshell fragments. There is a hearth within three metres of this feature associated with both small fauna, quartz chips and ostrich eggshell fragments to approximately the same extent. This area of the site, therefore, seems to represent the overlapping of two focal activity areas. It would therefore seem necessary to rename this feature as a possible hearth. Features 3 and 4 do not seem to be associated with either of these categories of items at this stage in the analysis and will therefore retain

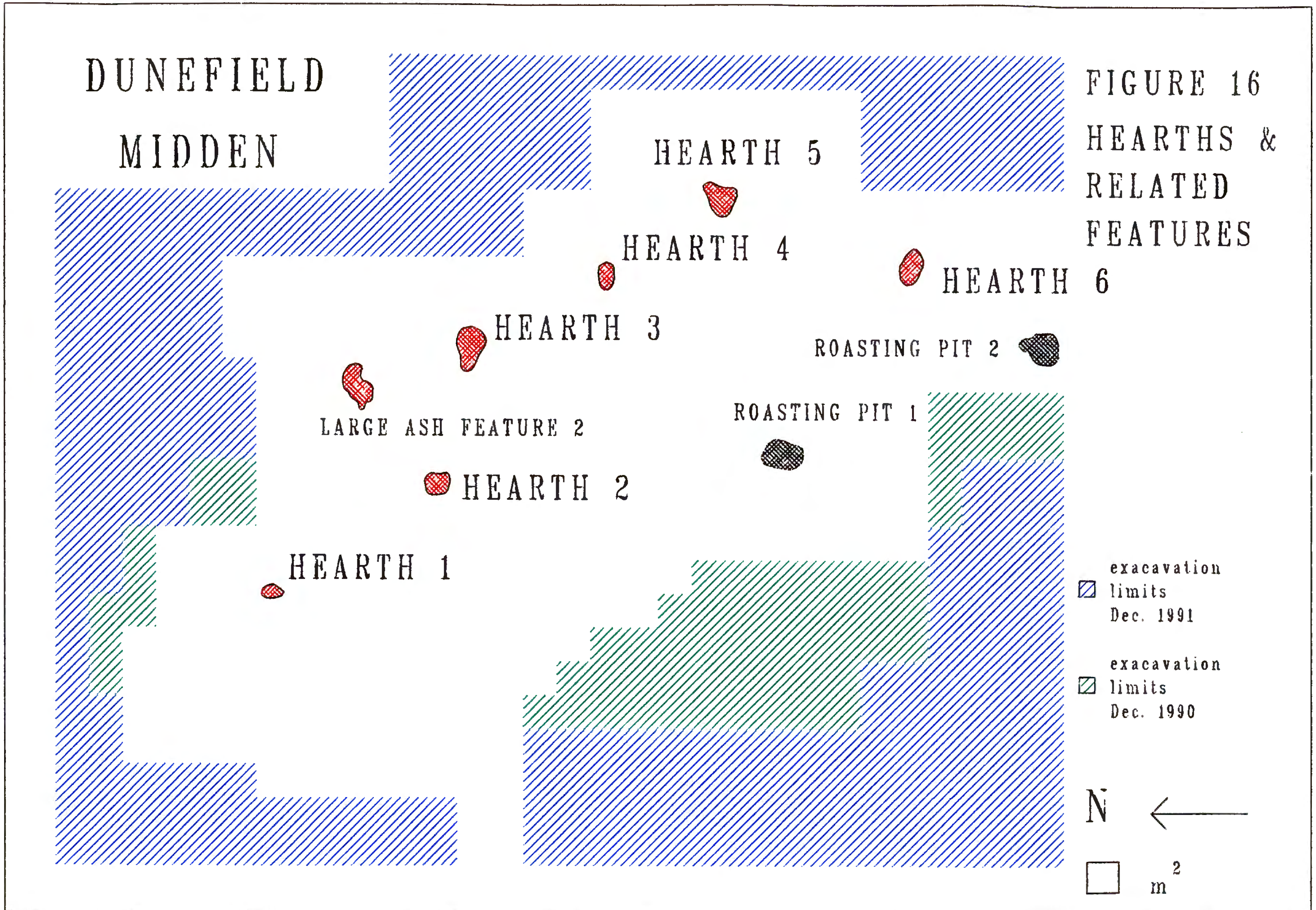

DUNEFIELD
MIDDEN
FIGURE 15
LARGE ASH
FEATURES
1
2
3
4
5
Large Ash
Features
exacavation
limits
Dec. 1991
exacavation
limits
Dec. 1990
N
m 2

their description of ash dump. Feature 5, although it does have associations of fauna and quartz chips, although not to the extent of Feature 2, is situated on the edge of the main dump and may therefore also reflect the dumping of a hearth and associated items.

The hearths and roasting pits may now be categorized according to their associated items (see Figure 16).

Hearth 1 is associated with a concentration of stone artefacts, mostly made up of quartz chips, the evidence of stone tool manufacture. The association of quartz chips argues for its in situ nature despite the fact that it is situated on the edge of the dump. It is associated to a lesser degree with small numbers of potsherds. It is also associated with large numbers of tortoise carapace bowl rim fragments suggesting the presence of a bowl. There are no ostrich eggshell fragments directly associated with this feature. There does not appear to be a strong association of small fauna with this feature, although it is difficult to say what the association of shellfish was, since the main dump extends past this feature on the western side. This feature may be termed a stone tool associated domestic hearth.

Hearth 2 is associated with potsherds and to a lesser degree with stone artefacts and quartz chips. The large ash feature north of this hearth is more closely associated with the concentration of quartz chips in this area. This hearth is loosely associated with small numbers of tortoise carapace bowl rim fragments and ostrich eggshell fragments. It is more closely associated with small faunal remains. There is some association of shellfish with this feature, although it is


DUNEFIELD
MIDDEN
FIGURE 16
HEARTHS &
RELATED
FEATURES
HEARTH 5
HEARTH 4
HEARTH 6
HEARTH 3
ROASTING PIT 2
LARGE ASH FEATURE 2
ROASTING PIT 1
HEARTH 2
HEARTH 1
exacavation limits Dec. 1991
exacavation limits Dec. 1990
N
m
2

fairly close to the main dump. This feature may be termed a potsherd associated domestic hearth.

Hearth 3 is associated with a concentration of stone artefacts and quartz chips. It also has associated potsherds and a few ostrich eggshell fragments, although no tortoise carapace bowl rim fragments. There is a concentration of shellfish north-east of this feature which extends northwards but may be associated with it. There are concentrations of small fauna associated closely with this feature. This feature may be termed a general domestic hearth.

Hearth 4 is loosely associated with low numbers of stone artefacts and quartz chips, although there is a concentration of potsherds near this feature. There are also low numbers of ostrich eggshell fragments in the immediate area, although only one tortoise carapace bowl rim fragment. There is a concentration of small fauna as well as a smaller one of shellfish within the 2 m area around the hearth. This feature may be termed a potsherd associated domestic hearth.

Hearth 5 is associated with a concentration of stone artefacts and quartz chips, although no potsherds. There is also a concentration of ostrich eggshell fragments, although only one tortoise carapace bowl rim fragment lies within the 2 m area. There is a small concentration of shellfish associated with this feature, as well as some faunal remains, although the main concentration of these lies further to the east. This feature may be termed a stone tool associated domestic hearth.

Hearth 6 has no stone artefacts or quartz chips associated with it in significant numbers, although there is a concentration of potsherds. There are no ostrich eggshell fragments and only one tortoise carapace bowl rim fragment. There is a very small concentration of shellfish and a similarly sized one of small fauna within 3 m of it. This hearth seems to contain the least amount of material associated with any hearth. This feature may be termed a potsherd associated domestic hearth.

Roasting Pit 1 is situated on the very edge of the main dump, which makes it difficult to state positively whether there is any shellfish directly associated with it. Similarly the associated fauna and few potsherds may or may not be associated with this feature. There are no significant amounts of stone artefacts in direct association, although there is a very small concentration of quartz chips nearby.

Roasting Pit 2 is situated on the extreme southern end of the site. There are no significant amounts of stone artefacts or quartz chips and only a low number of potsherds associated with it. There are only two pieces of ostrich eggshell and no tortoise carapace bowl rim fragments within 3 m of the feature. There is a small amount of shellfish within this 3 m area, but no significant amounts of small faunal remains.

Large Ash Feature 2 (Hearth 7) is associated with a concentration of stone artefacts, mostly made up of quartz chips. It is also associated with a concentration of small faunal remains and numbers of ostrich eggshell pieces. There are however, few potsherds in the immediate area and no tortoise carapace bowl rim fragments. It may be termed a possible stone tool associated domestic hearth.

Excluding the roasting pits the arrangement of hearths forms a rough semi-circle from the northern through the eastern to the southern ends of the site, predominantly lying in the north-eastern part of the site. This arrangement is not significantly altered by the inclusion of the possible hearth. If the positioning of hearth 6 is regarded as aberrant, however, then the hearths may be described as lying in a line across the north-eastern part of the site. Both of these arrangements of hearths are described in the ethnographic literature and sometimes relate to the season and/or population of the camp (Bartram *et al.* 1991). Whitelaw 1991:181 shows that the circular arrangement is favoured in camps occupied for periods of time ranging from weeks to months, whilst the linear arrangement tends to predominate in camps occupied for a period of months, or permanent camps. The circular arrangement would therefore reflect a period of occupation of weeks to months. An occupation of that length seems quite likely from the evidence for Dunefield Midden.

However, a more useful definition of camp layout may be one made in terms of a separation between 'front' and 'back' areas. This separation allows a definition of camp orientation that is independent of the linear vs circular argument. The definition of front/back can be given from an analysis of the position of hearths and dumps associated with a structure (cf Fisher and Strickland 1991). It is possible that it could be used even when the structures themselves are absent, as is the case at Dunefield Midden, although a suggestion of the orientation of possible structures would need to be made. As will be seen in the section on camp layout below, this is not possible at this stage of the analysis.

Dumps

Dumping or discard behaviour (Murray 1980) is one of the characteristic areas of analysis of a spatial site. All the items found on a site are assumed to have been the result of discard behaviour. This includes whether the items were placed intentionally or lost (Murray 1980). Two of the main interests of ethnoarchaeologists with respect to discard behaviour have been the creation of distinct refuse dumps (Yellen 1977 Binford 1978a Brooks and Yellen 1987 O'Connell 1987 Whitelaw 1989 Bartram *et al.* 1991 Fisher and Strickland 1991 Keeley 1991 O'Connell *et al.* 1991 Stevenson 1991) and size sorting of items (Binford 1978a Fehon and Scholtz 1978 O'Connell 1987 Kroll and Price 1991 O'Connell *et al.* 1991 Stevenson 1991). Both of these issues will be addressed in this section.

The creation of distinct refuse dumps has been related to length of occupation, with items being removed to places that are not in the main areas of use, such as behind the structures or on the perimeter of the camp (Brooks and Yellen 1987 O'Connell 1987 Bartram *et al.* 1991 Fisher and Strickland 1991 O'Connell *et al.* 1991 Stevenson 1991). The length of occupation may refer to actual or anticipated length of occupation (Kent and Vierich 1989 Whitelaw 1989 Kent 1991). It is suggested that short term occupations do not lead to the creation of refuse dumps removed from the main areas, whereas occupations of a longer term, or anticipated longer term, do. These refuse dumps are often created mainly by the sweeping or clearing and dumping of ash from a hearth (Bartram *et al.* 1991 O'Connell *et al.* 1991).

As an example, Bartram *et al.* (1991) record that refuse dumps are present at the hot dry season camps of the Kua in Botswana. These camps are large and are occupied for approximately three months. There are several different forms of dumping behaviour visible at these camps. Both 'drop' and 'toss' behaviour is evident (cf Binford 1983). There are small dumps associated with ash a little distance from hearths, as well as scatters of material adjacent to the hearths. Sweeping of the hearths and adjacent areas produces dumps of material at a slight distance from the hearths. Rainy season camps are smaller and are occupied for about a week. Clusters of bones are found around hearths at these camps, but there is very little relocation of refuse onto dumps. The differential distribution of body parts and different animals is apparently very evident in the patterning of the bones on these sites. Yellen (1977) records similar differences between dry season and rainy season camps amongst the San in Botswana. Cool dry season camps amongst the Kua are occupied for varying lengths of time, from just over a week to three months. There are clusters of bones adjacent to hearths and windbreaks as well as clearly visible bands of refuse slightly further away ('toss' zones). Material is swept up although Bartram *et al.* (1991) record that there are no ashdumps. Transient camps contain only a windbreak and a hearth or two with clusters of bones in front of the windbreak and adjacent to hearths (Bartram *et al.* 1991). This latter type of camp is clearly not what is represented at Dunefield Midden, which contains far more material than is present at these sites.

Size sorting of items is closely related to the creation of refuse dumps, since it is generally in the creation of these dumps that it occurs. Nevertheless, it also occurs when distinct refuse dumps are not created. The idea is very closely tied to Binford's (1978a) definition of 'drop' and 'toss' zones, as created by him to explain patterning at the Mask site in Alaska. He defined the 'drop' zone as the area within about 20 cm of a man (sic) sitting cross-legged, into which items fall from his hands. Although not specifically stated at this stage, Binford's (1978a) description indicated that these were small items (for example splinters of bone and wood).

The 'toss' zone is the area within 1 to 2 and a half metres of a man (sic) sitting cross-legged. This is the area in which items are discarded by being tossed away. Binford (1978a) distinguished between this activity which occurred at the same time as the activity producing the waste, and clearing activities which occurred later. Tossed items were generally larger ones, for example large bones and cans, which would prove a hindrance in the immediate area (Binford 1978a). This pattern has been very clearly demonstrated for stone tool manufacture, where the smaller waste items remain in the immediate area (Binford 1986) and has been demonstrated for the site of Dunefield Midden (Vermeulen 1990).

The 'toss' zones may later become refuse dumps onto which other material is deposited, or they may be cleared later themselves (O'Connell 1987 Stevenson 1990). Although Binford's (1983) application of these patterns to the site of Pincevent has been criticised and shown not to be a very good fit (Whitelaw 1989 Carr 1990), as a general model the idea of 'drop' and 'toss' zones is thought to have value. The size sorting that takes place in this way may be encouraged by the ground surface (O'Connell *et al.* 1990). Thus, size sorting probably occurred at Dunefield Midden, which is on a fairly soft sandy surface whose ability to swallow up items dropped on it has been experienced by excavators. Stevenson (1990) has added the effects of scuffage and trampling to this model, but the displacement caused by these factors is largely vertical and thus applies to stratified sites and not to the single horizon site of Dunefield Midden. Although vertical displacement of material has taken place at this site it is recovered by excavation to an adequate depth.

The implication of size sorting on the position of items on the site is that areas containing certain items, generally of the same size, may not relate to a discrete activity, nor one which is necessarily separated from areas containing items of a different size. The same items, e.g. stone debris from the manufacture of stone artefacts, will, however, necessarily relate to the same activity. Large items, such as larger stone chunks, are unlikely to remain in the area in which they were used. Small items, such as quartz chips, however, will tend to remain in situ. The situation of the smaller items may be used to determine areas where certain activities took place (for example stone tool manufacture, see Vermeulen 1990).

Ethnographic Refuse Dumps

There are many descriptions of refuse dumps in the ethnoarchaeological literature. These dumps may occur mostly behind or adjacent to structures and/or hearths, and there may also be others, often larger ones, on the perimeter of the camp (See Figure 5). These dumps may be used to define the perimeter, or other specific areas of the camp. In the case of forest camps, such as those of the Efe, the perimeter of the camp seems to be defined both by the extent of cleared vegetation and by the presence of refuse dumps (Fisher and Strickland 1990). Amongst the Alyawara in Australia where camps themselves consist of relatively separated activity areas, these activity areas are described as surrounded by a band of refuse up to 30 m wide with the densest area on the edge immediately surrounding the activity area (O'Connell 1987).

The pattern of larger dumps on the perimeter and smaller ones near structures and hearths seems to be common amongst !Kung, Alyawara, Efe, Pintupi, Hadza, and Kua (Yellen 1977 Brooks and Yellen 1987 O'Connell 1987 Bartram *et al.* 1990 Fisher and

Strickland 1990 Gargett and Hayden 1990 O'Connell *et al.* 1990). Since there is also a relationship between structures and hearths, a relationship between refuse dumps and hearths may be inferred (cf Fisher and Strickland 1990). Given the possible diameter of a structure, it is possible to suggest that refuse dumps and hearths should occur within a certain distance of each other. If these two features do occur then the presence of a structure can be inferred (this will be examined further in the section on structures below). Fisher and Strickland (1990) state further that there may be a refuse dump in the central open area of a campsite.

These refuse dumps are very likely to contain the ashes swept from fires; in fact these may form the basis of the dump (Fisher and Strickland 1990 O'Connell *et al.* 1990). The refuse dumps also tend not to contain specialised refuse or single categories of items, for example bones (Fisher and Strickland 1990). They are more likely to contain a cross-section of items, although in the case of the smaller dumps, these may relate specifically to the activities carried out nearby (Bartram *et al.* 1990). Small dumps of a specific item (for example bones) may relate to a specific activity (such as snacking at night) (Bartram *et al.* 1990).

This pattern may be made slightly more complex by the fact that there may be no clearing of the camp on the days preceding departure (Fisher and Strickland 1990). Thus items are left lying about rather than discarded onto dumps. This later deposition need not obscure the interpretation of the patterning, since if cognisance is taken of this fact it can be used to confirm the nature of activities taking place in specific areas (although these do not necessarily represent the full range of activities that did take place in those areas).

Dunefield Midden Dumps

The definition of refuse dumps is therefore a very important component of understanding the patterning on a site. Firstly, it must be decided whether or not refuse dumps are present. This fact has implications for the length of the occupation represented, as mentioned above. It also allows the researcher to decide how to interpret the rest of the patterning. Refuse dumps are present at the site of Dunefield Midden. This is very clearly indicated by the presence of a feature known as the main dump.

The Main Dump

The main dump is an area of the site containing very large amounts of shellfish, intermingled with bones and other items. Since the weight of these items is over 20 kilograms in some squares the most likely explanation is that this area was used for discard. The fact that most of the artefacts found within this area are broken is also felt to be significant. These include potsherds, ostrich eggshell and stone tools. Whilst no complete pots or ostrich eggs have been found in other areas of the site, it is nevertheless felt to be significant that large numbers of the broken items are found in this area. Furthermore many of the larger animal bones, such as eland, found within the main dump show tooth punctures and gnaw marks, suggesting that dogs or other carnivores may have had access to them in this area (Nilssen 1989).

It was noticed during excavation that squares containing a relatively large amount of shellfish, as well as other material, were found in one area of the site. This area was named the main dump. The shellfish are the most noticeable constituent of this feature, although bones occur in large numbers in this area as well. Almost all other items found on the site are represented in this area to some degree. The shellfish and other items seemed to occur in clusters within this feature. It has been suggested that these may refer to 'dumping episodes' or instances when a concentration of refuse of various types was collected from one area, perhaps adjacent to a hearth or structure, and was dumped in the main dumping area of the site. Behaviour of this kind is recorded in the ethnoarchaeological literature (O'Connell *et al.* 1991).

These 'dumping episodes' were noted during excavation. Transects made through the dump along north-south lines illustrate the clustered nature of the dumping area to a small extent. The graphs of weight of shellfish along the transect lines show the peaks and troughs of differing concentrations within the dumping area (see Figures 17 - 19). The three graphs illustrate three adjacent lines of squares and it can be clearly seen how the concentrations of shellfish change within a given area. However, the graphs are based on information with a resolution of one square metre. The clusters noted during excavation would be more clearly revealed with a finer resolution. The differing concentrations within the area known as the main dump decrease the homogeneity of this feature.

The exact spatial definition of the main dump is therefore complex. Shellfish weight was taken to be the determining factor, since all squares containing the greatest weight of shellfish occur in central western area of the site, in other words in the area called the main dump during excavation. The lower limit of shellfish weight used to determine the boundary of this feature was determined through experimental mapping of various shellfish weight distributions across the site using GIS. The minimum weight which gave a spatially coherent distribution to this feature was chosen as the definition of the feature. It is recognised that the main dump itself is most likely to

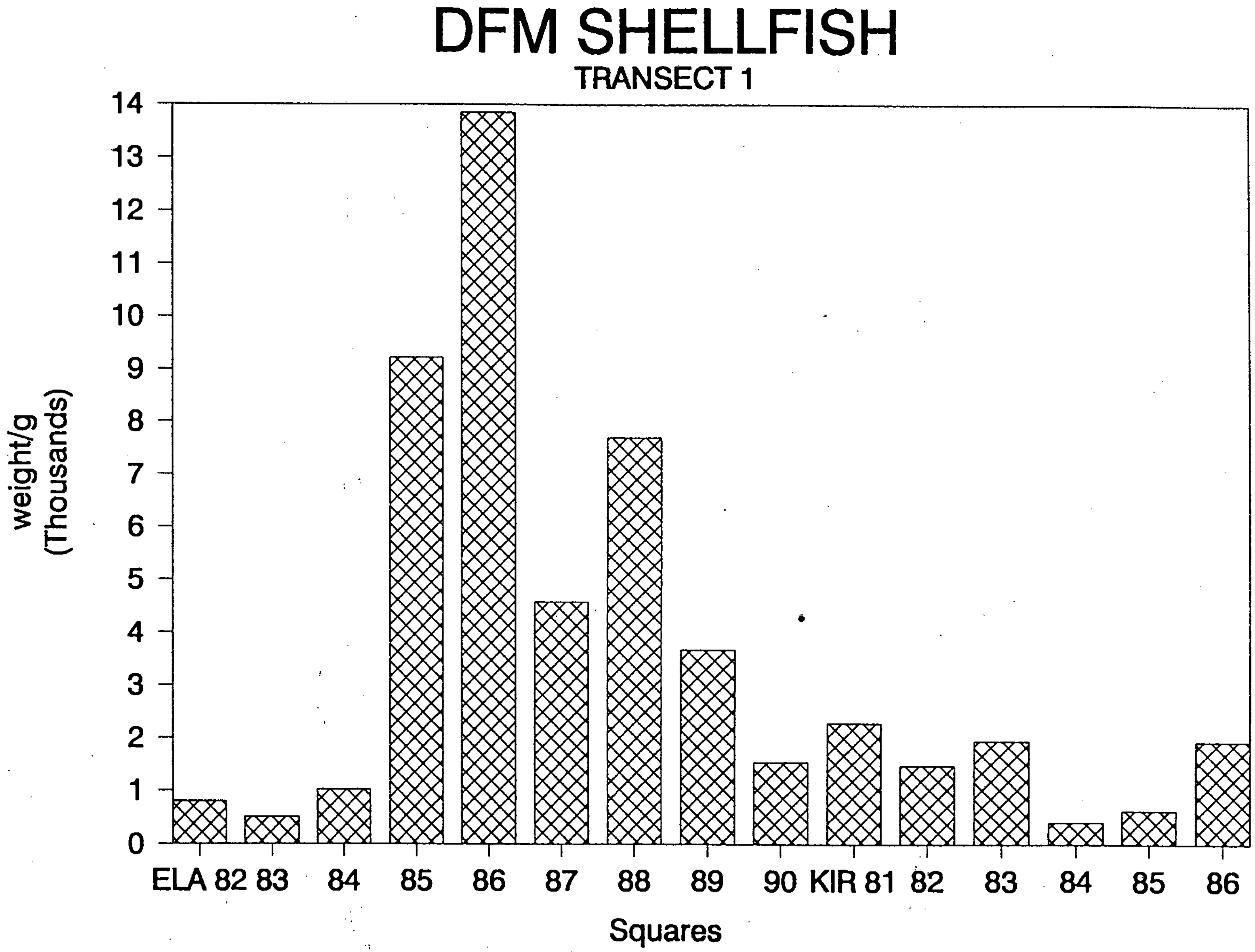

DFM SHELLFISH
TRANSECT 1
weight/g
(Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
ELA 82
83
84
85
86
87
88
89
90
KIR 81
82
83
84
85
86
Squares

