CHAPTER 9: RESEARCH QUESTIONS AND METHODOLOGY

9.1 RESEARCH QUESTIONS

In so far as it has proved possible, the so-called 'hypothetico-deductive' method has been followed throughout. This rather grandiose phrase describes the simple process of defining relevant, appropriate questions (the research questions) and determining tests which are ideally necessary and sufficient to provide unambiguous answers to them.

The research questions considered in this project were derived, where possible, from the existing body of relevant literature reviewed in Chapters 2 and 3 above. Strict adherence to this practice would, however, have left many relatively obvious problems untackled. The nature of the deposits on the sites and the mechanisms by which the sites were formed, for example, have not been widely discussed (but see Davidson *et al* 1983, on comparable Orcadian sites). The research questions relating to matters not formally discussed in the existing literature were formulated by first developing models, based on general principles, which seemed applicable to the particular circumstances of the sites, in the light of our knowledge of them and our recent experiences at Balelone. Research questions were then formulated to test the validity of the models.

The 'relevance' of research questions is in part founded in their derivation from previously published work or from properly formulated models, as outlined above. However, it is also dependant on their relationship with the data, in that only questions which can be answered directly from the available data may be considered relevant. Middle range theories, for example, those relating to the nature of the agricultural economics of Hebridean Iron Age machair sites, are not research questions, because their elucidation relies on inferences drawn from the answers to more basic questions, ie from the answers to relevant research questions. Topics of this type are discussed in the concluding chapters after the research questions have been considered.

Six principal areas of research seemed to present themselves. The nature of the sites themselves, their structures and deposits constitute the first and their chronology, the second. The regional environment in which they functioned, through time, may be considered next, because it sets outer limits to the possibilities for the development of the economies of the sites, the fourth research area. Technology and trade, while aspects of site economy, merit separate consideration and the settlement landscape, the distribution and location of these sites is also of sufficient importance to stand alone, as a research topic. Hereunder are listed, without comment, the questions with which we approached these sites. This is followed by the methods employed to answer to them.

9.1.1 The sites

i) What processes were involved in the formation of the sites themselves?

ii) What processes of post-depositional change are evidenced in the sites and to what extent do they constrain interpretation?

9.1.2 Deposits

i) What is the character of the soil matrix of the deposits? How does it differ from the machair soils? What is the source of the materials in which they differ? What is the depositional mechanism by which they were formed?

ii) What is the anthropic contribution to the deposits and what light does it cast on the process of formation of the deposits?

iii) What natural, non-soil, materials are present in the deposits and what information do they convey about the formation of the deposits?

9.1.3 Structures

i) What types of structures, and of what date and duration, are evidenced in the sites?

ii) If structures of the dun/broch/wheelhouse complex are uncovered, do the different structures represent chronological succession or social differentiation?

iii) What was the local environment of the sites like? To what extent did the sites modify the ambient environment?

9.1.4 Artefacts

i) What classes of artefacts are present in each site and where the deposits are of sufficient duration, do they provide evidence for the existence of chronosequences or typologies?

ii) Do the artefactual assemblages from each deposit convey meaningful information about the nature or function of the individual deposits?

9.1.5 Chronology

i) What is the date of the inception of each site?

ii) What is the duration of each site?

iii) Are there significant breaks in the depositional chronology of the sites, representing phases of abandonment between periods of occupation?

iv) Are there less significant breaks indicative of phases of relative inactivity in the sampled areas during periods of continuing occupation at other foci within the site?

9.1.6 Regional environment

i) What is the impact of the post-glacial vegetational succession of the Uists on the natural succession of human settlement, especially during those periods when the excavated sites were occupied?

ii) By what date was the machair system established in the areas it now occupies?

iii) At what date did the general spread of blanket peat take place?

9.1.7 Site economies

This research topic breaks naturally into two parts the first of which concerns the agricultural economy of the site while the second covers the hunting and gathering aspect of the settlements.

Agricultural economy

i) Were both animal and crop husbandry being practised by the occupants of the sites?

ii) What domesticated animals are represented in the site assemblages, and in what proportions?

iii) Were the animals kept primarily for meat or for secondary products like milk or wool?

iv) Is there any evidence for the use of domesticated animals as draft animals?

v) Is there evidence for the existence of non-consumable animals such as pets or commensals?

vi) What implications do the likely herd sizes and structures have for the scale and organisation of the farms?

vii) Is there evidence for cultivation, direct or indirect?

viii) What crops were cultivated?

ix) Is there evidence for crop processing including storage, on the sites?

x) Where were the cultivated fields, and what sizes were they?

xi) What was their likely fertility and how was it improved or maintained?

xii) At what level was their agricultural technology practised and what agricultural hardware is evidenced from the sites?

Non-agricultural aspects of site economies

i) To what extent were the sites truly subsistence economies, ie they consumed all they produced and produced all they consumed? Were animals or plants present which could not have occurred naturally in the islands natural and man-made ecosystems?

ii) To what extent did the marine produce, derived from both flora and fauna, contribute to the site economies?

iii) To what extent were undomesticated animals or birds used in the sites economies?

9.1.8 Technology

i) What level of technology is evidenced in the artefacts, both finished products and by-products?

ii) What level of technology is evidenced in the architecture of the sites' structures?

iii) What level of technology is evidenced in the food producing activities recorded on the site?

iv) How does the general level of technological achievement evidenced on the sites compare with that of contemporary sites elsewhere in the Isles, on mainland Scotland, in Britain and further afield?

9.1.9 Trade

i) Are any of the sites materials necessarily derived from non-local sources and can these sources be identified?

ii) Are there any locally available materials, used on the sites, which might be identified on sites elsewhere?

iii) Does the analysis of the sites economies indicate possible surpluses of potential trade goods, which are not detectable in the archaeological record?

9.1.10 Site distribution and location

i) Why are the sites in the positions they now occupy?

ii) How does their distribution relate to the overall distribution of contemporaneous sites of all types?

iii) Why have the sites survived and what is the prognosis for their continued survival?

9.2 METHODS USED IN ADDRESSING THE RESEARCH QUESTIONS

It seems useful to present here the methods used to address the research questions outlined above. The specific methodologies employed by the various specialist contributions to this project are provided below.