Figure 17

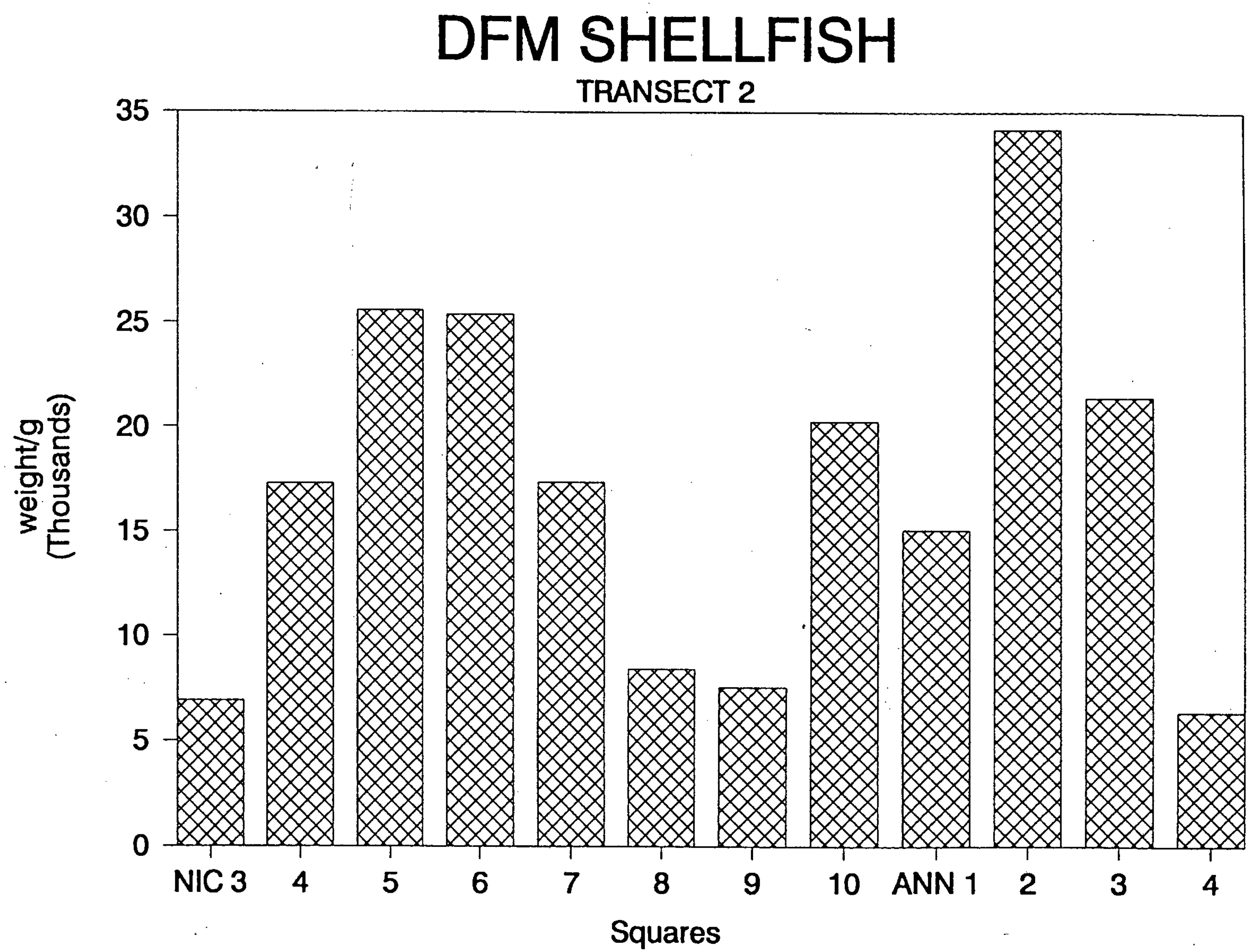

DFM SHELLFISH
TRANSECT 2
weight/g
(Thousands)
35
30
25
20
15
10
5
0
NIC 3
4
5
6
7
8
9
10
ANN 1
2
3
4
Squares

Figure 18

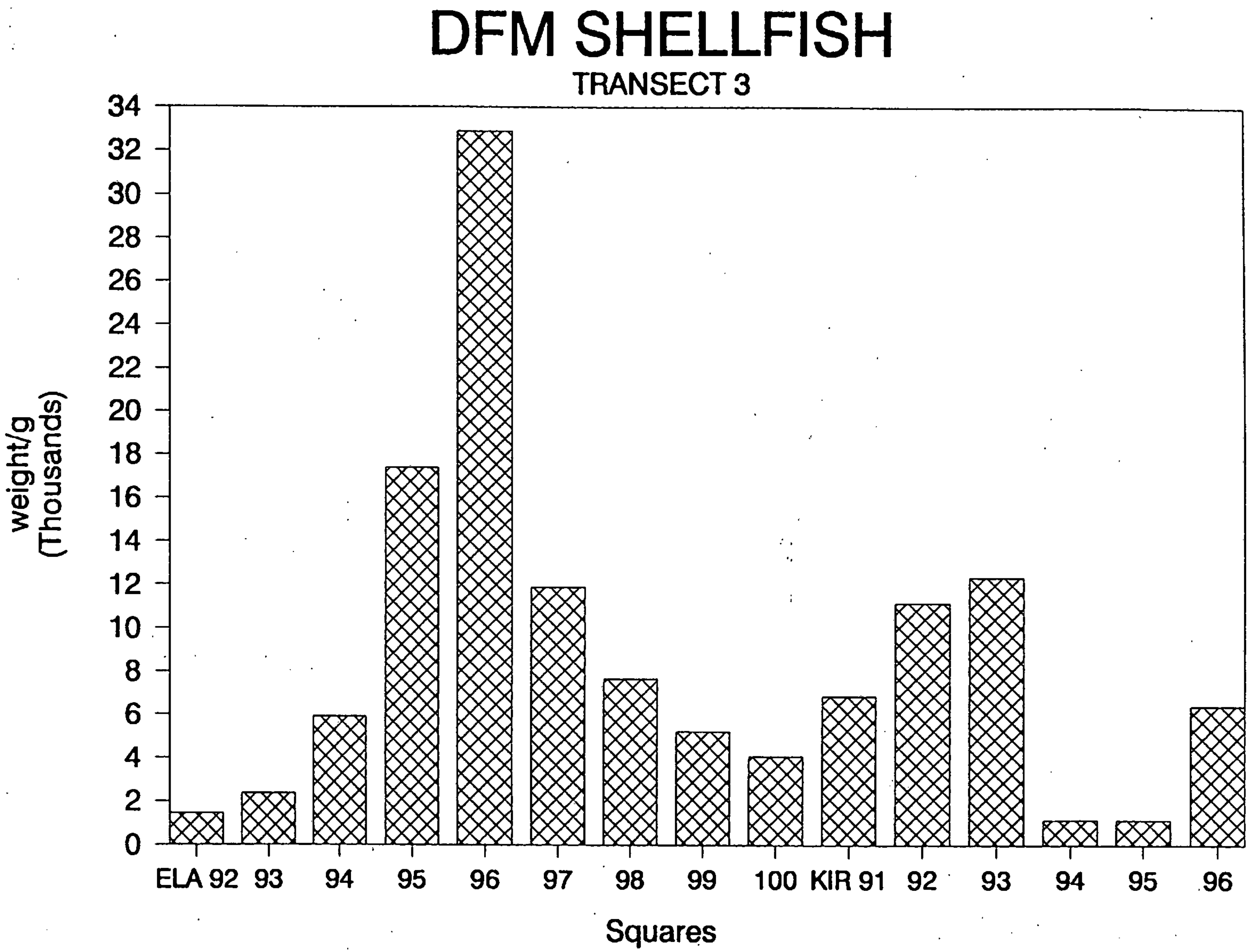
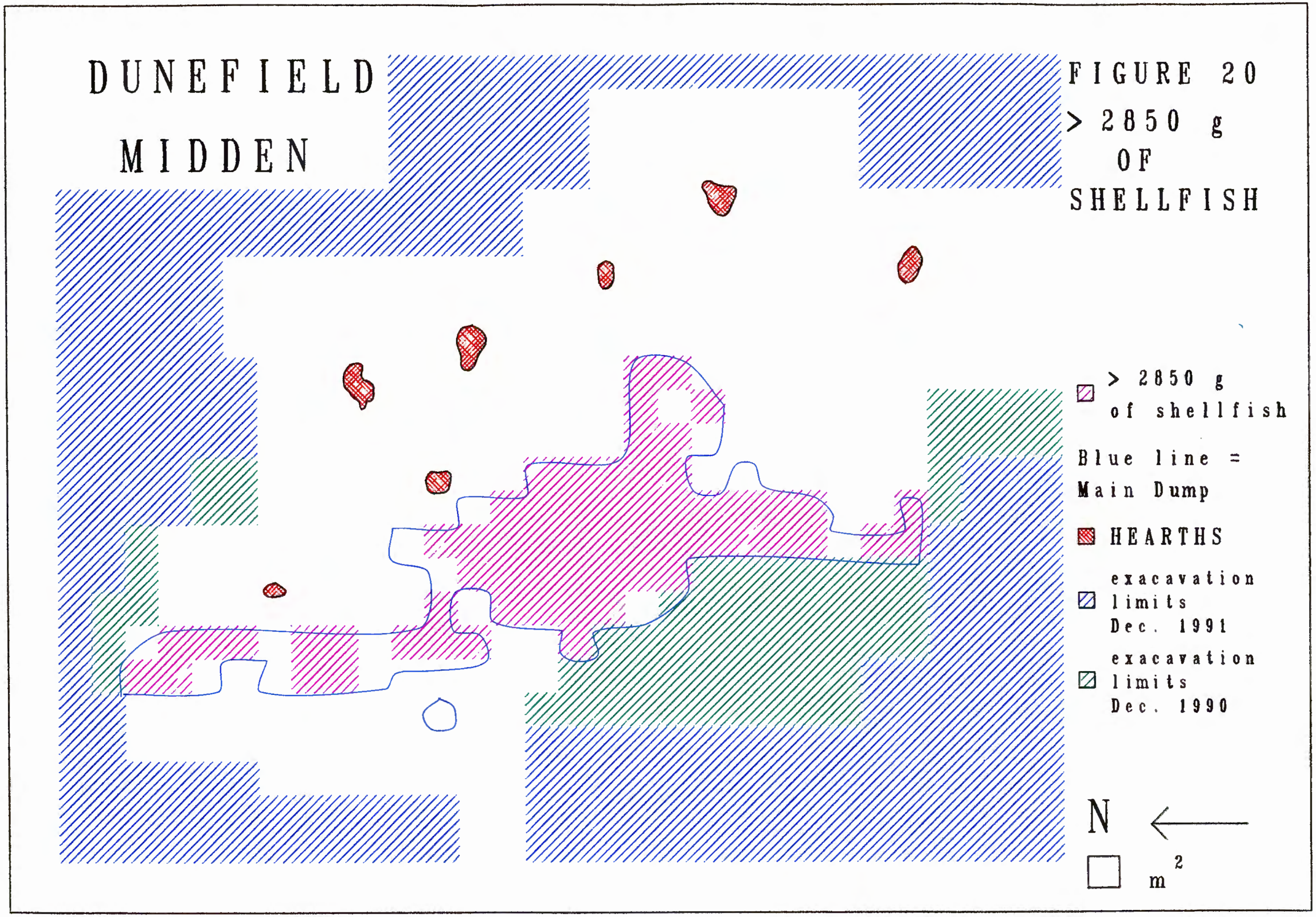

DFM SHELLFISH
TRANSECT 3
weight/g
(Thousands)
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
ELA 92
93
94
95
96
97
98
99
100
KIR 91
92
93
94
95
96
Squares

Figure 19

cover a fairly wide area, with its outlying edges tapering off and probably 'blurred' to some extent, as seen ethnographically (O'Connell 1987). Nevertheless a definition of the 'core' area of this feature was deemed necessary.

A suitable minimum weight was found to be 2000 g. All squares containing greater than 2000 g are continuous in the western part of the site, except for one square metre, separated from the other squares by one metre. The continuity of the squares supports the suggestion that these squares form part of a coherent feature. This feature covers most of the western part of the site (see Figure 11). The feature itself can be represented in other ways. Maps of different densities of shellfish illustrate the nature of this feature more clearly. For example, a map illustrating the distribution of squares containing greater than 2850 g of shellfish isolates four features (see Figure 20). The central, large feature is the main dump covering 49 m². The other three features are smaller dumps surrounding the main dump. There are two north of the main dump measuring 5 and 4 m² respectively and one south of the main dump, measuring 3 m². These smaller dumps contain slightly lower densities of shellfish than the main dump, nevertheless they still contain a significant weight of shellfish. They probably represent dumping episodes of the kind that made up the main dump, although slightly separated in space.

The spatial differentiation may be a result of differences in time, perhaps reflecting dumping towards the end of the occupation when the main dump was starting to grow too large. These smaller dumps may also result from the dumping behaviour of particular subgroups within the main group. The ethnographic records of Bleek and Lloyd (1911:275 - 285) refer to differential dumping such as that according to animal and body part amongst the hunter - gatherers in the Northern Cape in the


DUNEFIELD
MIDDEN
FIGURE 20
> 2850 g
OF
SHELLFISH
> 2850 g
of shellfish
Blue line =
Main Dump
HEARTHS
exacavation
limits
Dec. 1991
exacavation
limits
Dec. 1990
N
m 2

nineteenth century. It is therefore possible that some household groups or other subgroups may have dumped their items in different areas from others.

These smaller dumps seem to be related in some way to the main dump. They do not fall within the main area of hearths as determined in the previous section. Instead, they seem to be on the perimeter of the camp. They therefore do not seem to be the same features as the smaller dumps found within the main living area, especially in close proximity to shelters and hearths, mentioned above. They are probably similar to the perimeter dumps amongst the Efe, which are not always continuous (Fisher and Strickland 1991). As has been shown above these dumps are in fact continuous in the range of squares containing greater than 2000 g of shellfish.

Temporal Dimensions within the Main Dump

The existence of these different concentrations within the main dumping area leads to a question of determining differences in time within the context of this feature. The growth and formation of the main dumping area is necessarily an issue of great interest. Relative dating of different parts of the site has been attempted previously by using shellfish size as an indicator of occupation period (early or late) (Vermeulen 1990). The assumption underlying this argument is that people would have preferentially chosen the largest specimens of shellfish as food items. The selection of larger shellfish would have had an impact on the shellfish population. Within a relatively short space of time there would have been no large specimens left and people would have been forced to choose smaller and smaller individuals as food items. This method of collection would maximise energy expenditure for food mass gain.

Therefore areas of the site that relate to the first part of the occupation should contain shellfish that are generally bigger than those from the latter part of the occupation.

Possible arguments against this suggestion are that larger specimens of shellfish would have only occurred in deep water, thus requiring a greater expenditure of energy than collecting in the intertidal zone, or that the shellfish found at the site represent a random sample of sizes. A comparison of the Dunefield Midden shellfish sample with those present on the shore today answers both of these arguments. The shellfish transects recorded on the present shore and discussed in the first section provide a modern sample. The sizes of shellfish recorded in these transects show that large individuals are available high up on the shore. Specimens of *Patella granatina* measuring 80 mm were found 5 metres from the beach under rocks in pools. *Patella granularis* is generally found slightly higher up the shore than *Patella granatina* and specimens measuring 70 mm were found as close as 3 m from the beach. Therefore it would not have been necessary for people to go into deep water in order to collect large individuals.

The size of the limpets from Dunefield Midden in comparison with the size of limpets on the modern shore may be examined in order to determine whether or not the Dunefield Midden sample reflects a random selection of sizes. A comparison between the measurements of limpet length in millimetres for *Patella granatina* and *Patella granularis* is presented in Table 4. The numbers of individuals measured in each case is recorded in parenthesis next to the mean length. It can be seen that the mean length for limpets from the site of Dunefield Midden is greater in both species than the mean length for specimens recorded on the modern shore.

Table 4

Limpets: Mean Lengths

(means calculated for the site on means per square - therefore standard deviation does not apply)
(number measured in parenthesis)

	Dunefield Midden	Modern Shore
Patella granatina	52,19 (4913)	47,36 (1145)
Patella granularis	37,79 (4036)	29,76 (2870)

Size is a direct measure of the age of the limpets. *P. granatina* reaches a size of approximately 35 mm in its first year. After that it increases in size by a smaller amount each year, reaching a maximum size of about 93 mm in its seventh or eighth year, although larger specimens have been recorded in Eland's Bay, since the bay is stated to have a high nutritive content (Branch 1974b). *P. granularis* grows to about 18 mm in its first year. As with *P. granatina*, growth ceases in about the seventh year. Branch (1974b) records that many do not live longer than about four years, thus reaching a size of about 40 - 50 mm. However, once again larger specimens have been found in Eland's Bay, some measuring over 65 mm (Branch 1974b:170).

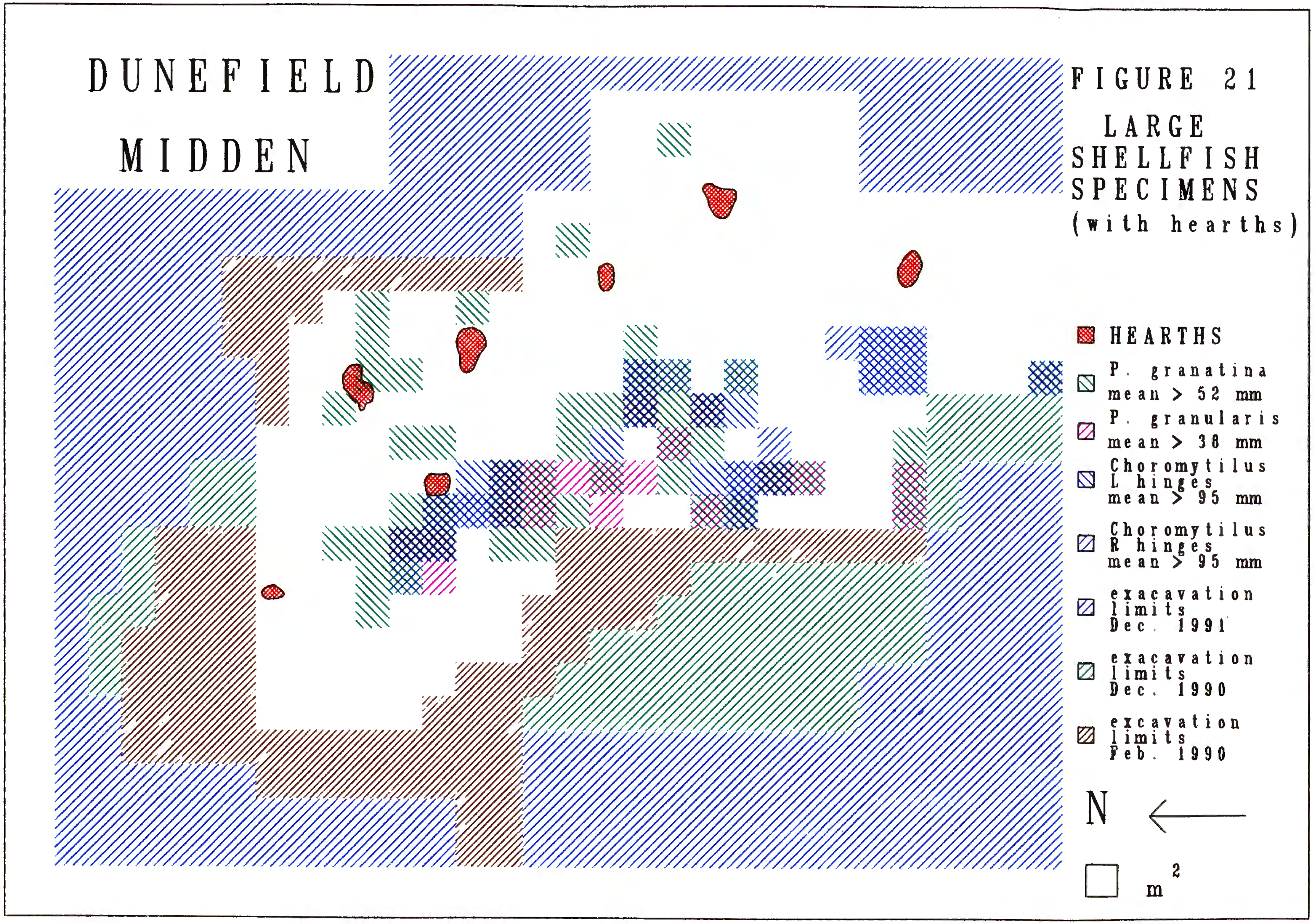
The difference in size between the archaeological and modern shellfish samples could have two possible explanations. It is possible that the modern shellfish are smaller due to a change in environment; pollution may inhibit growth rate or the nutritive content of the area may have decreased; there may be increased predation by marine animals or even people. However, this is not the most likely scenario, since the measurements given by Branch (1974b) include a sufficient sample of larger individuals, similar in size to those found at Dunefield Midden and the above explanation would therefore imply a change within the last twenty years. The more likely explanation is that the Dunefield Midden sample represents a preference for larger individuals, whilst the modern sample represents a random cross-section of the sizes available on the shore. If this is the case then it supports the argument that the inhabitants of the site preferentially chose larger individuals of the shellfish species. This behaviour would also maximise food return for least effort.

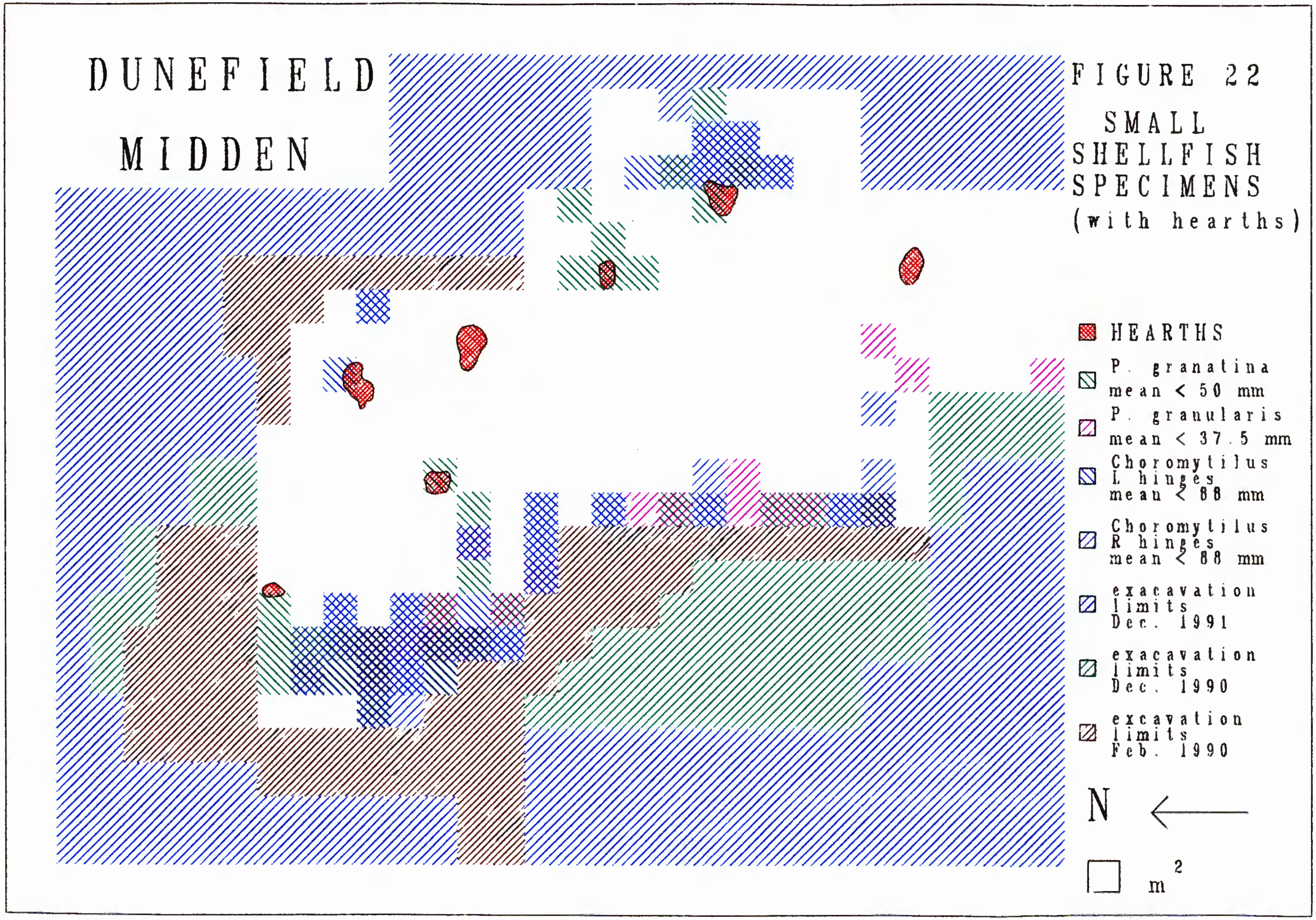
The patterning of limpet sizes should be particularly evident in the core area of the main dump, since presumably this part of the feature is of relatively early date. The patterning should also be consistent throughout the different shellfish species.

Determination of 'early' and 'late' areas with respect to stone tools was done on the basis of the sizes of the two main species of limpet, *P. granatina* and *P. granularis* (Vermeulen 1990). Experimental mapping of varying sizes of these shells using GIS was attempted in order to obtain the most coherent results. Only squares containing at least 10 representatives of each species were included in the sample, so that small sample size would not have an effect. For the species *P. granatina*, squares containing large specimens were determined as those with a mean size of larger than 52 mm in length and squares containing small specimens were determined as those with a mean size of less than 50 mm in length, these measurements being close to the mean length for the species. For the species *P. granularis*, squares containing large specimens were determined as those with a mean size of larger than 38 mm in length, while squares containing small specimens were determined as those with a mean size of less than 37,5 mm. Once again these measurements approximate the mean for that species.

The distribution of the squares determined according to the above measurements illustrated a fairly high degree of overlap between the large specimens of both species (see Figures 21 and 22). This was also true for the distributions of the small specimens. Furthermore, the different size distributions seemed relatively spatially separated from each other. Large specimens seem to be clustered in the central part of the site, whilst smaller specimens are distributed in the more easterly and westerly parts of the site. Unfortunately this information is not complete as measurements are not yet available of the most western and northern parts of the site illustrated on the maps.

Specimens from another important species on the site, the mussel species, *Choromytilus meridionalis*, were added to the distributions of different size classes. Squares containing large specimens of this species were determined as those with a mean size of greater than 95 mm (once again with a minimum number of 10


DUNEFIELD
MIDDEN
FIGURE 21
LARGE
SHELLFISH
SPECIMENS
(with hearths)
HEARTHS
P. granatina
mean > 52 mm
P. granularis
mean > 38 mm
Choromytilus
L hinges
mean > 95 mm
Choromytilus
R hinges
mean > 95 mm
exacavation
limits
Dec. 1991
exacavation
limits
Dec. 1990
excavation
limits
Feb. 1990
N
m 2


DUNEFIELD
MIDDEN
FIGURE 22
SMALL
SHELLFISH
SPECIMENS
(with hearths)
HEARTHS
P. granatina
mean < 50 mm
P. granularis
mean < 37.5 mm
Choromytilus
L hinges
mean < 88 mm
Choromytilus
R hinges
mean < 88 mm
exacavation
limits
Dec. 1991
exacavation
limits
Dec. 1990
excavation
limits
Feb. 1990
N
m 2

individuals). Squares containing small specimens were determined as those with a mean size of less than 88 mm. Once again both of these measurements surround the mean, although by a larger margin than in limpets, because of the larger mean sizes of the mussels.

Maps of the distributions of large specimens of both limpets and mussels support the distributions discussed above (see Figure 21). In the central part of the site there is a fairly high degree of overlap between the three species. There are additional features, however. An area in the northern part of the site is characterised only by large limpet species. Similarly an area in the southern part of the site is characterised only by large mussel specimens. This suggests that the overlap in the central part of the site relates to dumping behaviour, whilst the species-specific clusters may relate to differential processing. All three clusters (central, northern and southern) are within a metre and a half of hearths (the limpets being closer than mussels).

Maps of the distributions of smaller specimens of the three species indicate a fairly high degree of overlap in the western part of the site (see Figure 22). Once again this suggests that this is the result of dumping behaviour. There are also species-specific clusters of shellfish. The two limpet species form clusters in the eastern part of the site, whilst there is a cluster of mussels near the concentrations of all three species in the western part of the site. A spatial autocorrelation test was run on the distributions of both large and small sizes of limpets and mussels. This method tests for randomness in the patterning of the distribution. In both cases the distributions were found to be non - random with test statistics (z) of -10 and -8 (see Appendix A), these are significant at $p = <0{,}001$.

individuals). Squares containing small specimens were determined as those with a mean size of less than 88 mm. Once again both of these measurements surround the mean, although by a larger margin than in limpets, because of the larger mean sizes of the mussels.

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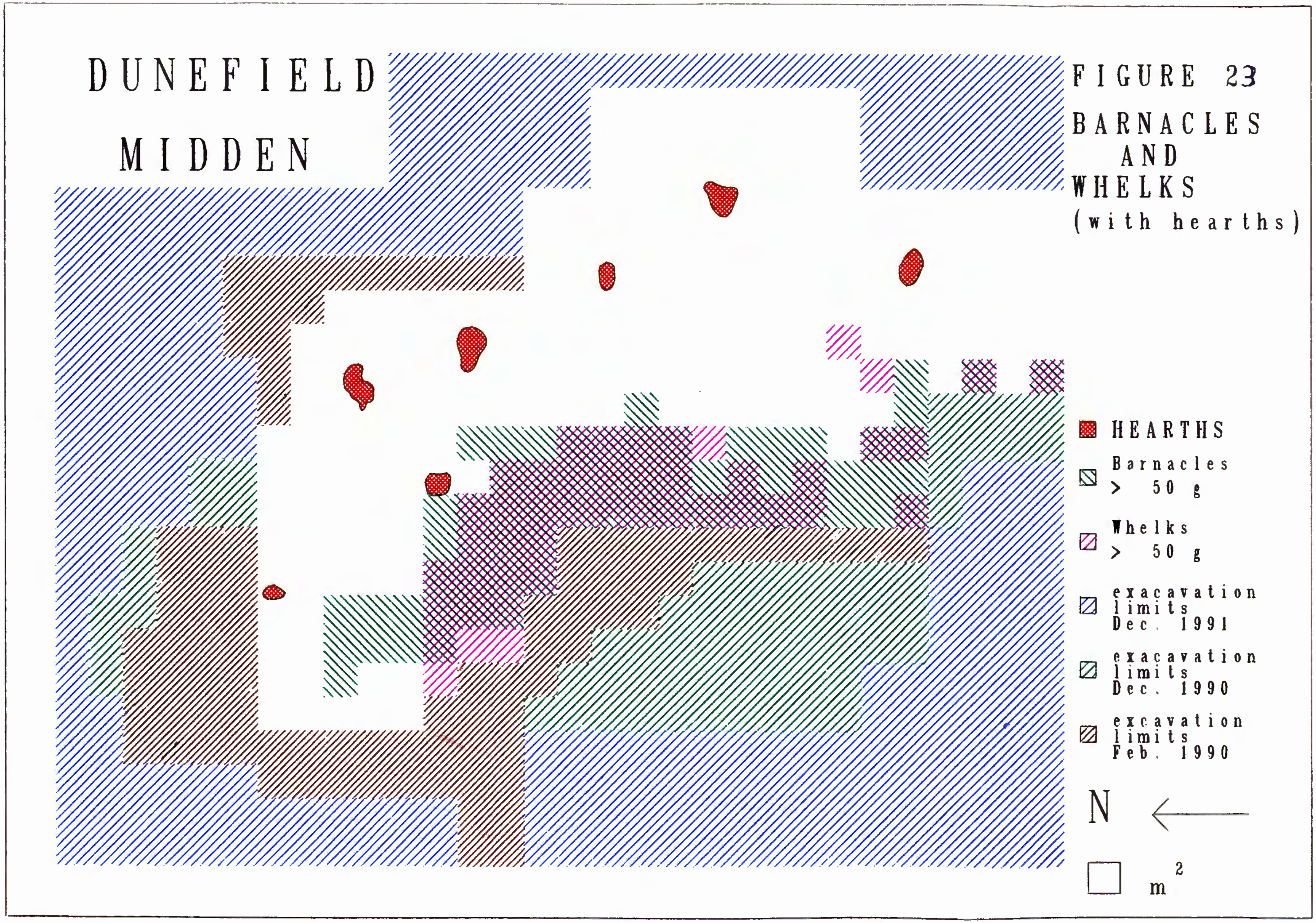
Maps of the distributions of smaller specimens of the three species indicate a fairly high degree of overlap in the western part of the site (see Figure 22). Once again this suggests that this is the result of dumping behaviour. There are also species-specific clusters of shellfish. The two limpet species form clusters in the eastern part of the site, whilst there is a cluster of mussels near the concentrations of all three species in the western part of the site. A spatial autocorrelation test was run on the distributions of both large and small sizes of limpets and mussels. This method tests for randomness in the patterning of the distribution. In both cases the distributions were found to be non - random with test statistics (z) of -10 and -8 (see Appendix A), these are significant at $p = < 0{,}001$.

These distributions suggest a division of the main dumping area into 'early' and 'late' areas. The 'early' area is situated in the central part of the site, in other words the western part of the dump or the core area of the main dump. The 'late' area of the dump seems to be the eastern, northern and possibly the extreme southern fringes of the dumping area. This distribution is not very clear because of a lack of information for most of the eastern and northern parts of the dumping area, nevertheless the trends indicated in the distribution suggest this patterning.

If these suggestions are correct then it would mean that the core area of the main dump is earlier than the subsidiary dumps to the north and south. This idea would support the suggestion that these smaller dumps grew up once the main dump grew too large. It is also possible that the proximity of the northern end of the dump to the westernmost hearth indicates that this hearth had been abandoned by the time refuse was dumped in this area. This is possible since the ethnoarchaeological records report that the populations of campsites are not static and that people leave or join the group during the course of the occupation (Yellen 1977).

The distributions of barnacles and whelks (in squares containing more that 50 g of either species), closely parallels the position of the core area of the main dump (see Figure 23). The spatial autocorrelation test gives a test statistic (z) of -16 (see Appendix A). This result is extremely significant, at p = <0,001. The strong correlation between these items and the main dump suggests that these items were collected early in the occupation. It is, however, unlikely that barnacles were collected for their own sakes. Smaller barnacles seem to have been introduced on the backs of limpets, whilst the larger barnacles (*Austromegabalanus maxillaris*), seems to have been introduced to the site on the backs of mussels. This fact combined with the relatively large size of the mussels suggests that the foraging patterns may have been more



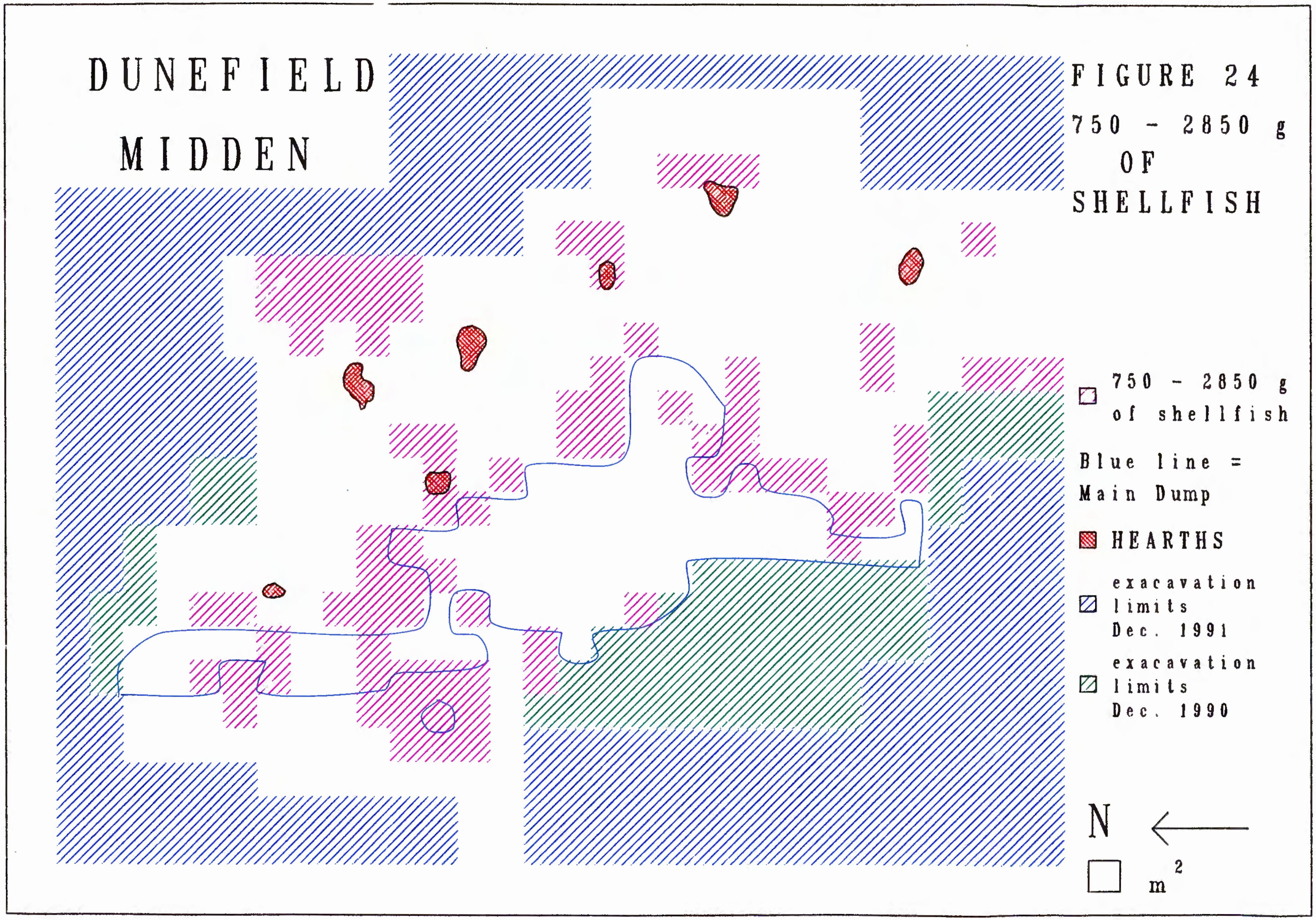
DUNEFIELD
MIDDEN
FIGURE 23
BARNACLES
AND
WHELKS
(with hearths)
HEARTHS
Barnacles
> 50 g
Whelks
> 50 g
exacavation
limits
Dec. 1991
exacavation
limits
Dec. 1990
excavation
limits
Feb. 1990
N
m2

complex than simple gathering on the rocky coast. This will be examined further below in the section on behaviours.

Satellite Dumps

As mentioned above other features of ethnographic campsites are the smaller dumps in between hearths and structures. These will be referred to as satellite dumps. It is expected that the site of Dunefield Midden would also exhibit these features. Since shellfish have been used as the major distinguishing feature of the main dump, they may be used to suggest the presence of smaller dumps (cf Meehan 1982). A dump will be characterised by a relative concentration of material, either within one metre square or within adjacent squares. Small dumps characterised by shellfish must necessarily contain less than 2000 g of shellfish, since all squares containing greater than this amount form the main dump and subsidiaries discussed above. The dumps must also be large enough to warrant the description 'concentration'. In order to define this minimum, maps were made of the distribution of shellfish across the site by weight using GIS. It was found that discrete areas of shellfish began to appear at about 750 g. In quantities below this weight shellfish occur generally across the site. 750 g is also regarded as a reasonable minimum by which to define a 'concentration'.

A map of the distribution of squares containing between 750 g and 2850 g of shellfish demonstrates the issue mentioned above of an area of spread or 'blurring' surrounding the main dump and its subsidiaries (see Figure 24). Over half the squares in this distribution are immediately adjacent to the main dump and its subsidiaries. It is not felt that these are the satellite dumps referred to in the ethnoarchaeological records. Therefore, it was necessary to attempt to minimise the inclusion of squares on the


DUNEFIELD
MIDDEN
FIGURE 24
750 - 2850 g
OF
SHELLFISH
750 - 2850 g
of shellfish
Blue line =
Main Dump
HEARTHS
exacavation
limits
Dec. 1991
exacavation
limits
Dec. 1990
N
m 2

edges of the dump from the analysis of smaller dumps. This was done by lowering the upper limit of shellfish weight included in the distribution. Most of the squares containing just less than 2850 g of shellfish are found on the edges of the main dump and its subsidiaries. Therefore it was possible to lower this upper limit to 1800 g without affecting the number of squares indicated in other areas of the site.

The regression analysis of the shellfish discussed in Appendix B demonstrated that squares containing between 1600 and 1800 g of shellfish were of interest. They are relatively isolated from other squares in terms of weight, as well as spatially. They seem to form a coherent group and thus can provide the starting point for a search for small dumps close to hearths and structures. Two of these squares are adjacent to squares containing greater than 2850 g of shellfish. These two squares probably reflect the spread or 'blurring' of the main dumps mentioned above. The others lie within the part of the site characterised by hearths (see Figure 13). There are no remains of structures evident at Dunefield Midden, therefore the small dumps were examined for their proximity to hearths. In all cases except the squares adjacent to the main dump, the small concentrations of shellfish are within 2 m of a hearth or roasting pit. However, not all hearths or roasting pits are associated with shellfish concentrations.

The ethnoarchaeological accounts mentioned above describe the small dumps near hearths and structures as combining a cross-section of items, but most especially those items associated with the activities performed in the immediate area. It was therefore expected that if the shellfish dumps are the results of the consumption of food in the immediate area, they would be found in the same place as concentrations of other food items. However, distributions generated on GIS show very little coincidence with concentrations of the bones of fish, snake, tortoise or lobster. One of the squares containing 1600 - 1800 g of shellfish also contains lobster mandibles in ranges in the upper 30 % of the sample (i.e. with an index number of greater than 80). Similarly two of the squares containing 1600 - 1800 g of shellfish also contain tortoise plastron fragments in the same ranges and one of these squares is the same as the one containing lobster mandibles. This low amount of coincidence means that the remains of fish, snake, lobster, tortoise and shellfish were generally not discarded in the same places, and were possibly not consumed in the same places or at the same time. Nevertheless the squares containing concentrations of these food items do occur within the same general area between the hearths.

The dumping of ash from hearths is argued to be a basis for many of the dumps in the ethnographic campsites. The main dump contains much ash which suggests that a similar behaviour may be expected at Dunefield Midden. However, there is not a high degree of coincidence between the features named ash dumps in the previous section and squares containing 1600 - 1800 g of shellfish. This is also true of squares containing the bones of fish, snake, tortoise and lobster.

It may be concluded that the squares containing between 1600 and 1800 g of shellfish do not form the basis for small dumps containing a cross-section of items including ash. It was therefore felt to be necessary to consider the squares containing shellfish in the range 750 g to 1800 g, in order to test whether satellite dumps occurred where there were smaller concentrations of shellfish.

As may be expected since this classification includes more squares than the previous one, there is a slightly greater association between squares containing shellfish in the range 750 to 1800 g and hearths, roasting pits and ashdumps. In some cases the shellfish squares overlap with the hearths, whilst in most cases the squares are adjacent to the hearths or roasting pits. The distribution is very similar with respect to ashdumps. Thus some of the overlap with ashdumps may be related to dumping behaviour, although this is not definite because of the overlap with hearths as well. The distribution may also be taken as support for the idea that some of the ashdumps represent smaller hearths, perhaps not reused as frequently as the larger concentrations of ash and charcoal, termed hearths.

Overlapping the squares containing shellfish in the range 750 to 1800 g with fish, snake, tortoise and lobster was attempted with the latter categories in two ranges. Firstly, the distributions were mapped with the faunal remains with an index number of greater than 20 out of a possible maximum of 255. This was done in order to obtain a clear idea of the spread of these items, whilst eliminating the 'noise' of the lower part of the sample. The small fauna exhibited a greater degree of overlap between their own categories than with shellfish and the overall map displayed a spread of items across a large part of the site, especially in the northern area.

The distribution of shellfish between 750 and 1800 g and fish, snake, tortoise and lobster with index values of above 160 out of a possible maximum of 255 (in other words the top values), gave a clearer illustration of the above pattern. There was very little overlap between shellfish and the small faunal categories, as well as very little overlap between the categories themselves. In three squares shellfish overlapped with tortoise plastron fragments and in one of these squares shellfish also overlapped with lobster. This small amount of coincidence would imply that these were generally not discarded in the same place. If these are all items of human consumption, this would also mean that they were either not eaten in the same place, or that if shellfish were eaten in the same place as any of these other items, they were discarded differently.

It is possible that a far clearer distribution would emerge from overlaying the distribution of the shellfish with that of the larger fauna, such as eland, seal and steenbok. As stated above these animals and their distributions at Dunefield Midden are being studied by Nilssen and so maps of the distribution these fauna will not be presented here.