9.2.1 Site formation

The processes of site formation and change are explored on two levels, that of the nature of the deposits which comprise them and that of their gross structure as geomorphological entities. The methods applicable to the former are the characterisation and sourcing of the anthropic contributions to the natural soil matrix of the area. This entailed routine soil analyses, site pollen analyses, phytolith analysis and a taphonomic analysis of the artefactual and ecofactual inclusions in the sites together with an assessment of their rates of sedimentation. The conclusions reached in this matter, together with field observations of the unexcavated coastal sites, provided the basis for comment on the sites as geomorphs.

9.2.2 Structures

The nature of the structures revealed in excavation would be determined by recording their forms and contents and by using primary contents, where they existed, to assess the function/s of the structures. Their dating forms part of the general problem of site chronology and is discussed below. Their impact on the immediately local environment would be assessed by pollen and phytolith analyses, snail assemblages and the nature of their associated deposits. The social status of the structures relies on an analysis of materials with which they have primary associations, together with a consideration of their relative sizes and elaboration.

9.2.3 Artefacts

The artefacts retrieved were subjected to standard archaeological studies. Their range was very restricted and, in practice, only the pottery assemblages proved sufficiently extensive for detailed study. The method favoured was that of attribute analysis. Chronological control was effected by the site chronologies (see below).

As noted above, the range and quantity of artefacts, manuports and some ecofacts provide an insight into the extent to which human activities have altered the natural wind blown sands of the area (see Chapter 1.3.6). Potsherds existed in such quantity that it was decided to explore their size distribution within each context, to assess the extent to which the contexts have undergone gross disturbance, by ploughing, for instance (see Sherd Size Distribution method, below). Both of these indices facilitate the use of artefactual assemblages in the exploration of the nature and function of the sites deposits.

9.2.4 Chronology

It was clear from the outset that close chronological control on the depositional sequence provided the only hope of unravelling the tangled skein of deposits which the large sites displayed. It was decided to eschew the traditional archaeological practice of dating specific interesting or important 'events' in the site's evolution and to try instead to date the depositional sequence of the site as a whole, interpolating to date specific events. This would facilitate dating the inception and duration of each site and, hopefully, the date and duration of the separate events represented in the depositional sequences. To that end dates were selected from contexts close to the boundaries of contiguous blocks. Shell was used for dating, because of its ubiquity, and carbonised material was also dated from a number of contexts to assess the marine reservoir effect (see Chapter 18.11).

9.2.5 Regional environment

It was decided to explore the regional environment by pollen analysis, diatom analysis, phytolith analysis and by analysis of snail assemblages. The phytolith and snail assemblages were derived from site deposits and the pollen and diatom analyses from peat and lake deposits nearby.

9.2.6 Site economies

Analyses of animal bone and macroplant assemblages, and of cultivation marks and cultivated deposits, the latter by pollen and soil analyses, were undertaken to provide some insight into the domestic economies of the sites. Analysis of the fish bone assemblages was undertaken to explore the contribution of the rich marine and peri-marine ecosystems of the domestic economies. Bird bones were also analysed to explore the use of fowling and its contribution to the sites. Carbonised macroplant remains of seaweeds and the remains of seaweed dwelling mollusca indicated the use of seaweed on these sites. While seashells were present in most deposits and abundant in some, no formal analysis was undertaken because the information yield, in the present state of marine molluscan studies, does not justify the costs entailed.

9.2.7 Technology and trade

The evidence of the pottery assemblages, of the structural analyses, and of the agricultural activities practised on the sites was used to assess the state of technological sophistication of the sites inhabitants. Evidence of trading was sought in the artefact and other assemblages, by looking for exotica. To this end, the fabrics of the pottery assemblage, the only significant artefact assemblage, were examined for non-local rock and mineral inclusions.

9.2.8 Site distribution and location

It is clear that most of the coastal erosion sites of the Long Isle are multi-period sites. Either the locations they occupy are special in some way or the existence of a site provided some advantage over the surrounding machair, such that subsequent settlement was attracted to it. This proposition was examined by a study of the known site distribution, by a separate coring exercise at Baleshare and by an analysis of the results of the study of the site deposits. This latter factor, together with current land-use trends, was explored in an assessment of the reasons for the sites' survival and the likelihood of their continuing survival.

9.3 SPECIFIC METHODS

9.3.1 Coarse pottery: analytical methods

D Lehane and L Crone (1986)

Introduction

The excavated sites all produced pottery in relatively large amounts as follows; Baleshare 5760 sherds, Balelone 1,500 sherds, Hornish Point 699 sherds and South Glendale 175 sherds. The site at Newtonferry produced 350 sherds all of which were uncontexted and therefore only received a cursory examination. The majority of the pottery came from the sieving of the excavated tapestry strips. However, prior to this any pottery exposed in the section had been recorded and removed.

Traditional pottery reports are based on the examination of a number of features observed on each sherd with a view to producing a typology of culturally significant classes. The features which can be observed are numerous and include colour, hardness, texture, decoration, etc. Those features chosen are not consistently used and are usually selected in response to specific questions posed by the assemblage. It was decided that a set list of features or attributes would be recorded for each sherd. Those attributes were chosen so that the assemblage could be described in terms of type, form, construction, decoration, function and site distribution or provenance. This process mimics the attribute analysis of flint and its strength in pottery analysis lies in the fact that pottery types can be defined easily and unambiguously in terms of any combination of some or all of the recorded attributes.

Attribute recording

A copy of the attribute list can be found in the site archive; the following supplies brief descriptions of the terms used.

The external curvatures in the horizontal and vertical planes of each sherd were measured using a set of curves with radii ranging from 50 mm to 210 mm, in 10 mm steps. The curvature was not always measurable and the smaller the sherd the less reliable the value taken in general. The net result of this may have been to increase somewhat the number of sherds with large radii, but since there is no direct relationship between sherd size and radius it is felt that no significant bias has been introduced.

The minimum and maximum thickness of each sherd was recorded in millimetres and its weight in grams. Colour was recorded for three locations on each sherd external (outer face), internal (inner face), and middle. The colour was defined by the use of the Munsell Colour Chart, (MSCC 1975). The pottery colours, as an index of their firing conditions (Shepard 1956, 107), were noted: fully oxidised (colours clear through cross section of wall), incompletely oxidised (colours clear on surface, grey on wall interior) incompletely or fully oxidised (brown light to dark), unoxidised or reduced (uniform colour).

The gross texture, (in this instance, texture does not refer to the size of the clay particles, but rather to the thickness of the sherd in general), was noted under the following headings: very coarse, coarse, medium, fine and very fine. Their categories were not based on any absolute scale, rather the complete assemblage was examined and relative groups defined.