As a result of an examination of the distributions presented above it is possible only to conclude that at this stage of the analysis there does not seem to be any indication of the generalised satellite dumps containing many kinds of refuse mentioned in the ethnoarchaeological records (Fisher and Strickland 1991). There are four possible explanations for this lack. One is that the faunal remains examined above were either of non-human origin or were of sufficiently small size that they were not discarded onto refuse dumps in the same way that shellfish, being larger and more of a hindrance underfoot, were discarded. These possible explanations should be indicated by an examination of the distribution of larger faunal remains. If the larger bones are found to coincide with the shellfish, it would support this explanation.

The second explanation is that there were no satellite dumps in the area of the site characterised by hearths. This is felt to be unlikely since much of the other discard behaviour represented at the site closely parallels that found in the ethnoarchaeological record, however it is possible. This explanation too can be verified by an examination of the distribution of the bones of the larger animals. If the latter are not strongly associated with the concentrations of shellfish, then it would support this explanation.

The third explanation is slightly more complex. The pattern of satellite dumps in the area of the hearths and larger dumps on the periphery of the camp may be slightly obscured by the debris left during the last few days of the occupation. Fisher and Strickland (1991:223) suggest that in the case of the Efe there is no "campsite maintenance" during the last few days or hours of the occupation. In other words when the people know that they are leaving the campsite they do not bother to discard things on the refuse dumps, but leave them in place. Food debris and other items are left around hearths or elsewhere in the general activity area. It is possible that the smaller dumps near the hearths had been cleared away onto the main dumps, as occurs periodically (O'Connell *et al.* 1991), immediately before the decision was made to abandon camp. In this case, all that would remain would be the main dumps and a general scatter of debris across the rest of the site. Once again this explanation will either be supported or contradicted by the distributions of the larger animal bones.

The fourth possible explanation is that the concentrations of shellfish and other material mentioned above are in fact refuse dumps, although specialised in the kind of refuse deposited in them. In other words there are shellfish dumps, tortoise plastron fragment and limb bone dumps, fish bone dumps etc. Specialised dumps are contrary to the pattern found in the ethnoarchaeological record of generalised dumps, but nevertheless may be the pattern at Dunefield Midden. This explanation will also be verified by an examination of the larger faunal remains.

Conclusions

Dunefield Midden therefore does have evidence of refuse dumps. However, these are large and occur in the western part of the site. There does not seem to be any evidence at this stage for the presence of generalised satellite dumps associated with hearths, although more concentrations of discrete types of remains are found close to hearths in some instances. The presence of refuse dumps suggests that the occupation of the site was longer than the very short term stops mentioned in the ethnoarchaeological records (Yellen 1977 Bartram *et al.* 1991). In other words the occupation was longer than an overnight stop or transitory campsite occupied for a couple of days. This may also be deduced from the amount of debris, especially food remains, on the site (see section 'Campsite Classification' below).

It may also be argued that there was some campsite maintenance behaviour, which created the refuse dumps. These dumps contain ash, as well as a cross-section of items found on the site. The relatively larger items are represented in the largest concentrations within the dumps. Cultural items, such as tortoise carapace bowls, stone tools, ostrich eggshell waterbottles and pieces of pottery, which occur in the dumps, are generally broken, implying that they were discarded as no longer of use.

The pattern of refuse disposal at Dunefield Midden seems closest to that at the Kua cool, dry season camps mentioned above (Bartram *et al.* 1991), although ashdumps seem to be present which were not recorded at these camps. The Kua camps are situated in an area designated as Sandveld, which is the same designation as the area in which Dunefield Midden is situated. However, an important difference is the location of Dunefield Midden on the coast, with the importance of marine resources, especially shellfish, perhaps altering the nature of the camp. An examination of the larger faunal remains from the site will hopefully reveal whether shellfish merely augmented the diet in the same way as other animals inland, or whether the shells were discarded differently from bones.

Layout

The definition of campsite layout is important in determining the nature of social interactions within the group. In the ethnoarchaeological literature, layout is discussed with respect to the placement of structures and refuse dumps and the existence of areas clear of debris, within the campsite. At the site of Dunefield Midden, there is no direct evidence for structures. To a large extent, therefore, this section will deal with things which 'are not there' . This is in contrast to the preceding sections, which have discussed the implications of features common to both the ethnographic literature and the site of Dunefield Midden. As stated before, both similarities between the site and the ethnoarchaeological literature, and differences between the two, are considered important for interpretation. This section may therefore be seen as a more direct attempt to identify difference than the two previous sections have been.

Structures

Structures are very important features of campsites in the ethnoarchaeological literature. Both spatial and social factors are closely linked to the placement of structures within a campsite. Some of these factors are kinship (see for example Binford 1991) and social notions of distance, both in terms of interpersonal space and perceived social differences between people (Gamble 1991 Whitelaw 1991); whilst others may be seasonal or climatic factors (Yellen 1977). It is therefore important to address this issue with respect to archaeological campsites in order to gain access to information regarding social, environmental and other spatial factors. Ethnoarchaeological observations of structures will be discussed at greater length here because of the lack of direct evidence from the site. The ethnographic information therefore illustrates possibilities. Structures are represented in the ethnoarchaeological literature in many different forms, with additional ones being known from the historical record, however studies of the placement of structures (Yellen 1977 Fisher and Strickland 1991) allow some generalisations to be made. These generalisations may be applied to the site of Dunefield Midden, although there is no direct evidence for structures from this site.

Ethnographic Structures

Structures reported in the ethnoarchaeological, ethnographic and historical records amongst hunter - gatherer and similar groups range from large, permanent buildings to rough meshings of branches to form windbreaks. Differences between the kinds of structures present at particular sites are partly influenced by climatic and environmental factors. In some areas and particularly at certain times of the year strong structures are required to protect people from the weather conditions. An example of this is the sod houses constructed by Nunamiut groups at winter camps in Alaska (Binford 1991). These structures are sometimes reused over several seasons by people returning to the same area. More favourable weather and climatic conditions, such as at certain times of the year in Southern Africa, require less sturdy measures and people may require nothing more than a simple screen to deflect wind (Yellen 1977 Bartram *et al.* 1991).

Sturdily built, relatively large, permanent structures would usually survive well into the archaeological record. Since the site of Dunefield Midden shows no evidence of such structures, it may be concluded that they were not present. This is supported by what is known of the climate at the time of occupation, which is thought to have been fairly similar to the present i.e. hot, dry summers and cool, fairly wet winters. Although the rainfall pattern is somewhat different, the range in temperature is similar to that found in the Kalahari and areas of Botswana mentioned in the ethnoarchaeological literature. It is therefore expected that the form of the structures, which seem to be largely related to climatic variables, would have been similar to the ones found in Botswana and the Kalahari.

The structures made in these areas are constructed from branches and wooden poles (Yellen 1977 Bartram *et al.* 1991). Since there is no survival of organic material such as wood at Dunefield Midden, it is possible that structures of these materials were present at the site although no evidence of them remains. These structures vary according to season. As may be expected, there is a greater need for shelter in the rainy season than in the dry season. Temperature also has an influence on the need for more protective shelters. Yellen's (1977) work amongst the !Kung San in Botswana revealed that camps were occupied for short periods during the rainy season and were small and widely scattered. During the dry season camps were larger and more permanent. Structures, therefore, in the latter camps were well constructed huts, evenly arranged. In the former camps there were fewer huts and sometimes only rudimentary structures were made if there was no rain. Since the dry and wet seasons represent winter and summer respectively it will be seen that the construction of larger structures also coincided with lower temperatures.

Bartram *et al.* (1991) report a similar pattern amongst the Kua San in Botswana, although they name three 'seasonal' variations. These are rainy season camps, hot, dry season camps and cool, dry season camps. Rainy season camps are small, often only individual household groups and may have only a single shelter or even only a windbreak. Cool, dry season camps are also fairly small representing aggregations of a few nuclear families. Huts are characteristic of these two kinds of camps. The huts are constructed of poles and branches, covered with brush and grass. Hot, dry season camps amongst the Kua are larger than rainy or cool, dry season camps. They represent the campsites of groups of households gathered near a borehole or other water source. Windbreaks and shade platforms are the characteristic shelters of a hot, dry season camp. Occasionally huts are constructed towards the end of the season (which precedes the rainy season) if rain is anticipated. The shade platforms mentioned are storage platforms constructed at some height from the ground and therefore provide a shaded area where people can shelter from the sun (Bartram *et al.* 1991).

This seasonal variation in structure type has relevance for the site of Dunefield Midden. Since the occupation of the site does not seem to span a length of time greater than one season at the most (see section 'Campsite Classification' below), it is possible that the type of structure could be inferred from the season of occupation. At this stage of the analysis the season of occupation has not yet been determined (although winter is suggested, Parkington pers. comm.) so it is not possible to suggest exactly which type of structure would have been constructed at the site. Nevertheless windbreaks occur at nearly all types of sites, even when huts are present, so it may be suggested that windbreaks were present at the site.

There is a further type of structure which may have been used at Dunefield Midden. The historical records of the South Western Cape record that the pastoralist people who inhabited the area made structures from poles covered with mats. These mat houses or "matjeshuise" could be constructed quickly since the mats were transported by oxen. The mat houses were arranged in a roughly circular pattern, enclosing a central open space. Placement of the structures was determined by kinship and status (Parkington and Mills 1991). It is possible that the inhabitants of Dunefield Midden were pastoralists and that they therefore made structures of this kind. Since the mats were made of organic material and were transported with the people, there would not be any direct evidence if these structures had been present.

It is, however, felt to be unlikely that the inhabitants of Dunefield Midden were pastoralists. Certainly their food remains indicate a hunting and gathering way of life. The size of the mat houses also makes it unlikely that they could have been arranged between the hearths at Dunefield Midden. The diameters of these structures were 3 to 8 m. Since the average spacing between hearths at Dunefield Midden is about 5 m, a structure with a 3 m diameter would be the largest that could possibly fit into that area. Furthermore, there is the evidence of the potsherds, implying that the inhabitants of the site could not themselves make pottery (making pottery is a characteristic of pastoralist people in the area) (Nilssen 1989). There is also no evidence for a difference in status between different members of the group. As suggested by the section on hearths above, differentiation between the hearths seems to be activity related rather than a representation of differential access to items. Therefore it seems more likely that the structures used at the site were of a kind similar to those mentioned in the ethnoarchaeological literature of hunter - gatherers.

Structures are also important features because they are very clearly involved in what Whitelaw (1989) terms 'perception'. He argues that features block people's ability to perceive each other, that is they are hindrances to sight and, to some extent, to hearing. Thus the placement of structures clearly indicates the society's attitudes to perception. Where social distancing is emphasised structures are used to isolate; where intimacy is encouraged and the closeness of the group is emphasised structures are used to include people into a cohesive area. The arrangement of the structures, Whitelaw (1989) argues, is therefore an important means of understanding the underlying social interaction between members of the group.

The arrangement of structures within a campsite has been studied by several authors. Yellen (1977) constructed models based on a circular arrangement of structures within a campsite. He stated that the circular arrangement was regarded as an ideal amongst the people themselves (Yellen 1977). The circular arrangement enclosing a central open space was regarded as a standard amongst hunter - gatherer groups. However, this model was later questioned. Whitelaw (1991) in a study of 800 communities around the world divided campsite arrangements into four types: random; clustered; circular and linear. These arrangements tended to vary with duration of occupation. At campsites occupied for a number of days most of the arrangements of structures were random. Those occupied for a number of weeks were mostly circular, although a large number were also clustered. Campsites occupied for several months were also mostly random, although there were large numbers of clustered and circular camps as well. Permanent campsites were mostly clustered, a large number were random, several were linear and only two (out of a total of 264) were circular. Corrected for differing sample sizes by duration, most of the random camps were occupied for days; the largest number of clustered and linear camps were permanent; while most of the circular camps were for occupations of weeks.

However, as mentioned in the section on ash features above, the Dunefield Midden hearths may be interpreted as having either a circular or a linear arrangement. It was therefore suggested that the definition of front and back areas would be a more useful indicator of campsite layout. The definition of front and back areas would be determined by the alignment of features such as hearths, dumps and structures. Hearths being predominantly in front of structures and dumps behind (Fisher and Strickland 1991).

The distances between structures and other features of campsites has been looked at by Fisher and Strickland (1991) amongst the Efe of Central Africa and by Nicholson and Cane (1991) amongst Australian Aborigines. These studies represent forest and desert environments respectively. Fisher and Strickland (1991) found that refuse dumps were situated behind or to the side of huts. The huts themselves were situated on the perimeter of the camp or infrequently, within the central open area. Most had at least one interior fire and one exterior fire situated near the door (however, Fisher and Strickland (1991) report that Yellen's (1977) sites did not have interior fires). The average distance between huts was 4,8 m. 66% of the sample were within 5 m of each other and only 4% were more than 10 m apart (Fisher and Strickland 1991:221). Nicholson and Cane (1991) found that most artefacts were within 1 to 2 m of the windbreaks. Stone artefacts were 1,2 to 1,35 m away from windbreaks and about 1 to 2 m from hearths (Nicholson and Cane 1991:340). The measurements may be compared to the patterning of items at Dunefield Midden in order to reveal likely areas for structures. It may also be possible to identify the possible alignment of the structures, thereby revealing the front/back dimension.

Dunefield Midden Structures

Possible Placement of Structures

The association of hearths and refuse dumps has been discussed in the section on dumps above. Since there is no direct evidence for small refuse dumps other than within the main dump, the association between these two features is not strong. This makes the identification of structures potentially difficult according to the Fisher and Strickland (1991) model. Nevertheless it is thought likely that structures would have been placed near hearths, especially if hearths are assumed to be analogous to households. It would therefore be inaccurate to discuss the implications of the placement of structures, when they are inferred from the presence of hearths. Layout with respect to hearths has been discussed in preceding sections. An attempt to trace alignment of structures between hearths and concentrations of items suggests a westerly or southwesterly orientation for the northern hearths.

Concentrations of artefacts, especially stone, around these hearths, coincide with either the concentrations of animal remains or the hearths themselves. If the structures were situated between the concentrations and the hearths, or slightly to one side of them, it would conform well with Nicholson and Cane's values for artefact to hearth and artefact to structure distance given above. The distributions of bone, however, plotted to the nearest centimetre, seem to exhibit more convincing evidence for the possible placement of structures. Some of these distributions show arc-shaped clear areas close to hearths, suggesting the presence of a windbreak (Nilssen pers. comm.). The presence of gnawed bone will add to this discussion. It would be assumed that gnawing of bones by carnivores would have taken place behind the structures since carnivores do not seem to have been encouraged in the camp (cf Walters 1984 for the actions of dogs at Australian sites). Final suggestions as to orientation of possible structures will therefore be left to the discussions of others.

Distance between Structures

Since the presence of structures is inferred from the positions of hearths and concentrations of food items, a value for structure to structure distance is not obtainable. However, hearths are interpreted as being associated with possible structures, and the hearth to hearth distance discussed in the section on hearths above may be taken as a rough guide to possible distance between structures. It is therefore not useful to repeat the arguments given for hearth spacing given in the section on hearths above. It would be a circular argument to use hearths to infer structures and then use structures to support the values for hearths.

Conclusion

The existence and positioning of structures at Dunefield Midden has been discussed. The presence of some form of structure is thought likely even if only windbreaks. The possible position of these structures has been related primarily to the placement of hearths, as well as the presence of concentrations of food items.

The definition of site layout may be related to the existence of a 'central open area'. This area may have been the focus for activities, including ones such as dances. The following section will examine the site for evidence of open areas. Nicholson and Cane (1991) found that the only areas free of artefacts at the Australian Aboriginal sites which they studied were sleeping areas. Sleeping areas are often within or beside structures (Yellen 1977). Therefore the identification of open areas may support the evidence for possible structure positioning at Dunefield Midden.

Central Open Area

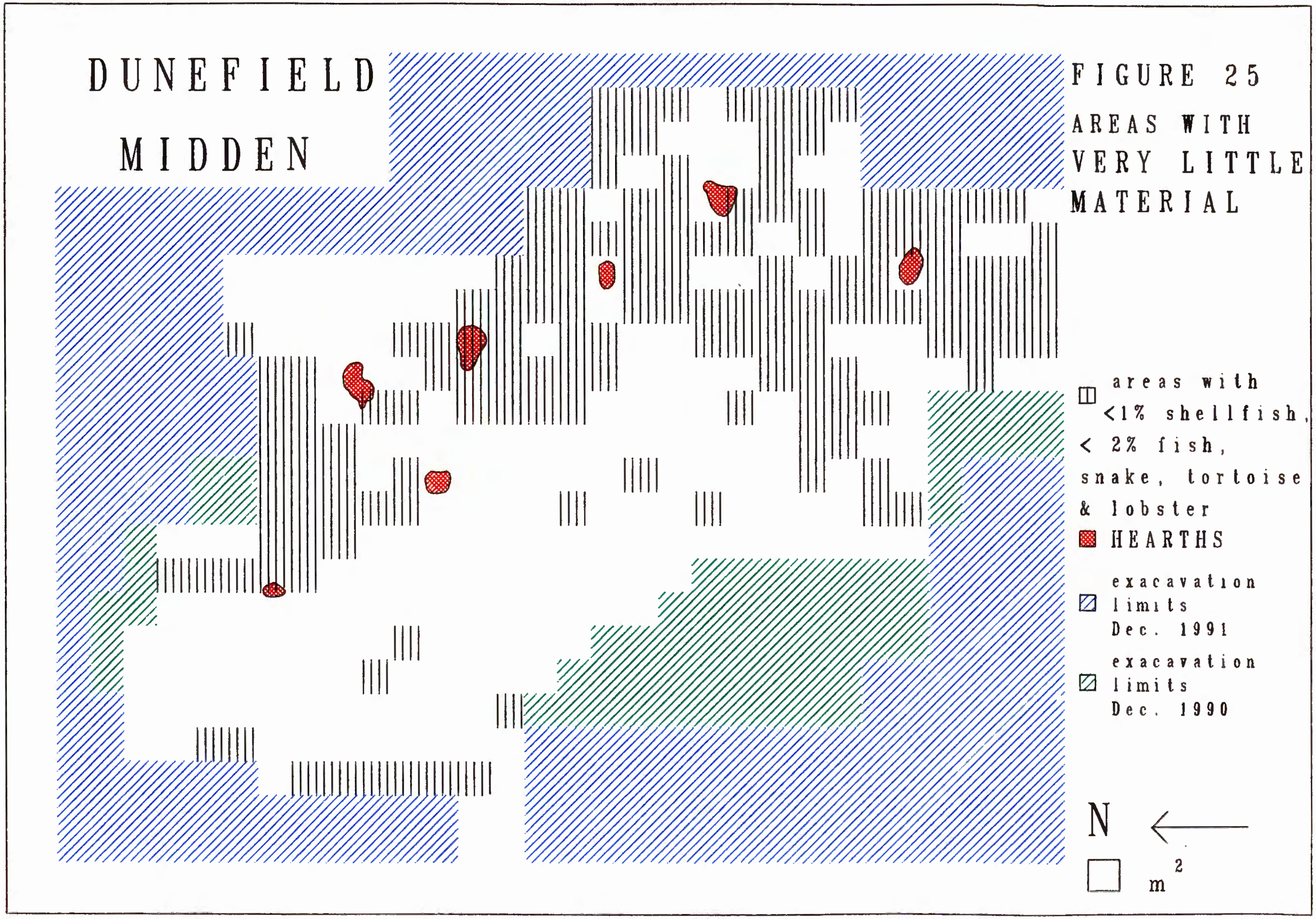
The central open area is one of the features of campsites referred to by Fisher and Strickland (1991). According to the ethnoarchaeological literature the centre of the camp is usually left relatively free of other features and is the focus of group activities such as dances (Yellen 1977). It has been argued that societies which emphasise sharing will orientate themselves towards the central open area, while societies emphasising personal ownership will orientate themselves away from it (Wiessner 1982 Brooks *et al.* 1984 Parkington and Mills 1991). However, one may well question how much the idea of a central open area is a real feature and how much it relates to the 'ideal' of camp layout as expressed by Yellen (1977). Yellen's (1977) camp plans show that whilst the ring model may have been regarded as an 'ideal', in fact camp layout varied significantly and even where the central area of the camp was free of huts or windbreaks, it often included trees, bushes, refuse dumps or hearths. This seems partly true of the Efe camp plans given by Fisher and Strickland (1991) as well (see Figure 5).

Parkington and Mills (1991) suggest that the historical mat house villages of the Khoi enclosed a central open space in a circular arrangement of domed houses. Whilst the historical drawings of these villages do suggest this arrangement, the artist may have been responding to the expressed ideal rather than the reality. On the other hand, it is also possible that the more stratified society of Khoi pastoralists enforced a stricter control over camp layout. Certainly, the camp plans of San settlements given by Bartram *et al.* (1991) show a range of variation, including linear arrangements for windbreaks in short term occupations. Most ethnoarchaeological accounts do not emphasise the central open area as a feature and therefore it may not be standard.

At Dunefield Midden there is no evidence for a central open area. The arrangement of hearths is almost linear and the most central feature of the camp appears to be the main dump! Using the concept of negative space discussed by Henderson (1990), a map of the areas **lacking** artefacts and faunal remains was made (see Figure 25). Areas felt to be relatively free of material were selected as containing less than 1% of shellfish, potsherds and stone artefacts, and less than 2% of snake, fish, tortoise and lobster. The percentage was increased marginally for the latter, since the total number of these items is far less than shellfish or artefacts.

An area relatively free of material was found in the southern part of the site. This is the area around the hearth in that part of the site. It contains very little shell, artefacts or small fauna and Nilssen (pers. comm.) agrees that there is a general lack of larger faunal remains (eland, seal and *Raphicerus*) in that area as well. The area covers about 20 m^2 and may be the area of the site used for dances or other group activities. It has also been suggested that this may have been a processing area for eland. If the people were working on skins then few of the bones would remain in the precise area where they were working (Nilssen pers. comm.). Binford (1983) has argued that butchery often occurs at a separate location or on the edge of the site since it is messy and requires a fairly large space. The southern part of the site is also where the roasting pits are located, thus supporting the idea that this area may relate to butchery or processing of the eland carcass.

There is one other small area lacking in shell, artefacts or small fauna. This does occur towards the centre of the site, just east of the main dump. However, the area only covers about 6 m^2 and thus is not a dominant feature in the site. It can not be termed a 'central open area' of the kind reported by Fisher and Strickland (1991).


DUNEFIELD
MIDDEN
FIGURE 25
AREAS WITH
VERY LITTLE
MATERIAL
areas with
<1% shellfish,
< 2% fish,
snake, tortoise
& lobster
HEARTHS
exacavation
limits
Dec. 1991
exacavation
limits
Dec. 1990
N
m2

There are a few other areas which seem relatively free of material and which may be sleeping areas as defined in the section on structures above. This will need to be confirmed by the maps of the distribution of other faunal remains examined by Nilssen. All other areas lacking in material occur near the outskirts of the site and probably reflect the perimeter of the site. This will be discussed in the following section.