The base angle, ie the external angle between the side of the pot and the horizontal plane on which the pot stands, was recorded together with the base thickness.

Rim types were defined by simply noting the different forms occurring within the assemblage.

The decoration of the pottery has been recorded under the categories of method and motif. Six different methods were noted: incised, applied, gouged, stabbed, impressed and stamped, along with twenty-four different motifs.

There are a number of attributes which occur so infrequently that a separate attribute space is not required. These include such features as the presence of grass and seed impressions, burnishing, slipping and coil lines or thumb and finger tip impressions associated with manufacture. The presence of adhesions was recorded; adhesion being defined as a deposit which has adhered to the outside or inside of a pot sherd and which is not a post-depositional feature, that is, it does not extend to the broken edges of the sherd.

Analysis

The analysis of the assemblage records falls into three main sections. Firstly, pot specific information, such as details of type, form, firing, construction and decoration were examined. Secondly, information on functions of individual vessels or vessel type was examined using the evidence from the adhesions, both internal and external. Finally, site specific information based on the nature and use of the sherd size index is discussed elsewhere in this chapter.

Typology has been the traditional requirement of pottery reports, in particular those dealing with material from the Western Isles. However, it is clear from reading the literature that a widespread overlap of types exist. In this project three methods of defining types were considered. It was decided to exclude 'provenance' from the definition of types and to use it as a test of typologies generated, in that it may be assumed that chronologically significant groups would cluster in mutually exclusive or slightly overlapping groups of strata.

i) Attribute analysis: in this report the attributes of colour, firing and gross texture were taken to define type.

ii) Stylistic analysis: a sample of the pottery was sent to a traditional formal and stylistic pottery specialist who produced a typology.

iii) Analysis of fabric.

There are a number of reasons for the occurrence of different pottery types on a site, chronological, functional, social and/or economic. Where the typology had a chronological significance, the defined types should be reflected in the stratigraphy. Therefore, on each site the defined types are tested for stratigraphic significance.

The remaining pot specific analysis details form using the attributes: rim with external horizontal curvature and base with base angle, firing, construction and decoration.

As outlined above, it was proposed to seek evidence for the function or use of the pots by analysing the adhesions which occurred on many sherds. Clearly the possibility exists that these adhesions are a post-depositional phenomenon, but no sherd was observed where the adhesions occurred on the edges of the sherds (on the faces of the breaks) and this implies that these adhesions may not be a post-depositional feature. Thus it is argued that the internal adhesion represents the remains of the pot contents and suitable analysis might reveal what these contents had been. If this hypothesis is true, the external adhesions should contain a high carbon content. (The assemblage of sample adhesions forms part of the site archive).

Finally, there are social and economic reasons for the differences observed in pottery types. Working in the Southern Sudan, Braithwaite noted the use of decorated and undecorated wares in the preparing and serving of food and found that woman used only undecorated pots while men used the decorated wares (Braithwaite 1982). A second example comes from the work undertaken by Hodder among the Nuba of Sudan, which revealed that pottery production was geared to their strong sex taboos (Hodder 1982). Unfortunately, social and economic differences are the most difficult to establish archaeologically and are virtually impossible to detect in a limited excavation.

9.3.2 The calculation of potsherd size distribution

J Barber

Common experience suggests that ceramic vessels break into a relatively small number of relatively large sherds when first broken. If at this point the sherds come to rest in a context (in or on a surface) where disturbance takes place, by trample, for example, then further breakage must ensue. If the disturbance of the deposit is prolonged, even if intermittently as it would be, for example in a cultivated deposit, continued breakage must result in the comminution of the sherds. If the forces involved are compressive, the sherds must finally be destroyed completely. If they are tensile, on the other hand, the sherds must be reduced to some minimum size, the dimension of which is related to the tensile strength of the sherd. In both cases the mean sherd size must reduce with time unless the rate of deposition of the sites sediments is sufficiently rapid to bury and thus preserve them. Since different sites produce pottery of different types, vessel size, wall thickness, tensile strength, etc inter-site comparisons are likely to prove difficult or misleading and the hypothesis is therefore restricted to inter- and intra-context comparisons for single sites. Differences in ceramic tradition can also arise through time and on sites of considerable duration, this may need to be taken into account.

The quickest and easiest measure of a sherd's 'size' is to weigh it. However, this is not usually a useful measure because of inter- and intra-vessel variation in wall thickness. The surface area of one face of the sherd is a more useful indicator of size, for our purposes, but this is both awkward and time consuming to measure directly. An index, directly related to this parameter can, however be calculated from the weight and mean thickness of the sherd and as these dimensions are usually recorded in the pottery catalogue, they do not entail any additional work.

To calculate this index it is necessary to assume first that potsherds are approximately tabular solids. The curvature of the sherds contradicts this assumption, but does not introduce significant errors, unless the sherds are small, tightly curved and thick walled. The volume, V, of a tabular body is the product of its thickness, T, with the surface area of one face, A_f; equation 1, thus:

$$V = T \times A_f$$

The mass (for which, here read weight, W) of a body is related to its volume, V, by its density, D, giving equation 2 thus:

$$W = D \times V$$

If we make the reasonable assumption that the density of the pottery from any one site is approximately constant, we can in fact ignore its real value and substitute for this with unity. Thus we can substitute weight, for volume and arrive thereby at an index of sherd size, I, which approximates to the area of the sherd face, A_f thus;

$$I = W/T_m \quad \text{(where } T_m = \text{mean thickness)}$$

The sherd size index (I) was calculated for all the sherds examined from each site, by dividing the sherd weight by the mean thickness. For each site, the mean and standard deviation of the index was calculated and the range was divided into size classes, each one standard deviation wide, on either side of the mean. The distribution was strongly skewed, the mean occurring in size class 3 of the fourteen size classes, ranging from large (1) to very small (14). However, the size classes are used merely as convenient groupings devoid of any statistical significance and the skewness of the distribution is irrelevant.

9.3.3 Mammalian fauna: analytical methods

P Halstead (1987)

Identification

Modern comparative specimens were consulted in the collections of the Department of Archaeology at Sheffield University, the Creswell Crags Visitor Centre, that of Dr. Peter Rowley-Conwy and of the author. Distinction between sheep and goat follows Boessneck *et al* (1964) and Payne (1985); between red and fallow deer follows unpublished notes of Dr Adrian Lister.

Quantification

The weaknesses of the traditional alternative systems of quantification (numbers of identified specimens or 'NISP', minimum numbers of individuals or 'MNI') are well documented (eg Klein & Cruz-Uribe 1984). For most purposes, the basic unit of relevance to archaeozoological analysis is smaller than the individual animal and larger than the (usually fragmentary) individual specimen. For the purposes of this study, therefore, quantification is in terms of the following (Halstead 1985): mandible (cheek tooth row), scapula (articular region), proximal humerus, distal humerus, proximal radius, distal radius, proximal ulna, promixal metacarpal, distal metacarpal, pelvis (acetabular region), proximal femur, distal femur, proximal tibia, distal tibia, astragalus, calcaneum, proximal metatarsal, distal metatarsal, first phalanx, second phalanx, third phalanx; for long bones, the proximal and distal units include their respective halves of the shaft. Units from the left-, and right-hand side of the skeleton are counted separately. The phalanges of the fore-, and hind-limb are not distinguished. In calculating the relative abundance of different species, allowance has been made for the greater numbers of foot bones in pig, dog and seal compared with sheep, cow and red deer.

As with MNI, a subjective element with this system of quantification concerns definition of the universe within which actual or notional 'joins' are sought between bone fragments. In the case of Baleshare and Hornish Point, such joins were sought within but not between stratigraphic 'blocks'. A few actual joins between different features within a Block argued against restricting the search to smaller stratigraphic units.

Ageing

Dental eruption and wear have been recorded for mandibular teeth as follows (codes are recorded in italics in text):

sheep(/goat) – after Payne (1973; 1987; Deniz & Payne 1982);
cow – after (Grant 1982);
pig – after Grant (1975; 1982);
dog – after Silver (1969).

Unfortunately the jaws from Baleshare and Hornish Point are extremely fragmentary and the dental material consists almost exclusively of loose teeth. Detailed consideration of age at death (only attempted for the two commonest species – sheep and cow) concentrates, therefore, on the deciduous mandibular fourth premolar (d4) and the mandibular third molar (M3). For sheep and cow, mandibular d4 and M3 are very easy to recognise as loose teeth and together they cover the full lifespan of the animal with only a slight overlap (Sheep – Payne 1973, 298 Figure 14; cow – Payne 1984, 79 Figure 11).

Although these d4 and M3 series could potentially overlap, the virtual absence of heavily worn d4s or lightly worn M3s of either sheep or cow argues that the same deaths are not being registered twice. Rather, a bimodal pattern of mortality, separated by the period in which d4 is shed and M3 erupts, seems apparent for both species. For cattle, the unusual contents of pit [138] are literally the exception that proves the rule: a pair of complete, identically worn mandibles from an individual dying in the interval between the two peaks of mortality confirms advanced wear of d4 long before M3 comes into wear, *viz*;

d2 W, d3 W, D4 *14L*, M1 *9A*, M2 *5A*, M3 E/V

For sheep, a similar conclusion is reached by a more circuitous route: in one mandible each, d4 at *23L* and M3 at *9A* are associated with M2 at respectively.

The remaining mandibular teeth are less distinctive than d4 or M3 and provide only a limited check on these data: the early mortality peaks are well represented however, by unworn or lightly worn specimens of d2 and d3 (cow) and lightly worn specimens (probably) of M1 (Sheep), while the second mortality peak is well attested for both species by heavily worn specimens of M1 and M2.

For postcranial bones, a 'neonatal' category was recognised, which may include foetal specimens, but largely refers to lambs/calves estimated (by comparison with modern material in the Creswell Crags collection) at 0–4 (–6) weeks old. Bones from [098] (Block 7) and [126] (Block 11) at Baleshare provide a limited amount of internal evidence for the relationship between the neonatal category of postcranial bones and dental development. In [098], the remains of a (large) 'neonatal' calf were associated with a pair of mandibles at the following stage of eruption/wear;

d2 1/2, d3 W, d4 *6L*, M1 E/V

In [126], the remains of two neonatal lambs were associated with a pair of mandibles at the following stage of eruption/wear;

d2 E, d3 E, d4 E

For material *older* than neonatal, the state of epiphyseal development was recorded as 'unfused', 'fusing' (treated for purposes of analysis as 'unfused'), 'fused' or 'indeterminate'. Ages of epiphyseal fusion are taken from Silver (1969). The two juvenile cattle in pits [138] and [481] provide a limited amount of internal evidence (broadly compatible with Silver) for the rate of epiphyseal fusion;

Pit [138]: proximal radius, axis fused; pelvis (acetabulum), proximal second phalanx fusing; proximal first phalanx, distal metacarpal, distal metatarsal, distal tibia, distal radius, proximal and distal femur, proximal tibia unfused.

Pit [481]: proximal second phalanx fused (just); distal humerus, atlas fusing; proximal first phalanx, distal metacarpal, distal metatarsal, distal tibia, calcaneum, proximal and distal femur unfused.

Note that a distinction between 'neonatal' and 'older' (than neonatal) is possible for *all* postcranial material. Within the 'older' category, however, a distinction between 'unfused' and 'fused' is possible for only a minority of specimens; also unfused specimens are more vulnerable to attrition than fused and so are more likely to be destroyed or rendered 'indeterminate'. Finally, an unfused specimen indicates an animal which died before the relevant fusion stage but, because each of the fusion stages defined in Table 13 covers a period of several months, the successive episodes of mortality are aged far less accurately than with dental evidence.

Sexing

There are too few well preserved, mature postcranial elements to determine adult sex ratios on metrical grounds, but a few pelves could be sexed on morphological grounds following Boessneck *et al* (1964) for sheep and Grigson (1982) for cattle.

Butchery, burning, gnawing and fragmentation

Cut marks were, where possible, assigned to skinning, dismembering or filleting, following Binford (1981). Evidence of gnawing by dogs and of burning were recorded as 'present' or 'absent'. As regards fragmentation, bones were recorded as 'whole' (including unfused but otherwise complete epiphyses or diaphyses), 'new break' (ie broken during/after excavation) or 'old break'. In two deposits, fragmentation has been attributed to marrow extraction following Binford (1981).