The apparent lack of a 'central open area' as defined in the ethnoarchaeological literature has a direct bearing on the question of campsite layout. The argument of expressed 'ideal' layout as against reality has been discussed above. A further influence on this question is the duration of the occupation. Whitelaw (1991) has linked camp layout to duration of occupation and a discussion of his results has been presented in a previous section. Briefly, he found general correlates between length of occupation and layout: random, clustered, circular or linear. It is possible that if the layout of the Dunefield Midden campsite is a reflection of the shortness of the occupation, then there may not have been a need for space to be provided for group activities, such as dancing. Certainly, the evidence from the superimposition of refuse dumps over hearths indicates that membership of the group was as fluid as reported in the ethnoarchaeological literature. There may not have been a need for expressions of group cohesiveness at such a temporary camp.

Perimeter

The perimeter of the site has not yet been fully established as excavation is not complete. Nevertheless in certain areas it appears that there may be indications of the edge of the site. The determination of the perimeter is further complicated by the degree to which analysis is complete or incomplete for different items. The edges of the site area defined in this study include areas where analysis has not yet been done. However, the total weight of shellfish for these squares has been calculated. Shellfish seems to be a fairly good indicator of other items on the site, for although there is not a direct correlation between weight of shellfish and all other items, where shellfish weight is very low there is generally a lack of other material as well. On this basis, it is possible to suggest that in the central northern and north-western ends of the site there seems to be some indication of a perimeter (see Figure 24). As mentioned in the section above, the southern part of the site is also relatively free of material, but the presence of two other sites of different dates close to this end of the site makes the exact definition of a perimeter difficult in this area.

Fisher and Strickland (1991) noted that refuse dumps often mark the perimeter of a site, occurring behind structures. The pattern at Dunefield Midden is probably slightly different, as influenced by the presence of the main dump. Nevertheless it is possible that this feature may mark the most westerly extension of the site. Analysis of the excavated material from the 1991 field season should answer this question.

The easterly extent of the site has also not been determined. The presence of the dune cordon immediately behind the site in this direction makes excavation difficult, but there is an indication that some material seems to occur within the fringes of this feature, although the dune cordon itself is thought to be older than the site. The intrusion of material into the fringes of the dune cordon may be as a result of movement of the dune in the period of time since the occupation of the site.

The indications available at this stage of the excavation indicate that it is likely that the edges of the site will be resolved relatively clearly. Care will have to be taken in determining the boundaries of the different sites on the southern end of the site, but on the other three sides it seems that the edges will be locatable by a decrease in material. Furthermore, there should be an increase in the proportion of Donax serra in the shellfish along the edges of the site. This species of mussel is very common in the dune cordon area, especially at the level of the yellow brown sand. The white mussels may have been dropped by gulls, or may be the remnants of an old beach, rather than a result of human predation. There is also a certain amount of shellfish found scattered throughout the dunefield area. It is therefore not necessary to excavate until 'sterile' sand is reached before the edges of the site may be defined. A decrease in shellfish weight per square metre and an increase in the proportion of Donax probably indicates that the edge of the site has been reached (Parkington *et al.* 1992).

Conclusion

The discussions of camp layout presented here emphasise the complexity of this level of analysis. It seems that Dunefield Midden does exhibit differences with the ethnoarchaeological descriptions of campsites, although it may not always be clear exactly what these differences mean. Definition of what is meant by a 'clear' space is also not an easy task. At this point in the interpretive process it seems that the hearths have far more information about social influences on camp spacing than any other feature. Although the picture may become a little clearer once the information on the distributions of animal bones is available, it is felt that comparisons between many sites of this nature will be needed to aid understanding.

Site Classification

Type of Site and Length of Occupation

There are several different types of sites reported in the ethnoarchaeological record. The types of sites are often defined as a result of the length of occupation, although a few are defined according to differences in food accumulating strategies. Examples of the latter are the Alaskan sites used as hunting stands or for storage (Binford 1978a 1978b 1983 Whitelaw 1989). Hunter - gatherer groups using strategies similar to those used in Botswana today are regarded as the closest analogs to the group that inhabited the site of Dunefield Midden. Amongst these groups the major factor in type of site is the length of occupation (either expected or actual), sometimes related to seasonal variations (Bartram *et al.* 1991 Kent 1991).

Bartram *et al.* (1991) identify four main types of site amongst the Kua in Botswana. These are base camps (hot, dry season; cool, dry season and rainy season camps); transient camps and special purpose camps and locations (Bartram *et al.* 1991:84). The base camps have been discussed in previous sections, they range in both size and length of occupation. Hot, dry season camps are occupied for about 3 months and are relatively large. Rainy season camps are occupied for about a week and consist usually of a single household group. Cool, dry season camps vary in length of occupation between the two other camps. They also consist of household groups and are relatively small. Rainy and cool, dry season camps cover about 250 - 500 m² (Bartram *et al.* 1991). Hadza base camps are similar to the Kua base camps described here (O'Connell *et al.* 1991). Transient camps are overnight stops used by small groups of people whilst travelling. At these camps the only traces left are one or two hearths and windbreaks and small concentrations of bones.

Special purpose camps are camps formed around the site of a particular activity, such as butchery of a carcass. They have associated shelters (although only one or two) and a few features such as hearths and roasting pits. They are similar in size to transient camps, covering less than 100 m². Unlike special purpose camps, special purpose locations do not have shelters. There is therefore a difference in the length of time that these two types of sites are occupied, as well as a difference in the size of the group using the location. Special purpose locations may be places such as hunting blinds or kill sites. Both special purpose camps and locations are occupied only as long as the activities performed there take. They are usually associated with kill sites and butchery activities. The basic difference between them is that people camp at a special purpose camp and not at a special purpose location (Bartram *et al.* 1991).

The presence or absence of secondary refuse dumps is also linked to the type of site and especially the length of occupation (Brooks and Yellen 1987 O'Connell 1987 Bartram *et al.* 1991 O'Connell *et al.* 1991). Only base camps occupied for more than a week show evidence of secondary refuse disposal. At other camps refuse is discarded where it is produced, usually forming small concentrations near hearths. If activities are not associated with a hearth, the refuse may be distributed around the area in which the activities were carried out.

The camp of Dunefield Midden can be seen from the above to fit the description of a base camp. It has seven hearths, two roasting pits, evidence of secondary refuse disposal in the form of the main dump and high densities of food remains. Currently the camp is thought to have covered about 350 m^2, which compares well with the values for base camps, especially of the rainy/cool, dry season kind (Bartram *et al.* 1991). The range of artefacts found at Dunefield Midden supports the suggestion that it was a base camp. Yellen (1977) argued that the longer a camp was occupied, the greater the range of activities represented. Dunefield Midden shows evidence of stone tool manufacture, several food processing behaviours, the breakage and discarding of several items (ostrich eggshell water bottles, tortoise carapace bowls), as well as different methods of procuring food. The remains of eland and small bovid indicate hunting or trapping. Seals may have been hunted or scavenged. Tortoises, rock lobsters and shellfish were collected. It is possible that the reason for setting up the camp may have been an eland kill (Nilssen pers. comm.). However, people were also supplementing their diet with all the other types of food mentioned above and the quantities of, for example, shellfish, suggest that the eland was not the main focus of the diet throughout the occupation.

It can therefore be concluded that if Dunefield Midden were to fit into the scheme presented above, it would be called a base camp, inhabited for longer than one week. It seems likely from the comparisons made that the site performed a similar function to that of a base camp and therefore the ethnoarchaeological examples may be used as a framework for interpretation of the site. The length of the occupation is further reflected in the differences in timing shown within the main dump feature. The temporal elements in the main dump have been discussed in more detail in the section on dumping behaviour above, but the conclusion is that there are at least two distinct 'time zones' within the main dump. Large mean sizes of shellfish are found clustered in the centre of this feature, whilst smaller mean sizes are found on the fringes and in subsidiary dumps within the main dump, especially in the northern area. The large shellfish are interpreted as representing collection early in the visit, whilst smaller shellfish represent collection towards the end of the visit. The distribution of these shellfish indicates two areas of discard within the main dump at two different times within the visit. Impact on the shellfish populations has been suggested in an earlier section by comparisons with sizes of shellfish found on the coast in recent times, including information gathered from shellfish transects made during two excavation seasons. This information shows that the larger shellfish (presumably collected early in the occupation) fall within modern ranges, whilst the smaller shellfish (presumably collected later in the occupation) tend towards the lower end of these ranges.

It is not suggested that the site of Dunefield Midden had the exact characteristics of the ethnoarchaeological examples to which it is most similar. It seems very likely that several aspects of the way of life of the inhabitants of the site were similar to the ways of life of the inhabitants of the ethnoarchaeological camps. Some of the areas of similarity seem to have been methods of procuring food and movement to take advantage of different resources, particularly the availability of fresh water. The movement of people is implied by the relatively short duration of the Dunefield Midden camp, which was not reoccupied. This short occupation certainly suggests mobility, and the utilisation of different areas in different seasons is a common behaviour reported in the ethnoarchaeological literature. However, this must not be seen as attempted support for the hypothesis that people were moving between the mountains and the sea at different times of the year (cf Parkington 1976). It merely suggests that people were not resident in the immediate area of Dunefield Midden year round. Furthermore as shown by Bartram *et al.* (1991), 'seasonal' variation in camp location or camp type may relate to different seasons from the Eurocentrically defined Summer, Autumn, Winter, Spring, as some parts of Africa experiences changes which may fit another cycle (for example hot, dry season, rainy season, cool, dry season).

Furthermore, the points of difference between this site and the ethnoarchaeological examples are regarded as of similar importance to the points of correspondence. Since the aim of this project is to gain an idea of the behaviours that led the archaeological material to be in the places it is found today, it is necessary to consider what both these similarities and differences mean. The use of comparison with the ethnoarchaeological examples is therefore seen as a way of determining possible behaviours, which otherwise might lie outside the boundaries of what a person who has been exposed to only one cultural example, their own, may expect.

Number of People

It can be seen from the above discussion of the type and length of occupation, that the question of how many people occupied the site has a direct bearing on the length of the occupation represented. The number of people present at the camp at any one time probably varied, as reported in the ethnoarchaeological literature (Yellen 1977). Nevertheless an estimate of the greatest number that could have been present is possible. The number of hearths is known, which is taken to give a guide to the number of households. The size of the household using each hearth cannot be too big, because of the relatively short distance between hearths, a household size of greater than about six (including adults and children) may be considered unlikely (Speth pers. comm.). This is consistent with the values given by Yellen (1977), where mean number of people per social unit at each of the camps he described never exceeds six. The mean for Yellen's (1977) combined sample is four people per social unit (all values given are rounded off since a fraction of a person does not seem a useful measurement!). Since there is evidence of seven hearths at Dunefield Midden, this gives a maximum of about 42 people. This number is above the range recorded by Yellen (1977). The maximum number of people recorded at any of the campsites he mentions is 24. Although it is recognised that these numbers may vary according to the type and/or season of the camp, if the number of social units is taken to equate with the number of hearths, then Dunefield Midden should fall at about the upper range of Yellen's (1977) sample (comparable to campsites containing 7 social units - Camps 10 and 11, see Figures 26 and 27). According to Yellen's range, it is therefore likely that there were between 10 and 25 people present for most of the occupation.

Estimates of the number of people present may also be made from food remains. The food value (in terms of kilojoules) is known for shellfish, although unfortunately is not available for all the animals represented at the site. Kilojoules may be calculated from shell weight, assuming 350 kJ per 100 g of shell for limpets and 150 kJ per 100 g of shell for black mussel (*Choromytilus meridionalis*) (Buchanan 1986 1988). As can be seen from Table 5, the number of kilojoules from the shellfish at Dunefield Midden (including limpets and mussels) is 1 127 126 kJ. Buchanan (1986:140) gives a mean kilojoule requirement per person per day of 9 000, although he reports that for San in Botswana it is closer to 5 000 or 6 000.

It has been suggested that shellfish would have provided between 5% and 30% of the diet of the people living at Dunefield Midden (Parkington pers. comm.). Based on the kilojoule requirement given above, the contribution of shellfish in terms of kilojoules can be calculated. The figures 5%, 15%, 20 % and 30% will be used as estimates. Results are shown in Table 6. By dividing the kilojoule estimates by the total number of kilojoules available from the shellfish at the site, estimates of numbers of person days represented by the amount of shellfish can be reached and the ranges of numbers of people and length of occupation can be established. The numbers of person days are shown in Table 7. The information of numbers of people per campsite and per social unit given by Yellen (1977), discussed above, allow the suggestion to be made that

Table 5

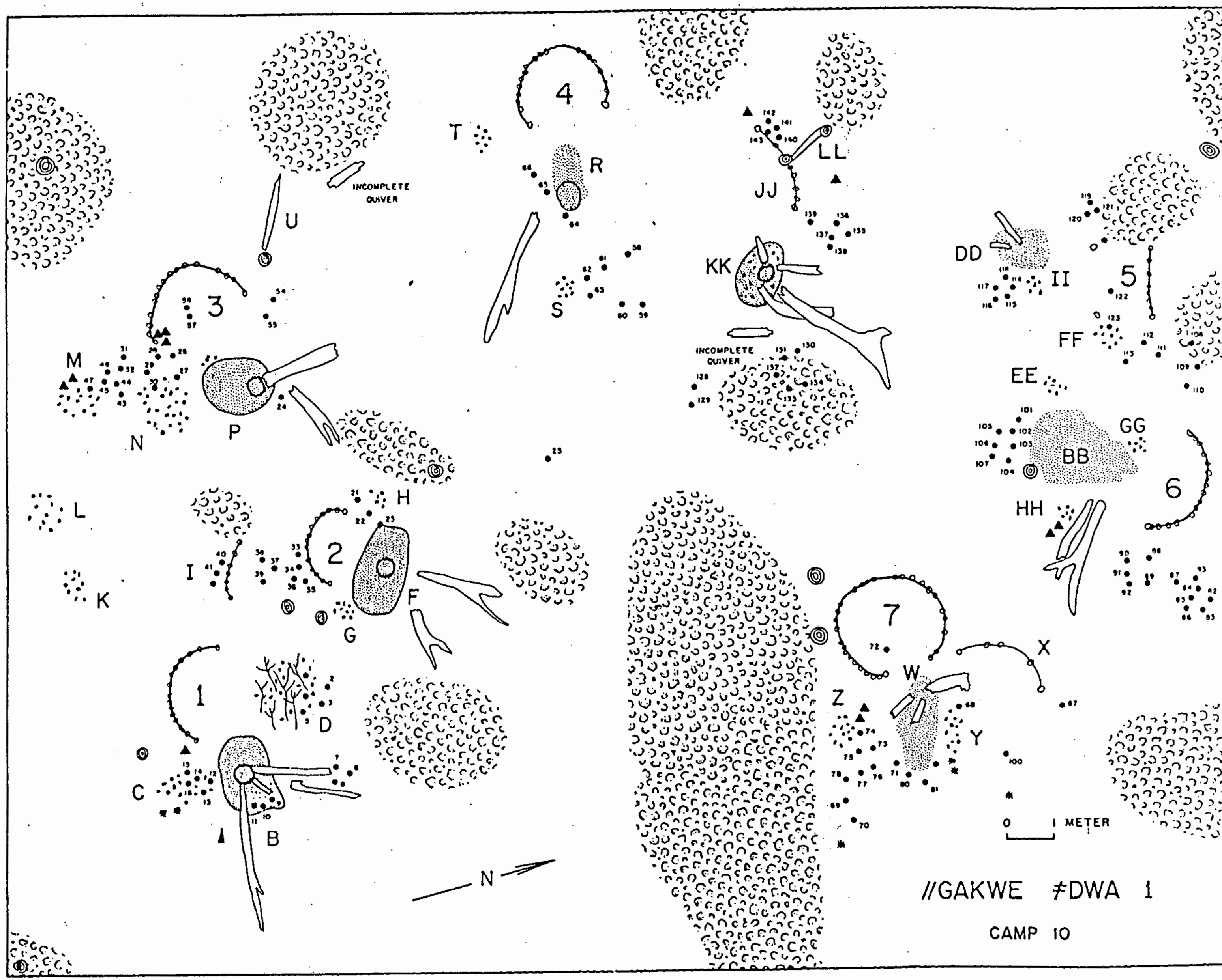
No. of kilojoules from shellfish at DFM

Shellfish type	Weight (g)	Kilojoules
Limpets	276024	966084
Mussels	107361,4	161042,1
Total	383385,4	1127126,1

Table 6

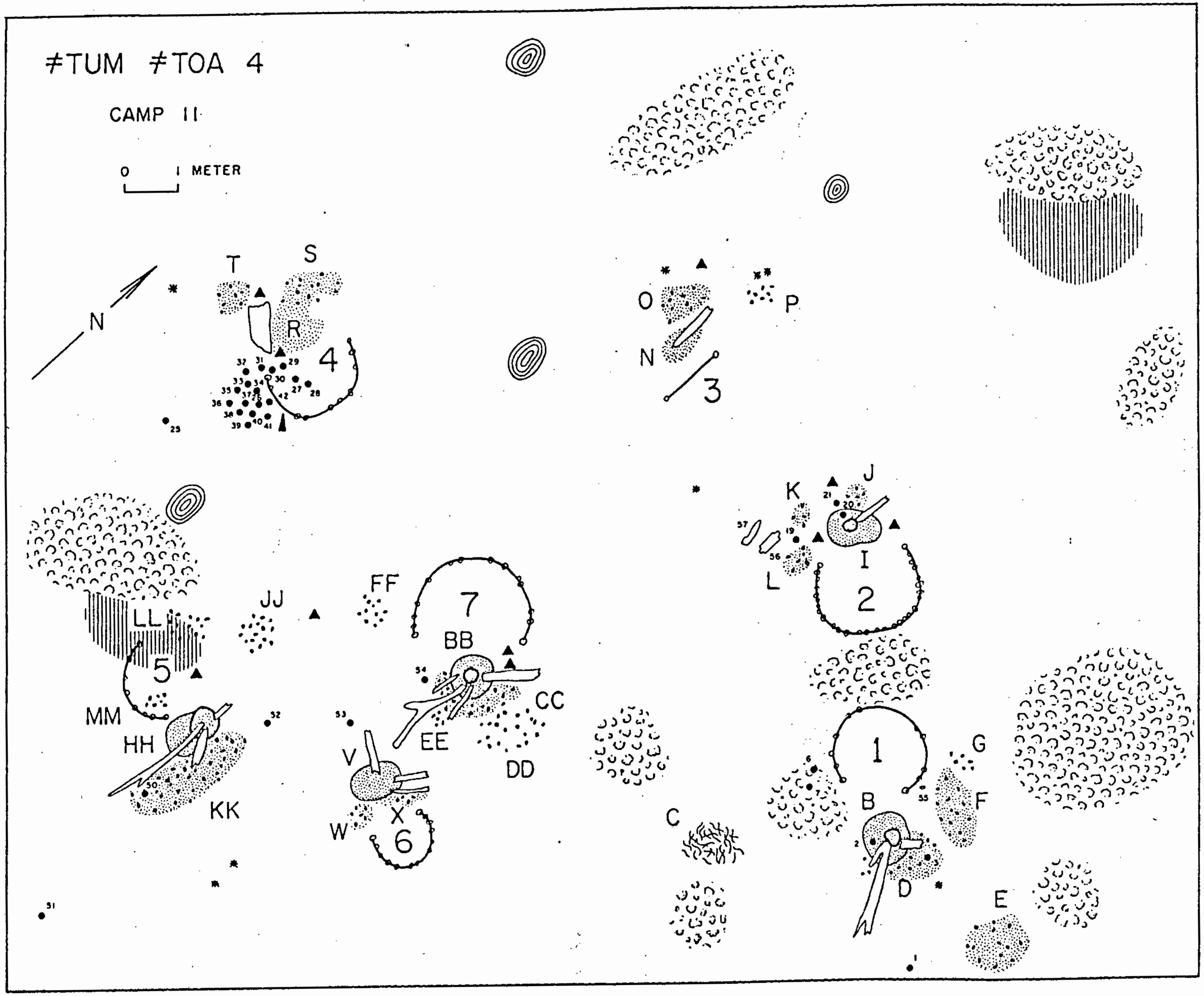
No. of Person days represented by Shellfish

Shellfish as a % of diet	Kilojoules	Person days
5	450	2505
15	1350	835
20	1800	626
30	2700	417



SITE PLAN: CAMP 10 //GAKWE ≠DWA 1

Figure 26 (from Yellen 1977)



SITE PLAN: CAMP 11 ≠TUM ≠TOA 4

Figure 27 (from Yellen 1977)

that numbers of people above about 40 are extremely unlikely. On this basis a length of time of more than about three months is considered unlikely unless the shellfish contributed less than 5 % of the diet. It therefore seems likely that Dunefield Midden was inhabited for between two weeks and two months, depending on whether the number of people tended towards the large or small end of the scale. A plausible measurement would suggest about 20 people for a month to a month and a half. This is consistent with the numbers measured at campsites recorded in the ethnography (Yellen 1977 Meehan 1982 Bartram *et al.* 1991).

It is recognised that the calculations given by Buchanan (1986) may be problematic. However, there are no other readily available, easy methods of performing these calculations available at time of writing. A mean of about 20 kJ per gram of dry flesh mass for limpets was given by Rebelo (1982). Unfortunately he did not give a direct conversion from dry flesh mass to shell weight. Therefore, the measurements given by Buchanan (1986) are used here to estimate number of people and length of occupation.

Dunefield Midden therefore appears to have been a site occupied by a group of people (averaging around twenty) for about a month. The focus of the site appears to have been residential, rather than, for example, the butchery of an animal (although this may have occurred within the context of the main site). The occupation of the site seems to compare with longer term modern hunter - gatherer sites, which is consistent with the suggestions made by Yellen (1977) that the only sites that would be recoverable in the archaeological record would be the sites occupied for a relatively long period of time. However, the length of occupation represented is still short enough for the resolution of activities and specific areas within the site to be possible. The most important factor, besides the fact that it was not a permanently occupied site, is probably the fact that it was not re-occupied and the patterning was not obscured by overprinting. In the next section the behaviours evident within the patterning will be discussed.

Behaviours

"Seven fires were burning and round each was assembled a little family....

[collecting shellfish] Most of them were provided with a little bit of wood, cut into the shape of a spatula... with these they separated from beneath the rocks, at great depths, very large sea ears. Perhaps they choose the biggest, for all they brought were of a great size" (Meehan 1982:5)

The above description is quoted by Meehan (1982) from the writings of a Frenchman, Labillardiére, who visited Tasmania in 1772. It is a particularly appropriate description with which to start this section, because of its applicability to the site of Dunefield Midden. The first sentence, coincidentally, parallels the picture from this site exactly, even to the number of hearths. Whilst there is no evidence from the site for implements such as those described in the second sentence, the lack of survival of organic remains, means that the possibility that similar artefacts were used can not be discarded. The last sentence is perhaps the most significant, since it is argued in this study that people would have preferentially chosen the largest specimens of shellfish available.

A glimpse into the lives of the inhabitants of the site can be gained from the analysis presented in the above sections, to a degree seldom possible from archaeological sites unsupported by written accounts. At the time that Dunefield Midden was occupied "seven fires were burning". They may not have been burning all at once. It seems more likely that at least some of the people who were present during the first part of the occupation had left before the last period of occupation. This is indicated by the way in which the main dump and its subsidiaries spread over the area where a stone tool orientated hearth had been in the northern part of the site.