9.3.4 Fish bone: methodology and analysis

A Jones (1987)

Despite the fragmentary nature of the remains, relatively few of the bones (fifteen from Baleshare, eleven from Hornish Point) were unidentifiable. However, it has not proved possible to assign all the identified remains to species; some were attributed to family, or broader taxonomic group.

All but three of the bones were retrieved by sieving excavated shell-sand deposits on 5 mm sieves on-site. All bone (mammal, bird and fish) was collected from the sieves and fish bone later sorted from other kinds of bone was submitted to the author for identification and comment. Three small gadid bones were recovered by flotation and provide the main evidence for the exploitation of small fish. The remains were identified by comparing the ancient specimens with specially prepared modern material forming the collection of fish skeletons at the Environmental Archaeology Unit, (EAU), University of York. Mineralized vertebral centra of cartilaginous fishes were identified by using X-ray photographs as well as surface features.

5 mm aperture meshes were used in the sieves to recover the bulk of the fish remains, as a result it is very likely that remains of several species of small-boned fishes, which were present in the deposits at the time of excavation, passed through these sieves. These are, of course, retained in the products of the wet-sieving and flotation samples, but were not subjected to analysis.

9.3.5 Charred plant remains: sampling, recovery and analysis

G Jones (1987)

Charred plant remains were recovered in three ways:

i) A 0.5 m strip of each context was sieved using a 5 mm mesh sieve. These samples have not been studied.

ii) A 20 kg sample of deposit was collected from each context. This was first sieved as above and the remainder of the sample was processed using a Cambridge froth flotation machine (Jarman *et al* 1972). The material was retrieved in 1 mm and 350 micron sieves.

iii) Samples (of unknown volume) were processed as above but without the addition of chemicals. These were subsequently used for radiocarbon dating.

Charred plant material was separated from the rest of the flots from the 1 mm sieves. Identifiable fragments were then sorted microscopically (at ×6) out of the charred material. The flots from the 350 mm sieve have not been studied and to do so in their present unsorted state would take a considerable amount of time (even if study was restricted to those samples rich in remains from the coarse sieve). They would provide information on the representation of wild species with seeds smaller than 1 mm but, given the difficulty of distinguishing weeds of cultivation from wild plants brought in with fuel (Jones, below) such information is of limited value.

Identifications were made by comparison with modern reference material. For the identification of Carex nutlets, descriptions and illustrations provided by Nilsson and Helmqvist (1967) and Berggren (1969) were also used. The nomenclature of species follows *Flora Europaea* (Tutin *et al* 1964, 80). Samples from 353 different contexts were examined (176 from Baleshare and 177 from Hornish Point). All but eleven of these (seven from Baleshare and four from Hornish Point) produced some identifiable charred remains.

9.3.6 Pollen: sampling, preparation and methodology

A Mannion & S Moseley (1986)

Field methods

In the absence of a boat, a detailed examination of the stratigraphy of Loch Scolpaig was impossible but the well developed hydrosere facilitated access on foot to all but the most central parts of the basin. Little variation in the stratigraphy across the basin was recorded and a core was collected with a Russian sampler (Jowsey 1966) from a position slightly south-west of centre where the sediment sequence was thickest. After extrusion in the field the cores were placed on plastic drainpipe, wrapped in cling film, aluminium foil and polythene and stored in an incubator at 3 °C on return to the laboratory.

At the Balelone Farm site, the deepest peat section in the area, sampling was carried out by digging a pit and extracting vertical sections of peat in metre-length metal monolith boxes. A wrapping procedure similar to that for the Loch Scolpaig samples was employed due to their bulk; storage at Reading was in a freezer. Prior to freezing samples from 75 cm, 150 cm, 225 cm and 300 cm (the base of the peat) were extracted for radiocarbon dating at SURRC (Chapter 19).

Sub-sampling

Sub-samples from the Loch Scolpaig core were extracted at approximately 5 cm intervals and from the Balelone core at approximately 10 cm intervals for pollen analysis. After cleaning, 1 cm^3 was extracted using a displacement method (Bonny 1972). A 5 cm^3 measuring cylinder was filled to the 3 cm^3 level with distilled water. Crumbs of the sediment were then added until the meniscus reached 4 cm^3 after which the sample was washed into a polypropylene centrifuge tube. Three *Lycopodium* spore tablets were added and allowed to dissolve. The samples were then centrifuged.

Chemical processing

i) *Removal of carbonates*: *circa* 10 ml of 10% HCL were added and after the reaction had ceased the samples were centrifuged and washed in distilled water.

ii) *Disaggregation and removal of humic acids*: *circa* 10 ml of 10% Na OH were added to each sample and stirred. The samples were then heated at 110–120 ^{0}C for 20 minutes with the occasional addition of distilled water to prevent destruction of pollen grains/spores which may occur if the NaOH becomes too concentrated. After washing and centrifuging, further washes were carried out until the supernatant liquid was clear.

iii) *Removal of coarse material*: The samples were washed through 180 micron sieves into 100 ml beakers and washed with distilled water. They were then retrieved by centrifuging.

iv) *Removal of mineral matter*: A few drops of distilled water were added to the samples and after re-suspension 10 ml of concentrated HF were added and left for three days. After centrifuging 10 ml of 10% HCL were added, heated for 5 minutes, centrifuged and washed in distilled water.

v) *Removal of cellulose*: To each sample 10 ml of glacial acetic acid were added, the sample resuspended, centrifuged and decanted. Some 10 ml of an acetolysis mixture (freshly made 9:1 mixture of acetic anhydride and concentrated sulphuric acid) were added to each sample and heated for 10 minutes. After centrifuging the samples were washed in glacial acetic acid and then in distilled water.

vi) *Mounting*: A few drops of water and 10% NaOH and a drop of safranin stain were added to each sample. After centrifuging any water remaining was evaporated off by gentle heating. A small amount of glycerol jelly was then added to each sample. One drop of the suspension was then placed on a warmed labelled microscope slide and a cover slip placed on top. Two slides were made up for each sample.

vii) *Counting*: The coverslip of each slide was traversed longitudinally at 1 mm intervals using a Leitz Laborlux microscope at ×400 magnification or ×1000 for difficult grains. Pollen and spore types were identified using keys and a pollen reference collection. A pollen sum of between 490 and 510 was counted for identifiable grains and indeterminate grains are retained in a separate group outside the pollen sum.

9.3.7 Snails: methodology

N Thew (1987)

Sampling

Previous studies of mollusca from calcareous coastal sand locations have employed column sampling. Though adequate for essentially natural deposits or for sites with thin, extensive occupation-horizons such as Northton, Harris (Evans 1971; 1972; 1979), column samples are not suitable for stratigrapically complex sites.

Bulk sampling of individual contexts was employed on the sites studied here. Standard bulk samples of approximately 20 kg were taken from every context which contained sufficient material. Larger samples, taken to collect material for radiocarbon dating occasionally yielded snail shells also. There are a few cases of inconsistencies between faunas from samples from these two sources. It should be noted that snail studies were not envisaged when the sampling strategy was evolved. Thus, as snail assemblages, those retrieved proved at times less than perfect.

Sample processing

Previous studies from calcareous sands have yielded minimum counts of fifty individuals from 1.5 or 2.0 kg samples, occasionally reaching maxima of 5,000 or more (Evans 1971; Spencer 1975; Evans & Spencer 1977; Evans & Vaughan 1983). In the sites considered here, 20 kg flotation samples produced between five and 500 specimens. This is largely due to the methods of sample processing employed on these sites.

Comparison with previous studies from coastal, calcareous sand deposits suggests that only 1–10% of the snail fragments present in a sample will float. Fragile and larger species such as *Vitreea, Oxyloma pfeifferi* and *Vitrina pellucida* are more likely to be fragmented and sink. The large land snail *Cepaea hortensis* is often only recovered as fragments and here was represented only by complete specimens caught in the 5 mm sieve. Fortunately most of the species recorded from previous studies have relatively small mouths and would probably be able to float even if some of the outer whorls had broken away. It is hoped though, that apart from these biases, that the recovered shells are representative of the original molluscan assemblages of flotation samples.

The restricted number of species from the study sites implies that extreme conditions with low diversity and poverty of habitats prevailed (cf Walden 1981, 370). This seems to have been a consequence of human activity. Comparison with modern studies of faunas on grazed machair in the Orkneys (Evans & Vaughan 1983) demonstrate their similarity with those from Baleshare, Balelone and Hornish Point.

Taphonomy of snails

Factors affecting the numbers of molluscs present within a context include original population size, rates of deposition (slower deposition allows more molluscs to accumulate), degree of stability (encourages richer vegetation and molluscan faunas) and preservation. The snails were well preserved throughout though some staining was observed. The mechanics of deposition appear to have been largely through burial by windblown sand, or through incorporation in a deepening turf horizon. Mechanical weathering may therefore reflect attrition by human or animal activity. Thus the majority of numerical variations within molluscan assemblages are attributable to differences in the original populations and the rate of layer accumulation.

Even allowing for the small numbers recovered by flotation the original populations appear to have been restricted both in numbers and species diversity especially in comparison with published sites. Northton, and Buckquoy (Evans & Spencer 1977) returned twenty-three and twenty non-wet species respectively, and, generally, more than twelve species indicate a high degree of stability and shade. Species counts of fifteen and over often indicate true shade, perhaps rich, long, very stable grassland or perhaps open woodland in the cases of Northton and Buckquoy. In only two instances do the counts of non-wet species equal or exceed twelve, in the present study. At Baleshare, one context produced twelve while at Hornish Point one context returned fourteen species. The assemblages from these two sites, together with those from Newtonferry and Balelone, on the criterion of species frequency, indicate very open environments, with almost no indication of true shade.

Identification and quantification

Identification of terrestrial snails was undertaken using the Sheffield University reference collection, guides by Evans (1972) and Kerney & Cameron (1979), and reference material held by the author. The specimen of *Columella edentula* was identified using the *Columella* guide by Paul (1975b). Species identification for *Oxychilus, Vertigo* and *Vitrea* were checked by Dr R P Reece.

Hybridization can sometimes take place between the two closely related *Cochlicop*a species (Paul 1975a), *Cochlicopa lubrica* and *C.lubricella* and this seems to have happened at Hornish Point and Baleshare where a continuum between the two species was observed. Samples from Hornish Point were speciated but this was undertaken in few of the Baleshare contexts. Therefore the species counts are under-represented by a value of one at Baleshare. Normally the ratio between the incidences of the two species is used as an environmental indicator, but this was not practicable here given the extensive hybridisation. Banding patters of *Cepaea* species (Cain *et al* 1969) were not studied, as their environmental significance is still unclear.

Problems of interpretation

Interpretation was affected by the low numbers recovered from each sample and the bias against certain species caused by flotation. However, the three species most likely to have been affected, *Vitrina, Oxyloma* and *Cepaea*, were only present in small numbers in previously published comparable studies.

The assemblages were characterised by the presence of variable numbers of a few dominant species (mainly, *Pupilla muscorum, Cochlicopa spp*, and *Vallonia spp*), and the presence or absence of small numbers of several other species, designated, indicator species. The latter included wet species indicative of flooding. A second indicator group included the *Helicelis* snails, including *Cepaea*. The third indicator group included species newly arrived in the area in the later Prehistoric period, such as *Helicella itala* and *Cochlicella acuta*. A further indicator group consisted of the Zonited group plus *Vitrina pellucida*, which being omnivores, can fluctuate independently, together with *Lauria cylindraea* and *Vertigo pygmaea*.

The interpretation of the assemblages retrieved from the sites examined here is based on fluctuations in relatively low counts of a restricted number of species. It is possible to generalise and consider that the assemblages as a whole represent open grassy landscape exhibiting variation in stability, dampness and degree of anthropogenically deposited organic refuse. In addition, the fluctuations between the faunas from individual contexts are interpreted as representative of variations in the micro-environments.

Small numbers of wet species have been found in contexts from all four sites, with a few specimens of freshwater aquatic snails. Baleshare, Hornish Point and Newtonferry are located on low-lying flat coastal machair plains liable to episodic winter flooding due to rising water tables (Ritchie 1979). This could account for wet species co-occurring with faunas suggestive of open, relatively dry environments. Consequently the significance of the wet species has been considered separately from the general interpretation of local environment.

Evans (1972; 1979) has shown that in periods of surface stability the fossil molluscan fauna represent the immediate local environment while, during periods of surface instability, the molluscs trapped in a sandy layer could represent a much wider catchment area. This problem is reduced, in the present instance, by the large numbers of samples, spatially separated across the sites, which were examined.

Despite the sources of potential bias described above, it is clear from the data that fluctuations among the dominant species seem, in the main, to reflect variations in the natural environment. Variations in certain of the indicator species seems to reflect patterns of human land-use.