The hearths identified at Dunefield Midden have been interpreted as representing household groups. Arrangements of this kind have been reported in the ethnoarchaeological literature. The spacing between the hearths suggests that they were the focal points around which various activities took place. The hearths have been characterised according to the artefacts found in the closest proximity to them. Food remains were common to the immediate area of all hearths, suggesting that the consumption of food occurred around all hearths. The artefacts, therefore, were used as indicators of other activities that may have occurred around hearths.

The hearths were found to be divided into two main types: stone tool orientated hearths and potsherd orientated hearths. It is possible that these differences indicate households where a toolmaker was present, as opposed to households where a toolmaker was not present. It is also possible that the hearths represent use at different times in the visit. If stone tool manufacture was early in the occupation (as suggested by the association of stone artefact manufacture debris with a hearth later covered by the dump) then the potsherd orientated hearths may reflect occupation towards the end of the visit when stone tool manufacture had ceased. A further possibility is that the two types of hearths represent gender and/or activity differences. The potsherd orientated hearths may represent female or food processing activities, whilst the stone tool orientated hearths may represent male or artefact manufacturing activities.

It is possible that some of the differences in hearth spacing at Dunefield Midden may represent kinship ties between subgroups. In particular, the spacing of hearths in the central northern part of the site may suggest kinship ties. The debris associated with these hearths overlaps and two of the three hearths indicate stone artefact manufacture of a very similar nature (Vermeulen 1990). It is possible that this grouping reflects a family group where a young, but not dependent family member was learning stone tool manufacture, in close proximity to the hearths of the older members of the family group.

The debris around roasting pits suggests that the processing of large faunal remains occurred in close proximity to them. The more southerly roasting pit is associated with the cranial fragments of an eland (Nilssen pers. comm.). This association is very reminiscent of the roasting of a gemsbok head in pits reported in the ethnoarchaeological literature (Yellen 1977). These features will therefore become more important in a discussion of the large faunal remains.

Other ash features are the smaller patches of ash which occur in many places across the site. These ash features may be the results of opportunistic fires made in order to complete some small task and never reused. As such they would not exhibit the characteristics of a 'hearth', which was probably reused several times. These features may also reflect the secondary dumping of ash, or almost complete hearths, from hearths that were growing too large. The clearing of hearths of ash and the occasional dumping of an almost complete hearth is reported in the ethnoarchaeological literature and provides a good example of the maintenance carried out at a campsite.

Thus details emerge of the campsite in the dunes. People orientated themselves around hearths where they prepared and consumed food, perhaps served in tortoise carapace bowls or pieces of incomplete pot, and made stone artefacts. The meals were accompanied by drinks of water from ostrich eggshell water bottles. At one hearth someone lost four ostrich eggshell beads, perhaps from a broken necklace. The people also dug shallow pits in which they roasted an eland head. Occasionally they made a small fire in order to complete some task, perhaps the hafting of a stone artefact. When they felt that the camp was beginning to look untidy or that the hearths were getting too large, people sometimes swept up the ash from the hearths and dumped it.

There is a distinct pattern of dumping behaviour that has emerged from the analysis of Dunefield Midden. The dumping of debris onto secondary refuse dumps probably began fairly early in the visit. This may have been because people thought that the site would be occupied for a considerable length of time (Kent 1991). Bones, ash and shellfish formed the basis of the main dump in the western part of the site, although broken pieces of pot, broken ostrich eggs, tortoise carapace bowls and even stone artefacts were also discarded. At this initial stage of the occupation, dumping occurred in what was to become the central, eastern part of this feature. Throughout the occupation people dumped debris forming concentrations within this feature reflecting 'dumping episodes'. The existence of these dumping episodes suggests that dumping behaviour probably followed the pattern reported in the ethnoarchaeological literature of periodic clean-ups of the camp. It seems likely that each household dumped debris in slightly different areas, perhaps even following the more formal rules reported in the Bleek and Lloyd accounts.

As the occupation continued the main dump grew in size and people began to deposit their debris over a wider area. The people occupying the most north-western hearth had moved by this time, either to a new hearth on the same site, or to a different site. The dump began to spread over this area where formerly activities such as stone tool manufacture had taken place. The change in dumping focus within the dump was reflected by a decrease in the mean sizes of the shellfish that were being collected as a food source. As people began to impact on the shellfish populations, the average sizes of the individuals they were able to collect decreased and so shells brought back to the site were smaller.

In between the periodic clean-ups of the site debris was left around hearths and in other areas where it was produced. When this material accumulated to above a certain amount it was cleared away and dumped. However, smaller items such as the quartz chips produced by stone tool manufacture and tiny bones, such as the limb bones of tortoises or the bones of fish, were dropped into the soft sand, where they sank rapidly. These items were often missed in the clean-ups of larger items and so remained in place as indicators of the positions where these activities took place.

As people began to realise that they would soon be leaving the site, the need to clean up the concentrations of debris around hearths diminished. Items were left where they had been discarded, thus leaving direct evidence of the positioning of these activities. Sometimes this debris obscured evidence of earlier activities, but it remained an indication of some of the last activities performed on the site - mostly consumption of food, including shellfish.

The pattern of food consumption is fairly clearly indicated at this site. A range of wild resources were utilised. These resources included bovids such as eland and steenbok, marine animals such as seals, fish, lobsters and shellfish, and smaller terrestrial animals such as tortoises, dassies and snakes. Animals were utilised in different ways. There is evidence for the differential allocation of eland bones (Nilssen pers. comm.), which may indicate food sharing. Other items were utilised differently either as food remains or artefacts. An example of the latter is given by the distribution of tortoise bones.

Distribution of Tortoise Bones

There are three characteristic types of tortoise bones found at Dunefield Midden. These are the tortoise plastron and carapace fragments and limb bones. The tortoise carapace fragments, and occasionally whole carapaces, seem to have been used as bowls. They have ground rims and are therefore classed as cultural artefacts. Plastron fragments and limb bones, on the other hand, are assumed to be refuse left after consumption of the tortoise. Being fairly small and rounded these bones would be likely to remain in the immediate area where the tortoise was consumed. It is also possible that these bones are the refuse left after the construction of bowls, but it seems likely that the tortoises were a food resource, especially since their bones are present in large numbers. It is therefore of interest to identify the spatial arrangement of the tortoise bones.

Tortoise limb bones are mostly found close to hearths. There are two main concentrations of these bones in the north eastern part of the site (Vermeulen 1990). These concentrations correspond very well to two of the areas containing concentrations of tortoise plastron fragments. These two types of bones therefore can be assumed to have undergone similar discard processes. This in turn suggests that they were the products of the same activity. Tortoise plastron fragments are therefore taken as indicative of tortoise limb bones as well for the purposes of comparison with tortoise carapace fragments.

On a visual inspection the plastron fragments and carapace fragments seem to be found in different parts of the site. The plastron fragments seem to be clustered near hearths, whilst the carapace fragments seem to be clustered in the area of the main dump. If this is the case it would support the suggestion that plastron fragments indicate tortoise consumption (taking place near hearths), whilst the carapace fragments are the remains of bowls which were discarded once they were no longer of use (if, for example, they were broken). The complete or almost complete tortoise carapace bowls which have been found on the site are in the general hearth area, although not in the same places as plastron fragments (Vermeulen 1990). This suggests that these artefacts were used in the main activity area and then discarded on or near the main dump when broken.

The spatial separation between these two categories is even clearer if only squares containing greater than five bones are included. Tortoise plastron fragments are very clearly represented in the eastern parts of the site, whilst tortoise carapace fragments are confined to the western part of the site. Since the western part of the site contains the main refuse dumps and the eastern part of the site contains more hearths, it can be concluded that the two categories are associated with the two features. Tortoise plastron fragments and limb bones are therefore associated with hearths, whilst tortoise carapace fragments are associated with the main refuse dump.

This distribution was tested using the Chi-squared test for cross-classified data, as described by Shennan (1988). This test determines whether two classifications are statistically independent of each other. In this case the classifications were plastron fragments and carapace fragments being represented in, respectively, the eastern and western parts of the site. The two halves of the site were determined by dividing the total number of squares in half and then counting to halfway from either the eastern or the westernmost part of the site. The square reached by counting to halfway was denoted the halfway square. The halfway line was determined as either left or right of the halfway square, by judging in which half most of the squares in that line lay. Once the halfway line was determined the categories plastron and carapace fragments were counted in each half and the chi-squared test was performed on the results.

The results of the test for these categories was an extremely significant result, significant at p = 0,001. In other words, the classifications are independent of each other. They are respectively confined to opposite halves of the site. Plastron fragments are found in the eastern part of the site, the area characterised by hearths. Carapace fragments are found in the western part of the site, the area characterised by main refuse dumps. This result gives a clear indication of the different uses of one type of food item.

Shellfish Processing

The question of how shellfish were processed at the site has not yet been answered. However, the existence of large ash features which may have been fires for processing the shellfish, indicates that the shellfish may also have been utilised in a variety of ways. They were almost certainly consumed around domestic hearths. It is possible, however, that some were dried, perhaps to be utilised after the people had left the site. It is also possible that certain species such as mussels and whelks were dried or processed in a different manner from limpets, which may have been consumed around domestic hearths.

Deductions can be made about foraging strategies from the analysis of spatial patterning at Dunefield Midden. Gathering behaviour will be concentrated on here, as other types of food procurement strategies such as hunting or scavenging refer to the larger faunal remains which do not fall within the scope of this thesis. Several food resources were gathered or collected. These resources include shellfish, lobsters and tortoises. Tortoises were probably picked up within the immediate environment of the site. Lobsters may have been procured by swimming or by collection from the beach after episodes of strandings. The latter occur fairly frequently due to movements of water beneath the Benguela current bringing up water containing very low levels of oxygen. The lobsters are forced into shallower and shallower water to get more oxygen and often walk right out onto the beach in large numbers (Buchanan 1986). According to eye-witness accounts they sometimes reach densities of up to a metre in depth. An occurrence such as this would no doubt have attracted people to this abundant food resource.

Shellfish were probably collected from the rocks at the southern end of the bay or as wash-ups on the beach. Violent winter storms along the Cape coast often throw large quantities of shellfish, especially mussels, up onto the beaches. This may be observed along the coast today and large numbers of gulls may be seen feeding on the abundant mussels lying on the beaches after storms. It seems that it is the larger mussels growing in the subtidal zone which are washed up onto the beach during these storms. As there is evidence that Dunefield Midden was occupied during winter, it is likely that this resource was also available to the people who occupied the site.

This leads to a possible interpretation for the way in which mussel sizes conform to the pattern of limpet sizes, being distributed in similar places according to size. The association of mussels and the barnacle *Austromegabalanus* has already been mentioned, as has the fact that this barnacle only occurs in the subtidal zone. It is possible therefore, that during the first part of the visit people collected larger specimens of limpets off the rocks and larger specimens of mussel washed up onto the beach in storms. After a few days however, the mussels lying on the beach would no longer have been edible. It is therefore possible that during the latter part of the visit when there is evidence for smaller mean sizes for all shellfish, people were collecting smaller mussels (with no *Austromegabalanus*) off the rocks. (This may have been necessary because of the decreasing availability of large limpets).

It is also possible that the storms may have washed dead seals up onto the beach, which would have been utilised by the people as well. If there had been a combination of all these events and there was an abundance of large mussels, lobsters and seals lying on the beach, then this may have encouraged people to situate the camp in the place that they did. In other words, it is possible that a concentration of readily available marine resources may have been a reason for occupying the site.

Similarly, it is possible that a decrease in the availability of food resources may have led to the abandonment of the site. As stated above, the washed-up items such as seals, lobsters and mussels, would not have remained edible for a great length of time. There is no evidence of larger mussels during the latter part of the occupation to suggest that further wash-ups occurred. Decreasing limpet sizes suggests impact on the shellfish populations living on the rocks at the southern end of the bay. An eland had been killed and consumed, as well as fair numbers of steenbok and tortoises. There may have been a general depletion of these resources. The main dump may also have grown to a point where it was felt that a new camp was needed. A "dirty" camp is often a reason given by modern hunter - gatherers for abandoning a site (O'Connell *et al.* 1991). For similar reasons old camps are not reused (Yellen 1977).

Once this was recognised, people began to make preparations to leave, perhaps stashing useful pieces of pot and tortoise carapace bowls in their windbreaks (the semi-complete or complete items found near the hearths) in case they returned to the general area. They began to leave piles of debris near the hearths as dumping of refuse onto refuse dumps was no longer necessary. Finally they left the site and never returned to reclaim their stashed items.

Conclusion

A variety of behaviours have been inferred from the spatial patterning of items at this site. The positions of features such as hearths have been used to identify households and even to make suggestions about kinship relations within the group. The spacing between the hearths has been used to infer social conditions of sharing and the placement of items around these hearths has been used to identify the nature of activities which took place. Campsite maintenance and dumping behaviour have been interpreted from concentrations of different items, primarily food remains. The interlinking of the patterning of different food remains, as well as differences between food items have been used to reconstruct possible patterns of food consumption and foraging strategies. It has even been possible to date areas within the site in relation to each other, which has led to an understanding of the dynamics of the occupation and the non-static nature of the group. Finally, reasons for both the occupation of the site and its abandonment have been suggested. A glimpse into the lives of the people who occupied Dunefield Midden has been taken and a deeper sense of understanding has been reached.

Conclusion

This thesis has sought to reach an understanding of some of the behaviours that caused the spatial patterning evident in the items found on the site of Dunefield Midden. As the last chapter will have shown, this has been achieved. The process by which these aims were achieved has included the use of new technologies and approaches. The use of a Geographical Information System is the first application of this technology to both African archaeology and intra-site spatial archaeology in the world. An introduction to the system has been given and the method of its use has been outlined for the benefit of later researchers. The use of the idea of Site Index is also unique in its application, as is the use of the test of Spatial Autocorrelation for statistical significance. There have therefore been several 'firsts' involved in this thesis.

The use of new and different approaches has necessitated that the first part of this thesis involve detailed descriptions of the Geographical Information Systems, Site Index and Spatial Autocorrelation, as well as discussions of theory, ethnography and the use of other approaches. However, the bulk of this thesis lies in the use of the applications themselves, put together in such a way that they provide maximum opportunity for interpretation of the spatial patterning. Perhaps the main achievement of this project, therefore, is the interpretation of both features and patterning presented in the second part of this thesis.

Here too, unique positions have been reached. The description of the site of Dunefield Midden in terms of human behaviour within such a limited space of time (probably around a month) is more complete than has hitherto been achieved within precolonial archaeology in this country. This is due to the nature of the site, which has provided such finely resolved information. It has been possible to show not only where people located themselves and their activities within the site, but also which members of the group (such as stone tool makers) and which activities were located in which specific areas. The types of ash features found on the site have been detailed, as have the items found in association with them, thereby indicating some of these activity areas.

Dumping behaviour has been inferred from the presence of refuse dumps on the site. This dumping behaviour has been shown to have temporal dimensions and to have been made up of 'dumping episodes'. Dumping occurred primarily in the general hearth area, with periodic 'clean-ups' transferring this material to the main dumping area. Dynamics within the main dumping area have led to suggestions of behaviour as far reaching as foraging methods, namely in connection with the sizes of mussels and the species of barnacle found in the main dump.

The structure or layout of the site has been discussed and what is immediately apparent is that this site differs in detail from the ethnoarchaeological examples cited, as well as differing markedly from the 'classic' notion of the layout of a hunter - gatherer campsite. Describing the layout as 'circular' or 'linear' has been found to be of little benefit. Neither is there a clear 'central open area'. The layout of the Dunefield Midden campsite has emphasised the complexities inherent in people's use of space. It has also cautioned against a direct application of ethnographic example to archaeological patterning. Rather, the use of ethnography must be seen as interactive, with differences from ethnographic models being as important for interpretation as similarities.

It has also been possible to estimate the reasons for the site's occupation, as well as the duration of the stay, weighed against the possible number of people present. On a very basic level, it appears that Dunefield Midden was occupied for the purpose of being a 'home base' from which people could operate in the environment. This can be deduced from the amount of material found at the site, as well as the presence of secondary refuse dumps. The question of the type of site represented here is closely linked to questions about the length of the occupation and the number of people occupying the site. Since both of these are unknowns and may only be estimated, they must be played off against each other in order to arrive at likely combinations. The problem is further complicated by the fact that the group was not a static entity and, as with many other hunter - gatherer groups, the number of people occupying the site probably varied on a day - to - day basis. It is therefore only possible to arrive at rough figures.

It may be argued that the bulk of the interpretations given here rest on the assumption that the site does indeed represent a single occupation. Obviously, even radiocarbon dates as close together as those obtained from this site can not prove that the site was indeed a single occupation. Other information has been presented supporting the argument that the site is a coherent whole, occupied only once. This includes the evidence from refits, especially of ostrich eggshell. These refits support the site's relative isolation from its neighbours. It seems very unlikely that objects such as ostrich eggshell fragments would be distributed across an area by agents such as carnivores, so it may be assumed that these refits reflect the distribution of these fragments at the end of the occupation.

Nevertheless, it is possible that the different hearths and dumps at the site do represent different occupations of the same general area, within 100 years or so of each other. If this was indeed the case, it necessary to ask how much of the interpretation presented here would be affected. Certain issues would be affected more than others. The types of ash features and the objects immediately associated with them, for example, would remain relatively unaffected. Whilst they would no longer form part of an integrated system, the relationship between hearth and associated items would remain the same. It would still be possible to trace the activities of tool makers producing stone artefacts around hearths, as well as of people involved in food processing and consumption. The dumping behaviour reflected by small concentrations of food items in the immediate areas of the hearths, as well as in the area interpreted as the main dump, would remain unchanged. Whilst the main dump could no longer be seen as the main area of dumping for a campsite, it would still reflect concentrated dumping behaviour, perhaps from the different occupations.

The differing sizes of shellfish within the area of the main dump, as well as the surrounding hearth areas would require a different interpretation. Similarly, different distributions of items, such as tortoise bones, between hearth and dump areas, would have to be attributed to other causes. If the main dump was accepted as a common dumping area for the different occupations represented by different hearths, then some of the suggestions given in preceding sections for the differential distributions could be retained, although it is difficult to imagine that people at different occupations would have dumped all their early refuse (with larger shellfish sizes) in one area and all their later refuse (with smaller shellfish sizes) in another area. Obviously, interpretations such as the type of site or number of people present and length of occupation (based on estimates from number of kilojoules of food represented), would have to be revoked. Nevertheless, as shown here, there are many aspects of this analysis that could be retained, some in a slightly altered form. The interpretations given here do not, therefore, stand or fall on the basis of the assumption that the site of Dunefield Midden represents a single occupation.

The strength of the interpretations presented in this thesis, lies in their ability to create an integrated whole. It is recognised that there is more than one interpretation possible for many of the features and associations discussed here. It is therefore most important that the interpretations chosen seem realistic and are consistent with each other. Comparison with ethnoarchaeological information, especially with respect to behaviours common to a wide variety of societies, allows suggestions made to be based on a realistic expectation of common human behaviours being present at this site as well. Where the archaeological record differs from the ethnoarchaeological information, interpretations, although necessarily different, must remain consistent with known expectations of general human behaviours.

Thus, for example, once it has been determined that taphonomic agents are unlikely to have been responsible for the differences in shellfish size within the area termed the main dump, then human agency must be assumed. There are several possible reasons for the differential disposal of differently sized shellfish, including individual preference. The ethnographically recorded preference amongst people for collecting the largest possible specimens, however, suggests the interpretation given above. It therefore becomes possible that the different sizes reflects an impact on the shellfish populations, reflected in differential dumping patterns at different times within the occupation. Furthermore, it seems likely that as the core area of the dump grew in size, people began dumping refuse on the fringes of this feature. This idea is, in turn, supported by the fact that one of the hearths lies beneath the outstretched northern fringe of the dump, interpreted as an area of late dumping, containing relatively smaller specimens of shellfish.

As has been shown by this example, the interpretations given form a coherent whole and are mutually reinforcing. This must be seen as a strengthening factor in the interpretations, since it seems unlikely that contradictory explanations for intrasite relationships could reflect behaviour at a site. It is of course possible that the site of Dunefield Midden does reflect behaviour wildly different from the general statements made in ethnoarchaeological literature. However since, if that were the case, the behaviour would be impossible to reconstruct with any form of security in the argument, it seems reasonable to assume that this site does reflect certain human norms.

This thesis ends with a glimpse into what life may have been like at this site, which, it may be argued, is the main purpose of archaeological research. If the people who were responsible for creating archaeological sites may be reached through our interpretation of those sites, then vital pieces of information about the past may be restored to the human family. This is particularly important in a socially - orientated study where the importance of everyday people and events is emphasised and may be used to empower everyday people in our own society with a sense of common history. The spatial approach presented here is not suggested to be the goal of all archaeological investigations. Indeed, analyses of this kind are only viable where the nature of the site allows the detailed resolution necessary for the distributions described above.

Different kinds of research questions are answered by the kinds of sites in which this level of resolution is not available. It may be argued that the long - term analyses (in terms of the amount of historical time covered) produced from sites with deep stratigraphy provide a useful framework to which details from sites such as Dunefield Midden may be added. Some of these deeply stratified sites do provide finely resolved levels from which some spatial information may be gathered, but even where this is not the case, information on changes in the faunal record and artefacts from different levels may provide descriptions and explanations with which information from sites such as Dunefield Midden may be compared. Sites such as Dunefield Midden provide much detailed knowledge about behaviours within a single occupation, whilst other types of archaeological investigations provide information about other factors such as diet and the faunal and other resources used by people over long periods of time.

This thesis is by no means a complete study of the site of Dunefield Midden. As mentioned in the first chapter, it was done as part of a group project involved in understanding this site. Discussion of the large faunal remains and their part in this picture has been left to Nilssen. Furthermore, excavation of the site is not yet complete and so the interpretation can not be complete either. This thesis has, however, attempted to lay some of the groundwork needed for further interpretation, as well as suggest directions for this further interpretation to go. It is hoped that it adequately indicates the value of the type of interpretations offered here.

Appendix A.1

Spatial Autocorrelation

Spatial Autocorrelation seems a good method by which to analyse the randomness of spatial patterns from archaeological sites since it compares these patterns to an independent determinant of randomness. The technique was developed in geography for examining patterns on maps. It involves relatively simple calculations. However, it also requires a very tedious counting in order to obtain the numbers required for the calculations. Methods of Spatial Autocorrelation have been described using geographical examples by Shaw and Wheeler (1985) and Ebdon (1977).

Spatial Autocorrelation calculations may be performed on distributions where the values are represented in a binary form, or where the actual values are taken into account. The latter calculations include a measurement of kurtosis, the measurement of the concentration of a distribution about its mean. In order to determine whether certain distributions from the site of Dunefield Midden were random or not it was only necessary to examine the values in a binary form and the actual values were not taken into account. Examinations of the nature of the areas discussed would utilise the second method.