The assemblages were classified into faunal associations on the basis of the relative proportions of the dominant species and the presence, or absence, of indicator species. The faunal associations proved adequate for the analysis of material from Baleshare. However, the complexity of the material from Hornish Point and Newtonferry required the construction of a faunal matrix, with variations in the dominant species mapped on one axis and the presence or absence of the indicator species on the other.

Examination of the distribution of the faunal associations indicated a need to sub-divide many of the Blocks of contexts, originally grouped on archaeological grounds. These sub-blocks contained faunal associations which reflected local environmental variations interpretable in terms of degrees of dampness or dryness, degrees of exposure or stability and the extent of middening.

In some cases, however, the archaeological evidence for middening conflicted with the snail evidence. These apparent conflicts may have arisen as a consequence of the nature of organic material added to the soil (fresh or already decomposed), the rapidity of sediment accumulation (fresh waste buried before colonisation) and possibly by discrepancies between samples taken from the base or surface of contexts reflecting not the environment during accumulation of the contexts themselves, so much as the environment before or after a context was formed.

Interpretation

The interpretation of molluscan fauna from archaeological deposits differs from that fauna from natural sediments in that they are couched in terms of anthropogenic interference, rather than environmental development. Ploughing, animal grazing and penning, and the disposal of different types of domestic rubbish create varying micro-environments superimposed upon the natural environment. Before these can be detected, however, the impact of the natural environment must be identified and discounted. Biological succession, climatic change and the height of the local water table have a significant affect on snail faunas. Aspect, relative to prevailing wind and the degree of isolation of the area, must also be considered, together with the nature of the local bedrock and soils which affect drainage, vegetation and the availability of standing rocks for rupestral snail species. When the variation which can be attributed to these factors has been eliminated, that which remains is due to human activity.

Layers are the products of different processes including, for these sites, the accumulation of wind blown sand, deepening turf horizons incorporating organic material, the deposition of organics matter by grazing animals and the dumping of various types of domestic waste by the inhabitants of the archaeological site. Layer boundaries must therefore represent interruptions to individual depositional processes.

It is important to remember that most molluscs live on or just below the surface. Therefore, molluscan faunas within layers may indicate that deposition was gradual, allowing the surface fauna to accumulate within the layer. Poor molluscan faunas within layers would, in these circumstances, indicate rapid sedimentation. In natural conditions such deposits would be interpreted in terms of a rapid build up of wind-blown sand with a restricted sparse herbaceous vegetation containing grass species adapted to unstable accumulating conditions. Thus boundaries observed within a deepening turf horizon, could mark interruptions to the depositional process caused by factors such as overgrazing, or a series of severe frosts or droughts. A diffuse change to a sandier layer could merely mark the onset of more rapid sand aggregation. These changes, however, should be detectable by a continuous molluscan record, varying in abundance, and diversity.

The depositional mechanics of dumping and ploughing are somewhat more complicated. If small deposits are regularly dumped, thin spreads will be incorporated into a single layer with a continuous molluscan assemblage reflecting the nature of the surfaces of the spread material. Larger deposits of dumped material form discrete layers with molluscan faunas and herbaceous floras restricted to the surfaces of these layers. In such deposits, few, if any molluscs should occur within the layer. The surface faunas and floras will reflect not only the nature of the dumped material below but also the amount of time that elapses before further dumping occurs or before natural sedimentation begins.

Erosion and redeposition of deposits, whether by human or natural agencies, can cause problems in the interpretation of the molluscan faunas as eroded material can either be lost completely, or redeposited elsewhere on site.

Ploughing is difficult to detect in the molluscan faunas. It mimics natural conditions of instability, and the molluscan faunas reflect the vegetation cover and surface conditions that develop after ploughing. If the fallow period between ploughing episodes is great the molluscan faunas indicate relatively stable grass cover. With shorter intervals between ploughing the fauna indicate greater instability. Ploughing damages and mixes the faunas of all the fallow episodes thus producing an average fauna.

9.3.8 Phytolith analysis: methodology

A Powers (1987)

Processing

The samples were prepared using the techniques described in Powers and Gilbertson (1987). The technique used simpler, cheaper and less dangerous substances than are commonly used (ibid). In brief, one gram of each sample was disaggregated in hydrochloric acid, centrifuged, desiccated and burnt in alchohol. To the resultant ash a proportion of *Lycopodium* tracer aliquot was introduced to facilitate 'absolute' phytolith studies in the manner pioneered for palynology by Stockmarr (1971).

Counting

In general two hundred and fifty phytoliths plus marker grains were counted at a magnification of × 1000 under phase contrast microscopy, after which point new phytolith morphotypes were found to be encountered only rarely (Powers *et al* 1986). This process took between 1.5 and 16.9 hours per sample. However, the numbers of phytoliths recovered from the modern windblown sands and dune sediments were so very low, that is was necessary to resort to employing 'time-catch' methods to compare the numbers of phytoliths noted per sample, per standard 60 minute search period (see Powers *et al* 1986; Powers & Gilbertson 1987).

Identification

The phytoliths recovered were counted and listed according to their shape. A simple but robust classification of phytolith types was employed (Figure 84) which is based on three criteria (see Powers *et al* 1989);

i) the overall shape of the phytoliths (eg rods or dumbells)

ii) overall size (small, medium, large)

iii) texture (coarse, fine)

Modern analogues

The examination and interpretation of prehistoric phytolith assemblages on the basis of the three specific questions outlined above, included several assumptions or expectations which were based on observed fact or logical expectation. Namely, that in respect of the first (and indirectly the second) question posed by the excavator the expectation was that a 'high' concentration of phytoliths per unit of sediment would suggest a stable layer or soil horizon and that a 'low' concentration would suggest an accumulation of blown sand in a locally 'unstable' situation.

The underlying assumptions derive from the oft-observed relationships between sand dune mobility/instability, vegetation abundance and soil development (see Ranwell 1972; Pethick 1983; Salisbury 1952).

The aforementioned sources suggest that per standard unit of sediment, the hypothesised 'stable' layers will contain a higher frequency of phytoliths than non-stabilised layers as a result of;

i) the greater abundance of vegetation and/or

ii) the greater input of plant debris (natural or anthropogenic sequences) which are thought to be associated with the 'stable' situation and/or

iii) the lack of erosion and re-working associated with more stable, well vegetated soils which also ought to lead to higher phytolith frequencies per standard volume of sediment.