Put very simply the method using binary information can be described as follows: Areas on a map are determined to be either negative or positive. In the analysis of Dunefield Midden, each of the 345 m^2 was designated as being an area. For example, areas containing a value above the mean might be determined positive and areas with a value below might be determined negative; or to use an archaèological example, squares on a site that have greater than the mean number of shellfish might be determined positive and those that have less than the mean number determined negative. These areas are shaded black and white according to their designation. Other criteria may also be used and squares may be determined black or white according to the size of limpets or any other experimental measure. The null hypothesis states that the spatial arrangement of black and white areas is random.

Within this method there are two alternative approaches, namely Free and Non - Free Sampling. Free Sampling is used if probabilities are calculated on the basis of an area larger than that of the study area (in other words independently of the study area). Non - Free Sampling is used with reference only to the study area and all probabilities are calculated with reference to the study area. The latter approach is best suited for analysis of the Dunefield Midden material. Unfortunately directional hypotheses (indicating whether the distribution is clustered or dispersed) involving a one - tailed test are only possible when the Free Sampling approach is used. Non - Free Sampling therefore involves a two - tailed test. However, an advantage of Non - Free Sampling is that the assumptions involved are minimal.

Non - Free Sampling: Method

The number of black and white areas are calculated, as are the total number of joins. If there are a large number of areas this operation can be extremely time consuming to perform by hand. The expected number of black/white joins (to support the null hypothesis) is calculated according to the following equation:

$$E_{BW} = \frac{2JBW}{n(n-1)}$$

where J is the total number of joins and B and W are the total number of black and white areas respectively. n is the total number of areas.

The standard deviation of the expected black/white joins is calculated as follows:

$$\sigma_{BW} = \sqrt{(E_{BW} + \frac{\Sigma L(L-1)BW}{n(n-1)} + \frac{4\{J(J-1)-\Sigma L(L-1)\}B(B-1)W(W-1)}{n(n-1)(n-2)(n-3)} - E_{BW}^2}$$

where L is the number of joins between each area and contiguous areas (this usually varies with the location of the area). The sum $\Sigma L(L-1)$ is a constant for a given site.

The test statistic (z) is then calculated according to the following formula:

$$z = \frac{O_{BW} - E_{BW}}{\sigma_{BW}}$$

where O_{BW} is the observed number of black/white joins.

z is a normal standard deviate and follows a normal distribution. Therefore the critical value for z in a two tailed test is 1,96 for a positive value and -1,96 for a negative value at a 0,05 significance level.

This test can be used as an independent test of randomness in patterns observed. For example, if the number of squares with greater than a mean number of shellfish seem to occur only in certain areas of the site, the test will determine the statistical significance of this observation.

The value of a test for randomness itself must be assessed, since statistical significance need not be a measure of human behaviour. Nevertheless such a test can be useful as a determinant of which patterning to investigate for behavioural aspects in a site such as Dunefield Midden where many different combinations of information are possible.

The calculations involved in this method are extremely time-consuming to do by hand, especially when based on such a large number of areas as contained by the Dunefield Midden site. In order to make the calculations quicker and more efficient a computer program was written in Pascal by Bruce Reeler in order to automate the calculations given above, specific to the site of Dunefield Midden. This program interprets the information in files in binary form (i.e. a value of 0 is given to white squares and a value of 1 to black squares). The program is given in Appendix A.2 below, by permission of the author. Without a program of this sort the number of Spatial Autocorrelation tests performed on this project could not have been done.

Appendix A.2

```
program Autocor1 (input, output);

{ Bruce Reeler   Last updated: 19 June 1992

  Does spatial autocorrelation on the values stored in 2nd column of a
  ASCII file.  The 1st col of the file contains the square number as per
  the DFM grid on GIS.  This prog uses the method described in "Statistics
  in Geography" by David Ebdon pub. Basil Blackwell Oxford. pp128-132.
  (Non-free sampling).  Only binary data are taken into account, i.e. only
  sqrs with no items or some items are differentiated. Sqrs containing
  items are referred to as black (and have a value of 1 or more in the input
  data file), sqrs containing nothing are white (and have a value of 0),
  undug squares have a value of -1.  Only the four sqrs bounding the four
  sides of a given sqr are used as neighbours.
}
uses Dos;

label EndofProgram;

const
   SqrArraySize = 680;   { Total # of sqrs in grid }
   DatArraySize = 1360;  { Size of dat array (=2xSqrArrarSize)}
   JoinNum = 639;        { Total # of joins between dug sqrs in grid }
   SqrTot = 345;         { Total # of sqrs dug }
   FirstSqrDug = 27;     { # of the first sqr dug }
   LastSqrDug = 634;     { # of last sqr dug }
   SumElElmin1 = 3564;   { Term SUM L(L-1) used in formula }
   NearJump = 20;        { Diff. between the #s of 2 sqrs separated vertically
                               in top part of site }
   FarJump = 30;         { Diff. between the #s of 2 sqrs separated vertically
                               in lower part of site }
   AllNearCutoff = 55;   { # of last sqr which is separated from its upper
                               and lower neighbours above and below by 20 }
   SomeNearCutoff = 75;  { # of last sqr which is separated from its upper
                               neighbour by 20 and its lower neighbour by 30 }
type
   SqrArrType = array[1..SqrArraySize] of integer;
   DatArrType = array[1..DatArraySize + 1] of integer;
                { Datafile contains 2 * # of sqrs, the 9+1' is for the extra CR
                    that GIS puts at the end of its 9dumped' ASCII file. This
                    does not influence calcs, which use SqrArraySize. }
var
   FullFileName : PathStr;            { Used to verify filename entered }
   I, J, DatumCount, Int1 : integer;  { Counters, Int1 is for vals read }
   NumBlack, NumWhite, ObsBW : integer; { # of blk & wht sqrs, observed #
                                              of blk/wht joins }
   ExpBW, MeanBW, Z : real;           { Expected (calced) # of B/W joins,
                                              Mean # B/W joins, z = test
stat }
   DatArray : DatArrType;             { Array of orig. data }
   SqrNum, SqrVal : SqrArrType;        { 2 arrs into whch Datarry is split}
   FileName : string;
   Datfile : text;            { File type of data file }
```

```
{------------------------------------------------------------
---}
{ This function counts the # of sqrs containing 1 or more items, collectively
called the black sqrs. This corresponds to the number of entries in array
SqrVal which are > = 1 }

function GetNumBlack (SqrArraySize : integer; SqrVal : SqrArrType) : integer;
   var
      ItemCount,I : integer;
   begin
      ItemCount := 0;
      for I := 1 to SqrArraySize do      { Size of SqrVal is SqrArraySize }
         if SqrVal[I] > = 1 then         { If there is something in this sqr..}
         ItemCount := ItemCount + 1;     { Incr. ItemCount }
      GetNumBlack := ItemCount;
   end;

{------------------------------------------------------------
---}
{ This function calculates the number of dug sqrs that contain no items }

function CalcNumWhite (SqrTot, NumBlack : integer) :integer;
   begin
      CalcNumWhite := SqrTot - NumBlack;
   end;

{------------------------------------------------------------
---}
{This function calculates the number of 'observed' black/white joins between
sqrs. Each sqr has 4 neighbours: above, below, left, right. Due to the site
shape, the top 24 sqrs have different sized jumps between themselves and their
upper/lower neighbour's sqr #s. Hence FarJump/NearJump. }

function CalcObsBW (SqrNum, SqrVal : SqrArrType; NearJump, FarJump,
   AllNearCutoff, SomeNearCutoff, FirstSqrDug, LastSqrDug : integer) : integer;
   var
      I, BWCount, UpJump, DownJump : integer;
   begin
      BWCount := 0;                          { Black/White join counter }
      for I := FirstSqrDug to LastSqrDug do      { From 1st to last sqr dug }
           begin                        { if there is something in }
        if SqrVal[I] > = 1 then               { the sqr, set the jump    }
        begin                          { size correctly for the  }
           if SqrNum[I] < AllNearCutoff then       { location of the sqr and }
           begin                        { check the 4 neighbours. }
              UpJump := NearJump;               { If a neighbour sqr has no}
              DownJump := NearJump;               { items, incr Black/White }
           end                          { join count.            }
           else if SqrNum[I] < SomeNearCutoff then
           begin
              UpJump := NearJump;
              DownJump := FarJump;
           end
```

```
          else
          begin
             UpJump := Farjump;
             DownJump := FarJump;
          end;
          if SqrVal[I-UpJump] = 0 then
             BWCount := BWCount +1;
          if SqrVal[I+1] = 0 then
             BWCount := BWCount + 1;
          if SqrVal[I+DownJump] = 0 then
             BWCount := BWCount + 1;
          if SqrVal[I-1] = 0 then
             BWCount := BWCount + 1;
       end {.. if SqrVal[I] >= 1 }
    end;
    CalcObsBW := BWCount;
 end;

{------------------------------------------------------------------
---}
{ This function calculates the expected # of B/W joins for a random distrib.
(The strange order of calc. is to keep the size of the resultant in
manageable bounds). longint prevents overflow.}

function CalcExpBW (JoinNum, NumBlack, NumWhite, SqrTot : longint) : real;
   begin
      CalcExpBW := ((2 * JoinNum) / SqrTot) * (NumBlack / (SqrTot-1)) *
NumWhite;
   end;

{------------------------------------------------------------------
---}
{ This function calculates the mean of the expected values. Note longint to
prevent overflow. }

function CalcMeanBW (ExpBW : real; SumElElmin1, NumBlack, NumWhite,
JoinNum, SqrTot : longint) : real;
   var
      Term1, Term2, Term3, Term4 : real;
      JoinTerm, BlackTerm, WhiteTerm : longint;
   begin
      JoinTerm := (JoinNum * (JoinNum - 1)) - SumElElmin1;
      BlackTerm := NumBlack * (NumBlack - 1);
      WhiteTerm := NumWhite * (NumWhite - 1);

      Term1 := ExpBW;
      Term2 := (SumElElmin1 / SqrTot) * (NumBlack / (SqrTot - 1)) * NumWhite;
      Term3 := (JoinTerm / SqrTot) * 4 / (SqrTot - 1) * BlackTerm / (SqrTot -2) *
WhiteTerm / (SqrTot - 3);
      Term4 := exp (2 * ln (ExpBW));

      CalcMeanBW := sqrt (Term1 + Term2 + Term3 - Term4);
   end;
```

```
{——————————————
——————————————
—}
{ This function calculates the test statistic Z which can then be compared
to a table given in the book }

function CalcZ (ObsBW : integer; ExpBW, MeanBW : real): real;
  begin
    CalcZ := (ObsBW - ExpBW) / MeanBW;
  end;

{——————————————
——————————————
—}
begin  { Main Program }
{ This section asks for the filename or lets you quit. }
  writeln;
  writeln('——————————————
——————————————
———');
  repeat
    writeln ('Enter the name of the file you want to test. ');
    write ('(Enter "Quit" as a filename to abort): ');
    readln (FileName);
    if FileName = 'Quit' then goto EndofProgram
    else if FileName = 'quit' then goto EndofProgram
    else if FileName = 'QUIT' then goto EndofProgram;

    FullFileName := FSearch(FileName, GetEnv('PATH'));
    if FullFileName = '' then
      begin;
        writeln;
        writeln(FileName,'  not found.  Check spelling, extension and filepath.')
      end
    else
      writeln('Working on:  ',FExpand(FullFileName)); { Show full path }
  until FullFileName <> '';

  assign (Datfile, FileName);  { Assign filename to file var }
  reset (Datfile);             { Open file }

{ This section allocates Col 1 (of Datfile) to SqrNum and Col 2 to SqrVal. }
  DatumCount := 0;              { Counts # of entries in Datfile }
  while not Eof (Datfile) do
  begin
    read (Datfile, Int1);        { Read Datfile integer by integer }
    DatumCount := DatumCount + 1;
    DatArray[DatumCount] := Int1;  { Give DatArray all the values in Datfile}
  end;
  close (Datfile);              { Close file }
  I := 1;                       { Reset counters for loop below }
  J := 1;
  while I <= DatArraySize do
  begin
    SqrNum[J] := DatArray[I];     { Give SqrNum the values in the }
    I := I + 1;                   { first column of Datfile, and }
    SqrVal[J] := DatArray[I];     { give SqrVal the assoc. values }
```

```
    I := I + 1;               { in the 2nd column. So SqrVal &}
    J := J + 1;               { SqrNum are each half as long  }
  end; {while I...}           { as DatArray, SqrNum has the # }
  writeln;                  { of the sqrs, SqrVal the corresponding}
                                                   { value }

{ The next section calculates the statistics by calling functions }
  NumBlack := GetNumBlack (SqrArraySize, SqrVal); {Number of sqrs with
something in}
  NumWhite := CalcNumWhite (SqrTot, NumBlack);
  ObsBW := CalcObsBW (SqrNum, SqrVal, NearJump, FarJump, AllNearCutoff,
  SomeNearCutoff, FirstSqrDug, LastSqrDug);
  ExpBW := CalcExpBW (JoinNum, NumBlack, NumWhite, SqrTot);
  MeanBW := CalcMeanBW (ExpBW, SumElElmin1, NumBlack, NumWhite,
JoinNum, SqrTot);
  Z := CalcZ(ObsBW, ExpBW, MeanBW);
  writeln ('Significance level (one-tailed): 0.1    0.05    0.01');
  writeln ('
------------------');
  writeln ('                          z:  1.282   1.645   2.326');
  writeln ('                         -z: -1.282  -1.645  -2.326');
  writeln;
  writeln ('For this pattern, the test statistic z = ', Z :9);
  writeln;
  if ((Z >= 1.645) or (Z <= -1.654)) then
  writeln ('The patterning is significant at the 0.05 level.')
  else writeln ('Sorry, the patterning is NOT significant at the 0.05 level.');

  EndofProgram: { This is a label to jump to for Quitting }
end.
```

Appendix B

Dunefield Midden Shellfish

Regression Analyses

The shellfish from Dunefield Midden are not distributed evenly across the site. There is a range of weight values per square metre from areas containing less than 100 g of shell to areas containing over 10 000 g of shell. There is one square metre of analysed shellfish that contains over 32 000 g of shell. Neither are all the species evenly represented across the site. Regression analyses were performed in order to gain a clearer picture of this distribution and to test whether the distribution could be said to be random. The results of these analyses are presented in Tables B1-B3. In these tables the R^2 value is given for each of the correlations. The subscript '1' indicates average weight, as opposed to total weight where there is no subscript.

Table B1 illustrates that across the site as a whole the total weight of each species per square metre seems to be related roughly to the total weight of shellfish in each square metre. The weakest correlation is for *Patella argenvillei* which gives an R^2 value of 0.52. However, on the level of average weight of each shellfish per species, there is not a correlation with total shell weight. In other words, greater weight of shellfish per square does not necessarily imply heavier individuals. The correlations between species are also generally weak across the site as a whole, excluding between total weights of whelk and mussel, *Patella granatina* and *Patella granularis* and, to a certain extent, barnacle and mussel. This suggests that these species were being treated in ways which resulted in similar weights of the paired species occurring in each square metre.

Different concentrations of shellfish occur across the site and thus the site may be divided into different areas. Site index values of total weight are the easiest way of isolating areas of concentrations. The western area of the site has been labelled a main dump because it contains the greatest density of shellfish, as well as concentrations of faunal remains and other items. This area is characterised by squares containing greater than 2000 g of shell. Other smaller concentrations of shellfish occur in the area of the site containing hearths. These are thought to be smaller dumps within the main part of the site. They fall between 1699 g and 1796 g of shell. These areas can be approximated by analysis of squares containing greater than 2000 g of shellfish for the main dump and squares containing greater than 250 g but less than 2000 g for the smaller concentrations. Regression analyses illustrated in Table B1 indicate that in these areas the total weight of each species is still generally determined by the weight of shellfish in each square. The average weight of *P. granatina* and *P. granularis* are still clearly independent of total weight of shellfish per square, although the values for the other comparisons between species are lower.

However, once the areas of highest concentrations of shellfish are removed, the remainder of the site gives a different picture, with values indicating that there is no correlation between the weight of each species and the total weight of shellfish in each square metre (see Table B1). These results indicate that in the squares containing less than 1000 g of shell species are not represented in proportion to the amount of shell in each square. It may be argued that this is a function of diminished sample size. Analysis of the areas of the site containing between 1000 g and 2000 g of shell, however, also indicates no correlation between species weight and total weight of shell (see Table B2). This includes dumping areas outside and on the fringes of the main dump. These results suggest that species weight is determined by total weight to a larger extent and that species are therefore more randomly represented in the main dump than in other areas of the site. There are also differences within the main dump,

Table B-1

Regression (R^2) values for Dunefield Midden Shellfish

RATIO	WHOLE SITE	> 250 g	>1 kg	>2 kg	<1 kg
Barnacle:Total Shell	0.75	0.73	0.7	0.66	0.14
Whelk:Total Shell	0.81	0.81	0.81	0.8	0.16
Mussel:Total Shell	0.94	0.94	0.95	0.94	0.33
P.argenvillei: Total Shell	0.52	0.02	0.57	0.62	0.1
P.barbara: Total Shell	0.82	0.04	0.82	0.82	0.11
P.granatina: Total Shell	0.93	0.77	0.91	0.89	0.76
P.granularis: Total Shell	0.77	0.3	0.68	0.6	0.45
$P.argenvillei_1$: Total Shell	0.03	0.02	0.02	0.02	0.04
$P.barbara_1$: Total Shell	0.08	0.04	0.01	0.04	0.07
$P.granatina_1$: Total Shell	0	0.02	0	0.1	0
$P.granularis_1$: Total Shell	0	0	0	0.1	0
Barnacle:Whelk	0.67	0.66	0.62	0.58	0.18
Barnacle:Mussel	0.79	0.77	0.75	0.71	0.08
Whelk:Mussel	0.81	0.8	0.78	0.75	0.24
P.argenvillei: P.barbara	0.46	0.01	0.45	0.45	0.02
P.granatina: P.granularis	0.87	0.3	0.8	0.75	0.49
$P.argenvillei_1$: P.barbara1	0.04	0.01	0.07	0.2	0
P.granatina1: P.granularis1	0.03	0.25	0.38	0.37	0.03

Table B-2

Regression (R^2) values for Dunefield Midden Shellfish

RATIO	1-2 kg	1700's incl.1699	1700area	> 10 kg
Barnacle:Total Shell	0.07	0.58	0.02	0.33
Whelk:Total Shell	0.03	0.53	0.1	0.49
Mussel:Total Shell	0.19	0.69	0.13	0.89
P.argenvillei: Total Shell	0.02	0.63	0.09	0.34
P.barbara:Total Shell	0.03	0.56	0.23	0.66
P.granatina: Total Shell	0.2	0.54	0.35	0.8
P.granularis: Total Shell	0.02	0.59	0.16	0.55
$P.argenvillei_1$: Total Shell	0.01	0.04	0.34	0.11
$P.barbara_1$: Total Shell	0	0.57	0	0.03
$P.granatina_1$: Total Shell	0.01	0.14	0	0.16
$P.granularis_1$: Total Shell	0.03	0.02	0.11	0.2
Barnacle:Whelk	0.07	0.89	0.81	0.24
Barnacle:Mussel	0.38	0.82	0.8	0.38
Whelk:Mussel	0.14	0.94	0.91	0.33
P.argenvillei: P.barbara	0.04	0.45	0.02	0.12
P.granatina: P.granularis	0.12	0.47	0.3	0.79
$P.argenvillei_1$: P.barbara1	0.03	0	0.24	0.12
$P.granatina_1$: $P.granularis_1$	0.41	0.93	0.63	0

however, and regression analyses performed on squares containing over 10 000 g of shell show a significant correlation only in the mussel to total shell ratio, with a slightly smaller correlation between total weights of *P. granatina* and *P. granularis*. Within the dumping areas containing 1000 g to 2000 g of shell there is a further interesting feature. There are several square metres which seem to be distinguished by containing roughly 1700 g of shellfish. There is a relative isolation around this range (see Figure 28). Regression analyses of these squares containing between about 1700 and 1800 g of shell indicate a very high correlation between the average weights of *P. granatina* and the average weights of *P. granularis*, as well as high values between barnacle and whelk weights, barnacle and mussel weights, whelk and mussel weights.

This does not appear to be a function of isolating a few squares containing similar amounts of shell. In order to test this, regression analyses were performed on squares containing 500 - 600 g of shell and squares containing 1500 - 1600 g of shell. These both gave much lower correlations overall between different species (see Table B3). Furthermore, an analysis of the squares containing between 1500 and 2000 g of shell also did not show the good correlations obtained between species for the squares containing about 1700 g.

One of the squares containing about 1700 g of shell is on the edge of the main dump, whilst all the others represent smaller concentrations of shell. When the squares containing between 1000 g and 2000 g of shell surrounding the squares containing about 1700 g are included in with this group, they reveal a similar pattern to the isolated squares, although the correlation between *P. granatina* and *P. granularis* average weights is slightly reduced and the correlation between total weight of *P. granularis* and total weight of shell becomes very insignificant. However, the other correlations noted above seem stronger when takes into account the generally lowered values in this column (see Table B2). This implies that these squares represent an

Squares containing approximately 1700 g of Shellfish

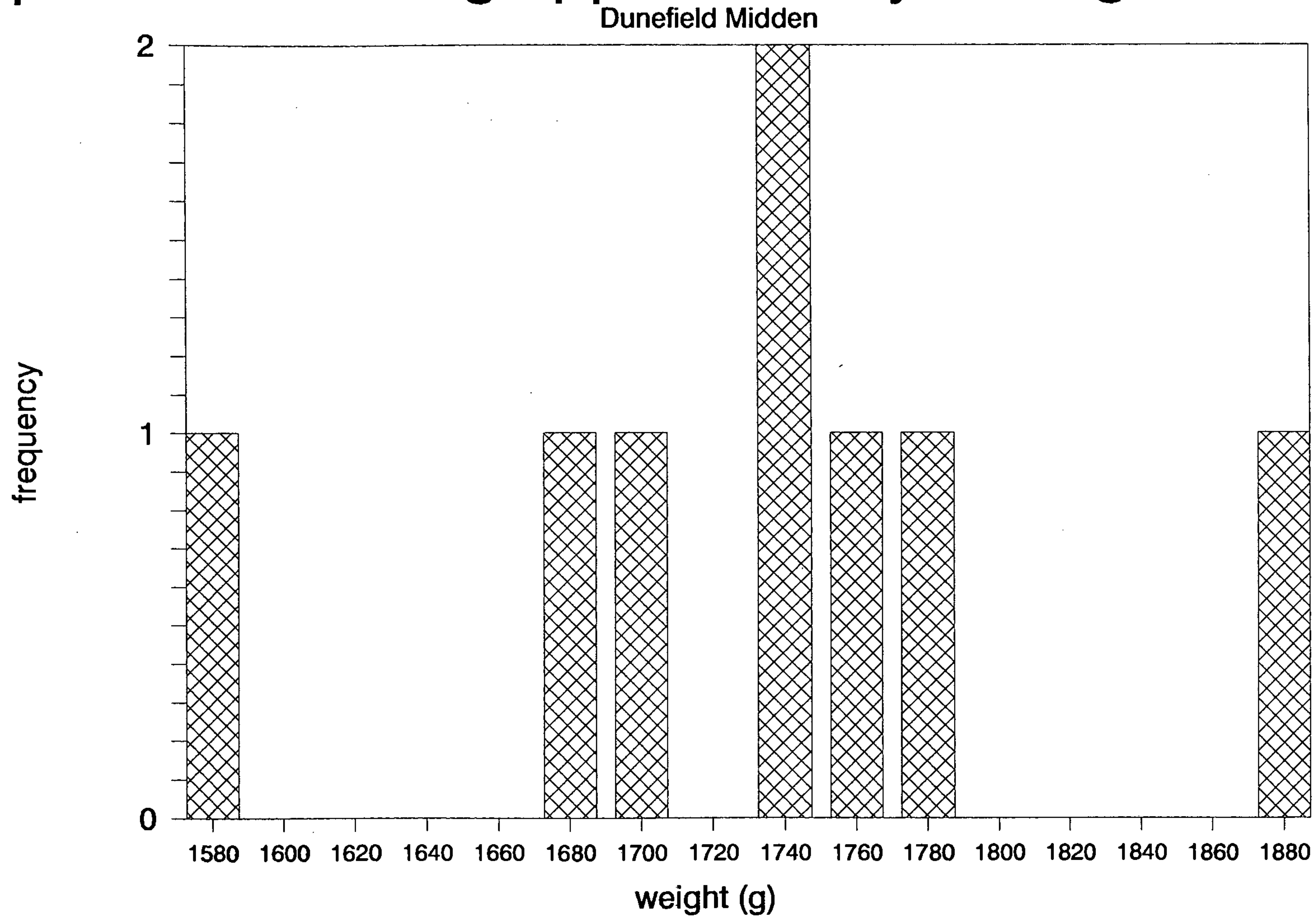


Figure 28

Table B-3

Regression (R^2) values for Dunefield Midden Shellfish

RATIO	500's	1500's	1.5-2 kg	excl <5%
Barnacle:Total Shell	0.11	0.84	0.25	
Whelk:Total Shell	0	0.15	0.14	
Mussel:Total Shell	0.11	0.03	0.07	
P.argenvillei: Total Shell	0.27	0.86	0.01	
P.barbara:Total Shell	0.3	0.34	0.12	
P.granatina: Total Shell	0	0.4	0.02	
P.granularis: Total Shell	0.17	0.86	0.04	
P.argenvillei$_1$: Total Shell	0.17	0.96	0.01	
P.barbara$_1$:Total Shell	0.36	0.34	0.24	
P.granatina$_1$: Total Shell	0	0.73	0.06	0.01
P.granularis$_1$: Total Shell	0.04	0.14	0	
Barnacle:Whelk	0	0.52	0.05	
Barnacle:Mussel	0.04	0.3	0.6	
Whelk:Mussel	0.25	0.95	0.13	
P.argenvillei:P.barbara	0.11	0.06	0.09	
P.granatina: P.granularis	0.04	0.77	0.48	
P.argenvillei$_1$: P.barbara1	0.01	0.16	0.03	
P.granatina$_1$: P.granularis$_1$	0.1	0.64	0.58	

interesting feature on the site, possibly constituting the main small dumps within the area of the site containing hearths.

The implications raised by this analysis are discussed within the main body of text of this thesis, in particular in the section dealing with dumping behaviour. This regression analysis was used to add further dimensions to the discussion of the Dunefield Midden shellfish.

Appendix C

Site Indices

Site indices were developed using a methodology imported from the field of Remote Sensing Analysis (Rüther pers. comm.). In order to examine subtle changes in the shading of types of vegetation in satellite images, a "Vegetative Index" is created. Raw satellite data is ratioed in order to provide directly comparable values which can be analysed by image processing programs. Various ratios can be used to provide values which suit the type of analysis undertaken (Szekielda 1988 Kraus 1990).

As an illustration of this method the categories of information available from the excavation of Dunefield Midden (such as small marine fauna) were subjected to similar analysis, primarily in order to resolve spatial patterning by investigating the relationship of various categories across space, as well as to investigate the usefulness of these categories through various recombinations and subdivisions (see example 1 below). The ratio thought appropriate for the analysis conducted in this study was a straight conversion of the values available. The assumption underlying the use of this ratio is that the square with the greatest density of one category has an equal weighting in the analysis with that of the greatest density in another category, regardless of the respective sizes of the original numbers in each category. This technique may therefore be regarded as a method of normalisation.

Numerical Analysis of Index Distributions

Indices were calculated for all total weights or numbers as applicable in each category. The categories were fish bones, quartz chips, all stone artefacts, flakes, bipolar cores, potsherds, lobster mandibles, snake bones, all shellfish and tortoise plastron fragments.

The indices were rated between 0 and 255, in order to be applicable for later computer analysis as well. Although it is accepted that most normalisation rates items on a scale of 1 to 100, thus allowing an easy recognition of relative amounts in terms of percentages, this is not applied here.

Computers work with information in the form of exponents of 2. In other words information must be in the form : 2, 2^2, 2^3, 2^4 ... The number 100 is not expressible in this form, the closest being 128 which is 2^7. Computer programs used in the analysis of satellite images require information ranged between 0 and 255 (i.e. 256 or 2^8) since this is the level of resolution of a computer image produced by a satellite (Rüther pers. comm.). If the information used in this study is to be available in a form where programs such as these can be used to analyse it, it is necessary that it also be in this form. The use of standard computer format in this study anticipates the greater use of computer techniques in analysis that may be expected in any discipline. The information is in a form that can be analysed by computer programs of any nature, not only specific types of program, such as databases.

Furthermore, there is felt to be additional advantages with the use of this numbering system. Firstly, it allows a greater resolution of the information. The greater resolution is particularly relevant to categories containing a great range of numbers, such as shellfish. It became important in isolating features such as relatively minor dumps of shellfish, which would have been obscured on a system of numbering from 1 to 100. Secondly, the mere fact that it is not in an easily recognisable form minimises the number of unconscious assumptions made about the information and allows the inherent patterning to become more obvious.

The rating of items by category was achieved by applying the following formula:

$$255(x/x_{max})$$

where 'x' is the total weight or number of items in the particular square
and 'x_{max}' is the maximum value in each category.

Different subdivisions of the indices are possible. In some cases a very small difference in numbering was required in order to reveal finely resolved patterns. In other cases, a more general analysis was required. In the latter cases the indices were subdivided into the following ranges:

20 - 40

40 - 80

80 - 160

160 - 255

All values below 20 were rejected as 'noise' in the samples. Each interval's size is double that of the preceding interval. This was done in order to obtain a more even spread of values, there being far fewer values in the upper ranges than in the lower.

An ordering system which applies a straight sequential number of intervals, (for example in the form 1,2,3,4...), weights the lower ranges of values where there is a spread from a low density to a high density. In other words, if a spread is from 0 to 1 to 4 to 12 to 25 to 70 (as is the case with one example of quartz chips see Vermeulen 1990), the number of intervals necessary to describe the spread of values is very large. It follows logically that there are many more representations of the lower ranges present than there are of the very high (in the example given above there are clearly fewer intervals unrepresented in the lower ranges than in the higher ranges). This weights the low ranges with respect to the higher ranges. The exponential ordering of intervals shown here avoids the problem of over-representation of the lower ranges.

An exponential ordering gives ranges that contain more values, the higher the interval (for example the first interval in a sequence 1,2,4,8... contains one value, the second interval contains twice as many values as the first and the third interval contains four times as many values as the first). In the example given above (0,1,4,12,25,70), using an exponential ordering, there are as many intervals unrepresented in the lower ranges as in the higher ranges. Therefore high numbers relatively separated from each other are represented on an even scale to low numbers close together. Exponential ordering was also found to give the best results when contouring the distributions of quartz chips from the site (Vermeulen 1990). This is interesting because it results from the fact that most high distributions fall within a meter square. If this was not the case and the areas of the site containing the densest material spread over several meters, there would be far more values in the upper intervals, and hence no need for doubling the interval each time. This is even true for the shellfish, where most of the denser squares are clustered in one area of the site, indicating that even though the densest areas extend over several square metres, it is nevertheless necessary to double the intervals in order to obtain a clearer result.

Even this doubling of the intervals does not yield completely equal results and the highest interval often still contains the lowest number of values overall. Nevertheless it remains a more equitable manner of analysing the values, as indicated by the examples given in Vermeulen (1990).

The indices for the separate categories were combined into composite indices distinguishing artefacts from food remains and subdividing the food remains into size classes and marine/terrestrial origins. In each case where indices were combined they were recalculated according to the above formula in order to remain within the 0 to 255 range and thus be directly comparable to all other indices.

Example of the use of Indices

One of the ways that the use of site indices can be applied to spatial archaeology is to test whether there is homogeneity in the definition of categories of information. Unless categories display a homogeneous distribution, they are not very useful in an examination of the information from the site. For example, there is no use in defining a category "small marine fauna" if components of this category such as shellfish and lobster are found in widely varying parts of the site.

It was decided that the potsherd/all stone artefact index would be a better marker of a range of activities involving artefacts than would an index combining potsherds and quartz chips. It is assumed that the quartz chips are the by-products of stone tool manufacture at this site (Vermeulen 1990) and therefore the potsherd/quartz chips index reflects only this activity and activities connected with potsherds, whereas the other index should reflect other activities involving stone artefacts as well.

The distribution of stone artefacts as plotted against that of potsherds supports the combination of these two categories into one index. Although there is very little overlap between these two categories (2 squares or 5% of the total number of squares, see Table C-2) and these overlapping squares reflect values within the same two lowest ranges, these items are found in complementary areas of the site. They were either found in adjacent squares, or within a few metres of each other and most were found in the area of the site characterised by hearths, outside the area of the main dump. Their final position indicates that they were less subject to being discarded on the main dump than were other items. It is therefore felt that the combination of these two items into the category 'artefacts' (a very common process in archaeological descriptions) has some value for analysis.

Tortoise carapace bowl fragments and ostrich eggshell fragments, although recognised as cultural items, were not included in the artefact index. The aim of producing these indices was to examine spatial patterning on the site by numerical analysis, thus fairly distinct categories needed to be defined in order for patterning to be evident. If categories were made too general and the patterning obscured by a diffuse scatter of variables across the site, the analysis would not prove very useful in determining small scale differences in distribution. Tortoise carapace bowl fragments and ostrich eggshell fragments occur mainly in the area of the site assumed to be the main location of refuse disposal at the site. The combination of these values with those of potsherds and stone tools would lead to the artefact index covering most of the site and would not provide the resolution necessary to distinguish small scale patterning of remains. Certainly the creation of such indices would reveal some information, but it would not be of the level of resolution that the acknowledgement of the different distributions would reveal. Thus a knowledge of the existence of different areas within the site can be used to enhance resolution.

Similarly shellfish are excluded from the small fauna index discussed below. This category itself exhibits a large spread of values and the inclusion of the values for shellfish would have similarly obscured all patterning. The low coincidence of the subcategories within the small fauna index encouraged the subdivision of this index, although its patterning in relation to other indices is included as a sample.

The small fauna index reflects the combination of the values for fish bones, snake bones, lobster mandibles and tortoise plastron fragments (see Table 4). This index was created in order to examine whether any of the patterning of remains on the site could be related to differential treatment of food waste on the basis of size. The small fauna index was then subdivided into a terrestrial small fauna index, consisting of values for snake bones and tortoise plastron fragments. Values for fish bones and lobster mandibles were combined with shellfish in order to obtain a small marine fauna index and were also combined distinct from the shellfish in order to investigate whether these two animals, although obtained from the sea, were treated differentially from shellfish (See Table C-1). The aim of comparing the distributions of various categories of information on the site to each other was to reveal intricacies of discard behaviour. Through an analysis of discard behaviour one may reach an understanding of other behaviours such as food processing.

One cannot ignore the fact that the patterning described here is partly a result of taphonomic forces. Small bones such as those of snake and fish, (which in the case of the snake could arguably have had a non-human origin such as dogs or other carnivores anyway), would be particularly sensitive to these factors. The non-human origin of the distribution of snake bones is considered unlikely, since they do not seem to be found in association either with carnivore faeces or gnawed bones. Furthermore, their small size makes it likely that non-human agents would have swallowed the bones along with other parts of the carcass. Since the site seems to have been covered by sand fairly quickly after being abandoned, many taphonomic factors such as weathering and removal by water or wind may be disregarded. The latter factor would argue against the presence of scavengers, as does the presence of small bones for the reasons mentioned with respect to carnivores above. This leaves the actions of burrowing animals as a primary concern. However, as shown by the integrity of the distributions of other small items such as quartz chips, it would seem that these factors did not have a significant effect, at least at the one metre square resolution level.

Table C-1

Categories for Site Index

Category	Comprised of:			
Artefacts	potsherds	all stone artefacts		
Small fauna	snake	tortoise	fish	lobster
Small marine fauna	shellfish	lobster	fish	
Small terrestrial fauna	snake	tortoise		
Fish and Lobster	fish	lobster		

Results

The results of this analysis are indicated in Table C-2. The categories and degrees and types of overlap are displayed and patterning can be described from an analysis of these results. An explanation of the table is felt to be necessary. The first two columns of the table indicate the categories which were compared with each other. The assigning of each category to either the first or the second place is arbitrary and is done for convenience. The distributions were analysed from maps produced on a GIS and thus the distributions of both categories were present simultaneously. For ease of description the categories are named 1 and 2.

The exact method by which these results were obtained was to produce maps of all the distributions with respect to each other. All the squares in which both categories were present were counted and expressed as a percentage of the total number of excavated squares. These squares in which both categories were present were then individually assigned as containing values within the same ranges as each other, or containing one category in excess of another, these assignations being mutually exclusive. Finally the number of squares assigned in each of these ways were added together and expressed as a percentage of the total number of squares containing both categories (overlapping and non-overlapping).

The third column in Table C-2 is headed "% Overlap". This refers to the number of squares across the whole site where **both** categories are present. These squares represent the **overlap** of both distributions. Squares containing **neither** of the categories are excluded from the numerical part of the analysis, since a square which contains neither of two categories can not represent an overlap of the two categories. Similarly squares where only one of the categories is present are excluded from the next part of the analysis, which is concerned with overlap, for the same reason.

Table C-2

Percentage Overlap of Categories

Category 1	Category 2	% Overlap	Overlap		
			% same range of values	% Category 1 outnumbers Category 2	% Category 2 outnumbers Category 1
Potsherds	Stone	5	100	0	0
Artefacts	Small fauna	21	28	16	56
Artefacts	Small terrestrial fauna	21	18	9	73
Artefacts	Small marine fauna	18	24	20	56
Artefacts	Fish and Lobster	17	50	12.5	37.5
Fish and Lobster	Shellfish	20	24	57	19
Artefacts	Shellfish	13	31	8	61.5
Small fauna	Shellfish	23	37	43	20
Small terrestrial fauna	Small marine fauna	30	24	44	31
Small terrestrial fauna	Fish and Lobster	27	37	30	33
Snake	Tortoise	16	38	31	31
Snake	Lobster	9	29	43	29
Fish	Tortoise	15.5	64	18	18
Snake	Fish	6	100	0	0
Tortoise	Lobster	17	31	62	8
Fish	Lobster	21	33	17	50

The last column, headed "Overlap" at the top of the table, is subdivided into a further three columns. This column's subdivisions all refer to overlapping squares (i.e. squares containing both categories to some degree). The first of these subdivided columns is headed "% same range of values". This column contains the percentage of the **overlapping** squares which contain both categories in the same **range** of values. This may mean that both categories are represented by only a small index value (indicating a low number/weight of items). Or it may mean that both categories are represented by a high index number (indicating a high number/weight of items). Or it may mean that both categories are represented by a medium sized index number (indicating a medium number/weight of items). However, it will **not** refer to squares containing neither category, nor only one of the categories (since it refers to overlapping squares), nor will it refer to squares where both categories are present but one outnumbers the other (in other words is present in a greater density than the other).

The second subdivided column under the heading "Overlap", is headed "% Category 1 outnumbers Category 2". This column gives the percentage of **overlapping** squares (in other words squares where both categories are present) where one category (named in column 1) outnumbers, or is present in greater density, than the other category (named in column 2). This does not refer to squares containing neither or only one category. Nor does it refer to squares where both categories are present in the same quantity, but only to squares where the first category has a greater density than the other category.

The third subdivided column under the heading "Overlap", is headed "% Category 2 outnumbers Category 1". As may be expected this indicates cases where the reverse of the last column is true. That is, it refers to instances amongst the **overlapping** squares where Category 2 outnumbers (or is present in a greater density) than Category 1.

It should therefore be obvious that the three columns must add up to 100%. In a square containing both categories, the first category is either present to the same amount as the other category, or it outnumbers the second category, or the second category outnumbers it. The amount to which any of the above statements is true for two categories across the whole site indicates the relative densities of the two categories with respect to each other in squares where both are present.

It may be argued that it is necessary to further subdivide those squares containing similar ranges of values into squares where both values are large, squares where both values are small and squares where both values are of medium size. This was not done, although the ranges represented were taken into account when reaching the conclusions discussed below.

The most general conclusion that can be drawn from this analysis is that the categories of remains from this site are spatially separated to a fairly high degree. In other words, in all cases the "% Overlap" is relatively small. The greatest amount of overlap between distinct categories is that between small terrestrial fauna and small marine fauna. This probably reflects the fact that these two categories are slightly too general to provide very fine resolution of the patterning, since the amount of overlap between the separate constituents of these categories reflect amongst the lowest amounts of overlap.

The high degree of separation evident between the subdivisions of categories such as small fauna, small terrestrial fauna and small marine fauna suggests that these broad categories do not reflect distinctions made by the inhabitants of the site. If these people had treated shellfish in the same way as lobster or fish, merely because they have a common marine origin, it seems likely that they would have distributed the remains of these animals in the same fashion. In other words, all these animals would have been processed in the same way and their remains would have been discarded together. The simple fact that they did not, allows us to conclude that they ascribed differences to these animals. The values given in Table C-2 show that these items did not end up in the same places and therefore were not treated as a homogeneous group.

However, despite the relatively low degree of overlap between categories, no category stands in complete isolation from the rest. In many cases categories which show a relative separation from each other in the numerical analysis in fact are found in quite close spatial association to each other, although their distributions do not overlap. The numerical analysis itself is useful for examining trends in the distributions of different categories.

Although the artefact category shows a generally high degree of separation from other categories, artefacts pervade areas characterised by other items to a small degree. In other words, concentrations of artefacts are not found on the fringes of dense areas of small faunal remains. On the other hand, food remains represented by small fauna tend to be found in greater density in the denser areas of artefacts. This is compatible with the suggestion made previously that the consumption of certain fauna was not prohibited in areas of artefacts' use or manufacture (Vermeulen 1990). Whilst this may not seem surprising in the case of pottery, which was probably used in food processing and consumption activities, the coincidence with areas of stone tool manufacture is more interesting since it suggests that this activity was not disassociated with 'snacking' behaviour. In other words the consumption of certain food items occurred in areas of stone tool manufacture and these areas were not completely isolated from all other areas of the site.

The patterning of food remains with respect to each other is also interesting. Certain areas of the site seem to be characterised by particular types of food remains. This is hinted at by the relative separation of all categories of small faunal remains indicated above in Table C-2. Since all categories display a relatively low degree of overlap, it can be concluded that no area of the site contains the whole contents of all the categories. It may also be concluded that all categories are not present in a general scatter across the site. Furthermore, the distributions of individual types of animals (e.g. fish or tortoise), although separated to a fairly high degree from each other, seem to show a general trend towards more overlap within the marine/terrestrial distinction area. For example, fish and lobster show a relatively high degree of overlap, whereas snake and fish do not. This suggests that although the marine/terrestrial distinction does not seem to have homogeneity as separate groups (in other words, the separate groups : small marine animals and small terrestrial animals do not show a large degree of homogeneity - indicated by the relatively low amounts of overlap of their component categories), there are slightly different areas of the site where one may expect a predominance of one type of fauna over the other.

A measure of statistical significance may be obtained for these results. Table C-3 illustrates the results of a chi-squared test for cross-classified data (Shennan 1988:70). The test has as its null hypothesis that the categories are unrelated to each other, in other words that the distributions of the two categories are independent of one another (Shennan 1988). As can be seen from the table certain distributions had samples too small to enable the test to be performed. Only two distributions of sufficient sample size gave a non significant result. These were the artefact/shellfish distribution and the snake/lobster distribution. Given the above description of the null hypothesis, the distribution of artefacts can be said to be unrelated to the distribution of shellfish. This is, however, not surprising since the components of the

Table C-3

Statistical Significance of Overlap of Categories

Category 1	Category 2	Statistical significance
Potsherds	Stone	sample too small
Artefacts	Small fauna	significant at 0,005 level
Artefacts	Small terrestrial fauna	significant at 0,005 level
Artefacts	Small marine fauna	significant at 0,005 level
Artefacts	Fish and Lobster	significant at 0,005 level
Fish and Lobster	Shellfish	significant at 0,005 level
Artefacts	Shellfish	not significant at 0,005 level
Small fauna	Shellfish	significant at 0,005 level
Small terrestrial fauna	Small marine fauna	significant at 0,005 level
Small terrestrial fauna	Fish and Lobster	significant at 0,005 level
Snake	Tortoise	significant at 0,005 level
Snake	Lobster	not significant at 0,005 level
Fish	Tortoise	sample too small
Snake	Fish	sample too small
Tortoise	Lobster	significant at 0,005 level
Fish	Lobster	sample too small

artefact category were chosen as those with the least coincidence with shellfish. Nevertheless, the test confirms the visual identification.

The result of confirmation of the null hypothesis for the distribution of snake and lobster supports the conclusion reached above, that there tends to be a greater degree of separation between terrestrial and marine small fauna. The separation seems evident even though the distributions of terrestrial and marine small fauna were not shown to be statistically unrelated. Unfortunately the distribution of fish gave an insufficient sample size.

The rejection of the null hypothesis in most cases for the distributions tested means that the different distributions are not independent of each other. The dependence may be of different forms. The distributions may either be avoiding each other, or they may be attracted to one another. In other words, there may be a negative or a positive correlation between them. The chi-squared test as performed here does not reveal which correlation exists. Columns 4 - 6 of Table C-2 are relevant to the identification of the nature of the correlation. If columns 5 or 6 (% Category 1 outnumbers Category 2 or % Category 2 outnumbers Category 1) are most highly represented then there is a negative correlation between the distributions. If column 4 (% same range of values) is highly represented then there is a positive correlation between the distributions. An examination of the table gives the result that most of the distributions are negatively correlated. Unfortunately, only the distribution of small terrestrial fauna against small marine fauna have a sample size large enough at this level to give a result on the chi-squared test for cross-classified information. This distribution gives a result of a statistically significant negative correlation.

The use of indices can therefore be said to aid an interpretation of the patterning of material. It also tests the validity of certain categories into which material can be divided, thereby helping to reveal the complexity of the patterning at the site and the interaction of material across space. As such it may be regarded as a useful method to employ when examining the patterning of material spatially on a site. This method will be used in this study whenever it is necessary to examine more than one category of material in order to provide a directly comparable frame of reference.

As can be seen from the above sections, there are many different methods available which can aid spatial analysis. This thesis has also explored the use of ethnographic and ethnoarchaeological examples. As stated before the use of ethnographic analogy is a more socially-orientated and interpretive approach than those discussed above. It is also one of the main methods used in this study.

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