To test the basic assumption that high frequencies of phytoliths are equated with stabilised horizons (and the reverse) a series of modern samples were collected by John Barber from the machair of Links of Noltland, Westray, Orkney. Twenty-five samples of free windblown sands were collected, together with twenty-four samples from a transect stretching inland from the dune foreshore and incorporating non-vegetated, marram and herb covered sands (see Powers *et al* 1986; 1989)

An unexpected paucity of phytoliths from sediments was found on the sheep grazed, vegetated surface at Noltland (between two and fifteen phytoliths recovered per 60 minute count [see Powers *et al* 1986; 1989 for full results]). This prompted the acquisition of a second set of modern 'machair-type' samples, this time from the Ainsdale National Nature Reserve on Merseyside (*ibid*).

It had been conjectured that on Westray the presence of large numbers of grazing ruminants (eg sheep) could have been the reason for the general absence of phytoliths from the vegetated surface sediments. There has been no ruminant grazing or other non-scientific access in the Ainsdale sand dunes for several decades. The effects of non-ruminant (rabbit) grazing on the phytolith suites recovered from machair environments is as yet unknown.

The Ainsdale results however, also indicated a marked absence of phytoliths from modern vegetated dune (between seven and twenty-four phytoliths recovered during a 60 minute count (see Powers *et al* 1986; 1989 for full results). The sub-surface samples were also practically devoid of phytoliths dismissing any hypothesis that the phytoliths might have been washed down the profile.

The absence of any significant numbers of phytoliths from both the modern analogue sites resulted in abandonment of the anticipated simple equation of 'many phytoliths = stable vegetated horizon' and its corollary 'few phytoliths = unstable poorly vegetated dune surface'. Unfortunately, this meant that it was not possible to address either of the first two questions posed by the excavator other than to answer in the negative. The data produced no clear differences in the total abundance of phytoliths, all samples produced extremely low counts and because of this it was impractical to make any statement about possible differences in phytolith suite composition.

In the event, only the third question posed by the excavator concerning the nature of the organic-rich layers found in the archaeological sites could be addressed. That is not to say however, that other interesting facts did not result from the analyses of the Baleshare and Hornish Point samples.

9.3.9 Diatom analysis: preparation and methods

A Mannion & S Moseley (1987)

Sub-samples from the core were extracted at approximately 0.30 m intervals and prepared for diatom counting following the recommendations of Battarbee (1979) and summarised in Mannion (1982) *viz* for each sample:

i) Approximately 1 cc of sediment was washed through a sieve of 0.5 mm mesh with distilled water to remove coarse mineral matter.

ii) The residue was then heated gently in dilute hydrochloric acid to remove carbonates and iron compounds.

iii) After washing in distilled water the residue was oxidised by gently heating in 30% hydrogen peroxide solution and washed again.

iv) Since a considerable amount of mineral material remained floatation in zinc bromide solution was carried out at least twice involving centrifugation at 2500-3000 rpm for approximately 5 minutes and the supernatant, containing the diatoms, was collected. The diatoms were recovered from this liquid by diluting with distilled water and centrifuging.

v) The residue was diluted in 2 mls of distilled water to achieve adequate dilution of diatom frustules

vi) Approximately 0.2 ml of the suspension was dropped onto a coverslip, placed on a slide warming plate and the water allowed to evaporate under gentle heat.

vii) The coverslip was mounted on a microscope slide using commercially available diatom mountant.

viii) Approximately 600 diatom frustules were counted for each sample using oil immersion objectives and magnification of x1000 on a Leitz Ortho-Lux microscope. Identifications were verified using keys such as Hustedt (1930), Patrick and Reimer (1966) and Barber and Haworth (1981). The identification of *Fragilaria virescens* ver *subsalina* was kindly undertaken by Mr Carter.

9.3.10 Investigation of lake sediments; methodology

K Hirons (1986)

Sediment characterisation

Sub-samples, 1 cm thick, were collected at 1 cm intervals using the cut-syringe method (Fletcher & Chapman 1974), for the determination of fresh density. The following sediment parameters were measured on each centimetre sample; water loss on drying overnight at 105–110 °C; estimated organic content by loss-on-ignition at 550 °C for 8 hours (LOI); estimated carbonate content by loss-on-ignition at 950 °C for 8 hours (HT-LOI) (Dean 1974). The pH of the wet sediment was determined by pressing the electrode bulb directly into the core at 1 cm intervals (cf Digerfeldt 1972).

Pollen analysis

Three further sub-samples, 1 cm thick, were collected for pollen analysis and two tablets of *Lycopodium clavatum* spores were added to allow the calculation of fossil pollen concentrations (Benninghoff 1962: Stockmarr 1971). The samples were prepared for pollen analysis using HF, acetolysis mixture and HCl. They were then mounted, unstained, in silicone fluid. Preliminary pollen counts of between 100-300 were undertaken on the samples. Outline percentage pollen diagrams were prepared, using a total land-pollen sum. A summary diagram showing tree, shrub (including Coryloid) and herb pollen as percentages of the pollen sum was also prepared. Pollen of aquatics and spores were included in the diagrams, calculated as percentages of total pollen outside the pollen sum. Charcoal fragments encountered in the pollen preparations were also counted and these are represented as a percentage of total pollen. A summary pollen concentration diagram of selected taxa was prepared for Askernish.

Sediment chemistry and mineralogy
Sample digestion for total elemental analysis was by an adaptation of the acid-pressure decomposition method of Bernas (1978). 0.100 gm of dried and ground (<63) sediment was weighted into a 20 ml Teflon 'bomb' with 6 cm of HF and 1 cm of aqua regia (HNO + HCL) and heated to 100 °C for one hour. Concentrations of NA, K, Mg and CA were determined by atomic absorption spectrophotometry and expressed as percentages of total sediment (dry weight) and as percentages of the mineral matter fraction (dry weight, cf Mackereth 1966).

Samples for mineralogical investigation were ground to pass a 63 mu sieve, digested in HO to remove organic matter and then washed and dried at room temperature. For further analysis of the clay fraction, major cations and carbonates were by shaking with ammonium acetate (pH 4.4) and the <2 fraction was obtained by dispersing in water with an ultrasonic probe and settling (Hutchison 1974). The supernatant containing the clay fraction was pipetted off and dried in a microwave oven for investigation by differential thermal analysis (DTA).